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Relative abundance, population structure, and stock status of blue cod off north Otago in 2013. Concurrent fixed and random site potting surveys.

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This report describes the results of the 2013 north Otago blue cod (*Parapercis colias*) potting surveys. This is the third fixed and first concurrent random site allocation potting survey to be undertaken in the time series for north Otago. Between 21 January and 18 February 2013, twenty-seven fixed sites and forty random sites were surveyed (6 pots per site, 402 pot lifts) from four coastal and two offshore strata off north Otago. The catch of each pot was weighed, and the length and sex of blue cod was recorded. Otoliths were read from 267 blue cod collected from both random and fixed sites representatively selected throughout the survey area. The resulting age-length keys were applied to the scaled length frequency distributions of both fixed and random site surveys to estimate the population age structures.

Fixed site survey
The fixed site survey used 24 phase 1 sites, with three additional sites allocated to the southern offshore stratum in phase 2. Total blue cod catch was 916 kg, consisting of 1776 fish. For all size blue cod, catch rates by stratum ranged from 2.7 to 8.1 kg.pot^{-1}, with an overall mean catch rate of 5.0 kg.pot^{-1} and coefficient of variation (CV) of 12.6%. Catch rates of legal size blue cod (at least 30 cm) ranged from 2.0 to 6.4 kg.pot^{-1}, with an overall mean catch rate of 3.9 kg.pot^{-1} and CV of 13.7%. Catch rates of legal size fish were highest in the inshore stratum south of Moeraki, and lowest in the most northern inshore stratum south of Oamaru. At fixed sites 58% of blue cod caught were of legal size.

Total lengths recorded at fixed sites ranged from 15 to 46 cm. The length frequency distributions were bimodal in many strata, with few fish below 20 cm or over 40 cm. Males were larger than females in most strata (except the northern inshore stratum) and overall mean length was 32 cm for males and 27 cm for females. Overall sex ratios for all and for legal sized fish were 1:0.3 (M:F) and 1:0.1 respectively. Age ranged from 2 to 24 years, with most blue cod between 7 and 11 years for males and 3 and 9 years for females. The total mortality estimate (Z) was 0.46, assuming age-at-recruitment to the fishery at 10 years. The spawning biomass per recruit ($F_{\%SPR}$) estimate indicates that the expected contribution to the spawning biomass over the lifetime of an average recruit has been reduced to 34% of the contribution in the absence of fishing, and this level of exploitation (F) is of some concern as it is below the Ministry of Primary Industries target reference point of $F_{45\%}$.

Temporal comparisons between fixed site surveys
For the fixed site survey, the overall catch rates of all blue cod and legal sized blue cod had declined by 57% and 56% respectively since the 2009 survey. Catch rates of all and of legal sized blue cod had declined dramatically within most strata except the inshore stratum south of Moeraki. The overall CVs for the 2013 survey catch rates were 13–14%, but these could not be compared to previous surveys due to a change in the method of calculation from earlier surveys. Gonad observations in the 2013 survey had most fish in the early maturing stage, with some running ripe and spent, which was consistent with both the 2005 and 2009 fixed site surveys.

Random site survey
The random site survey used 36 phase 1 sites, and four phase 2 sites allocated equally to the southern offshore stratum and the inshore stratum north of Moeraki. Total blue cod catch was 1168 kg, consisting of 2450 fish. For all size blue cod, catch rates by stratum ranged from 0.9 to 7.5 kg.pot^{-1} with an overall mean catch rate of 4.2 kg.pot^{-1} and CV of 14%. Catch rates of legal size blue cod by stratum ranged from 0.5 to 5.3 kg.pot^{-1} with an overall mean catch rate of 3.0 kg.pot^{-1} and CV of 14%. Catch rates of legal sized fish were highest in the most southern inshore stratum, and lowest in the most northern inshore stratum. At random sites 50% of blue cod caught were of legal size.

Total lengths recorded at random sites ranged from 16 to 49 cm. The length frequency distributions were often bimodal, with few fish below 20 cm or over 40 cm. Males were larger than females in most strata

(except the northern inshore stratum), and overall mean length was 31 cm for males and 28 cm for females. Overall sex ratios for all and for legal sized blue cod were 1:0.5 (M:F) and 1:0.3 respectively. Age ranged from 2 to 26 years, with most fish between 3 and 10 years for males and 3 and 9 years for females. The *Z* estimate for the random site survey was 0.43, assuming an age-at-recruitment of 10 years. The $F_{\%SPR}$ estimate indicates that the spawning biomass has been reduced to 36% and beyond the Ministry of Primary Industries target reference point of $F_{45\%}$.

Comparison between survey designs

Overall catch rates of all and legal sized blue cod from the 2013 random site potting survey were 84% and 76% respectively of the catch rates from the concurrent fixed site survey, but were not consistent among strata for either all (35–119%) or legal (46–89%) sized blue cod. The strata rank order of random site catch rates of all blue cod was consistent with the rank order of fixed sites, and was also very similar for legal sized blue cod. The overall CVs of the catch rates from the random site survey (about 13%) were also very similar to the CVs from the concurrent fixed site survey (about 12%).

Catchability and size selectivity of survey pots

Due to swell size and poor water visibility in conjunction with the often rugged, topographical complexity of rocky sea bed encountered, only one site could be surveyed with flown video transects prior to potting during the 2013 north Otago surveys. To further investigate the relationship between survey pot catch rates and size structure with direct *in situ* video observations of blue cod in the general Otago region, the 2013 north Otago DUV site was pooled with five 2013 south Otago potting survey sites concurrently surveyed with flown video transects.

1 INTRODUCTION

Blue cod (*Parapercis colias*) is a particularly desirable finfish caught easily by line or pot and the most frequently landed recreational species in the South Island (Ministry for Primary Industries 2017). Blue cod is also an important species for Maori customary fishers in all areas, but the catch is unknown. Tagging shows that most blue cod have a restricted home range (Rapson 1956, Mace & Johnston 1983, Mutch 1983, Carbines & McKenzie 2001, 2004), and stocks of this species largely consist of many independent sub-stocks within each Fisheries Management Area (FMA) (Carbines 2004a). Due to this philopatric behaviour, blue cod may be especially susceptible to localised depletion within subareas of FMAs, and in response to local fishing pressure. Daily bag limits for recreational fishers therefore vary within South Island FMAs (Ministry for Primary Industries 2017).

Commercial blue cod catch along the east coast of the South Island (BCO 3) has been constrained by a relatively small total allowable commercial catch (163 t), and accounts for only 7% of BCO quota nationally (Ministry for Primary Industries 2017). However, BCO 3 has been overcaught by up to 20 t in most years since 2003–04 (Ministry for Primary Industries 2017). Estimates of the recreational blue cod catch for BCO 3 have been highly variable (101–752 t), but the most recent estimate in 2012 of 101 t suggests that BCO 3 is a shared fishery with similar amounts of harvest from the commercial and recreational sectors.

Within BCO 3 there are currently three areas where recreational minimum legal size (MLS) and daily bag limits have been varied (i.e., Otago, north Canterbury and Kaikoura; Ministry for Primary Industries 2017). However, unlike north Canterbury and Kaikoura, neither the MLS (30 cm) or the daily bag limit (30 fish) has been altered within the Otago area (Ministry for Primary Industries 2017). The "reef" area off north Otago supporting blue cod is not extensive, but consists of both inshore and offshore areas (See Figure 1). For some time recreational fishers have been concerned about reported declines in catches and sizes of blue cod in the north Otago area, and have blamed an apparent increase in the number of Canterbury based private recreational and charter boats operating in the area (South Marine Recreational Fishers Advisory Group pers. comm.). Local recreational fishers are concerned that lowering the blue cod bag limit down to 10 per day in north Canterbury, 6 per day in Kaikoura, and 2 per day in the Marlborough Sounds (BCO 7), has resulted in a transfer of fishing effort into the Otago region.

Ministry for Primary Industries potting surveys

To monitor South Island blue cod populations, the Ministry for Primary Industries undertakes a quadrennial series of potting surveys to generate relative biomass estimates in key recreational fisheries within all three South Island FMAs, these include the Marlborough Sounds, Kaikoura, Motunau, Banks Peninsula, north and south Otago, Dusky Sound, Foveaux Strait, and Paterson Inlet (Ministry for Primary Industries 2017). These surveys provide relative abundance indices as well as information on population size/age structure, mortality estimates, and sex ratio used to monitor blue cod stocks. In addition to catch rate information, monitoring age structure provides a possible means of evaluating the response of a population to changes in fishing pressure. Otoliths collected during potting surveys are used to calculate the age structure of blue cod within survey areas throughout the South Island. Subsequent estimates of total mortality (*Z*) for each survey are based on catch curve analysis (Ricker 1975) of the age distributions derived specifically for each survey; thus it is possible to determine stock status using an MSY-related proxy. For blue cod there is insufficient information to estimate B_{MSY} for blue cod populations supporting small local fisheries in part because recreational catches have not been estimated reliably, and most likely represent a significant proportion of the total catch. F_{MSY} is a more appropriate reference point for these blue cod populations and the most widely used proxy for F_{MSY} currently is from spawner per recruit analyses ($F_{\%SPR}$). Hence, we are interested in where fishing mortality, derived from the catch curve analysis (Z) and estimates of *M*, lies in relation to the recommended $F_{45\%SPR}$ reference point for blue cod. This is documented in the Ministry for Primary Industries 'Operational Guidelines for New Zealand's Harvest Strategy Standard' (Ministry of Fisheries 2011).

North Otago 2005 potting survey

The initial 2005 north Otago survey used a two-phase stratified fixed site design with five sites per stratum randomly selected for phase 1 from a list of 62 possible fixed sites (at least 10 per stratum) identified prior to the survey (Carbines & Beentjes 2006). From 12 to 27 January 2005, 34 sites were surveyed (6 pots per site = 204 pot lifts) in five strata from Oamaru south to Bobbys Head (strata 1–5 in Figure 1). Twenty-five sites were completed in phase 1, and a further 9 sites (26%) in phase 2. The total blue cod catch was 2076 kg, consisting of 3518 blue cod. Most gonads were early maturing stages with only 6% of males and 2% of females running ripe, indicating that spawning was in its later stages in January 2005. For all sized blue cod, strata catch rates ranged from 7.5 to 14.5 kg.pot^{-1} with an overall mean catch rate of 10.12 kg.pot^{-1} and coefficient of variation (C.V.) of 5.4%. Strata catch rates of legal size blue cod (30 cm and over) ranged from 5.4 to 11.7 kg.pot^{-1}, with an overall mean catch rate of 8.2 kg.pot^{-1} and CV of 5.3%. Catch rates in 2005 were highest in the offshore strata (strata 3 and 5, Figure 1) and lowest in the northern and southern inshore strata (strata 2 and 4, Figure 1). Sixty-two percent of blue cod caught exceeded the minimum legal size (30 cm). Note that the CVs reported in Carbines & Beentjes (2006) cannot be compared to latter surveys due to a change in the method of calculation (Francis 2011).

Total length ranged from 17 to 54 cm, with an overall mean length of 33.2 cm for males and 28.2 cm for females, the sex was heavily skewed in favour of males (72%). Otoliths were prepared and read for 125 males and 94 females, and the resulting ages ranged from 3 to 19 years with a mean age of 7.1 years for males and 6.3 years for females (note that the age data and subsequent analysis for the 2005 survey is presented in Carbines & Beentjes 2011). Total mortality estimates (Z) for age at recruitment from 5 to 8 years ranged between 0.33 and 0.43. The resulting spawner (biomass) per recruit (SPR) estimate (adopting the default M value of 0.14, age of recruitment of 6) was $F_{25\%}$, which means that the expected contribution to the spawning biomass over the lifetime of an average recruit had been reduced to 25% of the contribution in the absence of fishing, and was beyond the target reference point of $F_{40\%}$.

North Otago 2009 potting survey

The 2009 north Otago survey also used a two-phase stratified fixed site design with five sites per stratum randomly selected for phase 1 from the original list of 62 possible fixed sites (Carbines & Beentjes 2011). From 16 to 30 January 2009, 37 sites were surveyed (6 pots per site = 222 pot lifts) in six strata from Oamaru south to Cornish Head near Waikouaiti (Figure 1). Thirty sites were completed in phase 1, and a further 7 sites (19%) in phase 2. The total blue cod catch was 2554 kg, consisting of 4595 blue cod. Most gonads were early maturing stages with only 5% of males and 8% of females running ripe, indicating that spawning was again in its late stages during January 2009. For all sized blue cod, stratum catch rates ranged from 6.2 to 19.9 kg.pot^{-1} with an overall mean catch rate of 11.5 kg.pot^{-1} and CV of 6.0%. Stratum catch rates of legal size blue cod ranged from 3.8 to 16.8 kg.pot^{-1}, with an overall mean catch rate of 8.9 kg.pot^{-1} and CV of 6.7%. Catch rates in 2009 were clearly highest in the offshore stratum 5 and lowest in the northern inshore stratum 2 (Figure 1). Fifty-seven percent of blue cod caught exceeded the minimum legal size.

Total length ranged from 16 to 56 cm, with an overall mean length of 31.8 cm for males and 27.6 cm for females, and sex continued to be heavily skewed in favour of males (73%). Otoliths were prepared and read for 164 males and 129 females, and the resulting ages ranged from 2 to 27 years with a mean age of 7.9 years for males and 6.8 years for females (Carbines & Beentjes 2011). Total mortality estimates for age at recruitment from 5 to 8 years ranged between 0.25 and 0.36. The resulting spawner (biomass) per recruit (SPR) estimate (adopting the default M value of 0.14, age of recruitment of 6) was $F_{36\%}$ and therefore lower than the target reference point of $F_{45\%}$

Comparison between survey designs

Because the fixed site survey design uses known fishing spots as sites (Carbines & Beentjes 2006, 2011) it has a number of potential biases, and the catch indices cannot be extrapolated to the whole survey area as the samples are not representative. In a review of blue cod potting surveys, Stephenson et al. (2009) suggested using a more statistically robust random site survey, but acknowledged the need for some continuity with previous fixed site survey data. Consequently, the 2013 north Otago potting survey

began a new random survey design done concurrently with a third fixed site survey in an initial comparison of these methods in the north Otago potting survey time series.

Pot catches verses underwater observations
The basic premise of potting surveys as long term monitoring programmes is that this passive capture method provides estimates of the relative abundance and size structure of blue cod populations within the survey area. However, a review of the blue cod potting programme recommended that this premise requires further validation (Stephenson et al. 2009). Different methods have different size selectivity and catch rates, and size composition from potting can differ between pot types (Beentjes & Carbines 2012, Carbines & Beentjes 2012, Carbines & Haist 2018) and with other methods such as line fishing (Carbines 1999, 2008).

Pot catches have a "weak" and highly variable and a largely unexplained relationship with counts from diver transects (Cole et al. 2001), and continuous video recordings of blue cod entries and exits from pots show that fewer than 8% of approaches lead to entries, and that local topography can constrain pot entries in some situations (Cole et al 2004). Comparisons of remote flown video transects taken immediately prior to potting also show a higher proportion of small blue cod observed than caught, and the relationship between pot catch and video counts (i.e., catchability) has often been poor and highly variable over time and/or location (Beentjes & Carbines 2012, Carbines & Beentjes 2012, Carbines & Haist 2014, 2017). To further investigate the relationship between potting survey catch rates and size structure with direct *in situ* video observations of blue cod, the 2013 north Otago potting survey employed fish counts from five replicate drop underwater video (DUV) flown transects immediately prior to setting six pots at a target of 10 survey sites.

Overall objective

1. To estimate relative abundance, maturity state, sex ratio, and age structure of blue cod (*Parapercis colias*) around north Otago.

Specific objectives

1. To undertake a potting survey between Oamaru and Cornish Head (BCO 3) to estimate relative abundance, 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 compare this with other previous surveys in this area and other survey areas.

4. To undertake a Dropped Underwater Video (DUV) survey concurrently with potting survey to provide comparative estimates of biomass.

5. To determine F_{msy} proxies for north Otago blue cod.

2 METHODS

In this report we use only the terms and methods defined in the blue cod potting survey manual (Beentjes & Francis 2011), but note that surveys carried out before this manual was written, may have used different and inconsistent terminology and methods (see Appendix 1).

2.1 Timing

Fixed and random site potting surveys off north Otago were carried out concurrently between 21 January and 18 February 2013. January was chosen to begin the 2013 potting surveys to be consistent with the timing of the 2005 and 2009 surveys (Carbines & Beentjes 2006, 2011).

2.2 Survey area

The original 2005 survey area was defined after discussions with local fishers, Ministry of Fisheries (now MPI) Dunedin, and the South Recreational Advisory Committee (Carbines & Beentjes 2006). Fishers were given charts of the area and asked to mark discrete locations around north Otago where blue cod are commonly caught. The survey area, between Oamaru and Bobbys Head, was divided arbitrarily into three inshore and two offshore strata (strata 1–5 in Figure 1). The outer boundaries of the inshore and offshore strata were defined by the 30 m and 50 m depth contours, respectively. The same five strata used in 2005 were surveyed again in 2009 with an additional inshore stratum added to the south (Bobbys Head to Cornish Head, Figure 1).

2.3 Survey design

Both fixed and random site potting surveys used six pots per site and ensured that sites were at least 300 m apart. The 2013 fixed site survey consisted of 27 sites (162 pot lifts) allocated to strata 1–6, and the random site survey consisted of 40 sites (240 pot lifts) also allocated to strata 1–6 (Figure 1). For the fixed site survey, four sites per strata (n=24 sites, 144 pot lifts) were allocated in a phase 1 and three sites (11.1%) were allocated to a second phase (Table 1). The random site survey also used a two-phase stratified design, with six sites per strata (n=36 sites, 216 pot lifts) allocated to phase 1, and four sites (10.0%) allocated to phase 2 (Table 2). Allocation of phase 2 sites was based on the mean catch rate (kg.pot^{-1}) of all blue cod per stratum and optimised using the "area mean squared" method of Francis (1984). In this way, phase 2 sites were assigned iteratively to the stratum in which the expected gain is greatest, where expected gain is given by:

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

where for the ith stratum, $mean_i$ is the mean catch rate, $area_i$ is the stratum area, and n_i is the number of sets in phase 1. In the iterative application of this equation, n_i is incremented by 1 each time a phase 2 set is allocated to stratum i. Pots were always allocated in groups of six which equates to one set (See Figure 2).

2.4 Vessels and gear

The 2013 north Otago potting surveys were conducted from F.V. *Triton*, a local commercial vessel equipped to set and lift rock lobster and blue cod pots. The vessel was chartered by Saltwater Science Ltd and skippered by the owner Mr Neil McDonald. The vessel specifications are: 11 m length, 4 m breadth, 12 t, wooden monohull, powered by a 120 hp diesel engine with propeller propulsion. The trip code for the survey was TRI1301.

Six custom designed and built cod pots were used to conduct the surveys. Pot specifications were: length 1200 mm, width 900 mm, depth 500 mm, 30 mm diameter synthetic inner mesh, 50 mm cyclone wire outer mesh, entrances 4 (Pot Plan 2 in Beentjes & Francis 2011). Pots were marked with a number from 1 to 6, and baited with paua guts in "snifter pottles". Bait was topped up after every lift and replaced each day. The same pot design and bait type were used in all previous South Island blue cod potting survey time series except Marlborough Sounds, where the pots used are of different dimensions and construction (Pot Plan 1 in Beentjes & Francis 2011).

A high-performance, 3-axis (3D) acoustic doppler current profiler (RDI - 1200 kHz) was deployed at each site. The ADCP records current flow and direction in 5 m depth bins.

2.5 Sampling methods

The ADCP was initially deployed at each fixed site location, and the six pots were then set at least 100 m apart. The position of each of the six pots was determined by the skipper using local knowledge and the vessel sounder on site to locate areas of foul ground (Figure 2).

At each random site location the ADCP was first deployed. Around this central point, six pots were set sequentially in a fixed hexagon pattern with each point (pot) approximately 200 m from the centre and 200 m from adjacent pots. The six pots were set blind (i.e., not targeted by sonar) in the fixed grid pattern determined from an initial starting point approximately 200 m north of the random site location occupied by the ADCP (Figure 2).

At both random and fixed sites pots were left to fish (soak) for approximately one hour during daylight hours. After each site was completed (six pot lifts) the next closest site in the stratum was sampled. While it was not logistically possible to standardise for time of day or tides, each stratum was surveyed throughout the day, collectively giving each stratum roughly equal exposure to all daily tidal and time regimes. The order that strata were surveyed depended on the prevailing weather conditions, as exposed strata could only be surveyed during the calmest conditions.

As each pot was set, a record was made on customised forms (See Beentjes & Francis 2011) of pot number, latitude and longitude, depth, time of day, and standard trawl survey physical oceanographic data, including wind direction, wind force, air temperature, air pressure, cloud cover, sea condition, sea colour, swell height, swell direction, bottom type, bottom contour, sea surface temperature, sea bottom temperature, wind speed, and water clarity (secchi depth). The ADCP was deployed at each site to record current speed and direction throughout the pot sets and was recovered after the last pot of each set was lifted.

After one hour, pots were lifted aboard using the vessel's hydraulic pot lifter, emptied, and the contents sorted by species. Total weight per pot was recorded for each species to the nearest 10 g using 10 kg Merel motion compensating scales. The number of individuals of each species was also recorded per pot. Total length down to the nearest centimetre, sex, and gonad maturity were recorded for all blue cod, and the sagittal otolith removed from a representative size range of males and females, from which weight of each fish was recorded to the nearest 10 g. Otoliths were removed from a target of five fish of each sex per one centimetre size class over the available length range collected representatively throughout the survey area.

During the 2013 potting surveys all blue cod were sexed through dissection and direct macroscopic observations, gonads were also recorded as one of five stages as follows: 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 Beentjes & Francis 2011).

2.6 Otolith preparation and reading

Due to the small size of blue cod otoliths, the most precise method for ageing is the thin section technique (Carbines 2004b). Collected otoliths were rinsed with water, air-dried, and stored in paper envelopes. These were later embedded in Araldite polymer resin, baked, and sectioned along the transverse plane with a diamond-tipped cut-off wheel. Sections were then coated with a slide mountant and sanded with 600-grit sandpaper to below 1 mm thickness before viewing. Sections were observed at ×40 and ×100 magnification under transmitted light with a compound microscope.

Otolith sections exhibit alternating opaque and translucent zones and age estimates are made by counting the number of annuli (opaque zones) from the core to the distal edge of the section, a technique previously validated and a protocol described for blue cod by Carbines (2004b). Translucent zones are used to define each complete opaque zone, i.e., annuli are counted only if they have a translucent zone on both sides. The readability of each otolith was also graded from 1 (excellent) to 5 (unreadable). Otoliths were read independently by two readers (G. Carbines and N. Usmar). Where counts differed, readers consulted to resolve the final age estimate. Otoliths given a grade 5 (unreadable) were removed from the analysis.

2.7 Data analysis

The data analyses follow the methods and equations described in the blue cod potting survey standards and specification document (Beentjes & Francis 2011).

CPUE for fish of minimum legal size
The potting survey manual does not provide equations for calculating catch rates of fish greater than the minimum legal size (MLS), however the approach that has been used in recent years is an extension of the equations for calculating catch rates for the entire catch. For blue cod potting surveys, individual fish weights are measured for only a subset of the sampled fish, and catch rates for fish greater than or equal to the MLS are based on the predicted weight of individual fish based on their length. The set-specific CPUE ($kg.pot^{-1}$) for fish greater than the MLS is,

$$C_{st}^{legal} = \left(\sum_{p} \sum_{k=1,2} \sum_{l \geq MLS} f_{lkpst}\, a_k\, l^{b_k} \right) \Big/ m \qquad (1)$$

Where f_{lkpst} is the number of fish of length l and sex k (k=1 for males and k=2 for females) caught in pot p of set s of stratum t, m is the number of pot lifts in set s, and a_k and b_k are sex-specific length-weight parameters (described below). Note that the above equation assumes that all fish have been sexed and measured for length.

The sex-specific length-weight parameters a_k, b_k are calculated by fitting (maximum likelihood) the following equation to all samples where length, weight, and sex were recorded:

$$w_{ki} = a_k \left(l_{ki} \right)^{b_k} \varepsilon_{ki} \qquad (2)$$

where w_{ki} and l_{ki} are the weight and length of fish i of sex k and the ε_{ki} are normally distributed. The equations for calculating the stratum and survey catch rates and CVs for fish greater than or equal to the MLS follow those in the potting survey manual (equations 2–5 of Beentjes & Francis 2011), replacing $\bar{C}_{st}$ with C_{st}^{legal}.

Length frequency, age frequency and total mortality estimates
Calculation of survey-level length frequency (LFs), age frequency (AFs), and total mortality (*Z*) follow the equations described in the potting survey manual (Beentjes & Francis 2011). Uncertainty in the LFs, AFs and *Z* estimates were calculated using the bootstrap procedures described in the survey manual. The LF and AF CVs were based on 300 bootstrap replicates and the *Z* confidence limits were based on 1000 replicates.

Growth parameters
Von Bertalanffy growth models were fitted (maximum likelihood) to the sex-specific length-age data:

$$l_{ki} = L_k^{\infty}\left(1-\exp\left(K_k\left(t_{ki}-t_k^0\right)\right)\right)+\varepsilon_{ki} \qquad (3)$$

where l_{ki} and t_{ki} are the length (cm) and age of fish *i* of sex *k*, respectively, $L_k^{\infty}, K_k,$ and t_k^0 are parameters of the growth model for sex *k*, and the ε_{ki} are normally distributed.

The estimated growth parameters, $L_k^{\infty}, K_k,$ and $t_k^0,$ were used in the spawning biomass per recruit analyses.

Spawning biomass per recruit calculations
Spawning biomass per recruit (*SPR*, Ministry of Fisheries 2011) analysis estimates the impact of fishing on the reproductive capacity of the stock. *SPR* is a deterministic calculation, dependent on population growth, natural and fishing mortality, maturation, and fishing selectivity. For blue cod, the calculations are based on age- and sex-specific dynamics and spawning biomass is summed over male and female fish. The following equations give the number of fish at age *a* and sex *k* (N_{ka}) and the spawning biomass per recruit (S_F) for a given *F*:

$$N_{ka} = \begin{cases} 0.5 & a = 0 \\ N_{k,a-1}\exp\left(-s_{k,a-1}F - M\right) & 1 \geq a < mage \\ N_{k,a-1}\exp\left(-s_{k,a-1}F - M\right) \Big/ 1-\exp\left(-s_{k,a-1}F - M\right) & a = mage \end{cases} \qquad (4)$$

$$S_F = \sum_k \sum_a \left(m_a a_k \left(l_{ka}\right)^{b_k} N_{ka} \right) \qquad (5)$$

where *M* is the natural mortality rate, s_{ka} is the selectivity for age *a* and sex *k*, m_a is the maturity for age *a*, l_{ka} is the mean length for age *a* and sex *k*, *mage* is the maximum age (50) and a_k and b_k are the length-weight parameters for sex *k* (see equation 2). $F_{\%SPR}$ is the fishing mortality (F) at a given spawning biomass per recruit (%SPR) relative to the spawning biomass per recruit in the absence of fishing $\left(\text{i.e. } S_f / S_0\right)$.

Population parameters are either estimated based on survey data (s_{ka}, l_{ka}, a_k and b_k) or fixed at default values as specified in the potting survey manual: the instantaneous natural mortality rate is assumed to be 0.14, with sensitivity analyses conducted for *M* values of 0.11 and 0.17; the maturation ogive assumes fish under age 3 are all immature, proportions mature of 0.1, 0.4, 0.7 for ages 4, 5, and 6, respectively, and 100% maturity for fish aged 7 and older; and fishery selectivity is assumed to be knife-edge at the age at MLS. The estimate of current fishing mortality (*F*) is equal to *Z*-*M*, and the SINS working group determined that the age of recruitment for the Z calculations would be the age where both male and

female blue cod were at or above the MLS. Z and *SPR* results are also provided for ages at recruitment from 5 through to 11.

Note that the above equations assume that the surveys which generate the length-age data (and von Bertalanffy growth curves) occur at the time of spawning so that a fish aged 3 is exactly 3 years old. Also, knife-edged fishery selectivity is interpreted to mean that age-classes become fully selected when they reach the birthday where their mean length-at-age is greater than or equal to the MLS. Alternative interpretations of knife-edge selectivity are possible – for example, assuming full selectivity at the exact age where the mean length is equal to the MLS (i.e., full selectivity at some mid-point in the year).

2.8 Pot catches as a proxy for abundance and size structure

To determine how well catch from potting surveys performs as a proxy for actual abundance and size structure, we attempted to estimate blue cod abundance and population structure using remotely flown video transects immediately prior to potting at up to ten survey sites.

Sample collection
The drop under water video (DUV) system used consists of a 35 kg bulb keel and tail fins which steady and orient a forward and downward facing mounting platform, fitted with a low-light camera and scaling lasers (Morrison & Carbines 2006, Carbines & Cole 2009, Beentjes & Carbines 2012, Carbines & Beentjes 2012, Carbines & Haist 2014, 2017). It was suspended beneath the vessel by a rope and a live-feed video cable so that location, time, depth, and date were all burned in real time onto the recorded digital video footage integrated with a surface Geographical Positioning System (GPS) and depth sounder.

The video camera was deployed at a height of at least 1.5 m off the seabed and the vessel steamed through the sample area. Once the speed of the surface vessel exceeded that of the deployed video, the keel and tail fin orients the platform forward, and the video records a transect of approximately 600 m length. Contact with the seabed is avoided by raising and lowering the video from the surface vessel throughout each transect and scaling lasers are used to back-calculate the size and variations of transect width. Transects were carried out between 0700 and 1630 hours, when the swell was no more than a metre, and when drift speed exceeded 0.8 $m.s^{-1}$ (to prevent fish being able to follow the video and re-enter the video transect). At least five replicate video transects were done at each site directly prior to sampling with six replicate pots (as described in Section 2.5).

Video analysis
Each video transect was processed (viewed) twice. On the first viewing, transect dimensions were geo-referenced and partitioned into general benthic habitat sections. All blue cod were geo-referenced and scaling lasers were used to estimate fish length (Morrison & Carbines 2006, Carbines & Usmar 2013). At the location of each blue cod, a benthic habitat sub-transect was sampled (approximately 5 m before and after the fish observed). During the second viewing, each section of general habitat was sampled with at least five sequential sub-transects to record transect width from scaling-lasers and provide fish independent descriptions of benthic habitat. Both fish-dependent and fish-independent habitat sub-transects recorded primary (geological) substrata (categories of grain size from sand to bedrock) and secondary habitat structure (categories of overlaying organic or geological benthic habitat), percentage cover (e.g., shells, sponges, macro-algae, etc.) topographic complexity and actual counts of benthic species where possible.

3 RESULTS

3.1 Sites surveyed

Twenty-seven fixed sites (6 pots per site, 162 pot lifts) and forty random sites (6 pots per site, 240 pot lifts) were surveyed between 21 January and 18 February 2013 (Tables 1 and 2, Figure 1, Appendix 2). Twenty-four of the fixed sites were carried out in phase 1 (4 per stratum) with three sites allocated to stratum 5 in phase 2 (Table 1). Of the 40 random sites, 36 were carried out in phase 1 (6 per stratum), with two phase 2 sites allocated to each of strata 1 and 5 (Table 2). Depth ranged from 14 to 45 m for fixed sites and 5 to 46 m for random sites. Environmental data recorded throughout the 2013 north Otago potting surveys are presented in Appendix 3 and are stored on the Ministry for Primary Industries database *trawl*. The ADCP data is archived in a spreadsheet with the Research Data Manager, NIWA, Greta Point, Wellington.

3.2 Catch

A total of 2216 kg of catch was taken on the 2013 north Otago fixed and random site potting surveys, of which 2087 kg (94%) was blue cod, consisting of 4226 fish. Blue cod accounted for 94% of catch in both the fixed site survey (Table 3) and an the random site survey (Table 4).

In the fixed site survey, bycatch included eight fish and one octopus species (Table 3). In the random site survey, bycatch also included eight fish and one octopus species (Table 4). For the fixed site survey, the five most common bycatch species by weight were octopus (*Octopus cordiformis*), leatherjackets (*Parika scaber*), scarlet wrasse (*Pseudolabrus miles*), banded wrasse (*Notolabrus fucicola*), and red cod (*Pseudophycis bachus*) (Table 3). For the random site survey the five most common bycatch species by weight were octopus, leatherjackets, scarlet wrasse, blue moki (*Latridopsis ciliaris*), and tarakihi (*Nemadactylus macropterus*) (Table 4).

In the fixed site survey the mean catch rates of blue cod (all sizes) ranged from 2.72 kg.pot^{-1} for the northern costal stratum 2, to 8.07 kg.pot^{-1} for the coastal stratum 4 south of Moeraki (Table 5, Figure 3). Overall mean catch rate and CV were 4.96 kg.pot^{-1} and 12.62%. For blue cod 30 cm and over (local minimum legal size) the lowest catch rates were also from stratum 2 (2.03 kg.pot^{-1}) and the highest were also from stratum 4 (6.42 kg.pot^{-1}). Overall mean catch rate and CV for fish of at least 30 cm from the fixed site survey were 3.94 kg.pot^{-1} and 13.7% (Table 6, Figure 3). Catch rates from the north Otago fixed site potting survey time series (2005, 2009, 2013) are shown in Figure 4.

In the random site survey, mean catch rates of blue cod (all sizes) ranged from 0.94 kg.pot^{-1} for the northern inshore stratum 2 to 7.46 kg.pot^{-1} for the southern inshore stratum 6 (Table 7, Figure 3). Overall mean catch rate and CV were 4.16 kg.pot^{-1} and 13.9%. For blue cod 30 cm and over the lowest catch rates were also from stratum 2 (0.46 kg.pot^{-1}) and the highest were also from stratum 6 (5.28 kg.pot^{-1}). Overall mean catch rate and CV for blue cod 30 cm and over from the random site survey were 3.01 kg.pot^{-1} and 14.4% (Table 8, Figure 3).

3.3 Biological and length frequency data

Of the 4226 blue cod caught on the 2013 north Otago fixed and random site surveys, all were measured for length and all were sexed, otoliths were taken throughout the survey area and ages read from 267 fish across the available size range (Appendix 4).

For the fixed site survey, the sex ratio of all blue cod ranged from 1:0.5 (M:F) in stratum 2 to 1:0.2 (M:F) in stratum 4, and overall were 77% male at 1:0.3 (M:F) (Table 9). The sex ratio for blue cod 30 cm and over (local minimum legal size) ranged from 1:0.5 (M:F) in stratum 2 to 1:0.1 (M:F) in stratum

6, and was heavily skewed towards males (1:0.1) (Table 9). The size of blue cod at fixed sites ranged from 15 to 42 cm for females and 19 to 46 cm for males, although size varied among strata (Figure 5).

For the random site survey, the sex ratio of all blue cod ranged from 1:1.0 (M:F) in stratum 2 to 1:0.4 (M:F) in stratum 4, and overall were 68% male at 1:0.5 (M:F) (Table 10). The sex ratio for blue cod 30 cm and over ranged from 1:2.0 (M:F) in stratum 2 to 1:0.1 (M:F) in stratum 4, but overall were skewed towards males (1:0.3) (Table 10). The size of blue cod at random sites ranged from 16 to 44 cm for females and 19 to 49 cm for males, but size also varied among strata (Figure 6).

The length frequency distributions were bimodal for many strata of both the fixed (Figure 5) and random site (Figure 6) potting surveys. Fish taken in the random site potting survey were similar in size to those from the fixed site survey in all strata except within the northern inshore stratum 2 (Figure 1), where males were 5 cm and females 4 cm smaller in the random site survey (Tables 9 and 10).

For both survey types, small blue cod (less than 20 cm) and large (over 40 cm) were reasonably uncommon (Figure 7). The southern offshore stratum 5 had the largest blue cod in both the fixed and random site surveys (Figures 5 and 6). In the fixed site survey the mean lengths of males were 4–6 cm longer than females in all strata except for the northern inshore stratum 2, where both sexes were 31 cm (Table 9). In the random site survey the mean lengths of males were 2–5 cm longer than females in all strata except for stratum 2, where females were 2 cm larger than males (Table 10). For the fixed site survey the overall mean length was 31.6 cm for males and 26.9 cm for females (Table 9), and for the random site survey the overall mean length was 30.7 cm for males and 27.6 cm for females (Table 10). The proportion of legal sized blue cod caught on the 2013 north Otago fixed site survey was 58% companied to 50% for the random site survey (Figure 7).

Blue cod from both the fixed and random site surveys had mainly early maturing phase gonads, with 8% of males and 2% of females running ripe in the fixed site survey (Table 11), and 11% of males and 3% of females running ripe in the random site survey (Table 12). Regardless of survey design, the smallest fish observed in the running ripe or spent stages was 21 cm for both males and females, with running ripe fish becoming common among males over 24 cm and among females over 28 cm. Using the derived model $W = aL^b$, the length-weight parameters for north Otago in 2013 were: males – a = 0.01093, b = 3.10941, females – a = 0.01202, b = 3.09201.

3.4 Ageing (between reader analyses)

From 280 otoliths collected during the 2013 north Otago survey, 13 were rejected as unreadable or damaged, leaving 267 otoliths (153 males 19–49 cm, 129 females 15–44 cm) (Table 13). These otoliths were collected across all strata (See Appendix 4).

Initial independently derived reader estimates of otolith age class are compared in Figure 8 and show 59% initial agreement between the two readers, with reader 2 estimating slightly lower age classes than reader 1 (tabulated in Appendix 5). When the differences between age class estimates were resolved by agreement between the readers, reader 1 was 82% consistent with the agreed age class and reader 2 was 69% consistent with the agreed age classes (Figure 8, Appendix 6).

3.5 Growth

The age/length data and fitted von Bertalanffy growth models for the 2013 north Otago surveys are shown in Figure 9, and the growth parameters (K, t_0 *and* L_{inf}) are shown below. Male and female size-at-age is similar until about age 4, after which males grow a little faster and achieve a slightly larger L_{inf} than females.

Parameter	Males	Females
K	0.08823	0.089508
T_0	-1.6514	-2.67451
L_{inf}	55.4	46.2

3.6 Length and age composition

The scaled length and age frequency distributions for all strata combined are shown for males, females, and both sexes combined for the 2013 north Otago fixed site (Figure 10) and random site (Figure 11) potting surveys. The scaled length frequency distributions tend to be bimodal for blue cod from both fixed and random sites (Figures 10 and 11). Males were generally larger than females in both survey designs, however the frequency of pre-recruited fish (i.e., less than 30 cm) was greater in the random site survey than in the fixed site survey (Figures 10 and 11).

Age of blue cod ranged from 2 to 26 years (Table 13), but there were very few fish older than 15 years (Figures 10 and 11). For males at fixed sites the dominant age-classes were 7–11 years, while for females at fixed sites the dominant age-classes were 3, 4, 6, 7, 8, and 9 years (Figure 10). At random sites the dominant age-classes were 3–10 years for males, and 3, 4, 6, 7, 8, and 9 years for females (Figure 11). The scaled mean age was similar in the fixed site and random site survey for both males (8.6 compared to 8.1 years) and females (7.9 compared to 7.9 years). The mean weighted coefficients of variation (MWCVs) around the age distributions are moderate for males (29% and 28%) indicating a fair representation of the overall male population. However the MWCVs around the female age distributions (38% and 33%) are a less convincing representation of the overall female population (Figures 10 and 11).

The cumulative length and age frequency distributions of blue cod from the fixed and random site surveys are shown in Figure 12. The age-length-keys (ALKs) are shown in Appendix 7 for males and Appendix 8 for females, and mean-age-at-length is shown in Appendix 9. For both males and females, all lengths measured on the survey had at least one valid age reading in the age-length-keys.

3.7 Total mortality (Z) estimates

Total mortality estimates (Z) and 95% confidence intervals for the 2013 north Otago fixed and random site potting surveys are given in Tables 14 and 15 respectively, and are very similar for the fixed and random site surveys. For the fixed site survey, Z estimates range from 0.22 to 0.47, and for the random site survey Z estimates range from 0.23 to 0.44.

3.8 Spawner per recruit analyses

The age- and sex-specific values for fish size, maturity, and selectivity used in the SPR analysis are given in Appendix 10.

The relationships between spawning biomass per recruit and fishing mortality rate (at three alternative values for natural mortality) are shown for data collected from the 2013 fixed site survey in Figure 13, and for data from the random site survey in Figure 14. Mortality parameters used in the analyses, and resulting $F_{\%SPR}$ values are shown in Tables 16 and 17. Based on the default value of M of 0.14 and age at recruitment of 10 years, the fishing mortality estimates for the 2013 north Otago fixed and random site surveys were 0.46 and 0.43, corresponding to %SPRs of 34% and 36%, respectively. For the fixed site survey %SPR estimates for M values of 0.11 and 0.17 were 25% and 43% respectively (Tables 16). For the random site survey %SPR estimates for M values of 0.11 and 0.17 were 26% and 45% respectively (Tables 17).

3.9 Pot catches as a proxy for abundance and size structure

Due to sea conditions (i.e., swells over 1.0 m and/or poor bottom water visibility) in conjunction with rugged and topographically complex rocky reef uncounted, only one site was surveyed with flown video transects prior to potting (Set 19, See Appendices 2 and 3). Attempting to complete the target 10 concurrent video sites (Objective 4) would have protracted the potting survey (Objective 1) beyond the fixed site time series sampling period (mid-January to early-February, Carbines & Beentjes 2006, 2011), so the primary objective was to complete the concurrent potting surveys before the end of February.

To further investigate the relationship between potting survey catch rates and size structure with direct *in situ* video observations of blue cod in the general Otago region, the 2013 north Otago video site was pooled with five 2013 south Otago potting survey sites concurrently video surveyed and reported in Carbines & Haist (in draft). However, below are some basic results from the one north Otago random survey site that successfully employed five replicate DUV transects immediately prior to setting six standard survey pots (See Section 2.5).

Video counts versus pot catch
Five drop underwater video (DUV) transects were undertaken at one random site directly prior to sampling with six pots (Table 18). The DUV surveyed 2.7 km of transects with an average transect width of only 2.3 m (s.e. ± 0.1 m) covering a total area of 5979 m^2. Within the area swept by the DUV, 25 general habitat breaks were identified and 125 fish-independent habitat transects were recorded within them. A total of 133 blue cod were observed using DUV, while the concurrent pots caught 98 blue cod (Table 18).

Species caught and observed
A total of 346 fish from ten species were observed in the five DUV transects, these included 178 tarakihi (*Nemadactylus macropterus*), 133 blue cod. 13 scarlet wrasse (*Pseudolabrus miles*), 8 red cod (*Pseudophycis bachus*), 7 spotties *(Notolabrus celidotus*), 2 blue moki (*Latridopsis ciliaris*), 2 skates (*Raja* species), a girdled wrasse (*Notolabrus cinctus*), a carpet shark (*Cephaloscyllium isabellum*) and an unidentified flat fish. A total catch of 98 blue cod and one leatherjacket (*Parika scaber*) was taken by the six pots.

4 DISCUSSION

The 2013 north Otago potting surveys were the first comparison of concurrent fixed and random site stratified survey designs for this area. This was the first random site survey and third fixed site survey to be done in the north Otago potting survey time series (Carbines & Beentjes 2006, 2011).

4.1 Fixed site survey design time series

For the fixed site survey, the overall catch rates of all blue cod (Table 5) and legal sized blue cod (at least 30 cm, Table 6) declined by 57% and 56% respectively since the 2009 survey (Figure 4). Catch rates of all and legal size blue cod declined dramatically within strata 1 (68% and 63%), 2 (56% and 46%), 3 (71% and 74%) and 5 (67% and 67%), but not inshore south of Moeraki (strata 4 and 6, Figure 4).

The historical declines in catch rates of blue cod within strata 2 and 3 have continued since the 2005 survey, while increases in strata 1 and 5 were reversed between the 2009 and 2013 surveys (Figure 4). Since 2005, the rank order of catch rates for all blue cod among strata (i.e., 5, 3, 1, 2, 4) changed only slightly in the 2009 survey (i.e., 5, 3, 1, 4, *(6)*, 2), but altered dramatically in the 2013 survey (i.e., 4, *(6)*, 5, 1, 3, 2) due to dramatic declines in strata 1, 2, 3, and 4 contrasted by relative stability in strata 2 and

6 (Figure 4). Historical changes in the strata catch rate rank orders for legal size blue cod were essentially the same as for all blue cod (Figure 4).

4.2 Comparisons of catch rates between survey designs

Overall catch rates of all and legal sized blue cod from the 2013 random site potting survey (Tables 7 and 8) were only 84% and 76% respectively of the catch rates from the concurrent fixed site survey (Tables 5 and 6). However this level of reduced catch in the random site survey was not consistent among strata for either all (35–119%) or legal (46–89%) sized blue cod (Figure 3).

In the 2013 north Otago potting surveys, the strata rank order of random site catch rates of all blue cod was consistent with the rank order of fixed sites (i.e., strata 4, 6, 5, 1, 3, 2, Figure 3), and for legal sized blue cod the strata rank order for random sites (i.e., strata 4, 6, 5, 1, 3, 2) was very similar to the rank order for fixed sites, (i.e., strata 4, 5, 6, 1, 3, 2). In 2013 the CV of the overall catch rate from the random site (n=40) survey (about 14%, Tables 7 and 8) was similar to the CV from the concurrent fixed site (n=27) survey (about 13%, Tables 5 and 6). The 2013 north Otago random site survey has been more successful at constraining the variance of catch rates than random site surveys in other areas (Carbines & Haist 2014, 2017, in draft).

4.3 Reproductive condition

Observations of gonad stages in the north Otago 2013 potting surveys were very similar between fixed and random sites, with most individuals in the maturing stage, only 7–9% running ripe and 3–4% of individuals spent (Tables 11 and 12). This indicates that the timing of the survey (summer) was during the late part of the spawning season and is consistent with the previous surveys in 2005 (Carbines & Beentjes 2006) and 2009 (Carbines & Beentjes 2011). In more enclosed survey areas fixed sites are often constrained to the coastline (Carbines & Haist 2012, 2017, 2018), however the similarity in reproductive condition between blue cod from the two survey designs suggest that there is little or no such fine scale variability in the onset of spawning at north Otago where fixed sites are not constrained along the coast (Figure 1).

Histological samples taken throughout the year are required to accurately determine the size/age-at-sexual maturity (Mutch 1983, Carbines 2004a). However, with running ripe fish being relatively common among males over 21 cm and females over 24 cm in the 2013 north Otago survey, it appears that sexual maturity can be attained by 5 years old. While blue cod in north Otago may be spawning at this small size, their fecundity is likely to be low and larger fish may contribute disproportionately more to the total egg production (Beer et al. 2013).

4.4 Size and sex ratio

In fixed site surveys, the relative number of males has gradually increased from 72% in 2005 (Carbines & Beentjes 2006) to 73% in 2009 (Carbines & Beentjes 2011), and to 76% in 2013 (Table 9). Sex ratios over the time series have remained consistent within stratum 3, but the percentage of males has steadily increased in strata 1, 2, 5, and 6, and increased dramatically in stratum 4, but has steadily declined in stratum 5 (Carbines & Beentjes 2006, 2011, Table 9). Eighty-eight percent of legal sized blue cod from fixed sites were male in 2013, and all strata were heavily biased towards males (over 81%), except stratum 2 (Table 9). The most pronounced male bias for both all and legal sized blue cod for both fixed and random sites was in the coastal stratum 4 south of Moeraki (Table 10). However, the male bias was higher in all strata for the fixed site survey, with overall 68% of all blue cod and 79% of legal sized blue cod in the random site survey being male (Table 10), compared to the fixed site survey where 77% of all blue cod and 88% of legal sized blue cod were male (Table 9).

4.5 Population length and age structure

Length frequency distributions were often bimodal at both fixed and random sites, with similar sizes of blue cod taken from both random and fixed sites (Tables 9 and 10, Figure 7). The proportion of legal sized blue cod caught on the three north Otago fixed site potting surveys initially declined from 62% in 2005 to 57% in 2009, but has since remained stable at 58% in the 2013 survey. The proportion of legal sized blue cod caught in the first north Otago random site survey was 50%, reflecting a slightly lower mean size in the random site survey (30 cm, Figure 11) than in the fixed site survey (31 cm, Figure 10). However, comparing proportions of legal sized blue cod across years or areas is difficult because they are affected by both recruitment and fishing mortality.

Because there are relatively few fish over 40 cm at either fixed or random sites the resulting population age structures both show a rapid decline on the right hand limb after ten years old and a low proportion of fish older than 14 years.

4.6 Total mortality (*Z*)

Because the two survey designs had similar age distributions (Figure 10 and 11) the resulting mortality estimates (*Z*) from the fixed site survey (Table 14) were similar to those from the random site survey (Table 15). Because differences in population structure have been observed between fixed and random site designs run concurrently in other areas (Carbines & Haist 2012, 2017, 2018), we have suggested that it is not appropriate to compare mortality estimates between random and fixed site surveys, however this does not appear to be the case in the north Otago surveys where the more consistent spatial distribution of random and fixed sites (Figure 1) is not as impacted by coastal clustering of fixed sites of other more sheltered areas (Carbines & Haist 2012, 2017, 2018).

Assuming a consistent age at recruitment of eight years, mortality estimates from the north Otago fixed site potting survey time series decreased between the 2005 (z=0.43, Carbines & Beentjes 2011) and 2009 (Z=0.36, Carbines & Beentjes 20011) surveys, but have not changed for the 2013 survey (Z=0.36, Table 14).

4.7 Stock status (spawning biomass per recruit ratio analyses)

The Ministry of Fisheries *Harvest Strategy Standard* (Ministry of Fisheries 2011) specifies that a Fishery Plan should include a fishery target reference point, and this may be expressed in terms of biomass or fishing mortality. The more appropriate target reference point for blue cod is F_{MSY}, which is the amount of fishing mortality that results in the maximum sustainable yield. The recommended proxy for F_{MSY} is the level of spawner per recruit $F_{\%SPR}$. The 'Operational Guidelines for New Zealand's Harvest Strategy Standard' (Ministry of Fisheries 2011) includes the following table of recommended default values for F_{MSY} (expressed as $F_{\%SPR}$ levels from spawning biomass per recruit analysis), and also for B_{MSY} (expressed as $\%B_0$).

Productivity level	**$\%B_0$**	**$F_{\%SPR}$**
High productivity	25%	$F_{30\%}$
Medium productivity	35%	$F_{40\%}$
Low productivity	40%	$F_{45\%}$
Very low productivity	$\geq$ 45%	$\leq F_{50\%}$

As a result of the impact of exploitation on sex change, resulting in a reduction in the proportion of females (and hence egg production) at even moderate rates of fishing mortality, blue cod is categorised as a low productivity species, which results in a target fishing mortality of $F_{SPR45\%}$. In the most recent north Otago potting surveys the SPR estimates for the default *M* value of 0.14 was 36% for the random site survey (Tables 16 and 17), indicating that the expected contribution to the spawning biomass over the lifetime of an average recruit has been reduced to 36% of the contribution in the absence of fishing. These results suggest that recent levels of exploitation (*F*) for the north Otago blue cod stock are beyond the F_{MSY} reference point.

Sensitivity analyses using *M* values of 0.11 and 0.17 (20% below and above the default of 0.14) resulted in substantial differences in the $F_{\%SPR}$ values (Tables 16 and 17, Figures 13 and 14). A higher natural mortality (0.17) increased the spawning biomass at current *F* relative to the unfished level by 9%., conversely a lower natural mortality (0.11) decreased the spawning biomass at current *F* relative to the unfished level by 10%.

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Table 1: North Otago 2013 fixed site survey stratum area, number of phase 1 and 2 sites, pot lifts, and depth of sites.

	Size of strata	Number of Selected sites		Number of pot lifts	Depth (m)	
Stratum	Area (km^2)	Phase 1	Phase 2	Total	Mean	Range
1	153.1	4		24	21.9	14–29
2	243.5	4		24	22.7	18–27
3	149.9	4		24	39.8	35–42
4	115.9	4		24	23.1	15–30
5	200.1	4	3	42	39.0	34–45
6	54.3	4		24		
Total	916.8	24	3	162	28.7	14–45

Table 2: North Otago 2013 random site survey stratum area, number of phase 1 and 2 sites, pot lifts, and depth of sites.

	Size of strata	Number of Selected sites		Number of Pot lifts	Depth (m)	
Stratum	Area (km^2)	Phase 1	Phase 2	Total	Mean	Range
1	153.1	6	2	36	23.0	5–33
2	243.5	6		48	19.5	13–24
3	149.9	6		36	35.8	31–42
4	115.9	6		36	25.9	16–36
5	200.1	6	2	48	38.3	33–46
6	54.3	6		24	24.9	9–33
Total	916.8	36	4	240	28.2	5–46

Table 3: Catch weights, numbers of blue cod, bycatch species, and percentage of total weight from the 2013 north Otago fixed site survey (n=27 sites).

Common name	Scientific name	Catch (kg)	Number	Percent of total catch
Blue cod	*Parapercis colias*	916.0	1776	94.02
Octopus	*Octopus cordiformis*	24.3	4	2.49
Leatherjacket	*Parika scaber*	12.05	41	1.24
Scarlet wrasse	*Pseudolabrus miles*	11.59	31	1.19
Banded wrasse	*Notolabrus fucicola*	5.25	8	0.54
Red cod	*Pseudophycis bachus*	1.7	1	0.17
Spotty	*Notolabrus celidotus*	1.3	4	0.13
Tarakihi	*Nemadactylus macropterus*	0.9	3	0.09
Blue moki	*Latridopsis ciliaris*	0.7	1	0.07
Girdled wrasse	*Notolabrus cinctus*	0.5	1	0.05
Total		974.3	1870	100

Table 4: Catch weights, numbers of blue cod, bycatch species, and percentage of total weight from the 2013 north Otago random site survey (n=40 sites).

Common name	Scientific name	Catch (kg)	Number	Percent of total catch
Blue cod	*Parapercis colias*	1167.7	2450	94.01
Octopus	*Octopus cordiformis*	31.7	5	2.55
Leatherjacket	*Parika scaber*	20.13	60	1.62
Scarlet wrasse	*Pseudolabrus miles*	9.35	23	0.75
Blue moki	*Latridopsis ciliaris*	5.0	7	0.40
Tarakihi	*Nemadactylus macropterus*	4.25	43	0.34
Girdled wrasse	*Notolabrus cinctus*	1.9	3	0.15
Butterfly Perch	*Caesioperca lepidoptera*	1.1	2	0.09
Spotty	*Notolabrus celidotus*	1.0	2	0.08
Banded wrasse	*Notolabrus fucacola*	0.6	1	<0.01
Total		1242.1	2627	100

Table 5: Mean catch rates for all blue cod caught in the 2013 north Otago fixed site potting survey (See Figure 1). Catch rates are expressed as kg.pot^{-1} and s.e. and CV are set-based estimates. s.e., standard error, CV coefficient of variation.

Stratum	Sites	Pot lifts (N)	Mean (kg/pot)	s.e.	CV (%)
1	4	24	4.34	0.33	7.60
2	4	24	2.72	1.56	57.39
3	4	24	3.62	1.05	29.03
4	4	24	8.07	2.06	25.50
5	7	42	6.52	1.37	21.00
6	4	24	8.02	2.91	36.25
Total	27	162	4.96	0.63	12.62

Table 6: Mean catch rates for blue cod 30 cm and over (MLS in BCO 3) in the 2013 north Otago fixed site potting survey (See Figure 1). Catch rates are expressed as kg.pot^{-1} and s.e. and CV are set-based estimates. s.e., standard error, CV coefficient of variation.

Stratum	Sites	Pot lifts (N)	Mean (kg/pot)	s.e.	CV (%)
1	4	24	3.51	0.44	12.44
2	4	24	2.03	1.34	65.94
3	4	24	2.76	0.91	33.06
4	4	24	6.42	1.97	30.67
5	7	42	5.60	1.14	20.40
6	4	24	5.51	1.94	35.28
Total	27	162	3.94	0.54	13.71

Table 7: Mean catch rates for all blue cod caught in the 2013 north Otago random site potting survey (See Figure 1). Catch rates are expressed as kg.pot^{-1} and s.e. and CV are set-based estimates. s.e., standard error, CV coefficient of variation.

Stratum	Sites	Pot lifts (N)	Mean (kg/pot)	s.e.	CV (%)
1	8	48	5.15	1.87	36.39
2	6	36	0.94	0.53	56.54
3	6	36	3.53	1.85	52.38
4	6	36	5.38	1.46	27.12
5	8	48	6.19	1.28	20.64
6	6	36	7.46	1.99	26.66
Total	40	240	4.16	0.58	13.91

Table 8: Mean catch rates for blue cod 30 cm and over (MLS in BCO 3) in the 2013 north Otago random site potting survey (See Figure 1). Catch rates are expressed as kg.pot^{-1} and s.e. and CV are set-based estimates. s.e., standard error, CV coefficient of variation.

Stratum	Sites	Pot lifts (N)	Mean (kg/pot)	s.e.	CV (%)
1	8	48	3.88	1.57	40.56
2	6	36	0.46	0.16	35.91
3	6	36	2.59	1.37	52.88
4	6	36	3.70	0.98	26.46
5	8	48	4.75	0.94	19.77
6	6	36	5.28	1.56	29.62
Total	40	240	3.01	0.43	14.37

Table 9: Mean lengths of blue cod in the 2013 north Otago fixed site potting survey, by strata and sex: m, males; f, female. The sex ratio is shown as the number of females per male, and the percent of males (shown in brackets) is also given for all blue cod and those over the MLS (30 cm).

			Length (cm)			Sex ratio M:F (% male)	
Strata	Sex	N	Mean	Minimum	Maximum	All blue cod	≥ 30 cm
1	M	138	31.5	19	46	1:0.3 (76%)	1:0.3 (81%)
	F	43	27.3	17	39		
2	M	84	30.9	20	43	1:0.5 (67%)	1:0.5 (65%)
	F	41	30.6	21	42		
3	M	133	31.5	19	45	1:0.3 (76%)	1:0.1 (91%)
	F	41	26.0	15	41		
4	M	317	31.3	20	42	1:0.2 (82%)	1:0.1 (92%)
	F	71	26.5	19	38		
5	M	345	33.8	20	46	1:0.3 (76%)	1:013 (88%)
	F	110	27.7	18	33		
6	M	345	30.0	19	41	1:0.3 (76%)	1:0.1 (94%)
	F	108	25.0	15	35		
Overall (un-weighted)	M	1362	31.6	19	46	1:0.3 (77%)	1:0.1 (88%)
	F	414	26.9	15	42		

Table 10: Mean lengths of blue cod in the 2013 north Otago random site potting survey, by strata and sex: m, males; f, female. The sex ratio is shown as the number of females per male, and the percent of males (shown in brackets) is also given for all blue cod and those over the MLS (30 cm).

			Length (cm)			Sex ratio M:F (% male)	
Strata	Sex	N	Mean	Minimum	Maximum	All blue cod	≥ 30 cm
1	M	325	31.2	19	45	1:0.6 (62%)	1:0.4 (70%)
	F	179	29.3	18	42		
2	M	52	25.6	19	43	1:1.0 (50%)	1:2.0 (33%)
	F	53	27.1	16	38		
3	M	158	30.8	19	45	1:0.4 (71%)	1:0.2 (84%)
	F	79	26.1	17	38		
4	M	327	30.0	19	47	1:0.4 (73%)	1:0.1 (92%)
	F	121	25.4	17	39		
5	M	399	32.2	19	46	1:0.4 (72%)	1:0.2 (86%)
	F	158	27.5	16	44		
6	M	415	30.0	19	45	1:0.4 (69%)	1:0.3 (75%)
	F	184	28.1	17	39		
Overall (un-weighted)	M	1676	30.7	19	49	1:0.5 (68%)	1:0.3 (79%)
	F	774	27.6	16	44		

Table 11: Gonad stages of north Otago blue cod in 2013 fixed sites. 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.

	Gonad stage					
	1	2	3	4	5	N
Males	23	1105	70	115	49	1362
Females	4	327	59	10	14	414

Table 12: Gonad stages of north Otago blue cod in 2013 random sites. 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.

	Gonad stage (%)					
	1	2	3	4	5	N
Males	30	1305	120	186	35	1676
Females	14	516	187	26	31	774

Table 13: Otolith raw data used in the catch at age, *Z* estimates, and SPR analyses for both the 2013 north Otago fixed and random surveys.

		Length of aged fish (cm)			Age (years)		
Survey	No. otos	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Total	267	31.2	15	49	9.5	2	26
Male	153	33.0	19	49	9.4	3	26
Female	129	29.1	15	44	9.7	2	24

Table 14: Blue cod total mortality estimates (*Z*) with 95% confidence intervals and corresponding spawning biomass per recruit ratios (assuming M=0.14) for ages of recruitment (AgeR) from 5 to 11 for the 2013 north Otago fixed site survey.

		Confidence intervals		
AgeR	*Z*	Lower	Upper	%SPR
5	0.22	0.16	0.30	62.26
6	0.26	0.19	0.35	52.87
7	0.31	0.22	0.44	45.22
8	0.36	0.26	0.50	40.32
9	0.39	0.29	0.54	38.15
10	0.46	0.33	0.66	34.11
11	0.47	0.33	0.68	33.70

Table 15: Blue cod total mortality estimates (*Z*) with 95% confidence intervals and corresponding spawning biomass per recruit ratios (assuming M=0.14) for ages of recruitment (AgeR) from 5 to 11 for the 2013 north Otago random site survey.

		Confidence intervals		
AgeR	*Z*	Lower	Upper	%SPR
5	0.23	0.17	0.33	58.51
6	0.27	0.20	0.38	50.30
7	0.33	0.23	0.46	43.60
8	0.37	0.26	0.52	39.80
9	0.38	0.28	0.54	38.63
10	0.43	0.30	0.61	35.73
11	0.44	0.31	0.63	35.30

Table 16: Mortality rates and spawning biomass per recruit ratios, assuming an age of recruitment of 10, at three values of M (natural mortality) for the 2013 north Otago fixed site potting survey. Z=total mortality.

M	Z	%SPR
0.11	0.46	25%
0.14	0.46	34%
0.17	0.46	43%

Table 17: Mortality rates and spawning biomass per recruit ratios, assuming an age of recruitment of 10, at three values of M (natural mortality) for the 2013 north Otago random site potting survey. Z=total mortality.

M	Z	%SPR
0.11	0.43	26%
0.14	0.43	36%
0.17	0.43	45%

Table 18: Drift underwater video (DUV) and pot sample details (site 19). Note that stations are individual transects and pots. *=includes equivalent number of fish-dependent habitat quadrats.

	DUV	Pots
Sites	1	1
Stations	5	6
Habitat sections	25	-
Habitat quadrats	125	-
Total transects length	2 720 m	-
Mean transect length	544 m (± 65.7)	-
Mean transect width	2.3 m (± 0.1)	-
Total area swept	5 979 m^2	
Blue cod		
Total	133*	98
Length range (cm)	10-39	18-44
Mean length ± se	21.2±0.5	28.3±0.6

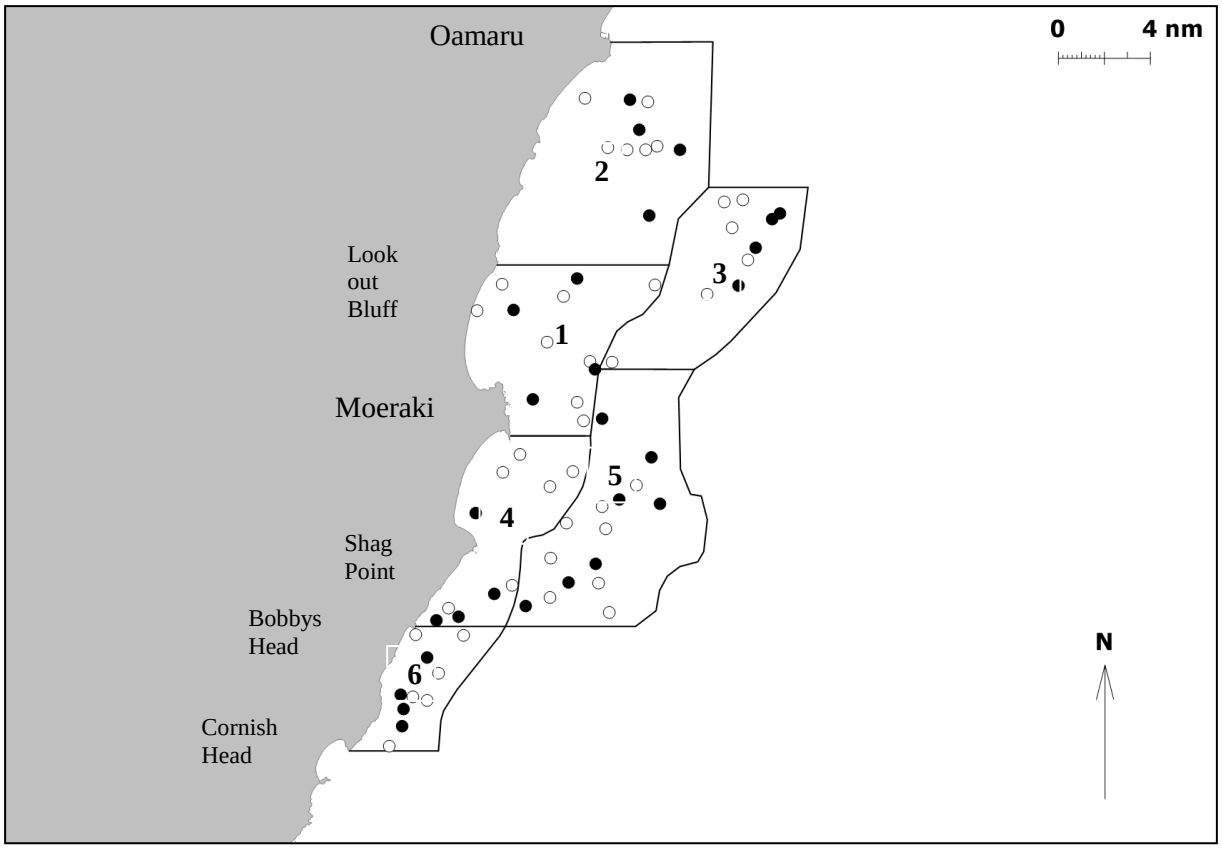


Figure 1: Strata and sites surveyed in the 2013 north Otago fixed site (●) and random site (○) surveys.

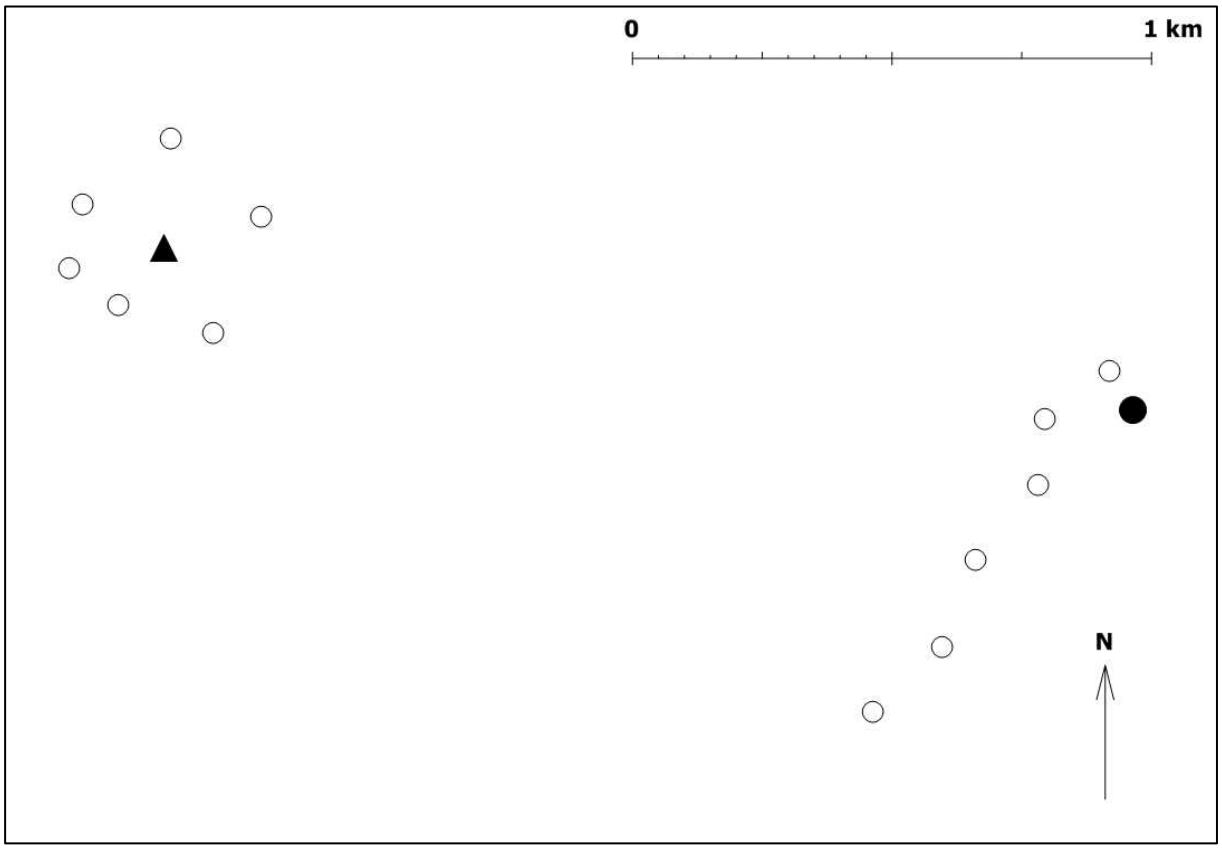


Figure 2: Placement of pots (○) at a typical fixed (●) and random (▲) site from the 2013 north Otago potting survey. Solid symbols are ADCP locations.

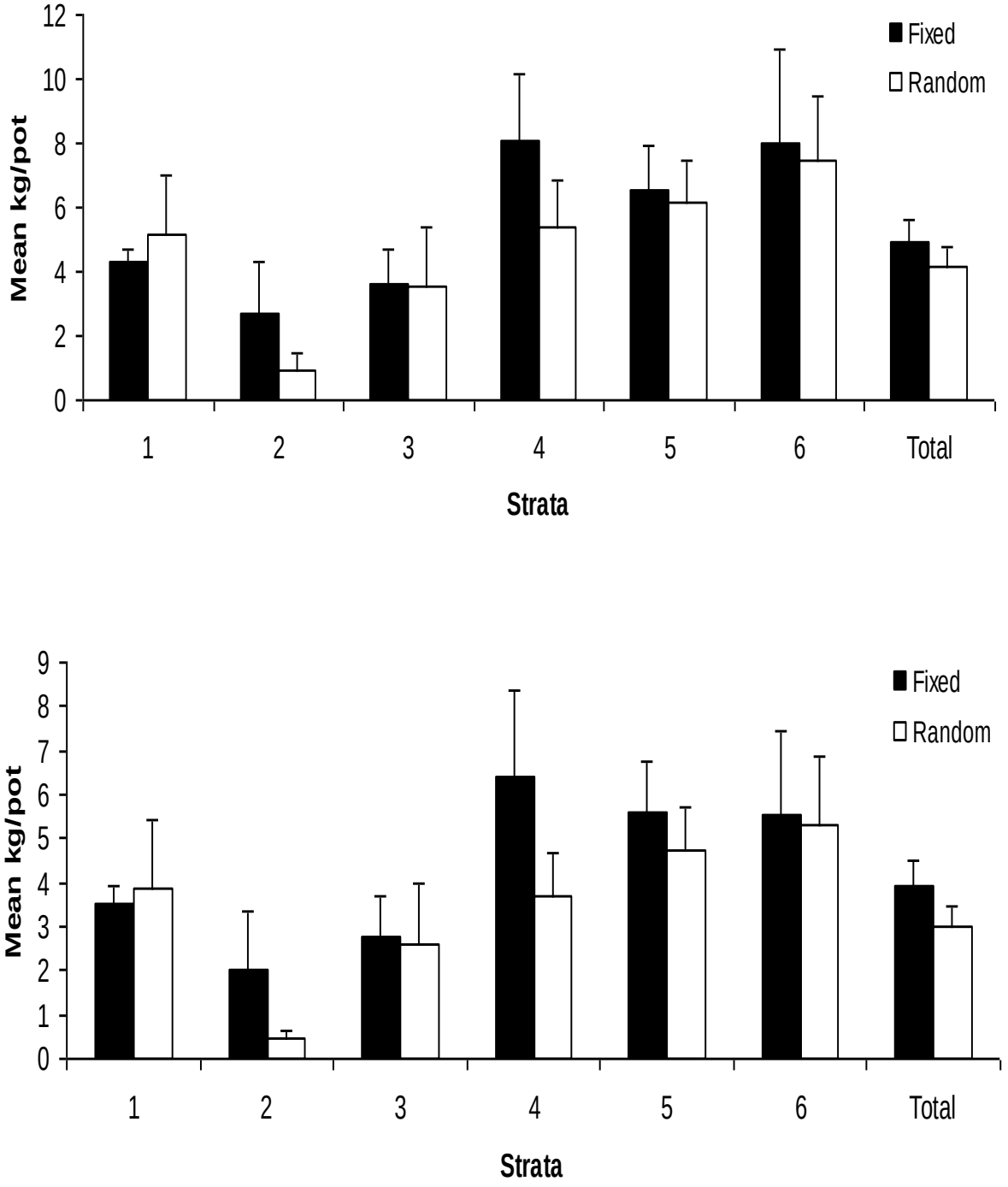


Figure 3: Catch rates (kg.pot^{-1}) and 95% confidence intervals for all blue cod (above) and those 30 cm and over (below) from the 2013 north Otago fixed and random site potting surveys. Strata and sites are shown in Figure 1.

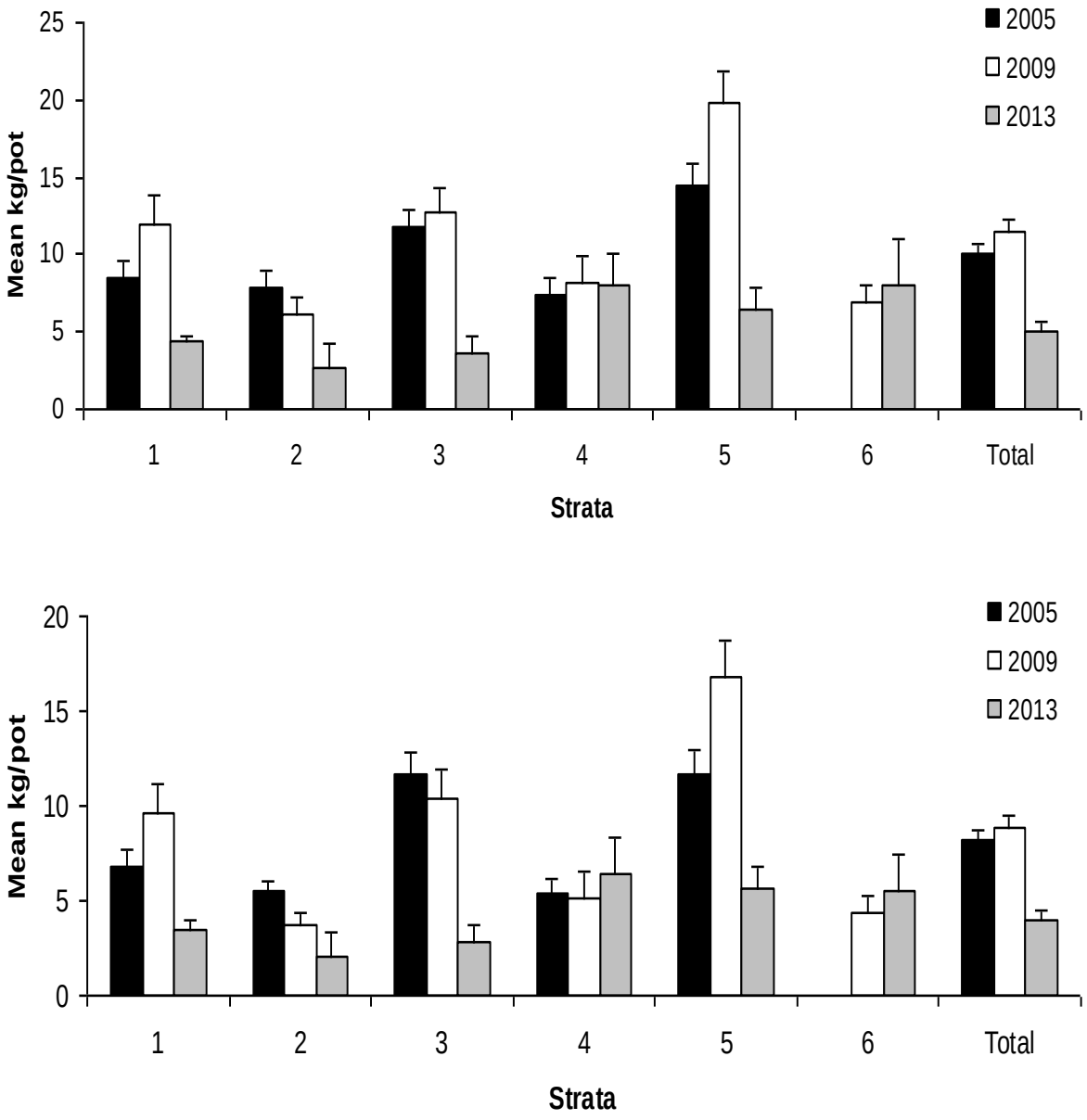


Figure 4: Catch rates (kg.pot^{-1}) and 95% confidence intervals for all blue cod (above) and those 30 cm and over (below) from the north Otago fixed site potting surveys time series. Strata and sites are shown in Figure 1.

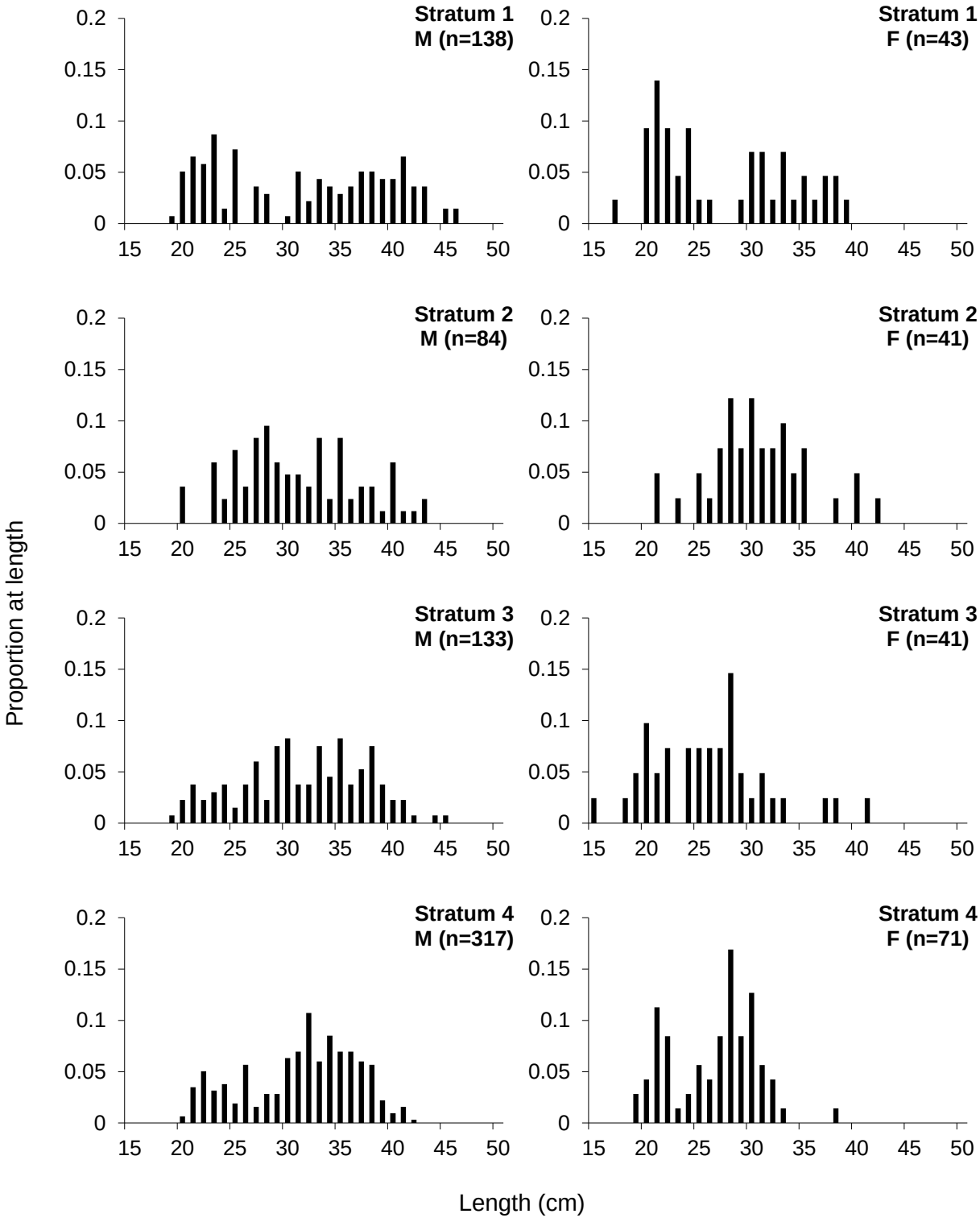


Figure 5: Fixed site survey unscaled proportion length frequency distributions by sex within stratum length frequency distributions by sex (M=male, F=female) for the 2013 north Otago potting survey. Strata are shown in Figure 1.

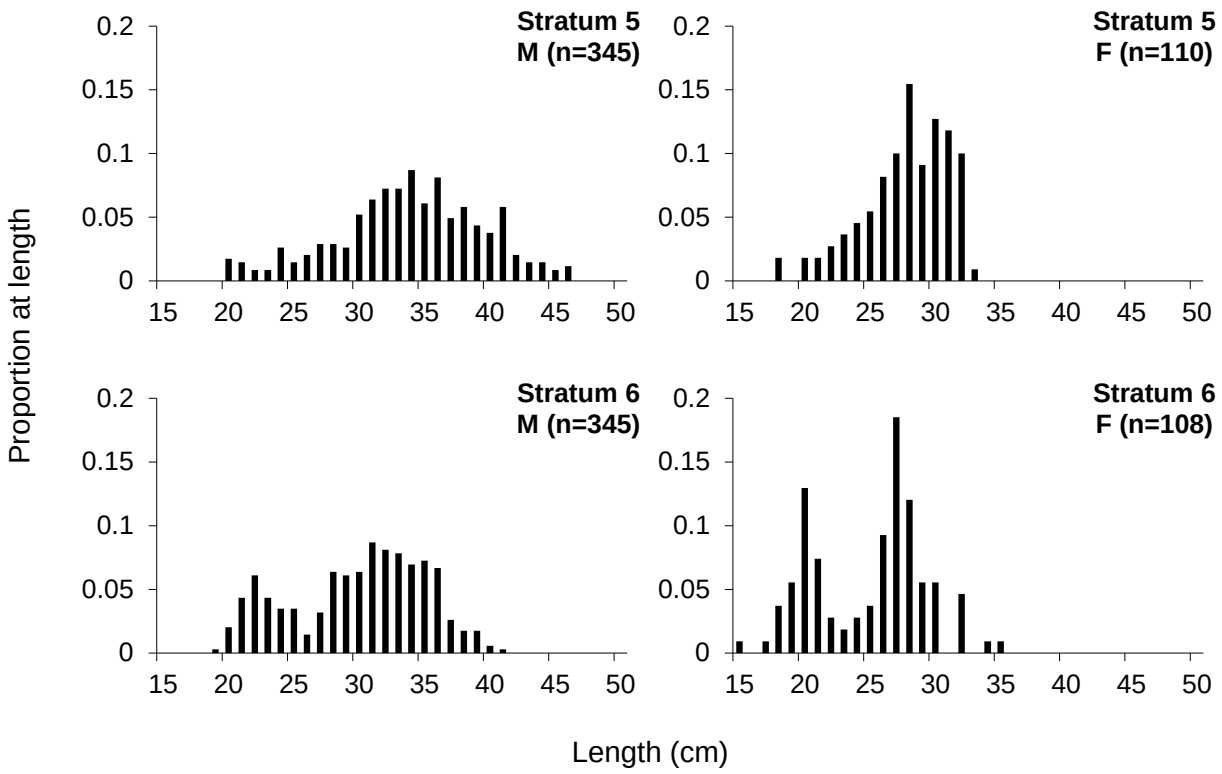


Figure 5 continued.

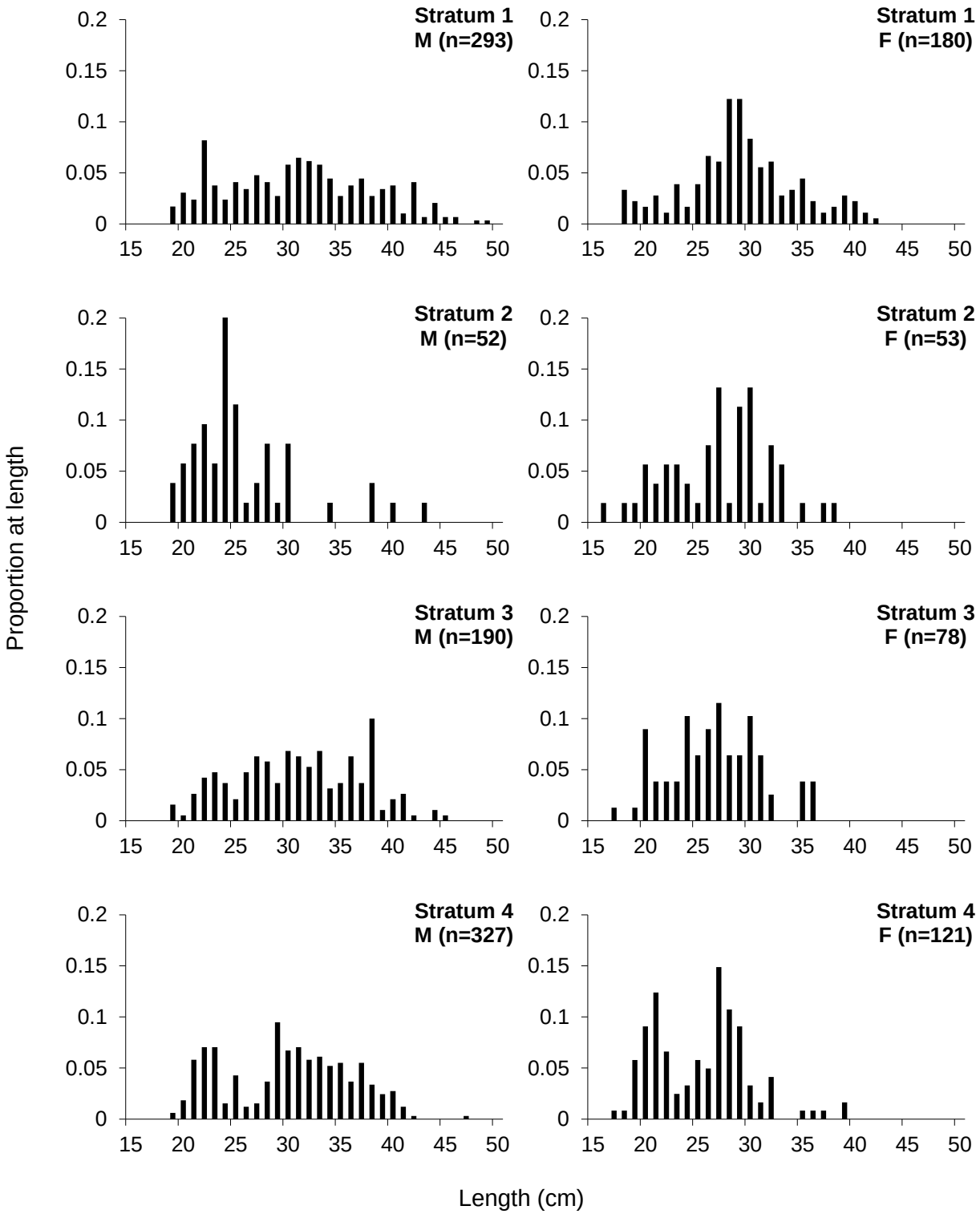


Figure 6: Random site survey unscaled proportional length frequency distributions within stratum by sex (M=male, F=female) for the 2013 north Otago potting survey. Strata are shown in Figure 1.

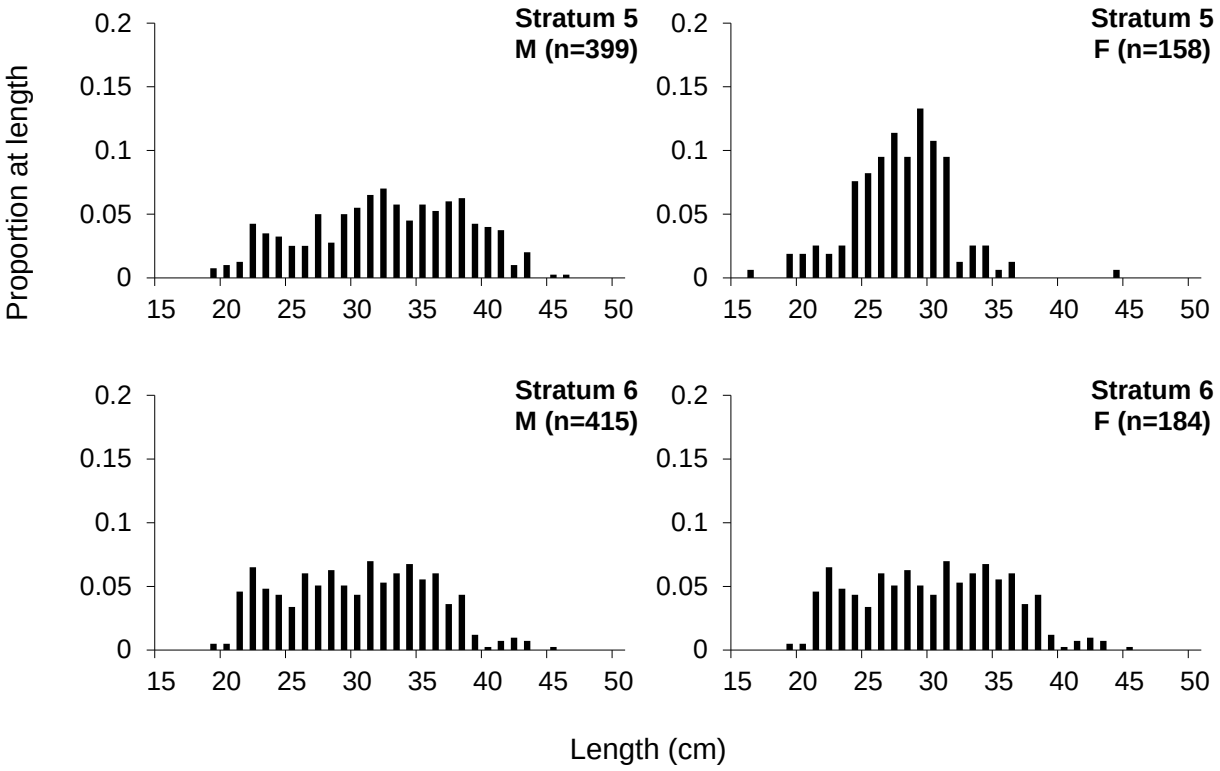


Figure 6 continued.

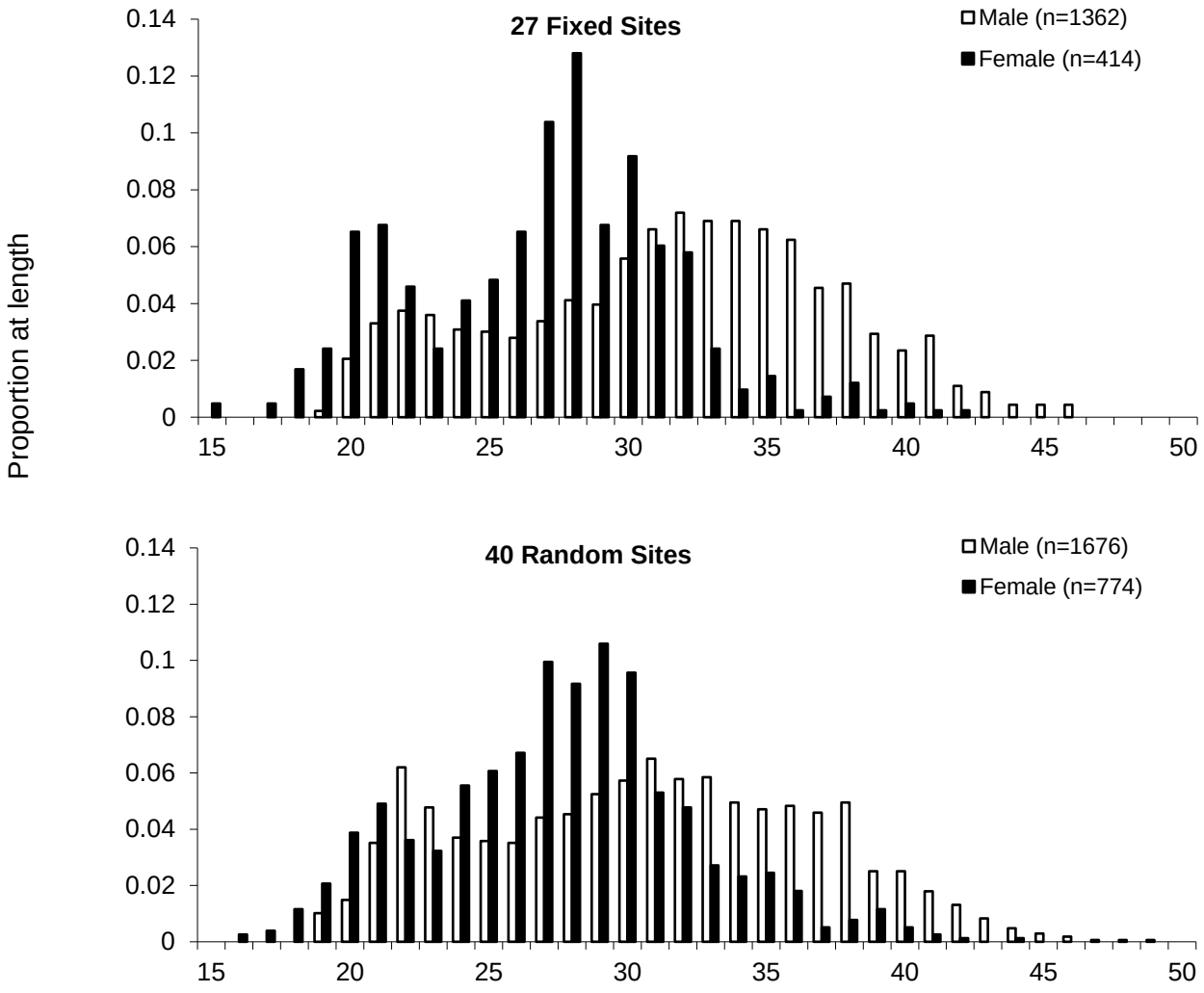


Figure 7: Unscaled proportional length frequency distributions within survey design (fixed sites above and random sites below) by sex for the 2013 north Otago potting surveys.

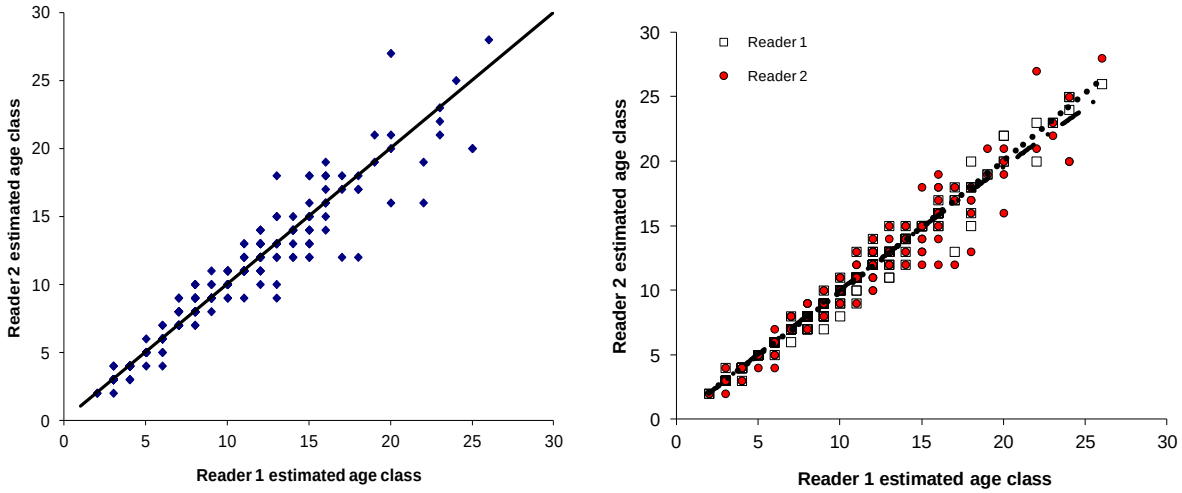


Figure 8: North Otago 2013 survey comparison of individual reader age class estimates from otoliths (n=267), on the left plotted against each other and on the left with the 1:1 line plotted. In the right panel the agreed age class estimates is plotted against the individual readers age class estimates with a polynomial trend line fitted for each reader.

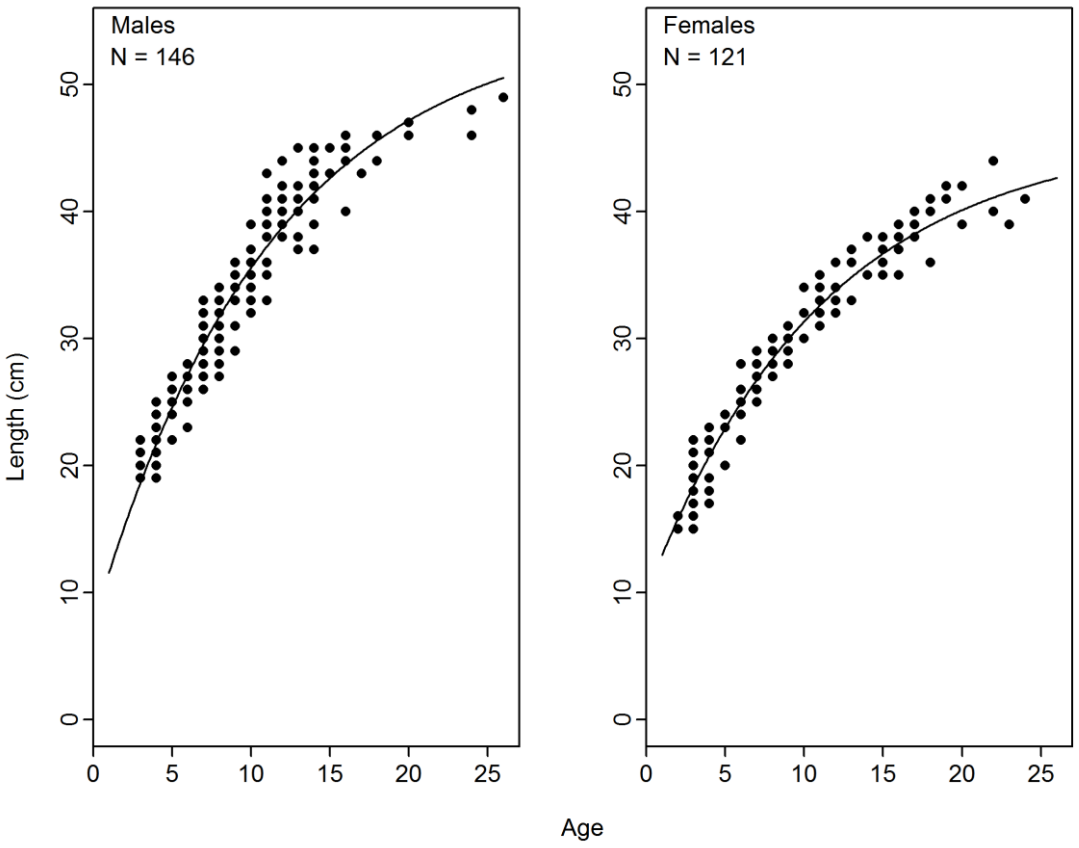


Figure 9: Observed length-at-age data and fitted von Bertalanffy growth models by sex for the 2013 north Otago survey. See Table 13 for description of biological samples.

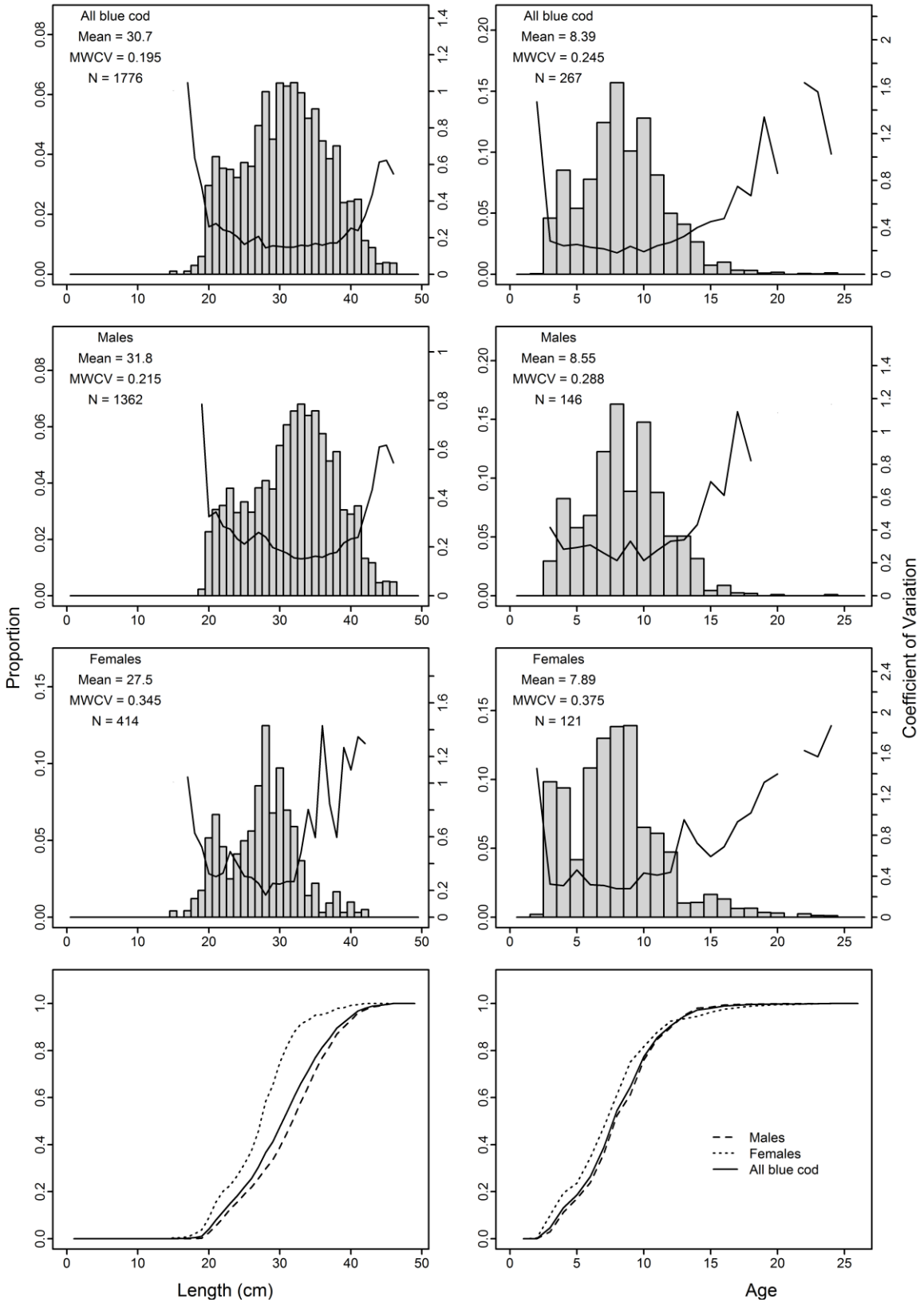


Figure 10: Scaled length frequency, age frequency, and cumulative distributions for total, male, and female blue cod for the 2013 north Otago Inlet fixed site potting survey. N, sample size; MWCV, mean weighted coefficient of variation.

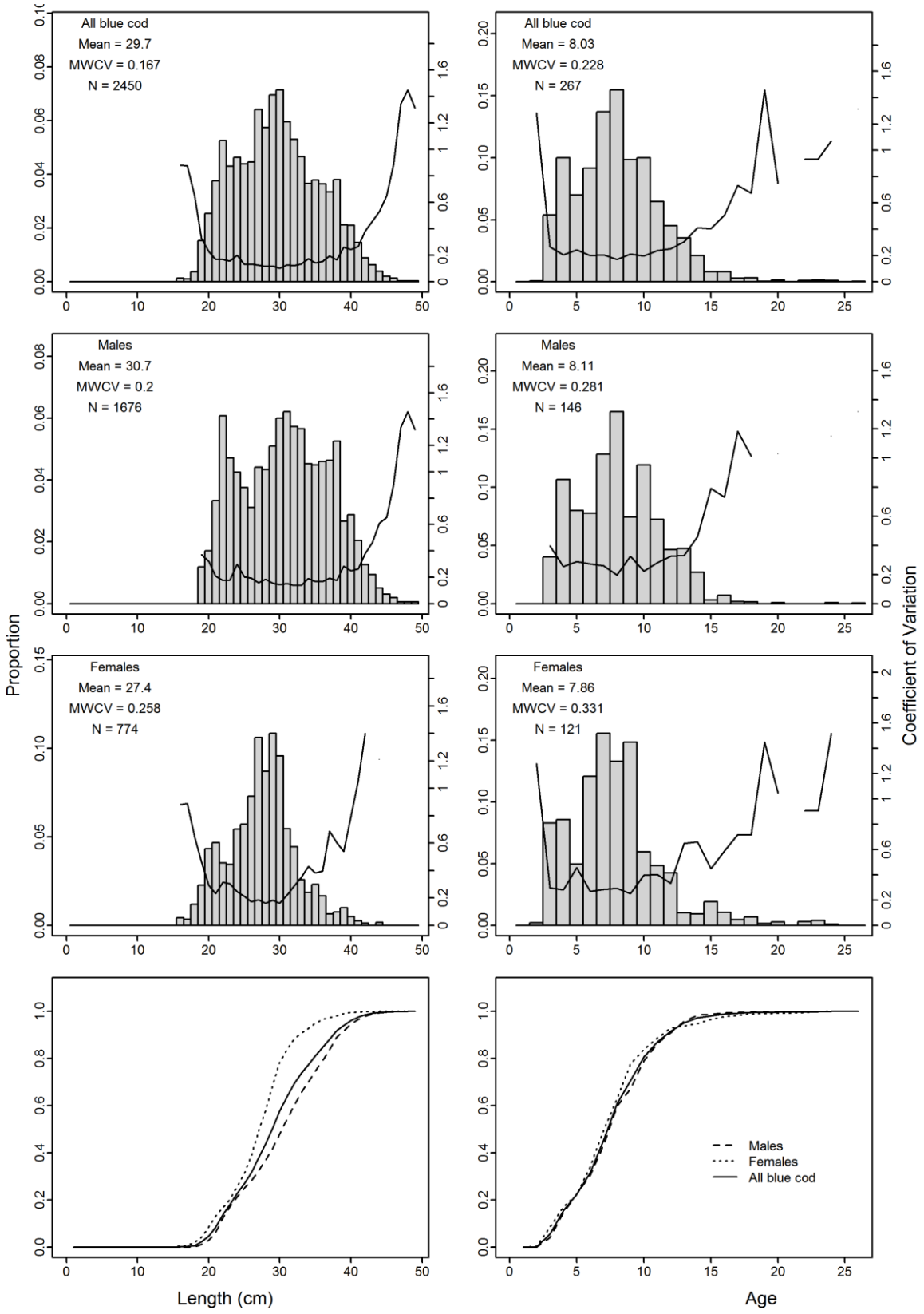


Figure 11: Scaled length frequency, age frequency, and cumulative distributions for total, male, and female blue cod for the 2013 north Otago random site potting survey. N, sample size; MWCV, mean weighted coefficient of variation.

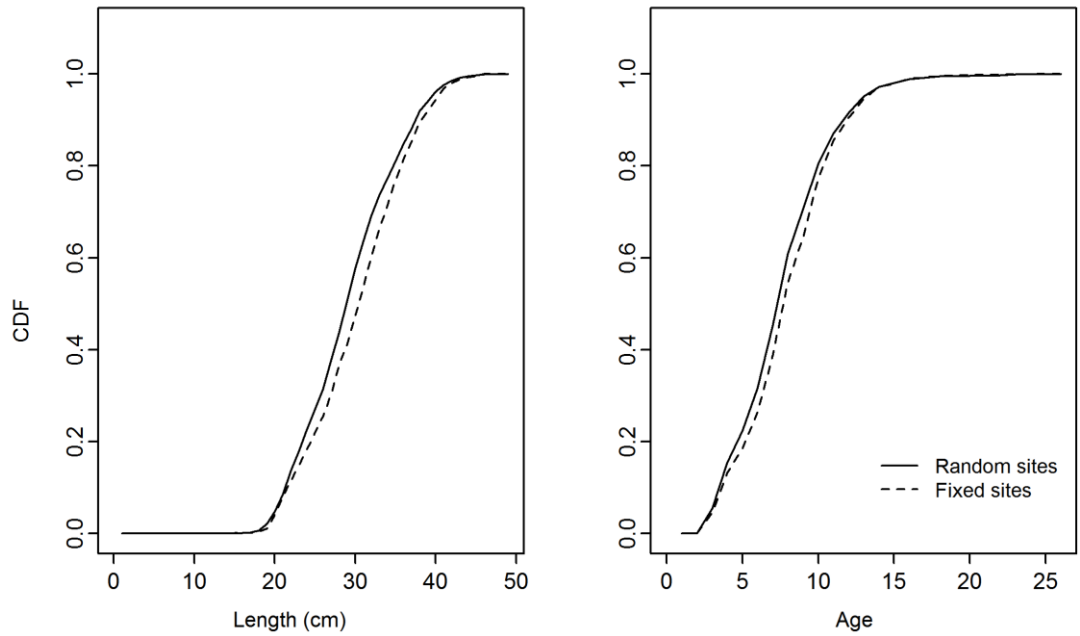


Figure 12: Cumulative length and age frequency distribution of all blue cod for the 2013 north Otago fixed and random site potting surveys.

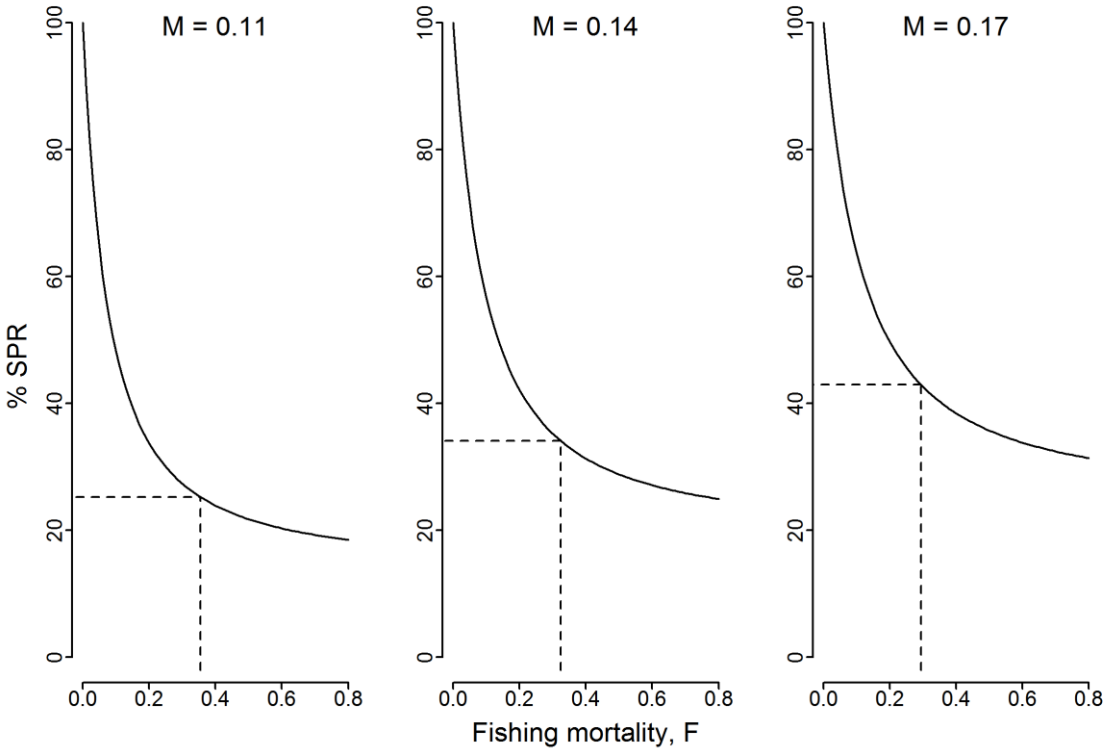


Figure 13: Plot of spawning biomass per recruit (SPR) as a function of fishing mortality for the 2013 north Otago fixed site potting survey at three values of M (0.11, 0.14, 0.17).

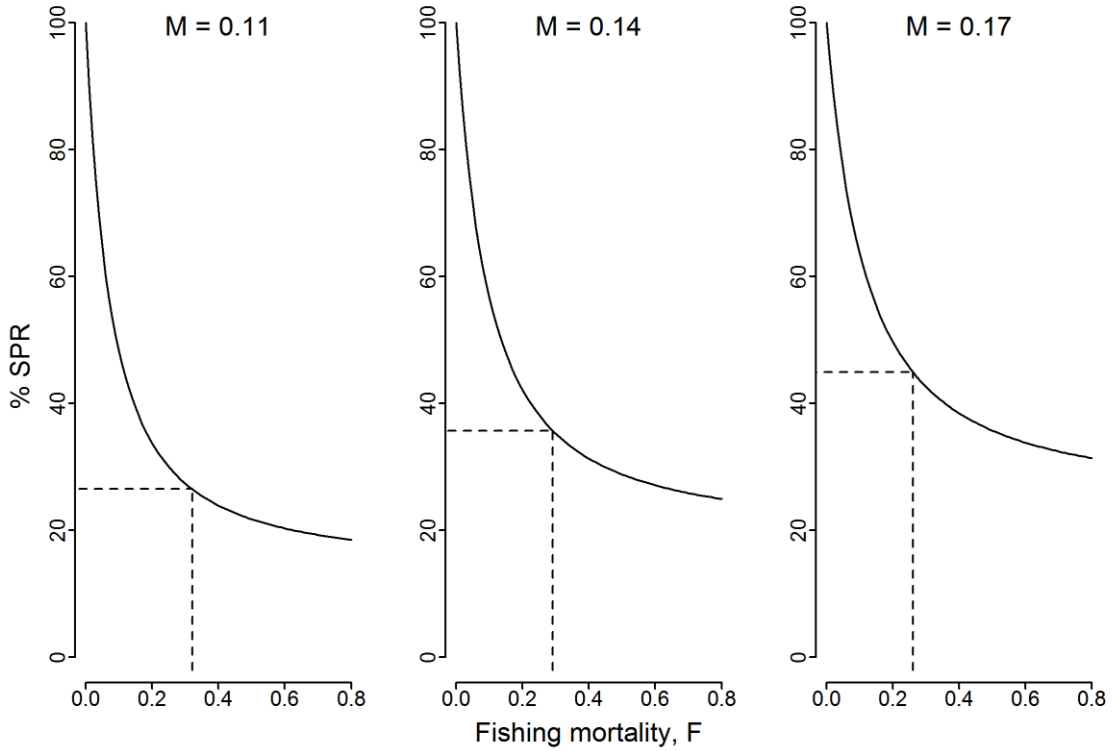


Figure 14: Plot of spawning biomass per recruit (SPR) as a function of fishing mortality for the 2013 north Otago random site potting survey at three values of M (0.11, 0.14, 0.17).

Appendix 1: Terminology used in potting surveys.

In this report we use the terms defined in the blue cod potting survey manual (Beentjes & Francis 2011)

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).

Fixed site A predetermined site within a given stratum, that has a fixed location (single latitude and longitude or the centre point location of a section of coastline) and is available to be used repeatedly on subsequent surveys in that area. Fixed sites are known fishing spots identified by local fishers. Which fixed sites are used in a particular survey is determined by random selection from all available fixed sites in each stratum. Fixed sites are sometimes referred to as an index site or a fisher-selected site**.**

Random site A site that can have any location (single latitude and longitude) generated randomly from within a stratum, given the constraints of proximity to other selected sites for a specific survey.

Site label An alphanumeric label of no more than 4 characters unique within a survey time series. A site label identifies each site and also specifies which stratum it lies in. Fixed 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. Note that fixed site label remain constantly fixed to that location for all surveys. In contrast, random sites are regenerated for each survey and use a numeric label based on the order in which they were randomly generated, followed by the letter R and then concatenated with the stratum code. Thus, sites within stratum 2 could be labelled 2R1, 2R3, and sites in stratum 3 could be labelled 3R1, 3R2 etc.

Set A group of pots deployed in the vicinity of a selected site in a specific survey. The pots are set in a cluster or linear configuration.

Set number A number assigned to the each set within a survey. Set numbers are defined sequentially in the order fished. Thus, any set within a survey is uniquely defined by a trip code and set number. Note that the set number is not recorded in the *trawl* database in isolation, but is entered as part of attribute *station_no*in table *t_station*.

Station The position (latitude and longitude) at which a single pot (or other fishing gear) is deployed at a site during a survey, i.e. it is unique for the trip.

Pot number Pots are numbered sequentially (1 to 6) in the order they are placed during a set.

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 number 234. This convention is important in enabling users of the *trawl* database to determine whether two pots are from the same set.

Pot placement There are two types of pot placement 1) Directed, where the position of each pot is directed by the skipper using local knowledge and the vessel SONAR to locate a suitable area of reef/cobble or biogenic habitat (this is how pots are set at fixed sites). 2) Systematic, where the position of each pot is determined from a fixed pattern set systematically around a site centre point. The pots are set blind with no knowledge of the bottom type (this is how pots are set at random sites).

Appendix 2: Summary of survey pot station data for north Otago 2013. Fixed sites are denoted by a single letter, random sites by the letter R and a number.

								Catch of blue cod	
Set	Date	Phase	Stratum	Site	Depth (m)	Time set	Pot	(kg)	Number
1	21-Jan-13	1	2	L	17.9	6:00	1	16.2	29
1	21-Jan-13	1	2	L	18.2	6:09	2	18.4	34
1	21-Jan-13	1	2	L	18.2	6:19	3	1.0	1
1	21-Jan-13	1	2	L	18.2	6:28	4	3.2	5
1	21-Jan-13	1	2	L	18.6	6:38	5	3.5	3
1	21-Jan-13	1	2	L	18.8	6:47	6	1.0	2
2	21-Jan-13	1	2	H	27.3	9:10	6	0	0
2	21-Jan-13	1	2	H	27.3	9:15	5	0	0
2	21-Jan-13	1	2	H	27.3	9:23	4	0.6	1
2	21-Jan-13	1	2	H	27.3	9:29	3	0	0
2	21-Jan-13	1	2	H	27.3	9:36	2	0.4	1
2	21-Jan-13	1	2	H	27.3	9:41	1	0	0
3	21-Jan-13	1	2	C	21.9	11:40	1	0	0
3	21-Jan-13	1	2	C	20.1	11:45	2	0	0
3	21-Jan-13	1	2	C	21.9	11:50	3	6.4	7
3	21-Jan-13	1	2	C	21.9	11:55	4	0.7	1
3	21-Jan-13	1	2	C	21.9	12:00	5	0	0
3	21-Jan-13	1	2	C	21.9	12:05	6	0	0
4	21-Jan-13	1	2	R2	23.7	13:33	6	0	0
4	21-Jan-13	1	2	R2	23.7	13:40	5	0	0
4	21-Jan-13	1	2	R2	23.7	13:45	4	0	0
4	21-Jan-13	1	2	R2	23.7	13:50	3	0	0
4	21-Jan-13	1	2	R2	22.8	13:55	2	0	0
4	21-Jan-13	1	2	R2	23.0	14:00	1	0	0
5	21-Jan-13	1	2	R1	21.9	15:28	1	0.7	1
5	21-Jan-13	1	2	R1	21.9	15:33	2	4.5	8
5	21-Jan-13	1	2	R1	20.1	15:37	3	0	0
5	21-Jan-13	1	2	R1	20.1	15:40	4	0	0
5	21-Jan-13	1	2	R1	20.1	15:44	5	0	0
5	21-Jan-13	1	2	R1	21.9	15:47	6	0.3	1
6	22-Jan-13	1	3	F	40.1	7:20	6	0	0
6	22-Jan-13	1	3	F	40.1	7:25	5	0	0
6	22-Jan-13	1	3	F	40.1	7:34	4	0	0
6	22-Jan-13	1	3	F	40.1	7:40	3	0	0
6	22-Jan-13	1	3	F	40.1	7:45	2	0	0
6	22-Jan-13	1	3	F	40.1	7:50	1	10.8	20
7	22-Jan-13	1	3	B	38.3	9:28	1	3.9	8
7	22-Jan-13	1	3	B	34.6	9:33	2	1.6	3
7	22-Jan-13	1	3	B	34.6	9:37	3	5.3	10
7	22-Jan-13	1	3	B	38.3	9:43	4	3.1	7
7	22-Jan-13	1	3	B	38.3	9:49	5	11.7	19
7	22-Jan-13	1	3	B	40.1	9:55	6	13.8	21
8	22-Jan-13	1	3	D	41.9	11:45	6	6.8	12
8	22-Jan-13	1	3	D	41.9	11:50	5	0.5	1
8	22-Jan-13	1	3	D	41.9	11:55	4	0	0

Set	Date	Phase	Stratum	Site	Depth (m)	Time set	Pot	Catch of blue cod (kg)	Catch of blue cod Number
8	22-Jan-13	1	3	D	40.1	12:00	3	4.5	9
8	22-Jan-13	1	3	D	41.9	12:05	2	0.2	1
8	22-Jan-13	1	3	D	41.9	12:10	1	3.1	9
9	22-Jan-13	1	2	B	21.9	14:50	1	13.5	40
9	22-Jan-13	1	2	B	23.7	14:55	2	0.4	1
9	22-Jan-13	1	2	B	23.7	15:00	3	0	0
9	22-Jan-13	1	2	B	23.7	15:06	4	0	0
9	22-Jan-13	1	2	B	23.7	15:11	5	0	0
9	22-Jan-13	1	2	B	23.7	15:16	6	0	0
10	23-Jan-13	1	3	R1	36.5	7:36	6	0	0
10	23-Jan-13	1	3	R1	34.6	7:40	5	0	0
10	23-Jan-13	1	3	R1	34.6	7:45	4	0	0
10	23-Jan-13	1	3	R1	34.6	7:49	3	0	0
10	23-Jan-13	1	3	R1	34.6	7:55	2	0.4	1
10	23-Jan-13	1	3	R1	32.8	8:02	1	0	0
11	23-Jan-13	1	3	R2	34.6	9:20	1	10.3	21
11	23-Jan-13	1	3	R2	36.5	9:24	2	17.5	32
11	23-Jan-13	1	3	R2	36.5	9:28	3	2.3	5
11	23-Jan-13	1	3	R2	36.5	9:32	4	12.2	22
11	23-Jan-13	1	3	R2	36.5	9:35	5	7.7	16
11	23-Jan-13	1	3	R2	36.5	9:38	6	3.1	14
12	23-Jan-13	1	3	R3	41.9	11:17	6	0	0
12	23-Jan-13	1	3	R3	41.9	11:21	5	0	0
12	23-Jan-13	1	3	R3	41.9	11:25	4	0	0
12	23-Jan-13	1	3	R3	41.9	11:29	3	1.7	2
12	23-Jan-13	1	3	R3	41.9	11:33	2	2.8	7
12	23-Jan-13	1	3	R3	41.9	11:37	1	0	0
13	23-Jan-13	1	3	R5	38.3	13:25	1	0	0
13	23-Jan-13	1	3	R5	38.3	13:29	2	0	0
13	23-Jan-13	1	3	R5	38.3	13:34	3	3.4	6
13	23-Jan-13	1	3	R5	38.3	13:37	4	4.9	11
13	23-Jan-13	1	3	R5	38.3	13:41	5	0	0
13	23-Jan-13	1	3	R5	38.3	13:45	6	0	0
14	25-Jan-13	1	2	R5	18.2	6:05	6	0	0
14	25-Jan-13	1	2	R5	20.1	6:10	5	0	0
14	25-Jan-13	1	2	R5	20.1	6:16	4	4.1	9
14	25-Jan-13	1	2	R5	20.1	6:21	3	0	0
14	25-Jan-13	1	2	R5	20.1	6:26	2	0.9	1
14	25-Jan-13	1	2	R5	20.1	6:31	1	0.2	1
15	25-Jan-13	1	2	R6	21.9	8:06	1	0.9	1
15	25-Jan-13	1	2	R6	21.9	8:10	2	0	0
15	25-Jan-13	1	2	R6	21.9	8:14	3	0	0
15	25-Jan-13	1	2	R6	21.9	8:18	4	1.5	2
15	25-Jan-13	1	2	R6	21.9	8:22	5	0	0
15	25-Jan-13	1	2	R6	21.9	8:26	6	0	0
16	25-Jan-13	1	2	R4	12.8	10:35	6	0	0
16	25-Jan-13	1	2	R4	12.8	10:39	5	0	0
16	25-Jan-13	1	2	R4	12.8	10:44	4	0	0

Set	Date	Phase	Stratum	Site	Depth (m)	Time set	Pot	Catch of blue cod (kg)	Catch of blue cod Number
16	25-Jan-13	1	2	R4	13.7	10:47	3	0	0
16	25-Jan-13	1	2	R4	12.8	10:50	2	0	0
16	25-Jan-13	1	2	R4	12.8	10:54	1	0	0
17	25-Jan-13	1	3	R6	32.1	6:40	1	0	0
17	25-Jan-13	1	3	R6	31.4	6:45	2	0.6	1
17	25-Jan-13	1	3	R6	32.1	6:50	3	0	0
17	25-Jan-13	1	3	R6	31.4	6:53	4	0	0
17	25-Jan-13	1	3	R6	31.0	6:58	5	0	0
17	25-Jan-13	1	3	R6	31.0	7:02	6	1.3	1
18	28-Jan-13	1	3	H	40.1	8:33	6	13.7	26
18	28-Jan-13	1	3	H	40.1	8:37	5	3.6	20
18	28-Jan-13	1	3	H	40.1	8:41	4	0.5	4
18	28-Jan-13	1	3	H	40.1	8:45	3	0	0
18	28-Jan-13	1	3	H	40.1	8:49	2	0	0
18	28-Jan-13	1	3	H	40.1	8:54	1	3.8	4
19	28-Jan-13	1	1	R1	32.8	14:00	1	16.5	30
19	28-Jan-13	1	1	R1	31.0	14:05	2	10.0	23
19	28-Jan-13	1	1	R1	32.8	14:08	3	6.1	12
19	28-Jan-13	1	1	R1	32.8	14:12	4	3.1	4
19	28-Jan-13	1	1	R1	32.8	14:16	5	1.9	13
19	28-Jan-13	1	1	R1	32.8	14:20	6	5.5	16
20	29-Jan-13	1	2	R3	18.2	5:36	6	4.5	11
20	29-Jan-13	1	2	R3	17.7	5:45	5	1.5	14
20	29-Jan-13	1	2	R3	18.2	5:52	4	6.5	13
20	29-Jan-13	1	2	R3	18.0	5:57	3	2.1	18
20	29-Jan-13	1	2	R3	17.9	6:03	2	3.5	6
20	29-Jan-13	1	2	R3	19.7	6:08	1	2.8	19
21	29-Jan-13	1	1	H	23.3	8:36	1	4.3	6
21	29-Jan-13	1	1	H	23.3	8:41	2	4.9	11
21	29-Jan-13	1	1	H	22.8	8:45	3	5.0	5
21	29-Jan-13	1	1	H	23.1	8:49	4	2.4	3
21	29-Jan-13	1	1	H	23.3	8:54	5	7.5	37
21	29-Jan-13	1	1	H	23.5	8:59	6	3.8	13
22	29-Jan-13	1	1	R4	21.5	10:18	6	13.8	38
22	29-Jan-13	1	1	R4	21.1	10:22	5	22.9	53
22	29-Jan-13	1	1	R4	21.1	10:26	4	3.9	8
22	29-Jan-13	1	1	R4	21.0	10:30	3	5.9	14
22	29-Jan-13	1	1	R4	21.1	10:34	2	2.3	3
22	29-Jan-13	1	1	R4	21.3	10:38	1	1.0	1
23	29-Jan-13	1	1	D	14.2	12:18	1	1.4	5
23	29-Jan-13	1	1	D	14.4	12:22	2	0	0
23	29-Jan-13	1	1	D	14.4	12:26	3	1.6	4
23	29-Jan-13	1	1	D	14.6	12:30	4	2.5	7
23	29-Jan-13	1	1	D	14.9	12:34	5	0.3	3
23	29-Jan-13	1	1	D	14.6	12:38	6	17.2	19
24	29-Jan-13	1	1	R5	10.8	6:36	2	2.6	9
24	29-Jan-13	1	1	R5	10.8	6:40	1	6.2	8
24	29-Jan-13	1	1	R5	11.1	6:44	3	7.6	10

Set	Date	Phase	Stratum	Site	Depth (m)	Time set	Pot	Catch of blue cod (kg)	Catch of blue cod Number
24	29-Jan-13	1	1	R5	11.8	6:49	4	1.8	4
24	29-Jan-13	1	1	R5	10.9	6:53	5	2.1	2
24	29-Jan-13	1	1	R5	11.3	6:57	6	1.2	5
25	29-Jan-13	1	1	R6	5.8	8:25	6	0	0
25	29-Jan-13	1	1	R6	6.2	8:30	5	0	0
25	29-Jan-13	1	1	R6	6.0	8:34	4	0	0
25	29-Jan-13	1	1	R6	5.5	8:38	3	0	0
25	29-Jan-13	1	1	R6	5.1	8:42	2	0	0
25	29-Jan-13	1	1	R6	4.7	8:46	1	0	0
26	31-Jan-13	1	1	I	21.9	10:45	1	2.5	3
26	31-Jan-13	1	1	I	21.5	10:50	2	8.1	10
26	31-Jan-13	1	1	I	20.4	10:55	3	0	0
26	31-Jan-13	1	1	I	20.4	11:00	4	3.3	6
26	31-Jan-13	1	1	I	20.1	11:05	5	8.1	10
26	31-Jan-13	1	1	I	21.0	11:10	6	8.7	8
27	31-Jan-13	1	1	F	29.2	6:06	6	7.3	10
27	31-Jan-13	1	1	F	29.2	6:11	5	1.1	2
27	31-Jan-13	1	1	F	29.2	6:16	4	1.4	3
27	31-Jan-13	1	1	F	29.2	6:21	3	0.9	1
27	31-Jan-13	1	1	F	29.2	6:26	2	10.2	13
27	31-Jan-13	1	1	F	29.0	6:31	1	1.6	2
28	31-Jan-13	1	3	R4	31.4	7:51	1	11.9	32
28	31-Jan-13	1	3	R4	32.3	7:56	2	26.5	50
28	31-Jan-13	1	3	R4	32.4	7:59	3	3.7	12
28	31-Jan-13	1	3	R4	31.0	8:03	4	10.2	21
28	31-Jan-13	1	3	R4	31.4	8:06	5	6.6	14
28	31-Jan-13	1	3	R4	31.5	8:10	6	0	0
29	31-Jan-13	1	1	R3	29.2	9:40	6	0	0
29	31-Jan-13	1	1	R3	27.7	9:44	5	0	0
29	31-Jan-13	1	1	R3	28.4	9:48	4	0	0
29	31-Jan-13	1	1	R3	28.3	9:52	3	3.9	4
29	31-Jan-13	1	1	R3	28.3	9:56	2	0	0
29	31-Jan-13	1	1	R3	28.3	10:00	1	0	0
30	31-Jan-13	1	1	R2	31.4	11:43	1	7.7	14
30	31-Jan-13	1	1	R2	33.2	11:47	2	19.1	53
30	31-Jan-13	1	1	R2	32.4	11:50	3	2.7	12
30	31-Jan-13	1	1	R2	32.8	11:54	4	2.4	3
30	31-Jan-13	1	1	R2	32.8	11:58	5	1.7	2
30	31-Jan-13	1	1	R2	32.1	12:02	6	0	0
31	1-Feb-13	1	5	F	34.3	6:06	6	0.9	3
31	1-Feb-13	1	5	F	34.5	6:11	5	7.0	12
31	1-Feb-13	1	5	F	34.5	6:16	4	5.6	16
31	1-Feb-13	1	5	F	34.5	6:21	3	3.9	11
31	1-Feb-13	1	5	F	34.8	6:26	2	6.7	12
31	1-Feb-13	1	5	F	35.0	6:31	1	20.0	30
32	1-Feb-13	1	5	E	41.6	8:10	1	0	0
32	1-Feb-13	1	5	E	41.4	8:15	2	0	0
32	1-Feb-13	1	5	E	40.6	8:20	3	10.6	17

Set	Date	Phase	Stratum	Site	Depth (m)	Time set	Pot	Catch of blue cod (kg)	Catch of blue cod Number
32	1-Feb-13	1	5	E	40.8	8:25	4	9.8	22
32	1-Feb-13	1	5	E	41.4	8:30	5	0	0
32	1-Feb-13	1	5	E	41.4	8:35	6	0	0
33	1-Feb-13	1	5	D	43.7	10:20	6	1.0	5
33	1-Feb-13	1	5	D	42.8	10:24	5	0	0
33	1-Feb-13	1	5	D	43.7	10:29	4	0	0
33	1-Feb-13	1	5	D	44.7	10:34	3	0	0
33	1-Feb-13	1	5	D	44.3	10:39	2	9.6	15
33	1-Feb-13	1	5	D	43.2	10:44	1	35.0	34
34	6-Feb-13	1	6	R5	18.6	6:55	1	1.3	4
34	6-Feb-13	1	6	R5	18.6	7:00	2	0.8	2
34	6-Feb-13	1	6	R5	19.0	7:05	3	8.3	22
34	6-Feb-13	1	6	R5	18.8	7:10	4	0	0
34	6-Feb-13	1	6	R5	24.8	7:15	5	0.4	1
34	6-Feb-13	1	6	R5	21.9	7:20	6	5.4	24
35	6-Feb-13	1	6	R3	31.9	9:15	6	12.7	43
35	6-Feb-13	1	6	R3	32.3	9:20	5	22.2	45
35	6-Feb-13	1	6	R3	32.4	9:25	4	0	0
35	6-Feb-13	1	6	R3	32.6	9:30	3	0	0
35	6-Feb-13	1	6	R3	32.4	9:33	2	11.2	35
35	6-Feb-13	1	6	R3	32.8	9:37	1	14.8	26
36	6-Feb-13	1	6	I	26.4	11:03	1	5.6	40
36	6-Feb-13	1	6	I	26.1	11:07	2	16.8	41
36	6-Feb-13	1	6	I	25.3	11:12	3	26.4	55
36	6-Feb-13	1	6	I	25.9	11:17	4	25.3	55
36	6-Feb-13	1	6	I	24.8	11:22	5	8.7	22
36	6-Feb-13	1	6	I	24.2	11:27	6	15.1	37
37	6-Feb-13	1	6	R6	26.4	13:15	6	13.2	30
37	6-Feb-13	1	6	R6	26.6	13:19	5	17.0	47
37	6-Feb-13	1	6	R6	24.6	13:24	4	13.8	30
37	6-Feb-13	1	6	R6	24.6	13:28	3	8.0	22
37	6-Feb-13	1	6	R6	25.0	13:32	2	13.9	24
37	6-Feb-13	1	6	R6	24.8	13:36	1	6.5	15
38	7-Feb-13	1	6	B	16.0	7:07	1	10.4	22
38	7-Feb-13	1	6	B	16.4	7:12	2	0.4	3
38	7-Feb-13	1	6	B	17.3	7:17	3	9.6	22
38	7-Feb-13	1	6	B	17.9	7:21	4	4.6	8
38	7-Feb-13	1	6	B	17.9	7:26	5	7.0	16
38	7-Feb-13	1	6	B	16.6	7:30	6	14.0	23
39	7-Feb-13	1	5	A	36.1	9:42	6	13.1	22
39	7-Feb-13	1	5	A	37.2	9:48	5	5.2	9
39	7-Feb-13	1	5	A	37.0	9:53	4	8.1	13
39	7-Feb-13	1	5	A	35.7	9:57	3	3.5	6
39	7-Feb-13	1	5	A	36.8	10:02	2	7.6	12
39	7-Feb-13	1	5	A	35.5	10:06	1	6.4	13
40	7-Feb-13	1	5	R5	37.5	11:25	1	13.8	27
40	7-Feb-13	1	5	R5	37.7	11:29	2	19.0	44
40	7-Feb-13	1	5	R5	39.0	11:33	3	4.0	9

Set	Date	Phase	Stratum	Site	Depth (m)	Time set	Pot	Catch of blue cod (kg)	Catch of blue cod Number
40	7-Feb-13	1	5	R5	39.2	11:37	4	4.5	6
40	7-Feb-13	1	5	R5	39.2	11:41	5	4.0	8
40	7-Feb-13	1	5	R5	38.6	11:45	6	11.3	26
41	7-Feb-13	1	5	R1	45.9	13:33	6	0	0
41	7-Feb-13	1	5	R1	45.8	13:37	5	0	0
41	7-Feb-13	1	5	R1	46.1	13:42	4	0	0
41	7-Feb-13	1	5	R1	46.1	13:47	3	0	0
41	7-Feb-13	1	5	R1	45.9	13:53	2	0	0
41	7-Feb-13	1	5	R1	45.8	13:58	1	0	0
42	8-Feb-13	1	4	R1	17.0	7:55	1	3.8	10
42	8-Feb-13	1	4	R1	17.7	8:00	2	9.4	25
42	8-Feb-13	1	4	R1	17.7	8:05	3	4.6	19
42	8-Feb-13	1	4	R1	17.7	8:10	4	7.4	18
42	8-Feb-13	1	4	R1	17.0	8:15	5	2.8	20
42	8-Feb-13	1	4	R1	16.0	8:20	6	5.6	11
43	8-Feb-13	1	4	H	23.9	9:33	6	6.4	18
43	8-Feb-13	1	4	H	23.3	9:37	5	14.2	25
43	8-Feb-13	1	4	H	23.5	9:41	4	7.9	16
43	8-Feb-13	1	4	H	23.3	9:45	3	5.2	12
43	8-Feb-13	1	4	H	23.7	9:50	2	18.2	36
43	8-Feb-13	1	4	H	24.6	9:54	1	5.7	20
44	8-Feb-13	1	4	D	16.0	11:10	1	4.4	10
44	8-Feb-13	1	4	D	17.1	11:14	2	1.2	2
44	8-Feb-13	1	4	D	17.9	11:18	3	5.4	14
44	8-Feb-13	1	4	D	18.0	11:23	4	7.0	25
44	8-Feb-13	1	4	D	18.0	11:28	5	1.2	6
44	8-Feb-13	1	4	D	17.9	11:32	6	9.9	23
45	10-Feb-13	1	6	R1	9.1	6:50	6	1.0	1
45	10-Feb-13	1	6	R1	8.6	6:54	5	0	0
45	10-Feb-13	1	6	R1	9.8	6:55	4	0	0
45	10-Feb-13	1	6	R1	9.7	6:59	3	0.7	1
45	10-Feb-13	1	6	R1	9.7	7:04	2	1.6	4
45	10-Feb-13	1	6	R1	8.6	7:08	1	0	0
46	10-Feb-13	1	6	R2	29.3	8:40	1	5.3	5
46	10-Feb-13	1	6	R2	29.9	8:44	2	13.5	24
46	10-Feb-13	1	6	R2	30.3	8:48	3	2.6	5
46	10-Feb-13	1	6	R2	30.3	8:52	4	9.3	14
46	10-Feb-13	1	6	R2	30.3	8:56	5	18.4	35
46	10-Feb-13	1	6	R2	30.3	9:00	6	22.4	38
47	10-Feb-13	1	4	E	28.1	10:32	6	12.1	20
47	10-Feb-13	1	4	E	29.0	10:36	5	19.1	37
47	10-Feb-13	1	4	E	29.9	10:40	4	12.3	23
47	10-Feb-13	1	4	E	29.5	10:44	3	14.8	22
47	10-Feb-13	1	4	E	29.7	10:48	2	8.5	14
47	10-Feb-13	1	4	E	29.5	10:52	1	12.4	19
48	10-Feb-13	1	4	R2	34.1	12:19	1	4.4	12
48	10-Feb-13	1	4	R2	34.3	12:23	2	7.3	14
48	10-Feb-13	1	4	R2	34.8	12:27	3	3.8	18

Set	Date	Phase	Stratum	Site	Depth (m)	Time set	Pot	Catch of blue cod (kg)	Catch of blue cod Number
48	10-Feb-13	1	4	R2	35.7	12:31	4	5.9	15
48	10-Feb-13	1	4	R2	33.5	12:35	5	9.2	14
48	10-Feb-13	1	4	R2	33.9	12:39	6	11.7	21
49	11-Feb-13	1	6	R4	31.7	7:31	6	15.3	32
49	11-Feb-13	1	6	R4	31.7	7:35	5	8.7	28
49	11-Feb-13	1	6	R4	31.7	7:39	4	0	0
49	11-Feb-13	1	6	R4	32.4	7:43	3	0	0
49	11-Feb-13	1	6	R4	32.6	7:47	2	0	0
49	11-Feb-13	1	6	R4	32.1	7:51	1	20.3	42
50	12-Feb-13	1	5	R6	39.0	7:30	1	7.5	22
50	12-Feb-13	1	5	R6	39.7	7:35	2	15.0	24
50	12-Feb-13	1	5	R6	39.9	7:40	3	0	0
50	12-Feb-13	1	5	R6	39.6	7:45	4	0	0
50	12-Feb-13	1	5	R6	39.2	7:49	5	1.0	3
50	12-Feb-13	1	5	R6	38.6	7:53	6	13.9	24
51	12-Feb-13	1	5	R4	34.1	9:30	6	9.0	15
51	12-Feb-13	1	5	R4	34.1	9:34	5	7.9	13
51	12-Feb-13	1	5	R4	34.3	9:38	4	1.5	8
51	12-Feb-13	1	5	R4	33.9	9:42	3	9.5	15
51	12-Feb-13	1	5	R4	33.7	9:46	2	3.5	4
51	12-Feb-13	1	5	R4	33.9	9:50	1	7.0	13
52	12-Feb-13	1	5	R2	33.7	11:16	1	7.0	12
52	12-Feb-13	1	5	R2	33.5	11:20	2	7.9	14
52	12-Feb-13	1	5	R2	34.3	11:24	3	9.4	15
52	12-Feb-13	1	5	R2	33.4	11:28	4	10.3	17
52	12-Feb-13	1	5	R2	33.7	11:32	5	13.5	17
52	12-Feb-13	1	5	R2	34.1	11:36	6	3.3	7
53	12-Feb-13	1	5	R3	41.0	13:08	6	0	0
53	12-Feb-13	1	5	R3	41.7	13:12	5	0	0
53	12-Feb-13	1	5	R3	41.6	13:16	4	0	0
53	12-Feb-13	1	5	R3	41.7	13:20	3	4.4	6
53	12-Feb-13	1	5	R3	41.9	13:24	2	4.3	6
53	12-Feb-13	1	5	R3	41.7	13:28	1	0	0
54	14-Feb-13	1	4	R4	30.8	8:32	1	5.9	14
54	14-Feb-13	1	4	R4	30.3	8:36	2	10.9	22
54	14-Feb-13	1	4	R4	30.8	8:40	3	15.4	25
54	14-Feb-13	1	4	R4	30.1	8:44	4	9.0	18
54	14-Feb-13	1	4	R4	29.5	8:48	5	7.8	20
54	14-Feb-13	1	4	R4	31.0	8:52	6	7.5	19
55	14-Feb-13	1	4	R5	30.8	10:12	6	3.5	3
55	14-Feb-13	1	4	R5	30.6	10:16	5	4.0	3
55	14-Feb-13	1	4	R5	30.8	10:20	4	1.4	2
55	14-Feb-13	1	4	R5	30.6	10:24	3	0	0
55	14-Feb-13	1	4	R5	31.2	10:28	2	3.5	4
55	14-Feb-13	1	4	R5	30.8	10:32	1	0	0
56	14-Feb-13	1	4	R3	21.5	12:10	1	0	0
56	14-Feb-13	1	4	R3	21.1	12:14	2	0	0
56	14-Feb-13	1	4	R3	22.1	12:18	3	0.4	1

Set	Date	Phase	Stratum	Site	Depth (m)	Time set	Pot	Catch of blue cod (kg)	Catch of blue cod Number
56	14-Feb-13	1	4	R3	22.1	12:22	4	0.1	1
56	14-Feb-13	1	4	R3	21.5	12:26	5	0.6	1
56	14-Feb-13	1	4	R3	21.0	12:30	6	0	0
57	14-Feb-13	1	4	R6	19.9	13:46	6	12.1	30
57	14-Feb-13	1	4	R6	20.4	13:50	5	11.1	27
57	14-Feb-13	1	4	R6	20.1	13:54	4	9.9	18
57	14-Feb-13	1	4	R6	22.4	13:58	3	2.3	13
57	14-Feb-13	1	4	R6	22.4	14:02	2	3.1	8
57	14-Feb-13	1	4	R6	22.4	14:06	1	9.3	22
58	15-Feb-13	2	1	R7	23.7	6:05	1	0.7	2
58	15-Feb-13	2	1	R7	23.7	6:09	2	0	0
58	15-Feb-13	2	1	R7	23.9	6:13	3	0	0
58	15-Feb-13	2	1	R7	24.1	6:18	4	0.9	1
58	15-Feb-13	2	1	R7	24.2	6:22	5	0	0
58	15-Feb-13	2	1	R7	23.9	6:26	6	0	0
59	15-Feb-13	2	1	R8	29.5	8:00	6	11.2	19
59	15-Feb-13	2	1	R8	29.7	8:04	5	0.9	2
59	15-Feb-13	2	1	R8	29.3	8:08	4	9.3	11
59	15-Feb-13	2	1	R8	29.3	8:12	3	21.5	31
59	15-Feb-13	2	1	R8	29.3	8:16	2	43.4	55
59	15-Feb-13	2	1	R8	29.5	8:20	1	7.3	11
60	15-Feb-13	2	5	C	37.7	10:21	1	13.1	19
60	15-Feb-13	2	5	C	37.7	10:25	2	10.0	19
60	15-Feb-13	2	5	C	37.9	10:29	3	0.4	1
60	15-Feb-13	2	5	C	37.9	10:33	4	9.2	20
60	15-Feb-13	2	5	C	37.5	10:37	5	12.0	18
60	15-Feb-13	2	5	C	37.0	10:41	6	14.3	19
61	15-Feb-13	2	5	R8	36.5	12:09	6	0	0
61	15-Feb-13	2	5	R8	36.5	12:13	5	11.1	30
61	15-Feb-13	2	5	R8	36.3	12:16	4	10.4	23
61	15-Feb-13	2	5	R8	35.9	12:19	3	22.6	38
61	15-Feb-13	2	5	R8	36.3	12:22	2	8.7	17
61	15-Feb-13	2	5	R8	36.6	12:25	1	4.9	12
62	16-Feb-13	1	4	B	14.6	7:12	1	6.2	10
62	16-Feb-13	1	4	B	14.6	7:17	2	5.3	7
62	16-Feb-13	1	4	B	14.6	7:22	3	5.9	9
62	16-Feb-13	1	4	B	14.6	7:27	4	1.9	5
62	16-Feb-13	1	4	B	14.6	7:32	5	3.5	6
62	16-Feb-13	1	4	B	14.6	7:37	6	5.0	9
63	16-Feb-13	2	5	R9	37.0	9:36	6	2.7	2
63	16-Feb-13	2	5	R9	35.9	9:40	5	5.1	12
63	16-Feb-13	2	5	R9	36.5	9:44	4	5.0	10
63	16-Feb-13	2	5	R9	37.4	9:48	3	9.6	14
63	16-Feb-13	2	5	R9	37.2	9:52	2	4.9	11
63	16-Feb-13	2	5	R9	37.4	9:56	1	19.8	33
64	18-Feb-13	2	5	R3	40.3	6:45	1	0	0
64	18-Feb-13	2	5	R3	40.3	6:49	2	0	0
64	18-Feb-13	2	5	R3	39.9	6:53	3	0	0

Set	Date	Phase	Stratum	Site	Depth (m)	Time set	Pot	Catch of blue cod (kg)	Catch of blue cod Number
64	18-Feb-13	2	5	I	40.3	7:01	5	0	0
64	18-Feb-13	2	5	I	40.1	7:05	6	0	0
65	18-Feb-13	2	5	I	39.2	8:24	6	17.2	30
65	18-Feb-13	2	5	I	39.2	8:28	5	7.9	15
65	18-Feb-13	2	5	I	38.8	8:32	4	4.8	12
65	18-Feb-13	2	5	I	38.8	8:36	3	8.5	16
65	18-Feb-13	2	5	H	40.1	8:40	2	17.5	26
65	18-Feb-13	2	5	H	40.6	8:44	1	4.8	8
66	18-Feb-13	1	6	H	16.6	11:15	1	4.5	12
66	18-Feb-13	1	6	H	15.7	11:19	2	5.8	11
66	18-Feb-13	1	6	H	17.0	11:22	3	3.8	10
66	18-Feb-13	1	6	H	17.3	11:25	4	3.0	6
66	18-Feb-13	1	6	H	19.0	11:28	5	7.5	12
66	18-Feb-13	1	6	H	19.9	11:31	6	3.3	5
67	18-Feb-13	1	6	H	17.9	12:55	6	0.4	3
67	18-Feb-13	1	6	H	14.6	12:58	5	1.4	3
67	18-Feb-13	1	6	H	19.0	13:02	4	3.6	6
67	18-Feb-13	1	6	H	21.0	13:06	3	5.2	16
67	18-Feb-13	1	6	A	21.3	13:09	2	7.9	18
67	18-Feb-13	1	6	A	21.3	13:13	1	2.1	7

Appendix 3: Summary of the north Otago 2013 survey oceanographic environmental station data recorded in the format of the trawl data base. Depths are measured in meters, directions in compass degrees (999 = nil), wind force in the Beaufort scale, temperatures in degrees Celcius, air pressure in millibars, cloud cover in oktas, sea condition in the Douglas scale, sea colour in a categorical scale from 1 (deep blue) to 8 (yellow green), swell height in metres, bottom type in a categorical scale from 1 (mud or ooze) to 13 (sponge beds), bottom contour in a categorical scale from 1 (smooth/flat) to 5 (very rugged), and wind speed in metres per second.

Set	ADCP Depth	Wind Direction	Wind Force	Air Temp	Air Pressure	Cloud Cover	Sea Condition	Sea Colour	Swell Height	Swell Direction	Bottom Type	Bottom Contour	Surface Temp	Bottom Temp	Wind Speed	Secchi Depth
1	19.1	270	2	19.8	1013	7	3	6	1.5	060	7	3	15.5	15.3	2.1	7.5
2	28.5	175	2	23.0	1013	6	3	6	1.5	160	7	4	15.5	14.9	1.8	6.6
3	22.3	050	2	18.6	1013	5	3	6	1.0	160	7	4	16.0	15.4	2.0	7.1
4	24.6	001	3	17.9	1013	5	3	6	1.0	100	6	1	15.5	15.1	4.2	15.1
5	21.7	010	3	19.5	1015	5	3	6	1.0	050	6	2	15.0	15.1	4.1	14.7
6	42.4	999	0	15.0	1019	0	3	4	2.0	000	6	3	14.5	14.0	0.0	0.0
7	41.0	999	0	18.0	1018	0	2	3	1.0	000	7	4	15.0	14.2	0.0	0.0
8	42.0	010	2	25.1	1014	0	2	8	1.0	020	7	2	15.0	13.8	2.8	10.0
9	24.9	030	3	22.6	1016	1	4	7	1.5	010	6	2	15.5	14.8	3.5	12.5
10	35.9	040	2	16.0	1013	8	1	5	1.5	060	6	1	15.0	14.0	3.1	11.2
11	37.7	999	0	18.5	1009	4	2	5	1.5	060	7	2	15.5	13.7	0.0	0.0
12	43.5	020	4	20.0	1008	4	3	7	1.0	015	6	2	15.5	13.7	6.7	24.0
13	38.9	105	4	22.0	1007	5	4	7	1.5	015	6	1	15.0	13.9	5.7	20.7
14	20.7	030	4	14.0	1028	0	3	7	1.5	000	6	2	16.0	15.2	7.9	28.6
15	23.0	010	5	18.0	1028	1	4	7	2.0	000	6	1	15.5	15.3	10.0	36.0
16	14.2	000	5	19.0	1028	4	4	8	1.5	045	7	1	16.0	15.8	9.3	33.5
17	33.7	080	1	17.0	1028	8	1	4	0.5	075	6	1	16.0	13.9	0.9	3.3
18	41.5	999	0	17.0	1028	8	1	4	0.5	075	6	2	17.0	13.5	0.0	0.0
19	33.9	050	4	19.0	1025	2	3	4	1.0	050	7	3	16.5	14.1	7.6	27.4
20	18.5	155	2	17.0	1024	8	2	4	0.5	140	7	3	16.0	14.9	2.3	8.4
21	24.4	130	1	17.5	1024	8	2	4	0.5	100	7	3	16.0	14.4	1.5	5.3
22	22.8	090	1	18.0	1023	8	1	4	0.5	100	7	3	16.0	14.4	0.8	3.0
23	16.2	060	3	17.5	1022	8	1	4	0.3	060	7	5	17.0	15.2	3.5	12.5
24	12.1	305	2	19.1	1018	8	2	7	0.5	030	7	3	17.0	15.2	3.1	11.1
25	6.2	020	3	19.1	1014	8	2	3	0.5	030	4	1	17.0	16.0	3.6	13.1
26	21.7	000	4	20.1	1014	8	2	5	0.8	015	7	3	17.1	14.4	5.6	20.1
27	30.4	040	2	23.1	1015	4	3	6	1.0	060	7	2	17.0	14.1	2.0	7.1
28	32.3	999	0	24.6	1016	3	3	6	1.0	060	7	2	17.0	13.9	0.0	0.0
29	29.3	005	2	26.5	1017	3	3	6	1.0	055	7	2	17.5	14.1	2.7	9.7

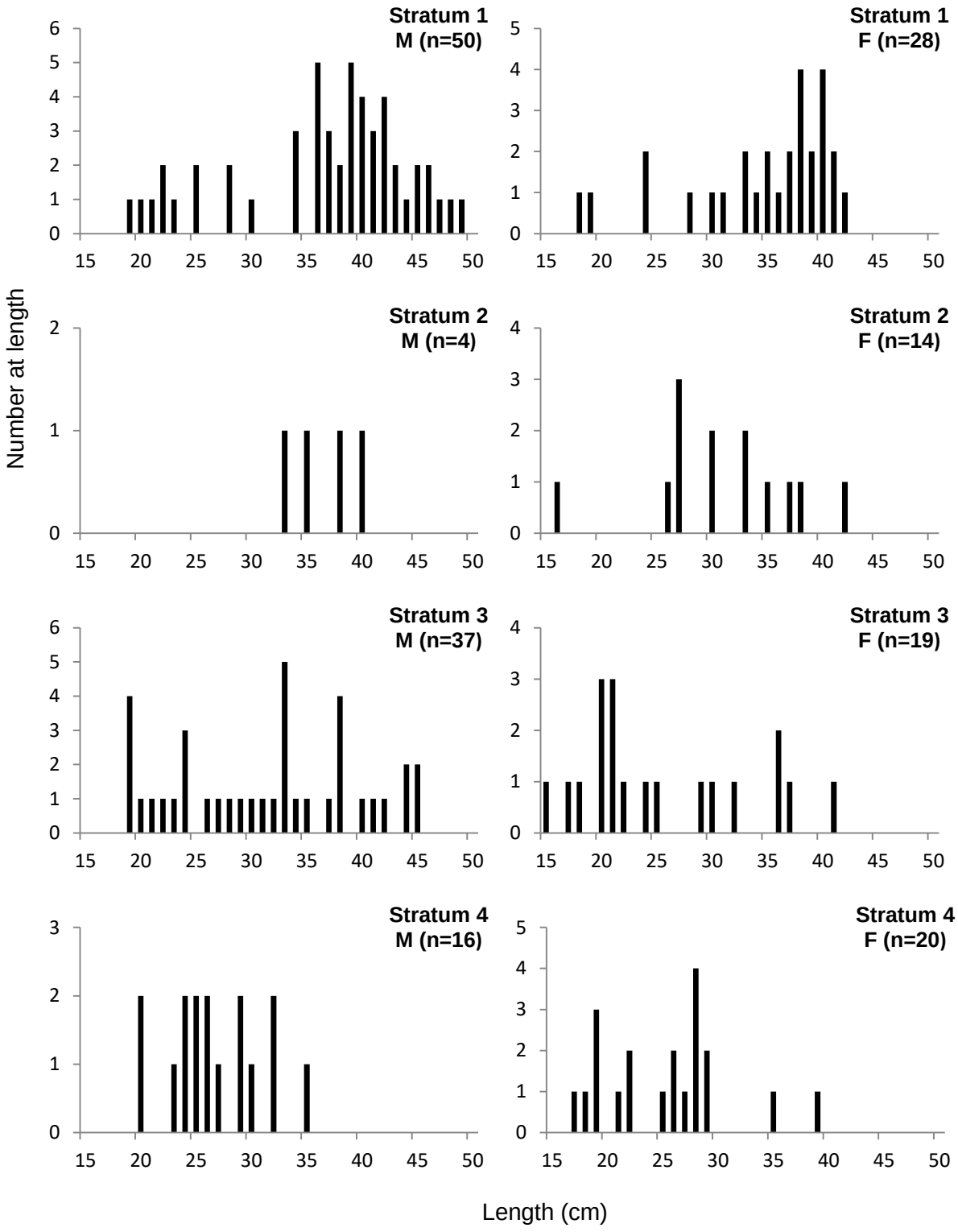
Appendix 3– ***continued***

Set	Average Depth	Wind Direction	Wind Force	Air Temp	Air Pressure	Cloud Cover	Sea Condition	Sea Colour	Swell Height	Swell Direction	Bottom Type	Bottom Contour	Surface Temp	Bottom Temp	Wind Speed	Secchi Depth
30	34.2	030	3	22.7	1016	3	4	6	1.3	050	7	3	18.0	14.0	5.4	19.5
31	35.6	020	2	22.5	1014	1	4	6	2.0	050	7	3	17.1	13.9	2.0	7.2
32	42.2	020	1	23.6	1015	1	4	6	1.5	050	7	2	17.3	13.6	0.9	3.4
33	44.9	005	3	25.2	1016	1	3	6	1.5	050	7	3	18.0	13.9	4.4	15.7
34	24.2	270	3	16.0	1013	8	4	6	2.0	135	6	1	15.0	14.6	3.4	12.4
35	33.6	250	2	15.1	1015	8	4	6	2.0	135	6	2	15.0	14.6	3.1	11.3
36	26.7	180	3	18.0	1015	7	4	6	2.0	135	7	3	15.3	14.6	3.8	13.6
37	26.3	180	3	16.2	1016	7	4	7	2.0	130	6	2	15.5	14.7	5.5	19.7
38	17.5	240	2	17.3	1024	0	4	8	2.0	130	7	4	14.9	14.9	2.0	7.3
39	38.1	090	1	22.9	1025	2	3	2	0.5	080	7	5	15.8	14.5	1.5	5.5
40	39.8	330	3	24.3	1019	2	4	4	2.0	110	7	2	15.2	14.5	3.6	13.1
41	47.1	000	2	21.1	1018	2	4	7	1.5	020	7	2	15.3	14.8	3.1	11.1
42	17.8	300	1	16.3	1024	7	4	7	1.5	060	7	3	15.5	14.7	1.3	4.7
43	25.9	030	3	19.2	1023	7	4	7	1.5	060	7	4	15.3	14.6	4.9	17.6
44	18.3	030	3	19.9	1022	6	3	7	1.3	030	7	4	15.6	14.7	5.5	19.9
45	9.9	020	4	20.6	1018	6	3	8	1.0	090	7	3	15.8	14.8	5.7	20.6
46	31.5	018	4	23.1	1018	5	3	7	1.0	010	7	3	15.8	14.7	6.6	23.7
47	31.0	010	4	20.3	1017	5	4	7	1.5	000	7	3	16.0	14.7	6.2	22.5
48	36.4	340	4	22.0	1017	5	4	5	1.5	030	7	4	16.1	14.7	7.6	27.3
49	32.8	210	3	21.6	1008	6	3	6	1.5	090	6	2	16.0	14.2	3.6	13.0
50	40.7	090	3	16.8	1011	8	3	6	1.0	150	6	3	15.0	14.3	5.2	18.7
51	35.2	150	2	17.4	1010	8	3	6	1.0	110	7	3	15.0	14.8	2.0	7.1
52	34.6	060	2	17.7	1010	8	3	6	1.0	040	7	3	14.8	15.0	2.6	9.2
53	43.7	100	3	18.9	1009	8	3	6	1.0	025	7	2	14.5	14.8	4.0	14.5
54	31.8	320	3	19.0	1009	6	3	6	1.5	015	7	3	15.0	14.7	4.1	14.8
55	31.8	330	4	20.9	1009	6	4	6	1.5	015	7	3	15.1	14.8	7.4	26.5
56	22.4	000	3	16.1	1009	8	3	7	1.0	015	7	3	15.5	15.2	4.5	16.1
57	21.4	005	2	21.9	1008	6	3	7	1.0	070	7	2	15.8	15.2	2.9	10.4
58	24.9	210	2	18.1	1010	7	3	6	1.5	150	6	2	15.0	15.1	2.2	8.0
59	30.7	000	1	20.2	1010	5	3	5	1.5	120	7	3	15.0	14.7	0.7	2.7
60	37.8	100	3	24.0	1011	5	3	6	2.0	155	7	3	15.2	14.6	3.6	13.0
61	37.9	060	3	25.7	1012	6	3	6	2.0	120	7	3	15.5	14.4	3.4	12.4

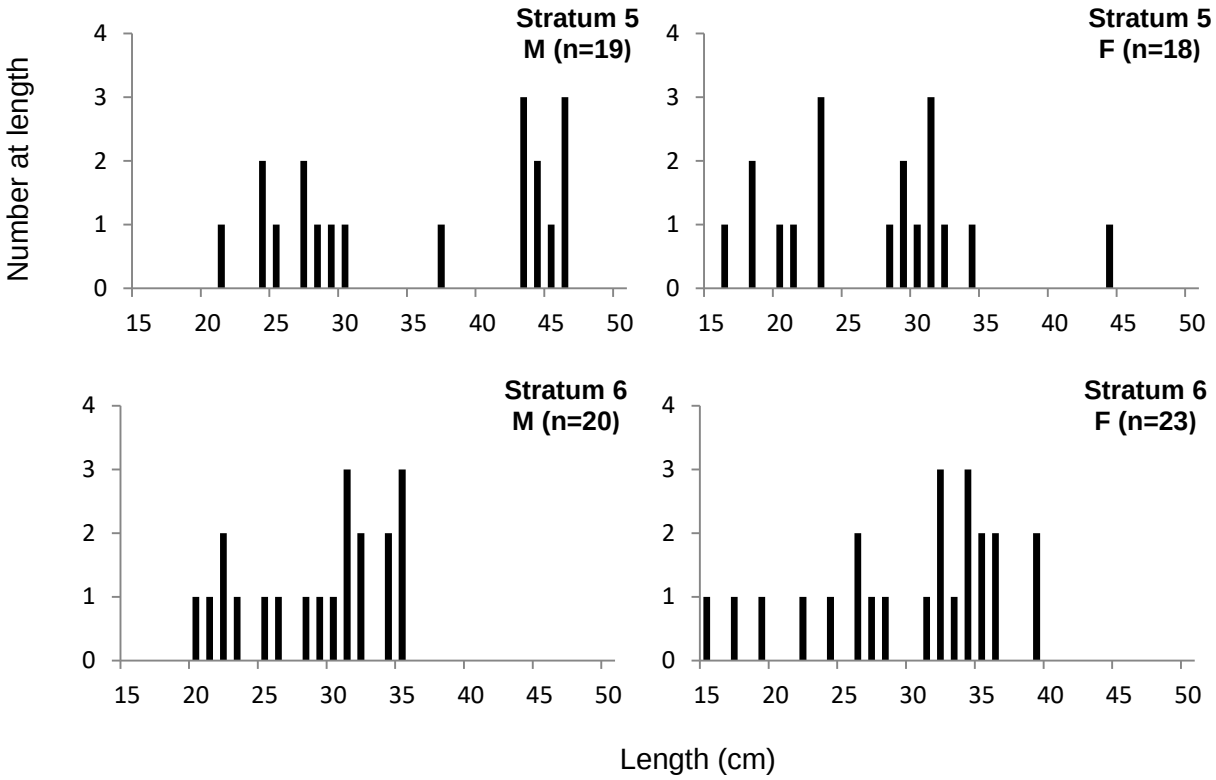
Appendix 3– ***continued***

Set	Average Depth	Wind Direction	Wind Force	Air Temp	Air Pressure	Cloud Cover	Sea Condition	Sea Colour	Swell Height	Swell Direction	Bottom Type	Bottom Contour	Surface Temp	Bottom Temp	Wind Speed	Secchi Depth
62	15.5	999	0	17.4	1010	8	2	6	1.0	030	7	4	15.2	14.7	0.0	0.0
63	37.9	340	2	17.0	1010	8	3	5	1.5	020	7	3	15.2	14.5	1.8	6.6
64	41.4	300	4	15.2	1022	2	4	6	2.0	005	7	2	15.1	14.5	7.2	26.1
65	40.6	320	4	19.1	1020	1	4	6	2.0	010	7	4	15.2	14.6	5.6	20.2
66	19.5	030	2	19.8	1021	1	3	6	1.0	020	7	4	16.0	14.8	2.5	9.1
67	15.9	030	2	22.4	1022	2	3	6	1.0	030	7	4	16.0	15.2	3.0	10.9

Appendix 4: Unscaled length frequency distributions of blue cod for each stratum from which otoliths were used in the north Otago 2013 age length keys.



Appendix 4 - *Continued*.



Appendix 5: Between-reader comparisons (using first independent readings only) for otolith data collected in north Otago 2013.

Reader two	Age class (reader one)															
difference	2	3	4	5	6	7	8	9	10	11	12	13	14	15	≥16	Total
-7															1	1
-5												1			0	1
-3														2	1	3
-2						2	3	1		2	3	2			4	17
-1		2		1	2	9	6	2	5	3	5		1	1	4	41
0	2	22	23	13	12	12	15	9	11	12	6	5	5	4	7	158
1		1	3	1	2		2	1	2		3	2	1	3	4	25
2					1					1	1		2	3	2	10
3												1		2	1	4
4												1			1	2
5															3	3
6															2	2
Total	2	25	26	15	17	23	26	13	18	18	18	12	9	15	30	267
% agreement	100	88	88	87	71	52	58	69	61	67	33	42	56	27	23	59

Appendix 6: Independent reader comparisons with agreed age from otolith data collected in north Otago 2013.

Reader one	Agreed age class															
difference	2	3	4	5	6	7	8	9	10	11	12	13	14	15	≥16	Total
-4															1	1
-3															1	1
-2								1	1	1		2	1		2	8
-1			1		1	1	4	5	2	2		2	1		2	21
0	2	24	25	14	16	18	19	10	15	15	15	7	8	10	20	218
1		1				1		1	1		2		1		5	12
2										1	1	1			3	6
Total	2	25	26	14	17	20	23	17	19	19	18	12	11	10	34	267
% agreement	100	96	96	100	94	90	83	59	79	79	83	58	73	100	59	82

Reader two	Agreed age class															
difference	2	3	4	5	6	7	8	9	10	11	12	13	14	15	≥16	Total
-5															2	2
-4															4	4
-3														1		1
-2					1						1	2		1	2	2	9
-1		1	2	1	2		1	1	2		3	3	1	2	6	25
0	2	23	24	13	13	14	18	14	14	15	8	7	7	4	9	185
1		1			1	6	4	2	3	2	4	1	2		5	31
2										1	1	1			4	7
3														1	1	2
5															1	1
Total	2	25	26	14	17	20	23	17	19	19	18	12	11	10	34	267
% agreement	100	92	92	93	76	70	78	82	74	79	44	58	64	40	26	69

Appendix 7: The proportion of fish at age and length and the total number at length and at age for male blue cod sampled from the 2013 north Otago (age -length-key, ALK).

	Age																									
Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
19	0	0	0.8	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
20	0	0	0.6	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
21	0	0	0.25	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
22	0	0	0.2	0.4	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
23	0	0	0	0.5	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
24	0	0	0	0.43	0.57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
25	0	0	0	0.17	0.33	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
26	0	0	0	0	0.25	0.5	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
27	0	0	0	0	0.25	0.25	0.25	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
28	0	0	0	0	0	0.2	0.4	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
29	0	0	0	0	0	0	0.4	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
30	0	0	0	0	0	0	0.4	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
31	0	0	0	0	0	0	0.25	0.5	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
32	0	0	0	0	0	0	0.4	0.4	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
33	0	0	0	0	0	0	0.17	0.33	0.17	0.17	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
34	0	0	0	0	0	0	0	0.17	0.33	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
35	0	0	0	0	0	0	0	0	0.33	0.33	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
36	0	0	0	0	0	0	0	0	0.2	0.6	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
37	0	0	0	0	0	0	0	0	0	0.6	0	0	0.2	0.2	0	0	0	0	0	0	0	0	0	0	0	0	5
38	0	0	0	0	0	0	0	0	0	0	0.29	0.29	0.43	0	0	0	0	0	0	0	0	0	0	0	0	0	7
39	0	0	0	0	0	0	0	0	0	0.2	0.2	0.4	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	5
40	0	0	0	0	0	0	0	0	0	0	0.33	0.33	0.17	0	0	0.17	0	0	0	0	0	0	0	0	0	0	6
41	0	0	0	0	0	0	0	0	0	0	0.25	0.25	0.25	0.25	0	0	0	0	0	0	0	0	0	0	0	0	4
42	0	0	0	0	0	0	0	0	0	0	0	0.4	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	5
43	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0.2	0.2	0	0.2	0	0	0	0	0	0	0	0	0	5
44	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0.4	0	0.2	0	0.2	0	0	0	0	0	0	0	0	5
45	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2	0.4	0.2	0	0	0	0	0	0	0	0	0	0	5
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0.2	0	0.2	0	0	0	0.2	0	0	5
47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	0	0	9	14	10	9	12	15	8	14	12	10	9	8	3	5	1	2	0	2	0	0	0	2	0	1	146

Appendix 8: The proportion of fish at age and length and the total number at length and at age for female blue cod sampled from the 2013 north Otago survey (age-length key, ALK).

	Age																									
Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
15	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
16	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
17	0	0	0.67	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
18	0	0	0.8	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
19	0	0	0.4	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
20	0	0	0.75	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
21	0	0	0.4	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
22	0	0	0.25	0.5	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
23	0	0	0	0.67	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
24	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
25	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
26	0	0	0	0	0	0.6	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
27	0	0	0	0	0	0	0.6	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
28	0	0	0	0	0	0.14	0.14	0.57	0.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
29	0	0	0	0	0	0	0.2	0.2	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
30	0	0	0	0	0	0	0	0.2	0.4	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
31	0	0	0	0	0	0	0	0	0.6	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
32	0	0	0	0	0	0	0	0	0	0.4	0.2	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
33	0	0	0	0	0	0	0	0	0	0	0.4	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	5
34	0	0	0	0	0	0	0	0	0	0.2	0.2	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
35	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0.33	0.33	0.17	0	0	0	0	0	0	0	0	0	0	6
36	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2	0	0.4	0	0	0.2	0	0	0	0	0	0	0	0	5
37	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0.5	0.25	0	0	0	0	0	0	0	0	0	0	4
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2	0.4	0.2	0	0	0	0	0	0	0	0	0	5
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2	0	0	0.2	0	0	0.4	0	0	0	5
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5	0	0	0	0.25	0	0	0	0	4
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33	0.33	0	0	0	0	0.33	0	0	3
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	2
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Total	0	2	16	12	4	8	8	8	9	5	7	8	3	3	7	5	3	4	2	2	0	2	2	1	0	0	121

Appendix 9: Mean age-at-length for the 2013 north Otago survey.

	Males		Females		All fish	
Length (cm)	N	Mean age	N	Mean age	N	Mean age
15	0	0.00	2	2.50	2	2.50
16	0	0.00	2	2.50	2	2.50
17	0	0.00	3	3.33	3	3.33
18	0	0.00	5	3.20	5	3.20
19	5	3.20	5	3.60	10	3.40
20	5	3.40	4	3.50	9	3.44
21	4	3.75	5	3.60	9	3.67
22	5	4.20	4	4.25	9	4.22
23	4	5.00	3	4.33	7	4.71
24	7	4.57	4	5.50	11	4.91
25	6	5.33	2	6.50	8	5.62
26	4	6.00	5	6.40	9	6.22
27	4	6.50	5	7.40	9	7.00
28	5	7.20	7	7.71	12	7.50
29	5	7.80	5	8.40	10	8.10
30	5	7.60	5	9.20	10	8.40
31	4	8.00	5	9.80	9	9.00
32	5	8.00	5	11.00	10	9.50
33	6	8.83	5	11.80	11	10.20
34	6	9.33	5	11.40	11	10.30
35	6	10.00	6	14.20	12	12.10
36	5	10.00	5	14.60	10	12.30
37	5	11.40	4	14.80	9	12.90
38	7	12.10	5	15.60	12	13.60
39	5	11.80	5	19.80	10	15.80
40	6	12.50	4	18.80	10	15.00
41	4	12.50	3	20.30	7	15.90
42	5	12.80	2	19.50	7	14.70
43	5	13.60	0	0.00	5	13.60
44	5	14.80	1	22.00	6	16.00
45	5	14.60	0	0.00	5	14.60
46	5	18.80	0	0.00	5	18.80
47	1	20.00	0	0.00	1	20.00
48	1	24.00	0	0.00	1	24.00
49	1	26.00	0	0.00	1	26.00
Total	146	9.43	121	9.69	267	9.55

Appendix 10: Parameter values used in the 2013 north Otago SPR analyses.

	Males				Females			
Age	Length (cm)	Weight (kg)	Selectivity	Maturity	Length (cm)	Weight (kg)	Selectivity	Maturity
1	11.6	0.022	0	0	12.9	0.033	0	0
2	15.3	0.052	0	0	15.8	0.061	0	0
3	18.6	0.098	0	0	18.4	0.098	0	0
4	21.7	0.157	0	0.1	20.8	0.143	0	0.1
5	24.6	0.231	0	0.4	23.0	0.194	0	0.4
6	27.2	0.315	0	0.7	24.9	0.251	0	0.7
7	29.6	0.409	0	1	26.8	0.312	0	1
8	31.7	0.510	1	1	28.4	0.376	0	1
9	33.7	0.617	1	1	29.9	0.441	0	1
10	35.6	0.727	1	1	31.3	0.508	1	1
11	37.2	0.839	1	1	32.6	0.574	1	1
12	38.8	0.951	1	1	33.8	0.640	1	1
13	40.2	1.062	1	1	34.8	0.704	1	1
14	41.5	1.171	1	1	35.8	0.767	1	1
15	42.6	1.277	1	1	36.7	0.827	1	1
16	43.7	1.380	1	1	37.5	0.886	1	1
17	44.7	1.479	1	1	38.3	0.941	1	1
18	45.6	1.574	1	1	38.9	0.994	1	1
19	46.4	1.664	1	1	39.6	1.043	1	1
20	47.2	1.750	1	1	40.1	1.090	1	1
21	47.9	1.831	1	1	40.6	1.135	1	1
22	48.5	1.908	1	1	41.1	1.176	1	1
23	49.1	1.979	1	1	41.5	1.215	1	1
24	49.6	2.047	1	1	41.9	1.251	1	1
25	50.1	2.110	1	1	42.3	1.285	1	1
26	50.6	2.169	1	1	42.6	1.317	1	1
27	51.0	2.224	1	1	42.9	1.346	1	1
28	51.3	2.275	1	1	43.2	1.373	1	1
29	51.7	2.322	1	1	43.5	1.398	1	1
30	52.0	2.366	1	1	43.7	1.421	1	1
31	52.3	2.407	1	1	43.9	1.443	1	1
32	52.5	2.445	1	1	44.1	1.463	1	1
33	52.8	2.480	1	1	44.3	1.481	1	1
34	53.0	2.512	1	1	44.5	1.498	1	1
35	53.2	2.542	1	1	44.6	1.513	1	1
36	53.4	2.569	1	1	44.7	1.527	1	1
37	53.6	2.594	1	1	44.9	1.541	1	1
38	53.7	2.618	1	1	45.0	1.553	1	1
39	53.8	2.639	1	1	45.1	1.564	1	1
40	54.0	2.659	1	1	45.2	1.574	1	1
41	54.1	2.677	1	1	45.3	1.583	1	1
42	54.2	2.694	1	1	45.3	1.592	1	1
43	54.3	2.709	1	1	45.4	1.600	1	1
44	54.4	2.724	1	1	45.5	1.607	1	1
45	54.5	2.736	1	1	45.5	1.614	1	1
46	54.6	2.748	1	1	45.6	1.620	1	1
47	54.6	2.759	1	1	45.6	1.625	1	1
48	54.7	2.769	1	1	45.7	1.630	1	1
49	54.7	2.779	1	1	45.7	1.635	1	1
50	54.8	2.787	1	1	45.8	1.639	1	1