Ministry for Primary Industries
Manatū Ahu Matua

Mean weight estimates for recreational fisheries in 2011–12

New Zealand Fisheries Assessment Report 2015/25

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ISSN 1179-5352 (online)
ISBN 978-0-477-10594-1 (online)

April 2015

New Zealand Government

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This report provides mean weight estimates for species commonly landed by recreational fishers from New Zealand fish stocks during the 2011–12 fishing year. A national panel survey was conducted in 2011–12 and fishstock specific mean weight estimates were required to convert national panel survey estimates of numbers of fish harvested by recreational fishers into harvest tonnage estimates, which are of more relevance to fisheries managers.

Potential sources of recreational catch length data were identified at an early planning stage, which included surveys of recreational fisheries planned for 2011–12 that included some form of creel survey component, and similar data collected in recent surveys in other parts of the country. A dedicated creel survey was then designed to provide recreational catch length data for those parts of the country which were not covered by existing or planned data sources. Creel survey interviews were subsequently conducted in most areas outside of Fisheries Management Area 1 (FMA 1 runs from North Cape and Cape Runaway in the eastern Bay of Plenty) during the 2011–12 fishing year.

The collation of data from all sources provided a data set of 118 057 lengths for 88 species measured throughout New Zealand. Two thirds of these measurements were of snapper, but at least 500 measurements were available for most of the fishstocks most fished by recreational fishers. Published length-weight relationships were used to convert fish lengths into fish weights for the 27 quota species for which at least 50 measurements were available, and for albacore and skipjack tuna, which are not quota species. These estimates were used to generate mean fish weights by Quota Management Area (QMA) as the length compositions of recreational catches can differ considerably in different parts of the country. Mean weight estimates were also generated for species commonly caught in regions of FMA 1 as these estimates are required by two other recreational harvest estimation programmes in this area, which have been conducted concurrently with the national panel survey for comparative purposes.

Previous mean weight estimation programmes have found evidence of seasonal differences in the mean weights for some species commonly landed by recreational fishers. Seasonal (summer, 1 October 2011 to 30 April 2012; winter, 1 May to 30 September 2012) mean weights were therefore calculated for the main fish stocks and then compared using t tests. Statistically significant seasonal differences were found for most of the fish stocks supporting large recreational fisheries, and in some cases seasonal mean weights were substantially different. These seasonal differences could be due to size related onshore/offshore movements and spawning migrations between regions. These results suggest that seasonal mean weights should be used when converting estimates of numbers of fish landed into tonnage estimates.

1. INTRODUCTION

New Zealand's marine fisheries are primarily managed on the basis of harvest weight rather than numbers of fish landed. Commercial fishers are required regularly to report the tonnage of fish harvested from each fish stock, but there is no requirement for recreational fishers to report their catch. The recreational harvest from some fish stocks can be substantial however, and survey methods are therefore used to provide recreational harvest tonnage estimates.

Off-site survey methods such as telephone/diary surveys offer the only viable means of estimating harvests from all of New Zealand's varied and diverse recreational fisheries, as on-site interview based approaches are not cost effective at the national scale. The harvest estimates provided by national off-site surveys are given in terms of numbers of fish harvested rather than fish tonnage, as diarists are usually required to self-report their catch in terms of numbers caught rather than catch weight. Telephone diary surveys in the early 1990s asked diarists to self-report both the number and weight of fish landed, but a comparison of diarist and boat ramp interview data collected concurrently during 1992–93 suggested that diarists tended to overestimate the size (and hence weight) of the fish they retained (Ryan & Kilner 1994). Subsequent telephone diary surveys have therefore relied on concurrent creel surveys to provide fish stock specific mean fish weight estimates (see Hartill et al.1998, Boyd & Gowing 2004), which are used to convert estimates of the number of fish caught by recreational fishers into harvest weights. Mean fish weights for individual species can vary considerably between fishstocks, and it is therefore necessary to conduct interviews of recreational fishers throughout New Zealand.

The telephone/diary survey methods used in the 1990s are no longer considered reliable, and alternative innovative methods have been since developed that should provide more accurate harvest estimates. This revised approach is called the National Panel Survey (NPS) method, which still relies on recreational fishers to self-report their catch in terms of numbers of fish caught. A concurrent national creel survey is therefore still required to provide mean fish weight estimates for all of the fish stocks commonly fished by recreational fishers, so that the NPS estimates of numbers caught could be converted into the tonnage estimates required by fisheries managers.

A NPS survey was conducted during the 2011–12 fishing year, and this report describes an associated concurrent programme that was undertaken to provide fish stock specific mean weight estimates for the same fishing year, which are used to convert NPS recreational harvest estimates into tonnage estimates.

The overall objectives of this research within the Ministry for Primary Industries marine amateur fisheries research portfolio are to contribute to the design and implementation of an integrated amateur fisheries harvest estimation system through data collection to allow for the provision of amateur fisheries stock-by-stock absolute harvest estimates which are comparable with future amateur harvest estimates. The specific objectives of this research project were to collate and collect length data describing amateur fisheries' catch of key species throughout New Zealand, to convert length data to weight data to inform estimation of the harvest of amateur fisheries, and to collaborate with concurrent onsite and offsite survey projects to provide information to corroborate and if possible calibrate harvest estimates.

2. METHODS

Recreational harvest fish length frequency measurements for commonly caught species were obtained from three sources (Figure 1):

- a creel survey of fishers returning to key boat ramps in FMAs 2, 3, 7, 8, and 9 (see Figure 1) during the 2011–12 fishing year,
- concurrent creel surveys undertaken for other purposes in FMAs 1, 8, and 9 (see Figure 1) during the 2011–12 fishing year,
- other recent surveys of recreational fishers.

2.1 Creel survey of recreational fishers of FMAs 2, 3, 7, 8, and 9

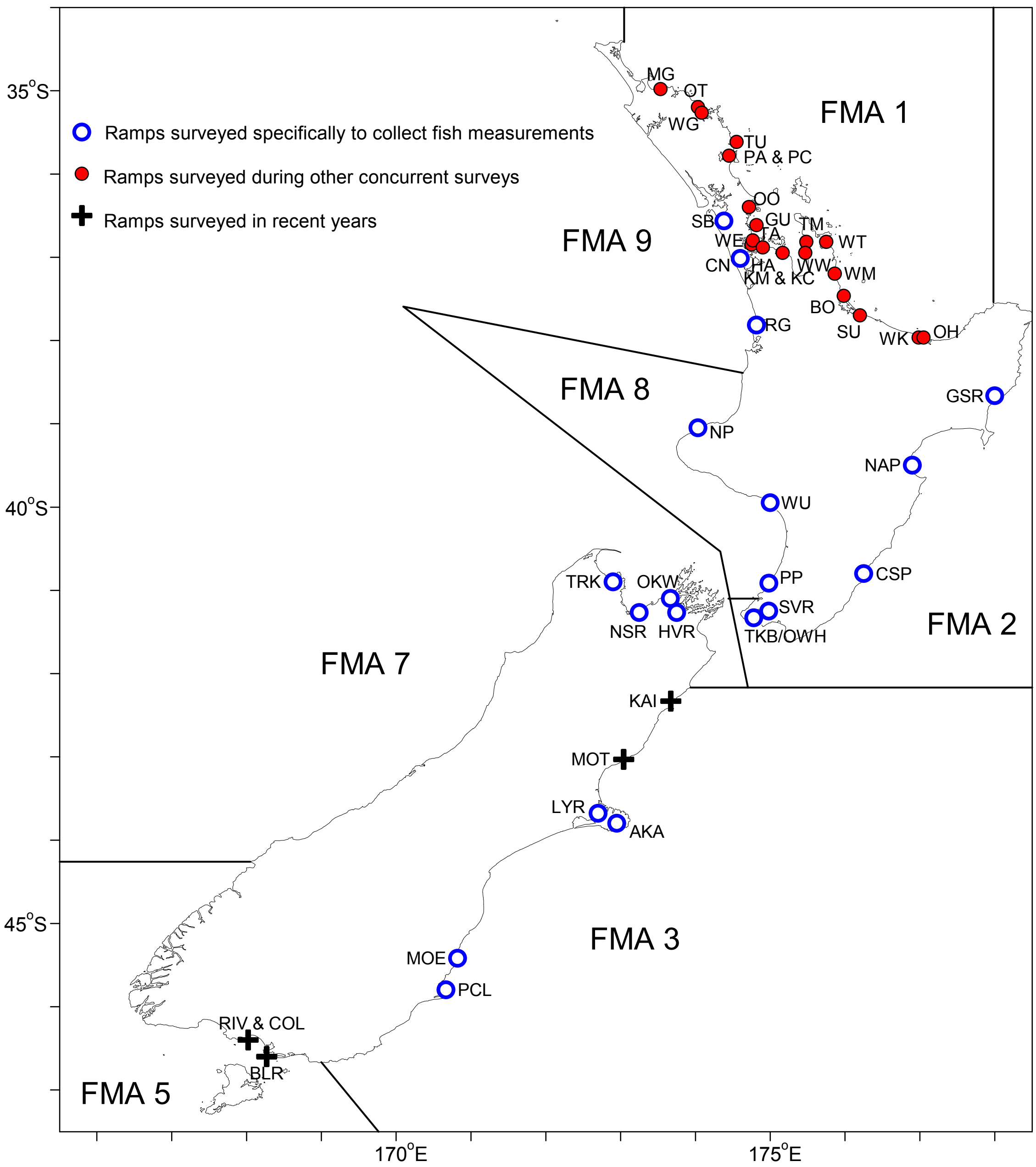
There were no recent data available for most FMAs and a dedicated creel survey was required to collect catch composition data in these areas. Creel survey interviews of fishers returning to high traffic ramps in FMAs 2, 3, 7, 8, and 9 were therefore conducted throughout the 2011–12 fishing year.

The sampling methods in these areas were designed to maximise the number of measurements obtained per interview hour, and sampling effort was therefore non-randomly allocated in space and time. Interviews were only conducted at the busiest ramps in each region (denoted by open circles in Figure 1). The selection of these ramps was based on both historical boat ramp interview data (which was limited in some areas) and conversations with others who had worked in these areas, such as Fisheries Officers. Interviews were conducted at boat ramps as these provide choke points through which relatively high volumes of traffic pass. Interviews were conducted with nearby shore based fishers when they were encountered, but no attempt was made to specifically target shore based fishers because these anglers tend to be dispersed along the shore and they usually land fewer fish than boat based fishers.

Interviewers were required to work on weekends and public holidays only, to maximise the likely potential number of fishers encountered. The decision to avoid midweek interviewing is unlikely to cause biased estimates of mean fish weight, as species specific comparisons of weekday and weekend length frequency data in 1996 found little apparent difference in mean size with respect to day type (Hartill et al. 1998). Two four hour interview shifts were scheduled for each month, with no two days falling in the same weekend. Interviewers were asked to reschedule their survey days if the weather forecast was unfavourable for fishing. In some instances interviewers decided to reschedule their survey day when they found that no empty boat trailers were parked at their assigned ramp.

Interviews were conducted throughout the fishing year, because seasonal differences in length frequency composition were found for some species in a similar survey in 1996 (Hartill et al. 1998). The season definitions used in the analysis of all data collected and collated as part of this programme are summer (1 October to 30 April) and winter (1 May to 30 September).

The format of interviews conducted as part of this project and other concurrent recreational creel surveys undertaken by NIWA followed that used in previous surveys over the last 16 years. As many fishing parties as possible were approached during each four hour interview session and boats were selected at random when the interviewer was too busy to approach all boats. Fishing parties were asked where they fished, for how long and by what methods, and who caught which fish. Individual fish were counted and then measured if time permitted. Finfish were measured to the nearest centimetre on measuring boards but interviewers were also given a smaller measuring board to measure rock lobster tail widths (tail lengths for packhorse lobster) to the nearest millimetre.



AKA	Akaroa	MOT	Motanau	SB	Shelley Beach
BLR	Bluff	NAP	Napier	SU	Sulphur Point
BO	Bowentown	NP	New Plymouth	SVR	Seaview
CN	Cornwallis	NSR	Nelson Haven	TA	Takapuna
COL	Colac Bay	OH	Ohope	TKB	Moa Point
CSP	Castle Point	OKW	Okiwi Bay	TM	Te Kouma
GSR	Gisborne	OO	Omaha	TRK	Tarakohe
GU	Gulf Harbour	OT	Opito Bay	TU	Tutukaka
HA	Half Moon Bay	OWH	Owhiro Point	WE	Westhaven
HVR	Havelock	PA	Parua Bay (public)	WG	Waitangi
KAI	Kiakoura	PC	Parua Bay (club)	WK	Whakatane
KC	kawakawa (club)	PCL	Port Charmers	WM	Whangamata
KM	Kawakawa (public)	PP	Paraparaumu	WT	Whitianga
LYR	Littleton	RG	Raglan	WU	Wanganui
MG	Mangonui	RIV	Riverton	WW	Waikawau
MOE	Moeraki				

Figure 1: Location of boat ramps where landed recreational catches were measured.

2.2 Collating data from other creel surveys in 2011–12

Species specific length frequency data were also available from concurrent NIWA surveys of recreational fishers conducted in FMAs 1, 8, and 9, for related purposes. These survey programmes were:

- An aerial-access survey of the boat based recreational fishery in FMA 1 during the 2011–12 fishing year (MAF201102). Although this survey provided harvest estimates for snapper, kahawai, red gurnard, trevally and tarakihi, all species were measured when possible.
- A survey of recreational landings of kahawai in FMA 1 during the first four months of 2012. (MAF201003) This survey described regional kahawai catch-at-length and catch-at-age distributions for the tenth year since the beginning of the time series in 2001.
- A year round creel survey of recreational fishers returning to a small number of key ramps overlooked by web cameras in FMAs 1, 8, and 9 (MAF201107). The web camera systems provided information used to monitor changes in levels of recreational boating effort, and some interviews of recreational fishers were also conducted to determine the proportion of those boats which were actually used for fishing, and the catch rates of those who went fishing. Additional interviews of fishers were also conducted at these ramps as part of this programme.
- A multi creel method survey of the western Bay of Plenty conducted throughout 2011–12 by Blue Water Marine Research (MAF201002). This survey provided length measurements for rock lobster and scallops.

The format of the interviews conducted during the NIWA surveys were identical to that used in the more widespread survey discussed in Section 2.1.

2.3 Collating data from other recent creel surveys

Measurements of fish landed by recreational fishers were also available from recent surveys, and the decision was made to use these data rather than collecting more length frequency data in 2011–12, to save costs. These survey programmes were:

- A creel survey of fishers returning to Kaikoura and Motanau (FMA 3) in 2009 (Kendrick et al. 2009). This programme provided length measurements for sea perch and blue cod only, as these are by far the most commonly landed species on this stretch of coast.
- A creel survey of fishers in Southland that was used to characterise the FMA 5 fishery around Bluff during the 2009–10 fishing year (Davey & Hartill 2011). These interviews followed NIWA's standard interview format.
- A recreational catch sampling programme for kingfish undertaken by Blue Water Marine Research and NIWA in 2010.

2.4 Deriving fishstock specific mean weight estimates from creel survey data

All catch data were assigned to species specific Quota Management Areas (QMAs). QMAs are comprised of one or more Fisheries Management Area (FMA). For example, SNA 1 is a QMA for snapper which has fish stock boundaries corresponding to FMA 1, whereas GUR 1 is a QMA for red gurnard caught in FMAs 1 and 9 combined. Measurements of individual fish were converted into individual fish weights using the length weight relationships given in Table 1.

Table 1: Length-weight relationships used to convert fish measurements into weight estimates.

Stock	Species		*a*	*b*	Reference
BAR	Barracota	*Thyrstites atun*	0.0075	2.900	Hurst & Bagley (1994)
BCO	Blue cod	*Parapercis colias*	5E-06	3.197	Beenjtes (Unpub. Data)
BNS	Bluenose	*Hyperoglyphe antarctica*	0.0096	3.173	Horn (1988)
BUT	Butterfish	*Odax pullus*	6E-06	3.239	Paul et al. (2000)
EMA	Blue mackerel	*Scomber australasicus*	0.0088	3.110	Shaun-ror (1970)
FLA	Flatfish	*Rhombosolea* spp.	0.0380	2.660	McGregor (Unpub. Data)
GMU	Grey mullet	*Mugil cephalus*	0.0424	2.826	Breen & McKenzie (unpublished)
GUR 1	Red gurnard	*Chelidonichthys kumu*	0.0100	2.990	Elder (1976)
GUR 2	Red gurnard	*Chelidonichthys kumu*	0.0053	3.190	Stevenson (2000)
HAP 1	Hapuku/Bass	*Polyprion oxygeneios & P. americanus*	0.0142	3.003	Johnston (1993)
HAP 2	Hapuku/Bass	*Polyprion oxygeneios & P. americanus*	0.0242	2.867	Johnston (1993)
HAP 7,8	Hapuku/Bass	*Polyprion oxygeneios & P. americanus*	0.0142	2.998	Johnston (1993)
JDO	John dory	*Zeus faber*	0.0480	2.700	MFish (2010a)
JMA	Jack mackerel	*Trachurus spp.*	0.0255	2.840	Horn (1991)
KAH	Kahawai	*Arripis trutta*	0.0236	2.890	Hartill & Walsh (2005)
KIN	Kingfish	*Seriola lalandi*	0.0365	2.762	Walsh et al. (2003)
MOK	Blue moki	*Latridopsis ciliaris*	0.0550	2.713	Francis (1979)
PAU	Paua	*Haliotis iris*	3E-08	3.303	Schiel & Breen (1991)
POR	Porae	*Nemadactylus douglasi*	0.0057	3.175	Taylor & Willis (1998)
RCO	Red cod	*Pseudophycis bachus*	0.0092	3.001	Beentjes (1992)
SCA	Scallop	*Pecten novaezelandiae*	0.0004	2.690	Cryer & Parkinson (2006)
SNA	Snapper	*Pagrus auratus*	0.0447	2.793	Paul (1976)
SPD	Spiny dogfish	*Squalus acanthias*	0.0021	3.150	Hanchet (1986)
SPE	Sea perch	*Helicolenus spp.*	0.0078	3.219	Schofield & Livingston (1996)
SPO	Rig	*Mustelus lenticulatus*	0.0010	3.320	Francis (Unpub. Data)
TAR	Tarakihi	*Nemadactylus macropterus*	0.0141	3.087	Tong & Vooren (1972)
TRE	Trevally	*Pseudocaranx dentex*	0.0160	3.064	James (1984)
TRU	Trumpeter	*Latris lineata*	0.0116	3.090	Beenjtes et al. (2010)
YEM	Yellow eyed mullet	*Aldrichetta forsteri*	0.0068	3.200	Gorman (1962)

weight = a length^b — greenweights in g for all species except blue cod and butterfish (kg); all lengths in cm except for scallops and paua (mm)

Stock	Species		*b0*	*b1*	Source
ALB	Albacore tuna	*Thunnus alalunga*	-10.29	2.900	MFish (2010b)
SKJ	Skipjack tuna	*Katsuwonus pelamis*	-11.7	3.160	Habib et al. (1981)

In(weight) = $b0 + b1$ * In(fork length) — greenweights in kg, fork lengths in cm

Rock lobster *Jasus edwardsii*

Stock	Males		Females		Source
	a	*b*	*a*	*b*	
CRA 1,2,3,4,5	0.00000416	2.935	0.000013	2.545	MFish (2010a)
CRA 6,7,8,9	0.000003394	2.967	0.00001037	2.632	MFish (2010a)

weight = a length^b — greenweights in kg, lengths in mm

Mean weight estimates were also calculated for sub regions of QMA 1: for snapper, kahawai, red gurnard, tarakihi and trevally; and for the western Bay of Plenty for kahawai and red gurnard. Mean weight estimates for these sub regions are required by other concurrent harvest estimation programmes so that estimates of numbers of fish caught can be converted into estimates of the tonnage harvested.

2.5 Review of length-weight relationships used to derive mean weight estimates

Interviewers measure but do not weigh fish, because weighing fish increases the duration of an interview and measurements have a greater general utility. This means that standard length-weight relationships are required to convert individual measurements in fish weights, which are then averaged.

The derivation of mean weights from length measurements has been the accepted practice to date (Hartill et al. 1998, Boyd & Gowing 2004), but concern has been expressed about the potential accuracy of available length-weight relationships. Most, if not all, of the available length-weight relationships are based on a linear regression of logged weights against logged lengths, and it has been suggested that this form of regression can lead to biased estimates of average fish weight.

Paired length weight data for three species were used to determine whether non-linear regression was a more appropriate means of deriving a length-weight relationship than the common practice fitting a linear regression to logged data. Length and weight data were readily available for three commonly caught species: kahawai, blue cod, and scallops. Comparisons of log-log and non-linear regression fits to these data are given in Figures 2, 3, and 4.

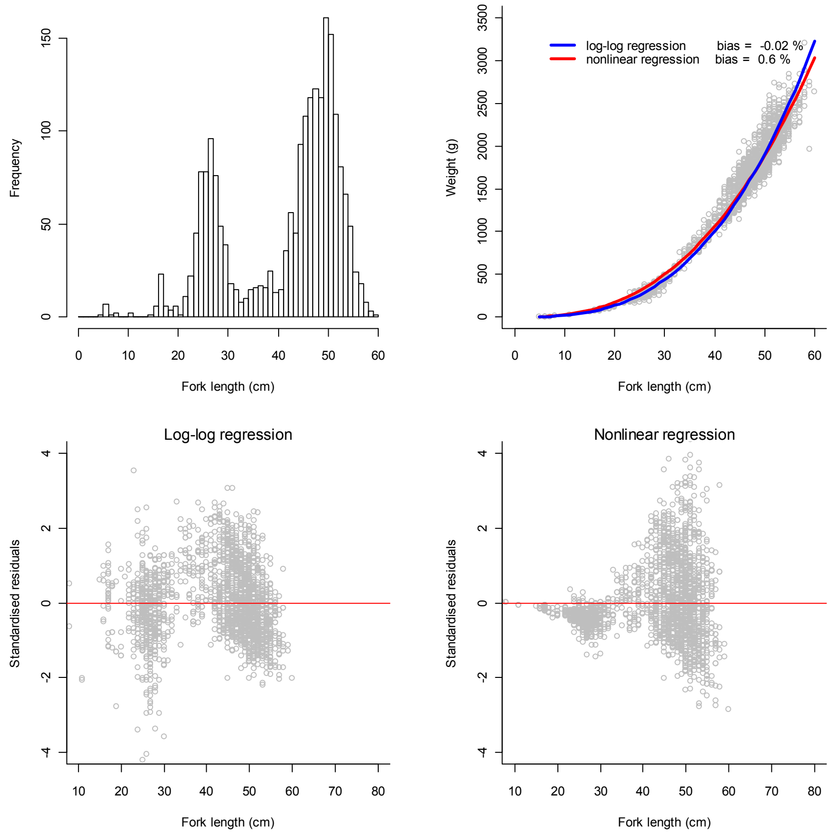


Figure 2: Comparison of log-log and non-linear regressions of kahawai length weight data.

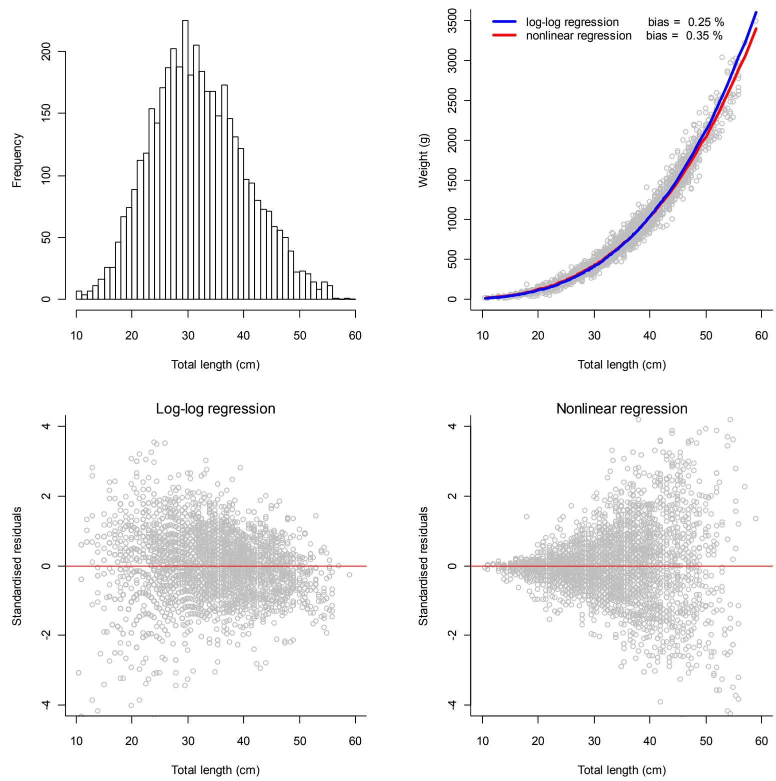


Figure 3: Comparison of log-log and non-linear regressions of blue cod length weight data.

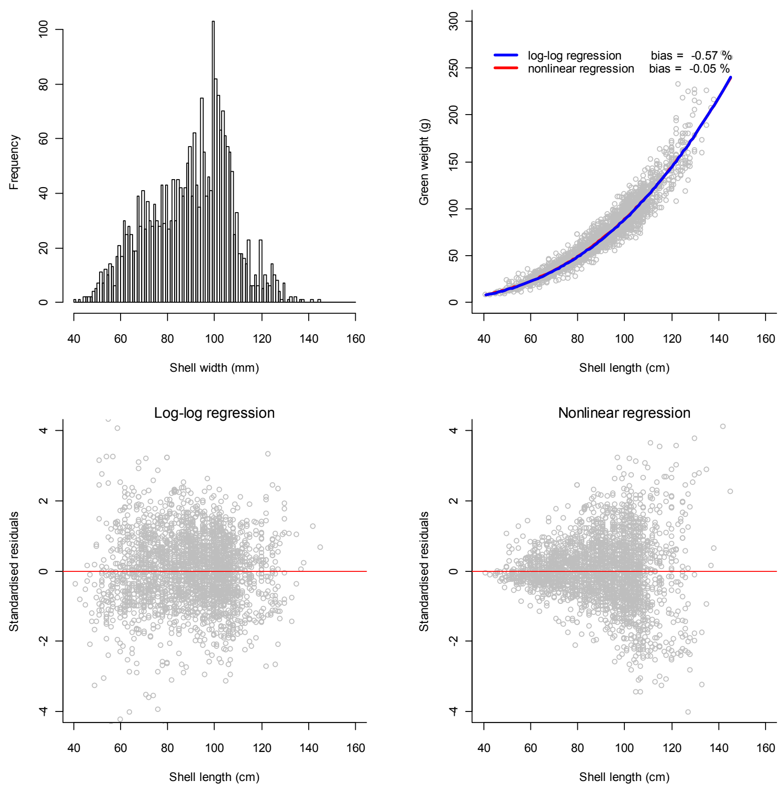


Figure 4: Comparison of log-log and non-linear regressions of scallop length weight data.

Similar results were obtained by log-log and nonlinear regressions. The level of bias resulting from these regressions (total estimated weight divided by total actual weight) ranged from -0.57 to 0.25% for the log-log approach and -0.05 to 0.60% for the non-linear approach. The level of bias is therefore relatively slight, especially when compared with other sources of bias that will ultimately influence the recreational harvest estimates that any mean weight estimate will inform.

Length and weight data are usually logged to homogenise the variance when regressing length measurements against fish weight measurements. This is because observed fish weights are typically more variable as size increases, yet regressive techniques normally assume homogeneity of variance to ensure the best fit across the entire range of the data. A comparison of residual plots derived from the two methods strongly suggests that the linear log-log approach is a more appropriate means of determining the relationship between length and weight, unless error structure is also modelled.

All estimates of mean fish weight given in this report are therefore based on measurements converted to weights using existing length-weight relationships (which we assume are derived from linear regressions of logged data).

3. RESULTS

3.1 Collection and collation of fish length data

The most intensive sampling of recreational catches in 2011–12 took place in FMA 1, where three independent survey methods were used to estimate recreational harvest estimates so that direct comparisons of these estimates could be made. FMA 1 is the most intensively fished recreational fishery in New Zealand, and this area is commonly regarded as three separate regions: East Northland (north of a line going from Cape Rodney to Cape Colville), the Hauraki Gulf (south of this line), and the Bay of Plenty (Cape Colville to Cape Runaway). The species mix and catch size distributions in these regions can differ markedly. Summary statistics for recreational catch sampling effort in each of these regions is given in Table 2.

Although interviews of recreational fishers were conducted at the busiest ramps in each region of FMA 1, interviews were conducted throughout the day, on both weekend and midweek days regardless of the weather, and consequently the average rate of interviewing at many ramps was less than one boat per hour, especially outside of the Hauraki Gulf. The overall level of sampling effort was high, however, with 15 918 boats interviewed during the 12 922 hours that interviewers were present at FMA 1 ramps.

The level of sampling effort and numbers of boats interviewed in other parts of New Zealand was far lower than in FMA 1, as the sole purpose of these interviews was to provide fish measurements which were not available as a by-product of other surveys conducted for other purposes (Table 3). Almost all interviewers completed at least two 4 hour interview sessions per month and some additional sampling was also undertaken at some FMA 8 and 9 ramps, which was primarily collected for another purpose (MAF201107).

Although the majority of fish measurements were obtained from the catch sampling described in Tables 2 and 3, additional fish measurements were available from other recent surveys: scallops (4284), blue cod (1916), kingfish (861), sea perch (409), rock lobster (126 although a small proportion of these measurements were for unsexed fish), trumpeter (83), and a small number of measurements for several other species.

The aggregate number of fish measurements available from all data sources for commonly caught species by QMA, and for some species by region of QMA 1, are given in Table 4. A small number of species account for the majority of the catch measured during recent surveys and the majority of these observations have been assigned to QMAs on the basis of the area fished, and not the location of the surveyed ramp (some ramps are close to QMA boundaries). Some species such as albacore and skipjack tuna are not currently part of the Quota Management System (QMS) and are therefore regarded as a single stock.

Table 2: The number of hours that interviewers were present at boat ramps and the number of fishing boats that they fully interviewed by region of FMA 1, by ramp, by season.

		Hours worked			Fishing boats interviewed		
Region	Ramp	Summer	Winter	Full year	Summer	Winter	Full year
FMA 1	Mangonui	404	150	554	557	52	609
East Northland	Opito Bay	395	156	551	309	36	345
	Parua Bay (public)	404	154	559	357	27	384
	Parua Bay (club)	451	173	623	446	50	496
	Tutukaka	403	148	550	222	27	249
	Waitangi	449	178	627	548	102	650
	Total	2 505	958	3 463	2 439	294	2 733
FMA 1	Gulf Harbour	408	154	562	604	83	687
Hauraki Gulf	Half Moon Bay	830	308	1 138	1 710	173	1 883
	Kawakawa (club)	402	158	560	860	126	986
	Kawakawa (public)	394	157	551	534	41	575
	Omaha	406	152	558	497	40	537
	Takapuna	439	173	612	810	124	934
	Te Kouma	387	152	540	619	130	749
	Westhaven	408	155	563	759	35	794
	Waikawau	403	152	554	1 199	151	1 350
	Total	4 077	1 562	5 639	7 592	903	8 495
FMA 1	Bowentown	401	156	557	406	37	443
Bay of Plenty	Ohope	412	124	536	340	46	386
	Sulphur Point	716	300	1 017	1 511	301	1 812
	Whakatane	441	158	599	608	109	717
	Whangamata	406	155	561	869	161	1 030
	Whitianga	406	144	550	270	32	302
	Total	2 782	1 037	3 820	4 004	686	4 690

Table 3: The number of hours that interviewers were present at boat ramps and the number of fishing boats that they fully interviewed by ramp and by season in FMAs 2,3,7,8,9.

		Hours worked			Fishing boats interviewed		
Region	Ramp	Summer	Winter	Full year	Summer	Winter	Full year
FMA 2	Castle Point	61	42	103	19	5	24
	Gisborne	59	40	99	57	30	87
	Napier	56	40	96	163	69	232
	Owhiro Bay	52	40	92	52	26	78
	Seaview	58	40	98	151	118	269
	Tarakena	8	–	8	4	–	4
	Total	293	202	495	446	248	694
FMA 3	Akaroa	59	46	105	74	30	104
	Lyttlelton	57	48	105	72	45	117
	Moeraki	56	52	108	93	33	126
	Port Chalmers	60	44	104	60	36	96
	Total	232	190	422	299	144	443
FMA 7	Havelock	60	40	100	114	22	136
	Nelson	60	41	101	256	53	309
	Okiwi Bay	56	40	96	180	63	243
	Tarakohe	59	42	101	132	78	210
	Total	236	163	398	682	216	898
FMA 8	New Plymouth	170	100	270	443	54	497
	Paraparaumu	56	40	96	174	66	240
	Wanganui	40	36	76	101	10	111
	Total	265	176	441	718	130	848
FMA 9	Cornwallis	56	38	94	99	32	131
	Manu Bay	71	–	71	213	–	213
	Raglan	71	98	169	99	32	131
	Shelley Beach	191	96	287	238	45	283
	Total	388	232	621	649	109	758

Table 4: Number of measurements by species by Quota Management Area from all available data sources.

					QMA1	QMA2	QMA3	QMA4	QMA5	QMA7	QMA8	QMA9	Unassigned	Total
Species		ENLD	HAGU	BPLE	All									
SNA	Snapper	4 772	51 677	13 249	69 698	230	–	–	–	1 454	4 423	–	–	75 805
KAH	Kahawai	1 088	4 611	2 999	8 698	847	589	–	–	–	1 395	–	–	11 529
BCO	Blue cod	–	–	–	139	823	1 111	–	1 471	2 179	675	–	–	6 398
GUR	Red gurnard	122	591	1 456	3 252	346	3	–	–	224	676	–	–	4 501
SCA	Scallop	1	–	4 349	–	–	–	–	–	–	–	–	–	4 350
TAR	Tarakihi	175	31	2 038	2 245	787	14	–	9	506	521	–	–	4 082
CRA*	Rock lobster	–	–	–	340	1 453	63	211	50	–	111	219	–	2 447
TRE	Trevally	227	638	971	1 836	52	–	–	–	146	–	–	–	2 034
KIN	Kingfish	–	–	–	1 185	12	6	–	–	8	52	–	–	1 263
SPE	Sea perch	–	–	–	9	132	481	–	1	413	9	–	–	1 045
JMA	Jack mackerel	–	–	–	765	–	–	–	–	91	–	–	–	856
JDO	John dory	–	–	–	370	19	–	–	–	–	–	–	–	389
FLA	Flatfish	–	–	–	311	5	–	–	–	16	–	–	–	332
PAU	Paua	–	–	–	–	190	46	–	48	1	–	–	–	285
BUT	Butterfish	–	–	–	180	47	16	–	–	39	–	–	–	282
RCO	Red cod	–	–	–	11	149	18	–	–	19	–	–	–	197
HPB	Hapuku/Bass	–	–	–	28	22	26	–	–	–	22	–	–	98
TRU	Trumpeter	–	–	–	1	4	9	–	83	–	–	–	–	97
BNS	Bluenose	–	–	–	37	57	–	–	–	–	–	–	–	94
BAR	Barracouta	–	–	–	37	–	–	–	5	49	–	–	–	91
MOK	Blue moki	–	–	–	79	–	–	–	–	–	–	–	–	79
POR	Porae	–	–	–	76	2	–	–	–	–	–	–	–	78
SPO	Rig	–	–	–	27	5	1	–	–	35	3	–	–	71
YEM	Yellow eyed mullet	–	–	–	6	2	1	–	2	43	–	–	–	54
GMU	Grey mullet	–	–	–	52	–	–	–	–	–	–	–	–	52
SPD	Spiny dogfish	–	–	–	–	–	–	–	–	52	–	–	–	52
EMA	Blue mackerel	–	–	–	36	5	–	–	–	10	–	–	–	51
PHC	Packhorse crayfish	–	–	–	48	–	–	–	–	–	–	–	–	48
PAR	Parorae	–	–	–	42	–	–	–	–	–	–	–	–	42
SCH	School shark	–	–	–	21	2	5	–	–	6	1	–	–	35
RSN	Red snapper	–	–	–	33	–	–	–	–	–	–	–	–	33
SKI	Gemfish	–	–	–	24	–	–	–	–	–	–	–	–	24
SKJ	Skipjack tuna	–	–	–	–	–	–	–	–	–	–	–	295	295
ALB	Albacore tuna	–	–	–	–	–	–	–	–	–	–	–	235	235
WSE	Wrasse spp	–	–	–	–	–	–	–	–	–	–	–	161	161
BMA	Blue maomao	–	–	–	–	–	–	–	–	–	–	–	104	104
STY	Spotty	–	–	–	–	–	–	–	–	–	–	–	93	93
GAR	Garfish	–	–	–	–	–	–	–	–	–	–	–	36	36
BPE	Butterfly perch	–	–	–	–	–	–	–	–	–	–	–	31	31
LEA	Leatherjacket	–	–	–	–	–	–	–	–	–	–	–	30	30
RRC	Grandaddy hapuku	–	–	–	–	–	–	–	–	–	–	–	21	21
47 other spp		–	–	–	–	–	–	–	–	–	–	–	257	257
Total		6 385	57 548	25 062	90 262	5 191	2 389	211	1 669	5 291	7 212	219	1 263	118 057

* Weights not calculated for some rock lobster as they were not sexed

3.2 Mean weight estimates

Length-weight relationships given in Table 1 were used to convert measurements of the 27 most commonly caught QMS species and for albacore and skipjack tuna also. The resulting individual fish weights were then averaged for each QMA, and by sub region of QMA 1 for some commonly caught species (Table 5). Mean weight estimates were then calculated from seasonal (summer compared to winter) and annual (all of 2011–12) fish weight data and t tests were used to determine whether there were seasonal mean weight differences for each fishstock. The standard errors calculated for estimates with low sample sizes are likely to be underestimated as distribution of the underlying data will be potentially poorly defined and highly influenced by a small number of individual measurements.

Snapper

Snapper was the most commonly encountered species in all three regions of SNA 1 (69 698 measured) and in SNA 8 (4423) and the second most commonly caught species in SNA 7 (1454) (Table 5, Figures 5 and 6). Snapper were also landed and measured in SNA 2 (230).

Snapper landed in the Hauraki Gulf were on average significantly heavier in the summer than in the winter, whereas in the Bay of Plenty the seasonal trend in mean weights was reversed, where the average weight of snapper landed in the winter was statistically heavier than the summer average. These seasonal trends in mean weight may be at least partially due to an influx of schooling fish from the Bay of Plenty into the Hauraki Gulf during the spawning season.

There are also marked regional differences in the length compositions of snapper landed in SNA 8 (Appendix 1). Snapper caught in the Manukau and Kaipara harbours are usually much smaller than those caught on the open coast. There are also latitudinal differences in the size of fish caught on the open coast, and separate mean weight estimates are therefore provided for: the harbour fisheries, for the open coast fishery north of Tirua Point, and for the open coast south of Tirua point.

Kahawai

The length frequency compositions of kahawai landed by recreational fishers in 2011–012 were highly variable, both seasonally and spatially. Most length compositions were multimodal with prominent secondary modes of sub-adults present in most cases. Marked seasonal differences in length composition are seen in all kahawai QMAs and sub-regions of QMA 1 (Table 5 and Figures 7 and 8).

Blue cod

Blue cod was the third most common species landed by interviewed fishers in 2011–12 and the most commonly caught species in the South Island. Summer caught blue cod were on average significantly heavier than winter caught fish in BCO 1 and BCO 5, but significantly lighter in BCO 7 (Table 5 and Figure 9).

Red gurnard

Red gurnard were commonly encountered in most areas except in East Northland in GUR 1 and in GUR 3. The GUR 1 management area spans the east and the west coasts at the top of the North Island and the size composition of fish caught on the two coasts differ (Figure 10). Gurnard landed from the west coast are on average larger than those landed on the east coast of GUR 1 (Figure 11). Within eastern GUR 1, gurnard were on average larger in East Northland, than elsewhere (Figure 10). Seasonal mean fish weights were statistically different in some parts of GUR 1 and in GUR 2 (Table 5).

Tarakihi

Tarakihi were landed by recreational fishers in most surveyed areas, but most were measured from the Bay of Plenty (TAR 1), and to a lesser extent, from TAR 2, 7, and 8 (Table 5 and Figures 12,13). The

TAR 1 management area spans both the east and the west coast of the top of the upper North Island, but only one tarakihi measurement is available from the west coast of TAR 1. The most significant difference between seasonal mean weights is in TAR 2, where the mean summer weight is 103 g heavier than the mean winter weight (Table 5).

Trevally

Most trevally measurements were collected from TRE 1, and most of these were from fish landed from the Hauraki Gulf and the Bay of Plenty (Table 5, Figure 14). Summer caught trevally were on average substantially and significantly heavier than winter caught trevally landed from East Northland and the Bay of Plenty.

Rock lobster

Weights of rock lobster harvested by recreational fisheries varied considerably by QMA, sex and fishing method. Only measurements of sexed rock lobster were used when estimating mean weights because both minimum size limits and morphology differ by sex. Fishing method specific mean weight estimates were calculated for CRA 4, CRA 5 and CRA 8 (Table 7) because insufficient length measurements were available from creel survey data, and because the commercial fishery observer programmes provide ample data for pot based fisheries if the selectivity of commercial pots is assumed to be the same as that of recreational pots. Analyses given in Appendices 2a, 2b, and 2c, clearly show that scuba divers and snorkelers tend to catch significantly larger lobster than pot fishers. This because recreational divers/snorkelers will preferentially select larger lobsters when they encounter more than six lobster, whereas recreational pot fishers are far less likely to encounter this many fish.

Table 5: Mean weight estimates (g) for finfish species commonly caught by recreational fishers by QMA, by season and for both seasons combined. Asterisks denote where t tests have detected a significant difference between seasonal mean weight estimates. Best estimates are boxed.

		Summer			Winter			All year			Seasonal	Best
Fishstock	Region	Estimate (g)	SE	n	Estimate (g)	SE	n	Estimate (g)	SE	n	difference	estimate
ALB		4 205	99.4	235	–	–	–	4 205	99.4	235	–	all ALB
BAR 1		2 132	160.1	31	2 847	523.4	6	2 248	161.2	37	–	too few
BAR 5		2 678	332.9	4	2 478	–	1	2 638	261.0	5	–	too few
BAR 7		2 011	112.7	45	2 081	116.0	4	2 017	103.7	49	–	too few
		2 091	90.7	80	2 535	298.3	11	2 145	88.2	91	–	all BAR
BCO 1		454	22.6	113	343	25.5	26	433	19.3	139	**	Seasonal
BCO 2		484	6.9	564	494	14.6	259	487	6.6	823	–	Annual
BCO 3		482	6.7	859	472	9.9	252	479	5.6	1 111	–	Annual
BCO 5		618	8.0	1347	529	22.0	124	610	7.5	1 471	***	Seasonal
BCO 7		415	4.2	1395	472	7.3	784	436	3.8	2 179	***	Seasonal
BCO 8		536	9.5	565	563	19.2	110	540	8.6	675	–	Annual
		506	3.3	4843	484	5.3	1555	501	2.8	6 398	***	not used
BNS 1		4 378	444.8	36	575	–	1	4 275	444.6	37	–	too few
BNS 2		4 869	432.1	40	3 973	501.7	17	4 602	340.1	57	–	too few
		4 636	309.2	76	3 784	509.3	18	4 473	269.5	94	–	all BNS
BUT 1		1 068	25.1	180	–	–	–	1 068	25.1	180	–	Annual
BUT 2		1 285	56.8	47	–	–	–	1 285	56.8	47	–	too few
BUT 3		1 152	26.5	7	1 253	78.7	9	1 209	46.3	16	–	too few
BUT 7		1 117	45.7	36	1 452	288.1	3	1 142	48.2	39	–	too few
		1 115	20.9	270	1 303	88.5	12	1 123	20.4	282	–	other than BUT 1
EMA 1		950	100.3	33	1 569	179.3	3	1 001	97.1	36	–	too few
EMA 2		293	63.7	4	345	–	1	304	50.4	5	–	too few
EMA 7		1 540	95.3	10	–	–	–	1 540	95.3	10	–	too few
		1 019	87.3	47	1 263	331.0	4	1 039	84.0	51	–	all EMA
FLA 1		426	10.3	197	345	10.9	114	396	8.0	311	***	Seasonal
FLA 2		–	–	–	339	36.1	5	339	36.1	5	–	too few
FLA 7		388	28.1	14	508	185.5	2	403	31.5	16	–	too few
		423	9.8	211	347	10.8	121	396	7.6	332	***	other than FLA 1
GUR 1		399	2.9	2633	427	6.4	619	404	2.7	3 252	***	Seasonal
	ENLD	413	14.6	115	315	44.2	7	408	14.1	122	–	Annual
	HAGU	342	4.8	509	341	13.1	82	342	4.5	591	–	Annual
	BPLE	366	3.7	1146	387	8.2	310	370	3.4	1 456	*	Seasonal
	BPLE west	395	4.4	687	429	10.1	213	403	4.2	900	**	Seasonal
	GUR 1 east	362	2.9	1770	376	7.0	399	365	2.7	2 169	–	Annual
	GUR 1 west	475	5.8	863	518	10.1	220	483	5.1	1 083	***	Seasonal
GUR 2		560	12.7	290	740	48.6	56	589	13.7	346	***	Seasonal
GUR 3		506	233.3	2	447	–	1	486	136.2	3	–	too few
GUR 7		548	21.5	132	497	20.1	92	527	15.2	224	–	Annual
GUR 8		506	6.6	602	439	19.0	74	499	6.3	676	**	Seasonal
		435	2.9	3659	456	6.9	842	439	2.7	4 501	**	for GUR 3
GMU 1		921	42.9	51	978	–	1	922	42.1	52	–	All GMU

Table 5: - continued: Mean weight estimates (g) for finfish.

		Summer			Winter			All year			Seasonal	Best
Fishstock	Region	Estimate (g)	SE	n	Estimate (g)	SE	n	Estimate (g)	SE	n	difference	estimate
HPB 1		7 754	1213.9	25	6 782	4251.5	3	7 650	1147.3	28	–	too few
HPB 2		6 152	1015.6	13	4 436	1276.2	9	5 450	797.5	22	–	too few
HPB 3		3 226	423.2	26	–	–	–	3 226	423.2	26	–	too few
HPB 8		7 079	1008.8	22	–	–	–	7 079	1008.8	22	–	too few
		5 970	514.4	86	5 023	1343.1	12	5 854	479.1	98	–	all HPB
JDO 1		1 300	26.5	295	1 099	52.2	75	1 259	23.9	370	***	Seasonal
JDO 2		1 336	111.4	16	1 327	163.6	3	1 334	95.8	19	–	too few
		1 302	25.7	311	1 108	50.7	78	1 263	23.2	389	***	other than JDO 1
JMA 1		319	6.3	744	310	35.4	21	318	6.2	765	–	Annual
JMA 7		510	25.3	88	539	15.4	3	511	24.4	91	–	Annual
		339	6.5	832	339	34.8	24	339	6.4	856	–	for JMA 3
KAH 1		1 522	9.9	7311	1 507	19.9	1387	1 520	8.9	8 698	–	by region
	ENLD	1 473	23.7	966	1 220	55.1	122	1 445	22.0	1 088	***	Seasonal
	HAGU	1 565	15.5	3841	1 475	28.6	770	1 550	13.7	4 611	**	Seasonal
	BPLE	1 477	13.4	2504	1 628	29.5	495	1 502	12.3	2 999	***	Seasonal
	BPLE west	1 449	16.8	1601	1 668	34.0	358	1 489	15.2	1 959	***	Seasonal
KAH 2		1 583	32.5	579	1 449	54.7	268	1 541	28.2	847	*	Seasonal
KAH 3		1 279	33.5	519	2 340	66.8	70	1 405	33.7	589	***	Seasonal
KAH 8		1 664	20.0	1083	1 318	35.4	312	1 586	17.8	1 395	***	Seasonal
		1 529	8.4	9492	1 499	16.9	2037	1 524	7.5	11 529	–	not used
KIN 1		10 118	154.2	836	11 218	217.4	349	10 442	127.0	1 185	***	Seasonal
KIN 2		7 108	888.1	10	7 932	639.4	2	7 245	743.4	12	–	too few
KIN 3		4 251	2059.4	6	–	–	–	4 251	2059.4	6	–	too few
KIN 7		9 903	1377.5	7	8 305	–	1	9 703	1209.5	8	–	too few
KIN 8		8 856	614.9	51	11 217	–	1	8 901	604.7	52	–	too few
		9 974	148.3	910	11 191	215.5	353	10 314	123.6	1 263	***	other than KIN 1
MOK 1		2 044	165.8	63	1 954	230.1	16	2 026	139.7	79	–	all MOK
POR 1		1 206	93.2	59	1 354	211.5	17	1 239	86.0	76	–	too few
POR 2		1 011	–	1	1 600	–	1	1 306	294.5	2	–	too few
		1 202	91.7	60	1 368	199.9	18	1 241	84.0	78	–	all POR
RCO 1		403	70.0	9	251	0.0	2	375	59.6	11	–	too few
RCO 2		1 152	50.5	79	1 247	60.6	70	1 197	39.1	149	–	Annual
RCO 3		855	86.2	10	1 004	214.7	8	921	104.6	18	–	too few
RCO 7		789	204.2	7	1 482	311.1	12	1 227	220.6	19	–	too few
		1 035	46.8	105	1 235	65.7	92	1 129	40.1	197	*	other than RCO 2
SKJ		2 236	56.7	295	–	–	–	2 236	56.7	295	–	all SKJ

Table 5: - continued: Mean weight estimates (g) for finfish.

Fishstock	Region	Summer Estimate (g)	Summer SE	Summer n	Winter Estimate (g)	Winter SE	Winter n	All year Estimate (g)	All year SE	All year n	Seasonal difference	Best estimate
SNA 1		1 027	2.7	63206	1 006	8.2	6492	1 025	2.6	69 698	*	by region
	ENLD	1 267	17.3	4430	1 247	67.1	342	1 266	16.8	4 772	–	Annual
	HAGU	1 022	2.9	47622	987	9.2	4055	1 019	2.8	51 677	***	Seasonal
	BPLE	956	5.8	11154	1 003	14.4	2095	963	5.4	13 249	**	Seasonal
SNA 2		1 016	54.0	202	1 105	210.9	28	1 027	53.7	230	–	Annual
SNA 7		793	15.2	1428	1 168	333.7	26	799	16.1	1 454	–	Annual
SNA 8		1043	12	4 253	1488	81	170	1060	12	4 423	***	not used
	Harbours	745	11	1 542	1588	162	46	770	12	1 588	***	Annual
	N coast	1245	21	1 839	1638	148	50	1255	21	1 889	*	Annual
	S coast	1146	28	872	1325	120	74	1160	28	946	–	Annual
		1 023	2.6	69089	1 019	8.4	6716	1 023	2.5	75 805	–	for SNA 3
SPD 7		1 158	130.4	29	842	70.3	23	1 018	81.4	52	*	All SPD
SPE 1		989	278.1	8	246	–	1	906	258.8	9	–	too few
SPE 2		531	28.8	84	504	28.0	48	521	20.9	132	–	Annual
SPE 3		436	10.9	458	831	55.3	23	455	11.4	481	***	Seasonal
SPE 5		868	–	1	–	–	–	868	–	1	–	too few
SPE 7		446	10.2	220	399	9.4	193	424	7.1	413	***	Seasonal
SPE 8		366	51.1	7	237	117.0	2	337	47.6	9	–	too few
		455	8.5	778	453	12.3	267	454	7.0	1 045	–	other than SPE 2,3,7
SPO 1		1 004	158.9	25	674	318.0	2	979	148.9	27	–	too few
SPO 2		1 167	523.9	3	1 409	942.3	2	1 264	417.9	5	–	too few
SPO 3		2 081	–	1	–	–	–	2 081	–	1	–	too few
SPO 7		1 117	275.2	35	–	–	–	1 117	275.2	35	–	too few
SPO 8		1 170	799.7	3	–	–	–	1 170	799.7	3	–	too few
		1 094	159.1	67	1 042	458.1	4	1 091	151.8	71	–	all SPO
TAR 1		709	16.5	1384	702	9.6	861	706	10.8	2 245	–	by region
	ENLD	784	27.8	140	700	30.8	35	767	23.2	175	*	Seasonal
	HAGU	1 047	191.2	27	1 086	56.1	4	1 052	166.2	31	–	see ENLD
	BPLE	693	18.0	1216	700	9.9	822	696	11.5	2 038	–	Annual
	TAR 1 east	709	16.5	1383	702	9.6	861	706	10.8	2 244	–	Annual
	TAR 1 west	624	–	1	–	–	–	624	–	1	–	see east
TAR 2		639	19.4	292	736	14.2	495	700	11.6	787	***	Seasonal
TAR 3		971	298.2	13	687	–	1	950	276.8	14	–	too few
TAR 5		598	51.1	8	2 183	–	1	774	181.7	9	–	too few
TAR 7		487	10.9	270	482	6.9	236	484	6.7	506	–	Annual
TAR 8		683	22.5	432	849	75.1	89	712	22.8	521	*	Seasonal
		672	10.9	2399	689	8.0	1683	679	7.2	4 082	–	for TAR 3,5
TRE 1		1 299	19.6	1629	1 168	52.1	207	1 284	18.3	1 836	*	by region
	ENLD	1 089	59.7	199	730	65.9	28	1 045	53.5	227	***	Seasonal
	HAGU	1 300	34.5	567	1 318	106.5	71	1 302	32.8	638	–	Annual
	BPLE	1 346	25.4	863	1 183	65.2	108	1 328	23.8	971	*	Seasonal
TRE 2		995	59.1	43	1 496	232.4	9	1 082	67.4	52	–	Annual
TRE 7		1 401	61.9	138	1 288	172.9	8	1 395	59.2	146	–	Annual
		1 299	18.3	1810	1 185	49.5	224	1 287	17.2	2 034	*	for TRE 3

Table 5: - continued: Mean weight estimates (g) for finfish.

		Summer			Winter			All year			Seasonal	Best
Fishstock	Region	Estimate (g)	SE	n	Estimate (g)	SE	n	Estimate (g)	SE	n	difference	estimate
TRU 1		–	–	–	572	–	1	572	–	1	–	too few
TRU 2		8 990	1231.4	4	–	–	–	8 990	1231.4	4	–	too few
TRU 3		1 036	146.2	5	1 417	187.0	4	1 205	127.4	9	–	too few
TRU 5		1 075	32.9	80	952	172.4	3	1 071	32.2	83	–	too few
		1 429	183.9	89	1 137	154.3	8	1 405	169.3	97	–	all TRU
YEM 1		286	38.4	6	–	–	–	286	38.4	6	–	too few
YEM 2		–	–	–	145	10.3	2	145	10.3	2	–	too few
YEM 3		202	–	1	–	–	–	202	–	1	–	too few
YEM 5		594	0.0	2	–	–	–	594	0.0	2	–	too few
YEM 7		172	12.5	43	–	–	–	172	12.5	43	–	too few
		202	16.4	52	145	10.3	2	200	15.9	54	*	all YEM

Table 6: Mean weight estimates (g) for shellfish species other than rock lobster, which are commonly caught by recreational fishers by QMA, by season and for both seasons combined. Asterisks denote where t tests have detected a significant difference between seasonal mean weight estimates. Best estimates are boxed.

		Summer			Winter			All year			Seasonal	Best
Fishstock	Region	Estimate (g)	SE	n	Estimate (g)	SE	n	Estimate (g)	SE	n	difference	estimate
PAU 2		286	2.5	190	–	–	–	286	2.5	190	–	Annual
PAU 3		304	7.9	41	274	13.3	5	301	7.3	46	–	too few
PAU 5		232	29.9	48	–	–	–	232	29.9	48	–	too few
PAU 7		325	–	1	–	–	–	325	–	1	–	too few
		280	5.6	280	274	13.3	5	280	5.5	285	–	other than PAU 2
SCA(CS)	BPLE west	111	0.2	4349	–	–	–	111	0.2	4 349	–	Annual

Table 7: Mean weight estimates (g) for rock lobster by QMA, by for diver and for pot caught fish. Best estimates are boxed.

		Summer			Winter			All year			
Fishstock	Method	Estimate (g)	SE	n	Estimate (g)	SE	n	Estimate (g)	SE	n	Source
CRA 1	All	799	20.5	277	852	49.5	45	806	18.9	322	NIWA survey
CRA 2	All	697	8.4	1191	720	19.7	227	701	7.7	1 418	BWMR/NIWA
BPLE west	All	698	9.1	1016	683	23.5	220	696	8.6	1 236	BWMR/NIWA
CRA 3	All	–	–	–	–	–	–	580	1.7	4 700	Observer data
CRA 4	Scuba	1018	39	161	874	46	34	993	33	195	NIWA survey
	Pot	–	–	–	–	–	–	582	1.7	9 586	Observer data
CRA 5	Scuba	938.1	46.0	148	–	–	–	938	46.0	148	Trophia survey
	Pot	–	–	–	–	–	–	699	5.8	1896	Observer data
CRA 7	ALL	–	–	–	–	–	–	641	5.4	338	Observer data
CRA 8	Scuba	1 621	95.3	93	–	–	–	1 621	95.3	93	NIWA survey
	Pot	–	–	–	–	–	–	784	3.0	9 069	Observer data
CRA 9	All	1 122	46.9	166	1 590	240.5	13	1 156	47.5	179	NIWA survey

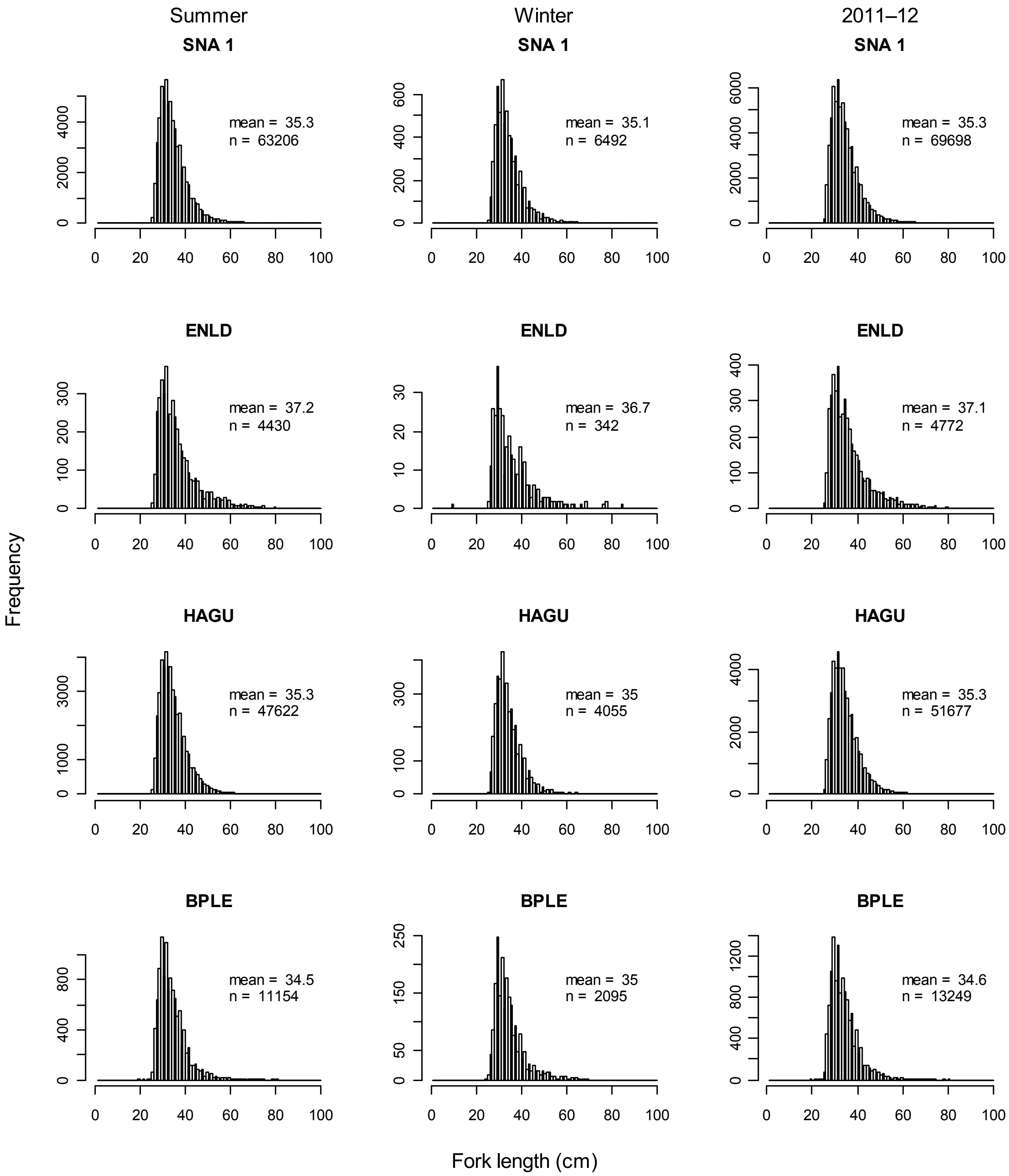


Figure 5: Length frequency distributions for snapper measured in QMA 1 by region and season.

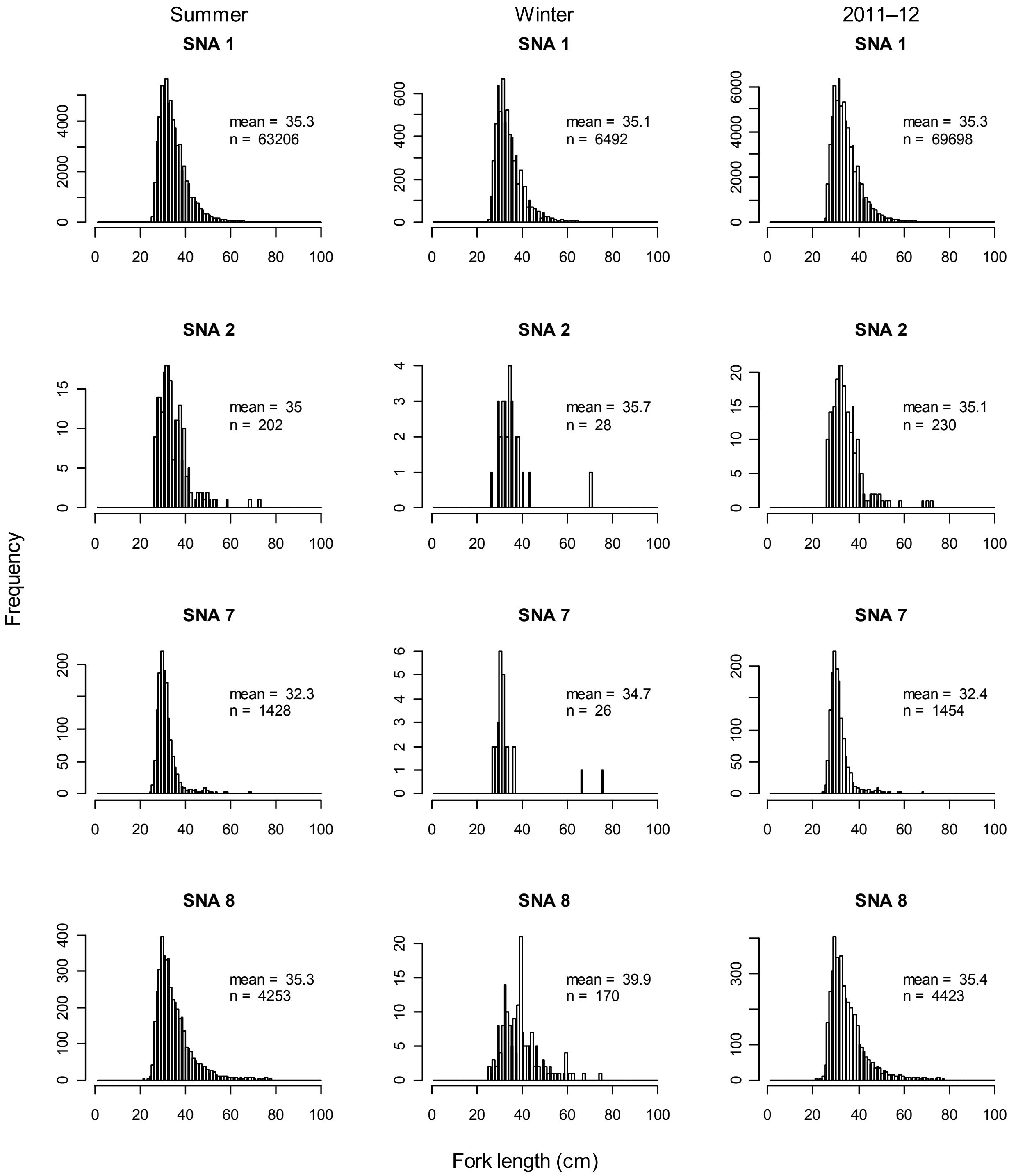


Figure 6: Length frequency distributions for snapper by QMA and season.

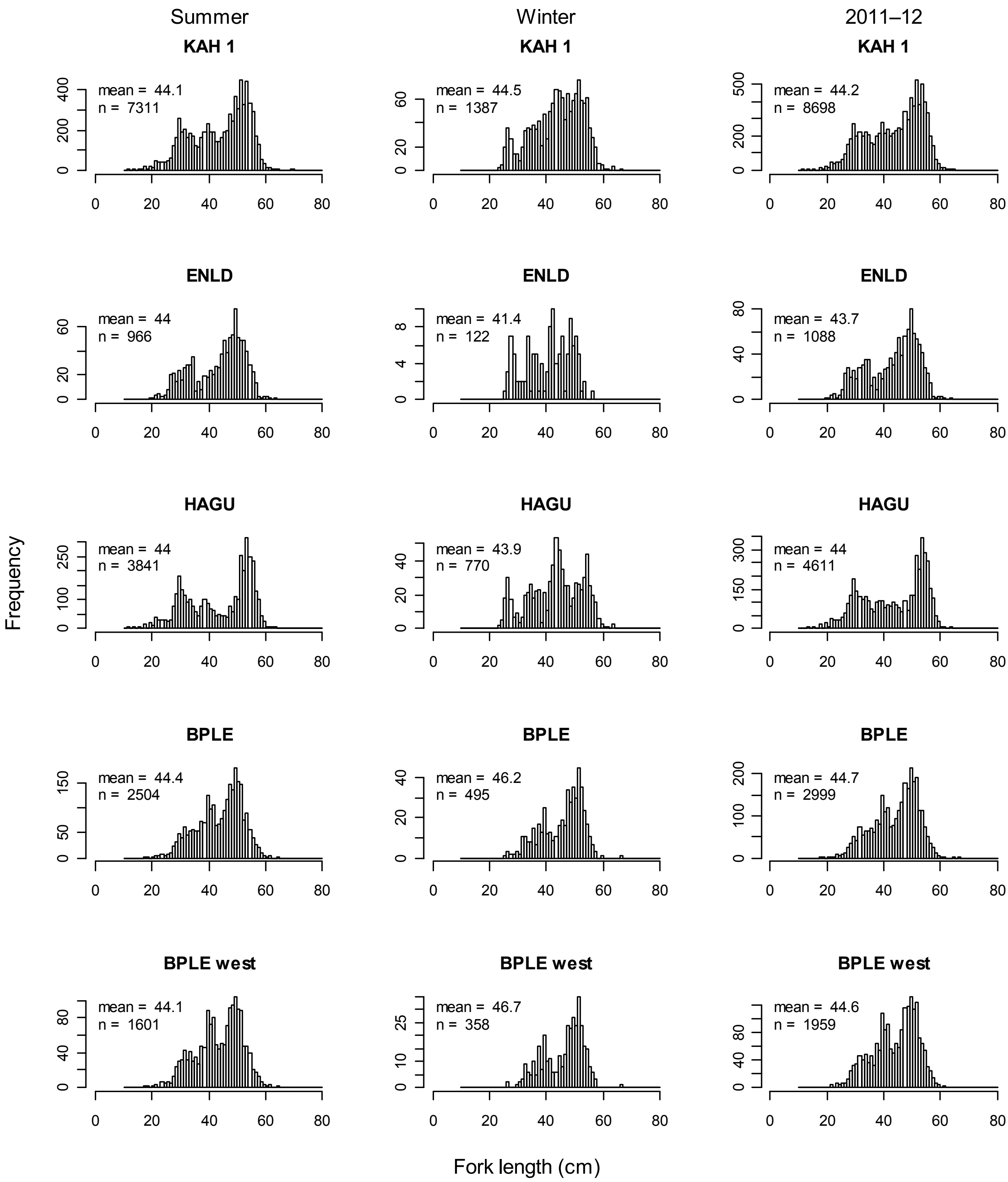


Figure 7: Length frequency distributions for kahawai measured in QMA 1 by region and season.

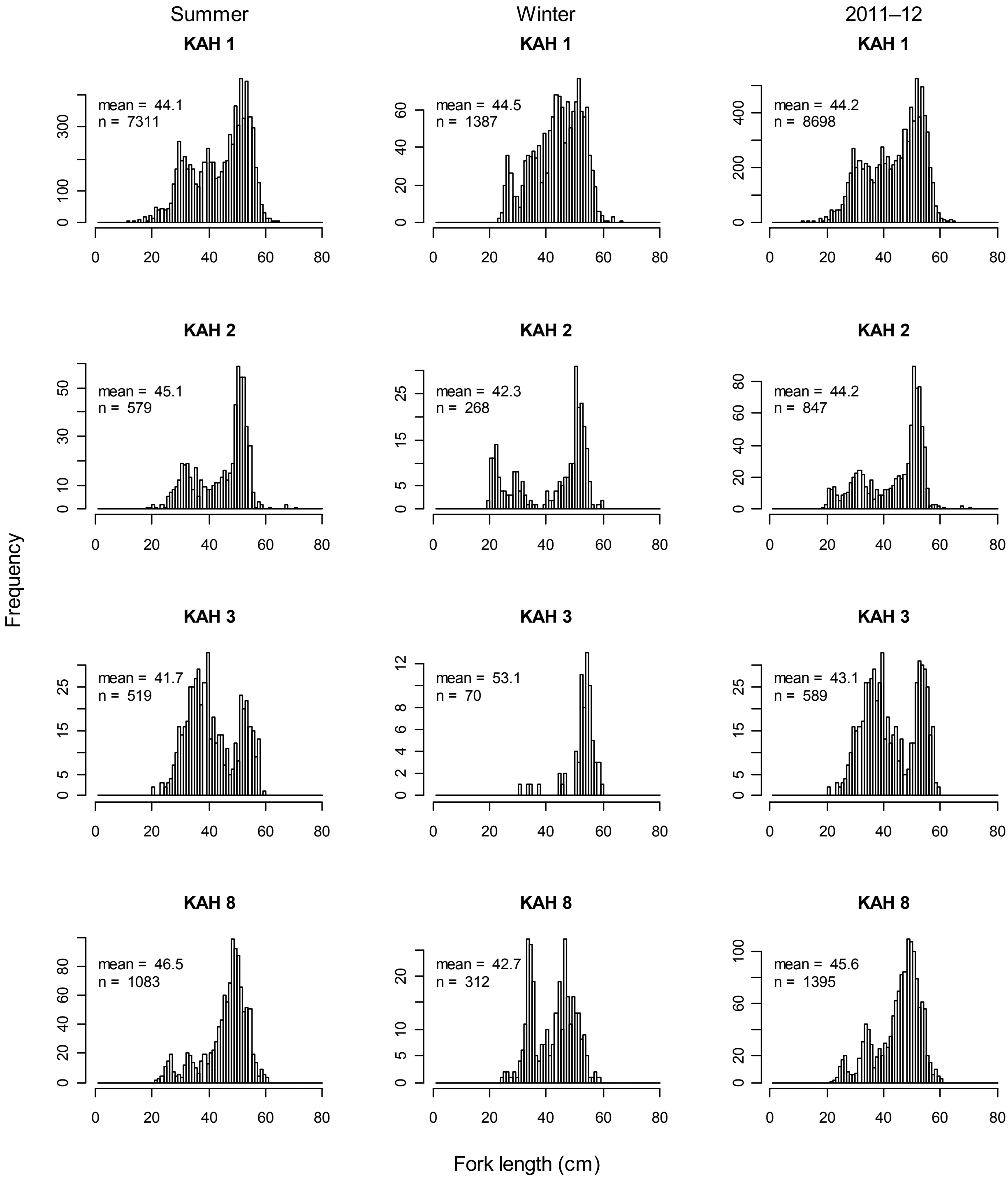


Figure 8: Length frequency distributions for kahawai by QMA and season.

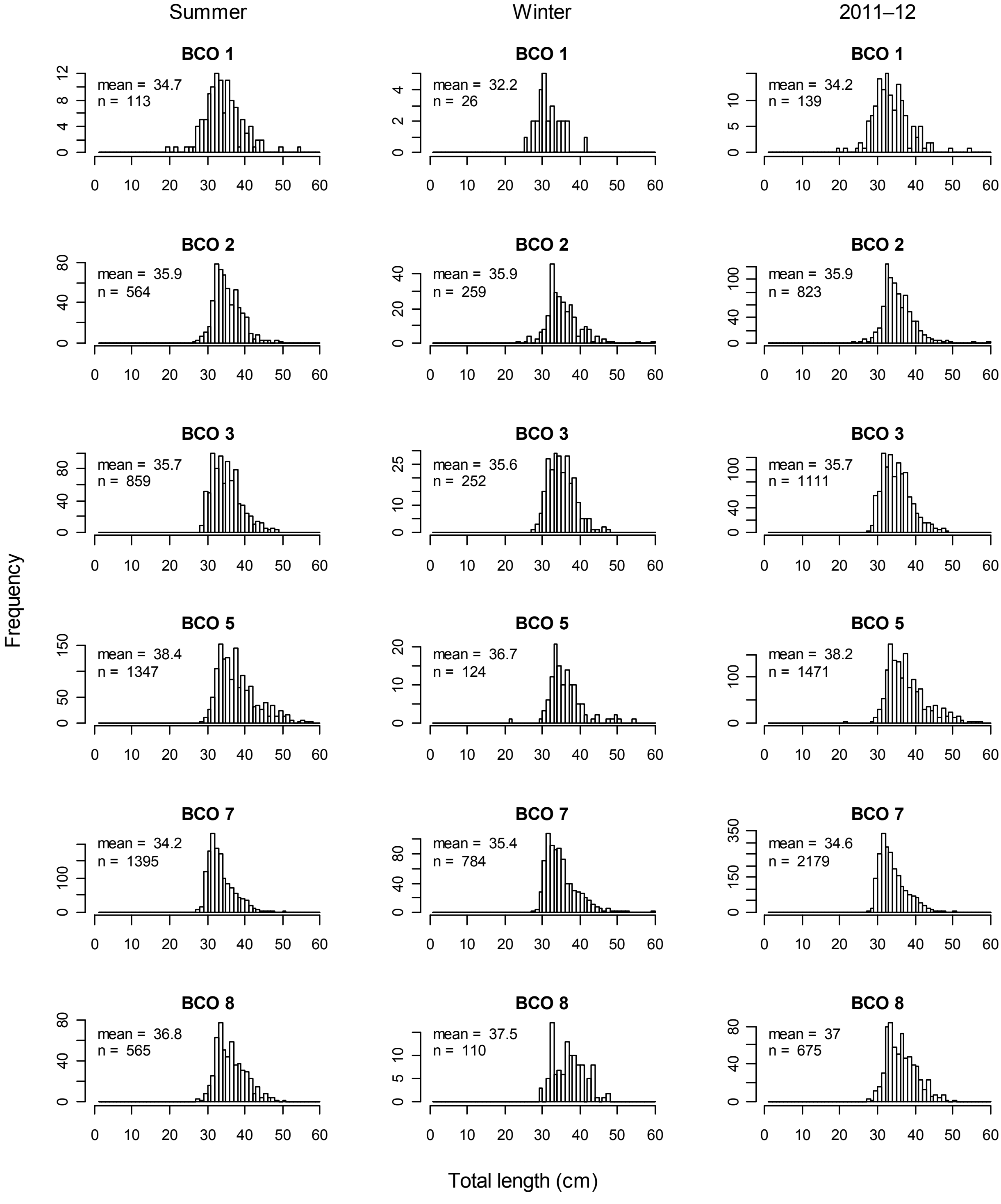


Figure 9: Length frequency distributions for blue cod by QMA and season.

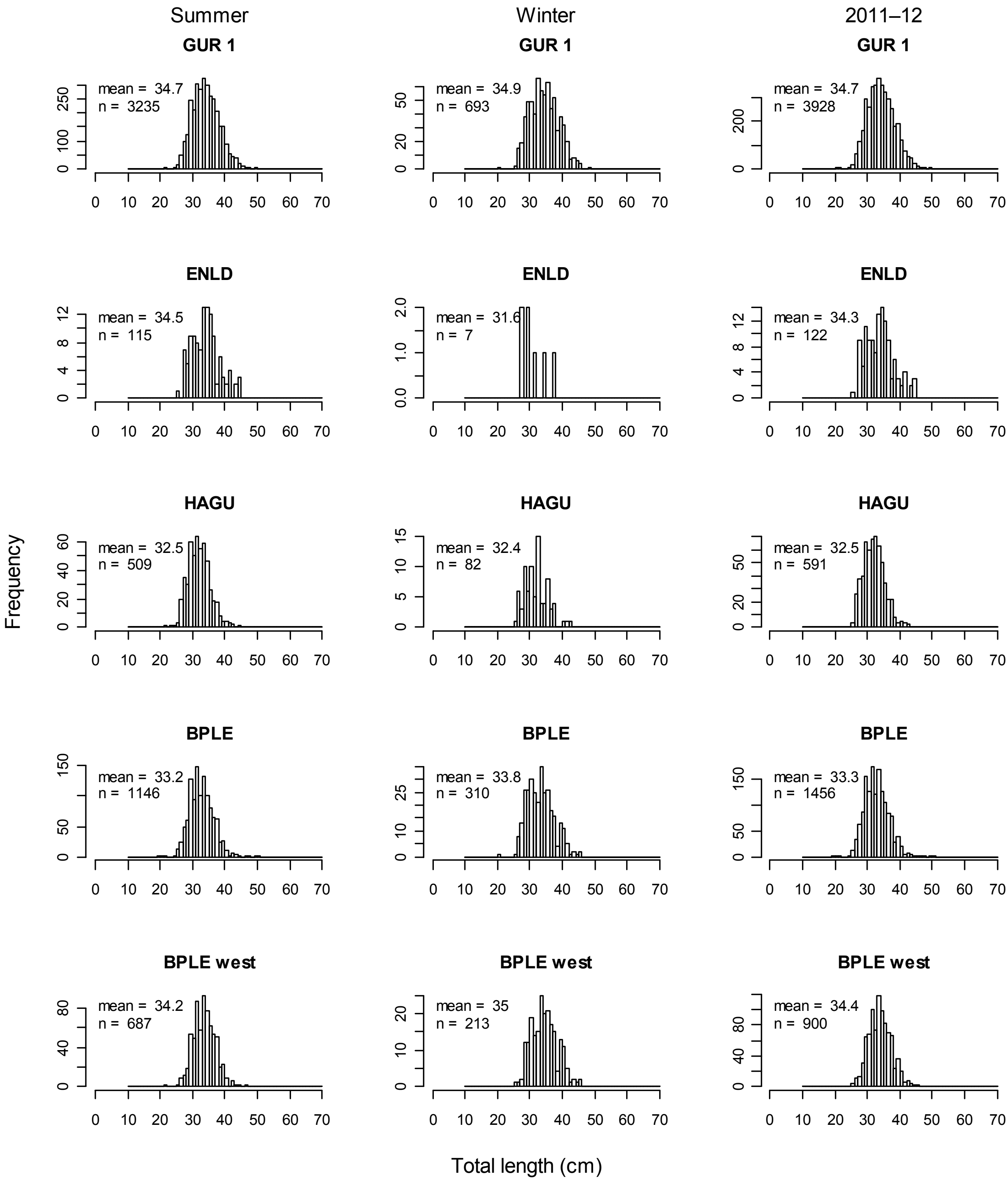


Figure 10: Length frequency distributions for red gurnard measured in QMA 1 by region and season.

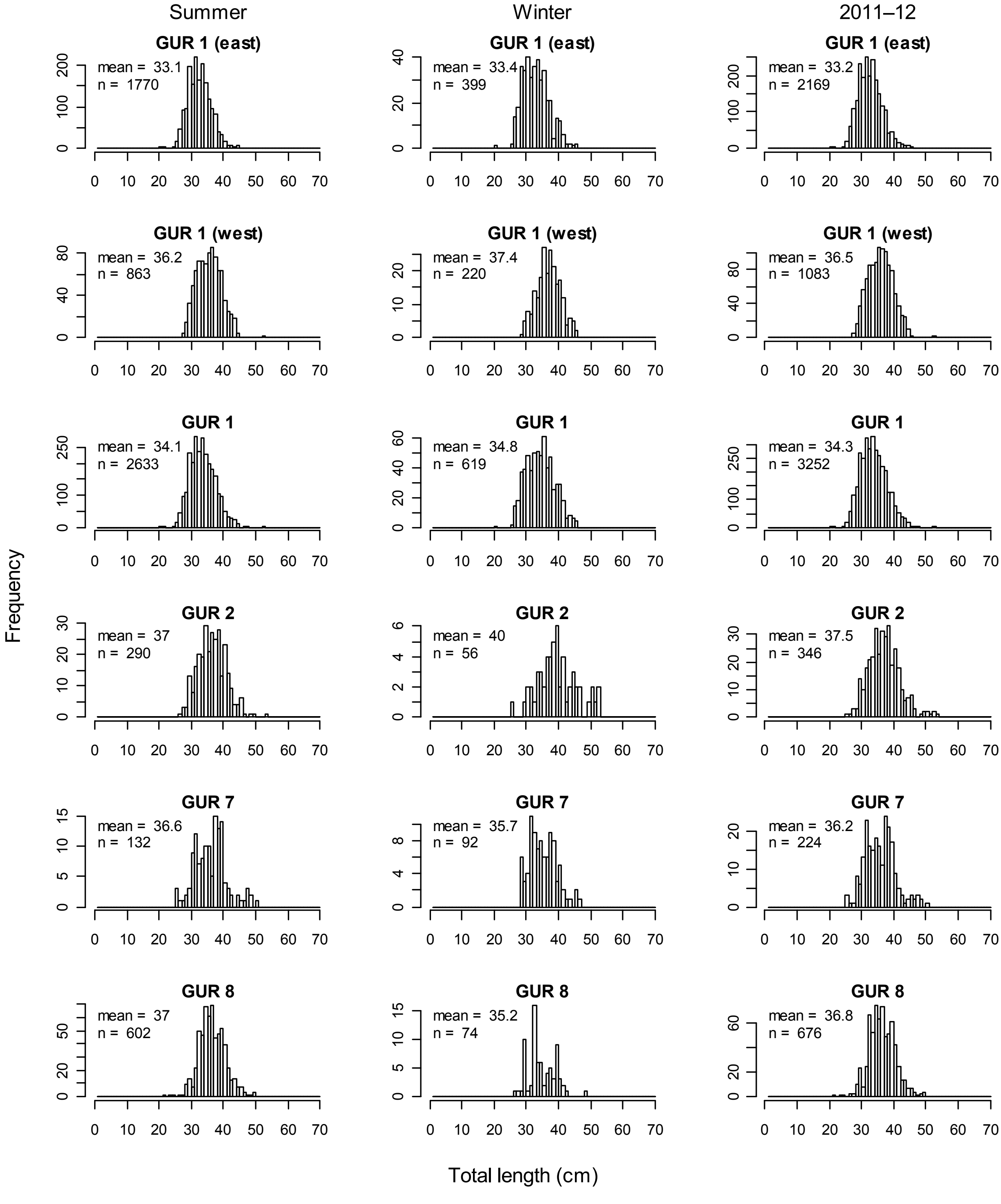


Figure 11: Length frequency distributions for red gurnard by QMA and season.

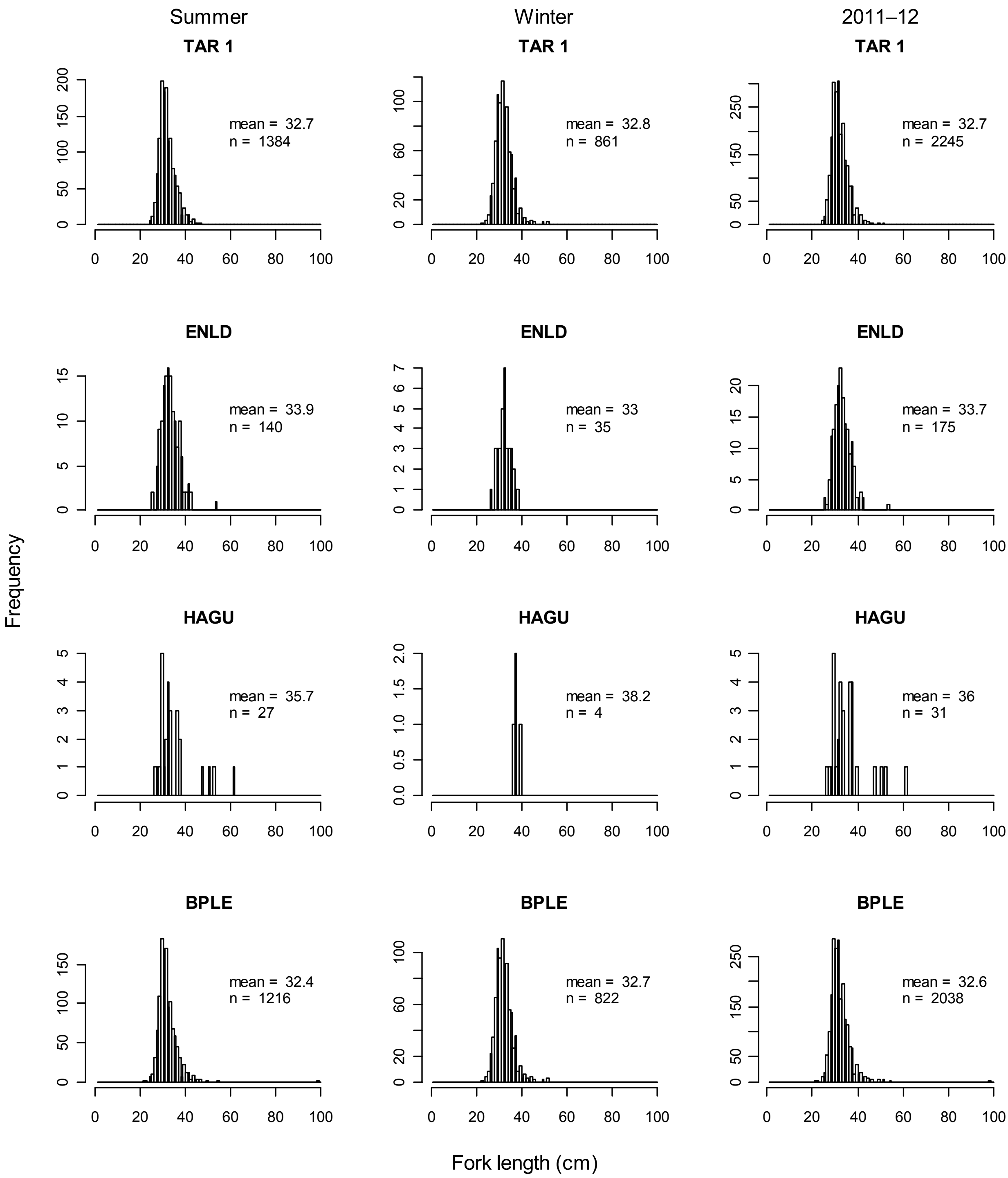


Figure 12: Length frequency distributions for tarakihi measured in QMA 1 by region and season.

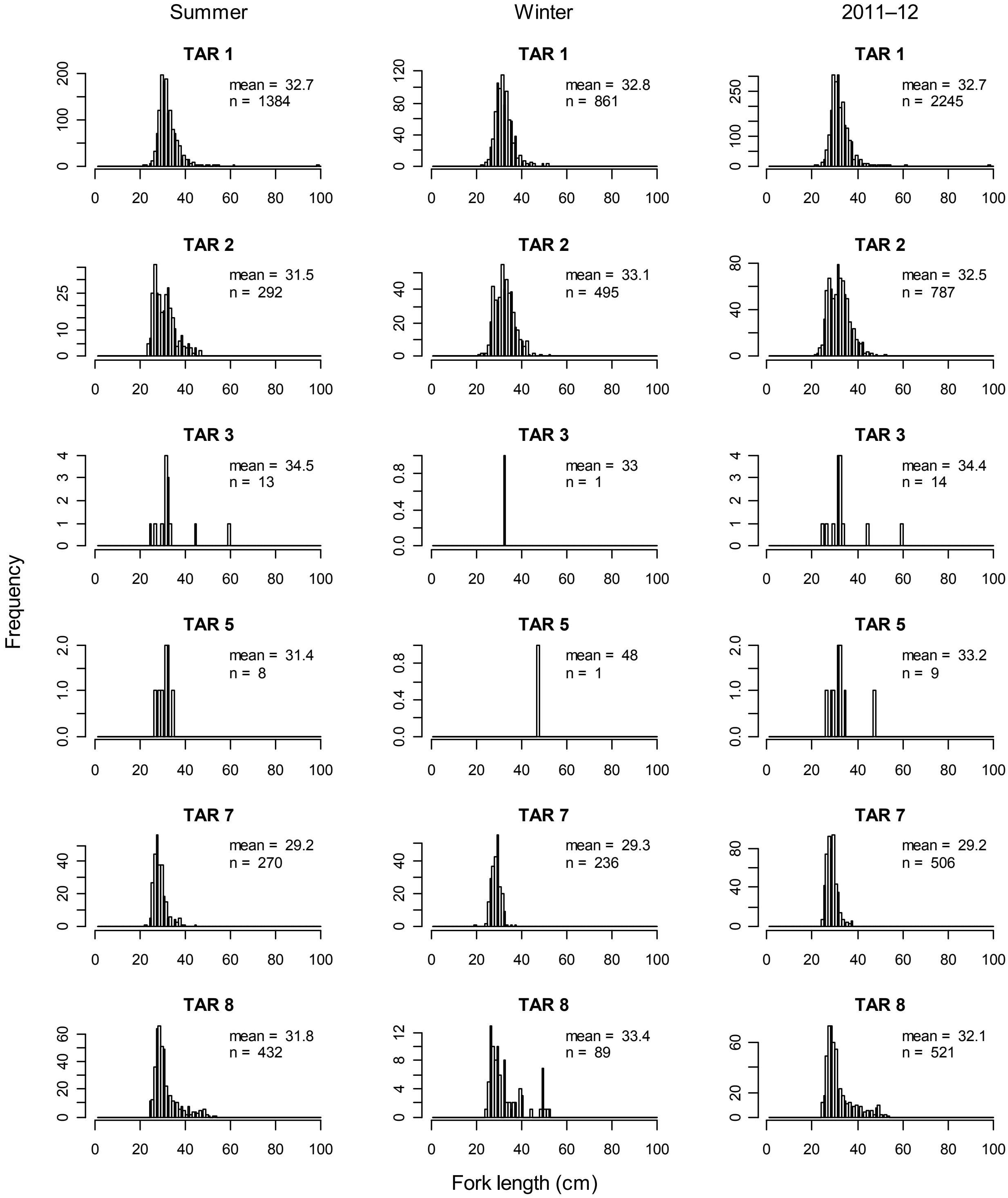


Figure 13: Length frequency distributions for tarakihi by QMA and season.

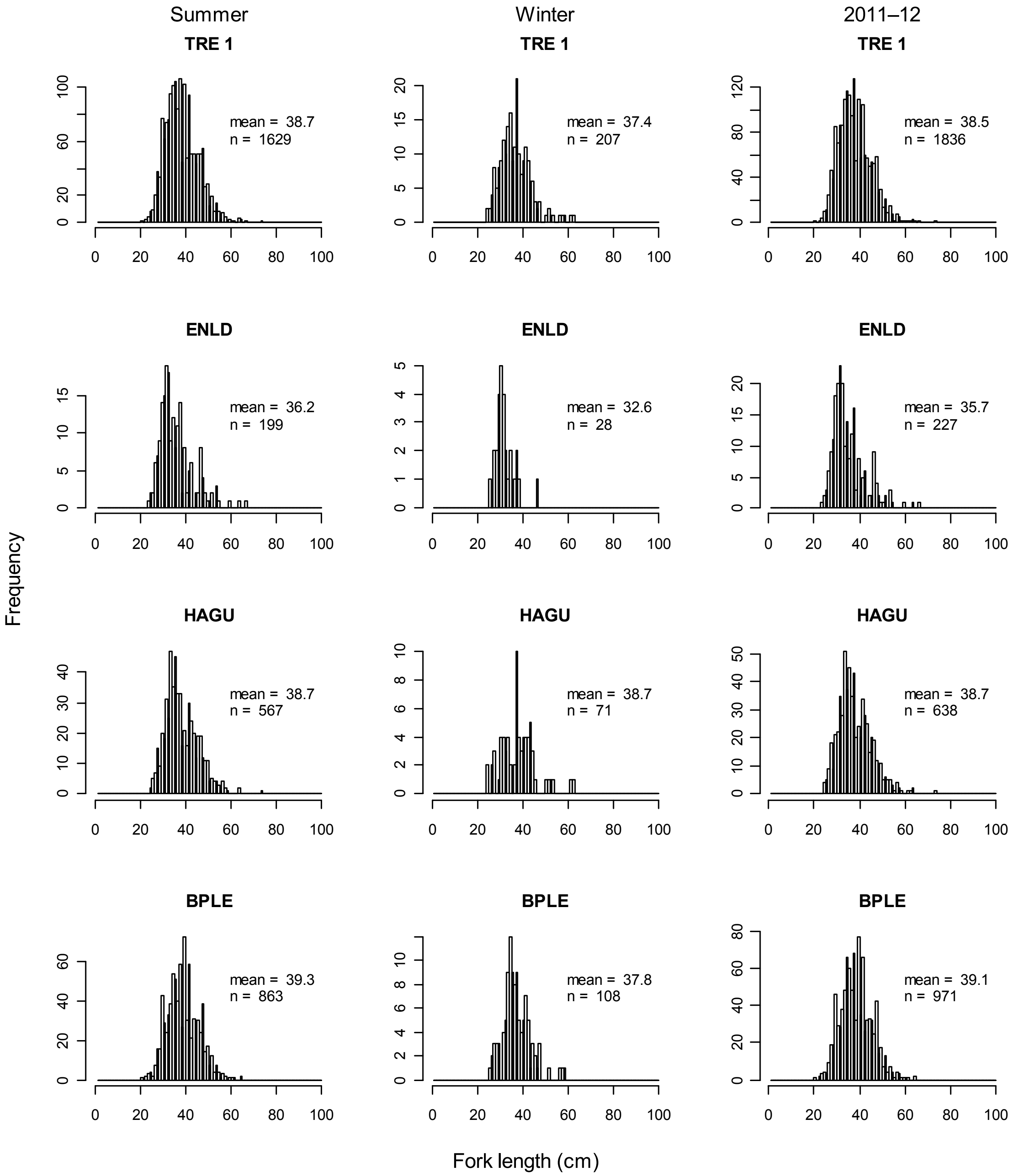


Figure 14: Length frequency distributions for trevally measured in QMA 1 by region and season.

4. DISCUSSION

Almost all of New Zealand's fisheries are managed on the basis of landed tonnage rather than the numbers of fish harvested. Although recreational fishers account for a significant proportion of the harvest from many of New Zealand's inshore and pelagic fisheries, they are not required to provide any form of information on their harvest. Accordingly, survey methods are used to estimate how much of the total harvest is taken by this sector. Indirect survey approaches such as the 2011–12 NPS are only able to provide estimates of numbers of fish taken by recreational fishers from each fishstock, and an additional programme such as that discussed here is required to provide mean weight estimates that can be used to translate estimates of numbers of fish caught into harvest tonnage estimates. Fisheries managers require harvest estimates in terms of tonnage as all commercial fisheries are managed on this basis. Similar research programmes have been conducted in conjunction with telephone diarist surveys in the past (Hartill et al. 1998, Boyd & Gowing 2004) but the most recent of these surveys occurred over ten years ago and those results were unlikely to be representative of current landings.

The fish length data used to generate the mean weight estimates provided in this report have come from a variety of mostly concurrent surveys, and although the objectives of these surveys have differed, the methods used to collect length data have been broadly consistent and fit for the purpose of this programme. A small proportion of the data have come from surveys conducted before the 2011–12 fishing year, but such studies were still relatively recent, and the use of their data helped to reduce the scope and cost of the creel survey required to collect measurements from those areas not covered by other existing data sources. Data collected by commercial fishery observers during commercial rock lobster fishing trips were also used to generate mean weight estimates for some lobster QMAs, as relatively few lobster were encountered in some areas during this survey. The availability of those additional tail width data and the generation of fishing method specific mean weight estimates will have significantly improved the accuracy of resulting recreational harvest estimates for CRA 4, 5, and 8, as scuba divers and snorkelers tend to land larger lobsters than those taken by recreational pot fishers.

Almost all of the data used here have been collected from boat based fishers, and although it is possible that shore based fishers tend to catch larger or smaller fish of a given species, by far the majority of the recreational catch of most species is taken by boat based fishers.

Almost all of the data collected outside of FMA 1 have been collected on weekends and public holidays, and not during the normal working week. Hartill et al. (1998) compared mean weight estimates for fish landed during weekends and during the working week, and found little apparent difference between day types in either summer or winter. Day type was therefore assumed to have little influence on the size of fish landed, and catch sampling focussed on weekends and public holidays when higher encounter rates with recreational fishers were expected, and hence more measurements were able to be obtained. The level of effort and cost required to collect sufficient length measurements across all days of the week in a representative manner is not warranted given the likely level of improvement in the accuracy of mean weight estimates.

Previous mean weight research programmes have found evidence of seasonal differences in mean weight estimates (Hartill et al. 1998; Boyd & Gowing 2004) which were also apparent in this study. In some cases the discrepancy between summer and winter mean weight estimates is quite marked, and seasonal mean weight estimates should be used to convert NPS estimates of the number of fish caught by season into tonnage estimates where they are available.

Simulations of the number of snapper measurements required to provide accurate mean weight estimates undertaken by Bradford (1996) suggested that at least 1000 measurements were required to detect a mean weight difference of 100 g, and that there was little additional increase in accuracy when 2000 fish were measured. The numbers of snapper measured in 2011–12 were substantially more than 1000 fish in all areas except SNA 2. More than 1000 length measurements are also available for some fish stocks for many other commonly caught species, but fewer than 500 measurements are available to calculate mean weight estimates for two thirds of the fishstocks considered here. New Zealand's recreational fisheries are diverse, however, and the diversity of catches in some areas is broad relative to the level of fishing effort taking place. Obtaining over 1000 fish measurements from these fisheries would therefore be prohibitively expensive, and not warranted given the low level of recreational catch from these fish stocks. Boat ramp interviewers employed by NIWA were required to measure all species landed by recreational fishers, and not just those required for the immediate purpose of a specific survey programme. This means that most of the landed catch encountered during this and associated programmes was available for measurement, although the number of fish measured for some of the less commonly caught species in some areas could have been greater if other surveys had collected measurements of all species landed by recreational fishers rather than focussing on selected species. Nonetheless, the mean weight estimates provided for the larger recreational fisheries are mostly based on a sufficient number of length measurements.

Fisheries managers usually require recreational harvest estimates by QMA, but we have also provided mean fish weight estimates for sub-regions of QMA 1 for some commonly caught species. This is because two other harvest estimation surveys have been conducted at the same time as the NPS survey in 2011–12: an aerial-access survey of the SNA 1, KAH 1, GUR 1, TAR 1, and TRE 1 fishery (MAF201102), and a multi creel method survey of the recreational rock lobster, scallops, kahawai and red gurnard fishery in the western Bay of Plenty (MAF201002). These two additional and concurrent surveys provide NPS independent harvest estimates at a range of spatial scales which will be used to assess the likely reliability of the NPS method. Mean weight estimates are therefore required for these regions of QMA 1 so that the estimates provided by all three concurrent surveys can be expressed in terms of tonnage harvested.

Interviewers measure individual fish rather than weighing them, because this approach is quicker and length measurements have other uses beyond those considered here, such as reviewing the effectiveness of minimum legal size limits or estimating selectivity. We have collated published length-weight relationships for all of the quota species for which at least 50 length measurements were available (27 species) and for albacore and skipjack. These have been used to convert length measurements into estimates of individual fish weight, which were then averaged, as the relationship between fish length and weight is always non-linear, and mean fish weight estimates should not be based on averaged fish lengths. Most, if not all, of the published length-weight relationships are based on a linear regression of logged weights against logged lengths. The logging of length and weight data homogenises the variance structure, as weights typically become more variable with increasing length. The suggestion was made that this log-log regression method could provide biased weight estimates, and that a non-linear regression was a more appropriate method of determining the relationship between a fish length and weight. Both linear log-log and non-linear regressions were used to fit relationships to paired length and weight data that were available for three species. Estimates of weights predicted by the two regression techniques were then compared with the actual weights for these three data sets, and both methods either overestimated or underestimated actual aggregated fish weights to a very marginal degree overall. The level of bias observed is trivial relative to other sources of bias that could influence the recreational harvest estimates that these mean weights are used for, and there is no reason to suggest that the published length-weight relationships used here are significantly biased or inappropriate.

A review of this and other concurrent programmes by two external reviewers from overseas has led to the recommendation that there should be a thorough review of all of the length-weight relationships used for the purposes described here (Lyle & Pollock 2013). The reviewers recommended that up to date length and weight data should be collected in a seasonally and spatially representative manner as important changes in fish populations may have occurred in recent years. They also recommend that non-linear regression techniques should be used to fit length-weight relationships to these data (rather than by linear log-log regression) with appropriate modelling of the associated variance structure. The reviewers also noted that length measurements should be made at the same level of precision as the data that were used to generate associated length-weight relationships. With this study all finfish length measurements were recorded to the nearest centimetre, but the mean weight estimates provided here will be negatively biased if any of the length-weight relationships used were based on length data collected at higher levels of precision (such as to the nearest millimetre). The data used to generate almost all the length-weight relationships used here are not available, and the extent of this source of bias is therefore unknown, although, for example, it could be in the order of 3% for some snapper stocks. Although the generation of up-to-date length-weight relations was not a requirement of this programme, we agree that a thorough review of these pivotal and commonly used relationships should be undertaken before a survey such as this is repeated in the future. Further, we recommend that the length-weight data used should be measured at a reasonably high level of precision and held on a central database so that they are readily available for further analyses and interpretation in the future.

5. ACKNOWLEDGMENTS

We thank the Helena Armiger, Nicola Rush, Anna Bradley, Megan Carter, and Brian Sanders from NIWA and the numerous boat ramp interviewers, who collected the data for this survey. We also thank John Holdsworth for providing rock lobster, scallop and kingfish measurement data from FMA 1, and Nokome Bentley and Paul Breen for providing survey and commercial observer based rock lobster tail width data. This project has also benefitted from suggestions made by Marine Amateur Fisheries working group members. Funding for this project, MAF-2011/03, was provided by the Ministry for Primary Industries. We also thank Jeremy McKenzie for reviewing this report.

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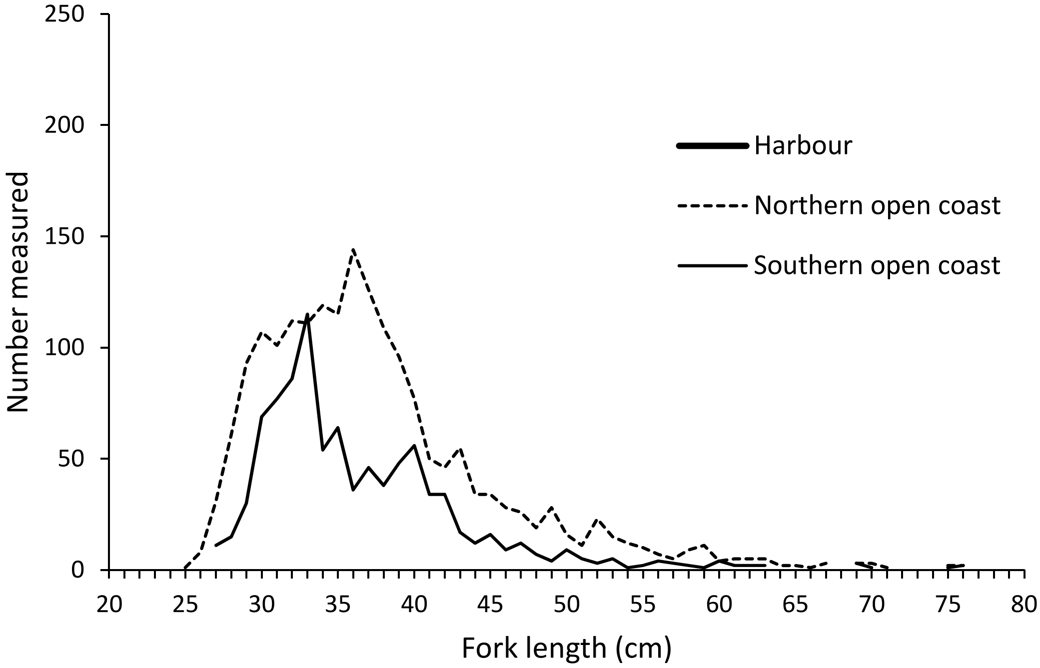
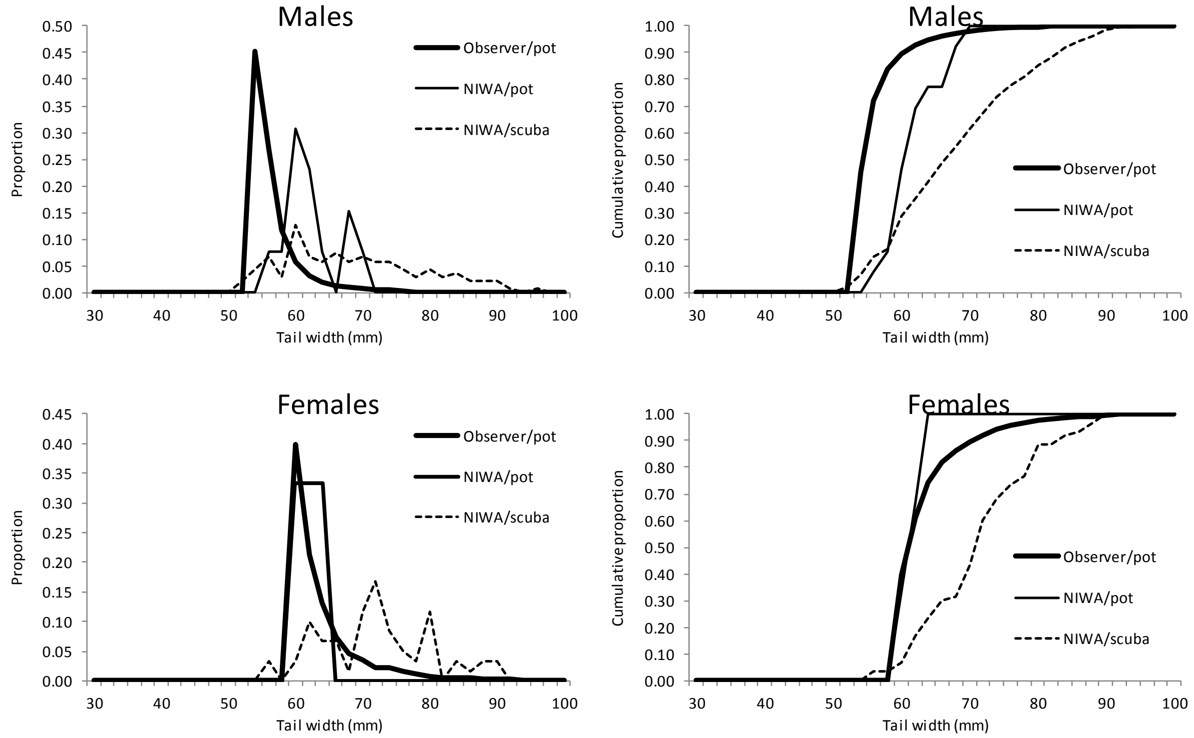
Appendix 1: Length compositions of snapper caught in three regions of SNA 8.

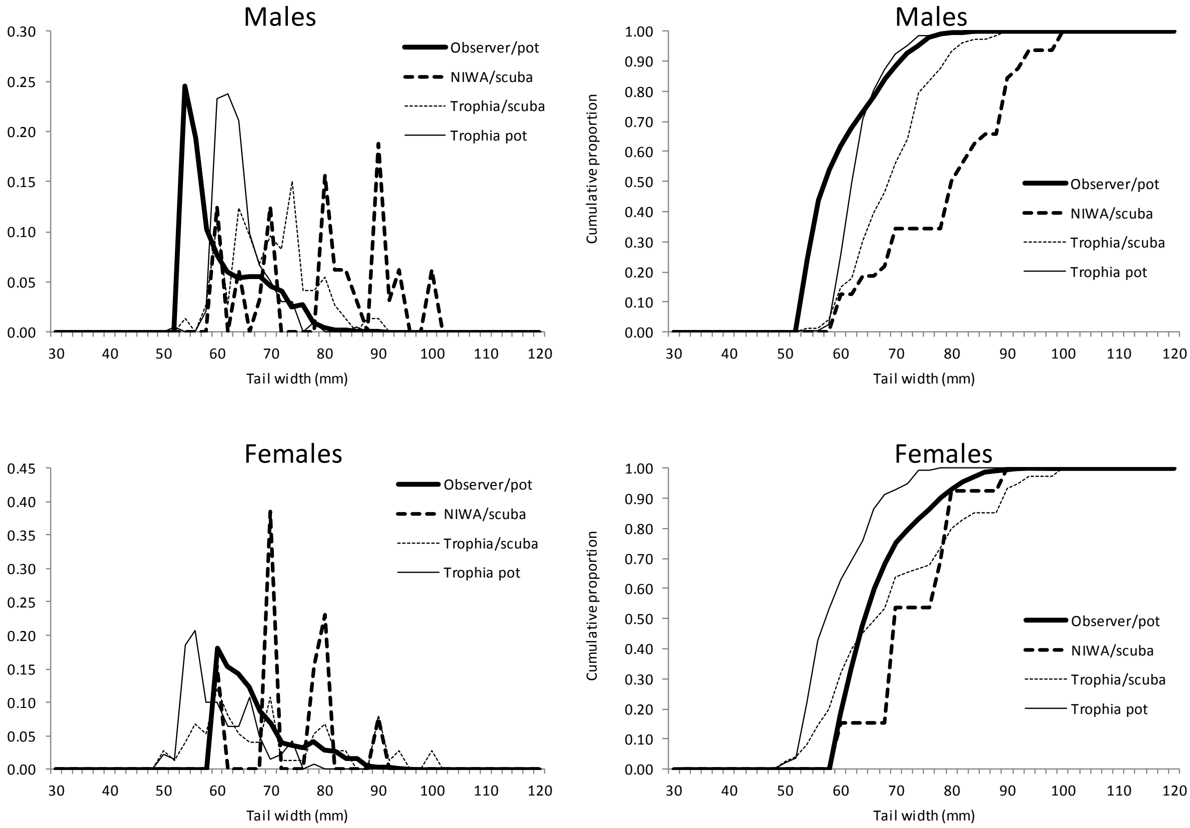


Harbour fisheries are defined as NRB diary areas 21 and 22; the Southern open coast as diary areas 18a, 18b, and 19; and the Northern open coast as diary areas 20, 23, 24 and 25.

Appendix 2a: Length compositions of rock lobster caught in CRA 4 by data source, method and sex.



Appendix 2b: Length compositions of rock lobster caught in CRA 5 by data source, method and sex.



Appendix 2c: Length compositions of rock lobster caught in CRA 8 by data source, method and sex.