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Striped marlin catch and CPUE in the New Zealand sport fishery 2013–14 to 2015–16

New Zealand Fisheries Assessment Report 2017/18

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EXECUTIVE SUMMARY

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The New Zealand Billfish Logbook programme has been operating for 10 years, collecting daily catch and effort data from experienced recreational fishers. Logbook data for 2013–14 to 2015–16 sport fishing years (July to June) are summarised in this report and compared with those from previous years. In the 2013–14 year 206 striped marlin were recorded in logbooks which was 18% of the national catch by sport fishing clubs, while in the 2015–16 year 207 striped marlin were recorded in logbooks but this was just 9% of the number recorded by New Zealand Sport Fishing Council clubs.

The summer of 2015–16 was characterised by relatively warm sea surface temperatures (SST) and good numbers of marlin caught, particularly around the Three Kings Islands and down the West Coast of the North Island. Striped marlin catch and catch per unit effort (CPUE) is summarised by month and area for the 2013–14 to 2015–16 sport fishing years (July to June).

A postal survey of East Northland charter boat skippers collected striped marlin CPUE from 1974–75 to 2005–06. The billfish logbook catch and effort data is rolled-up to emulate the data collected in the postal survey. The core fleet was restricted to those vessels that had fished five years or more and a negative binomial model fitted to data including zero catches.

The standardised CPUE shows an increasing trend following the introduction of the billfish moratorium in 1987 to the mid-1990s and a decreasing trend since then. The 2013–14 and 2014–15 seasons were relatively poor years for the recreational striped marlin fishery in East Northland. The record high striped marlin national catch recorded by all New Zealand Sport Fishing Council (NZSFC) clubs in 2015–16 is not reflected in the East Northland charter boat CPUE. A new CPUE time series, using detailed logbook data that includes private vessels from a wider area, may be more representative of the relative abundance of striped marlin around New Zealand than the East Northland charter boat time series.

This report also summarises the combined catch from 56 sport fishing clubs affiliated to the New Zealand Sport Fishing Council. This includes fish landed at club weigh stations and fish tagged and released. Fishers who are not members of clubs may choose to weigh their fish at a weigh station (where they can also arrange for it to be smoked). The details of these fish are also recorded by clubs.

For many years club records have been considered a reasonably complete record of billfish and large pelagic shark landings in the sport fishery. However, over the last few years there has been an increase in new entrants to the fishery who are less inclined to join a club or weigh their marlin. Very few mako sharks were landed from 2013–14 to 2015–16 and 95% of club catch for this species is tagged and released.

NZSFC records show that the annual number of striped marlin that were landed or tagged rose from one of the lowest (1138) in 2013–14 to the highest (2430) in the 2015–16 fishing year. The summer in 2015–16 was atypical, it was a warm El Nino period with more easterlies than the predicted cool westerlies and more small striped marlin were caught than usual. The average weight of striped marlin reported landed or tagged by the largest East Northland clubs shows a decline from about 115 kg average in the 1950s to about 90 kg in the late-1990s. Over the last 15 years annual average weights have mostly been about 100 kg.

Annual catch of blue marlin since 2013–14 has been close to 100 fish which is about average. Swordfish catch has increased over the last 7 years from about 30 per year to 120 per year. There

were 91 shortbill spearfish landed or tagged in 2015–16 close to the historic high. Black marlin are caught in low numbers, generally between 5 and 15 each year. Yellowfin tuna were a major component of catch in the mid-1990s, but by 2008–09 they were effectively absent in the gamefish fishery. There was a return of mainly small yellowfin in 2014–15 and over 550 recorded in 2015–16. Many of those weighed by clubs where in the 25 to 35 kg range.

1 INTRODUCTION

There are five billfish species reported from New Zealand waters. Striped marlin (*Kajikia audax*) are a major target species of the recreational gamefish fishery in northern New Zealand. Broadbill swordfish (*Xiphias gladius*) are increasingly targeted by recreational fishers with deep set baits during the day and by commercial fishers with night set surface longlines. Other billfish occasionally caught by recreational and commercial fishers are blue marlin (*Makaira nigricans*), black marlin (*Makaira indica*), and shortbilled spearfish (*Tetrapturus angustirostris*). The marlins and spearfish are most abundant in summer and autumn around northern New Zealand. Swordfish are caught year round in New Zealand, with the main season for recreational fishers being between March and July (Holdsworth et al. 2016).

Striped marlin in the southwest Pacific grow rapidly and enter the New Zealand recreational fishery as 3 or 4 year olds. Most striped marlin caught in New Zealand are sexually mature and a maximum age of 8 years was observed (Kopf et al. 2011, Kopf et al. 2012).

Regulations in New Zealand have prohibited commercial vessels from retaining marlins and spearfish caught in New Zealand fisheries waters. Although required to report marlin caught and released, commercial operators have not consistently reported species that they cannot land (Francis et al. 2000). Many New Zealand sport fishers are willing to report catch to help monitor trends in availability of billfish.

Recreational sport fishing clubs have kept catch records for pelagic gamefish for many years. The Bay of Islands Swordfish Club (BOISC) and Whangaroa Sport Fishing Club have published yearbooks with detailed catch records since 1925. These contain the date, weight and vessel name for each fish recorded. For many years these records contained an almost complete record of billfish caught by sportfishers as few skippers had the specialist knowledge and fishing tackle to target marlin. Since 1990, and the switch to fishing mainly with lures, there has been a significant increase in the number of private launches and trailer boats targeting marlin (Holdsworth & Kopf 2005).

The New Zealand Gamefish Tagging Programme has operated since 1975. This project is supported by the Ministry for Primary Industries (MPI) and NZSFC and encourages anglers to tag and release striped marlin to aid research and conservation. The tagging database contains a good record of where and when these fish were released but only estimated weights are available for these fish.

A 40 year time series of striped marlin CPUE data has been collected from gamefish charter skippers fishing the northeast coast of New Zealand. It started as a simple, low cost, annual postal survey. The main problems with it were that it only provided catch and effort on a coarse scale (fish and vessel days per vessel per season) and in a limited area (North Cape to Cape Rodney). The postal survey was last used to collect striped marlin CPUE in east Northland for the 2005–06 season (Holdsworth et al. 2007). This report is part of an expanded project collecting daily information in a billfish logbook which has been used since 2006–07.

Recreational charter boat operators have been required to report their fishing activity since November 2010 under MPI's Amateur Charter Vessel (ACV) requirements. Subsequently, they have also had to report area of operation and the catch of certain species. There will unavoidably be some duplication of data reporting between the two reporting schemes but as no billfish are required to be reported under the ACV scheme, the overlap between the two projects is limited to the effort section. There has been a

sharp decline in the number of billfish charter boats over the last three years due to changes in the tax provisions and maritime safety regulations.

Specific Objectives:

1. To update time series of catches, landings, and size composition data collected from recreational sources for the 2013–14, 2014–15 and 2015–16 fishing years.

2. To undertake a logbook programme for striped marlin for the recreational fishery for the 2013–14, 2014–15 and 2015–16 fishing years.

2 METHODS

2.1 Catches, landings and size composition

The number of billfish, shark and tuna landed by recreational fishers and weighed by fishing clubs is collated annually by the New Zealand Sport Fishing Council (NZSFC) and published in their yearbook. The New Zealand Gamefish Tagging Programme collects tag and release details from clubs and individuals. Annual catches of fish landed or tagged are summarised and plotted by species. The fishing year used by NZSFC and in this report is July to June.

Catch records of individual billfish including weight, vessel and capture date are collected by long established gamefish clubs. These are requested at the end of each year from the Bay of Islands Swordfish Club, Whangaroa Big Gamefish Club, Whangarei Deep Sea Anglers Club, Tauranga Game Fishing Club, Whakatane Sportfishing Club and the Mercury Bay Ocean Sports Club. Data from within the New Zealand EEZ were separated into landed fish and released fish and summarised by fishing year and club.

Average annual weights are plotted with available data from the three Northland clubs with the longest time series. Where fewer than 10 striped marlin were landed by a club in a season the average weight was not plotted.

2.2 Logbook programme

The gamefish logbook scheme is designed to collect data on striped marlin CPUE. However, data on other New Zealand gamefish species is also requested. These are blue marlin, black marlin, shortbill spearfish, swordfish, yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*) and shortfin mako shark (*Isurus oxyrinchus*). The logbook forms were designed with input from charter boat organisations and experienced private skippers as part of MPI project STM2005/01 (Holdsworth et al. 2007) and reviewed by the Highly Migratory Species Working Group. Data collected includes target species; hours fished per day; fishing method; location at noon; primary target species; water temperature at noon; a record of billfish strikes; wind speed and direction; and precise locations for fish caught. Distribution of logbooks has focused on charter vessels and private boats that target billfish more than 10 days per season. Fishing effort is measured as vessel days or vessel hours targeting billfish as the number of lines set or number of anglers on board does not effectively increase fishing power.

Most skippers or owners were recruited in December and January 2006–07, but new volunteers have been actively sought and accepted in subsequent seasons. Regular contact with participants is maintained including in-season newsletters. Free nylon (PIMA) billfish tags are provided to logbook participants during the year and a free logbook shirt is provided to each skipper if they return their logbook at the end of the season.

A database with a 3-tier architecture built in Microsoft .NET Framework 2.0 is used to store the information. The first tier is the front-end or presentation layer which uses Windows Forms created in Microsoft Visual Studio 2005. The middle tier contains all the business rules for the system that check

the data before it is inserted into the database. The final tier is the data access layer which handles all the database access. The data model adopts the table and field names of the MPI **rec_data** database with the addition of several tables and fields required to support functionality in the application. Summary tables were exported into MS Excel for analysis and plotting.

2.3 Catch per unit effort

The gamefish logbook scheme has been running for 10 seasons (2006–07 to 2015–16) and collects data on catch and effort from charter and private vessels from around New Zealand. A subset of data was selected to match the previous East Northland postal survey (1974–75 to 2005–06) so that the East Northland charter boat CPUE time series now extends over 40 years. It excludes catch and effort from the productive Three Kings fishery which started in the early 1990s north of New Zealand. For trends in CPUE to be comparable across the whole time series it is important to standardise the fishing area and methods where possible. Effectively the survey area is covered by Ministry for Primary Industries Statistical Areas 002, 003 and 004.

Standardisation of CPUE was undertaken on core vessels in the fleet. These were vessels that had provided at least five years of data. Vessel characteristics such as length and hull type have also been compiled. A negative binomial model was fitted to all data including zero catches in GLM runs undertaken using R software (Bentley et al. 2012).

3 RESULTS

3.1 Catch trends from fishing club records

Striped marlin has been the main large pelagic species targeted and caught in the New Zealand gamefish fishery over the last 18 years (Figure 1). Details of landed catch comes from fishing clubs affiliated to the New Zealand Sport Fishing Council. For many years this has been a reasonably complete record of billfish and large pelagic shark landings. Clubs also record fish taken by non-members who may choose to weigh their fish at a club and have it smoked. A record number of striped marlin (2430) were landed or tagged by sport fishers in the 2015–16 fishing year (Figure 1).

Yellowfin tuna were a major component of catch in the mid-1990s, but by 2008–09 they were effectively absent from the gamefish fishery (Figure 1). In 2014–15 some, mainly small, yellowfin were caught and in 2015–16 over 550 were landed or tagged. Many yellowfin weighed by clubs were in the 25 to 35 kg range.

The number of mako sharks recorded also declined since the mid-1990s (Figure 1), in part because of a shift in fisher attitudes. Fishing tournaments now discourage landing of sharks and over 95% of recorded mako catch is tagged and released. The NZSFC clubs have minimum weights for landed pelagic sharks of 40 kg and some clubs have increased this to 70 kg or do not recognise landed sharks at all.

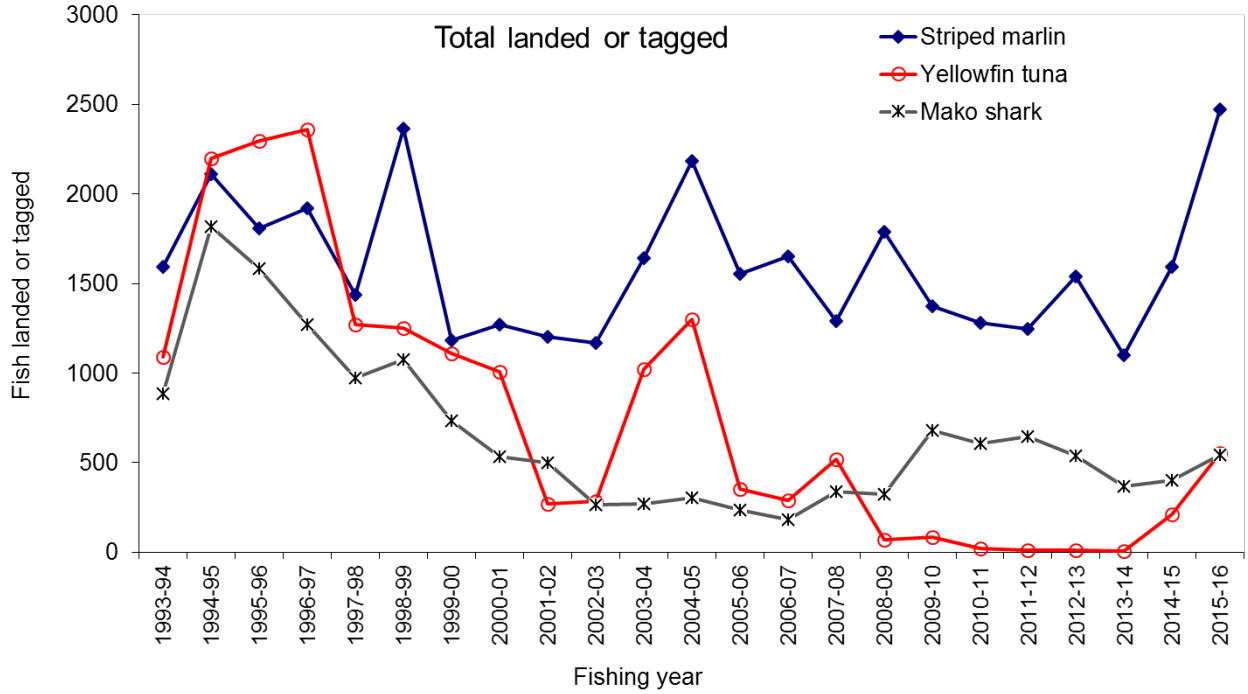

Figure 1: The total of landed or tagged fish by year for the main billfish, tuna and shark species in the New Zealand gamefish fishery.

Blue marlin are a major component of the catch of the other billfish caught in New Zealand waters, with occasionally over 250 blue marlin landed or tagged in a season. Over the last three years annual catch has been close to 100 fish which is about average (Figure 2). Swordfish catch has increased over the last seven years from about 30 per year to 120 per year. There were 91 shortbill spearfish landed or tagged in 2015–16 which is close to the historic high. Black marlin are caught in low numbers, generally between 5 and 15 each year (Figure 2, Appendix 1).

The annual landed catches for billfish other than striped marlin are shown in Figure 3. About 25% of these billfish have been tagged and released and these show similar trends to the total catch. Since 1993–94 62% of striped marlin recorded by NZSFC clubs have been tagged and released.

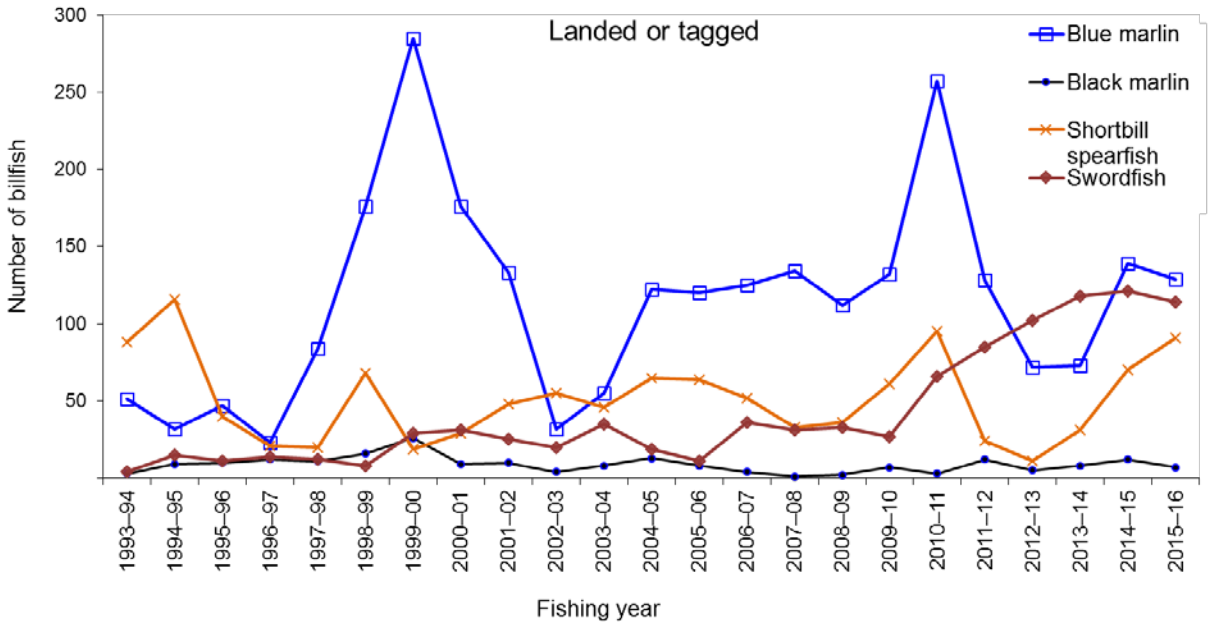

Figure 2: Total number of billfish, other than striped marlin, landed or tagged by year in the New Zealand gamefish fishery.

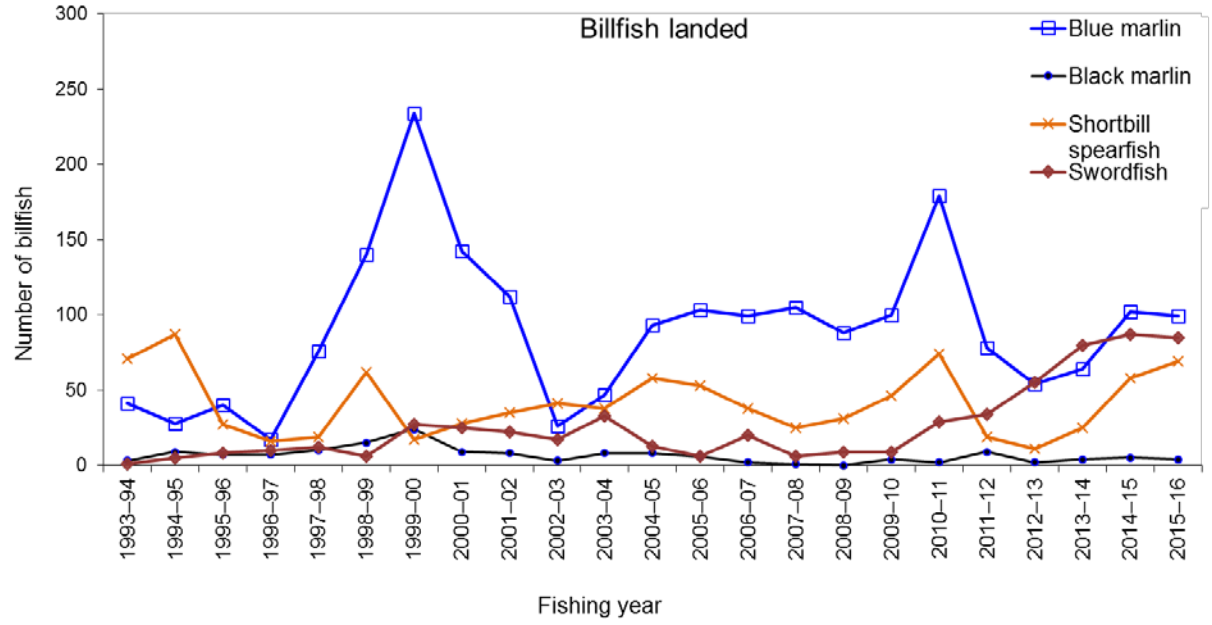

Figure 3: The number of landed billfish per year, other than striped marlin, in the New Zealand gamefish fishery.

The three clubs with the longest time series of individual fish are all based in East Northland: at Whangaroa, Bay of Islands and Tutukaka. The majority of striped marlin caught in the first half of the time series came from the Bay of Islands charter fleet (Figure 4). Since 1945 the combined total is 34 964 striped marlin with a minimum of 46 in 1969–70 and a maximum of 1486 in the 1998–99 fishing year. These data have been used to calculate the average annual weight of striped marlin in the New Zealand sport fishery.

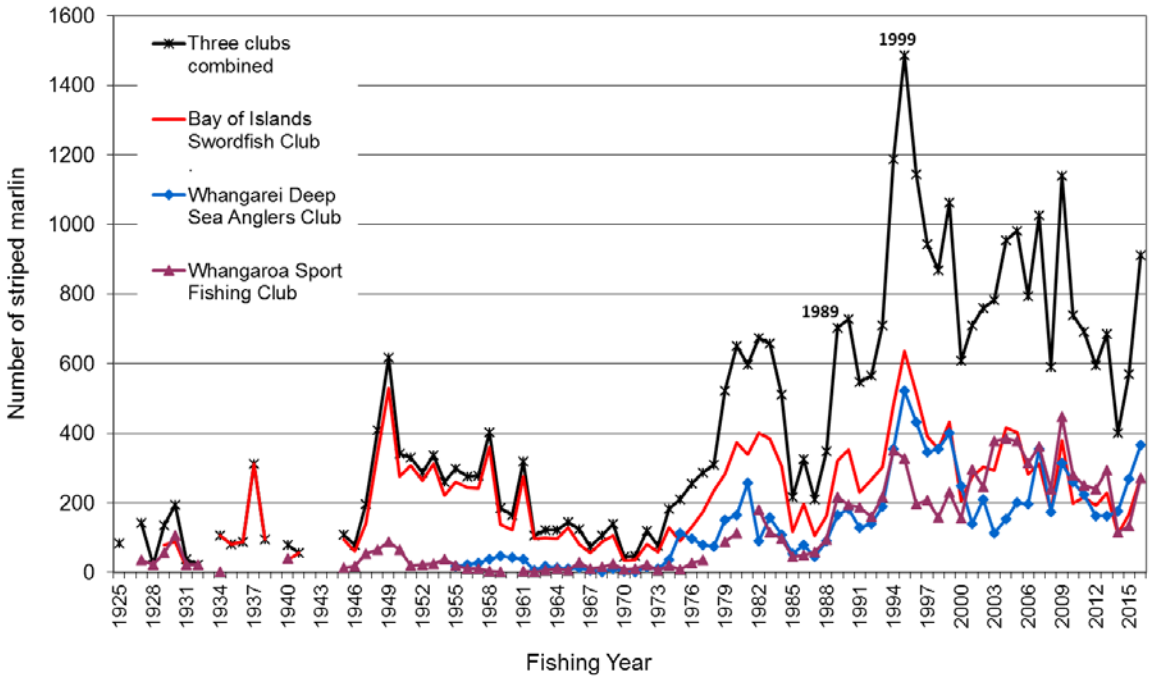

Figure 4: Number of striped marlin caught by recreational fishers in three long established clubs and the national catch by all New Zealand Sport Fishing Council affiliated clubs.

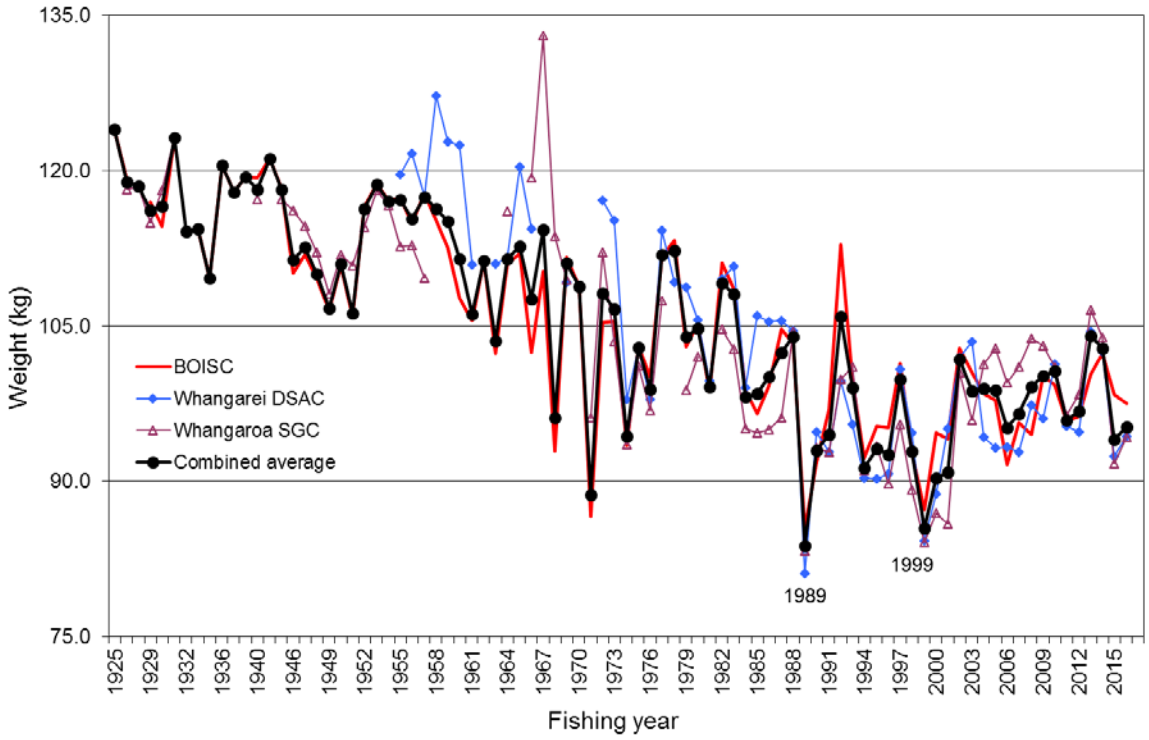

Figure 5: Average weight of striped marlin (landed and tagged combined) from three Northland clubs and the combined mean weight by fishing year.

The average weight of striped marlin reported landed or tagged by the three East Northland clubs shows a decline from about 115 kg average in the 1950s to about 90 kg in the late 1990s (Figure 5). Over the last 15 years annual average weights are mostly about 100 kg. Since 1988–89 a high proportion of striped marlin have been tagged and released with weight estimated by the crew when

the fish is alongside the boat. Undoubtedly this will have reduced the accuracy of the mean weights calculated from club records. Prior to 1989 fish were almost all weighed on certified scales by club weigh masters. NZSFC introduced a voluntary minimum size for striped marlin in 1988 to encourage fishers to tag and release 50% of the recreational catch. Consequently, more small marlin are tagged and the annual average weights of tagged fish from the three East Northland clubs is usually smaller than the average weight of landed fish (Figure 6, Appendix 2). The proportion of marlin tagged has decreased over the last ten years. A structural change in the fleet has contributed to this, with a shift away from long range charter boats tagging large numbers of marlin at the Three Kings toward many new entrants to the fishery in trailer boats that catch one or two fish per year.

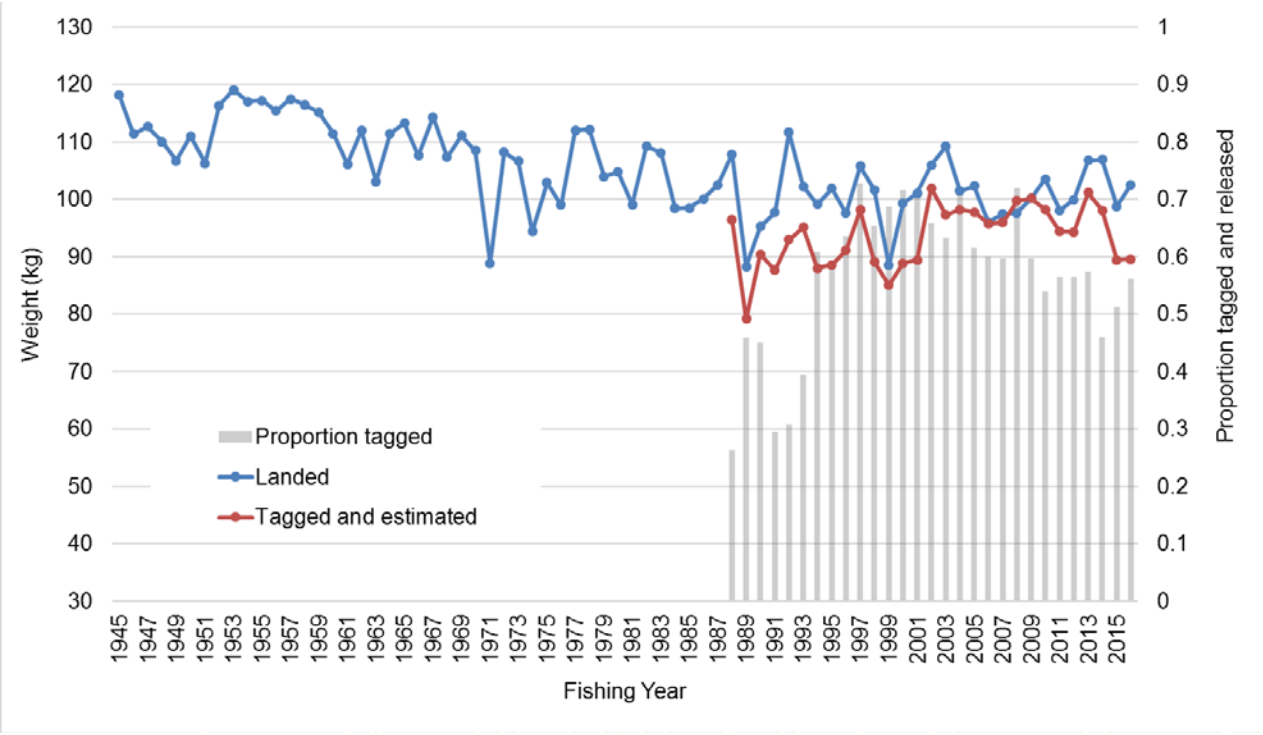

Figure 6: Average weight of landed striped marlin and tagged striped marlin from three Northland clubs and the proportion tagged and released by fishing year.

3.2 Billfish logbook CPUE

The billfish logbook programme has now collected 10 years of data with an average of 247 (sd = 65) striped marlin recorded per year. The annual catch of striped marlin by sport fishers in New Zealand has been quite variable in recent years. It ranged from 1138 in 2013–14 to 2430 in 2015–16 (Table 1). The average annual reported total catch is 1560 (sd = 365) over the last 10 years. For many years the charter boat skippers were the main participants in the billfish postal surveys that make up much of this time series. The number of charter boats engaged in the billfish fishery and the number of days fished per year has declined in recent years (Table 2). The summer of 2015–16 was characterised by relatively warm sea surface temperatures (SST) and good numbers of marlin caught, particularly around the Three Kings Islands and down the West Coast of the North Island. There was not much fishing effort by charter boats in these areas in 2015–16.

A subset of logbook data can be used to extend the existing time series of East Northland charter catch and effort. From 2013–14 to 2015–16 there were 833 logbook days targeting billfish and 141 striped marlin caught by charter vessels in MPI statistical areas 002, 003 and 004 (Table 2, Figure 7). This includes days fished under charter and days when fishing privately. Arithmetic CPUE for East Northland ranged from 0.165 STM/day in 2014–15 to 0.198 STM/day in 2015–16 (Table 2).

Table 1: Number of landed striped marlin recorded in club records and number tagged from the gamefish tagging programme. Also totals from two catch effort surveys of skippers, the East Northland charter boat postal survey 1974–75 to 2005–06 and the national Billfish Logbook Programme 2006–07 to 2015–16.

Fishing	NZ Recreational Striped Marlin (STM)		Total	East Northland Survey STM	NZ Billfish Logbook STM	Proportion of catch surveyed
Year	Landed	Tagged				
1974–75	242	0	242	4		0.02
1975–76	281	3	284	11		0.04
1976–77	332	2	334	140		0.42
1977–78	445	7	452	70		0.15
1978–79	547	18	565	150		0.27
1979–80	692	17	709	136		0.19
1980–81	792	2	794	84		0.11
1981–82	704	11	715	127		0.18
1982–83	702	6	708	126		0.18
1983–84	543	9	552	149		0.27
1984–85	262		262	66		0.25
1985–86	395	2	397	67		0.17
1986–87	226	2	228	51		0.22
1987–88	281	136	417	165		0.4
1988–89	647	408	1 055	407		0.39
1989–90	463	367	830	308		0.37
1990–91	532	232	764	181		0.24
1991–92	519	242	761	197		0.26
1992–93	608	386	994	226		0.23
1993–94	663	929	1 592	438		0.28
1994–95	910	1 206	2 116	510		0.24
1995–96	705	1 104	1 809	489		0.27
1996–97	619	1 302	1 921	116		0.06
1997–98	543	898	1 441	116		0.08
1998–99	823	1 541	2 364	451		0.19
1999–00	398	791	1 189	206		0.17
2000–01	422	851	1 273	267		0.21
2001–02	430	771	1 201	96		0.08
2002–03	495	671	1 166	142		0.12
2003–04	592	1 051	1 643	206		0.13
2004–05	834	1 348	2 182	181		0.08
2005–06	630	923	1 553	134		0.09
2006–07	675	965	1 640		270	0.16
2007–08	485	806	1 291		316	0.24
2008–09	741	1 058	1 799		384	0.21
2009–10	607	858	1 465		276	0.19
2010–11	607	731	1 338		185	0.14
2011–12	635	663	1 298		176	0.14
2012–13	744	858	1 602		243	0.15
2013–14	620	518	1 138		206	0.18
2014–15	696	1 086	1 782		209	0.12
2015–16	900	1 530	2 430		207	0.09
Total	23 987	24 121	48 108	6 017	2 472	

Table 2: Total and mean number of days fished by charter boats in the East Northland survey area and raw CPUE from two catch effort surveys, the charter boat postal survey 1974–75 to 2005–06 and the Billfish Logbook Programme 2006–07 to 2015–16.

Year	Total days	Days /vessel	Striped marlin	Arithmetic CPUE	CPUE SD	CV
1974–75	63	21	4	0.063	0.0553	0.87
1975–76	143	47.7	11	0.077	0.0291	0.38
1976–77	1 301	92.9	140	0.108	0.0123	0.11
1977–78	385	77.0	70	0.182	0.0271	0.15
1978–79	862	95.8	150	0.174	0.0118	0.07
1979–80	545	90.8	136	0.250	0.0244	0.10
1980–81	508	84.7	84	0.165	0.0234	0.14
1981–82	580	96.7	127	0.219	0.0324	0.15
1982–83	802	100.3	126	0.157	0.0297	0.19
1983–84	1 361	97.2	149	0.109	0.0084	0.08
1984–85	1 247	95.9	66	0.053	0.0079	0.15
1985–86	982	81.8	67	0.068	0.0148	0.22
1986–87	905	69.6	51	0.056	0.0071	0.13
1987–88	1 505	62.7	163	0.108	0.0099	0.09
1988–89	2 049	68.3	401	0.196	0.0122	0.06
1989–90	1 830	65.4	301	0.164	0.0110	0.07
1990–91	1 563	74.4	149	0.095	0.0095	0.10
1991–92	1 586	61.0	197	0.124	0.0107	0.09
1992–93	1 538	59.2	226	0.147	0.0141	0.10
1993–94	1 435	57.4	356	0.248	0.0252	0.10
1994–95	1 516	75.8	384	0.253	0.0182	0.07
1995–96	1 367	68.4	275	0.201	0.0169	0.08
1996–97	608	43.4	116	0.191	0.0328	0.17
1997–98	660	44.0	116	0.176	0.0235	0.13
1998–99	928	48.8	241	0.269	0.0262	0.10
1999–00	710	47.3	135	0.194	0.0249	0.13
2000–01	882	35.3	168	0.190	0.0254	0.13
2001–02	432	39.3	60	0.137	0.0238	0.17
2002–03	450	37.5	107	0.237	0.0395	0.17
2003–04	665	28.9	181	0.272	0.0382	0.20
2004–05	685	26.3	163	0.238	0.0368	0.17
2005–06	489	24.5	127	0.260	0.0394	0.15
2006–07	570	22.8	135	0.237	0.0249	0.11
2007–08	392	21.8	51	0.130	0.0289	0.22
2008–09	404	20.2	108	0.267	0.0361	0.14
2009–10	453	23.8	96	0.212	0.0377	0.18
2010–11	418	24.6	89	0.213	0.0389	0.18
2011–12	344	21.5	64	0.186	0.0277	0.15
2012–13	372	23.3	90	0.242	0.0457	0.19
2013–14	335	22.3	57	0.170	0.0310	0.18
2014–15	255	21.3	36	0.165	0.0383	0.23
2015–16	243	27.0	48	0.198	0.0288	0.15

The main season for striped marlin is from January to May and the number of fish recorded in logbooks is spread across the season in a similar way to fishing club data (Figure 7). The 2013–14 year was unusual with relatively poor catches in January and February, but with high numbers in club and logbook records in May which exceeded the January catch. The monthly catch profile was more typical in 2014–15. The five clubs recorded more than 200 marlin per month in January, February and March 2017, which is exceptional (Figure 7).

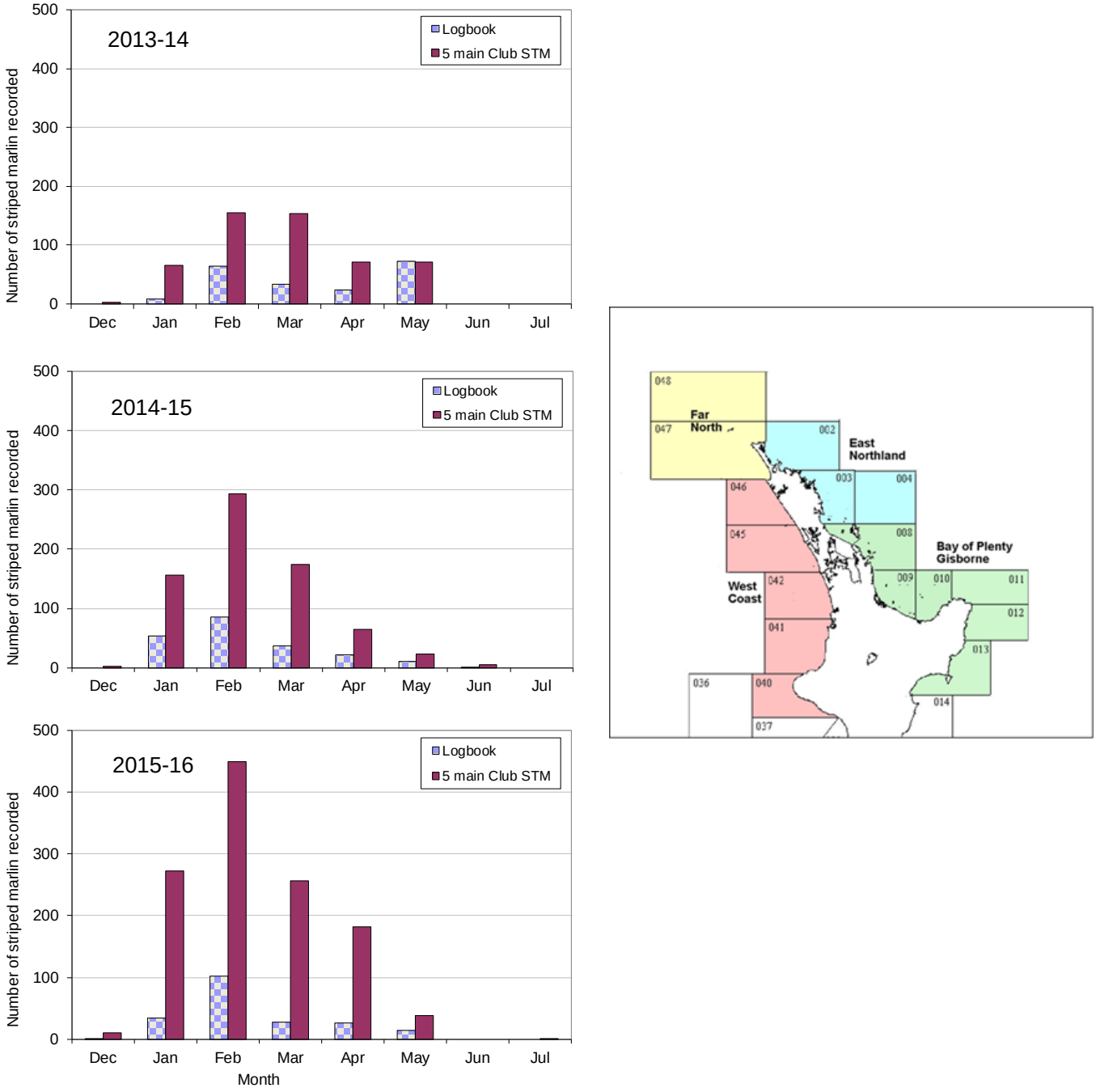

Figure 7: Striped marlin catch by month recorded by five large fishing clubs in East Northland and Bay of Plenty and recorded in billfish logbooks. MPI statistical areas and the regional boundaries used in this report.

Billfish logbook data by month and region shows a mode of striped marlin reported in March 2014, in East Northland, with the highest catch in the Far North area during February and May 2014. Striped marlin catch in the far north area is often high, but variable. In 2015 and 2016 striped marlin catch was high in January and February in the Far North while catch and fishing effort was highest in East Northland in February (Figure 8).

The overall distribution of logbook days fished shows a similar monthly trend in each year, but with more April and May days fished in 2014 (Figure 8).

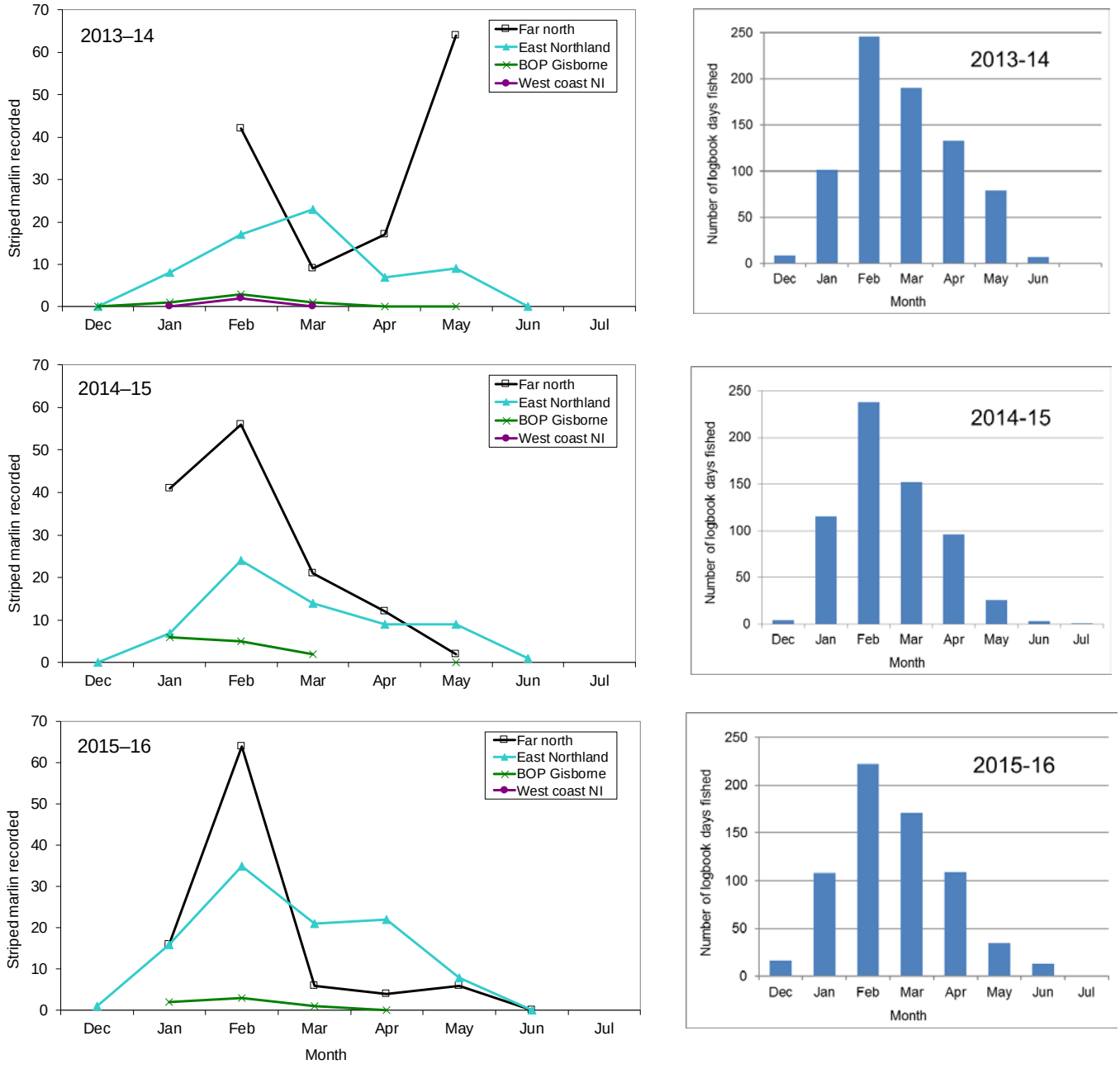

Figure 8: Logbook reported striped marlin catch by region and month for 2013–14 to 2015–16 (left) and total logbook days fish targeting billfish by month (right).

Striped marlin and blue marlin catch and billfish strikes by week are shown in Figure 9. A strike is when a bait or lure is taken. This does not always result in a hook up or capture. The number of marlin caught tends to increase in April and May (weeks 17 to 20). The exception to this was in 2014–15. The last week of February is when the New Zealand Sport Fishing Council run their six day Nationals Tournament. There tends to be a spike in club catch for many species at this time. Blue marlin catch was spread across the warmest months in all years (Figure 9).

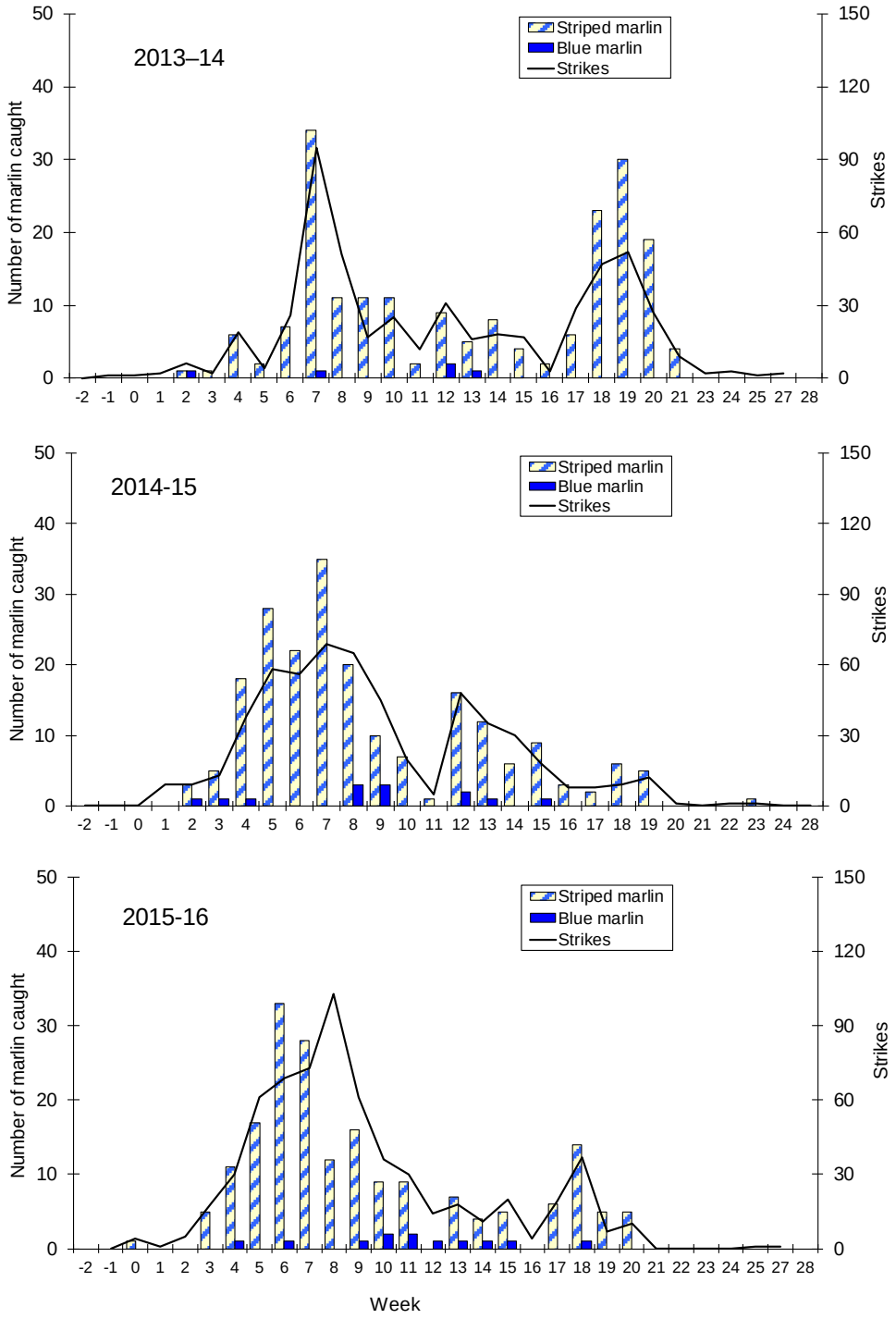

Figure 9: The number of striped or blue marlin caught by week and the number of strikes per week (right axis) 2013–14 to 2015–16. Week 0 starts 24 December.

Catch rates of striped marlin have been relatively consistent between January and April in East Northland in 2013–14 and 2014–15, at around 0.2 fish per day but tend to increase in May (Figure 10). The Far North, which includes the Three Kings area, generally has higher catch rates than other areas, but the number of fishable days and the distance from port limits fishing effort. The highest daily catch rates for striped marlin in 2013–14 were achieved in May in both East Northland and the Three Kings area. In 2014–15 and 2015–16 catch rates in the Far North were very high in late January (Figure 10).

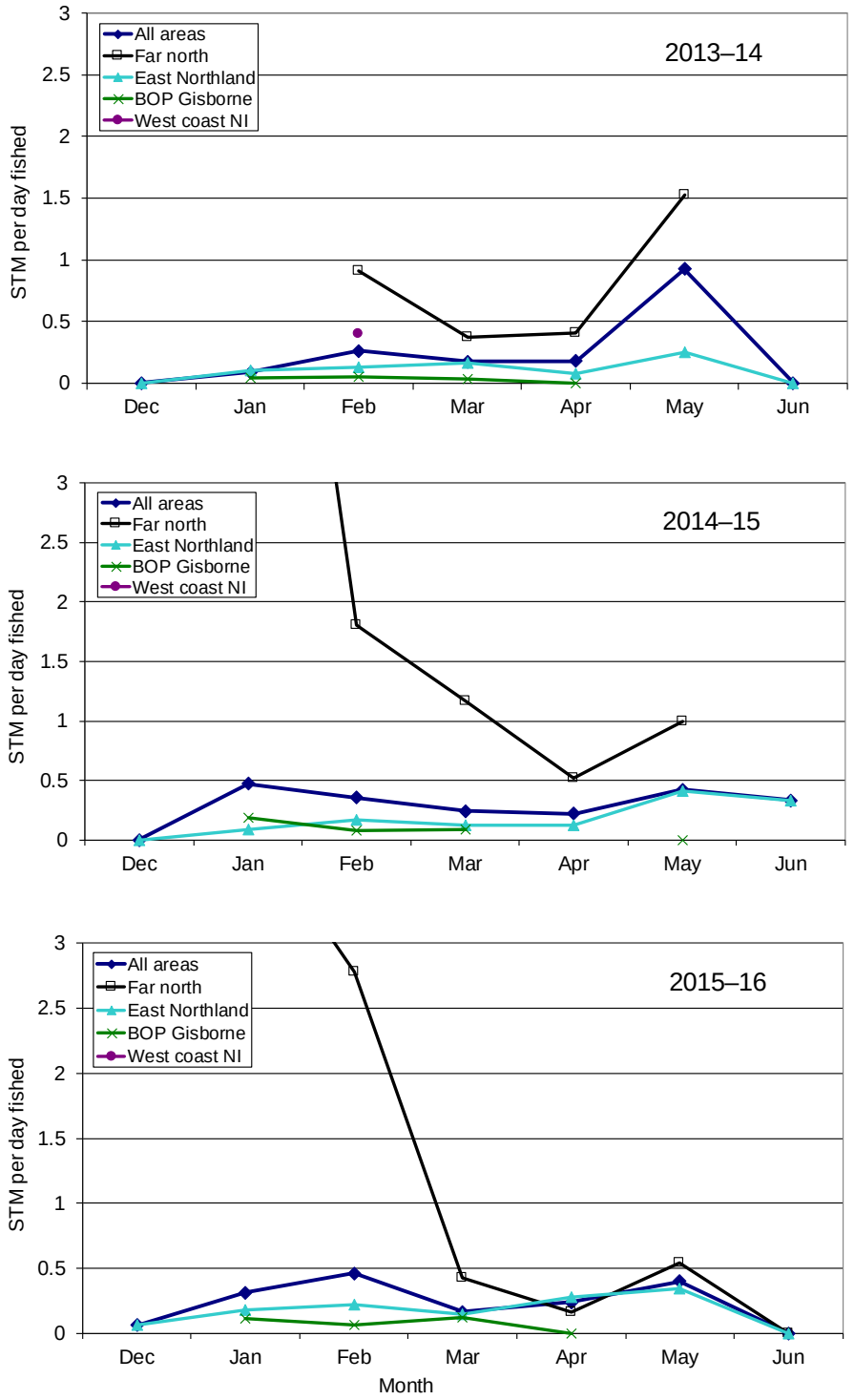

Figure 10: Striped marlin catch per vessel day by area and month from logbook data for 2013–14 to 2015–16.

The CPUE averaged by week for all regions combined in 2013–14 was low throughout most of the fishing year but notably higher in May (weeks 18–21) (Figure 11). High catch rates in June in both years came from relatively few fish. In 2014–15 CPUE was highest in late January and early February and patchy for the rest of the season. Very few days were fished in May and June 2015 and CPUE may overstate the availability of marlin at that time.

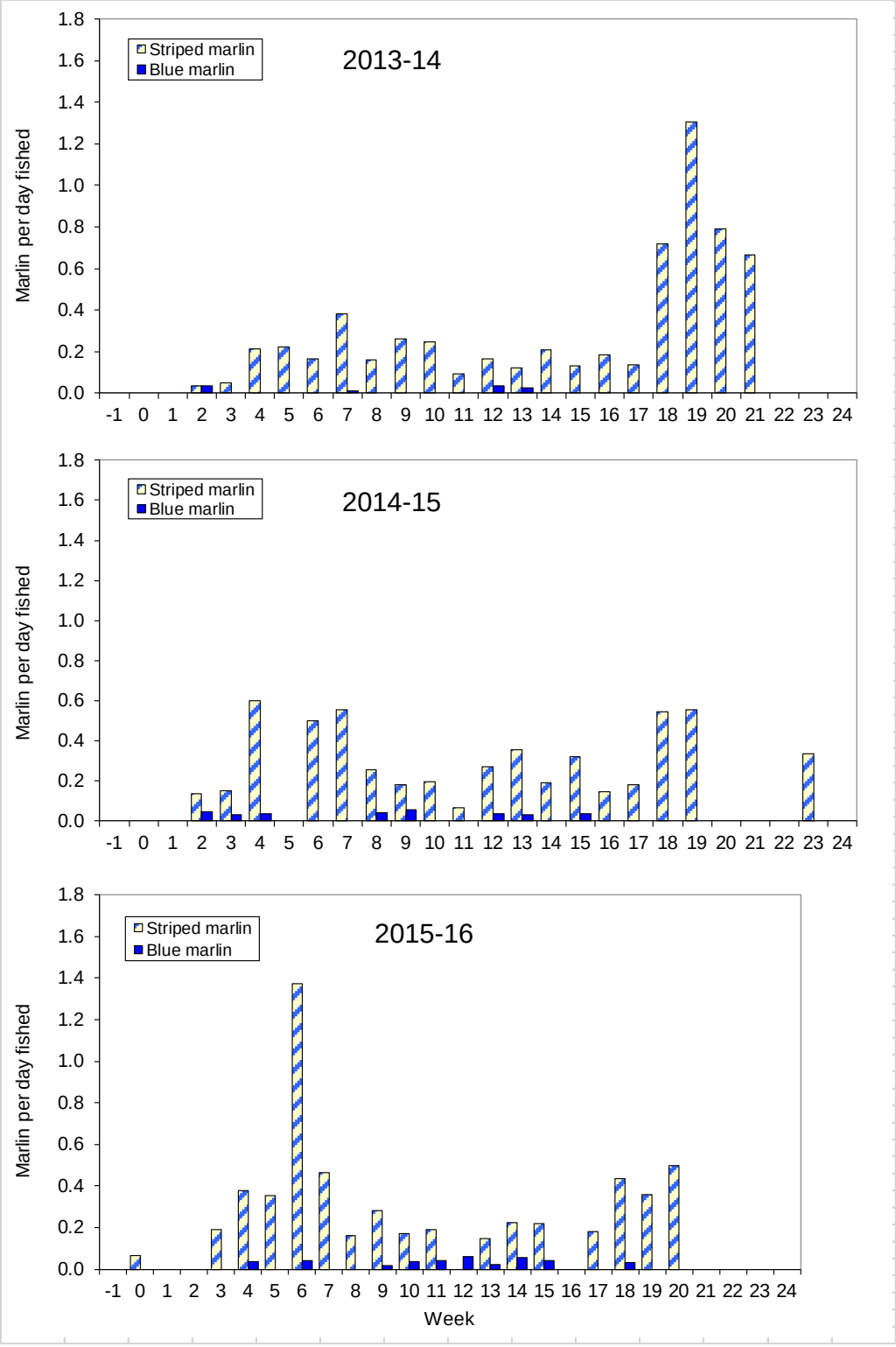

Figure 11: Catch per unit effort as the number of striped or blue marlin caught per vessel day grouped by week of the calendar year. Week 0 starts 24 December.

Average monthly sea surface temperatures (SST) from logbook records during 2016 were warmer that the long term average (Table 3). In 2015, January was the warmest month of the year from logbook data, in part because of the number of days fished in late January in the Three Kings Area. The temperatures recorded in logbooks in 2016 were the warmest to date in all months – January to May, with one exception (Table 3). The warmest month in logbook records remains February 2011 with an average of 22.43° C.

Table 3: Average monthly SST January to May by fishing year from logbook data all regions combined, highest monthly average per year in bold.

All regions	Sea surface temperature by month				
Season	Jan	Feb	Mar	Apr	May
2006–07	20.88	**21.12**	21.01	19.75	19.2
2007–08	20.72	**21.05**	20.99	20.87	19.33
2008–09	20.68	**21.46**	20.79	20.54	18.67
2009–10	20.35	**21.47**	21.00	20.02	18.32
2010–11	21.46	**22.43**	21.55	20.11	17.92
2011–12	20.14	**20.85**	19.98	19.92	18.57
2012–13	20.46	**21.37**	20.76	20.14	19.43
2013–14	20.21	20.33	**20.57**	20.02	18.95
2014–15	**21.50**	21.44	21.33	20.54	18.93
2015–16	21.74	**22.13**	21.86	20.93	20.43
Combined mean	20.71	21.28	20.89	20.21	18.81

3.3 East Northland charter CPUE time series

CPUE data from 1974–75 to 2005–06 are available from the annual postal survey of charter skippers. A subset of logbook data from the gamefish logbook scheme has been used to extend the postal survey time series from 2006–07 to 2014–15. The data was restricted to recreational charter vessels, fishing in East Northland (MPI Statistical Areas 002, 003 and 004).

The resolution of the data summarises catch and effort by vessel year and the core fleet was restricted to those vessels that had fished for at least five years. This resulted in a core fleet size of 51 vessels which took 85% of the catch from this dataset. A plot of the degree of overlap of data among core vessels is provided (Figure 12). A comparison between data from all vessels and from core vessels only, for key indicators of catch rates is also given (Figure 13). There is little difference, and similar trends between years.

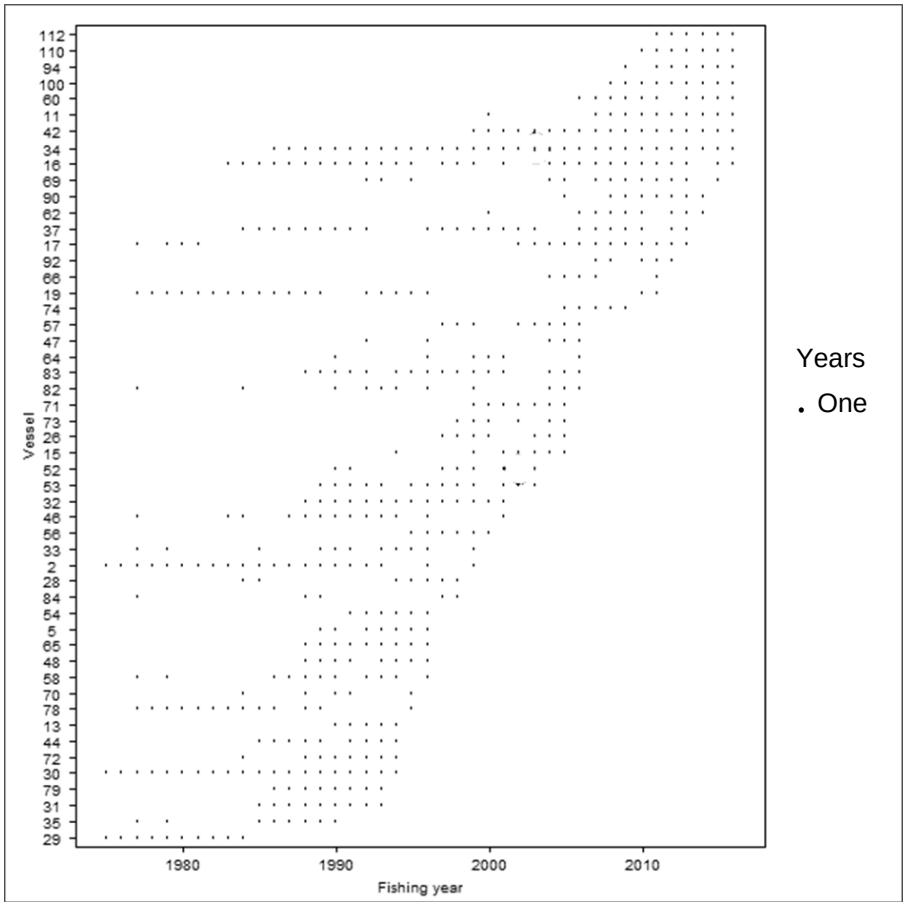

Figure 12: Participation of the core vessels used. Each observation summarises one year of fishing, whether or not successful with respect to striped marlin. Fishing years are labelled by the later calendar year e.g. 1990 = 1989–90.

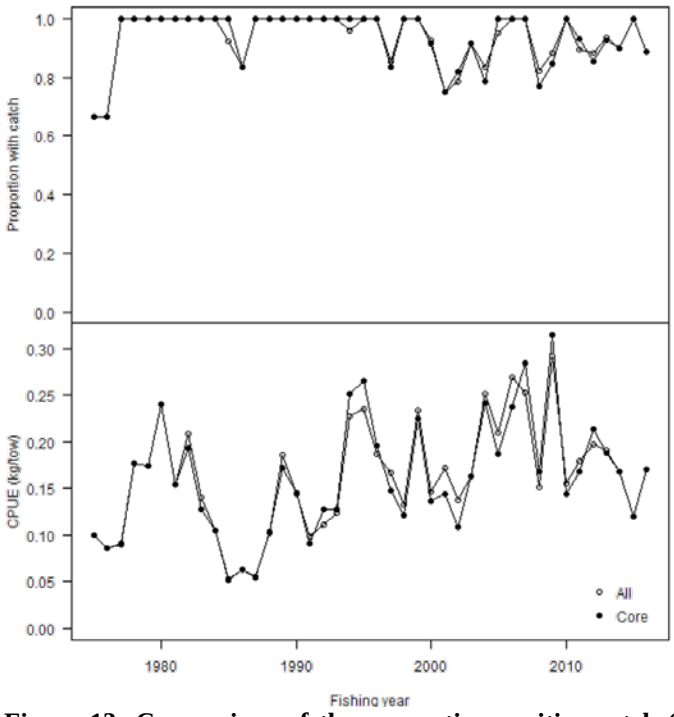

Figure 13: Comparison of the proportion positive catch (upper) and unstandardised CPUE (geometric mean of catch divided by effort where catch was positive; lower) for all and for core vessels.

3.4 Stepwise selection of model terms

A negative binomial model was fitted to all data including zero catches, with a forward stepwise selection of model terms made on the basis of the Akaike Information Criterion (AIC). The maximal set of model terms offered to the stepwise selection algorithm was:

~ fyear + area + vessel + hulltype + poly(log(days), 3) + poly(log(length), 3)

with the term *fyear* forced into the model. *Area* denotes the home port of the vessel, *hulltype* differentiates between vessels with planing hulls and displacement hulls, *length* is a polynomial term for the length of the vessel. Terms were only added to the model if they increased the percent deviance explained by at least 0.1%. Table 4 provides a summary of the changes in the deviance explained and in AIC as each term was added to the model. The final model formula was

~ fyear + poly(log(days), 3) + vessel

Table 4: Summary of stepwise selection. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Term	DF	Log likelihood	AIC	Deviance pseudo-R2 (%)	Nagelkerke pseudo-R2 (%)	
fyear	42	-1 603	3 291	35.33	37.74	*
poly(log(days), 3)	45	-1 459	3 008	61.75	63.50	*
vessel	95	-1 350	2 889	74.33	75.66	*

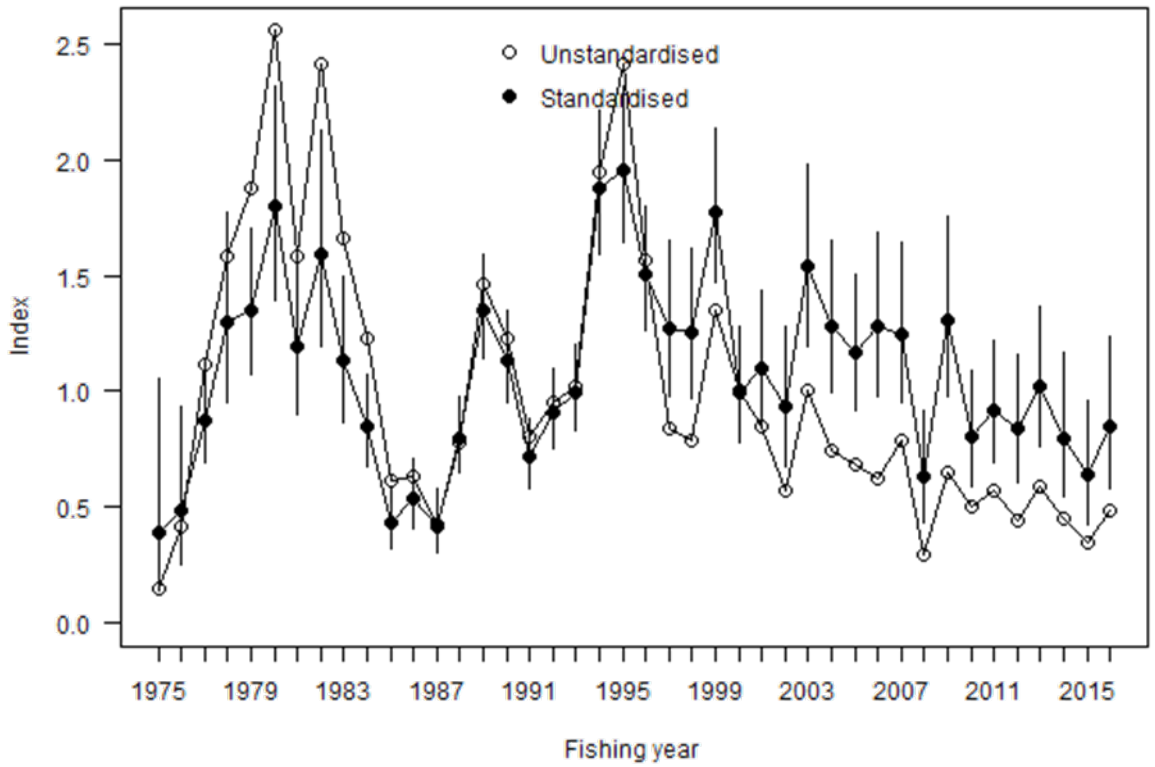

Figure 14: The effect of standardization on East Northland charter boat striped marlin catch. The unstandardised index is based on the geometric mean of the catch only and is not adjusted for effort. The standardised index is adjusted for fishing effort and vessel.

Standardised and unstandardised CPUE indices by year are presented in Appendix 3. The standardization effect of the model was a tendency to reduce the index in the early years and lift the index since the late 1990s (Figure 14). The main driver for this was the effort term which shows a large and consistent trend toward fewer days fished by charter boats in East Northland between 1982 and 2009 (Table 2). The vessel effect pushed the index back down as a number of new high performing vessels entered the fishery in the mid-2000s (Figure 15). (See distribution and influence plots in Appendix 4).

The diagnostic plots of the residuals from the fit of this model to the data show an adequate fit to the negative binomial assumption (Appendix 5).

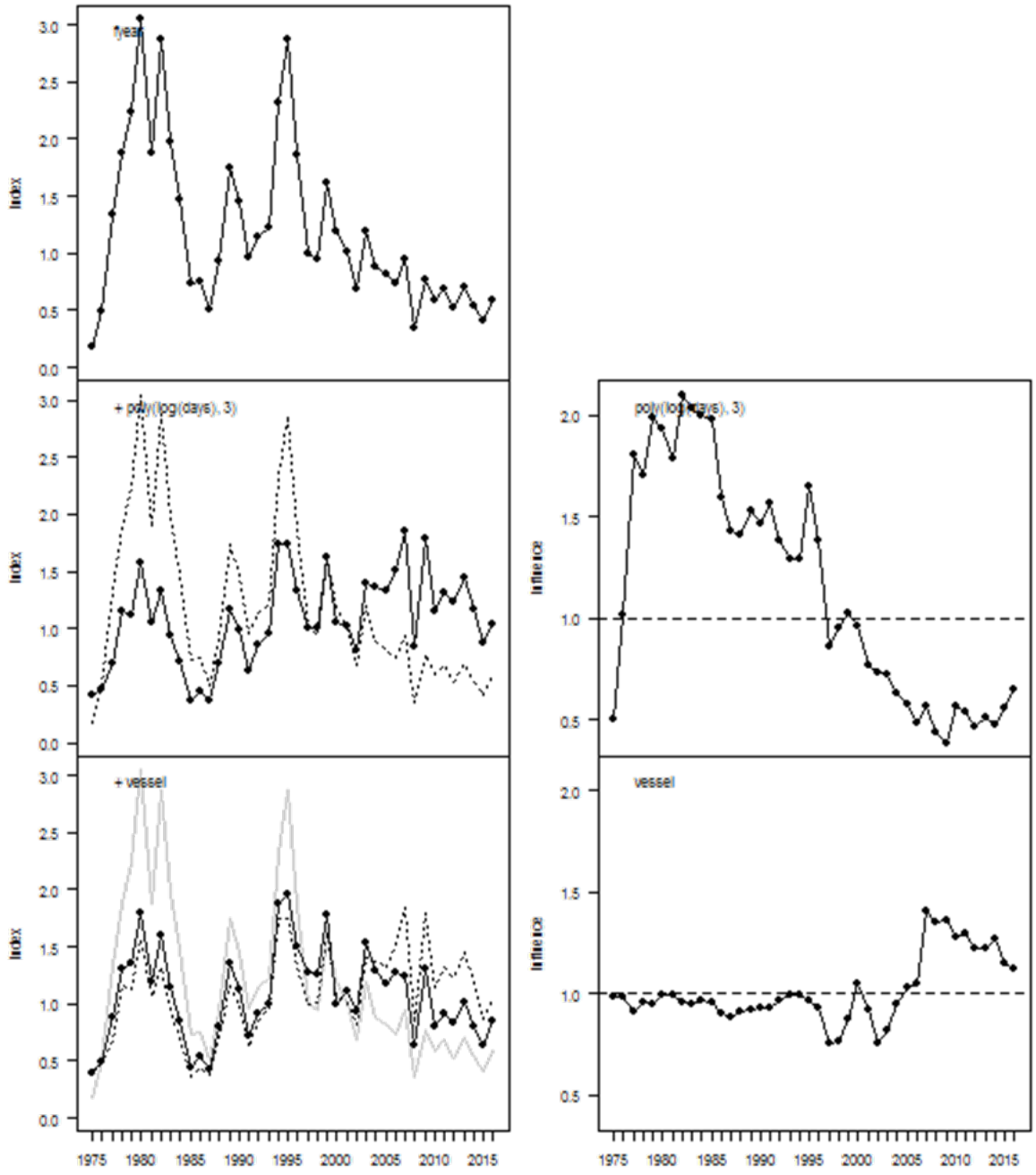

Figure 15: Step plot (left) and influence plots (right) with fishing year at the top, adding polynomial of days fished in the middle, and adding vessel at the bottom.

Overall there is an increasing trend in standardised CPUE following the introduction of the billfish moratorium in 1987 to the mid-1990s and a decreasing trend since then (Figure 16). The 2013–14 and 2014–15 seasons were relatively poor years for the recreational striped marlin fishery in East Northland. The record high striped marlin catch tally recorded by all NZSFC clubs in 2015–16 is not reflected in the East Northland charter vessel CPUE. The proportion of catch caught in the far north and west coast of the North Island was higher than usual in 2015 –16.

The previous analyses of charter boat CPUE in 2011 (Holdsworth & Kendrick 2012) and 2013 (Holdsworth & Saul 2013) are compared with this negative binomial model in Figure 16. The three series show a close match and similar trends.

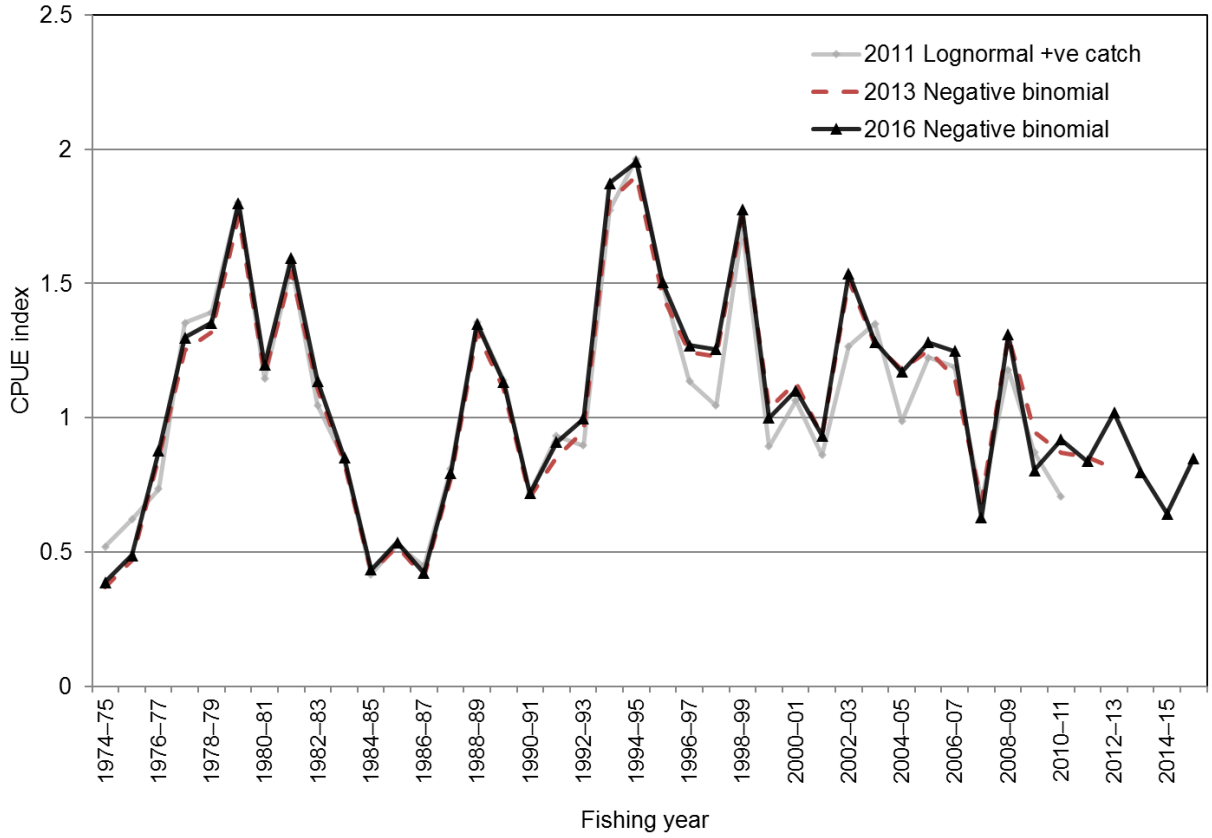

Figure 16: Comparison between the lognormal model of striped marlin CPUE using positive catch used in 2011, the negative binomial model from 2013 and the 2016 model of CPUE for East Northland recreational charter boats.

4 DISCUSSION

The New Zealand Sport Fishing Council collates and publishes catch records from 56 sport fishing clubs from Houhora in the north to Invercargill in the south. This is considered to have produced a reasonably complete record of billfish and large pelagic shark captures by recreational fishers for many years (Holdsworth & Kopf 2005). Historically, deep sea anglers tended to collaborate and compete, with fishing effort concentrated off the main sport fishing ports. Billfish hookups and catches were reported over VHF radio to the club as they occurred. Over the last 10 to 15 years there has been an increase in the number of well-appointed trailer boats targeting pelagic gamefish. These can launch at a wide variety of locations and are less likely to be affiliated to a club. As non-members they may still choose to weigh their fish at a club, where it can be picked up and taken to a local smoke house. The details of

these fish are recorded by clubs. Anecdotally, however, there were a lot of new entrants to the gamefish fishery in 2015–16 and the unreported billfish catch has increased.

NZSFC records show the annual number of striped marlin that were landed or tagged rose from one of the lowest in 2013–14 (1138) to the highest (2430) in the 2015–16 fishing year. 2015–16 was atypical, it was a warm El Nino summer with more easterlies than the predicted cool westerlies, there were more small striped marlin caught than usual, and good numbers of striped marlin were available on the west coast of the North Island. This is the first year the New Plymouth Sportfishing and Underwater Club recorded more striped marlin (373) than the Bay of Islands Swordfish Club, which landed or tagged 262 striped marlin.

The annual average weight of striped marlin tends to be lower in warm, high catch years. The increased abundance or availability of marlin may be a result of good recruitment or more small fish migrating as far south as New Zealand.

A number of long term charter operators are leaving the industry and we are recruiting new entrants and more private vessels to the logbook scheme. There has also been a shift in target species with more charter and private vessels deep drifting baits during the day for swordfish. This shift may reduce fishing effort for striped marlin from existing logbook boats.

The billfish logbook collects details of daily fishing effort and catch from charter and private vessels but the CPUE used in the GLM is rolled up to catch and effort by season for East Northland charter boats only, in order to emulate the data collected in the postal survey. There has been a strong decline in the number of days fishing for marlin per season across the fleet of East Northland charter boats - most obvious in the distribution plot in Appendix 4 (Figure A1).

The model also shows a strong vessel effect over the last 10 years as new more efficient vessels have entered the fishery (Figure A2). This coincides with the introduction of the billfish logbook programme in 2006–07 and the associated effort to recruit participants. About five medium to long term participants were issued logbooks to collect daily catch and effort information, but did not fill them in or did not return them. There are now 10 years of daily logbook data and in future it will be analysed as a parallel CPUE time series. This will allow factors such as hours fished per day, latitude, sea surface temperature and month to be used in the algorithm selecting model terms.

The number of striped marlin recorded in logbooks was very similar over the three years 2013–14 to 2015–16 (mean = 207 sd = 1.5), while the number of days fished for marlin declined. Raw CPUE was higher in 2015–16 but did not capture data from the west coast North Island fishery where catch rates were very good (pers. com. Peter Saunders, New Plymouth Sportfishing and Underwater Club). Trailer boats are used a lot in the west coast fishery as they are suitable for bar crossing or beach launch. Fishers can be quite mobile, switching from east to west coast depending on weather conditions and good fishing reports. More trailer boat fishers will be recruited into the logbook programme. A new CPUE time series, using detailed logbook data that includes private vessels from a wider area, may be more representative of the relative abundance of striped marlin around New Zealand than the East Northland charter boat time series.

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6 APPENDIX 1. LANDED CATCH FROM NZSFC RECORDS 1993–94 TO 2015–16

	Striped marlin	Blue marlin	Black marlin	Shortbill spearfish	Broadbill swordfish	Albacore tuna	Yellowfin tuna	Mako shark	Blue shark	Hammerhead shark	Thresher shark
1993–94	663	41	3	71	1	703	996	220	96	57	6
1994–95	910	28	9	87	5	617	1 997	288	235	49	14
1995–96	705	40	7	27	8		2 187	424	198	44	5
1996–97	619	17	7	16	10	803	2 325	352	114	44	9
1997–98	543	76	10	19	12	993	1 268	455	177	47	13
1998–99	823	140	15	62	6	599	1 235	320	70	36	11
1999–00	398	234	24	17	27	453	1 085	338	79	50	11
2000–01	422	142	9	28	25	803	988	255	54	40	18
2001–02	430	112	8	35	22	576	262	155	100	39	14
2002–03	495	26	3	41	17	1 005	211	109	30	24	9
2003–04	592	47	8	38	33	789	838	82	18	12	4
2004–05	834	93	8	58	13	839	1 219	61	25	9	3
2005–06	630	103	6	53	6	868	346	44	30	7	5
2006–07	688	99	2	38	20	970	283	34	15	8	1
2007–08	485	105	1	25	6	1 189	496	45	12	7	2
2008–09	731	88	0	31	9	848	69	47	12	4	1
2009–10	607	100	4	46	9	794	59	51	13	4	0
2010–11	607	179	2	74	29	596	20	58	18	6	2
2011–12	635	78	9	19	34	535	10	40	15	4	2
2012–13	744	54	2	11	55	778	10	31	13	2	3
2013–14	620	64	4	25	80	592	8	24	6	11	1
2014–15	696	102	5	58	87	808	198	21	12	1	1
2015–16	900	99	4	69	85	877	492	24	8	9	1
Total	14 777	2 067	150	948	599	17 035	16 602	3 478	1 350	514	136

7 APPENDIX 2. STRIPED MARLIN CATCH AND AVERAGE WEIGHT FROM EAST NORTHLAND FISHING CLUBS BY YEAR

	Number		Average weight			Number		Average weight	
Year	landed	tagged	landed	tagged and estimated (kg)	Year	landed	tagged	landed	tagged and estimated (kg)
1945	108		118.17		1993	428	279	102.27	95.10
1946	78		111.41		1994	460	715	99.12	87.97
1947	196		112.64		1995	601	871	101.90	88.57
1948	410		110.02		1996	412	721	97.54	91.10
1949	618		106.71		1997	256	685	105.78	98.13
1950	341		111.02		1998	298	565	101.69	89.12
1951	329		106.26		1999	329	726	88.47	85.03
1952	287		116.34		2000	170	429	99.28	88.87
1953	335		119.06		2001	203	493	101.09	89.44
1954	259		117.09		2002	256	493	105.97	101.95
1955	298		117.20		2003	279	481	109.22	97.31
1956	276		115.39		2004	269	684	101.48	98.23
1957	278		117.46		2005	375	599	102.35	97.77
1958	402		116.46		2006	315	472	96.05	95.73
1959	186		115.13		2007	414	614	97.42	96.01
1960	164		111.46		2008	166	424	97.67	99.69
1961	319		106.12		2009	454	674	100.18	100.16
1962	105		111.93		2010	340	399	103.54	98.19
1963	122		103.08		2011	297	386	98.07	94.42
1964	122		111.47		2012	219	285	99.93	94.33
1965	145		113.23		2013	284	382	106.74	101.15
1966	124		107.63		2014	215	183	106.95	98.08
1967	74		114.32		2015	274	288	98.79	89.43
1968	96		107.35		2016	398	508	102.54	89.58
1969	140		111.10						
1970	46		108.52						
1971	47		88.84						
1972	119		108.19						
1973	76		106.65						
1974	184		94.38						
1975	211		102.91						
1976	254		99.03						
1977	284		112.01						
1978	305		112.20						
1979	515		103.99						
1980	647		104.78						
1981	597		99.09						
1982	668		109.25						
1983	657		108.11						
1984	501		98.44						
1985	217		98.48						
1986	325		100.08						
1987	209		102.50						
1988	255	91	107.88	96.40					
1989	379	321	88.31	79.15					
1990	400	327	95.25	90.43					
1991	385	161	97.69	87.64					
1992	392	174	111.67	92.98					

8 APPENDIX 3. SUMMARY OF CPUE INDICES

Table A1. Standardised and unstandardised CPUE indices. Fishing year labelled by later calendar year e.g. 1990=1989–90. All: all vessels, Core: core vessels, Geom.: geometric mean, Arith: arithmetic mean, Stand.: standardised using GLM, SE: standard error.

Fishing year	All/Arith.	Core/Arith.	Core/Geom.	Core/Stand.	Core/Stand. SE
1975	0.5861	0.5965	0.6738	0.3868	0.50282
1976	0.3761	0.3828	0.5830	0.4869	0.32493
1977	0.6217	0.6328	0.6018	0.8768	0.11918
1978	1.1192	1.1390	1.1947	1.2983	0.15660
1979	1.0808	1.0999	1.1722	1.3532	0.11523
1980	1.4903	1.5166	1.6167	1.7991	0.12700
1981	1.0159	1.0339	1.0419	1.1976	0.14259
1982	1.3374	1.2649	1.3049	1.5955	0.14399
1983	0.9862	0.9056	0.8607	1.1371	0.13601
1984	0.6669	0.6798	0.7059	0.8517	0.11707
1985	0.3142	0.3405	0.3470	0.4342	0.14818
1986	0.3920	0.3989	0.4290	0.5358	0.14146
1987	0.3824	0.3873	0.3656	0.4205	0.16220
1988	0.6813	0.6959	0.6948	0.7952	0.10388
1989	1.2147	1.1481	1.1587	1.3508	0.08304
1990	0.9599	0.9597	0.9804	1.1322	0.08639
1991	0.7120	0.6407	0.6114	0.7185	0.10336
1992	0.7792	0.8569	0.8621	0.9094	0.09324
1993	0.9036	0.9584	0.8588	0.9972	0.09321
1994	1.4619	1.6657	1.6989	1.8744	0.08245
1995	1.5198	1.7023	1.7868	1.9526	0.08617
1996	1.2523	1.3273	1.3185	1.5037	0.08870
1997	0.9889	0.8665	1.0007	1.2694	0.13217
1998	0.9962	0.9409	0.8192	1.2553	0.12766
1999	1.6352	1.6237	1.5146	1.7750	0.09263
2000	0.9519	0.9020	0.9243	0.9996	0.12533
2001	0.9107	0.7910	0.9674	1.1017	0.13255
2002	0.8589	0.6810	0.7365	0.9333	0.15897
2003	1.2540	1.2762	1.1006	1.5381	0.12588
2004	1.6718	1.4675	1.6295	1.2823	0.12618
2005	1.6007	1.5541	1.2599	1.1710	0.12410
2006	1.9901	1.8567	1.5997	1.2811	0.13657
2007	1.7947	2.0312	1.9134	1.2480	0.13729
2008	1.1265	1.2391	1.1314	0.6285	0.18950
2009	1.8434	1.9421	2.1184	1.3103	0.14676
2010	1.2099	1.2167	0.9747	0.8036	0.15292
2011	1.1954	1.2085	1.1329	0.9192	0.14247
2012	1.1696	1.2295	1.4416	0.8379	0.16263
2013	1.3691	1.3938	1.2677	1.0191	0.14658
2014	1.3329	1.3565	1.1333	0.7977	0.18929
2015	0.8835	0.8991	0.8126	0.6428	0.20282
2016	1.0660	1.0848	1.1538	0.8487	0.18881

9 APPENDIX 4. COEFFICIENT, DISTRIBUTION AND INFLUENCE PLOTS

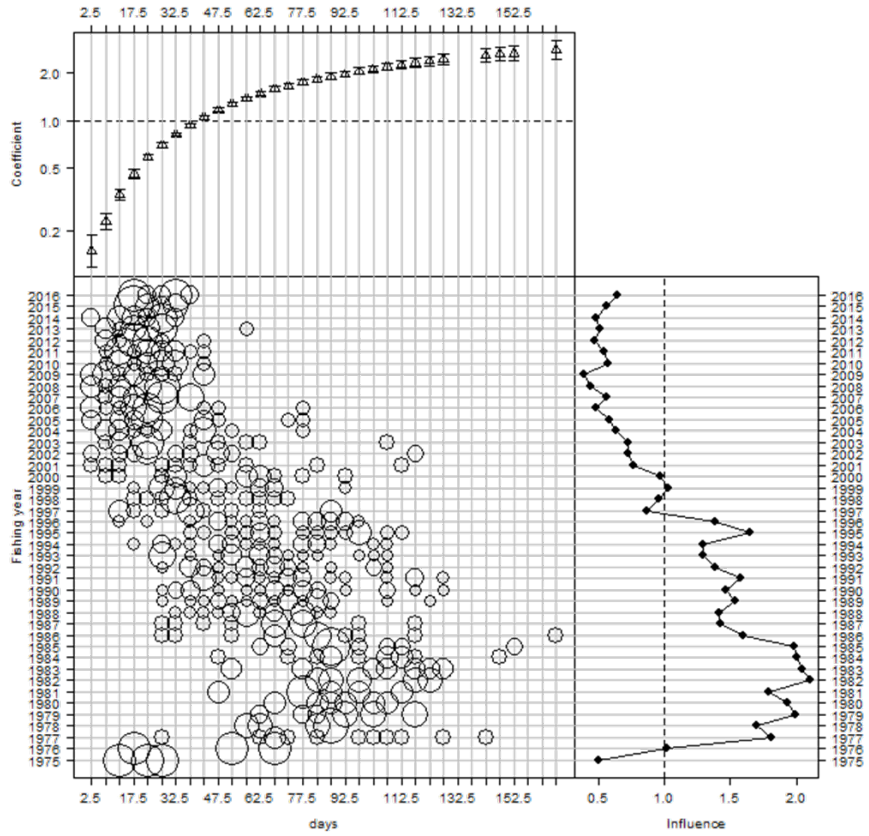

Figure A1: Coefficient distribution influence plot for poly(log(days), 3).

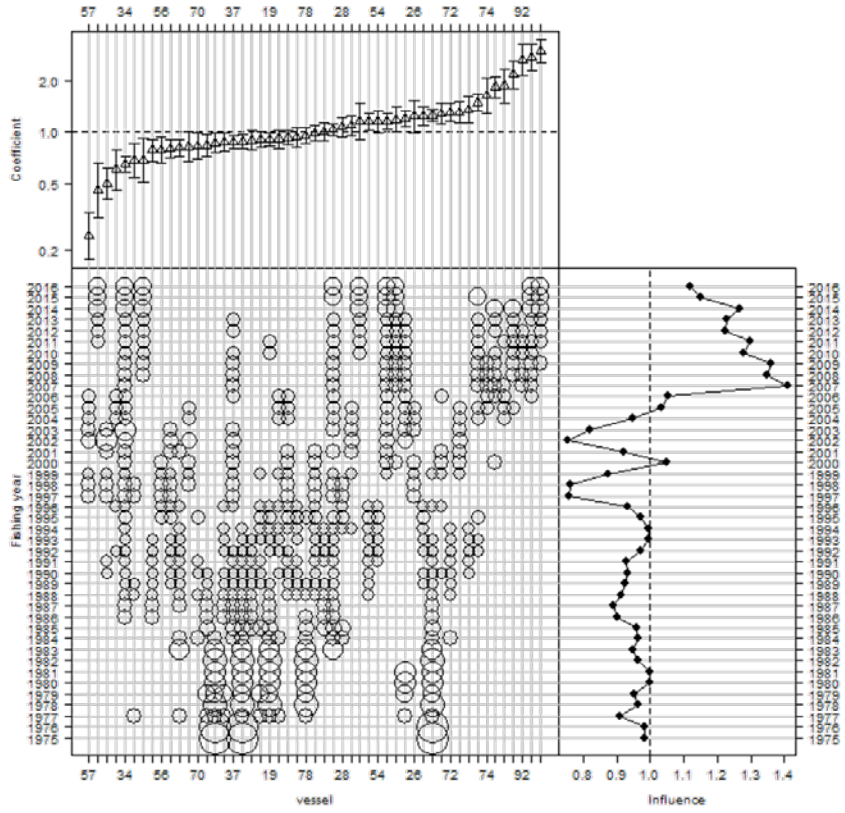

Figure A2: Coefficient distribution influence plot for *vessel*.

10 APPENDIX 5. RESIDUAL DIAGNOSTICS

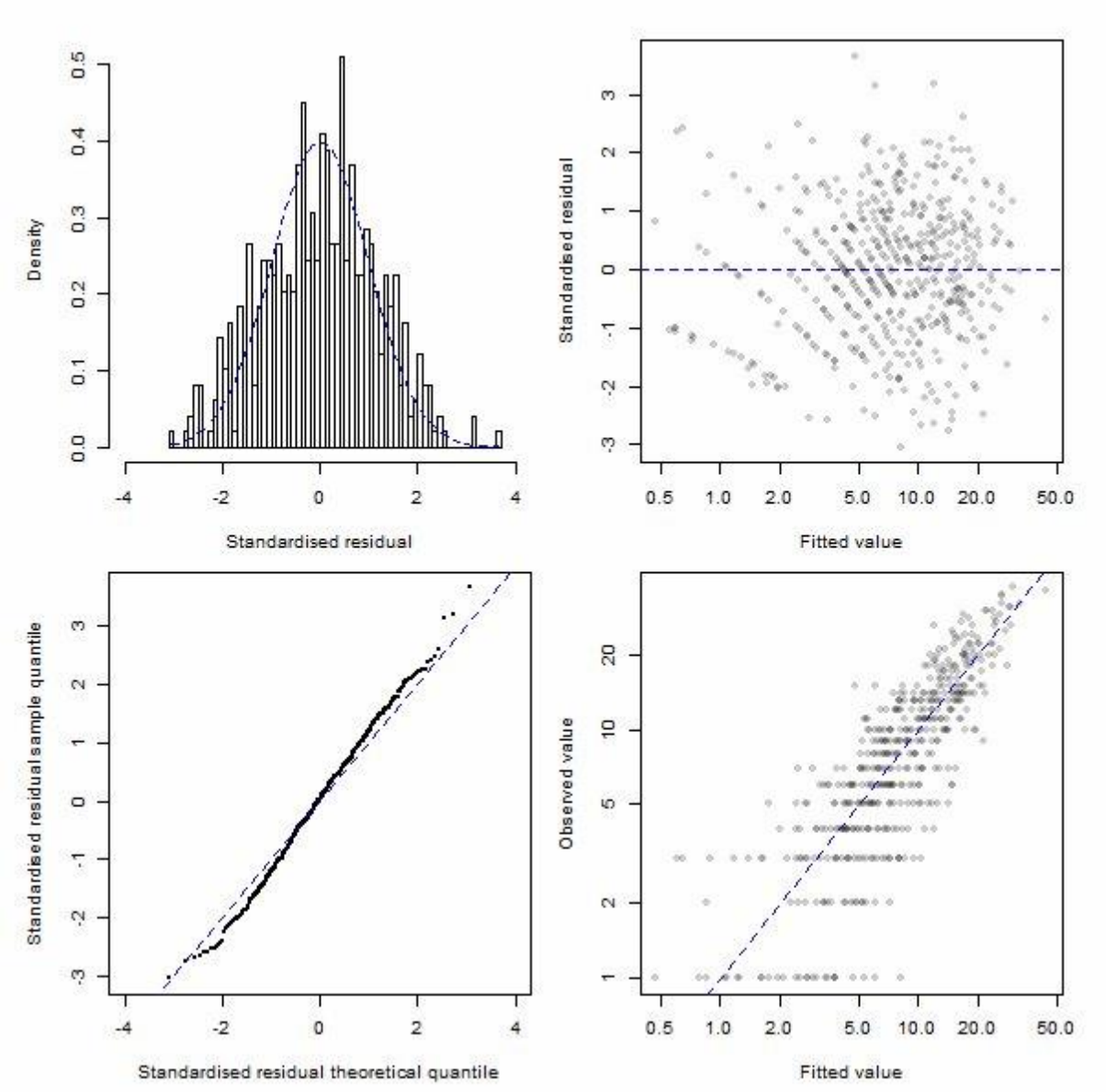

Figure A3: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values.