New Zealand striped marlin recreational catch and effort 2010–11

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Striped marlin (*Kajikia audax*) are large migratory fish that appear in New Zealand waters during summer and autumn. They have been one of the main target species for a summer recreational fishery from ports in Northland and Bay of Plenty for over 80 years. Surface longlining is the principal commercial method to catch striped marlin and a significant number have been caught each year in the southwest Pacific Ocean for the last 50 years.

A large proportion of the recreational catch is reported through fishing clubs and the gamefish tagging programme. The number of striped marlin reported landed or tagged and released by recreational fishers was 607 and 809 respectively in 2009–10, with 529 landed and 698 tagged and released in 2010–11.

The mean weight of striped marlin recorded by the main fishing clubs in the New Zealand recreational fishery was 100.5 kg in 2009–10 dropping to 95.9 kg in 2010–11. Even with this drop mean weights from 2002–03 to the present have been relatively stable and generally higher than other years since 1989.

The gamefish logbook scheme has been collecting daily effort and catch data since 2006–07. Records from 1030 days fished with 1035 strikes and 264 striped marlin caught were collected from 44 completed logbooks in 2009–10. This amounted to 19% of the total recreational catch recorded by New Zealand Sport Fishing Council (NZSFC) affiliated clubs for that season.

Records from 914 days fished with 743 strikes and 173 striped marlin caught were collected from 44 completed logbooks in 2010–11, accounting for 14% of that season's NZSFC striped marlin catch.

Fishing effort is highest in east Northland, but the highest Catch per unit effort (CPUE) is usually achieved in the Far North, Fisheries Statistical Areas 047 and 048, where catch rates are typically two or three times higher than in east Northland, but effort is limited due to the remoteness of the fishing grounds and rough weather.

CPUE peaked in February in both years. It remained stable but relatively low in east Northland throughout the 2009–10 and 2010–11 seasons.

The 2010–11 season was influenced by constant easterly conditions which affected the ability of vessels to fish off east Northland. Striped marlin catches on the west coast of the North Island were high in January 2011 but declined quickly in February and remained low thereafter. Raw CPUE for coastal east Northland fell below the long-term mean for the last 10 years and this year was similar to the poor year in 2007–08.

Five years of logbook CPUE from the east Northland gamefish charter boat skippers was used to extend the existing 32 year time series of mean catch per day per season by vessel. Core vessels were selected that had provided data for five or more years. CPUE was standardised using a Lognormal GLM. Fishing year was forced as the first variable but nevertheless explained most of the variance in catch (33.5%). The effort term days fished entered the model second, explaining an additional 24% of the variance and was followed by vessel (11.7%). The final model explained 69% of the variance.

Overall there is an increasing trend in CPUE following the introduction of the billfish moratorium in 1987 to the mid 1990s and a decreasing trend since then. 2009–10 and 2010–11 were relatively poor years for the recreational striped marlin fishery in New Zealand. The peak years in the late 1970s are about equivalent to the best years in the 1990s.

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1. INTRODUCTION

1.1 Overview

Catch records for individual fish have been collected and published annually by sport fishing clubs for many years. For marlin species these records are believed to be reasonably complete. National catch tallies are compiled annually by the New Zealand Sport Fishing Council (NZSFC). Striped marlin catch per unit effort from the recreational fishery has been collected in the past by postal surveys of skippers and more recently using the gamefish logbook scheme. This report updates the time series of striped marlin data and has the results from gamefish logbooks for the 2009–10 and 2010–11 seasons as a reporting requirement for the Ministry of Fisheries, project STM2009/01.

1.2 Description of the fishery

The recreational fishery for large pelagic species is very important for many New Zealanders and attracts tourist fishers from around the world. The fishery operates mainly over the warm summer and autumn months. Striped marlin (*Kajikia audax*) is the mainstay of the gamefishery on the Northland east coast, with blue marlin (*Makaira nigricans*), small numbers of black marlin (*Makaira indica*), shortbill spearfish (*Tetrapturus angustirostris*), and swordfish (*Xiphias gladius*) also caught. Yellowfin tuna (*Thunnus albacares*) and yellowtail kingfish (*Seriola lalandi*) have historically been caught in large numbers, although several poor yellowfin seasons have seen an increase in targeting of striped marlin and blue marlin.

Marlin species are also a bycatch of the commercial surface longline fishery that mainly targets bigeye (*Thunnus obesus*), swordfish and southern bluefin tuna. Within the New Zealand Exclusive Economic Zone (EEZ), commercial fishers are obliged by regulation to release all billfish, except swordfish, alive or dead. This regulation has been in place since the 1987–88 season and the number of striped marlin released has been under reported in commercial catch records.

2. METHODS

2.1 Catches, landings and size composition

The time series of recreational catch data for individual striped marlin was expanded to include the 2009–10 and 2010–11 fishing seasons for the Bay of Island Swordfish Club, Whangaroa Sport Fishing Club, Whangarei Deep Sea Anglers Club, and Tauranga Game Fishing Club. Data from within the New Zealand EEZ were separated into landed fish and released fish and summarised by season and club. The annual number of striped marlin landed by recreational fishers is taken from NZSFC national club tallies published in their yearbook. The annual number of tagged striped marlin is sourced from the New Zealand gamefish tagging programme database.

The average annual weights are plotted for the three oldest Northland clubs. When fewer than 10 striped marlin were landed by a club in a season the average was not plotted. Data from the Tauranga club was excluded because they have not recorded the estimated weights of tagged fish in their catch records until recently and in a number of years in the 1960s and 1970s their landed catch was less than 10 striped marlin.

2.2 Catch per unit effort

The gamefish logbook scheme has been running for five seasons (2006–07 to 2010–11) 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). Charter vessels with positive catches for the season were selected. The East Northland charter boat CPUE time series

now extends over 37 years. It excludes catch and effort from the productive Three Kings fishery which started in the early 1990s north of New Zealand. Effectively the survey area is the area covered by Ministry of Fisheries statistical areas 002 and 003.

Standardisation of CPUE was undertaken on core vessels in the fleet which were vessels that had provided five years or more of data. Vessel characteristics such as length and hull type have also been compiled. The distribution of CPUE for the fleet is approximately log normal. Log CPUE was used in GLM runs that were undertaken using R software.

2.3 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, and swordfish, yellowfin tuna, and shortfin mako shark (*Isurus oxyrinchus*). In the 2010–11 season bigeye tuna was added to the list following some sport fishing interest and catch in the previous season. The logbook forms were designed with input from charter boat organisations and experienced private skippers as part of the Ministry of Fisheries 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; a record of billfish strikes; wind speed and direction; and precise locations for fish caught. In 2007–08 a change was made to the logbook form to include primary target species and water temperature at noon in the effort section (see Appendix Figure 1A). Distribution of logbooks has focused on charter vessels and private boats that fish more than 10 days per season.

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 an in-season newsletter. A free logbook shirt is provided to each skipper if they return their logbook at the end of the season. During the 2007–08 and 2008–09 seasons data from 1062 and 985 gamefishing days respectively was collect in logbooks (Holdsworth & Saul 2009).

A database has been developed for vessel, skipper and logbook data. It has a 3-tier architecture built in Microsoft .NET Framework 2.0 and designed to run standalone on a single desktop. 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 MFish **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.

3 RESULTS

3.1 Catches, landings and size composition

Estimates of total recreational landings for striped marlin in New Zealand and the number captured in CPUE surveys are given in Table 1. The total numbers of striped marlin reported by recreational fishers in NZSFC records both in 2009–10 (1416) and in 2010–11 (1227) were below the average of the last 15 years (1547 sd.= 378).

There is a fairly complete historical record for each striped marlin caught by the main gamefish clubs. The estimated total of all catch recorded by fishing clubs has declined from 1955 to the early 1970s and rose steadily in the late 1970s and early 1980s (Figure 1). Striped marlin catch was low in the mid 1980s but increased significantly over the subsequent eight years following the introduction of regulations prohibiting landing of marlin on commercial vessels in New Zealand waters from October 1987. National annual reported catch by fishing clubs has been high for the last 15 years compared to historic

levels. (Figure 1) A description of the trends in recreational catch, the introduction of the Billfish Moratorium and subsequent regulation changes are provided in Holdsworth & Kopf (2005). The proportion of reported striped marlin catch that was tagged and released by recreational fishers in 2009–10 was 57% and in 2010–11 was 54%.

The individual weights of recreationally caught marlin are recorded by gamefish clubs. Prior to 1988 a high proportion of the recreational catch was landed and accurately weighed. Since 1990 more than half of the recreational catch has been tagged and released and weight estimated when the fish was alongside the boat (Holdsworth & Saul 2011). The average annual striped marlin weights for three of the oldest deep sea angling clubs declined from around 117 kg in the 1950s to 85.5 kg in 1998–99 (Figure 2). The average weight for striped marlin caught by these three clubs subsequently rose each season to 100.5 kg in 2009–10 then fell to 95.9 kg in 2010–11, which was a La Nina summer in which sea surface temperatures were warmer than normal. A similar phenomenon has been noted in other La Nina seasons, notably 1988–89 and 1989–90, where an increasing proportion of small fish led to a lower average weight in the landed catch. Mean annual weights do vary between clubs in the same season and at times the sample sizes are quite small. Some of the outlier years have been checked and in most cases the high years are a result of a small number of large fish being landed which inflates the overall mean. There were a large number of small striped marlin caught in the recreational fishery in 1999 and since then average weights have tended to increase, with low points in 2007–08 and 2010–11 (Figure 2).

3.2 Logbook numbers of fish recorded

Logbook data have been collected for the past five seasons with 47 usable sets of data collected in 2009–10 (Table 2) recording 1035 days of effort targeting billfish, resulting in the capture of 279 billfish from 792 billfish strikes. Usually fishers can distinguish marlin from other species when a strike occurs. Often it is not possible to determine which species of marlin struck if no capture is made.

The 2009–10 season was characterised by a slow start, with very few fish until late January. There was a strong showing of marlin in February, particularly in the Three Kings area, and catches remained excellent throughout March. In April, a concentration of striped marlin off Tutukaka resulted in good catches until the end of that month. The monthly pattern of catches is tracked in club records (Figure 3a) and logbook data (Figure 4a). Striped marlin recorded in the 2009–10 gamefish logbook scheme amounted to 19% of the total striped marlin catch recorded for that season by NZSFC clubs and the tagging database.

In 2010–11 there were 44 usable logbooks returned. These reported 914 days of effort targeting billfish, resulting in the capture of 205 striped and blue marlin from 743 recorded strikes. In contrast to the previous season the 2010–11 season began with good catches in January. Catches in the Three Kings area were relatively low throughout the season, mainly due to reduced fishing effort. February was again the peak month especially off east Northland but the fishing quickly declined in March, and fishing success in April was poor compared to the year before. The monthly pattern of catches is tracked in club records (Figure 3b) and logbook data (Figure 4b). Striped marlin recorded in 2010–11 logbooks captured 13% of the total NZSFC catch (Table 1).

The distribution of all billfish strikes and catches by week through the season shows an increase in mid-February in both seasons. The catch of blue marlin is generally restricted to the period of warmest water temperatures in February and March (Figures 5a and 5b). However, with warmer surface temperatures experienced in 2011, some blue marlin were caught in January (Figure5b). Generally, there are about three strikes per striped marlin capture across both seasons (Figures 5a and 5b).

3.3 Logbook catch per unit effort

In 2009–10 billfish logbook raw CPUE varied by area and month (Figure 6a). It remained stable in east Northland, rising slightly to peak in April. West Coast North Island CPUE was high in February

and about equal to east Northland in March. There was no recorded effort after April on the west coast as the weather pattern changed to a more westerly aspect, and water temperatures fell. The Bay of Plenty/East Cape area experienced a relatively poor season for striped marlin (Figure 6a). CPUE was very high in the Three Kings area in February and March but, as it has in recent years, fell away and was relatively poor in May. An apparent upturn in June 2010 was an aberration caused by a small amount of data for that month (Figure 6a). For all areas combined, CPUE plotted by week for 2009–10 shows a peak in late February and relatively consistent weekly catch rates through to week 19 (the beginning of May) (Figure 7a).

In 2010–11 billfish logbook CPUE started well in January and February in most areas then declined each month from there (Figure 6b). Again the best catch rates were at the Three Kings Islands and it was a very poor year for Bay of Plenty fishers. CPUE by week for all areas this season shows a similar story with a good start to the season but inconsistent from week 9 on. Occasional catches from a few days fished late in the season may not reflect the true availability of marlin at that time (Figure 7b).

3.4 East Northland charter CPUE time series

The gamefish logbook scheme expanded the area and vessel type targeted for catch and effort information in 2006–07. The core fishing area remains east Northland with 70% of logbook days and 49% of the billfish catch in 2009–10, with 73% of logbook days and 70% of the billfish catch in 2010–11 recorded there. CPUE data from 1974–75 to 2005–06 are available from the annual postal survey of charter skippers. A subset of logbook data can be used to extend the existing time series. Charter CPUE over all years is log normally distributed with a mode at 0.16 striped marlin per day (Figure8). The distribution of striped marlin catch per season is broad for core vessels (Figure 9).

A total of 5422 striped marlin have been reported in the surveys of charter vessels in east Northland since 1975 from a total of 32 505 fishing days. Core vessels were selected if they had reported at least 5 years in the time series and only positive catches for the season were included. This reduced the total data set used in the Lognormal model to 4535 striped marlin (84%) from 27 705 fishing days. Fishing year was forced as the first variable but nevertheless explained most of the variance in the catch (33.5%). The effort term (log of days fished) entered the model second, explaining an additional 24% of the variance and was followed by vessel with an additional 11.7% of the variance (Table 3). The final model explained 69% of the variance in catch is:

Log(number STM per season) = fishing year + log(days fished) + vessel

A plot of model indices at each step of variable selection is shown in Figure 10. There has been a marked change in the operation of the fleet over the survey period with a decline in the number of days fished in a season. Prior to 1987 most charter boats fished over 50 days per season, this has steadily declined. Since 2004, few charter boats fished more than 50 days per year in the survey area (Figure 11). For many years the top charter boats fished local waters from tourist ports such as the Bay of Islands using slow baits trolled at 4 knots. The top boats in the 1990s were large fast vessels that fished a wider area and trolled plastic lures at 8 knots or more. They fished a large number of days per season but many of these were outside the survey area, north of New Zealand and at the Three Kings. Boats that remained doing day trips from popular ports lost customers to the long range boats and to an ever increasing pool of private launches and trailer boats that were equipped to target marlin. The influence of days fished shows a positive relation between fishing more days per season and catch (Figure 11).

Changes to the core fleet had a positive influence on catch rates overall (Figure 12) with the inclusion of new vessels over the last seven or eight years. These were mostly large new boats run by experienced skippers employed by the vessel owner. In this situation earning a living and getting a return on investment are less dependant on the number of charter days fished than with owner/operator boats. The model adjusts for the number of high performing vessels in the survey in the last eight years and reduces the standardised CPUE index of those years (Figure 13). Home port of

vessel was also offered to the model but was not selected as an explanatory variable, although it is likely that vessel acts as a proxy for this. Various attempts have been made in previous years to include environmental variables in a GLM with these data but without better temporal resolution in CPUE they are not useable.

The diagnostic plots of the residuals from the fit of this model to the data show an adequate but not good fit to the log normal assumption (Figure 14).

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 15). The 2009–10 and 2010–11 seasons were relatively poor years for the recreational striped marlin fishery in New Zealand. The peak years in the late 1970s are approximately equivalent to the best years in the 1990s. A table of CPUE indices are provided in the appendix (Table A1).

4. DISCUSSION

Striped marlin catch data collected from five large clubs have been added to the existing time series of data. This captures individual fish details for a significant proportion of the national recreational striped marlin catch (Holdsworth & Kopf 2005). The national annual club catch tallies have been relatively high for the last 15 years. In 2010–11 catch was at the lower end of the range for the period. This season was influenced by constant easterly conditions which affected the ability of vessels to fish off east Northland.

The mean weight of striped marlin recorded in the New Zealand recreational fishery has progressively declined and become more variable between 1960 and 2002. The two seasons with the lowest mean weights prior to this season (1988–89 and 1998–99) both had relatively high CPUE. There were large numbers of small striped marlin (less than 80 kg) available in those years, possibly from a period of particularly good recruitment or favourable oceanographic conditions for small fish associated with the *La Nina* weather pattern. Mean weights from 2002–03 to 2009–10 were generally higher than other years since 1989.

Five years of logbook CPUE from the east Northland gamefish charter boat skippers was used to extend the existing 32 year time series of mean catch per day per season by vessel. There has been a trend for charter vessels to fish fewer days per year in the survey area, which will reduce the number of marlin caught per season per vessel. There are a number of likely reasons for this including larger faster vessels coming into the fishery with skippers as employees rather than owners, the increase in private boats targeting billfish and the global recession.

There is general support for the voluntary billfish logbook, but a perceived conflict with the establishment of a general charter boat reporting regime by MFish in 2010 caused difficulties for some operators, resulting in less data becoming available for the 2010–11 season. The full effect of the compulsory reporting scheme which comes into full effect in the northern billfish fishery in 2012 is yet to be seen. The difficulty of establishing this voluntary reporting as a routine task for skippers when fishing for pelagic gamefish should not be underestimated. Any substantial increase in reporting in future may come primarily from private skippers who have a strong interest in the fishery, rather than from charter boat operators. The shorter season is another likely reason that a lower proportion of the estimated national catch was captured in logbooks in 2001–11. A high proportion of catch was taken in January and February in 2012 when most boats participate in the fishery. Avid marlin fishers (with logbooks) who normally fish though April and even May fished less during those months and were less successful.

The model adjusts for the number of high performing vessels in the survey in the last 8 years and down weights the CPUE index. Overall there is an increasing trend in CPUE following the introduction of the billfish moratorium in 1987 to the mid 1990s and a decreasing trend in the standardised index since then. The 2009–10 and 2010–11 seasons were relatively poor years for the

recreational striped marlin fishery in New Zealand. The peak years in the late 1970s are about equivalent to the best years in the 1990s.

5. ACKNOWLEDGEMENTS

This research was undertaken under contract to the Ministry of Fisheries as project STM2009/01. Thanks to Terese Kendrick for the GLM analysis. Thanks also to the New Zealand Sport Fishing Council and member clubs for providing detailed catch records. The contribution of Northland charter vessel operators who completed the postal catch and effort surveys is much appreciated. We also acknowledge all the charter boat and private skippers who have completed logbooks which will assist in monitoring their fishery now and in the future.

6. REFERENCES

Holdsworth, J.C.; Kopf, R.K. (2005). Characterisation of striped marlin fisheries in New Zealand. *New Zealand Fisheries Assessment Report 2005/31.* 63 p.

Holdsworth, J.C.; Saul, P.J.; van der Straten, K.M. (2007). Striped marlin fisheries in New Zealand. *New Zealand Fisheries Assessment Report 2007/32.* 37 p.

Holdsworth, J.C.; Saul, P.J. (2009). Stock monitoring of striped marlin 2007–08 and 2008–09. Final Research Report held by Ministry of Fisheries Wellington.

Holdsworth, J.; Saul, P. (2011). New Zealand billfish and gamefish tagging, 2009–10. *New Zealand Fisheries Assessment Report 2011/23*. 26 p.

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 1976–77 to 2005–06 and the Billfish Logbook Programme 2006–07 to 2010–11.

Fishing	NZ Recreational STM		Total	East Northland	NZ Billfish	Proportion of catch surveyed
Year	Landed	Tagged		Survey STM	Logbook STM	
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	1 345	2 179	181		0.08
2005–06	630	922	1 552	134		0.09
2006–07	675	963	1 638		254	0.16
2007–08	469	732	1 201		306	0.25
2008–09	731	1 058	1 789		370	0.21
2009–10	607	809	1 416		264	0.19
2010–11	529	698	1 227		173	0.14
Total	18 441	19 462	37 903	5 642	1 367	

Table 2: Number of days fished and catch by species recorded in billfish logbooks 2006–07 to 2010–11.

		Landed				Tagged and released			
	Days	Striped marlin	Blue marlin	Shortbilled spearfish	Other species	Striped marlin	Blue marlin	Shortbilled spearfish	Other species
2006–07	922	54	2	1	37	200	8	2	11
2007–08	1 062	62	12	3	57	244	8	3	36
2008–09	985	88	9	0	2	282	9	0	3
2009–10	1 035	67	7	0	22	197	8	0	41
2010–11	914	46	13	1	8	127	19	0	61
Total	2 969	317	43	5	126	1050	52	5	151

Table 3: Summary of final Lognormal model for the fishery. Independent variables are listed in the order of acceptance to the model. AIC: Akaike Information Criterion, R^2: Proportion of deviance explained, Final: Whether or not variable was included in final model, See text for explanation of influence measures.

Term	DF	Deviance	AIC	R^2	Final
None	0	330	1 151	0.000	
Fyear	37	219	1 037	0.335	*
Poly(log(days),3)	40	140	838	0.575	*
Vessel	86	101	783	0.692	*

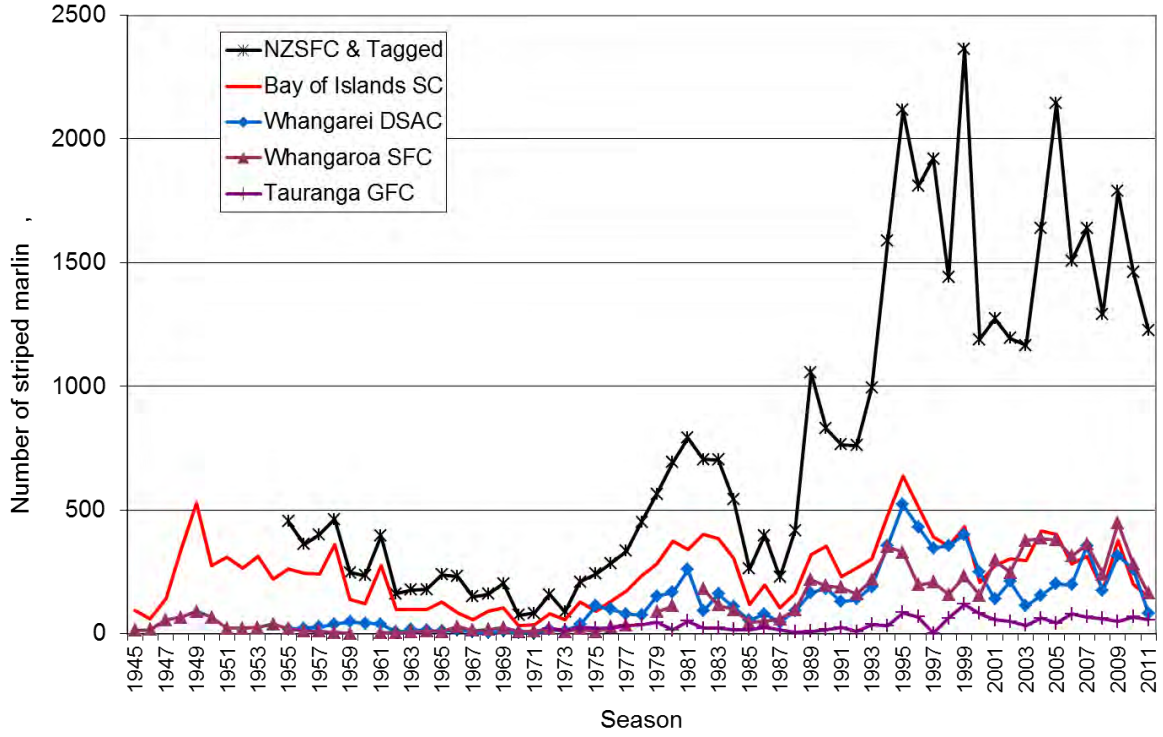


Figure 1: Number of striped marlin caught by recreational fishers in four long established clubs compared to the national catch by all New Zealand Sport Fishing Council affiliated clubs.

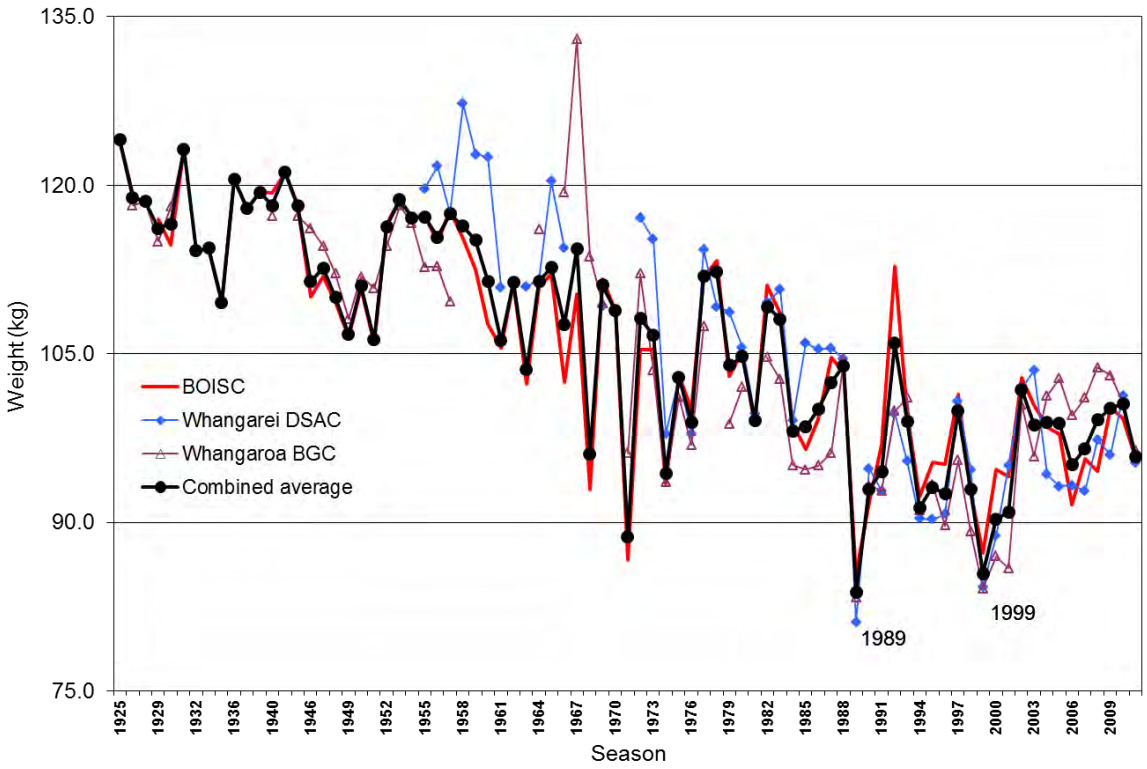
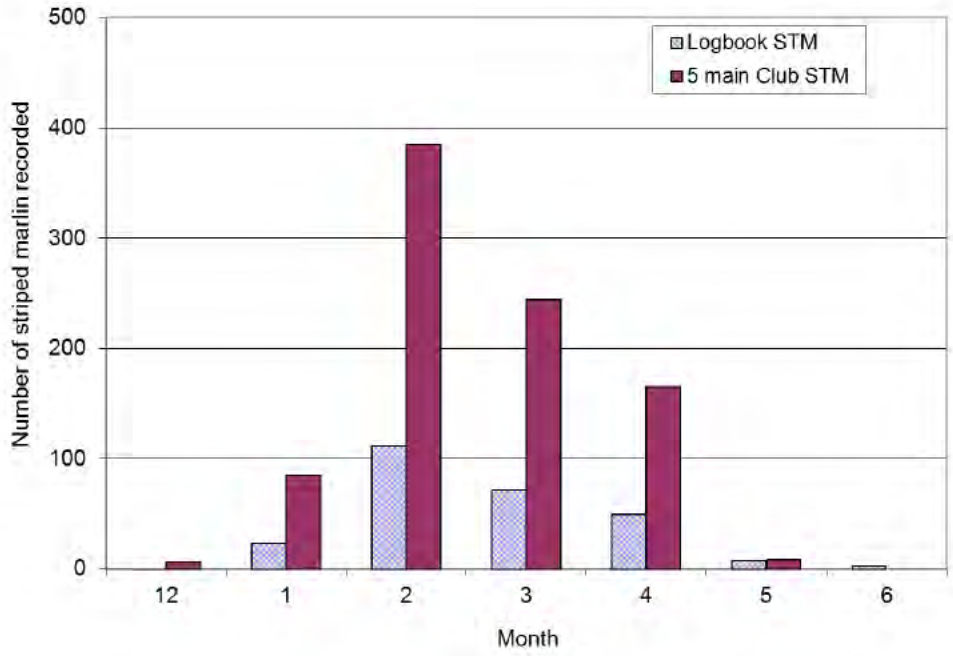


Figure 2: Average annual weight of striped marlin (landed and tagged) from three Northland clubs and the combined mean weight by season.

a)



b)

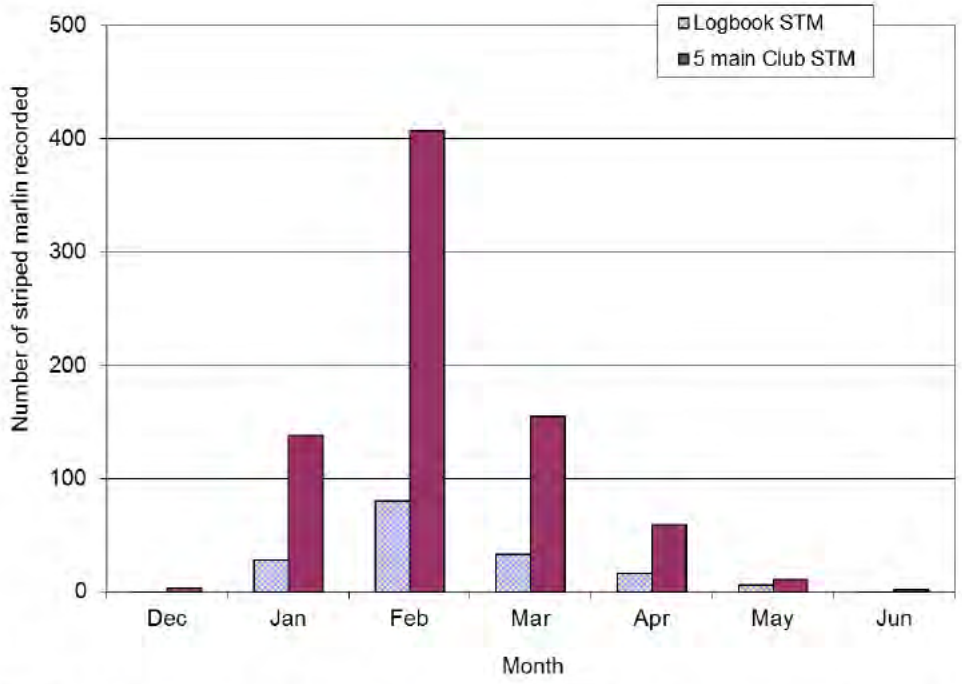


Figure 3: Number of striped marlin recorded in billfish logbooks and number recorded by the five main clubs by month a) in the 2009–10 season; and b) in the 2010–11 season.

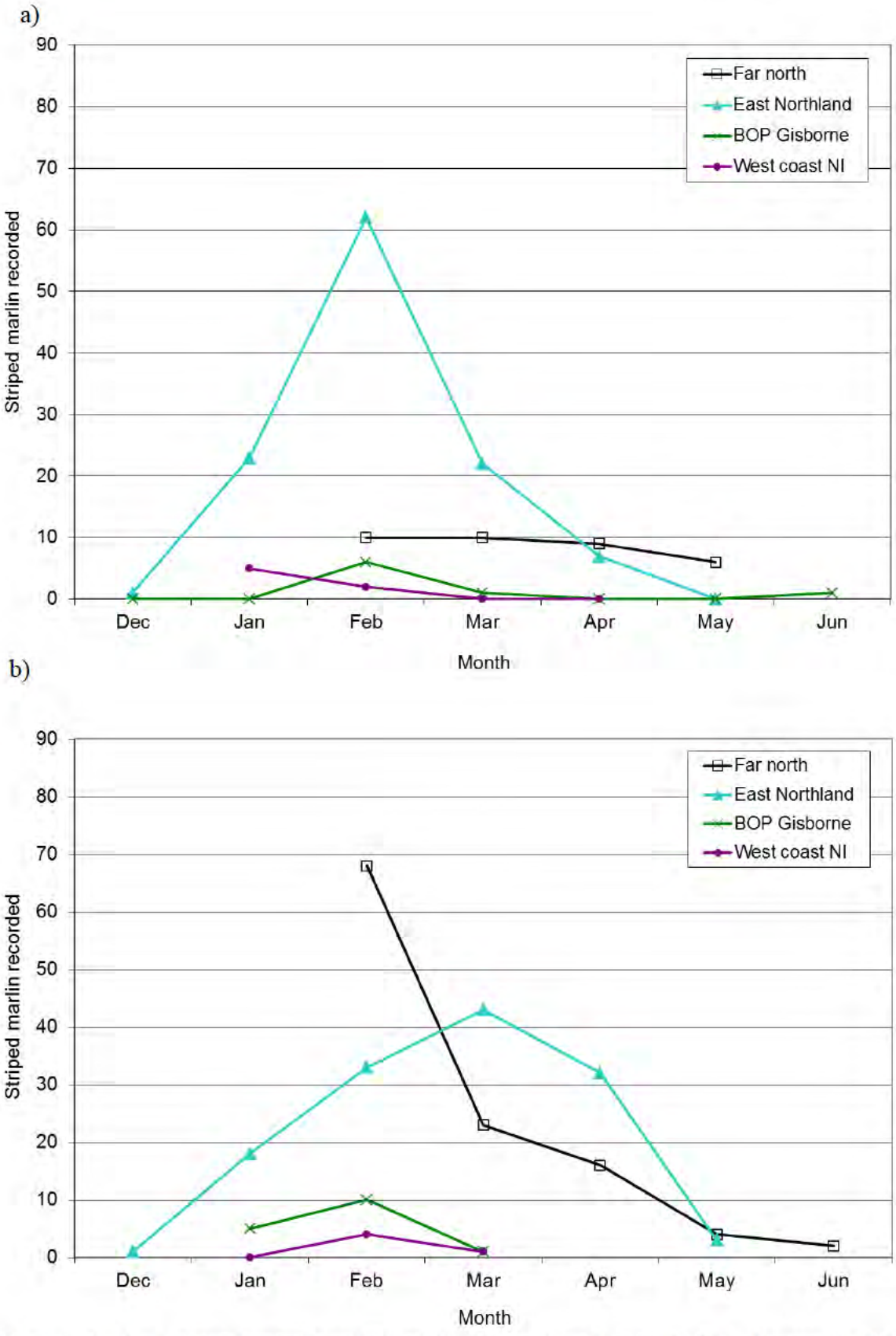


Figure 4: Logbook reported striped marlin catch by area and month a) in the 2009–10 season; and b) in the 2010–11 season.

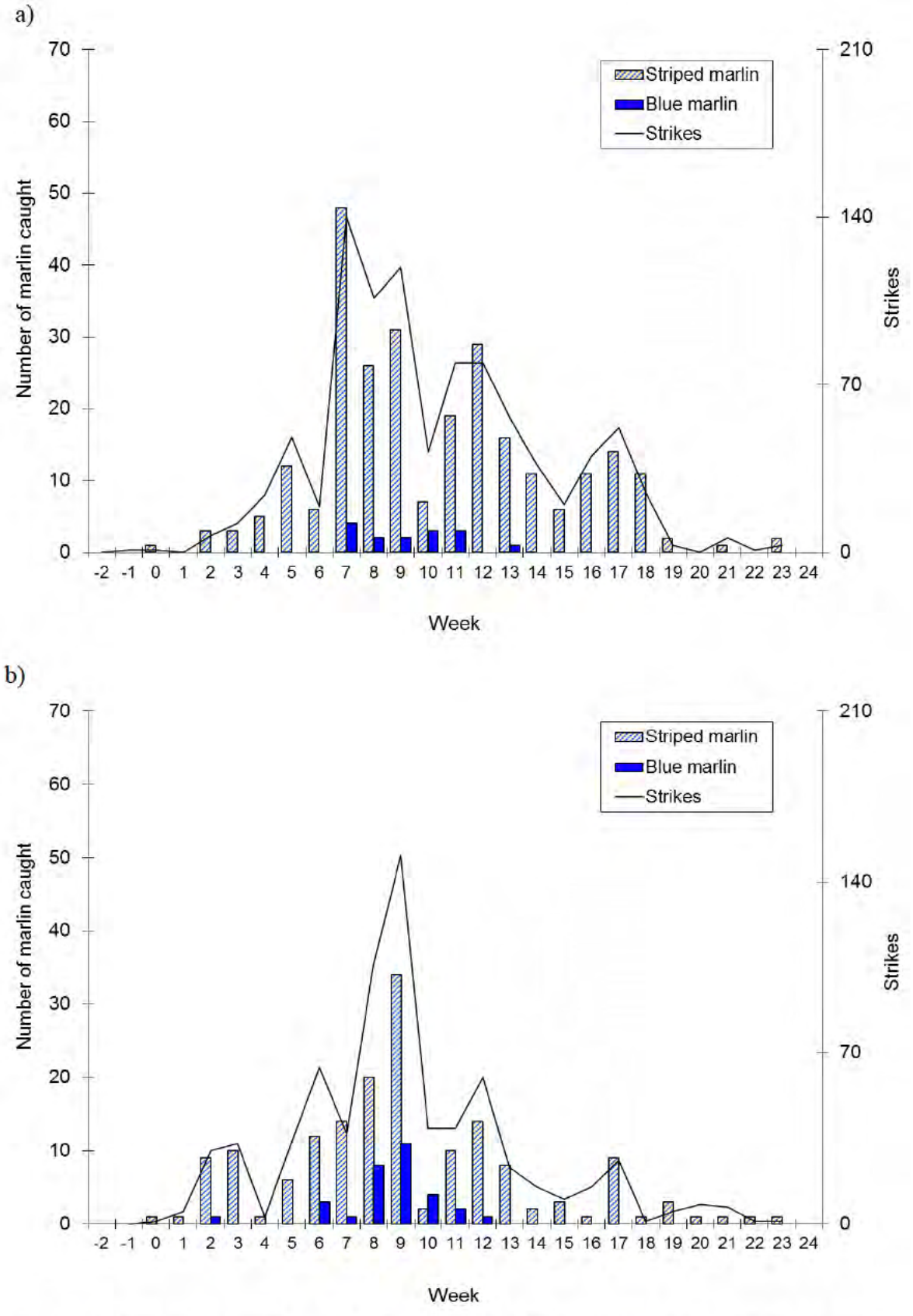
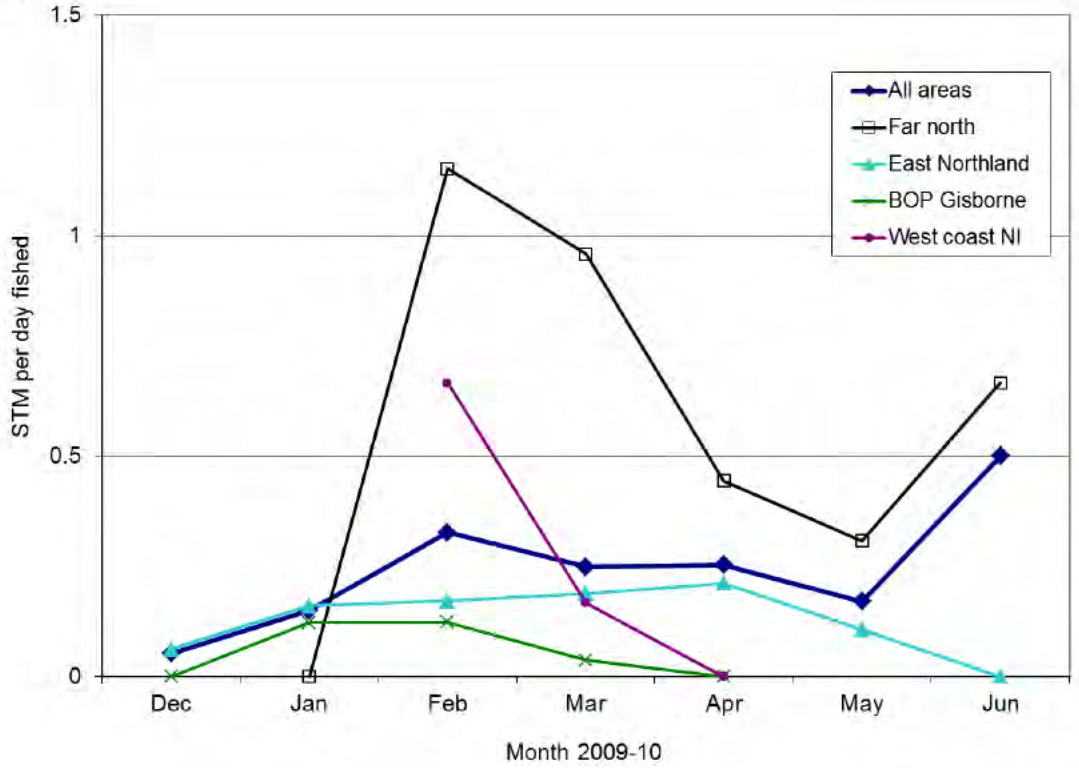


Figure 5: The number of striped or blue marlin caught by week and the number of strikes per week (right axis) a) in the 2009–10 season; and b) in the 2010–11 season. Week 0 starts 24 December.

a)



b)

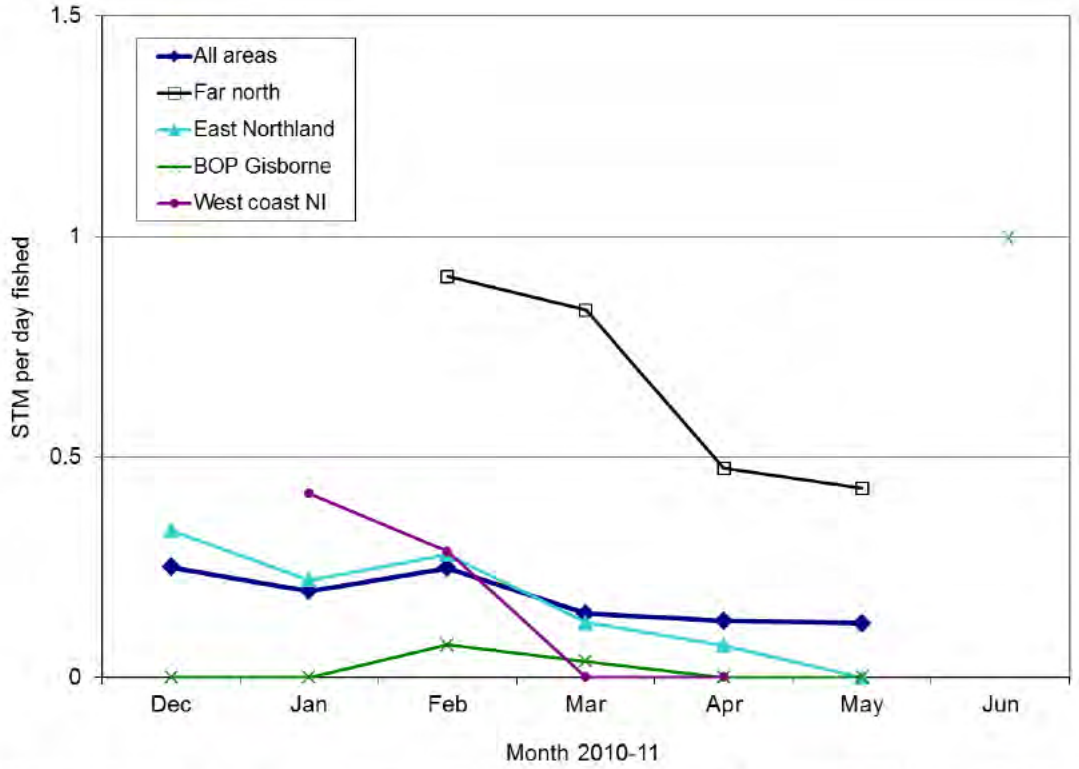
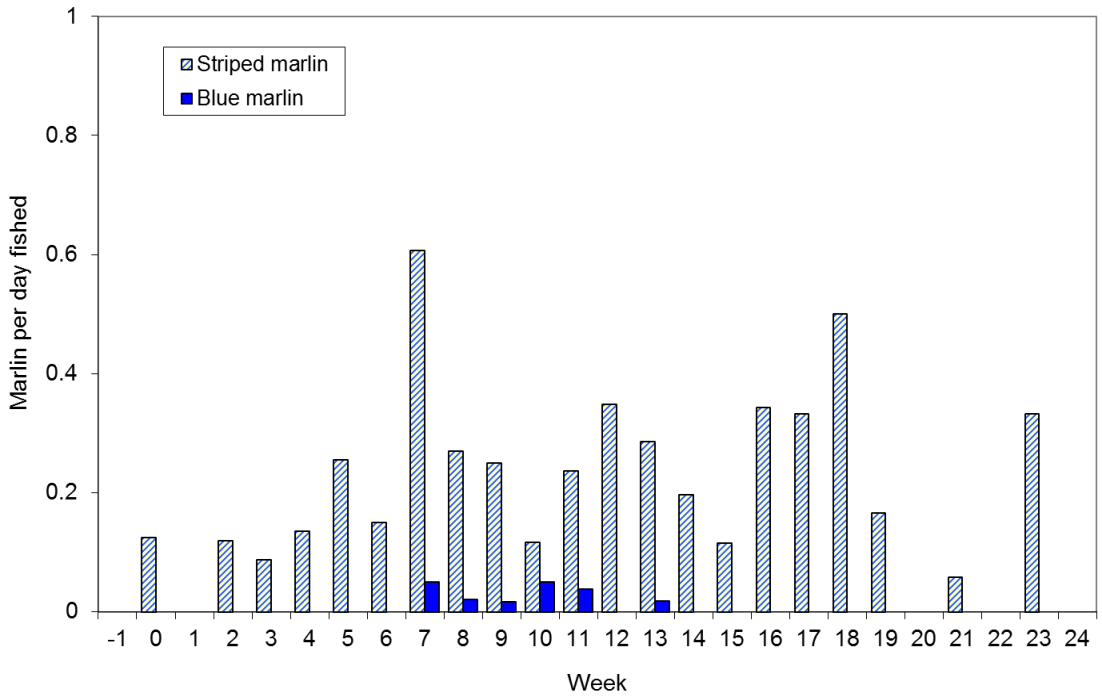


Figure 6: Striped marlin catch per vessel day by area and month from logbook data a) in the 2009–10 season; and b) in the 2010–11 season.

a)



b)

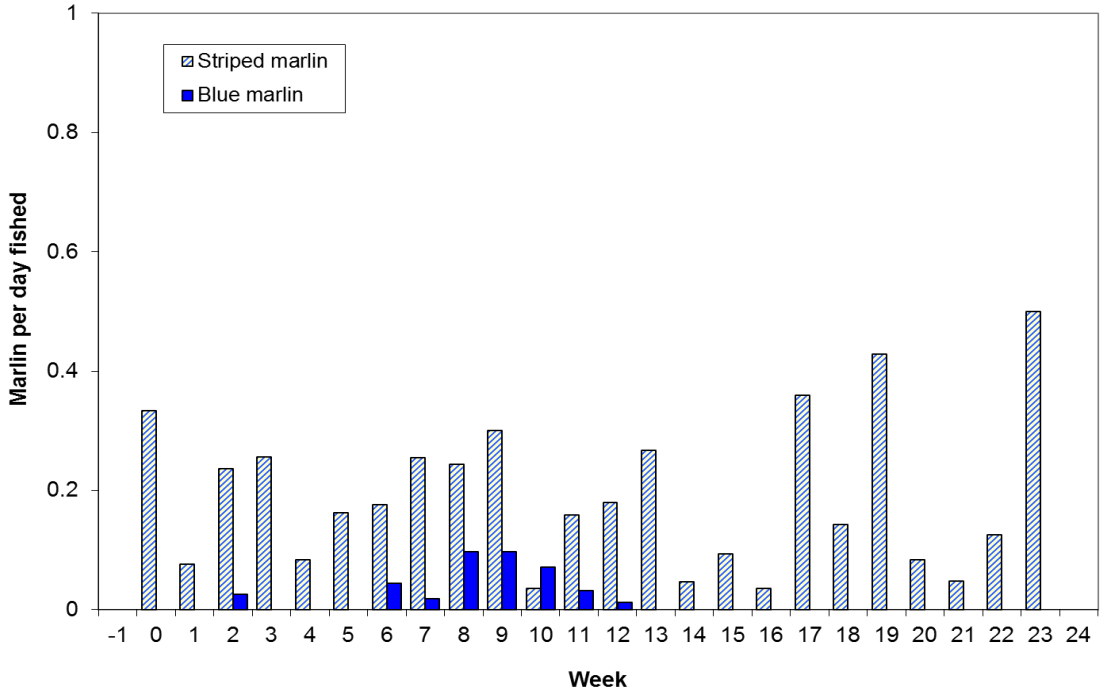


Figure 7: Catch per unit effort as the number of striped or blue marlin caught per vessel day grouped by week a) in the 2009–10 season; and b) in the 2010–11 season. Week 0 starts 24 December.

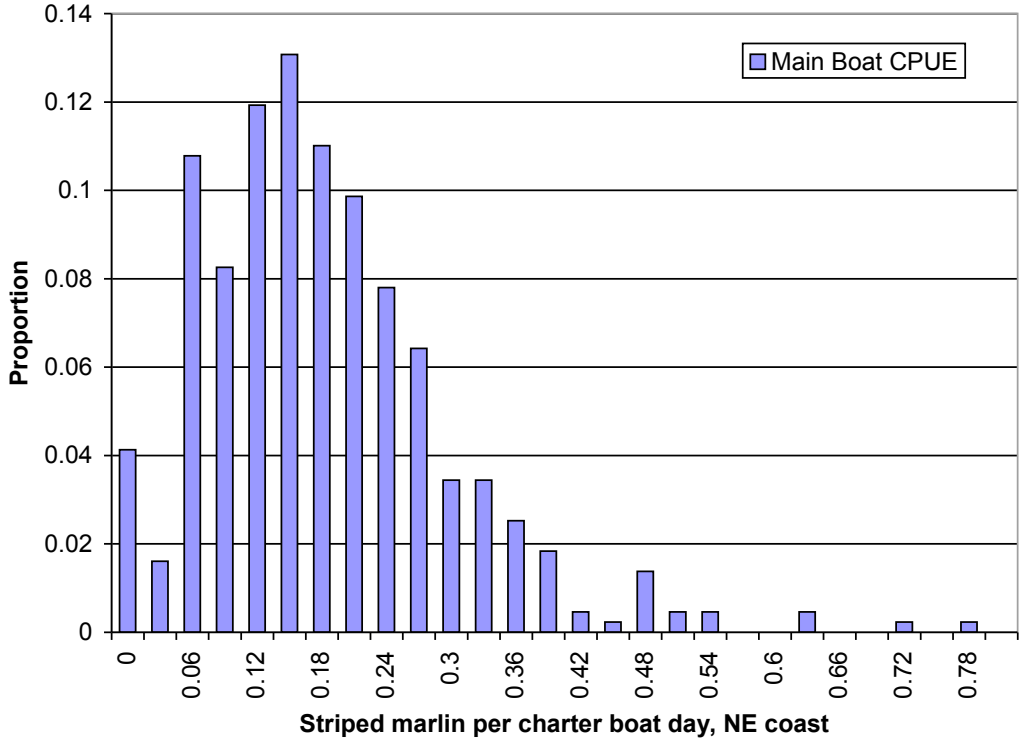


Figure 8: Distribution of CPUE for main vessels for all years in the east Northland charter surveys.

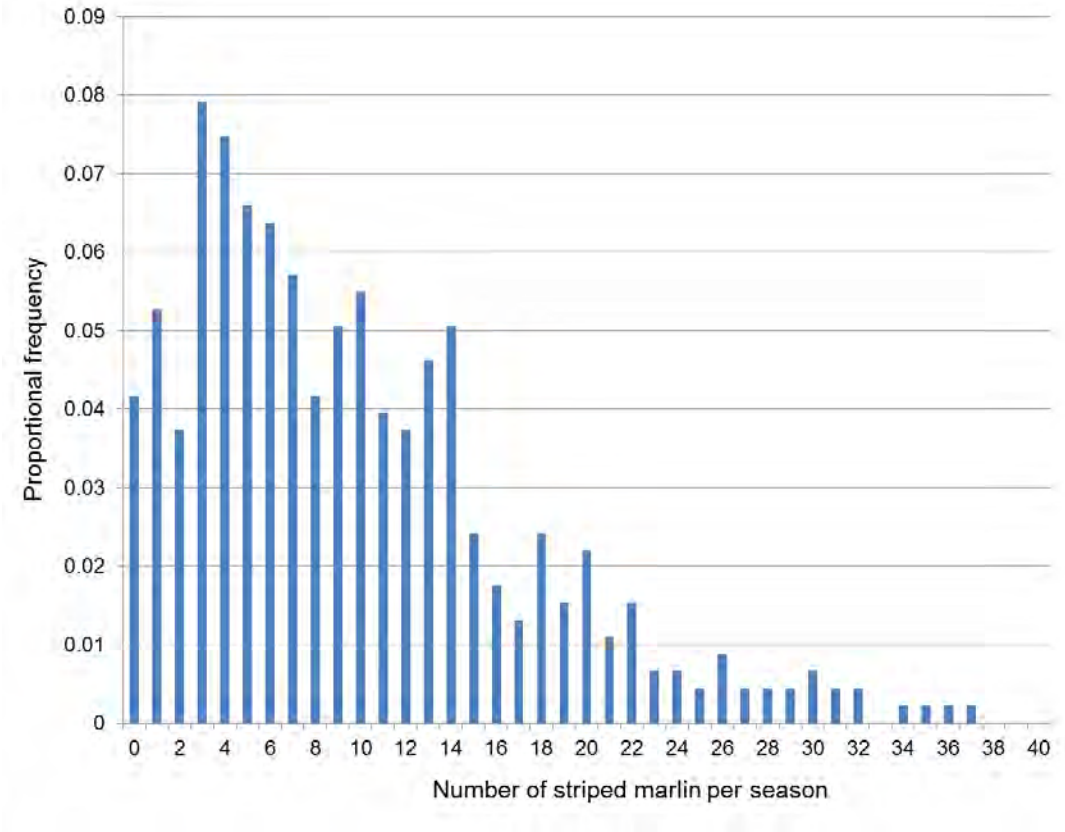


Figure 9: Distribution of striped marlin catch per season for core vessels across all years in the east Northland charter surveys.

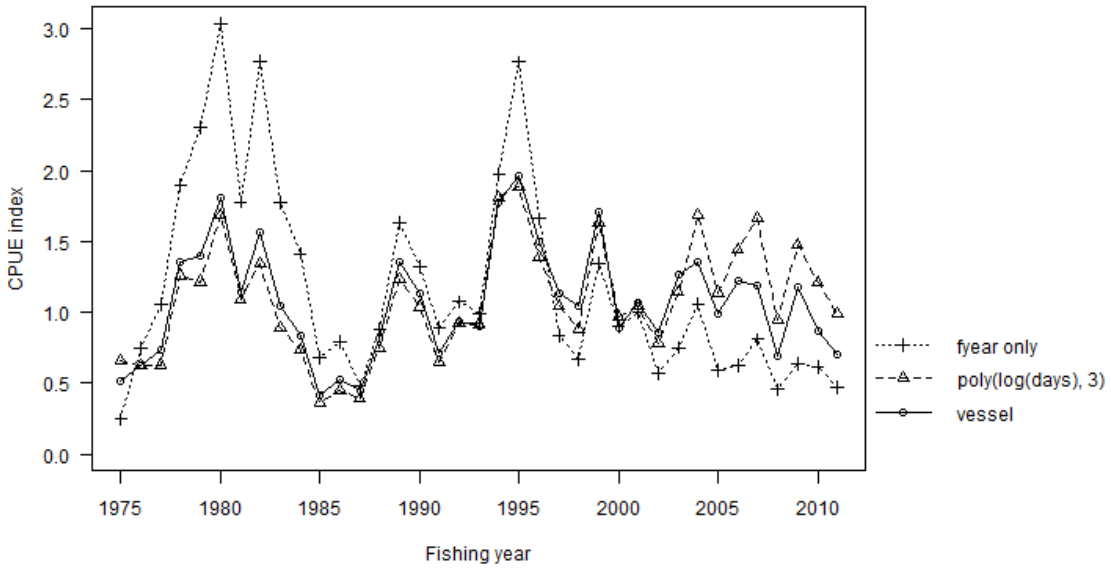


Figure 10: Annual indices from the Lognormal model at each step in the variable selection process.

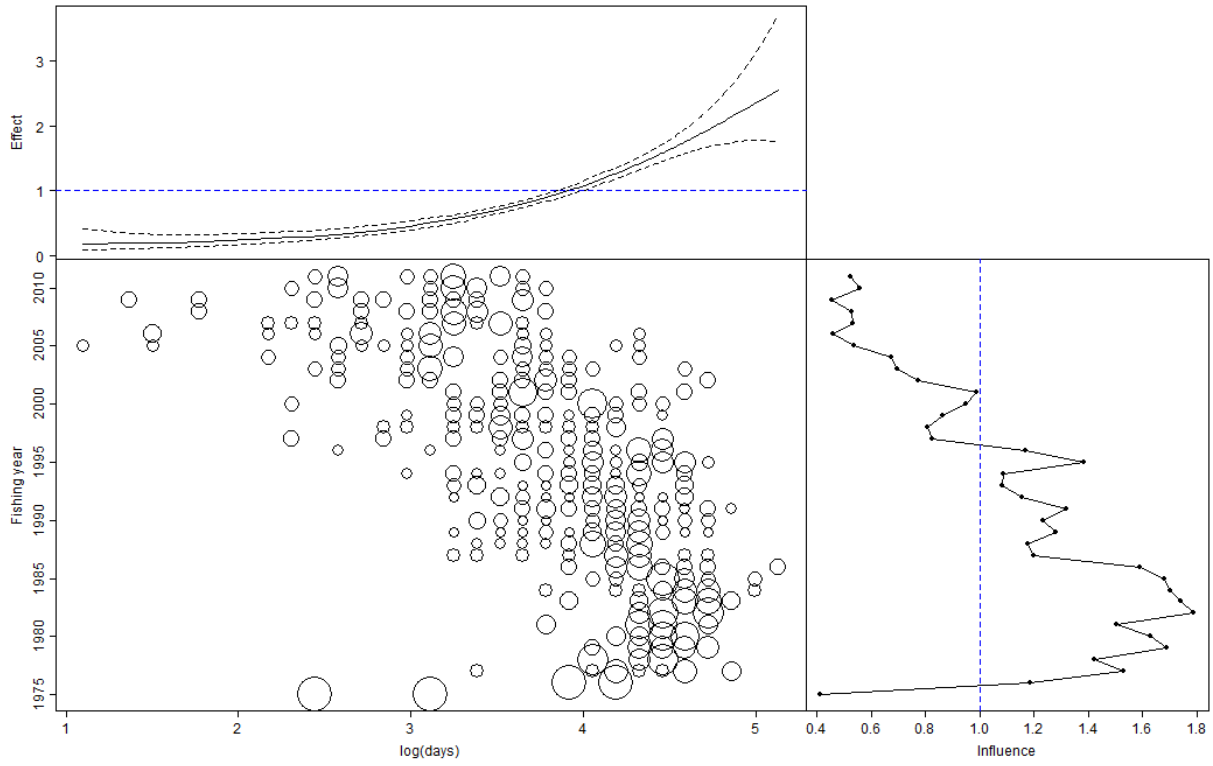


Figure 11: Effect and influence of days in the Lognormal model. Top: relative effect by level of variable (left-axis: log space, additive; right-axis: natural space, multiplicative).Bottom-left: relative distribution of log (days) by fishing year (3.91 is the log of 50 days). Bottom-right: influence of variable on unstandardised CPUE by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

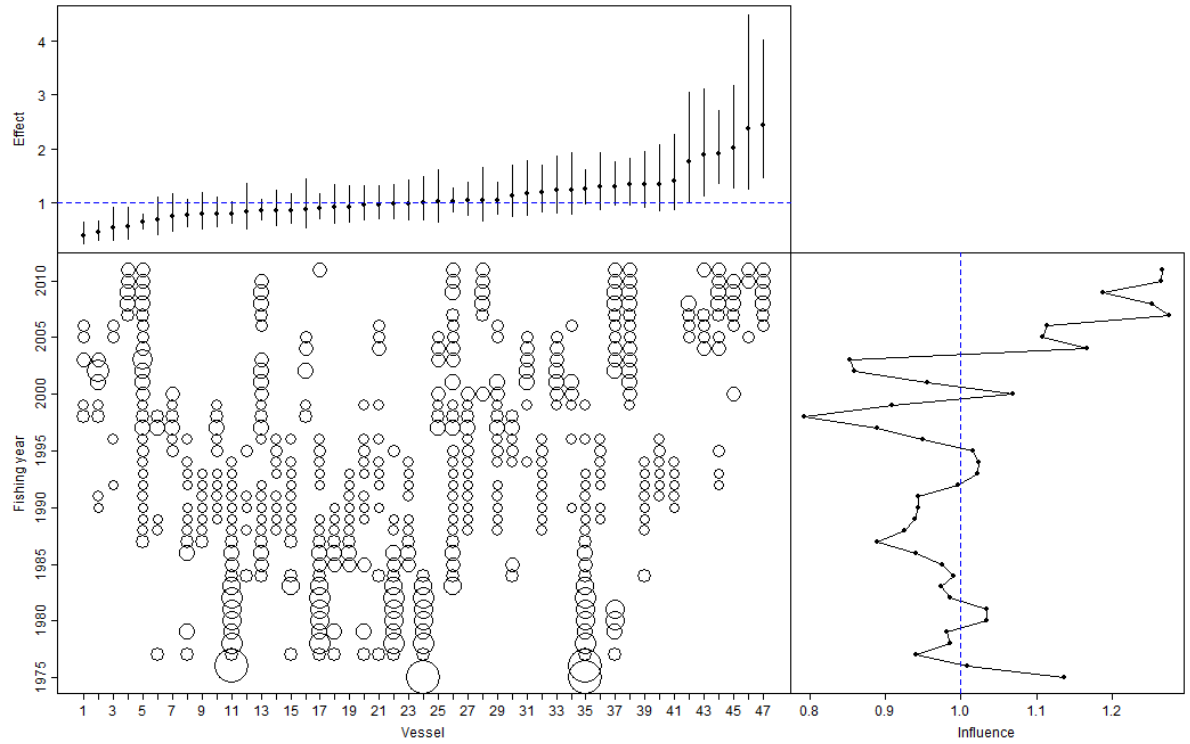


Figure 12: Effect and influence of vessel in the Lognormal model. Top: relative effect by level of variable (left-axis: log space, additive; right-axis: natural space, multiplicative).Bottom-left: relative distribution of variable by fishing year. Bottom-right: influence of variable on unstandardised CPUE by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

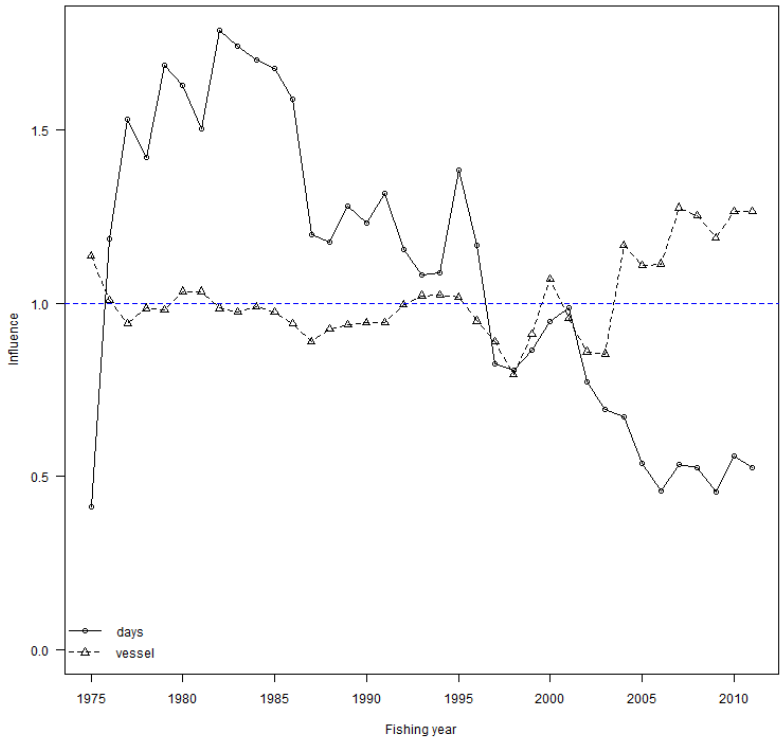


Figure 13: Influence (multiplicative) of each variable in the final Lognormal model for the fishery

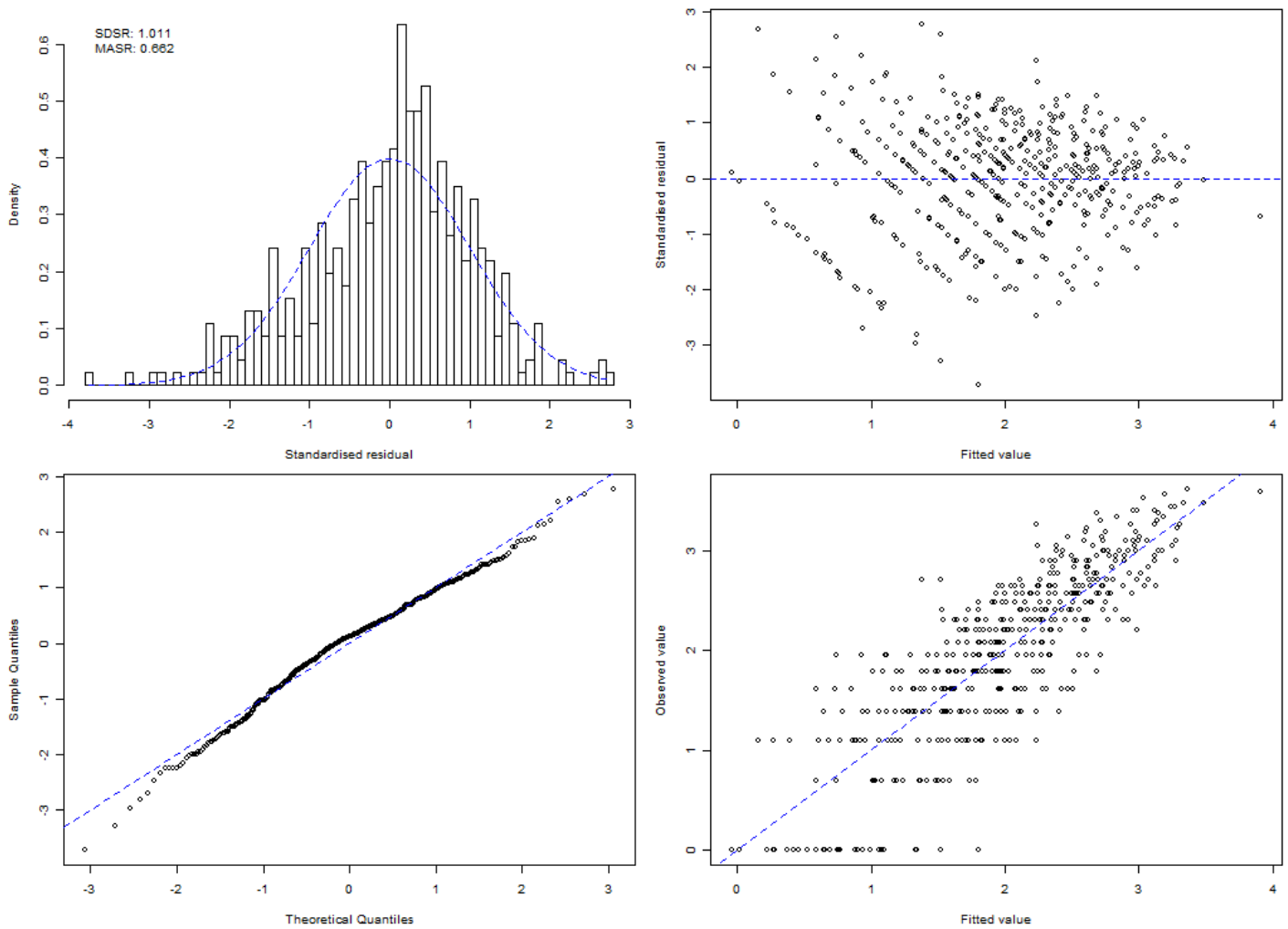


Figure 14: Diagnostic plots for the Lognormal model for the fishery. Top left: histogram of standardised residuals compared to standard normal distribution. (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals.) Bottom left: quantile-quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values.

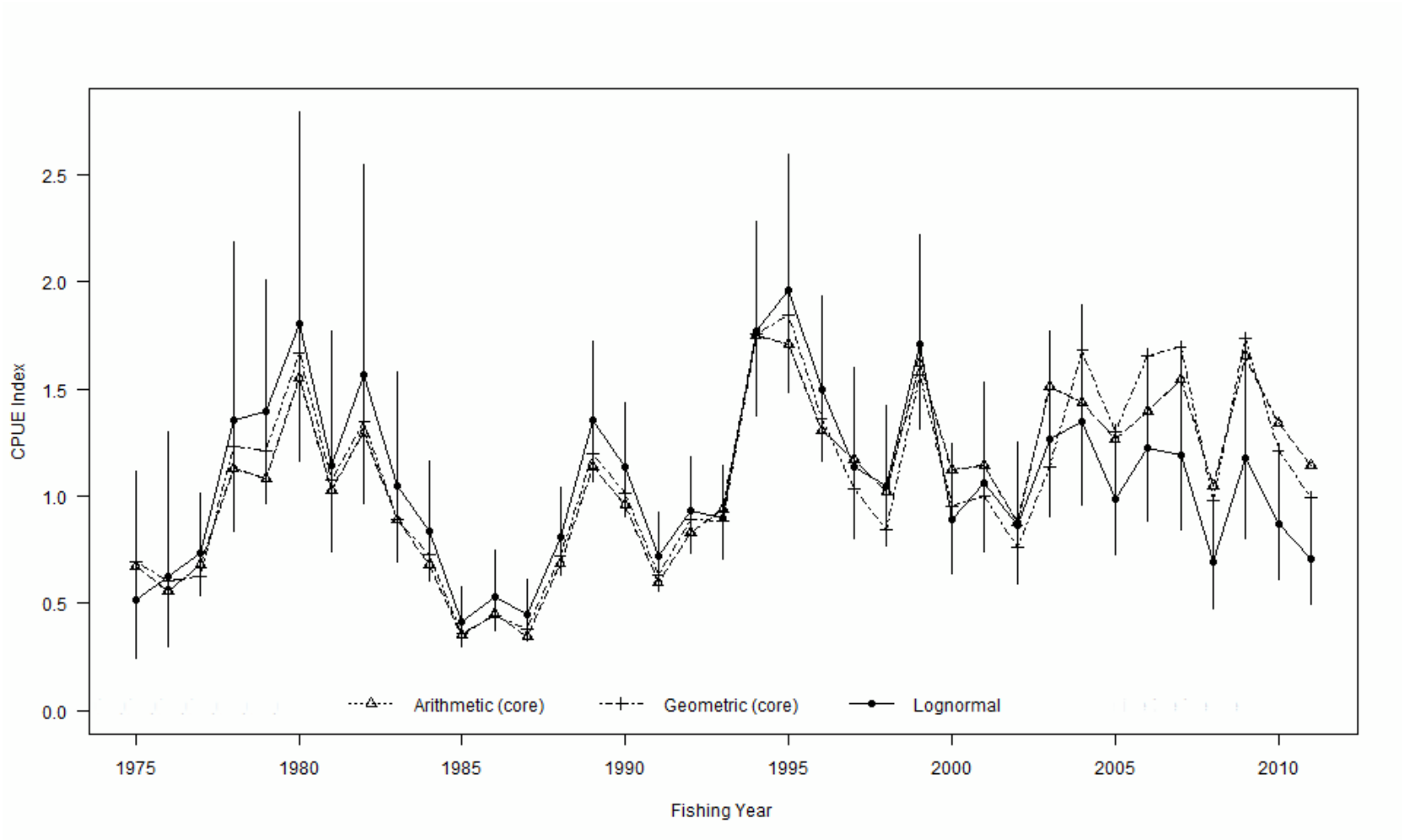


Figure 15: Unstandardised CPUE (arithmetic and geometric mean number of STM per vessel season), the year effects from the model of non-zero catches from recreational charter logbooks (± 2 s.e.).

APPENDIX

Figure A1. Billfish logbook form used in 2010 and 2011.

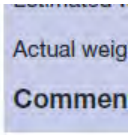


Table A1: Striped marlin catch per unit effort indices for core recreational charter vessel data.

Fishing year	Arithmetic mean	Geometric mean	Lognormal standardisation
1975	0.672	0.696	0.519 (0.241–1.120)
1976	0.556	0.602	0.622 (0.297–1.302)
1977	0.683	0.622	0.735 (0.535–1.012)
1978	1.131	1.234	1.353 (0.838–2.186)
1979	1.082	1.211	1.393 (0.968–2.007)
1980	1.552	1.67	1.803 (1.164–2.794)
1981	1.028	1.077	1.145 (0.741–1.770)
1982	1.297	1.348	1.569 (0.966–2.549)
1983	0.892	0.889	1.047 (0.692–1.583)
1984	0.681	0.729	0.839 (0.606–1.161)
1985	0.353	0.359	0.416 (0.299–0.578)
1986	0.451	0.443	0.528 (0.375–0.745)
1987	0.343	0.378	0.447 (0.328–0.610)
1988	0.684	0.718	0.810 (0.630–1.042)
1989	1.135	1.197	1.357 (1.070–1.722)
1990	0.958	1.013	1.138 (0.901–1.437)
1991	0.598	0.632	0.718 (0.559–0.923)
1992	0.828	0.891	0.932 (0.735–1.182)
1993	0.937	0.887	0.897 (0.704–1.142)
1994	1.751	1.755	1.774 (1.378–2.283)
1995	1.711	1.846	1.964 (1.488–2.593)
1996	1.305	1.362	1.498 (1.161–1.932)
1997	1.17	1.034	1.136 (0.805–1.602)
1998	1.023	0.846	1.045 (0.768–1.421)
1999	1.623	1.565	1.708 (1.313–2.221)
2000	1.12	0.955	0.893 (0.641–1.245)
2001	1.145	1	1.065 (0.741–1.529)
2002	0.877	0.761	0.861 (0.592–1.251)
2003	1.509	1.137	1.267 (0.906–1.770)
2004	1.434	1.684	1.350 (0.962–1.894)
2005	1.265	1.302	0.987 (0.730–1.336)
2006	1.396	1.653	1.224 (0.885–1.692)
2007	1.545	1.695	1.189 (0.843–1.677)
2008	1.049	0.978	0.690 (0.474–1.005)
2009	1.657	1.738	1.179 (0.803–1.733)
2010	1.343	1.21	0.870 (0.609–1.243)
2011	1.145	0.991	0.706 (0.495–1.008)