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Monitoring the length structure of commercial landings of albacore (*Thunnus alalunga*) during the 2009–10 to 2011–12 fishing years

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A characterisation of the albacore tuna troll fishery in New Zealand waters was carried out and the results of this were used to develop a sampling design that was representative of the fishery, spatially and temporally.

Albacore caught by trolling during the 2009–10 to 2011–12 fishing seasons were sampled in fish sheds to determine the length frequency composition and length-weight relationship. Albacore were sampled from two ports: Auckland and Greymouth. Sample targets were based on the monthly distribution of the commercial catch during the previous three years.

During 2009–10, 4185 fish were sampled from 42 landings, in 2010–11, 4783 fish were sampled from 48 landings, and in 2011–12, 5100 fish were sampled from 50 landings. The total number of fish measured over the three years was 14 068, and 1386 were weighed.

Albacore showed a multimodal length distribution with three modes visible in most samples in each year, month and port. The median fork lengths were 61 cm, 59 cm and 60 cm respectively for the three fishing seasons. The mean fork length over the three years was 60.9 cm, and the size range was 41–96 cm, with nearly all fish (99%) in the 48–77 cm range. Length-weight relationships were determined.

Nearly all (99%) of the 72 045 albacore sampled in the troll fishery over a 15-year period from 1996–97 to 2011–12 (excluding 2008–09) were in the 47–81 cm size range, with a median fork length of 62 cm and mean fork length of 62.9 cm. With maturity occurring at 85 cm, these fish are almost all juveniles. There is considerable variability in the size composition from year to year. Length composition scaled to the total catch is presented.

Data from troll caught albacore provided to the WCPFC (Western Central Pacific Fisheries Commission) are an important input in the South Pacific albacore stock assessment. Data from the shed sampling programme have been provided to WCPFC since 1996–97.

This report also summarises data collected by MPI (Ministry for Primary Industries) observers on troll vessels, and compares the data collected by the port sampling with those collected by observers.

After trial trips in 2007 and 2008, the MPI Observer Programme had assigned targets for number of observer days at sea from 2009 onwards. Observers record information on fishing effort, fishing gear, catch composition, and discard practices. In 2011 and 2012 albacore lengths were recorded. Observers do not record weight data.

Raw and scaled length frequencies were compared and considered to be different enough to warrant further investigation into the reasons for these differences. The spatial and temporal coverage achieved by observer sampling was less comprehensive than that achieved by shed sampling. Targets were difficult to achieve in this fishery. The Observer Programme sampled too few vessels for the length data to be representative, especially given the variable fishing and discarding practices among different vessels.

Albacore caught by trolling around New Zealand tend to be smaller than those caught by United States troll vessels from the fishing in the subtropical convergence zone in the eastern Pacific, the only other surface fishery for the South Pacific albacore stock. Fish caught by longline throughout the South Pacific, including those caught by longline in New Zealand waters, are all larger sub-adult and adult fish.

Continued monitoring of the catch composition of juvenile albacore in the New Zealand troll fishery is a critical input to the length-based regional stock assessment of the South Pacific albacore stock. The New Zealand fishery catches up to half of the total removals of juveniles from this stock and is one of only two target fisheries for this stock. Failure to monitor size composition in this stock would appreciably increase the uncertainty of stock assessments.

1. INTRODUCTION

Albacore tuna (*Thunnus alalunga*) caught in the New Zealand EEZ (Exclusive Economic Zone) are part of a single South Pacific Ocean stock that ranges from the equator to about 45° S. Female albacore mature at about 85 cm fork length and spawn in the austral summer from November to February in tropical and subtropical waters, between about 10° S and 20° S, west of 140° W (Murray 1994, Ramon & Bailey 1996, Murray et al. 1999).

Juvenile albacore recruit to surface fisheries in New Zealand coastal waters and in the vicinity of the subtropical convergence zone (STCZ) at about 2 years of age, at 45−50 cm fork length. They then appear to gradually disperse north (Hampton & Fournier 2000) where they are caught by longline fleets. Longline fleets from Japan, Korea, and Taiwan, and domestic fleets of several Pacific Island countries, catch adult albacore throughout their range. Fish caught by longline in the southern part of the region are smaller than those caught further north (Hampton & Fournier 2000). The New Zealand longline fishery catches adult and sub-adult albacore (Murray et al. 1999).

There has been a troll fishery for juvenile albacore in New Zealand coastal waters since the 1960s, and in the central region of the STCZ since the mid 1980s (Murray 1994, Hampton & Fournier 2000). The New Zealand troll fishery, operated by domestic vessels mostly in New Zealand coastal waters, catches up to 6000 t of albacore annually, over half of the total South Pacific surface fishery catch (Murray et al. 2000). Trolling for albacore occurs primarily off the west coasts of the North Island and South Island with Onehunga (Auckland), New Plymouth, Westport, and Greymouth being major landing ports.

Troll vessels from the United States have fished for albacore in the South Pacific since 1986, in the STCZ (Subtropical Convergence Zone), approximately 39–41º S, from 1000 n. miles east of New Zealand to waters off South America. Landings from these vessels fluctuated between 603 t and 2916 t from 1986–87 to 1994–95, with no real trend (Childers & Coan 1996). Over the 5 years from 1999–2002 to 2003–04, American catches were highest in 1999–2000 (2562 t) and lowest in 2003–04 (955 t) (Ito et al. 2005). Canadian landings in this fishery from its inception in 1987–88 to 2000–04 are estimated to have ranged from 134 to 351 t per season (Stocker & Shaw 2005). In 2007 US vessels caught 218 t, with minor contributions from the Canadian, Cook Islands and French Polynesian fleets (Williams & Terawasi 2008). The United States troll fleet caught 321 t in 2011, while the other fleets were not active in the STCZ (Williams & Terawasi 2012).

Labelle (1993) noted that STCZ albacore tend to be larger than those around New Zealand. Albacore sampled in the STCZ by the American fleet in 2003–04 had an average fork length of 66 cm.

The New Zealand albacore fleet caught 2093 t in 2007, the lowest for nearly 20 years, mainly because of a reduction in active vessel numbers due to economic conditions. Catches have fluctuated since then with 3720 t caught in 2008, around 2200 t in 2009 and 2010, and an increase to 3213 t in 2011 (Anon 2012, Williams & Terawasi 2012).

The size composition, sex ratio, and length-weight relationship of albacore caught by troll in New Zealand have previously been investigated by NIWA (Griggs & Murray 2000, 2001a, 2001b, Griggs 2002a, 2002b, 2003a, 2003b, 2004a, 2004b, 2005a, 2005b, 2008a, 2008b, Griggs & Doonan 2010). Fish sampled in the 2005–06 season, mostly juveniles, ranged from 45 to 92 cm fork length, with nearly all fish (99%) in the 50−83 cm range (Griggs 2008a), fish sampled in the 2006−07 season ranged from 43 to 92 cm fork length, with nearly all fish (99%) in the 49−80 cm range (Griggs 2008b). A significant linear relationship was found between the logs of albacore fork length and greenweight. Griggs & Murray (2000) found that the sex ratio was not statistically different from 1:1.

The present study updates and extends those previous analyses for three more years, thus increasing the time series to 15 years. It addresses the following objectives.

OVERALL OBJECTIVES:

1. To determine the length composition of the commercial catch of albacore (*Thunnus alalunga*) in New Zealand fisheries waters.

2. To support the stock assessment of the wider South Pacific albacore stock.

SPECIFIC OBJECTIVES:

1. To characterise the fishery for albacore (*Thunnus alalunga*) in New Zealand fisheries waters.

2. To conduct representative sampling to determine the length composition, sex and maturity state and length-weight relationships of albacore tuna during the 2009/2010 fishing year from samples collected in fish sheds. The target coefficient of variation (CV) for the length composition is 20 % (mean weighted CV across all length classes).

3. To conduct representative sampling to determine the length composition and length-weight relationships of albacore tuna during the 2010/2011 fishing year from samples collected in fish sheds. The target coefficient of variation (CV) for the length composition is 20 % (mean weighted CV across all length classes).

4. To conduct sampling in fish sheds and determine the length composition and length-weight relationships of albacore tuna during the 2011/2012 fishing year from samples collected in fish sheds. The target coefficient of variation (CV) for the length composition is 20 % (mean weighted CV across all length classes).

This work is an extension to the sampling funded in 1996−97 and 1997–98 by the South Pacific Commission (SPC, now Secretariat of the Pacific Community), and 1998–99 to 2007–08 by the Ministry of Fisheries, now Ministry for Primary Industries (MPI).

This report also incorporates work carried out under projects SEA2010-09 and SEA2011-15, summarising data collected by MPI observers on troll vessels, and comparing the data collected by the port sampling with those collected by observers.

2. CHARACTERISATION OF THE FISHERY

2.1 Methods

Specific Objective One:

A characterisation of the albacore troll fishery was carried out to determine the spatio-temporal sampling effort required in order to obtain representative sampling. The characterisation will also provide valuable input for the fisheries plan that is presently being developed.

2.1.1 Catch effort and sampling data

Spatial and temporal data recorded on CELR forms from the albacore troll fishery were summarised by appropriate strata, focusing on the most recent years. Representativeness of the sampling strategy used previously was assessed.

Commercial troll catch effort data recorded by vessel personnel are recorded on CELR (Catch Effort Landing Return) forms. These data were extracted from the *tuna* database (Wei 2007). Vessels record fishing positions daily on CELR forms, which is recorded as either as latitude and longitude or a statistical area. If a statistical area is recorded, a 'centroid' position is assigned in the tuna database (Wei 2007).

Shore based catch sampling of albacore began in 1996−97 and has occurred each year for twelve consecutive years up to 2007−08. In most years two ports were sampled, Onehunga (Auckland) and Greymouth, and in some years fish were also sampled in New Plymouth. The number of fish sampled in each year and port is shown in Table 1.

This characterisation focuses on the 2005−06, 2006−07 and 2007−08 albacore fishing years. These are the three most recent years sampled by the shore based catch sampling programme under MPI project ALB200501 (Griggs 2008a, 2008b, Griggs & Doonan 2010). The 2008−09 year was not sampled.

Because the fishery extends over the summer months, the 'albacore year' is from 1 July to 30 June, so 2005−06 is 1 July 2005 to 30 June 2006, with the majority of fishing in 2006.

Shore based catch sampling is described in more detail in Section 3 of this report. Observer coverage on troll vessels is summarised in Section 4, and Section 5 is a comparison of the representativeness of shore based catch sampling and observer sampling.

2.1.2 GAM analysis on mean length

A generalized additive model (GAM) analysis was conducted to determine the variables that affect mean length in the catches as this determines sampling strata. Current strata are port and month. Data used were from the landing samples taken in the 2005−06 to 2007−08 years. The mean length from each landing sample was regressed against the factors listed in Table 2. Variables were selected step-wise according to the largest R^2 from the remaining candidates.

Using the above step-wise order, the fits at each step were put into an ANOVA and an F-test performed to determine the significance of the added variable at each step. The GAM analysis used the R functions *gam* and *anova* in the R package 'mgcv' (R Development Core Team, 2010).

2.1.3 Consistency of catch sampling to fishery

There were 12 years of sample data. We analysed the three most recent years individually, i.e., 2005−06 to 2007−08, and the rest in 4–5 year groups, 1996−97 to 2000−01, and 2001−02 to 2004−05.

Consistency between catch sampling and the fishery was evaluated from the percentage of the number of fish in the catch sampling by month and latitude groups compared to that from the fishery. Latitude groups were 30° to 36°, 36° to 42° 36′, and 42° 36′ to 50°.

Data were displayed using plots of distributions by latitude (0.1 degree bins) for each month. Factors examined were: number of vessels in the fishery, number of albacore reported, and total troll duration.

2.2 Results

The fishing positions of the commercial troll vessels and fishing positions of boats that were sampled are shown in Figure 1. Almost all trolling was on the west coast of New Zealand and most of that was off the South Island. Positional accuracy is limited on CELR forms, and some of the positions in Figure 1 represent many points as they are shown as the centroid position of the statistical area reported.

The number of vessels by month and year during 2005−06 to 2007−08 are shown in Figure 2. February and March were the main months for the fishery every year, along with January in two of the years, and April in one year (Figure 2).

2.2.1 GAM analysis on mean length

The selection order of variables is shown in Table 3, and the F test on the resultant cascade of models from the ANOVA in Table 4. Only latitude, month, and year were statistically significant.

The GAM diagnostic plots are shown in Figure 3 for the model using latitude, month, and year. The diagnostics all look good. The upper left panel in Figure 3 shows that the residuals are normal (i.e., residuals lie on an approximately straight line) with a standard deviation of about 2 (twice that of the standard normal distribution which forms the x-axis scale).

The pattern of the estimated effects are shown in Figure 4. Two effects stand out: the month effect and latitude effect. For the month effect, we would have expected a monotonic trend one way or another, but it was a see-saw pattern which is hard to interpret. The latitude effect shows larger fish in northern waters and south of Greymouth.

Raw mean length by latitude during 2005−06 to 2007−08 is plotted in Figure 5. The data still shows the latitude effect found in the GAM, but the 2005−06 data only supports larger fish south of Greymouth. Given the proximity of large and small mean length to each port, port of sampling seems to be a minor effect.

2.2.2 Consistency of sampling

Catch (numbers of fish)
Sampling was broadly similar between sample and CELR data by latitude-month cells for 2005−06 to 2007−08. In 2005−06 latitude south of 42.6°S was relatively over sampled, while in 2007−08 January and the middle latitude group were under-sampled, and south of 42.6°S in April the fishery was over-sampled (Table 5).

In the grouped earlier years, sampling was broadly similar to the CELR distribution in 2001−02 to 2004−05, but the period from 1996−97 to 2000−01 was over-sampled in January and under-sampled in March (Table 6).

Most fish were caught south of latitude 41°S, although there was an exception in January 2006 when a significant numbers were taken between latitude 36°S and 39°S (Figure 6). The sampling broadly follows the distribution for the fishery, but there is clear over- and under-sampling in some months at some latitudes, e.g., April 2008 (Figures 6 and 7). A similar pattern is shown for total troll duration (Figures 8 and 9). An example of over-sampling for troll time was in January 2007 where the far north was over-sampled relative to other latitudes and also January relative to other months.

Figures 10 and 11 show a comparison of the number of fish by latitude-month for the two 4–5 year groups. Again sampling was broadly consistent with the fishery, but there was under-sampling of fish around 41°S latitude in all months.

3. CATCH SAMPLING

3.1 Methods

Characterisation of the size composition of the fishery requires regular sampling through the season (December–April/May) and should take account of any differences in size composition between areas and between boats.

The original sampling design, as specified by the SPC, required fish to be sampled from at least five vessel unloadings, and selected at random from each unloading. At least 1000 fork lengths were to be recorded in each port, each month, and at least 100 of these fish were to be subsampled for length and weight.

The sampling strategy was revised by the HMS (Highly Migratory Species) Working Group to measure a number of fish each month that is proportional to the commercial catch each month, and to sample more landings, in order to increase the representativeness of the sampling data to that of the fishery. In each landing, 100 fish should be sampled, and each month 100 fish would be subsampled for length and weight. Logistically this is more difficult to achieve in Auckland, and the target was a maximum of 200 fish per landing. Proportional catch sampling began at the start of this project, in 2009−10.

Two ports, Auckland (Port Onehunga, on the west coast) and Greymouth, were sampled during the 2009–10, 2010−11 and 2011−12 troll fishing seasons from December–January to April–May.

At each port, sampling was carried out when the troll vessel unloaded its catch. The fish were kept on ice while on the vessel and frozen once they were discharged into the fish receivers. Fish were sampled before freezing and before any grading. Fork length was measured to the whole centimetre, rounded down, and weight was recorded to the nearest 0.1 kg.

Catch sampling data was used to estimate the size composition, and length:weight relationships of albacore caught by trolling. Size frequency distributions was compiled by month and area. The sampled catch was scaled to the total catch using CELR data collected from the troll fishery and mean weighted CVs were calculated using catch-at-age. The spatial and temporal representativeness of the sampling data relative to the commercial catch data was assessed.

Extra fish were sampled in 2009−10 as part of collaboration with SPC and CSIRO. The requirement was for collection of otoliths, first dorsal fin spines, gonads and muscle tissue from 40 fish each month, along with lengths and weights, collected as evenly as possible across 10 cm size bands.

Handling of tag returns from the SPC albacore tagging programme (2009) and collection of samples from oxytetracycline (OTC) injected fish with white tags was also handled within this project.

Size composition and length-weight relationships

Size composition and length-weight relationships for fish sampled during the 2009–10 to 2011−12 troll seasons are summarised and presented.

Scaled catches

The total catch of albacore by year and month as recorded by fishers on CELR forms was extracted from the *tuna* database for the 2009–10 to 2011−12 albacore fishing years. Sampled landings were matched to records on CELR forms. This provided the total catch of albacore in each landing.

Estimated scaled numbers-at-length were calculated for 2009–10 to 2011−12 using the "R" software (R Development Core Team 2010) "Catch-at-age", developed by NIWA (Bull & Dunn 2002).

Vessels record fishing positions daily on CELR forms, which is recorded as either latitude and longitude or a statistical area. If a statistical area is recorded, a centroid position is assigned in the tuna database.

Samples were matched to the corresponding trip in the CELR data. Samples were assigned to the FMA in the CELR data that they were linked to. Where fishing occurred in more than one FMA, the sample was assigned to the FMA with the most catch (by fish number). Samples were stratified by month and North-South area. The North area was defined by FMA areas 1, 2, 8, 9, and 10. The other samples were assigned to the South area.

Samples were first scaled up by the total albacore catch in each landing. These were then scaled up by the total catch in the month to give an overall scaled-up LF (length frequency). Some months were not sampled and so the catches from these months were assigned to the nearest month that was sampled.

Target coefficient of variation

Mean weighted CVs were calculated using the 'catch.at.age' software developed by NIWA for the analysis of mean weighted CVs across length classes.

Mean weighted CVs of length frequency estimates were calculated with the original port sampling data analysed in 1 cm length classes. The mean weighted CV was calculated as the average of the CVs for the individual length classes weighted by the proportion of fish in each class. Coefficients of variation were calculated by bootstrapping with fish resampled within each landing and landings resampled within each month. Although the resulting CVs would be smaller if the size classes were aggregated, the finer resolution of the original data has been maintained because the purpose of the data is for inferring growth rate within a length-based age-structured model, MULTIFAN-CL (Fournier et al. 1998).

3.2 Results

3.2.1 Total troll catch

The total albacore troll catch, shown as fish numbers and fish weights, for 1999–00 to 2011–12 is shown in Table 7 and a plot of fish numbers is shown in Figure 12. Fishers should record number of fish caught for the tuna species on CELR forms, but sometimes record weights, and these are separated when loading data to the tuna database (Wei 2007). Catch weights were estimated from catch numbers by multiplying them by the average fish weight for each year which was determined by the albacore troll sampling programme. Where fishers recorded weight instead of fish number, these weights were divided by average weights to estimate catch numbers. Weights were recorded for 1.9% of CELR records.

Over this period, the troll fishery peaked in 2003–04 and has declined to 2006–07. Catches fluctuated during to 2011−12 (Table 7, Figure 12).

3.2.2 Catch sampling

Sample targets were based on the monthly distribution of the commercial catch during 2005–06 to 2007–08 (Figure 13). The average proportions each month over the three years (shown as black bars in Figure 13) were used to set the targets for the 2009−10 to 2011–12 fishing seasons, based on approximately 5000 fish each year. The targets and the numbers sampled each year and month during 2009−10 to 2011–12 are shown in Table 8 and Figure 14.

During 2009−10, 4185 fish were sampled from 41 landings, 600 fish from three landings in January in Auckland, and 3585 fish from 38 landings in Greymouth between January and April. During 2010–11, 4783 fish were sampled from 48 landings between January and April, all in Greymouth. During 2011–12, 5100 fish were sampled from 50 landings, 400 fish from three landings in Auckland in December, and 4700 fish from 47 landings in Greymouth, between January and April.

Fishing seasons were short in the North region in these three years, and boats headed south in January and fished until April in each of the three years. Access to sampling sheds was denied in Auckland in 2010–11. Auckland fish were sampled by staff of Sanford Limited in December 2011.

Weights were recorded for 1386 fish over the three years, 500 in 2009−10, 386 in 2010−11, and 500 in 2011−12. Two outliers were removed from the 2011−12 sample, leaving 498 for that year and a total of 1384 records.

An additional four landings were sampled in 2009−10 to collect biological samples for SPC and CSIRO. Forty fish were sampled each month from January to April in Greymouth, collected as evenly as possible across 10 cm size bands. Otoliths, dorsal fin spines, gonads, and tissue samples were collected from these fish as well as length and weight measurements. These samples were frozen and sent by frozen freight to CSIRO in Australia. NIWA also assisted with handling and freight of biological samples (otoliths, spines, gonads, stomach, muscle, liver, blood) collected by a SPC scientist on board a New Zealand vessel chartered in April–May 2010 to catch albacore by longline and tag and release them.

There were two tag returns of OTC-injected albacore with white tags, one in February 2010 and one in March 2012. Both of the fish were recovered from the fishers by NIWA staff who measured the fish and collected otoliths and fin spines from them. Recapture information, tags and samples and were sent to CSIRO in Australia.

3.2.3 Size composition

The length frequency distributions of fork length, by month, for albacore sampled from troll vessels during 2009−10, 2010−11 and 2011−12 in Auckland and Greymouth are shown by month and port in Figure 15.

Three modes were visible in most months during 2009−10 and 2010−11 (Figure 15), but there only two clear modes during 2011−12, and few small fish less than 50 cm fork length. The second mode, at about 60 cm was the predominant mode in 2009−10 and 2010−11. The dominant mode in 2011−12 was at 57–58 cm in the fish sampled in Greymouth from January to April, while the second mode was larger in the fish sampled in December in Auckland.

Fish sampled during 2009−10 to 2011−12 ranged in size from 41 to 96 cm, with nearly all fish (99%) in the 48–77 cm range. The median fork length was 61 cm, 59 cm and 60 cm respectively for the three fishing seasons with an overall median of 60 cm. The mean fork length over the three years was 60.9 cm.

The distributions of the fish sampled in the two ports and their median lengths were difficult to compare because there were few fish sampled in Auckland. The distribution and medians appeared similar in January 2010. In 2011−12, the Auckland median in December 2011 was 65 cm with a larger second mode, while in January to April, in Greymouth, the median was 60 cm.

The greatest proportion of small fish was in the 2010−11 sample, with 361 fish (7.55%) under 50 cm. In 2009−10 there were 113 (2.70%). Only four fish (0.08%) less than 50 cm were recorded in 2011−12. Few fish were longer than 75 cm (1.43% in 2009−10, 1.17% in 2010−11, and 1.29% in 2011−12).

Length statistics for each month for each port sampled in the 2009−10 to 2011−12 seasons are shown in Table 9, and statistics for 1996–97 to 2011−12 are summarised in Table 10, with the length frequency distributions for each of these years in Figure 16. During the 15 years of sampling, the fork length of troll-caught albacore ranged from 38 to 99 cm, with nearly all of the fish (99%) in the 47–81 cm range; the mean was 62.9 cm, and the median 62 cm (Table 10). The lowest median, 59 cm, was seen in 2010−11. Three modes were visible in most months of the years sampled. These modes tended to increase by about 1 cm each month during the sampling period.

There was considerable variability in the distributions from year to year (Figure 16). In 1998–99 there was a large proportion of small fish (46–56 cm). There was one dominant mode centred around 60 cm in the fish sampled in the 1999–2000 season. The greatest proportion of large fish (68–78 cm) was seen in the 2000–01 sample. In 2001–02, there were more small fish with the peak of the largest mode at 62 cm, and there were also a significant number of large fish (over 75 cm). The peak of the largest mode was at 61 cm in 2002–03, and there were few fish over 75 cm, and more smaller fish (less than 55 cm). In 2003–04 there were two prominent modes with peaks at 62 cm and 70 cm, few small fish (less than 55 cm) and a large proportion of bigger fish, but few over 75 cm. A larger proportion of both smaller and bigger fish was seen in 2004–05. The 2005–06 distribution showed two distinct modes, and a good representation of both small fish (less than 55 cm) and large fish (over 75 cm). There were three prominent modes in the 2006–07 distribution. Small and large fish were well represented, and there were more fish longer than 85 cm fork length than seen in any of the previous years. Three modes are again seen in 2007–08, with a good representation of small and large fish, although there were fewer fish longer than 85 cm fork length than in the previous year.

Three modes were visible in 2009−10 and 2010−11, but there were few fish longer than 75 cm. The lowest mean and median across the fifteen years of sampling were seen in 2010−11. There were two clear modes in 2011−12, and a lack of small fish. There were only four fish less than 50 cm, this being the smallest proportion of small fish.

Length distributions of troll- and longline-caught albacore are shown in Figure 17. Troll-caught albacore were from 15 years of sampling combined (1996–97 to 2011−12) and longline-caught albacore were measured by observers from 1997 to 2012. Albacore caught in New Zealand by longline were larger than troll-caught fish, with a median fork length of 78 cm, mean fork length of 80.0 cm, and most fish (99%) in the 56–106 cm size range (Table 10). Albacore are usually taken as bycatch in longline operations targeting southern bluefin tuna and bigeye tuna, and they are caught over a wider geographic area, and are caught all year round.

3.2.4 Length-weight relationship

Length and weight data have been recorded for 13 fishing years, 1998–99 to 2011–12. The length-weight relationships for troll sampled albacore sampled are shown in Figure 18 for each of the three years, 2009−10, 2010−11 and 2011−12.

A summary of the linear regression parameters and their standard errors is shown in Table 11, for the following equation:

$\ln(\text{greenweight}) = b_0 + b_1 * \ln(\text{fork length})$

3.2.5 Scaled catches and target coefficient of variation

The length frequencies scaled to the total catch numbers are shown in Figure 19 for 2009–10 to 2011–12.

The pooled mean weighted CVs by year were 13.0 in 2009–10, 13.6 in 2010–11, and 15.6 in 2011–12. The MWCVs were well below the target CV for this port sampling project of 20%.

3.2.6 Representativeness of sampling

Most troll fishing was in FMA 7, with 77.5% of days fished in this FMA over the three years 2009–10 to 2011–12 (Table 12). Sampling over this period was in FMAs 5, 7, 8, and 9 with similar proportions to those fished (Table 13). Fishing in FMAs 5, 7, 8, and 9 (i.e. the west coast) accounted for 96.5% of the commercial catch. Fishing in the north in FMA9 declined over the three year period 2009–10 to 2011–12, and increased in the south, especially FMA 7 (Table 12).

This will be expanded on in Section 5, where both shore-based catch sampling and observer sampling are compared with commercial data for spatial and temporal representativeness.

4. ALBACORE TROLL FISHERY COVERAGE BY OBSERVERS

4.1 Methods

Under projects SEA2010-09 and SEA2011-15, albacore troll data collected by observers were summarised.

These projects address the following:
1. How many vessels and landings were observed.
2. What proportion of the effort was covered by observers.
3. How well the observers covered the fleet spatially and temporally.
4. How the observer coverage compared to the catch sampling.
5. The catch and bycatch composition recorded by observers.

4.1.1 Data sources

Observers from the MPI Observer Programme began to go to sea on troll vessels in 2007. After one trial trip in 2007 and one in 2008, the Observer Programme was assigned by MPI Policy a target number of days to be observed on troll trips from 2009 onwards. Since the development of the HMS fisheries plan in 2010 observer targets were set by the plan.

Observers on troll vessels complete the following forms
1. Observer Trolling Hourly Observation Form.
2. Observer Trolling Line Configuration Form.
3. Observer Trolling Fishing Gear Form.
4. Observer Temperature Calibration Form.

The hourly observation form is completed as close to hourly as possible. Observers record the following:
1. Trip and observer information.
2. Vessel information.
3. Effort and environmental conditions at the start of the observation period (time, position, FMA, target species, number of lines fished, vessel speed, wind speed and direction, sea state, cloud cover and sea surface temperature).
4. Catch (number of fish retained and non-retained, by species).
5. Activities during this recording period.

Observers began to record lengths of albacore in 2011.

Observer data were extracted from the *cod* database (Sanders & Fisher 2011).

As for the shore based catch sampling data (in Section 3 above), observer data were stratified by month and North-South area, and linked to corresponding CELR data.

The data available were summarised, length frequencies were plotted and scaled to the total catch, and the data were assessed for spatial and temporal representativeness. Catch composition and discard practices were summarised.

The observer programme counts the number of days in a trip starting from the day that the observer joins the vessel to the day that the observer leaves the vessel. All days in between are counted as sea days including those spent steaming, searching and dodging bad weather. Any day that the observer spends on the vessel in port is also counted as a sea day. The number of days fishing is therefore less than the number of days counted as a trip.

4.1.2 Scaling of observer data to troll catch

The total length frequency for a fishing year was stratified by region (North or South) and month within region. Hourly observed number of albacore were scaled up to commercial fishery numbers at the daily, trip, month, region (North or South), and total for the year levels. Bootstrapping was used to estimate CVs. The program NIWA Catch At Length and Age (CALA) program was used to do the scaling and bootstrapping (Dan Fu, pers. comm.).

4.2 Results

A summary of the number of trips, including the number of days, months fished, FMAs, methods and the number of albacore lengths recorded by observers is shown in Table 14. This includes trips where any troll fishing occurred, either solely trolling for albacore or those that fished used a mixture of fishing methods. Information on the number of days counted as 'sea days' by the Observer Programme was not available for all trips especially prior to 2011−12. We could only summarise the number of days for which there were data collected for the majority of trips.

There was one (exploratory) observer trip on a troll vessel in 2006−07, and another trip in 2007−08. In 2008−09 there were two troll trips targeting albacore and a third which was an inshore trip mainly fishing by trawl, with two troll events, one targeting albacore and one targeting kahawai. In 2010 there were 7 trips. One of these was not a typical trip – it was chartered for albacore tagging and fishing was by a combination of surface longline and troll, and often there was a combination of the two methods each day. There were four trips in 2010−11 and one of these trips was atypical, with just one day of trolling and the catch was mainly barracouta. Albacore lengths were recorded from February 2011 onwards. In 2011−12 there was one long trip, spanning a number of landings, months and areas.

4.2.1 Observer targets

Table 15 and Figure 20 show the target number of observer troll days each year and the number observed each year. The number of days counted against the Observer Programme targets was not available for all trips, so the numbers used in Table 15 and Figure 20 may not match those of the Observer Programme. All troll days including those in mixed method trips are counted, so it is an over-estimate of the days of true troll days. In some cases the trip days are less than the days counted by the Observer Programme, for example the trip in 2012 which spanned several landings is counted as 36 sea days while there were data for 22 days. Even when including all possible troll days, the yearly target was only achieved in 2009−10.

Table 16 and Figure 21 show the target number of days and the days observed per month. Monthly targets were not achieved in most months. Targets were only achieved in February 2010, March 2010, December 2010 and March 2011. The best observer coverage was during February and March, and the best coverage of the season occurred in 2010−11.

Targets have been set for the 2012−13 fishing year, with an increase in the number of days and a requirement to sample more vessels (Table 17).

The number of albacore lengths recorded by observers is summarised in Table 18. Observers recorded lengths of 58% of the retained observed albacore catch in 2011 and 94% in 2012.

4.2.2 Catch composition

The catch composition recorded by observers is shown in Table 19. Trips that did not reflect typical troll fishing for albacore or catch retention were excluded from this table, namely the trips fishing by mixed methods (one predominantly trawl, one mainly bottom longline, and one mainly surface longline), and the trip that was chartered for albacore tagging (mainly fishing by surface longline). The trip fishing one day only with high barracouta catch was also excluded. The percentage of the catch that was comprised of each species is also shown in Table 19.

Albacore made up the majority of the catch, 97–99% in most years. There were small catches of Ray's bream and skipjack tuna (approximately 2–3% over six years), and all other recorded species amounted to less than 1%. In 2009−10 there were 174 fish recorded as unidentified.

Ray's bream (*Brama brama*) may include Southern Rays bream (*Brama australis*) and bronze bream (*Xenobrama microlepis*). Observers now have identification guides and training to distinguish between these species but some mis-identification may occur, particularly in earlier years.

4.2.3 Discard status

The number of each species that were retained or discarded and the percentage retained each year are shown in Table 20. Most albacore were retained, with an average of 91% over the six year period. This varied with year, trip, and vessel. Individual trip and vessel data are not shown (for confidentiality) but the rate of albacore discarding ranged from 0–68% among trips.

Most Ray's bream were retained, while most skipjack were discarded particularly in 2010−11. Fish that observers recorded as unidentified were discards (Table 20).

Discarded fish were not measured. Discarded fish were small or in poor condition, and this varied from vessel to vessel. Some fishers kept everything, others just retained the higher value fish.

4.2.4 Length frequency data

Observers recorded lengths of 2699 albacore in 2011, and 2526 in 2012. Length frequencies by month are shown in Figure 22, and with all months combined in Figure 23.

4.2.5 Scaled catches

Length frequencies scaled to the total catch numbers with CVs are shown in Figure 24 for 2011 and 2012.

4.2.6 Representativeness of sampling

This will be covered in Section 5, where both shore-based catch sampling and observer sampling are compared with commercial data for spatial and temporal representativeness.

5. COMPARISON OF CATCH SAMPLING DATA AND OBSERVER DATA

5.1 Methods

Troll data collected by observers were compared with data from the catch sampling programme to assess the usefulness of different types of data collected, and to compare spatial and temporal coverage of the troll fishery.

The first year that could be used to compare observer coverage and shed sampling was 2009−10, because the first two years were exploratory in terms of observer coverage, and there was no shed sampling in 2008−09. The spatial and temporal coverage of the sampling data and the observer data collected during the three years, 2009−10 to 2011−12 were compared with CELR data. Most fishers recorded statistical area and this limits the precision of the fishing effort data in terms of showing spatial coverage.

Length data collected by observers during 2010−11 and 2011−12 were compared with the length structure of the port sample data, before and after scaling.

5.2 Results

5.2.1 Comparison of spatial and temporal coverage

The number of vessels, landings, and days fished were compared with the number of vessels, landings, and days observed (Table 21). The most recent three years, 2009−10, 2010−11, and 2011−12, are shown in bold, and these three years were used for more detailed comparisons, in particular 2010−11 and 2011−12 which have albacore length data.

During 2009−10 to 2011−12 a greater proportion of days fished, vessels, and landings were covered by shed sampling than by observers. In these three years, shed sampling coverage ranged from 4.3–6.5% of days fished, 19.4–25.0% of vessels, and 3.6–4.8% of landings, while observer coverage ranged from 0.5–1.5% of days fished, 0.6–5.0% of vessels, and 0.7–1.2% of landings (Table 21).

The days, and percentage of days fished, sampled and observed, by month are shown in Table 22 and Figure 25. The days fished and percentage of days, fished, sampled and observed by FMA during 2009−10 to 2011−12 is shown in Table 23 and Figure 26.

Most fishing occurred from December to April, with over 80% of the effort during January to March. The shed sampling distribution over months more closely followed the fishery than the observer coverage (Table 22, Figure 25). Most of the fishing occurred in FMA 7, and there was some effort in west coast FMAs 5, 8, and 9, and only a small amount off the east coast in FMA 1 and 2. The distribution of the shed sampling more closely matched the fishing effort by FMA than the observed trips (Table 23, Figure 26).

Catch of albacore by month is shown in Table 24 and by FMA is shown in Table 25. Most of the fish was caught between January and March, with 66% caught during the three years in the peak months January and February. Catch by FMA is shown in Table 25. Almost all (96–97%) of the fish was caught on the west coast in FMAs 5,7,8, and 9, with 80% in FMA 7.

Statistical area density plot maps compare areas fished, sampled, and observed in 2010−11 and 2011−12 (Figure 27 and Figure 28) and percentages of catch (number of fish) caught, sampled and observed in each statistical area are compared in Figure 29.

The sampling over statistical areas more closely matched the fishing effort than the observer coverage does (Figures 27, 28, and 29). Most of the fishing was off the West Coast of the South Island (WCSI)

Statistical Areas 033, 034, and 035. Several mismatches can be seen from these figures. In 2011 there was high observer cover in Statistical Area 014 on the East Coast of the North Island (Figure 27 and 29), and a lack of cover in area 035. In 2012 there was a lack of cover in areas 033 and 034 and high cover in area 045 off the West Coast of the North Island. In both years the catch sampling was well spread over the west coast particularly the WCSI in Statistical Areas 033, 034 and 035.

5.2.2 Comparison of scaled and unscaled catches from catch sampling and observer data

Raw unscaled length frequencies by month are compared side by side for sampled and observer data for 2010−11 in Figure 30, and for 2011−12 in Figure 31. Raw and scaled annual length frequencies for 2010−11 and 2011−12 are presented side by side in Figures 32 and 33. Sampling and observer length frequencies are also shown for two overlapping months each year, February and March 2011, and January and February 2012 in Figure 34 and Figure 35.

These figures all show the same general trend, that there are differences between the observer and catch sampling data, and that these differences are not explained by scaling.

No overlapping trips were from vessels that were both observed and sampled.

5.2.3 Representativeness of the observer and sampling data

The main differences in the sample and observer data are as follows

- In 2011, the observer data had relatively more small fish and also very large fish.
- In 2012, the observer data had relatively more small fish and fewer fish in the 65–75 cm range (the third mode).

This can be seen in Figure 36 where the two distributions are overlaid.

Table 26 gives a summary of the catch, in number of albacore, by month and FMA for fished catch from CELR data, and corresponding sample and observed data.

In Table 26, and also in the comparisons of statistical areas (Figures 27, 28, and 29) it can be seen that the catch sampling data was fairly representative of the fishery in spatial and temporal coverage with the sampling well distributed among the months and FMAs similar to that of the catch.

The observer coverage was much less representative. The following points were noted for the 2011 observer coverage:

- In 2011, a trip in March–April in Statistical Area 014 (FMA 2), was very oversampled. Only 2% of the catch corresponded to these two months in FMA 2. Statistical Area 014 was where all the large fish were from.
- There was no observer coverage in January 2011, when 32% of the catch was landed.
- The FMA 7 coverage on WCSI was only from Statistical Areas 033 and 034, while 035 was not observed (Figure 29).

The following points were noted for the 2012 observer coverage:

- There was coverage of only one vessel in 2012, covering several landings and three areas.
- March 2012 in Statistical Area 045 (FMA 9) was very oversampled, corresponding to only 0.3% of the landed catch for this month and area.
- FMA 7 on WCSI was relatively undersampled.
- The coverage of WCSI in 2012 all came from Statistical Area 035, with no coverage of statistical areas 033 and 034 (Figure 29).

Most of the catch came from WCSI especially FMA 7 with some from FMA 5, and it is distributed over Statistical Areas 032, 033, 034, 035, and 036. Larger fish tend to be caught further south and that is taken into account in sampling the west coast and making sure to sample boats fishing further south in Statistical Areas 032 and 033 (M. O'Driscoll, pers. comm.).

Figure 37 shows catch known to come entirely from one statistical area in areas 033, 034, and 035 from catch sampling in 2011. It doesn't take month into account and many trips were excluded because they fished over two or more statistical areas, but it gives an indication that there are larger fish in area 033.

Figure 38 shows length distributions from three observed trips in 2011. Trip A fished only in area 034 while Trip B fished in areas 033 and 034. A comparison of sampled LFs from Statistical Area 034 (Figure 37, centre) and observed Trip A (Figure 38, top) suggests that there were a greater proportion of small fish in the observed samples. The larger fish from Statistical Area 014 came from Trip C (Figure 38).

Differences seen in the 2012 data can be attributed to sampling from only one vessel in three particular areas that didn't adequately reflect the spread of fish along the west coast, in particular the spatial mismatch on WCSI.

Scaling does not appear to be the main reason for differences between sampled and observed catches as raw and scaled length frequencies are very similar. There also appeared to be over-representation of small fish in observer samples.

5. DISCUSSION

Catch sampling in landing sheds

Characterisation of the fishery was carried out to show the spatial and temporal distribution of the albacore troll fishery effort and catch during previous years, especially 2005−06 to 2007−08, to ensure that sampling in the landing sheds over the 2009−10 to 2011−12 fishing seasons was representative of the fishery.

Prior to 2009−10 the number of fish sampled was 1000 fish per month per port, as specified by SPC. The sampling regime was changed for the three years that this project covers with the aim of collecting samples proportional to the commercial catch. Target numbers of fish to be sampled each month were based on the proportions of albacore caught per month during 2005−06 to 2007−08. Monthly distributions of the numbers of fish sampled during 2009−10 to 2011−12 matched the targets quite closely.

Over 2009−10 to 2011−12, 14 068 albacore were measured in the landing sheds. Fish ranged in size from 41–96 cm, with most of the fish (99%) in the 48–77 cm range. As albacore reach sexual maturity at about 85 cm almost all of these fish were juveniles.

Sampling was carried out in two ports. The distributions of the fish sampled in the two ports and their median lengths were difficult to compare, with few fish sampled in Auckland. The only month with overlap of Greymouth and Auckland fish was in January 2010, when three samples were obtained in Auckland and only one in Greymouth, when the season started in late January. The second and third modes appeared similar but there were fewer small fish in the Greymouth samples. The median fork length was 60 cm in the Auckland samples and 62 cm in the Greymouth samples. Three samples were obtained in December 2011 (2011–12 season) and there may have been a difference in the size distribution of these fish with a greater proportion of larger fish relative to the January sample from Greymouth but this was not conclusive. There are fishing area and vessel practices which lead to a lot of variation and the need for more samples to conduct meaningful comparisons.

There are differences in prices paid to fishers by the licenced fish receivers, and a pricing differential between fish that are above or below 4.5 kg. These can vary from year to year and affect the proportion of small fish retained.

Display of accurate fishing positional information is limited by the data recorded on CELR forms, where less than 5% of forms have latitude and longitude recorded.

Observer troll data and comparison with shore based catch sampling

MPI observers have recently been going to sea on albacore troll trips. Biological data collected by these observers were summarised and compared with data from the commercial fishery and the catch sampling data to show what data are collected, how representative they are, and whether targets were reached.

The coverage achieved by observers was less than that achieved by the shore based catch sampling in terms of number of days, number of vessels, and number of landings. In most years and most months targets were not reached and the coverage was particularly poor in the early part of the season (December–January).

The troll fishery is comprised of many vessels, and most of them are small vessels, some of the trips are quite short, and many of the vessels are difficult to track down. Cost effectiveness is a major consideration in assigning observers to vessels and there is a tendency to place observers on the larger vessels and those that are more accessible, as opposed to aiming for random placement or representativeness of the fishery (MPI Observer Programme, pers. comm.). It tends to be an expensive fishery in terms of ‘observer days’ which include time in port, steaming, and dodging bad weather. Sometimes vessels fish by a combination of different methods (eg. troll and surface longline, or troll and trawl) and this cannot always be anticipated in advance. Intended fishing areas can also change. Taking these factors into account, data from observed trips is less likely to be random or representative of the fishery than the shed sampling.

Shed samplers are able to record catch composition data from a larger number of vessels and landings and to select landings based on where fishing occurred.

The data recorded by observers and the shed sampling programme differ. In the shed sampling, a random sample is taken of the catch in a landing, while observers could be able to quantify the whole catch for that landing. Shed samplers record fish lengths, and a sub-sample of weights, and collect biological samples as required, including otoliths, fin spines, gonads, and tissue samples. Prior to January 2011 observers did not record biological data but did quantify bycatch and discard practices.

There appeared to be over-representation of small fish in observer samples. There are several possibilities for this. It could be that there is not enough sampling to even out different fish sizes in different areas, and different discard practices between different vessels. Observers record the number of discarded fish but discards are not measured, so the observers and the shed sampling programmes were sampling the same fish. There does seem to be an observer effect with observed vessels retaining more small fish.

There is a price differential for small and large fish, where fish below 4.5 kg get a lower price, so there may be a financial incentive for some fishers to discard the smaller fish. It has been suggested that observed vessels start fishing later in the morning and stop fishing earlier (possibly to avoid Ray’s bream bycatch) and this may affect the albacore catch. There is wide variation in discard practices from vessel to vessel with some retaining all of their catch and some retaining larger fish and discarding small ones (MPI, Observer Programme, pers. comm).

Scaling does not appear to be the main reason for differences between sampled and observed length frequencies as both raw and scaled length frequencies are very similar. Observer length frequencies can be atypical with data from small parts of the fishery. With too few vessels sampled, the between vessel effects are fixed into the fishery length frequency.

The New Zealand albacore troll fishery has Marine Stewardship Council certification. This requires sufficient observer coverage to ensure that bycatch species, particularly those at risk, are not overexploited. The albacore troll fishery is relatively species specific, with few other species caught. If further monitoring of bycatch is required it will need to be collected by observers. However, with low levels of observer coverage, quantification of bycatch would be uncertain, especially if the presence of an observer were to alter fishing practices.

Another limitation of CELR forms is the lack of provision for reporting bycatch and discards. Creation of a new custom troll form (similar to the TLCER form) would enable to fishers to record bycatch, discards, accurate positional information, and both fish number and weight.

International use of troll data for stock assessment

Data from this albacore troll sampling programme are provided to SPC for incorporation into the stock assessment of South Pacific albacore. This was most recently described by Hoyle et al. (2012).

Continued monitoring of the catch composition of juvenile albacore in the New Zealand troll fishery is a critical input to the length-based regional stock assessment of the South Pacific albacore stock. The New Zealand fishery accounts for up to half of the total removals of juveniles from this stock and is one of only a few target fisheries for this stock.

The New Zealand troll data were specifically mentioned as informative data for the WCPFC South Pacific albacore stock assessment (Hoyle et al. 2012). Currently, the New Zealand troll size data provide essential information about growth rates of young fish. Hoyle et al. (2012) state "The data that provide by far the most information about growth rates is the New Zealand troll data, mostly sampled from 165–175°E, which is modelled at a monthly time step and demonstrates very clear and consistent growth modes."

If the growth curve changes these data are essential. The relative strength of different size modes in the same year provides information to the model about relative year class strength, i.e. relative recruitment. This information needs to be constantly updated and missing a year means losing precision.

In future, SPC plans to use New Zealand troll size data to improve the assessment, and understanding of the albacore fishery by investigating variability in growth and recruitment timing between years (S. Brouwer, MPI). Annual variation is seen, with fish growing faster or recruiting earlier in some years, but the level of variation has not been assessed or linked to covariates such as oceanographic variables. The time series of good quality data is still fairly short for this kind of analysis, and cutting back on sampling would make this work harder to do. In addition, climate change may affect growth rates, which would change the productivity of the stock. This would be important to identify, and it should be noted that these changes could be detected sooner with more frequent sampling.

Conclusions

The HMS Working Group decided that troll fishery data collected by observers was not representative enough to enable length data collected by observers to be used for albacore stock assessment instead of shore based catch sampling. The Observer Programme sampled too few vessels for the length data to be representative, especially with the variable fishing and discarding practices among different vessels.

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Table 1: Number of fish sampled for length from each year and port from 1996−97 to 2007−08.

	Port			
ALB year	Auckland	Greymouth	New Plymouth	All ports
1996–97	200	4 017		4 217
1997–98	982	2 996		3 978
1998–99	400	3 031		3 431
1999–00	949	3 013		3 962
2000–01	2 000	3 192		5 192
2001–02	1 400	3 770		5 170
2002–03	2 002	2 602	3 002	7 606
2003–04	1 821	2 666	998	5 485
2004–05	2 431	3 071		5 502
2005–06	1 600	3 070		4 670
2006–07	1 600	2 600		4 200
2007–08	400	4 164		4 564
Total	15 785	38 192	4 000	57 977

Table 2: Variables considered in the GAM analysis.

Code	Variable
Mth	Calendar month
Lat	Latitude
Year	Albacore fishing year (2005–06 is plotted as 2006)
Long	Longitude
overall.length.m	Overall length in m (only length present for all vessels)
horse.power	Horse power
Port	Port the sample was taken in

Table 3: Order of variables as determined by step-wise procedure using the largest increase in R^2. *See* Table 2 for code descriptions. S( ), spline.

Added variable	df	Deviance	AIC	R^2 (%)
mth	4.00	453	332	22.3
+s(lat)	9.45	364	328	37.6
+year	11.90	271	313	53.6
+s(long)	12.94	256	311	56.2
+s(overall.length.m)	17.32	237	314	59.5
+s(horse.power)	22.45	181	307	69
+port	22.93	176	305	69.9

Table 4: ANOVA and F-test results from the cascade of models on mean length (meanL, cm). ***See*** **Table 2 for code descriptions. Cascade order determined from Table 3.**

Model description

Model number	Model
1	meanL ~ 1
2	meanL ~ mth
3	meanL ~ s(lat) + mth
4	meanL ~ s(lat) + mth + year
5	meanL ~ s(lat) + s(long) + mth + year
6	meanL ~ s(lat) + s(long) + mth + year + s(overall.length.m)
7	meanL ~ s(lat) + s(long) + mth + year + s(overall.length.m) + s(horse.power)
8	meanL ~ s(lat) + s(long) + mth + year + s(overall.length.m) + s(horse.power) + port

ANOVA

Model	Residual df	Residual Deviance	Df	Deviance	F	Pr(>F)	Signifiance code
1	67.0	583.8					
2	64.0	453.5	3.00	130.3	11.1	0.00001	***
3	58.5	364.2	5.45	89.3	4.2	0.00257	**
4	56.1	270.8	2.45	93.5	9.8	0.00012	***
5	55.1	255.9	1.04	14.9	3.7	0.06062	.
6	50.7	236.6	4.38	19.3	1.1	0.35740	
7	45.6	181.3	5.13	55.4	2.8	0.02813	*
8	45.1	175.9	0.48	5.3	2.8	0.11094	

Signifiance codes: *** , ≥0, <0.001; ** , ≥ 0.001, <0.01; * , ≥ 0.01, <0.05; . , ≥0.05, <0.01; blank, <0.01

Table 5: Comparison of annual CELR catch numbers of fish and sample catch by month and latitude group for the previous three years that were sampled, expressed as percentages. - , no data. Percentages have been rounded to nearest 0.1% so grand total does not necessarily add up to 100%. Latitude group (30,36] is ≥ 30 and <36, etc.

	CELR data				Sample data			
	Latitude group				Latitude group			
Month	(30,36]	(36,42.6]	(42.6,50]	Total month (%)	(30,36]	(36,42.6]	(42.6,50]	Total month (%)
2005–06								
Oct	-	-	-	-	-	-	-	-
Nov	-	-	-	-	-	-	-	-
Dec	0.9	1.4	-	2.3	-	-	-	-
Jan	2.2	33.0	1.4	36.6	-	42.0	-	42.0
Feb	0.1	30.9	9.6	40.6	-	20.3	13.9	34.2
Mar	0.1	13.1	4.7	17.9	-	9.0	14.7	23.7
Apr	-	1.6	0.2	1.8	-	-	-	-
May	-	0.7	-	0.7	-	-	-	-
Jun	-	-	-	-	-	-	-	-
Total	3.3	80.7	15.9	99.9	-	71.3	28.6	99.9
2006–07								
Oct	-	-	-	-	-	-	-	-
Nov	-	-	-	-	-	-	-	-
Dec	0.2	2.9	-	3.1	-	-	-	-
Jan	1.4	10.3	0.2	11.9	8.6	11.2	-	19.8
Feb	0.4	33.1	11.4	44.9	-	32.9	9.0	41.9
Mar	-	23.2	4.2	27.4	-	16.3	6.2	22.5
Apr	0.2	10.1	0.9	11.2	-	8.2	7.7	15.9
May	-	1.4	-	1.4	-	-	-	-
Jun	-	-	-	-	-	-	-	-
Total	2.2	81.0	16.7	99.9	8.6	68.6	22.9	100.1
2007–08								
Oct	-	-	-	-	-	-	-	-
Nov	-	-	-	-	-	-	-	-
Dec	-	-	-	-	-	-	-	-
Jan	0.4	27.2	3.0	30.6	3.2	6.8	6.6	16.6
Feb	-	23.5	11.2	34.7	-	8.1	25.0	33.1
Mar	-	18.8	8.8	27.6	-	7.5	23.0	30.5
Apr	-	4.7	2.0	6.7	-	5.1	14.6	19.7
May	-	0.3	-	0.3	-	-	-	-
Jun	-	-	-	-	-	-	-	-
Total	0.4	74.5	25	99.9	3.2	27.5	69.2	99.9

Table 6: Comparison of annual CELR catch numbers of fish and sample catch by month and latitude group for the years 1996–97 to 2004–05 years expressed as percentages. - , no data. Percentages have been rounded to nearest 0.1% so grand total does not necessarily add up to 100%. Latitude group (30,36] is ≥ 30 and <36, etc.

	CELR data				Sample data			
	Latitude group				Latitude group			
Month	(30,36]	(36,42.6]	(42.6,50]	Total month (%)	(30,36]	(36,42.6]	(42.6,50]	Total month (%)
1996–97 to 2000–01								
Oct	-	-	-	-	-	-	-	-
Nov	-	0.1	-	0.1	-	-	-	-
Dec	0.7	1.5	-	2.2	-	0.2	-	0.2
Jan	3.0	23.7	1.4	28.1	2.8	43.8	0.9	47.5
Feb	3.7	30.5	3.5	37.7	2.6	26.4	4.3	33.3
Mar	2.6	21.3	1.8	25.7	-	15.3	1.0	16.3
Apr	0.8	4.1	0.2	5.1	1.1	1.6	-	2.7
May	0.2	0.9	0.1	1.2	-	-	-	-
Jun	-	-	-	-	-	-	-	-
Total	11.0	82.1	7.0	100.1	6.5	87.3	6.2	100.0
2001–02 to 2004–05								
Oct	-	-	-	-	-	-	-	-
Nov	0.1	-	-	0.1	-	-	-	-
Dec	2.7	2.6	-	5.3	0.6	1.7	-	2.3
Jan	2.7	29.6	0.9	33.2	0.7	32.4	3.6	36.7
Feb	1.7	23.3	3.0	28.0	-	30.9	5.6	36.5
Mar	0.3	19.6	3.7	23.6	-	15.4	7.4	22.8
Apr	0.5	7.3	1.1	8.9	0.1	1.6	0.3	2.0
May	0.1	0.7	-	0.8	-	-	-	-
Jun	-	-	-	-	-	-	-	-
Total	8.1	83.1	8.7	99.9	1.4	82.0	16.9	100.3

Table 7: Total troll catch recorded on CELR forms.

Year	No. of fish	Weight (kg)
1999–00	566 247	2 672 202
2000–01	550 467	2 986 363
2001–02	555 510	2 826 972
2002–03	674 283	3 130 960
2003–04	568 179	3 167 817
2004–05	476 717	2 928 249
2005–06	393 427	2 183 331
2006–07	329 775	1 716 409
2007–08	436 442	2 018 381
2008–09	373 664	1 950 843
2009–10	325 928	1 720 897
2010–11	434 300	2 067 270
2011–12	435 736	2 169 966

Table 8: Target number of fish to sample each month, and number sampled each year and month.

	Target no. of fish	2009–10	2010–11	2011–12
December	215	0	0	400
January	1 318	785	1 298	1 300
February	1 929	1 900	1 899	2 000
March	1 185	1 300	1 200	1 000
April	314	200	386	400
Total	4 961	4 185	4 783	5 100

Table 9: Summary of mean fork length, standard deviation, median, and percentiles for albacore sampled each month during 2009–10 to 2011−12.

ALB yr	Port	Month	n	mean	stdev	min	1%	5%	median	95%	99%	max
2009–10	Auckland	Jan-2010	600	61.1	6.0	42	45	49	60	71	76	81
	Greymouth	Jan-2010	185	63.2	4.2	54	57	58	62	70	72	75
	Greymouth	Feb-2010	1 900	62.8	5.1	47	53	57	61	71	79	87
	Greymouth	Mar-2010	1 300	59.7	6.0	41	48	49	60	70	72	79
	Greymouth	Apr-2010	200	61.8	4.1	51	52	56	62	70	73	82
2010–11	Greymouth	Jan-2011	1 298	59.6	5.5	44	46	50	59	70	75	96
	Greymouth	Feb-2011	1 899	59.0	5.8	45	47	49	59	70	75	89
	Greymouth	Mar-2011	1 200	60.0	6.6	45	47	49	60	72	78	87
	Greymouth	Apr-2011	386	57.7	6.4	45	46	48	59	68	72	94
2011–12	Auckland	Dec-2011	400	63.5	5.7	46	52	54	65	73	75	79
	Greymouth	Jan-2012	1 300	62.4	5.7	47	54	55	61	71	78	92
	Greymouth	Feb-2012	2 000	61.9	5.6	51	54	56	60	71	77	93
	Greymouth	Mar-2012	1 000	60.7	4.6	50	55	56	59	69	74	92
	Greymouth	Apr-2012	400	60.9	5.0	55	55	56	59	70	76	86

Table 10: Summary of length frequency statistics for albacore sampled during 15 years of troll sampling.

	n	mean	stdev	min	1%	5%	median	95%	99%	max
1996–97	4 217	65.0	6.9	40	49	51	66	76	81	92
1997–98	3 978	66.0	6.7	45	51	59	64	78	81	91
1998–99	3 431	61.4	8.7	38	47	48	62	74	81	91
1999–00	3 962	61.1	5.6	39	49	55	60	74	81	94
2000–01	5 192	65.2	8.5	40	46	49	68	75	78	99
2001–02	5 170	63.6	8.6	42	47	51	62	80	83	89
2002–03	7 606	60.9	6.4	42	47	50	61	71	76	92
2003–04	5 485	64.3	5.1	40	52	58	63	73	76	94
2004–05	5 502	66.5	7.1	45	52	55	68	76	80	94
2005–06	4 670	63.3	7.5	45	50	52	63	78	83	92
2006–07	4 200	61.4	8.1	43	49	50	61	74	80	92
2007–08	4 404	61.7	6.3	42	47	49	61	73	77	92
2008–09	0									
2009–10	4 185	61.6	5.6	41	48	51	61	71	77	87
2010–11	4 783	59.3	6.0	44	46	49	59	70	76	96
2011–12	5 100	61.8	5.4	46	54	56	60	71	77	93
All troll	71 885	62.9	7.2	38	47	50	62	75	81	99
Longline	69 276	80.0	11.8	37	56	63	78	101	106	135

Table 11: Linear regression parameters for length-weight relationships.

	n	b_0	SE_{b0}	b_1	SE_{b1}	R^2
1998–99	317	-10.61	0.13	2.95	0.03	0.97
1999–00	397	-9.46	0.16	2.67	0.04	0.93
2000–01	599	-9.86	0.12	2.77	0.03	0.94
2000–02	606	-9.69	0.1	2.73	0.02	0.95
2002–03	709	-9.82	0.16	2.76	0.04	0.87
2003–04	598	-10.33	0.14	2.89	0.03	0.92
2004–05	400	-10.36	0.13	2.9	0.03	0.96
2005–06	600	-10.47	0.1	2.92	0.02	0.96
2006–07	598	-10.63	0.06	2.97	0.02	0.98
2007–08	574	-10.33	0.11	2.89	0.03	0.96
2009–10	500	-10.57	0.11	2.96	0.03	0.96
2010–11	386	-10.22	0.15	2.86	0.04	0.94
2011–12	498	-10.09	0.14	2.84	0.03	0.93
All years	6782	-10.14	0.03	2.84	0.01	0.94

Table 12: Number of days fished by FMA and fishing year, and percentage in each FMA.

	No. of days fished					%			
	2009–10	2010–11	2011–12	3 years		2009–10	2010–11	2011–12	3 years
FMA 1	52	152	26	230	FMA 1	1.63	3.30	0.54	1.82
FMA 2	142	112	146	400	FMA 2	4.45	2.43	3.03	3.17
FMA 3	7	0	0	7	FMA 3	0.22	-	-	0.06
FMA 5	5	100	129	234	FMA 5	0.16	2.17	2.68	1.86
FMA 7	2 080	3 633	4 056	9 769	FMA 7	65.22	78.98	84.24	77.51
FMA 8	272	194	247	713	FMA 8	8.53	4.22	5.13	5.66
FMA 9	631	405	211	1 247	FMA 9	19.79	8.80	4.38	9.89
Other	0	4	0	4	other	-	0.09	-	0.03
Total	3 189	4 600	4 815	12 604					

Table 13: Number of fishing days sampled by FMA and fishing year, and percentage in each FMA.

	No. of days sampled					%			
	2009–10	2010–11	2011–12	3 years		2009–10	2010–11	2011–12	3 years
FMA 5	0	4	4	8	FMA 5	0.00	1.69	1.93	1.23
FMA 7	186	226	188	600	FMA 7	89.42	95.36	90.82	92.02
FMA 8	5	0	6	11	FMA 8	2.40	0.00	2.90	1.69
FMA 9	17	7	9	33	FMA 9	8.17	2.95	4.35	5.06
Total	208	237	207	652					

Table 14: Summary of observed trips that were solely albacore troll trips or included some albacore trolling, by albacore year, calendar year, month, days, FMA, fishing methods, and the number of albacore lengths recorded by observers. SLL, surface longline; BLL, bottom longline; BT, bottom trawl. Days below refer to the number of days from which data were available.

ALB-year	Year	Month/s	Days	FMA	Method/s	Other methods	No. of lengths
2006–07	2007	February	10	8	troll		
2007–08	2008	March	8	7	troll		
2008–09	2008	December	8	9	troll		
2008–09	2009	February	2	9	BT, troll	27 BT	
2008–09	2009	March	4	7	troll		
2009–10	2010	February	11	2,7,8,9	troll		
2009–10	2010	February	5	7	troll		
2009–10	2010	February–March	16	7	troll		
2009–10	2010	February–March	9	7	troll		
2009–10	2010	March	4	7	troll		
2009–10	2010	March	3	7	troll		
2009–10	2010	April–May	4	2	SLL, troll	12 SLL sets, tagging	
2010–11	2010	December	10	1,9	BLL/troll	counted as 7 BLL/5 troll	
2010–11	2011	February–March	13	7	troll		1 352
2010–11	2011	February–March	11	7	troll		820
2010–11	2011	March	1	7	troll		9
2010–11	2011	March–April	10	2	troll		518
2011–12	2012	January–March	22	7,8	troll	counted as 36 days troll	2 526
2011–12	2012	February	3	7	SLL, troll	counted as SLL trip	

Table 15: Target and observed days each year.

	No. of trips	Target no. of days	Days observed	Target achieved
2006–07	1	n/a	10	
2007–08	1	n/a	8	
2008–09	3	50	14	no
2009–10	7	50	52	yes
2010–11	5	50	45	no
2011–12	2	50	25	no

Table 16: Target and observed days each month, 2008–09 (above) and 2009–10 to 2011–12 (below).

2008–09	Target no. of days	Days observed	Target achieved
December	20	8	no
January	20	0	no
February	10	2	no
March	n/a	4	

	Target no.	Days observed			Target achieved		
	of days	2009–10	2010–11	2011–12	2009–10	2010–11	2011–12
December	5	0	10	0	no	yes	no
January	10	0	0	4	no	no	no
February	20	30	16	18	yes	no	no
March	10	22	16	3	yes	yes	no
April	5	0	3	0	no	no	no

Table 17: Target number of days set for observer coverage on troll vessels in 2012−13.

	Days	Vessels
December	7	2
January	14	3
February	28	4
March	14	3
April	7	2

Table 18: Number of lengths recorded by observers each month and year.

	No. of lengths	
	2011	2012
January	-	669
February	1 510	1 363
March	990	494
April	199	-
Total	2 699	2 526

Table 19: Catch composition recorded by observers, number of fish (above), and percentage of catch (below).

		Number of fish caught						
Species	Scientific name	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12	Total of 6 years
Albacore	*Thunnus alalunga*	1 684	1 776	1 755	5 403	4 905	2 772	18 295
Rays bream*	*Brama brama*		18	12	537	35	7	609
Skipjack tuna	*Katsuwonus pelamis*	1	2	26	20	359	2	410
Barracouta	*Thyrsites atun*			1		24	13	38
Kahawai	*Arripis trutta*			6		3	14	23
Kingfish	*Seriola lalandi*			2	4	4		10
Dolphinfish	*Coryphaena hippurus*				1			1
Mako shark	*Isurus oxyrinchus*						1	1
Unidentified		2			174			176

		% of catch						
Species	Scientific name	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12	Total of 6 years
Albacore	*Thunnus alalunga*	99.82	98.89	97.39	88.01	92.03	98.68	93.52
Rays bream*	*Brama brama*		1.00	0.67	8.75	0.66	0.25	3.11
Skipjack tuna	*Katsuwonus pelamis*	0.06	0.11	1.44	0.33	6.74	0.07	2.10
Barracouta	*Thyrsites atun*			0.06		0.45	0.46	0.19
Kahawai	*Arripis trutta*			0.33		0.06	0.50	0.12
Kingfish	*Seriola lalandi*			0.11	0.07	0.08		0.05
Dolphinfish	*Coryphaena hippurus*				0.02			0.01
Mako shark	*Isurus oxyrinchus*						0.04	0.01
Unidentified		0.12			2.83			0.90

*Note that Ray's bream may include Southern Rays bream and bronze bream. Observers now have identification guides and training to distinguish between these species but some mis-identification may occur.

Table 20: Number of fish recorded and retained and discarded by observers and the percentage retained.

		Number of fish retained						
Species	Scientific name	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	Total of 6 years
Albacore	*Thunnus alalunga*	1 295	1 641	1 413	4 939	4 584	2 686	16 558
Rays bream*	*Brama brama*		15	5	454	21	6	501
Skipjack tuna	*Katsuwonus pelamis*			26	13	81	2	122
Barracouta	*Thyrsites atun*			1		1	0	2
Kahawai	*Arripis trutta*			6		3	7	16
Kingfish	*Seriola lalandi*			2				2
Dolphinfish	*Coryphaena hippurus*				1			1
Mako shark	*Isurus oxyrinchus*							0
Unidentified								0
Total		1 295	1 656	1 453	5 407	4 690	2 701	17 202

		Number of fish non-retained						
Species	Scientific name	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	Total of 6 years
Albacore	*Thunnus alalunga*	389	135	342	464	321	86	1 737
Rays bream*	*Brama brama*		3	7	83	14	1	108
Skipjack tuna	*Katsuwonus pelamis*	1	2		7	278		288
Barracouta	*Thyrsites atun*					23	13	36
Kahawai	*Arripis trutta*						7	7
Kingfish	*Seriola lalandi*				4	4		8
Dolphinfish	*Coryphaena hippurus*							0
Mako shark	*Isurus oxyrinchus*						1	1
Unidentified		2			174			176
Total		392	140	349	732	640	108	2 361

		% of fish retained						
Species	Scientific name	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	Total of 6 years
Albacore	*Thunnus alalunga*	76.9	92.4	80.5	91.4	93.4	96.9	90.5
Rays bream*	*Brama brama*		83.3	41.7	84.5	60.0	85.7	82.3
Skipjack tuna	*Katsuwonus pelamis*	0.0	0.0	100.0	65.0	22.5	100.0	29.8
Barracouta	*Thyrsites atun*			100.0		4.2	0.0	5.3
Kahawai	*Arripis trutta*			100.0		100.0	50.0	69.6
Kingfish	*Seriola lalandi*			100.0	0.0	0.0		20.0
Dolphinfish	*Coryphaena hippurus*				100.0			100.0
Mako shark	*Isurus oxyrinchus*						0.0	0.0
Unidentified		0.0			0.0			0.0

*Note that Ray's bream may include Southern Rays bream and bronze bream. Observers now have identification guides and training to distinguish between these species but some mis-identification may occur.

Table 21: Summary of days, vessels and landings fished, sampled, and observed, and the percentages observed and sampled. The three most recent years, shown in bold, are the focus for this study.

	Fished		
ALB-year	Days	Vessels	Landings
2006–07	3 389	134	845
2007–08	4 479	153	1 296
2008–09	4 478	161	1 163
2009–10	**3 196**	**120**	**856**
2010–11	**4 619**	**154**	**1 225**
2011–12	**4 817**	**155**	**1 370**

	Observed			% Observed		
ALB-year	Days	Vessels	Landings	Days	Vessels	Landings
2006–07	10	1	1	0.3	0.7	0.1
2007–08	8	1	1	0.2	0.7	0.1
2008–09	18	3	4	0.4	1.2	0.3
2009–10	**49**	**6**	**10**	**1.5**	**5.0**	**1.2**
2010–11	**46**	**5**	**8**	**1.0**	**3.2**	**0.7**
2011–12	**24**	**1**	**9**	**0.5**	**0.6**	**0.7**

	Shed sampled			% Shed sampled		
ALB-year	Days	Vessels	Landings	Days	Vessels	Landings
2006–07	125	14	21	3.7	10.4	2.5
2007–08	157	22	31	3.5	14.4	2.4
2008–09	0	0	0	-	-	-
2009–10	**208**	**30**	**41**	**6.5**	**25.0**	**4.8**
2010–11	**237**	**35**	**48**	**5.1**	**22.7**	**3.9**
2011–12	**207**	**30**	**50**	**4.3**	**19.4**	**3.6**

Table 22: Number of days fished, sampled and observed by month for the 2009–10 to 2011–12 years.

			Number of days			%		
ALB yr	Year	Month	Fished	Sampled	Observed	Fished	Sampled	Observed
2009–10	2009	Sep	1	0	0	0.0	-	-
		Nov	4	0	0	0.1	-	-
		Dec	225	0	0	7.0	-	-
	2010	Jan	874	32	0	27.3	15.4	-
		Feb	964	107	31	30.2	51.4	63.3
		Mar	726	61	18	22.7	29.3	36.7
		Apr	331	8	0	10.4	3.8	-
		May	71	0	0	2.2	-	-
		All	3 196	208	49			
2010–11	2010	Oct	3	0	0	0.1	-	-
		Nov	36	0	0	0.8	-	-
		Dec	399	7	12	8.6	3.0	26.1
	2011	Jan	1 383	57	0	29.9	24.1	-
		Feb	1 493	106	16	32.3	44.7	34.8
		Mar	1 046	59	16	22.6	24.9	34.8
		Apr	255	8	2	5.5	3.4	4.3
		May	4	0	0	0.1	-	-
		All	4 619	237	46			
2011–12	2011	Nov	20	0	0	0.4	-	-
		Dec	421	18	0	8.7	8.7	-
	2012	Jan	1 458	54	4	30.3	26.1	16.7
		Feb	1 627	76	15	33.8	36.7	62.5
		Mar	815	45	5	16.9	21.7	20.8
		Apr	443	14	0	9.2	6.8	-
		May	33	0	0	0.7	-	-
		All	4 817	207	24			

Table 23: Number and percentage of days fished, sampled and observed by FMA during 2009–10 to 2011–12.

		Number of days			%		
ALB year	FMA	Fished	Sampled	Observed	Fished	Sampled	Observed
2009–10	1	52	0	0	1.6	-	-
	2	142	0	3	4.5	-	6.1
	5	5	0	0	0.2	-	-
	7	2 080	186	45	65.2	89.4	91.8
	8	272	5	1	8.5	2.4	2.0
	9	631	17	0	19.8	8.2	-
	Other	7	0	0	0.2	-	-
	All	3 189	208	49			
2010–11	1	152	0	0	3.3	-	-
	2	112	0	9	2.4	-	19.6
	5	100	4	0	2.2	1.7	-
	7	3 633	226	25	79.0	95.2	54.3
	8	194	0	0	4.2	-	-
	9	405	7	8	8.8	3.0	17.4
	Other	4	0	4	0.1	-	8.7
	All	4 600	237	46			
2011–12	1	26	0	0	0.5	-	-
	2	146	0	0	3.0	-	-
	5	129	4	0	2.7	1.9	-
	7	4 056	188	18	84.2	90.8	75.0
	8	247	6	1	5.1	2.9	4.2
	9	211	9	5	4.4	4.3	20.8
	All	4 815	207	24			

Table 24: Number of fish caught by month during 2009–10 to 2011–12.

	Catch (number of fish)			% of catch		
Month	2009–10	2010–11	2011–12	2009–10	2010–11	2011–12
Sep/Oct	1	420	0	0.0	0.1	-
Nov	50	1 084	823	0.0	0.2	0.2
Dec	17 781	32 383	30 510	5.5	7.5	7.0
Jan	91 964	138 897	176 007	28.2	32.0	40.4
Feb	95 694	159 060	132 055	29.4	36.6	30.3
Mar	80 971	86 956	63 659	24.8	20.0	14.6
Apr	35 090	15 377	31 922	10.8	3.5	7.3
May	4 377	122	759	1.3	0.0	0.2
Total	325 928	434 300	435 736			

Table 25: Number of fish caught by FMA during 2009–10 to 2011–12.

	Catch (number of fish)			% of catch		
FMA	2009–10	2010–11	2011–12	2009–10	2010–11	2011–12
1	1 134	11 070	763	0.3	2.5	0.2
2	10 111	4 611	11 690	3.1	1.1	2.7
5	28	8 713	9 455	0.0	2.0	2.2
7	222 427	358 663	379 323	68.2	82.6	87.1
8	25 746	15 959	19 476	7.9	3.7	4.5
9	65 769	34 108	14 763	20.2	7.9	3.4
Other	712	1 176	267	0.2	0.3	0.1
Total	325 928	434 300	435 736			

Table 26: Percentage of fish caught by month and FMA during 2009–10 to 2011–12.

Year	Month	FMA 1	FMA 2	FMA 5	FMA 7	FMA 8	FMA 9	Other	Total
2009	Oct/Nov	0.0	-	-	-	-	-	-	0.0
	Nov	0.0	-	-	-	-	0.0	-	0.0
	Dec	0.1	-	-	0.0	0.7	4.6	0.1	5.5
2010	Jan	0.1	0.0	0.0	6.7	6.4	15.0	-	28.2
	Feb	0.1	0.9	0.0	27.4	0.6	0.3	0.0	29.4
	Mar	0.0	0.2	0.0	24.3	0.2	0.1	0.1	24.8
	Apr	0.1	1.0	-	9.5	0.0	0.2	-	10.8
	May	-	0.9	-	0.4	-	-	0.0	1.3
2009–10 total		**0.3**	**3.1**	**0.0**	**68.2**	**7.9**	**20.2**	**0.2**	
2010	Oct/Nov	-	-	-	-	-	0.1	-	0.1
	Nov	0.0	-	-	0.1	0.0	0.1	-	0.2
	Dec	2.5	-	-	0.0	1.2	3.7	0.1	7.5
2011	Jan	0.0	0.0	0.1	25.8	2.1	3.9	0.0	32.0
	Feb	0.0	0.0	0.4	35.9	0.1	0.0	0.1	36.6
	Mar	0.0	0.5	1.5	17.8	0.3	0.0	-	20.0
	Apr	0.0	0.5	0.0	3.0	0.0	-	-	3.5
	May	-	-	-	0.0	-	0.0	-	0.0
2010–11 total		**2.5**	**1.1**	**2.0**	**82.6**	**3.7**	**7.9**	**0.3**	
2011	Nov	0.0	-	-	0.1	-	0.1	-	0.2
	Dec	0.0	0.0	-	4.0	0.9	2.1	-	7.0
2012	Jan	0.1	0.1	0.1	38.6	1.0	0.5	-	40.4
	Feb	0.0	0.0	1.9	26.0	1.9	0.3	0.1	30.3
	Mar	0.0	0.9	0.1	12.7	0.6	0.3	-	14.6
	Apr	0.0	1.6	0.0	5.6	0.0	0.0	-	7.3
	May	-	0.0	-	0.1	-	-	-	0.2
2011–12 total		**0.2**	**2.7**	**2.2**	**87.1**	**4.5**	**3.4**	**0.1**	

Table 26 (continued): Percentage of catch sampled and observed by month FMA during 2009–10 to 2011–12.

Sampled

Year	Month	FMA 1	FMA 2	FMA 5	FMA 7	FMA 8	FMA 9	Other	**Total**
2010	Jan	-	-	-	2.4	1.8	6.5	-	**10.7**
	Feb	-	-	-	51.3	-	-	-	**51.3**
	Mar	-	-	-	32.7	-	-	-	**32.7**
	Apr	-	-	-	5.3	-	-	-	**5.3**
2009–10 total		**-**	**-**	**-**	**91.7**	**1.8**	**6.5**	**-**	
2010	Dec	-	-	-	-	-	3.8	-	**3.8**
2011	Jan	-	-	0.7	25.7	-	-	-	**26.5**
	Feb	-	-	1.5	43.8	-	-	-	**45.3**
	Mar	-	-	-	21.3	-	-	-	**21.3**
	Apr	-	-	-	3.1	-	-	-	**3.1**
2010–11 total		**-**	**-**	**2.2**	**94.0**	**-**	**3.8**	**-**	
2011	Dec	-	-	-	1.0	3.5	1.4	-	**5.9**
2012	Jan	-	-	-	31.8	-	-	-	**31.8**
	Feb	-	-	0.8	37.0	-	-	-	**37.9**
	Mar	-	-	-	19.4	-	-	-	**19.4**
	Apr	-	-	-	4.9	-	-	-	**4.9**
2011–12 total		**-**	**-**	**0.8**	**94.2**	**3.5**	**1.4**	**-**	

Observed

Year	Month	FMA 1	FMA 2	FMA 5	FMA 7	FMA 8	FMA 9	Other	Total
2010	Feb	-	2.8	-	47.4	1.4	-	-	**51.6**
	Mar	-	-	-	48.4	-	-	-	**48.4**
2009–10 total		**-**	**2.8**	**-**	**95.8**	**1.4**	**-**	**-**	
2010	Dec	-	-	-	-	-	2.1	-	**2.1**
	Jan	-	-	-	-	-	-	-	**-**
2011	Feb	-	-	-	48.9	-	-	-	**48.9**
	Mar	-	10.8	-	30.1	-	-	-	**40.9**
	Apr	-	8.2	-	-	-	-	-	**8.2**
2010–11 total		**-**	**19.0**	**-**	**79.0**	**-**	**2.1**	**-**	
2012	Jan	-	-	-	22.3	-	-	-	**22.3**
	Feb	-	-	-	38.2	4.5	-	-	**42.7**
	Mar	-	-	-	-	-	35.0	-	**35.0**
2011–12 total		**-**	**-**	**-**	**60.5**	**4.5**	**35.0**	**-**	

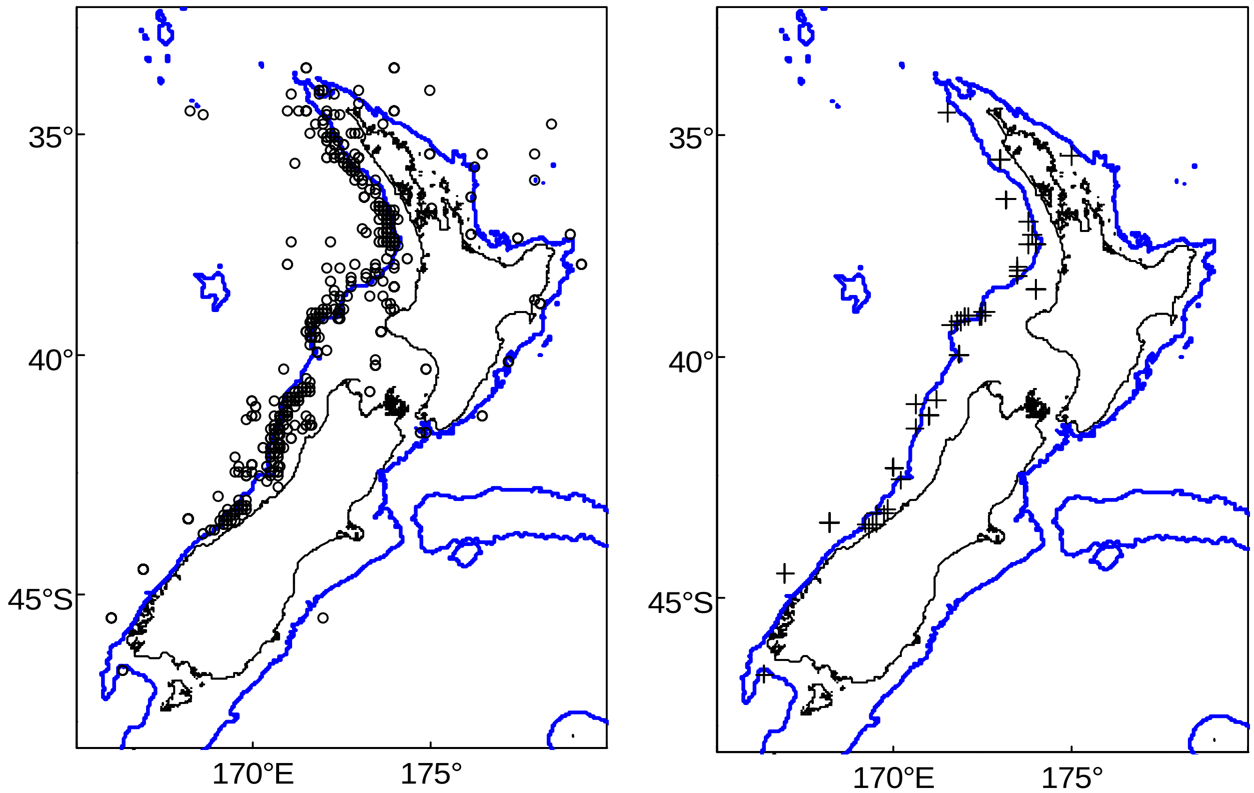


Figure 1: Positions of troll fishing from 2005–06 to 2007–08 recorded on CELR returns (left) and from catch sampling (right). The 500 m depth contour is shown in blue. West coast troll fishing represents 98% of the total.

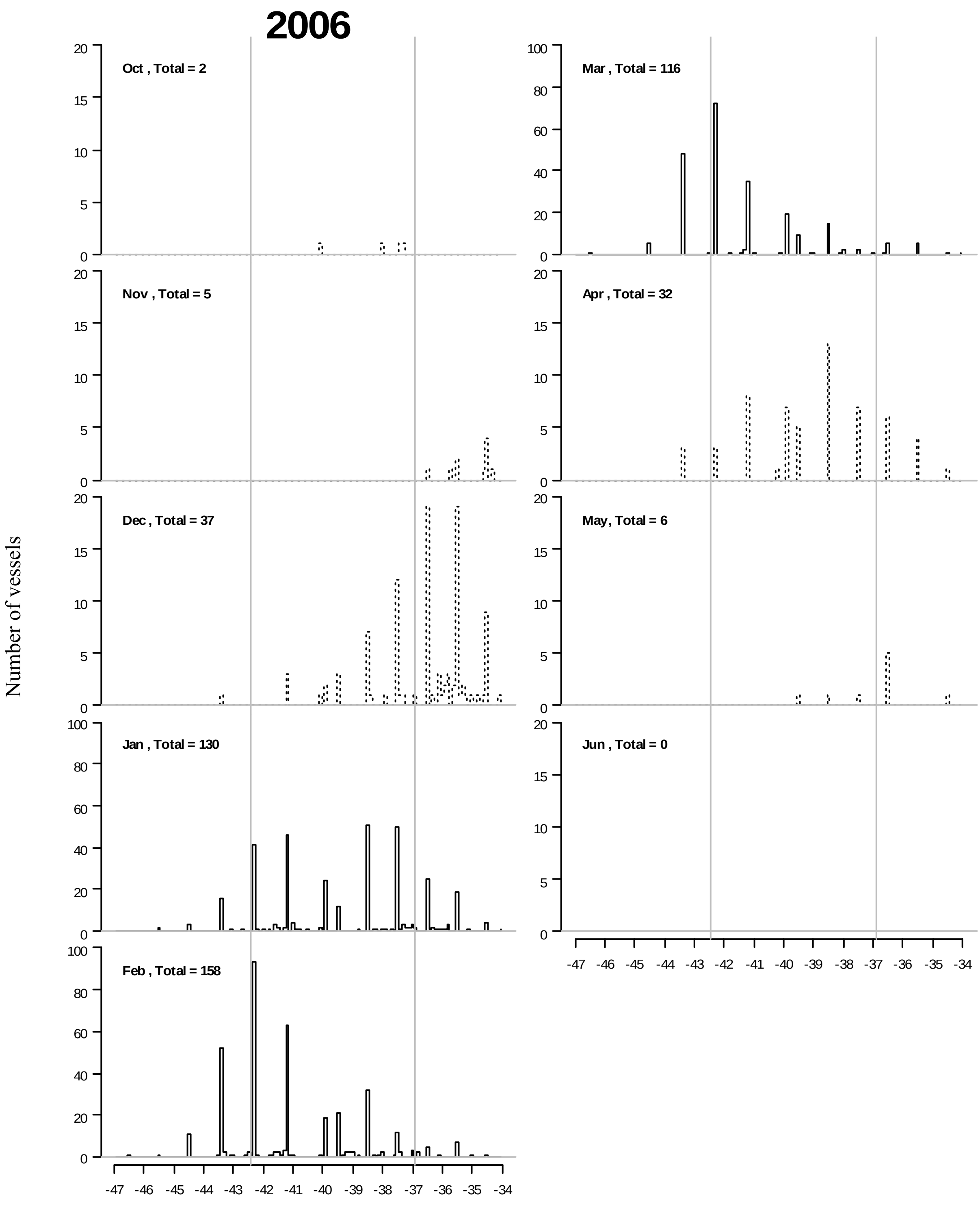


Figure 2: Number of vessels in CELR data by month and latitude (0.1 degree bins) for 2005–06 (2006), 2006–07 (2007), and 2007–08 (2008). Vertical grey lines mark Greymouth and Kaipara Harbour. Dotted bars are used for small sample sizes, where the y-axis scale is less than the scale used for dark bars representing more vessels.

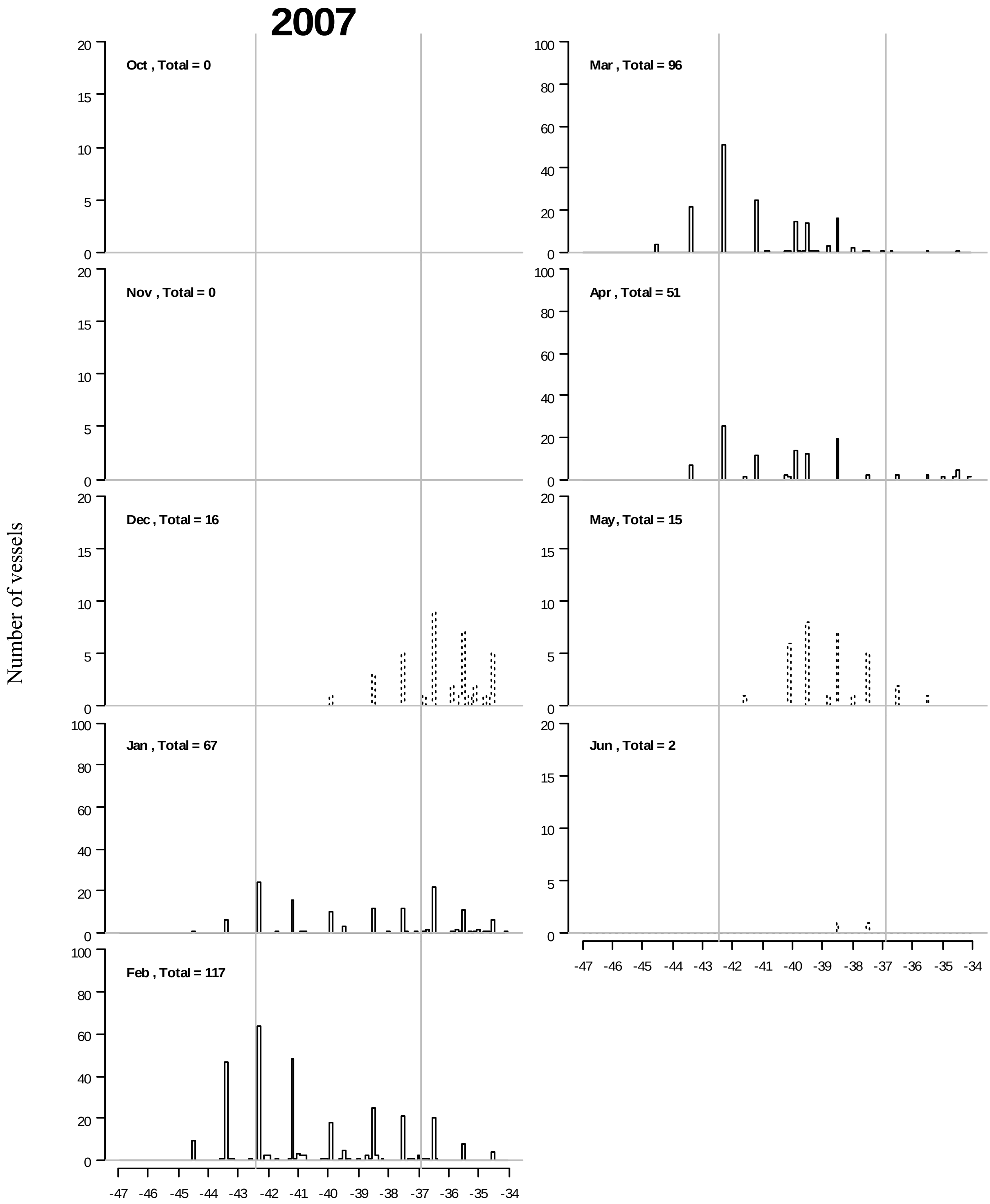


Figure 2 (continued).

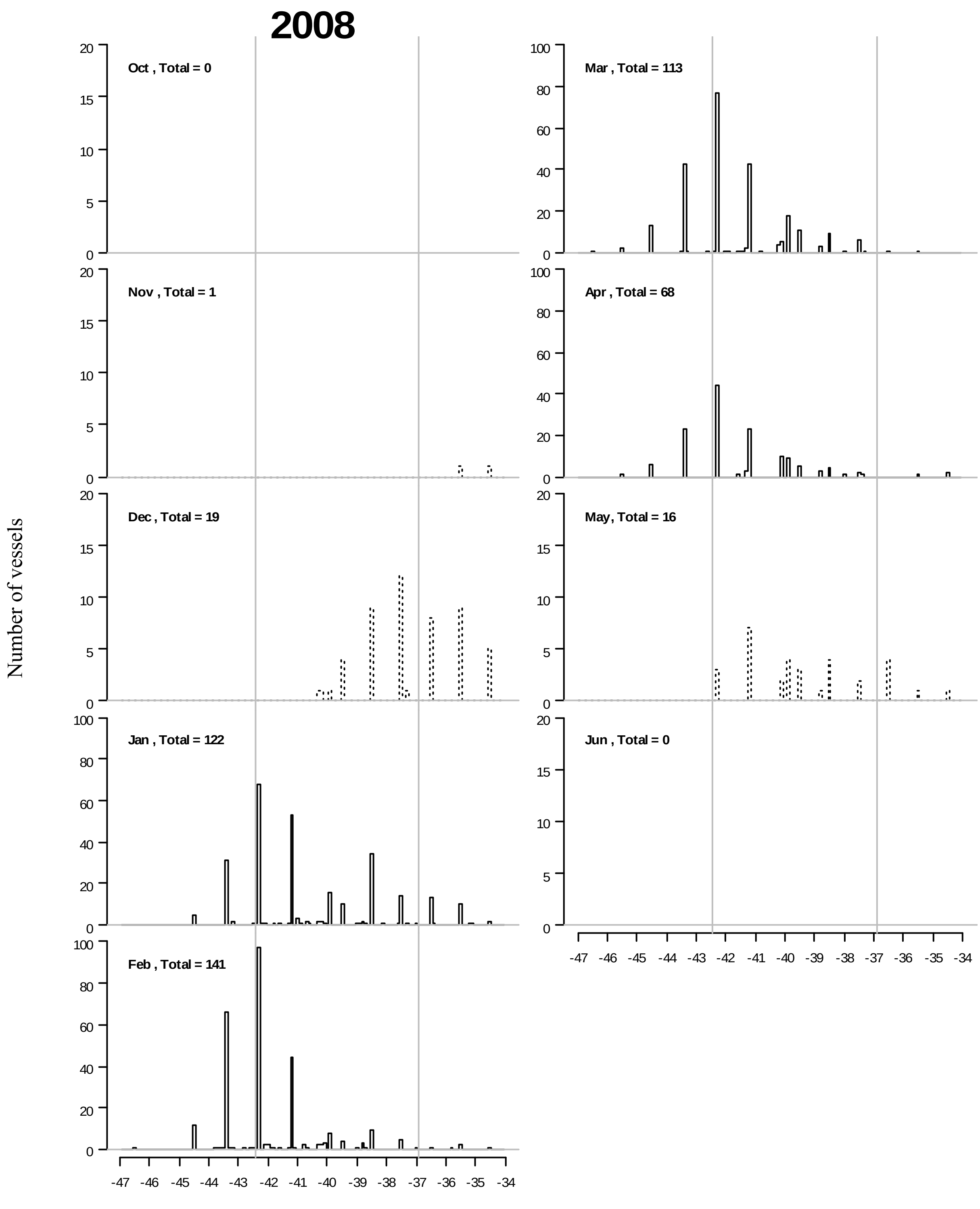


Figure 2 (continued).

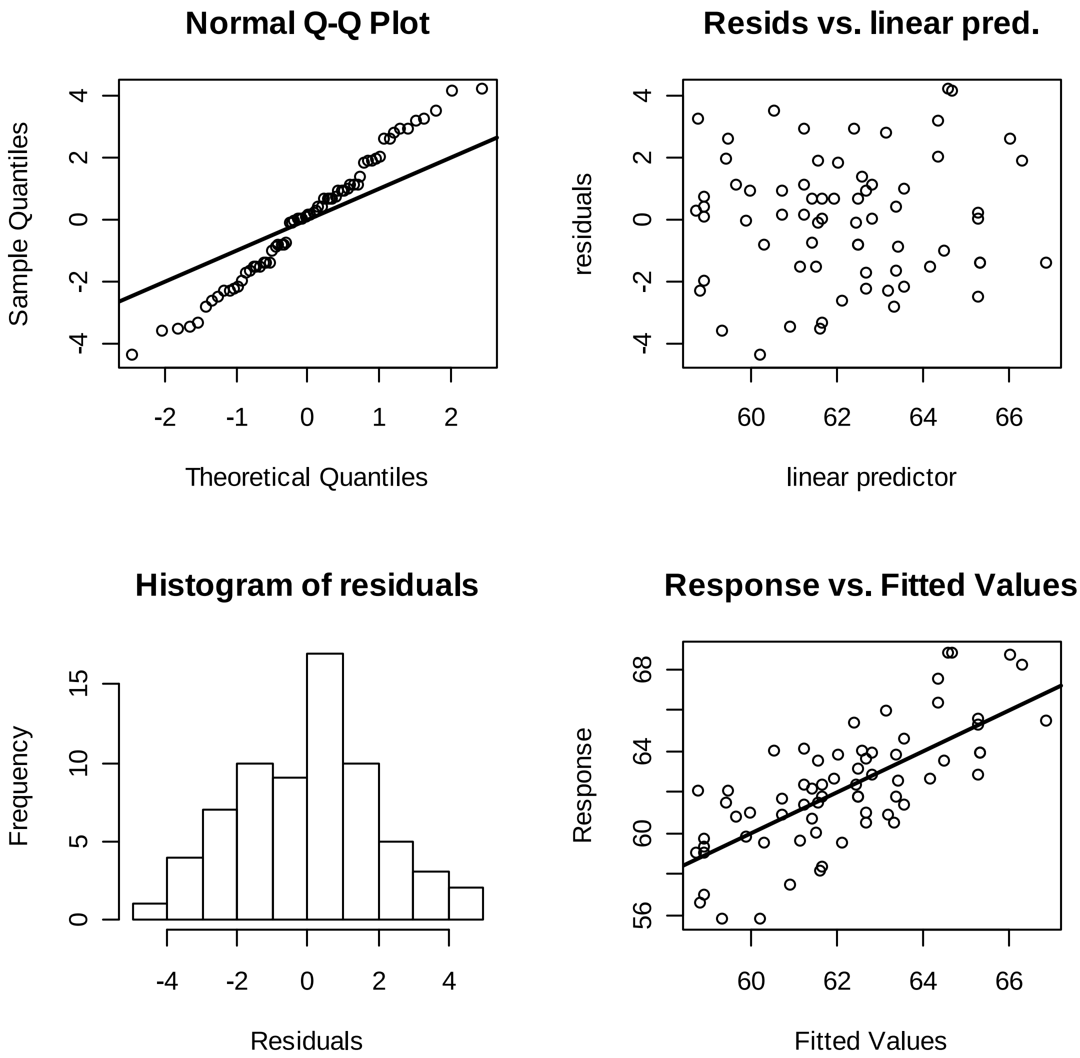


Figure 3: Diagnostics of the GAM regression on mean length from port sampling.

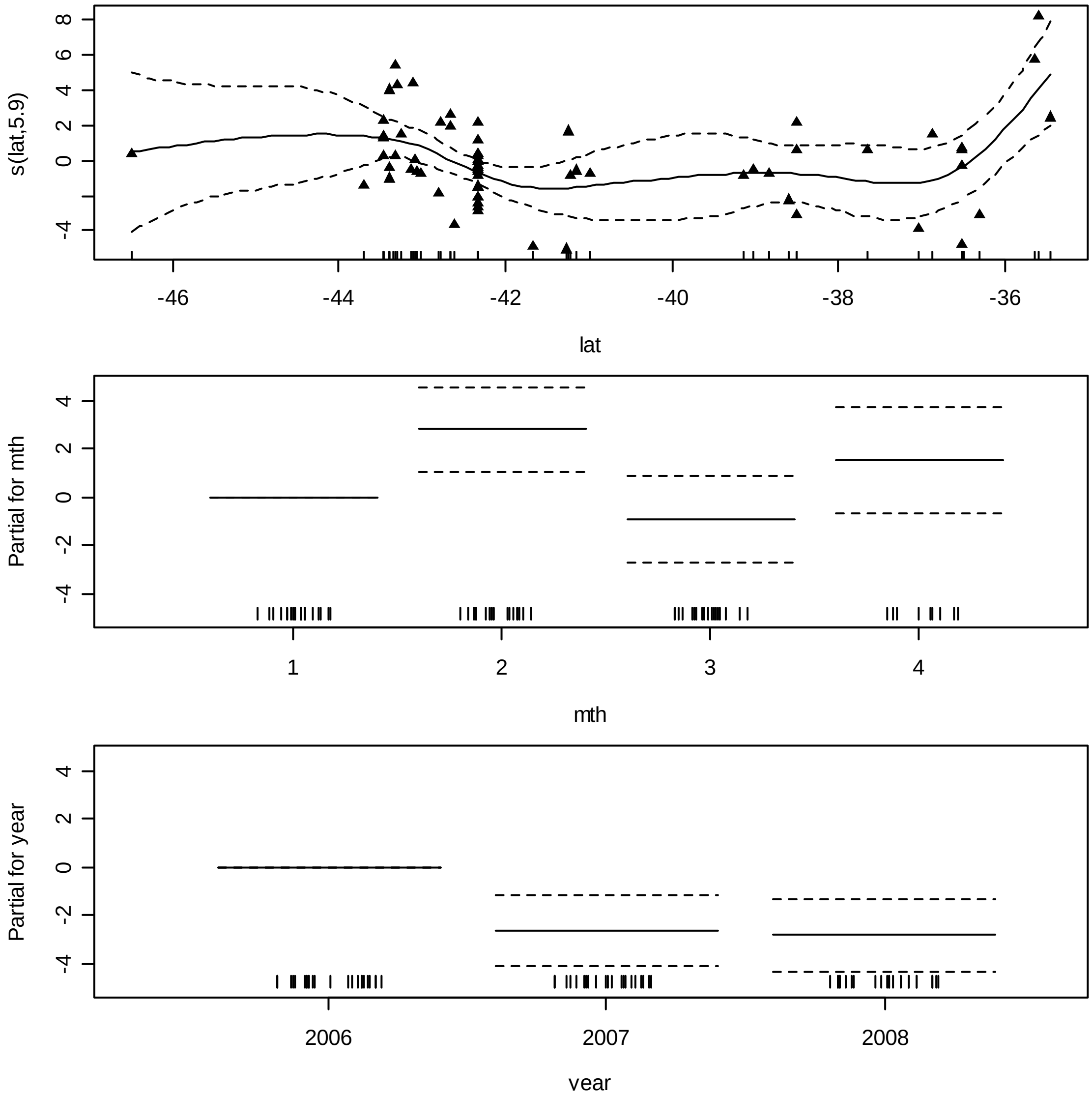


Figure 4: Effects of statistically significant factors in the GAM regression of length. The mean is the solid line, 95% confidence levels are the dotted lines, and marks at the bottom are the data used (jittered). The plot showing the effect of Latitude also shows the residuals (filled triangles).

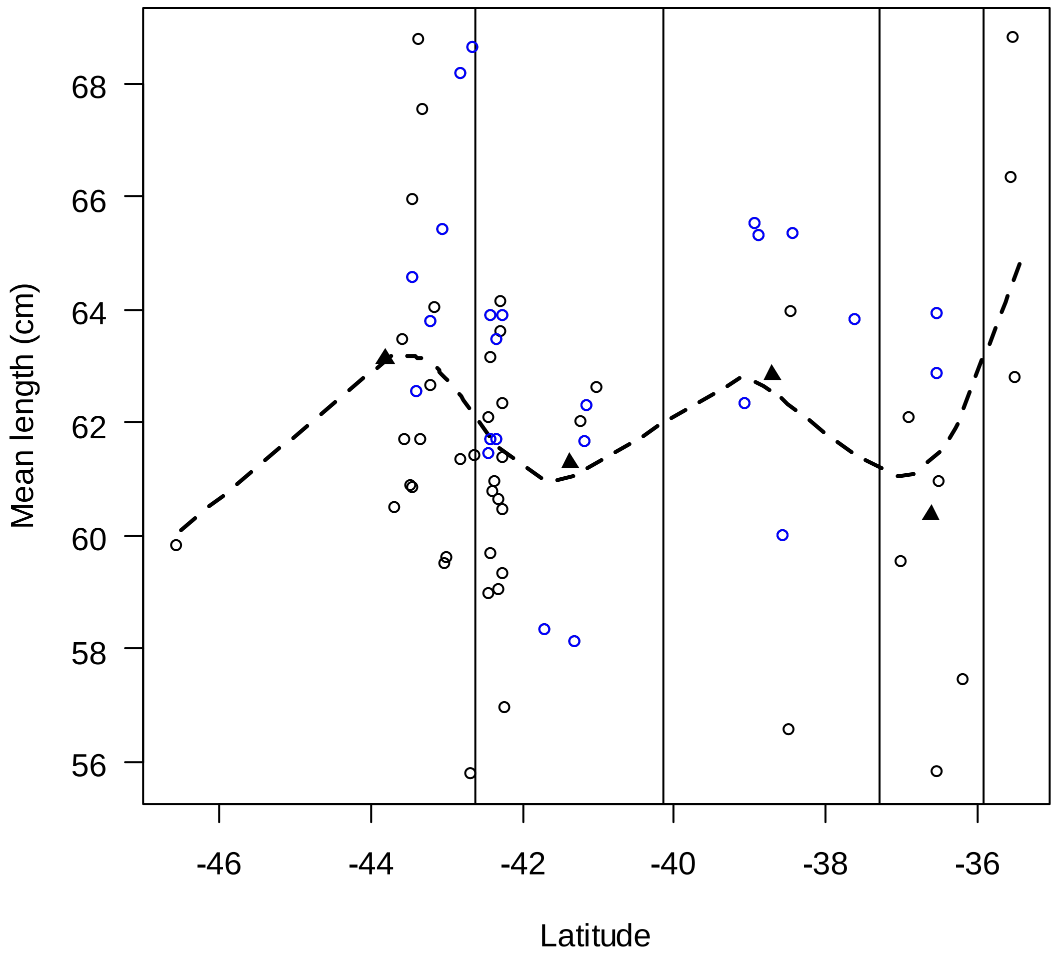


Figure 5: Mean length by latitude (2005–06 to 2007–08 data). Dashed line is a smoothing spline through the data. Vertical lines are the cutoffs for the group means shown as solid triangles. Blue circles are 2005–06 data.

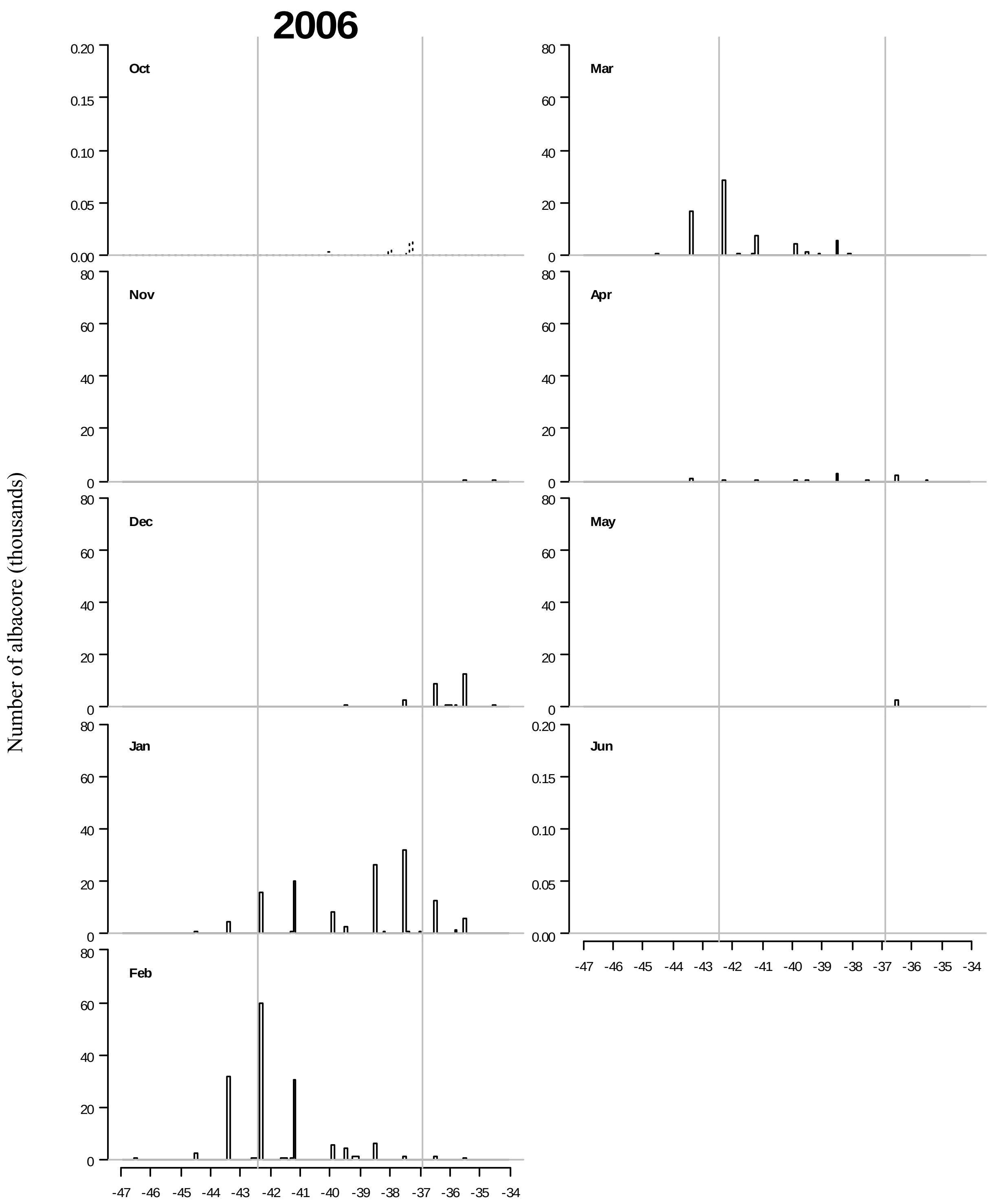


Figure 6: Number of albacore reported ('000) in CELR data by month and latitude (0.1 degree bins) for 2005–06 (2006), 2006–07 (2007), and 2007–08 (2008). Vertical gray lines mark Greymouth and Kaipara Harbour.

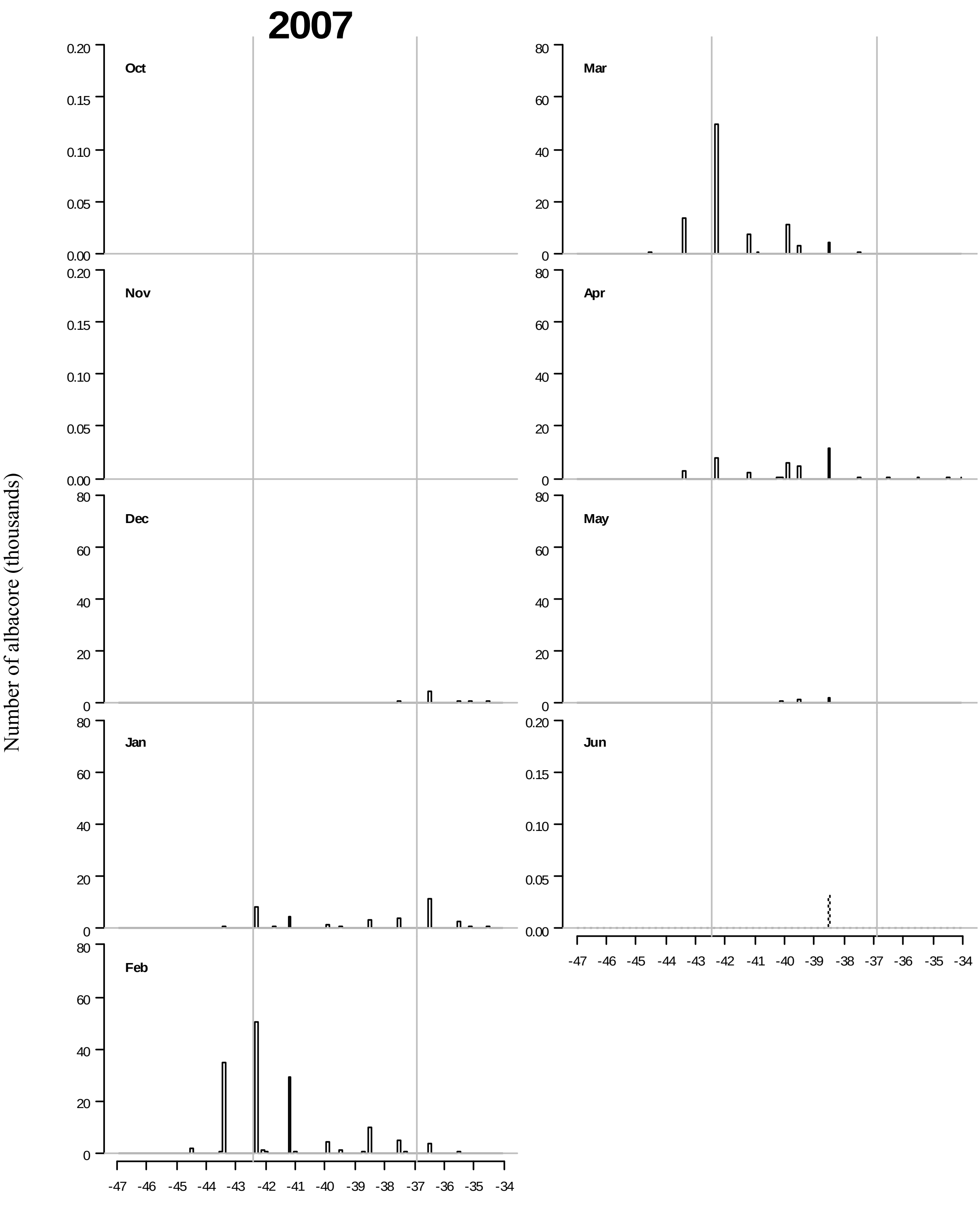


Figure 6 (continued).

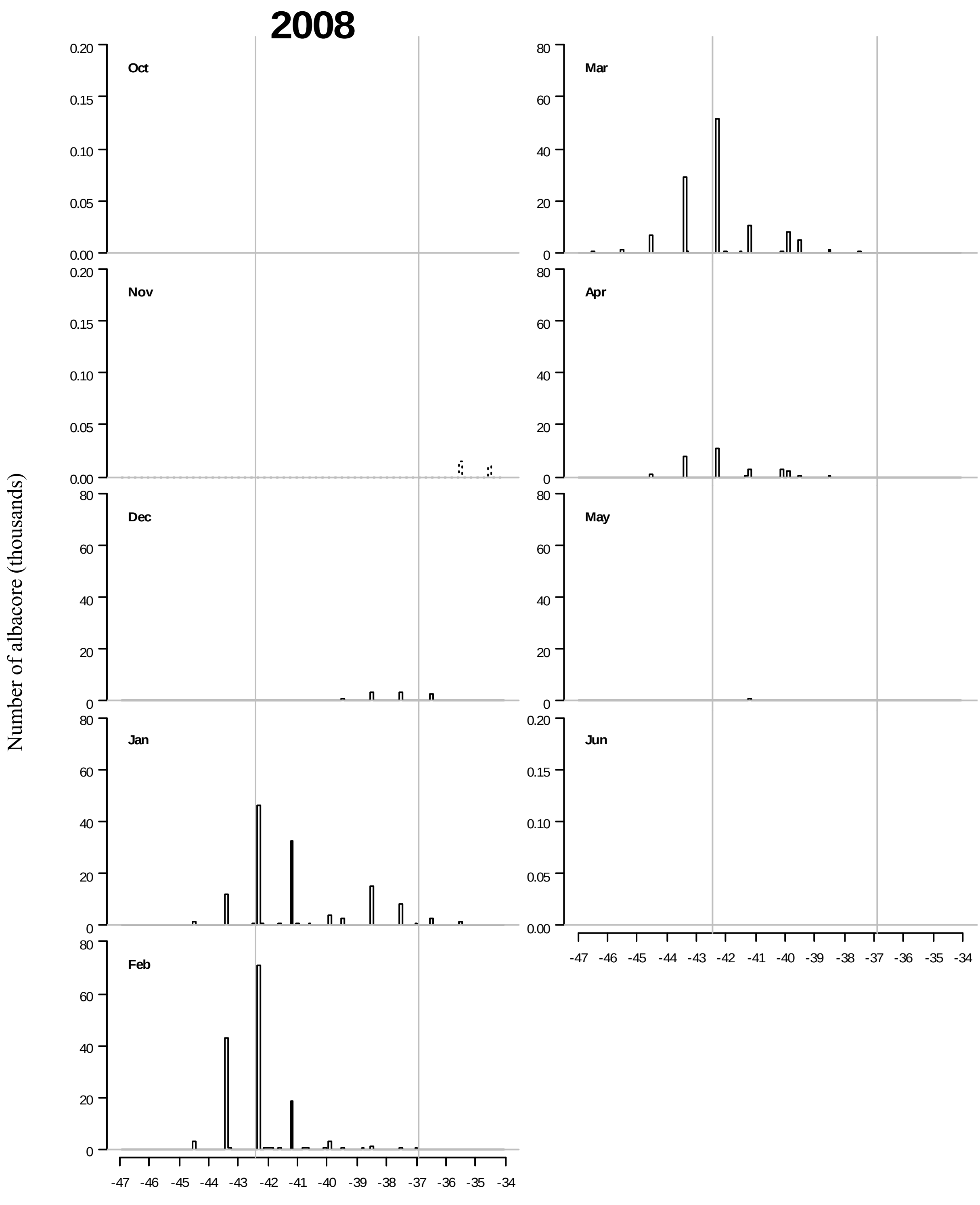


Figure 6 (continued).

2006

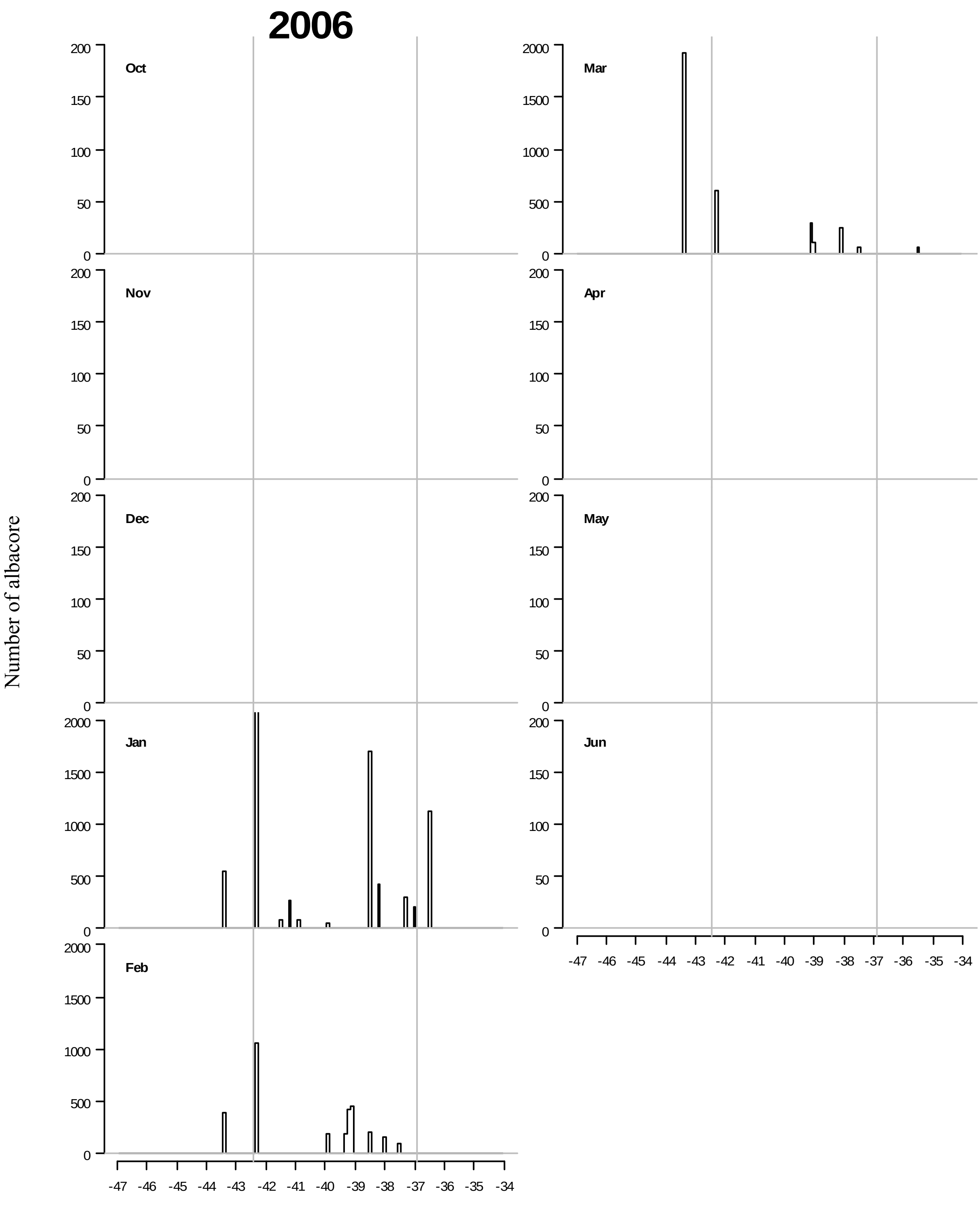


Figure 7: Number of albacore reported in sampling data by month and latitude (0.1 degree bins) for 2005–06 (2006), 2006–07 (2007), and 2007–08 (2008). Vertical gray lines mark Greymouth and Kaipara Harbour.

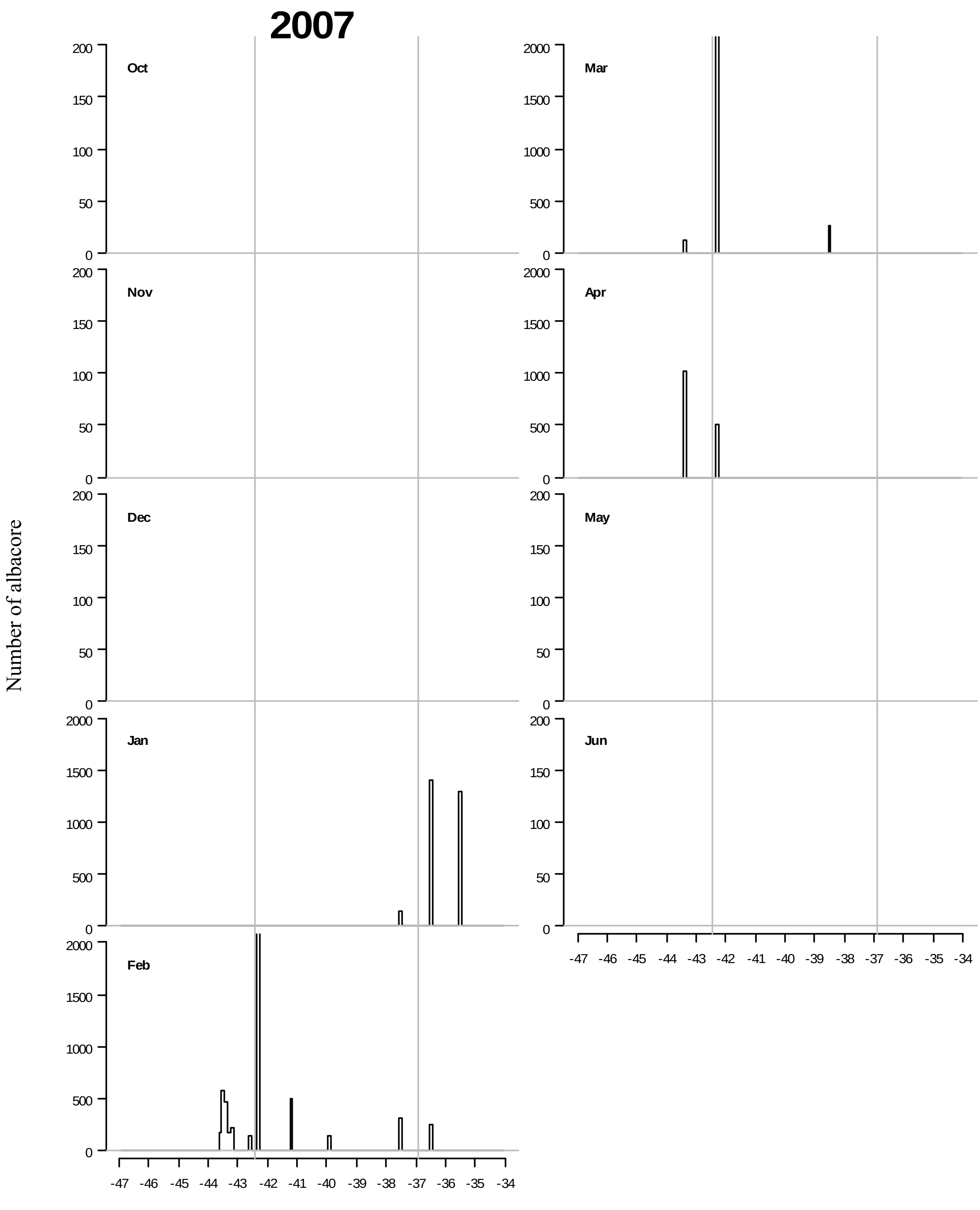


Figure 7 (continued).

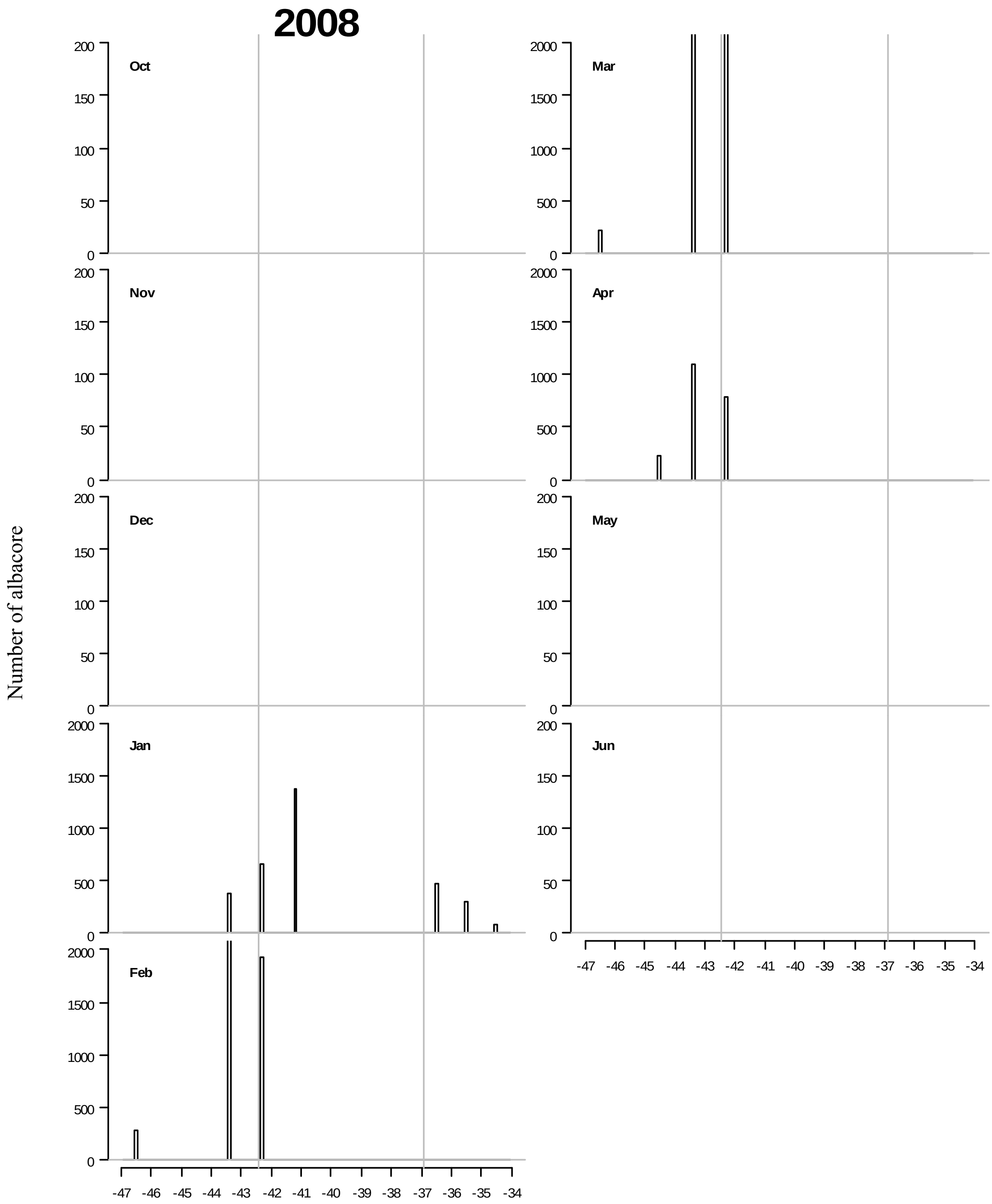


Figure 7 (continued).

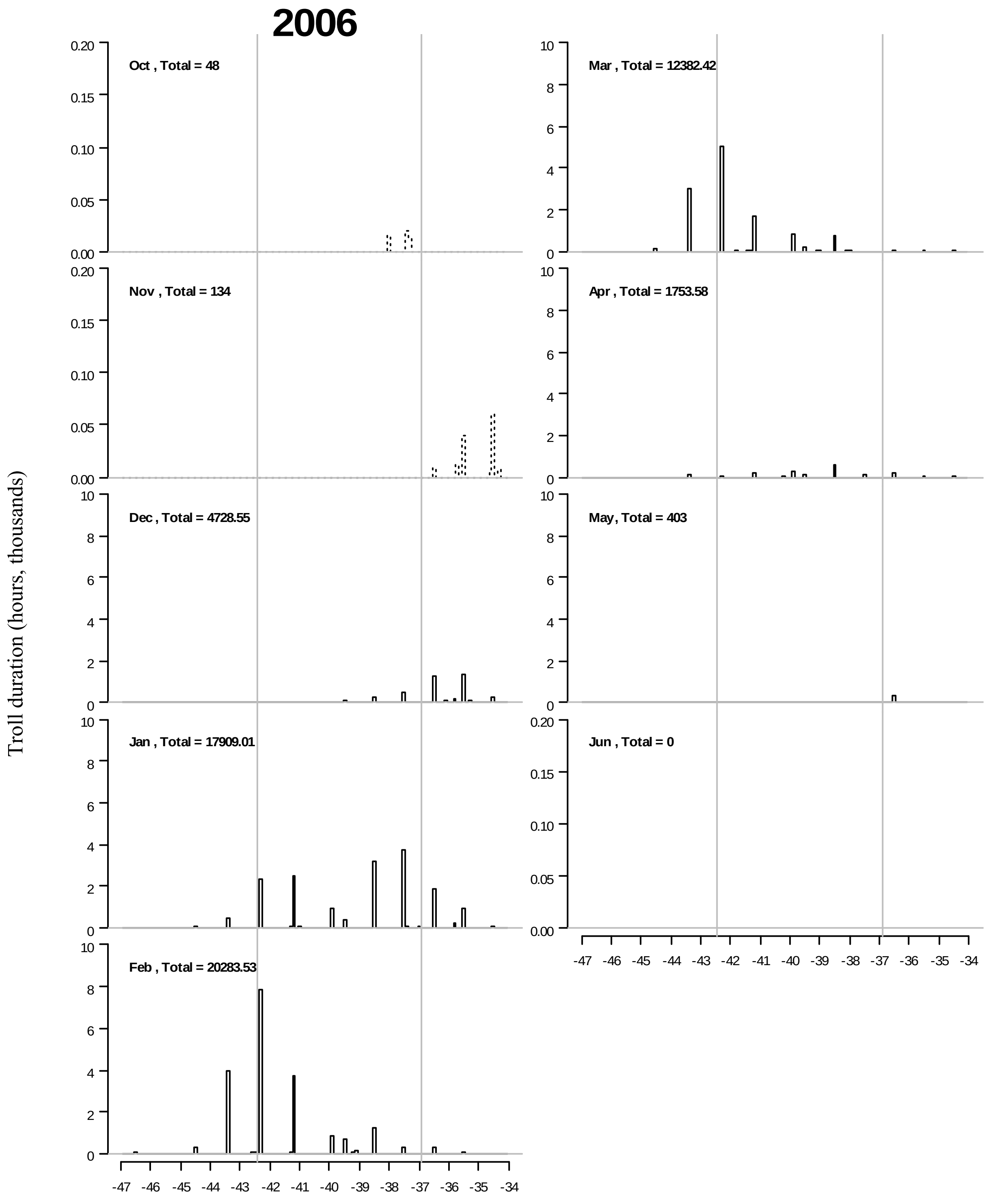


Figure 8: Troll duration reported ('000 hr) in CELR data by month and latitude (0.1 degree bins) for 2005–06 (2006), 2006–07 (2007), and 2007–08 (2008). Vertical gray lines mark Greymouth and Kaipara Harbour.

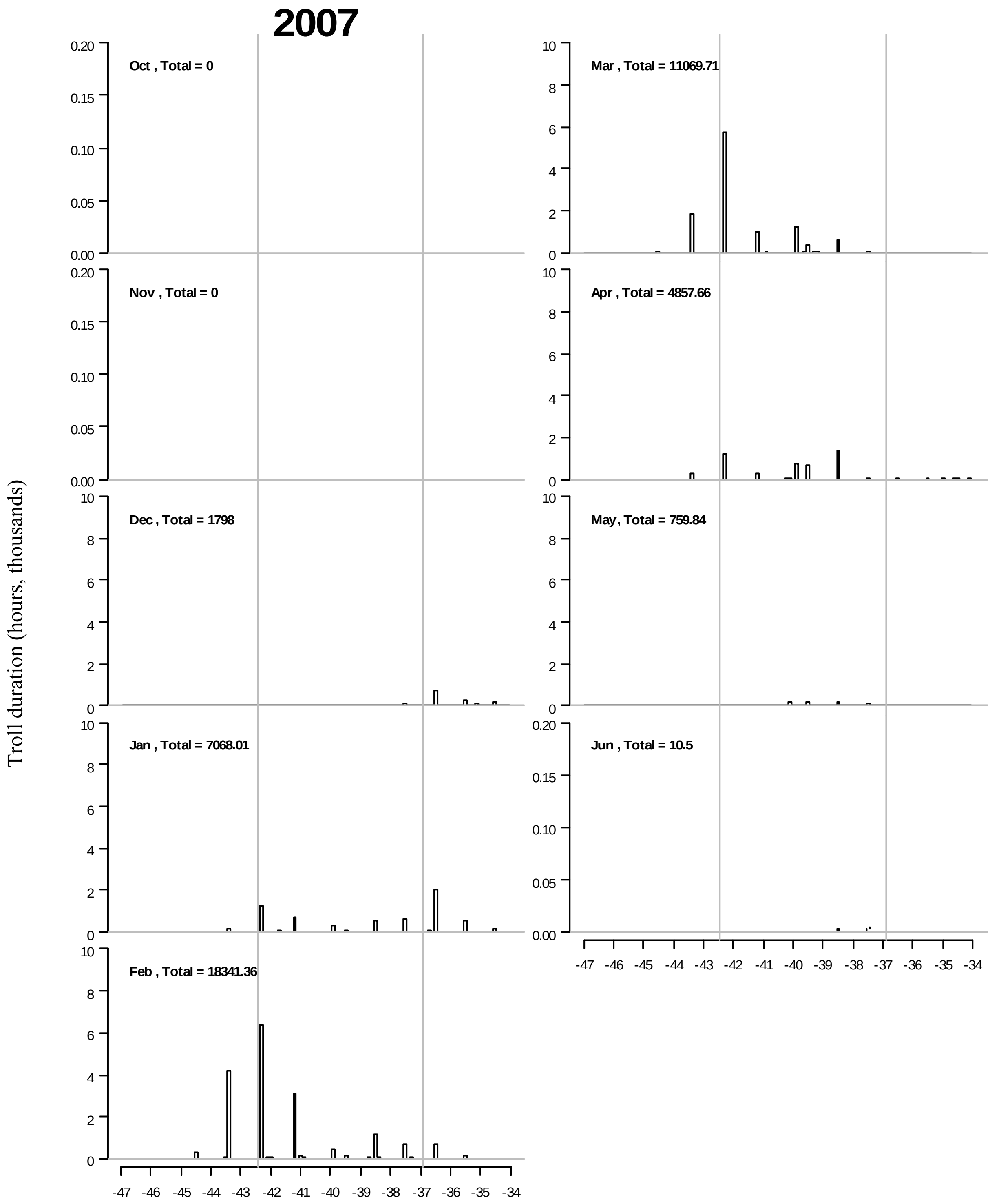


Figure 8 (continued).

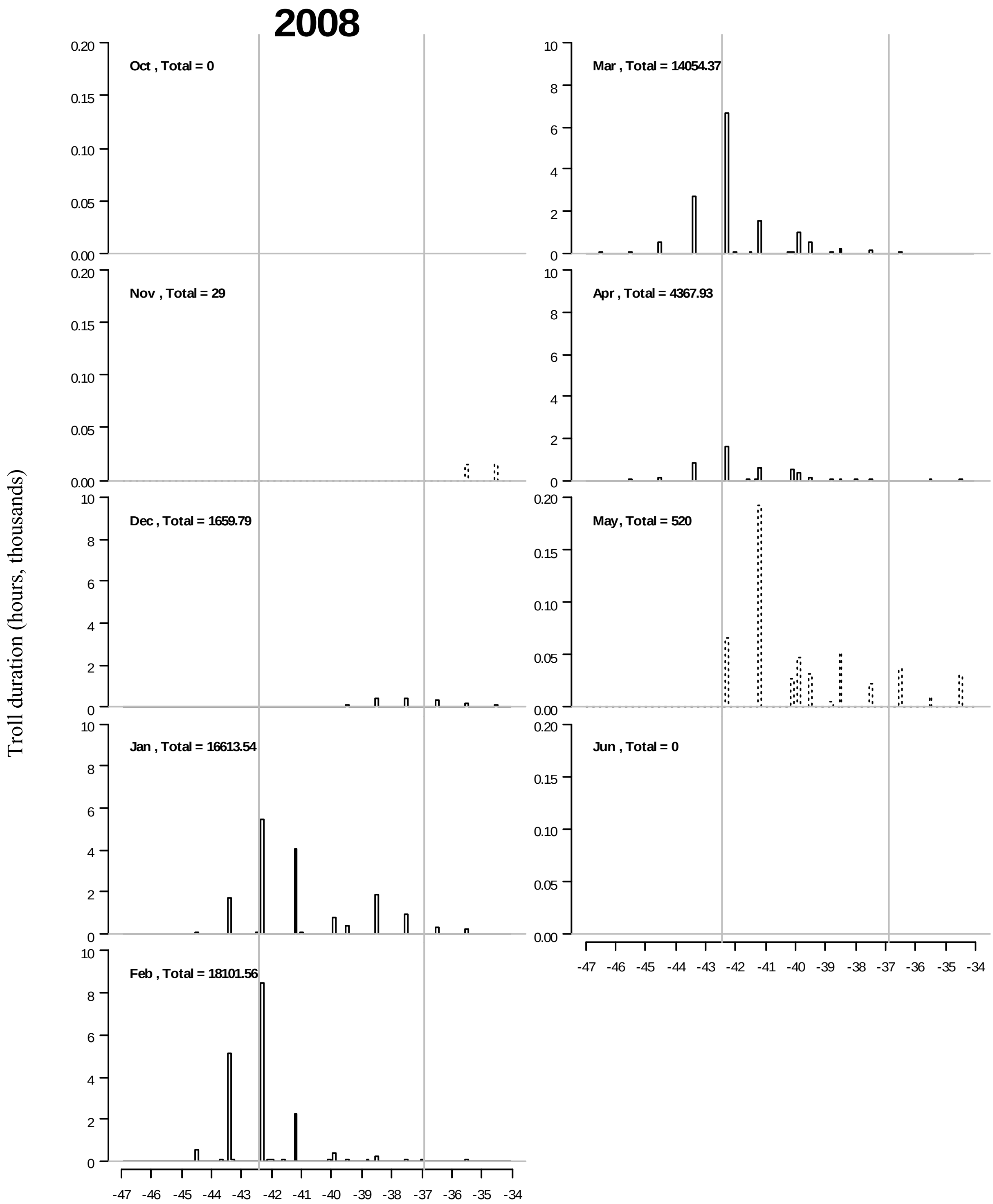


Figure 8 (continued).

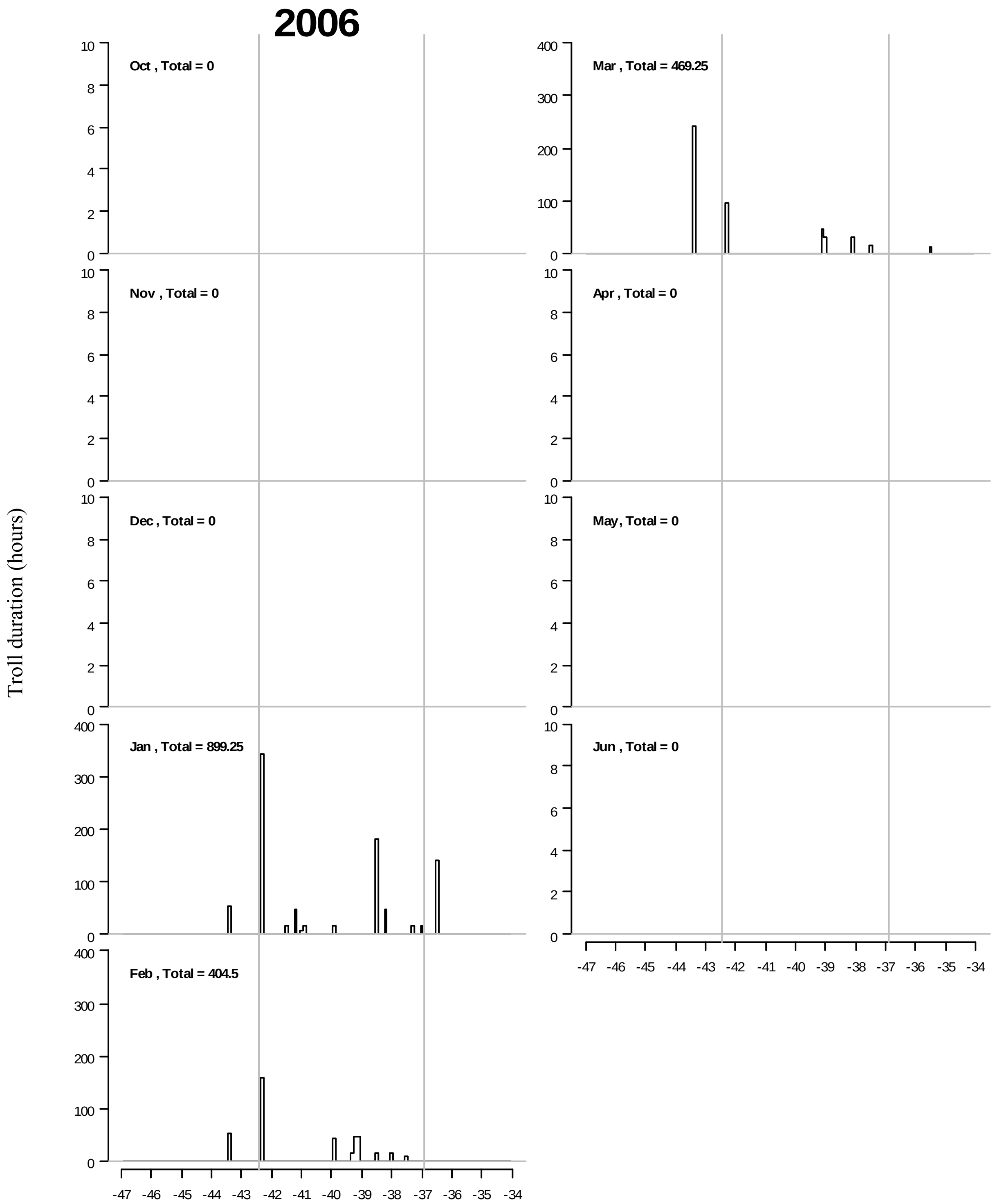


Figure 9: Troll duration reported (hr) in sampling data by month and latitude (0.1 degree bins) for 2005–06 (2006), 2006–07 (2007), and 2007–08 (2008). Vertical gray lines mark Greymouth and Kaipara Harbour.

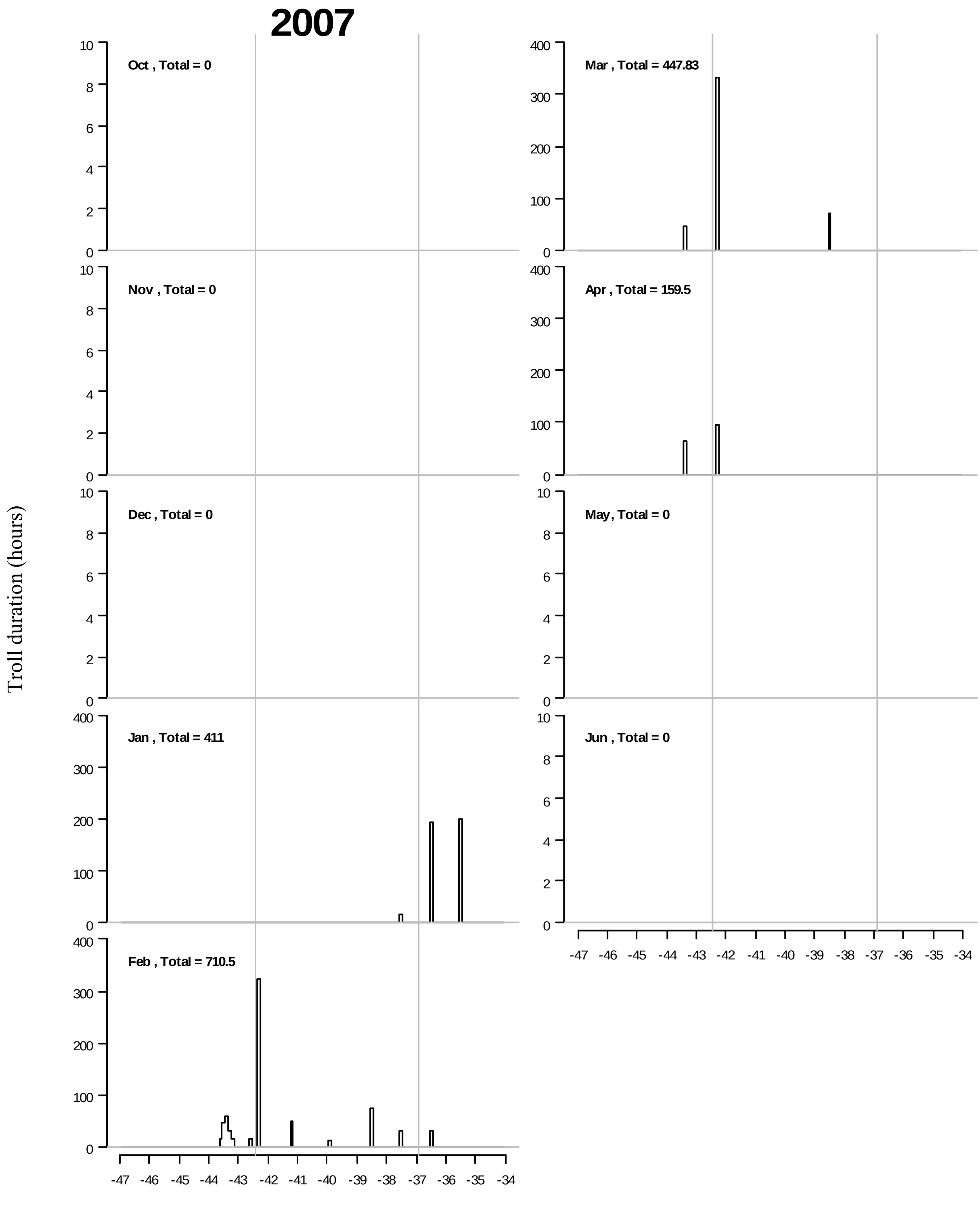


Figure 9 (continued).

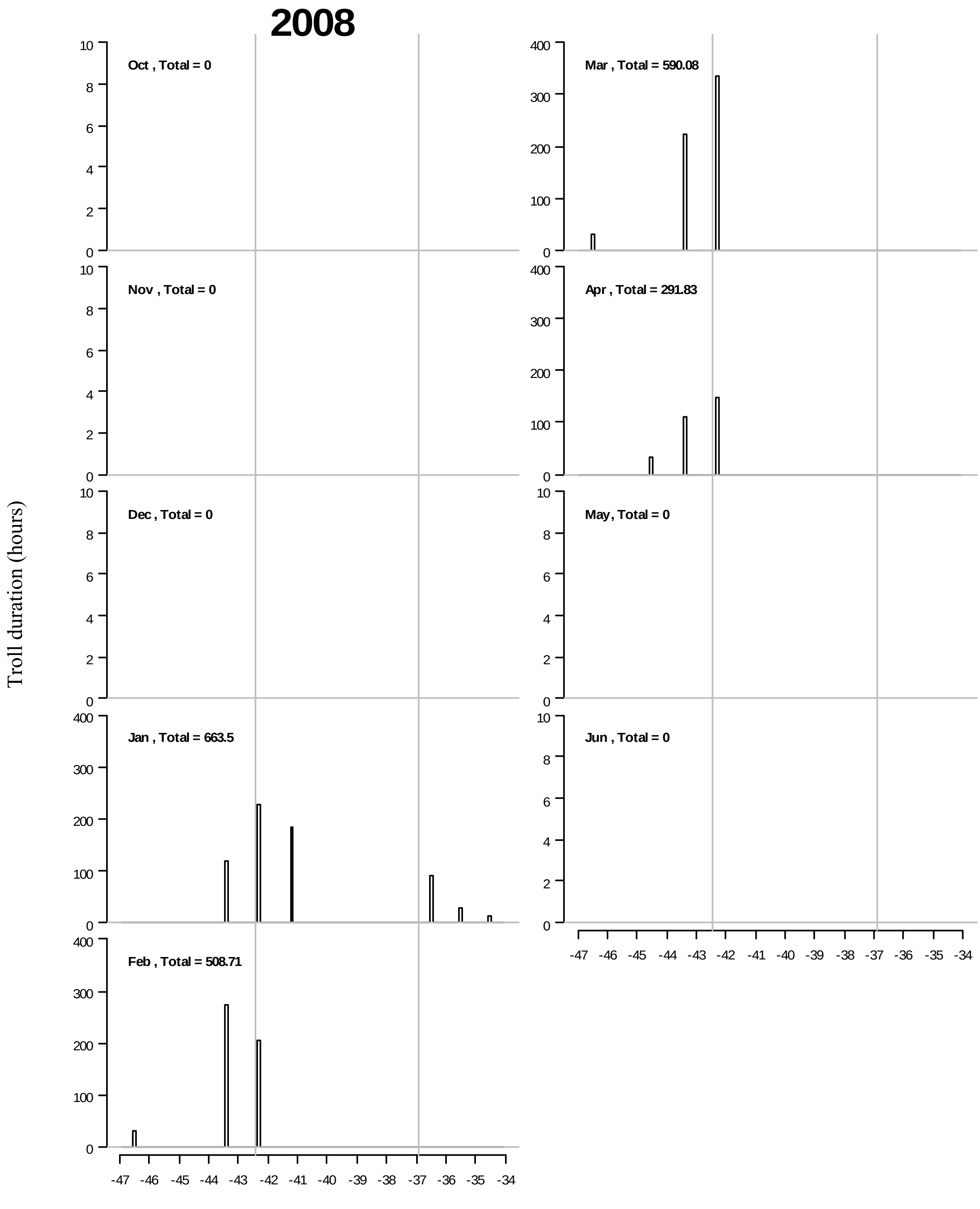


Figure 9 (continued).

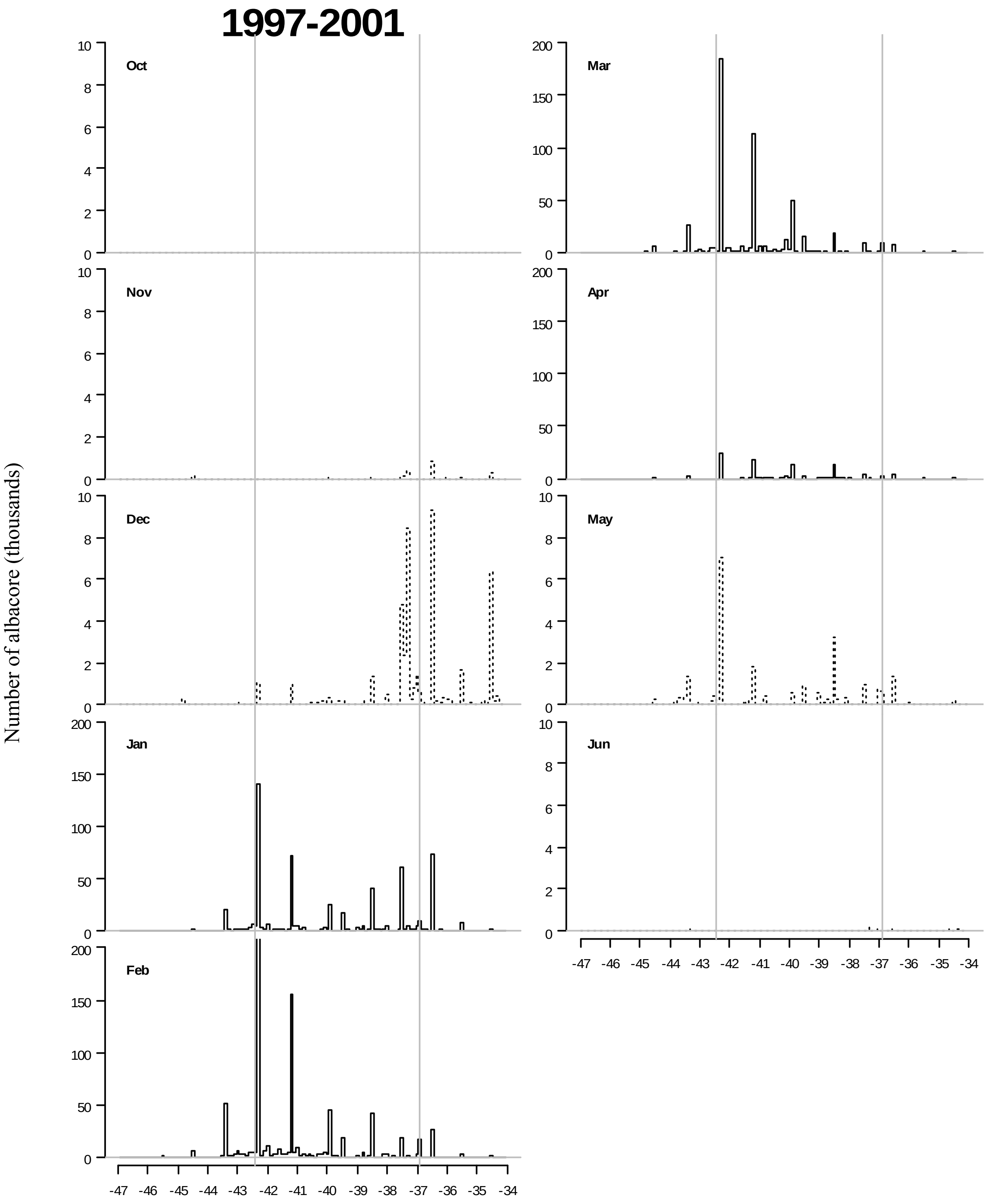


Figure 10: Number of albacore reported (`000) in CELR data by month and latitude (0.1 degree bins) for 1996–07 to 2000–01 (1997–2001) and 2001–02 to 2004–05(2002–2005). Vertical gray lines mark Greymouth and Kaipara Harbour.

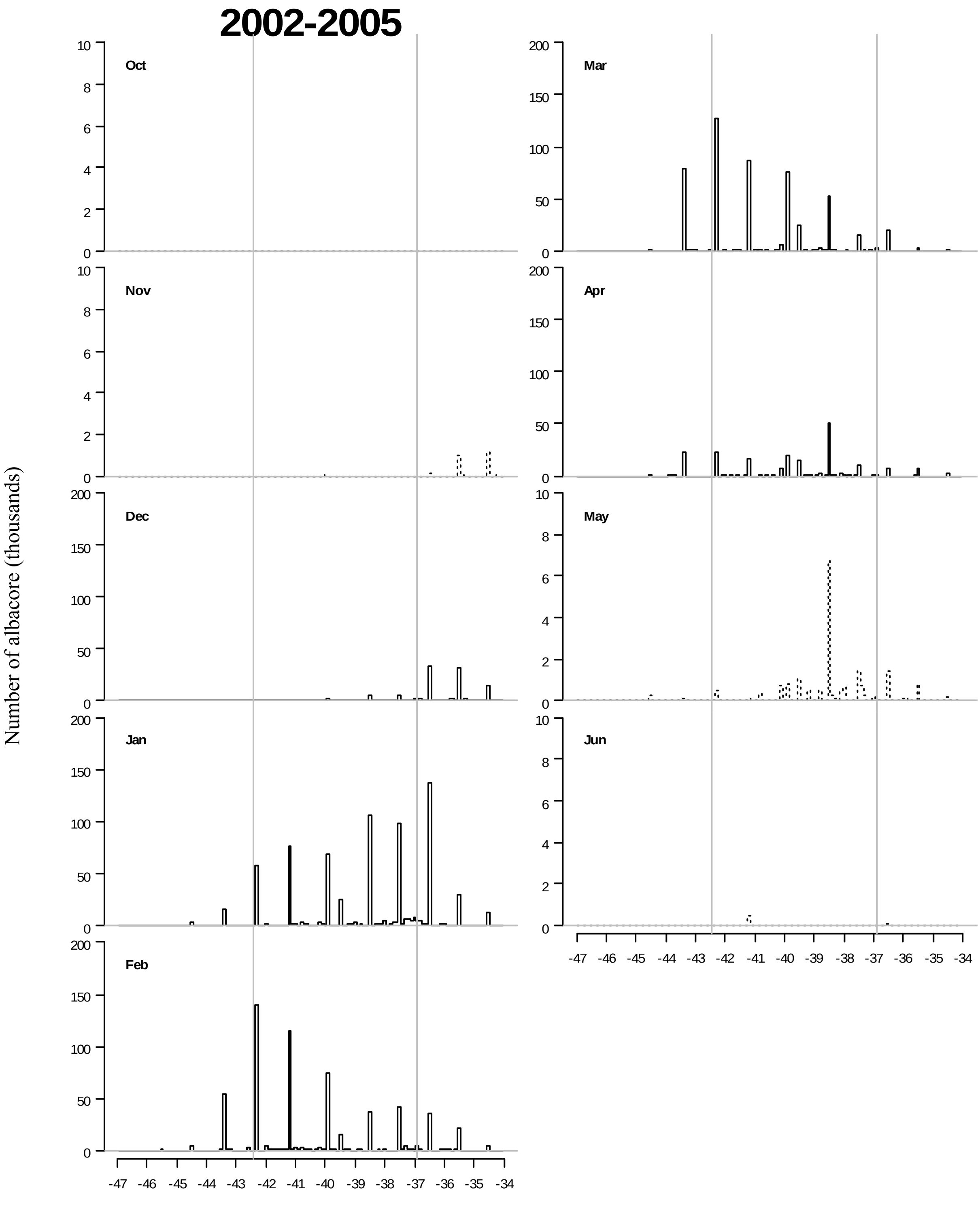


Figure 10 (continued).

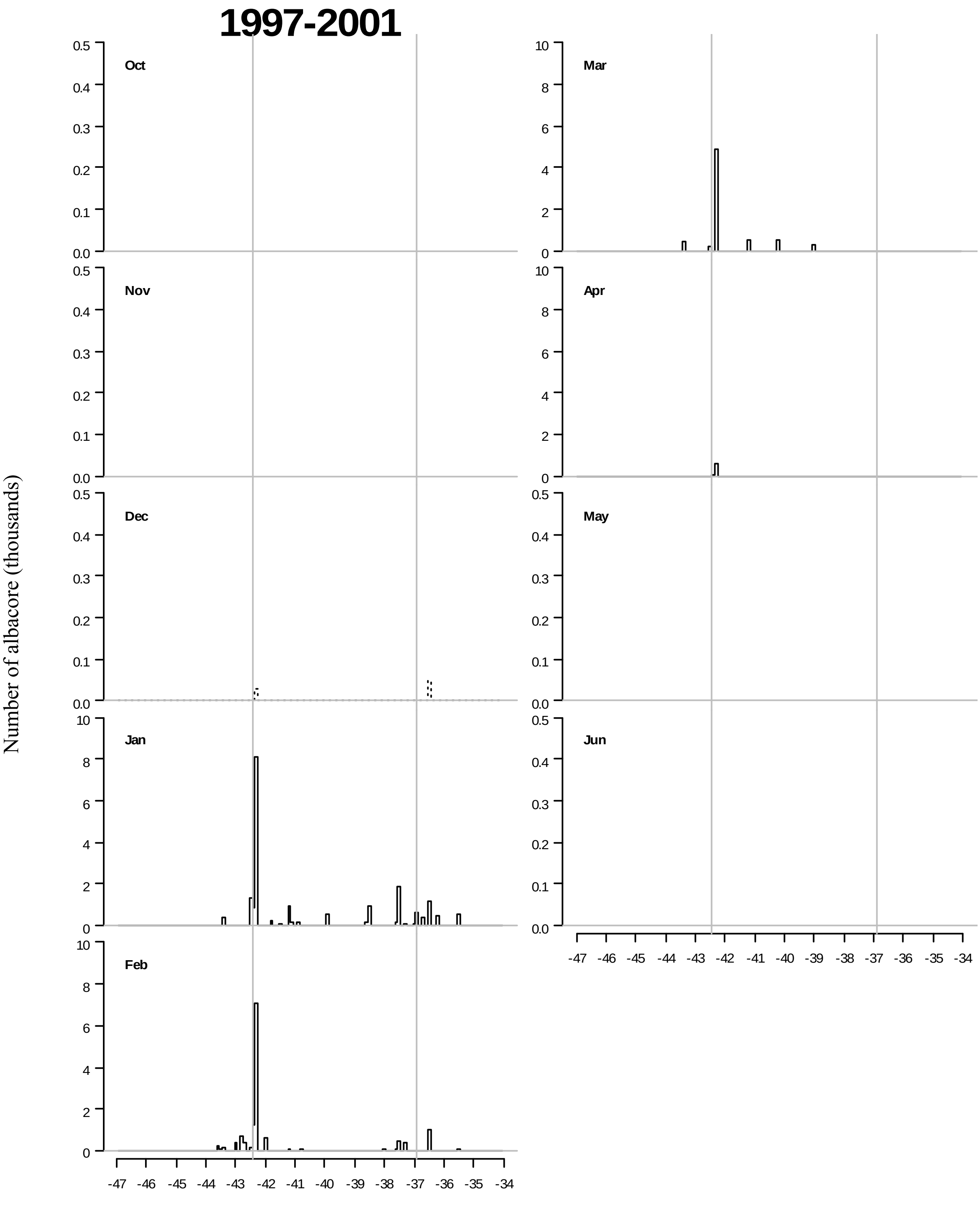


Figure 11: Number of albacore reported (`000) in sampling data by month and latitude (0.1 degree bins) for 1996–07 to 2000–01 (1997–2001) and 2001–02 to 2004–05(2002–2005). Vertical gray lines mark Greymouth and Kaipara Harbour.

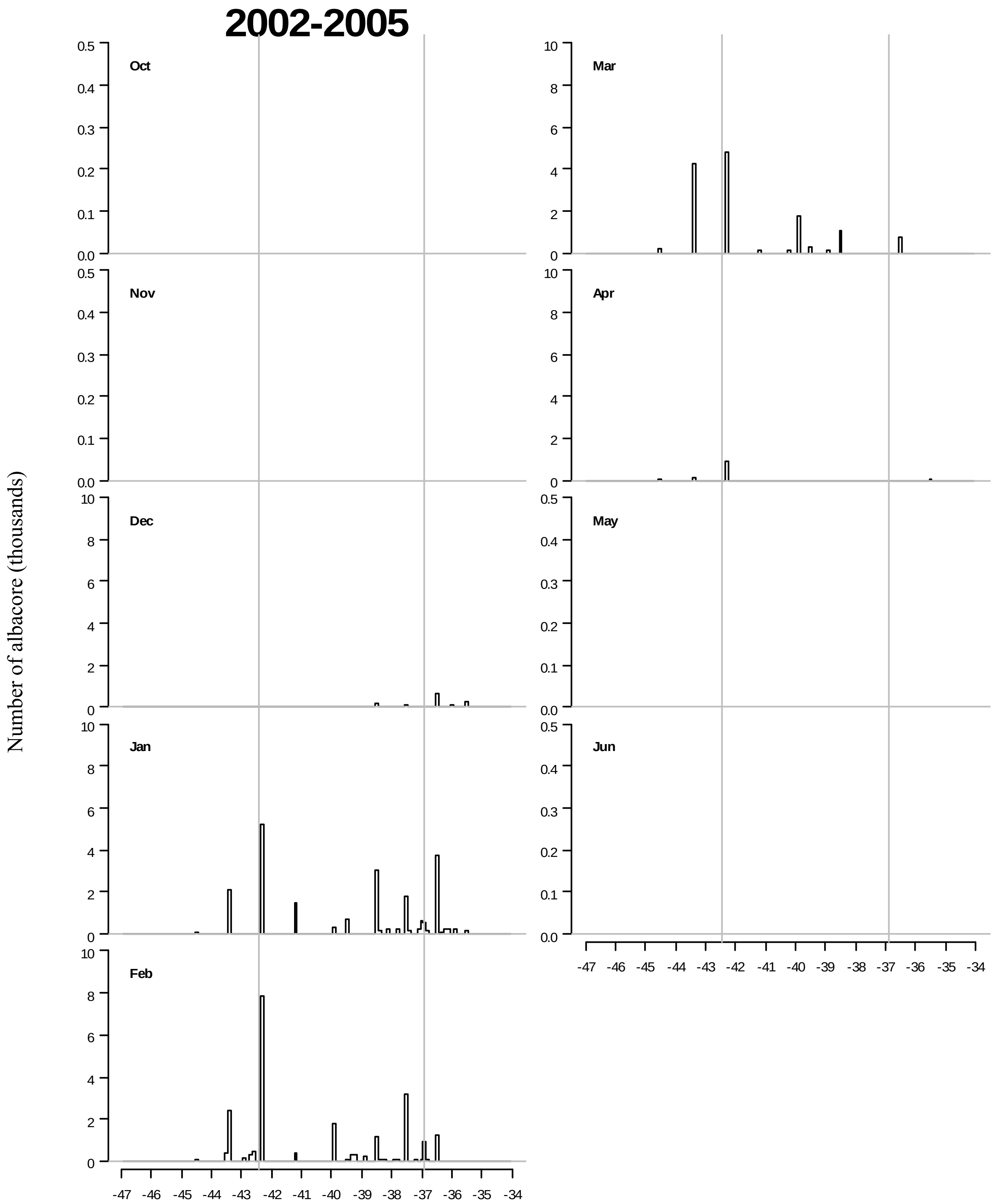


Figure 11 (continued).

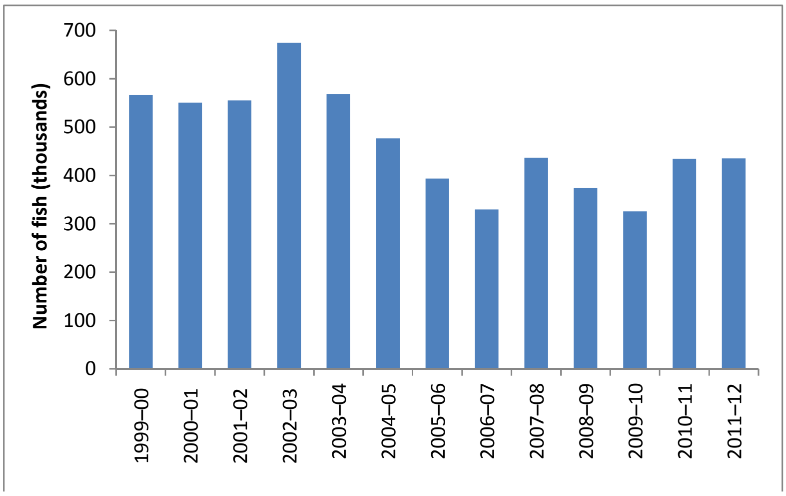


Figure 12: Total troll catch recorded on CELR forms.

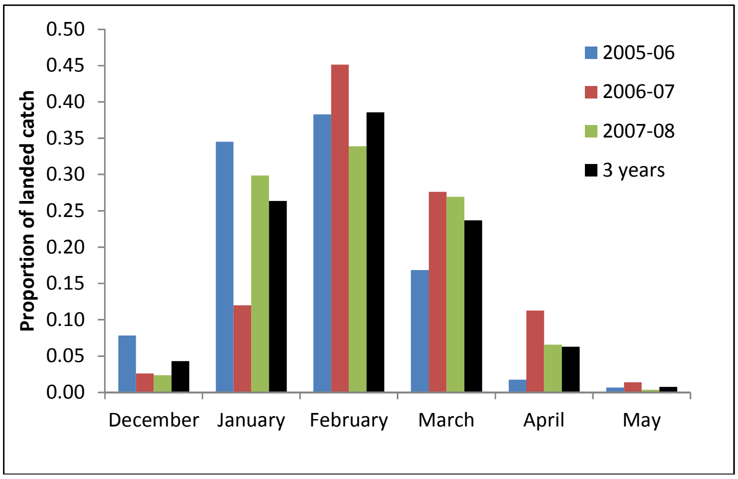


Figure 13: Proportion of catch landed each month during the 2005–06 to 2007–08 albacore fishing seasons.

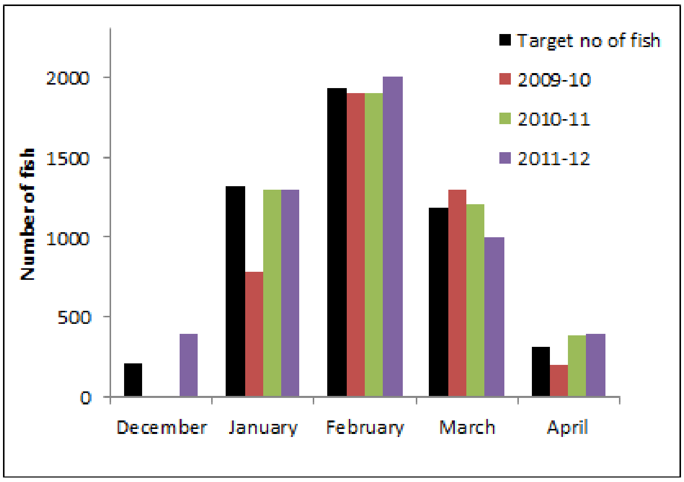


Figure 14: Target number of fish and actual number sampled each month during the 2009–10 to 2011–12 albacore fishing seasons.

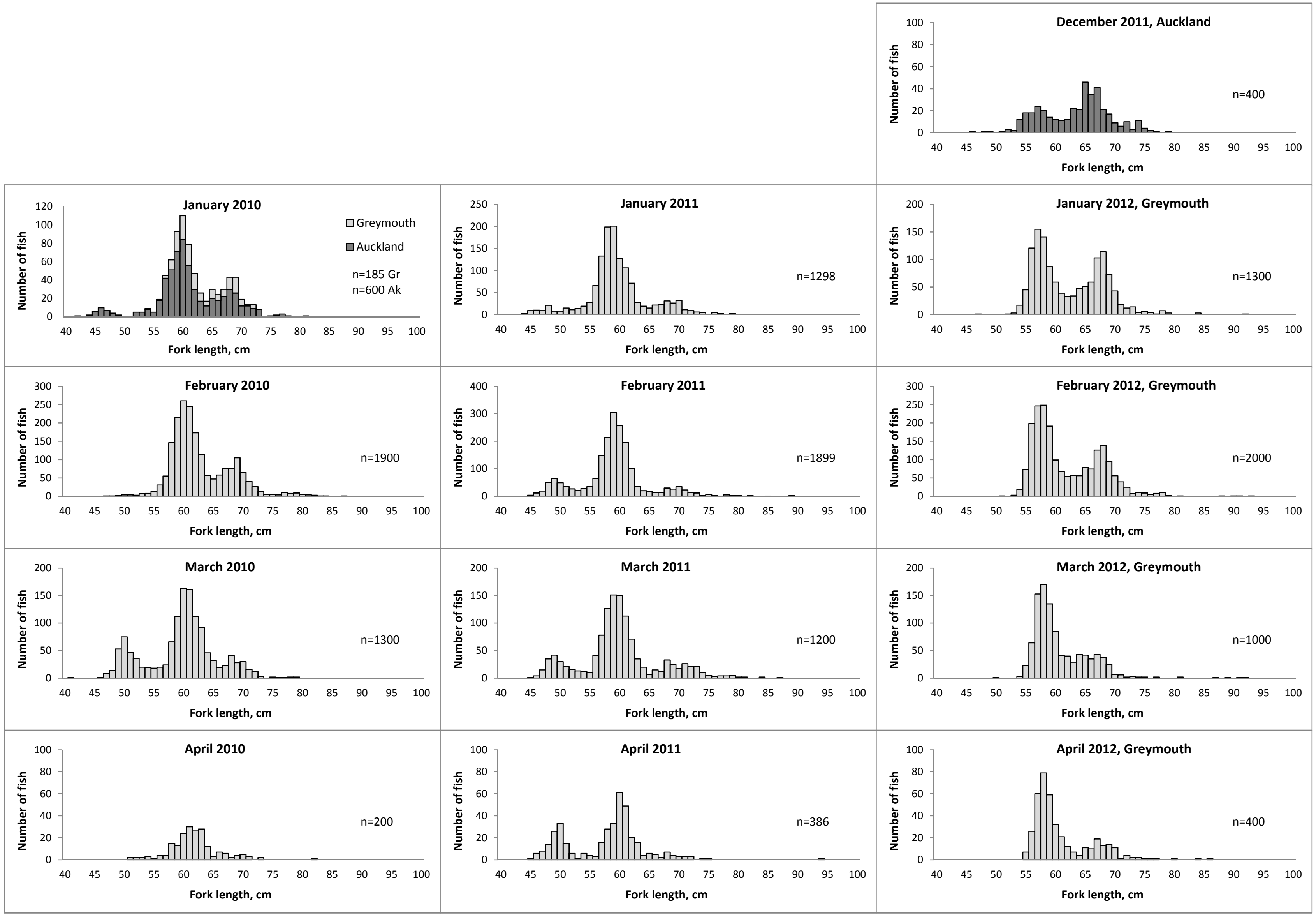

December 2011, Auckland
n=400
January 2010
Greymouth
Auckland
n=185 Gr
n=600 Ak
January 2011
n=1298
January 2012, Greymouth
n=1300
February 2010
n=1900
February 2011
n=1899
February 2012, Greymouth
n=2000
March 2010
n=1300
March 2011
n=1200
March 2012, Greymouth
n=1000
April 2010
n=200
April 2011
n=386
April 2012, Greymouth
n=400
Number of fish
Fork length, cm

Figure 15: Albacore length frequency distributions, sampled from landings by troll vessels, Auckland and Greymouth, 2009−10, 2010−11 and 2011–12. Fish sampled in Auckland are shown with dark bars, fish sampled in Greymouth are shown with pale grey bars.

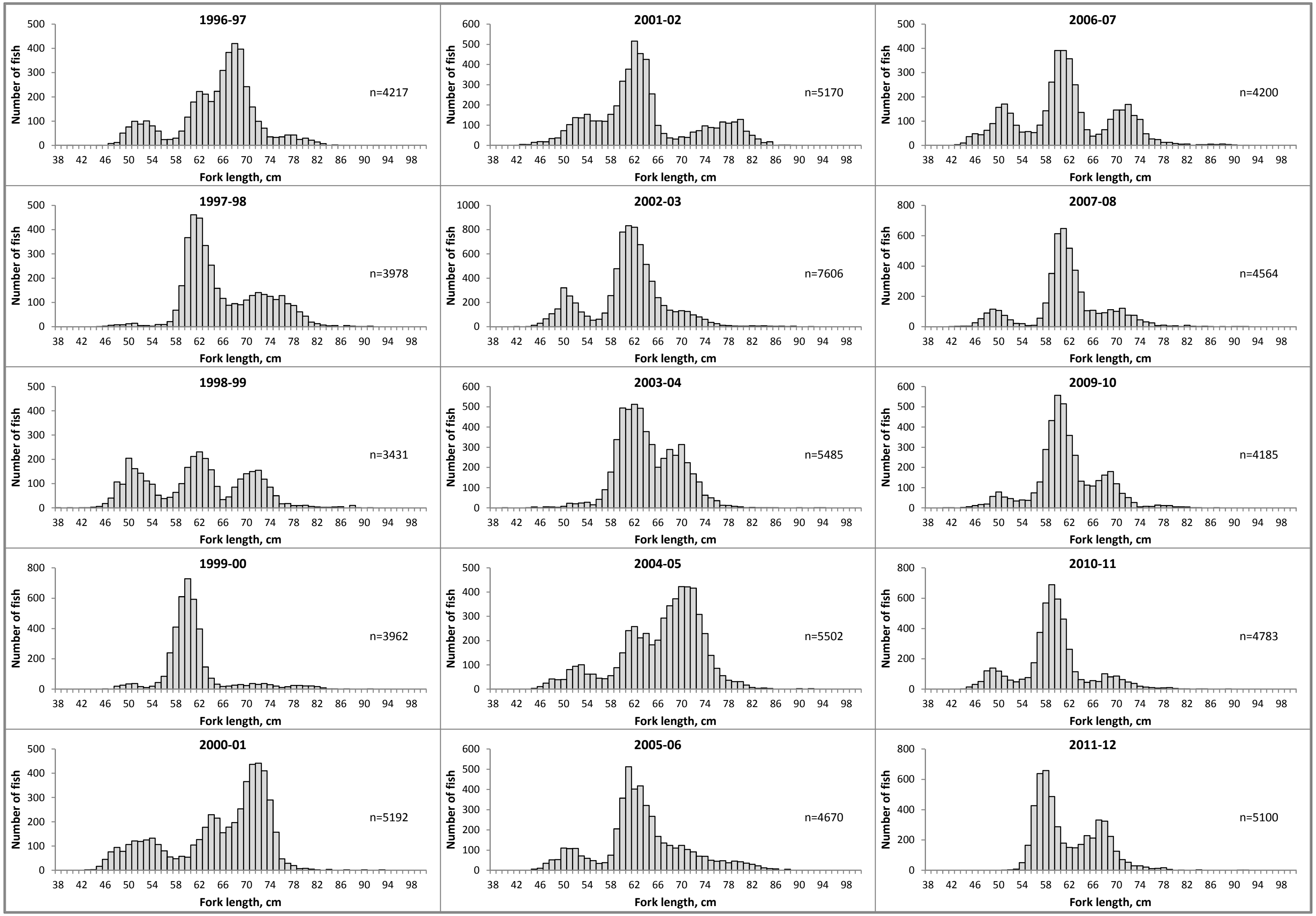


Figure 16: Albacore length frequency distributions for 15 years of sampling landings from troll vessels, 1996–97 to 2011–12.

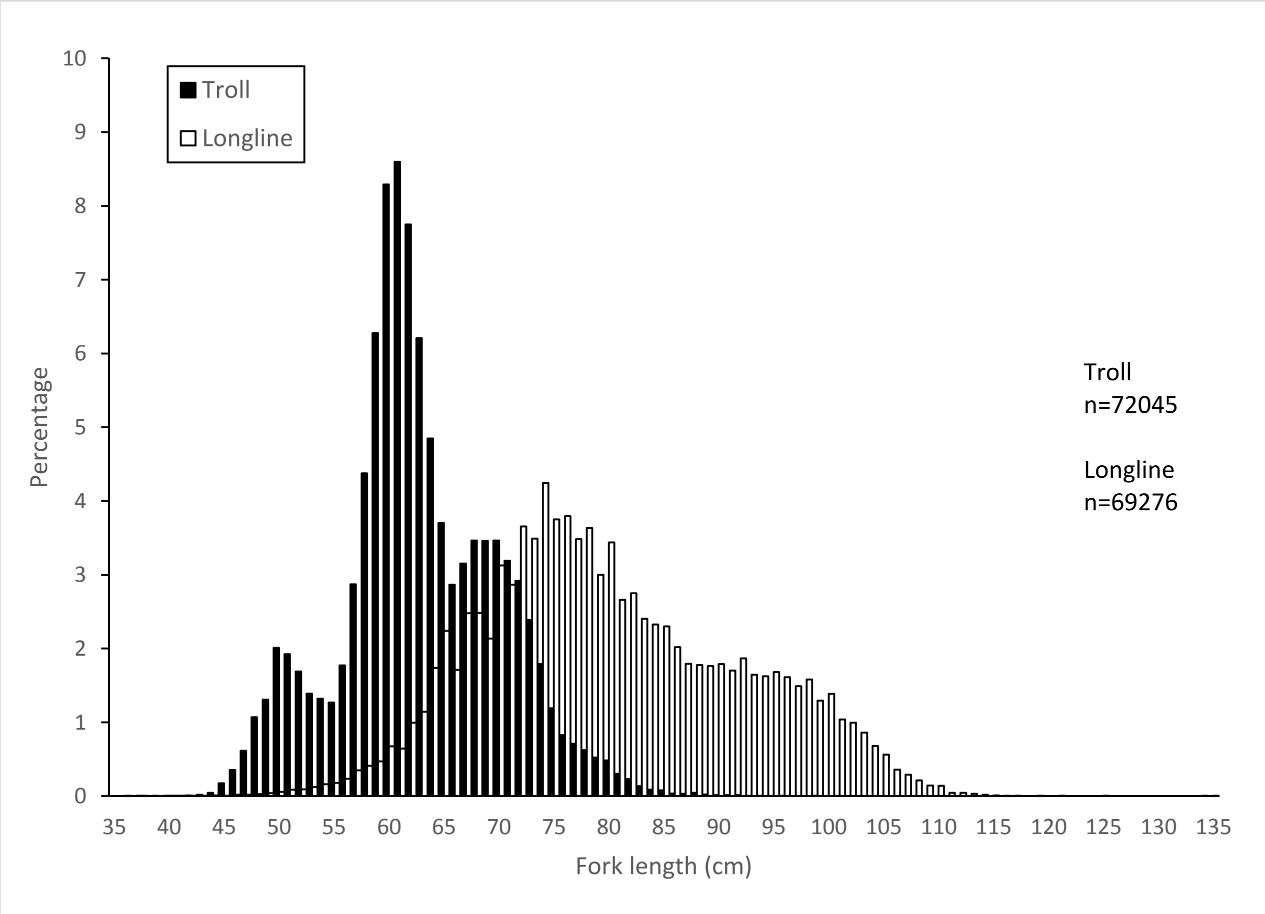


Figure 17: Length frequency distributions of albacore caught by troll and longline in New Zealand waters. Troll-caught albacore were from 15 years of sampling combined (1996–97 to 2011–12) and longline-caught albacore were measured by observers from 1997 to 2012.

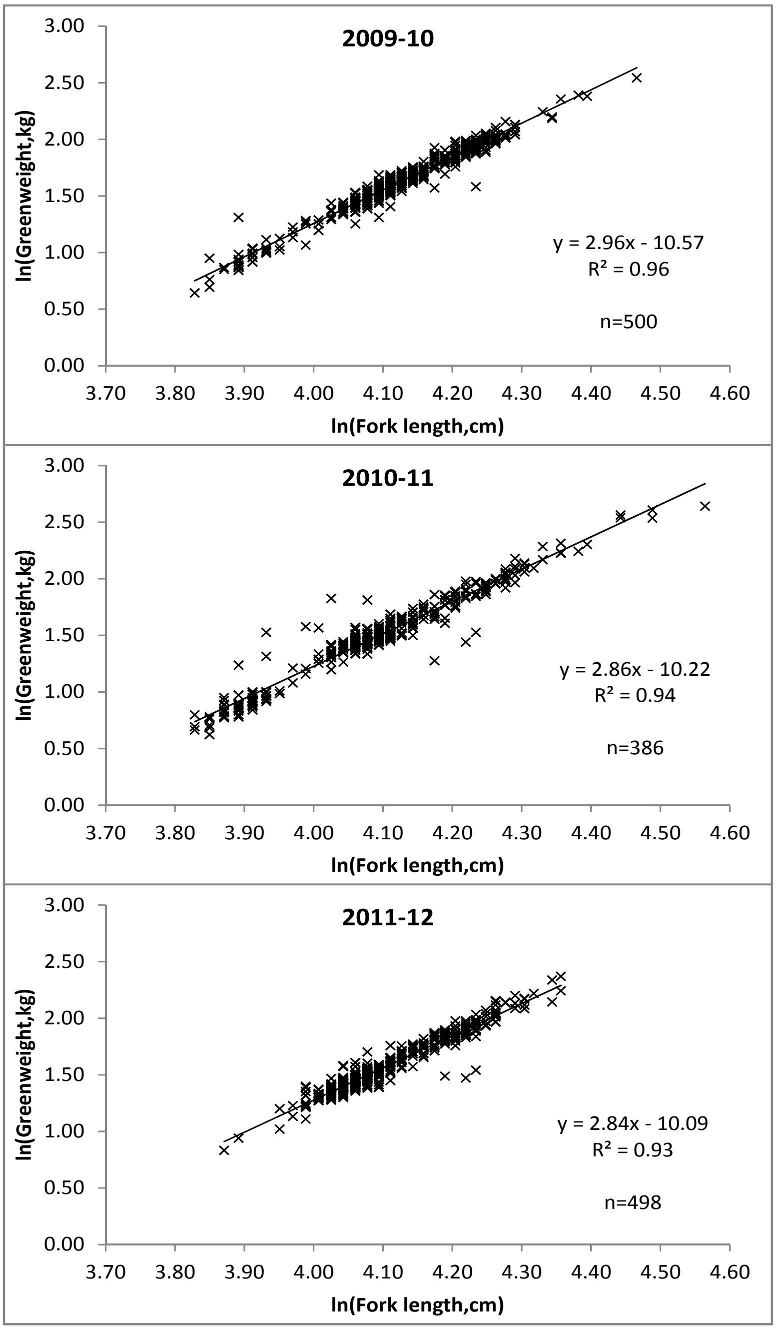


Figure 18: Length-weight relationship for troll caught albacore sampled from troll vessel landings, 2009–10 to 2011−12.

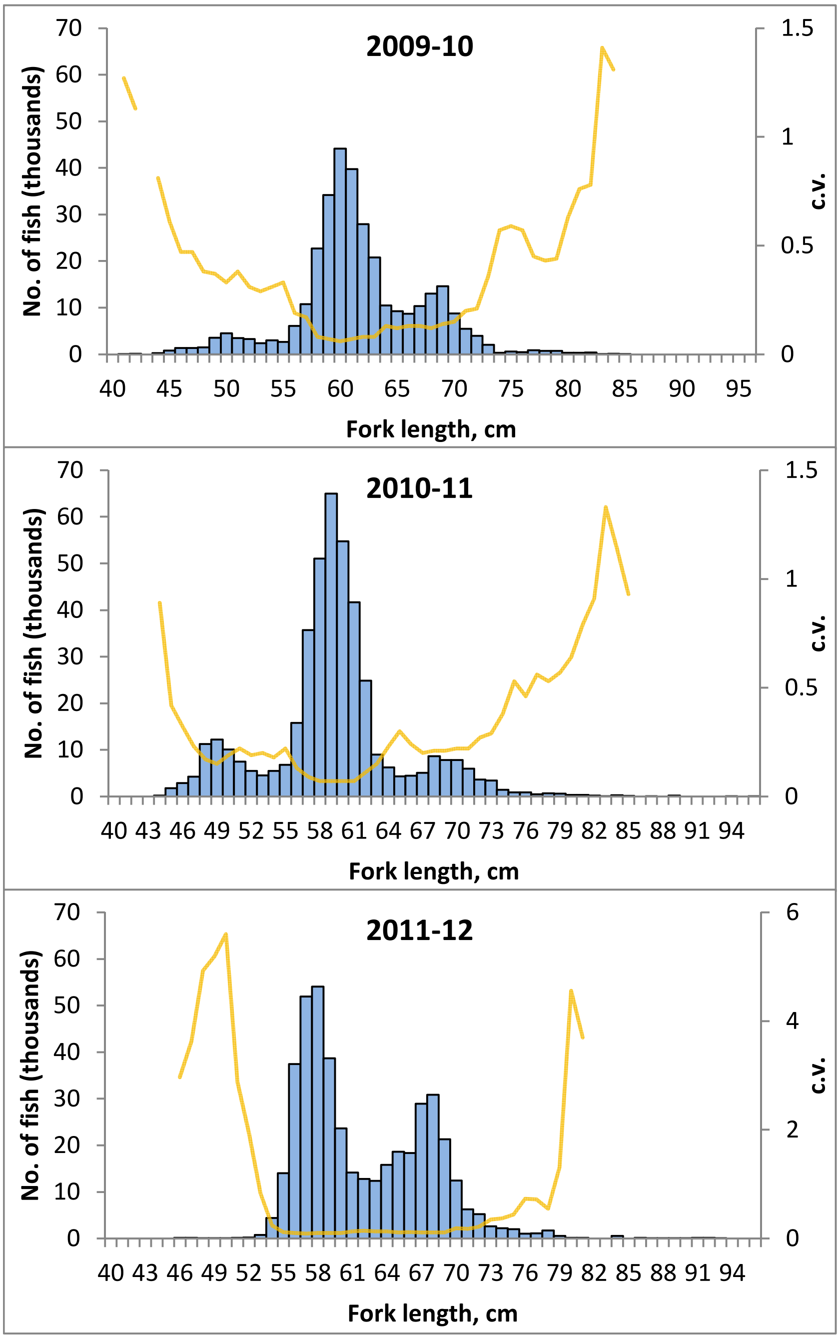


Figure 19: Albacore length frequency distributions, scaled to the total catch, 2009–10 to 2011–12.

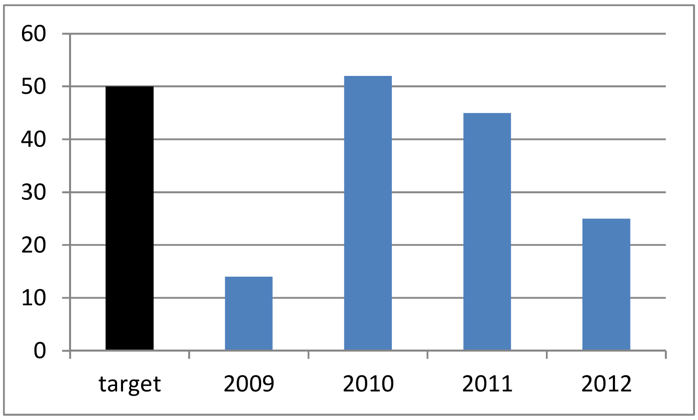


Figure 20: Target number of days and number of days observed each year.

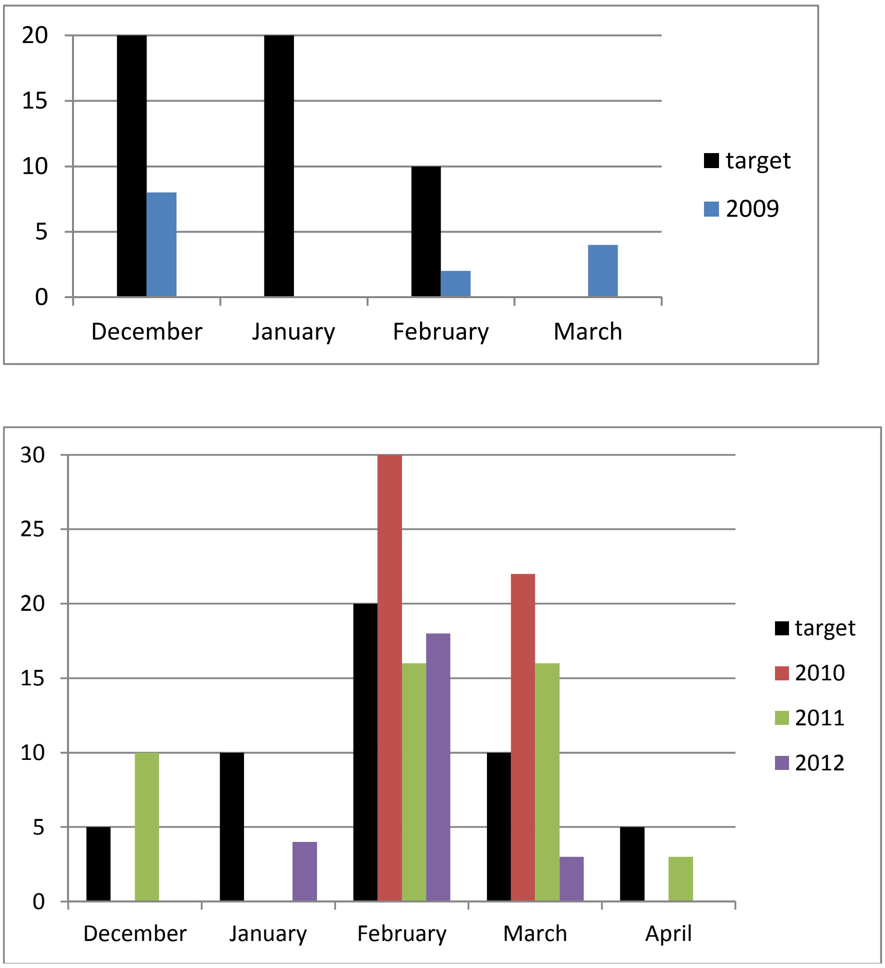


Figure 21: Target number of days and number observed each month, 2008–09 (above) and 2009–10 to 2011–12 (below).

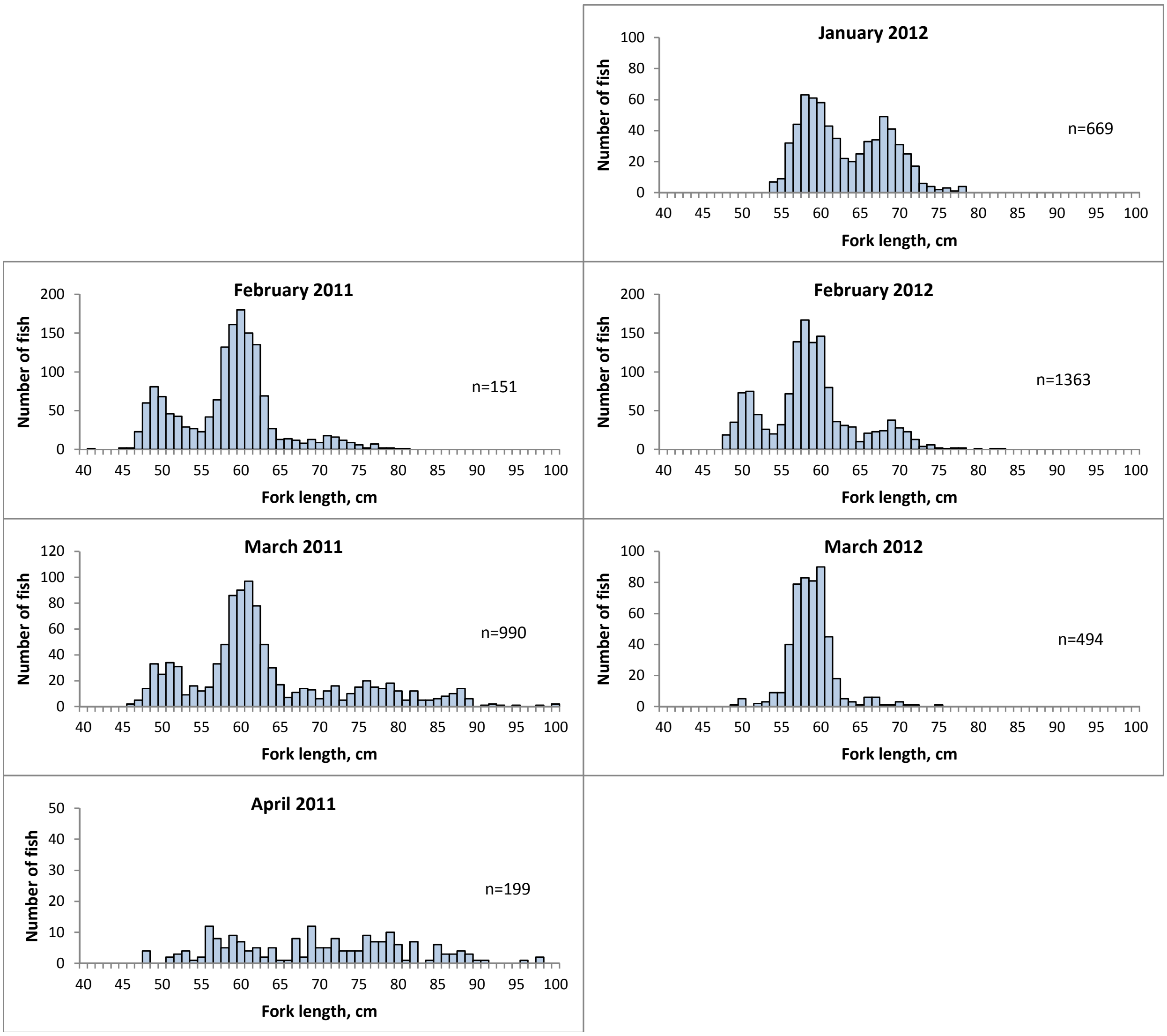


Figure 22: Albacore length frequency distributions, sampled by observers on troll vessels, 2010−11 and 2011–12.

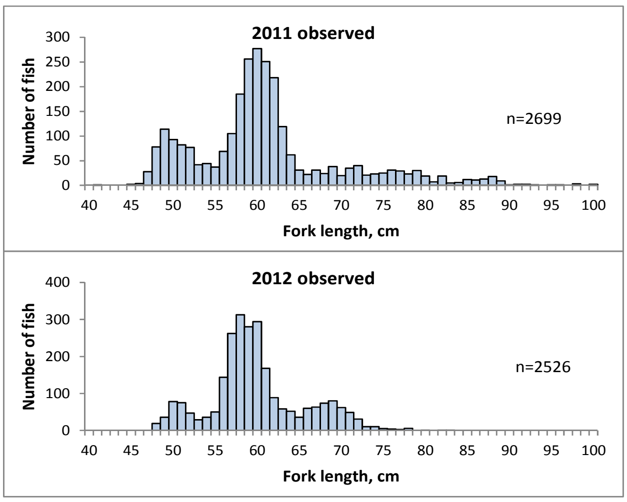
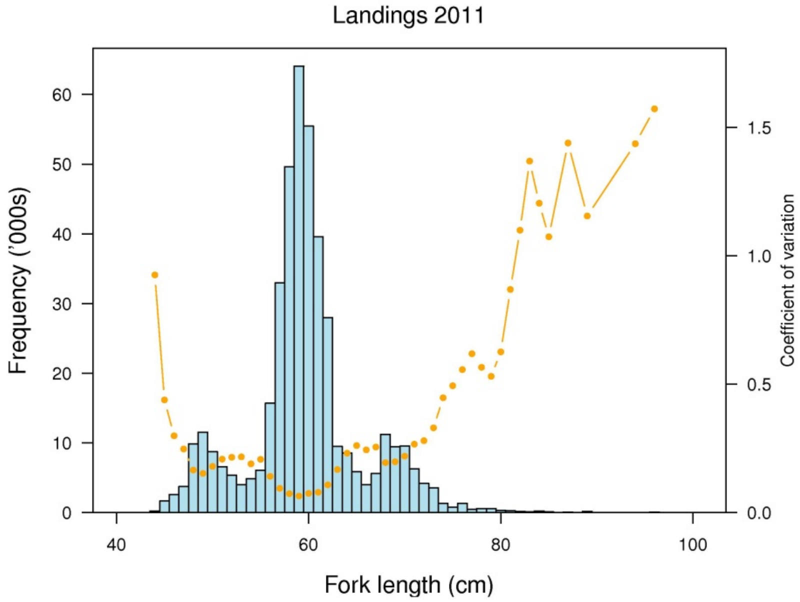


Figure 23: Albacore length frequency distributions, sampled by observers on troll vessels, 2010−11 and 2011–12, all months combined.



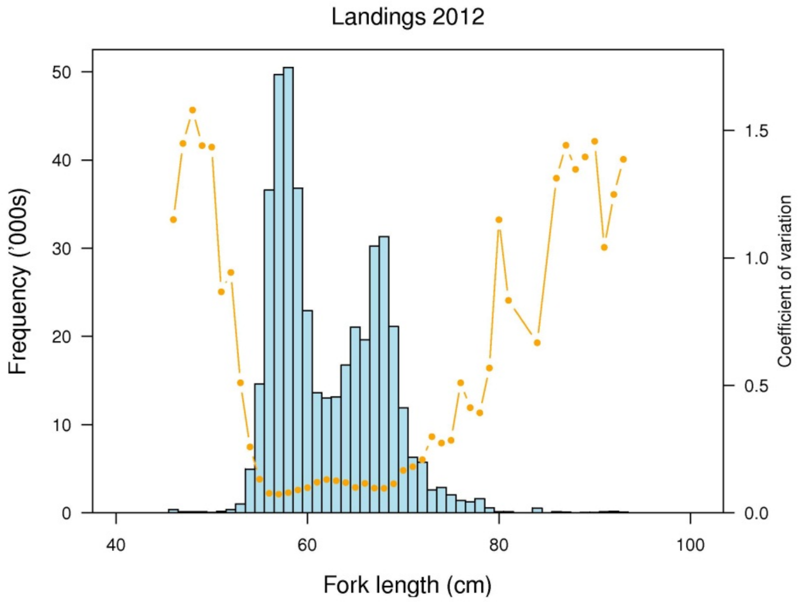


Figure 24: Albacore length frequency distributions, sampled by observers on troll vessels, scaled to the commercial catch, 2010−11 (2011 above) and 2011−12 (2012 below).

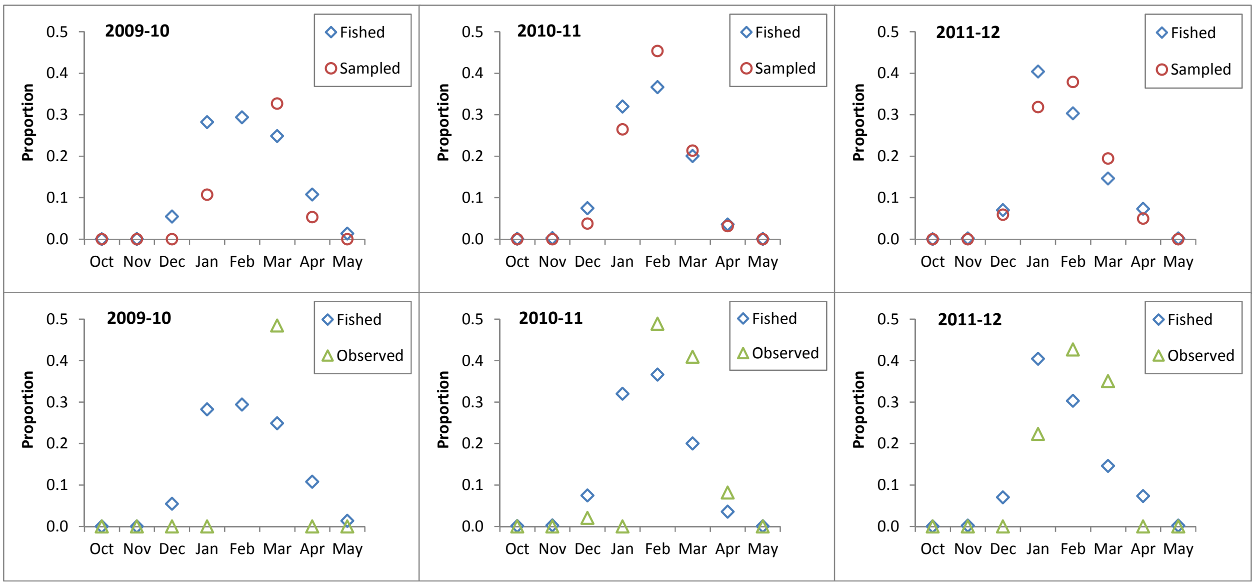


Figure 25: Proportion of catch (number of fish) fished, sampled and observed, by month.

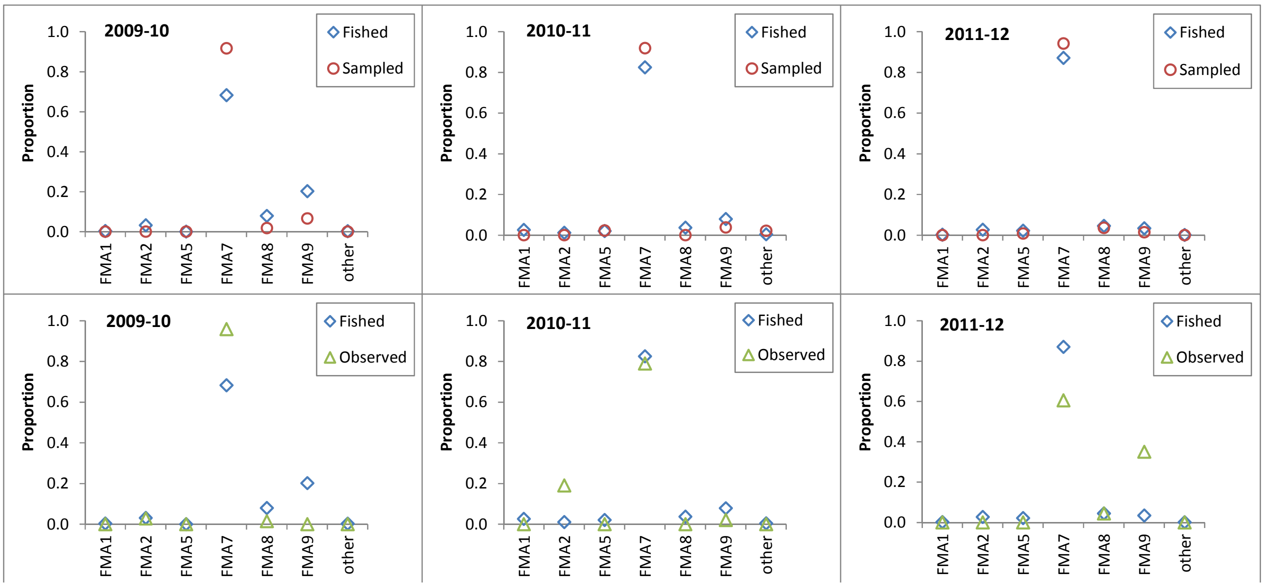


Figure 26: Proportion of catch (number of fish) fished, sampled and observed, by FMA.

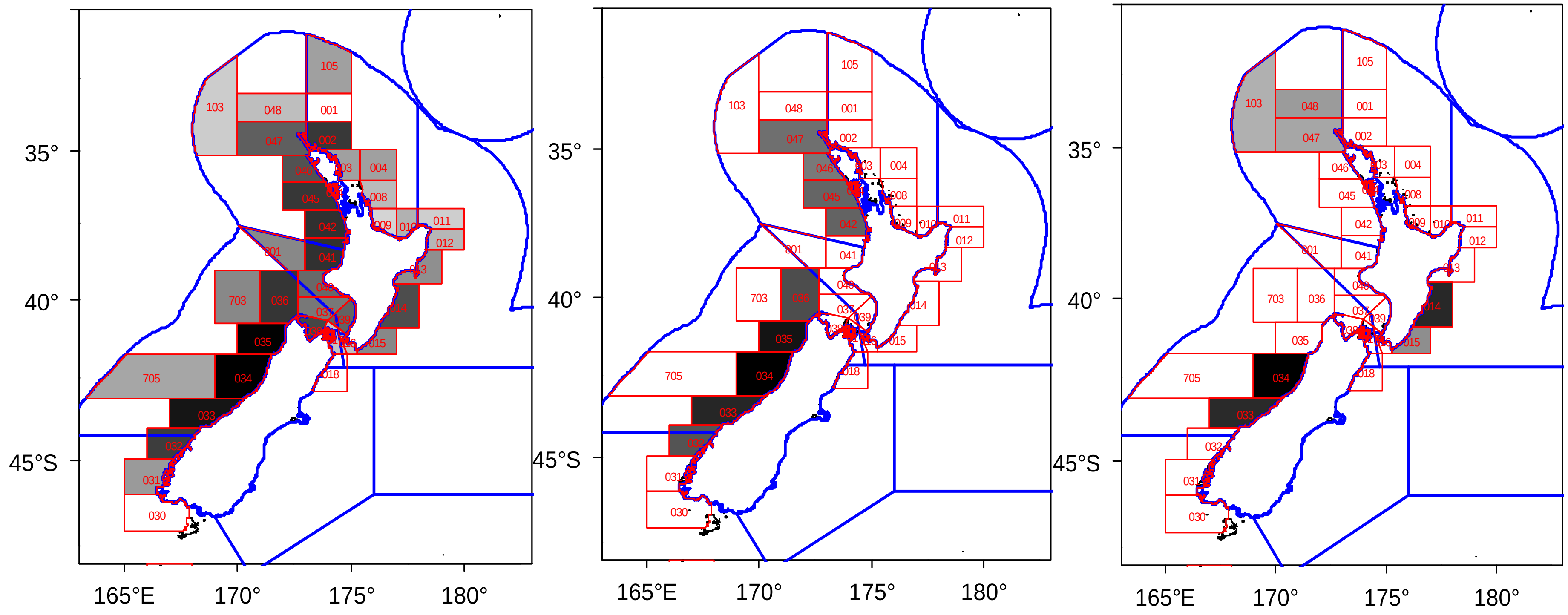


Figure 27: Statistical area density plots, fished (left), sampled (centre), and observed (right) for the 2010−11 year. A logarithmic density scale was used where 0=white and 1=black.

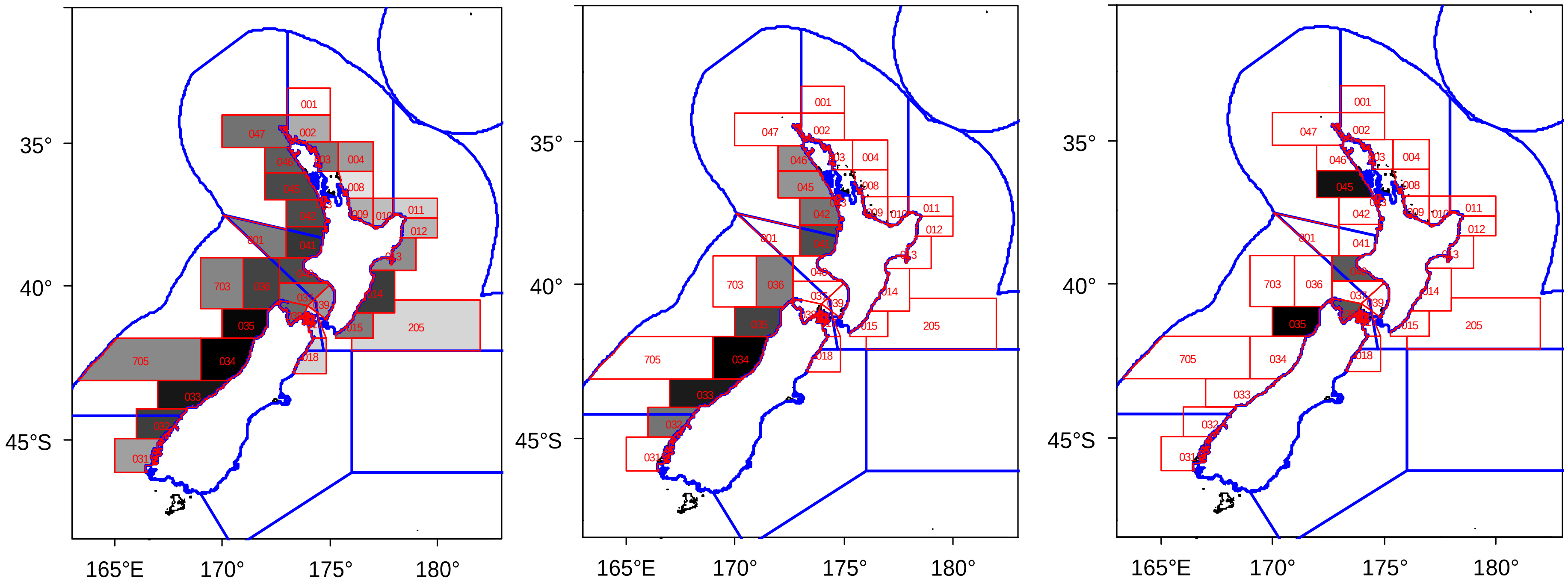
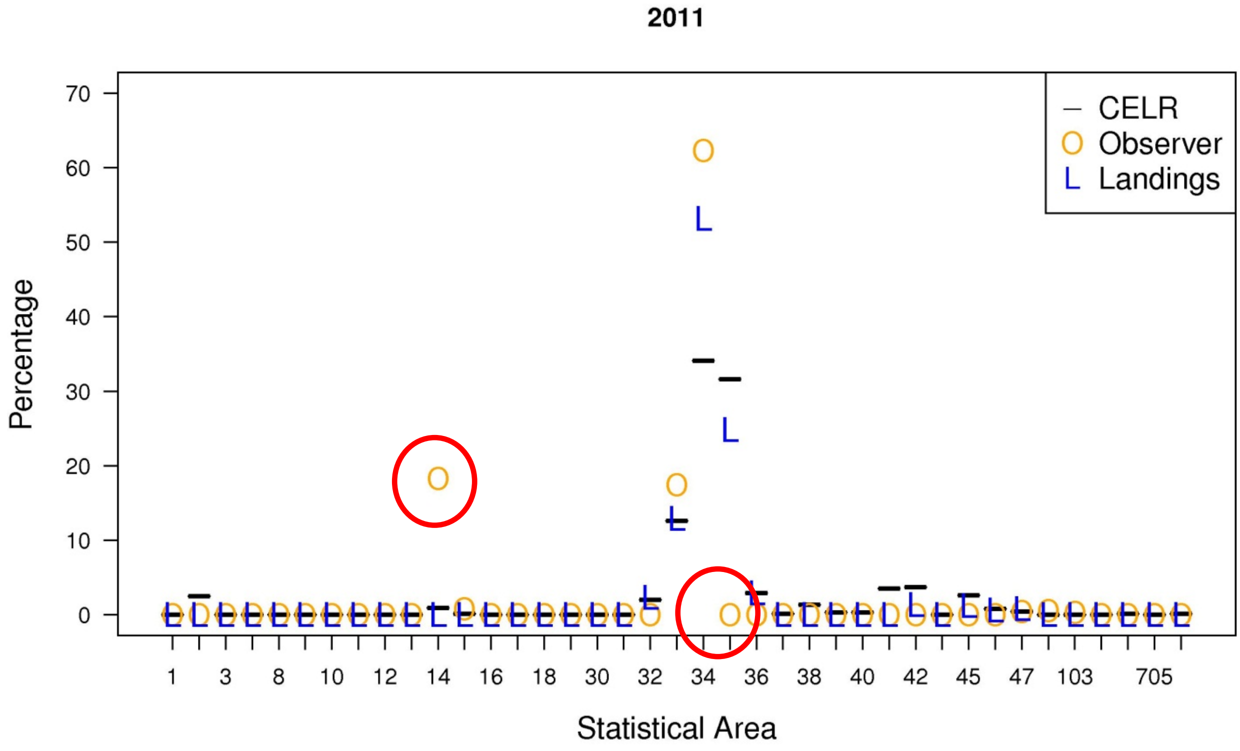


Figure 28: Statistical area density plots, fished (left), sampled (centre), and observed (right) for the 2011−12 year. A logarithmic density scale was used where 0=white and 1=black.



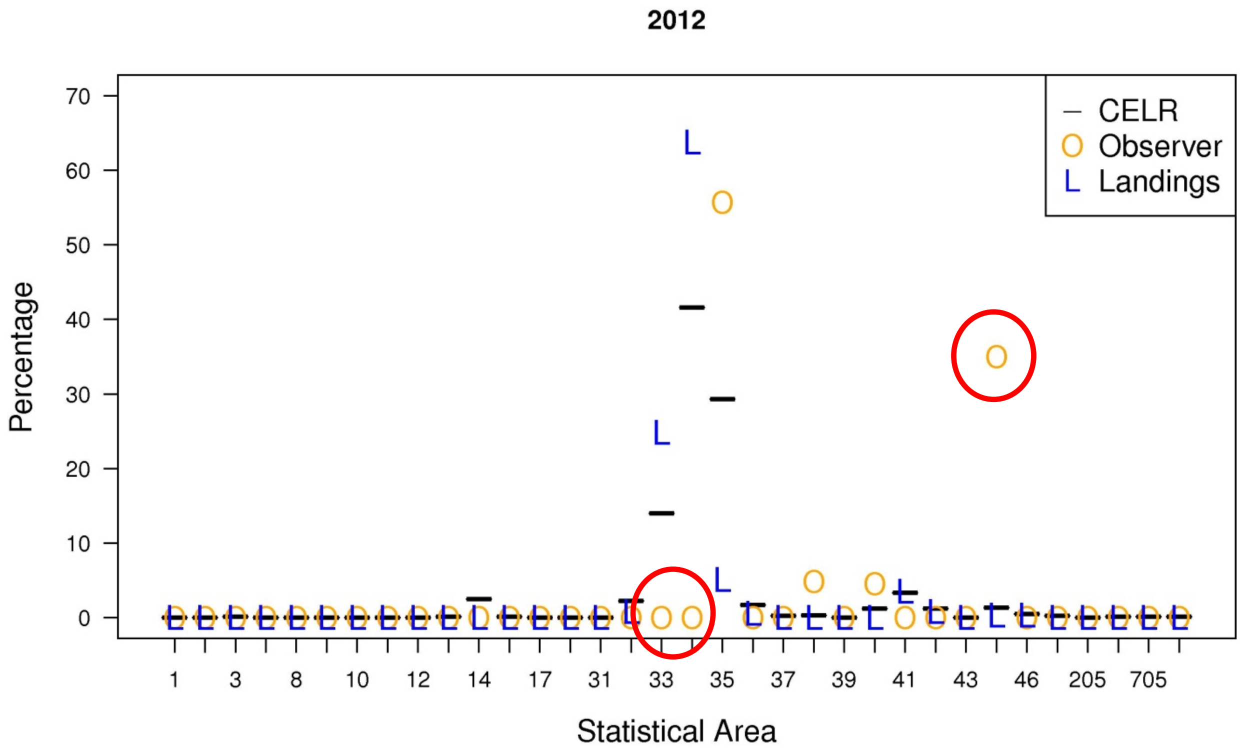


Figure 29: Percentage (number of fish) of catch (−), catch sampling landings (L), and observer coverage (O), in fishery statistical areas. Red circles highlight spatial mismatches.

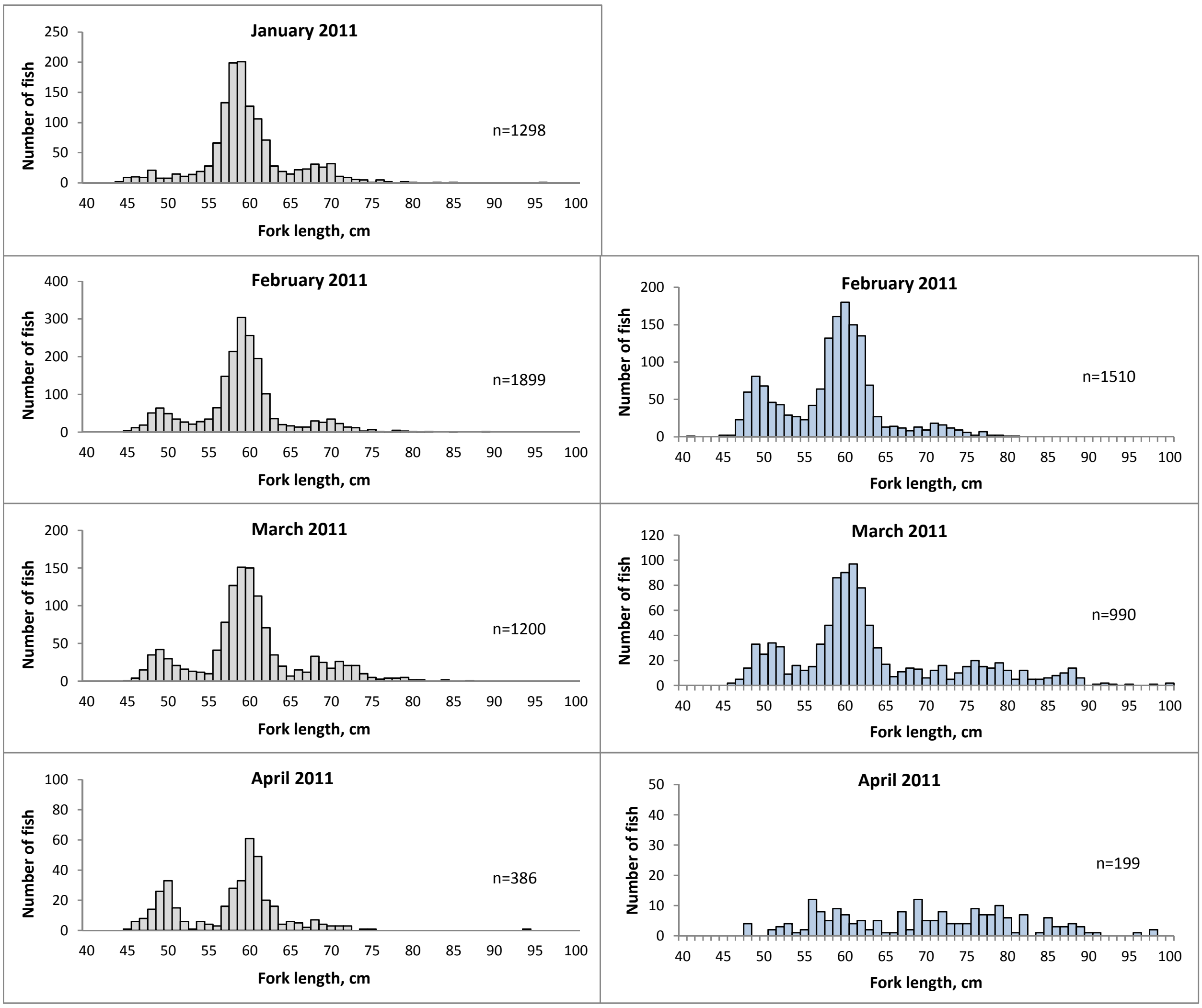


Figure 30: Comparison of unscaled length frequencies by month in 2010−11, catch sampled (left) and observed (right).

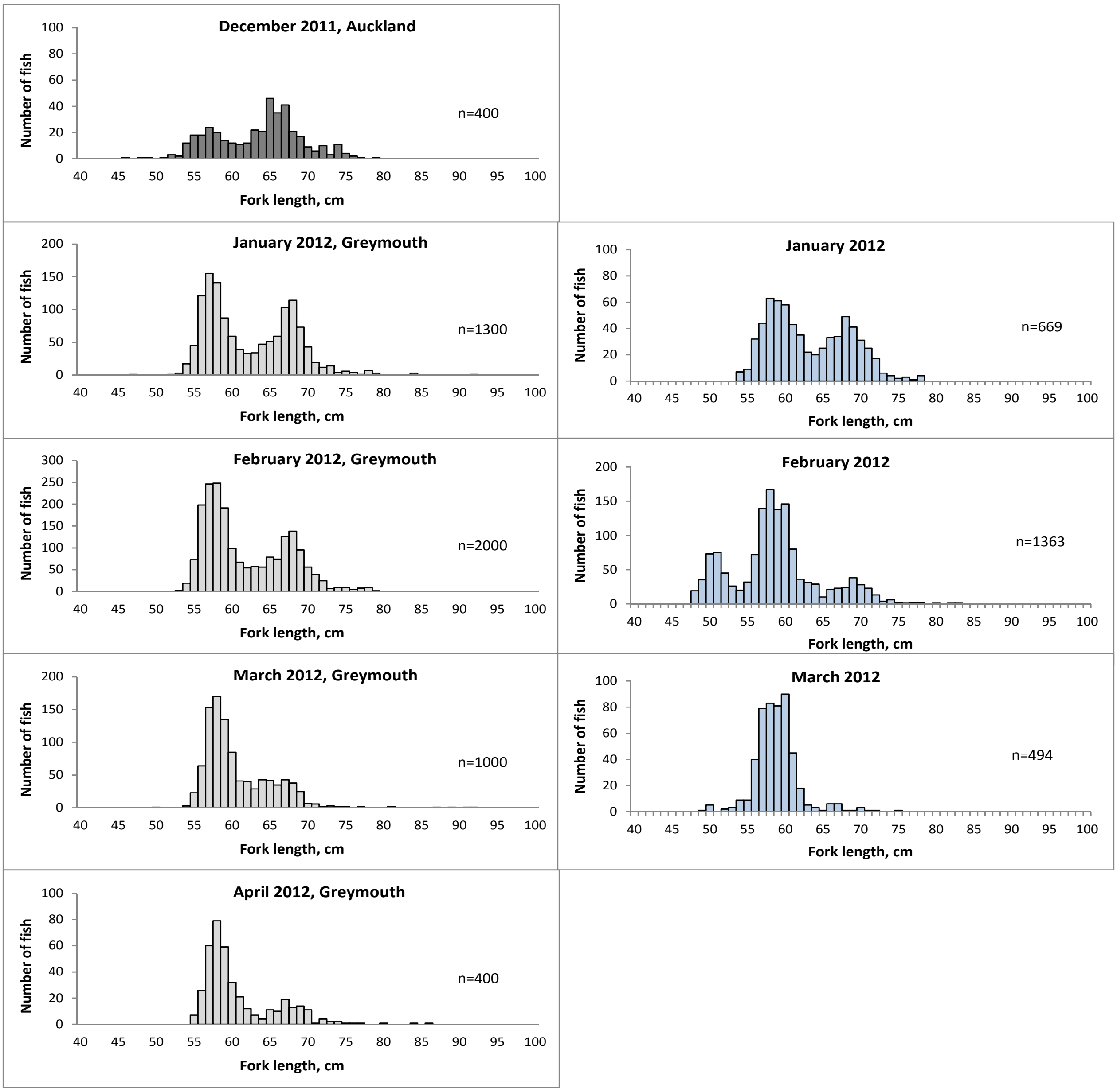


Figure 31: Comparison of unscaled length frequencies by month in 2011−12, catch sampled (left) and observed (right).

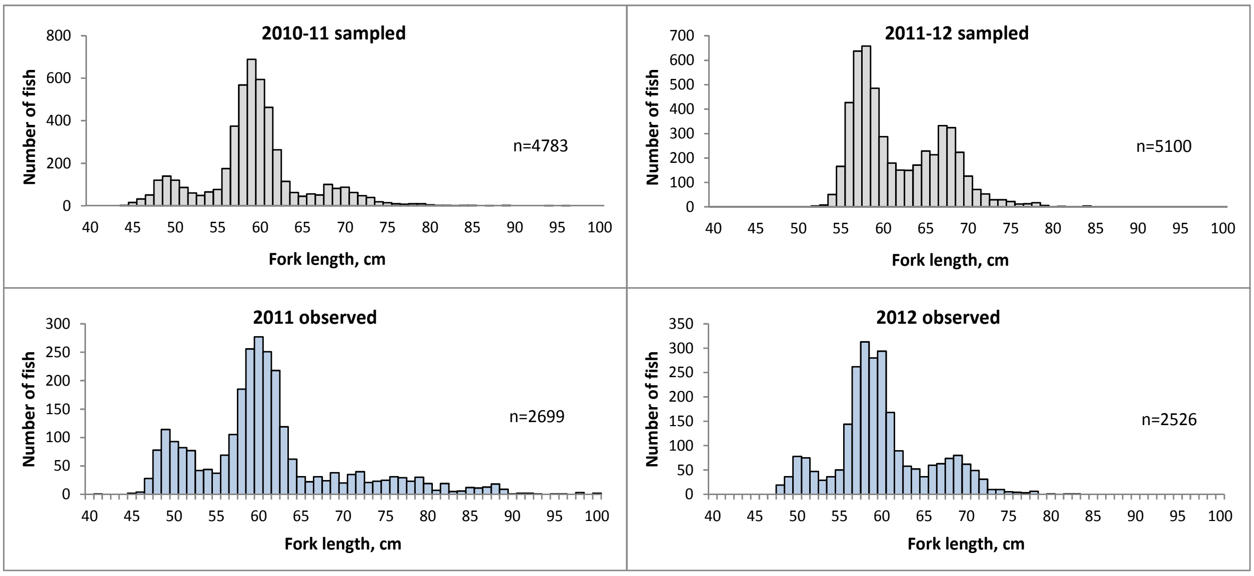


Figure 32: Comparison of unscaled length frequencies by year in 2010−11 (left) and 2011−12 (right), catch sampled (above) and observed (below).

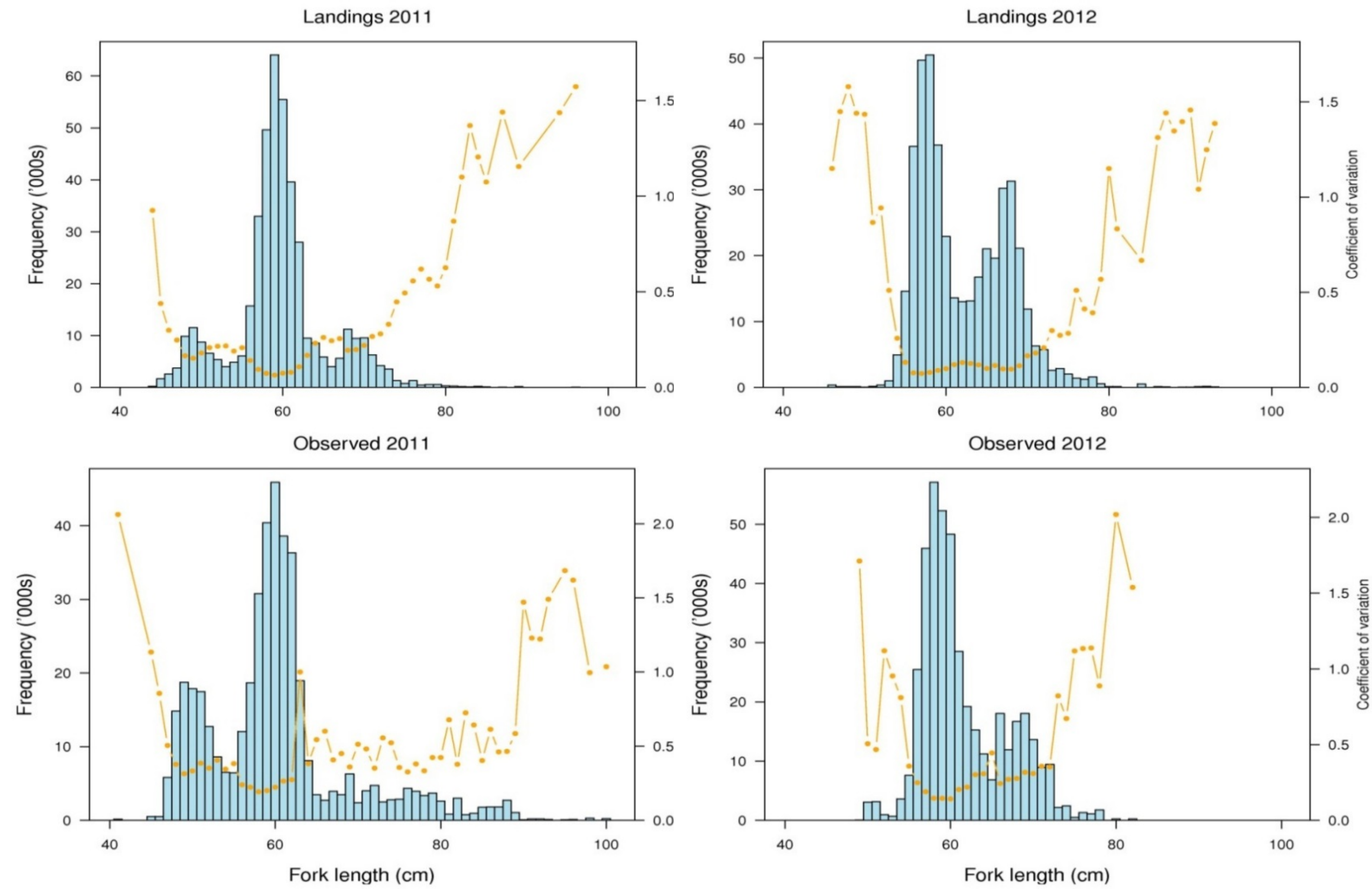


Figure 33: Scaled length frequencies with CVs, by year in 2010−11 (left) and 2011−12 (right), catch sampled (above), observed (below).

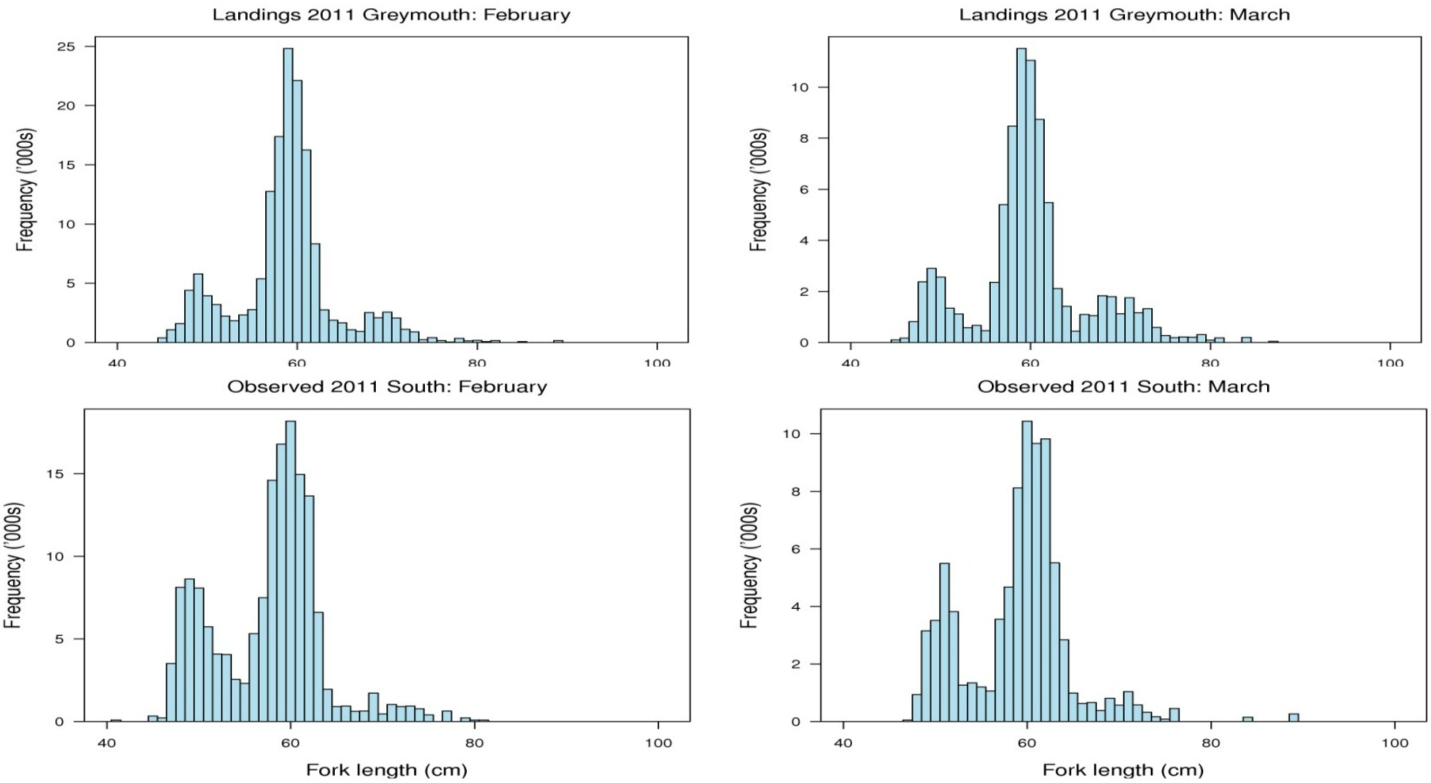


Figure 34: February 2011 (left), March 2011 (right), catch sampled (above), observed (below).

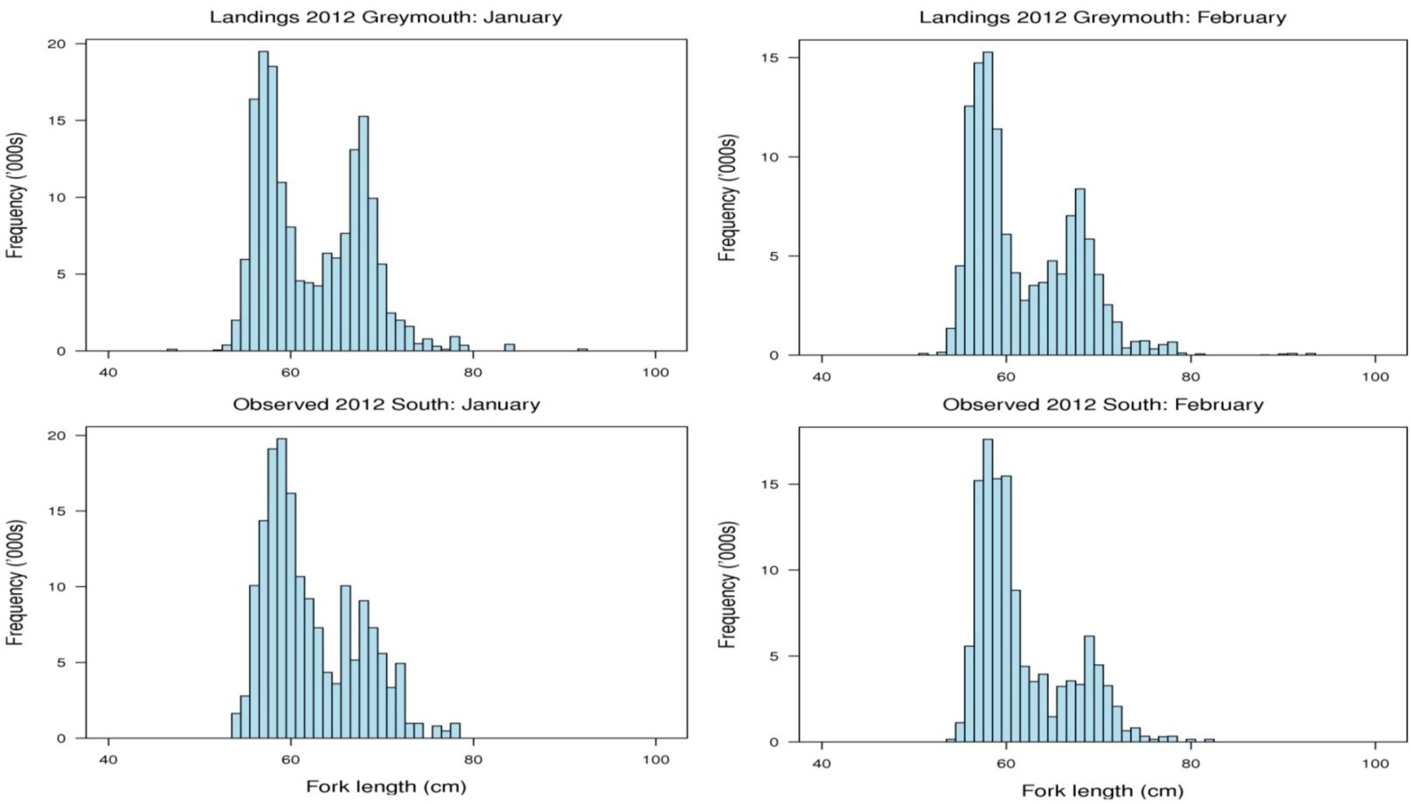
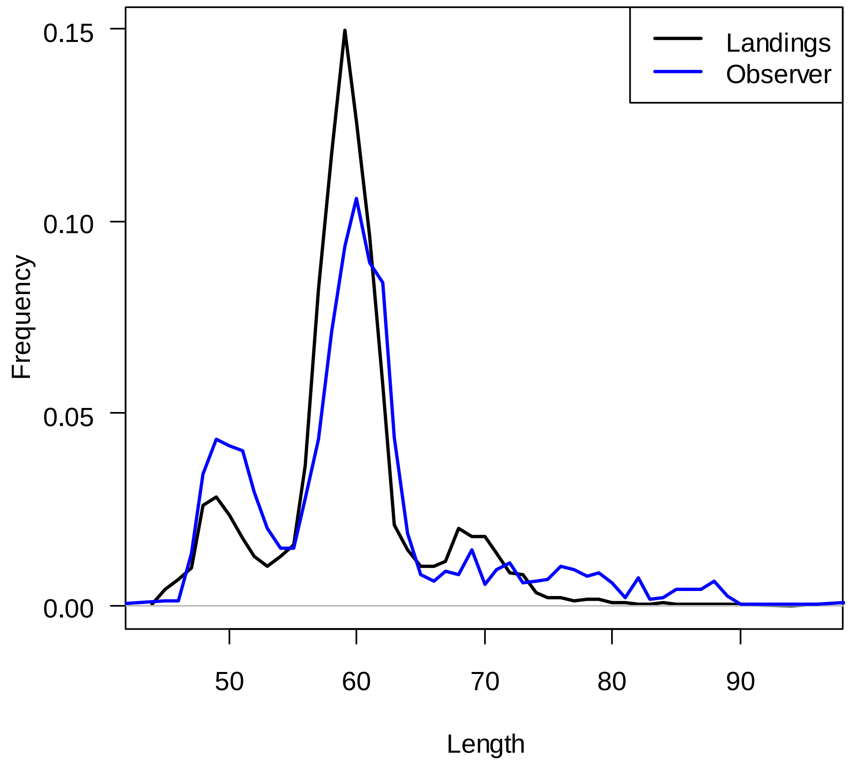


Figure 35: January 2012 (left), February 2012 (right), catch sampled (above), observed (below).



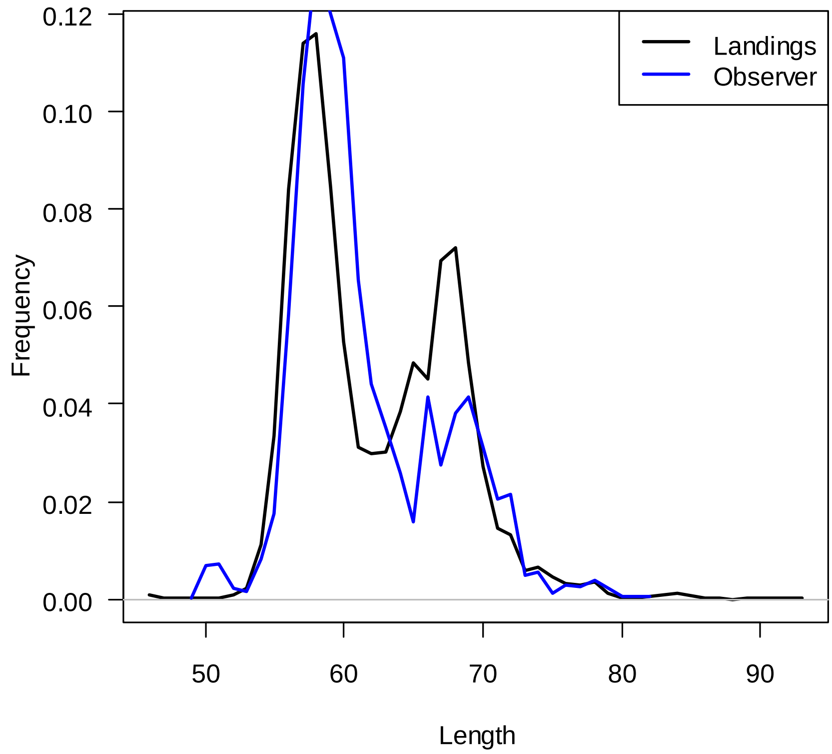


Figure 36: Catch sampling landings and observer length frequencies overlaid, 2010−11 (above) and 2011−12 (below)

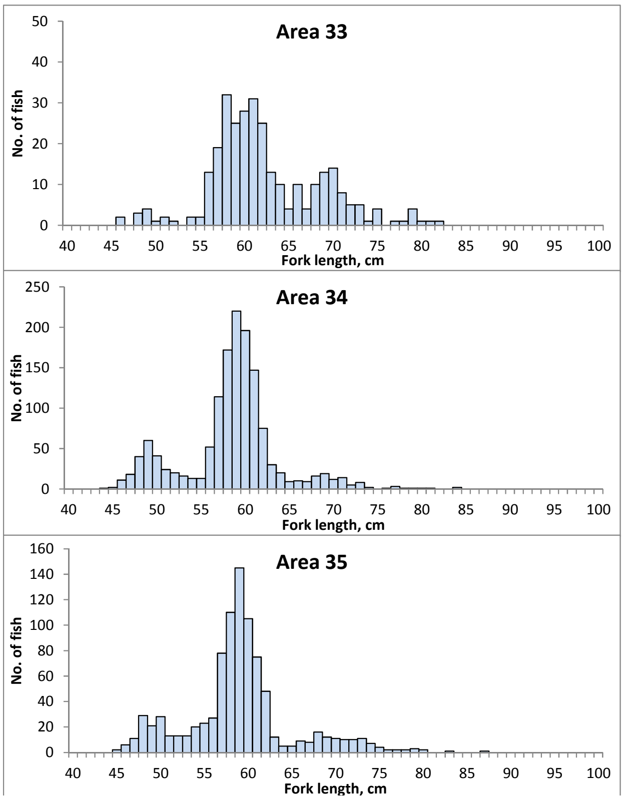


Figure 37: Length frequencies of fish from Statistical Areas 033, 034 and 035, from catch sampling in 2011.

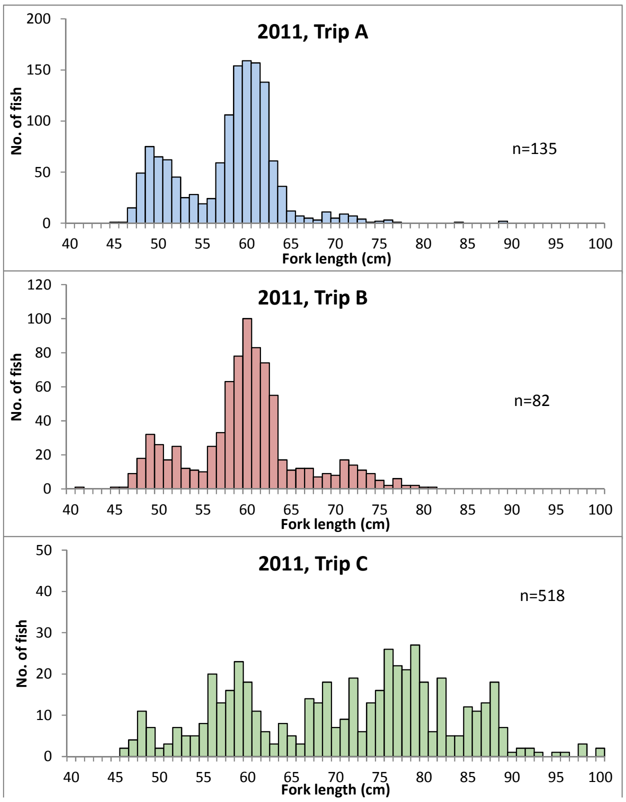


Figure 38: Comparison of lengths from three observed trips in 2011.