Ministry for Primary Industries
Manatū Ahu Matua

Report from the Fisheries Assessment Plenary, May 2012: stock assessments and yield estimates

Part 3: Red Gurnard
to Yellow-eyed Mullet

Compiled by

Ministry for Primary Industries
Fisheries Science Group

May 2012

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RED GURNARD (GUR)

(*Chelidonichthys kumu*)
Kumukumu
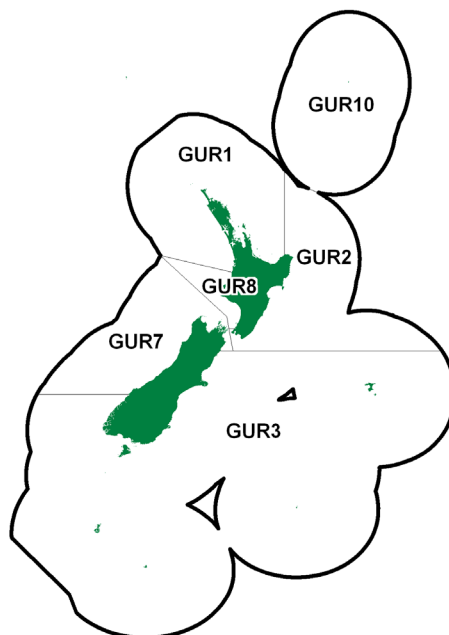
1.   FISHERY SUMMARY

1.1   Commercial fisheries

Red gurnard are a major bycatch of inshore trawl fisheries in most areas of New Zealand, including fisheries for red cod in the southern regions and flatfish on the west coast of the South Island (WCSI) and in Tasman Bay. They are also directly targeted in some areas. Some minor target fisheries for red gurnard are known in Pegasus Bay, off Mahia and off the west coast South Island. Red gurnard is also a minor bycatch in the jack mackerel trawl fishery in the South Taranaki Bight. Up to 15% of the total red gurnard catch is taken by bottom longline and setnet.

Red gurnard was introduced into the Quota Management System (QMS) in 1986. The 1986 TACCs were based on 1984 landings for Southland and 1983 landings for other regions. TACCs for GUR 3 and 7 were increased by 76 t (14%) and 137 t (20%) respectively for the 1991-92 fishing year under the Adaptive Management Programme (AMP), to 600 t in GUR 3 and to 815 t in GUR 7. The GUR 7 TACC was reduced to 678t, in 1997-98. For the 2009-10 fishing season, the TACC in GUR 7 was increased from 681 t to 715 t, including an allocation of 10 t for customary, 20 t for recreational use, and 14 t allocation for other sources of mortality. The TACC for GUR 3 was increased, by 300 t (50%) to 900 t, for the 1996-97 fishing year under the AMP, but decreased to 800 t in 2002-03. For the 2009-10 fishing season, the TACC for GUR 3 was increased from 800 t to 900 t, including a 3 t, 5 t, and 45 t allocation for customary, recreational, and other sources of mortality respectively. All AMP programmes ended on 30 September 2009.

Recent reported landings and actual TACCs by Fishstock are shown in Table 1, while Figure 1 depicts the historical landings and TACC values for the main GUR stocks.

Annual landings of GUR 1 have been relatively stable since 1986-87, generally ranging between 900 and 1300 t; substantially lower than the 2287 t TACC. About 60% of the GUR 1 total is taken from FMA 1, as a bycatch of a number of fisheries including inshore trawl fisheries for snapper, John dory and tarakihi. The remaining 40% is taken from FMA 9, mainly as a bycatch of the snapper and trevally inshore trawl fisheries.

RED GURNARD (GUR)

GUR 2 landings have fluctuated within the range of 400-700 t since 1991-92, typically well below the TACC. In addition to the target fishery off Mahia, red gurnard are taken as a bycatch of the tarakihi, trevally and snapper inshore trawl fisheries.

Table 1: Reported landings (t) of red gurnard by Fishstock from 1983-84 to 2010-11 and actual TACCs (t) from 1986-87 to 2010-11. The QMS data is from 1986-present.

Fishstock	GUR 1		GUR 2		GUR 3		GUR 7	
QMA (s)	1 & 9		2		3, 4, 5 & 6		7	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983-84*	2 099	-	782	-	366	-	468	-
1984-85*	1 531	-	665	-	272	-	332	-
1985-86*	1 760	-	495	-	272	-	239	-
1986-87	1 021	2 010	592	610	210	480	421	610
1987-88	1 139	2 081	596	657	386	486	806	629
1988-89	1 039	2 198	536	698	528	489	479	669
1989-90	916	2 283	451	720	694	501	511	678
1990-91	1 123	2 284	490	723	661	524	442	678
1991-92	1 294	2 284	663	723	539	600	704	815
1992-93	1 629	2 284	618	725	484	601	761	815
1993-94	1 153	2 284	635	725	711	601	469	815
1994-95	1 054	2 287	559	725	685	601	455	815
1995-96	1 163	2 287	567	725	633	601	382	815
1996-97	1 055	2 287	503	725	641	900	378	815
1997-98	1 015	2 287	482	725	477	900	309	678
1998-99	927	2 287	469	725	395	900	323	678
1999-00	944	2 287	521	725	411	900	331	678
2000-01	1 294	2 287	623	725	569	900	571	678
2001-02	1 109	2 287	619	725	717	900	686	681
2002-03	1 256	2 287	552	725	888	800	793	681
2003-04	1 225	2 287	512	725	725	800	717	681
2004-05	1 354	2 287	708	725	854	800	688	681
2005-06	1 113	2 287	542	725	957	800	604	681
2006-07	1 180	2 287	575	725	1 004	800	714	681
2007-08	1 198	2 287	517	725	842	800	563	681
2008-09	1 060	2 287	621	725	939	800	595	681
2009-10	1 075	2 287	853	725	1 018	900	603	715
2010-11	1 046	2 288	587	725	929	900	545	715

Fishstock	GUR 8		GUR 10		Total	
QMA (s)	8		10			
	Landings	TACC	Landings	TACC	Landings	TACC
1983-84*	251	-	0	-	3 966	-
1984-85*	247	-	0	-	3 047	-
1985-86*	163	-	0	-	2 929	-
1986-87	159	510	0	10	2 403	4 230
1987-88	194	518	0	10	3 121	4 381
1988-89	167	532	0	10	2 749	4 596
1989-90	173	538	0	10	2 745	4 730
1990-91	150	543	0	10	2 866	4 762
1991-92	189	543	0	10	3 390	4 975
1992-93	208	543	0	10	3 700	4 978
1993-94	174	543	0	10	3 142	4 978
1994-95	217	543	0	10	2 969	4 982
1995-96	182	543	0	10	2 927	4 982
1996-97	219	543	0	10	2 796	5 281
1997-98	249	543	0	10	2 532	5 143
1998-99	170	543	0	10	2 284	5 143
1999-00	222	543	0	10	2 429	5 143
2000-01	291	543	0	10	3 348	5 143
2001-02	302	543	0	10	3 429	5 143
2002-03	342	543	0	10	3 831	4 993
2003-04	329	543	0	10	3 508	4 993
2004-05	370	543	0	10	3 974	4 993
2005-06	373	543	0	10	3 589	4 993
2006-07	349	543	0	10	3 822	4 993
2007-08	223	543	0	10	3 344	4 993
2008-09	274	543	0	10	3 489	4 993
2009-10	239	543	0	10	3 789	5 181
2010-11	182	543	0	10	3 289	5 181

*FSU data.

GUR 3 landings regularly exceeded the TACC between 1988-89 and 1995-96. Ageing of fish collected during the east coast South Island trawl (ECSI) surveys suggests there were 1 or 2 relatively strong year classes moving through the fishery, which may help explain the overcatches. GUR 3 has been consistently overcaught since 2004.
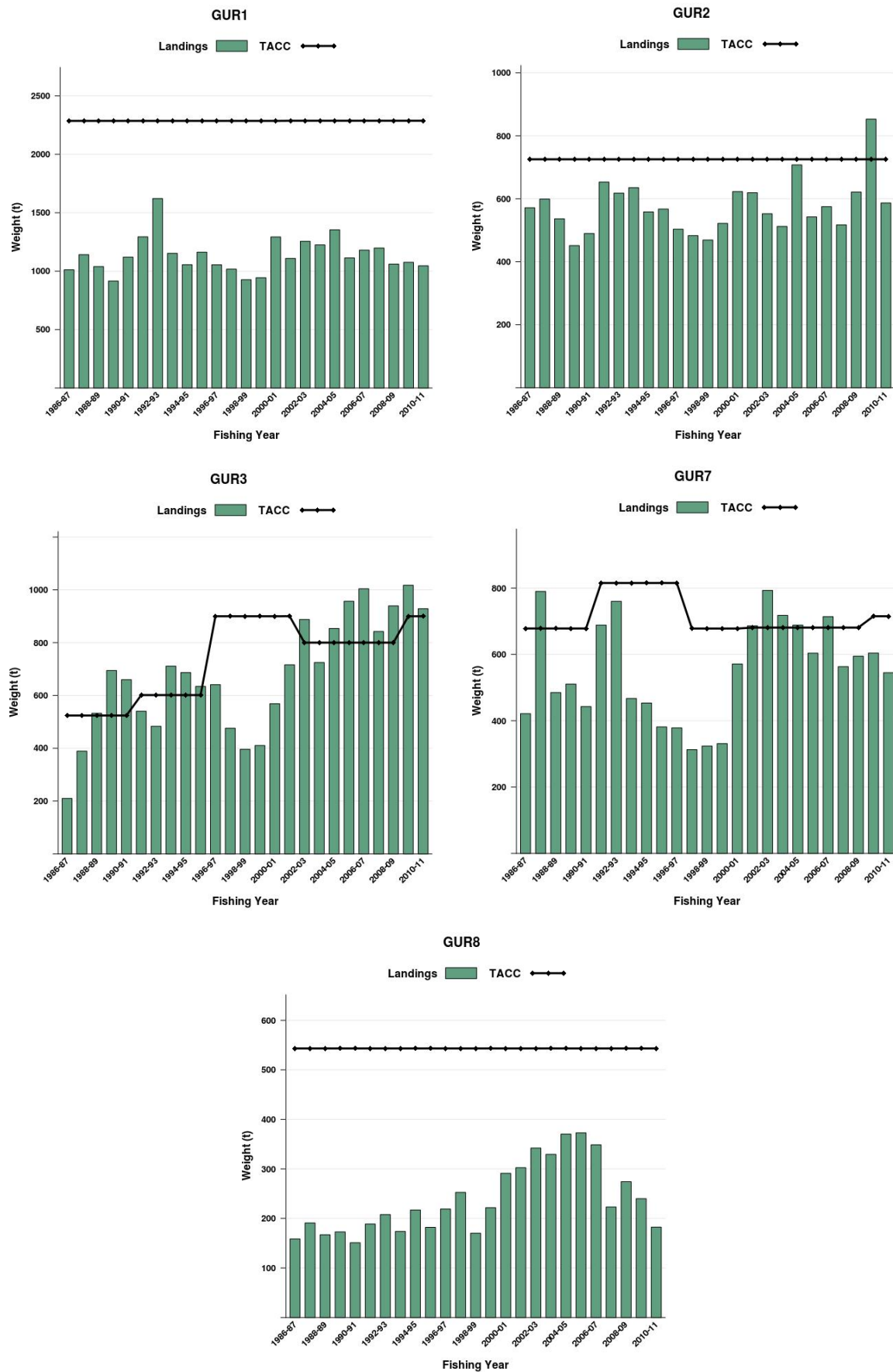
Figure 1: Historical landings and TACC for the five main GUR stocks. From top left: GUR1 (Auckland East), GUR2 (Central East), GUR3 (South East Coast), GUR7 (Challenger), and GUR8 (Central Egmont). Note that these figures do not show data prior to entry into the QMS.

 GUR 7 landings declined steadily from 761 t in 1992-93, to 309 t in 1997-98, but then increased to a peak of 793 t in 2002-03. The TACC has not been caught in the last two years. Landings in GUR 8 have remained well below the levels of the TACC since 1986-87.

1.2   Recreational fisheries

Red gurnard is, by virtue of its wide distribution in shallow coastal waters, an important recreational species. Vulnerable to recreational fishing methods, it is often taken by snapper and tarakihi anglers, particularly in the Northern Region.

Recreational harvest estimates were obtained from national telephone diary surveys undertaken in 1996 and 2001. Regional diary surveys were undertaken from 1991 to 1994. The Recreational Technical Working Group concluded that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and, c) the 2000 and 2001 estimates are implausibly high for many important fisheries. The 1999-2000 Harvest estimates for each Fishstock should be evaluated with reference to the coefficient of variation. Recreational catch estimates are given in Tables 2-4.

Table 2:   Estimated number and weight of red gurnard harvested by recreational fishers by Fishstock and survey. Surveys were carried out in different years in the Ministry of Fisheries regions: South in 1991-92, Central in 1992-93 and North in 1993-94 (Teirney *et al*. 1997). The estimated Fishstock harvest is indicative and was made by combining estimates from the different years.

Fishstock	Survey	Number	CV(%)	Survey harvest (t)
GUR 1	North	349 000	14	155-245
GUR 2	North	2 000	-	-
GUR 2	Central	156 000	31	50-125
GUR 7	Central	21 000	23	5-20
GUR 8	Central	157 000	37	50-110

Table 3:   Results of a national diary survey of recreational fishers in 1996. Estimated number of red gurnard harvested by recreational fishers by Fishstock and the corresponding harvest tonnage. The mean weights used to convert numbers to catch weight are considered the best available estimates. Estimated harvest is presented as a range to reflect the uncertainty in the estimates (from Bradford 1998).

Fishstock	Number caught	CV (%)	Harvest Range (t)	Harvest Point
GUR 1	262 000	7	100-120	108
GUR 2	38 000	18	10-20	16
GUR 3	1 000	-	-	-
GUR 7	26 000	15	10-15	12
GUR 8	67 000	15	25-35	28

Table 4: Results of the 1999-00 national diary survey of recreational fishers (Dec 1999 - Nov 2000). Estimated number of red gurnard harvested by recreational fishers by Fishstock and the corresponding harvest tonnage. Estimated harvest is presented as a range to reflect the uncertainty in the estimates (Boyd & Reilly 2002).

Fishstock	Number caught	CV (%)	Harvest Range (t)	Harvest Point
GUR 1	465 000	16	188-256	223
GUR 2	209 000	37	80-173	127
GUR 3	11 000	70	2-9	5
GUR 7	36 000	23	9-14	11
GUR 8	99 000	36	26-55	40

Owing to the limitations of diary surveys a combined aerial overflight/boat ramp survey was undertaken in FMA 1 during 2005 (1 December 2004 to 30 November 2005), primarily targeting snapper (Hartill *et al*. 2007). The GUR 1 recreational harvest was estimated by this survey to be 127 t (CV 14%).

1.3 Customary non-commercial fisheries

Red gurnard is an important species for customary non-commercial fishing interests, by virtue of its wide distribution in shallow coastal waters. However, no quantitative estimates of customary non-commercial catch are currently available.

1.4 Illegal catch

No quantitative information is available.

1.5 Other sources of mortality

No quantitative information is available**.**

2. BIOLOGY

Gurnard growth rate varies with location, and females grow faster and are usually larger at age than males. Maximum age (A_{MAX}) is about 16 years and maximum size is 55+ cm. Red gurnard reach sexual maturity at an age of 2-3 years and a fork length (FL) of about 23 cm, after which the growth rate slows. An analysis of the age and growth of red gurnard in FMA 7 revealed that young fish 1-4 years old tend to be most common in Tasman and Golden Bays. Three to six year old fish are found on the inshore areas of the West coast South Island and the older fish are predominantly found further offshore (Lyon and Horn 2011).

M was estimated using the equation $M = \log_e 100/\text{maximum age}$, where maximum age is the age to which 1% of the population survives in an unexploited stock. Samples from the ECSI suggested an A_{MAX} of about 16 years for males and 13 years for females, giving estimates for M of 0.29 and 0.35 respectively. Samples from the WCSI indicate an A_{MAX} of about 15 years for both sexes, giving an estimate of 0.31 for M. These samples were not from virgin populations, so M may be slightly overestimated.

Red gurnard have a long spawning period which extends through spring and summer with a peak in early summer. In the Hauraki Gulf, ripe adults can be found throughout the year. Spawning grounds appear to be widespread, although perhaps localised over the inner and central shelf. Egg and larval development takes place in surface waters, and there is a period of at least eight days before feeding starts. Small juveniles (< 15 cm FL) are often caught in shallow harbours, but rarely in commercial trawls.

Biological parameters relevant to the stock assessment are shown in Table 5.

**Table 5: Estimates of biological parameters for red gurnard.**

Fishstock					Estimate		Source
1. Natural mortality (M)							
				Female	Males		
GUR 1W & 1E				0.30	0.35		Stevenson (2000)
GUR 3				0.29	0.35		Sutton (1997)
GUR 7				0.31	0.31		Sutton (1997)

2. Weight = a(length)^b (Weight in g, length in cm fork length).

					Both Sexes		
				a	b		
GUR 1				0.00998	2.99		Elder (1976)
GUR 1W & 1 E				0.026	2.775		Stevenson (2000)
GUR 2				0.0053	3.19		Stevenson (2000)

3. von Bertalanffy growth parameters

		Females			Males		Source
	L_∞	k	t_0	L_∞	k	t_0	
GUR 1	36.4	0.641	0.189	28.8	0.569	-0.552	Elder (1976)
GUR 1W	45.3	0.25	-0.88	36.5	0.45	-0.30	Stevenson (2000)
GUR1E	44.5	0.28	-0.76	35.2	0.49	-0.24	Stevenson (2000)
GUR 3	48.2	0.44	0.1	42.2	0.49	-0.26	Sutton (1997)
GUR 7	45.7	0.40	-0.36	40.3	0.37	-0.96	Sutton (1997)

3. STOCKS AND AREAS

There are no data that would alter the current stock boundaries. No information is available on stock separation of red gurnard. For GUR 3 the Working Group noted that spatial information from the CPUE analyses indicated that separate stocks or sub-stocks may exist between the East and South coasts of the South Island.

4. STOCK ASSESSMENT

There are no new data which would alter the yield estimates given for the GUR stocks in the 1997 Plenary Report. Those yield estimates were based on commercial landings data only and have not changed since the 1992 Plenary Report.
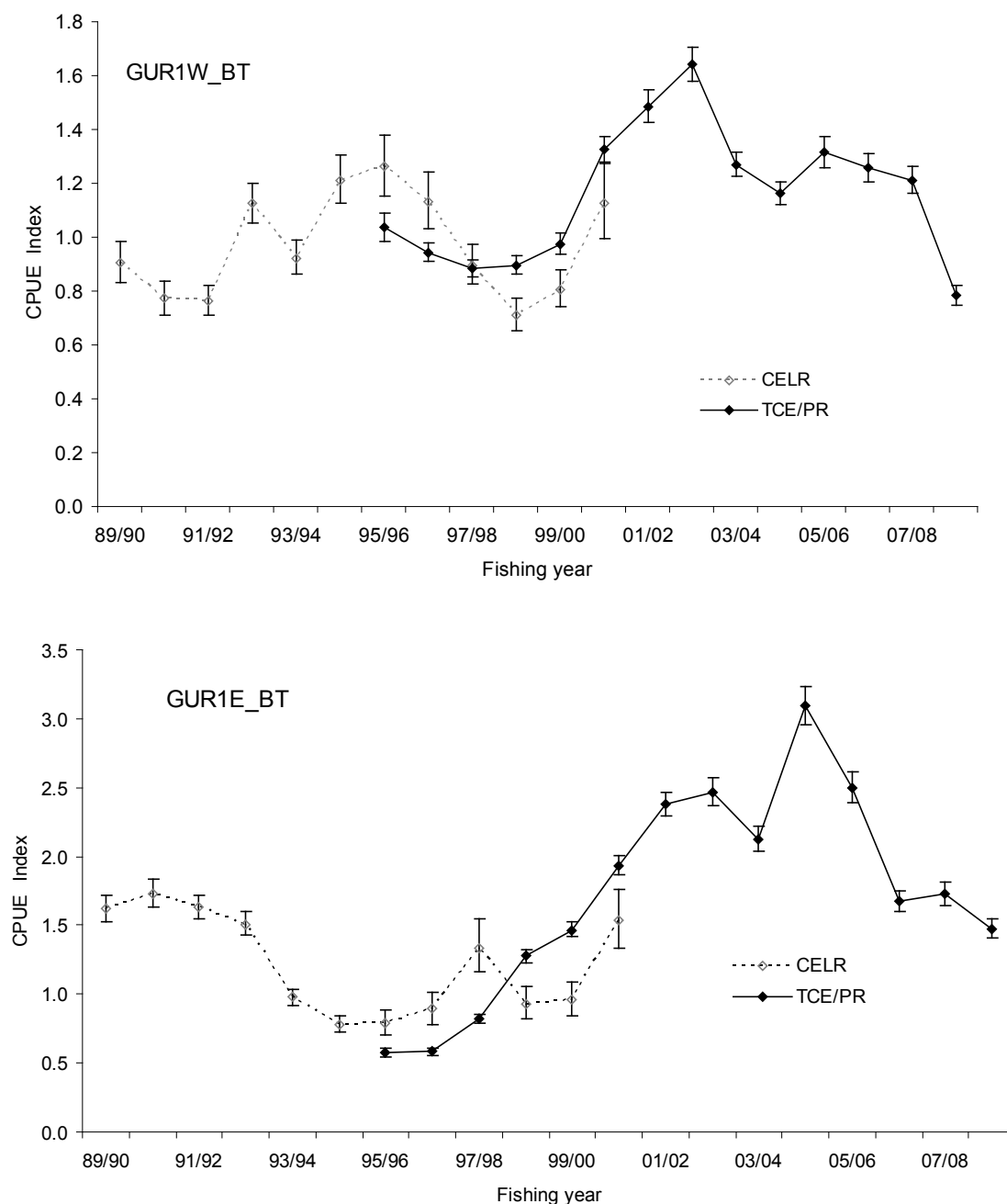
Figure 2: Comparison of indices for GUR 1E and GUR 1W. Lognormal indices for bottom trawl based on CELR format data, and the lognormal series based on TCEPR/ TCE format data (Kendrick & Bentley 2010).
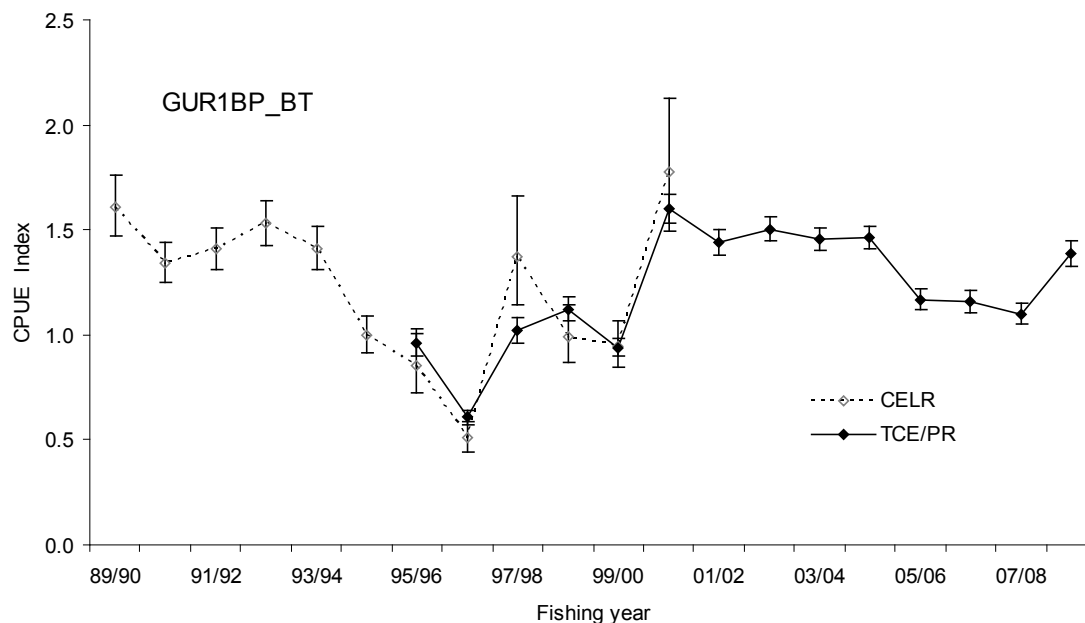
Figure 3: Comparison of indices for and GUR 1BP. Lognormal indices for bottom trawl based on CELR format data, and the lognormal series based on TCEPR/ TCE format data (Kendrick & Bentley 2010).

In 2010, Kendrick & Bentley (2010) updated CPUE analyses for GUR 1W, GUR 1E, and GUR 1BP (Figures 2 & 3). In each substock positive catches from single bottom trawl targeted at gurnard, snapper, trevally, tarakihi or John dory were standardised using lognormal models. Separate analyses were done for each of the two main form types (CELR and TCEPR/TCE) and the data were analysed in their original resolution (daily and tow-by-tow respectively) This was done because of concern that the systematic shift in this fishery from reporting on daily CELR forms to reporting tow-by-tow on TCEPRs may potentially confound the year effects and yield overly-optimistic trajectories.

For each substock, there appears to have been an increase in abundance from a low in the mid-1990s to a peak in the early to mid-2000s followed by a subsequent decline. GUR 1W has returned to around the level observed in 1997-98, while GUR 1E and GUR 1 BP are currently above the mean for the series.

GUR 2

In 2006, Kendrick (2009b) updated CPUE analyses for GUR 2 (Figure 4). Presently GUR 2 is monitored using the bottom trawl target fishery and standardised CPUE is based on a lognormal model of positive estimated catches from statistical areas 011-014.

For contrast or corroboration the bycatch of red gurnard from tows targeted at tarakihi in the same areas is also monitored. Whilst the lognormal model of positive estimated catches shows no trend up or down, analyses that include unsuccessful effort were markedly more optimistic.

Aside from a decline in the early part of the bycatch CPUE series and an increase in the later part of the target series, there have been no drastic changes in CPUE with current levels similar to that from the early 1990s.

GUR 3

Two standardised CPUE series for GUR 3 were prepared for 2012, with both series based on the bycatch of red gurnard in bottom trawl fisheries defined by different target species combinations. The Working Group concluded in 2009 that trends in the BT(RCO) indices north and south of Banks Peninsula were virtually identical, with no indication of separate stocks in these areas as were similar analyses for the Canterbury Bight and Southland BT(FLA) indices. The Working Group

recommended that these analyses be combined to provide two independent indices: targeted RCO, STA, BAR, TAR, GUR and targeted FLA indices, each applicable to all GUR 3 statistical areas.
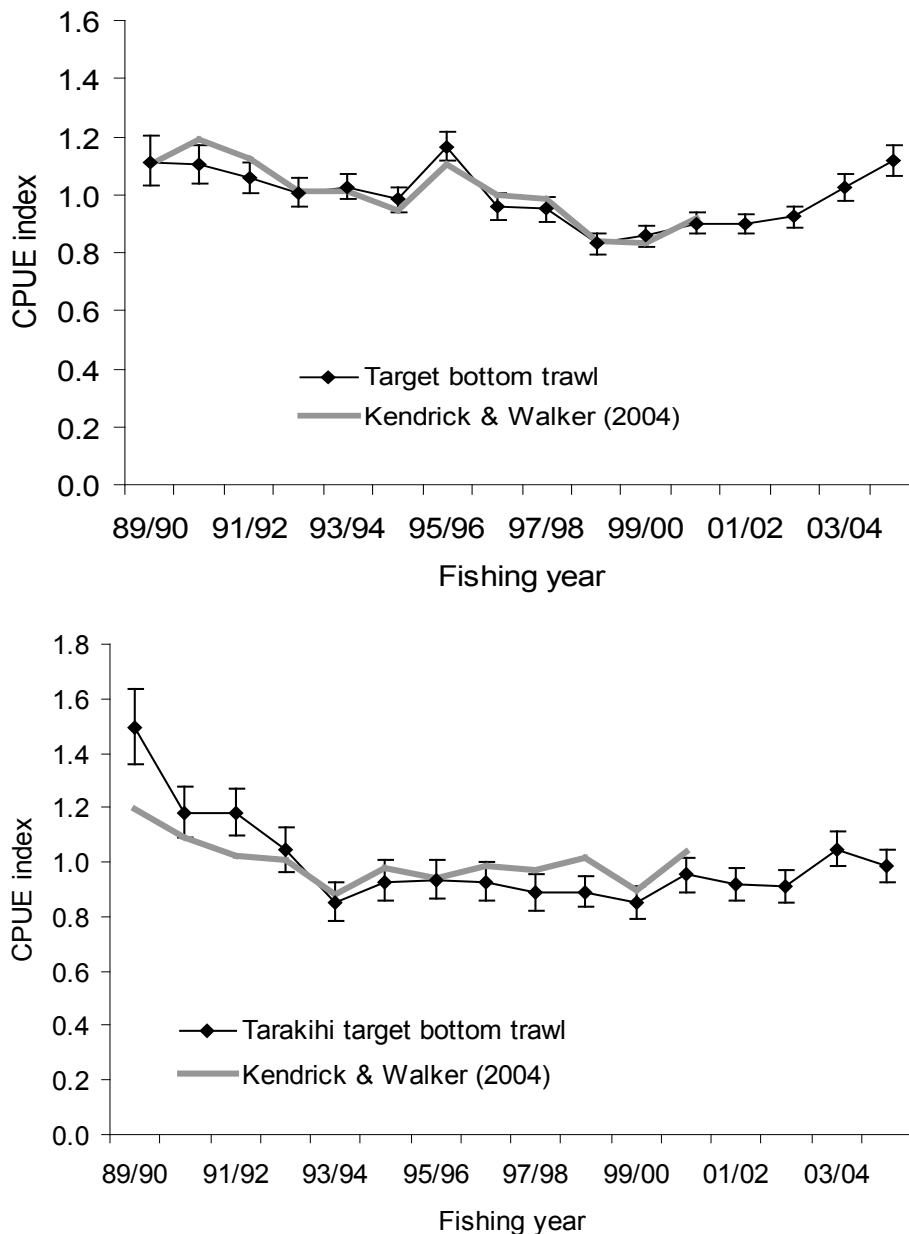
Figure 4: Comparison of lognormal models of successful catches of red gurnard in the target GUR 2 fishery (top) and bycatch from the TAR target fishery (bottom); this study and previous series from Kendrick & Walker (2004). Both series rescaled relative to the geometric mean of the years in common (1989-90 to 2000-01) (Kendrick 2009b).

These analyses were based on data which had been amalgamated into "trip-strata" (Starr 2007), defined as the sum of the catch and effort within a trip characterised by unique statistical areas, target species and method of capture. This approach loses much of the detailed information available in tow-by-tow records, but reduces all data to a common level of stratification, allowing the calculation of linked year coefficients. Unfortunately, the "trip-stratum" approach ignores problems associated with shifts in reporting behaviour associated with changes in form type requirements, while relying on the model parameterisation to adjust for potential biases. The Working Group was concerned in 2009 whether the shift to the new TCER forms in October 2007 may have affected the indices in the 2007–08 fishing year. As a further three years of catch/effort data have now been collected using the new, more detailed, TCER forms, a further standardised analysis was run on data which had been

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summarised to the level of a complete "trip" to test the sensitivity of the annual coefficients to the level of amalgamation. The presumption being that amalgamating the data to the level of a "trip" would minimise the effect of the change in form type, with the definition of a "trip" unaffected by form requirements.

Each series was modelled in the same manner, with log(catch) offered as the dependent variable and a range of explanatory variables offered, including duration and number of tows as continuous polynomials, and statistical area, target species, vessel and month as categorical explanatory variables. In every case, year was forced into the model as the first variable and was considered to be a proxy for relative annual abundance. Data were restricted to vessels which had participated for a specified number of years at a minimum level of participation (expressed as number of trips in a year). This filtering of the data was done to reduce the number of vessels in the data set without overly reducing the amount of catch represented in the model.

Trial models based on five alternative distributional assumptions were fitted to a reduced set of explanatory variables, with the distribution giving the best log-likelihood fit selected for the final stepwise model fit. Table 6 lists the distribution giving the best fit for each model. A logit model which modelled the probability of success was also fit to the same data using a binomial distribution. This model was generated as a diagnostic but is not presented.

Table 6: **Names and descriptions of the three red gurnard GUR 3 bottom trawl CPUE series accepted by the Working Group in 2012. Also shown is the error distribution that had the best fit to the distribution of standardised residuals for the fitted model.**

Name	Code	Statistical areas	Target species	Best distribution
GUR 3 bottom trawl mixed target species	BT(MIX)	018, 020, 022,024, 026, 025, 030	RCO, STA, BAR, TAR, GUR	Weibull
GUR 3 bottom trawl flatfish target	BT(FLA)	018, 020, 022,024, 026, 025, 030	FLA	Weibull
GUR 3 bottom trawl trip-based	BT(MIX)-trip	018, 020, 022,024, 026, 025, 030	N/A	Weibull

BT(MIX): This series showed a generally declining trend to the late 1990s, when it reached a nadir at about one-half of the long-term mean (Figure 5, left panel). The indices then increased steadily until 2007-08, when they peaked at around 1.8 times the long-term mean. The series has since declined to about 1.5 times the long-term mean.

BT(FLA): This series has a trajectory similar to the BT(MIX) series, also reaching a nadir in the late 1990s slightly above one-half of the long-term mean (Figure 5, right panel). The indices then increased steadily until 2009-10, when they peaked at around 1.9 times the long-term mean, where it has remained.

BT(MIX)-trip: This series was run as a diagnostic sensitivity to test whether the change in form type in October 2007 introduced a bias into the analysis. This series was nearly identical the BT(MIX) series (Figure 6), leading to the conclusion that, for GUR 3, the form type change did not introduce strong bias. This conclusion is further advanced by the strong similarity of the BT(FLA) series with the BT(MIX) series because there is much less evidence in the data of a "form type" effect in the former series.

BT(MIX+FLA): This series, plotted in Figure 6, is the mean of the BT(MIX) and BT(FLA) series in each year, beginning with the 1990-91 fishing year.

The Working Group accepted the BT(MIX+FLA) series as an index of the abundance of gurnard in GUR 3. These fisheries cover different aspects of gurnard distribution, both by depth and spatially, but still have very similar trajectories, providing some confidence that these series are likely to be tracking abundance.

Establishing B_{MSY} compatible reference points
The mean from 1997-98 to 1999-00 of BT(MIX+FLA) was selected as the Soft Limit because it was a well-defined low point in the series, along with the observations that both catch and CPUE

increased simultaneously from that point. The Working Group accepted the default Harvest Strategy Standard definitions that the target "B_{MSY} compatible proxy" for GUR 3 would be twice the Soft Limit and the Hard Limit was one-half the Soft Limit.
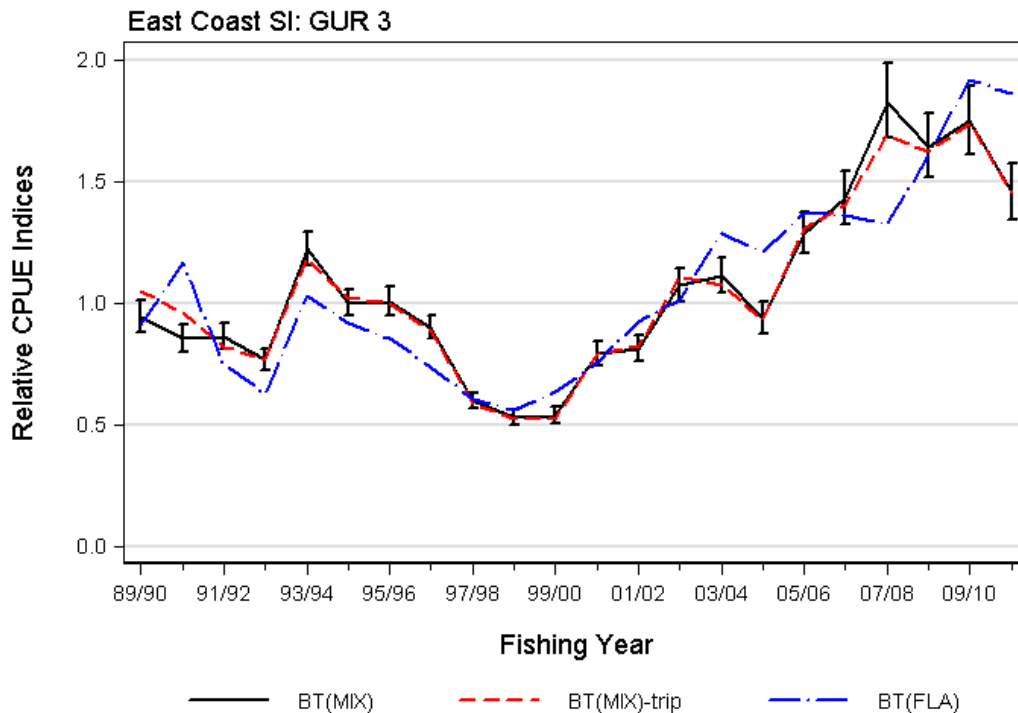

Figure 5: Standardised CPUE indices for three east coast South Island bottom trawl fisheries [BT(MIX), BT(MIX)-trip and BT(FLA)]; Table 6) These series have been normalised to a geometric mean=1.0. Error bars show ±97.5% confidence intervals.
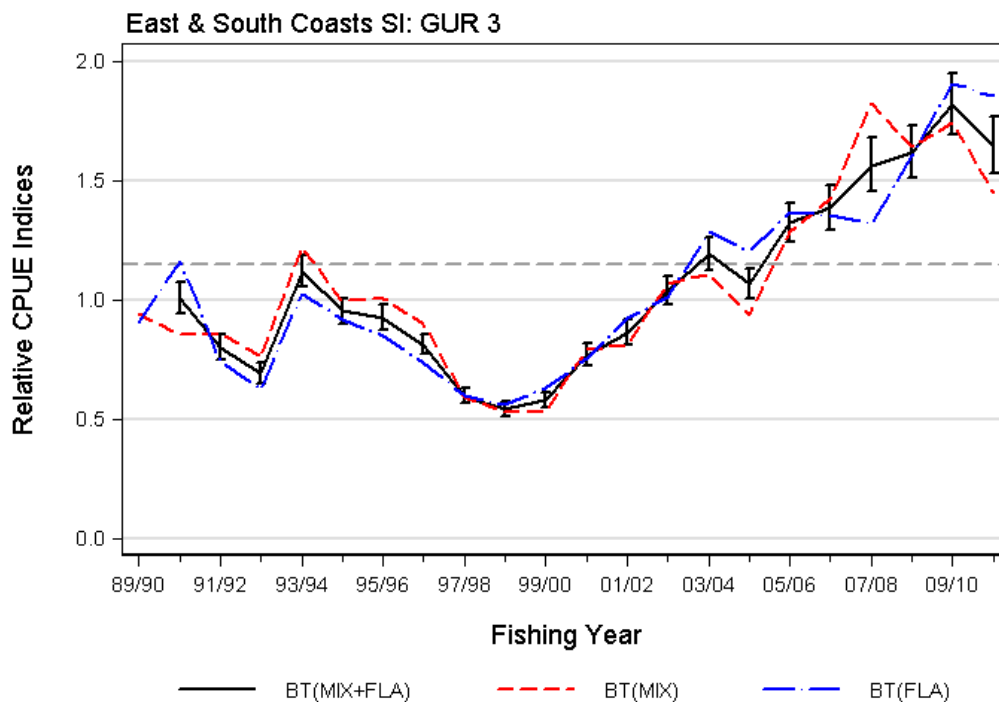

Figure 6: Standardised CPUE indices for two east coast South Island bottom trawl fisheries [BT(MIX) and BT(FLA)]; plotted along with the mean of these two series [BT(MIX+FLA)], which is proposed as the "B_{MSY} compatible proxy". Error bars show ±97.5% confidence intervals.

GUR 7

The relative biomass index calculated for the whole stock (West coast and Tasman Bay combined) declined from 1995 to 2000 and has increased steadily from 2003 to the highest level in the series in 2009, the 2009 estimate is preliminary.
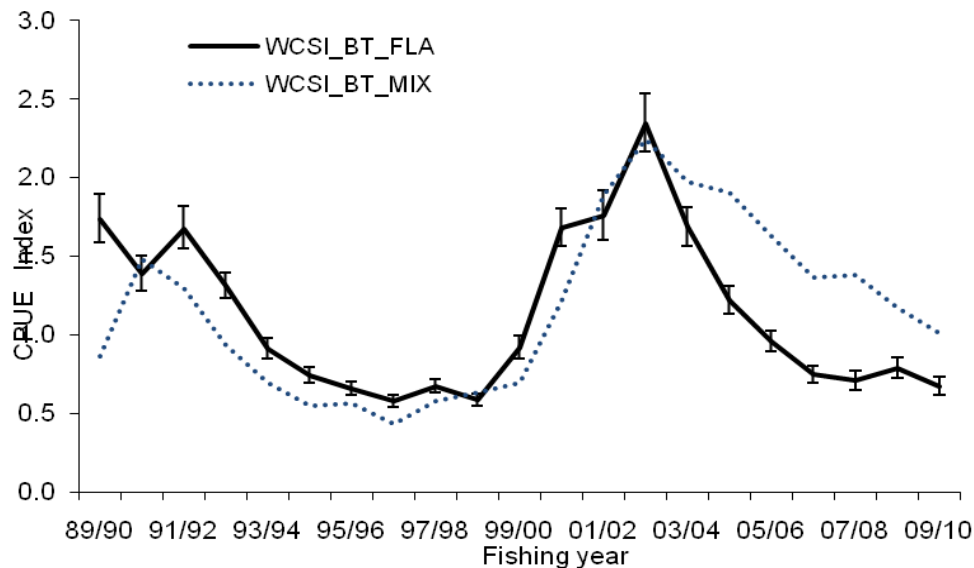
Figure 7: Comparison of the lognormal indices from two independent CPUE series for GUR 7 in statistical areas (033, 034, 035, and 036); a) WCSI_BT_FLA: bottom trawl, target FLA or RCO; b) WCSI_BT_MIX: bottom trawl, target, BAR, TAR, WAR.
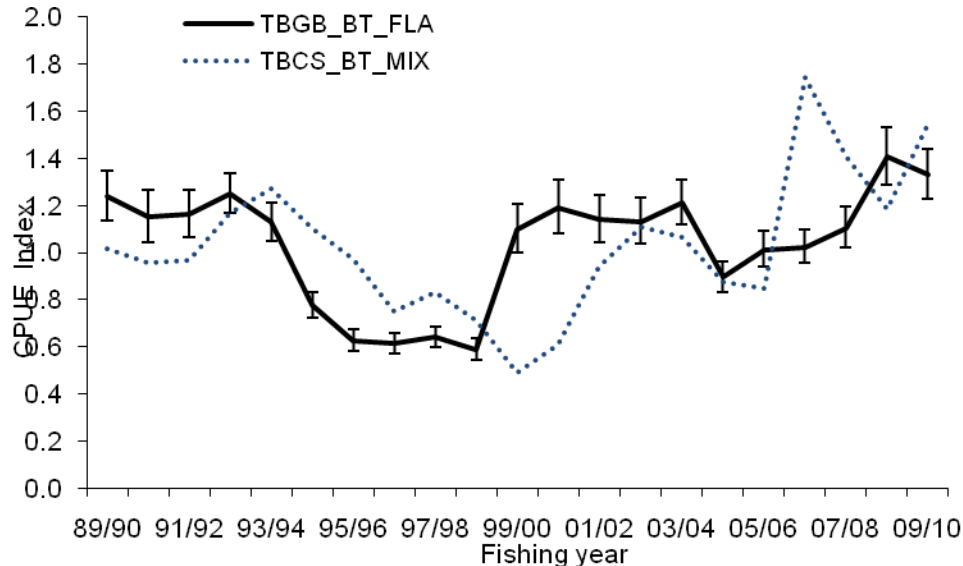
Figure 8: Comparison of the lognormal indices from two independent CPUE series for GUR 7 ; a) TBGB_BT_FLA: bottom trawl in statistical areas 38, and 17, target FLA or RCO ; b) TBCS_BT_MIX: bottom trawl in statistical areas 38,39, 17 and 18, target, BAR, TAR, WAR.

Relative abundance indices have been obtained from trawl surveys of the Bay of Plenty, west coast North Island and Hauraki Gulf within the GUR 1 Fishstock and the South Island west coast and Tasman/Golden Bays combined (GUR 7) (Table 7). The biomass trends from the west and east coast South Island trawl surveys are shown in Figure 5.

RED GURNARD (GUR)

CPUE indices were developed for four bottom trawl fisheries as described by Langley (2011), that operate in different depth ranges and substock areas and account for most of the catch of GUR 7. Standardised CPUE analyses were based on lognormal models of positive (allocated) landed catches at trip-stratum resolution, using the Starr (2007) methodology (Kendrick *et al.* 2011).
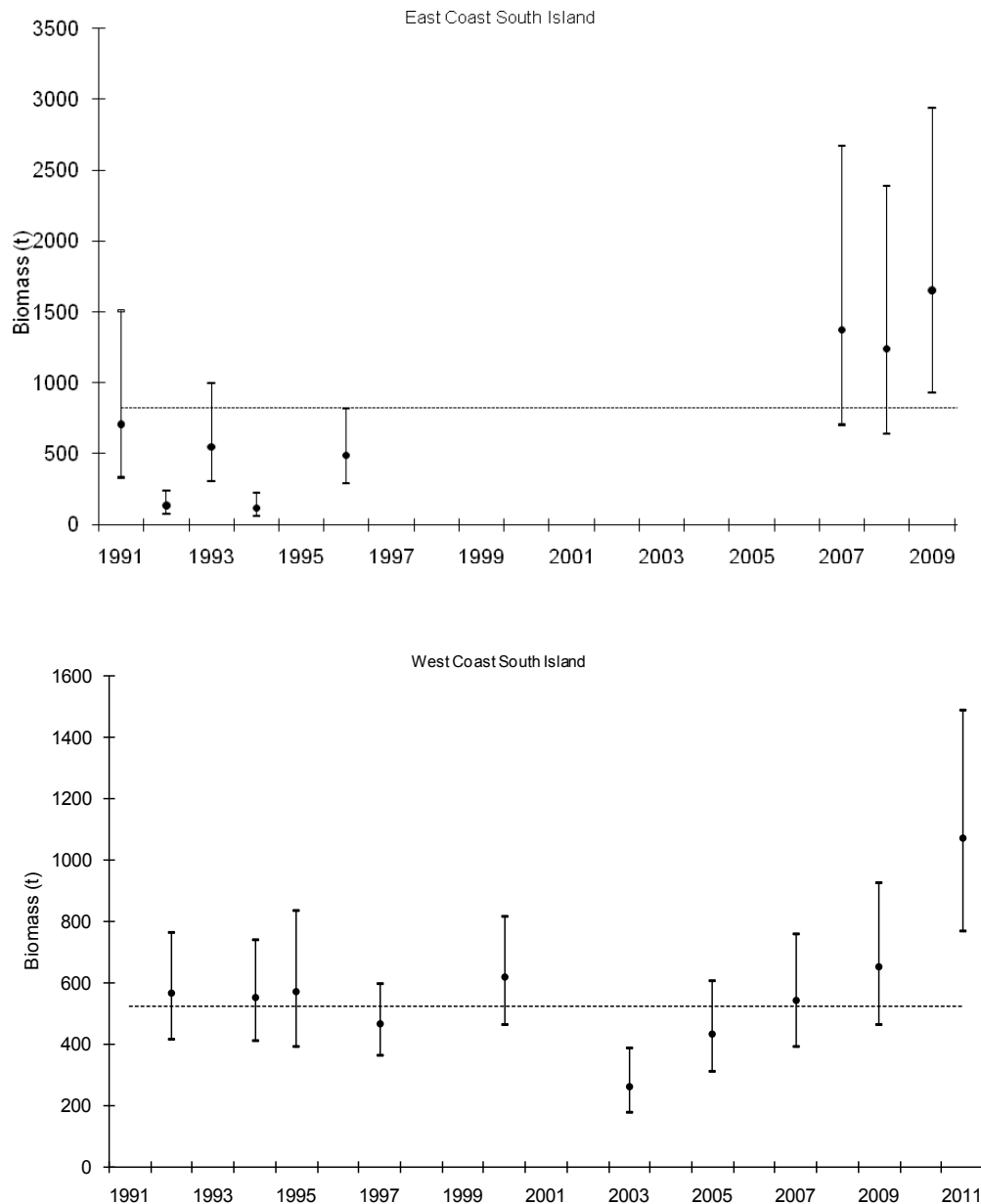
Figure 9: Biomass trends ± 95% CI (estimated from survey CV's assuming a lognormal distribution) and the time series mean (dotted line) from the West (top) and East (bottom) Coast South Island trawl surveys.

The series show similar patterns for target fisheries (BT_FLA or BT_MIX) within each substock area, but markedly different trends between the substock areas, with both West Coast series declining from a peak in 2002-03 to a low in 2009-10 that equals the lowest for the series (Figure 7). The Tasman Bay/Golden Bay/Cook Strait series (BT_FLA or BT_MIX) (Figure 8) show broadly similar peaks and troughs as those on the West Coast up to 2004-05 thereafter the indices diverge and the West coast indices decline while those on in Tasman/Golden Bay increase. The West Coast South Island trawl survey (Figure 9) indices previously used to monitor GUR 7 resemble CPUE in Tasman Bay/ Golden Bay more closely than off the west coast.

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Table 7:   Estimates of red gurnard biomass (t) from *Kaharoa* trawl surveys.

Year and location	Trip Code	Biomass	CV (%)
Bay of Plenty			
1983	KAH8303	380	23
1985	KAH8506	57	17
1987	KAH8711	410	28
1990	KAH9004	432	12
1992	KAH9202	290	9
1996	KAH9601	332	14
1999	KAH9902	364	14
North Island west coast (QMA 9)			
1986	KAH8612	1 763	16
1987	KAH8715	2 022	24
1989	KAH8918	1 013	12
1991	KAH9111	1 846	23
1994	KAH9410	2 498	30
1996	KAH9615	1 820	14
North Island west coast (QMA 8)			
1989	KAH8918	628	15
1991	KAH9111	817	9
1994	KAH9410	685	22
1996	KAH9615	370	37
1999	KAH9915	(QMAs 8 & 9 combined) 2099	13
Hauraki Gulf			
1984	KAH8421	595	15
1985	KAH8517	49	44
1986	KAH8613	426	36
1987	KAH8716	255	15
1988	KAH8810	749	19
1989	KAH8917	105	29
1990	KAH9016	141	16
1992	KAH9212	330	9
1993	KAH9311	177	17
1994	KAH9411	247	19
1997	KAH9720	242	14
2000	KAH0012	24	46
South Island west coast and Tasman/Golden Bays			
1992	KAH9204	572	15
1994	KAH9404	559	15
1995	KAH9504	584	19
1997	KAH9704	471	13
2000	KAH0004	625	15
2003	KAH0304	270	20
2005	KAH0503	442	17
2007	KAH0704	553	17
2009	KAH0904	651	18
2010	KAH1004	1 070	17
North Island east coast			
1993	KAH9304	439	44
1994	KAH9402	871	16
1995	KAH9502	178	26
1996	KAH9605	708	29
South Island east coast (winter)			
1991	KAH9105	763	40
1992	KAH9205	142	30
1993	KAH9306	576	31
1994	KAH9406	112	34
1996	KAH9606	505	27
2007	KAH0705	1 453	35
2008	KAH0806	1 309	35
2009	KAH0905	1 725	30
South Island east coast (summer)			
1996/97	KAH9618	765	13
1997/98	KAH9704	317	16
1998/99	KAH9809	493	13
1999/00	KAH9917	202	20
2000/01	KAH0014	146	34

Length frequency trends for the West Coast South Island red gurnard catch are presented in Figure 10. These data show that there were substantial numbers of 20-25 cm fish in 1997 and 2000. These size fish did not appear in large numbers in 2003 or 2005 but high numbers were landed again in 2007.

4.1 Estimation of Maximum Constant Yield (*MCY*)

The level of risk to the stock by harvesting the population at the estimated *MCY* value cannot be determined.
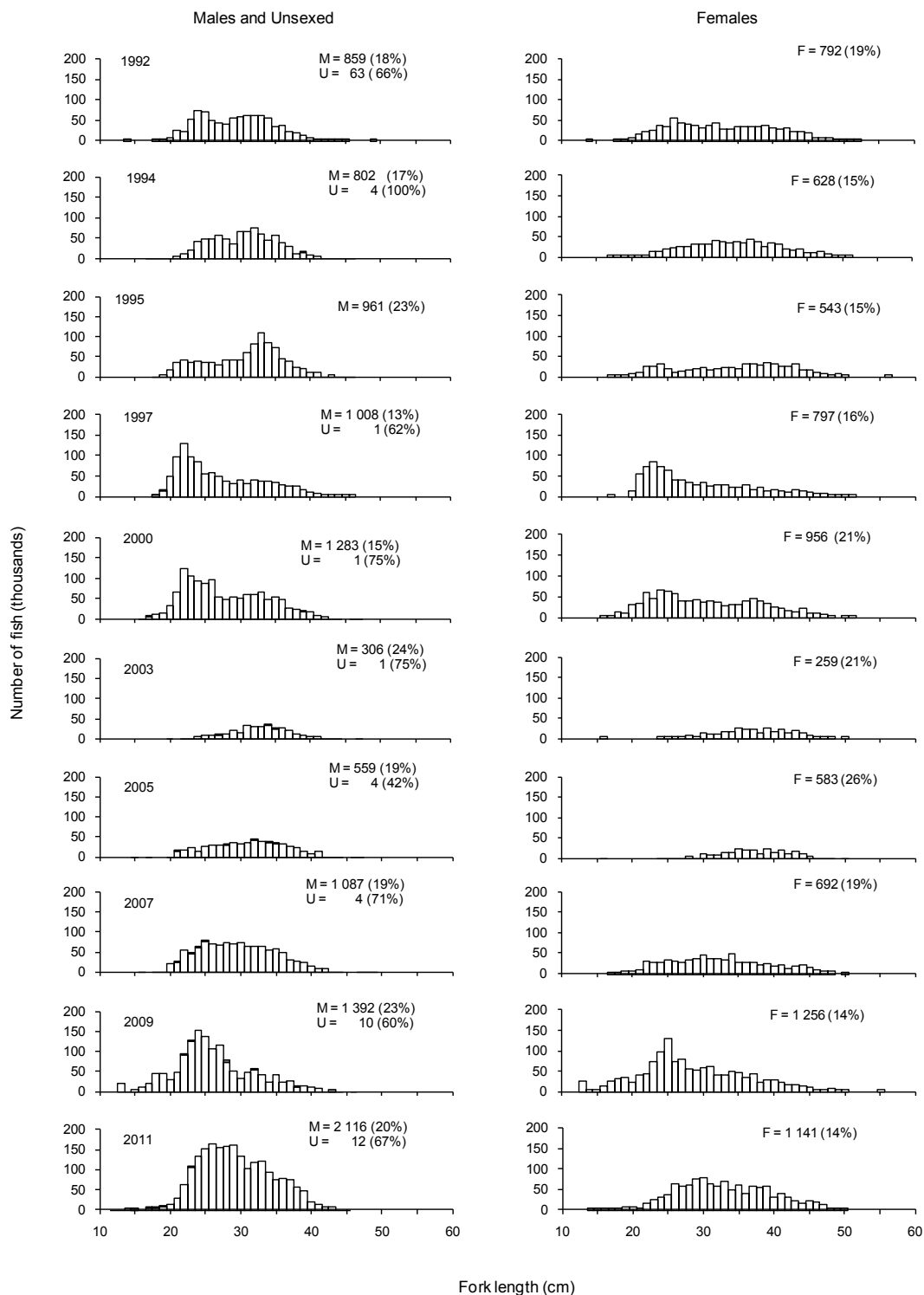

Figure 10: Scaled length frequency distributions for red gurnard in 30-400 m, for all WCSI surveys. M, males; F, females; (CV%) (Stevenson in press).

4.2   Estimation of Current Annual Yield (*CAY*)

No estimate of *CAY* is available for red gurnard.

4.3   Other yield estimates and stock assessment results

Other yield estimates and stock assessment results are not available.

4.4   Other factors

Red gurnard is a major bycatch of target fisheries for several different species, such as snapper and flatfish. The target species may differ between areas and seasons. The recorded landings are influenced directly by changes in the fishing patterns of fisheries for these target species and indirectly by the abundance of these target species. Some target fishing for gurnard also occurs. Therefore, *MCY* estimates based on catch data are subject to a great deal of uncertainty.
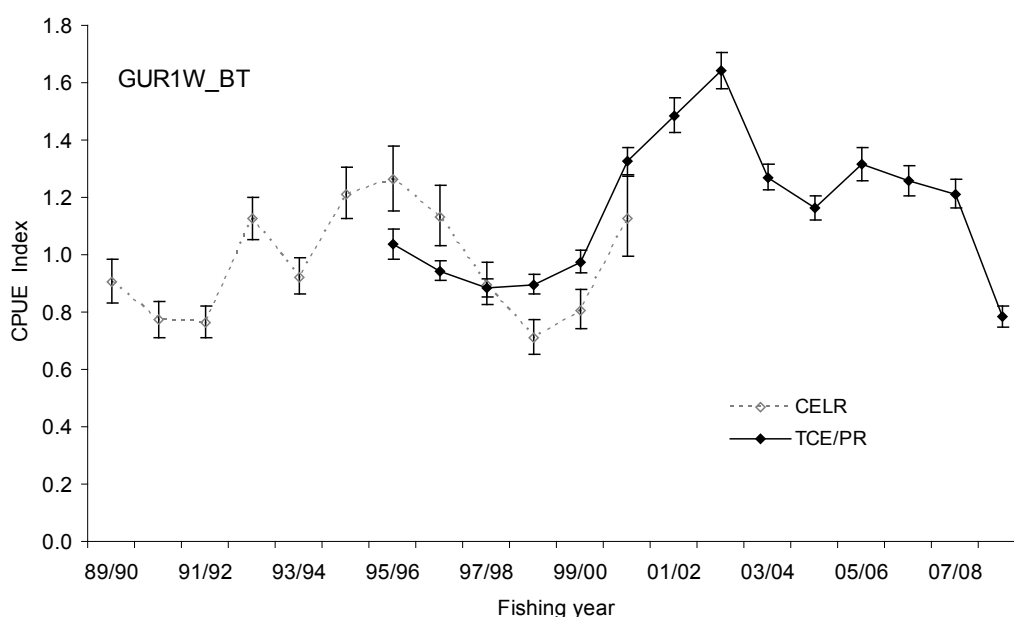
5.   STATUS OF THE STOCKS

Stock Structure Assumptions

For the purpose of this summary GUR1 is considered to be a single stock with three sub-stocks.

GUR 1W

Stock Status	
Year of Most Recent Assessment	2010
Assessment Runs Presented	
Reference Points	Target: Not established Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unknown

Historical Stock Status Trajectory and Current Status

Standardised CPUE indices for red gurnard in GUR 1W from lognormal models of catch rate in successful bottom trawl trips done separately by the two main data formats (Kendrick & Bentley 2010).

Fishery and Stock Trends	
Recent Trend in Biomass or	The lognormal CPUE indices depict a trend that cycles over a 4-8

Proxy	year period that is consistent with what one would expect from a short lived species with variable recruitment. Indices of abundance suggest that stock size has fluctuated around the long-term average since 1989-90. An increase that was sustained over five consecutive years peaked in 2002-03 and then declined, suggesting that the stock is now in a downward part of the cycle.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Without corroborating information on recruitment from a trawl survey, it is not possible to predict how the stock is going to respond in the next few years.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology		
Assessment Type	Level 2 - Partial quantitative stock assessment	
Assessment Method	Standardised CPUE based on lognormal error distribution and positive catches.	
Main data inputs	Catch and effort data	
Period of Assessment	Latest assessment: 2010	Next assessment: 2014
Changes to Model Structure and Assumptions	Improvements in the analysis of the daily CELR data have made the two CPUE series more comparable.	
Major Sources of Uncertainty	Uncertainty in the stock structure Relationship between CPUE and biomass.	

Qualifying Comments
As the red gurnard fishery in FMAs 1 and 9 has a long history, it is not possible to infer stock status from abundance trends from only the last 20 years. The abundance of all three sub-stocks appears to be cyclical, probably in response to recruitment variation, and in at least two sub-stocks trends are currently downward. This makes it difficult to predict future trends without recruitment information. Given that the catch levels observed over the last 23 years have been relatively consistent (averaging 1100 t for all of GUR 1) and that red gurnard are mainly taken as bycatch, current catch is unlikely to affect the long-term viability of this stock.   As the TACC is substantially higher than the current catch, it is not possible to evaluate catches at the level of the TACC.

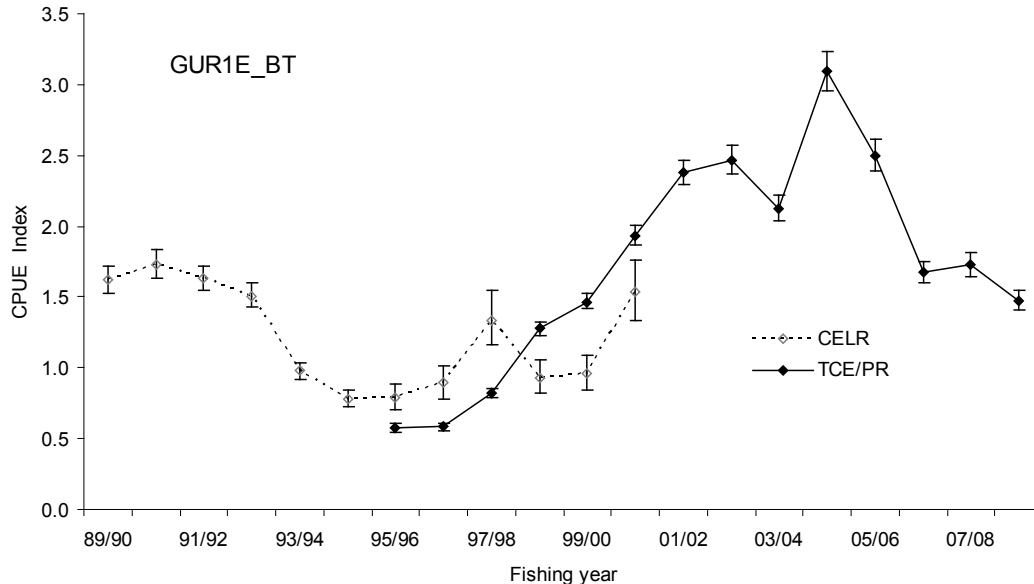| **Fishery Interactions** |
|---|
| Red gurnard is taken on the west coast by bottom trawl targeted at snapper and trevally.

 Incidental captures of seabirds occur and there is a risk of incidental capture of Maui's dolphins. |

GUR 1E

Stock Status	
Year of Most Recent Assessment	2010
Assessment Runs Presented	
Reference Points	Target: Not established

	Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unknown

Historical Stock Status Trajectory and Current Status

Standardised CPUE indices for red gurnard in GUR 1E from lognormal models of catch rate in successful bottom trawl trips done separately by the two main data formats (Kendrick & Bentley 2010).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	An increase in CPUE was sustained over six consecutive years, peaked in 2004-05 and has since declined. The most recent years are currently near the mean for the TCE/PR series. The lognormal CPUE indices depict a trend that cycles over a period that is consistent with what one would expect from a short lived species with variable recruitment.
Recent Trend in Fishing Mortality or Proxy	
Other Abundance Indices	
Trends in Other Relevant Indicators or Variables	

Projections and Prognosis	
Stock Projections or Prognosis	Without corroborating information on recruitment from a trawl survey, it is not possible to predict how the stock is going to respond in the next few years.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology		
Assessment Type	Level 2 - Partial quantitative stock assessment	
Assessment Method	Standardised CPUE based on lognormal error distribution and positive catches.	
Main data inputs	Catch and effort data	
Period of Assessment	Latest assessment: 2010	Next assessment: 2014
Changes to Model Structure and Assumptions	Improvements in the analysis of the daily CELR data have made the two CPUE series more comparable.	

Major Sources of Uncertainty	Uncertainty in the stock structure Relationship between CPUE and biomass.

Qualifying Comments

 As the red gurnard fishery in FMAs 1 and 9 has a long history, it is not possible to infer stock status from abundance trends from only the last 20 years. The abundance of all three sub-stocks appears to be cyclical, probably in response to recruitment variation, and in at least two sub-stocks trends are currently downward. This makes it difficult to predict future trends without recruitment information. Given that the catch levels observed over the last 23 years have been relatively consistent (averaging 1100 t for all of GUR 1) and that red gurnard are mainly taken as bycatch, current catch is unlikely to affect the long-term viability of this stock.

As the TACC is substantially higher than the current catch, it is not possible to evaluate catches at the level of the TACC.
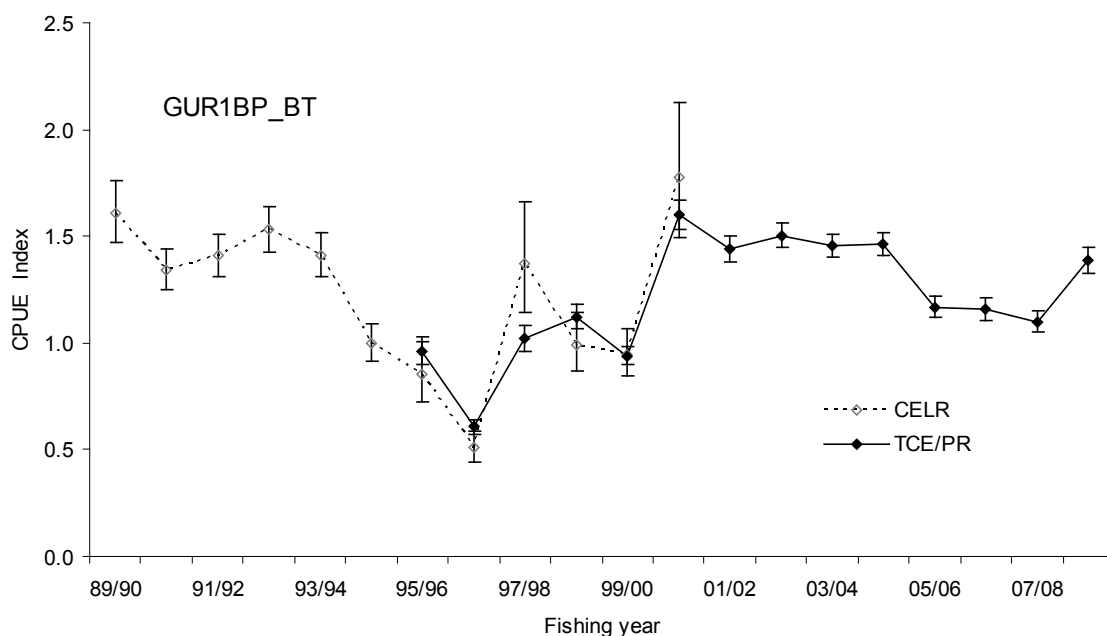
Fishery Interactions

Red gurnard is taken as a bycatch on the east coast mainly by bottom longline targeted at snapper, with the balance taken almost equally by bottom trawl and Danish seine targeting snapper and John dory.

Incidental captures of seabirds occur and there is a risk of incidental capture of Maui's dolphins.

GUR 1 - BoP

Stock Status	
Year of Most Recent Assessment	2010
Assessment Runs Presented	
Reference Points	Target: Not established Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%) to be below

Historical Stock Status Trajectory and Current Status

GUR1BP_BT

Standardised CPUE indices for red gurnard in GUR 1BP from lognormal models of catch rate in successful bottom trawl trips done separately by the two main data formats (Kendrick & Bentley in prep).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass increased from a low in 1996-97 to a peak in 2000-01 and has been relatively stable at the new level.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis		
Stock Projections or Prognosis	Without corroborating information on recruitment from a trawl survey, it is not possible to predict how the stock is going to respond in the next few years.	
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%) (current catch only)	

Assessment Methodology		
Assessment Type	Level 2 - Partial quantitative stock assessment	
Assessment Method	Standardised CPUE based on lognormal error distribution and positive catches.	
Main data inputs	Catch and effort data	
Period of Assessment	Latest assessment: 2010	Next assessment: 2014
Changes to Model Structure and Assumptions	Improvements in the analysis of the daily CELR data have made the two CPUE series more comparable.	
Major Sources of Uncertainty	Uncertainty in the stock structure Relationship between CPUE and biomass.	

Qualifying Comments

As the red gurnard fishery in FMAs 1 and 9 has a long history, it is not possible to infer stock status from abundance trends from only the last 20 years. The abundance of all three sub-stocks appears to be cyclical, probably in response to recruitment variation, and in at least two sub-stocks trends are currently downward. This makes it difficult to predict future trends without recruitment information. Given that the catch levels observed over the last 23 years have been relatively consistent (averaging 1100 t for all of GUR 1) and that red gurnard are mainly taken as bycatch, current catch is unlikely to affect the long-term viability of this stock.

As the TACC is substantially higher than the current catch, it is not possible to evaluate catches at the level of the TACC.

Fishery Interactions

Red gurnard is taken as a bycatch on the east coast mainly by bottom longline targeted at snapper, with the balance taken almost equally by bottom trawl and Danish seine targeting snapper and John dory.

Incidental captures of seabirds occur and there is a risk of incidental capture of Maui's dolphins.

GUR 2
Stock Structure Assumptions
For the purpose of this summary GUR2 is considered to be a single stock with three sub-stocks.

A stock assessment of GUR2 was attempted in 1997-98, but rejected by the Inshore Working Group. CPUE analyses suggest that GUR2 abundance remained fairly stable between 1989/90 and 2004/05. Reported landings were also reasonably stable during this period, fluctuating between 450 t and 708

t. These results suggest that catches in this time period and the TACC are probably sustainable, at least in the short-term.

GUR 3
Stock Structure Assumptions
No information is available on the stock separation of red gurnard. The Fishstock GUR 3 is treated in this summary as a unit stock.

Stock Status	
Year of Most Recent Assessment	2012
Reference Points	Target: B_{MSY}-compatible proxy based on CPUE is twice the mean from 1997-98 to 1999-00 of BT(MIX+FLA) series, as defined in Starr and Kendrick (2012) Soft Limit:Mean from 1997/98 to 1999/00 of BT(MIX+FLA) series, as defined in Starr and Kendrick (2012). Hard Limit: 50% of soft limit
Status in relation to Target	Very Likely (> 90%) to be above the target
Status in relation to Limits	Soft Limit: Very Unlikely (< 10%) to be below Hard Limit: Very Unlikely (< 10%) to be below

Fishery and Stock Trends	
Trend in Biomass or Proxy	Two bottom trawl CPUE series (one targeted at flatfish and the other at red cod), which are considered to be an index of stock abundance, have been increasing steadily since the late 1990s. The resumed east coast South Island trawl survey has returned three biomass indices in 2007, 2008 and 2009 which are greater than equivalent estimates from the early 1990s.
Trend in Fishing Mortality or Proxy	Unlikely (< 40%) that overfishing is occurring. Catches and relative abundance are both increasing.

Historical Stock Status Trajectory and Current Status

East coast South Island winter trawl survey, CPUE, Catch and TACC Trajectories
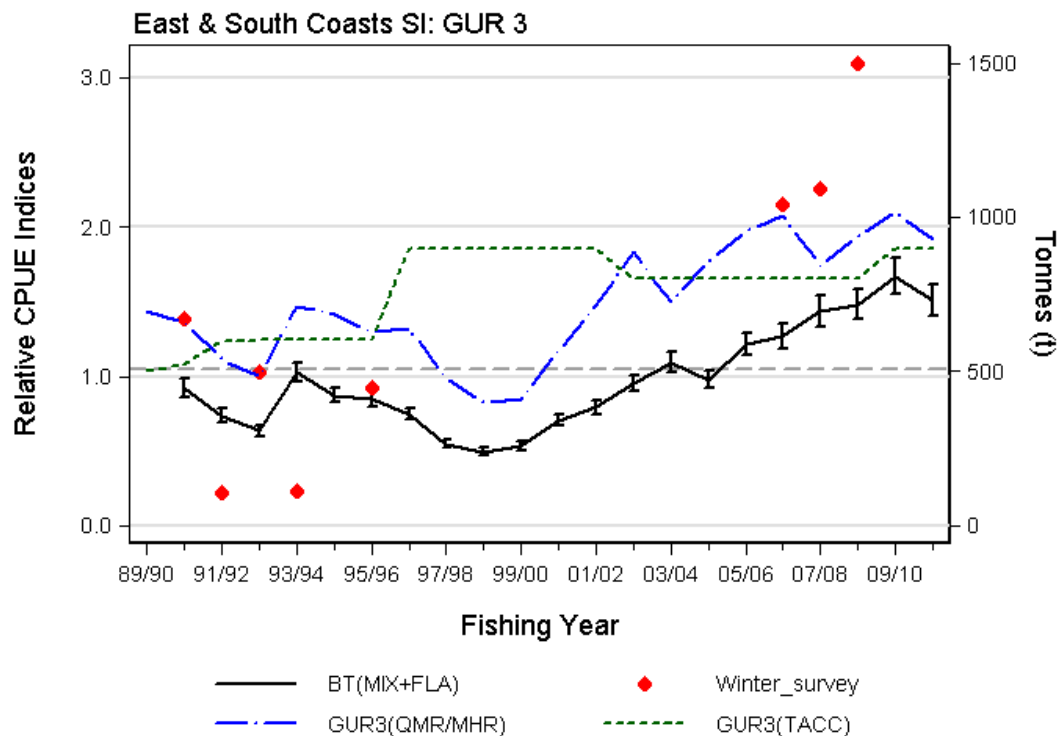
Comparison of three available biomass series (east coast South Island winter trawl survey and two bottom trawl CPUE series, one targeted at flatfish and the other at red cod) with the trajectories of catch and TACCs from 1989-90 to 2007-08. The three biomass series have been standardised to the mean of each series for the survey years (90-91 to 93-94, 95-96 and 06-07 to 08-09).

Other Abundance Indices	ECSI summer survey - not used
Trends in Other Relevant Indicator or Variables	N/A

Projections and Prognosis

Stock Projections or Prognosis	Quantitative stock projections are unavailable.
Probability of Current Catch / TACC causing decline below Limits	Soft Limit: Unlikely (< 40%) Hard Limit: Unlikely (< 40%)

Assessment Methodology and Evaluation

Assessment Type	Level 2: Standardised CPUE abundance index and a trawl survey,	
Assessment Method	Evaluation of agreed standardised CPUE indices which reflect changes in abundance as well as the trawl survey biomass indices.	
Period of Assessment	Latest assessment: 2012	Next assessment: 2015
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	-Trawl survey biomass indices and associated length frequencies - Catch and effort data derived from the MPI compulsory logbooks.	1- High Quality 1- High Quality

Data not used (rank)	N/A
Changes to Model Structure and Assumptions	None
Major Sources of Uncertainty	Prior to 2007 the ECSI trawl survey did not cover the entire depth range for red gurnard. Uncertainty in stock structure assumptions and the relationship between CPUE and biomass.

Qualifying Comments
Red gurnard are relatively short-lived and reasonably productive. They exhibit strong interannual fluctuations and were at apparent low levels in the mid-1990s. Stock size appears to have increased substantially since then and commercial fishers indicate that they find it difficult to stay within the TACC despite the low level of targeting on this species. Two independent CPUE series and the trawl survey corroborate that stock size for GUR 3 has increased since the late 1990s. There are potentially enough data to undertake a quantitative stock assessment for GUR 3. This would allow the estimation of B_{MSY} and other reference points.

| **Fishery Interactions** |
|---|
| Red gurnard in GUR 3 are taken almost entirely by bottom trawl in fisheries targeted at red cod, barracouta and flatfish. Some gurnard are also taken in the target tarakihi and stargazer bottom trawl fisheries. The level of targeting on this species is low, averaging less than 10% of the total landed catch since 1989-90.

Incidental captures of seabirds occur and there is a risk of incidental capture of Hector's dolphins. |

GUR 7
Stock Structure Assumptions
Stock boundaries are unknown, but for the purpose of this summary, GUR 7 is considered to be a single management unit.

Stock Status	
Year of Most Recent Assessment	2011 (West Coast South Island trawl survey); 2011 CPUE analysis
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft limit: Unlikely (< 40%) to be below Hard Limit: Unlikely (< 40%) to be below

Fishery and Stock Trends	
Trend in Biomass or Proxy	The West Coast South Island trawl survey relative biomass index declined from 1995 to 2000 and has increased steadily from 2003 to the highest level in the series in 2011. The CPUE analysis suggests that the index has increased steadily since 2004-05 in Tasman and Golden Bays (probably a juvenile index). But on the West Coast (possibly an adult index) the index has declined steadily since 2002-03 and is now almost half the long-term mean.
Trend in Fishing Mortality or Proxy	Unlikely (< 40%) that overfishing is occurring. Catches have increased since 2000-01 coincident with an apparent increase in the survey biomass indices.

Historical survey biomass, Catch and TACC Trajectories

GUR 7
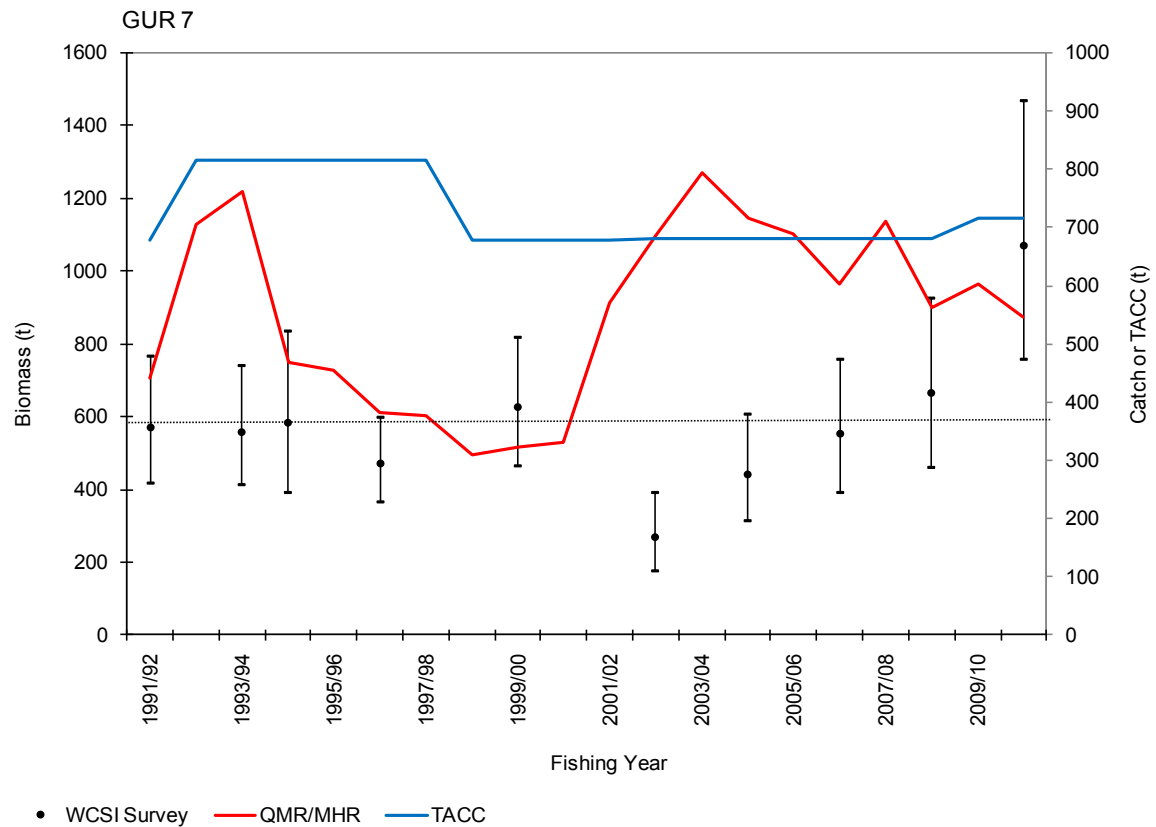
West Coast South Island survey biomass (points) commercial catch (red line) and TACC (blue line) for the period 1990 to 2007. Horizontal dashed line is the mean biomass index, 1992-2011.
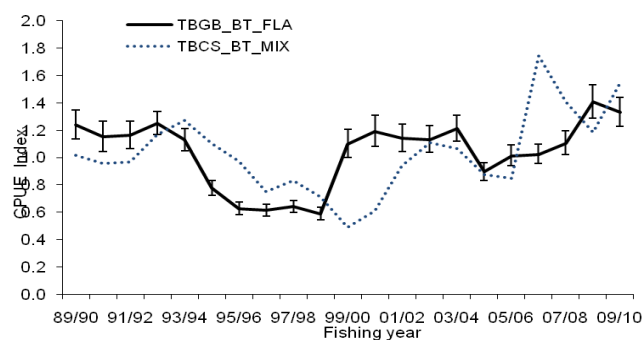
Comparison of the lognormal indices from two independent CPUE series for GUR 7 ; a) TBGB_BT_FLA: bottom trawl in statistical areas 38, and 17, target FLA or RCO ; b) TBCS_BT_MIX: bottom trawl in statistical areas 38,39, 17 and 18, target, BAR, TAR, WAR.

Comparison of the lognormal indices from two independent CPUE series for GUR 7 in statistical areas (033, 034, 035, and 036); a) WCSI_BT_FLA: bottom trawl, target FLA or RCO; b) WCSI_BT_MIX: bottom trawl, target, BAR, TAR, WAR.

Other Abundance Indices	-
Projections and Prognosis	
Stock Projections or Prognosis	Recent catches and the TACC are probably sustainable, at least in the short-term. Quantitative stock projections are unavailable.
Probability of Current Catch / TACC causing decline below Limits	Soft Limit: Unlikely (< 40%) Hard Limit: Unlikely (< 40%)

Assessment Methodology		
Assessment Type	Level 2: Agreed abundance index	
Assessment Method	West Coast South Island Trawl survey biomass - Survey length frequency.	
Main data inputs	Survey biomass and length frequencies.	
Period of Assessment	Latest assessment: 2011	Next assessment: 2013
Changes to Model Structure and Assumptions	N/A	
Major Sources of Uncertainty		

Qualifying Comments
Red gurnard are a survey target of the West Coast South Island trawl survey and the Southern Inshore Working Group regards the series as a reliable index of abundance.

Fishery Interactions
Red gurnard are primarily taken in conjunction with the following QMS species: barracouta, stargazer, red cod, tarakihi and other species in the West Coast South Island target bottom trawl fishery.   Incidental captures of seabirds occur and there is a risk of incidental capture of Hector's dolphins.

GUR 8

It is not known if recent catch levels or the current TACC are sustainable.

Yields estimates, TACCs, and reported landings for red gurnard for the most recent year are summarised in Table 8.

Table 8: Summary of yield estimates (t), TACCs (t) and reported landings (t) of red gurnard for the most recent fishing year.

Fishstock	QMA		2010-11 Actual TACC	2010-11 Reported landings
GUR 1	Auckland (GUR 1W & GUR 1E)	1 & 9	2 288	1 046
GUR 2	Central (east)	2	725	587
GUR 3	South-East, Southland and Sub-Antarctic	3, 4, 5, & 6	900	929
GUR 7	Challenger	7	715	545
GUR 8	Central (west)	8	543	182
GUR 10	Kermadec	10	10	0
Total			5 181	3 289

7.   FOR FURTHER INFORMATION

Blackwell R. 1988. Red gurnard. New Zealand Fisheries Assessment Research Document 1988/23: 18 p.

Boyd R.O., Reilly J.L. 2002. 1999-00 national marine recreational fishing survey: harvest estimates. Draft New Zealand Fisheries Assessment Report.

Bradford E. 1998. Harvest estimates from the 1996 national recreational fishing surveys. New Zealand Fisheries Assessment Research Document 1998/16. 27 p.

Cordue P.L. 1998. Designing optimal estimators for fish stock assessment. Canadian Journal of Fisheries and Aquatic Science *55*: 376-386.

Challenger Finfisheries Management Company 2003. Report to the Adaptive Management Programme Fishery Assessment Working Group. GUR 7 Adaptive Management Proposal for the 2004-05 fishing year. Copies held by MFish.

Elder R.D. 1976. Studies on age and growth, reproduction and population dynamics of red gurnard, *Chelidonichthys kumu* (Lesson and Garnot), in the Hauraki Gulf, New Zealand. Fisheries Research Bulletin No: 12. 62 p.

Francis R.I.C.C. 1992. Recommendations concerning the calculation of maximum constant yield (*MCY*) and current annual yield (*CAY*). New Zealand Fisheries Assessment Research Document 1992/8. 26 p.

Hartill B., Bian R., Armiger H., Vaughan M., Rush N. 2007. Recreational marine harvest estimates of snapper, kahawai, and kingfish in QMA 1 in 2004-05. New Zealand Fisheries Assessment Report 2007/26. 44 p

Hartill B., Bian R., Davies N.M. 2008. Review of methods used to estimate recreational harvests. Draft FAR

Kendrick T.H., Walker N. 2004. Characterisation of the GUR 2 red gurnard (*Chelidonichthys kumu)* and associated inshore trawl fisheries, 1989-90 to 2000-01 New Zealand Fisheries Assessment Report 2004/21. 83 p.

Kendrick T.H. 2009a. Fishery characterisation and catch-per-unit-effort indices for three sub-stocks of red gurnard in GUR 1; 1989-90 to 2004-05. New Zealand Fisheries Assessment Report 2009/10.

Kendrick T.H. 2009b. Updated Catch-per-Unit effort indices for red gurnard in GUR 2; 1989-90 to 2004-05 New Zealand Fisheries Assessment Report 2009/11.

Kendrick T.H., Bentley N., Langley A. 2011. Report to the Challenger Fishfish Company: CPUE analyses for FMA 7 Fishstocks of gurnard, tarakihi, blue warehou, and ghost shark. (Unpublished client report held by Trophia Limited, Kaikoura).

Langley A. 2011. Characterisation of the Inshore Finfish fisheries of Challenger and South East coast regions (FMAs 3, 5, 7 & 8). . (Unpublished client report available from http://www.seafoodindustry.co.nz/SIFisheries).

Lydon G.J., Middleton D.A.J., Starr P.J. 2006. Performance of the GUR 3 Logbook Programme. AMP-WG-06/22. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).

Lyon W.S., Horn P.L. 2011. Length and age of red gurnard (Chelidonichthys kumu) from trawl surveys off west coast South Island in 2003, 2005, and 2007, with comparisons to earlier surveys in the time series. New Zealand Fisheries Assessment Report 2011/46.

Morrison M.A., Francis M.P., Parkinson D.M. 2002. Trawl survey of the Hauraki Gulf, 2000 (KAH0012). New Zealand Fisheries Assessment Report 2002/46. 48 p.

Starr P.J., Kendrick T.H., Lydon G.J., Bentley N. 2007. Report to the Adaptive Management Fishery Assessment Working Group: Full term review of the GUR 3 Adaptive Management Programme. AMP-WG-07/11v2. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).

Starr P.J., Kendrick T.H. 2012. GUR 3 Fishery Characterisation and CPUE Report. SINS-WG-2012-14v2. 72 pp.

Stevenson M.L. 2000. Assessment of red gurnard (*Chelidonichthys kumu*) stocks GUR 1 and GUR 2. New Zealand Fisheries Assessment Report 2000/40. 51 p.

Stevenson M.L. 2004. Trawl survey of the west coast of the South Island and Tasman and Golden Bays, March-April 2003 (KAH0304). New Zealand Fisheries Assessment Report 2004/4. 69 p.

Stevenson M.L. 2006. Trawl survey of the west coast of the South Island and Tasman and Golden Bays, March-April 2005 (KAH0503). New Zealand Fisheries Assessment Report 2006/4. 69 p

Stevenson M.L. 2007. Inshore trawl survey of the west coast of the South Island and Tasman and Golden Bays, March-April 2007 KAH0704. New Zealand Fisheries Assessment Report 2007/41. 64 p.

Stevenson M.L. 2009. Inshore trawl survey of the west coast of the South Island and Tasman and Golden Bays, March-April 2009. New Zealand Fisheries Assessment Report 2010/11. 77 p.

Stevenson M.L. in press. Inshore trawl survey of the west coast of the South Island and Tasman and Golden Bays, March-April 2011. New Zealand Fisheries Assessment Report 2012/xx.

Sutton C.P. 1997. Growth parameters, and estimates of mortality for red gurnard (*Chelidonichthys kumu*) from off the east and west coasts of the South Island, New Zealand. New Zealand Fisheries Assessment Research Document 1997/1: 15 p.

Vignaux M. 1997. CPUE analyses for fishstocks in the adaptive management programme. New Zealand Fisheries Assessment Research Document 1997/24. 68 p.

Teirney L.D., Kilner A.R., Millar R.E., Bradford E., Bell J.D. 1997. Estimation of recreational catch from 1991-92 to 1993-94 New Zealand Fisheries Assessment Research Document 1997/15. 43 p.

RED SNAPPER (RSN)

(Centroberyx affinis)
Kaorea
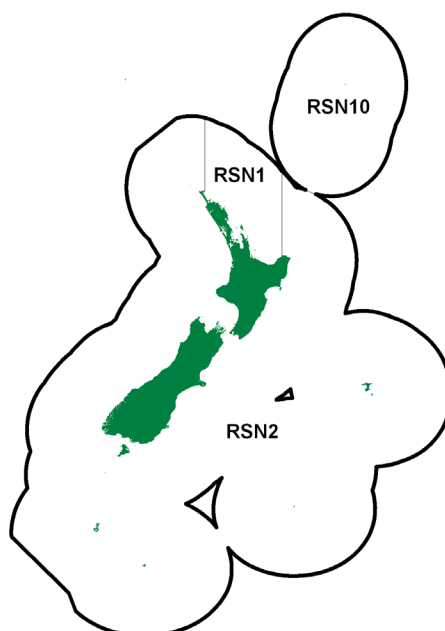
1. FISHERY SUMMARY

Red snapper was introduced into the Quota Management System on 1 October 2004 with the TAC, TACC and allowances as shown in Table 1. These have not changed.

Table 1: Recreational and customary non-commercial allowances, TACCs and TACs of red snapper.

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other sources of mortality	TACC	TAC
RSN 1	13	2	1	124	140
RSN 2	2	1	1	21	25
RSN 10	1	1	1	1	4
Total	16	4	3	146	169

1.1 Commercial fisheries

Small commercial catches of red snapper in New Zealand have almost certainly been made for decades, but would have been included among "assorted minor species" in reported landings. Annual landings peaked at 112 t from 1989-90 to 1994-95, and have continued to increase to a peak of 197 t in 2000-2001. Landings then dropped to 51 t in 2003-04 and have remained near this level since 2004-05 (Tables 2 & 3).

Red snapper is mostly taken as a bycatch of 1) the longline fishery for snapper off east Northland, 2) the trawl fisheries for tarakihi off east and west Northland, and 3) the setnet fishery for snapper and trevally in the Bay of Plenty.

1.2 Recreational fisheries

The National Marine Recreational Fishing surveys in 1994, 1996, and 2000 do not provide an estimate of the recreational catch of red snapper. However, it is likely that recreational fishers will periodically catch red snapper while line fishing on deep reefs in Northland, the outer Hauraki Gulf, and Bay of Plenty.

1.3 Customary non-commercial fisheries

There is no quantitative information available to allow the estimation of the amount of red snapper taken by customary non-commercial fishers.

Table 2: Reported landings (t) by commercial fishers of red snapper by FMA from 1989-90 to 2003-04. Data are derived from the landing section of CELRs and CLRs.

	FMA 1	FMA 2	FMA 3	FMA 4	FMA 7	FMA 8	FMA 9	FMA 10	Unknown	Total
1989-90	67.9	3	3.1	0	1.8	0.9	0	0	0.0	76.7
1990-91	107.3	1.2	2.8	0	0.6	0.7	0	0	0.0	112.7
1991-92	89.1	0.7	1.1	0	0	1.6	0	0.6	0.0	93.2
1992-93	98.2	2.1	0.4	0	0	0.6	0	0	0.3	101.6
1993-94	78.2	2.6	0.3	0.1	0.4	0.4	0.2	0	0.0	82.4
1994-95	78.2	1.8	0.3	0	0.2	0.6	0.5	0	1.0	82.6
1995-96	126.7	2.1	0.8	0.2	1.2	0.2	1	0	1.3	133.4
1996-97	186.4	17.4	0.9	0	1	0.3	2.9	0.2	2.8	211.8
1997-98	159.1	3.4	0.3	0	0.2	0.7	3.6	0	0.8	168.2
1998-99	134.4	1.5	0.4	0.1	0.3	1	4.7	0	0.4	142.8
1999-00	108.1	1.3	0.8	0	0.1	21.3	25.4	0	0.7	157.7
2000-01	140.0	1.1	2.3	0.8	0	0.8	51.5	0	0.0	196.5
2001-02	109.7	1.5	2.2	0.1	0	0.4	12.3	0	0.6	126.7
2002-03	117.5	2.2	0.3	0	0	0.6	37.5	0	14.2	172.5
2003-04	40.9	1.8	0.2	0	0.3	1.3	6.7	0	0	51.3

Table 3: Reported domestic landings (t) of red snapper Fishstock and TACC from 2004-05 to 2010-11.

	RSN 1 FMA 1		RSN 2 FMA 2-9		RSN 10 FMA 10		Total	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
2004-05	43	124	11	21	0	1	54	146
2005-06	41	124	8	21	0	1	49	146
2006-07	44	124	10	21	0	1	53	146
2007-08	70	124	17	21	0	1	87	146
2008-09	30	124	12	21	0	1	42	146
2009-10	22	124	9	21	0	1	31	146
2010-11	27	124	8	21	0	1	35	146
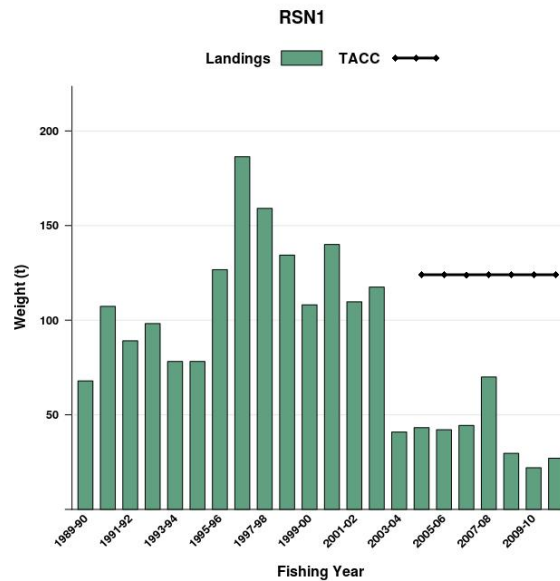
Figure 1: Historical landings and TACC for the main RSN stock, RSN1 (Auckland).

2. BIOLOGY

The red snapper (*Centroberyx affinis*) is present throughout New Zealand coastal waters, but is generally rare south of East Cape and Cape Egmont. In southeastern Australia (known as redfish) it occurs from Brisbane to Melbourne, and off northern Tasmania.

Red snapper occur in association with deep coastal reefs, in particular caves and overhangs, as well as in open water, to depths of about 400 m. Their relative abundance within this depth range is unknown. The southeastern Australian target fishery operates at depths of 100-250 m (Rowling 1994).

There have been no formal aging studies of New Zealand red snapper, but Leachman *et al*. (1978) reported a maximum ring count of 80, based on examination of a few broken and burned otoliths. These rings were not, however, validated. Work in Australia, based on tagging and thin otolith sections suggest unvalidated ages of at least 35 (Rowling 1994) and 40 years (Smith & Robertson 1992). Radiocarbon analysis supported an age of at least 37 years (Kalish 1995).

Red snapper attain 55 cm in New Zealand but average 30-40 cm. Nothing is known of their reproductive biology.

3.   STOCKS AND AREAS

There has been no research to determine if there are separate biological stocks of red snapper.

4.   STOCK ASSESSMENT

There has been no scientific stock assessment of the biomass that can support the Maximum Sustainable Yield (*MSY*) for red snapper.

5.   STATUS OF THE STOCK

The reference or current biomass is not known for any red snapper stock. It is not known if the recent catch levels are sustainable. The status of RSN 1, 2 and 10 relative to B_{MSY} is unknown.

TACCs and reported landings by Fishstock, for the 2010-11 fishing year, have been summarised in Table 4.

Table 4: Summary of TACCs (t) and reported landings (t) of red snapper for 2010-11 fishing year.

Fishstock		FMA	2010-11 Actual TACC	2010-11 Reported landings
RSN 1	Auckland (East)	1	124	27
RSN 2	Auckland (West), South east, Southland, Sub-Antarctic, Central, Challenger	2,3,4,5,6, 7,8&9	21	8
RSN 10	Kermadec	10	1	0
Total			146	35

6.   FOR FURTHER INFORMATION

Ayling T., Cox G.J. 1984. Collins guide to the sea fishes of New Zealand. Collins, Auckland. 343 p.

Francis M. 2001. Coastal fishes of New Zealand. An identification guide. Reed Books, Auckland. 103p. + pls.

Kalish J.M. 1995. Application of the bomb radiocarbon chronometer to the validation of redfish *Centroberyx affinis* age. Canadian Journal of Fisheries and Aquatic Sciences 52(7): 1399-1405.

Leachman A., Ritchie L., Robertson D. 1978. Should red moki be shot in New Zealand UA competitions? New Zealand Diver 3(2): 2.

Paul L.J. 1992. Age and growth studies of New Zealand marine fishes, 1921-90: a review and bibliography. Australian Journal of Marine and Freshwater Research 43(5): 879-912.

Paul L. 2000. New Zealand fishes. Identification, natural history and fisheries. Reed Books, Auckland. 253 p.

Rowling K.R. 1994. Redfish, *Centroberyx affinis*. *In* Tilzey, R.D.J. (Ed), The south east fishery. A scientific review with particular reference to quota management. pp. 149-158. Bureau of Rural Resources, Australia.

Smith D.C., Robertson S.G. 1992. Age determination for redfish, *Centroberyx affinis*, from samples submitted to the Central Ageing Facility: 1991/1992. Marine Science Laboratories, Queenscliff, Victoria, Australia. Internal Report 203 p.

Stewart P. 1993. Redfish, *Centroberyx affinis*. *In* Kailola *et al*. (Ed), Australian fisheries resources. pp. 232-234. Bureau of Resource Sciences, Canberra. 422 p.

Thompson S. 1981. Fish of the Marine Reserve. A guide to the identification and biology of common coastal fish of north-eastern New Zealand. Leigh Laboratory, University of Auckland. 364 p.

Yearsley G.K., Last P.R., Ward R.D. (Ed) 1999. Australian seafood handbook: identification guide to domestic species. CSIRO Marine Research, Australia. 461 p.

RIBALDO (RIB)

(*Mora moro*)
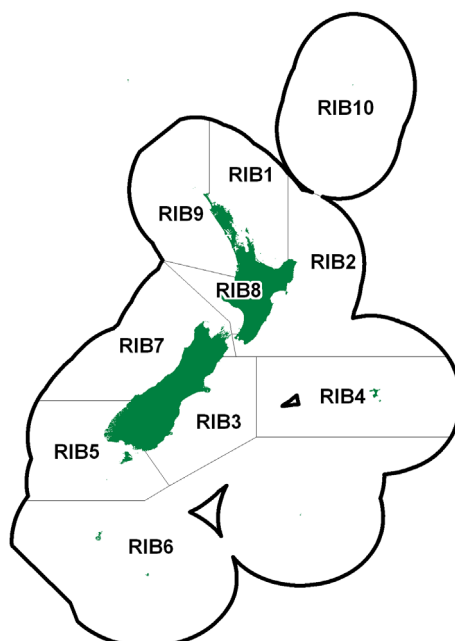
1.   FISHERY SUMMARY

1.1   Commercial fisheries

In New Zealand ribaldo is caught mainly on bottom longlines and as a bycatch of trawling. Up to 4500 t were reported in 1977 by Japanese and Korean longline vessels target fishing for ling on the Chatham Rise and east coast of the South Island in the 1970s. Since 1982-83, overall reported catch has been mainly from the Chatham Rise and east coast South Island (QMAs 3 & 4) but has declined somewhat from these areas since being introduced into the QMS in the 1998-99 fishing year. Since entering the QMS, a similar decline in reported ribaldo catch is seen in other QMAs with the exception of RIB 7 where reported catches have been increasing. RIB 7 now has the highest reported catch of any QMA. The reasons for these changes in catch levels are not well understood as ribaldo is mainly taken as bycatch. Levels of discarding and unreported catch are likely to have changed with the introduction of ribaldo into the QMS. Ribaldo are caught throughout the New Zealand Exclusive Economic Zone by a variety of fishing methods in different target fisheries but mainly as bycatch in bottom trawls targeting hoki (*Macruronus novaezelandiae*), hake (*Merluccius australis*) and ling (*Genypterus blacodes*) and bottom longlines for ling.

There is no seasonality of catch other than on the west coast South Island which is related to target fishing of hoki and hake during the winter spawning season. Catches by Japanese and Korean longliners in the mid 1970s are shown in Table 1. Landings from 1982-83 onwards are shown in Table 2, while Figure 1 shows the historical landings and TACC values for the main RIB stocks.

Table 1: Japanese and Korean longline catch (t) of ribaldo ("deep-sea cod[1]") from New Zealand waters, probably mostly Chatham Rise and east coast South island, by calendar year from 1975-77.

Year	1975	1976	1977
Japan	2 417	4 920	4 283
Korea	-	-	2 86

    1. Reported as "cods" but considered to be mainly ribaldo. The Korean fleet began fishing in April 1977.

Ribaldo was introduced into the QMS from 1 October 1998, no customary, recreational or other mortality allowances have been given. Historical catch limits up to the most recent fishing year (2009-10) are shown in Table 2. TACCs were increased from 1 October 2006 in RIB 6 to 231 t and in RIB 7 to 330 t. In these stocks landings were above the TACC for a number of years and the TACCs have

been increased to the average of the previous 7 years plus an additional 10%. Current levels of reported catch are well below TACCs apart from in RIB 7 where they have continued to exceed the TACC, with the exception of the most recent fishing year.

Table 2: Reported landings (t) of ribaldo by QMA for fishing years 1983-84 to 2010-11 and TACCs (t). QMA 10 has no catches and a TACC of 0. Total includes catches from outside the NZ EEZ.

	QMA 1		QMA 2		QMA 3		QMA 4		QMA 5	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1982-83	0		8		15		33		111	
1983-84	0		3		24		21		68	
1984-85	0		4		17		61		21	
1985-86	1		1		26		13		35	
1986-87	4		1		44		20		41	
1987-88	19		4		65		31		56	
1988-89	1		2		33		41		6	
1989-90	8		9		23		28		6	
1990-91	15		15		177		119		34	
1991-92	95		40		160		169		73	
1992-93	131		54		217		228		67	
1993-94	87		70		217		186		23	
1994-95	116		136		437		303		68	
1995-96	121		168		286		253		26	
1996-97	114		188		365		843		64	
1997-98	78		122		141		375		80	
1998-99	24	121	55	176	161	394	290	357	71	52
1999-00	22	121	89	176	264	394	347	357	80	52
2000-01	5	121	107	176	269	394	306	357	78	52
2001-02	7	121	53	176	198	394	370	357	62	52
2002-03	12	121	98	176	211	394	183	357	50	52
2003-04	12	121	120	176	175	394	299	357	50	52
2004-05	28	121	127	176	156	394	379	357	44	52
2005-06	49	121	137	176	126	394	202	357	47	52
2006-07	39	121	125	176	149	394	312	357	49	52
2007-08	53	121	135	176	134	394	173	357	43	52
2008-09	45	121	74	176	216	394	216	357	31	52
2009-10	28	121	63	176	213	394	162	357	27	52
2010-11	42	121	67	176	348	394	137	357	30	52

|	QMA 6		QMA 7		QMA 8		QMA 9		Total	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1982-83	0		58		0		0		225	
1983-84	1		25		0		0		142	
1984-85	13		18		0		0		134	
1985-86	2		37		0		0		115	
1986-87	10		6		0		0		126	
1987-88	12		68		0		0		255	
1988-89	6		69		1		10		169	
1989-90	13		21		0		0		108	
1990-91	106		55		0		0		521	
1991-92	98		40		0		0		675	
1992-93	96		106		0		0		899	
1993-94	92		42		1		0		718	
1994-95	122		39		2		6		1 231	
1995-96	109		62		0		0		1 025	
1996-97	158		77		1		0		1 824	
1997-98	262		110		1		1		1 214	
1998-99	223	124	243	55	1	1	0	2	1 081	1 282
1999-00	237	124	300	55	< 1	1	< 1	2	1 359	1 282
2000-01	191	124	275	55	< 1	1	< 1	2	1 242	1 282
2001-02	322	124	254	55	0	1	< 1	2	1 311	1 282
2002-03	172	124	338	55	< 1	1	1	2	1 209	1 282
2003-04	205	124	364	55	< 1	1	2	2	1 302	1 282
2004-05	105	124	307	55	< 1	1	2	2	1 240	1 282
2005-06	62	124	336	55	0	1	4	2	1 018	1 282
2006-07	61	231	404	330	0	1	9	2	1 162	1 664
2007-08	80	231	356	330	< 1	1	14	2	992	1 664
2008-09	63	231	456	330	< 1	1	10	2	1 111	1 664
2009-10	104	231	137	330	< 1	1	21	2	755	1 664
2010-11	67	231	198	330	2.7	1	20	2	913	1 664
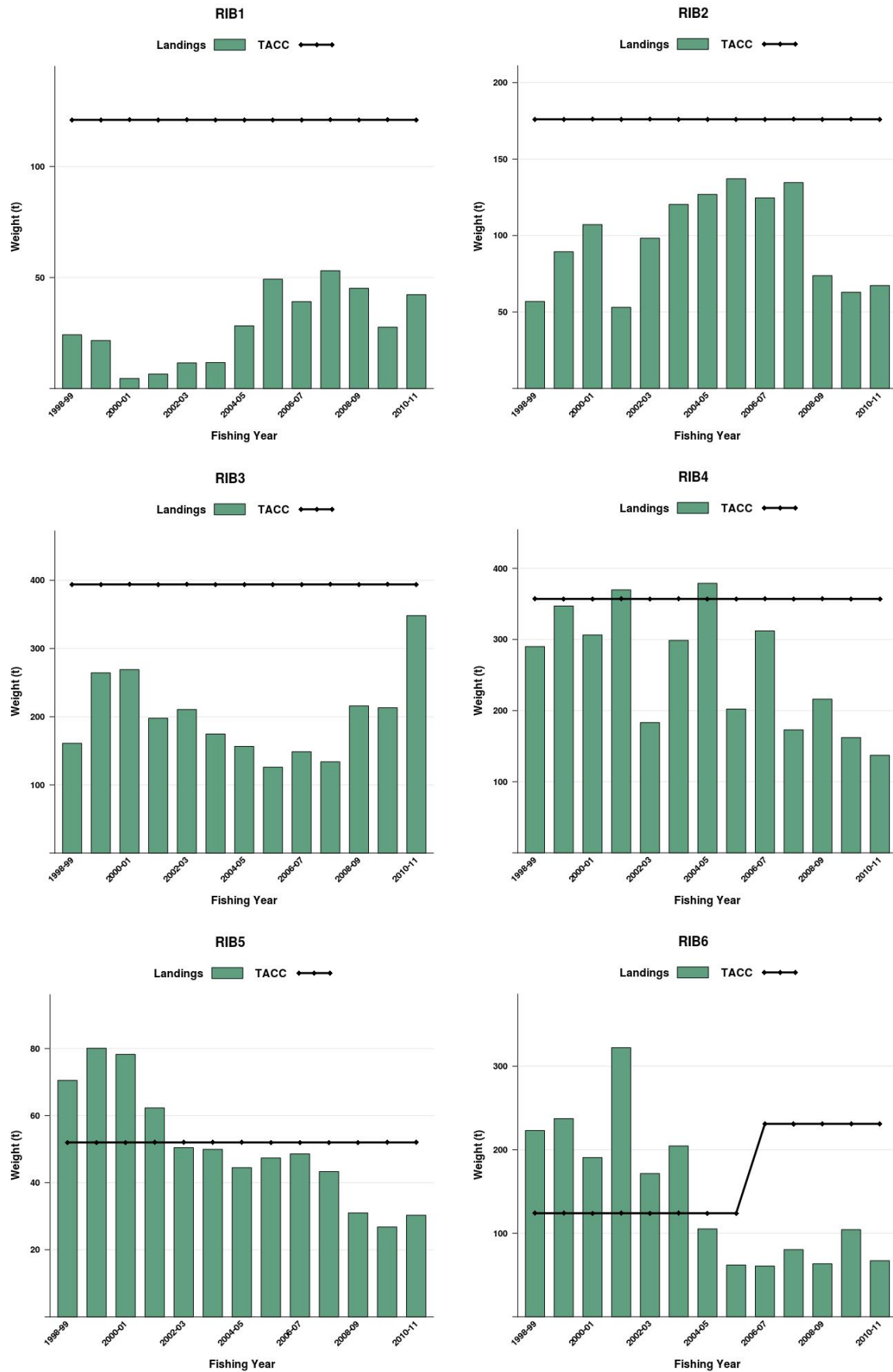
Figure 1: Historical landings and TACC for the seven main RIB stocks. From top left: RIB1 (Auckland East), RIB2 (Central East), RIB3 (South East Coast), RIB4 (South East Chatham Rise), RIB5 (Southland), RIB6 (Sub-Antarctic). [Continued on next page].
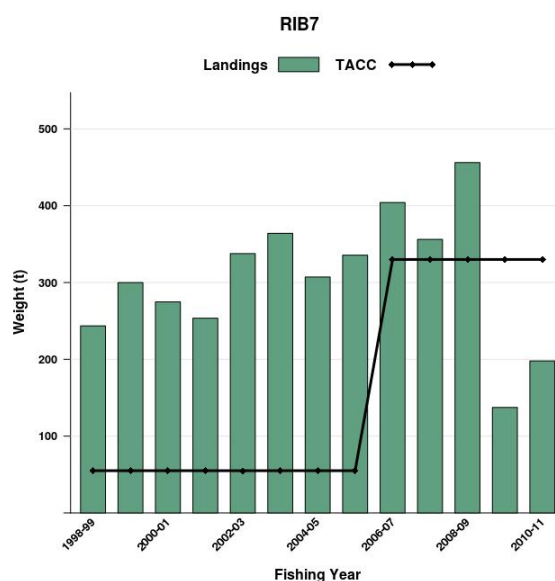
RIB7

Figure 1 [Continued]: Historical landings and TACC RIB7 (Challenger). Note that these figures do not show data prior to entry into the QMS.

In RIB 1, ribaldo are taken as bycatch primarily in the ling and to lesser extent bluenose bottom longline fisheries. There is also some direct targeting of ribaldo by bottom longline. In RIB 2, ribaldo are taken as bycatch primarily in the ling and bluenose bottom longline fisheries and to a lesser extent the hoki and orange roughy bottom trawl fisheries. There is also some direct targeting of ribaldo by bottom longline. In RIB 8 very small catches (< 1 t) of ribaldo are reported mainly in bottom trawl and bottom longline fisheries for a variety of target species. There is no reported targeting of ribaldo in RIB 8 and since entering the QMS in the 1998-99 fishing year the TACC of one tonne has never been caught. In RIB 9 very small amounts of ribaldo are taken as bycatch in orange roughy, cardinal and alfonsino target trawl fisheries and in the ling bottom longline fishery. In all areas, a variety of other fishing methods and target fisheries also report catching ribaldo but only in negligible amounts. The majority of the ribaldo catch is taken in RIB 3-7. Fisheries interactions for these areas are described in the Status of the Stocks tables in Section 5.

1.2   Recreational fisheries
There are no known recreational fisheries for ribaldo.

1.3   Customary non-commercial fisheries
There is no known customary non-commercial fishing for ribaldo.

1.4   Illegal catch
Estimates of illegal catch are not available.

1.5   Other sources of mortality
There is no quantitative information on the level of other sources of mortality.

2.   BIOLOGY

Ribaldo is known from the North Atlantic Ocean from Iceland to West Africa, the western Mediterranean Sea, the Indian Ocean south of Madagascar and the Pacific Ocean from Australia, New Zealand and Chile. In New Zealand it is widespread and has been caught by research trawl at depths of about 200-1300 m. It appears to be most common at 500-1000 m. The relatively high catch by bottom longline suggests that it favours rough bottom habitats.

Ribaldo reaches fork lengths (FL) of about 75 cm and 65 cm for females and males respectively. Most research trawls have caught fish ranging from 30 to 70 cm FL. The 50% length at sexual maturity has

been estimated at 45 cm total length for New Zealand ribaldo (O'Driscoll *et al.* 2003). Analyses of data on female gonad development, collected by the Ministry of Fisheries Observer Programme, indicates a winter/early spring spawning season. Fish do not appear to form large spawning aggregations. Locations at which spawning fish have been observed are the upper North Island (extending outside the EEZ), north-east and west Chatham Rise, the area between the Snares and Auckland Islands shelves, and west coast of the South Island. Early life history is largely unknown but a few individuals less than 10 cm FL were captured in plankton nets in the upper 200 m of the water column over bottom depths of about 1000 m at the south west end of Chatham Rise. The distribution of juveniles < 28 cm is similar to that of observed spawning females. Juveniles up to 35 cm have been observed in all fished areas of the EEZ except for the Bounty Islands.

Ageing by zone counts of otoliths has been validated using radiometric techniques (Sutton *et al.* 2010) using ribaldo caught on Chatham Rise trawl surveys by *Tangaroa* from 2001 to 2005. Maximum observed ages were 37 and 39 years for females and males respectively. Von Bertalanffy growth parameters are presented in Table 3, estimates of natural mortality (*M*) are presented in Table 4 and length-weight parameters in Table 5.

Ribaldo are caught in low numbers both in research trawl surveys and in observed commercial fisheries making tracking of cohorts by length frequencies difficult. Collection of otoliths is required to construct catch-at-age series for any fishing areas. Analyses of trawl survey and observer data has shown that biomass of females is usually greater than that of males on the Chatham Rise although sex ratios are about 1:1. In the SubAntarctic the biomass and numbers of females are significantly greater than males, often over 10:1. Sex ratios elsewhere in the EEZ are less clear.

Table 3: Von Bertalanffy growth parameter values for ribaldo. Source: Sutton *et al.* 2010.

Von Bertalanffy growth parameters

	K	t_0	*L∞*
RIB 3 & 4 females	0.135	0.221	67.526
RIB 3 & 4 males	0.072	-5.246	61.444
RIB 3 & 4 combined sexes	0.14	-0.287	60.47

Table 4: Estimates of natural mortality (*M*). Source: Sutton *et al.* 2010.

	Females	Males
Natural mortality (*M*)	0.106	0.112

Table 5: Length-weight parameter values for ribaldo.

Fishstock				**Estimate**		**Source**
Weight = a(length)b (Weight in g, length in cm total length)						
	Females		Males			
	a	b	a	b		
RIB 3 & 4	0.0037	3.27	0.0053	3.18		Sutton *et al.* (2010)
RIB 5 & 6	-	-	-	-		
			Sexes combined			
			a	b		
RIB 3 & 4			0.004289	3.237753		Sutton *et al.* (2010)
RIB 5 & 6			0.0039	3.15		Bagley *et al.* (unpublished data)

3. STOCKS AND AREAS

It is not known whether different regional stocks of ribaldo occur in New Zealand waters but it is possible that there are separate stocks based on natural bathymetric boundaries. The Working Group had previously agreed on five fishstocks based on the four main fishing areas plus the Kermadec area, i.e., the east coast of the North Island (QMAs 1 and 2), Chatham Rise and east coast South Island (QMAs 3 and 4), Southland and Sub-Antarctic (QMAs 5 and 6), the west coast of New Zealand (QMAs 7, 8 and 9) and QMA 10. A review of all available information in 2010 indicated that the main fishing areas are still as found previously. The review also indicated spawning activity in all areas, except RIB 8 and RIB 10 (for which there is no information). This is not inconsistent with the

management of the fishery by the current 10 FMAs. Highly skewed sex ratios in the SubAntarctic have unknown implications for stock structure.

4. STOCK ASSESSMENT

The Middle Depths Working Group agreed in February 2011 that relative biomass estimates of ribaldo from middle depth trawl surveys on the Chatham Rise and the SubAntarctic were suitable for monitoring major changes in ribaldo abundance for RIB 3 & 4 and RIB 5 & 6 respectively. Standardised CPUE indices from the spawning hoki and hake target fisheries in RIB 7 were not accepted although this could possibly be revisited in future using daily processed catch of ribaldo instead of estimated catch at the tow by tow level. There are no stock monitoring indices available for RIB 1, 2, 8 & 9

4.1 Estimates of fishery parameters and abundance
No estimates of fishery parameters have been made. Analyses of research trawl survey abundance estimates on the Chatham Rise and Sub-Antarctic suggest they may be suitable for monitoring major changes in abundance. While the Sub-Antarctic survey does not fully cover the depth range of ribaldo the Chatham Rise survey has been extended down to 1300 m since 2010. Biomass from the deep strata (800-1300 m) accounted for 23% of the total ribaldo biomass in 2010.

Dunn (2006) described the fishery up to 2002-03 but found that interpreting CPUE data was difficult because ribaldo are taken mainly as by-catch of other fisheries and the CPUE may reflect changes in those fisheries rather than ribaldo abundance. MacGibbon & Hurst (2011) carried out a standardised trawl CPUE analysis of hoki and hake in RIB 7 from 1999-2009. The index was problematic for the same reasons listed above. The trend showed a slight decline from 1999 to 2002 and was fairly steady thereafter.

4.2 Biomass estimates
Estimates of biomass are given in Table 6.

4.3 Estimation of Maximum Constant Yield (*MCY*)
MCY cannot be estimated.

4.4 Estimation of Current Annual Yield (*CAY*)
CAY cannot be estimated.

4.5 Other yield estimates and stock assessment results
No information is available.

Table 6: Biomass indices (t) and coefficients of variation (CV) of ribaldo from *Tanagroa* trawl surveys (Assumptions: areal availability, vertical availability and vulnerability = 1). NB: estimates are for the core strata only for the respective time series.

| Vessel	Trip code	Date	Biomass (t)	%CV
Chatham Rise (RIB 3 & 4)				
Tangaroa	TAN9106	Dec 91-Feb 92	417	12.2
	TAN9212	Dec 92-Feb 93	336	17.2
	TAN9401	Jan-94	602	10.8
	TAN9501	Jan-Feb 95	406	19.7
	TAN9601	Dec 95-Jan 96	470	18.2
	TAN9701	Jan-Jan 97	333	21.3
	TAN9801	Jan-Jan 98	510	14.3
	TAN9901	Jan-Jan 99	395	18
	TAN0001	Dec 99-Jan 00	387	20.8
	TAN0101	Dec 00-Jan 01	762	18.3
	TAN0201	Dec 01-Jan 02	417	13.2
	TAN0301	Dec 02-Jan 03	455	18.1
	TAN0401	Dec 03-Jan 04	535	15.6
	TAN0501	Dec 04-Jan 05	491	14.2
	TAN0601	Dec 05-Jan 06	313	16.9
	TAN0701	Dec 06-Jan 07	380	15
	TAN0801	Dec 07-Jan 08	479	14.3
	TAN0901	Dec 08-Jan 09	463	12.7
	TAN1001	Jan-10	416	19.9
	TAN1101	Jan-11	396	16.7
SubAntarctic (summer, RIB 5 & 6)				
Tangaroa	TAN9105	Nov-Dec 91	1035	11.2
	TAN9211	Nov-Dec 92	389	18.6
	TAN9310	Nov-Dec 93	996	12.8
	TAN0012	Nov-Dec 00	873	14
	TAN0118	Nov-Dec 01	1 017	17.2
	TAN0219	Nov-Dec 02	656	17.5
	TAN0317	Nov-Dec 03	653	18.9
	TAN0414	Nov-Dec 04	951	16.5
	TAN0515	Nov-Dec 05	721	14.6
	TAN0617	Nov-Dec 06	780	16.4
	TAN0714	Nov-Dec 07	1 062	13.5
	TAN0813	Nov-Dec 08	658	18
	TAN0911	Nov-Dec 09	1 056	13.4
	TAN1117	Nov-Dec 11	1 017	17.2
Tangaroa	TAN9204	Apr-May 92	768	17.1
	TAN9304	May-Jun 93	1 162	15.1
	TAN9605	Mar-Apr 96	989	16.7
	TAN9805	Apr-May 98	837	14.2
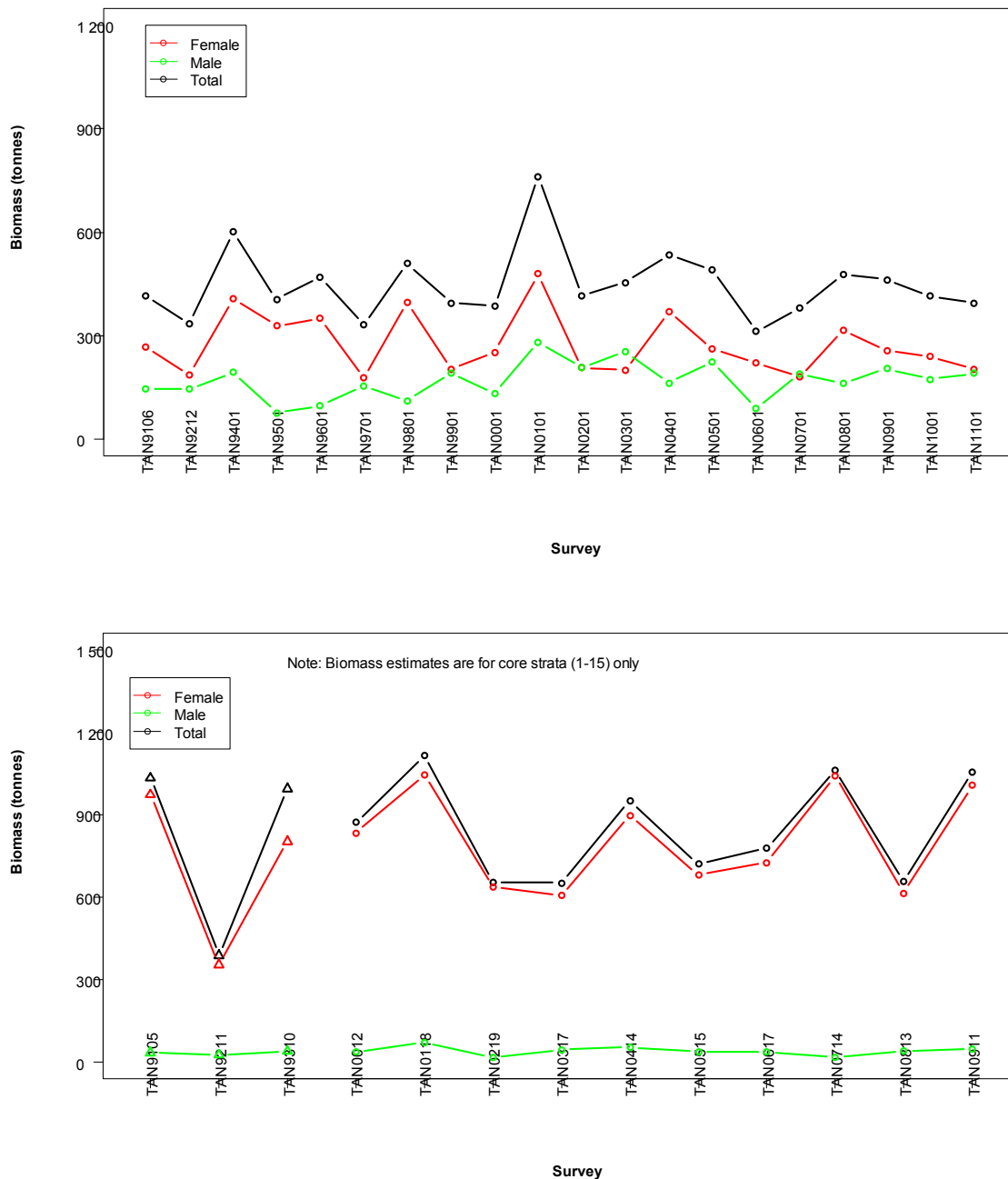
Figure 2: Doorspread biomass estimates of ribaldo by sex from the Chatham Rise 1991 to 2011 (upper) and Sub-Antarctic 1991 to 1993 and 2000 to 2009 (lower), from *Tangaroa* trawl surveys.

5.   STATUS OF THE STOCKS

RIB 1, 2, 7, 8 and 9

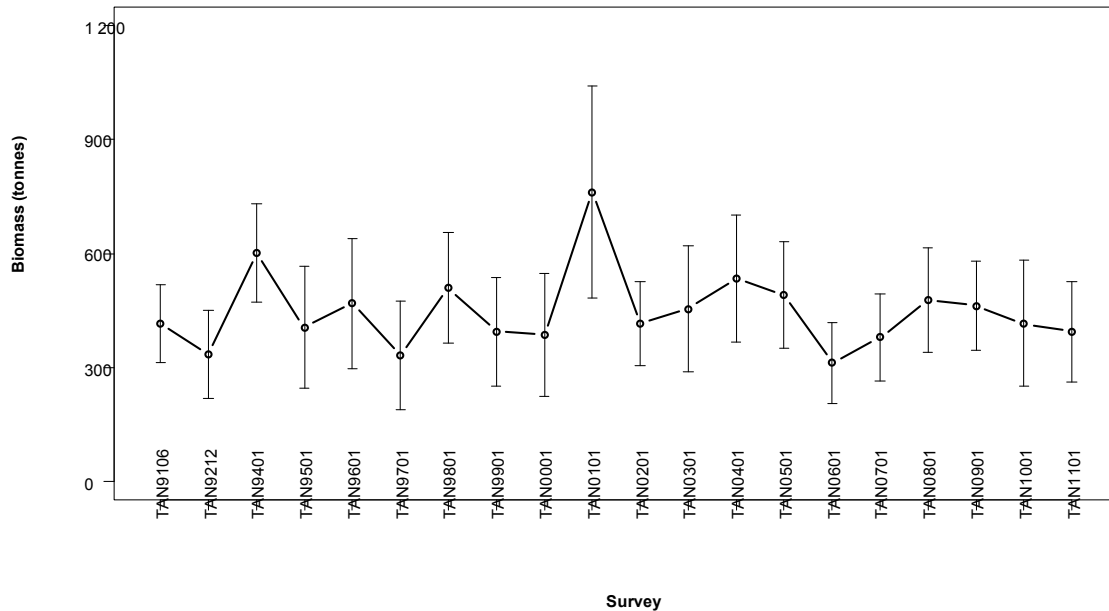There are no accepted stock monitoring indices available for RIB 1, 2, 7, 8 & 9.

RIB 3 & 4

Stock Status	
Year of Most Recent Assessment	2011
Reference Points	Target: Not established but 40% B_0 assumed Soft Limit: 20% B_0

	Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Unlikely (< 40%) to be below soft limit.
	Unlikely (< 40%) to be below hard limit

Historical Stock Status Trajectory and Current Status

Doorspread biomass estimates of ribaldo (error bars are ± two standard deviations) from the Chatham Rise, from *Tangaroa* surveys from 1991 to 2011.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The relative biomass index of ribaldo from summer middle depth trawl surveys of the Chatham Rise is relatively flat. Precision is generally good in this time series (< 20%). Although numbers of individual ribaldo caught are low the Working Group considered this index to be suitable to monitor major trends in this stock.
Recent Trend in Fishing Mortality or Proxy	

Projections and Prognosis	
Stock Projections or Prognosis	Stock size is Likely (> 60%) to remain near current levels under current catches.
Probability of Current Catch or TACC causing decline below Limits	Soft limit: Unlikely (< 40%) for current catches Hard limit: Unlikely (< 40%) for current catches

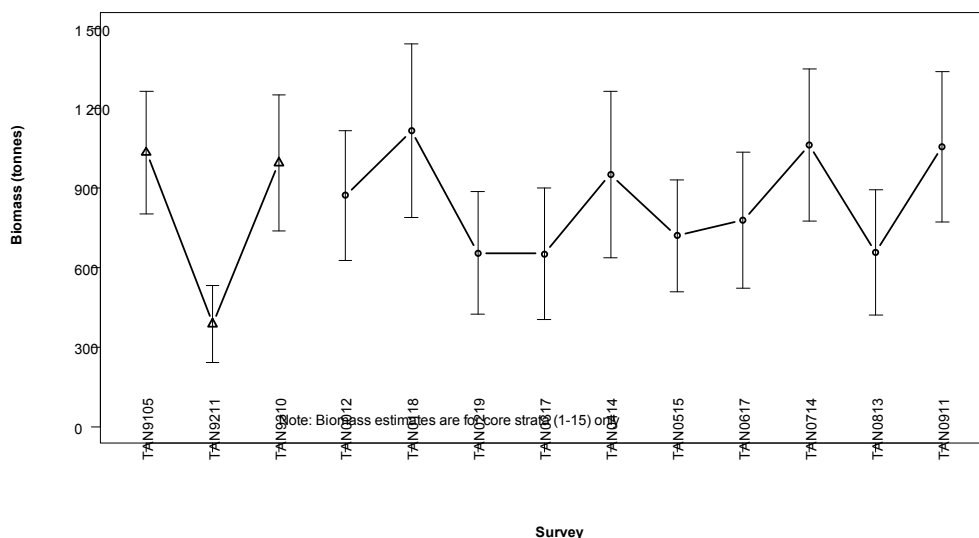| **Assessment Methodology**		
Assessment Type	Level 2: Partial quantitative stock assessment	
Assessment Method	Evaluation of agreed trawl survey indices thought to index RIB 3 & 4 abundance.	
Main data inputs	Data collected on trawl surveys.	
Period of Assessment	Latest assessment: 2011	Next assessment: 2012
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	Low numbers of individuals caught on trawl surveys; proportion of biomass deeper than 800 m (not surveyed in core strata)	
Qualifying Comments		
-		

Fishery Interactions
In RIB 3 & 4, ribaldo are taken as bycatch primarily in the ling and hoki bottom trawl fisheries and ling bottom longline fishery.

RIB 5 & 6

Stock Status	
Year of Most Recent Assessment	2011
Reference Points	Target: Not established but 40% B_0 assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Unlikely (< 40%) to be below soft limit Unlikely (< 40%) to be below hard limit
Historical Stock Status Trajectory and Current Status	

Doorspread biomass estimates of ribaldo (error bars are ± two standard deviations) from the Sub-Antarctic, from *Tangaroa* surveys from 1991 to 1993, and 2000 to 2009.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Relative biomass estimates of ribaldo from summer middle depth surveys of the SubAntarctic show a relatively flat index. CVs are consistently low in this time series (< 20%). Although numbers of individual ribaldo caught are low the Working Group considered this index to be suitable to monitor major trends in this stock.

Recent Trend in Fishing Mortality or Proxy	Unknown

Projections and Prognosis	
Stock Projections or Prognosis	Stock size is Likely (> 60%) to remain near current levels under current catches and TACCs.
Probability of Current Catch or TACC causing decline below Limits	Soft limit: Unknown Hard limit: Unlikely (< 40%)
Assessment Methodology	
Assessment Type	Level 2: Partial quantitative stock assessment
Assessment Method	Evaluation of agreed trawl survey indices thought to index RIB 5 & 6 abundance.
Main data inputs	Data collected on trawl surveys.

Period of Assessment	Latest assessment: 2011	Next assessment: 2012
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	Low numbers of individuals caught on trawl surveys; proportion of biomass deeper than 800 m (not surveyed in core strata); and unknown implications of highly skewed sex ratios (females usually make up > 90% of biomass) for stock structure. Observer data also shows skewed sex ratios in favour of females.	

Qualifying Comments
-

Fishery Interactions
In RIB 5 & 6, ribaldo are mainly caught as bycatch in hoki and ling bottom trawl fisheries and ling bottom longline fisheries.

TACCs and reported landings for the 2010-11 fishing year are summarised in Table 7.

Table 7: Summary of TACCs (t) and reported landings (t) of ribaldo for the most recent fishing year.

| Fishstock		QMA	2010-11 Actual TACC	2010-11 Estimated landings
RIB 1	Auckland (East)	1	121	42
RIB 2	Central (East)	2	176	67
RIB 3	South-east (Coast)	3	394	348
RIB 4	South-east (Chatham)	4	357	137
RIB 5	Southland	5	52	30
RIB 6	Sub-Antarctic	6	231	67
RIB 7	Challenger	7	330	198
RIB 8	Central (West)	8	1	3
RIB 9	Auckland (West)	9	2	20
RIB 10	Kermadec	10	0	0
Total			1 664	913

6.   FOR FURTHER INFORMATION

Bagley N.W., O'Driscoll R.L. 2010. Trawl survey of middle depth species in the Southland and Sub-Antarctic areas, November-December 2009 (TAN0911). New Zealand Fisheries Assessment Report (in press).

Cohen D.M., Inada T., Iwamoto T., Scialabba N. 1990. FAO species catalogue. Vol. 10. Gadiform fishes of the world (Order Gadiformes). An annotated and illustrated catalogue of cods, hakes, grenadiers and other gadiform fishes known to date. Food and Agriculture Orginisation Fisheries Synopsis. No. 125, Vol. 10. Rome, FAO. 442p.

Dunn M.R. 2006. Descriptive and catch per unit effort analyses for New Zealand ribaldo fisheries for the fishing years 1988-78 to 2002-03> New Zealand Fisheries Assessment Document 2006/22. 55p.

Elder R.D., Taylor J.L. (Comps.) 1979. Prospects and problems for New Zealand's demersal fisheries. Proceedings of the Demersal Fisheries Conference October 1978. Fisheries Research Division Occasional Publication No. 19. 123p.

MacGibbon D.J., Hurst R.J. 2011. Fishery characterisation and standardised CPUE analyses for ribaldo, *Mora moro*, (Risso, 1810) (Moridae), 1989-90 to 2008-09. New Zealand Fisheries Assessment Report 2011/XX

McMillan P.J., Hart A.C. 1998. Summary of biology and commercial landings, and a stock assessment of ribaldo *Mora moro* (Risso, 1810), in New Zealand waters. New Zealand Fisheries Assessment Research Document 1998/9. 16p.

O'Driscoll R.L., Booth J.D., Bagley N.W., Anderson O.F., Griggs L.H., Stevenson M.L., Francis M.P. 2003. Areas of importance for spawning, pupping or egg-laying, and juveniles of New Zealand deepwater fish, pelagic fish, and invertebrates. NIWA Technical Report 119. 377 p.

Sutton C.P., Tracey D.M., Andrews A.H., Hart A.C., MacGibbon D.J. 2010. Validated age and growth of ribaldo (*Mora moro*). *New Zealand Fisheries Assessment Report 2010/24.*26 p.

RIG (SPO)

(Mustelus lenticulatus)
Pioke, Makoo
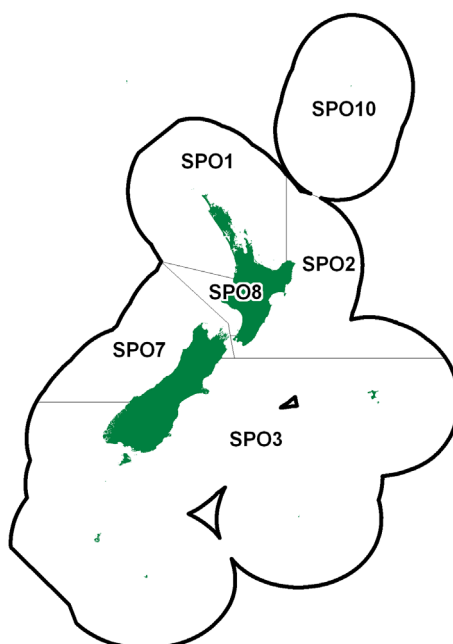
1. FISHERIES SUMMARY

1.1 Commercial fisheries

Rig are caught in coastal waters throughout New Zealand. Most of the catch is taken in water less than 50 m deep during spring and summer, when rig aggregate inshore. Before the introduction of the QMS in 1986, 80% of the commercial catch was taken by bottom setnet and most of the remainder by trawl. Total reported landings of rig increased rapidly during the 1970s, and averaged about 3200 t per year during the late 1970s and early 1980s (Table 1). Since then, a larger proportion has been taken by trawlers as bycatch, but the exact split by method is unknown (because method data were available only for a portion of the rig catch in the CELR database). The most important bottom setnet fisheries are at 90-Mile Beach, Kaipara Harbour, Manukau Harbour, South Taranaki Bight – Tasman/Golden Bay, Canterbury Bight, Kaikoura and Hauraki Gulf. Due to a decline in CPUE the TACC for SPO 7 was decreased to 221 t on the 1st October 2006. Figure 1 shows the historical landings and TACC values for the main SPO stocks.

Table 1: Reported total New Zealand landings (t) of rig for the calendar years 1965 to 1985. Sources: MAF and FSU data.

Year	Landings	Year	Landings	Year	Landings	Year	Landings	Year	Landings
1965	723	1970	930	1975	1 841	1980	3 000	1985	3 222
1966	850	1971	1 120	1976	2 610	1981	3 006		
1967	737	1972	1 011	1977	3 281	1982	3 425		
1968	677	1973	–	1978	3 300	1983	3 826		
1969	690	1974	2 040	1979	2 701	1984	3 562		

Following the introduction of rig to the QMS in 1986, landings declined to less than half those of the previous decade in response to the TACCs. Since 1986–87, landings have generally increased in response to TACC increases (Table 2). TACCs for all Fishstocks except SPO 10 were increased by 20% for the 1991–92 fishing year under the Adaptive Management Programme (AMP). Another TACC increase (from 454 t to 600 t) was implemented in SPO 3 for the 2000–01 fishing year. The TACCs for SPO 1, SPO 2 and SPO 8 reverted to the pre-AMP levels in the 1997–98 fishing year, when these Fishstocks were removed from the AMP in July 1997. The TACC for SPO 2 was increased from 72 t to 86 t from 1 October 2004 under the low knowledge bycatch framework (Table 4).

In October 1992, the conversion factors for headed and gutted, and dressed, rig were both reduced from 2.00 to 1.75. They were each further reduced to 1.55 in 2000-01. Landings prior to 2000-01 have not been adjusted for the changes in the conversion factor. All AMP programmes ended on 30 September 2009.

Commercial landings of rig in SPO 1 have declined consistently since 1991-92. Although changes to the conversion factors mean that landings prior to 2000-01 are overestimated, catches since that time have continued to decline.

The Banks Peninsula Marine Mammal Sanctuary was established in 1988 by the Department of Conservation under the Marine Mammal Protection Act 1978, for the purpose of protecting Hector's dolphins. The sanctuary extends 4 nautical miles from the coast from Sumner Head in the north to the Rakaia River mouth in the south. Prior to 1 October 2008, no setnets were allowed within the sanctuary between 1 November to the end of February. For the remainder of the year, setnets were allowed; but could only be set from an hour after sunrise to an hour before sunset, be no more than 30 metres long, with only one net per boat which was required to remain tied to the net while it was set.

Voluntary setnet closures were implemented by the SEFMC from 1 October 2000 to protect nursery grounds for rig and elephantfish and to reduce interactions between commercial setnets and Hector's dolphins in shallow waters. The closed area extended from the southern most end of the Banks Peninsula Marine Mammal Sanctuary to the northern bank of the mouth of the Waitaki River. This area was closed permanently for a distance of 1 nautical mile offshore and for 4 nautical miles offshore for the period 1 October to 31 January.

From 1 October 2008, a suite of regulations intended to protect Maui's and Hector's dolphins was implemented for all of New Zealand by the Minister of Fisheries.

For SPO 1, there have been two recent changes to the management regulations affecting setnet fisheries which take school shark off the west coast of the North Island. The first was a closure to setnet fishing from Maunganui Bluff to Pariokariwa Point for a distance of 4 nautical miles on 1 October 2003. This closure was extended by the Minister to 7 nautical miles on 1 October 2008. An appeal was made by affected fishers who were granted interim relief by the High Court, allowing setnet fishing beyond 4 nautical miles during daylight hours between 1 October to 24 December.

For SPO 3, commercial and recreational set netting was banned in most areas to 4 nautical miles offshore of the east coast of the South Island, extending from Cape Jackson in the Marlborough Sounds to Slope Point in the Catlins. Some exceptions were allowed, including an exemption for commercial and recreational set netting to only one nautical mile offshore around the Kaikoura Canyon, and permitting setnetting in most harbours, estuaries, river mouths, lagoons and inlets except for the Avon-Heathcote Estuary, Lyttelton Harbour, Akaroa Harbour and Timaru Harbour. In addition, trawl gear within 2 nautical miles of shore was restricted to flatfish nets with defined low headline heights.

For SPO 5, commercial and recreational setnetting was banned in most areas to 4 nautical miles offshore, extending from Slope Point in the Catlins to Sandhill Point east of Fiordland and in all of Te Waewae Bay. An exemption which permitted setnetting in harbours, estuaries and inlets was allowed. In addition, trawl gear within 2 nautical miles of shore was restricted to flatfish nets with defined low headline heights.

For SPO 7, both commercial and recreational setnetting were banned to 2 nautical miles offshore, with the recreational closure effective for the entire year and the commercial closure restricted to the period 1 December to the end of February. The closed area extends from Awarua Point north of Fiordland to the tip of Cape Farewell at the top of the South Island. There is no equivalent closure in SPO 8, with the southern limit of the Maui's dolphin closure beginning north of New Plymouth at Pariokariwa Point. There have been two recent changes to the management regulations affecting setnet fisheries which take school shark off the west coast of the North Island.

Table 2: Reported landings (t) of rig by Fishstock from 1985–86 to 2010–11 and actual TACCs (t) from 1986–87 to 2010-11. QMS data from 1986–present.

Fishstock FMA (s)	SPO 1 1 &		SPO 2 2		SPO 3 3,4,5, & 6		SPO 7 7		SPO 8 8	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1985–86*	845	–	96	–	921	–	367	–	465	–
1986–87	366	540	55	60	312	330	233	240	125	240
1987–88	525	614	66	68	355	347	262	269	187	261
1988–89	687	653	68	70	307	352	239	284	212	295
1989–90	689	687	61	70	292	359	266	291	206	310
1990–91	656	688	63	71	284	364	268	294	196	310
1991–92	878	825	105	85	352	430	290	350	145	370
1992–93	719	825	90	86	278	432	324	350	239	370
1993–94	631	829	96	86	327	452	310	350	255	370
1994–95	666	829	88	86	402	454	341	350	273	370
1995–96	603	829	107	86	408	454	400	350	330	370
1996–97	681	829	99	86	434	454	397	350	277	370
1997–98	621	692	85	72	442	454	325	350	287	310
1998–99	553	692	86	72	426	454	336	350	235	310
1999–00	608	692	86	72	427	454	330	350	219	310
2000–01	554	692	81	72	458	600	338	350	174	310
2001–02	436	692	86	72	391	600	282	350	216	310
2002–03	477	692	86	72	417	600	264	350	209	310
2003–04	481	692	81	72	354	600	293	350	203	310
2004–05	429	692	108	86	366	600	266	350	208	310
2005–06	345	692	110	86	389	600	288	350	163	310
2006–07	400	692	101	86	423	600	265	221	176	310
2007–08	297	692	104	86	472	600	231	221	220	310
2008–09	297	692	106	86	328	600	233	221	222	310
2009-10	302	692	114	86	371	600	229	221	246	310
2010-11	311	692	106	86	395	600	229	221	220	310

Fishstock FMA (s)	SPO 10 10		Total	
	Landings	TACC	Landings§	TACC
1985–86*	0	–	2 906	–
1986–87	0	10	1 091	1 420
1987–88	0	10	1 395	1 569
1988–89	0	10	1 513	1 664
1989–90	0	10	1 514	1 727
1990–91	0	10	1 467	1 737
1991–92	0	10	1 770	2 070
1992–93	0	10	1 650	2 072
1993–94	0	10	1 619	2 097
1994–95	0	10	1 769	2 098
1995–96	0	10	1 848	2 098
1996–97	0	10	1 888	2 098
1997–98	0	10	1 760	1 888
1998–99	0	10	1 635	1 888
1999–00	0	10	1 670	1 888
2000–01	0	10	1 607	2 034
2001–02	0	10	1 411	2 034
2002–03	0	10	1 453	2 034
2003–04	0	10	1 412	2 034
2004–05	0	10	1 377	204 8
2005–06	0	10	1 295	2 048
2006–07	0	10	1 365	1 919
2007–08	0	10	1 324	1 919
2008–09	0	10	1 186	1 919
2009-10	0	10	1 262	1 919
2010-11	0	10	1 260	1 919

*FSU data.

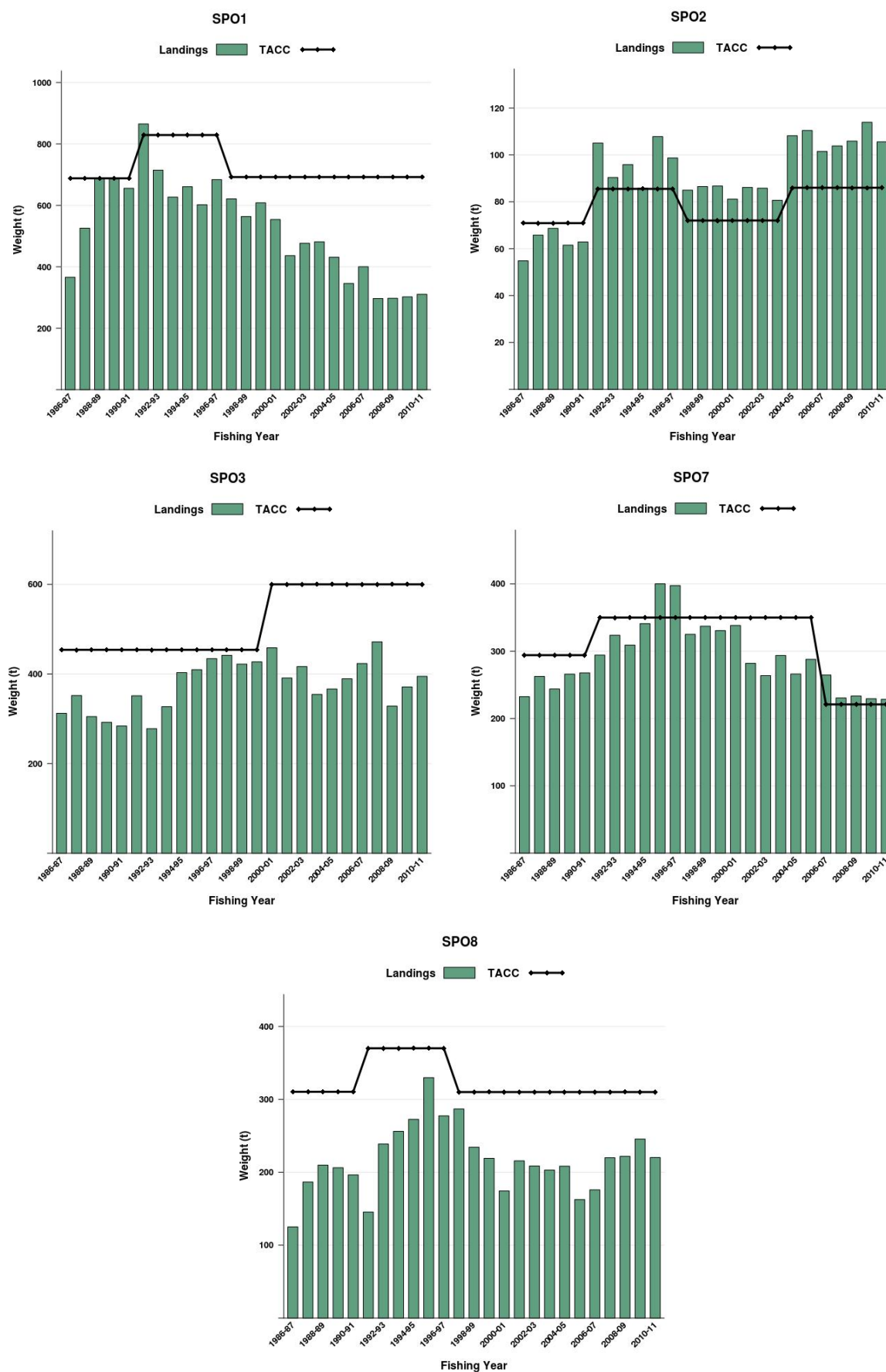§Includes landings from unknown areas before 1986-87

Figure 1: Historical landings and TACC for the five main SPO stocks. From top left: SPO1 (Auckland East), SPO2 (Central East), SPO3 (South East Coast), SPO7 (Challenger), and SPO8 (Central Egmont). Note that these figures do not show data prior to entry into the QMS.

SPO 7 is managed under a stakeholder led fisheries plan. This fisheries plan was developed by the Challenger Finfisheries Management Company Limited on behalf of quota owners and includes details of rebuild goals and objectives for the rig fishery in quota management area 7 (SPO 7). It represents part of the commitment made by 93% of the rig quota owners towards improving the value of their property rights and ensuring the future utilisation of the fishery for future generations. This plan was submitted to the Minister of Fisheries for approval pursuant to Section 11(a) of the Fisheries Act 1996. The plan seeks to improve the productivity of the SPO 7 fishstock through implementing area closures and catch reductions.

1.2   Recreational fisheries

Rig are caught by recreational fishers throughout New Zealand. Less that 3% of the recaptures of rig tagged around the South Island and Manawatu coasts in 1982–84 were returned by recreational fishers. Estimates of recreational landings obtained from three surveys, 1991–92 to 1993–94, 1996 and 1999–00 are given in Table 3. Recreational landings between 1991 and 1994 comprised only a small proportion (< 15%) of the total rig harvest in all Fishstocks.

Table 3: Estimated number and weight of rig harvested by recreational fishers by Fishstock and survey. Surveys were carried out in different years in the Ministry of Fisheries regions: South in 1991–92, Central in 1992–93, North in 1993–94 (Teirney *et al*. 1997) and nationally in 1996 (Bradford 1998) and 1999–00 (Boyd & Reilly 2002). Survey harvests are presented as a range to reflect the uncertainty in the estimates.

Fishstock	Survey	Number	CV%	Harvest Range (t)	Point estimate (t)
1991–92					
SPO 3	South	12 000	22	15–30	-
1992–93					
SPO 2	Central	5 000	-	5–15	-
SPO 7	Central	8 000	39	10–25	
SPO 8	Central	18 000	43	20–60	-
1993–94					
SPO 1	North	11 000	21	5–25	-
SPO 8	North	1 000	-	0–5	
1996					
SPO 1	National	28 000	31	25–45	35
SPO 2	National	4 000	-	-	-
SPO 3	National	12 000	20	10–20	15
SPO 7	National	19 000	20	20–30	24
SPO 8	National	7 000	-	-	-
1999–00					
SPO 1	National	13 000	30	12–23	17
SPO 2	National	16 000	58	9–33	21
SPO 3	National	43 000	32	39–75	57
SPO 7	National	33 000	38	21–46	33
SPO 8	National	7 000	48	5–13	9

The Recreational Technical Working Group concluded that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and, c) the 2000 and 2001 estimates are implausibly high for many important fisheries.

1.3   Customary non-commercial fisheries

Maori fishers traditionally caught large numbers of "dogfish" during the last century and early this century. Rig was probably an important species, though spiny dogfish and school shark were also taken. The historical practice of having regular annual fishing expeditions, during which thousands of dogfish were sun-dried on wooden frames, is no longer prevalent. However, rig are still caught in small quantities by customary non-commercial fishers in parts of the North Island, especially the harbours of the Auckland region. Quantitative information on the current level of customary non-commercial take is not available.

1.4   Illegal Catch

Quantitative information on the level of illegal catch is not available.

1.5   Other sources of mortality

Unknown quantities of juvenile rig are caught by setnets placed in harbours and shallow bays. Quantitative information on the level of other sources of mortality is not available.

Table 4: Total Allowable Catch (TAC, t), Total Allowable Commercial Catch (TACC, t), and recreational, non-commercial customary, and other fishing mortality allowances (t) declared for SPO as of October 2010.

Fishstock	TAC	TACC	Customary Non-Commercial Catch	Recreational	Other Mortality
SPO 1 (FMA 1 & 9)	752	692	20	25	15
SPO 2	122	86	20	10	6
SPO 3 (FMA 3-6)	710	600	20	60	30
SPO 7	270	221	15	29	5
SPO 8	401	310	0	0	0
SPO 10	10	10	0	0	0

2.   BIOLOGY

Rig are born at a total length (TL) of 25–30 cm. On the South Island male and female rig attain maturity at 5–6 yrs (~ 85 cm) and 7–8 yrs (~ 100 cm), respectively (Francis & O'Maolagain 2000). Rig in the Hauraki Gulf mature earlier – 4 yrs for males and 5 yrs for females – and at smaller sizes (Francis & Francis 1992). Longevity is not known because few large fish have been aged, however, a male rig that was mature at tagging was recaptured after nearly 14 years of liberty, suggesting a longevity of 20 years or longer. Females reach a maximum length of 151 cm and males 126 cm TL.

Rig give birth to young during spring and summer following a 10–11 month gestation period. Most females begin a new pregnancy immediately after parturition, and therefore breed annually. The number of young produced increases exponentially with the length of the mother, and ranges from 2 to 37 (mean ~ 11). Young are generally born in shallow coastal waters, especially in harbours and estuaries, throughout North and South Islands. They grow rapidly during their first summer, and then disappear as water temperatures drop in autumn-winter. They presumably move into deeper water.

Rig make extensive coastal migrations, with one tagged female moving a least 1160 km. Over half of the tagged rig that were recaptured had moved over 50 km, and over half of the females had moved more than 200 km. Females travel further than males, and mature females travel further than immature females.

Biological parameters relevant to stock assessment are shown in Table 5.

Table 5:   Estimates of biological parameters for rig.

Fishstock							Estimate	Source
1. Natural mortality (*M*)								
All							0.2–0.3	Francis & Francis (1992a)

2. Weight = a(length) (Weight in g, length in cm fork length).

	Females		Males		Source
	a	b	a	b	
SPO3	3.67×10^{-7}	3.54	1.46×10^{-6}	3.22	Francis (1979)
SPO 7&8	9.86×10^{-7}	3.32	$3.85 \times 10^{-}$	3.01	Blackwell (unpubl. data)

3. von Bertalanffy growth parameters

	Females			Males			Source
	L_∞	k	t_o	L_∞	k	t_o	
SPO 1	90.7	0.42	-0.77	118.7	0.16	-2.02	Francis & Francis (1992a)
SPO3	87.0	0.40	-0.68	161.1	0.11	-1.91	Francis & Francis (1992a)

	Both Sexes			Source
	L	k	t_o	
SPO 3 &7	147.2	0.119	-2.35	Francis & Ó Maolagáin (2000)

3.   STOCKS AND AREAS

Information relevant to determining rig stock structure in New Zealand was reviewed in 2009 (Smith 2009, Blackwell & Francis 2010, Francis 2010). These reviews concluded that the existing QMAs are a suitable size for rig management, although the boundaries between biological stocks are poorly defined, especially in the Cook Strait region. Insufficient tagging occurred in SPO 1 to determine whether division of that stock into separate 1E and 1W stocks is warranted.

Genetic, biological, fishery and tagging data were all considered, but the evidence available for the existence and geographical distribution of biological stocks is poor. Some differences were found in CPUE trends at a small spatial scale but stock separation at the indicated spatial scales seems unlikely, and the CPUE differences may have resulted from processes acting below the stock level, such as localised exploitation of different sexes or different size classes of sharks. Genetic and morphological evidence indicate that a separate undescribed species of *Mustelus* occurs at the Kermadec Islands, but it is not known if rig also occurs there.

The most useful source of information was a tagging programme undertaken mainly in 1982–84 (Francis 1988). However, most tag releases were made around the South Island, so little information was available for North Island rig. Male rig rarely moved outside the release QMA, even after more than 5 years at liberty. Female rig were more mobile than male rig, with about 30% of recaptures reported beyond the release QMA boundaries within 2–5 years of release. The proportion reported beyond the release QMA increased steadily with time. However, few females moved more than one QMA away from the release point. Because males move shorter distances than females, a conservative management approach is to set rig QMAs at a size appropriate for male stock ranges.

4.   STOCK ASSESSMENT

There are no new data which would alter the yield estimates given in the 1997 Plenary Report. The yield estimates are based on commercial landings data only.

4.1   Estimates of fishery parameters and abundance

SPO 1 and SPO 8
Standardised CPUE indices were calculated for SPO 8 and for five sub-areas in SPO 1 by modelling (GLM) non-zero catches by core vessels targeting rig with setnets between 1989–90 and 2009-10 (Kendrick & Bentley 2011). The SPO 1 analyses were complicated by the fact that up to 50% of catches were accumulated ashore for subsequent landing to Licensed Fish Receiver, breaking the link between effort and the landing. Estimated catches are unreliable in rig fisheries because many fishers report the processed weight rather than the expected green weight. A standardised CPUE analysis which attempted to correct this bias by calculating an annual correction factor for each vessel was rejected by the NINSWG, which suggested that this new methodology required further detailed investigation before acceptance. CPUE standardisations based on SPO 1 bottom trawl data were accepted as indices of abundance by the NINSWG, which noted that the landing behaviour which characterised the setnet fishery was not active in the bottom trawl fishery.

Similarly, the SPO 8 landing data, regardless of the method of capture, did not exhibit the behaviour of landing to temporary holding receptacles. Consequently, the NINSWG accepted the standardized set net CPUE for SPO 8 which fluctuated without trend, and recent indices are near the long-term average (Figure 2). The SPO 8 bottom trawl CPUE indices were not considered to be reliable as they were based on very small data sets
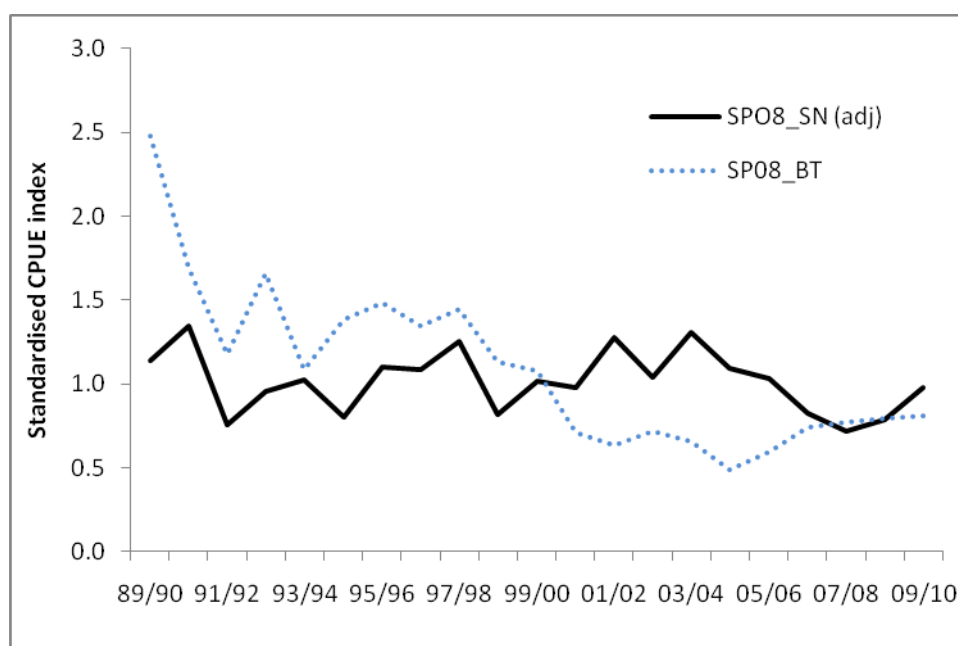
Figure 2: Comparison of standardised CPUE for SPO8 in target shark (SPO, SCH, SPD or NSD) setnet (bold line) and bycatch of bottom trawl (target SNA, GUR, TRE, TAR) in areas 037, 039, 040, and 041.

SPO 2

The standardised CPUE analysis conducted on SPO 2 in 2009 (Starr & Kendrick 2009) was extended by two years (Bentley *et.al* 2011). This analysis was based on complete trips which landed SPO 2 using the bottom trawl or setnet methods from 1989–90 to 2009–108, adjusted for changes in conversion factors. The use of complete trips was necessary because of the large proportion of trips which landed SPO 2 but did not report any estimated catch (26% by weight for the dataset). In addition, estimated catches severely underestimated landings (median estimated catch by trip was 2/3 the landed catch). The use of complete trips limited the number of explanatory factors that could be applied in the analysis. However, no difference was found between analyses which adjusted for zone of capture or target species category compared to the analyses which only corrected for year, month and vessel. The indices presented in this report are those corrected for year, month and vessel as they are based on the greatest amount of available data. The bottom trawl index is based on 18 434 trips representing 912 t of landings while the setnet index is based on 5 458 trips representing 326 t of landings. The SPO 2 landing data, regardless of the method of capture, did not exhibit the behaviour observed in SPO 1 of landing to temporary holding receptacles.

The SPO 2 series constructed from bottom trawl data shows a gradually increasing trend from 1989–90 to 2002–03 after which the series remains reasonably stable through to 2009–10 with three consecutive high years from 2001–02 to 2003-04 (Figure 3). A series based on setnet data is reasonably similar to the bottom trawl series until the mid-2000s when the setnet series goes into a steep decline. The WG agreed that the setnet series was less credible than the bottom trawl series due to fewer available data, poor vessel overlap, and the fact that the set net fishery largely targets blue moki and blue warehou.

SPO 3

Rig in SPO 3 are mostly landed in the shark setnet and bottom trawl fisheries, with additional small amounts landed by Danish seine vessels. The commercial catch in SPO 3 has never achieved the TACC. Two CPUE standardisations were accepted by the WG, one based on a shark target setnet fishery and the other based on a mixed target (barracouta, red cod, tarakihi, and stargazer) bottom trawl fishery. Both CPUE analyses are extensions of equivalent analyses which have been previously reviewed by the WG (SeaFIC 2005; Starr *et al.* 2008). These two fisheries are modelled separately because they operate at different depth ranges, with rig in the trawl fishery taken strictly as a bycatch while the species is targeted by the setnet fishery. These fisheries will clearly have different

selectivities, harvesting a different size range of rig, with the setnet fishery taking larger fish while the trawl fishery takes sub-adults. The SPO 3 landing data, regardless of the method of capture, did not exhibit the behaviour observed in SPO 1 of landing to temporary holding receptacles.
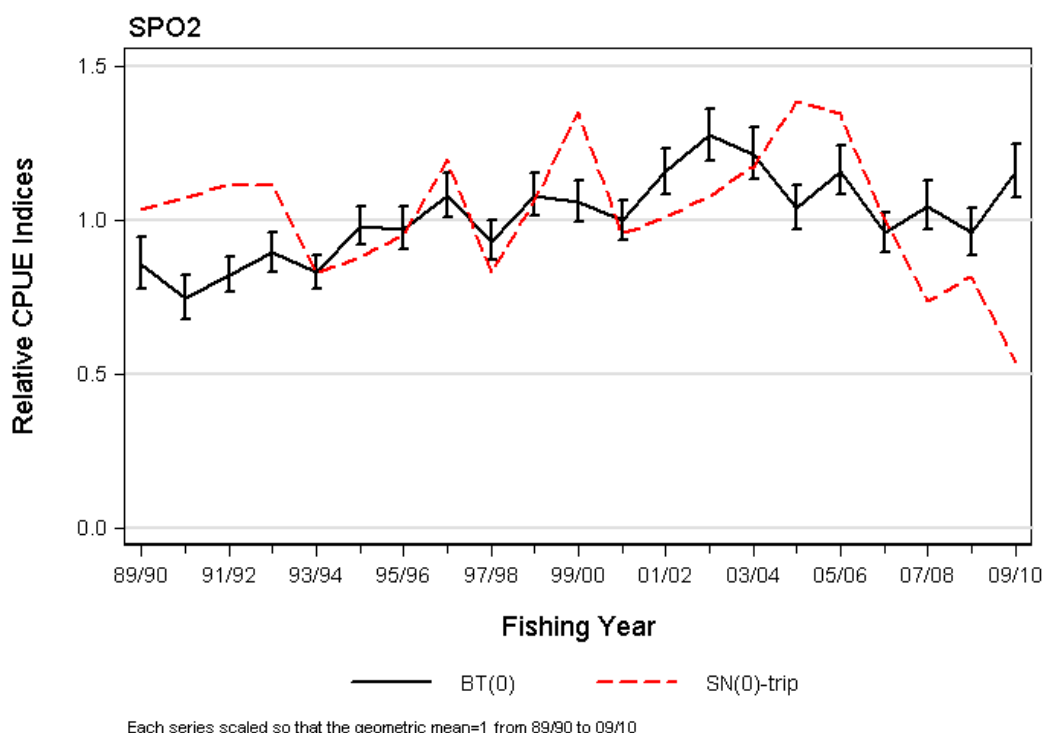
Figure 3: **Comparison of two lognormal standardised CPUE series for SPO 2 based on all valid bottom trawl and setnet trips which landed to SPO 2 up to 2009-10**
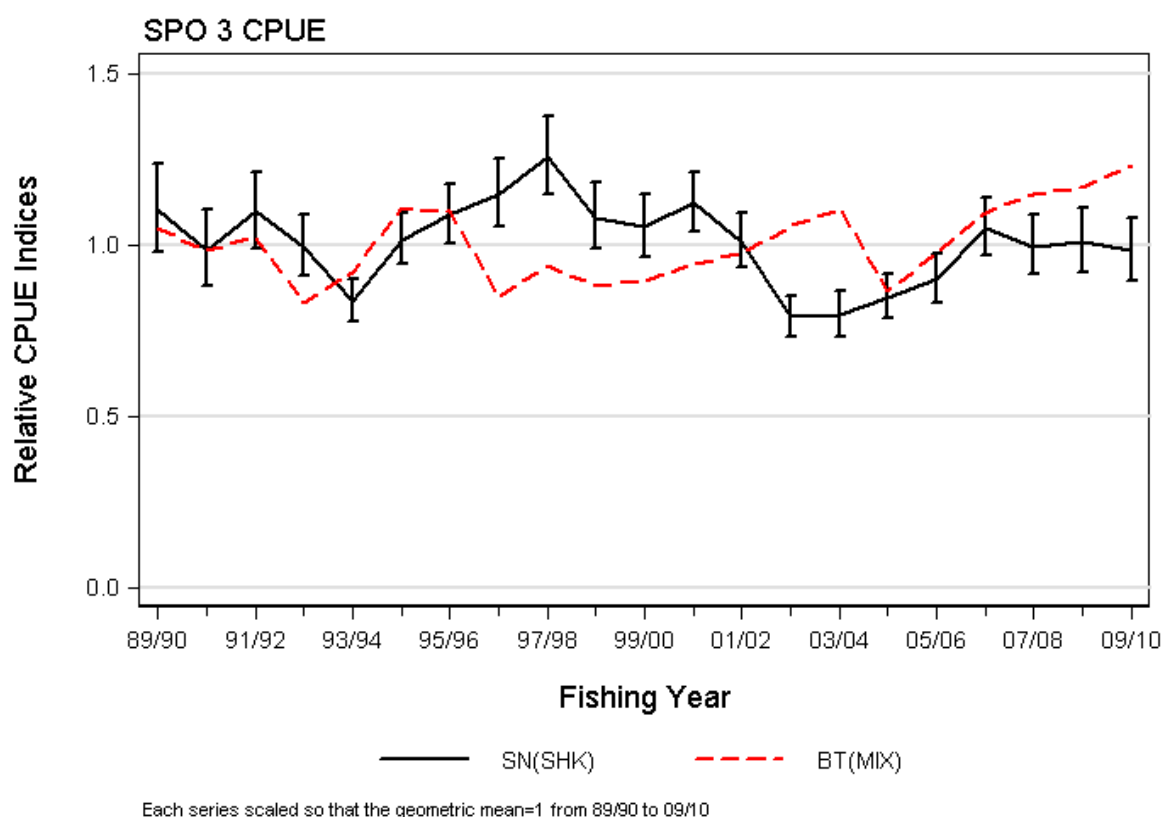
Each CPUE analysis was performed in the same manner. The effort data were matched with the landing data at the trip level to avoid relying on the estimated catch information in the effort part of the form and the resulting biases that exist in the reporting of estimated catches of rig. Core vessels which participated consistently in the fishery for a reasonably long period were identified within each data set so that the analysis could be confined to these vessels. Two standardised analyses using a stepwise selection of explanatory variables were performed: a lognormal regression on non-zero catch records and a binomial regression on the presence/absence of rig by trip stratum. The explanatory variables offered to each model included fishing year (forced), month, vessel, statistical area, target species, duration of fishing, and length of net set (for the setnet analysis). These two analyses were then combined into a single series using the delta method (Vignaux 1994) but only the lognormal analysis is reported. The landing information used in this CPUE analysis has been corrected for changes in conversion factors that have occurred over the history of the dataset (Starr & Kendrick 2011).

The two indices fluctuate about the long-term mean up to the mid-2000s (Figure 4). The SN(SHK) series increased consistently from a low in 2002–03, and then stabilises about the long term mean, while the BT(MIX) series clearly is trending upward. The SN(SHK) series shows a slight decline after TACC and catches increased in 2004/05. The WG accepted these indices as indices of abundance and considered the trend based on the SN(SHK) data to be more reliable because it should be indexing adult fish. Given the known vulnerability of shark species, these series should be repeated on a regular basis so that the trend can be evaluated.

SPO 7

CPUE analyses using lognormal standardisation of non-zero setnet catches for core vessels were undertaken to assess relative abundance of SPO 7. These analyses were updates of analyses previously accepted by the Working Group in 2006. The 2010 analyses used the same fishery

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definitions as the previous analysis: 1) setnet fishery in Statistical Areas 032–037 targeting rig, school shark and spiny dogfish [SN(WC)]; 2) setnet fishery in Statistical Area 038 targeting rig, spiny dogfish and school shark [SN(038)]; and 3) bottom trawl fishery in Statistical Areas 016–018, 032–037, 038, and 039 targeting flatfish, red cod and rig [BT(All)].

Figure 4: Comparison of the lognormal indices from the two CPUE series for SPO 3: a) SN[SHK]: target shark species setnet fishery; b) BT[MIX]: mixed target species bottom trawl fishery.

The analysis of each fishery/area was performed in the same manner (Starr *et al.* 2010). The effort data were matched with the landing data at the trip level. Each analysis was confined to a set of core vessels which had participated consistently in the fishery for a reasonably long period. The explanatory variables offered to each model included fishing year (forced), month, vessel, statistical area, target species, duration of fishing, and length of net set (for the setnet analysis). The Working Group had previously concluded that the SN(038) index was the most credible index of SPO 7 abundance. Concerns were raised in 2010 about the continued reliability of the SN(WC) index which may have been compromised by fleet behaviour changes in response to setnet closures on the west coast of the South Island designed to protect Hector's dolphins.

The SN(038) index showed a continuous declining trend from the beginning of the series to a low in the mid-2000s. It is this series which led to the decision to reduce the SPO 7 TACC to 221 t. That index has now increased four years in succession to 2008–09. The BT(All) series mirrored the SN(038) from the late-1990s and it too has shown an increasing trend since the mid-2000s. In 2006, the SN(WC) series was the most optimistic of the three series, showing little trend up to the mid-2000s. However, this index has since declined, although the Working Group thought it was likely that this may be in part be the result of other factors. Examination of the distribution of setnet effort on the west coast of the South Island shows that there has been a substantial decline in the number of vessels operating there since 2005–06.
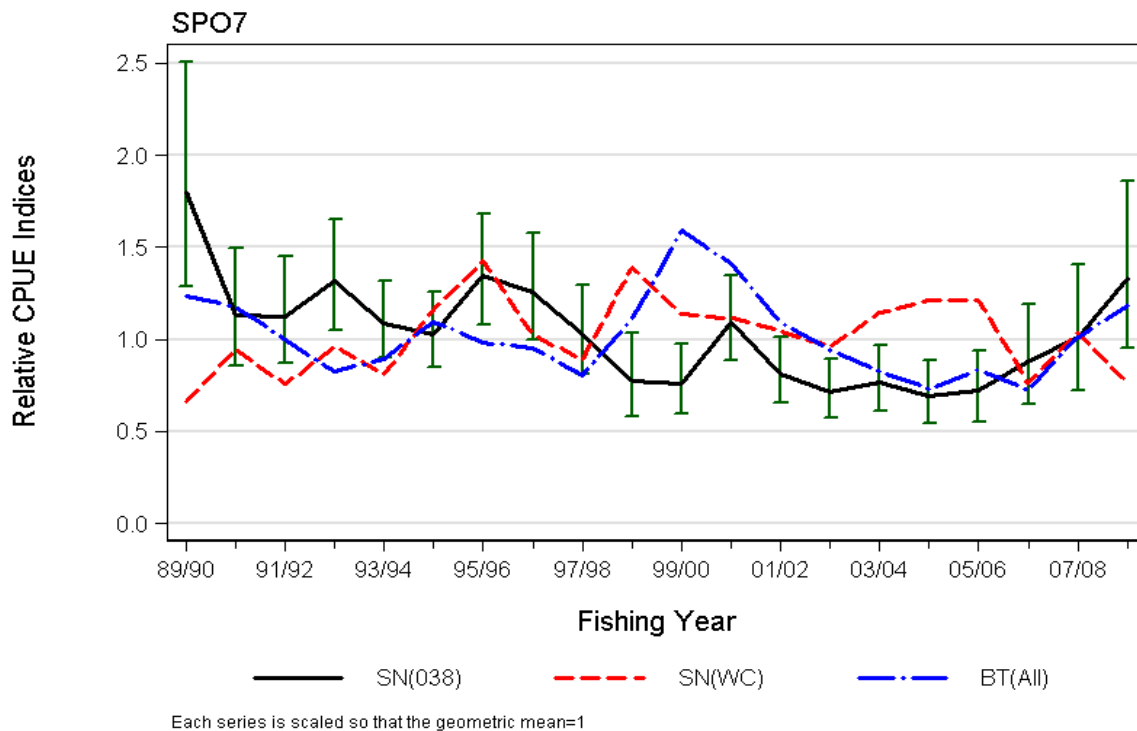
Figure 5: Comparison of three SPO 7 standardised CPUE series: i) setnet fishery (shark target and west coast South Island) [SN(WC)]; ii) setnet fishery (shark target and Tasman/Golden Bays) [SN(038)];iii) bottom trawl fishery (mix target and all SPO 7) [BT(All)].

Although large rig are not effectively targeted with bottom trawl gear, the WCSI trawl survey is believed to provide reliable indices of the relative biomass of males and younger females in SPO 7. Relative biomass indices declined by more than 50% between 1995 and 2005 but have since increased toward the long-term mean (Figure 5).
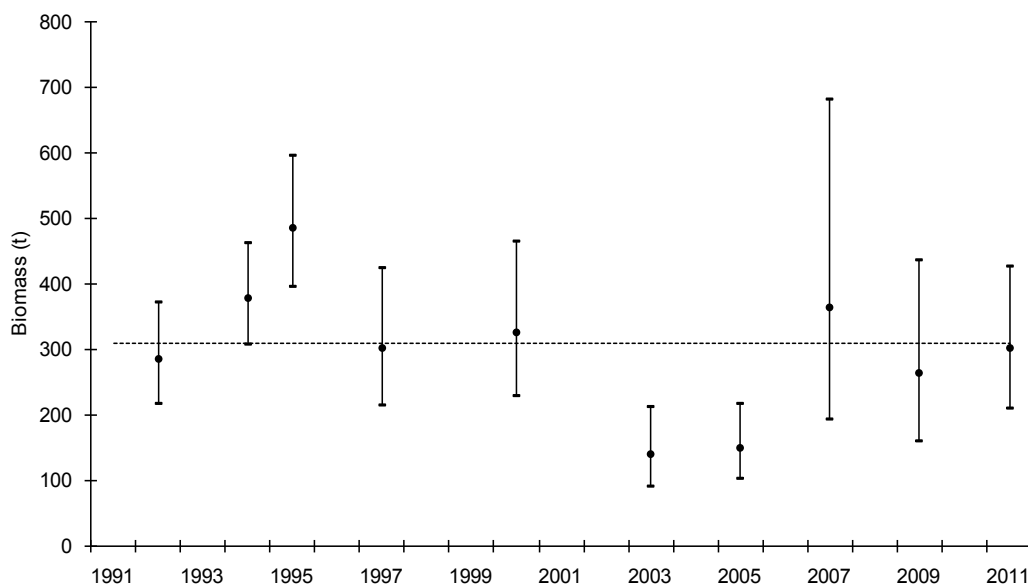
Figure 6: Plots of biomass estimates (t) for rig from the west coast South Island trawl survey by year. Error bars are approximated from the CVs assuming a lognormal distribution dashed line is the series mean.

SPO 7 Stock Assessment

A stock assessment for SPO 7 was presented to the AMP Working Group in 2006 (AMP-WG-06/24, AMP-WG-06/25). This assessment was an age-structured model fitted to setnet CPUE indices from two areas: Tasman/Golden Bays (Statistical Area 038) and the west coast South Island biomass indices from the WCSI survey (Figure 6), commercial length frequency data (setnet and trawl fisheries), length frequency data from the WCSI survey, and age-length data (for estimating the growth model). Historical catches were reconstructed back to 1965, which were assumed to be the beginning of the model, starting with an unfished biomass at equilibrium. The model had two sexes, with growth models for each sex estimated in the model and a plus group at age 23 to accommodate the largest females in the length frequency data. Sex-specific commercial and survey selectivities were estimated. Descending right-hand limbs were allowed in the commercial trawl and survey selectivity functions to account for an assumed reduction in catchability associated with large rig by trawl nets. Natural mortality (M) was fixed at 0.25 and steepness (h) at 0.5 (Francis & Francis 1992). This latter value was consistent with values used for low productivity shark species. Bayesian methods were used to estimate uncertainty.

The Working Group noted that this assessment was the first stock assessment completed within an AMP programme and was also the first chondrichthyan assessment completed in New Zealand. The Working Group accepted the methods, including data preparation steps and model structure and considered the results satisfactory.

The Working Group made the following conclusions based on this stock assessment:
- The SPO 7 stock was almost certainly below B_{MSY}. There was however some uncertainty as to where the stock was in relation to B_0. It was therefore not possible to produce reliable stock projections necessary to derive an assessment based TACC.
- Based on declining indices of abundance, current catches and the TACC (which has been substantially under caught for the last five years) were not sustainable.

The Working Group requested that the stock assessment should be repeated in 2008. The next assessment should include the following:
- sensitivity runs based on larger historical catches prior 1975 to account for probable dumping by trawlers;
- additional length-age data, particularly for large females; more rig would therefore need to be aged;
- new length composition data from the commercial catch (trawl and setnet);
- appropriate stock recruit relationships for sharks;
- 5-year stock projections;
- an understanding of the relationship of rig stocks between areas: what is the appropriate relationship of sub-areas within SPO 7 or with SPO 3 or SPO 8? The Working Group agreed that there was uncertainty in this issue and that information should be collected to address this problem.

4.2   Biomass estimates

Absolute estimates of current biomass are not available for any rig stocks. Relative biomass estimates are available for the West and East Coast South Island, however, the Working Group does not consider that these surveys monitor the full size range of these populations.

4.3   Estimation of Maximum Constant Yield (*MCY*)

No estimates of *MCY* are available for these stocks. This conclusion has not changed since the 2008 Plenary Report. Yield estimates are summarised in Table 6.

4.4   Estimation of Current Annual Yield (*CAY*)

CAY cannot be determined with available data.

Table 6: Yield estimates (t) of rig by stock.

Paramet	Fishstock	Estimates
MCY	SPO 1 (WCNI + NECNI)	630*
	SPO 2 (SECNI)	< 70
	SPO 3 (ECSI)	Cannot be determined
	SPO 7 (WCSI)	Cannot be determined
	SPO 8 (WCNI)	270*
	SPO 10	Cannot be determined
CAY	All	Cannot be determined

* *MCY* estimate for the WCNI stock was apportioned pro-rata between SPO 1 and SPO 8 Fishstocks on the basis of historical catches.

4.5   Other factors

Stock mixing occurs in the South Taranaki Bight to the Cook Strait and South Westland regions, and probably elsewhere. Some regional fisheries therefore exploit more than one stock. Also, biological stock boundaries do not always coincide with Fishstock boundaries. Consequently, management by quota within Fishstocks is likely to be sub optimal for individual stocks.

The use of small mesh commercials setnets (125 mm) in the Auckland FMA probably results in a large proportion of the rig catch being immature fish. Elsewhere, the minimum size is 150 mm.

There have been several changes to the rig conversion factors over the period that SPO has been managed within the QMS. The trend has been towards lower conversion factors. While researchers correct catches for these changes in undertaking CPUE analyses, this has not been done for total landings reported in this Working Group Report. These changes have the effect of reducing the effect of catches in recent years compared to early years, e.g. if actual catch had been constant it would appear to be declining. This has implication for historically set TACCs and any yield estimates (e.g. *MCY*).

5.   STATUS OF THE STOCKS

No estimates of current and reference biomass are available.

SPO 1

For SPO 1, reported landings have consistently declined since 1991–92.

As there is currently no accepted index of abundance for SPO 1, it is not known whether current catches or the TACC will cause the stock to decline.

SPO 2

Stock Structure Assumptions
Recent reviews in 2009 conclude that the existing QMAs are a suitable size for rig management, although the boundaries between biological stocks are poorly defined, especially in the Cook Strait region. For the purposes of this summary SPO2 is treated as a discrete stock.

Stock Status	
Year of Most Recent Assessment	2011
Assessment Runs Presented	
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%) to be below

Historical Stock Status Trajectory and Current Status

Comparison of two lognormal standardised CPUE series for SPO 2 based on all valid bottom trawl and setnet trips which landed to SPO 2 up to 2009–10

Fishery and Stock Trends

Recent Trend in Biomass or Proxy	The SPO 2 CPUE series constructed from bottom trawl data shows a gradually increasing trend from 1989–90 to 2002–03 after which the series remains reasonably stable through to 2009–10 with three consecutive high years from 2001–02 to 2003-04 (Figure 3). A series based on setnet data is reasonably similar to the bottom trawl series until the mid-2000s when the setnet series goes into a steep decline. The WG agreed that the setnet series was less credible than the bottom trawl series due to fewer available data, poor vessel overlap, and the fact that the set net fishery largely targets blue moki and blue warehou.
Recent Trend in Fishing Mortality or Proxy	It is Unknown whether overfishing is occurring.
Other Abundance Indices	
Trends in Other Relevant Indicators or Variables	

Projections and Prognosis

Stock Projections or Prognosis	Current catches are Unlikely (< 40%) to cause the stock to decline.
Probability of Current Catch or TACC causing decline below Limits	While current catches are Unlikely (< 40%) to cause the stock to decline below the hard limit, it is Unknown whether they will cause it to decline below the soft limit. Since current catches are above the TACC, it is Unlikely (< 40%) that the TACC will cause the stock to decline.

Assessment Methodology

Assessment Type	Level 2
Assessment Method	Fishery characterisation and CPUE analysis

Main data inputs	Setnet and bottom trawl catch and effort data.	
Period of Assessment	Latest assessment: 2011	Next assessment: 2013
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	Relationship between CPUE and abundance	

Qualifying Comments
The WG agreed that the setnet series was less credible than the bottom trawl series due to fewer available data, poor vessel overlap , and the fact that the set net fishery largely targets blue moki and blue warehou.

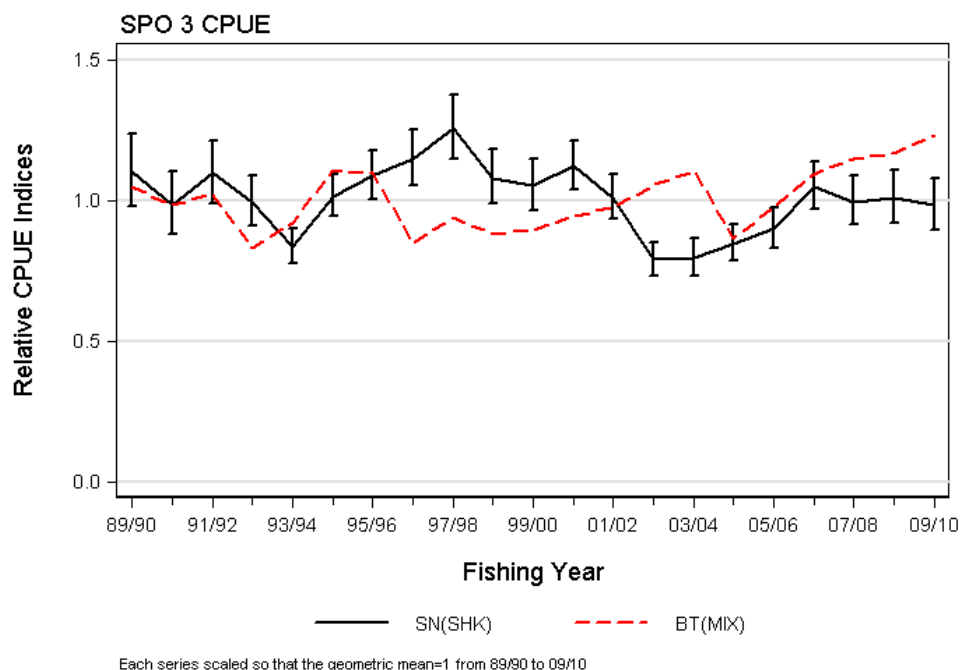| **Fishery Interactions** |
|---|
| Rig is largely a bycatch of both mixed trawl and set net fisheries (add main species later). |

SPO 3

Stock Structure Assumptions
Recent reviews in 2009 conclude that the existing QMAs are a suitable size for rig management, although the boundaries between biological stocks are poorly defined, especially in the Cook Strait region. For the purposes of this summary SPO3 is treated as a discrete stock.

Stock Status	
Year of Most Recent Assessment	2011
Assessment Runs Presented	
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%) to be below

Historical Stock Status Trajectory and Current Status

Comparison of the lognormal indices from the two CPUE series for SPO 3: a) SN[SHK]: target shark species setnet fishery; b) BT[MIX]: mixed target species bottom trawl fishery.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The two indices fluctuate about the long-term mean up to the mid-2000s (Figure 4). From 2003-03, the SN(SHK) series increases consistently from a low in 2002-03, and then stabilises about the long term mean, while the BT(MIX) series is trending upward.
Recent Trend in Fishing Mortality or Proxy	It is Unknown whether overfishing is occurring.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

| Projections and Prognosis	
Stock Projections or Prognosis	Current catches are Unlikely (< 40%) to cause the stock to decline.
Probability of Current Catch or TACC causing decline below Limits	While current catches are Unlikely (< 40%) to cause the stock to decline below the hard limit, it is Unknown whether they will cause it to decline below the soft limit. Since current catches are below the TACC, it is Unknown if the TACC will cause the stock to decline below Hard or Soft limits.
Assessment Methodology	
Assessment Type	Level 2
Assessment Method	Fishery characterisation and CPUE analysis
Main data inputs	Setnet and bottom trawl catch and effort data.
Period of Assessment	Latest assessment: 2011 Next assessment: 2013
Changes to Model Structure and Assumptions	-
Major Sources of Uncertainty	-
Qualifying Comments	
-	

Fishery Interactions
There is a 4 nm setnet closure that has been in place since October 2008 for the entire area. Rig are largely targeted but they are also caught as bycatch in target fisheries for school shark, flatfish, red cod, spiny dogfish and elephant fish in setnet, botton trawl and bottom longline fisheries.

SPO 7

Stock Structure Assumptions
Recent reviews in 2009 conclude that the existing QMAs are a suitable size for rig management, although the boundaries between biological stocks are poorly defined, especially in the Cook Strait region. For the purposes of this summary SPO7 is treated as a discrete stock.

Stock Status	
Year of Most Recent Assessment	2010
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	The SPO 7 stock was assessed in 2006 to be Very Unlikely (< 10%) to be at or above B_{MSY} but has since increased. The stock is Unlikely (< 40%) to be above the target.
Status in relation to Limits	Soft limit: About as Likely as Not (40-60%) to be below (< 40%) Hard limit: Unlikely (< 40%) to be below

Historical Stock Status Trajectory and Current Status
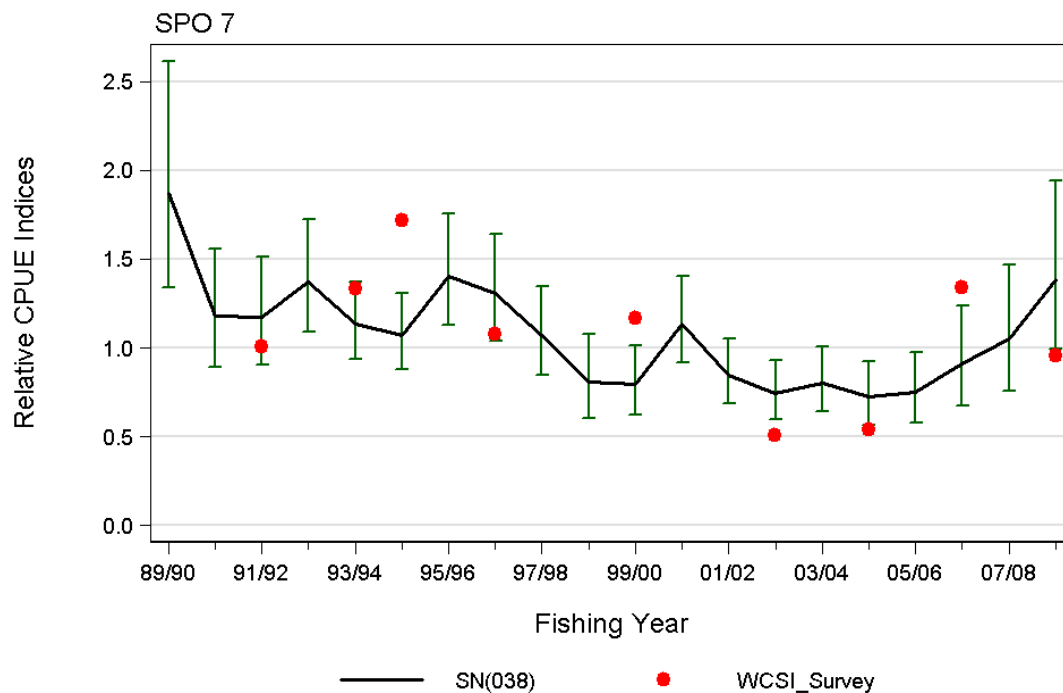
SPO 7

Comparison of SPO 7 CPUE index series with the west coast South Island Kaharoa trawl survey. The survey index has been assigned to the final calendar year of the fishing year pair.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Available indices suggest an increase in recent years from a low point in 2004-05, to levels possibly near the long-term average.
Recent Trend in Fishing Mortality or Proxy	Reduced landings and evidence of increased recruitment suggest reduced levels of fishing mortality in recent years.

Projections and Prognosis	
Stock Projections or Prognosis	The increasing trends in abundance and evidence of improved recruitment suggest that the stock is Likely (> 60%) to increase under current catch and TACC.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%)

Assessment Methodology	
Assessment Type	Level 1: 2006 Quantitative stock assessment Level 2: 2010 Standardised CPUE abundance index and West Coast South Island trawl survey index and length frequency analysis.
Assessment Method	2006: Bayesian statistical catch-at-age model 2010: Evaluation of agreed standardised CPUE indices, and length frequency analysis.

Main data inputs	2006: • West Coast South Island trawl survey index • Setnet CPUE from area 38 and the west coast • Length data from SN (38), SN(WC) and bottom trawl(WC) • Age/length data 2010: • Catch and effort data derived from the Ministry of Fisheries catch reporting. • Length frequency data summarised from logbooks compiled under the industry Adaptive Management Programme. • Abundance indices derived from the West Coast South Island trawl surveys.	
Period of Assessment	Latest assessment: 2010	Next assessment: 2013
Changes to Model Structure and Assumptions	In 2006: SPO 7 stock status was evaluated using an age-structured model fitted to setnet CPUE indices, biomass indices from the WCSI survey, length frequency data and age-length data. In 2010, updated CPUE standardisations were conducted, including on the two series used in the 2006 assessment, and using similar standardisation models to those used previously.	
Major Sources of Uncertainty		

Qualifying Comments
-

Fishery Interactions
SPO 7 are mainly caught in a targeted setnet fishery (61%), which also targets school shark and spiny dogfish. This fishery has historically been particularly focussed in statistical area 038 (Tasman and Golden Bays). The remaining catch is taken by a bottom trawl fishery targeting flatfish, barracouta, red cod and tarakihi.

SPO 8
Stock Structure Assumptions
Recent reviews in 2009 conclude that the existing QMAs are a suitable size for rig management, although the boundaries between biological stocks are poorly defined, especially in the Cook Strait region. For the purposes of this summary SPO8 is treated as a discrete stock.

Stock Status	
Year of Most Recent Assessment	2011
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft limit: Unknown Hard limit: Unlikely (< 40%) to be below

Historical Stock Status Trajectory and Current Status

Comparison of standardised CPUE for SPO8 in target setnet (bold line) and bycatch of bottom trawl (target SNA, GUR, TRE, TAR) in areas 037, 039, 040, and 041.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Setnet CPUE has fluctuated without trend and recent indices are near the longterm average.
Recent Trend in Fishing Mortality or Proxy	It is Unknown whether overfishing is occurring

Projections and Prognosis	
Stock Projections or Prognosis	Current catches are Unlikely (< 40%) to cause the stock to decline.
Probability of Current Catch or TACC causing decline below Limits	While current catches are Unlikely (< 40%) to cause the stock to decline below the hard limit, it is Unknown whether they will cause it to decline below the soft limit. Since current catches are below the TACC, it is Unknown if the TACC will cause the stock to decline below Hard or Soft limits.

Assessment Methodology	
Assessment Type	Level 2: Standardised CPUE abundance index.
Assessment Method	-

Main data inputs	Catch and effort data derived from the Ministry of Fisheries catch reporting.	
Period of Assessment	Latest assessment: 2011	Next assessment: 2013
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	-	

Qualifying Comments

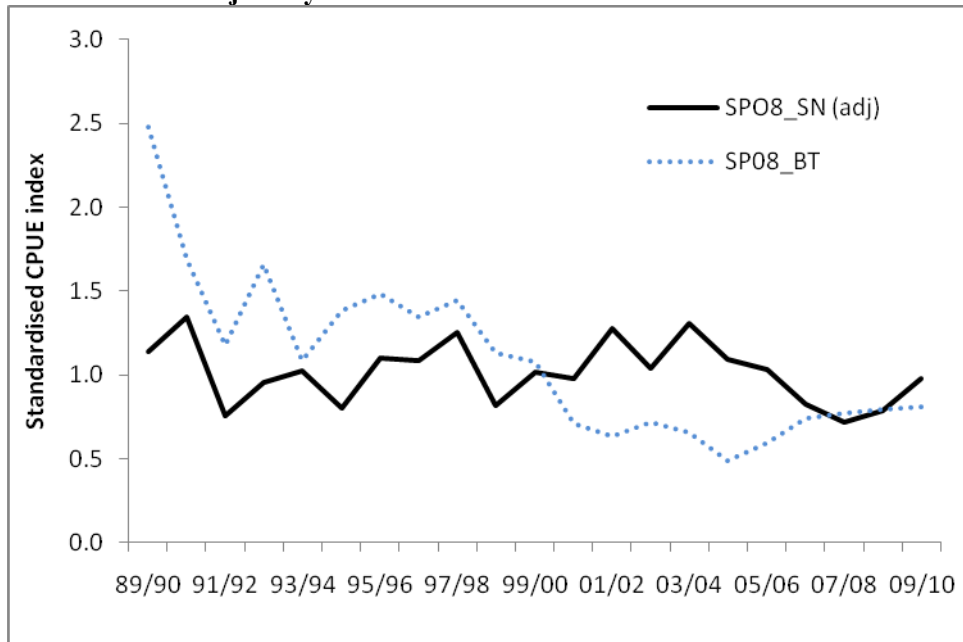| |
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Fishery Interactions

SPO 8 are mainly caught in a targeted setnet fishery which also targets school shark and spiny dogfish. The remaining catch is taken by a bottom trawl fishery targeting snapper, gurnard, trevally and tarakihi.

Yield estimates, TACCs and reported landings of rig are summarised in Table 7.

Table 7: Summary of yield estimates (t), TACCs (t) and reported landings (t) of rig for the most recent fishing year.

Fishstock		FMA	MCY	2010-11 Actual TACC	2010-11 Reported landings
SPO 1	Auckland (East) (West)	1 & 9	630	692	311
SPO 2	Central (East)	2	< 70	86	106
SPO 3	South-East (Coast) (Chatham), Southland and Sub-Antarctic	3, 4, 5 & 6	–	600	395
SPO 7	Challenger	7	–	221	229
SPO 8	Central (West)	8	270	310	220
SPO 10	Kermadec	10	–	10	0
Total				1 919	1 260

7.   FOR FURTHER INFORMATION

Bradford E. 1998. Harvest estimates from the 1996 national recreational fishing surveys. New Zealand Fisheries Assessment Research Document 1998/16: 27p.

Blackwell R.G., Manning M.J., Gilbert D.G., Baird S.J. 2006. Standardized CPUE analysis of the target rig (*Mustelus lenticulatus*) setnet fishery in northern New Zealand (SPO 1 and 8). New Zealand Fisheries Assessment Report 2006/32: 56p.

Blackwell R.G., Francis M.P. 2010. Review of life–history and fishery characteristics of New Zealand rig and school shark. *New Zealand fisheries assessment report No.* 2009/02. 38 p.

Bentley N. 2011. Characterisation of FMA 2 inshore fisheries including CPUE indices of abundance for key species.Unpublished Progress Report for MFish project INS2009-03 held by Ministry of Fisheries.

Boyd R.O., Reilly J.L. 2002. 1999/2000 national marine recreational fishing survey: harvest estimates. Draft New Zealand Fisheries Assessment Report. CFMC. 2001. (Challenger Finfish Management Company.) Performance of the SPO 7 Adaptive Management Programme dated 7 May 2001. Copies held by MFish.

Francis M.P. 1979. A biological basis for the management of New Zealand moki (*Latridopsis ciliaris*) and smoothhound (*Mustelus lenticulatus*) fisheries. (Unpublished MSc thesis, University of Canterbury).

Francis M.P. 1988a. Movement patterns of rig (*Mustelus lenticulatus*) tagged in southern New Zealand. New Zealand Journal of Marine and Freshwater Research 22: 259–272.

Francis M.P. 1988b. Rig. New Zealand Fisheries Assessment Research Document 1988/24: 19p.

Francis M.P., Francis R.I.C.C. 1992a. Growth, mortality and yield estimates for rig (Mustelus lenticulatus). New Zealand Fisheries Assessment Research Document 1992/5: 32p.

Francis M.P., Francis R.I.C.C. 1992b. Growth rate estimates for New Zealand rig (*Mustelus lenticulatus*). Australian Journal of Marine and Freshwater Research 43: 1157–1176.

Francis M.P., Ó Maolagáin C. 2000. Age, growth and maturity of a New Zealand endemic shark (*Mustelus lenticulatus*) estimated from vertebral bands. Marine and Freshwater Research 51 (1): 35–42.

Francis M.P., Mace J.T. 1980. Reproductive biology of *Mustelus lenticulatus* from Kaikoura and Nelson. New Zealand Journal of Marine and Freshwater Research 14: 303–311.

Francis M.P., Smith D.W. 1988. The New Zealand rig fishery: Catch statistics and composition, 1974–85. New Zealand Fisheries Technical Report No 7: 30p.

Francis M.P. 2010. Movement of tagged rig and school shark among QMAs, and implications for stock management boundaries. *New Zealand fisheries assessment report No.* 2009/xx. 22 p.

Kendrick T.H., Bentley, N. 2011. Fishery characterisation and setnet catch-per-unit-effort indices for rig in SPO1 and SPO 8, 1989–90 to 2009–10. Project Progress Report for MFish project SPO2010-01. Unpublished report held by the Ministry of Fisheries.

Lydon G.J., Middleton D.A.J., Starr P.J. 2006. Performance of the SPO 3 Logbook Programme. AMP-WG-06/23. (Unpublished manuscript available from the New Zealand Seafood Industry Council, Wellington).

Massey B.R., Francis M.P. 1989. Commercial catch composition and reproductive biology of rig (Mustelus lenticulatus) from Pegasus Bay, Canterbury, New Zealand. New Zealand Journal of Marine and Freshwater Research 23: 113–20.

Paul L.J. 2003. Characterisation of the commercial and recreational fisheries for rig (*Mustelus lenticulatus*) in northern New Zealand (SPO 1 and SPO 8), and unstandardised CPUE analyses of the targeted setnet fisheries. New Zealand Fisheries Assessment Report 2003/22: 69p.

Seafood Industry Council (SeaFIC) 2001. Performance of the SPO 7 Adaptive Management Programme dated 7 May 2000. Copies held by the Ministry of Fisheries.

Seafood Industry Council (SeaFIC) 2002a. Report to the Inshore Fishery Assessment Working Group. Performance of the SPO 3 Adaptive Management Programme (dated 18 March 2002). Copies held by the Ministry of Fisheries.

Seafood Industry Council (SeaFIC) 2002b. Report to the Inshore Fishery Assessment Working Group. Performance of the SPO 7 Adaptive Management Programme (dated 19 March 2002). Copies held by Ministry of Fisheries.

Seafood Industry Council (SeaFIC) 2003a. Report to the Adaptive Management Fishery Assessment Working Group: Performance of the SPO 3 Adaptive Management Programme. AMP-WG-2003/03 42 p. Copies held by the Ministry of Fisheries.

Seafood Industry Council (SeaFIC) 2003b. 2003 performance report SPO 7 Adaptive Management Programme. AMP-WG-2003/08 4 p. Copies held by the Ministry of Fisheries.

Seafood Industry Council (SeaFIC) 2004a. Report to the Adaptive Management Fishery Assessment Working Group: Performance of the SPO 7 Adaptive Management Programme. AMP-WG-2004/04 54 p. Copies held by the Ministry of Fisheries.

Seafood Industry Council (SeaFIC) 2004b. 2003 performance report SPO 3 Adaptive Management Programme. AMP-WG-2004/16 6 p. Copies held by the Ministry of Fisheries.

Seafood Industry Council (SeaFIC) 2005a. 2005 Report to the Adaptive Management Programme Fishery Assessment Working Group: Review of the SPO 3 Adaptive Management Programme. AMP-WG-2005/15. Copies held by the Ministry of Fisheries.

Seafood Industry Council (SeaFIC) 2005b. 2005 Performance Report to the Adaptive Management Programme Fishery Assessment Working Group: SPO 7 Adaptive Management Programme. AMP-WG-2005/10 . Copies held by the Ministry of Fisheries.

RIG (SPO)

Seafood Industry Council (SeaFIC) 2005c. SPO3: Additional Analysis. AMP-WG-05/25. Copies held by the Ministry of Fisheries.

Smith P.J. 2009. Review of genetic studies of rig and school shark. *Final research report for Ministry of Fisheries research project No. INS200803*. 16 p.

Starr P.J., Kendrick T.H., Lydon G.J. 2006a. Full Term Review of the SPO 7 Adaptive Management Programme. 90p. (Unpublished manuscript available from the New Zealand Seafood Industry Council, Wellington).

Starr P.J., Hicks A. 2006b. SPO 7 Stock Assessment. 57 p. (Unpublished manuscript available from the New Zealand Seafood Industry Council, Wellington).

Starr P.J., Kendrick T.H., Lydon G.J., Bentley N. 2007. Report to the Adaptive Management Programme Fishery Assessment Working Group: Review of the SPO 3 Adaptive Management Programme. AMP-WG-2007/06. 87pp.

Starr P.J., Kendrick T.H., Bentley N. 2010. Report to the Adaptive Management Programme Fishery Assessment Working Group: Characterisation, CPUE analysis and logbook data for SPO 7. Document 2010/10-v2, 93 p. (Unpublished document held by the Ministry of Fisheries, Wellington, N.Z.) (http://cs.fish.govt.nz/forums/thread/3877.aspx).

Teirney L.D., Kilner A.R., Millar R.E., Bradford E., Bell J.D. 1997. Estimation of recreational catch from 1991/92 to 1993/94 New Zealand Fisheries Assessment Research Document 1997/15: 43p.

Vignaux M. 1997. CPUE analyses for stocks in the adaptive management programme. New Zealand Fisheries Assessment Research Document 1997/24: 68p.

RUBYFISH (RBY)

(*Plagiogeneion rubiginosum*)
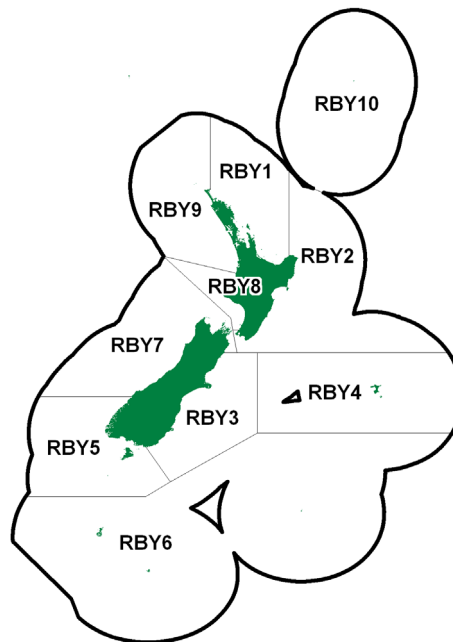
1. FISHERY SUMMARY

1.1 Commercial fisheries

Rubyfish catches were first reported in 1982-83. In 1990-91, 245 t were landed, mainly as bycatch in the trawl fisheries for alfonsino, gemfish, barracouta, hoki, and jack mackerel. In the following year landings doubled, and from 1992-93 to 1994-95 landings were about 600 t. In 1995-96, landings peaked at 735 t and in subsequent years catches fluctuated between 200 t and 500 t (Tables 1 & 2). The level of direct targeting on rubyfish has increased over the history of the fishery. At least one third of recent annual catches were taken by targeted mid-water trawling with gear usually fished close to the bottom.

The main rubyfish grounds (target species and alfonsino bycatch) are the banks or "hills" off the east coast of the North Island in QMA 2. Rubyfish is also targeted in the Bay of Plenty. The areas where rubyfish is predominantly taken as bycatch (with the target fisheries) are: Westland (hoki and barracouta); north-western South Island (jack mackerel); North Taranaki Bight (jack mackerel). Rubyfish have also been reported as an intermittent bycatch with bluenose, black cardinalfish, orange roughy, silver warehou, tarakihi, trevally and scampi. Commercial concentrations of rubyfish probably also exist in areas that have not been fished in appropriate depths, especially in the northern half of New Zealand. Since 1990-91, on average about 70% of total landings are from QMA 2, and 20% are from QMA 1.

Rubyfish was introduced into the QMS on 1 October 1998. Allowances were not made for non commercial catch. The historical landings and TACC values for the two main RCO stocks are shown in Figure 1.

In the 2002-03 fishing year, the TACC for RBY 1 was increased under the adaptive management programme (AMP) to 300 t. At the same time a customary allowance of 1 t, a recreational allowance of 2 t and an allowance of 15 t for fishing-related mortality took the TAC to 318 t. All AMP programmes ended on 30th September 2009.

In these stocks landings were above the TACC for a number of years and the TACCs have been increased to the average of the previous 7 years plus an additional 10%. From the 1st October 2006 the TACCs for RBY 4, 7 and 8 were increased to 6, 33 and 5 t respectively. Landings continued to exceed the TACC after 2006, resulting in a TACC increase to 18 t for RBY 4 from the first of October 2010. An allowance of 1 t was allocated to RBY 4 at the same time, bringing the TAC to 19 t.

RUBYFISH (RBY)

Table 1: Reported landings (t) of rubyfish by QMA and fishing year, 1983-84 to 1997-98. The data in this table has been updated from that published in previous Plenary Reports by using the data through 1996-97 in table 35 on p. 270 of the "Review of Sustainability Measures and Other Management Controls for the 1999-00 Fishing Year - Final Advice Paper" dated 6 August 1998.

	QMA 1	QMA 2	QMA 3	QMA 4	QMA 5	QMA 6	QMA 7	QMA 8	QMA 9	QMA 10	Other	Total
1990-91	66	159	5	3	0	0	9	0	3	0		245
1991-92	147	390	0	0	0	0	20	1	6	0		564
1992-93	90	491	0	0	0	0	31	0	0	0		612
1993-94	116	379	3	0	0	0	72	0	5	0		575
1994-95	43	500	3	12	0	0	13	0	10	0		581
1995-96	106	595	2	0	0	0	9	0	23	0		735
1996-97	128	297	2	1	< 1	0	14	< 1	21	< 1	1	463
1997-98	50	308	< 1	1	0	0	6	< 1	13	< 1	< 1	380

† QMS data.

Table 2: Reported landings (t) of rubyfish by Fishstock and TACCs from 1998-99 to 2010-11.

Fishstock FMA	RBY 1 1		RBY 2 2		RBY 3 3		RBY 4 4		RBY 5 5	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1998-99	55	104	180	433	< 1	2	< 1	2	0	0
1999-00	138	104	321	433	6	2	< 1	2	0	0
2000-01	39	109	433	433	< 1	3	2	3	0	0
2001-02	36	109	414	433	1	3	8	3	1	0
2002-03	21	300	233	433	< 1	3	11	3	1	0
2003-04	19	300	343	433	< 1	3	2	3	< 1	0
2004-05	109	300	217	433	< 1	3	10	3	1	0
2005-06	135	300	303	433	< 1	3	33	3	0	0
2006-07	293	300	198	433	4	3	37	6	0	0
2007-08	120	300	427	433	< 1	3	11	6	< 1	0
2008-09	192	300	467	433	< 1	3	19	6	0	0
2009-10	351	300	309	433	2	3	11	6	< 1	0
2010-11	297	300	435	433	< 1	3	9	18	< 1	0

Fishstock FMA	RBY 6 6		RBY 7 7		RBY 8 8		RBY 9 9		RBY 10 10	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1998-99	0	0	4	27	< 1	0	7	9	< 1	0
1999-00	0	0	13	27	< 1	0	15	9	0	0
2000-01	< 1	0	7	27	0	1	16	19	0	0
2001-02	0	0	35	27	< 1	1	3	19	0	0
2002-03	< 1	0	32	27	2	1	2	19	0	0
2003-04	< 1	0	9	27	8	1	1	19	0	0
2004-05	< 1	0	99	27	< 1	1	3	19	0	0
2005-06	< 1	0	8	27	8	1	20	19	0	0
2006-07	0	0	13	33	< 1	55	1	19	0	0
2007-08	< 1	0	4	33	1	6	1	19	0	0
2008-09	< 1	0	14	33	< 1	6	2	19	0	0
2009-10	0	0	4	33	< 1	6	< 1	19	0	0
2010-11	0	0	5	33	< 1	6	< 1	19	0	0

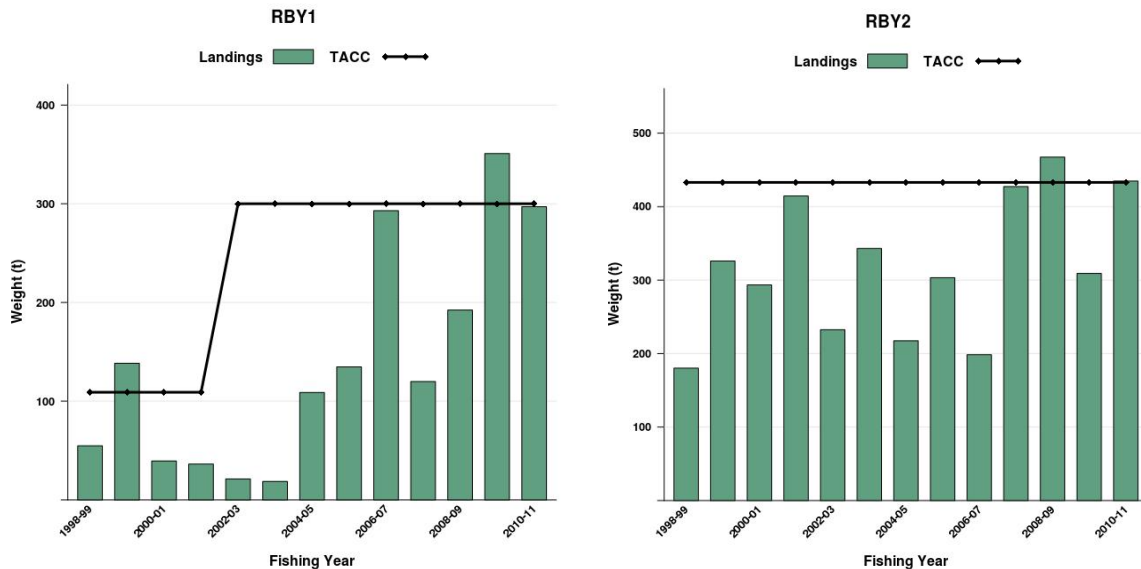|	Total	
	Landings	TACC
1998-99	247	577
1999-00	493	577
2000-01	358	595
2001-02	498	595
2002-03	302	595
2003-04	382	595
2004-05	439	595
2005-06	507	786
2006-07	546	849
2007-08	564	800
2008-09	694	800
2009-10	677	800
2010-11	747	812

Figure 1: Historical landings and TACC for the two main RBY stocks. Left to right: RBY1 (Auckland East) and RBY2 (Central East). Note that these figures do not show data prior to entry into the QMS.

1.2   Recreational fisheries
There is no reported recreational catch.

1.3   Customary non-commercial fisheries
There is no quantitative information on the current level of customary non-commercial take.

1.4   Illegal catch
There is no quantitative information on the level of illegal catch.

1.5   Other sources of mortality
There is no quantitative information on the level of other sources of mortality.

2.   BIOLOGY

Rubyfish are recorded from southern Australia, South Africa and from banks in the southern Indian and south-east Atlantic oceans. They occur in the subtropical water around northern and central New Zealand, but are absent from the southern Chatham Rise and Campbell Plateau. Rubyfish occur at depths ranging from 50 to at least 800 m. Commercial catch data suggests the species is most abundant between 200 and 400 m.

Rubyfish have been recorded up to 58 cm in length. Small catches by research trawling have all been of similar-sized fish, suggesting schooling by size. Ageing research based on simple counts of otolith structures appeared to indicate that rubyfish are a slow-growing and long-lived species (Paul *et al*. 2000). Paul *et al*. (2003) used radiocarbon dating techniques on otoliths from 10 rubyfish to determine whether the sudden 1960s increase in atmospheric/oceanic radiocarbon (^{14}C) levels, resulting from nuclear testing, could be detected in these otoliths. Based on the low levels of radioactive ^{14}C measured in the core of these otoliths, they concluded that the oldest fish in this sample were born prior to the beginning of the period of atmospheric testing and therefore were at least 45 years old (calculated from the date of otolith collection).

There is no information on rubyfish spawning cycles or areas. Observations on gut contents show that rubyfish feed on mid-water crustaceans, salps and myctophid fishes.

Table 3: Estimates of biological parameters for rubyfish.

Fishstock	Estimate			Source
1. Natural mortality (*M*)				
All	$M = 0.03 - 0.1$*			Paul *et al.* (2000, 2003)
2. Weight = a (length)^b (Weight in g, length in cm fork length)				
	Both sexes			
	a	b		
RBY 2	0.0255	2.9282		NIWA (unpub. Data)
3. von Bertalanffy growth parameters				
	Both sexes			
	L_∞	K	t_0	
QMA 2	48.68	0.045	-16.53	Paul *et al.* (2002)

*revised range from 2002; see text.

3. STOCKS AND AREAS

It is not known whether different regional stocks of rubyfish occur in New Zealand waters.

Although landings are reported by Fishstocks which equal the standard QMAs, for stock assessment purposes it may be more appropriate to consider Fishstocks RBY 1 and RBY 9 as one (northern) unit, Fishstock RBY 2 (the main fishery) as an eastern unit, Fishstocks RBY 3−5 as a minor southern unit, and Fishstocks RBY 7 and RBY 8 as a western unit.

4. STOCK ASSESSMENT

4.1 Estimates of fishery parameters and abundance
A biomass index derived from a standardised CPUE (log linear, kg/day) analysis of the target trawl fishery represented by 10 main vessels (Blackwell 2000) was calculated for RBY 2. However, the results were highly uncertain, mainly due to the limited amount of data available, and were not accepted by the Inshore Working Group.

4.2 Biomass estimates
No information is available.

4.3 Estimation of Maximum Constant Yield (*MCY*)
MCY cannot be determined.

4.4 Estimation of Current Annual Yield (*CAY*)
CAY cannot be determined.

4.5 Other yield estimates and stock assessment results
No information is available.

4.6 Other factors
A substantial catch of rubyfish has been taken in conjunction with alfonsino by the trawl fishery off the North Island east coast. Future quotas and catch restraints imposed on rubyfish could, in turn, constrain the alfonsino fishery. Rubyfish is taken in smaller, irregular quantities in other target trawl fisheries and these fisheries could also be affected by future rubyfish management policy.

Catch sampling has occurred in RBY 2 for four years 1998-99 to 2000-01, and 2006-07 and 2007-08 though data for the recent years are of little value. It is likely that the age composition of RBY vary across features and exact location of the samples is not known so it is unclear if the samples have come from the areas that have been consistently fished over time. The earlier catch sampling data show that the fishery is comprised of a large number of age classes with a reasonable proportion of the catch coming from fish of greater than 50 years old (Horn & Sutton 2009).

5. ANALYSIS OF ADAPTIVE MANAGEMENT PROGRAMMES (AMP)

The Ministry of Fisheries revised the AMP framework in December 2000. The AMP framework is intended to apply to all proposals for a TAC or TACC increase, with the exception of fisheries for which there is a robust stock assessment. In March 2002, the first meeting of the new Adaptive Management Programme Working Group was held. Two changes to the AMP were adopted:
- a new checklist was implemented with more attention being made to the environmental impacts of any new proposal
- the annual review process was replaced with an annual review of the monitoring requirements only. Full analysis of information is required a minimum of twice during the 5 year AMP.

RBY 1
The TACC for RBY 1 was increased from 109 t to 300 t under the Adaptive Management Programme (AMP) in October 2002.

Full-term Review of RBY 1 AMP in 2007
In 2007 the AMP FAWG reviewed the performance of the AMP (Starr *et al*. 2007). The WG noted:

Fishery characterisation
- Fish are landed as green weight, so there are no conversion factor issues.
- Historical landings have been primarily taken as a bycatch of the bottom trawl fishery targeted at gemfish in the Bay of Plenty. These landings have nearly disappeared as a result of the decline in that fishery.
- The main target fishery has been a mid-water trawl fishery associated with features in the Bay of Plenty which has operated in 2004-05 and 2005-06.
- It was noted that there may be some merit in considering management options like feature limits in this fishery.

CPUE analysis
- There are insufficient data to use for a standardised analysis so four unstandardised analyses were presented, three from bycatch trawl fisheries for gemfish, tarakihi and hoki and one from a bycatch bottom longline fishery directed at hapuku and bluenose. No series was constructed from the target rubyfish fishery as there were sufficient data in only three years. The CPUE trends in the four bycatch fisheries showed variable trends which appeared to reflect effort trends in the respective fisheries rather than RBY biomass trends.

Logbook programme
- There are no logbook data in the database, except 1 trip and 4 tows. There is a problem in obtaining samples as it is difficult to sample the fish, as they are directly dumped into sea water tanks on the ship.
- Recommend a shed sampling programme, or a similar approach to obtain biological data, but the programme will endeavour to collect data that will allow the fish to be linked to a tow.

Environmental effects
- Catch has never exceeded the TACC over the term of the AMP. The target gemfish fishery, the primary bycatch fishery for this species, has diminished considerably in recent years.
- No code of practice in RBY fishery.

Conclusion
- If the AMP continues, there is a need to improve the collection of information. There is a need for more biological data, such as otoliths and lengths from every large landing of this species.
- There is also a need for improved fine-scale catch and effort information for smaller areas.
- The Working Group indicated that a catch curve analysis approach is likely to be the most effective way to monitor this Fishstock.

6.   STATUS OF THE STOCKS

RBY 1
In 2002, RBY 1 was included in the AMP on the basis that the stock had been lightly fished and it seemed likely that the stock was above B_{MSY}.

RBY 2
Catch sampling between 1998-99 and 2000-01 indicated that the fishery is comprised of a large number of age classes with a reasonable proportion of the catch coming from fish of greater than 50 years old. Although relatively high catches were made prior to this period there is no obvious truncation of the age distribution that would occur under high and unsustainable levels of fishing mortality.

Most of the current RBY catch comes from QMA 2. It is not known whether the level of recent commercial catches in this QMA is sustainable. The status of RBY 2 relative to B_{MSY} is unknown.

Other areas
For most other areas it is not known if recent catches are sustainable. Commercial concentrations of rubyfish probably also exist in areas that have not been fished. The status of other RBY stocks relative to B_{MSY} is unknown.

TACCs and reported landings are summarised in Table 4.

Table 4: Summary of TACCs (t) and reported landings (t) of rubyfish for the most recent fishing year.

Fishstock		FMA	2010-11 Actual TACC	2010-11 Reported Landings
RBY 1	Auckland (East)	1	300	297
RBY 2	Central (East)	2	433	435
RBY 3	South-east (Coast)	3	3	0.152
RBY 4	South-east (Chatham)	4	18	9
RBY 5	Southland	5	0	0.921
RBY 6	Sub-Antarctic	6	0	0
RBY 7	Challenger	7	33	5
RBY 8	Central (West)	8	6	0.502
RBY 9	Auckland (West)	9	19	0.297
RBY 10	Kermadec	10	0	0
Total			812	747

7.   FOR FURTHER INFORMATION

Blackwell R. 2000. Rubyfish (*Plagiogeneion rubiginosum*) abundance indices from standardised catch per unit effort (CPUE) analysis for the east coast North Island target trawl fishery 1988-89 to 1997-98. New Zealand Fisheries Assessment Report 2000/54. 24 p.

Heemstra P.C., Randall J.E. 1977. A revision of the Emmelichthyidae (Pisces: Perciformes). Australian Journal of Marine and Freshwater Research 28(3): 361-396.

Hoenig J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fisheries Bulletin 82: 898–903.

Horn, P.L., Sutton C.P. 2009. Commercial catch sampling for length and age of gemfish, alfonsino and rubyfish in QMA 2 in the 2006-07 and 2007-08 fishing years.). New Zealand Fisheries Assessment Report. 2009/19. 38 p.

Mel'nikov Yu. S., Ivanin H.A. 1995. Age-size composition and mortality of *Plagiogeneion rubiginosum* (Emmelichthyidae) in West Indian Submarine Ridge. Journal of Ichthyology 35(6): 20-27.

Parin N.V. 1991. Three new species of the bentho-pelagic fish genus *Plagiogeneion* from the southern Pacific and Indian oceans (Teleostei: Emmelichthyidae). Proceedings of the Biological Society of Washington 104(3): 459-467.

Paul L.J. 1997. A summary of biology and commercial landings, and a stock assessment of rubyfish, *Plagiogeneion rubiginosum* (Hutton, 1875) (Percoidei: Emmelichthyidae). N.Z. Fisheries Research Assessment Document 1997/27. 22p.

Paul L.J., Horn P.L., Francis M.P. 2000. Development of an ageing methodology, and first estimates of growth parameters and natural mortality for rubyfish (*Plagiogeneion rubiginosum*) off the east coast of the North Island (QMA 2). New Zealand Fisheries Assessment Report. 2000/22. 28 p.

Paul L.J., Sparks R., Neil H.L., Horn P.L. 2003. Maximum ages for bluenose (*Hyperoglyphe antarctica*) and rubyfish (*Plagiogeneion rubiginosum*) determined by the bomb chronometer method of radiocarbon ageing, and comments on the inferred life history of these species). Final Research Report to the Ministry of Fisheries for Project INS2000-02. 70 p.

SeaFIC 2005. Report to the Adaptive Management Programme Fishery Assessment Working Group: Performance of the RBY1 Adaptive Management Programme. AMP-WG-2005/04.

Starr P.J. 2006. Performance of the RBY 1 Adaptive Management Programme. AMP-WG-2006/12. (Unpublished manuscript available from the Seafood Industry Council, Wellington.)

Starr P.J., Kendrick T.H., Lydon G.J. 2005 Report to the Adaptive Management Programme Fishery Assessment Working Group: Full term review of the RBY 1 Adaptive Management Programme. AMP-WG-2007/33. (Unpublished manuscript available from the Seafood Industry Council, Wellington.)

SCAMPI (SCI)

(*Metanephrops challengeri*)
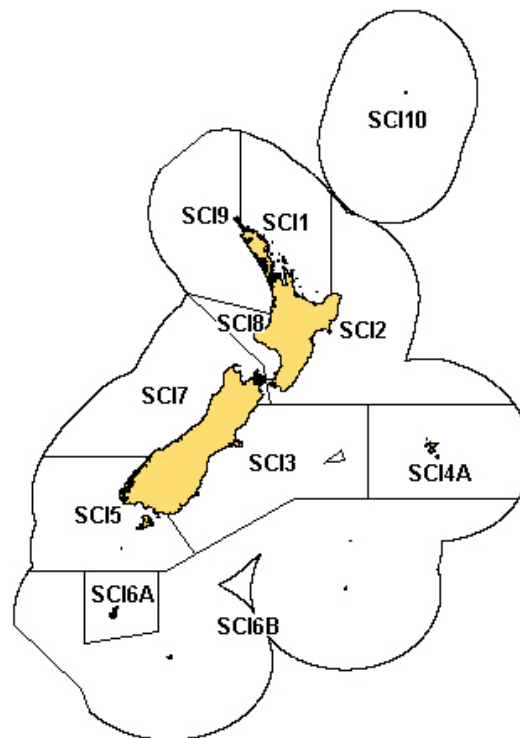
1.   FISHERY SUMMARY

Scampi were introduced to the QMS on 1 October 2004. At this time management protocols for scampi and man0agement areas on the Chatham Rise (SCIs 3 and 4) and in the SubAntarctic (SCIs 6A and 6B) were substantially modified. TACs and TACCs by Fishstock are shown in Table 1.

Table 1: Total allowable catches (TAC, t) allowances for customary fishing, recreational fishing, and other sources of mortality (t) and Total Allowable Commercial Catches (TACC, t) declared for scampi on introduction to the QMS in October 2004. These limits are still in force. * Details of components of 'Other' allowances provided in section 1.5.

Stock	TAC	Customary	Recreational	Other*	TACC
SCI 1	126	0	0	6	120
SCI 2	210	0	0	10	200
SCI 3	357	0	0	17	340
SCI 4A	126	0	0	6	120
SCI 5	42	0	0	2	40
SCI 6A	321	0	0	15	306
SCI 6B	53	0	0	3	50
SCI 7	79	0	0	4	75
SCI 8	5	0	0	0	5
SCI 9	37	0	0	2	35
SCI 10	0	0	0	0	0

(Note: the header "Allowances" spans the Customary, Recreational, and Other* columns.)

1.1   Commercial fisheries

Target trawl fisheries for scampi developed first in the late 1980's. Access was restricted and, until the 1999–00 fishing year, there were restrictions on the vessels that could be used in each stock. Between October 1991 and September 2002, catches were restrained using a mixture of competitive and individually allocated catch limits but between October 2001 and September 2004, all scampi fisheries were managed using competitive catch limits (Table 2).

The fishery is conducted mainly by 20–40 m vessels using light bottom trawl gear. All vessels use multiple rigs of two or three nets of very low headline height. The main fisheries are in waters 300–500 m deep in SCI 1 (Bay of Plenty), SCI 2 (Hawke Bay, Wairarapa Coast), SCI 3 (Mernoo Bank) SCI 4A (western Chatham Rise and Chatham Islands) and SCI 6 (Sub-Antarctic). Some fishing has been reported on the Challenger Plateau outside the EEZ.

Table 2. Estimated commercial landings (t) from the 1986–87 to 2010-11 fishing years (based on management areas in force since introduction to the QMS in October 2004) and catch limits (t) by Fishstock (from CLR and TCEPR, MFish landings and catch effort databases, early years may be incomplete). No limits before 1991–92 fishing year, (†) catch limits allocated individually until the end of 2000–01. *Note that management areas SCI 3, 4A, 6A and 6B changed in October 2004, and the catch limits applied to the old areas are not relevant to the landings, which have been reallocated to the revised areas on a pro-rata basis in relation to the TECPR data, which has previously been found to match landings well.

	SCI 1		SCI 2		SCI 3		SCI 4A		SCI 5	
	Landings	Limit (†) / TACC	Landings	Limit (†) / TACC	Landings	Limit / TACC	Landings	Limit (†) / TACC	Landings	Limit / TACC
1986–87	5	–	0	–	0	–	0	–	–	–
1987–88	15	–	5	–	0	–	0	–	0	–
1988–89	60	–	17	–	0	–	0	–	0	–
1989–90	104	–	138	–	0	–	0	–	0	–
1990–91	179	–	295	–	0	–	32	–	0	–
1991–92	132	120	221	246	153	–	78	–	0	60
1992–93	114	120	210	246	296	–	11	–	2	60
1993–94	115	120	244	246	324	–	0	–	1	60
1994–95	114	120	226	246	292	–	0	–	0	60
1995–96	117	120	230	246	306	–	0	–	0	60
1996–97	117	120	213	246	304	–	0	–	2	60
1997–98	107	120	224	246	296	–	0	–	0	60
1998–99	110	120	233	246	292	–	28	–	30	60
1999–00	124	120	193	246	322	–	23	–	9	40
2000–01	120	120	146	246	333	–	0	–	7	40
2001–02	124	120	247	246	304	–	30	–	< 1	40
2002–03	121	120	134	246	264	–	79	–	7	40
2003–04	120	120	64	246	277	–	41	–	5	40
2004–05	114	120	71	200	335	340	101	120	1	40
2005–06	109	120	77	200	319	340	79	120	< 1	40
2006–07	110	120	80	200	307	340	39	120	< 1	40
2007–08	102	120	61	200	209	340	8	120	< 1	40
2008–09	86	120	52	200	190	340	1	120	< 1	40
2009–10	111	120	125	200	302	340	< 1	120	< 1	40
2010-11	114	120	128	100	256	340	43	120	< 1	40

	SCI 6A		SCI 6B		SCI 7		SCI 8		SCI 9	
	Landings	Limit (†) / TACC	Landings	Limit / TACC	Landings	Limit / TACC	Landings	Limit / TACC	Landings	Limit / TACC
1986–87	0	–	0	–	0	–	0	–	0	–
1987–88	0	–	0	–	0	–	0	–	0	–
1988–89	0	–	0	–	0	–	0	–	0	–
1989–90	0	–	0	–	0	–	0	–	0	–
1990–91	2	–	0	–	0	–	0	–	0	–
1991–92	325	–	0	–	0	75	0	60	0	60
1992–93	279	–	0	–	2	75	0	60	2	60
1993–94	303	–	0	–	0	75	0	60	1	60
1994–95	239	–	0	–	2	75	0	60	0	60
1995–96	270	–	0	–	1	75	0	60	0	60
1996–97	275	–	0	–	0	75	0	60	0	60
1997–98	279	–	0	–	0	75	0	60	0	60
1998–99	325	–	< 1	–	1	75	0	60	< 1	60
1999–00	328	–	0	–	1	75	0	5	0	35
2000–01	264	–	0	–	< 1	75	0	5	0	35
2001–02	272	–	0	–	< 1	75	0	5	0	35
2002–03	255	–	0	–	< 1	75	0	5	0	35
2003–04	311	–	0	–	1	75	0	5	0	35
2004–05	295	306	0	50	1	75	0	5	0	35
2005–06	286	306	0	50	1	75	0	5	0	35
2006–07	302	306	0	50	< 1	75	0	5	0	35
2007–08	287	306	0	50	1	75	0	5	0	35
2008–09	264	306	< 1	50	1	75	0	5	0	35
2009–10	144	306	0	50	2	75	0	5	0	35
2010–11	198	306	< 1	50	4	75	0	5	0	35
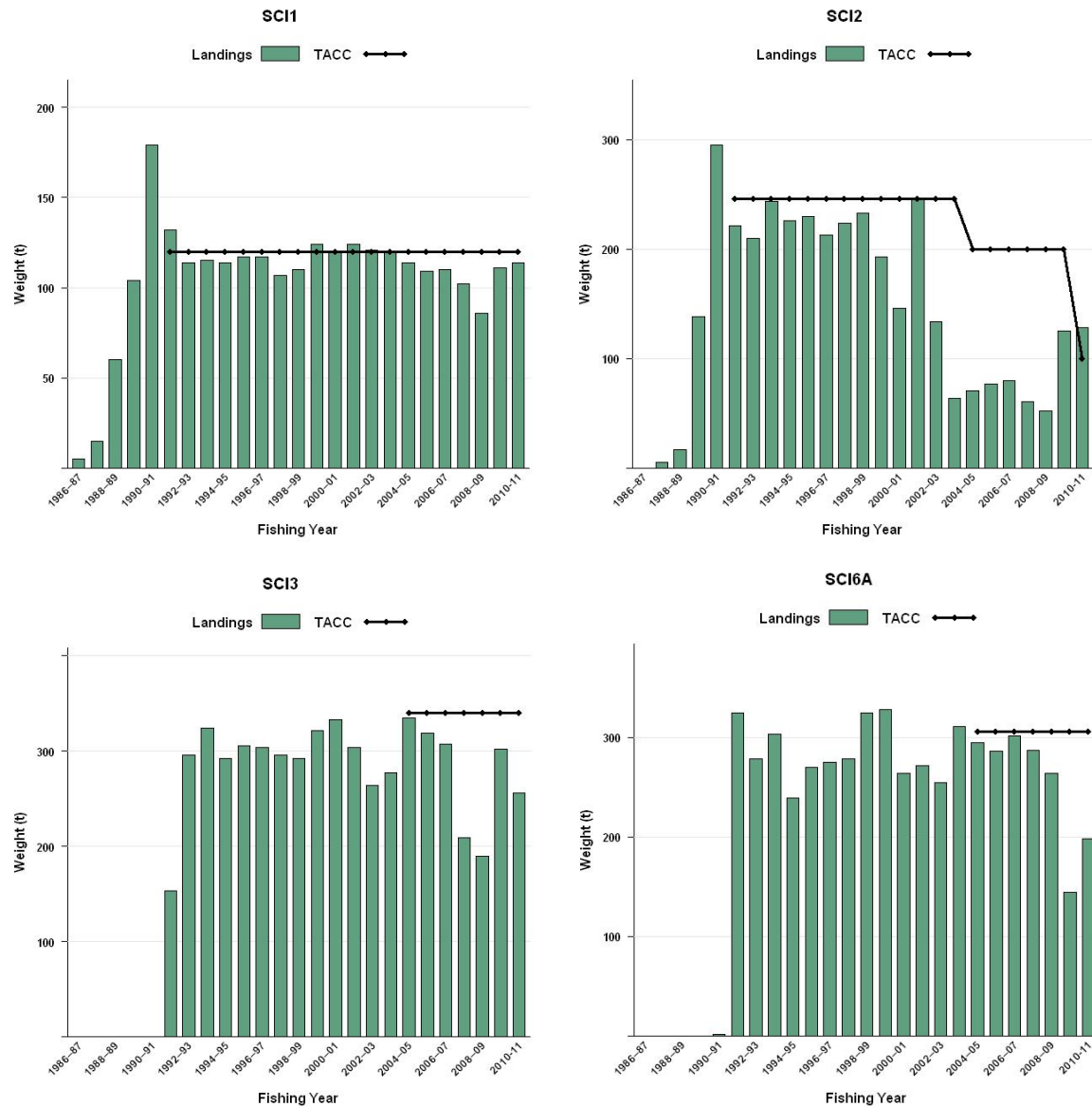
Figure 1: Historical landings and TACC for the four main SCI stocks from fishing years 1986-97 to present. Left to right: SCI 1, SCI 2, SCI 3 and SCI6A. QMS data from 1991-92 to present for SCI 1 and SCI 2 stocks, and 2004-05 to present for SCI 3 and SCI 6A stocks.

In all Fishstocks, but especially in SCI 2, landings are below the TACC. This may be related to fleet economics to some extent. Minimal fishing for scampi has taken place in SCI 5, 6B, 7, 8 and 9.

1.2 Recreational fisheries

There is no recreational fishery for scampi.

1.3 Maori customary fisheries

There is no customary fishery for scampi.

1.4 Illegal catch

There is no quantitative information on the level of illegal catch.

1.5   Other sources of mortality

Unaccounted sources of mortality in scampi could include incidental effects of trawl gear on the animals and their habitat.

2.   BIOLOGY

Scampi are widely distributed around the New Zealand coast, principally in depths between 200 and 500 m on the continental slope. Like other species of *Metanephrops* and *Nephrops*, *M. challengeri* builds a burrow in the sediment and may spend a considerable proportion of time within this burrow. From trawl catch rates, it appears that there are daily and seasonal cycles of emergence from burrows onto the sediment surface.

Scampi moult several times per year in early life and probably about once a year after sexual maturity (at least in females). Early work suggested that female *M. challengeri* achieve sexual maturity at about 40 mm orbital carapace length (OCL) in the Bay of Plenty and on the Chatham Rise, about 36 mm OCL off the Wairarapa coast, and about 56 mm OCL around the Auckland Islands. Examination of ovary maturity on more recent trawl surveys suggest that 50% of females were mature at 30 mm OCL in SCI 1 and 2, and at about 38 mm in SCI 6A. The peak of moulting and spawning activity seems to occur in spring or early summer. Larval development of *M. challengeri* is probably very short, and may be less than 3 days in the wild. The abbreviated larval phase may, in part, explain the low fecundity of *M. challengeri* compared with *N. norvegicus* (that of the former being about 10–20% that of the latter).

Relatively little is known of the growth rate of any of the *Metanephrops* species in the wild. Tagging of *M. challengeri* to determine growth rates was undertaken in the Bay of Plenty in 1995, and the bulk of recaptures were made late in 1996. About 1% of tagged animals were recaptured, similar to the average return rate of similar tagging studies for scampi and prawns overseas. Many more females than males were recaptured, and small males were almost entirely absent from the recapture sample. Scampi captured and tagged at night were much more likely to be recaptured than those exposed to sunlight. Estimates from this work of growth rate and mortality for females are given in Table 3. The data for males were insufficient for analysis, although the average annual increment with size appeared to be greater than in females.

Table 3: Estimates of biological parameters.

Population	Estimate		Source
1. Weight = a(orbital carapace length)^b (weight in g, OCL in mm)			
All males: SCI 1	a = 0.000373	b = 3.145	Cryer & Stotter (1997)
Ovigerous females: SCI 1	a = 0.003821	b = 2.533	Cryer & Stotter (1997)
Other females: SCI 1	a = 0.000443	b = 3.092	Cryer & Stotter (1997)
All females: SCI 1	a = 0.000461	b = 3.083	Cryer & Stotter (1997)
2. von Bertalanffy growth parameters			
	K (yr^{-1})	L_∞ (OCL, mm)	
Females: SCI 1 (tag)	0.11–0.14	48.0–49.0	Cryer & Stotter (1999)
Females: SCI 2 (aquarium)	0.31	48.8	Cryer & Oliver (2001)
Males: SCI 2 (aquarium)	0.32	51.2	Cryer & Oliver (2001)
3. Natural mortality (M)			
Females: SCI 1	M = 0.20–0.25		Cryer & Stotter (1999)

Scampi from SCI 2 were successfully reared in aquariums for over 12 months in 1999–2000. Results from these growth trials suggested a von Bertalanffy K of about 0.3 for both sexes, compared with < 0.15 for the tagging trial. Extrapolating the length-based results to age-based curves suggests that scampi are about 3–4 years old at 30 mm carapace length and may live for 15 years. There are many uncertainties with captive reared animals, however, and these estimates should not be regarded as

definitive. In particular, the rearing temperature was 12º C compared with about 10º C in the wild (in SCI 1 and 2), and the effects of captivity are largely unknown.

The maximum age of New Zealand scampi is not known, although analysis of tag return data and aquarium trials suggest that this species may be quite long lived. *Metanephrops* spp in Australian waters may grow rather slowly and take up to 6 years to recruit to the commercial fishery (Rainer 1992), consistent with estimates of growth in *M. challengeri* (Table **3**). *N. norvegicus* populations in some northern European populations achieve a maximum age of 15–20 years (Bell *et al*. 2006), consistent with the estimates of natural mortality, *M*, for *M. challengeri*.

A tagging project has been conducted in SCI 6A, with three release events (March 2007, 2008 and 2009). By August 2010, 6.3% of the 2007 releases had been recaptured, 3.5% of the 2008 releases and 4% of the 2009 releases. Most recaptures occur within a year of release. Tagging work has also more recently been conducted in SCI 1, 2 and 3. These data will be fitted within assessment models to estimate growth.

3.   STOCKS AND AREAS

Stock structure of scampi in New Zealand waters is not well known. Preliminary electrophoretic analyses suggest that scampi in SCI 6A are genetically distinct from those in other areas, and there is substantial heterogeneity in samples from SCIs 1, 2, and 4A. The abbreviated larval phase of this species may lead to low rates of gene mixing. Differences among some scampi populations in average size, size at maturity, the timing of diel and seasonal cycles of catchability, catch to bycatch ratios and CPUE trends also suggest that treatment as separate management units is appropriate.

A review of stock boundaries between SCI 3 and SCI 4A and between SCI 6A and SCI 6B was conducted in 2000, prior to introduction of scampi into the Quota Management System. Following the recommendation of this review, the boundaries were changed on 1 October 2004, to reflect the distribution of scampi stocks and fisheries more appropriately.

4.   STOCK ASSESSMENT

Attempts have been made to index scampi abundance using CPUE and trawl survey indices and, more recently, photographic surveys of scampi burrows. There is some level of agreement between the relative trends shown, at least for SCI 1 (Figure 2), and all three indices are included in the length based assessment model.

Standardised CPUE indices were first calculated for SCI 1 and used as abundance indices for the assessments in 1992, 1993 and 1995. Similar standardised indices for SCIs 2, 3, 4 and 6A were estimated in 1997, 1998 and 1999. These indices for all areas were highly correlated with the unstandardised index (total catch divided by total effort). In 1998 the Shellfish Fishery Assessment Working Group concluded that the standardised CPUE analyses may not be providing reliable indices of abundance for scampi.

4.1   Estimates of fishery parameters and abundance

Annual unstandardised CPUE indices (total catch divided by total effort in hours of trawling) have been calculated for each area using the data from all vessels that fished (Figure 2). The Shellfish Fishery Assessment Working Group has raised concerns in the past that potential variability in catchability between years mean that CPUE may not provide a reliable index of abundance. The indices for areas SCI 3, 4A 6A and 6B have been recalculated over the time series in light of the alterations of some stock boundaries, following the review described above. In SCI 1, CPUE increased in the early 1990s, and then declined between 1995–96 and 2001–02, increased to 2002-03, but has decreased to the 2001-02 level in the most recent years. In SCI 2, CPUE declined steadily

between 1994–95 and 2001–02 and has increased slowly since then. In SCI 3, CPUE rose steadily through the early 1990s, fluctuated around a slowly declining trend in the late 1990s and early 2000s, showed a steeper decline to 2007-08, but has increased in recent years. In SCI 4A, CPUE observations were intermittent between 1991−92 and 2002-03, showing a dramatic increase over this period. Since 2002-03 CPUE has been far lower, but 2010-11 data show an increase on the more recent years. In SCI 6A, after an initial decline in the early 1990s, CPUE has been relatively stable, although CPUE in the most recent years appears to be slightly lower than the longer term average. With the revision of the stock boundaries, data are only available for one year for SCI 6B, and are therefore not presented. For both SCI 5 and SCI 7, observations have been intermittent, and consistently low.

A time series of trawl surveys designed to measure relative biomass of scampi in SCIs 1 and 2 ran between January 1993 and January 1995 (Table 4). Research trawling for other purposes has been conducted in both SCI 1 and SCI 2 in several other years, and catch rates from appropriate hauls within these studies have been plotted alongside the dedicated trawl survey data in Figure 3 and Figure 4. In SCI 1 the additional trawling was conducted in support of a tagging programme (1995 & 1996), which was conducted by a commercial vessel in the peak area of the fishery, while work to assess trawl selectivity (1996) and in support of photographic surveys (since 1998) may have been more representative of the overall area. In SCI 2 the additional trawling was conducted in support of a growth investigation through length frequency data (1999 & 2000) and in support of photographic surveys (since 2003). All the work was carried out by the same research vessel, but while the work in support of photographic surveys was carried out over the whole area, the work related to the growth investigation was concentrated in a small area at the south of the SCI 2 area. Only the additional trawl survey work in support of photographic surveys has been included in Table 4, since the other studies did not have comparable spatial coverage. The trends observed are similar to the trends in commercial CPUE (Figure 2).

Surveys have been conducted in SCI 3 in 2001 (two surveys, pre and post fishery), 2009 and 2010. The trawl component of the surveys did not suggest any difference between the pre and post fishery periods in 2001, but the photographic survey observed more scampi burrows after the fishery. Trawl, photographic and CPUE data indicate a significant decline in scampi abundance between 2001 and 2009, but an increase in the most recent year (Figure 5).

Table 4: Trawl survey indices of biomass (t) for scampi in survey strata within SCIs 1, 2, 3 and 6A. CVs of estimates in parenthesis.

	SCI 1	SCI 2	SCI 3	SCI 6A	Comments
1993	175.8 (0.12)	174.6 (0.12)			Dedicated trawl survey
1994	192.1 (0.17)	141.7 (0.14)			Dedicated trawl survey
1995	243.3 (0.17)	154.4 (0.17)			Dedicated trawl survey
1996					
1997					
1998	123.3 (0.21)				Trawling in support of photo survey
1999					
2000	129.9 (*)				Trawling in support of photo survey
2001	115 (0.27)		311.7 (0.26) (strata 902–3)		Trawling in support of photo survey
					SCI 3 pre season survey
2002	75.7 (0.22)				Trawling in support of photo survey
2003		17.8 (*)			Trawling in support of photo survey
2004		29.7 (0.21)			Trawling in support of photo survey
2005		33.1 (0.34)			Trawling in support of photo survey
2006		26.8 (0.26)			Trawling in support of photo survey
2007				780.6 (0.18)	Trawling in support of photo survey
2008	132.4 (*)			952.1 (0.15)	Trawling in support of photo survey
2009			63.2 (0.39) (strata 902–3)	697.3 (0.09)	Trawling in support of photo survey
			377.9 (0.29)		
2010			64.6 (0.12) (strata 902–3)		Trawling in support of photo survey
			611.7 (0.04)		
2011					
2012	90.0 (0.25)	102.7 (0.33)			Trawling in support of photo survey

* - where no cv is provided, one stratum had only one valid station. Strata included: SCI 1 – 302,303, 402, 403; SCI 2 – 701, 702, 703, 801, 802, 803; SCI 3 – 902, 903, 904; SCI 6A (main area) – 350m, 400m, 450m, 500m. SCI 3 survey in 2009 of split into area surveyed in 2001, and new area (strata 902A–C & 903A)

SCAMPI (SCI)
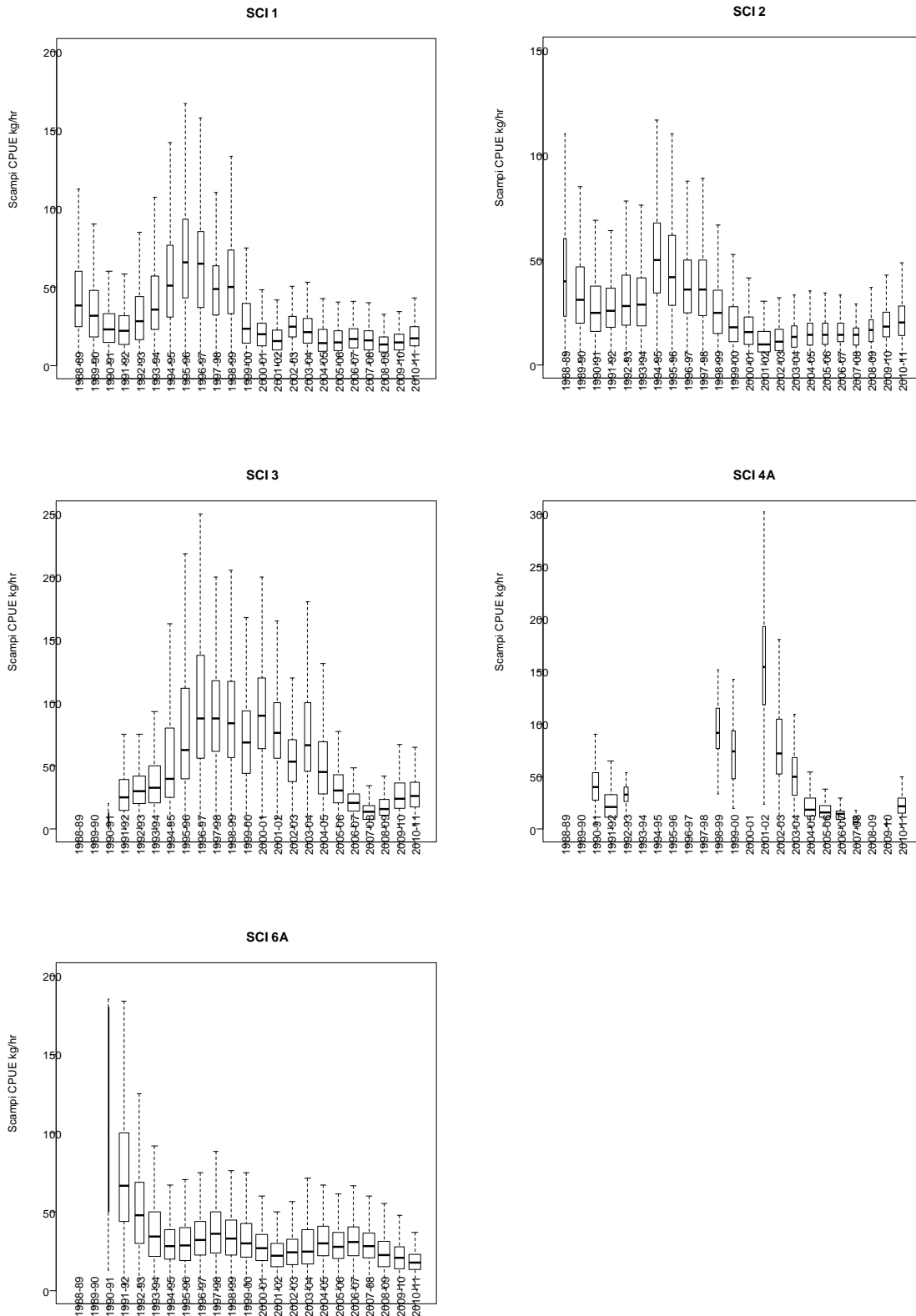
Figure 2: Box plots (with outliers removed) of individual observations of unstandardised catch rate for scampi (tow catch (kg) divided by tow effort (hours)) with tows of zero scampi catch excluded, by fishing year for main stocks. Note different scales between plots. Horizontal bars within boxes represent distribution median. Upper and lower limits of boxes represent upper and lower quartiles. Whisker extends to largest (or smallest) observation which is less than or equal (greater than or equal) to the upper quartile plus 1.5 times the interquartile range (lower quartile less 1.5 times the interquartile range). Outliers (removed from this plot) are values outside the whiskers. Box width proportional to square root of number of observations.
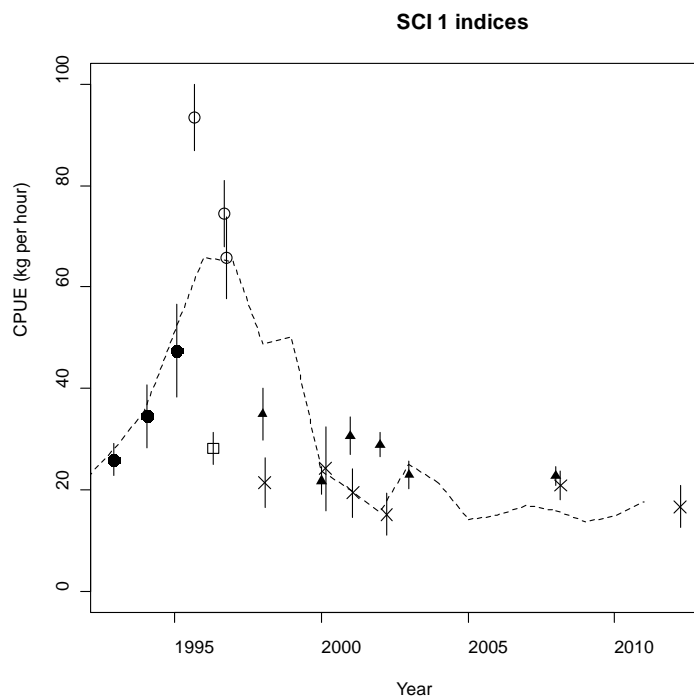
Figure 3: Mean catch rates and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 1. Symbols represent different aims of survey work (● – trawl survey, ○ – tagging work, □ – trawl selectivity, ×- trawling within photo survey, ▲-scaled photo survey abundance). Dotted line represents median of annual unstandardised CPUE for SCI 1 from Figure.

Figure 4: Mean catch rates and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 2. Symbols represent different aims of survey work (● – trawl survey, ○ – tagging work, , ×- trawling within photo survey, ▲-scaled photo survey abundance). Dotted line represents median of annual unstandardised CPUE for SCI 2 from Figure.
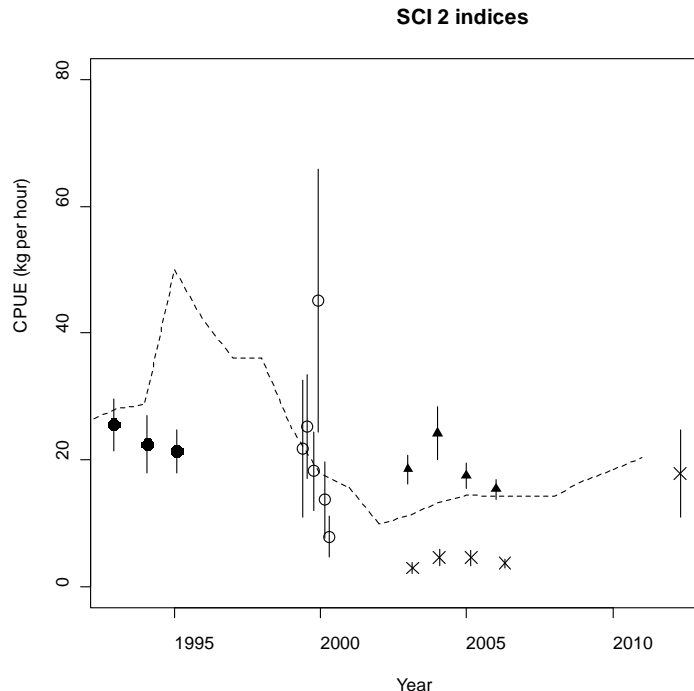
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Table 5: Photographic survey estimates of abundance (millions) based on major openings and visible scampi in survey strata within SCIs 1, 2, 3 and 6A. CVs of estimates in parenthesis.

	SCI 1		SCI 2		SCI 3		SCI 6A		Comments
	Major openings	Visible scampi	Major openings	Visible scampi	Major openings	Visible scampi	Major openings	Visible scampi	
1998	155.1 (0.15)	27.9 (0.22)							
1999									
2000	96.7 (0.13)	18.2 (0.18)							
2001	135.9 (0.12)	12.3 (0.26)			267.3 (0.09) (strata 902–3) 443.8 (0.17) (strata 902–3)	72.9 (0.16) (strata 902–3) 77.5 (0.14) (strata 902–3)			SCI 3, two surveys in 2001, Aug/Sept and Oct
2002	128.2 (0.08)	16.7 (0.21)							
2003	101.9 (0.12)	14.4 (0.21)	161.6 (0.12)	10.0 (0.39)					
2004			210.8 (0.17)	20.6 (0.28)					
2005			152.5 (0.11)	14.6 (0.20)					
2006			134.2 (0.10)	13.3 (0.23)					
2007							153.7 (0.08)	44.5 (0.10)	SCI 6A estimate for main area*
2008	100.8 (0.08)	12.5 (0.13)					57.3 (0.07)	24.9 (0.10)	
2009					61.1 (0.20) (strata 902–3) 260.6 (0.08) (larger survey)	23.6 (0.17) (strata 902–3) 124.8 (0.10) (larger survey)	120.4 (0.08)	24.2 (0.11)	SCI 3, estimates provided for 2001 survey coverage (strata 902–3) and new larger survey
2010					74.6 (0.11) (strata 902–3) 348.0 (0.05) (larger survey)	10.9 (0.23) (strata 902–3) 91.4 (0.10) (larger survey)			SCI 3, estimates provided for 2001 survey coverage (strata 902–3) and new larger survey

* - SCI 6A estimate provided for main area as future surveys may not survey secondary area

Table 6: Photographic survey estimates of biomass (t) based on major openings and visible scampi in survey strata within SCIs 1, 2, 3 and 6A. CVs of estimates in parenthesis.

	SCI 1		SCI 2		SCI 3		SCI 6A		Mean weight*
	Major openings	Visible scampi	Major openings	Visible scampi	Major openings	Visible scampi	Major openings	Visible scampi	
1998	3996 (0.15)	719 (0.22)							SCI 1 – 25.76g
1999									
2000	2373 (0.13)	447 (0.18)							SCI 1 – 24.54g
2001	3451 (0.12)	312 (0.26)			9490 (0.09) 15756 (0.17)	2588 (0.16) 2752 (0.14)			SCI 1 – 25.40g SCI 3 – 35.5g
2002	3366 (0.08)	438 (0.21)							SCI 1 – 26.26g
2003	3364 (0.12)	475 (0.21)	4572 (0.12)	283 (0.39)					SCI 1 – 33.01g SCI 2 – 28.29g
2004			4298 (0.17)	420 (0.28)					SCI 2 – 20.28g
2005			4701 (0.11)	450 (0.20)					SCI 2 – 30.83g
2006			3727 (0.10)	369 (0.23)					SCI 2 – 27.77g
2007							4775 (0.08)	1382 (0.09)	SCI 6A – 31.70g
2008	2723 (0.08)	338 (0.13)					1816 (0.07)	789 (0.10)	SCI 1 – 27.0g SCI 6A – 31.70g
2009					2169 (0.20) (strata 902–3) 9251 (0.08) (larger survey)	838 (0.17) (strata 902–3) 4430 (0.10) (larger survey)	3817 (0.08)	767 (0.11)	SCI 6A – 31.70g SCI 3 – 35.5g
2010					2648 (0.11) (strata 902–3) 12354 (0.05) (larger survey)	387 (0.23) (strata 902–3) 3245 (0.10) (larger survey)			SCI 3 – 35.5g

* - Mean weight for SCI 1 and SCI 2 for each survey to 2006 estimated from size distribution of burrows, and relationship between burrow and scampi size. Mean weight for SCI 1 in 2008 taken as average of previous SCI 1 surveys. Mean weight for SCI 3 assumed. Mean weight for SCI 6A estimated from length cohort analysis of removals to estimate population size >20 mm CL. The same mean weight has been applied to both the major openings and visible scampi within each survey/year combination.
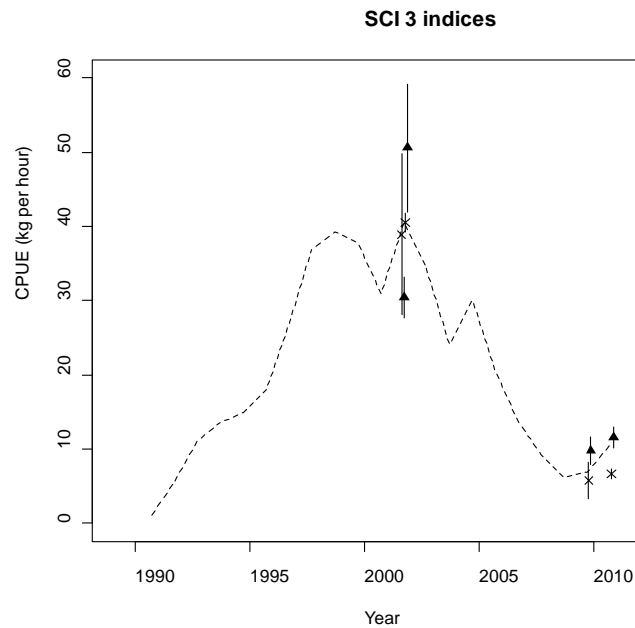
SCI 3 indices

Figure 5: Mean catch rates and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 3. Symbols represent different aims of survey work (×- trawling within photo survey, ▲-scaled photo survey abundance). Dotted line represents median of annual unstandardised CPUE for SCI 3 from Figure .

SCI 6A indices

Figure 6: Mean catch rates and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 6A. Symbols represent different aims of survey work (×- trawling within photo survey, ▲-scaled photo survey abundance). Dotted line represents median of annual unstandardised CPUE for SCI 6A from Figure .
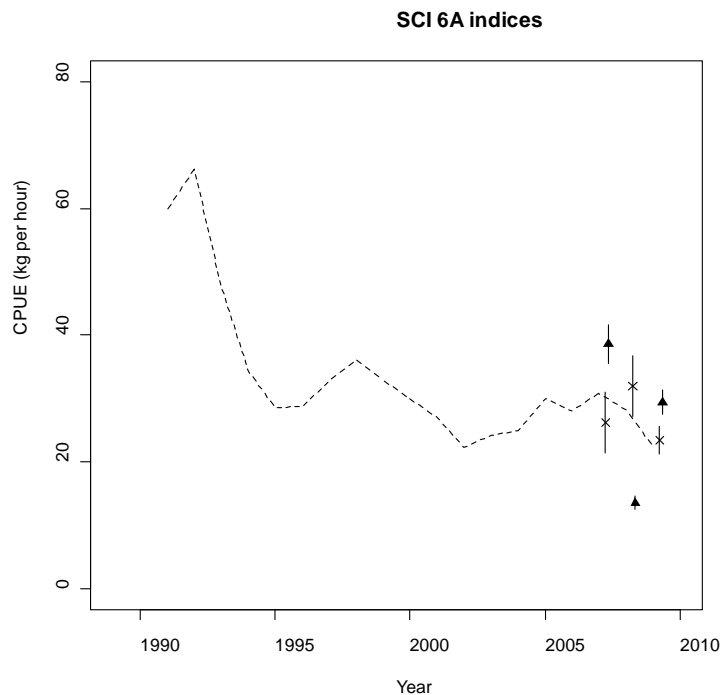
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Surveys have only been conducted in SCI 6A in 2007–2009. The trawl component of the surveys suggests that biomass has remained relatively stable in recent years. The photographic survey suggested a considerable decline in abundance between 2007 and 2008, but an increase towards the 2007 level in 2009. Over the longer term, the CPUE data indicate that following a rapid decline in the early 1990s, abundance may have declined slightly since 1995 (Figure 6).

Photographic surveying (usually by video) has been used extensively to estimate the abundance of the European scampi *Nephrops norvegicus*. In New Zealand, development of photographic techniques, including surveys, has been underway since 1998. To-date, six surveys have been undertaken in SCI 1 (between Cuvier Island and White Island at a depth of 300 to 500 m), four surveys have been undertaken in SCI 3 (northeastern Mernoo Bank only, 200 to 600 m depth), four surveys have been undertaken in SCI 2 (Mahia Peninsula to Castle Point 200 to 500 m depth), and three surveys in SCI 6A (to the east of the Auckland Islands, 350–550 m depth). The association between scampi and burrows in SCI 6A appears to be different to other areas examined, and it is uncertain whether the relationship between scampi and burrow abundance is constant between areas, or whether the marked decline in burrow abundance observed between 2007 and 2009 in SCI 6A (Table 5 and Table 6) reflects scampi abundance (particularly when trawl survey catch rates increased (Table 4).
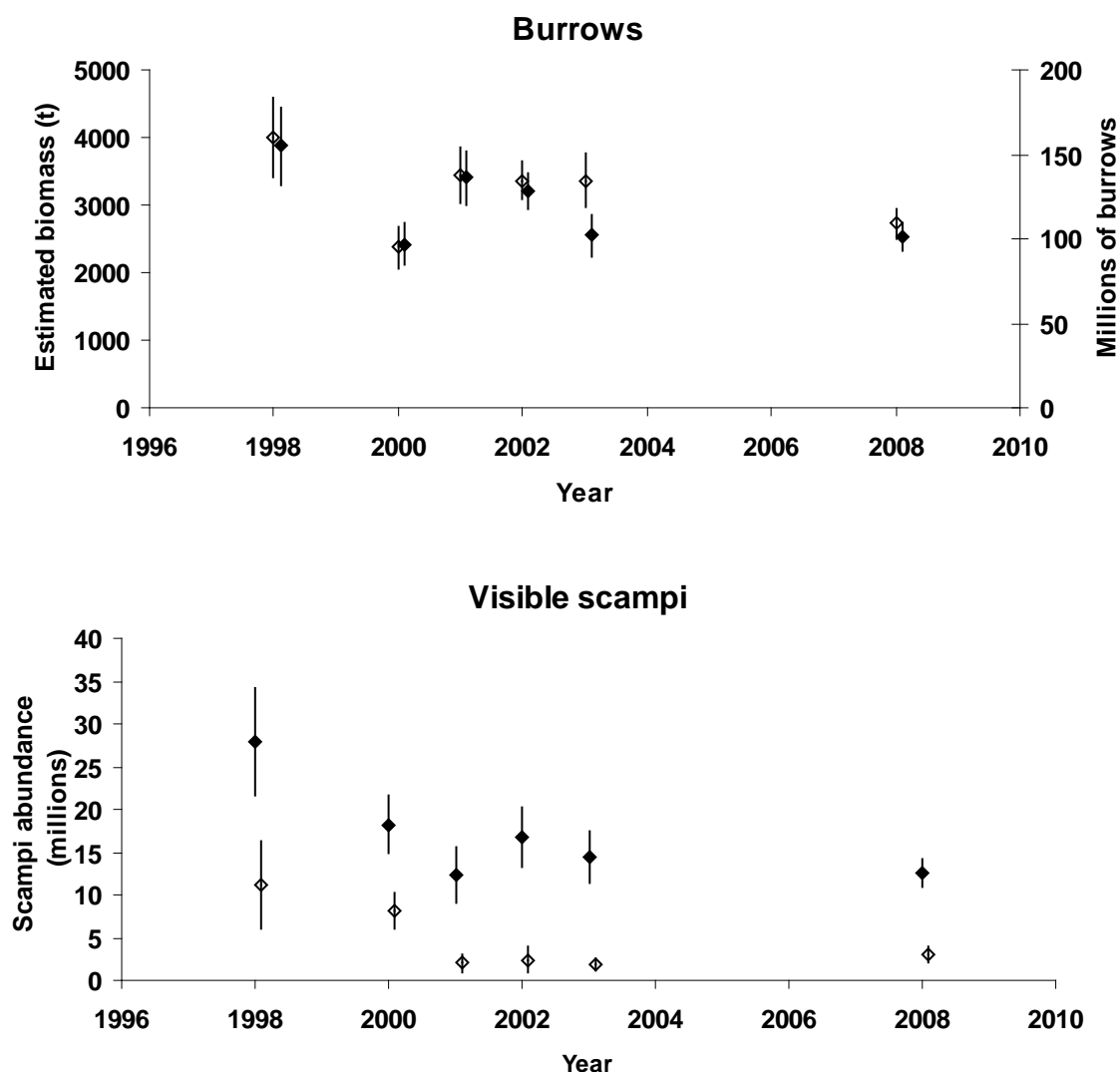

Figure 7: Estimated abundance (± c.v.s) of major burrow openings (upper plot, solid symbols), biomass (upper plot, open symbols, assuming 100% occupancy and a relationship between burrow and occupant size), all visible scampi (lower plot, solid symbols), and scampi entirely free of burrows (lower plot, open symbols) in the core area of the SCI 1 fishery, 1998 to 2008.

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At this stage in the development of photographic survey techniques, two indices are showing promise: the density of visible scampi and the density of major burrow openings (counts of which are now consistent among experienced readers, and repeatable, following development of a between reader standardisation process). Both of these can be used to estimate indices of biomass, using estimates of mean individual weight or the size distribution of animals in the surveyed population. The Bayesian length based model currently under development for scampi uses the estimated abundance of major burrow openings as an abundance index, and future development plans include using the estimated abundance of visible scampi.

Estimates of major burrow opening and visible scampi abundance are provided in Table 5. The two indices estimated from the core areas of SCI 1 and SCI 2 are shown in Figure 7 and Figure 8.
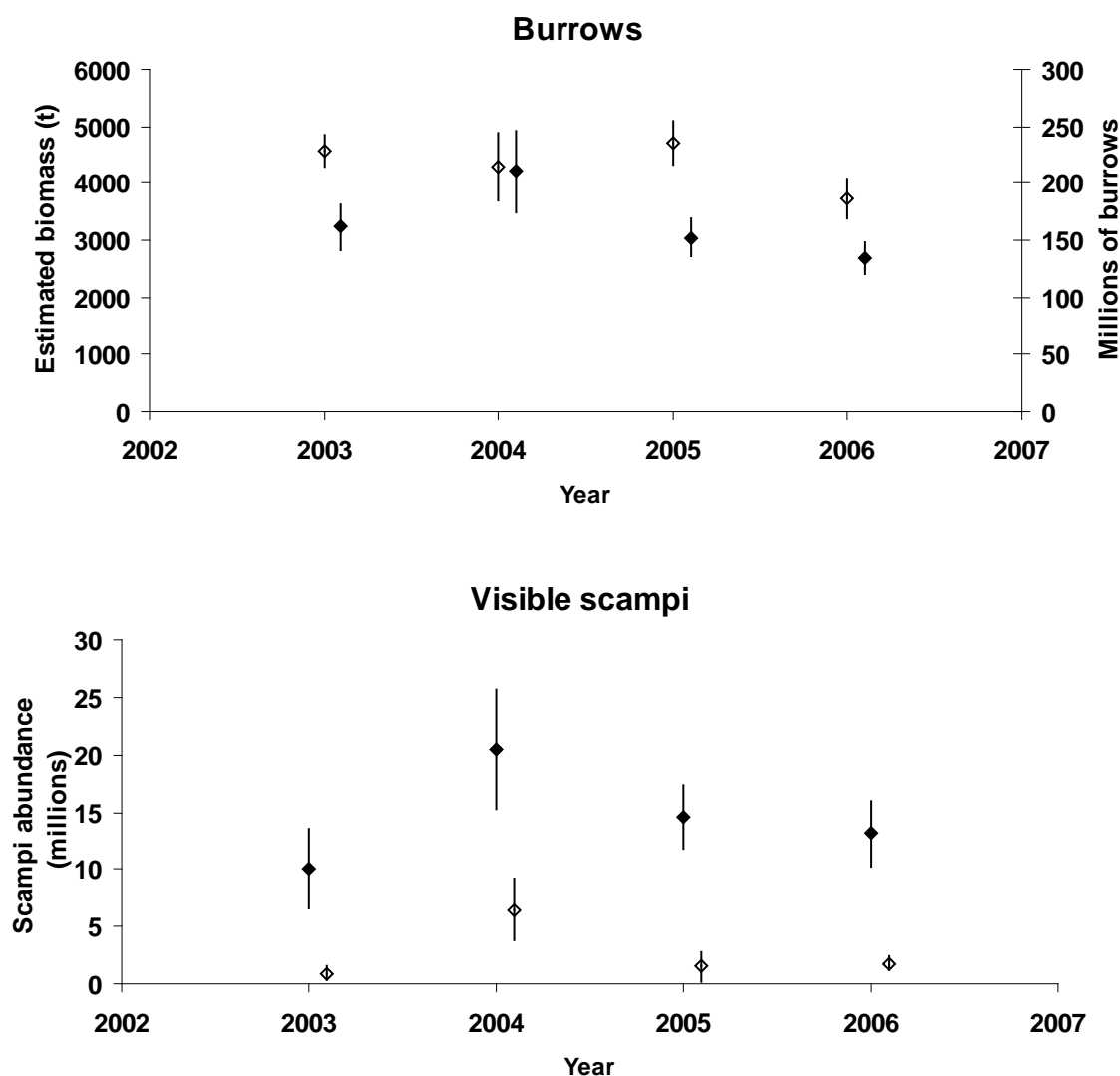

Figure 8: Estimated abundance (± c.v.s) of major burrow openings (upper plot, solid symbols), biomass (upper plot, open symbols, assuming 100% occupancy and a relationship between burrow and occupant size), all visible scampi (lower plot, solid symbols), and scampi entirely free of burrows (lower plot, open symbols) in the core area of the SCI 2 fishery, 2003 to 2006.

Length frequency distributions from trawl surveys and from scientific observers do not show a consistent increase in the proportion of small individuals in any SCI stock following the development of significant fisheries for scampi. Analyses of information from trawl survey and scientific observers

in SCI 1 and 6A up to about 1996 suggested that the proportion of small animals in the catch declined markedly in both areas, despite the fact that CPUE declined markedly in SCI 6A and increased markedly in SCI 1. Where large differences in the length frequency distribution of scampi measured by observers have been detected (as in SCIs 1 and 6A), detailed analysis has shown that the spatial coverage of observer samples has varied with time, and this may have influenced the nature of the length frequency samples. Observer sampling practices may have also introduced bias or increased uncertainty. The length composition of scampi is known to vary with depth and geographical location, and fishers may deliberately target certain size categories.

Some commercial fishers reported that they experienced historically low catch rates in SCI 1 and 2 between 2001 and 2004. They further suggest that this reflects a decrease in abundance of scampi in these areas. Other fishers consider that catch rates do not necessarily reflect changes in abundance because they are influenced by management and fishing practices.

4.2   Biomass estimates

In 2010 the SFWG accepted the stock assessments for SCI 1 and SCI 2, undertaken using the length-based population model that has been under development for several years (Tuck and Dunn 2012). A number of model runs were examined over a range of combinations of structural complexities (spatial and depth structure) and sets of included data (CPUE, trawl surveys, length distributions). For SCI 1, model runs 1C (stratification on basis of time step) and 2C (stratification on basis of time step and depth) could not be decided between by the SFWG so both were accepted. For SCI 2, model run 4C (stratification on basis of time step) was accepted.

The model's annual cycle is based on the fishing year and is divided into three time-steps (Table 7). The choice of three time steps was based on current understanding of scampi biology and sex ratio in catches. Note that model references to "year" within this report refer to the modelled or fishing year, and are labelled as the most recent calendar year, i.e., the fishing year 1998–99 is referred to as "1999" throughout.

Table 7: Annual cycle of the population model for SCI 1, showing the processes taking place at each time step, their sequence within each time step, and the available observations. Fishing and natural mortality that occur together within a time step occur after all other processes, with 50% of the natural mortality for that time step occurring before and 50% after the fishing mortality.

Step	Period	Process	Proportion in time step
1	Oct–Jan	Growth (both sexes)	
		Natural mortality	0.33
		Fishing mortality	From TCEPR
2	Feb–April	Recruitment	1.0
		Maturation	1.0
		Growth (males)*	
		Natural mortality	0.25
		Fishing mortality	From TCEPR
3	May–Sept	Natural mortality	0.42
		Fishing mortality	From TCEPR

* - the main period of male moulting appears to be from February to April. In the model both sexes are assumed to grow at the start of step 1, and this male growth period (February to April) is ignored. Sensitivities to an additional growth for males at this time are explored.

Investigations into factors affecting scampi catch rates and size distributions (Cryer & Hartill 2000, Tuck 2009) have identified significant depth and spatial effects and therefore spatial and depth stratification was also considered for the model. Catches generally occur throughout the year, and were divided among the time-steps according to the proportion of estimated catches recorded on Trawl Catch, Effort, and Processing Returns (TCEPR). Recreational catch, customary catch, and illegal catch are ignored. The maximum exploitation rate (i.e., the ratio of the maximum catch to

biomass in any year) is not known, but was constrained to no more than 0.9 in a time-step. Individuals are assumed to recruit to the model at age 1, with the mean expectation of recruitment success predicted by a Beverton & Holt stock-recruitment relationship. Length at recruitment is defined by a normal distribution with mean of 10 mm OCL with a c.v. of 0.4. Relative year class strengths are encouraged to average 1.0. Natural mortality is assumed known at 0.2 (Cryer & Stotter 1999). Growth is estimated in the model, fitting to the tag (Cryer & Stotter 1997, Cryer & Stotter 1999) and aquarium data (Cryer & Oliver 2001) from SCI 1 and SCI 2.

The model uses logistic length based selectivity curves for commercial fishing, research trawl surveys, and photographic surveys, assumed constant over years, but allowed to vary with sex, time step and spatial strata (where included). While the sex ratio data suggest that the relative catchability of the sexes vary through the year (hence the model time structure adopted), there is no reason to suggest that assuming equal availability, selectivity at size would be different between the sexes. Therefore a new selectivity implementation was developed within CASAL, which allowed the L_{50} and a_{95} selectivity parameters to be estimated as single values shared by both sexes in a particular time step and spatial strata, but allowed for different availability between the sexes through estimation of different a_{max} values for each sex. In SCI 1 and SCI 2 selectivity is assumed to be the same in time steps 1 and 3, owing to the relative similarity in sex ratio.

Data inputs included CPUE, trawl and photographic survey indices, and associated length frequency distributions. The stocks were considered over a single area, and also stratified on the basis of depth and latitude.

The assessment reported B_0, and $B_{current}$ and used the ratio of current and projected spawning stock biomass ($B_{current}$ and B_{2015}) to B_0 as preferred indicators. Projections were conducted up to 2015 on the basis of a range of catch scenarios (slightly above and below catch in most recent year or recent average catch, and also TACC if this differs from the previous catch levels). Recent recruitment is estimated to have been lower than the long term average, and projections have been conducted on the basis of both long term and recent (last decade) recruitment scenarios. The probability of exceeding the default Harvest Strategy Standard target and limit reference points are reported.

For SCI 1, model outputs suggest that spawning stock biomass (SSB) decreased until the early 1990s, increased to a peak in about 1995, declined to the early 2000s, and has remained relatively stable since this time. The SSB in SCI 1 in 2010 is estimated to be 40%–60% of B_0 (Figure 9 & Figure 10, Table 8). For SCI 2, model outputs suggest that spawning stock biomass (SSB) in SCI 2 decreased until 1990, increased to a peak in about 1994, declined to the early 2000s, increased slightly until about 2005, and has remained relatively stable since this time. The SSB in SCI 2 in 2010 is estimated to be 38%–50% of B_0 (Figure 11, Table 10).

The default management target for scampi of 40% B_0 is within the range of % B_0 estimated for both stocks. On the basis of the outputs from model 1C, and annual catches at the TACC (120 tonnes), the probability of SSB in SCI 1 being below either of the limits by 2015 is very low (Table 9), irrespective of the recruitment scenario applied. Model 2C suggests the probability of SSB in SCI 1 being below the limits is greater, particularly for the recent recruitment scenario. For SCI 2, on the basis of outputs from model 4C, and annual catches at the TACC (200 tonnes), the probability of SSB being below the 20% B_0 limit is 63% and 29% for the recent and long term recruitment scenarios, respectively. For annual catches at the level of 2009-10 (125 tonnes), the probability of SSB being below the 20% B_0 limit is 15% and 5% for the recent and long term recruitment scenarios, respectively, while for catches at the level of the average of the last 5 years (75 tonnes), the probability of being below either limit is very low, irrespective of the recruitment scenario applied (Table 11).

Length based assessments are also under development for SCI 3 and SCI 6A, but are yet to be accepted by the SFWG.
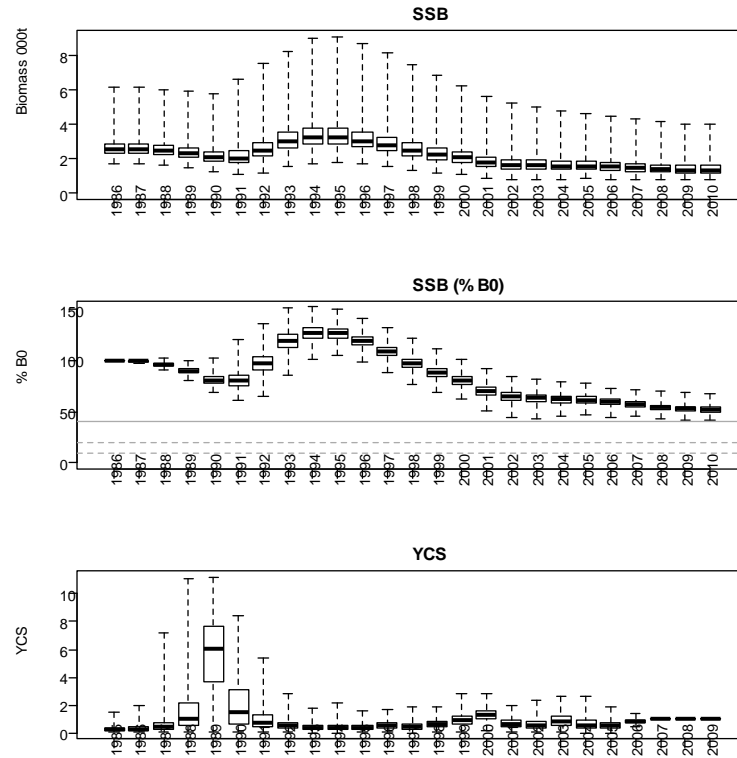
Figure 9: Posterior trajectory from model 1C of spawning stock biomass and YCS. Upper plot shows boxplots of SSB, while middle plot shows SSB as a percentage of B_0. On middle plot, target and limit reference points shown in grey solid and dashed lines. Box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution.

Table 8: Results from MCMC runs showing B_0, B_{curr} and B_{2015} estimates at varying catch levels for both models for SCI 1 for recent (R) and long term (L) recruitment scenarios.

				100 tonnes		110 tonnes (2009-10 catch)		120 tonnes (TACC)		130 tonnes	
Model	B_0	B_{curr}	B_{curr}/B_0	B_{2015}/B_0	B_{2015}/B_{curr}	B_{2015}/B_0	B_{2015}/B_{curr}	B_{2015}/B_0	B_{2015}/B_{curr}	B_{2015}/B_0	B_{2015}/B_{curr}
1C (R)	2521	1267	0.50	0.44	0.87	0.42	0.84	0.41	0.81	0.39	0.78
2C (R)	1883	772	0.41	0.32	0.77	0.30	0.72	0.28	0.67	0.26	0.63
1C (L)	2521	1297	0.50	0.50	0.94	0.48	0.92	0.47	0.88	0.45	0.86
2C (L)	1883	834	0.43	0.47	1.00	0.45	0.95	0.43	0.90	0.41	0.86

Table 9: Results from MCMC runs for SCI 1, showing probabilities of projected spawning stock biomass exceeding the default Harvest Strategy Standard target and limit reference points.

|			100 tonnes		110 tonnes (2009-10 catch)		120 tonnes (TACC)		130 tonnes	
	2010		2015		2015		2015		2015	
Recent recruitment	1C	2C	1C	2C	1C	2C	1C	2C	1C	2C
P(SSB<10% B_0)	0	0	0	0.016	0	0.028	0.001	0.047	0.001	0.064
P(SSB<20% B_0)	0	0	0.005	0.134	0.007	0.183	0.013	0.235	0.020	0.297
P(SSB<40% B_0)	0.035	0.473	0.341	0.757	0.405	0.797	0.467	0.832	0.530	0.860
P($B_{2015}<B_{2010}$)			0.800	0.839	0.851	0.868	0.879	0.902	0.908	0.929
Long term recruitment										
P(SSB<10% B_0)	0	0	0	0.014	0	0.027	0	0.041	0	0.059
P(SSB<20% B_0)	0	0	0.008	0.097	0.011	0.127	0.020	0.151	0.028	0.185
P(SSB<40% B_0)	0.041	0.377	0.300	0.402	0.335	0.432	0.373	0.463	0.401	0.493
P($B_{2015}<B_{2010}$)			0.570	0.506	0.605	0.540	0.621	0.575	0.638	0.611
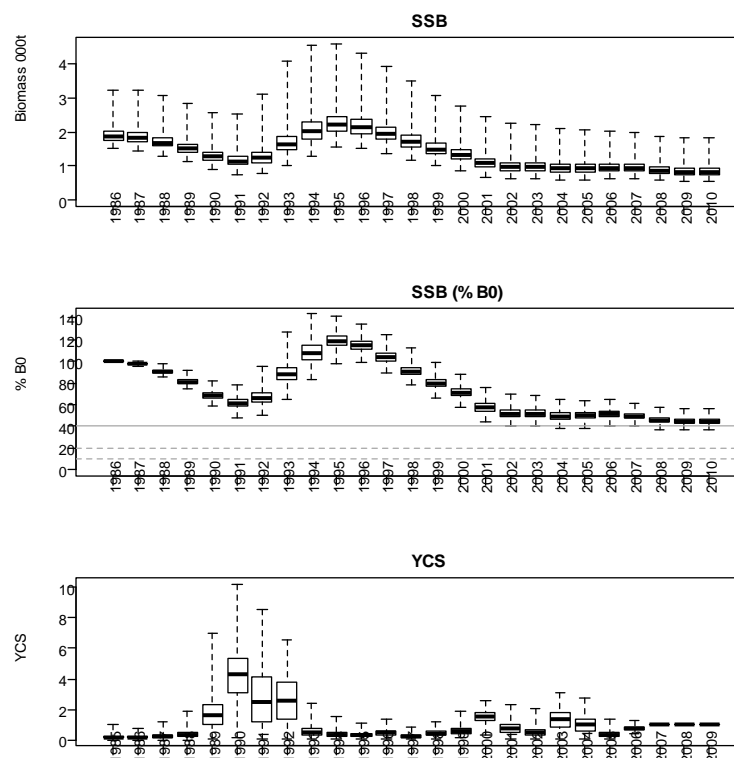
Figure 10: Posterior trajectory from model 2C of spawning stock biomass and YCS. Upper plot shows boxplots of SSB, while middle plot shows SSB as a percentage of B_0. On middle plot, target and limit reference points shown in grey solid and dashed lines. Box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution.

Table 10: Results from MCMC runs showing B_0, B_{curr} and B_{2015} estimates at varying catch levels for SCI 2 for recent (R) and long term (L) recruitment scenarios.

				75 tonnes (average last 5 years)		100 tonnes		125 tonnes (2009-10 catch)		200 tonnes (TACC)	
Model	B_0	B_{curr}	B_{curr}/B_0	B_{2015}/B_0	B_{2015}/B_{curr}	B_{2015}/B_0	B_{2015}/B_{curr}	B_{2015}/B_0	B_{2015}/B_{curr}	B_{2015}/B_0	B_{2015}/B_{curr}
4C (R)	2248	881	0.39	0.38	0.95	0.34	0.84	0.30	0.74	0.17	0.43
4C (L)	2248	938	0.41	0.50	1.15	0.46	1.06	0.41	0.96	0.29	0.67

Table 11: Results from MCMC runs for SCI 2, showing probabilities of projected spawning stock biomass exceeding the default Harvest Strategy Standard target and limit reference points.

|		75 tonnes (average last 5 years)	100 tonnes	125 tonnes (2009-10 catch)	200 tonnes (TACC)
	2010	2015	2015	2015	2015
Recent recruitment	4C	4C	4C	4C	4C
P(SSB<10% B_0)	0	0	0.002	0.015	0.243
P(SSB<20% B_0)	0	0.021	0.071	0.146	0.635
P(SSB<40% B_0)	0.572	0.609	0.768	0.863	0.986
P($B_{2015}<B_{2010}$)		0.614	0.799	0.919	0.999
Long term recruitment					
P(SSB<10% B_0)	0	0	0.001	0.002	0.091
P(SSB<20% B_0)	0	0.003	0.019	0.051	0.291
P(SSB<40% B_0)	0.443	0.256	0.373	0.467	0.678
P($B_{2015}<B_{2010}$)		0.303	0.433	0.551	0.771
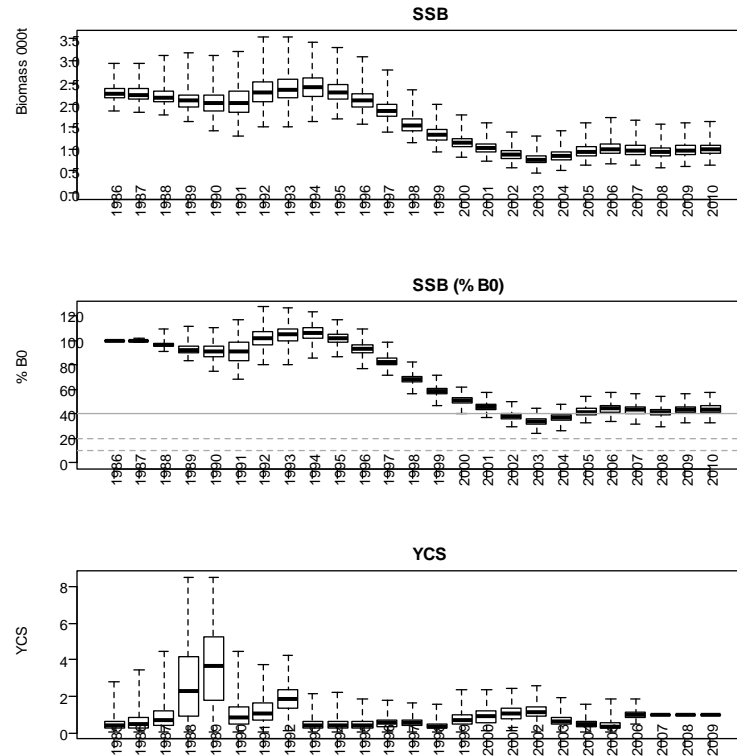
Figure 11: Posterior trajectory from model 4C of spawning stock biomass and YCS. Upper plot shows boxplots of SSB, while middle plot shows SSB as a percentage of B_0. On middle plot, target and limit reference points shown in grey solid and dashed lines. Box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution.

Biomass estimates for SCI also include estimates made using the area swept method from trawl surveys (Table 4) and using photography in parts of SCI 1, 2, 3 and 6A (Table 6). Trawl survey estimates can be considered to be minimum estimates of biomass as it is unlikely that there will be any herding effect of sweeps and bridles. Vertical availability to trawls can be expected to be <1 as many scampi will be found in burrows during the day. A preliminary estimate of scampi abundance for an area off the Auckland Islands has been generated from tag return data, although it should be noted that this programme was not designed to estimate biomass and violates many of the assumptions of the Petersen method. The estimated density of scampi for the Petersen method was similar to that estimated for visible scampi over the whole survey area from the photographic survey, although no account was taken of mortality or tag loss.

Burrow counts from photographic surveys are intended as an index of abundance, as an input into an assessment model. Estimates of biomass on the basis of abundance estimates of major openings and visible scampi are provided in Table 6. These estimates are calculated from estimates of abundance and an annually calculated mean weight (estimated from burrow size distributions and a relationship between burrow and scampi size, where possible). There is some uncertainty over the most appropriate mean weight to apply to the abundance estimates.

4.3   Estimation of Maximum Constant Yield (*MCY*)

MCY was not determined.

4.4   Estimation of Current Annual Yield (*CAY*)

CAY was not determined.

4.6 Other yield estimates and stock assessment results

There are no other yield estimates.

5. ENVIRONMENTAL & ECOSYSTEM CONSIDERATIONS

This section was updated for the May 2012 Fishery Assessment Plenary after review by the Aquatic Environment Working Group. This summary is from the perspective of the scampi fishery; a more detailed summary from an issue-by issue perspective is, or will shortly be, available in the Aquatic Environment & Biodiversity Annual Review (http://fs.fish.govt.nz/Page.aspx?pk=113&dk=22982).

5.1 Role in the ecosystem

Scampi are predators which are thought to prey mainly on invertebrates (Meynier *et al*. 2008) or carrion. A 3-year diet study on the Chatham Rise showed scampi was the first, third and fourth most important item (by IRI, Index of Relative Importance) in the diet of smooth skate, ling and sea perch, respectively (Dunn *et al*. 2009). Scampi build and maintain burrows in the sediment and this bioturbation is thought to influence oxygen and nutrient fluxes across the sediment-water boundary, especially when scampi density is high (e.g., Hughes and Atkinson 1997, who studied *Nephrops norvegicus* at densities of 1–3 m^{-2}). Observed densities from photographic surveys in New Zealand have been 0.02–0.1 m^{-2} (Tuck 2009), similar to densities of *N. norvegicus* in comparable depths.

5.2 Incidental catch (fish and invertebrates)

In the 1999–00 to 2005–06 fishing years, total annual bycatch was estimated to range from 2 910 to 8 070 t compared with total landed scampi catches of 791–1 045 t and scampi typically represents less than 20% of the catch by weight (Ballara and Anderson 2009). The main QMS bycatch species (>2% of the total catch) were sea perch, ling, hoki, red cod, silver warehou, and giant stargazer. The amount and composition of bycatch varies both within and between QMAs (see also Cryer 2000), being lowest in SCI 1 and SCI 6A (0.5 and 0.6 t per tow, respectively) and higher in SCI 3 and SCI 4A (1.0 and 1.1 t per tow) with SCI 2 intermediate. The most bycatch per tow is taken in SCI 5 (2.7 t per tow) but this is a very small fishery.

The non-QMS incidental catch ranges from a similar weight to the QMS bycatch (SCI 2 and 3) to about double the QMS bycatch (SCI 3 and 6A). Most of this non-QMS incidental catch is discarded on the grounds (Ballara and Anderson record 485 species as discarded). Total annual discard estimates from 1999–00 to 2005–06 ranged from 1 540 to 5 140 t and were dominated by sea perch (especially SCI 2 and 3) javelinfish and other rattails (all areas), spiny dogfish (all areas), skates (SCI 1 and 2), crabs (SCI 6A), toadfish (SCI 3 and 6A), and flatheads (SCI 1–3) (Ballara and Anderson 2009). Discards averaged 2.5 kg per kilogram of scampi caught, typical of crustacean trawl fisheries internationally (Kelleher 2005). Bycatch and discards may have reduced since about 2005 because of modifications to the gear (Tuck 2012 in press, also evident in the most recent year analysed by Ballara and Anderson 2009).

The finer mesh used by scampi trawlers has the potential to catch more juvenile fish than standard finfish trawls and Cryer *et al*. (1999) showed raw length frequency distributions for major QMS bycatch species up to 1996–97. Small proportions of small gemfish (20–40 cm) and small hoki (30–50 cm) were recorded in SCI 1–4 in a few years, but juveniles made up a major proportion of the catch only for ling in SCI 6A where more than half of ling measured were 30–70 cm long in 4 of the 6 years studied (1990 to 1996-97).

5.3 Incidental Catch (seabirds, mammals, and protected fish)

For protected species, capture estimates presented here include all animals recovered to the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds struck by a warp or caught on a hook but not brought onboard the vessel, Middleton and Abraham 2007, Brothers *et al*. 2010).

Marine mammal interactions

Scampi trawlers occasionally catch marine mammals, including NZ sea lions and NZ fur seals (which were classified as "Nationally Critical" and "Not Threatened", respectively, under the NZ Threat Classification System in 2010, Baker *et al*. 2010).

In the 2009/10 fishing year there were no observed captures of NZ sea lion in scampi trawl fisheries (Table 12) and no estimates of total sea lion captures were made. Sea lions captured in previous years were all taken close to the Auckland Islands in SCI 6A (Thompson and Abraham 2012). In the 2009/10 fishing year there was one observed capture of a NZ fur seal in scampi trawl fisheries. There were 6 (95% c.i.: 1 - 15) estimated captures, with the estimates made using a statistical model (Table 13). Since 2002–03, only about 1% of the estimated total captures of NZ fur seals have been taken in scampi fisheries; these have been on the western Chatham Rise, on the Stewart-Snares shelf, and close to the Auckland Islands. Rates of capture for both species were low and have fluctuated without obvious trend.

Table 12: Number of tows by fishing year and observed NZ sea lion captures in scampi trawl fisheries, 2002–03 to 2009–10. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows. Data from Thompson and Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/

	Tows	No. obs	% obs	Captures	Rate
2002–03	5130	512	10.0	0	0.00
2003–04	3753	412	11.0	3	0.73
2004–05	4652	143	3.1	0	0.00
2005–06	4867	331	6.8	1	0.30
2006–07	5135	389	7.6	1	0.26
2007–08	4804	524	10.9	0	0.00
2008–09	3975	396	10.0	1	0.25
2009–10	4251	348	8.2	0	0.00

Table 13: Number of tows by fishing year and observed and model-estimated total NZ fur seal captures in scampi trawl fisheries, 2002–03 to 2009–10. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows, % inc, percentage of total effort included in the statistical model. Data from Thompson and Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/

				Observed			Estimated	
	Tows	No. obs	% obs	Captures	Rate	Captures	95% c.i.	% inc.
2002–03	5 130	512	10.0	2	0.39	7	2 - 16	99.8
2003–04	3 753	412	11.0	1	0.24	5	1 - 13	99.4
2004–05	4 652	143	3.1	0	0.00	18	3 - 48	99.8
2005–06	4 867	331	6.8	0	0.00	8	1 - 22	100.0
2006–07	5 135	389	7.6	0	0.00	6	0 - 18	100.0
2007–08	4 804	524	10.9	1	0.19	10	2 - 26	100.0
2008–09	3 975	396	10.0	1	0.25	6	1 - 16	99.9
2009–10	4 251	348	8.2	1	0.29	6	1 - 15	100.0

Seabird interactions

Observed seabird capture rates in scampi fisheries ranged from about 1 to 6 per 100 tows between 1998-99 and 2008-09 (Baird 2001, 2004 a,b,c, 2005a, Abraham & Thompson 2009, Abraham *et al*. 2009, Abraham & Thompson 2011) and have fluctuated without obvious trend. In the 2009/2010 fishing year there were five observed captures of birds in scampi trawl fisheries. There were 162 (95% c.i.: 101 - 245) estimated captures, with the estimates made using a statistical model (Thompson and Abraham 2012). These estimates are based on relatively low observer coverage and include all bird species and should, therefore, be interpreted with caution. The average capture rate in scampi trawl fisheries over the last eight years (all areas combined) is about 3.53 birds per 100 tows, a moderate

rate relative to trawl fisheries for squid (13.3 birds per 100 tows) and hoki (2.2 birds per 100 tows) over the same years. The scampi fishery accounted for about 5% of seabird captures in the trawl fisheries modelled by Thompson & Abraham (2012).

Observed seabird captures since 2002–03 have been dominated by four species: Salvin's and white-capped albatrosses make up 51% and 27% of the albatrosses captured, respectively; and flesh-footed and sooty shearwaters make up 42% and 38% of other birds, respectively (Table 15). Most of the captures occur on the Chatham Rise (36%), close to the Auckland Islands (30%), or in the Bay of Plenty (29%). These numbers should be regarded as only a general guide on the distribution of captures because observer coverage is not uniform across areas and may not be representative.

Table 14: Number of tows by fishing year and observed and model-estimated total NZ seabirds captures in scampi trawl fisheries, 2002–03 to 2009–10. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows, % inc, percentage of total effort included in the statistical model. Data from Thompson and Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/

				Observed			Estimated		
	Tows	No. obs	% obs	Captures	Rate		Captures	95% c.i.	% inc.
2002–03	5 130	512	10.0	8	1.56		161	104 - 240	100.0
2003–04	3 753	412	11.0	8	1.94		106	67 - 155	100.0
2004–05	4 652	143	3.1	9	6.29		240	156 - 360	100.0
2005–06	4 867	331	6.8	13	3.93		219	140 - 332	100.0
2006–07	5 135	389	7.6	24	6.17		172	117 - 246	100.0
2007–08	4 804	524	10.9	11	2.10		155	101 - 232	100.0
2008–09	3 975	396	10.0	19	4.80		187	126 - 271	100.0
2009–10	4 251	348	8.2	5	1.44		162	101 - 245	100.0

Table 15: Number of observed seabird captures in scampi trawl fisheries, 2002–03 to 2009–10, by species and area. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR (from Richard *et al*. 2011 where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for scampi. Other data from Thompson and Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/

Species	Risk ratio	Auckland Islands	Bay of Plenty	Chatham Rise	ECNI	ECSI	Total
Salvin's albatross	2.49	0	0	21	1	3	25
White capped albatross	0.83	11	1	1	0	0	13
Unidentified albatross	–	0	2	2	0	1	5
Southern Buller's albatross	1.28	0	0	4	0	0	4
Campbell albatross	1.84	0	1	0	0	0	1
Chatham Island albatross	2.71	0	0	1	0	0	1
Total albatrosses		**11**	**4**	**29**	**1**	**4**	**49**
Flesh footed shearwater	2.51	0	20	0	0	0	20
Sooty shearwater	0.02	14	1	3	0	0	18
Cape petrel	0.76	1	0	2	0	0	3
Unidentified petrel	–	0	2	0	0	0	2
White chinned petrel	0.79	1	0	1	0	0	2
Black petrel	11.15	0	1	0	0	0	1
Common diving petrel	0.00	1	0	0	0	0	1
Northern giant petrel	3.00	1	0	0	0	0	1
Total other birds		**18**	**24**	**6**	**0**	**0**	**48**

5.4   Benthic interactions

Bottom trawl effort for scampi peaked in 2001–02 at over 6 500 tows (roughly 10% of all TCEPR bottom trawls in that year) but has typically been 3 500 to 5 200 tows per year since 1989–90. About

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98% has been reported on TCEPR forms (Baird *et al*. 2011) with most of the 1 477 reports on CELR forms being between 1998–99 and 2002–03. Tows were located in Benthic Optimised Marine Environment Classification (BOMEC, Leathwick *et al* 2009) classes F, G (upper slope), H, J, and L (mid-slope) (Baird and Wood 2012), and 95% were between 300 and 500 m depth (Baird *et al*. 2011).

Bottom trawling for scampi, like trawling for other species, is likely to have effects on benthic community structure and function (e.g., Cryer *et al*. 2002 for a specific analysis and Rice 2006 for an international review) and there may be consequences for benthic productivity (e.g., Jennings 2001, Hermsen *et al*. 2003, Hiddink *et al*. 2006, Reiss *et al*.2009). These consequences are not considered in detail here but are discussed in the Aquatic Environment and Biodiversity Annual Review (2012).

5.5   Other considerations
None

6.   STATUS OF THE STOCKS

Stock Structure Assumptions

Stock structure of scampi in New Zealand waters is not well known. Preliminary electrophoretic analyses suggest that scampi in SCI 6A are genetically distinct from those in other areas, and there is substantial heterogeneity in samples from SCIs 1, 2, and 4A. The abbreviated larval phase of this species may lead to low rates of gene mixing. Differences among some scampi populations in average size, size at maturity, the timing of diel and seasonal cycles of catchability, catch to bycatch ratios and CPUE trends also suggest that treatment as separate management units is appropriate.

- **SCI 1**

Stock Status	
Year of Most Recent Assessment	2011
Assessment Runs Presented	Bayesian length based models with (model 2C) and without (model 1C) spatial structure
Reference Points	Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Likely (> 60%) to be at or above target
Status in relation to Limits	Very Unlikely (< 10%) to be below the soft or hard limits

Historical Stock Status Trajectory and Current Status

SSB (% B0)

SSB (% B0)
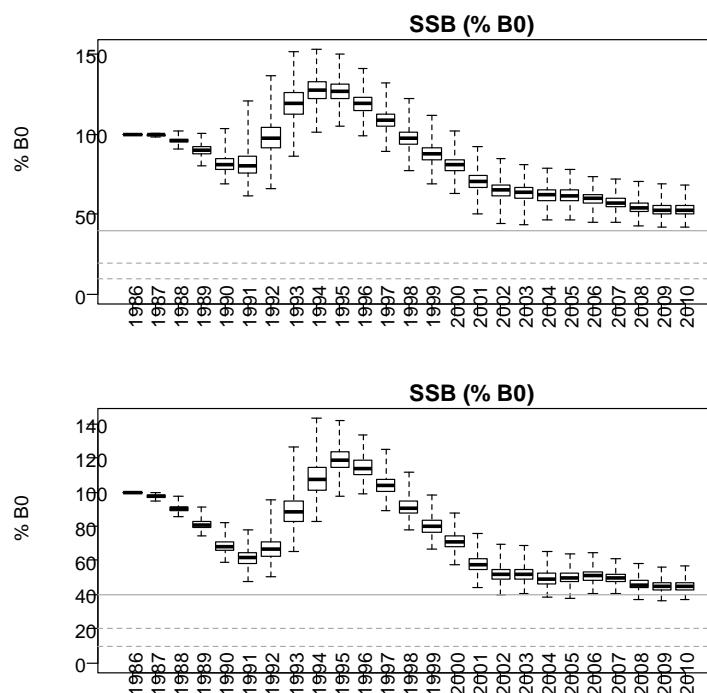
Posterior trajectory spawning stock biomass (SSB) as a percentage of B_0 for SCI 1, from model 1C (upper plot) and model 2C (lower plot). Target and limit reference points shown in grey solid and dashed lines. Box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Spawning stock biomass decreased up to the early 1990s, increased to a peak in about 1995, declined to the early 2000s, and has remained relatively stable since this time.
Recent Trend in Fishing Mortality or Proxy	Catches and stock abundance appear to have remained relatively stable in recent years, suggesting exploitation rates have been relatively stable.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis		
Stock Projections or Prognosis	Under the recent recruitment scenario, the stock is predicted to remain at or above 40% B_0 up to 2015 under current catches and TACC for model 1C, while the stock is projected to decline to 30% B_0 by 2015 for model 2C.	
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Very Unlikely (< 10%) for model 1C, Unlikely (< 40%) for model 2C Hard Limit: Very Unlikely (< 10%)	
Assessment Methodology and Evaluation		
Assessment Type	Level 1. Full Quantitative stock assessment	
Assessment Method	Length-based Bayesian Model	
Assessment Dates	Latest assessment: 2011	Next assessment: 2013
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Standardised catch and effort data (TCEPR) from MPI	1 – High Quality

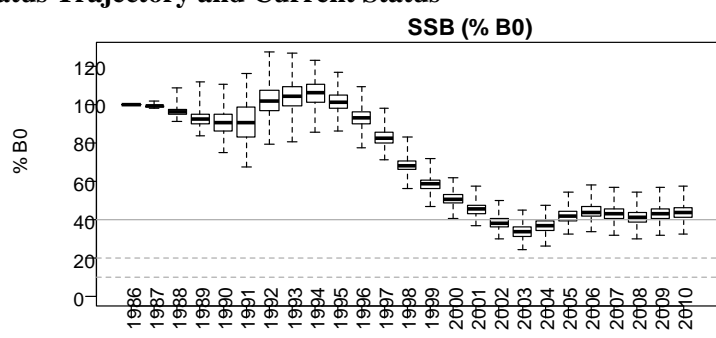|	- Length frequency data from MPI observer sampling	1 – High Quality
	- Photographic survey abundance index	1 – High Quality
	- Trawl survey abundance index	1 – High Quality
	- Length frequency data from research sampling	1 – High Quality
	- Length frequency predicted from burrow sizes	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions		
Major Sources of Uncertainty	Relationship between CPUE and abundance, growth, burrow occupancy, emergence and catchability	

Qualifying Comments
Projections are sensitive to recruitment scenarios applied. CPUE index previously considered to be potentially strongly influenced by changes in catchability, and therefore not reliable as an index of abundance. Re-examination of the data, consistency between indices and also with similar species has addressed some of the concerns. The Plenary has accepted the recommendations of the WG that CPUE is an acceptable index of abundance.

Fishery Interactions
Main QMS bycatch species include ling, hoki, sea perch, red cod, silver warehou and giant stargazer. Discards dominated by rattails, javelinfish, skates and crabs, ling, red cod, hoki, spiny dogfish and sea perch. There have been interactions with seabirds recorded. A wide range of benthic invertebrate species are taken as bycatch.

- **SCI 2**

Stock Status	
Year of Most Recent Assessment	2011
Assessment Runs Presented	Bayesian length based model without (model 4C) spatial structure
Reference Points	Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Likely ($> 60\%$) to be at or above target
Status in relation to Limits	Very Unlikely ($< 10\%$) to be below the soft or hard limits
Historical Stock Status Trajectory and Current Status	

Posterior trajectory spawning stock biomass (SSB) as a percentage of B_0 for SCI 2, from model 4C. Target and limit reference points shown in grey solid and dashed lines. Box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution.

Fishery and Stock Trends

Recent Trend in Biomass or Proxy	CPUE, trawl survey and photo survey data suggest the stock has remained at a relatively stable level since early 2000s. CPUE data suggest abundance may have increased (from levels higher to those currently observed) quite rapidly through the early 1990s, peaked about 1995, and then declined to current levels by the early 2000s.
Recent Trend in Fishing Mortality or Proxy	Catches and stock abundance appear to have remained relatively stable in recent years, suggesting that exploitation rates have been relatively stable.
Other Abundance Indices	
Trends in Other Relevant Indicators or Variables	

Projections and Prognosis

Stock Projections or Prognosis	Under the recent recruitment scenario the stock is predicted to decline slightly to 38% B_0 under recent average catch of 75 tonnes by 2015, and to 30% under 2009-10 catch (125 tonnes) and to 17% B_0 under the current TACC of 200 tonnes.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unlikely ($< 40\%$) for 2009-10 catch, Likely ($> 60\%$) for 2009-10 TACC, both assuming recent recruitment Hard Limit: Unlikely ($< 40\%$)

Assessment Methodology and Evaluation

Assessment Type	Level 1. Full Quantitative stock assessment	
Assessment Method	Length-based Bayesian Model	
Assessment Dates	Latest assessment: 2011	Next assessment: 2013
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Standardised catch and effort data (TCEPR) from MPI	1 – High Quality
	- Length frequency data from MPI observer sampling	1 – High Quality
	- Photographic survey abundance index	1 – High Quality
	- Trawl survey abundance index	1 – High Quality
	- Length frequency data from research sampling	1 – High Quality
	- Length frequency predicted from burrow sizes	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions		
Major Sources of Uncertainty	Relationship between CPUE and abundance, growth, burrow occupancy, emergence and catchability	

Qualifying Comments

Projections are sensitive to recruitment scenarios applied. CPUE index previously considered to be potentially strongly influenced by changes in catchability, and therefore not reliable as an index of abundance. Re-examination of the data, consistency between indices and also with similar species has addressed some of the concerns. The Plenary has accepted the recommendations of the WG that CPUE is an acceptable index of abundance.

Fishery Interactions

Main QMS bycatch species include ling, hoki, sea perch, red cod, silver warehou and giant stargazer. Discards dominated by rattails, javelinfish, skates and crabs, ling, red cod, hoki, spiny dogfish and sea

perch. There have been interactions with seabirds recorded. A wide range of benthic invertebrate species are taken as bycatch.

- **SCI 3**

Stock Status	
Year of Most Recent Assessment	No accepted assessments.
Assessment Runs Presented	
Reference Points	Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Unknown

Historical Stock Status Trajectory and Current Status

SCI 3 indices

Mean catch rates and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 3. Symbols represent different aims of survey work (×- trawling within photo survey, ▲-scaled photo survey abundance). Dotted line represents median of annual unstandardised CPUE for SCI 3.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	CPUE, trawl survey and photo survey data suggest the stock declined between 2001 and 2009, but increased in 2010. CPUE data suggest abundance may have increased through the early 1990s, peaked from mid 1990s to early 2000s, and then declined 2007, and then increased in recent years.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Quantitative stock projections are unavailable.
Probability of Current Catch or TACC causing decline below	Soft Limit: Unknown Hard Limit: Unknown

Limits		
Assessment Methodology and Evaluation		
Assessment Type	Level 2. Abundance indices from CPUE, trawl and photo surveys	
Assessment Method		
Assessment Dates	2012	Next assessment: 2015
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Standardised catch and effort data (TCEPR) from MPI	1 – High Quality
	- Length frequency data from MPI observer sampling	1 – High Quality
	- Photographic survey abundance index	1 – High Quality
	- Trawl survey abundance index	1 – High Quality
	- Length frequency data from research sampling	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions		
Major Sources of Uncertainty	Relationship between CPUE and abundance, growth, burrow occupancy, emergence and catchability	

Qualifying Comments

Scampi catches from SCI 3 are taken from three relatively distinct areas near the Mernoo Bank on the Chatham Rise. Trends in CPUE from these areas both increase and then decrease, but peaked in different years (1997 & 2001). Where available, the CPUE for the most recent years suggests an increase. The extended period of higher CPUE shown from this area may be an artefact of the fishing activity moving location.

CPUE index previously considered to be potentially strongly influenced by changes in catchability, and therefore not reliable as an index of abundance. Re-examination of the data has addressed some of the concerns, and the consistency between indices and also with similar species, may indicate the index is not as implausible as first considered.

Fishery Interactions

Main QMS bycatch species include ling, hoki, sea perch, red cod, silver warehou and giant stargazer. Discards dominated by rattails, javelinfish, skates and crabs, ling, red cod, hoki, spiny dogfish and sea perch. There have been interactions with seabirds recorded. A wide range of benthic invertebrate species are taken as bycatch.

- **SCI 6A**

Stock Status	
Year of Most Recent Assessment	No accepted assessments
Assessment Runs Presented	
Reference Points	Target(s): 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Unknown

Historical Stock Status Trajectory and Current Status
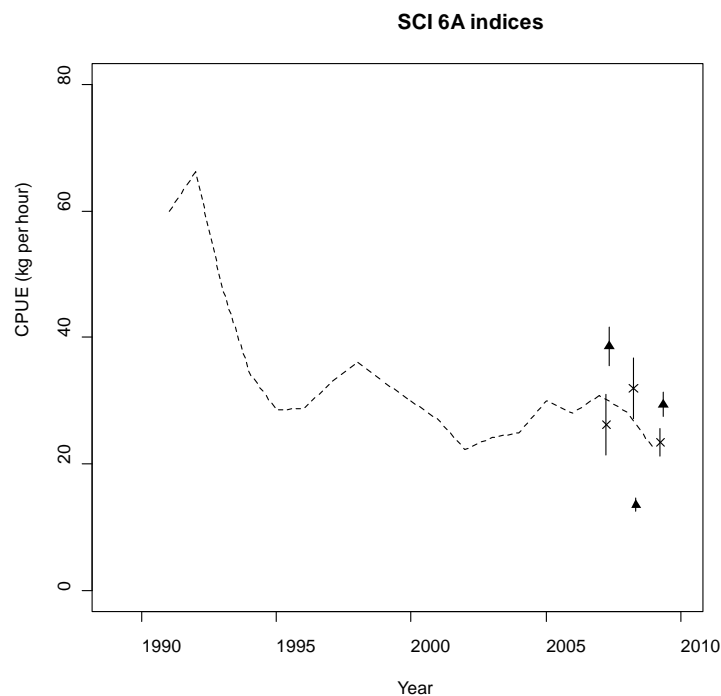
Mean catch rates and relative abundance (± one standard error) of research trawling and photo survey counts in the core area of SCI 6A. Symbols represent different aims of survey work (×-trawling within photo survey, ▲-scaled photo survey abundance). Dotted line represents median of annual unstandardised CPUE for SCI 6A.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	CPUE data suggest the stock may have declined in the early years of the fishery, but has remained at a relatively stable level since the mid 1990s. Photo and trawl survey data (2007 - 2009) suggest the stock has remained relatively stable in recent years
Recent Trend in Fishing Mortality or Proxy	Catches and stock abundance appear to have remained relatively stable in recent years, suggesting exploitation rates have been relatively stable
Other Abundance Indices	
Trends in Other Relevant Indicators or Variables	

Projections and Prognosis		
Stock Projections or Prognosis	Quantitative stock projections are unavailable.	
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown	
Assessment Methodology and Evaluation		
Assessment Type	Level 2. Abundance indices from CPUE, trawl and photo surveys	
Assessment Method		
Assessment Dates	Latest assessment: 2011 (CPUE analysis), 2009 (photo survey)	Next assessment: 2014 (CPUE & assessment model), 2013 (photo survey)
Overall assessment quality rank	1 – High Quality	
Main data inputs	- Standardised catch and effort	1 – High Quality

	data (TCEPR) from MPI - Length frequency data from MPI observer sampling	1 – High Quality
	- Photographic survey abundance index	1 – High Quality
	- Trawl survey abundance index	1 – High Quality
	- Length frequency data from research sampling	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	Length based model currently under development	
Major Sources of Uncertainty	Relationship between CPUE and abundance, growth, burrow occupancy, emergence and catchability	

Qualifying Comments

Photo surveys in SCI 6A observer a high number of scampi out of burrows, relative to burrows counted, than has been observed in other areas. This may be related to animal size or sediment characteristics. If emergence is greater, this may imply scampi in SCI 6A are more vulnerable to trawling than other areas.

CPUE index previously considered to be potentially strongly influenced by changes in catchability, and therefore not reliable as an index of abundance. Re-examination of the data has addressed some of the concerns, and the consistency between indices and also with similar species, may indicate the index is not as implausible as first considered.

Fishery Interactions

Main QMS bycatch species include ling, hoki, sea perch, red cod, silver warehou and giant stargazer. Discards dominated by rattails, javelinfish, skates and crabs, ling, red cod, hoki, spiny dogfish and sea perch. There have been interactions with seabirds and mammals (fur seals and sealions) recorded. A wide range of benthic invertebrate species are taken as bycatch.

7.   FOR FURTHER INFORMATION

Abraham E.R., Thompson F.N. 2011. Summary of the capture of seabirds, marine mammals, and turtles in New Zealand commercial fisheries, 1998–99 to 2008–09 New Zealand Aquatic Environment and Biodiversity Report No. 80.

Baird S.J. 2004a. Estimation of the incidental capture of seabird and marine mammal species in commercial fisheries in New Zealand waters, 1999-2000. New Zealand Fisheries Assessment Report 2004141.56 p.

Baird SJ. 2004b. Incidental capture of seabird species in commercial fisheries in New Zealand waters,2000-01. New Zealand Fisheries Assessment Report 2004158.63 p.

Baird S.J. 2004c. Incidental capture of seabird species in commercial fisheries in New Zealand waters, 2001-02. New Zealand Fisheries Assessment Report 2004160.51 p.

Baird S.J. 2005. Incidental capture of New Zealand fur seals (*Arctocephalus forsteri*) in commercial fisheries in New Zealand waters, 2002-03. New Zealand Fisheries Assessment Report 2005/13. 36 p.

Baird S.J. 2005. Incidental capture of seabird species in commercial fisheries in New Zealand waters, 2002-03. New Zealand Fisheries Assessment Report 200512.50 p.

Baird S.J., Doonan I.J. 2005. *Phocarctos hookeri* (New Zealand sea lions): incidental captures in New Zealand commercial fisheries during 2000-01 and in-season estimates of captures during squid trawling in SQU 6T in 2002. New Zealand Fisheries Assessment Report 2005/17. 20 p.

Baird S.J., Smith M.H. 2007. Incidental capture of New Zealand fur seals (*Arctocephalus forsteri*) in commercial fisheries in New Zealand waters, 2003–04 to 2004–05. New Zealand Aquatic Environment and Biodiversity Report No. 14. 98 p.

Baird S.J., Wood B.A., *et al*. 2011. Nature and extent of commercial fishing effort on or near the seafloor within the New Zealand 200 n. mile Exclusive Economic Zone, 1989-90 to 2004-05. New Zealand Aquatic Environment and Biodiversity Report 73. 143 p.

Baird S.J., Wood B.A. 2012. Extent of coverage of 15 environmental classes within the New Zealand EEZ by commercial trawling with sealoor contact. New Zealand Aquatic Environment and Biodiversity Report 89. 43 p.

Baker C.S., Chilvers B.L., Constantine R., DuFresne S., Mattlin R.H., van Helden A., Hitchmough R. 2010. Conservation status of New Zealand marine mammals (suborders Cetacea and Pinnipedia), 2009. New Zealand Journal of Marine and Freshwater Research 44: 101-115.Ballara, S.L.; Anderson, O.F. (2009). Fish discards and non-target fish catch in the trawl fisheries for arrow squid and scampi in New Zealand waters. New Zealand Aquatic Environment and Biodiversity Report No. 38. 102 p.

Ballara S.L., Anderson O.F. 2009. Fish discards and non-target catch in the trawl fisheries for arrow squid and scampi in New Zealand waters. New Zealand Aquatic Environment and Biodiversity Report, No 38.

Bell M.C., Redant F., Tuck I.D. 2006. Nephrops species. Lobsters: Biology, management, Aquaculture and Fisheries. B. Phillips. Oxford, Blackwell Publishing**:** 412-461.

Brothers N., Duckworth A.R., Safina C., Gilman E.L. 2010. Seabird bycatch in pelagic longline fisheries is grossly underestimated when using only haul data. PloS One 5: e12491. doi: 10.1371/journal.pone.001249

Chapman C.J. 1979. Some observations on populations of Norway Lobster, Nephrops norvegicus (L.), using diving, television, and photography. Rapports et process verbeaux de la Reunion Conseil international pour l'Exploration de la Mer 175:127-133.

Chapman C.J. 1980. Ecology of juvenile and adult Nephrops. In: The biology and management of lobster, Vol. 1. pp 143-178. (S. Cobb; B. Phillips, eds.), Academic Press, New York.

Chapman C.J., Howard F.G. 1979. Field observations on the emergence rhythm of the Norway Lobster Nephrops norvegicus, using different methods. Marine Biology 51:157-165.

Chapman C.J., Howard F.G. 1988. Environmental influences on Norway lobster (Nephrops norvegicus) populations and their implications for fishery management. Symposium of the Zoological Society, London 59:343-353.

Cryer M., Coburn R., Hartill B.W., O'Shea S., Kendrick T.H., Doonan I. 1999. Scampi stock assessment for 1998 and an analysis of the fish and invertebrate bycatch of scampi trawlers. New Zealand Fisheries Assessment Research Document 99/4. Ministry of Fisheries, Wellington. 74 p

Cryer M. 2000. A consideration of current management areas for scampi in QMAs 3, 4, 6A and 6B. Final Fisheries Report for Ministry of Fisheries Research Project MOF199904K, Objective 1.

Cryer M., Coburn R. 2000. Scampi assessment for 1999. N.Z. Fisheries Assessment Report 2000/7. 60 p.

Cryer M., Coburn R., Hartill B., O'Shea S., Kendrick T., Doonan I. 1999. Scampi stock assessment for 1998 and an analysis of the fish and invertebrate bycatch of scampi trawlers. N.Z. Fisheries Assessment Research Document 99/4. 75 p.

Cryer M., Doonan I., Coburn R., Hartill B. 1998. Scampi assessment for 1997. N.Z. Fisheries Assessment Research Document 98/28. 78 p.

Cryer M., Dunn A., Hartill B. 2004. Length-based population model for scampi (Metanephrops challengeri) in the Bay of Plenty (QMA 1). Draft FAR dated December 2004, held by MFish.

Cryer M., Hartill B. 1998. Final Research Report to Ministry of Fisheries on an experimental comparison of trawl and photographic methods of estimating the biomass of scampi. Final Research Report for Project SCI9701 held at NIWA Wellington library. 26 p.

Cryer M., Hartill B. 2001. Scampi assessment for 2000 and unstandardised CPUE 1988-89 to 1999-00. Draft FAR dated December 2000, held by MFish.

Cryer M., Hartill B.W., O'Shea S. 2002. Modification of marine benthos by trawling: toward a generalization for the deep ocean? Ecological Applications 12: 1824–1839.

Cryer M., Hartill B., O'Shea S. 2005. Deepwater trawl fisheries modify benthic community structure in similar ways to fisheries in coastal systems. Am. Fish. Soc. Symp. 41: 695-696.

Cryer M., Hartill B., Drury J., Armiger H.J., Smith M.D., Middleton C.J. 2003. Indices of relative abundance for scampi, Metanephrops challengeri, based on photographic surveys in QMA 1 (1998-2003) and QMA 2 (2003). Final Research Report for Project SCI2002/01 (Objectives 1-3). 18 p, held by MFish.

Cryer M., Hartill B., Drury J., Tuck I., Cadenhead H.J., Smith M.D., Middleton C.J. 2002. Indices of relative abundance for scampi, Metanephrops challengeri, based on photographic surveys in QMA 1, 1998-2002. Final Research Report for Projects SCI2000/02 (Objectives 1 & 2) and SCI2001/01 (Objectives 1 & 2), dated November 2002, held by MFish.

Cryer M., Oliver M. 2001. Estimating age and growth in New Zealand scampi, Metanephrops challengeri. Final Research Report for Ministry of Fisheries Project SCI9802 (Objective 2), held by MFish.

Cryer M., Stotter D.R 1997. Trawling and tagging of scampi off the Alderman Islands, western Bay of Plenty, September 1995 (KAH9511). N.Z. Fisheries Data Report #84. 26 p.

Cryer M., Stotter D.R 1999. Movements and growth rates of scampi inferred from tagging, Aldermen Islands, western Bay of Plenty. NIWA Technical Report #49. 35 p.

Cryer M., Vignaux M., Gilbert D.J. 1995. Assessment of the scampi fishery for 1995. Draft N.Z. Fisheries Assessment Research Document., held by MFish.

Dunn M.P., Horn *et al.* 2009. Ecosystem-scale trophic relationships: diet composition and guild structure of middle-depth fish on the Chatham Rise. Ministry of Fisheries Research Project, ZBD2004-02 Final Report.

Farmer A.S.D. 1974. Reproduction in Nephrops norvegicus (Decapoda: Nephropidae). J. Zool. Lond. 174:161-183.

Fenaughty C. 1989. Reproduction in Metanephrops challengeri. Unpublished Report, MAF Fisheries, Wellington.

Hartill B., Cryer M. 2001. Unstandardised CPUE indices for scampi 1988-2001. Final Research Report for Project SCI2001/02, dated November 2001, held by MFish.

Hartill B., Cryer M. 2002. Unstandardised CPUE indices for scampi 1988-2002. Final Research Report for Project SCI2001/02 (Objective 2), dated December 2002, held by MFish.

Hartill B., Cryer M. 2004. Unstandardised scampi CPUE indices update for scampi 1988-2003. Final Research Report for Ministry of Fisheries Research Project SCI2001/02, Obj. 2. 35p, held by MFish.

Hartill B., Cryer M., MacDiarmid A.D. 2004. Reducing bycatch in scampi trawl fisheries. Draft New Zealand Fisheries Assessment Report dated December 2004, held by MFish.

Hartill B., Tuck I.D. 2010. Potential utility of scampi processor grade data as a source of length frequency data. Final Research Report for Ministry of Fisheries Project SCI2007-03

Hermsen J.M., Collie J.S., Valentine P.C. 2003. Mobile fishing gear reduces benthic megafaunal production on Georges Bank Mar. Ecol. Prog. Ser. 260: 97-108

Hiddink J.G., Jennings S., Kaiser M.J., Queiros A.M., Duplisea D.E., Piet G.J. 2006. Cumulative impacts of seabed trawl disturbance on benthic biomass, production, and species richness in different habitats. Can. J. Fish. Aquat. Sci. 63:721–36

Hore A.J. 1992. Management of the New Zealand Scampi Fishery: an interim report to the Director General of Agriculture and Fisheries. Unpublished Report. MAF Fisheries, Wellington.

Hughes D., Atkinson R. 1997. A towed video survey of megafaunal bioturbation in the north-eastern Irish Sea. Journal of the Marine Biological Association of the United Kingdom 77(3): 635-653.

Jennings S., Dinmore T.A., Duplisea D.E., Warr K.J., Lancaster J.E. 2001. Trawling disturbance can modify benthic production processes. Journal of Animal Ecology 70: 459–475.

Kelleher K. 2005. Discards in the world's marine fisheries. An update. FAO Fisheries Technical Paper 470. 131 p.

Leathwick J.R., Rowden A., Nodder S., Gorman R., Bardsley S., Pinkerton M., Baird S.J., Hadfield M., Currie K., Goh A. 2009. Benthic-optimised marine environment classification for New Zealand waters. Final Research Report project BEN2006/01. 52 p.

MacKenzie D., Fletcher D. 2006. Characterisation of seabird captures in NZ fisheries. Final Research Report for Ministry of Fisheries project ENV2004/04. 99 p.

Meynier L., Morel P.C.H., *et al.* 2008. Proximate composition, energy content, and fatty acid composition of marine species from Campbell Plateau, New Zealand. New Zealand Journal of Marine and Freshwater Research 42(4): 425-437

Middleton D.A.J., Abraham E.R. 2007. The efficacy of warp strike mitigation devices: Trials in the 2006 squid fishery. Final Research Report for research project IPA2006/02. (Unpublished report held by Ministry of Fisheries, Wellington).

Rainer S.F. 1992. Growth of Australian scampi, Metanephrops australiensis. The fisheries biology of deepwater crustacea and finfish on the continental slope of Western Australia. S. F. Rainer. Final Report FRDC Project 1988/74.

Reiss *et al*. 2009. Effects of fishing disturbance on benthic communities and secondary production within an intensively fished area. Marine Ecology Progress Series394: 201–213.

Rice J. 2006. Impacts of Mobile Bottom Gears on Seafloor Habitats, Species, and Communities: A Review and Synthesis of Selected International Reviews. Canadian Science Advisory Secretariat Research Document 2006/057. 35 p. (available from http://www.dfo-mpo.gc.ca/CSAS/Csas/DocREC/2006/RES2006_057_e.pdf)

Tuck I., Cryer M., Hartill B., Drury J., Armiger H., Smith M., Parkinson D., Middleton C. 2006. Measuring the abundance of scampi - Indices of abundance for scampi, Metanephrops challengeri, based on photographic surveys in SCI 2 (2003-2005). Final Research Report for Ministry of Fisheries Research Project SCI2004/01 (Objectives 1 & 2) , held by MFish.

Tuck I.D., Hartill B., Drury J., Armiger H., Smith M., Parkinson D. 2006. Measuring the abundance of scampi – Indices of abundance for scampi, *Metanephrops challengeri*, based on photographic surveys in SCI 2 (2003-2006). Draft Final Fisheries Report for Ministry of Fisheries Research Project SCI2005-01 (Objective 1).

Tuck. I.D. 2007. A medium term research plan for scampi (*Metanephrops challengeri*). Final Research Report for Ministry of Research Project SAP200607.

Tuck I.D. 2009. Scampi burrow occupancy, burrow emergence, and catchability, New Zealand Fisheries Assessment Report 2009/xx.

Tuck I.D., Dunn A. 2009. Length-based population model for scampi (*Metanephrops challengeri*) in the Bay of Plenty (SCI 1) and Wiararapa / Hawke Bay (SCI 2). Final Research Report for Ministry of Fisheries research projects SCI2006-01 & SCI2008-03W

Tuck I.D., Dunn A. 2012. Length-based population model for scampi (*Metanephrops challengeri*) in the Bay of Plenty (SCI 1), Wiararapa / Hawke Bay (SCI 2), and Auckland Islands (SCI 6A). New Zealand Fisheries Assessment Report 2012/01

Tuck I.D., Hartill B., Parkinson D., Harper S., Drury J., Smith M., Armiger H. 2009. Estimating the abundance of scampi - Relative abundance of scampi, *Metanephrops challengeri*, from a photographic survey in SCI 1 and SCI 6A (2008). Final Research Report for Ministry of Fisheries research project SCI2007-02.

Vignaux M., Gilbert D.J. 1993. A production model for the QMA 1 scampi fishery 1989-1991. N.Z. Fisheries Assessment Research Document 93/18.

Vignaux M., Gilbert D.J. 1994. A production model for the QMA 1 scampi fishery 1989-1992. N.Z. Fisheries Assessment Research Document 94/8.

Wear R.G. 1976. Studies on the larval development of *Metanephrops challengeri* (Balss, 1914) (Decapoda, Nephropidae). Crustaceana 30:113-122.

SCHOOL SHARK (SCH)

(*Galeorhinus galeus*)
Tupere, Tope, Makohuarau
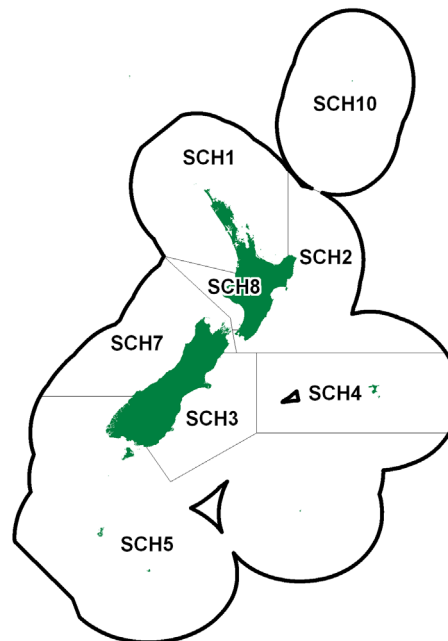
1.   FISHERY SUMMARY

1.1   Commercial fisheries

This moderate-sized shark has supported a variety of fisheries around New Zealand from the early 1940s onwards. Landings rose steeply from the late 1970s until 1983 (Table 1), with the intensification of setnetting targeting this and other species, and a general decline in availability of other, previously more desirable, coastal species. However, because of the earlier discarding and under-reporting, this recorded rise in landings does not reflect an equal rise in catches. After a small decline in 1984-85, catches decreased by about 50% from 1986 onwards because of reduced quotas within the QMS (Table 2). From 1987-88 to 1991-92 total reported landings were around 2200-2500 t. In 1995-96 total landings increased markedly to 3387 t and the total TACC (3107 t) was exceeded for the first time. Landings have remained around the TACC level since 1995-96. TACCs for SCH 3, 5, 7 & 8 were increased by between 5% (SCH 5) and 20% (the remainder) under AMP management in October 2004. From the 1 October 2007 the TACC for SCH 1 was increased to 689 t, at that time a TAC was set for the first time at 893 t with 102 t, 68 t and 34 t being allocated to customary, recreational and other sources of motility respectively. In 2004 SCH 3, 5, 7 & 8 were allocated an equal recreational and customary non-commercial catch of 48 t, 7 t, 58 t, and 21 t respectively and other sources of mortality were allocated 19 t, 37 t, 32 t, and 26 t respectively. All AMP programmes ended on 30th September 2009. Table 1 shows the historical landings and TACC values for the main SCH stocks.

Table 1: Reported domestic landings (t) of school shark from 1948 to 1983.

Year	Landings	Year	Landings	Year	Landings	Year	Landings
1948	75	1957	301	1966	316	1975	518
1949	124	1958	323	1967	376	1976	914
1950	147	1959	304	1968	360	1977	1 231
1951	157	1960	308	1969	390	1978	161
1952	179	1961	362	1970	450	1979	481
1953	142	1962	354	1971	597	1980	1 788
1954	185	1963	380	1972	335	1981	2 716
1955	180	1964	342	1973	400	1982	2 965
1956	164	1965	359	1974	459	1983	3 918

Source: MAF data.

During the period of high landings in the mid 1980s setnetting was the main fishing method, providing about half the total catch, with lining accounting for one-third of the catch, and trawling the remainder. There were large regional variations.

Small amounts of school shark are also caught by the foreign charter tuna longliners fishing offshore in the EEZ to well beyond the shelf edge.

The Banks Peninsula Marine Mammal Sanctuary was established in 1988 by the Department of Conservation under the Marine Mammal Protection Act 1978, for the purpose of protecting Hector's dolphins. The sanctuary extends 4 nautical miles from the coast from Sumner Head in the north to the Rakaia River mouth in the south. Prior to 1 October 2008, no setnets were allowed within the sanctuary between 1 November to the end of February. For the remainder of the year, setnets were allowed; but could only be set from an hour after sunrise to an hour before sunset, be no more than 30 metres long, with only one net per boat which was required to remain tied to the net while it was set.

Voluntary setnet closures were implemented by the SEFMC from 1 October 2000 to protect nursery grounds for rig and elephantfish and to reduce interactions between commercial setnets and Hector's dolphins in shallow waters. The closed area extended from the southernmost end of the Banks Peninsula Marine Mammal Sanctuary to the northern bank of the mouth of the Waitaki River. This area was closed permanently for a distance of 1 nautical mile offshore and for 4 nautical miles offshore for the period 1 October to 31 January.

From 1 October 2008, a suite of regulations intended to protect Maui's and Hector's dolphins was implemented for all of New Zealand by the Minister of Fisheries.

For SCH 1, there have been two recent changes to the management regulations affecting setnet fisheries which take school shark off the west coast of the North Island. The first was a closure to setnet fishing from Maunganui Bluff to Pariokariwa Point for a distance of 4 nautical miles on 1 October 2003. This closure was extended by the Minister to 7 nautical miles on 1 October 2008. An appeal was made by affected fishers who were granted interim relief by the High Court, allowing setnet fishing beyond 4 nautical miles during daylight hours between 1 October to 24 December.

For SCH 3, commercial and recreational set netting was banned in most areas to 4 nautical miles offshore of the east coast of the South Island, extending from Cape Jackson in the Marlborough Sounds to Slope Point in the Catlins. Some exceptions were allowed, including an exemption for commercial and recreational set netting to only one nautical mile offshore around the Kaikoura Canyon, and permitting setnetting in most harbours, estuaries, river mouths, lagoons and inlets except for the Avon-Heathcote Estuary, Lyttelton Harbour, Akaroa Harbour and Timaru Harbour. In addition, trawl gear within 2 nautical miles of shore was restricted to flatfish nets with defined low headline heights.

For SCH 5, commercial and recreational setnetting was banned in most areas to 4 nautical miles offshore, extending from Slope Point in the Catlins to Sandhill Point east of Fiordland and in all of Te Waewae Bay. An exemption which permitted setnetting in harbours, estuaries and inlets was allowed. In addition, trawl gear within 2 nautical miles of shore was restricted to flatfish nets with defined low headline heights.

For SCH 7, both commercial and recreational setnetting were banned to 2 nautical miles offshore, with the recreational closure effective for the entire year and the commercial closure restricted to the period 1 December to the end of February. The closed area extends from Awarua Point north of Fiordland to the tip of Cape Farewell at the top of the South Island. There is no equivalent closure in SCH 8, with the southern limit of the Maui's dolphin closure beginning north of New Plymouth at Pariokariwa Point. There have been two recent changes to the management regulations affecting setnet fisheries which take school shark off the west coast of the North Island.

1.2 Recreational fisheries

Although school shark is a listed gamefish and is regularly caught by recreational fishers, it is not considered to be a particularly desirable target species at the present time. Recreational catch records have been obtained from diary surveys undertaken in 1991-94, 1996 and 1999-00 (Tables 3 and 4).

Table 2: Reported landings (t) of school shark by Fishstock from 1983-84 to 2010-11 and actual TACCs (t) from 1986-87 to 2010-11. QMS data from 1986-present.

| Fishstock | SCH 1 | | SCH 2 | | SCH 3 | | SCH 4 | | SCH 5 | |
| FMA (s) | 1 & 9 | | 2 | | 3 | | 4 | | 5 & 6 | |
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983-84*	1 087	-	298	-	630	-	8	-	792	-
1984-85*	861	-	237	-	505	-	12	-	995	-
1985-86*	787	-	214	-	370	-	23	-	647	-
1986-87	418	560	137	160	283	270	19	200	382	610
1987-88	530	604	123	168	320	289	22	200	529	613
1988-89	483	624	134	188	222	294	25	200	494	615
1989-90	585	652	154	197	272	305	27	235	450	635
1990-91	559	664	139	198	227	318	21	239	480	649
1991-92	596	664	161	198	264	318	34	239	612	686
1992-93	820	664	202	199	220	320	38	239	593	686
1993-94	658	667	156	199	202	322	41	239	624	686
1994-95	658	668	159	199	237	322	86	239	656	694
1995-96	804	668	212	199	296	322	229	239	690	694
1996-97	793	668	228	199	290	322	179	239	662	694
1997-98	764	668	214	199	270	322	127	239	623	694
1998-99	783	668	275	199	331	322	100	239	714	694
1999-00	820	668	250	199	341	322	97	239	706	694
2000-01	799	668	178	199	364	322	100	239	724	694
2001-02	691	668	208	199	324	322	93	239	673	708
2002-03	689	668	225	199	410	322	130	239	746	708
2003-04	758	668	187	199	323	322	149	239	727	708
2004-05	694	668	201	199	424	387	206	239	743	743
2005-06	634	668	177	199	325	387	183	239	712	743
2006-07	661	668	200	199	376	387	88	239	738	743
2007-08	708	689	227	199	345	387	133	239	781	743
2008-09	713	689	232	199	364	387	145	239	741	743
2009-10	589	689	213	199	426	387	191	239	784	743
2010-11	777	689	187	199	366	387	174	239	701	743

| Fishstock | SCH 7 | | SCH 8 | | SCH 10 | | | |
| FMA (s) | 7 | | 8 | | 10 | | Total | |
	Landings	TACC	Landings	TACC	Landings	TACC	Landings§	TACC
1983-84*	1 039	-	694	-	0	-	4 776	-
1984-85*	1 030	-	698	-	0	-	4 501	-
1985-86*	851	-	652	-	0	-	3 717	-
1986-87	454	470	229	310	0	10	1 946	2 590
1987-88	515	500	374	345	0	10	2 367	2 729
1988-89	532	522	419	433	0	10	2 309	2 886
1989-90	516	524	371	438	0	10	2 377	2 996
1990-91	420	531	369	441	0	10	2 215	3 050
1991-92	431	531	409	441	0	10	2 508	3 086
1992-93	482	531	484	441	0	10	2 839	3 089
1993-94	473	531	448	441	0	10	2 603	3 093
1994-95	370	534	417	441	0	10	2 583	3 105
1995-96	635	534	521	441	0	10	3 387	3 107
1995-96	542	534	459	441	0	10	3 153	3 107
1997-98	471	534	447	441	0	10	2 917	3 107
1998-99	681	534	533	441	0	10	3 421	3 107
1999-00	639	534	469	441	0	10	3 324	3 107
2000-01	576	534	453	441	0	10	3 193	3 107
2001-02	501	534	449	441	0	10	2 913	3 121
2002-03	512	534	448	441	0	10	3 161	3 121
2003-04	574	534	405	441	0	10	3 124	3 121
2004-05	546	641	554	529	0	10	3 368	3 416
2005-06	568	641	503	529	0	10	3 102	3 416
2006-07	583	641	534	529	0	10	3 180	3 416
2007-08	606	641	497	529	0	10	3 299	3 437
2008-09	694	641	588	529	0	10	3 477	3 437
2009-10	605	641	460	529	0	10	3 268	3 436
2010-11	677	641	587	529	0	10	3 469	3 436

* FSU data. § Includes landings from unknown areas before 1986-87.
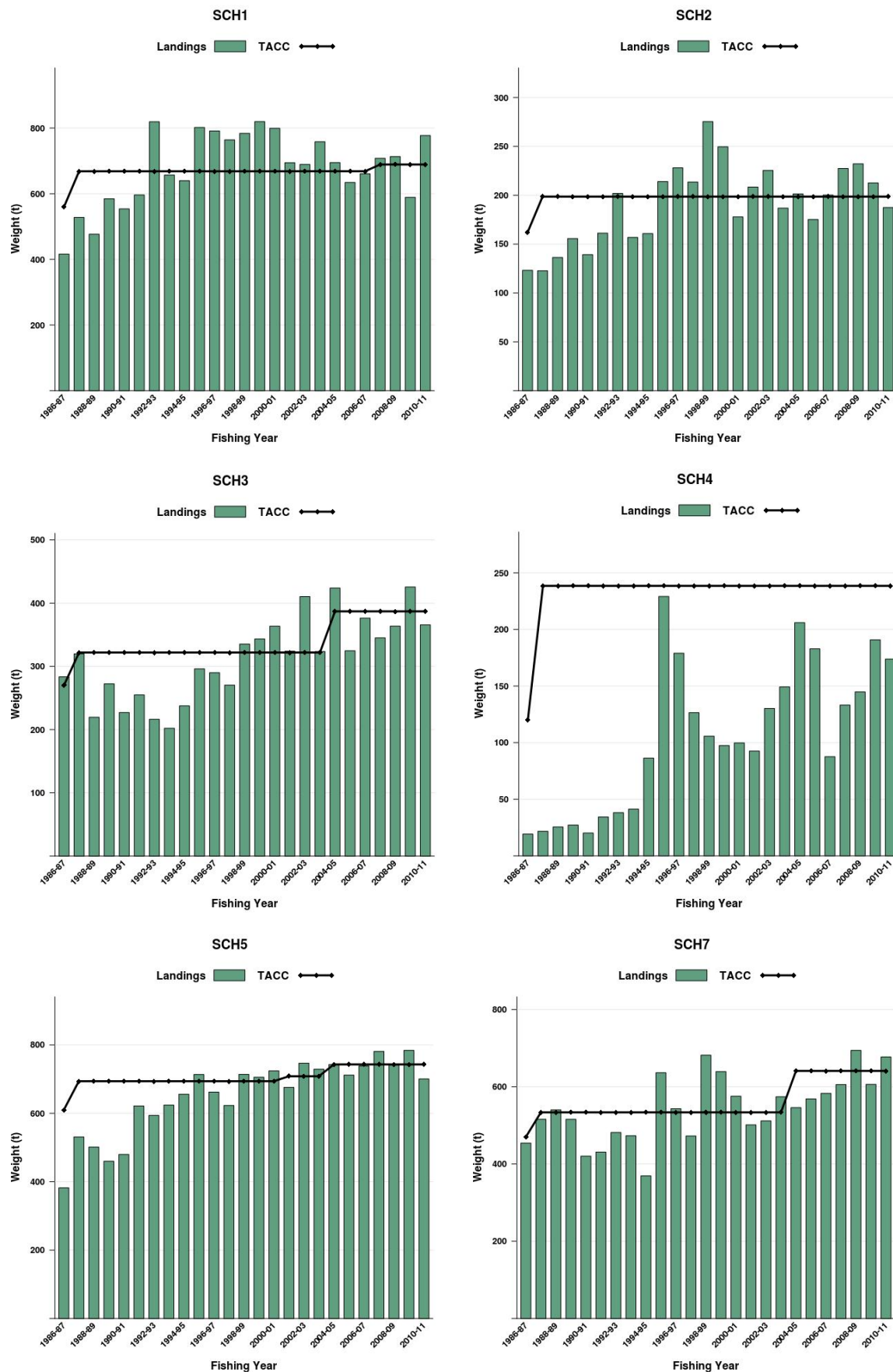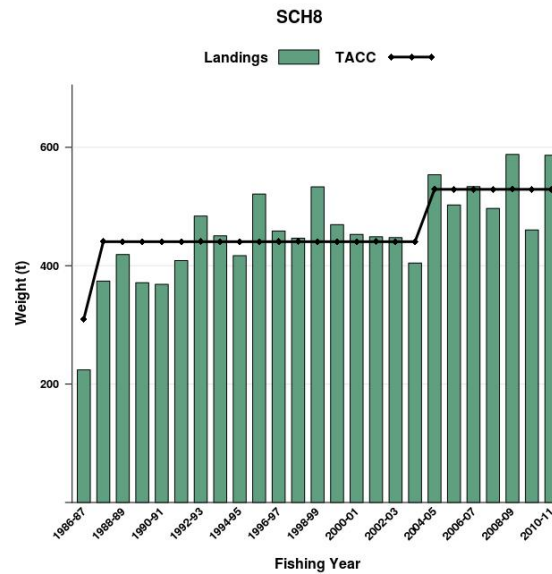
SCHOOL SHARK (SCH)

Figure 1: Historical landings and TACC for the seven main SCH stocks. From top left: SCH1 (Auckland East), SCH2 (Central East), SCH3 (South East coast), SCH4 (South East Chatham Rise), SCH5 (Southland), SCH7 (Challenger). [Continued on next page].

Figure 1 [Continued]: Historical landings and TACC for the seven main SCH stocks. SCH8 (Central Egmont). Note that these figures do not show data prior to entry into the QMS.

The Recreational Technical Working Group recommends that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and c) the 2000 and 2001 estimates are implausibly high for many important fisheries. Relative comparisons may be possible between stocks within these surveys.

Table 3: Estimated number and weight of school sharks harvested by recreational fishers relative to Fishstock and survey. Surveys were carried out in different years in the Ministry of Fisheries regions: South in 1991-92, Central in 1992-93 and North in 1993-94 (Teirney *et al.* 1997).

Fishstock	Survey	Number	Total CV (%)	Survey harvest (t)
SCH 1	North	17 000	24	10-170
SCH 1	Central	1 000	-	0-10
SCH 2	Central	13 000	27	25-45
SCH 3	South	6 000	33	15-35
SCH 5	South	1 000	-	0-10
SCH 7	Central	9 000	84	10-35
SCH 7	South	3 000	-	5-15
SCH 8	Central	7 000	45	10-30

Table 4: Estimates of annual number and weight of school shark harvested by recreational fishers from national diary surveys in 1996 (Bradford 1998) and Dec1999-Nov 2000 (Boyd & Reilly 2005). The mean weights used to convert numbers to catch weight are considered the best available estimates. Estimated harvest is also presented as a range to reflect the uncertainty in the point estimates.

Fishstock	Number caught	CV (%)	Estimated harvest range (t)	Point estimate (t)
1996				
SCH 1	23 000	17	35-55	46
SCH 2	5 000	-	-	-
SCH 3	3 000	-	-	-
SCH 5	1 000	-	-	-
SCH 7	8 000	24	5-25	16
SCH 8	11 000	22	15-25	21
1999-00				
SCH 1	27 000	42	38-93	66
SCH 2	7 000	30	13-24	18
SCH 3	19 000	46	26-70	48
SCH 5	3 000	66	2-11	7
SCH 7	23 000	56	26-91	58
SCH 8	3 000	55	4-13	8

1.3 Customary non-commercial fisheries

Maori fishers made extensive use of school shark in pre-European times for food, oil, and skin. There is no quantitative information on the current level of customary non-commercial take.

1.4 Illegal catch

There is no quantifiable information on the level of illegal catch. There is an unknown amount of unreported offshore trawl and pelagic longline catch of school shark, either landed (under another name, or in "mixed") or discarded.

1.5 Other sources of mortality

There is an unknown discarded bycatch of juvenile, mainly first-year, school shark taken in harbour and bay setnets. Quantitative information is not available on the level of other sources of mortality.

2. BIOLOGY

School sharks are distributed across the shelf, generally being inshore in summer and offshore in winter. They extend in smaller numbers near the seafloor down the upper continental slope, to at least 600 m. The capture of school sharks by tuna longliners shows that their distribution extends well offshore, up to 180 nm off the South Island, and 400 nm off northern New Zealand towards the Kermadec Islands. They feed predominantly on small fish and cephalopods (octopus and squid).

Growth rates have not been estimated for New Zealand fish, but in Australia and South America school sharks are slow growing and long-lived (Grant *et al.* 1979, Olsen 1984, Peres & Vooren 1991). They are difficult to age by conventional methods, but up to 45 vertebral rings can be counted. Growth is fastest for the first few years, slows appreciably between 5 and 15 years, and is negligible at older ages, particularly after 20. Results from an Australian long-term tag recovery suggest a maximum age of at least 50 years. Age-at-maturity has been estimated at 12-17 years for males and 13 to 15 years for females (Francis & Mulligan 1998). The size range of commercially caught maturing and adult school shark is 90-170 cm total length (TL), with a broad mode at 110-130 cm TL, which varies with area, season and depth.

Breeding is not annual; it has generally been assumed to be biennial, but recent work on a Brazilian stock suggests that females have a 3-year cycle (Peres & Vooren 1991). Fecundity (pup number) increases from 5-10 in small females to over 40 in the largest. Mating is believed to occur in deep water, probably in winter. Release of pups occurs during spring and early summer (November-January), apparently earlier in the north of the country than in the south. Nursery grounds include harbours, shallow bays and sheltered coasts. The pups remain in the shallow nursery grounds during their first one or two years and subsequently disperse across the shelf. The geographic location of the most important pupping and nursery grounds in New Zealand is not known.

Table 5: Estimates of biological parameters for school shark.

Fishstock	Estimate		Source
1. Weight = a (length)^b (Weight in g, length in cm fork length)			
	Both sexes combined		
	a	b	
SCH 1	0.0003	3.58	McGregor (unpub.)
SCH 3	0.0035	3.08	McGregor (unpub.)
SCH 5	0.0181	2.72	McGregor (unpub.)
SCH 5	0.0068	2.94	Hurst *et al.* (1990)
SCH 7	0.0061	2.94	Blackwell (unpub.)
SCH 8	0.0104	2.84	Blackwell (unpub.)
2. Estimate of *M* for Australia			
	0.1		Grant *et al*. (1979), Olsen (1984)

The combination of late maturity, slow growth, and low fecundity gives a low overall productivity. In Australia, *M* has been estimated as 0.1.

New Zealand tagging studies have shown that school shark may move considerable distances, including trans-Tasman migrations (for details see the 1995 Plenary Report).

Biological parameters relevant to stock assessment are shown in Table 5.

3. STOCKS AND AREAS

Information relevant to determining school shark stock structure in New Zealand was reviewed in 2009 (Smith 2009, Blackwell & Francis 2010, Francis 2010). Primarily based on the tagging evidence, there is probably a single biological stock in the New Zealand EEZ. Genetic, biological, fishery and tagging data were all considered, but the evidence for the existence of distinct biological stocks is poor. Some differences were found in CPUE trends between OMAs, but stock separation at the QMA level seems unlikely, and the CPUE differences may have resulted from processes acting below the stock level, such as localised exploitation of different sexes or different size classes of sharks. An apparent lack of juvenile school shark nursery areas in SCH 4 and SCH 5 suggests that these Fishstocks are not distinct, but are instead maintained by recruitment from other QMAs.

The most useful source of information was an opportunistic tagging programme undertaken mainly on research trawlers since 1985 (Hurst *et al*. 1999). However most tag releases were made around the South Island so little information is provided for North Island school shark. Female school shark were slightly more mobile than males, with higher proportions of the former moving to non-adjacent QMAs and to Australia. About 30% of school shark recaptures were reported from outside the release QMA within a year of release, and this was maintained in the second year after release. After 2-5 years at liberty about 60% of recaptured school sharks (both sexes) were reported from outside the release QMA. After more than 5 years at liberty, 8% of males and 19% of females were recaptured from Australia. A large proportion of tagged school sharks moved outside the QMA of release within 5 years, and a significant proportion eventually moved to Australia. These trends in apparent movement are consistent across two decades of tagging. The relative importance of various breeding grounds around New Zealand (e.g., aggregations of breeding females in Kaipara Harbour) and whether females return to the area in which they were born are unknown.

The current stock management units are a precautionary measure to spread fishing effort; amalgamation of all QMAs into one QMA for the whole EEZ could create unacceptable risks to stock sustainability.

4. STOCK ASSESSMENT

4.1 Estimates of fishery parameters and abundance
Fishery characterisations and CPUE analyses for SCH 1, SCH2, SCH3, SCH 5, SCH 7 and SCH 8 were undertaken in 2010 as part of the review of AMP stocks. Although SCH 1 and SCH 2 are not AMP stocks they were included by Industry to obtain a better understanding of the status of New Zealand school shark.

SCH 1
SCH 1 are primarily taken by bottom trawl while targeting tarakihi and snapper, with smaller catches when targeting trevally and red gurnard. The bottom longline SCH 1 fishery is primarily directed at school shark, with hapuku and snapper being other important targets. The setnet fishery is also primarily targeted at school shark, with some targeting of rig, trevally, gurnard and snapper.

The previously accepted indices for SCH 1 were based on bottom longline snapper (1E) and a bottom trawl mixed (1W) catches. The 2010 assessment explored a wide range of alternative fishery definitions and the AMP FAWG accepted indices based on SN and BLL catches on both the east and

west coasts. These indices were based on Generalized Linear Models of positive catches with log normal error distribution. Models of bottom trawl catch were not explored.

Standardised CPUE abundance indices for SCH 1 show different trends west and east of North Cape (Fig. 2).

SCH 1 W
Discounting the last two years of the analysis (2007/08 and 2008/09) for setnet (which are poorly estimated), the SN and BLL indices for SCH 1W are flat, indicating no change in abundance over the past 20 years (Fig. 2). Analysis of the spatial distribution of catches revealed that the BLL catches were concentrated around North Cape and the SN catches were mostly made in the North Taranaki Bight; near the SCH 8 boundary line. The SN index shows very high uncertainty over the last two years of the analysis (2007/08 and 2008/09), potentially being affected by recent setnet closures on the west coast. There are now only two vessels in this west coast SN fishery and the index may become unreliable in future.

SCH 1E
Since 1998-99 the SCH 1E index shows an increasing trend to above the long-term average, peaking in 2003-04, and then dropping to just above the average by 2005-06 and remained at about that level to 2008/09(Fig. 2).
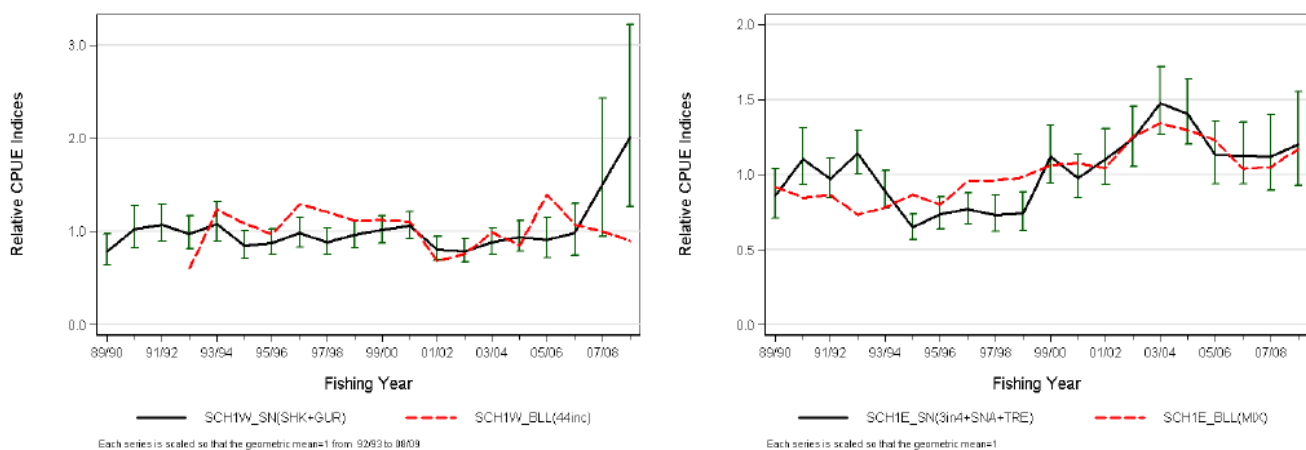

1W_BLL(44inc); [right panel] comparison of the two SCH 1E standardised series: SCH 1E_SN(3in4+SNA+TRE) and SCH 1W_BLL(MIX). (Each series is scaled so that the geometric mean = 1) Starr & Kendrick (2010a).

SCH 2
SCH 2 are caught primarily in the bottom trawl fishery (46%) targeting tarakihi, hoki, gemfish and gurnard; and the bottom longline fishery (30%) targeting school shark, ling, hapuku/bass and bluenose. Sixteen per cent of the catch is taken in setnet targeting school shark, blue warehou and blue moki.

The 2010 analyses used setnet and bottom longline (no bottom trawl index was attempted), based on a broader range of target fisheries than previously. The previous assessment used tarakihi bottom trawl index.

Two indices were considered for SCH 2 in 2010: one based on setnet catches with a range of target (SN[MIX]) and the other based on bottom longline catches, also with a range of targets. These two indices present conflicting trends, the setnet index generally increasing over the series and the bottom longline index decreasing steadily (Fig. 3). The AMP FAWG noted particular concerns with the bluenose targeted bottom longline index, related to suggestions of a steady shift towards mid-water targeting of bluenose. There is a substantial correspondence between the standardised setnet index for SCH 2 with setnet and bottom longline indices for SCH 1E, which together indicate a slow but steady increase in CPUE to 2005-06, levelling off since then.
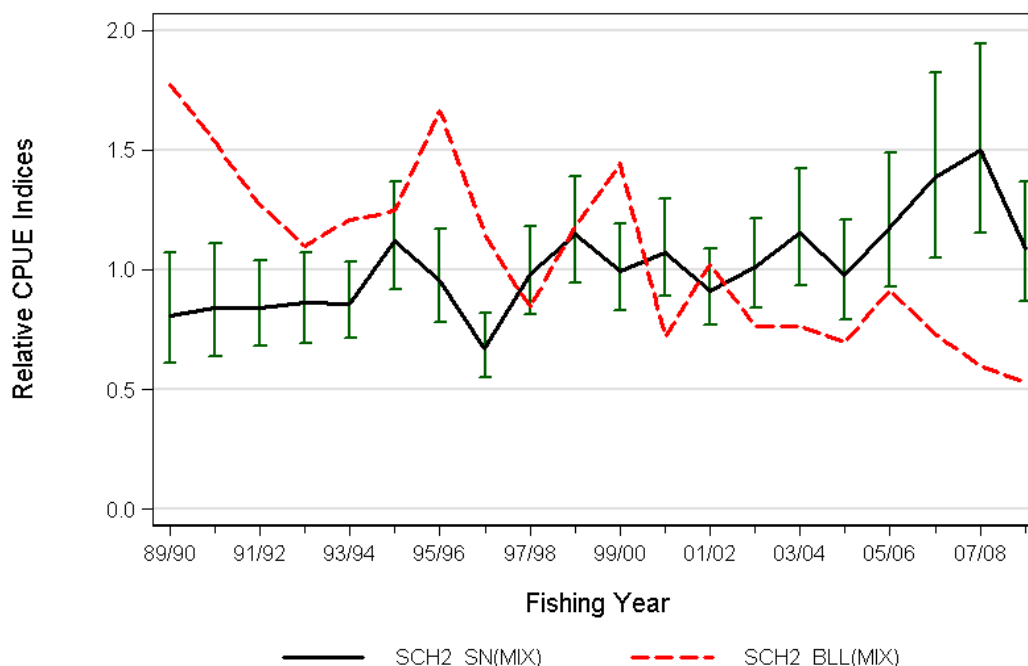
Figure 3: Comparison of the lognormal indices from the two fisheries operating in SCH 2: a) SN[MIX]: mixed target species; b) BLL[MIX]: mixed target species Starr & Kendrick (2010b).

SCH 3

SCH 3 is predominantly caught in the setnet fishery (56%) targeting school shark and rig, with some targeting of spiny dogfish and tarakihi; and in the bottom trawl fishery (36%) targeting red cod, with some targeting of flatfish, barracouta and tarakihi. Mixed targeted bottom longline takes 7% of the catch.

The mixed shark target SN(SHK) standardised CPUE is the accepted index of abundance for SCH 3. The 2010 CPUE analysis is an update of the shark-targeted setnet CPUE analysis conducted in 2003 and 2007, with no extension to other target species or other model changes. This index shows a sharp decline of almost 60% from a peak in 1989-90 to its lowest point over the 20 year series in 1992-93 (Fig. 4). Thereafter the index shows a steady and continual increase through to 2003-04 / 2004-05 to a level about 10% above the long-term average and about 40% above the lowest level, fluctuating around this level thereafter.
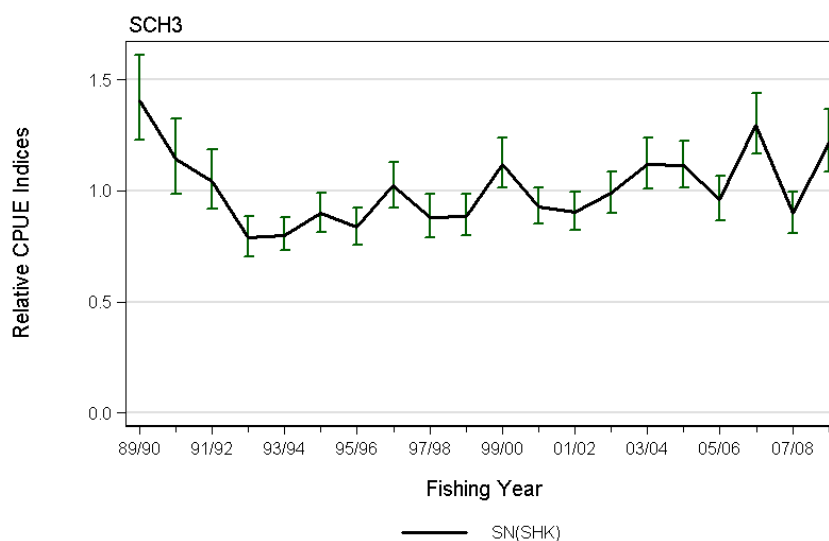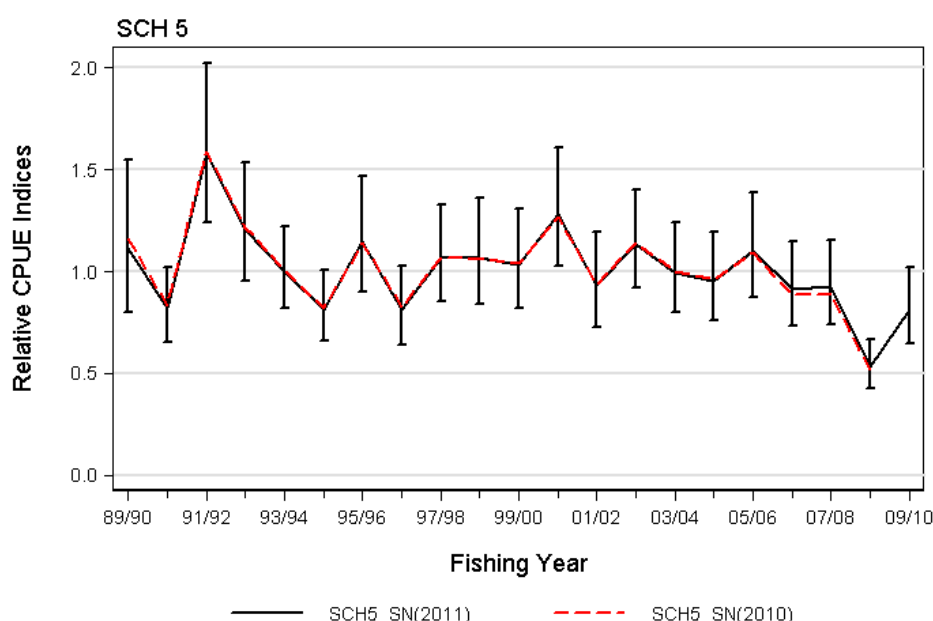

Figure 4: Lognormal SCH 3_SN(SHK) standardised indices with core vessel criteria of at least 10 trips in a minimum of 6 years) (series is scaled so that the geometric mean = 1). From Starr *et al*. (2010a).

SCH 5

SCH 5 is almost entirely caught in the school shark targeted setnet fishery (83%), with some minor targeting of rig. Seven percent is taken by bottom trawl primarily targeting stargazer and squid, and 5% by bottom longline primarily targeting hapuku/bass and ling.

The targeted SN(SCH) standardised CPUE index is the accepted indicator of SCH 5 abundance. The 2011 CPUE analysis is an update of previous analyses conducted in 2003, 2007 and 2010, with no substantial changes to the fishery definitions or standardisation models. The index fluctuated around long-term average levels through to 2005-06 (Fig. 5). Thereafter the index declines to slightly below average levels over 2006-07/2007-08, and then steeply to about half average levels in 2008-09. The index is considered to be less reliably estimated in the final year, due to changes in fleet size and structure.

Figure 5: Lognormal SCH 5_SN(2011) standardised index and the index from the 2010 assessment SCH5_SN(2010). From Starr and Kendrick (2011).

There is close correspondence in the declining indices for SCH 5 and SCH 7, except in the final year. Both indices monitor mature fish caught around Southland and the WCSI, raising some concern about the declines in both these areas.

SCH 7

SCH 7 are caught about one-third each by setnet targeting school shark, rig and spiny dogfish; bottom longline targeting school shark, hapuku/bass and ling; and bottom trawl targeting barracouta, tarakihi, flatfish, hoki, red cod and others.

The mixed shark target SHK7_SN(2011) standardised CPUE index is the accepted indicator of SCH 7 abundance. The 2011 CPUE analysis updates previous analyses conducted in 2003, 2007 and 2010, with no substantial changes to the fishery definitions or standardisation models. The index remained stable around long-term average levels over 1989-90 to 1995-96 and then increased to a peak about 50% above average levels in 1999-00, then declined steadily to its lowest value over the 20 year period by 2007-08 (Figure 6). The index increased in 2008-09 and then decreased in the final year to below the long-term mean.

There is close correspondence in the declining indices for SCH 5 and SCH 7, except in the final two years where SCH 5 and SCH 7 vary inversely. Both indices monitor mature fish caught around Southland and the WCSI, raising some concern about the declines in both these areas.
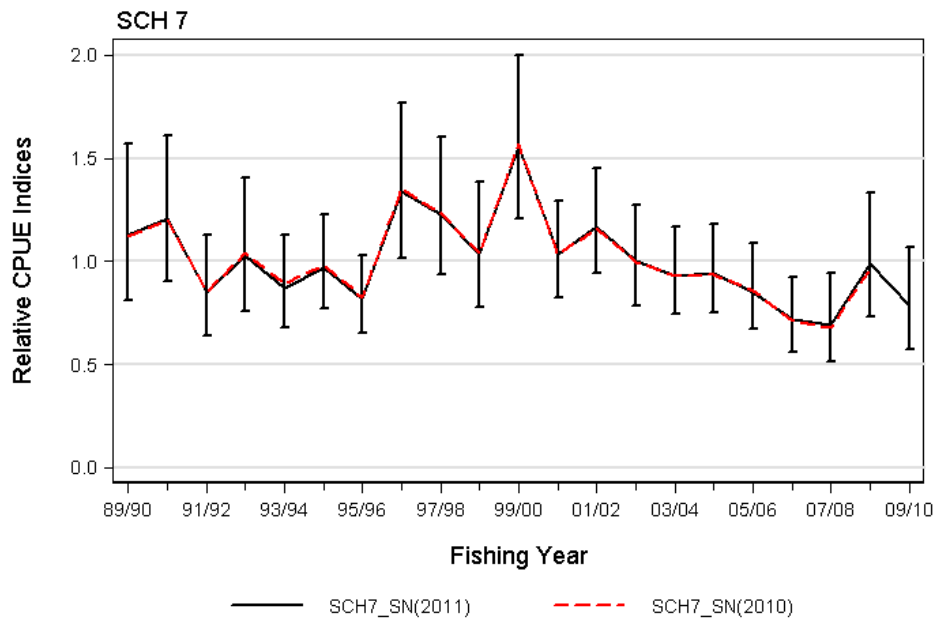
Figure 6: Lognormal indices from the setnet target shark CPUE series for SCH 7 SCH7_SN(2011) and the index from the 2010 assessment SCH7_SN(2010). From Starr & Kendrick (2011).

SCH 8

SCH 8 are caught mainly (66%) by setnet targeting school shark and rig; and by bottom longline (22%) targeting school shark and hapuku/bass. Ten percent is caught by bottom trawl targeting gurnard, tarakihi and trevally.

The mixed shark target SCH8_SN(2011) standardised CPUE index is the accepted indicator of SCH 8 abundance. The 2011 CPUE analysis is an update of previous analyses conducted in 2003, 2007 and 2010, with no substantial changes to the fishery definitions or standardisation models. The index remains flat at the long-term average, apart from a drop to lower levels over 1997-98 to 2000-01 (Figure 7). The Working Group concluded that the SCH 8 index showed no change in abundance over the series. There was an inverse relationship between the SCH 7 and SCH 8 indices over this period, suggesting a possible shift in stock distribution between these areas.
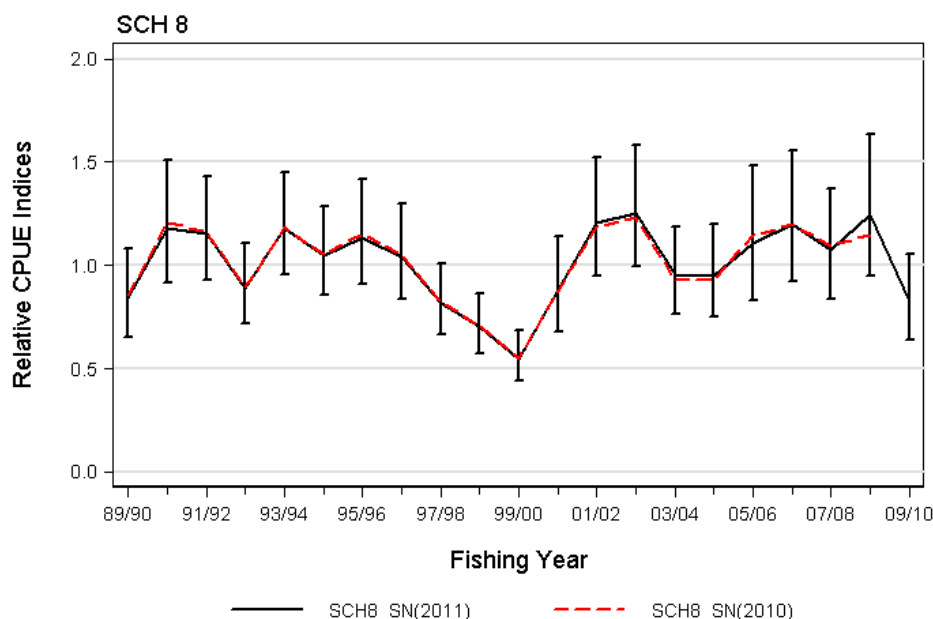

Figure 7: Lognormal indices from the setnet target shark CPUE series for SCH 8 SCH8_SN(2011) and the index from the 2010 assessment SCH8_SN(2010). From Starr and Kendrick (2011).

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SCH overview
SCH are mainly caught in setnet fisheries targeting sharks (school shark, rig, elephantfish and spiny dogfish); in bottom trawl fisheries targeting red cod, tarakihi, gurnard and snapper and others; and in bottom longline fisheries targeting school shark, hapuku/bass and ling.

In SCH 3, 5, 7 and 8, CPUE indices have been conducted using the same, or similar, models since entry into AMPs. In some areas, additional target species have been added to fishery definitions, particularly for bottom longline indices. New analyses were developed for SCH 1 and 2. Bottom trawl indices previously produced for SCH 1 and 2 were not updated in 2010.

There is a close similarity in trends in the indices for 1E, 2 and 3; SCH 5 and SCH 7; and SCH 8 and 1W. The indices show higher recent CPUE for SCH 1E, 2 and 3; stable CPUE for SCH 1W and 8; and declining CPUE for SCH 5 and 7. The Working Group noted that SCH 5 and 7 have accounted for 41% of the SCH catch over the past 20 years, and are the areas in which the highest proportion of mature fish are caught. SCH 1E, 2 and 3, have accounted for 26% of the SCH catch over the past 20 years. Areas 1W and 8 have accounted for 30% of the catch.

Recent setnet closures have potentially compromised the continuity of setnet indices for SCH 1W, 3, 5 and 7.

4.2   Biomass estimates
Estimates of current and reference biomass are not available.

4.3   Estimation of Maximum Constant Yield (*MCY*)
The estimates of *MCY* are no longer considered valid.

4.4   Estimation of Current Annual Yield (*CAY*)
Current biomass cannot be estimated, so *CAY* cannot be determined.

4.5   Other yield estimates and stock assessment results
No information is available.

4.6   Other factors
In Australia, recruitment overfishing has occurred to such an extent that the stock is considered seriously threatened and a series of conservative management measures (TAC reductions) have been progressively imposed between 1996 and 2007 (Wilson *et al*. 2008). The Australian modelling work indicates that the stock is overfished. Wilson *et al*. (2008) note that the stock has been in an overfished state and overfishing was occurring from 1992 to 2004. While the stock was still listed as overfished since then, they are uncertain as to whether overfishing is still occurring.
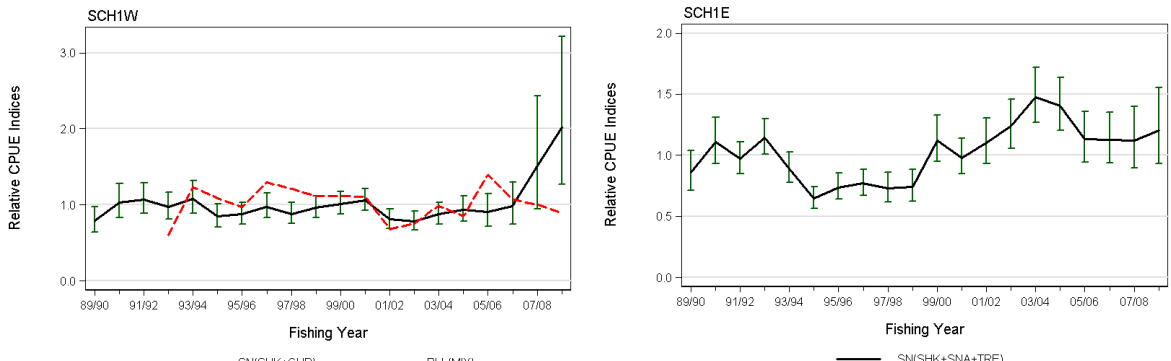
The most important conclusion from this for New Zealand is that fishing pressure on large mature females should be minimised to maintain the productivity of this species.

5.   STATUS OF THE STOCKS

Stock Structure Assumptions
SCH are known from tagging studies to be highly mobile, moving between the North and South Islands, and as far as Australia. From the tagging evidence, there is probably a single biological SCH stock in the New Zealand EEZ. However, differences in average modal length and CPUE trends between FMAs indicate that movement between areas may be viscous, and that components of the stock may aggregate in different areas. Larger females predominate in catches around Southland and west coast of the South Island. Therefore, the current stock management units are a precautionary measure to spread fishing effort and mortality across components of the stock.

SCH 1

Stock Status

Year of Most Recent Assessment	2010 (Fishery characterisation and CPUE standardisation)
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%)
Historical Stock Status Trajectory and Current Status	

Left: Comparison of the two SCH 1W standardised series: SCH 1W_SN(SHK+GUR) and SCH 1W_BLL(44inc); Right: The SN (SHK+SNA+TRE) index for SCH 1E.

Fishery and Stock Trends

Recent Trend in Biomass or Proxy	Standardised CPUE abundance indices for SCH 1 show different trends west and east of North Cape. Discounting the last two years for setnet (which are poorly estimated), the SN and BLL indices for SCH 1W are flat, indicating no change in abundance over the past 20 years. The index for SCH 1E shows higher than long-term average abundance since 1999-00. From 1999-00 the SCH 1E index shows an increasing trend to above the long-term average, peaking in 2003-04, and then dropping to just above the average by 2006-07.

Recent Trend in Fishing Mortality or Proxy	Overfishing is Unlikely (< 40%) to be occurring.

Projections and Prognosis

Stock Projections or Prognosis	SCH 1E: Stock size is Likely (> 60%) to remain near current levels or increase under current catches and TACCs SCH 1W: Stock size is Likely (> 60%) to remain near current levels under current catches and TACCs.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%)

Assessment Methodology

Assessment Type	Level 2: Standardised CPUE abundance index.	
Assessment Method	Evaluation of agreed standardised CPUE indices thought to index SCH 1 abundance.	
Main data inputs	Catch and effort data derived from the Ministry of Fisheries catch returns	
Period of Assessment	Latest assessment: 2010	Next assessment: 2013

Changes to Model Structure and Assumptions	The previously accepted indices were based on bottom longline snapper (1E) and a bottom trawl mixed (1W). This assessment explored a wide range of alternative fishery definitions. Four credible indices were selected: setnet (SN) and bottom longline (BLL) on both the east and west coasts.
Major Sources of Uncertainty	Setnet closures have jeopardised the continuity of the west coast setnet index in recent years. The BLL(W) index is considered to index the top of the North Island and lacks data.

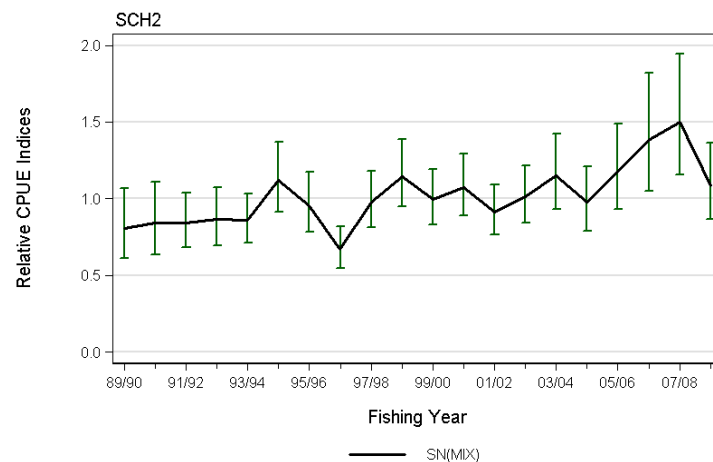| **Qualifying Comments** |
| --- |
| Recent setnet closures designed to protect Maui's dolphin have affected setnet fisheries which take school shark off the west coast of the North Island. These closures have resulted in changes in fleet deployment and jeopardised the setnet indices. |

Fishery Interactions
SCH 1 are primarily taken by bottom trawl while targeting tarakihi and snapper, with smaller catches when targeting trevally and red gurnard. The bottom longline SCH 1 fishery is primarily directed at school shark, with hapuku and snapper being other important targets. The setnet fishery is also primarily targeted at school shark, with some targeting of rig, trevally, gurnard and snapper. The bottom pair trawl fishery is almost entirely directed at snapper and trevally, with tarakihi becoming more important in recent years.

SCH 2

Stock Status	
Year of Most Recent Assessment	2010 (Fishery characterisation and CPUE standardisation)
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%)

Historical Stock Status Trajectory and Current Status
The lognormal index for SCH 2: SN[MIX]: mixed target species (scaled so that the geometric mean = 1).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The CPUE index generally increases over the series. There is a substantial correspondence between the standardised SN index for SCH 2 with SN and BLL indices for SCH 1E, which together

	indicate a slow but steady increase in CPUE to 2005-06, levelling off since then.
Recent Trend in Fishing Mortality or Proxy	Overfishing is Unlikely (< 40%) to be occurring.

Projections and Prognosis	
Stock Projections or Prognosis	Correspondence between SN indices for SCH 1E, SCH 2 and SCH 3 indicates that. SCH 2 stock size is Likely to remain near current levels or increase under current catches and TACCs.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%)

Assessment Methodology	
Assessment Type	Level 2: Standardised CPUE abundance index.
Assessment Method	Evaluation of agreed standardised CPUE indices thought to index SCH 2 abundance.
Main data inputs	- Catch and effort data derived from the Ministry of Fisheries compulsory catch reporting.
Period of Assessment	Latest assessment: 2010 Next assessment: 2013
Changes to Model Structure and Assumptions	The previous assessment used tarakihi bottom trawl index. The 2010 analyses used setnet and bottom longline (no bottom trawl index was attempted), based on a broader range of target fisheries than previously.
Major Sources of Uncertainty	

Qualifying Comments
There have been no regulation changes affecting SCH 2 in recent years.

Fishery Interactions
SCH 2 are caught primarily in the bottom trawl fishery (46%) targeting tarakihi, hoki, gemfish and gurnard; and the bottom longline fishery (30%) targeting school shark, ling, hapuku/bass and bluenose. 16% of the catch is taken in setnet targeting school shark, blue warehou and blue moki.

SCH 3

Stock Status	
Year of Most Recent Assessment	2010 (Fishery characterisation and CPUE standardisation)
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%)

Historical Stock Status Trajectory and Current Status

Lognormal SCH 3_SN(SHK) standardised indices with core vessel criteria of at least 10 trips in a minimum of 6 years) (series is scaled so that the geometric mean = 1).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The mixed shark target SN(SHK) standardised CPUE is the accepted index of abundance. This index shows a sharp decline of almost 60% from a peak in 1989-90 to its lowest point over the 20 year series in 1992-93. Thereafter the index shows a steady and continual increase through to 2003-04 to 2004-05 to a level about 10% above the long-term average and about 40% above the lowest level, fluctuating around this level thereafter.
Recent Trend in Fishing Mortality or Proxy	Overfishing is Unlikely (< 40%) to be occurring.

Projections and Prognosis	
Stock Projections or Prognosis	Quantitative stock projections are unavailable. The long period of increase in the SN(SHK) index for SCH 3 since 1992-93, over a period when catches have increased steadily from about 200t to an average of 366t over the recent five years, indicates that stock size is Likely to remain near current levels or increase under current catches.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%)

Assessment Methodology	
Assessment Type	Level 2: Standardised CPUE abundance index, and a review of length data.
Assessment Method	Evaluation of agreed standardised CPUE indices thought to index SCH 3 abundance.
Main data inputs	- Catch and effort data derived from the Ministry of Fisheries reporting requirements. - Length frequency data summarised from logbooks compiled under the industry Adaptive Management Programme.
Period of Assessment	Latest assessment: 2010	Next assessment: 2013
Changes to Model Structure and Assumptions	The 2010 CPUE analysis is an update of the shark-targeted setnet CPUE analysis conducted in 2003 and 2007, with no extension to

	other target species or other model changes.
Major Sources of Uncertainty	Recent setnet closures have affected fleet distribution patterns, potentially jeopardising setnet indices in this area. These changes may have contributed to the strong fluctuations in the SCH 3 SN indices in recent years.

Qualifying Comments

Like other setnet abundance indices, the SCH 3 setnet indices have been affected, and possibly compromised, by setnet closures.
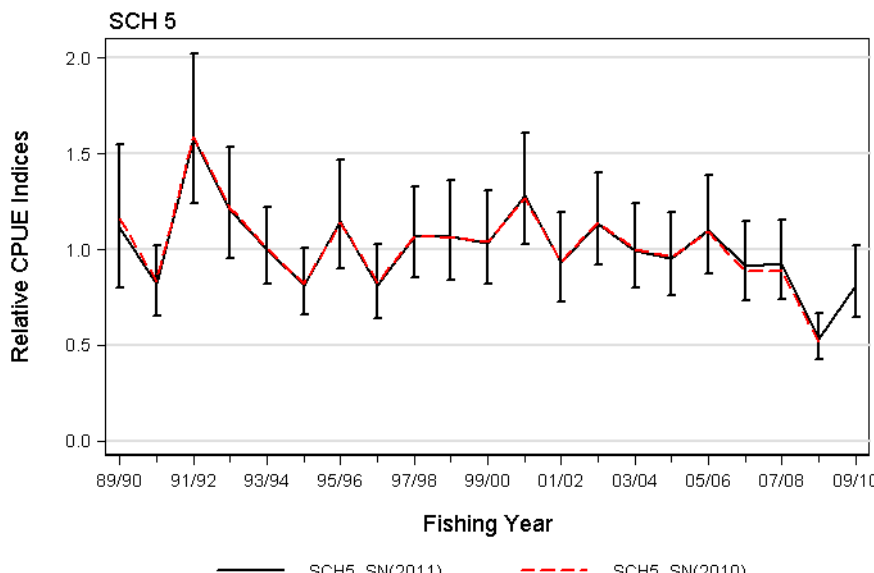
Fishery Interactions

SCH 3 is predominantly caught in the setnet fishery (56%) targeting school shark and rig, with some targeting of spiny dogfish and tarakihi; and in the bottom trawl fishery (36%) targeting red cod, with some targeting of flatfish, barracouta and tarakihi. Mixed targeted bottom longline takes 7% of the catch.

SCH 4

The status of SCH 4 relative to B_{MSY} is unknown.

SCH 5

Stock Status

Year of Most Recent Assessment	2011 (Fishery characterisation and CPUE standardisation)
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%) to be below
Historical Stock Status Trajectory and Current Status	

Lognormal SCH 5_SCH5_SN(2011) standardised index.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The targeted **SCH5_SN(2011)** CPUE index fluctuated around long-term average levels through to 2005-06. Thereafter the index declines to slightly below average levels over 2006-07 / 2007-08,

	and then steeply to about half average levels in 2008-09. The value of the index in the most recent year has increased but is still below the long-term mean.
Recent Trend in Fishing Mortality or Proxy	Overfishing is About as Likely as Not (40-60%) to be occurring.

Projections and Prognosis	
Stock Projections or Prognosis	The **SCH5_SN(2011)** abundance index has declined steadily since 2005-06, reaching the lowest level over the 20 year period of the index in 2008-09, at about half of long-term average levels. This gives rise to concern that current catches, and the current TACC, may not be sustainable. While the most recent data point is above that of 2010, it is still below the long-term mean. The working group therefore concluded that the SCH 5 stock is Likely to decline under current catches and TACCs.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology	
Assessment Type	Level 2: Standardised CPUE abundance index, and a review of length data.
Assessment Method	Evaluation of agreed standardised CPUE indices thought to index SCH 5 abundance.
Main data inputs	- Catch and effort data derived from the Ministry of Fisheries catch reporting. - Length frequency data summarised from logbooks compiled under the industry Adaptive Management Programme.
Period of Assessment	Latest assessment: 2011	Next assessment: 2013
Changes to Model Structure and Assumptions	The 2011 CPUE analysis is an update of previous analyses conducted in 2003, 2007 and 2010, with no substantial changes to the fishery definitions or standardisation models.
Major Sources of Uncertainty	Recent setnet closures have affected fleet distribution patterns, potentially jeopardising setnet indices in this area.

Qualifying Comments
Concerns regarding the status of this stock are prompted by the decline in CPUE from the early 2000s. There is close correspondence in the indices for SCH 5 and SCH 7. Both indices monitor mature fish caught around Southland and the WCSI, raising some concern for both these areas.

Fishery Interactions
SCH 5 is almost entirely caught in the school shark targeted setnet fishery (83%), with some minor targeting of rig. Seven percent is taken by bottom trawl primarily targeting stargazer and squid, and 5% by bottom longline primarily targeting hapuku/bass and ling.

SCH 7

Stock Status	
Year of Most Recent Assessment	2011
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown

Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%) to be below

Historical Stock Status Trajectory and Current Status

Lognormal indices from the setnet target shark CPUE series for SCH 7.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The mixed shark target SHK7_SN(2011) standardised CPUE index remained stable around long-term average levels over 1989-90 to 1995-96 and then increased to a peak about 50% above average levels in 1999-00, then declined steadily to its lowest value over the 20 year period by 2007-08. There was a sharp increase in the final year; however, the working group considered the last data point to be less reliably estimated.
Recent Trend in Fishing Mortality or Proxy	Overfishing is About as Likely as Not (40-60%) to be occurring.
Projections and Prognosis	
Stock Projections or Prognosis	The SHK7_SN(2011) abundance index declined steadily from 1999-00 to its lowest level over the 20 year period of the index in 2007-08. The Working Group concluded that the SCH 7 Fishstock stock size is Likely to decline under current catches and TACCs.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology		
Assessment Type	Level 2: Standardised CPUE abundance index, and review of length frequency data.	
Assessment Method	Evaluation of agreed standardised CPUE indices thought to index SCH 7 abundance.	
Main data inputs	- Catch and effort data derived from the Ministry of Fisheries catch reporting. - Length frequency data summarised from logbooks compiled under the industry Adaptive Management Programme.	
Period of Assessment	Latest assessment: 2011	Next assessment: 2013
Changes to Model Structure and Assumptions	The 2011 CPUE analysis is an update of previous analyses conducted in 2003, 2007 and 2010, with no substantial changes to the fishery definitions or standardisation models.	

Major Sources of Uncertainty	SCH 7: The fleet distribution has changed in the last 2-3 years. Furthermore, setnet closures have potentially compromised the setnet indices in the last two years.

Qualifying Comments

Concerns regarding the status of this stock are prompted by the decline in CPUE from the early 2000s. There is close correspondence in the indices for SCH 5 and SCH 7. Both indices monitor mature fish caught around Southland and the WCSI, raising some concern for both these areas.
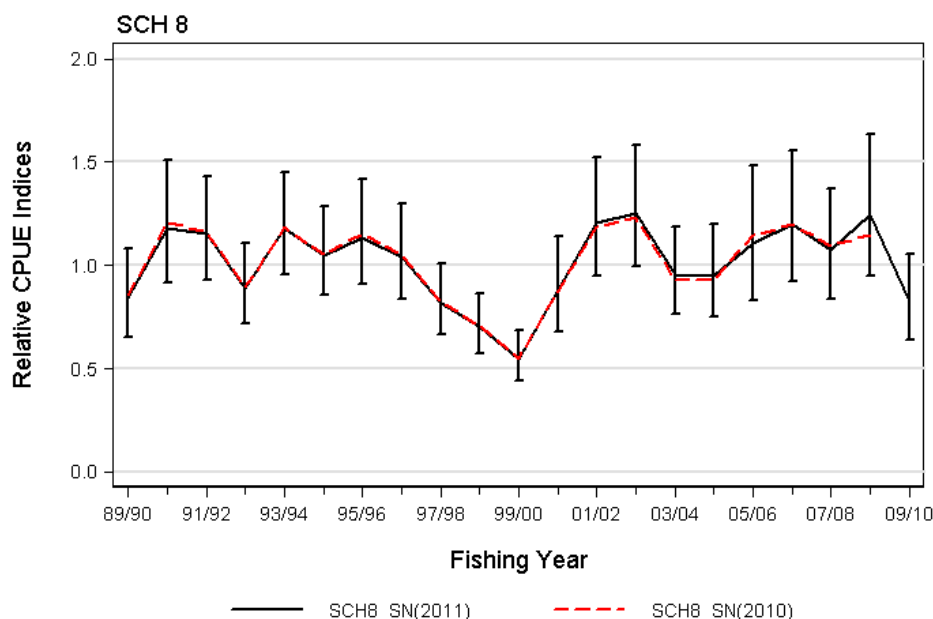
Fishery Interactions

SCH 7 are caught about one-third each by setnet targeting school shark, rig and spiny dogfish; bottom longline targeting school shark, hapuku/bass and ling; and bottom trawl targeting barracuda, tarakihi, flatfish, hoki, red cod and others.

SCH 8

Stock Status

Year of Most Recent Assessment	2011
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft limit: Unknown Hard Limit: Unlikely (< 40%) to be below.

Historical Stock Status Trajectory and Current Status

Lognormal indices from the setnet target shark CPUE series for SCH 8

Fishery and Stock Trends

Recent Trend in Biomass or Proxy	The SCH8SN(2011) index remains flat at the long-term average, apart from a drop to lower levels over 1997-98 to 2000-01. The Working Group concluded that the SCH 8 index showed no change in abundance over the series. There is an inverse relationship between the SCH 7 and SCH 8 indices over this period, suggesting a possible shift in stock distribution between these areas.
Recent Trend in Fishing Mortality or Proxy	Overfishing is Unlikely (< 40%) to be occurring.

Projections and Prognosis	
Stock Projections or Prognosis	The lack of any trend in the SCH 8 CPUE index indicates the stock size is Likely to remain near current levels under current catches and TACCs.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%)
Assessment Methodology	
Assessment Type	Level 2: Standardised CPUE abundance index, and review of length frequency data.
Assessment Method	Evaluation of agreed standardised CPUE indices thought to index SCH 8 abundance.
Main data inputs	- Catch and effort data derived from the Ministry of Fisheries catch reporting. - Length frequency data summarised from logbooks compiled under the industry Adaptive Management Programme.
Period of Assessment	Latest assessment: 2011 Next assessment: 2013
Changes to Model Structure and Assumptions	The 2010 CPUE analysis are updates of previous analyses conducted in 2003 and 2007, with no substantial changes to the fishery definitions or standardisation models.
Major Sources of Uncertainty	

Qualifying Comments
-

Fishery Interactions
SCH 8 are caught mainly (66%) by setnet targeting school shark and rig; and by bottom longline (22%) targeting school shark and hapuku/bass.   Ten percent is caught by bottom trawl targeting gurnard, tarakihi and trevally.

Combined SCH Stocks

School shark are believed to be a single biological stock around the North and South Islands. It may therefore be appropriate for management responses to be consistent across areas broader than single QMAs.

Stock Status	
Year of Most Recent Assessment	2010; 2011 for SCH 5, 7 and 8
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft limit: Unknown Hard Limit: Unlikely (< 40%)

Historical Stock Status Trajectory and Current Status
SCH 1E, 2 and 3

E Coast North & South Islands
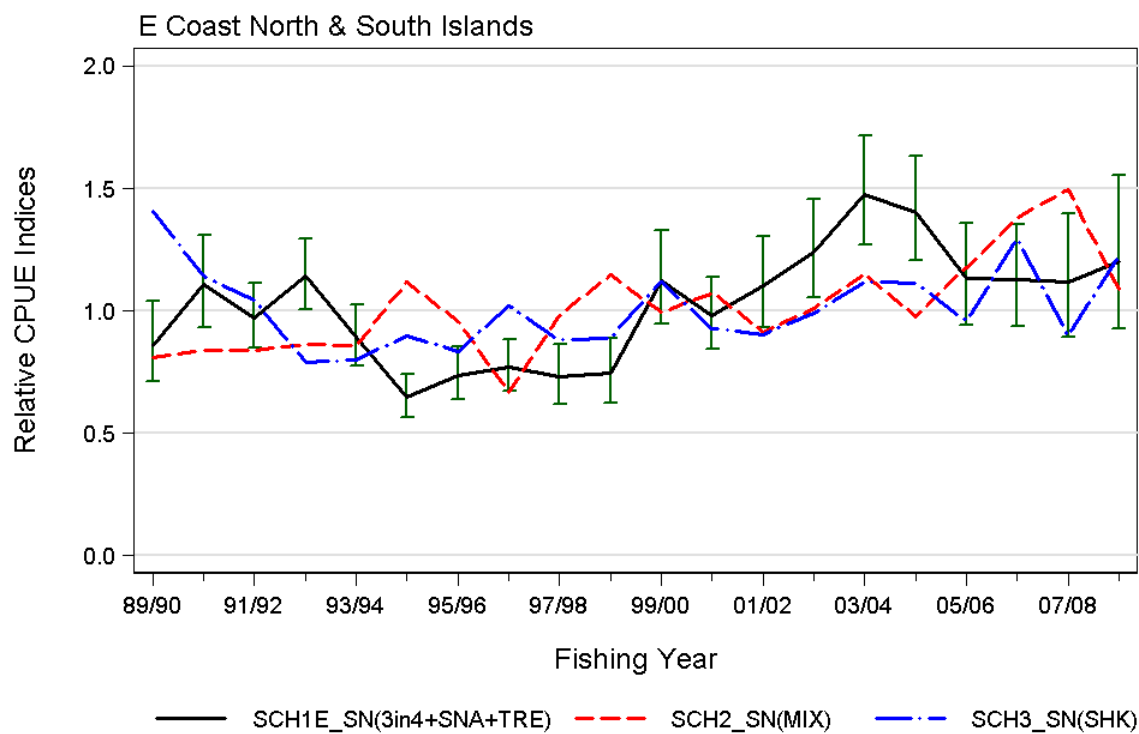
Comparison of three lognormal indices from a) the SCH 1E setnet series: [SCH 1E_SN(3in4+SNA=TRE)]; b) a setnet series from SCH 2: [SCH2_SN(MIX)]; c) a setnet series from SCH 3: [SCH3_SN(SHK)]

S & W Coasts South Island
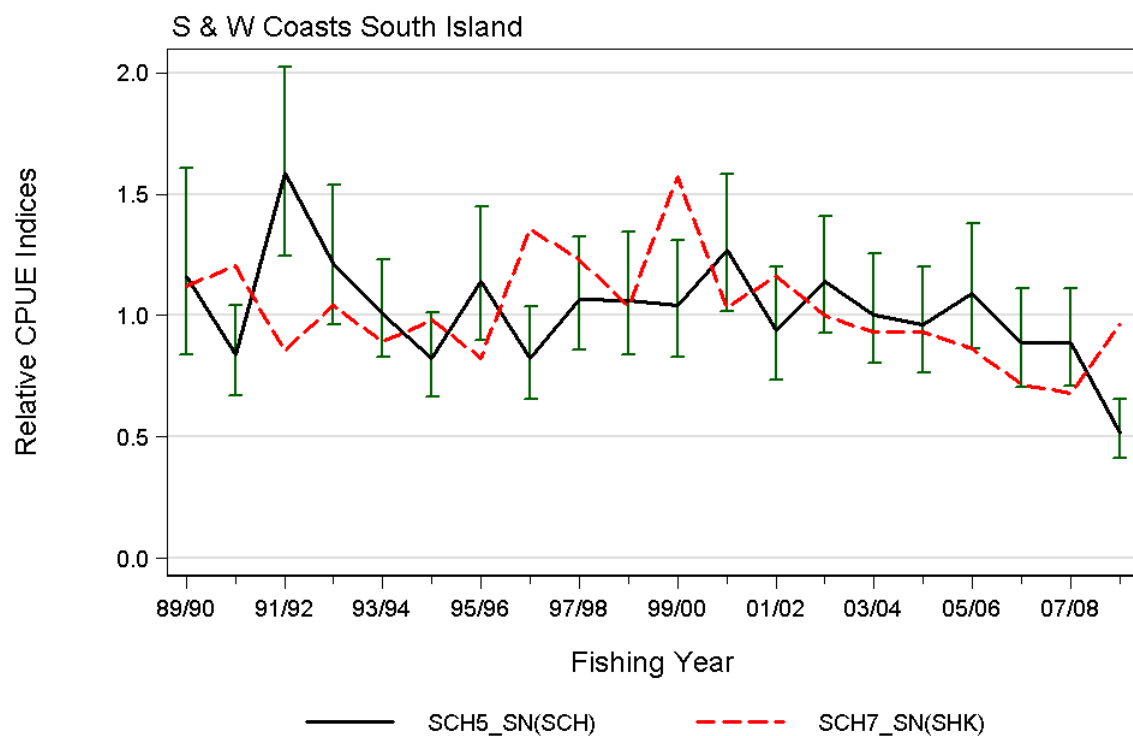
Comparison of the selected SCH 5 [SCH5_SN(SCH)] series with the equivalent series selected for the SCH 7 [SCH7_SN(SHK)] CPUE evaluation. Confidence intervals only shown for one series.

SCH 8 and 1W

W Coast South & North Islands
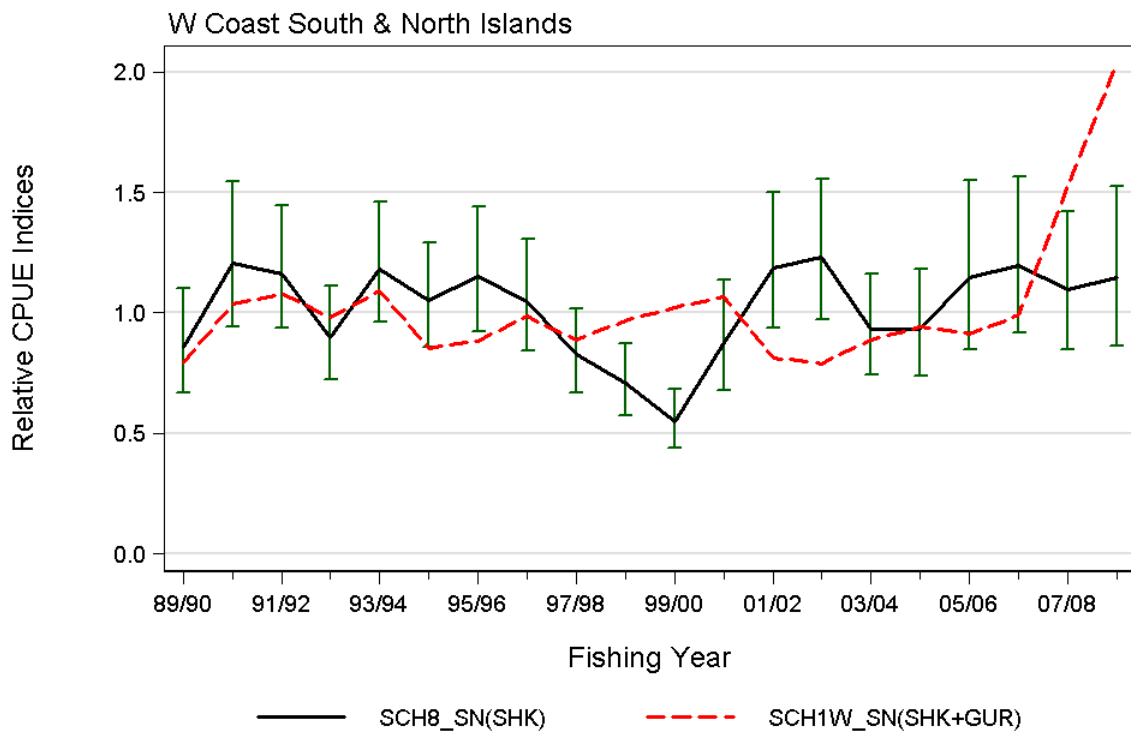
Comparison of the selected SCH 8 [SCH8_SN(SHK)] series with the equivalent series selected for the SCH1W [SCH1W_SN(SHK+GUR)] CPUE evaluation.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	There is a close similarity in trends in the indices for 1E, 2 and 3; SCH 5 and SCH 7; and SCH 8 and 1W. The indices show an increase or higher recent CPUE for SCH 1E, 2 and 3; and stable CPUE for SCH 1W and 8; SCH 5 and 7 show CPUE declining. The Working Group noted that SCH 5 and 7 have accounted for 41% of the SCH catch over the past 20 years, and are the areas in which the largest females are caught. SCH 1E, 2 and 3, have accounted for 26% of the SCH catch over the past 20 years. Areas 1W and 8 have accounted for 30% of the catch.
Recent Trend in Fishing Mortality or Proxy	Varies among FMAs.

Projections and Prognosis	
Stock Projections or Prognosis	• SCH 1E, 2, 3: Stock size is Likely to remain near current levels or increase under current catches and TACCs. • SCH 1W, 8: Stock size is Likely to remain near current levels under current catches and TACCs. • SCH 5&7: Stock size is Likely to decline under current catches and TACCs.
Probability of Current Catch or TACC causing decline below Limits	Combined stocks: Soft Limit: Unknown Hard Limit: Varies among FMAs

Assessment Methodology	
Assessment Type	Level 2: Standardised CPUE abundance index, and length frequency analysis.
Assessment Method	Evaluation of a range of agreed standardised CPUE indices

	thought to index abundance of the SCH fishstocks in each FMA. Comparison of length frequencies from SCH 3, 5, 7 and 8.
Main data inputs	- Catch and effort data derived from the Ministry of Fisheries catch reporting. - Length frequency data summarised from logbooks compiled under the industry Adaptive Management Programme.
Period of Assessment	Latest assessment: 2010 Next assessment: 2011 (SCH 5 and 7) and 2013 (SCH 1 , 2, 3 and 8)
Changes to Model Structure and Assumptions	In SCH 3, 5, 7 and 8, CPUE indices have been conducted using the same, or similar, models since entry into AMPs. In some areas, additional target species have been added to fishery definitions, particularly for bottom longline indices. New analyses were developed for SCH 1 and 2. Bottom trawl indices previously produced for SCH 1 and 2 were not updated in 2010.
Major Sources of Uncertainty	Recent setnet closures have potentially compromised the continuity of setnet indices for SCH 1W, 3, 5 and 7.

Qualifying Comments

See individual Fishstock Status of Stocks summaries.

Fishery Interactions

SCH are predominantly caught in setnet fisheries targeting sharks (school shark, rig, elephantfish and spiny dogfish); in bottom trwl fisheries targeting red cod, tarakihi, gurnard and snapper and others; and in bottom longline fisheries targeting school shark, hapuku/bass and ling.

Yield estimates, reported landings and TACCs for the 2010-11 fishing year are summarised in Table 6.

Table 6: Summary of yield estimates (t), TACCs (t) and reported landings (t) of school shark for the most recent fishing year.

Fishstock		QMA	*MCY* Estimates	2010-11 Actual TACC	2010-11 Reported Landings
SCH 1	Auckland (East) (West)	1 & 9		689	777
SCH 2	Central (East)	2		199	187
SCH 3	South-east (Coast)	3		387	366
SCH 4	South-east (Chatham)	4		239	174
SCH 5	Southland and Sub-Antarctic	5 & 6		743	701
SCH 7	Challenger	7		641	677
SCH 8	Central (West)	8		529	587
SCH 10	Kermadec	10		10	0
Total				3 436	3 469

6. FOR FURTHER INFORMATION

Anon 1990. Management meets industry. Papers from the Southern Shark Fishery seminars held in Victor Harbour, Phillip Island and Hobart, October 1989.

Ayers D., Paul L.J., Sanders B.M. 2004. Estimation of catch per unit effort analyses for school shark (*Galeorhinus galeus*) from bycatch and target fisheries in New Zealand, 1989-90 to 2001-02. New Zealand Fisheries Assessment Report 2006/26. 121p.

Blackwell R.G., Francis M.P. in press. Review of life-history and fishery characteristics of New Zealand rig and school shark. *New Zealand fisheries assessment report No.* 2009/xx. 38 p.

Boyd R.O., Reilly J.L. 2005. 1999-2000 national marine recreational fishing survey: harvest estimates. Draft New Zealand Fisheries Assessment Report.

Bradford E. 1998. Harvest estimates from the 1996 national recreational fishing surveys. New Zealand Fisheries Assessment Research Document. 1998/16. 27p.

Bradford E. 2001. Standardised catch rate indices for New Zealand school shark, *Galeorhinus galeus,* in New Zealand, 1989-90 to 1998-99. New Zealand Fisheries Assessment Report 2001/33. 75p.

Campbell D., Battaglene T., Pascoe S. 1991. Management options for the Southern Shark Fishery - an economic analysis. Australian Bureau of Agricultural and Resource Economics Discussion Paper 91.12. 43p.

Coutin P., Bruce B., Paul L. 1992. New Zealand school sharks cross the Tasman Sea. Australian Fisheries 51(3): 24-25.

Francis M.P. 1998. New Zealand shark fisheries: development, size and management. Marine and Freshwater Research 49: 579-591.

Francis M.P., Mulligan K.P. 1998. Age and growth of New Zealand school shark, *Galeorhinus galeus*. New Zealand Journal of Marine and Freshwater Research 32(3): 427-440.

Francis M.P. in press. Movement of tagged rig and school shark among QMAs, and implications for stock management boundaries. *New Zealand fisheries assessment report No.* 2009/xx. 22 p.

Grant C.J., Sandland R.L., Olsen A.M. 1979. Estimation of growth, mortality and yield per recruit of the Australian school shark, *Galeorhinus australis* (Macleay), from tag recoveries. Australian Journal of Marine and Freshwater Research 30(5): 625-637.

Hurst R.J., Bagley N.W., McGregor G.A., Francis M.P. 1999. Movements of the New Zealand school shark, *Galeorhinus galeus*, from tag returns. New Zealand Journal of Marine and Freshwater Research 33(1): 29-48.

Hurst R.J., Bagley N.W., Uozumi Y. 1990. New Zealand-Japan trawl survey of shelf and upper slope species off southern New Zealand, June 1986. N.Z. Fisheries Technical Report No. 18. 50p.

Hurst R.J., Bagley N.W., McGregor G.A., Francis M.P. (1999). Movements of the New Zealand school shark, *Galeorhinus galeus*, from tag returns. *New Zealand journal of marine and freshwater research 33*: 29-48.

Livingston M.E., Uozumi Y., Berben P.H. 1991. Abundance, distribution, and spawning condition of hoki and other mid-slope fish on the Chatham Rise, July 1986. New Zealand Fisheries Technical Report No. 25. 47p.

Lydon G.J., Middleton D.A.J., Starr P.J. 2006. Performance of the SCH 7 and SCH 8 Logbook Programmes. AMP-WG-06-06. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).

Olsen A.M. 1984. Synopsis of biological data on the school shark, *Galeorhinus australis* (Macleay 1881). FAO Fisheries Synopsis No. *139*. 42p.

Paul L.J. 1988. School shark. New Zealand Fisheries Assessment Research Document 1988/27. 32p.

Paul L.J. 1991. Overseas travel report: "Sharks Down Under" conference, Taronga Zoo, Sydney, February 1991. MAF Fisheries Greta Point Internal Report No. 176. 137 p. (Draft report held in MAF Fisheries Greta Point library, Wellington).

Paul L.J., Saunders B. 2001. A description of the commercial fishery for school shark, *Galeorhinus galeus,* in New Zealand, 1945 to 1999. New Zealand Fisheries Assessment Report 2001/32. 63p.

Peres M.B., Vooren C.M. 1991. Sexual development, reproductive cycle, and fecundity of the school shark *Galeorhinus galeus* off southern Brazil. Fishery Bulletin, U.S. 89(4): 655-667.

Seafood Industry Council (SeaFIC). 2003a. SCH 3 Adaptive Management Programme Proposal for the 2004-05 Fishing year. 50p. (Unpublished report held at the Seafood Industry Council, Wellington).

Seafood Industry Council (SeaFIC). 2003b. SCH 5 Adaptive Management Programme Proposal for the 2004-05 Fishing year. 49p. (Unpublished report held at the Seafood Industry Council, Wellington).

Seafood Industry Council (SeaFIC). 2003c. SCH 7 Adaptive Management Programme Proposal for the 2004-05 Fishing year. 42p. (Unpublished report held at the Seafood Industry Council, Wellington).

Seafood Industry Council (SeaFIC). 2003d. SCH 8 Adaptive Management Programme Proposal for the 2004-05 Fishing year. 42p. (Unpublished report held at the Seafood Industry Council, Wellington).

Smith P.J. (2009). Review of genetic studies of rig and school shark. *Final research report for Ministry of Fisheries research project No. INS200803*. 16 p.

Starr P.J. 2005. CPUE indices for groper, *Polyprion* spp., when targeted and as a bycatch in four New Zealand fisheries, 1990-2003. New Zealand Fisheries Assessment Report 2005/51. 29p.

Starr P.J., Kendrick T.H., Lydon G.J., and Bentley N. 2007a. Report to the Adaptive Management Programme Fishery Assessment Working Group: Two year review of the SCH 3 Adaptive Management Programme. AMP-WG-07-08. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).

Starr P.J., Kendrick T.H., Lydon G.J., Bentley N. 2007b. Report to the Adaptive Management Programme Fishery Assessment Working Group: Two year review of the SCH 5 Adaptive Management Programme. AMP-WG-07-09. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).

Starr P.J., Kendrick T.H., Lydon G.J., Bentley N. 2007c. Report to the Adaptive Management Programme Fishery Assessment Working Group: Two year review of the SCH 7 Adaptive Management Programme. AMP-WG-07-15. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).

Starr P.J., Kendrick T.H., Lydon G.J., Bentley N. 2007d. Report to the Adaptive Management Programme Fishery Assessment Working Group: Two year review of the SCH 8 Adaptive Management Programme. AMP-WG-07-16. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).

Starr P.J., Kendrick T.H., Bentley N. 2010. Report to the Adaptive Management Programme Fishery Assessment Working Group: Characterisation, CPUE analysis and logbook data for BYX 1. Document 2010/04-v3, 86 p. (Unpublished document held by the Ministry of Fisheries, Wellington, N.Z.) (http://cs.fish.govt.nz/forums/thread/3871.aspx)

Starr P.J., Kendrick T.H. 2010a. Report to the Adaptive Management Programme Fishery Assessment Working Group: Characterisation and CPUE analysis for SCH 1. Document 2010/05-v3, 85 p. (Unpublished document held by the Ministry of Fisheries, Wellington, N.Z.) (http://cs.fish.govt.nz/forums/thread/3872.aspx)

Starr P.J., Kendrick T.H. 2010b. Report to the Adaptive Management Programme Fishery Assessment Working Group: Characterisation and CPUE analysis for SCH 2. Document 2010/06-v2, 64 p. (Unpublished document held by the Ministry of Fisheries, Wellington, N.Z.) (http://cs.fish.govt.nz/forums/thread/3873.aspx)

Starr P.J., Kendrick T.H., Bentley, N. 2010a. Report to the Adaptive Management Programme Fishery Assessment Working Group: Characterisation, CPUE analysis and logbook data for SCH 3. Document 2010/07-v2, 62 p. (Unpublished document held by the Ministry of Fisheries, Wellington, N.Z.) (http://cs.fish.govt.nz/forums/thread/3874.aspx)

Starr P.J., Kendrick T.H., Bentley N. 2010b. Report to the Adaptive Management Programme Fishery Assessment Working Group: Characterisation, CPUE analysis and logbook data for SCH 5. Document 2010/08-v2, 65 p. (Unpublished document held by the Ministry of Fisheries, Wellington, N.Z.) (http://cs.fish.govt.nz/forums/thread/3875.aspx)

Starr P.J., Kendrick T.H., Bentley N. 2010c. Report to the Adaptive Management Programme Fishery Assessment Working Group: Characterisation, CPUE analysis and logbook data for SCH 7 and SCH 8. Document 2010/09-v2, 149 p. (Unpublished document held by the Ministry of Fisheries, Wellington, N.Z.) (http://cs.fish.govt.nz/forums/thread/3876.aspx)

Teirney L.D., Kilner A.R., Millar R.E., Bradford E., Bell J.D. 1997. Estimation of recreational catch from 1991-92 to 1993-94. New Zealand Fisheries Assessment Research Document 1997/15. 43p.

Wilson D., Curtotti R., Begg G., Phillips K. (eds) 2008. F*ishery Status Reports, 2008: status of fish stocks and fisheries managed by the Australian Government*, Bureau of Rural Sciences & Australian Bureau of Agricultural and Resource Economics, Canberra. 395p.

SEA CUCUMBER (SCC)

(*Stichopus mollis*)
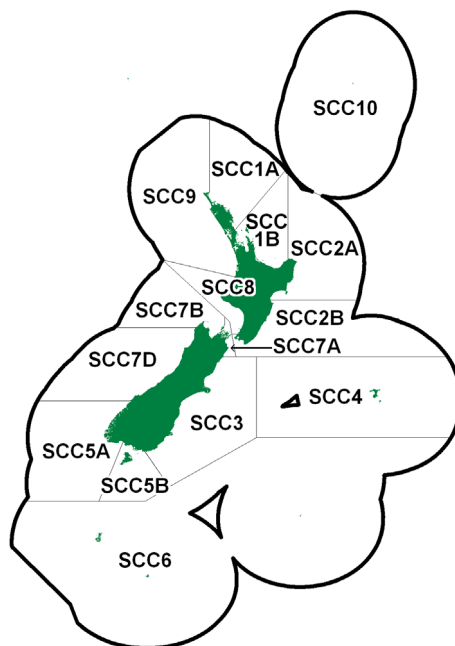
1. FISHERY SUMMARY

Sea cucumbers were introduced into Quota Management System on 1 April 2004. The fishing year is from 1 April to 31 March. A breakdown of each QMAs Total Allowable Catch (TAC) is listed in Table 1. Each TAC is made up of a total allowed commercial catch (TACC), customary, and recreational allocation and has remained unchanged since entering the QMS.

1.1 Commercial fisheries

More than 100 species of sea cucumber are found in New Zealand waters, but *Stichopus mollis* is the only species of commercial value, and the only species for which exploratory commercial fishing has taken place. Sea cucumbers are currently targeted only by diving but they are also a common bycatch of bottom trawl and scallop dredge fisheries. Sea cucumber landings of all species are reported as a single code (SCC), although most reported landings are probably *S. mollis,* as other species have no commercial value.

Table 1: Recreational and customary non-commercial allowances (t), Total Allowable Commercial Catches (TACC, t) and Total Allowable Catch (TAC, t) as declared for SCC on introduction into the QMS in October 2004.

Fishstock	Recreational Allowance	Customary non-commercial Allowance	TACC	TAC
SCC 1A	3	2	2	7
SCC 1B	4	2	2	8
SCC 2A	1	1	2	4
SCC 2B	4	2	5	11
SCC 3	2	1	2	5
SCC 4	1	1	2	4
SCC 5A	1	1	2	4
SCC 5B	1	1	2	4
SCC 6	0	0	0	0
SCC7A	2	1	5	8
SCC 7B	2	1	5	8
SCC 7D	1	1	2	4
SCC 8	1	1	2	4
SCC 9	1	1	2	4
SCC 10	0	0	0	0
TOTAL	24	16	35	75

Table 2: TACCs and reported landings (t) of Sea cucumber by Fishstock from 1990-91 to 2011-12 from CELR and TCEPR data. Until 2003-04 QMAs are the same as FMAs, since when FMAs 1, 2, 5, and 7 were subdivided. These landings are reported in the 2ⁿᵈ and 3ʳᵈ parts of this table.

Fishstock	SCC 1 Landings	SCC 1 TACC	SCC 2 Landings	SCC 2 TACC	SCC 3 Landings	SCC 3 TACC	SCC 4 Landings	SCC 4 TACC
1998-99	0	-	0	-	0.032	-	0	-
1999-00	0	-	0	-	0.04	-	0.01	-
2000-01	0.037	-	0	-	0.652	-	0.001	-
2001-02	0.16	-	0.012	-	1.005	-	1.683	-
2002-03	0.39	-	0.365	-	4.616	-	0.92	-
2003-04	0.07	N/A	N/A	N/A	3.785	2	0.115	2
2004-05	N/A	N/A	N/A	N/A	1.136	2	0.4	2
2005-06	N/A	N/A	N/A	N/A	2.853	2	0	2
2006-07	N/A	N/A	N/A	N/A	2.699	2	0.004	2
2007-08	N/A	N/A	N/A	N/A	3.673	2	0	2
2008-09	N/A	N/A	N/A	N/A	3.795	2	0	2
2009-10	N/A	N/A	N/A	N/A	0.366	2	0.009	2
2010-11	N/A	N/A	N/A	N/A	0.780	2	0.009	2
2011-12	N/A	N/A	N/A	N/A	3.397	2	0.004	2

Fishstock	SCC 1A Landings	SCC 1A TACC	SCC 1B Landings	SCC 1B TACC	SCC 2A Landings	SCC 2A TACC	SCC 2B Landings	SCC 2B TACC	SCC 5A Landings	SCC 5A TACC
2003-04	0	2	0	2	0	2	0	5	0	2
2004-05	0	2	1.503	2	0	2	0	5	0.005	2
2005-06	0	2	1.429	2	0	2	0	5	0	2
2006-07	0	2	2.089	2	0	2	0	5	0	2
2007-08	0.120	2	2.176	2	0	2	0	5	0	2
2008-09	0.122	2	0.531	2	0	2	0	5	0.001	2
2009-10	0.176	2	1.780	2	0	2	0.190	5	0	2
2010-11	0.012	2	1.403	2	0	2	0.047	5	0	2
2011-12	1.468	2	2.013	2	0	2	0.666	5	0.307	2

Fishstock	SCC 5B Landings	SCC 5B TACC	SCC 7A Landings	SCC 7A TACC	SCC 7B Landings	SCC 7B TACC	SCC7D Landings	SCC7D TACC	SCC6 Landings	SCC6 TACC
2003-04	0.005	2	0	5	0	5	0	2	0	0
2004-05	0.102	2	3.194	5	1.076	5	0	2	5	0
2005-06	0.002	2	5.467	5	0.122	5	0	2	0.310	0
2006-07	0	2	0.17	5	0.04	5	0	2	0	0
2007-08	0.004	2	8.341	5	0	5	0.023	2	0	0
2008-09	0.018	2	4.190	5	0	5	0	2	0.011	0
2009-10	0	2	4.314	5	1.357	5	0	2	0	0
2010-11	0.014	2	5.086	5	5.458	5	0	2	0	0
2011-12	0.366	2	4.768	5	4.700	5	2.146	2	0.042	0

Table 2 Continued :

Fishstock	SCC 9 Landings	SCC 9 TACC	SCC 10 Landings	SCC 10 TACC	Total Landings	Total TACC
1990-91	0	-	0	-	4.653[+]	-
1991-92	0	-	0	-	3.843[+]	-
1992-93	0	-	0	-	0.682[+]	-
1993-94	0	-	0	-	2.5[+]	-
1994-95	0	-	0	-	2.41[+]	-
1995-96	0	-	0	-	2.679[+]	-
1996-97	0	-	0	-	1.415[+]	-
1997-98	0.05	-	0	-	0.148	-
1998-99	0	-	0	-	0.032	-
1999-00	0	-	0	-	0.052	-
2000-01	0	-	0	-	1.659	-
2001-02	0	-	0	-	8.954	-
2002-03	0	-	0	-	16.847*	-
2003-04	0	2	0	0	21.861	35
2004-05	0.016	2	0	0	12.213	35
2005-06	0	2	0	0	10.183	35
2006-07	0.01	2	0	0	5.012	35
2007-08	0.001	2	0	0	14.315	35
2008-09	0.074	2	0	0	8.731	35
2009-10	0.029	2	0	0	8.221	35
2010-11	0.137	2	0	0	12.946	35
2011-12	0.141	2	0	0	20.249	35

*In 2002-03 50 kg were reportedly landed, but the QMA is not recorded. This amount is included in the total landings for that year.
[+]In 1990-1997, catch was reported, but no QMA was, therefore only the total is shown.
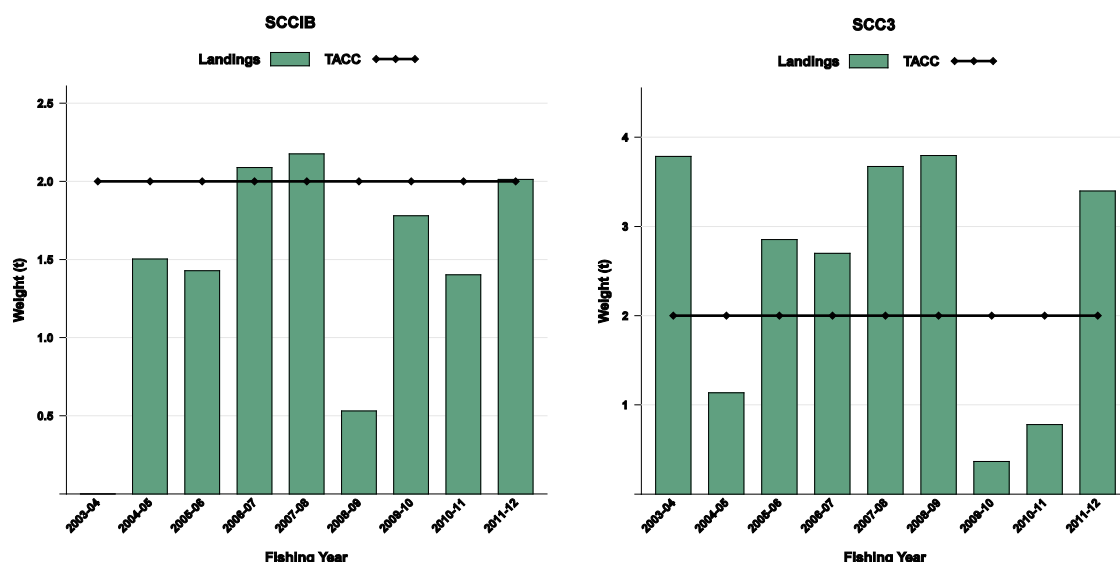
Figure 1: From Top Left: Historical landings and TACC for SCC1B (Hauraki Gulf, Bay of Plenty) and SCC3 (South East Coast). Note that these figures do not show data prior to entry into the QMS.
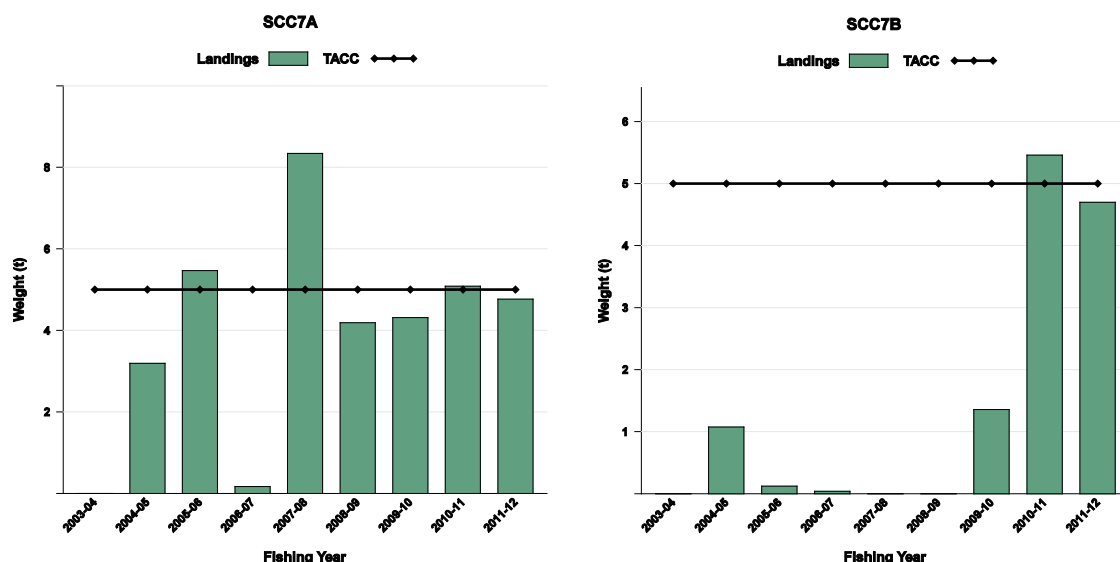
Figure 1 [Continued]: From Top Left: Historical landings and TACC for SCC7A (Challenger Marlborough Sounds) and SCC7B (Challenger Nelson). Note that these figures do not show data prior to entry into the QMS.

Between 1990 and 2001 about 45% of the catch was taken as bycatch in scallop dredging in Tasman and Golden Bays. About 13% was taken as bycatch in bottom trawling around the Auckland Islands, and about 38% was taken by diving. The remainder of the bycatch has been reported from mid-water trawls, rock lobster pots and bottom longlining.

Reported landings have generally been small except for the period between 2001-2002 and 2005-2006, when they ranged between about 9 and 22 t (Table 2). Most of this catch was bycatch from bottom trawling in SSC 6. The catches taken by diving were from Fisheries Statistical Area 31 (Fiordland) in 1990-91 (when a special permit was being operated) and 1995-96. The historical landings and TACC for the main SCC stocks are depicted in Figure 1.

1.2   Recreational fisheries
Recreational fishing surveys indicate that sea cucumbers are not caught by recreational fishers. It is likely that members of the Asian community harvest sea cucumber, but their fishing activity is poorly represented in the recreational surveys.

1.3   Customary non-commercial fisheries

There is no documented customary non-commercial use of sea cucumbers.

1.4   Illegal catch

There is no known illegal catch of sea cucumbers.

1.5   Other sources of mortality

There is no quantitative information on other sources of mortality, although sea cucumbers are often taken as a bycatch in bottom trawl and dredge fisheries.

2.   BIOLOGY

Stichopus mollis is distributed throughout New Zealand, and as far south as the Snares Islands. It also occurs off west and south Australia. It is found in shallow water between 5 and 40 m in a wide range of habitats from rocky shores to sandy bottoms. It is common in north-east New Zealand, Fiordland, the Marlborough Sounds, and Stewart Island, and displays a preference for sheltered coastline with complex and diverse habitats. *S. mollis* is less common on exposed coasts, but if present, tends to be in deeper water.

Sea cucumbers are mobile and form part of the benthic epifaunal community where they are detritus feeders. If disturbed, they can eviscerate their entire gut which can then be regenerated. They tend to be sedentary in suitable habitat, but are able to move away relatively quickly if stressed.

Little is known about the biology of *S. mollis*. They have an annual reproductive cycle, spawning between November and February. The sexes are separate and develop synchronously. They are broadcast spawners, eggs and sperm are released into the water column, and following fertilization, they undergo a 3 to 4 week larval phase before settlement. Populations from sheltered areas such as fiords and sheltered bays may be largely 'self seeding', while larvae released on open coasts may disperse more widely.

There is some evidence that recruitment and growth are both patchy and variable. Recruited fish appear in the adult population at about 10–12 cm (40–60 g) and adults grow to about 18–20 cm (180 g). During an exploratory fishing survey in Fiordland (SCC5A) in 1989, divers observed small *S. mollis* under rubble, suggesting that pre-recruit sea cucumbers may have different habitat preferences to adults. By contrast, comprehensive surveying in the Mahurangi harbour (SCC1B) showed the substratum at sites with high densities of juveniles to be dominated by silt and mud with large shell fragments (>10 cm) of the horse mussel *Atrina zelandica* (Morrison 2000). The restricted distribution of juveniles at this locality was shown to be unrelated to sediment type, and theorized to be a consequence of localised effects such as predation or larval settlement (Slater & Jeffs 2010). Caging studies comparing growth at different densities underneath and away from a Coromandel mussel farm (SCC1B) showed growth ranged from a 15.4% increase in weight over 6 months, at a density of 2.5 per m^2 under a mussel farm, to a 13.9% decrease in weight over 2 months, at a density of 15 per m^2 away from the mussel farm (Slater & Carton 2007). Age at maturity is thought to be about 2 years, and the life span of *S. mollis* is thought to be between 5 and 15 years.

3.   STOCKS AND AREAS

The management of sea cucumbers is based on 15 QMAs, which are a combination of existing and sub-divided FMAs. Although there is currently little biological or fishery information which could be used to identify stock boundaries, the QMAs recognise that sea cucumbers are a sedentary shallow water species, and that many sheltered populations may be isolated and vulnerable to localised depletion. Finer scale QMAs therefore provide a mechanism whereby stocks can be managed more appropriately. Also, because it is likely that the same group of commercial fishers will be targeting kina and sea cucumbers, and because there are some similarities in their respective habitats, the QMAs for sea cucumber are the same as those for kina.

4.   STOCK ASSESSMENT

4.1   Estimates of fishery parameters and abundance
There are no estimates of fishery parameters or abundance for any sea cucumber fishstock.

4.2   Biomass estimates
There are no biomass estimates for any sea cucumber fishstock, although estimates exist for some discrete areas. For Fiordland, crude biomass estimates of 59, 89, 97 and 134 t for Thompson, Bradshaw, Charles and Doubtful Sounds respectively are reported by Mladenov & Gerring (1991), and Mladenov & Campbell (1998). Their survey did not include the outer coastline, but extrapolating to all fiords between Puysegur Point and Cascade Point, they estimate a total biomass of 1937 t in the 0 to 20 m depth range.

4.3   Estimation of Maximum Constant Yield (*MCY*)
There are no estimates of *MCY* for any sea cucumber fishstock.

4.4   Estimation of Current Annual Yield (*CAY*)
There are no estimates of *CAY* for any sea cucumber fishstock.

5.   STATUS OF THE STOCKS

There are no estimates of reference or current biomass for any sea cucumber fishstock.

6.   FOR FURTHER INFORMATION

Alcock N. 2000. Brooding behaviour of two New Zealand cucumariids (Echinodermata: Holothuroidea) (Abstract). 10th International Echinoderm Conference 31 January– 4th February 2000 University of Otago, Dunedin, New Zealand.

Beentjes M.P. 2003. New species into the QMS - sea cucumber. Final Research Report for Ministry of Fisheries Research Project MOF200203D, Objective 1. 13p.

Bradford E. 1998. Harvest estimates from the 1996 national marine recreational fishing surveys. New Zealand Fisheries Assessment Research Document 1998/16. 27p.

Bradford E., Fisher D., Bell J. 1998. National marine recreational fishing survey 1996: overview of catch and effort results. NIWA Technical Report 18. 55p.

Chantal C., Byrne M. 1993. A review of recent developments in the world sea cucumber fisheries. Marine Fisheries Review 55: 1–13.

Conrad C., Sloan N.A. 1989. World Fisheries for echinoderms. *In* Caddy, J.F. (Eds). Marine Invertebrate Fisheries, pp. 647–663. Wiley and sons, New York.

Dawbin W.H. 1948. Auto–evisceration and regeneration of the viscera in the holothurian *Stichopus mollis* (Hutton). Transactions of the Royal Society of New Zealand 77: 497–523.

Mladenov P.V., Campbell A. 1998. Resource evaluation of the sea cucumber (*Stichopus mollis*) in the environmentally sensitive Fiordland region of New Zealand. Proceedings of the 9th International Echinoderm Conference San Francisco. 481–487.

Mladenov P.V., Gerring P. 1991. Resource evaluation of the sea cucumber (*Stichopus mollis*) in Fiordland, New Zealand. Marine Science and Aquaculture Research Centre, University of Otago. 34p.

Morgan A. 1999. Overview: aspects of sea cucumber industry research and development in the South Pacific. SPC Bêche–de–mer Information Bulletin 12: 15–17.

Morgan A. 2000a. Sea cucumber farming in New Zealand. Australasia Aquaculture August–September 2000: 54–55.

Morgan A. 2000b. Sea cucumbers in demand. Seafood New Zealand July 2000: 69–70.

Morgan A. 2003. Variation in reproduction and development of the temperate sea cucumber *Stichopus mollis*. PhD thesis, University of Auckland, Auckland.

Morrison M.A. 2000. Mahurangi Harbour Habitat Map. NIWA Information Series no. 13., National Institute of Water and Atmospheric Research, Wellington, NZ: Map 1p. colour.

Pawson D.L. 1970. The marine fauna of New Zealand: Sea cucumbers (Echinodemata: Holothuroidea). Bulletin of New Zealand Department of Scientific and Industrial Research 69p.

Pawson D.L. 2002. A new species of bathyal elasipod sea cucumber from New Zealand (Echinodermata: Holothuroidea). New Zealand Journal of Marine & Freshwater Research 36: 333–338.

Sewell M.A. 1990. Aspects of the ecology of *Stichopus mollis* (Echinodermata: Holothuroidea) in north eastern New Zealand. New Zealand Journal of Marine & Freshwater Research 24: 87–93.

Sewell M.A. 1992. Reproduction of the temperate aspidochirate Stichopus mollis (Echinodermata: Holothuroidea) in New Zealand. *Ophelia 35*: 103–121.

Slater M.J., Carton A.G. 2007. "Survivorship and growth of the sea cucumber Australostichopus (Stichopus) mollis (Hutton 1872) in polyculture trials with green-lipped mussel farms." Aquaculture 272(1-4): 389-398.

Slater M.J., Jeffs A.G. 2010. "Do benthic sediment characteristics explain the distribution of juveniles of the deposit-feeding sea cucumber Australostichopus mollis?" Journal of Sea Research 64(3): 241-249.

van Eys S., Philipson P.W. 1986. The market for beche–de–mer from the Pacific Islands. Chapter 11, Marine Products Marketing. p. 207–223.

SEA PERCH (SPE)

(*Helicolenus percoides*)
Pohuiakaroa
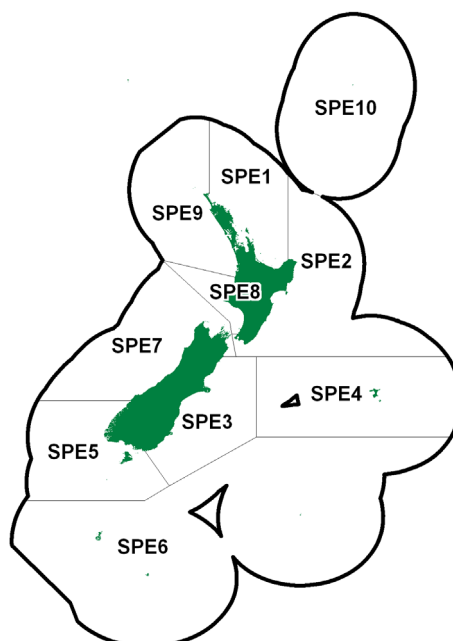
1. FISHERY SUMMARY

1.1 Commercial fisheries

Sea perch was introduced into the QMS from 1 October 1998. From 1 October 2000 the TACC for SPE 3 was increased to 1000 t under the Adaptive Management Programme (AMP). The TACC for SPE 4 was increased from 533 t to 910 t from 1 October 2004 under the low knowledge bycatch framework, and from 1 October 2006 the TACC for SPE 1 was increased from 18 to 33 t. In SPE 1 landings were above the TACC for a number of years and the TACC has been increased to the average of the previous 7 years plus an additional 10%. Current TACCs and allowances for non-commercial fishers are displayed in Table 1, while the historical landings and TACC values for the four major SPE stocks are depicted in Figure 1.

Very small quantities of sea perch have been landed for local sale for many years, but are largely unreported. Catches have been made by foreign vessels since the 1960s, but were also not recorded (they were most probably included within a "mixed" or "other finfish" category), and most were probably discarded. Despite poor reporting rates, estimated landings are thought to have increased from 400 t in the early 1980s to approximately 2000 t in recent years; an unknown quantity has been discarded over this period.

Table 1: Recreational and customary non-commercial allowances and Current TACCs, by Fishstock, for sea perch.

	Recreational	Customary non-commercial	Other sources	TACC	TAC
SPE 1	1	1	0	33	35
SPE 2	9	5	0	79	93
SPE 3	11	11	0	1 000	1 022
SPE 4	0	0	46	910	956
SPE 5	1	1	0	36	38
SPE 6	0	0	0	9	9
SPE 7	8	8	0	82	98
SPE 8	4	2	0	15	21
SPE 9	1	1	0	6	8
SPE 10	0	0	0	0	0
Total	34	21	46	2 155	2280

About 75% of New Zealand's landed sea perch is taken as a bycatch in trawl fisheries off the east coast of the South Island, including the Chatham Rise. A small catch is made in some central and southern line fisheries, e.g., for groper.

Recent reported landings of sea perch by QMAs are shown in Table 2. The most important QMAs in most years are QMA 3 (east coast South Island) and QMA 4 (Chatham Rise).

The catch from SPE 3 is spread throughout the fishing year. There is a variable seasonal distribution between years. A higher proportion of the catch is taken during April, May and September and catches are lower from December to February, and in July. Most of the SPE 3 catch is taken as a bycatch from the red cod (~30 %) and hoki fisheries (15%) and from the sea perch target fishery (21%). The remainder is taken as a bycatch from the target barracouta, flatfish, ling, squid and tarakihi fisheries. Virtually all the SPE 3 catch is taken by bottom trawling, with a small proportion taken by bottom longline. SPE 3 catch rates are highest between 150-400 m depth.

The trawl fisheries operating in SPE 4 catch sea perch along the northern and southern edge of the Chatham Rise between 200 and 700 m depth. The majority of the SPE 4 catch is taken as a bycatch of the hoki target fishery (~ 59%), with the ling and hake fisheries accounting for around 25% and 10% of the total SPE 4 catch, respectively.

Table 2: Reported landings (t) of sea perch by fishstock and fishing year, 1983-84 to 2010-11. The data in this table have been updated from that published in previous Plenary Reports by using the data through 1996-97 in table 38 on p. 278 of the "Review of Sustainability Measures and Other Management Controls for the 1998-99 fishing year - Final Advice Paper" dated 6 August 1998.

| Fishstock | SPE 1 | | SPE 2 | | SPE 3 | | SPE 4 | | SPE 5 & 6 | |
| FMA | 1 | | 2 | | 3 | | 4 | | 5 &6 | |
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983-84	14	-	2	-	150	-	58	-	36	-
1984-85	10	-	2	-	290	-	70	-	26	-
1985-86	14	-	2	-	213	-	218	-	28	-
1986-87	19	-	2	-	507	-	71	-	19	-
1987-88	20	-	1	-	544	-	63	-	18	-
1988-89	14	-	1	-	262*	-	36	-	18	-
1989-90	2	-	6	-	287*	-	177	-	9	-
1990-91	5	-	9	-	559*	-	68	-	33	-
1991-92	12	-	8	-	791*	-	222	-	36	-
1992-93	15	-	15	-	783*	-	317	-	55	-
1993-94	16	-	26	-	690*	-	223	-	28	-
1994-95	25	-	66	-	626*	-	415	-	18	-
1995-96	23	-	50	-	1 047*	-	404	-	62	-
1996-97	19	-	77	-	655*	-	435	-	45	-
1997-98	24	-	54	-	913	-	656	-	29	-
1998-99	21	18	79	79	903	738	872	533	27	45
1999-00	27	18	82	79	862	738	821	533	28	45
2000-01	25	18	81	79	798	738	840	533	19	45
2001-02	41	18	89	79	720	1 000	910	533	22	45
2002-03	19	18	78	79	696	1 000	1 685	533	25	45
2003-04	30	18	80	79	440	1 000	1 287	533	28	45
2004-05	27	18	104	79	372	1 000	894	910	24	45
2005-06	40	18	73	79	436	1 000	502	910	24	45
2006-07	30	33	98	79	519	1 000	591	910	31	45
2007-08	38	33	91	79	422	1 000	568	910	20	45
2008-09	27	33	46	79	328	1 000	338	910	13	45
2009-10	47	33	53	79	428	1 000	345	910	21	45
2010-11	53	33	83	79	644	1 000	572	910	24	45

1.2 Recreational fisheries

Sea perch are seldom targeted by recreational fishers, but are caught in large numbers. Some are used for bait, but most are probably discarded.

Three recreational fishing surveys were carried out by the Ministry of Fisheries in the 1990s (Table 3). However, because of identification problems and incomplete records, recreational fishing surveys

probably do not provide good estimates of the recreational sea perch catch. The highest reported recreational catch of sea perch during these surveys was from QMAs 2, 3 and 7.
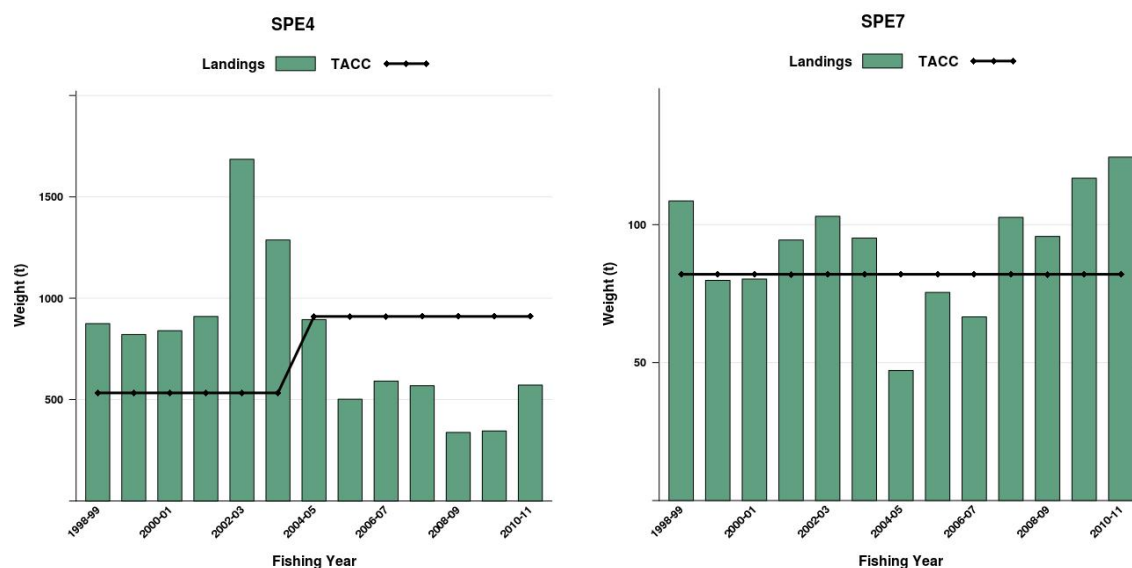
Table 2 [Continued].

Fishstock	SPE 7		SPE 8		SPE 9		SPE 10			
FMA	7		8		9		10			Total
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983-84	16	-	2	-	55	-	0	-	0	-
1984-85	14	-	1	-	2	-	0	-	0	-
1985-86	12	-	2	-	4	-	0	-	0	-
1986-87	11	-	3	-	1	-	0	-	0	-
1987-88	8	-	6	-	0	-	0	-	0	-
1988-89	5	-	2	-	1	-	0	-	0	-
1989-90	14	-	1	-	0	-	0	-	0	-
1990-91	28	-	1	-	0	-	0	-	0	-
1991-92	20	-	2	-	0	-	0	-	0	-
1992-93	71	-	18	-	0	-	2	-	2	-
1993-94	52	-	10	-	0	-	0	-	0	-
1994-95	67	-	7	-	0	-	0	-	0	-
1995-96	78	-	7	-	1	-	0	-	0	-
1996-97	64	-	7	-	1	-	< 1	-	1 310	-
1997-98	118	-	5	-	7	-	< 1	-	1 808	-
1998-99	109	82	< 1	15	2	6	0	0	2 014	1 516
1999-00	80	82	2	15	5	6	0	0	1 907	1 516
2000-01	80	82	4	15	3	6	0	0	1 853	1 778
2001-02	95	82	6	15	3	6	0	0	1 888	1 778
2002-03	103	82	4	15	4	6	0	0	2 619	1 778
2003-04	95	82	6	15	3	6	0	0	1 972	1 778
2004-05	47	82	5	15	2	6	0	0	1 475	2 155
2005-06	75	82	5	15	2	6	0	0	1 157	2 155
2006-07	67	82	2	15	2	6	0	0	1 338	2 170
2007-08	103	82	2	15	2	6	0	0	1 247	2 170
2008-09	96	82	2	15	4	6	0	0	854	2 170
2009-10	117	82	4	15	3	6	0	0	1 016	2 170
2010-11	124	82	3	15	2	6	0	0	1 506	2 170

*These numbers may contain erroneous landings data, the situation is currently under investigation and the data will be amended if an error is identified during the course of that investigation.
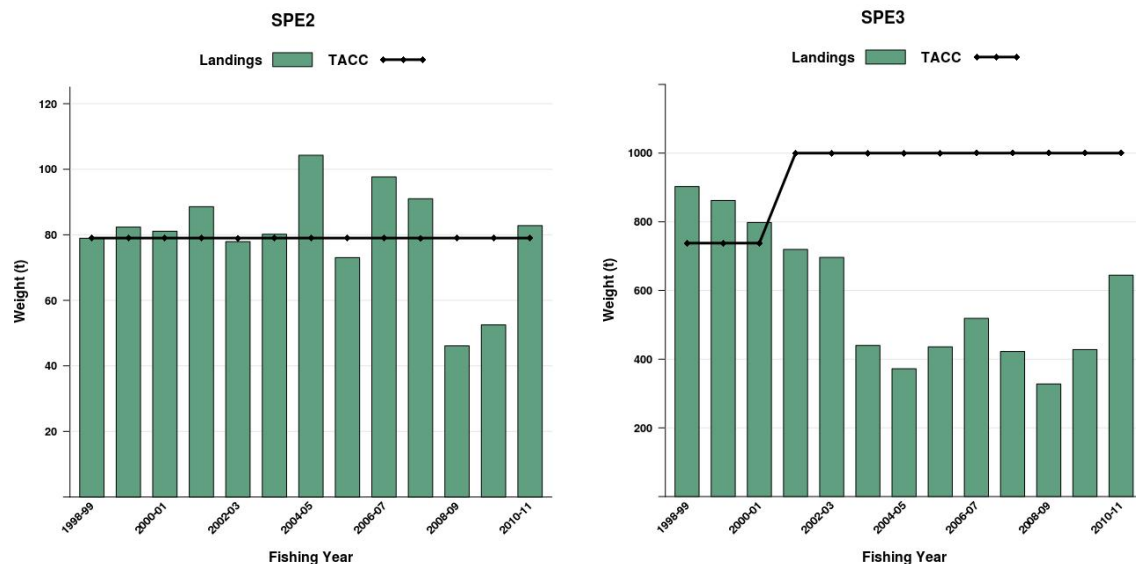
Figure 1: Historical landings and TACC for the four main SPE stocks. From left to right: SPE2 (Central East) and SPE3 (South East Coast). Note that these figures do not show data prior to entry into the QMS.

SEA PERCH (SPE)

Figure 1 [Continued]: Historical landings and TACC for the four main SPE stocks. From left to right: SPE4 (South East Chatham Rise) and SPE7 (Challenger). Note that these figures do not show data prior to entry into the QMS.

Table 3: Estimated number and weight of sea perch harvested by recreational fishers by Fishstock and survey. Surveys were carried out in different years in the Ministry of Fisheries regions: South in 1991-92, Central in 1992-93, North in 1993-94 (Teirney *et al.* 1997) and nationally in 1996 (Bradford, 1998) and 1999-00 (Boyd & Reilly 2005).

Fishstock	Survey	Number	CV%
1991-92			
SPE 3	South	110 000	25
SPE 5	South	18 000	35
SPE 7	South	16 000	-
1992-93			
SPE 2	Central	27 000	-
SPE 3	Central	< 500	-
SPE 5	Central	< 500	-
SPE 7	Central	65 000	40
SPE 8	Central	11 000	-
1993-94			
SPE 1 + 9	North	< 500	-
SPE 2	North	< 500	-
SPE 8	North	< 500	-
1996			
SPE 1 + 9	National	2000	37
SPE 2	National	23 000	-
SPE 3	National	28 000	17
SPE 5	National	3000	-
SPE 7	National	20 000	17
SPE 8	National	11 000	-
1999-00			
SPE 2	National	10 000	94
SPE 2	National	16 000	64
SPE 3	National	154 000	38
SPE 5	National	10 000	58
SPE 7	National	63 000	46
SPE 8	National	< 500	101

A key component of estimating recreational harvest from diary surveys is determining the proportion of the population that fish. The Recreational Technical Working Group concluded that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and, c) the 2000

and 2001 estimates are implausibly high for many important fisheries. The 1999-2000 Harvest estimates for each Fishstock should be evaluated with reference to the coefficient of variation.

1.3   Customary non-commercial fisheries
The customary non-commercial take has not been quantified.

1.4   Illegal catch
There is no quantitative information on illegal fishing activity or catch, and given the low commercial value of sea perch, such activity is unlikely.

1.5   Other sources of mortality
No quantitative estimates are available about the impact of other sources of mortality on sea perch stocks. However, they are commonly caught as bycatch and a moderate quantity, particularly of small fish, is undoubtedly discarded.

2.   BIOLOGY

Sea perch are widely distributed around most of New Zealand, but are rare on the Campbell Plateau. They inhabit waters ranging from the shoreline to 1200 m and are most common between 150 and 500 m. Previously it was believed that there were two species of sea perch, *H. percoides* and *H. barathri* in New Zealand waters. However, genetics research determined that there is probably only one species of sea perch in New Zealand waters, *H. percoides* (Smith 1998). Because of confusion between *H. percoides* and *H. barathri* until recent years, there is limited information on sea perch biology. Trawl surveys from about 1990 show sea perch size to vary with depth and locality without an obvious pattern, possibly representing population differences as well as life history characteristics.

Sea perch are viviparous, extruding small larvae in floating jelly-masses during an extended spawning season. Sex ratios observed in trawl survey samples show more males, generally in the ratio 1:0.7 to 1:0.8. Sea perch are opportunistic feeders and prey on a variety of animals on or close to the seafloor.

Table 4: Estimates of biological parameters for sea perch.

Fishstock	Estimate	Source
1. Natural mortality (M)		
SPE 3	0.10-0.13 (Hoenig method)	Paul & Francis (2002)
SPE 3	0.07-0.09 (Chapman Robson estimator)	Paul & Francis (2002)

2. Weight = a (length)^b (Weight in g, length in cm fork length)

		Both sexes	
	a	b	
SPE 3	0.007767	3.219132	Schofield & Livingston (1996)

3. von Bertalanffy growth parameters

	Females			Males			
	K	t_0	L_∞	K	t_0	L_∞	
ECSI 1996	0.128	-0.725	40.7	0.117	-0.64	43.6	Paul & Francis (2002)
ECSI 2000	0.13	-0.895	37.9	0.116	-0.956	42.4	Paul & Francis (2002)

Growth is relatively slow throughout life. After about age 5 years, males appear to grow faster than females (there is some uncertainty due to small sample sizes). Males mature at 19-25 cm, about 5−7 years, whereas females mature at between 15 and 20 cm, around 5 years (Paul & Francis 2002). Maximum observed ages estimated for sea perch from the east coast South Island and Chatham Rise were 32 and 43 years. The natural mortality estimates derived from these are 0.13 and 0.10 (using the Hoenig method) and 0.07−0.09 (using the Chapman-Robson estimator) (Paul & Francis 2002). Ageing studies have not identified the species involved, but the maximum age of Australian fish listed as

H. percoides by Withell & Wankowski (1988)*,* is about 40 years. The maximum size for sea perch is about 56 cm.

Biological parameters relevant to stock assessment are shown in Table 4.

3. STOCKS AND AREAS

There are no data relevant to stock boundaries. However, regional variation in colouration suggests that separate populations could exist.

4. STOCK ASSESSMENT

4.1 Estimates of fishery parameters and abundance

Estimates of relative abundance from trawl surveys are presented in Table 5. Annual biomass estimates from the winter and summer east coast South Island and Southland surveys have been variable between years, and were determined with only moderate precision (generally CVs around 30%).

The time series of biomass estimates from the West Coast South Island surveys increased between 1992 and 1995 and declined substantially from 667 t in the subsequent surveys. The 2005 estimate of relative biomass was 150 t. Annual trawl survey biomass estimates from the Chatham Rise have a low associated coefficient of variation (8-15%). The time series of indices is relatively constant between 1992 and 1994, drops significantly in 1995, and recovers in 1996. Biomass estimates increased dramatically from 2713 t in 1997 to 8417 t in 2002, but then declined until 2008. (Figure 2). The 2010 estimate was 5594 t (Table 5).

4.2 Biomass estimates

Estimates of current and reference absolute biomass are not available.

4.3 Estimation of Maximum Constant Yield (*MCY*)

No estimate of *MCY* can be made. The method $MCY = cY_{AV}$ (Method 4) requires a longer period of relatively stable, or at least known, catches (in view of a potential longevity of 40 years) than is available.

4.4 Estimation of Current Annual Yield (*CAY*)

No estimates of current biomass, fishing mortality, or other information are available which would permit the estimation of *CAY*.

4.5 Other factors

Factors influencing yield estimates (species identification, catch history, biomass estimates, longevity/mortality, and natural fluctuations in population size) are poorly known for sea perch and preclude any reliable yield estimates at present.
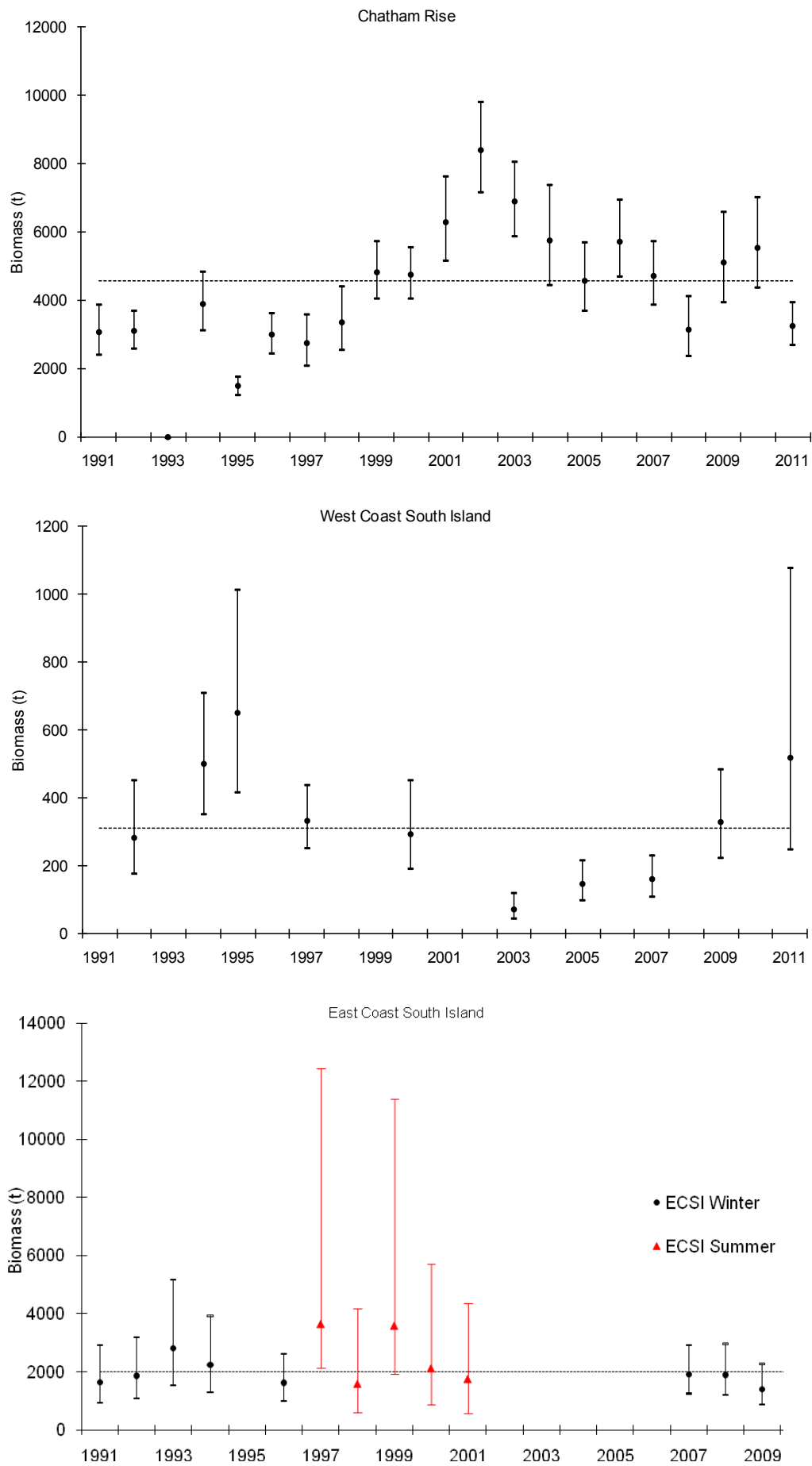
Figure 2: Biomass estimates ±95% CI from the Chatham Rise (top), West (middle), and East (bottom) Coast South Island trawl surveys.

SEA PERCH (SPE)

Table 5: Relative biomass indices (t) and coefficients of variation (CV) for west coast South Island, Stewart-Snares Island, east coast South Island (ECSI) - summer and winter, and Chatham Rise trawl surveys. Note, because trawl survey biomass estimates are indices, comparisons between different seasons (e.g., summer and winter ECSI) are not strictly valid.

| Region	Survey	Date	Biomass (t)	CV%
West coast,	KAH9204	Mar-Apr 1992	293	24
South Island	KAH9404	Mar-Apr 1994	510	18
	KAH9504	Mar-Apr 1995	667	23
	KAH9701	Mar-Apr 1997	338	14
	KAH0004	Mar-Apr 2000	302	22
	KAH0304	Mar-Apr 2003	76	25
	KAH0503	Mar-Apr 2005	150	20
	KAH0704	Mar-Apr 2007	163	19
	KAH0904	Mar-Apr 2009	336	20
	KAH1004	Mar-Apr 2010	558	39
Southland	TAN9301	Feb-Mar 1993	469	33
(Stewart-Snares	TAN9402	Feb-Mar 1994	443	26
shelf)	TAN9502	Feb-Mar 1995	450	27
	TAN9604	Feb-Mar 1996	480	29
East coast.	KAH9105	May-Jun 1991	1 802	30
South Island	KAH9205	May-Jun 1992	2 288	27
(Winter)	KAH9306	May-Jun 1993	3 348	30
	KAH9406	May-Jun 1994	2 327	29
	KAH9606	May-Jun 1996	1 671	26
	KAH0705	May-Jun 2007	1 954	22
	KAH0806	May-Jun 2008	1 944	23
	KAH0905	May-Jun 2009	1 444	25
East coast.	KAH9618	Dec-Jan 1996-97	4 041	47
South Island	KAH9704	Dec-Jan 1997-98	1 638	25
(Summer)	KAH9809	Dec-Jan 1998-99	3 889	41
	KAH9917	Dec-Jan 1999-00	2 203	27
	KAH0014	Dec-Jan 2000-01	1 792	20
Chatham Rise	TAN9106	Dec-Jan 1991-92	3 050	12
	TAN9212	Dec-Jan 1992-93	3 110	9
	TAN9401	Jan 1994	3 914	11
	TAN9501	Jan 1995	1 490	9
	TAN9601	Jan 1996	3 006	10
	TAN9701	Jan 1997	2 713	14
	TAN9801	Jan 1998	3 448	14
	TAN9901	Jan 1999	4 842	9
	TAN0001	Jan 2000	4 776	8
	TAN0101	Jan 2001	6 310	10
	TAN0201	Jan 2002	8 417	8
	TAN0301	Jan 2003	6 904	8
	TAN0401	Jan 2004	5 786	13
	TAN0501	Jan 2005	4 615	11
	TAN0601	Jan 2006	5 752	10
	TAN0701	Jan 2007	4 737	10
	TAN0801	Jan 2008	3 081	14
	TAN0901	Jan 2009	5 149	13
	TAN1001	Jan 2010	5 594	12
	TAN1101	Jan 2011	3 278	10
	TAN1201	Jan 2012	4 827	10
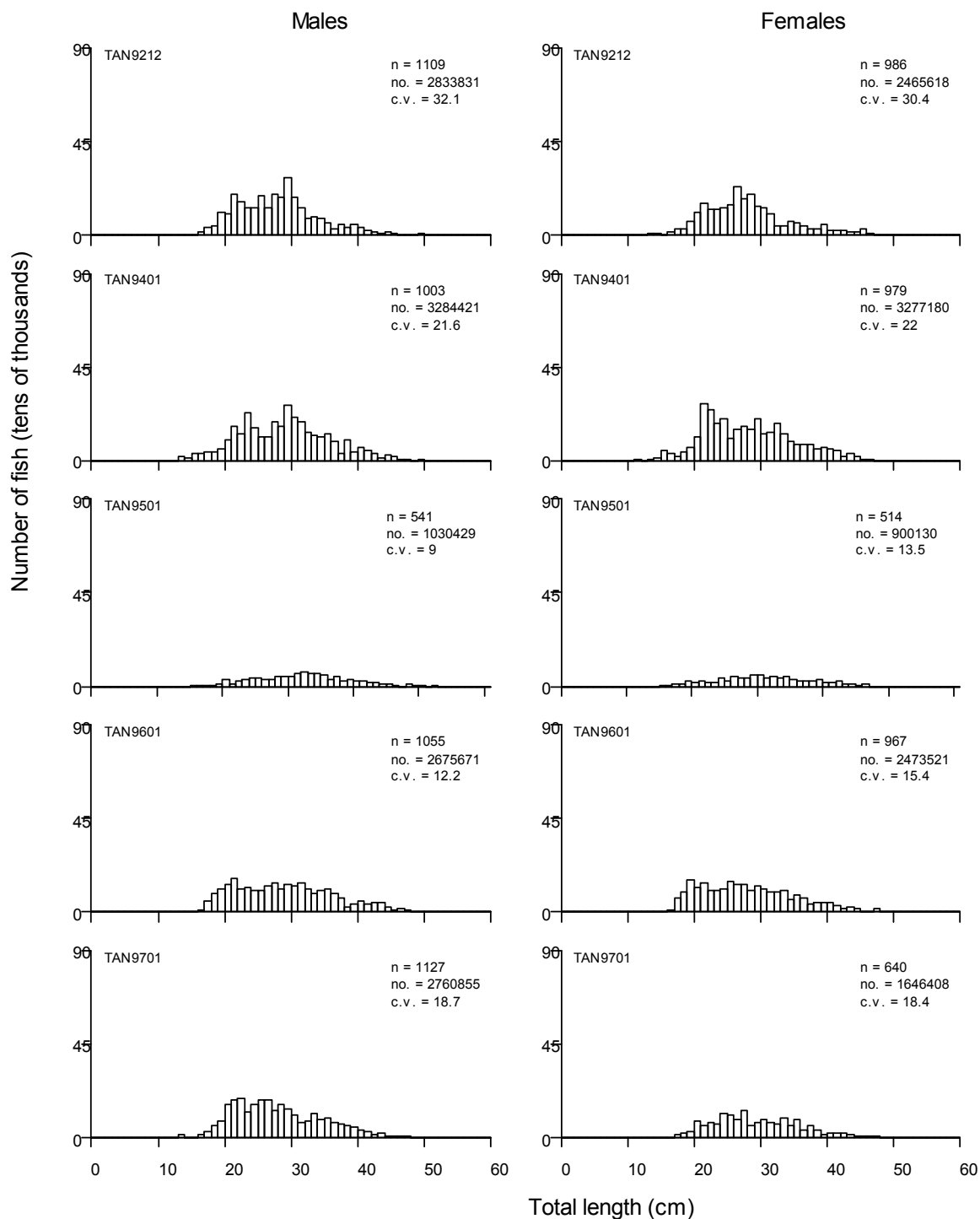
Figure 3: Scaled length frequency distributions for sea perch, for Chatham Rise surveys. M, males and F, females, (CV) (Stevens *et al.* 2011).

Figure 3 [Continued].

Males

Females

TAN0301

n = 2390
no. = 8294306
c.v. = 12.9

TAN0301

n = 1955
no. = 6398758
c.v. = 9.8

TAN0401

n = 950
no. = 5971939
c.v. = 33.1

TAN0401

n = 1061
no. = 7837374
c.v. = 40.7

TAN0501

n = 1256
no. = 4522360
c.v. = 14.9

TAN0501

n = 1086
no. = 3767223
c.v. = 11.4

TAN0601

n = 1203
no. = 5411751
c.v. = 12.4

TAN0601

n = 1270
no. = 5760468
c.v. = 15.2

TAN0701

n = 1214
no. = 4595854
c.v. = 10.9

TAN0701

n = 1304
no. = 5330989
c.v. = 16.6

Number of fish (tens of thousands)
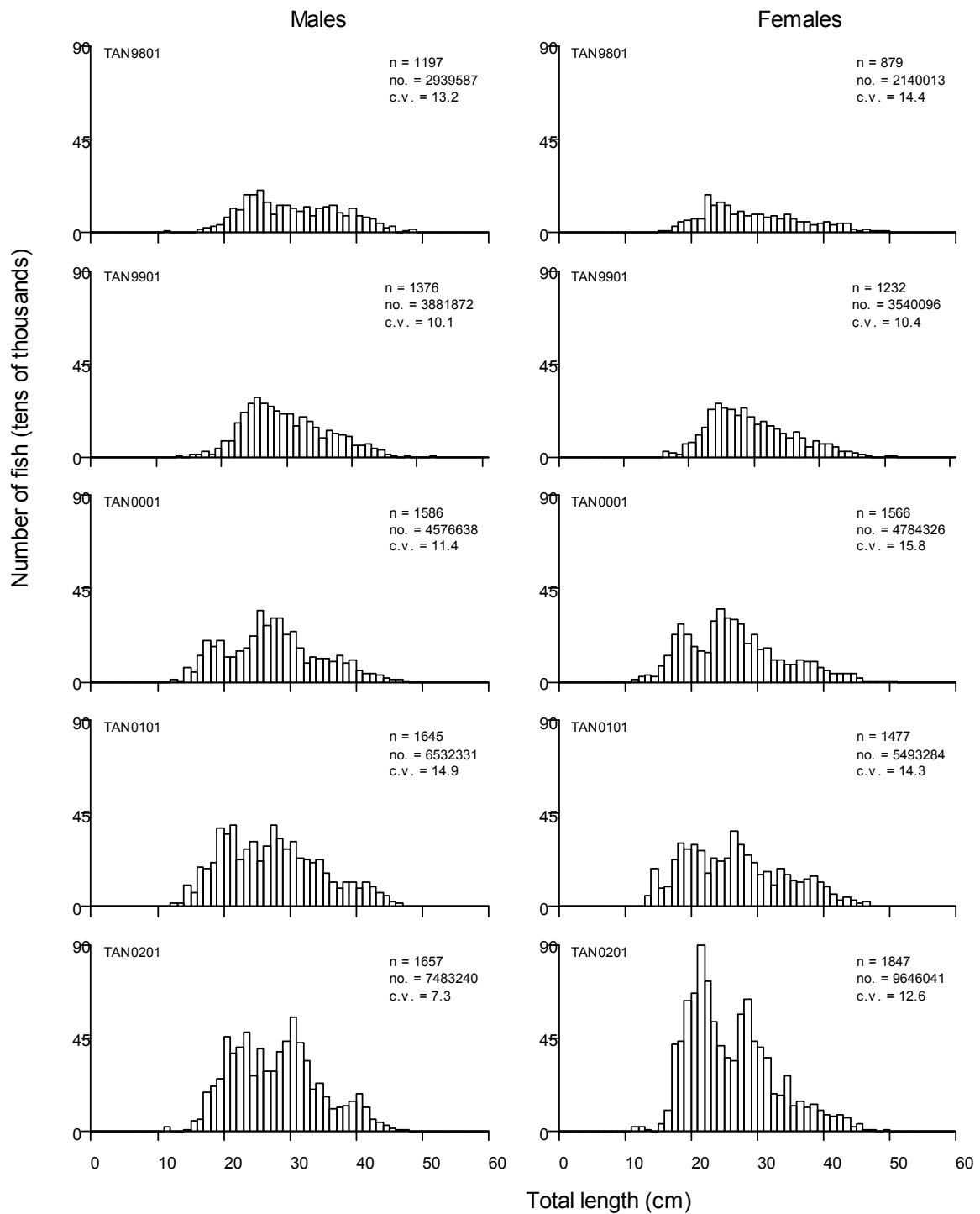
Total length (cm)

Figure 3 [Continued].

927

Males | Females

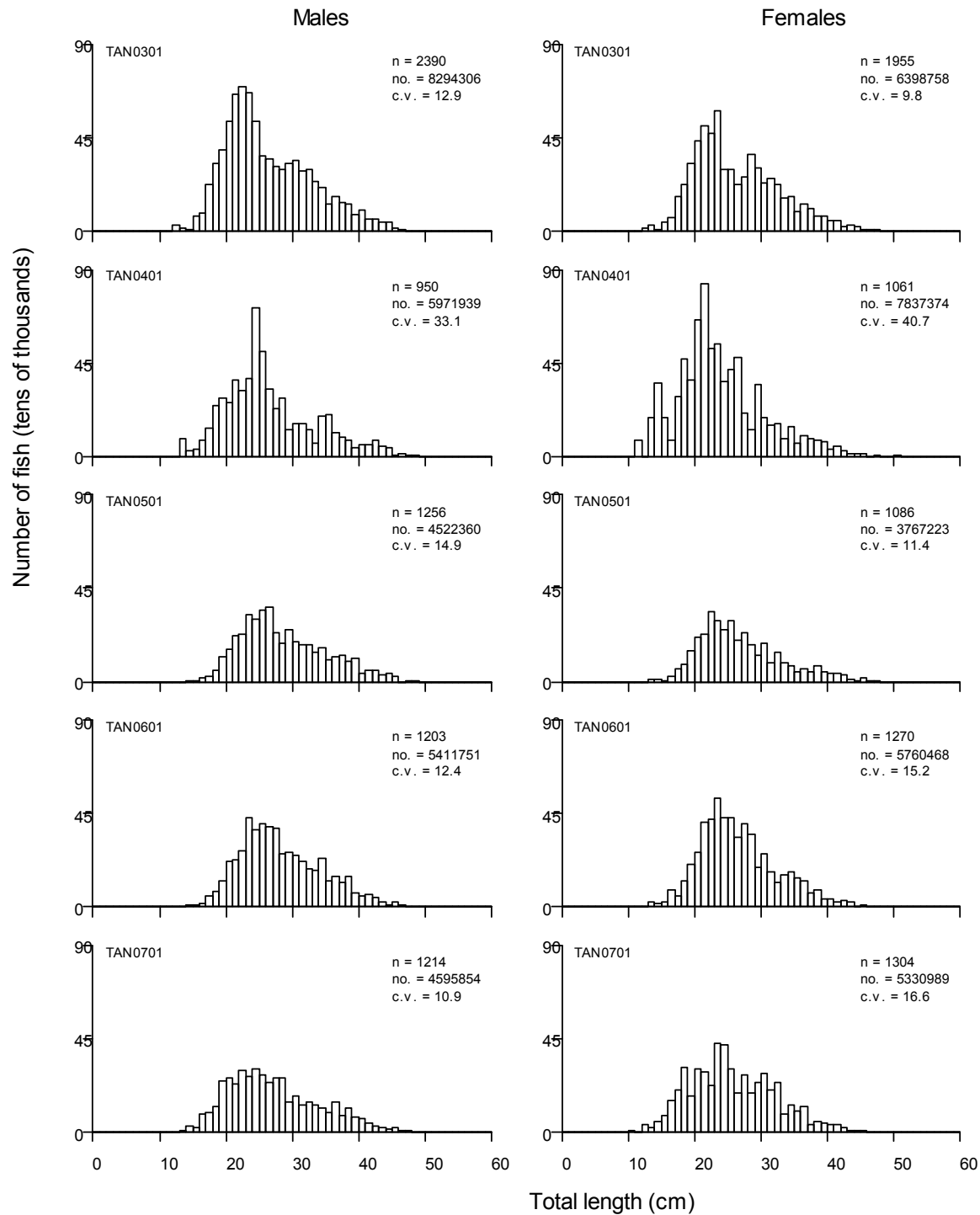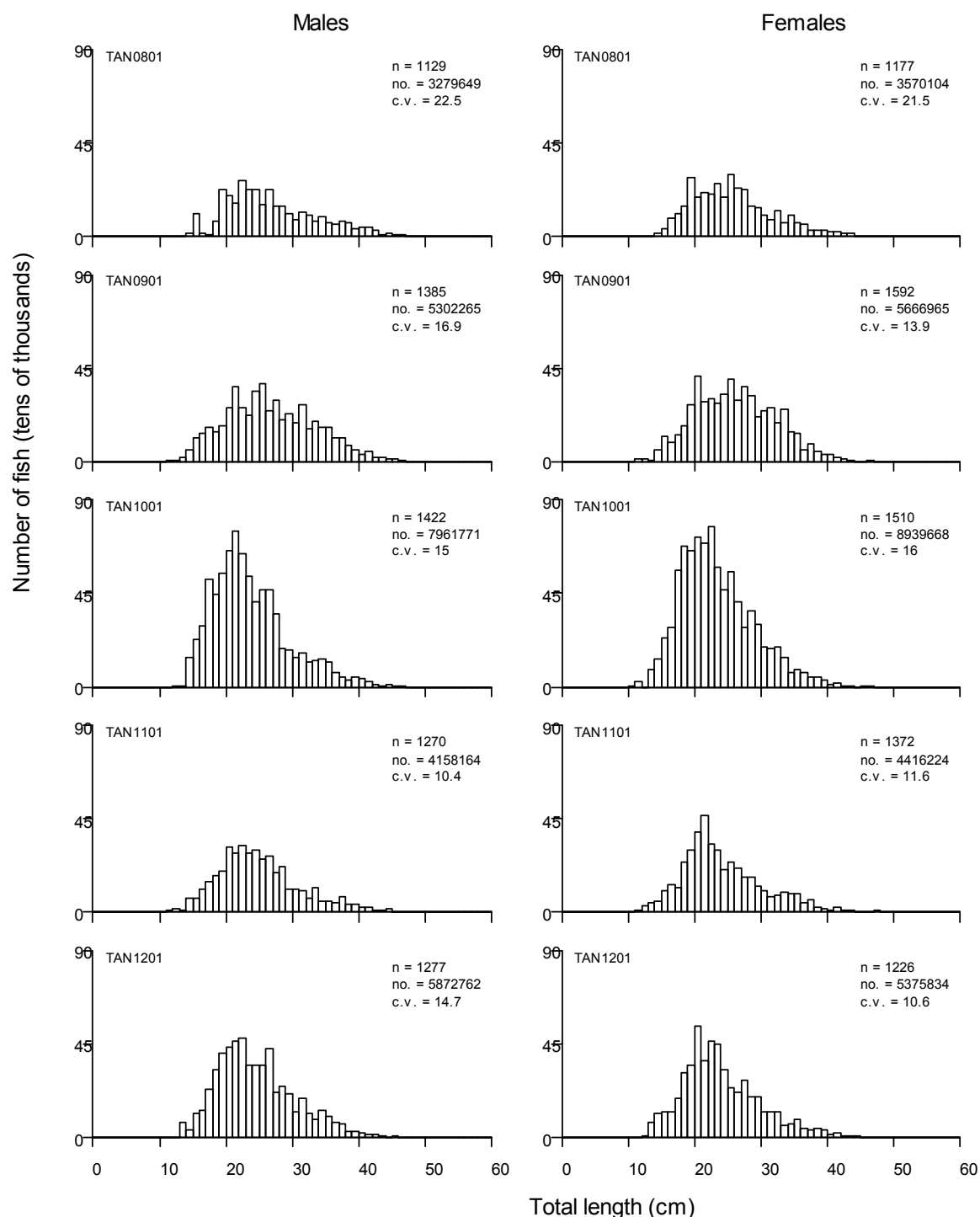**Figure 3 [Continued].**

5. ANALYSIS OF ADAPTIVE MANAGEMENT PROGRAMMES

The Ministry of Fisheries revised the AMP framework in December 2000. The AMP framework is intended to apply to all proposals for a TAC or TACC increase, with the exception of fisheries for which there is a robust stock assessment. In March 2002, the first meeting of the new AMP Working Group was held.

Two changes to the AMP were adopted:
- a new checklist was implemented with more attention being made to the environmental impacts of any new proposal,
- the annual review process was replaced with an annual review of the monitoring requirements only. Full analysis of information is required a minimum of twice during the 5 year AMP.

2008 AMP review of SPE 3

SPE 3 entered the QMS in 1998-99, and subsequently was put in the AMP in October 2001 with a TACC increase from 738 t to 1000 t. The TACC has since remained at that level with a 11 t customary and recreational catch, raising the TAC to 1022 t. Prior to entry into the QMS, catches of SPE 3 increased steadily from approximately 100 t/year in 1982-83 to a peak of 903 t in 1998-99. After the TACC increase to 1000 t, catches declined to 372 t by 2004-05, then increased to 519 t in 2006-07, around the level of catch in the mid-1990s. Since entry into the AMP, SPE 3 annual catches have averaged about half of the TACC.

In 2008 the AMP FAWG reviewed the performance of the AMP (Starr *et al.* 2008). The Working Group noted:

Fishery characterization
- Most (94%) SPE 3 have been caught by bottom trawl (BT) since 1998-99, with the remaining 6% divided between bottom longline, mid-water trawl, setnet and Dahn line fisheries. 48 t of SPE is reported as being caught in cod and rock lobster pots, but this may the result of misreporting species such as Māori chief and Jock Stewart.
- Most bottom trawl effort landing SPE occurs in Area 020: Pegasus Bay and Area 022: Canterbury Bight. Significant SPE-directed effort also occurred in Area 018: Kaikoura, although this fishery almost ceased since 2001-02. Bottom longline (BLL) SPE 3 effort occurs mainly off Pegasus Bay, with some effort in Areas 018 022.
- BT and BLL SPE 3 landings occur throughout the year, with somewhat higher BT catches in late autumn or early winter in some years. Setnet landings mainly occur from December to May, and have also been diminishing in recent years. A Dahn line fishery for sea perch has developed since 2004-05, primarily from October to February.
- Landings of SPE 3 by statistical area show changes over time. Most notable is the disappearance of the Area 018 target SPE fishery after 2001-02. Area 022 has higher landings in many years from February to May, coinciding with the peak of the red cod fishery. Area 020 tends to have higher landings in October and September, whereas Areas 020 or 022 show no strong seasonal patterns.
- SPE is caught by BT targeting barracouta, tarakihi and flounder. BLL effort catching sea perch mainly target ling, with some targeting of bluenose and hapuku/bass. Setnet SPE 3 catches are taken by fisheries targeting tarakihi, ling, spiny dogfish, bluenose and rig. The recently developed Dahn line fishery is almost entirely targeted at sea perch.
- Depth information on TCEPR forms show that sea perch are mainly taken between 90 m and 580 m of depth (median 323 m, mean 369 m), depending on target species, shallower for red cod and barracouta targeting, and deeper for hoki, scampi or hake tows.

CPUE analysis
- Two CPUE analyses were performed on the SPE 3 catch and effort for sea perch catches in a range of east coast South Island bottom trawl fisheries, updating similar analyses presented to the AMP FAWG in 2006:
  - BT(MIX): a mixed target trawl fishery targeting red cod, barracouta, tarakihi and sea perch in statistical areas valid for SPE 3.
  - BT(HOK): a target hoki trawl fishery operating at the deeper end of the sea perch depth distribution fishing in statistical areas valid for SPE 3.
- The target SPE 3 bottom trawl fishery, under which the original SPE 3 AMP was granted, largely ceased when the main participant withdrew from the fishery in 2002-03. The total

number of target SPE tows has since declined and it appears that new participants are fishing in different areas from the previous fishery that was centred around Kaikoura. The SPE-targeted BT CPUE series presented in 2004 is therefore no longer considered to be representative of SPE abundance, and has not been updated.

- Unstandardised CPUE indices for the BT(HOK) analysis show high variability and no clear trends. Sea perch are not well reported from this fishery, resulting in an unreliable index, and the Working Group also did not accept the BT(HOK) analysis.

- The preferred lognormal BT(MIX) model shows a gradual declining trend since the start of the series in 1998/99, with some suggestion that the decline may have levelled off since 2005-06 (Figure 3). Unstandardised series are similar to the standardised series, although with a somewhat steeper decline to a slightly lower level in recent years.

- The decline in the BT(MIX) series occurred over a period when catches were decreasing, partially as a result of departure of the main participant in this fishery. Changes in participation and spatial fishing patterns are probably contributing both to the observed CPUE decline as well as possible changes in abundance.
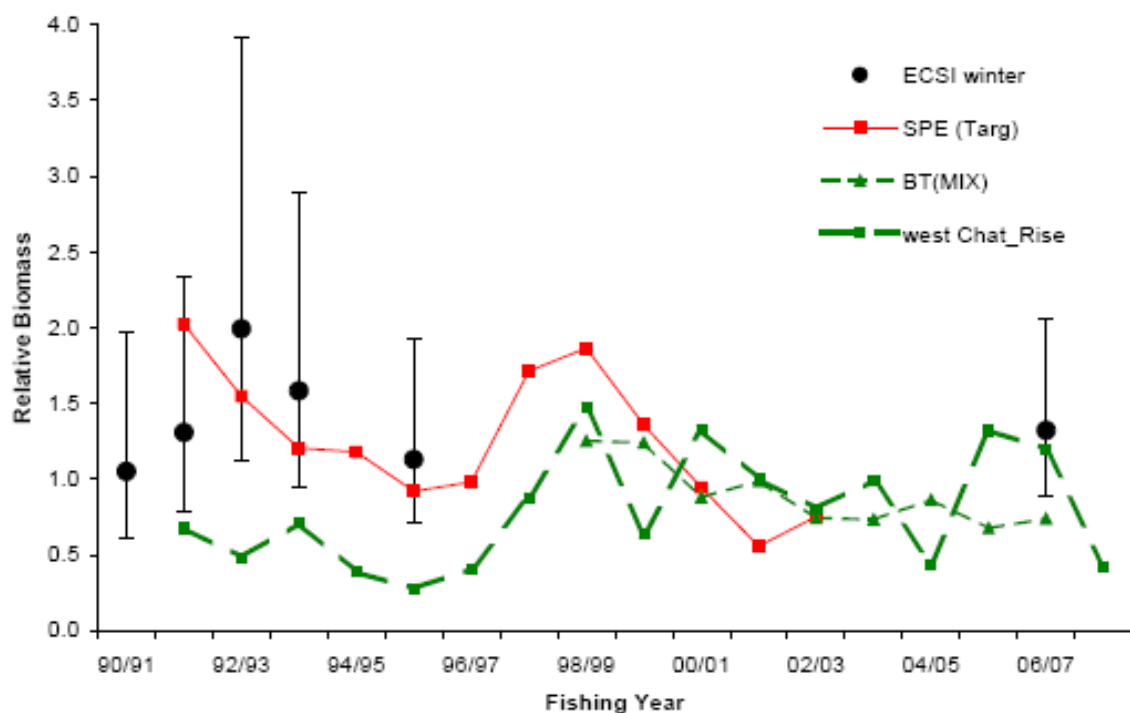

Figure 4: Comparison plot of the winter ECSI and western Chatham Rise SPE survey biomass indices with the SPE(Targ) CPUE series and the BT(MIX) CPUE series. The survey series were assumed to relate to the final year of the fishing year pair. The two CPUE series and the western Chatham Rise series have been standardised to a common geometric mean from 1998- 99 to 2002-03 and the ECSI series has been standardised to the common geometric mean with the SPE(Targ) series from 1991-92 to 1993-94 and 1995-96.

Trawl survey abundance indices

- Data from three trawl surveys in SPE 3 and 4 have been summarised to examine trends in SPE relative abundance and length composition: east coast South Island (ECSI) winter surveys from 1991-1996 (5 surveys) and 2007 (1 survey); ECSI summer surveys from 1997-2001 (5 surveys) and Chatham Rise summer surveys (restricted to the strata west of 176°E) from 1992-2008 (17 surveys).

- Catches of sea perch from the ECSI trawl surveys were low in depths < 80 m in the Canterbury Bight and Pegasus Bay. Highest catch rates were achieved in the 100 m to 180 m depth along the edge of the continental shelf, and catches were low in depths exceeding 200m. SPE were only caught in small quantities in the Chatham Rise survey, with highest catches in the shallower areas of the northern central Chatham Rise.

- Biomass estimates from the ECSI winter survey show no trend among the first five survey indices, increasing between 1991 and 1993 and then declining in 1994 and 1996 (Figure 2 and 3). The ECSI winter series was reinstated in 2007, with a biomass estimate near the median of the earlier five surveys and likely indicative of no overall trend in the 11 year gap between survey periods. ECSI summer survey results are not considered to be reliable indices of SPE abundance.

- Biomass estimates from the western Chatham Rise show no overall trend, with a steady increase from the lowest estimate in 1995 to a peak in 2002, followed by a decline at a similar rate to a level in 2008 similar to the 1996-1998 levels (Figure 3). It is not known how the sea perch population on the Chatham Rise relates to the population being fished in SPE 3.

- Length compositions from the winter ECSI surveys were dominated by a strong 20-25 cm length mode. There was no significant difference in the length composition for male and female fish and no indication of substantial changes in the length composition over the study period.

- Length compositions from the Chatham Rise surveys were slightly larger, mostly 20 cm - 30 cm and attaining 50 cm, but with high variability between surveys. Strong modal peaks are evident, with some suggestion from modal progression that these may represent year classes. It may be feasible to assess recruitment variation from these data once information on SPE age and growth is available. However, most of this survey falls into SPE 4.

Logbook programme

- A bottom trawl logbook programme which only sampled the target SPE 3 fishery was introduced in 2001-02. This programme collected data for about one year before the primary participant left the fishery, after which the programme was discontinued. A general programme to sample the east coast South Island trawl fishery started in 2003-04, initially to sample elephantfish, but was gradually extended to sample other AMP species, including sea perch.

- The SPE 3 bottom trawl logbook programme obtained possibly adequate coverage of the SPE 3 target bottom trawl fishery for sea perch in 2001-02 and 2004-05. The coverage of the by-catch of sea perch was poor in all years due to the diversity of the mixed BT fishery and the scarcity of SPE in individual tows. The number of reported tows in the programme has ranged from 144 to 905 per year, over all sampled tows. However, the amount of sea perch catch sampled was only 200 kg to 11 t of estimated catch. Coverage levels of SPE by catch weight have ranged from 0 to 2.5% and only 153 tows, out of the total of 2 526 reported tows, recorded sampled SPE catch.

- Coverage of the target sea perch fishery was over 10% in 2001-02 when the principal operator was participating, and coverage of the smaller target SPE fishery in 2004-05 was about 16%. Coverage of the bycatch fishery was 0.3% in 2006-07.

- There are indications in length-frequency data from logbooks of a decrease in the proportion of large (> 35 cm) fish from catches between 2001-02 and 2006-07, and a resultant decrease in modal size from around 32 cm in 2001-02 to 25 cm in 2006-07. However, these conclusions need to be considered against the general lack of representative and consistent sampling from this programme.

Effects of fishing

- Incidental mortality of Hectors dolphin from trawling appears to be rare. One capture of a Hectors dolphin was observed in the red cod trawl fishery in QMA 3 in 1997 -1998 (Starr & Langley 2000). In particular, the majority of trawls which catch SPE 3 occur between 90 m and 600 m (median 330 m), outside the known distribution of Hectors dolphin, which is within 4 nautical miles of the coast, particularly in the summer months.

- Low observer coverage and lack of fine scale catch reporting has made it difficult to objectively evaluate the environmental effects of fishing under the STA 3 AMP. The rates of non-fish bycatch are unknown, monitoring is not adequate. Since the last review of STA 3 in 2006:

- ▪ The Non-fish/Protected Species Catch Return to be implemented from 1 October 2008 should provide information on the level of non-fish/protected species bycatch for the next review of STA 3. However, adequate observer coverage will still be required to validate reporting rates.
- ▪ The draft Hector's and Maui's Dolphin Threat Management Plan (TMP) released for consultation (MFish and DOC 2007) proposes an extension to the existing Banks Peninsula marine mammal sanctuary.
- ▪ Under the seabird sustainability measures that begin on 1 June 2008, trawlers cannot discharge offal or fish on more than one occasion per tow or during shooting or hauling or within 20 minutes before shooting.

Conclusions

- A direct comparison of the indices considered most reliable for SPE 3 (the historic SPE(Targ) CPUE, the BT(MIX) CPUE and the ECSI and West Chatham Rise surveys) indicates that the indices from the ECSI survey agree reasonably well with the historic SPE(Targ) CPUE series but lie above the two current CPUE series. The two survey series (western Chatham Rise and ECSI) show similar trends (Figure 2). The western Chatham Rise survey series lies below the ECSI series and the SPE(Targ) series in the early 1990s, but agrees reasonably well with the two CPUE series in the early to mid-2000s.
- Interpretation of these results depends on the relative weight given to the various indices. The ECSI survey series, and particularly the 2007 survey estimate, suggests stable catch rates with no trend across the series. However, the SPE(Targ) index, the BT(MIX) index and the western Chatham Rise survey index from 1999-2005 all indicate a decline in abundance since 1998-99, perhaps levelling off in the last two years. The 2007 ECSI survey estimate requires confirmation from repeat surveys in 2008 and 2009.

AMP review checklist

1. The East Coast South Island winter trawl survey is likely to be the best index of abundance for the SPE 3 stock, although there are concerns that this may not be indexing the full population (SPE occur deeper than the survey), and that SPE 3 may be linked to the Chatham Rise SPE population. Of the CPUE indices, the BT(MIX) index may be providing a reasonable index of the currently fished component of SPE 3.
2. With the drop in interest in the targeted SPE bottom trawl fishery and the departure of the main, logbook coverage of remaining SPE 3 bycatch fishery has been negligible.
3. Additional analyses recommended by the Working Group included:
   o For the next review, CPUE standardisation should be conducted for the full time series in the BT(MIX) SPE bycatch fishery, and not just from 1998-99 onwards, to evaluate the degree of correspondence with the historic SPE(Targ) index. In extending this analysis back in time, target should be used as a categorical explanatory variable to evaluate the possible effect of change in reporting practices before and after entry of SPE 3 into the QMS in 1998-99.
4. The combination of optimistic recent trawl surveys estimates and levelling off in the BT(MIX) CPUE index indicate that current harvest levels should be sustainable. However, most indices indicate a decline over the period of the targeted SPE 3 fishery from 1998-99 to 2002-03, when catches were about double current levels. There are therefore indications that the current TACC may not be sustainable.
5. The status of the SPE 3 stock in relation to B_{MSY} has not been estimated. Further ECSI winter trawl survey results may further inform this view over the next two years.
6. Observer coverage levels of the inshore trawl fisheries are low, and the effects of fishing are not currently adequately monitored. Introduction of the '*Non-fish/Protected Species Catch Return*' into the suite of regulated MFish forms from 1st October 2008 may provide a credible source of information on the level of protected species bycatch. However, observer coverage will still be required to validate fisher reporting rates.
7. Given the low observer coverage in this fishery, rates of non-fish bycatch are not known with any confidence, and it is not known whether rates of bycatch are acceptable.

8. The Working Group concluded that this stock does not need to be referred to the Plenary for review. However, catches should be monitored and consideration given to bringing forward the next SPE 3 review if catches increase substantially.

6.   STATUS OF THE STOCKS

No estimates of current and reference biomass are available.

For all SPE Fishstocks it is not known if recent catch levels are sustainable.

TACCs and reported landings of sea perch in the 2010-11 fishing year are summarised in Table 6.

Table 6: Summary of TACCs (t), and reported landings (t) of sea perch for the most recent fishing year.

Fishstock		QMA	2010-11 Actual TACC	2010-11 Reported landings
SPE 1	Auckland (East)	1	33	53
SPE 2	Central (East)	2	79	83
SPE 3	South-east (coast)	3	1 000	644
SPE 4	South-east (Chatham)	4	910	572
SPE 5	Southland	5	36	22
SPE 6	Sub-Antarctic	6	9	2
SPE 7	Challenger	7	82	124
SPE 8	Central (West)	8	15	3
SPE 9	Auckland (West)	9	6	2
SPE 10	Kermadec	10	0	0
Total			2 170	1 506

7.   FOR FURTHER INFORMATION

Beentjes M.P., Horn P.L., Bagley N.W. 2007. Characterisation of the Chatham Rise sea perch fishery. New Zealand Fisheries Assessment Report 2007/16. 84p.

Bradford E. 1998. Harvest estimates from the 1996 national recreational fishing surveys. New Zealand. Fisheries Assessment Research Document 1998/16. 27p.

Boyd R.O., Reilly J.L. 2005. 1999/2000 national marine recreational fishing survey: harvest estimates. Draft New Zealand Fisheries Assessment Report.

CFMC 2001. (Challenger Finfish Management Company.) Performance of the SPO 7 Adaptive Management Programme dated 7 May 2001. Copies held by The Ministry of Fisheries.

Hart A.M., Walker N.A. 2004. Monitoring the recreational blue cod and sea perch fishery in the Kaikoura - North Canterbury area. New Zealand Fisheries Assessment Report 2004/45. 88p.

Park T.J. 1994. Ocean perch, *Helicolenus* sp. *In* Tilzey, R.D.J. (Ed.), The South East Fishery. A scientific review with particular reference to quota management. pp. 237-246. Bureau of Resource Sciences, Canberra. 360p.

Paul L.J. 1998. A summary of biology and commercial landings, and a stock assessment of the sea perches, *Helicolenus* spp. (Scorpaenidae) in New Zealand waters. New Zealand Fisheries Assessment Research Document 1998/29. 30p.

Paulin C.D. 1982. Scorpion fishes of New Zealand. New Zealand Journal of Zoology 9(4): 437-450.

Paulin C.D. 1989. Redescription of *Helicolenus percoides* (Richardson) and *H. barathri* (Hector) from New Zealand (Pisces, Scorpaenidae). Journal of the Royal Society of New Zealand 19(3): 319-325.

Schofield K.A., Livingston M.E. 1996. Trawl survey of hoki and middle depth species on the Chatham Rise, January 1996 (TAN9601). NZ Fisheries Data Report No. 71. 50p.

Seafood Industry Council (SeaFIC). 2003. 2003 performance report SPE 3 Adaptive Management Programme. AMP-WG-2003/05 11p. Copies held at The Ministry of Fisheries.

Seafood Industry Council (SeaFIC). 2004. Report to the Adaptive Management Fishery Assessment Working Group: Performance of the SPE 3 Adaptive Management Programme. AMP-WG-2004/07 53 p. Copies held by The Ministry of Fisheries.

Seafood Industry Council (SeaFIC). 2004 performance report SPE 3 Adaptive Management Programme. AMP-WG-2003/05 11p. Copies held at The Ministry of Fisheries.

Southeast Finfish Management Company (SEFMC) 2001. SPE 3 Adaptive Management Programme Proposal - 2001 dated 7 May 2001.

Smith P. 1998. Molecular identification of sea perch species. Final Report to the Ministry of Fisheries for Project MOF706. 17p.

Starr P.J., Kendrick T.H., Lydon G.J. 2006. Full Term Review of the SPE 3 Adaptive Management Programme. 71p. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).

Starr P.J., Kendrick T.H., Bently N., Lydon G.J. 2008. Review of the SPE 3 Adaptive Management Programme. 82p. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).

Stevens D.W., O'Driscoll R.L., Ballara S.L., Bagley N., Horn P.L. 2011. Chatham Rise Trawl Survey, 2 Jan - 28 Jan 2011 (TAN1011). WG-HOK-2011/X. X p. (Unpublished report held by Ministry of Fisheries, Wellington.)

SEA PERCH (SPE)

Stewart P. (Comp.) 1993. Ocean perch. *In* Kailola PJ., Williams MJ., Stewart PC., Reichelt RE., McNee A., Grieve C.. (Ed), Australian Fisheries Resources. 241-242 pp. Bureau of Resource Sciences, Canberra. 422p.

Teirney L.D., Kilner A.R., Millar R.E., Bradford E., Bell J.D. 1997. Estimation of recreational catch from 1991/92 to 1993/94 New Zealand. Fisheries Assessment Research Document 1997/15. 43p.

Withell A.F., Wankowski J.W. 1988. Estimates of age and growth of ocean perch. *Helicolenus percoides* Richardson, in south-eastern Australian waters. Australian Journal of Marine and Freshwater Research 39(4): 441-457.

SILVER WAREHOU (SWA)

(*Seriolella punctata*)
Warehou
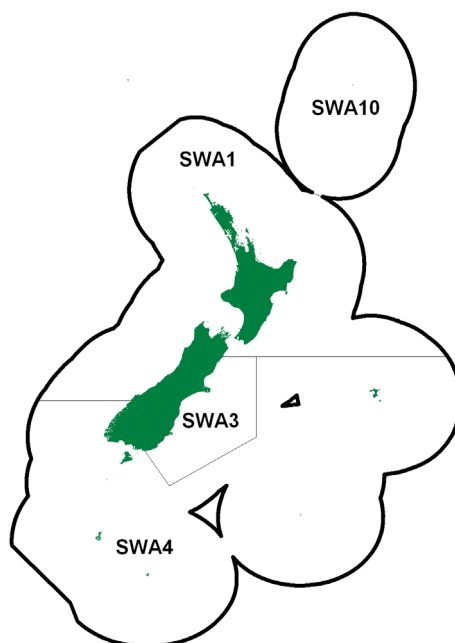
1.   FISHERY SUMMARY

1.1   Commercial fisheries

Silver warehou entered the Quota Management System (QMS) on 1 October 1986. Silver warehou are common around the South Island and on the Chatham Rise in depths of 200-800 m. The majority of the commercial catch is taken from the Chatham Rise, Canterbury Bight, southeast of Stewart Island and the west coast of the South Island. Reported landings by nation from 1974 to 1987-88 are shown in Table 1.

Table 1: Reported landings (t) by nation from 1974 to 1987-88. Source: 1974-1978 (Paul 1980); 1978 to 1987-88 (FSU).

Fishing Year	New Zealand			Japan	Korea	USSR	Foreign Licensed Total	Grand Total
	Domestic	Chartered	Total					
1974*								7 412
1975*								6 869
1976*	estimated as 70% of total warehou landings							13 142
1977*								12 966
1978*								12 581
1978-79**	?	629	629	3 868	122	212	4 203	4 832
1979-80**	?	3 466	3 466	4 431	217	196	4 843	8 309
1980-81**	?	2 397	2 397	1 246	-	13	1 259	3 656
1981-81**	?	2 184	2 184	1 174	186	3	1 363	3 547
1982-83**	?	3 363	3 363	1 162	265	189	1 616	4 979
1983†	?	1 556	1 556	510	98	3	611	2 167
1983-84§	303	3 249	3 552	418	194	3	615	4 167
1984-85§	203	4 754	4 957	1 348	387	15	1 749	6 706
1985-86§	276	5 132	5 408	1 424	217	5	1 646	7 054
1986-87§	261	4 565	4 826	1 169	29	100	1 299	6 125
1987-88§	499	7 008	7 507	431	111	39	581	8 088

* Calendar year.

**1 April to 31 March.

†1 April to 30 September.

§1 October to 30 September.

Before the establishment of the EEZ, silver warehou landings were lumped with white and blue warehou landings under the title "warehous". Between 1974 and 1977, 70% of the "warehou" landings are estimated to have been silver warehou because of the areas fished. The depth distributions of silver warehou and blue warehou are reasonably distinct, and white warehou form a very small proportion of more recent warehou catches and biomass estimates from trawl surveys.

The estimated catches of silver warehou before the declaration of the EEZ were particularly high in 1976, 1977 and 1978 (Table 1). Concern about overfishing on the eastern Stewart-Snares shelf led to closure of this area to trawlers between October 1977 and January 1978. The high catch in 1978 represents a shift in effort, particularly by Japan, to the Chatham Rise, presumably because of the restriction on the Stewart-Snares shelf. Total reported catches since 1978-79 have been generally lower than estimated landings before 1978.

In recent years, most of the silver warehou catch has been taken as a bycatch of the hoki, squid, barracouta and jack mackerel trawl fisheries. Catches from SWA 1 increased substantially after 1985-86 following the development of the west coast South Island hoki fishery. Overruns of the TAC probably partly reflected the hoki fleet fishing in relatively shallow water (northern grounds) in the later part of the season, but could also have reflected changes in abundance. Some target fishing for silver warehou does still occur, predominantly on the Mernoo Bank and along the Stewart-Snares shelf. Recent reported landings are shown in Table 2, while Figure 1 shows the historical landings and TACC values for the main SWA stocks.

The TACC in SWA 1 was increased in 1991-92 under the "adaptive management" programme (AMP). A review of this fishstock at the completion of 5 years in the AMP concluded that it was not known if the current TACC would be sustainable and an appropriate monitoring programme was not in place. Under the criteria developed for the AMP the Minister therefore removed this fishstock from the AMP in October 1997 and set the TACC at 2132 t. A new AMP proposal in 2002 resulted in the TACC being increased to 3000 t from 1 October 2002, with 1 t customary and 2 t recreational allowances within a TAC of 3003 t. Catches have not approached the new TACC level in recent years as reductions in the hoki quota have resulted in much less effort on the WCSI in winter.

In most years from 2000-01 to 2006-07 catches in SWA 3 and SWA 4 were well above the TACCs as fishers landed catches well in excess of ACE holdings and paid deemed values for the overcatch. From 1 October 2007 the deemed values were increased to $1.22 per kg for all SWA stocks and two differential rates were also introduced. The second differential rate applies to all catch over 130% of ACE holding at which point the deemed value rate increased to $3 per kg. The effect of these measures was seen immediately in 2007-08 as fishing without ACE was reduced and catch fell well below the TACCs in both SWA 3 and SWA 4.

Table 2: Reported landings (t) of silver warehou by Fishstock from 1983-84 to 2010-11 and TACCs (t) from 1986-87 to 2010-11. QMS data from 1986-present.

Fishstock	SWA 1		SWA 3		SWA 4		SWA 10			
FMA (s)	1, 2, 7, 8 & 9		3		4, 5 & 6		10			Total
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983-84*	541	-	725	-	1 829	-	0	-	3 095	-
1984-85*	587	-	1 557	-	4 563	-	0	-	6 707	-
1985-86*	806	-	2 284	-	3 966	-	0	-	7 056	-
1986-87	1 337	1 800	1 931	2 600	2 779	3 600	0	10	6 047	§8 010
1987-88	2 947	1 815	3 810	2 601	2 600	3 600	0	10	9 357	§8 026
1988-89	1 605	1 821	1 476	2 640	2 789	3 745	0	10	5 870	8 216
1989-90	2 316	2 128	2 713	3 140	3 596	3 855	0	10	8 625	9 133
1990-91	2 121	2 128	1 889	3 144	3 176	3 855	0	10	7 186	9 137
1991-92	1 388	2 500	2 661	3 144	3 018	3 855	0	10	7 066	9 509
1992-93	1 231	2 504	2 432	3 145	3 137	3 855	0	10	6 800	9 514
1993-94	2 960	2 504	2 724	3 145	2 993	3 855	0	10	8 677	9 514
1994-95	2 281	2 504	2 336	3 280	2 638	4 090	0	10	7 255	9 884
1995-96	2 884	2 504	2 939	3 280	3 581	4 090	0	10	9 404	9 884
1996-97	3 636	2 504	4 063	3 280	5 336	4 090	0	10	13 035	9 884
1997-98	3 380	2 132	3 721	3 280	3 944	4 090	0	10	11 045	9 512
1998-99	1 980	2 132	2 796	3 280	4 021	4 090	0	10	8 797	9 512

Table 2 Continued:

	SWA 1		SWA 3		SWA 4		SWA 10		Total	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1999-00	2 525	2 132	4 129	3 280	4 606	4 090	0	10	11 260	9 512
2000-01	3 025	2 132	3 664	3 280	4 650	4 090	0	10	11 339	9 512
2001-02	1 004	2 132	2 899	3 280	4 648	4 090	0	10	8 551	9 512
2002-03	1 029	3 000	3 772	3 280	4 746	4 090	0	10	9 547	10 380
2003-04	1 595	3 000	3 606	3 280	5 529	4 090	0	10	10 730	10 380
2004-05	1 467	3 000	3 797	3 280	4 279	4 090	0	10	9 543	10 380
2005-06	1 023	3 000	4 524	3 280	5 591	4 090	0	10	11 138	10 380
2006-07	2 093	3 000	6 059	3 280	6 022	4 090	0	10	14 174	10 380
2007-08	1 679	3 000	2 918	3 280	3 510	4 090	0	10	8 107	10 380
2008-09	1 366	3 000	3 264	3 280	4 213	4 090	0	10	8 843	10 380
2009-10	712	3 000	2 937	3 280	3 429	4 090	0	10	7 078	10 380
2010-11	938	3 000	3 559	3 280	3 507	4 090	0	10	8 004	10 380

*FSU data.

§Totals do not match those in Table 1 as the data were collected independently and there was under-reporting to the FSU in 1987-88.
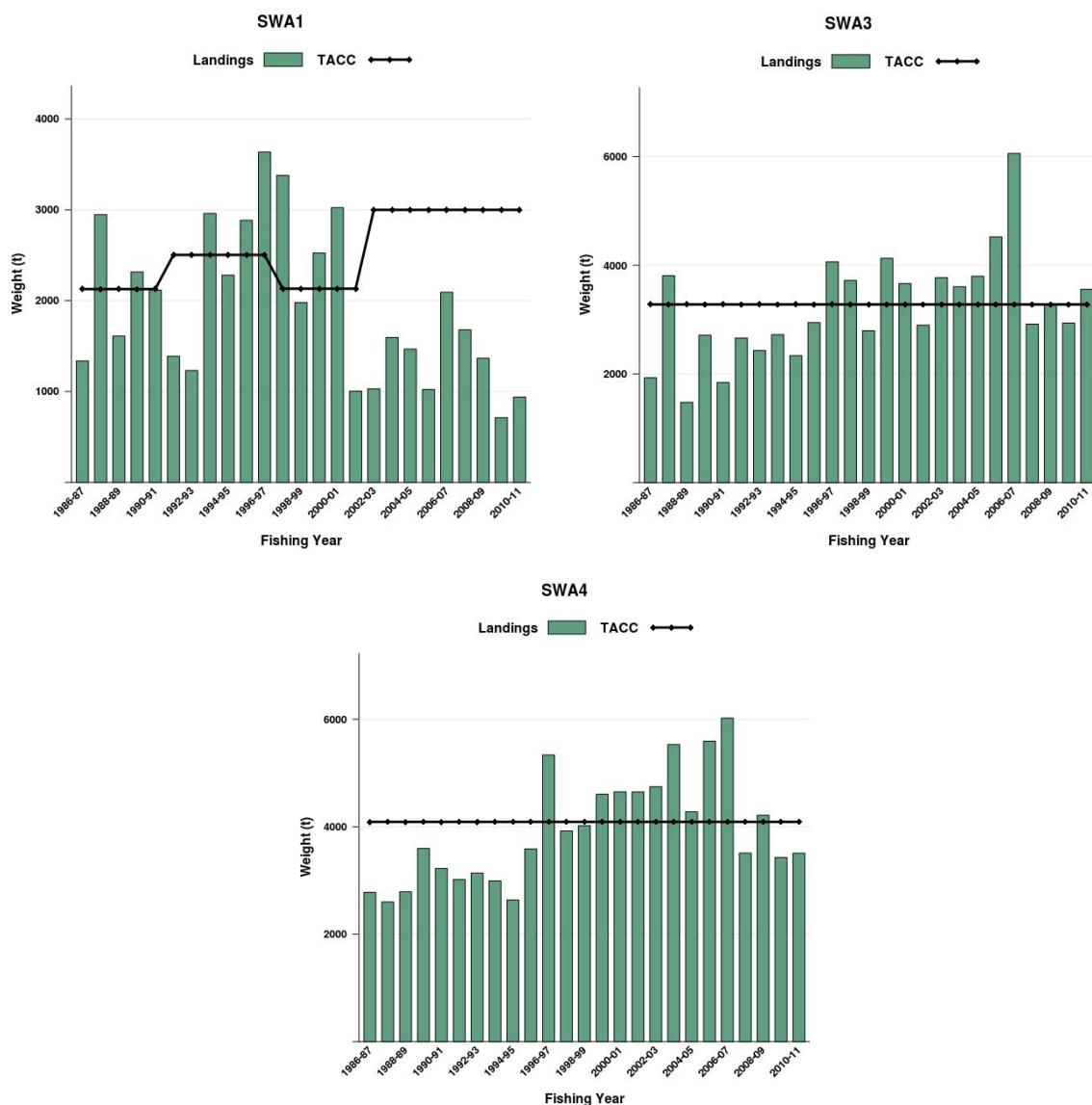

Figure 1: Historical landings and TACC for the three main SWA stocks. From top left: SWA1 (Auckland East), SWA3 (South East Coast), and SWA4 (South East Chatham Rise). Note that these figures do not show data prior to entry into the QMS.

1.2 Recreational fisheries

There are no current recreational fisheries for silver warehou.

1.3 Customary non-commercial fisheries
Quantitative information on the current level of customary non-commercial take is not available.

1.4 Illegal catch
Silver warehou have been misreported as white and blue warehou in the past. The extent of this practice is unknown and could lead to under-reporting of silver warehou catches.

1.5 Other sources of mortality
Other sources of mortality are unknown.

2. BIOLOGY

Initial growth is rapid and fish reach sexual maturity at around 45 cm fork length in 4 years. Based on a study of ageing methodology and growth parameters (Horn & Sutton 1995), maximum age is considered to be 23 years for females and 19 years for females. An estimate of instantaneous natural mortality (M) was derived by using the equation $M = \log_e 100/A_{MAX}$, where A_{MAX} is the age reached by 1% of the virgin population. From their study, A_{MAX} of 19 years for female silver warehou and 17 years for males produced estimates of M of 0.24 and 0.27 respectively. Horn & Sutton (1995) qualified this result as the samples used in their study were not from virgin populations and the sampling method did not comprehensively sample the whole population. Based on these results M is likely to fall within the range 0.2-0.3.

Horn & Sutton also calculated von Bertalanffy growth curve parameters from their sample of fish from off the south and southeast coasts of the South Island (Table 3). Other biological parameters relevant to the stock assessment are shown in Table 3. Length weight regressions were calculated from two series of random trawl surveys using *Tangaroa*. One series was conducted on the Chatham Rise in January, 1992-97 and the other in Southland during February-March, 1993-96.

Silver warehou is a schooling species, aggregating to both feed and spawn. During spring-summer, both adult and juvenile silver warehou migrate to feed along the continental slope off the east and southeast coast of the South Island. Late-stage silver warehou eggs and larvae have been identified in plankton samples, and the early life history of silver warehou appears typical of many teleosts. Juvenile silver warehou inhabit shallow water at depths of 150-200 m and remain apart from sexually mature fish. Few immature fish are consequently taken by trawlers targeting silver warehou. Juveniles have been caught in Tasman Bay, on the east coast of the South Island and around the Chatham Islands. Once sexually mature, fish move out to deeper water along the shelf edge.

Table 3: Estimates of biological parameters of silver warehou.

Fishstock				Estimate		Source
1. Weight = a(length)^b (Weight in g, length in cm, total length).						
				Both sexes		
				a	b	Tangaroa Survey:
Chatham Rise				0.00848	3.214	January 1992-97
Southland				0.00473	3.380	February - March 1993-96

2. von Bertalanffy growth parameters						
	Female			Males		
L_∞	k	t_0	L_∞	k	t_0	
54.5	0.33	-1.04	51.8	0.41	-0.71	Horn & Sutton (1995)

3. STOCKS AND AREAS

The stock structure is unknown. However, there is no new data which would alter the stock boundaries given in previous assessment documents. Horn *et al.* (2001) found no differences in growth rates of silver warehou from the Southern Plateau, Chatham Rise and WCSI, and reached the

same conclusions as Livingston (1988) based on an analysis of gonad stages (ripe female samples) and juvenile distribution.

Livingston (1988) found that spawning occurs on the Chatham Rise (Mernoo), east coast North Island and west coast South Island in late winter and at the Chatham Islands in late spring-early summer. There is some evidence for another spawning ground on the Stewart-Snares shelf, also in late winter. It is uncertain whether the same stock migrates from one area to another, spawning whenever conditions are appropriate, or if there are several separate stocks. The current boundaries bear little relation to known spawning areas and silver warehou distribution.

4.   STOCK ASSESSMENT

The assessment of silver warehou stocks was not updated in 2009 but a mid-term review was carried out for the SWA 1 AMP. There are no new data that would alter the yield estimates given in the 1997 Plenary Report. Yield estimates are based on commercial landings only.

4.1   Estimates of fishery parameters and abundance
CPUE data of silver warehou from the west coast South Island hoki fishery were analysed as a possible means of monitoring abundance in this part of SWA 1. However, the Middle Depths FAWG did not accept that the CPUE from the WCSI fishery were an index of abundance.

Age frequency distributions from otoliths collected by the Scientific Observer Programme from the west coast south island hoki fishery indicate that a wide range of year classes were present in the catch for all seasons 1992-96. Catch curve analysis based on the age structure of annual catches made from 1992-05 suggested that fishing mortality is lower than natural mortality (SeaFIC 2007).

4.2   Biomass estimates
Estimates of reference and current biomass are not available for any Fishstock.

Biomass indices from *Tangaroa* trawl surveys in QMAs 3 (part), 4 and 5 since 1991 are variable between years and have high CVs, and are therefore unsuitable for stock assessment.

4.3   Estimation of Maximum Constant Yield (*MCY*)
MCY cannot be determined. Problems with mis-reporting of warehou catches and the lack of consistent catch histories make *MCY* estimates based on catch data alone unreliable.

4.4   Estimation of Current Annual Yield (*CAY*)
An estimate of current biomass is not available, and *CAY* cannot be estimated.

4.5   Other factors
The degree of interdependence between Fishstocks is unknown. The 1996-97 landings were the highest on record but catches have decreased in both 1997-98 and 1998-99.

5.   ANALYSIS OF ADAPTIVE MANAGEMENT PROGRAMMES (AMP)

The Ministry of Fisheries revised the AMP framework in December 2000. The AMP framework is intended to apply to all proposals for a TAC or TACC increase, with the exception of fisheries for which there is a robust stock assessment. In March 2002, the first meeting of the new Adaptive Management Programme Working Group was held. Two changes to the AMP were adopted:
- a new checklist was implemented with more attention being made to the environmental impacts of any new proposal
- the annual review process was replaced with an annual review of the monitoring requirements only. Full analysis of information is required a minimum of twice during the 5 year AMP.

SWA 1

The SWA 1 TACC was increased from 2132 to 3000 t in October 2002 under the Adaptive Management Programme (AMP). A full-term review of the LIN 1 AMP was carried out in 2007.

Mid-term review 2009 (AMP WG/09/10, 11)

Characterisation

- Silver warehou were introduced into the QMS from 1 Oct 1986 as four fishstocks, the SWA 1 fishstock including the waters around the North Island and the west coast of the South Island (FMAs 1, 2, 7, 8 and 9). The SWA 1 TACC rose from 1800 t in 1986-97 to 2128 t in 1989-90 as a result of quota appeals and was increased to 2500 t in 1991-92 upon entry into an AMP. A further 4 t increase in 1992-93 resulted from a quota appeal. The TACC was reduced to 2132 t for 1997-98 and increased to 3000 t (within a TAC of 3003 t) from 2002-03 onwards under a second AMP.
- The early catch history for SWA 1 has been reconstructed from historical data collected by the Fisheries Statistical Unit (FSU) data from January 1979 onwards. While total New Zealand SWA catches are reported in these data to be highest in the 1970s, most of this catch is thought to have been made on the Chatham-Rise and Stewart-Snares Shelf by Japanese vessels, with only a small proportion made in SWA 1. Estimated annual SWA 1 catches averaged about 260 t per year over the period 1979 - 1982.
- Subsequent catches increased from around 500 t – 1000 t in 1983-84 to 2948 t in 1987-88, declined to 1 231 t in 1992-93 and then increased to a historic peak of 3636 t in 1996-87. Catches remained at high levels through to 2000-01, exceeding the TACC in all but two years from 1993-94 to 2000-01. Catches then dropped sharply to only 1004 t in 2001-02 due to reduction in the hoki TACC, of which SWA is primarily a by-catch, and have continued to fluctuate below the TACC, between 1023 t and 2093 t up to 2007-08. Increased catches over 2006-07 to 2007-08 have resulted from increased active targeting of SWA
- From 1989-90 to 2000-01 82% of the SWA 1 catch was taken by midwater trawl off the west coast of the South Island. However, 87% of the catch since 2001-02 in the WCSI fishery is now taken by bottom trawl. In other regions, bottom trawl catches have dominated throughout the entire period 1989-90 to 2007-08. The proportion of catch taken by midwater trawl has not decreased to the same extent as the WCSI fishery. Catches by bottom longline and other methods have been sporadic.
- SWA 1 has primarily been a bycatch of trawls targeting hoki. As catches of hoki have declined since 2000-01, the proportion of SWA target trawls has increased. Since 2006-07 target SWA catches have dominated, with bycatch in barracouta and hake target trawls also increasing in importance.
- Peak catches in the WCSI fishery are taken in July to September. In other parts of the SWA 1 fishery, the seasonal pattern has shown more variation.

Length-frequency & catch at age

- SWA have been biologically sampled by Ministry of Fisheries observers from 1989-90 to 2007-08. Sampling has generally been representative of areas where SWA are caught, but length-frequency samples have varied in the extent to which they represented catches from which they came, with the majority of samples prior to 2006-07 comprising < 10 fish. Catch-weighted length-frequency distributions were calculated from these samples.
- There is little variation in the mean length of SWA in the WCSI fishery. Smaller fish tend to occur in the north of the area, and in shallower depths, with larger fish in deeper areas to the west and south.
- Length distributions show dominance of fish 45 cm – 55 cm in catches, but with evidence of strong year classes (modes of smaller fish 40 cm – 45 cm) in 1993-94, 1997 and 2002 - 2005.
- Observers also collect otoliths from measured fish. Of the otoliths collected, 2240 from 1991-92 to 1995-96 and 4350 from 1995-96 to 2004-05 have been aged by NIWA and the Central Ageing Facility, Victoria, Australia (CAF) respectively. There is generally good agreement between age

readings by these two facilities. Age frequency distributions were then estimated for the WCSI fishery from weighted length frequency distributions and applying an annual age-length key.

Catch curve estimation of total mortality

- Resulting annual age-frequency distributions by sex were used to generate annual total mortality (Z) estimates from 1992 to 2005 using catch curves and either regression-based or Chapman-Robson estimators. These estimates of Z are unchanged from the previous report on SWA 1 made to the AMP WG in 2007 (Middleton *et al*. 2007).

- The 224 mortality estimates calculated using the Chapman Robson estimator span a range from 0.22 to 0.63. Eleven are less than 0.25, the current estimate of natural mortality for silver warehou (Horn & Sutton 1996, Ministry of Fisheries 2006) and 172 (77%) are less than 0.4. Strong year classes entering the fishery appear to produce a temporary upward shift in the estimated total mortality, especially for younger assumed ages at full recruitment, but otherwise no particular trends in the estimates are apparent.
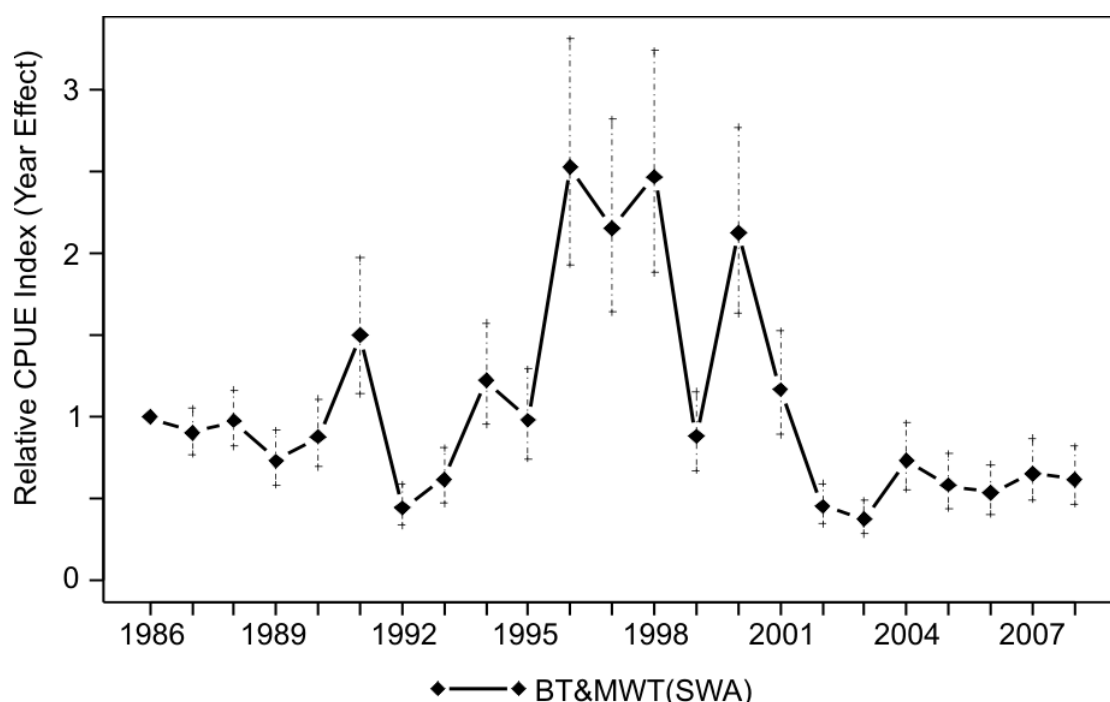
CPUE analysis

Figure 2: **Standardised CPUE index (year effects) for SWA 1 from an analysis of Scientific Observer Programme trawl records (Cordue 2009).**

- Previous SWA 1 CPUE analyses based on the MFish catch/effort returns were rejected as being unreliable as indices of SWA 1 abundance.

- A CPUE analysis for this stock was conducted in 2009 using selected observer catch and effort data for positive bottom and midwater trawl SWA catches in area FMA 7 for winter fishing within a WCSI box (40.2°S - 43.3°S).

- The data were groomed and records were selected for a core fleet (vessels which fished in at least 2 years with at least 20 tows in each year). The core fleet records were checked to ensure there was adequate linkage of vessels across years. The final data selection included 74 vessels that fished at some time over the period 1986 to 2008.

- CPUE for this data selection was standardised using a variety of lognormal models, including an all categorical variables model, a partly continuous (depth and tow duration) model, and complex models with interactions and year * latitude interactions. An adequate fit was obtained with a model that includes year, duration, month, latitude and vessel; specifying continuous variables

and complex interactions offered little improvement over the all categorical model. Strongest effects on the standardisation were by target, vessel, month and tow duration.

- The resulting index (Figure 2) is noisy but shows a general trend of slow CPUE decline from 1986 to 1992, a steep increase from 1992 to 1996 and high levels through to 2000, followed by a steep decline back to low levels by 2002 and a stable trend at slightly above historically lowest levels since then.
- The WG considered that this CPUE index was possibly consistent with strong year classes in 1993-94 and in 1997 (evident in the length frequency data), and resulting increased abundance over the ensuing few years.
- The WG considered that this CPUE standardisation might be indexing SWA 1 abundance and, given the substantial amount of catch-at-age data for this stock, recommended that a stock assessment should now be conducted to investigate the coherence between catch-at-age data and this abundance index.

Status of the stock

Analysis recommendations

The following analyses were recommended following the 2009 review:

- Given the amount of length-frequency and catch-at-age data, and the availability of a potential CPUE abundance index for SWA 1, the WG suggested that a stock assessment now be conducted for this stock. The WG noted that a stock assessment would require updating the age frequencies since 2005.

Abundance indices

CPUE indices have previously been considered to be unreliable for SWA 1. However, the WG considered that the BT&MWT(SWA) index prepared in 2009 using observer data seems to be consistent with observed good recruitment in 1993-94 and in 1997, with ensuing strong year classes contributing to increased catch rates over the ensuing few years. The WG concluded that this CPUE index was potentially indexing SWA 1 abundance.

This index shows a period of slowly declining CPUE from 1986 - 1992, followed by a rapid increase in CPUE to levels twice the long-term average by 1996. High catch rates continued to 1998, dipped in 1999 and rose to high levels again in 2000. Thereafter CPUE declined back to about half historic average levels, and appears to have remained stable at that level since 2004.

Sustainability of current catches

Catch curve analyses indicate that the average exploitation rate on silver warehou in the WCSI hoki fishery is probably less than the natural mortality rate, indicating that the stock was not being overfished.

Annual catches have averaged 1 480 t since the increase in TACC to 3000 t in 2002-03 and catches at this level are likely sustainable in the short to medium term. However, the TACC is double the current catch and it is not known whether catches at the level of the TACC are sustainable.

The WG noted that this Fishstock sustained catches which averaged 2800 t/year from 1993-94 to 2000-01 without resulting in high Z estimates, but that this occurred over a period where CPUE indices indicate abundance of more than double current levels. A stock assessment is considered to be a more appropriate methodology to assess this Fishstock than relying on analyses of catch curves.

Stock status

This stock is most likely above B_{MSY} as the average F over the last 10 years has been below M. Estimates of B/B_{MSY} should be provided by the recommended stock assessment.

6. STATUS OF THE STOCKS

Since the 2008 Plenary report was published, no new stock assessments have been completed for SWA stocks but a mid-term review has been completed for the SWA 1 AMP.

SWA 1

SWA 1 has been managed with a TACC of 3000 t since October 2002 under the AMP. CPUE indices have previously been considered to be unreliable for SWA 1. However, the SWA bottom and midwater trawl index prepared in 2009 seems to be consistent with indications of good recruitment in 1993, 1994 and 1997, with strong year classes contributing to increased catch rates over the ensuing few years. The WG concluded that this CPUE index may be indexing SWA 1 abundance.

This index shows a period of stable or slowly declining CPUE from 1986 - 1992, followed by a rapid increase in CPUE to levels twice the long-term average by 1996. High catch rates continued to 1998, dipped in 1999, and rose to high levels again in 2000. Thereafter CPUE declined back to about half historic average levels, and appears to have remained stable at that level since 2004.

Catch curve analyses indicate that the average exploitation rate on silver warehou in the WCSI hoki fishery is probably less than the natural mortality rate, indicating that overfishing is not occurring.

Annual catches have averaged 1480 t since the increase in TACC to 3000 t in 2002-03 and catches at this level are likely sustainable in the short to medium term. However, it is not known whether catches at the level of the TACC are sustainable.

Other stocks

No estimates of biomass are available.

In most years from 2000-01 to 2008-09 catches in SWA 3 and SWA 4 were well above the TACCs as fishers landed catches well in excess of ACE holdings. The sustainability of current TACCs and recent catch levels for these Fishstocks is not known, and it is not known if they will allow the stocks to move towards a size that will support the maximum sustainable yield.

Yield estimates, TACCs and reported landings for the 2010-11 fishing year are summarised in Table 4.

Table 4: Summary of yields (t), TACCs (t), and reported landings (t) of silver warehou for the most recent fishing year.

Fishstock		FMA	*MCY*	2010-11 Actual TACC	2010-11 Reported landings
SWA 1	Auckland (East) (West),	1, 2, 7,	650-1400	3 000	938
	Central (East) (West), & Challenger	8, & 9			
SWA 3	South-East (Coast)	3	-	3 280	3 559
SWA 4	South-East (Chatham), Southland, and Sub-Antarctic	4, 5 & 6	-	4 090	3 507
SWA 10	Kermadec	10	-	10	0
Total			-	10 380	8 004

7. FOR FURTHER INFORMATION

Cordue P. 2009. SWA 1 CPUE analysis. AMPWG09/11 (Powerpoint presentation to AMP FAWG)

Gavrilov G.M. 1975. Natural death rate and theoretical prerequisites for the optimum intensity of fishing, using as an example the population of *Seriollela maculata* Forster, which is not being fished. News of the Pacific Ocean Scientific Research Institute of Fishing and Oceanography (TINRO). 96: 187-195 (in Russian, English translation held at MAF Fisheries Greta Point library, Wellington).

Gavrilov G.M. 1974. The age and rate of growth in the silver warehou (*Seriolella maculata* Forster). From "Investigations into the biology of fish and productivity of oceanography" Part 5: Vladivostock, 1974. TINRO report (in Russian, English translation held at MAF Fisheries Greta Point library, Wellington).

Horn P.H., Bagley N.W., Sutton C.P. 2001. Stock structure of silver warehou (*Seriolella punctata*) in New Zealand waters, based on growth and reproductive data. New Zealand Fisheries Assessment Report 2001/13. 29p.

SILVER WAREHOU (SWA)

Horn P.H., Sutton C.P. 1995. An ageing methodology, and growth parameters for silver warehou (*Seriolella punctata*) from off the southeast coast of the South Island, New Zealand. New Zealand Fisheries Assessment Research Document 1995/15. 16p.

Langley A.D. 1992. Analysis of silver warehou (Seriolella punctata) catch and effort data from the WCSI hoki fishery (SWA 1). New Zealand Fisheries Assessment Research Document 1992/7. 5p.

Livingston M.E. 1988. Silver warehou. New Zealand Fisheries Assessment Research Document 1988/36.

Phillips N.L. 2001. Analysis of silver warehou (Seriolella punctata) catch-per-unit-effort (CPUE) data. New Zealand Fisheries Assessment Report 2001/73. 48p.

Seafood Industry Council (SeaFIC) 2002. SWA 1 Adaptive Management Programme proposal - 2002 (dated 19 February 2002). Copy held by the Ministry of Fisheries.

Seafood Industry Council (SeaFIC) 2007. Silver Warehou: SWA 1 Adaptive Management Programme Full-term Review Report.. AMP-WG-2007/22. Copies held by the Ministry of Fisheries.

ROUGH SKATE (RSK)
(*Zearaja nasuta*)
Waewae
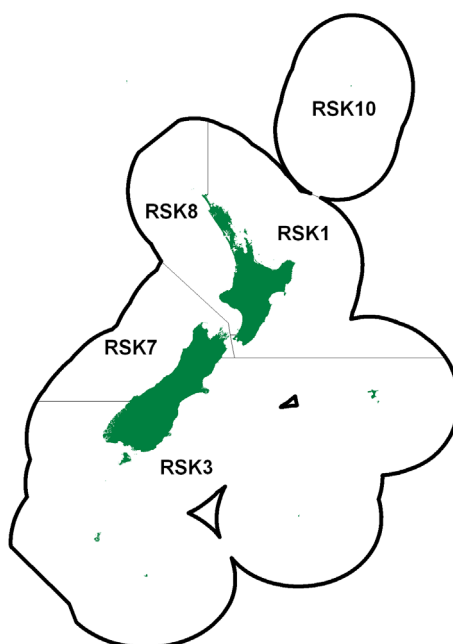
1. FISHERY SUMMARY

1.1 Commercial fisheries

Rough skate (*Zearaja nasuta*, RSK) are fished commercially in New Zealand in close association to smooth skates, which are also known as barndoor skates. Although rough skates grow considerably smaller than smooth skates, RSK is still landed and processed. Two other species of deepwater skate (*Bathyraja shuntovi* and *Raja hyperborea*) are large enough to be of commercial interest but are relatively uncommon and probably comprise a negligible proportion of the landings.

Skate flesh ammoniates rapidly after death, so the wings are removed at sea, and chilled or frozen. On arrival at the shore factories, the wings are machine-skinned, graded and packed for sale. Most of the product is exported to Europe, especially France and Italy. Skates of all sizes are processed, though some factories impose a minimum weight limit of about 1 kg (200 g per wing), and occasionally wings from very large smooth skates are difficult to market.

Rough skates occur throughout New Zealand, but are most abundant around the South Island in depths down to 500 m. Most of the catch is taken as bycatch by bottom trawlers, but skates are also taken by longliners. Significant longline bycatch has been reported from the Bounty Plateau in QMA 6. There is no clear separation of the depth ranges inhabited by rough and smooth skates; however, smooth skate tend to occur slightly deeper than rough skate (Beentjes & Stevenson 2000, 2001, Stevenson & Hanchet 2000).

Many fishers and processors do not distinguish rough and smooth skates in their landing returns, and code them instead as "skates" (SKA). Because it is impossible to determine the species composition of the catch from landings data prior to introduction of these species into the QMS, all pre-QMS data reported here consist of the sum of the three species codes RSK, SSK and SKA. Landings have been converted from processed weight to whole weight by application of conversion factors.

There have been historical changes to the conversion factors applied to skates by MAF Fisheries and Ministry of Fisheries. No record seems to have been kept of the conversion factors in use before 1987, so it is not possible to reconstruct the time series of landings data using the currently accepted factors. Consistent and appropriate conversion factors have been applied to skate

landings since the end of the 1986-87 fishing year. Before that, it appears that a lower conversion factor was applied, resulting in an underestimation of landed weight by about 20%. No correction has been made for that in this report.

New Zealand annual skate landings, estimated from a variety of sources, are shown in Table 1. No FSU deepwater data were available before 1983, and it is not known whether deepwater catches, including those of foreign fishing vessels, were significant during that period. CELR and CLR data are provided by inshore and deepwater trawlers respectively. "CELR estimated" landings were always less than "CELR landed" landings, because the former include only the top five fish species (by weight) caught by trawlers, whereas the latter include all species landed. As a relatively minor bycatch, skates frequently do not fall into the top five species. The sum of the "CELR landed" and CLR data provides an estimate of the total skate landings. This estimate usually agreed well with LFRR data supplied by fish processors, especially in 1993-94 and 1994-95, but in 1992-93 the difference was 467 t. The "best estimate" of the annual historical landings comes from FSU data up to 1985-86, and LFRR data thereafter.

Table 1: New Zealand skate landings for calendar years 1974-1983, and fishing years (1 October - 30 September) 1983-84-1995-96. Values in parentheses are based on part of the fishing year only. Landings do not include foreign catch before 1983, or unreported discards. FSU = Fisheries Statistics Unit; CELR = Catch, Effort and Landing Return; CLR = Catch Landing Return; LFRR = Licensed Fish Receivers Return; Best Estim. = best available estimate of the annual skate catch; - = no data.

Year	FSU Inshore	FSU Deepwater	FSU Total	CELR Estim	CELR Landed	CLR	CELR Landed +CLR	LFRR	Best Estimate
1974	23	-	-	-	-	-	-	-	23
1975	30	-	-	-	-	-	-	-	30
1976	28	-	-	-	-	-	-	-	28
1977	27	-	-	-	-	-	-	-	27
1978	36	-	-	-	-	-	-	-	36
1979	165	-	-	-	-	-	-	-	165
1980	441	-	-	-	-	-	-	-	441
1981	426	-	-	-	-	-	-	-	426
1982	648	-	-	-	-	-	-	-	648
1983	634	178	812	-	-	-	-	-	812
1983-84	686	298	983	-	-	-	-	-	983
1984-85	636	250	886	-	-	-	-	-	886
1985-86	613	331	944	-	-	-	-	-	944
1986-87	723	285	1 007	-	-	-	-	1 019	1 019
1987-88	1 005	421	1 426	-	-	-	-	1 725	1 725
1988-89	(530)	(136)	(665)	(252)	(265)	(28)	(293)	1 513	1 513
1989-90	-	-	-	780	1 171	410	1 581	1 769	1 769
1990-91	-	-	-	796	1 334	359	1 693	1 820	1 820
1991-92	-	-	-	1 112	1 994	703	2 698	2 620	2 620
1992-93	-	-	-	1 175	2 595	824	3 418	2 951	2 951
1993-94	-	-	-	1 247	2 236	788	3 024	2 997	2 997
1994-95	-	-	-	956	1 973	829	2 803	2 789	2 789
1995-96	-	-	-	-	-	-	-	2 789	2 789

Total skate landings (based on the "best estimate" in Table 1) were negligible up to 1978, presumably because of a lack of suitable markets and the availability of other more abundant and desirable species. Landings then increased linearly to reach nearly 3000 t in 1992-93 and 1993-94, and have remained between 2600 and 3100 t ever since (Table 2).

Rough skates (RSK) were introduced into the QMS as separate species from 1 October 2003 with allowances, TACCs and TACs as follow in Table 2. Figures 1 shows the historical landings and TACC values for the main RSK stocks. Owing to problems associated with identification of rough and smooth skates, reported catches of each species are probably not accurate. Initiatives to improve identification of these species begun in 2003 may have resulted in more accurate data.

Table 2: Reported landings (t) of SKA and RSK by QMA and fishing year, 1996-97 to 2010-11.

QMA	1	3	7	8	10	Total
FMA	1-2	3-6	7	8-9	10	All
Skate (SKA)*						
1996-97	43	894	380	30	0	1 347
1997-98	44	855	156	31	0	1 086
1998-99	48	766	228	12	0	1 054
1999-00	75	775	253	25	0	1 128
2000-01	88	933	285	28	0	1 334
2001-02	132	770	311	35	0	1 248
2002-03	121	857	293	32	0	1 303
2003-04	< 1	< 1	< 1	< 1	0	1
Rough skate (RSK)						
1996-97	15	265	69	3	0	352
1997-98	32	493	44	5	0	574
1998-99	22	607	33	4	0	666
1999-00	20	720	37	2	0	779
2000-01	27	569	42	4	0	642
2001-02	24	607	25	3	0	659
2002-03	18	1 060	27	11	0	1 118
2003-04	48	1 568	191	33	0	1 840
2004-05	72	1 815	173	55	0	2 115
2005-06	72	1 446	153	28	0	1 699
2006-07	68	1 475	197	35	0	1 768
2007-08	80	1 239	206	46	0	1 573
2008-09	79	1 591	226	46	0	1 942
2009-10	87	1 546	225	46	0	1 905
2010-11	91	1 547	199	45	0	1 882

*Use of the code SKA ceased once skates were introduced into the QMS in October 2003 and rough skates and smooth skates were recognised as a separate species. From this time all landings of skates have been reported against either the RSK or SSK code.

Table 3: Recreational, customary, and other mortality allowances (t), Total Allowable Commercial Catches (TACC, t) and Total Allowable Catches (TAC, t) declared for RSK on introduction into the QMS in October 2003.

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other Mortality	TACC	TAC
RSK 1 (FMAs 1-2)	1	1	1	111	114
RSK 3 (FMAs 3-6)	1	1	17	1 653	1 672
RSK 7	1	1	2	201	205
RSK 8 (FMAs 8-9)	1	1	1	21	24
RSK 10	0	0	0	0	0

1.2 Recreational fisheries

Recreational fishing surveys indicate that rough skates are very rarely caught by recreational fishers.

1.3 Customary non-commercial fisheries

Quantitative information on the level of customary non-commercial take is not available.

1.4 Illegal catch

Quantitative information on the level of illegal catch is not available.

1.5 Other sources of mortality

Because skates are taken mainly as bycatch of bottom trawl fisheries, historical catches have probably been proportional to the amount of effort in the target trawl fisheries. Past catches were probably higher than historical landings data suggest, because of unrecorded discards and unrecorded foreign catch before 1983.
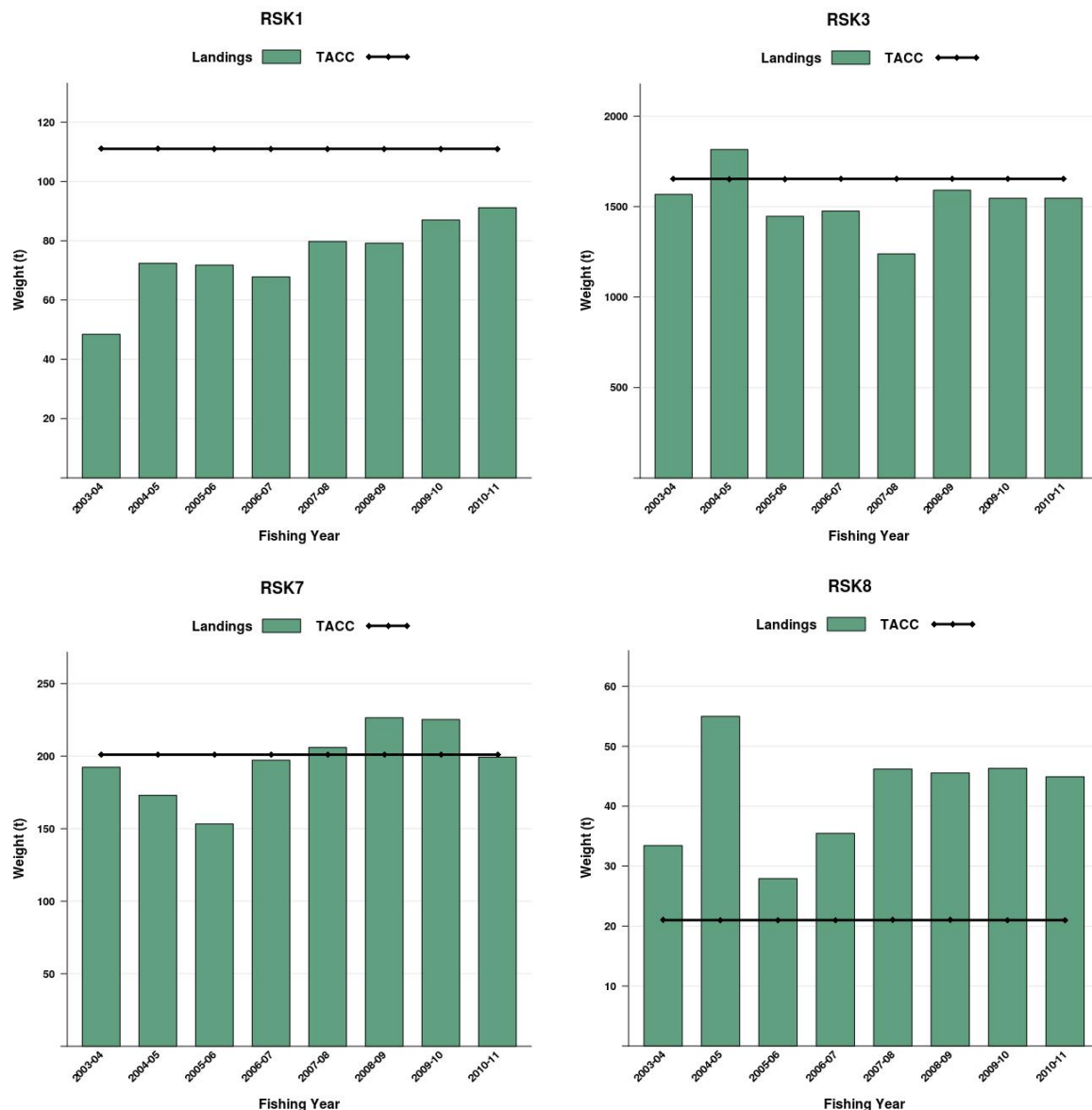
Figure 1: **Historical landings and TACC for the four main RSK stocks. From top left to bottom right: RSK1 (Auckland East), RSK3 (South East Coast, South East Chatham Rise, Sub Antarctic, Southland), RSK7 (Challenger), and RSK8 (Central Egmont, Auckland West). Note that these figures do not show data prior to entry into the QMS.**

2. BIOLOGY

Little is known about the reproductive biology of rough skates. Rough skates reproduce by laying yolky eggs, enclosed in leathery cases, on the seabed. Rough skates lay their eggs in spring-summer (Francis 1997). Two eggs are laid at a time, but the number of eggs laid annually by a female is unknown. A single embryo develops inside each egg case and the young hatch at about 10-15 cm pelvic length (body length excluding the tail) (Francis 1997).

Rough skates grow to at least 79 cm pelvic length, and females grow larger than males. The greatest reported age is 9 years for a 70 cm pelvic length female, and females may live longer than males (Francis *et al.* 2001a, b). There are no apparent differences in growth rate between the sexes. Males reach 50% maturity at about 52 cm and 4 years, and females at 59 cm and 6 years. The most plausible estimate of *M* is 0.25-0.35. Biological parameters relevant to stock assessment are shown in Table 4.

Table 4: Estimates of biological parameters for Rough skates (RSK).

Fishstock			Estimate	Source
1. Natural mortality (M)				
RSK 3			0.25-0.35	Francis *et al.* (2001b)
2. Weight = a (length) [b] (weight in g, length in cm pelvic length)				
	a		b	
RSK males	0.0393		2.838	Francis (1997)
RSK females	0.0218		3.001	Francis (1997)
3. von Bertalanffy growth parameters				
	K	t_0	L_∞	
RSK 3 (both sexes)	0.16	-1.2	91.3	Francis *et al.* (2001b)
RSK 3 (both sexes)	0.096	-0.78	151.8	Francis *et al.* (2004)

3. STOCKS AND AREAS

Nothing is known about stock structure or movement patterns in skates. Rough skates are distributed throughout most of New Zealand, from the Three Kings Islands to Campbell Island and the Chatham Islands, including the Challenger Plateau, Chatham Rise and Bounty Plateau. Rough skates have not been recorded from QMA 10.

In this report, rough skate landings have been presented by QMA. QMAs would form appropriate management units in the absence of any information on biological stocks.

4. STOCK ASSESSMENT

This is the first stock assessment for skates. No yield estimates have been made for skates.

4.1 Estimates of fishery parameters and abundance

Relative biomass estimates are available for rough skates from a number of trawl survey series (Table 5). Biomass estimates are not provided for surveys of: (a) west coast North Island because of major changes in survey areas and strata during the series; or (b) east Northland, Hauraki Gulf and Bay of Plenty because of the low relative biomass of rough skates present (usually less than 100 t). In the first survey of each of two series -east coast South Island and Chatham Rise- the two skate species were not (fully) distinguished. Furthermore, there are doubts about the accuracy of species identification in some other earlier surveys (prior to 1996). Consequently, trends in biomass of individual species must be interpreted cautiously. To enable comparison among all surveys within each series, total skate biomass is also reported.

As the catch from the South Island trawl surveys changes without wide inter-annual fluctuations and the CVs are relatively low it appears that they are able to track rough skate biomass in FMA 3, 7, and on the Stewart Snares. West Coast South Island surveys show that the relative biomass of rough skate in FMA 7 declined in the early 2000s but has since increased marginally.

4.2 Biomass estimates

There are no absolute biomass estimates for rough skates.

4.3 Estimation of Maximum Constant Yield (*MCY*)

MCY cannot be estimated.

The *MCY* estimator, that has the lowest data requirements ($MCY = cY_{AV}$; Method 4), relies on selecting a time period during which there were "no systematic changes in fishing mortality (or fishing effort, if this can be assumed to be proportional to fishing mortality)". This method was not applied because no information is currently available on skate fishing mortality, or on trawl fishing effort in the main skate fishing areas.

ROUGH SKATE (RSK)

Table 5: Doorspread biomass estimates (t) and coefficients of variation (CV %) of rough skates and total skates (both rough and smooth).

Year	Trip Code	Rough skate Biomass	Rough skate CV	Total Biomass	Total CV
East coast North Island					
1993	KAH9304	76	28	99	-
1994	KAH9402	189	12	333	-
1995	KAH9502	52	20	72	-
1996	KAH9602	309	24	394	-
South Island west coast and Tasman/Golden Bays (FMA 7)					
1992	KAH9204	173	27	512	-
1994	KAH9404	196	23	537	-
1995	KAH9504	251	22	566	-
1997	KAH9701	185	30	487	-
2000	KAH0004	186	23	326	-
2003	KAH0304	43	34	134	-
2005	KAH0503	58	30	138	-
2007	KAH0704	256	23	300	-
2009	KAH0904	114	21	181	-
2011	KAH1104	347	23	532	-
East coast South Island (FMA 3) Winter					
1991	KAH9105	-	-	1928	25
1992	KAH9205	224	24	829	16
1993	KAH9306	335	21	993	21
1994	KAH9406	517	20	823	15
1996	KAH9606	177	19	562	18
2007	KAH0705	878	22	1 580	-
2008	KAH0806	858	19	1 412	-
2009	KAH0905	1 029	30	1 765	-
East coast South Island (FMA 3) Summer					
1996-97	KAH9618	1 336	15	2 057	-
1997-98	KAH9704	1 082	13	1 567	-
1998-99	KAH9809	1 175	10	1 625	-
1999-00	KAH9917	329	23	698	-
2000-01	KAH0014	222	34	470	-
Chatham Rise					
1991-2	TAN9106	-	-	2 129	-
1992-3	TAN9212	55	83	1 126	-
1994	TAN9401	220	44	1 178	-
1995	TAN9501	76	43	845	-
1996	TAN9601	11	100	1 522	-
1997	TAN9701	12	58	1 944	-
1998	TAN9801	10	100	1 935	-
1999	TAN9901	34	60	1 772	-
2000	TAN0001	0	-	1 369	-
2001	TAN0101	72	59	2 393	-
2002	TAN0201	37	65	2 148	-
2003	TAN0301	32	64	1 387	-
2004	TAN0401	22	60	2 066	-
2005	TAN0501	89	45	1 869	-
2006	TAN0601	56	45	1 577	-
2007	TAN0701	29	56	1 951	-
2008	TAN0801	0	-	1 376	-
2009	TAN0901	23	67	1 185	-
2010	TAN1001	-	-	1 576	-
2011	TAN1101	-	-	1 009	-
2012	TAN1201	-	-	813	-
Stewart-Snares Shelf					
1993	TAN9301	592	20	1 120	-
1994	TAN9402	1 064	15	1 406	-
1995	TAN9502	801	7	1 136	-
1996	TAN9604	1 055	11	1 559	-
Survey discontinued					
Stewart-Snares Shelf and Sub-Antarctic (Summer)*					
1991	TAN9105	37	72	419	-
1992	TAN9211	52	69	165	-
1993	TAN9310	132	57	249	-
2000	TAN0012	201	56	267	-
Stewart-Snares Shelf and Sub-Antarctic (Autumn)*					
1992	TAN9204	48	100	141	-
1993	TAN9304	251	57	428	-
1996	TAN9605	22	71	857	-
1998	TAN9805	71	77	607	-

*Biomass estimates are for core 300-800 m strata only
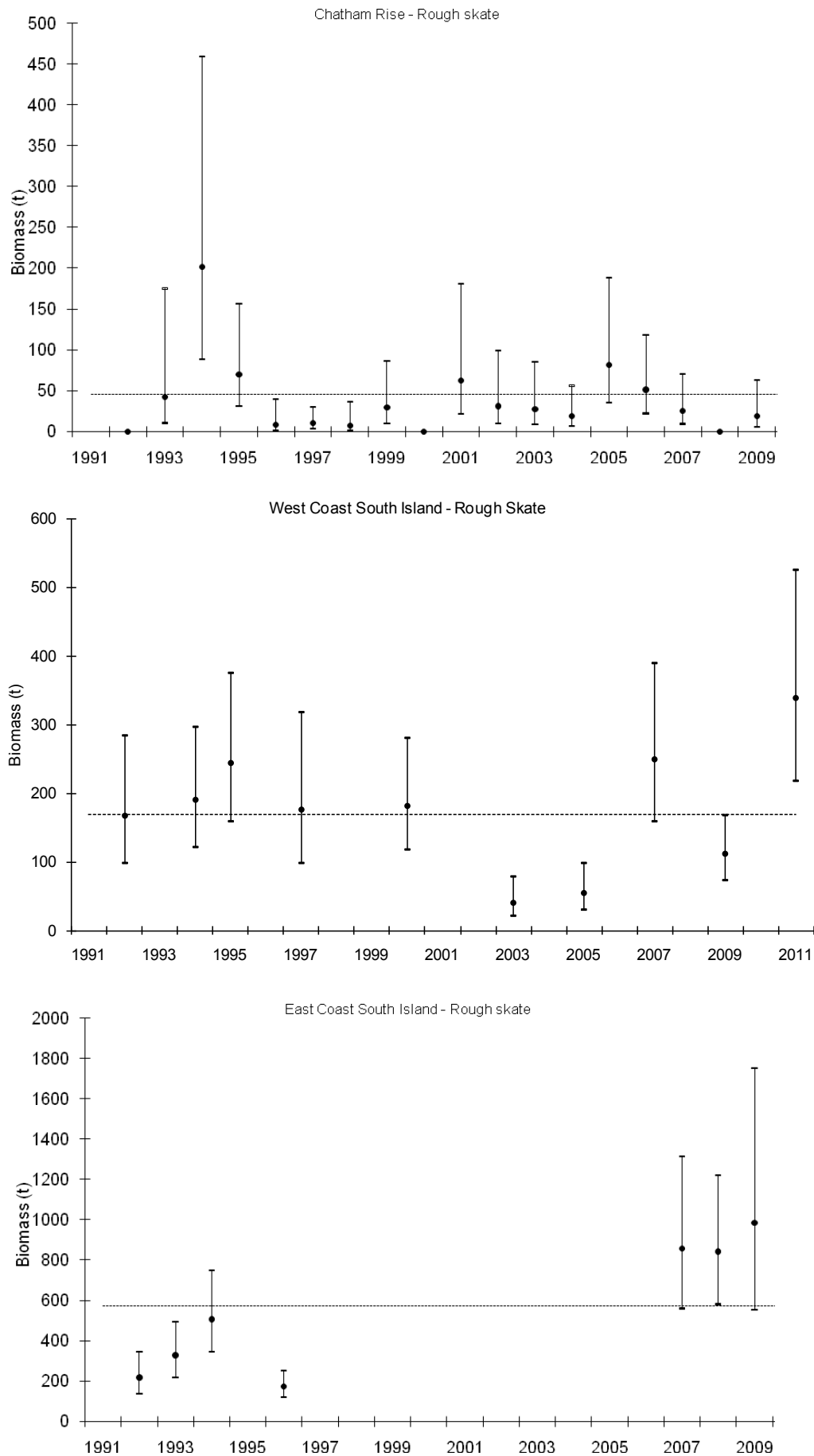
Figure 3: Rough skate biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the time series mean (dotted line) estimated from the Chatham Rise (Top), West (Middle) and East (bottom) Coast South Island trawl survey.

4.4　　Estimation of Current Annual Yield (*CAY*)

CAY cannot be estimated.

4.5　　Other yield estimates and stock assessment results

No other yield estimates are available.

4.6　　Other factors

Species that constitute a minor bycatch of trawl fisheries are often difficult to manage using TACCs and ITQs. Skates are widely and thinly distributed, and would be difficult for trawlers to avoid after the quota had been caught. A certain level of incidental bycatch is therefore inevitable. However, skates are relatively hardy, and frequently survive being caught in trawls (though mortality would depend on the length of the tow and the weight of fish in the cod end). Skates returned to the sea alive probably have a greater chance of survival than most other fishes.

5.　　STATUS OF THE STOCKS

No estimates of current and reference biomass are available.

For rough skate it is Unknown if recent catch levels or the TACC will cause their populations to decline. Reported landings and TACCs for the 2010-11 fishing year are summarised in Tables 6.

Table 6:　Summary of TACCs (t), and reported landings (t) for rough skates for the most recent fishing year.

Fishstock		QMA	2010-11 Actual TACC	2010-11 Reported landings
RSK 1 (FMAs 1-2)	Auckland (East) Central (East)	1 & 2	111	91
RSK 3 (FMAs 3-6)	South-east (Coast) (Chatham), Southland, and Sub-Antarctic	3, 4, 5 & 6	1 653	1 547
RSK 7	Challenger	7	201	199
RSK 8 (FMAs 8-9)	Central (West), Auckland (West)	8 & 9	21	45
RSK 10	Kermadec	10	0	0
Total			1 986	1 882

6.　　FOR FURTHER INFORMATION

Beentjes M.P., Stevenson M.L. 2000. Review of the east coast South Island winter trawl survey time series, 1991-96. NIWA Technical Report 86. 64 p.

Beentjes M.P., Stevenson M.L. 2001. Review of the east coast South Island summer trawl survey time series, 1996-97 to 1999-2000. NIWA Technical Report 108. 92 p.

Francis M.P. 1997. A summary of biology and commercial landings, and a stock assessment of rough and smooth skates (*Raja nasuta* and *R. innominata*). New Zealand Fisheries Assessment Research document 1997/5 27p.

Francis M.P., Ó Maolagáin C., Stevens D. 2001a. Age, growth, and sexual maturity of two New Zealand endemic skates, *Dipturus nasutus* and *D. innominatus*. New Zealand Journal of Marine and Freshwater Research 35: 831-842.

Francis M.P., Ó Maolagáin C., Stevens D. 2001b. Age, growth, maturity, and mortality of rough and smooth skates (*Dipturus nasutus* and *D. innominatus*). New Zealand Fisheries Assessment Report 2001/17. 21 p.

Francis M.P., Ó Maolagáin C., Stevens D. 2004. Revised growth, longevity and natural mortality of smooth skate (*Dipturus innominatus*). Final Research Report for Ministry of Fisheries Project MOF2003/01H (Dated June 2004).

Stevenson M.L., Hanchet S. 2000. Review of the inshore trawl *survey* series of the west coast South Island and Tasman and Golden Bays, 1992-97. NIWA Technical Report 82. 79 p.

SMOOTH SKATE (SSK)
(*Dipturus innominata*)
Uku
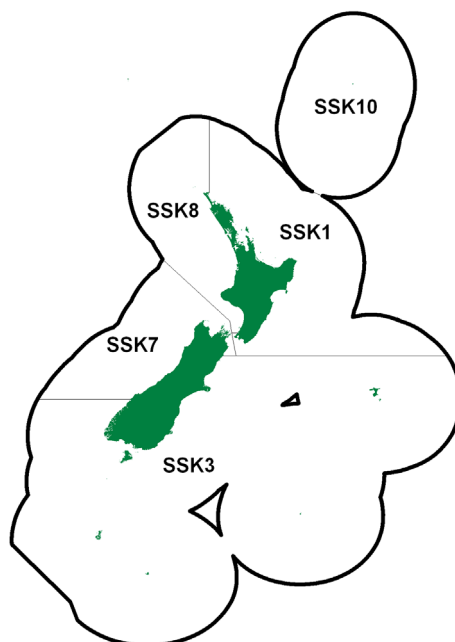
1. FISHERY SUMMARY

1.1 Commercial fisheries

Smooth skate (*Dipturus innominata*, SSK), which are also known as barndoor skates, are fished commercially in close association with rough skates (RSK) in New Zealand. Smooth skates grow considerably larger than rough skates, but both species are landed and processed. Two other species of deepwater skate (*Bathyraja shuntovi* and *Raja hyperborea*) are large enough to be of commercial interest but are relatively uncommon and probably comprise a negligible proportion of the landings.

Skate flesh ammoniates rapidly after death, so the wings are removed at sea, and chilled or frozen. On arrival at the shore factories, the wings are machine-skinned, graded and packed for sale. Most of the product is exported to Europe, especially France and Italy. Skates of all sizes are processed, though some factories impose a minimum weight limit of about 1 kg (200 g per wing), and occasionally wings from very large smooth skates are difficult to market.

Smooth skates occur throughout New Zealand, but are most abundant around the South Island in depths down to 500 m. Most of the catch is taken as bycatch by bottom trawlers, but skates are also taken by longliners. Significant longline bycatch has been reported from the Bounty Plateau in QMA 6. While there is no clear separation of the depth ranges inhabited by rough and smooth skates, smooth skates tend to occur slightly deeper than rough skate (Beentjes & Stevenson 2000, 2001, Stevenson & Hanchet 2000).

Many fishers and processors do not distinguish rough and smooth skates in their landing returns, and code them instead as "skates" (SKA). Because it is impossible to determine the species composition of the catch from landings data prior to introduction of these species into the QMS, all pre-QMS data reported here consist of the sum of the three species codes RSK, SSK and SKA. Landings have been converted from processed weight to whole weight by application of conversion factors.

There have been historical changes to the conversion factors applied to skates by MAF Fisheries and Ministry of Fisheries. No record seems to have been kept of the conversion factors in use before 1987, so it is not possible to reconstruct the time series of landings data using the currently accepted factors. Consistent and appropriate conversion factors have been applied to skate

landings since the end of the 1986-87 fishing year. Before that, it appears that a lower conversion factor was applied, resulting in an underestimation of landed weight by about 20%. No correction has been made for that in this report.

New Zealand annual skate landings, estimated from a variety of sources, are shown in Table 1. No FSU deepwater data were available before 1983, and it is not known whether deepwater catches, including those of foreign fishing vessels, were significant during that period. CELR and CLR data are provided by inshore and deepwater trawlers respectively. "CELR estimated" landings were always less than "CELR landed" landings, because the former include only the top five fish species (by weight) caught by trawlers, whereas the latter include all species landed. As a relatively minor bycatch, skates frequently do not fall into the top five species. The sum of the "CELR landed" and CLR data provides an estimate of the total skate landings. This estimate usually agreed well with LFRR data supplied by fish processors, especially in 1993-94 and 1994-95, but in 1992-93 the difference was 467 t. The "best estimate" of the annual historical landings comes from FSU data up to 1985-86, and LFRR data thereafter.

Table 1: New Zealand skate landings for calendar years 1974-1983, and fishing years (1 October - 30 September) 1983-84-1995-96. Values in parentheses are based on part of the fishing year only. Landings do not include foreign catch before 1983, or unreported discards. FSU = Fisheries Statistics Unit; CELR = Catch, Effort and Landing Return; CLR = Catch Landing Return; LFRR = Licensed Fish Receivers Return; Best Estim. = best available estimate of the annual skate catch; - = no data.

Year	FSU Inshore	FSU Deepwater	FSU Total	CELR Estim	CELR Landed	CLR	CELR Landed +CLR	LFRR	Best Estimate
1974	23	-	-	-	-	-	-	-	23
1975	30	-	-	-	-	-	-	-	30
1976	28	-	-	-	-	-	-	-	28
1977	27	-	-	-	-	-	-	-	27
1978	36	-	-	-	-	-	-	-	36
1979	165	-	-	-	-	-	-	-	165
1980	441	-	-	-	-	-	-	-	441
1981	426	-	-	-	-	-	-	-	426
1982	648	-	-	-	-	-	-	-	648
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1985-86	613	331	944	-	-	-	-	-	944
1986-87	723	285	1 007	-	-	-	-	1 019	1 019
1987-88	1 005	421	1 426	-	-	-	-	1 725	1 725
1988-89	(530)	(136)	(665)	(252)	(265)	(28)	(293)	1 513	1 513
1989-90	-	-	-	780	1 171	410	1 581	1 769	1 769
1990-91	-	-	-	796	1 334	359	1 693	1 820	1 820
1991-92	-	-	-	1 112	1 994	703	2 698	2 620	2 620
1992-93	-	-	-	1 175	2 595	824	3 418	2 951	2 951
1993-94	-	-	-	1 247	2 236	788	3 024	2 997	2 997
1994-95	-	-	-	956	1 973	829	2 803	2 789	2 789
1995-96	-	-	-	-	-	-	-	2 789	2 789

Total skate landings (based on the "best estimate" in Table 1) were negligible up to 1978, presumably because of a lack of suitable markets and the availability of other more abundant and desirable species. Landings then increased linearly to reach nearly 3000 t in 1992-93 and 1993-94, and have remained between 2600 and 3100 t ever since (Table 2).

Smooth (SSK) skates were introduced into the QMS as a separate species from 1 October 2003 with allowances, TACCs and TACs as follow in Table 3. Figures 1 shows the historical landings and TACC values for the main SSK stocks. Owing to problems associated with identification of rough and smooth skates, reported catches of each species are probably not accurate. Initiatives to improve identification of these species begun in 2003 may have resulted in more accurate data.

Table 2: Reported landings (t) of SKA and SSK by QMA and fishing year, 1996-97 to 2010-11.

QMA	1	3	7	8	10	Total
FMA	1-2	3-6	7	8-9	10	All
Skate (SKA)*						
1996-97	43	894	380	30	0	1 347
1997-98	44	855	156	31	0	1 086
1998-99	48	766	228	12	0	1 054
1999-00	75	775	253	25	0	1 128
2000-01	88	933	285	28	0	1 334
2001-02	132	770	311	35	0	1 248
2002-03	121	857	293	32	0	1 303
2003-04	< 1	< 1	< 1	< 1	0	1
Smooth skate (SSK)						
1996-97	10	782	102	5	0	899
1997-98	5	901	121	4	0	1 031
1998-99	5	1 011	100	15	0	1 131
1999-00	5	877	73	16	0	971
2000-01	9	859	104	7	0	979
2001-02	17	794	89	7	0	907
2002-03	19	704	167	3	0	893
2003-04	79	431	146	15	0	671
2005-06	72	468	163	12	0	715
2006-07	58	473	155	6	0	693
2007-08	47	422	171	21	0	661
2008-09	38	332	168	22	0	560
2009-10	36	290	194	26	0	546
2010-11	27	307	243	32	0	609

*Use of the code SKA ceased once skates were introduced into the QMS in October 2003 and rough skates and smooth skates were recognised as a separate species. From this time all landings of skates have been reported against either the RSK or SSK code.

Table 3: Recreational and customary non-commercial allowances (t), Total Allowable Commercial Catches (TACC, t) and Total Allowable Catch (TAC, t) declared for SSK on introduction into the QMS in October 2003.

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other Mortality	TACC	TAC
SSK 1 (FMAs 1-2)	1	1	1	37	40
SSK 3 (FMAs 3-6)	1	1	6	579	587
SSK 7	1	1	2	213	217
SSK 8 (FMAs 8-9)	1	1	1	20	23
SSK 10	0	0	0	0	0

1.2   Recreational fisheries

Recreational fishing surveys indicate that skates are very rarely caught by recreational fishers.

1.3   Customary non-commercial fisheries

Quantitative information on the level of customary non-commercial take is not available.

1.4   Illegal catch

Quantitative information on the level of illegal catch is not available.

1.5   Other sources of mortality

Because skates are taken mainly as bycatch of bottom trawl fisheries, historical catches have probably been proportional to the amount of effort in the target trawl fisheries. Past catches were probably higher than historical landings data suggest because of unrecorded discards and unrecorded foreign catch before 1983.
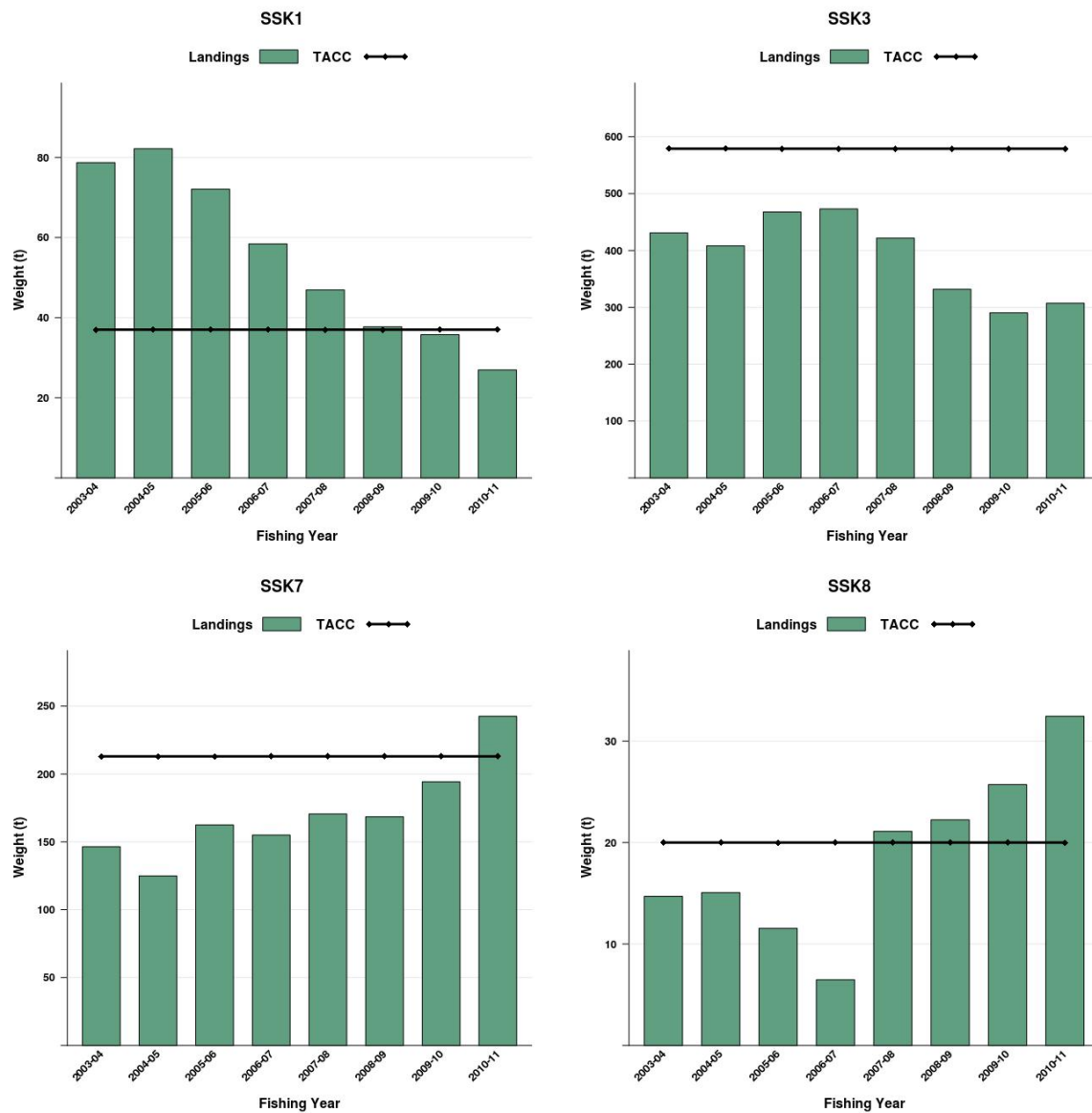
Figure 1: Historical landings and TACC for the four main SSK stocks. From top left to bottom right: SSK1 (Auckland East), SSK3 (South East Coast, South East Chatham Rise, Sub Antarctic, Southland), SSK7 (Challenger), and SSK8 (Central Egmont, Auckland West). Note that these figures do not show data prior to entry into the QMS.

2. BIOLOGY

Little is known about the reproductive biology of smooth skates. Smooth skates reproduce by laying yolky eggs, enclosed in leathery cases, on the seabed. Two eggs are laid at a time, but the number of eggs laid annually by a female is unknown. A single embryo develops inside each egg case and the young hatch at about 10-15 cm pelvic length (body length excluding the tail) (Francis 1997).

The greatest reported age for smooth skate is 28 years for a 155 cm pelvic length female (Francis *et al.* 2004). Females grow larger than males, and also appear to live longer than them. There are no apparent differences in growth rate between the sexes. Males reach 50% maturity at about 93 cm and 8 years, and females at 112 cm and 13 years. However, the small sample size of mature animals, particularly females, means that the maturity ogives are poorly defined. The most plausible estimate of *M* is 0.10-0.20. Biological parameters relevant to stock assessment are shown in Table 4.

Table 4:   Estimates of biological parameters for skates.

Fishstock			Estimate	Source
1. Natural mortality (*M*)				
SSK 3			0.12-0.15	Francis *et al.* (2004)
2. Weight = a (length) ^{b} (weight in g, length in cm pelvic length)				
		a	b	
SSK both sexes		0.0268	2.933	Francis (1997)
3. von Bertalanffy growth parameters*				
	K	t_0	L_∞	
SSK 3 (both sexes)	0.095	-1.06	150.5	Francis *et al.* (2001b)
SSK 3 (Males)	0.117	-1.28	133.6	Francis *et al.* (2004)

3.   STOCKS AND AREAS

Nothing is known about stock structure or movement patterns of smooth skates. Smooth skates are distributed throughout most of New Zealand, from the Three Kings Islands to Campbell Island and the Chatham Islands, including the Challenger Plateau, Chatham Rise and Bounty Plateau. Smooth skates have not been recorded from QMA 10.

In this report, smooth skate landings have been presented by QMA. QMAs would form appropriate management units in the absence of any information on biological stocks.

4.   STOCK ASSESSMENT

This is the first stock assessment for skates. No yield estimates have been made for skates.

4.1   Estimates of fishery parameters and abundance

Relative biomass estimates are available for smooth skates from a number of trawl survey series (Table 5). Biomass estimates are not provided for surveys of: (a) west coast North Island because of major changes in survey areas and strata during the series; or (b) east Northland, Hauraki Gulf and Bay of Plenty because of the low relative biomass of smooth skates present (usually less than 100 t). In the first survey of each of two series -east coast South Island and Chatham Rise- the two skate species were not (fully) distinguished. Furthermore, there are doubts about the accuracy of species identification in some other earlier surveys (prior to 1996). Consequently, trends in biomass of individual species must be interpreted cautiously. To enable comparison among all surveys within each series, total skate biomass is also reported.

As the catch from the South Island trawl surveys changes without wide inter-annual fluctuations and the CVs are relatively low it appears that they are able to track smooth skate biomass in FMA 3, 7, and on the Chatham Rise. West Coast South Island surveys show that the relative biomass of smooth skate in FMA 7 has declined substantially since 1997. Smooth skate relative biomass on the on the Chatham Rise was fairly stable between 1997 and 2010, fluctuating between 1300 and 2300 t, with no overall trend.

4.2   Biomass estimates

There are no absolute biomass estimates for smooth skates.

4.3   Estimation of Maximum Constant Yield (*MCY*)

MCY cannot be estimated.

The *MCY* estimator, that has the lowest data requirements ($MCY = cY_{AV}$; Method 4), relies on selecting a time period during which there were "no systematic changes in fishing mortality (or fishing effort, if this can be assumed to be proportional to fishing mortality)". This method was not applied because no information is currently available on skate fishing mortality, or on trawl fishing effort in the main skate fishing areas.

SMOOTH SKATE (SSK)

Table 5: Doorspread biomass estimates (t) and coefficients of variation (CV %) of smooth skates and total skates (smooth and rough).

Year	Trip Code	Smooth skate Biomass	CV	Total Biomass	CV
East coast North Island					
1993	KAH9304	23	52	99	-
1994	KAH9402	144	38	333	-
1995	KAH9502	20	59	72	-
1996	KAH9602	85	36	394	-
South Island west coast and Tasman/Golden Bays (FMA 7)					
1992	KAH9204	339	19	512	-
1994	KAH9404	341	18	537	-
1995	KAH9504	315	20	566	-
1997	KAH9701	302	26	487	-
2000	KAH0004	140	29	326	-
2003	KAH0304	91	79	134	-
2005	KAH0503	80	30	138	-
2007	KAH0704	55	44	300	-
2009	KAH0904	67	61	181	-
2010	KAH1004	185	33	532	-
East coast South Island (FMA 3) Winter					
1991	KAH9105	-	-	1928	25
1992	KAH9205	605	18	829	16
1993	KAH9306	658	25	993	21
1994	KAH9406	306	25	823	15
1996	KAH9606	385	24	562	18
2007	KAH0705	705	20	1 580	-
2008	KAH0806	554	18	1 412	-
2009	KAH0905	736	23	1 765	-
East coast South Island (FMA 3) Summer					
1996-97	KAH9618	721	32	2 057	-
1997-98	KAH9704	485	21	1 567	-
1998-99	KAH9809	450	26	1 625	-
1999-00	KAH9917	369	30	698	-
2000-01	KAH0014	248	33	470	-
Chatham Rise					
1991-2	TAN9106	-	-	2 129	-
1992-3	TAN9212	1 071	18	1 126	-
1994	TAN9401	958	23	1 178	-
1995	TAN9501	769	31	845	-
1996	TAN9601	1 511	30	1 522	-
1997	TAN9701	1 932	22	1 944	-
1998	TAN9801	1 425	26	1 935	-
1999	TAN9901	1 738	20	1 772	-
2000	TAN0001	1 369	23	1 369	-
2001	TAN0101	2 321	19	2 393	-
2002	TAN0201	2 111	17	2 148	-
2003	TAN0301	1 355	21	1 387	-
2004	TAN0401	2 006	21	2 066	-
2005	TAN0501	1 780	24	1 869	-
2006	TAN0601	1 521	29	1 577	-
2007	TAN0701	1 922	17	1 951	-
2008	TAN0801	1 376	26	1 376	-
2009	TAN0901	1 162	18	1 185	-
2010	TAN1001	1 576	21	1 576	-
2011	TAN1101	1 009	32	1 009	-
2012	TAN1201	813	22	813	-
Stewart-Snares Shelf					
1993	TAN9301	528	20	1 120	-
1994	TAN9402	342	21	1 406	-
1995	TAN9502	335	19	1 136	-
1996	TAN9604	504	29	1 559	-
Survey discontinued					
Stewart-Snares Shelf and Sub-Antarctic (Summer)*					
1991	TAN9105	382	23	419	-
1992	TAN9211	113	47	165	-
1993	TAN9310	117	43	249	-
2000	TAN0012	434	66	267	-
Stewart-Snares Shelf and Sub-Antarctic (Autumn)*					
1992	TAN9204	93	61	141	-
1993	TAN9304	177	33	428	-
1996	TAN9605	835	39	857	-
1998	TAN9805	536	62	607	-

*Biomass estimates are for core 300-800 m strata only
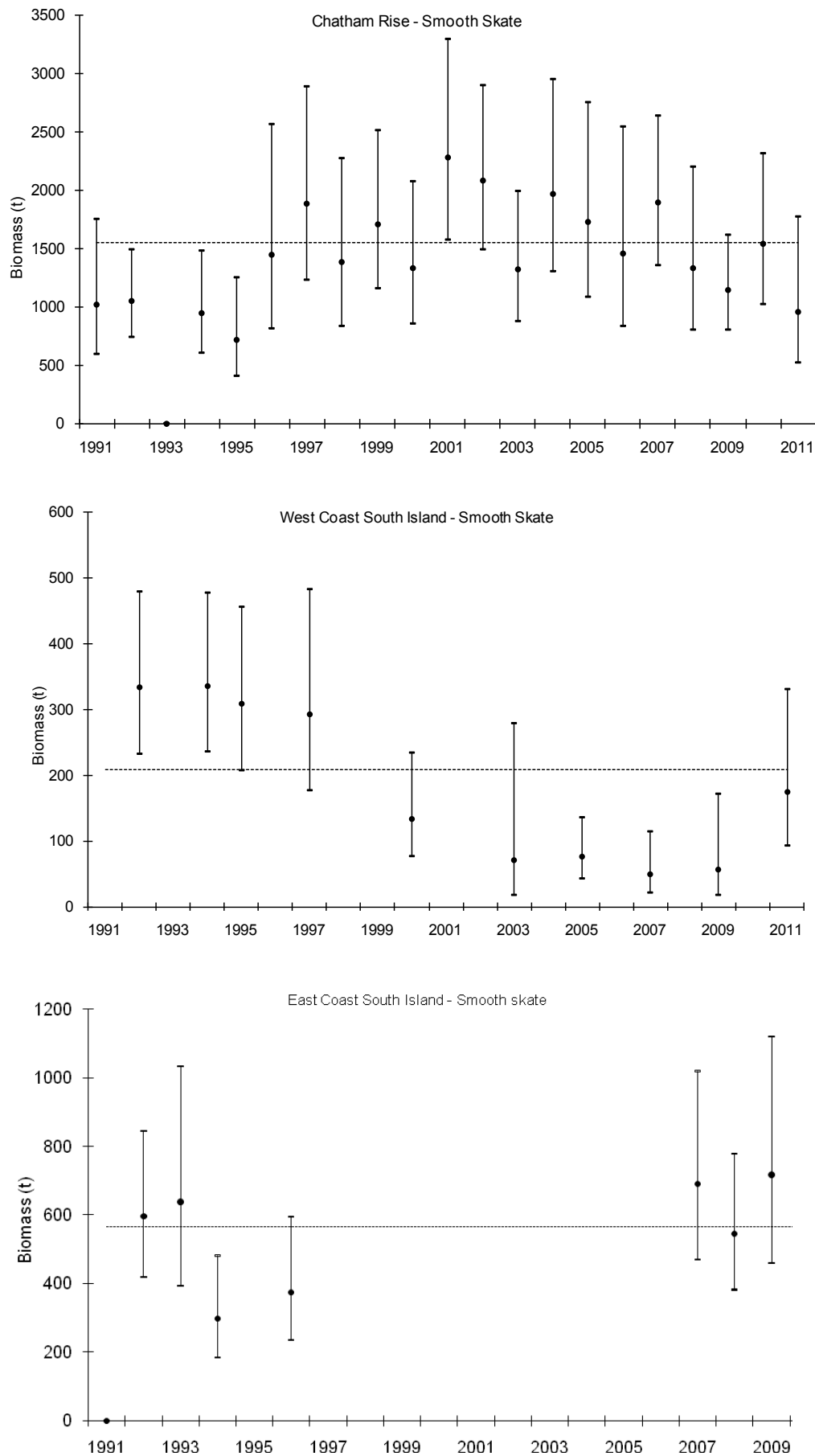
Figure 2: Smooth skate biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) estimated from the Chatham Rise (Top), West (Middle) and East (bottom) Coast South Island trawl survey.

4.4   Estimation of Current Annual Yield (*CAY*)

CAY cannot be estimated.

4.5   Other yield estimates and stock assessment results

No other yield estimates are available.

4.6   Other factors

Species that constitute a minor bycatch of trawl fisheries are often difficult to manage using TACCs and ITQs. Skates are widely and thinly distributed, and would be difficult for trawlers to avoid after the quota had been caught. A certain level of incidental bycatch is therefore inevitable. However, skates are relatively hardy, and frequently survive being caught in trawls (though mortality would depend on the length of the tow and the weight of fish in the cod end). Skates returned to the sea alive probably have a greater chance of survival than most other fishes.

5.   STATUS OF THE STOCKS

No estimates of current and reference biomass are available.

SSK 7 relative biomass estimates from West Coast South Island trawl surveys revealed a strong decline. Although this decline is cause for concern, the reason for the decline is uncertain and requires further investigation.

For all other skate QMAs it is Unknown if recent catch levels or the TACC will cause skate populations to decline. Reported landings and TACCs for the 2010-11 fishing year are summarised in Tables 6.

Table 6: Summary of TACCs (t), and reported landings (t) for smooth skates for the most recent fishing year.

Fishstock		QMA	2010-11 Actual TACC	2010-11 Reported landings
SSK 1 (FMAs 1-2)	Auckland (East) Central (East)	1 & 2	37	27
SSK 3 (FMAs 3-6)	South-east (Coast) (Chatham), Southland, and Sub-Antarctic	3, 4, 5 & 6	579	307
SSK 7	Challenger	7	213	243
SSK 8 (FMAs 8-9)	Central (West), Auckland (West)	8 & 9	20	32
SSK 10	Kermadec	10	0	0
Total			849	609

6.   FOR FURTHER INFORMATION

Beentjes M.P., Stevenson M.L. 2000. Review of the east coast South Island winter trawl survey time series, 1991-96. NIWA Technical Report 86. 64 p.

Beentjes M.P., Stevenson M.L. 2001. Review of the east coast South Island summer trawl survey time series, 1996-97 to 1999-2000. NIWA Technical Report 108. 92 p.

Francis M.P. 1997. A summary of biology and commercial landings, and a stock assessment of rough and smooth skates (*Raja nasuta* and *R. innominata*). New Zealand Fisheries Assessment Research document 1997/5 27p.

Francis M.P., Ó Maolagáin C., Stevens D. 2001a. Age, growth, and sexual maturity of two New Zealand endemic skates, *Dipturus nasutus* and *D. innominatus*. New Zealand Journal of Marine and Freshwater Research 35: 831-842.

Francis M.P., Ó Maolagáin C., Stevens D. 2001b. Age, growth, maturity, and mortality of rough and smooth skates (*Dipturus nasutus* and *D. innominatus*). New Zealand Fisheries Assessment Report 2001/17. 21 p.

Francis M.P., Ó Maolagáin C., Stevens D. 2004. Revised growth, longevity and natural mortality of smooth skate (*Dipturus innominatus*). Final Research Report for Ministry of Fisheries Project MOF2003/01H (Dated June 2004).

Stevenson M.L., Hanchet S. 2000. Review of the inshore trawl *survey* series of the west coast South Island and Tasman and Golden Bays, 1992-97. NIWA Technical Report 82. 79 p.

SNAPPER (SNA)

(*Pagrus auratus*)
Tamure, Kouarea
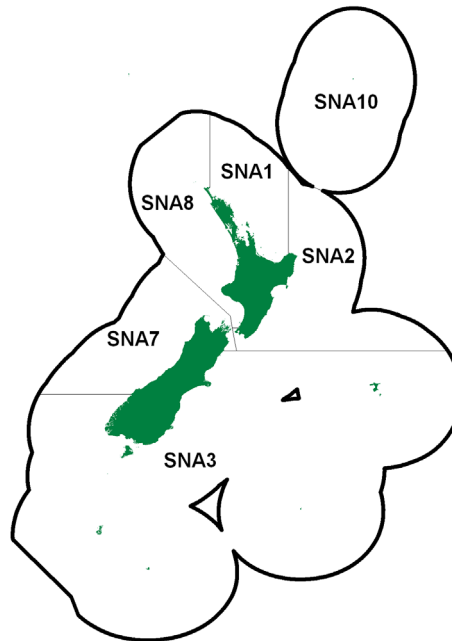
1.   FISHERY SUMMARY

1.1   Commercial fisheries

The snapper fishery is one of the largest and most valuable coastal fisheries in New Zealand. The commercial fishery, which developed last century, expanded in the 1970s with increased catches by trawl and Danish seine. Following the introduction of pair trawling in most areas, landings peaked in 1978 at 18 000 t (Table 1). Pair trawling was the dominant method accounting for on average 75% of the annual SNA 8 catch from 1976 to 1989. In the 1980s an increasing proportion of the SNA 1 catch was taken by longlining as the Japanese "iki jime" market was developed. By the mid 1980s catches had declined to 8500-9000 t, and some stocks showed signs of overfishing. The fisheries had become more dependent on the recruiting year classes as stock size decreased. With the introduction of the QMS in 1986, TACCs in all Fishstocks were set at levels intended to allow for some stock rebuilding. Decisions by the Quota Appeal Authority saw TACCs increase, in the case of SNA 1 to over 6000 t, and for SNA 8 from 1330 t to 1594 t (Table 2).

In 1986-87, landings from the two largest Fishstocks (i.e., SNA 1 and SNA 8) were less than their respective TACCs (Table 2), but catches subsequently increased in 1987-88 to the level of the TACCs (Figure 1). Landings from SNA 7 remained below the TACC after introduction to the QMS, and in 1989-90 the TACC was reduced to 160 t. Changes to TACCs that took effect from 1 October 1992 resulted in a reduction for SNA 1 from 6010 t to 4904 t, an increase for SNA 2 from 157 t to 252 t, and a reduction for SNA 8 from 1594 t to 1500 t. The TACC for SNA 1 was exceeded in the 1992-93 fishing year by over 500 t. Some of this resulted from carrying forward of up to 10% under-runs from previous years by individual quota holders, but most of this over-catch was not landed against quota holdings (deemed penalties were incurred for about 400 t).

SNAPPER (SNA)

Table 1: Reported landings (t) for the main QMAs from 1931 to 1990.

Year	SNA 1	SNA 2	SNA 7	SNA 8	Year	SNA 1	SNA 2	SNA 7	SNA 8
1931	3 465	0	69	140	1961	5 318	589	583	1 178
1932	3 567	0	36	159	1962	5 582	604	582	1 352
1933	4 061	21	65	213	1963	5 702	636	569	1 456
1934	4 484	168	7	190	1964	5 643	667	574	1 276
1935	5 604	149	10	108	1965	6 039	605	780	1 182
1936	6 597	78	194	103	1966	6 429	744	1 356	1 831
1937	5 918	114	188	85	1967	6 557	856	1 613	1 477
1938	6 414	122	149	89	1968	7 333	765	1 037	1 491
1939	6 168	100	158	71	1969	8 674	837	549	1 344
1940	5 325	103	174	76	1970	9 792	804	626	1 588
1941	5 003	148	128	62	1971	10 737	861	640	1 852
1942	4 279	74	65	57	1972	9 574	878	767	1 961
1943	4 643	60	29	75	1973	9 036	798	1 258	3 038
1944	5 045	49	96	69	1974	7 635	716	1 026	4 340
1945	4 940	59	118	124	1975	5 894	732	789	4 217
1946	5 382	77	232	244	1976	7 220	732	1 040	5 326
1947	5 815	36	475	251	1977	7 514	374	714	3 941
1948	6 745	53	544	215	1978	10 128	454	2 720	4 340
1949	5 866	215	477	277	1979	10 460	662	1 776	3 464
1950	5 107	285	514	318	1980	7 370	636	732	3 309
1951	4 301	265	574	364	1981	7 872	283	592	3 153
1952	3 795	220	563	361	1982	7 242	160	591	2 636
1953	3 703	247	474	1 124	1983	6 256	160	544	1 814
1954	4 316	293	391	1 093	1984	7 141	227	340	1 536
1955	4 442	309	504	1 202	1985	6 774	208	270	1 866
1956	4 742	365	822	1 163	1986	5 969	255	253	959
1957	5 285	452	1 055	1 472	1987	4 532	122	210	1 072
1958	5 154	483	721	1 128	1988	5 082	165	193	1 565
1959	5 778	372	650	1 114	1989	5 816	227	292	1 571
1960	5 697	487	573	1 202	1990	5 757	429	200	1 551

Notes:
1. The 1931-1943 years are April-March but from 1944 onwards are calendar years.
2. The "QMA totals" are approximations derived from port landing subtotals, as follows: SNA 1, Mangonui to Whakatane; SNA 2 Gisborne to Wellington/Makara; SNA 7, Marlborough Sounds ports to Greymouth; SNA 8 Paraparaumu to Hokianga.
3. Before 1946 the "QMA" subtotals sum to less than the New Zealand total because data from the complete set of ports are not available. Subsequent minor differences result from small landings in SNA 3, not listed here.
4. Data up to 1985 are from fishing returns: Data from 1986 to 1990 are from Quota Management Reports.

Table 2: Reported landings (t) of snapper by Fishstock from 1983-84 to 2010-11 and gazetted and actual TACCs (t) for 1986-87 to 2010-11. QMS data from 1986-present.

Fishstock	SNA 1		SNA 2		SNA 3		SNA 7		SNA 8	
QMAs	1		2		3,4,5,6		7		8,9	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983-84†	6 539	-	145	-	2	-	375	-	1 725	-
1984-85†	6 898	-	163	-	2	-	255	-	1 546	-
1985-86†	5 876	-	177	-	0	-	188	-	1 828	-
1986-87	4 016	4 710	130	130	0	30	257	330	893	1 330
1987-88	5 061	5 098	152	137	1	30	256	363	1 401	1 383
1988-89	5 793	5 614	210	157	1	30	176	372	1 526	1 508
1989-90	5 826	5 981	364	157	< 1	30	294	160	1 550	1 594
1990-91	5 315	6 002	427	157	< 1	31	160	160	1 658	1 594
1991-92	6 191	6 010	373	157	< 1	31	148	160	1 464	1 594
1992-93	5 423	4 904	316	252	2	32	165	160	1 543	1 500
1993-94	4 846	4 928	307	252	< 1	32	147	160	1 542	1 500
1994-95	4 831	4 938	307	252	< 1	32	150	160	1 434	1 500
1995-96	4 941	4 938	279	252	< 1	32	146	160	1 558	1 500
1996-97	5 049	4 938	352	252	< 1	32	162	160	1 613	1 500
1997-98	4 524	4 500	286	252	< 1	32	182	200	1 589	1 500
1998-99	4 411	4 500	283	252	3	32	142	200	1 636	1 500
1999-00	4 500	4 500	391	252	< 1	32	174	200	1 604	1 500
2000-01	4 347	4 500	360	252	< 1	32	156	200	1 630	1 500
2001-02	4 372	4 500	252	252	1	32	141	200	1 577	1 500
2002-03	4 484	4 500	334	315	< 1	32	187	200	1 558	1 500
2003-04	4 466	4 500	339	315	< 1	32	215	200	1 667	1 500
2004-05	4 641	4 500	399	315	< 1	32	178	200	1 663	1 500
2005-06	4 539	4 500	389	315	< 1	32	166	200	1 434	1 300
2006-07	4 429	4 500	329	315	< 1	32	248	200	1 327	1 300
2007-08	4 548	4 500	328	315	< 1	32	187	200	1 304	1 300
2008-09	4 543	4 500	307	315	< 1	32	205	200	1 344	1 300
2009-10	4 465	4 500	296	345	< 1	32	188	200	1 280	1 300
2010-11	4 516	4 500	320	345	< 1	32	206	200	1 312	1 300

Table 2 Continued:

Fishstock	SNA 10			
QMAs	10			Total
	Landings	TACC	Landings§	TACC
1983-84†	0	-	9 153	-
1984-85†	0	-	9 228	-
1985-86†	0	-	8 653	-
1986-87	0	10	5 314	6 540
1987-88	0	10	6 900	7 021
1988-89	0	10	7 706	7 691
1989-90	0	10	8 034	7 932
1990-91	0	10	7 570	7 944
1991-92	0	10	8 176	7 962
1992-93	0	10	7 448	6 858
1993-94	0	10	6 842	6 883
1994-95	0	10	6 723	6 893
1995-96	0	10	6 924	6 893
1996-97	0	10	7 176	6 893
1997-98	0	10	6 583	6 494
1998-99	0	10	6 475	6 494
1999-00	0	10	6 669	6 494
2000-01	0	10	6 496	6 494
2001-02	0	10	6 342	6 494
2002-03	0	10	6 563	6 557
2003-04	0	10	6 686	6 557
2004-05	0	10	6 881	6 557
2005-06	0	10	6 527	6 357
2006-07	0	10	6 328	6 357
2007-08	0	10	6 367	6 357
2008-09	0	10	6 399	6 357
2009-10	0	10	6 230	6 357
2010-11	0	10	6 355	6 357

† FSU data. SNA 1 = stat areas 1-10; SNA 2 = stat areas 11-16; SNA 3 = stat areas 18-32; SNA 7 = stat areas 17, 33-36, 38; SNA 8 = stat areas 37, 39-48. § Includes landings from unknown areas before 1986-87.

Table 3: **TACs, TACCs and allowances (t) for snapper by Fishstock from 1 October 2005.**

Fishstock	TAC	TACC	Customary allowance	Recreational allowance	Other mortality
SNA 1	7 550	4 500		2 600*	450
SNA 2	450	315	14	90	31
SNA 3		32.3			-
SNA 7	306	200	16	90	-
SNA 8	1 785	1 300	43	312	130
SNA 10		10			

* SNA 1 has a combined non-commercial allowance of 2 600 t.

From 1 October 1997 the TACC for SNA 1 was reduced to 4500 t, within an overall TAC of 7550 t, while the TACC for SNA 7 was increased to 200 t within an overall TAC of 306 t. In SNA 2, the bycatch of snapper in the tarakihi, gurnard and other fisheries has resulted in overruns of the snapper TACC in all years from 1987-88 up to 2000-01. From 1 October 2002, the TACC for SNA 2 was increased from 252 to 315 t, within a total TAC of 450 t. Although the 315 t TACC was substantially over-caught from 2002-03 to 2006-07, catches have since been closer to the TACC. From 1 October 2005 the TACC for SNA 8 was reduced to 1300 t within a TAC of 1785 t to ensure a faster rebuild of the stock. Table 3 shows the TACs, TACCs and allowances for each Fishstock from 1 October 2004. All commercial fisheries have a minimum legal size (MLS) for snapper of 25 cm.

Foreign fishing

Japanese catch records and observations made by New Zealand naval vessels indicate significant quantities of snapper were taken from New Zealand waters from the late 1950s until 1977. There are insufficient data to quantify historical Japanese catch tonnages for the respective snapper stocks. However, trawl catches have been reported by area from 1967 to 1977, and longline catches from 1975 to 1977 (Table 4). These data were supplied to the Fisheries Research Division of MAF in the late 1970s, however, the data series is incomplete, particularly for longline catches.

SNAPPER (SNA)

**Table 4: Reported landings (t) of snapper from 1967 to 1977 by Japanese trawl and longline fisheries.**

Year	(a) Trawl	Trawl catch (all species)	Total snapper trawl catch	SNA 1	SNA 7	SNA 8
1967		3092	30	NA	NA	NA
1968		19 721	562	1	17	309
1969		25 997	1 289	-	251	929
1970		31 789	676	2	131	543
1971		42 212	522	5	115	403
1972		49 133	1 444	1	225	1 217
1973		45 601	616	-	117	466
1974		52 275	472	-	98	363
1975		55 288	922	26	85	735
1976		133 400	970	NA	NA	676
1977		214 900	856	NA	NA	708

Year	(b) Longline		Total Snapper	SNA 1	SNA 7	SNA 8
1975			1 510	761	-	749
1976			2 057	930	-	1 127
1977			2 208	1 104	-	1 104

In 1997 the sensitivity of the SNA 1 and SNA 8 assessments (Davies 1999) to the assumed level of Japanese catch was investigated. Higher assumed levels of catch generally resulted in higher estimates of virgin biomass and mean recruitment.

Japanese catch was assumed to have occurred between 1960 and 1977, with cumulative total removals over the period at 30 000 t. The pattern of annual catches was assumed to increase linearly to a peak in 1968 (reaching 2202 t) then decline linearly to 1978 (zero). The catch was split evenly between East Northland and the Hauraki Gulf/Bay of Plenty.

For SNA 8, Japanese longline catch was assumed to be at a constant annual removal each year for 1965-74. An annual catch level of 2000 t was assumed. Trawl catches for 1967-77 and longline catch for 1975-77 were assumed to be at the reported levels.
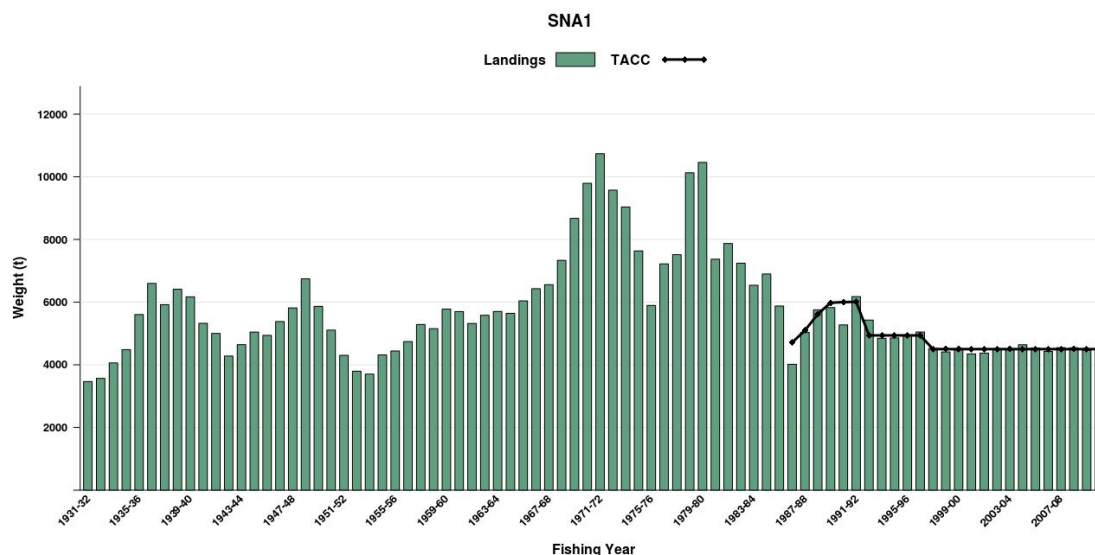
Figure 1: Historical landings and TACC for the four main SNA stocks. SNA1 (Auckland East). [Continued on next page].
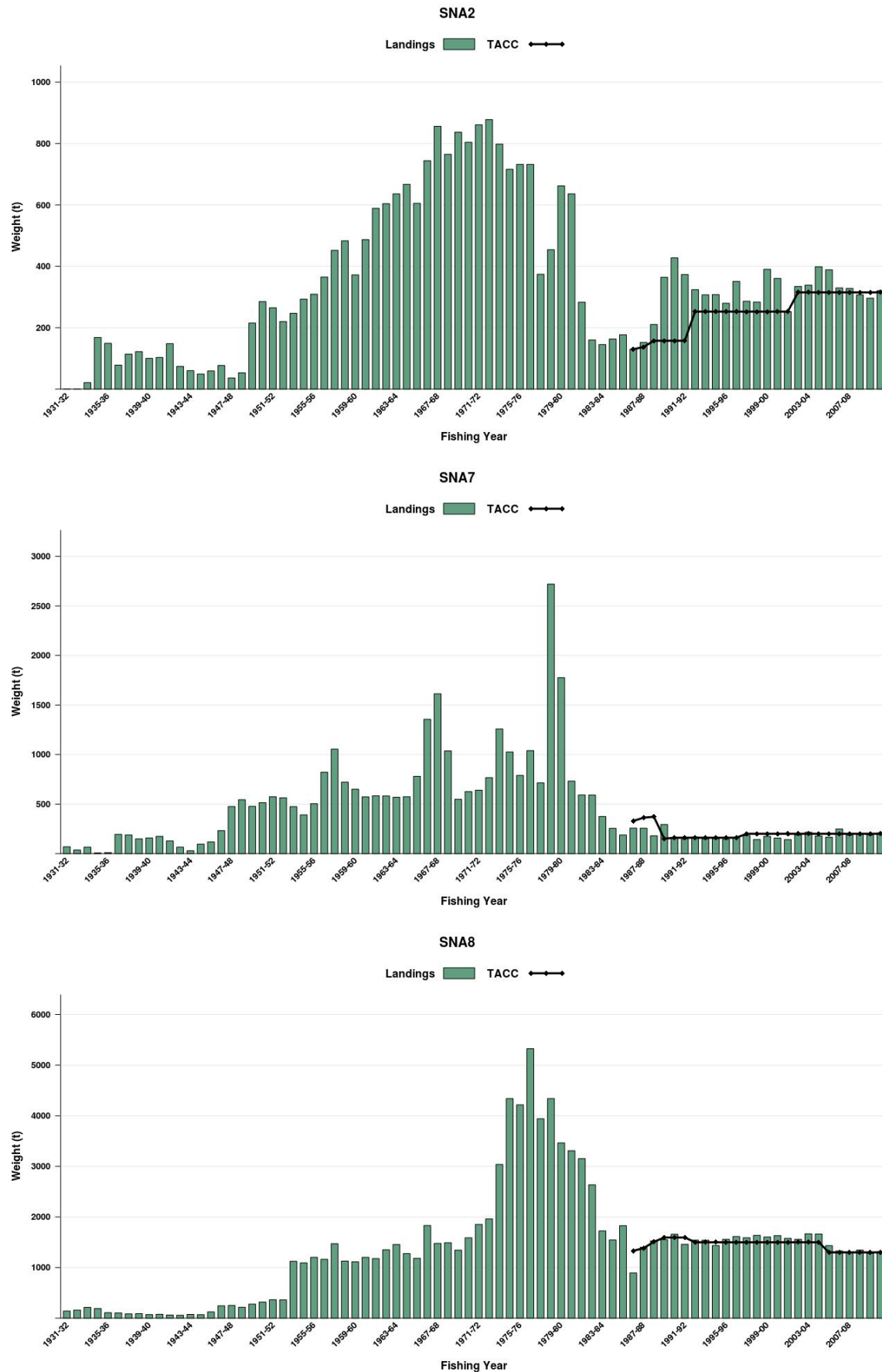
Figure 1 [Continued]: Historical landings and TACC for the four main SNA stocks. From top to bottom: SNA2 (Central East), SNA7 (Challenger) and SNA8 (Central Egmont).

1.2 Recreational fisheries

The snapper fishery is the largest recreational fishery in New Zealand. It is the major target species on both coasts of the North Island. The allowances within the TAC for each Fishstock are shown in Table 3.

Nationally the snapper bag limit for amateur fishers was set at 30 per person and minimum legal size (MLS) at 25 cm in January 1985. This bag limit was retained until 30 September 1993 when a new limit of 20 per person was applied in FMA 1 and 9. Following further consideration on snapper bag limits in northern New Zealand, against the backdrop of sustainability measures required for the overall fishery in SNA 1 and SNA 8, differential bag limits were introduced for SNA 1 and SNA 8 stocks on 30 October 1995. In FMA 9 (the northern part of SNA 8) between Tirua Point and North Cape, the bag limit was set at 15, whereas the limit in SNA 1 was set at 9 and the size limit in both FMA 1 and 9 was raised to 27 cm for amateur fishers only. The amateur daily bag limit for FMA 9 was reduced to 10 in 2005. In FMA 8 (the southern part of SNA 8) and in SNA 2 the bag limit is 10 per person per day with a MLS of 27 cm. Around the South Island (most of SNA 3 and SNA 7) the snapper bag limit is 10 per person per day and the MLS is 25 cm.

The tag ratio method gave the first estimates of recreational catch (Table 5). A tonnes per tag ratio was obtained from commercial tag returns and this was applied to the recreational returns to estimate catch. Regional telephone and diary surveys gave later estimates: MAF Fisheries South (1991-92), Central (1992-93) and North (1993-94) regions (Teirney *et al*. 1997). Estimates for 1996 came from a national telephone and diary survey (Bradford 1998). Another national telephone and diary survey was carried out in 2000 (Boyd & Reilly 2002) and a rolling replacement of diarists in 2001 (Boyd & Reilly in press) allowed estimates for a further year (population scaling ratios and mean weights were not re-estimated). The diary method used mean weights of snapper obtained from fish measured at boat ramps.

Table 5: Recreational catch estimates for snapper stocks. Totals for a stock are given in bold. The telephone/diary surveys ran from December to November but are denoted by the January calendar year. Mean fish weights were obtained from boat ramp surveys. Numbers and mean weights are not calculated in the tag ratio method.

Stock	Year	Method	Number of fish (thousands)	Mean weight (g)	Total weight (t)
SNA 1					
East Northland	1985	Tag ratio	-	-	370
Hauraki Gulf	1985	Tag ratio	-	-	830
Bay of Plenty	1984	Tag ratio	-	-	400
Total	1985[1]	Tag ratio	-	-	**1 600**
Total	1994	Telephone/diary	3 804	871	**2 857**
East Northland	1996	Telephone/diary	684	1 039	711
Hauraki Gulf/Bay of Plenty	1996	Telephone/diary	1 852	870	1 611
Total	1996	Telephone/diary	2 540	915	**2 324**
East Northland	2000	Telephone/diary	1 457	1 154	1 681
Hauraki Gulf	2000	Telephone/diary	3 173	830	2 632
Bay of Plenty	2000	Telephone/diary	2 274	872	1 984
Total	2000	Telephone/diary	6 904	904	**6 242**
East Northland	2001	Telephone/diary	1 446	-[5]	1 669
Hauraki Gulf	2001	Telephone/diary	4 225	-[5]	3 507
Bay of Plenty	2001	Telephone/diary	1 791	-[5]	1 562
Total	2001	Telephone/diary	7 462	-[5]	**6 738**
Hauraki Gulf	2004	Aerial overflight	-	-	1 334
East Northland	2005	Aerial overflight	-	-	557
Hauraki Gulf	2005	Aerial overflight	-	-	1 354
Bay of Plenty	2005	Aerial overflight	-	-	516
Total	2005	Aerial overflight	-	-	**2 419**

Table 5 [Continued].

Stock	Year	Method	Number of fish (thousands)	Mean weight (g)	Total weight (t)
SNA 2	1993	Telephone/diary	28	1 282	36
	1996	Telephone/diary	31	1 282[2]	40
	2000	Telephone/diary	268	1 2004	322
	2001	Telephone/diary	144	-[5]	173
SNA 7					
Tasman/Golden Bays	1987	Tag ratio	-	-	15
Total	1993	Telephone/diary	77	2 3983	184
Total	1996	Telephone/diary	74	2 398	177
Total	2000	Telephone/diary	63	2 148	134
Total	2001	Telephone/diary	58	-[5]	125
Total	2005/06	Aerial overflight	-	-	42.6
SNA 8					
Total	1991	Tag ratio	-	-	250
Total	1994	Telephone/diary	361	658	238
Total	1996	Telephone/diary	271	871	236
Total	2000	Telephone/diary	648	1 020	661
Total	2001	Telephone/diary	1 111	-	1 133
Total	2007	Aerial overflight	-	-	260

[1] The Bay of Plenty programme was carried out in 1984 but is included in the 1985 total estimate
[2] Mean weight obtained from 1992-93 boat ramp sampling
[3] Mean weight obtained from 1995-96 boat ramp sampling
[4] Mean weight obtained from 1999-2000 commercial landed catch sampling
[5] The 2000 mean weights were used in the 2001 estimates

Several potential causes of bias have been identified for the recreational catch estimates. The three most serious are described:

- The tag ratio method requires that all tagged fish caught by recreational fishers are recorded, or at least that the under-reporting rate of recreational fishers is the same as that of commercial fishers. This was assumed, although no data were available to test the assumption. If the recreational under-reporting rate was greater than that of the commercial fishers a negative bias would result. In SNA 8 there was evidence that many tags recovered by commercial fishing were reported as recreational catch, which would give a positive bias to estimates.

- In the telephone/diary method fishers are recruited to fill in diaries by way of a telephone survey that also estimates the proportion of the population that is eligible (likely to fish). A "soft refusal" bias in the eligibility proportion arises if interviewees who do not wish to co-operate falsely state that they never fish. The proportion of eligible fishers in the population is thereby under-estimated. The 2000 telephone/diary survey (pilot studies) demonstrated that this effect occurred when recreational fishing was established as the subject of the interview at the outset. It established that soft refusals were highly likely to have biased all the previous telephone/diary surveys. A correction would be required to overcome this bias in the pre-2000 estimates.

- Another equally serious cause of bias in telephone/diary surveys was identified. This was the potential for diarists who did not immediately record their day's catch after a trip to overstate their catch or even to overstate the number of trips they had made. There is some indirect evidence that this may have occurred in all the telephone/diary surveys (Wright *et al*. 2004).

The Recreational Technical Working Group concluded that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and, c) the 2000 and 2001 estimates are implausibly high for many important fisheries.

Owing to the limitations of diary surveys a combined aerial overflight / boat ramp survey was developed for SNA 1. It was tested in the Hauraki Gulf in 2004 and then applied to the entire SNA 1

QMA in 2005. Based on the success of this approach it was later applied to SNA 7 (2005-06 fishing year) and SNA 8 (2006-07). The Recreational and Snapper Working Groups both concluded that the boat ramp/ aerial overflight approach provides the most reliable estimates of recreational harvest for these Fishstocks. The methodology is described in Hartill *et al*. (2007).

In 2005, the Snapper Working Group and Plenary considered recreational catches from SNA 8. Two alternative levels were assumed for the recreational catch from 1990 to 2004, either 300 t or 600 t. The Plenary considered these values were likely to bracket the true average level of catch in this period. The estimate from the 2006-07 aerial overflight survey of the SNA 8 fishery (260 t) suggests that the assumed value of 300 t may have been the more plausible. There are potential sources of bias associated with the overflight estimate, both negative (a potential underestimation of the shore based harvest, especially to the south) and positive (over reporting of harvests by charter boat operators in a log book survey).

1.3 Customary non-commercial fisheries

Snapper form important fisheries for customary non-commercial, but the annual catch is not known.

1.4 Illegal catch

No new information is available to estimate illegal catch. For modelling SNA 1 and SNA 8 an assumption was made that non-reporting of catch was 20% of reported domestic commercial catch prior to 1986 and 10% of reported domestic commercial catch since the QMS was introduced. This was to account for all forms of under-reporting. These proportions were based on the black market trade in snapper and higher levels of under-reporting (to avoid tax) that existed prior to the introduction of the QMS. The 10% under-reporting post-QMS accounts for the practice of "weighing light" and the discarding of legal sized snapper.

1.5 Other sources of mortality

No estimates are available regarding the quantum of other sources of mortality on snapper stocks; although high-grading of longline fish and discarding of under-sized fish by all methods occurs.
An at-sea study of the SNA 1 commercial longline fishery in 1997 (McKenzie 2000) found 6-10% of snapper caught by number were under 25 cm (MLS). Results from a holding net study indicate mortality levels amongst lip-hooked snapper caught shallower than 35 m were low.

Estimates for incidental mortality were based on other catch-at-sea data using an age-length structure model for longline, trawl, seine and recreational fisheries. In SNA1, estimates of incidental mortality for the year 2000 from longline were less than 3% and for trawl, seine and recreational fisheries between 7% and 11% (Millar *et al*. 2001). In SNA8, estimates of trawl and recreational incidental mortality were lower, mainly because of low numbers of 2 and 3 year old fish estimated in 2000.

In SNA 1, recreational fishers release a high proportion of their snapper catch, most of which is less than 27 cm (recreational MLS). An at sea study in 2006–07 recorded snapper release rates of 54.2% of the catch by trailer boat fishers and 60.1% of the catch on charter boats (Holdsworth & Boyd 2008). Incidental mortality estimated from condition at release was 2.7% to 8.2% of total catch by weight depending on assumptions used.

2. BIOLOGY

Snapper are demersal fish found down to depths of about 200 m, but are most abundant in 15-60 m. They are the dominant fish in northern inshore communities and occupy a wide range of habitats, including rocky reefs and areas of sand and mud bottom. They are widely distributed in the warmer waters of New Zealand, being most abundant in the Hauraki Gulf.

Snapper are serial spawners, releasing many batches of eggs over an extended season during spring and summer. The larvae have a relatively short planktonic phase which results in the spawning grounds corresponding fairly closely with the nursery grounds of young snapper. Young fish school in

shallow water and sheltered areas and move out to deeper water in winter. The fish disperse more widely as they grow older. They first reach maturity from 20 to 28 cm fork length at 3-4 years of age. Large schools of snapper congregate before spawning and move on to the spawning grounds, usually in November-December. The spawning season may extend to January-March in some areas and years before the fish disperse, often inshore to feeding grounds. The winter grounds are thought to be in deeper waters where the fish are more widespread.

Water temperature appears to play an important part in the success of recruitment. Generally strong year classes in the population correspond to warm years, weak year classes correspond to cold years. (Francis 1993)

Growth rate varies geographically and from year to year. Snapper from Tasman Bay/Golden Bay and the west coast of the North Island grow faster and reach a larger average size than elsewhere. Snapper have a strong seasonal growth pattern, with rapid growth from November to May, and then a slowing down or cessation of growth from June to September. They may live up to 60 years or more and have very low rates of natural mortality. An estimate of $M = 0.06$ yr^{-1} was made from catch curves of commercial catches from the west coast North Island pair trawl fishery in the mid-1970s. These data were re-analysed in 1997 and the resulting estimate of 0.075 yr^{-1} has been used in the base case assessments for SNA 1, 2, and 7 (and SNA 8 up to 2004). In the 2005 assessment for SNA 8, natural mortality was estimated within the model.

Estimates of biological parameters relevant to stock assessment are shown in Table 6.

Table 6: Estimates of biological parameters.

Fishstock	Estimate			Source
1. Instantaneous rate of natural mortality (M)				
SNA 1, 2 & 7	0.075			Hilborn & Starr (unpub. analysis)
SNA 8	0.051 or 0.054			estimated within model
2. Weight = a(length)b (Weight in g, length in cm fork length)				
All	$a = 0.04467$	$b = 2.793$		Paul (1976)
3. von Bertalanffy growth parameters				
	Both sexes combined			
	K	t_0	L_∞	
SNA 1	0.102	-1.11	58.8	Gilbert & Sullivan (1994)
SNA 2	0.061	-5.42	68.9	NIWA (unpub. analysis)
SNA 7	0.122	-0.71	69.6	MAF (unpub. data)
SNA 8	0.16	-0.11	66.7	Gilbert & Sullivan (1994)
4. Age at recruitment (years)				
SNA 1*	4 (39%) 5 (100%)			Gilbert *et al.* (2000)
SNA 7	3			MAF (unpub. data)
SNA 8	3			Gilbert & Sullivan (1994)

*   For years when not estimated

3.   STOCKS AND AREAS

There are no new data that would alter the stock boundaries given in previous assessment documents (Gilbert *et al.* 2000).

New Zealand snapper are thought to comprise either seven or eight biological stocks based on: the location of spawning and nursery grounds; differences in growth rates, age structure and recruitment strength; and the results of tagging studies. These stocks comprise three in SNA 1 (East Northland, Hauraki Gulf and BoP), two in SNA 2 (one of which may be associated with the BoP stock), two in SNA 7 (Marlborough Sounds and Tasman/Golden Bay) and one in SNA 8. Tagging studies reveal

that limited mixing occurs between the three SNA 1 biological stocks, with greatest exchange between BoP and Hauraki Gulf.

4.   ENVIRONMENTAL & ECOSYSTEM CONSIDERATIONS

This section was updated with new tables for the May 2012 Fishery Assessment Plenary based on reviews of similar chapters by the Aquatic Environment Working Group. This summary is from the perspective of the snapper fisheries; a more detailed summary from an issue-by issue perspective is, or will shortly be, available in the Aquatic Environment & Biodiversity Annual Review (http://fs.fish.govt.nz/Page.aspx?pk=113&dk=22982).

4.1   Role in the ecosystem
Not yet considered

4.2   Incidental catch (fish and invertebrates)
Not yet considered

4.3   Incidental Catch (seabirds, mammals, and protected fish)
For protected species, capture estimates presented here include all animals recovered to the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds struck by a warp or caught on a hook but not brought onboard the vessel, Middleton & Abraham 2007, Brothers *et al.* 2010).

4.3.1 Marine mammal interactions
There were no observed captures of marine mammals in trawls targeting snapper between 2002-03 and 2009-10 but low observer coverage of inshore trawlers (average 0.85% in FMAs 1 and 9 over these years, Thompson & Abraham 2012) means that the frequency of interactions is highly uncertain. In these same years, there were no observed marine mammal captures in snapper longline fisheries where coverage has averaged 1.6% of hooks set (3.0 and 4.3% in the two most recent years).

4.3.2 Seabird interactions
There were only two observed captures of seabirds (one flesh-footed shearwater and one unidentified small bird) in trawls targeting snapper between 2002-03 and 2009-10 but low observer coverage of inshore trawlers (average 0.85% in FMAs 1 and 9 over these years, Thompson and Abraham 2012) means that the frequency of interactions is highly uncertain. The estimated number of seabird captures in the snapper bottom longline fishery declined from 3 436 in 2000-01 to 247–644 in 2003-04 (depending on the model used, Table 7, estimates from McKenzie & Fletcher 2006, Baird & Smith 2007, 2008, Abraham & Thompson 2010). The estimated number of captures between 2003-04 and 2006-07 appears to have been relatively stable at about 400–600 birds each year.

Table 7: **Model based estimates of seabird captures in the SNA 1 bottom longline fishery from 1998-99 to 2006-07 (from McKenzie & Fletcher 2006 (for vessels under 28 m), Baird & Smith 2007, 2008, Abraham & Thompson 2010). Numbers in parentheses are 95% confidence limits or estimated cvs.**

					Model based estimates of captures	
Fishing year	MacKenzie & Fletcher		Baird & Smith		Abraham & Thompson	
1998-99	1 464	(271 – 9 392)	–	–	–	–
1999-00	2 578	(513 – 13 549)	–	–	–	–
2000-01	3 436	(697 – 17 907)	–	–	–	–
2001-02	1 856	(353 – 11 260)	–	–	–	–
2002-03	1 583	(299 – 9 980)	–	–	739	(332 – 1 997)
2003-04	247	(51 – 1 685)	546	(c.v. = 34%)	644	(301 – 1 585)
2004-05	–	–	587	(c.v. = 42%)	501	(245 – 1 233)
2005-06	–	–	–	–	469	(222 – 1 234)
2006-07	–	–	–	–	457	(195 – 1 257)

Between 2002–03 and 2009–10, there were 83 observed captures of birds in snapper longline fisheries (Table 8) but no estimates of total captures for the later years are yet available. The rate of capture varied between 0 and 0.1 birds per 1000 hooks observed, fluctuating without obvious trend. Seabirds observed captured in snapper longline fisheries were mostly flesh-footed shearwater (43%), black (Parkinson's) petrel (34%) or fluttering shearwater (14%) and all were taken in the Northland-Hauraki area (Table 9). These numbers should be regarded as only a general guide on the composition of captures because the observer coverage is low, is not uniform across the area, and may not be representative.

Table 8: Number of tows by fishing year and observed seabird captures in the snapper bottom longline fishery, 2002–03 to 2009–10. No. obs, number of observed hooks; % obs, percentage of hooks observed; Rate, number of captures per 1000 observed hooks. Data from Thompson & Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/

	All hooks	No. obs	% obs	Captures	Rate
2002–03	13 730 262	0	0.0	0	-
2003–04	12 276 448	193 893	1.6	10	0.052
2004–05	11 548 941	250 985	2.2	13	0.052
2005–06	11 696 613	116 290	1. 0	12	0.103
2006–07	10 351 591	62 360	0.6	0	0
2007–08	9 052 322	0	0.0	0	-
2008–09	8 970 134	268 746	3.0	21	0.078
2009–10	11 032 105	479 078	4.3	27	0.056

Table 9: Number of observed seabird captures in the snapper longline fishery, 2002–03 to 2009–10, by species or species group. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR (from Richard *et al.* 2011 where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for snapper. Other data from Thompson & Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/

Species	Risk ratio	Captures
Flesh footed shearwater	2.51	36
Black petrel	11.15	28
Fluttering shearwater	–	12
Gannets	0.10	2
Pied shag	–	2
Black backed gull	0.00	1
Petrels, prions, and shearwaters	–	1
Red billed gull	–	1
Total other birds		**83**

4.4 Benthic interactions

Snapper are sometimes taken using bottom trawls and Danish seines, both of which have direct contact with the seabed. Snapper tows accounted for about 6% of all tows reported on TCEPR forms to have been fished on close to the bottom between 1989–90 and 2004–05 (Baird *et al.* 2011), but 54% of snapper trawls and all Danish seine sets during those years were reported on CELR forms. The TCEPR trawl tows were located in Benthic Optimised Marine Environment Classification (BOMEC, Leathwick *et al* 2009) classes A, C (northern shelf) and H (upper slope) (Baird & Wood 2012), and 90% were shallower than 100 m (Baird *et al.* 2011).

Trawling and Danish seining for snapper, like trawling for other species, is likely to have effects on benthic community structure and function (e.g., Rice 2006) and there may be consequences for benthic productivity (e.g., Jennings 2001, Hermsen *et al.* 2003, Hiddink *et al.* 2006, Reiss *et al.*2009). These consequences are not considered in detail here but are discussed in the Aquatic Environment and Biodiversity Annual Review (2012).

4.5   Other considerations

None

5.   STOCK ASSESSMENT

The stock assessments for SNA 2, SNA 7 and SNA 8 were done in 2009, 2002 and 2005 respectively. A partial new assessment of SNA 1 was conducted in 2012, the previous assessment was undertaken in 2000.

5.1   SNA 1 (Auckland East)

5.1.1   Model structure

The model used for the 2012 assessment is an age structured population model, built using NIWA's CASAL (C++ Algorithmic Stock Assessment Laboratory) stock modelling software (Bull *et al.* 2012).   The model contains significant improvements to the stock structure and movement assumptions on the 2000 assessment.

The 2012 assessment model for SNA 1 assesses three stocks (east Northland; Hauraki Gulf; BoP). In the 2000 assessment, only two stocks were assessed: East Northland and a combined Hauraki Gulf and BoP stock (these stock areas had to be combined due to data and modelling limitations).

The 2012 model has 20 age partitions: 19 age classes (1- 19) plus a 20+ amalgamated age class. Recruitment is defined as the number of fish entering the population at age 1.

As with the 2000 assessment, the 2012 model commences in 1970 at an estimated exploited state. One reason for commencing the model in 1970 was to reduce the importance of assumptions concerning Japanese, recreational and other historical catch uncertainties. To initialise the starting stock populations, a starting equilibrium age structure is derived by estimating recruitment in 1970 for each stock as a proportion (R_{init}) of mean recruitment in an unfished state (R_0).   This is a simplification from the initialisation procedure used in the previous assessment, which estimated the exploited age structure in 1970 using two estimates of Z for each stock.

The model spanned the years 1970 to 2011; 2011 being the 2010-11 fishing year and 1970 being the 1969-70 "start" fishing year. The model had two time steps within each year (Table 10). The model was a single sex model with the proportion mature for the purposes of spawning stock biomass (SSB) calculation assumed to be 0% at age 3, 50% at age 4, and 100% at age 5 onwards.

Table 10:   **Annual model time steps and the processes and observations used in each time step Note that the home area for a fish is where it spawns (and was recruited). Each year some fish migrate away from their home ground (in step 2) and then return home in step 1 of the following year.**

Time step	Model processes (in temporal order)	Observations[2,3]
1	age incrementation, migration to home area, recruitment, spawning, tag release	
2	migration from home area, natural and fishing mortality[1]	biomass, length and age compositions, tag recapture

[1]Fishing mortality was applied after half the natural mortality
[2]The tagging biomass estimate was assumed to occur immediately before the mortality; all other observations occurred half-way through the mortality
[3]See Table x for more details of all observations

Year class strengths (YCS) were estimated as free parameters but only for years where there was at least one observation of catch-at-age. The YCS estimation period in the model was also the period over which the R0 parameter was also estimated. YCS estimation conformed to the Haist parameterisation in which the mean of the YCSs is constrained to 1 (Bull *et al.* 2012). For years where YCS could not be estimated as free parameters YCS was set to 1.

For the purposes of converting numbers at-age to length for each stock, the model is provided with three mean length-at-age tables. These tables were derived using a combination of longline catch-at-age observations (ages 6 and above) and trawl survey observations (ages 5 and below). The reason for using a growth table as opposed to a simple growth function (as was done on the 2000 assessment) was to incorporate temporal changes in snapper growth rates into the assessment. Global length-at-age averages were used for years where no independent data existed. As with the 2000 assessment a constant natural mortality of 0.075 was used..

A Beverton and Holt (BH) stock recruit relationship was incorporated into the 2012 assessment model with an assumed steepness of 0.85. This is a significant difference to the 2000 assessment model where no stock recruitment relationship was used (i.e. equivalent to assuming a steepness of 1.0 in the BH model).

Selectivity functions for all gear methods represented in the model were 3-parameter double-normal functions (Bull *et al.* 2012).

A major change in the 2012 assessment was that the tagging data (with the exception of 1983 Bay of Plenty tagging data which were not available) were analysed inside the model while the 2000 assessment these data were analysed separately from the model to produce estimates of biomass that were included in the model (Table 11).

Table 11: Details of observations used in the stock assessment model

Type	Likelihood	Area[1]	Source	Range of years	No. of years
Absolute biomass	Lognormal	BOP	1983 tagging	1983	1
Relative biomass (CPUE or survey)	Lognormal	BOP	longline	1990-2011	22
		ENLD	longline	1990-2011	22
		HAGU	longline	1990-2011	22
		BOP	single trawl	1996-2011	16
		HAGU	research survey	1983-2001	13
Age composition	Multinomial	HAGU	longline	1985-2010	22
		BOP	longline	1990-2010	19
		ENLD	longline	1985-2010	18
		HAGU	Danish seine	1970-1996	11
		HAGU	research survey	1985-2001	10
		HAGU	single trawl	1975-1994	6
		BOP	single trawl	1990-1995	4
		BOP	research survey	1990-1996	3
		ENLD	research survey	1990	1
		BOP	Danish seine	1995	1
Length composition		BOP	recreational fishing	1991-2011[2]	13
		ENLD	recreational fishing	1991-2011[2]	13
		HAGU	recreational fishing	1991-2011[2]	13

		Area tagged[1]	Year tagged	Areas recaptured[1]	Years recaptured
Tag recapture	Binomials	ENLD	1983	ENLD, HAGU	1984, 1985
		HAGU	1983	ENLD, HAGU	1984, 1985
		ENLD	1993	ENLD, HAGU, BOP	1994, 1995
		HAGU	1993	ENLD, HAGU, BOP	1994, 1995
		BOP	1993	ENLD, HAGU, BOP	1994, 1995

[1] Areas are East Northland (ENLD), Hauraki Gulf (HAGU), and Bay of Plenty (BOP)

[2] All length composition data sets were split into pre-1995 (2 years) and post-1995 (11 years) because recreational selectivity was assumed to change in 1995

The 2012 assessment explicitly modelled the movement of fish between areas, whereas the 2000 assessments ignored movement. Two alternative movement models were considered: Markovian and home-fidelity (HF) and the HF model was selected. Under the HF movement assumption, fish spawn in their home area and some move to other areas at other times of the year where they are subject to fishing. Model yield calculations (SSBs, *MSY*, BMYS, B_0, etc) under a HF movement dynamic pertain to the unit "home" stock, not to an area. The yield from a specific area is derived as an area integration of "home" stock yields as determined by the movement dynamics.

5.1.2   Catch History

Recreational catch

Annual recreational harvest estimates used in the model were based on the commercial longline CPUE index by stock (1990 to 2011) scaled to the 2004-05 harvest estimates from the aerial over-flight survey by stock (Table 8) (Hartill *et al*. 2007). Estimates between 1989-90 and 1994-95 were scaled up by 10% to compensate for the lower MLS (25 cm), more hooks allowed per longline (50) and higher bag limit (15 per person) that was in place at that time. Harvest by recreational fishers in 1970 was assumed to be 70% of the 1989-90 estimate with a linear increase in annual catch across the intervening years.   The customary harvest is not known and is assumed to be included in the recreational catch.
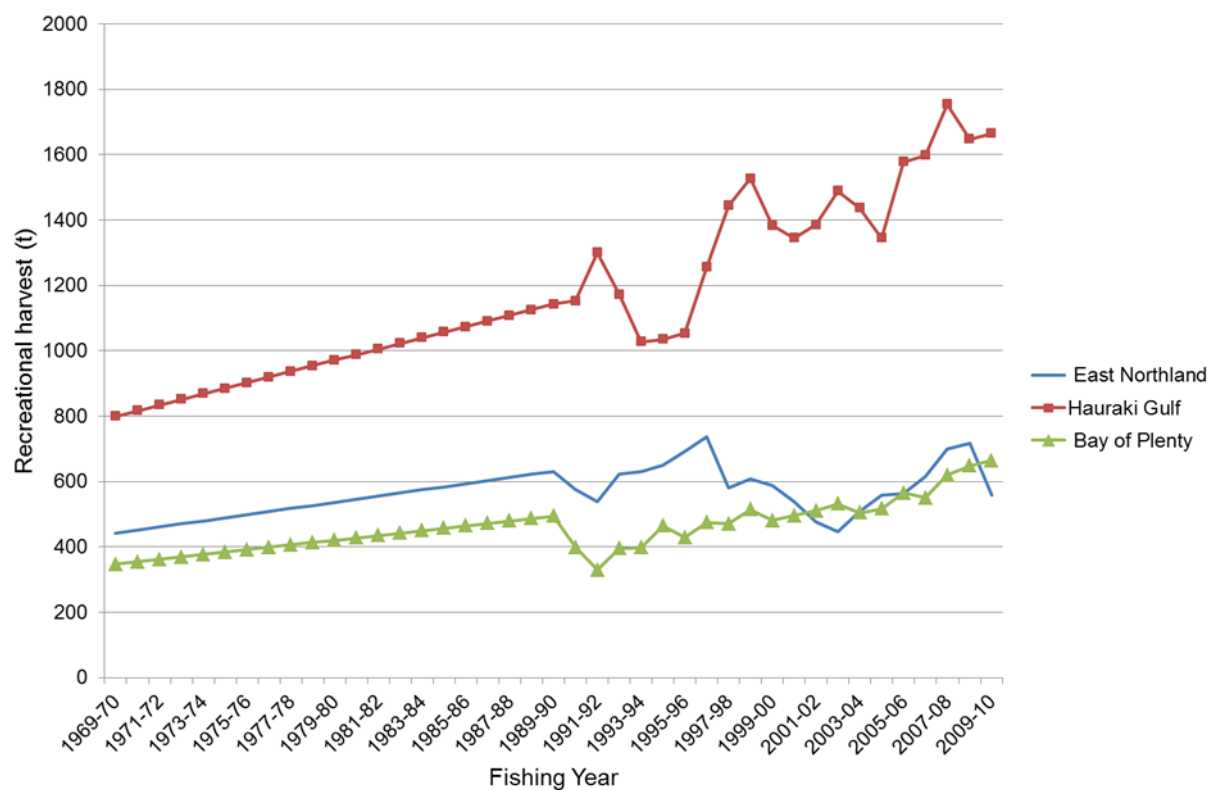
Figure 2: Recreational catch history used in the 2012 SNA 1 assessment model

Commercial catch

The SNA 1 commercial catch histories for the various method area fisheries after 1989-90 were derived from the Ministry of Fisheries catch effort reporting database (*warehou*). Historical catches for method and area, over the preceding two decades, were constructed on the basis of data contained in the fishery characterisation reports of King (1985; 1986; 1987) and Paul & Sullivan (1988). Area-method catches were prorated to the SNA 1 annual catch totals given in Table 1 & 2. Commercial catch was divided into four method fisheries: longline; single bottom trawl; pair bottom trawl; Danish seine; "other" commercial methods (predominately setnet) (Figure3 & 4) As was done for the 2000 assessment; commercial catch totals prior to the 1986 QMS year were adjusted upwards to account for an assumed 20% level of under-reporting. Catch totals post QMS were likewise scaled assuming 10% under-reporting.
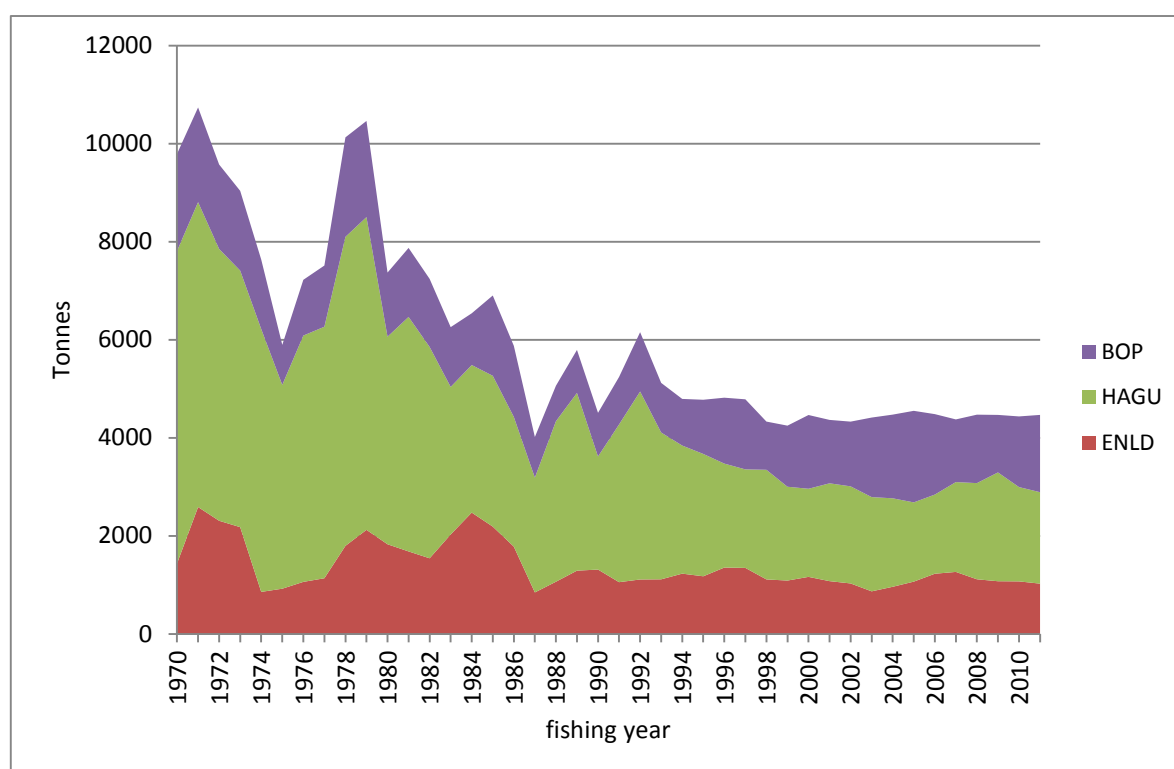
Figure 3: Area commercial catch histories (not adjusted for under reporting) used in the 2012 SNA 1 assessment model.
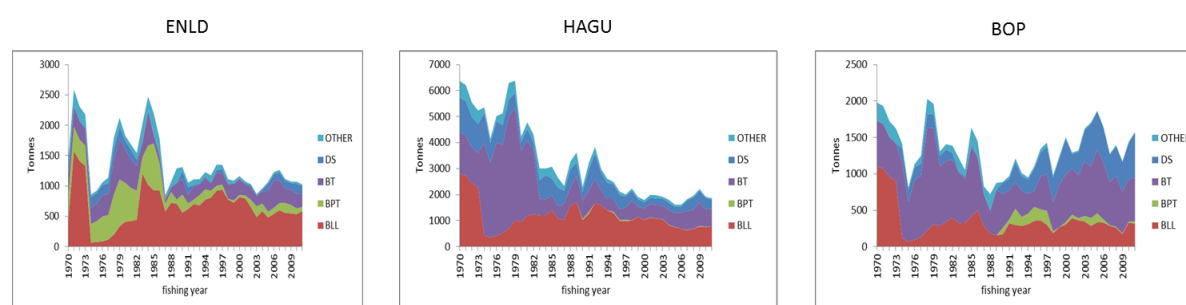
Figure 4: Method-area commercial catch histories (not adjusted for under reporting) used in the 2012 SNA 1 assessment model.

5.1.3 Abundance indices

Trawl surveys

Trawl surveys were carried out in all three areas between the mid-1980s to 2000. Unfortunately, the only area for which a viable series of abundance estimates exists is the Hauraki Gulf. An index of relative numbers of fish surveyed from the Hauraki Gulf trawl survey series was fitted in the model and was assigned an overall cv of 0.15. (Table 9).

Longline CPUE

The area specific longline CPUE indices were fitted by the 2012 model, with each series assigned overall cv of 0.15 (section below; Table 9).

Bay of Plenty single trawl CPUE

The single trawl Bay of Plenty CPUE was fitted with assigned overall cv of 0.15 (section below; Table 9).

5.1.4 Catch at age and length observations

Commercial data

Catch-at-age observations from single trawl, Danish Seine and longline are available from the Bay of Plenty and Hauraki Gulf stocks; longline only for east Northland (Table 11).

Recreational data

Observations of recreational catch at length are available from 1990, spanning the 1994 change in minimum legal size (Table 11).

Research Trawl data

Catch-at-age observations from research trawl surveys are available for most surveys and fitted in the model for all areas (Table 11).

5.1.5 Snapper 1983, 1985 and 1994 tagging programmes

Analysis of past snapper tagging programmes revealed a number of sources of bias that need to be accounted for if these data are to be used for assessment purposes. Data from the 1985 and 1994 tagging programmes were corrected for bias and input directly into the assessment model. Data from the 1983 Bay of Plenty tagging programme was unavailable. The published biomass estimate (6000 t Sullivan 1987) was fitted in the model as a point estimate but given a high cv (0.4) in recognition the likely inherent but unaccountable biases in the data.

Initial mortality

The release data were adjusted for initial mortality outside the model using methods given in Gilbert & McKenzie (1999).

Tag-loss

The effect of tag-loss was only an issue for the 1983 and 1985 tagging programmes where external tags were used. A revised estimate of tag loss was derived from a double-tagging experiment in 1985.

Trap avoidance

Trap avoidance was found to occur for both trawl and longline tagged fish (Gilbert and McKenzie 1999), the result of this was that released fish were less likely to be recaptured using the same method.

Trawl and longline methods were used to tag fish in both the 1985 and 1994 tagging programmes. The CASAL models used the scaling factors derived by Gilbert and McKenzie (1999) to adjust the tagging data for trap-avoidance.

Detection of recaptured tags

Because a fishery independent tag recovery process was used in the 1994 programme, a reliable estimate of tag under-detection was obtained. The model was provided this estimate to adjust the 1994 tag recovery data.

The recovery of tags in 1983 and 1984 programmes relied on fishers to voluntarily return tags. Estimates of under-reporting from these programmes are less precisely known but were assumed to be 15% (1988 Snapper Plenary Report).

Differential growth of tagged fish

There is evidence that tagged fish may stop growing for 6 months after tagging (Davies *et al.* 2006).The growth differential between tagged and untagged fish may bias results as the model will expect these fish to be larger than they are. As it was not possible to incorporate this source of bias in the model, it was assumed that, given the majority of tags recovered in both programmes came from the first year after release, growth bias would be minimal.

5.1.7   Selectivity

The selectivity parameterisation in the model was the same for all three stocks. The composition data allowed selectivity to be estimated for all methods, with the exception of pair trawl, and the lumped commercial method "other" category (Figure 4).

The selectivity curves used by the model for pair trawl and method "other", were based on selectivity curves used in previous SNA 1 & 8 assessments (Gilbert *et al.* 2000, Davies *et al.* 2006, Bian *et al.* 2009).

5.1.6 Model Parameters and likelihood weighting

Model parameters

The fixed and estimated parameters used in the 2012 assessment model are given in Tables 12 and 13.

Table 12: Details of parameters estimated in the stock assessment model

Type	Description	No. of parameters	Prior
R_0	Mean unfished recruitment for each stock	3	uniform-log
R_{init}	Pre-1970 recruitment (as proportion of R_0)	3	uniform
YCS	Year class strengths by year and stock	115[1]	lognormal[3]
Migration	Proportions migrating from home grounds	6	uniform
Selectivity	Proportion selected by age by a survey or fishing method	18[2]	uniform[4]
q	Catchability (for relative biomass observations)	5	uniform-log

[1]YCSs were estimated for years 1969-2007 (for East Northland and Hauraki Gulf) and 1971-2001 (Bay of Plenty)
[2]Selectivities (assumed to be double normal and independent of area) were estimated for research surveys, and the following fishing methods: longline, single trawl, Danish seine, and pre-1995 recreational, and post-1995 recreational
[3]With mean 1 and coefficient of variation (0.6)
[4]Except for the recreational selectivities, where normal priors were assumed for each parameter with means 4.55, 0.50, 10.24 (pre-1995) and 5.30, 0.50, 10.40 (post-1995) and coefficients of variation 0.20, 0.05, and 0.05 (both pre- and post-1995)

Table 13: Details of parameters that were fixed in the stock assessment model

Natural mortality	0.075 y^{-1}
Stock-recruit steepness	0.085
Tag shedding (instantaneous rate, 1985 tagging)	0.486 y^{-1}
Tag detection (1985 and 1994 tagging)	0.85
Proportion mature	0 for ages 1-3, 0.5 for age 4, 1 for ages > 4
Length-weight [mean weight (kg) = a (length (cm))^b]	$a = 4.467 \times 10^{-5}$, $b = 2.793$
Mean lengths at age	provided for years 1989-2011
Coefficients of variation for length at age	0.10 at age 1, 0.20 at age 20

Model likelihoods and data weighting

The tagging data were fitted in the model using binomial likelihoods representing the probability of tags being present or absent in scanned/examined catches. It was not feasible to adjust the relative weighting of these data in the model. The CV's on the various abundance data sets were defined *a priori* to be consistent with the most "plausible" fit the model was expected to achieve to the data (as agreed by the working group). Reweighting of the compositional data fits in the model used method TA1.8 of Francis (2011).

5.1.7 Base model and model sensitivity parameterisation

Input values for the base and sensitivity model runs, as agreed by the working group, are given in Table 14.

Table 14: Base model fixed model and sensitivity model input values

Element	Base model	Sensitivities	2000 SNA 1 assessment (base)
Natural mortality	0.075	0.065(mLw) 0.085(mHi)	0.075
BH steepness	0.8	0.85(hLw) 0.9(hHi)	1 (no stock recruit)
trap avoidance	0.65	-	1.0 (no trap)
recreational catch	relative abundance fixed at 2005 aerial survey estimate	scale up 2005 survey estimate by 25% (rec25%)	history of the same order

5.1.8 Model projections

Five year stock projections were undertaken using the base model under the following assumptions:
- Commercial and recreational harvest at the level of the TACC with gear and area catches being proportionally the same as the final model year (2011)
- Recreational catch in each area being the average of the last three years
- Recruitment is to be based on strengths of year classes entering the fishery from 1995 to 2004 for which at least three observations were available.

The deterministic B_{MSY} was estimated using the approach developed for hoki by Francis (see Hoki 2011 WG Report).

5.1.9 Results

Base model

The base model MPD achieved good fits to the abundance data and reasonably good fits to the composition data. The model fitted the majority of tag movement data cells within the confidence bounds of most of the observations. The expected number of Hauraki Gulf/Hauraki Gulf and East Northland/East Northland recoveries in 1995 were not well fitted, although these represent 2 out of 26 possible recovery cells, these cells had some of highest numbers of tag observations.

The likelihood profiles on the R_{init} parameter for the Hauraki Gulf stock show the initial starting status of the stock in 1970 was well determined by the early Danish seine age composition data. R_{init} for the Bay of Plenty and east Northland stocks was poorly determined in each stock. Stock status (B_{2011}/B_0) was not sensitive to R_{init} over the 95% confidence range of this parameter for the three stocks. This implies that poor determination of R_{init} had little influence on the stock status conclusions from the model, i.e. B_0, recent SSBs and projections.

Patterns observed in MCMC traces for B_0 and the ratio of B_{2011}/B_0 suggest the model MCMCs are inadequate for estimating probabilities and other derived parameters required for management. Consequently all results shown below for this model are MPD results.

The model stock movement estimates (Table 15) suggest that most fish stay in their home area, the exception being the Bay of Plenty where 27% move to the Hauraki Gulf.

Table 15: **Model stock movement estimates from and to east Northland (ENLD), Hauraki Gulf (HAGU) and the Bay of Plenty (BOP)] The table describes the movement away from the home area.**

		to	
from	ENLD	HAGU	BOP
ENLD	0.94	0.04	0.02
HAGU	0.07	0.89	0.04
BOP	0.03	0.27	0.70

Model biomass and stock status trajectories (Figure 4) for stocks and areas are reasonably similar for East Northland and Hauraki Gulf, less so for the Bay of Plenty due to the higher level of interchange. In the context of this model, management advice can be given in two ways: 1) by stock (where the fish spawn); 2) by area (where the fish are caught and observed) (Table 16).

Table 16: **MPD B_0 (000t) estimates by stock and area**

	ENLD	HAGU	BOP
stock	69	255	145
area	85	270	114
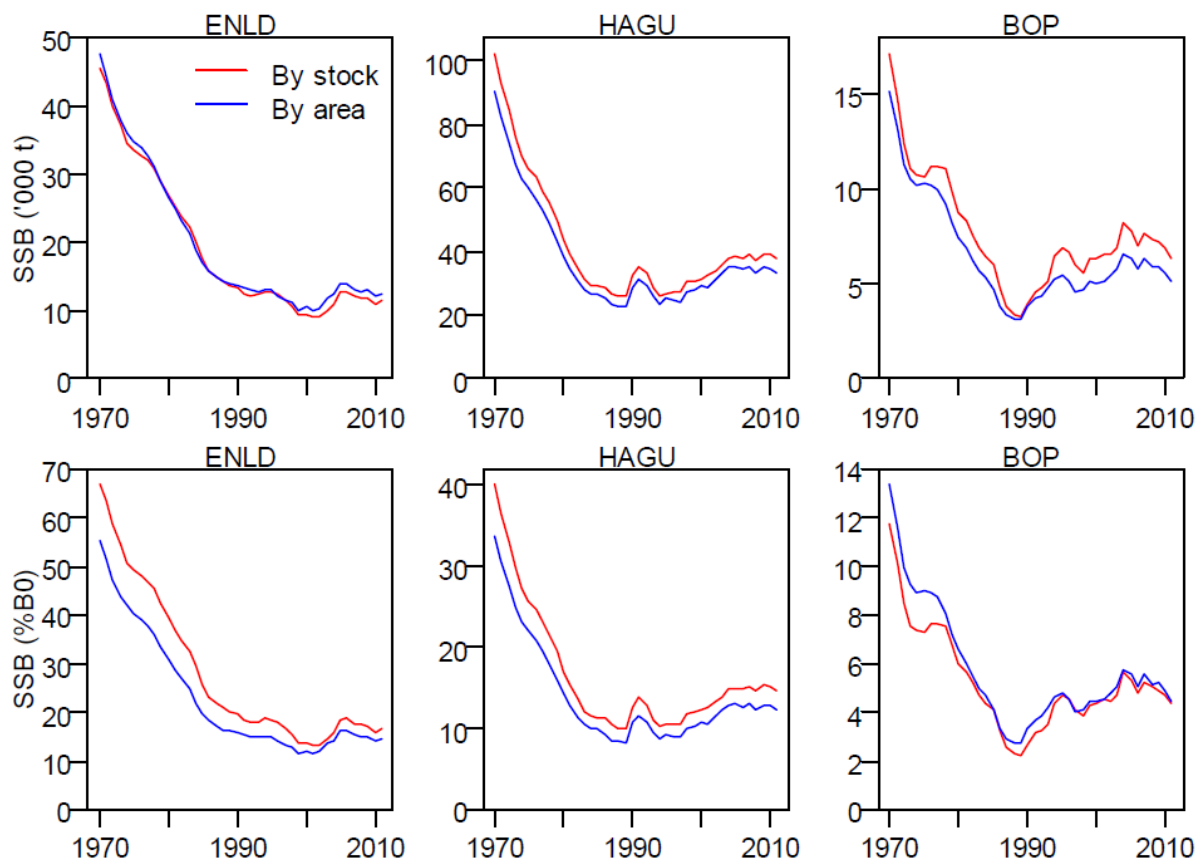
Figure 5: **MPD base model SSB and status trajectories by stock and area.**

Figure 5 shows the east Northland, Hauraki Gulf, and Bay of Plenty 2011 SSBs are all below 20% B_0. In the Bay of Plenty, 2011 SSB was estimated to be below 10% B_0. The reason for the model's poor prognosis for the Bay of Plenty stock is that the area has been subjected to high fishing pressure

(Figure 5). However, stock status is influenced by the rate of exchange between the BoP and HG. There is uncertainty in this estimate because there are only 45 tag recoveries available.
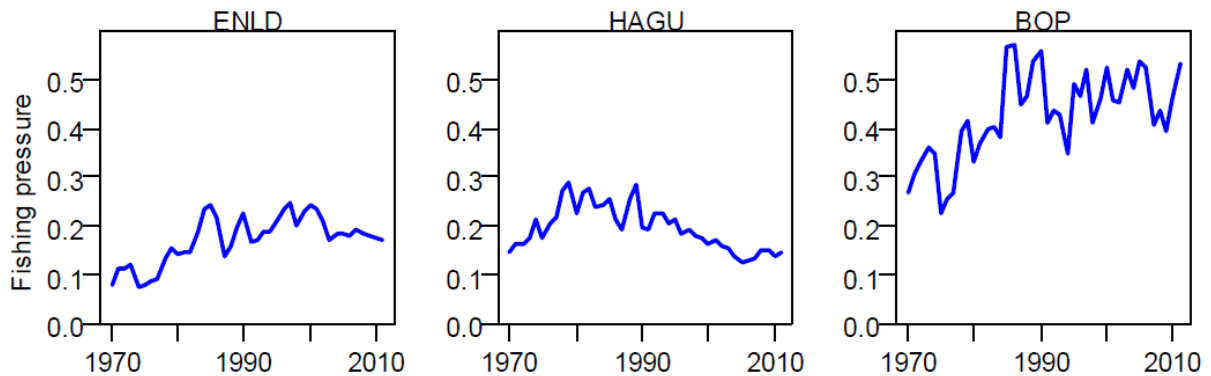
Figure 6: Estimated MPD exploitation rates (aggregated across all fishing methods) by year and area.

The model SSB trajectories for all three stocks after 2007 are either decreasing or flat (Figure 5). Model five year projections from the MPD predict decreasing SSBs in all three stocks (Figure 7). The 5-year projections suggest that current catches will not rebuild populations in EN and HG, and are likely to reduce abundance in the BoP. This result is consistent with trends in standardised CPUE, which although increasing in EN and HG had flattened off in recent years.
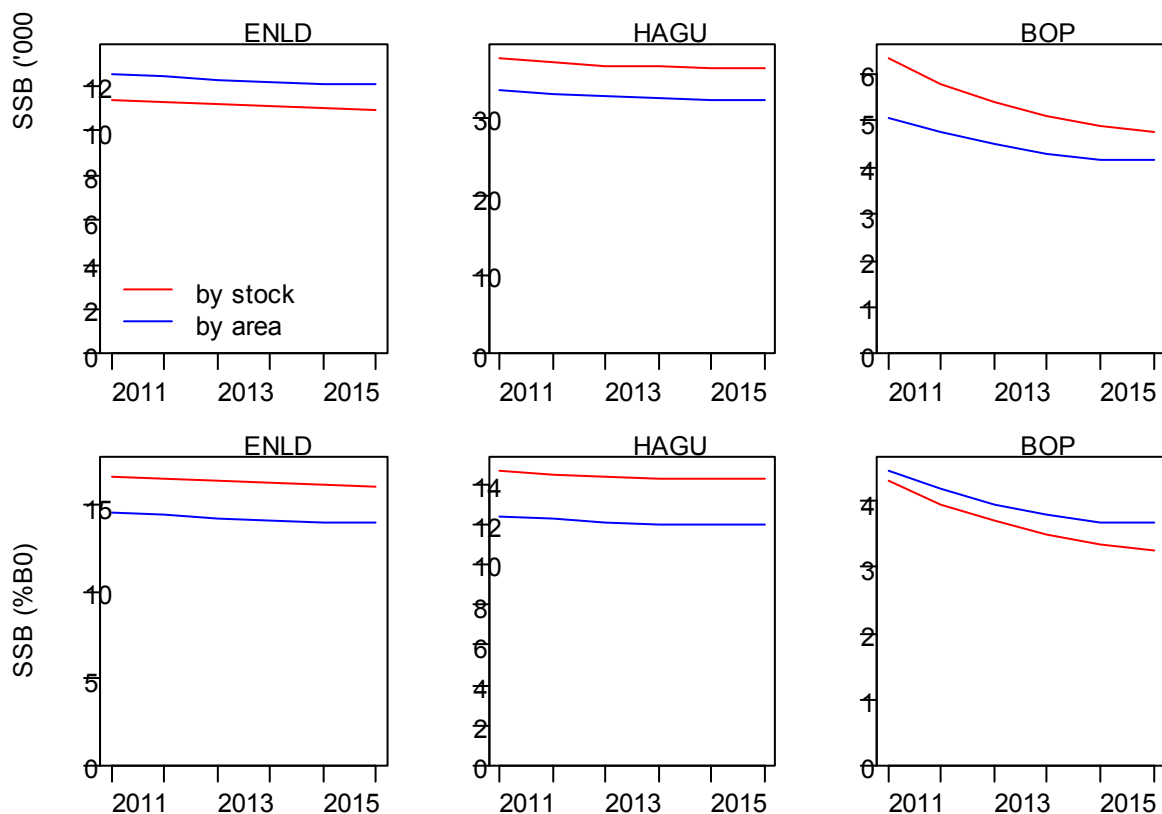
Figure 7: Projected spawning-stock biomass (SSB) from MPD projections

Deterministic B$_{MSY}$

Deterministic B_{MSY} was 26-27% B_0 for all stocks and areas. There are several reasons why B_{MSY}, as calculated in this way, is not a suitable target for management of the SNA 1 fishery. First, it assumes a harvest strategy that is unrealistic in that it involves perfect knowledge including perfect catch and

biological information and perfect stock assessments (because current biomass must be known exactly in order to calculate the Stock $B_{MSY}s$ corresponding with exploitation rates that achieve maximum yield from the fishery are shown target catch), a constant-exploitation management strategy with annual changes in TACC (which are unlikely to happen in New Zealand and not desirable for most stakeholders), and perfect management implementation of the TACC and catch splits with no under- or overruns. Second, it assumes perfect knowledge of the stock-recruit relationship, which is actually very poorly known (Francis 2009). Fourth, it would be very difficult with such a low biomass target to avoid the biomass occasionally falling below 20% B_0, the default soft limit according to the Harvest Strategy Standard. Thus, the actual target probably needs to be considerably above this theoretical optimum; but the extent to which it needs to be above has not been determined.

Model sensitivity runs

The higher recreational catch sensitivity produced implausible fits to the observed data. Increased recreational catch also resulted in a lower biomass in HG, and prevented the model from fitting the observed 1983 biomass estimate in the BoP. The increased recreational catch sensitivity run was therefore inconsistent with observations and rejected by the Working Group.

Stock area SSB trajectories from all model sensitivity runs show very little difference in predicted biomass over the recent model history (mid-1980s to 2011) (Figure 8). This result implies the recent (mid-1980s to 2011) area biomass estimates are reasonably well determined by the model. Changing natural mortality and steepness had most effect on the area B_0 estimates (Table 17; Figure 8). Higher m and h values lowered B_0 lower m and h values raised B_0. The range in m and h explored had similar magnitude effects on B_0 (Table 17; Figure 8).

Table 17: Area and (stock) base and sensitivity model B_0 and 2011 stock status estimates

Model name	East Northland B_0	East Northland B_{2011}/B_0	Hauraki Gulf B_0	Hauraki Gulf B_{2011}/B_0	Bay of Plenty B_0	Bay of Plenty B_{2011}/B_0
Base	85 (68)	0.15 (0.17)	270 (256)	0.12 (0.14)	114 (146)	0.04 (0.05)
M low [0.065]	103 (80)	0.12 (0.15)	334 (307)	0.1 (0.11)	162 (213)	0.03 (0.03)
M Hi [0.085]	74 (59)	0.17 (0.2)	226 (218)	0.15 (0.16)	82 (103)	0.06 (0.07)
h Low [0.80]	97 (73)	0.13 (0.16)	331 (287)	0.1 (0.12)	206 (274)	0.03 (0.03)
H Hi [0.90]	79 (63)	0.16 (0.18)	235 (232)	0.14 (0.15)	81 (100)	0.06 (0.07)
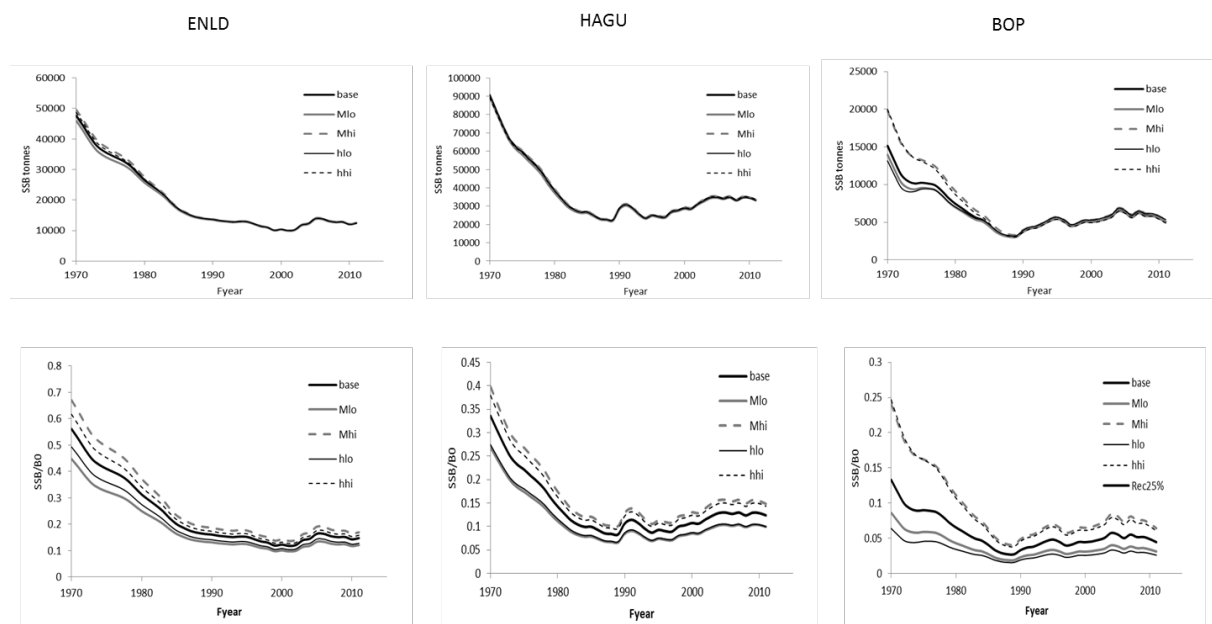
Figure 8: Area MPD SSBs and SSB/B_0 ratios for base and sensitivity model runs.

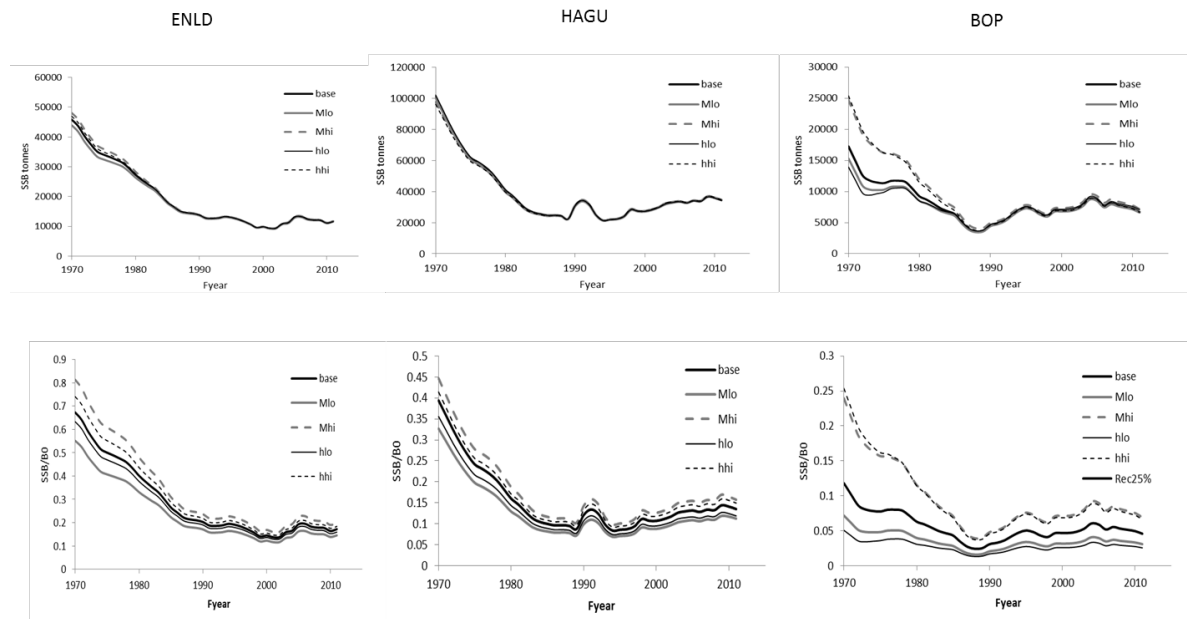ENLD   HAGU   BOP

Figure 9: Stock MPD SSBs and SSB/B_0 ratios for base and sensitivity model runs.

5.1.5 Updated CPUE indices 1989-90 - 2010-11

A CPUE index was developed based on data from bottom longline fisheries operating in the East Northland, Hauraki Gulf and Bay of Plenty sub-stocks within SNA1. While this analysis used methods similar to the CPUE analysis described above, with each data series covering the 1989-90 to the 2010-11 fishing years, it differed in several aspects:

a)   the analysis was based on prorating the landings for each trip back to the estimated catches recorded in each effort record;

b)   the analysis used log(catch) from each effort record as the dependent variable rather than the log(catch/hook) as in the previous analysis. Number hooks and number sets were offered to the model as explanatory variables approximated by a third-order polynomial, thus allowing for a non-linear relationship between catch and the effort variables;

c)   there was a change in the way data were reported commencing 1 October 2007. Previously, effort data were reported on an effective daily basis while the new forms reported effort on an "event" basis. The analysis therefore required combining daily catch information from the earlier daily CELR data series with event based information from the LTCER form series after 2006-07 fishing year. Combining the data required aggregating the more detailed LTCER data at the daily catch level. The validity of doing this was explored by looking for discontinuities in the annual median number of hooks reported by the core vessels over the form change interval. It was concluded combining the two data series in a single analysis was appropriate.

The NINSWG accepted these indices as indices of abundance.

Since 1989 the East Northland index has fluctuated without trend, with no overall change (Figure 10a). The Hauraki Gulf and Bay of Plenty indices have shown a steady increase since 1989, with > 50% improvement since 1989 (Figure 10 b & c).

5.1.6 Longline catch-at-age 1984-85 - 2009-10

Catch-at-age sampling since 1985 in East Northland shows a greater accumulation of fish older than 20 years than observed in the Hauraki Gulf or Bay of Plenty sub-stocks (Figures 5-7). There is some evidence that there has been an increase in the relative proportion of the 20+ age class in all three sub-stocks since the mid-2000s (Figure 11).
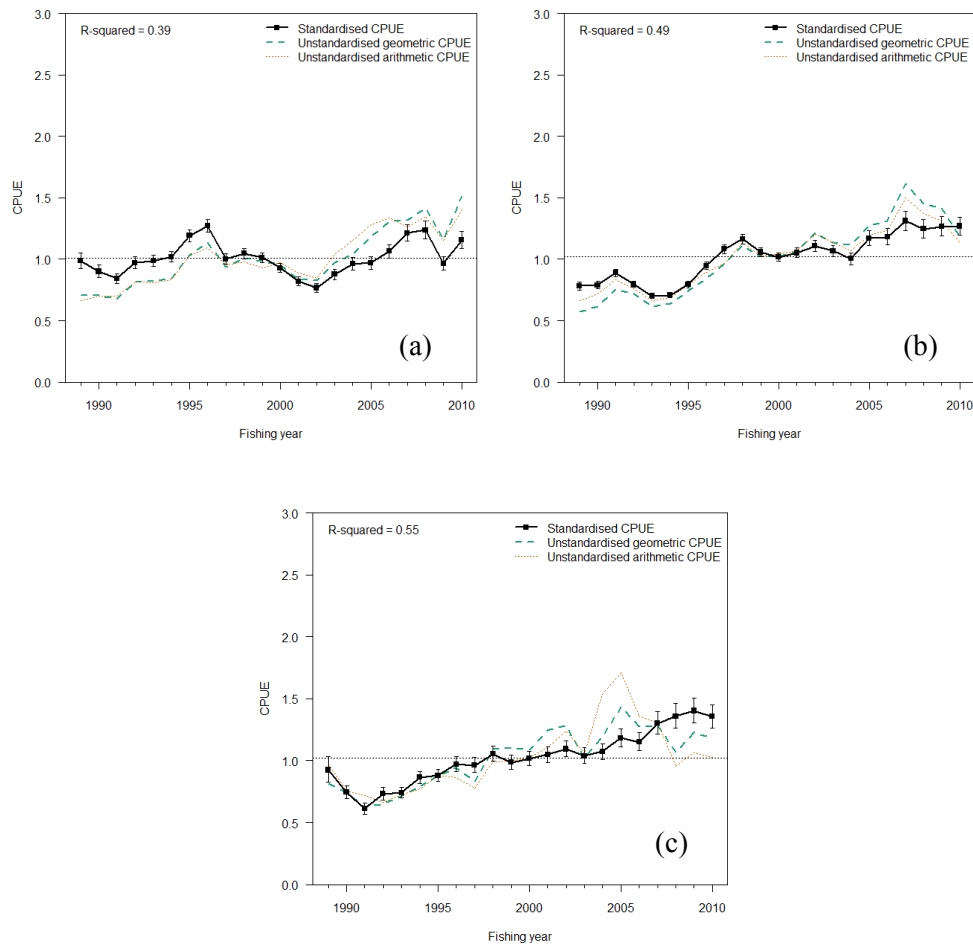
Figure 10: Longline CPUE indices of abundance from 1989-2011 for the three component stocks of SNA 1: (a) East-Northland, (b) Hauraki Gulf, (c) Bay of Plenty.

Despite having proportionally fewer fish older than 20 years than east Northland, the age composition of the Hauraki Gulf longline fishery has fluctuated since 1995-96 with little discernable trend up 2007-08, after which there is some evidence that the Hauraki Gulf age composition has broadened (Figure 12).

The Bay of Plenty long line age composition is similar to SNA 8, with the fishery largely comprised of only 4-6 dominant age classes with few fish older than 20 years present in the catch samples. Like the Hauraki Gulf, there is some evidence that Bay of Plenty age structure may have broadened over the last three years to 2009-10 (Figure 13).

5.2   SNA 2

Previous assessments of SNA 2 were done by Harley & Gilbert (2000) and Gilbert & Phillips (2003). A stock assessment for SNA 2 was done in 2009 (Langley 2010). The model incorporates seven years of catch at age data sampled from the commercial fishery between 1991-92 and 2007-08 and a standardised CPUE index for the bottom trawl fishery for the recent period of the fishery (1989-90 to 2008-09).
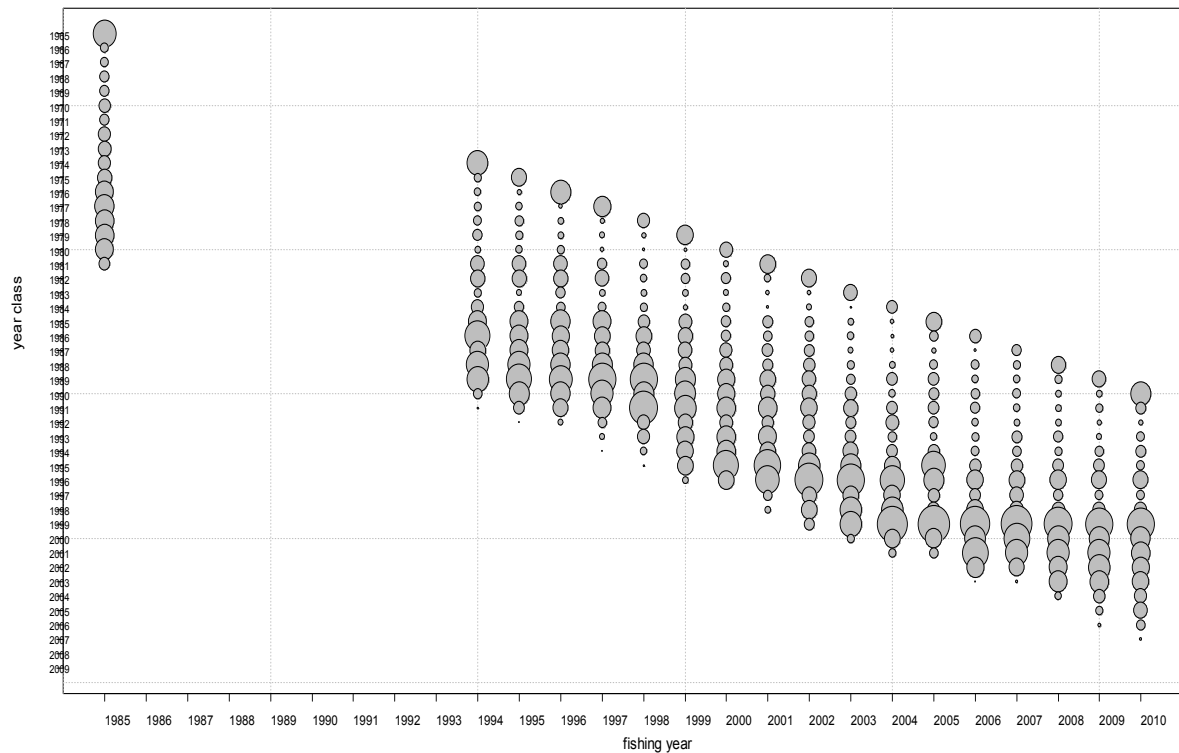
Figure 11: Relative year-class strength observed in the east Northland longline fishery 1984-85 - 2009-10. Year on the X-axis refers to the second part of the fishing year. The oldest year class is a 20+ group.
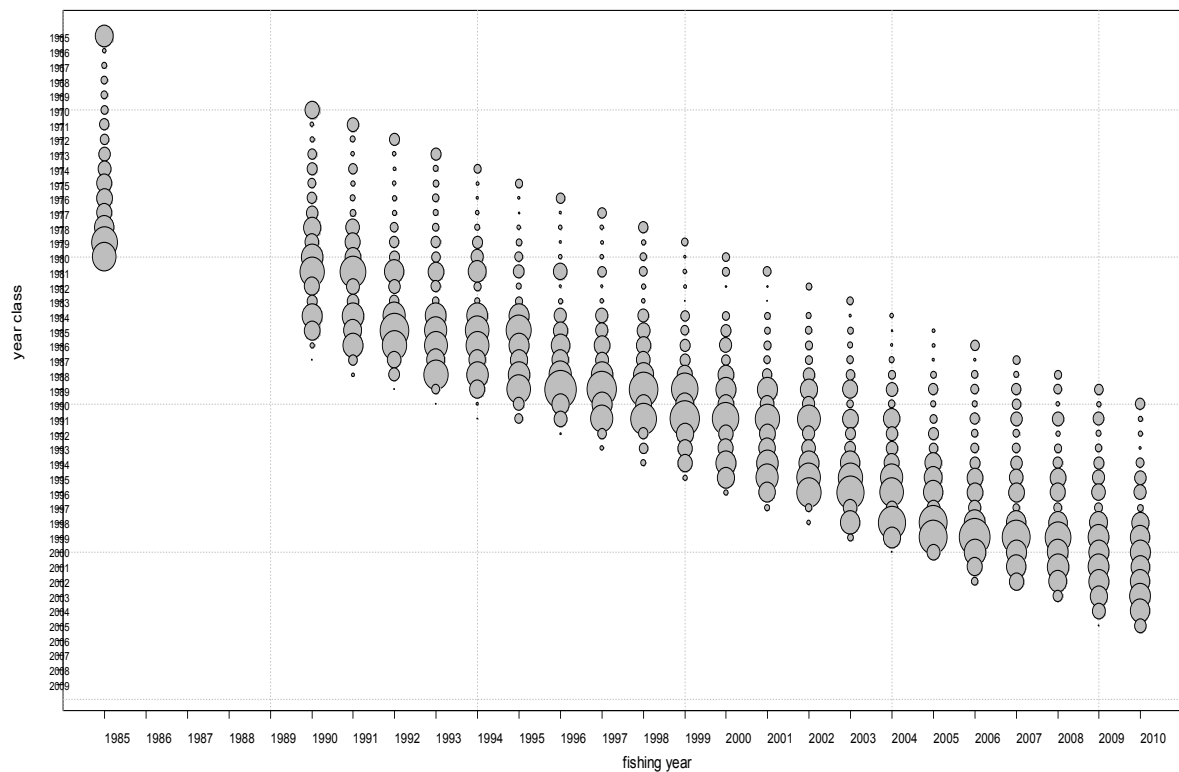
Figure 12: Relative year-class strength observed in the Hauraki Gulf longline fishery 1984-85 - 2009-10. Year on the X-axis refers to the second part of the fishing yearThe oldest year class is a 20+ group
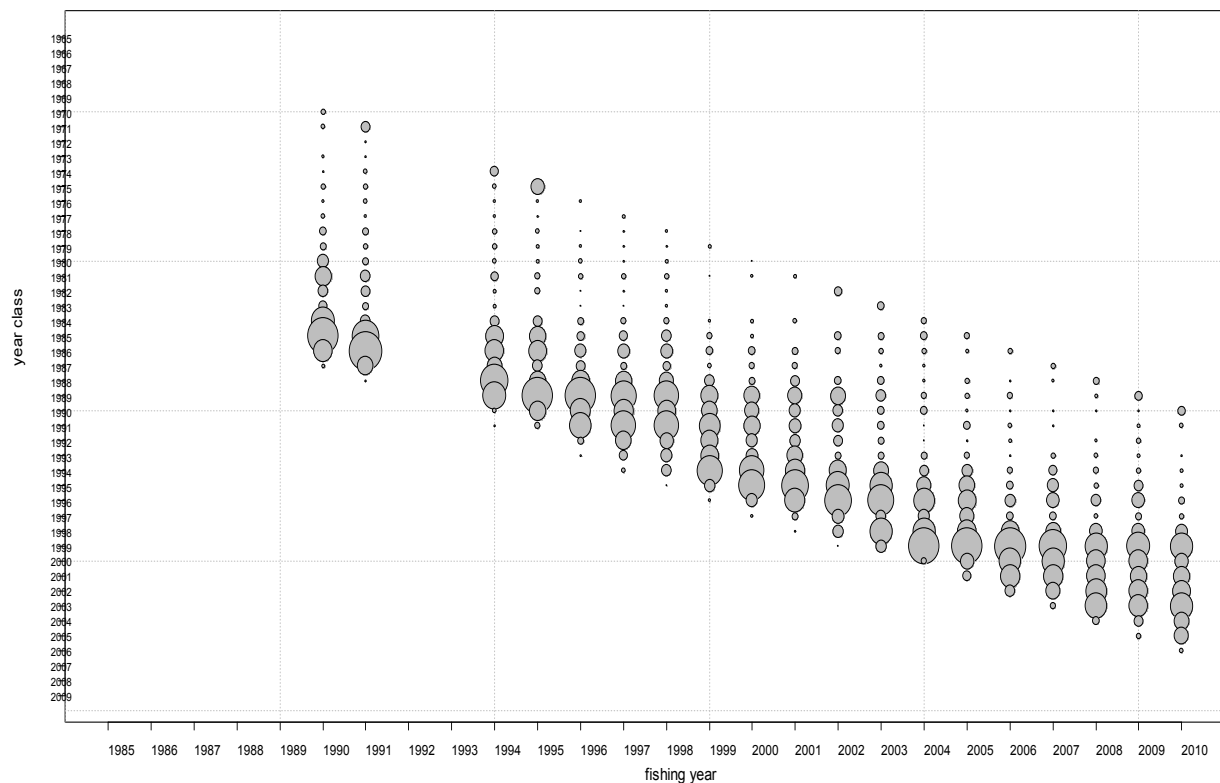
984

Figure 13: Relative year-class strength observed in the Bay of Plenty longline fishery 1990-91 - 2009-10. Year on the X-axis refers to the second part of the fishing year. The oldest year class is a 20+ group.

5.2.1 Model data sets

CPUE indices

A series of standardised indices were derived from the inshore trawl fishery for 1989-90 to 2008-09 (Kendrick & Bentley In press). These indices were accepted by the NINS WG; however, given that the indices are principally derived from a bycatch fishery, there are concerns that the indices are likely to be influenced by changes in regulations affecting the fishery. For example, the decline in the CPUE indices in the two most recent years may be attributable to changes in targeting behaviour caused by a considerable increase in the deemed value for SNA 2. Therefore, the resulting CPUE indices are unlikely to be a reliable index of abundance. In addition, the CPUE indices reveal a very large decline in the early years of the time series. These observations are inconsistent with the observed age frequency data from the fishery and the underlying population dynamic of the species.

Catch at age data

Seven years of age frequency data are available from the commercial fishery. There is considerable variability in the age compositions among years which is likely to be due, in part, to the sampling of the snapper bycatch from a number of different target fisheries. The age compositions are principally comprised of younger age classes and few old fish are sampled from the catch. Consequently, the age frequency distributions are likely to be uninformative regarding the cumulative impact of fishing mortality on the underlying population age structure. There are also concerns regarding the representative nature of the sampling and comparability of the ageing in earlier years.

Commercial catch

The pre-QMS catches are assumed to include a level of unreported catch (equivalent to 20%) of the reported catch. Following the introduction of the QMS, the unreported catch was assumed to be 10% of the reported catch in 1986 and then decline by 1% annually to 1996 and maintained at that level for the remainder of the model period.

Recreational catch

Four estimates of recreational catch are available for the SNA 2 fishery. Estimates were obtained by way of a diary survey in 1992–93 and 1996, and cover the whole of the SNA 2 fishery (Bradford 1998, Teirney *et al.* 1997). The more recent recreational catch estimates (for 2000 and 2001) were substantially higher and were considered to be less reliable and consequently were not used.

Recreational catches from 1933-2008 were assumed using a step function that increased catches from 0 in 1933 by 5 t every 10 years with an annual catch of 45 t in the last decade. The assumed catch history was consistent with the lower estimates of recreational catch obtained in the 1990s.

Customary non-commercial catch

No estimates are available on the levels of customary non-commercial catch. It has been assumed that the recreational catch estimates include a portion of the catch representing the customary take.

5.2.2   Model structure

A statistical, age-structured population model was implemented using the Stock Synthesis (Methot 2009). The model encompasses the 1933-2009 period. The model structure includes two sexes, 1-19 year age classes, and an accumulating age class for older fish (20+ years). The age structure of the population at the start of the model is assumed to be in an unexploited, equilibrium state.

The total annual catch is attributed to a single fishery and the CPUE indices represent an index of the vulnerable component of the population. There is considerable variability in the age frequency data among years and, consequently, these data were assigned a relatively low weight in the total objective function (sample size of 50).

Preliminary model runs revealed that the model was highly sensitive to the assumptions regarding fishery selectivity. Two initial scenarios were considered: full selectivity of the older age classes (logistic selectivity) or estimation of the age selectivity of the older age classes (double normal). The double normal selectivity resulted in a very low selectivity for the older age classes and a very optimistic current stock status, although this was largely attributable to the model estimating a large, cryptic component of the population.

It was considered that there was insufficient information content in the age frequency data to estimate the selectivity of the older age classes due to confounding with fishing mortality. On that basis, it was decided to adopt an externally derived selectivity function. The selectivity of the Bay of Plenty SNA 1 single bottom trawl fishery (Gilbert *et al.* 2000), modified to account for the more rapid growth of younger snapper in SNA 2, was applied to define the selectivity of the older age classes. The selectivity of the younger (1-5 year) age classes was based on the age-specific estimates of selectivity obtained from the double normal selectivity model.

It is important to note that the model results, particularly current stock status, are highly dependent on the selectivity function applied and, consequently, should be considered very uncertain. The model results were also highly sensitive to the relative weighting assigned the CPUE indices and the age frequency data. For this reason, the estimates of current stock status from the model are not reported. Nonetheless, other model stock indicators (particularly estimates of *MSY*) were less sensitive to the selectivity assumption and the model is likely to be more informative regarding estimates of yield.

Model assumptions:
- Natural mortality $M = 0.075$ y^{-1} or 0.06 y^{-1},
- Deterministic recruitment for 1933-1984 and 2003-09 assuming no stock recruitment relationship. Recruitment deviates estimated for 1985-2002 assuming a standard deviation of the natural logarithm of recruitment (σ_R) equal 0.6,
- Fishery selectivity was temporally invariant and fixed based on an externally derived selectivity function.
- SNA 2 specific growth parameters (Table 18).

Two model runs are presented based on the alternative values assumed for natural mortality.

Model uncertainty was estimated using a Markov chain Monte Carlo (MCMC) approach. However, the model is highly constrained by the assumptions that the key parameters (selectivity, M, and growth) are known without error and, therefore, the level of uncertainty is greatly under-estimated. The resulting estimate of virgin, equilibrium recruitment (R_0) is largely dependent on the historical catch history.

Current stock status is unknown and therefore stock projections are not considered informative.

5.2.3   Results

The model fit to both the age composition data and the CPUE indices is poor. There is a clear conflict between the two data sources as evidenced by the fit to the most recent years' data; the model fits the recent decline in the CPUE indices only by estimating lower year class strengths than evident in the commercial age frequency observations. Conversely, the model is unable to fit to the strong decline in the CPUE indices in the early 1990s given the observed age compositions.

The biomass trajectory derived from the model displays a strong decline in biomass during the 1960s and 1970s concomitant with the higher levels of catch during the period (Figure 14). The estimated biomass trajectory is highly constrained throughout this period and during the preceding years due to structural assumptions of the model, principally the fixed selectivity, deterministic recruitment and fixed biological parameters. The model is essentially estimating a R_0 that is consistent with these assumptions and thereby yields a minimum level of virgin biomass necessary to support the historical catches under the assumptions of deterministic recruitment.

Table 18: The median and 5 and 95 percentiles of the marginal posterior distributions for SNA 2 model runs assuming different values for natural mortality (Steepness = 1). B_0 is the virgin biomass (mature female); B_{MSY} is biomass at MSY; MSY is maximum sustainable yield and includes under-reporting and non-commercial catch. The current stock status is very uncertain and, consequently, not reported (see text for details).

Run	B_0	B_{MSY}	MSY	B_{MSY}/B_0
M 0.075	8,669	1,650	496	0.190
	(8,583-8,816)	(1,634-1,678)	(491-505)	(0.190-0.190)
M 0.06	9,228	1,798	443	0.195
	(9,166-9,314)	(1,786-1,815)	(440-447)	(0.195-0.195)

The fishing mortality rates derived from the model in the more recent period are determined, in part, by the observed age composition and the assumed selectivity function. Consequently, the assumed selectivity function has considerable influence on the estimates of current stock status. Further, given the conflict between the data sources, the relative weighting of the CPUE and age frequency data is also highly influential. On that basis, estimates of current stock status are not considered reliable and it is not possible to make conclusions regarding current stock status from the assessment models. Nonetheless, for the range of model options investigated, the estimates of MSY are comparable. This is attributable to the similar estimates of R_0 (and therefore B_0) among the various model options. Again, the estimates of virgin biomass are consistent with the minimum biomass levels necessary to support the catch history during the period prior to the mid 1980s.

5.2.4   Yield Estimates

Maximum Sustainable Yield (MSY)

The two models yielded median values of MSY of 496 t and 443 t for the higher ($M = 0.075$) and lower ($M = 0.06$) natural mortality scenarios, respectively. The MSY estimates are highly constrained due to the structural assumptions of the model and the confidence intervals do not represent the high uncertainty associated with the yield estimates. These yield estimates are likely to be conservative as they are based on estimates of R_0 that approach the minimum level of (deterministic) recruitment

necessary to support the historical catches from the stock. Conversely, the models will over-estimate yields to the extent that the historical catches have been over-estimated i.e. the allowance for 20% over-catch of the reported catch.
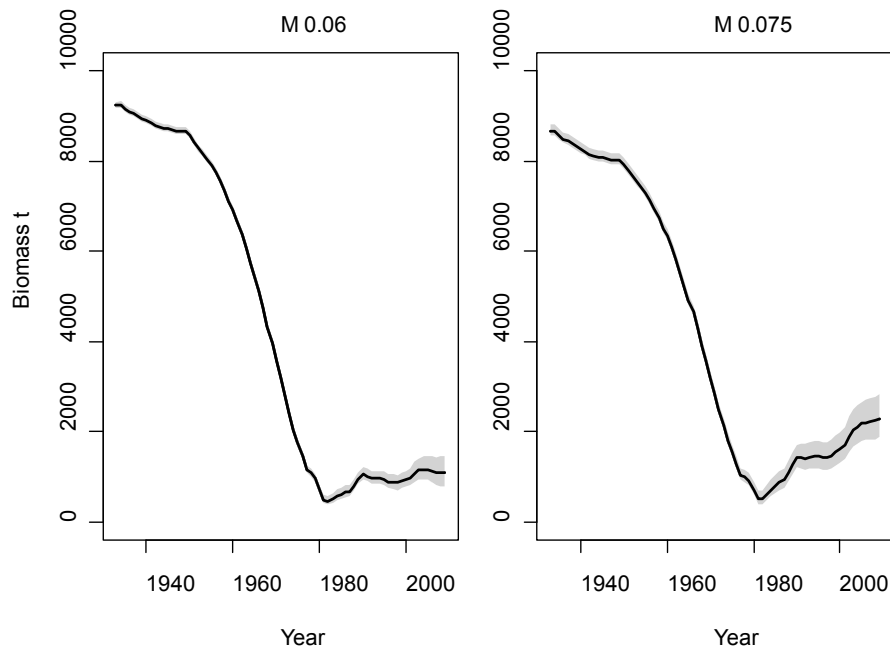

Figure 14: **Biomass (median and 90 percentiles of the posterior distribution) for SNA 2 with the alternative assumptions of lower (0.06) and higher (0.075) natural mortality. Biomass is defined as mature, female biomass.**

5.3 SNA 7 (Challenger)

5.3.1 Stock Assessment
A stock assessment of SNA 7 was undertaken in 2002 (Gilbert & Phillips 2002) (see 2008 Plenary for details). This assessment was externally reviewed in 2006. Based on that review, the Snapper Working Group concluded (25 September 2006) that the model was depicting the 2001 SNA 7 biomass at an unrealistically high level (100-200% B_{MSY}) and rejected the results of the assessment. This was largely a result of the model using long-term historical catch (since 1930s) to estimate initial biomass. The historical catch data indicated that the initial biomass was large and that the associated productivity would be expected to be high under average recruitment. Based on the 1986-88 tag estimate of absolute biomass and low catches, the stock was assumed to have collapsed, and the TACC was reduced. Current catch levels are below the expected level of productivity predicted by the model, which suggests that the stock should be rebuilding. This prediction has not been corroborated by catches or other information external to the model.

The Working Group concluded that an assessment should not be repeated for SNA 7 until a reliable index of abundance is available.

5.3.2 Index of Abundance
A characterisation of the SNA 7 fishery identified three fisheries operating in Tasman Bay/Golden Bay that could potentially provide indices of abundance (Hartill & Sutton 2011). These were the trawl fisheries targeting SNA, FLA, and BAR. Although standardised indices derived from all three fisheries showed a high degree of interannual variability, the general long-term trend was broadly the same,. The characterisation suggested that all three fisheries could potentially interact with different components of the wider stock, both spatially and temporally. The Southern Inshore Working Group suggested that catch data from all three fisheries should be combined into a single model that explicitly considered the manner in which these fisheries might interact with the components of the Tasman Bay/Golden Bay snapper stock. The resulting combined fishery CPUE index was considered

to be the most plausible index of abundance available for SNA 7 (Figure 15). The level of inter-annual variability seen in this combined fishery index, while lower than in the three individual fishery indices, remained large, with between year swings that are larger than would be expected from abundance changes in such a long-lived species. CPUE generally declined to 2001, after which it has fluctuated without trend.
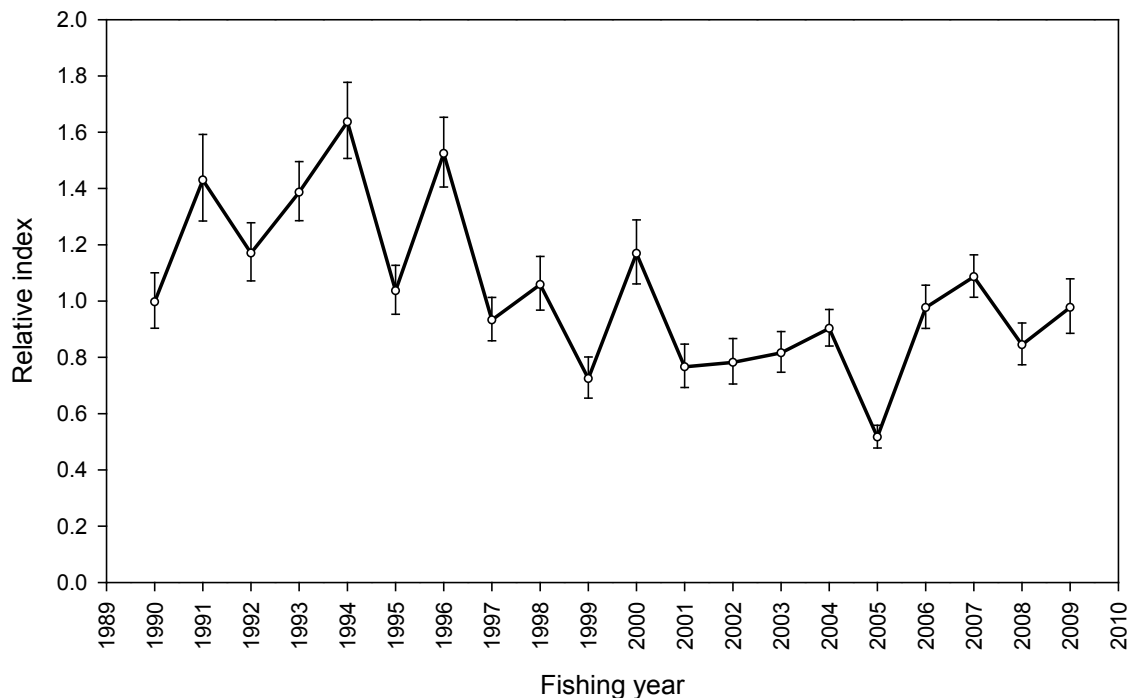

Figure 15: A Standardised snapper CPUE index derived from catch effort data provided by trawlers operating in Tasman Bay/Golden Bay (Statistical Reporting Areas 037 & 038). This index was based on data provided by a core set of trawlers for days where either SNA, FLA, and/or BAR were targeted (Hartill & Sutton 2011).

5.4   SNA 8 (Auckland West/Central West)

A revised assessment of SNA 8 was completed in 2005 including updated observations on:
- method-specific catch weights to 2003-04;
- catch-at-age for commercial pair and single trawl in 2003-04; and,
- single trawl CPUE time series from 1996-2004 incorporating tow duration as the unit of effort from core vessels in the fleet.

New information added to the 2005 assessment included:
- single trawl catch-at-age 1974 to 1976;
- pair trawl catch-at-age with recalculated observations for 1974 to 1976; 1978 to 1980;
- mean size-at-age 1975, 1976 and 1979;
- pair trawl catch-at-sea length frequency in 1986; and,
- boat ramp samples of recreational length frequency in 1991, 1994, 1996 and 2000.

Using this new information assisted the estimation of selectivities-at-length for the single trawl, pair trawl and recreational fishing methods, and natural mortality. A revised time series of observed and assumed mean size-at-age was input to the model for the period 1931-04.

Estimates of fishery parameters and abundance

The assessment model was written using CASAL (Bull *et al*. 2004). It was age-based but included approximations for length-based selectivities. It models the SNA 8 exploitation history by maximising the likelihood fit to a time series of observations. Bayesian estimates for the fitted parameters were the means of the estimated marginal posterior distributions; priors were specified for key model parameters such as R_0 (mean recruitment), q (catchability coefficient), selectivity at length, natural mortality and year class strengths. For particular types of observations the model incorporates process

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error as defined by Bull *et al*. (2004). Stochastic projections of the model to 2025 were undertaken to assess the probability of population increase and the decline in annual harvest proportions under alternative future catch levels.

Model assumptions:
- an equilibrium unexploited population in 1931, calculated using constant annual recruitment, was assumed to represent virgin stock biomass,
- the level of under-reporting for domestic commercial catch was 20% before 1987 and 10% after 1987,
- Japanese longline catch in the period 1965-74 was assumed to be 2000 t per year,
- YCS was estimated for the 1971-00 year classes (30 parameters),
- 1971-2000 represented mean recruitment, i.e., average year class strength (YCS) = 1.0,
- the catch at age fit assumed a multinomial distribution,
- CPUE, trawl survey YCS indices, and tag-recapture biomass and population proportions at length were fitted assuming log-normal distributions,
- 1990 and 2002 tag-recapture estimates were fitted as absolute biomass and proportions-at-length assuming log-normal distributions,
- the CVs assumed for the 1990 and 2002 absolute biomass estimates were 0.3 and 0.2 respectively,
- selectivity-at-length was estimated for the single trawl, pair trawl and recreational methods as independent parameters; time-variant recreational selectivities were specified to take account of changed minimum legal size (MLS) from 25 cm to 27 cm in October 1994;
- selectivity-at-length for the longline method was assumed to be constant at a value of 1.0.

Catch at age

Catch at age information from the Ministry of Fisheries stock monitoring programme was available for the following methods and years:
- pair trawl 1974-76, 1978-80, 1986-87, 1989-90, 2000-04,
- single trawl 1974-76, 1991-04.

For the period 1974 to 1980, estimates were calculated as the mean catch-at-age weighted by the catches taken in each season sampled in that year.

Year class strength (YCS)

The age structured model was constructed to estimate constant annual recruitment (number of 1-year-old fish entering the stock) from 1928 to 1970. Year class strength information came from catch at age data and trawl survey indices (Table 19). Separate catchability coefficients were estimated for the 2+ and 3+ indices to account for differences in vulnerability. The annual YCS's were estimated as indices relative to the average recruitment for 1971-2000.

Table 19: SNA 8 trawl survey indices of relative year class strength with the ages at which individual year classes were sampled.

Survey year	Year class	Index	CV	Age surveyed
1987	1984	0.82	0.27	3+
	1985	2.73	0.28	2+
1989	1986	0.78	0.10	3+
	1987	0.67	0.20	2+
1991	1988	0.18	0.37	3+
	1989	0.96	0.32	2+
1994	1991	1.27	0.15	3+
	1992	0.79	0.26	2+
1996	1993	0.93	0.31	3+
	1994	0.89	0.20	2+
1999	1996	1.90	0.13	3+
	1997	0.29	0.19	2+

Recreational catch

Recreational catch estimates range between 236 and 1133 t (Table 5). The uncertainty in these estimates discussed above, means that their utility is mainly limited to identifying a plausible range. The Working Group agreed to use two alternative recreational catch scenarios that were deemed to represent the upper and lower bounds of average recreational catch. For the lower catch scenario an annual recreational catch of 300 t was assumed between 1990 and 2004. For the higher catch scenario the 1990 to 2004 value was 600 t. For both scenarios the 1931 catch was assumed to be 20% of the 1990 catch and the intermediate year catches were determined by linear interpolation. These two recreational catch scenarios were used in the alternative stock assessments presented below. No additional catch is assumed for customary catch above either recreational level.

CPUE analyses

A time series of annual pair trawl CPUE indices (catch per day) for 1974-91 for SNA 8 was derived by Vignaux (1993). The recent time series of single and pair trawl catch and effort data cover the period 1989-90 through 2003-04. There was a shift to more detailed reporting forms in 1994-95. To use the data prior to this year, a coarser unit of effort must be defined over the whole time series that limits the resolution of a descriptive effort variable. In past analyses the unit used was catch per tow (Davies *et al*. 1999). Davies *et al*. found that there were significant differences between pair and single trawl CPUE after 1989-90. The Snapper Working Group rejected the pair trawl index after 1990-91 on the grounds that it possibly contained duplicated effort data.

For the 2004 assessment a time series of single trawl CPUE indices was calculated using the recent detailed catch-effort data reported since 1994-95. The effort term was catch per nautical mile derived from "tow speed" and "tow duration". Covariates in the general linear model included: a length/breadth/depth (LBD) parameter representing vessel-power; month; stat-area; and target. Zero catches were included in the GLM by the addition of 1 kg to all recorded catch estimates. The index derived from the GLM fit is given in Figure 5.

This series was updated to 2003-04 for the 2005 assessment and a GLM standardisation was undertaken using the same parameters as in 2004. The data showed a decreasing trend in the proportion of zero catches which the WG felt was important to include in the standardised model. Various methods were attempted to include this information, such as adding a constant to the zero catches or using a combined model where the zero catches were modelled separately based on a binomial distribution and then combining the binomial model with the lognormal model (positive catch data) using a delta method. The former approach resulted in unacceptable model diagnostics and the delta method showed that the effect of adding the trend in proportion zero catch was relatively minor compared to the trend obtained from the positive catch data. Consequently the WG recommended not including the zero catch data in the GLM fits but that this issue could be explored more fully in future assessments.

The WG also requested that the LBD parameter previously used to describe vessel fishing power be replaced by an individual categorical "vessel" variable and that the analysis be restricted to vessels which had been active in the fishery for at least three years. This data selection resulted in the construction of two datasets describing the catch and effort data for the top 20 and the top 12 catching vessels.

The updated single trawl GLM index showed a shallow decreasing trend from 1995-96 to 2000-01 followed by a general increase to 2003-04 (Figure 16). The Working group considered these indices were more appropriate than the analysis used to generate the 2004 series, given that the 2005 analysis was based on data from core vessels only and that the model diagnostics were acceptable. There was virtually no difference between the year indices based on the data from the top 20 or the top 12 vessels and the WG adopted the series based on the top 12 vessels to include in the SNA 8 assessment model.
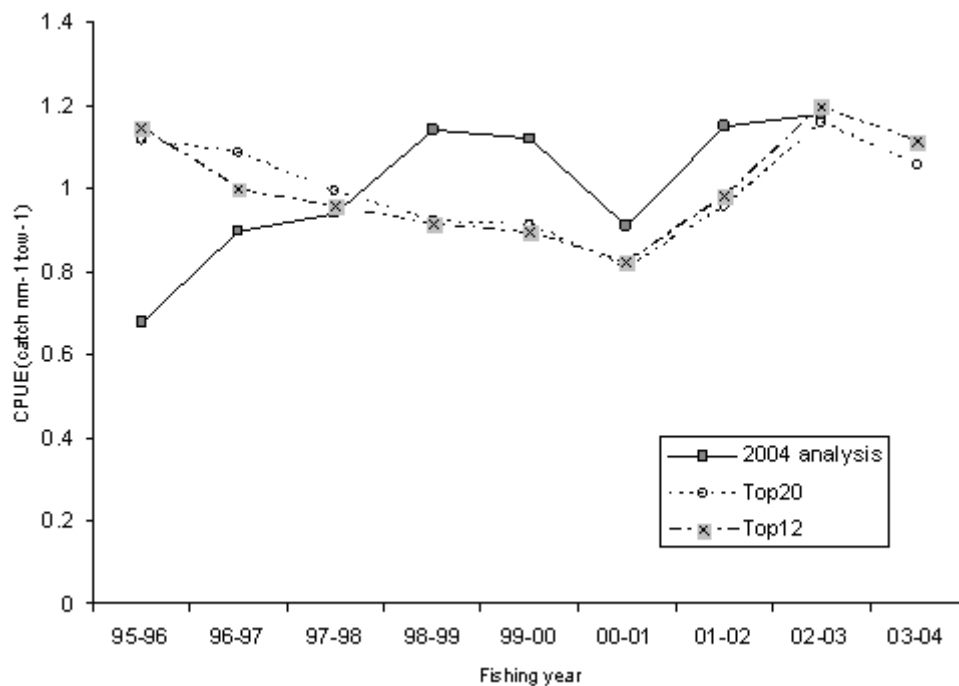
Figure 16: Single trawl CPUE indices of catch per n. mile used in the 2004 and 2005 assessments.

2002 Tagging program biomass

A tag-recapture programme was carried out in 2002 and 2003 to estimate recruited population size in SNA 8. In February 2002, 22854 fish were tagged with internal passive integrated transponder tags. Fish 20 cm and larger were tagged from 335 trawl tows distributed from Ninety Mile Beach to South Taranaki, out to a depth of 75 m. SNA 8 was divided into five inshore strata (less than 75 m) and five adjacent offshore strata. Fish were not tagged from the offshore strata because of the likely high mortality rate of snapper that are caught in deeper water. It was assumed that fish would mix between inshore and offshore strata. Some fish under 25 cm were tagged to allow the estimation of the growth rate of recruiting fish. Commercial landings were scanned for tags between October 2002 and July 2003. The fishing location of each landing or part-landing was recorded. The primary data were therefore the release location and size of each fish tagged; the location, date, weight and a length frequency sample of each part-landing that was scanned; and a unique identifier (tag number) and length for each recaptured fish.

Ancillary data were required to allow the estimation of initial (immediate post-tagging) mortality, scanner failure rates and the difference between the growth rates of tagged and untagged fish. Length frequency samples taken during the release phase were also used to improve the precision of the estimates of numbers at length. Evidence obtained from double-tagged fish showed that tag deterioration and tag loss did not occur over the duration of the experiment.

Estimation

Maximum likelihood was used to estimate the recruited population size as a vector of numbers at length in each of the ten strata in February 2002. A model was developed to calculate the binomial likelihood of a tagged fish being either recaptured or not recaptured in each scanned landing. Likelihoods for initial survival, movement, growth of fish and scanner failure were included. Binomial likelihoods were also calculated for the numbers of survivals from three initial mortality experiments (in 1992, 1994 and 2002) where tagged fish were retained in a holding net for two weeks. The probability of a tagged fish being detected by each scanner was calculated from a series of tag seeding trials. A normal likelihood involving the growth of untagged fish was calculated from sample proportions by age and length from commercial landings and research trawl survey samples. Multinomial likelihoods were also obtained for length frequency samples taken during the release and the recapture phases.

A total of 103 parameters were estimated. These were: 16 numbers at length parameters for each inshore/offshore pair of strata; a North/South movement parameter; two growth parameters for tagged fish and two for untagged fish; a phase parameter for growth seasonality; a parameter for growth variability; five scanner success rate parameters; three initial survival rate parameters; four release phase selectivity parameters and four recapture phase (commercial fishery) selectivity parameters.

The population in each stratum between 15 and 80 cm was obtained by interpolating between adjacent pairs of the 16 numbers at length parameters. The numbers of fish between 15 and 24 cm was estimated to account for the recruitment of fish below 25 cm into the population in the period from February 2002 (tag release) to October 2002 to July 2003 (recapture period).

Because fish were not tagged from the offshore strata there was a confounding of inshore/offshore movement and the offshore population size. The populations in the offshore strata were therefore assumed to have the same proportions at length as the adjacent inshore strata and two non-estimated parameters were also required: inshore/offshore movement and the proportion of fish whose home stratum was offshore.

Each fish had a hypothetical home stratum. The probability that a fish would, at any time, be in another stratum was a constant function of how far that stratum was from the home stratum, dependent on the two movement parameters. Thus the model did not allow net movement over time. Inshore and offshore movement was equally likely and northerly and southerly movement was equally likely. The probability of movement more than one stratum north or south declined as a power function of the movement parameter. Impermeable boundaries were assumed at the north of the Ninety Mile Beach stratum and at the south of South Taranaki.

Results

The estimated biomass in each stratum is given in Table 20. A substantial fraction of the total biomass (37%) comes from fish above 55 cm in length. The CV of the recruited population biomass estimate was 0.12. The estimated numbers per centimetre length class have CVs that fall from 0.24 at 25 cm to a minimum of 0.06 in the mid-30's and then rise to exceed 0.30 at 66 cm, based on the estimated Hessian matrix. Estimates in adjacent length classes are highly correlated with correlation coefficients exceeding 0.85 above 31 cm. CASAL does not at present contain any multivariate likelihood function with covariances. To simply ignore these high correlations would give these data excessive weighting.

Table 20: Estimated population biomass.

Stratum name	Biomass (t)	
	< 75 m	≥ 75 m
Ninety Mile Beach	685	104
Kaipara	887	135
Manukau	3 465	526
North Taranaki	2 131	324
South Taranaki	1 897	288
Total		10 442
CV of total		0.12

The estimate of biomass from the 1990 tagging programme in SNA 8 was recalculated. After correcting for sources of bias, the revised estimate was 9505 t; a CV of 0.18 was assumed. The programme also provided estimates of the recruited population length composition. The CVs assumed for these (0.11 to 0.48) were double those derived from the 2002 programme.

After consideration of the low CVs estimated from the 2 tagging programmes the WG agreed to fit the absolute biomass estimates and proportions at length for the 1990 and 2002 tagging data in both alternative runs, but to increase the CVs of the absolute biomass estimate to 0.3 for the 1990 programme and to 0.2 for the 2002 value.

Mean weight-at-age estimates

Comparison of mean weight at age data from the age samples over time indicated that, on average, fish at the same age were heavier in the 1990s than in the 1970s. It is not known what has caused this

change in mean weight-at-age, but it is possible that it results from density-dependence or from changes in the mean temperature. This shift in mean weight at age has important implications for the calculation of the B_0 and B_{MSY} reference points because they will differ, depending on which set of mean weight at age are used.

The WG agreed to calculate all biomass levels prior to 1980 using the mean weight at age derived from the 1975-79 catch-at-age samples. Biomass levels after 1989 used the post-1989 mean weight-at-age estimates. Biomass levels in the period from 1980 to 1988 used a mean weight at age values calculated from the mean of the two sets of available estimates. This means in the model that B_0, based on the 1931 initial equilibrium biomass, has been calculated using the mean weight-at-age levels appropriate to the 1970s.

Revised selectivity estimates from tagging

Length-based selectivity curves for single and pair trawl were obtained from the tagging estimator model, primarily from the recapture phase length frequencies. Both had steeply declining right hand limbs with 50% selectivity at 49.2 and 54.1 cm respectively. Although these estimates were consistent with the lower recapture rates of larger fish, previous estimates and other data in the population model suggested shallower declines, especially for pair trawl. In the population model runs single and pair trawl length-based selectivities were estimated as independent parameters, with the tagging selectivity estimates defining the means of informed priors. Alternative recreational length-based selectivities before and after 1994 were estimated to take account of the effect of a change in the minimum legal size (MLS) from 25 cm to 27 cm in October 1994. Knife-edge left hand limbs and the join parameters corresponding to the MLS values were assumed, with the right hand limbs of the selectivity functions being estimated.

Assumed error and priors

The level of observational and process error (*see* Bull *et al.* 2004) assumed for fitting to the observational data is given in Table 22. Process error was added to CPUE, trawl survey recruitment indices (TSI), and boat ramp length frequency data. The level of process error for CPUE was set such that the total CV was approximately 0.2 to 0.3. Process error for TSI and boat ramp length frequency data was added to reduce the relative weight of these observations in the overall model fit (Table 21). The list of priors assumed for model parameters is given in Table 20. The uniform prior for YCS was deliberately chosen to overcome a problem with the YCS parameterisation for calculating Bayesian estimates using the MCMC algorithm; the impact of this on the assessment has not been determined.

The natural weighting for the observations fitted in the model is that which produces a standard deviation for the standardised residuals that is close to 1.0. This was not the weighting used in the SNA 8 model. A lower weighting was assigned to the catch-at-age data and pair trawl length frequency data (low effective sample sizes) to maintain the relative weight of the tagging programme estimates in the overall model fit.

Table 21: Observation error assumed for data input to the SNA 8 model (effective sample size = N, coefficient of variation =CV), and process error assumed.

Observation type	Observation error	Process error	Error type
Catch at age pair trawl post-1986	N = 13 to 63	0	Multinomial
Catch at age single trawl post-1991	N = 13 to 72	0	Multinomial
Catch at age pair trawl 1974-80	N = 8 to 86	0	Multinomial
Catch at age single trawl 1974-76	N = 7 to 35	0	Multinomial
CPUE pair trawl 1974-1991	CV range = 0.07 - 0.67	0.2	Log-normal
CPUE single trawl 1996-2004	CV range = 0.023 - 0.047	0.2	Log-normal
Tag biomass 1990	CV = 0.3	0	Log-normal
Observation type	Observation error	Process error	Error type
Tag biomass 2002	CV = 0.2	0	Log-normal
Tag population proportions at length 1990	CV range = 0.11 - 1.28	0	Log-normal
Tag population proportions at length 2002	CV range = 0.06 - 0.76	0	Log-normal
Trawl survey 2+ year class strength index	CV range = 0.19 - 0.32	0.2	Log-normal
Trawl survey 3+ year class strength index	CV range = 0.10 - 0.37	0.4	Log-normal
Boat ramp recreational catch length frequency	*N* = 100	N = 60	Multinomial
Pair trawl catch-at-sea length frequency 1986	*N* = 10	0	Multinomial

Table 22: Assumed model priors.

Parameter	Prior	Specification
Mean recruitment, R_0	Uniform-log	Range = $(10^4, 10^8)$
Year class strengths (1971-00)	Uniform	Range = $(0.01, 20.0)$
Catchability coefficients (CPUE and trawl survey indices), q_1, q_2, q_3, q_4	Uniform-log	Range = $(10^{-9}, 3.0)$
Selectivity (all double-normal) - single and pair trawl	Normal	Means = tag 2002 estimates (6 parameters) CVs range = 0.11 - 0.63
Selectivity (all double-normal) - recreational	Normal	Means = 12 cm above Ljoin (2 parameters) CV = 0.5
Natural mortality, M*	Log-normal	Mean = 0.075, CV = 0.5

* M was fixed in the MCMC for both runs at the value estimated in the MPD

Alternative model runs

A range of alternative models were explored to test the sensitivity of the model to alternative assumptions concerning the value of natural mortality, assumed catch history and the information obtained from the tagging programmes. The WG finally agreed on two runs that differed only in the level of recreational catch assumed (either 300 t or 600 t from 1990 to 2004). Both runs fit the tag-recapture data from 1990 and 2002 as absolute biomass estimates plus proportions at length.

Results

As the weights at age vary over the time period of the model it is necessary to determine what population parameters should be used in defining the virgin biomass. The 1989-04 length-at-age data give greater weights-at-age than the 1975-79 data. It was inferred that these increased growth rates were a result of density dependence rather than of a positive relationship with mean water temperature. The WG agreed that virgin stock biomass (B_0) should therefore be defined as that resulting from mean recruitment and the 1975-79 mean weights-at-age and is equal to the modelled 1931 biomass.

The model estimates of natural mortality were 0.051 and 0.054, depending on which level of recreational catch was assumed. These estimates are lower than the value (0.075) assumed in previous SNA 8 assessments, based on the catch-at-age data collected in the 1970's, but analysed independent of the assessment model. The model fit to the observations was significantly improved when estimating natural mortality compared to a model fit when assuming a fixed value of 0.075. The effect of lower estimates of natural mortality is to reduce the estimates of mean recruitment and the stock productivity.

The mean of the posterior distributions and 90% credible intervals for B_0 and B_{04} are shown in Table 23 for the alternative runs. A higher B_0 estimate was obtained for the run that assumed higher recreational catch (R600), but stock status was similar. This range for B_0 is not considered to adequately describe the full uncertainty in B_0 for a number of reasons:

- the model may be described as a "total catch history model", so the time series of historical catches strongly determines the estimate of B_0. The alternative recreational catch history resulted in a higher estimate of B_0 but with similar levels of uncertainty. There is further substantial uncertainty in the assumed catch history for Japanese longline catch, commercial catch overruns and the pattern of recreational catches.
- There are a large number of observations to which the model was fitted over the period 1974 to 2004. Amongst these the catch-at-age data in the 1970's has moderate leverage on the estimates of R_0 and M. An evident constraint on the model biomass is that it remains above zero in the mid-1980s while at the same time fits the absolute abundance estimates from the later tagging programmes. Throughout this period, 1986 to 1990, there was strong agreement in the model fit to six of the data types. The model fits to these data serves to constrain the estimates of R_0 and M, and, hence, B_0.
- The model trajectory differed somewhat from the recent CPUE index. However the observed indices were within a narrow range (0.9 to 1.2) and the fit was consistent with the CV's.
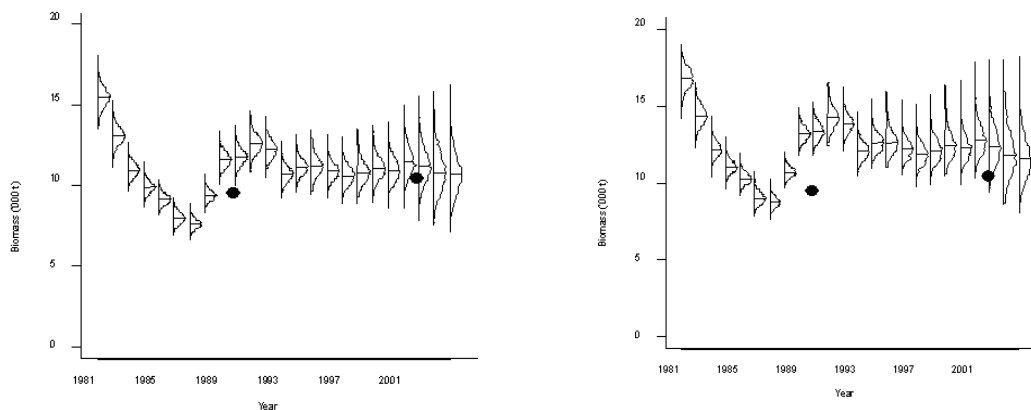
Table 23: Mean of posterior distributions of biomass for the SNA 8 model using recreational catch levels of 300 t (R300) and 600 t (R600). B_0 is virgin stock biomass. B_{04} is the start of year biomass for 2003-04, and B_{04}/B_0 is the ratio of 2003-04 biomass to B_0. The 90% credible intervals were derived from the marginal posterior distributions for the Base case. The biomass units are 1000 t.

Model run	B_0	5%	95%	B_{04}	5%	95%	B_{04}/B_0	5%	95%
R300	110	108	112	10.8	8.5	13.4	9.8%	7.8%	12.1%
R600	117	114	119	11.7	9.2	14.6	10.0%	8.0%	12.5%

The Working Group discussed the use of appropriate reference points for reporting the stock status of SNA8. Because the model uses variable growth curves through the calculation period, B_{MSY} will vary depending on the assumed growth rate and how growth might vary with stock size. For instance, if a constant mean size-at-age equal to that for 1931-2004 was used, $B_{MSY} = 18.3\%\,B_0$. Alternatively, if the 1989-2004 mean size-at-age were used, $B_{MSY} = 17.5\%\,B_0$. Ideally, a functional relationship defining density dependent growth would be used to calculate the SNA 8 B_{MSY} but the functional relationship of size-at-age with density is not defined and was not possible to model in the time available. Based on exploratory modelling of density-dependent growth, the Working Group adopted 20% B_0, where B_0 is the Base case model estimate of biomass in 1931, as the definition for B_{MSY}. Under the mean size-at-age for 1931-2004 the catch to biomass ratio at B_{MSY} was 0.098.

Bayesian posterior estimates for the model parameters were derived from MCMC chains of 3.2 million (R300) and 2.6 million (R600) iterations (Figure 17). It was necessary to hold M constant at the MPD values (0.051 and 0.054) to produce convergence of the MCMC. The MCMC traces for the two main model runs showed no obvious signs of non-convergence.

Figure 17: Posterior distributions of the biomass trajectories for the SNA 8 model estimates assuming historical recreational catch of 300 t (left panel) and 600 t (right panel) with the tagging programme estimates of biomass (solid circles).

Projections

Projections of population biomass have been modelled assuming future commercial catch over the range 500 to 1500 t, with a 10% overrun component. Two options were investigated for future recreational catch in projections: firstly, assuming a constant recreational exploitation rate at the level estimated in the model in 2004 (F_{rec}); and secondly, assuming a constant catch capped at the level assumed for 1990-2004 (R_{cap}). Two alternative levels were assumed for the recreational catch from 1990 to 2004, either 300 t or 600 t. The WG considered these values were likely to bracket the true average level of catch in this period. The impact of the increase in minimum legal size (MLS) in the recreational fishery has been incorporated into the model assumptions. A projection was also investigated that included zero future removals (commercial or non-commercial) from the population in all years. This was to determine the maximum rate of rebuilding possible for the population.

The posteriors of the model parameters were sampled for projections while assuming stochastic recruitments (by randomly resampling with replacement the year class strengths (Figure 18) in each

draw), and constant commercial catches. Constant mean size-at-age using the 1989-2004 mean was assumed. At each catch level, simulations were carried out, projecting forward to 2025. For projections assuming future annual recreational exploitation rates are constant (F_{rec}) the value was estimated from the model MPD value (i.e. the recreational catch to absolute biomass ratio in 2004).
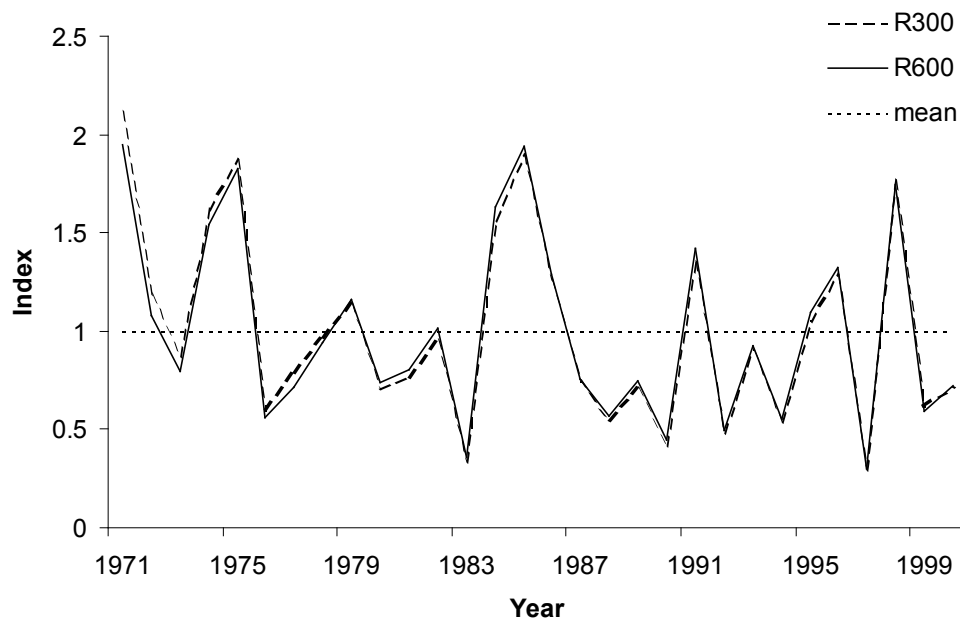

Figure 18: SNA 8 Base case model MPD estimates of the relative strengths of the 1971 to 2000 year classes.

In this case the commercial catch was assumed to be constant at the alternative levels, however, the recreational catch varied as stock size and age structure changed. For projections assuming constant future recreational catch (R_{cap}) this did not occur.

Under all future recreational catch options and at alternative levels of future TACC the stock is predicted to increase on average (Table 24, and Figure 19). The rate of increase was slightly lower for F_{rec} options (constant recreational exploitation rate, Figure 19a and 19c) compared to the R_{cap} projection options (constant recreational catch, Figure 18b and 18d). The rate of rebuilding varied widely depending upon the assumed future TACC.

Under the F_{rec} projection option, recreational take increases as the stock increases but is mediated by the domed recreational selectivity curve. The high proportion of young fish in the population after a period of rapid rebuild gives recreational fishers higher catches for the same effort. Under the slower rebuild the young fish make up a relatively smaller fraction of the population leading to relatively smaller recreational catch.

In summary the SNA 8 stock is predicted to increase under any future TACC level and alternative recreational catch assumptions. However, with a TACC of 1500 t the rate of rebuild is very slow.

Estimation of Maximum Constant Yield (*MCY*)
Estimates of *MCY* were not calculated.

Estimation of Current Annual Yield (*CAY*)
Estimates of *CAY* were not calculated.

Table 24: SNA 8: Projection estimates for the R300 and R600 model runs under two alternative options for recreational catch: a) constant proportional recreational catch (Frec) equivalent to the proportional recreational harvest in 2005; and b) constant annual recreational catch (Rcap). Estimates are shown for a range of future TACCs and for a projection under zero removals, i.e. TACC = 0 t and zero recreational catch. B_{05} and B_{10} are start of year biomasses for 2004-05, and 2009-10, respectively. P(B_{10}>B_{05}) is the probability of B_{10} exceeding B_{05} and E( ) denotes expected value. The 90% credible interval for B_{10}>B_{05} were derived from the marginal posterior distributions. CR_{2010} is recreational catch in 2010. $E(B_y)$ denotes the year B_{MSY} is expected to be reached.

(a) R300_Rcap

TACC	$E(B_{05})$ (t)	$E(B_{10})$ (t)	Expected	5%	B_{10}/B_{05} 95%	$P(B_{10}>B_{05})$	$E(CR_{2010})$	Year when $E(By) = B_{MSY}$
500	10 891	18 538	1.7	1.29	2.13	1	300	2011
1 000	10 882	15 266	1.39	0.99	1.81	0.94	300	2014
1 250	10 869	13 709	1.25	0.83	1.67	0.84	299	2018
1 375	10 866	12 876	1.17	0.74	1.59	0.74	297	2021
1 500	10 904	12 206	1.1	0.71	1.51	0.64	296	>2025

(b) R300_Frec

TACC	$E(B_{05})$ (t)	$E(B_{10})$ (t)	Expected	5%	B_{10}/B_{05} 95%	$P(B_{10}>B_{05})$	$E(CR_{2010})$	Year when $E(By) = B_{MSY}$
0	10 929	23 614	2.18	1.77	2.68	1	-	2010
500	10 929	17 747	1.63	1.3	2.01	0.96	561	2012
1 000	10 901	14 746	1.35	1.02	1.71	0.96	472	2016
1 250	10 913	13 288	1.21	0.84	1.57	0.83	426	2022
1 375	10 929	12 556	1.14	0.79	1.48	0.75	401	>2025

(c) R600_Rcap

TACC	$E(B_{05})$ (t)	$E(B_{10})$ (t)	Expected	5%	B_{10}/B_{05} 95%	$P(B_{10}>B_{05})$	$E(CR_{2010})$	Year when $E(By) = B_{MSY}$
500	11 693	18 429	1.57	1.17	2.01	0.99	600	2012
1 000	11 713	15 353	1.3	0.87	1.74	0.88	599	2016
1 250	11 683	13 781	1.17	0.76	1.58	0.73	596	2020
1 375	11 676	13 087	1.1	0.7	1.53	0.64	591	>2025
1 500	11 695	12 337	1.04	0.67	1.46	0.53	583	>2025

(d) R600_Frec

TACC	$E(B_{05})$ (t)	$E(B_{10})$ (t)	Expected	5%	B_{10}/B_{05} 95%	$P(B_{10}>B_{05})$	$E(CR_{2010})$	Year when $E(By) = B_{MSY}$
0	11 730	25 592	2.2	1.77	2.7	1	-	2010
500	11 676	17 346	1.49	1.19	1.84	1	1 013	2014
1 000	11 729	14 596	1.24	0.93	1.57	0.9	856	2021
1 250	11 710	13 106	1.11	0.8	1.43	0.71	767	>2025
1 375	11 702	12 419	1.05	0.75	1.39	0.59	726	>2025
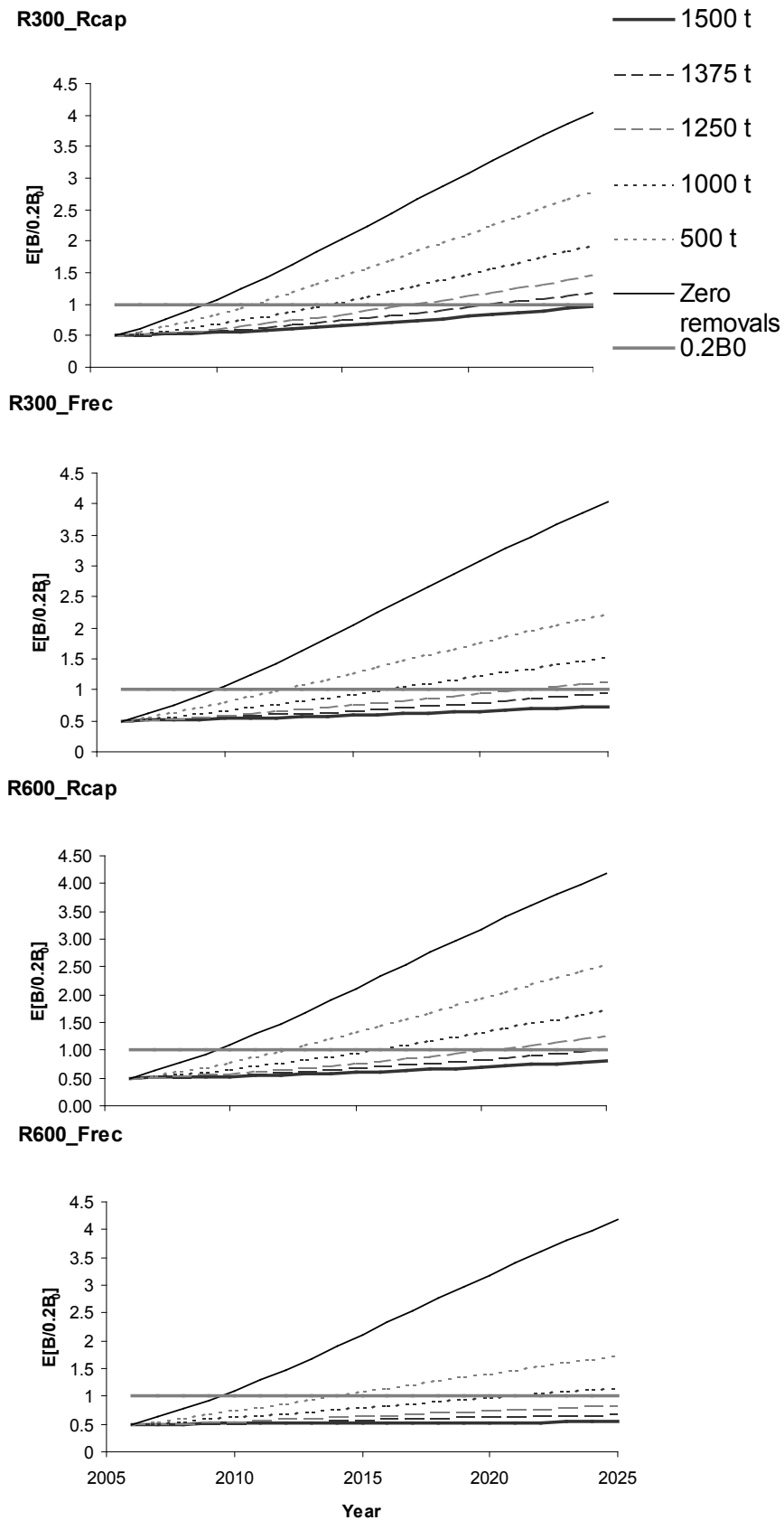
Figure 19: Mean of expected biomass relative to 20% of virgin biomass (B_0) forecast to 2025 for the R300 and R600 models under two alternative options for recreational catch: Frec, constant annual exploitation rate at the MPD level estimated in 2004; and, Rcap, constant annual catch of 300 or 600 t respectively. For each model option a range of future TACC levels were investigated (500 to 1500 t), and compared to an option for zero removals from the population.

Other factors that may modify assessment results

The WG considered that there were a number of other factors that should be considered in relation to the stock assessment results presented here for SNA 8. The current assessment produces very precise results, which are the product of the available data and various model assumptions. However, many of the model assumptions may be violated to some extent. Some of the more important considerations are:

- the tagging estimates may be biased;
- the MPD residuals are not consistent with the statistical assumptions of the model and give extra weight to the tagging estimates;
- natural mortality is not known exactly (as was assumed in the MCMCs);
- the catch history is uncertain with regard to Japanese longline catch and commercial catch overruns in addition to recreational catch.

A full exploration of these factors has not been performed. Additional sensitivity runs taking account of these factors would produce a greater range of uncertainty than is present in the current assessment.
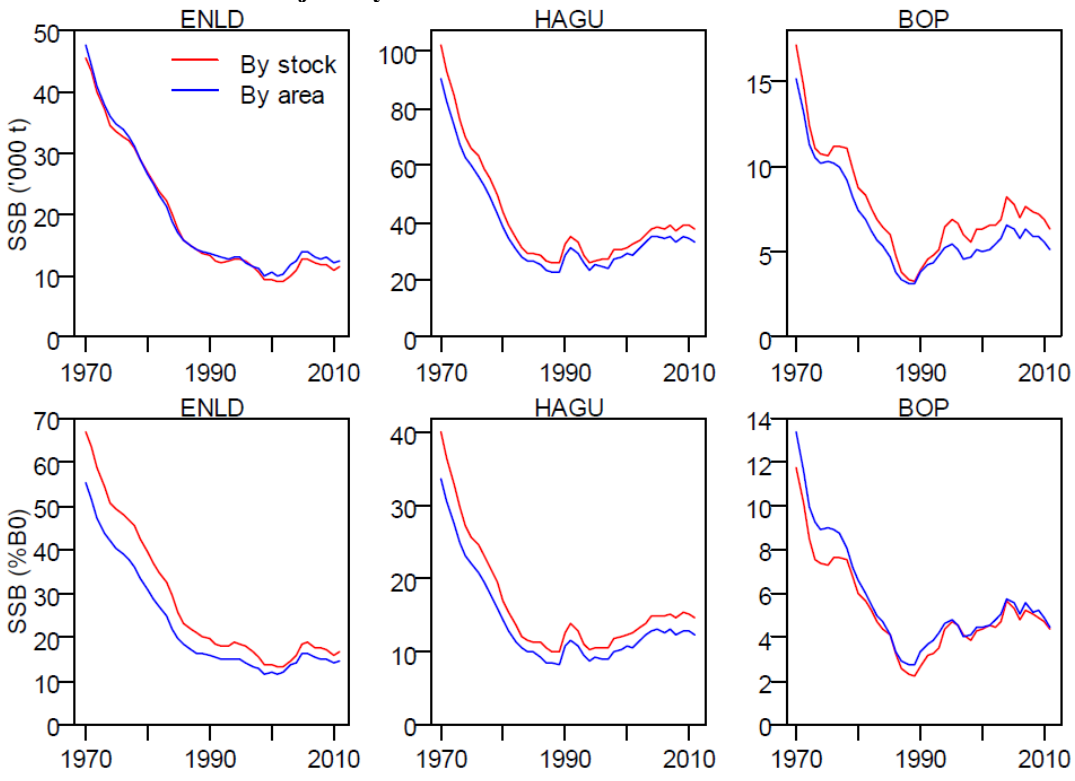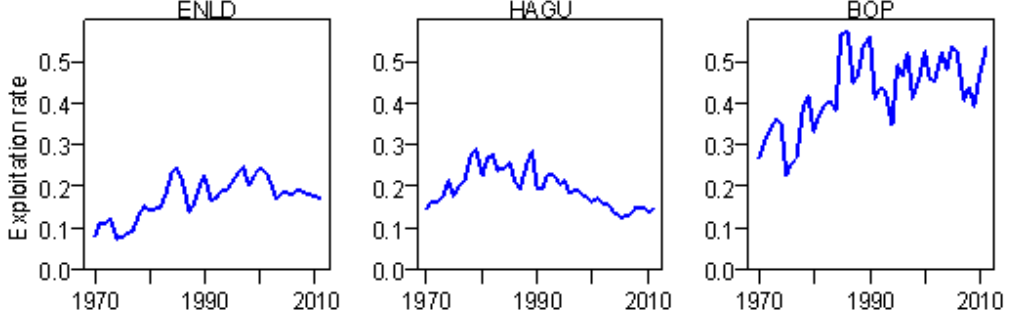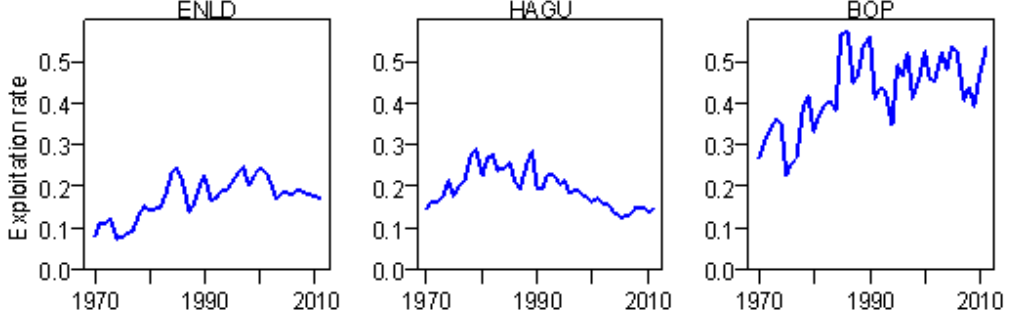
6.   STATUS OF THE STOCKS

Stock Structure Assumptions

New Zealand snapper are thought to comprise either seven or eight biological stocks based on: the location of spawning and nursery grounds; differences in growth rates, age structure and recruitment strength; and the results of tagging studies. These stocks comprise three in SNA 1 (East Northland, Hauraki Gulf and BoP), two in SNA 2 (one of which may be associated with the BoP stock), two in SNA 7 (Marlborough Sounds and Tasman/Golden Bay) and one in SNA 8. Tagging studies reveal that limited mixing occurs between the three SNA 1 biological stocks, with greatest exchange between BoP and Hauraki Gulf.

SNA 1

Stock Status	
Year of Most Recent Assessment	2012
Assessment Runs Presented	Base case models ($M = 0.075$, $h = 0.85$) for East Northland and the Hauraki Gulf and Bay of Plenty to 2010-11
Reference Points[3]	Interim target: B_{MSY} (40% B_0) Deterministic B_{MSY}: 26-27% B_0 Soft Limit: 20% B_0 (HSS default) Hard Limit: 10% B_0 (HSS default)
Status in relation to Target	East Northland B_{2011} was Very Unlikely (< 10%) to be at or above 40% B_0 Hauraki Gulf B_{2011} was Very Unlikely (< 10%) to be at or above 40% B_0 Bay of Plenty B_{2011} was Very Unlikely (< 10%) to be at or above 40% B_0
Status in relation to Limits	East Northland B_{2011} was About as Likely as Not (40-60%) to be below 20% B_0 (Soft Limit) B_{2011} was Unlikely (< 40%) to be below 10% B_0 (Hard Limit) Hauraki Gulf B_{2011} was About as Likely as Not (40-60%) to be below 20% B_0 (Soft Limit) B_{2011} was Unlikely (< 40%) to be below 10% B_0 (Hard Limit)

Bay of Plenty
B_{2011} was Likely (> 60%) to be below 20% B_0 (Soft Limit)
B_{2011} was About as Likely as Not (40-60%) to be below 10% B_0 (Hard Limit)

Historical Stock Status Trajectory and Current Status

MPD base model SSB and status trajectories by stock and area.

Fishery and Stock Trends

Recent Trend in Biomass or Proxy	East Northland Stock biomass was estimated to have experienced a long steep decline from 1970 to about 2000, after which it increased to 2005 and has then declined slightly. Hauraki Gulf Stock biomass was estimated to have experienced a long steep decline from 1970 to about 1990, after which it gradually increased to about 2007 and then stabilised. Bay of Plenty Stock biomass was estimated to have experienced a long steep decline from 1970 to about 1990, after which it steadily increased to 2005 and has then declined slightly.
Recent Trend in Fishing Mortality or Proxy	 East Northland The exploitation rate in this area increased steadily from 1970 to 2000 and then

	decreased marginally and stabilised in the early 2000s. _Hauraki Gulf_ The exploitation rate in this area increased steadily from 1970 to 1980 and then decreased to about the 1970 level by the mid-2000s and has remained stable since then. _Bay of Plenty_ The exploitation rate in this area increased sharply from 1970 to the mid-1980s and while it has fluctuated markedly it has remained high.
Other Abundance Indices	None
Trends in Other Relevant Indicators or Variables	None

Projections and Prognosis	
Stock Projections or Prognosis	Model five year projections from the MPD predict decreasing SSBs in all three stocks.
Probability of Current Catch or TACC causing decline below Limits (5 years)	The 5-year projections suggest that current catches will not rebuild populations in EN and HG, and are Likely to reduce abundance in the BoP.

Assessment Methodology and Evaluation		
Assessment Type	Level 1: Quantitative stock assessment.	
Assessment Method	Spatially-disaggregated, 3-stock, age-structured, single-sex model undertaken in CASAL	
Assessment Dates	Latest assessment: 2012	Next assessment: 2013
Overall assessment quality rank	2 - Medium Quality. MCMC did not converge	
Main data inputs (rank)	- Proportions-at-age from the commercial fisheries, and historic trawl surveys.	1 – High Quality
	- Proportions-at-length from the recreational fishery	1 – High Quality
	- Estimates of biological parameters (e.g., growth, age-at-maturity and length/weight).	1 – High Quality
	- Standardised longline CPUE indices	1 – High Quality
	- Standardised single trawl for the BoP	1 – High Quality
	- Estimates of recreational Harvest	1 – High Quality
	- Commercial catch	1 – High Quality
	- Tag-based biomass estimates (BoP - 1983)	2 – Medium or Mixed Quality: data no longer available
	- Data from tagging experiments in 1985 (HG, EN) and 1994 (All areas)	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	- BoP stock area considered as separate from the Hauraki Gulf - Model accounts for movement between three SNA 1 stock areas:	

	East Northland; Hauraki Gulf; Bay of Plenty - 1985 and 1994 SNA 1 tagging data fitted in the model - Model recruitment at age 1; 20 age classes explicitly modelled - Revised estimates of tag loss for the 1985 programme - Tag observational data adjusted for trap avoidance - Stock recruit relationship explicit in model (Beverton & Holt) with a steepness of 0.85 (base model) - Method for relative weighting of abundance and composition data
Major Sources of Uncertainty	Degree of exchange between BoP and HG The stocks size in 1970 relative to B_0 is poorly estimated.

Qualifying Comments
Alternative hypotheses such as stock structure and the full range of parameter estimates have not been fully explored. This is assessment is regarded to be a work in progress and will be improved as the work progresses. A more thoroughly explored assessment is expected in 2013.

Fishery Interactions
Main QMS bycatch species are trevally, red gurnard, John dory and tarakihi.

SNA 2

Stock Status	
Year of Most Recent Assessment	2010
Assessment Runs Presented	Two model runs, both with a steepness fixed at 1, are reported with alternative values of natural mortality and a fixed fishery selectivity function.
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 (HSS default) Hard Limit: 10% B_0 (HSS default)
Status in relation to Target	Unknown
Status in relation to Limits	Soft: Unlikely (< 40%) Hard: Unlikely (< 40%)
Historical Stock Status Trajectory and Current Status Due to the unreliability of the assessment no figure is displayed.	
Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	For the range of model runs investigated, estimates of *MSY* (443-496 t) are higher than the recent catch levels (376 t). By inference, the stock biomass would be expected to have increased slowly over the last decade if recruitment has been maintained at or above long-term average levels.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	The broad range of ages present in the catch suggests that the stock is unlikely to be at very low levels.

Projections and Prognosis	
Stock Projections or Prognosis	Given that the catch is below the range of *MSY* estimates, it is Likely that biomass would increase at current catch levels provided that recruitment is maintained at or above average levels.
Probability of Current Catch or	Soft Limit: Unlikely (< 40%)

| TACC causing decline below Limits | Hard Limit: Unlikely (< 40%) |

Assessment Methodology	
Assessment Type	Level 1- Quantitative Stock Assessment.
Assessment Method	Bayesian statistical catch at age model implemented in Stock Synthesis
Main data inputs	- Proportions at age data from the commercial fishery - Estimates of biological parameters (e.g., M, growth, age-at-maturity and length/weight) - Commercial catch - Standardised single trawl CPUE index of abundance - Estimates of recreational harvest - Estimates of commercial over catch
Period of Assessment	Latest assessment: 2010 — Next assessment: to be determined
Changes to Model Structure and Assumptions	The previous assessment was done in 2002. The 2010 model includes three additional years of catch-at-age data from the commercial fishery and a series of CPUE indices (1989/90-2008/09). The most crucial difference between the two assessments is the assumptions relating to the selectivity of the commercial fishery. The previous assessment assumed logistic selectivity (full selectivity for older age classes) while the current assessment assumed a fixed dome shaped selectivity.
Major Sources of Uncertainty	• There is a high degree of uncertainty regarding the assumed selectivity function for the commercial fishery. Furthermore, selectivity of the commercial fishery is likely to have changed over the history of the fishery. • The CPUE indices are unlikely to represent a reliable index or abundance. • The catch-at-age data do not track year classes well and may not be representative of the catch. • The values of M have been derived from other snapper stock and may not be appropriate for SNA 2. • There is uncertainty regarding the catch history prior to the introduction of the QMS. • There is assumed to be no stock-recruitment relationship.
Qualifying Comments	
There is a high level of uncertainty associated with the assessment, with the result that stock status and projections cannot be reliably determined. However, estimates of *MSY* were robust to the range of assumptions investigated but are dependent on the assumptions regarding historical catch. For the range of model scenarios considered, estimates of *MSY* were higher than the recent and current levels of catch. Despite the limitations of the catch-at-age data, the broad range of ages present in the catch suggests that the stock is unlikely to be at very low levels.	

Fishery Interactions
Snapper is a bycatch of the main inshore fisheries within SNA 2, principally the red gurnard and tarakihi bottom trawl fisheries. The operation of these fisheries is constrained by the SNA 2 TACC.

SNA 7

Stock Status	
Year of Most Recent Assessment	2011

Assessment Runs Presented	A CPUE index that combined the snapper catch and effort from trawl fisheries directed at SNA, FLA and BAR in Tasman and Golden Bays
Reference Points	Target(s): Not established but B_{MSY} assumed Soft Limit: 20% B_0 (HSS default) Hard Limit: 10% B_0 (HSS default)
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unknown

Historical Stock Status Trajectory and Current Status
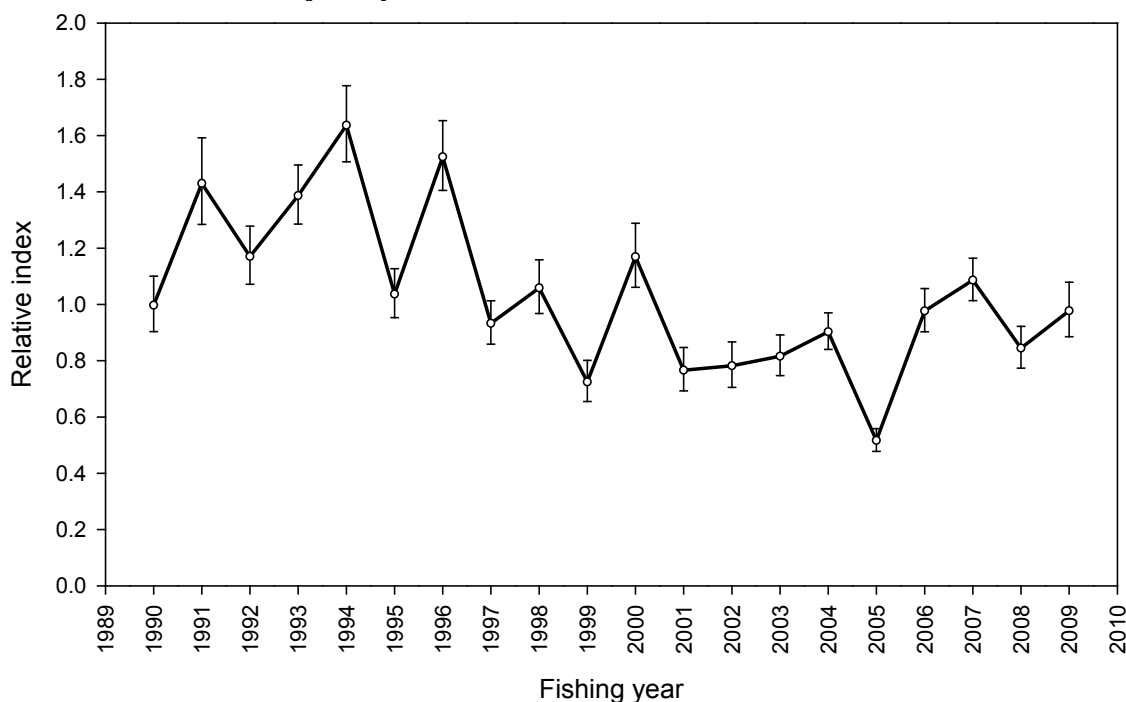
A Standardised snapper CPUE index derived from catch effort data provided by trawlers operating in Tasman Bay/Golden Bay (Statistical Reporting Areas 037 & 038). This index was based on data provided by a core set of trawlers for days where either SNA, FLA, and/or BAR were targeted (Hartill & Sutton 2011).

Fishery and Stock Trends

Recent Trend in Biomass or Proxy	CPUE generally declined to 2001, after which it has fluctuated without trend
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	Unknown
Trends in Other Relevant Indicators or Variables	Catch-at-age data collected in 2003-04 and 2006-07 had a lack of fish over 8 years old, which were relatively common in earlier samples collected between 1997 and 2001. The current level of commercial catch is 25% of the average catch from 1945-1980.

Projections and Prognosis	
Stock Projections or Prognosis	Current catch or TACC is About as Likely as Not (40-60%) to cause the stock to decline
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown
Assessment Methodology	

Assessment Type	Level 2 - Qualitative Evaluation	
Assessment Method	Characterisation and CPUE analysis	
Main data inputs	Trawl catch and effort from SNA, FLA and BAR target sets.	
Period of Assessment	Latest assessment: 2011	Next assessment:2012
Changes to Model Structure and Assumptions		
Major Sources of Uncertainty		

Qualifying Comments
Lack of older age classes implies that the available stock biomass should be strongly affected by recruitment variability.
The voluntary closure of shallow regions in TB/GB on 1 October 1994 probably influenced the spatial distribution of fishing effort and potentially, catch rates and any index should probably start from this date.
There is no evidence of a rebuild as suggested by the 2000-01 stock assessment.

Fishery Interactions
The primary species landed in association with snapper in SNA 7 are flatfish, barracouta, gurnard and trevally. There is spatial conflict between commercial and recreational fisheries in Tasman and Golden Bays. There are seasonal area closures for the commercial fishery.

SNA 8
Stock Structure Assumptions
Tagging, genetic and morphological studies have revealed that snapper off the west coast of the North Island (i.e., SNA 8) comprise a separate biological unit.

Stock Status	
Year of Most Recent Assessment	2005
Assessment Runs Presented	Given the uncertainty in estimates of recreational harvest, two alternate model runs 1) recreational harvest of 300 t and 2) recreational harvest of 600 t.
Reference Points	Target: Not established but B_{MSY} (20% B_0) assumed. Soft Limit: 20% B_0 (HSS default) Hard Limit: 10% B_0 (HSS default)
Status in relation to Target	R300 B_{2004} estimated to be 9.8% B_0, Very Unlikely (< 10%) to be at or above the target. R600 B_{2004} estimated to be 10% B_0, Very Unlikely (< 10%) to be at or above the target.
Status in relation to Limits	Soft Limit: Very Likely (> 90%) to be below (in 2005) Hard Limit: About as Likely as Not (40-60%)

Historical Stock Status Trajectory and Current Status
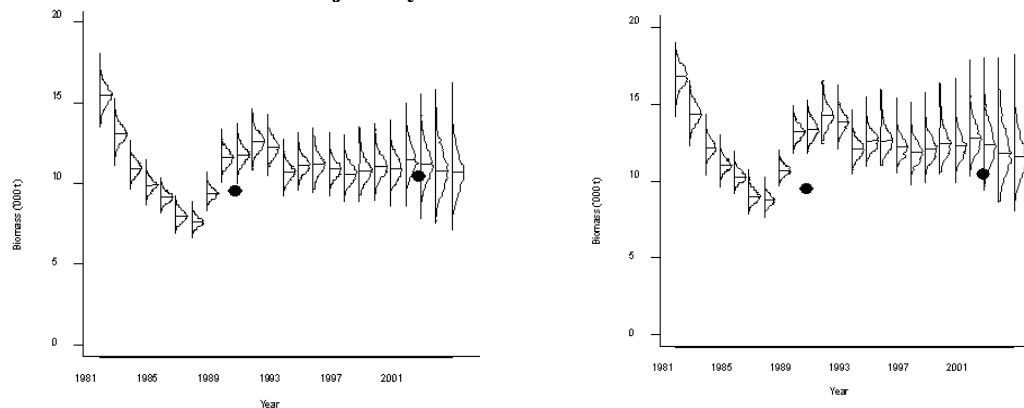
Posterior distributions of the biomass trajectories for the SNA 8 model estimates assuming historical recreational catch of 300 t (left panel) and 600 t (right panel) with the tagging programme estimates of biomass (solid circles).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Unknown
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	Unknown
Trends in Other Relevant Indicators or Variables	Recent catch-at-age sampling shows that the age structure in the fishery has changed little over the last 20 years averaging around 6 years (this is the lowest average of all the snapper stocks). The fishery is held up in most years by only 4-5 dominant age classes with a negligible accumulation of biomass beyond 20 years. Given the current age structure the stock would be very vulnerable to recruitment failure extending more than 2-3 years in duration.

Projections and Prognosis	
Stock Projections or Prognosis	The 2005 stock assessment indicated that current biomass (start of year 2004-05) was between 8% and 12% B_0 and the biomass was predicted to slowly increase at the TACC level of 1500 t. However, from 1 October 2005 the TACC was reduced to 1300 t to ensure a faster rebuild of the stock. At this TACC level the predicted rebuild to B_{MSY} (20% B_0) occurred after 2018 in all cases assuming either constant recreational effort, or capped recreational catch at the alternative levels of 300 t or 600 t per year. Rebuilding tended to be slower for runs that allowed the recreational catch to rise with increasing biomass.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unlikely (< 40%) Hard Limit: Unlikely (< 40%)

Assessment Methodology	
Assessment Type	Level 1 - Quantitative Stock Assessment
Assessment Method	Age-structured Bayesian stock assessment implemented with CASAL software.
Main data inputs	- Proportions at age data from the commercial fisheries, recreational fishery and historic trawl surveys. - Estimates of biological parameters (e.g., growth, age-at-maturity and length/weight). - Standardised single trawl CPUE index of abundance. - Sea Surface temperatures - Estimates of recreational Harvest

	- Commercial catch - Two tag-based biomass estimates.	
Period of Assessment	Latest assessment: 2005	Next assessment: Unknown
Changes to Model Structure and Assumptions	A revised assessment of SNA 8 was completed in 2005 including updated observations on: - method-specific catch weights to 2003-04; - catch-at-age for commercial pair and single trawl in 2003-04; and, - single trawl CPUE time series from 1996-2004 incorporating tow duration as the unit of effort from core vessels in the fleet. New information added to the 2005 assessment included: - single trawl catch-at-age 1974 to 1976; - pair trawl catch-at-age with recalculated observations for 1974 to 1976; 1978 to 1980; - mean size-at-age 1975, 1976 and 1979; - pair trawl catch-at-length frequency in 1986; and, - boat ramp samples of recreational length frequency in 1991, 1994, 1996 and 2000. Using this new information assisted the estimation of selectivities-at-length for the single trawl, pair trawl and recreational fishing methods, and natural mortality. A revised time series of observed and assumed mean size-at-age was input to the model for the period 1931-2004.	
Major Sources of Uncertainty	The current assessment produces very precise results, which are the product of the available data and various model assumptions. However, many of the model assumptions may be violated to some extent. Some of the more important considerations are: - the tagging estimates may be biased; - the MPD residuals are not consistent with the statistical assumptions of the model because extra weight was given to the tagging estimates; - natural mortality is not known exactly (as was assumed in the MCMCs); - the catch history is uncertain with regard to Japanese longline catch and commercial catch overruns in addition to recreational catch. A full exploration of these factors has not been performed. Additional sensitivity runs taking account of these factors would produce a greater range of uncertainty than is present in the current assessment.	

Qualifying Comments

An aerial overflight survey in 2007 estimated recreational harvest to be 260 t, thereby suggesting the 600 t run was less plausible than the 300 t estimate.

All SNA 8 stock assessments have assumed steepness is 1.0 (no stock recruitment relationship), which given the stocks low biomass relative to B_0 is a questionable assumption. Alternative values of steepness have not been investigated for SNA 8.

Fishery Interactions

The primary species caught in association with snapper in bottom trawl fisheries are trevally, red gurnard, John dory and tarakihi.

Yield estimates, TACCs and TACs for the 2010-11 fishing year are summarised in Table 25.

Table 25: Summary of yield estimates (t), TACCs (t) and reported landings (t) for the most recent fishing year.

| Fish stock	QMA	*MCY*	*CAY*[99-00]	*MSY*	2010-11 Actual TACC	2010-11 Commercial landings
SNA 1	1	9 911	8 712	10 050	4 500	4 516
SNA 2	2	-	-	440-500	315	320
SNA 3	3, 4, 5 & 6	-	-	-	32	< 1
SNA 7	7	-	-	850	200	208
SNA 8	8, 9	-	-	-	1 300	1 313
SNA 10	10	-	-	-	10	0
Total					6 357	6 358

7.   FOR FURTHER INFORMATION

Abraham E.R., Thompson F.N. 2010. Summary of the capture of seabirds, marine mammals and turtles in New Zealand commercial fisheries, 1998–99 to 2008–09. Draft New Zealand Aquatic Environment and Biodiversity Report. 155 p.

Abraham E.R., Thompson F.N. 2011. Summary of the capture of seabirds, marine mammals, and turtles in New Zealand commercial fisheries, 1998–99 to 2008–09 New Zealand Aquatic Environment and Biodiversity Report No. 80.

Annala J.H., Sullivan K.J. (Comps.) 1997. Report from the Fishery Assessment Plenary, May 1997: stock assessments and yield estimates. 381 p. (Unpublished report held in NIWA library, Wellington.).

Baird S.J. 2004a. Estimation of the incidental capture of seabird and marine mammal species in commercial fisheries in New Zealand waters, 1999-2000. New Zealand Fisheries Assessment Report 2004141.56 p.

Baird S.J. 2004b. Incidental capture of seabird species in commercial fisheries in New Zealand waters,2000-01. New Zealand Fisheries Assessment Report 2004158.63 p.

Baird S.J. 2004c. Incidental capture of seabird species in commercial fisheries in New Zealand waters, 2001-02. New Zealand Fisheries Assessment Report 2004160.51 p.

Baird S.J 2005. Incidental capture of seabird species in commercial fisheries in New Zealand waters, 2002-03. New Zealand Fisheries Assessment Report 200512.50 p.

Baird S.J., Smith M.H. 2007. Incidental capture of New Zealand fur seals (Arctocephalus forsteri) in commercial fisheries in New Zealand waters, 2003–04 to 2004–05. New Zealand Aquatic Environment and Biodiversity Report No. 14. 98 p.

Baird S.J., Wood B.A., *et al.* 2011. Nature and extent of commercial fishing effort on or near the seafloor within the New Zealand 200 n. mile Exclusive Economic Zone, 1989-90 to 2004-05. New Zealand Aquatic Environment and Biodiversity Report 73. 143 p.

Baird S.J., Wood B.A. 2012. Extent of coverage of 15 environmental classes within the New Zealand EEZ by commercial trawling with sealoor contact. New Zealand Aquatic Environment and Biodiversity Report 89. 43 p.

Baker C.S., Chilvers B.L., Constantine R., DuFresne S., Mattlin R.H., van Helden A., Hitchmough R. 2010. Conservation status of New Zealand marine mammals (suborders Cetacea and Pinnipedia), 2009. New Zealand Journal of Marine and Freshwater Research 44: 101-115.Ballara, S.L.; Anderson, O.F. (2009). Fish discards and non-target fish catch in the trawl fisheries for arrow squid and scampi in New Zealand waters. New Zealand Aquatic Environment and Biodiversity Report No. 38. 102 p.

Bian R., McKenzie J.R., Davies N.M. 2009: Determination of optimum frequency for SNA 8 snapper market sampling based on retrospective analysis. New Zealand Fisheries Assessment Report 2009/50. 15 p.

Blackwell R.G.. Gilbert D.J. 2006. Age composition of commercial snapper landings in SNA 2, 2004-05. New Zealand Fisheries Assessment Report 2006/46. 18 p.

Boyd R.O., Reilly J.L. 2002. 1999/2000 National Marine Recreational Fishing Survey: harvest estimates. New Zealand Fisheries Assessment Report.

Boyd R.O., Reilly J.L. In press. 2000/2001 National Marine Recreational Fishing Survey: harvest estimates. New Zealand Fisheries Assessment Report.

Bradford E. 1998. Harvest estimates from the 1996 national marine fishing surveys. New Zealand Fisheries Assessment Research Document 1998/16. 27 p.

Brothers N., Duckworth A.R., Safina C., Gilman E.L. 2010. Seabird bycatch in pelagic longline fisheries is grossly underestimated when using only haul data. PloS One 5: e12491. doi: 10.1371/journal.pone.001249

Bull B., Francis R.I.C.C., Dunn A., McKenzie A., Gilbert D.J., Smith M.H. 2004. CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v2.06-2004/09/26. NIWA Technical Report 126. 261 p.

Bull B., Francis RICC., Dunn A., Gilbert DJ., Bian, R., Fu, D. 2012. CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v2.30.2012/03/21. NIWA Technical Report 135. 280 p.

Davies N.M. 1997. Assessment of the west coast snapper (*Pagrus auratus*) stock (SNA 8) for the 1996-97 fishing year. New Zealand Fisheries Assessment Research Document 1997/12. 47 p.

Davies N.M. 1999: Assessment of the SNA 1 and 8 stocks for the 1997-98 fishing year. New Zealand Fisheries Assessment Research Document 99/19. 87 p.

Davies N.M., Gilbert D.J., McKenzie J.R. 1999. Assessment of the SNA 1 and 8 stocks for the 1998-99 fishing year. New Zealand Fisheries Assessment Research Document 1999/28. 82 p.

Davies N.M., Walsh C., Hartill B. 1993. Estimating catch at age of snapper from west coast and Hauraki Gulf fisheries, 1992-93. Northern Fisheries Region Internal Report No.17. 58 p. (held by MAF Fisheries North Region, Auckland.)

Davies N.M., McKenzie J.R., Gilbert D.J. 2006. Assessment of the SNA 8 stock for the 2003-04 fishing year. New Zealand Fisheries Assessment Report 2006/9. 32 p.

Francis M.P. 1993. Does water temperature determine year class strength in New Zealand snapper (*Pagrus auratus*, Sparidae)? Fisheries Oceanography 2(2): 65-72.

Francis M.P., Langley A.D., Gilbert D.J. 1995. Snapper recruitment in the Hauraki Gulf. New Zealand Fisheries Assessment Research Document 1995/17. 26 p.

Francis R.I.C.C. 2011 Data weighting in statistical fisheries stock assessment models *Can. J. Fish. Aquat. Sci.* 68 pp 1124-1138

Gilbert D.J. 1994. A total catch history model for SNA 1. New Zealand Fisheries Assessment Research Document 1994/24. 16 p.

Gilbert D.J., Taylor P.R. 2001. The relationships between snapper (*Pagrus auratus*) year class strength and temperature for SNA 2 and SNA 7. New Zealand Fisheries Assessment Report 2001/64. 33 p.

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Gilbert D.J., McKenzie J.R. 1999. Sources of bias in biomass estimates from tagging programmes in the SNA 1 snapper (*Pagrus auratus*) stock New Zealand Fisheries Assessment Research Document 1999/16. 47 p.

Gilbert D.J., Phillips N.L. 2003. Assessment of the SNA 2 and Tasman and Golden Bays (SNA 7) snapper fisheries for the 2001-02 fishing year. New Zealand Fisheries Assessment Report 2003/45.

Gilbert D.J., Sullivan K.J. 1994. Stock assessment of snapper for the 1992-93 fishing year. New Zealand Fisheries Assessment Research Document 1994/3. 37 p.

Gilbert D.J., McKenzie J.R., Davies N.M., Field K.D. 2000. Assessment of the SNA 1 stocks for the 1999-200 fishing year. New Zealand Fisheries Assessment Report 2000/38. 52 p.

Harley S.J., Gilbert D.J. 2000. Assessment of the Tasman and Golden Bays snapper fishery for the 1999-2000 fishing year. New Zealand Fisheries Assessment Report 2000/28. 42 p.

Hartill B., Watson T., Cryer M., Armiger H. 2007. Recreational marine harvest estimates of snapper and kahawai in the Hauraki Gulf in 2003-04. New Zealand Fisheries Assessment Report 2007/25. 55 p.

Hartill B., Bian R., Armiger H., Vaughan M., Rush N. 2007. Recreational marine harvest estimates of snapper, kahawai, and kingfish in QMA 1 in 2004-05. New Zealand Fisheries Assessment Report 2007/26. 44 p.

Hartill B., Sutton C. 2011.

Hermsen J.M., Collie J.S., Valentine P.C. 2003. Mobile fishing gear reduces benthic megafaunal production on Georges Bank Mar. Ecol. Prog. Ser. 260: 97-108

Hiddink J.G., Jennings S., Kaiser M.J., Queiros A.M., Duplisea D.E., Piet G.J. 2006. Cumulative impacts of seabed trawl disturbance on benthic biomass, production, and species richness in different habitats. Can. J. Fish. Aquat. Sci. 63:721–36

Holdsworth J.C., Boyd R.O. (2008). Size, condition and estimated release mortality of snapper (Pagrus auratus) caught in the SNA1 recreational fishery, 2006–07. New Zealand Fisheries Assessment Report 2008/53. 37 p.

Langley A.D. 2010. Stock assessment of SNA 2 for 2010. *New Zealand Fisheries Assessment Report 2010/26.*

Leathwick J.R., Rowden A., Nodder S., Gorman R., Bardsley S., Pinkerton M., Baird S.J., Hadfield M., Currie K., Goh A. 2009. Benthic-optimised marine environment classification for New Zealand waters. Final Research Report project BEN2006/01. 52 p.

Maunder M.N., Starr P.J. 1995. Validating the Hauraki Gulf snapper pre-recruit trawl surveys and temperature recruitment relationship using catch at age analysis with auxiliary information. New Zealand Fisheries Assessment Research Document 1998/15.

McKenzie J.R., Diggles B., Tubbs L., Poortenaar C., Parkinson D., Webster K., Miller N. 2006. An evaluation of a new type of plastic-coated PIT tag for tagging snapper (*Pagrus auratus*). New Zealand Fisheries Assessment Report 2006/8. 40 p.

McKenzie J.R. 2000: Factors Affecting Mortality of small Snapper (Pagrus auratus) caught and released by the SNA 1 Longline Fishery draft Fisheries Assessment Report (held NIWA Library Wellington).

Millar R.B., Akroyd J.M., Walshe K.A.R. (2001). Incidental mortality of snapper in SNA 1 and SNA 8. New Zealand Fisheries Assessment Report 2001/78. 36 p.

Methot R.D. 1990. Synthesis model: an adaptable framework for analysis of diverse stock assessment data. International North Pacific Fisheries Commission Bulletin 50: 259–275.

Methot R.D. 2009. User manual for Stock Synthesis, model version 3.02C.

Paul L.J. 1976. A study on age, growth and population structure of the snapper, *Chrysophrys auratus* in Hauraki Gulf, N.Z. Fish. Res. Bull., Min. Agric. Fish., New Zealand 13: 63 p.

Paul L.J. 1977: The commercial fishery for snapper Chrysophrys (Pagrus) auratus in the Auckland region, New Zealand, from 1900 to 1971. Fisheries Research Division Bulletin, Fisheries Research Division, N.Z. Ministry of Agriculture & Fisheries, No 15 84 p.

Rice J. 2006. Impacts of Mobile Bottom Gears on Seafloor Habitats, Species, and Communities: A Review and Synthesis of Selected International Reviews. Canadian Science Advisory Secretariat Research Document 2006/057. 35 p. (available from http://www.dfo-mpo.gc.ca/CSAS/Csas/DocREC/2006/RES2006_057_e.pdf).

Rowe S. 2009. Level 1 Risk Assessment Methodology for incidental seabird mortality associated with New Zealand fisheries in the NZ EEZ. Unpublished report to the Seabird Stakeholder Advisory 138 Group (SSAG09.49) held by the Department of Conservation, Wellington.

Sullivan K.J. 1985. Snapper. *In* Colman, J.A., McKoy, J.L., Baird, G.G. (Comps. and Eds.) (1985). Background papers for the 1985 Total Allowable Catch recommendations, pp. 187-214. (Unpublished report, held in MAF Fisheries Greta Point library, Wellington.)

Sullivan K.J., Hore A.J., Wilkinson V.H. 1988. Snapper. *In* Baird, G.G., McKoy, J.L. Papers from the workshop to review fish stock assessments for the 1987-88 New Zealand fishing year, pp. 251-275. (Unpublished report, held in MAF Fisheries Greta Point library, Wellington.)

Sylvester T. 1995. Initial results of the Northern boat ramp survey. Seafood New Zealand, February 1995. pp. 11-13.

Teirney L.D., Kilner A.R., Millar R.B., Bradford E., Bell J.D. 1997. Estimation of recreational harvests from 1991-92 to 1993-94. New Zealand Fisheries Assessment Research Document 1997/15. 43 p.

Vignaux M. 1993. Catch per unit of effort (CPUE) analysis of the SNA 8 snapper fishery. New Zealand Fisheries Assessment Research Document 1993/2. 12 p.

Walsh C., Davies N.M. 2004. Length and age composition of commercial landings in SNA 8, 2003-04. New Zealand Fisheries Assessment Report 2004/56. 18 p.

Walsh C., McKenzie J., Arminger H. 2006. Spatial and temporal patterns in snapper length and age composition and movement, west coast North Island, New Zealand. New Zealand Fisheries Assessment Report 2006/6. 59 p.

Walsh C., Davies N.M., Rush N., Middleton C., Smith M., Newmarch G. 2006. Length and age composition of commercial snapper landings in SNA 1, 2003-04. New Zealand Fisheries Assessment Report 2006/7. 46 p.

Walsh C., Davies N.M., Rush N., Buckthought D., Smith M. 2006. Age composition of commercial snapper landings in SNA 1, 2004-05. New Zealand Fisheries Assessment Report 2006/39. 34 p.

Walsh C., Davies N.M., Buckthought D. 2006. Length and age composition of commercial snapper landings in SNA 8, 2005-06. New Zealand Fisheries Assessment Report 2006/54. 21 p.

Walsh C., Davies N.M., Rush N., Buckthought D., Vaughn M., Smith M. 2007. Length and age composition of commercial snapper landings in SNA 1, 2005-06. New Zealand Fisheries Assessment Report 2007/01. 30 p.

Wright P., McClary D, Boyd R.O. In press. 2000/2001 National Marine Recreational Fishing Survey: direct questioning of fishers compared with reported diary data. Final Research Report for Ministry of Fisheries Project REC2000-01: Objective 2.

SOUTHERN BLUE WHITING (SBW)

(*Micromesistius australis*)
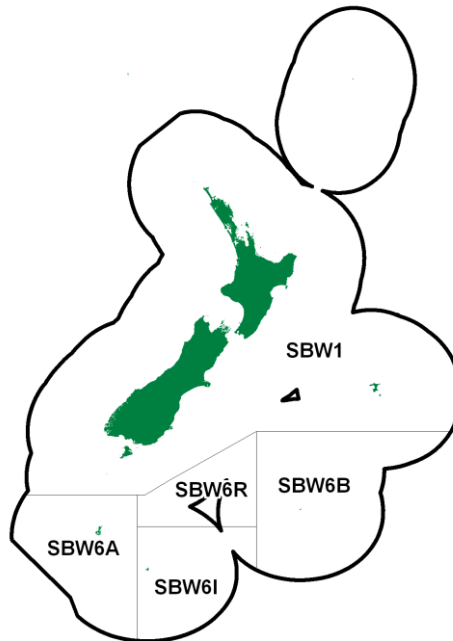
1.   FISHERY SUMMARY

1.1   Commercial fisheries

Southern blue whiting are almost entirely restricted in distribution to sub-Antarctic waters. They are dispersed throughout the Campbell Plateau and Bounty Platform for much of the year, but during August and September they aggregate to spawn near the Campbell Islands, on Pukaki Rise, on Bounty Platform, and near Auckland Islands over depths of 250-600 m. During most years, fish in the spawning fishery range between 35-50 cm fork length (FL), although occasionally a smaller size class of males (29-32 cm FL) is also present.

Reported landings for the period 1971 to 1977 are shown in Table 1. Estimated landings by area from the trawl catch and effort logbooks and QMRs are given from 1978 to the present in Table 2, while Figure 1 shows the historical landings and TACC values for the main SBW stocks. Landings were chiefly taken by the Soviet foreign licensed fleet during the 1970s and early 1980s, and the fishery fluctuated considerably peaking at almost 50 000 t in 1973 and again at almost 30 000 t in 1979. The Japanese surimi vessels first entered the fishery in 1986, and catches gradually increased to a peak of 76 000 t in 1991-92. A catch limit of 32 000 t, with area sub-limits, was introduced for the first time in the 1992-93 fishing year (Table 2). The total catch limit increased to 58 000 t in 1996-97 for three years. The southern stocks of southern blue whiting were introduced to the Quota Management System on 1 Nov 1999, with the TACCs given in Table 2. The fishing year was also changed to 1 April to 31 March to reflect the timing of the main fishing season. TACC changes since 2000-01 are shown in Table 2. A nominal TACC of 8 t (SBW 1) was set for the rest of the EEZ, and typically less than 10 t per year has been reported from SBW 1 since 2000-01.

Landings have been between 25 000 t and 40 000 t since 2000, with the majority of the catch currently taken by foreign charter vessels (predominantly Ukrainian) producing headed and gutted or dressed product. On the Campbell Island Rise and the Bounty Platform the TACC has been almost fully caught in each year since 2005-06. However on the other grounds, the catch limits have generally been under-caught in most years since their introduction. This reflects the relatively low economic value of the fish and difficulties in both the timing and locating of aggregations experienced by operators. On the Pukaki Rise and Auckland Islands Shelf, operators have generally found it difficult to justify expending time to locate fishable aggregations, given the small allocation available in these areas, the relatively low value of the product, and the more certain option available to fish southern blue whiting at Campbell Island where aggregations are concurrent.

The TACC for the Bounty Platform stock was increased to 9800 t for the 2008 season and further increased to 14 700 t for the 2009 and 2010 seasons but decreased to 6860 t for the 2011 season. From 1 April 2006, the TACC for the Campbell Island Rise stock was reduced from 25 000 t to 20 000 t, where it remained until 2009. For the 2010 season the catch limit for the Campbell stock was raised to 23 000 t, and in 2011 it was further raised to 29 400 t. Catch limits for Pukaki Rise and Auckland Islands have remained unchanged since 1997.

Table 1: Reported annual landings (t) of southern blue whiting from 1971 to 1977.

Fishing year	Total
1971	10 400
1972	25 800
1973	48 500
1974	42 200
1975	2 378
1976	17 089
1977	26 435

Table 2: Estimated catches (t) and actual TACCs of southern blue whiting by area from vessel logbooks and QMRs. - no catch limit in place. *, before 1997-98 there was no separate catch limit for Auckland Is.

Fishing year	Bounty Platform Catch	Bounty Platform Limit	Campbell Island Rise Catch	Campbell Island Rise Limit	Pukaki Rise Catch	Pukaki Rise Limit	Auckland Is. Catch	Auckland Is. Limit*	Total Catch	Total Limit
1978ƒ	0	-	6 403	-	79	-	15	-	6 497	-
1978-79+	1 211	-	25 305	-	601	-	1 019	-	28 136	-
1979-80+	16	-	12 828	-	5 602	-	187	-	18 633	-
1980-81+	8	-	5 989	-	2 380	-	89	-	8 466	-
1981-82+	8 325	-	7 915	-	1 250	-	105	-	17 595	-
1982-83+	3 864	-	12 803	-	7 388	-	184	-	24 239	-
1983-84+	348	-	10 777	-	2 150	-	99	-	13 374	-
1984-85+	0	-	7 490	-	1 724	-	121	-	9 335	-
1985-86+	0	-	15 252	-	552	-	15	-	15 819	-
1986-87+	0	-	12 804	-	845	-	61	-	13 710	-
1987-88+	18	-	17 422	-	157	-	4	-	17 601	-
1988-89+	8	-	26 611	-	1 219	-	1	-	27 839	-
1989-90+	4 430	-	16 542	-	1 393	-	2	-	22 367	-
1990-91+	10 897	-	21 314	-	4 652	-	7	-	36 870	-
1991-92+	58 928	-	14 208	-	3 046	-	73	-	76 255	-
1992-93+	11 908	15 000	9 316	11 000	5 341	6 000	1 143	-	27 708	32 000
1993-94+	3 877	15 000	11 668	11 000	2 306	6 000	709	-	18 560	32 000
1994-95+	6 386	15 000	9 492	11 000	1 158	6 000	441	-	17 477	32 000
1995-96+	6 508	8 000	14 959	21 000	772	3 000	40	-	22 279	32 000
1996-97+	1 761	20 200	15 685	30 100	1 806	7 700	895	-	20 147	58 000
1997-98+	5 647	15 400	24 273	35 460	1 245	5 500	0	1 640	31 165	58 000
1998-00†	8 741	15 400	30 386	35 460	1 049	5 500	750	1 640	40 926	58 000
2000-01#	3 997	8 000	18 049	20 000	2 864	5 500	19	1 640	24 804	‡35 140
2001-02#	2 262	8 000	29 999	30 000	230	5 500	10	1 640	31 114	‡45 140
2002-03#	7 564	8 000	33 445	30 000	508	5 500	262	1 640	41 795	‡45 140
2003-04#	3 812	3 500	23 718	25 000	163	5 500	116	1 640	27 812	‡35 640
2004-05#	1 477	3 500	19 799	25 000	240	5 500	95	1 640	21 620	‡35 640
2005-06#	3 962	3 500	26 190	25 000	58	5 500	66	1 640	30 287	‡35 640
2006-07#	4 395	3 500	19 763	20 000	1 115	5 500	84	1 640	25 363	‡30 640
2007-08#	3 799	3 500	20 996	20 000	513	5 500	278	1 640	25 587	‡30 640
2008-09#	9 863	9 800	20 483	20 000	1 377	5 500	143	1 640	31 867	‡36 948
2009-10#	15 468*	14 700	19 040	20 000	4 853	5 500	174	1 640	39 540	‡42 148
2010-11#	13 912	14 700	20 224	23 000	4 433	5 500	131	1 640	38 708	‡44 848
2011-12#	6 590	6 860	30 840	29 400	677	5 500	65	1 640	38 174	‡43 400

ƒ 1 April-30 September   + 1 October-30 September
† 1 October 1998-31 March 2000   # 1 April -31 March
‡ SBW 1 (all EEZ areas outside QMA6) had a TACC of 8 t, and reported catches of 9 t in 2000-01, 1 t in 2001-02, 16 t in 2002-03, 3 t in 2003-04, 9 t in 2004-05, 2 t in 2005-06, 7 t in 2006-07, 1 t in 2007-08, 21 t in 2008-09, 5 t in 2009-10, 8 t in 2010-11, and 2 t in 2011-12.
* Reported catch total for 2009-10 does not include fish lost when *FV Oyang 70* sank on 18 August 2010.
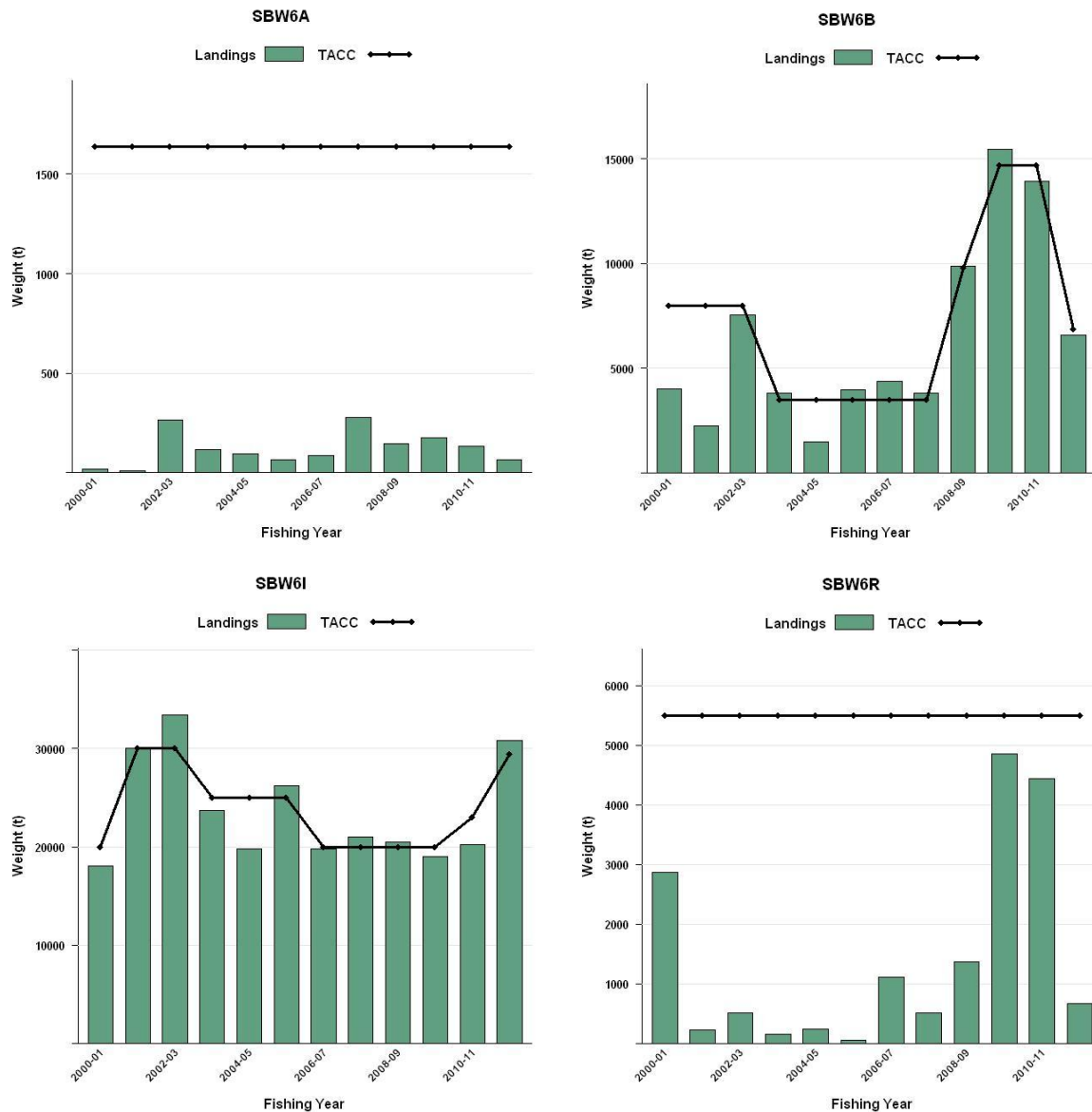
Figure 1: Historical landings and TACC for the four main SBW stocks. From top left to bottom right: SBW6A (Auckland Islands), SBW6B (Bounty Platform), SBW6I (Campbell Island Rise), and SBW6R (Pukaki Rise). Note that these figures do not show data prior to entry into the QMS.

1.2 Recreational fisheries

There is no recreational fishery for southern blue whiting.

1.3 Customary non-commercial fisheries

Customary non-commercial take is not known to occur for southern blue whiting.

1.4 Illegal catches

The level of illegal and unreported catch is thought to be low. However, a number of operators have been convicted for area misreporting; where the catch returns have been revised the corrected totals by area are shown in Table 2. In addition, the operators of another vessel were convicted of discarding without reporting fish in 2004: crew members estimated that between 40 and 310 t of SBW were illegally discarded during a two and a half week period fishing on the Campbell Island Rise.

1.5 Other sources of mortality

Scientific observers have occasionally reported discards of undersize fish and accidental loss from torn or burst codends. The amount of possible discarding was estimated by Clark *et al.* (2000) and Anderson (2004, 2009). Anderson (2004) quantified total annual discard estimates (including

estimates of fish lost from the net at the surface) as ranging between 0.4% and 2.0% of the estimated SBW catch over all the SBW fisheries. Anderson (2009) reviewed fish and invertebrate bycatch and discards in the SBW fishery based on observer data from 2002 to 2007. He estimated that 0.23% of the catch was discarded from observed vessels. The low levels of discarding occur primarily because most catch came from vessels that targeted spawning aggregations.

In August 2010, the F.V. Oyang 70 sank while fishing for SBW on the Bounty Platform. It was fishing an area between 48°00' S and 48°20' S, and 179°20' E and 180°00' E between 15 and 17 August 2010, before sinking on 18 August 2010. The Ministry of Fisheries estimated that it had taken a catch of between 120 t and 190 t that was lost with the vessel.

2.   BIOLOGY

Southern blue whiting is a schooling species that is confined to sub-Antarctic waters. Early growth has been well documented with fish reaching a length of about 20 cm FL after one year and 30 cm FL after two years. Growth slows down after five years and virtually ceases after ten years. Ages have been validated up to at least 15 years by following strong year classes, but ring counts from otoliths suggest a maximum age of 25 years.

The age and length of maturity, and recruitment to the fishery, varies between areas and between years. In some years a small proportion of males mature at age 2, but the majority do not mature until age 3 or 4, usually at a length of 33-40 cm FL. The majority of females also mature at age 3 or 4 at a length of 35-42 cm FL. Ageing studies have shown that this species has very high recruitment variability.

Southern blue whiting are highly synchronised batch spawners. Four spawning areas have been identified: on Bounty Platform, Pukaki Rise, Auckland Islands Shelf, and Campbell Island Rise. The Campbell Island Rise has two separate spawning grounds, to the north and south respectively. Fish appear to recruit first to the southern ground but thereafter spawn on the northern ground. Spawning on Bounty Platform begins in mid-August and finishes by mid-September. Spawning begins 3-4 weeks later in the other areas, finishing in late September/early October. Spawning appears to occur at night, in mid-water, over depths of 400-500 m on Campbell Island Rise but shallower elsewhere.

Natural mortality (M) was estimated using the equation $\log_e(100)$/maximum age, where maximum age is the age to which 1% of the population survives in an unexploited stock. Using a maximum age of 22 years, M was estimated to equal 0.21. The value of 0.2 is assumed to reflect the imprecision of this value. Recent Campbell Island stock assessments have estimated M within the model, using an informed prior with a mean of 0.2 (see Table 3).

Table 3:   Estimates of biological parameters for the Campbell Island Rise southern blue whiting stock.

Fishstock			Estimate		Source
1. Natural mortality (*M*)					
			Males	Females	
Campbell Island Rise			0.2	0.2	Hanchet (1992)
2. Weight = a (length)^b (Weight in g, length in cm fork length)					
		Males		Female	
	a	b	a	b	
Campbell Island Rise	0.00515	3.092	0.00407	3.152	Hanchet (1991)

Note: Estimates of natural mortality and the length-weight coefficients are assumed to be the same for the other stocks. Observed length-at-age data are used for all stocks.

3.   STOCKS AND AREAS

Hanchet (1999) reviewed the stock structure of southern blue whiting. He examined historical data on southern blue whiting distribution and abundance, reproduction, growth, and morphometrics. There appear to be four main spawning grounds of southern blue whiting; on the Bounty Platform, Pukaki

Rise, Auckland Islands Shelf, and Campbell Island Rise. There are also consistent differences in the size and age distributions of fish, in the recruitment strength, and in the timing of spawning between these four areas. Multiple discriminant analysis of data collected in October 1989 and 1990 showed that fish from Bounty Platform, Pukaki Rise and Campbell Island Rise could be distinguished on the basis of their morphometric measurements. The Plenary concluded that this constitutes strong evidence that fish in these areas return to spawn on the grounds to which they first recruit. No genetic studies have been carried out, but given their close proximity, it is unlikely that there would be detectable genetic differences in the fish between these four areas.

For the purposes of stock assessment it is assumed that there are four stocks of southern blue whiting with fidelity within stocks: the Bounty Platform stock, the Pukaki Rise stock, the Auckland Islands stock, and the Campbell Island stock.

4.   ENVIRONMENTAL & ECOSYSTEM CONSIDERATIONS

This section was updated with new tables for the May 2012 Fishery Assessment Plenary based on reviews of similar chapters by the Aquatic Environment Working Group. This summary is from the perspective of the southern blue whiting fishery; a more detailed summary from an issue-by issue perspective is, or will shortly be, available in the Aquatic Environment & Biodiversity Annual Review (http://fs.fish.govt.nz/Page.aspx?pk=113&dk=22982).

4.1   Role in the ecosystem
Not discussed by the AEWG.

4.2   Incidental catch (fish and invertebrates)
Not discussed by the AEWG.

4.3   Incidental Catch (seabirds, mammals, and protected fish)
For protected species, capture estimates presented here include all animals recovered to the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds struck by a warp or caught on a hook but not brought onboard the vessel, Middleton & Abraham 2007, Brothers *et al*. 2010).

4.3.1 Marine mammal interactions
Southern blue whiting trawlers occasionally catch marine mammals, including NZ sea lions and NZ fur seals (which were classified as "Nationally Critical" and "Not Threatened", respectively, under the NZ Threat Classification System in 2010, Baker *et al*. 2010).

In the 2009-10 fishing year there were 11 observed captures of NZ sea lion in southern blue whiting trawl fisheries (Table 1). There were 25 (95% c.i.: 16 - 38) estimated captures, with the estimates made using a statistical model. The model includes less than 50% of the tows for 2009/10 so the estimate of captures should be treated with caution. Sea lion captures were all close to the Campbell Islands in SBW 6I (Thompson & Abraham 2012) and are almost all males.

In the 2009-10 fishing year there were 16 observed captures of NZ fur seal in southern blue whiting trawl fisheries. There were 106 (95% c.i.: 45 - 223) estimated captures, with the estimates made using a statistical model (Table 2). Since 2002–03, about 8% of the estimated total captures of NZ fur seals in trawl fisheries have been taken in the southern blue whiting fishery; these captures have been throughout the Subantarctic region in SBW 6B, 6I, and 6R. The rate of capture for NZ fur seals species has averaged 8.1 captures per 100 tows and has fluctuated without obvious trend (with a high in 2005-06).

Table 4: Number of tows by fishing year and observed and model-estimated total NZ sea lion captures in southern blue whiting trawl fisheries, 2002–03 to 2009–10. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows, % inc, percentage of total effort included in the statistical model. Data from Thompson & Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/

				Observed			Estimated	
	Tows	No.obs	%obs	Captures	Rate	Captures	95%c.i.	%inc.
2002–03	638	275	43.1	0	0.00	0	0-3	95.0
2003–04	740	241	32.6	1	0.41	3	1-9	95.4
2004–05	870	335	38.5	2	0.60	5	2-12	83.8
2005–06	624	217	34.8	3	1.38	10	3-21	81.7
2006–07	630	224	35.6	3	1.34	15	5-29	88.7
2007–08	819	331	40.4	5	1.51	8	5-14	68.3
2008–09	1187	299	25.2	0	0.00	1	0-6	52.1
2009–10	1115	397	35.6	11	2.77	25	16-38	48.0

Table 5: Number of tows by fishing year and observed and model-estimated total NZ fur seal captures in southern blue whiting trawl fisheries, 2002–03 to 2009–10. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows, % inc, percentage of total effort included in the statistical model. Data from Thompson & Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/

				Observed			Estimated	
	Tows	No.obs	%obs	Captures	Rate	Captures	95%c.i.	%inc.
2002–03	638	275	43.1	8	2.91	22	10-51	100.0
2003–04	740	241	32.6	13	5.39	38	18-87	100.0
2004–05	870	335	38.5	33	9.85	76	44-152	100.0
2005–06	624	217	34.8	52	23.96	65	55-84	100.0
2006–07	630	224	35.6	13	5.80	24	15-44	100.0
2007–08	819	331	40.4	24	7.25	80	38-173	100.0
2008–09	1187	299	25.2	17	5.69	107	49-224	100.0
2009–10	1115	397	35.6	16	4.03	106	45-223	100.0

4.3.2 Seabird interactions

Annual observed seabird capture rates ranged from 0.00 to 1.34 per 100 tows in southern blue whiting fisheries between 1998-99 and 2007-08 (Baird 2001, 2004 a,b,c, 2005a, Abraham & Thompson 2009, Abraham *et al*. 2009, Abraham & Thompson 2011) and have fluctuated without obvious trend. In the 2009-2010 fishing year there were 10 observed captures of birds in southern blue whiting trawl fisheries at a rate of 2.52 birds per 100 observed tows (Thompson & Abraham 2012). No estimates of total captures were made. The average capture rate in southern blue whiting trawl fisheries over the last eight years (all areas combined) is only 0.8 birds per 100 tows, a low rate relative to trawl fisheries for squid (13.3 birds per 100 tows), scampi (3.53 birds per 100 tows) and hoki (2.2 birds per 100 tows) over the same years. Observed seabird captures since 2002–03 have been dominated by grey petrels (15 of the 20 observed seabird captures since 2002-03). Grey petrel was estimated to have a relatively low risk ratio (potential captures across all New Zealand trawl and longline fisheries equal to 39% of PBR) by Richard *et al* (2011). Captures in the southern blue whiting fishery have been observed in SBW 6B, 6I, and 6R.

Mitigation methods such as streamer (tori) lines, Brady bird bafflers, warp deflectors, and offal management are used in the southern blue whiting trawl fishery. Warp mitigation was voluntarily introduced from about 2004 and made mandatory in April 2006 (MFish 2006). The 2006 notice mandated that all trawlers >28 m in length use a seabird scaring device while trawling (being "paired streamer lines", "bird baffler" or "warp deflector" as defined in the notice).

4.4   Benthic interactions

Southern blue whiting are taken using trawls that are sometimes fished on or near the seabed. Target southern blue whiting tows accounted for only 1% of all tows reported on TCEPR forms to have been

fished on close to the bottom between 1989–90 and 2004–05 (Baird *et al.* 2011). These tows were located in Benthic Optimised Marine Environment Classification (BOMEC, Leathwick *et al.* 2009) classes F (upper slope), I, L (mid-slope), and M (mid-deep slope) (Baird & Wood 2012), and 95% were between 300 and 600 m depth (Baird *et al.* 2011).

Table 6: Number of tows by fishing year and observed seabird captures in southern blue whiting trawl fisheries, 2002–03 to 2009–10. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows. Data from Thompson & Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/

	Tows	No. obs	% obs	Captures	Rate
2002–03	638	275	43.1	0	0.00
2003–04	740	241	32.6	0	0.00
2004–05	870	335	38.5	2	0.60
2005–06	624	217	34.8	2	0.92
2006–07	630	224	35.6	3	1.34
2007–08	819	331	40.4	3	0.91
2008–09	1187	299	25.2	0	0.00
2009–10	1115	397	35.6	10	2.52

Trawling for southern blue whiting with some or all of the gear contacting the bottom, like trawling for other species, is likely to have effects on benthic community structure and function (e.g., Rice 2006) and there may be consequences for benthic productivity (e.g., Jennings 2001, Hermsen *et al.* 2003, Hiddink *et al.* 2006, Reiss *et al.*2009). These consequences are not considered in detail here but are discussed in the Aquatic Environment and Biodiversity Annual Review (2012).

4.5   Other considerations
None

5.   STOCK ASSESSMENT

A new assessment of the Campbell Island Rise stock was completed in 2012 using research time series of abundance indices from wide-area acoustic surveys from 1993 to 2011, and proportion-at-age data from the commercial fishery. New information included a wide area acoustic survey of the Campbell Island Rise carried out in August-September 2011. The general purpose stock assessment program, CASAL (Bull *et al.* 2012) was used and the approach, which used Bayesian estimation, was similar to that in previous assessments (Dunn & Hanchet 2011).

A stock assessment was also completed for the Bounty Platform stock using data up to 2009 from industry acoustic surveys of aggregations. However, more recent data from surveys in 2010 and 2011 led the Working Group to believe this assessment model did not adequately explain the observations. The model-based assessment was therefore not accepted by the Working Group. In 2012, the assessment advice was based on the 2011 acoustic results alone (see section 4.4).

No new assessment is available for the Pukaki Rise stock. No assessment has been made of the Auckland Islands Shelf stock. The years given in the biomass and yield sections of this report refer to the August-September spawning/fishing season.

5.1   Estimates of fishery parameters and abundance indices

Between 1993 and 2001, a series of wide area acoustic surveys for southern blue whiting were carried out by the R.V. *Tangaroa* on the Bounty Platform. From 2004 to 2011, a series of local area aggregation surveys has been carried out from industry vessels fishing the Bounty Platform (O'Driscoll 2012). The fishing vessels have opportunistically collected acoustic data from the Bounty Platform fishing grounds using a random survey design over an ad-hoc area that encompassed an

aggregation of southern blue whiting (O'Driscoll 2012). The local area aggregation surveys have had mixed levels of success (Table 7). Acoustic data collected in 2005 could not be used because of acoustic interference from the scanning sonar used by the vessel for searching for fish marks and inadequate survey design. There was originally some concern that the surveys in 2006 and 2009 may not have sampled the entire aggregation as fish marks extended beyond the area being surveyed on some transects. However, the surveys in 2010 and 2011 appeared to have sampled the entire aggregation and gave a similar estimate of biomass to that in 2009, suggesting that the 2009 survey was not overly biased.

Table 7: Estimates of biomass (t) for age 4+ fish from wide area acoustic surveys of the Bounty Platform in 1993-2001 (from Grimes *et al*. 2007), and of spawning stock biomass (SSB) from local aggregation surveys in 2004 to 2011 (O'Driscoll 2012a). Sampling CVs are given in parentheses.

Year	*Wide are surveys* Age 4+ fish	*Local aggregation surveys* SSB
1993	47 087 (64%)	-
1994	20 844 (25%)	-
1995	23 480 (24%)	-
1997	31 929 (32%)	-
1999	34 194 (73%)	-
2001	16 396 (36%)	-
2004	-	13 473 (69%)
2005	-	-
2006	-	21 765 (12%)
2007	-	159 589 (19%)
2008	-	144 187 (34%)
2009	-	28 242 (21%)
2010	-	27 782 (36%)
2011	-	35 597 (28%)

O'Driscoll (2011) explored various reasons for the much lower observed biomass estimates from the surveys in 2009 and 2010 compared with 2007 and 2008, including changes in survey methodology, equipment (including calibration), and changes in timing and extent of survey coverage. He could find no reason in the survey methodology, equipment, or changes in timing and extent of survey coverage for the observed reduction in these estimates.

A wide area survey of the Campbell Island Rise was carried out in August-September 2011 O'Driscoll *et al*. (2012b). Estimates of 2 year old fish were above average, but estimates of 3 year olds were very low. The adult biomass was high, but not as high as might have been expected based from the estimates of 2 and 3 year old fish in 2009 (Table 8).

Estimates of biomass from acoustic surveys from the Bounty Platform, Pukaki Rise and Campbell Island Rise are shown in Table 8.

A standardised CPUE analysis of the Campbell Island stock was completed up until the 2002 fishing season, and the indices are shown in Table 8. In the past there has been concern that because of the highly aggregated nature of the fishery, and the associated difficulty in finding and maintaining contact with the highly mobile schools in some years, the CPUE series may not be monitoring abundance. The indices have therefore not been used in the stock assessment since 1998. A standardised CPUE analysis was also recently carried out for the Bounty Platform. However, this analysis was based on a much more limited data set, the results were inconsistent with the acoustic survey estimates, and there was strong evidence of targeting. The indices were therefore rejected by the WG as indices of abundance and have not been used in assessments.

Table 8: Estimates of biomass (000 t) for age 1, 2, 3 and 4+ fish from acoustic surveys of Bounty Platform, Pukaki Rise, and Campbell Island Rise, and CPUE indices for the Campbell Island Rise. - no data. *Estimates include fish from outside the standard survey area.

Year	Bounty Platform 1	2	3	4+	Pukaki Rise 1	2	3	4+	Campbell Island Rise 1	2	3	4+	CPUE
1986	-	-	-	-	-	-	-	-	-	-	-	-	1.00
1987	-	-	-	-	-	-	-	-	-	-	-	-	0.91
1988	-	-	-	-	-	-	-	-	-	-	-	-	0.88
1989	-	-	-	-	-	-	-	-	-	-	-	-	1.38
1990	-	-	-	-	-	-	-	-	-	-	-	-	1.06
1991	-	-	-	-	-	-	-	-	-	-	-	-	1.30
1992	-	-	-	-	-	-	-	-	-	-	-	-	0.60
1993	29.06	11.35	0.78	47.09	1.06	41.97	9.21	18.82	0.21	107.19	13.40	16.78	1.03
1994	0.30	9.08	36.44	20.84	0.02	1.98	8.91	27.12	0.70	19.63	168.01	23.21	1.19
1995	155.46	7.11	7.87	23.48	0.00	0.14	0.88	8.38	0.00	17.27	27.95	124.89	1.23
1996	-	-	-	-	-	-	-	-	-	-	-	-	2.28
1997	5.05	7.28	30.67	31.93	0.04	4.44	0.89	22.70	-	-	-	-	2.28
1998	-	-	-	-	-	-	-	-	8.68	20.90	35.58	139.39	1.74
1999	0.99	1.13	5.62	34.19	-	-	-	-	-	-	-	-	2.55
2000	-	-	-	-	0.10	10.18	5.58	16.28	2.44	15.61	8.79	110.93	1.85
2001	0.38	4.67	7.26	16.40	-	-	-	-	-	-	-	-	1.83
2002*	-	-	-	-	-	-	-	-	13.44	4.61	10.63	103.42	1.94
2004*	-	-	-	-	-	-	-	-	3.14	24.38	36.68	39.01	-
2006*	-	-	-	-	-	-	-	-	2.23	27.93	10.20	56.21	-
2009	-	-	-	-	-	-	-	-	0.00	110.25	115.94	92.60	-
2011	-	-	-	-	-	-	-	-	0.00	61.51	1.67	116.40	-

5.2 Biomass estimates

(i) Campbell Island stock (2012 stock assessment)

The stock assessment model

An updated stock assessment for the Campbell Island stock was completed in 2012. The model partitioned the Campbell Island stock into two sexes and age groups 2-11, with a plus group at age 11. There are two time steps in the model (Table 9). In the first time step 90% of natural mortality takes place. In the second time step, fish ages are incremented; the 2-year-olds are recruited to the population, which is then subjected to fishing mortality; and the remaining 10% of natural mortality.

Table 9: Annual cycle of the stock model, showing the processes taking place at each step, and the available observations. Fishing mortality (F) and natural mortality (*M*) that occur within a time step occur after all other processes. *M*, proportion of *M* occurring in that time step.

Period	Process	*M*	Length at age	Observations
1. Nov-Aug	Natural mortality	0.9	-	-
2. Sep-Oct	Age, recruitment, F, M	0.1	Matrix applies here	Proportion at age, acoustic indices

The model assumes that a logistic fishing selectivity with full selectivity typically estimated for fish aged 4+. Selectivities were assumed constant over all years in the fishery, and hence there was no allowance for annual changes in selectivity. A Beverton-Holt stock-recruitment relationship was assumed with steepness of $h = 0.9$. The proportion of males at recruitment (age 2) was assumed to be 0.5 of all recruits. We assumed a constant maturity ogive based on estimates derived in previous model with most (95%) fish mature at age 4 and all fish assumed mature at age 5. The maximum exploitation rate (U_{max}) was set at a value of 0.7. The choice of the maximum exploitation rate has the effect of determining the minimum possible virgin biomass allowed by the model. Because of the large inter-annual differences in growth, caused by the occurrence of the strong and weak year classes, length-at-age vectors were calculated for each year, and used in the modelling. Lengths-at-age were converted to weights-at-age in the model using the length-weight relationship given in Table 3.

The model was fitted to the two series of acoustic biomass estimates of ages 2, 3, and 4+ fish given in Table 10 and the proportions-at-age data from the commercial fishery. The acoustic survey estimates were used as relative estimates of mid-season biomass (i.e., after half the catch has been removed),

with associated CVs estimated from the survey analysis. Catch-at-age observations were available from the commercial fishery for the period 1979 to 2011. Catch-at-age data were fitted to the model as proportions-at-age, where estimates of the proportions-at-age and associated CVs by age were estimated using the NIWA catch-at-age software by bootstrap (Bull & Dunn 2002).

Lognormal likelihoods, with the survey sampling CVs were assumed for the relative biomass (acoustic indices) data. Multinomial likelihoods, with sample sizes derived from the bootstrap estimates of CVs, were used for the proportions-at-age data. The likelihoods errors for these data allowed for sampling error only. However, additional variance assumed to arise from differences between model simplifications and real world variation, was added to the sampling variance. The additional variance, termed process error, was estimated in an initial run of the model using all the available data. Additional process error was iteratively estimated for the proportions-at-age data and was added to each observation for all subsequent model runs. The process error estimated for the relative biomass indices was zero.

Table 10: Decomposed biomass estimates (t) and CVs by survey and age group used for the Campbell Island Rise stock assessment.

Year	Age 2 Biomass	Age 2 CV	Age 3 Biomass	Age 3 CV	Age 4+ Biomass	Age 4+ CV
1993	107 192	0.28	13 396	0.23	16 784	0.25
1994	19 634	0.29	168 006	0.32	23 213	0.28
1995	17 269	0.27	27 952	0.21	124 892	0.25
1998	20 895	0.15	35 579	0.12	139 388	0.18
2000	15 606	0.16	8 785	0.16	110 931	0.17
2002	4 609	0.65	10 632	0.64	103 422	0.68
2004	24 380	0.15	36 683	0.30	39 007	0.39
2006	27 933	0.23	10 199	0.34	56 206	0.32
2009	110 250	0.22	115 944	0.26	92 598	0.27
2011	61 512	0.17	1 668	0.22	116 396	0.22

Estimation

Model parameters were estimated using Bayesian methods implemented using the NIWA stock assessment program CASAL v2.30 (Bull *et al.* 2012). For initial runs only the mode of the joint posterior distribution was sampled. For the final runs presented here, the full posterior distribution was sampled using Markov Chain Monte Carlo (MCMC) methods, based on the Metropolis-Hastings algorithm.

MCMC chains were estimated using a burn-in length of 1 million iterations, with every 10 000th sample taken from the next 10 million iterations (i.e., a final sample of length 1000 was taken from the Bayesian posterior).

Equilibrium "virgin" biomass is equal to the population that there would have been if all the YCS were equal to one and there was no fishing. However, there was a period of unknown (and possibly large) catches from the Campbell Island stock before 1979, and there is high recruitment variability in the stock, so the initial 1979 biomass was allowed to differ from the equilibrium virgin biomass. The initial population in 1979 (ages 3 to 11+) was estimated for each of the ages in the initial population, and assumed to be equal by sex. Year class strengths were estimated for all years from 1977 to 2008, under the assumption that the estimates from the model should average one.

Prior distributions and penalty functions

The assumed prior distributions used in the assessment are given in Table 11. Most priors were intended to be relatively uninformative, and had wide bounds. However, a log-normal prior was used for natural mortality and for the acoustic survey 4+ q.

The prior used for the wide area acoustic survey catchability coefficient for ages 4+ was originally obtained using the approach of Cordue (1996), and was detailed by Hanchet (2002). Uncertainty over various factors, including mean target strength, acoustic system calibration, target identification, shadow or dead zone correction, and areal availability were included within the derivation of the

prior. That approach suggested a mean of 1.4 and CV 0.2 with bounds 0.1-2.8. Following the recalibration of the acoustic estimates with revised estimates of the target strength relationship and sound absorption coefficients, the Middle Depths Fisheries Assessment Working Group revised the prior parameters to have mean 1.0 but retained the CV and bounds.

Table 11: The distributions, priors, and bounds assumed for the various parameters being estimated in the Campbell Island Rise stock assessment. The parameters are mean and CV for lognormal; and mean and s.d. for normal. Process errors were fixed at MPD values when carrying out MCMCs.

Parameter	N	Distribution	Values		Bounds	
			Mean	CV / s.d.	Lower	Upper
B_0	1	Uniform-log	-	-	30 000	800 000
Acoustic qs age 2, 3	2	Uniform-log	-	-	0.1	2.8
Acoustic age 4+ q	1	Lognormal	1.00	0.20	0.1	2.8
YCS	28	Lognormal	1.00	1.30	0.001	100
Initial population	18	Uniform-log	-	-	5e5	1e10
Selectivity (by sex)	3	Uniform	-	-	1	20
M (average)	1	Lognormal	0.20	0.20	0.075	0.325
M (difference)	1	Normal	0.00	0.05	-0.05	0.05
Lognormal process error	4	Uniform-log			0.0001	1

The prior on natural mortality was determined by assuming that the true value could differ from the current value by about 0.05, and not more than 0.1. Natural mortality was parameterised by the average of male and female, with the difference estimated with an associated normal prior with mean zero and standard deviation 0.05. Penalty functions were used to constrain the model so that any combinations of parameters that did not allow the historical catch to be taken were strongly penalised. A small penalty was applied to encourage the estimates of year class strengths to average to 1.

Base case

Two main model runs were considered, based on the development of exploratory models. The first assumed a constant age-based selectivity ogive for the fishery, while the second made the same assumptions for the model population structure, but assumed that the fishing selectivities were size-based (Table 12). As the results from the age-based and sized-based models were similar, the Working Group agreed that the age-based model would be reported as the base case.

For each model run, MPD fits were obtained and qualitatively evaluated. MCMC estimates of the median of the posterior and 95% credible intervals are reported for virgin biomass, B_{2011} and B_{2011} (as %B_0).

Table 12: Model run labels and descriptions for the base case.

Model run	Description
1.2	Age-based fishing selectivity
1.3	Size-based fishing selectivity

Recruitment in the Campbell Island Rise stock is characterised by periods of moderate recruitment interspersed by relatively infrequent but extremely strong recruitment events. Given the high variability in recruitment levels and the few strong year classes that have been observed, B_0 is probably not well determined. At the time of the last assessment, only one such event (1991 year class) has been observed (although historical data suggests that this may have happened in the past). The catch-at-age data and the acoustic indices available for this assessment suggested that there was at least one more strong year class since 1991, in 2006, 2007, and possibly 2009.

Results

The estimated MCMC marginal posterior distributions for spawning stock biomass trajectories are shown for the base case (model 1.2) in Figure 2, and the results summarised in Table 13. The run suggests that the stock biomass showed a steady decline from the early 1980s until 1993 followed by

a large increase to 1996, and a general decline thereafter. A moderate year class in 2003 and then two strong year classes in 2006 and 2007 have resulted in a relatively stable stock size until 2009, and then increased in 2010 as the 2006 and 2007 year classes recruited to the fishery. Exploitation rates and relative year class strengths are shown in Figure 3. Estimates of the adult acoustic q and M are given in Table 14.

Table 13: Bayesian median and 95% credible intervals of equilibrium (B_0), initial, and current biomass for the model runs 1.2 (base case) and 1.3 (sensitivity)

Model	B_0	B_{1991} (%B_0)	B_{2011}	B_{2011} (%B_0)
1.2 (Base case)	396 510 (339 760–476 900)	10.9 (7.4–17.7)	199 120 (146 670–278 820)	50 (35–67)
1.3	340 130 (300 730–386 840)	13.9 (10.1–18.8)	220 391 (154 050–317 060)	65 (45–86)

Table 14: Bayesian median and 95% credible intervals of the catchability coefficients (q) and natural mortality parameters for the wide area acoustic biomass indices for model runs 1.2 (base case) and 1.3 (sensitivity)

Model	Catchability			Natural mortality	
	Age 2	Age 3	Age 4	Male	Female
1.2 (Base case)	1.12 (0.79–1.48)	1.02 (0.73–1.30)	0.72 (0.56–0.88)	0.17 (0.12–0.22)	0.17 (0.13–0.22)
1.3	0.92 (0.63–1.28)	0.86 (0.61–1.19)	0.73 (0.56–0.92)	0.22 (0.17–0.28)	0.23 (0.17–0.28)
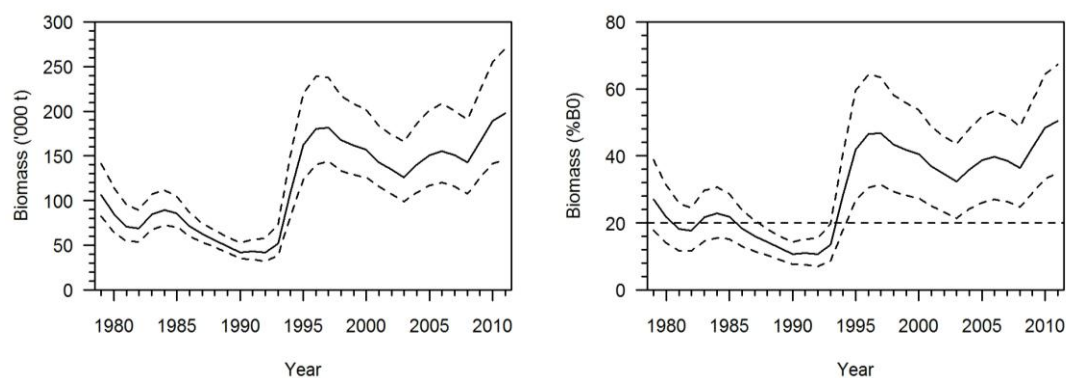
Figure 2: MCMC posterior plots of the biomass trajectories of (left) B_0 and (right) current biomass (%B_{2011}/B_0) for the Campbell Island stock for the base case.
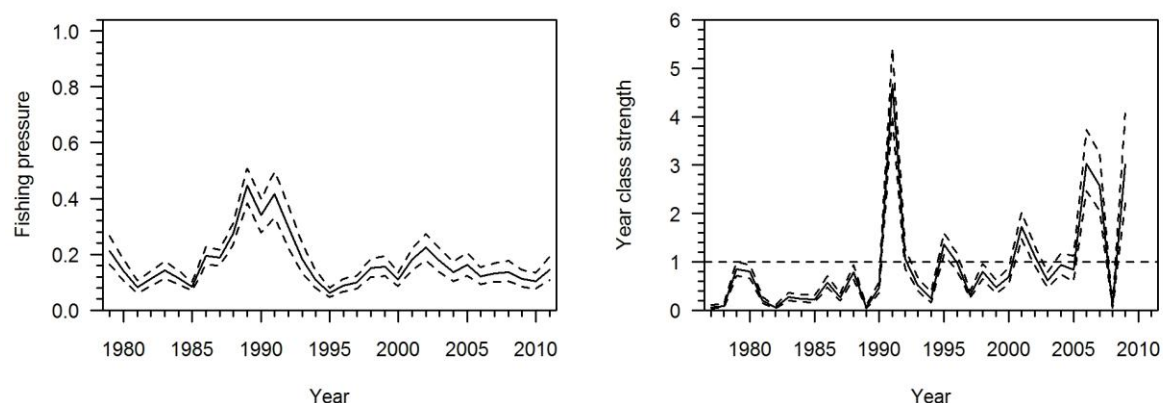
Figure 3: Estimated posterior distributions of (left) exploitation rates and (right) relative year class strength for the Campbell Island stock for the base case.

Projections were made assuming fixed catch levels of 30 000 t. Projections were made using the MCMC samples, with recruitments drawn randomly from the distribution of year class strengths for the period 1977–2008 estimated by the model and (i) applied from year 2009 onwards (i.e., ignoring

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the estimate of a high year class strength for 2009) or (ii) applied from year 2010 onwards. The two scenarios were chosen as the 2011 acoustic survey indicated that the size of the 2009 year class was likely to be large (from age 2 estimates), but this should be considered uncertain as the year class has not yet been observed entering the fishery.

For each scenario, the probability that the mid-season biomass for the specified year will be less than the threshold level (20% B_0) is given in Table 15. The probability of dropping below the threshold biomass at catch levels of 30 000 t is less than 10% for all models and all years. Under average recruitment conditions the biomass is expected to increase in the few years immediately after 2011, then begin to decline. The probability that the mid-season biomass for the specified year will be less than the limit reference biomass (B_{1991}) is reported in Table 15.

Table 15: Probability that the projected mid-season vulnerable biomass for 2012-2016 will be less than 20% B_0, and the median projected biomass (%B_0), at a projected catch of 30 000 t, for the base case model assuming average recruitment over the period 1997—2008 for 2009+ and for 2010+.

Catch (t)	Recruitment	Pr (SSB < 0.2B_0)					Median SSB (%B_0)				
		2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
30 000	2009+	0.00	0.00	0.00	0.01	0.03	53.2	52.5	49.0	45.4	41.7
	2010+	0.00	0.00	0.00	0.00	0.01	64.0	72.3	69.4	59.9	54.9

(ii) Bounty Platform stock (2010 assessment)

The assessment documented below was completed in 2010 and included data up to and including the 2009 season. It differs from the previous (2004) assessment primarily in the inclusion of the time series of industry based acoustic aggregation surveys from 2003 to 2009 as well as proportion-at-age data from 1990 to 2009.

Preliminary model runs did not provide a satisfactory fit to either the aggregation acoustic survey estimates or the proportion-at-age data. Hence, the development of the assessment focused on (i) freeing up the aggregation survey catchability between years so that the large variation in biomass estimates between years could be adequately fitted; (ii) constraining the aggregation survey estimates to have a similar q to that of the adult (4+) biomass from the wide area surveys; (iii) allowing the fishing selectivity to vary over time to allow for the conflict between the observations from the aggregation survey biomass estimates, and (iv) resolving computational difficulties when considering the 2002 year class estimate in the calculation of virgin biomass. The resulting stock assessments are likely to be highly dependent on these underlying assumptions, possibly over-parameterised, and the uncertainty may not be adequately reflected in the quantitative outputs.

Population dynamics and model structure

A two-sex, single stock and area Bayesian statistical catch-at-age model for the Bounty Platform southern blue whiting stock was implemented in CASAL (Bull *et al.* 2008). The model partitioned the stock into two sexes with age groups 2-11, with a plus group at age 11, and was run for the years 1979 to 2009. Five year projections were run for the years 2010-2014. The annual cycle was partitioned into two time steps. In the first time step (nominally the non-spawning season), 90% of natural mortality was assumed to have taken place. In the second time step (spawning season), fish ages were incremented; the 2-year-olds were recruited to the population, which were then subjected to fishing mortality and the remaining 10% of natural mortality. A two sex model was used because there are significant differences observed between males and females in both the proportions at age in the commercial catch for fished aged 2-4 (see later) and their mean size at age (Hanchet & Dunn 2010). The stock recruitment relationship was assumed to be Beverton-Holt with a steepness of 0.9, with the proportion of males at recruitment (at age 2) assumed to be 0.5 of all recruits.

Southern blue whiting exhibit large inter-annual differences in growth, presumably caused by local environmental factors but also closely correlated with the occurrence of the strong and weak year classes. Hence, an empirical size-at-age matrix was used which was derived by qualitatively reviewing the empirically estimated mean sizes-at-age from the commercial catch-at-length and -age data (Hanchet & Dunn 2010). Missing estimated mean sizes in the matrix were inferred from the

relative size of their cohort and the mean growth of similar ages in other years; and cohorts with unusually small or large increments were similarly adjusted. The mean size-at-ages in the future years were assumed for projections. The mean size in 2010 was calculated by adding the observed mean growth increment from 1990-2009 to each age class in 2009 to determine their expected sizes in 2010, with the mean size of aged 2 fish in 2010 assumed to be equal to the mean of the annual mean sizes of aged 2 fish from 1990-2009. By iteratively applying the above algorithm, the mean sizes for the years 2011-2014 were determined.

In general, southern blue whiting are assumed to be fully or almost fully selected by the fishery at either age four or five and not vulnerable to fishing at age one. It was assumed that fishing selectivities were logistic by sex, and that the maximum exploitation rate (Umax) was 0.8. Further, in order to include potential changes in selectivity either as a function of age or sex, both age-based selectivities with an annual shift parameter and size-based selectivities with an annual shift parameter were investigated. The choice of models with either age- or size-based selectivities are described later.

In previous models of southern blue whiting on the Bounty Platform (e.g., Hanchet & Dunn 2009a) fish available to the fishery were all assumed to be mature and spawning, with all of these fish equally likely to be vulnerable to fishing (i.e., a fishing selectivity was assumed that was equal to one for all mature fish). In the models presented here, the estimates of the maturity ogive were disentangled from the fishing selectivity. Hence, a fixed proportion of fish at age and sex was assumed to be mature, and a logistic shaped fishing selectivity was estimated for males and females respectively.

The model was started in 1990 and the numbers in the population at the start of the model were estimated for each age and sex separately (i.e., described as a Cinitial starting state in Bull *et al.* 2008). Estimates of the initial age structure were constrained so that the number of males within each age class was equal to the number of females within that age class. However, in developing the models for southern blue whiting on the Bounty Platform, it was found that in the exploratory model runs the estimates of the very large year class observed in 2002 were strongly confounded with model estimates of the overall mean recruitment, equilibrium (B_0), and initial abundance (Cinitial). To resolve this issue, the mean year class strength constraint was modified to exclude the 2002 year class, i.e., the constraint that the mean of the relative year class strengths for years 1988-2006 equal one was replaced with the constraint that the mean of the relative year class strengths for the years 1988-2001 and 2003-2006 combined equal one. This modification removed most of the confounding between key parameters, and resulted in much more numerically stable models.

Note that in other, similar assessment models, the equilibrium unexploited spawning biomass (B_0) is typically defined as being equal to the spawning biomass that there would have been if the mean relative year class strength was equal to one over some defined period and there was no fishing (see Bull *et al.* 2008 for rationale). Here, as we ignore the 2002 year class in the averaging process, we define the equilibrium unexploited spawning biomass as being equal to the spawning biomass that there would have been if the mean relative year class strength was equal to one over the period 1998-2001 and 2003-2006 combined with no fishing.

This modification has a number of consequences. First, projections that assume a mean relative year class strength of one ignore the possibility of a very strong year class like that observed in 2002, and second, biomass reference points will have a lower value than otherwise i.e., 20% B_0 will have a lower absolute value with this assumption than it would have if the 2002 year class was included in the calculations.

Observations

The model was fitted to two time series of acoustic biomass estimates and the proportion-at-age data from the fishery. One time series of acoustic biomass estimates came from a wide area survey series conducted by the research vessel Tangaroa in the years 1993-1996, 1997, 1999, and 2001 (Hanchet & Dunn 2010). The acoustic survey estimates were used as relative estimates of mid-season biomass (i.e., after half the catch has been removed), with associated CVs estimated from the survey analysis (Table 16).

The second time series of acoustic biomass estimates came from a series of southern blue whiting local area aggregation surveys carried out from industry vessels fishing the Bounty Platform (Table 7). It was assumed that the local area aggregation survey estimates were relative estimates of mid-season spawning stock biomass (i.e., after half the catch has been removed), with a CV equal to the sampling CV estimated from the survey. However, as the coverage was likely to have been different in each year, the series was assumed to be a time series with non-constant catchability, and hence the catchability coefficient (q) for each year was allowed to be an independent parameter in the model. In order to use these survey estimates and allow the biomass estimates to provide some information to the model, it was assumed that the local area aggregation survey catchability coefficients were related to the wide area acoustic survey estimates via a q ratio prior (see Section 6.5.7 of Bull *et al.* 2012 for detail). Hence a prior distribution on the ratio of catchabilities for the local area aggregation survey and the wide area surveys were specified, with the ratio prior assumed to be lognormally distributed and parameterised by a mean and CV

Catch-at-age observations by sex were available from the commercial fishery for the period 1990 to 2009. These catch-at-age data were fitted to the model as proportions-at-age, where estimates of the proportions-at-age and associated CVs by age were estimated using the NIWA catch-at-age software by bootstrap (Bull & Dunn 2002).

Table 16: R.V. *Tangaroa* age 2, 3 and 4+ acoustic biomass estimates for the Bounty Platform using the revised   target strength and sound absorption coefficient, 1993-2001 (Grimes *et al.* 2007).

Year	Age 2		Age 3		Age 4+	
	Biomass	CV	Biomass	CV	Biomass	CV
1993	11 347	0.25	777	0.37	47 087	0.64
1994	9 082	0.28	36 445	0.25	20 844	0.25
1995	7 108	0.32	7 874	0.34	23 480	0.24
1997	7 274	0.36	30 668	0.41	31 929	0.32
1999	1 134	0.33	5 618	0.62	34 194	0.73
2001	4 669	0.23	7 261	0.19	16 396	0.36

Estimation

Model parameters were estimated using Bayesian methods implemented using the NIWA stock assessment program CASAL v2.20 (Bull *et al.* 2008). Initial model fits were evaluated at the maximum of the posterior density (MPD) and by investigating model fits and residuals. For the final runs presented here, the full posterior distribution was sampled using Markov Chain Monte Carlo (MCMC) methods, based on the Metropolis-Hastings algorithm. MCMCs were estimated using a burn-in length of 1x106 iterations, with every 10 000th sample taken from the next 1x107 iterations (i.e., a systematic sample of length 1000 was taken from the Bayesian posterior). Chain diagnostic plots, autocorrelation estimates, and single chain convergence tests of Geweke (1992) and Heidelberger & Welch (1983) stationarity and half-width were used to determine evidence of non-convergence. The tests used a significance level of 0.05 and the diagnostics were calculated using the Bayesian Output Analysis software (Smith 2003).

Prior distributions and penalty functions

In general, the assumed prior distributions used in the assessment were intended to be non-informative with wide bounds (Table 17). The exceptions to this were the priors and penalties on biomass catchability coefficients and on relative year class strengths. The prior assumed for the relative year class strengths was lognormal, with mean 1.0 and CV 1.3, for all year classes except for the 2002 year class. To allow for the possibility that the 2002 year class was much stronger than average, the lognormal prior CV was modified to be less constraining and set to 10.

A log-normal prior was used for the wide area acoustic survey catchability coefficient with mean 1.0 and CV 0.2. The prior used for the wide area acoustic survey catchability coefficient was originally obtained using the approach of Cordue (1996), and was detailed by Hanchet (2002). Uncertainty over various factors, including mean target strength, acoustic system calibration, target identification, shadow or dead zone correction, and areal availability were included within the derivation of the prior. That

approach suggested a mean of 1.4 and CV 0.2 with bounds 0.1-2.8. Following the recalibration of the acoustic estimates with revised estimates of the target strength relationship and sound absorption coefficients, the Middle Depths Working Group revised the prior to have mean 1.0 with CV 0.2, and retained the same bounds.

Priors for the local area aggregation surveys were non-informative, but a q ratio prior was added to encourage the estimates to be specific ratios of the wide area acoustic catchability coefficient. The specification of the q ratio priors was based on the assumption that (i) the wide area surveys covered all of the vulnerable population, (ii) the 2004, 2007, and 2008 local area aggregation surveys also covered all of the vulnerable population, and (iii) the 2006 and 2009 surveys missed a large, but unknown, proportion of the vulnerable population.

Two alternative model scenarios were implemented. The first assumed a prior that strongly constrained the catchability coefficients of the 2004, 2007, and 2008 surveys to be very like the catchability coefficient of the wide area surveys (tight prior), and the second where this assumption was relaxed to be less constraining (diffuse prior). The values of the prior assumed for the q ratio for each survey and for the two scenarios are given in Table 18.

Lognormal errors, with known CVs, were assumed for the relative biomass and proportions-at-age data. The CVs available for these data allow for sampling error only. However, additional variance, assumed to arise from differences between model simplifications and real world variation, was added to the sampling variance. The additional variance, termed process error, was estimated in each of the initial runs (MPDs) using all the available data. Process errors were estimated separately for the proportion-at-age data, and for the acoustic estimates from the wide area and local area aggregation surveys.

Table 17: The distributions, priors, and bounds assumed for the various parameters being estimated for the Bounty Platform stock assessment (q ratio priors are given in Table 18).

Parameter	N	Distribution	Mean	CV	Lower	Upper
B_0	1	Uniform-log	-	-	20 000	250 000
Initial population (by sex)	10	Uniform	-	-	2e2	2e9
Male fishing selectivity	2	Uniform	-	-	1	20
Female fishing selectivity	2	Uniform	-	-	0.02	20
Selectivity shift parameters	3	Uniform	-	-	-20	20
Year class strength	19	Lognormal	1.0	1.3 [1]	0.001	100
Wide area catchability 4+ q	1	Lognormal	1.0	0.2	0.1	2.8
Wide area catchability 3+ q	1	Uniform	-	-	0.1	2.8
Wide area catchability 2+ q	1	Uniform	-	-	0.1	2.8
2004 local area catchability q	1	Uniform	-	-	0.1	2.8
2006 local area catchability q	1	Uniform	-	-	0.1	2.8
2007 local area catchability q	1	Uniform	-	-	0.1	2.8
2008 local area catchability q	1	Uniform	-	-	0.1	2.8
2009 local area catchability q	1	Uniform	-	-	0.1	2.8

Note 1: Except for 2002. Here the CV = 10.

Table 18: Aggregation survey biomass estimates for the Bounty Platform (with the revised target strength and sound absorption coefficient) from O'Driscoll (2011b) and the assumed q ratio prior, 2004-2009.

Year	Biomass	CV	Reference	Tight prior μ	Tight prior CV	Diffuse prior μ	Diffuse prior CV
2004	13 473	0.69	(O'Driscoll & Hanchet 2004)	1.00	0.05	1.00	0.50
2006	21 765	0.12	(O'Driscoll et al. 2006)	0.50	0.50	0.50	0.50
2007	159 589	0.19	(O'Driscoll et al. 2007)	1.00	0.05	1.00	0.50
2008	144 187	0.34	(O'Driscoll & Dunford 2008)	1.00	0.05	1.00	0.50
2009	28 242	0.21	(O'Driscoll et al. 2009)	0.50	0.30	0.50	0.30

Model runs and sensitivity tests

As a result of preliminary investigations the WG agreed on two main scenarios for modelling the Bounty Platform stock. The first assumed age-based selectivity ogives for the fishery, but with an annual

shift parameter for the years 2005-2007. The second made the same assumptions for the model population structure and selectivity shifts, but assumed that the fishing selectivities were size-based.

Further, in order to investigate the impact of the q ratio prior assumption on the models outputs, we investigated 'tight' and 'diffuse' prior assumptions. The first assumed a prior that strongly constrained the catchability coefficients of the 2004, 2007, and 2008 surveys to be very like the catchability coefficient of the wide area surveys (tight priors, Table 18), and the second where this assumption was relaxed to be less constraining (diffuse priors, Table 18). These four model runs are summarised in Table 19.

Table 19: Model run labels and descriptions for the model runs.

Model type	Label	Description
Final Models	3.4	Age-based fishing selectivity with 'tight' q ratio priors (3 fisheries)
	3.6	Size-based fishing selectivity with 'tight' q ratio priors (3 fisheries)
	4.4	Age-based fishing selectivity with 'diffuse' q ratio priors (3 fisheries)
	4.6	Size-based fishing selectivity with 'diffuse' q ratio priors (3 fisheries)

Results

MCMC diagnostics showed that the trace plots for the key parameters (B_0 and B2009) were not ideal and showed some evidence of large scale correlation between iterations. The lag plots for the tight prior models identified problems with some autocorrelation in parameters for up to 6000-7000 iterations. In contrast, there was little evidence for similar autocorrelations in the diffuse prior models (4.4 and 4.6). Plots of median jump size indicated that the shift parameters for the 2005-2007 selectivity shift for the 2007 year for models 3.4 and 4.4 had poor chain performance. This was also indicated by chain convergence tests of Geweke (1992) and Heidelberger & Welch (1983) stationarity and half-width tests that tended to indicate some evidence for poor convergence of at least one of the shift parameters in all of the models.

The MCMC posterior plots for B_0 and current biomass (%B2009/B_0) are shown for the four models in Figures 4-7 and the results summarised in Table 20. Median estimates of B_0 were similar across models and ranged from 60 000 to 73 000 t. Estimates of B_0 from the diffuse prior models (4.4 and 4.6) were slightly higher than the estimates from the tight prior models (3.4 and 3.6). Median estimates of B2009 were much more variable, ranging from 82 000 to 150 000 t. The highest estimates of B2009 came from the tight prior model with the size based fishing selectivity (model 3.6). The other three models were more similar with estimates of B2009 ranging from 82 000 to 105 000 t.

Estimates of the adult (4+) catchability coefficient q for the wide area surveys were reasonably similar for the four models ranging from 0.98-1.23. However, in order to fit the various acoustic local area aggregation surveys the estimates of q from the individual aggregation surveys ranged from 0.33 to 2.05 across the various model runs and surveys fitted. The catchability coefficients need to be interpreted with some caution because they are fitted to the model biomass estimates via the selectivity ogive and the selectivity ogive was right shifted (by about a year) for the two size-base selectivity models 3.6 and 4.6. (This means that the qs for model 3.4 should be best compared with model 4.4 and for model 3.6 should be compared with model 4.6). Notwithstanding this, the estimates of the adult acoustic q for southern blue whiting should be reasonably close to 1, and the median estimates from model runs 3.6, 4.4 and 4.6 for the 2007 and 2008 surveys might be less plausible. The estimates of adult acoustic q for model 3.4 are the most plausible across the entire time series of wide area and aggregation surveys.

After the modelling work was completed, an additional aggregation survey was carried out on the Bounty Platform in August 2010 (see Table 7). Two snapshots were completed during the survey which appeared to fully cover the spawning aggregation. The estimate of adult biomass from the two snapshots was similar to that recorded for 2009. O'Driscoll (2011a) explored various reasons for the much lower observed biomass estimates from the surveys in 2009 and 2010 compared with 2007 and 2008, including changes in survey methodology, equipment (including calibration), and changes in timing and extent of survey coverage, but could find no reason for these low estimates. Given the conclusions of

O'Driscoll (2011a) and the low biomass estimates in 2009 and 2010, the Working Group concluded that the estimates of current biomass calculated from the model were likely to be biased high. It further noted that some of the model assumptions (e.g., the assumption of a constant rate of natural mortality or the priors on the acoustic surveys for 2007-2009) will need to be investigated to resolve the inconsistency.

Table 20: Bayesian estimates of median and credible intervals of (B_0), initial, and current biomass for the model runs.

Model	B_0	B_{2009}	B_{2009} (%B_0)
Model 3.4	60 710 (53 270-72 930)	105 020 (88 470-125 170)	173 (143-210)
Model 3.6	62 100 (55 720-70 550)	150 420 (132 990-171 920)	242 (206-283)
Model 4.4	73 180 (61 030-94 010)	82 080 (51 190-130 270)	111 (74-162)
Model 4.6	69 580 (60 150-82 830)	92 290 (57 510-138 330)	132 (88-186)
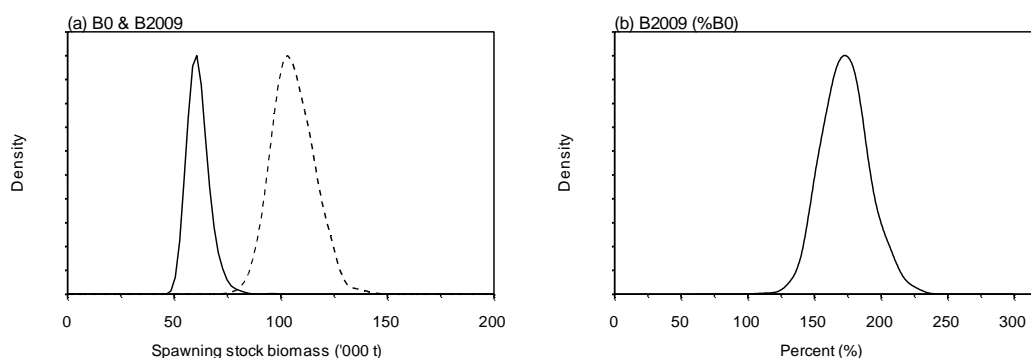
Figure 4: MCMC posterior plots for (a) B_0 and (b) current biomass (%B_{2009}/B_0) for model 3.4.
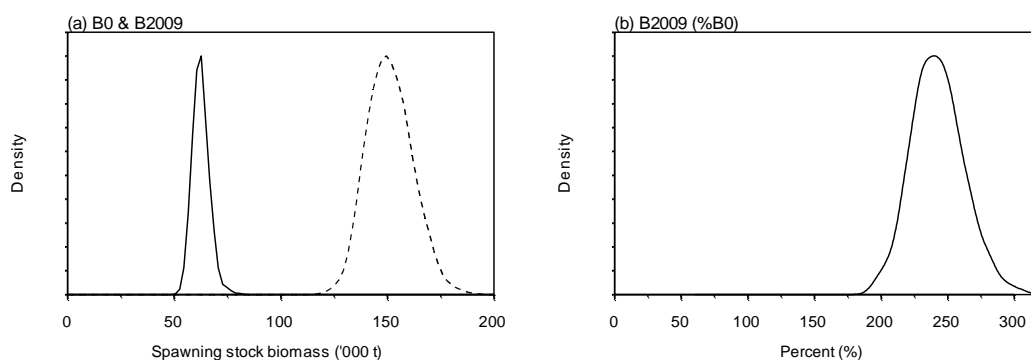
Figure 5: MCMC posterior plots for (a) B_0 and (b) current biomass (%B_{2009}/B_0) for model 3.6.
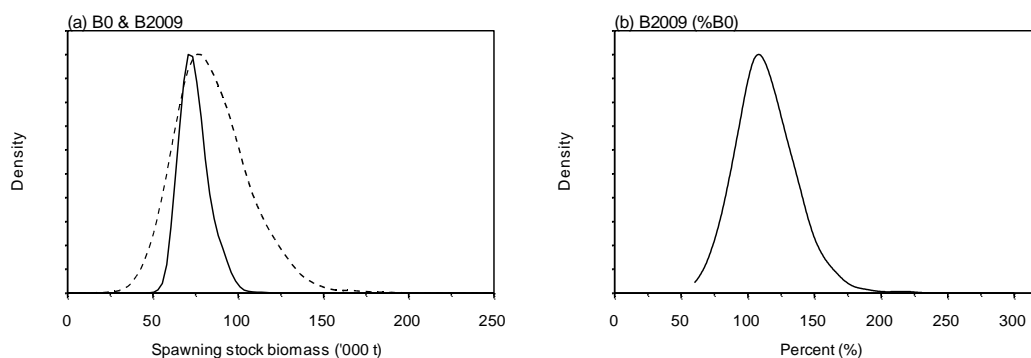
Figure 6: MCMC posterior plots for (a) B_0 and (b) current biomass (%B_{2009}/B_0) for model 4.4.
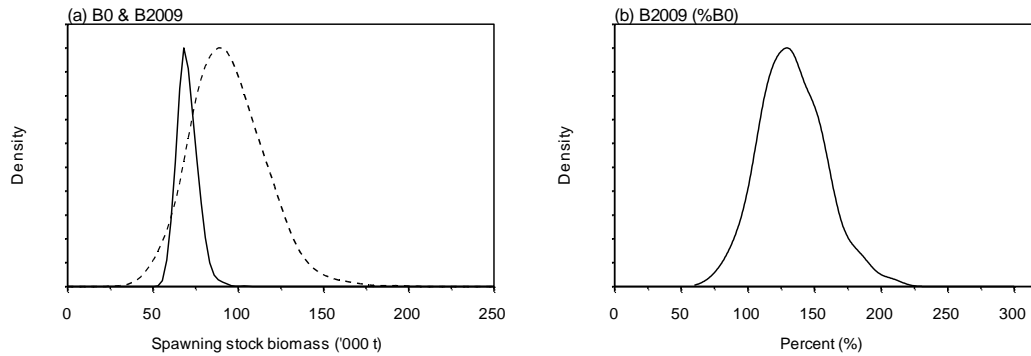
Figure 7: MCMC posterior plots for (a) B_0 and (b) current biomass ($\%B_{2009}/B_0$) for model 4.6.

(iii)   Pukaki Rise stock

A new assessment of the Pukaki Rise stock was carried out in 2002. The sSPA model was used to estimate the numbers at age in the initial population in 1989 and subsequent recruitment. The model estimates selectivity for ages 2, 3, and 4 and assumes that the selectivity after age 4 is 1.0. No stock-recruitment relationship is assumed in the sSPA.

Preliminary runs of the model were fitted to proportion-at-age data from 1989 to 2000, and the acoustic indices given in Table 21, which differ from those in Table 8 because they were calculated with an older estimate of target strength and sound absorption. The indices were fitted in the model as relative estimates of mid-season biomass (i.e., after half the catch has been removed), with the CVs as shown in Table 22. The proportion-at-age data are assumed to be multinomially distributed with a median sample size of 50 (equivalent to a CV of about 0.3). Details of the input parameters for the initial and sensitivity runs are given in Table 22.

Table 21: R.V. *Tangaroa* age 2, 3 and 4+ acoustic biomass estimates (t) for the Pukaki Rise used in the 2002 assessment. Estimates differ from those in Table 8 because they were calculated with old estimates of target strength and sound absorption.

Year	Age 1	Age 2	Age 3	Age 4+
1993	578	26 848	9 315	31 152
1994	13	1 193	6 364	35 969
1995	0	102	775	11 743
1997	22	2 838	864	34 086
2000	58	7 268	5 577	24 931

Table 22: Values for the input parameters to the separable Sequential Population Analysis for the initial run and sensitivity runs for the Pukaki Rise stock.

Parameter	Initial run	Sensitivity runs
M	0.2	0.15, 0.25
Acoustic age 3 and 4+ indices *CV*	0.3	0.1, 0.5
Acoustic age 1, 2 indices *CV*	0.7	0.5, 1.0
Weighting on proportion-at-age data	50	5, 100
Years used in analysis	1989-2000	1979-2000
Acoustic *q*	estimated	0.68, 1.4, 2.8

Biomass estimates in the initial run and also in the sensitivity runs all appeared to be over-pessimistic because the adult (4+) acoustic *q* was very high. For example, for the initial run the 4+ acoustic *q* was estimated to be 2.7. The WG did not accept this initial run as a base case assessment, but agreed to present a range of possible biomass estimates. The Plenary also agreed to present a range, based on assumptions concerning the likely range of the value for the acoustic *q*.

Bounds for the adult (4+) acoustic *q* were obtained using the approach of Cordue (1996). Uncertainty over various factors including mean target strength, acoustic system calibration, target identification, shadow or dead zone correction, and areal availability were all taken into account. In addition to obtaining the bounds, a 'best estimate' for each factor was also calculated. The factors were then

multiplied together. This independent evaluation of the bounds on the acoustic q suggested a range of 0.65-2.8, with a best estimate of 1.4. Clearly the q from the initial run is almost at the upper bound and probably outside the credible range. When the model was run fixing the acoustic q at 0.65 and 2.8, estimates of B_0 were 18 000 t and 54 000 t, and estimates of B_{2000} were 8000 t and 48 000 t respectively (Table 23, Figure 8). Within these bounds current biomass is greater than B_{MAY}. Assuming the 'best estimate' of q of 1.4 gave B_0 equal to 22 000 t and B_{2000} equal to 13 000 t.

Based on the range of stock biomass modelled in the assessment, the average catch level since 2002 (380 t) is unlikely to have made much impact on stock size. A more intensive fishery or more consistent catches from year to year would seem to be required to provide any contrast in the biomass indices. This stock has been only lightly exploited since 1993, when over 5000 t was taken in the spawning season.
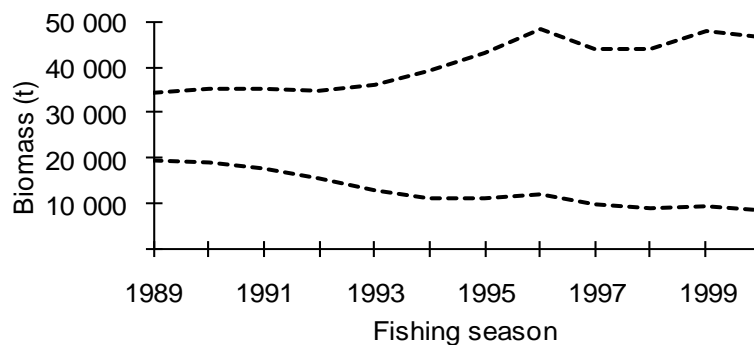
Figure 8: Mid-season spawning stock biomass trajectory bounds for the Pukaki Rise stock. Bounds based on acoustic q of 0.65 and 2.8.

Table 23: Parameter estimates for the Pukaki stock as a result of fixing the adult 4+ acoustic q at various values. B_{mid}, mid-season spawning stock biomass; $N_{2,1992}$ size of the 1990 year class (millions). All values in t x 10^3.

Fixing the acoustic q value	B_0	$B_{mid\ 89}$	$B_{mid\ 00}$	$N_{2,1992}$	$B_{mid\ 00}$ (%B_0)	$B_{mid\ 00}$ (%B_{may})
$q = 0.65$	54	36	48	63	88	246
$q = 1.4$	22	22	13	28	58	161
$q = 2.8$	18	19	8	23	44	123

(iv) Auckland Islands stock

No estimate of current biomass is available for the Auckland Islands Shelf stock. The acoustic estimate of the adult biomass in 1995 was 7800 t.

4.3 Other yield estimates and stock assessment results

Decision tables

As an alternative to the *CAY* estimates, the results have been presented in the form of decision tables. In the Campbell Island Rise assessment the probability of biomass falling below the limit biomass level (1991 biomass) is presented for a catch level of 30 000 t (Table 15).

4.4 Additional stock assessment results for the Bounty Platform

Since the 2010 stock assessment was completed, two aggregation surveys have been carried out on the Bounty Platform in 2010 and 2011. Both surveys appeared to fully cover the spawning aggregation. The estimate of adult biomass from the two surveys was similar to that recorded in 2009 but considerably lower than that for surveys in 2007 and 2008 (see Table 7). O'Driscoll (2011a) explored various reasons for the much lower observed biomass estimates from the surveys in 2009 and 2010 compared with 2007 and 2008, including changes in survey methodology, equipment (including calibration), and changes in timing and extent of survey coverage, but could find no reason for these low estimates. The authors re-iterated the need to adequately survey the entire aggregation, ensure that some snapshots were carried out whilst fish were actively spawning, and recommended

that 'wide area' surveys encompassing the likely adult distribution on the spawning grounds be considered. Given the conclusions of O'Driscoll (2011a) and the low biomass estimates in 2009, 2010, and 2011 the Working Group therefore concluded that the estimates of current biomass from the stock assessment were likely to be biased high. In order to provide advice on sustainable yields for the Bounty Platform stock for the 2012-13 fishing year, the Working Group agreed to use the most recent aggregation acoustic survey as the basis for determining yield estimates for management of the fishery.

In making these calculations the Working Group assumed:

a. That the acoustic survey biomass estimate in each year was equal to midseason vulnerable biomass available in each year and had lognormally distributed errors.
b. That the 80% quantiles (i.e., the 10th and 90th percentiles) represent an adequate bound on the sampling uncertainty in the acoustic estimates.
c. That an adequate representation of uncertainty in the target strength of southern blue whiting is ±3 dB, which approximates to a doubling or halving of the resulting biomass calculated from the target strength relationship.
d. That the combined effects of recruitment, the increase or change in mean weight from the growth of individuals, and natural mortality over a one year time frame are negligible and can be ignored.
e. That the biomass was measured after half of the reported catch had been taken.
f. That the maximum exploitation rate possible for the fleet in future years is 100%.

The absolute estimates of southern blue whiting biomass from the 2007-2011 industry acoustic surveys for the 80% intervals and with a ±3 dB uncertainty in the acoustic biomass estimates are given in Table 24.

Assuming that an appropriate exploitation rate for southern blue whiting is 0.20 (i.e., the U_{CAY} that was previously calculated for southern blue whiting on the Bounty Platform in the most recent assessment), and that the total catch taken in 2011 was 6590 then expected *CAY* proxy yields for the biomass estimates in Table 24 for the following year is given in Table 25. Under the assumptions above, the estimate of the *CAY* proxy yield from the 2011 local area aggregation survey projected forward for 2012 was 6460 t with a lower uncertainty bound between 2 901 t and 4 162 t.

The WG noted that there were possible indications of another strong year class (the 2007 cohort) in the 2011 catch at age data. Another acoustic survey is planned for 2012 on the Bounty Platform stock.

Table 24: Absolute estimates of midseason southern blue whiting vulnerable biomass (±3 dB) from the 2011 local area aggregation acoustic surveys, ignoring any corrections for the potential bias in the catchability coefficient, *q*.

| Year | Option | TS multiplier | Biomass estimate | | |
			10th percentile	Mean	90th percentile
2011	Snapshot	0.5	12 050	17 800	24 370
	6 & 7	1.0	24 110	35 600	48 750
		2.0	48 210	71 190	97 490

Table 25: Approximate *CAY* proxy yields for southern blue whiting biomass from the 2011 local area aggregation acoustic survey, assuming the combined effect on the biomass in the year following the survey from recruitment, change in mean weight, and natural mortality is negligible; and ignoring a correction for the potential bias in the catchability coefficient, *q*.

| Survey year | Yield Year | Option | TS multiplier | Biomass estimate | | |
				10th percentile	Mean	90th percentile
2011	2012	Snapshots	0.5	1 752	2 901	4 216
		6 & 7	1.0	4 162	6 460	9 090
			2.0	8 983	13 580	18 839

5. STATUS OF THE STOCKS

Stock Structure Assumptions
Southern blue whiting are assessed as four independent biological stocks, based on the presence of four main spawning areas (Auckland Islands Shelf, Bounty Platform, Campbell Island Rise, and Pukaki Rise), and some differences in biological parameters and morphometrics between these areas (Hanchet 1999).

The four main stocks SBW6A (Auckland Islands), SBW6B (Bounty Platform), SBW6I (Campbell Island Rise), and SBW6R (Pukaki Rise) cover the four main bathymetric features in the Subantarctic QMA6. SBW1 is a nominal stock covering the rest of the New Zealand EEZ where small numbers of fish may occasionally be taken as bycatch.

- **Auckland Islands (SBW 6A)**

Stock Status	
Year of Most Recent Assessment	-
Assessment Runs Presented	-
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Unknown
Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Catches have fluctuated without trend
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	No reliable indices of abundance
Trends in Other Relevant Indicators or Variables	Catch in 2007 and 2008 dominated by large (40-50 cm long) fish - no sign of recent strong year classes.

Projections and Prognosis	
Stock Projections or Prognosis	N/A
Probability of Current Catch or TACC causing decline below Limits	Unknown

Assessment Methodology		
Assessment Type	Level 4 - Low information	
Assessment Method	None	
Main data inputs	Catch history - erratic catches with no trend Limited catch-at-age data (1993-1998) and 2008.	
Period of Assessment	None	Next assessment:
Changes to Model Structure and Assumptions	N/A	
Major Sources of Uncertainty	No reliable time series of data available. Catches have been erratic for the past 10 years and have been taken as bycatch in other middle depth fisheries so unlikely to provide reliable CPUE indices.	

Qualifying Comments
There were several years of high catches (700-1100 t) during the mid 1990s but since then annual catches have averaged about 100 t. Good recruitment in southern blue whiting tends to be episodic and

it is likely that the period of high catches was due to the presence of the strong year 1991 year class. Catches will probably remain low until another strong year class enters the fishery.	

Fishery Interactions

The main incidental captures of concern at the Auckland Islands are New Zealand sea lions. There was virtually no fish bycatch when it was a target fishery during the mid 1990s.

- **Bounty Platform (SBW 6B)**

Stock Status

Year of Most Recent Assessment	2011
Assessment Runs Presented	A matrix of current biomass estimates was presented based on using acoustic survey estimates as absolute abundance under a range of assumptions. B_0 was not estimated.
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Unknown if the current biomass is below the Soft Limit Unknown if the current biomass is below the Hard Limit
Historical Stock Status Trajectory and Current Status	Unknown

Fishery and Stock Trends

Recent Trend in Biomass or Proxy	Biomass was Unlikely ($< 40\%$) to have been above the target level from 1993 to 2005 but, with the recruitment of the very strong 2002 year class, the stock increased to be at or above pre-exploitation levels until 2008 but has subsequently declined.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	The assessment is based on estimates of absolute abundance from acoustic surveys conducted on industry vessels.
Trends in Other Relevant Indicators or Variables	Recruitment was estimated to be relatively low from 1995 to 2001 but was extremely high in 2002 and has been relatively low since then. The 2007 year class appears to be higher than 2003–2006.

Projections and Prognosis

Sock Projections or Prognosis	The biomass of the Bounty stock is expected to decrease over the next 5 years at the current catch level as the 2002 year class is fished down
Probability of Current Catch or TACC causing decline below Limits	Unknown

Assessment Methodology

Assessment Type	Level 2 - Partial quantitative stock assessment	
Assessment Method	Proxy *CAY* yield based on absolute biomass estimates from the 2011 aggregated acoustic survey	
Main data inputs	Absolute biomass estimates from acoustic survey of spawning aggregations conducted in 2011	
Period of Assessment	Latest assessment: 2011	Next assessment: 2012
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	Biomass estimates use an estimate of target strength that is	

	uncertain. The reason for the change in biomass since 2008 is unknown (see below).

Qualifying Comments

The catch at age data for the last four years have been dominated by the strong 2002 year class. Local area aggregation acoustic surveys carried out in 2007 and 2008 suggested that this was an extremely strong year class, and suggested biomass of 140 000-160 000 t. However, recent surveys in 2009, 2010, and 2011 have suggested a biomass of 25 000 -30 000 t. The observed decline is too great to be explained solely by fishing and average levels of natural mortality of the 2002 year class and it is only possible to speculate on the causes of this decline. Suggested causes include an unusually high natural mortality.
Note: The TAC was reduced to 6860 t from 1 April 2011.

Fishery Interactions

The main incidental capture of concern is of NZ fur seals. There is virtually no fish bycatch in the fishery.

- **Campbell Island Rise (SBW 6I)**

Stock Status

Year of Most Recent Assessment	2012
Assessment Runs Presented	Base Case Stock Assessment Model
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	B_{2011} was estimated to be 50% B_0 and is Likely (> 60%) to be at or above the target
Status in relation to Limits	B_{2011} is Exceptionally Unlikely (< 1%) to be below soft or hard limits

Historical Stock Status Trajectory and Current Status
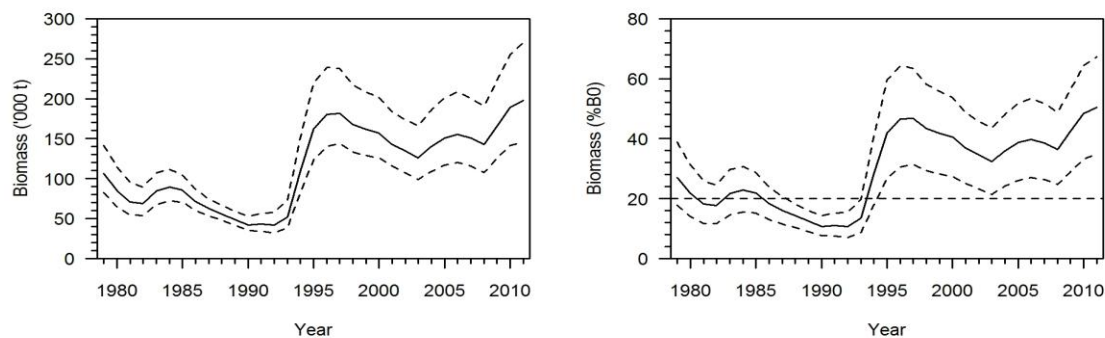
Trajectory over time of spawning biomass (absolute, and %B_0, with 95% credible intervals shown as broken lines) for the Campbell Island stock from the start of the assessment period in 1979 to 2011 (the final assessment year). Years on the x-axis indicate fishing year with "2005" representing the 2004-05 fishing year. Biomass estimates are based on MCMC results.

Fishery and Stock Trends

Recent Trend in Biomass or Proxy	Biomass was likely to have been below the management target around 1990 and at or above the management target since 2000. With strong recent recruitment the biomass is now increasing.
Recent Trend in Fishing Mortality or Proxy	Fishing pressure has reduced with the increase in stock size.
Other Abundance Indices	-

Trends in Other Relevant Indicators or Variables	The 2006 and 2007 year classes appear to be exceptionally strong, but slightly less than the 1991 year class. Acoustic estimates of age 2 fish indicate the 2009 year class will likely be strong.

Projections and Prognosis

Stock Projections or Prognosis	The biomass of the Campbell stock is expected to increase over the next 1-2 years as the strong recent year classes grow and enter the fishery. The TAC was increased to 30,000 t from 1 April 2011.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Exceptionally Unlikely ($< 1\%$) over next 2-3 years Hard Limit: Exceptionally Unlikely ($< 1\%$) over next 2-3 years

Assessment Methodology

Assessment Type	Level 1 - Quantitative Stock Assessment	
Assessment Method	Age-structured CASAL model with Bayesian estimation of posterior distributions.	
Main data inputs	- Research time series based on acoustic indices - Proportions-at-age data from the commercial fisheries and trawl surveys - Estimates of biological parameters	
Period of Assessment	Latest assessment: 2012	Next assessment: 2014
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty	Uncertainty about the size of recent year classes affects the reliability of stock projections. The data suggest that the 2009 year class is strong, but there is only one observation on this year class.	

Qualifying Comments

-

Fishery Interactions

The main incidental capture species of concern is the New Zealand sea lion. There is virtually no fish bycatch in the fishery.

- **Pukaki Rise (SBW 6R)**

Stock Status

Year of Most Recent Assessment	2002
Assessment Runs Presented	The results of three runs were presented assuming different values for the adult acoustic q.
Reference Points	Interim Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Current status unknown. Believed to be only lightly exploited between 1993 and 2002
Status in relation to Limits	Current status unknown. Believed to be only lightly exploited between 1993 and 2002
Historical Stock Status Trajectory and Current Status	Unknown

Fishery and Stock Trends

Recent Trend in Biomass or Proxy	Catches over the last 10 years have fluctuated without trend
Recent Trend in Fishing	Unknown

Mortality or Proxy	
Other Abundance Indices	No current reliable indices of abundance (wide area surveys were discontinued in 2000)
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis (2002)	
Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing decline below Limits	Unknown

Assessment Methodology		
Assessment Type	Level 1 - Full Quantitative Stock Assessment	
Assessment Method	Age structured separable Sequential Population Analysis (sSPA) with maximum likelihood estimation	
Main data inputs	Abundance indices from wide area acoustic surveys Catch-at-age data	
Period of Assessment	Last assessment: 2002	Next assessment: 2013
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty	The adult acoustic q was estimated in the model to be 2.7 which the Working Group thought was unrealistically high. A run based on a more plausible value for q suggested the 2000 biomass was above 50% B_0.	

Qualifying Comments
Fishers reported large aggregations of fish and made good catches in 2009. However, aggregation surveys by industry vessels in 2009 yielded generally low biomass estimates which were at a level consistent with that during the 1990s. The Subantarctic trawl surveys may provide an index of abundance for this stock, but this has yet to be determined. Catch at age data are available for 2007 and 2009 and suggest the catch is dominated by relatively young fish from the 2003-2006 year classes.

Fishery Interactions
There is little fish bycatch or marine mammal incidental captures in the target fishery.

Table 26: Summary of TACCs and preliminary estimates of landings (t) (1 April-31 March fishing year).

Area	2011-12 Actual TACC	2011-12 Landings
SBW 1 (EEZ excluding Sub-Antarctic)	8	2
Campbell Island	29 400	30 840
Bounty Platform	6 860	6 590
Pukaki Rise	5 500	677
Auckland Islands Shelf	1 640	65
Total	43 408	38 174

6.   FOR FURTHER INFORMATION

Abraham E.R., Thompson F.N., Oliver M.D. 2010. Summary of the capture of seabirds, mammals, and turtles in New Zealand commercial fisheries, 1998-99 to 2007-08. New Zealand Aquatic Environment and Biodiversity Report No.45.

Abraham E.R., Thompson F.N. 2011. Summary of the capture of seabirds, marine mammals, and turtles in New Zealand commercial fisheries, 1998–99 to 2008–09 New Zealand Aquatic Environment and Biodiversity Report No. 80.

Baird S.J. 2004a. Estimation of the incidental capture of seabird and marine mammal species in commercial fisheries in New Zealand waters, 1999-2000. New Zealand Fisheries Assessment Report 2004141.56 p.

Baird SJ. 2004b. Incidental capture of seabird species in commercial fisheries in New Zealand waters,2000-01. New Zealand Fisheries Assessment Report 2004158.63 p.

Baird S.J. 2004c. Incidental capture of seabird species in commercial fisheries in New Zealand waters, 2001-02. New Zealand Fisheries Assessment Report 2004160.51 p.

Baird S.J 2005. Incidental capture of seabird species in commercial fisheries in New Zealand waters, 2002-03. New Zealand Fisheries Assessment Report 200512.50 p.

Baird S.J., Smith M.H. 2007. Incidental capture of New Zealand fur seals (Arctocephalus forsteri) in commercial fisheries in New Zealand waters, 2003–04 to 2004–05. New Zealand Aquatic Environment and Biodiversity Report No. 14. 98 p.

Baird S.J., Wood B.A., *et al*. 2011. Nature and extent of commercial fishing effort on or near the seafloor within the New Zealand 200 n. mile Exclusive Economic Zone, 1989-90 to 2004-05. New Zealand Aquatic Environment and Biodiversity Report 73. 143 p.

Baird S.J., Wood B.A. 2012. Extent of coverage of 15 environmental classes within the New Zealand EEZ by commercial trawling with sealoor contact. New Zealand Aquatic Environment and Biodiversity Report 89. 43 p.

Baker C.S., Chilvers B.L., Constantine R., DuFresne S., Mattlin R.H., van Helden A., Hitchmough R. 2010. Conservation status of New Zealand marine mammals (suborders Cetacea and Pinnipedia), 2009. New Zealand Journal of Marine and Freshwater Research 44: 101-115.Ballara, S.L.; Anderson, O.F. (2009). Fish discards and non-target fish catch in the trawl fisheries for arrow squid and scampi in New Zealand waters. New Zealand Aquatic Environment and Biodiversity Report No. 38. 102 p.

Brothers N, Duckworth AR, Safina C, Gilman EL. (2010). Seabird bycatch in pelagic longline fisheries is grossly underestimated when using only haul data. PloS One 5: e12491. doi: 10.1371/journal.pone.001249

Bull B., Dunn A. 2002. Catch-at-age: User manual v1.06.2002/09/12. NIWA Internal Report 114. 23 p. NIWA. (Unpublished report).

Bull B., Francis RICC., Dunn A., Gilbert DJ., Bian, R., Fu, D. 2012. CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v2.30.2012/03/21. NIWA Technical Report 135. 280p.

Cordue PL. 1996. A model-based method for bounding virgin biomass using a catch history, relative biomass indices, and ancillary information. New Zealand Fisheries Assessment Research Document 1996/8. 48p.

Dunford A. 2003. Review and revision of southern blue whiting (*Micromesistius australis*) target strength. Final Research Report for Ministry of Fisheries Research Project SBW2001/02 Objective 2. 16 p. (Unpublished report held by the Ministry of Fisheries, Wellington.)

Dunford A.J.; Macaulay, G.J. 2006. Progress in determining southern blue whiting (*Micromesistius australis*) target strength: results of swimbladder modelling. *ICES Journal of Marine Science 63*: 952-955.

Dunn A., Grimes PJ., Hanchet SM. 2001. Comparative evaluation of two-phase and adaptive cluster sampling designs for acoustic surveys of southern blue whiting (*M. australis*) on the Campbell Rise. Final Research Report for MFish Research Project SBW1999/01. Objective 1. 15 p. (Unpublished report held by the Ministry of Fisheries, Wellington.)

Dunn, A., Hanchet, S.M. (2011). Southern blue whiting (Micromesistius australis) stock assessment for the Bounty Platform for 2009–10. New Zealand Fisheries Assessment Report 2011/26. 30 p.

Dunn, A., Hanchet, S.M. (2011). Southern blue whiting (Micromesistius australis) stock assessment for the Campbell Island Rise for 2009–10. New Zealand Fisheries Assessment Report 2011/40. 37 p.

Francis RICC. 1992. Recommendations concerning the calculation of maximum constant yield (*MCY*) and current annual yield (*CAY*). New Zealand Fisheries Assessment Research Document 1992/8. 27p.

Gauthier, S.; Fu, D.; O'Driscoll, R.L.; Dunford, A. 2011. Acoustic estimates of southern blue whiting from the Campbell Island Rise, August-September 2009. New Zealand Fisheries Assessment Report 2011/xx, 40 p.

Grimes P., Fu, D., Hanchet, S.M. 2007. Estimates of biomass and CVs of decomposed age classes of southern blue whiting from previous acoustic surveys from 1993 to 2004 using a new target strength - fish length relationship. Final Research Report for MFish Research Project SBW2005-01. 34 p. (Unpublished report held by the Ministry of Fisheries, Wellington.)

Hanchet S.M. 1991. Southern blue whiting fishery assessment for the 1991-92 fishing year. New Zealand Fisheries Assessment Research Document 1991/7. 48p.

Hanchet S.M. 1999. Stock structure of southern blue whiting (*Micromesistius australis*) in New Zealand waters. New Zealand Journal of Marine and Freshwater Research 33(4): 599-610.

Hanchet S.M. 2002. Southern blue whiting (*Micromesistius australis*) stock assessment for the Bounty Platform for 2002 and 2003. New Zealand Fisheries Assessment Report 2002/53. 23p.

Hanchet S.M. 2005. Southern blue whiting (*Micromesistius australis*) stock assessment for the Bounty Platform for 2004-05. New Zealand Fisheries Assessment Report 2005/45. 36p.

Hanchet S.M. 2005. Southern blue whiting (*Micromesistius australis*) stock assessment update for the Campbell Island Rise for 2005. New Zealand Fisheries Assessment Report 2005/40. 40p.

Hanchet S.M. 2005. Southern blue whiting (Micromesistius australis) stock assessment for the Bounty Platform for 2004-05. New Zealand Fisheries Assessment Report 2005/45. 36p.

Hanchet S.M., Blackwell RG. 2005. Development and evaluation of catch-per-unit-effort indices for southern blue whiting (*Micromesistius australis*) on the Campbell Island Rise (1986-2002) and the Bounty Platform (1990-2002). New Zealand Fisheries Assessment Report 2005/55. 60p.

Hanchet S.M., Blackwell RG., Dunn A. 2005. Development and evaluation of catch-per-unit-effort indices for southern blue whiting (*Micromesistius australis*) on the Campbell Island Rise New Zealand. ICES Journal of Marine Sciences. *62:* 1131-1138.

Hanchet S.M., Blackwell RG. Stevenson ML. 2006. Southern blue whiting (Micromesistius australis) stock assessment for the Campbell Island Rise for 2006. New Zealand Fisheries Assessment Report 2006/41. 45p.

Hanchet S.M., Dunn, A., Stevenson, M.L. (2003). Southern blue whiting (*Micromesistius australis*) stock assessment for the Campbell Island Rise for 2003. New Zealand Fisheries Assessment Report 2003/59. 42 p.

Hanchet S.M., Dunn, A. 2010. Review and summary of the time series of input data available for the assessment of southern blue whiting (*Micromesistius australis*) stocks. New Zealand Fisheries Assessment Report 2010/32. 37p

Hanchet S.M., Grimes PJ., Coombs RF. 2002. Acoustic biomass estimates of southern blue whiting (*Micromesistius australis*) from the Bounty Platform, August 2001. New Zealand Fisheries Assessment Report 2002/58. 35p.

Hanchet S.M., Grimes PJ., Coombs RF., Dunford A. 2003. Acoustic biomass estimates of southern blue whiting (*Micromesistius australis*) for the Campbell Island Rise, August-September 2002. New Zealand Fisheries Assessment Report 2003/44. 38p.

Hanchet S.M., Grimes PJ., Dunford A., Ricnik A. 2002. Classification of fish marks from southern blue whiting acoustic surveys. Final Research Report for MFish Research Project SBW2000/02 Objective 2. 55p.

Hanchet S.M., Haist V., Fournier D. 1998. An integrated assessment of southern blue whiting (*Micromesistius australis*) from New Zealand waters using separable Sequential Population Analysis. *In* Funk, F. *et al*. (Eds). Alaska Sea Grant College Program Report No. AK-SG-98-01. University of Alaska, Fairbanks, 1998.

Hanchet S.M., Renwick JA. 1999. Prediction of southern blue whiting (*Micromesistius australis*) year class strength in New Zealand waters. New Zealand Fisheries Assessment Research Document 1999/51. 24p.

Hermsen, J.M.; Collie, J.S.; Valentine, P.C. (2003). Mobile fishing gear reduces benthic megafaunal production on Georges Bank Mar. Ecol. Prog. Ser. 260: 97-108

SOUTHERN BLUE WHITING (SBW)

Hiddink JG, Jennings S, Kaiser MJ, Queiros AM, Duplisea DE, Piet GJ. 2006. Cumulative impacts of seabed trawl disturbance on benthic biomass, production, and species richness in different habitats. Can. J. Fish. Aquat. Sci. 63:721–36.

Leathwick, J.R.; Rowden, A.; Nodder, S.; Gorman, R.; Bardsley, S.; Pinkerton, M.; Baird, S.J.; Hadfield, M. ; Currie, K.; Goh, A (2009). Benthic-optimised marine environment classification for New Zealand waters. Final Research Report project BEN2006/01. 52 p.

MacKenzie, D., Fletcher, D., 2006. Characterisation of seabird captures in commercial trawl and longline fisheries in New Zealand 1997/98 to 2003/04. Final Research Report for ENV2004/04, held by Ministry of Fisheries, New Zealand. 102p.

McClatchie S., Macaulay G., Hanchet S., Coombs RF. 1998. Target strength of southern blue whiting (*Micromesistius australis*) using swimbladder modelling, split beam and deconvolution. ICES Journal of Marine Science 55: 482–493.

McClatchie S., Thorne R., Grimes PJ., Hanchet S. 2000. Ground truth and target identification for fisheries acoustics. Fisheries Research 47: 173-191.

Monstad T., Borkin I., Ermolchev V. 1992. Report of the joint Norwegian-Russian acoustic survey on blue whiting, spring 1992. ICES C.M. 1992/H:6, Pelagic Fish Committee. 26p.

O'Driscoll R.L. 2011a. Acoustic biomass estimates of southern blue whiting on the Bounty Platform in 2010. NIWA Client Report WLG2011-01 for The Deepwater Group Ltd, January 2011. 28 p. Unpublished report held by NIWA, Wellington).

O'Driscoll R.L. 2011b. Industry acoustic surveys of spawning southern blue whiting on the Bounty Platform and Pukaki Rise 2004-09. New Zealand Fisheries Assessment Report 2011/xx. 53 p.

O'Driscoll R.L. 2012. Acoustic biomass estimates of southern blue whiting on the Bounty Platform in 2011. New Zealand Fisheries Assessment Report 2012/xx. 29 p..

O'Driscoll R.L., Grimes PJ., Hanchet SM., Dunford A. 2005. Acoustic estimates of southern blue whiting from the Campbell Island Rise, August-September 2004. New Zealand Fisheries Assessment Report 2005/41. 29p.

O'Driscoll R.L., Hanchet SM. 2004. Acoustic survey of spawning southern blue whiting on the Campbell Island Rise from FV *Aoraki* in September 2003. New Zealand Fisheries Assessment Report 2004/27. 31p.

O'Driscoll R.L., Hanchet SM., Gauthier S., Grimes PJ. 2007. Acoustic estimates of southern blue whiting from the Campbell Island Rise, August-September 2006. New Zealand Fisheries Assessment Report 2007/20. 34 p.

O'Driscoll R.L., Macaulay GJ., Gauthier S. 2006. Biomass estimation of spawning southern blue whiting from industry vessels in 2006. NIWA Client Report WLG2006-xx for the Deepwater Stakeholders' Group. 39p. (Unpublished report held by NIWA, Wellington.)

Rice J. (2006). Impacts of Mobile Bottom Gears on Seafloor Habitats, Species, and Communities: A Review and Synthesis of Selected International Reviews. Canadian Science Advisory Secretariat Research Document 2006/057. 35 p. (available from http://www.dfo-mpo.gc.ca/CSAS/Csas/DocREC/2006/RES2006_057_e.pdf).

Shpak VM. 1978. The results of biological investigations of the southern putassu *Micromesistius australis* (Norman, 1937) on the New Zealand plateau and perspectives of its fishery. Unpublished TINRO manuscript. (Translation held in NIWA library, Wellington.)

Smith M.H., Baird, S.J., (2009). Model-based estimation of New Zealand fur seal (*Arctocephalus forsteri*) incidental captures and strike rates for trawl fishing in New Zealand waters for the years 1994-95 to 2005-06. New Zealand Aquatic Environment and Biodiversity Report No. 40. 92p.

Thompson F.N., Abraham, E.R., Oliver, M.D., 2010a. Estimation of fur seal bycatch in New Zealand trawl fisheries, 2002-03 to 2007-08. DRAFT New Zealand Aquatic Environment and Biodiversity Report No. 56. 29p.

Thompson F.N., Oliver, M.D., Abraham, E.R., 2010b. Estimation of the capture of New Zealand sea lions (*Phocarctos hookeri*) in trawl fisheries, from 1995-96 to 2007-08. DRAFT New Zealand Aquatic Environment and Biodiversity Report No. 52. 25p.

SPINY DOGFISH (SPD)

(*Squalus acanthias*)
Makohuarau, Pioke, Kāraerae
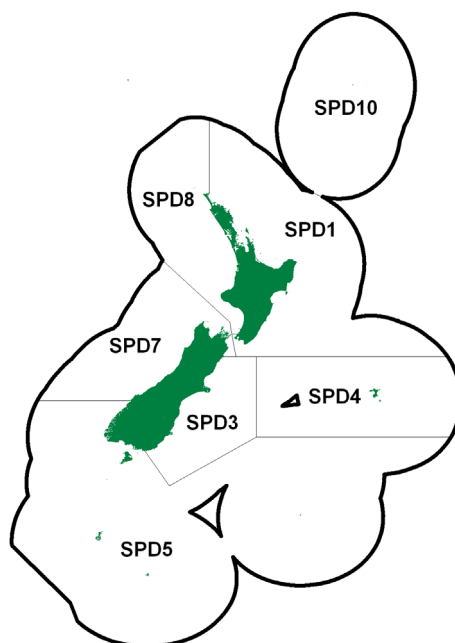
1.   FISHERY SUMMARY

1.1   Commercial fisheries

Spiny dogfish are found throughout the southern half of New Zealand, extending to East Cape and Manakau Harbour on the east and west coasts of the North Island respectively. A related species the northern spiny dogfish (*Squalus mitsukurii*), is mainly restricted to North Island waters, overlapping with its conspecific in the central west coast area and around the Chatham Islands. Although they have different species codes for reporting purposes it is probable that some misidentification and misreporting occurs - particularly in FMAs 1, 8 and 9.

The best estimate of reported catch from the fishery is shown in the final column in Table 1. For the period 1980-81 to 1986-87 the best estimate of landings is the sum of the FSU data. For the period 1987-88 to 1996-97 this is the sum of the LFRR and the discards from the CELR and CLR. It has been assumed here that all the fish which have been caught and discarded will die, and that all the discarded fish have been recorded. Although neither assumption is likely to be true, and the biases they produce will at least partially cancel each other out, it is likely that the true level of discards is considerably higher. However, these figures are currently the best estimates of total removals from the fishery.

Before 1980-81 landings of rig, and both *Squalus* species were included together and catches of the latter were probably small. Since then the reported catch of spiny dogfish has fluctuated between about 3000 and 7000 t. The reported catch by the deepwater fleet has remained fairly constant during most of the period, averaging 2000-4000 t, with a slight decrease in recent years. Reported catch by the inshore fleet has shown a steady increase throughout the period and is now at a similar level to the catch from the deepwater fleet.

Most of the spiny dogfish caught by the deepwater fleet are taken as a bycatch in the jack mackerel, barracouta, hoki, red cod, and arrow squid fisheries, in depths from 100 to 500 m. Some are packed whole but most are trunked and exported to markets in Asia and Europe.

Table 1: Reported catches of spiny dogfish (t) by fishing year. FSU (Fisheries Statistics Unit), LFRR (Licensed Fish Receiver Return. Discards reported from CELR (Catch Effort Landing Return), and CLR (Catch Landing Return). Numbers in brackets are probably underestimates. (- no data).

	FSU				Best
	Inshore	Deepwater	LFRR	Discards	Estimate
80-81	-	(196)	-	-	196
81-82	-	1 881	-	-	1 881
82-83	(107)	2 568	-	-	2 675
83-84	309	2 949	-	-	3 258
84-85	303	3 266	-	-	3 569
85-86	311	2 802	-	-	3 113
86-87	870	2 277	2 608	-	3 147
87-88	834	3 877	4 823	-	4 823
88-89	(351)	(500)	3 573	(16)	3 589
89-90	(14)	0	2 952	321	3 273
90-91	-	-	5 983	333	6 316
91-92	-	-	3 274	521	3 795
92-93	-	-	4 157	616	4 773
93-94	-	-	6 150	1 063	7 213
94-95	-	-	4 793	628	5 421
95-96	-	-	6 230	1 920	8 150
96-97	-	-	4 887	2 572	7 459

Spiny dogfish are also taken as bycatch by inshore trawlers, setnetters and longliners targeting flatfish, snapper, tarakihi and gurnard. Because of processing problems due to their spines, sandpaper-like skin, and short shelf life, and their low economic value many inshore fishers are not interested in processing and landing them. Furthermore, because of their sheer abundance they can at times severely hamper fishing operations for other commercial species and they are regarded by many fishers as a major nuisance. Trawlers working off Otago during the summer months often reduce towing times and headline heights, and at times leave the area altogether to avoid having to spend hours pulling hundreds of meshed dogfish out of trawl nets. Setnetters and longliners off the Otago coast, and in Tasman Bay and the south Taranaki Bight have also complained about spiny dogfish taking longline baits, attacking commercial fish caught in the nets or lines, and rolling up nets.

The catch by FMA from the FSU, CELR and CLR databases is shown in Table 2. Large catches have been made from FMAs 3, 5, 6, and 7 since 1982-83. Catches from FMA 4 have increased substantially since the mid-1990s. Landings from FMA 5 and 6 were most important in the early 1980s, with 1000-2000 t taken annually by factory trawlers. In more recent years FMA 3, and to a lesser extent, FMA 7 have become more important. The catch in both these areas is taken equally by factory trawlers and inshore fleets. The catch in FMA 1 is unlikely to be spiny dogfish which is considered to be virtually absent from the area, and so these catches should probably be attributed to *S. mitsukurii*.

Competitive quotas of 4075 t for FMA 3, and of 3600 t for FMAs 5 and 6, were introduced for the first time in the 1992-93 fishing year. These quotas were based on yields derived from trawl surveys using a method that is now considered obsolete, and harvest levels which are now considered unreliable. The reported catches exceeded the FMA 3 quota in 1997-98, 2000-01 and 2001-02 and the FMA 5/6 quota in 2002-02.

Spiny dogfish was introduced into the QMS in October 2004. Catches and TACCs are shown in Table 3, while Figure 1 depicts historical landings and TACC values for the main SPD stocks. A breakdown of the TAC for each SPD stock is shown in Table 9.

Prior to their introduction into the QMS spiny dogfish were legally discarded at sea (provided that total catch is reported). Although discard rates increased dramatically through the 1990s (Table 4),

this is believed to reflect a change in reporting practise rather than an increase in the proportion of catch discarded.

Table 2: Reported landings of spiny dogfish by proposed Fishstock. Proportions by area have been taken from CELR and CLR and pro-rated to the best estimate from Table 1. Competitive quotas of 4075 t for FMA 3, and of 3600 t for FMAs 5 and 6, were introduced for the first time in the 1992-93 fishing year.

Year	FMA1	FMA2	FMA3	FMA4	FMA5	FMA6	FMA7	FMA8	FMA9	FMA 10	Other	Total
1982-83	4	0	151	131	2 089	81	145	66	7			2 675
1983-84	22	18	409	347	565	1 700	119	63	16			3 258
1984-85	21	12	557	481	451	1 899	90	48	10			3 569
1985-86	13	11	892	411	537	1 017	120	92	20			3 113
1986-87	64	18	1 048	162	1 002	29	501	296	27			3 147
1987-88	50	9	1 664	172	642	16	1 402	841	27			4 823
1988-89	341	16	1 510	168	771	7	633	132	11			3 589
1989-90	36	14	2 243	136	241	2	521	80	0			3 273
1990-91	129	14	2 987	513	1 708	14	883	67	0			6 316
1991-92	54	23	1 801	66	538	33	1 031	249	0			3 795
1992-93	50	9	2 128	218	817	22	1 163	366	0			4 773
1993-94	51	34	3 165	358	1 158	21	2 212	214	0			7 213
1994-95	84	47	2 883	363	606	37	1 205	196	0			5 421
1995-96	68	177	2 558	969	1 147	152	1 205	186	15			7 052
1996-97	30	159	2 428	1 287	764	120	1 517	235	7	1	1	6 555
1997-98	52	165	5 042	917	428	223	2 389	1 172	34	0	11	10 433
1998-99	45	488	3 148	1 048	1 996	154	1 902	74	< 1	0	< 1	8 424
1999-00	15	328	3 309	994	1 163	189	1 505	25	7	0	5	7 540
2000-01	38	336	4 355	1 075	1 389	212	1 310	54	16	0	28	8 811
2001-02	12	222	4 249	1 788	3 734	487	961	71	12	0	-	11 530
2002-03	10	245	3 553	1 010	2 621	413	772	85	19	0	0	8 727
2003-04	12	91	2 077	516	1 032	302	423	20	5	0	0	4 477

Table 3: Reported domestic landings (t) of spiny dogfish by Fishstock and TACC from 2004-05 to 2010-11.

Fishstock	SPD 1		SPD 3		SPD 4		SPD 5		SPD 7	
FMA	1&2		3		4		5&6		7	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
2004-05	234	331	2 707	4 794	839	1 626	2 479	3 700	842	1 902
2005-06	186	331	3 831	4 794	1 055	1 626	2 298	3 700	832	1 902
2006-07	239	331	2 712	4 794	822	1 626	2 165	3 700	1 125	1 902
2007-08	156	331	2 082	4 794	1 397	1 626	1 501	3 700	928	1 902
2008-09	229	331	1 981	4 794	866	1 626	2 071	3 700	929	1 902
2009-10	128	331	1 855	4 794	667	1 626	2 205	3 700	1 116	1 902
2010-11	149	331	1 976	4 794	825	1 626	1 443	3 700	1 413	1 902

Fishstock	SPD 8		Total	
FMA	8&9			
	Landings	TACC	Landings	TACC
2004-05	121	307	7 222	12 660
2005-06	108	307	8 311	12 660
2006-07	118	307	7 181	12 660
2007-08	124	307	6 188	12 660
2008-09	150	307	6 226	12 660
2009-10	194	307	6 166	12 660
2010-11	219	307	6 026	12 660

Table 4: Discard rates (% of catch) by QMA and fishing year (after Manning *et al*. 2004).

Fishing year						QMA						
	1	2	3	4	5	6	7	8	9	10	Other	Total
1989-90	11	17	18	4	46	100	13	34	0	0	0	18
1990-91	7	0	6	2	29	11	21	24	0	0	0	11
1991-92	9	3	8	13	34	90	42	18	0	0	0	20
1992-93	13	47	5	51	39	43	20	80	0	0	0	21
1993-94	5	65	13	42	21	34	29	66	0	0	0	23
1994-95	2	52	8	31	20	74	29	64	98	0	5	19
1995-96	7	39	18	55	39	94	45	72	100	0	11	36
1996-97	15	61	26	40	70	68	59	89	93	0	16	44
1997-98	53	83	51	53	72	86	81	92	100	0	16	64
1998-99	20	92	57	60	29	78	82	63	0	0	16	58
1999-00	9	86	60	55	39	68	81	84	35	0	0	62
2000-01	37	70	60	77	57	77	72	56	29	0	87	64
Total	15	74	35	53	42	78	54	68	78	0	16	45

SPINY DOGFISH (SPD)
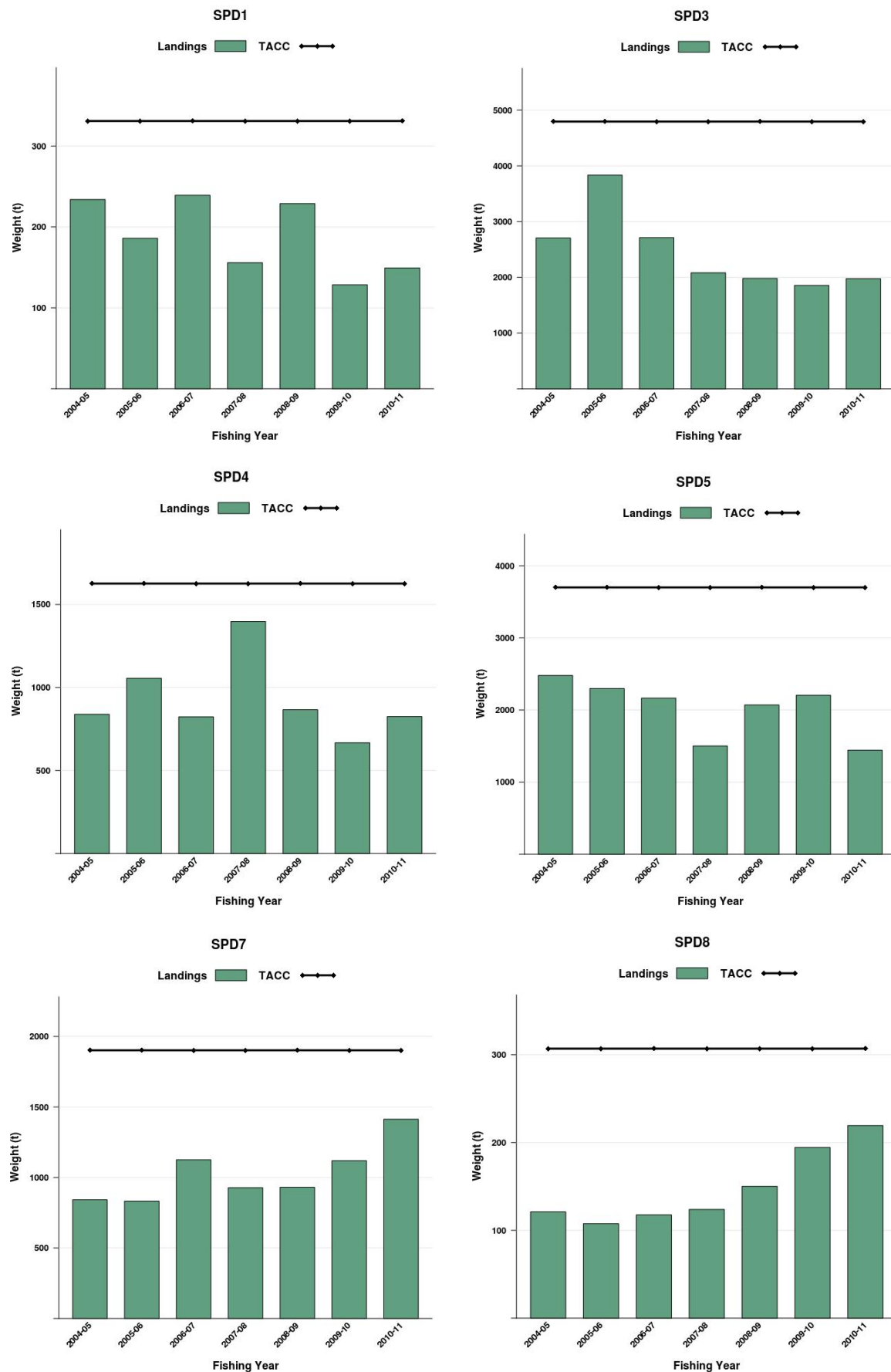
Figure 1: Historical landings and TACC for the six main SPD stocks. From top left to bottom right: SPD1 (Auckland East, Central East), SPD3 (South East Coast), SPD4 (South East Chatham Rise), SPD5 (Sub Antarctic, Southland), SPD7 (Challenger), and SPD8 (Central Egmont, Auckland West). Note that these figures do not show data prior to entry into the QMS.

1.2 Recreational fisheries

Spiny dogfish are caught by recreational fishers throughout their geographical range in New Zealand. They are mainly taken as bycatch when targeting other more valued species using rod and line and setnet. In many parts of New Zealand, spiny dogfish are regarded by recreational anglers as a pest, often clogging nets and taking baits from hooks. Estimates of recreational landings obtained from three surveys in 1991-92 to 1993-94, 1996 and 1999-00 are given in Table 5. Overall, recreational landings probably comprise only a small proportion (< 10 %) of the total spiny dogfish catch.

Table 5: Estimated number and weight of spiny dogfish harvested by recreational fishers by Fishstock and survey. Surveys were carried out in different years in the Ministry of Fisheries regions: South in 1991-92, Central in 1992-93, North in 1993-94 (Teirney *et al*. 1997) and nationally in 1996 (Bradford 1998) and 1999-00 (Boyd & Reilly 2005). Survey harvests are presented as a range to reflect the uncertainty in the estimates.

Fishstock	Survey	Number	CV%	Harvest Range (t)	Point estimate (t)
1991-92					
QMA 3	South		23		120
QMA 5	South		-		2
QMA 7	South		92		11
1992-93					
QMA 2	Central		42		133
QMA 7	Central		35		46
QMA 8	Central		45		143
1993-94					
QMA 1,9	North		-		< 10
1996					
QMA 1	National	1 000	-	-	-
QMA 2	National	5 000	-	-	-
QMA 3	National	21 000	17	25-40	33
QMA 5	National	9 000	-	-	-
QMA 7	National	24 000	21	30-45	37
QMA 9	National	15 000	-	-	-
1999-00					
QMA 1	National	9 000	61	4.4-17.9	11
QMA 2	National	22 000	37	17.3-37.8	28
QMA 3	National	93 000	27	83.2-145.9	115
QMA 5	National	7 000	47	4.4-12.3	8
QMA 7	National	25 000	35	20.4-41.9	31
QMA 8	National	21 000	52	12.7-40.3	27
QMA 9	National	12 000	82	2.7-26.2	14

The Recreational Technical Working Group concluded that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and c) the 2000 and 2001 estimates are implausibly high for many important fisheries.

1.3 Customary non-commercial fisheries

Maori fishers traditionally caught large numbers of "dogfish" during the last century and this included rig, school shark, and spiny dogfish. Quantitative information on the current level of customary non-commercial fisheries take is not available.

1.4 Illegal catch

It is unlikely that there is an illegal catch of spiny dogfish as the quota for this species has never been reached, and it has low commercial value.

1.5 Other sources of mortality

It is likely that there is a large amount of spiny dogfish discarded by fishers which is never reported on the returns. The level of mortality and any temporal trends from non-reported discards have not been estimated. The introduction of cost recovery charges in 1994-95 may account for the decline in reported discards in that year.

2.   BIOLOGY

Spiny dogfish are widely distributed around the South Island and extend as far north as Manakau Harbour and East Cape on the west and east coasts of the North Island respectively. They are most abundant on the east coast of the South Island and the Stewart/Snares Shelf. They are found on the continental shelf and upper slope down to a depth of at least 500 m, but are most common in depths of 50-150 m. Schools are strongly segregated by size and sex. The size of fish in the commercial fishery is not known but will depend to a large extent on the method of capture and area fished.

Spiny dogfish are born at a size of 18-30 cm total length (TL). They have been aged using fin spines, and early growth has been validated by following modes in length-frequency and eye lens weight frequency data. Males mature at 58 cm TL at age 6, and females mature at 73 cm TL at age 10. The maximum ages and lengths in a study of east coast South Island dogfish were 21 years and 90 cm TL for males, and 26 years and 111 cm TL for females.

M was estimated using the equation $\log_e 100$/maximum age, where maximum age is the age to which 1% of the population survive in an unexploited stock. Using a maximum age of 26 gave an estimate of M of 0.18. This has been revised up to 0.2 to reflect the imprecision with which this estimate is known. A similar estimate of M was obtained using a survivorship table approach (Hanchet 1986). At an instantaneous mortality rate of 0.2 $year^{-1}$ an initial population of 1000 females would replace themselves over their lifespan (given their length-at-age, length-at-maturity and fecundity-length relationships).

Female spiny dogfish give birth to young over an extended period between April and September, mainly on the shelf edge in depths of 200-300 m. Mating also occurs in deeper water (coincident with a movement of mature males offshore), after which females with young "candled" embryos move into shallower waters of 100 m or less. They remain there for 12 months until the embryos are 15 cm long after which they return to deeper water. Parturition occurs after a gestation period approaching 24 months, and is closely followed by mating and ovulation and the biennial cycle is repeated. Both the number and the size of young increase linearly with the length of the mother. The number of young per litter ranges from 1 to 19.

Young of the year move inshore into shallower waters shortly after birth. Over the next few years they move steadily into deeper water but remain in size segregated schools comprising up to 2 or 3 age classes. Once maturity is reached both males and females undergo inshore/offshore migrations associated with reproductive activity. A north/south migration along the east coast South Island during autumn/spring has also been postulated but the full extent of this migration is unknown.

Spiny dogfish are found both on the bottom and in mid-water and feed on a very wide range of species, including *Munida*, krill, fish, squid, and crabs.

Biological parameters relevant to the stock assessment are shown in Table 6.

Table 6: Estimates of biological parameters of spiny dogfish for QMA3 (Hanchet 1986).

1. Natural mortality (M)

0.2				

2. Weight = a (length)^b (Weight in g, length in cm fork length)

	Males		Females	
	a	b	a	b
	0.0027	3.05	0.0013	3.25

3. von Bertalanffy growth parameters

Males			Females		
K	t_0	L_∞	K	t_0	L_∞
0.116	-2.88	89.5	0.069	-3.45	120.1

4. Maturity ogive

Age (years)	3	4	5	6	7	8	9	10	11	12	➤ 12
Males	0.00	0.02	0.21	0.68	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Females	0.00	0.00	0.00	0.00	0.04	0.04	0.23	0.52	0.75	1.00	1.00

3. STOCKS AND AREAS

No specific research on the stock structure of spiny dogfish has been carried out. Limited tagging has been conducted, so the only available data come from seasonal trawl surveys, and fisheries landings data.

The analysis of *W.J. Scott* and *James Cook* surveys carried out from 1978 to 1983 clearly showed seasonal migrations of spiny dogfish along the east coast of South Island (ECSI). Spiny dogfish were most abundant in the southern part of the coast from October to April, and more abundant to the north in May to September. It is also clear from summer trawl surveys of the area that there is a resident part of the population of spiny dogfish on the Stewart/Snares Shelf over the summer months. However, there have been no comparable series of seasonal surveys there and so it is presently unclear whether the East Coast South Island (ECSI) fish migrate south as far as the Stewart/Snares Shelf. Until more data become available fish from the two areas should be treated as separate stocks.

Seasonal trawl surveys were also carried out on West Coast South Island (WCSI) between June 1981 and April 1983 using the *W.J. Scott.* The catches showed a strong seasonal component being highest in summer and autumn and lowest in winter and spring. It is likely that some fish migrate north in winter, perhaps to the northern and southern Taranaki Bights, and Tasman Bay and Golden Bay. However, it is also clear from summer trawl surveys of the areas that there is a resident part of the population of spiny dogfish in the Taranaki Bights over the summer months. It may therefore be appropriate to treat fish from QMA 7 and 8 as a single stock.

There is little commercial catch in QMAs 1, 2, 4, and 9, and little data on movement in or between the areas. Until more data have been obtained it would seem appropriate to manage spiny dogfish with the following 5 Fishstocks:

SPD 1: QMA 1 & 2
SPD 3: QMA 3
SPD 4: QMA 4
SPD 5: QMA 5 & 6
SPD 7: QMA 7, 8 & 9

4. STOCK ASSESSMENT

There are no estimates of current or virgin biomass. This is the first stock assessment for spiny dogfish.

4.1 Estimates of fishery parameters and abundance

Biomass indices of spiny dogfish from recent trawl surveys using *Tangaroa* and *Kaharoa* are summarised in Table 7 and Figure 2. Based on a combination of CVs, variability in biomass indices and the time span of each series, it is concluded that surveys only provide reliable indices of dogfish abundance off the west coast of the South Island and on the Chatham Rise. Relative biomass indices suggest that spiny dogfish became more abundant on the Chatham rise during the early to mid 1990s. Apart from a temporary increase during the mid-1990s, the abundance of dogfish off the west coast of South Island appears to have been fairly stable between 1991 and 2003. Although the relevant surveys were discontinued, spiny dogfish appear also to have increased substantially in abundance off the east coast of the South Island and on the Stewart-Snares shelf in the mid 1990s.

SPINY DOGFISH (SPD)

Table 7: **Biomass indices (t) and coefficients of variation (CV) from trawl surveys assuming vulnerability, spatial availability and vertical availability equal 1. Note: because trawl survey biomass estimates are indices, comparisons between different seasons (e.g., summer and winter ECSI) are not strictly valid.**

QMA	Area	Vessel	Trip code	Date	Fishing year	Biomass (t)	CV (%)
2	East coast North Island	KAH	KAH9304	Feb-Mar 1993	1992-93	963	78
			KAH9402	Feb-Mar 1994	1992-94	988	47
			KAH9502	Feb-Mar 1995	1994-95	658	25
			KAH9602	Feb-Mar 1996	1995-96	1 026	51
3	East coast South Island (*Winter*)	KAH	KAH9105	May-Jun 1991	1990-91	12 873	22
			KAH9205	May-Jun 1992	1991-92	10 787	26
			KAH9306	May-Jun 1993	1992-93	13 949	17
			KAH9406	May-Jun 1994	1993-94	14 530	10
			KAH9606	May-Jun 1996	1995-96	35 169	15
			KAH0705	May-Jun 2007	2006-07	35 386	24
			KAH0806	May-Jun 2008	2007-08	28 476	22
			KAH0905	May-Jun 2009	2008-09	25 311	31
	East coast South Island (*Summer*)	KAH	KAH9618	Dec-Jan 1996-97	1996-97	35 776	28
			KAH9704	Dec-Jan 1997-98	1997-98	29 765	25
			KAH9809	Dec-Jan 1998-99	1998-99	22 842	16
			KAH9917	Dec-Jan 1999-00	1999-00	49 832	37
			KAH0014	Dec-Jan 2000-01	2000-01	30 508	34
4	Chatham Rise	TAN	TAN9106	Dec-Feb 1991-92	1991-92	2 390	14
			TAN9212	Dec-Feb 1992-93	1992-93	2 220	11
			TAN9401	Jan-Feb 1994	1993-94	3 449	13
			TAN9501	Jan-Feb 1995	1994-95	2 841	21
			TAN9601	Dec-Jan 1995-96	1995-96	4 969	11
			TAN9701	Jan 1997	1996-97	9 570	14
			TAN9801	Jan 1998	1997-98	5 724	17
			TAN9901	Jan 1999	1998-99	8 551	13
			TAN0001	Dec-Jan 1999-00	1999-00	8 905	9
			TAN0101	Dec-Jan 2000-01	2000-01	9 586	9
			TAN0201	Dec-Jan 2001-02	2001-02	6 334	8
			TAN0301	Dec-Jan 2002-03	2002-03	6 191	17
			TAN0401	Jan 2004	2003-04	12 289	18
			TAN0501	Jan 2005	2004-05	7 227	15
			TAN0601	Jan 2006	2005-06	5 650	14
			TAN0701	Jan 2007	2006-07	5 906	10
			TAN0801	Jan 2008	2007-08	15 674	38
			TAN0901	Jan 2009	2008-09	5 548	11
			TAN1001	Jan 2010	2009-10	6 698	17
			TAN1101	Jan 2011	2010-11	7 794	14
			TAN1201	Jan 2012	2012	5 438	14
5	Stewart-Snares Shelf	TAN	TAN9301	Feb-Mar 1993	1992-93	36 023	13
			TAN9402	Feb-Mar 1994	1993-94	36 328	17
			TAN9502	Feb-Mar 1995	1994-95	91 364	29
			TAN9604	Feb-Mar 1996	1995-96	89 818	29
6	Sub-Antarctic (*Spring*)	TAN	TAN9105	Nov-Dec 1991	1991-92	8 502	55
			TAN9211	Nov-Dec 1992	1992-93	1 150	15
			TAN9310	Nov-Dec 1993	1993-94	1 585	21
			TAN0012	Nov-Dec 2000	2000-01	4 173	12
			TAN0118	Nov-Dec 2001	2001-02	8 528	31
			TAN0219	Nov-Dec 2002	2002-03	3 505	19
			TAN0317	Nov-Dec 2003	2003-04	2 317	17
			TAN0414	Nov-Dec 2004	2004-05	3 378	27
			TAN0515	Nov-Dec 2005	2005-06	4 344	19
			TAN0617	Nov-Dec 2006	2006-07	3 039	19
6	Sub-Antarctic (*Autumn*)	TAN	TAN9204	Apr-May 1992	1991-92	0 926	30
			TAN9304	May-Jun 1993	1992-93	0 440	38
			TAN9605	Mar-Apr 1996	1995-96	0 207	56
			TAN9805	Apr-May 1998	1997-98	1 532	36
7	West coast South Island	KAH	KAH9204	Mar-Apr 1992	1991-92	3 919	15
			KAH9404	Mar-Apr 1994	1993-94	7 145	7
			KAH9504	Mar-Apr 1995	1994-95	8 370	10
			KAH9701	Mar-Apr 1997	1996-97	5 275	13
			KAH0004	Mar-Apr 2000	1999-00	4 777	12
			KAH0304	Mar-Apr 2003	2002-03	4 446	15
			KAH0503	Mar-Apr 2005	2004-05	6 175	12
			KAH0704	Mar-Apr 2007	2006-07	6 219	14
			KAH0904	Mar-Apr 2009	2008-09	10 270	19
			KAH1004	Mar-Apr 2010	2010-11	6 402	13
9	West coast North Island	KAH	KAH9111	Oct 1991	1991-92	443*	34
			KAH9410	Oct 1994	1994-95	381*	30
			KAH9615	Oct 1996	1996-97	634*	68
			KAH9915	Nov 1999	1999-00	106*	15

Manning *et al.* (2004) recently evaluated the usefulness of commercial CPUE, commercial length composition, trawl survey relative biomass estimates and trawl-survey-catch length-composition for monitoring all major SPD stocks (Table 8).

Table 8: Catch and effort data sets and analyses evaluated as monitoring tools for major SPD stocks.

QMA	Data set and analysis
SPD 3 - East coast South Island	1. Standardised setnet CPUE for core vessels targeting SPD.
	2. Standardised setnet CPUE for core vessels targeting all species.
	3. Standardised bottom trawl CPUE for core vessels targeting all species.
	4. Relative abundance indices from East Coast South Island trawl surveys (discontinued after 2001)
SPD 4 - Chatham Rise	5. Standardised bottom trawl CPUE for core Korean vessels
	6. Standardised bottom trawl CPUE for core domestic vessels
	7. Standardised bottom longline CPUE for core domestic vessels
	8. Relative abundance indices from Chatham Rise trawl surveys.
SPD 5 - Stewart Snares Shelf	9. Standardised bottom trawl CPUE.
	10. Relative abundance indices from Stewart-Snares shelf surveys (discontinued after 1996)
SPD 7 - West Coast South Island	11. Standardised bottom trawl CPUE for core vessels
	12. Relative abundance indices from West coast South Island Trawl Surveys.

Based on the results of the analyses listed in Table 8, the following methods were recommended for monitoring SPD:

QMA	Recommended Monitoring Tools
SPD 3 - East coast South Island	Standardised setnet CPUE using model 2 (core vessels targeting all species)
SPD 4 - Chatham Rise	Chatham Rise Trawl Survey and length composition of commercial catch
SPD 5 - Stewart Snares Shelf	*Standardised bottom trawl CPUE and length composition of commercial catch.
SPD 7 - West Coast South Island	West coast South Island Trawl survey and length composition of commercial catch

* Information on historical changes in reporting rates is required before this index can be used.

4.2 Biomass estimates

Lack of suitable information has precluded estimation of virgin and current biomass for spiny dogfish. Although most of the necessary biological parameters (Hanchet 1986, 1988, Hanchet & Ingerson 1997), relative indices of abundance and data required to estimate fishing selectivity for most important fisheries (with the exception FMA 4 bottom longline and QMA 3 setnet fisheries) are now available, robust stock assessments will also require estimates of historical, unreported discarding and discard mortality so that an accurate history of fishery related removals can be constructed.

4.3 Estimation of Maximum Constant Yield (*MCY*)

MCY cannot be estimated.

4.4 Estimation of Current Annual Yield (*CAY*)

CAY cannot be determined.

4.5 Other factors

The ability to withstand harvesting depends on the strength of a number of compensatory mechanisms. For example, under exploitation individuals may grow faster, show increased fecundity, or suffer reduced natural mortality. In elasmobranchs the number of young born is related directly to the number of adult females, and, because of the relatively large size and hence good survival of the young at birth, it is presumed that there is a strong stock recruit relationship for these species.
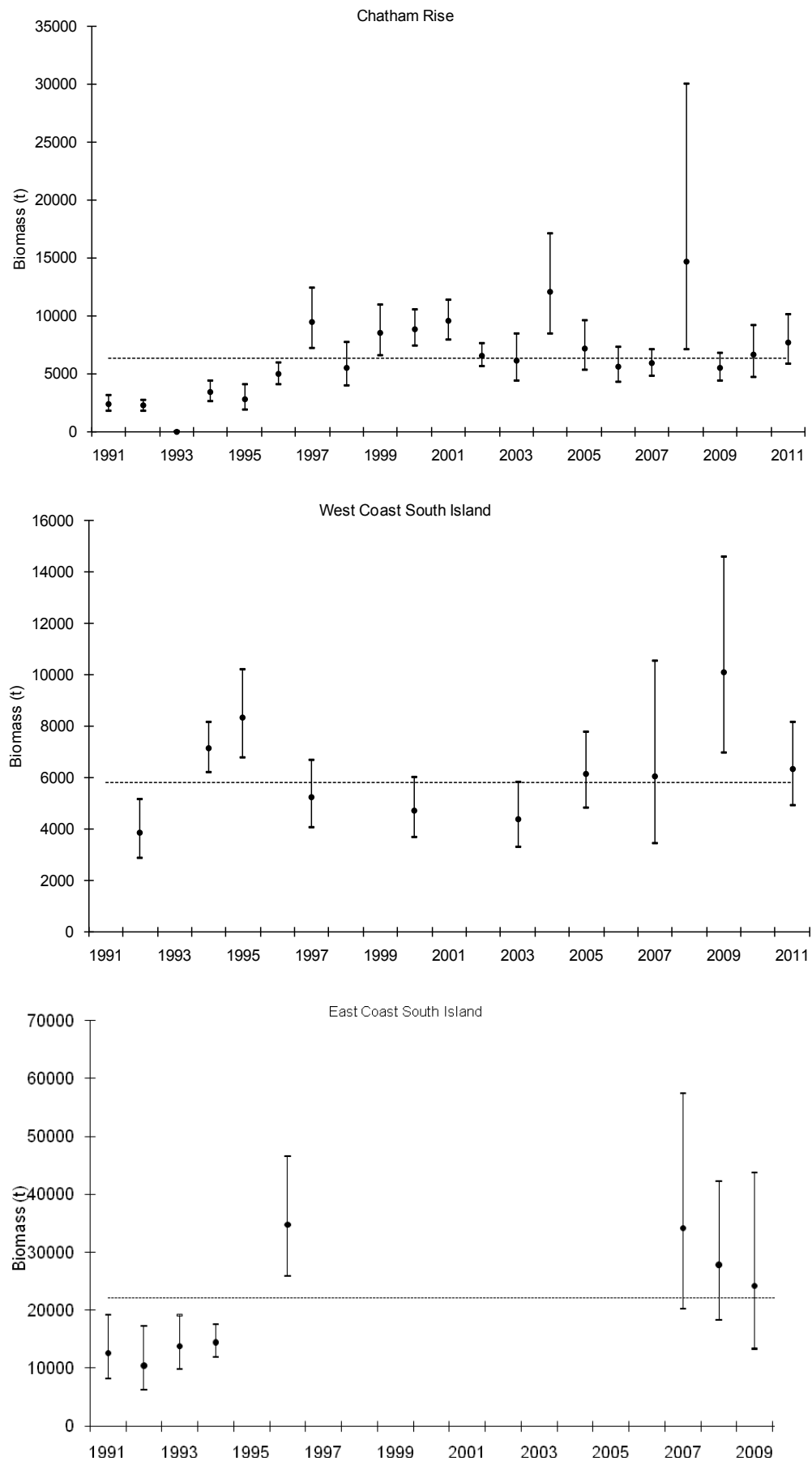
Figure 2: Spiny dogfish biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the time series mean (dotted line) estimated from the Chatham Rise (Top), West (Middle) and East (bottom) Coast South Island trawl survey.
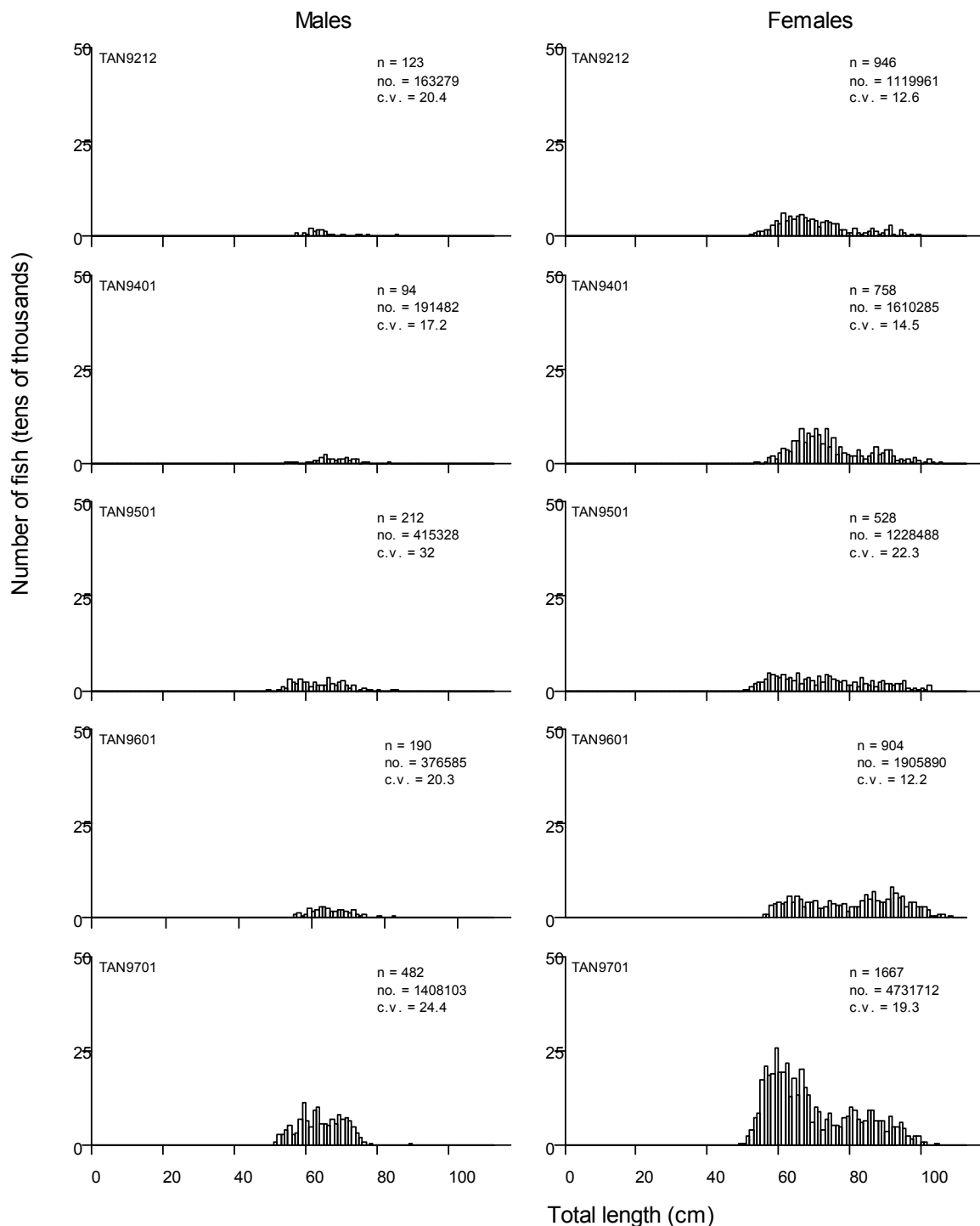
Figure 3: Scaled length frequency distributions for spiny dogfish, for Chatham Rise surveys. M, males and F, females, (CV) (Stevens _et al._ 2011).

Several methods of estimating *MCY* involve the multiplication of a harvest level by an estimate of B_0 or B_{av}. Francis & Francis (1992) used Monte Carlo simulation to estimate harvest levels for calculating *MCY* for a rig stock. No stock-recruitment data were available for elasmobranchs at the time and so they used values for the Beverton & Holt steepness parameter ranging from 0.35 to 0.50, and recruitment variability of 0.4. These values were all at the low range of values used for teleost species and which they considered appropriate for rig. The results of their simulation studies showed that the estimates of *MCY* obtained using the harvest levels given in the equations in the Guide to Biological Reference

Points were overly optimistic for rig. Given that spiny dogfish have a slower growth rate and are less fecund than rig, it seems reasonable to assume that those harvest levels are also unsuitable for spiny dogfish.
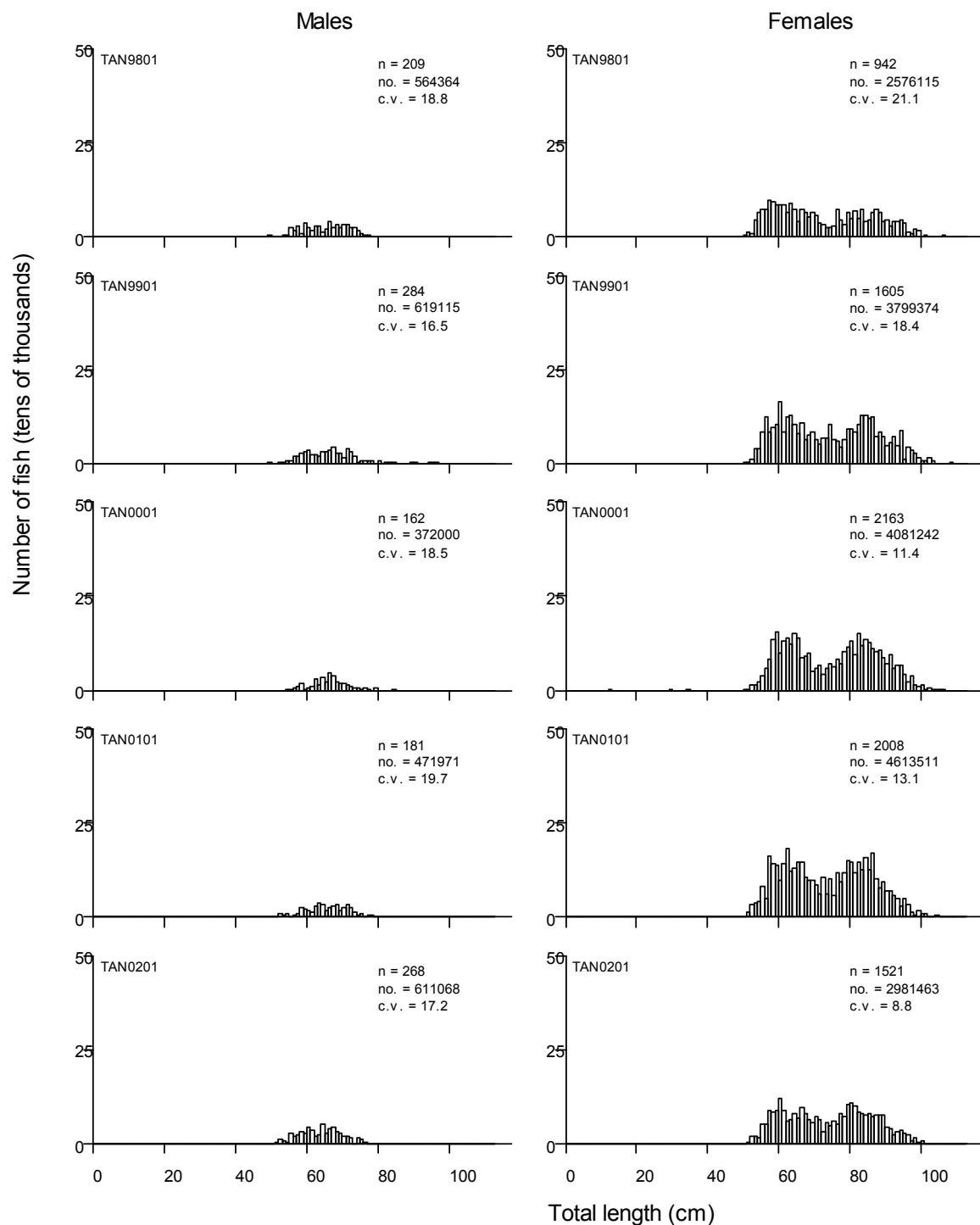
Figure 3 [Continued].
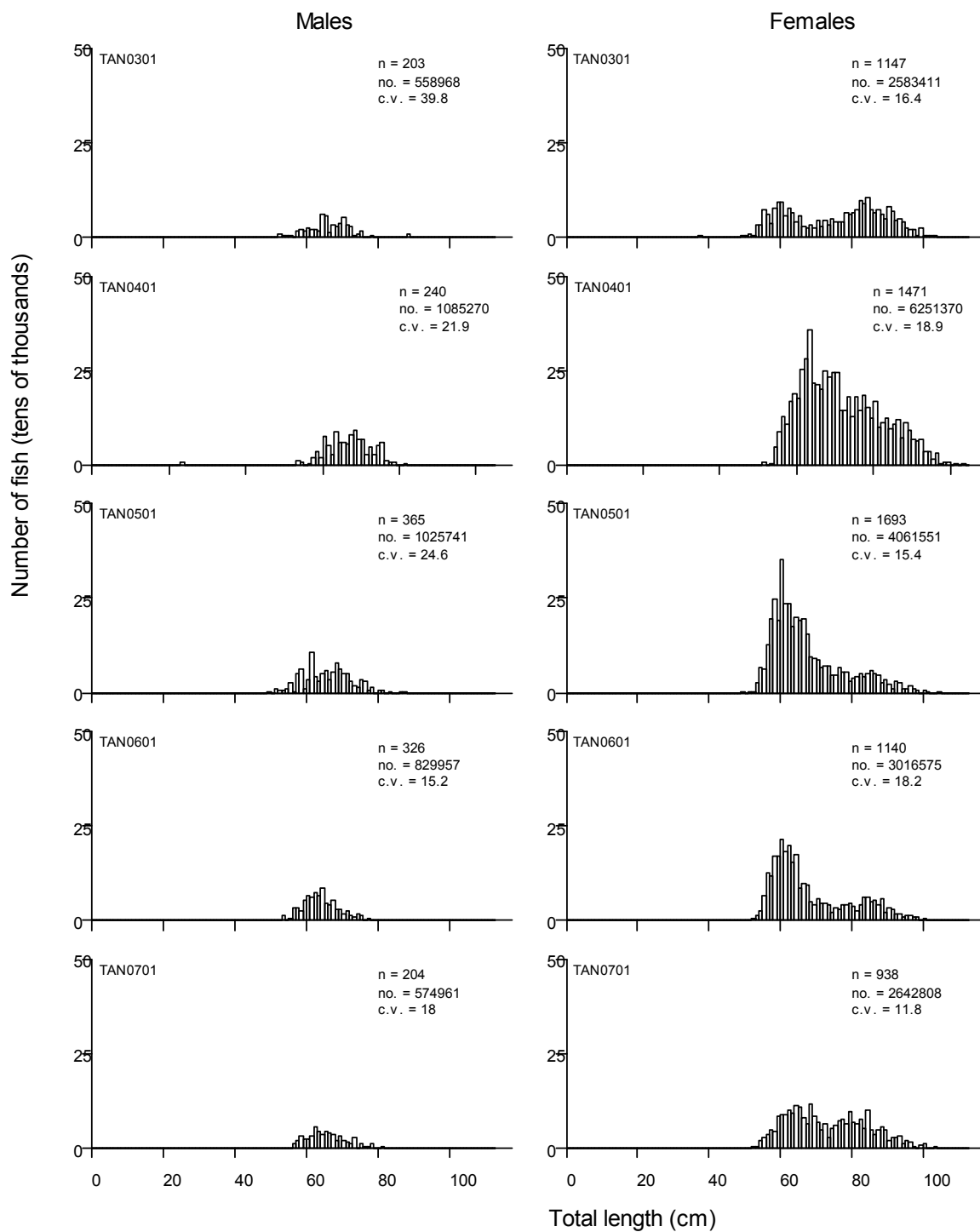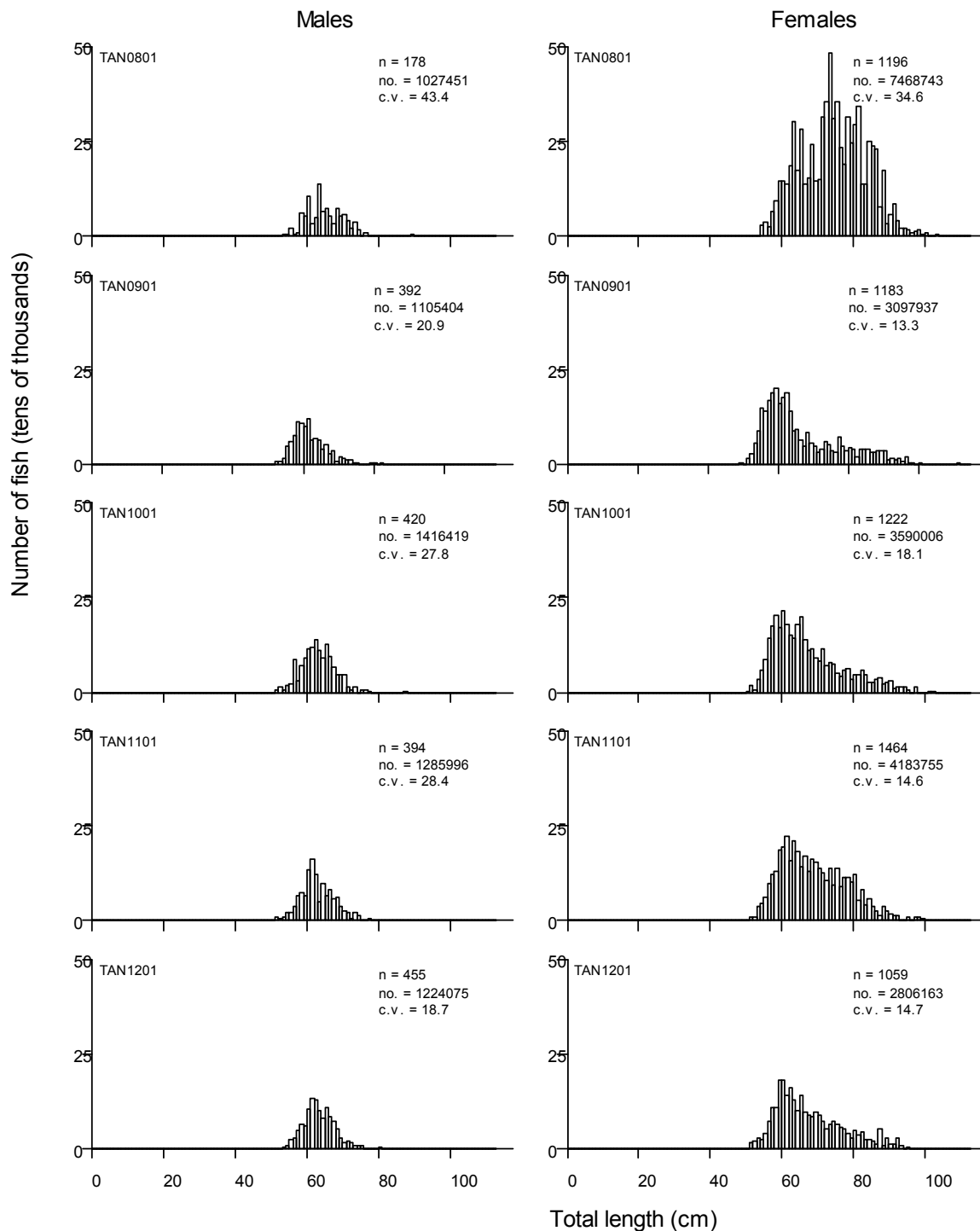
Figure 3 [Continued].

Figure 3 [Continued].

5.   STATUS OF THE STOCKS

No estimates of current or reference biomass are available, but trawl survey estimates of abundances are all at or above the long term average (1991-2009 or 2011).

Although reported commercial catches of spiny dogfish were observed to increase in all major FMAs during the 1990s, the extent to which these increases can be attributed to changes in reporting practice (i.e., more accurate reporting of discards in recent times) is uncertain. Trawl surveys, on the other hand, indicate that there was a general increase in the abundance of spiny dogfish, particularly around the South Island, in the mid 1990s.

Reported landings and TACCs for the 2010-11 fishing year are summarised in Table 9.

Table 9: Other mortality, recreational, and customary non-commercial allowances (t), Total Allowable Commercial Catches (TACC, t) and Total Allowable Catch (TAC, t), along with reported landings (t) of SPD for the most recent fishing year.

Fishstock		FMA	Other Mortality	Recreational	Customary	TACC	TAC	2010-11 Reported landings
SPD 1	Auckland (East), Central (East)	1&2	4	39	39	331	413	149
SPD 3	South east (coast)	3	51	115	115	4 794	5 075	1 976
SPD 4	South east (Chatham)	4	16	10	10	1 626	1 662	825
SPD 5	Southland, sub-Antarctic	5&6	37	8	8	3 700	3 753	1 443
SPD 7	Challenger	7	19	31	31	1 902	1 983	1 413
SPD 8	Central (west), Auckland (west)	8&9	3	41	41	307	392	219
SPD 10	Kermadec	10	0	1	1	0	2	0
Total			130	245	245	12 660	13 280	6 026

6.   FOR FURTHER INFORMATION

Bradford E. 1998. Harvest estimates from the 1996 national recreational fishing surveys. New Zealand Fisheries Assessment Research Document 1998/16. 27p.

Boyd R.O., Reilly J.L. 2005. 1999/2000 national marine recreational fishing survey: harvest estimates. Draft New Zealand Fisheries Assessment Report.

Da Silva H.M. 1993. The causes of variability in the stock-recruitment relationship of spiny dogfish, *Squalus acanthias*, in the NW Atlantic. *ICES CM 1993/G:52.* 17 p.

Francis M.P.F., Francis R.I.C.C. 1992. Growth, mortality, and yield estimates for rig (*Mustelus lenticulatus*). New Zealand Fisheries Assessment Research Document 1992/5. 32 p.

Hanchet S.M. 1986. The distribution and abundance, reproduction, growth and life history characteristics of the spiny dogfish (*Squalus acanthias* Linnaeus) in New Zealand. PhD Thesis, University of Otago, New Zealand.

Hanchet S.M. 1988. Reproductive biology of *Squalus acanthias* from the east coast, South Island, New Zealand. New Zealand Journal of Marine and Freshwater Research 22: 537-549.

Hanchet S.M. 1991. Diet of spiny dogfish, *Squalus acanthias* Linnaeus, on the east coast, South Island, New Zealand. Journal of Fish Biology 39: 313-323.

Hanchet S.M., Ingerson, J.K.V. 1997. A summary of biology and commercial landings, and a stock assessment of spiny dogfish (*Squalus acanthias*). New Zealand Fisheries Assessment Research Document 1997/6. 32p.

Manning M.J., Hanchet S.M., Stevenson M.L. 2004. A description and analysis of New Zealand's spiny dogfish (*Squalus acanthias*) fisheries and recommendations on appropriate methods to monitor the status of the stocks. New Zealand Fisheries Assessment Report 2004/61. 135p.

Palmer G. 1994. Spiny dogfish - pest or potential. Seafood New Zealand, March 1994. 31-36p.

Phillips N.L. 2004. Length Erequency distributions of spiny dogfish from the Chatham Rise, Sub-Antarctic, and the west coast South Island fisheries. New Zealand Fisheries Assessment Report 2004/53.

Stevens D.W., O'Driscoll R.L., Ballara S.L., Bagley, N., Horn P.L. 2011. Chatham Rise Trawl Survey, 2 Jan - 28 Jan 2011 (TAN1011). WG-HOK-2011/X. X p. (Unpublished report held by Ministry of Fisheries, Wellington.)

Stevenson M.L. 2007. Inshore trawl survey of the west coast of the South Island and Tasman and Golden Bays, March-April 2007 (KAH0704). New Zealand Fisheries Assessment Report 2007/41.

Teirney L.D., Kilner A.R., Millar R.E., Bradford E., Bell J.D. 1997. Estimation of recreational catch from 1991/92 to 1993/94 New Zealand. Fisheries Assessment Research Document 1997/15. 43 p.

SPRAT (SPR)

(*Sprattus antipodum, S. muelleri*)
Kupae
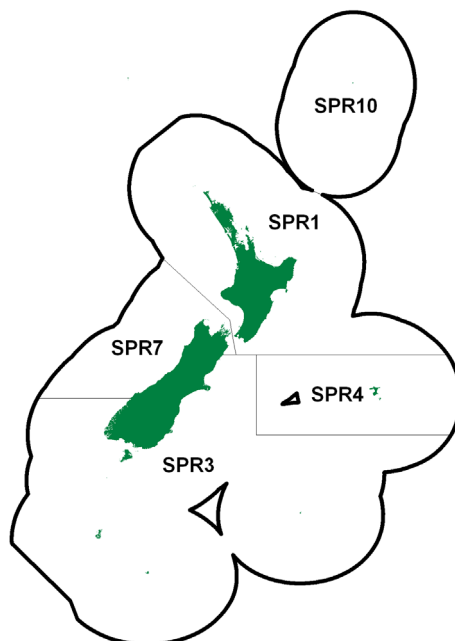
1.   FISHERY SUMMARY

There are two species of sprats in New Zealand, *Sprattus antipodum* (slender sprat) and *S. muelleri* (stout sprat). They can be distinguished by body shape, colour, and some morphological features, but are very similar and it is impractical to separate them in large catches.

Sprats were introduced into the QMS on 1 October 2002, with allowances, TACCs and TACs in Table 1 and have not been changed since.

Table 1: Recreational and customary non-commercial allowances, TACCs and TACs for sprats by Fishstock.

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other mortality	TACC	TAC
SPR 1	20	10	0	70	100
SPR 3	10	5	0	285	300
SPR 4	3	2	0	10	15
SPR 7	10	5	0	85	100
SPR 10	0	0	0	0	0
Total	43	22	0	450	515

1.1   Commercial fisheries

The sprat "fishery" is minor and intermittent. There is no information on catches or landings of sprats prior to 1990, although occasional catches were made during exploratory fishing projects on small pelagic species, mainly in the 1960s and 1970s. Sprats have undoubtedly been caught in most years, but were either not reported, reported as "bait" or included in the category "mixed species". The name "sprat" is used in a general sense for several unrelated small fishes, and the juveniles of some larger species. This may have introduced errors into catch records. Reported catches and landings since 1990 have ranged from less than 1 t to 7 t (Table 2). The most consistent (but small) catches have been by bottom trawl. Reported catches by setnet and beach seine could be of true sprats, but may also be of yellow-eyed mullet (*Aldrichetta forsteri*), known colloquially as sprats. This is particularly likely in the upper North Island where the presence of sprats is considerably reduced or non-existent. Sprat was introduced into the QMS in October 2002.

Table 2: Reported landings (t) of Sprat by fishstock and fishing year. No catches reported for SPR 10, which has a TACC of 0.

FMA	SPR 1 1, 2, 8 & 9		SPR3 3, 5 & 6		SPR 4 4		SPR 7 7		Total	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1990-91†	3	-	< 1	-	0	-	< 1	-	3	-
1991-92†	1	-	0	-	0	-	0	-	1	-
1992-93†	< 1	-	< 1	-	0	-	0	-	< 1	-
1993-94†	< 1	-	< 1	-	0	-	< 1	-	1	-
1994-95†	< 1	-	< 1	-	0	-	< 1	-	1	-
1995-96†	< 1	-	6	-	0	-	< 1	-	7	-
1996-97†	< 1	-	1	-	0	-	< 1	-	1	-
1997-98†	< 1	-	< 1	-	0	-	< 1	-	< 1	-
1998-99†	2	-	< 1	-	0	-	< 1	-	4	-
1999-00†	< 1	-	< 1	-	0	-	1	-	2	-
2000-01†	< 1	-	< 1	-	0	-	< 1	-	< 1	-
2001-02	< 1	-	< 1	-	0	-	< 1	-	< 1	-
2002-03	< 1	70	< 1	285	0	10	0	85	< 1	450
2003-04	< 1	70	3	285	0	10	0	85	3	450
2004-05	< 1	70	0	285	0	10	0	85	< 1	450
2005-06	< 1	70	0	285	0	10	0	85	< 1	450
2006-07	< 1	70	< 1	285	0	10	0	85	< 1	450
2007-08	< 1	70	0	285	0	10	0	85	< 1	450
2008-09	< 1	70	< 1	285	0	10	< 1	85	1	450
2009-10	< 1	70	0	285	0	10	0	85	0	450
2010-11	< 1	70	0	284	0	10	0	85	< 1	450

†   CELR

1.2   Recreational fisheries

There is no known recreational fishery, but small numbers are caught in small-mesh setnets and beach seines.

1.3   Customary non-commercial fisheries

Quantitative information on the current level of customary non-commercial take is not available.

1.4   Illegal catch

Estimates of illegal catch are not available, but this is probably insignificant or nil.

1.5   Other sources of mortality

Some accidental captures of sprats by vessels purse seining for other small pelagic species may be discarded if no market is available.

2.   BIOLOGY

Sprats occur in coastal waters from the Bay of Islands to Stewart Island, and are present at the Auckland Islands. It is not known whether the two species have different distributions. Sprats appear to be most abundant off the southeastern coast of the South Island, where anchovies are absent. Their vertical distribution within the water column is not known.

Spawning occurs in areas of reduced salinity when water temperatures are coolest 9-10.5 ^{o}C; there are consequently regional differences in spawning season with spawning peaks occurring between June and November (Taylor & Marriott 2004). The eggs are pelagic.

No reliable ageing work has been undertaken. Sprats are assumed to feed on zooplankton, and are preyed upon by larger fishes, seabirds, and marine mammals.

There have been no biological studies that are directly relevant to the recognition of separate stocks, or to yield estimates. Consequently no estimates of biological parameters are available. There is an extensive international literature base on sprats, mainly *Sprattus sprattus*, but the relevance of this to the New Zealand species is unknown.

3.   STOCKS AND AREAS

There is no biological information on which to make an assessment on whether separate stocks exist. However, there are two species, and their relative distributions are unknown. As presently understood, both species are more common around southern New Zealand. If their distributions do differ, and the biomass of each species fluctuates independently, there are unknown implications for localised stock depletion.

4.   STOCK ASSESSMENT

There have been no previous stock assessments of sprats. There have been two very general estimates of biomass in the Canterbury Bight region: 50 000 t (Robertson 1978), and 60 000 t (Colman 1979), with a possible yield of 10 000 t. No information on biomass variability is available.

4.1   Estimates of fishery parameters and abundance
No fishery parameters are available.

4.2   Biomass estimates
No estimates of biomass (B_0, B_{MSY}, or $B_{CURRENT}$) are available.

4.3   Estimation of Maximum Constant Yield (*MCY*)
MCY cannot be determined.

4.4   Estimation of Current Annual Yield (*CAY*)
Current biomass cannot be estimated, so *CAY* cannot be determined.

Yield estimates are summarised in Table 2.

4.5   Other yield estimates and stock assessment results
No information is available.

4.6   Other factors
Data from some ichthyoplankton surveys show one or both sprat species to be locally abundant. However, it is unlikely that the biomass is comparable to the very large stocks in the northern hemisphere where there are large sprat fisheries.

It is not known whether the biomass of sprats is stable or variable, but the latter is considered more likely.

In some localities around the South Island, sprats are a major food source for many fishes, seabirds, and marine mammals. Excessive localised harvesting may disrupt ecosystems.

5.   STATUS OF THE STOCKS

No estimates of current biomass are available. At the present level of minimal catches, stocks are at or close to their natural level. This is nominally a virgin biomass, but not necessarily a stable one.

Yield estimates, reported landings, and TACCs for the 2010-11 fishing year are summarised in Table 2.

Table 2: Summary of yield estimates (t), TACCs (t), and reported landings (t) for the most recent fishing year.

Fishstock		FMA	*MCY*	2010-11 Actual TACC	2010-11 Reported Landings
SPR 1	North Island	1, 2, 8, 9	–	70	0.01
SPR 3	South-east + Southland/Subantarctic	3, 5, 6	–	285	0
SPR 4	Chatham	4	–	10	0
SPR 7	Challenger	7	–	85	0
SPR 10	Kermadec	10	–	0	0
Total				450	0.01

6.   FOR FURTHER INFORMATION

Baker A.N. 1973. Spawning and development of the New Zealand sprat, *Sprattus antipodum* (Hector). Zoology Publications from Victoria University of Wellington No. 62. 12 p.

Colman J.A. 1979. Spawning of the sprat, *Sprattus antipodum* (Hector), round the South Island of New Zealand. N.Z. Journal of Marine and Freshwater Research 13(2): 263-272.

Fenaughty J.M., Bagley N.W. 1981. *W.J. Scott* New Zealand trawling survey: South Island east coast. Fisheries Technical Report No. 157. 224 p.

Morgans J.F.C. 1966. Possibilities raised by a study of the size distribution in a sample of a shoal of sprats, *Sprattus antipodum* (Hector). Transactions of the Royal Society of N.Z., Zoology 8(13): 141-147.

Robertson D.A. 1978. Blue mackerel, pilchard, anchovy, sprat, saury, and lanternfish. In Habib, G., and Roberts, P.E. (Comps.) Proceedings of the Pelagic Fisheries Conference July 1977. p. 85-89.

Smith P.J., Robertson D.A. 1981. Genetic evidence for two species of sprat (*Sprattus*) in New Zealand waters. Marine Biology 62(4): 227-233.

Taylor P.R., Marriot P.M. 2004. A summary of information on spawning of the small inshore pelagic species, anchovy (*Engraulis australis*), garfish (*Hyporhamphus ihi*), pilchard (*Sardinops sagax*), and sprat (*Sprattus antipodum* and *S. muelleri*), with a series of stock boundaries proposed for future testing. New Zealand Fisheries Assessment Report 2004/xx. 33 p.

Whitehead P.J.P., Smith P.J., Robertson D.A. 1985. The two species of sprat in New Zealand waters (*Sprattus antipodum* and *S. muelleri*). N.Z. Journal of Marine and Freshwater Research 19(2): 261-271.

STARGAZER (STA)

(*Kathetostoma giganteum*)
Puwhara
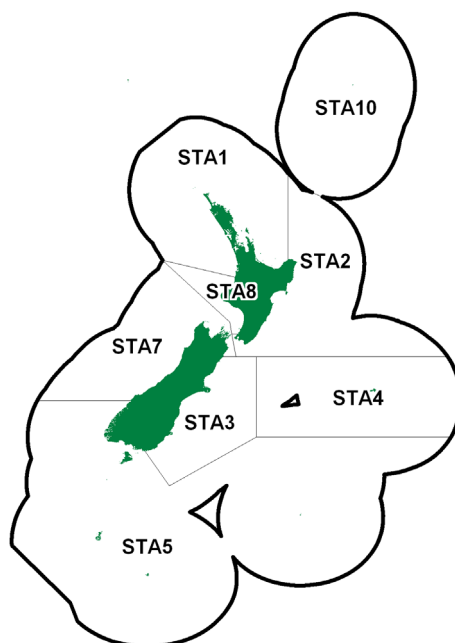
1.   FISHERY SUMMARY

1.1   Commercial fisheries

Giant stargazer (*Kathetostoma giganteum*, Uranocopidae) is a moderate-sized benthic teleost distributed widely in New Zealand waters. It is found on muddy and sandy substrates to depths of 500 m, but is most common between 50-300 m on the continental shelf around the South Island (Anderson *et al*. 1998), where it supports a moderate-value, commercial trawl fishery. It was incorporated into the QMS on 1 October 1997 and is managed as eight separate Quota Management Areas (QMAs) or Fishstocks at this time: STA 1-5, 7-8, and 10.

It is caught by both directed fishing and as bycatch of fisheries targeting other species. The main target fishery is on the Stewart-Snares shelf west of Stewart Island (statistical areas 029-030). Other target fisheries exist on the west coast of the South Island (WCSI) and off Cape Campbell on the east coast of the South Island (ECSI). It is also caught by small domestic trawl vessels targeting red cod (*Pseduophycis baccus*), tarakihi (*Nemadactylus macropterus*), flatfishes (*Colistum* spp., *Peltorhamphus* spp., and *Rhombosolea* spp.), and scampi (*Metanephrops challengeri*) on the continental shelf throughout its range, and by larger, foreign-licensed and New Zealand-chartered foreign vessels targeting barracouta (*Thyrsites atun*), jack mackerels (*Trachurus* spp.), and squids *(Nototodarus* spp.) in deeper waters, in particular on the western Chatham Rise and on the continental slope surrounding the Stewart-Snares shelf. Giant stargazer is an important bycatch of scampi fishing in STA 2-4. Catches by methods other than bottom trawling are minimal. Reported landings from 1979 to 1987-88 are given in Table 1.

Table 1:   Reported landings (t) of giant stargazer by vessel flag from 1979 to 1987-88.

Year	New Zealand Domestic	Chartered	Foreign licensed	Total	Year	New Zealand Domestic	Chartered	Foreign licensed	Total
1979*	387	155	159	701	1983-84†	1 463	525	360	2 348
1980*	723	-	-	723	1984-85†	1 027	321	178	1 526
1981*	1 010	314	84	1 408	1985-86†	1 304	386	142	1 832
1982*	902	340	283	1 526	1986-87†	1 126	379	63	1 568
1983*	1 189	329	465	1 983	1987-88†	839	331	26	1 196

*MAF data.   †FSU data.

The total catch between 1979 and 1986-87 was variable, ranging between 701-2348 t and averaging 1481 t. Different trends are apparent for domestic and foreign vessels. The domestic and chartered catch was relatively stable throughout the middle and later half of the series, which probably reflects the stability of effort in the red cod, tarakihi, flatfish, and barracouta fisheries at this time as well as better reporting compliance. However, landings by licensed foreign vessels declined steadily from a high of 465 t in 1983 to a low of 26 t in 1986-87, probably reflecting the declining importance of licensed foreign vessels in New Zealand's deepwater fisheries following the phasing-in of the QMS, which began in 1983 and which was fully implemented by 1986-87. Reported landings since 1983 by Fishstock are given in Table 2, and Figure 1 graphs the historical landings and TACC values for the main STA stocks. The total catches for 1986-87 and 1987-88 in Table 1 are less than those in Table 2 because of under-reporting to the FSU during those years.

After 1983, the catch began to increase rapidly, reaching 3426 t in 1990-91, and averaging 3204 t thereafter. The increase in catch is due to a number of factors, including: (a) increased target fishing in Southland (STA 5); (b) the availability of more quota through the decisions of the QAA; (c) better management of quotas by quota owners; (d) quota trading in STA 3, 4, 5 and 7; (e) changes in fishing patterns in the Canterbury Bight (STA 3) and the west coast of the South Island (STA 7); (f) a possible increase in abundance of stargazer in STA 7; and (g) increases in the STA 3, 5, and 7 TACCs introduced under the Adaptive Management Programme (AMP) in the 1991-92 fishing year.

The AMP is a management regime within the QMS for data-poor New Zealand Fishstocks that are likely to be able to sustain increased exploitation. Under the AMP, quota owners collect additional data from the fishery (typically fine-scale catch-effort data and rudimentary but necessary biological data such as fish length and sex) in return for an increased TACC. Under the AMP, TACCs for five giant stargazer Fishstocks (STA 1-3, 5, and 7) were increased at the start of the 1991-92 fishing year, and a sixth (STA 8) was increased in 1993-94. However, the TACCs for Fishstocks STA 1-3, 5, and 8 reverted to their pre-AMP levels in 1997-98, following the removal of these fishstocks from the AMP in July 1997 because of the failure of quota owners to meet the data-collection requirements of the AMP. In recent years, landings in three of these Fishstocks (STA 1-2 and 5) have exceeded their reduced, post-AMP TACCs; although of these, STA 5 is the only one with a TACC greater than 40 t at this time. STA 3 and STA 7 were reviewed in 1998 and retained in the AMP until the end of the 2002-03 fishing year. The TACC in STA 7 further increased to 997 t at the start of the 2002-03 fishing year with a TAC of 1000 t (which includes a 2 t recreational and a 1 t customary allowance). STA 7 was reviewed again in 2007 (Starr *et al*. 2007) and retained in the AMP, in October of 2010 the TACC was increased to 1 042 t increasing the TAC to 1 072 t. STA 3 was reviewed in 2008 (Starr *et al*. 2008) and retained at the existing TACC of 902 t, a customary and recreational allocation of 1 t and 2 t respectively, totalling a 905 t TAC. All AMP programmes ended on 30th September 2009.

Of the eight Fishstocks, the most important, in terms of the recorded landed catch, are STA 5, STA 7, and STA 3 (where landings since 1990-91 have averaged 1163 t, 883 t, and 748 t, for each stock respectively) with smaller contributions from STA 2 and STA 4, although a high TACC is set for STA 4 compared with the other seven Fishstocks, it has never been approached or exceeded. Most of the STA 4 catch is caught as bycatch of fishing directed at other target species. A high recorded landed catch in 1990-91 (790 t) was due to exploratory fishing for these target species, this has since declined. The recorded landed catch has averaged 278 t per fishing year since then. Increased catches in STA 2 from 1990-91 were due to the development of the scampi fishery in this Fishstock.

As noted, the TACC in STA 7 was increased to 700 t in 1991-92 under the terms of the AMP. The TACC was overcaught in nearly every subsequent fishing year up to 2002-03, when the TACC was further increased to 997 t. Landings reached a high of 1440 t in 2000-01, before dropping back to 800 t in 2001-02. These high recorded landings resulted mainly from the use of bycatch trades with barracouta and flatfishes. With the removal of the bycatch trade system in October 2001, fishers now face the penalty of high deemed-values for any overcatch, and it is likely that these penalties have been the cause of the reduction in the overcatch in this Fishstock.

STARGAZER (STA)

Table 2: Reported landings (t) of giant stargazer by QMS Fishstock (QMA) from 1983 to 2010-11. TACCs from 1986-87 to 2010-11 are also provided.

Fishstock FMA(s)	STA 1 1 & 9		STA 2 2		STA 3 3		STA 4 4		STA 5 5 & 6	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983*	8	-	34	-	540	-	168	-	843	-
1984*	5	-	24	-	588	-	143	-	1023	-
1985*	9	-	15	-	438	-	82	-	695	-
1986*	12	-	24	-	415	-	95	-	566	-
1986-87	10	20	31	30	644	560	72	2 000	738	1 060
1987-88	3	20	46	33	783	581	110	2 005	886	1 144
1988-89	3	20	41	37	675	591	134	2 005	1 215	1 173
1989-90	9	21	53	37	747	703	218	2 009	1 150	1 175
1990-91	8	21	125	37	674	734	790	2 014	1 061	1 239
1991-92	18	50	105	100	756	900	366	2 014	1 056	1 500
1992-93	19	50	115	101	811	901	231	2 014	1 247	1 500
1993-94	8	50	73	101	871	902	113	2 014	1 327	1 500
1994-95	10	50	74	101	829	902	223	2 014	1 216	1 525
1995-96	17	50	69	101	876	902	259	2 014	1 159	1 525
1996-97	22	50	77	101	817	902	149	2 014	977	1 525
1997-98	29	21	54	38	667	902	263	2 014	544	1 264
1998-99	27	21	46	38	641	902	137	2 014	1 145	1 264
1999-00	36	21	42	38	719	902	161	2 014	1 327	1 264
2000-01	26	21	45	38	960	902	233	2 014	1 439	1 264
2001-02	34	21	58	38	816	902	391	2 158	1 137	1 264
2002-03	31	21	41	38	863	902	308	2 158	967	1 264
2003-04	23	21	27	38	578	902	186	2 158	1 193	1 264
2004-05	27	21	28	38	646	902	366	2 158	1 282	1 264
2005-06	34	21	30	38	824	902	359	2 158	1 347	1 264
2006-07	22	21	31	38	719	902	292	2 158	1 359	1 264
2007-08	36	21	26	38	572	902	436	2 158	1 171	1 264
2008-09	35	21	22	38	574	902	139	2 158	1 137	1 264
2009-10	17	21	26	38	576	902	198	2 158	1 339	1 264
2010-11	21	21	19	38	570	902	134	2 158	1 235	1 264

Fishstock FMA(s)	STA 7 7		STA 8 8		STA 10 10		Total	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983*	323	-	3	-	0	-	1 919	-
1984*	444	-	3	-	0	-	2 230	-
1985*	328	-	4	-	0	-	1 571	-
1986*	362	-	3	-	0	-	1 477	-
1986-87	487	450	7	20	0	10	1 990	4 150
1987-88	505	493	5	20	0	10	2 338	4 306
1988-89	520	499	5	20	0	10	2 593	4 355
1989-90	585	525	1	22	0	10	2 763	4 502
1990-91	762	528	6	22	0	10	3 426	4 605
1991-92	920	700	18	22	0	10	3 239	5 296
1992-93	861	702	5	22	0	10	3 289	5 300
1993-94	715	702	4	50	0	10	3 111	5 329
1994-95	730	702	7	50	0	10	3 089	5 354
1995-96	877	702	4	50	0	10	3 261	5 354
1996-97	983	702	10	50	0	10	3 034	5 354
1997-98	564	702	10	22	0	10	2 132	4 973
1998-99	949	702	2	22	0	10	2 946	4 973
1999-00	1 184	702	3	22	0	10	3 472	4 973
2000-01	1 440	702	4	22	0	10	4 146	4 973
2001-02	802	702	4	22	0	10	3 238	5 117
2002-03	957	997	4	22	0	10	3 171	5 412
2003-04	934	997	6	22	0	10	2 947	5 412
2004-05	1 028	997	5	22	0	10	3 381	5 412
2005-06	1 010	997	3	22	0	10	3 606	5 412
2006-07	1 051	997	4	22	0	10	3 478	5 412
2007-08	1 014	997	3	22	0	10	3 258	5 412
2008-09	1 001	997	5	22	0	10	2 913	5 412
2009-10	1 093	997	6	22	0	10	3 247	5 456
2010-11	1 037	1 042	7	22	0	10	3 023	5 456

* MAF data

Figure 1: Historical landings and TACC for the seven main STA stocks. From top left: STA1 (Auckland East), STA2 (Central East), STA3 (South East Coast), STA4 (Chatham Rise), STA5 (Southland), and STA7 (Challenger). [Continued on next page].
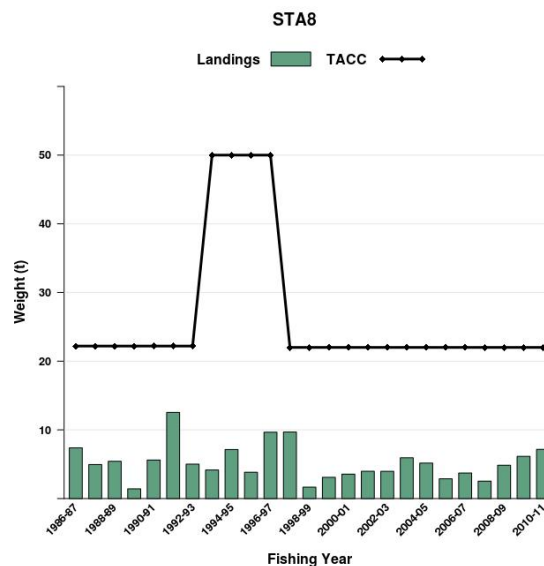
Figure 1 [Continued]: Historical landings and TACC for the seven main STA stocks. STA8 (Central Egmont). Note that these figures do not contain data prior to entry into the QMS.

The landings data (Table 1 and Table 2) probably include an unknown quantity of catch from other uranoscopid species misidentified as *K. giganteum*. Fishers in STA 1-3 and 8 have been known to report brown (*Gnathagnus innotabilis*) and spotted stargazer (*Genyagnus monopterygius*) as *K. giganteum* in the past. Landings in STA 4 and 5 probably include an unknown amount of an undescribed sister species, banded stargazer (*Kathetostoma* sp.). Although the true extent of misreporting due to misidentification is unknown, it is likely to be small.

1.2   Recreational fisheries

Stargazer were not reported as being caught by recreational fishers in surveys conducted in the Ministry of Fisheries South region in 1991-92, Central region in 1992-93 and North region in 1993-94. In a Ministry of Fisheries national survey in 1996, a few giant stargazer were reported in STA 1 and 3, with an estimated take of 1000 fish in STA 1 and less than 500 fish taken in STA 3 (Bradford 1998). No giant stargazer catch was recorded for the recreational fishers during the 1999-2000 national diary survey (Boyd & Reilly 2005).

1.4   Customary non-commercial fisheries

No quantitative information is available on the level of customary non-commercial take.

1.5   Illegal catch

No quantitative information is available on the level of illegal catch.

1.6   Other sources of mortality

No quantitative information is available on the level of other sources of mortality.

2.   BIOLOGY

Giant stargazer is found throughout the New Zealand EEZ. It is most plentiful around the South Island (STA 3, 5, & 7) and at the Mernoo Bank on the Chatham Rise (STA 4).

Using data collected from the west coast South Island trawl survey series (Drummond & Stevenson, 1995a, 1995b, 1996; Stevenson 1998; Stevenson & Hanchet 2000; Stevenson 2002, 2004), Manning (2008) found that giant stargazer reach sexual maturity at a length of about 40-55 cm in total length (TL), depending on sex, at an age of between 5-7 years. Age and growth studies suggest that some individuals reach a maximum age of at least 25 years (Sutton 1999; Manning & Sutton 2004; Sutton

2004; Manning & Sutton 2007a, 2007b). Otolith growth zones have not been validated. A number of attempts at growth zone validation have been undertaken unsuccessfully. A tag and release programme was initiated with all released fish being injected with oxytetracycline as part of the East Coast South Island trawl survey. A single fish has been recaptured but the otoliths were not recovered. Andrews (2009) investigated the feasibility of using lead-radium dating of otoliths as a means of validating age. However, the levels of radium-226 in stargazer otoliths were too low (nearly 10 times lower than expected) to generate meaningful results. Using maximum-likelihood methods, Manning & Sutton (2004) found that giant-stargazer growth differs significantly between the east, south, and west coasts of the South Island. They suggested that these differences represented different biological stock units in these areas, although the true stock structure is unclear (Tate 1987). Manning (2005) investigated the effect of assuming alternative growth models with different functional forms on the data and conclusions presented by Manning & Sutton (2004). His results were consistent with the earlier results.

M was estimated using the equation $M = \ln 100 / t_{max}$, where t_{max} is the maximum age to which 1% of the population survives in an unexploited stock. Using an unvalidated maximum age of 26 years, yields $M = 0.18$. Preliminary results of the STA 7 quantitative stock that is underway at this time (2008) suggest that 0.18 is an underestimate of the unknown true value. A revised estimate based on applying Hoenig's (1983) regression to the age composition data from the west coast South Island survey series suggested that a value of 0.23 is more reasonable (Manning 2008). Although the west coast South Island age composition data were collected from an exploited stock, 0.23 is considered to be closer to the true value than 0.18.

Stargazer have an annual reproductive cycle with a winter spawning season. Spawning probably occurs in mid and outer shelf waters all around New Zealand. The generalised spawning date assumed in the age and growth studies cited above is 1 July in any given calendar year.

Biological parameters relevant to the stock assessment are given in Table 3.

Table 3: Estimates of giant stargazer biological parameters

Fishstock							Estimate	Source
1. Natural mortality (*M*)								
STA 5							0.20	Sutton (2004)
STA 7							0.18	Manning (2006a)

2. Weight = a(length)^b (Weight in g, length in cm fork length).								
	Females		Males		All fish			
	a	b	a	b	a	b		
STA 3	-	-	-	-	0.015	3.01		McClatchie (uppub. data)
STA 5	-	-	-	-	0.024	2.92		McGregor (unpub. data)
STA 7	0.018	2.97	0.013	3.07	-	-		Manning & Sutton (2007a)

3. Length at maturity (cm total length)					
	Females		Males		
	L_{50}	L_{95}	L_{50}	L_{95}	
STA7	54.37	11.24	40.98	14.90	Manning (2008)

4. Age at maturity (years)					
	Females		Males		
	A_{50}	A_{95}	A_{50}	A_{95}	
STA7	7.23	4.34	5.53	4.38	Manning (2008)

3. von Bertalanffy length-at-age model parameter estimates							
	Females			Males			
	L_∞	K (yr^{-1})	t_0 (yr)	L_∞	K (yr^{-1})	t_0 (yr)	
STA 3	78.11	0.14	-1.25	61.49	0.2	-0.97	Sutton (1999)
STA 5	73.92	0.18	-0.22	59.12	0.19	-1.19	Sutton (1999)
STA 5	72.61	0.17	-0.02	60.76	0.18	-1.16	Sutton (2004)
STA 7	85.74	0.13	-0.666	71.00	0.15	-0.664	Manning & Sutton (2007a); a revision of earlier results presented by Manning & Sutton (2004)

3.   STOCKS AND AREAS

There are no new data that would alter the stock boundaries given in previous assessment documents.

It is not known if there is more than one giant stargazer stock in New Zealand. The present QMAs were used as a basis for Fishstocks, except for QMAs 5 and 6, which were combined (STA 5). The basis for choosing these boundaries was a general review of the distribution and relative abundance of stargazer within the fishery.

As noted, length-at-age differs significantly between the east, south and west coasts of the South Island (Manning & Sutton 2004, Manning 2005). This is consistent with the Fishstock boundaries.

4.   STOCK ASSESSMENT

There are no new data that are available at this time that would alter the yield estimates of STA 1, 2, 3, 4, 5, and 8 given in the 1997 Plenary Report. The yield estimates are based on commercial landings data.

An integrated assessment for STA 7 was updated in 2008 with data that included the commercial catch, trawl survey biomass and proportions-at-age estimates, and commercial catch proportions-at-age.

4.1   Estimates of fishery parameters and abundance

Trawl surveys
Indices of relative biomass are available from recent *Tangaroa* and *Kaharoa* trawl surveys (Table 4).

Table 4:   **Relative biomass indices of stargazer and coefficients of variation (CV) for east coast North Island (ECNI), east coast South Island (ECSI) - winter and summer, Chatham Rise, west coast South Island (WCSI) and the Stewart-Snares Island survey areas assuming areal availability, vertical availability and vulnerability equal 1.0. Note: because trawl survey biomass estimates are relative indices, comparisons between different seasons (e.g., summer and winter ECSI) are not strictly valid.**

Species	Region	Fishstock	Year	(Trip Code)	Relative biomass (t)	CV (%)
Giant stargazer	ECNI	STA 2	1993	KAH9304	184	22
	Inshore		1994	KAH9402	58	47
			1995	KAH9502	44	35
			1996	KAH9602	57	17
	ECNI	STA 2	1993	KAH9301	250	16
	(Scampi)		1994	KAH9401	215	20
			1995	KAH9501	122	17
	ECSI	STA 3	1991	KAH9105	600	17
	(Winter)		1992	KAH9205	669	16
			1993	KAH9306	609	14
			1994	KAH9406	462	15
			1996	KAH9606	465	11
			2007	KAH0705	755	18
			2008	KAH0806	606	14
			2009	KAH0905	475	15
	ECSI	STA 3	1996	KAH9618	897	12
	(Summer)		1997	KAH9704	543	11
			1998	KAH9809	999	10
			1999	KAH9917	472	14
			2000	KAH0014	214	16

Table 4 [Continued].

Species	Region	Fishstock	Year	(Trip Code)	Relative biomass (t)	CV (%)
	Chatham Rise	STA 4	1992	TAN9106	2 570	11
			1993	TAN9212	2 560	13
			1994	TAN9401	2 853	12
			1995	TAN9501	1 429	13
			1996	TAN9601	3 039	16
			1997	TAN9701	2 328	15
			1998	TAN9801	1 702	14
			1999	TAN9901	1 903	13
			2000	TAN0001	2 148	13
			2001	TAN0101	1 772	16
	Chatham Rise	STA 4	2002	TAN0201	2 195	16
			2003	TAN0301	1 380	15
			2005	TAN0501	3 045	13
			2006	TAN0601	2 007	19
			2007	TAN0701	1 684	12
			2008	TAN0801	4 677	40
			2009	TAN0901	3 154	24
			2010	TAN1001	1 140	17
			2011	TAN1101	3 169	28
			2012	TAN1201	1 751	13
	WCSI	STA 7	1992	KAH9204	1 302	12
			1994	KAH9404	1 350	17
			1995	KAH9504	1 551	16
			1997	KAH9701	1 450	15
			2000	KAH0004	1 023	12
			2003	KAH0304	827	15
			2005	KAH0503	1 429	19
			2007	KAH0704	1 630	12
			2009	KAH0904	1 952	19
			2011	KAH1004	1 645	16
	Stewart-Snares	STA 5	1993	TAN9301	2 650	20
			1994	TAN9402	3 755	11
			1995	TAN9502	2 452	11
			1996	TAN9604	1 733	11
Banded stargazer	Stewart-Snares	BGZ 5	1993	TAN9301	409	27
			1994	TAN9402	250	21
			1995	TAN9502	316	29
			1996	TAN9604	232	34
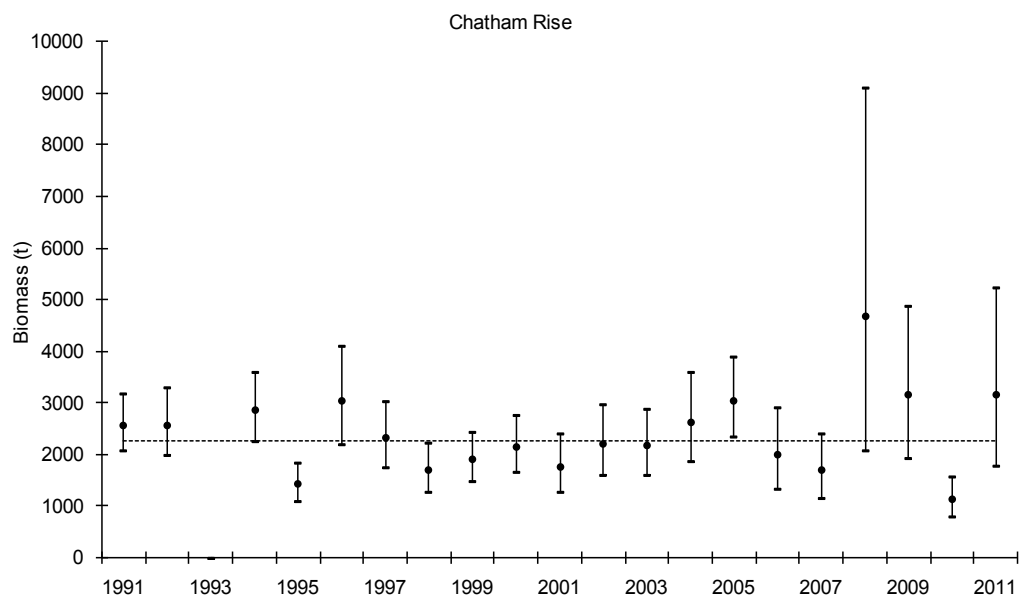
Figure 2:   Stargazer biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the time series mean (dotted line) estimated from the Chatham Rise trawl survey.

West Coast South Island
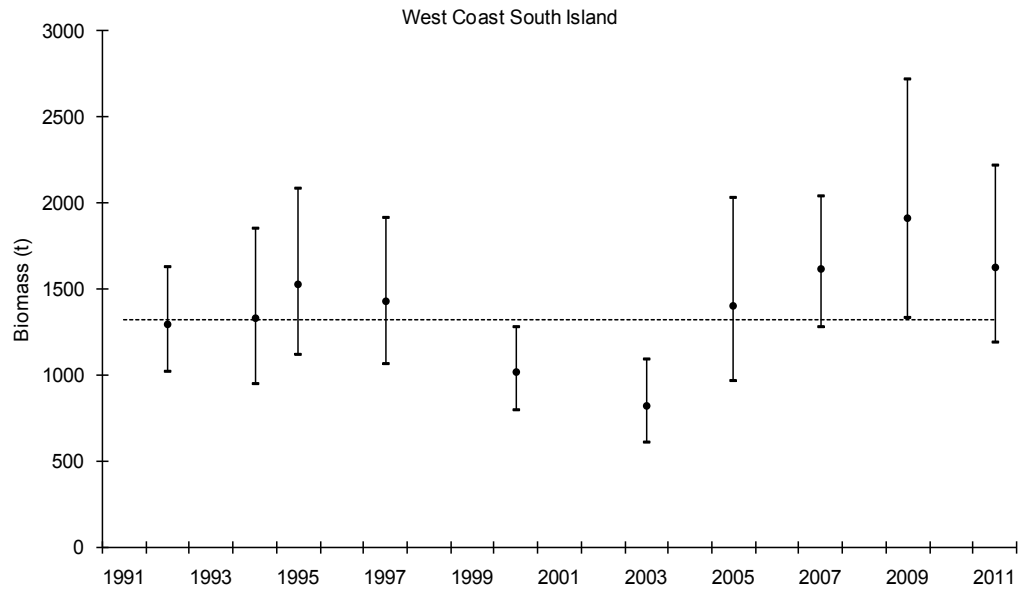
Figure 3: Stargazer biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the time series mean (dotted line) estimated from the West Coast South Island trawl survey.

East Coast South Island
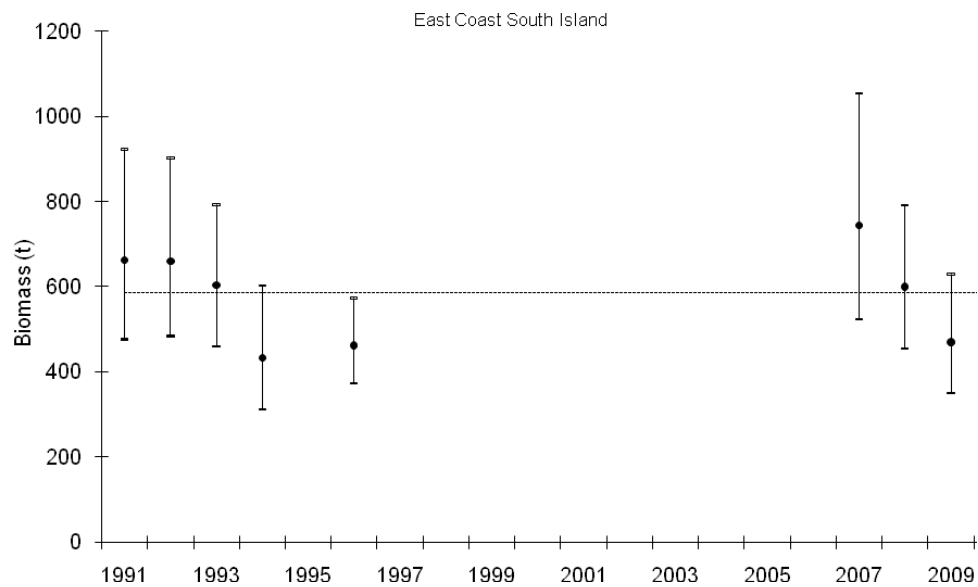
Figure 4: Stargazer biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the time series mean (dotted line) estimated from the East Coast South Island trawl survey.
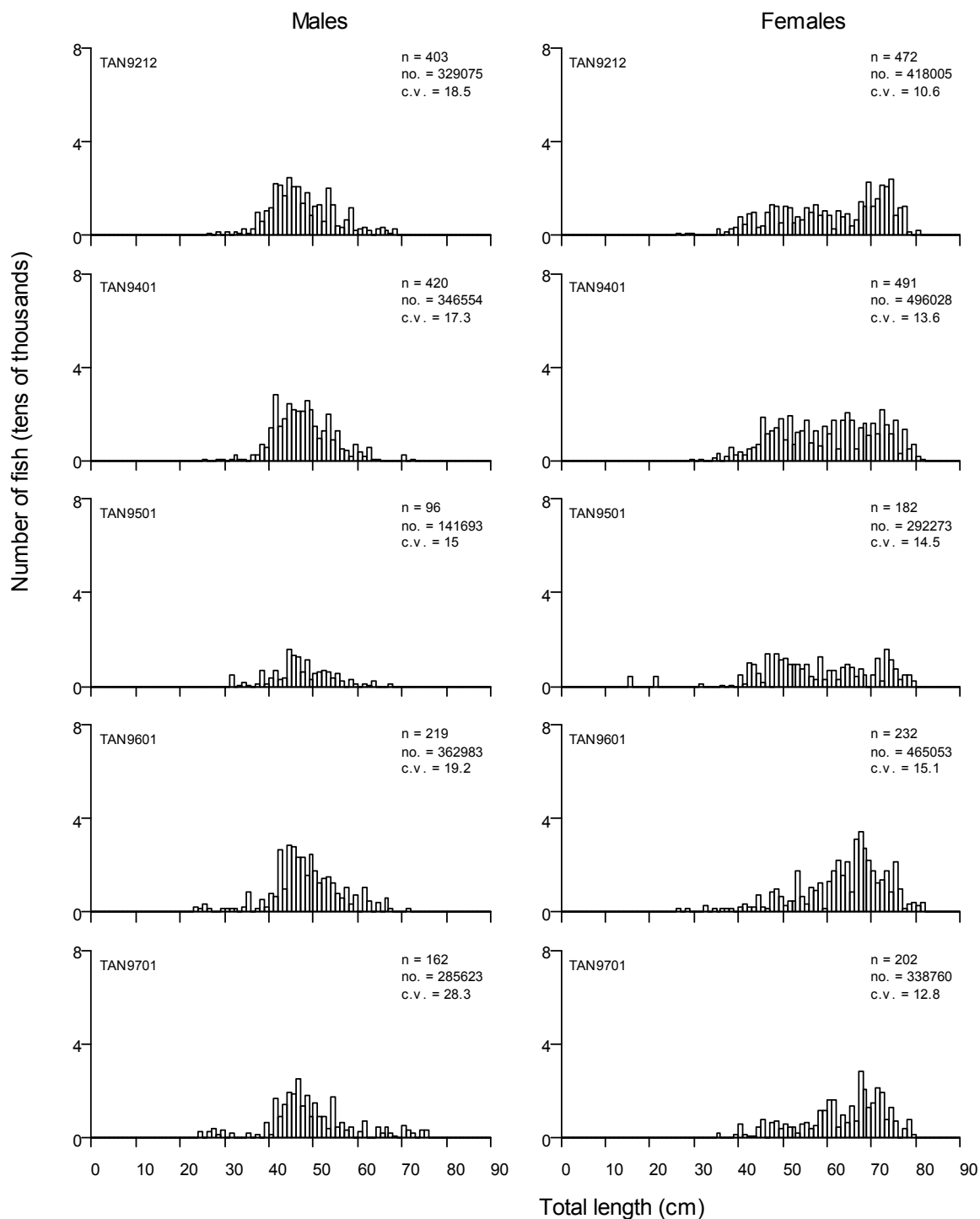
Figure 5: Scaled length frequency distributions for giant stargazer in 30-400 m, for Chatham Rise surveys. M, males and F, females, (CV) (Stevens *et al.* 2011).

Males

Females

Number of fish (tens of thousands)

Total length (cm)
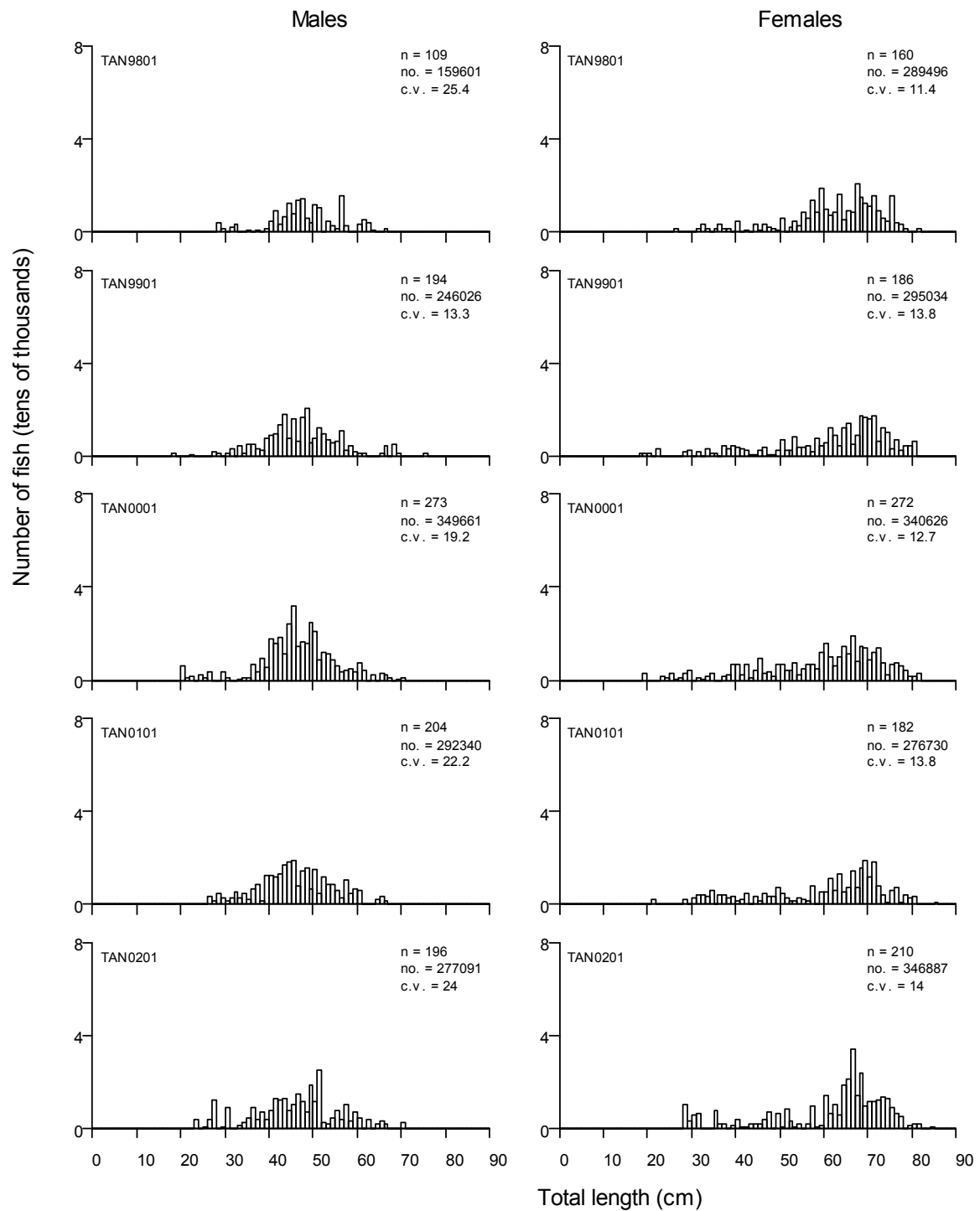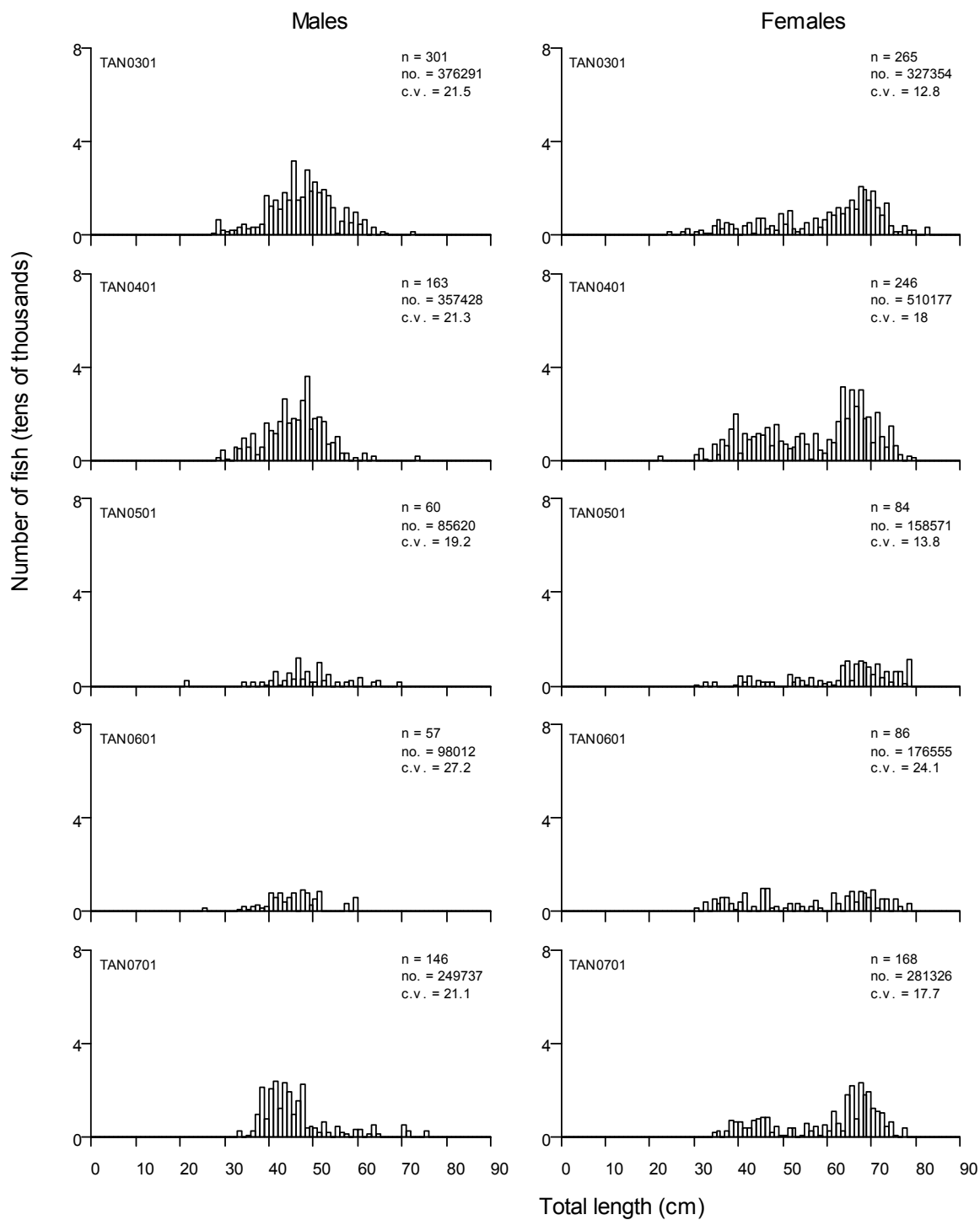
Figure 5 [Continued].

Figure 5 [Continued].
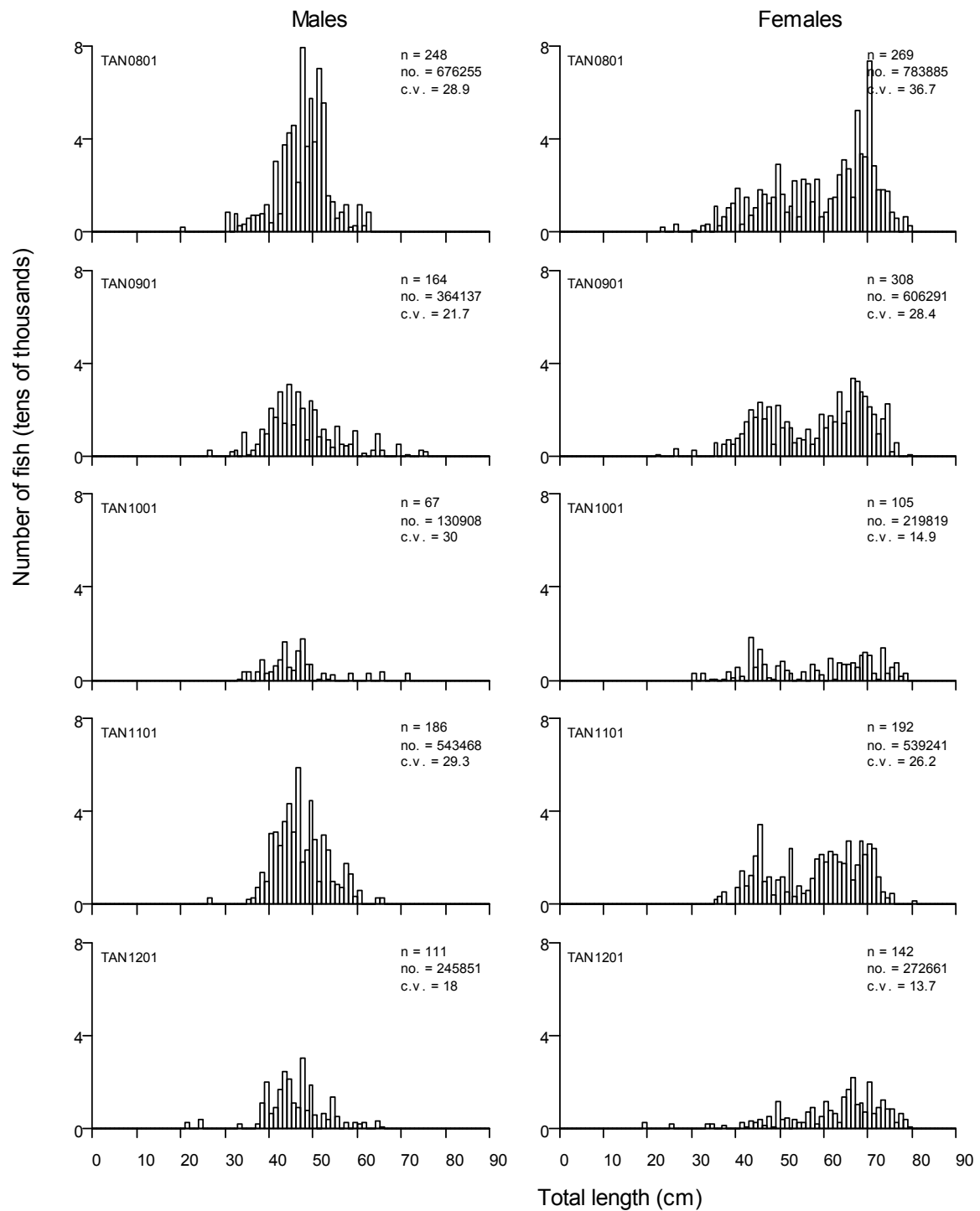
Males

Females

Figure 5 [Continued].
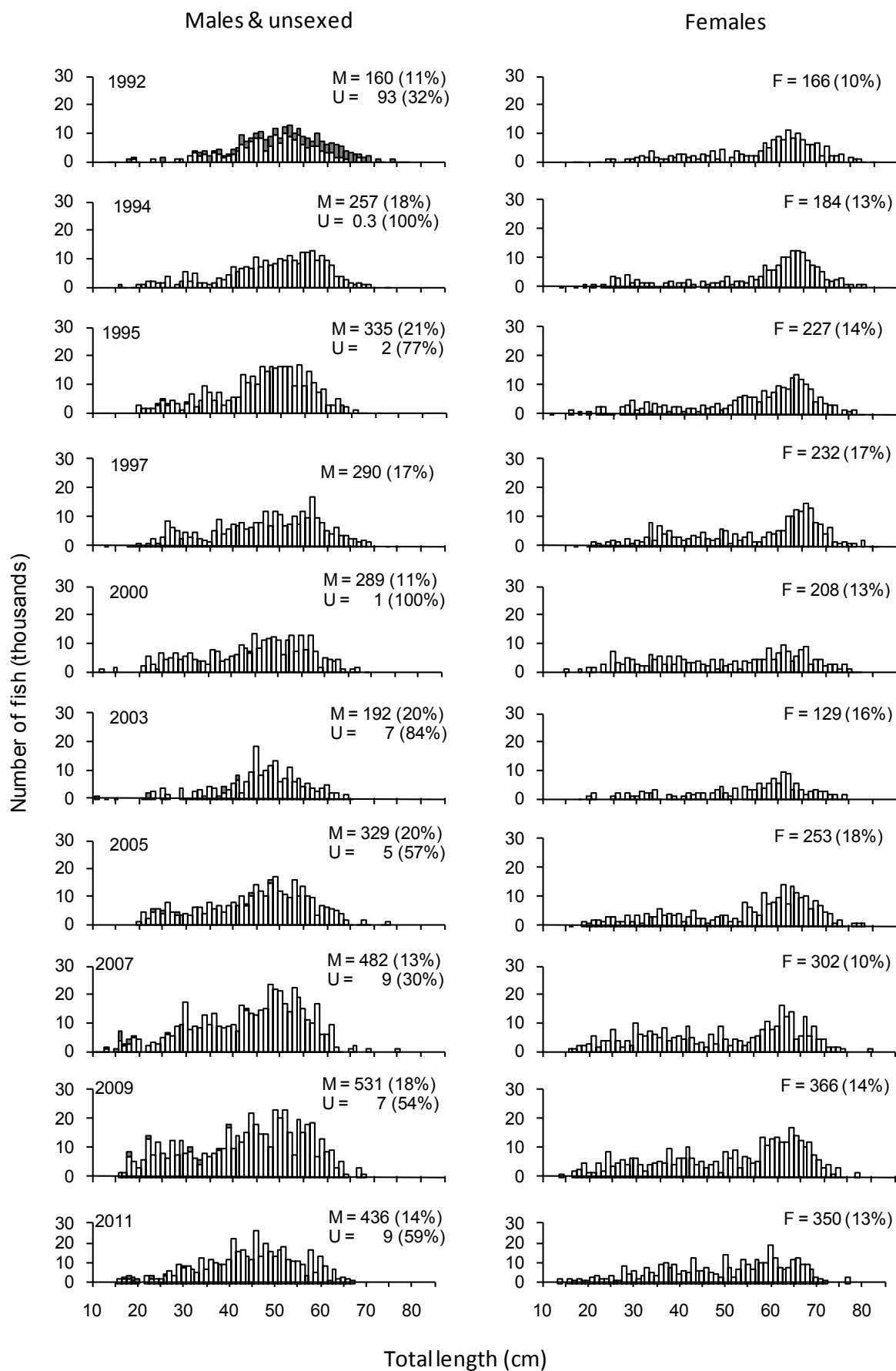
Figure 6: Scaled length frequency distributions for giant stargazer in 30-400 m, for WCSI surveys. M, males; F, female and u, unsexed, (CV) (Stevenson in press).

4.2   CPUE analysis

STA 2, 3, and 7

CPUE indices have been calculated for STA 2 (Vignaux 1997) and STA 3 (SEFMC 2002, SeaFIC 2005a, Starr *et al.* 2008). The currently accepted CPUE series for STA 3 (Figure 5) is based on a mixed target species fishery including red cod, barracouta, tarakihi and stargazer and shows no trend since about 2000-01. A CPUE series calculated for STA 7 (SeaFIC 2002, 2003b, 2005b, Starr *et al.* 2007), based on a mixed west coast South Island target species (stargazer, barracouta, red cod and tarakihi) fishery, has not been accepted by the AMP WG as an indicator of STA 7 abundance. The Inshore and AMP Fishery Assessment Working Groups (FAWG) have had concerns over using bycatch fisheries to monitor stargazer abundance in these areas due to possible changes in recording and fishing practices.
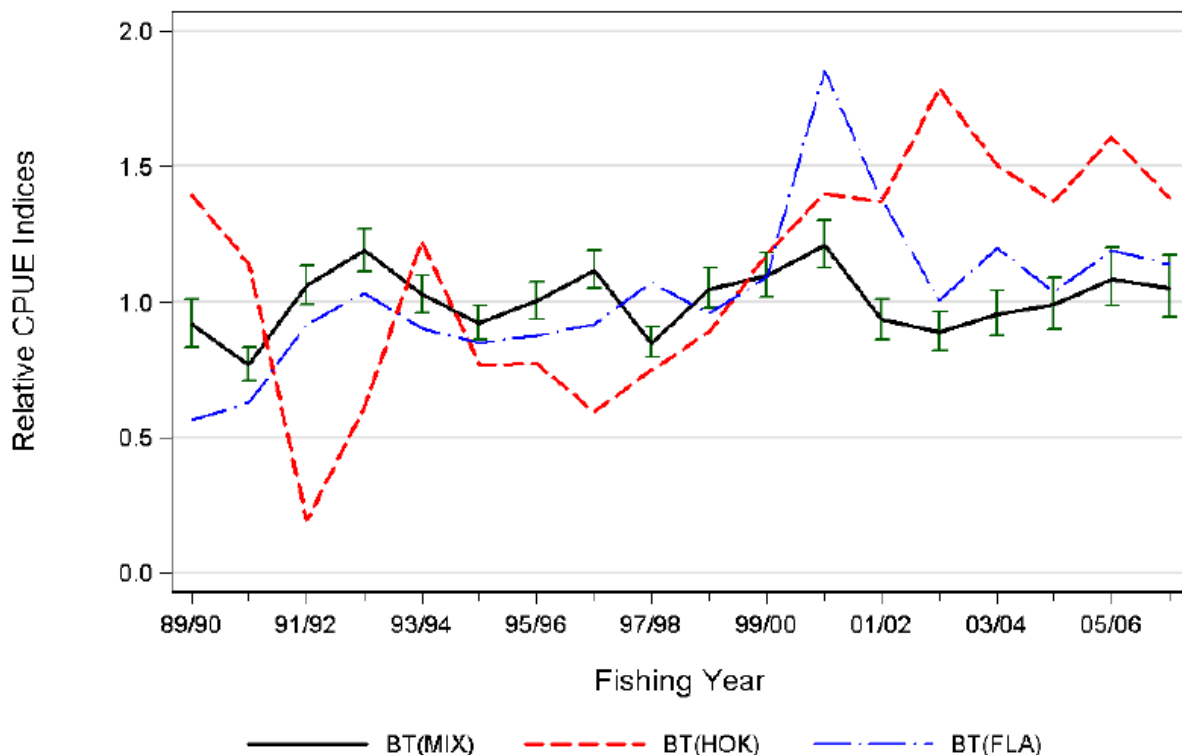
Figure 7: Comparison of the lognormal indices from the three bottom trawl CPUE series for STA 3; a) BT(MIX): mixed species target trawl fishery; b) BT(FLA): hoki target trawl fishery; c) BT(FLA): target flatfish trawl fishery. Each series is scaled to the geometric mean = 1. (Starr *et al.* 2008).

STA 4

Stargazer in STA 4 are taken as a bycatch in the fisheries for hoki, ling, silver warehou, squid, barracouta, red cod and scampi on the Chatham Rise, as bycatch in a barracouta fishery near the Chatham Islands, and in a small targeted stargazer fishery north of the Chatham Islands.

An unstandardised CPUE analysis of stargazer in these fisheries, singly and in appropriate combinations, showed no clear trend (Table 5). The stargazer CPUE is strongly correlated with the stargazer catch, suggesting that it is influenced by being in or out of the top five species reported on fishing returns. The unstandardised CPUE indices of the stargazer bycatch are not considered reliable, and are not used in stock assessment. Further, the Working Group noted the localised nature of the fishing effort in STA 4 and that fishing occurs in two geographically distinct locations, one around the Chatham Islands and the other to the west, adjacent to eastern STA 3. The Working Group agreed that the catch statistics from statistical areas 19, 21 and 23 (in STA 3) should be considered in any STA 4 analysis.

Table 5: Summary of unstandardised CPUE indices* for stargazer as a bycatch in STA 4† target fisheries.

Years	Hoki	Ling	S. warehou	Squid	Barracouta	Red cod	Scampi	Combined‡
1989-90	0.14	0.72	0.31	1.00	0.29	0.86	-	0.34
1990-91	0.88	0.83	1.15	1.26	0.56	1.03	0.06	0.87
1991-92	0.39	0.56	0.61	0.47	0.66	0.97	0.04	0.46
1992-93	0.32	0.89	0.33	0.80	0.62	0.32	0.07	0.37
1993-94	0.22	0.27	0.40	0.53	0.68	0.55	0.07	0.38
1994-95	0.54	2.56	0.65	0.48	0.59	0.43	0.10	0.61
1995-96	0.38	0.41	0.43	0.54	0.39	0.67	0.09	0.44

* Catch per tow, for tows in which stargazer were reported caught.

† Statistical areas 021 and 023 (STA 3) and 401 and 407 (STA 4), covering the western end of Chatham Rise.

‡ Hoki, ling, silver warehou, squid, barracouta, red cod, but not scampi

STA 5

About 80% of the STA 5 catch is caught by small (< 43 m) inshore bottom-trawl vessels targeting giant stargazer. The remainder of the catch is caught mostly by large (≥ 43 m), deepwater bottom-trawl vessels targeting other species such as barracouta, jack mackerels, and squids. Catches by methods other than bottom trawling are very small.

Vignaux (1997) was the first to present standardised CPUE indices for STA 5. Data were analysed from the 1991-92 to 1995-96 fishing years only and the indices she presented showed no trend. Her analysis was superseded by that of Phillips (2001), who analysed data from the 1989-90 to 1999-00 fishing years. He used a log normal generalised linear model to describe non-zero estimated catches reported by both the inshore and deepwater fleets. However, the indices he presented also showed no trend and were rejected as a relative abundance index by the New Zealand Inshore Fisheries Working Group (Inshore FAWG).

Manning (2007) updated Phillips' (2001) analysis with four more fishing years of data and used a different data processing method. His analysis spanned the 1989-90 to 2003-04 fishing years, and he groomed and restratified the catch-effort data in his series tripwise, allocating the groomed landed catch for each trip to the recomputed effort strata using Starr's (2003) method for processing MFish catch-effort and landings data, as implemented by Manning *et al.* (2004). His analysis also rigorously considered and accounted for changes in stargazer conversion factors over time, which neither Vignaux's (1997) nor Phillips' (2001) analyses did.

Manning (2007) fitted a suite of different generalised-linear-models (GLMs) to different subsets of the groomed dataset. The model, accepted by the Inshore FAWG as the best indication of STA 5 relative abundance, was a log normal GLM fitted to non-zero records associated with small, inshore bottom trawl vessels where giant stargazer was recorded as the target species, where the vessels had a consistent presence in the fishery (i.e., those vessels active in the fishery for five years or more with ten or more associated records per fishing year; a so-called "core" vessel subset), and where the response variable was defined as giant stargazer *catch* rather than *catch-per-unit-effort* (model fit 2.4). The canonical indices obtained from this model suggest that stargazer abundance in STA 5 has remained static, or at worst, declined only slightly over the data series (Figure 3). The trend in the standardised CPUE indices between the 1992-93 to 1995-96 fishing years appears consistent with stargazer relative biomass estimates from research trawl surveys of the Stewart-Snares shelf carried out by RV *Tangaroa*, 1993-96 (Figure 6) (Hurst & Bagley 1994, Bagley & Hurst 1995, 1996a, 1996b, Hurst & Bagley 1997). The peak then declined in the standardised CPUE and trawl survey relative biomass indices may, however, reflect a change in catchability rather than in stock abundance.

4.3 Biomass estimates

STA 2

An age structured model using deterministic recruitment was fitted to the abundance indices from the ECNI inshore and the ECNI scampi trawl surveys results (Table 4). The declines in the indices suggest that the current exploitation rate is very high, but the model results are determined by the choice of maximum allowable exploitation rate. An upper bound of 80% for the catch/biomass ratio

was used in the base case, but this is considered unrealistically high, because stargazer is mainly caught as a bycatch of other fisheries and because the ECNI inshore trawl surveys suggest that there are parts of the stock not being fished. The virgin biomass estimated by the model of 563 t is therefore considered a minimum estimate of virgin biomass.
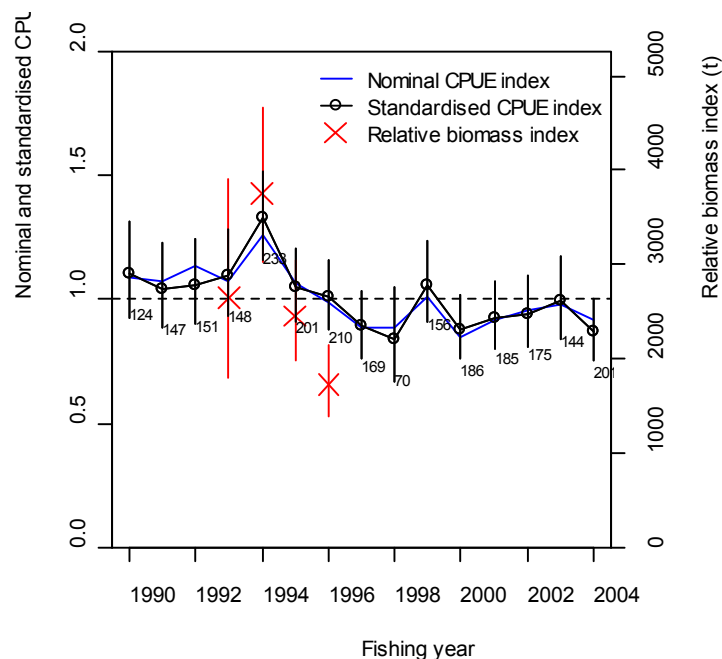
Figure 8: The standardised CPUE indices from the fit of model 2.4 presented by Manning (2008). The nominal CPUE and trawl survey relative biomass estimates from the SCSI survey series by RV Tangaroa (1993-1996) have been overlaid for comparison. The nominal CPUE and trawl survey relative biomass indices have been rescaled so that all three series can be displayed on the same plot.

STA 7

An age-structured model partitioned by age (0-25 years) and sex was fitted to the WCSI trawl survey relative abundance indices (1992-05), WCSI survey proportions-at-age data (1992-05), and WCSI fishery catch-at-age data (2005 only) (Manning 2008). The stock boundary assumed in the model included the west coast of the South Island, Tasman and Golden Bays, but not eastern Cook Strait (a catch history was compiled for the model stock that excluded eastern Cook Strait). A summary of the model's annual cycle is given in Table 6. A preliminary model that included data up to the end of the 2005 year was revised and updated with additional data from 2007 West Coast South Island survey relative biomass, survey proportions-at-age, and fishery proportions-at-age data.

Table 6: The STA 7 model's annual cycle (Manning 2008). Processes within each time step are listed in the time step in which they occur in particular order (e.g., in time step 3, new recruits enter the model partition first followed by the application of natural and fishing mortality to the partition). M, the proportion of natural mortality assumed during each time step. F, the nominal amount of fishing mortality assumed during each time step as a proportion of the total catch in the stock area. Age, the proportion of fish growth that occurs during each time step in each model year

| Time step | Duration | Process applied | Proportions | | | Observations |
			M	F	Age	
1	Oct-Jun	Mortality (M, F)	0.75	0.77	1.00	Survey relative biomass Survey proportions-at-age Survey length-at-age Fishery catch-at-age Fishery relative abundance
2	Jun (instantaneaous)	Spawning Age incrementation	0.00	0.00	0.00	NIL
3	Jun-Sept	Recruitment Mortality (M, F)	0.25	0.23	0.00	Fishery catch-at-age

Table 7: MCMC initial and current biomass estimates for the STA 7 model runs R3.1 R3.6 and R3.7 (Manning in prep). B_0, virgin or unfished biomass; B_{2005}, mid-year biomass in 2005 (current biomass); (B_{2005}/ B_0) %, B_0 as a percentage of B_{2005}; Min, minimum; Max, maximum; Q_i, ith quantile. The interval ($Q_{0.025}$, $Q_{0.975}$) is a Bayesian credibility interval (a Bayesian analogue of frequentist confidence intervals).

| | R3.3 | | | R3.6 | | |
	B_0	B_{2007}	(B_{2007}/B_0) %	B_0	B_{2007}	(B_{2007}/B_0) %
Min	7 740	1 860	24.1	8 960	2 390	25.5
$Q_{0.025}$	8 290	2 410	28.5	10 170	3 680	35.9
Median	9 210	3 580	38.8	13 750	7 490	54.2
Mean	9 250	3 640	39.1	14 630	8 330	54.5
$Q_{0.975}$	10 580	5 290	50.7	24 910	18 580	76.3
Max	11 800	6 350	55.0	35 920	31 310	87.4
	R3.7					
Min	7 840	1 900	24.2			
$Q_{0.025}$	8 220	2 370	28.8			
Median	9 190	3 580	39.0			
Mean	9 220	3 640	39.1			
$Q_{0.975}$	10 470	5 260	50.1			
Max	11 300	6 120	58.2			
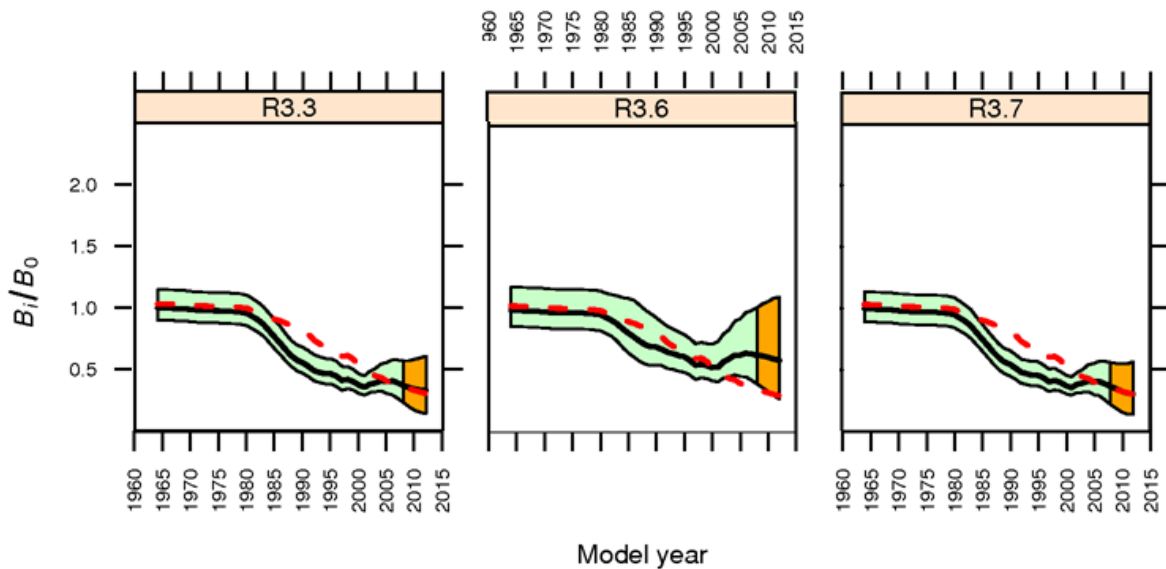
Figure 9: Relative SSB trajectories (green) and projected status assuming a future constant catch equal to the current catch (orange) calculated from the MCMC runs for model runs 3.3, 3.6, and 3.7 in the quantitative stock assessment of STA 7. The shaded region indicates the 95% credibility region about median SSB (dotted lines) calculated from each model's SSB posterior distribution.

Monte Carlo Markov chain estimates for three models (3.3, 3.6, and 3.7) are given in Table 7. Sensitivities to the base case model (R3.3) assumed domed survey selectivities (R3.6), and down-weighted the 2000 and 2003 survey indices (R3.7). Spawning stock biomass was estimated as 29-51% B_0 for the base case model, and ranged between 29 and 76% B_0 for the two model sensitivities (Table 7).

4.4 Estimation of Maximum Constant Yield (*MCY*)

(i) Chatham Rise (STA 4) and Southland and Sub-Antarctic (STA 5)

In previous assessments *MCY* was estimated from the absolute biomass estimates from trawl surveys. This method is now considered obsolete and the yield estimates are not reported here.

(ii) Other areas

MCY was estimated using the equation, $MCY = cY_{AV}$ (Method 4). The landings data from 1981-86 were relatively stable and were used to estimate Y_{AV}. The parameter c was set equal to 0.8 based on

the estimate of $M = 0.23$.

The estimates of MCY were:

STA 1:	0.8 *	5.8 t	=	5 t
STA 2:	0.8 *	21.8 t	=	17 t	(rounded to 20 t)
STA 3:	0.8 *	492.3 t	=	394 t	(rounded to 390 t)
STA 7:	0.8 *	346.6 t	=	277 t	(rounded to 280 t)
STA 8:	0.8 *	4.8 t	=	4 t	(rounded to 5 t)

These estimates of MCY are likely to be conservative because of under-reporting in the past and are highly uncertain. These estimates of MCY have not changed since the 1989 Plenary Report.

The level of risk to the stock by harvesting the population at the estimated MCY value cannot be determined.

4.5   Estimation of Current Annual Yield (CAY)

Estimates of current biomass are not yet available and CAY cannot yet be estimated for any giant stargazer Fishstock.

Yield estimates are summarised in Tables 8 and 9.

Table 8: Giant stargazer yield estimates (t) for all stocks except STA 7.

Parameter	Fishstock	Yield estimate
MCY	STA 1	5
	STA 2	20
	STA 3	390
	STA 4	Cannot be determined
	STA 5	Cannot be determined
	STA 8	5
CAY	All	Cannot be determined

Table 9: Yield estimates (t) for STA 7

		Run	
Parameter	3.3	3.6	3.7
MCY	595	649	600
B_{MCY}	6 813	11 282	6 720
CAY	936	2 065	938
F_{CAY}	0.24	0.24	0.24
MAY	854	1 124	852
B_{MAY}	3 205	4 348	3 209

4.6   Other yield estimates and stock assessment results

For STA 2, long-term yields are of the order of 50-60 t based on the minimum virgin biomass estimated by the model. No other yield estimates are yet available.

4.7   Other factors

The use of a single conversion factor for deepwater and inshore vessels has resulted in about a 5-10% under-estimate pre 1990-91 of the reported greenweight landings. In 1990-91, separate deepwater and inshore conversion factors were introduced.
The TACC in STA 4 has been under-caught because it is apparently uneconomical to target stargazer except near the Chatham Islands. It is a bycatch in the trawl fisheries for hoki, ling, silver warehou, squid, red cod and scampi on the Chatham Rise.

Stargazer landings have been influenced by changes in fishing patterns and fishing methods in the target species fisheries and indirectly by the abundance of those target species. Landings have also

been influenced by changes in reporting behaviour for the different species. Stargazer were also taken historically in large quantities by foreign licensed and chartered trawlers fishing offshore grounds for other species (see Table 1). Because stargazer is mainly a bycatch, there is likely to be under-reporting in these data. Therefore, any estimate of *MCY* based on catch data is likely to be conservative.

5.   ANALYSIS OF ADAPTIVE MANAGEMENT PROGRAMMES (AMP)

The Ministry of Fisheries revised the AMP framework in December 2000. The AMP framework is intended to apply to all proposals for a TAC or TACC increase, with the exception of fisheries for which there is a robust stock assessment. In March 2002, the first meeting of the new Adaptive Management Programme Working Group was held. Two changes to the AMP were adopted:
- a new checklist was implemented with more attention being made to the environmental impacts of any new proposal
- the annual review process was replaced with an annual review of the monitoring requirements only. Full analysis of information is required a minimum of twice during the 5 year AMP.

STA 3
The STA 3 TACC was increased from 734 t to 900 t under the AMP, beginning in the 1991-92 fishing year. The previous 5-year AMP term for STA 3 ended in September 2003 with the current one beginning in October of that year. A formal proposal was not required for the current term as the AMP FAWG supported the continuation of the AMP (March 2003) and no change was requested to the TACC.

2008 Review of STA 3
STA 3 was one of the initial stocks to enter an AMP, with a TACC increase from 734 t to 900 t in October 1991. Slight adjustments to this TACC have since occurred. The STA 3 AMP was reviewed in 1998 and retained in the programme until the end of 2002-03. It was further extended for another five years in October 2003. The STA 3 AMP was scheduled to end in September 2008, but will now be retained in an AMP until this Fishstock is incorporated into a Fisheries Plan. STA 3 catches increased quite rapidly in response to the AMP TACC increase from a pre-1991 level of around 600 t to around the new TACC level from 1993-94 to 1995-96. Catches have since fluctuated between about 600 t and 900 t, being below the TACC in all years except 2000-01 (960 t). Catches have averaged 750 t/year over 1996-97 to 2006-07, with 719 t reported in 2006-07. The Working Group noted that:

Fishery characterisation
- Most (95%) of STA 3 are caught using bottom trawl (BT), with a few landings in the setnet fishery (5%). About two-thirds of the bottom trawl landings have historically come from the two statistical areas north and south of Banks Peninsula: Area 020 - Pegasus Bay, and Area 022 - Canterbury Bight. The remaining third of the STA 3 BT landings are evenly distributed amongst the remaining inshore statistical areas. Only one offshore statistical area (Area 023) registered any STA 3 landings. Area 018 accounts for three-quarters of the STA 3 setnet landings.
- 40% of the BT landings of STA 3 are taken in the target red cod fishery, with remaining catches coming from the target flatfish, barracouta, hoki and tarakihi fisheries. STA itself only accounts for about 4% of the landings since 1989-90. The small amount of STA 3 setnet landings come from targeting on a range of species, including ling, hapuku/bass, and rig.
- Target species vary by area, with BT fishing for red cod predominating in the northern statistical areas (Areas 018, 020 and 022), and fishing for flatfish in the southern part of the East Coast South Island. Target BT fishing for barracouta is primarily confined to Area 22, while target fishing for hoki and scampi predominate in offshore areas. Ling, hapuku/bass, rig and tarakihi all take stargazer as a setnet bycatch in Area 018 while rig is the predominant setnet target species in Area 024

- There is some monthly variability, but little evidence of seasonality in landings of either bottom trawl or setnet catches of STA 3. Depending on target species, stargazer are caught over a wide depth range, between 50 m and 530 m depth (median 300 m).

CPUE analysis

- Three CPUE analyses were conducted for STA 3 catch and effort data, using the following fishery definitions from trips which fished in statistical areas valid for STA 3:
    - BT(MIX): a mixed target trawl fishery targeting a range of species: red cod, barracouta, tarakihi and stargazer.
    - BT(FLA): a target flatfish bottom trawl fishery operating at the shallower end of the stargazer depth distribution.
    - BT(HOK): a target hoki trawl fishery operating at the deeper end of the stargazer depth distribution.
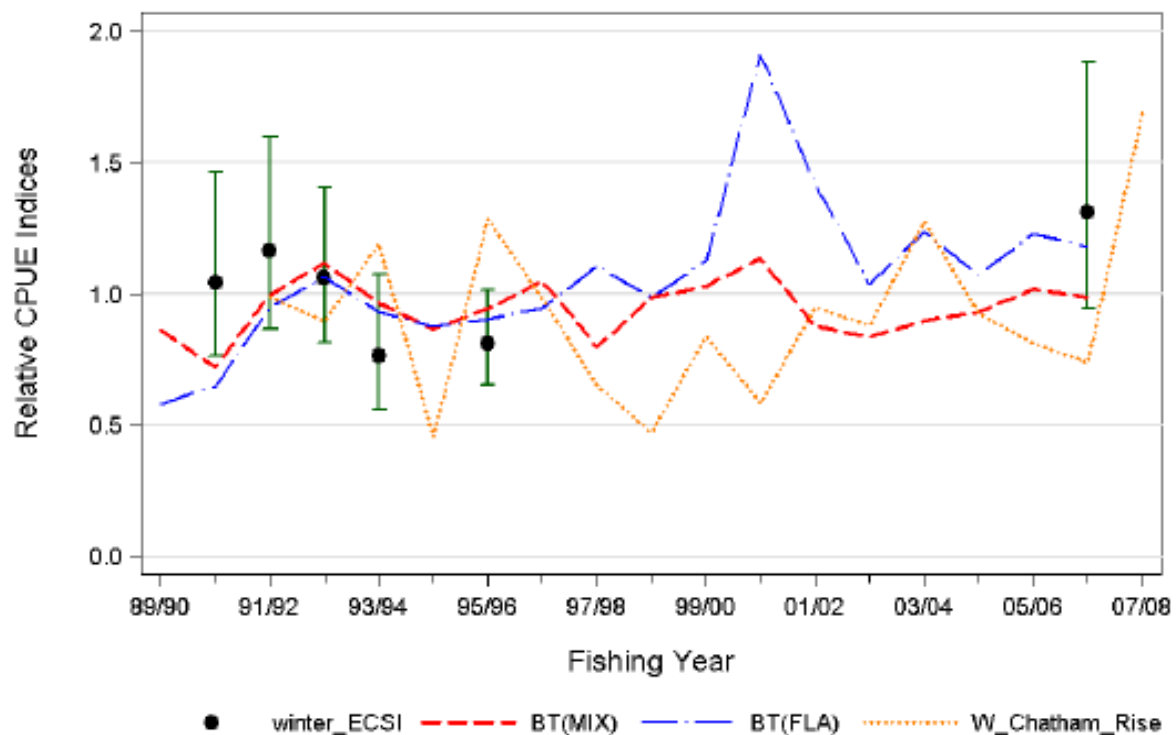
Figure 10: **Comparison plot of two STA CPUE biomass indices [BT(MIX) and BT(FLA)] plotted with the survey biomass indices for stargazer from the winter ECSI and western Chatham Rise trawl surveys. The trawl surveys were assumed to relate to the final year of the fishing year pair. Each series has been standardised to a common geometric mean from 1990-91 to 1993-94, 1995-96 and 2006-07.**

- The lognormal BT(MIX) mixed target bottom trawl fishery model shows only minor inter-annual variability, and no long-term trend since 1989-90 (Figure 8). Unstandardised series for this fishery are very similar to the standardised series, although standardisation does flatten the increasing trend in unstandardised CPUE over past five years.
- The lognormal BT(FLA) flatfish series also shows an increasing trend and, apart from an unexplained doubling of CPUE between 2000-01 and 2001-02, has lower variability than the hoki target fishery index (Figure 7). Unstandardised indices closely match the standardised BT(FLA).
- The lognormal BT(HOK) hoki target trawl series is more variable, with larger error bars, and shows greater deviation from the unstandardised indices. This index shows a generally increasing trend since 1991-92, which may result from the manner that this fishery is conducted. The high variation in this index probably results from the fact that this fishery operates at the deeper end of the stargazer depth range, where STA catch rates are relatively low.

- There appears to be reasonable similarity between the BT(MIX) and BT(FLA) series, particularly in the early to mid-1990s, and an overlay of the three series suggests a slowly increasing trend over the past decade. All three series also show a steady decline in the proportion of records with zero STA landings, which may result either from improved availability of STA, or from changes in fishing practices.

Trawl survey abundance indices
- Abundance indices for STA have been summarised for four trawl surveys series: East Coast South Island (ECSI) winter surveys from 1991 to 1996 (five surveys); ECSI winter survey in 2007 (one survey); ECSI summer surveys from 1997 to 2001 (five surveys); and Chatham Rise surveys from 1992 to 2008 (17 surveys) (Figures 2 and 3).
- Annual STA biomass estimates for the ECSI derived from these surveys (Figure 3) have good precision (CVs of 11% to 18%). The initial five winter surveys conducted in the first half of the 1990s did not show any trend, although the last two indices were lower than the first three. This survey was resumed in May 2007, with the most recent estimate similar to the early survey indices and showing no trend over the 11 year gap. These survey indices also correspond well to the three CPUE series discussed in the previous section (Figure 7). The discontinued summer survey series from 1997 to 2001 was highly variable, showing a strong decline in the last three surveys that appeared to be inconsistent with biomass changes, and was judged to be most likely caused by a change in relative catchability/availability of stargazer.
- An index for the western end of the Chatham Rise has been created for stargazer from annual *RV Tangaroa* surveys during December and January. Although this index is likely to be representative of the stargazer population on the western Chatham Rise, it is highly variable and imprecise, particularly in the most recent survey, where the survey CV exceeds 60%. However, there appears to be no overall trend over this series.

Logbook programme
- A logbook programme to sample the east coast South Island trawl fishery was implemented in 2003-04. Initially, this programme only sampled elephantfish, but it was gradually extended to sample other AMP species in this fishery, including stargazer.
- As a result of diversity of the fishery and scarcity of stargazer catches in individual tows, this programme has never obtained good coverage. The number of tows reported has ranged from 230 to 905 over all species sampled, but which represents only 300 kg to 3.7 t of estimated stargazer catch. Coverage levels ranged from 0.1 to 0.5% of the total STA 3 trawl catch, based on simple ratios of estimated catches. Coverage has been low, even when only the target stargazer fishery is considered, which achieved coverage from 0% to 8.5%.
- Comparison of the logbook coverage by statistical area with comparable catch/effort data shows that the logbook programme over-sampled Area 022, under-sampled in Area 020 and sampled appropriately in Area 024. The bottom trawl logbook programme has failed to achieve consistent seasonal representation of the stargazer catch in any year.
- Most of the reported logbook data are from the Canterbury Bight, in inner shallow areas, and along the shelf edge. Some tows were reported on the shelf off of Banks Peninsula. The depth range fished ranged from 42 to 125 m (median 55 m, mean 69 m).
- Analyses of length-frequency data showed general consistency between years for each surveys series, with no evidence of trends in mean size. However, females were often larger than males across surveys, and STA in the Chatham Rise surveys were consistently larger than those caught in the ECSI surveys. This raises questions regarding relationships and/or differences between the ECSI and Chatham Rise populations.

Effects of fishing
- Low observer coverage and lack of fine scale catch reporting has made it difficult to objectively evaluate the environmental effects of fishing under the STA 3 AMP. The rates of non-fish bycatch are unknown, monitoring is not adequate. Since the last review of STA 3 in 2006:

- The Non-fish/Protected Species Catch Return to be implemented from 1 October 2008 should provide information on the level of non-fish/protected species bycatch for the next review of STA 3. However, adequate observer coverage will still be required to validate reporting rates.
- The draft Hector's and Maui's Dolphin Threat Management Plan (TMP) released for consultation (MFish and DOC 2007) proposes an extension to the existing Banks Peninsula marine mammal sanctuary.
- Under seabird sustainability measures begin on 1 June 2008. Trawlers can not discharge offal or fish on more than one occasion per tow or during shooting or hauling or within 20 minutes before shooting.

Conclusions

- A comparison of the most credible abundance indices for the STA 3 stock (BT(MIX) and BT(FLA) CPUE indices, ECSI winter and western Chatham Rise summer trawl surveys) shows fairly good correspondence between the series, suggesting a flat or slowly increasing trend over the history of the fishery, particularly in the preferred BT(MIX) CPUE index (Figure 5).
- These results support the conclusions of the Inshore Fishery Assessment Working Group in 1997 that recent catch levels are probably sustainable. It is not known if the TACC is sustainable because catches have averaged about 15% below the TACC since 1989-90.

AMP review checklist

1. The Working Group concluded that the ECSI winter trawl surveys and, in their absence, the BT(MIX) standardised CPUE series, provide reasonable indices of the STA 3 stargazer population. Analyses prepared in 2008 show these two indices to be consistent with one another, and with the BT(FLA) index derived from a fishery operating shallower depths. Together, these indices are considered to monitor abundance of the fished component of the stock reasonably well. However, the full extent of the stargazer population which contributes to the STA 3 fisheries may not be covered by these fisheries, and there are questions about the relationships of the fished population with STA stock components in deeper water, or on the western Chatham Rise.

2. The current logbook programme provides reasonable coverage of the mixed-species bottom trawl fishery in FMA 3. However, its coverage of STA catches in this fishery has been very low, and improvements are needed to improve seasonal and spatial representivity of the fishery, and of variable distribution of STA in the area.

3. Additional analyses recommended by the Working Group included:
   o The relationship between the stargazer populations in STA 3 and STA 4 could be investigated by comparing Chatham Rise trawl survey biological data with equivalent data from the inshore east coast survey and possibly the target hoki fishery to ascertain whether there is a size / depth relationship for STA.
   o It may be possible to perform a stock assessment on the available stargazer data, now that a reasonable set of CPUE biomass indices are available and the winter ECSI trawl survey has been reinstated. Such an assessment would need to understand the relationship between STA 3 and STA 4, as there may be migration between these two areas. Ageing of stargazer from the more recent winter surveys will also be required for such an assessment,

4. Consistency between all of the credible indices for the STA 3 fishery, all of which show a flat, or perhaps slightly increasing, trend across the history of the fishery, indicate that current catches are sustainable.

5. STA 3 remains primarily a bycatch in the mixed-species inshore trawl fishery. At time of entry into the AMP, the STA 3 stock was considered to be most likely above B_{MSY} and views regarding the status of the STA 3 stock have not changed subsequently.

6. Observer coverage levels of the inshore trawl fisheries are low, and the effects of fishing are not currently adequately monitored. Introduction of the '*Non-fish/Protected Species Catch Return*' into the suite of regulated MFish forms from 1 October 2008, may provide a credible source of information on the level of protected species bycatch in STA 3. However, observer coverage will still be required to validate fisher reporting rates.

7. Given the low observer coverage in this fishery, rates of non-fish bycatch are not known with any confidence, and it is not known whether rates of bycatch are acceptable.
8. The Working Group agreed that this stock did not need to be referred to the Plenary for review.

STA 7

The STA 7 TACC was first increased under the AMP from 734 t to 900 t, beginning in the 1991-92 fishing year. The TACC was further increased to 997 t (TAC 1000 t) in October 2003, and again in 2010 to 1042 t. The TAC in 2010 therefore increased to 1072 t, which included a 1 t customary and 2 t recreational catch.

Review of STA 7 AMP in 2007

In 2007 the AMP FAWG reviewed the performance of the AMP after 5 years (Starr *et al.* 2007b). This report was not updated in 2008. In 2007 the Working Group noted:

Fishery characterisation
- The STA7 TACC was increased from 528 t to 700 t in 1991-92 under an AMP. Two proposals were made in 2002 to increase this TACC, and the TACC was increased to 997 t in October 2002, with an additional 3 t for non-commercial catch, giving a total TAC of 1000 t.
- Catches exceeded the TACC in this fishery from entry into the QMS in 1986-87 until implementation of the most recent TACC increase in 2002-03, except in 1997-98 when a decline in the Asian market caused catches to dip below the TACC. In particular, catches escalated dramatically from 1997-98 to reach about double the TACC in 2000-01.
- Active management intervention (stopping of bycatch trading, implementation of the ACE provisions of the Fisheries Act and implementation of ramped deemed values) caused an even more dramatic drop in catches to just above the TACC level in 2001-02. Following the increase in TACC to 997 t in 2002-03, catches have remained near the TACC level.
- The Working Group noted that the ~ 50% drop in catch in 2001-02 in response to changes in the ACE and deemed value systems indicated a particularly strong ability to actively target or avoid stargazer in this fishery. It is certainly clear that the rapid increase in stargazer occurred in the 'barracouta' target fishery, probably due to the fact that barracouta was the cheapest quota to obtain at the time.
- Catch reporting in this fishery is poor, with estimated catches averaging 50% of landed catch, and landings exceeding estimated catches by up to 6 times. The Working Group also noted some unexplainable changes in conversion factors. RDM will be asked whether these are data capture errors, or actual entries on return forms.
- 97% of STA 7 are caught in bottom trawls, with 80% of the trawl landings coming from the southern half of the west coast South Island (Areas 032 to 034). Small amounts of catches are made by setnet or mid-water trawl. The trawl fishery catches STA year-round, whereas setnet fishery catches are mainly made from July to September. Seasons differ by area, with the Cook Strait mainly being fished in summer, whereas the southern areas are fished all year.
- Stargazer are mainly reported from the barracouta targeted trawl fishery, but data presented at previous meetings showed that no barracouta were caught when the large catches of stargazers were made.
- There has been a recent increase in STA catch in the tarakihi, red cod and stargazer targeted trawl fisheries, particularly in the southern areas. The bycatch of stargazer in the barracouta target fishery, has decreased in recent years, possibly due to regulation changes which reduced the incentive to declare this species as the target. Setnet STA catches are mainly made while targeting ling.

CPUE analysis
- Three fishery definitions were used in developing standardised CPUE indices for STA7: Trawl fishery targeting STA, BAR, RCO or TAR on the WCSI; the same mixed bottom trawl fishery in the Cook Strait; and the flatfish targeted WCSI trawl fishery.

- CPUE for these fishery definitions was standardised using a lognormal model based on non-zero catches. In addition, a binomial model was used to investigate the effect of changing proportion of non-zero catches.
- Standardisation had very little effect on the indices for the mixed target trawl fisheries relative to the unstandardised index. The standardised WCSI MIX index shows a steady increase to a peak in 2000-01, followed by a sharp drop to near the long-term average, coinciding with the drop in catches. The Cook Strait index shows a flat, stable trend across most of the series, but also with a sharp peak in 2000-01. It seems likely that the CPUE peaks and subsequent drop in catch rates relate more to targeting practices than to abundance.
- The FLA target index shows a steady increase from 1993-94 to a very strong peak in 1999-00, followed by a rapid decline back to the lowest levels by 2003-04. These changes are too large to relate to proportional changes in abundance, and may relate more to changes in availability to the near-shore flatfish fleet, fishing on the inshore edge of the stargazer depth distribution.
- The Working Group noted that the rapid doubling and halving of catch rates in the standardised CPUE indices cannot reflect proportional changes in abundance, and was rather an indication of very strong changes in fleet behaviour and targeting practices. This makes it difficult to decide what confidence to place in the indices.
- The group did note, however, that rapid changes in CPUE in the shallow flatfish fishery could reflect changes in availability of stargazer to this fleet, on the edge of the stargazer depth distribution.
- The strong effect that management changes (the introduction of ACE and changes in deemed values), and targeting responses by the industry, have likely had on CPUE were emphasized. The Working Group considered CPUE after these changes in 2000 to be less reliable and probably not comparable with CPUE prior to 2000.
- The Working Group again noted problems in interpreting reasons for the increase in non-zero catches in many fisheries, and confirmed that the binomial analyses should be accorded very little weight.
- In overview, the overlay of the trawl fishery indices seems to suggest fluctuations (related to targeting?) around a fairly flat trend across the series.

Trawl surveys
- The west coast trawl surveys are considered to be more reliable as indicators of abundance than those conducted on the east coast. Eight surveys have now been conducted from 1992 to 2007.
- Trawl survey estimates suggested a substantial decline in STA abundance in 2000, and again in 2003, after a period of stable estimates from 1992 - 1997, prompting concern that the stock was declining.
- However, estimates for 2005 and 2007 are again at or above the average of the 1992 to 1997 historic estimates. These recent estimates indicate that the low levels in 2000 and 2003 may have been due to catchability changes, as has occurred in the east coast survey.
- The overall trawl survey series indicates that the stock has remained stable at a fairly constant level, which seems to support indications in the trawl CPUE indices of a stable long-term trend.

Logbook programme
- Coverage of the west coast South Island trawl fishery is good, but no biological data for stargazer are being collected.

Effects of fishing
- Hector's dolphins aggregate in two areas of STA 7, Westport and Hokitika. However, there have been no known interactions between these trawl fisheries and dolphins off the WCSI. The Challenger Code of Practice states that trawlers are required not to haul nets when dolphins are present.
- Seabirds do occasionally get caught in BAR targeted fisheries in which STA 7 is caught. During 2005-06, 24 seabird captures were observed on 277 BAR trawls; an incidence rate

was estimated to be 6.5%. However, observer coverage is inadequate to provide reliable estimates of effects of fishing across the fishery.

- The Working Group noted that fishers are able to target stargazer, which has lead to changes in fleet behaviour, probably related to changing fishing area and depth. This suggests that seabed effects, at least, may have changed. Changes such as this need to be measured and reported on.

Conclusions
- The results of the trawl surveys indicate that the STA 7 stock has remained stable since 1992.
- The standardised CPUE indices presented do not change that conclusion.

6. STATUS OF THE STOCKS

No estimates of current and reference biomass are available.

STA 1

The TACC for STA 1 was increased from 21 t to 50 t in the 1991-92 fishing year under the AMP. In 1997, the TACC was reduced to 21 t upon its removal from the programme. Recent catches have exceeded this level. It is not known if recent catch levels and current TACC are sustainable. The status of STA 1 relative to B_{MSY} is unknown.

STA 2

The TACC for STA 2 was increased from 37 t to 100 t in the 1991-92 fishing year under the AMP. Landings in the early 1990s peaked in the range of 105-125 t, but have subsequently declined.

The TACC was reduced to 38 t in the 1997-98 fishing year, upon the removal of STA 2 from the AMP. Landings have been below the TACC since 2003-04. It is not known whether recent catches and the current TACC will cause the STA 2 stock size to decline. The status of STA 2 relative to B_{MSY} is unknown.

STA 3

Stock Status	
Year of Most Recent Assessment	2008 (CPUE); 2010 (trawl survey)
Assessment Runs Presented	
Reference Points	Target: *MSY*-compatible proxy based on the East Coast South Island trawl survey index (to be determined) Soft Limit: 50% of target Hard Limit: 25% of target
Status in relation to Target	Unknown
Status in relation to Limits	Unlikely (< 40%) to be below both soft and hard limits

Historical Stock Status Trajectory and Current Status

STA 3
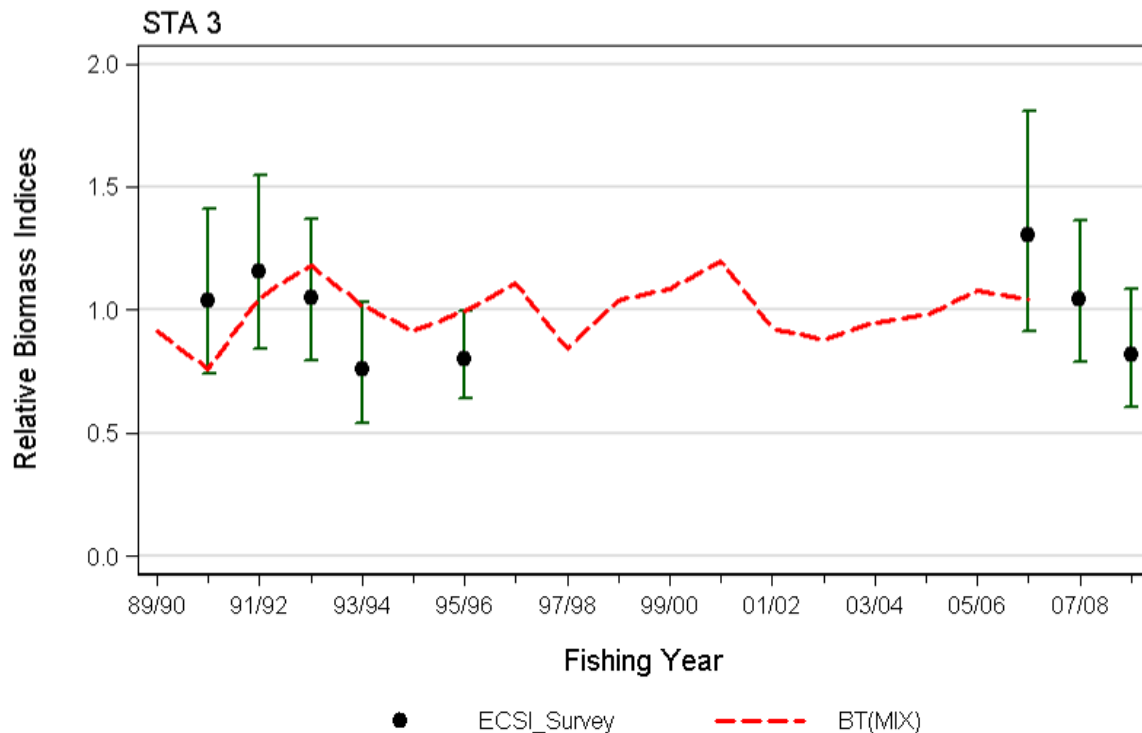
Comparison plot of a STA CPUE biomass index with the west coast South Island survey biomass index for. The trawl surveys were assumed to relate to the final year of the fishing year pair.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	While the CPUE indices have been relatively flat, fluctuating about the long-term mean, the two recent (2008 and 2009) ECSI survey estimates have shown progressive declines from the high in 2007 to just below the long-term mean.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	STA 3 remains primarily a bycatch in the mixed-species inshore trawl fishery. STA 3 stock size is Likely (> 60%) to remain near current levels under current catch (2007-08 and 2008-09). It is Unknown if catches near the TACC would cause the stock to decline.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unlikely (< 40%) Hard Limit: Unlikely (< 40%)

Assessment Methodology		
Assessment Type	Level 2 - Partial quantitative stock assessment	
Assessment Method	-Trawl survey biomass and standardised CPUE based on lognormal error distribution and positive catches. -Science information quality ranking	1 – High Quality
Assessment Dates	Latest assessment: 2008	Next assessment: 2011 (trawl

	(CPUE) 2010 (trawl survey)	survey)
Main data inputs	Catch and effort data	
Data not used (rank)	N/A	N/A
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty		

The Southern Inshore Working Group agreed that both the East Coast South Island trawl survey is a credible measure of relative biomass, and the BT(M)X CPUE index is credible measures of abundance.

Qualifying Comments
-

Fishery Interactions
40% of the bottom trawl landings of STA 3 are taken in the target red cod fishery, with remaining catches coming from the target flatfish, barracouta, hoki and tarakihi fisheries. Target STA has only accounted for about 4% of total landings since 1989-90.

STA 4

Stargazer in this Fishstock occur mainly on the Chatham Rise on the shelf around the Chatham Islands, but are sparsely distributed over the rest of the Rise. In most of this Fishstock they may not be economic to target. However, if fishing is overly concentrated in those areas where stargazer can be targeted, such as close to the Chatham Islands, there are concerns that local depletion may occur.

The 2011 estimate of biomass from the Chatham Rise trawl survey was above the long-term mean (1991-2011). The original TACC of 2014 t for STA 4 was based on a yield estimate from a single trawl survey in 1983. This method is now considered obsolete. The TACC was increased in 2000-01 to 2158 t. Catches have always been substantially less than the TACC. The average catch since the TACC increase has been 300 t. It is not known if catches at the level of the current TACC would be sustainable.

STA 5

The TACC for STA 5 was increased from 1239 t to 1500 t in the 1991-92 fishing year under the AMP. Landings increased to 1327 t in 1993-94, declined to 544 t in 1997-98, but have subsequently increased. The TACC was reduced to 1264 t in 1997, upon the removal of STA 5 from the AMP. This new TACC is at the level of recent catches, and is probably sustainable. The status of STA 5 relative to B_{MSY} is unknown.

STA 7

Stock Status	
Year of Most Recent Assessment	2008 - Stock assessment 2009 - Analysis of survey indices of abundance
Assessment Runs Presented	Run 3.3 (base case), 3.6 (domed selectivity) and 3.7 (down weight 2000 and 2003 survey data points)
Reference Points	Target(s): Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	The range of model results for STA 7 west coast stock assessment suggests that, given the assumptions about recruitment, the stock is Likely (> 60%) to be at or above B_{MSY}.
Status in relation to Limits	Soft Limit: Very Unlikely (< 10%) to be below Hard limit: Very Unlikely (< 10%) to be below

Historical Stock Status Trajectory and Current Status
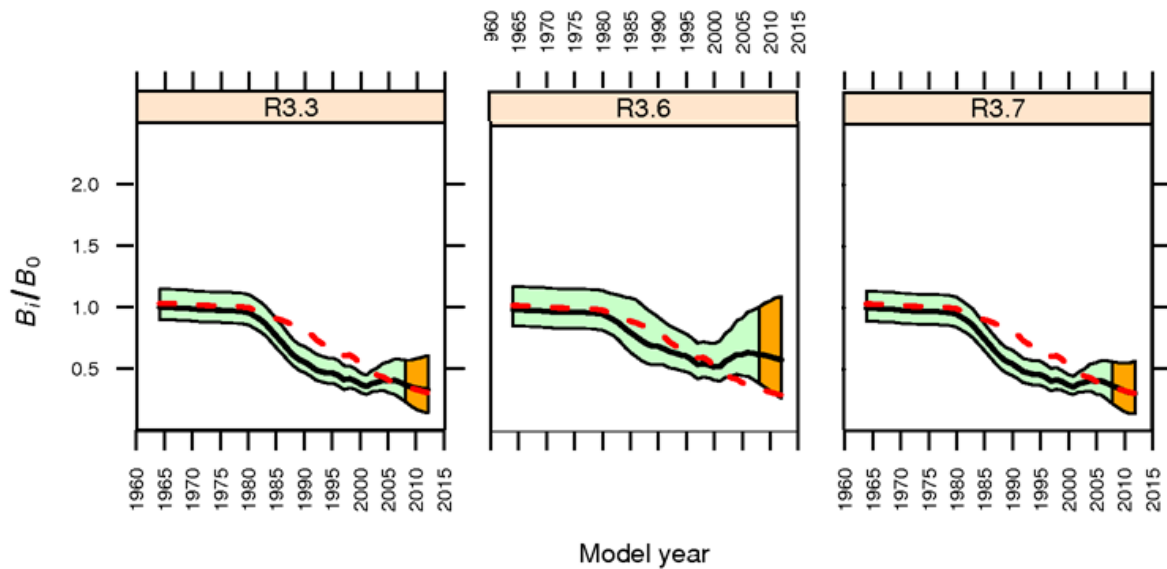
Relative SSB trajectories (green) and projected status assuming a future constant catch equal to the current catch (orange) calculated from the MCMC runs for model runs 3.3, 3.6, and 3.7 in the quantitative stock assessment of STA 7. The shaded region indicates the 95% credibility region about median SSB (dotted lines) calculated from each model's SSB posterior distribution.
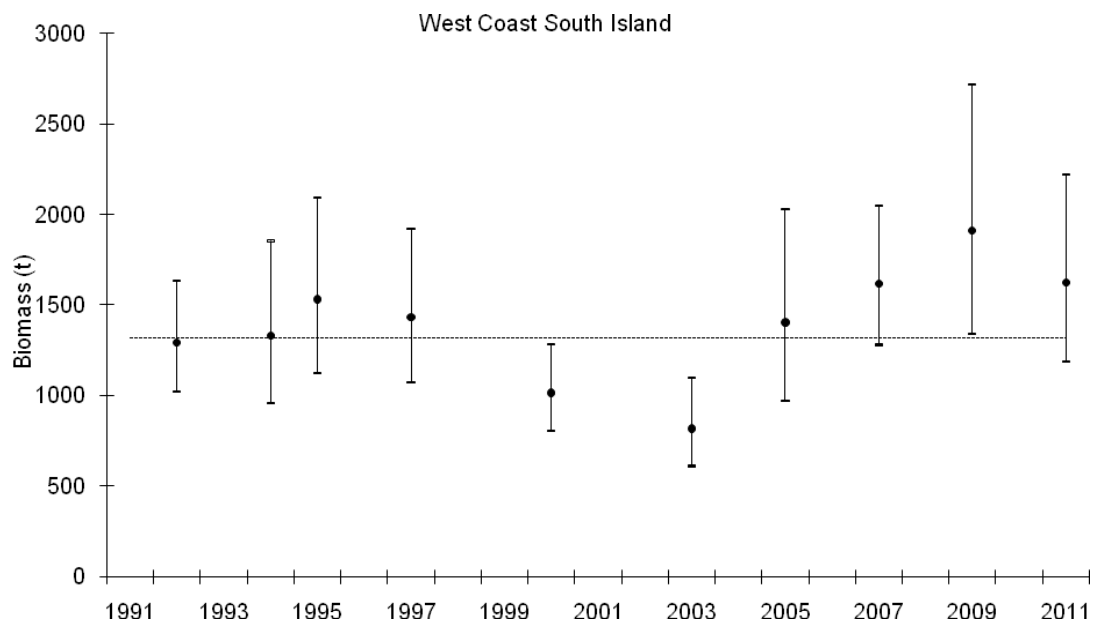
Stargazer biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the time series mean (dotted line) estimated from the West Coast South Island trawl survey.

Fishery and Stock Trends

Recent Trend in Biomass or Proxy	The WCSI trawl survey indices have increased from a low observed in 2003 to the highest in the series in 2009.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis

Stock Projections or Prognosis	STA 7 stock is Likely (> 60%) to remain at or above B_{MSY} at current catch levels.

Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)

Assessment Methodology		
Assessment Type	Level 1 - Quantitative stock assessment Level 2 - Agreed biomass index (WCSI trawl survey)	
Assessment Method	Bayesian Statistical stock assessment model implemented in CASAL. Evaluation of recent trawl survey indices (up to 2009).	
Assessment Dates	Latest assessment: 2008 (assessment) 2009 (survey)	Next assessment: 2011 (survey)
Main data inputs (rank)	- An age-structured model partitioned by age (0-25 years) and sex was fitted to the WCSI trawl survey relative abundance indices (1992-05), WCSI survey proportions-at-age data (1992-05), and WCSI fishery catch-at-age data (2005 only) - Commercial catch, trawl survey biomass and proportions-at-age estimates, and commercial catch proportions-at-age. - Science information quality ranking	1 – High Quality; The Southern Inshore Working Group accepted the assessment as a credible means to assess B_{MSY} and the West Coast South Island trawl survey as a credible measure of relative biomass.
Data not used (rank)	N/A	N/A
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty		

Qualifying Comments
-

Fishery Interactions
Smooth skates are caught as a bycatch in this fishery, and the biomass index for smooth skates in the west coast trawl survey has declined substantially since 1997. There may be similar concerns for rough skates but the evidence is less conclusive.

**STA 8**

The TACC for STA 8 increased from 22 t to 50 t in the 1993-94 fishing year under the AMP. Landings increased to 18 t in 1991-92 but have since declined to less than 5 t. The TACC was reduced back to 22 t in 1997, upon the removal of STA 8 from the programme. It is not known if recent catch levels and current TACC are sustainable. The status of STA 8 relative to B_{MSY} is unknown.

Yield estimates, TACCs, and reported landings for the 2010-11 fishing year are summarised in Table 10.

Table 10: Summary of yields (t), TACC (t), and reported landings (t) of giant stargazer for the most recent fishing year.

Fishstock	QMA		*MCY*	*CAY*	TACC	Landings
STA 1	Auckland (East and West)	1 & 9	5	-	21	21
STA 2	Central (East)	2	20	-	38	19
STA 3	South-East (Coast)	3	390	-	902	570
STA 4	South-East (Chatham)	4	-	-	2 158	134
STA 5	Southland and Sub-Antarctic	5 & 6	-	-	1 264	1 235
STA 7	Challenger	7	595	936	1 042	1 037
STA 8	Central (West)	8	5		22	7
STA 10	Kermadec	10	-	-	10	0
Total			-	-	5 456	3 023

7. FOR FURTHER INFORMATION

Anderson O.F., Bagley N.W., Hurst J., Francis M.P., Clark M.R., McMillan P.J. 1998. Atlas of New Zealand fish and squid distributions from research bottom trawls. NIWA Technical Report 42. 303 p.

Andrews A.H. 2009. Feasibility of lead-radium dating giant stargazer (*Kathetostoma giganteum*). Final report submitted to the Ministry of Fisheries. Project STA2004-03, 6 p.

Bagley N.W., Hurst R.J. 1995. Trawl survey of middle depth and inshore bottom species off Southland, February-March 1994 (TAN9402). New Zealand Fisheries Data Report 57. 50 p.

Bagley N.W., Hurst R.J. 1996a. Trawl survey of middle depth and inshore bottom species off Southland, February-March 1995 (TAN9502). New Zealand Fisheries Data Report 73. 47 p.

Bagley N.W., Hurst R.J. 1996b. Trawl survey of middle depth and inshore bottom species off Southland, February-March 1996 (TAN9604). New Zealand Fisheries Data Report 77. 51 p.

Boyd R.O., Reilly J.L. 2005. 1999/2000 national marine recreational fishing survey: harvest estimates. Draft New Zealand Fisheries Assessment Report.

Bradford E. 1998. Harvest estimates from the 1996 national marine recreational fishing surveys. New Zealand Fisheries Assessment Research Document 1998/16. 27p. (Unpublished report held in NIWA library, Wellington).

Drummond K.L., Stevenson M.L. 1995a. Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 1992 (KAH9204). New Zealand Fisheries Data Report 63. 58 p.

Drummond K.L., Stevenson M.L. 1995b. Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 1994 (KAH9404). New Zealand Fisheries Data Report 64. 55 p.

Drummond K.L., Stevenson M.L. 1996. Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 1995 (KAH9504). New Zealand Fisheries Data Report 74. 60 p.

Hoenig J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fishery Bulletin 81: 898-903.

Hurst R.J., Bagley N.W., Uozumi Y. 1990. New Zealand-Japan trawl survey of shelf and upper slope species off southern New Zealand, June 1986. New Zealand Fisheries Technical Report No. 18. 50 p.

Hurst R.J., Bagley N.W. 1987. Results of a trawl survey of barracouta and associated finfish near the Chatham Islands, New Zealand, December 1984. New Zealand Fisheries Technical Report No. 3. 44 p.

Hurst R.J., Fenaughty J.M. 1986. Report on biomass surveys 1980-84; summaries and additional information. Fisheries Research Division Internal Report No. 21.

Hurst R.J., Bagley N.W. 1994. Trawl survey of middle depth and inshore bottom species off Southland, February-March 1993 (TAN9301). New Zealand Fisheries Data Report 52. 58 p.

Hurst R.J., Bagley N.W. 1997. Trends in Southland trawl surveys of inshore and middle depth species, 1993-96. New Zealand Fisheries Technical Report 50. 66 p.

Langley A.D. 2002. The analysis of STA 3 catch and effort data from the RCO 3 target trawl fishery, 1989-90 to 2000-01. Draft New Zealand Fisheries Assessment Report.

Lydon G.J., Middleton D.A.J., Starr P.J. 2006. Performance of the STA 3 Logbook Programmes. AMP-WG-06/21. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington).

Manning M.J. 2005. On fitting and comparing selected statistical models of fish growth. Unpublished MSc thesis, University of Auckland, Auckland, New Zealand. 162 p.

Manning M.J. (2008). The first quantitative stock assessment of giant stargazer (*Kathetostoma giganteum*) in STA 7. New Zealand Fisheries Assessment Report 2008/33. 82 p.

Manning M.J. (2007). Relative abundance of giant stargazer (*Kathetostoma giganteum*) in STA 5 based on commercial catch-per-unit-effort data. New Zealand Fisheries Assessment Report 2007/14. 42 p.

Manning M.J., Sutton C.P. 2004. Age and growth of giant stargazer, *Kathetostoma giganteum*, from the West Coast of the South Island (STA 7). New Zealand Fisheries Assessment Report 2004/17. 60 p.

Manning M.J., Sutton C.P. (2007). Further study on the age and growth of giant stargazer, *Kathetostoma giganteum*, from the west coast of the South Island (STA 7). New Zealand Fisheries Assessment Report 2007/12. 68 p.

Manning M.J., Sutton C.P. (2007). The composition of the commercial and research stargazer (*Kathetostoma giganteum*) catch off the west coast of the South Island (STA 7) during the 2004-05 fishing year. New Zealand Fisheries Assessment Report 2007/36. 43p.

Phillips N.L. 2001. Descriptive and CPUE analysis of catch and effort data for the giant stargazer (*Kathetostoma giganteum*) in the STA 5 fishery from the 1989-90 to the 1999-00 fishing year. Draft New Zealand Fisheries Assessment Report.

Seafood Industry Council (SeaFIC) 2002. Performance of the STA 7 Adaptive Management Programme. Unpublished report presented to the Adaptive Management Programme Fishery Assessment Working Group on 4 March 2002. p. (Unpublished report available from Ministry of Fisheries, Wellington).

Seafood Industry Council (SeaFIC) 2003a. Performance of the STA 3 Adaptive Management Programme. Unpublished report presented to the Adaptive Management Programme Fishery Assessment Working Group as document AMP-WG-2003/02. 43 p. (Unpublished report available from Ministry of Fisheries, Wellington).

Seafood Industry Council (SeaFIC) 2003b. Performance of the STA 7 Adaptive Management Programme. Unpublished report presented to the Adaptive Management Programme Fishery Assessment Working Group as document AMP-WG-2003/14. 42 p. (Unpublished report available from Ministry of Fisheries, Wellington).

Seafood Industry Council (SeaFIC) 2005a. Performance of the STA 3 Adaptive Management Programme. Unpublished report presented to the Adaptive Management Programme Fishery Assessment Working Group as document AMP-WG-2005/19. p. (Unpublished report available from Ministry of Fisheries, Wellington).

Seafood Industry Council (SeaFIC) 2005b. Performance of the STA 7 Adaptive Management Programme. Unpublished report presented to the Adaptive Management Programme Fishery Assessment Working Group as document AMP-WG-2005/09. p. (Unpublished report available from Ministry of Fisheries, Wellington).

SEFMC 2002. 2002 report to the Adaptive Management Programme Fishery Assessment Working Group: review of the STA 3 Adaptive Management Programme. Unpublished report presented to the Adaptive Management Programme Fishery Assessment Working Group on 1 March 2002. p. (Unpublished report available from Ministry of Fisheries, Wellington).

Starr P.J., Kendrick T.H., Lydon G.J., Bentley N. 2007a. Report to the Adaptive Management Programme Fishery Assessment Working Group: STA 3 Adaptive Management Programme. AMP-WG-07/27. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington). 6 p.

Starr P.J., Kendrick T.H., Lydon G.J., Bentley N. 2007b. Report to the Adaptive Management Programme Fishery Assessment Working Group: Full-term review of the STA 7 Adaptive Management Programme. AMP-WG-07/14. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington). 65 p.

Starr P.J., Kendrick T.H., Lydon G.J., Bentley N. 2008. Report to the Adaptive Management Programme Fishery Assessment Working Group: Full-term review of the STA 3 Adaptive Management Programme. AMP-WG-08/07-rev.2 (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington). 102 p.

Stevens D.W., O'Driscoll R.L., Ballara S.L., Bagley N., Horn P.L. 2011. Chatham Rise Trawl Survey, 2 Jan - 28 Jan 2011 (TAN1011). WG-HOK-2011/X. X p. (Unpublished report held by Ministry of Fisheries, Wellington.)

Stevenson M.L. 1998. Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 1997 (KAH9701). NIWA Technical Report 12. 70 p.

Stevenson M.L. 2002. Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 2000 (KAH0004). NIWA Technical Report 115. 71 p.

Stevenson M.L. 2004. Trawl survey of the west coast of the South Island and Tasman and Golden Bays, March-April 2003 (KAH0304). New Zealand Fisheries Assessment Report 2004/4. 69 p.

Stevenson M.L., Hanchet S.M. 2000. Review of the inshore trawl survey series of the west coast South Island and Tasman and Golden Bays, 1992-1997. NIWA Technical Report 82. 79 p.

Stevenson M.L. 2007. Inshore trawl surveys of the west coast of the South Island and Tasman and Golden Bays, March-April 2007 (KAH0704). New Zealand Fisheries Assessment Research Document 2007/41: 64 p

Stevenson M.L. in press. Inshore trawl survey of the west coast of the South Island and Tasman and Golden Bays, March-April 2011. New Zealand Fisheries Assessment Report 2012/xx.

Sutton C.P. 1999. Ageing methodology, growth parameters, and estimates of mortality for giant stargazer (*Kathetostoma giganteum*) from the east and south coasts of the South Island. New Zealand Fisheries Assessment Research Document 1999/15. 19 p.

Sutton C.P. 2004. Estimation of age, growth, and mortality of giant stargazer (*Kathetostoma giganteum*) from Southland trawl surveys between 1993 and 1996. New Zealand Fisheries Assessment Report 2004/38. 14 p.

Tate M.L. 1987. The species and stock structure of the New Zealand inshore fishery for giant stargazer. University of Otago, Dunedin. 134 p.

Vignaux M. 1997. CPUE analyses for fishstocks in the adaptive management programme. New Zealand Fisheries Assessment Research Document 1997/24. 68 p.

SURF CLAMS

Surf clam is a generic term used here to cover the following seven species:

Deepwater tuatua, *Paphies donacina* (PDO),
Fine (silky) dosinia, *Dosinia subrosea* (DSU)*,*
Frilled venus shell, *Bassina yatei* (BYA)*,*
Large trough shell, *Mactra murchisoni* (MMI),
Ringed dosinia, *Dosinia anus* (DAN),
Triangle shell, *Spisula aequilatera* (SAE),
Trough shell, *Mactra discors* (MDI).

The same FMAs apply to all these species and this introduction will cover issues common to all of these species.
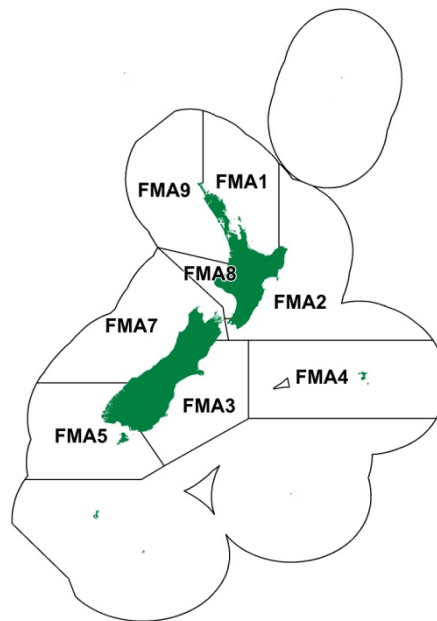
All surf clams were introduced into the Quota Management System on 1 April 2004. The fishing year is from 1 April to 31 March and commercial catches are measured in greenweight. There is no minimum legal size (MLS) for surf clams. Surf clams are managed under Schedule 6 of the Fisheries Act 1996. This allows them to be returned to the sea soon after they are taken provided they are likely to survive.

1. INTRODUCTION

Commercial surf clam harvesting before 1995–96 was managed using special permits. From 1995–96 to 2002–03 no special permits were issued because of uncertainty about how best to manage these fisheries.

New Zealand operates a mandatory shellfish quality assurance programme for all bivalve shellfish grown and harvested in areas for human consumption. Shellfish caught outside this programme can only be sold for bait. This programme is based on international best practice and is managed by the New Zealand Food Safety Authority (NZFSA), in cooperation with the District Health Board Public Health Units and the shellfish industry[1]. This involves surveying the water catchment area for

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[1]. For full details of this programme, refer to the Animal Products (Regulated Control Scheme-Bivalve molluscan Shellfish) Regulations 2006 and the Animal Products (Specifications for Bivalve Molluscan

pollution, sampling water and shellfish microbiologically over at least 12 months, classifying and listing areas for harvest, regular monitoring of the water and shellfish, biotoxin testing, and closure after rainfall and when biotoxins are detected. Products are traceable by source and time of harvest in case of contamination.

2. BIOLOGY

Three families of surf clams dominate the biomass in different regions of New Zealand. At the northern locations, the venerids *D. anus* and *D. subrosea* make up the major proportion of the surf clam biomass, and *D. anus* is abundant at all other North Island locations. The mactrids and mesodesmatid become increasingly abundant south of Ohope (Bay of Plenty). The mesodesmatid *P. donacina* is most abundant around central New Zealand from Nuhaka on the east coast south to the Kapiti coast, Cloudy Bay and as far south as Pegasus Bay. The mactrids *M. murchisoni* and *M. discors* dominate in southern New Zealand (Blueskin Bay, Te Waewae, and Oreti), where they account for more than 80% of the total biomass (Cranfield *et al.* 1994, Cranfield & Michael 2001).

Each species grows to a larger size in the South Island than in the North Island (Cranfield & Michael 2002). Growth parameters are available for many surf clam species from up to two locations. Length frequencies of sequential population samples were analysed by Cranfield *et al.* (1993) using MULTIFAN to estimate the von Bertalanffy growth parameters (Table 1). MULTIFAN simultaneously analyses multiple sets of length frequency samples using a maximum likelihood method to estimate the proportion of clams in each age class and the von Bertalanffy growth parameters (see Fournier *et al.* 1990, and Francis & Francis 1992).

Incremental growth of recaptured marked clams at Cloudy Bay was analysed using GROTAG to confirm the MULTIFAN estimates (Cranfield *et al.* 1993). GROTAG uses a maximum-likelihood method to estimate growth rate (Francis 1988, Francis & Francis 1992). The estimates and annual mean growth estimates at lengths α and β are shown in Table 2.

Table 1: Von Bertalanffy growth parameter estimates from Cranfield *et al.* (1993) for surf clams estimated using MULTIFAN (SE in parentheses). - Indicates where estimates were not generated

Stock	Site	L_∞ (mm)	K
BYA 7	Cloudy Bay	-	-
BYA 8	Kapiti Coast	-	-
DAN 7	Cloudy Bay	0.10 (0.03)	77.5 (0.71)
DAN 8	Kapiti Coast	0.13 (0.02)	58.7 (0.28)
DSU 7	Cloudy Bay	-	-
DSU 8	Kapiti Coast	-	-
MDI 7	Cloudy Bay	0.41 (0.03)	68.0 (0.35)
MDI 8	Kapiti Coast	0.42 (0.02)	56.0 (0.95)
MMI 7	Cloudy Bay	0.57 (0.01)	88.0 (0.44)
MMI 8	Kapiti Coast	0.35 (0.01)	75.2 (0.30)
PDO 7	Cloudy Bay	0.33 (0.01)	94.1 (0.29)
PDO 8	Kapiti Coast	-	-
SAE 7	Cloudy Bay	1.01 (0.02)	60.3 (0.92)
SAE 8	Kapiti Coast	0.80 (0.03)	52.1 (0.25)

The maximum ages for these species were estimated from the number of age classes indicated in MULTIFAN analyses, and from shell sections. Estimates of natural mortality come from age estimates (Table 3). Higher mortality is seen where the surf clams are subject to higher wave energies, e.g., *S. aequilatera* and *M. murchisoni* are distributed within the primary wave break and hence show higher mortality (Cranfield *et al.* 1993). Kapiti shells show higher mortality than Cloudy Bay, perhaps because these shells having a higher chance of being eroded out of the bed by storms as the Kapiti Coast is more

Shellfish) Notice 2006 (both referred to as the BMSRCS), at:
http://www.nzfsa.govt.nz/industry/sectors/seafood/bms/page-01.htm

exposed (Cranfield *et al.* 1993). Surf clam populations are subject to catastrophic mortality from erosion during storms, high temperatures and low oxygen levels during calm summer periods, blooms of toxic algae and excessive freshwater outflow (Cranfield & Michael 2001)

Less confidence should be placed in the estimates from MULTIFAN for Cloudy Bay relative to the Kapiti Coast as there was a small sample size at Cloudy Bay and a lack of juveniles.

Table 2: Mean annual growth estimates (mm/year) at lengths α and β (95% confidence intervals in parentheses for mean growth values) from Cloudy Bay (Cranfield *et al.* 1996). L* is the transitional length, at which point the model allows an asymptotic reduction in growth rate and values of L∞ are included for reference.

Species	α (mm)	g_α (mm year^{-1})	β (mm)	g_β (mm year^{-1})	L^* (mm)	L_∞ (mm)	Residual error (mm)
Paphies donacina	50.0	10.26 (9.7 – 10.8)	80.0	1.41 (1.1 – 1.7)	80.0	84.8	1.25
Spisula aequilatera	30.0	22.71 (22.2 – 23.0)	50.0	6.23 (6.0 – 6.4)	55.0	57.6	2.04
Mactra murchisoni	40.0	17.83 (17.4 – 18.2)	70.0	4.65 (4.3 – 4.9)	80.0	80.6	1.42
Mactra discors	35.0	11.01 (10.5 – 11.7)	55.0	2.69 (2.4 – 2.9)	62.0	61.5	0.63
Dosinia anus	20.0	12.5 (12.0 – 13.2)	55.0	1.99 (1.8 – 2.2)	63.0	61.6	0.44

Table 3: Estimates of the instantaneous natural mortality rate, M. A = minimum number of year classes indicated by MULTIFAN, B = maximum age indicated by shell sections, M1: mortality range estimated from using two equations: $lnM = 1.23 - 0.832 ln(t_{max})$ and $1nM = 1.44 - 0.9821n$, (t_{max}), (Hoenig 1983). M2 mortality estimated from $M = ln100/(t_{max})$; t_{max} is the estimate of maximum age

Cloudy Bay

	A	B	M1	M2
Mactra murchisoni	8	11	0.40-0.46	0.42
Mactra discors	7	14	0.32-0.38	0.33
Spisula aequilatera	5	7	0.63-0.68	0.66
Paphies donacina	10	17	0.26-0.32	0.27
Dosinia anus	16	22	0.20-0.26	0.21

Kapiti coast

	A	B*	M1	M2
Mactra murchisoni	8	11	0.40-0.46	0.42
Mactra discors	8	16	0.28-0.34	0.29
Spisula aequilatera	3	5	0.87-0.89	0.92
Paphies donacina[i]				
Dosinia anus	19	26	0.17-0.23	0.18

*Shell sections not yet examined. Ages are inferred from Cloudy Bay data.
[i]Growth data could not be analysed.

4. ENVIRONMENTAL EFFECTS OF FISHING

This section is new for the May 2011 Plenary after review by the Aquatic Environment Working Group. This summary is from the perspective of the surf clam fisheries; a more detailed summary from an issue-by issue perspective will be available in the Ministry's Aquatic Environment Plenary being developed.

4.1 Ecosystem role

Only two published papers examine aspects of the role of surf clams in the ecosystem in New Zealand. Predation of *Dosinia* spp. by rock lobsters has been documented from the reef/soft sediment interface zones (Langlois *et al.* 2005, Langlois *et al.* 2006), notably surf clams are usually harvested from exposed beaches, not reef/soft sediment interface zones.

Surf clams are filter-feeders; recent research suggests that most of their food is obtained from microalgae from the top 2 cm of the sediment and the bottom 2-3cm of the water column (Sasaki *et al.* 2004). The effects of predation are difficult to study on exposed sandy beaches and it is believed internationally that there are no keystone species in this environment and predation is not important in structuring the community (Mclachlan & Brown 2006).

4.2   Fishery interactions (fish and invertebrates)

The only bycatch caught in large quantities associated with surf clam dredging in New Zealand is *Fellaster zelandiae* - the sand dollar or sea biscuit (Haddon *et al.* 1996). Other species caught in association with surf clams include paddle crabs (*Ovalipes catharus*), a number of bivalves including the lance shell (*Resania lanceolata*), otter clams (*Zenatia acinaces*), battle axe (*Myadora striata*), olive tellinid (*Hiatula nitidia*), the wedge shell (*Peronaea gairmadi*), and the gastropods the olive shell (*Baryspira australis*) and ostrich foot shell (*Struthiolaria papulosa*). Fish are rarely caught, but include juvenile common soles (*Peltorhamphus novaeezeelandiae*) and stargazers (*Kathetostoma* spp.) (NIWA, unpublished data).

4.3   Fishery interactions (seabirds and mammals)

Not relevant to surf clam fisheries.

4.4   Benthic impacts

Surf clams mainly inhabit the surf zone, a high-energy environment characterised by high sand mobility (Michael *et al.* 1990). Divers observed that the rabbit dredge (which has been used for surf-clam surveys) formed a well defined track in the substrate, but within 24 hours the track was could not be distinguished, indicating that physical recovery of the substrate was rapid (Michael *et al.* 1990). Commercially, a different dredge is used whose impacts should theoretically be less, but the impacts of this dredge have not been tested. Shallow water environments such as the surf zone or those subjected to frequent natural disturbance tend to recover faster from the effects of mobile fishing gears compared to those in deeper water (Collie *et al.* 2000, Hiddink *et al.* 2006, Kaiser *et al.* 2006, Kaiser *et al.* 1996).

Surf clam species show zonation by substrate type which is generally, although not always, correlated with depth and wave exposure. Species with good burrowing ability are generally found in shallow, mobile sediment zones (for example *Paphies donacina*), and those species less able to burrow (for example *Dosinia subrosea* and *Bassina yatei*) are generally found in softer more stable sediments. The present high-value species (*Spisula aequilatera, Mactra murchisoni, Paphies donacina* and *Mactra discors*) generally occur in shallower zones. Mobile fishing gear effects will be primarily determined by the characteristics of the beach and target species. Little fishing presently takes place in the most vulnerable areas characterised by stable, soft fine sediment communities.

An Italian study showed that widespread intensive hydraulic dredging can adversely modify some depths within this environment (4-6 m), although recovery in this study occurred within 6 months (Morello *et al.* 2006). The applicability of this studies finding to New Zealand is unknown.

4.5   Other considerations

None.

4.6   Key information gaps

The impacts of widespread and intensive dredging in New Zealand, which is not presently occurring, are unknown.

5.   FOR FURTHER INFORMATION

Collie J., Escanero G., Valentine P. 2000. Photographic evaluation of the impacts of bottom fishing on benthic epifauna. ICES Journal of Marine Science, 57, 987-1001.

Constantino R., Caspar M. B., *et al.* 2009. Clam dredging effects and subsequent recovery of benthic communities at different depth ranges. Marine Environmental Research 67(2): 89-99.

Cranfield H., Michael K. 2001. The surf clam fishery in New Zealand: description of the fishery, its management, and the biology of surf clams. In: New Zealand Fisheries Assessment Report 2001/62, p. 24p.

Cranfield H., Michael K. 2002. Potential area boundaries and indicative TACs for the seven species of surf clam. NIWA unpublished report to the Ministry of Fisheries

Cranfield H.J., Michael K.P., Stotter D.R. 1993. Estimates of growth, mortality, and yield per recruit for New Zealand surf clams. New Zealand Fisheries Research Assessment Document 1993/20. 26 p.

Cranfield H.J., Michael K.P., Stotter D.R., Doonan I.J. 1994. Distribution, biomass and yield estimates of surf clams off New Zealand beaches. New Zealand Fisheries Research Assessment Document 9411. 17p. (Unpublished report held in NIWA library, Greta Point, Wellington).

Cranfield H., Michael K., Francis R. 1996. Growth Rates of Five Species of Subtidal Clam on a Beach in the South Island, New Zealand. New Zealand journal of Marine & Freshwater Research 47: 773-784

Francis R.I.C.C. 1988: Maximum likelihood estimation of growth and growth variability from tagging data. New Zealand Journal of Marine and Freshwater Research 22: 42-5 1.

Francis M.P., Francis R.I.C.C. 1992: Growth, mortality, and yield estimates for rig (Mustelus lenticulancs). New Zealand Fisheries Assessment Research Document W5. 23 p. (Unpublished report held in MAF Fisheries Greta Point library, Wellington.)

Fournier D.A., Sibert J.R., Majkowski J., Hampton J. 1990: MULTIFAN a likelihood-based method for estimating growth parameters and age composition from multiple length frequency data sets illustrated using data for southern bluefin tuna (Thunnus maccoyii) . Canadian Journal of Fisheries and Aquatic Science 47: 30 1 -3 17.

Haddon M., Willis T. J., *et al*. 1996. Biomass and distribution of five species of surf clam off an exposed west coast North Island beach, New Zealand." Journal of Shellfish Research 15(2): 331-339.

Hiddink J., Jennings S., Kaiser M., Queiros A., Duplisea D., Piet G. 2006. Cumulative impacts of seabed trawl disturbance on benthic biomass, production, and species richness in different habitats. Canadian Journal of Fisheries and Aquatic Sciences 63, 721-736.

Hoenig J.M. 1983: Empirical use of longevity data to estimate mortality rates. FisheryBulletin 82: 898-903.

Kaiser M., Clarke K., Hinz H., Austen M., Somerfield P., Karakassis I. 2006. Global analysis of response and recovery of benthic biota to fishing. . Marine Ecology-Progress Series, 311:

Kaiser M., Hill A., Ramsay K., Spencer B., Brand A., Veale L., Prudden K., Rees E., Munday B., Ball B., Hawkins S. 1996. Benthic disturbance by fishing gear in the Irish Sea: a comparison of beam trawling and scallop dredging. Aquatic Conservation: Marine and Freshwater Ecosystems, 6, 269-285.

Langlois T., Anderson M.J., Babcock R., Kato S. 2005. Marine reserves demonstrate trophic interactions across habitats Oecologia 147(1): 134-140.

Langlois T. J., Anderson M.J., Brock M., Murman G. 2006. Importance of rock lobster size-structure for trophic interactions: choice of soft-sediment bivalve prey. Marine Biology 149(3): 447-454.

Mclachlan A., Brown A.2006. The Ecology of Sandy Shores, Academic Press.

Michael K., Olsen G., Hvid B., Cranfield H. 1990. Design and performance of two hydraulic subtidal clam dredges in New Zealand. In: New Zealand Fisheries Technical Report No. 21, p. 16p

Minami T., Sasaki K., Ito K. 2009. Recent research topics in biological production processes of marine bio-resources in the coastal waters and estuaries   Tohoku journal of agricultural research 59(3-4): 67-70.

Morello E.B., Froglia C., Atkinson R.G.A., Moore P.G. 2005. Impacts of hydraulic dredging on a macrobenthic community of the Adriatic Sea, Italy. Canadian Journal of Fisheries and Aquatic Sciences 62(9): 2076-2087.

Morello E.B., Froglia C., Atkinson R.G.A., Moore P.G. 2006. Medium-term impacts of hydraulic clam dredgers on a macrobenthic community of the Adriatic Sea (Italy). Marine Biology 149(2): 401-413.

Reise K. 1984. Tidal flat ecology. Berlin, Springer-Verlag.

Sasaki K., Sanematsu A., kato Y., Ito K. 2004. Dependence of the Surf Clam Pseudocardium Sachalinense (Bivalvia: Mactridae) On the Near-Bottom Layer for Food Supply   Journal of Molluscan Studies 70(3): 207-212.

Triantifillos L. 2008. Survey of subtidal surf clams in Pegasus Bay, November-December 2007. , Prepared by NIWA for Saefood Innovations Limited and SurfCo. limited. : 43p.

Triantifillos L. 2008. Survey of subtidal surf clams in Quota Management Area 2, June - August 2008. , Prepared by NIWA foe Saefood Innovations Limited and SurfCo. limited. : 40p.

DEEPWATER TUATUA (PDO)

(*Paphies donacina*)
Tuatua
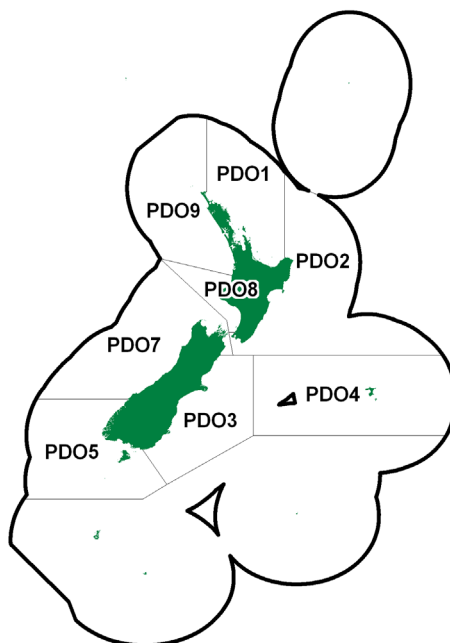
1.   FISHERY SUMMARY

This species is part of the surf clam fishery and the reader is guided to the surf clam introductory chapter for information common to all relevant species.

Deepwater Tuatua (*Paphies donacina*) were introduced into the Quota Management System on 1 April 2004 with a total TACC of 168 t. Biomass surveys in QMA 2 supported a TAC increase from April 2010. This increased the value for TACC 5 to 466 t. This increased the overall TACC to 629 t. An allowance of 25 t was also made in PDO 2 in 2010 for other sources of mortality (Table 1).

Table 1: Current TAC, TACC and allowances for other sources of mortality for *Paphies donacina*.

QMA	TAC (t)	TACC (t)	Recreational catch	Customary catch	Other sources of mortality (t)
1	1	1	0	0	0
2	509	466	9	9	25
3	150	108	21	21	0
4	3	1	1	1	0
5	3	1	1	1	0
7	52	50	1	1	0
8	19	1	9	9	0
9	53	1	26	26	0
Total	**791**	**629**	**68**	**68**	**25**

1.1   Commercial fisheries

Landings have only been reported from PDO 3, PDO 5, PDO 7 and PDO 8. Between the years 1992-93 and 1995-96, reported landings ranged from a few kilograms to about 6 t. No further landings were reported until 2002-03; since then reported total landings have ranged between 2 and 24 t. Reported landings and TACCs are shown for fishstocks with historical landings in Table 2. New survey information for QMA 2 and QMA 3 (Triantifillos 2008a, Triantifillos 2008b) resulted in increases to a number of surf clam TACCs from 1 April 2010, including in PDO 2 (Table 1).

1.2   Recreational fisheries

Estimates of recreational landings of tuatua were made between 1991 and 1994 and ranged from 237 t in FMA1 in 1993-4 to zero tonnes in most FMA in most years (Bradford 1998). The survey did not specify the species of tuatua landed, and most of the catch is thought to comprise the intertidal tuatua

P. subtriangulata (Cranfield & Michael 2001). On beaches where *P. donacina* extends to just below low water, some recreational catch occurs of this species, during low spring tides.

Table 2: **TACCs and reported landings (t) of Deepwater Tuatua by Fishstock from 1992-93 to 2011-12 from CELR and CLR data. PDO areas where catch has never been reported are not tabulated. PDO 1, 4 and 9 all have TACC of 1 t and PDO 2 has a TACC of 466 t.**

Fishstock	PDO 3 Landings	TACC	PDO 5 Landings	TACC	PDO 7 Landings	TACC	PDO 8 Landings	TACC	Total Landings	TACC
1992-93	0	-	0	-	0.289	-	0	-	0.294	-
1993-94	0	-	0.005	-	3.384	-	0	-	3.384	-
1994-95	0	-	0	-	5.036	-	0	-	5.036	-
1995-96	4.439	-	0	-	1.668	-	0	-	6.107	-
1996-97	0	-	0	-	0	-	0	-	0	-
1997-98	0	-	0	-	0	-	0	-	0	-
1998-99	0	-	0	-	0	-	0	-	0	-
1999-00	0	-	0	-	0	-	0	-	0	-
2000-01	0	-	0	-	0	-	0	-	0	-
2001-02	0	-	0	-	0	-	0	-	0	-
2002-03	0	-	0	-	2.253	-	0	-	2.253	-
2003-04	0	108	0	1	10.144	50	0	1	10.144	168
2004-05	0	108	0	1	12.532	50	0	1	12.692	168
2005-06	0	108	0	1	10.627	50	0.148	1	13.728	168
2006-07	1.17	108	0	1	19.995	50	0	1	21.16	168
2007-08	3.17	108	0	1	21.145	50	0	1	24.315	168
2008-09	4.09	108	0	1	4.320	50	0	1	8.41	168
2009-10	11.21	108	0	1	1.50	50	0	1	12.71	168
2010-11	3.928	108	0	1	38.800	50	0	1	42.728	629
2011-12	0	108	0	1	17.050	50	0	1	17.050	629

*In 2004-05 and 2005-06 0.16 and 2.953 t respectively were reportedly landed, but the QMA is not recorded. These amounts are included in the total landings for those years.

1.3 Customary fisheries

P. donacina is an important handpicked resource of local iwi, especially in Pegasus Bay, Canterbury. There are no estimates of current customary use of this clam.

1.4 Illegal catch

There is no documented illegal catch of this clam.

1.5 Other sources of mortality

There is no quantitative information on other sources of mortality, although this clam is subject to localized catastrophic mortality from erosion during storms, high temperatures and low oxygen levels during calm summer periods, blooms of toxic algae and excessive freshwater outflow (Cranfield & Michael 2001).

2. BIOLOGY

P. donacina occurs mainly around the lower half of the North Island and from Pegasus Bay north in the South Island, and on the north coast of Stewart Island. It is found from low tide to about 4 m, although juveniles may extend to the mid-tide mark. Maximum length is variable between areas, ranging from 73 to 109 mm (Cranfield *et al.* 1993). The sexes are separate, they are broadcast spawners, and the larvae are thought to be planktonic for between 18 and 21 days (Cranfield *et al.* 1993). Settlement and early juveniles occur in the intertidal zone; these animals are mobile and migrate offshore as they grow. The deepwater tuatua (*Paphies donacina*) showed seasonal adjustment in its oxygen uptake and filtration rates to compensate for seasonal temperature variation in the habitat (Marsden 1999).

3. STOCKS AND AREAS

For management purposes stock boundaries are based on QMAs, however, the boundaries of stocks of surf clams are likely to be the continuous lengths of exposed sandy beaches between geographical features (rivers, headlands etc). Circulation patterns may isolate surf clams genetically as well as ecologically.

4.   ENVIRONMENTAL EFFECTS OF FISHING

See the introductory surf clam chapter.

5.   STOCK ASSESSMENT

All stocks are considered in effectively virgin state and an *MCY* is estimated from the surveyed biomass estimates. All stocks were considered in an effectively virgin state in 1993-4 when the initial biomass estimates were made (Cranfield *et al.* 1993). Total catches in PDO 7 have since been in the range of 2.2 to 21 t, catches in other Fishstocks have been below 5 t.

5.1   Estimates of fishery parameters and abundance
No fisheries parameters or abundance estimates are available for any deepwater tuatua stocks.

5.2   Biomass estimates
Biomass has been estimated from one site in each of PDO 8 and PDO 3, and multiple sites within PDO 2 and PDO 7 (Table 3 and 4). A stratified random survey using a hydraulic dredge was employed for all these surveys.

Table 3:   A summary of biomass estimates in tonnes green weight with standard deviation in parentheses from exploratory surveys of Cloudy Bay, Marlborough (Cranfield *et al.* 1994b), and Clifford Bay, Marlborough (Michael *et al.* 1994), Rabbit Island, Nelson (Michael & Olsen 1988), and Foxton beach, Manawatu coast (Haddon *et al.* 1996).

Area	Cloudy Bay (PDO 7)	Clifford Bay (PDO 7)	Foxton Beach (PDO 8)	Rabbit Island (PDO 7)
Length of beach (km)	11	21	27.5	8
Biomass (t)	154 (60)	284 (123)	171	108

Table 4: A summary of biomass estimates in tonnes green weight from the surveys in PDO 2 and 3 (Triantifillos 2008a, 2008b). Note: unless otherwise stated the CV is less than 20%.

Location	Five sites (PDO 2)	Ashley River to 6 nm south of the Waimakariri River (PDO 3)
Area surveyed (km^2)	28.0	13.4
Biomass (t)	5651.8	320.8

5.3   Estimation of Maximum Constant Yield (*MCY*)
Growth and mortality data from Cloudy Bay, Marlborough and the Kapiti Coast, Manawatu (Cranfield *et al.* 1993) have been used in a yield per recruit model to estimate the reference fishing mortality $F_{0.1}$ (Cranfield *et al.* 1994b, Triantifillos 2008a, 2008b). The shellfish working group did not accept these estimates of $F_{0.1}$ as there was considerable uncertainty in both the estimate and the method used to generate them. The *MCY* estimates of Triantafillos (2008b) that use the full range of $F_{0.1}$ estimates from Cranfield *et al.* (1993) are shown in Table 5, but should be interpreted cautiously.

Estimates of *MCY* are available from numerous locations and were calculated using Method 1 for a virgin fishery (Annala *et al.* 2001) with an estimate of virgin biomass B_0, where:

$$MCY = 0.25* F_{0.1} B_0$$

Table 5: Mean *MCY* estimates (t) for *P. donacina* from virgin biomass at locations sampled around New Zealand (Triantifillos 2008a, 2008b).

Location	$F_{0.1}$	MCY
Five sites (PDO 2)**	0.36/0.52	508.7/734.7
Ashley River to 6 nm south of the Waimakariri River (PDO 3)*	0.36/0.52	28.9/41.7

5.4   Estimation of Current Annual Yield (*CAY*)

CAY has not been estimated for *P. donacina*.

6.   STATUS OF THE STOCKS

- PDO 2, 3, 7 & 8 - *Paphies donacina*

Stock Status	
Year of Most Recent Assessment	2008 for PDO 2 & 3, 1994 for PDO 7 and 1996 for PDO 8
Assessment Runs Presented	Survey biomass
Reference Points	Target: Not defined, but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Because of the relatively low levels of exploitation of *P. donacina*, it is likely that all stocks are still effectively in a virgin state, therefore they are Very Likely (> 90%) to be at or above the target.
Status in relation to Limits	Very Unlikely (< 10%) to be below the soft and hard limits
Historical Stock Status Trajectory and Current Status Unknown	

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Unknown
Recent Trend in Fishing Mortality or Proxy	Fishing minimal in all QMAs other than PDO 7. In PDO 7 fishing has been light, averaging 11.6 t since 2002-03.
Other Abundance Indices	None
Trends in Other Relevant Indicators or Variables	None

Projections and Prognosis		
Stock Projections or Prognosis	None	
Probability of Current Catch or TACC causing decline below Limits	For all stocks current catches are Very Unlikely (< 10%) to cause declines below soft or hard limits.	
Assessment Methodology		
Assessment Type	Level 2: Partial quantitative stock assessment	
Assessment Method	Absolute biomass estimates from quadrat surveys	
Main data inputs	Abundance and length frequency information	
Period of Assessment	Latest assessment: 2008 for PDO 2 & 3, 1994 for PDO 7 and 1996 for PDO 8	Next assessment: Unknown
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty	None	

Qualifying Comments
Stock size could fluctuate markedly as a result of catastrophic mortality from a number of causes.
There is a need to review the fishery parameters for this species.

Fishery Interactions
PDO can be caught together with other surf clam species and non-QMS bivalves.

Table 6: Calculated *MCY* estimates, TACCs, and 2011-12 recorded landings for PDO.

Fishstock	QMA	*MCY*	2011-12 Actual TACC	2011-12 Reported Landings
PDO	2	508 - 734	466	0
	3	30 - 43	108	0
	7	2	50	17
	8	3	1	0

For all other PDO stocks there is no current evidence of appreciable biomass.

7. FOR FURTHER INFORMATION

Annala J.H., Sullivan K.J., O'Brien C.J., Smith N.W.M. (compilers.) 2001. Report from the fishery assessment plenary, May 2001: stock assessments and yield estimates. 515 p. (Unpublished report held in NIWA library, Wellington).

Bradford E. 1998. Harvest estimates from the 1996 national marine recreational fishing surveys. New Zealand Fisheries Assessment Research Document 98/16 27p. (unpublished report held in NIWA library, Wellington).

Brierley P. (Convenor) 1990. Management and development of the New Zealand sub-tidal clam fishery. Report of the surf clam working group, MAF Fisheries (unpublished report held in NIWA library, Wellington). 57 p.

Cranfield H.J., Michael K.P., Stotter D.R. 1993. Estimates of growth, mortality, and yield per recruit for New Zealand surf clams. New Zealand Fisheries Research Assessment Document 1993/20. 26p.

Cranfield H.J., Michael K.P. 2001. The surf clam fishery in New Zealand: description of the fishery, its management, and the biology of surf clams. New Zealand Fisheries Assessment Report 2001/62. 24 p.

Cranfield H.J., Michael K.P., Stotter D.R., Doonan I.J. 1994a. Distribution, biomass and yield estimates of surf clams off New Zealand beaches. New Zealand Fisheries Research Assessment Document 94/1. 17 p.

Cranfield H.J., Doonan I.J., Michael K.P. 1994b. Dredge survey of surf clams in Cloudy Bay, Marlborough. New Zealand Fisheries Technical Report 39: 18 p.

Haddon M., Willis T.J., Wear R.G., Anderlini V.C. 1996. Biomass and distribution of five species of surf clam off an exposed west coast North Island beach, New Zealand. Journal of Shellfish Research 15: 331–339.

Marsden I.D. 1999. "Respiration and feeding of the surf clam Paphies donacina from New Zealand." Hydrobiologia **405**: 179-188.

Marsden I.D. 2000. Variability in low tide populations of tuatua, *Paphies donacina*, in Pegasus Bay, Canterbury, New Zealand. New Zealand Journal of Marine and Freshwater Research 34:359-370.

Michael K.P, Olsen G.P. 1988. Surf clam resource, Rabbit Island, Nelson. Fisheries Research Centre Internal Report no. 84, 17p. (Draft held in NIWA library, Greta Point, Wellington).

Michael K, Cranfield H, Doonan I, Hadfield J. 1994.Dredge survey of surf clams in Clifford Bay, Marlborough, New Zealand Fisheries Data Report, No. 54

Triantifillos L. 2008a. Survey of subtidal surf clams in Pegasus Bay, November-December 2007. . In, p. 43p. Prepared by NIWA for Seafood Innovations Limited and SurfCo. Limited.

Triantifillos L. 2008b. Survey of subtidal surf clams in Quota Management Area 2, June - August 2008. . In, p. 40p. Prepared by NIWA for Seafood Innovations Limited and SurfCo. Limited.

FINE (SILKY) DOSINIA (DSU)

(*Dosinia subrosea*)
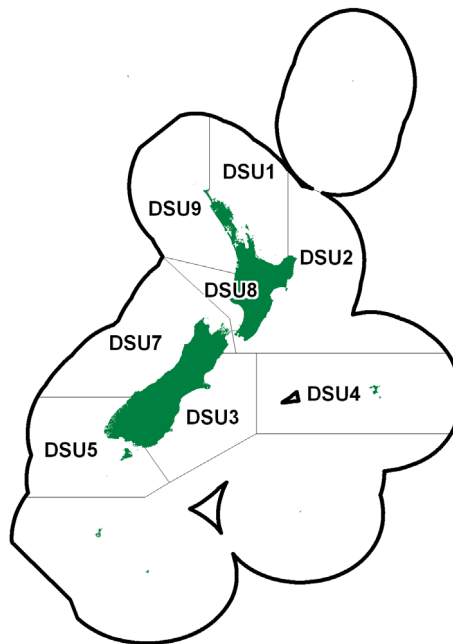
1. FISHERY SUMMARY

This species is part of the surf clam fishery and the reader is guided to the surf clam introductory chapter for information common to all relevant species.

Fine Dosinia (*Dosinia subrosea*) were introduced into the Quota Management System on 1 April 2004 with a TAC of 8 t and TACC of 8 t (Table 1). There were no allowances for customary, recreational or other sources of mortality and no changes to any of these values have occurred since.

Table 1: Current TAC and TACC for *Dosinia subrosea*.

QMA	TAC (t)	TACC (t)
1	1	1
2	1	1
3	1	1
4	1	1
5	1	1
7	1	1
8	1	1
9	1	1
Total	**8**	**8**

1.1 Commercial fisheries
Landings have only ever been reported from DSU 1 and DSU 7. In 1993-94 total landings were 235 kg and since 1994-95, landings have been only been reported from DSU 7 and all have been less than 100 kg (Table 2).

1.2 Recreational fisheries
There are no known records of recreational use of this surf clam.

1.3 Customary fisheries
Offshore clams such as *D. subrosea* are likely to have been harvested for customary use only when washed ashore after storms (Carkeek 1966). There are no estimates of current customary use of this clam

Table 2: **TACCs and reported landings (t) of Fine Dosinia by Fishstock from 1993-94 to 2011-12 from CELR and CLR data for Fishstocks where landings have been reported. DSU 2, 3, 4, 5, 8 and 9 all have TACC of 1 t.**

Fishstock	DSU 1 Landings	TACC	DSU 7 Landings	TACC	Total Landings	TACC
1993-94	0.123	-	0.112	-	0.235	-
1994-95	0	-	0.026	-	0.026	-
1995-96	0	-	0.011	-	0.038	-
1996-97	0	-	0	-	0	-
1997-98	0	-	0	-	0	-
1998-99	0	-	0	-	0	-
1999-00	0	-	0	-	0	-
2000-01	0	-	0	-	0	-
2001-02	0	-	0	-	0	-
2002-03	0	-	0	-	0	-
2003-04	0	1.0	0.089	1.0	0.089	8.0
2004-05	0	1.0	0.078	1.0	0.110*	8.0
2005-06	0	1.0	0.061	1.0	0.169*	8.0
2006-07	0	1.0	0.003	1.0	0.003	8.0
2007-08	0	1.0	0	1.0	0	8.0
2008-09	0	1.0	0.001	1.0	0.001	8.0
2009-10	0	1.0	0	1.0	0	8.0
2010-11	0	1.0	0	1.0	0	8.0
2011-12	0	1.0	0	1.0	0	8.0

*In 2004-05 and 2005-06 32.4 and 90 kg were reported but the QMA is not recorded. This amount is included in the total landings for these years.

1.4 Illegal catch

There is no known illegal catch of this clam.

1.5 Other sources of mortality

There is no quantitative information on other sources of mortality, although this clam is probably sometimes taken as a bycatch in inshore trawling. Harvesters claim that the hydraulic clam rake does not damage surf clams and minimises damage to the few species of other macrofauna captured. Surf clam populations are also subject to localised catastrophic mortality from erosion during storms, high temperatures and low oxygen levels during calm summer periods, blooms of toxic algae and excessive freshwater outflow (Cranfield & Michael 2001).

2. BIOLOGY

D. subrosea has not been found in high densities in any survey work. It is found around the New Zealand coast in deeper softer sediment habitats. In the North Island it is found between 6 and 10 m in depth, and in the South Island between 5 and 8 m (Cranfield & Michael 2002). It is smaller and smoother than *D. anus*, and is usually found in more stable habitats. Maximum length is variable between areas, ranging from 41 to 68 mm (Cranfield *et al*. 1993). The sexes are believed to be separate, and they are likely to be broadcast spawners with planktonic larvae (Cranfield & Michael 2001). Anecdotal evidence suggests that spawning is likely to occur in the summer months. Recruitment of surf clams is thought to be highly variable between years.

For information on, growth, age and natural mortality of this species and general statements about relative biomass of all surf clam species around the country (excluding *Bassinia yatei*) see the introductory surf clam chapter.

3. STOCKS AND AREAS

For management purposes stock boundaries are based on QMAs, however, the boundaries of stocks of surf clams are likely to be the continuous lengths of exposed sandy beaches between geographical

features (such as rivers and headlands). Circulation patterns may isolate surf clams genetically as well as ecologically.

4. ENVIRONMENTAL EFFECTS OF FISHING

See the introductory surf clam chapter.

5. STOCK ASSESSMENT

All stocks are considered in effectively virgin state and an *MCY* is estimated from the surveyed biomass estimates. All stocks were considered in an effectively virgin state in 1993-4 when the initial biomass estimates were made (Cranfield *et al.* 1993). Total catches of DSU have not exceeded 1 t in any Fishstock since then.

5.1 Estimates of fishery parameters and abundance
No fisheries parameters or abundance estimates are available for any DSU stocks.

5.2 Biomass estimates
Biomass has been estimated from 11 km of beach at Cloudy Bay (DSU 7) with a stratified random survey using a hydraulic dredge (Cranfield *et al.* 1994b). The virgin biomass for this area was estimated to be 21 t. Subsequent surveys estimated biomass from one site in DSU 3 and a number of sites in DSU 2 (Table 3).

Table 3: A summary of biomass estimates greenweight (t) from the surveys in DSU 2 and 3 (Triantifillos 2008a, Triantifillos 2008b). Note: Unless otherwise stated the CV is less than 0.2.

Location	Five sites (DSU 2)	Ashley River to 6 nm south of the Waimakariri River (DSU 3)
Area surveyed (km^2)	28.0	13.4
Biomass (t)	5.9	12.2*

* CV is 0.29.

5.3 Estimation of Maximum Constant Yield (*MCY*)
Growth and mortality data from Cloudy Bay in Marlborough and the Kapiti Coast in Manawatu (Cranfield *et al.* 1993) have been used in a yield per recruit model to estimate the reference fishing mortality $F_{0.1}$ (Cranfield *et al.* 1994b, Triantifillos 2008a, 2008b). The shellfish working group did not accept these estimates of $F_{0.1}$ as there was considerable uncertainty in both the estimate and the method used to generate them. The *MCY* estimates of Triantafillos (2008b) that use the full range of $F_{0.1}$ estimates from Cranfield *et al.* (1993) are shown in Table 4 but should be interpreted cautiously.

Estimates of *MCY* are available from numerous locations and were calculated using Method 1 for a virgin fishery (Annala *et al.* 2001) with an estimate of virgin biomass B_0, where:

$$MCY = 0.25* F_{0.1} B_0$$

Table 4: Mean *MCY* estimates (t) for *D. subrosea* from virgin biomass at locations sampled around New Zealand (Triantifillos 2008a and b).

Location	$F_{0.1}$	*MCY*
Five sites (DSU 2)	0.27/0.54	0.4/0.8
Ashley River to 6 nm south of the Waimakariri River (DSU 3)**	----------	--------

5.4 Estimation of Current Annual Yield (*CAY*)
CAY has not been estimated for *D. subrosea*.

6.   STATUS OF THE STOCKS

- DSU-*Dosinia subrosea*

There is no evidence of appreciable biomass of this species in any area.

Table 5:   Calculated *MCY* estimates, TACC, and 2011-12 reported landings for DSU.

Fishstock	QMA	*MCY*	2011-12 Actual TACC	2011-12 Reported Landings
DSU	1	< 1	1	0
	2	< 1	1	0
	3	< 1	1	0
	7	< 1	1	0
	8	< 1	1	0

7.   FOR FURTHER INFORMATION

Annala J.H., Sullivan K.J., O'Brien C.J., Smith N.W.McL (compilers.) 2001. Report from the fishery assessment plenary, May 2001: stock assessments and yield estimates. 515p. (Unpublished report held in NIWA library, Wellington).

Brierley P. (Convenor) 1990. Management and development of the New Zealand sub-tidal clam fishery. Report of the surf clam working group, MAF Fisheries (unpublished report held in NIWA library, Wellington). 57p.

Carkeek W.C. 1966. The Kapiti coast. Reed, Wellington. 187 p.

Cranfield H.J., Michael K.P. 2001. The surf clam fishery in New Zealand: description of the fishery, its management, and the biology of surf clams. New Zealand Fisheries Assessment Report 2001/62: 24p.

Cranfield H., Michael K. 2002. Potential area boundaries and indicative TACs for the seven species of surf clam. NIWA unpublished report to the Ministry of Fisheries

Cranfield H.J., Michael K.P., Stotter D.R. 1993. Estimates of growth, mortality, and yield per recruit for New Zealand surf clams. New Zealand Fisheries Research Assessment Document 1993/20: 26p.

Cranfield H.J., Michael K.P., Stotter D.R., Doonan I.J. 1994a. Distribution, biomass and yield estimates of surf clams off New Zealand beaches. New Zealand Fisheries Research Assessment Document 1994/1: 17p.

Cranfield H.J., Doonan I.J., Michael K.P. 1994b. Dredge survey of surf clams in Cloudy Bay, Marlborough. New Zealand Fisheries Technical Report 39: 18p.

Haddon M., Willis T.J., Wear R.G., Anderlini V.C. 1996. Biomass and distribution of five species of surf clam off an exposed west coast North Island beach, New Zealand. Journal of Shellfish Research 15: 331–339.

Triantifillos L. 2008a. Survey of subtidal surf clams in Pegasus Bay, November-December 2007. . In, p. 43p. Prepared by NIWA for Seafood Innovations Limited and SurfCo. limited.

Triantifillos L. 2008b. Survey of subtidal surf clams in Quota Management Area 2, June - August 2008. . In, p. 40p. Prepared by NIWA for Seafood Innovations Limited and SurfCo. Limited.

FRILLED VENUS SHELL (BYA)

(*Bassina yatei*)
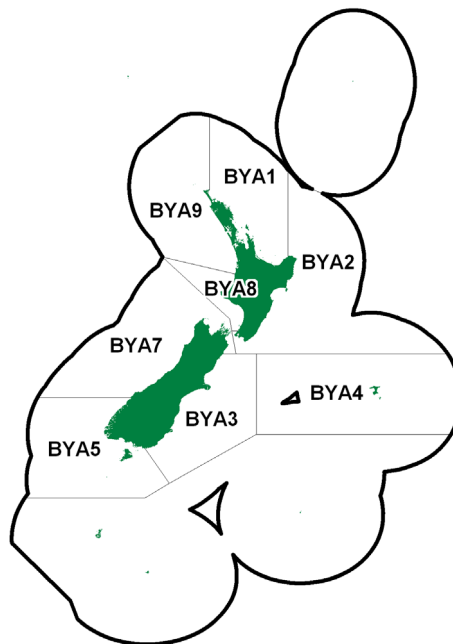
1. FISHERY SUMMARY

This species is part of the surf clam fishery and the reader is guided to the surf clam introductory chapter for information common to all relevant species.

The Frilled Venus Shell (*Bassina yatei*) was introduced into the Quota Management System on 1 April 2004 with a combined TAC of 16 t and a TACC of 16 t. There were no allowances for customary, recreational or other sources of mortality. These limits have not been changed (Table 1).

Table 1: Current TAC and TACC for *Bassina yatei*.

QMA	TAC (t)	TACC (t)
1	1	1
2	1	1
3	1	1
4	1	1
5	1	1
7	9	9
8	1	1
9	1	1
Total	**16**	**16**

1.1 Commercial fisheries
Landings have been small (all around 1 t or less), from BYA 7 and only reported from 1992-5, 2001-5 and 2008-09. One landing of over 7 t was reported from BYA1 in 2002-3 (Table 2).

1.2 Recreational fisheries
There are no known records of recreational use of this surf clam.

1.3 Customary fisheries
Offshore clams such as *B. yatei* are likely to have been harvested for customary use only when washed ashore after storms. Shells of this clam have been found irregularly, and in small numbers in a few middens. There are no estimates of current customary use of this clam.

Table 2: TACCs and reported landings (t) of frilled venus shell by Fishstock from 1992-93 to 2011-12 from CELR and CLR data. There have never been any reported landings in BYA 2, 3, 4, 5, 8 or 9. These stocks each have a TACC of 1 t and are not tabulated below.

	BYA 1		BYA 7		Total	
	Landings	TACC	Landings	TACC	Landings	TACC
1992-93	0	-	0.026	-	0.026	-
1993-94	0	-	0.007	-	0.007	-
1994-95	0	-	0.001	-	0.001	-
1995-96	0	-	0	-	0	-
1996-97	0	-	0	-	0	-
1997-98	0	-	0	-	0	-
1998-99	0	-	0	-	0	-
1999-00	0	-	0	-	0	-
2000-01	0	-	0	-	0	-
2001-02	7.473	-	0.049	-	7.522	-
2002-03	0	-	1.132	9	1.132	16
2003-04	0	1	1.295	9	1.296	16
2004-05	0	1	0.207	9	0.207	16
2005-06*	0	1	0	9	0.036*	16
2006-07	0	1	0	9	0	16
2007-08	0	1	0	9	0	16
2008-09	0	1	0.003	9	0.003	16
2009-10	0	1	0	9	0	16
2010-11	0	1	0	9	0	16
2011-12	0	1	0.350	9	0.350	16

*In 2005-06 36.4 Kg were reportedly landed, but the QMA is not recorded. This amount is included in the total landings for that year.

1.4   Illegal catch

There is no documented illegal catch of this clam.

1.5   Other sources of mortality

There is no quantitative information on other sources of mortality, although this clam is subject to localised catastrophic mortality from erosion during storms, high temperatures and low oxygen levels during calm summer periods, blooms of toxic algae and excessive freshwater outflow (Cranfield & Michael 2001).

2.   BIOLOGY

B. yatei is endemic to New Zealand and is found around the coast in sediments at depths between 6 and 9 m. Maximum length is variable between areas, ranging from 48 to 88 mm (Cranfield & Michael 2002).The sexes are likely to be separate, and they are likely to be broadcast spawners with planktonic larvae. Anecdotal evidence suggests spawning is likely to occur in the summer months. Recruitment of surfclams is thought to be highly variable between years.

3.   STOCKS AND AREAS

For management purposes stock boundaries are based on QMAs, however, the boundaries of stocks of surf clams are likely to be the continuous lengths of exposed sandy beaches between geographical features (rivers, headlands etc). Circulation patterns may isolate surf clams genetically as well as ecologically.

4.   ENVIRONMENTAL EFFECTS OF FISHING

See the introductory surf clam chapter.

5.   STOCK ASSESSMENT

5.1   Estimates of fishery parameters and abundance
No estimates of fisheries parameters or abundance are available for this species.

5.2   Biomass estimates
Biomass has been estimated for two sites in the Marlborough Sounds with a stratified random survey using a hydraulic dredge. Estimates are shown in Table 3.

Table 3: **A summary of biomass estimates in tonnes greenweight with standard deviation in parentheses from exploratory surveys of Cloudy Bay (Cranfield *et al*. 1994b), and Clifford Bay, both in Marlborough (Michael *et al*. 1994).**

Area	Cloudy Bay (BYA 7)	Clifford Bay (BYA 7)
Length of beach (km)	11	21
Biomass (t)	123 (50)	0.2 (0.8)

5.3   Estimation of Maximum Constant Yield (*MCY*)
Growth and mortality data from Cloudy Bay in Marlborough and the Kapiti Coast in Manawatu (Cranfield *et al*. 1993) have been used in a yield per recruit model to estimate the reference fishing mortality $F_{0.1}$ (Cranfield *et al*. 1994b). The shellfish working group did not accept these estimates of $F_{0.1}$ as there was considerable uncertainty in both the estimate and the method used to generate them.

5.4   Estimation of Current Annual Yield (*CAY*)
CAY has not been estimated for *B. yatei*.

6.   STATUS OF THE STOCKS

- BYA 7 - *Bassina yatei*

Stock Status	
Year of Most Recent Assessment	1994
Assessment Runs Presented	Survey biomass
Reference Points	Target: Not defined, but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Because of the relatively low levels of exploitation of *B. yatei*, it is likely that all stocks are still effectively in a virgin state, therefore they are Very Likely (> 90%) to be at or above the target.
Status in relation to Limits	Very Unlikely (< 10%) to be below the soft and hard limits
Historical Stock Status Trajectory and Current Status Unknown	

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Unknown
Recent Trend in Fishing Mortality or Proxy	Fishing is light in all Fishstocks. In BYA 7 landings have averaged 0.34 t since 2001-02.
Other Abundance Indices	None
Trends in Other Relevant Indicators or Variables	None

Projections and Prognosis	
Stock Projections or Prognosis	None
Probability of Current Catch or	For all stocks fishing is Very Unlikely (< 10%) to cause declines

TACC causing decline below Limits	below soft or hard limits.

Assessment Methodology

Assessment Type	Level 2: Partial quantitative stock assessment	
Assessment Method	Absolute biomass estimates from quadrat surveys	
Main data inputs	Abundance and length frequency information	
Period of Assessment	Latest assessment: 1994	Next assessment: Unknown
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty	None	

Qualifying Comments

Stock size could fluctuate markedly as a result of catastrophic mortality from a number of causes.
There is a need to review fishery parameters for this species.
Virgin stock size in areas sampled has been small. It is not known if peak abundances may be outside the surveyed areas.

Fishery Interactions

BYA can be caught together with other surf clam species and non-QMS bivalves.

Table 4: Calculated *MCY* estimates, TACCs, and 2011-12 reported landings for BYA.

Fishstock	QMA	*MCY*	2011-12 Actual TACC	2011-12 Reported Landings
BYA	7	--	0.35	0

For all other BYA stocks there is no current evidence of appreciable biomass.

7.   FOR FURTHER INFORMATION

Annala J.H., Sullivan K.J., O'Brien C.J., Smith N.W.M. (comps.) 2001. Report from the fishery assessment plenary, May 2001: stock assessments and yield estimates. 515p. (Unpublished report held in NIWA library, Wellington).

Beentjes M.P., Baird S.J. 2004. Review of dredge fishing technologies and practice for application in New Zealand. New Zealand Fisheries Assessment Report 2004/37. 40p.

Brierley P. (Convenor) 1990. Management and development of the New Zealand sub-tidal clam fishery. Report of the surf clam working group, MAF Fisheries (unpublished report held in NIWA library, Wellington). 57p.

Cranfield H., Michael K.P. 2001. The surf clam fishery in New Zealand: description of the fishery, its management, and the biology of surf clams. New Zealand Fisheries Assessment Report 2002/62: 24p.

Cranfield H., Michael K. 2002. Potential area boundaries and indicative TACs for the seven species of surf clam. NIWA unpublished report to the Ministry of Fisheries.

Cranfield H.J., Michael K.P., Stotter D.R. 1993. Estimates of growth, mortality, and yield per recruit for New Zealand surf clams. New Zealand Fisheries Research Assessment Document 1993/20: 26p.

Cranfield H.J., Michael K.P., Stotter D.R., Doonan I.J. 1994a. Distribution, biomass and yield estimates of surf clams off New Zealand beaches. New Zealand Fisheries Research Assessment Document 1994/1: 17p.

Cranfield H.J., Doonan I.J., Michael K.P. 1994b. Dredge survey of surf clams in Cloudy Bay, Marlborough. New Zealand Fisheries Technical Report 39: 18p.

Haddon M., Willis T.J., Wear R.G., Anderlini V.C. 1996. Biomass and distribution of five species of surf clam off an exposed west coast North Island beach, New Zealand. Journal of Shellfish Research 15: 331–339.

Michael K., Cranfield H., Doonan I., Hadfield J. 1994. Dredge survey of surf clams in Clifford Bay, Marlborough, New Zealand Fisheries Data Report, No. 54

LARGE TROUGH SHELL (MMI)

(*Mactra murchisoni*)
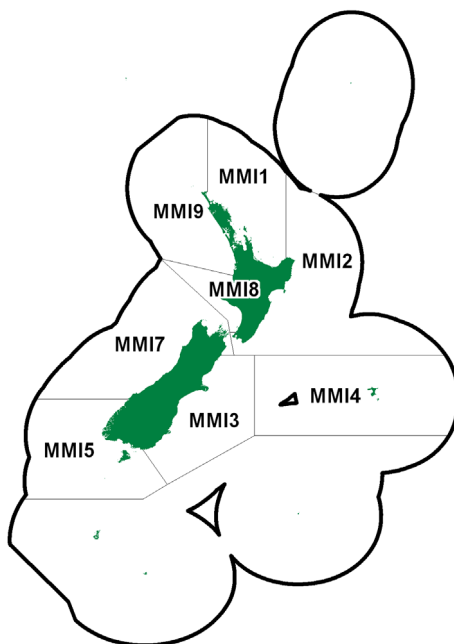
1. FISHERY SUMMARY

This species is part of the surf clam fishery and the reader is guided to the surf clam introductory chapter for information common to all relevant species.

Large trough shells (*Mactra murchisoni*) were introduced into the Quota Management System on 1 April 2004 with a total TACC of 162 t. No allowances were made for customary, recreational or other sources of mortality. Biomass surveys in QMA 2 supported a TACC increase from April 2010. This increased the TACC for MMI 2 to 62 t. An allowance of 3 t for other sources of mortality was also made. This increased the total TACC to 180 t and the total TAC to 183 t (Table 1).

Table 1: Current TAC, TACC and allowances for other sources of mortality for *Mactra murchisoni*.

QMA	TAC (t)	TACC (t)	Other sources of mortality (t)
1	2	2	0
2	3	3	0
3	65	62	3
4	1	1	0
5	1	1	0
7	61	61	0
8	25	25	0
9	25	25	0
Total	**183**	**180**	**3**

1.1 Commercial fisheries

All reported landings have been from MMI 3 and MMI 7. Between the 1991-92 and 1995-96 fishing years landings were small and confined to MMI 7. No further landings were reported until 2002-03; since then the reported catch has ranged between about 20 t to 60 t (Table 2). Figure 1 shows the historical landings and TACC for the two main MMI stocks.

1.2 Recreational fisheries

Offshore clams such as *M. murchisoni* are likely to have been harvested for recreational use only when washed ashore after storms. There are no estimates of recreational take for this surf clam.

Table 2: **TACCs and reported landings (t) of Large Trough Shell by Fishstock from 1991-92 to 2011-12 from CELR and CLR data. Fishstocks where no catch has been reported are not tabulated. MM1 1, 2, 4, 5, 8 and 9 have TACC of 2, 3, 1, 1, 25 and 25 t, respectively.**

Fishstock	MMI 3 Landings	TACC	MMI 7 Landings	TACC	Total Landings	TACC
1991-92	0	0	0.349	-	0.349	-
1992-93	0	0	1.541	-	1.541	-
1993-94	0	0	8.327	-	8.327	-
1994-95	0	0	10.432	-	10.432	-
1995-96	0	0	0.142	-	0.142	-
1996-97	0	0	0	-	0	-
1997-98	0	0	0	-	0	-
1998-99	0	0	0	-	0	-
1999-00	0	0	0	-	0	-
2000-01	0	0	0	-	0	-
2001-02	0	0	0	-	0	-
2002-03	0	0	22.623	-	22.623	-
2003-04	0	44	29.681	61	29.681	162
2004-05*	0	44	60.023	61	60.863	162
2005-06*	0	44	53.961	61	57.916	162
2006-07	7.476	44	54.091	61	61.567	162
2007-08	36.901	44	15.036	61	51.937	162
2008-09	32.149	44	6.657	61	38.806	162
2009-10	25.764	44	3.416	61	29.180	162
2010-11	12.600	62	17.432	61	30.032	180
2011-12	0	62	47.338	61	47.338	180

*In 2004-05 and 2005-06 0.84 and 3.9554 t respectively were reportedly landed, but the QMA is not recorded. These amounts are included in the total landings for these years.
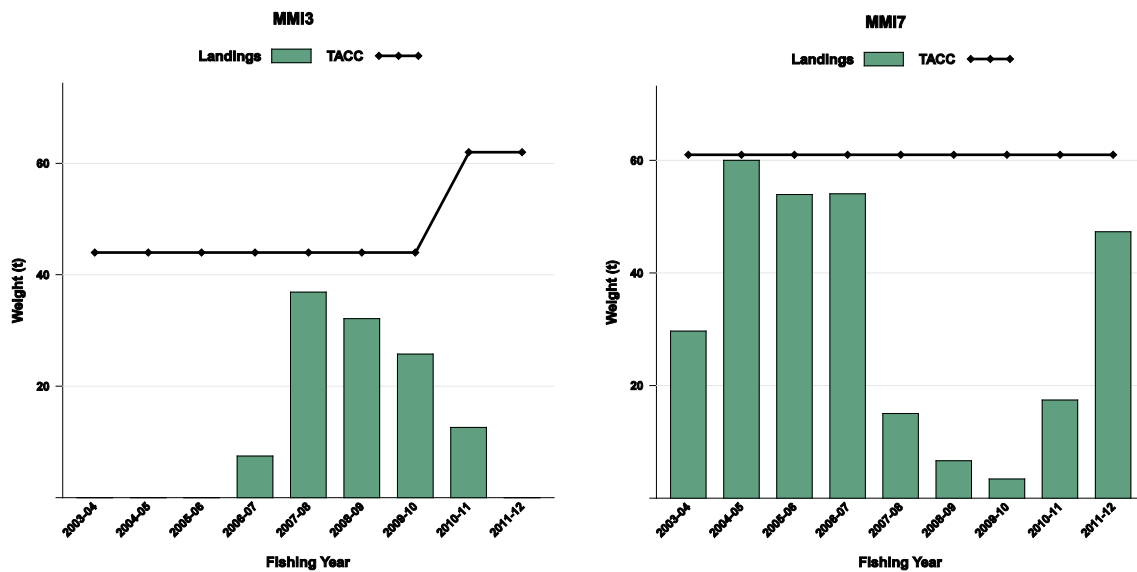
Figure 1: **Historical landings and TACC for MMI 3 (South East Coast), and MMI 7 (Challenger). Note that these figures do not show data prior to entry into the QMS.**

1.3   Customary fisheries

Offshore clams such as *M. murchisoni* are likely to have been harvested for customary use only when washed ashore after storms. Shells of this clam have been found irregularly, and in small numbers, in a few middens (Conroy *et al.* 1993). There are no estimates of current customary catch of this clam.

1.4   Illegal catch

There is no documented illegal catch of this clam.

1.5   Other sources of mortality

There is no quantitative information on other sources of mortality, although this clam is subject to localised catastrophic mortality from erosion during storms, high temperatures and low oxygen levels during calm summer periods, blooms of toxic algae and excessive freshwater outflow (Cranfield & Michael 2001).

2.   BIOLOGY

M. murchisoni is most abundant in the lower half of the North Island and the South Island. It is found most commonly between about 4 m and 8 m in depth. Maximum length is variable between areas, ranging from 63 to 102 mm (Cranfield *et al.* 1993) The sexes are separate, they are broadcast spawners, and the larvae are thought to be planktonic for between 20 and 30 days (Cranfield & Michael 2001). Recruitment of spat is to the same depth zone that adults occur in, although recruitment between years is highly variable (Conroy *et al.* 1993).

3.   STOCKS AND AREAS

For management purposes stock boundaries are based on QMAs, however the boundaries of stocks of surf clams are likely to be the continuous lengths of exposed sandy beaches between geographical features (rivers, headlands etc). Circulation patterns may isolate surf clams genetically as well as ecologically.

4.   ENVIRONMENTAL EFFECTS OF FISHING

See the introductory surf clam chapter.

5.   STOCK ASSESSMENT

5.1   Estimates of fishery parameters and abundance
No estimates of fisheries parameters or abundance are available for this species.

5.2   Biomass estimates
Biomass has been estimated at one site within MMI 3 and 8 and multiple sites within MMI 2 and 7 with stratified random surveying using a hydraulic dredge (Tables 3 and 4).

Table 3:   A summary of biomass estimates in tonnes greenweight with standard deviation in parentheses from exploratory surveys of Cloudy Bay (Cranfield *et al.* 1994b) and Clifford Bay in Marlborough (Michael *et al.* 1994), and Foxton beach on the Manawatu coast (Haddon *et al.* 1996). - not estimated.

Area	Cloudy Bay (MMI 7)	Clifford Bay (MMI 7)	Foxton Beach (MMI 8)
Length of beach (km)	11	21	27.5
Biomass (t)	248 (96)	192(79)	145 (-)

Table 4:   A summary of biomass estimates in greenweight (t) from the surveys in MMI 2 and 3 (Triantifillos 2008a, Triantifillos 2008b). Note: unless otherwise stated the CV is less than 20%.

Location	Five sites (MMI 2)	Ashley River to 6 nm south of the Waimakariri River (MMI 3)
Area surveyed (km^2)	28.0	13.4
Biomass (t)	33.8	444.1

5.3   Estimation of Maximum Constant Yield (*MCY*)
Growth and mortality data from Cloudy Bay in Marlborough and the Kapiti Coast in Manawatu (Cranfield *et al.* 1993) have been used in a yield per recruit model to estimate the reference fishing mortality $F_{0.1}$ (Cranfield *et al.* 1994b, Triantifillos 2008a, 2008b). The shellfish working group did not accept these estimates of $F_{0.1}$ as there was considerable uncertainty in both the estimate and the method used to generate them. The *MCY* estimates of Triantafillos (2008b) that use the full range of $F_{0.1}$ estimates from Cranfield *et al.* (1993) are shownin Table 5, but should be interpreted cautiously.

Estimates of *MCY* are available from numerous locations and were calculated using Method 1 for a virgin fishery (Annala *et al*. 2001) with an estimate of virgin biomass B_0, where:

$$MCY = 0.25* F_{0.1} B_0$$

Table 5: *MCY* estimates (t) for *M. murchisoni* from virgin biomass at locations sampled around New Zealand (Triantifillos 2008a and b).

Location	$F_{0.1}$	*MCY*
Five sites (MMI 2)	0.43/0.57	47.7/63.3
Ashley River to 6 nm south of the Waimakariri River (MMI 3)	0.70/0.89	5.9/7.5

5.4   Estimation of Current Annual Yield (*CAY*)
CAY has not been estimated for *M. murchisoni*.

6.   STATUS OF THE STOCKS

- MMI 3, 7 & 8 - *Mactra murchisoni*

Stock Status	
Year of Most Recent Assessment	2008 for MMI 3, 1994 for MMI 7 and 1996 for MMI 8
Assessment Runs Presented	Survey biomass
Reference Points	Target: Not defined, but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Because of the relatively low levels of exploitation of *M. muchisoni*, it is likely that all stocks are still effectively in a virgin state, therefore they are Very Likely (> 90%) to be at or above the target.
Status in relation to Limits	Very Unlikely (< 10%) to be below the soft and hard limits
Historical Stock Status Trajectory and Current Status Unknown	

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Unknown
Recent Trend in Fishing Mortality or Proxy	Fishing is light in all Fishstocks other than MMI 3 and MMI 7. In MMI 7 landings have averaged 34.6 t since 2002-03 and in MMI 3 landing have averaged 25.5 t since 2006-07.
Other Abundance Indices	None
Trends in Other Relevant Indicators or Variables	None

Projections and Prognosis		
Stock Projections or Prognosis	None	
Probability of Current Catch or TACC causing decline below Limits	For all stocks current catches are Very Unlikely (< 10%) to cause declines below soft or hard limits.	
Assessment Methodology		
Assessment Type	Level 2: Partial quantitative stock assessment	
Assessment Method	Absolute biomass estimates from quadrat surveys	
Main data inputs	Abundance and length frequency information	
Period of Assessment	2008 for MMI 3, 1994 for MMI 7 and 1996 for MMI 8	Next assessment: Unknown
Changes to Model Structure and Assumptions	None	

Major Sources of Uncertainty	None

Qualifying Comments
Stock size could fluctuate markedly as a result of catastrophic mortality from a number of causes. There is a need to review fishery parameters for this species.

Fishery Interactions
MMI can be caught together with other surf clam species and non-QMS bivalves.

Table 6: Calculated *MCY* estimates, TACCs, and 2011-12 reported landings for MMI.

Fishstock	QMA	*MCY*	2011-12 Actual TACC	2011-12 Reported Landings
MMI	1	< 1	2	0
	2	48 - 64	3	0
	3	7 - 8	62	0
	5	< 1	1	0
	7	2	61	47
	8	2	25	0

For all other MMI stocks there is no current evidence of appreciable biomass.

7. FOR FURTHER INFORMATION

Annala J.H., Sullivan K.J., O'Brien C.J., Smith N.W.M. (compilers.) 2001. Report from the fishery assessment plenary, May 2001: stock assessments and yield estimates. 515 p. (Unpublished report held in NIWA library, Wellington.)

Beentjes M.P., Baird S.J. 2004. Review of dredge fishing technologies and practice for application in New Zealand. New Zealand Fisheries Assessment Report 2004/37. 40p.

Brierley P. (Convenor) 1990. Management and development of the New Zealand sub-tidal clam fishery. Report of the surf clam working group, MAF Fisheries (unpublished report held in NIWA library, Wellington). 57p.

Conroy A., Smith P., Michael K., Stotter D. 1993. Identification and recruitment patterns of juvenile surf clams, *Mactra discors* and *M. murchisoni* from central New Zealand. New Zealand Journal of Marine and Freshwater Research, 27, 279-285.

Cranfield H.J., Michael K.P. 2001. The surf clam fishery in New Zealand: description of the fishery, its management, and the biology of surf clams. New Zealand Fisheries Assessment Report 2001/62. 24 p.

Cranfield H.J., Michael K.P., Stotter D.R. 1993. Estimates of growth, mortality, and yield per recruit for New Zealand surf clams. New Zealand Fisheries Research Assessment Document 1993/20. 26p.

Cranfield H.J., Michael K.P., Stotter D.R., Doonan I.J. 1994a. Distribution, biomass and yield estimates of surf clams off New Zealand beaches. New Zealand Fisheries Research Assessment Document 1994/1. 17p.

Cranfield H.J., Doonan I.J., Michael K.P. 1994b. Dredge survey of surf clams in Cloudy Bay, Marlborough. New Zealand Fisheries Technical Report 39: 18p.

Haddon M., Willis T.J., Wear R.G., Anderlini V.C. 1996. Biomass and distribution of five species of surf clam off an exposed west coast North Island beach, New Zealand. Journal of Shellfish Research 15: 331–339.

Michael K., Cranfield H., Doonan I., Hadfield J. 1994. Dredge survey of surf clams in Clifford Bay, Marlborough, New Zealand Fisheries Data Report, No. 54

Triantifillos L. 2008a. Survey of subtidal surf clams in Pegasus Bay, November-December 2007. , Prepared by NIWA for MMIfood Innovations Limited and SurfCo. limited. : 43p.

Triantifillos L. 2008b. Survey of subtidal surf clams in Quota Management Area 2, June - August 2008. , Prepared by NIWA foe MMIfood Innovations Limited and SurfCo. limited. : 40p.

RINGED DOSINIA (DAN)

(*Dosinia anus*)
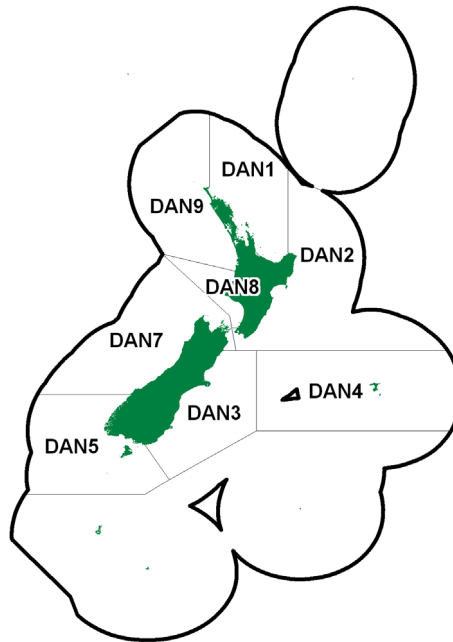
1.   FISHERY SUMMARY

This species is part of the surf clam fishery and the reader is guided to the surf clam introductory chapter for information common to all relevant species. .

Ringed Dosinia (*Dosinia anus*) were introduced into the Quota Management System on 1 April 2004 with a combined TAC of 112 t and catches are measured in greenweight. There were no allowances for customary, recreational or other sources of mortality. Biomass surveys in QMA 2 and 3 supported a TACC increase from April 2010. This increased the TACC for DAN 2 from 18 to 61 t and DAN 3 from 4 to 52 t. An allowance of 3 t for other sources of mortality was also made for DAN 2 and DAN 3. This increased the total TACC to 203 t and the total TAC to 209 t (Table 1).

Table 1: Current TAC, TACC and allowances for other sources of mortality for *Dosinia anus.*

QMA	TAC (t)	TACC (t)	Other sources of mortality (t)
1	7	7	0
2	64	61	3
3	55	52	3
4	1	1	0
5	1	1	0
7	15	15	0
8	33	33	0
9	33	33	0
Total	**209**	**203**	**6**

1.1   Commercial fisheries

Prior to 2006-07 landings had only been reported in DAN 7 and ranged from about 10 to 300 kgs. Small catches (< 1 t) were reported in DAN 3 for 2006-07, but have increased to 1.4 t in 2008-09. From 2002-03 onwards, landings in DAN 7 increased up to a maximum of 2.4 t in 2006-07, but have since decreased to 0.16 t in 2008-09 (Table 2).

1.2   Recreational fisheries

There are no known records of recreational use of this surf clam.

Table 2: **TACCs and reported landings (t) of Ringed Dosinia by Fishstock from 1991-92 to 2011-12 from CELR and CLR data. Fishstocks where no catch has been reported are not tabulated. DAN 1, 2, 4, 5, 8 and 9 have TACC of 7, 61, 1, 1, 33 and 33 t, respectively.**

	DAN 3		DAN 7		Total	
Fishstock	Landings	TACC	Landings	TACC	Landings	TACC
1991-92	0	-	0	-	0	
1992-93	0	-	0.164	-	0.164	-
1993-94	0	-	0.293	-	0.293	-
1994-95	0	-	0.07	-	0	0.07
1995-96	0	-	0.012	-	0	0.012
1996-97	0	-	0	-	0	0
1997-98	0	-	0	-	0	-
1998-99	0	-	0	-	0	-
1999-00	0	-	0	-	0	-
2000-01	0	-	0	-	0	-
2001-02	0	-	0	-	0	-
2002-03	0	-	0.114	-	0.114	-
2003-04	0	4.0	0.895	15.0	0.895	112.0
2004-05	0	4.0	1.982	15.0	2.016*	112.0
2005-06	0	4.0	1.095	15.0	1.022*	112.0
2006-07	0.086	4.0	2.464	15.0	2.55	112.0
2007-08	0.768	4.0	0.821	15.0	1.589	112.0
2008-09	1.398	4.0	0.159	15.0	1.557	112.0
2009-10	0.836	4.0	0.209	15.0	1.045	112.0
2010-11	0.768	52.0	2.199	15.0	3.022	203.0
2011-12	0	52.0	5.303	15.0	5.303	203.0

*In 2004-05 and 2005-06 32.4 and 90 kg were reported but the QMA is not recorded. This amount is included in the total landings for these years.

1.3 Customary fisheries

Offshore clams such as *D. anus* are likely to have been harvested for customary use only when washed ashore after storms. Shells of this clam have been found irregularly, and in small numbers in a few middens (Carkeek 1966). There are no estimates of current customary use of this clam.

1.4 Illegal catch

There is no known illegal catch of this clam.

1.5 Other sources of mortality

There is no quantitative information on other sources of mortality, although this clam is probably sometimes taken as a bycatch in inshore trawling. Harvesters claim that the hydraulic clam rake does not damage surf clams and minimises damage to the few species of other macrofauna captured. Surf clam populations also are subject to localised catastrophic mortality from erosion during storms, high temperatures and low oxygen levels during calm summer periods, blooms of toxic algae and excessive freshwater outflow (Cranfield & Michael 2001).

2. BIOLOGY

D. anus is found around the New Zealand coast on sediments in the North Island at depths between 5 and 8 m, and in the South Island between 6 and 10 m. It is larger and rougher than *D. subrosea*, and is usually found on more exposed beaches shallower in the substrate. Maximum length is variable between areas, ranging from 58 to 82 mm (Cranfield *et al*. 1993). The sexes are likely to be separate, and they are likely to be broadcast spawners with planktonic larvae. Anecdotal evidence suggests that spawning is likely to occur in the summer months and spat probably recruit to the deeper water of the outer region of the surf zone. Recruitment of surf clams is thought to be highly variable between years.

3. STOCKS AND AREAS

For management purposes stock boundaries are based on QMAs, however, the boundaries of stocks of surf clams are likely to be the continuous lengths of exposed sandy beaches between geographical features (such as rivers and headlands). Circulation patterns may isolate surf clams genetically as well as ecologically.

4.   ENVIRONMENTAL EFFECTS OF FISHING

See the introductory surf clam chapter.

5.   STOCK ASSESSMENT

5.1   Estimates of fishery parameters and abundance
No estimates of fisheries parameters or abundance are available for this species.

5.2   Biomass estimates
Biomass has been estimated at Cloudy and Clifford Bay in DAN 7 with a stratified random survey using a hydraulic dredge (Table 3).

Table 3: A summary of biomass estimates for *D. anus* in tonnes green weight with standard deviation in parentheses from exploratory surveys of Cloudy Bay (Cranfield *et al.* 1994b), and Clifford Bay, both in Marlborough (Michael *et al.* 1994).

Area	Cloudy Bay (DAN 7)	Clifford Bay (DAN 7)
Length of beach (km)	11	21
Biomass (t)	72 (30)	5 (3)

5.3   Estimation of Maximum Constant Yield (*MCY*)
Growth and mortality data from Cloudy Bay in Marlborough and the Kapiti Coast in Manawatu (Cranfield *et al.* 1993) have been used in a yield per recruit model to estimate the reference fishing mortality $F_{0.1}$ (Cranfield *et al.* 1994b, Triantifillos 2008a and 2008b). The shellfish working group did not accept these estimates of $F_{0.1}$ as there was considerable uncertainty in both the estimate and the method used to generate them. The *MCY* estimates of Triantafillos (2008b) that use the full range of $F_{0.1}$ estimates from Cranfield *et al.* (1993) are shown in Table 4, but should be interpreted cautiously.

Estimates of *MCY* were calculated using Method 1 for a virgin fishery (Annala *et al.* 2001) with an estimate of virgin biomass B_0, where:

$$MCY = 0.25 * F_{0.1} B_0$$

Table 4: Mean *MCY* estimates (t) for *D. anus* from virgin biomass at locations sampled around New Zealand (2008a and b).

Location	$F_{0.1}$	*MCY*
Five sites (DAN 2)**	0.25/0.42	52.8/88.7
Ashley River to 6 nm south of the Waimakariri River (DAN 3)*	0.27/0.54	63.8/127.7

5.4   Estimation of Current Annual Yield (*CAY*)
CAY has not been estimated for *D. anus*.

6.   STATUS OF THE STOCKS

- DAN 2, 3, & 7 - *Dosinia anus*

Stock Status	
Year of Most Recent Assessment	2008 for DAN 2 and 3, 1994 for DAN 7
Assessment Runs Presented	Survey biomass
Reference Points	Target: Not defined, but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Because of the relatively low levels of exploitation of *D. anus*, it is likely that all stocks are still effectively in a virgin state, therefore

	they are Very Likely (> 90%) to be at or above the target.
Status in relation to Limits	Very Unlikely (< 10%) to be below the soft and hard limits
Historical Stock Status Trajectory and Current Status	
Unknown	

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Unknown
Recent Trend in Fishing Mortality or Proxy	Fishing is minimal in all Fishstocks other than DAN 3 and 7. In DAN 7 fishing has been light with landings averaging 1.1 t since 2002-03.
Other Abundance Indices	None
Trends in Other Relevant Indicators or Variables	None

Projections and Prognosis	
Stock Projections or Prognosis	None
Probability of Current Catch or TACC causing decline below Limits	For all stocks current catches are Very Unlikely (< 10%) to cause declines below soft or hard limits.

Assessment Methodology		
Assessment Type	Level 2: Partial quantitative stock assessment	
Assessment Method	Absolute biomass estimates from quadrat surveys	
Main data inputs	Abundance and length frequency information	
Period of Assessment	Latest assessment: 2008 for DAN 2 and 3, 1994 for DAN 7	Next assessment: Unknown
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty	None	

Qualifying Comments
Stock size could fluctuate markedly as a result of catastrophic mortality from a number of causes. There is a need to review fishery parameters for this species

Fishery Interactions
DAN can be caught together with other surf clam species and non-QMS bivalves.

Table 5: Calculated *MCY* estimates, TACCs, and 2011-12 recoded landings for DAN.

Fishstock	QMA	*MCY*	2011-12 Actual TACC	2011-12 Reported Landings
DAN	2	52-88	61	0
	3	63-127	52	0
	7	< 1	15	5.303

For all other DAN stocks there is no current evidence of appreciable biomass.

7.   FOR FURTHER INFORMATION

Annala J.H., Sullivan K.J., O'Brien C.J., Smith N.W.McL. (compilers) 2001. Report from the fishery assessment plenary, May 2001: stock assessments and yield estimates. 515p. (Unpublished report held in NIWA library, Wellington.)

Brierley P. (Convenor) 1990. Management and development of the New Zealand sub-tidal clam fishery. Report of the surf clam working group, MAF Fisheries (unpublished report held in NIWA library, Wellington). 57p.

Carkeek W. 1966. The Kapiti Coast. Reed, Wellington. 187pp.

Cranfield H.J., Michael KP. 2001. The surf clam fishery in New Zealand: description of the fishery, its management, and the biology of surf clams. New Zealand Fisheries Assessment Report 2001/62. 24p.

Cranfield H.J., Michael K.P., Stotter D.R. 1993. Estimates of growth, mortality, and yield per recruit for New Zealand surf clams. New Zealand Fisheries Research Assessment Document 1993/20. 26p.

Cranfield H.J., Michael K.P., Stotter D.R., Doonan I.J. 1994a. Distribution, biomass and yield estimates of surf clams off New Zealand beaches. New Zealand Fisheries Research Assessment Document 1994/1. 17p.

Cranfield H.J., Doonan I.J., Michael K.P. 1994b. Dredge survey of surf clams in Cloudy Bay, Marlborough. New Zealand Fisheries Technical Report 39: 18p.

Haddon M., Willis T.J., Wear R.G., Anderlini V.C. 1996. Biomass and distribution of five species of surf clam off an exposed west coast North Island beach, New Zealand. Journal of Shellfish Research 15: 331–339.

Michael K., Cranfield H., Doonan I.J., Hadfield J.D. 1994. Dredge survey of surf clams in Clifford Bay, Marlborough. New Zealand Fisheries Data Report 54: 15p.

Triantifillos L. 2008a. Survey of subtidal surf clams in Pegasus Bay, November-December 2007. , Prepared by NIWA for Saefood Innovations Limited and SurfCo. limited. **:** 43p.

Triantifillos L. 2008b. Survey of subtidal surf clams in Quota Management Area 2, June - August 2008. , Prepared by NIWA foe Saefood Innovations Limited and SurfCo. limited. **:** 40p.

TRIANGLE SHELL (SAE)

(*Spisula aequilatera*)
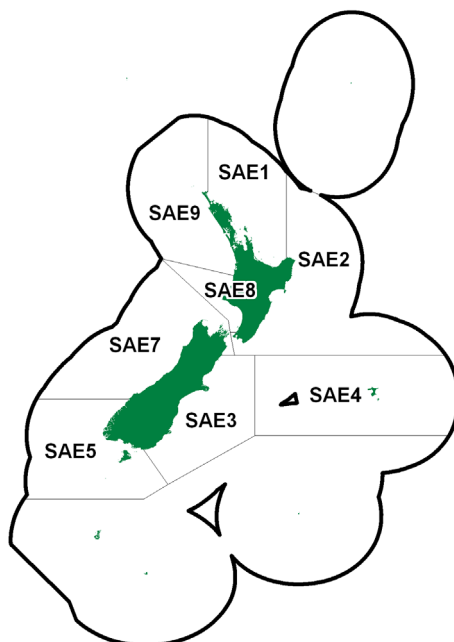
1.   FISHERY SUMMARY

This species is part of the surf clam fishery and the reader is guided to the surf clam introductory chapter for information common to all relevant species.

Triangle shells (*Spisula aequilatera*) were introduced into the QMS on 1 April 2004 with a total TACC of 406 t. No allowances were set for customary, non-commercial, recreational or other sources of mortality. Biomass surveys supported an increase in TAC in SAE 2 and SAE 3 from 1 April 2010 from 1 and 264 t respectively to 132 and 483 t, respectively. This change included an increase in TACC and a new allowance for other sources of mortality. The total TAC is currently 756 tonnes (Table 1).

Table 1: Current TAC, TACC and allowances for other sources of mortality for *Spisula aequilatera*

QMA	TAC (t)	TACC (t)	Other sources of mortality (t)
1	9	9	0
2	132	125	7
3	483	459	24
4	1	1	0
5	3	3	0
7	112	112	0
8	8	8	0
9	8	8	0
Total	**756**	**725**	**31**

1.1   Commercial fisheries

Apart from a small catch in SAE 2 in 2003-04 and small catches in SAE 3 since 2006-07, all reported landings have been from SAE 7. Between the 1991-92 and 1995-96 fishing years, landings were small and no further landings were reported until 2002-03. Since then landings have increased with a maximum of 52 t in 2002-03. Reported landings and TACCs are shown for the fishstocks with historical landings in Table 2. Figure 1 shows historical landings and TACC for the two main SAE stocks. New survey information for QMA 2 and QMA3 (Triantifillos 2008a, 2008b) resulted in increases in a

number of surf clam TACCs from 1 April 2010, including SAE 2 (to 125 t) and SAE 3 (to 459 t) . Landings are market-driven and have not been constrained by the TACCs.

Table 2: TACCs and reported landings (t) of Triangle shell by Fishstock from 1990-91 to 2011-12 from CELR and CLR data. SAE 1, 4, 5, 8 and 9 have TACC of 9, 1, 3, 8 and 8 t, respectively.

Fishstock	SAE 2 Landings	SAE 2 TACC	SAE 3 Landings	SAE 3 TACC	SAE 7 Landings	SAE 7 TACC	Total Landings	Total TACC
1991-92	0	-	0	-	0.175	-	0.175	-
1992-93	0	-	0	-	0.396	-	0.396	-
1993-94	0	-	0	-	2.846	-	2.846	-
1994-95	0	-	0	-	2.098	-	2.098	-
1995-96	0	-	0	-	0.12	-	0.120	-
1996-97	0	-	0	-	0	-	0	-
1997-98	0	-	0	-	0	-	0	-
1998-99	0	-	0	-	0	-	0	-
1999-00	0	-	0	-	0	-	0	-
2000-01	0	-	0	-	0	-	0	-
2001-02	0	-	0	-	0	-	0	-
2002-03	0	-	0	-	52.146	-	52.146	-
2003-04	0.198	1.0	0	264.0	9.583	112.0	9.781	406.0
2004-05	0	1.0	0	264.0	18.527	112.0	19.364*	406.0
2005-06	0	1.0	0	264.0	28.067	112.0	31.019*	406.0
2006-07	0	1.0	0.608	264.0	45.955	112.0	46.563	406.0
2007-08	0	1.0	3.912	264.0	5.022	112.0	8.934	406.0
2008-09	0	1.0	10.909	264.0	2.506	112.0	13.415	406.0
2009-10	0	1.0	8.619	264.0	1.460	112.0	10.078	406.0
2010-11	0	125.0	4.043	459.0	16.919	112.0	20.962	725.0
2011-12	0	125.0	0	459.0	82.266	112.0	82.266	725.0

*In 2004-05 and 2005-06, 0.837 and 2.952 t respectively were reported landed, but the QMA is not recorded. These amounts are included in the total landings for these years.
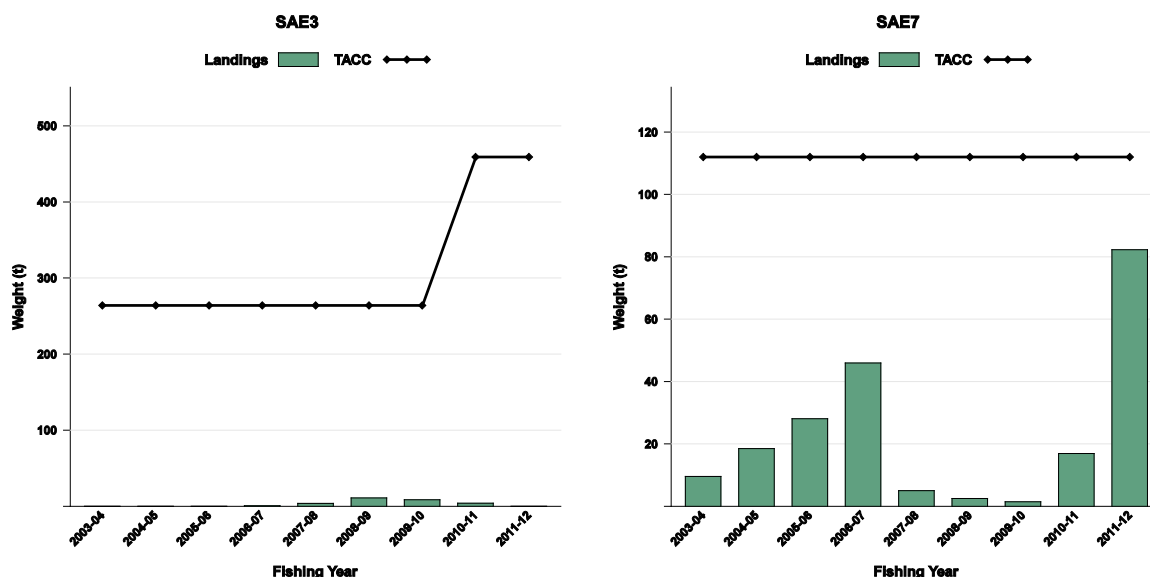
Figure 1: Historical landings and TACC for selected areas. Note that these figures do not show data prior to entry into the QMS.

1.2   Recreational fisheries
There are no estimates of recreational take for this surf clam.

1.3   Customary fisheries
Shells of this species have been found irregularly, and in small numbers in a few middens (Carkeek 1966). There are no estimates of current customary catch of this species.

1.4   Illegal catch
There is no documented illegal catch of this species.

1.5 Other sources of mortality

There is no quantitative information on other sources of mortality, although this clam is subject to localised catastrophic mortality from erosion during storms, high temperatures and low oxygen levels during calm summer periods, blooms of toxic algae and excessive freshwater outflow (Cranfield & Michael 2001).

2. BIOLOGY

S. aequilatera occurs from Bay of Plenty southwards on the east coast of both islands, and on the Wellington-Manawatu coast. No information is available concerning its distribution on the West Coast of the South Island. In the North Island this species is most abundant between 3 m and 5 m depth, and in the South Island between 4 m and 8 m depth. Maximum length is variable between areas, ranging from 39 to 74 mm (Cranfield & Michael 2002). The sexes are separate; they are broadcast spawners; they are reasonably fast growing and reach maximum size in 2-3 years. Nothing is known of their larval life.

3. STOCKS AND AREAS

For management purposes stock boundaries are based on QMAs, however, the boundaries of stocks of surf clams are likely to be the continuous lengths of exposed sandy beaches between geographical features (rivers, headlands etc). Circulation patterns may isolate surf clams genetically as well as ecologically.

4. ENVIRONMENTAL EFFECTS OF FISHING

See the introductory surf clam chapter.

5. STOCK ASSESSMENT

5.1 Estimates of fishery parameters and abundance

No estimates of fisheries parameters or abundance are available for this species. Early estimates were made of M and $F_{0.1}$ but the SFWG considers that the methods were not well documented, and the estimates should not be used.

5.2 Biomass estimates

Biomass was estimated at one site in each of SAE 3 and SAE 8, and multiple sites within SAE 2 and SAE 7 with stratified random surveying using a hydraulic dredge (Tables 3 & 4).

Table 3: A summary of biomass estimates in tonnes green weight with standard deviation in parentheses from exploratory surveys of Cloudy Bay (Cranfield *et al*. 1994b) and Clifford Bay in Marlborough (Michael *et al*. 1994), and Foxton beach on the Manawatu coast (Haddon *et al*. 1996). - Indicates where estimates were not generated.

Area	Cloudy Bay (SAE 7)	Clifford Bay (SAE 7)	Foxton Beach (SAE 8)
Length of beach (km)	11	21	27.5
Biomass (t)	53 (22)	358 (152)	29 (-)

5.3 Estimation of Maximum Constant Yield (*MCY*)

Growth and mortality data from Cloudy Bay in Marlborough and the Kapiti Coast in Manawatu (Cranfield *et al*. 1993) have been used in a yield per recruit model to estimate the reference fishing

mortality $F_{0.1}$ (Cranfield *et al.* 1994b, Triantifillos 2008a, 2008b). The shellfish working group did not accept these estimates of $F_{0.1}$ as there was considerable uncertainty in both the estimate and the method used to generate them. The *MCY* estimates of Triantafillos (2008b) that use the full range of $F_{0.1}$ estimates from Cranfield *et al.* (1993) are shown in Table 5, but should be interpreted cautiously.

Table 4: **A summary of biomass estimates in tonnes green weight from the surveys in SAE 2 and SAE 3 (Triantifillos 2008a, Triantifillos 2008b). Unless otherwise stated the CV is less than 20%.**

Location	Five sites (SAE2)	Ashley River to 6 nm south of the Waimakariri River (SAE3)
Area surveyed (km^2)	28.0	13.4
Biomass (t)	471.1	1567.2

Estimates of *MCY* are available from a number of locations and were calculated using Method 1 for a virgin fishery (Annala *et al.* 2001) with an estimate of virgin biomass B_0, where:

$$MCY = 0.25 * F_{0.1} B_0$$

Table 5: ***MCY* estimates (t) for *S. aequilatera* from virgin biomass at locations sampled around New Zealand (Triantifillos 2008a and b).**

Location	$F_{0.1}$	MCY
Five sites (SAE 2)	1.12/1.56	131.9/183.7
Ashley River to 6 nm south of the Waimakariri River (SAE 3)	1.06/1.37	415.3/536.8

5.4 Estimation of Current Annual Yield (*CAY*)

CAY has not been estimated for *S. aequilatera*.

6. STATUS OF THE STOCKS

- SAE 2, 3 & 7 - *Spisula aequilatera*

Stock Status	
Year of Most Recent Assessment	2008 for SAE 2 and 3, 1994 for SAE 7
Assessment Runs Presented	Survey biomass
Reference Points	Target: Not defined, but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Because of the relatively low levels of exploitation of *S. aequilatera*, it is likely that all stocks are still effectively in a virgin state, therefore they are Very Likely (> 90%) to be at or above the target.
Status in relation to Limits	Very Unlikely (< 10%) to be below the soft and hard limits
Historical Stock Status Trajectory and Current Status	Unknown

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Unknown
Recent Trend in Fishing Mortality or Proxy	Fishing is light in all QMAs other than SAE 7. In SAE 7 it has averaged 23 t since 2002-03.
Other Abundance Indices	None

Trends in Other Relevant Indicators or Variables	None

Projections and Prognosis	
Stock Projections or Prognosis	None
Probability of Current Catch or TACC causing decline below Limits	For all stocks current catches are Very Unlikely (< 10%) to cause declines below soft or hard limits.
Assessment Methodology		
Assessment Type	Level 2: Partial quantitative stock assessment	
Assessment Method	Absolute biomass estimates from quadrat surveys	
Main data inputs	Abundance and length frequency information	
Period of Assessment	Latest assessment: 2008 for SAE 2 and 3, 1994 for SAE 7	Next assessment: Unknown
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty	None	

Qualifying Comments
Stock size could fluctuate markedly as a result of catastrophic mortality from a number of causes.
There is a need to review the fishery parameters for this species.
SAE have slower digging ability relative to PDO therefore are at higher relative risk of mortality during storms.

Fishery Interactions
SAE can be caught together with other surf clam species and non-QMS bivalves.

Table 6: Calculated *MCY* estimates, TACCs, and 2011-12 reported landings for SAE.

Fishstock	QMA	*MCY*	2011-12 Actual TACC	2011-12 Reported Landings
SAE	2	131 - 183	125	0
	3	423 - 544	459	0
	7	< 1	112	82.266

For all other SAE stocks there is no current evidence of appreciable biomass.

7. FOR FURTHER INFORMATION

Annala J.H., Sullivan K.J., O'Brien C.J., Smith N.W.M. (comps.) 2001. Report from the fishery assessment plenary, May 2001: stock assessments and yield estimates. 515p. (Unpublished report held in NIWA library, Wellington.)

Beentjes M.P., Baird S.J. 2004 Review of dredge fishing technologies and practice for application in New Zealand. New Zealand Fisheries Assessment Report 2004/37. 40p.

Brierley P. (Convenor) 1990. Management and development of the New Zealand sub-tidal clam fishery. Report of the surf clam working group, MAF Fisheries (unpublished report held in NIWA library, Wellington). 57p.

Carkeek W. 1966. The Kapiti Coast. Reed, Wellington. 187pp.

Cranfield H.J., Michael K.P. 2001. The surf clam fishery in New Zealand: description of the fishery, its management, and the biology of surf clams. New Zealand Fisheries Assessment Report 2001/62. 24p.

Cranfield H, Michael K (2002) Potential area boundaries and indicative TACs for the seven species of surf clam. NIWA unpublished report to the Ministry of Fisheries

Cranfield H.J., Michael K.P., Stotter D.R. 1993. Estimates of growth, mortality, and yield per recruit for New Zealand surf clams. New Zealand Fisheries Research Assessment Document 1993/20. 26p.

Cranfield H.J., Michael K.P., Stotter D.R., Doonan I.J. 1994a. Distribution, biomass and yield estimates of surf clams off New Zealand beaches. New Zealand Fisheries Research Assessment Document 1994/1. 17p.

Cranfield H.J., Doonan I.J., Michael K.P. 1994b. Dredge survey of surf clams in Cloudy Bay, Marlborough. New Zealand Fisheries Technical Report 39: 18p.

Haddon M., Willis T.J., Wear R.G., Anderlini V.C. 1996. Biomass and distribution of five species of surf clam off an exposed west coast North Island beach, New Zealand. Journal of Shellfish Research 15: 331–339.

Michael K., Cranfield H., Doonan I., Hadfield J. 1994. Dredge survey of surf clams in Clifford Bay, Marlborough, New Zealand Fisheries Data Report, No. 54

Triantifillos L. 2008a. Survey of subtidal surf clams in Pegasus Bay, November-December 2007. , Prepared by NIWA for Saefood Innovations Limited and SurfCo. Limited. : 43p.

Triantifillos L. 2008b. Survey of subtidal surf clams in Quota Management Area 2, June - August 2008. , Prepared by NIWA for Saefood Innovations Limited and SurfCo. Limited. : 40p.

TROUGH SHELL (MDI)

(*Mactra discors*)
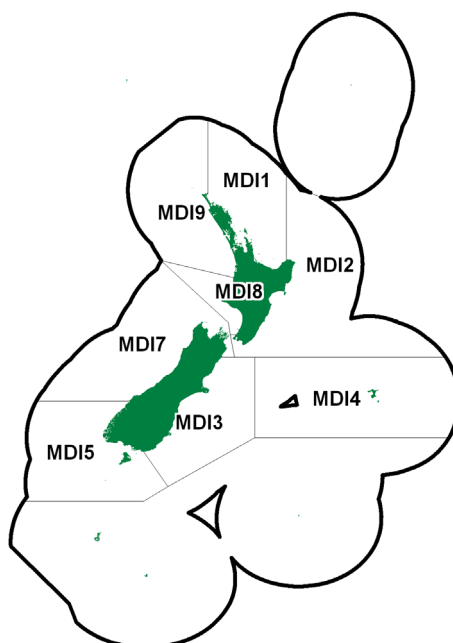
1.   FISHERY SUMMARY

This species is part of the surf clam fishery and the reader is guided to the surf clam introductory chapter for information common to all relevant species.

Trough shells (*Mactra discors*) were introduced into Quota Management System on 1 April 2004 with a total TACC of 98 t. No allowances were made for customary or recreational usage, or for other sources of mortality. New survey information for QMA 2 and 3 resulted in increases to a number of surf clam TACCs from 1 April 2010, including MDI 2. This change included an increase in TACC and a new allowance for other sources of mortality. The total TAC is currently 163 t (Table 1).

Table 1: Current TAC, TACC and allowances for other sources of mortality for *Mactra discors*.

QMA	TAC (t)	TACC (t)	Other sources of mortality (t)
1	1	1	0
2	66	63	3
3	1	1	0
4	1	1	0
5	14	14	0
7	26	26	0
8	27	27	0
9	27	27	0
Total	**163**	**160**	**3**

1.1   Commercial fisheries

Most reported landings have been from MDI 7. Between 1994 and 1996, landings of a few kgs were also reported from MDI 3 and MDI 5. No further landings were reported until 2002-03; since then the only significant reported catch has been from MDI 7, with only one other landing in MDI 1. These landings have ranged from about 0.7 t to 3.8 t. Landings and TACCs for fishstocks with historical landings are shown in Table 2. The historical landings and TACC values for MDI 7 are depicted in Figure 1.

1.2   Recreational fisheries

Offshore clams such as *M. discors* are likely to have been harvested for recreational use only when washed ashore after storms. There are no estimates of recreational take for this surf clam.

1.3 Customary fisheries

Offshore clams such as *M. discors* are likely to have been harvested for customary use only when washed ashore after storms (Carkeek 1966). There are no estimates of current customary use of this clam.

Table 2: TACCs and reported landings (t) of Trough Shell for Fishstocks with landings from 1992-93 to 2011-12 from CELR and CLR data. MDI 2, 4, 8 and 9 have TACC of 63, 1, 27 and 27 t, respectively.

Fishstock	MDI 1 Landings	MDI 1 TACC	MDI 3 Landings	MDI 3 TACC	MDI 5 Landings	MDI 5 TACC	MDI 7 Landings	MDI 7 TACC	Total Landings	Total TACC
1992-93	0	-	0	-	0	-	0.254	-	0.254	-
1993-94	0	-	0	-	0	-	2.198	-	2.198	-
1994-95	0	-	0	-	0.033	-	2.399	-	2.432	-
1995-96	0	-	0.049	-	0	-	0.017	-	0.066	-
1996-97	0	-	0	-	0	-	0	-	0	-
1997-98	0	-	0	-	0	-	0	-	0	-
1998-99	0	-	0	-	0	-	0	-	0	-
1999-00	0	-	0	-	0	-	0	-	0	-
2000-01	0	-	0	-	0	-	0	-	0	-
2001-02	0	-	0	-	0	-	0	-	0	-
2002-03	0	-	0	-	0	-	0.691	-	0.691	-
2003-04	0	1	0	1	0	14	2.685	26	2.685	98
2004-05	0	1	0	1	0	14	3.304	26	3.375*	98
2005-06	0.041	1	0	1	0	14	3.207	26	3.525*	98
2006-07	0	1	0	1	0	14	3.889	26	3.889	98
2007-08	0	1	0.015	1	0.001	14	1.045	26	1.061	98
2008-09	0	1	0	1	0	14	0.009	26	0.009	98
2009-10	0	1	0.057	1	0	14	0.118	26	0.175	98
2010-11	0	1	0	1	0	14	0.007	26	0	160
2011-12	0	1	0	1	0	14	0	26	0	160

*In 2004-05 and 2005-06, 71 and 277 kg respectively were reportedly landed, but the QMA is not recorded. This amount is included in the total landings for that year.
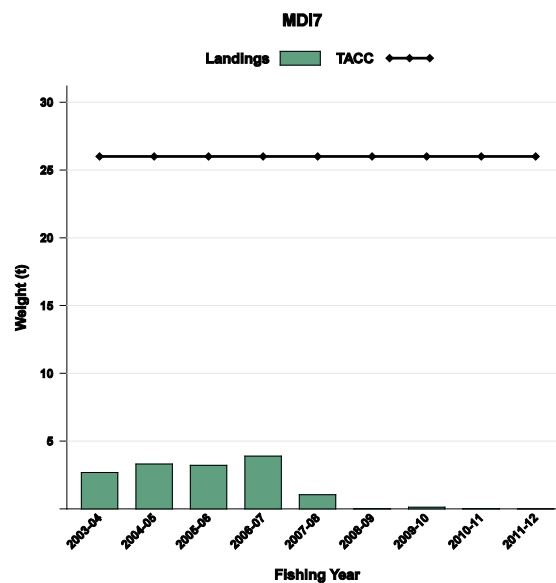
Figure 1: Historical landings and TACC for MDI 7 (Challenger). Note that this figure does not show data prior to entry into the QMS.

1.4 Illegal catch

There is no known illegal catch of this clam.

1.5 Other sources of mortality

There is no quantitative information on other sources of mortality. This clam is subject to localised catastrophic mortality from erosion during storms, high temperatures and low oxygen levels during calm summer periods, blooms of toxic algae and excessive freshwater outflow (Cranfield & Michael 2001).

2.   BIOLOGY

M. discors is most abundant in Southland (Te Waewae and Oreti), Otago (Blueskin Bay), Wellington, Manawatu and Cloudy Bay. Maximum length is variable between areas, ranging from 63 to 95 mm (Cranfield *et al.* 1993). The sexes are separate; the species is a broadcast spawner; the larvae are thought to be planktonic for between 20 and 30 days (Cranfield & Michael 2001). Recruitment of spat is to the same depth zone as adults occur in and recruitment between years is highly variable (Conroy *et al.* 1993).

3.   STOCKS AND AREAS

For management purposes stock boundaries are based on QMAs, however, the boundaries of stocks of surf clams are likely to be the continuous lengths of exposed sandy beaches between geographical features (rivers, headlands etc). Circulation patterns may isolate surf clams genetically as well as ecologically.

4.   ENVIRONMENTAL EFFECTS OF FISHING

See the introductory surf clam chapter.

5.   STOCK ASSESSMENT

5.1   Estimates of fishery parameters and abundance
No estimates of fisheries parameters or abundance are available for this species.

5.2   Biomass estimates
Biomass has been estimated at one site within MDI 3 and 8 and multiple sites within MDI 2 and 7 using stratified random surveying with a hydraulic dredge (Tables 3 and 4).

Table 3: A summary of biomass estimates in tonnes green weight with standard deviation in parentheses from exploratory surveys of Cloudy Bay (Cranfield *et al.* 1994b) and Clifford Bay in Marlborough (Michael *et al.* 1994) and Foxton beach on the Manawatu coast (Haddon *et al.* 1996). - = not estimated

Area	Cloudy Bay (MDI 7)	Clifford Bay (MDI 7)	Foxton Beach (MDI 8)
Length of beach (km)	11	21	27.5
Biomass (t)	55 (11)	89 (3)	195 (-)

Table 4: A summary of biomass estimates in tonnes green weight from the surveys in MDI 2 and 3 (Triantifillos 2008a, Triantifillos 2008b). Note: unless otherwise stated the CV is less than 20%.

Location	Five sites (MDI2)	Ashley River to 6 nm south of the Waimakariri River (MDI3)
Area surveyed (km^2)	28.0	13.4
Biomass (t)	471.2	0

5.3   Estimation of Maximum Constant Yield (*MCY*)
Growth and mortality data from Cloudy Bay, Marlborough and the Kapiti Coast, Manawatu (Cranfield *et al.* 1993) have been used in a yield per recruit model to estimate the reference fishing mortality $F_{0.1}$ (Cranfield *et al.* 1994b, Triantifillos 2008a and 2008b). The shellfish working group did not accept these estimates of $F_{0.1}$ as there was considerable uncertainty in both the estimate and the method used to generate them. The *MCY* estimates of Triantafillos (2008b) that use the full range of $F_{0.1}$ estimates from Cranfield *et al.* (1993) are shown in Table 5, but should be interpreted cautiously.

Estimates of *MCY* are available from numerous locations and were calculated using Method 1 for a virgin fishery (Annala *et al.* 2001) from an estimate of virgin biomass B_0, where:

$$MCY = 0.25* F_{0.1} B_0$$

Table 5: ***MCY* estimates (t) for *M. discors* from virgin biomass at locations sampled around New Zealand (Triantifillos 2008b).**

Location	$F_{0.1}$	MCY
Five sites (MDI 2)**	0.56/0.87	66.1/102.7

5.4   Estimation of Current Annual Yield (*CAY*)

CAY has not been estimated for *M. discors*

6.   STATUS OF THE STOCKS

- MDI 2, 7 & 8 - *Mactra discors*

Stock Status	
Year of Most Recent Assessment	2008 for MDI 2, 1994 for MDI 7 and 1996 for MDI 8
Assessment Runs Presented	Survey biomass
Reference Points	Target: Not defined, but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Because of the relatively low levels of exploitation of *P. donacina*, it is likely that all stocks are still effectively in a virgin state, therefore they are Very Likely (> 90%) to be at or above the target.
Status in relation to Limits	Very Unlikely (< 10%) to be below the soft and hard limits
Historical Stock Status Trajectory and Current Status Unknown	

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Unknown
Recent Trend in Fishing Mortality or Proxy	Catches are minimal in all QMAs other than MDI 7. In MDI 7 catches have been light, averaging 2.12 t since 2002-03
Other Abundance Indices	None
Trends in Other Relevant Indicators or Variables	None

Projections and Prognosis	
Stock Projections or Prognosis	None
Probability of Current Catch or TACC causing decline below Limits	For all stocks current catches are Very Unlikely (< 10%) to cause declines below soft or hard limits.

Assessment Methodology		
Assessment Type	Level 2: Partial quantitative stock assessment	
Assessment Method	Absolute biomass estimates from quadrat surveys	
Main data inputs	Abundance and length frequency information	
Period of Assessment	Latest assessment: 2008 for MDI 2, 1994 for MDI 7 and 1996 for MDI 8	Next assessment: Unknown
Changes to Model Structure and Assumptions	None	

Major Sources of Uncertainty	None

Qualifying Comments

Stock size could fluctuate markedly as a result of catastrophic mortality from a number of causes. There is a need to review fishery parameters for this species.

Fishery Interactions

MDI can be caught together with other surf clam species and non-QMS bivalves.

Table 6: Calculated *MCY* estimates, TACCs, and 2011-12 recorded landings for MDI.

Fishstock	QMA	*MCY*	2011-12 Actual TACC	2011-12 Reported Landings
MDI	2	66 - 102	63	0
	7	2	26	0
	8	2	27	0

For all other MDI stocks there is no current evidence of appreciable biomass.

7.   FOR FURTHER INFORMATION

Annala J.H., Sullivan K.J., O'Brien C.J., Smith N.W.M. (compilers.) 2001. Report from the fishery assessment plenary, May 2001: stock assessments and yield estimates. 515 p. (Unpublished report held in NIWA library, Wellington.)

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Brierley P. (Convenor) 1990. Management and development of the New Zealand sub-tidal clam fishery. Report of the surf clam working group, MAF Fisheries (unpublished report held in NIWA library, Wellington). 57p.

Carkeek W. 1966. The Kapiti Coast. Reed, Wellington. 187pp.

Conroy A., Smith P., Michael K., Stotter D. 1993. Identification and recruitment patterns of juvenile surf clams, *Mactra discors* and *M. murchisoni* from central New Zealand. New Zealand Journal of Marine and Freshwater Research, 27, 279-285.

Cranfield H.J., Michael K.P. 2001. The surf clam fishery in New Zealand: description of the fishery, its management, and the biology of surf clams. New Zealand Fisheries Assessment Report 2001/62. 24p.

Cranfield H.J., Michael K.P., Stotter D.R. 1993. Estimates of growth, mortality, and yield per recruit for New Zealand surf clams. New Zealand Fisheries Research Assessment Document 1993/20. 26p.

Cranfield H.J., Michael K.P., Stotter D.R., Doonan I.J. 1994a. Distribution, biomass and yield estimates of surf clams off New Zealand beaches. New Zealand Fisheries Research Assessment Document 1994/1. 17p.

Cranfield H.J., Doonan I.J., Michael K.P. 1994b. Dredge survey of surf clams in Cloudy Bay, Marlborough. New Zealand Fisheries Technical Report 39: 18p.

Haddon M., Willis T.J., Wear R.G., Anderlini V.C. 1996. Biomass and distribution of five species of surf clam off an exposed west coast North Island beach, New Zealand. Journal of Shellfish Research 15: 331−339.

Michael K., Cranfield H., Doonan I., Hadfield J. 1994. Dredge survey of surf clams in Clifford Bay, Marlborough, New Zealand Fisheries Data Report, No. 54

Triantifillos L. 2008a. Survey of subtidal surf clams in Pegasus Bay, November-December 2007. . Prepared by NIWA for Seafood Innovations Limited and SurfCo. limited.

Triantifillos L. 2008b. Survey of subtidal surf clams in Quota Management Area 2, June - August 2008. , Prepared by NIWA for Seafood Innovations Limited and SurfCo. limited. : 40p.

TARAKIHI (TAR)

(*Nemadactylus macropterus*)
Tarakihi
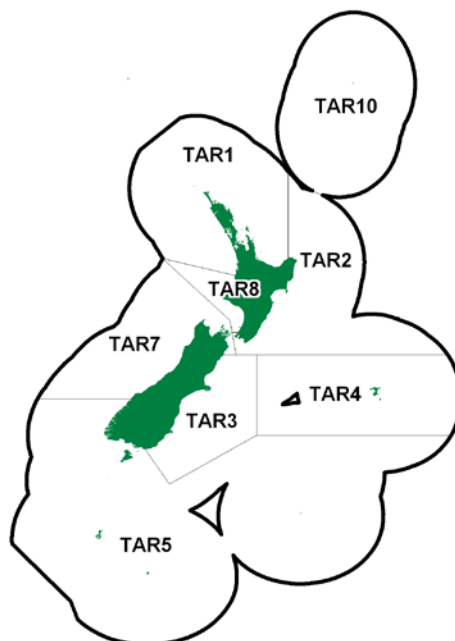
1.   FISHERY SUMMARY

1.1   Commercial fisheries

Tarakihi are caught in coastal waters of the North and South Islands, Stewart Island and the Chatham Islands, down to depths of about 250 m. The fishery appears to have been relatively stable since the initial development phase. Between 1968 and 1985 domestic and foreign landings combined ranged between 4082 t and 6444 t, averaging 5042 t per year (Table 2 and Table 3). Figure 1 shows the historical landings and TACC values for the main tarakihi stocks. Since the introduction of the QMS in 1986, the total landings have fluctuated between 4090 t and 6205 t. Reported landings and actual TACCs are shown in Table 2. From 1 October 2007 the TAC for TAR 1 was increased to 2029 t and the TACC was increased from 1399 to 1447 t. Under the new TAC, the allowances for customary non-commercial, recreational and other sources of mortality were increased to 73 t, 487 t, and 22 t respectively (Table 1). In October 2001 the TAR 7 TACC was increased to 1088 t but no recreational, customary, or other sources of fishing mortality allocation was made. In October 2004 the TACC for TAR 2 and TAR 3 were increased to 1796 t and 1403 t respectively. TAR 4, 5, 8, 10 have not been assessed since entering the QMA in October 1986 and therefore the TACC and TACs have remained unchanged.

Table 1:   Total allowable catches (TAC, t) allowance for customary non-commercial fishing, recreational fishing, and other sources of mortality (t), as well as the total allowable commercial catch (TACC, t) declared for TAR as of 1 October 2010.

Fishstock	TAC	TACC	Customary non-commercial	Recreational	Other Mortality
TAR 1 (FMA 1 & 9)	2 029	1 447	73	487	22
TAR 2	2 082	1 796	100	150	36
TAR 3	1 503	1 403	15	15	70
TAR 4	316	316	0	0	0
TAR 5 (FMA 5 & 6)	153	153	0	0	0
TAR 7*	1 088	1088	0	0	0
TAR 8	225	225	0	0	0
TAR 10	10	10	0	0	0

Table 2:   Reported total landings (t) of tarakihi from 1968 to 1982-83.

Year	Landings	Year	Landings	Year	Landings
1968	5 683	1974	5 294	1980-81*	4 990
1969	4 082	1975	4 941	1981-82*	5 193
1970	5 649	1976	4 689	1982-83*	4 666
1971	5 702	1977	6 444		
1972	5 430	1978-79*	4 427		
1973	4 439	1979-80*	4 344		

Source - MAF data.
*   Sums of domestic catch for calendar years 1978 to 1982, and foreign and chartered vessel catch for fishing year April 1 to March 31.

Tarakihi are caught by commercial vessels in all areas of New Zealand from the Three Kings Islands in the north to Stewart Island in the south. The main fishing method is trawling. The major target trawl fisheries occur at depths of 100-200 m and tarakihi are taken as a bycatch at other depths as well. The major fishing grounds are west and east Northland (QMA 1), the western BoP to Cape Turnagain (QMAs 1 and 2), Cook Strait to the Canterbury Bight (mainly QMA 3), and Jackson Head to Cape Foulwind (QMA 7). Around the North Island 70-80% of the tarakihi catch is targeted. Around the South Island only about 30% of the tarakihi are targeted; much of the remainder is reported as bycatch in target barracouta and red cod bottom trawl fisheries. In addition, there is a small target tarakihi setnet fishery off Kaikoura. The commercial minimum legal size (MLS) for all TAR stocks is 25cm.

1.2   Recreational fisheries

Tarakihi are taken by recreational fishers using lines and setnets. Estimates of recreational catch of tarakihi are given for three surveys in Table 4 and Table 5. The most recently completed nationwide recreational survey was undertaken in 2000 and extended into 2001, but the results are still under review and are not currently available. A new national survey is currently underway and the results are expected to be available in early 2013. The recreational MLS for all TAR stocks is 25cm.

The RTWG recommended that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and c) the 2000 and 2001 estimates are implausibly high for many important fisheries. Relative comparisons may be possible between stocks within these surveys.

A recent survey undertaken in FMA1 using aerial overflights to estimate effort and ramp interviews to estimate catch rate was used to estimate the recreational catch of tarakihi from 1 July 2005 to 30 June 2006 in the waters bounded by North Cape to East Cape (Hartill *et al.* In Press). This estimate is 90 t, with a CV=18%.

1.3   Customary non-commercial fisheries
No quantitative information on the level of customary non-commercial fishing is available.

1.4   Illegal catch
No quantitative information on the level of illegal tarakihi catch is available.

1.5   Other sources of mortality
No information is available.

Table 3: Reported landings (t) of tarakihi by Fishstock from 1983-84 to 2010-11 and TACCs (t) from 1986–87 to 2010-11. QMS data from 1986-present.

Fishstock	TAR 1		TAR 2		TAR 3		TAR 4		TAR 5	
FMA (s)	1 & 9		2		3		4		5 & 6	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983-84*	1 326	-	1 118	-	902	-	287	-	115	-
1984-85*	1 022	-	1 129	-	1 283	-	132	-	100	-
1985-86*	1 038	-	1 318	-	1 147	-	173	-	48	-
1986-87	912	1 210	1 382	1 410	938	970	83	300	42	140
1987-88	1 093	1 286	1 386	1 568	1 024	1 036	227	314	88	142
1988-89	940	1 328	1 412	1 611	758	1 061	182	314	47	147
1989-90	973	1 387	1 374	1 627	1 007	1 107	190	315	60	150
1990-91	1 125	1 387	1 729	1 627	1 070	1 148	367	316	35	153
1991-92	1 415	1 387	1 700	1 627	1 132	1 148	213	316	55	153
1992-93	1 477	1 397	1 654	1 633	813	1 168	45	316	51	153
1993-94	1 431	1 397	1 594	1 633	735	1 169	82	316	65	153
1994-95	1 390	1 398	1 580	1 633	849	1 169	71	316	90	153
1995-96	1 422	1 398	1 551	1 633	1 125	1 169	209	316	73	153
1996-97	1 425	1 398	1 639	1 633	1 088	1 169	133	316	81	153
1997-98	1 509	1 398	1 678	1 633	1 026	1 169	202	316	21	153
1998-99	1 436	1 398	1 594	1 633	1 097	1 169	104	316	51	153
1999-00	1 387	1 398	1 741	1 633	1 260	1 169	98	316	80	153
2000-01	1 403	1 398	1 658	1 633	1 218	1 169	242	316	58	153
2001-02	1 480	1 399	1 742	1 633	1 244	1 169	383	316	75	153
2002-03	1 517	1 399	1 745	1 633	1 156	1 169	218	316	92	153
2003-04	1 541	1 399	1 638	1 633	1 089	1 169	169	316	53	153
2004-05	1 527	1 399	1 692	1 796	905	1 403	262	316	57	153
2005-06	1 409	1 399	1 986	1 796	1 010	1 403	339	316	62	153
2006-07	1 193	1 399	1 729	1 796	1 080	1 403	263	316	94	153
2007-08	1 286	1 447	1 715	1 796	843	1 403	348	316	50	153
2008-09	1 398	1 447	1 901	1 796	1 017	1 403	77	316	45	153
2009-10	1 332	1 447	1 858	1 796	757	1 403	138	316	81	153
2010-11	1 349	1 447	1 660	1 796	1 207	1 403	180	316	135	153

Fishstock	TAR 7		TAR 8		TAR 10			
FMA (s)	7		8		10		Total	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings§	TACC
1983-84*	896	-	109	-	0	-	5 430	-
1984-85*	609	-	102	-	0	-	4 816	-
1985-86*	519	-	122	-	0	-	5 051	-
1986-87	904	930	185	190	0	10	4 446	5 160
1987-88	840	1 046	197	196	0	10	4 855	5 598
1988-89	630	1 059	121	197	0	10	4 090	5 727
1989-90	793	1 069	114	208	0	10	4 473	5 873
1991-92	710	1 087	190	225	2	10	5 417	5 953
1992-93	929	1 087	189	225	0	10	5 158	5 989
1990-91	629	1 087	131	225	< 1	10	5 086	5 953
1993-94	780	1 087	191	225	0	10	4 878	5 990
1994-95	978	1 087	171	225	0	10	5 129	5 991
1995-96	890	1 087	105	225	0	10	5 375	5 991
1996-97	1 013	1 087	133	225	0	10	5 512	5 991
1997-98	685	1 087	153	225	0	10	5 287	5 991
1998-99	1 041	1 087	175	225	0	10	5 501	5 991
1999-00	964	1 087	189	225	0	10	5 719	5 991
2000-01	1 178	1 087	178	225	0	10	5 935	5 991
2001-02	1 000	1 088	223	225	0	10	6 119	5 993
2002-03	1 069	1 088	211	225	0	10	6 008	5 993
2003-04	1 116	1 088	197	225	0	10	5 723	5 993
2004-05	1 056	1 088	184	225	0	10	5 683	6 390
2005-06	1 114	1 088	285	225	0	10	6 205	6 390
2006-07	1 116	1 088	254	225	0	10	5 729	6 390
2007-08	990	1 088	196	225	0	10	5 428	6 438
2008-09	977	1 088	169	225	0	10	5 584	6 438
2009-10	1 162	1 088	226	225	0	10	5 553	6 438
2010-11	983	1 088	194	225	0	10	5 708	6 439

* FSU data.

§ Includes landings from unknown areas before 1986-87.
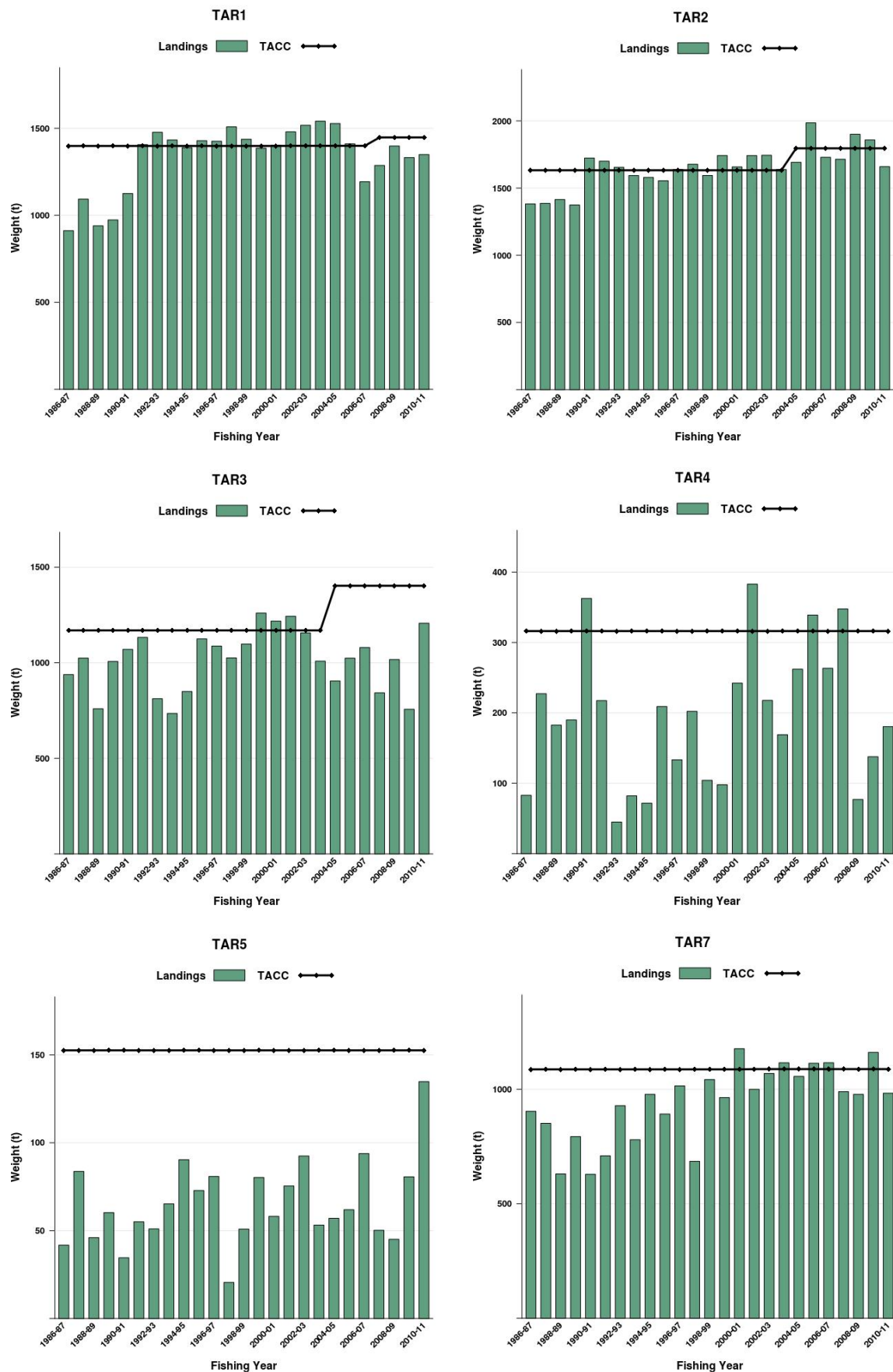
TARAKIHI (TAR)

Figure 1: **Historical landings and TACC for the seven main TAR stocks. From top left: TAR1 (Auckland), TAR2 (Central East), TAR3 (South East Coast), TAR4 (Chatham Rise), TAR5 (Southland), and TAR7 (Challenger). [Continued on next page].**

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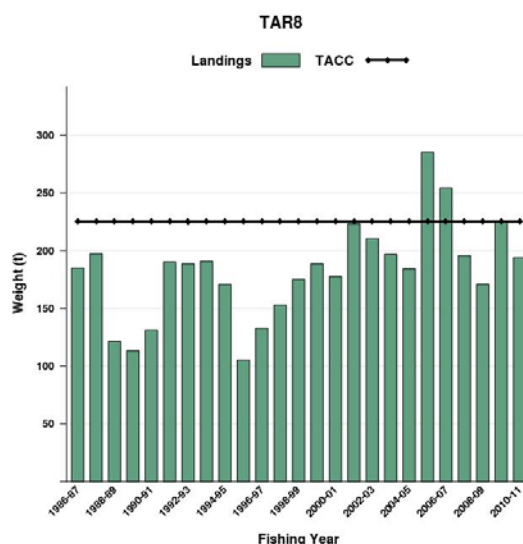
Figure 1 [Continued]: Historical landings and TACC for the seven main TAR stocks. TAR8 (Central Egmont). Note that these figures do not show data prior to entry into the QMS.

Table 4: Estimated number and weight of tarakihi harvested by recreational fishers by Fishstock and survey. Surveys were carried out in different years in the Ministry of Fisheries regions: South in 1991-92, Central in 1992-93 and North in 1993-94 (Teirney *et al*. 1997).

Fishstock	Survey	Total Number	CV (%)	Survey harvest (t)
TAR 1	North	333 000	15	225-400
TAR 1	Central	18 000	55	10-20
TAR 2	North	7 000	-	0-5
TAR 2	Central	48 000	25	20-40
TAR 3	South	1 000	-	0-5
TAR 5	South	1 000	-	0-5
TAR 7	Central	29 000	25	5-15
TAR 7	South	6 000	33	0-5
TAR 8	Central	10 800	60%	0-10

Table 5: Estimates of annual number and weight of tarakihi harvested by recreational fishers from national diary surveys in 1996 (Bradford 1998), Dec 1999-Nov 2000 (Boyd & Reilly 2005), and Dec 2000-Nov 2001 (Boyd, Gowing and Reily unpublished). The mean weights used to convert numbers to catch weight are considered the best available estimates. Estimated harvest is also presented as a range to reflect the uncertainty in the point estimates.

Fishstock	Number caught	CV (%)	Estimated harvest range (t)	Point estimate (t)
1996				
TAR 1	498 000	8	280-330	305
TAR 2	114 000	14	55-75	65
TAR 3	3 000	-	-	-
TAR 5	3 000	-	-	-
TAR 7	69 000	13	20-30	24
TAR 8	46 000	17	25-35	28
1999-00				
TAR 1	1 035 000	19	516-755	636
TAR 2	310 000	27	139-243	191
TAR 3	25 000	51	8-23	15
TAR 5	10 000	57	3-9	6
TAR 7	87 000	18	27-39	33
TAR 8	66 000	38	19-42	30
2000-01				
TAR 1	679 000	16		417
TAR 2	484 000	18		298
TAR 3	7 000	37		4
TAR 5	13 000	37		7
TAR 7	9 000	15		34
TAR 8	78 000	28		36

2.   BIOLOGY

Sexual maturity is reached at 25-35 cm fork length (FL) at an age of 4-6 years, after which the growth rate slows. This species reaches a maximum age of 40+ years.

Tarakihi spawn in summer and autumn in several areas around New Zealand. The three main spawning grounds identified are Cape Runaway to East Cape, Cape Campbell to Pegasus Bay, and the west coast of the South Island near Jackson Bay.

Few larval and post-larval tarakihi have been caught and identified. The post-larvae appear to be pelagic, occur in offshore waters, and are found in surface waters at night. Post-larval metamorphosis to the juvenile stage occurs in spring or early summer when the fish are 7-9 cm FL and 7-12 months old.

Several juvenile nursery areas have been identified in shallower, inshore waters, including the southwest coast of the North Island, Tasman Bay, near Kaikoura, northern Pegasus Bay, Canterbury Bight, Otago and the Chatham Islands. Juveniles move out to deeper water at a length of about 25 cm FL at an age of 3-4 years. Recent sampling of the TAR 3 trawl catch revealed that a high proportion of the landed catch is comprised of immature fish. Conversely, TAR 3 set net and TAR 2 trawl landed catches were comprised mainly of mature fish.

The results of tagging experiments carried out near Kaikoura during 1986 and 1987 indicate that some tarakihi are capable of moving long distances. Fish have been recaptured from as far away as the Kaipara Harbour on the west coast of the North Island, south of Whangarei on the east coast of the North Island, and Timaru on the east coast of the South Island.

The best available estimate of M is a value of 0.10 as determined from the age frequency distribution of unexploited and lightly exploited populations. Estimates of Z for the area near Kaikoura made during 1987 ranged from 0.12-0.16 for fish between 8 and 20 years old. Assuming $M = 0.10$ suggests that F ranged between 0.02-0.06. Estimates of Z for the area near the Chatham Islands made during 1984 were equal to or less than 0.20.

Biological parameters relevant to the stock assessment are shown in Table 6.

Table 6:   Estimates of biological parameters of tarakihi.

Fishstock			Estimate			Source
1. Natural mortality (*M*)						
All			0.08-0.15			Annala (1987)
			0.10 considered best estimate for all areas for both sexes			Annala *et al*. (1989, 1990)

2. Weight = a (length)[b] (Weight in g, length in cm fork length)

	Females		Males		Source
	a	b	a	b	
TAR 3	0.04	2.79	0.0433	2.77	Annala *et al*. (1990)
TAR 4	0.023	2.94	0.017	3.02	Annala *et al*. (1989)
TAR 7	0.015	3.058	0.0141	3.07	Manning (2008)

3. von Bertalanffy growth parameters

	Females			Males			Source
	K	t_0	*L∞*	*K*	t_0	*L∞*	
TAR 3	0.2009	- 1.103	44.6	0.2085	- 1.397	42.1	Annala *et al*. (1990)
TAR 4	0.2205	- 1.026	44.6	0.1666	- 2.479	44.7	Annala *et al*. (1989)
TAR 7	0.234	- 0.57	45.6	0.252	- 0.41	42.7	Manning (In prep.)

3. STOCKS AND AREAS

The results of tagging experiments have shown that tarakihi are capable of moving large distances around the coasts of the main islands of New Zealand. The long pelagic larval phase of 7-12 months indicates that larvae will also be widely dispersed. Previously these two factors, in addition to the lack of any evidence of genetic isolation, had been used to suggest that tarakihi around the main islands of New Zealand consist of one continuous stock, and for stock assessment purposes they had been considered to be one stock. Further it was concluded that because of the large distance between the mainland and the Chatham Islands, and the separation of these two areas by water deeper than that which is usually inhabited by adult tarakihi, the tarakihi around the Chatham Islands are considered to be a separate stock.

In 2008, the Working Group concluded that the tagging programmes had not been designed in such a way to adequately test stock structure hypotheses and the results were not conclusive. The Working Group suggested that further analysis was necessary before firm conclusions could be made on the number of tarakihi stocks in the North and South Islands.

A 2012 review of tarakihi stock structure along the east coast of mainland New Zealand revealed that recent trends in CPUE in TAR 3 are similar to those from the BoP and TAR 2 fisheries. However, the CPUE trend and age structure for East Northland were different from the other east coast areas, suggesting that we cannot link all of the east coast into a single stock.

There are distinct spawning grounds in each of the two Islands (off East Cape in the northern area and off Cape Campbell in the south), but there is a preponderance of juvenile fish in the southern area and low densities of juvenile tarakihi within the BoP and TAR 2 fisheries. The long pelagic phase of tarakihi may provide a mechanism for the transfer of larvae to the nursery grounds in Canterbury Bight/Pegasus Bay and then subsequently recruit to the East Cape area at maturity. This hypothesis is supported by the northward movement of tagged fish from the Kaikoura coast to the Wairarapa, East Cape and BoP areas.

These observations are consistent with some mixing between the two fishery areas, with the southern area (TAR 3) representing a source of recruitment to the northern (TAR 2) area. However, it is not possible to assess the extent of mixing and whether or not movement occurs in the opposite direction (from TAR 2 to TAR 3). Thus, there exist a range of potential stock hypotheses which occupy a continuum between the following two extremes: 1) the TAR 2 and TAR 3 fisheries represent discrete stocks or 2) there is substantial mixing of the fish between the two areas. The most plausible working hypothesis is that there is local recruitment in both areas, with the TAR 2 fishery being augmented by additional recruitment from the TAR 3 fishery area. The juvenile tarakihi that settle and reside in the TAR 3 nursery grounds potentially include the progeny of fish spawning in areas outside of TAR 3.

Results from previous tagging studies indicate some connectivity between Kaikoura and the west coast North Island. The TAR 3 fishery may therefore represent a source of recruitment to areas beyond the BoP and TAR 2.

Catches of king tarakihi (*Nemadactylus sp.*), have been reported as *N. macropterus* in the past.

4. STOCK ASSESSMENT

An integrated assessment for TAR 7 was updated in 2008 with data that included the commercial catch, trawl survey biomass and proportions-at-age estimates, CPUE indices, and commercial catch proportions-at-age.

4.1 Estimates of fishery parameters and abundance

4.1.1 Trawl survey indices

Indices of relative biomass are available from *Kaharoa* trawl surveys in TAR 2, TAR 3 and TAR 7 (Table 7, Figure 2, Figure 3). Note that these estimates were revised in 1996 as a result of new doorspread estimates becoming available from SCANMAR measurements. In TAR 2 and TAR 3 no trend is apparent in the biomass estimates. In TAR 7, tarakihi biomass estimates declined from 1992 to 2003, followed by an increase in 2005, but reducing to slightly higher than previous levels in 2007, after which biomass has been stable. Relative biomass indices are used to estimate biomass and yields for TAR 7. The TAR 2 survey was conducted for four consecutive years: 1993–1996 and then discontinued.
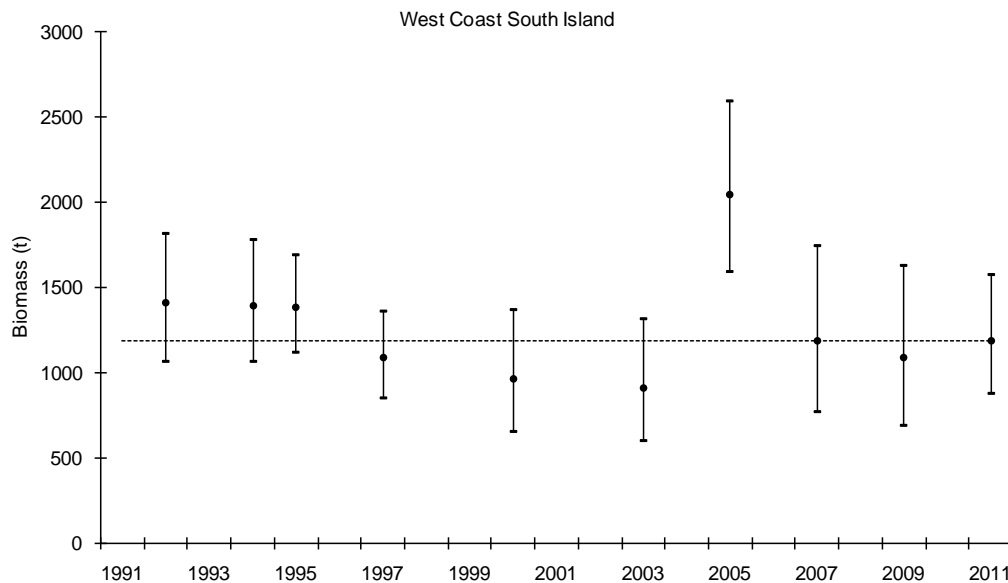
Figure 2: Biomass trends ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the biomass in 2007 (dotted line) from the West Coast South Island trawl survey. The 2008 assessment concluded that the stock was at or above B$_{MSY}$ in 2007.
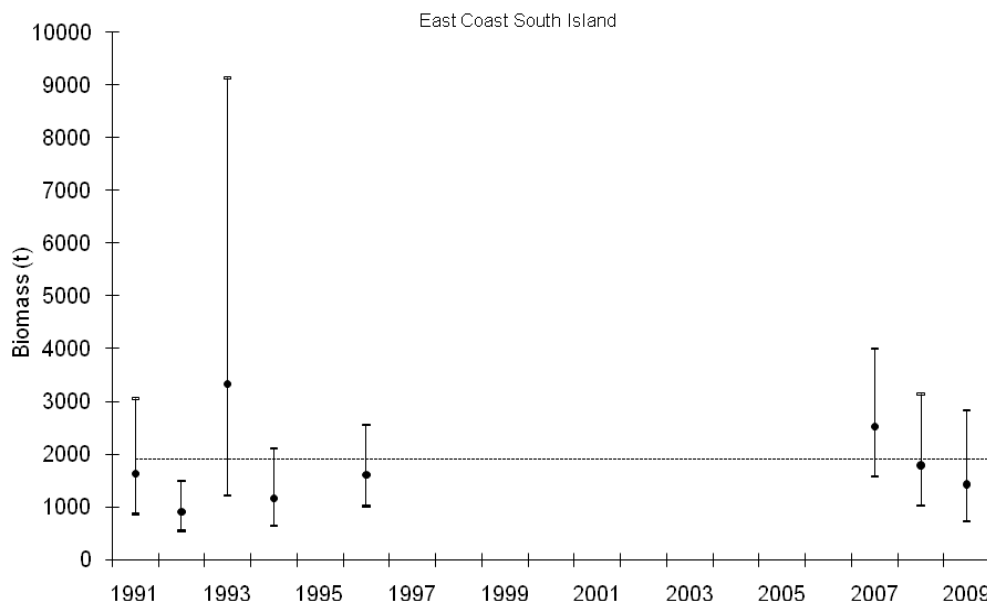
Figure 3: Biomass trends ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the time series mean (dotted line) from the East Coast South Island trawl survey.

Table 7: **Relative biomass estimates (t) and coefficients of variation (CV) for tarakihi available from trawl survey data.**

QMA	Area	Year	Trip Code	Biomass (t)	CV (%)
TAR 2	Cape Runaway to Cook Strait	1993	KAH9304	885	27
		1994	KAH9402	1 128	20
		1995	KAH9502	791	23
		1996	KAH9602	943	15
TAR 3	Pegasus Bay to Canterbury Bight	1991 W	KAH9105	1 657	33
		1992 W	KAH9205	932	26
		1993 W	KAH9306	3 805	55
		1994 W	KAH9406	2 050	41
		1996 W	KAH9606	1 656	24
		2007 W	KAH0705	2 589	24
		1996 S	KAH9618	3 818	21
		1997 S	KAH9704	2 036	24
		1998 S	KAH9809	4 277	24
		1999 S	KAH9917	2 606	15
		2000 S	KAH0014	1 510	13
		2007 W	KAH0705	2589	24
		2008 W	KAH0806	1 863	29
		2009 W	KAH0905	1 519	36
TAR 7	Tasman Bay to Haast	1992	KAH9204	1 409	14
		1994	KAH9404	1 420	14
		1995	KAH9504	1 389	11
		1997	KAH9701	1 087	12
		2000	KAH0004	964	19
		2003	KAH0304	912	20
		2005	KAH0503	2 050	12
		2007	KAH0704	1 089	21
		2009	KAH0904	1 088	22
		2011	KAH1104	1 188	15

S = summer and W = winter survey (Note: because trawl survey biomass estimates are indices, comparisons between different seasons e.g., summer and winter in the same area are not strictly valid).

Summer surveys in the BoP (from Mercury Islands to Cape Runaway) were carried out from 1983 to 1999. These surveys were extended to 250 m, in February 1996 (KAH9601) and 1999 (KAH9902), so that tarakihi depths would be covered. However, the estimates of biomass were low (35 t CV 46% in 1996 and 50 t CV 27% in 1999). Most of the catch in the 1999 survey was taken in 150 to 200 m.
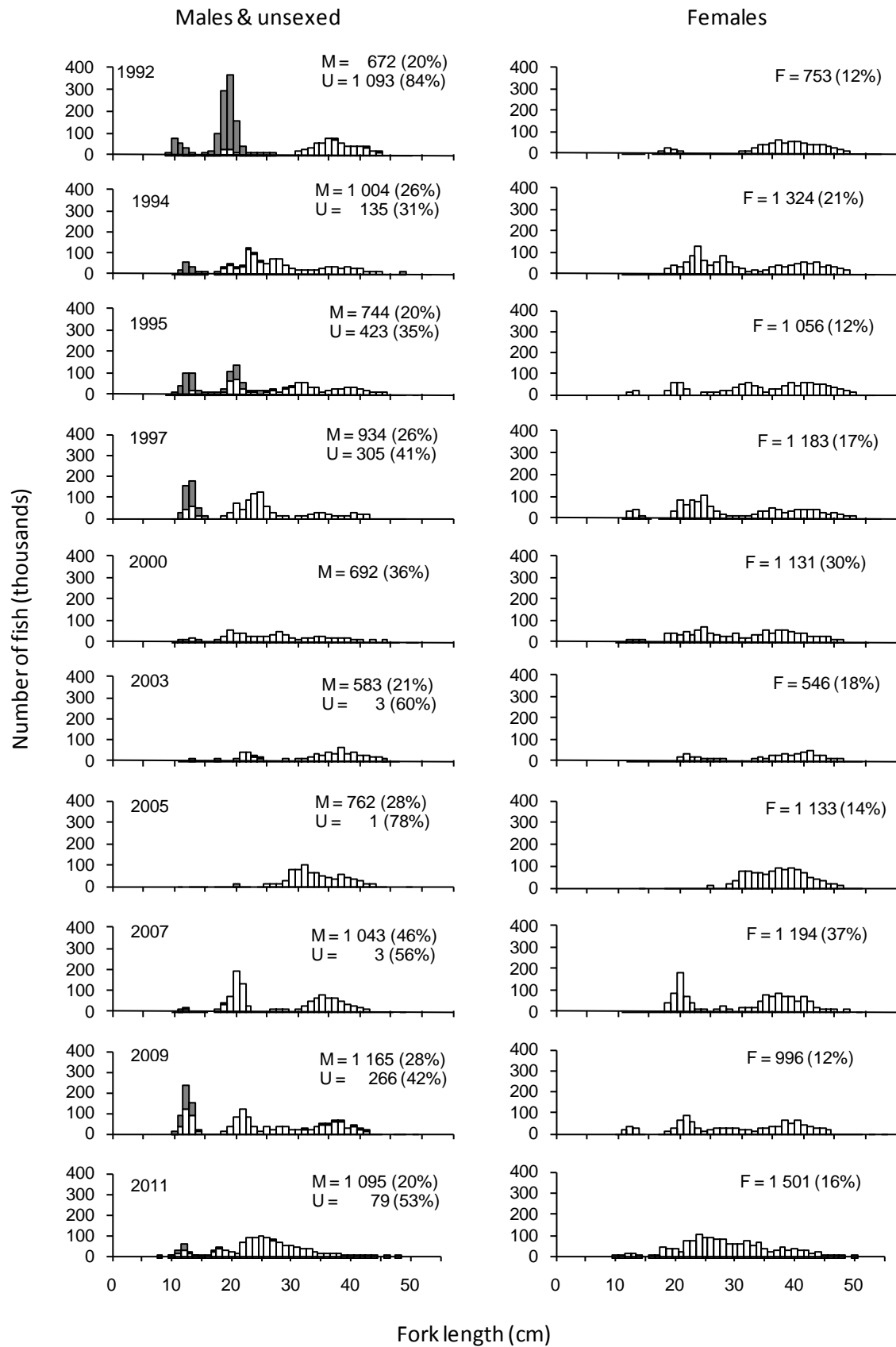
Figure 4: **Scaled length frequency distributions for tarakihi in 30-400 m, for WCSI surveys. M, males; F, females; (CV%),** (Stevenson in press).

4.1.2 CPUE analyses

4.1.2.1 East coast and WCNI CPUE analyses

CPUE indices for all TAR QMAs, except for TAR 7 (west coast South Island), were reviewed in 2012 for use in a planned east coast North and South Islands tarakihi stock assessment. The Working Group did not accept this stock assessment because the available data were inadequate to differentiate between a range of movement and stock hypotheses, as well as requiring strong unsubstantiated assumptions when fitting the data (see discussion below in Section 4.2). In lieu of a stock assessment, the Working Group agreed to present the accepted CPUE series as the best available indicators of tarakahi abundance.

Six CPUE series (Table 8) were reviewed and accepted by the Working Group in 2012. All but one of these series were extensions of series already accepted by the Working Group, developed through MPI research projects or through the AMP. The only new series accepted by the Working Group was the ECNI mixed target species bottom trawl series, which previously had been restricted to tows targeting TAR only. The Working Group agreed to widening the target species definition in this series to include additional target species to conform with existing practice with respect to CPUE analyses, where a broader definition of target species allows for greater comparability across years and form types, as well as guarding against hyperstability in the series confined to a single species definition (Table 8).

Table 8: **Names and descriptions of the six tarakihi CPUE series accepted by the WG in 2012. Also shown is the error distribution that had the best fit to the distribution of standardised residuals for the fitted model.**

Name	Code	QMA	Method	Statistical areas	Target species	Best distribution
West coast North Island	WCNI-BT	TAR 1	BT	041, 042, 045, 046, 047, 048	TAR, SNA, TRE	Weibull
East Northland	EN-BT	TAR 1	BT	002, 003, 004, 005, 006, 007	TAR, SNA, TRE, BAR, JDO, GUR	Weibull
Bay of Plenty	BoP-BT	TAR 1	BT	008, 009, 010	TAR, SNA, TRE, SKI, JDO, GUR	Weibull
East coast North Island	ECNI-BT	TAR 2	BT	011, 012, 013, 014, 015, 016	TAR, SNA, BAR, SKI, WAR, GUR	Weibull
East coast South Island	ECSI-BT	TAR 3	BT	017, 018, 020, 022, 024, 026	TAR, BAR, RCO, WAR, GUR	Lognormal
Area 18 target setnet	ECSI-SN	TAR 3	SN	018	TAR	Weibull

All six analyses (Table 8) were based on data which had been amalgamated into "trip-strata" (Starr 2007), defined as the sum of the catch and effort within a trip characterised by unique statistical areas, target species and method of capture. This approach loses much of the detailed information available in tow-by-tow records, but reduces all data to a common level of stratification, allowing the calculation of linked year coefficients for use in the stock assessment model and obviating the necessity of estimating multiple scaling [q] parameters in the stock assessment model.

A problem with the "trip-stratum" approach is that it ignores problems associated with shifts in reporting behaviour associated with changes in form type requirements, while relying on the model parameterisation to adjust for potential biases. This represents a change in approach for the three models for WCNI, EN and BoP (Table 8), which previously had handled the form change issue by calculating independent indices for each form type. The Working Group agreed that calculating a single series across all years was a better approach for stock assessment modelling in the face of limited data, but requested that future tarakihi CPUE analyses continue to investigate the effect of the form type change on the estimated annual coefficients and to return, when justified, to analyses which were restricted to form types which collected data at equivalent resolution. As well, the Working Group reviewed analyses which investigated the effects of form type changes in these models and concluded that the models had been reasonably successful in accounting for potential biases.

Each series was modelled in the same manner, with log(catch) offered as the dependent variable and a range of explanatory variables offered, including duration and number of tows (length of net set in the setnet analysis) as continuous polynomials, and statistical area, target species, vessel and month as categorical explanatory variables. In every case, year was forced into the model as the first variable

and was considered to be a proxy for relative annual abundance. Data were restricted to vessels which had participated for a specified number of years at a minimum level of participation (expressed as number of trips in a year). This filtering of the data was done to reduce the number of vessels in the data set without overly reducing the amount of catch represented in the model.

Trial models based on five alternative distributional assumptions were fit to a reduced set of explanatory variables, with the distribution giving the best log-likelihood fit selected for the final stepwise model fit. Table 8 lists the distribution giving the best fit for each model. A logit model which modelled the probability of success was also fit to the same data using a binomial distribution. This model was generated as a diagnostic but is not presented.

TAR 1: Three standardised CPUE models (Table 8) are used to track the abundance of tarakihi populations in TAR 1, because of the wide area covered by this QMA and the divergence in trends between the three areas. The WCNI model showed almost no trend, fluctuating around the long-term mean with fairly wide error bars, indicating that the model is not well determined (Figure 5). The East Northland series dropped sharply after the first year, which is likely due to data issues in the first year of operation (Figure 6). After that drop, the series showed a long gradual declining trend beginning towards the end of the 1990s. This decline appears to have stabilised at about 60% of the long-term mean since 2006–07. Finally the BoP series shows no long-term trend, with current levels near to the levels observed at the beginning of the series, interrupted by about 5 years of increased CPUE in the early 2000s (Figure 7).

TAR 2: Only one standardised CPUE series is used to monitor the east coast of the North Island tarakihi (Table 8). This series closely resembles the BoP series with no strong long-term trend over the full 22 years, except that the recent (4 to 5 years) indices appear to lie slightly below the indices at the beginning of the series (Figure 8). This series also shows an elevated period in the early 2000s that mirrors the BoP indices. The close similarity between these two series is taken as evidence that there is a linkage between the tarakihi populations in these two areas.
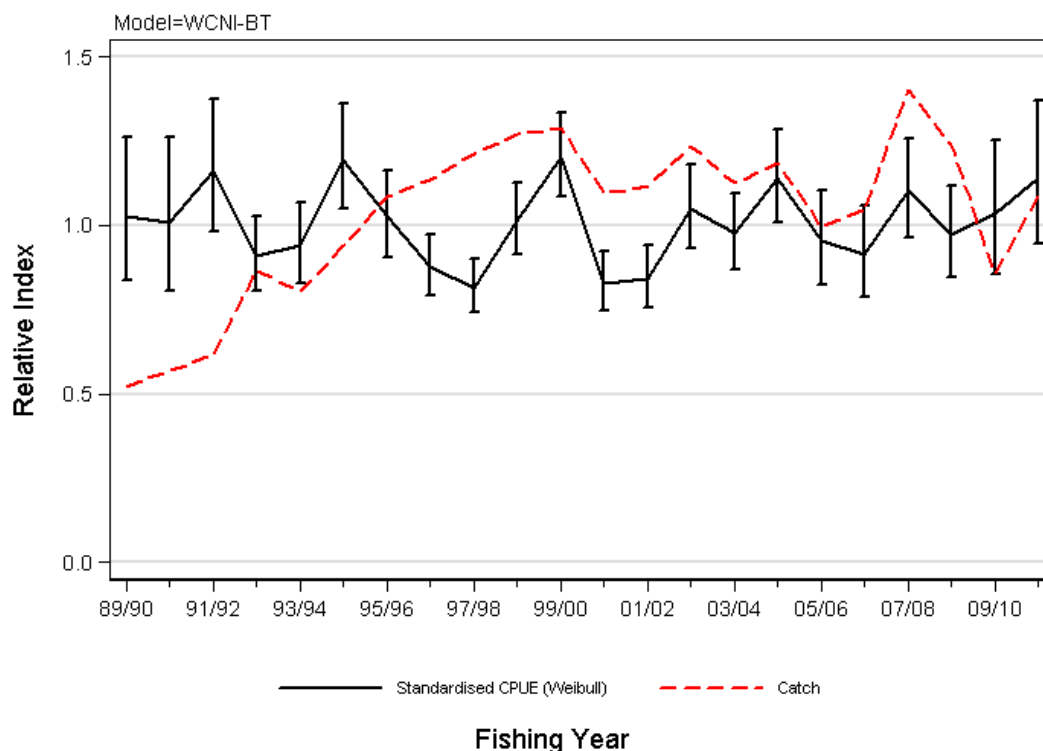
Figure 5: **Standardised CPUE index for the west coast substock of TAR 1 (Table 8) plotted along with the annual sum of catches from the series statistical areas listed in Table 8. Both series have been normalised to a geometric mean =1.0. Error bars show ±97.5% confidence intervals.**
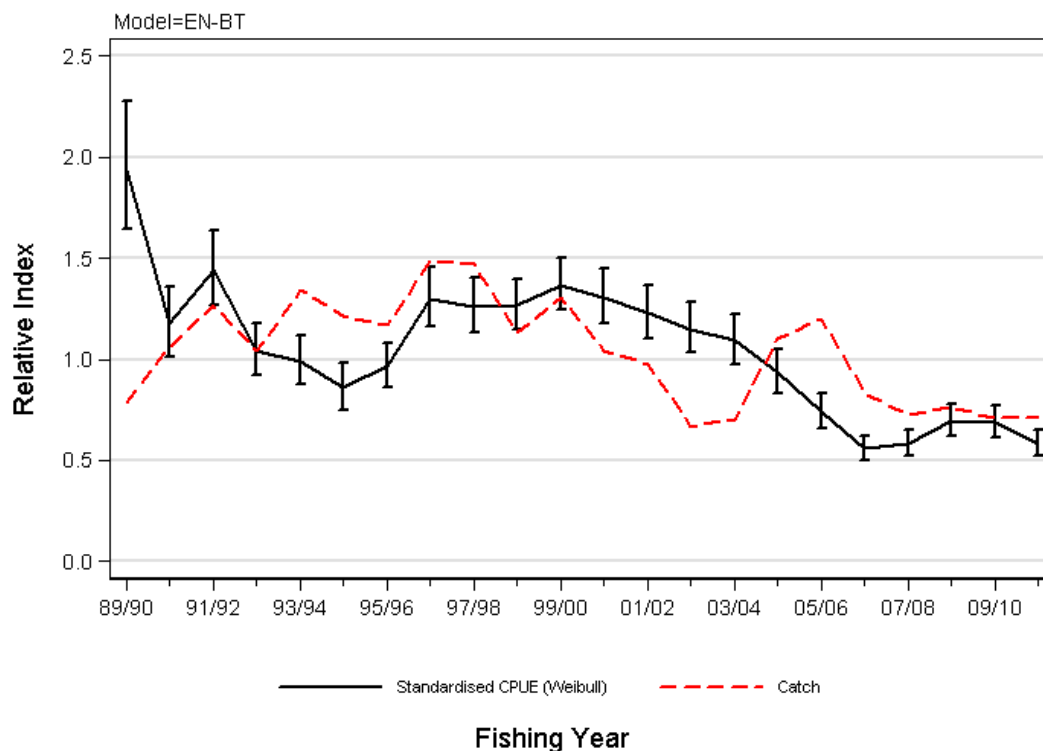
Figure 6:   **Standardised CPUE index for the East Northland substock of TAR 1 (Table 8) plotted along with the annual sum of catches from the series statistical areas listed in Table 8. Both series have been normalised to a geometric mean =1.0. Error bars show ±97.5% confidence intervals.**
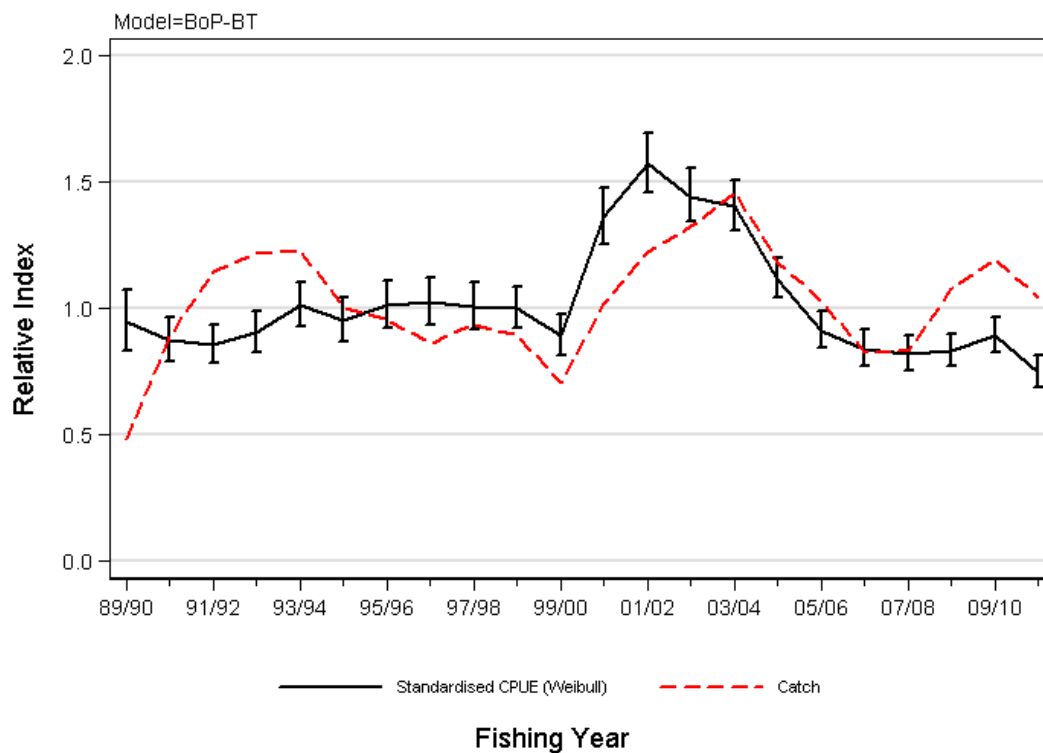
Figure 7:   **Standardised CPUE index for the Bay of Plenty substock of TAR 1 (Table 8) plotted along with the annual sum of catches from the series statistical areas listed in Table 8. Both series have been normalised to a geometric mean =1.0. Error bars show ±2.5% confidence intervals.**
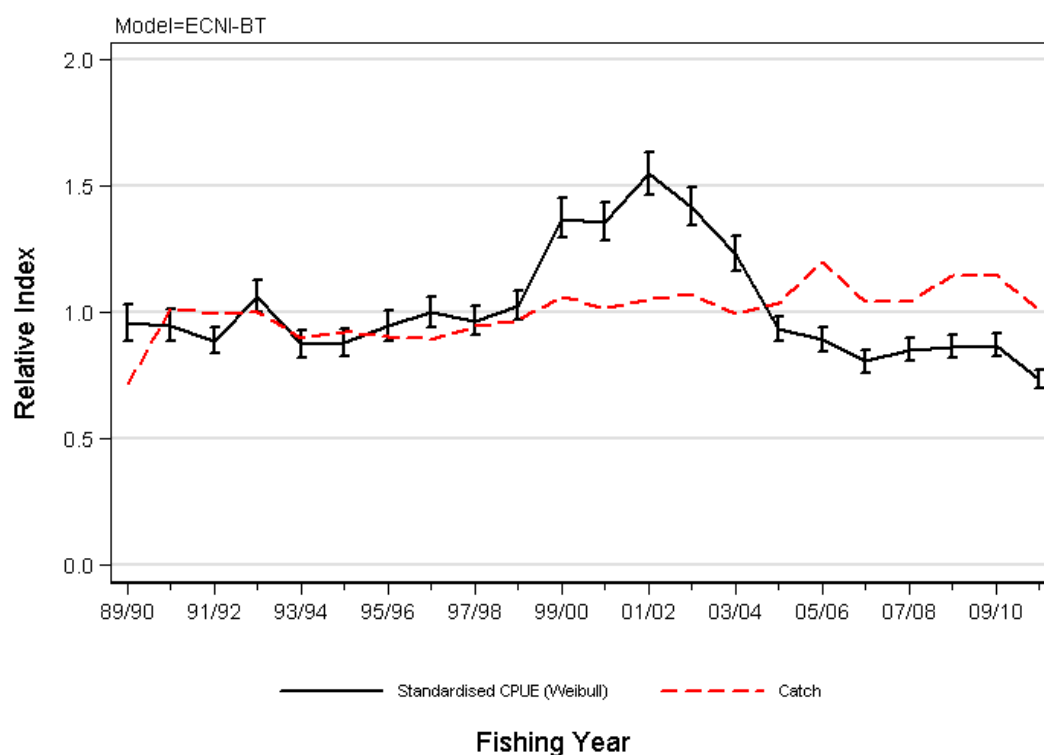
Figure 8: Standardised CPUE index for the east coast North Island bottom trawl (TAR 2; Table 8) plotted along with the annual sum of catches from the series statistical areas listed in Table 8. Both series have been normalised to a geometric mean =1.0. Error bars show ±2.5% confidence intervals.
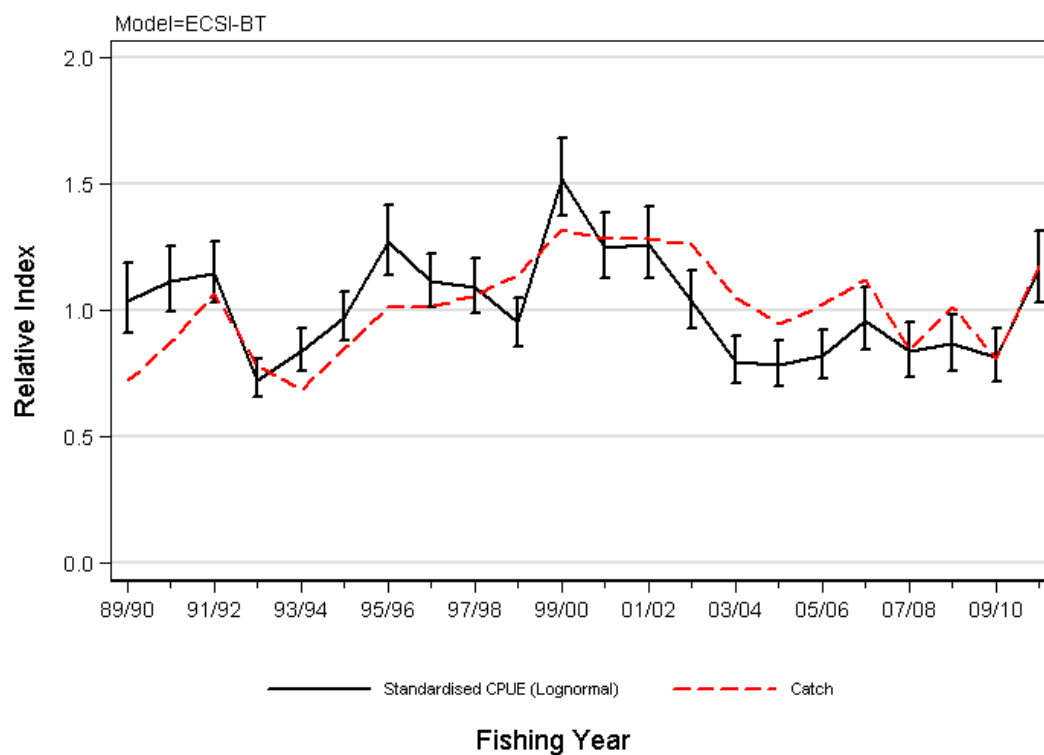
Figure 9: Standardised CPUE index for the east coast South Island bottom trawl (TAR 3; Table 8) plotted along with the annual sum of catches from the series statistical areas listed in Table 8. Both series have been normalised to a geometric mean =1.0. Error bars show ±97.5% confidence intervals.
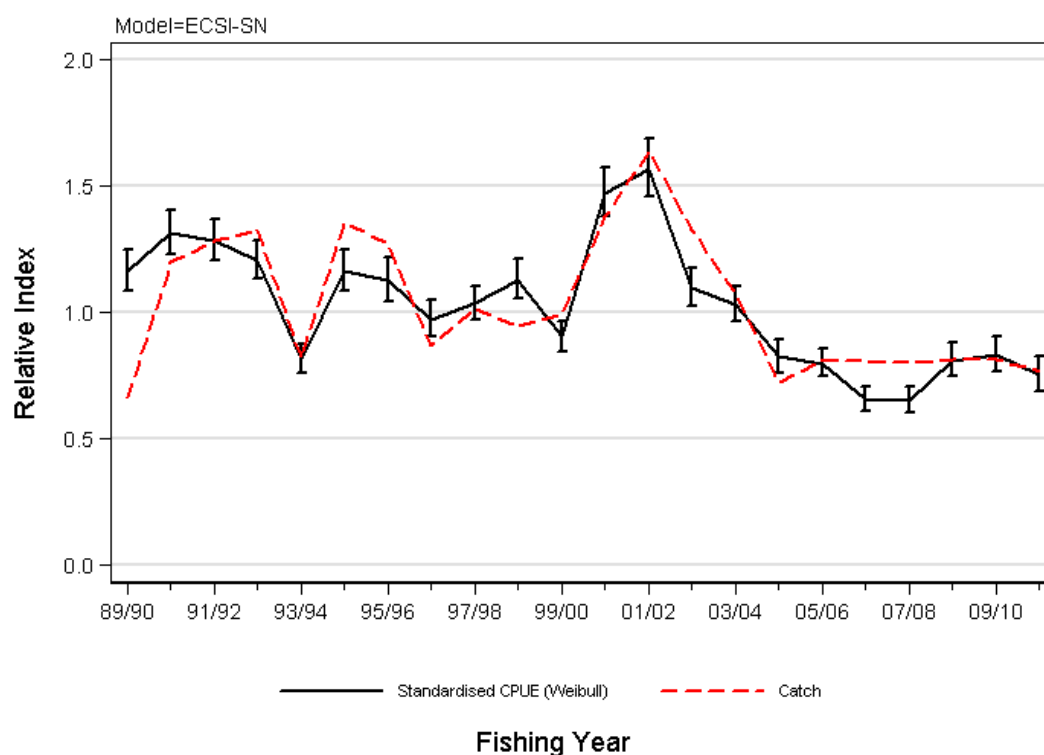
Figure 10: Standardised CPUE index for the east coast South Island setnet (TAR 3; Table 8) plotted along with the annual sum of catches from the series statistical areas listed in Table 8. Both series have been normalised to a geometric mean =1.0. Error bars show ±97.5% confidence intervals.

TAR 3: Two standardised CPUE series are available for monitoring the east coast of the South Island tarakihi populations (Table 8). One, based on bottom trawl data collected from Cook Strait to the Catlins, shows a trend that superficially resembles the trends observed for the BoP and the east coast of the North Island, with the abundance peak shifted earlier by about two years and possibly less broad (Figure 9). Stock hypotheses described in Section 3 (above) suggest that the east coast of the South Island may serve as a nursery area to the North Island fisheries, in which case the 50% increase in CPUE and catch in 2010–11 may bode well for the more northerly fisheries. A second TAR 3 series is provided from a setnet fishery located in Area 018 (Kaikoura) (Figure 10). This series also bears a resemblance to the BoP-BT, ECNI-BT and ECSI-BT series, but with the recent indices located below the long-term average.

4.1.2.2 West coast South Island (TAR 7)

CPUE indices were developed in two bottom trawl fisheries as described by (Langley 2011) that operate in different substock areas and account for most of the catch of TAR 7. The data for analysis were further restricted to that from a core fleet of vessels with consistent participation in the fishery. Standardised CPUE analyses were based on lognormal models of positive (allocated) landed catches at trip-stratum resolution, using the Starr (2007) methodology (Kendrick *et al.* 2011).

The series demonstrate differences between substock areas, the West Coast and Tasman/Golden Bay indices are both cyclical, but asynchronous with the West Coast series peaking 2-3 years after that in Tasman/Golden Bays. Both series have declined over the last six years and are currently at near the lowest level of the series (Figure 11).
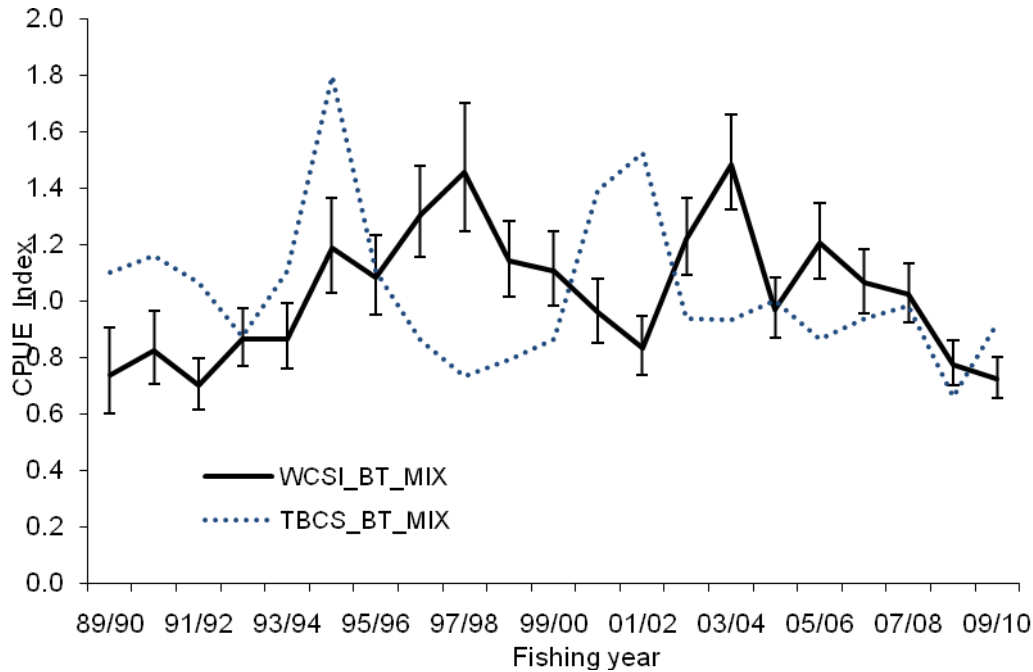
Figure 11: Comparison of the lognormal indices from two independent CPUE series for TAR 7; a) WCSI_BT_MIX: bottom trawl, target TAR, BAR, WAR, STA or RCO in statistical areas (033, 034, 035, and 036) ; b) TBCS_BT_MIX: bottom trawl, target, BAR, TAR, WAR in statistical areas (038, 039, 017, or 018).

4.2   Biomass estimates

TAR 1, 2, 3, and 4

Estimates of current absolute biomass for TAR 1, 2, 3, and 4 are not available.

In 2012, an assessment of the east coast mainland New Zealand tarakihi stocks was attempted (Langley & Starr in press). Three alternative models were configured with spatial domain and structure representing the range of alternative hypotheses regarding stock structure.

  i.   A *TAR2/BPLE* model (statistical areas 008-016);
  ii.   A *TAR3* model (statistical areas 017, 018, 020, 022 and 024); and
  iii. A *combined* model encompassing two separate regions equivalent to the *TAR2/BPLE* and *TAR3*. Northward age-specific movement between the two regions was estimated.

The three models were configured as age structured population models and implemented in Stock Synthesis (Methot 2009). The models incorporated the available catch, CPUE indices, trawl survey biomass estimates and length frequency distributions, historical age frequency data and recent commercial age frequency samples that corresponded to the spatial domain of the respective model.

A key source of uncertainty in the models related to the vulnerability of the older age classes to the fishery, at least in the recent period. Age frequency data from the commercial fishery are only available for the final two years of the model. The limited number of age classes sampled in the catch of the main fisheries could be interpreted as the result of high fishing mortality rates or to the lower vulnerability of the older age classes. Preliminary modelling results indicated the first explanation was less likely given the relatively low natural mortality (0.1) of the species and the consistent historical levels of catch from the fishery (informing estimates of R_0 and, therefore, potential yields). Relaxing the constraints on the main fishery selectivities resulted in substantial improvements to the fits to the main input data sets. However, these models estimated that a large (80-85%) proportion of the current adult biomass was not vulnerable to the fishery and, therefore, not monitored by the

principal abundance indices (primarily CPUE). Furthermore, the model options with a domed selectivity resulted in a much higher model uncertainty, particularly at the upper bound, suggesting that very large biomass levels were possible, which the Working Group found implausible.

Given the uncertainty associated with the key model assumptions, particularly related to fishery selectivity and stock structure, the Northern Inshore Working Group concluded that the range of models investigated was not adequate for the formulation of management advice for the tarakihi stocks along the east coast of New Zealand. It is considered unlikely that a more definitive stock assessment could be undertaken until a more extensive time-series of age frequency data became available from the main commercial fisheries. These data would improve the capacity of the model to estimate fishery selectivity and to distinguish between hypotheses.

TAR 7

An integrated statistical catch-at-age stock assessment for TAR 7 was carried out in 2008 for data up to the end of the 2006-07 fishing year (Manning, in prep.). The model partitioned by age (0-45 years) and sex was fitted to the trawl survey relative abundance indices (1992-07), survey proportions-at-age data (1995-07), and WCSI fishery catch-at-age data (2005-2007). The stock boundary assumed in the model included the west coast of the South Island, Tasman and Golden Bays, but not eastern Cook Strait (a catch history was compiled for the model stock that excluded eastern Cook Strait). A summary of the model's annual cycle is given in Table 9. The base case model (R4.1) was fit to trawl survey biomass indices (lognormal likelihood) and proportion at age data (multinomial likelihood), U_{max} was set at 0.8, steepness was assumed to be 0.75, and M was fixed at 0.1. The base case model assumed an equilibrium biomass at the beginning of the population reconstruction in 1940. One sensitivity R4.5 was the same as R4.1 but was also fit to the CPUE data (lognormal likelihood). The other sensitivity (R4.6) also included the CPUE data; however, the model was started in 1985 from a non-equilibrium start. Model run 4.5 was very similar to the base case (4.1) in terms of biomass trajectory and stock status, but sensitivity 4.6 was more pessimistic in terms of stock status (Table 10). None of the three runs reported in Table 10 estimate a mean or median stock status that is below B_{MSY} and the stock is expected to rebuild, on average, for all three runs under current levels of removals and with average recruitment (Figure 12).

Table 9: **The TAR 7 model's annual cycle (Manning in prep.). Processes within each time step are listed in the time step in which they occur in particular order (e.g., in time step 3, new recruits enter the model partition first followed by the application of natural and fishing mortality to the partition). M, the proportion of natural mortality assumed during each time step. F, the nominal amount of fishing mortality assumed during each time step as a proportion of the total catch in the stock area. Age, the proportion of fish growth that occurs during each time step in each model year**

			Proportions			
Time step	Duration	Process applied	M	F	Age	Observations
1	Oct-Apr	Mortality (M, F)	0.58	0.74	0.90	Survey relative biomass (KAH)
						Survey proportions-at-age (KAH)
						Survey proportions-at-age (JCO)
						Survey proportions-at-length (KAH)
						Fishery catch-at-age
						Fishery relative abundance (CPUE)
2	May (instantaneaous)	Spawning Age incrementation	0.00	0.00	0.00	NIL
3	May-Sept	Recruitment Mortality (M, F)	0.42	0.26	0.10	Fishery catch-at-age

Table 10: **MCMC initial and current biomass estimates for the TAR 7 model runs R4.1, 4.5, and 4.6. B_0, virgin or unfished biomass; B_{2007}, mid-year biomass in 2007 (current biomass); (B_{2007} / B_0) %, B_0 as a percentage of B_{2007}; Min, minimum; Max, maximum; Q_i, ith quantile. The interval $(Q_{0.025}, Q_{0.975})$ is a Bayesian credibility interval (a Bayesian analogue of frequentist confidence intervals).**

	R4.1			R4.5		
	B_0	B_{2007}	(B_{2007} / B_0) %	B_0	B_{2007}	(B_{2007} / B_0) %
Min	13 010	4 340	33.4	12 810	4 180	32.6
$Q_{0.025}$	14 290	6 060	42.3	13 780	5 350	39.1
Median	16 440	9 010	54.7	15 640	7 880	50.4

Mean	16 570	9 180	54.9	15 730	8 020	50.6
$Q_{0.975}$	19 630	13 410	68.3	18 310	11 500	63.0
Max	22 030	16 510	75.0	21 430	15 420	72.0

	R4.6		
Min	14 660	4 150	28.3
$Q_{0.025}$	18 350	6 490	34.7
Median	24 540	10 190	41.6
Mean	25 680	10 940	41.9
$Q_{0.975}$	40 600	19 890	50.5
Max	63 300	34 700	58.3
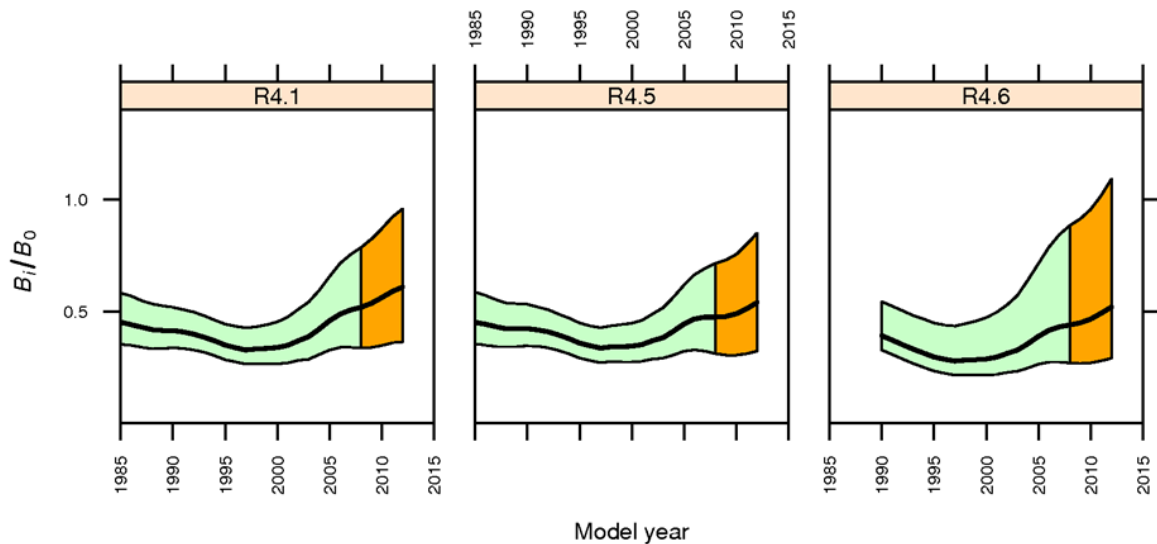
Figure 12: **Relative SSB trajectories (green) and projected status assuming a future constant catch equal to the current catch (orange) calculated from the MCMC runs for model runs 4.1, 4.5, and 4.6 in the quantitative stock assessment of TAR 7. The shaded region indicates the 95% credibility region about median SSB (dotted lines) calculated from each model's SSB posterior distribution.**

Table 11: **Yield estimates (t) of tarakihi (TAR 7)**

Parameter	Run 4.1	Run 4.5	Run 4.6
MCY	549	522	755
B_{MCY}	18237	16233	18620
CAY	1588	1361	1682
F_{CAY}	0.1685	0.1661	0.1508
MAY	1086	976	1203
B_{MAY}	6350	5790	7865

4.3 Estimation of Maximum Constant Yield (*MCY*)

The Working Group concluded that *MCY* estimates are not appropriate.
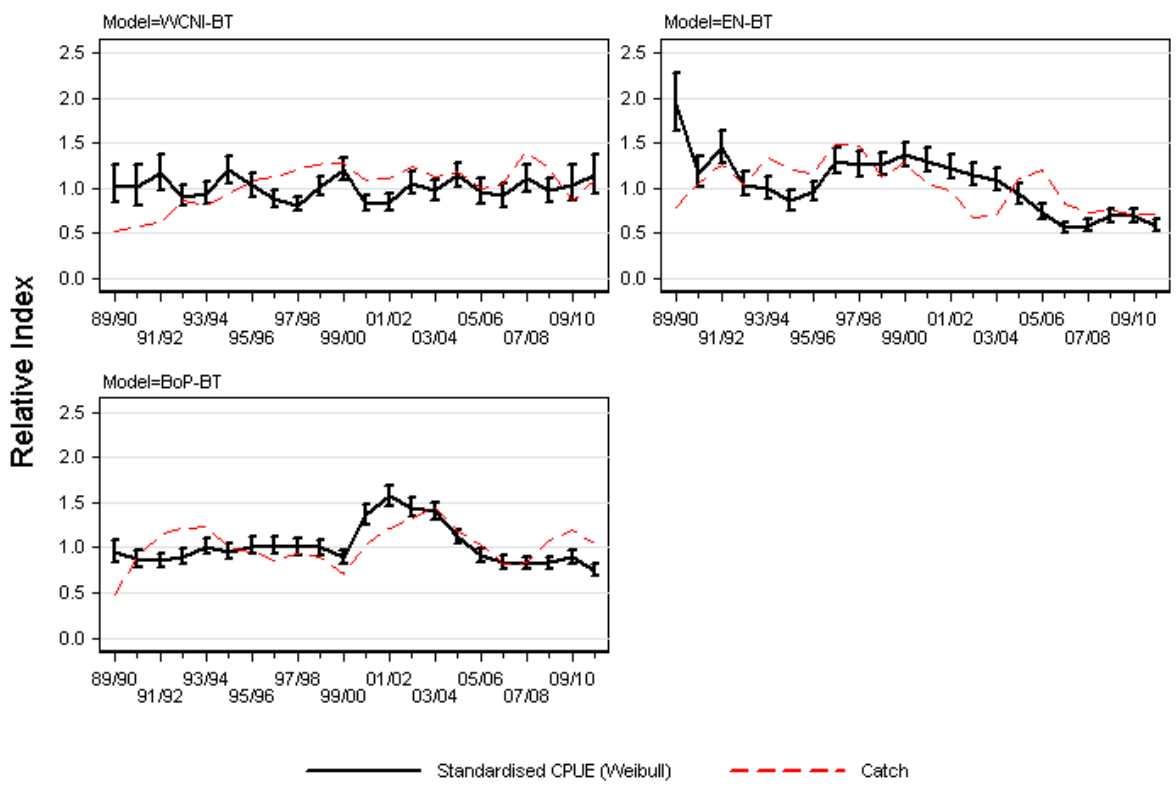
4.4 Estimation of Current Annual Yield (*CAY*)

Estimates of current biomass are not available and *CAY* cannot be determined.

5.   STATUS OF THE STOCKS

TAR 1

Three substocks are recognised within TAR 1: BoP, East Northland and west coast North Island. The BoP fishery accounts for approximately 50% of the TAR 1 catch but is considered to be an extension of the TAR 2 stock with a primary spawning area around East Cape.

Stock Status	
Year of Most Recent Assessment	2012
Assessment Runs Presented	The following three standardised CPUE series were developed using positive catches: WCNI - West Coast North Island bottom trawl mixed target species. EN - East Northland bottom trawl mixed target species. BoP - Bay of Plenty bottom trawl mixed target species.
Reference Points	Target: B_{MSY} (value to be determined) Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unknown
Historical Stock Status Trajectory and Current Status	

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Overall trend in CPUE varies between substocks: WCNI - the series shows almost no trend, fluctuating around the long-term mean with fairly wide error bars, indicating that the

	model is not well determined. EN - the series showed a long gradual declining trend beginning towards the end of the 1990s. This decline appears to have stabilised at about 60% of the long-term mean since 2006–07. BoP - the series shows no long-term trend, with current levels near to the levels observed at the beginning of the series, interrupted by about 5 years of increased CPUE in the early 2000s.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	None
Trends in Other Relevant Indicators or Variables	None

Projections and Prognosis	
Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology and Evaluation		
Assessment Type	Level 2 - Fishery characterisation and CPUE analysis	
Assessment Method	CPUE analysis of trawl catch and effort data	
Assessment Dates	Latest assessment: 2012	Next assessment: 2015
Overall assessment of quality rank	1- High Quality	
Main data inputs (rank)	- Bottom trawl catch and effort data	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	Change to a trip stratum roll-up and using target species definition instead of depth as an explanatory variable.	
Major Sources of Uncertainty	Uncertainty in the stock structure and relationship between CPUE and biomass.	

Qualifying Comments
-

Fishery Interactions
The main fishing method is trawling target tarakihi sets land snapper, john dory, gemfish and trevally in East northland; snapper, trevally and gemfish in the Bay of Plenty; and snapper and trevally as bycatch.

TAR 2

The stock relationships between TAR 2 (including TAR 1 BoP) and TAR 3 are unclear. Data from the main fisheries reveal similarities in abundance trends and age composition and it is possible that the two areas represent a single tarakihi stock or, at a minimum, that there is substantial connectivity between the two areas. However, definitive conclusions regarding the stock structure are not possible and, hence, the status of the two stocks is reviewed separately.

Stock Status	
Year of Most Recent Assessment	2012
Assessment Runs Presented	The standardised CPUE series was developed using positive catches of mixed target species in bottom trawl from TAR 2.
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0

	Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown
	Hard Limit: Unlikely (< 40%) to be below

Historical Stock Status Trajectory and Current Status

Standardised CPUE index for the east coast North Island bottom trawl plotted along with the annual sum of catches from the series statistical areas. Both series have been normalised to a geometric mean =1.0. Error bars show ±2.5% confidence intervals.

Fishery and Stock Trends

Recent Trend in Biomass or Proxy	There is no strong long-term trend since the early 1990s, with current levels slightly below the levels observed at the beginning of the series, interrupted by 5 years of increased CPUE in the early 2000s.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	None
Trends in Other Relevant Indicators or Variables	None

Projections and Prognosis

Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown
	Hard Limit: Unlikely (< 40%)

Assessment Methodology and Evaluation

Assessment Type	Level 2 - Fishery characterisation and CPUE analysis	
Assessment Method	CPUE analysis of trawl catch and effort data	
Assessment Dates	Latest assessment: 2012 CPUE analysis	Next assessment: 2015
Overall assessment of quality rank	1- High Quality	
Main data inputs (rank)	Bottom trawl catch and effort	

	data	1 – High Quality
Data no used (rank)	N/A	

Changes to Model Structure and Assumptions	Changed form a target TAR fishery to a bottom trawl mixed fishery.
Major Sources of Uncertainty	Uncertainty in the stock structure and relationship between CPUE and biomass.

Qualifying Comments
None

Fishery Interactions
This is mostly (83%) a TAR target fishery the main fishing method is trawling the following species are caught as bycatch in this fishery GUR, SKI and WAR.

TAR 3

The stock relationships between TAR 2 (including TAR 1 BoP) and TAR 3 are unclear. Data from the main fisheries reveal similarities in abundance trends and age composition and it is possible that the two areas represent a single tarakihi stock or, at a minimum, that there is substantial connectivity between the two areas. However, definitive conclusions regarding the stock structure are not possible and, hence, the status of the two stocks is reviewed separately.

Stock Status	
Year of Most Recent Assessment	2012
Assessment Runs Presented	Two standardised CPUE series were developed using positive catches: bottom trawl mixed target species; and setnet TAR target.
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unlikely ($<40\%$) to be below

Historical Stock Status Trajectory and Current Status
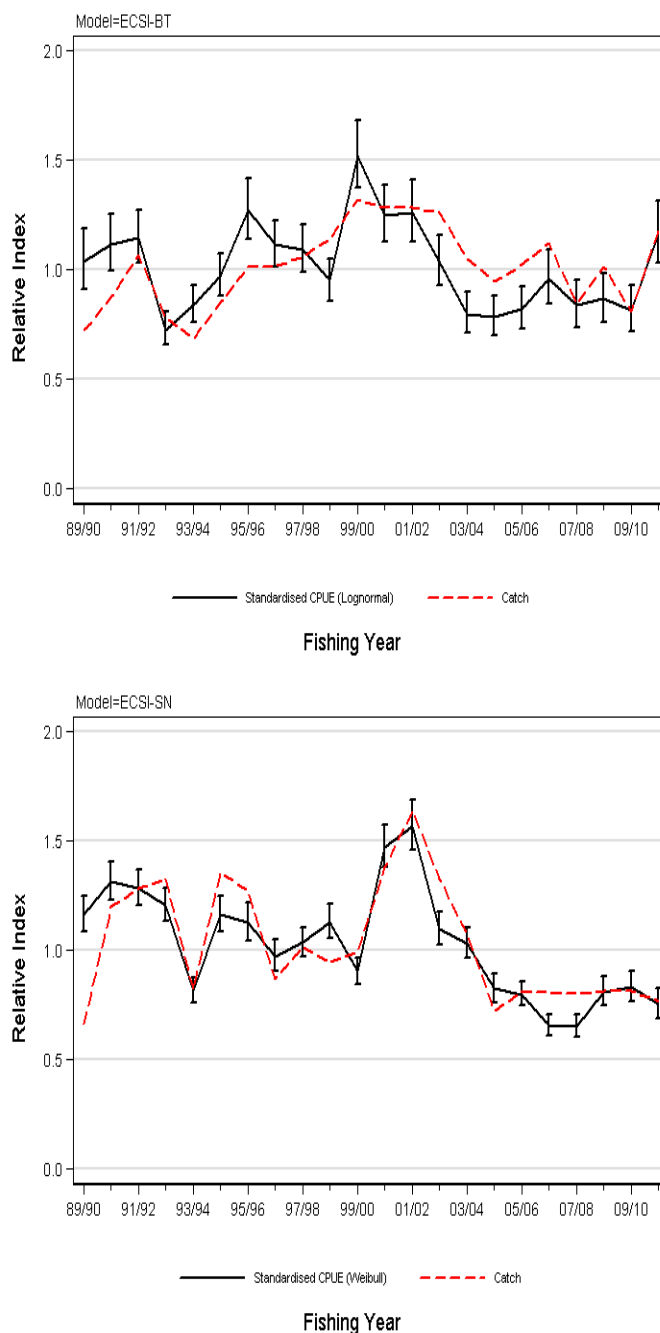
Standardised CPUE index for the east coast South Island bottom trawl (ECSI-BT) and setnet (ECSI-SN) plotted along with the annual sum of catches from the series statistical areas. Both series have been normalised to a geometric mean =1.0. Error bars show ±97.5% confidence intervals.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	
	The BT-MIX series shows no long-term trend, with current levels near to the levels observed at the beginning of the series, interrupted by about 3 years of increased CPUE from the late 1990s. The The increase in 2010/11 may indicate strong recent recruitment to the fishery. The setnet index is similar but the peak is offset by a few years, the last few years are lower than the long-term mean.
Recent Trend in Fishing Mortality or Proxy	Unknown

Other Abundance Indices	None
Trends in Other Relevant Indicators or Variables	None

Projections and Prognosis	
Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unlikely ($< 40\%$)

| **Assessment Methodology and Evaluation**		
Assessment Type	Level 2 - Fishery characterisation and CPUE analysis	
Assessment Method	CPUE analysis of positive trawl and setnet catch and effort data	
Assessment Dates	Latest assessment: 2012	Next assessment: 2015
Overall assessment of quality rank	1 – High Quality	
Main data inputs (rank)	Bottom trawl and setnet catch and effort data	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty	Uncertainty in the stock structure and relationship between CPUE and biomass.	

Qualifying Comments
None

Fishery Interactions
The main fishing method is trawling the following species are caught as bycatch in this fishery RCO, BAR and FLA. The Tarakihi target setnet fishery bycatch includes very small amounts of LIN and SPD.

TAR 4

For TAR 4, the fishery around the Chatham Islands has generally been lightly fished and the stock can probably support higher catch levels for the next few years.

TAR 7

Stock Structure Assumptions

For the purpose of this assessment TAR 7 is assumed to be a discrete stock.

Stock Status	
Year of Most Recent Assessment	2011
Assessment Runs Presented	CPUE indices were developed in two bottom trawl fisheries that operate in different substock areas and account for most of the catch of TAR 7.

Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	In 2007 the range of model results for TAR 7 estimated that the stock was Likely ($> 60\%$) to be at or above B_{MSY}, assumed to be approximately 40% B_0. The 2011 CPUE analysis has shown that since 2007 the index has declined for three consecutive years,

	suggesting that the stock is now Unlikely (< 40%) to be at or above the target.
Status in relation to Limits	Soft Limit: Unlikely (< 40%) to be below Hard Limit: Very Unlikely (< 10%) to be below

Historical Stock Status Trajectory and Current Status
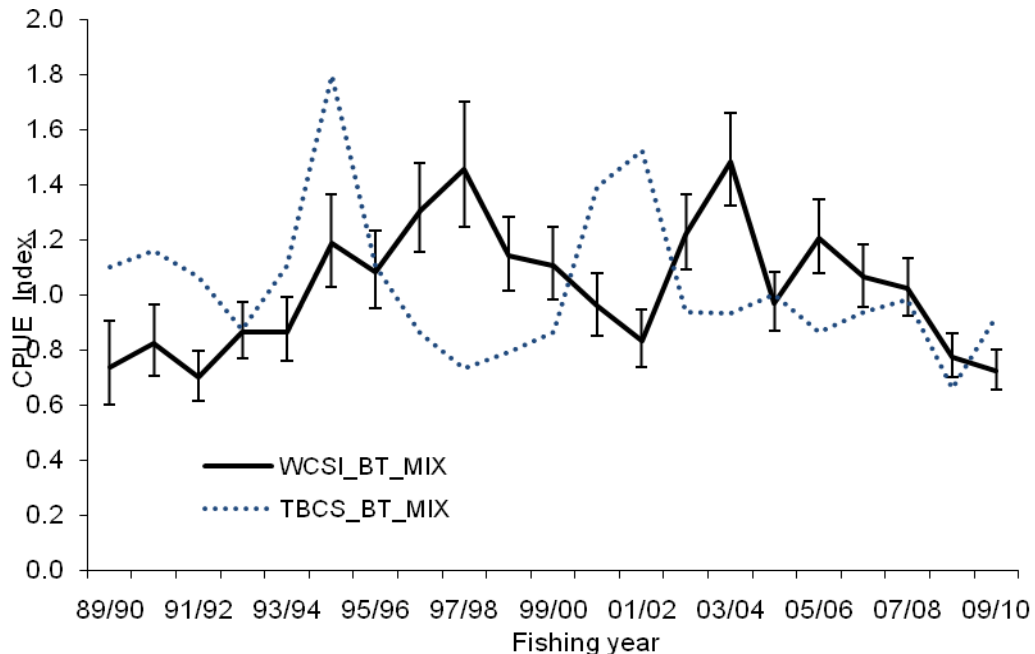
Comparison of the lognormal indices from two independent CPUE series for TAR 7; a) WCSI_BT_MIX: bottom trawl, target TAR, BAR, WAR, STA or RCO in statistical areas (033, 034, 035, and 036) ; b) TBCS_BT_MIX: bottom trawl, target, BAR, TAR, WAR in statistical areas (038, 039, 017, or 018)

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The index has been declining for five consecutive years and is now below the long-term mean.
Recent Trend in Fishing Mortality or Proxy	Likely (> 60%) that overfishing is occurring.
Other Abundance Indices	The west coast south Island trawl survey series indicates that TAR 7 biomass declined from 1995 to 2003 but increased in 2006 and since then has declined to the long-term mean.
Trends in Other Relevant Indicators or Variables	

Projections and Prognosis	
Stock Projections or Prognosis	The index has been declining for five consecutive years and is now below the long-term mean.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%)

Assessment Methodology	
Assessment Type	Level 2 - Fishery characterisation and CPUE analysis
Assessment Method	CPUE analysis of trawl catch and effort data
Main data inputs	Bottom trawl catch and effort data

Period of Assessment	Latest assessment: 2011 (trawl survey)	Next assessment: 2013 (trawl survey)
Changes to Model Structure and Assumptions		
Major Sources of Uncertainty	Stock structure is currently uncertain.	

Qualifying Comments

There is evidence for the 2009 survey that there may be two strong year classes which would recruit to the fishery in 2012-2014.

Fishery Interactions

The main fishing method is trawling. The major target trawl fisheries occur at depths of 100-200 m and tarakihi are taken as a bycatch at other depths as well. TAR 7 is reported as bycatch in target barracouta and red cod bottom trawl fisheries. Smooth skates are caught as a bycatch in this fishery, and the biomass index for smooth skates in the west coast trawl survey has declined substantially since 1997. There may be similar concerns for rough skates but the evidence is less conclusive.

TAR 8

Overall, landings from the North and South Islands have remained relatively stable, since at least the late 1960s, despite changes in effort and methods of fishing. Given the long, stable catch history of this fishery, current catch levels and TACCs are thought to be sustainable.

Yield estimates, TACCs and reported landings for the 2010-11 fishing year are summarised in Table 13.

Table 12: **Summary of yield estimates (t), TACCs (t) and reported landings (t) of tarakihi for the most recent fishing year.**

Fishstock	QMA			2010-11 Actual TACC	2010-11 Reported landings
TAR 1	Auckland (East) (West)	1 & 9		1 447	1 349
TAR 2	Central (East)	2		1 796	1 660
TAR 3	South-East (Coast)	3	⎬	1 403	1 207
TAR 4	South-East (Chatham)	4		316	180
TAR 5	Southland and Sub-Antarctic	5 & 6		153	135
TAR 7	Challenger	7		1 088	983
TAR 8	Central (West)	8		225	194
TAR 10	Kermadec	10		10	0
Total				6 439	5 708

7.   FOR FURTHER INFORMATION

Anon 2007. TAR 2 Adaptive Management Programme Report: 2005/06 fishing year. AMP-WG-06/19. Copies held by MFish. 30p.

Annala J.H. 1987. The biology and fishery of tarakihi, *Nemadactylus macropterus*, in New Zealand waters. Fisheries Research Division Occasional Publication No. 51. 16p.

Annala J.H. 1988. Tarakihi. New Zealand Fisheries Assessment Research Document 1988/28. 31p.

Annala J.H., Wood B.A., Smith D.W. 1989. Age, growth, mortality, and yield-per-recruit estimates of tarakihi from the Chatham Islands during 1984 and 1985. Fisheries Research Centre Internal Report No. 119. 23 p. (Draft report held in NIWA Greta Point library, Wellington.)

Annala J.H., Wood B.A., Hadfield J.D., Banks D.A. 1990. Age, growth, mortality and yield-per-recruit estimates of tarakihi from the east coast of the South Island during 1987. MAF Fisheries Greta Point Internal Report No. 138. 23 p. (Draft report held in NIWA Greta Point library, Wellington.)

Boyd R.O., Reilly J.L. 2005. 1999/2000 national marine recreational fishing survey: harvest estimates. Draft New Zealand Fisheries Assessment Report.

Boyd R.O., Gowing L., Reilly J.L. unpublished. 2000-2001 national marine recreational fishing survey: diary results and harvest estimates. Draft New Zealand Fisheries Assessment Report.

Bradford E. 1998. Harvest estimates from the 1996 national recreational fishing surveys. New Zealand Fisheries Assessment Research Document 1998/16. 27p.

Hanchet S.M., Field K. 2001. Review of current and historical data for tarakihi (*Nemadactylus macropterus*) Fishstocks TAR 1, 2, 3, and 7, and recommendations for future monitoring. New Zealand Fisheries Assessment Report 2001/59. 42p.

Hartill B., Bian R., Davies N.M. in Press. A review of approaches used to estimate recreational harvests in New Zealand between 1984 and 2007. New Zealand Fisheries Assessment Report 2012/xx. 59pp.

Kendrick T.H. 2006. Updated catch-per-unit-effort indices for three substocks of tarakihi in TAR 1, 1989-90 to 2003-04. New Zealand Fisheries Assessment Report 2006/14. 66p.

Kendrick T.H., Bentley N., Langley A. 2011. Report to the Challenger Fishfish Company: CPUE analyses for FMA 7 Fishstocks of gurnard, tarakihi, blue warehou, and ghost shark. (Unpublished client report held by Trophia Limited, Kaikoura).

Langley A. 2011. Characterisation of the Inshore Finfish fisheries of Challenger and South East coast regions (FMAs 3, 5, 7 & 8). . (Unpublished client report available from http://www.seafoodindustry.co.nz/SIFisheries).

Langley A. Starr P. In Press. Stock relationships of tarakihi off the east coast of mainland New Zealand, including a feasibility study to undertake an assessment of the tarakihi stock(s).

Lydon G.J., Middleton D.A.J., Starr P.J. 2006. Performance of the TAR 3 Logbook Programmes. AMP-WG-06/20. (Unpublished manuscript available from the New Zealand Seafood Industry Council, Wellington.)

Methot R.D. 2009. User manual for Stock Synthesis: Model Version 3.04. (Updated September 9, 2009), 159p.

Northern Inshore Fisheries Company Ltd 2001. Tarakihi (TAR 1) - revised 30/04/01 Proposal to manage TAR 1 as part of an Adaptive Management Programme.

Phillips N.L., Hanchet S.M. 2003. Updated catch-per-unit-effort (CPUE) analysis for tarakihi (*Nemadactylus macropterus*) in TAR 2 (east coast North Island) and CPUE analysis of tarakihi in Pegasus Bay/Cook Strait (mainly TAR 3). New Zealand Fisheries Assessment Report 2003/53. 54p.

SeaFIC 2003. Report to the Adaptive Management Programme Fishery Assessment Working Group. TAR 3 Adaptive Management Programme Proposal for the 2004-05 fishing year (dated 11 November 2003). Copies held by the Ministry of Fisheries.

Starr P.J., Kendrick T.H., Lydon G.J., Bentley N. 2007. Report to the Adaptive Management Programme Fishery Assessment Working Group: Two year review of the TAR 3 Adaptive Management Programme. AMP-WG-07/12. (Unpublished manuscript available from the NZ Seafood Industry Council, Wellington.). 68p.

Stevenson M.L. 2007. Inshore trawl survey of the west coast of the South Island and Tasman and Golden Bays, March-April 2007 (KAH0704). New Zealand Fisheries Assessment Report 2007/41. 64p.

Stevenson M.L. 2006. Trawl survey of the west coast of the South Island and Tasman and Golden Bays, March-April 2005 (KAH0503). New Zealand Fisheries Assessment Report 2006/4. 69p.

Stevenson M.L. in press. Inshore trawl survey of the west coast of the South Island and Tasman and Golden Bays, March-April 2011. New Zealand Fisheries Assessment Report 2012/xx.

Stevenson M.L., Horn P.L. 2004. Growth and age structure of tarakihi (Nemadactylus macropterus) off the west coast of the South Island. Fisheries Assessment Research Document 2004/11 21p

Teirney L.D., Kilner A.R., Millar R.E., Bradford E., Bell J.D. 1997. Estimation of recreational catch from 1991/92 to 1993/94 New Zealand Fisheries Assessment Research Document 1997/15. 43p.

TREVALLY (TRE)

(*Pseudocaranx dentex*)
Arara
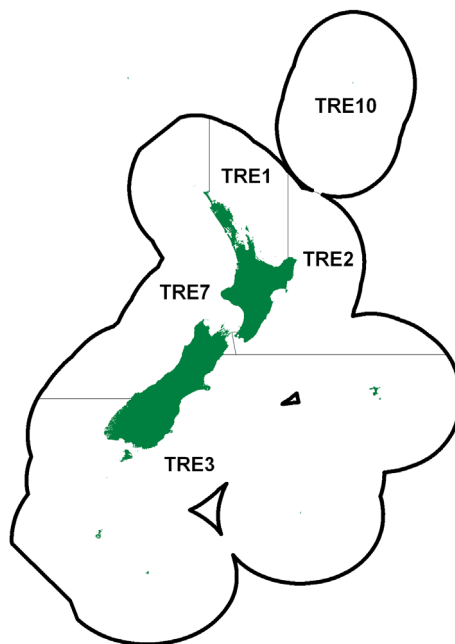
1.   FISHERY SUMMARY

1.1   Commercial fisheries

Trevally was introduced into the QMS in 1986 with five QMAs. A Total Allowable Catch (TAC) was set under the provisions of the 1983 Fisheries Act initially at 3220 t. Since the introduction into the QMS there have been no recreational or customary allocations in TRE 1, 3, 7, or 10, therefore for the total allowable commercial catch (TACC) is the same as the TAC. In 2010 TRE 2 was allocated a 100 t recreational catch, 1 t customary catch, and 7 t for other mortality, combining to make a 350 t TAC.

Trevally is caught around the North Island and the north of the South Island, with the main catches from the northern coasts of the North Island. Trevally is taken in the northern coastal mixed trawl fishery, mostly in conjunction with snapper. Since the mid 1970s trevally has been taken by purse seine, mainly in the Bay of Plenty (BoP), in variable but often substantial quantities. Setnet fishermen take modest quantities. Recent reported trevally landings and TACCs are shown in Table 1, while Figure 1 shows the historical landings and TACC values for the main trevally stocks.

Landings from TRE 1 were 855 t and 814 t in 2008-09 and 2009-10 respectively (57 and 54% of the TACC). This is a slight increase since the low catch of 790 t in 2006-07. For TRE 2, catches have exceeded the TAC in 12 of the last 14 fishing years. Landings from TRE 7 have been under the TACC for the last six fishing years.

1.2   Recreational fisheries

Recreational fishers catch trevally by setnet and line. Although highly regarded as a table fish, some trevally may be used as bait. There is some uncertainty with all recreational harvest estimates for trevally as presented in Table 2.

Recreational harvest estimates by fish stock were obtained from national telephone diary surveys undertaken in 1996 and 2000, with a follow up survey in 2001. Regional telephone diary surveys were undertaken in 1991-92 in the South Region, 1992-93 in the Central Region and in 1993-04 in the North Region.

Table 1: Reported landings (t) of trevally by Fishstock from 1983 to 2010-11 and actual TACs (t) from 1986-87 to 2010-11. QMS data from 1986-present.

Fishstock QMA (s)	TRE 1 1		TRE 2 2		TRE 3 3, 4, 5, 6		TRE 7 7, 8, 9		TRE 10 10	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983*	1 534	-	77	-	3	-	2 165	-	0	-
1984*	1 798	-	335	-	1	-	1 707	-	0	-
1985*	1 887	-	162	-	1	-	1 843	-	0	-
1986*	1 431	-	161	-	3	-	1 830	-	0	-
1986-87	982	1 210	237	190	< 1	20	1 626	1 800	0	10
1987-88	1 111	1 210	267	219	< 1	20	1 752	1 800	0	10
1988-89	818	1 413	177	235	< 1	20	1 665	2 010	0	10
1989-90	1 240	1 493	275	237	18	20	1 589	2 146	0	10
1990-91	1 011	1 495	273	238	8	22	2 016	2 153	0	10
1991-92	1 169	1 498	197	238	< 1	22	1 367	2 153	< 1	10
1992-93	1 328	1 505	247	241	< 1	22	1 796	2 153	< 1	10
1993-94	1 162	1 506	230	241	< 1	22	2 231	2 153	0	10
1994-95	1 242	1 506	179	241	< 1	22	2 138	2 153	0	10
1995-96	1 175	1 506	211	241	< 1	22	2 019	2 153	0	10
1996-97	1 174	1 506	317	241	< 1	22	1 843	2 153	0	10
1997-98	1 027	1 506	223	241	3	22	2 102	2 153	0	10
1998-99	1 469	1 506	284	241	24	22	2 148	2 153	0	10
1999-00	1 424	1 506	309	241	3	22	2 254	2 153	0	10
2000-01	1 049	1 506	211	241	< 1	22	1 888	2 153	0	10
2001-02	1 085	1 506	243	241	< 1	22	1 856	2 153	0	10
2002-03	1 014	1 507	270	241	< 1	22	2 029	2 153	0	10
2003-04	1 111	1 507	251	241	< 1	22	2 186	2 153	0	10
2004-05	977	1 507	319	241	< 1	22	1 945	2 153	0	10
2005-06	1 149	1 507	417	241	< 1	22	1 957	2 153	0	10
2006-07	790	1 507	368	241	< 1	22	1 739	2 153	0	10
2007-08	847	1 507	230	241	< 1	22	1 797	2 153	0	10
2008-09	855	1 507	302	241	< 1	22	2 018	2 153	0	10
2009-10	814	1 507	261	241	< 1	22	1 966	2 153	0	10
2010-11	1 408	1 507	245	241	< 1	22	1 922	2 153	0	10

QMA (s)	Total	
	Landings	TAC
1983*	3 779	-
1984*	3 841	-
1985*	3 893	-
1986*	3 425	-
1986-87	2 845	2 230
1987-88	3 131	3 259
1988-89	2 651	3 688
1989-90	3 122	3 906
1990-91	3 308	3 918
1991-92	2 733	3 921
1992-93	3 371	3 931
1993-94	3 624	3 932
1994-95	3 559	3 932
1995-96	3 405	3 932
1996-97	3 333	3 932
1997-98	3 355	3 932
1998-99	3 925	3 932
1999-00	3 989	3 932
2000-01	3 148	3 932
2001-02	3 185	3 933
2002-03	3 313	3 933
2003-04	3 548	3 933
2004-05	3 241	3 933
2005-06	3 524	3 933
2006-07	2 897	3 933
2007-08	2 875	3 933
2008-09	3 175	3 933
2009-10	3 042	3 933
2010-11	3 575	3 933

The Recreational Technical Working Group recommends that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and c) the 2000 and 2001 estimates are implausibly high for many important fisheries. Relative comparisons may be possible between stocks within these surveys.

Owing to the limitations of diary surveys a combined aerial over flight / boat ramp survey was undertaken in FMA 1 during 2005, primarily targeting snapper (Hartill *et al*. 2007). The TRE 1 recreational harvest was estimated by this survey to be 105t (Hartill *et al*. 2008); which is substantially lower than estimates from diary surveys.

TREVALLY (TRE)
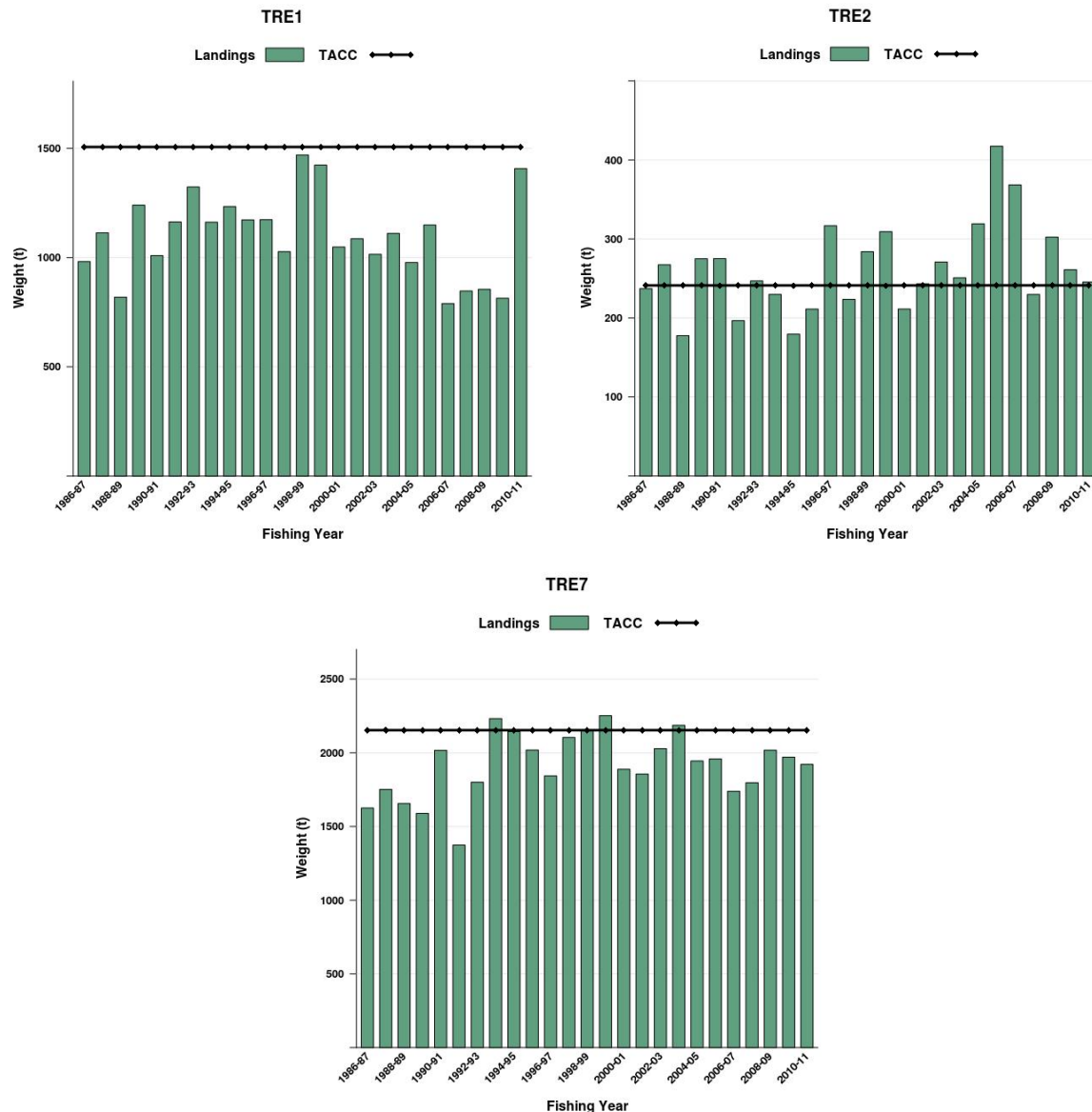
Figure 1: Historical landings and TACC for the three main TRE stocks. Top Left: TRE1 (Auckland) and Top Right: TRE2 (Central East). Lower: TRE7 (Challenger). Note that these figures do not show data prior to entry into the QMS

Table 2: Estimated number of trevally harvested by recreational fishers by Fishstock. (Source: Tierney *et al*. 1997; Bradford 1997; Bradford 1998; Boyd & Reilly 2002; Boyd *et al*. 2004; Hartill *et al*. 2008).

	TRE 1				TRE 7			
Survey Year	Number	CV (%)	Range	Estimated Harvest (t)	Number	CV (%)	Range	Estimated Harvest (t)
1992	186 000	-	240-280	260	68 000	-	65-120	92.5
1994	180 000	9	-	228#	62 000	18	-	78.5
1996	194 000	7	215--255	234	67 000	11	60-80	70
2000	701 000	13	5 90.9-764	677.4	69 000	27	58.8-102.6	81
2001	449 000	19	-	434.2	107 000	21	-	124.3
2005		18		104.7				
	TRE 2				TRE 3			
Survey Year	Number	CV (%)	Range	Estimated Harvest (t)	Number	CV (%)	Range	Estimated Harvest (t)
1992	10 000	-	15-25	20	6 000	-	-	7.6#
1994	-	-	-	-	-	-	-	-
1996	9 000	19	10-15	13	2 000	-	-	2.5#
2000	153 000	60	63.2-256.6	160	10 000	45	5.6-14.8	10
2001	32 000	23	-	339	2 000	46	-	1.7

#No harvest estimate available in the survey report, estimate presented is calculated as average fish weight for all years and areas by the number of fish estimated caught.

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1.3　Customary non-commercial fisheries

Trevally is an important traditional and customary food fish for Maori. No quantitative information is available on the current level of customary non-commercial take.

1.4　Illegal catch

No quantitative information is available on the level of illegal trevally catch. An estimate of historic illegal catch is incorporated in the TRE 7 stock assessment model catch history (see Table 5).

1.5　Other sources of mortality

No quantitative estimates are available regarding the impact of other sources of mortality on trevally stocks. Trevally are known to occur in sheltered harbour and estuarine ecosystems particularly as juveniles. Some of these habitats are known to have suffered substantial environmental degradation.

2.　BIOLOGY

Trevally are both pelagic and demersal in behaviour. Juvenile fish up to 2 years old are found in shallow inshore areas including estuaries and harbours. Young fish enter a demersal phase from about 1 year old until they reach sexual maturity. At this stage adult fish move between demersal and pelagic phases. Schools occur at the surface, in mid-water and on the bottom, and are often associated with reefs and rough substrate. Schools are sometimes mixed with other species such as koheru and kahawai. The occurrence of trevally schools at the surface appears to correlate with settled weather conditions rather than with a specific time of year.

Surface schooling trevally feed on planktonic organisms, particularly euphausids. On the bottom, trevally feed on a wide range of invertebrates.

Trevally are known to reach in excess of 40 years of age. The growth rate is moderate during the first few years, but after sexual maturity at 32 to 37 cm fork length (FL), the growth rate becomes very slow. The largest fish are typically around 60 cm FL and weigh about 4.5 kg, however much larger fish of 6-8 kg are occasionally recorded.

Fecundity is relatively low until females reach about 40 cm FL. They appear to be partial spawners, releasing small batches of eggs over periods of several weeks or months during the summer. Biological parameters relevant to stock assessment are shown in Table 3.

Table 3: Estimates of biological parameters.

Fishstock			Estimate	Source
1. Natural mortality (M)		See section 4.1.4		
2. Weight = a(length)^b (Weight in g, length in cm fork length).				
			Both sexes	
		a	b	James (1984)
TRE 1		0.016	3.064	
3. von Bertalanffy growth parameters				
			Both sexes	
	L_∞	k	t_0	
TRE 1	47.55	0.29	-0.13	Walsh *et al.* 1999
TRE 7	46.21	0.28	-0.25	

3.　STOCKS AND AREAS

There are no new data that would alter the stock boundaries given in previous assessment documents.

4.　STOCK ASSESSMENT

A stock assessment was attempted for TRE 1, but was not accepted by the Pelagic Working Group as no reliable abundance index was available. The TRE 7 stock assessment was updated in 2009 (Langley & Maunder 2009).

Estimates of absolute biomass are not available for any stock. Biomass indices are available from *Kaharoa* trawl surveys of the Hauraki Gulf, BoP, east Northland, and the west coast of the North Island. These relative indices are unlikely to be directly proportional to true stock abundance due to the following factors: (a) the mixed demersal-pelagic nature of trevally; (b) trawl survey gear efficiency is not optimal for the sampling of trevally; and (c) a direct correlation has been found to exist between sea surface temperature during surveys and relative biomass. These factors are most likely to confound any visible trend in the relative abundance indices for trevally produced from past trawl surveys.

In 2012, an index based on aerial sightings was accepted by the NINSWG using data from the MFish database *aer_sight* and the generalised additive model (GAM) to produce standardised annual relative abundance indices (Taylor, 2011). This method is referred to as sightings per unit effort (SPUE).

Flights were restricted to those that were exclusive to the BoP (i.e., those having flightpaths that remained within an area defined as the BoP), were flown by pilot #2, and were the first flight of the day (apart from some defined exceptions, e.g., refuelling at the start of the day).

Estimates of relative year effects were obtained using a forward stepwise GAM, where the data were fitted using a two-part model: the chance of a flight with positive sightings was modelled using a binomial regression and the tonnage sighted on positive flights was modelled using a lognormal regression. The data used for the SPUE analyses consisted of aerial sightings of kahawai, trevally, jack mackerel, blue mackerel, and skipjack tuna from 1986–87 to 2010–11 with missing years in 1988–89, from 1994–95 to 1996–97, and in 2006–07. Most of these missing years were the result of no available data. By contrast, 2006–07 was dropped because the working group identified a biasing of the annual index in that year because of the low number of available flights. Similarly, the first year of the original series (1985–86) was dropped by the working group.

Table 3b: Standardised SPUE indices for TRE 1 from the binomial-lognormal model fitted to the series 1986–87 to 2010–11 with years of missing data shown.

fsyr	LNinds	BNinds	CBinds
1986–87	1.3	1.67	2
1987–88	1.3	1.9	2.54
1988–89	No data	No data	No data
1989–90	1.62	1.55	2.76
1990–91	1.53	1.1	1.84
1991–92	1.98	1.01	1.54
1992–93	0.94	1.27	1.15
1993–94	1.51	0.82	1.47
1994–95	No data	No data	No data
1995–96	No data	No data	No data
1996–97	No data	No data	No data
1997–98	1.04	0.68	0.44
1998–99	1.26	1.65	1.6
1999–00	0.63	1.26	0.9
2000–01	0.99	1.21	1.01
2001–02	1.23	1.48	1.5
2002–03	1.28	0.9	1.32
2003–04	0.68	1.01	0.95
2004–05	0.69	0.65	0.72
2005–06	0.4	1.19	0.47
2006–07	Insufficient data	Insufficient data	Insufficient data
2007–08	0.84	0.31	0.28
2008–09	0.69	0.62	0.41
2009–10	0.81	0.81	0.76
2010–11	0.75	0.63	0.43

A proxy for target comprised purse-seine catches in the BoP; catch data before 1989 were from the *fsu-new* database; data from 1989 to 2011 were from *warehou*. Target was not recorded in purse-seine catch data before 1998 so this could not be used here.

The working group concluded that the model of SPUE for trevally probably does reflect, to some degree, the abundance of this species in the BoP and that the SPUE indices should be used for stock assessment, with stock assessment model diagnostics employed to gauge the quality (and appropriate weight) of the abundance indices.

For TRE 1, the combined indices show a declining trend throughout the time series, with the highest value occurring in 1989–90 and the lowest in 2007–08 (Table 3b, Figure 1b).
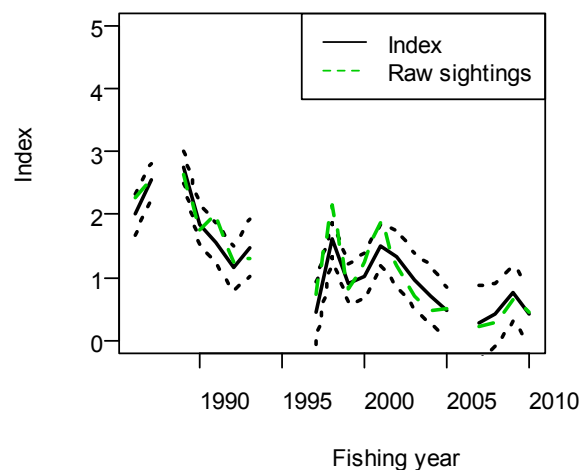
Figure 1b: Standardised sightings per unit effort indices for the Bay of Plenty TRE 1 stock, derived as a combination of year effect estimates from a lognormal and a binomial regression; gaps result from missing and insufficient data (see text).

4.1 Challenger, Central West and Auckland West (TRE 7)

4.1.1 CPUE
A standardised CPUE index of abundance was used in the 2009 assessment (Table 4). This was based on positive catches made using single bottom trawls whilst targeting trevally or snapper and covered the period 1989-90 to 2007-08 (Kendrick & Bentley 2009). A second standardised CPUE index - based on data aggregated by month, vessel class and statistical area (Francis *et al.* 1999) was used for an earlier period (1977-78 to 1996-97) in one of the sensitivity runs.

Table 4: Standardised single trawl CPUE indices (relative year effects) with number of vessel days fished from 1989-90 to 2007-08 (Kendrick & Bentley 2009).

Fishing year	Year of relative effect	CPUE index	Fishing year	Year of relative effect	CPUE index
1989-90	1990	5.94	2004-05	2005	2.43
1990-91	1991	3.79	2005-06	2006	3.05
1991-92	1992	3.06	2006-07	2007	2.42
1992-93	1993	2.22	2007-08	2008	2.73
1993-94	1994	2.51			
1994-95	1995	2.29			
1995-96	1996	2.48			
1996-97	1997	2.56			
1997-98	1998	2.36			
1998-99	1999	2.88			
1999-00	2000	2.57			
2000-01	2001	2.34			
2001-02	2002	2.62			
2002-03	2003	3.05			
2003-04	2004	2.86			

4.1.2 Catch history

Commercial catch records for TRE 7 date back to 1944. Before that time the stock is assumed to have been lightly exploited and close to its virgin state. It is likely that reported catches prior to 1970 are underestimates of the true catch due to large-scale discarding of fish (James 1984).

Over the period since 1944, there has also been a recreational and customary catch as well as an illegal or non-reported catch. For the purposes of modelling the TRE 7 stock, it is necessary to make allowance for mortality due to discarded fish, recreational catch, customary catch, and non-reported catch. The agreed catch history for the model is given in Table 5.

Table 5: Catch history (t) for the TRE 7 fishery including total annual reported commercial catch, estimated discarded (D) commercial catch, estimated non-reported commercial catch, recreational catch, and customary catch. (The year denotes the year at the end of the fishing year).

Year	Reported landings	D	Under-reported catch	Rec. catch	Cust. catch	Total	Year	Reported landings	D	Under-reported catch	Rec. catch	Cust. catch	Total
1944	3	2	1	14	15	34	1960	595	128	119	48	10	900
1945	3	2	1	16	15	36	1961	471	101	94	51	10	727
1946	3	2	1	18	15	38	1962	543	116	109	53	10	831
1947	14	7	3	20	15	59	1963	662	142	132	55	10	1 001
1948	8	4	2	23	15	52	1964	534	114	107	57	10	822
1949	7	4	1	25	15	52	1965	544	117	109	59	10	839
1950	15	8	3	27	15	68	1966	1 080	60	216	61	10	1 427
1951	36	18	7	29	15	105	1967	1 493	83	299	64	10	1 949
1952	31	16	6	31	15	99	1968	1 515	84	303	66	10	1 978
1953	103	52	21	33	15	223	1969	1 322	73	264	68	10	1 737
1954	78	39	16	36	15	184	1970	1 682	0	336	70	10	2 098
1955	138	69	28	38	15	288	1971	2 037	0	407	70	10	2 524
1956	130	65	26	40	15	276	1972	2 226	0	445	70	10	2 751
1957	296	148	59	42	15	560	1973	2 320	0	464	70	10	2 864
1958	343	172	69	44	15	642	1974	2 024	0	405	70	10	2 509
1959	351	176	70	46	15	658	1975	1 598	0	320	70	10	1 998
1976	1 894	0	379	70	10	2 353	1993	1796	0	72	70	12	1950
1977	2 113	0	423	70	10	2 616	1994	2231	0	67	70	12	2380
1978	2 322	0	464	70	10	2 866	1995	2138	0	43	70	12	2263
1979	2 600	0	520	70	10	3 200	1996	2019	0	20	70	12	2121
1980	2 493	0	499	70	12	3 074	1997	1844	0	18	70	12	1944
1981	2 844	0	569	70	12	3 495	1998	2103	0	21	70	12	2206
1982	2 497	0	499	70	12	3 078	1999	2148	0	21	70	12	2251
1983	2 165	0	433	70	12	2 680	2000	2254	0	23	70	12	2359
1984	1 707	0	341	70	12	2 130	2001	1888	0	19	70	12	1989
1985	1 843	0	369	70	12	2 294	2002	1810	0	18	70	12	1910
1986	1 678	0	336	70	12	2 095	2003	2050	0	21	70	12	2153
1987	1 626	0	163	70	12	1 871	2004	2156	0	22	70	12	2260
1988	1752	0	158	70	12	1992	2005	1945	0	19	70	12	2046
1989	1665	0	133	70	12	1880	2006	1957	0	20	70	12	2059
1990	1589	0	111	70	12	1782	2007	1739	0	17	70	12	1838
1991	2016	0	121	70	12	2219	2008	1739	0	17	70	12	1838
1992	1367	0	68	70	12	1517							

4.1.3 Catch at age

A time series of age frequency distributions is available from the target TRE 7 single trawl fishery from 1997-98 to 2008-09. There are also some age frequency samples for the pair trawl method. Previous comparisons found no significant difference between the age composition of catches made by pair and single trawl methods (Hanchet 1999).

In addition, two sources of age frequency data are available from the 1970s: (1) a series covering the years 1971-74 derived from research sampling carried out by the vessel *James Cook,* and (2) a series derived from market sampling carried out in the 1974-76 and 1978-79 fishing years. These data were incorporated in the assessment, but further exploration is required with respect to the sampling protocols, data validation, and the weighting given to the data.

4.1.4   Estimate of natural mortality (*M*)

Initial model runs fixed the value of natural mortality at 0.10, the value used in previous assessments. A likelihood profile for the parameter indicated that 0.10 was at the upper range of the plausible values for *M*, given the observational data and the structural assumptions of the model, and two alternative values of *M* were considered: the most likely value (*M* = 0.087) and a lower value corresponding to a relative likelihood of 0.05 (*M* = 0.075) (Langley & Maunder 2009).

Estimates of current biomass and stock status were highly sensitive to the assumed value of natural mortality. This was due to the lack of contrast in the CPUE indices which allows the model considerable freedom to fit the age frequency data. These data include a relatively large proportion in the accumulated oldest age class. Alternative assumptions regarding *M* substantially influence the time series of recruitment estimates, particularly over the last 20 years, to attain the best fit to the age frequency distributions.

4.1.5   Model structure

The age structured population model encompasses the 1944-2008 period. The model structure includes two sexes, 1-20 year age classes and an accumulating age class for older fish (20+ years). The age structure of the population at the start of the model is assumed to be in an unexploited, equilibrium state. The biological parameters are equivalent to those used in previous assessments and equivalent for the two sexes (see Table 3). For the initial model, natural mortality was invariant with age at a value of 0.1. A Beverton-Holt spawning stock - recruitment relationship (SRR) was assumed with steepness (*h*) fixed at 0.75 and the standard deviation of the natural logarithm of recruitment (σ_R) was fixed at 0.6. Recruitment deviates were estimated for the 1960-2006 years.

Primary differences in the models used in the previous (2005) and current (2009) assessments are as follows:

- Additional data, including three years catch-at-age and an updated CPUE index.
- Refinement of the assumed level of unreported catch since 1986.
- Change in model software from CASAL to Stock Synthesis. This was demonstrated to have minimal effect on the model results.
- A change in the definition of adult biomass with knife-edge maturity at 5 years old (it was previously assumed that all fish were mature).
- Estimation of separate selectivities for the periods pre and post 1986 to account for an increase in trawl mesh size associated with the introduction of a minimum legal size.

The model was fitted to: (a) a combined (either trevally or snapper targeted) CPUE index for the years 1990 to 2008, (b) a research sampling proportions-at-age series for 1971 to 1974, (c) a market sampling proportions-at-age series covering 1974 to 1976 and 1978 to 1979 (d) a commercial proportions-at-age series for 1997 to 2008. A range of sensitivity analyses were conducted to examine the key structural assumptions of the model.

Model projections were conducted with annual catches assumed equivalent to the TAC plus an allowance for customary, recreational, and non-reported commercial catch (of total catch of 2257 t). In the projection period, recruitment variation was incorporated in the model with the recruitment deviates simply constrained by the assumed variation in the deviates (σ_R = 0.60). Parameter uncertainty was incorporated using a Markov chain Monte Carlo (MCMC) approach.

4.1.6   Results

The assessment indicated that the spawning biomass gradually declined during the 1940s and 1950s. The rate of decline increased in the 1960s and 1970s consistent with the increase in the total annual catch. In the MPD runs, the spawning biomass trajectory from the early 1980s was sensitive to the assumed value of *M*, but was relatively insensitive to the range of other alternative structural assumptions investigated.

An MCMC approach was applied to estimate model uncertainty for the models with different values of natural mortality. Reasonable results were attained for the two higher values of natural mortality

(0.087 and 0.10); however, problems were encountered for the lower value of natural mortality (0.075) with MCMC parameter values being constrained by the bounds of key parameters (particularly selectivity parameters), thereby, resulting in biased estimates of stock status. On this basis, the MCMC results for the lower value of natural mortality were rejected and it was concluded that the lower value of natural mortality was less plausible than the other two values. The female spawning biomass trajectories for runs with $M = 0.1$ and $M = 0.087$ are presented in Figures 2 and 3 respectively. Female spawning biomass is predicted to have remained stable ($M = 0.087$) or to have increased ($M = 0.1$) since the 1980s, with moderate-high probability that the current biomass is above the B_{MSY} level (61% and 100%, respectively)

Table 6: **Probability (*Pr*) of the TRE 7 stock falling below key reference points in 2008, using model runs with the two plausible estimates of M. B_{2008} is the mid-year female spawning biomass in 2008. Estimates are derived from MCMC analysis.**

	Pr ($B_{2008} < B_{MSY}$)	*Pr* ($B_{2008} < 0.2B_0$)	*Pr* ($B_{2008} < 0.1B_0$)
$M = 0.10$	0	0	0
$M = 0.087$	0.39	0.05	0

Table 7: **Biomass estimates (medians, with 95% confidence intervals in parentheses) for model runs with the two plausible estimates of M. B_{2008} is the mid-year female spawning biomass in 2008. Estimates are derived from MCMC analysis.**

	B_0	B_{2008}	B_{MSY}	MSY	B_{MSY}/B_0	B_{2008}/B_0	$B_{2008}/$
$M = 0.10$	31,968	16,889	8,956	2,461	0.280	0.53	1.87
	(29,177-38,119)	(11,067-24,506)	(8,172- 10,683)	(2,246- 2,924)	(0.279-0.281)	(0.38-0.67)	(1.34-2.38)
$M = 0.087$	30,729	9,171	8,619	2,106	0.280	0.30	1.07
	(28,223-33,736)	(5,121-14,613)	(7,914- 9,468)	(1,932- 2,309)	(0.279-0.281)	(0.18-0.44)	(0.64-1.55)
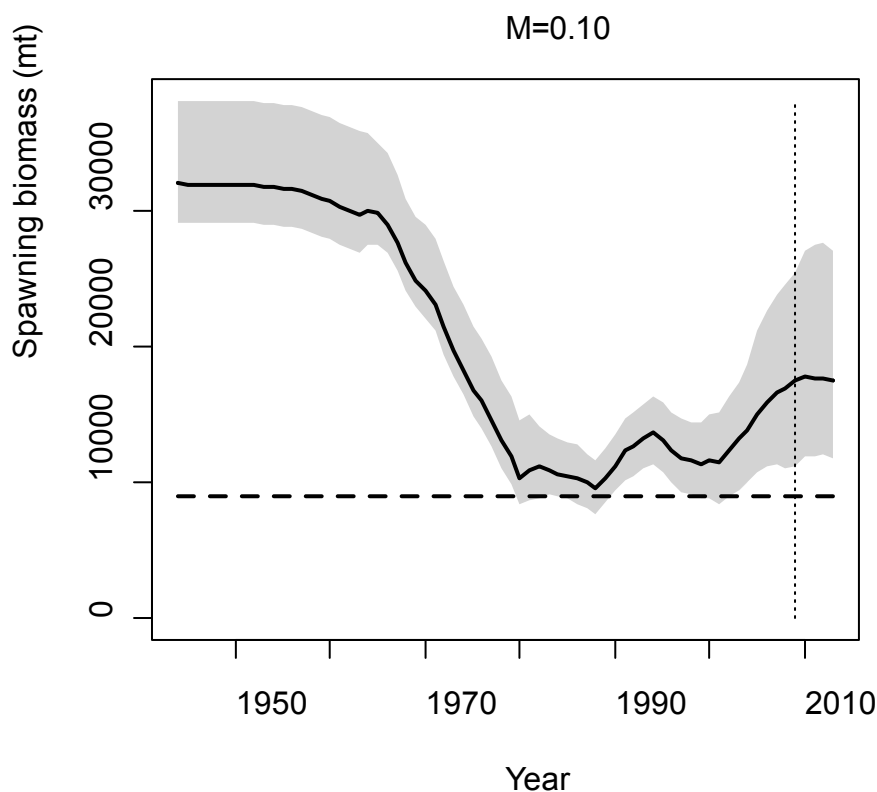
Figure 2: **Spawning biomass (female only) trajectory (median of MCMCs) for the model run with natural mortality at 0.10. 95% confidence intervals were derived from MCMC. The horizontal line represents the B_{MSY} and dashed vertical line represents the first year of the projection period (2009).**
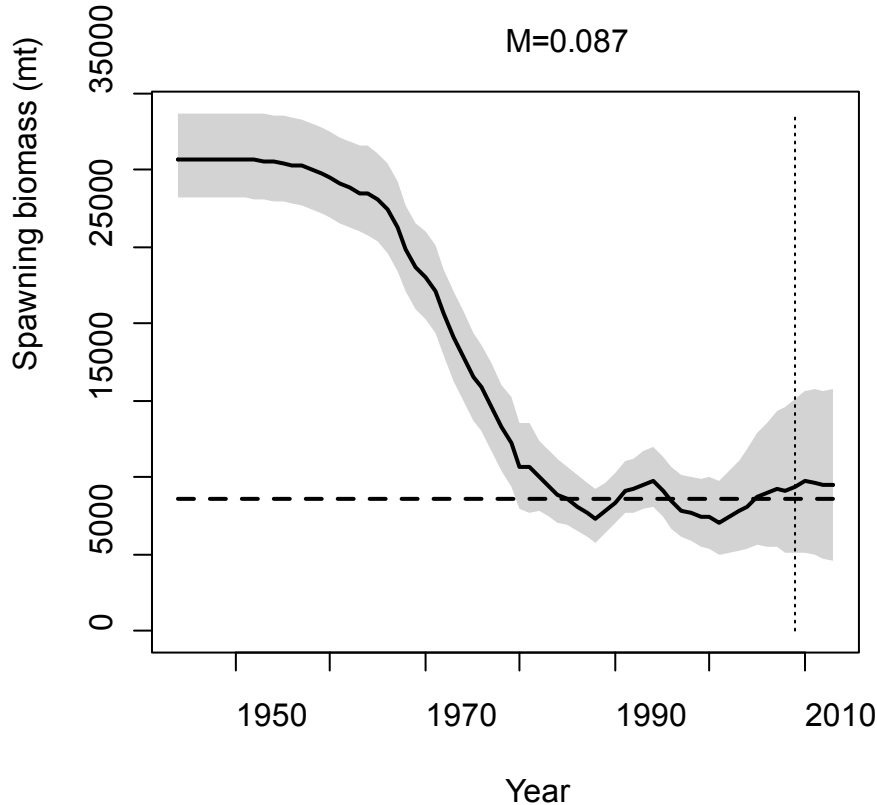
Figure 3: Spawning biomass (female only) trajectory (median of MCMCs) for the model run with natural mortality at 0.087. 95% confidence intervals were derived from MCMC. The horizontal line represents the B_{MSY} and dashed vertical line represents the first year of the projection period (2009).

Stock projections, for a five-year period, were conducted for the two accepted models ($M = 0.087$ and $M = 0.10$). The projections assumed a constant catch based on the TAC and an allowance for recreational and customary catch. For both models, the stock size is predicted to remain at about the current level over the next five years, and remain at or above the B_{MSY} level (probability of 61% and 100% for natural mortality of 0.087 and 0.10, respectively) with a high probability (95% and 100%, respectively) that the biomass will remain above 20% of the unexploited level (B_0). For both models the stock was virtually certain to remain above 10% of B_0 (Probability of 100% in both cases).

Table 8: Biomass estimates (medians, with 95% confidence intervals in parentheses) for model runs with the two plausible estimates of M. B_{2013} is the mid-year female spawning biomass in 2013. Estimates are derived from MCMC analysis. Probability (*Pr*) of the spawning biomass remaining above default reference points is also given.

	B_{2013}/B_{MSY}	B_{2013}/B_0	$Pr(B_{2013}>B_{MSY})$	$Pr(B_{2013}>0.2B_0)$	$Pr(B_{2013}>0.1B_0)$
$M = 0.10$	1.95	0.55	1.00	1.00	1.00
	(1.43-2.60)	(0.40-0.73)			
$M = 0.087$	1.08	0.31	0.61	0.95	1.00
	(0.55-1.68)	(0.15-0.47)			

4.2   Yield estimates

There are no new data that would alter the yield estimates given in the 1999 Plenary Report for the TRE 1, 2, and 3. The TRE 1 yield estimates are based on commercial landings data and the results of a historical stock reduction analysis. Yield estimates for TRE 2 and TRE 3 were derived from commercial landings data.

4.2.1 Estimation of Maximum Constant Yield (*MCY*)

The estimates of *MCY* are summarised in Table 8 and detailed in the following sections for each stock. The level of risk to the stock by harvesting the population at the estimated *MCY* value has not been determined.

TRE 1

An estimate of current surplus production (CSP) is available from a stock reduction analysis of the BoP fishery using data from 1973 to 1983. The stock was estimated to have fallen to between 0.3 and 0.7 of its initial size in the period. Using a modified estimate of absolute stock size from a tagging experiment in 1977 and conservative net stock productivity values (0.02-0.06 y^{-1}) the estimate for CSP in 1984 was 600 t. No new information has become available to permit updating the stock reduction analysis estimate of CSP made in 1984. Although not an estimate of equilibrium surplus production, this value for CSP was used to estimate *MCY* using the equation $MCY = 2/3$ CSP (Method 3). This is believed to be a conservative estimate of *MCY*.

$$MCY = 2/3 * 600 \text{ t} = 400 \text{ t}.$$

MCY was estimated using the equation $MCY = cY_{AV}$ (Method 4) for the Hauraki Gulf and North east coast sub-areas. Y_{AV} was set equal to the mean annual commercial landings for the decade 1977-86 and equalled 924 t. Based on an estimate of $M = 0.1$, c was set equal to 0.9.

$$MCY = 0.9 * 924 \text{ t} = 830 \text{ t}.$$

These *MCY* values were combined to provide the overall *MCY* estimate for TRE 1 of 1230 t. This estimate of *MCY* has not changed since the 1992 Plenary Report.

TRE 2 and TRE 3

MCY estimates using the equation $MCY = cY_{AV}$ (Method 4) with mean annual commercial landings for the decade 1977-86 and the natural variability factor c, set equal to 0.9 for these areas, has not changed since the 1989 Plenary Report.

4.2.2 Other yield estimates and stock assessment results

TRE 7

Estimates of *MSY* derived from the 2009 TRE 7 assessment were 2461 t (2246-2924) for $M = 0.1$ and 2106 t (1932-2309) for $M = 0.087$. The current commercial allowance is 2153 t.

4.2.3 Other factors

Trevally are caught by trawling, together with other species such as snapper, red gurnard and John dory. Mismatches between the proportions of quota held for these species in any year for individual quota holders may affect landings in any one year. As a result of the interaction between snapper and trevally in the TRE 7 trawl fishery, the trevally catch is sometimes constrained by the availability of snapper quota.

Catch sampling of the TRE 1 purse seine catch was carried out annually from 1997-98 to 2002-03. Catch-at-age sampling of TRE 1 caught by single trawl gear was reinstated during the 2006-07 fishing year (Walsh *et al.* 2009). Prior to this the TRE 1 single trawl fishery was last sampled in 1999-2000. The 1999-2000 single trawl samples had a broad range of age classes and a relatively strong 20+ aggregate year class (mean age 8.4 years). There were proportionally fewer older age classes in the 2006-07 single trawl samples and the 20+ aggregate year class was significantly smaller (mean age 6.9 years). In contrast, the age composition of TRE 1 purse seine catches sampled in 1999-00 and 2006-07 showed very little difference in age distribution (mean age 1999-00 9.6 years; mean age 2006-07 10.4 years). The purse seine method appears to select a narrow range of lengths and ages while single trawl catch probably provides better representation of "true" age structure of the stock (Walsh *et al.* 2009).

The 2006-07 TRE 7 catch-at-age study sampled catches from three spatial areas (90 mile beach; Kaipara Manukau; South Taranaki Bight). This was the first time area specific age information had been collected from TRE 7. Strong evidence of spatial heterogeneity in age structure was seen in the catch sampling results. Both 90 mile beach and Kaipara-Manukau sub-areas had a broad range of age classes but 90 mile beach was unique in having relatively high numbers of 3 and 4 year old fish. The Southern Taranaki Bight age composition differed markedly from the two northern areas having a very large proportion of fish older than 20 years and very few fish aged 3 and 4 years (Walsh *et al.* 2009). This pattern may have implications for stock assessment (if it is observed to be persistent) and is currently being investigated with additional catch-at-age programmes and CPUE analysis.

5.   STATUS OF THE STOCKS

TRE 1
The assessment for TRE 1 undertaken in 2006 was not accepted by the Pelagic Working Group due to the lack of a reliable abundance index. Recent catches reported for TRE 1 are less than the estimated *MCY* levels and below the TACC. Reduced proportions of older age classes in the single bottom trawl catch between 1999-00 and 2006-07 combined with the strong drops in landings in 2006-07 and 2007-08 may indicate that stock abundance is declining at current catch levels.

TRE 2
From 2002-03 to 2006-07 reported catches for TRE 2 were substantially larger (average 325 t) than the TACC (241 t) but fell to the level of the TACC in 2007-08. It is not known if these recent catches are sustainable.

TRE 7
Stock Structure Assumptions
Trevally occurring along the west coast of the North Island are believed to comprise a single stock.

Stock Status	
Year of Most Recent Assessment	2009
Assessment Runs Presented	Two alternate model runs, one with $M = 0.1$ and the other with $M = 0.087$, were used to evaluate TRE 7 status.
Reference Points[3] (Note: These have not actually been set by fisheries managers yet)	Target: Not established but B_{MSY} (28% B_0) assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Model run $M = 0.1$: B_{2008} estimated to be 38% - 67% B_0 (median = 53% B_0); Very Likely (> 90%) to be at or above the target Model Run $M = 0.087$: B_{2008} estimated to be 18% - 44% B_0 (median = 30% B_0); Likely (> 60%) to be at or above the target
Status in relation to Limits	Model Run $M = 0.1$: B_{2008} Very Unlikely (< 10%) to be below the Soft and Hard Limits Model Run 0.087 B_{2008} Very Unlikely (< 10%) to be below the Soft Limit and Hard Limits

Historical Stock Status Trajectory and Current Status
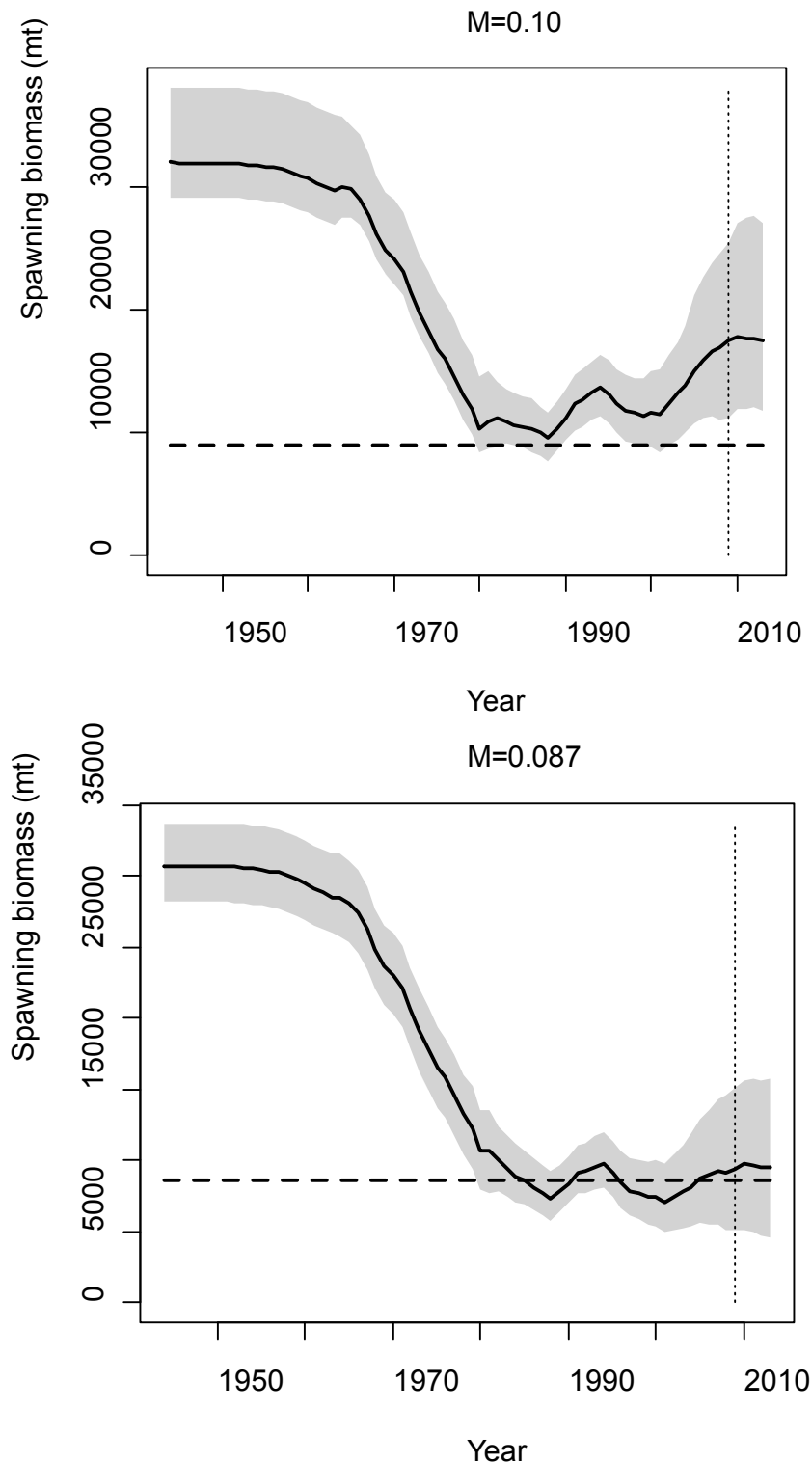
Spawning biomass (female only) trajectories (median of MCMCs) for the model runs with natural mortality at 0.10 and 0.087. 95% confidence intervals were derived from MCMC. The horizontal line represents the B_{MSY} and dashed vertical line represents the first year of the projection period (2009).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Spawning Biomass is estimated to have declined gradually during the 1940s and 1950s. The rate of decline increased in the 1960s and 1970s consistent with the increase in the total annual catch. Since 1980 spawning biomass appears to have remained fairly stable ($M = 0.087$), or to have increased to 2008 ($M = 0.1$).

Recent Trend in Fishing Mortality or Proxy	- Relatively large proportions of fish > 10 years, including a healthy 20+ age group (as evidenced by the age structure of the commercial catch) suggest that TRE 7 have not been heavily exploited.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Model projections indicate that the biomass of TRE 7 stock is About as Likely as Not (40-60%) to remain stable over the next 5 years and the probability of the stock going below B_{MSY} in 2013 is estimated at 0% ($M = 0.1$) and 38% ($M = 0.087$).
Probability of Current Catch or TACC causing decline below Limits (5 years)	Model Run $M = 0.1$: B_{2013} Very Unlikely (< 10%) to decline below Soft and Hard Limits. Model Run 0.087: B_{2013} Very Unlikely (< 10%) to decline below Soft Limit and Very Unlikely (< 10%) to decline below Hard Limit.

Assessment Methodology	
Assessment Type	Level 1 - Quantitative stock assessment
Assessment Method	Age-structured Stock Synthesis model with Bayesian estimation of posterior distributions.
Main data inputs	- Proportions at age data from the commercial fisheries and historic trawl surveys. - Estimates of biological parameters. - Standardised CPUE index of abundance
Period of Assessment	Latest assessment: 2009 Next assessment: 2013
Changes to Model Structure and Assumptions[10]	Primary differences in the models used in the previous (2005) and current (2009) assessments are as follows: • Additional data, including three years catch-at-age and an updated CPUE index. • Refinement of the assumed level of unreported catch since 1986. • Change in model software from CASAL to Stock Synthesis. This was demonstrated to have minimal effect on the model results. • A change in the definition of adult biomass with knife-edge maturity at 5 years old (it was previously assumed that all fish were mature). • Estimation of separate selectivities for the periods pre and post 1986 to account for an increase in trawl mesh size associated with the introduction of a minimum legal size.
Major Sources of Uncertainty	The model allows only a narrow range of plausible M, which does not reflect real uncertainty in this parameter.

Qualifying Comments
Analysis of the age structure of commercial bottom trawl catches in 2006-07 suggest there may be some spatial structure within TRE 7 stock. Future TRE 7 assessments may need to be spatially structured.

Fishery Interactions
Main QMS bycatch species are snapper, red gurnard, John dory and tarakihi.

Yield estimates, TACCs and reported landings by Fishstock are summarised in Table 9.

Table 9: Summary of yields (t), TACCs (t) and reported landings (t) of trevally for the most recent fishing year.

Fishstock	QMA		*MCY*	2010-11 Actual TACC	2010-11 Commercial landings
TRE 1	Auckland (East)	1	1 230	1 507	1 408
TRE 2	Central (East)	2	310	241	245
TRE 3	South-East, Chatham, Southland and Sub-Antarctic	3, 4, 5, 6	5	22	< 1
TRE 7	Auckland (West), Central (West), Challenger	7, 8, 9	*see assessment	2 153	1 922
TRE 10	Kermadec	10	0	10	0
Total				3 933	3 575

6. FOR FURTHER INFORMATION

Annala J.H. *et al*. (Comps). 1999. Report from the Fishery Assessment Plenary, May 1999: stock assessment and yield estimates. Unpublished report held in NIWA library, Wellington.

Annala J.H. *et al*. (Comps). 2004. Report from the Fishery Assessment Plenary, May 2004: stock assessment and yield estimates. Unpublished report held in NIWA library, Wellington.

Bradford E. 1997. Estimated recreational catches from Ministry of Fisheries North region marine recreational fishing surveys, 1993-94. New Zealand Fisheries Assessment Research Document 1997/7: 16 p.

Bradford E. 1998. Harvest estimates from the 1996 national recreational fishing surveys. New Zealand Fisheries Assessment Research Document 1998/16: 27p.

Boyd R.O., Reilly J.L. 2002. 1999/2000 National marine recreational fishing survey: harvest estimates. Draft New Zealand Fisheries Assessment Report 2002 .Rec1998-03 obj. 2

Boyd R.O., Gowing L., Reilly J.L. 2004. 2000-2001 National marine recreational fishing survey: diary results and harvest estimates. New Zealand Fisheries Assessment Report 2004.

Francis M.P., Bradford E., Paul L.J. 1999. Trevally catch per unit effort in TRE 7. New Zealand Fisheries Assessment Research Document 1999/13: 27p. (Unpublished report held in NIWA library, Wellington.)

Gilbert D.J. 1988. Trevally. New Zealand Fisheries Assessment Research Document 1988/29: 28 p.

Hanchet S.M. 1999. Stock assessment of Trevally (*Caranx georgianus*) in TRE 7. New Zealand Fisheries Assessment Research Document 1999/55: 20p.

Hartill B., Bian R., Armiger H., Vaughan M., Rush N. 2007. Recreational marine harvest estimates of snapper, kahawai, and kingfish in QMA 1 in 2004-05. New Zealand Fisheries Assessment Report 2007/26. 44 p

Hartill B., Bian R., Davies N.M. 2008. Review of methods used to estimate recreational harvests.

James G.D. 1980. Tagging experiments on trawl-caught trevally, *Caranx georgianus*, off north-east New Zealand. New Zealand Journal of Marine and Freshwater Research 14 (3): 249-254.

James G.D. 1984. Trevally. *Caranx georgianus*: age determination, population biology and fishery. Ministry of Agriculture and Fisheries. Fisheries Research Bulletin; 25. 51 p.

Kendrick T.H., Bentley N. 2009. Fishery characterisation and catch-per-unit-effort indices for trevally in tre 7; 1989-90 to 2007-08. Draft FAR

Langley A.D. 2001. Length and age composition of trevally in commercial landings from TRE 1 and TRE 7, 1999-2000. New Zealand Fisheries Assessment Report 2001/42: 32 p.

Langley A.D. 2002a. Length and age composition of trevally in commercial landings from TRE 1 and TRE 7, 2000-01. New Zealand Fisheries Assessment Report 2002/19: 34 p.

Langley A.D. 2002b. Analysis of catch and effort data from the TRE 7 fishery. New Zealand Fisheries Assessment Report 2002/32: 28p.

Langley A.D. 2003. Length and age composition of trevally in commercial landings from TRE 1, 2001-02. New Zealand Fisheries Assessment Report 2003/48: 18p

Langley A.D. 2004. Length and age composition of trevally (*Pseudocaranx dentex*) in commercial landings from the TRE 1 purse-seine fishery, 2002-03. New Zealand Fisheries Assessment Report 2004/39: 17 p

Langley A.D, Maunder M 2009. Stock assessment of TRE 7 Draft FAR

Maunder M.N., Langley A.D. 2004. Integrating the standardisation of catch-per-unit-effort into stock assessment models: testing a population dynamics model and using multiple data types. Fisheries Research 70 (2-3): 389-395.

McKenzie A. 2008. Standardised CPUE analysis and stock assessment of the west coast trevally fishery (TRE 7). New Zealand Fisheries Assessment Report 2008/44.

Taylor P.R. In review. Developing indices of relative abundance from observational aerial sightings of inshore pelagic finfish; step 1, exploring the data. Draft New Zealand Fisheries Assessment Report. 66 p.

Teirney L.D., Kilner A.R., Millar R.E., Bradford E., Bell J.D. 1997. Estimation of recreational catch from 1991/92 to 1993/94. New Zealand Fisheries Assessment Research Document 1997/15: 43 p.

Walsh C., McKenzie J., Ó Maolagáin C., Stevens D. 1999. Length and age composition of trevally in commercial landings from TRE 1 and TRE 7, 1997-98. NIWA Technical Report 66. ISSN 1174-2631.

Walsh C., McKenzie J.M. 2010. Review of length and age sampling for trevally in TRE 1 and TRE 7. New Zealand Fisheries Assessment Report 2010/09 27 p.

Walsh C., McKenzie J.M., Ó Maolagáin C., Buckthought D., Blackwell R., James G.D., Rush N. 2009. Length and age composition of commercial trevally landings in TRE 1 and TRE 7, 2006-07.

TRUMPETER (TRU)

(*Latris lineata*)
Kohikohi
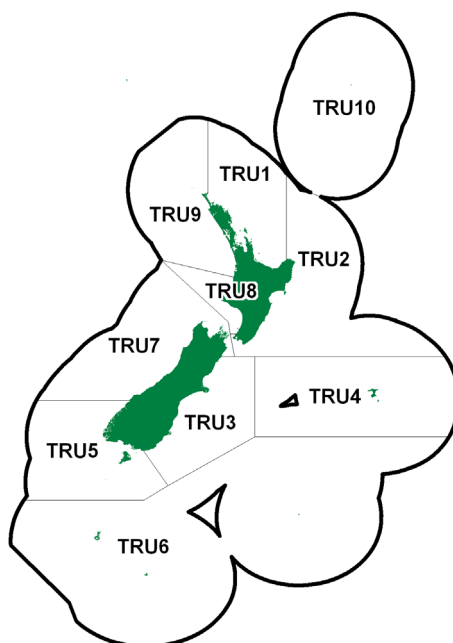
1. FISHERY SUMMARY

1.1 Commercial fisheries

Total reported landings of trumpeter were generally less than 10 t until the early 1980s, when they increased steadily to reach 162 t in 1995-96 (Tables 1 & 2). Since 1995-96 landings continued to decrease, reaching 25 t in 2000-01 and remaining at that level in 2001-02. Over recent years landings have increased, with over 100 t reported in the 2007-08 fishing year. Historic under-reporting is probable (Paul 1999).

Most landings of trumpeter have come from the east coast between the eastern Bay of Plenty and Southland. There have been changes over time in contributions from different parts of the east coast, but the reason for this is not known. Until the early 1950s most landings were made in QMA 3. From the mid 1950s until the mid 1980s most landings were in QMA 2. The rapid increase in landings since the mid 1980s has come predominantly from QMAs 3 and 4, reportedly from an increase in line fishing on the outer shelf and in the Mernoo Bank region. Landings in QMA 3 and 4 have declined in the last few years, falling well below the TACC. Figure 1 shows the historical landings for TRU from 1936.

Most trumpeter is taken as bycatch in line-fisheries; a small amount is trawled, and from the 1970s it has also been taken by setnet. Only a small proportion of trumpeter is targeted. Catches are irregular with no seasonal trend and are likely to be driven by fishing activities for other species. No information on changes in fishing effort is available.

Trumpeter have been managed under the Quota Management System in New Zealand since 1 October 1988 with a TACC of 144 t (Ministry of Fisheries Science Group 2006). The TACC was increased to this level in October 2001 following a period of declining landings, and landings have never reached this TACC (the greatest landings in the last eight years were 90 t in 2004-05, and the next greatest landings were 51 t). In recent years (2004/05 to 2009/10), significant landings have come only from TRU 4 (Table 2) on the Chatham Rise, with small landings also coming from TRU 2, 3, 5, and 7 (south-eastern North Island and South Island). Trumpeter are also taken by recreational fishers in southern New Zealand, and although good estimates of recreational catch are not available, they may be around one-third to one-half of the commercial.

Table 1: Reported total landings (t) of trumpeter from 1931 to 1982. Values for 1931 through 1944 are April-March years, listed against the April year. Fisheries Annual Report (1931 to 1974) or FSU data (Paul 1999).

Year	Landings	Year	Landings	Year	Landings	Year	Landings	Year	Landings
1936	20	1946	16	1956	5	1965	4	1974	5
1937	41	1947	13	1957	5	1966	5	1975	4
1938	30	1948	19	1958	3	1967	7	1976	3
1939	37	1949	6	1959	3	1968	5	1977	3
1940	17	1950	6	1960	3	1969	5	1978	6
1941	11	1951	11	1961	3	1970	7	1979	17
1942	5	1952	11	1962	4	1971	10	1980	10
1943	5	1953	5	1963	3	1972	4	1981	12
1944	11	1954	5	1964	3	1973	5	1982	37
1945	11	1955	6						

Table 2: Reported landings (t) of trumpeter by QMA and fishing year, 1983-84 to 2010-11*.

Fishstock	TRU 1		TRU 2		TRU 3		TRU 4		TRU 5	
FMA	1		2		3		4		5	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1982-83	0	-	5	-	3	-	0	-	0	-
1983-84	1	-	17	-	2	-	0	-	1	-
1984-85	0	-	15	-	3	-	0	-	4	-
1985-86	0	-	4	-	6	-	0	-	1	-
1986-87	0	-	4	-	5	-	0	-	5	-
1987-88	0	-	4	-	4	-	0	-	0	-
1988-89	0	-	7	-	1	-	0	-	0	-
1989-90	0	-	8	-	5	-	0	-	0	-
1990-91	3	-	16	-	13	-	5	-	0	-
1991-92	1	-	16	-	25	-	19	-	1	-
1992-93	3	-	21	-	21	-	4	-	1	-
1993-94	3	-	17	-	26	-	24	-	2	-
1994-95	2	-	20	-	27	-	65	-	5	-
1995-96	2	-	19	-	29	-	69	-	37	-
1996-97	2	-	16	-	35	-	33	-	42	-
1997-98	1	-	11	-	28	-	23	-	6	-
1998-99	< 1	1	11	9	15	28	16	42	4	18
1999-00	< 1	1	6	9	11	28	8	42	5	18
2000-01	< 1	1	6	9	7	28	6	42	3	18
2001-02	< 1	3	6	20	5	33	9	59	< 1	22
2002-03	< 1	3	7	20	7	33	32	59	1	22
2003-04	1	3	6	20	7	33	24	59	4	22
2004-05	< 1	3	5	20	8	33	70	59	3	22
2005-06	< 1	3	7	20	8	33	65	59	3	22
2006-07	< 1	3	8	20	16	33	66	59	3	22
2007-08	1	3	9	20	22	33	63	59	4	22
2008-09	< 1	3	9	20	21	33	19	59	6	22
2009-10	< 1	3	8	20	22	33	56	59	5	22
2010-11	< 1	3	5	20	15	33	78	59	8	22

1.2 Recreational fisheries

Results from two separate recreational fishing surveys undertaken in the 1990s are shown in Table 3. Most of the recreational catch was taken in QMAs 3, 5 and 7 with a marked increase in catch reported in QMA 5 in 1996 compared to the early 1990s. Provisional estimates of the tonnage of the recreational catch can be derived by multiplying the total number of fish by a mean weight of 1 kg. Note, however, this mean weight was derived from a sample of mainly small fish and is possibly unrepresentative, so an estimate of the recreational catch by weight may have been underestimated. The Recreational Technical Working Group concluded that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and c) the 2000 and 2001 estimates are implausibly high for many important fisheries.

1.3 Customary non-commercial fisheries

The customary non-commercial take has not been quantified.

1.4 Illegal catch

There is no quantitative information on illegal fishing activity or catch.

1.5 Other sources of mortality

No quantitative estimates are available regarding the impact of other sources of mortality on trumpeter stocks. Trumpeter principally occur on deep coastal reefs, where they are taken in net and line fisheries targeted at other species.

Table 2 [Continued].

Fishstock	TRU 6		TRU 7		TRU 8		TRU 9			
FMA	6		7		8		9		Total	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1982-83	0	-	0	-	0	-	0	-	8	-
1983-84	0	-	0	-	0	-	0	-	21	-
1984-85	0	-	0	-	0	-	0	-	22	-
1985-86	0	-	0	-	0	-	0	-	11	-
1986-87	0	-	2	-	0	-	0	-	16	-
1987-88	0	-	0	-	0	-	0	-	8	-
1988-89	0	-	1	-	0	-	0	-	9	-
1989-90	0	-	0	-	1	-	0	-	14	-
1990-91	0	-	7	-	0	-	0	-	44	-
1991-92	0	-	4	-	0	-	0	-	69	-
1992-93	0	-	4	-	2	-	0	-	56	-
1993-94	0	-	6	-	0	-	0	-	78	-
1994-95	0	-	4	-	0	-	0	-	123	-
1995-96	0	-	6	-	0	-	0	-	162	-
1996-97	2	-	3	-	< 1	-	< 1	-	133	-
1997-98	< 1	-	3	-	< 1	-	0	-	72	-
1998-99	0	0	3	2	< 1	0	0	0	50	100
1999-00	0	0	2	2	< 1	0	0	0	33	100
2000-01	0	0	3	2	< 1	0	< 1	0	25	100
2001-02	0	0	5	6	< 1	1	0	0	25	144
2002-03	0	0	3	6	< 1	1	< 1	0	51	144
2003-04	0	0	2	6	< 1	1	< 1	0	44	144
2004-05	0	0	4	6	< 1	1	0	0	90	144
2005-06	0	0	4	6	< 1	1	0	0	88	144
2006-07	0	0	4	6	< 1	1	0	0	99	144
2007-08	< 1	0	2	6	< 1	1	< 1	0	101	144
2008-09	0	0	2	6	< 1	1	< 1	0	63	144
2009-10	0	0	3	6	< 1	1	0	0	95	144
2010-11	< 1	0	4	6	< 1	1	< 1	0	110	144

*The data in this table have been updated from those published in previous Plenary Reports by using the data through 1996–97 in table 41 on p. 288 of the "Review of Sustainability Measures and Other Management Controls for the 1998–99 Fishing Year - Final Advice Paper" dated 6 August 1998. There are no landings reported from TRU 10, which has a TAC of 0.
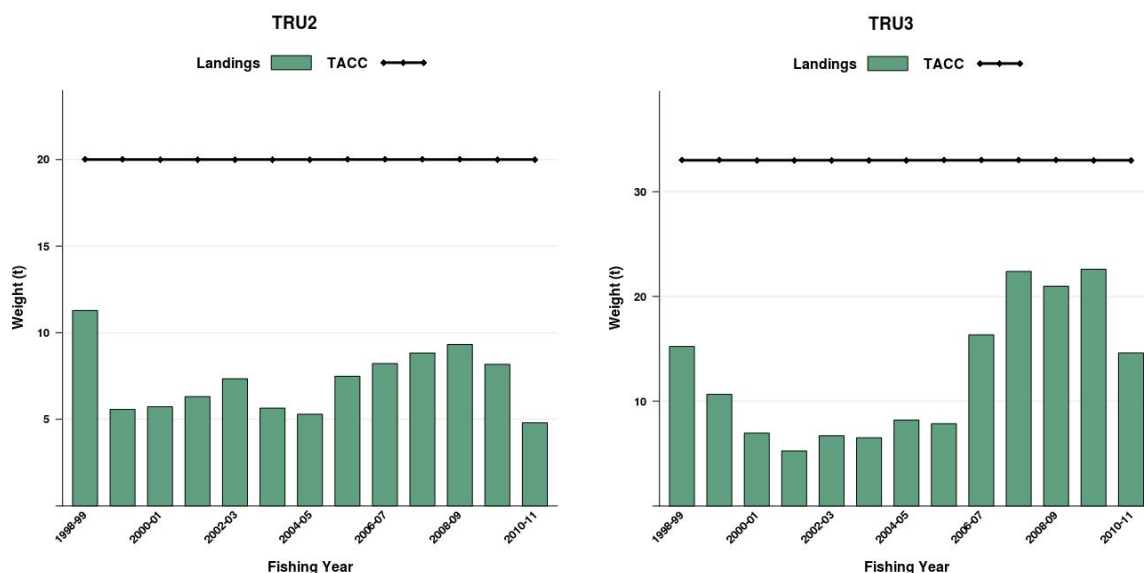
Figure 1: Historical landings and TACC for the four main TRU stocks. From top left to bottom right: TRU2 (Central East) and TRU3 (South East Coast). Note that these figures do not show data prior to entry into the QMS.
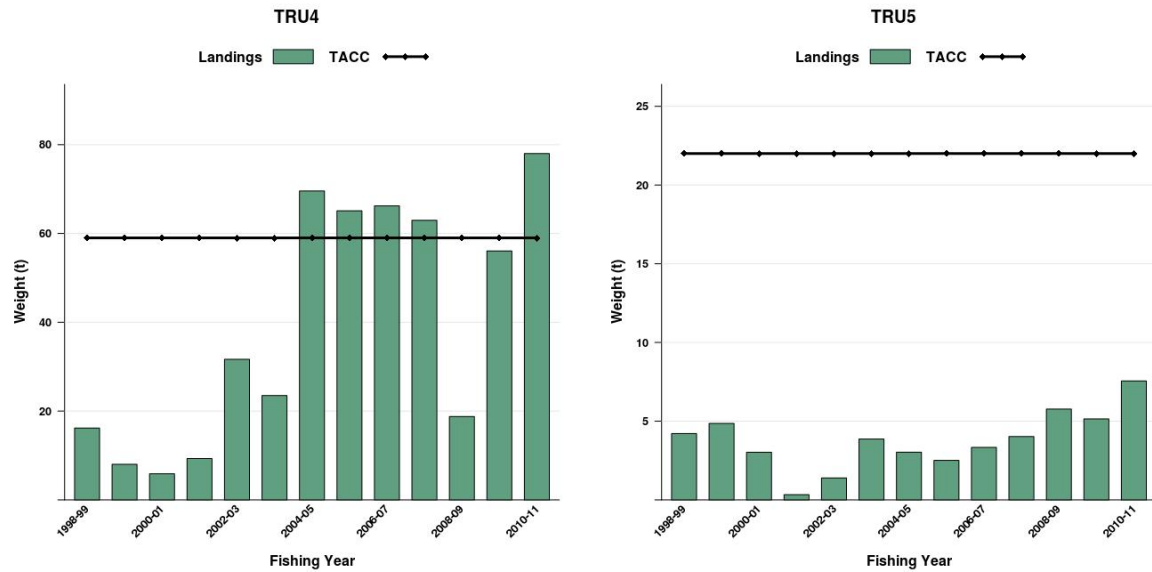
Figure 1 [Continued]: Historical landings and TACC for the four main TRU stocks. From top left to bottom right: TRU4 (South East Chatham Rise) and TRU5 (Southland). Note that these figures do not show data prior to entry into the QMS.

Table 3: Estimated number of trumpeter caught by recreational fishers by QMA and survey. Surveys were carried out in different years in Ministry of Fisheries regions: South in 1991-92, Central in 1992-93, North in 1993-94 and National in 1996 (Bradford 1998).

FMA	Survey	Number	Total CV (%)
1991-92			
FMA 3	South	6 000	29
FMA 5	South	6 000	33
FMA 7	South	8 000	-
1992-93			
FMA 2	Central	1 000	-
FMA 3	Central	3 000	-
FMA 5	Central	1 000	-
FMA 7	Central	0	-
FMA 8	Central	0	-
1993-94			
FMA 1+9	North	0	-
FMA 2	North	1 000	-
FMA 8	North	0	-
1996			
FMA 1	National	< 500	-
FMA 2	National	1 000	-
FMA 3	National	13 000	19
FMA 5	National	21 000	19
FMA 7	National	3 000	-

2.   BIOLOGY

Trumpeter have a Southern Hemisphere distribution in cool temperate waters. They occur in New Zealand, Australia, the subantarctic islands of the southern Indian and Atlantic oceans, the Foundation Seamount in the central South Pacific, and possibly off Chile (Roberts 2003, Tracey & Lyle 2005). In New Zealand, trumpeter occur from the Three Kings Islands through all of mainland New Zealand to the Auckland Islands; however they are rare north of East Cape and Cape Egmont (Kingsford *et al*. 1989, Francis 1996, 2001). The greatest concentrations of trumpeter apparently occur on the Chatham Rise and around the southern South Island and Stewart Island.

Trumpeter have an extended larval and postlarval duration of up to 9 months in surface waters (Tracey & Lyle 2005), resulting in extensive drift of young fish among geographic regions. Juveniles are largely sedentary, but some adults are highly migratory with tagged fish travelling 650 km from Tasmania to southern New South Wales, and 5800 km from Tasmania to St Paul Island in the southern Indian Ocean (Lyle & Murphy 2002). This suggests there is one circum-global genetic stock in the Southern Hemisphere, though analysis of otolith morphometrics from Tasmania and St Paul and Amsterdam Islands showed regional variation (Tracey et al. 2006) suggesting that migration and inter-breeding may be limited.

Trumpeter occur mainly over rocky reefs ranging from shallow inshore waters to deep reefs on the central continental shelf. In New Zealand, they apparently range from a depth of a few metres down to about 200 m. In Australia some reports indicate they may go as deep as 300 m (reviewed by Paul 1999). Fish inhabiting inshore reefs tend to be smaller, whereas fish from deep reefs tend to be much larger. Trumpeter initially settle on to inshore reefs at the end of their long postlarval period, where they remain for several years, before migrating into deeper areas as they reach maturity (Tracey & Lyle 2005).

Some biological traits differ between New Zealand and Tasmanian populations. Notably, trumpeter are thought to spawn in winter (July) in New Zealand (Graham 1939), and late winter to spring in Australia (peaking around September in Tasmania) (Ruwald et al. 1991, Furlani & Last 1993, Morehead 1998, Morehead et al. 1998, 2000, Furlani & Ruwald 1999). However, the New Zealand data seem to be based on limited sampling, and it is uncertain whether the apparent regional difference is real.

Trumpeter grow to about 110-120 cm fork length (FL) and 25-27 kg weight in New Zealand and Australia (Gomon et al. 1994, Paul 1999, Francis 2001). Nothing is known about growth, longevity or maturity in New Zealand waters. However, because of their importance for aquaculture in Australia, a comprehensive study has recently been completed on their age and growth in Tasmania (Tracey & Lyle 2005, Tracey et al. 2006). Partial validation of age estimates was completed there by comparison of otolith growth in known-age reared fish and wild fish (enabling validation of the time of formation of the first growth band), and tracking a strong wild cohort over seven years (ages 1+ to 7+). Although full validation was not achieved, the authors considered their ages validated up to and beyond the size and age of habitat transition.

In Australia, trumpeter grow rapidly during the first 4-5 years, reaching about 45 cm FL at that stage, and moving offshore to deeper water (Tracey & Lyle 2005, Tracey et al. 2006). At that time, there is a reduction in growth rate. They reach a maximum age of about 43 years (though the largest fish in the samples was 95 cm FL, which is well below the reported maximum length of 120 cm), and there are no clear differences between males and females (though small sample sizes of fish older than 10 years meant the power to detect differences was low). Similarly, no differences were found in growth rates between fish from Tasmania and St Paul and Amsterdam Islands. Growth rates are seasonally variable, at least for the first few years, with maximum growth in late summer-autumn. It is thought that maturation coincides with the offshore movement to deep habitat.

In New Zealand, the only population information available for trumpeter comes from a 6-year survey (1994-1999) in Paterson Inlet, Stewart Island. Chadderton & Davidson (2003) carried out underwater visual counts, and obtained comprehensive length-frequency distributions from 1,065 fish caught by rod at 12-15 different sites. Their length-frequency data show two or three clear juvenile cohorts which progress through time (a strong cohort was also found in Tasmania by Tracey & Lyle (2005)). Chadderton & Davidson (2003) interpreted this as evidence of variable annual recruitment pulses. Their largest fish was 46.9 cm FL with few fish over 40 cm in most years. This is consistent with evidence from Australia of offshore migration at about 45 cm, though the migration may occur at a slightly smaller size in the New Zealand population.

3.   STOCKS AND AREAS

There are no data relevant to stock boundaries in New Zealand. Trumpeter are potentially wide-ranging, and there is one circum-global genetic stock in the Southern Hemisphere, although analysis of otolith morphometrics from Tasmania and St Paul and Amsterdam Islands showed regional variation (Tracey *et al*. 2006) suggesting that migration and inter-breeding may be limited. Therefore there may be localised populations in areas of suitable habitat as they seem to be restricted to rocky reef habitat.

4.   STOCK ASSESSMENT

4.1   Estimates of fishery parameters and abundance
No estimates are available.

4.2   Biomass estimates
No estimates are available.

4.3   Estimation of Maximum Constant Yield (*MCY*)
No estimate of *MCY* is available.

The level of risk to the stock by harvesting trumpeter at recent catch levels cannot be determined.

4.4   Estimation of Current Annual Yield (*CAY*)
No estimates of current biomass, fishing mortality, or other information are available which would permit the estimation of *CAY*.

4.5   Other factors
There is anecdotal information from Australia and New Zealand that localised populations of trumpeter can be quickly depleted.

5.   STATUS OF THE STOCKS

No estimates of current and reference biomass are available.

It is not known if recent catch levels are sustainable.

TACCs and reported landings of trumpeter for the 2010-11 fishing year are summarised in Table 4.

Table 4: Recreational and customary non-commercial allowances (t), Total Allowable Commercial Catches (TACC, t) and Total Allowable Catch (TAC, t), along with reported landings (t) of trumpeter for the most recent fishing year.

Fishstock		FMA	TAC	TACC	Customary	Recreational	2010-11 Reported Landings
TRU 1	Auckland (East)	1	5	3	1	1	< 1
TRU 2	Central (East)	2	22	20	1	1	5
TRU 3	South-east (Coast)	3	53	33	7	13	15
TRU 4	South-east (Chatham)	4	59	59	0	0	78
TRU 5	Southland	5	54	22	11	21	8
TRU 6	Sub-Antarctic	6	0	0	0	0	0
TRU 7	Challenger	7	11	6	2	3	4
TRU 8	Central (West)	8	1	1	0	0	< 1
TRU 9	Auckland (West)	9	0	0	0	0	<1
TRU 10	Kermadec	10	0	0	0	0	0
Total			205	144	22	39	110

6.   FOR FURTHER INFORMATION

Bradford E. 1998. Harvest estimates from the 1996 national recreational fishing surveys. New Zealand Fisheries Assessment Research Document 1998/16. 27p.

Chadderton W.L., Davidson R.J. 2003: Baseline monitoring report on fish from the proposed Paterson Inlet (Waka a Te Wera) marine reserve, Stewart Island (Rakiura) 1994 to 1999. Prepared by Davidson Environmental Ltd for Department of Conservation, Southland. Research, survey and monitoring report 168. 47 p.

Francis M.P. 1996: Geographic distribution of marine reef fishes in the New Zealand region. New Zealand journal of marine and freshwater research 30: 35-55.

Francis M. 2001: Coastal fishes of New Zealand. An identification guide. Third edition. Reed Publishing, Auckland. 103 p.

Furlani D., Last P. 1993. Trumpeter. *In*: Kailola *et al*. (Eds), Australian Fisheries Resources. Bureau of Resource Sciences, Canberra: 403.

Furlani D.M., Ruwald F.P. 1999: Egg and larval development of laboratory-reared striped trumpeter Latris lineata (Forster in Bloch and Schneider 1801) (Percoidei: Latridiidae) from Tasmanian waters. New Zealand journal of marine and freshwater research 33: 153-162.

Graham D.H. 1938. Fishes of Otago Harbour and adjacent seas, with additions to previous records. Transactions and Proceedings of the Royal Society of New Zealand 68(3): 399-419.

Graham D.H. 1939a. Food of the fishes of Otago Harbour and adjacent sea. Transactions of the Royal Society of New Zealand 68(4): 421-36.

Graham D.H. 1939b. Breeding habits of the fishes of Otago Harbour and adjacent seas. Transactions and Proceedings of the Royal Society of New Zealand 69(3): 361-372.

Graham D.H. (1956). A Treasury of New Zealand Fishes. Reed, Wellington. 424p.

Gomon M.F., Glover J.C.M., Kuiter R.H. (eds) 1994: The fishes of Australia's south coast. State Print, Adelaide. 992 p.

Kingsford M.J., Schiel D.R., Battershill C.N. 1989: Distribution and abundance of fish in a rocky reef environment at the subantarctic Auckland Islands, New Zealand. Polar biology 9: 179-186.

Lyle J., Murphy R. 2002: Long distance migration of striped trumpeter. Fishing today 14(6): 16.

Morehead D.T., Pankhurst N.W., Ritar A.J. 1998: Effect of treatment with LHRH analogue on oocyte maturation, plasma sex steroid levels and egg production in female striped trumpeter Latris lineata (Latrididae). Aquaculture 169: 315-331.

Paul L.J. 1999. A summary of biology and commercial landings, and a stock assessment of the trumpeter, *Latris lineata* (Bloch and Schneider 1801) (*Latrididae*) in New Zealand waters. New Zealand Fisheries Assessment Research Document 1999/8. 20p.

Ruwald F.P., Searle L.D., Oates L.A. 1991. A preliminary investigation into the spawning and larval rearing of striped trumpeter, *Latris lineata*. Technical Report, Sea Fisheries Research Laboratory, Division of Sea Fisheries, Tasmania, No: 44. 17p.

Roberts C.D. 2003: A new species of trumpeter (Teleostei; Percomorpha; Latridae) from the central South Pacific Ocean, with a taxonomic review of the striped trumpeter Latris lineata. Journal of the Royal Society of New Zealand 33. 731-754.

Teirney L.D., Kilner A.R., Millar R.E., Bradford E. Bell J.D. 1997. Estimation of recreational catch from 1991/92 to 1993/94. New Zealand Fisheries Assessment Research Document 1997/15. 43p.

Tracey S.R., Lyle J.M. 2005: Age validation, growth modelling, and mortality estimates for striped trumpeter (Latris lineata) from southeastern Australia: making the most of patchy data. Fishery bulletin 103: 169-182.

Tracey S.R., Lyle J.M., Duhamel G. 2006: Application of elliptical Fourier analysis of otolith form as a tool for stock identification. Fisheries research 77: 138-147.

TUATUA (TUA)

(*Paphies subtriangulata*)
Tuatua
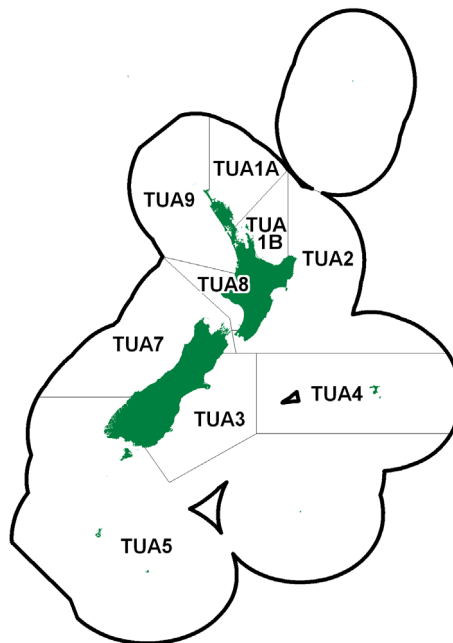
1. FISHERY SUMMARY

Tuatua (*Paphies subtriangulata*) were introduced into the QMS on 1 October 2005. The fishing year runs from 1 October to 30 September, and commercial catches are measured in greenweight. In October of 2005 all TUA QMAs were allocated customary and recreational catch allowances. A breakdown of all each QMA Total Allowable Catch (TAC) is listed in Table 1.

1.1 Commercial fisheries

QMA boundaries for tuatua were set the same as those established for FMAs, except for FMA 1 (the area between North Cape and Cape Runaway), which was divided into two QMAs, TUA 1A and TUA 1B, on either side of Te Arai Point (Pakiri Beach). The formerly specified historic commercial areas within TUA 1B (Papamoa domain to Maketu Beach, Bay of Plenty) and TUA 9 (i.e., Ninety Mile Beach, Hokianga Harbour to Maunganui Bluff, and specific areas between Maunganui Bluff to the North Head of the Kaipara Harbour) were revoked, and regulations were amended to remove the commercial daily catch limits for tuatua, which were no longer applicable. Commercial fishing was allowed to continue only in TUA 9 in the specified commercial area of the Kaipara Harbour entrance. A TACC of 43 t, which reflected the average of the reported landings taken from the Kaipara fishery between 1990-91 and 2003-04, was allocated to the TUA 9 stock in recognition that commercial tuatua fishing was constrained to the Kaipara Harbour entrance.

There is no minimum legal size (MLS) for tuatua, although fishers probably favor large individuals. Tuatua are available for harvest year-round, so there is no apparent seasonality in the fishery. Significant landings since 1989-90 have been reported from TUA 9 only (Table 2), and there have been no reported landings from TUA 5, TUA 6, and TUA 8. Landings from TUA 9 reached a peak of 192 t in 1997-98, and subsequently decreased, ranging from 4 to 76 t (average 32 t) between 1998-99 and 2003-04. This decline in commercial catches from the Kaipara bed is probably related to historic participants retiring from the fishery. The commercial effort had greatly reduced by 1992, post moratorium implementation, and catches have been influenced by the fact that commercial fishing is intermittent with only one or two fishers involved. No landings were reported from TUA 9 for 2004-05 to 2009-10.

Table 1: Recreational, customary, and other mortality allowances (t); Total Allowable Commercial Catches (TACC, t) and Total Allowable Catch (TAC, t) declared for TUA in October 2005.

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other Mortality	TACC	TAC
TUA 1A	40	40	4	0	84
TUA 1B	60	60	6	0	126
TUA 2	3	3	1	0	7
TUA 3	3	3	1	0	7
TUA 4	1	1	1	0	3
TUA 5	1	1	1	0	3
TUA 7	1	1	1	0	3
TUA 8	1	1	1	0	5
TUA 9	26	26	7	43	102

Table 2: Reported landings (t) of tuatua (*Paphies subtriangulata*) by Fishstock from 1989-90 to 2010-11. Data up to 2003-04 taken from page 163 of MFish's Initial Position Paper (IPP), dated 31 March 2005, data since from CELR and CLR (early CELR and CLR data erroneously record commercial landings from FMA 9 as FMA 1 because permit holders were not filling in the forms correctly). There have been no reported landings of tuatua in TUA 5, TUA 6, and TUA 8. There were no landings reported from 2004-05 to 2010-11. Tuatua were introduced into the QMS on 1 October 2005; a TACC of 43 t was allocated (to TUA 9 only), and FMA 1 was divided into TUA 1A and TUA 1B.

Year	TUA 1	TUA 2	TUA 3	TUA 4	TUA 7	TUA 9	Total	TACC
1989-90	0	0	0	0	0	69.015	69.015	-
1990-91	0	0	0	0	0.176	68.245	68.421	-
1991-92	0	0	0	0	1.667	82.002	83.669	-
1992-93	0	0	0	0	0.891	109.280	110.171	-
1993-94	0	0	0.042	0	0	177.165	177.207	-
1994-95	0	0	0	0	0	182.262	182.262	-
1995-96	0	0	0	0	0	100.016	100.016	-
1996-97	0	0	0.125	0	0.005	68.575	68.705	-
1997-98	0	0	0.184	0	0	192.262	192.446	-
1998-99	0	0	0	0	0	76.205	76.205	-
1999-00	0	0	0	0	0	44.450	44.450	-
2000-01	0	0	0	0	0	16.150	16.150	-
2001-02	0	0	0	0	0	4.900	4.900	-
2002-03	0	0	0	0	0	36.160	36.160	-
2003-04	0	0	0.054	0	0	34.336	34.390	-
2004-05	0	0	0	0	0	0	0	-
2005-06	0	0	0	0	0	0	0	43
2006-07	0	0	0	0	0	0	0	43
2007-08	0	0	0	0	0	0	0	43
2008-09	0	0	0	0	0	0	0	43
2009-10	0	0	0	0	0	0	0	43
2010-11	0	0	0	0	0	0	0	43

1.2   Recreational fisheries

Tuatua support an extensive recreational fishery, with harvesting occurring in all stocks wherever there are accessible beds, particularly in the upper North Island. Tuatua are harvested entirely by hand gathering, and there is no MLS (although large tuatua are preferred).

There is a recreational daily catch limit of 150 tuatua per person, except in the Auckland - Coromandel region where the limit has been 50 per day per person since November 1999.

Currently, there are no reliable estimates of recreational harvest of tuatua. Estimates of tuatua catch by recreational fishers have been made on three occasions (1996, 1999-2000, and 2000-01) as part of national recreational fishing (telephone and diary) surveys. These estimates indicate that the majority of recreational tuatua harvests were taken from QMA 1, moderate harvests were taken from QMA 9, and smaller quantities were taken from other areas. A review by the Marine Recreational Fisheries Technical Working Group concluded that these estimates were not likely to be reliable. The current level of recreational harvest and its impact on the status of tuatua beds are unknown. There are

concerns about the depletion of popular tuatua beds in some areas, whereas in other areas it appears they are in a healthy state.

1.3   Customary non-commercial fisheries

In common with many other intertidal shellfish, tuatua are an important customary species taken as kaimoana. Both oral tradition and the numerous middens of *P. triangulata* shells around the coastline clearly show this fishery has been an important one to Maori for at least several hundred years. However, no quantitative information on the level of customary non-commercial take is available.

1.4   Illegal catch

The illegal catch of tuatua is probably significant in some areas, with some recreational fishers exceeding their bag limit, but no quantitative information on the level of illegal catch is available.

1.5   Other sources of fishing-related mortality

No quantitative information on the level of other sources of mortality is available. Tuatua are generally sedentary and beds are susceptible to localised depletion, not only by harvesting pressure, but also by habitat disturbance and degradation. Incidental mortality of tuatua is likely in the Kaipara Harbour dredge fishery if tuatua are damaged during encounters with the dredge. Changes in bank stability could arise from dredging operations and might cause additional incidental mortality. However, the level of dredge-related mortality is unknown. As suspension feeders, tuatua may also be adversely affected by high sedimentation loads in the water column. In some areas, such as Ninety Mile Beach, Dargaville and Muriwai, vehicles driven along the beach pass directly over tuatua beds, increasing mortality either directly by damaging tuatua or indirectly by adversely modifying surface sand conditions leading to desiccation of tuatua.

2.   BIOLOGY

Tuatua (*Paphies subtriangulata*) belong to the family Mesodesmatidae, a group of moderate to large wedge-shaped surf clams that include toheroa (*Paphies ventricosum*), deepwater tuatua (*Paphies donacina*), and pipi (*Paphies australis*). *P. subtriangulata* is extensively distributed around New Zealand in localised abundant populations, but mainly occurs around the North Island, and at more scattered locations in the northern South Island, Stewart Island, and the Chatham Islands.

Tuatua are ecological markers of fine, clean, fluid sands on ocean beaches with moderate wave exposure The densest beds are found in the zone from the low intertidal to the shallow subtidal (down to about 4 m depth). The tuatua is a suspension feeder with short siphons. It is usually wedged only a few centimetres into the sand, with the straight siphonal end often characteristically exposed and discoloured by a green or brown algal film. Individuals are often dragged about the surface and redistributed by swash and backwash before actively burrowing back into the sand.

Tuatua have separate sexes (1:1 sex ratio) and reproduce by broadcast spawning, synchronously releasing eggs and sperm into the water column for external fertilisation. In north-eastern New Zealand, two main spawning periods have been documented, one between September and November, the other between February and April. Spawning events have been observed *in situ* at high water on a number of occasions, with only a small proportion of the population participating in each event. These spawning events were synchronous with pipi spawning in the same area.

Planktonic larval development takes about two to three weeks, so larvae have the potential to disperse widely if conditions allow. Larval settlement is thought to occur high in the intertidal, but spat and juveniles are highly mobile, moving around with the tidal flow before reburying themselves rapidly. Tuatua appear to migrate down the beach to occupy the lower intertidal and shallow subtidal as they grow larger. Growth appears to be rapid but variable, with tuatua reaching 40-70 mm shell length in about 3 years. Maximal length is variable among areas, ranging from about 50 to 80 mm, and the maximum age is probably about 5 or more years. Highly variable recruitment has been observed on the northwest coast of the North Island, and this is likely to occur in other areas. As in other surf clams, natural mortality is likely to be high.

A length-weight relationship has been estimated for tuatua sampled from East Auckland, and a southern population (probably Dunedin) where weight (in g) = a (length (in mm))^b, where a = 0.2 x 10^{-3} and b = 2.927. Data source: D. Allen (MFish) unpublished data. Because the samples were from one northern and one southern population, the estimated relationship may not be representative of other populations.

3. STOCKS AND AREAS

Little is known of the stock structure of tuatua. There have been no biological studies directly relevant to the identification of separate stocks of *P. subtriangulata* around New Zealand, although "stocks" are likely to be linked by larval dispersal. For management purposes stock boundaries are based on QMAs, with the exception of TUA 1, which was divided into TUA 1A and TUA 1B on either side of Te Arai Point because there are likely to be significant differences in the state and use of the tuatua beds between the Northland and Hauraki Gulf / Bay of Plenty areas, and the respective alignment of recreational and customary fishing interests to those management areas. The circulation patterns that maintain the separation of the surf zone habitat to form a self contained ecosystem also retain planktonic larvae of surf clams probably isolating surf clams genetically as well as ecologically.

4. STOCK ASSESSMENT

4.1 Estimates of fishery parameters and abundance
There are no estimates of fishery parameters or abundance for any tuatua fishstock.

4.2 Biomass estimates
There is no time series of biomass surveys for tuatua both in the bed in the Kaipara Harbour entrance where commercial harvesting by dredge occurs now, or anywhere else that would indicate whether tuatua populations are changing in response to past and current levels of harvesting.

4.3 Estimation of Maximum Constant Yield (*MCY*)
MCY has not been estimated for *P. subtriangulata*.

4.4 Estimation of Current Annual Yield (*CAY*)
CAY has not been estimated for *P. subtriangulata*.

5. STATUS OF THE STOCKS

There are no estimates of biomass or sustainable yields of tuatua for any tuatua stock and the status of all stocks is unknown. Because natural mortality is high and recruitment is variable, the biomass of tuatua is likely to be highly variable.

- **TUA -** *Paphies subtriangulata*

Stock Status	
Year of Most Recent Assessment	No formal assessment done of any of the stocks
Assessment Runs Presented	Recruited biomass (shells $\geq$ 50mm)
Reference Points[4]	Target: Undefined Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	N/A
Status in relation to Limits	Unknown
Historical Stock Status Trajectory and Current Status	
Unknown	

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Unknown
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	Landings are less than a quarter of the TACC and have generally been declining since 2002-03.

Projections and Prognosis	
Stock Projections or Prognosis	N/A
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology		
Assessment Type	None	
Assessment Method	N/A	
Main data inputs		
Period of Assessment		Next assessment: Unknown
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty		

Qualifying Comments
Landings are thought to have been declining in recent times due to economic rather than biological reasons.

| Fishery Interactions |
|---|
| Concerns over interactions between dredge fishing and complex habitats |

7.   FOR FURTHER INFORMATION

Beu A.G., De Rooij-Schuiling L.A. 1982. Subgeneric classification of New Zealand and Australian species of *Paphies lesson* (Bivalvia: Mesodesmatidae), and names for the two species of tuatua in New Zealand. New Zealand Journal of Zoology 9: 211-230.

Boyd R.O., Gowing L., Reilly J.L. 2004. 2000-2001 national marine recreational fishing survey: diary results and harvest estimates. Final Research Report for Ministry of Fisheries Project REC2000/03 (Unpublished report held by Ministry of Fisheries, Wellington).

Boyd R.O., Reilly J.L. 2002. 1999/2000 National marine recreational fishing survey: harvest estimates. Final Research Report for the Ministry of Fisheries Project 1998/03 28p. (Unpublished report held by Ministry of Fisheries, Wellington).

Bradford E. 1998. Harvest estimates from the 1996 national marine recreational fishing surveys. New Zealand Fisheries Assessment Research Document 1998/16. 27p.

Cranfield H.J., Michael K.P., Stotter D., Doonan I.J. 1994. Distribution, biomass and yield estimates of surf clams off New Zealand beaches. New Zealand Fisheries Assessment Research Document 1994/1: 27p.

Grant C.M. 1994. Demographics and reproduction of the tuatua *Paphies subtriangulata*. Unpublished MSc thesis. University of Auckland, Auckland, New Zealand. 120p.

Grant C.M., Creese R.G. 1995. The reproductive cycle of the tuatua-*Paphies subtriangulata* (Wood, 1828), in New Zealand. Journal of Shellfish Research 14: 287-292.

Grant C.M., Hooker S.H., Babcock R.C., Creese R.G. 1998. Synchronous spawning and reproductive incompatibility of two bivalve species: *Paphies subtriangulata* and *Paphies australis*. Veliger 41: 148-156.

Haddon M., Wear R. 1987. Biology of feeding in the New Zealand paddle crab *Ovalipes catharus* (Crustacea, Portunidae). New Zealand Journal of Marine and Freshwater Research 21: 55-64.

Ministry of Fisheries Science Group (Comps.) (2006). Report from the Fishery Assessment Plenary, May 2006: stock assessments and yield estimates. 875p. (Unpublished report held in NIWA library, Wellington.)

Morton J.E., Miller M.C. 1968. The New Zealand sea shore. Collins, Auckland, New Zealand. 638p.

Powell A.W.B. 1979. New Zealand Mollusca: marine, land and freshwater shells. Collins, Auckland, New Zealand. 500p.

Redfearn P. 1987. Larval shell development of the northern tuatua, *Paphies subtriangulata* (Bivalvia, Mesodesmatidae). New Zealand Journal of Marine and Freshwater Research 21: 65-70.

WHITE WAREHOU (WWA)

(Seriolella caerulea)
Warehou
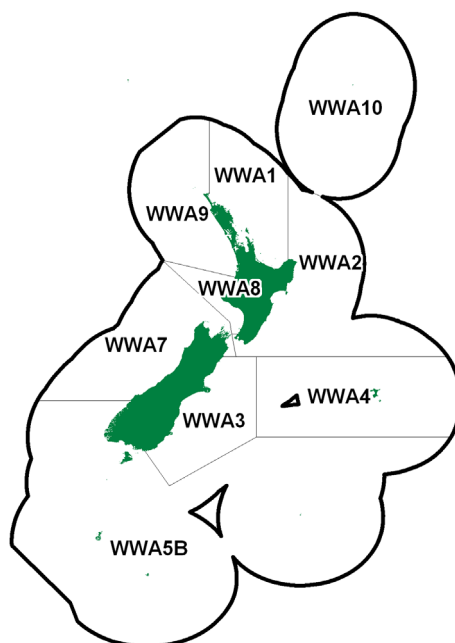
1. FISHERY SUMMARY

1.1 Commercial fisheries

White warehou are predominantly taken as bycatch from target trawl fisheries on hoki and silver warehou, and to a lesser extent, hake, ling and scampi. White warehou were mostly caught in 150 to 800 m depth by larger vessels owned or chartered by New Zealand fishing companies.

Prior to the establishment of the EEZ on 1 March, 1978, white warehou landings were combined with both silver and blue (or common) warehou as 'warehous'. An estimate of total white warehou catches for 1970 to 1977 calendar years has been made (Table 1). From 1978-79 to 1982-83 annual catches of up to 900 t during the fishing year were reported, mainly from Southland and the Chatham Rise (Table 2).

Annual catches of white warehou have been variable (i.e., ranging from 315 t in the 1978-79 fishing year to 3694 t in 1996-97, Tables 2 and 3). The main areas of fishing are the Southland area, with some extension into the Sub-Antarctic area since 1990-91, and the Chatham Rise. The annual catch from other fisheries has been relatively small; the west coast South Island catch is usually less than 100 t and the North Island catch rarely exceeds 50 t. Figure 1 shows the historical landings and TACC values for the main white warehou stocks.

Target fishing on white warehou has been reported from around Mernoo Bank, the Stewart-Snares shelf, Puysegur Bank and on the west coast of the South Island, with the best catch rates recorded in the southern areas. Target fisheries accounted for only 8% of the total white warehou catch for the years from 1988-89 to 1994-95. Most catches are taken from 300-7000 m by bottom trawls targeted at hoki, squid, ling and silver warehou (Bull & Kendrick in prep.).

White warehou was added to the QMS on 1 October 1998. The TACCs for each QMA are given in Table 3. A nominal allowance of 1 t was made for both recreational and customary catch in each of WWA 2-7.

TACCs were increased from 1 October 2006 in WWA 3 to 583 t, in WWA 4 to 330 t, and in WWA 7 to 127 t. In these stocks landings were above the TACC for a number of years and the TACCs have

been increased to the average of the previous 7 years plus an additional 10%. Despite this change the catch in WWA 3 in 2006-07 was well above the new TACC, but has been under the TACC since 2007-08.

Table 1: Estimated catch (t) of white warehou for years 1970 to 1977.

Vessel nationality	1970*	1971*	1972	1973	1974	1975	1976	1977
Japanese	17	25	222	447	234	1 453	1 558	334
Russian	NA	NA	1 300	1 200	1 480	40	440	1 260
Korean	-	-	-	-	-	-	-	400
Total	17	25	1 522	1 647	1 714	1 493	1 998	1 994

* Japanese data only.

Table 2: Reported landings (t) of white warehou by fishing year and area, by foreign licensed and joint venture vessels, 1978-79 to 1983-83. The EEZ areas (*see* Figure 2 of Baird & McKoy 1988) correspond approximately to the QMAs as indicated. Fishing years are from 1 April to 31 March. The 1983-83 is a six month transitional period from 1 April to 30 September. No data are available for the 1980-81 fishing year.

EEZ area	B	C(M)	C(1)	D	E(B)	E(P)	E(C)	E(A)	F(E)	F(W)	G	H	
QMA area	1& 2		3	4				6		5	7	8 & 9	Total
1978-79	1	20	10	1	0	5	0	141	86	26	20	6	315
1979-80	2	8	5	230	57	5	4	312	34	97	42	0	795
1980-81	-	-	-	-	-	-	-	-	-	-	-	-	-
1981-82	0	41	2	53	0	2	5	153	27	248	10	1	542
1982-83	0	375	1	88	0	11	0	198	39	137	33	0	882
1983-83	0	167	5	49	0	0	0	12	9	34	24	0	300

Note: The EEZ area E(A) also included part of QMA 5, south of 48°30' S.

Table 3: Reported landings (t) of white warehou by fishstock and fishing year, 1982-83 to 2010-11. The data in this table has been updated from that published in previous Plenary Reports by using the data through 1996-97 in table 44 on p. 296 of the "Review of Sustainability Measures and Other Management Controls for the 1998-99 Fishing Year - Final Advice Paper" dated 6 August 1998. Data since 1997-98 are based on catch and effort returns. There are no landings reported from QMA 10.

Fishstock	WWA 1		WWA 2		WWA 3		WWA 4		WWA 5(5B)*	
FMA	1		2		3		4		5	
									(&6)*	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1982-83	0	-	35	-	179	-	69	-	248	-
1983-84	0	-	28	-	111	-	33	-	282	-
1984-85	0	-	2	-	123	-	39	-	150	-
1985-86	0	-	5	-	589	-	61	-	277	-
1986-87	0	-	10	-	239	-	29	-	167	-
1987-88	< 1	-	9	-	431	-	26	-	113	-
1988-89	6	-	1	-	118	-	43	-	843	-
1989-90	1	-	9	-	484	-	16	-	555	-
1990-91	2	-	12	-	695	-	88	-	568	-
1991-92	6	-	22	-	589	-	113	-	833	-
1992-93	2	-	13	-	281	-	106	-	560	-
1993-94	6	-	34	-	197	-	23	-	1 235	-
1994-95	4	-	41	-	327	-	243	-	1 936	-
1995-96	2	-	68	-	566	-	137	-	1 555	-
1996-97	3	-	89	-	508	-	220	-	2 309	-
1997-98	2	-	31	-	516	-	153	-	1 217	-
1998-99	< 1	4	34	73	398	399	120	220	1 269	2 127
1999-00	< 1	4	48	73	559	399	277	220	1 112	2 127
2000-01	< 1	4	21	73	661	399	303	220	703	2 127
2001-02	0	4	8	73	446	399	262	220	921	2 127
2002-03	< 1	4	20	73	852	399	397	220	1 462	2 127
2003-04	< 1	4	47	73	458	399	365	220	1 141	2 127
2004-05	< 1	4	24	73	347	399	365	220	1 568	2 127
2005-06	< 1	4	35	73	589	399	312	220	1 176	2 127
2006-07	< 1	4	10	73	733	583	304	330	1 484	2 127
2007-08	< 1	4	43	73	345	583	207	330	*1 431	*2 617
2008-09	< 1	4	22	73	302	583	85	330	*1 644	*2 617
2009-10	< 1	4	7	73	355	583	179	330	*1 106	*2617
2010-11	< 1	4	12	73	391	583	81	330	*787	*2 617

Table 3 continued:

Fishstock	WWA 6		WWA 7		WWA 8		WWA 9			
FMA	6		7		8		9		Total	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1982-83	7	-	24	-	< 1	-	0	-	562	-
1983-84	24	-	29	-	< 1	-	0	-	510	-
1984-85	12	-	15	-	< 1	-	0	-	342	-
1985-86	43	-	81	-	< 1	-	0	-	1 058	-
1986-87	144	-	15	-	< 1	-	0	-	573	-
1987-88	20	-	28	-	< 1	-	0	-	629	-
1988-89	16	-	10	-	0	-	0	-	1 040	-
1989-90	291	-	83	-	0	-	0	-	1 438	-
1990-91	278	-	69	-	1	-	0	-	1 713	-
1991-92	1 028	-	45	-	0	-	0	-	2 636	-
1992-93	645	-	125	-	2	-	0	-	1 734	-
1993-94	592	-	69	-	0	-	0	-	2 156	-
1994-95	185	-	80	-	0	-	0	-	2 816	-
1995-96	50	-	62	-	0	-	0	-	2 440	-
1996-97	494	-	71	-	0	-	0	-	3 694	-
1997-98	126	-	98	-	< 1	-	< 1	-	2 155	-
1998-99	412	490	73	60	< 1	1	0	0	2 306	3 374
1999-00	211	490	153	60	< 1	1	0	0	2 351	3 374
2000-01	119	490	90	60	< 1	1	0	0	1 897	3 374
2001-02	219	490	85	60	< 1	1	< 1	0	1 941	3 374
2002-03	457	490	158	60	0	1	0	1	3 346	3 374
2003-04	211	490	135	60	0	1	0	1	2 357	3 374
2004-05	436	490	123	60	< 1	1	0	1	2 863	3 374
2005-06	250	490	133	60	0	1	0	1	2 495	3 374
2006-07	563	490	121	127	0	1	0	0	3 215	3 735
2007-08	NA	NA	90	127	0	1	< 1	0	2 116	3 735
2008-09	NA	NA	110	127	< 1	1	< 1	0	2 164	3 735
2009-10	NA	NA	44	127	< 1	1	0	0	1 691	3 735
2010-11	NA	NA	52	127	< 1	1	0	0	1 324	3 735

* In 2007-08 WWA 5 was merged with WWA 6 to create WWA 5B. The landings and TACC for WWA 5B are presented after 2007-08 in the WWA 5(5B)* column.
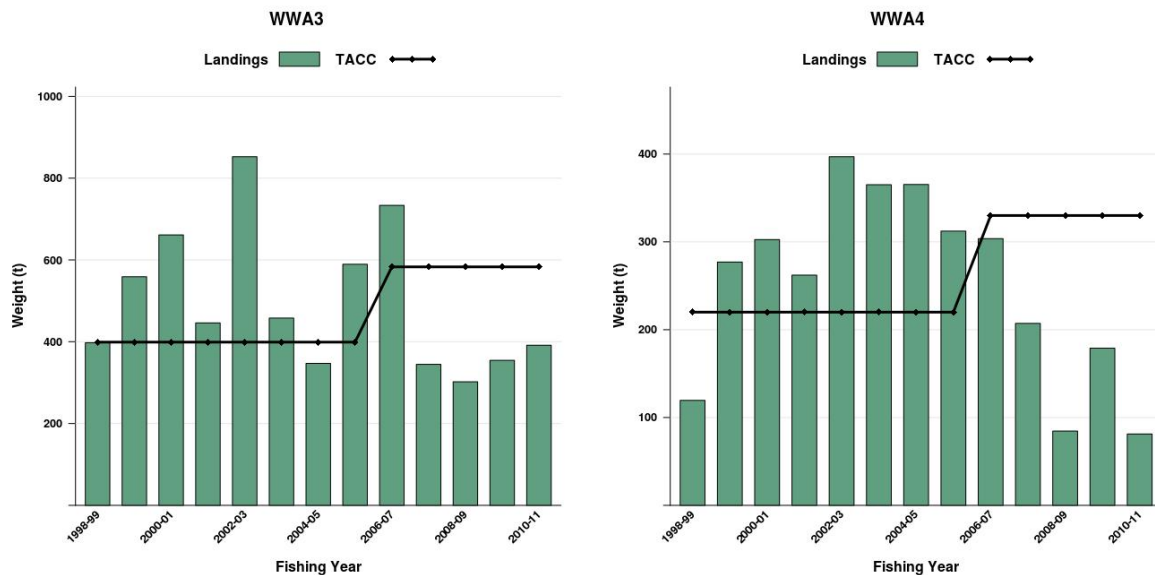
Figure 1: Historical landings and TACC for the four main WWA stocks. Left to right: WWA3 (South East Coast), WWA4 (South East Chatham Rise) [Continued on next page].

1.2 Recreational fisheries

The recreational take of white warehou is likely to be very small given its distribution and depth preferences.

1.3 Customary non-commercial fisheries

No quantitative information is available on the current level of customary non-commercial take.
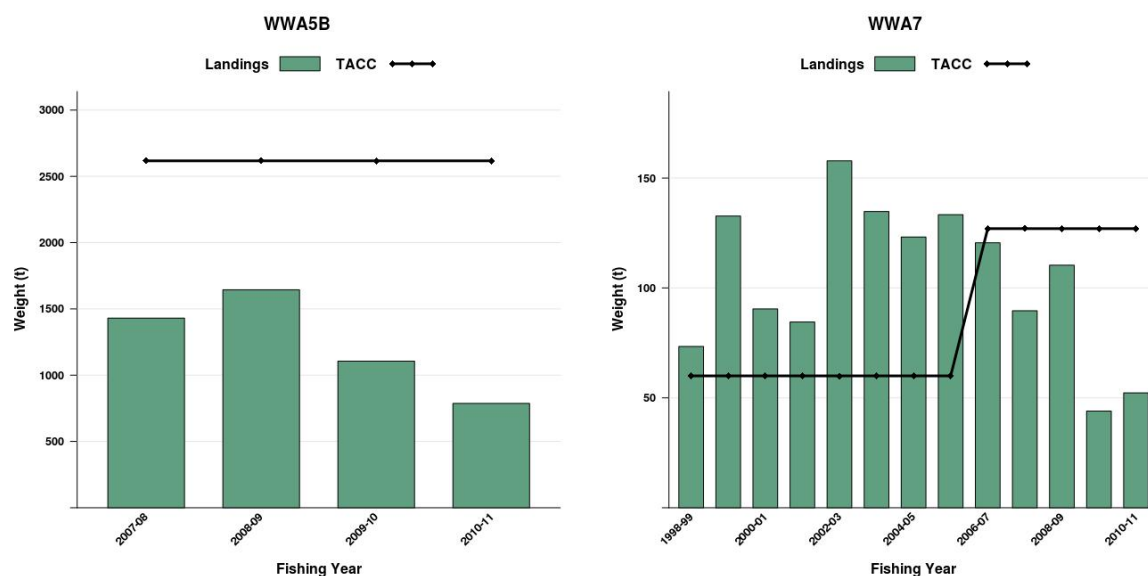
Figure 1 [continued]: Historical landings and TACC for the four main WWA stocks. WWA5B* (Southland, Sub Antarctic), and WWA7 (Challenger). Note that of these figures only WWA3 show data prior to entry into the QMS.

1.4 Illegal catch

Silver warehou were reported as white warehou when the latter was a non QMS species. Compliance investigations in 1988 successfully proved substantial quantities of silver warehou were reported as white warehou, but catch statistics were not altered as a result. The true extent of misreporting is unknown and thus the accuracy of annual catch records cannot be determined.

1.5 Other sources of mortality

No information is available on other sources of mortality.

2. BIOLOGY

Adult white warehou range between 40-60 cm fork length (FL) and reach a maximum length and weight of 67 cm and 5.7 kg respectively. Sexual maturity is reached at an age of about 3 or 4 years at a length of approximately 38-47 cm. The length at age for the first three years appears to be similar to that described for silver and blue warehou (Horn & Sutton 1995, 1996, Gavrilov 1979).

White warehou were aged by Gavrilov (1979) who gives the maximum age as 12 years. Horn & Sutton (1996) suggested that Gavrilov underestimated the maximum age of silver warehou (as 10-11 years) because he read whole otoliths and scales. They determined a maximum age of 23 years for silver warehou using sectioned otoliths. The maximum age of white warehou is therefore uncertain. Without validated ageing and population age structures it is not possible to estimate mortality for white warehou.

Sex ratio data derived from scaled length frequencies appear to show a slight bias towards males. On the Chatham Rise sex ratios vary from 1.0 : 1 to 1.4 : 1 (males to females). In the southern area, ratios vary from 0.7 : 1 to 4.2 : 1, but sample sizes at either extreme of the range are very small. There are insufficient data to enable detection of any changes in sex ratio with season.

Feeding records from the MFish research database show salps as the predominant prey item observed in white warehou stomachs. Occasional records of fish and euphausiids have also been made. Gavrilov and Markina (1979) noted salps (*Iasis*) and the tunicate *Pyrosoma* as major food items.

3.   STOCKS AND AREAS

The existence of three possible spawning areas for white warehou, (Mernoo Bank, Puysegur Bank and the west coast of the South Island) at the same time of year, suggests the possibility of three separate stocks. Bagley & Hurst (1997) proposed the following Fishstock areas: WWA 1 (QMAs 1, 2, 3 and 4), WWA 5 (QMAs 5 and 6) and WWA 7 (QMAs 7, 8 and 9) for white warehou. TACs were set for each QMA (1-9) in 1998 and are managed separately.

4.   STOCK ASSESSMENT

No assessments are available for any stocks for white warehou, therefore estimates of biomass and yield are not available.

4.1   Estimates of fishery parameters and abundance
No estimates of fishing parameters are available for white warehou.

Several time series of relative abundance estimates are available from trawl surveys, but these estimates are not reliable indicators of relative abundance because of large fluctuations between years and moderate to high CVs. The larger biomass estimates are generally associated with moderate to high CVs (i.e., over 40%), having resulted from one or two large catches. Smaller biomass estimates have lower CVs, but this could be because the survey missed the main white warehou schools.

4.2   Biomass estimates
No biomass estimates are available for white warehou.

4.3   Estimation of Maximum Constant Yield (*MCY*)
MCY cannot be determined. Problems with mis-reporting of silver warehou as white warehou and the lack of consistent catch histories make *MCY* estimates based on catch data alone unreliable. Also the amount of effort on white warehou relates very closely to effort on other target species such as hoki and silver warehou. Large fluctuations in the availability of white warehou to the trawl, as indicated by trawl surveys, are also likely to apply to commercial fishing operations. Estimates of *M* need to be determined.

4.4   Estimation of Current Annual Yield (*CAY*)
CAY cannot be estimated because of the lack of current biomass estimates.

4.5   Other yield estimates and stock assessment results
There are no other yield estimates or stock assessment results available for white warehou.

4.6   Other factors
None

5.   STATUS OF THE STOCKS

It is not known whether recent catches are sustainable or if they are at levels that will allow the stock to move towards a size that will support the maximum sustainable yield.

TACCs were increased from 1 October 2006 in WWA 3 to 583 t, in WWA 4 to 330 t, and in WWA 7 to 127 t. In these stocks landings were above the TACC for a number of years and the TACCs have been increased to the average of the previous 7 years plus an additional 10%.

TACCs and reported landings for the 2010-11 fishing year are summarised in Table 4.

Table 4: Summary of TACCs (t), and reported landings (t) of white warehou for the most recent fishing year.

| Fishstock		QMA	2010-11 Actual TACC	2010-11 Reported landings
WWA 1	Auckland (East)	1	4	< 1
WWA 2	Central (East)	2	73	12
WWA 3	South-east (Coast)	3	583	391
WWA 4	South-east (Chatham)	4	330	81
WWA 5B	Southland, Sub-Antarctic	5	2 617	787
WWA 7	Challenger	7	127	52
WWA 8	Central (West)	8	1	< 1
WWA 9	Auckland (West)	9	0	0
WWA 10	Kermadec	10	0	0
Total			3 735	1 324

6. FOR FURTHER INFORMATION

Bagley N.W., Hurst R.J. 1997. A summary of the biology and commercial landings and a stock assessment of white warehou *Seriolella caerulea* Guichenot, 1848 (Stromateoidei: Centrolophidae) in New Zealand waters. New Zealand Fisheries Assessment Research Document 1997/13. 34p.

Bull B., Kendrick T.H. (in prep.): Fishery characterisations and CPUE analyses for white warehou (*Seriolella caerulea*). Draft New Zealand Fisheries Assessment Report.

Cousseau M.B., Fortciniti L., Ubaldi G. 1993. Species of the Genus *Seriolella* in Southwest Atlantic waters. Japanese Journal of Icthyology 40(2): 183-187.

Gavrilov G.M. 1979. *Seriolella* of the New Zealand plateau. Report of the Pacific Ocean Scientific Research Institute of Fisheries and Oceanography (TRINO). (In Russian, English translation held in NIWA, Wellington.)

Gavrilov G.M., Markina N.P. 1979. The feeding ecology of fishes of the genus *Seriolella* (fam. Nomeidae) on the New Zealand plateau. Journal of Ichthyology 19(6): 128-135.

Horn P.L. 1999. A validated ageing method and updated stock assessment for white warehou (*Seriolella caerulea*) in New Zealand waters. New Zealand Fisheries Assessment Research Document. 1999/44.

Horn P.L., Sutton C.P. 1995. An ageing methodology, and growth parameters for silver warehou (*Seriolella punctata*) from off the southeast coast of the South Island, New Zealand. New Zealand Fisheries Assessment Research Document 1995/15: 16p.

Horn P.L., Sutton C.P. 1996. Validated ages, growth, and productivity parameters for silver warehou (*Seriolella punctata*) off the south and east coasts of South Island, New Zealand. New Zealand Journal of Marine and Freshwater Research 30: 301-312.

Hurst R.J., Bagley N.W. 1992. Trawl survey of barracouta and associated finfish near the Chatham Islands, New Zealand. December 1995. 36p.

Kerstan M., Sahrhage D. 1980. Biological investigation on fish stocks in the waters off New Zealand. Mitteilungen aus dem Institut fur Seefischerei der Bundesforschungsanstalt fur Fischerei, Hamburg: 29. 168p.

Teirney L.D., Kilner A.R., Bradford E., Bell J.D., Millar R.B. 1997 Estimation of recreational catch from 1991-92 to 1993-94. New Zealand Fisheries Assessment Research Document 1997/15: 43p.

McDowall R.M. 1980. *Seriolella caerulea* Guichenot, 1884 in New Zealand waters (Stromateoidei: Centrolophidae). Journal of the Royal Society of New Zealand 10(1): 65-74.

McDowall R.M. 1982. The centrolophid fishes of New Zealand (Pisces: Stromateoidei). Journal of the Royal Society of New Zealand 12: 103-142.

NZFIB 1996. The New Zealand seafood industry economic review 1994-1996. New Zealand fishing industry board, Wellington. 65p.

Sparre P., Ursin E., Venema, S.C. 1989. Introduction to tropical fish stock assessment. Part 1. Manual. FAO Fisheries Technical Paper 306. 337p.

YELLOW-EYED MULLET (YEM)

(*Aldrichetta forsteri*)
Aua
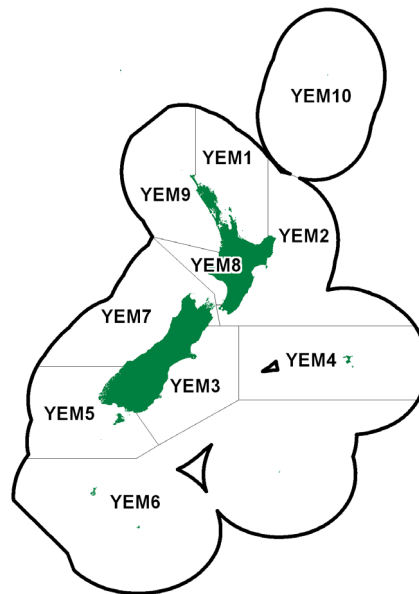
1. FISHERY SUMMARY

1.1 Commercial fisheries

Yellow-eyed mullet entered the Quota Management System (QMS) on 1 October 1998. There is very little published information on the commercial fishery for yellow-eyed mullet apart from brief comments about its use as bait. From 1934 to 1972 information from catch records indicate that yellow-eyed mullet was taken by "other nets", meaning nets other than trawl or Danish seine. Catch by gear-type data from the Fisheries Statistics Unit (FSU) records between 1982-83 and 1988-89 show a predominant use of setnets and gillnets (about 95.5% of total catch) over beach seine and drag net (about 4.5% of total catch).

There is the potential for incorrect assignment of yellow-eyed mullet in landings records because of similarity in the common names of grey mullet and yellow-eyed mullet and the possibility that some fishers refer to both as *mullet*. A second possible classification error may arise from erroneous use of the names *herring* or *sprat*. The level of error in the landings data due to misidentification is not known.

Before 1960 the majority of the recorded catch of yellow-eyed mullet was taken in Northland. Between 1960 and 1968, there was a marked increase in landings from Lake Ellesmere. Regular records are also available for Napier beginning in 1941, and Manukau Harbour. Apart from Lake Ellesmere, records for the South Island are generally incomplete.

Pre-1980, landings of yellow-eyed mullet by QMA were low, perhaps as a result of under-reporting. Landings increased in the early 1980s due to an increase in landings in QMA 9, and to a lesser extent in QMA 1. In the 1990s landings in QMA1 equaled and often exceeded landings in QMA 9. Landings have remained below 20 t in QMA 9 during the past eleven years, with the exception of the 1999-00 catch, which was almost triple that of the previous year and more than double the catch recorded in QMA 1.

The high landings recorded since the mid 1980s most likely reflect increased fishing in the Auckland area in response to an increase in market demand for yellow-eyed mullet. Since the peak total landings in 1996-97 the catch fluctuated around an average of 37 t between 1996-97 to 1999-2000. Catches have fluctuated over time with a high of 68 t being recorded in 1986-87. The last 5 years have seen low catches averaging just 18 t, which is below the long-term (26 year) average of 28 t.

Strong seasonal trends are evident in the catch data for each QMA with annual peaks mostly in July-August indicating a winter fishery.

A breakdown of the current Total Allowable Catch (TAC) is shown in Table 1. Recent reported landings of yellow-eyed mullet are shown in Table 2, while Figure 1 shows the historical landings and TACC values for the main YEM stocks.

Table 1: Recreational and customary non-commercial allowances (t), Total Allowable Commercial Catches (TACC, t) and Total Allowable Catches (TAC, t) declared for YEM.

Fishstock		FMA	TAC	TACC	Customary	Recreational
YEM 1	Auckland (East)	1	50	20	15	15
YEM 2	Central (East)	2	14	2	4	8
YEM 3	South-east (Coast)	3	14	8	2	4
YEM 4	South-east (Chatham)	4	0	0	0	0
YEM 5	Southland	5	2	0	1	1
YEM 6	Sub-Antarctic	6	0	0	0	0
YEM 7	Challenger	7	20	5	5	10
YEM 8	Central (West)	8	18	3	5	10
YEM 9	Auckland (West)	9	38	30	4	4
Total			156	68	36	52

Table 2: Reported landings (t) of yellow-eyed mullet by fishstock and fishing year, 1983-84 to 2010-11. The data in this table has been updated from that published in previous Plenary Reports using the data through 1996-97 in Table 47 on p. 304 of the "Review of Sustainability Measures and Other Management Controls for the 1999-2000 Fishing Year - Final Advice Paper" dated 6 August 1998. There are no landings from FMA 10, which has a TACC of 0.

Fishstock	YEM 1		YEM 2		YEM 3		YEM 4		YEM 5	
FMA	1		2		3		4		5	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1982-83	2	-	35	-	3	-	0	-	0	-
1983-84	2	-	28	-	5	-	0	-	0	-
1984-85	12	-	2	-	1	-	0	-	0	-
1985-86	24	-	5	-	7	-	0	-	0	-
1986-87	14	-	10	-	4	-	0	-	0	-
1987-88	11	-	9	-	9	-	0	-	0	-
1988-89	3	-	1	-	4	-	0	-	0	-
1989-90	1	-	9	-	17	-	0	-	0	-
1990-91	21	-	12	-	13	-	0	-	0	-
1991-92	15	-	22	-	23	-	0	-	0	-
1992-93	32	-	13	-	1	-	1	-	0	-
1993-94	53	-	34	-	2	-	0	-	0	-
1994-95	32	-	41	-	1	-	0	-	0	-
1995-96	19	-	68	-	2	-	0	-	0	-
1996-97	32	-	89	-	7	-	< 1	-	0	-
1997-98	10	-	31	-	< 1	-	0	-	0	-
1998-99	16	10	34	1	7	6	0	0	0	0
1999-00	10	10	48	1	7	6	0	0	0	0
2000-01	9	10	21	1	5	6	0	0	0	0
2001-02	6	20	8	2	< 1	8	0	0	0	0
2002-03	9	20	< 1	2	4	8	0	0	0	0
2003-04	4	20	< 1	2	6	8	0	0	0	0
2004-05	4	20	< 1	2	1	8	0	0	< 1	0
2005-06	3	20	1	2	3	8	0	0	0	0
2006-07	5	20	< 1	2	5	8	0	0	< 1	0
2007-08	3	20	< 1	2	3	8	0	0	0	0
2008-09	6	20	< 1	2	< 1	8	0	0	0	0
2009-10	15	20	< 1	2	4	8	0	0	0	0
2010-11	10	20	< 1	2	7	8	0	0	0	0

Commercial catches of yellow-eyed mullet have been well below the TACC in each QMA since it was introduced into the QMS in 1 October 1998.

1.2 Recreational fisheries

Yellow-eyed mullet are a popular recreational species throughout New Zealand, particularly in QMA 1. Estimated numbers of fish and harvest tonnages for yellow-eyed mullet taken by recreational fishers are presented in Table 2.

Table 2 continued:

| Fishstock	YEM 6		YEM 7		YEM 8		YEM 9			
FMA	6		7		8		9			Total
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1982-83	0	-	0	-	5	-	5	-	17	-
1983-84	0	-	0	-	5	-	26	-	26	-
1984-85	0	-	3	-	3	-	33	-	33	-
1985-86	0	-	4	-	2	-	61	-	61	-
1986-87	0	-	6	-	0	-	68	-	68	-
1987-88	0	-	4	-	0	-	43	-	43	-
1988-89	0	-	5	-	0	-	21	-	21	-
1989-90	0	-	0	-	3	-	11	-	11	-
1990-91	0	-	10	-	0	-	21	-	21	-
1991-92	0	-	14	-	1	-	25	-	25	-
1992-93	0	-	2	-	5	-	31	-	31	-
1993-94	0	-	3	-	4	-	20	-	20	-
1994-95	0	-	8	-	2	-	18	-	18	-
1995-96	0	-	4	-	0	-	10	-	10	-
1996-97	0	-	5	-	2	-	11	-	58	-
1997-98	0	-	0	-	0	-	2	-	12	-
1998-99	0	0	2	4	< 1	2	9	33	34	56
1999-00	0	0	1	4	< 1	2	26	33	44	56
2000-01	0	0	< 1	4	< 1	2	12	33	28	56
2001-02	0	0	3	5	0	3	15	30	24	68
2002-03	0	0	< 1	5	< 1	3	19	30	34	68
2003-04	0	0	1	5	0	3	11	30	22	68
2004-05	0	0	0	5	< 1	3	7	30	13	68
2005-06	0	0	0	5	4	3	4	30	14	68
2006-07	0	0	< 1	5	3	3	9	30	23	68
2007-08	0	0	< 1	5	2	3	9	30	17	68
2008-09	0	0	2	5	2	3	10	30	20	68
2009-10	0	0	2	5	3	3	5	30	30	68
2010-11	0	0	2	5	2	3	17	30	38	68
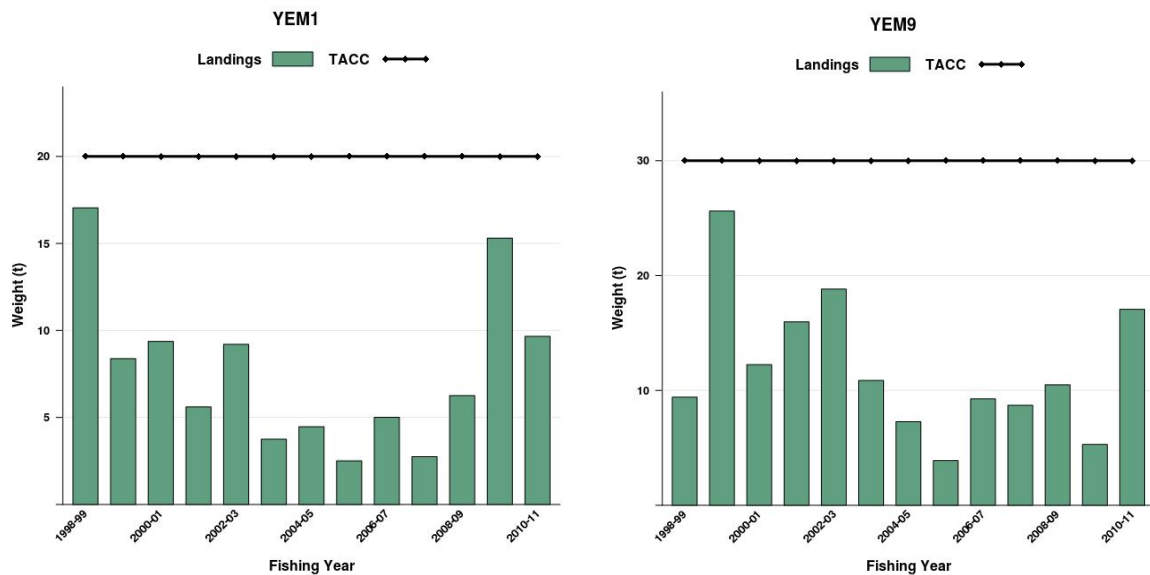
Figure 1: **Historical landings and TACC for the two main YEM stocks. From left to right: YEM1 (Auckland East) and YEM9 (Auckland West). Note that these figures do not show data prior to entry into the QMS.**

The survey data have a number of sources of uncertainty. For example, there is a level of misidentification arising from similarity in the common names grey mullet and yellow-eyed mullet, and erroneous use of the names *herring* or *sprat*. The level of assignment to the general mullet category "MUU" is also unknown. Estimates of the number of fish and harvest tonnage are presented for MUU in part (iii) of Table 3.

A key component of the estimating recreational harvest from diary surveys is determining the proportion of the population that fish. The Recreational Technical Working Group concluded that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and c)

the 2000 and 2001 estimates are implausibly high for many important fisheries.The 1999-00 Harvest estimates for each Fishstock should be evaluated with reference to the coefficient of variation.

Table 3: Estimated number of yellow-eyed mullet and unassigned mullet (MUU) harvested by recreational fishers by Fishstock and survey. Surveys were carried out in different years in Ministry of Fisheries regions: South in 1991-92, Central in 1992-93, North in 1993-94 (Bradford 1996) and National in 1996 (Bradford 1998) and 1999-00 (Boyd & Reilly 2005). Estimates of CV and harvest tonnages are not presented where sample sizes are considered too small. The mean weight (100 g) used to convert numbers to catch weight is from Manikiam (1963) and considered the best available estimate. Survey tonnages are presented as a range to reflect the uncertainty in the estimate. It is assumed that some proportion of unassigned mullet are yellow-eyed mullet.

Fishstock	Survey	Total Number	CV (%)	Estimated Harvest Range (t)	Point Estimate (t)
1991-92					
QMA1	South	1 000			
QMA3	South	29 000	34	1-5	
QMA7	South	3 000			
QMA9	South	2 000			
1992-93					
QMA1	Central	14 000			
QMA2	Central	57 000			
1993-94					
QMA1	North	289 000	15	25-33	
QMA2	North	7 000			
QMA8	North	1 000			
QMA9	North	52 000	33	2-8	
1996					
Yellow eyed mullet					
QMA1	National	91 000	14	5-15	9
QMA2	National	80 000	-	-	-
QMA3	National	38 000	-	-	-
QMA5	National	2 000	-	-	-
QMA7	National	66 000	19	5-10	7
QMA8	National	74 000	21	5-10	7
QMA9	National	31 000	-	-	-
Unassigned mullet					
QMA1	National	43 000	23	3-5	4
QMA2	National	1 000	-	-	-
QMA3	National	6 000	-	-	-
QMA7	National	16 000	-	-	-
QMA8	National	5 000	-	-	-
QMA9	National	1 000	-	-	-
1999-00					
YEM 1	National	342 000	28	12-21	-
YEM 2	National	432 000	72	6-36	-
YEM 3	National	168 000	29	6-11	-
YEM 5	National	7 000	88	0-1	-
YEM 7	National	86 000	37	3-6	-
YEM 8	National	89 000	33	3-6	-
YEM 9	National	127 000	53	3-10	-

1.3 Customary non-commercial fisheries

No quantitative information is available on the current level of customary non-commercial take.

1.4 Illegal catch

No quantitative information is available on the level of illegal catch.

1.5 Other sources of mortality

No quantitative estimates are available about the impact of other sources of mortality on yellow-eyed mullet stocks. Yellow-eyed mullet principally occur in sheltered harbour and estuarine ecosystems. Some of these habitats are known to have suffered environmental degradation.

2. BIOLOGY

The yellow-eyed mullet, *Aldrichetta forsteri* (Cuvier & Valenciennes 1836), is a member of the Mugilidae family (mullets). It is found in New Zealand, Norfolk Island and Australia. Its range extends from North Cape to Stewart Island in New Zealand and from the Murchison River in Western Australia, across South Australia and around Tasmania, to the Hawkesbury River in New South Wales. It is typically a schooling species that occurs commonly along coasts, in estuaries and in lower river systems, with juveniles sometimes observed in freshwater where they have been observed feeding on algae. In New Zealand, the species is widely but erroneously known as herring.

Yellow-eyed mullet are omnivorous and feed on a wide range of food types including algae, crustaceans, diatoms, molluscs, insect larvae, fish, polychaetes, coelenterates, fish eggs and detritus.

Egg development begins in July and maturity occurs by late December. Generally, spawning is during summer from late December to mid-March although there is some evidence in females from Canterbury to suggest biennial spawning, with peaks in winter and summer. Yellow-eyed mullet appear to leave their estuarine habitat to spawn in coastal waters, with eggs and larvae being found in surface waters up to 33 km offshore. There is no information available on the age of recruitment into estuarine systems of New Zealand waters.

Within estuaries and river systems, yellow-eyed mullet are separated to some extent by age, with older fish preferring more saline water and juveniles sometimes found in freshwater. The larger fish also prefer deeper water than juveniles.

M was estimated from the equation $M = \log_e 100/\text{maximum age}$, where maximum age is the age to which 1% of the population survives in an unexploited stock. Using 7 years for the maximum age results in an estimate of $M = 0.66$. The maximum age used here is for a yellow-eyed mullet taken in Wellington Harbour in 1963.

Biological parameters relevant to stock assessment are shown in Table 3.

Table 4: Estimates of biological parameters of yellow-eyed mullet.

Fishstock		Estimate	Source
1. Natural mortality (*M*)			
		Both Sexes	NIWA (unpub. Data)
Wellington Harbour		0.66	
2. Weight = a(length) (Weight in g, length in cm fork length).			
		Both Sexes	
	a	b	
Lake Ellesmere	0.000239	3.2	Gorman (1962)

3. STOCKS AND AREAS

No information is available to determine the stock structure of yellow-eyed mullet in New Zealand waters. Because catches are generally taken locally within harbours and estuarine systems that are relatively easy to identify, boundaries for Fishstocks should take this natural division into account.

4. STOCK ASSESSMENT

4.1 Estimates of fishery parameters and abundance
No estimates of fishery parameters or stock abundance are available for yellow-eyed mullet.

4.2 Biomass estimates
Biomass estimates are not available for any stocks.

4.3 Estimation of Maximum Constant Yield (*MCY*)
Estimates of *MCY* are not available.

4.4 Estimation of Current Annual Yield (*CAY*)
No estimates of current biomass, fishing mortality, or other information are available which would permit the estimation of *CAY*.

4.5 Other factors
Because of the highly localised nature of the fishery and the relatively high landings taken recently, particularly in the Manukau Harbour, yellow-eyed mullet may be susceptible to localised depletion.

Concern has been expressed by the Working Group about the effects of the small-meshed nets used to fish yellow-eyed mullet on other species within estuarine systems. For example, species such as grey mullet may suffer increased pressure as a consequence of increased target fishing for yellow-eyed mullet.

5. STATUS OF THE STOCKS

Estimates of current and reference biomass are not available. It is not known if recent catch levels are sustainable.

TACCs and reported landings for the 2010-11 fishing year are summarised in Table 5.

Table 5: Summary of TACs (t), and reported landings (t) of yellow-eyed mullet for the most recent fishing year.

Fishstock		FMA	2010-11 Actual TACC	2010-11 Reported landings
YEM 1	Auckland (East)	1	20	9.7
YEM 2	Central (East)	2	2	0.3
YEM 3	South-east (Coast)	3	8	7
YEM 4	South-east (Chatham)	4	0	0
YEM 5	Southland	5	0	0
YEM 6	Sub-Antarctic	6	0	0
YEM 7	Challenger	7	5	2.1
YEM 8	Central (West)	8	3	1.5
YEM 9	Auckland (West)	9	30	17
Total			68	37.6

6. FOR FURTHER INFORMATION

Boyd R.O., Reilly J.L. 2005. 1999-2000 national marine recreational fishing survey: harvest estimates. Draft New Zealand Fisheries Assessment Report.

Bradford E. 1996. Marine recreational fishing survey in the Ministry of Fisheries North Region, 1993-94. New Zealand Fisheries Data Report No: 80.

Bradford E. 1998. Harvest estimates from the 1996 national recreational fishing surveys. New Zealand. Fisheries Assessment Research Document 1998/16. 27 p.

Gorman T.B.S. 1962. Yellow-eyed mull*et aldrichetta forsteri* Cuvier and Valenciennes in Lake Ellesmere. Fisheries Technical Report No: 7 20 p.

Manikiam J.S. 1963. Studies on the yellow-eye mullet. Unpublished thesis submitted to the Victoria University of Wellington for the degree of Master of Science.

Taylor P.R., Paul L.J. 1998. A summary of biology, commercial landings, and stock assessment of yellow-eyed mullet, *Aldrichetta forsteri* (Cuvier and Valenciennes, 1836) *(Mugiloidei: Mugilidae)*. New Zealand Fisheries Research Document 1998/17. 34 p.

Webb B.F. 1973b. Fish populations of the Avon-Heathcote estuary. 2. Breeding and gonad maturity. New Zealand Journal of Marine and Freshwater Research 7(1): 45-66.

Teirney L.D., Kilner A.R., Millar R.E., Bradford E., Bell J.D. 1997. Estimation of recreational catch from 1991/92 to 1993/94. New Zealand Fisheries Assessment Research Document 1997/15. 43 p.