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Abundance and size composition of recruited blue cod in the Marlborough Sounds, September 2001

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7. Executive summary

The report describes a pot and line fishing survey carried out to assess the distribution and relative abundance of blue cod *Parapercis colias* in the Marlborough Sounds during September 2001. It fulfils the reporting requirements of project BCO 2001/01.

Objective 1 – To assess the status of blue cod (*Parapercis colias*) stocks in the Marlborough Sounds (BCO 7).

The size structure, distribution and relative abundance of blue cod were assessed from 378 pot and 84 line fishing stations completed from 5–16 September 2001. A total of 1935 blue cod (1127 males and 808 females) were captured, and these represented 83% of the total survey catch of 783 kg. In 2001, paua *Haliotis iris* bait was used, due to the unavailability of the pilchard *Sardinops neopilchardus* bait used for the previous (1995 and 1996) surveys. Bycatch of conger eel *Conger verreauxi* and octopus *Octopus condiformis* formed less than 3% of the 2001 survey total catch, and catch of other species was insignificant. This level of bycatch was lower than in the previous surveys, although bait trials competed as part of the 2001 programme (see Appendix 2) determined no significant difference in blue cod mean size, abundance, or size composition between these two bait types.

This survey determined that the mean catch (kg/pot hour) of recruited blue cod (total length greater than 28 cm) decreased for all strata in 2001, as compared to previous surveys for Queen Charlotte Sound (1995) and Pelorus Sound (1996), although this scale of decrease varied among strata. For the Queen Charlotte Sound strata, this decrease ranged from 36% (IQCH) to 60% (EQCH). For the Pelorus Sound strata, the decrease ranged from 51%

(DURV) to 87% (IPEL). A similar scale of decrease occurred in the mean catch (number/hour) of recruited blue cod/hour during this period, in Queen Charlotte Sound, from 34% (IQCH) to 58% (EQCH), and in Pelorus Sound, from 50% (DURV) to 87% (IPEL). Although the scale of the indicated reduction in catch rate is significant, there are only two points in this time series, and these data should be treated with caution as indicating a substantial decrease in relative blue cod abundance. However, this trend is supported by available data from the two Pelorus Sound strata (OPEL, EOPE) that were sampled in all three years (1995, 1996, 2001), where mean recruited catch rates varied slightly between 1995 and 1996, but decreased significantly between 1995 and 2001. This trend occurred both in catch by weight (kg/hour), and catch by numbers of fish (no./hour).

During 2001, little difference occurred in mean size of blue cod among the Queen Charlotte strata, but mean size was lower among the Pelorus Sound strata, than for DURV, and lowest in the IPEL stratum for both males and females. For all strata sampled in 2001, mean size of male and female blue cod is lower than the data recorded from the 1995 and 1996 surveys. These data are consistent with a high level of fishing pressure operating on recruited blue cod in the Marlborough Sounds, and are suggestive of local depletion, particularly in the inner sounds.

Recreational blue cod target fishing in the Marlborough Sounds during 1997–98 approximated to the strata used in the 1995, 1996 and 2001 research surveys indicated that effort focused on the outer areas of both sounds, and D'Urville Island, whilst little fishing effort occurred in the inner sounds strata (IPEL and IQCH). This shift in effort to the outer sounds partially explains the reduction in mean catch rates determined from research survey data in the outer sounds strata between 1995–96 and 2001. The low mean catch rates determined from the inner sounds strata from the 1997–98 recreational diary survey were similar to the mean catch rates for all blue cod derived from the line fishing stations of the 1995, 1996 and 2001 blue cod research surveys. Mean catch rates or recreational fishers were lower than the data from the line fishing stations from the research survey line fishing stations, although the decrease in mean catch rate from the inner to the outer strata was consistent between the 1997–98 diary survey data and the line fishing stations from the research surveys.

Based on these estimates of the relative abundance of recruited blue cod, the Marlborough Sounds population appears to have roughly halved between 1995–96 and 2001. The limited data available for three years of sampling supports these trends, but further sampling in subsequent years is necessary to validate these data. From the review of soak time (Appendix 1 of this report), most blue cod are caught in the first 0.5 hr of the soak time. As soak time did not affect mean size, or sex ratio of blue cod, some operational savings may be made in subsequent surveys by reducing survey soak time from 1 hour to 0.5 hour.

8. Objectives

The objective for project BCO2001/01 was:

1. To assess the status of blue cod (*Parapercis colias*) stocks in the Marlborough Sounds (BCO 7).

Specific objectives for 2001/02 were:

1. To provide a second point in the time series of relative abundance indices of blue cod (BCO 7) in the Marlborough Sounds using a pot and line fishing survey.

2. To compare the effect of 0.5 hour and 1 hour pot soak times for blue cod.

9. Introduction

This report describes a pot and line fishing survey of blue cod *Parapercis colias* carried out during September 2001 in the Marlborough Sounds. The survey provides a second point in a time series of relative abundance indices of the Marlborough Sounds blue cod fishery, initiated by pot and line surveys completed in Queen Charlotte Sound during September 1995 (Blackwell 1997a) and in Pelorus Sound/D'Urville Island during September 1996 (Blackwell 1998). The work was completed as part of Ministry of Fisheries contract BCO2001/01.

Blue cod has been identified as one of the most important recreational target fish species in the Central Region (Blackwell 1997b, Bradford 1998a, Hartill et al. 1998), and 52% of the 2707 fishing trips reviewed in the 1997–1998 Marlborough Sounds recreational fishing survey (Bell 2001) nominated blue cod as the preferred target species. Blue cod was also the major target species for recreational fishers on charter vessels in the Marlborough Sounds (James & Unwin 2000). Previous potting/line fishing surveys (Blackwell 1997a, 1998) determined that the relative abundance of blue cod appeared to be inversely proportional to the level of access to recreational fishers. Anecdotal evidence (D. Boulton, French Pass, pers. comm. 2001) suggested that fishing pressure has continued to increase, particularly in the Outer Pelorus Sound and the east coast of D'Urville Island, since these earlier surveys were completed. Following concerns about the release mortality of blue cod, the minimum legal size for recreational fishers was reduced from 33 cm to 28 cm in 1993 (Carbines 1999), for the Marlborough Sounds and the east coast of D'Urville Island sub-area of the Challenger Fishery Management Area (Annala et al. 2001). The maximum recreational bag limit was reduced from 20 to 10 blue cod in this sub-area in 1993, and further reduced to 6 fish/day in 1994 (Annala et al. 2001). The Ministry of Fisheries and stakeholder groups are currently developing a Fisheries Management Plan (FMP) for blue cod.

Blue cod also supports a small target commercial fishery based in the outer Marlborough Sounds (EOPE, EQCH, and DURV strata), and in Cook Strait. Whilst no commercial target blue cod fishing occurs in the Marlborough Sounds, trawl fishing for snapper and flatfish in these areas incurs an occasional blue cod bycatch (Warren 1994). The TACC for the BCO 7 fishstock (which includes the Marlborough Sounds) of 70 tonnes (t) has been under-caught since 1997–98. Recent landings in BCO 7 have declined from 60 t in 1997–98 to 52 t in 1988–89, and 28 t in 1999–2000. The minimum commercial legal size remains at 33 cm (Annala et al. 2001).

The changes in blue cod associated with the Long Island Kokomohua Marine Reserve have been monitored by Davidson (2001). Recent surveys in the Long Island Kokomohua Marine Reserve (Villouta et al. ms) suggest that strong recruitment of blue cod may have occurred since 1996. Diver surveys also reported a second cohort of recruited blue cod (Villouta et al. ms), possibly from a second spawning event in late summer. This is supported by observations of spawning adults occurring in late summer (C. Aston, commercial fisher, French Pass, pers. comm. 1999).

A side scan sonar survey (BCO 9701) completed in 1999, mapped the area of rocky bottom habitat available for blue cod in the Marlborough Sounds (Cole 1999). Cod pots with a fine mesh inner liner, combined with standardised line fishing stations have been shown to be an effective way of sampling the recruited blue cod population in the Marlborough Sounds, providing data on age structure and sex ratios (Blackwell 1998). The use of pot fishing CPUE (kg/pot hour) was accepted by the 1999 Inshore Working Group as able to provide a valid estimate of the relative abundance of blue cod.

Under a sub-objective of the contract BCO 2001/01, two soak times (30 min and 60 min) for blue cod potting were evaluated. The results of this review are presented in Appendix 1 of this report.

10. Project and voyage personnel

The blue cod pot and line fishing survey was carried out from 4 to 17 September 2001. The project leader was Ron Blackwell, assisted by Kelly May. Craig Aston was the skipper of the fishing vessel Lady H.R. (Helen Rose), chartered for the survey.

11. Methods

11.1 Survey area

The Marlborough Sounds (Figure 1) comprise two drowned valley systems situated at the north-eastern end of the South Island of New Zealand. The two major sounds within this area (Queen Charlotte and Pelorus) include diverse habitat, from sheltered reefs, to exposed rocky coasts and offshore islands. Both are essentially shallow water bodies that are influenced by the input of cold nutrient-rich upwelling waters from the adjacent deep waters of Cook Strait. Queen Charlotte Sound, bounded to the east by Arapawa Island, and by Alligator Head in the west, has no major freshwater input. It is characterised by complex tidal current patterns, through the mouth of the Sound and through Tory Channel to the southeast (Heath 1974).

Pelorus Sound is bounded by Alligator Head in the east and by D'Urville Island to the west. It is perhaps less influenced by cold water input than Queen Charlotte Sound, due to the intrusion of warmer, less nutrient-rich tidal currents from Tasman Bay that enter through French Pass, and also by the major freshwater input of the Pelorus River (Heath 1982).

Blue cod habitat was assumed to include all possible sites over rocky reefs and rubble banks that are commonly found off the headlands and drop-offs within a band 10–100 m offshore and approximately 10–60 m in depth. The nature and extent of this blue cod habitat has been assessed by side scan sonar by Cole (1999). The estimated area of blue cod habitat for each sampling stratum was used to determine the mean weighted CPUE (kg/pot) and associated sampling c.v. (see Table 8).

11.2 Sampling methodology and survey design

Previous surveys (Blackwell 1997a, 1998) assessed the relative abundance of all sampled blue cod. However, recent comparisons between pot fishing and diver count methods (Cole et al. 2001) indicated that pots were less successful in catching small blue cod. It was agreed that this, and subsequent surveys, would concentrate on blue cod that had recruited into the fishery (i.e. greater than 28 cm total length). The sampling gear and sampling methods were standardised with the methods used for the previous surveys, including the use of a 15 cm galvanised wire pot mesh liner (Blackwell 1997a, 1998).

11.2.1 Stratification

The 2001 survey was designed to achieve an estimate of relative biomass (kg/pot hour fished) of recruited blue cod with a c.v. of less than 20%. Each major sound was divided into sampling strata using a hierarchical sampling design, based on the distance from the head of the sound, and on major topographical features (see Figures 1 & 2). Greater Queen Charlotte Sound was divided into three strata: Inner Queen Charlotte Sound (IQCH); Outer Queen Charlotte Sound (OQCH); and Extreme Outer Queen Charlotte (EQCH), as defined in Blackwell (1997a).

Greater Pelorus Sound was divided into five strata (see Figures 1 & 2). These were: Inner Pelorus Sound (IPEL); Mid Pelorus Sound (MPEL); Outer Pelorus Sound (OPEL); Extreme Outer Pelorus Sound (EOPE); D'Urville (DURV), as defined in Blackwell (1998).

11.2.2 Analysis of previous survey data

In the 1995 and 1996 surveys, eight sampling areas of suitable rocky/rubble reef habitat were identified within each stratum (Blackwell 1998). Four of these eight sampling areas (A-D) were randomly selected (using random number tables) and sampled using an equal allocation sampling strategy, to determine mean CPUE. Additional sampling was completed for age and length information, but these data were not included in the CPUE analysis.

To estimate the c.v.'s of the 1995 and 1996 potting surveys, the 1995–96 mean weighted catch rates (kg per set) were calculated for each stratum (D. Gilbert, NIWA, pers. comm. 2001). From the sampling data and the 1998 side scan sonar survey (Cole 1999), blue cod habitat of rocky/cobble bottom extends approximately 10–60 m offshore. Beyond this distance, the bottom generally consists of silty sand or mud, and was not considered blue cod habitat. The area of blue cod habitat was estimated by measuring the length of coastline in each stratum, assuming that the habitat consisted of a band of equal width extending out from the coast. The curvature of all strata was assumed similar, and therefore the length of the coastline was proportional to the amount of blue cod habitat. Each stratum mean catch rate and biomass was weighted by the stratum coastline length, then divided by the sum of all stratum coastline lengths, to give an overall weighted mean. The stratum standard errors of the means were correspondingly combined (by squaring each standard error times its weighting, summing them, and then taking the square root), to obtain an estimate of the sampling c.v. For the 1995 and 1996 surveys, where 36 pot stations were sampled per stratum, the overall relative abundance index was 2.8 kg/pot and the estimated c.v. was 5.1%.

11.2.3 Review of sample design

Data from the 1995–96 survey were reviewed to optimize the sampling design. Although the equal allocation model used in 1995–96 achieved the design accuracy, anecdotal evidence from recreational fishers (D. Boulton, pers. comm. 2001) indicated that the density of recruited blue cod was likely to have been reduced since the earlier surveys were completed. Statistical advice (D. Gilbert, NIWA, pers. comm. 2001) indicated that application of the original sample design to recruited blue cod may not achieve the design target c.v. of 20%. Variance component analysis (PROC VARCOMP SAS Institute Inc., 1989) of the 1995–96 catch by weight (kg/pot) data determined that the among stratum variance was high ($Var_{(stratum)}$ = 4.18, s.e. = 2.32), whilst minimal variance was associated with area ($Var_{(area(stratum))}$ = 0.00, s.e. = 0.00), or sample site ($Var_{(site(stratum*area))}$ = 0.25, s.e. = 0.33). The remainder of the variance was associated with random sampling error ($Var_{(error)}$ = 4.84, s.e. = 0.49).

Review of the 1995–96 catch by numbers (no./pot) data also determined that the among stratum variance was high ($Var_{(stratum)}$ = 32.89, s.e. = 18.47), with almost no variation at the area ($Var_{(area(strata))}$ = 0.00, s.e. = 0.00) or station level ($Var_{(site(strata*area))}$ = 0.00, s.e. = 0.00). The remainder was associated with random sampling error ($Var_{(error)}$ = 59.87, s.e. = 5.06. These comparisons indicated that the among stratum variance was high and the review of the sample design should concentrate in reduction of this variance by increasing the number of areas sampled within strata.

Use of a two phase sample design may significantly reduce sampling variance (Francis 1984). The effect of additional sampling was simulated using previous survey data. Analysis of the 1995–97 mean catch by weight, and catch by numbers of fish indicated that a significant gain in sampling precision could be achieved by the addition of one extra sampling area in each of the OQCH, EQCH, MPEL, OPEL, and the DURV strata. Additional sampling areas were selected from the original eight sampling areas initially identified per stratum (see Blackwell 1997a, 1998). For the OQCH stratum, additional areas (see Table 2) for first phase sampling were established within OQCH at Arapawa Island (2E), and within the EQCH stratum at Cape Jackson (3C). Additional areas were established within the EOPE stratum at Goat Point (4E), within the DURV stratum at Bonne Point (6L), and within the MPEL stratum at Maud Island-West (8E).

After the first phase of the survey was completed, an additional four sampling areas were allocated, based on the gain in sampling precision that could be achieved, using the methods of Francis (1984).

11.2.4 Sampling methodology

For the first phase, sampling generally followed the hierarchical sampling design of Blackwell (1997a, 1998), where sampling areas were selected within each stratum, and sampling sites and fishing stations were selected within each sampling area. Within each stratum, four sampling areas were selected in IQCH and IPEL, and five sampling areas were selected in the remaining strata, using random number tables from the original areas selected for the 1995–96 survey (Blackwell 1997a). To avoid any time bias, the time of sampling (morning or afternoon) was randomly allocated among the four areas sampled each day. Two areas were completed in the morning, and two areas in the afternoon.

For the nine replicate pot stations allocated to each sampling area, three sampling sites (1–3) were randomly chosen from the available blue cod habitat. At each of these sites, three replicate pot fishing stations (a-c) were established. Two line fishing stations (d & e) were also established adjacent to the first (station a) and last (station c) pot stations within each sampling area.

After the first stage sampling was completed, the catch rate data for catch by weight and for catch by number, were entered into the NIWA second phase sample allocation programme, to determine the highest relative gain per stratum for the four additional sampling areas allocated to the second phase of the survey. Two areas (see Table 2) were allocated within the OQCH stratum at Clark Point (2F), and Outer Tory Channel (2G). Within the OPEL stratum, one area was allocated at Te Akaroa (5G), and within the DURV stratum, one area was allocated at Catherine Cove (6M).

11.3 Vessel and gear specifications

The commercial fishing vessel *Lady H.R.* and associated pot fishing gear, as used in the 1995–96 surveys was again used for the 2001 survey, to standardise methodology. This vessel is 9.6 m in length, with a 3.2 m beam and a displacement of 10 t. It is powered by a Ford diesel generating 60 kW and is fitted with power hauling gear for cod pot fishing. It is equipped with a Koden colour depth sounder, and was equipped for the survey with 5 kg and 1 kg motion-compensating Seaway electronic scales, Trimble portable GPS system, and the standard NIWA-electronic data capture systems.

The cod pots used in the 1995 and 1996 surveys (see Blackwell 1997a, 1998) were used for the 2001 sampling. These are rectangular in shape (1.87 x 1.40 x 0.93 m), constructed from a 40 mm diameter steel rod. This framework was covered with 60 cm nylon mesh, and a 15 mm galvanised wire mesh inner liner was added to the bottom and sides. Each pot has four entrances, each leading into a short steel wire tube. The internal entrance of this tube was provided with inward-facing wire spines, as detailed in Blackwell (1997a). The pot was attached by a polypropylene rope to a large buoy with the vessel name and number. The length of rope was adjusted for differences in tide and current as appropriate.

Bait used for pot and line fishing stations in the 2001 survey was frozen paua *Haliotis iris,* as the frozen pilchard *Sardinops neopilchardis* bait previously used in the 1995 and 1996 surveys was commercially unavailable (C. Aston, commercial fisher, pers. comm. 2001). Local abundance of pilchard in the Marlborough Sounds and Tasman/Golden Bays has been low since the late 1990s, following a herpes virus epidemic (Smith et al. 1996). The commercial blue cod pot fishery now uses paua *Haliotis iris* guts (C. Aston, pers. comm. 2001). A series of paired t-test comparisons (see Appendix 2) failed to determine any difference in overall catch rate, sex ratio, or catch of large blue cod (greater than 28 cm TL) due to bait type for blue cod pot fishing, and the effect of bait type has been ignored in subsequent analysis. The paua guts were stored frozen, and thawed as required. For use in pots, the paua guts were enclosed in a perforated plastic bait box, which was attached to the inside bottom surface of the pot. The tough membranes of the paua guts were attached directly to the hooks in the line fishing stations.

The line fishing stations established for the 1995–96 surveys were repeated in the 2001 survey, as a control, and to provide comparisons with the major fishing method employed by amateur fishers targeting blue cod (see Appendix 4). One line fishing station was established adjacent (approximately 50 m) from the first pot set, and a second, adjacent to the last pot set, at each sampling area (see Table 2). Fishing gear and methods used were standardised with the 1995–96 surveys, and consisted of two braided nylon handlines were fished for 15 minutes at each line fishing station. Each line was baited with frozen paua guts and set with two 6/0 Kale hooks on a 0.5 m trace, fixed at 0.5 m and 1.0 m from the weight.

11.4 Sampling procedure

All stations were occupied in daylight, and morning sampling generally commenced at 07:00 hours. The pots were sequentially deployed at approximately two-minute intervals. Each pot was deemed to be fishing once the float was detached from the vessel. The pots were fished for 1 hour; during which time the two line fishing stations were sampled. After 1 hour, the pots were sequentially recovered, and the catch was removed and processed. The vessel then steamed to the second and subsequent sampling areas. Afternoon fishing continued until 16:00.

11.4.1 Catch and biological sampling

Data were collected on the standard NIWA biological survey forms (trawl survey forms 1989 edition), and later entered on to the NIWA research database (as LHR2001), with each pot fishing stations starting sequentially from 1, and line fishing stations from 901. For each station, location and environmental data were recorded on to the standard NIWA research database recording forms (trawl survey forms, 1989 edition): location (date, latitude and longitude, depth, and times of set and haul); wind direction (degrees true), strength (Beaufort scale); cloud cover (1–8); water condition and colour; and height and direction of swell. Bottom type was recorded in the standard NIWA categories: 1, mud; 2, sand/mud; 3, sand/gravel; 7, rock/rubble, based upon data from the depth sounder and on observations of the substrate attached to the pot upon recovery.

The catch from each pot or line fishing station was sorted by species on deck and weighed (to the nearest 0.1 kg) using 5 kg electronic motion-compensating Seaway scales. The number and total weight by species were recorded. For major commercial finfish species, the total length (to the nearest whole centimetre below actual length) and sex were recorded by the method appropriate for the species. Bycatch species were returned alive to the sea where possible.

For each blue cod, length, weight, sex and gonad maturity stage (determined by dissection and visual examination) were measured and recorded. Biological data were collected for a sub-sample of 20 blue cod from each station. Gonad samples of each maturation stage were collected for subsequent histological examination. The gonad stages were: 1, immature or resting; 2, developing (oocytes visible in females); 3, mature (hyaline oocytes in females, milt expressible in males; 4, running ripe (eggs and milt freely flowing); 5, spent. To determine the minimum length at sexual maturity for each stratum, the minimum size of fish with stage 4 gonads was recorded. The presence of stage 4 gonads was regarded as a conservative estimate of sexual maturity.

Otoliths were collected from 20 blue cod from each 1 cm size class, per sex and sampling stratum, and these were inventoried for storage at NIWA Nelson. Stomach contents were collected from 170 blue cod, selected at random during the survey, within a size range of 18–48 cm for males and 16–30 cm for females. The stomach contents were fixed in 4% formalin, and stored in 40% formalin for later analysis.

11.5 Data analysis

Length frequency distributions were determined by fishing method (pot and line) for all areas combined, and for each sample stratum (pot and line data combined). The sex ratio (percentage of males) was determined for each sampling area.

Catch rates were determined from the pot fishing station data only. The overall mean catch rate (kg per pot-hour), and the mean catch rate of recruited blue cod were determined by stratum. Following a review of the data diagnostics, these data were subjected to a log (x+1) transformation, and a standard amount (0.001 kg or 0.001 fish) were added as appropriate, to avoid taking the log of zero (Green 1979). The mean catch rates for recruited blue cod were compared among strata and fishing years (1995, 1996, and 2001) using the analysis of variance (ANOVA) procedure in PROC GLM (SAS 1989). Where the first order interaction between stratum and fishing year was significant, the differences between the means of the levels of the main effects could not be interpreted. Given the high number of stations with zero catch of recruited blue cod, the main effects (year and stratum) were also analysed using the non-parametric Wilcoxon Rank Sums test (Snedecor & Cochran 1980) of PROC NPAR1WAY (SAS 1989).

12. Results

Of the 462 stations completed (Table 2), 378 were potting stations and 84 were line fishing stations. All planned first and second phase stations were completed, and only one half-day was lost due to bad weather. Station location and catch data are given in Appendix 3.

12.1 Catch composition

Blue cod occurred at 306 (66%) of the 462 stations sampled. Bycatch was relatively low, with juvenile leatherjackets *Parika scaber* occurring at 16 stations (8%) and juvenile tarakihi *Nemadactylus macropterus,* at 15 stations (3%) sampled (Table 3). Blue cod dominated the catch by weight, representing 83% of the total survey catch of 783 kg (Table 3). The 1935 blue cod sampled comprised 1127 males and 808 females (58.2% males). Bycatch by weight was low, with conger eel *Conger verreauxi* and octopus *Octopus condiformis* each representing less than 3% of the catch by weight, and the remaining 9 species (Table 3) representing a further 6% of the landed weight. The size range and numbers taken of the major species are given in Table 4.

12.2 Total blue cod catch

12.2.1 Catch by method

Catches from the line fishing stations were low in all strata (Table 5), with a size range from 19–47 cm (Figure 3). Of the 139 blue cod taken, 99 were male and 40 were female (71% were male). For the pot fishing stations, 1796 blue cod were caught, with a size range from 12–48 cm (Figure 3). Of these, 1028 were male and 768 female (57% were male). The catch and mean sizes by stratum are given in Table 5.

From the unscaled length frequency distributions (Figure 3) by method, the larger (recruited) blue cod length classes tend to be male-dominated in both fishing methods, whilst the smaller length classes (pre-recruits) tend to have a more even sex ratio. These length frequency distributions differ between fishing methods for male blue cod. The median length for line fishing (28.0 cm) was significantly different at the 5% level, as compared to pot fishing (median length 29.32 cm) using the median test ($Z = 0.0154$: $Pr < 0.05$) of PROC NPAR1WAY of SAS (1989). For females, the median length for both methods was 26.0 cm. These data indicate that sex, or size-related differences may occur in gear selectivity. Insufficient numbers of fish were taken by line fishing to analyse the among-stratum trends in the line catch data, and subsequent analysis of mean catch rate is confined to pot fishing sites only. The 2001 line fishing data are compared to data from the previous (1995 and 1996) surveys in Appendix 4.

12.2.2 Catch by stratum (pot fishing stations only)

Overall mean catch (kg/pot) was highest (5.9 ± 1.2 kg/pot) for the DURV stratum and lowest (0.2 ± 0.1 kg/pot) for the IPEL stratum (Figure 4). This represents a decrease of 27% in overall mean catch for the DURV stratum (7.48 ± 1.15), and a decrease of 78% for the IPEL stratum (0.90 ± 0.43), as sampled in 1996. Similar rates of decrease in mean catch occurred for the strata sampled in 1995 and 2001. These low catch rates are reflected in the high number of zero catches in both sounds (see Appendix 3).

12.3 Recruited blue cod catch by weight (kg/pot)

The mean catch rates for the 2001 survey (Figure 5) indicate a progressive decrease in mean catch rate from the inner, to the outer sounds, for both the Queen Charlotte Sound strata (IQCH, OQCH, EQCH), and the Pelorus Sound strata (IPEL, MPEL, OPEL, EOPE). The highest mean catch rates occurred in the D'Urville stratum (DURV).

12.3.1 Queen Charlotte Sound (1995 and 2001 surveys)

The catch rates of recruited blue cod (Table 6a) were generally poor for both survey years (Table 6a.1). The percentage of zero catch (Table 6a.2) remained high in IQCH (66% in 1995, 63% in 2001), increased slightly in EQCH (from 22% to 31%), and doubled in OQCH (from 22% to 43%).

The decrease in mean catch (kg/pot), between 1995 and 2001 was statistically significant, but the year*stratum interaction ($F_{(2,249)} = 3.21$: $Pr < 0.05$) was also statistically significant (Table 6a.3). This precluded interpretation of the main effects of year and stratum, as the reduction in mean catch varied among strata (from 36% in IQCH, to 60% in EQCH). Analysis by the Wilcoxon Rank Sums test on the main effects was consistent with the ANOVA results (Table 6a.4).

12.3.2 Pelorus Sound (1996 and 2001 surveys)

Although the mean catch rate of recruited blue cod was highest in the DURV stratum (Table 6b.1), mean catch rates were generally lower for the other strata in Pelorus Sound, than for the Queen Charlotte Sound strata (see Figure 5). From Table 6b.2, the proportion of zero catch of recruited blue cod increased slightly between the 1996 and 2001 surveys in

DURV (from 5% to 9%) and OPEL (from 50% to 61%), but increased substantially in EOPE (from 11% to 24%), in IPEL (from 50% to 83%), and in MPEL (from 8% to 69%).

The decrease in mean recruited catch (kg/pot) between 1996 and 2001 was also statistically significant (Table 6b.3), but the significant year*stratum interaction term ($F_{(4,422)} = 5.96$: $Pr<0.001$) indicated that the scale of decrease between the survey years varied among strata (from 51% in DURV, to 87% in IPEL). This precluded further analysis of the main effects. Analysis by the Wilcoxon Rank Sums test on the main effects was consistent with the results of the ANOVA (Table 6b.4).

12.3.3 Three-year comparison (1995, 1996 and 2001)

The mean recruited catch (kg/pot) was sampled in the EOPE and OPEL strata within Pelorus Sound during 1995, 1996 and 2001 (Table 6c.1), and the proportion of zero catch increased in both strata between 1995, 1996, and 2001 (Table 6c.3). Mean recruited catch among the three survey years was reviewed by ANOVA (Table 6c.2). The significant year*stratum interaction ($F_{(2,251)} = 3.53$: $Pr<0.05$) indicated that the scale of decline in mean catch varied between stratum and year. Whilst the change in mean catch was minor between 1995 and 1996 (Table 6c.1), a significant decrease occurred between 1996 and 2001 for both strata (61% for EOPE and 84% for OPEL). The significant interaction term precluded further analysis between the main effects, although results of analysis using the Wilcoxon Rank Sums test on the main effects was consistent with the results of the ANOVA (Table 6c.4).

12.4 Recruited blue cod catch (numbers of fish/hr)

12.4.1 Queen Charlotte Sound (1995 and 2001 surveys)

The decline in mean recruited catch by numbers of fish (Table 7a.1) is statistically significant from ANOVA, although the significant year*stratum interaction ($F_{(2,249)} = 3.29$: $Pr <0.001$) indicated that the scale of decline (Table 7.a.2) varied among strata (from 34% in IQCH, to 58% in both OQCH and EQCH). The main effects were significant, but cannot be further interpreted. Analysis using the Wilcoxon Rank Sums test on the main effects was consistent with the results of the ANOVA (Table 7a.3).

12.4.2 Pelorus Sound (1996 and 2001 surveys)

The decline in mean catch (Table 7b.1) is statistically significant, and the significant year*stratum interaction term ($F_{(4,422)}=6.38$: $P<0.001$), indicated this rate of decline varied among strata (Table 7b.2), from 48% in DURV, to 87% in IPEL (Table 7b.1). The main effects were significant, but cannot be further interpreted. Analysis using the Wilcoxon Rank Sums test on the main effects (Table 7b.3) was consistent with the results of the ANOVA.

12.4.3 Three year comparison (1995, 1996 and 2001)

From ANOVA, the decline in mean numbers of recruited blue cod between the EOPE and OPEL strata between 1995, 1996 and 2001 (Table 7c.1) was statistically significant ($F_{(2,251)} = 3.77$: $Pr<0.05$), indicating these trends varied among years and strata (Table 7c.2). Although mean catch varied between 1995 and 1996 (an increase in OPEL of 13%, a decrease in EOPE by 18%), mean catch decreased between 1996 and 2001, in both strata (by 58% in EOPE and by 84% in OPEL). The main effects were significant but cannot be interpreted, and analysis using the Wilcoxon Rank Sums test (Table 7c.3) was consistent with the results of the ANOVA.

12.5 2001 survey mean weighted catch rates and estimation of sampling c.v.

The raw mean catch (kg/pot), weighted by the estimated area of coastline in each sampling stratum provide mean weighted relative abundance indices and estimated c.v.'s for all blue cod, and for recruited blue cod (Table 8). These mean weighted catch rates are lower than the initial survey indices, when corrected for the areas of blue cod habitat per stratum.

The mean weighted stratum estimates of overall catch rate vary from 0.03 ± 0.02 kg/pot (c.v. 23%) in IQCH, to 0.78 ± 0.16 kg/pot (c.v. 10%) in DURV. The overall mean weighted catch rate of 1.55 kg/pot has an estimated sampling c.v. of 7%, which is within the survey target sampling c.v. of 20%.

Estimated mean weighted catch rates for recruited blue cod (Table 8) ranged from 0.01 ± 0.01 kg/pot (40% c.v.) in IPEL, to 0.15 ± 0.01 kg/pot (19% c.v.) in OQCH. The overall mean weighted catch rate for recruited blue cod is 1.07 ± 0.01 kg/pot. The estimated sampling c.v. of 7%, is within the target sampling c.v. of 20%.

12.6 Length frequency

Length frequency distributions by stratum (Figure 6), indicate a strong size selectivity operating on the fishery, which is reflected in the mean size of fish sampled. However, this trend may be confounded by the heavy fishing pressure that appears to be operating, which is in turn represented by the low numbers of fish sampled in the inner sounds strata. In Pelorus Sound, the mean size (Table 5) of both male and female blue cod increased from the inner to the outer sounds. While a similar trend is suggested for males sampled in the OQCH and EQCH strata in Queen Charlotte Sound, the IQCH stratum does not follow this trend. The mean length for males (30.28 cm ± 2.88 cm) in IQCH is strongly influenced by two large fish (44 and 46 cm, Figure 6) due to the small number of blue cod (n = 52) taken from this stratum in 2001. Little difference could be seen in mean length for females among these strata (Table 5). The smallest blue cod were sampled in IPEL (mean size = 26.87 ± 1.96 cm for males, and 21.14 ± 1.80 cm for females), and in MPEL (mean size = 27.49 + 0.82 cm for males, 22.52 + 1.34 cm for females), although the mean size for IPEL may also be influenced by the low number (n = 30) of fish caught in this stratum. The largest blue cod occurred in the DURV stratum (mean size 30.74 ± 0.42 cm for males, 27.33 ± 0.24 cm for females).

12.7 Sex ratio

Male blue cod generally dominated the survey catches (58.2% overall), and formed 57% of the overall pot catch (see Table 5). Among sampling strata (Table 9), sex ratios were approximately equal in IQCH (48% male), IPEL (53% male), and in DURV (52% male), but varied from 61% male (OQCH) to 67% male (OPEL) for the other strata. No consistent trends overall could be determined in sex ratio by size class (Table 9).

12.8 Length at sexual maturity

No consistent relationship could be determined between fish length and gonad maturity stage among sampling strata (Figure 7), although this may be related to the size range of the blue cod sampled in each stratum. The minimum size of sexual maturity (actively spawning stage

4 gonads) for female blue cod varied from 14 cm in OQCH, to 28 cm in EOPE, although spawning females were recovered in all strata, except EQCH and OPEL (Table 10). For males, the minimum size of sexual maturity (Figure 7) also varied widely, from 18 cm in OQCH, to 25 cm in MPEL. Actively spawning males were found in all strata (Table 10).

The relative proportions of sexual maturity stage varied among strata (Table 10), although most fish were in pre-spawning or maturing stages. Low numbers of post-spawning fish were found in the Queen Charlotte strata, but none in the Pelorus strata, which suggests that spawning was only beginning to occur at the time of sampling (5–15 September 2001).

12.9 Length and weight

Overall length-weight regressions were derived for males in the size range from 15 to 55 cm, and for females from 12 to 45 cm (Figure 8). These data are consistent with the calculated length-weight data for previous blue cod (1995–96) surveys (Blackwell 1997a, 1998), and for previously published data from trawl surveys completed in Tasman/Golden Bay (reviewed in Blackwell 1998).

13. Discussion

Blue cod is the most important recreational target finfish species in the Marlborough Sounds (Bell 2001), and the second most important recreational finfish nationally, after snapper (Bradford 1998). The Marlborough Sounds blue cod fishery (Annala et al. 2001) is managed as a sub-stock of the Challenger blue cod stock (BCO 7). It supports a small target commercial fishery, which is restricted to the outer sounds (Warren 1994). Although blue cod is also taken as a trawl bycatch in deeper waters of the Marlborough Sounds and in Tasman/Golden Bay, the total allowable commercial catch (TACC) for BCO 7 of 70 t has been under-caught in recent years. The 1999–2000 commercial landings for the BCO 7 fishery were 28 t (Annala et al. 2001).

The Marlborough Sounds blue cod substock is considered to be over-fished, mainly due to recreational fishing effort (Warren 1994). Recreational catch in BCO 7 has increased from 20–40 t in 1991–92, to 145–205 t in 1992–93 (Tierney et al. 1997). The most recent (1995–96) estimate of 239 t from Bradford (1998) represents a further increase in recreational catch. Although the diary survey included recreational fishers on charter boats, the sample size was insufficient to estimate this component of the recreational catch. (Bradford 1998). The catch from recreational fishers on charter vessels was estimated at 76 t in 1997–98 (James & Unwin 2000). These data suggest that the current total recreational blue cod catch in BCO 7 is over 300t.

Although the 1997–98 Marlborough Sounds recreational fishing diary survey (Bell 2001) does not provide catch estimates, blue cod was the nominated target species for 52% of fishing trips reported. Blue cod fishing was mostly carried out by rod or landline from private vessels or from the shore, with a relatively small amount of fishing from charter vessels (Bell 2001).

The 1995 survey of Queen Charlotte Sound (Blackwell 1997a), and the 1996 survey of Pelorus Sound (Blackwell 1998) provided initial indices of mean catch per hour, length frequency and mean size data, for all blue cod, based on an equal allocation sample design. Within each sound, catch rates were inversely proportional to the level of access to fishing areas, and Blackwell (1998) attributed these patterns to local depletion, due to recreational fishing pressure. Later comparisons between diver count and pot survey data in the inner sounds suggested that pot fishing may be biased towards larger fish (Cole et al. 2001), and the 2001 survey indexed the mean catch rate of recruited blue cod.

The 2001 survey re-sampled the 1995–96 survey strata to provide a second point in an index of mean catch of recruited blue cod in the Marlborough Sounds, using a revised two phase sample design. The overall estimated sampling c.v. of 7% for these estimates is within the design criterion of 20%. Indices of mean recruited catch (kg/pot) determined from the 2001 survey were substantially lower than the indices derived from the previous surveys in Queen Charlotte Sound (1995) and in Pelorus Sound (1996). The year*stratum interaction was statistically significant for both the Queen Charlotte and Pelorus Sound strata, and this indicated that the scale of decrease between survey years varied among strata. For the Queen Charlotte Sound strata, the decrease between 1995 and 2001 ranged from 36% in IQCH, to 60% in EQCH. For the Pelorus Sound strata, the decrease between 1996 and 2001 ranged from 51% (DURV) to 87% (IPEL and MPEL). A similar pattern of decrease occurred in mean recruited catch (numbers/pot) for these strata and time periods. The reduction in catch rate also increased the number of stations where no recruited blue cod were caught, and the data were log transformed (Green 1979) before examination by ANOVA. However, analysis of the main effects (year and stratum) by non-parametric methods was consistent with the results of the ANOVA on the log transformed data. This indicated decrease in mean catch rate is consistent with the decrease in the overall mean size of blue cod during the review period. In comparison with the data reported from the 1995 and 1996 surveys (see Figure 9), the mean size of both male and female blue cod from the 2001 survey decreased for all strata. The scale of this decrease varied among strata, from 1% (IPEL), to 10% (DURV) for males, and from 1% (DURV), to 16% (OPEL) for females.

A similar trend occurred in mean catch (as measured both by weight (kg/pot), and by numbers of fish) for the sub-sample of two strata (OPEL & EOPE) where data from three years (1995, 1996 and 2001) are available. These data showed little change between 1995 and 1996, but the scale of the reduction between 1996 and 2001 was statistically significant, and consistent with the trends described above. These data are consistent with a substantial reduction in the relative abundance of recruited blue cod, in the order of 50% between 1995–96, and 2001. However, this interpretation should be treated with some caution, until sampling in subsequent years in all strata can determine the validity of this trend.

These data indicate a substantial increase in recreational fishing effort between 1995–96 and 2001, particularly in the outer sounds strata. From the 1997–98 recreational diary survey of Bell (2001), recreational fishing catch and effort was approximated to the 1995, 1996 and 2001 survey strata (Appendix 4). This excluded recreational fishing in the Kenepuru and Mahau Sounds that were not surveyed in the 1995–96 and 2001 blue cod surveys. These data indicated that 90% of recreational fishing effort targeting blue cod was directed to the outer sounds during 1997–97. Mean catch rates in these outer strata were almost double that of the inner strata (IQCH, IPEL, MPEL). The high catch rates of in these outer strata during 1997–98 (Bell 2001) are consistent with the reduction in relative abundance of blue cod indicated between the 1995–96 and 2001 surveys.

Mean catch rates from the line fishing stations from the 1995, 1996 and 2001 surveys were variable (Figure A2), but generally followed the trends of reduction in catch effort described for the pot fishing data. Mean catch rates in the inner strata (IQCH, IPEL) were similar to the recreational diary data (Figure A2), but substantially higher for the outer strata. This difference may relate, in part to the small sample size of the line fishing stations. These line fishing stations were fished over known blue cod habitat, as determined by colour depth sounder, whilst not all of the recreational diary fishing may have occurred over blue cod habitat.

The inner sounds areas were identified as experiencing local depletion in 1995 and 1996 (Blackwell 1997a, 1998), and the 2001 data are consistent with a further decline in mean catch rate in these areas. Whilst Bell (2001) indicates that little recreational fishing activity occurred in these inner sounds areas during 1997–98, catch rates in these areas remain low. As recreational fishers travel over the inner sounds strata to fish in the more distant outer areas, they may "prospect fish" the inner sounds, by using electronic fish finders. Fishing may occur in these inner strata if suitable areas of high density of blue cod are located. As this searching activity may have been regarded as steaming time and not included in fishing time, the recreational fishing data may be an under-estimate of the actual fishing effort in these inner sounds areas.

The length frequency data by stratum from the 2001 survey are unimodal, and dominated by males in all strata. This is consistent with previous data (Blackwell 1997a, 1998), although the percentage of females sampled in 2001 actually increased in all strata, except OQCH, as compared to the 1995 and 1996 surveys (Blackwell 1997a, 1998). Sex ratios in 2001 were approximately equal for pre-recruit blue cod (less than 28 cm total length), and fewer large females were caught than in these previous surveys.

Blue cod are taken as bycatch of trawl fishing in the middle reaches of the Marlborough Sounds and also in Tasman/Golden Bays (Warren 1994). The length frequency data from the summer 1992–1995 trawl survey series in Tasman Bay (summarised in Blackwell 1998) were bimodal and strongly female-dominated. This contrasts with the male-dominated and unimodal length frequency data determined from the September 1995, 1996 and 2001 Marlborough Sounds surveys, although further sampling in comparable seasons would be required to compare length frequency data between these areas.

Whilst the presence of blue cod in deeper waters was initially related to spawning activity (Rapson 1956, Robertson 1973), blue cod appear unlikely to migrate over large distances in the Marlborough Sounds (Mace & Johnstone 1973). Spawning occurs within the Marlborough Sounds, as mature or spawning blue cod were observed in most strata during the 1995, 1996 and 2001 surveys (Blackwell 1997a, 1998). Tagging studies (Mace & Johnston 1983) suggest a low level of movement of blue cod (4% over 2.2 years) within the Marlborough Sounds, and the discernable differences in growth rate of blue cod that occur between Queen Charlotte Sound and Pelorus Sound (Carbines 2000) support this conclusion.

Blue cod are protogynous hermaphrodites (Mutch 1983, Carbines 1998). Many species with this reproductive strategy are not resilient to high fishing pressure, as increased fishing mortality may reduce the abundance of older age classes and hence the relative abundance of males (Hunstman & Schaaf 1994). For blue cod, the rate of sex change appears to be more plastic (Carbines 1998) than other protogynous species, where the time of sex change appears fixed (Shapiro 1986). High fishing pressure on blue cod, such as that operating in the inner Sounds may have the potential to select out faster growing fish (Carbines 2000). As male blue cod grow significantly faster than females (Blackwell 1998, Carbines 2000), the strongly male-biased sex ratios observed in the Sounds may result from earlier onset of sex inversion, as a response to high fishing pressure (Carbines 2000).

Shapiro (1986) and Siau (1994) note that for most protogynous species, the transition from ovary to testis usually occurs soon after spawning. Blue cod gonads were clearly differentiated during September 1995, 1996 and 2001, which probably represents the peak of the primary spawning season. Secondary male blue cod can only be differentiated from primary males for a short time after sex change (Carbines 1998), and the trigger for sex change appears complex (Carbines 1998). The rate of sex change may be influenced by factors such as the overall density of blue cod, fishing mortality, sex ratio, differential growth rates, and natural mortality, as well as by sex- or age-related differential migration (Cole & Robertson 1988, Huntsman & Schaaf 1994, Carbines 1989). Further sampling would be required to describe the second (Spring-Summer) spawning event (Villouta et al. ms), and to determine the nature and extent of protogyny in blue cod.

For protogynous species such as blue cod, determination of the rate of sex change is necessary for yield per recruit modelling, that allows the effects of management measures (such as the minimum legal size) to be evaluated. The initial yield per recruit model for blue cod (Blackwell 1998) was based on a fixed rate of sex change, determined from 1995 and 1996 growth rate data that was applied to both Queen Charlotte and Pelorus Sound blue cod. This model indicated that any increase in minimum legal size above 25 cm would fail to compensate for losses due to natural mortality. Blue cod reach sexual maturity at a relatively small size (23–26 cm for males, 21–26 cm for females), and diver observations indicate that juvenile blue cod appear to be abundant throughout the Marlborough Sounds (R. Cole, NIWA, pers. comm. 2000). Given the variation in growth rate (Carbines 2000), the low level of migration among sampling strata (Mace & Johnston 1983), and the high fishing pressure on blue cod in the Marlborough Sounds (see Appendix 4), it is likely that sex change also varies widely among strata, in a complex and flexible fashion (Carbines 2000). The applicability of a single YPR model to the entire Marlborough Sounds blue cod fishery may be questionable.

Based on the research survey indices of mean catch rate, the relative abundance of recruited blue cod in the Marlborough Sounds appears to have roughly halved between 1995–96 and 2001, whilst the mean size of blue cod has decreased in all strata during this period. The review of patterns in recreational fishing during 1997–98 indicates that effort has shifted to more distant grounds, which is consistent with local depletion of the inner sounds areas. The substantial reduction in mean catch rates for the outer sounds strata between 1995–96 and 2001 are consistent with such a shift in effort. Although the limited data available for three years of sampling are consistent with these trends, further sampling in subsequent years over all survey strata is required to accurately determine the magnitude of these temporal trends in relative abundance.

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15. Publications

Nil.

16. Data storage

All data have been archived in a Microsoft Access database, and will be transferred to the Research database, administered by NIWA.

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Table 1: Stratification used in the 2001 Marlborough Sounds blue cod survey

Stratum code	Area	Site code	Location of area
IQCH	**1**		**Inner Queen Charlotte**
	A	1A1–1A3	Kaipapa
	B	1B1–1B3	Dieffenbach Point
	C	1C1–1C3	Luke Rock
	D	1D1–1D3	Bay of Many Coves
OQCH	**2**		**Outer Queen Charlotte Sound**
	A	2A1–2A3	Inner Tory Channel
	B	2B1–2B3	Hawes Rock
	C	2C1–2C3	Resolution Bay
	D	2D1–2D3	Pickersgill Island
	E	2E1–2E3	Arapawa Island
	F	2F1–2F3	Clark Point
	G	2G1–2G3	Outer Tory Channel
EQCH	**3**		**Extreme Outer Queen Charlotte Sound**
	A	3A1–3A3	Stella Rock
	B	3B1–3B3	The Twins
	C	3C1–3C3	Cape Jackson
	D	3D1–3D3	Alligator Head
	E	3E1–3E3	Cape Lambert
IPEL	**7**		**Inner Pelorus Sound**
	A	7A1–7A3	Jacob's Bay
	B	7B1–7B3	Mary's Bay
	C	7C1–7C3	Te Puraka Point
	D	7D1–7D3	Te Rawa
MPEL	**8**		**Mid Pelorus Sound**
	A	8A1–8A3	Kauauroa Bay
	B	8B1–8B3	Ram's Head
	C	8C1–8C3	Maud Island
	D	8D1–8D3	Tapaapa Point
	E	8E1–8E3	Maud Island-West
OPEL	**5**		**Outer Pelorus Sound**
	A	* 5A1–5A3	The Reef
	B	* 5B1–5B3	Boat Rock Point
	C	* 5C1–5C3	Katira Point
	D	* 5D1–5D3	Duffers Reef
	F	5F1–5F3	Camp Bay
	G	5G1–5G3	TeAkaroa
EOPE	**4**		**Extreme Outer Pelorus Sound**
	A	* 4A1–4A3	Forsyth Island
	B	* 4B1–4B3	Chetwode Island
	C	* 4C1–4C3	Clay Point
	D	* 4D1–4D3	Harris Bay
	E	4E1–4E3	Goat Point
DURV	**6**		**D'Urville Island**
	A	6A1–6A3	Rangitoto Islands
	B	6B1–6B3	West Trios Islands
	C	6C1–6C3	East Trios Islands
	D	6D1–6D3	Penguin Bay
	L	6L1–6L3	Bonne Point
	M	6M1–6M3	Catherine Cove

* Denotes stations sampled in 1995, 1996 and 2001

Table 2: Numbers of stations sampled by stratum and area in the 2001 Marlborough Sounds blue cod survey

+ denotes additional sampling area
* denotes second phase sampling area

Stratum	Area	Site code	Location of area		Stations Pots	Stations Lines
IQCH	**1**		**Inner Queen Charlotte**			
	1A	1A1–1A3	Kaipapa		9	2
	1B	1B1–1B3	Dieffenbach Point		9	2
	1C	1C1–1C3	Luke Rock		9	2
	1D	1D1–1D3	Bay of Many Coves		9	2
			Total		36	8
OQCH	**2**		**Outer Queen Charlotte Sound**			
	2A	2A1–2A3	Inner Tory Channel		9	2
	2B	2B1–2B3	Hawes Rock		9	2
	2C	2C1–2C3	Resolution Bay		9	2
	2D	2D1–2D3	Pickersgill Island		9	2
	2E	2E1–2E3	Arapawa Island	+	9	2
	2F	2F1–2F3	Clark Point	*	9	2
	2G	2G1–2G3	Outer Tory Channel	*	9	2
			Total		63	14
EQCH	**3**		**Extreme Outer Queen Charlotte Sound**			
	3A	3A1–3A3	Stella Rock		9	2
	3B	3B1–3B3	The Twins		9	2
	3C	3C1–3C3	Cape Jackson		9	2
	3D	3D1–3D3	Alligator Head		9	2
	3E	3E1–3E3	Cape Lambert	+	9	2
			Total		45	10
EOPE	**4**		**Extreme Outer Pelorus Sound**			
	4A	4A1–4A3	Forsyth Island		9	2
	4B	4B1–4B3	Chetwode Island		9	2
	4C	4C1–4C3	Clay Point		9	2
	4D	4D1–4D3	Harris Bay		9	2
	4E	4E1–4E3	Goat Point	+	9	2
			Total		45	10
OPEL	**5**		**Outer Pelorus Sound**			
	5A	5A1–5A3	The Reef		9	2
	5B	5B1–5B3	Boat Rock Point		9	2
	5C	5C1–5C3	Katira Point		9	2
	5D	5D1–5D3	Duffers Reef		9	2
	5F	5F1–5F3	Camp Bay	+	9	2
	5G	5G1–5G3	TeAkaroa	*	9	2
			Total		54	12
DURV	**6**		**D'Urville Island**			
	6A	6A1–6A3	Rangitoto Islands		9	2
	6B	6B1–6B3	West Trios Islands		9	2

Table 3: Species caught, total and percentage occurrence by weight at all stations from the 2001 Marlborough Sounds blue cod survey

Common name	Code	Scientific name	Catch (kg)	Catch % by wt.	No. caught	Occurrence by station	Min depth (m)	Max depth (m)
Blue cod	BCO	*Parapercis colias*	690	88.1	1935	306	5	45
Conger eel	CON	*Conger verreauxi*	22.9	2.9	6	5	10	31
Octopus	OCT	*Octopus condiformis*	21.4	2.7	4	4	11	18
Sea perch	SPE	*Helicolenus percoides*	13.2	1.7	28	16	16	45
Leatherjacket	LEA	*Parika scaber*	11.2	1.4	46	29	8	27
Tarakihi	TAR	*Nemadactylus macropterus*	10.6	1.4	32	15	10	27
Spiny dogfish	SPD	*Squalus acanthias*	4.7	0.6	2	1	27	27
Scarlet wrasse	SPF	*Pseudolabrus miles*	4.6	0.6	15	11	11	22
Spotty	STY	*Notolabrus celidotus*	2.4	0.3	12	10	11	22
Red cod	RCO	*Pseudophycis bachus*	1	0.1	1	1	33	33
Red mullet	RMU	*Upeneichthys lineatus*	0.7	0.1	1	1	14	14
Hagfish	HAG	*Eptatretus cirrhatus*	0.6	<0.1	13	6	12	38
Total landings			783.3	100.0	2095	462		

Table 4: Minimum and maximum length (cm) of main fish species caught at all stations from the 2001 Marlborough Sounds blue cod survey (where TL=total length, FL=fork length)

Common name	Code	Scientific name	Measurement method	Length min	Length max	No. caught
Blue cod	BCO	*Parapercis colias*	TL	12	46	1935
Sea perch	SPE	*Helicolenus percoides*	TL	18	37	28
Leatherjacket	LEA	*Parika scaber*	TL	20	30	46
Tarakihi	TAR	*Nemadactylus macropterus*	FL	18	29	32
Scarlet wrasse	SPF	*Pseudolabrus miles*	TL	14	36	15
Spotty	SPT	*Notolabrus celidotus*	FL	10	24	12

Table 5: Numbers and mean length of blue cod caught by pots, by stratum and area, and the numbers and mean length of line caught fish per stratum, from the 2001 Marlborough Sounds blue cod survey (* where C.I. = 2 x S.E.)

Stratum	Area		Number of blue cod			Mean length of blue cod			
			Males	Females	Total	Males	CI *	Females	CI *
IQCH	1	**Inner Queen Charlotte**							
	A	Kaipapa Bay	3	6	9	34.00	12.00	28.66	1.52
	B	Dieffenbach Point	9	6	15	28.33	3.86	25.83	5.84
	C	Luke Rock	5	3	8	33.00	4.96	21.66	5.44
	D	Bay of Many Coves	8	12	20	29.37	6.12	24.66	2.58
		Pots overall	25	27	52	30.28	2.88	25.48	1.92
		Lines overall	0	0	0	0.00	0.00	0.00	0.00
		Total	25	27	52	30.28	2.88	25.48	1.92
OQCH	2	**Outer Queen Charlotte**							
	A	Tory Channel	6	6	12	31.16	5.04	19.00	3.00
	B	Hawes Rock	17	19	36	29.41	1.89	24.89	1.48
	C	Resolution Bay	12	11	23	26.41	4.16	22.63	1.98
	D	Pickersgill Island	22	15	37	25.63	1.31	22.66	3.08
	E	Arapawa Island	50	25	75	26.50	1.17	26.72	1.62
	F		16	15	31	30.62	3.64	25.80	1.86
	G		29	11	40	29.72	1.50	23.27	2.36
		Pots overall	152	102	254	27.92	0.80	24.38	0.88
		Lines overall	15	4	19	25.46	1.78	24.75	2.98
		Total	167	106	273	27.70	0.77	24.40	0.86
EQCH	3	**Extreme Outer Queen Charlotte**							
	A	Stella Rock	15	7	22	31.60	4.06	23.28	0.95
	B	The Twins	23	14	37	26.61	1.64	21.93	1.90
	C	Cape Jackson	32	13	45	28.53	1.50	24.07	2.90
	D	Alligator Head	38	20	58	28.26	1.17	23.30	1.91
	E	Cape Lambert	27	21	48	32.66	2.74	25.52	1.44
		Pots overall	135	75	210	29.29	0.96	23.74	0.92
		Lines overall	16	7	23	30.68	2.84	29.85	4.68
		Total	151	82	233	29.44	0.91	24.31	1.00
IPEL	7	**Inner Pelorus Sound**							
	A	Jacobs Bay	5	2	7	29.2	3.86	21.5	3.00
	B	Marys Bay	6	8	14	24	1.26	20.62	2.53
	C	Te Puraka Point	0	2	2	0	0.00	25.5	1.00
	D	TeRawa	4	2	6	27.75	4.57	18.5	1.00
		Pots overall	15	14	29	26.73	2.08	21.14	1.81
		Lines overall	1	0	1	29	0.00	0	0.00
		Total	16	14	30	26.87	1.96	21.14	1.80

Table 5: – *continued*

Stratum	Area		Number of blue cod			Mean length of blue cod			
			Males	Females	Total	Males	CI *	Females	CI *
MPEL	**8**	**Mid Pelorus Sound**							
	A	Kauauroa	5	2	7	23.4	3.38	16.5	9.00
	B	Rams Head	13	21	34	28.23	1.58	22.47	1.72
	C	Maud Island	20	6	26	27.35	1.16	23	3.82
	D	Tapapa Point	12	6	18	28.5	2.31	23.5	0.85
	E	Maud Island-West	2	0	2	30.5	1.00	0	0.00
		Pots overall	52	35	87	27.57	0.93	22.4	1.35
		Lines overall	9	1	10	27	1.58	27	0.00
		Total	61	36	97	27.49	0.82	22.52	1.34
OPEL	**5**	**Outer Pelorus Sound**							
	A	The Reef	11	5	16	28.81	2.88	20.80	2.56
	B	Boat Rock Point	9	1	10	29.88	1.26	27.00	0.00
	C	Katira Point	22	8	30	27.68	1.88	21.25	1.44
	D	Duffers Reef	8	2	10	29.50	4.04	22.50	9.00
	F	Camp Bay	12	5	17	29.41	3.01	22	3.88
	G	TeAkaroa	9	13	22	29.11	2.02	20.00	1.01
		Pots overall	71	34	105	28.82	1.04	21.05	1.14
		Lines overall	14	7	21	26.07	1.86	24.00	2.64
		Total	85	41	126	28.36	0.94	21.56	1.08
EOPE	**4**	**Extreme Outer Pelorus**							
	A	Outer Forsyth Island	11	7	18	28.82	1.92	20.28	1.36
	B	Chetwode Islands	32	8	40	28.4	2.08	21.75	3.01
	C	Clay Point	40	17	57	27.52	1.66	22.82	1.54
	D	Harris Bay	23	20	43	24.56	1.54	25.80	2.46
	E	Goat Point	36	22	58	28.80	1.62	22.22	1.64
		Pots overall	142	74	216	27.66	0.84	23.09	1.01
		Lines overall	17	7	24	28.23	1.74	26.57	2.04
		Total	159	81	240	27.72	0.79	23.39	0.98
DURV	**6**	**D'Urville Island**							
	A	Rangitoto Islands	40	23	63	30.62	1.29	28.52	0.76
	B	West Trio Islands	86	67	153	32.47	1.16	27.83	0.60
	C	East Trio Islands	198	95	293	29.74	0.59	26.37	0.50
	D	Penguin Bay	43	62	105	30.74	1.31	27.59	0.71
	L	Bonne Point	44	99	143	30.04	1.16	26.95	0.45
	M	Catherine Cove	25	61	86	30.72	2.28	28.21	0.77
		Pots overall	436	407	843	30.55	0.44	27.34	0.26
		Lines overall	27	14	41	33.92	1.94	27.35	1.18
		Total	463	421	884	30.74	0.42	27.33	0.24

Table 6: Recruited blue cod CPUE (kg/pot) from the pot fishing stations of the 2001 Marlborough Sounds blue cod survey, compared to previous survey data (Source: Blackwell 1997b, 1998)

6a. Queen Charlotte Sound strata (1995 & 2001)

6a.1 Mean CPUE (kg/pot), where C.I. = 2x S.E.

Year	Stratum	Mean CPUE (kg/pot)	C.I.	Percentage change
1995	IQCH	0.64	0.55	
	OQCH	1.74	0.57	
	EQCH	2.84	1.14	
2001	IQCH	0.41	0.20	-36%
	OQCH	0.80	0.31	-54%
	EQCH	1.15	0.44	-60%

6a.2 Percentage of zero catch of recruited blue cod

Stratum	Year 1995	2001
IQCH	66%	63%
OQCH	22%	43%
EQCH	22%	31%

6a.3 Analysis of variance for CPUE ln(kg+0.001)/pot

Class	Levels	Values
Year	2	1995 2001
Stratum	3	1 2 3
No. observations		250

Source	DF	SS	MS	F	Pr > F
Model	5	497.21	99.44	8.96	< 0.0001
Error	244	2708.50	11.10		
Total	249	3205.71			
Year	1	64.67	64.67	5.83	< 0.05
Stratum	2	361.33	180.66	16.28	< 0.0001
Year*stratum	2	71.21	35.60	3.21	< 0.05

6a.4 Wilcoxon Rank sums test for CPUE (kg/pot)

Variable Year	Sum of scores	Expected H_0	Std. Dev under H_0	Mean score	Pr > Z
1995	15011.50	13303.00	547.20	141.62	< 0.001
2001	16363.50	18072.00	547.20	113.64	

Variable Stratum	Sum of scores	Expected H_0	Std. Dev under H_0	Mean score	Pr > Z
IQCH	6675.50	9036.00	501.41	92.71	< 0.001
OQCH	12632.00	12173.50	539.56	130.22	
EQCH	12067.50	10165.50	518.20	148.98	

Table 6: – *continued*

6b. Pelorus Sound strata (1996 & 2001)

6b.1 Mean CPUE (kg/pot), where C.I. = 2x S.E.

Year	Stratum	Mean CPUE (kg/pot)	C.I.	Percentage change
1996	IPEL	0.70	0.38	
	MPEL	2.12	0.60	
	OPEL	2.51	0.72	
	EOPE	2.52	0.68	
	DURV	9.25	1.84	
2001	IPEL	0.09	0.07	-87%
	MPEL	0.28	0.16	-87%
	OPEL	0.41	0.19	-84%
	EOPE	0.98	0.30	-61%
	DURV	4.54	0.98	-51%

6b.2 Percentage of zero catch of recruited blue cod

Stratum	Year	
	1996	2001
IPEL	50%	83%
MPEL	8%	69%
OPEL	50%	61%
EOPE	11%	24%
DURV	5%	9%

6b.3 Analysis of variance for CPUE ln(kg+0.001)/pot

Class	Values
Year	1996 2001
Stratum	1 2 3
No. observations	250

Source	DF	SS	MS	F	Pr > F
Model	9	2357.82	261.98	30.01	< 0.0001
Error	413	3604.81	8.72		
Total	422	5962.63			
Year	1	604.67	604.67	69.39	< 0.0001
Stratum	4	1545.01	386.25	44.25	< 0.0001
Year*stratum	4	208.13	52.03	5.96	< 0.0001

Table 6: – *continued*

6b.4 Wilcoxon Rank sums test for CPUE (kg/pot)

Variable Year	Sum of scores	Expected H_0	Std. Dev under H_0	Mean score	Pr > Z
1996	48680.50	40068.00	1221.87	257.56	< 0.001
2001	40995.50	49608.00	1221.87	175.19	

Variable Stratum	Sum of scores	Expected H_0	Std. Dev under H_0	Mean score	Pr > Z
IPEL	18062.50	17172.00	967.03	223.00	< 0.001
MPEL	18458.00	20988.00	1040.58	186.44	
OPEL	29736.00	19080.00	1005.84	330.40	
EOPE	8957.00	15264.00	923.64	124.40	
DURV	14462.50	17172.00	967.03	178.55	

6c. Pelorus Sound strata (OPEL,EOPE), 3 year comparison (1995, 1996 & 2001)

6c.1 Mean CPUE (kg/pot), where C.I. = 2x S.E.

Year	Stratum	Mean CPUE (kg/pot)	C.I.	Percentage change from 1995	Percentage change from 1996
1995	OPEL	2.21	1.13		
	EOPE	3.02	1.11		
1996	OPEL	2.51	0.72	+14%	
	EOPE	2.52	0.68	-17%	
2001	OPEL	0.41	0.19	-81%	-84%
	EOPE	0.98	0.30	-68%	-61%

6c.2 Analysis of variance for CPUE ln(kg+0.001)/pot

Class	Values
Year	1995 1996 2001
Stratum	4 5
No. observations	252

Source	DF	SS	MS	F	Pr > F
Model	5	558.55	111.71	10.02	< 0.0001
Error	246	2743.48	11.15		
Total	251	3302.03			
Year	2	287.64	143.82	12.90	< 0.0001
Stratum	1	192.09	192.09	17.22	< 0.0001
Year*stratum	2	78.82	39.41	3.53	<0.05

6c.3 Percentage of zero catch of recruited blue cod

Stratum	Year 1995	1996	2001
OPEL	24%	50%	61%
EOPE	39%	11%	24%

Table 6: – *continued*

6c.4 Wilcoxon Rank sums test for CPUE (kg/pot)

Variable Year	Sum of scores	Expected H_0	Std. Dev under H_0	Mean score	Pr > Z
1995	9968.00	9108.00	512.94	138.44	< 0.0001
1996	12669.00	10246.50	530.29	156.40	
2001	9241.00	1253.50	554.54	93.34	

Variable Stratum	Sum of scores	Expected H_0	Std. Dev under H_0	Mean score	Pr > Z
OPEL	14918.50	13662.00	561.90	138.13	< 0.05
EOPE	16959.50	18216.00	561.90	117.77	

Table 7: Recruited blue cod CPUE (No/pot) from the pot fishing stations of the 2001 Marlborough Sounds blue cod survey, compared to previous survey data (Source: Blackwell 1997b, 1998)

7a. **Queen Charlotte Sound strata (1995–2001)**

7a.1 Mean CPUE No./pot), where C.I. = 2x S.E.

Year	Stratum	Mean CPUE (no./pot)	C.I.	Percentage change
1995	IQCH	1.13	0.74	
	OQCH	3.70	1.20	
	EQCH	5.11	2.10	
2001	IQCH	0.75	0.35	-34%
	OQCH	1.55	0.60	-58%
	EQCH	2.13	0.70	-58%

7a.2 Analysis of variance for CPUE ln(No.+0.001)/pot

Class	Levels	Values
Year	2	1995 2001
Stratum	3	1 2 3
No. observations		250

Source	DF	SS	MS	F	Pr > F
Model	5	593.13	118.62	8.99	< 0.0001
Error	244	3218.20	13.18		
Total	249	3811.33			
Year	1	72.19	72.19	5.47	<0.05
Stratum	2	434.18	217.09	16.46	< 0.0001
Year*stratum	2	86.75	43.37	3.29	<0.05

7a.3 Wilcoxon Rank sums test for CPUE (No./pot)

Variable Year	Sum of scores	Expected H_0	Std. Dev under H_0	Mean score	Pr > Z
1995	15050	13303.00	544.53	141.98	< 0.01
2001	16325.5	18072.00	544.53	113.37	

Variable Stratum	Sum of scores	Expected H_0	Std. Dev under H_0	Mean score	Pr > Z
IQCH	6594.00	9063.00	498.95	91.58	< 0.0001
OQCH	12653.50	12173.50	536.93	130.44	
EQCH	12127.5	10165.5	515.67	149.72	

Table 7:– *continued*

7b. Pelorus Sound strata (1996 & 2001)

7b.1 Mean CPUE (No./pot), where C.I. = 2x S.E.

Year	Stratum	Mean CPUE (no. /pot)	C.I.	Percentage change
1996	IPEL	1.44	0.82	
	MPEL	4.72	1.30	
	OPEL	5.28	1.14	
	EOPE	4.86	1.33	
	DURV	18.00	3.67	
2001	IPEL	0.19	0.14	-87
	MPEL	0.66	0.38	-86
	OPEL	0.87	0.39	-84
	EOPE	2.06	0.61	-58
	DURV	9.39	2.06	-48

7b.2 Analysis of variance for CPUE Ln(No.+0.001)/pot

Class	Levels	Values
Year	2	1996 2001
Stratum	3	4 5 6 7 8
No. observations		423

Source	DF	SS	MS	F	Pr > F
Model	9	2729.36	303.26	28.64	< 0.0001
Error	413	4373.42	10.59		
Total	422	7102.79			
Year	1	701.47	701.47	66.24	< 0.0001
Stratum	4	1757.56	439.39	41.49	< 0.0001
Year*stratum	4	270.33	67.58	6.38	< 0.0001

7b.3 Wilcoxon Rank sums test for CPUE (No./pot)

Variable Year	Sum of scores	Expected H_0	Std. Dev under H_0	Mean score	Pr > Z
1996	48695.50	40068.00	1219.90	257.64	< 0.001
2001	40980.50	49608.00	1219.90	175.13	

Variable Stratum	Sum of scores	Expected H_0	Std. Dev under H_0	Mean score	Pr > Z
IPEL	17834.50	17172.00	965.48	220.18	< 0.001
MPEL	18527.00	20988.00	1038.91	187.14	
OPEL	29682.50	19080.00	1004.22	329.80	
EOPE	8868.50	15264.00	922.16	123.17	
DURV	14763.50	17172.00	965.48	182.26	

Table 7:– *continued*

7c. **Pelorus Sound strata (OPEL, EOPE), 3 year comparison (1995, 1996 & 2001**

7c.1 **Mean CPUE (No./pot), where C.I. = 2x S.E.**

Year	Stratum	Mean CPUE (No./pot)	C.I.	Percentage change from 1995	Percentage change from 1996
1995	OPEL	4.66	2.38		
	EOPE	5.92	2.16		
1996	OPEL	5.28	1.40	+13%	
	EOPE	4.86	1.22	-18%	
2001	OPEL	0.87	0.19	-81%	-84%
	EOPE	2.06	0.60	-65%	-58%

7c.2 **Analysis of variance for CPUE ln(No.+0.001)/pot**

Class	Values
Year	1995 1996 2001
Stratum	4 5
No. observations	252

Source	DF	SS	MS	F	Pr > F
Model	5	652.38	130.47	9.76	< 0.0001
Error	246	3289.75	13.37		
Total	251	3942.14			
Year	2	327.22	163.16	12.23	< 0.0001
Stratum	1	224.31	224.31	16.77	<0.0001
Year*stratum	2	100.85	50.42	3.77	<0.05

7c.3 **Wilcoxon Rank sums test for CPUE (No./pot)**

Variable Year	Sum of scores	Expected H_0	Std. Dev under H_0	Mean score	Pr > Z
1995	9955.00	9108.00	511.86	138.26	< 0.0001
1996	12696.50	10246.50	529.16	156.74	
2001	9226.50	1253.50	553.37	93.19	

Variable Stratum	Sum of scores	Expected H_0	Std. Dev under H_0	Mean score	Pr > Z
OPEL	14862.50	13662.00	560.72	137.61	< 0.05
EOPE	17015.50	18216.00	560.72	118.16	

Table 8: Raw and mean weighted CPUE (kg/pot) by stratum, and overall for the 2001 blue cod potting survey. Results are given for (a) all blue cod, and (b) those recruited to the fishery

(a) All blue cod

Stratum	Coastline (km)	Weight	Raw mean	s.e.	Weighted mean	SE*wt	$(SE*wt)^2$	C.V. (=SE/mean)
IQCH	20.0	0.05	0.57	0.13	0.03	0.01	0.00	0.23
OQCH	75.2	0.19	1.34	0.21	0.25	0.04	0.00	0.16
EQCH	30.0	0.07	1.68	0.25	0.13	0.02	0.00	0.15
EOPE	40.8	0.10	1.46	0.18	0.15	0.02	0.00	0.12
OPEL	55.4	0.14	0.65	0.13	0.09	0.02	0.00	0.20
MPEL	62.8	0.15	0.60	0.16	0.09	0.03	0.00	0.27
IPEL	59.8	0.15	0.19	0.07	0.03	0.01	0.00	0.35
DURV	52.4	0.13	5.90	0.62	0.78	0.08	0.01	0.10
ALL					1.55		0.01	0.07
								c.v =7%

(b) Recruited blue cod (Total length ≥ 28 cm)

Stratum	Coastline (km)	Weight	Raw mean	s.e.	Weighted mean	SE*wt	$(SE*wt)^2$	C.V. (=SE/mean)
IQCH	20.0	0.05	0.41	0.10	0.02	0.00	0.00	0.25
OQCH	75.2	0.19	0.80	0.15	0.15	0.01	0.00	0.19
EQCH	30.0	0.07	1.15	0.22	0.09	0.00	0.00	0.19
EOPE	40.8	0.10	0.98	0.15	0.10	0.04	0.00	0.15
OPEL	55.4	0.14	0.41	0.09	0.06	0.01	0.00	0.23
MPEL	62.8	0.16	0.28	0.08	0.04	0.00	0.00	0.30
IPEL	59.8	0.15	0.09	0.04	0.01	0.01	0.00	0.40
DURV	52.4	0.13	4.54	0.49	0.06	0.03	0.00	0.11
ALL					1.07		0.00	0.07
								c.v.=7%

Table 9: Sex ratios of blue cod by stratum and length class* for the 2001 blue cod potting survey

* length classes based on 30 cm and 35 cm length classes, as used in the 1995–96 surveys

Queen Charlotte Sound strata

Area	Length (cm)	Males	Females	Total	Percentage male
IQCH	< 18 cm	1	2	3	33
	19-30 cm	16	21	37	43
	31-35 cm	2	3	5	40
	>35 cm	6	1	7	86
	Total	25	27	52	48
OQCH	<18 cm	2	13	15	13
	19-30 cm	129	88	217	59
	31-35 cm	26	3	29	90
	>35 cm	10	2	12	83
	Total	167	106	273	61
EQCH	<18 cm	1	7	8	13
	19-30 cm	107	67	174	61
	31-35 cm	25	6	31	81
	>35 cm	18	2	20	90
	Total	151	82	233	65

Pelorus Sound Strata

Area	Length (cm)	Males	Females	Total	Percentage male
IPEL	<18 cm	0	3	3	0
	19-30cm	13	11	24	54
	31-35 cm	3	0	3	100
	>35 cm	0	0	0	0
	Total	16	14	30	53
MPEL	<18 cm	1	5	6	17
	19-30cm	49	31	80	61
	31-35 cm	11	0	11	100
	>35 cm	0	0	0	0
	Total	61	36	97	63
OPEL	<18 cm	2	7	9	22
	19-30cm	56	34	90	62
	31-35 cm	24	0	24	100
	>35 cm	3	0	3	100
	Total	85	41	126	67
EOPE	<18 cm	7	10	17	41
	19-30cm	106	68	174	61
	31-35 cm	39	2	41	95
	>35 cm	7	1	8	88
	Total	159	81	240	66
DURV	<18 cm	1	1	2	50
	19-30 cm	245	380	625	39
	31-35 cm	154	37	191	81
	>35 cm	63	3	66	95
	Total	463	421	884	52

Table 10: Blue cod relative sexual maturity stages by sampling stratum, for the 2001 blue cod potting survey

		Gonad sexual maturity stages					Total
Stratum		1	2	3	4	5	no.
IQCH	Numbers of males	18	6	0	1	0	25
	%	72.0	24.0	0.0	4.0	0.0	100.0
	Numbers of females	17	3	2	1	4	27
	%	63.0	11.1	7.4	3.7	14.8	100.0
OQCH	Numbers of males	50	39	13	65	0	167
	%	29.9	23.4	7.8	38.9	0.0	100.0
	Numbers of females	31	18	41	15	1	106
	%	29.2	17.0	38.7	14.2	0.9	100.0
EQCH	Numbers of males	104	20	7	20	0	151
	%	68.9	13.2	4.6	13.2	0.0	100.0
	Numbers of females	0	11	16	0	1	28
	%	0.0	39.3	57.1	0.0	3.6	100.0
IPEL	Numbers of males	9	4	1	2	0	16
	%	56.3	25.0	6.3	12.5	0.0	100.0
	Numbers of females	10	0	4	0	0	14
	%	71.4	0.0	28.6	0.0	0.0	100.0
MPEL	Numbers of males	38	10	4	9	0	61
	%	62.3	16.4	6.6	14.8	0.0	100.0
	Numbers of females	28	2	5	1	0	36
	%	77.8	5.6	13.9	2.8	0.0	100.0
OPEL	Numbers of males	37	8	6	34	0	85
	%	43.5	9.4	7.1	40.0	0.0	100.0
	Numbers of females	23	1	17	0	0	41
	%	56.1	2.4	41.5	0.0	0.0	100.0
EOPE	Numbers of males	67	24	31	37	0	159
	%	42.1	15.1	19.5	23.3	0.0	100.0
	Numbers of females	44	5	24	8	0	81
	%	54.3	6.2	29.6	9.9	0.0	100.0
DURV	Numbers of males	10	206	139	108	0	463
	%	2.2	44.5	30.0	23.3	0.0	100.0
	Numbers of females	2	13	374	32	0	421
	%	0.5	3.1	88.8	7.6	0.0	100.0

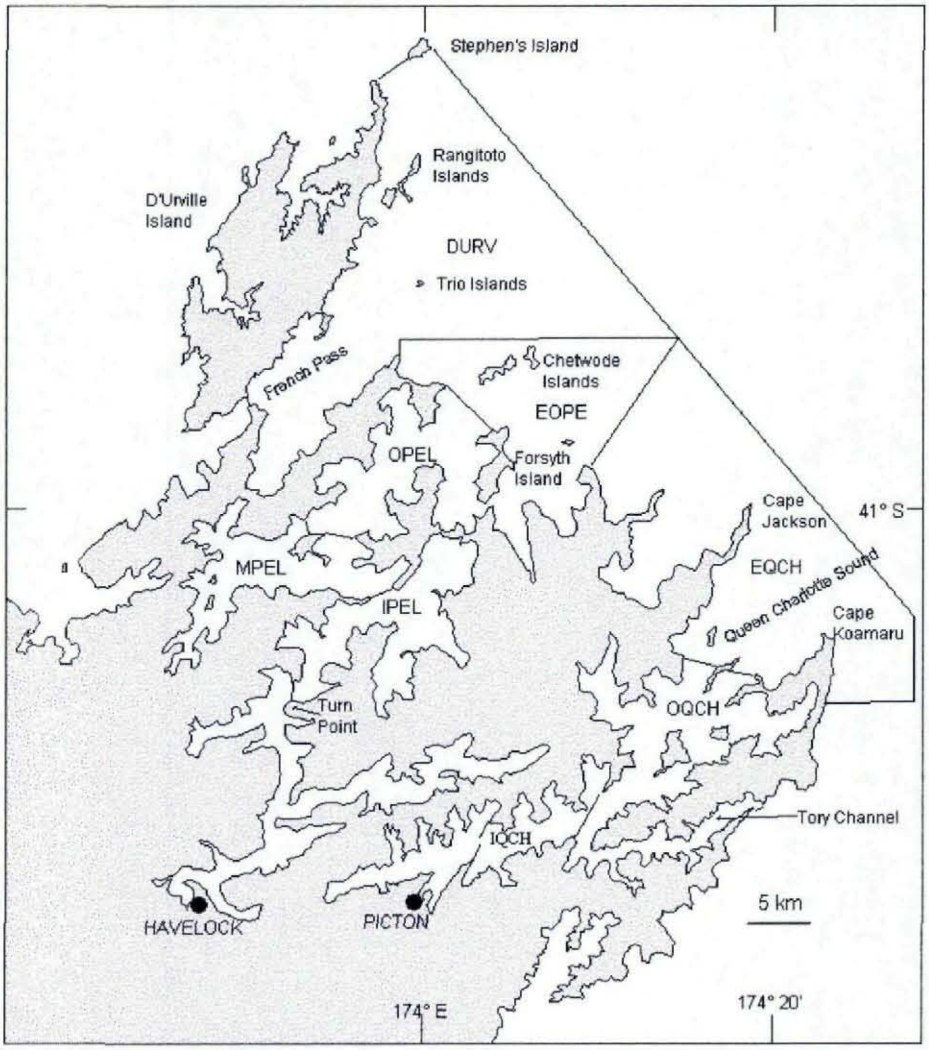

Figure 1: Marlborough Sounds survey area showing strata surveyed in 2001:
IQCH, OQCH, EQCH in Queen Charlotte Sound
IPEL, MPEL, OPEL, EOPE, and DURV in Pelorus Sound.

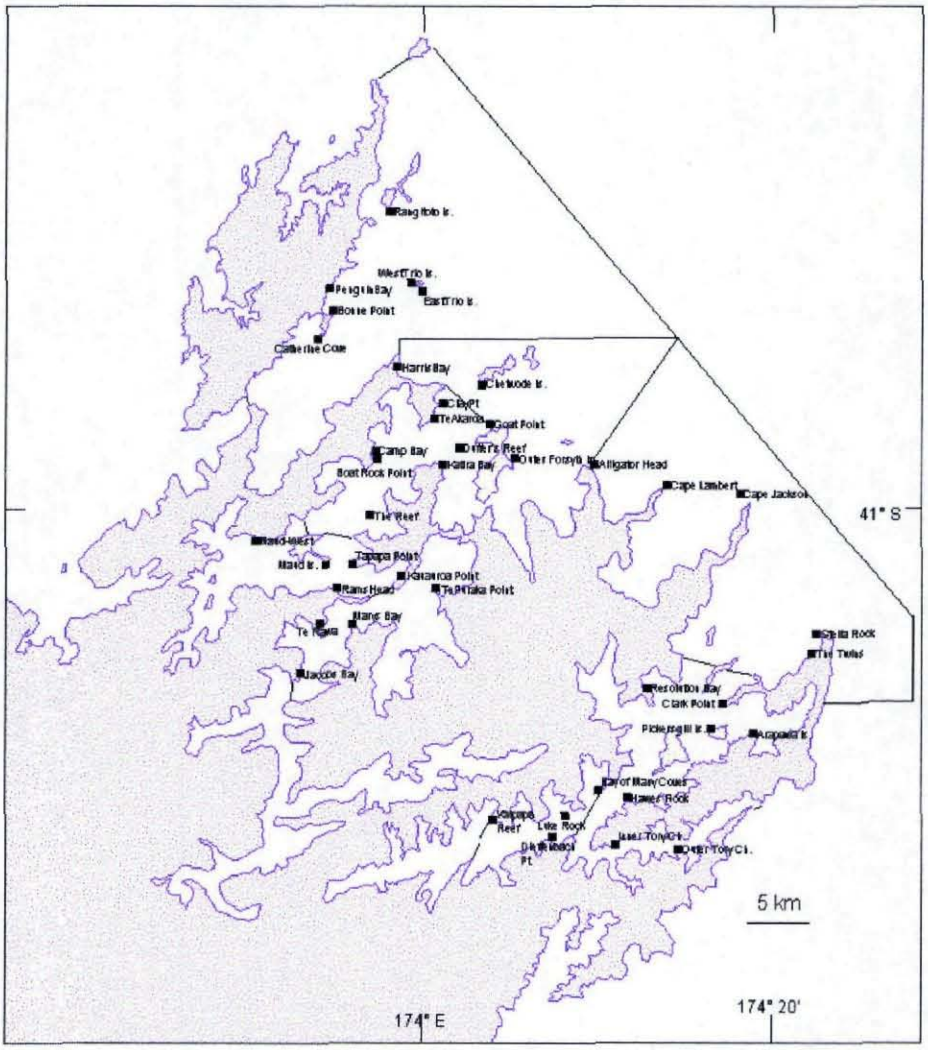

Figure 2: Stratum boundaries and sampling areas (Stratum codes are defined in the text).

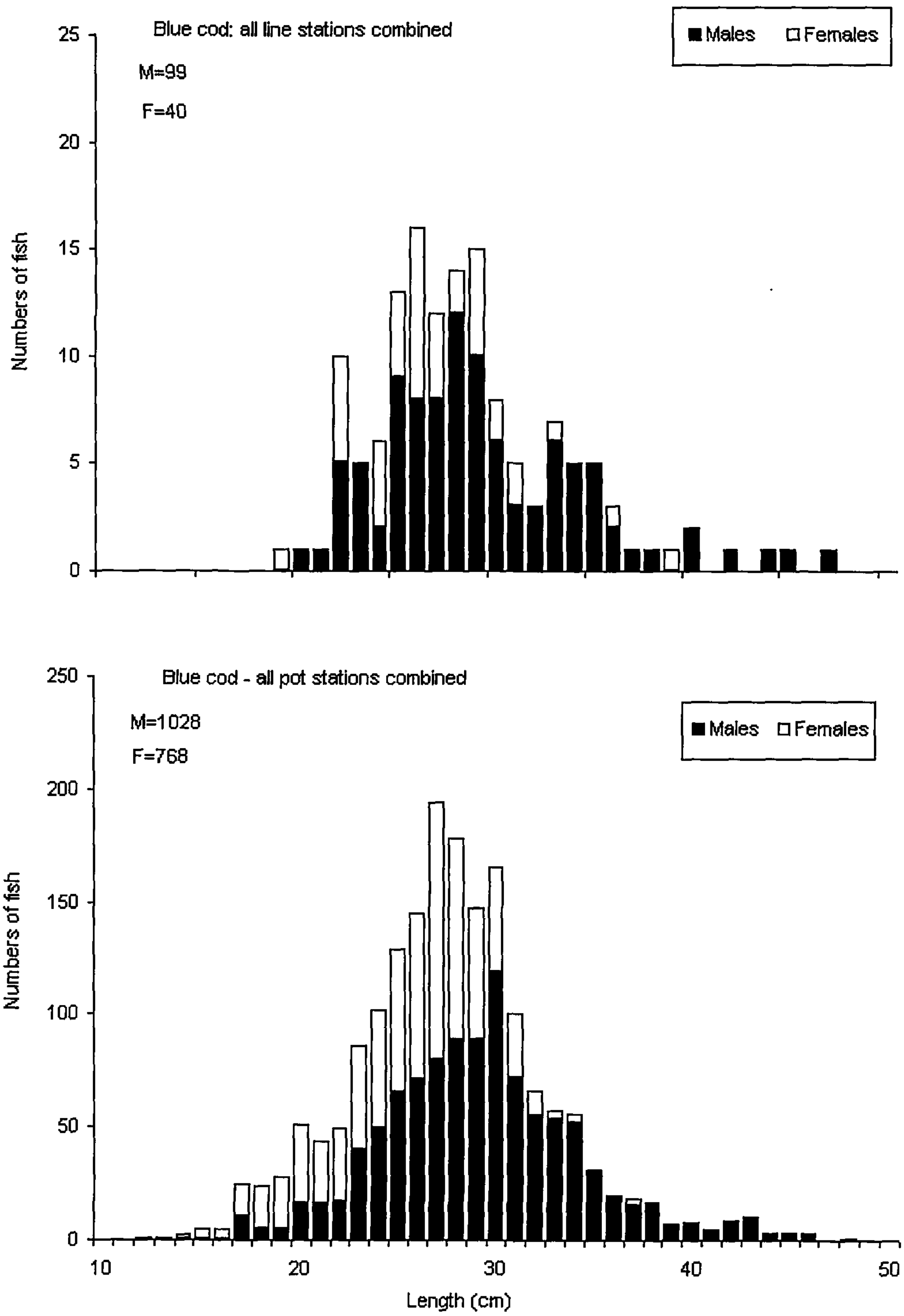

Figure 3: Length frequency distribution of blue cod from the 2001 Marlborough Sounds survey, by fishing method. Frequency of male and female blue cod are actual numbers measured.

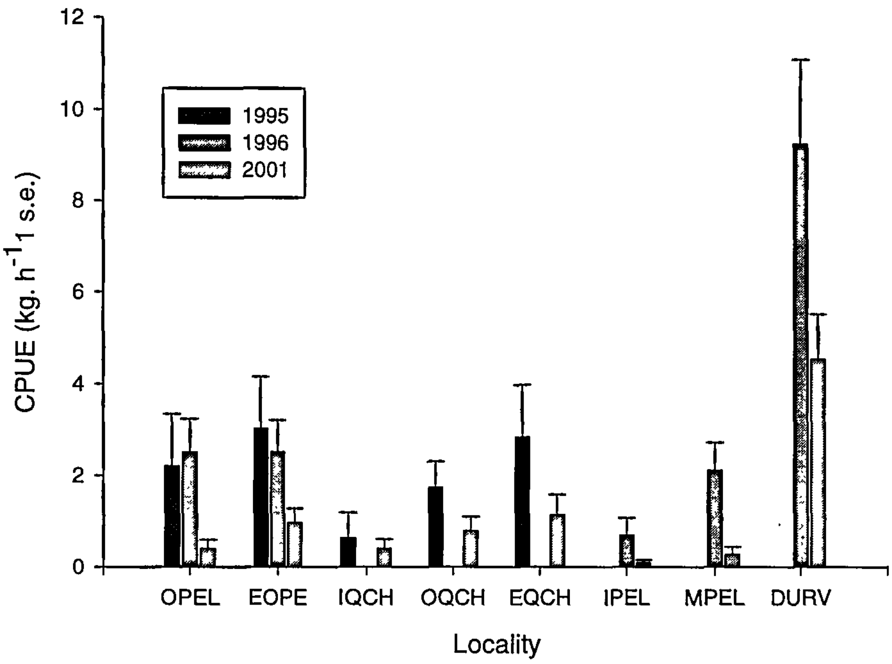

Figure 4: Blue cod recruited CPUE (kg/hr) from the Marlborough Sounds by survey year (1995, 1996 and 2002), and sampling stratum, where stratum codes are given in Figure 1. Strata EOPE and OPEL were surveyed in all three survey years. Error bars represent 1 x s.e.

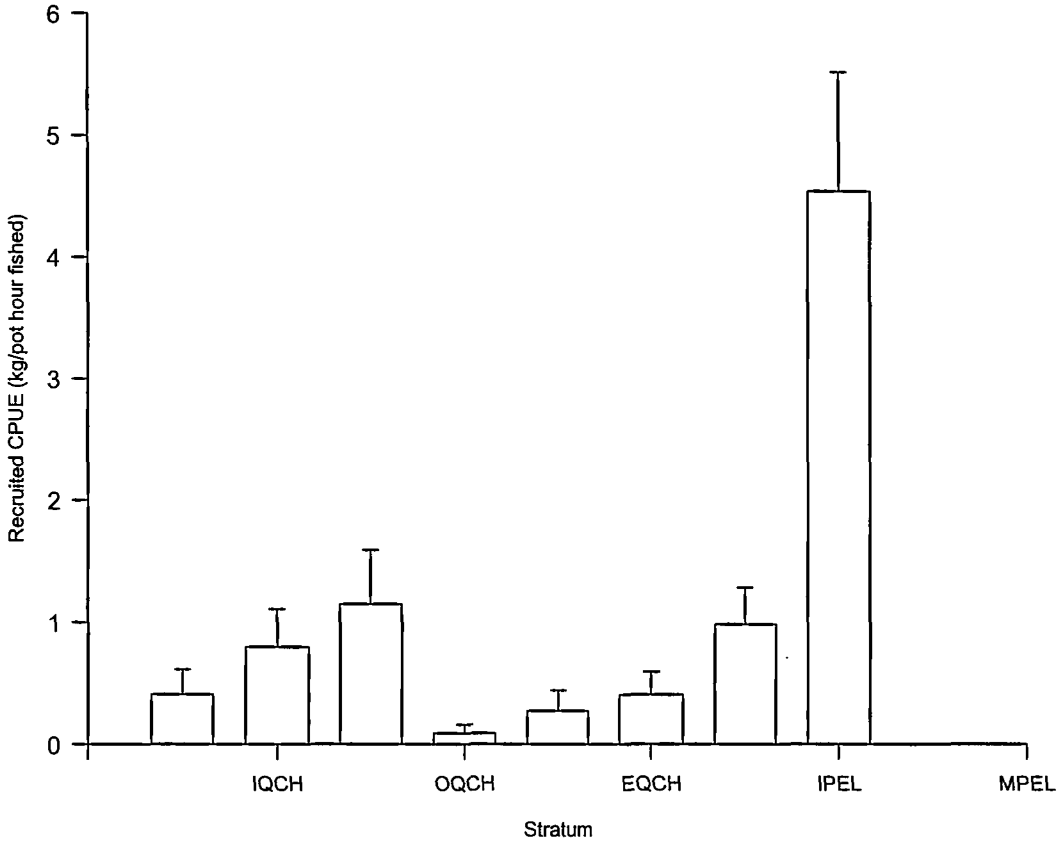

Figure 5: Blue cod: Recruited CPUE (kg/pot hour fished) from the 2001 survey by sampling stratum, where codes are given in Figure 1. Error bars represent 2 * s.e.

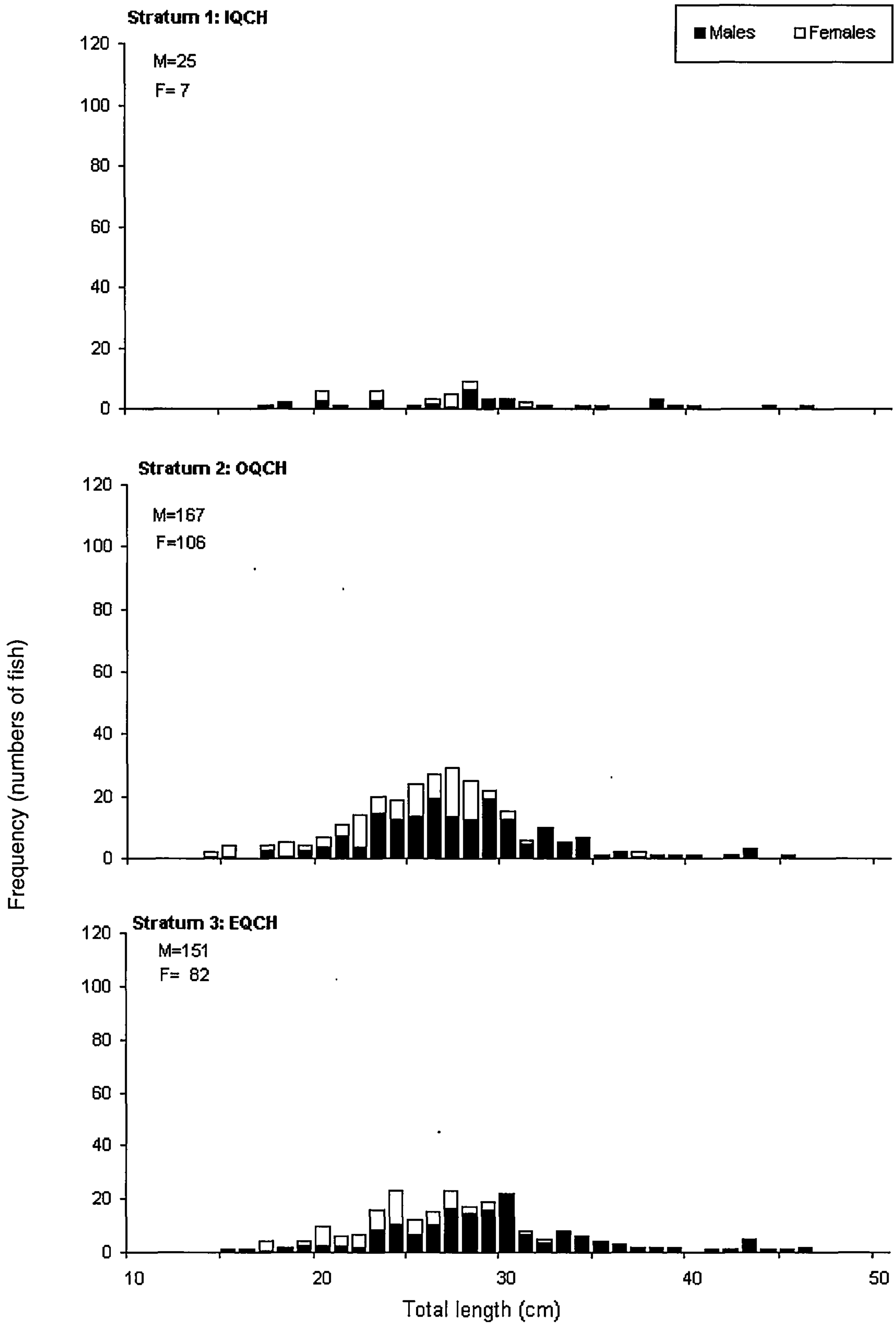

Figure 6: Length frequency distribution of blue cod from the 2001 Marlborough Sounds survey. Frequency of male and female blue cod are actual numbers measured. Stratum codes are given in Figure 1.

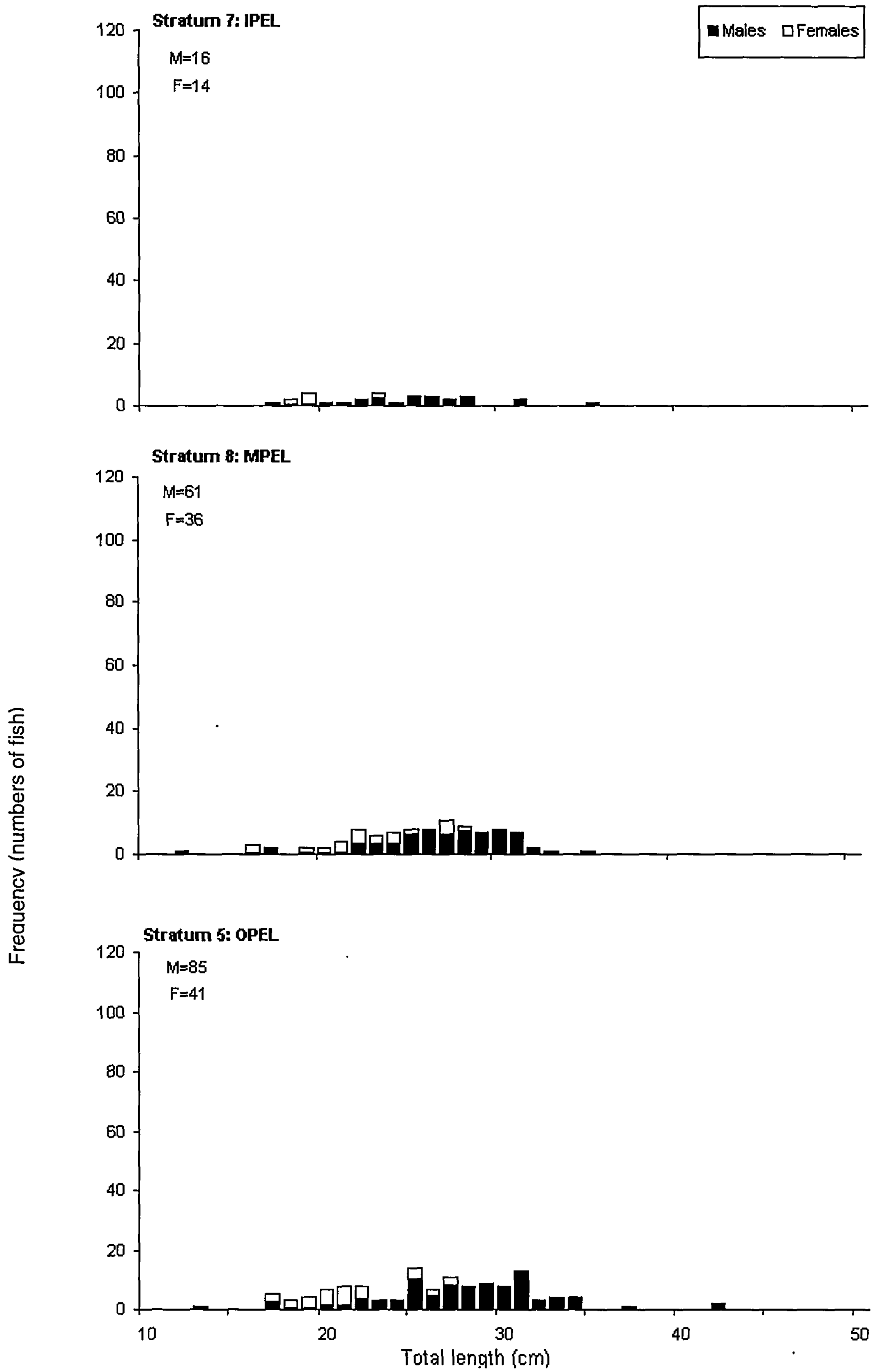

Figure 6: – *continued*

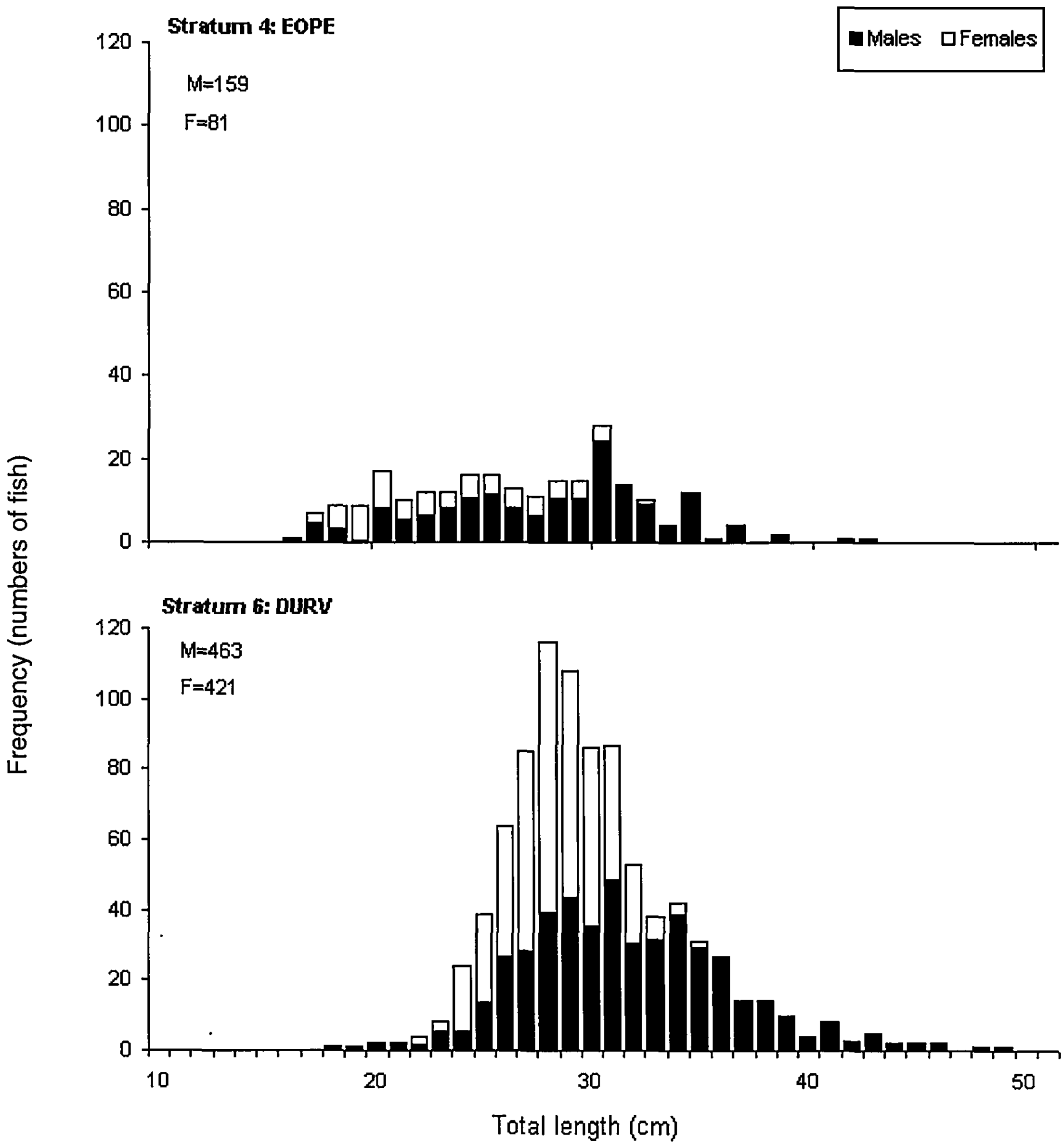

Figure 6: – *continued*

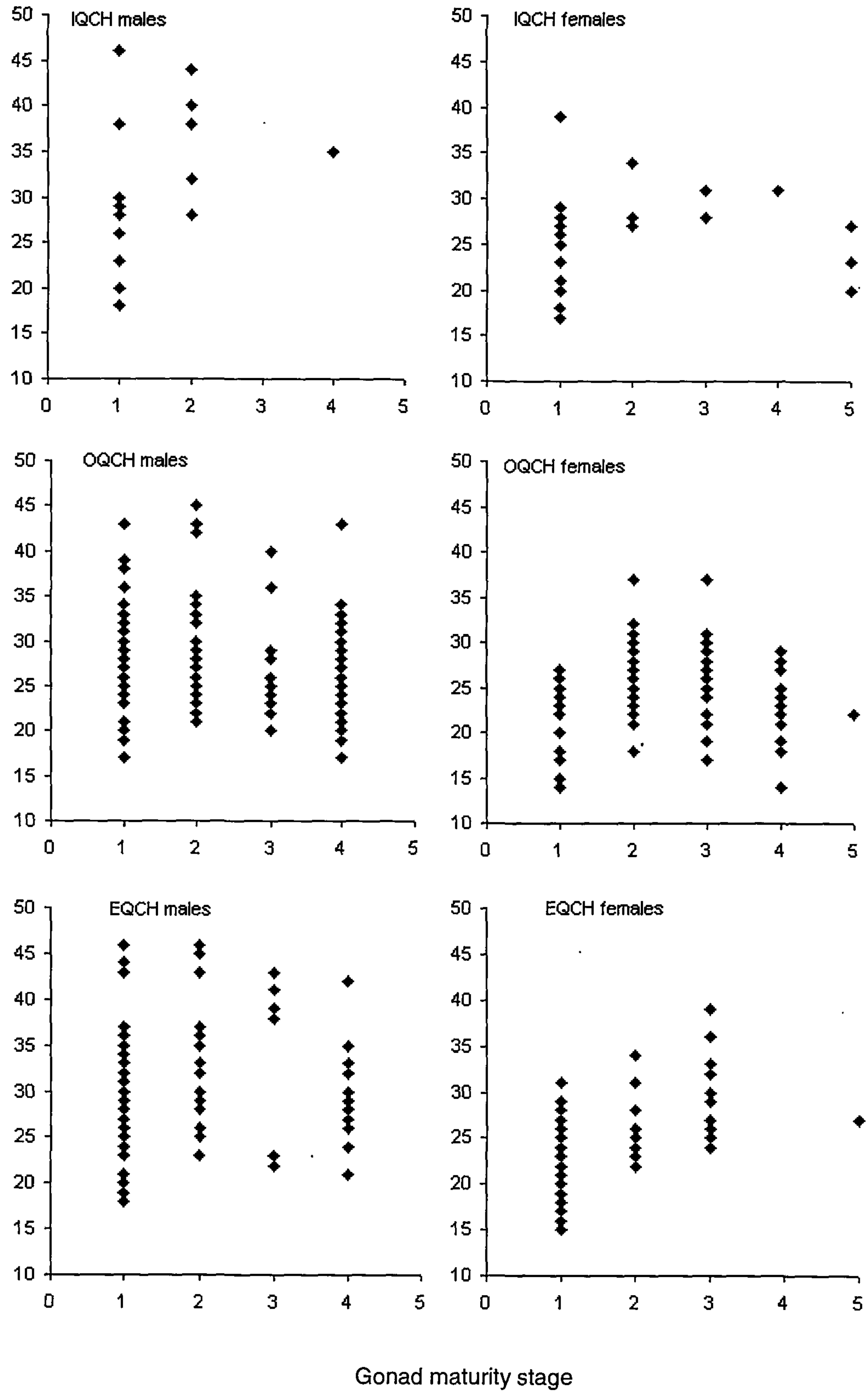

Figure 7: Blue cod length and gonad maturity stage from the 2001 Marlborough Sounds survey, by sampling stratum. Stratum codes are given in Figure 1.

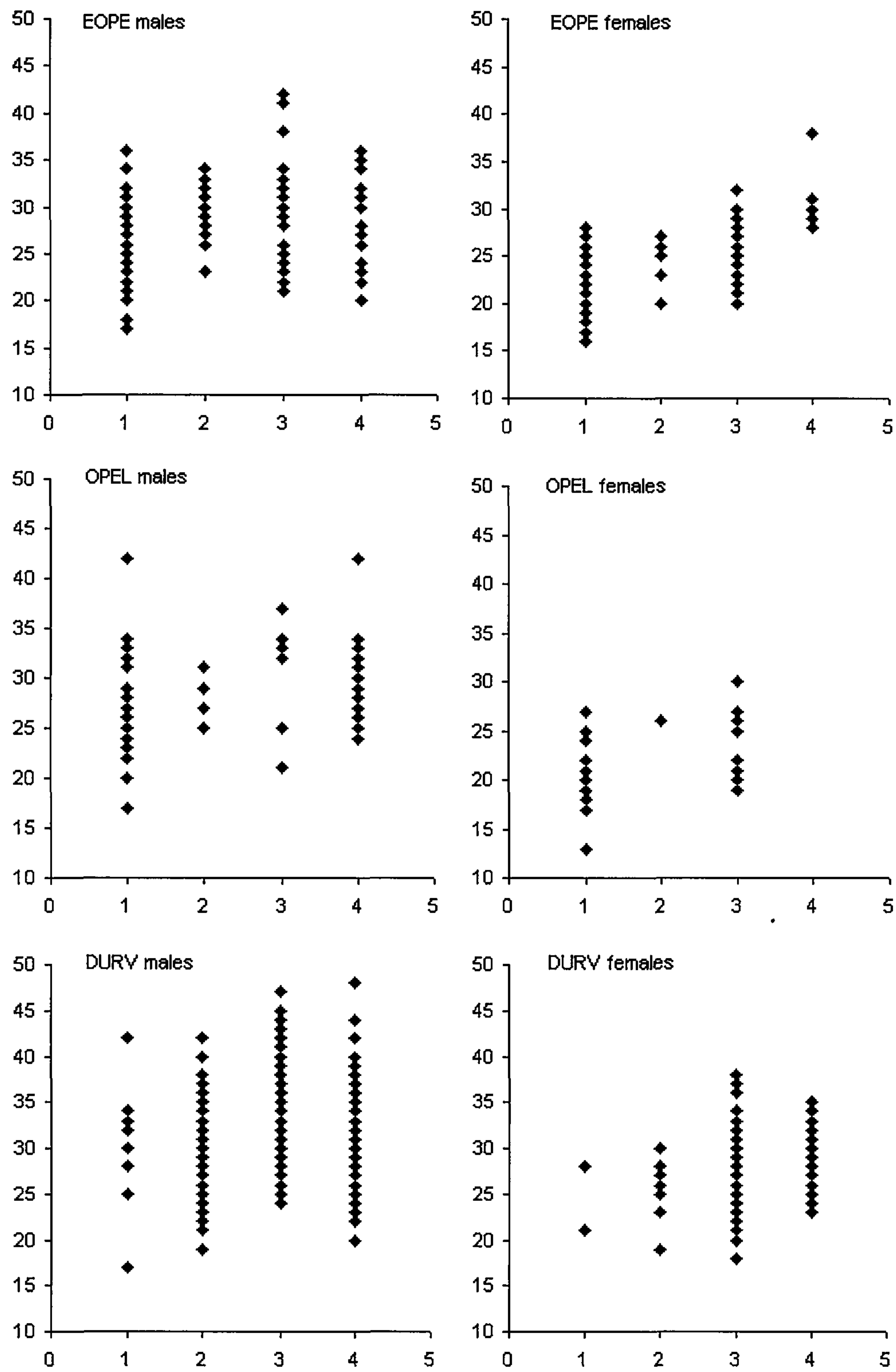

Figure 7: – continued

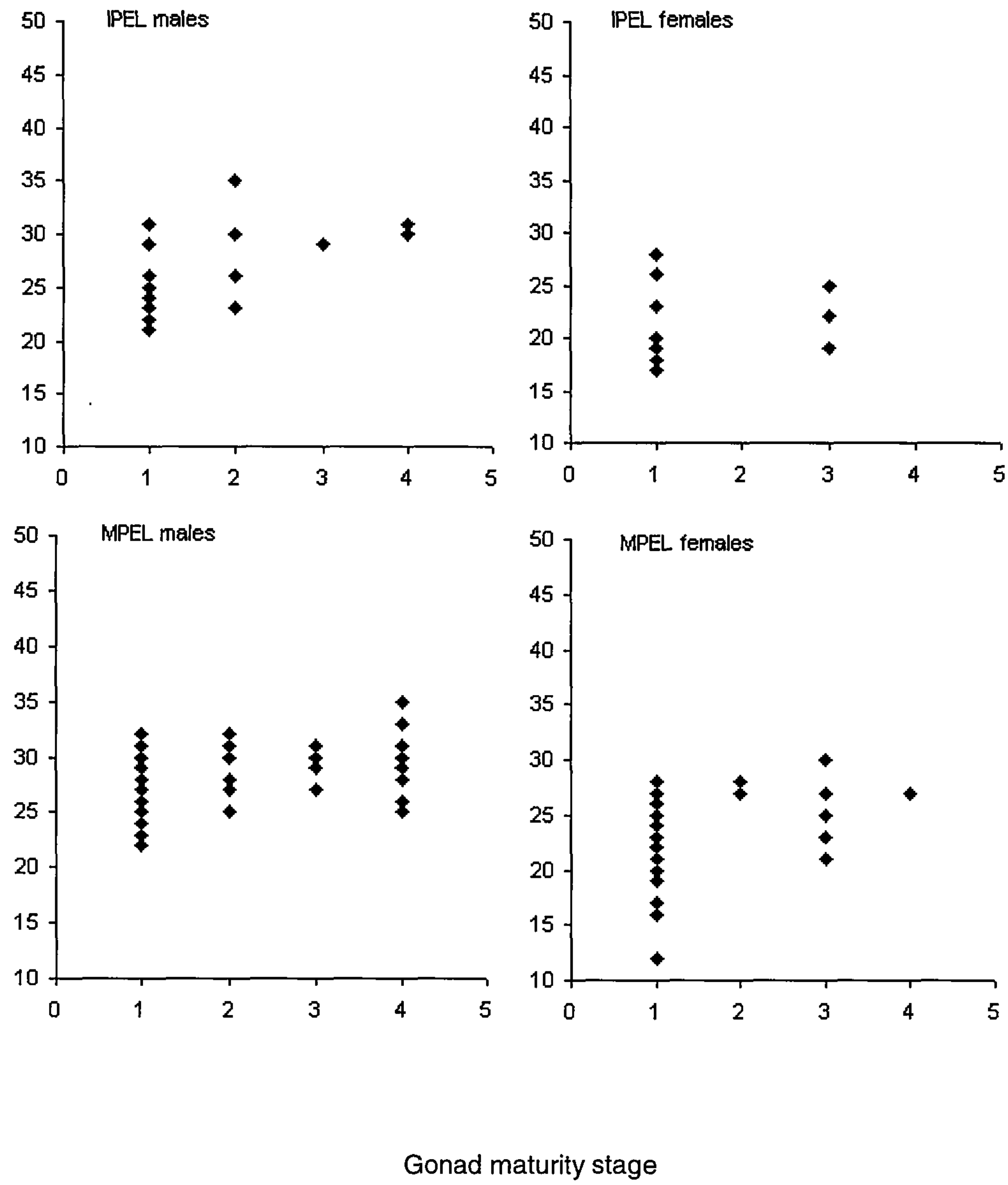

Figure 7: – continued

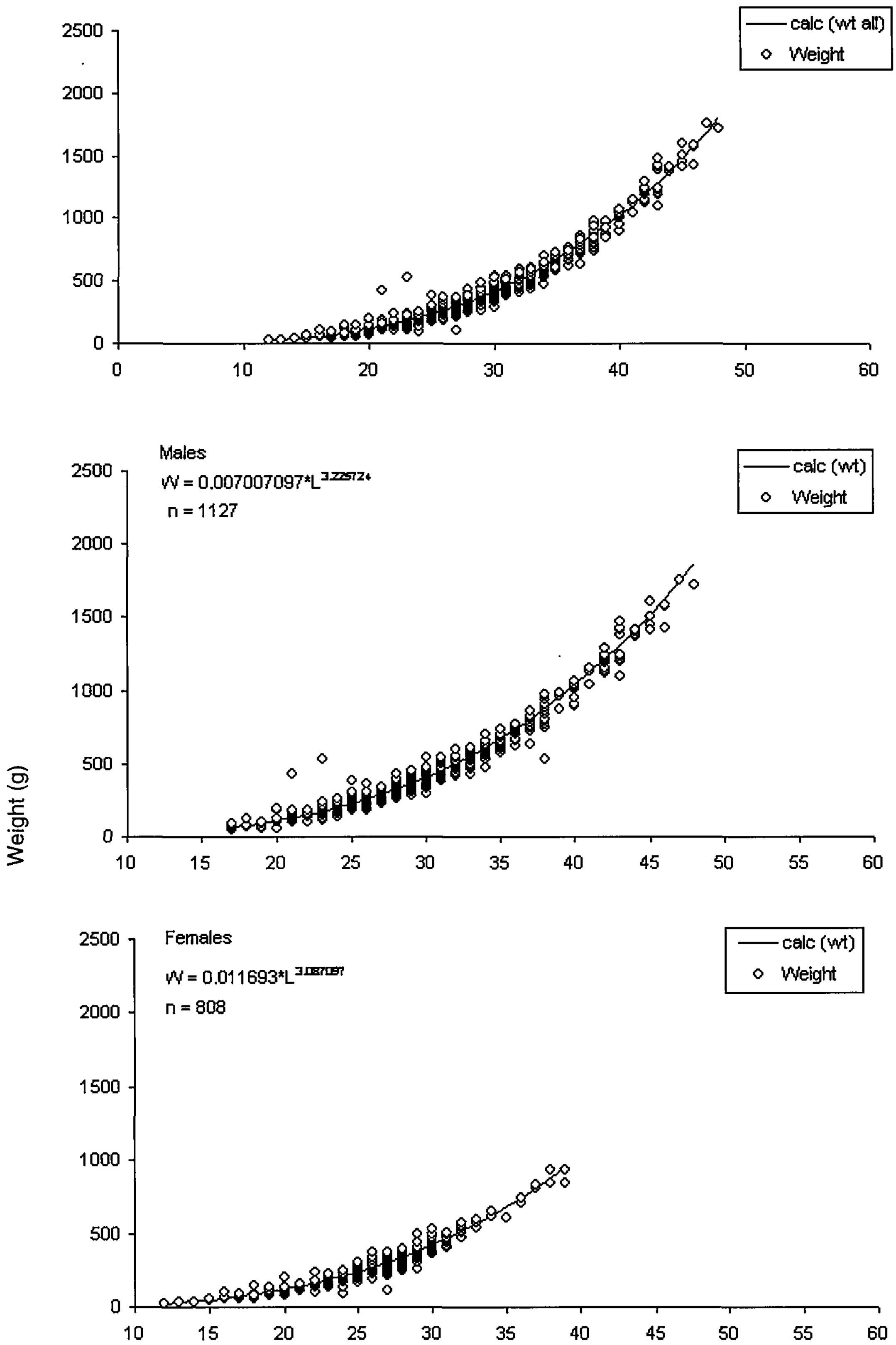

Figure 8: Blue cod length-weight relationships for the 2001 Marlborough Sounds survey

Appendix 1: Comparison of soak time

1.1 Background

The commercial blue cod pot fishery in the Marlborough Sounds prior to the 1995 pot fishing survey used a standard 1 hour soak time, and this was adopted as a standard for the 1995 and subsequent pot fishing surveys. In a 1997 pilot study of blue cod fishing (Blackwell, unpublished), the effects of soak time was reviewed. This study indicated that most blue cod appeared to enter the pots after 30 minutes, and entry tailed off slowly after this time. Blue cod also appeared to remain in the pots at least for an hour, or until the bait was consumed. Use of a 30 min fishing time may provide operational efficiencies in subsequent blue cod surveys. However, in practice, the usefulness of a shorter soak time needs to be balanced against time requirements to process the samples collected.

A small pilot programme was proposed, to review the entry of blue cod into the baited pots, after 0.5 hour and after 1 hour. Firstly, a series of replicate pairs of pots were fished for 0.5 hour, and 1 hour respectively, and the effects upon blue cod catch composition were compared. Secondly, the fishing activity of the pots were examined using an underwater video camera monitoring system, and the catch rates after 0.5 hour and 1 hour were compared. This programme was funded by NRM024, a NIWA NSOF project.

1.2 Methods

(a) Underwater video experiment

The underwater video camera experiments were carried out in the DURV strata in August 2001, prior to the commencement of the potting survey. A standard pot was modified, with four underwater video cameras mounted to monitor each of the four entrances to the pot. In this way, the numbers of entries and exits of individual fish could be observed and recorded, by use of a video signal splitter. Data are available from a single 60-minute pot set, where video data were recorded on to a video camera on the fishing boat, in real time. The data were visually examined, and the number of entries and exits were summarised and plotted by 1 minute intervals between 0 and 60 min.

(b) Soak time comparisons

It was originally intended to carry out the soak time trials in both Sounds, but the experiment was relocated to the D'Urville Island stratum, due to the low catch rates found in all of the strata sampled in Queen Charlotte Sound. The vessel and gear were prepared as previously described, with eight pots, fished in four groups of two pairs. Fishing locations were randomised within the DURV stratum, and fishing was carried out 17–18 September, at the conclusion of the main fishing survey.

Before the pots were placed, the depth was examined using the sounder to determine that the substrate was hard rock or cobble, and that conditions were equivalent between each pair. The eight pots were sequentially set, as four groups of two, with each pair of replicates placed adjacent to each other, approximately 15 m apart. Each pot took approximately 2 minutes to set and was deemed to be fishing once the float had been detached from the vessel. The first set of pots were sequentially recovered after 30 minutes, and the second set of pots were sequentially recovered after 60 minutes. The catch was separated to species, weighed and processed as previously described. Where possible, bycatch species were measured and released alive. For blue cod, the sex ratio, total number per pot, total weight per pot, and the number of large (greater than 28 cm total length) were compared between replicates by the paired sample t-test in PROC MEANS of the SAS programme (SAS 1989).

2.1 Results

(a) Underwater video experiment

The number of approaches, entries and exits plotted against elapsed time indicate that the number of approaches increases during the first 10 minutes, as fish are attracted to the baited pot (Figure A1). The number of approaches slowly decreases from 11 to 30 minutes, then appears to tail off between 31 and 50 minutes. However, the number of approaches appears to increase in the last ten minutes of the soak time. For the number of entries, this appears to follow a similar pattern, with a brief peak in the first 10 minutes, a variable number of entries in the next 20 minutes, then a relatively constant pattern of entries in the remaining time period. The number of exits is highest in the first two minutes, which may relate to fish that partially enter the pot, and then leave again. There is little pattern to the exits during the subsequent time period.

(b) Soak time experiment

From the paired sample t-test ($n = 32$ paired comparisons), no differences could be determined between the two soak times (30 minutes and 60 minutes), for either the total weight of blue cod taken per pot ($t = 0.40$: $Pr > 0.05$), the total number of blue cod taken per pot ($t = 0.56$: $Pr > 0.05$), the number of male blue cod ($t = 0.64$: $Pr > 0.05$), the number of females per pot ($t = 0.32$: $Pr > 0.05$), or the number of recruited blue cod ($t = 1.32$: $Pr > 0.05$).

3.1 Summary

The pilot experiment and video observation data indicate that the effective soak time for blue cod is approximately 30 minutes, as capture rates are lower in the second 30 minute period. These experiments were conducted in an area of relatively high blue cod density, and the multiple entry and exit data reported from the video observations may relate to the foraging activity of individual fish as they make several abortive entries before finally entering the pot. As the fish were not marked, observations of individual fish could not be separated.

These data suggest that moving to a shorter soak time may have practical advantages for subsequent surveys. In particular, it would allow the number of replicates within a stratum or area to be increased, which would be an advantage in strata where blue cod density is low. However, practical experience from the fishing trials also indicated that steaming time and the time required for handling and processing large catches were likely to remain the major barriers to improved sampling efficiency. These factors are independent of the soak time used.

Previous sampling and real-time video observations (Blackwell et al. unpublished) indicate that most fish enter the pots in the initial 30 minutes, and are retained in the pots by the availability of bait. Whitelaw et al. (1991) in a study of the commercial trap fishery in northwestern Australia found that only 60% of fish of all species that entered traps were retained during a 1–2 hour soak time. Cole et al. (unpublished) show that blue cod entries increase to a plateau after a four minute soak time, and that entries and exits remained constant from then until the end of the soak time at 60 minutes. Fogarty & Addison (1997) in a review of models of pot fishing, noted that catch rate is not a linear function of soak time, but a complex interplay of capture and escapement processes. Pot catching efficiency may also be influenced by the radial distance within which fish are attracted to the bait (Eggers et al. 1982) and trapped fish may attract other fish to the pots (Fogarty & Addison 1997). The catching ability of static fishing gear may vary with habitat. On simple, flat bottom, the gear itself increases the spatial complexity of the bottom (Robichaud et al. 2000), and blue cod are known to be attracted to un-baited pots (Blackwell et al. unpublished). Blue cod are known to be attracted to Blackwell et al. (unpublished results) found a correlation of 0.98 between the number retained per pot, and the mean density of blue cod 0–10 m from diver observations, in 15 pot/diver replicates. Blue cod were attracted to the pots from a distance of 30–40 m, and video camera observations indicated little aggressive behaviour occurred between blue cod in pots, in contrast to other species (Furevik 1994). Escapement appeared to be low in these observations.

This pilot programme suggests that use of a 30 minute soak time may result in operational benefits and cost reduction, and the shorter soak time does not appear to influence the catch rate or size frequency of blue cod. As these comparisons were competed in areas where blue cod abundance is high, the effect of a reduction in soak time on catch rate where blue cod abundance is low is unknown. This must be balanced against the possible increase in sampling precision available from an increase in sample size potentially available from a shorter soak time. However, the major time constraints in a pot fishing survey remain steaming time and handling time, and these are independent of soak time. Before the standard soak time is changed, it is suggested that further experiments be completed comparing the costs and benefits of these options. This may be competed as part of a subsequent pot fishing monitoring programme.

4.1 References

Fogarty, M.J. & Addison, J.T. 1997: Modelling capture processes in individual traps: entry, escapement and soak time. *ICES Journal of Marine Science, 54*: 193–205.

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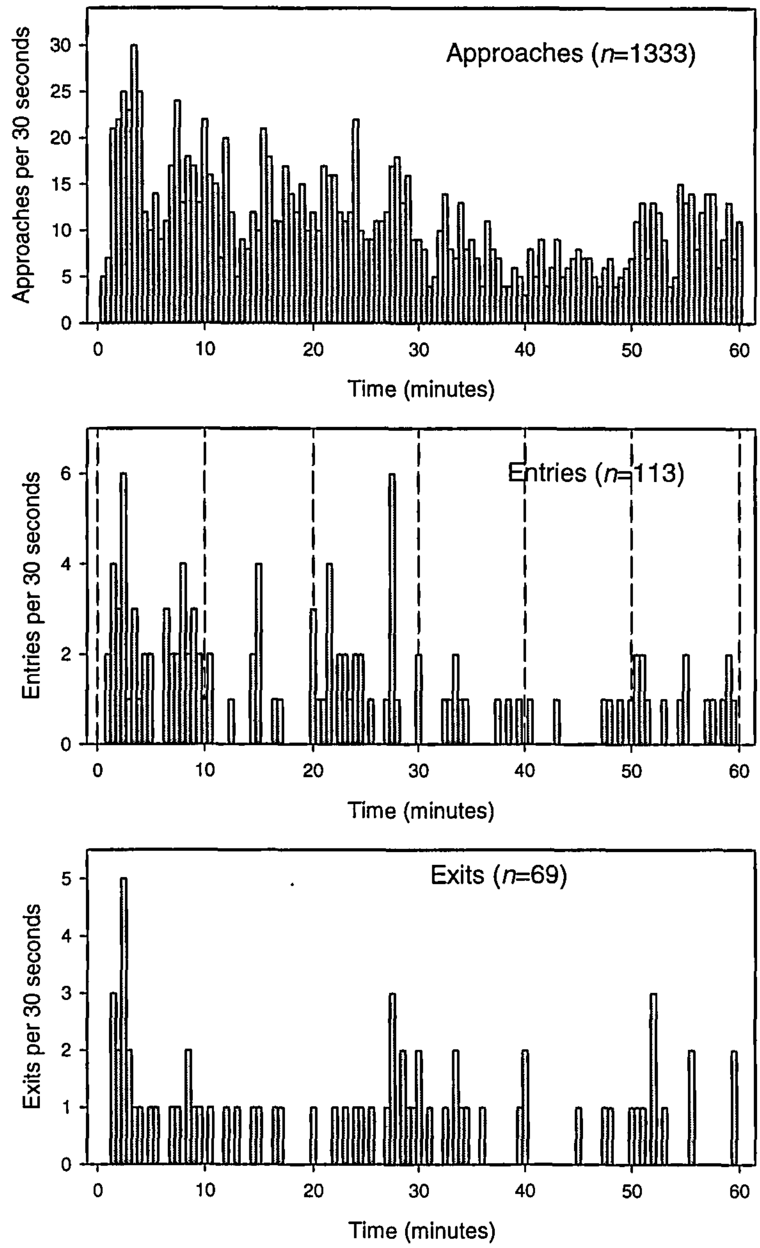

Figure A1: Summary of blue cod activity around baited pots, showing approaches, entries and exits for a single 60 minute pot deployment off D'Urville Island.

Appendix 2: Comparison of bait type

1.1 Background

In the 1995 and 1996 blue cod surveys, the bait type used was frozen pilchard *Sardinops neopilchardus*), caught locally in the Marlborough Sounds, and stored frozen until required. This was taken on the survey on-ice, and thawed as required. The frozen pilchard bait was enclosed in a mesh bait bag which was attaced to the bottom inner surface of the blue cod pot.

During the late 1990s, the abundance of pilchards decreased in Australia and New Zealand following the outbreak of a herpesvirus epidemic (Smith et al. 1996), and since then, local pilchards have not been available to take as bait. Local fishers have used alternative baits, mainly paua (*Haliotis iris*) guts, which have been commercially frozen and made available to fishers for this purpose (C. Aston, commercial fisher, pers. comm. 2001). A small amount of frozen pilchard bait was obtained from Australia through a local fish processor, and this was used to provide comparisons with paua guts bait.

1.2 Methods

The bait type experiments were carried out in the D'Urville Island stratum (DURV), on 17–18 September, at the conclusion of the main fishing survey. The vessel and gear were prepared as previously described, and a total of 16 pots were fished, in eight groups of two pairs (pilchard and paua). Fishing locations were randomised within the stratum. Before the pots were placed, the depth was examined using the sounder to determine that the pots were to be placed on hard substrate, and that conditions were equivalent between each pair. The eight pots were sequentially set, as four groups of two, with each pair of replicates placed adjacent to each other, approximately 15m apart. Each pot took approximately 2 mins to set and was deemed to be fishing once the float had been detached from the vessel, and were fished for 60 minutes. The pairs of pots were sequentially recovered. Upon recovery, the catch was separated to species, weighed and processed as previously described. Where possible, bycatch species were measured and released alive. For blue cod, the sex ratio, total number per pot, total weight per pot, and the number of large (greater than 28 cm total length) were compared between replicates by the paired sample t-test in PROC MEANS of the SAS programme (SAS 1989). The sign (+/-) of the t value refers to the direction of difference between the paired means.

These data were also combined with previous data (Cole *et al.* submitted 2001) collected in an earlier bait comparison for blue cod in the D'Urville stratum during August 2001. In this comparison, total numbers of blue cod, and numbers greater than 28 cm t.l. were recorded. This allowed the number of pot comparisons to be increased to 52 pots (26 pairs) for total numbers and numbers of recruited blue cod.

Results

No differences could be determined by paired sample t-test between the two bait types (pilchard or paua guts), for the total number of blue cod per pot (n=26, t= -1.08: Pr > 0.05), or for the total number of recruited blue cod (n=26, t= -0.88: Pr > 0.05). Comparisons between total weight of blue cod per pot (n=8: t= -1.21: Pr > 0.05), the number of male blue cod per pot (n=8: t= -1.42: Pr > 0.05), the number of females per pot (n=8: t= -1.14: Pr > 0.05), ($F_{(1,15)}$=1.75: Pr > 0.005) also failed to demonstrate a difference due to bait type.

Although there were no differences in blue cod catch rate, the pilchard bait seemed to attract a larger number of bycatch species such as carpet shark. The low rate of bycatch from the 2001 survey is largely due to the use of paua guts as bait. A similar trend was noted by Cole et al. (submitted ms).

Summary

The comparison between bait types failed to demonstrate a difference in catch rate or size of blue cod attracted to the pots. It is concluded that the use of paua bait makes a minimal difference in this experiment.

References

Cole, R.G., Alcock, N.K., Handley, S.J., Grange, K.R., Black, S. Cairney, D., Day, J., Ford, S., Jerrett, A.R. (Submitted ms.). Selective capture of blue cod *Parapercis colias* by potting: behavioural observations and effects of capture method on peri-mortem fatigue. *Fisheries Research.*

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Appendix 3: Summary of station data

Station	Date	Time	Type	Location	Latitude ° ' S	Longitude ° ' E	Stratum	Area	Site	Pot	Depth (m)	No. BCO > 28 cm	No. BCO total
1	5-Sep-01	6:39	Pot	Kaipapa	41.13.42	174.04.11	1	A	1	a	16	0	0
2	5-Sep-01	6:41	Pot	Kaipapa	41.13.45	174.04.12	1	A	1	b	19	0	0
3	5-Sep-01	6:43	Pot	Kaipapa	41.13.45	174.04.18	1	A	1	c	14	0	0
4	5-Sep-01	6:47	Pot	Kaipapa	41.13.67	174.04.47	1	A	2	a	27	1	1
5	5-Sep-01	6:48	Pot	Kaipapa	41.13.69	174.04.47	1	A	2	b	20	2	3
6	5-Sep-01	6:51	Pot	Kaipapa	41.13.78	174.04.48	1	A	2	c	20	2	3
7	5-Sep-01	6:57	Pot	Kaipapa	41.13.74	174.04.83	1	A	3	a	18	0	0
8	5-Sep-01	6:59	Pot	Kaipapa	41.13.74	174.04.87	1	A	3	b	27	0	0
9	5-Sep-01	7:01	Pot	Kaipapa	41.13.71	174.04.89	1	A	3	c	18	1	2
901	5-Sep-01	8:41	Line	Kaipapa	41.13.44	174.04.13	1	A	1	g	16	0	0
902	5-Sep-01	9:01	Line	Kaipapa	41.13.74	174.04.86	1	A	3	g	18	0	0
10	5-Sep-01	9:42	Pot	Dieffenbach	41.14.15	174.07.47	1	B	1	a	18	0	0
11	5-Sep-01	9:43	Pot	Dieffenbach	41.14.15	174.07.53	1	B	1	b	22	0	0
12	5-Sep-01	9:45	Pot	Dieffenbach	41.14.15	174.07.56	1	B	1	c	24	0	0
13	5-Sep-01	9:51	Pot	Dieffenbach	41.14.07	174.08.25	1	B	2	a	14	2	3
14	5-Sep-01	9:52	Pot	Dieffenbach	41.14.03	174.08.29	1	B	2	b	22	3	4
15	5-Sep-01	9:54	Pot	Dieffenbach	41.13.99	174.08.33	1	B	2	c	16	0	0
16	5-Sep-01	9:57	Pot	Dieffenbach	41.13.88	174.08.73	1	B	3	a	18	0	3
17	5-Sep-01	9:59	Pot	Dieffenbach	41.13.83	174.08.76	1	B	3	b	27	2	5
18	5-Sep-01	10:01	Pot	Dieffenbach	41.13.80	174.08.82	1	B	3	c	26	0	0
903	5-Sep-01	10:07	Line	Dieffenbach	41.14.02	174.08.33	1	B	2	g	11	0	0
904	5-Sep-01	10:27	Line	Dieffenbach	41.14.16	174.07.55	1	B	1	g	29	0	0
19	5-Sep-01	11:42	Pot	Inner Tory	41.14.48	174.11.06	2	A	1	a	15	0	1
20	5-Sep-01	11:43	Pot	Inner Tory	41.14.47	174.11.13	2	A	1	b	18	0	0
21	5-Sep-01	11:45	Pot	Inner Tory	41.14.44	174.11.19	2	A	1	c	16	0	0
22	5-Sep-01	11:51	Pot	Inner Tory	41.14.61	174.11.96	2	A	2	a	20	1	3
23	5-Sep-01	11:52	Pot	Inner Tory	41.14.59	174.12.02	2	A	2	b	15	1	2
24	5-Sep-01	11:54	Pot	Inner Tory	41.14.60	174.12.11	2	A	2	c	18	1	2
25	5-Sep-01	11:59	Pot	Inner Tory	41.14.20	174.12.56	2	A	3	a	22	1	3
26	5-Sep-01	12:00	Pot	Inner Tory	41.14.20	174.12.63	2	A	3	b	17	0	1
27	5-Sep-01	12:02	Pot	Inner Tory	41.14.18	174.12.61	2	A	3	c	7	0	0
905	5-Sep-01	12:03	Line	Inner Tory	41.14.18	174.12.61	2	A	3	g	8	0	0
906	5-Sep-01	13:28	Line	Inner Tory	41.14.60	174.12.06	2	A	2	g	10	0	0
28	5-Sep-01	14:02	Pot	Outer Tory	41.14.69	174.14.69	2	G	1	a	19	1	6
29	5-Sep-01	14:03	Pot	Outer Tory	41.14.63	174.14.73	2	G	1	b	28	3	3
30	5-Sep-01	14:06	Pot	Outer Tory	41.14.64	174.14.80	2	G	1	c	18	1	4
31	5-Sep-01	14:10	Pot	Outer Tory	41.14.19	174.14.97	2	G	2	a	16	9	14
32	5-Sep-01	14:12	Pot	Outer Tory	41.14.22	174.14.98	2	G	2	b	27	4	7
33	5-Sep-01	14:15	Pot	Outer Tory	41.14.24	174.15.06	2	G	2	c	18	0	0
34	5-Sep-01	14:21	Pot	Outer Tory	41.14.45	174.15.84	2	G	3	a	10	0	0
35	5-Sep-01	14:22	Pot	Outer Tory	41.14.38	174.15.87	2	G	3	b	15	1	1
36	5-Sep-01	14:23	Pot	Outer Tory	41.14.38	174.15.95	2	G	3	c	11	0	5
907	5-Sep-01	14:25	Line	Outer Tory	41.14.38	174.15.95	2	G	3	g	14	0	0
908	5-Sep-01	14:46	Line	Outer Tory	41.14.62	174.14.77	2	G	1	g	15	0	0
37	5-Sep-01	6:38	Pot	Luke	41.13.26	174.08.22	1	C	1	a	23	1	1
38	6-Sep-01	6:41	Pot	Luke	41.13.21	174.08.24	1	C	1	b	26	1	3
39	6-Sep-01	6:43	Pot	Luke	41.13.17	174.08.28	1	C	1	c	25	0	0
40	6-Sep-01	6:50	Pot	Luke	41.12.64	174.08.98	1	C	2	a	10	0	0
41	6-Sep-01	6:53	Pot	Luke	41.12.60	174.08.43	1	C	2	b	11	0	0
42	6-Sep-01	6:55	Pot	Luke	41.12.56	174.07.96	1	C	2	c	13	3	4

Appendix 3: – *continued*

Station	Date	Time	Type	Location	Latitude ° ' S	Longitude ° ' E	Stratum	Area	Site	Pot	Depth (m)	BCO > 28 cm	BCO total
43	6-Sep-01	7:02	Pot	Luke	41.12.85	174.08.66	1	C	3	a	9	0	0
44	6-Sep-01	7:05	Pot	Luke	41.12.88	174.08.63	1	C	3	b	11	0	0
45	6-Sep-01	7:07	Pot	Luke	41.12.91	174.08.56	1	C	3	c	23	0	0
909	6-Sep-01	7:18	Line	Luke	41.12.88	174.08.64	1	C	3	g	12	0	0
910	6-Sep-01	7:40	Line	Luke	41.13.19	174.08.25	1	C	1	g	18	0	0
46	6-Sep-01	8:48	Pot	Coves	41.12.18	174.10.14	1	D	1	a	15	0	0
47	6-Sep-01	8:51	Pot	Coves	41.12.09	174.10.13	1	D	1	b	10	0	0
48	6-Sep-01	8:52	Pot	Coves	41.12.05	174.10.13	1	D	1	c	14	0	3
49	6-Sep-01	8:58	Pot	Coves	41.11.68	174.09.33	1	D	2	a	11	1	1
50	6-Sep-01	9:01	Pot	Coves	41.11.65	174.09.36	1	D	2	b	13	0	0
51	6-Sep-01	9:03	Pot	Coves	41.11.54	174.09.22	1	D	2	c	11	1	5
52	6-Sep-01	9:05	Pot	Coves	41.11.31	174.09.27	1	D	3	a	15	1	2
53	6-Sep-01	9:07	Pot	Coves	41.11.27	174.09.31	1	D	3	b	15	1	1
54	6-Sep-01	9:10	Pot	Coves	41.11.23	174.09.31	1	D	3	c	17	3	8
911	6-Sep-01	9:20	Line	Coves	41.11.23	174.09.31	1	D	3	g	13	0	0
912	6-Sep-01	9:45	Line	Coves	41.12.16	174.10.12	1	D	1	g	19	0	0
55	6-Sep-01	11:01	Pot	Hawes	41.12.47	174.11.76	2	B	1	a	35	3	3
56	6-Sep-01	11:03	Pot	Hawes	41.12.49	174.11.76	2	B	1	b	24	0	0
57	6-Sep-01	11:05	Pot	Hawes	41.12.53	174.11.78	2	B	1	c	20	0	2
58	6-Sep-01	11:13	Pot	Hawes	41.12.36	174.12.80	2	B	2	a	16	10	19
59	6-Sep-01	11:14	Pot	Hawes	41.12.33	174.12.87	2	B	2	b	16	3	10
60	6-Sep-01	11:16	Pot	Hawes	41.12.30	174.12.93	2	B	2	c	18	0	0
61	6-Sep-01	11:23	Pot	Hawes	41.11.68	174.12.82	2	B	3	a	21	0	0
62	6-Sep-01	11:26	Pot	Hawes	41.11.71	174.12.71	2	B	3	b	20	0	0
63	6-Sep-01	11:27	Pot	Hawes	41.11.75	174.12.75	2	B	3	c	45	1	2
913	6-Sep-01	11:30	Line	Hawes	41.11.71	174.12.75	2	B	3	g	22	0	0
914	6-Sep-01	11:58	Line	Hawes	41.12.50	174.11.70	2	B	1	g	26	0	0
64	6-Sep-01	13:31	Pot	Pickersgill	41.09.51	174.16.61	2	D	1	a	29	0	0
65	6-Sep-01	13:33	Pot	Pickersgill	41.09.26	174.16.37	2	D	1	b	27	0	3
66	6-Sep-01	13:35	Pot	Pickersgill	41.09.31	174.16.41	2	D	1	c	26	0	2
67	6-Sep-01	13:39	Pot	Pickersgill	41.09.65	174.16.36	2	D	2	a	16	3	20
68	6-Sep-01	13:41	Pot	Pickersgill	41.09.74	174.16.36	2	D	2	b	24	0	4
69	6-Sep-01	13:43	Pot	Pickersgill	41.09.82	174.16.40	2	D	2	c	17	2	3
70	6-Sep-01	13:45	Pot	Pickersgill	41.09.89	174.16.75	2	D	3	a	15	0	0
71	6-Sep-01	13:48	Pot	Pickersgill	41.09.92	174.16.79	2	D	3	b	15	1	2
72	6-Sep-01	13:49	Pot	Pickersgill	41.09.94	174.16.84	2	D	3	c	21	1	3
915	6-Sep-01	13:51	Line	Pickersgill	41.09.93	174.16.82	2	D	3	g	11	0	4
916	6-Sep-01	14:15	Line	Pickersgill	41.09.84	174.16.47	2	D	2	g	8	1	1
73	6-Sep-01	15:50	Pot	Arapawa Isl	41.09.71	174.18.97	2	E	1	a	21	6	18
74	6-Sep-01	15:51	Pot	Arapawa Isl	41.09.67	174.19.01	2	E	1	b	20	2	9
75	6-Sep-01	15:52	Pot	Arapawa Isl	41.09.67	174.19.03	2	E	1	c	17	2	10
76	6-Sep-01	15:54	Pot	Arapawa Isl	41.09.59	174.19.17	2	E	2	a	16	5	15
77	6-Sep-01	15:55	Pot	Arapawa Isl	41.09.57	174.19.18	2	E	2	b	18	4	8
78	6-Sep-01	15:56	Pot	Arapawa Isl	41.09.56	174.19.22	2	E	2	c	16	10	15
79	6-Sep-01	15:58	Pot	Arapawa Isl	41.09.67	174.19.33	2	E	3	a	20	0	0
80	6-Sep-01	16:00	Pot	Arapawa Isl	41.09.69	174.19.36	2	E	3	b	17	0	0
81	6-Sep-01	16:02	Pot	Arapawa Isl	41.09.72	174.19.30	2	E	3	c	16	0	0
917	6-Sep-01	16:04	Line	Arapawa Isl	41.09.72	174.19.29	2	E	3	g	13	1	4
918	6-Sep-01	16:29	Line	Arapawa Isl	41.09.67	174.19.04	2	E	1	g	13	1	8
82	7-Sep-01	7:31	Pot	Stella Rock	41.05.41	174.22.58	3	A	1	a	9	1	1
83	7-Sep-01	7:32	Pot	Stella Rock	41.05.50	174.22.35	3	A	1	b	11	2	4

Appendix 3: – *continued*

Station	Date	Time	Type	Location	Latitude ° ' S	Longitude ° ' E	Stratum	Area	Site	Pot	Depth (m)	BCO > 28 cm	BCO total
84	7-Sep-01	7:34	Pot	Stella Rock	41.05.34	174.22.49	3	A	1	c	12	3	3
85	7-Sep-01	7:39	Pot	Stella Rock	41.05.29	174.22.24	3	A	2	a	17	1	1
86	7-Sep-01	7:41	Pot	Stella Rock	41.05.26	174.22.42	3	A	2	b	38	0	0
87	7-Sep-01	7:44	Pot	Stella Rock	41.05.24	174.22.32	3	A	2	c	45	0	0
88	7-Sep-01	7:49	Pot	Stella Rock	41.05.25	174.22.79	3	A	3	a	14	2	5
89	7-Sep-01	7:52	Pot	Stella Rock	41.05.24	174.22.88	3	A	3	b	15	0	5
90	7-Sep-01	7:55	Pot	Stella Rock	41.05.23	174.22.92	3	A	3	c	14	2	3
919	7-Sep-01	8:04	Line	Stella Rock	41.05.31	174.22.59	3	A	1	g	13	2	4
920	7-Sep-01	8:24	Line	Stella Rock	41.05.30	174.22.92	3	A	2	g	20	0	0
91	7-Sep-01	9:38	Pot	The Twins	41.06.29	174.22.29	3	B	1	a	19	9	15
92	7-Sep-01	9:40	Pot	The Twins	41.06.29	174.19.58	3	B	1	b	18	0	4
93	7-Sep-01	9:42	Pot	The Twins	41.06.32	174.19.59	3	B	1	c	20	0	2
94	7-Sep-01	9:45	Pot	The Twins	41.06.44	174.19.65	3	B	2	a	18	1	5
95	7-Sep-01	9:47	Pot	The Twins	41.06.47	174.19.64	3	B	2	b	18	0	1
96	7-Sep-01	9:48	Pot	The Twins	41.06.49	174.19.61	3	B	2	c	20	0	0
97	7-Sep-01	9:56	Pot	The Twins	41.06.85	174.19.52	3	B	3	a	21	0	0
98	7-Sep-01	9:57	Pot	The Twins	41.06.87	174.19.57	3	B	3	b	16	0	1
99	7-Sep-01	9:59	Pot	The Twins	41.06.88	174.19.60	3	B	3	c	10	2	9
921	7-Sep-01	9:59	Line	The Twins	41.16.88	174.19.59	3	B	3	g	12	1	3
922	7-Sep-01	11:54	Line	The Twins	41.06.33	174.19.57	3	B	3	h	18	0	0
100	7-Sep-01	13:14	Pot	Resolution Bay	41.07.75	174.12.88	2	C	1	a	14	0	1
101	7-Sep-01	13:14	Pot	Resolution Bay	41.07.71	174.12.94	2	C	1	b	29	0	2
102	7-Sep-01	13:18	Pot	Resolution Bay	41.07.74	174.12.96	2	C	1	c	21	0	0
103	7-Sep-01	13:25	Pot	Resolution Bay	41.07.89	174.13.34	2	C	2	a	23	3	4
104	7-Sep-01	13:25	Pot	Resolution Bay	41.07.93	174.13.34	2	C	2	b	16	1	8
105	7-Sep-01	13:27	Pot	Resolution Bay	41.07.97	174.13.34	2	C	2	c	18	1	4
106	7-Sep-01	13:31	Pot	Resolution Bay	41.08.36	174.13.31	2	C	3	a	25	1	1
107	7-Sep-01	13:30	Pot	Resolution Bay	41.08.39	174.13.31	2	C	3	b	19	0	2
108	7-Sep-01	13:34	Pot	Resolution Bay	41.08.43	174.13.33	2	C	3	c	14	0	1
923	7-Sep-01	13:40	Line	Resolution Bay	41.07.99	174.13.34	2	C	2	g	13	0	0
924	7-Sep-01	14:02	Line	Resolution Bay	41.07.73	174.12.94	2	C	1	g	14	0	1
109	7-Sep-01	16:01	Pot	Clark Point	41.08.46	174.17.20	2	F	1	a	18	1	3
110	7-Sep-01	16:02	Pot	Clark Point	41.08.46	174.17.18	2	F	1	b	26	2	3
111	7-Sep-01	16:04	Pot	Clark Point	41.08.47	174.17.19	2	F	1	c	22	1	1
112	7-Sep-01	16:05	Pot	Clark Point	41.08.49	174.17.18	2	F	2	a	21	8	11
113	7-Sep-01	16:06	Pot	Clark Point	41.08.51	174.17.17	2	F	2	b	33	1	1
114	7-Sep-01	16:08	Pot	Clark Point	41.08.52	174.17.18	2	F	2	c	34	1	2
115	7-Sep-01	16:10	Pot	Clark Point	41.08.53	174.17.22	2	F	3	a	36	0	3
116	7-Sep-01	16:12	Pot	Clark Point	41.08.50	174.17.26	2	F	3	b	18	2	7
117	7-Sep-01	16:14	Pot	Clark Point	41.08.49	174.173.20	2	F	3	c	9	0	0
925	7-Sep-01	16:19	Line	Clark Point	41.08.51	174.17.21	2	F	3	g	18	1	1
926	7-Sep-01	16:40	Line	Clark Point	41.08.51	174.17.18	2	F	2	g	25	0	0
118	8-Sep-01	7:52	Pot	Cape Jackson	40.59.42	174.18.21	3	C	1	a	15	2	2
119	8-Sep-01	7:55	Pot	Cape Jackson	41.59.57	174.18.73	3	C	1	b	27	2	3
120	8-Sep-01	7:57	Pot	Cape Jackson	50.59.59	174.18.68	3	C	1	c	28	3	8
121	8-Sep-01	8:01	Pot	Cape Jackson	40.59.78	174.86.61	3	C	2	a	16	1	4
122	8-Sep-01	8:03	Pot	Cape Jackson	40.59.81	174.18.58	3	C	2	b	20	2	5
123	8-Sep-01	8:05	Pot	Cape Jackson	50.59.84	174.18.55	3	C	2	c	19	2	4
124	8-Sep-01	8:08	Pot	Cape Jackson	40.59.92	174.18.34	3	C	3	a	20	3	6
125	8-Sep-01	8:10	Pot	Cape Jackson	40.59.93	174.18.32	3	C	3	b	25	1	1
126	8-Sep-01	8:12	Pot	Cape Jackson	40.59.98	174.18.26	3	C	3	c	22	5	11

Appendix 3: – *continued*

Station	Date	Time	Type	Location	Latitude 0° 0.0' S	Longitude 0° 0.0' E	Stratum	Area	Site	Pot	Depth (m)	BCO > 28 cm	BCO total
927	8-Sep-01	8:14	Line	Cape Jackson	40.59.97	174.18.28	3	C	3	g	22	1	2
127	8-Sep-01	10:06	Pot	Cape Lambert	40.59.09	174.14.03	3	E	1	a	30	8	9
128	8-Sep-01	10:08	Pot	Cape Lambert	40.59.04	174.14.01	3	E	1	b	36	0	2
129	8-Sep-01	10:10	Pot	Cape Lambert	40.59.01	174.13.97	3	E	1	c	38	0	0
130	8-Sep-01	10:14	Pot	Cape Lambert	40.5897	174.13.72	3	E	2	a	33	1	2
131	8-Sep-01	10:20	Pot	Cape Lambert	40.5898	174.13.65	3	E	2	b	33	5	16
132	8-Sep-01	10:21	Pot	Cape Lambert	40.59.00	174.13.62	3	E	2	c	31	7	7
133	8-Sep-01	10:25	Pot	Cape Lambert	40.59.22	174.13.37	3	E	3	a	16	3	9
134	8-Sep-01	10:28	Pot	Cape Lambert	40.59.24	174.13.30	3	E	3	b	20	0	0
135	8-Sep-01	10:29	Pot	Cape Lambert	40.59.28	174.13.24	3	E	3	c	17	1	3
929	8-Sep-01	10:31	Line	Cape Lambert	40.59.23	174.13.32	3	E	3	g	29	6	7
930	8-Sep-01	10:57	Line	Cape Lambert	40.59.22	174.13.32	3	E	1	g	18	0	2
136	8-Sep-01	12:32	Pot	Alligator Head	40.58.18	174.09.86	3	D	1	a	14	7	10
137	8-Sep-01	12:34	Pot	Alligator Head	40.58.15	174.09.84	3	D	1	b	15	6	10
138	8-Sep-01	12:35	Pot	Alligator Head	40.58.15	174.09.80	3	D	1	c	12	4	10
139	8-Sep-01	12:38	Pot	Alligator Head	40.58.00	174.09.54	3	D	2	a	21	4	7
140	8-Sep-01	12:40	Pot	Alligator Head	40.58.02	174.09.50	3	D	2	b	16	2	8
141	8-Sep-01	12:41	Pot	Alligator Head	40.58.06	174.09.48	3	D	2	c	11	4	10
142	8-Sep-01	12:45	Pot	Alligator Head	40.58.09	174.09.20	3	D	3	a	17	0	0
143	8-Sep-01	12:49	Pot	Alligator Head	40.58.17	174.09.21	3	D	3	b	11	0	2
144	8-Sep-01	12:51	Pot	Alligator Head	40.58.20	174.09.16	3	D	3	c	11	1	2
931	8-Sep-01	12:52	Line	Alligator Head	40.58.17	174.09.22	3	D	3	g	10	2	4
932	8-Sep-01	13:19	Line	Alligator Head	40.58.17	174.09.84	3	D	1	g	15	1	1
145	9-Sep-01	6:43	Pot	Outer Forsyth	40.57.87	174.05.36	4	A	1	a	13	0	2
146	9-Sep-01	6:44	Pot	Outer Forsyth	40.57.85	174.05.41	4	A	1	b	21	0	3
147	9-Sep-01	6:46	Pot	Outer Forsyth	40.57.81	174.05.40	4	A	1	c	16	0	3
148	9-Sep-01	6:54	Pot	Outer Forsyth	40.57.53	174.04.85	4	A	2	a	10	0	0
149	9-Sep-01	6:55	Pot	Outer Forsyth	40.57.43	174.05.79	4	A	2	b	10	0	0
150	9-Sep-01	6:58	Pot	Outer Forsyth	40.57.35	174.04.72	4	A	2	c	7	1	1
151	9-Sep-01	7:04	Pot	Outer Forsyth	40.56.91	174.04.87	4	A	3	a	14	1	2
152	9-Sep-01	7:06	Pot	Outer Forsyth	40.56.86	174.04.92	4	A	3	b	11	5	6
153	9-Sep-01	6:58	Pot	Outer Forsyth	40.56.81	174.04.94	4	A	3	c	20	0	1
933	9-Sep-01	7:11	Line	Outer Forsyth	40.56.89	174.04.89	4	A	3	g	14	2	2
934	9-Sep-01	7:36	Line	Outer Forsyth	40.57.82	172.05.33	4	A	1	g	12	1	2
154	9-Sep-01	8:54	Pot	Chetwode Islands	40.54.73	174.03.48	4	B	1	a	18	3	3
155	9-Sep-01	8:56	Pot	Chetwode Isl.	40.54.68	174.03.48	4	B	1	b	18	1	1
156	9-Sep-01	8:57	Pot	Chetwode Isl.	40.54.63	174.03.51	4	B	1	c	16	4	10
157	9-Sep-01	9:02	Pot	Chetwode Isl.	40.54.42	174.03.98	4	B	2	a	12	2	6
158	9-Sep-01	9:03	Pot	Chetwode Isl.	40.54.46	174.03.01	4	B	2	b	13	4	9
159	9-Sep-01	9:04	Pot	Chetwode Isl.	40.54.50	174.03.03	4	B	2	c	18	4	6
160	9-Sep-01	9:08	Pot	Chetwode Isl.	40.54.30	174.04.17	4	B	3	a	11	1	1
161	9-Sep-01	9:09	Pot	Chetwode Isl.	40.54026	174.04.12	4	B	3	b	9	0	0
162	9-Sep-01	9:10	Pot	Chetwode Isl.	40.54.20	174.04.21	4	B	3	c	12	2	4
935	9-Sep-01	9:11	Pot	Chetwode Isl.	40.54.23	174.04.21	4	B	3	g	10	1	2
936	9-Sep-01	9:38	Line	Chetwode Isl.	40.54.71	174.03.47	4	B	1	g	11	3	4
163	9-Sep-01	10:53	Pot	Goat Point	40.56.44	174.03.93	4	E	1	a	13	1	3
164	9-Sep-01	10:54	Pot	Goat Point	40.56.44	174.03.93	4	E	1	b	21	4	11
165	9-Sep-01	10:55	Pot	Goat Point	40.56.46	174.03.89	4	E	1	c	29	2	2
166	9-Sep-01	10:59	Pot	Goat Point	40.56.66	174.03.81	4	E	2	a	9	7	13
167	9-Sep-01	10:59	Pot	Goat Point	40.56.67	174.03.79	4	E	2	b	10	2	4
168	9-Sep-01	11:10	Pot	Goat Point	40.56.67	174.03.78	4	E	2	c	8	4	7

Appendix 3: – *continued*

Station	Date	Time	Type	Location	Latitude 0° 0.0' S	Longitude 0° 0.0' E	Stratum	Area	Site	Pot	Depth (m)	BCO > 28 cm	BCO total
169	9-Sep-01	11:08	Pot	Goat Point	40.56.85	174.03.29	4	E	3	a	9	4	7
170	9-Sep-01	11:09	Line	Goat Point	40.56.85	174.03.25	4	E	3	b	12	1	6
171	9-Sep-01	11:10	Line	Goat Point	40.56.86	174.03.21	4	E	3	c	12	2	5
937	9-Sep-01	11:13	Line	Goat Point	40.56.85	174.03.24	4	E	3	g	11	1	3
938	9-Sep-01	11:35	Line	Goat Point	40.56.86	174.03.25	4	E	1	g	12	0	0
172	9-Sep-01	13:19	Pot	Duffers Reef	40.57.42	174.02.15	5	D	1	a	14	0	1
173	9-Sep-01	13:21	Pot	Duffers Reef	40.57.43	174.02.23	5	D	1	b	13	0	0
174	9-Sep-01	13:22	Pot	Duffers Reef	40.57.42	174.02.27	5	D	1	c	12	0	0
175	9-Sep-01	13:28	Pot	Duffers Reef	40.57.15	174.02.97	5	D	2	a	20	0	0
176	9-Sep-01	13:30	Pot	Duffers Reef	40.57.17	174.03.06	5	D	2	b	12	3	5
177	9-Sep-01	13:33	Pot	Duffers Reef	40.57.21	174.03.17	5	D	2	c	13	0	1
178	9-Sep-01	13:36	Pot	Duffers Reef	40.57.11	174.03.50	5	D	3	a	20	0	0
179	9-Sep-01	13:38	Pot	Duffers Reef	40.57.14	174.03.53	5	D	3	b	21	0	0
180	9-Sep-01	13:40	Pot	Duffers Reef	40.57.15	174.03.59	5	D	3	c	16	1	3
939	9-Sep-01	13:43	Line	Duffers Reef	40.57.14	174.03.60	5	D	3	g	16	3	4
940	9-Sep-01	14:58	Line	Duffers Reef	40.57.21	174.03.20	5	D	2	g	26	0	0
181	10-Sep-01	6:20	Pot	BoatRockPoint	40.5794	173.57.44	5	B	1	a	25	2	2
182	10-Sep-01	6:22	Pot	BoatRockPoint	40.57.98	173.57.34	5	B	1	b	24	0	0
183	10-Sep-01	6:24	Pot	BoatRockPoint	40.58.04	173.57.34	5	B	1	c	20	3	3
184	10-Sep-01	6:26	Pot	BoatRockPoint	40.58.15	173.57.13	5	B	2	a	20	1	1
185	10-Sep-01	6:28	Pot	BoatRockPoint	40.58.17	173.57.09	5	B	2	b	16	0	0
186	10-Sep-01	6:29	Pot	BoatRockPoint	40.58.14	173.57.09	5	B	2	c	19	2	3
187	10-Sep-01	6:35	Pot	BoatRockPoint	40.58.38	173.56.85	5	B	3	a	21	0	1
188	10-Sep-01	6:37	Pot	BoatRockPoint	40.58.45	173.56.80	5	B	3	b	37	0	0
189	10-Sep-01	6:41	Pot	BoatRockPoint	40.58.44	173.56.76	5	B	3	c	17	0	0
941	10-Sep-01	6:46	Line	BoatRockPoint	40.58.37	173.56.77	5	B	3	g	16	0	0
942	10-Sep-01	7:10	Line	BoatRockPoint	40.58.01	173.57.36	5	B	1	g	17	0	1
190	10-Sep-01	8:16	Pot	The Reef	41.00.33	173.57.09	5	A	1	a	24	7	8
191	10-Sep-01	8:18	Pot	The Reef	41.00.36	173.57.09	5	A	1	b	20	0	1
192	10-Sep-01	8:20	Pot	The Reef	41.00.39	173.57.08	5	A	1	c	15	0	0
193	10-Sep-01	8:25	Pot	The Reef	41.00.71	173.57.04	5	A	2	a	10	0	3
194	10-Sep-01	8:26	Pot	The Reef	41.00.73	173.56.98	5	A	2	b	9	0	1
195	10-Sep-01	8:27	Pot	The Reef	41.00.79	173.56.91	5	A	2	c	8	0	1
196	10-Sep-01	8:33	Pot	The Reef	41.00.97	173.56.56	5	A	3	a	14	0	0
197	10-Sep-01	8:34	Pot	The Reef	41.00.97	173.56.55.	5	A	3	b	13	0	2
198	10-Sep-01	8:36	Pot	The Reef	41.00.00	173.56.47	5	A	3	c	14	0	0
943	10-Sep-01	8:37	Line	The Reef	41.00.97	173.56.56	5	A	3	g	14	0	3
944	10-Sep-01	8:58	Line	The Reef	41.00.75	173.56.97	5	A	2	g	6	0	0
199	10-Sep-01	10:10	Pot	TapaapaPt	41.02.44	173.56.08	8	D	1	a	19	0	1
200	10-Sep-01	10:11	Pot	TapaapaPt	41.02.49	173.56.12	8	D	1	b	12	0	4
201	10-Sep-01	10:12	Pot	TapaapaPt	41.02.52	173.56.17	8	D	1	c	20	0	1
202	10-Sep-01	10:17	Pot	TapaapaPt	41.02.36	173.56.62	8	D	2	a	13	1	1
203	10-Sep-01	10:18	Pot	TapaapaPt	41.02.35	173.56.67	8	D	2	b	18	1	6
204	10-Sep-01	10:21	Pot	TapaapaPt	41.02.32	173.56.80	8	D	2	c	21	4	4
205	10-Sep-01	10:27	Pot	TapaapaPt	41.02.55	173.57.30	8	D	3	a	15	0	0
206	10-Sep-01	10:29	Pot	TapaapaPt	41.02.60	173.57.36	8	D	3	b	15	0	0
207	10-Sep-01	10:31	Pot	TapaapaPt	41.02.67	173.57.40	8	D	3	c	16	0	1
945	10-Sep-01	10:33	Line	TapaapaPt	41.02.56	173.57.30	8	D	3	g	15	0	0
946	10-Sep-01	10:56	Line	TapaapaPt	41.02.49	173.57.14	8	D	1	g	15	0	0
208	10-Sep-01	12:06	Pot	KauauroaBy	41.02.89	173.58.87	8	A	1	a	11	0	0
209	10-Sep-01	12:08	Pot	KauauroaBy	41.02.90	173.58.83	8	A	1	b	11	0	0

Appendix 3: – *continued*

Station	Date	Time	Type	Location	Latitude 0° 0.0' S	Longitude 0° 0.0' E	Stratum	Area	Site	Pot	Depth (m)	BCO > 28 cm	BCO total
210	10-Sep-01	12:10	Pot	KauauroaBy	41.02.87	173.58.88	8	A	1	c	12	0	1
211	10-Sep-01	12:15	Pot	KauauroaBy	41.03.1	174.58.52	8	A	2	a	11	0	0
212	10-Sep-01	12:16	Pot	KauauroaBy	41.03.11	173.35.85	8	A	2	b	13	0	5
213	10-Sep-01	12:18	Pot	KauauroaBy	41.03.15	173.58.48	8	A	2	c	10	0	1
214	10-Sep-01	12:20	Pot	KauauroaBy	41.03.29	173.58.30	8	A	3	a	18	0	0
215	10-Sep-01	12:22	Pot	KauauroaBy	41.03.31	173.58.27	8	A	3	b	14	0	0
216	10-Sep-01	12:23	Pot	KauauroaBy	41.03.33	173.58.26	8	A	3	c	14	0	0
947	10-Sep-01	12:25	Line	KauauroaBy	41.03.35	173.58.27	8	A	3	g	14	0	0
948	10-Sep-01	12:49	Line	KauauroaBy	41.02.88	173.58.89	8	A	1	g	10	0	0
217	11-Sep-01	6:43	Pot	TePurakaPt	41.03.43	174.00.85	7	C	1	a	11	0	1
218	11-Sep-01	6:45	Pot	TePurakaPt	41.03.38	179.00.79	7	C	1	b	10	0	0
219	11-Sep-01	6:47	Pot	TePurakaPt	41.03.35	174.00.75	7	C	1	c	12	0	0
220	11-Sep-01	6:51	Pot	TePurakaPt	41.03.53	174.00.54	7	C	2	a	13	0	0
221	11-Sep-01	6:53	Pot	TePurakaPt	41.03.56	174.00.54	7	C	2	b	12	0	1
222	11-Sep-01	6:55	Pot	TePurakaPt	41.03.57	174.00.59	7	C	2	c	16	0	0
223	11-Sep-01	6:58	Pot	TePurakaPt	41.03.61	174.00.87	7	C	3	a	15	0	0
823	11-Sep-01	6:59	Pot	TePurakaPt	41.03.66	174.00.92	7	C	3	b	9	0	0
224	11-Sep-01	6:59	Pot	TePurakaPt	41.03.69	174.00.95	7	C	3	c	11	0	0
949	11-Sep-01	7:01	Pot	TePurakaPt	41.03.64	174.00.91	7	C	3	g	8	0	0
950	11-Sep-01	7:02	Pot	TePurakaPt	41.03.56	174.00.57	7	C	2	g	14	0	0
225	11-Sep-01	8:48	Pot	MarysBay	41.05.01	173.56.02	7	B	1	a	11	0	0
226	11-Sep-01	8:48	Pot	MarysBay	41.05.01	173.56.02	7	B	1	b	11	0	0
227	11-Sep-01	8:50	Pot	MarysBay	41.05.02	173.55.97	7	B	1	c	12	0	0
228	11-Sep-01	8:51	Pot	MarysBay	41.05.04	173.55.96	7	B	2	a	15	0	11
229	11-Sep-01	8:55	Pot	MarysBay	41.05.31	173.55.95	7	B	2	b	8	0	2
230	11-Sep-01	8:58	Pot	MarysBay	41.05.35	173.55.94	7	B	2	c	7	1	1
231	11-Sep-01	9:01	Pot	MarysBay	41.05.50	173.55.70	7	B	3	a	12	0	0
232	11-Sep-01	9:03	Pot	MarysBay	41.05.34	173.55.89	7	B	3	b	12	0	0
233	11-Sep-01	9:05	Pot	MarysBay	41.05.64	173.55.63	7	B	3	c	10	0	0
951	11-Sep-01	9:06	Line	MarysBay	41.05.63	173.55.64	7	B	3	g	11	0	0
952	11-Sep-01	9:27	Line	MarysBay	41.05.04	173.55.97	7	B	1	g	11	0	0
234	11-Sep-01	10:45	Pot	JacobsBay	41.07.11	173.53.12	7	A	1	a	7	0	0
235	11-Sep-01	10:47	Pot	JacobsBay	41.07.06	173.53.13	7	A	1	b	10	1	5
236	11-Sep-01	10:48	Pot	JacobsBay	41.07.03	173.53.14	7	A	1	c	8	1	1
237	11-Sep-01	10:56	Pot	JacobsBay	41.06.58	173.53.19	7	A	2	a	10	0	0
238	11-Sep-01	10:55	Pot	JacobsBay	41.06.56	173.53.29	7	A	2	b	10	0	0
239	11-Sep-01	10:57	Pot	JacobsBay	41.06.32	173.53.56	7	A	2	c	10	0	0
240	11-Sep-01	10:59	Pot	JacobsBay	41.06.39	173.53.27	7	A	3	a	10	0	0
241	11-Sep-01	11:00	Pot	JacobsBay	41.06.36	173.53.31	7	A	3	b	10	0	0
242	11-Sep-01	11:02	Pot	JacobsBay	41.06.34	173.53.32	7	A	3	c	5	1	1
953	11-Sep-01	11:07	Line	JacobsBay	41.06.40	173.53.26	7	A	3	g	11	0	0
954	11-Sep-01	11:31	Line	JacobsBay	41.07.08	173.53.13	7	A	1	g	18	0	0
243	11-Sep-01	12:34	Pot	TeRawa	41.04.96	173.54.20	7	D	1	a	9	0	0
244	11-Sep-01	12:35	Pot	TeRawa	41.04.90	173.54.29	7	D	1	b	9	0	0
245	11-Sep-01	12:37	Pot	TeRawa	41.04.91	173.54.32	7	D	1	c	8	0	0
246	11-Sep-01	12:39	Pot	TeRawa	41.04.90	173.54.54	7	D	2	a	9	0	0
247	11-Sep-01	12:40	Pot	TeRawa	41.04.89	173.54.58	7	D	2	b	13	1	2
248	11-Sep-01	13:43	Pot	TeRawa	41.04.82	173.54.64	7	D	2	c	8	2	3
249	11-Sep-01	12:44	Pot	TeRawa	41.04.69	173.54.69	7	D	3	a	10	0	1
250	11-Sep-01	12:46	Pot	TeRawa	41.04.62	173.54.67	7	D	3	b	10	0	0
251	11-Sep-01	12:47	Pot	TeRawa	41.04.56	173.54.65	7	D	3	c	10	0	0

Appendix 3: – *continued*

Station	Date	Time	Type	Location	Latitude 0° 0.0' S	Longitude 0° 0.0' E	Stratum	Area	Site	Pot	Depth (m)	BCO > 28 cm	BCO total
955	11-Sep-01	12:49	Line	TeRawa	41.04.65	173.54.67	7	D	3	g	8	1	1
956	11-Sep-01	13:12	Line	TeRawa	41.04.89	173.54.29	7	D	1	g	10	0	0
252	12-Sep-01	6:51	Pot	RamsHead	41.03.45	173.55.15	8	B	1	a	14	3	6
253	12-Sep-01	6:54	Pot	RamsHead	41.03.41	173.55.15	8	B	1	b	17	1	2
254	12-Sep-01	6:56	Pot	RamsHead	41.03.44	173.55.07	8	B	1	c	9	4	10
255	12-Sep-01	6:59	Pot	RamsHead	41.03.27	173.54.77	8	B	2	a	13	1	6
256	12-Sep-01	7:01	Pot	RamsHead	41.03.28	173.54.64	8	B	2	b	10	2	3
257	12-Sep-01	7:03	Pot	RamsHead	41.03.28	173.54.56	8	B	2	c	13	1	1
258	12-Sep-01	7:09	Pot	RamsHead	41.03.41	173.54.03	8	B	3	a	10	0	0
259	12-Sep-01	7:10	Pot	RamsHead	41.03.40	173.53.99	8	B	3	b	11	0	6
260	12-Sep-01	7:12	Pot	RamsHead	41.03.42	173.53.88	8	B	3	c	9	0	0
957	12-Sep-01	8:14	Line	RamsHead	41.03.42	173.53.91	8	B	3	g	7	0	0
958	12-Sep-01	7:40	Line	RamsHead	41.03.43	173.55.13	8	B	1	g	8	0	0
261	12-Sep-01	8:47	Pot	Maud Isl.	41.02.46	173.54.56	8	C	1	a	12	1	8
262	12-Sep-01	8:48	Pot	Maud Isl.	41.02.47	173.54.56	8	C	1	b	15	0	0
263	12-Sep-01	8:50	Pot	Maud Isl.	41.02.46	173.54.56	8	C	1	c	13	5	9
264	12-Sep-01	8:54	Pot	Maud Isl.	41.02.46	173.54.57	8	C	2	a	10	0	0
265	12-Sep-01	8:55	Pot	Maud Isl.	41.02.46	173.54.56	8	C	2	b	14	0	2
266	12-Sep-01	8:57	Pot	Maud Isl.	41.02.05	173.54.22	8	C	2	c	12	4	7
267	12-Sep-01	9:00	Pot	Maud Isl.	41.01.88	173.53.88	8	C	3	a	11	0	0
268	12-Sep-01	9:01	Pot	Maud Isl.	41.02.87	173.54.76	8	C	3	b	12	0	0
269	12-Sep-01	9:03	Pot	Maud Isl.	41.01.86	173.53.73	8	C	3	c	11	0	0
959	12-Sep-01	9:04	Line	Maud Isl.	41.01.83	173.53.70	8	C	3	g	9	0	1
960	12-Sep-01	10:31	Line	Maud Isl.	41.02.46	173.54.33	8	C	2	g	14	3	6
270	12-Sep-01	10:53	Pot	Maud-West	41.01.40	173.50.54	8	E	1	a	16	0	0
271	12-Sep-01	10:55	Pot	Maud-West	41.01.35	173.50.56	8	E	1	b	14	0	0
272	12-Sep-01	10:56	Pot	Maud-West	41.01.34	173.50.57	8	E	1	c	12	0	0
273	12-Sep-01	11:00	Pot	Maud-West	41.01.32	173.50.98	8	E	2	a	12	1	1
274	12-Sep-01	11:02	Pot	Maud-West	41.01.35	173.50.10	8	E	2	b	12	1	1
275	12-Sep-01	11:03	Pot	Maud-West	41.01.33	173.51.11	8	E	2	c	12	0	0
276	12-Sep-01	11:09	Pot	Maud-West	41.01.26	173.51.68	8	E	3	a	8	0	0
277	12-Sep-01	11:10	Pot	Maud-West	41.01.29	173.51.69	8	E	3	b	12	0	0
278	12-Sep-01	11:12	Pot	Maud-West	41.01.30	173.51.73	8	E	3	c	15	0	0
961	12-Sep-01	11:14	Line	Maud-West	41.01.33	173.51.72	8	E	3	g	18	2	3
962	12-Sep-01	12:23	Line	Maud-West	41.01.39	173.51.07	8	E	2	g	12	0	0
279	12-Sep-01	13:37	Pot	Camp Bay	40.57.54	173.57.42	5	F	1	a	14	0	0
280	12-Sep-01	13:38	Pot	Camp Bay	40.57.52	173.57.48	5	F	1	b	14	0	0
281	12-Sep-01	13:39	Pot	Camp Bay	40.57.46	173.57.55	5	F	1	c	14	0	0
282	12-Sep-01	13:43	Pot	Camp Bay	40.57.27	173.57.45	5	F	2	a	12	0	0
283	12-Sep-01	13:45	Pot	Camp Bay	40.57.24	173.57.45	5	F	2	b	14	4	7
284	12-Sep-01	13:46	Pot	Camp Bay	40.57.22	173.57.46	5	F	2	c	15	2	2
285	12-Sep-01	13:48	Pot	Camp Bay	40.57.14	173.57.45	5	F	3	a	11	3	6
286	12-Sep-01	13:49	Pot	Camp Bay	40.57.11	173.57.43	5	F	3	b	11	1	1
287	12-Sep-01	13:50	Pot	Camp Bay	40.57.11	173.57.38	5	F	3	c	14	0	1
963	12-Sep-01	13:54	Line	Camp Bay	40.57.26	173.57.45	5	F	2	g	9	0	1
964	12-Sep-01	14:12	Line	Camp Bay	40.57.45	173.57.52	5	F	1	g	12	0	1
288	13-Sep-01	6:30	Pot	Katira Bay	40.58.16	174.01.19	5	C	1	a	9	3	5
289	13-Sep-01	6:33	Pot	Katira Bay	40.58.11	174.01.09	5	C	1	b	7	0	2
290	13-Sep-01	6:36	Pot	Katira Bay	40.58.08	174.01.03	5	C	1	c	7	1	2
291	13-Sep-01	6:38	Pot	Katira Bay	40.57.94	174.00.94	5	C	2	a	13	3	10
292	13-Sep-01	6:40	Pot	Katira Bay	40.57.91	174.00.93	5	C	2	b	18	0	3

Appendix 3: – *continued*

Station	Date	Time	Type	Location	Latitude 0° 0.0' S	Longitude 0° 0.0' E	Stratum	Area	Site	Pot	Depth (m)	BCO > 28 cm	BCO total
293	13-Sep-01	6:41	Pot	Katira Bay	40.57.89	174.00.89	5	C	2	c	11	1	1
294	13-Sep-01	6:47	Pot	Katira Bay	40.58.09	174.00.46	5	C	3	a	8	2	2
295	13-Sep-01	6:49	Pot	Katira Bay	40.58.06	174.00.37	5	C	3	b	8	1	2
296	13-Sep-01	6:50	Pot	Katira Bay	40.58.04	174.00.30	5	C	3	c	10	1	1
965	13-Sep-01	6:52	Line	Katira Bay	40.58.03	174.00.29	5	C	3	g	10	1	4
966	13-Sep-01	7:13	Line	Katira Bay	40.57.96	174.00.95	5	C	2	g	12	0	6
297	13-Sep-01	8:34	Pot	TeAkaroa	40.56.21	174.00.72	5	G	1	a	10	0	2
298	13-Sep-01	8:36	Pot	TeAkaroa	40.56.86	173.59.86	5	G	1	b	9	0	4
299	13-Sep-01	8:37	Pot	TeAkaroa	40.56.77	173.59.97	5	G	1	c	10	0	4
300	13-Sep-01	8:41	Pot	TeAkaroa	40.56.43	174.00.16	5	G	2	a	8	0	0
301	13-Sep-01	8:42	Pot	TeAkaroa	40.56.45	174.00.21	5	G	2	b	9	1	6
302	13-Sep-01	8:43	Pot	TeAkaroa	40.56.44	174.00.24	5	G	2	c	10	0	0
303	13-Sep-01	8:47	Pot	TeAkaroa	40.56.23	174.00.28	5	G	3	a	15	0	0
304	13-Sep-01	8:48	Pot	TeAkaroa	40.56.24	174.00.61	5	G	3	b	11	4	6
305	13-Sep-01	8:49	Pot	TeAkaroa	40.56.24	174.00.69	5	G	3	c	7	0	0
967	13-Sep-01	8:50	Line	TeAkaroa	40.56.25	174.00.70	5	G	3	g	10	1	1
968	13-Sep-01	9:13	Line	TeAkaroa	40.56.82	173.59.93	5	G	2	g	10	0	0
306	13-Sep-01	10:17	Pot	ClayPt	40.55.55	174.01.18	4	C	1	a	27	2	5
307	13-Sep-01	10:19	Pot	ClayPt	40.55.57	174.01.16	4	C	1	b	16	0	4
308	13-Sep-01	10:21	Pot	ClayPt	40.55.49	174.01.15	4	C	1	c	12	2	11
309	13-Sep-01	10:27	Pot	ClayPt	40.54.89	174.01.13	4	C	2	a	5	8	10
310	13-Sep-01	10:28	Pot	ClayPt	40.54.91	174.01.16	4	C	2	b	6	4	4
311	13-Sep-01	10:29	Pot	ClayPt	40.54.90	174.01.19	4	C	2	c	8	7	8
312	13-Sep-01	10:32	Pot	ClayPt	40.54.72	174.01.38	4	C	3	a	8	2	7
313	13-Sep-01	10:33	Pot	ClayPt	40.54.68	174.01.41	4	C	3	b	9	0	8
314	13-Sep-01	10:35	Pot	ClayPt	40.54.61	174.01.41	4	C	3	c	9	0	0
969	13-Sep-01	10:36	Line	ClayPt	40.54.61	174.01.40	4	C	1	g	11	0	2
970	13-Sep-01	10:00	Line	ClayPt	40.55.57	174.01.18	4	C	2	g	18	0	0
315	13-Sep-01	12:37	Pot	HarrisBay	40.53.95	173.58.57	4	D	1	a	15	1	5
316	13-Sep-01	12:39	Line	HarrisBay	40.53.90	173.58.60	4	D	1	b	15	1	14
317	13-Sep-01	12:40	Line	HarrisBay	40.53.87	173.58.62	4	D	1	c	18	3	9
318	13-Sep-01	12:43	Pot	HarrisBay	40.53.62	173.58.76	4	D	2	a	26	1	3
319	13-Sep-01	12:45	Pot	HarrisBay	40.53.57	173.58.77	4	D	2	b	20	2	3
320	13-Sep-01	12:48	Pot	HarrisBay	40.53.55	173.58.76	4	D	2	c	12	0	3
321	13-Sep-01	12:50	Pot	HarrisBay	40.53.38	173.58.74	4	D	3	a	16	4	5
322	13-Sep-01	12:51	Pot	HarrisBay	40.53.36	173.58.75	4	D	3	b	14	0	0
323	13-Sep-01	12:53	Pot	HarrisBay	40.53.31	173.58.76	4	D	3	c	27	1	1
971	13-Sep-01	12:55	Line	HarrisBay	40.53.36	173.58.74	4	D	3	g	18	1	4
972	13-Sep-01	13:17	Line	HarrisBay	40.53.89	173.58.60	4	D	2	g	15	4	5
324	14-Sep-01	7:19	Pot	EastTrio	40.50.71	173.59.99	6	C	1	a	38	26	33
325	14-Sep-01	7:21	Pot	EastTrio	40.50.75	174.00.02	6	C	1	b	38	18	25
326	14-Sep-01	7:22	Pot	EastTrio	40.50.80	174.00.07	6	C	1	c	37	9	13
327	14-Sep-01	7:28	Pot	EastTrio	40.50.75	174.00.54	6	C	2	a	36	7	20
328	14-Sep-01	7:29	Pot	EastTrio	40.50.83	174.00.55	6	C	2	b	33	5	9
329	14-Sep-01	7:30	Pot	EastTrio	40.50.88	174.00.57	6	C	2	c	31	17	46
330	14-Sep-01	7:56	Pot	EastTrio	40.51.21	174.00.36	6	C	3	a	32	35	68
331	14-Sep-01	7:38	Pot	EastTrio	40.51.24	174.00.32	6	C	3	b	35	22	39
332	14-Sep-01	7:39	Pot	EastTrio	40.51.29	174.00.27	6	C	3	c	38	26	40
973	14-Sep-01	7:42	Line	EastTrio	40.51.31	174.00.43	6	C	3	g	33	2	6
974	14-Sep-01	8:06	Line	EastTrio	40.50.86	174.00.12	6	C	1	g	35	3	3
333	14-Sep-01	11:46	Pot	EastTrio	40.50.39	173.59.49	6	B	1	a	43	11	15

Appendix 3: – *continued*

Station	Date	Time	Type	Location	Latitude 0° 0.0' S	Longitude 0° 0.0' E	Stratum	Area	Site	Pot	Depth (m)	BCO > 28 cm	BCO total
334	14-Sep-01	11:48	Pot	EastTrio	40.50.39	173.59.41	6	B	1	b	39	13	16
335	14-Sep-01	11:49	Pot	WestTrios	40.50.40.	173.59.36	6	B	1	c	38	15	19
336	14-Sep-01	11:52	Pot	WestTrios	40.50.19	173.59.50	6	B	2	a	32	10	13
337	14-Sep-01	11:53	Pot	WestTrios	40.50.19	173.59.46	6	B	2	b	31	2	2
338	14-Sep-01	11:54	Pot	WestTrios	40.50.20	173.59.45	6	B	2	c	30	7	9
339	14-Sep-01	11:57	Pot	WestTrios	40.49.90	173.59.56	6	B	3	a	25	12	19
340	14-Sep-01	11:58	Pot	WestTrios	40.49.90	173.59.48	6	B	3	b	26	10	14
341	14-Sep-01	11:59	Pot	WestTrios	40.49.91	173.59.41	6	B	3	c	26	23	46
975	14-Sep-01	12:00	Line	WestTrios	40.49.90	173.59.39	6	B	3	g	26	1	1
976	14-Sep-01	12:21	Line	WestTrios	40.50.31	173.59.39	6	B	2	g	35	2	2
342	14-Sep-01	14:17	Pot	Rangitoto	40.47.29	173.58.19	6	A	1	a	34	4	7
343	14-Sep-01	14:18	Line	Rangitoto	40.47.30	173.58.18	6	A	1	b	29	1	1
344	14-Sep-01	14:19	Line	Rangitoto	40.47.33	173.58.19	6	A	1	c	27	1	8
345	14-Sep-01	14:20	Pot	Rangitoto	40.47.50	173.58.10	6	A	2	a	27	1	1
346	14-Sep-01	14:21	Pot	Rangitoto	40.47.53	173.58.08	6	A	2	b	28	4	4
347	14-Sep-01	14:23	Pot	Rangitoto	40.47.54	173.58.05	6	A	2	c	30	12	18
348	14-Sep-01	14:27	Pot	Rangitoto	40.47.18	173.57.91	6	A	3	a	31	7	9
349	14-Sep-01	14:28	Pot	Rangitoto	40.47.14	173.57.93	6	A	3	b	33	0	0
350	14-Sep-01	14:29	Pot	Rangitoto	40.47.12	173.57.94	6	A	3	c	35	15	15
977	14-Sep-01	14:30	Line	Rangitoto	40.47.14	173.57.92	6	A	1	g	33	1	1
978	14-Sep-01	14:50	Line	Rangitoto	40.47.33	173.58.15	6	A	2	g	27	9	10
351	15-Sep-01	7:07	Pot	PenguinBay	40.50.63	173.54.69	6	D	1	a	13	10	21
352	15-Sep-01	7:12	Pot	PenguinBay	40.50.57	173.54.84	6	D	1	b	14	7	8
353	15-Sep-01	7:16	Pot	PenguinBay	40.50.58	173.54.96	6	D	1	c	15	14	23
354	15-Sep-01	7:22	Pot	PenguinBay	40.50.28	173.54.99	6	D	2	a	23	10	14
355	15-Sep-01	7:24	Pot	PenguinBay	40.50.24	173.55.03	6	D	2	b	21	6	6
356	15-Sep-01	7:26	Pot	PenguinBay	40.50.18	173.55.04	6	D	2	c	21	6	10
357	15-Sep-01	7:31	Pot	PenguinBay	40.50.09	173.55.20	6	D	3	a	25	0	0
358	15-Sep-01	7:32	Pot	PenguinBay	40.50.13	173.55.24	6	D	3	b	31	0	1
359	15-Sep-01	7:34	Pot	PenguinBay	40.50.09	173.55.29	6	D	3	c	25	11	22
979	15-Sep-01	8:38	Line	PenguinBay	40.50.11	173.55.25	6	D	3	g	24	5	7
980	15-Sep-01	8:01	Line	PenguinBay	40.50.63	173.55.01	6	D	2	g	25	2	2
360	15-Sep-01	9:09	Pot	Bonne Point	40.51.58	173.54.90	6	L	1	a	16	15	35
361	15-Sep-01	9:10	Pot	Bonne Point	40.51.56	173.54.94	6	L	1	b	19	6	10
362	15-Sep-01	9:13	Pot	Bonne Point	40.51.57	173.54.97	6	L	1	c	15	10	20
363	15-Sep-01	9:17	Pot	Bonne Point	40.51.54	173.55.33	6	L	2	a	27	5	12
364	15-Sep-01	9:19	Pot	Bonne Point	40.51.50	173.55.33	6	L	2	b	34	16	21
365	15-Sep-01	9:20	Pot	Bonne Point	40.51.50	173.55.31	6	L	2	c	36	13	21
366	15-Sep-01	9:25	Pot	Bonne Point	40.51.64	173.55.04	6	L	3	a	16	7	16
367	15-Sep-01	9:27	Pot	Bonne Point	40.51.65	173.55.00	6	L	3	b	13	1	4
368	15-Sep-01	9:28	Pot	Bonne Point	40.51.66	173.54.96	6	L	3	c	11	3	4
981	15-Sep-01	9:33	Line	Bonne Point	40.51.51	173.55.31	6	L	2	g	31	1	1
982	15-Sep-01	10:00	Line	Bonne Point	40.51.51	173.55.08	6	L	1	g	25	3	5
369	15-Sep-01	11:29	Pot	Catherine Cove	40.52.77	173.54.04	6	M	1	a	22	16	24
370	15-Sep-01	11:31	Pot	Catherine Cove	40.52.72	173.53.97	6	M	1	b	19	3	6
371	15-Sep-01	11:33	Pot	Catherine Cove	40.52.67	173.53.90	6	M	1	c	27	2	14
372	15-Sep-01	11:36	Pot	Catherine Cove	40.52.65	173.53.64	6	M	2	a	33	0	0
373	15-Sep-01	11:37	Pot	Catherine Cove	40.52.64	173.53.71	6	M	2	b	27	5	9
374	15-Sep-01	11:38	Pot	Catherine Cove	40.52.64	173.53.72	6	M	2	c	29	3	4
375	15-Sep-01	11:40	Pot	Catherine Cove	40.52.53	173.53.90	6	M	3	a	18	2	2
376	15-Sep-01	11:44	Pot	Catherine Cove	40.52.54	173.53.01	6	M	3	b	8	12	13

Appendix 3: – *continued*

Station	Date	Time	Type	Location	Latitude 0° 0.0′ S	Longitude 0° 0.0′ E	Stratum	Area	Site	Pot	Depth (m)	BCO > 28 cm	BCO total
377	15-Sep-01	11:47	Pot	Catherine Cove	40.52.50	173.54.05	6	M	3	c	15	12	14
983	15-Sep-01	11:48	Pot	Catherine Cove	40.52.51	173.54.03	6	M	1	g	16	2	2
984	15-Sep-01	12:10	Pot	Catherine Cove	40.52.73	173.53.96	6	M	3	g	21	0	1

Appendix 4: Review of blue cod data from recreational fishing diary surveys

1. Introduction

Blue cod *Parapercis colias* is the second most important recreational target finfish nationally, after snapper *Pagrus auratus* (Bradford 1998), and is the most important recreational target finfish in the Marlborough Sounds (Blackwell 1997b, Bradford 1998, Hartill et al. 1998, Bell 2001). The Marlborough Sounds blue cod sub-stock is managed as part of the Challenger blue cod fishstock BCO 7 (Annala et al. 2001).

The Marlborough Sounds blue cod sub-stock is considered to be depleted, mainly by recreational fishing activity (Warren 1994). The blue cod recreational catch in BCO 7 estimated at 20–40 t by the 1991–92 diary survey had increased to 145–205 t by 1992–93 (Tierney et al. 1997). The most recent estimate indicates a further increase to 239 t (220–260 t) for 1995–96, when 356 000 fish, c.v. 9% were taken. Although the 1995–96 diary survey included the catch from recreational fishers on charter vessels, available data were limited and the sample size did not provide a reasonable estimate of this component of the catch (Bradford 1998b). This catch was estimated at 76 t (110 000 fish) for 1997–98 by James & Unwin (2000), and is in addition to the general recreational catch estimate (239 t), providing a total estimated recreational catch of BCO 7 in excess of 300 t (Annala et al. 2002). The estimated charter vessel landings during 1997–98 were 5 246 blue cod (c.v. 100%) from Queen Charlotte Sound, and 16 621 blue cod (c.v. 85%) from Pelorus Sound. Current recreational fishing activity in BCO 7 substantially exceeds the current commercial catch (28 t in 1999–2000) and TACC of 70 t (Annala et al. 2001).

Whilst these previous diary surveys indicate the scale of increase in recreational fishing catch regionally, the 1997–98 Marlborough Sounds recreational diary survey Bell (2001) provides the first review of recreational blue cod fishing activity within the Marlborough Sounds. Although Bell (2001) does not provide scaled estimates of total recreational catch, these data describe the location of recreational catch and effort, and allow relative catch rates to be compared among areas, within the Marlborough Sounds. As most recreational blue cod fishing within the Marlborough Sounds is carried out by lines (handline or fishing rods), these data were compared to the line fishing control stations from the 1995, 1996 and 2001 blue cod surveys (Blackwell 1997a, 1998).

2. Methods

2.1 Recreational diary survey data

Bell (2001) describes catch rates for individual areas defined in the 1997–98 diary survey programme. These data have been approximated to the survey areas used in the 1995, 1996 and 2001 blue cod potting surveys (as defined in Figure 1 of the main report), and catch and effort diary data are summarised in Table A1.

2.2 Line fishing survey data

Catch and effort data are available from the line fishing control stations, completed as part of the 1995, 1996 and 2001 blue cod research surveys (Blackwell 1997a, 1998). Two line fishing stations were completed at each of the sampling locations. The first station was positioned approximately 50 m from the last of the nine pots set at each sampling area. After this station was completed, the second line fishing station was established, approximately 50 m from the first of the nine pot stations in the sampling area. At each line station, two braided nylon handlines were fished, each for 15 minutes. The line was set with two 6/0 Kale hooks, on a 0.5 m monofilament trace, fixed at 0.5 m apart, and positioned 1.0 m from the weight. The hooks were baited with frozen paua guts in the 2001 survey. This gear was used in the previous surveys (Blackwell 1997a, 1998), although frozen pilchard bait was previously used. From the bait comparison trial (Appendix 2 of this report), no differences in mean weight, fish length or sex ratio were determined between these two bait types.

The catch was summed from these four lines, each fished for 15 m to provide a standard unit of catch/hour fished, and provide a basis for comparison among strata, and survey years.

3. Results

3.1 Recreational diary data

Of the total 2707 fishing trips completed in the Marlbrough Sounds, 52% (1277) nominated blue cod as the preferred target species. Most used rod/handline methods, and 4,866 recruited blue cod were taken (Table A1). From 1254 trips totaling 3386 hours of target fishing, 4631 recruited blue cod were taken. The estimated mean catch rate of 1.37 recruited blue cod/hour is likely to be biased towards experienced fishers (Bell 2001).

This fishing activity (Table A1) included areas inside Turn Point (Figure 1 of the main report) that were not surveyed in Blackwell (1997b, 1998). Within the areas covered by the 1995, 1996 and 2001 blue cod surveys, 1277 trips were completed (47% of the total trips reviewed), representing 2,548 hours of fishing. Of these 1277 trips, 849 trips target fished blue cod (66%), and a total of 3248 recruited blue cod were taken.

For areas approximating the Queen Charlotte Sound strata of the research surveys (Table Figure A2, Table A1), only 4.5% of recruited blue cod fishing effort occurred in the inner sound (IQCH), where the mean catch rate was low (Figure A2). Most recreational fishing effort was directed to the outer sounds (OQCH, 25% of trips, and EQCH, 15.7% of trips), where mean catch rates were higher (Figure A3). Mean catch rates are given in Table A1.

For the areas approximating the Pelorus Sound strata, only 2.5% of trips occurred in the inner sound (IPEL), where the mean catch rate was low (Figure A2). Although an additional 12.4% of trips fished in the mid-Pelorus Sound (MPEL), the mean catch rate in this area was also low (Figure A3). Whilst moderate fishing effort was expended in the OPEL and EOPE strata (8.8% and 9.3% of targeted trips respectively), mean catch rates were higher than the catch rates for the Queen Charlotte strata (Figure A3). Most fishing effort was directed at the D'Urville Island strata (21.9%), where the catch rate (1.62 BCO/hr) was the highest reported in the survey. Mean catch rates are given in Table A1.

3.2 Line fishing survey data

In the 2001 survey, 84 line fishing stations were established, representing 2 stations per sampling area. The number of areas sampled per stratum varied, as shown in Tables 1 & 2 of the main report. For the 1995 survey, 60 stations were completed, representing 12 stations sampled within the five strata sampled (see Table 2 in Blackwell 1997a). For the 1996 survey, 40 stations were completed, representing 8 stations at each of the 5 strata sampled (see Table 2 in Blackwell 1998).

The mean recruited blue cod catch rates (No./hr) by sampling stratum for each of the three years surveyed (Figure A3) are variable with wide confidence intervals due to the relatively small sample size, and these data must be interpreted with caution. For the Queen Charlotte Sound strata sampled in 1995 and in 2001, mean catch rates were low in IQCH, and higher for the outer sounds strata (OQCH and EQCH). Little difference in mean catch rate could be seen among these strata between the 1995 and 2001 surveys. Mean catch rates are given in Table A2.

For the two Pelorus Sound strata (OPEL, EOPE) sampled in 1995, mean recruited catch rates were similar to the rates for the Queen Charlotte strata (Table A2), and mean catch increased in the 1996 survey, but decreased in the 2001 survey. Mean recruited catch rates for the Pelorus Sound strata sampled in 1996 (Figure A3) were low in the inner strata (IPEL, MPEL), higher in the outer strata (OPEL, EOPE) and highest in DURV. The 2001 survey data (Figure A3) indicates mean recruited catch rates have decreased in all strata (except MPEL, where the catch rate increased slightly). The scale of decrease in the DURV stratum was 50%. Mean catch rates are given in Table A2.

4. Discussion

Recreational blue cod fishing in BCO 7 has increased substantially between 1991–91 (20–40 t) and 1995–96 (220–260 t), and the total recreational blue cod catch may exceed 300 t. Much of this fishing effort is concentrated in the Marlborough Sounds, where the blue cod fishery is considered to be depleted (Warren 1994). The 1997–98 survey data (Bell 2001) indicates that most target blue cod effort is focused on the outer sounds strata. This is consistent with the substantial reduction in blue cod relative abundance indices in these outer sounds areas between 1995–96 and 2001, as determined by the 2001 pot fishing survey. Mean recruited catch from recreational fishers is low in the inner sounds strata (IQCH, IPEL), and these data are similar to the mean catch rates of the line fishing stations sampled in 1995, 1996 and 2001. Data from these line fishing survey stations are variable, with wide confidence intervals. Whilst the line fishing station data for Pelorus Sound between 1996 and 2001 generally follow the trends determined by the 1996 and 2001 pot fishing surveys (Blackwell 1997b, 1998), the sample size is insufficient to demonstrate clear trends in catch and effort among survey years for the remaining strata.

The mean catch rates derived from the line fishing stations for the outer strata are much higher and more variable than the 1997–98 diary survey catch rate data (Bell 2001). Although the sample size of this recreational diary survey is large (n = 849), not all fishing may have been located over blue cod habitat. In contrast, the line fishing stations were all located over blue cod habitat of hard rock or cobble bottom, as determined by colour depth sounder (Blackwell 1997a, 1998).

Previous potting/line fishing surveys (Blackwell 1997a, 1998) suggested that the relative abundance of blue cod was inversely proportional to the level of access to recreational fishers. The patterns of recreational catch from the 1997–98 diary survey confirm these trends.

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Table A1: Blue cod recreational catch and effort data from the 1997–98 Marlborough Sounds Recreational Diary Survey (after Bell 2001), summarised by sampling strata approximated to the survey strata used in the 1995–2001 blue cod pot fishing surveys

** sampling stratum defined by Bell (2001)*

Survey stratum	Zone *	No. trips	Percent trips targeting BCO in zone	No. trips targeting BCO in zone	Percent effort by zone	Overall total no. hrs by rod or handline	Total no. of blue cod taken	Catch per trip targeted
IQCH	32	24	62.5	15		32	17	1.13
	33	50	46.0	23		65	52	2.26
	Total	74	51.4	38	4.5	97	69	1.82
OQCH	17	49	53.1	26		82	52	2.00
	34	171	78.9	135		324	465	3.45
	35	14	92.9	13		29	47	3.61
	16	39	97.4	38		83	121	3.19
	Total	273	77.6	212	25.0	518	685	3.23
EQCH	15	71	64.8	46		119	117	2.54
	6	82	59.8	49		136	200	4.08
	5	31	71.0	22		59	89	4.04
	14	29	55.2	16		64	65	4.06
	Total	213	62.5	133	15.7	378	471	3.54
IPEL	28	54	38.9	21		105	79	3.76
	Total	54	38.9	21	2.5	105	79	3.76
MPEL	23	48	66.7	32		127	97	3.03
	20	11	72.7	8		9	0	0.00
	27	76	65.8	50		136	112	2.24
	19	27	55.6	15		54	19	1.27
	Total	162	64.8	105	12.4	326	228	2.17
OPEL	22	102	60.8	62		217	314	5.06
	24	19	68.6	13		25	41	3.15
	Total	121	62.0	75	8.8	242	355	4.73
EOPE	13	98	61.2	60		205	299	4.99
	26	36	52.8	19		74	85	4.47
	Total	134	58.9	79	9.3	279	384	4.86
DURV	12	186	75.8	141		462	770	5.46
	21	60	75.0	45		141	207	4.60
	Total	246	75.6	186	21.9	603	977	5.25
Area total		1277		849	100.0	2548	3248	3.70
Survey								
Targeted							4631	overall
Overall						3386	4866	

Table A2: Blue cod pot fishing survey. Catch (numbers of blue cod) per hour from line fishing stations, by stratum and survey year.

		Effort (no.)		Blue cod catch (no. fish/station)		Scaled catch (no./hr)	
Survey year	Survey stratum	stations	hours	total	recruited	Mean	C.I.
1995	IQCH	12	2.75	2	2	0.70	± 1.30
	OQCH	14	3.50	12	10	2.90	± 2.70
	EQCH	10	2.50	12	10	4.00	± 5.60
	OPEL	12	3.00	13	6	3.3	± 4.30
	EOPE	14	3.50	32	19	4.70	± 3.60
1996	IPEL	8	2.00	15	10	5.00	± 4.20
	MPEL	8	2.00	6	3	1.50	± 2.10
	OPEL	10	2.50	19	13	9.50	± 7.80
	EOPE	8	2.00	31	19	5.20	± 4.80
	DURV	8	2.00	64	41	20.50	± 19.10
2001	IQCH	8	2.00	0	0	0	0
	OQCH	14	3.50	19	4	1.1	± 1.0
	EQCH	10	2.50	23	13	5.80	± 5.0
	IPEL	8	2.00	1	1	0.50	± 1.0
	MPEL	10	2.50	10	5	2.0	± 2.70
	OPEL	12	3.00	21	5	5.20	± 3.40
	EOPE	10	2.50	24	13	1.70	± 2.10
	DURV	12	3.00	41	31	10.30	± 5.50

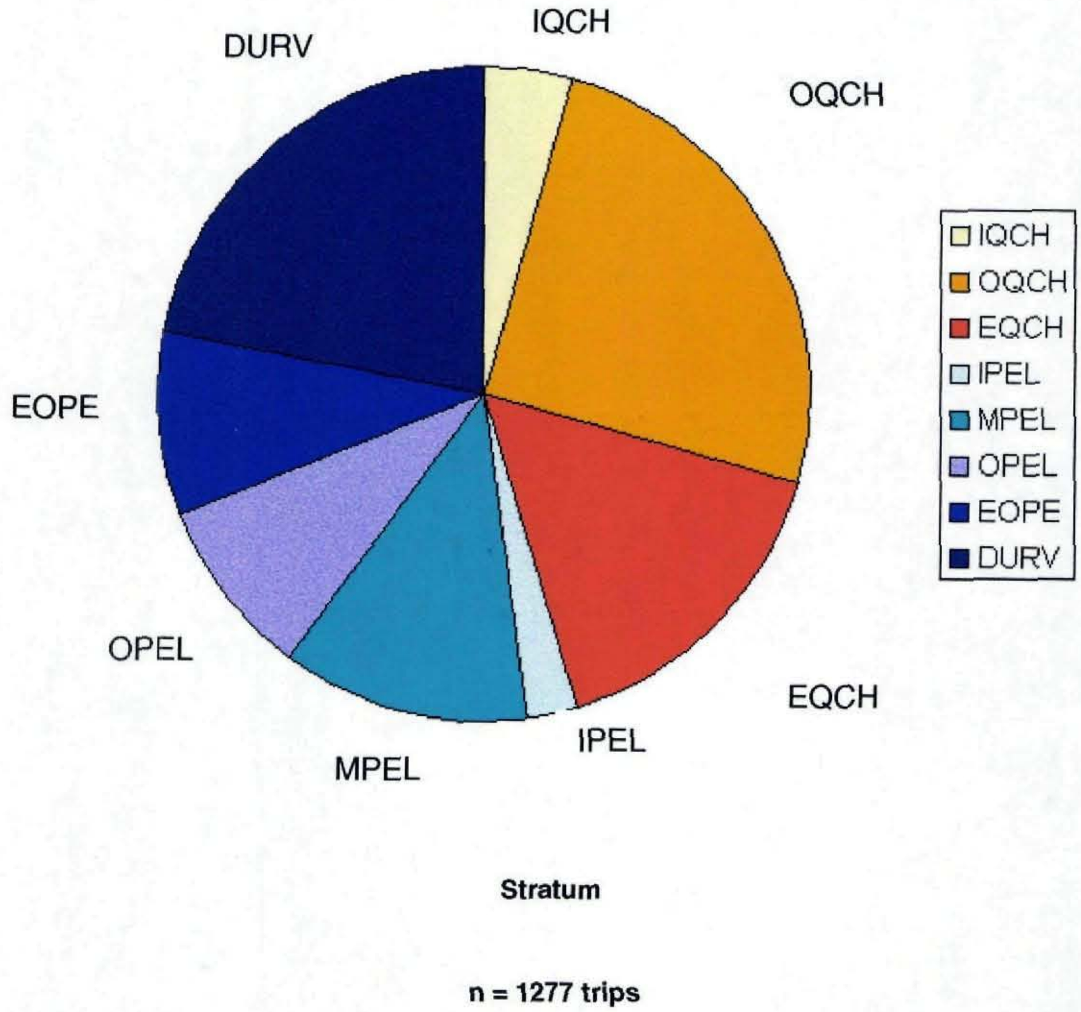

Figure A2: Percentage recreational fishing effort (number of hours targeting blue cod) from the 1997–98 Marlborough Sounds Recreational Fishing Diary Survey (after Bell 2001), by area approximated to the strata used in the 1995 –2001 research pot fishing surveys (strata defined in Figure 1).

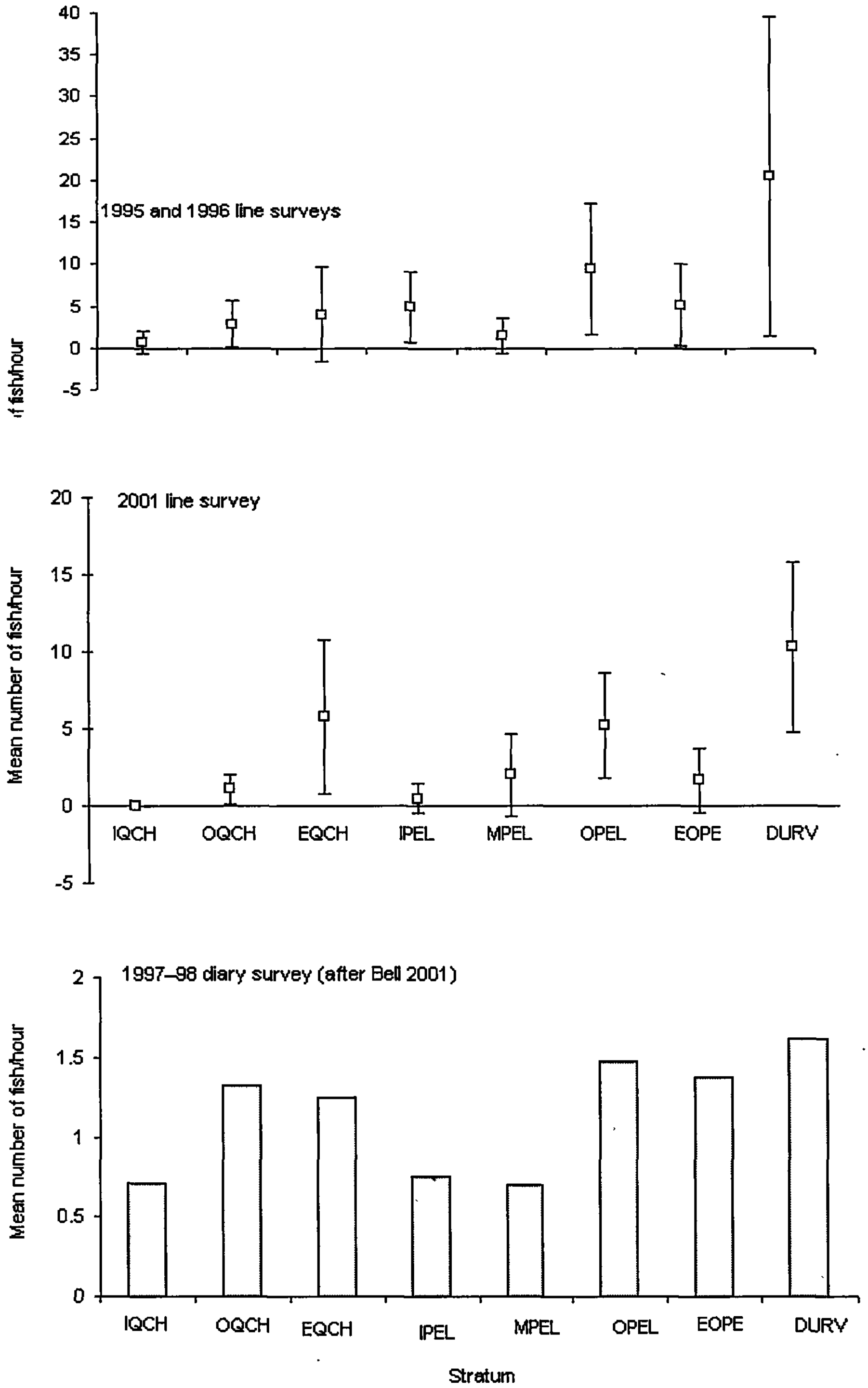

Figure A3: Blue cod catch (mean numbers of fish/hour) from line fishing stations by stratum and year, from the Marlborough Sounds during September 1995 (IQCH, OQCH EQCH), September 1996 (IPEL, MPEL, OPEL, EOPE, DURV), September 2001, all strata, (where error bars = 2* s.e). Data compared to mean catch (numbers of fish/hour) by approximated stratum from the 1997–98 Marlborough Sounds Recreational Fishing Survey (after Bell 2001).