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New Zealand striped marlin recreational catch and effort 2011–12 and 2012–13

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Striped marlin (*Kajikia audax*) are large migratory fish that appear in New Zealand waters during summer and autumn. A recreational fishery has targeted striped marlin on the northeast coast for over 80 years. The New Zealand Sport Fishing Council (NZSFC) compile catch reports from 54 affiliated clubs including most that target marlin. A large proportion of the recreational catch is reported through fishing clubs and the gamefish tagging programme. There were 635 striped marlin reported landed and 661 tagged and released by recreational fishers in 2011–12 which is the lowest in the last five years. In 2012–13, 730 striped marlin were landed and 745 tagged and released which is close to the average in recent years.

The mean weight of striped marlin recorded by the main fishing clubs in the New Zealand recreational fishery was 96.8 kg in 2011–12 and much higher at 104.1 kg in 2012–13. There were more large striped marlin in 2013 with many over 130 kg and several that exceeded 180 kg.

The gamefish logbook scheme has been collecting daily effort and catch data since 2006–07. In 2011–12 logbook participants recorded 702 days fishing for billfish with a mean of 19.5 days/boat (s.d.15.5) and catch of 175 striped marlin. This equates to 14% of the national catch. The 2011–12 season was influenced by strong easterly conditions which reduced the fishable days in east Northland. Also the average sea surface temperature recorded in logbooks in 2011–12 was lower than in the previous five years.

In 2012–13 logbook participants recorded 796 days fishing for billfish with a mean of 24.1 days/boat (s.d. 20.7) and caught 242 striped marlin. This equates to 16% of the national recreational catch for the year. Weather conditions were generally settled but catch and CPUE were uncharacteristically low in February 2013 and improved in March and April 2013. The Far North still had good catches in May and June.

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. However effort is limited due to the remoteness of the fishing grounds, reduced interest from charter fishers and the limited number of suitable weather windows.

CPUE from the east Northland gamefish charter boat skippers has been collected in various forms for 39 years, most recently and comprehensively by the billfish logbook programme since 2006–07. Core vessels were selected that had provided data for five or more years. CPUE was standardised using a negative binomial model fitted to all data including zero catches. Fishing year was forced as the first variable but nevertheless explained much of the variance in catch (33.4%). The effort term days fished entered the model second, explaining an additional 30% of the variance and was followed by vessel (10.4%). The final model explained 74% of the variance.

The CPUE time series for East Northland recreational charter vessels, although relatively long, suffers from a limited spatial scale and limited number of records. There are some quite large changes in availability from year to year in the CPUE index but recently a relatively steady decline. The point estimates for the last four years are below the long term mean. The Fisheries Plan for Highly Migratory Species has a performance indicator for the recreational striped marlin fishery "if CPUE

drops below the long-term mean for three consecutive years, a management review will be triggered". A review was completed in May 2013 which resulted in no significant change to the management or regulations for New Zealand fishers. There is some concern however from the Western and Central Pacific Fisheries Commission that the southwest Pacific striped marlin stock is likely to decline without international management intervention.

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 mostly caught by commercial surface longline vessels. Other billfish occasionally caught by recreational and commercial fishers are blue marlin (*Makaira nigricans*), black marlin (*Makaira indica*), and shortbilled spearfish (*Tetrapturus angustirostris*). The marlin and spearfish species are most abundant in summer and autumn around northern New Zealand. Striped marlin are widespread in subtropical waters of the Pacific and Indian Oceans. New Zealand has a long established and internationally recognised fishery for large striped marlin. All of the current International Game Fish Association (IGFA) world records for this species for men and women anglers on line weights 1, 3, 4, 6, 8, 10, 15, 24, 37 and 60 kg are held by striped marlin caught in New Zealand. The all tackle world record of 224 kg caught off Tutukaka in 1986 still stands (IGFA World Record Game Fishes 2011).

Regulations in New Zealand have prohibited domestic commercial vessels from retaining billfish caught in the Auckland FMA since October 1987. In 1991 these regulations were amended to allow the retention of broadbill swordfish, but prohibiting the retention of marlin species (striped, blue and black marlin) by commercial fishers in the whole EEZ. These regulations and government policy changes on foreign licensed surface longline access have replaced the billfish moratorium. Although required to report marlin caught, commercial operators have not consistently report species that they cannot land (Francis et al. 2000). For this reason, efforts to monitor trends in availability of billfish are of necessity directed at the target (recreational) fishery. The gamefish charter operators form the professional arm of this fishery, in general spending more days at sea and catching more billfish, than amateur fishers.

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. Each season the number of marlin caught by an angler, vessel and club have been of interest to participants in the fishery. Consequently a high proportion of avid billfish anglers belong to clubs and most recreationally caught striped marlin are recorded in club records. Since 1975 anglers have been encouraged to tag and release striped marlin as part of a Ministry research project. For the last 15 years over 60% of all striped marlin caught by recreational anglers have been tagged and released. The tagging database contains a good record of where and when these fish were tagged but only estimated weights are available for these fish.

Ministry of Fisheries (MFish) (now Ministry for Primary Industries, MPI) research project STM2009/02 provided a characterisation of the New Zealand striped marlin fisheries from MPI databases and gamefish club records (Holdsworth & Kopf 2005). Commercial catch records for the tuna longline fishery in New Zealand commence in 1980 and striped marlin have been underreported by fishers, who have not been permitted to land them since 1987 (Francis et al. 2000). Data from the Ocean Fisheries Programme (OFP) of the Secretariat of the Pacific Community (SPC), which attempts to combine all commercial tuna catch and effort since the fishery began in the South Pacific in 1952, was used to describe trends in the commercial striped marlin catch and CPUE in the southwest Pacific Ocean. New information on the age and growth of striped marlin in the southwest Pacific shows that young fish 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 was observed (Kopf 2010, Kopf et al. 2010).

An extensive time series of striped marlin catch per unit effort (CPUE) data has been collected from gamefish charter skippers fishing the northeast coast of New Zealand. A stepwise multiple regression was used to develop a model of striped marlin recreational CPUE to determine the factors that best accounted for the variation observed for the period 1981 to 1997 (Holdsworth et al. 2003). Factors investigated were sea surface temperature during the fishing season, El Nino southern oscillation index, the position of the 20^{o} C isotherm at the beginning of the fishing season, annual commercial catch of striped marlin in the New Zealand 200 mile zone and surface longline CPUE in the wider southwest

Pacific. Surface longline CPUE in the general southwest Pacific (10° S to 40° S latitude, 165° E to 160° W longitude) had the strongest correlation with recreational CPUE (P = 0.001), but a poor correlation was found with longline CPUE from the western Tasman Sea and Coral Sea (10° to 40° S latitude, 145° E to 165° E longitude). The total commercial catch of striped marlin in New Zealand each season was negatively correlated with recreational CPUE (P = 0.019), which indicates a possible interaction between these fisheries (Holdsworth et al. 2003).

There have been a number of projects aimed at collecting data on catch and effort, or economic factors from charter boat skippers. The striped marlin catch and effort survey of Northland charter boat skippers was the longest running. The reason it lasted so long is that it was 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 season) and in a limited area (North Cape to Cape Rodney). When the survey form was changed to collect more detailed breakdowns of CPUE per month there was a drop off in response rate, which could reduce how representative the sample was. The postal survey was last used to collect striped marlin CPUE in east Northland for the 2005–06 season by Blue Water Marine Research Ltd as part of MFish Project STM2006/01 (Holdsworth & Saul 2008). This report is part of an expanded project collecting daily information in a billfish logbook which has been used since then.

During 1997–98 a national survey of charter vessels was undertaken by NIWA (MFish project REC9703) with the objective of estimating fish catch and effort for one year. From a mailing list of 376 operators there were 85 who took up the diaries and completed them (James & Unwin 2000). The participation rate varied by region, ranging from about 16% in Northland to 55% in Fiordland. A total of 630 trips targeting striped marlin were made with a catch of 117 fish. It seems likely from the fact that only 31 trips were successful that some were multi day trips and the catch may have been skewed by a few highly successful vessels. Also diary returns tended to drop away in this survey after April, possibly as the charter season wound down and skippers moved into other work.

Since November 2010, when compulsory charter boat reporting was introduced in New Zealand, recreational charter boat operators have been required to report their fishing effort, area of operation and the catch of certain species. There will unavoidably be some duplication of data reporting between the two schemes but this will largely be restricted to effort reporting. There will be discrepancies in the reported effort due to differences in what is reported. The billfish logbook project collects data on all days fished by charter boats, whereas the new scheme collects data only when the vessel is under charter, i.e. the skipper is being paid to fish. No billfish are required to be reported under the national charter boat reporting scheme, so the overlap between the two projects is limited to the effort section.

Project Objectives:

1. To monitor recreational fisheries for billfish within New Zealand fisheries waters.

Specific Objectives:

1. To update time series of catches, landings, and size composition data collected from recreational sources for the 2011/12 and 2012/13 fishing years.

2. To undertake a logbook programme for striped marlin for the recreational fishery for the 2011/12 and 2012/13 fishing years.

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 Islands 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 New Zealand Sport Fishing Council (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 and in a number of years in the 1960s and 1970s their landed catch was fewer than 10 striped marlin.

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, 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 MFish 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. 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. 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 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 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 seven seasons (2006–07 to 2012–13) 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 for Primary Industries 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. A negative binomial model was fitted to all data including zero catches in GLM runs undertaken using R software.

3 RESULTS

3.1 Catches, landings and size composition

There were 1296 striped marlin recorded as landed and tagged by recreational fishers in 2011–12. This was the lowest in the last 5 years (Table 1, Figure 1). Fishing was adversely affected along the east coast of the North Island throughout the summer and autumn of 2011–12 by prevailing strong easterly-quarter winds reducing the number of fishable days. Some Charter operators also reported that they had regular clients who cancelled bookings due to the economic situation. The overall effect was a reduction in fishing effort. Many fishing clubs also reported a down turn in contestants fishing their fishing competitions, as well as difficulties with scheduling them due to the weather conditions that prevailed from February to April 2012. (John Robbins pers. comm. President Whangarei Deep Sea Anglers Club). The national landed catch of striped marlin recorded in 2011–12 by the NZSFC (635) was up slightly on the previous two years, but the number tagged (661) was down (Table 1, Figure 1).

The 2012–13 season was characterised by better weather conditions than in the previous season, allowing fishers greater access to the fishing grounds on the east coast. Fishing was better than average, particularly on the west coast of the North Island with striped marlin distributed as far south as Taranaki. The weather also allowed better access to the Three Kings area with the King Bank providing the most consistent catches. The national landed catch of striped marlin recorded by the NZSFC (730) was up in the last three years as was the number tagged (745) for a total of 1475 (Table 1, Figure 1). This is close to the average (1472) of the last seven years.

The number of large striped marlin caught was a feature in 2012–13 resulting in a mean weight of 104.1 kg up on 2011–12 (96.8) and previous seasons (Figure 2). Striped marlin of 180 kg green weight are rarely caught. However, there were a number of striped marlin caught between Whangaroa and the Bay of Plenty that exceeded 180 kg in 2013, with several tagged marlin also estimated to exceed that size. This was out of the ordinary.

A ten year moving average helps visualise the long term trends in weight recorded by three established East Northland clubs (Figure 3). There is a decline in average weight from around 115 kg in the late 1950s to around 105 kg in the mid 1970s. The moving average declines again from the mid 1980s to around 95 kg in the early 2000s. A couple of years that stand out over this period were the warm La Nina years of 1989 and 1999 which saw large number of small fish (70 kg) caught and record low annual average weights, followed by three years of increasing mean weights (Figure 3). The moving average striped marlin weight in recreational catch has risen in the last 10 years.

3.2 Logbook numbers of fish recorded

Logbooks were collected from 36 vessels that fished 702 days for billfish with a mean of 19.5 days (s.d.15.5) per vessel in 2011–12 and 796 days with a mean of 24.1 days (s.d. 20.7) from 33 vessels in 2012–13 (Table 2). Catch varies by region. The boundaries of the four regions used are based on MPI statistical areas (Figure 4). For the two years covered in this report East Northland recorded 55% of

logbook striped marlin catch followed by 38% in the Far North, 5% in Bay of Plenty/Gisborne and 2% from West Coast North Island.

In 2011–12 there were 175 striped marlin recorded as landed or tagged in the logbook records. This is lower than previous logbook seasons (Table 2). That year the total number of fish landed and tagged in NZSFC and the New Zealand Gamefish Tagging Programme (NZGTP) records (1296) is also the second lowest for 10 years. The striped marlin catch reported in logbooks in 2011–12 represents about 14% of the national catch estimated above. The distribution of catch by month recorded in logbooks and by clubs was reasonable in January and February but was down in March and April 2012 (Figure 5a).

In 2012–13 there were 242 striped marlin recorded as landed or tagged in the logbook records. This is higher than the previous season (Table 2). That year the total number of fish landed and tagged in NZSFC and NZGTP records (1475) is average for the seven logbook years. The striped marlin catch reported in logbooks in 2012–13 represents about 16% of the national catch estimated above (Table 2). The distribution of catch by month recorded in logbooks and by clubs was lower in January and February than usual but was better than average in March and April 2013 (Figure 5b).

Catch varies by region and month. Plotting these helps characterise the recreational fishery for the year. The boundaries of the four regions used are based on MPI statistical areas (Figure 4). The core fishing area remains east Northland with 69% of logbook days and 50% of the billfish catch in 2011–12 recorded there.

A subset of logbook data can be used to extend the existing time series of East Northland charter catch and effort. In 2011–12 there were 344 days fished and 64 striped marlin caught by charter vessels (Table 2). This includes days fished under charter and days when fishing privately. Raw CPUE in 2011–12 was the second lowest in the last 10 years.

Logbook striped marlin catch was plotted by region and month to help characterise the recreational fishery in each year. In 2011–12 catch peaked in February, as it usually does, and in East Northland catches in January, March and April were similar (Figure 6a). The plot for East Northland in 2012–13 is almost a mirror image of the year before, with a peak in March and catches in January, February and April quite similar (Figure 6b). Also catch in the Far North was relatively high for April, May and June 2013.

Logbook skippers record their location and sea surface temperature (SST) at noon when fishing for billfish. The increase and decline in average monthly water temperature in East Northland in 2011–12 is very similar to the pattern in striped marlin catch (Table 3, Figure 6a, 7a). The SST is relatively high in March 2013 in East Northland and in April and May 2013 in the Far North (Figure 7b). This probably contributes in part to the better late season fishing seen in 2012–13 (Figure 6b).

Catch and strikes by week shows fishing success in a finer temporal scale (Figure 8a, 8b). As seen in previous years the catch peaked in late February with a good week in April 2012. Late season catch in 2013 was boosted by a couple of good weeks in early May, mostly in the Far North. Few blue marlin were caught in 2012 with more in 2013 and an unusually wide spread from week 2 to week 18 (Figure 8a, 8b). Billfish strikes tend to follow the pattern of catches through each year with a conversion rate to captures improving as the season progresses (Figure 8a, 8b). Over both seasons a little better than 1 out of 3 strikes resulted in a billfish capture (36.6% in 2011–12 and 35.9% in 2012–13).

3.3 Logbook catch per unit effort

Catch rates of striped marlin are relatively consistent in East Northland between January and April in 2012, around 0.2 fish per day (Figure 9a). This was less than a quarter of the catch rates in March and April 2012 in the Far North. The high catch rates for West Coast North Island in March 2012 are a result of just two days fishing for five striped marlin (Figure 9a).

Striped marlin catch rates were high in the Far North from February to June 2013 (Figure 9b). However they were surprisingly low in East Northland during February with catch rates lower than January, March and April 2013. High catch rates and a large proportion of fishing effort in the Far North lifted the combined catch rates in April, May and June (Figure 9b).

3.4 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 can be used to extend the postal survey time series from 2006–07 to 2012–13.

The data was restricted to recreational charter vessels, fishing in East Northland (MPI statistical areas 002 and 003), and fishing years from 1974–75 to 2012–13. The resolution of the data summarises catch and effort for a year of fishing in each observation and the core fleet was restricted to those vessels that had fished in at least 5 years. This resulted in a core fleet size of 46 vessels which took 83% of the catch from this dataset. A plot of the degree of overlap of data among core vessels is provided (Figure10). A comparison between data from all vessels and from core vessels only, for key indicators of catch rates is also given (Figure 11). There is little difference and similar trends in most years but some divergence in the last three years.

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 planning 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 + area*

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 12). 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 (Figure 13). The vessel effect pushed the index back down as a number of new high performing vessels entered the fishery in the mid-2000s (Figure 13). (See distribution and influence plots in Appendix 2).

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 3).

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 14). The 2011–12 and 2012–13 seasons were relatively poor years for the recreational striped marlin fishery in East Northland. The peak years in the late 1970s were approximately equivalent to the best years in the 1990s. A table of CPUE indices are provided in Appendix 1.

The previous analysis of this charter boat CPUE assumed a lognormal distribution of positive catches and included years up to 2010–11 (Holdsworth & Kendrick 2012, Holdsworth & Kendrick 2013). A comparison of this lognormal index with the negative binomial index presented in this report, shows a close match and similar trends (Figure 15).

4 DISCUSSION

The national recreational catch (landed and tagged) of striped marlin was low in 2011–12 compared to recent fishing years and about average in 2012–13. A feature of the 2012–13 season was an increase in the number of large striped marlin (130 to 180 kg) landed, and tagged and released. A project coordinated by Te Papa is analysing DNA samples and investigating morphometric differences between marlin species. Nineteen striped marlin between 130 and 180 kg were measured and sampled by fishing club volunteers in 2012–13. Over the last three years 244 marlins have been included in this study including 197 striped marlin, 43 blue marlin and 4 black marlin.

The billfish logbook programme continued to run successfully in 2011–12 and 2012–13. The number of striped marlin recorded in logbooks for 2011–12 (175) was down on previous seasons, as was the number of days fished (702). This reflects a generally poor season with lower national catch recorded by NZSFC and in the Gamefish Tagging Programme. The mean sea surface temperature recorded in logbooks in 2011–12 was lower than in the previous 5 years over the peak months for all areas combined and for the East Northland area where most fishing effort is recorded.

Striped marlin generally have a preference for sea surface temperatures (SST) above 20^{o} C (Holdsworth & Kopf 2005, Sippel et al. 2007, Squire 1985). Fishers targeting marlin often seek out the warmest water in the area fished. While the number of marlin caught by month rises and falls in a similar pattern to SST in 2011–12, CPUE for months during the main season remain fairly constant. This implies that fishing effort was reduced when the water cooled in March 2012. Either fishers felt that there was less chance of success in cooler water or the wind and wave mixing that cools surface water also reduced the number of fishable days.

In 2012–13 the better weather conditions were demonstrated by an increase in both total days fished (796) and average number of days fished per vessel (24.1 in 2012–13, compared to 19.5 in 2011–12). National reported catch was close to the average for the past seven years, with 1475 striped marlin landed or tagged.

The CPUE time series for East Northland recreational charter vessels, although relatively long, suffers from a limited spatial scale and a limited number of records. Data are becoming more limited as the economic downturn and changes to tax provisions for charter boat owners has seen the continued decline in the number of days fished and the number of vessels. The size and sophistication of many trailer boats launched in recent years has seen an increase in the number of private boats targeting marlin in offshore waters. There are some quite large changes in availability from year to year in the CPUE index. This may be indicative of changes in abundance or recruitment in some part of the south western Pacific stock but the scale of the changes may be amplified by annual variability in weather and oceanographic conditions.

There has been a declining trend in the CPUE index over the last five years and the point estimates for the last four years are below the long-term mean. The Fisheries Plan for Highly Migratory Species has a management objective to maintain and enhance recreational catch rates for HMS gamefisheries. While acknowledging that these fisheries may be difficult to actively manage there is a performance indicator for striped marlin "if CPUE drops below the long-term mean for three consecutive years, a management review will be triggered". A review was completed in May 2013 which resulted in no significant change to the management or regulations for New Zealand fishers. All marlin species remain non-commercial species in New Zealand fisheries waters. Catch in the wider southwest Pacific may also impact on the New Zealand fishery.

A stock assessment was completed for the southwest Pacific striped marlin stock in 2012 (Davies et al. 2012). While a number of sensitivity runs were undertaken, the WCPFC Scientific Committee selected a reference case which estimated catch in 2011 at 1758 t and MSY at 2081 t. This assessment indicates that overfishing is not occurring but that the current spawning stock biomass was below the spawning stock biomass at MSY, indicating that the stock may be overfished. With catch estimated from the most recent years uncertain but likely to be increasing it was concluded that the stock is likely to decline without international management intervention.

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6 REFERENCES

Davies, N.; Hoyle, S.; Hampton, J. (2012). Stock assessment of striped marlin (*Kajikia audax*) in the southwest Pacific Ocean. Report to the Western and Central Pacific Fisheries Commission Scientific Committee. WCPFC-SC8-2012/SA-WP-05. 84 p.

Francis, M.P.; Griggs, L.H.; Baird, S.J.; Murray, T.E.; Dean, H.A. (2000). Fish bycatch in New Zealand tuna longline fisheries, 1988–89 to 1997–98. *NIWA Technical Report 76*. 79 p.

Holdsworth J.C.; Kendrick, T.H. (2012) Characterisation and catch per unit effort of striped marlin in New Zealand. Report to the Western and Central Pacific Fisheries Commission Scientific Committee. WCPFC-SC8-2012/SA-IP-08. 52 p.

Holdsworth, J.C.; Kendrick, T.H. (2013) Characterisation and catch per unit effort of striped marlin in New Zealand. *New Zealand Fisheries Assessment Report 2013/54*. 43 p.

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.; Saul, P.; Browne, G. (2003). Factors affecting striped marlin catch rate in the New Zealand recreational fishery. *Marine and Freshwater Research 54*: 473–481.

Holdsworth, J.C.; Saul, P.J. (2008). Striped marlin fisheries in New Zealand. New Zealand Fisheries Assessment Report 2008/00.

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.

IGFA (2011). 2011 IGFA world record game fishes. Published by International Game Fish Association. Florida. ISBN-13: 978-0-935217-37-7

James, G.D.; Unwin, M.J. (2000). National marine dairy survey of recreational fishing from charter vessels, 1997–98. *NIWA Technical Report 70*. 51p.

Kopf, R.K. (2010). Age, growth, and reproductive dynamics of striped marlin, *Kajikia audax* in the southwest Pacific Ocean. PhD Thesis. Charles Sturt University, Australia, 235p.

Kopf R.K.; Drew K.; Humphreys R.L Jr. (2010). Age estimation of billfishes (*Kajikia* spp.) using fin spine cross-sections: the need for an international code of practice. *Aquatic Living Resources* 23(1): 13–23.

Sippel T.J.; Davie, P.S.; Holdsworth, J.C.; Block B.A. (2007). Striped marlin (*Tetrapturus audax*) movements and habitat utilization during a summer and autumn in the southwest Pacific Ocean. *Fisheries Oceanography* 16:5 459–472.

Squire, J. (1985). Relationship of sea surface temperature isotherm patterns off northwestern Mexico to the catch of striped marlin, *Tetrapturus audax*, off southern California. *Marine Fisheries Rev*iew 47:43–47.

Table 1: Number of landed striped marlin recorded in club records and 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 2012–13.

Fishing	NZ Recreational 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		0.40
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	661	1 296		175	0.14
2012–13	730	745	1 475		242	0.16
Total	19 910	21 030	40 940	5 642	1 848	

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 2012–13.

Year	Total days	Days /vessel	Striped marlin	Raw CPUE	CPUE Var.	CV
1974–75	63	25.5	4	0.063	0.00305	0.87
1975–76	143	47.7	11	0.077	0.00085	0.38
1976–77	1 301	92.9	140	0.108	0.00015	0.11
1977–78	385	77.0	70	0.182	0.00073	0.15
1978–79	862	95.8	150	0.174	0.00014	0.07
1979–80	545	90.8	136	0.250	0.00059	0.10
1980–81	508	84.7	84	0.165	0.00055	0.14
1981–82	580	96.7	127	0.219	0.00105	0.15
1982–83	802	100.3	126	0.157	0.00088	0.19
1983–84	1 361	97.2	149	0.109	0.00007	0.08
1984–85	1 247	95.9	66	0.053	0.00006	0.15
1985–86	982	81.8	67	0.068	0.00022	0.22
1986–87	905	69.6	51	0.056	0.00005	0.13
1987–88	1 505	62.7	163	0.108	0.00010	0.09
1988–89	2 049	68.3	401	0.196	0.00015	0.06
1989–90	1 830	65.4	301	0.164	0.00012	0.07
1990–91	1 563	74.4	149	0.095	0.00009	0.10
1991–92	1 586	61.0	197	0.124	0.00011	0.09
1992–93	1 538	59.2	226	0.147	0.00020	0.10
1993–94	1 435	57.4	356	0.248	0.00064	0.10
1994–95	1 516	75.8	384	0.253	0.00033	0.07
1995–96	1 367	68.4	275	0.201	0.00029	0.08
1996–97	608	43.4	116	0.191	0.00108	0.17
1997–98	660	44.0	116	0.176	0.00055	0.13
1998–99	928	48.8	241	0.269	0.00069	0.10
1999–00	710	47.3	135	0.194	0.00062	0.13
2000–01	882	35.3	168	0.190	0.00064	0.13
2001–02	432	39.3	60	0.137	0.00056	0.17
2002–03	450	37.5	107	0.237	0.00156	0.17
2003–04	665	28.9	181	0.272	0.00197	0.20
2004–05	685	26.3	163	0.238	0.00107	0.17
2005–06	489	24.5	127	0.260	0.00155	0.15
2006–07	570	22.8	135	0.237	0.00062	0.11
2007–08	392	21.8	51	0.130	0.00084	0.22
2008–09	404	20.2	108	0.267	0.00130	0.14
2009–10	453	23.8	96	0.212	0.00142	0.18
2010–11	418	24.6	89	0.213	0.00152	0.18
2011–12	344	21.5	64	0.186	0.00077	0.15
2012–13	496	24.1	90	0.242	0.00209	0.19

Table 3: Average monthly SST for January to May for all regions combined by fishing year.

All regions	Sea surface temperature by month				
Season	Jan	Feb	Mar	Apr	May
2006–07	20.88	21.12	21.01	19.75	19.20
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
Combined mean	20.67	21.45	20.91	20.27	18.75

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	39	–1 474	3 027	33.38	35.91	*
poly(log(days), 3)	42	–1 323	2 730	63.42	65.50	*
vessel	87	–1 240	2 654	73.80	75.49	*
area	90	–1 237	2 653	74.13	75.81	*

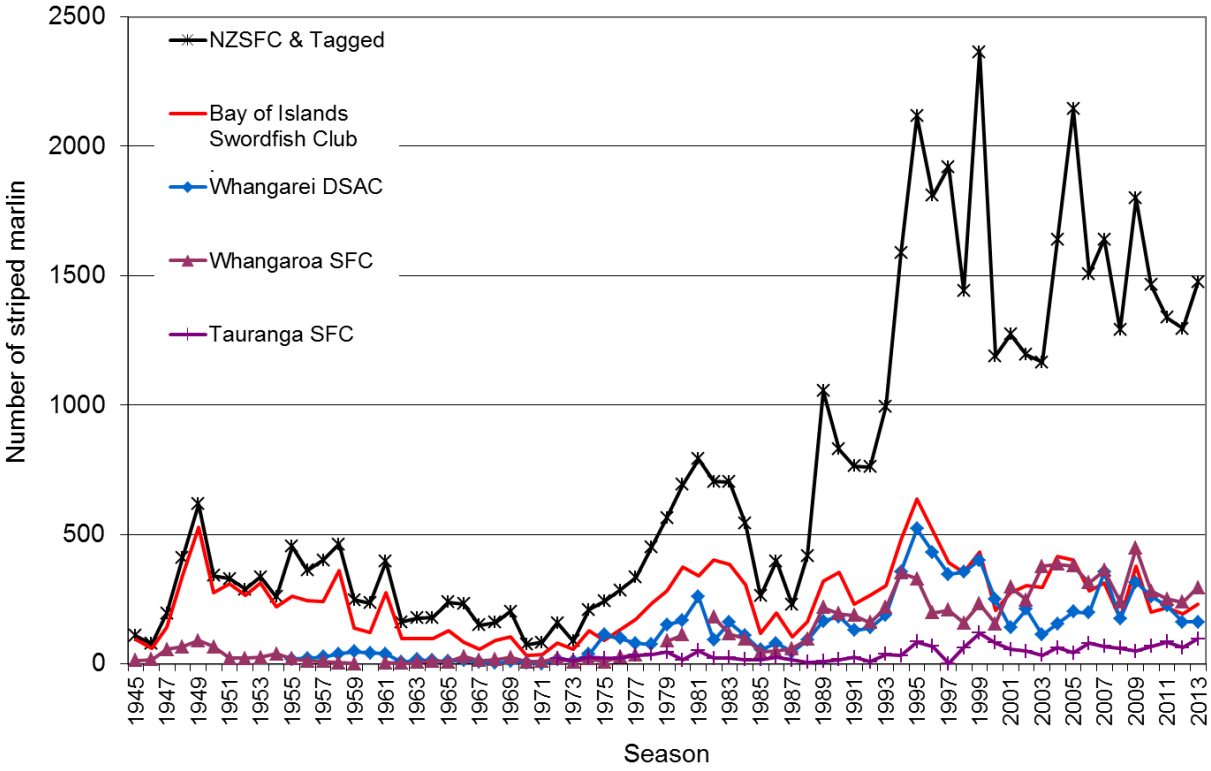


Figure 1: Number of striped marlin caught by recreational fishers in four long established clubs and the national catch by all New Zealand Sport Fishing Council affiliated clubs.

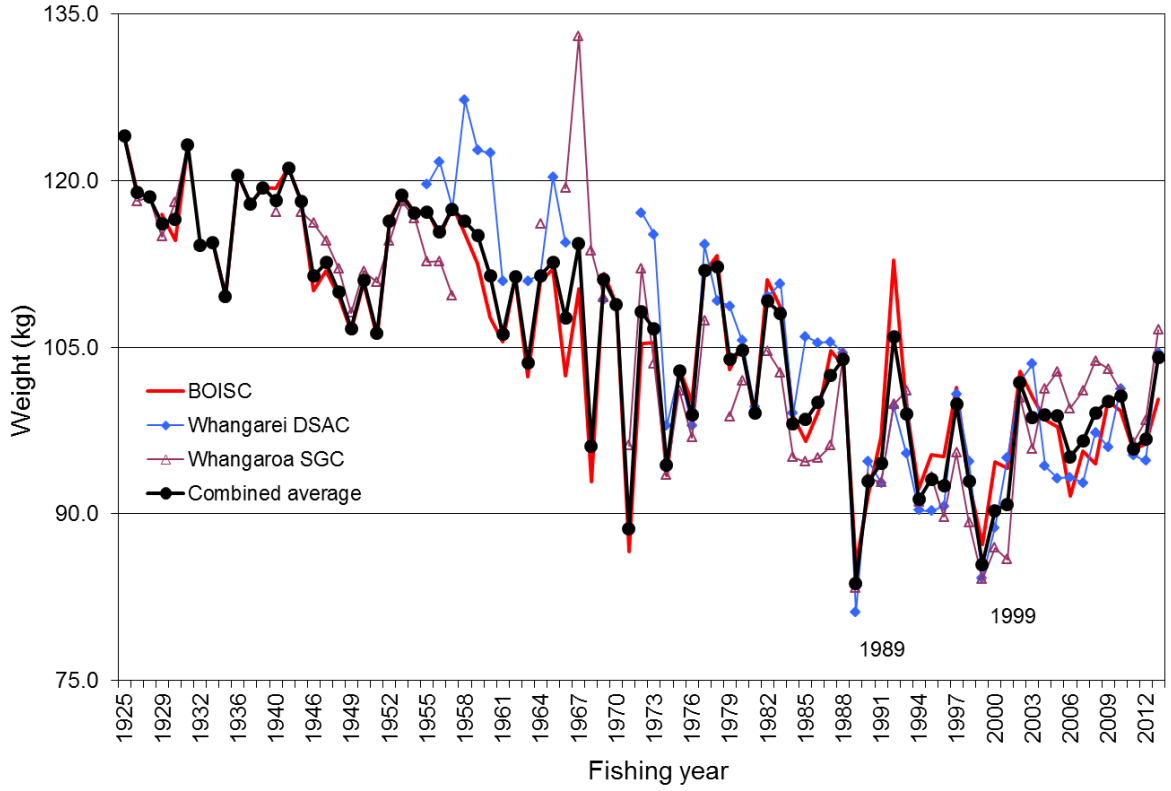


Figure 2: Average annual weight of striped marlin (landed and tagged) from three Northland clubs and the combined mean weight by fishing year.

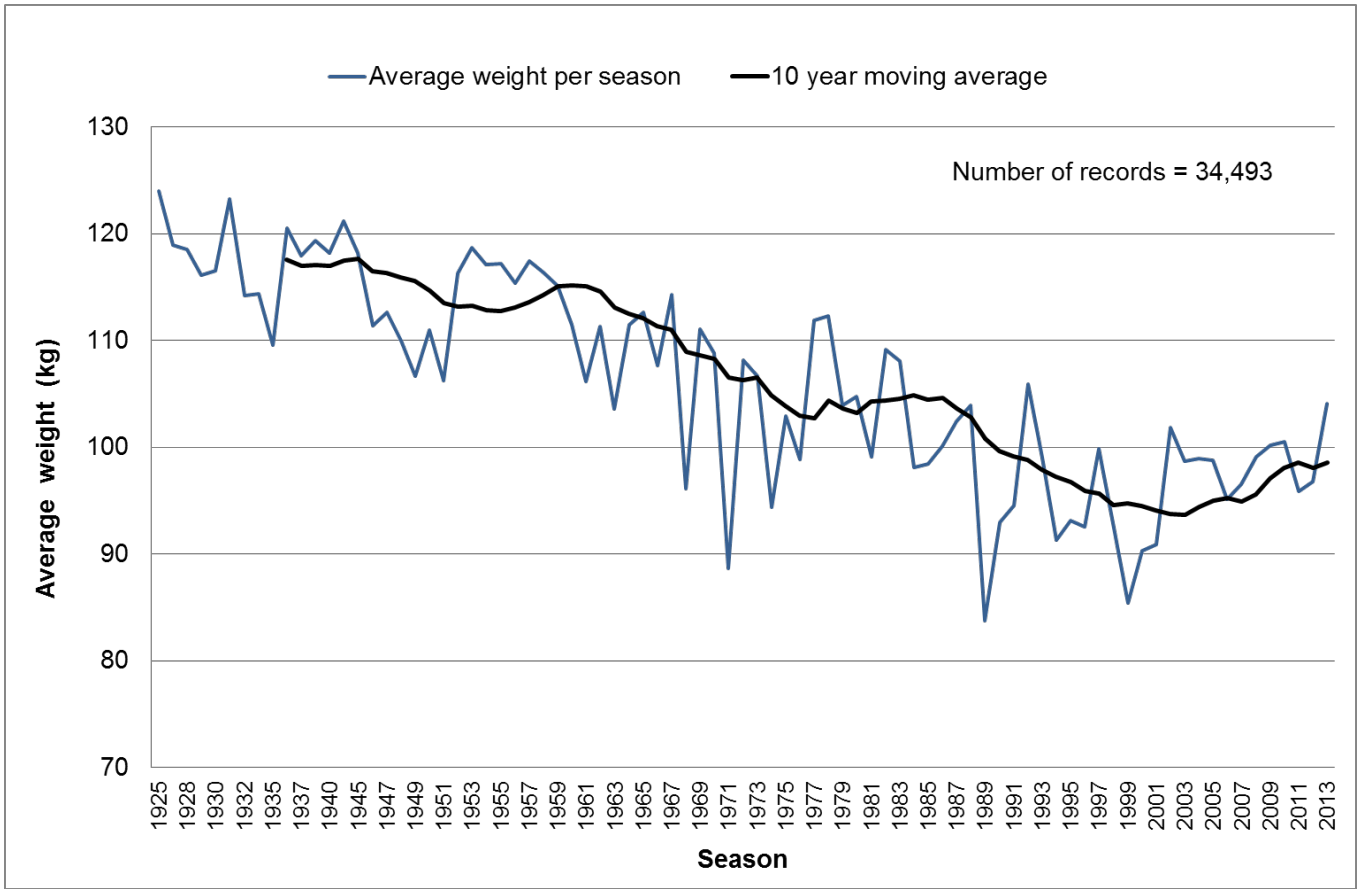


Figure 3: Ten year moving average weight of striped marlin (landed and tagged) from three Northland clubs combined.

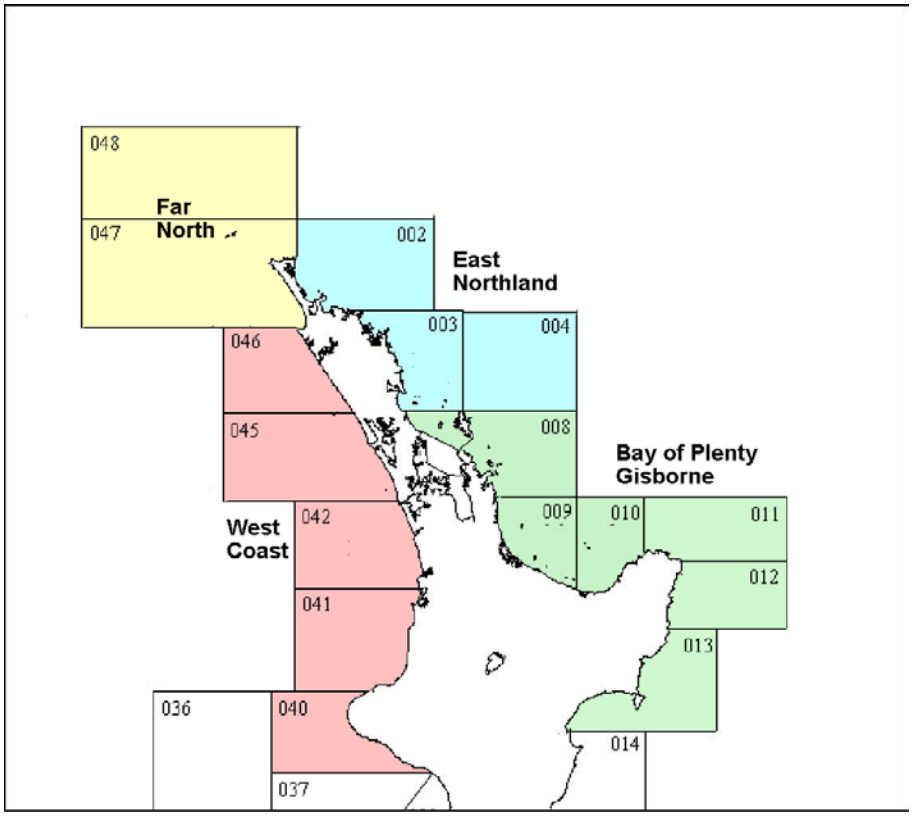
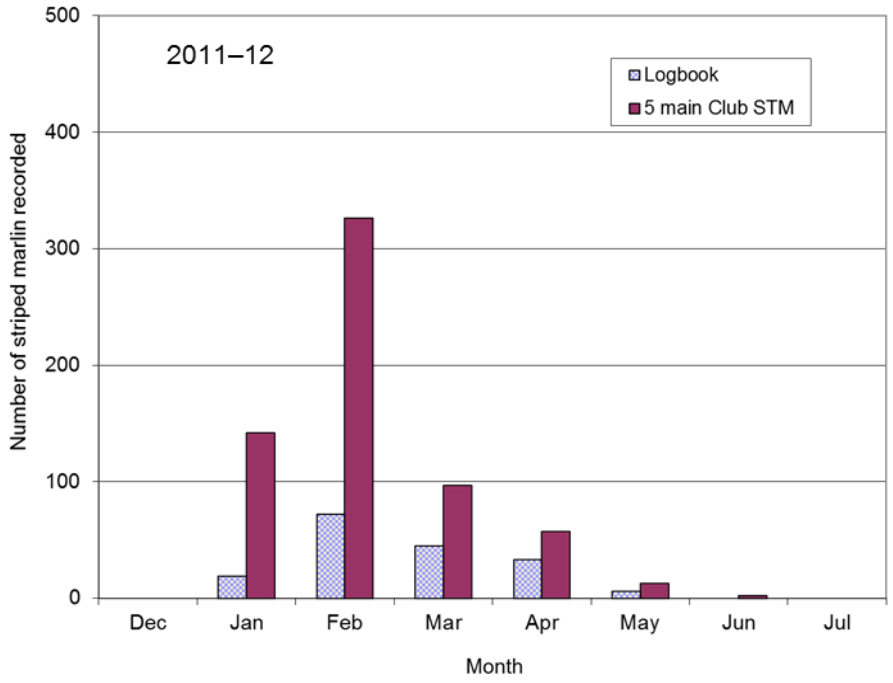


Figure 4: The four regions used in summaries of billfish logbook data using boundaries of MPI statistical areas.

(a)



(b)

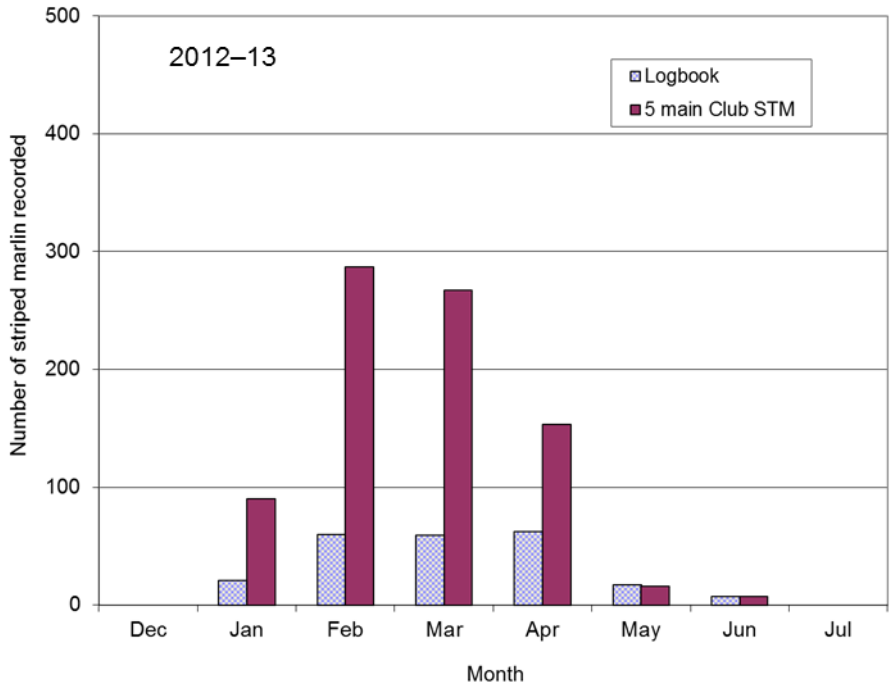


Figure 5: Number of striped marlin recorded in billfish logbooks and number recorded by the five main clubs by month a) in the 2011–12; and b) in the 2012–13 fishing year.

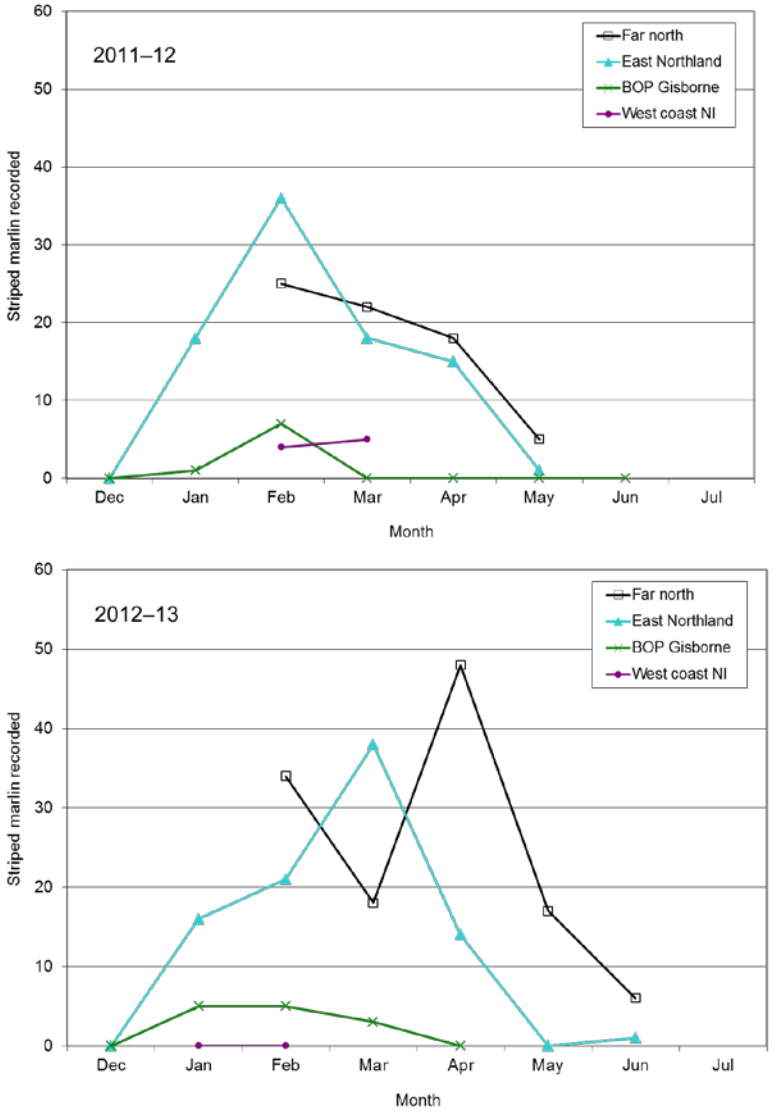


Figure 6: Logbook reported striped marlin catch by area and month in a) the 2011–12 year; and b) the 2012–13 year.

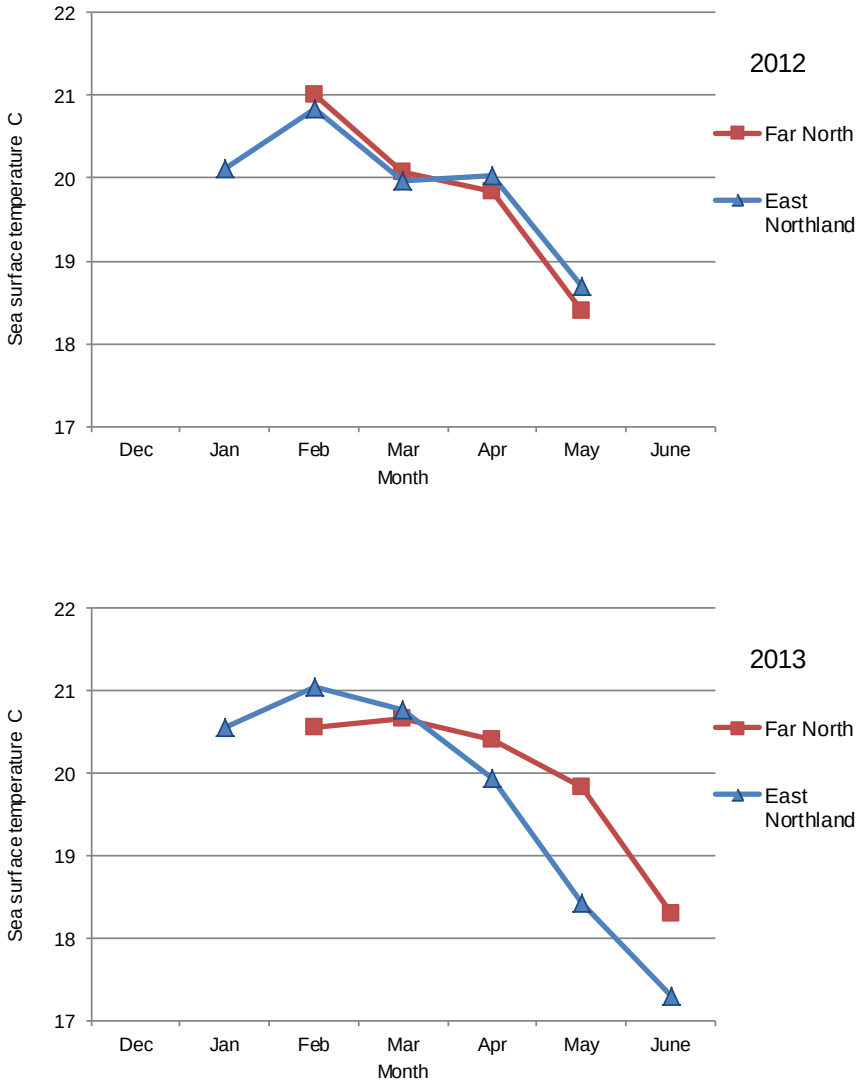
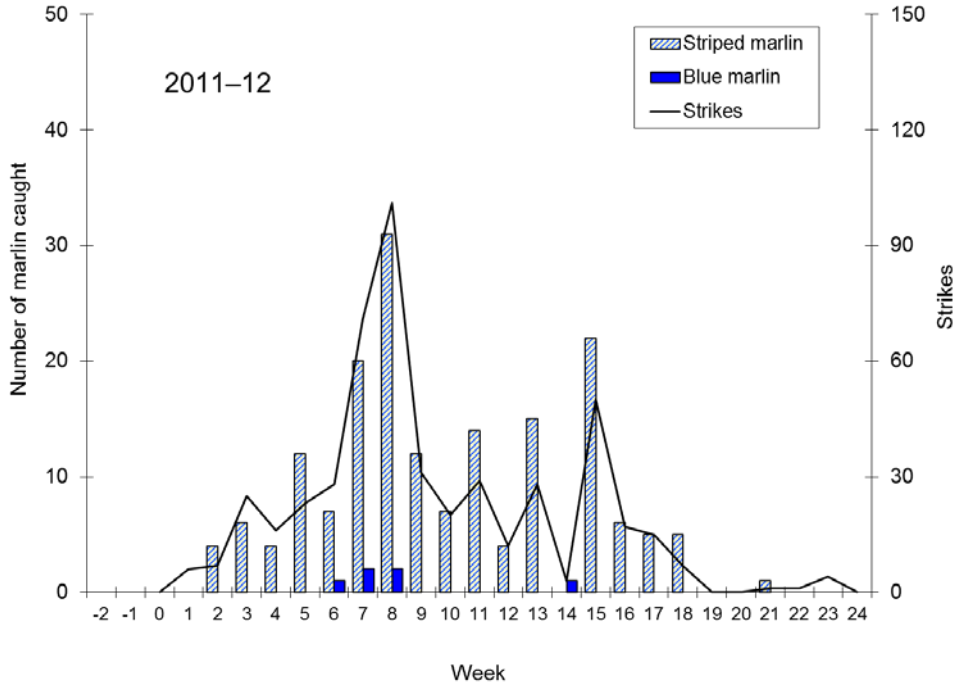


Figure 7: Average sea surface temperatures by month from data recorded by logbook fishers for (a) the 2011–12 year; and (b) the 2012–13 year.

a)



b)

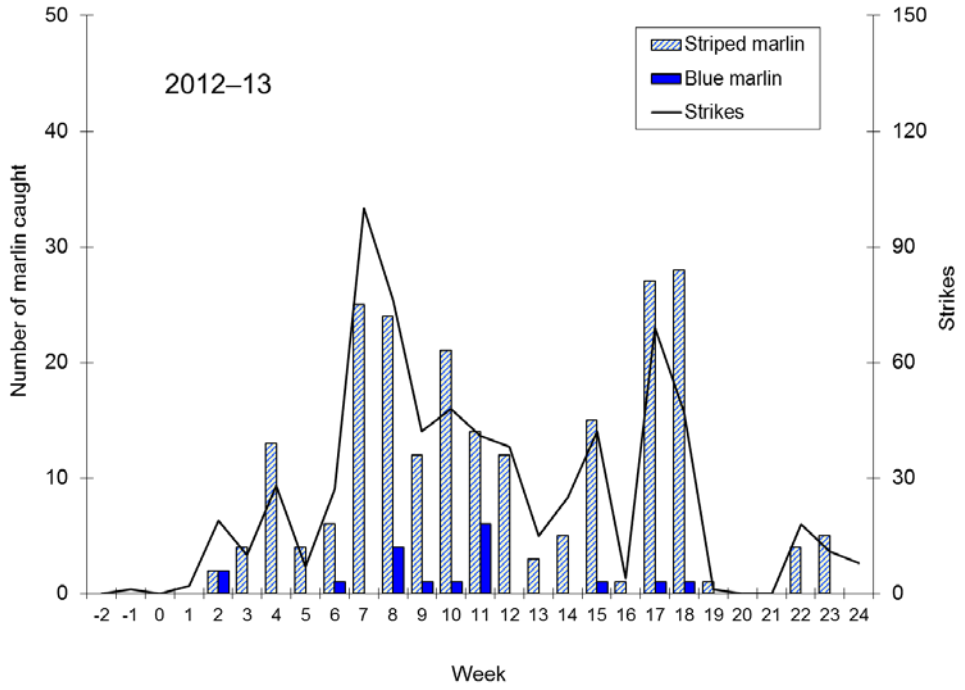


Figure 8: The number of striped or blue marlin caught by week and the number of strikes per week (right axis) a) in the 2011–12 season; and b) in the 2012–13 season. Week 0 starts 24 December.

a)

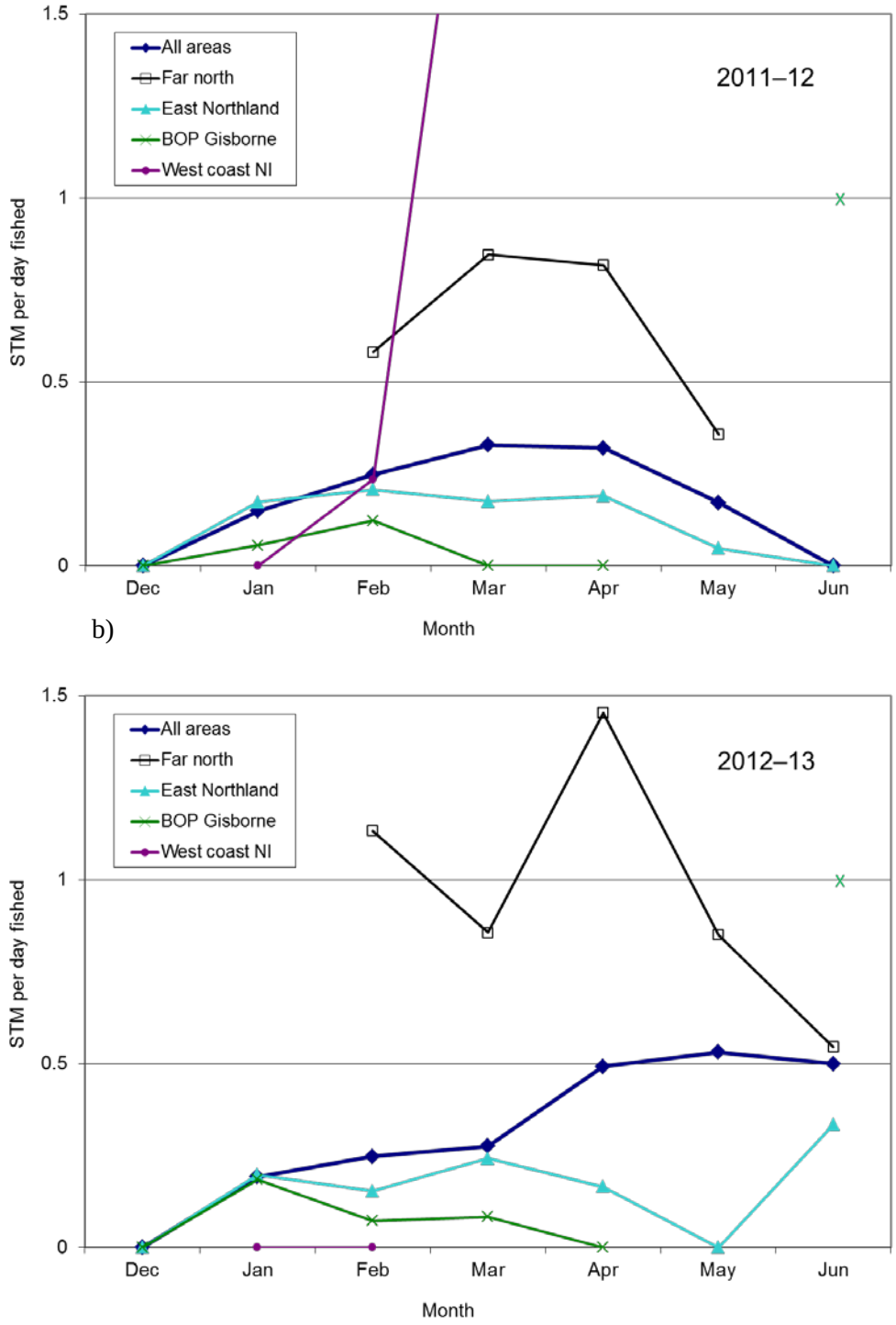


Figure 9: Striped marlin catch per vessel day by area and month from logbook data a) in the 2011–12 season; and b) in the 2012–13 season.

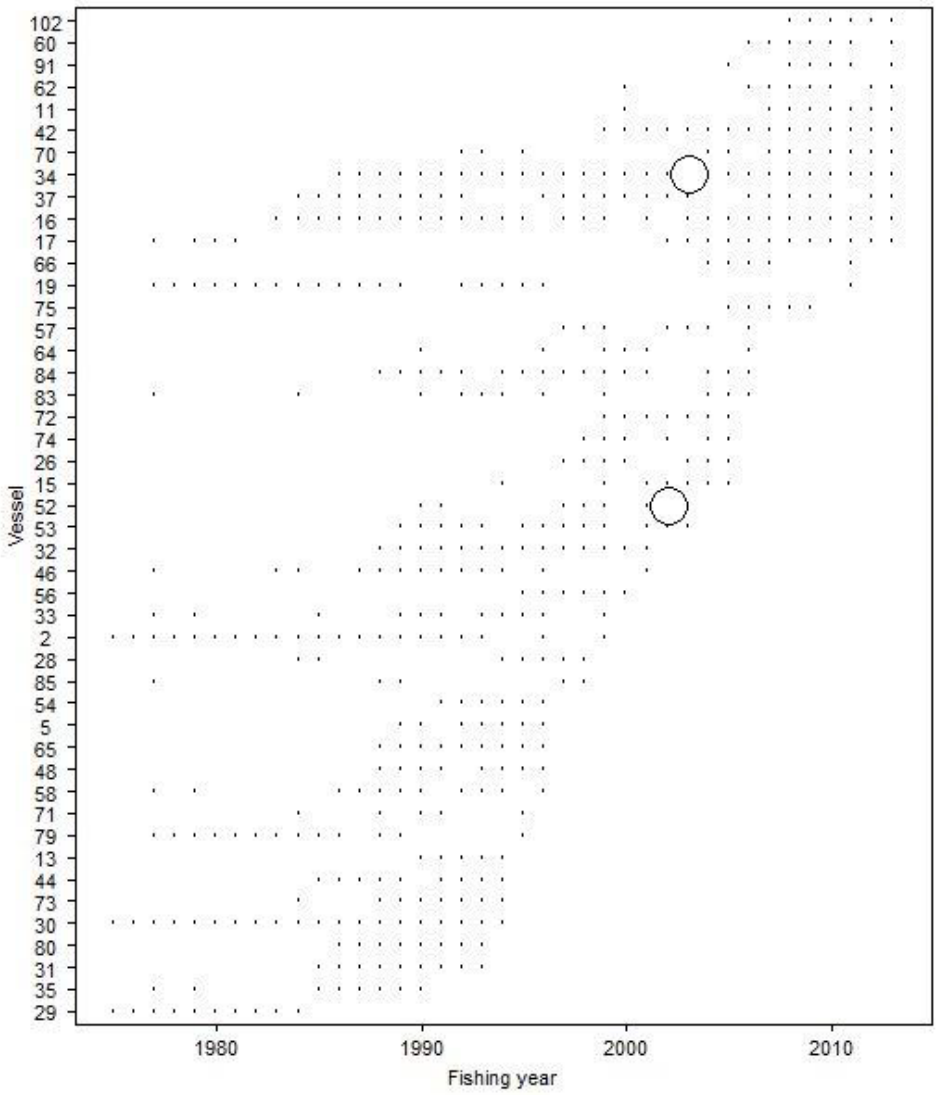


Figure 10: Participation of the core vessels used. Each observation summarises one year of fishing, whether or not successful with respect to STM. The large circles are non informative (an artefact of two separate observations for a single year) Fishing years are labelled by the later calendar year e.g. 1990 = 1989–90.

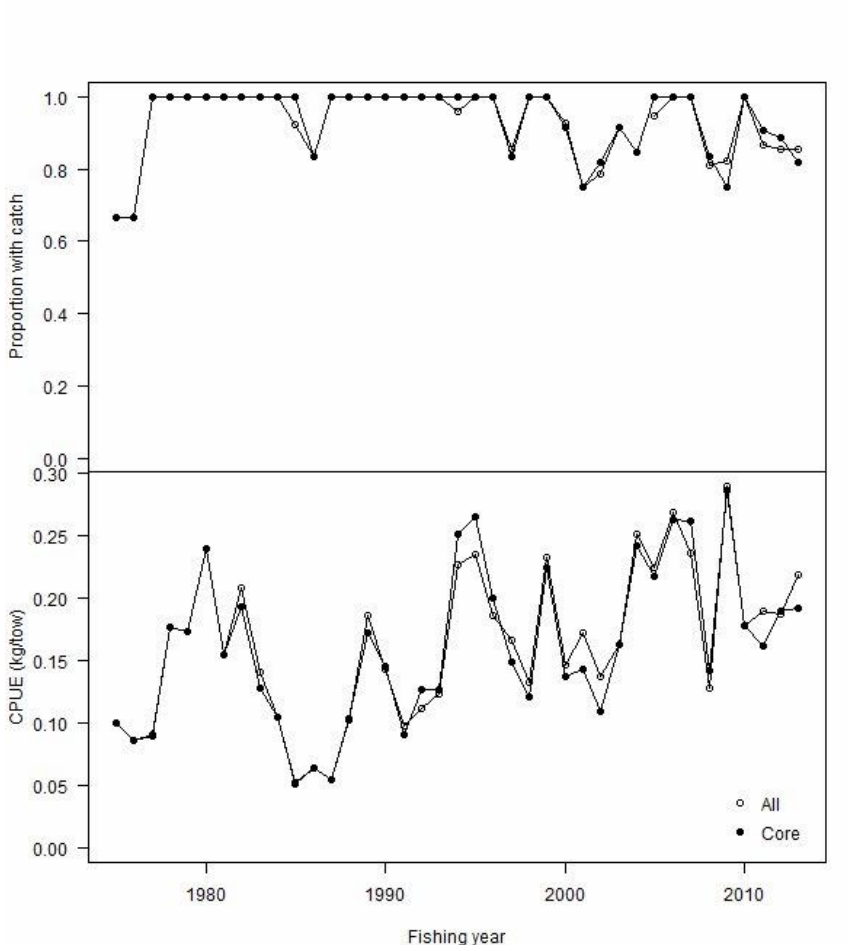


Figure 11: Comparison of the proportion of strata with positive catch (upper) and unstandardised CPUE (geometric mean of catch divided by effort where catch was positive; lower) for the all and core vessels.

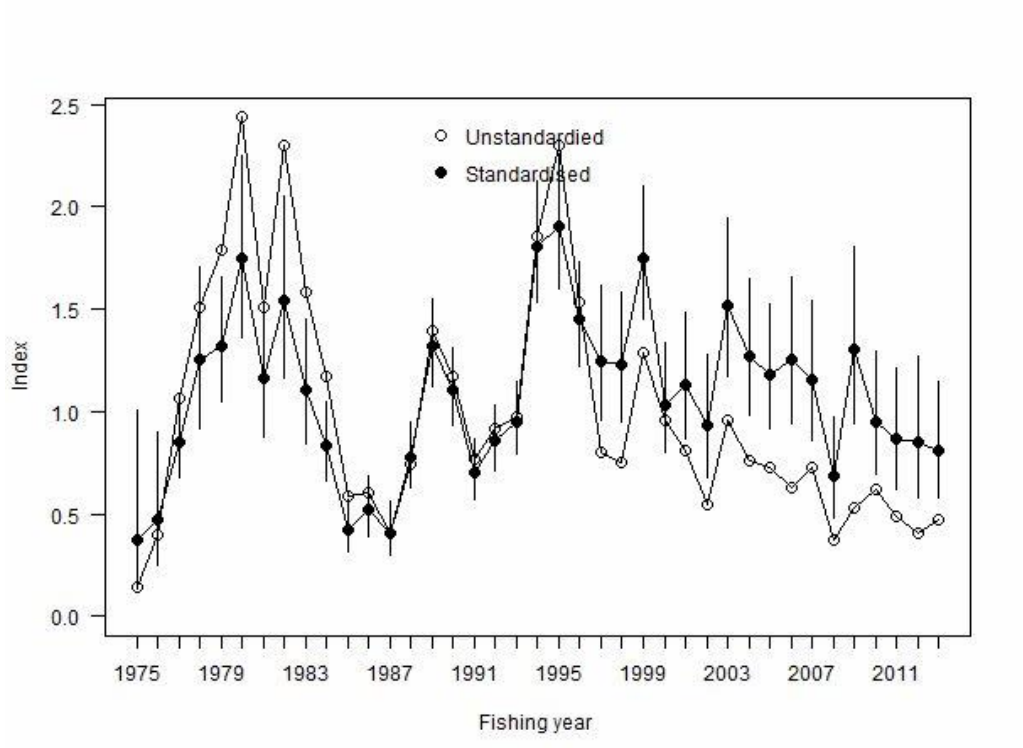


Figure 12: Overall standardization effect of the model. The unstandardised index is based on the geometric mean of the catch per strata and is not adjusted for effort.

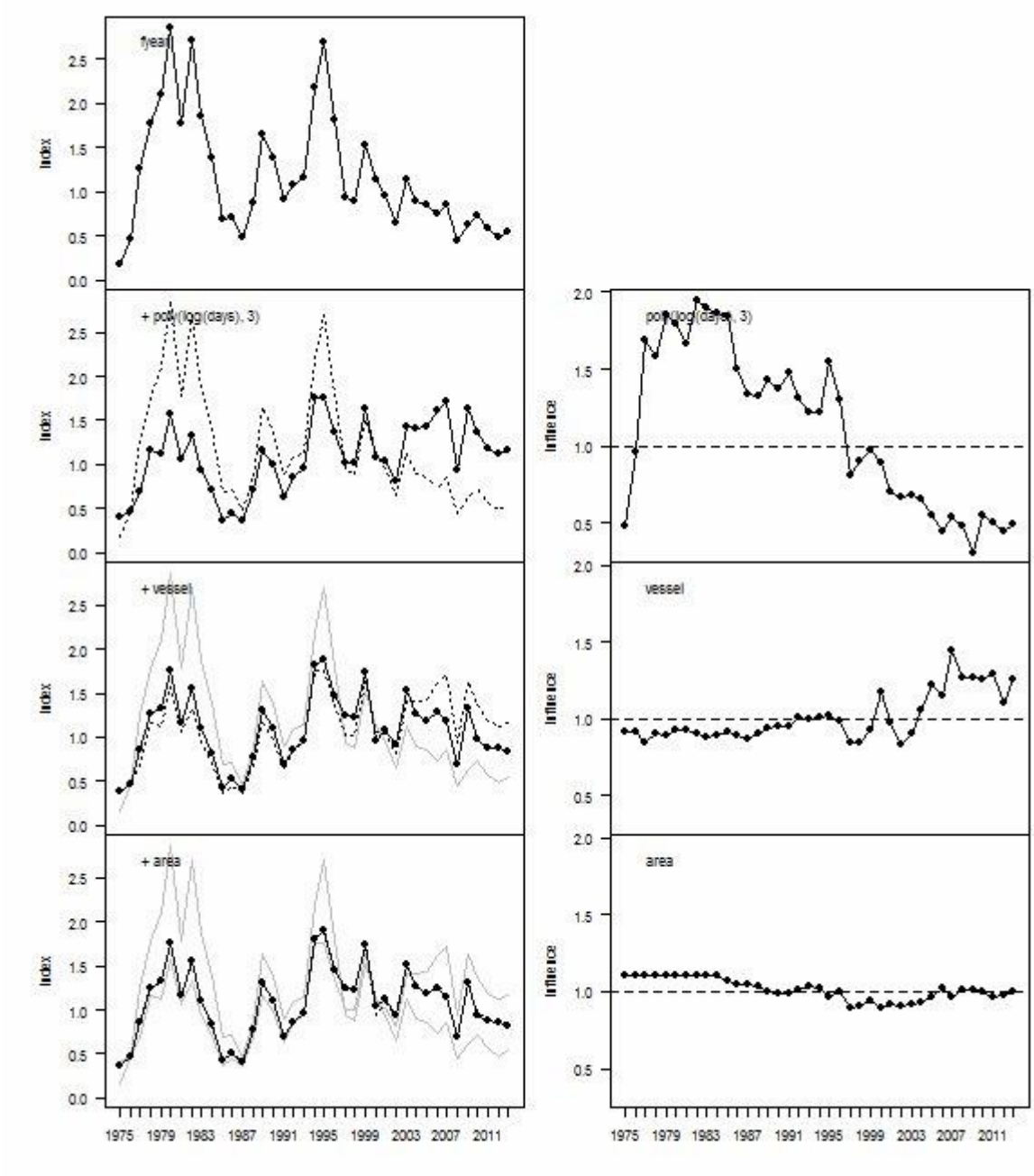


Figure 13: Step and influence plot

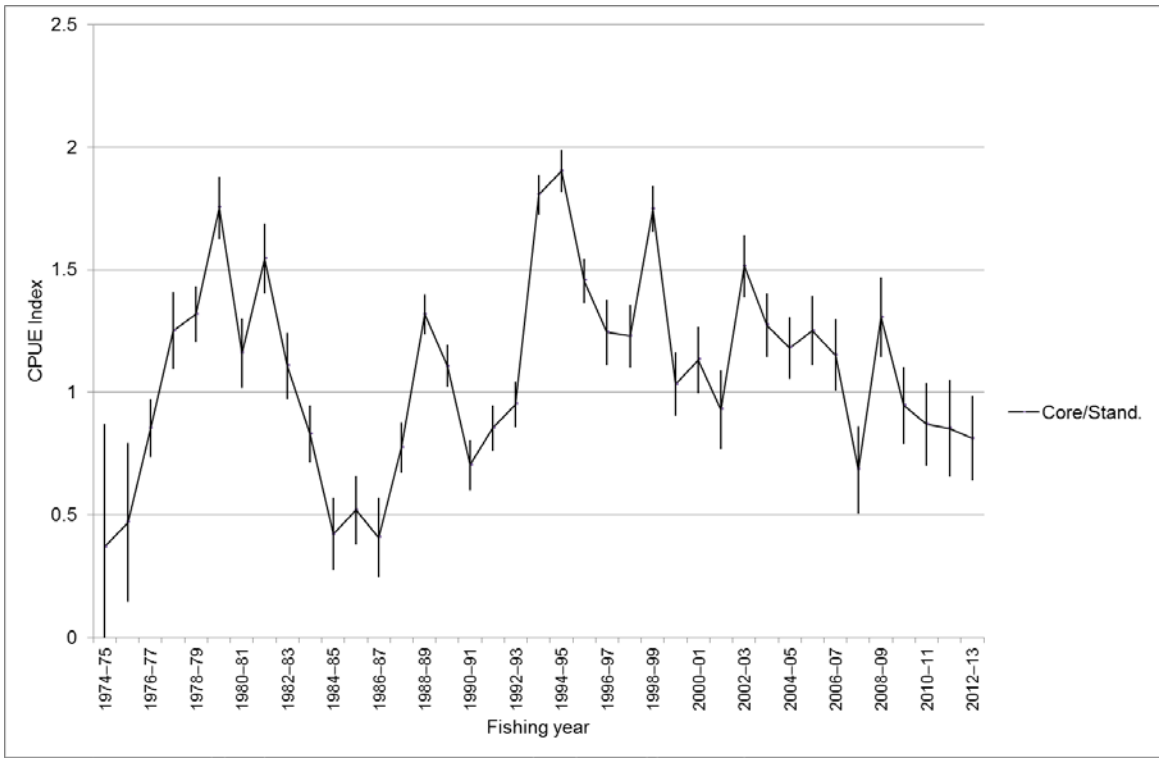


Figure 14: Standardised striped marlin CPUE for East Northland recreational charter boats.

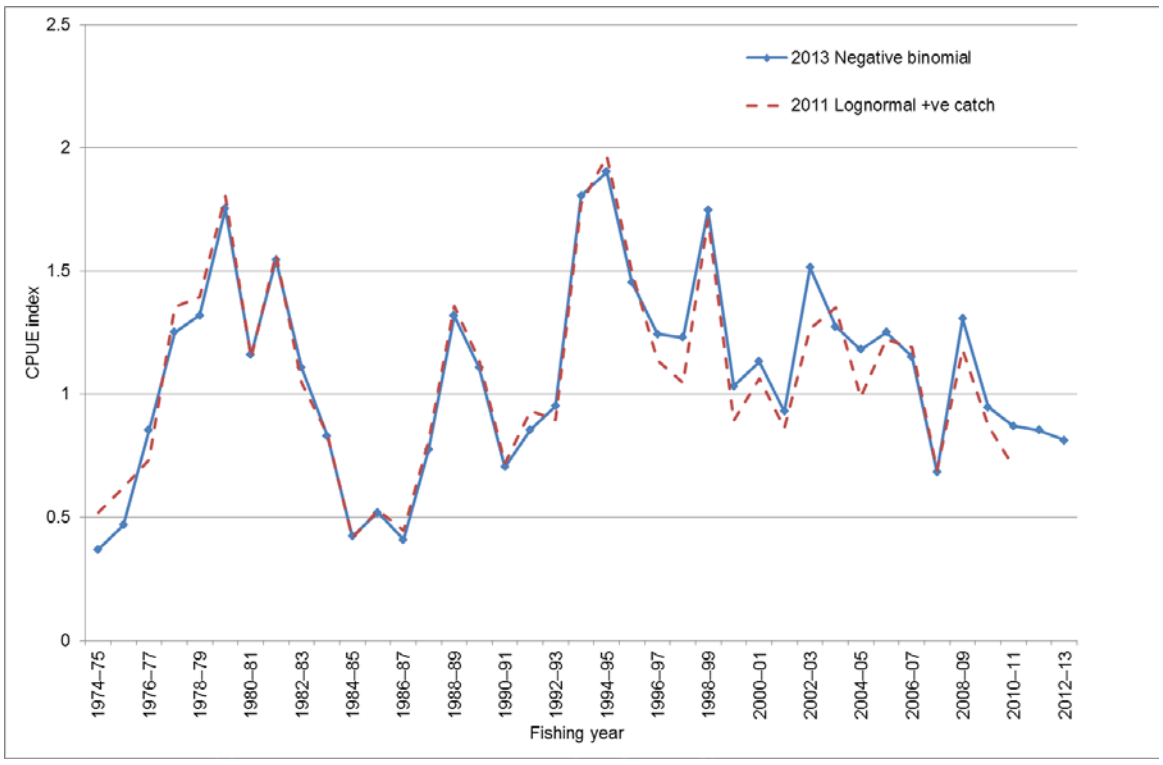


Figure 15: Comparison between the lognormal model of striped marlin CPUE using positive catch (Holdsworth & Kendrick 2013) and the current negative binomial model of CPUE for East Northland recreational charter boats.

7 APPENDIX 1. 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	0.6029	0.6086	0.6747	0.3700	0.50200
1976	0.3869	0.3906	0.5838	0.4694	0.32370
1977	0.6395	0.6457	0.6026	0.8537	0.11802
1978	1.1513	1.1622	1.1964	1.2514	0.15531
1979	1.1118	1.1223	1.1738	1.3191	0.11370
1980	1.5330	1.5474	1.6190	1.7524	0.12543
1981	1.0450	1.0549	1.0434	1.1598	0.14129
1982	1.3758	1.2906	1.3068	1.5446	0.14234
1983	1.0144	0.9240	0.8619	1.1073	0.13541
1984	0.6860	0.6937	0.7069	0.8309	0.11607
1985	0.3232	0.3474	0.3475	0.4225	0.14694
1986	0.4032	0.4070	0.4296	0.5195	0.14028
1987	0.3933	0.3951	0.3661	0.4087	0.16122
1988	0.7008	0.7101	0.6958	0.7748	0.10310
1989	1.2495	1.1714	1.1603	1.3179	0.08201
1990	0.9874	0.9792	0.9818	1.1070	0.08598
1991	0.7324	0.6538	0.6123	0.7043	0.10266
1992	0.8015	0.8660	0.8525	0.8547	0.09406
1993	0.9295	0.9779	0.8600	0.9516	0.09254
1994	1.5038	1.6995	1.7013	1.8059	0.08178
1995	1.5633	1.7369	1.7893	1.9021	0.08542
1996	1.2882	1.3841	1.3509	1.4549	0.08821
1997	1.0172	0.8841	1.0021	1.2440	0.13219
1998	1.0248	0.9600	0.8203	1.2290	0.12771
1999	1.6820	1.6567	1.5167	1.7469	0.09280
2000	0.9792	0.9203	0.9256	1.0333	0.12975
2001	0.9368	0.8071	0.9688	1.1321	0.13554
2002	0.8835	0.6948	0.7375	0.9302	0.15941
2003	1.2899	1.3021	1.1022	1.5143	0.12650
2004	–	1.6125	1.6317	1.2738	0.12838
2005	1.7113	1.7541	1.4687	1.1810	0.12728
2006	2.0471	2.0099	1.7752	1.2515	0.14034
2007	1.7255	1.9269	1.7684	1.1514	0.14570
2008	0.9143	1.0681	0.9575	0.6843	0.17758
2009	1.7251	1.6533	1.9361	1.3062	0.16212
2010	1.3382	1.4152	1.2059	0.9468	0.15697
2011	1.2704	1.1143	1.0951	0.8701	0.16732
2012	1.1316	1.1529	1.2825	0.8536	0.19737
2013	1.3867	1.0814	1.2993	0.8124	0.17229

8 APPENDIX 2. COEFFICIENT, DISTRIBUTION AND INFLUENCE PLOTS

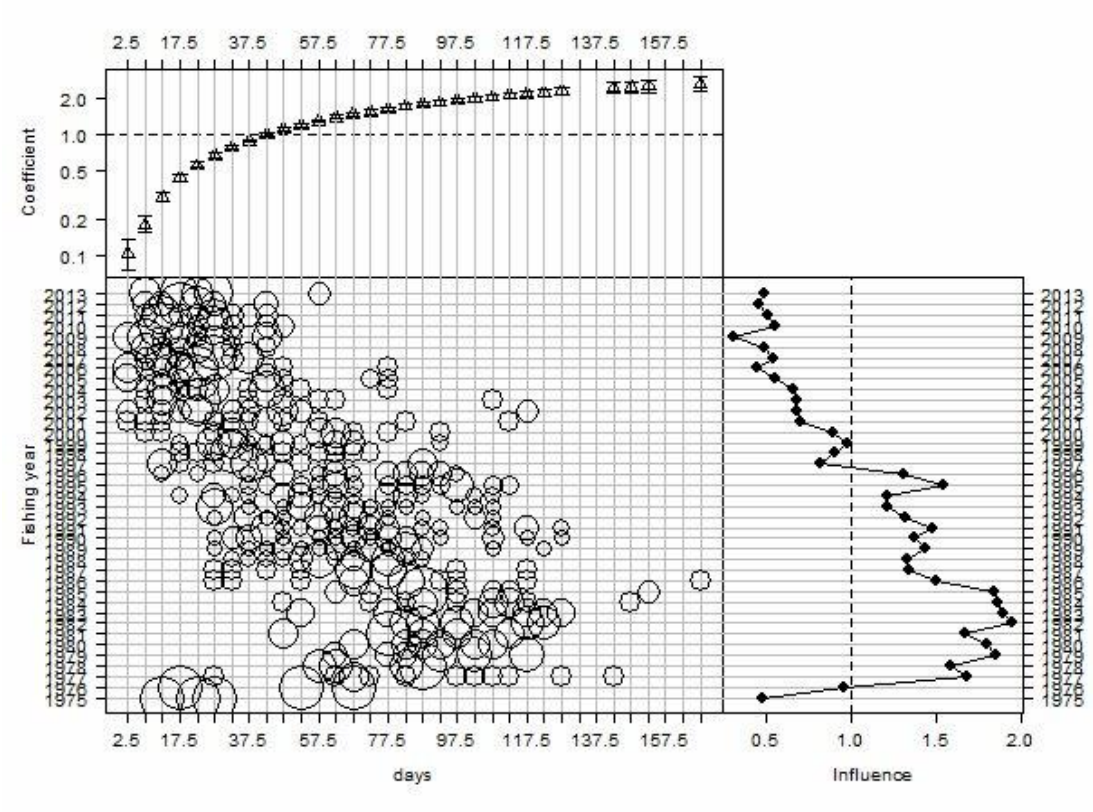


Figure A1: Coefficient–distribution–influence plot for poly(log(days), 3).

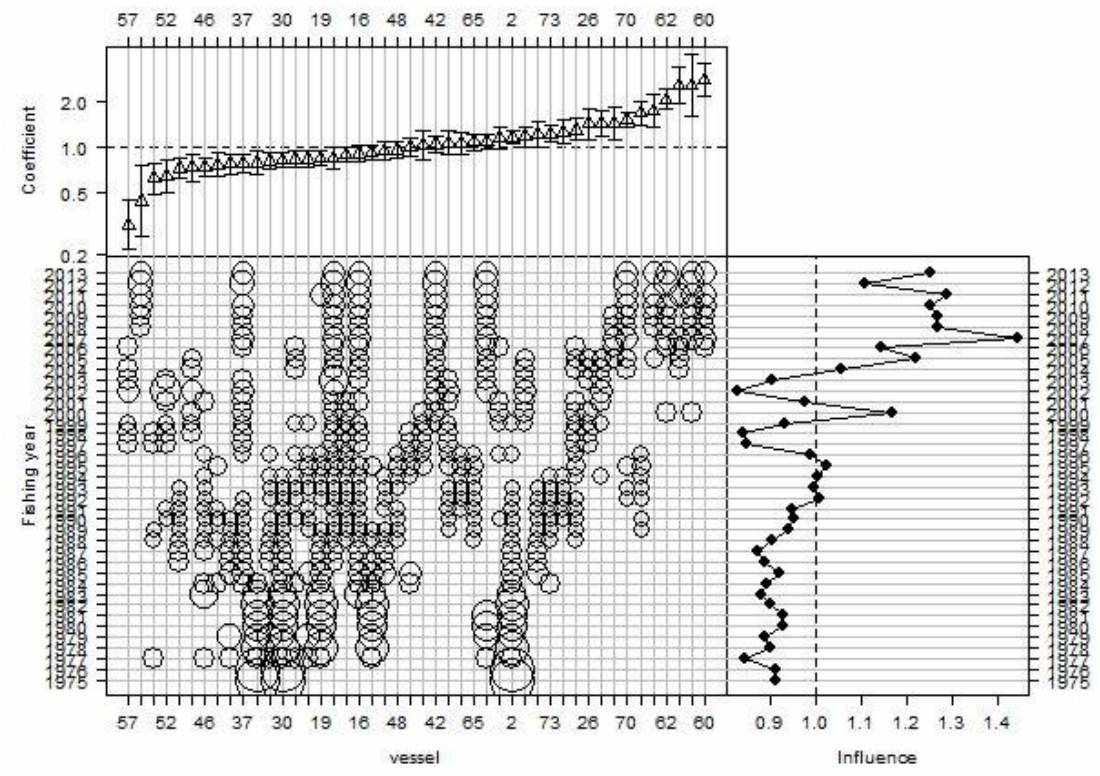


Figure A2: Coefficient–distribution–influence plot for *vessel*.

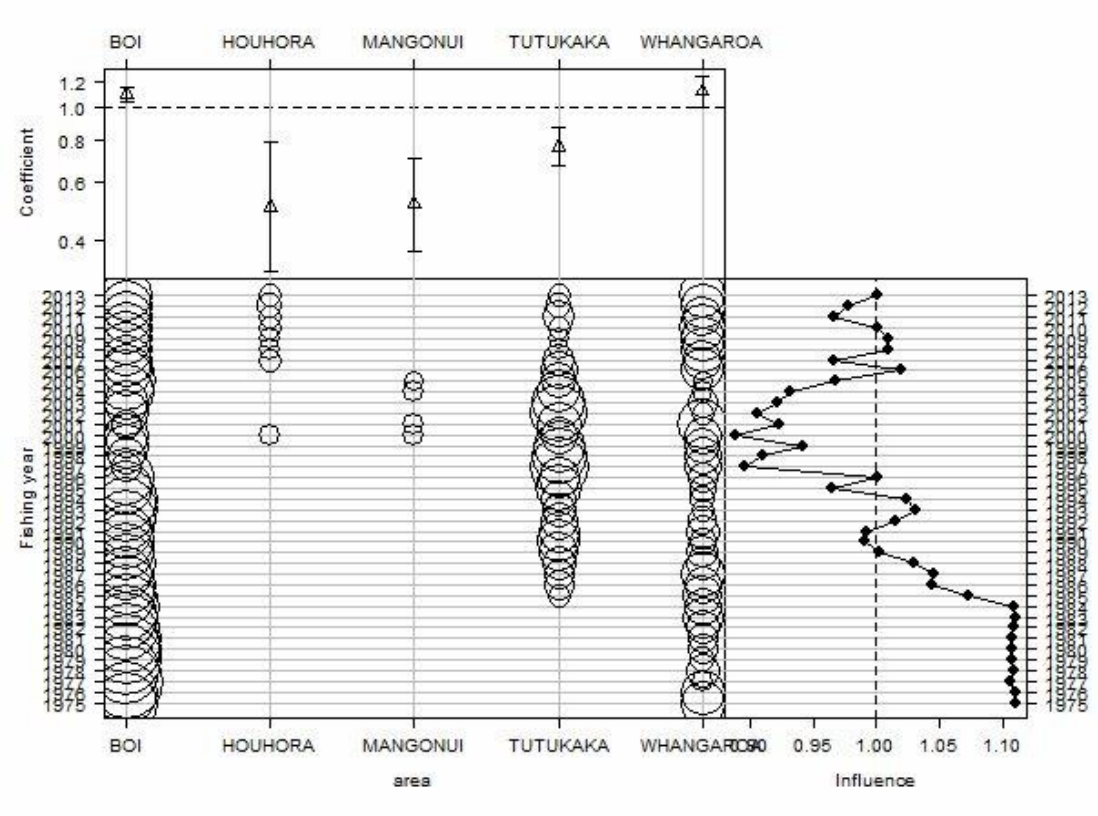


Figure A3: Coefficient–distribution–influence plot for *area*.

9 APPENDIX 3. RESIDUAL DIAGNOSTICS

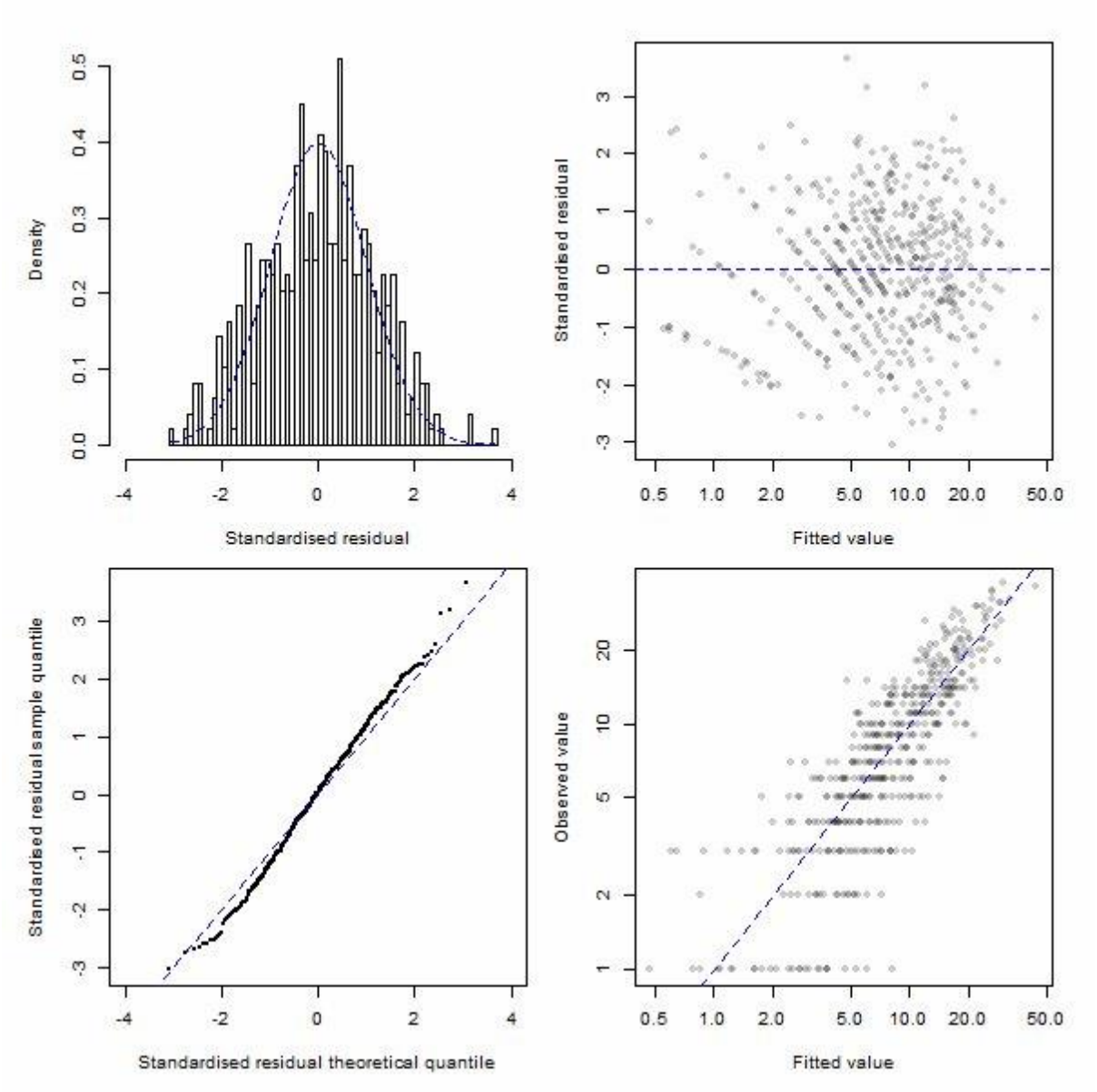


Figure A4: Residual diagnostics. Top left: histogram of standardised residuals compared to standard normal distribution. Bottom left: quantile–quantile plot of standardised residuals. Top right: fitted values versus standardised residuals. Bottom right: observed values versus fitted values.