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Relative abundance, size, age structure, and stock status of blue cod from the 2025 survey in Marlborough Sounds

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PLAIN LANGUAGE SUMMARY

South Island recreational blue cod fisheries are monitored by Fisheries New Zealand using potting surveys. The Marlborough Sounds surveys, carried out every four years, are important for assessing the status of the blue cod stock in this region.

This report describes the results of the random-site blue cod potting survey carried out in Marlborough Sounds in October 2025 and compares these with the results from three previous surveys in 2012, 2017 and 2021. Abundance of blue cod has been low, but relatively stable, throughout the Sounds. Fish are generally small and the population is dominated by males (66–72% male). Fishing mortality has been higher than the target reference point for all surveys, indicating that overfishing is occurring.

The Long Island Marine Reserve has been included in the survey series since 2017. In 2025, blue cod abundance was 4–8-fold greater and mean length was 3–5 cm greater in the marine reserve than in adjacent fished strata in Queen Charlotte Sound, with no clear trend over time. Maud Island Closed Area was surveyed for the first time in 2025. Although mean catch rates were lower than those in Long Island Marine Reserve, abundance, size, and condition in the Maud Island Closed Area were all greater than outside. All blue cod caught in Long Island Marine Reserve and Maud Island Closed Area were released alive.

EXECUTIVE SUMMARY

Beentjes, M.P.; Miller, A.; Hamill, J. (2026). Relative abundance, size, age structure, and stock status of blue cod from the 2025 survey in Marlborough Sounds.

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This report describes the results of the blue cod (*Parapercis colias*) random-site potting survey carried out in the Marlborough Sounds from 30 September to 3 November 2025. Estimates are provided for population abundance, size and age structure, sex ratio, total mortality (*Z*), and fishing mortality (*F*). This was the fourth fully random-site blue cod survey conducted in the Marlborough Sounds, following surveys in 2013, 2017, and 2021, and the eleventh survey overall (with nine fixed-site surveys carried out between 1995 and 2017). The 2025 survey was also the third in the time series for Long Island Marine Reserve (LIMR), following those in 2017 and 2021. Maud Island Closed Area (MAUD) and Stephens Island (STEP) were also surveyed for the first time in 2025.

Sixty random sites (9 pots per site; 540 pot lifts) were successfully surveyed across twelve core strata in four regions: Queen Charlotte Sound (QCH), Pelorus Sound (PEL), D'Urville Island (DUR), and Cook Strait (CKST). Catch rates for all blue cod were 1.69 kg pot^{-1} in QCH (coefficient of variation, CV, 19%), 0.68 kg pot^{-1}in PEL (CV 23%), 3.53 kg pot^{-1} in DUR (CV 35%), and 1.24 kg pot^{-1} in CKST (CV 21%); the overall catch rate for Marlborough Sounds (MS) was 1.69 kg pot^{-1} (CV 18%). Of the 540 pots, 223 (41%) had zero catch of blue cod.

Scaled length-frequency distributions were similar among the four regions and were either unimodal or included a smaller juvenile mode for both sexes. The overall mean size in MS was 31.5 cm for males and 29.1 cm for females. Sex ratios were male-biased in all regions (QCH 79% male, PEL 77%, DUR 71%, CKST 87%, and MS 77%). Mean ages were 5.5 years (2–17 years) for males and 6.9 years (2–20 years) for females. The MS Chapman-Robson total mortality (*Z*) estimate for the age at recruitment of males at six years was 0.92 yr^{-1}. Based on the default *M* of 0.17, fishing mortality (*F*) was 0.75 yr^{-1}, well above the target reference point of 0.15 (F=0.87M), which is also the overfishing threshold. There was spawning activity during the survey period and, overall, approximately 9% of males and 12% of females were running ripe.

Mean catch rates in QCH have progressively increased by more than three-fold between 2013 and 2025, whereas PEL catch rates showed a clear decline, halving from 2013 to 2021, then stable, and DUR, CKST and MS overall catch rates have all fluctuated without trend. The sex ratios of all blue cod ranged from 66–79% male (QCH), 77–90% male (PEL), 57–73% male (DUR), 80–87% male (CKST), and 66%–72% male (MS excluding CKST), all without trend except QCH which showed a progressive increasing trend.

All blue cod from LIMR and MAUD were released alive, without sex determination. The 2025 catch rate for all blue cod in LIMR was 8.9 kg pot^{-1} (CV 10%) and over the three surveys catch rates were 4–8 fold greater, and mean length was 3–5 cm greater than adjacent fished QCH strata (outside). Similarly, the proportions of catch rates inside LIMR that were ≥ 33 cm, which is the MLS, was 54–86%, compared to 30–45% outside, and 1–10% of pots were empty in LIMR compared to 20–70% in adjacent strata. Mean catch rates in MAUD were not as high as those in LIMR (4.12 kg pot^{-1}, CV 15%). But like LIMR, abundance and size and condition were all greater inside than outside the MAUD closed area. STEP blue cod catch rate was 10.4 kg pot^{-1} (CV 10%), the highest of all strata, including LIMR and MAUD.

1. INTRODUCTION

This report describes the results of the blue cod (*Parapercis colias*) random-site potting survey carried out in Marlborough Sounds in October 2025. Estimates are provided for population abundance, size and age structure, sex ratio, total mortality (*Z*), and fishing mortality (F). This is the fourth full random-site blue cod survey carried out in the Marlborough Sounds after those in 2013, 2017, and 2021, and the eleventh survey overall, with nine fixed-site surveys carried between 1995 and 2017. The report also presents time series comparisons of these indices.

1.1 Blue cod potting surveys

South Island recreational blue cod fisheries are monitored using potting surveys. These surveys take place in the most important blue cod recreational fisheries areas, although there is often substantial overlap between the commercial and recreational fishing grounds, e.g., Foveaux Strait, north and south Otago. Surveys are generally carried out every four years to monitor local relative abundance, size, age, and sex structure of geographically separate blue cod populations. The surveys provide a measure of the response of populations to fishing pressure and management intervention, such as changes to the daily bag limit, minimum legal size, and area closures. In addition to the Marlborough Sounds, there are currently eight other areas surveyed, located in key recreational fisheries: Kaikōura, Motunau, Banks Peninsula, north Otago, south Otago, Foveaux Strait, Paterson Inlet, and Dusky Sound (Appendix 1). In the Marlborough Sounds, previous potting surveys were carried out in 1995, 1996, 2001, 2004, 2007, 2008, 2010, 2013, 2017, and 2021 (Blackwell 1997, 1998, 2002, 2006, 2008, Beentjes & Carbines 2012, Beentjes et al. 2017, Beentjes et al. 2018, Beentjes et al. 2022b). The length of the time series for the Marlborough Sounds varies among the regions and survey design type (Table 1).

All Marlborough Sounds potting surveys before 2010 used a fixed-site design (see Appendix 2, glossary of terms), where sites with predetermined locations (fixed sites) were randomly drawn from a limited list of such sites (Beentjes & Francis 2011, Beentjes 2019). Fixed sites represent 'good' fishing spots or locations where blue cod were known to be abundant. The South Island potting surveys were reviewed by an international expert panel in 2009, which recommended that blue cod would be more appropriately surveyed using random-site potting surveys (Stephenson et al. 2024). A random site is any location (single latitude and longitude) generated randomly from within a stratum (Beentjes & Francis 2011, Beentjes 2019). Subsequently, in 2010, experimental random sites were trialled in selected strata within Pelorus Sound, D'Urville Island, and the entire Cook Strait region (Beentjes & Carbines 2012); and in 2013 and 2017, full random-site and full fixed-site surveys were conducted concurrently (Beentjes et al. 2017, Beentjes et al. 2018). The 2021 survey was the first solely random-site survey carried out in Marlborough Sounds and this survey time series has now fully transitioned to the random-site design. The 2017, 2021, and 2025 random-site surveys also included Long Island Marine Reserve (Kokomohua), and the 2025 survey included Maud Island Closed Area and Stephens Island (Table 1).

1.2 Stock status of blue cod in the Marlborough Sounds

Previously, the standard method of assessing the stock status of blue cod around the South Island by Fisheries New Zealand was to estimate fishing mortality (*F*) and the associated spawner-biomass-per-recruit ratio (*SPR*), which was used as a proxy for F_{MSY} (maximum sustainable yield biomass) (Beentjes & Page 2021, Fisheries New Zealand 2024). The Fisheries New Zealand Stock Assessment Plenary meeting on 18 July 2022 agreed that the standard *SPR* was no longer appropriate as a target reference point for blue cod in Marlborough Sounds because few females currently grow large enough to recruit to the fishery and the standard spawner-per-recruit approach does not model blue cod sex change dynamics (Beentjes et al. 2022b, Fisheries New Zealand 2024). The Plenary meeting also recommended F=0.87M (natural mortality) as an alternative B_{MSY} proxy target reference point or overfishing threshold for Marlborough Sounds blue cod based on the study of Zhou et al. (2012), where *Z* (total mortality)

and F were estimated from the male-only age composition in the population. In both cases, the age-at-full recruitment was taken as the male average age at minimum legal size plus one year to ensure that more than 50% of males are recruited to the fishery. Based on the same rationale applied to the 2021 Marlborough Sounds survey, the B_{MSY} proxy target reference point for other potting surveys was changed to F=0.87M (natural mortality), i.e., surveys in Kaikoura, Motunau, north Otago, south Otago, and Foveaux Strait (Beentjes et al. 2022b, Beentjes & Fenwick 2023a, 2023b, Beentjes & Miller 2024a, 2024b, Beentjes & Page 2024).

The previous estimates of F for the last three Marlborough Sounds survey were 0.43, 0.58, and 0.48 (Beentjes et al. 2022b). These are between three to four times higher than the F target reference point of 0.15 indicating that overfishing is occurring.

As blue cod are protogynous hermaphrodites with some (but not all) females changing into males as they grow, monitoring the sex ratio of the populations is important because the largest fish in the populations are invariably males (Carbines 2004). In heavily fished blue cod populations, sex ratios skewed towards males are often observed (Beentjes & Carbines 2009, Beentjes 2021). This is thought to result from the removal of the inhibitory effect of large males and a consequent higher rate (and possibly earlier onset) of sex change by primary females (Beentjes & Carbines 2005, Beentjes 2021).

Tagging experiments indicate that blue cod have a restricted home range (Rapson 1956, Mace & Johnston 1983, Mutch 1983, Carbines & McKenzie 2001, 2004) and that stocks of this species are likely to consist of many largely independent sub-populations within Fisheries Management Areas (FMA) (Carbines 2004). This suggests that blue cod are susceptible to localised and serial depletion within an FMA. However, blue cod are not genetically distinct around the New Zealand mainland (Gebbie 2014), indicating that some genetic mixing is occurring on a wider geographical scale than within the restricted home range indicated by tagging studies.

1.3 Blue cod recreational fishery in the Marlborough Sounds

Blue cod is the second most important recreational target species in the Marlborough Sounds and Tasman Bay/Golden Bay (TB/GB) after snapper. The recreational take of blue cod within BCO 7 was estimated at 63 t from the 2017–18 national panel survey (Wynne-Jones et al. 2019), 75 t from a 2016 aerial-access survey (Hartill et al. 2017), and most recently at 33 t from the 2022–23 national panel survey (Heinemann & Gray 2024, Fisheries New Zealand 2026). Recreational catch estimates were similar to those of the commercial fishery in BCO 7, which is confined to the outer sounds and Cook Strait (Davey et al. 2008), with reported commercial landings of 34–70 t annually over the last 10 years (Fisheries New Zealand 2026).

In the Marlborough Sounds, there have been frequent changes to both the minimum/maximum legal size and to the daily bag limit, as well as area closures in the 'Marlborough Sounds Area' (Figures 1 and 2). The daily bag limit (DBL) progressively declined from 12 blue cod in 1985 to 2 since 2011, while the inner Sounds was closed to target blue cod fishing from October 2008 to April 2011. The minimum legal size (MLS) has varied from 28 cm to 33 cm, with a slot limit of 30 to 35 cm from April 2011 to December 2015 (Figure 2). From December 2015, within 'Marlborough Sounds Area' and 'Challenger Area East', the MLS has been 33 cm, DBL 2 blue cod (or 2 from each area), with a maximum of two hooks per line, and the fishery has been closed from 1 September to 19 December (inclusive), extended to 10 January in August 2025. The area from Farewell Spit to Clarence River (out to 12 nautical miles), including Marlborough Sounds, is known as the Tasman Area, and on 1 July 2020, was assigned a 'traffic light' colour of red by Fisheries New Zealand, indicating that the blue cod stocks in this area are considered to be overfished.

1.4 Response to management interventions

There was a marked reduction in length of blue cod in the Marlborough Sounds from the late 1930s (Rapson 1956) to the mid-1990s, when Fisheries New Zealand potting surveys began monitoring the population. The Marlborough Sounds potting surveys showed a decline in abundance in the inner Sounds of about one-third to a half between 1995–96 and 2001, and indicated that local depletion had occurred in the inner Sounds where blue cod catch rates were consistently lower and mean length was smaller than the outer Sounds (Beentjes & Carbines 2012, Beentjes et al. 2017). The closure of the inner Marlborough Sounds to blue cod fishing from October 2008 had a dramatic effect on the population length composition and abundance in the closed area by October 2010 (Beentjes & Carbines 2012). For the first time since 2001, and presumably for many years before that, blue cod were larger and more abundant within the inner than the outer Sounds, indicating that fishing in the inner Sounds has had a substantial effect on the length distribution and abundance of fish. There may have been some movement of blue cod from the outer to the inner Sounds that contributed to the improved size structure and higher abundance, so the change may not necessarily have been solely due to growth of resident inner Sounds fish.

The 2013 survey took place 30 months after the inner Sounds were reopened with a slot limit legal size (30–35 cm) covering the entire 'Marlborough Sounds Area'. The results of the 2013 survey indicated that blue cod abundance and length had declined in the previously closed areas (inner Pelorus and Queen Charlotte Sounds) after the re-opening of the fishery and slot limit introduction in April 2011, indicating that the blue cod population was responding to fishing effort (Beentjes et al. 2017). The blue cod potting survey time series appears to have successfully tracked trends in abundance and length distributions that resulted from changes in the fisheries management regime.

The closed season from 1 September to 19 December in place since 2015, has likely limited fishing pressure or even greater overfishing, but does not yet appear to have resulted in an improvement to the stock status. It was extended to 10 January for the 2025–26 summer and following years (i.e. after this potting survey was conducted).

1.5 Objectives

Overall objective

1. To estimate relative abundance, sex ratio, and age structure of blue cod (*Parapercis colias*) in the Marlborough Sounds

Specific objectives

1. To undertake a potting survey in the Marlborough Sounds (BCO 7) to estimate relative abundance, age structure, size- and age-at-maturity, and sex ratio and collect otoliths from pre-recruited and recruited blue cod.
2. To analyse biological samples collected from this potting survey.
3. To determine stock status of blue cod populations in this area and establish how this has changed in response to management interventions.

2. METHODS

2.1 Timing and survey area

A potting survey of the Marlborough Sounds area was carried out by Earth Sciences New Zealand (ESNZ) between 30 September and 3 November 2025, including mobilisation, demobilisation, and steaming between Wellington and Picton. The survey dates were consistent with previous surveys and coincided with the known spawning time in this region.

In this report, the terms defined in the blue cod potting survey standards and specifications are used (Beentjes & Francis 2011, Beentjes 2019) (Appendix 2).
Four regions in Marlborough Sounds (Queen Charlotte Sound, QCH; Pelorus Sound, PEL; D'Urville Island, DUR; and Cook Strait, CKST), comprising 12 core strata, were surveyed in 2025. The core survey strata for the 2025 blue cod potting survey were identical to those covered by the previous surveys in 2010, 2013, 2017, and 2021 except for: PEL, which excluded Maud Island Closed Area; and DUR, which excluded Stephens Island (Figure 3). In addition to the core survey the following surveys were carried out: 1) the Long Island Marine Reserve (LIMR) near the entrance to Queen Charlotte Sound was surveyed for the third time, following surveys in 2017 and 2021; 2) Maud Island Closed Area (MAUD) was surveyed for the first time as a standalone stratum; and 3) Stephens Island (STEP) was surveyed for the first time as a standalone stratum. The length (km) of coastline within each stratum was taken as a proxy of available habitat for blue cod in the absence of specific habitat information or a clear understanding of the habitat requirements of blue cod. Coastline lengths in 2025 were adjusted for PEL and DUR, excluding coastline from MAUD and STEP, respectively. Earlier surveys were not reanalysed retrospectively using these adjusted coastline lengths as this is likely to make negligible difference to the scaled abundance, lengths and age estimates given the small size of the two new strata.

2.2 Survey design

The survey design and all terminology used here are consistent with the blue cod potting manual (Beentjes 2019). The 2025 survey was a random-site design with systematic pot placement. A random site has a location (single latitude and longitude) generated randomly within a stratum (Beentjes & Francis 2011, Beentjes 2019).

Simulations using ESNZ optimal station allocation program (*allocate*, Francis 2006) were carried out using catch rates from previous Marlborough Sounds surveys to determine the optimal allocation of sites among the core strata within each of the four regions. Random site allocations for QCH were based on the 2013, 2017, and 2021 random-site surveys and those for PEL/DUR/CKST, on the 2010, 2013, 2017, and 2021 random-site surveys. Simulations were constrained to have a minimum of three sites per stratum and a CV (coefficient of variation) of no greater than 20% for each region. The simulations indicated that 67 random sites were required (19 in QCH, 18 in PEL, 16 in CKST, and 14 in DUR). Of the possible 10 random sites in Long Island Marine Reserve, nominally 8 were randomly selected. Similarly, 10 of the 19 possible sites were randomly selected from MAUD, and all five possible sites around STEP were selected.

The coastline of all strata was divided into 1.01 km blocks (excluding coastline sections less than 1.01 km such as rocks or small islands) and a latitude and longitude at the centre of each block was assigned, giving 1195 potential random sites. From this list of all possible sites, the allocated number of random sites per stratum to be surveyed was randomly selected.

The random-site survey used a two-phase stratified random station design (Francis 1984). Ten percent of the 67 sites were allocated to phase 2 leaving 60 sites for phase 1. Allocation of phase 2 stations to strata is based on the mean pot catch rate (kg pot.$^{-1}$) of all blue cod per stratum and is optimised using the "area mean squared" method of Francis (1984). In this way, stations are assigned iteratively to the stratum in which the expected gain is greatest, where expected gain is given by:

$$expected\ gain_i = area_i^{\,2}\ mean_i^{\,2} / (n_i(n_i+1))$$

where for the ith stratum $mean_i$ is the mean catch rate of blue cod per pot, $area_i$ is the fishable stratum area, and n_i is the number of sets in phase 1. In the iterative application of this equation, n_i is ncremented by 1 each time a phase 2 set is allocated to stratum i.

In the Marlborough Sounds, because blue cod habitat is largely restricted to a band of reef and rubble adjacent to the coastline, pots were set along the coastline, no further than 0.5 km from the random site

position. Nine pots (Pot Plan 1) were set along the shoreline every 100 m, starting from a point 450 m from the random site position, each in a randomly selected depth over the extent of the habitat as it extends out perpendicular from the shore, but not less than 2 m depth (Beentjes 2019).

The survey initially completed Queen Charlotte Sound and Cook Strait, before moving to Pelorus Sound and D'Urville Island, consistent with the 2010, 2013, 2017, and 2021 surveys. The Long Island Marine Reserve and Stephens Island were sampled last whereas Maud Island Closed Area was sampled mostly in conjunction with those in Pelorus Sound and as time and weather conditions allowed.

2.3 Vessel and gear

The 2025 survey was carried out using the Wellington-based ESNZ inshore research vessel *Ikatere.* The R.V. *Ikatere* is an aluminium-alloy catamaran with a length of 13.9 m, beam of 4.85 m, equipped with 322 Hamilton water-jet units, and powered by twin Cummins QSC engines rated at 500 HP, capable of 25 knots cruising speed. This vessel was also used on the 2013, 2017 and 2021 surveys. The *Ikatere* was skippered by Richard Leppard.

Nine custom designed and built cod pots were used to conduct the survey (Pot Plan 1 in Beentjes 2019). Pots were baited with 700 g of paua viscera in 'snifter pottles' and replaced after every lift. The proportion of bait remaining was recorded after every lift. The same pot design and bait were used in all previous Marlborough Sounds blue cod potting surveys.

At each site, nine pots were set and left to fish (soak) for a target period of one hour during daylight hours. As each pot was placed, a record was made of sequential pot number (1 to 9), latitude and longitude from GPS, depth, and time of day. After each site was completed, the next closest site in the stratum was sampled, weather permitting.

A high-performance, 3-axis (3D) acoustic Doppler current profiler (Nortek Signature 500 kHz) was deployed at the centre of each site prior to the setting of pots and recovered after the last pot of each set was lifted. The ADCP records current flow and direction in 1 m depth bins above the seafloor. An attached probe recorded bottom water temperature. Following pot placement, the following environmental data were recorded: wind direction, speed, and force; air temperature and pressure; water clarity using secchi disc, sea condition and colour; swell height and direction; bottom type and contour; and surface water temperature. These variables and their units are defined in the potting manual (Beentjes 2019).

2.4 Sampling of catch

All sampling methods adhered strictly to the blue cod potting survey standards and specifications (Beentjes & Francis 2011, Beentjes 2019).

Pots were lifted aboard using the vessel's hydraulic pot lifter in the order they were set, and the time of each lift was recorded. The proportion of the bait remaining in the snifter pottle was recorded. Pots were then emptied and the contents were sorted by species. Total catch weight per pot was recorded for each species to the nearest 10 g using 0–6/6–15 kg Marel motion compensating scales. The number of individuals of each species per pot was also recorded. Total length to the nearest millimetre, individual fish weight to the nearest 10 g, sex, and gonad maturity were recorded for all blue cod.

Both sagittal otoliths were removed from a representative length range of blue cod males and females. Separate otolith collections were made for each of the four regions with a target of about 150 otoliths per region. To ensure that adequate numbers of large and small fish and females were included, the following blue cod otolith collection schedule was adhered to for each region, while attempting to spread the collection across strata within each region:

Males: four otoliths per 1-cm size class; and all males under 27 and over 36 cm.
Females: all otoliths, except for DUR, where it was 4 otoliths per 1-cm size class and all females under 28 and over 34 cm.

Sex and maturity were determined by dissection and macroscopic examination of the gonads (Carbines 1998, 2004). Blue cod gonad staging was undertaken using the five stage Stock Monitoring method used on previous surveys: 1, immature or resting; 2, maturing (oocytes visible in females); 3, mature (hyaline oocytes in females, milt expressible in males); 4, running ripe (eggs and milt free flowing); 5, spent.

2.5 Long Island Marine Reserve and Maud Island Closed Area

Pot placement and sampling of blue cod in the Long Island Marine Reserve and Maud Island Closed Area was carried out using the standard random site methodology described above. Pots were cleaned with freshwater, dried, and cleaned of any fouling organisms prior to being deployed in the Marine Reserve. As each pot was hauled, the blue cod catch was weighed and transferred into a bin with circulating seawater, before being measured for length and individual weight, and returned alive below the sea surface through a 100 mm diameter pipe fed with running seawater. Catch weight and numbers of bycatch species were recorded before being released alive in the same way. The release chute was deployed about 300 mm below the water surface to protect blue cod and other bycatch species from predation by shags. Maximum exposure time to air of fish was approximately 1 minute and processing time was less than 5 minutes between pots. All fish were released close to the capture location.

All sampling within the Long Island Marine reserve was permitted under a Department of Conservation Special Permit issued to NIWA (Authorisation to undertake specified scientific study within a marine reserve, Authorisation number 122399-MAR). Sampling within the Maud Island Closed Area was permitted under ESNZ Special Permit 942, issued by Fisheries New Zealand.

2.6 Data storage

The trip code for the 2025 survey is IKA2507. At the completion of the survey, data were entered into the *trawl* and *age* databases in accordance with the business rules and the blue cod potting survey standards and specifications (Beentjes 2019). All analyses were carried out from data extracted from the *trawl* database. Random sites were entered into *trawl* table *t_station* in attribute *stn_code* (concatenating stratum number and site label and prefixed with R, e.g., R1F, R2B). Random site locations were also entered into *trawl* table *t_site*. Pot locations were entered in table *t_station* in attribute *station_no* (concatenating set number and pot number e.g., 11 to 19, or 31 to 39). In the *age* database the *sample_no* is equivalent to *station_no* in the *trawl* database.

ADCP data containing current speed and direction were sent to the Fisheries New Zealand Research Database Manager in raw form (.adcp2) and also in a customised version with user friendly variable naming and corrections for magnetic declination to the compass data (.mat). The raw temperature file from the temperature logger was also provided (.cnv). Mean bottom temperature and mean current speed were calculated for each site and stored in *t_station* and *t_stat_comm*.

2.7 Age estimates

Preparation and reading of otoliths followed the methods of the blue cod age determination protocol (ADP) (Walsh 2017).

1. Blue cod otolith thin-section preparations were made as follows: otoliths were individually marked on their distal faces with a dot in the centrum using a cold light source on low power to light the otolith from behind. Five otoliths (from five different fish) were then embedded in an epoxy resin mould and cured at 50 ºC. Thin sections were taken along the otolith dorso-ventral axis through the centrum of all five otoliths, using a Struers Accutom-50 digital sectioning machine, with a section thickness of approximately 350 µm. Resulting thin section wafers were cleaned and embedded on microscope slides using epoxy resin and covered with a coverslip. Finally, these slides were oven cured at 50 ºC.
2. Otolith sections were read against a black background using reflected light under a compound microscope at a magnification of 40–100 times. Under reflected light, opaque zones appear light and translucent zones appear dark. Translucent zones were counted (ageing of blue cod otolith thin sections prior to 2015 counted opaque zones to estimate age).
3. Two readers initially read all otoliths without reference to fish length, sex, or previous age estimates.
4. When interpreting blue cod zone counts, both ventral and dorsal sides of the otolith were read, mainly from the core toward the proximal surface close to the sulcus.
5. The forced margin method was used: 'Wide' (a moderate to wide translucent zone present on the margin), October–February; 'Line' (an opaque zone in the process of being laid down or fully formed on the margin), March–April; 'Narrow' (a narrow to moderate translucent zone present on the margin), May–September.
6. Where between-reader counts differed, the readers rechecked the count and conferred until agreement was reached, unless the section was a grade 5 (unreadable) or damaged (removed from the collection).
7. Between-reader ageing precision was assessed by the application of the methods and graphical techniques documented by Campana et al. (1995) and Campana (2001); including APE (average percent error) and coefficient of variation.

To assess reader competency in ageing before reading the 2025 survey otoliths, the two readers aged a subsample of 50 reference otolith preparations with the aim of achieving a score for Index of Average Percentage Error (IAPE) (Beamish & Fournier 1981), and mean coefficient of variation (Chang 1982) of below 1.50% and 2.12%, respectively (Walsh 2017).

2.8 Data analyses

Analyses of catch rates, sex ratios, scaled length distribution, catch-at-age, and mortality estimates (*Z* and *F*), and condition factor, were carried out and are presented for the 2025 Marlborough Sounds random-site survey.

Analyses of catch rates and CVs, length-weight parameters, scaled length and age frequencies and CVs, sex ratios, mean length, and mean age were carried out using the equations documented in the blue cod potting survey standards and specifications (Beentjes & Francis 2011, Beentjes 2019). Fish length was recorded to the nearest millimetre on the survey, but following standard protocol, all lengths were rounded down to the nearest centimetre for analyses of the scaled length distribution and mean length (i.e., using data extracted from t_lgth in the *trawl* database). Length was also rounded down when producing the age-length-keys for catch-at-age analyses and for estimating von Bertalanffy parameters.

2.8.1 Catch rates

The catch rate (kg pot^{-1}) estimates were pot-based and the CV estimates were set-based (Beentjes & Francis 2011, Beentjes 2019). Catch rates and 95% confidence intervals (± 1.96 standard error) were estimated for all blue cod and for recruited blue cod (33 cm and over). Catch rates of recruited blue cod were based on the sum of the weights of individual recruited fish. The stratum areas (shown in Table 2) were used as the area of the stratum (A_t) when scaling catch rates (equations 3 and 5 given by Beentjes & Francis 2011). Catch rates are presented by stratum, by region, and overall for all core strata.

2.8.2 Length-weight parameters

The length-weight parameters a_k, b_k from the 2025 Marlborough Sounds survey were used in the following equation:

$$w_{lk} = a_k l^{b_k}$$

This calculates the expected weight (g) for a fish of sex k and length l (cm) in the survey catch. These parameters were calculated from the coefficients of sex-specific linear regressions of log(weight) on log(length) using all fish for which length, weight, and sex were recorded: b_k is the slope of the regression line, and log(a_k) is its y-intercept. Separate length weight coefficients were estimated for the unsexed fish caught in Long Island Marine Reserve, and Maud Island Closed Area.

2.8.3 Growth parameters

von Bertalanffy growth models (von Bertalanffy 1938) for each sex were fitted to the 2025 Marlborough Sounds survey length-age data as follows:

$$L_t = L_\infty(1 - \exp^{-K[t - t_0]})$$

where L_t is the length (cm) at age t, L_∞ is the asymptotic mean maximum length, K is a constant (growth rate coefficient), and t_0 is hypothetical age (years) for a fish of zero length.

2.8.4 Scaled length and age frequencies

Length and age compositions were estimated using the ESNZ program *catch-at-age* (Bull & Dunn 2002). The program scales the length frequency data by the area of the stratum, number of sets in each stratum, and estimated catch weight determined from the length-weight relationship of individual fish. The latter scaling should be negligible or very close to one if all fish caught during the survey were measured (which they were) and if the actual weight of the catch is close to the estimated weight of the catch (which it was). The stratum coastline length shown in Table 2was taken as the area of the stratum (A_t), and the length-weight parameter estimates are from the 2025 Marlborough Sounds core strata survey data for males and females separately. For the Long Island Marine Reserve, the length-weight parameters for the unsexed fish caught in the reserve were used in the estimates of the scaled length composition, because they were substantially different from the main survey core strata. Similarly, the length-weight parameters for the unsexed fish caught in the Maud Island Closed Area were used in the estimates of the scaled length composition.

Length and age frequencies were calculated as numbers of fish from equations 7, 8, and 9 of the manual (Beentjes & Francis 2011, Beentjes 2019). The length and age frequencies are expressed as proportions by dividing by total numbers.

Bootstrap resampling (300 bootstraps) was used to calculate CVs for proportions- and numbers-at-length and -at-age using equation 12 of the manual (Beentjes & Francis 2011, Beentjes 2019). That is, simulated data sets were created by resampling (with replacement) sets from each stratum, and fish from each set (for length and sex information).

Catch-at-age was estimated using a single age-length key (ALK) from the 2025 survey for each sex applied to the scaled length data from the entire survey area. Stephens Island ages were excluded from the age–length key (ALK) applied to core strata length data to maintain consistency with previous random-site survey analyses. Scaled length frequency and age frequency proportions are presented, together with CVs for each length and age class, and the mean weighted coefficients of variation (MWCV).

2.8.5 Unsexed fish

All blue cod caught during the 2025 survey were sexed, except those in the Long Island Marine Reserve and Maud Island Closed Area (because these were returned to the sea alive). The unsexed fish in these areas were used to generate the total scaled length frequency compositions, but were not included in age composition analyses or to estimate total mortality because the ALKs from the core strata did not include the upper size range of fish caught in the reserve and closed area.

2.8.6 Sex ratios, and mean length and age

Sex ratios (expressed as percentage male) and mean lengths for the stratum and survey were calculated using equations 10 and 11 of Beentjes & Francis (2011) from the stratum or survey scaled length frequencies (LFs). Mean ages were calculated analogously from the scaled age frequencies. Sex ratios were also estimated for recruited blue cod (33 cm and over), and overall survey 95% confidence intervals around sex ratios were generated from the 300 LF bootstraps. The proportion of fish of recruited size was estimated from the scaled LFs.

2.8.7 Total mortality (Z) and fishing mortality (F) estimates

Total mortality (Z) was estimated from catch-curve analysis using the Chapman-Robson estimator (CR) (Chapman & Robson 1960). Catch curve analyses measure the sequential decline of cohorts annually. The CR method was shown to be less biased than the simple regression catch curve analysis (Dunn et al. 2002). Catch curve analysis assumes that the right-hand descending part of the curve declines exponentially and that the slope is equivalent to the total mortality Z (M + F). This assumes that recruitment and natural mortality are constant, that all recruited fish are equally vulnerable to capture, and that there are no age estimation errors.

Estimates of CR total mortality, Z, were calculated for age-at-recruitment values of 5 to 10 years using the maximum-likelihood estimator (equation 13 of Beentjes & Francis 2011). Variance (95% confidence intervals) associated with Z was estimated under three different parameters of recruitment, ageing error, and Z estimate error (equations 14 to 18 of Beentjes & Francis 2011). Catch-at-age distributions were estimated separately for males and females and then combined, hence providing a single Z estimate for the population. A second set of Z estimates were made using only ages of males. The male-only Z was estimated because there are often very few females larger than the MLS in heavily fished populations and the fishing mortality of males is more informative (see section 1.2). Fishing mortality ($F = Z–M$) was estimated from the results of the Chapman-Robson analyses and the current default estimate of M was assumed to be 0.17, revised from 0.14 in 2019 (Doonan 2020). Age-at-full recruitment (AgeR) was assumed to be equal to the average age at which males reached the MLS of 33 cm (selectivity based on the combined 2025 survey von Bertalanffy growth coefficients) plus one

year (i.e., 6 years of age in this case). Sensitivity analyses of F were carried out for M values 20% above and below the default (0.14 and 0.20).

A traditional catch curve was also plotted from the natural log of catch (numbers) against age and a regression line fitted to the descending curve from age-at-full recruitment. Although the Z estimate from the traditional catch curve was not used, it provides a diagnostic tool to illustrate how well data conform to the assumptions made for estimating Z from age structure. This is particularly important when there are not many age classes, with potential for strong or weak year classes to introduce bias.

2.8.8 Condition factor

Fulton's condition factor (K) (Nash et al. 2006) was estimated for blue cod as follows:

$K = 100w/l^b$

where l is the total length (centimetres) and w is the fish weight (grams) and $b = 3$.

2.9 Time series trends in random site surveys

Trends are compared for mean catch rates, sex ratio, F, and mean recruited length from random-site surveys for each region and overall for the Marlborough Sounds core strata (QCH, PEL and DUR combined, excluding CKST, and including CKST). Cook Strait was excluded to allow valid comparison of catch rates from the same strata (1 to 9) between fixed and random-site surveys. The fixed-site survey catch rates and sex ratios are shown for completeness. Trends in catch rates and size are also shown for the three Long Island Marine Reserve surveys.

3. RESULTS

3.1 Marlborough Sounds 2025 random-site blue cod potting survey

3.1.1 Catch and effort

Sixty random sites (9 pots per site, producing 540 pot lifts) from the twelve core strata throughout the Marlborough Sounds were surveyed in 2025 (Table 2, Figure 4). Depths sampled were 5–75 m (mean 15 m). All sixty sites were carried out in phase 1, with no phase 2 component on the survey due to extended periods of bad weather.

A total of 977.6 kg of blue cod (2042 fish) was caught, comprising 91% of the catch of all species on the survey (Table 3A). Bycatch species included 12 teleost fishes, 1 shark, and 1 octopus. The three most abundant bycatch species, by number, were banded wrasse (*Notolabrus fucicola*), scarlet wrasse (*Pseudolabrus miles*), and octopus (*Macroctopus maorum*).

3.1.2 Blue cod catch rates, length, and sex ratio

Core strata mean catch rates (kg pot^{-1}) of all blue cod and recruited blue cod (33 cm and over) are presented by stratum, overall for each region, and overall for Marlborough Sounds (Table 4, Figures 5 and 6).

Queen Charlotte Sound

Queen Charlotte Sound (QCH) mean catch rates of blue cod (all sizes) were 0.21–2.25 kg pot^{-1}, with highest catch rates in the outer sounds (OQCH) and lowest in the inner sounds (IQCH) (Table 4, Figure 6). The overall QCH blue cod catch rate was 1.69 kg pot^{-1} with a CV of 19.4%. Catch rates for recruited blue cod 33 cm and over followed the same pattern among strata as for all blue cod; the overall catch rate was 0.73 kg pot^{-1} (CV 21.8%). All of the 18 random sites had some blue cod catch, but of the 162 pots, 64 (39%) had zero catch of blue cod.

All 591 blue cod caught in QCH were measured for length and weight, and all fish were sexed. The sex ratio was 53–80% male across the three strata and the weighted sex ratio was 79% male (Table 5). Length was 11–42 cm for males and 14–38 cm for females, and the weighted mean length was 30.8 cm for males and 27.2 cm for females. The length-frequency distributions lacked the numbers in the inner Sounds strata to describe length composition well, but overall there was an adult mode and a juvenile mode for both sexes (Figure 7).

Pelorus Sound

Pelorus Sound (PEL) mean catch rates of blue cod (all sizes) were 0.35–1.73 kg pot^{-1}, increasing markedly from the inner to the outer Sounds and were more than 5-fold greater in EOPE than IPEL (Table 4, Figure 6). The overall PEL blue cod catch rate was 0.68 kg pot^{-1} with a CV of 23%. Catch rates for recruited blue cod 33 cm and over, followed the same pattern among strata as for all blue cod, and the overall catch rate was 0.43 kg pot^{-1} (CV 21%). All but two of the 16 random sites had some blue cod catch, but of the 144 pots, 81 (56%) had zero catch of blue cod.

All 270 blue cod caught in PEL were sexed and measured for length and weight. The sex ratio was 38–90% male across the four strata and the weighted sex ratio was 77% male (Table 5). Length was 19–44 cm for males and 14–42 cm for females, and the weighted mean length was 32.2 cm for males and 30.3 cm for females. The length-frequency distributions lacked the numbers in the inner Sounds strata to describe length composition well, but overall there was an adult mode and a juvenile mode for both sexes (Figure 8).

D'Urville Island

D'Urville (DUR) mean catch rates of blue cod (all sizes) were 2.20–4.75 kg pot^{-1}, with the higher catch rates in DURE (Table 4, Figure 6). The DUR all blue cod catch rate was 3.53 kg pot^{-1} with a CV of 34.8%. Catch rates for recruited blue cod 33 cm and over followed a similar pattern among strata as for all blue cod and the overall catch rate was 1.85 kg pot^{-1} (CV 29%). All 14 random sites had some blue cod catch, but of the 126 pots, 43 (34%) had zero catch of blue cod.

All 789 blue cod caught in DUR were sexed and measured for length and weight. The sex ratio was 72–74% male across the two strata and the weighted sex ratio was 73% male (Table 5). Length was 20–43 cm for males and 24–38 cm for females and the weighted mean length was 32.4 cm for males and 30.1 cm for females. The length-frequency distributions were unimodal (Figure 9).

Cook Strait

Cook Strait (CKST) mean catch rates of blue cod (all sizes) were 0.28–2.69 kg pot^{-1}, with highest catch rates in Arapaoa Island east (APAE) (Table 4, Figure 6). The CKST all blue cod catch rate was 1.24 kg.pot^{-1} with a CV of 21%. Catch rates for recruited blue cod 33 cm and over followed the same pattern among strata as for all blue cod and the overall catch rate was 0.56 kg.pot^{-1} (CV 18%). All 12 random sites had some blue cod catch, but of the 108 pots, 35 (32%) had zero catch of blue cod.

All 392 blue cod caught in CKST sites were sexed and measured for length and weight. The sex ratio was 84–95% male across the three strata and the weighted sex ratio was 87% male (Table 5). Length was 14–48 cm for males and 15–35 cm for females and the weighted mean length was 29.9 cm for males and 27.0 cm for females. The length-frequency distributions lacked the numbers in the Port Underwood stratum (UNDW) to describe length composition well, but overall there was an adult mode for both sexes and a juvenile mode for males (Figure 10).

Marlborough Sounds core strata

Marlborough Sounds core strata mean catch rate of blue cod (all sizes) was 1.69 kg pot^{-1} with a CV of 17.6%. The highest catch rates were in DURE and APAE, and the lowest in IQCH and UNDW (Table 4, see Figure 6). Catch rates for recruited blue cod 33 cm and over followed the same pattern among strata as for all blue cod and was 0.85 kg pot^{-1} (CV 16%). All but one of the 60 random sites had some blue cod catch, but of the 540 pots, 223 (41%) had zero catch of blue cod.

Of the 2042 blue cod caught in Marlborough Sounds core strata, all but one fish were sexed, and all were measured for length and weight. The weighted sex ratio was 77% male across the 12 strata (Table 5). Length was 11–48 cm for males and 14–42 cm for females and the weighted mean length was 31.5 cm for males and 29.1 cm for females. The length-frequency distributions show an adult mode and a much smaller juvenile mode for both sexes (Figure 11).

Length frequency and cumulative plots of population length for each of the four core strata regions in 2025 showed only minor differences in length distributions for males or females among the regions, although cumulative curves were unlikely to be fully representative of the female population for PEL and CKST, where only 47 and 55 females, respectively, were sampled (Figures 12 and 13).

3.1.3 Age and growth

Otoliths from 401 males and 304 females were used to estimate the population age structure of Marlborough Sounds in 2022 (Table 6). Otoliths were collected from all regions and all lengths, for both sexes (Appendix 3). Older fish were not well represented in any region, which results in implausible von Bertalanffy parameters or in curves that do not reach an asymptote. On previous surveys, analyses of mean length-at-age indicated that growth from about 4 to 8 years old, which includes most fish, was not discernibly different among regions (Beentjes et al. 2022b). On this basis, and as agreed by the Inshore Working Group (15 April 2026), sex-specific ALKs were produced for the combined regions (Figure 14). There was a large range in age-at-length for both sexes and males grew faster and were larger than females, typical of blue cod. The von Bertalanffy curves are similar for the four surveys with differences more likely to be due to lack of older fish to model the asymptote more accurately, than to annual variation in growth (Figure 15).

Between-reader comparisons are presented in Figure 16. The two readers achieved agreement on 92% of read otoliths. Overall, no bias existed between readers, with a between-reader precision (CV) of 1.1% and an index of average percentage error (IAPE) of 0.8%.

The length-weight parameters from the 2025 Marlborough Sounds core strata survey were $a = 0.0076$ and $b = 3.193$ for males ($N = 1583$, range = 11–48 cm); $a = 0.0081$ and $b = 3.177$ for females ($N = 432$, range = 15–44 cm); and $a = 0.0079$ and $b = 3.181$ for males and females combined ($N = 2015$, range = 11–48 cm).

Age estimates from previous surveys

Only surveys in 2013, 2017, and 2021 have been aged using the ADP. Although otoliths collected from the 2001 to 2010 surveys have been read, this was before the ADP was established and the ages are not likely to be accurate. These otoliths would need to be re-aged under the ADP before any comparisons of age composition for surveys before 2013 should be attempted.

3.1.4 Spawning activity

Gonad stages of blue cod sampled on the 2025 survey between late September and early November are presented by region and for all regions combined (Table 7). There was a clear indication of some spawning activity during the survey period and, overall, approximately 9% of males and 12% of females

were running ripe. The area with the most spawning activity was DUR, and areas with the least were CKST and STEP.

3.1.5 Population length and age composition in Marlborough Sounds

The scaled length-frequency and age distributions for the 2025 random-site survey are shown for all regions combined (Marlborough Sounds) (Figure 17).

Marlborough Sounds scaled length-frequency distributions for both males and females were characterised by a strong single mode and a small juvenile mode, with mean lengths of 31.5 cm and 29.1 cm, respectively (Figures 11 and 17). The cumulative distribution plots of the length-frequency clearly showed that a higher proportion of larger fish were males and that the largest fish were males. The mean weighted coefficients of variation (MWCVs) around the length distributions are 17% for males and 31% for females, indicating that the population was reasonably well represented, particularly for males.

Marlborough Sounds age estimate ranges were 2–17 years for males and 2–20 years for females, but most males were 4–7 years old and most females were 5–7 years old (Figure 17). The estimated population age distributions indicate knife-edge selectivity to the potting method at two to three years of age. Strong five- to seven-year-old fish were present for both males and females, with a steep decline in eight-year-olds, apparent in the cumulative distribution plots of age frequency (Figure 17). The estimated population age distributions were unimodal for both males and females, with peaks at five years for males and five to seven for females. The cumulative distribution plots of the age-frequency clearly showed that females had a much higher proportion of older fish. Further, the mean age of females was greater than that of males (6.9 years for females and 5.5 years for males). The MWCVs around the age distributions were 16% for males and 25% for females, indicating that the population was reasonably well represented.

3.1.6 Mortality (*Z* and *F*)

Chapman-Robson (CR) total male mortality estimates (*Z*) and 95% confidence intervals for the 2025 Marlborough Sounds random-site survey are given for a range of blue cod recruitment ages (5–10 years) in Table 8. Age-at-full recruitment (*AgeR*) was assumed to be equal to the average age at which males reached the MLS of 33 cm, plus one year (i.e., 6 years of age in all cases) (see growth curve in Figure 14). The male CR *Z* for this age was 0.92 (95% confidence interval of 0.62–1.30) (Table 8).

The traditional catch curve based on log catch (numbers) plotted against age with a regression line fitted to the descending limb from age-at-full recruitment of six years, was plotted for diagnostic purposes (Figure 18). The catch curves display the traditional shape characterised by smooth ascending and descending limbs, and an intermediate domed portion, adding confidence to CR *Z* estimates. There were few blue cod older than 7 years of age which has influenced the slope of the regression line and hence *Z*. The steepness of the descending curves, and hence high *Z* values, were a direct result of the lack of recruited older age classes in the population (Figure 18). The natural log of numbers-at-age largely follows the ideal straight-line descending limb, and this suggests that the assumption of constant recruitment had not been violated to a great extent, and gives confidence in the CR *Z*. Although the CR estimation is less sensitive to age classes with few fish, this will have introduced error (and probably bias) into the *Z* estimate, which was reflected in the wide 95% confidence intervals around the male *Z* (Dunn et al. 2002) (see Table 8).

The male mortality parameters (CR *Z* and *F*) at three values of *M* and age-at-full recruitment of 6 years are shown in Table 9. Based on the default *M* of 0.17, male estimated fishing mortality (*F*) in 2025 was 0.75 (95% confidence intervals 0.45–1.13).

3.2 Long Island Marine Reserve survey

Eight random sites (9 pots per site, producing 72 pot lifts) from inside the Long Island Marine Reserve (LIMR) were surveyed from 28–30 October 2025 (Table 2, Figure 19). Depths sampled were 5–40 m (mean 16 m). A total of 896 blue cod (582.5 kg) was sampled comprising 98% of the catch of all species from the LIMR survey (Table 3B). Bycatch species included three teleost species and one shark species. No mortality of blue cod was observed after release.

The mean catch rate of all blue cod (all sizes) was 8.09 kg pot^{-1} (CV of 6%) and for recruited blue cod 33 cm and over it was 5.75 kg pot^{-1} (CV 10%) (Table 4, Figure 20). Catch rates of all blue cod were nearly three to seven times higher in LIMR than in adjacent fished strata in Queen Charlotte Sound.

All eight random sites had some blue cod catch, and of the 72 pots, only 1 (1.4%) had zero catch of blue cod. The proportion of empty pots was substantially less than for the three Queen Charlotte Sound strata, including those adjacent to the marine reserve (OQCH and EQCH) (Figure 21).

All 896 blue cod caught in LIMR were measured for length and individual weight before being released alive. Consequently, sex was not determined and no otoliths were collected to estimate age. Length was 17–51 cm (Table 5) and the weighted mean length was 33.4 cm (Figure 22). The length-frequency distributions in the LIMR appear to be unimodal with a peak at about 31–34 cm and a more pronounced right-hand tail than the distributions from adjacent strata in Queen Charlotte Sound (Figure 22). The mean length was 3.3 cm and 3.2 cm greater in the LIMR than OQCH and EQCH, respectively.

The mean and median Fulton's condition factor (K) for blue cod in the LIMR (mean 1.57) were the second highest of the 15 strata surveyed in 2025, behind MAUD with a mean of 1.62 (Table 10, Figure 23). This compares with mean values of 1.41 in adjacent strata in Queen Charlotte Sound, and 1.50 overall for Marlborough Sounds (excluding LIMR and MAUD) (Table 10).

The length-weight parameters from the 2025 LIMR survey were a = 0.0199 and b = 2.932 for unsexed fish (N = 891, range 16–50 cm).

3.3 Maud Island Closed Area survey

Ten random sites (9 pots per site, producing 90 pot lifts) from inside the Maud Island Closed Area (MAUD) were surveyed between 20–25 October 2025 (Table 2, Figure 24). Depths sampled were 5–25 m (mean 14 m). A total of 539 blue cod (370.8 kg) was sampled comprising 98% of the catch of all species on the MAUD survey (Table 3C). Bycatch species included one teleost and one shark species. No mortality of blue cod was observed after release.

The mean catch rate of all blue cod (all sizes) was 4.12 kg pot^{-1} (CV of 15%) and for recruited blue cod 33 cm and over it was 3.15 kg pot^{-1} (CV 18%) (Table 4, Figure 25). Catch rates of all blue cod were over ten times higher in MAUD than in the two adjacent fished strata (MPEL and OPEL) in Pelorus Sound.

All ten random sites had some blue cod catch, and of the 90 pots, 14 (15.5%) had zero catch of blue cod. The proportion of empty pots was substantially less than for the four Pelorus Sound strata, including those adjacent to the closed area (MPEL and OPEL) (Figure 26).

All 539 blue cod caught in MAUD were measured for length and individual weight before being released alive. Consequently, sex was not determined and no otoliths were collected to estimate age. Length was 15–46 cm (Table 5) and the weighted mean length was 34.0 cm (Figure 27). The length-frequency distribution in MAUD is unimodal with a peak at about 33 cm, but with indications of a small juvenile mode (Figure 27). Comparison of length with the adjacent strata are not strictly valid given

that only 39 fish were caught here, although the mean size was nearly 2 cm greater in the MAUD than outside.

The mean and median Fulton's condition factor (*K*) for blue cod in MAUD (mean 1.62) were the highest of the 15 strata surveyed in 2025 (Table 10, see Figure 23). This compares with values of 1.45 in adjacent strata in Pelorus Sound, and 1.50 overall for Marlborough Sounds (excluding LIMR and MAUD) (Table 10, Figure 28).

The length-weight parameters from the 2025 MAUD survey were $a = 0.0318$ and $b = 2.8081$ for unsexed fish ($N = 527$, range 15–46 cm).

3.4 Stephens Island survey

Five random sites (9 pots per site, producing 45 pot lifts) from around Stephens Island (STEP) coastline were surveyed between 24 October and 1 November 2025 (Table 2, Figure 29). Depths sampled were 9–59 m (mean 22 m). A total of 879 blue cod (463.4 kg) was sampled comprising 94% of the catch of all species on the STEP survey (Table 3D). Bycatch species included six teleost and one shark species.

The mean catch rate of all blue cod (all sizes) was 10.38 kg pot^{-1} (CV of 21%) and for recruited blue cod 33 cm and over it was 5.42 kg pot^{-1} (CV 18%) (Table 4, see Figure 5). Catch rates of all blue cod in STEP were the highest among the 15 strata surveyed (including LIMR and MAUD) and were about six times higher than in the core strata.

Blue cod were caught at all five random sites. Of the 45 pots, 5 (11.1%) were empty, a substantially lower proportion than in the core strata (32–56%).

All 879 blue cod caught in STEP were measured for length and individual weight, sex recorded and otoliths taken. Length was 19–41 cm for males and 14–37 cm for females with weighted mean lengths of 32.4 cm and 29.6 cm, respectively (Table 5, Figure 30). The length-frequency distributions in STEP were unimodal with a peak at about 33 cm for males and 28 cm for females. Comparison with the core strata indicates no real differences in length distribution or mean length (compare Figures 30 and 12).

The mean and median Fulton's condition factor (*K*) for blue cod in STEP (mean 1.56) were higher than all core strata, except DURW where they were the same, and less than MAUD and LIMR (see Figure 23).

The length-weight parameters from the 2025 STEP survey were $a = 0.011$ and $b = 3.102$ for males ($N = 731$, range 19–41 cm); $a = 0.009$ and $b = 3.160$ for females ($N = 140$, range 14–37 cm); and $a = 0.0107$ and $b = 3.110$ for males and females combined ($N = 871$, range 14–41 cm).

3.5 Random-site survey time series trends

There are four surveys in the random-site time series for QCH, PEL, and DUR, and five for CKST, therefore, conclusions about trends should be interpreted with caution. Time series trends for fixed-site surveys are not described in this section but are summarised in the discussion.

Catch rates

Mean catch rates (kg pot^{-1}) for all blue cod from random-site surveys are shown in Figure 31 (along with those from fixed-site surveys). Random-site all blue cod mean catch rates (kg pot^{-1}) in QCH have progressively increased by more than three-fold between 2013 and 2025. PEL catch rates showed a clear decline, halving from 2013 to 2021, then stable. DUR, CKST and Marlborough Sounds overall catch rates have all fluctuated without trend (Figure 31).

The proportion of pots with no blue cod ranged from 39%–62% in QCH with a declining temporal trend; the range was 53%–58% in PEL, 32%–38% in DUR, and 32%–53% in CKST, with no clear temporal trends in these three regions (Figure 32).

Sex ratios

Sex ratios (percent male) for all blue cod and recruited blue cod from random-site surveys are shown by region in Figure 33, and for the Marlborough Sounds overall in Figure 34 (along with those from fixed-site surveys).

The QCH sex ratio for all blue cod ranged from 66–79% male and showed a progressive increasing trend; the sex ratio for recruited blue cod was about 15% higher and also increased over time.

The PEL sex ratio for all blue cod ranged from 77–90% male and showed no clear trend, while the sex ratio for recruited blue cod was higher and was nearly entirely male in two of the four years

The DUR sex ratio for all blue cod ranged from 57–73% male and showed indications of an increasing trend, whereas the sex ratio for recruited blue cod was approximately 20% higher but showed no clear trend

The CKST sex ratio for all blue cod ranged from 80–87% male and showed no clear trend, while the sex ratio for recruited blue cod was nearly or entirely male.

The Marlborough Sounds overall sex ratio for all blue cod ranged from 66–71% male and showed no clear trend, while the sex ratio for recruited blue cod was about 86% male and also showed no clear trend (Figure 34).

Length composition

The scaled length-frequency distributions and cumulative distributions for 2010 (CKST only), 2013, 2017, 2021, and 2025 random-site surveys by region and Marlborough Sounds overall are shown in Figures 35 and 36. There was little difference in the shapes of these distributions among regions, within regions, or for Marlborough Sounds overall across the four surveys. Females show more variation between surveys largely due to lower numbers sampled (Figures 35 and 36).

Age composition

There are no consistent trends in age structure from 2013 to 2025. The scaled age compositions for males were broadly similar across the four surveys for all regions combined, but less so for females (Figure 37). The cumulative distributions are shaped by the strength of the dominant 5- to 7-year-old cohorts, particularly males, and the length of the right-hand tail comprising older fish. Female age distributions contain proportionally more older fish than males in all years.

There is no clear evidence of cohort progression, with the possible exception of the weak four-year-old female age class in 2017, progressing to a weak eight-year-old age class in 2021.

Mortality

The male only CR total mortality estimates (Z), ranged from 0.60 in the 2013 random-site survey to 0.92 in 2025, with a large increase between 2017 and 2025 (Table 11). Similarly, fishing mortality (F) increased from 0.43 in 2013 to 0.75 in 2025 (Table 11, Figure 38). The increase in Z and F in 2017 was partly due to the higher age at recruitment, reflecting the increase in minimum legal size from 30 cm in 2013 to 33 cm in subsequent survey years. Fishing mortality estimates for fixed-site surveys in 2013 and 2017, where ageing was carried out using the ADP, were similar to those from random-site surveys in the same years (Table 11, Figure 38).

3.6 Long Island survey time series trends

Random-site mean catch rates (kg pot^{-1}) for all blue cod in LIMR were about 8 kg pot^{-1} for all three surveys (2017, 2021, and 2025) and were four- to eight-fold higher than those in adjacent fished strata, with no temporal trends (Figure 39). Catch rates of recruited blue cod (33 cm and over) were also proportionally higher in LIMR than in adjacent strata.

The proportion of pots with no blue cod was very low in LIMR ranging from 1%–10%, compared to between about 20% and 85% of pots for the three QCH strata, two of which are adjacent to the reserve (Figure 40). There were no temporal trends in proportion of empty pots.

The scaled length-frequency and cumulative distributions for the 2017, 2021, and 2025 random-site surveys inside LIMR, and in adjacent strata (outside), are shown in Figure 41. There was little difference in the shapes of the LIMR unsexed length distributions among the three years, and in all three years fish were larger on average in the reserve than in the adjacent fished strata, with a greater proportion of fish exceeding 40 cm (Figure 41).

3.7 Fixed versus random site surveys

The fixed-site survey results were analysed and documented in the 2017 survey report (Beentjes et al. 2018). In 2013, catch rates of all blue cod were higher at fixed than at random sites in all three regions; this difference was statistically significant for QCH and PEL ($p < 0.05$), but not for DUR (see Figure 31). In 2017, there was no statistically significant difference between fixed- and random-site catch rates in QCH; however, in PEL and DUR, fixed-site catch rates were significantly higher ($p < 0.01$ and $p < 0.05$, respectively) (see Figure 31). There was little or no difference in length-frequency distributions between fixed- and random-site surveys in 2013 and 2017 (not shown) (Beentjes et al. 2018).

4. DISCUSSION

4.1 General

The 2025 random-site survey was the fourth in Queen Charlotte Sound, Pelorus Sound, and D'Urville Island, in which all strata in these regions were sampled, and the fifth for Cook Strait. The 2025 survey was the second solely random-site survey carried out in Marlborough Sounds after fully transitioning to the random-site design in 2021 following concurrent fixed and random-site surveys in 2013 and 2017. The fixed-site surveys were discontinued because the random-site design was deemed to be more accurate, statistically robust, and more likely to represent the entire blue cod population (Stephenson et al. 2024).

Differences in catch rates between fixed- and random-site surveys suggest that there may be no suitable way of quantitatively linking the two series. Future analyses could, however, determine whether information in the fixed-site surveys could be combined into a single series by, for example, using a GLM to standardise catch rates from fixed- and random-site surveys by including survey type as a predictor variable. Notwithstanding the differences in catch rates that can be ascribed to the survey design (fixed or random), there are no clear indications that blue cod biomass has declined substantially between 2004 and 2025 (see Figure 31).

Fishing mortality estimates from the fixed- and random-site surveys conducted in 2013 and 2017 can be directly compared because the size and age compositions were similar (Beentjes et al. 2017, Beentjes et al. 2018) (see Figure 38). Fishing mortality could also be estimated for earlier fixed-site surveys before 2013 if the otoliths were re-aged ageing using the ADP.

The results of all previous surveys in the time series are discussed in the context of the fisheries management regulations that were in place in the Marlborough Sounds area. The key findings from the previous fixed-site surveys are also briefly summarised for completeness.

4.2 Fixed-site survey trends

The highest catch rates of all blue cod from fixed sites by region were from DUR, followed by PEL and QCH, although there was considerable variation among strata within a region (see Figure 31).

In both Queen Charlotte Sound (QCH) and Pelorus Sound (PEL), large increases in catch rates and mean length in 2010 were consistent with closures of the inner Sounds to fishing in 2008 (see Figure 31). Catch rates declined again by 2013 (after the closure was lifted in 2011) to levels similar to, or intermediate within, historical ranges, despite restrictive size regulations (slot limit 30–35 cm). Catch rates showed some recovery in 2017, possibly reflecting the implementation of a 33 cm minimum legal size (MLS). Length distributions generally followed these trends, with increases in mean length in 2010 and variable changes thereafter, indicating population responses to fisheries management measures. However, responses were not consistent across subsequent regulatory changes, suggesting complex or interacting effects. Sex ratios differed between regions: QCH remained relatively stable at about 60–70% male; whereas PEL showed an increasing and more strongly male-skewed sex ratio over time, with no clear link to changes in abundance or size structure.

Around D'Urville Island (DUR), catch rates and length distributions showed no clear trends until 2017, when both increased markedly (see Figure 31). This relative stability likely reflects the absence of a fishery closure in 2008, unlike QCH and PEL, while the slot limit appeared to have had little effect. The 2017 increase in abundance and mean size may be associated with the introduction of the 33 cm MLS across the region. The sex ratio increased earlier and then remained stable at 61–70% male, showing little response to subsequent management changes.

4.3 Random-site survey trends

With only four random site surveys in QCH, PEL, DUR and five in CKST, a detailed examination of trends in the times series is premature, however some comment on trends in relation to management changes are appropriate.

The 2013 random-site survey took place when the Sounds were fully open to fishing and more than two years after the introduction of the 30–35 cm slot limit. The 2017, 2021 and 2025 surveys were two, six, and ten years, respectively, after the slot limit was removed and replaced by a MLS of 33 cm, a DBL of 2 blue cod, and seasonal closure of the fishery from 1 September to 19 December, extended to 10 January in August 2025.

The highest catch rates of blue cod from the four random-site surveys (excluding areas closed to fishing) consistently occurred in D'Urville Island (DUR), where they were two to three times higher than in other regions (see Figure 31). However, there was substantial variability among strata within regions, with lower catch rates in the inner sounds, and higher rates in the outer sounds, around D'Urville Island, and along the Cook Strait side of Arapara Island (see Figure 5). This spatial pattern of abundance was consistent across the 2013, 2017, 2021, and 2025 surveys.

Notwithstanding the limitations of a four-survey time series, there were differing trends in the three areas that are difficult to rationalize in terms of management measures which were the same in each of the three regions (QCH, PEL, DUR), i.e., increasing catch rates in QCH, decreasing catch rates in PEL (see Figure 31), and no trend in DUR. There was little difference in the length distributions among and within the four regions over the four surveys, although the 2021 and 2025 distributions appear to have

fewer larger male fish in QCH and PEL, with a lower mean size (see Figure 35). Sex ratio has remained largely unchanged and strongly skewed towards males in all regions.

The only regulatory change affecting Cook Strait was the increase in the minimum legal size (MLS) from 30 to 33 cm in December 2015, as the seasonal closure does not apply to this area. Catch rates in Cook Strait show no clear trend from 2013 to 2025, aside from a temporary increase in 2017 - about one-third higher than in 2013 - two years after the MLS change, followed by a similar magnitude decline in 2021 (see Figure 31). Length distributions from the four random-site surveys were similar, with no evident trend, and the sex ratio remained consistently male-dominated and stable over time (see Figures 33 and 35).

4.4 Stock status trends (random sites)

The Harvest Strategy Standard specifies that a harvest strategy should include a fishery target reference point and that this may be expressed in terms of biomass or fishing mortality (Ministry of Fisheries 2011). As discussed in Section 1.2, the Inshore Working Group agreed that *SPR* is no longer appropriate as a target reference point for blue cod from Marlborough Sounds, as well as Kaikōura, Motunau , north Otago, south Otago, and Foveaux Strait and, instead, recommended F=0.87M as an overfishing threshold (Zhou et al. 2012), where Z and F are estimated from the male-only age composition in the population.

Estimation of total mortality assumes that recruitment and mortality are constant, that all recruited fish are equally vulnerable to capture, and that there are no age estimation errors. In Marlborough Sounds, however, fishing mortality has not been constant due to multiple management changes, including the closure of the inner Sounds in 2008 and the subsequent changes in the MLS, bag limits, and the introduction of a slot limit. Only the Z and F estimates from the 2013 surveys onward are valid indices as ageing before this time predated the blue cod age determination protocol (ADP). However, these estimates should be interpreted with caution given potential violations of the underlying mortality assumptions; specifically the slot limit in place during the 2013 survey, and the change to a 33 cm MLS about two years before the 2017 survey (see Table 11).

The revised method of estimating Z, and F using only males, rather than using the conventional method where male and female age compositions were combined, has resulted in higher estimates of mortality. Relative to the target reference point of F=0.15 (F=0.87M), the estimated F in the four random-site surveys was three to five times this target, with an increasing trend, indicating that the current level of fishing may be unsustainable (see Table 11, Figure 38).

Most female blue cod in Marlborough Sounds have historically been less than 33 cm in length (see Figure 35) and in 2025, 83% of female blue cod were less than 33 cm. Hence the increase in the MLS from 30 cm to 33 cm MLS in 2015 effectively removed all but the largest females from the fishery, although there is still likely to be some mortality from caught and released undersize females. A Fisheries New Zealand research programme in 2026 and 2027 seeks to investigate the mortality of undersize blue cod caught and returned to the water (project MAF2025-04).

4.5 Population response to fisheries management regulations

The two-year period between the closure of the inner Marlborough Sounds to blue cod fishing on 1 October 2008, and when the 2010 survey was carried out, clearly had a dramatic effect on the population length composition and abundance inside the closed area (Beentjes 2023). For the first time since 2001, and presumably for many years before this, blue cod were larger and more abundant within the inner than the outer Sounds, indicating that fishing in the inner Sounds had a substantial effect on the size and abundance of fish. There may have been some movement of blue cod from the outer to the inner Sounds

that contributed to the improved size structure, so the change may not necessarily have been solely due to growth of resident inner Sounds fish.

The 2013 fixed-site survey took place two and half years after the fishery was reopened and a 30–35 cm MLS slot limit was put in place for the 'Marlborough Sounds Area'. Abundance and length of fish declined in the previously closed areas (PEL and QCH) after the re-opening of the blue cod fishery, indicating that the blue cod population was responding to fishing effort (see Figure 31). The 2017 survey took place about two years after the 33 cm MLS and seasonal closure were implemented for the 'Marlborough Sounds Area' and 'Challenger Area'. The blue cod fixed-site potting survey time series appears to have tracked changes in abundance and length resulting from changes in the fisheries management regulations.

The Marlborough Sounds random-site surveys (2013, 2017, 2021, and 2025) have not shown any clear increases in abundance except in Queen Charlotte Sound, and in all regions there have been no increase in size, or a drop in the high proportion of males, despite the reduced bag limit or 2 blue cod and increase in MLS to 33 cm in December 2015, and the closed season.

4.6 Long Island Marine Reserve and Maud Closed Area

The key finding from the random-site surveys of Long Island Marine Reserve in 2017, 2021, and 2025 was that blue cod were more abundant and larger inside the marine reserve; catch rates were consistently about 5–6 fold greater in the marine reserve than in the adjacent fished strata in Queen Charlotte Sound (Figure 39), and mean length was 3–5 cm larger (Figure 41). The proportion of blue cod that were recruited fish (33 cm and over) was also greater in the marine reserve at 54–86% compared to 30–45% outside (see Figure 39) Further, only 1–10% of pots were empty in the marine reserve compared to 20 to 70% in the two adjacent Queen Charlotte Sound strata, indicating that blue cod distribution was less patchy within the reserve (Figure 40). The mean and median condition factor of blue cod in 2021 and 2025 were substantially higher in the marine reserve than outside indicating that fish are heavier for a given length in the marine reserve, plausibly because of more abundant food supply (see Table 10, Figure 23). Surprisingly, the diversity of bycatch species was very low in the marine reserve compared to other strata in Marlborough Sounds (see Table 3A and 3B).

These LIMR potting survey results are consistent with a time series of line fishing surveys of the marine reserve and adjacent fished areas that began in 1992, a year before the marine reserve was established by the Department of Conservation in April 1993 (Davidson et al. 2014). The potting survey demonstrated a greater difference in abundance and size, inside and outside, than the line surveys, possibly a result of selectivity issues relating to line versus potting. For example, small blue cod were observed to be more aggressive in taking a baited hook than larger fish (Rob Davidson pers. comm.) and this may have biased the abundance and size estimates in the marine reserve downward.

The results from Long Island Marine Reserve were largely mirrored by those in MAUD, although catch rates were not as high in MAUD. Importantly, abundance and size and condition were all greater inside than outside the closed area.

The results are a clear indicator that fishing effort throughout the Marlborough Sounds has markedly reduced blue cod size and abundance. We cannot comment on the age structure or sex ratio of blue cod within the marine reserve and closed area, however, because all fish were returned alive. The intention is to continue to include the Long Island Marine Reserve and Maud Closed Area in future surveys of the Marlborough Sounds to provide ongoing control sites to compare with fished sites. This work and another recent Fisheries New Zealand study suggests that the creation of more no-take areas spread throughout the sounds would benefit the overall population through increased egg production and recruitment (Brough et al. 2025).

4.7 Stephens Island

This was the first dedicated survey of Stephens Island. The finding that catch rates were the highest of all strata, including LIMR and MAUD, was unexpected given that this area is commercially fished. Indeed, the catch rates are the highest of any survey carried out by Fisheries New Zealand throughout the South Island. The catch rates were uniformly high in all five sites indicating that abundance was high around the entire 6 km of coast. The high abundance around Stephens Island is most likely due to favourable habitat, clear water, and a dynamic current regime. Although catch rates were high, the size of blue cod and the sex ratio were similar to those of neighbouring D'Urville Island, most likely a reflection of fishing pressure.

5. FULFILMENT OF BROADER OUTCOMES

This project supported the local community and regional businesses in several ways: during the survey, ESNZ crew and science staff required accommodation and meals throughout the Sounds; the ESNZ vessel required fuel and moorings; the bait used in pots on the survey was purchased from a Dunedin Fish Receiver; pot maintenance and replacement was undertaken using locally sourced materials and/or local netmakers; blue cod of legal size were landed to a local Licensed Fish Receiver in Nelson; and local freight companies transported pots, bait, and equipment. The Long Island Marine Reserve survey provides DOC with information on the status of blue cod in the protected area.

Voyage Programmes and Voyage Reports were circulated to all relevant stakeholders including iwi, fishing industry, Fisheries New Zealand, Regional Compliance Managers, recreational fishing representatives, Department of Conservation, and NGOs.

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8. TABLES

Table 1: Fixed- and random-site blue cod potting survey time series in the Marlborough Sounds by region, including the 2025 survey. See Figure 1 for spatial representation of the areas. Surveys before 2013 were carried out on F.V. *Lady H R* and thereafter on the NIWA vessel R.V. *Ikatere*. QCH, Queen Charlotte Sound; PEL, Pelorus Sound; DUR, D'Urville Island; CKST, Cook Strait; SEPR, Separation Point; LIMR, Long Island Marine Reserve; MAUD, Maud Island closed Area; STEP, Stephens Island; all, all strata surveyed; partial, not all strata surveyed; – no survey. See Figure 3 for spatial location of strata.

	Fixed-site surveys by region					Random-site surveys by region						
Year	QCH	PEL	DUR	CKST	SEPR	QCH	PEL	DUR	CKST	LIMR	MAUD	STEP
1995	all	partial	–	–	–	–	–	–	–	–		
1996	–	all	partial	–	–	–	–	–	–	–		
2001	all	all	partial	–	–	–	–	–	–	–		
2004	all	all	all	–	all	–	–	–	–	–		
2007	all	all	all	–	all	–	–	–	–	–		
2008	–	–	–	all	–	–	–	–	–	–		
2010	all	all	all	–	–	–	partial	partial	all	–		
2013	all	all	all	–	–	all	all	all	all	–		
2017	all	all	all	–	–	all	all	all	all	all		
2021	–	–	–	–	–	all	all	all	all	all		
2025	–	–	–	–	–	all	all	all	all	all	all	all

Table 2: Effort and catch of blue cod for the 2025 random-site Marlborough Sounds potting survey. Regions: QCH, Queen Charlotte Sound; PEL, Pelorus Sound; DUR, D'Urville Island; CKST, Cook Strait; Strata: IQCH, inner QCH; OQCH, outer QCH; EQCH, extreme outer QCH; IPEL, inner PEL; MPEL, mid PEL; OPEL, outer PEL; EOPE, extreme outer PEL; DURW, D'Urville Island west; DURE, D'Urville Island east; APAE, Arapaoa Island east; UNDW, Port Underwood; COOK, Cook Strait; LIMR, Long Island Marine Reserve; Maud, Maud Island Closed Area; STEP, Stephens Island. See Figure 3 for spatial location of strata.

Region	Stratum		Area (km coast)	Site type	Sites (*N*)		Pots (*N*)	Blue cod		Depth (m)		
	No.	Code			Phase 1	Phase 2		No.	Catch (kg)	Mean	Min	Max
QCH	1	IQCH	43.2	Random	3		27	13	5.6	16	5	38
QCH	2	OQCH	170	Random	9		81	452	190.1	19	5	40
QCH	3	EQCH	79	Random	6		54	126	58.8	13	5	35
PEL	4	EOPE	69.5	Random	7		63	213	108.7	17	5	36
PEL	5	OPEL	91.3	Random	3		27	18	11.8	13	5	26
DUR	6	DURE	102.4	Random	6		54	518	256.6	14	5	30
PEL	7	IPEL	100.1	Random	3		27	18	9.4	13	5	28
PEL	8	MPEL	55.6	Random	3		27	21	9.7	13	5	27
DUR	9	DURW	94.2	Random	8		72	271	158.4	13	5	28
CKST	11	APAE	21.6	Random	5		45	263	114.5	27	6	75
CKST	12	COOK	30	Random	4		36	111	46.4	16	6	71
CKST	13	UNDW	34	Random	3		27	18	7.6	9	5	15
Totals					60		540	2 042	977.6	15	5	75
QCH	14	LIMR	11.4	Random	8		72	896	582.5	16	5	40
PEL	15	MAUD	20.6	Random	10		90	539	370.8	14	5	25
DUR	16	STEP	5.7	Random	5		45	879	463.4	22	9	59
Totals					23		207	2 314	1 416.7			
Grand total					83		747	43 56	2 394.3	16	5	75

Table 3: Total catch and numbers of blue cod, and bycatch species caught on the 2025 Marlborough Sounds random-site potting survey core strata (A), in the Long Island Marine Reserve potting survey (B), Maud Island Closed Area (C), and Stephens Island (D).

(A) Core strata

Common name	Scientific name	Code	Catch (kg)	Number	% catch
Blue cod	*Parapercis colias*	BCO	977.6	2 042	90.87
Banded Wrasse	*Notolabrus fucicola*	BPF	31.9	63	2.97
Common octopus	*Macroctopus maorum*	OCT	31.6	9	2.94
Carpet shark	*Cephaloscyllium isabella*	CAR	15.1	5	1.40
Scarlet wrasse	*Pseudolabrus miles*	SPF	6.7	27	0.62
Red mullet	*Upeneichthys lineatus*	RMU	3.7	5	0.34
Southern conger	*Conger verreauxi*	CVR	3.0	2	0.28
Copper moki	*Latridopsis forsteri*	CMO	1.6	2	0.15
Leatherjacket	*Meuschenia scaber*	LEA	1.0	3	0.09
Marblefish	*Aplodactylus arctidens*	GTR	1.0	1	0.09
Dwarf scorpionfish	*Scorpaena papillosa*	RSC	0.8	2	0.07
Moki	*Latridopsis ciliaris*	MOK	0.8	1	0.07
Spotted Wrasse	*Notolabrus celidotas*	STY	0.6	5	0.06
Tarakihi	*Nemadactylus macropterus*	NMP	0.3	3	0.03
Girdled wrasse	*Notolabrus cinctus*	GPF	0.1	1	0.01
			1 075.8	2 171	100

(B) Long Island Marine Reserve

Common name	Species	Code	Catch (kg)	Number	% catch
Blue cod	*Parapercis colias*	BCO	582.5	896	98.26
Carpet shark	*Cephaloscyllium isabella*	CAR	6.2	2	1.05
Tarakihi	*Nemadactylus macropterus*	NMP	2.6	2	0.44
Snapper	*Chrysophrys auratus*	SNA	0.9	1	0.15
Leatherjacket	*Meuschenia scaber*	LEA	0.6	3	0.10
			592.8	904	100

(C) Maud Island Closed Area

Common name	Species	Code	Catch (kg)	Number	% catch
Blue cod	*Parapercis colias*	BCO	370.8	539	97.89
Carpet shark	*Cephaloscyllium isabella*	CAR	5.5	2	1.45
Southern conger	*Conger verreauxi*	CVR	2.5	1	0.66
			378.8	542	100

(D) Stephens Island

Common name	Species	Code	Catch (kg)	Number	% catch
Blue cod	*Parapercis colias*	BCO	463.4	879	94.36
Carpet shark	*Cephaloscyllium isabella*	CAR	14.9	5	3.03
Scarlet wrasse	*Pseudolabrus miles*	SPF	7.4	22	1.51
Banded Wrasse	*Notolabrus fucicola*	BPF	2.4	4	0.49
Red cod	*Pseudophycis bachus*	RCO	2	1	0.41
Tarakihi	*Nemadactylus macropterus*	NMP	0.5	1	0.10
Leatherjacket	*Meuschenia scaber*	LEA	0.3	1	0.06
Dwarf scorpionfish	*Scorpaena papillosa*	RSC	0.2	1	0.04

Table 4: Mean catch rates for all blue cod and recruited blue cod (33 cm and over) caught from the 2025 Marlborough Sounds random-site potting survey by strata, region and overall for the Marlborough Sounds core strata (MS). Catch rates are pot-based and s.e. and CV are set-based. s.e., standard error; CV, coefficient of variation. MS, Marlborough Sounds overall. See Figure 3 for spatial location of strata and Table 2 for strata names.

				All blue cod			Recruited blue cod (33 cm and over)		
Region	Stratum	Site type	Pot lifts (N)	Catch rate (kg pot^{-1})	s.e.	CV (%)	Catch rate (kg pot^{-1})	s.e.	CV (%)
QCH	1 (IQCH)	Random	27	0.21	0.04	17.9	0.08	0.04	53.6
	2 (OQCH)	Random	81	2.35	0.53	22.5	0.98	0.26	26.1
	3 (EQCH)	Random	54	1.09	0.43	39.2	0.55	0.20	37.1
	Overall		162	1.69	0.33	19.4	0.73	0.16	21.8
PEL	4 (EOPE))	Random	63	1.73	0.60	35.0	1.01	0.33	33.2
	5 (OPEL)	Random	27	0.44	0.04	8.1	0.34	0.03	7.7
	7 (IPEL)	Random	27	0.35	0.22	64.4	0.24	0.16	66.7
	8 (MPEL)	Random	27	0.36	0.15	41.6	0.20	0.03	17.5
	Overall		144	0.68	0.15	22.6	0.43	0.09	20.9
DUR	6 (DURE)	Random	54	4.75	2.18	45.8	2.33	0.93	39.9
	9 (DURW)	Random	72	2.20	0.98	44.4	1.33	0.53	39.9
	Overall		126	3.53	1.23	34.8	1.85	0.55	29.5
CKST	11 (APAE)	Random	45	2.69	1.00	37.3	1.03	0.35	33.7
	12 (COOK)	Random	36	1.29	0.13	9.8	0.71	0.12	16.9
	13 (UNDW)	Random	27	0.28	0.12	42.2	0.13	0.07	54.9
	Overall		108	1.24	0.26	21.1	0.56	0.10	18.0
MS	Overall	Random	540	1.69	0.30	17.6	0.85	0.14	15.9
QCH	14 (LIMR)	Random	72	8.09	0.50	6.2	5.75	0.60	10.4
PEL	15 (MAUD)	Random	90	4.12	0.61	14.9	3.15	0.58	18.3
DUR	16 (STEP)	Random	45	10.38	2.14	20.6	5.42	1.00	18.5

Table 5: Descriptive statistics for blue cod caught on the 2025 Marlborough Sounds and random-site potting survey. Outputs are raw for each stratum and weighted for the regions overall, and for the core strata overall. Recruited size is 33 cm and over. m, male; f, female; –, no data. See Figure 3 for spatial location of strata and Table 2 for strata names.

Queen Charlotte Sound

					Length (cm)			Percent male	
Region	Stratum	Site type	Sex	*N*	Mean	Minimum	Maximum	All blue cod	Recruited
QCH	1 (IQCH)	Random	m	7	26.9	11.0	36.4	52.9	64.4
			f	6	32.3	30.5	36.4		
	2 (OQCH)	Random	m	361	31.3	15.5	38.6	80.1	94.8
			f	91	27.3	14.2	35.5		
	3 (EQCH)	Random	m	98	31.5	11.4	41.7	77.9	95.2
			f	28	28.2	15.9	37.9		
QCH	Overall	Random	m	466	30.8	11.0	41.7	79.2	94.4
			f	125	27.2	14.2	37.9		
QCH	14 (LIMR)	Random	u	896	33.4	16.7	50.9	–	–

Pelorus Sound

					Length (cm)			Percent male	
Region	Stratum	Site type	Sex	*N*	Mean	Minimum	Maximum	All blue cod	Recruited
PEL	7 (IPEL)	Random	m	12	33.0	27.6	43.5	65.2	68.8
			f	6	33.0	29.7	37.7		
	8 (MPEL)	Random	m	8	30.3	18.9	38.5	38.1	49.8
			f	13	31.9	25.2	42.1		
	5 (OPEL)	Random	m	11	34.7	21.7	44.5	60.3	71.2
			f	7	32.6	28.5	37.6		
	4 (EOPE)	Random	m	192	32.4	18.6	42.1	90.4	95.9
			f	21	25.2	14.3	35.3		
PEL	Overall	Random	m	223	32.2	18.6	44.5	76.6	82.7
			f	47	30.3	14.3	42.1		
PEL	MAUD		u	539	34.4	15.4	46.5	–	–

D'Urville Island

Region	Stratum	Site type	Sex	*N*	Length (cm)			Percent male	
					Mean	Minimum	Maximum	All blue cod	Recruited
DUR	6 (DURE)	Random	m	380	32.4	19.8	43.4	73.6	86.9
			f	138	30.4	24.4	37.6		
	9 (DURW)	Random	m	194	33.8	26.9	42.3	71.8	87.0
			f	77	31.3	25.6	40.2		
DUR	Overall	Random	m	574	32.4	19.8	43.4	73.1	86.9
			f	215	30.1	24.4	37.6		
DUR	STEP	Random	m	738	32.4	19.0	41.4	84.0	95.2
			f	141	29.6	14.5	36.6		

Cook Strait

Region	Stratum	Site type	Sex	*N*	Length (cm)			Percent male	
					Mean	Minimum	Maximum	All blue cod	Recruited
CKST	11 (APAE)	Random	m	222	30.0	14	48.5	84.3	96.5
			f	41	26.5	15.3	34		
	12 (COOK)	Random	m	98	29.9	16.6	41.8	88.3	97.1
			f	13	27.3	20.8	35.5		
	13 (UNDW)	Random	m	17	29.9	17.6	37.7	94.6	100
			f	1	27.0	27	27		
CKST	Overall	Random	m	337	29.7	14	48.5	86.7	97.1
			f	55	26.6	15.3	35.5		

Marlborough Sounds core strata

Region	Stratum	Site type	Sex	*N*	Length (cm)			Percent male	
					Mean	Minimum	Maximum	All blue cod	Recruited
MS_core	1–13	random	m	1600	31.5	11	48	76.8	89.0
			f	442	29.1	14	42		

Table 6: Otolith ageing data used in the catch-at-age, *Z* and *F* estimates for the 2025 Marlborough Sounds blue cod survey. Only those ages from the core strata (QCH, PEL, DUR and CKST) were used in estimating *Z* and *F*.

			Length of aged fish (cm)		Age (years)	
Survey region	Sex	No. otoliths	Minimum	Maximum	Minimum	Maximum
QCH	Male	87	15	41	2	8
	Female	119	14	37	2	18
PEL	Male	67	18	43	2	8
	Female	41	14	42	2	11
DUR	Male	114	19	43	2	17
	Female	81	24	40	4	20
CKST	Male	96	14	48	2	11
	Female	41	15	34	2	7
STEP	Male	37	19	41	3	9
	Female	22	14	27	2	7
Overall	Male	401	14	48	2	17
	Female	304	14	42	2	20

Table 7: Gonad stages of Marlborough Sounds blue cod in September–October 2025 by region. Stages are: 1, immature or resting; 2, maturing (oocytes visible in females); 3, mature (hyaline oocytes in females, milt expressible in males); 4, running ripe (eggs and milt free flowing); 5, spent. See Table 2 for region names. See Figure 3 for spatial location of strata and Table 2 for strata names.

		Gonad stage (%)					
Region	Sex	1	2	3	4	5	*N*
QCH	Males	5.4	50.4	32.2	12.0	0.0	466
	Females	24.0	17.6	44.8	12.0	1.6	125
PEL	Males	1.3	54.7	18.4	18.8	6.7	223
	Females	17.0	21.3	51.1	8.5	2.1	47
DUR	Males	1.4	52.3	18.8	13.2	14.3	574
	Females	7.0	27.0	34.9	24.2	7.0	215
CKST	Males	22.6	53.4	18.4	5.3	0.3	337
	Females	56.4	30.9	10.9	1.8	0.0	55
STEP	Males	1.5	62.7	12.5	4.2	19.1	738
	Females	48.2	36.9	6.4	0.0	8.5	141
All regions	Males	5.3	55.6	19.4	9.5	10.2	2 338
	Females	26.1	27.3	29.2	12.3	5.1	583

Table 8: Chapman-Robson total mortality estimates (*Z*) and 95% confidence intervals (CI) for blue cod males from the 2025 Marlborough Sounds random-site blue cod potting survey for all regions combined. AgeR, age at full recruitment (years).

AgeR	*Z*	Lower CI	Upper CI
5	0.71	0.5	0.96
6	0.92	0.62	1.3
7	1.17	0.78	1.66
8	0.56	0.36	0.83
9	0.45	0.3	0.64
10	0.34	0.23	0.49

Table 9: Mortality parameters (*Z*, *F*) point-estimates at three values of *M* for male blue cod from the 2025 Marlborough Sounds random-site potting survey, for all regions combined. The mortality parameters *Z* and *F* are also given for the 95% confidence interval values around the default *M* (0.17). *AgeR* is the age-at-recruitment at which males reach MLS of 33 cm plus one year (i.e. 6 years). AgeR, age at full recruitment; *F*, fishing mortality; *M*, natural mortality; *Z*, total mortality; lower CI, lower 95% confidence interval; upper CI, upper 95% confidence interval.

M	*Z*	*F*	Estimate
0.14	0.92	0.78	Point
0.17	0.92	0.75	Point
0.2	0.92	0.72	Point
0.17	0.62	0.45	Lower CI
0.17	1.3	1.13	Upper CI

Table 10: Fulton's mean condition factor (*K*) for blue cod of all sizes for the 2017, 2021 and 2025 Marlborough Sounds random-site blue cod potting surveys. Mean values are shown for all strata combined (excluding LIMR and MAUD), LIMR, outside LIMR, MAUD, and outside MAUD. Outside LIMR refers to combined adjacent strata OQCH and EQCH; Outside MAUD refers to combined adjacent strata MPEL and OPEL. LIMR, Long Island Marine Reserve; MAUD, Maud Island Closed Area. See Figure 3 for spatial location of strata.

	Mean (*K*)				
Survey	All strata (excl. LIMR and MAUD)	LIMR	Outside LIMR	MAUD	Outside MAUD
2017	1.45	NA	1.44	NA	NA
2021	1.44	1.61	1.41	NA	NA
2025	1.50	1.57	1.41	1.62	1.45

Table 11: Mortality (*Z*, *F*) point-estimates for male blue cod from the 2013, 2017, 2021, and 2025 Marlborough Sounds potting surveys, for all regions combined. The mortality parameters are for the default *M* (0.17) and age at recruitment equal to the minimum legal size, plus one year. The 95% confidence intervals around estimates are also presented. *F*, fishing mortality; *M*, natural mortality; *Z*, total mortality; CI, 95% confidence intervals.

Survey	Site type	*M*	*Z* (CIs)	*F* (CIs)
2013	Fixed	0.17	0.66 (0.46–0.88)	0.49 (0.29–0.71)
2017		0.17	0.77 (0.54–1.03)	0.60 (0.37–0.86)
2013	Random	0.17	0.60 (0.42–0.81)	0.43 (0.25–0.64)
2017		0.17	0.75 (0.52–1.02)	0.58 (0.35–0.85)
2021		0.17	0.65 (0.43–0.90)	0.48 (0.26–0.73)
2025		0.17	0.92 (0.62–1.3)	0.75 (0.45–1.13)

9. FIGURES

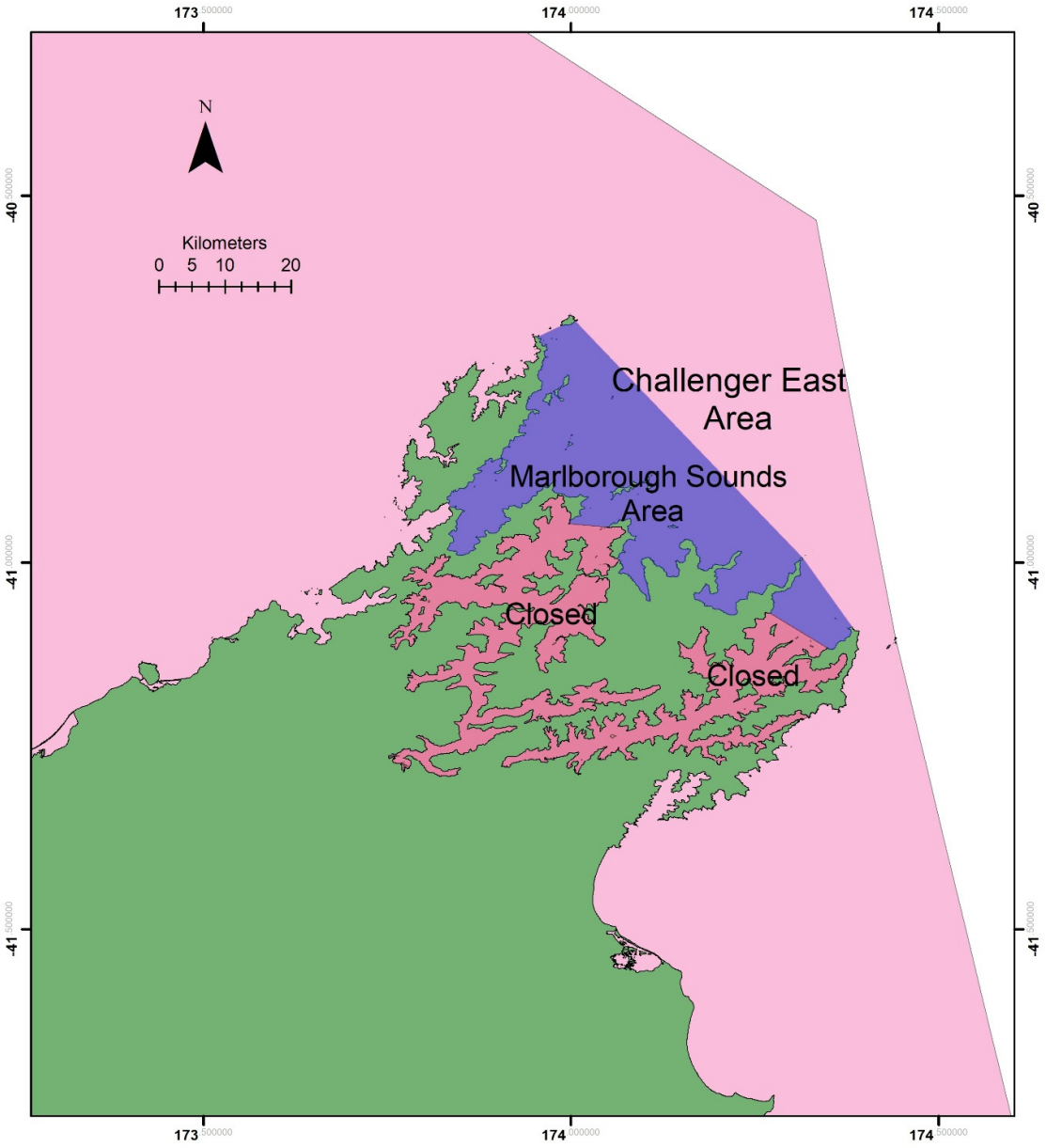


Figure 1: Marlborough Sounds showing fisheries management areas 'Marlborough Sounds Area' and the 'Challenger East Area'. From 1 October 2008 to April 2011, the inner Queen Charlotte Sound and inner Pelorus Sound (part of the Marlborough Sounds Area) were closed to fishing. The Challenger East Area includes the Marlborough Sounds Area.

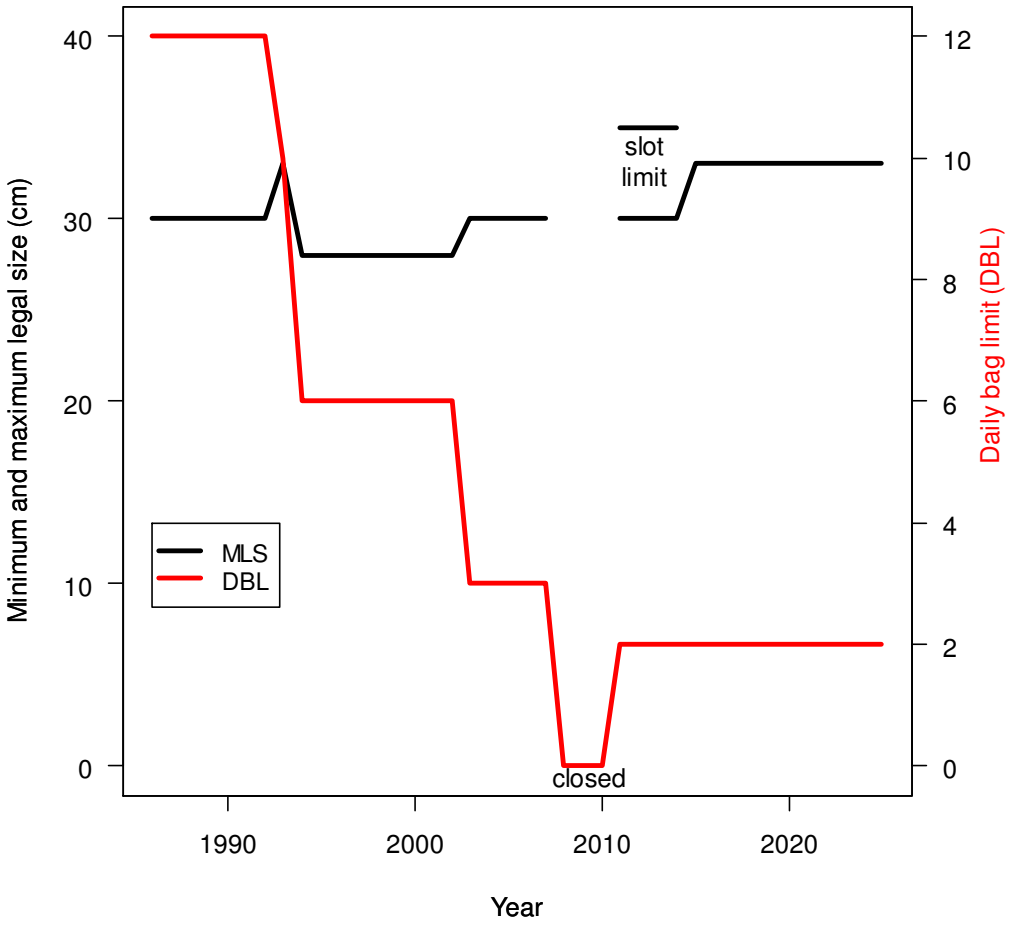


Figure 2: Minimum and maximum legal size (MLS) and daily bag limit (DBL) within the 'Marlborough Sounds Area' since 1985 (see Figure 1 for areas). From 1 October 2008 to April 2011, outside of the inner Queen Charlotte and Pelorus Sounds, the minimum legal size was 30 cm and DBL was 3 blue cod.

Chronology of changes to blue cod recreational fisheries regulations in the Marlborough Sounds:

1 October 2008 to April 2011: The Queen Charlotte and Pelorus Sounds were closed to fishing. Elsewhere in the 'Marlborough Sounds Area' and 'Challenger Area East', the minimum legal size (MLS) was 30 cm and DBL was 3 blue cod.

1 April 2011 to 20 December 2015: 30–35 cm slot limit within 'Marlborough Sounds Area' with DBL of 2 blue cod, max of 2 hooks per line, and fishery closed from 1 September to 20 December. In the 'Challenger Area East', the MLS was 30 cm and DBL 3 blue cod.

From 20 December 2015 to 1 July 2020: Within 'Marlborough Sounds Area' and 'Challenger Area East', a MLS of 33 cm, DBL of 2 blue cod (or 2 from each area), and a maximum of two hooks per line. The fishery inside the Marlborough Sounds Area was closed to fishing for blue cod from 1 September to 19 December, extended to 10 January in August 2025.

1 July 2020: The area from Farewell Spit to Clarence River (out to 12 nautical miles), including Marlborough Sounds, known as the 'Tasman Area' was assigned a 'traffic light' colour of red by Fisheries New Zealand, indicating that the blue cod stocks in this area are considered to be overfished. The MLS in this area is 33 cm the DBL is 2 per person.

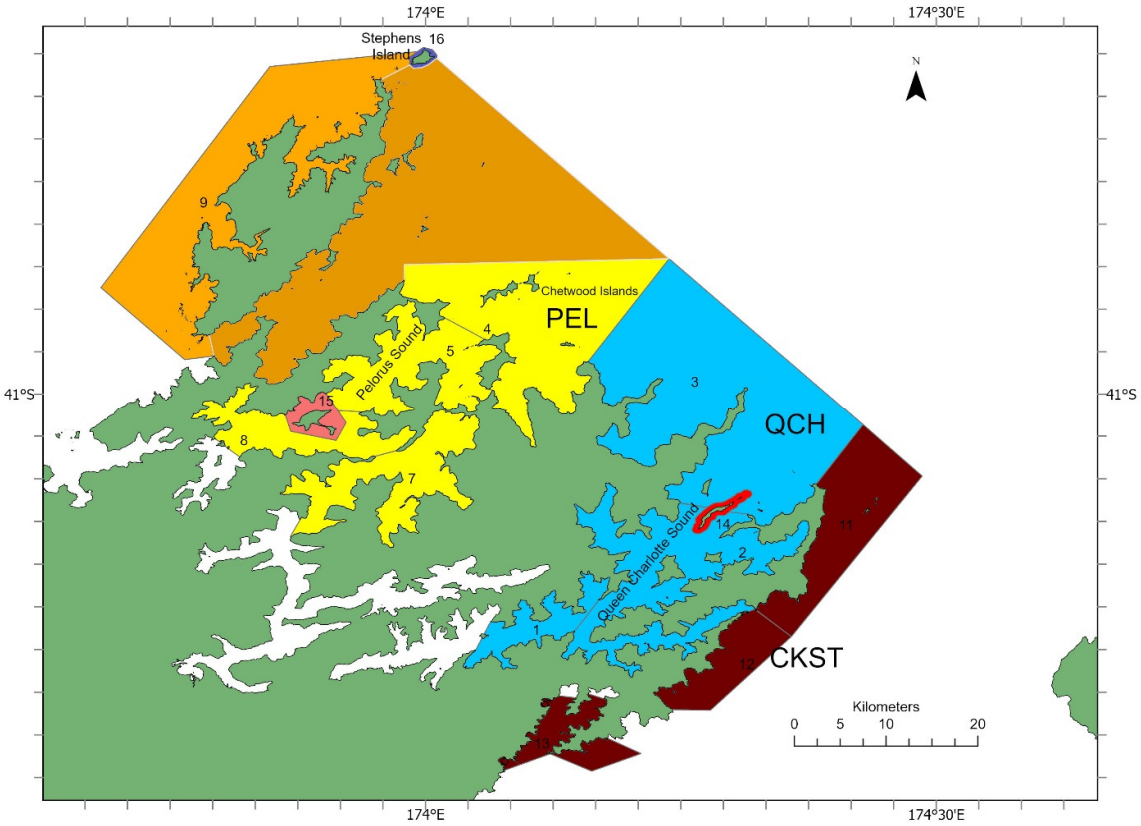


Figure 3: Map of Marlborough Sounds showing the 12 core strata in 2025. The regions are colour coded: orange, D'Urville (DUR); yellow, Pelorus Sound (PEL); blue, Queen Charlotte Sound (QCH); dark red, Cook Strait (CKST). See Table 2 for strata names. Other strata surveyed in 2025 were: Long Island Marine Reserve (stratum 14, red border at the head of Queen Charlotte Sound); Maud Island Closed Area (stratum 15, pink polygon in the inner Pelorus Sounds); and Stephens Island (stratum 16, dark blue border north of D'Urville Island).

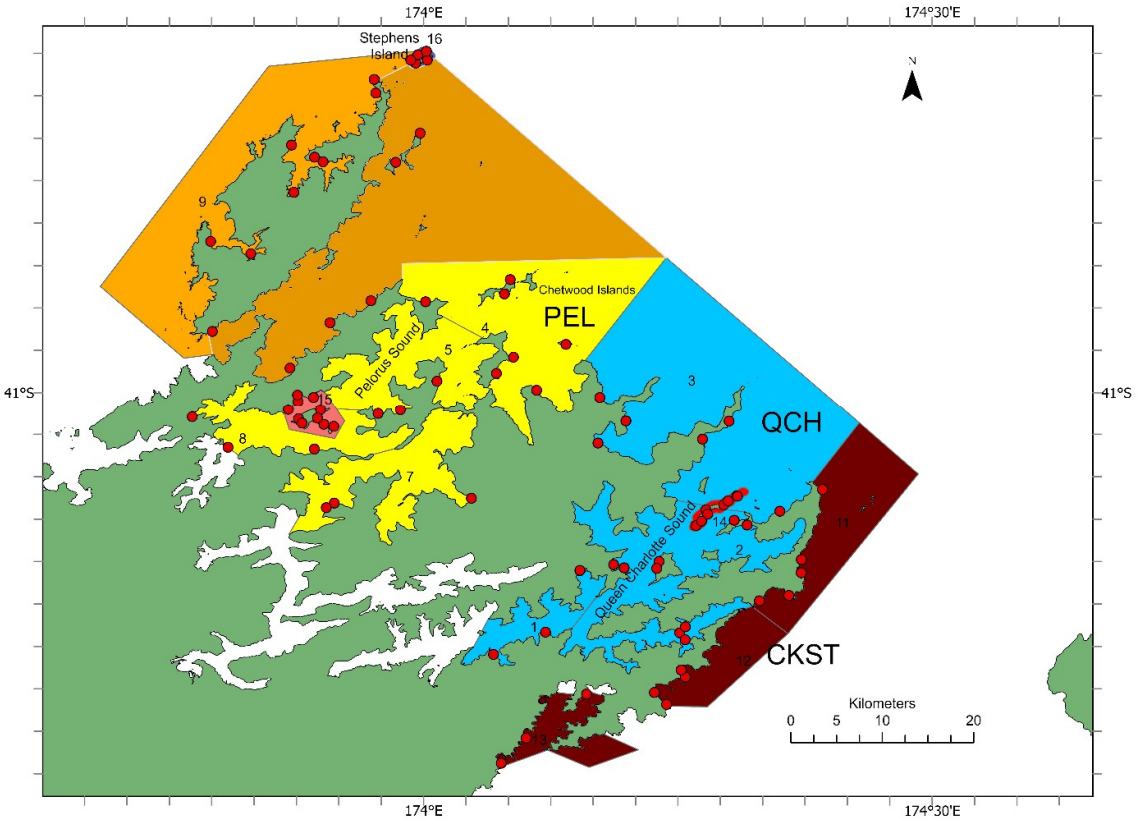


Figure 4: Map of Marlborough Sounds showing the strata and locations of the 83 random sites surveyed in 2025 (60 in core strata, 8 in Long Island Marine Reserve; 10 in Maud Island Closed Area; and 5 around Stephens Island). The regions are colour coded: orange, D'Urville (DUR); yellow, Pelorus Sound (PEL); blue, Queen Charlotte Sound (QCH); red, Cook Strait (CKST). See Table 2 for strata names. Other strata surveyed in 2025 were: Long Island Marine Reserve (stratum 14, red border at the head of Queen Charlotte Sound); Maud Island Closed Area (stratum 15, pink polygon in the inner Pelorus Sounds); and Stephens Island (stratum 16, dark blue border north of D'Urville Island).

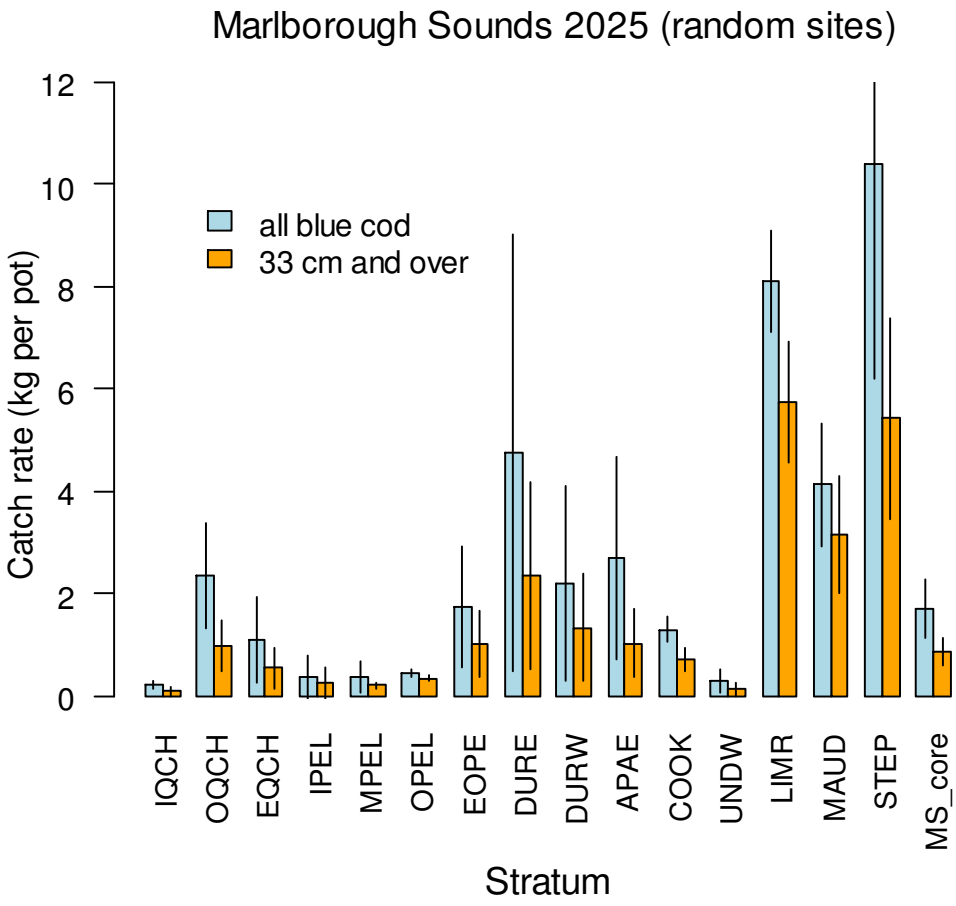


Figure 5: Marlborough Sounds 2025 random-site potting survey catch rates of all blue cod and recruited blue cod by strata and for Marlborough Sounds core strata overall (MS_core). Error bars are 95% confidence intervals. See Figure 3 for location of strata and Table 2 for strata names.

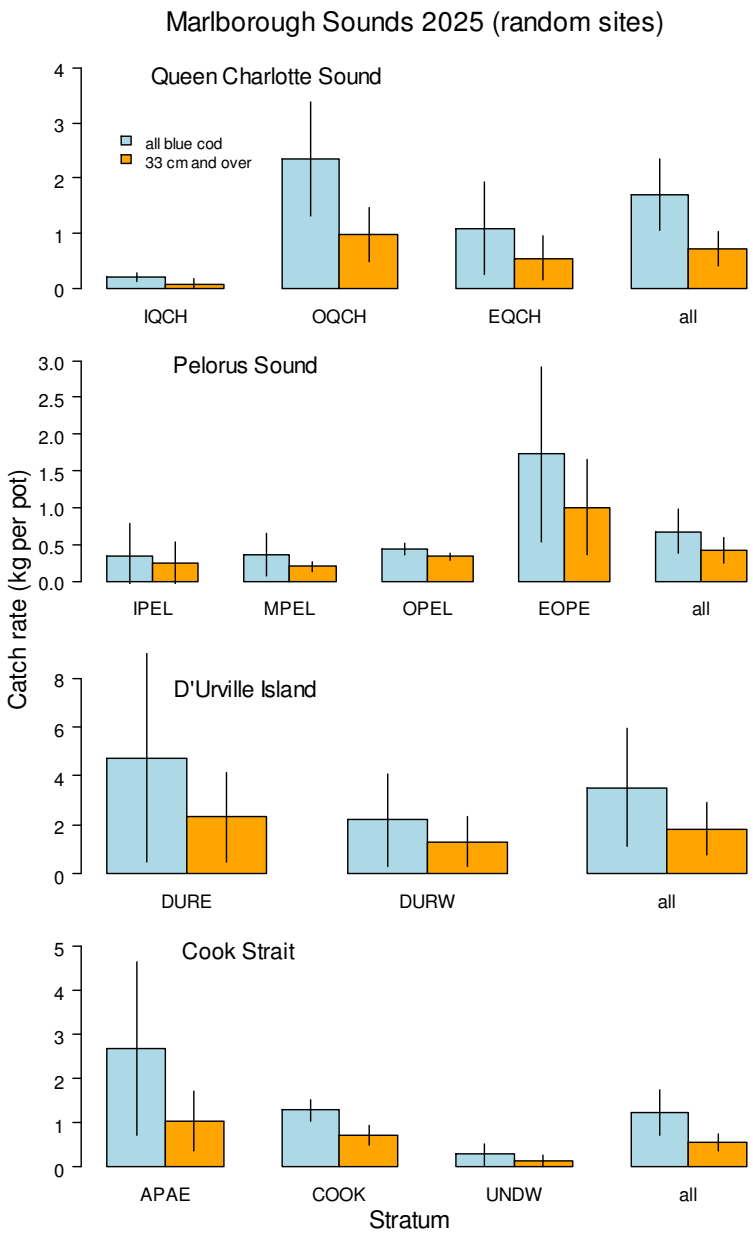


Figure 6: Marlborough Sounds 2025 random-site potting survey core strata catch rates of all blue cod and recruited blue cod by strata and overall for each region. Error bars are 95% confidence intervals. See Figure 3 for location of strata and Table 2 for strata names.

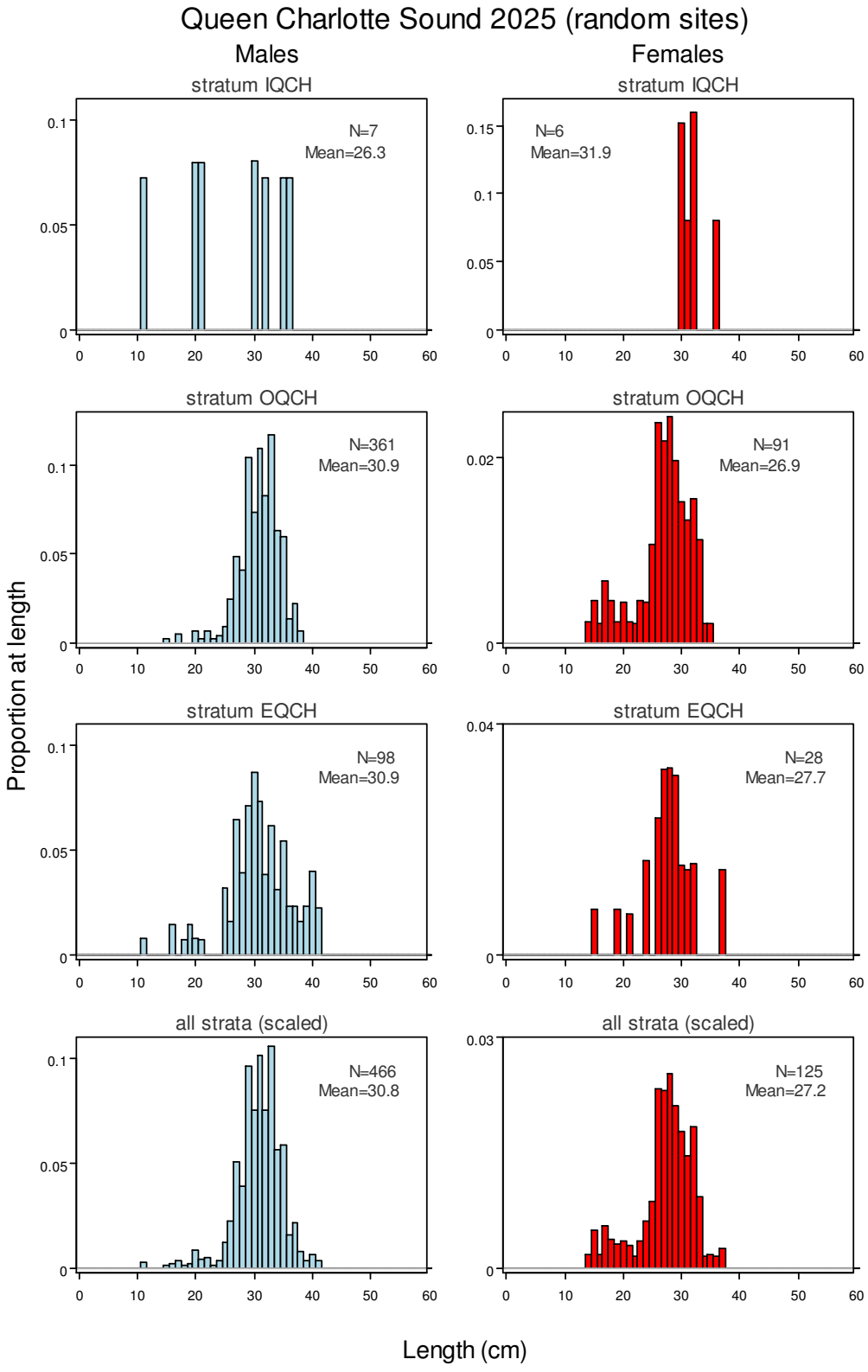


Figure 7: Scaled length frequency distributions by strata and overall for the 2025 Queen Charlotte Sound random-site potting survey. N, sample numbers; Mean, mean length (cm). Proportions sum to one within each stratum. See Figure 3 for location of strata and Table 2 for strata names.

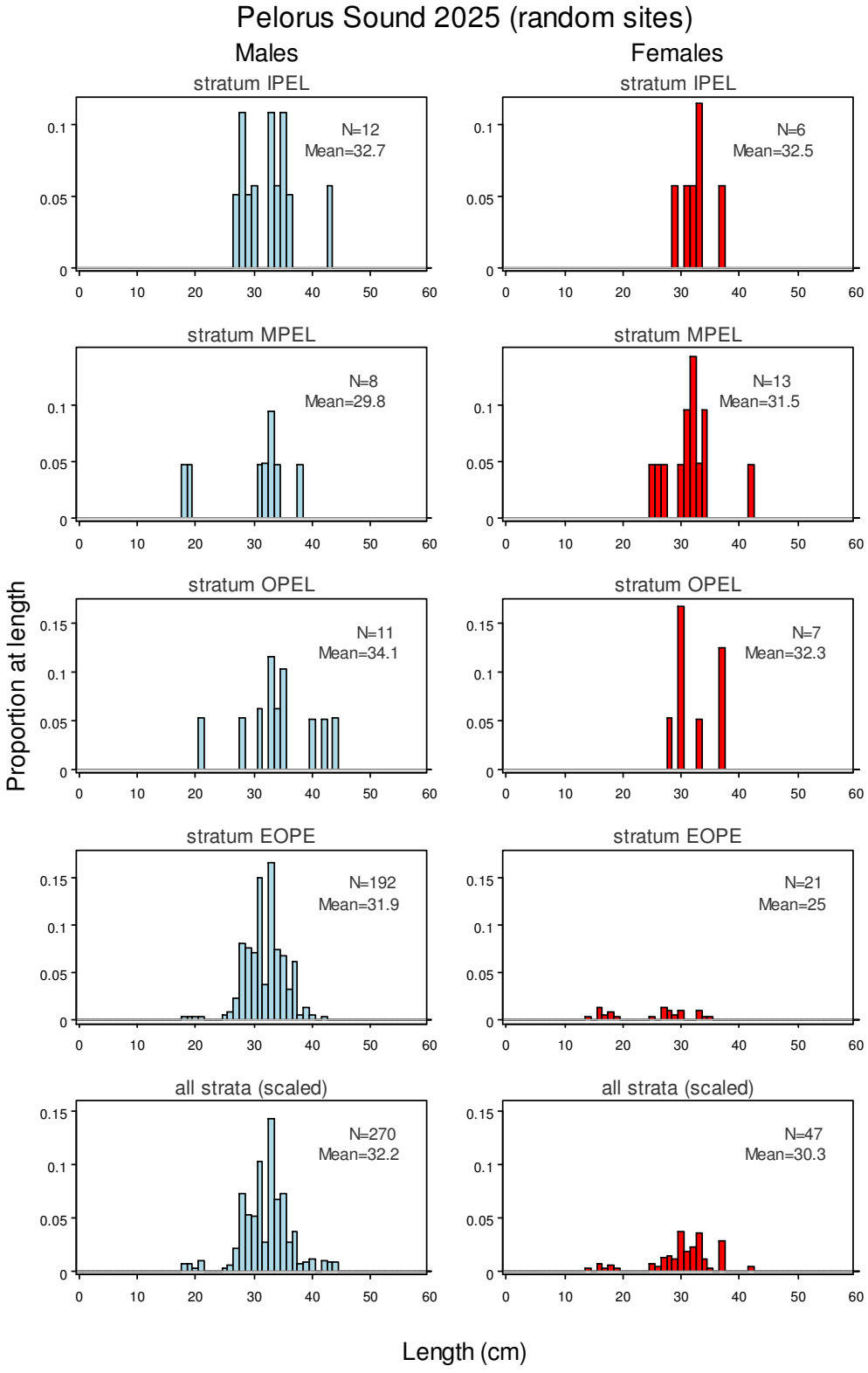


Figure 8: Scaled length frequency distributions by strata and overall for the 2025 Pelorus Sound random-site potting survey. N, sample numbers; Mean, mean length (cm). Proportions sum to one within each stratum. See Figure 3 for location of strata and Table 2 for strata names.

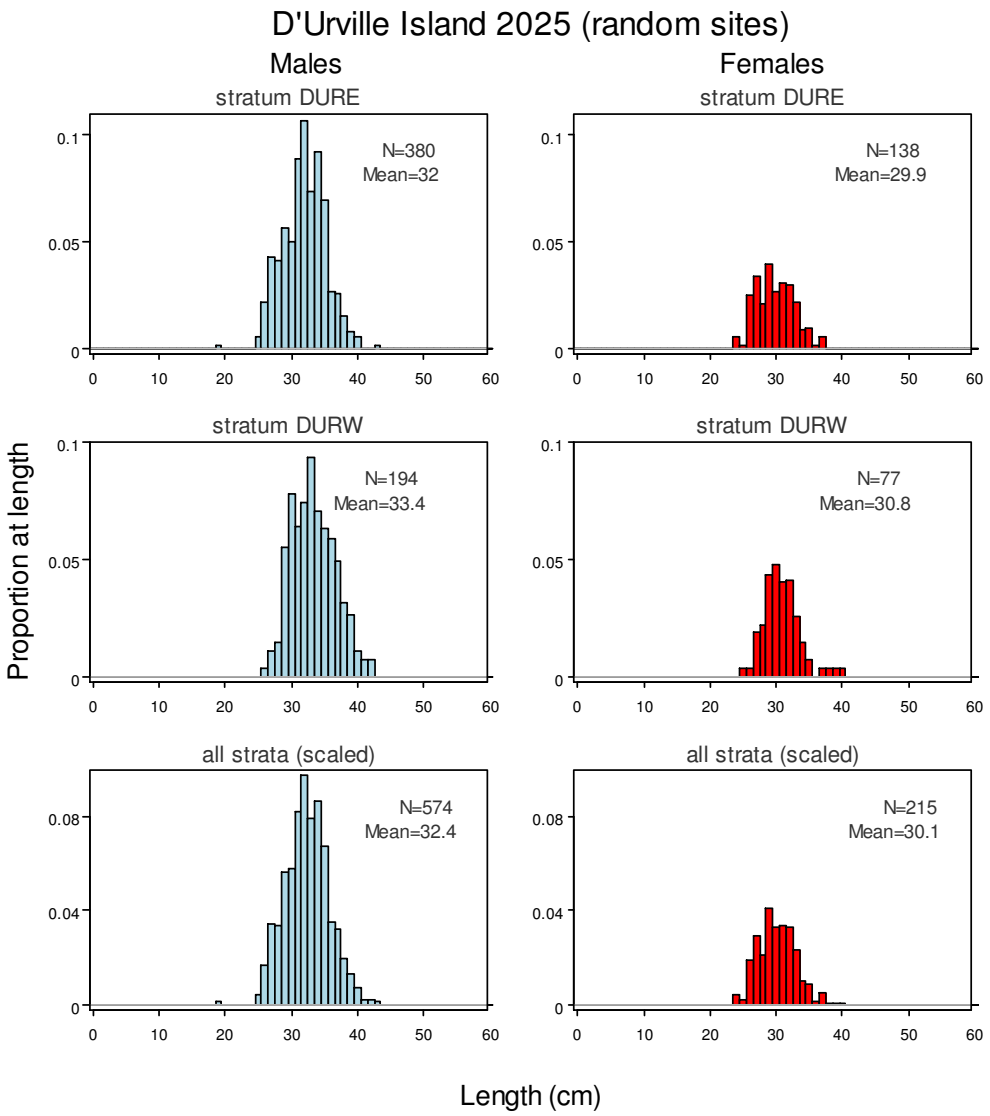


Figure 9: Scaled length frequency distributions by strata and overall for the 2025 D'Urville Island random-site potting survey. N, sample numbers; Mean, mean length (cm). Proportions sum to one within each stratum. See Figure 3 for location of strata and Table 2 for strata names.

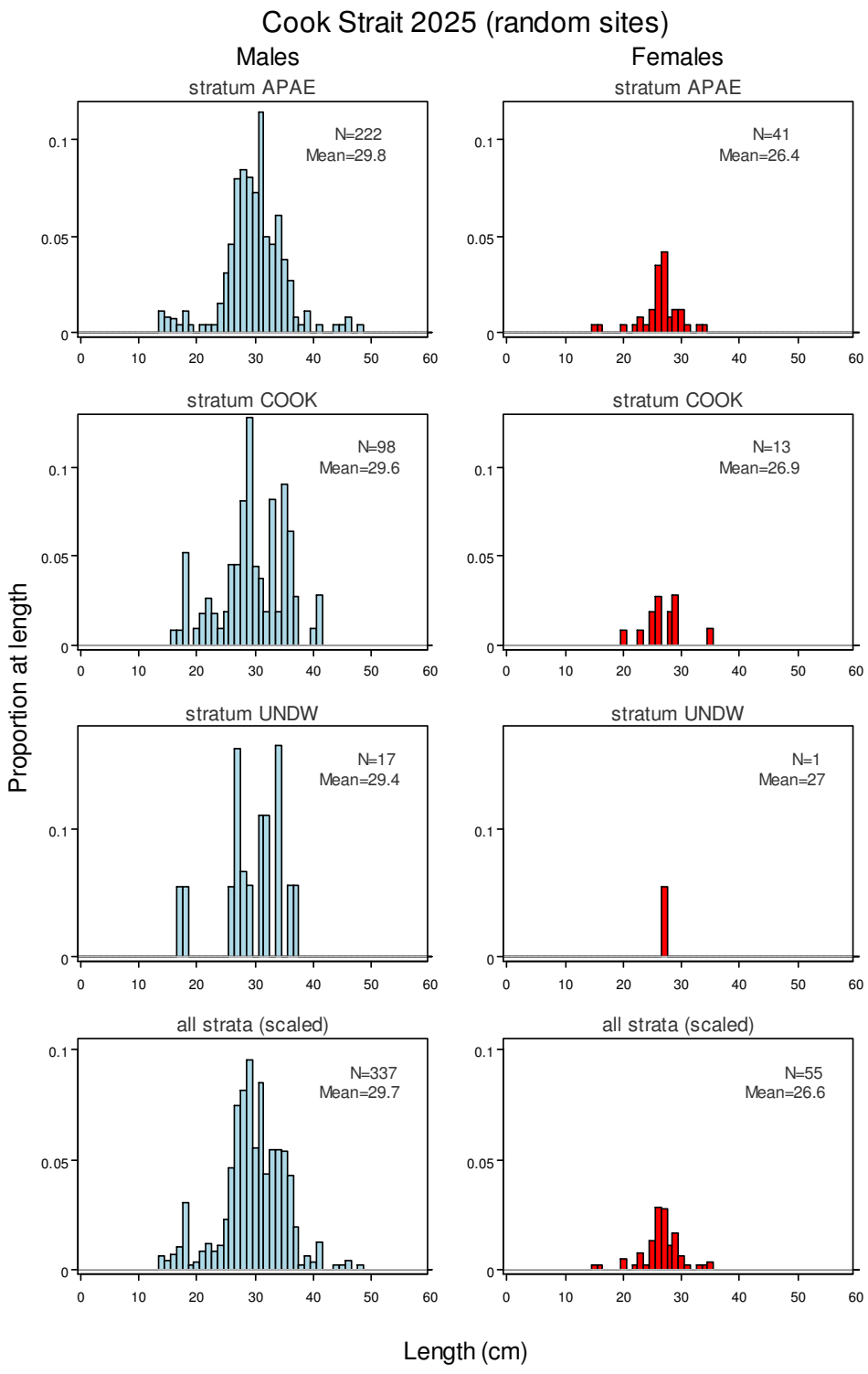


Figure 10: Scaled length frequency distributions by strata and overall for the 2025 Cook Strait random-site potting survey. N, sample numbers; Mean, mean length (cm). Proportions sum to one within each stratum. See Figure 3 for location of strata and Table 2 for strata names.

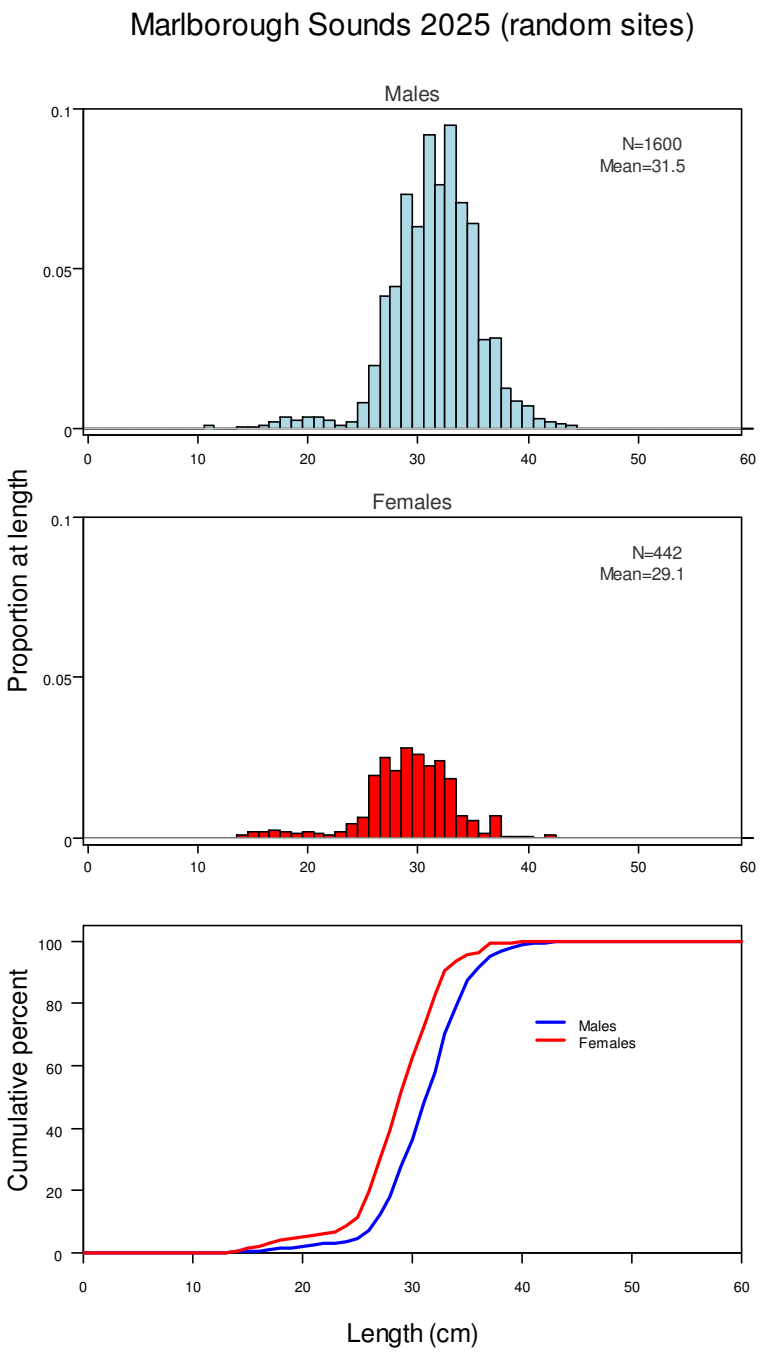


Figure 11: Scaled length frequency and cumulative distributions for the 2025 Marlborough Sounds random-site potting survey for the 12 core strata combined. N, sample numbers; Mean, mean length (cm). Proportions sum to one within each stratum. See Table 2 for strata names.

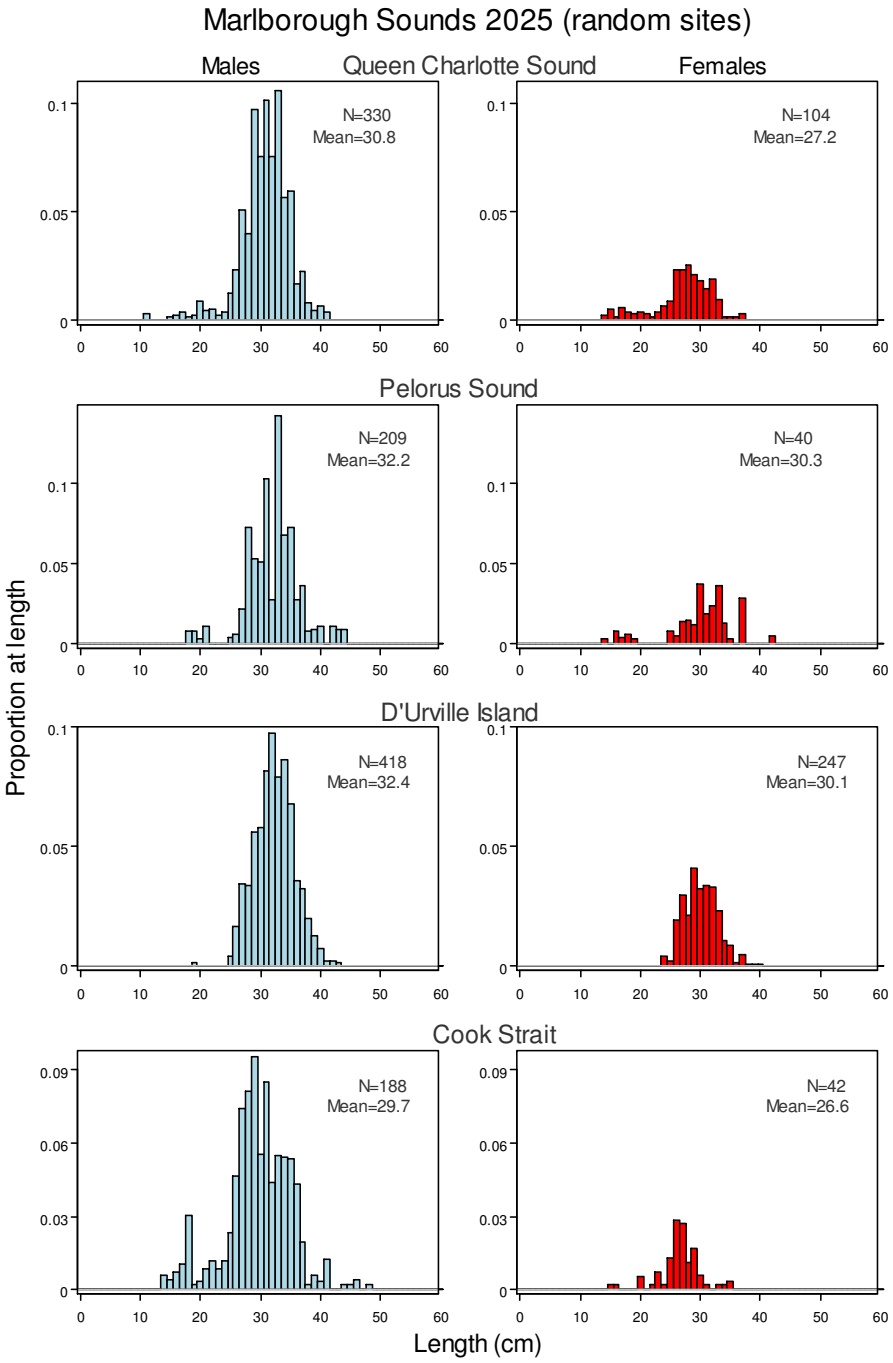


Figure 12: Scaled length frequency distributions by region for the 2025 core strata random-site potting survey. N, sample numbers; Mean, mean length (cm). Proportions sum to one within each stratum. See Figure 3 for location of strata and Table 2 for strata names.

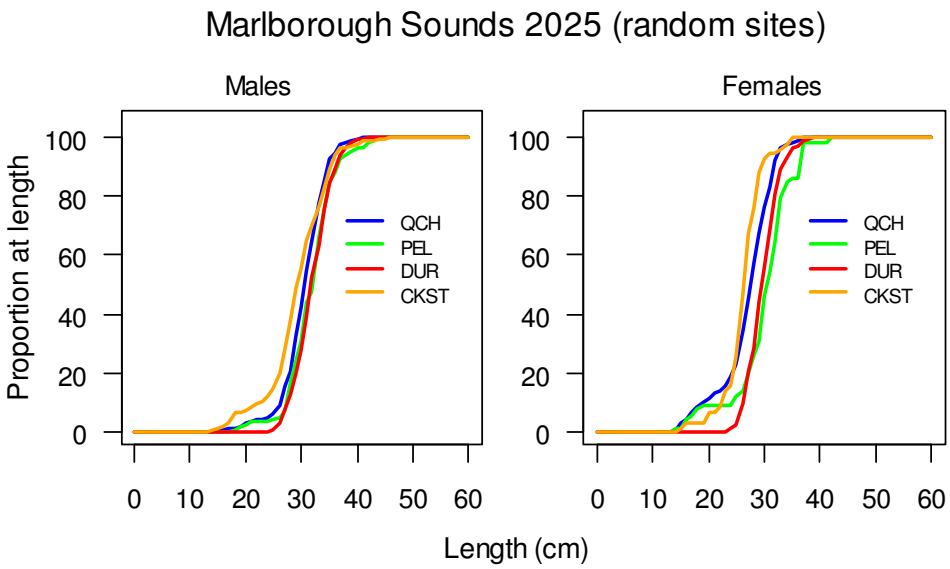


Figure 13: Cumulative distributions of scaled length frequencies for male and female blue cod for the 2025 Marlborough Sounds core strata random-site potting survey by region. QCH, Queen Charlotte Sound; PEL, Pelorus Sound; DUR, D'Urville Island; CKST, Cook Strait.

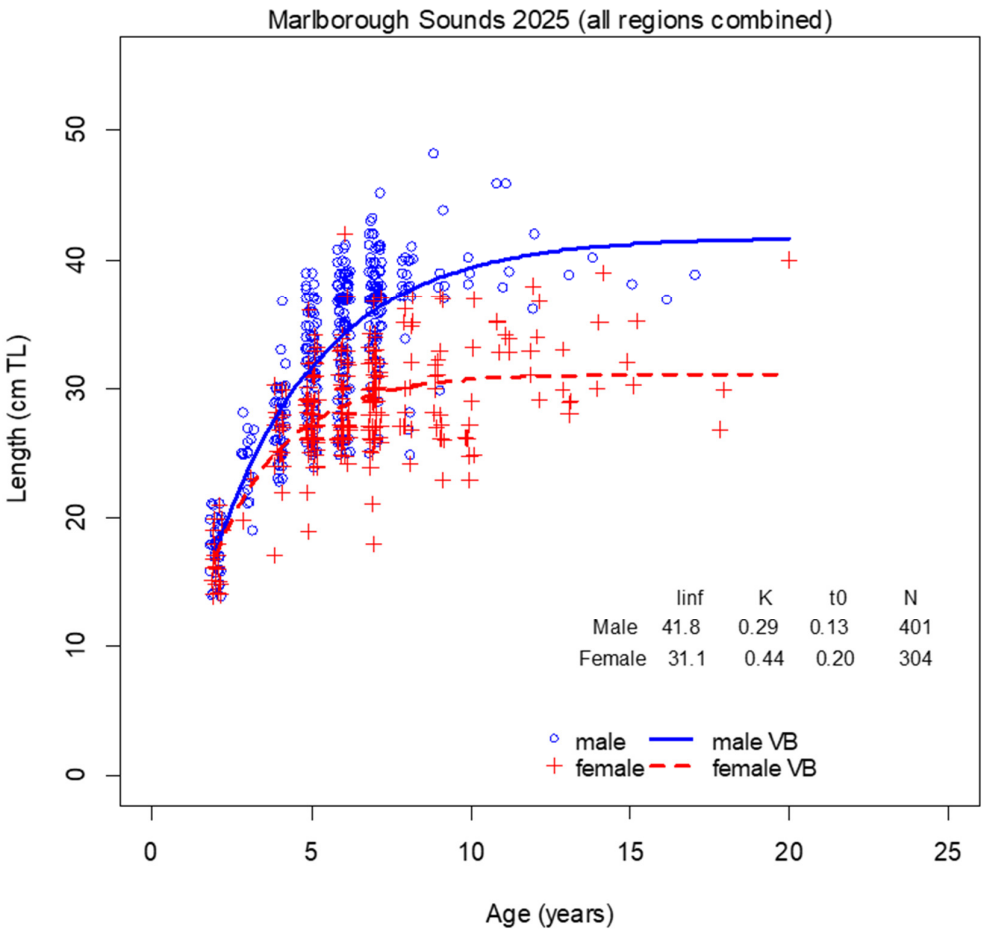


Figure 14: Observed age and length data by sex for blue cod from the 2025 Marlborough Sounds survey (all regions combined, including Stephens Island) with fitted von Bertalanffy growth models.

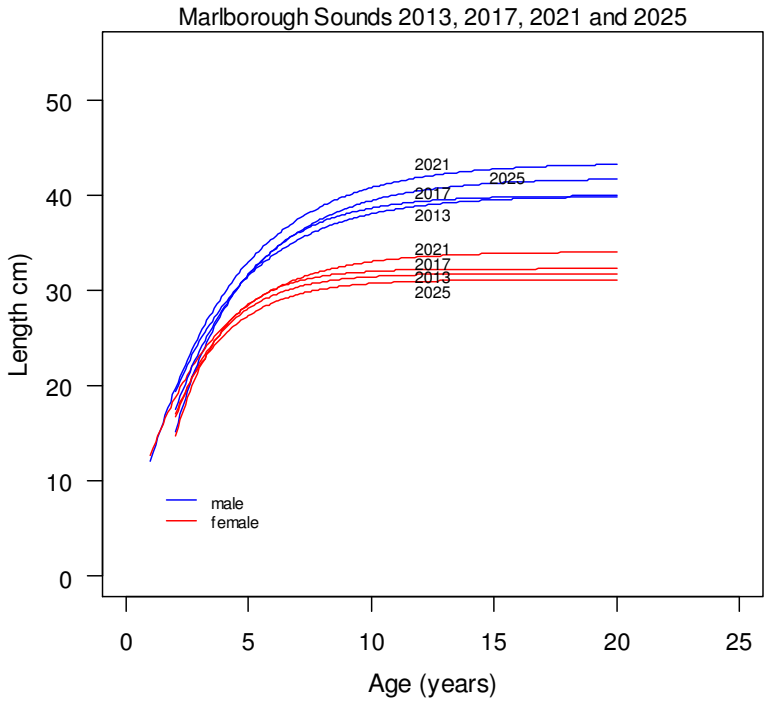


Figure 15: von Bertalanffy growth models fitted to the 2013, 2017, 2021, and 2025 blue cod survey age and length data (all regions combined, including Stephens Island in 2025).

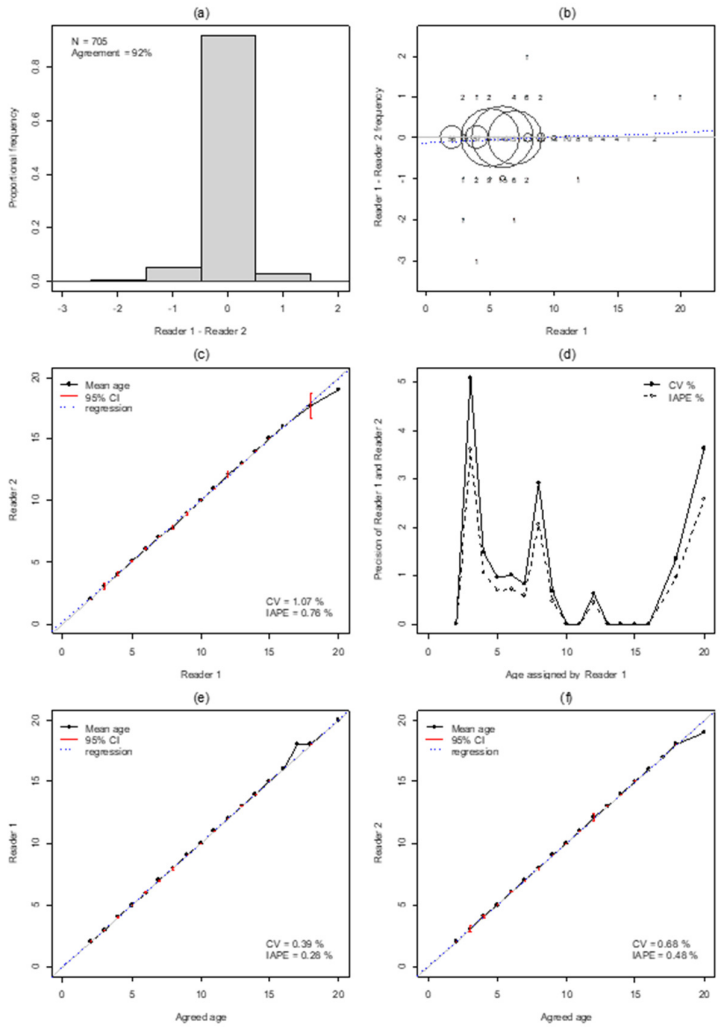


Figure 16: Blue cod otolith reader comparison plots between reader 1 and reader 2 for the 2025 Marlborough Sounds survey: (a) histogram of age differences between two readers; (b) difference between reader 1 and reader 2 as a function of the age assigned by reader 1, where the numbers of fish in each age bin are annotated and proportional to circle size; (c) age bias plot, showing the correspondence of ages between reader 1 and reader 2 for all ages; (d) precision of readers; (e and f) reader age compared with agreed age. In panels b, c, e, and f, solid lines show perfect agreement, dashed lines show the trend of a linear regression of the actual data.

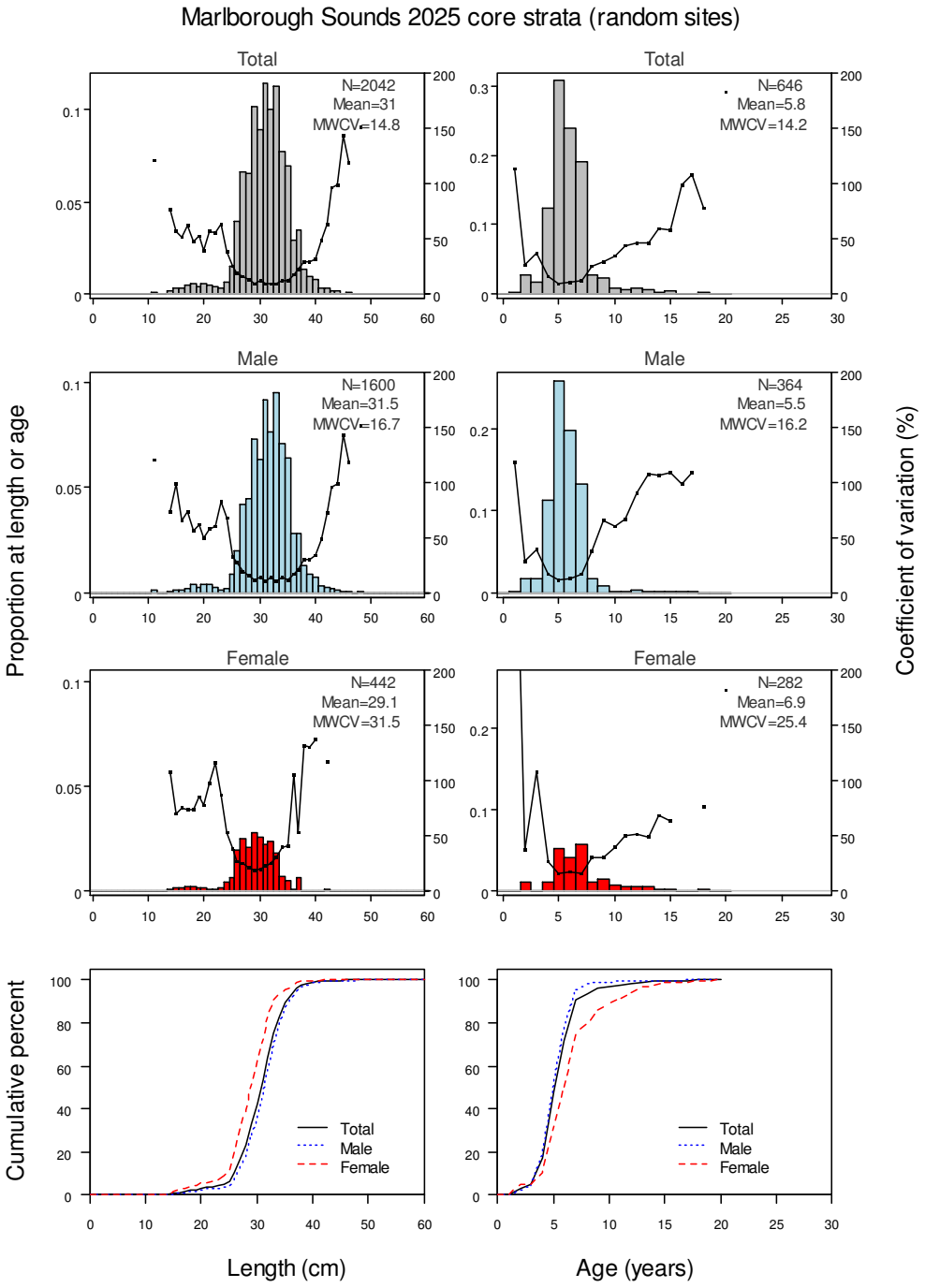


Figure 17: Scaled length-frequency, age-frequency, and cumulative distributions for total, male, and female blue cod for the 2025 Marlborough Sounds random-site potting survey core strata (QCH, PEL, DUR and CKST combined). N, sample size; MWCV, mean weighted coefficient of variation (%). Proportions at length or age sum to one.

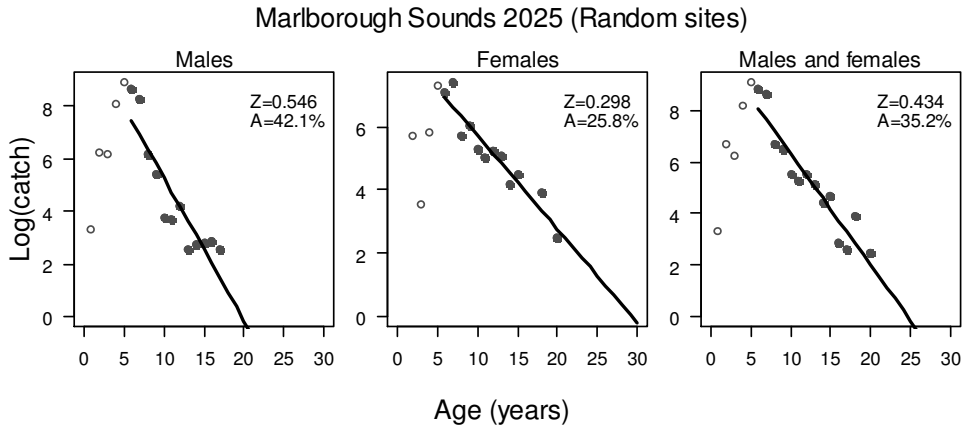


Figure 18: Catch curves (natural log of catch numbers versus age) for the 2025 Marlborough Sounds random-site survey. The regression line is plotted from age at full recruitment, nominally, of 6 years (i.e., dark points on the graph). *Z*, instantaneous total mortality; *A*, the annual mortality rate or the proportion of the population that suffers mortality in a given year.

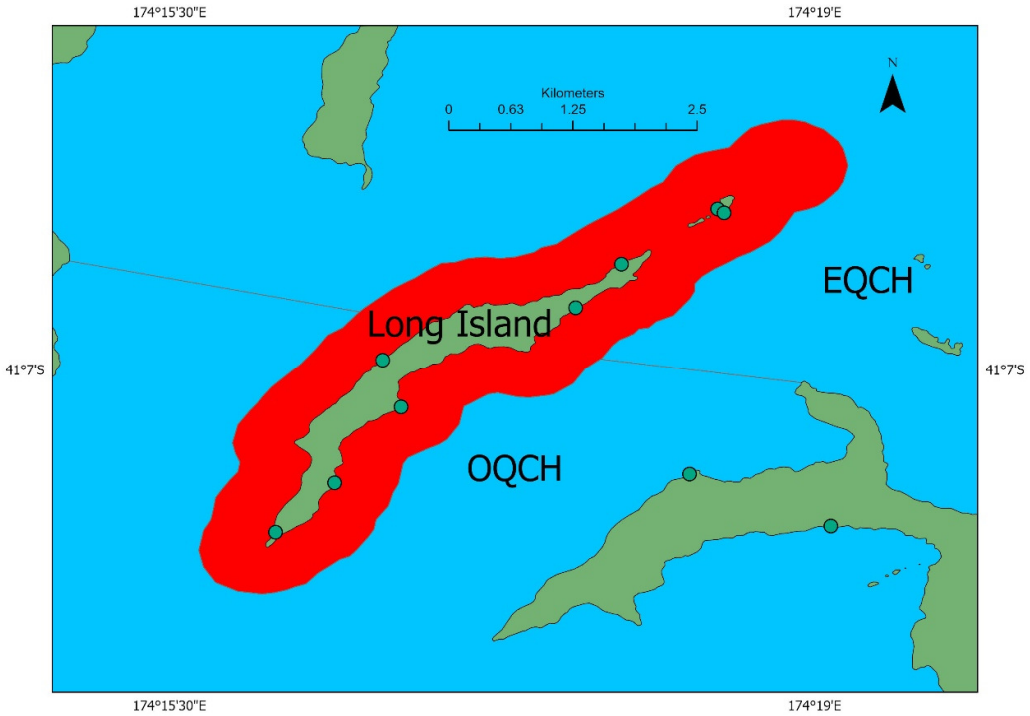


Figure 19: Map of Long Island Marine Reserve (red polygon) showing the eight random site locations (green circles) surveyed in 2025. Two sites are also shown outside of the reserve in stratum OQCH (bottom right left).

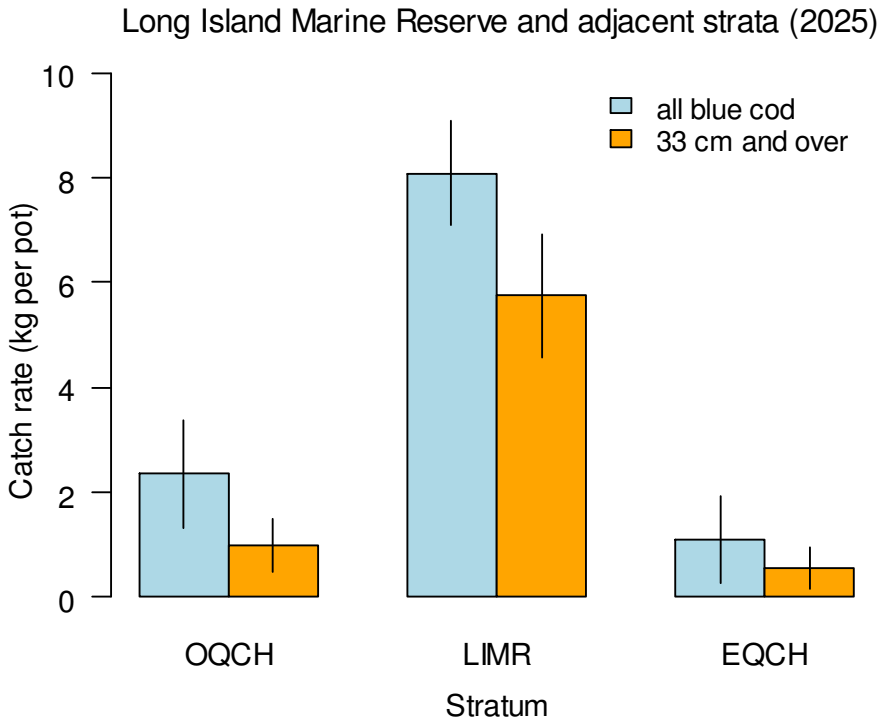


Figure 20: Marlborough Sounds 2025 random-site potting survey catch rates of all blue cod and recruited blue cod from sites inside the Long Island Marine Reserve (LIMR) and from all sites in adjacent strata in Queen Charlotte Sound (OQCH, EQCH). Error bars are 95% confidence intervals. See Figure 3 for location of strata and Table 2 for strata names.

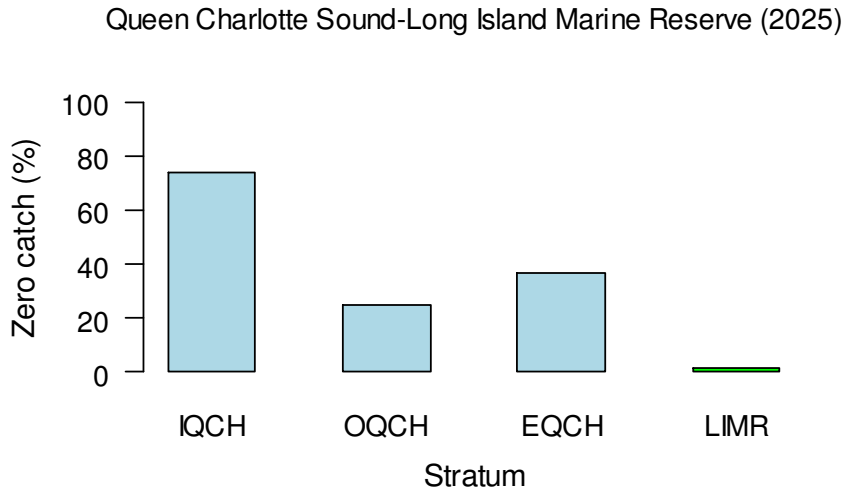


Figure 21: Marlborough Sounds 2025 random-site potting survey proportion of pots with zero blue cod from sites inside the Long Island Marine Reserve (LIMR) and from all sites in Queen Charlotte Sound strata (IQCH, OQCH, EQCH). See Figure 3 for location of strata and Table 2 for strata names.

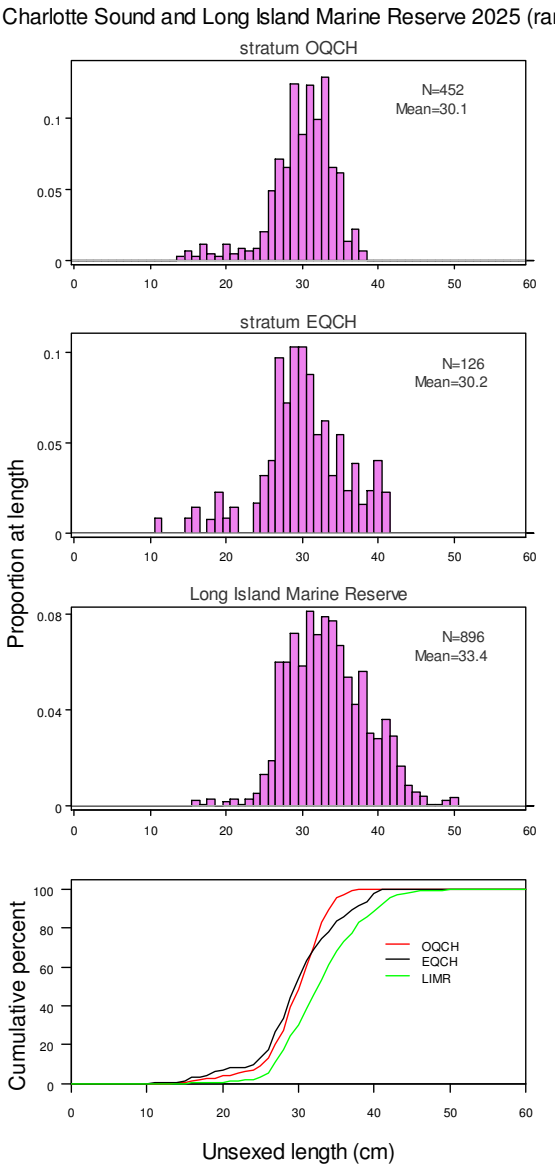


Figure 22: Marlborough Sounds 2025 random-site potting survey scaled length frequency and cumulative distributions of unsexed blue cod for sites inside Long Island Marine Reserve (LIMR) and from all sites in the adjacent Queen Charlotte Sound strata (OQCH, EQCH). N, sample numbers; Mean, mean length (cm). See Figure 3 for strata locations and Table 2 for strata names.

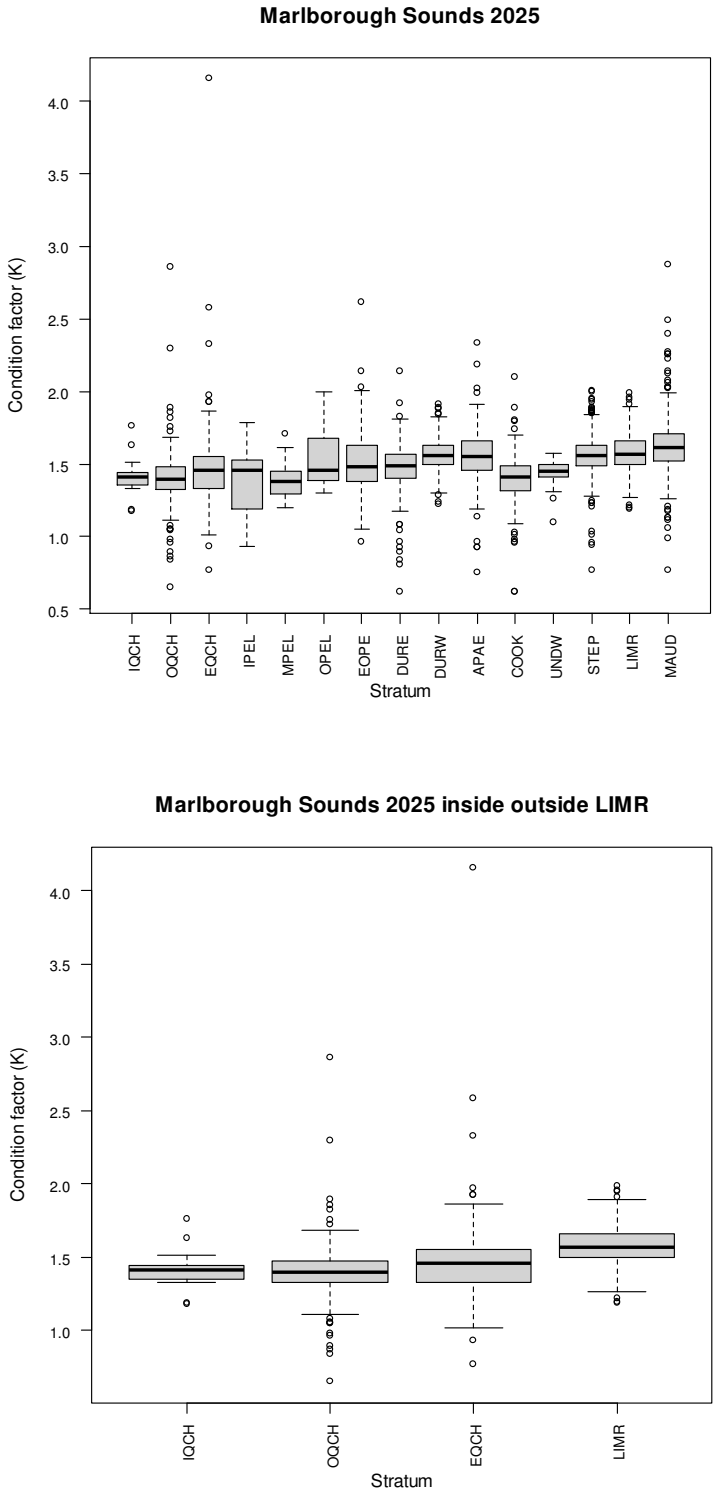


Figure 23: Box plot of Fulton's condition factor (*K*) for all blue cod on the Marlborough Sounds 2025 random-site potting survey for all strata (top panel), and inside-outside LIMR (bottom panel). Data shown are the minimum and maximum (whiskers), 25th and 75th percentiles (shaded box), median (dark line), and outliers (open circles). See Figure 3 for location of strata and Table 2 for strata names.

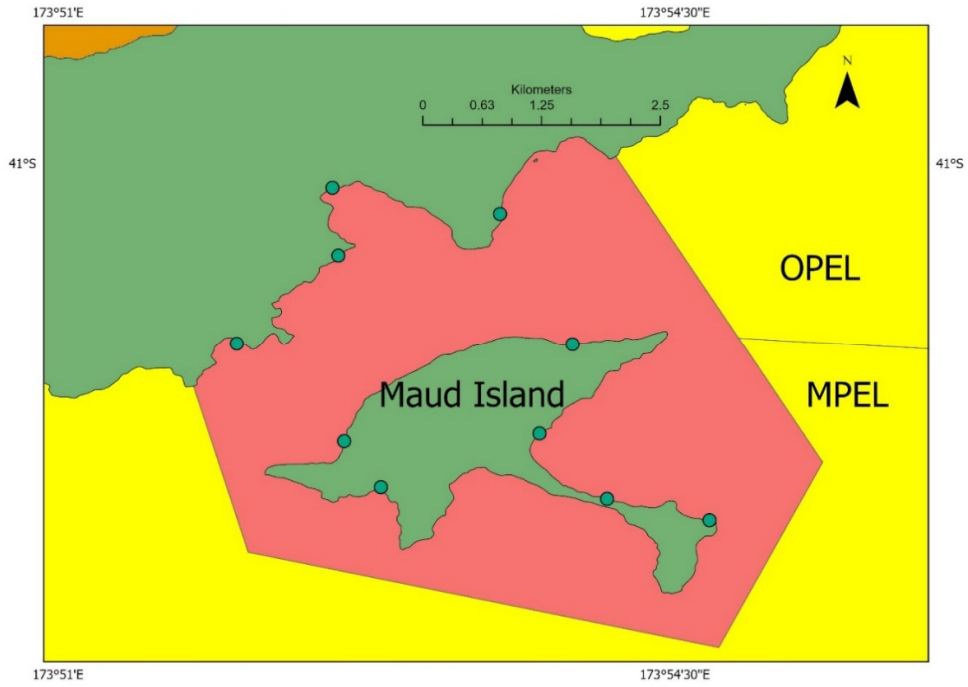


Figure 24: Map of Maud Island Closed Area (red polygon) showing the ten random site locations (green circles) surveyed in 2025.

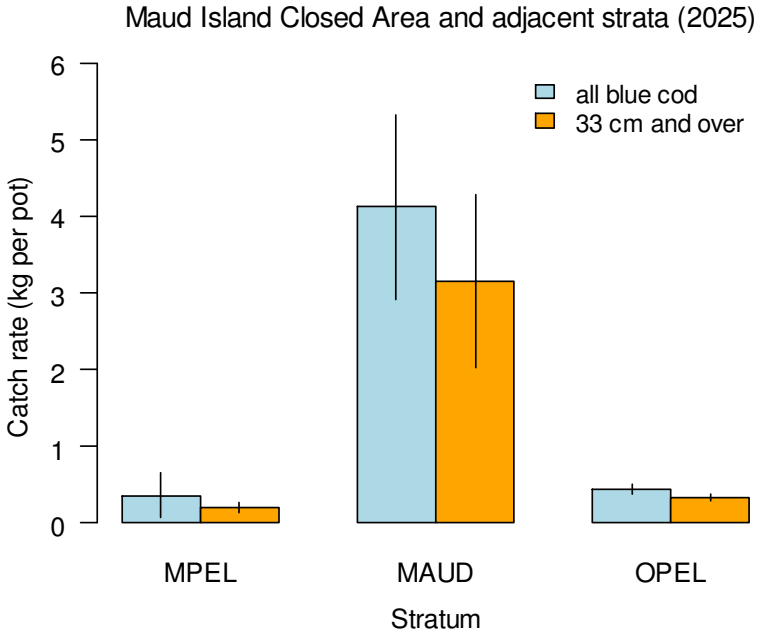


Figure 25: Marlborough Sounds 2025 random-site potting survey catch rates of all blue cod and recruited blue cod from sites inside Maud Island Closed Area (MAU) and from all sites in adjacent strata in Pelorus Sound (MPEL, OEPL). Error bars are 95% confidence intervals. See Figure 3 for location of strata and Table 2 for strata names.

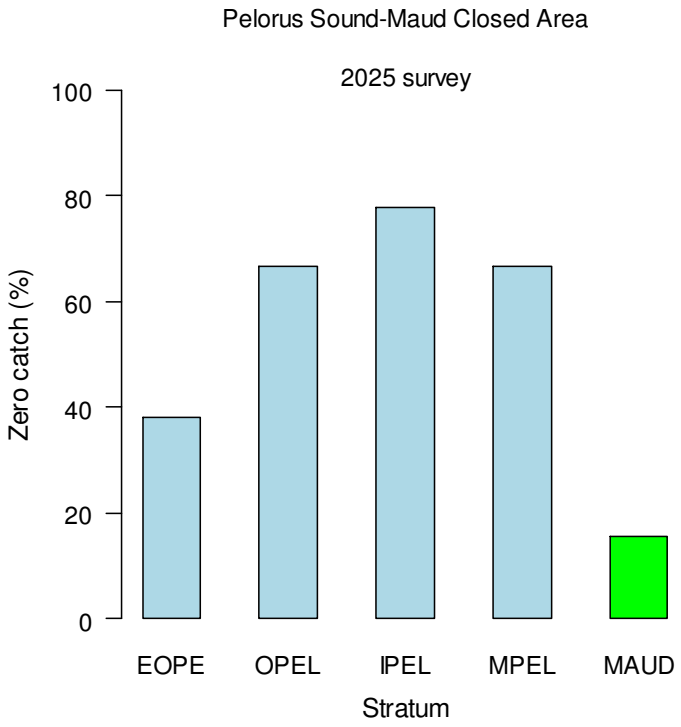


Figure 26: Marlborough Sounds 2025 random-site potting survey proportion of pots with zero blue cod from sites inside Maud Island Closed Area (MAUD) and from all sites in Pelorus Sound strata (EOPE, OPEL, IPEL, and MPEL). See Figure 3 for location of strata and Table 2 for strata names.

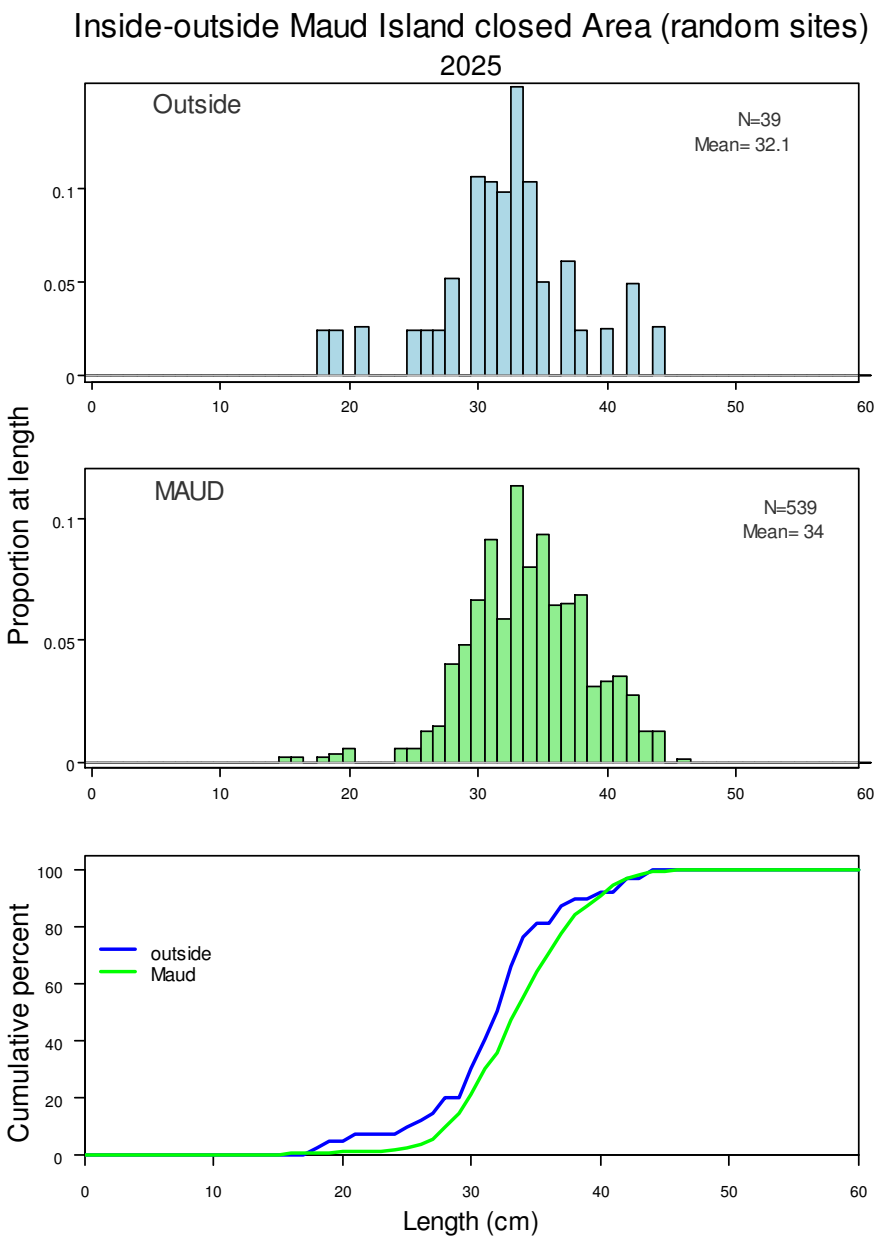


Figure 27: Marlborough Sounds 2025 random-site potting survey scaled length frequency and cumulative distributions of unsexed blue cod for sites inside Maud Island Closed Area (MAUD) and from all sites outside in the adjacent Pelorus Sound strata (MPEL and OPEL). N, sample numbers; Mean, mean length (cm). See Figure 3 for strata locations and Table 2 for strata names.

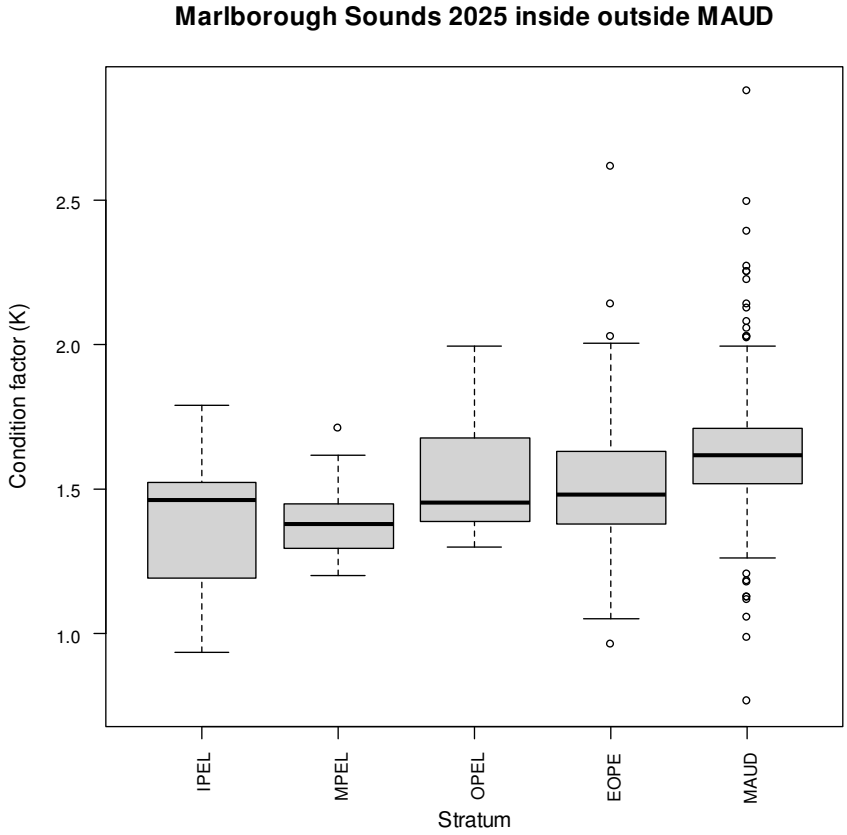


Figure 28: Box plot of Fulton's condition factor (*K*) for all blue cod on the Marlborough Sounds 2025 random-site potting survey in MAUD and Pelorus Sound strata. Adjacent strata are MPEL and OPEL. Data shown are the minimum and maximum (whiskers), 25th and 75th percentiles (shaded box), median (dark line), and outliers (open circles). See Figure 3 for location of strata and Table 2 for strata names.

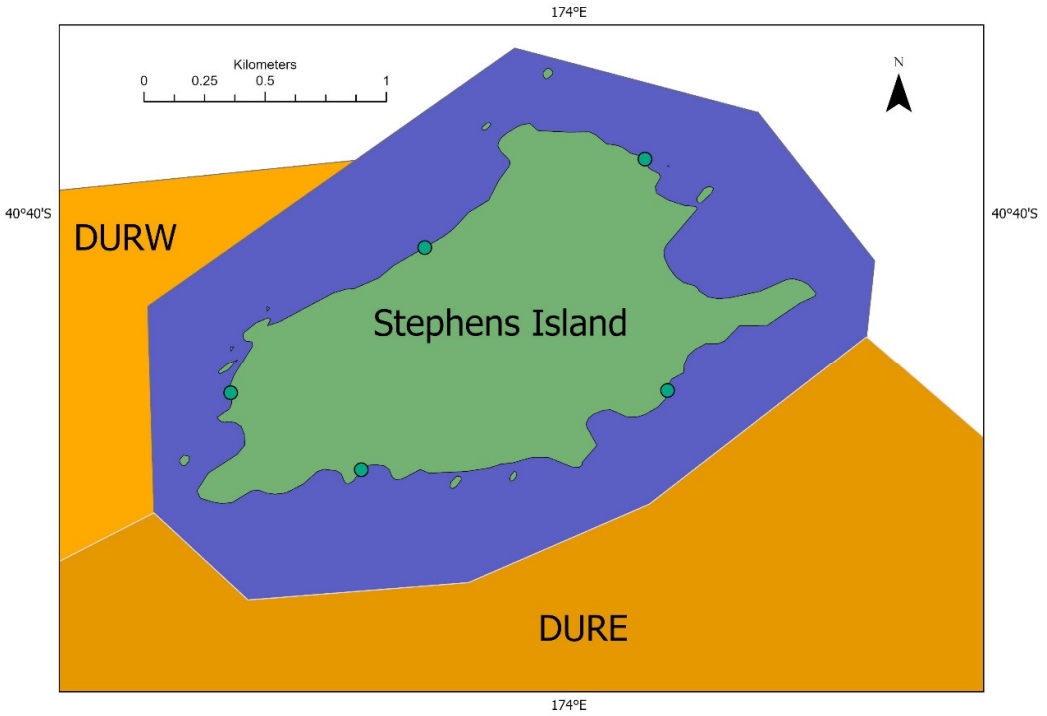


Figure 29: Map of Stephens Island stratum (blue polygon) showing the five random site locations (green circles) surveyed in 2025.

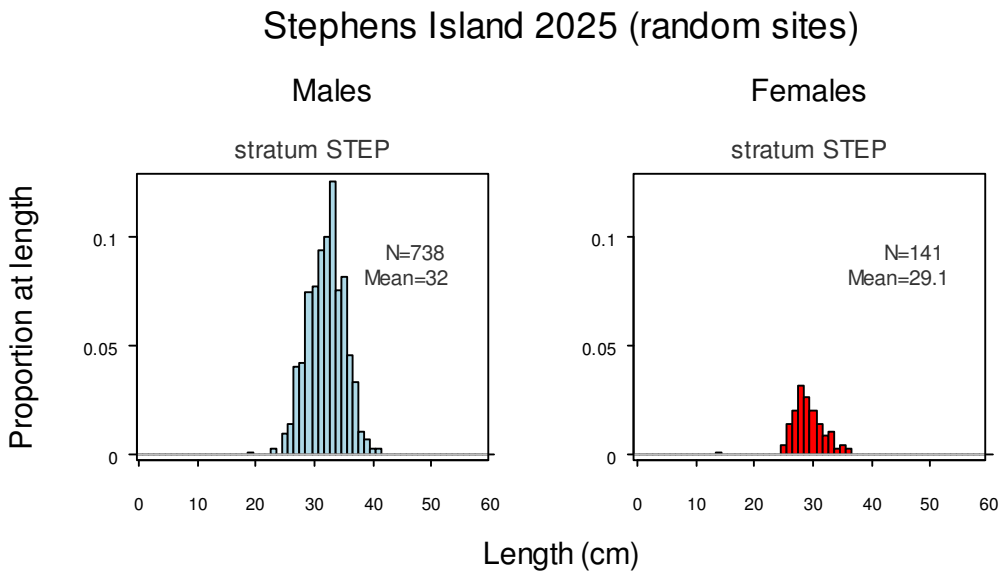


Figure 30: Scaled length frequency distributions by strata and overall for the 2025 Stephens Island random-site potting survey. N, sample numbers; Mean, mean length (cm). Proportions sum to one within each stratum. See Figure 3 for location of strata and Table 2 for strata names.

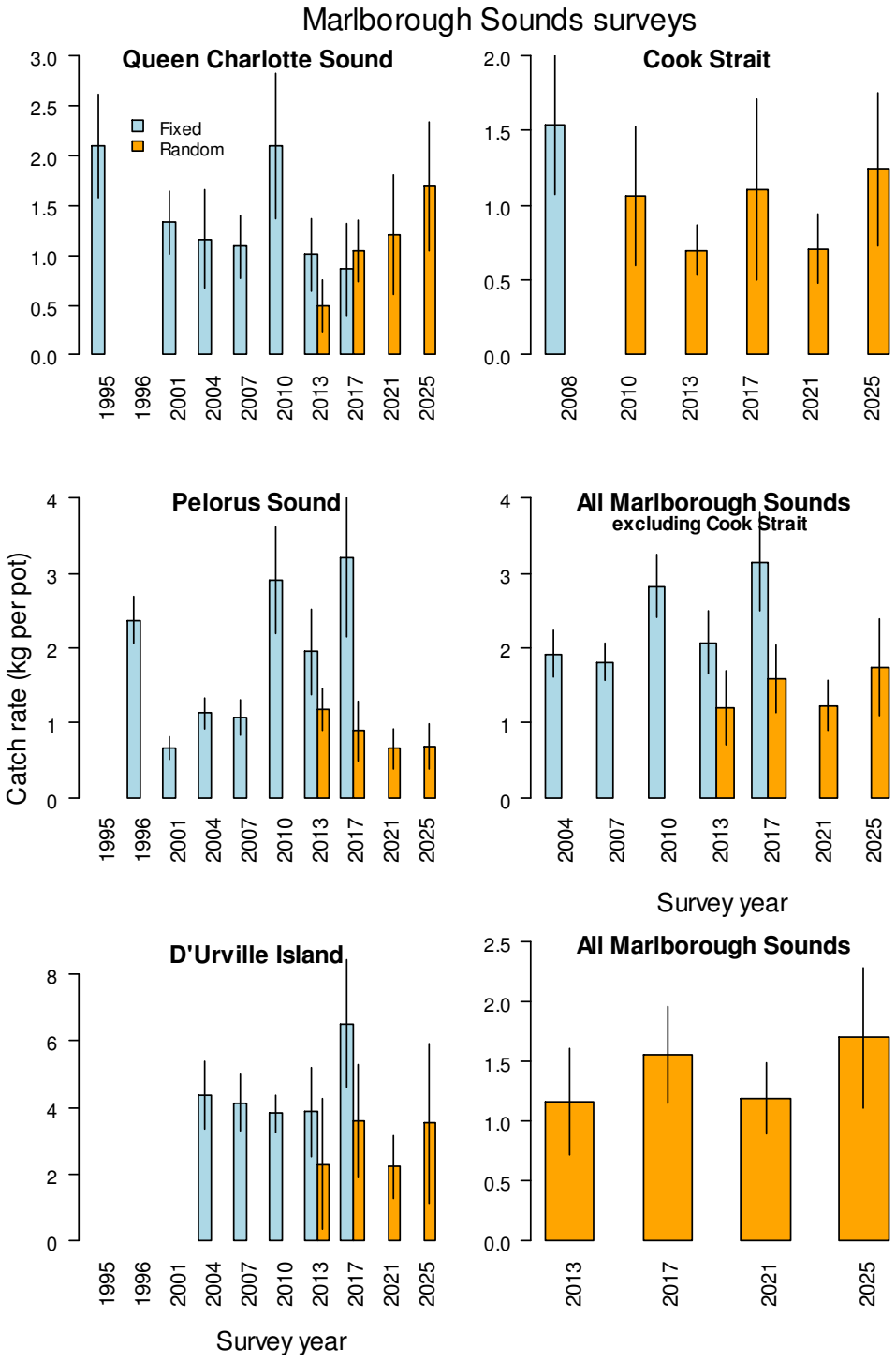


Figure 31: Marlborough Sounds fixed-site and random-site potting survey catch rates of all blue cod by survey year for each region, and overall for Marlborough Sounds from 2004. Cook Strait was excluded from the 'all Marlborough Sounds' plot to ensure that strata were consistent across all surveys (see Table 1). Error bars are 95% confidence intervals. See Figure 3 for location of regions.

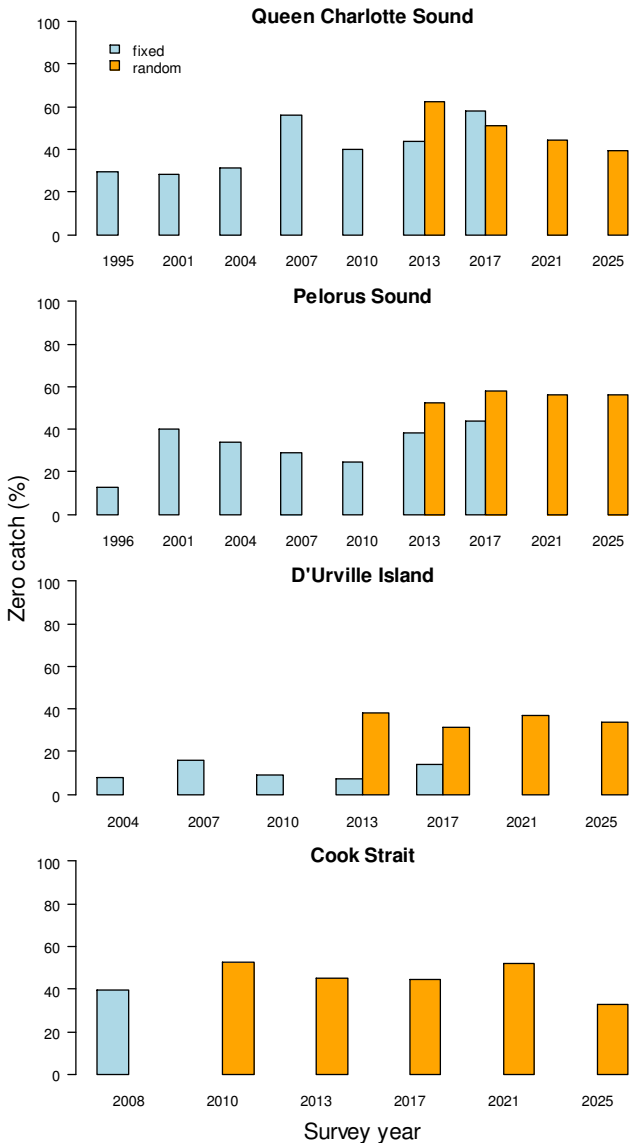


Figure 32: Proportion of pots with zero catch of blue cod for the Marlborough Sound fixed-site and random-site potting surveys by region and survey year.

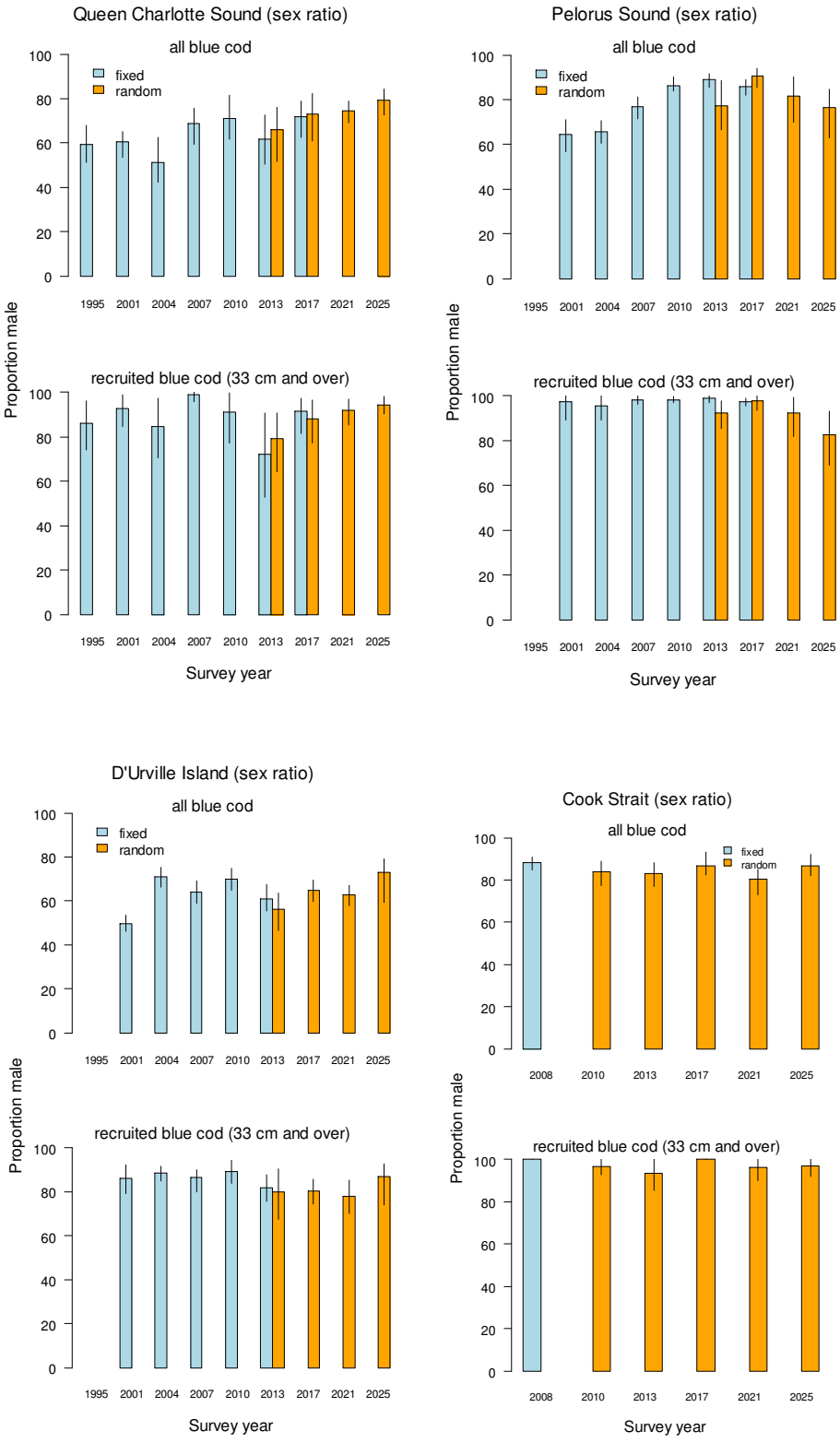


Figure 33: Sex ratio (expressed as percent male) for all blue cod and recruited blue cod for fixed-site and random-site potting surveys for each region by survey year. Error bars are 95% confidence intervals .

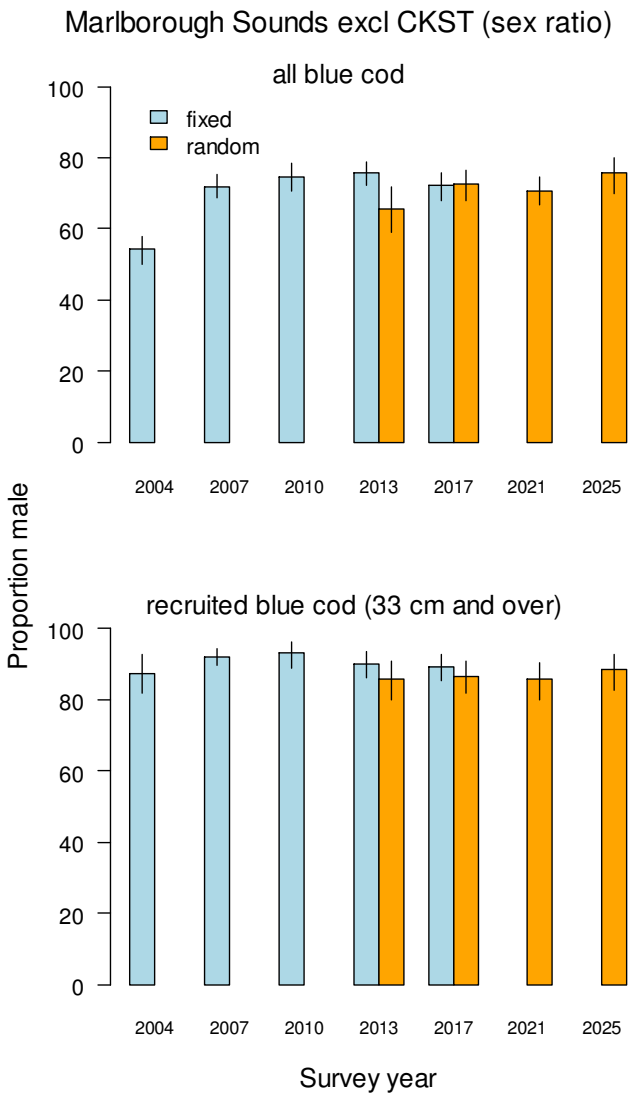


Figure 34: Sex ratio (expressed as percent male) for all blue cod and recruited blue cod for fixed-site and random-site potting surveys for all Marlborough Sounds (excluding CKST). Cook Strait was excluded to ensure that strata were consistent across all surveys. Error bars are 95% confidence intervals.

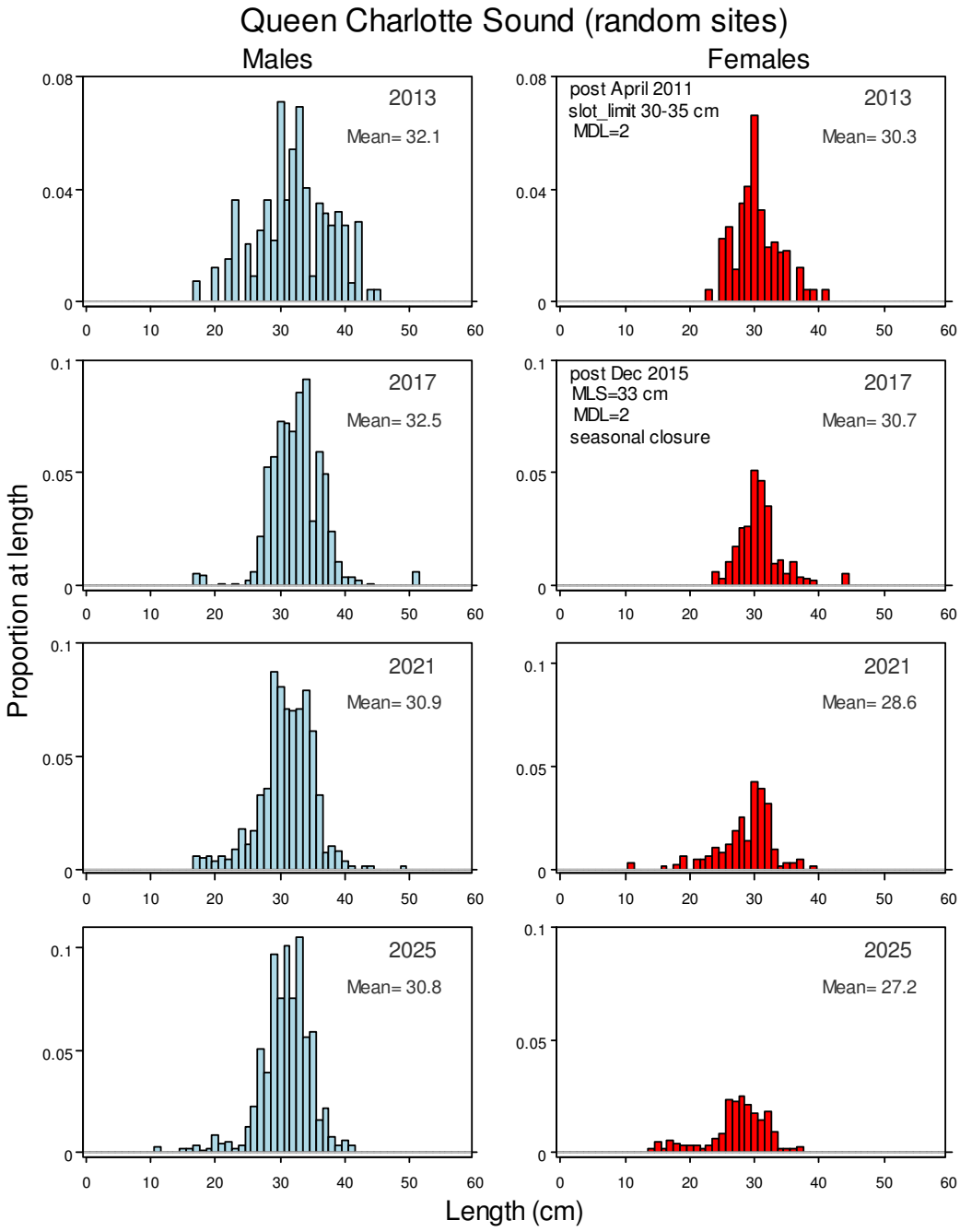


Figure 35: Scaled length distributions for male and female blue cod from random-site potting surveys in 2010 (CKST only), 2013, 2017, 2021 and 2025 for each region. Changes in fisheries regulations are annotated on the female panels. MLS, minimum legal size; MDL, maximum daily limit. The seasonal closure is from 1 September to 19 December, extended to 10 January in August 2025. Proportions at length sum to one. [Contined on next page].

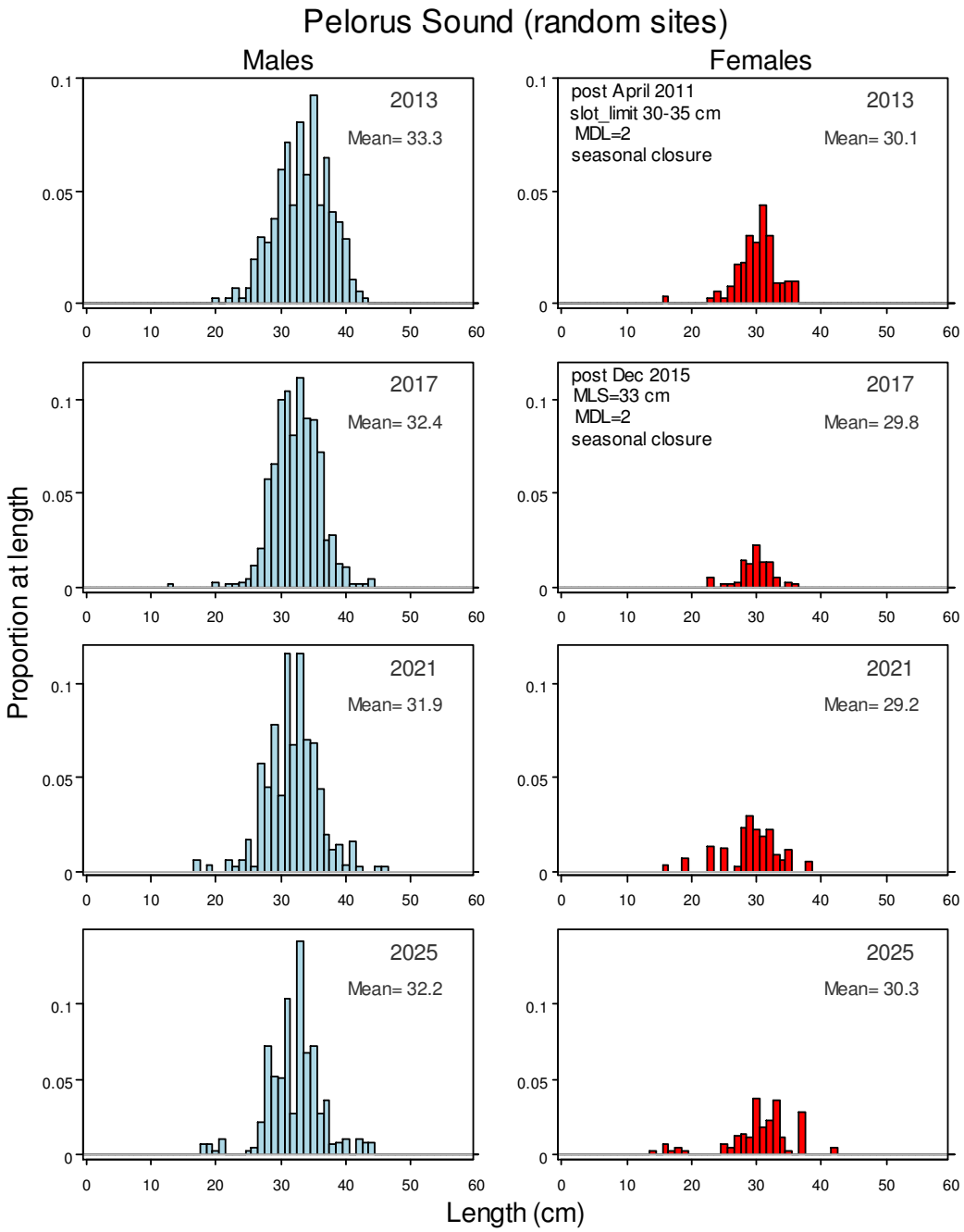


Figure 35 – ***continued***

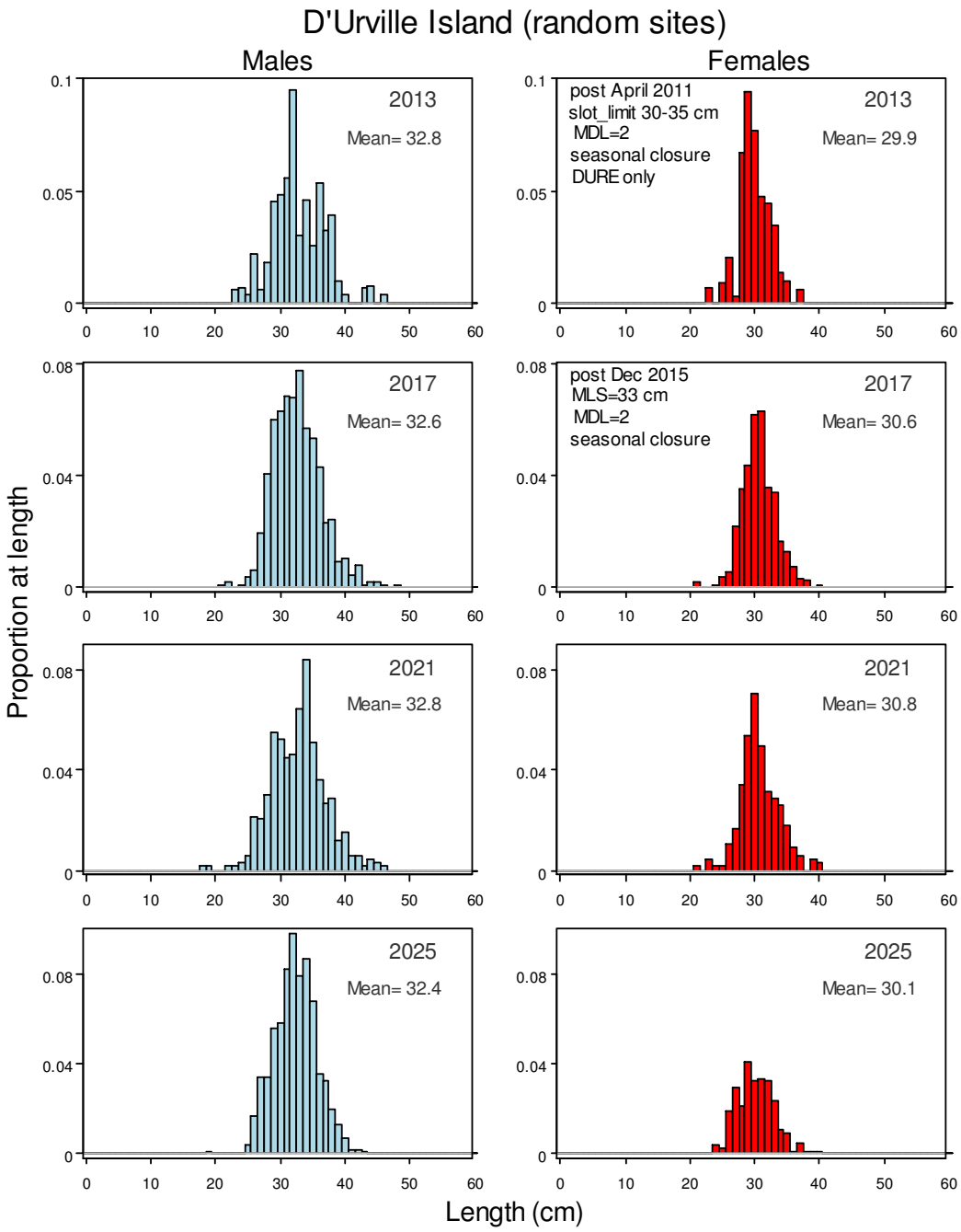


Figure 35 – ***continued***

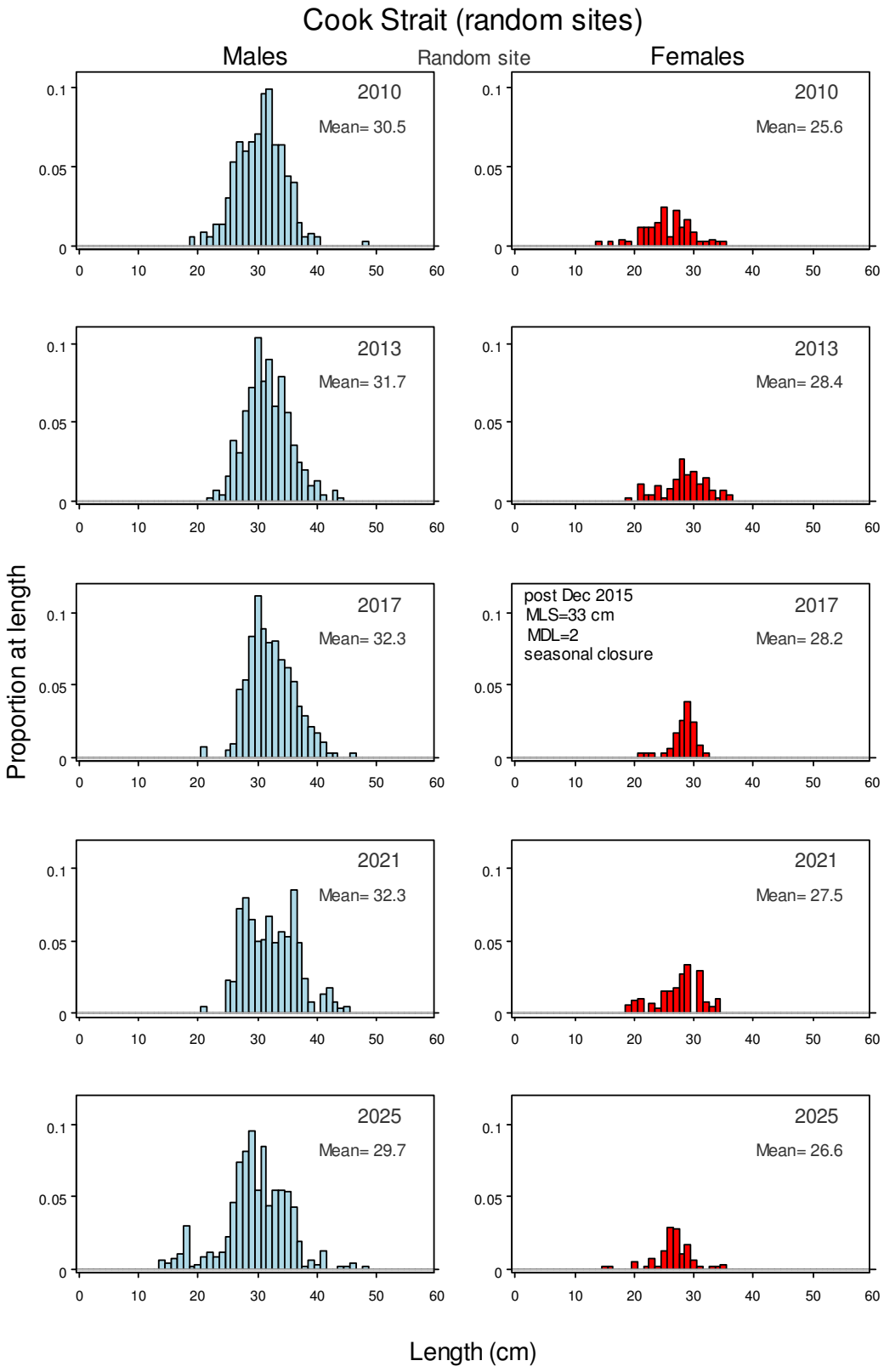


Figure 35 – ***continued***

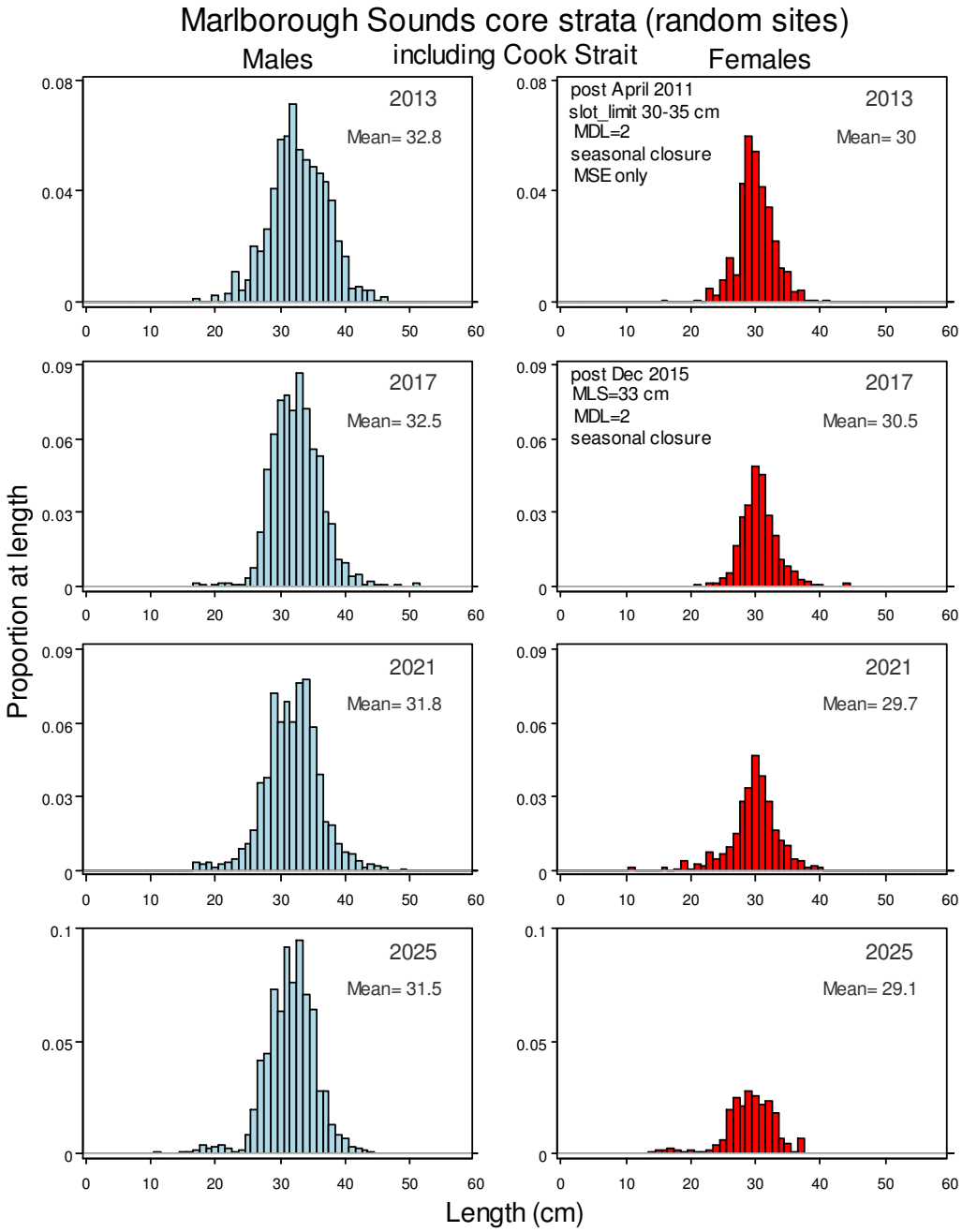


Figure 35 – ***continued***

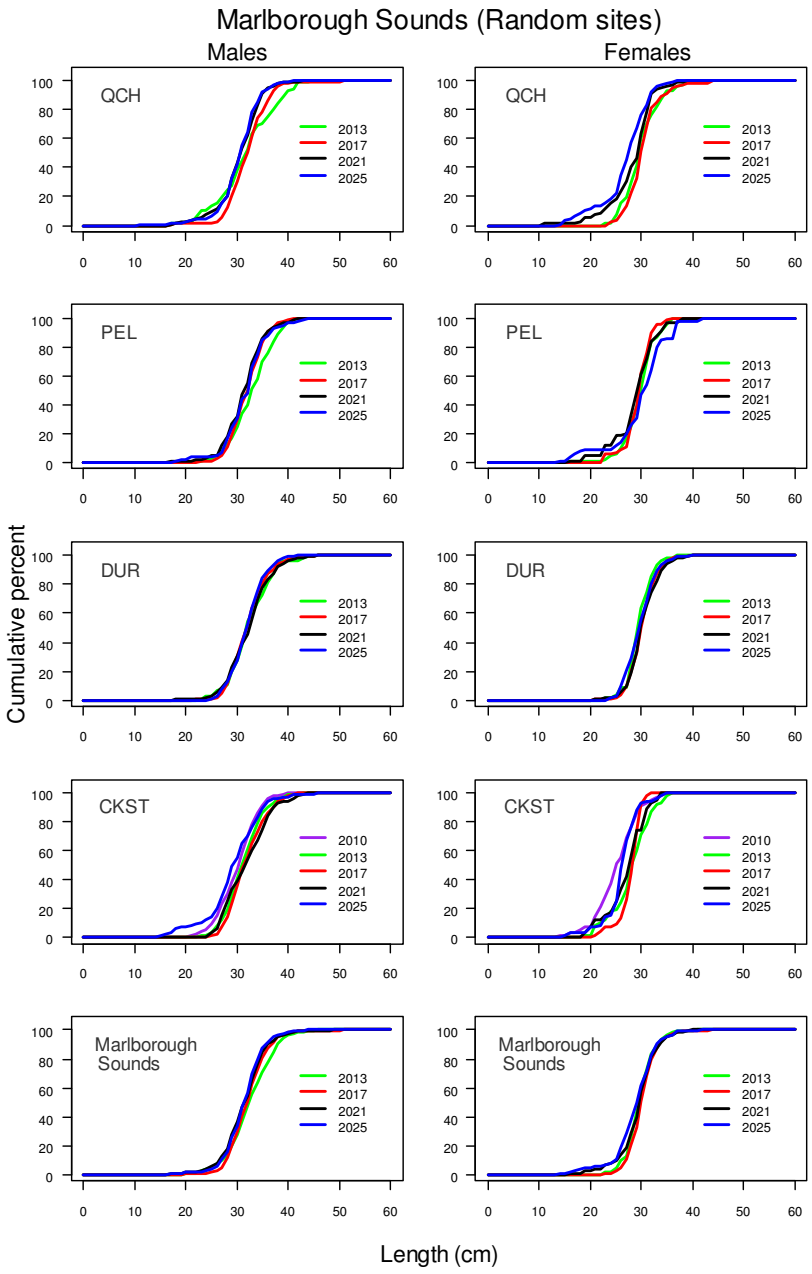


Figure 36: Cumulative distributions of scale length frequencies for male and female blue cod from random-site potting surveys by region and all Marlborough Sounds.

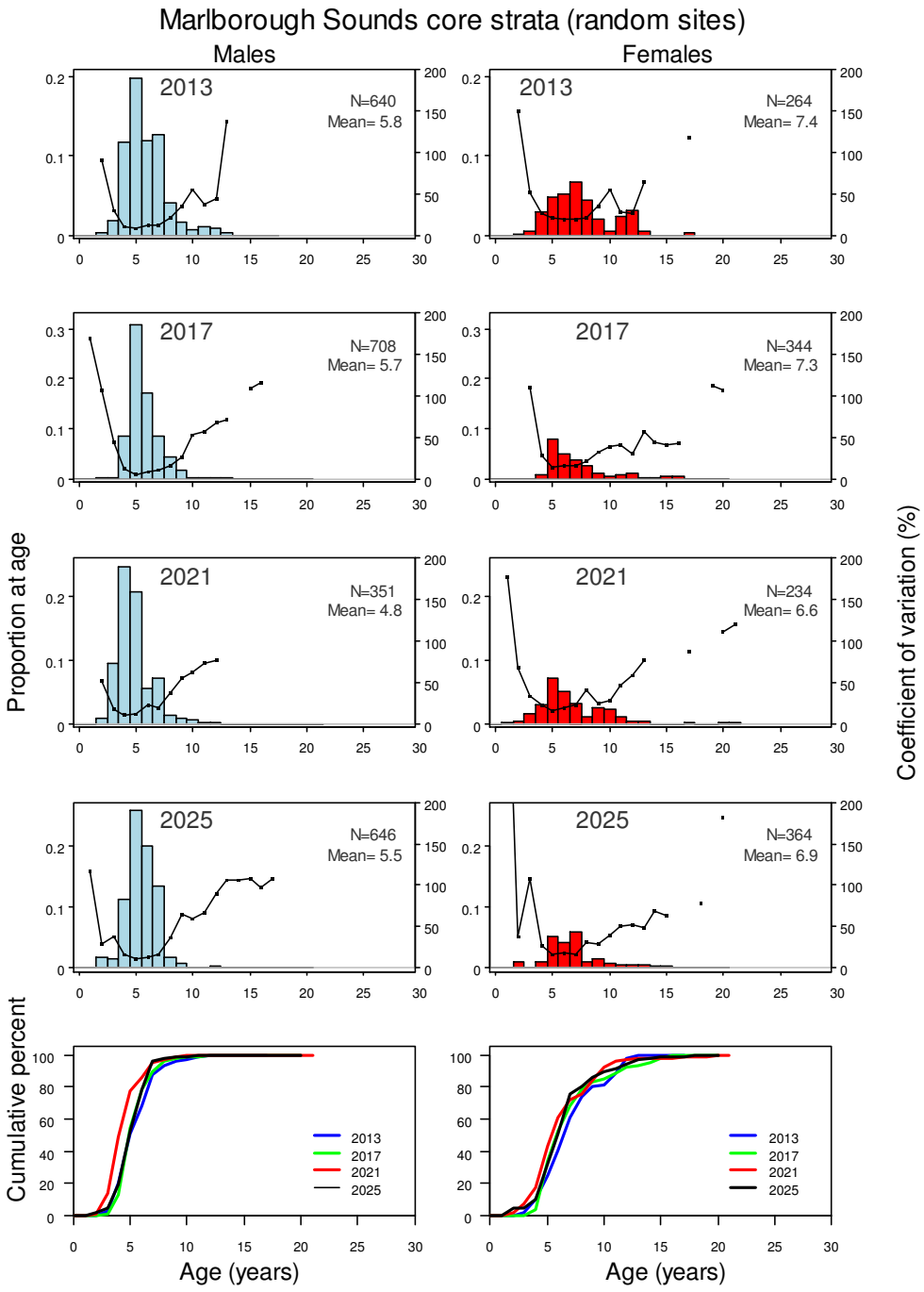


Figure 37: Scaled age-frequency and cumulative distributions for male and female blue cod for the 2013, 2017, 2021, and 2025 Marlborough Sounds random-site potting surveys (QCH, PEL, DUR, and CKST combined). N, sample size. Proportions at age sum to one.

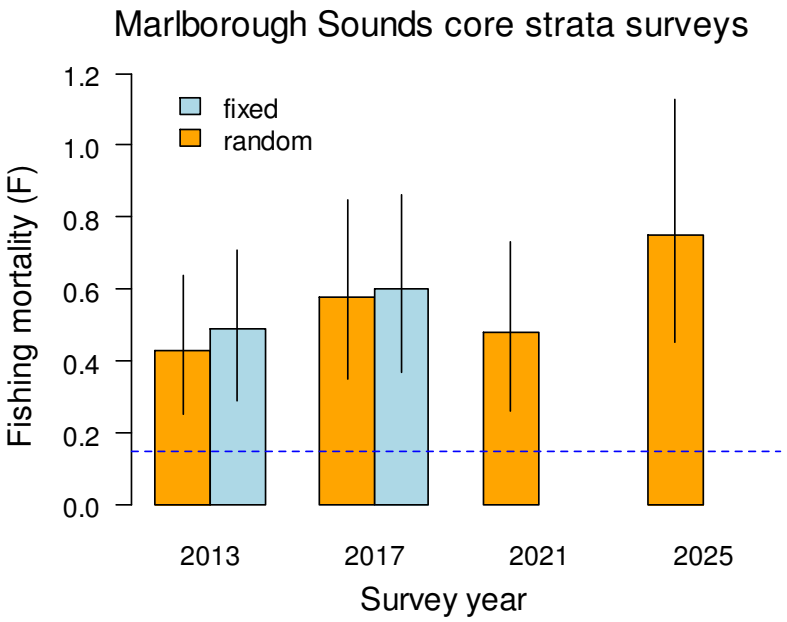


Figure 38: Fishing mortality (*F*) point-estimates for male blue cod from the 2013, 2017, 2021, and 2025 Marlborough Sounds potting surveys, for all regions combined. There were no fixed-site surveys after 2017. The mortality parameters are for the default *M* (0.17) and age at recruitment equal to the minimum legal size, plus one year. The 95% confidence intervals around estimates are also presented.

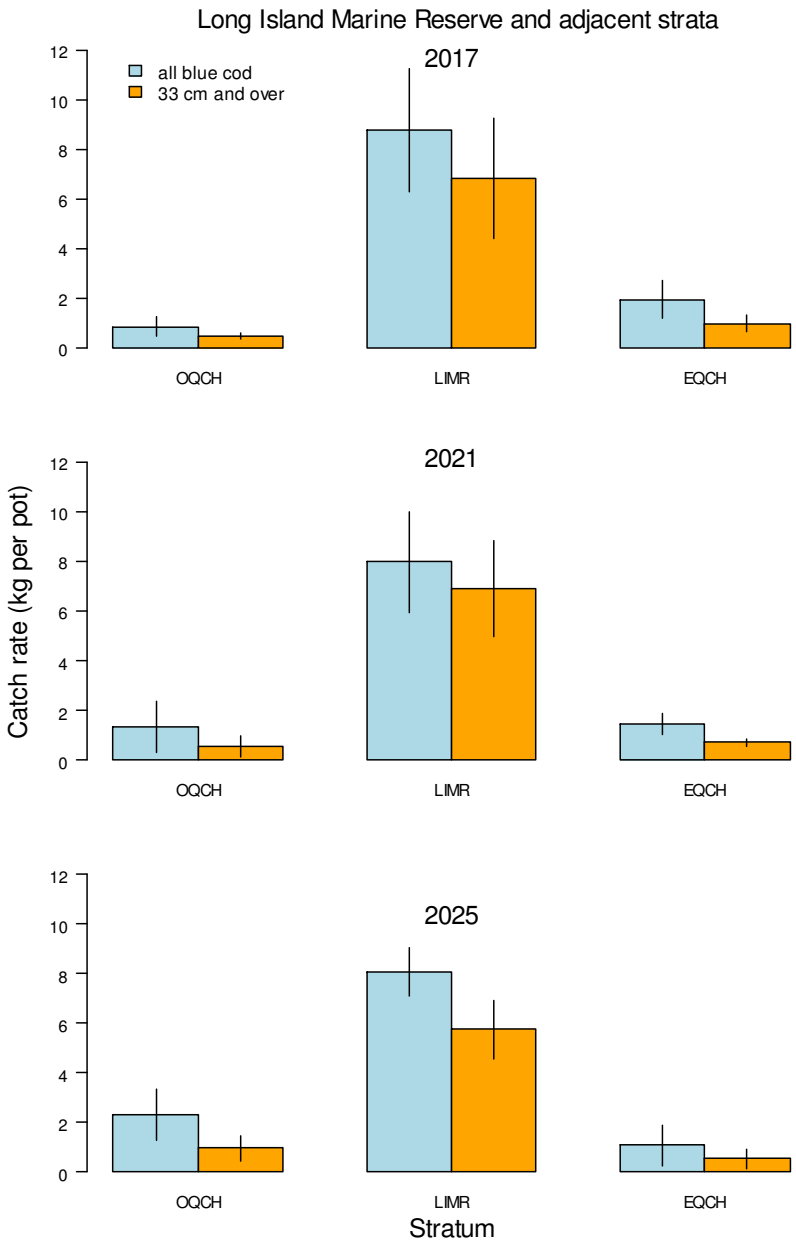


Figure 39: Marlborough Sounds 2017, 2021, and 2025 random-site potting survey catch rates of all blue cod and recruited blue cod from sites inside the Long Island Marine Reserve (LIMR) and from all sites in adjacent strata in Queen Charlotte Sound (OQCH, EQCH). Error bars are 95% confidence intervals. See Figure 3 for location of strata and Table 2 for strata names.

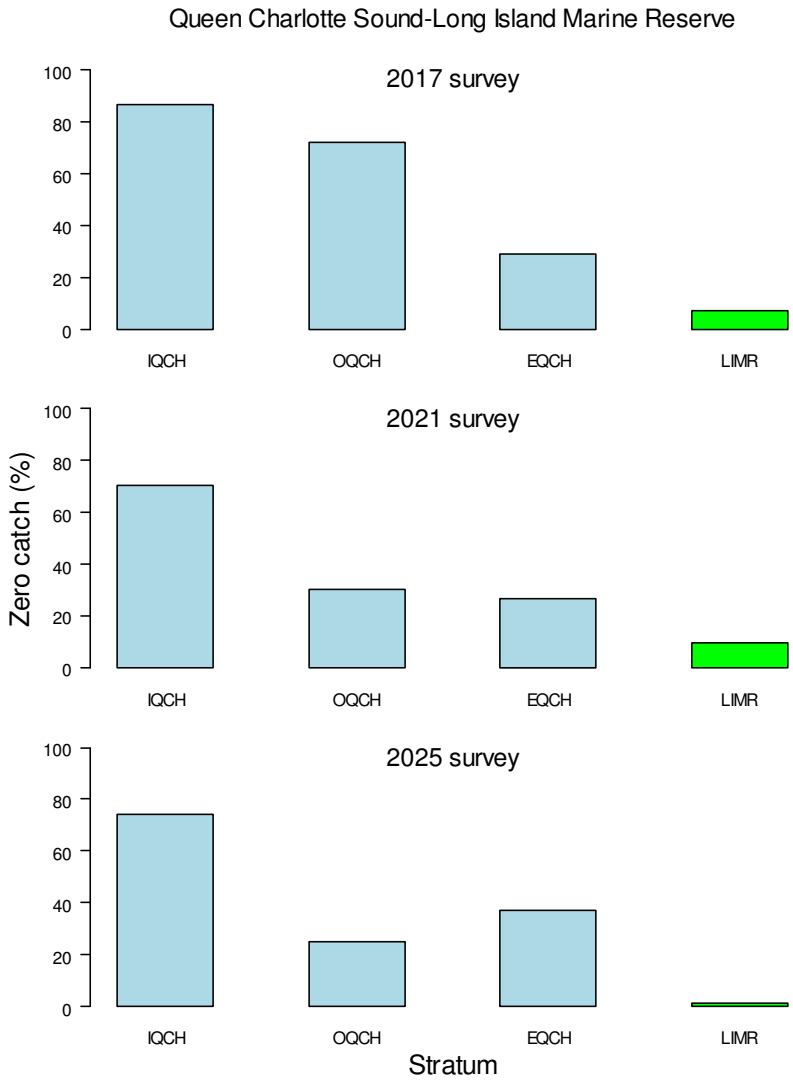


Figure 40: Marlborough Sounds 2025 random-site potting survey proportion of pots with zero blue cod from sites inside the Long Island Marine Reserve (LIMR) and from all sites in Queen Charlotte Sound strata (IQCH, OQCH, EQCH). See Figure 3 for location of strata and Table 2 for strata names.

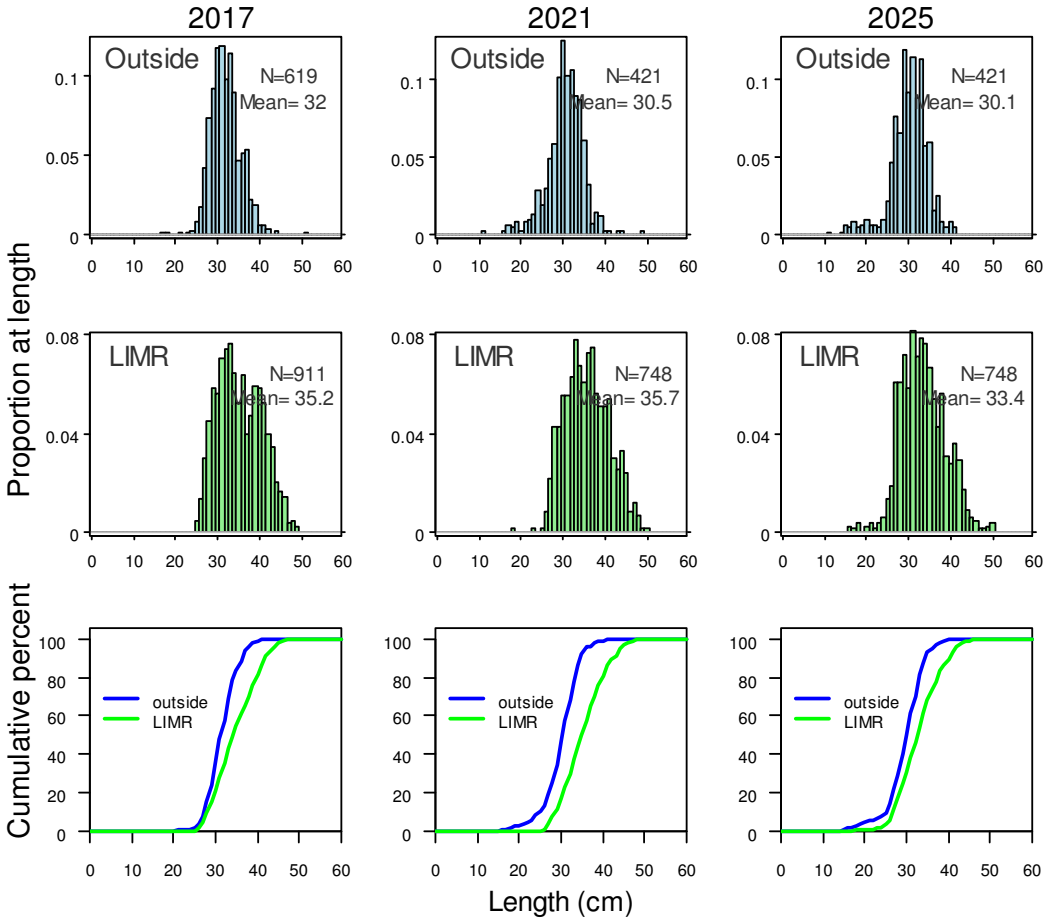


Figure 41: Marlborough Sounds 2017, 2021, and 2025 random-site potting survey scaled length frequency and cumulative distributions of unsexed blue cod for sites inside Long Island Marine Reserve (LIMR) and from sites in the adjacent Queen Charlotte Sound strata (OQCH, EQCH). N, sample numbers; Mean, mean length (cm). See Figure 3 for strata locations and Table 2 for strata names.

10. APPENDICES

Appendix 1: Blue cod potting surveys carried out for Fisheries New Zealand in nine South Island recreational fisheries. See Appendix 2 for definitions of fixed-site and random-site surveys, and directed and systematic pot placement.

Survey area	Survey year	Survey design type	Pot placement	References
Marlborough Sounds	1995, 1996, 2001, 2004, 2007, 2008	Fixed-site	Directed	(Blackwell 1997, 1998, 2002, 2005, 2008)
	2010	Fixed-site and partial Random-site	Directed and systematic	(Beentjes & Carbines 2012)
	2013	Fixed-site and Random-site	Directed and systematic	(Beentjes et al. 2017)
	2017	Fixed-site and Random-site	Directed and systematic	(Beentjes et al. 2018)
	2021, 2025	Random-site	Systematic	(Beentjes et al. 2022b), This report
Kaikōura	2004, 2007	Fixed-site	Directed	(Carbines & Beentjes 2006a, 2009)
	2011, 2015	Fixed-site and Random-site	Directed and systematic	(Carbines & Haist 2012, Beentjes & Page 2017)
	2017, 2019, 2023	Random-site	Systematic	(Beentjes & Page 2018, 2021, 2024)
Motunau	2005, 2008	Fixed-site	Directed	(Carbines & Beentjes 2006a, 2009)
	2012, 2016	Fixed-site and Random-site	Directed and systematic	(Carbines & Haist 2012, Beentjes & Sutton 2017)
	2020, 2024	Random-site	Systematic	(Beentjes & Miller 2021, 2024b)
Banks Peninsula	2002, 2005, 2008	Fixed-site	Directed	(Beentjes & Carbines 2003, 2006, 2009)
	2012	Fixed-site and Random-site	Directed and systematic	(Carbines & Haist 2017b)
	2016	Fixed-site and Random-site	Directed and systematic	(Beentjes & Fenwick 2017)
	2021	Random-site	Systematic	(Beentjes et al. 2022a)
North Otago	2005, 2009	Fixed-site	Directed	(Carbines & Beentjes 2006b, 2011b)
	2013, 2018	Fixed-site and Random-site	Directed and systematic	(Carbines & Haist 2018b, Beentjes & Fenwick 2019a)
	2022	Random-site		(Beentjes & Fenwick 2023a)
South Otago	2010	Fixed-site and Random-site	Directed and systematic	(Beentjes & Carbines 2011)
	2013, 2018, 2022	Random-site	Systematic	(Carbines & Haist 2018c, Beentjes & Fenwick 2019b, 2023b)
Foveaux Strait	2010, 2014, 2018, 2023	Random-site	Systematic	(Carbines & Beentjes 2012, Carbines & Haist 2017a, Beentjes et al. 2019, Beentjes & Miller 2024a)
Paterson Inlet	2006	Fixed-site	Directed	(Carbines 2007)
	2010, 2014	Fixed-site and Random-site	Directed and systematic	(Carbines & Haist 2014, 2018a)
	2018	Random-site	Systematic	(Beentjes & Miller 2020)
Dusky Sound	2002, 2008	Fixed-site	Directed	(Carbines & Beentjes 2003, 2011a)
	2014	Fixed-site and Random-site	Directed and systematic	(Beentjes & Page 2016)

Appendix 2: Glossary of terms used in this report (modified from Beentjes & Francis 2011, Beentjes 2019). See the potting survey standard and specifications for more details.

Fixed site	A site that has a fixed location (single latitude and longitude or the centre point location of a section of coastline) in a stratum and is available to be used repeatedly on subsequent surveys in that area. The fixed sites used in a survey were randomly selected from the list of all available fixed sites in each stratum. Fixed sites are sometimes referred to as index sites or fisher-defined sites and were defined at the start of the survey time series (using information from recreational and commercial fishers)
Pot number	Pots are numbered sequentially (1–6 or 1–9) in the order they were placed during a set. In the Marlborough Sounds nine pots were used.
Pot placement	Pot placement is the method used to determine where to place the pot on the seafloor. There are two types of pot placement: Directed – used only for fixed sites where the position of each pot is directed by the skipper using local knowledge and the vessel echo-sounder to locate a suitable area of reef/cobble or biogenic habitat. Directed pot placement depends on the perceived suitability of the habitat. Systematic – used only for random sites where the position of each pot is arranged 1) systematically around the site in a hexagon pattern, or 2) either side of the site position for a length of coastline. Systematic pot placement is independent of the perceived suitability of the habitat.
Random site	A site that has the location (single latitude and longitude) generated randomly within a stratum, given the constraints of proximity to other selected sites for a specific survey.
Site	A geographical location near to which sampling may take place during a survey. A site may be either fixed or random (see below). A site may be specified as a latitude and longitude or a section of coastline (for the latter, use the latitude and longitude at the centre of the section).
Site label	An alphanumeric label of no more than four characters, unique within a survey time series. A site label identifies each fixed site and also specifies which stratum it lies in. Site labels are constructed by concatenating the stratum code with an alpha label (A–Z) that is unique within that stratum. Thus, sites within stratum 2 could be labelled 2A, 2B, and sites in stratum 3 could be labelled 3A, 3B etc. Site labels for random sites are constructed in the same way but prefixed with R (e.g., R4A, R4B etc).
Station	The position (latitude and longitude) at which a single pot (or other fishing gear such as ADCP) is deployed at a site during a survey, i.e., it is unique for the trip.
Station number	A number which uniquely identifies each station within a survey. The station number is formed by concatenating the set number with the pot number. Thus, pot 4 in set 23 would be *station_no* 234. This convention is important in enabling users of the *trawl* database to determine whether two pots are from the same set. Note that the set numbers for potting surveys are not recorded anywhere else in the *trawl* database.

Appendix 3. Numbers of otoliths collected during the 2025 Marlborough Sounds survey for males and females, by strata and length class.

Length (cm)	Stratum 1	2	3	4	5	6	7	8	9	11	12	13	16	Male total
14										3				3
15		1								2				3
16			1							2	1			4
17		2								1		1		4
18			1	1				1		3	2	1		9
19			2	1		1		1					1	6
20		2	1	1										4
21			1	1	1					1	1			5
22											2			2
23										1	2		2	5
24		1								3				4
25		2	4	1		3				3			8	21
26		2	1	1		10			1	5	1		5	26
27		4		1		4				5				14
28		4		3		4				4				15
29		3	1	5		3				4				16
30		3		5		3				3				14
31		5		5		4				4				18
32		5	1	2		4				4				16
33		6		4		4				3				17
34		4		6		5				5				20
35		4		3		4				4				15
36		3	1	2		5				5				16
37		5	2	12		14			8	2	3	1	5	52
38		2	2	1		8		1	8	1			8	31
39			3	3		4			6	3			4	23
40			5	1	1	3			3		1		2	16
41			3						2	1	3		2	11
42				1	1				2					4
43						1	1							2
44										1				1
45										1				1
46										2				2
47														
48										1				1
Totals		58	29	60	3	84	1	3	30	77	16	3	37	401

Appendix 3 – ***continued***

Length (cm)	Stratum 1	2	3	4	5	6	7	8	9	11	12	13	16	Female total
14		1		1									1	3
15		2	1							1				4
16		1		3										4
17		3		1										4
18		2		2										4
19		1	1	1										3
20		2									1			3
21		1	1											2
22		1								1				2
23		2									1			3
24		2	2			3				1				8
25		5				1		1	1		2		4	14
26		11	2			13		1	1	7	3		12	50
27		10	4	3		16		1	1	7		1	5	48
28		9	4	2	1	4				2	2			24
29		9	3			6	1			3	3			25
30	1	7	2	2	3	4		1		3				23
31	1	5	2			4		1		1				14
32	2	7	2			4	1	3						19
33		5		1		5	2	1		1				15
34		1		1		5		2		1				10
35		1		1		5								7
36	1					1								2
37			2		2	3	1		1					9
38									1					1
39									1					1
40									1					1
41														
42								1						1
Totals	5	88	26	18	6	74	5	12	7	28	12	1	22	304