Fish discards and non-target fish catch in the trawl fisheries for hoki, hake, and ling in New Zealand waters

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EXECUTIVE SUMMARY

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Non-target fish bycatch and discard levels in the target hoki, hake, and ling trawl fisheries from 2000–01 to 2006–07 were estimated using data from the Ministry of Fisheries Observer Programme and commercial fishing returns. Ratio estimators were calculated for scaling up observed discard and bycatch rates to the total fishery. Bootstrapping techniques were used to select the most appropriate ratio estimator and to provide confidence limits for annual bycatch and discard estimates. For hoki, hake, and ling target fisheries a ratio estimator based on number of tows had the smallest coefficient of variation (c.v.), so this estimator was used in all calculations.

Regression analyses were used to determine which factors had the most influence on bycatch and discard ratios and to select the most appropriate stratification for calculation of these values. For bycatch, the most influential factors were *hoki area*, and *duration*, although *tow type* (midwater or bottom trawl), *average depth*, *company*, and *headline height* were also important. For discards, *company*, *vessel tonnage*, *fishing month of year*, *duration*, and *hoki area* were the more influential variables. As *hoki area* featured strongly in bycatch models and some discard models, further stratification by *hoki area* was done.

Total bycatch in the hoki, hake, and ling fishery ranged from about 36 000 to 58 000 t per year (compared to the combined total landed catch of hoki, hake, and ling of 130 000 to 238 000 t). Bycatch ratios of commercial species were highest in Puysegur and lowest in Cook Strait. Bycatch ratios of non-commercial species were highest on the Chatham Rise and lowest for Cook Strait.

Total annual discard estimates ranged from about 5500 to 29 000 t per year with the main species being discarded including spiny dogfish, rattails, javelinfish, hoki, and shovelnose dogfish. Discard ratios of commercial species were highest in Cook Strait and Sub-Antarctic and discard ratios of non-commercial species were lowest in Cook Strait. Spiny dogfish was the main QMS species discarded. Discarded hoki, hake, and ling made up 9.7% of total observed discards. There was an average of 0.03 kg of observed species discarded per kilogram of observed hoki, hake, and ling caught.

The precision of the estimates of bycatch and discard levels was strongly linked to the coverage of the fishery by observers. Coverage in the hoki, hake, and ling trawl fishery was 11–21% of the annual target fishery catch. This was considered sufficient to be representative of the overall fishery, although coverage was variable by area, month, and year, meaning estimates in some strata were highly uncertain. The hoki, hake, and ling fishery is very complex, with many confounding factors. Changes in fishing practice in particular are likely to have contributed to variability in annual levels of bycatch and discards. For example, non-commercial species such as javelinfish and rattails which were previously discarded are now mealed. There is potential for future analyses to further explore trends by subareas, species, species groups, or trophic level. We also recommend doing a complete analysis on all data (back to 1990–91) rather than an update of a few years (as required for this project), so methods and assumptions are similar through time.

1. INTRODUCTION

Non-target catch (often referred to as 'bycatch') is common to almost every commercial fishery. Marketable species are typically retained for sale, with species for which there is no market, or which cannot economically be brought to market, discarded, i.e., thrown back into the sea. Bycatch and discarding in commercial fisheries have become an important issue in fisheries management in recent years, and are increasingly being incorporated into the stock assessment process. The emphasis was, in the past, on shrimp trawl and drift-net fisheries, but the focus has now shifted more on to bottom trawl fisheries which, as well as having the potential to catch a variety of unwanted species, are also seen as being destructive to the benthic environment. There is an extensive literature, which was summarised by Alverson et al. (1994), and a number of scientific workshops in the 1990s which focussed on bycatch and discard issues, e.g., the Technical Consultation on Reduction of Wastage in Fisheries in Japan (Clucas & James 1996). Discarding of low value fish species is a global problem, with an estimated 7.3 million tonnes of dead or dying fish returned to the sea annually (Kelleher 2004). This is considerably less than in the late 1980s and early 1990s when it was estimated that 20–22 million tonnes were discarded annually (Clucas & James 1996); the change is due mostly to higher retention rates, improved fishing methods, and better fishery management.

In New Zealand, the Ministry of Fisheries has the responsibility for determining impacts of fishing on both target species that are discarded and non-target species taken during normal fishing operations. This obligation includes the principle that the abundance of these species should be maintained above a level that ensures their long-term viability. Information on the level of non-target fish catch and discards in commercial fisheries is useful for fisheries management. Successful stock assessment requires good data on the true catch and mortality of fish species, both target and non-target, and commercial and non-commercial species. As well as contributing to an improved understanding of fish communities, these data can help to assess the impact of fishing on the long-term sustainability of exploited ecosystems.

1.1 Hoki, hake, and ling fisheries

The hoki fishery has historically been New Zealand's largest and most valuable, with total reported catches of between 101 000 t and 136 000 t per year for the fishing years 2003–04 to 2006–07 (Ballara et al. 2008a). The hake and ling trawl fisheries are considerably smaller, but together account for 25 000 t to 30 000 t of landed fish per year over recent years. Total reported catches in 2006–07 were 101 000 t of hoki, 10 592 t of hake, and 16 102 t of ling (Ministry of Fisheries 2008). Trawl fisheries for hoki, hake, and ling operate in similar areas (see below) and with similar gear types, so in this report target fisheries for these three species are combined. Since 1990 there have been between 18 000 and 40 000 trawls targeting hoki are carried out within the New Zealand EEZ each year In addition there are 3000–7000 trawls targeting hake and 1000–7000 trawls targeting ling annually.

Hoki are widely distributed throughout the New Zealand Exclusive Economic Zone (EEZ), mainly between 200 and 800 m (Ministry of Fisheries 2008), However, the commercial fisheries operate in four main areas: two spawning fisheries, which are centred on the west coast of the South Island (WCSI) and in Cook Strait during the winter months (July–early September); and two non-spawning fisheries, on the Chatham Rise and on the Sub-Antarctic during the remainder of the year when hoki are in their dispersed phase (Ballara et al. 2008a). Smaller spawning fisheries occur in Puysegur and off the east coast of the South Island (Ballara et al. 2008a) catching a small proportion of the total catch. The hoki fishery operates throughout the year using a mixture of head-and-gut vessels, fillet vessels, and whole fish ice vessels. Some vessels also have meal plants. Changes in processing type and presence or absence of a meal plant are likely to have contributed to variability in annual levels of bycatch and discards. Twin-trawl rigs were introduced in about 2000 and their use has been increasing, particularly in the non-spawning fisheries, but also on the WCSI outside the 25 n. mile line. There are also management controls that may contribute to variability in bycatch and discards. These include restrictions prohibiting vessels longer than 46 m fishing within 25 n. miles of the coast, agreed catch splits between eastern and western stocks, and an industry Code of Practice for hoki target trawling, introduced in 2001 with the aim of protecting small fish (less than 60 cm). The main components of

this Code of Practice are: 1) a restriction on fishing in waters shallower than 450 m; 2) a rule requiring vessels to 'move on' if there are more than 10% hoki under 60 cm in the catch. More recently, the Code of Practice has been extended to include seasonal and area closures in spawning fisheries.

Hake are widely distributed throughout the middle depths of the New Zealand EEZ, mostly south of 40° S. The main fisheries are on the WCSI, the Chatham Rise, and the Sub-Antarctic, where hake are taken by large trawlers, often as bycatch in hoki target fisheries, although target fisheries exist in each of these areas (Horn & Dunn 2007). The largest hake fishery has been off the WCSI. This fishery has undergone a number of changes in TACCs, and in fishing practices such as gear used, tow duration, and strategies to limit hake bycatch in the hoki target fishery (Horn & Dunn 2007). In some years, there has been a hake target fishery on the WCSI in September after the peak of the hoki fishery, and bycatch levels of hake early in the fishing season in some years have been relatively high. In the Sub-Antarctic and or the Chatham Rise, hake have been caught mainly as bycatch by trawlers targeting hoki, although some targeting for hake occurs, particularly in Statistical Area 404 in HAK 4, which is a known spawning area for hake northwest of the Chatham Islands (Horn & Dunn 2007).

Ling are also widely distributed throughout the middle depths of the New Zealand EEZ, mostly south of 40° S, and are also fished mainly on the WCSI, the Chatham Rise, and the Sub-Antarctic, with up to a third of the landings taken by bottom longliners, which target this species (Horn 2007). Ling are mainly caught by large trawlers at Puysegur Bank, the slope of the Stewart-Snares shelf, and in the Auckland Islands area. There are at least five ling stocks: WCSI, Chatham Rise, Cook Strait, Bounty Plateau, and the Southern Plateau (including the Stewart-Snares Shelf, and Puysegur Bank) (Horn 2005). Time of spawning varies between areas: July to November on the Chatham Rise; September to December on Campbell Plateau and Puysegur Bank; September to February on the Bounty Plateau; July to September off west coast South Island and in Cook Strait. Ling appear to be mainly bottom dwellers (Horn 2005), although they may at times be caught well above the bottom, for example when feeding on hoki during the hoki spawning season.

1.2 This project

In this project, the level of catch of non-target species and discards in the hoki, hake, and ling trawl fisheries is estimated. The work undertaken here follows on from previous studies to estimate the level of bycatch and discards in the hoki fishery from 1999–2000 to 2002–03 (Anderson & Smith 2005) and from 1990–91 to 1998–99 (Anderson et al. 2001). These reports estimated that total annual bycatch in the hoki trawl fishery fluctuated during the 1990–91 to 2002–03 period, ranging from 15 000 to 60 000 t. Estimates of total annual discards ranged from 6000 to 18 000 t for the 1990–91 to 2002–03 period. The main factors influencing bycatch and discards appeared to be area and time of year, with vessel processing type (ice-boats, factory trawlers, vessels with meal plants) also influencing discards of commercial species, and fishing method (midwater and bottom trawl) also influencing discards of non-commercial species (Anderson & Smith 2005). The main bycatch species in the target hoki fishery were ling and hake, but silver warehou, javelinfish, rattails, and spiny dogfish were also frequently caught (Anderson & Smith 2005). The main discard species identified were rattails, including javelinfish, and spiny dogfish. The overall discard level equated to about 0.06 kg discarded for every 1 kg of hoki landed for the whole period, one of the lowest levels of the major New Zealand offshore trawl fisheries.

This project complements other studies investigating bycatch and discards in New Zealand fisheries, including trawl fisheries for orange roughy, oreos, jack mackerel, southern blue whiting, scampi, squid, and the ling longline fishery (Anderson et al. 2000, Anderson 2004a, 2004b, Clark et al. 2000, Clark & Anderson, 2001, Anderson 2009, Ballara & Anderson 2009). This is the first time that bycatch in the hake and ling fisheries has been assessed alongside bycatch in the hoki fishery.

This report was prepared as an output from the Ministry of Fisheries project ENV2008/01
"*To estimate the level of non-target fish catch and discards of target and non-target fish species in selected New Zealand fisheries*".

The specific objective of this project requires
"*Estimates of the catch of non-target fish species, and the discards of target and non-target fish species in the hoki (*Macruronus novaezelandiae*), hake (*Merluccius australis*), and ling (*Genypterus blacodes*) trawl fisheries for the fishing years 2003–04 to 2006–07 using data from Scientific Observers and commercial fishing returns*".

The intention for this analysis was to treat target hoki, hake, or ling tows as a single fishery with three target species, rather than treating each fishery (based on the declared target species) separately. This is similar to the approach taken previously in analyses of the jack mackerel (three species) and arrow squid (two species) fisheries (Anderson 2004a).

Ministry of Fisheries observers have been collecting bycatch and discard information from the hoki fishery since the early 1990s. In most years, observers cover between 7 and 17% of the fishery (by hoki catch), and 2 to 7% of hoki tows (Ballara et al. 2008b). Observers record the catch and discards from each trawl or group of trawls, as well as details of the fishing gear used, location and depth, and various other incidental information. Fishers record catch and effort from all commercial fishing with details of fishing activity, including total catch and target species catch (per tow or per day), recorded on Trawl, Catch, Effort, and Processing Returns (TCEPR) and Catch, Effort and Landing Returns (CELR).

This study calculates bycatch and discards for the hoki, hake, and ling fishery by scaling up estimates determined from the fraction observed, using effort data collected by the fishing industry. The process is fine-tuned by stratification, and precision estimated using bootstrap procedures which take into account vessel to vessel differences and variability in the total amount of fishing effort per trip. Although not an objective in this project, an examination of the influence of various factors on the levels of bycatch and discards was made as part of the stratification.

2. METHODS

2.1 Definition of terms

For this study *non-target fish species catch* is equivalent to *bycatch*, defined as "all fish caught that were not the stated target species for that tow, whether or not they were discarded" (McCaughran 1992). *Discarded catch* (or *discards*) is defined as "all the fish, both target and non-target species, which are returned to the sea whole as a result of economic, legal, or personal considerations" (McCaughran 1992). *Discarded catch* in this report includes estimates of any fish lost from the net at the surface. Estimates of *non-target catch*, if required, can be obtained from this report by adding target species *discards* to total *bycatch*.

2.2 Commercial fishing return data

Catch records from commercial fishing returns were obtained from Ministry of Fisheries databases for the hoki, hake, and ling fishery from 2000–01 to 2006–07. TCEPR, CELR, and Catch Landing Returns (CLR) and CELR landings data were examined to determine the appropriate dataset to analyse. All data were extracted from any trip in which hoki, hake or ling were targeted or caught. Vessels in this fishery generally recorded catch (including bycatch) and effort on TCEPR, i.e., tow-by-tow data, or CELR, i.e., daily summary forms. These forms record only the top five species by weight, and non-commercial species are often not recorded, and hence data are incomplete for direct estimation of bycatch or discards. Data were groomed for errors, using checking and imputation algorithms developed by Dunn & Livingston (2004). Records were assigned to the hoki, hake, and ling areas defined in Figure 1: hoki areas, WCSI, CHAT (Chatham Rise), SUBA (Sub-Antarctic), CSTR (Cook Strait), PUYS (Puysegur Bank); hake areas, WCSI, CHAT (Chatham Rise, and part of ECNI), and SUBA (Sub-Antarctic and Puysegur Bank); ling areas WCSI, CHAT (Chatham Rise), SUBA (Stewart-Snares Shelf, and Puysegur Bank), CSTR (Cook Strait), BOUNTY (Bounty Plateau). Areas outside defined by boxes in Figure 1 were combined into a single NULL area category.

The species with the largest catch in each tow was determined and defined as the main catch species. If the total catch was zero, target species, as stated on the relevant form, was assumed to be the main catch species. If there was more than one species with maximum catch: the target species was assumed to be the main catch if it was one of the species with maximal catch; if neither of the species with maximal catch was the main target, the main catch was defined as multiple species, e.g., HOK.HAK, HOK.SPD.

Summaries of hoki, hake, and ling catch and effort were made, with stratification determined by analysis of the observer data, in order to scale up estimates of bycatch and discards from the observed part of the fishery to the entire target fishery. Comparison of total catch with the catch of hoki, hake, and ling was made with these data, and used to provide an independent estimate of total annual bycatch.

2.3 Observer data

Observer records of catch and discards for the combined hoki, hake, and ling fishery were extracted from the Ministry of Fisheries database '*obs*' for the fishing years being examined. Records were extracted for all tows from a trip where hoki, hake, or ling were caught.

Two datasets were prepared from observer data, one the bycatch data (tow-by-tow data), and the other the discard data (processing group data). Data were groomed for errors, as for the commercial data. Individual vessel data (gross registered tonnage (GRT), overall length (m), and company) were obtained from a combination of sources due to incomplete records in any single source; the *obs* database, observer trip reports, and TCEPR catch-effort data for matching vessels. Observer data were available by vessel and company but no vessel or company is identified in this report, and alphanumeric codes are presented where necessary.

Each bycatch record was assigned to a *fishing year* (1 October to 30 September) and to three *area* variables based on known stock divisions of hoki, hake or ling (Figure 1) (Horn 2007, Horn & Dunn 2007, Ballara et al. 2008a).

Each record was also assigned to a processing type (*process capacity*): FR, fresher/ice boat; PR, processing/factory vessel (no meal plant); MP, processing/factory vessel with meal plant.

Three *season* variables were assigned to each record, based on the main fishing season for each target species. The high season for hoki was defined as June–September, the hoki spawning season (Ballara et al. 2008a). The high season for ling was also defined as June–September as the ling trawl fishery is mainly bycatch of hoki (Horn 2007). The high season for hake was more complicated with the high season defined as October–February on the Chatham Rise, September–January for the Sub-Antarctic, and July–September for WCSI (Horn & Dunn 2007).

Fishing method was assigned to a tow as "mid" if a midwater trawl was used, the net was off the bottom throughout the tow, and the headline height was greater than 20 m, and to "bottom" if a bottom trawl was used, the net was on the bottom throughout the tow, and the headline height was less than 20 m. Tows which met neither criteria were set to "NULL".

When fish were lost from the net before it was brought aboard, observers estimated the amount lost by recording *total greenweight on surface* and *total greenweight on board*. These losses were from a mixture of burst codends, burst windows/escape panels, and rips in the belly of the net, either below the sea surface, at the surface, or on the stern ramp of the vessel. Obvious errors in these values were corrected, for example, where the recorded value for *total greenweight on board* was greater than *total greenweight on surface* the weight of fish lost was set to zero unless an obvious error could be corrected by comparing greenweight totals from species by species tallies with the two total greenweight figures. Differences in the recorded values for *total greenweight on surface*, and *total greenweight on board* were accepted as valid fish losses only if they were accompanied by a code

identifying the cause of the loss. After these corrections, real cases of observed fish losses were very few (58 records out of 18 795 tows) (see Section 3.6.1).

For the discard data, the weights of each species retained and discarded were extracted by processing group (the level at which observers record discard information). Although often represented by a single tow, the discards from two or more trawls can also be combined into one processing group. This grouping of processing data results from the difficulty of keeping track of the catch from individual trawls in the factory of a vessel. In order to examine how discard levels varied with fishing depth, area, season, etc., it was necessary to summarise these data over all trawls within each processing group. Hence the catch and discards of each species, and trawl durations, were summed within each processing group. Some variables, such as fishing year, processing type, vessel, and company were always constant between trawls within a processing group, but frequently trawls in a group went over two months or two areas, and a range of trawl depths and headline heights. Therefore depth of trawl was assigned to each processing group as a categorical variable. Depth of each trawl was taken as the average of the depth of the groundline at the start and end of the trawl, and was defined as "shallow" if it was less than 200 m, "mid" if it was between 200 and 800 m, and "deep" if it was greater than 800 m. Processing group depths were assigned "shallow", "mid" or "deep" if all tows in the process group fell within these categories, and those with a mixture of tow depths were set to "NULL". If the processing group had a mixture of fishing methods, fishing method was set to "NULL". If a set of tows belonging to a processing group had target species other than only HOK, HAK, or LIN, target species "MIX" was assigned, and hence 241 processing groups with "MIX" were removed from the dataset.

From the datasets the weights of fish caught and fish discarded were calculated for the following species categories.

- The *target* species (hake and ling, for bycatch using target hoki dataset; hoki, hake, and ling, for discards)

- Selected individual species

- Commercial species (*Commercial*)
  Commercial species were defined as those which represented 0.1% or more of the total observed catch and either were quota species or 75% or more of the catch was retained. They comprised the following 13 species/species groups: silver warehou (*Seriolella punctata*), frostfish (*Lepidopus caudatus*), pale ghost shark (*Hydrolagus bemisi*), ribaldo (*Mora moro*), sea perch (*Helicolenus* spp.), barracouta (*Thyrsites atun*), white warehou (*Seriolella caerulea*), lookdown dory (*Cyttus traversi*), arrow squid (*Nototodarus* spp.), oreos, stargazer (*Kathetostoma giganteum*), gemfish (*Rexea solandri*), and spiny dogfish (*Squalus acanthias*).

- Non-commercial species (*Non-commercial*)
  The non-commercial category included all other species not in the commercial category, although excluding hoki, hake, and ling

- QMS species combined (*QMS*)
  QMS species were defined as all species managed under the New Zealand's Quota Management System (QMS) before 1 April 2008, 96 species, except hoki, hake, and ling.

- All non-QMS species combined (*non-QMS*)
  Non-QMS species included all other species not in the QMS category, again excluding hoki, hake, and ling.

- Deepwater sharks
  The deepwater shark category included the species codes SND (shovelnose dogfish, *Deania calcea*), BSH (seal shark, *Dalatias licha*), ETL (lucifer dogfish, *Etmopterus lucifer*), ETB (Baxter's dogfish, *Etmopterus baxeri*), ETM (*Etmopterus* spp.), APR (catsharks, *Apristurus* spp.), CYP (longnose velvet dogfish, *Centroscymnus crepidater*), CYL (Portuguese dogfish,

Centroscymnus coelepis), CSQ (leafscale gulper shark, *Centrophorus squamosus*), CYO (Owston's dogfish, *Centroscymnus owstoni*), PLS (Plunket's shark, *Centroscymnus plunketi*), PDG (prickly dogfish, *Oxynotus bruniensis*), OSD (other sharks and dogs), SQA (*Squalus* spp.), DWD (deepwater dogfish), SHA (shark), and DOG (dogfish).

- Other sharks
  The other-shark category included the species codes BSK (basking shark, *Cetorhinus maximus*), POS (porbeagle shark, *Lamna nasus*), SSH (slender smooth hound, *Gollum attenuatus*), THR (thresher shark, *Alopias vulpinus*), MAK (mako shark, *Isurus oxyrinchus*), SEV (broadnose sevengill shark, *Notorhynchus cepedianus*), and SRI (knifetooth dogfish, *Scymnodon ringens*).

- Skates
  The skates category included the species codes SSK (smooth skate, *Dipturus innominatus*), RSK (rough skate, *Dipturus nasutus*), and SKA (skate families Rajidae and Arhynchobatidae).

- Spiny dogfish
  The spiny dogfish category included both the spiny dogfish (*Squalus acanthias*) and northern spiny dogfish (*Squalus mitsukuii*) as there is some misidentification and misreporting especially in FMAs 1, 8, and 9 (Ministry of Fisheries, 2008).

The headings above are used throughout the remainder of this report to refer to these species categories. Summaries by species of the overall observed catch and percentage discarded are tabulated for each fishery in Appendix 1 for the hoki areas. Hake and ling bycatch in the hoki fishery were calculated for only target hoki tows.

A total of 18 795 tows and 13 161 processing groups targeting hoki, hake, or ling was used in the analysis, 70% and 52% of total data respectively. For the 2006–07 data, 819 process groups were not used in the analysis as data were not available.

2.4 Examination of factors influencing bycatch and discards

A number of regression analyses investigated stratification of bycatch and discard data. A large number of variables were available for each observed tow, but only a few were useful for stratifying commercial data, as only a few variables are applicable to the CELR data. Each species grouping was examined separately in each fishery and one or two regressions were run on each group: (1) a linear regression for tows/processing groups recording a positive catch/discard of the species in the group; (2) a binomial regression on the presence/absence of catch/discards of the species in the group. An offset of the log of the target species catch was used. The binomial regression uses a response variable which is a binomial vector of discards in two categories. For each record this variable was assigned "1" if bycatch/discard was recorded and "0" otherwise. These two regressions enabled an examination of factors influencing both the probability and the level of a bycatch/discard.

Table 1 shows the response variables used, with the response variable or the linear regressions determined from the outcome of a selection process as described by Anderson (2004), and a log transformation was made to provide an approximately normal distribution. The log transformation was found to be the most appropriate in each case, after examination of histograms and normal probability plots of untransformed and transformed data. Because tows were combined within processing groups for discards analysis, the influence of variables such as *headline height* and *vessel speed* could not be tested. *Fishing year* was defined as the year variable in the model as hoki has its spawning season from July to September, and it was not possible to consistently define a year in either of the hake or ling fisheries as spawning timing varied between areas for these species.

Variables were added to the model until the model stopped at 0.5% improvement, and only one of *vessel*, *vessel length,* and *vessel tonnage* was allowed into the model. Each of the variables selected as significant by the model process was examined closely using model predictions. The intention was to use variables with a strong influence to make sensible predictions to stratify bycatch and discard data.

A detailed examination of the influence of the main factors identified is beyond the scope of this project, and there is no intention of trying to predict bycatch and discard rates from these regressions, so summaries were made only of the order of variable selection in each model. Variables used to stratify bycatch and discard data were determined from these summaries.

Hoki area was generally the most influential factor, so it was decided to further stratify hoki areas (Chatham Rise, Sub-Antarctic, and WCSI as these areas had a lot of data), using tree regression to further explain trends in bycatch and discards. The regression tree method (Breiman et al. 1984) was used to stratify the three fishing areas by minimising the weighted least squares of the log of the species group weight in each tow. Variables used in the tree regression included *tow type* (midwater or bottom trawls), *fday* (day of fishing year) and *latitude* and *longitude* at start of tow, as these were variables that could be applied to the TCEPR, CELR and observer data in stratification. For the CELR data latitude and longitude were calculated as the midpoint of the statistical area.

Separate estimates of ratios for an area stratum were made where there were at least 2 vessels and 50 records available in the stratum. Where there was not enough data to create a stratum, i.e., if there were not at least 2 vessels and 50 records in a stratum this was defined as a "null" stratum. Null strata bycatch or discard ratios were calculated for an area if the area variable was more influential in the models than fishing year, otherwise ratios were calculated for that fishing-year.

2.5 Calculation of discard and bycatch ratios

The methods to calculate discards and bycatch were similar to those used in the previous analysis (Anderson & Smith 2005) where bycatch and discard ratios derived from the observed portion of the hoki fishery were used to make estimates for the entire target fishery. This analysis treated hoki, hake, and ling as a single fishery with three target species, rather than treating each fishery (based on the declared target species) separately. The multi-level bootstrapping methods developed by Anderson & Smith (2005) were applied which take into account the effect of correlation between trawls in the same trip and fishery stratum to provide more appropriate confidence limits for the estimates. Three alternative forms of the ratio estimator were considered: one based on the target catch (catch of hoki, hake, and ling in each trawl), one on the number of hoki, hake, and ling tows, and the third based on trawl duration.

2.5.1 Discard ratios

Discarded catch, the total catch of hoki, hake, and ling, total number of tows, and the total trawl duration were summed within each stratum and species category. This provided three estimators for the "Discard ratio" $\hat{DR}$, with the following form:

$$\hat{DR}_1 = \frac{\sum_{i=1}^{m} d_i}{\sum_{i=1}^{m} l_i}, \quad \hat{DR}_2 = \frac{\sum_{i=1}^{m} d_i}{m}, \quad \text{and} \quad \hat{DR}_b = \frac{\sum_{i=1}^{m} d_i}{\sum_{i=1}^{m} t_i}$$

where m processing groups were sampled from a stratum, d_i is the weight of discarded catch from the i^{th} processing group sampled, l_i is the weight of hoki, hake, and ling caught in the i^{th} processing group sampled, and t_i is the total trawl duration for the processing group i. It was assumed that all trips are sampled with equal probability, that all trawls in the trip are observed, and that vessel behaviour is unaffected by the presence of an observer. Estimates of the discard ratios, $\hat{DR}_1$, $\hat{DR}_2$ and $\hat{DR}_3$ for selected strata were produced to determine which was the best of the three estimators. Bootstrap procedures were used to derive the variance of the estimates of each ratio which involved sampling at random (with replacement) 1000 sets of pairs of ratio values from each stratum. Each of the sets was

the same length as the number of records in each stratum. This resulted in 500 or 1000 estimates of each ratio from which, providing they were approximately normally distributed, variances and confidence intervals were calculated. Variances of these estimates were compared, with the estimator with the lowest variance overall used for all subsequent calculations.

Once the best estimator was chosen, estimates of $\hat{DR}$ were derived for each stratum in each fishing year, where possible. Variances were derived by a more sophisticated bootstrapping procedure that allowed for correlation of discards between sample units, in this case processing groups, within an observed trip. Separate ratios were calculated only for strata with 50 records or more. Overall ratios (e.g., for all years within an area) were substituted for strata with fewer than 50 records. The discard ratio calculated for each stratum was then multiplied by either the number of hoki, hake, and ling tows, total estimated catch of hoki, hake, and ling, or the total tow duration in the stratum (depending on the version of the estimator chosen), from commercial catch records, to estimate total discards $\hat{D}$:

$$\hat{D} = \hat{DR}_1 \times \hat{L} \ , \ \hat{D} = \hat{DR}_2 \times \hat{M} \text{ or } \hat{D} = \hat{DR}_2 \times \hat{T}$$

where $\hat{L}$ is the total catch of hoki, hake, and ling, $\hat{M}$ the total number of tows, and $\hat{T}$ the total trawl duration, in the stratum. From this, annual estimates of discarded catch for the hoki, hake, and ling fishery, with confidence intervals, were completed by summing the discarded catch in each stratum.

To obtain a 95% confidence interval for the total discards that allows for correlation between sampling units within a trip, 1000 bootstrap samples were generated from the sampling units within each stratum using a three-step sequential sampling procedure. First a trip was chosen at random, then a bootstrap sample of the processing groups that were from that trip in the stratum. These steps were repeated until the effective number of discard groups was approximately equal to the effective number of observed discard groups for the stratum. At step 3 the effective number of trips in the bootstrap sample was calculated. If this was within 5% of the effective number of observed trips in the stratum then the bootstrap sample was accepted. Otherwise a new bootstrap sample was drawn until 1000 samples in all had been accepted. The effective number of discard groups and the effective number of trips was calculated from the effort (either number of tows, catch or duration) and reflected the contributions to the variance of the discard rate ($\hat{DR}$)from the variance of the discards and the covariance between pairs of discards within the same trip and stratum. Matching a bootstrap sample to the stratum on these criteria ensured that the variation in the bootstrap sample estimate matched the sampling variation of $\hat{D}$. An empirical distribution for the total discards was obtained by totalling the bootstrap estimates across the strata, and the 95% confidence interval was obtained from the 2.5% and 97.5% quantiles. Bootstrapping was carried out using the statistical software package R (Ihaka & Gentleman 1996).

2.5.2 Bycatch ratios

Bycatch estimates were calculated in a similar manner to discards but, because catch estimates are not pooled across tows, it was possible to use tow-by-tow data and so there was a slightly larger set of records for comparing estimators and calculating ratios. Bycatch ratios were calculated for each stratum, and for each of the species categories. Bycatch, the total catch of the target species, the total number of tows, and the total trawl duration were summed within each stratum and species category which provided three alternative estimators for the "Bycatch ratio" $\hat{BR}$, with the following forms:

$$\hat{BR}_1 = \frac{\sum_{i=1}^{m} n_i}{\sum_{i=1}^{m} l_i} \ , \quad \hat{BR}_2 = \frac{\sum_{i=1}^{m} n_i}{m} , \text{ and } \quad \hat{BR}_3 = \frac{\sum_{i=1}^{m} n_i}{\sum_{i=1}^{m} t_i}$$

where m trawls are sampled from a stratum, n_i is the weight of the non-target catch from the i^{th} trawl sampled, l_i is the weight of hoki, hake, and ling caught in the i^{th} trawl sampled, and t_i is the trawl duration for trawl i. As for discards, estimates of the bycatch ratios, $\hat{BR}_1$, $\hat{BR}_2$ and $\hat{BR}_3$ for selected strata were produced, to determine which was the better of the three alternative estimators as for discards. The bycatch ratio calculated for each stratum was then multiplied by the total trawl duration, the total number of tows, or the total estimated catch of hoki, hake, and ling in the stratum from TCEPR and CELR records to estimate annual total bycatch $\hat{B}$:

$$\hat{B} = \hat{BR}_1 \times \hat{L} \quad \text{or} \quad \hat{B} = \hat{BR}_2 \times \hat{M} \quad \text{or} \quad \hat{B} = \hat{BR}_3 \times \hat{T}$$

where $\hat{L}$ is the total catch of hoki, hake, and ling in the stratum, $\hat{M}$ is the total number of tows in the stratum, and $\hat{T}$ is the total trawl duration in the stratum. From this, annual estimates of the bycatch of each species category, with confidence intervals, were calculated by summing the bycatch in each stratum.

The bycatch of ling and hake was calculated in a similar manner but using only the dataset where hoki was the declared target species.

3. RESULTS

3.1 Commercial data

TCEPR and CELR data were extracted for the whole trip, where any individual tow on the trip targeted or caught hoki, hake, or ling. Overall, this extract of TCEPR and CELR data represented 87–91% of the total hoki, hake, and ling landings (Appendix 2). Most of the hoki, hake, and ling catch recorded on TCEPR was from tows targeting hoki, hake, or ling (Appendix 3). In most cases the target species had the largest catch. Therefore we decided it was appropriate to assess the bycatch and discards of the combined hoki, hake, and ling fishery based on tows targeting these three species (Table 2). Bycatch and discards associated with hoki, hake, and ling caught while trawling for other species are likely to contribute to only a small fraction of the total bycatch and discards in the combined (hoki, hake, and ling) trawl fishery.

Most hoki catch comes from the hoki target fishery (Appendix 3), so this is also an appropriate dataset to do a bycatch and discard analysis on. Although not strictly part of this project, bycatch of hake and ling from the hoki fishery were calculated using this dataset. Conversely, it was not possible to consistently define either a hake or ling dataset in order to assess the bycatch from these fisheries independently of the hoki fishery. Hake catches are mainly from target hoki and hake tows in the WCSI, Chatham Rise and ECSI, and Sub-Antarctic (Appendix 3, see Figure 1). Overall, the proportion of the hake catch taken in hoki target tows has decreased and the proportion taken in hake target tows has increased from 2004–05. Hake are mainly targeted on the WCSI, the north Chatham Rise, the east coast South Island (ECSI), the southern slope of the Stewart-Snares shelf, and in a deeper area off the Stewart-Snares shelf (see Figure 1). Ling catches are mainly from target hoki tows in the WCSI, Chatham Rise and ECSI, and Cook Strait, and mainly from target hoki and ling tows in the Sub-Antarctic and Puysegur (see Figure 1, Appendix 3). Over the last few years in the Sub-Antarctic there has also been an increasing trend in ling catches from target ling tows and a corresponding decrease in ling catches from target hoki (Appendix 3). Ling are mainly targeted on the north of the Chatham Rise, on the slope of the Stewart-Snares shelf and in a deeper area off the Stewart-Snares shelf, in the Auckland Islands area, the Campbell Plateau, Puysegur Bank, and WCSI (see Figure 1).

The total target TCEPR fishery catch has decreased during the period of the study, from 230 698 t in 2000–01 to 105 179 t in 2006–07 (Table 2), reflecting the decrease in hoki TACCs and catches over this period.

3.2 Distribution and representativeness of observer data

The positions of all observed tows in the target hoki, hake, or ling fisheries from 2000–01 to 2006–07, with the TCEPR commercial tows from the same period and dataset definition, are shown in Figure 2. Observed hoki target tows covered most of the range where the commercial fleet targeted hoki. Observed hake target tows almost covered the range where the commercial fleet targeted hake on the north Chatham Rise, WCSI, and Stewart-Snares shelf, but did not cover tows targeting hake in deeper area off the Stewart-Snares shelf. There were very few observed ling target tows, and these were mainly on Puysegur Bank, on the Stewart-Snares shelf, and around the Auckland Islands.

Seventy-eight vessels were observed during the 7-year period, although 28–43 vessels were observed in any one year from 2000–01 to 2006–07 (Table 2). The annual number of observed tows decreased from 3580 in 2000–01 to 1999 in 2006–07, with the percentage of the fishery observed ranging from 11 to 21% during the period (Table 2). The percentage coverage for each year was above the nominal 10% considered sufficient to be representative of a fishery, although this is slightly misleading as coverage of hoki in the Sub-Antarctic is unrepresentative of the commercial fleet in some years (Ballara et al. 2006, 2008b), and coverage of Puysegur Bank and the Chatham Rise has been patchy in some years. Coverage of hake and ling tows has also been poor in some areas and years.

Observer coverage was spread over the geographical range of this fishery, with high sampling throughout WCSI and Chatham Rise fishing grounds, and in the Sub-Antarctic from 2000–01 to 2002–03 (Table 3, Figure 2), and lower levels of sampling in Cook Strait, Puysegur, and in some years on the Sub-Antarctic. This reflects the good hoki observer coverage in these areas, as hake and ling coverage has often been sparse. Observer coverage around the North Island was poor, although this area represents very little of the overall catch.

Examination of density plots (Figure 3a) showed that the observed tows were distributed throughout the spatial range of the fishery in each of the seven years. Longitudinally 168–172° E was well sampled each year reflecting sampling on the WCSI. By latitude the Chatham Rise was well sampled, but in some years the eastern side was under-sampled, and in other years the western side was under-sampled (Figure 3b). The Sub-Antarctic was under-sampled from 167–169° E in some years, 166–168° E in 2000–01, and south of 50° S in some years (Figure 3c).

The spread of observer effort over the range of vessel sizes was compared to the spread of vessel sizes over the entire target fishery using density plots (Figure 4). There was a very wide range of vessel sizes operating in this fishery, from 20 to 120 m overall length. Most vessel sizes were well covered by observers, but vessels over 80 m were over-sampled in all areas they fished and small vessels (under 50 m) were under-represented, except in Cook Strait.

The spread of observer effort over each fishing year was determined and compared to the spread of effort for the whole fishery, by applying a density function to numbers of trawls per day (Figure 5). These plots show a very similar pattern of effort from year to year, with good observer coverage during the hoki spawning season of July to early September. Coverage during the hoki non-spawning season was variable and under-representative in some months in some years. Coverage by date has been particularly patchy in the Sub-Antarctic, Chatham Rise, and Puysegur in some years (Ballara et al. 2006, 2008b).

3.3 Comparison of estimators

Using observer data, the target (hoki, hake, and ling) estimated catch-based, tow-based, and tow duration-based forms of the bycatch and discard ratio estimators were examined and compared with the aim of selecting and using the one which would provide ratios with the smallest amount of associated error. For each of the three forms in turn, ratios were calculated for the bycatch and discards in the commercial, non-commercial, QMS, non-QMS species, and silver warehou categories, without any stratification, and coefficients of variation (c.v.) estimated by bootstrapping.

All estimated c.v.s were low, ranging from 1.4 to 7.1% for bycatch estimators and 2.1 to 12.1% for discard estimators (Table 4). Differences in c.v.s between the three forms of the ratio estimator were also small, but the tow-based estimator provided a lower c.v. than the catch-based or tow-duration-based estimators in all cases but one (Table 4). Therefore we selected the tow-based estimator for all subsequent bycatch and discard calculations.

3.4 Observer bycatch data

3.4.1 Overview of raw bycatch data

Hoki, hake, and ling accounted for 87% (77%, 6%, and 4% respectively) of the total observed catch from trawls targeting hoki, hake, and ling between 1 October 2000 and 30 September 2007. The remaining 13% was made up of a large range of species, especially javelinfish (2.1%), silver warehou (1.7%), rattails (1.4%), and spiny dogfish (1.1%).

About 470 species or species groups were identified by observers, most of which were non-commercial species caught in low numbers. Dogfish and sharks, often unspecified but including spiny dogfish and basking shark, accounted for much of the non-commercial catch. Deepwater dogfish and sharks comprised 0.5%, and other sharks and skates both comprised 0.1% of the total observed catch. Echinoderms, squids, crustaceans, and other unidentified invertebrates were also well represented among the main bycatch species groups caught in this fishery (see Appendix 1 for a list of the top bycatch species in each area).

Exploratory plots of total bycatch per tow (plotted on a log scale) showed total bycatch was highly variable between trawls, ranging from 0 to 77 t (Figure 6). There was little trend in total bycatch by fishing-year. Bycatch increased with increasing tow duration, although with no trend with increasing bottom depth (Figure 6). Most tows were between 1 and 10 h long, but ranged from a few minutes to 12 h long, and most tows were between 200 and 800 m. There was lower median total bycatch in vessels for larger headline heights, which was related to the midwater tows (0.3 $t.tow^{-1}$) having lower median total bycatch than bottom tows (1.0 $t.tow^{-1}$).

There was high variability in bycatch among companies and vessels, with vessels ranging from 0.1 to 30 $t.tow^{-1}$. Median total bycatch was lower for the smaller and larger vessels. There was higher median total bycatch in vessels with higher fishing speeds, and ice boats (0.4 $t.tow^{-1}$) had lower median total bycatch than factory vessels (1.0 $t.tow^{-1}$) or factory vessels with a meal plant (0.7 $t.tow^{-1}$). Russian and Ukrainian vessels had lower median total bycatch (0.15 and 0.3 $t.tow^{-1}$) than other nations (0.5–1.0 $t.tow^{-1}$).

Median total bycatch varied between hoki areas with most hoki areas ranging 0.4 and 0.6 $t.tow^{-1}$, although Cook Strait had a lower bycatch level (median 0.15 $t.tow^{-1}$) and Chatham Rise much higher one (1.3 $t.tow^{-1}$). Bycatch levels were at similar levels for all months during the hoki non-spawning season (0.8–1.1 $t.tow^{-1}$), and were lower during the hoki spawning season, July–September (0.37–0.45 $t.tow^{-1}$). Target hake tows (0.44 $t.tow^{-1}$) had slightly lower median total bycatch than hoki target tows (0.67 $t.tow^{-1}$) and target ling tows (0.79 $t.tow^{-1}$).

Bycatch of commercial and QMS species generally followed similar trends to total bycatch (Appendix 8, Figure 1a and 1b), although there was a slight decrease in bycatch of commercial and QMS species with increasing bottom depth, and there was no decrease in bycatch of these species in the hoki spawning months. Bycatch of non-commercial and non-QMS species also followed similar trends to total bycatch (Appendix 8, Figure 1c and 1d), although there was a slight increase in bycatch of these groups with increasing bottom depth, and smallest and largest vessels had much lower bycatch.

3.4.2 Regression modelling and stratification of bycatch data

Of the 18 975 observed trawls examined, 94–96 % of tows recorded bycatch of commercial, QMS, or non-commercial species, and about 88% of tows recorded bycatch of non-QMS species (Table 5). Silver warehou, as one of the main bycatch species in the hoki fishery after hake and ling (Anderson & Smith 2005), was recorded as bycatch in 49% of tows, and other individual species were recorded as bycatch in 9–85% of tows.

Regression tree analysis, using the log of the tow-based bycatch ratio as the dependent variable, split the fishing year in each species category into between one and five time intervals with similar patterns of bycatch. This variable was included in the GLM (*period*).

The dependent variable of the GLM models was the bycatch ratio, expressed as the log of species category catch per tow (kg). In model runs, variables *hoki area*, *duration,* and *tow-type* were often the most influential variables in the linear models, although *average depth*, *company,* and *headline height* were sometimes important (Table 6).

The variable *hoki area* was usually the most influential variable, and *ling area* was also chosen in two models. As noted above, Cook Strait had lower bycatch levels and Chatham Rise much higher bycatch (Figure 6). As *hoki area* featured strongly in all models, further stratification of hoki areas (Chatham Rise, Sub-Antarctic, and WCSI) were done for some species categories as these areas had a lot of data which could be partitioned and hence would further explain trends in bycatch (Table 6). Variables used in the tree regression included *tow type* (midwater or bottom trawls), *fday* (day of fishing year) and *latitude* and *longitude* at start of tow, as these were variables that could be applied to the TCEPR, CELR, and observer data in stratification. Bycatch ratios for null strata were calculated across a *hoki area* rather than fishing-year, as the *hoki area* variable was more important than *fishing year* variable. *Tow type* was the most important variable in all species categories except silver warehou and hake to further split the WCSI data (Table 7). *Latitude*, *longitude*, and *fday* were also important. On the Chatham Rise and in the Sub-Antarctic *latitude* and *longitude* were used to further partition these hoki areas, except for silver warehou where *fday* was used on the Chatham Rise. Other species categories were not further partitioned (Table 7).

Trawl *duration* was often important for bycatch (see Table 6), with longer trawls producing more bycatch per hour than shorter trawls (Figure 6). This could happen if longer trawls tended to be more speculative than short trawls, used mainly to explore unfamiliar grounds, or were perhaps trawls that missed the targeted fish mark but continued on for a period. Trawl *duration* had a particularly marked influence on the bycatch ratios of the QMS and non-commercial species categories.

Tow type was an influential variable for bycatch in most models (Tables 6 and 7), with midwater trawls having much lower bycatch than bottom trawls (Figure 6). The variable *headline height* had little influence in most models except for the silver warehou and frostfish categories.

The time of year factors, (*period*, *season*, and *fishing month*) had very little or no influence in most models, although a large influence on the bycatch of silver warehou, spiny dogfish, and arrow squid (see Table 6). The depth variables (*start depth*, *average depth*) also were of lower importance in most of the models, although they had a large influence on the commercial, QMS, hake, spiny dogfish, ribaldo, stargazer, frostfish, shovelnose dogfish, and barracouta species categories. *Fishing year* showed very little or no importance in all models except white warehou.

The variable *company* entered most regressions, generally in the top four variables, and was influential in most individual species categories (see Table 6). The *vessel* variables were of little importance in most models, and were only important as *vessel length* for spiny dogfish. *Target species* was of lower importance in most models except for white warehou, and *hake season* and *process capacity* were of lower importance in a few models.

3.5 Observer discard data

3.5.1 Overview of raw discard data

A total of 389 species or species groups was observed as being discarded. Commercial and QMS species accounted for 30.6% and 32.6% of total observed discards respectively. Spiny dogfish made up 29.5% of total observed discards, and 90% of observed QMS species discards. Other QMS species observed being discarded included hoki (8.7%), hake (0.1%), and ling (0.05%), silver warehou (0.02%), barracouta (0.4%), and frostfish (0.4%).

Non-commercial and non-QMS species accounted for 60.5% and 58.5% of total observed discards respectively, and included rattails (12.9%), javelinfish (16.5%), and shovelnose dogfish (4.6%). Combined deepwater dogfish and sharks, many of which were unidentified by observers made up 14.1%, other sharks 2.1%, and skates 1.2% of the total observed discards. Other groups frequently discarded included crab species, other crustaceans, echinoderms, squids, and unidentified invertebrates (see Appendix 1 for details).

Fish lost from the net during landing from 2000–01 to 2006–07 accounted for only a small fraction (0–14.5%) of the total fish discards each year in the hoki, hake, and ling fishery. For the years examined, only 58 tows recorded fish losses, and the total percentage of discards due to lost fish in each year was: 2000–01: 7.5%; 2001–02: 2.1%; 2002–03: 0.0%; 2003–04: 3.7%; 2004–05: 14.5% 2005–06: 8.2; and 2006–07: 2.6%. The great majority of discarding was due to the intentional return to the sea of unwanted fish.

Exploratory plots showed the quantity of discards increased slightly with increasing trawl *duration*, with the duration of most tows less than 10 hours (Figure 7). Tows with shallow trawls (200 m or less) had a similar median level of bycatch to mid or deep (800 m or more) tows but had a wider range to the upper and lower quartiles. The factors showing the most variability were *company* and *vessel*, for which median discard levels ranged from 10 to 830 kg.tow^{-1} and 2 to 1121 kg.tow^{-1}, respectively. Discard levels were lower for the largest vessels (median 54 kg.tow^{-1} for vessels greater than 80 m, and 124–377 kg.tow^{-1} for other vessels). The total discards by *fishing year* were similar, although 2006–07 had a wider range. Discards were similar between *hoki areas* (92.5–235 kg.tow^{-1}). Discards were lower for Russian and Ukrainian vessels than for other nationalities, and were higher for factory vessels without a meal plant. There was no trend in discards with *month*.

Discards for commercial, QMS, non-commercial, and non-QMS species generally showed similar trends to total discards (Appendix 8, Figure 2), although there were more discards of commercial and QMS species in shallow tows, and more discards of non-commercial and non-QMS species in deeper tows. Cook Strait had higher discards than other areas for commercial and QMS species, and lower discards than other areas for non-commercial and non-QMS species.

3.5.2 Regression modelling and stratification of discard data

Of the 13 161 observed groups (consisting of 17 376 trawls) examined, 50.1% and 53.6% of processing groups recorded discards of commercial or QMS species respectively, and 67.4% and 64.4% of processing groups recorded discards of non-commercial or non-QMS species respectively (Table 8). Commercial discards were recorded in only 9.5% of process groups when spiny dogfish was excluded. Deepwater sharks were discarded in 42.9% of process groups.

Discarding of target species hoki, hake or ling occurred in only 6.3%, 1.6% and 1.6% of processing groups observed respectively (Table 8), and silver warehou was recorded as discarded in only 0.9% of groups. It is difficult to interpret regression results for these species, as most recorded discard weights were zero.

The discard ratio in the regression analyses was expressed as the log of discards (kg) per tow. Both linear and binomial regressions were run on the discards of some individual species or species groups. There was no further grouping of area or month variables as inputs into the GLM. Variables *company*, *vessel tonnage, fishing month*, *hoki area,* and *duration* were the key factors in these regressions

(Table 9). As in the bycatch calculations, separate ratios were calculated only where there were at least 50 tows and at least two vessels represented within a stratum.

As for the bycatch analysis, further splits of the *hoki areas* WCSI and Chatham Rise were carried out using tree regression (Table 10) on the commercial, non-commercial, QMS, and non-QMS species categories. There was not enough data to further stratify hoki areas for individual species discards. There was also difficulty in stratifying 2007 discard data as some trips had all tows combined as one group, especially for the WCSI, so there was often not enough data to calculate separate estimates of ratios for an area sub-stratum (at least 2 vessels and 50 records available in the stratum) in this year. Tree regressions found certain variables helped explain differences in discards within an area such as *vessel tonnage* on the Chatham Rise and WCSI, and trawl *duration* on the Chatham Rise (Table 10).

The variable *company* was very influential (in the top two linear and binomial variables for almost all species categories (see Table 9). The variable *vessel tonnage* was of medium importance in most linear models, and was influential in explaining the presence or absence of several species categories as discard species. Clearly there are differences in the way that vessels and companies treat discards of non-target species, but these differences were difficult to correlate with characteristics that are recorded by observers.

The time of year factor, *fishing month*, had varying influence in some models (see Table 9), with a large influence on the discards of commercial, commercial excluding spiny dogfish, QMS, hoki, rattails, javelinfish, and spiny dogfish species categories. *Fishing year* was of lower importance in most models, but obviously annual estimates were still required (see Section 3.8).

Trawl *duration* was often important in the discard models (Tables 9 and 10), with longer trawls producing more discards per tow than shorter trawls (Figure 7). Trawl *duration* had the most influence on the discards of the non-commercial species, non-QMS species, ling, shovelnose dogfish, deepwater sharks, and skates, and had some influence in most other species categories.

Tow type was important in the binomial regressions for non-commercial, non-QMS, deepwater sharks, and skates species categories. Midwater trawls likely have a higher probability of avoiding species like deepwater sharks and skates, so differences are probably due to this rather than reduced discarding. *Process capacity, target species*, and *depth category* were of little importance in most models.

3.6 Bycatch

3.6.1 Overall bycatch levels

Annual bycatch was determined by multiplying the bycatch ratios calculated from observed data for each stratum (see Tables 6 and 7) by the total number of tows targeting hoki, hake, and ling fishery in the equivalent stratum as described in Section 2.5. Precision of the estimates was determined from the variability in the bootstrap samples of 1000 ratios (Appendix 4, Figure 8).

The total level of bycatch of commercial species was higher from 2000–01 to 2003–04 (25 000 to 31 700 t), and at slightly lower levels from 2004–05 to 2006–07 (16 400–19 400 t). However, the 95% confidence intervals around the commercial bycatch overlap between all years (Figure 8). Years with higher annual bycatch levels had wider confidence intervals. Bycatch of QMS species (Appendix 4) showed a similar pattern to that for the commercial species, which was not surprising given that the commercial species are a subset of the major QMS species.

Bycatch of non-commercial species was at a peak in 2001–02 at 31 500 t, and then decreased slightly each year to 16 600 t in 2006–07 (Figure 8). Bycatch of non-QMS species showed a similar trend to the non-commercial species (Appendix 4). Bycatch of non-commercial species (16 600–31 500 t) was in a similar range to bycatch of commercial species (16 400–31 700 t) throughout the time period (Figure 8).

Bycatch of commercial and non-commercial species in the hoki fishery from 1990–91 to 1998–99 was estimated by Anderson et al. (2001), and from 1999–2000 to 2000–03 by Anderson & Smith (2005). There is an overlap of three years for 2000–01 to 2002–03 between the Anderson & Smith (2005) and current analysis (Figure 8). Although bycatch estimates were similar for these three overlapping years, caution is required when comparing the estimates between the two studies. Anderson & Smith (2005) used the target hoki tows dataset, and in the current study, the dataset includes target hoki, hake, or ling. In Anderson & Smith (2004) the 15 "COM" species comprised a slightly different set of species than the commercial species list in this study. Spiny dogfish are also included in the commercial species in this study, whereas they were incorporated in the "other" category in Anderson & Smith (2005). In Anderson & Smith (2005) the ratio estimator was based on tow duration rather than number of tows, and the precision was calculated differently, giving narrower confidence limits (Figure 8). The Anderson & Smith (2005) estimates also are based on simpler strata definitions, e.g., area for "COM" and "OTH".

Noting these differences in methodology, it appears that total bycatch decreased from 1990–91 to 1993–94, increased to 1999–2000, where it levelled off to 2003–04, and then decreased to a lower level from 2004–05 to 2006–07 (Figure 8). Total bycatch appears to have been highest in the five years from 1999–2000 to 2003–04. Levels of bycatch in 2004–05 to 2006–07 levels were estimated to be at similar levels to those in 1996–97.

Estimates of total bycatch from this study based on observed ratios were higher than estimates of bycatch calculated directly from commercial data (total TCEPR and CELR catch minus the TCEPR and CELR catch of hoki, hake, and ling from the target hoki, hake, and ling fishery), but both indices showed similar trends (Figure 9a, see Appendix 3a).

Changes in total levels of bycatch may reflect changes in the total catches in the target fishery, notably serial reductions in hoki TACC from 2001–02. Total hoki, hake, and ling catches decreased from 305 000 to 138 000 t from 1997–98 to 2004–05 (Figure 9b). To attempt to disentangle the effects of reduced catches in the target fishery, we estimated bycatch rates (defined as total estimated bycatch as the percentage of the hoki, hake, and ling catch). Bycatch rates increased from 1998–99 to 2003–04 as the fishery declined (Figure 9b), but have decreased from 2003–04 to 2006–07 (Figure 9b). This reduction in bycatch rates in the past four years has occurred in a period of reduction in effort and number of vessels in hoki fishery (see Appendix 3).

Bycatch rates were also explored by area (Figure 9c). On the WCSI, total bycatch decreased slightly from 8900 to 4500 t.y-1 from 2000–01 to 2006–07, over the period when catches of hoki, hake, and ling decreased substantially from 106 000 t to 39 000 t, meaning bycatch rates increased (Figure 9c). Even with this increase, bycatch rates remained relatively low on the WCSI (0.08–0.14). Bycatch rates on both the Sub-Antarctic and Chatham Rise increased to a peak in 2003–04 and have since declined (Figure 9c). The Sub-Antarctic fishery had the highest bycatch rates, ranging from 0.65 to 0.81 kg of bycatch per kilogram of target catch from 2003–04 to 2006–07. Bycatch rates on the Chatham Rise over the same period were 0.30–0.58. Bycatch rates in Cook Strait remained very low in all years (0.01–0.07) (Figure 9c).

Annual estimates of bycatch by species are shown in Figure 10. Estimates of silver warehou bycatch ranged from 2400 to 13 400 $t.y^{-1}$ and were highest in 2000–01 (Figure 10, Appendix 4), although the estimates for this year had wide confidence intervals. The bycatch of both hake and ling in the hoki fishery only decreased over the study period (Figure 10). Bycatch of hake in the hoki fishery decreased from 10 500 in 2000–01 to 1500 t in 2006–07. Hake catches remained relatively stable over this period (Appendix 3b), and the reduction was probably due to a change in targeting on the WCSI, with increased catches of hake on the WCSI from hake target tows and decreased catches of hake from hoki targeting. Bycatch of ling in the hoki target fishery decreased from 9000 t in 2000–01 to 2700 t in 2006–07. Again, this was probably due to an increase in ling targeting and a corresponding decrease in ling catches from target hoki in the Sub-Antarctic and Puysegur (Appendix 3d and 3f). Annual estimates of bycatch of other species in the hoki, hake, and ling fishery showed various patterns (Figure 10, Appendix 4). Bycatch of spiny dogfish increased in the first four years (3900–

6800 t.y-1), and was lower in the last three years (2400–2600 t.y-1). Bycatch of frostfish, pale ghost sharks, rattails, and ribaldo appear to show decreasing trends. Bycatch of white warehou is increasing. Other species showed no trend.

3.6.2 Bycatch ratios by area

Bycatch ratios for some species categories were calculated from the observer data separately for each area and fishing year. These ratios provide a guide to the rate at which bycatch species were caught in each of the hoki areas, and how this may have changed over time.

Annual median bycatch ratios of commercial species in the five hoki areas (excluding the null area) ranged from 231 to 2220 kg.tow^{-1} (Figure 11, Appendix 5), with Puysegur having the highest bycatch ratios in most years, and Cook Strait generally having the lowest bycatch ratios. Median bycatch ratios of non-commercial species ranged from 16 to 1079 kg.tow^{-1}, and were highest on the Chatham Rise (743–1078 kg.tow^{-1}) and the lowest in Cook Strait (16–52 kg.tow^{-1}). High bycatch ratios of silver warehou were seen in Puysegur in most years except 2004–05, and seem to drive the commercial trend in Puysegur.

Annual median bycatch ratios of hake in the hoki target fishery ranged from 0.1 to 893 kg.tow^{-1} (Appendix 5, Figure 11). Bycatch ratios for hake were highest on the WCSI (range 213–893 kg.tow^{-1}) and decreased in this area over the study period. Bycatch ratios of hake were moderate on the Chatham Rise (69–150 kg.tow^{-1}) and in the Sub-Antarctic (57–136 kg.tow^{-1}), lower at Puysegur (9–52 kg.tow^{-1}), and very low in Cook Strait (less than 1 kg.tow^{-1}).

Annual median bycatch ratios of ling in the hoki target fishery ranged from 30 to 1134 kg.tow^{-1} (Appendix 5, Figure 11). Bycatch ratios were highest in the Sub-Antarctic (361–1134 kg.tow^{-1}) and generally increased over the study period. Bycatch ratios of ling were also high at Puysegur (321–878 kg.tow^{-1}). Lower ling bycatch ratios were seen on the WCSI, Cook Strait and on the Chatham Rise.

Annual median bycatch ratios for other species showed a lot of variation by area and by year (Figure 11, Appendix 5). Spiny dogfish made up 16% of commercial species bycatch in the hoki, hake, and ling target fishery, and were observed in half of all tows. Bycatch ratios for spiny dogfish were highest in Cook Strait (228–764 kg.tow^{-1}) and in the Sub-Antarctic (35–551 kg.tow^{-1}), but spiny dogfish were also caught in other areas (Figure 11, Appendix 5). Rattails had very high bycatch ratios on the Chatham Rise (210–450 kg.tow^{-1}). Javelinfish had high and increasing bycatch ratios on the Chatham Rise (274–647 kg.tow^{-1}), and high bycatch ratios in the Sub-Antarctic. Shovelnose dogfish had higher bycatch ratios on the Chatham Rise and at Puysegur. Frostfish (145–250 kg.tow^{-1}) and barracouta (23–188 kg.tow^{-1}) had high bycatch ratios on the WCSI, with low bycatch ratios in other areas. Sea perch had high bycatch ratios on the Chatham Rise (55–117 kg.tow^{-1}). Pale ghost sharks had high bycatch ratios on the Chatham Rise (81–130 kg.tow^{-1}) and in the Sub-Antarctic (42–111 kg.tow^{-1}). Lookdown dory had high bycatch ratios on the Chatham Rise (41–60 kg.tow^{-1}) and on the WCSI in some years (6–31 kg.tow^{-1}). White warehou had increasing bycatch ratios in the Sub-Antarctic from 2003–04 to 2006–07 (115–823 kg.tow^{-1}). Giant stargazers had higher bycatch ratios in most years in all areas except Cook Strait, and arrow squid had higher bycatch ratios on the WCSI, the Sub-Antarctic, and Puysegur.

To investigate whether standardised bycatch ratios might provide estimates of abundance for some species we compared bycatch ratios with trawl survey biomass indices from *Tangaroa* surveys of the Chatham Rise and Sub-Antarctic (Figure 12). Both indices appear to show similar patterns for some species (within the limits of uncertainty of both bycatch and trawl estimates), e.g., hake, silver warehou, giant stargazer, and sea perch on the Chatham Rise (Figure 12a), and ribaldo in the Sub-Antarctic (Figure 12b). Other species show quite different patterns, e.g., white warehou in both areas. This preliminary analysis suggests that the use of bycatch rates to monitor abundance may be worthy of further investigation.

3.7 Discards

3.7.1 Annual discard levels

Annual discard levels were determined by multiplying the bycatch ratios calculated from observed data for each stratum (see Tables 9 and 10) by the total number of tows targeting hoki, hake, and ling in the equivalent stratum as described in Section 2.5. (Appendix 6, Figure 13). As with bycatch, previous estimates of discards of commercial, non-commercial, and total species were calculated for the hoki target fishery for 1990–91 to 1998–99 by Anderson et al. (2001), and for 1990–91, 1994–95, 1998–99, and 1999–2000 to 2002–03 by Anderson & Smith (2005).

Discard levels of commercial species were higher in the first four years of our study period, increasing from 3500 t in 2000–01 to 9400 t in 2003–04, and then dropping to a lower level (1200–3800 $t.y^{-1}$) from 2004–05 to 2006–07 (Appendix 6, Figure 13). Discard estimates for non-commercial species decreased from 2001–02 (21 900 t) to 2004–05 (4300 t), levelling off in 2005–06 and 2006–07. Total discards showed a similar pattern to the non-commercial discards (Figure 13). The 95% confidence intervals around the commercial and non-commercial discards overlapped across all years (Figure 13). QMS and non-QMS discard levels were similar to the commercial and non-commercial discard estimates (Appendix 6).

The discard estimates for commercial species from Anderson & Smith (2005) were much lower than those of the current analysis for the three overlapping years with much tighter confidence intervals (Figure 13). Estimates of non-commercial and total discards from Anderson & Smith (2005) were more similar to the estimates from this study with overlapping confidence limits (Figure 13). As discussed in Section 3.6.1, estimates from the two studies should be compared with caution because of differences in analysis methodology. With this caveat, it appears that total annual discards were at lower levels in the early 1990s, increased slightly to 1999–2000, then increased through to 2001–02, and have decreased again to lower levels in the last few years (Figure 13).

Estimated annual discards of hoki were low and ranged from 100 to 2500 $t.y^{-1}$ from 2000–01 to 2006–07 (Appendix 6, Figure 13). Our estimates were within the range calculated by Anderson & Smith (2005) for overlapping years. Estimates of hoki discards have decreased from a high in 1994–95 of 5636 t to the lowest discard level in 2005–06 of 100 t. Annual estimates of discards of hake, ling, and silver warehou were very low (Appendix 6) and are unlikely to have been well estimated, so are not plotted here.

Total discards of spiny dogfish increased from 3500 t in 2000–01 to 9400 t in 2003–04, dropped to 1200 t in 2004–05 and increased to 3800 t in 2006–07. (Appendix 6, Figure 14). Spiny dogfish are one of the species in the "commercial species" category and were the major contributor to discards in this category, making up 95% of observed discards of commercial species. Discards of commercial species excluding spiny dogfish were very low, ranging from 0 to 500 t per year (Appendix 6). Total discards for most species, including javelinfish, rattails, deepwater sharks, shovelnose dogfish, skates, and other sharks appears to have decreased over the study period (Figure 14).

The apparent decrease in discards may be related to vessel processing practice (Figure 15). For non-commercial species, decreases in discards have been associated with increases in fish processed to meal for javelinfish, rattails, deepwater sharks, and skates (Figure 15). From 2004–05 most observed javelinfish and rattails were mealed. Although most spiny dogfish are still discarded, the proportions processed (mealed, greenweight or finned) has increased in the last few years. Other sharks are more likely to be finned than in the past and skates are mealed, filleted, or finned (Figure 15).

3.7.2 Discard ratios by area

Discard ratios for some species categories were calculated from the observer data separately for each area and each of the seven fishing years for areas and years where there were sufficient data (Figure

16, Appendix 7). For some of the individual species there were few discard events recorded by observers and calculated ratios may not be reliable.

Annual median discard ratios of commercial species in the five areas ranged from 12 to 958 kg per tow (Figure 16, Appendix 7), with Cook Strait (12–709 kg.tow^{-1}) and Sub-Antarctic (30–958 kg.tow^{-1}) having the highest discard ratios in most years. Ratios of discarding for commercial species were lower on the Chatham Rise (31–145 kg.tow^{-1}), Puysegur (50–58 kg.tow^{-1}), and WCSI (20-110 kg.tow^{-1}) respectively. Annual median discard ratios of the commercial species were mainly driven by discarding of spiny dogfish (Figure 16, Appendix 7). Once spiny dogfish were removed from the commercial species category, bycatch ratios were low in all areas in all years ranging from 0 to 9 kg.tow^{-1}, except on the WCSI in 2002–03 where there was a discard rate of 43 kg.tow^{-1} (large discards of commercial species were reported in observer logbooks).

Discard ratios of hoki were generally less than 100 kg.tow^{-1}, and in most areas and years were much lower (Figure 16, Appendix 7). Discard ratios of hake, ling, and silver warehou were also very low in all areas (Appendix 7), with only a very small amount discarded on the WCSI, Chatham Rise, Sub-Antarctic, and Puysegur.

Annual discard ratios of non-commercial species ranged from 2 to 790 kg.tow^{-1}, with the lowest discard ratios in Cook Strait (2–43 kg.tow^{-1}), and the highest discard ratios on both the Chatham Rise (86–788 kg.tow^{-1}), and Sub-Antarctic (118–790 kg.tow^{-1}), with peak levels in 2000–01 in both areas (Figure 16, Appendix 7). Discard ratios for deepwater sharks ranged from 0 to 337 kg .tow^{-1}, and were highest in 2001–02 on the Chatham Rise and in the Sub-Antarctic (Figure 16, Appendix 7). Other sharks had lower overall discard ratios (0–74 kg .tow^{-1}), with discard ratios generally less than 10 kg .tow^{-1}. Shovelnose dogfish had relatively high discard ratios on the Chatham Rise (19–129 kg .tow^{-1}), medium discard ratios at Puysegur (35–70 kg.tow^{-1}), and low discard ratios on the WCSI, Sub-Antarctic and Cook Strait. Skates had higher discard ratios on the Chatham Rise from 2000–01 to 2002–03 (14–16 kg.tow^{-1}), and low discard ratios in all other areas and years except for the Sub-Antarctic in 2003–04. Javelinfish discard ratios were generally less than 100 kg.tow^{-1}, except from the Chatham Rise and Sub-Antarctic from 2000–01 to 2002–03. Rattail discards were generally less than 50 kg.tow^{-1}, except on the Chatham Rise where discard ratios were 167–252 kg.tow^{-1} from 2000–01 to 2002–03.

4. DISCUSSION

The precision of the estimates of bycatch and discard levels is dependent on the coverage of the fishery achieved by observers. In general, this requires at least 10–15% of the target fishery be observed and a good spread of observer coverage across different types of vessels, areas, and times of the year. Observer effort of the annual target fishery catch over the seven years was 11–21%. Although this should be sufficient to be representative of the overall fishery, coverage was patchy over time, between areas, and over vessel sizes in some years and areas, and consequently estimates of bycatch and discard ratios for some strata are uncertain. Even so, a modest degree of precision in estimates was achieved.

There was consistency between our observer-based estimates of total bycatch and estimates obtained directly from TCEPR and CELR data (see Figure 9a). This was reassuring. As expected, our estimates of total bycatch (36 000 to 58 000 t per year) were higher than that from the direct analysis of TCEPR and CELR (26 000–38 000 t) because observers report a much more detailed and broader range of bycatch species than the top five species summaries provided by commercial catch-effort returns.

Total annual estimates of discards ranged from about 5500 to 29 000 $t.y^{-1}$ with the main species discarded including spiny dogfish, rattails, javelinfish, hoki, and shovelnose dogfish. Discarding of hoki, hake, and ling accounted for 9.7% of total observed discards. An average of 0.03 kg of fish was discarded per kilogram of hoki, hake, and ling caught, lower than the 0.06 kg figure calculated by Anderson & Smith (2005). Fish lost from the net during landing accounted for a small fraction (0–14.5%) of the total fish discards each year in the hoki, hake and ling fishery. For the 2006–07 data, a large proportion of process groups was not available and was not used in the analysis, so care needs to be taken in interpretation of the discard 2006–07 data, especially for WCSI and Sub-Antarctic discard results.

The hoki fishery has been considered to have low discard ratios relative to other fisheries, both in New Zealand and internationally, but the levels of discards could potentially be reduced further. *Company* and *vessel tonnage* were important variables in estimating discards of hoki. The effect of the individual vessels on the variability in bycatch ratios as well as target species catch ratios has been well documented in many New Zealand fisheries (see, e.g., Clark & Anderson 2001, Horn 2004, Anderson & Smith 2005,). Individual vessels (and companies, through fishing strategies) are better at avoiding unwanted bycatch and minimising discards than others, suggesting that there is potential for reducing discards in this fishery through changing fishing practices. Other discretionary factors such as use of midwater rather than bottom trawl, and shorter tow duration also influenced the level of bycatch and discards. A major factor reducing discarding has been increased use of meal plants. Non-commercial species such as javelinfish and rattails that were previously discarded are now mainly mealed. Lower levels of discarding from 2004–05 to 2006–07 were mainly a result of more vessels using meal plants. Discards of non-commercial species by factory vessels without meal plants was up to twice the level of discards for vessels with meal plants.

The hoki, hake, and ling fishery is very complex, with many confounding factors, and changes in fishing practice are likely to have contributed to variability in annual levels of bycatch and discards. Changes have included: the implementation of the Hoki Code of Practice – including avoidance of small fish, seasonal and area closures, and catch splits; a reduction in effort and fewer vessels in the hoki fishery over last few years; increase in the number of vessels under 43 m; changes in amount of fishing inside the 25 n. mile line on the WCSI; twin-trawl vessels; use of meal plants; targeting and avoidance of hake and ling. The variability in the annual level of bycatch and discards in the hoki, hake, and ling fishery is likely to continue as fishing practices alter, as the abundance or distribution of these species varies, and as new fisheries develop with different characteristics. As a result (and as with any fisheries-dependent data) it is very difficult to disentangle contributing factors and interpret changes in bycatch ratios as indices of abundance. Changes in bycatch ratios followed trends in survey biomass estimates for some species on the Chatham Rise and in the Sub-Antarctic (see Figure 12), but further validation is required to determine whether estimates of commercial bycatch could provide long-term monitoring approaches for low-value species.

There is a wide scope to take this analysis further. For example, there is potential for further analysis on each area separately focussing on trends within subareas, species groups, individual species, or trophic levels. We also recommend that any future analysis covers all data (back to 1990–91) so that assumptions and methods are consistent, rather than an update of only the most recent years as contracted under this project.

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Table 1: Summary of variables tested in models b:, bycatch models; d, discard models.

Variable	Type	Description
Year (b, d)	categorical	fishing year
Trip number (b, d)	categorical	unique number assigned to each trip
Vessel (b, d)	categorical	vessel key
Vessel length (b, d)	categorical	overall vessel length (m)
Vessel tonnage(b, d)	categorical	gross vessel tonnage (tonnes)
Company (b, d)	categorical	company owning or chartering vessel
Area (b, d)	categorical	area in which tow occurred, for either hoki, hake, or ling
Area (b, d)	categorical	calculated using tree regression for each species
Month (b, d)	categorical	fishing year month of tow
Season (b)	categorical	high or low, for either hoki, hake, or ling
Season(b)	categorical	calculated using tree regression for each species
Depth (b, d)	categorical	depth of tow (deep or shallow, see text)
Depth (b)	continuous	depth of tow (m)
Depth (b)	continuous	average depth of tow (m)
Duration (b, d)	continuous	duration of tow (hours))
Headline height (b)	continuous	recorded headline height of tow (m)
Towtype (b)	categorical	bottom or midwater gear
Process capacity of vessel (b, d)	continuous	maximum process of a vessel, FR, ice vessel; PR, factory vessel; MP, factory vessel with a meal plant
Target species(b, d)	continuous	recorded target species

Table 2: Number of TCEPR and observer vessels, trips, tows, total catch and hoki, hake, and ling catch in the target hoki, hake, and ling trawl fishery, by year.

	Fishing year						
	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07
TCEPR data							
Number of vessels	85	81	79	74	68	65	54
Number of trips	944	769	820	795	572	597	480
Number of tows	31 166	27 412	27 185	22 576	15 982	13 390	12 890
Total catch (t)	252 503.5	227 101.8	206 910.5	163 029.0	132 769.4	125 156.8	121 850.6
Hoki, hake, ling catch (t)	230 697.5	205 592.0	184 741.3	138 946.5	115 754.7	109 384.4	105 178.8
Hoki catch (t)	208 575.2	185 213.9	164 789.5	116 090.6	94 414.5	93 174.1	86 701.8
Hake catch (t)	1 133.2	10 105.9	9 812.6	12 207.8	11 827.3	8 626.9	9 576.0
Ling catch (t)	10 289.1	10 272.1	10 139.2	10 648.1	9 512.9	7 583.4	8 901.0
Observer data							
Number of vessels	43	37	33	31	31	28	32
Number of tows	3580	3319	2634	2489	2285	2297	1999
Hoki, hake, ling catch (t)	33 357.3	31 152.1	20 492.7	18 877.9	19 140.0	22 734.8	18 984.0
% of TCEPR hoki, hake, and ling catch	14.46	15.15	11.09	13.59	16.54	20.78	18.05
Hoki catch (t)	31 430.9	28 092.0	18 540.4	15 756.3	16 588.9	18 851.7	16 244.3
% of TCEPR hoki catch	15.07	15.17	11.25	13.57	17.57	20.23	18.74
Hake catch (t)	892.9	2 020.5	1 089.8	1 925.1	1 379.0	2 678.4	1 584.1
% of TCEPR hake catch	7.55	19.99	11.11	15.77	11.66	31.05	16.54
Ling catch (t)	1 033.5	1 039.6	862.5	1 196.4	1 172.2	1 204.7	1 155.6
% of TCEPR ling catch	10.04	10.12	8.51	11.24	12.32	15.89	12.98

Table 3: Number of observed hoki, hake, and ling tows and catches by hoki area in the target hoki, hake, and ling target fishery,

	Fishing year						
Area	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Number of tows							
WCSI	1 099	1 329	959	1 382	1 085	1 108	663
Chatham Rise	1397	972	886	622	812	742	870
Sub-Antarctic	708	809	590	320	187	330	398
Cook Strait	263	144	134	131	139	65	226
Puysegur	111	50	55	32	60	49	21
Null	2	15	10	2	2	3	13
Total	3 580	3 319	2 634	2 489	2 285	2 297	2 191
Hoki catch (t)							
WCSI	16 242.2	16 628.3	10 064.7	8 481.2	7 354.3	10 242.5	12469.0
Chatham Rise	5 549.5	4 738.8	3 305.8	3 420.2	5 278.4	5 693.4	5687.9
Sub-Antarctic	4 302.0	3 957.8	2 041.7	807.4	474.1	1 285.8	1670.7
Cook Strait	4 322.7	2 031.8	2 435.7	2 486.0	2 207.0	1 079.7	2352.5
Puysegur	1 013.2	572.4	683.9	561.8	1 275.2	546.8	65.5
Null	2.2	156.8	9.3	0.8	0.1	2.8	12.5
Total	31 431.8	28 085.9	18 541.1	15 757.4	16 589.1	18 851.0	22 258.1
Hake catch (t)							
WCSI	520.0	1 457.1	899.7	1 329.8	1 090.9	1 778.0	1 256.4
Chatham Rise	193.9	92.7	97.2	128.4	214.9	50.8	181.6
Sub-Antarctic	161.9	454.3	81.6	464.9	61.0	836.5	433.1
Cook Strait	0.1	0.0	0.0	0.0	0.1	0.0	39.9
Puysegur	6.1	0.2	2.2	0.3	0.6	3.6	2.0
Null	0.0	10.3	0.3	0.2	0.0	2.7	0.0
Total	882.0	2 014.6	1 081.0	1 923.6	1 367.5	2 671.6	1 913.0
Ling catch (t)							
WCSI	262.3	508.6	189.8	504.9	294.1	291.8	87.9
Chatham Rise	271.4	222.9	220.3	177.9	179.6	131.4	180.2
Sub-Antarctic	439.1	271.5	384.7	470.9	663.4	635.2	814.0
Cook Strait	15.5	5.7	4.9	3.4	5.1	1.6	11.2
Puysegur	35.9	20.5	53.6	32.4	26.0	140.6	84.8
Null	0.0	4.3	1.4	0.3	0.0	0.4	4.2
Total	1 024.2	1 033.5	854.7	1 189.8	1 168.2	1 201.0	1 182.3

Table 4: Comparison of bycatch and discard estimators for hoki, hake, and ling target tows. Target catch is hoki, hake, and ling combined catch.

Bycatch/discard	Species category	Estimator	Bycatch ratio	c.v. (%)
Bycatch	Commercial	Target catch	0.074	2.07
		Number of tows	675.6	1.89
		Tow duration	167.2	1.87
	Non-commercial	Target catch	0.06309	1.76
		Number of tows	574.6	1.47
		Tow duration	142.232	1.89
	QMS	Target catch	0.079	2.01
		Number of tows	719.1	1.86
		Tow duration	178	1.90
	non-QMS	Target catch	0.05719	1.83
		Number of tows	520.9	1.50
		Tow duration	128.936	1.96
	SWA	Target catch	0.0199	4.50
		Number of tows	181.5	4.29
		Tow duration	44.9	7.06
Discards	Commercial	Target catch	0.0116	12.06
		Number of tows	130.17	10.23
		Tow duration	24.4	12.03
	Non-commercial	Target catch	0.023	2.87
		Number of tows	253.93	2.14
		Tow duration	47.5	2.63
	QMS	Target catch	0.0122	11.72
		Number of tows	137.87	9.67
		Tow duration	25.8	11.27
	non-QMS	Target catch	0.022	2.87
		Number of tows	245.4	2.20
		Tow duration	45.9	2.57

Table 5: Percentage of non-zero tows by species for the hoki, hake, and ling target dataset. See Appendix 1 for definition of species codes. Hake and ling data analysis on hoki target tows only (17 298 tows).

Species category	Percentage of non-zero tows (18 795 tows)
Commercial	94.5
Non-commercial	94.6
QMS	96.0
Non-QMS	88.2
LIN	85.3
HAK	73.6
JAV	73.1
RAT	67.2
SPD	51.4
SWA	49.0
LDO	47.3
SQU	44.8
RIB	38.3
GSP	37.2
SPE	36.4
WWA	32.4
STA	28.0
FRO	20.3
SND	17.2
BAR	9.3

Table 6: Summary of GLM modelling of bycatch for selected species categories in the target hoki, hake, or ling fishery using the bycatch ratio log(catch) up to 0.5% improvement. The numbers denote the order in which the variable entered the model; –, not selected; *duration* and *depth* are logged. *area*: hoki areas (hok), ling areas (lin); *depth*: average depth (av), start depth (s); Vessel: *vessel* (vess), *vessel length* (lgth), *vessel tonnage* (ton); Other: *hake season* (hak), *target species* (target), *process capacity* (proc). Hake and ling data analysis on hoki target tows only. See appendix 1 for species codes.

			Variable									
Species category	Model type	Model R^2 (%)	*Area*	*Tow type*	*Average depth*	*Duration*	*Company*	*Fishing month*	*Fishing year*	*Headline height*	*Vessel*	*Other*
Commercial	Normal	29.4	6_{hok}	1	2_{av}	3	4	5	-	-	-	-
	Binomial	18.9	1_{hok}	-	6_{av}	5	3	4	7	2	-	-
Non-commercial	Normal	53.2	1_{hok}	3	-	2	4	-	-	-	-	-
	Binomial	26.6	-	4	-	1	2	3	5	-	6_{lgth}	-
QMS	Normal	30.1	6_{hok}	3	2_{av}	1	4	5	-	-	-	-
	Binomial	17.9	1_{hok}	-	3_{av}	2	5	4	-	6	-	-
Non-QMS	Normal	57.1	1_{hok}	2	5_{av}	3	4	6	-	-	-	-
	Binomial	32.3	7_{hok}	3	-	1	2	5	6		4_{lgth}	-
SWA	Normal	18.8	6_{hok}	-	4_{av}	3	5	2	-	1	-	-
	Binomial	21.5	1_{hok}	-	4_{av}	2	5	3	6	7	-	-
HAK	Normal	36.0	1_{hok}	7	2_{av}	4	3	5	9	8	6_{lgth}	-
	Binomial	26.1	1_{hok}	-	3_{av}	2	4	5	-	7	6_{ton}	8_{hak}
LIN	Normal	25.5	1_{hok}	2	6_{av}	4	3	5	-	-	-	-
	Binomial	17.6	7_{hok}		5_{av}	1	3	2		4	6_{ton}	8_{hak}
JAV	Normal	52.6	1_{hok}	7	6_{av}	3	2	4	5	-	8_{lgth}	9_{target}
	Binomial	38.3	1_{hok}	2	9_{av}	5	4	3	7	-	6_{lgth}	8_{proc}
RAT	Normal	46.0	1_{hok}	-	-	4	3	6	-	2	-	5_{target}
	Binomial	41.1	2_{hok}	1	-	3	5	4	-	6	-	-
SPD	Normal	25.7	6_{hok}	4	3_{av}	-	5	2	-	-	1_{lgth}	7_{proc},8_{target}
	Binomial	13.7	2_{hok}	-	1_{av}	-	4	3	-	-	-	-
LDO	Normal	40.5	2_{hok}	1	-	5	3	4	-	-	6_{ton}	7_{target}
	Binomial	29.2	1_{hok}	2	-	4	3	5	-	-	-	6_{target}
SQU	Normal	37.8	4_{hok}	3	7_{av}	8	1	2	-	-	6_{ton}	5_{target}
	Binomial	10.8	1_{hok}	-	-	4	3	2	-	-	-	5_{target}
RIB	Normal	35.4	5_{hok}	3	2_{av}	4	1	-	-	-	7_{ton}	6_{target}
	Binomial	39.7	5_{lin}	1	2_{av}	3	4	7	-	6	-	-
GSP	Normal	31.9	1_{hok}	-	-	2	3	-	-	4	-	5_{target}
	Binomial	50.5	1_{hok}	-	-	3	4	5	-	2	-	6_{target}
SPE	Normal	45.4	1_{hok}	2	-	4	3	5	-	-	-	6_{proc}
	Binomial	48.7	1_{hok}	2	-	4	3	-	-	-	-	-
WWA	Normal	14.6	6_{hok}	4	-	-	3	5	2	-	7_{vess}	1_{target}
	Binomial	32.6	2_{hok}	1	-	4	3	6	-	-	-	5_{target}, 7_{hak}
STA	Normal	22.4	5_{hok}	1	2_{av}	3	4	7	-	-	6_{ton}	8_{target}
	Binomial	32.9	3_{hok}	1	2_{av}	5	6	4	-	-	-	7_{target}
FRO	Normal	40.1	4_{lin}	6	3_{av}	5	2	-	-	1	-	7_{target}
	Binomial	63.7	1_{hok}	2	3_{av}	5	6	7	-	-	-	4_{target}
SND	Normal	30.9	1_{hok}	4	2_{av}	6	3	5	-	-	-	-
	Binomial	25.6	1_{hok}	4	3_{av}	7	2	5	6	-	-	-
BAR	Normal	13.5	1_{hok}	-	2_{av}, 5_{s}	4	-	3	-	-	6_{vess}	7_{proc}
	Binomial	33.3	6_{hok}	-	4_{av}	-	3	2	5	1	-	7_{target}

Table 7: Further splits by tree regression of the hoki areas WCSI, Chatham Rise and Sub-Antarctic for selected species categories. MW, midwater trawl; BT, bottom trawl; fday, fishing day of year; long, longitude start; lat, latitude start. Hake and ling data analysis on hoki target tows only.

Data	WCSI	CHAT	SUBA
Commercial	1. MW 2. BT	1. lat ≤ 42.98 2. lat > 42.98 & long < 174.7 3. lat > 42.98 & long ≥ 174.7	1. lat > 48.8 2. lat ≥ 48.8
Non-commercial	1. MW & long <170.5 2. MW & long ≥ 170.5 3. BT	1. long < 174 2. long ≥ 174	1. long < 166.9 2. long ≥ 166.9 & lat ≤ 49.6 3. long ≥ 166.9 & lat > 49.6
QMS	1. MW & long < 170.5 & lat ≤ 42.58 2. MW & long < 170.5 & lat > 42.58 3. MW & long ≥ 170.5 4. BT	1. lat ≤ 42.94 2. lat > 42.94 & long < 174.7 3. lat > 42.94 & long ≥ 174.7	1. lat > 48.79 2. lat ≤ 48.79
Non-QMS	1. MW & fday <295.5 2. MW & fday ≥ 295.5 3. BT	1. long < 174.1 2. long ≥ 174.1	1. long < 167 2. long ≥ 167 & lat ≤ 49.51 3. long ≥ 167 & lat > 49.51
SWA	1. lat > 42.42 2. lat ≤ 42.42	1. fday < 237.5 2. fday ≥ 237.5	-
HAK	1. long < 170.5 2. long ≥ 170.5	1. lat ≤ 43.29 2. lat > 43.29	1. lat > 48.9 2. lat ≤ 48.9
LIN	1. MW & lat < 42.41 2. MW & lat ≥ 42.41 3. BT	1. long < 174.1 2. long ≥ 174.1	1. long ≥ 169.5 2. long < 169.5 & lat ≤ 49.55 3. long < 169.5 & lat > 49.55

Table 8: Percentage of non-zero groups by species for the hoki, hake, and ling target discard dataset. See Appendix 1 for definition of species codes. Hake and ling data analysis on hoki target species groups only (12 243 groups).

Species category	Percentage of non-zero groups (total 13 161)
Commercial	50.1
Non-commercial	67.4
QMS	53.6
Non-QMS	64.4
Deep water sharks	42.9
SPD	32.1
RAT	23.5
JAV	21.4
SND	16.0
Skates	10.5
Commercial, excl SPD	9.5
HOK	6.3
Other sharks	4.8
HAK	1.6
LIN	1.6
SWA	0.9

Table 9: Summary of regression modelling for discards in the target hoki, hake, or ling target fishery. The numbers denote the order in which the variable entered the model to 0.5% improvement; –, not selected; Variables— *Fyear*, fishing year; *Fmonth*, month of fishing year; *Dur*, log duration of tow; *Area*: HOK, hoki areas; HAK, hake areas; LIN, ling areas; Vessel variables: lgth, vessel length; ton, vessel tonnage; ves, vessel; *Depth*, depth category. See Appendix 1 for species codes.

			Variable									
Species category	Model type	Model R^2 (%)	*Company*	*Fmonth*	*Vessel*	*Area*	*Dur*	*Process capacity*	*Target species*	*Fyear*	*Tow type*	*Depth*
Commercial	Normal	34.1	1	2	3_{ton}	4_{LIN}	5	-	-	-	-	-
	Binomial	6.7	1	2	3_{ton}	4_{LIN}	-	-	-	-	-	-
Commercial, excluding SPD	Normal	35.7	1	2	6_{ton}	-	4	3	5	-	-	-
	Binomial	45.7	2	5	1_{ton}	3_{HOK}	6	4	-	7	-	-
QMS	Normal	32.5	1	2	3_{ton}	5_{LIN}	4	-	-	-	-	-
	Binomial	6.6	1	2	4_{ton}	-	-	-	-	3	-	-
Non-commercial	Normal	51.0	2	4	3_{ton}	5_{HOK}	1	7	-	-	6	-
	Binomial	33.5	2	4	-	6_{HOK}	-	5	-	3	1	-
Non-QMS	Normal	53.5	2	4	3_{ton}	5_{HOK}	1	7	-	-	6	-
	Binomial	34.8	2	4	-	-	-	5	-	3	1	-
HOK	Normal	40.3	2	1	7_{ton}	-	3	6	4	5	-	-
	Binomial	55.3	1	4	2_{ton}	3_{HOK}	5	-	-	-	-	-
HAK	Normal	40.9	1	5	2_{ves}	-	3	-	2	-	-	-
	Binomial	54.9	1	5	2_{ton}	-	4	3	6	-	-	-
LIN	Normal	36.8	1	4	3_{ton}	5_{HOK}	2	-	-	7	6	-
	Binomial	47.7	1	4	2_{ton}	5_{HAK}	6	3	-	-	5	-
SWA	Normal	35.5	1	-	-	-	-	-	-	-	-	2
	Binomial	33.7	2	4	3_{ton}	-	6	1	-	5	-	-
RAT	Normal	54.9	2	3	6_{ves}	1_{HOK}	4	-	7	-	5	-
	Binomial	49.8	1	6	2_{ton}	-	3	-	5	4	-	-
JAV	Normal	59.1	1	2	6_{ves}	3_{LIN}	4	7	-	8	5	-
	Binomial	61.0	1	6	2_{ton}	-	3	5	7	4	8	-
SPD	Normal	34.1	1	2	5_{ton}	3_{LIN}	4	-	-	-	-	-
	Binomial	6.1	1	2	-	3_{HOK}	-	-	-	-	-	-
SND	Normal	55.6	2	4	5_{ton}	3_{HOK}	1	-	-	-	-	-
	Binomial	17.0	1	4	-	2_{HOK}	-	-	-	-	3	-
Deepwater sharks	Normal	41.1	2	4	-	3_{HOK}	1	-	-	-	5	-
	Binomial	26.4	2	3	5_{ton}	-	-	6	-	4	1	-
Other sharks	Normal	38.1	2	-	1_{ves}	4_{LIN}	3	7	8	5	6	-
	Binomial	14.9	2	3	-	1_{HOK}	-	-	4	-	-	-
Skates	Normal	55.7	2	4	1_{lgth}	3_{HOK}	1	7	-	-	6	-
	Binomial	27.6	4	3	-	-	-	-	-	2	1	-

Table 10: Further splits by tree regression of the hoki areas WCSI and Chatham Rise for selected species categories. MW, midwater trawl; BT, bottom trawl.

Data	WCSI	CHAT
Commercial	1. vessel tonnes < 4134.5	1. duration < 6.167
	2. vessel tonnes ≥ 4134.5	2. duration ≥ 6.167
Non-commercial	1. vessel tonnes < 973.55	1. vessel tonnage < 1888.35
	2. vessel tonnes ≥ 973.55	2. vessel tonnage ≥ 1888.35; duration < 6.1 hours
		3. vessel tonnage ≥ 1888.35; duration ≥ 6.1 hours
QMS	1. vessel tonnes < 4134.5	(Tree regression resulted in two duration splits, but not
	2. vessel tonnes ≥ 4134.5	enough data)
Non-QMS	1. vessel tonnes < 973.55	1. vessel tonnes < 973.55
	2. vessel tonnes ≥ 973.55	2. vessel tonnes ≥ 973.55

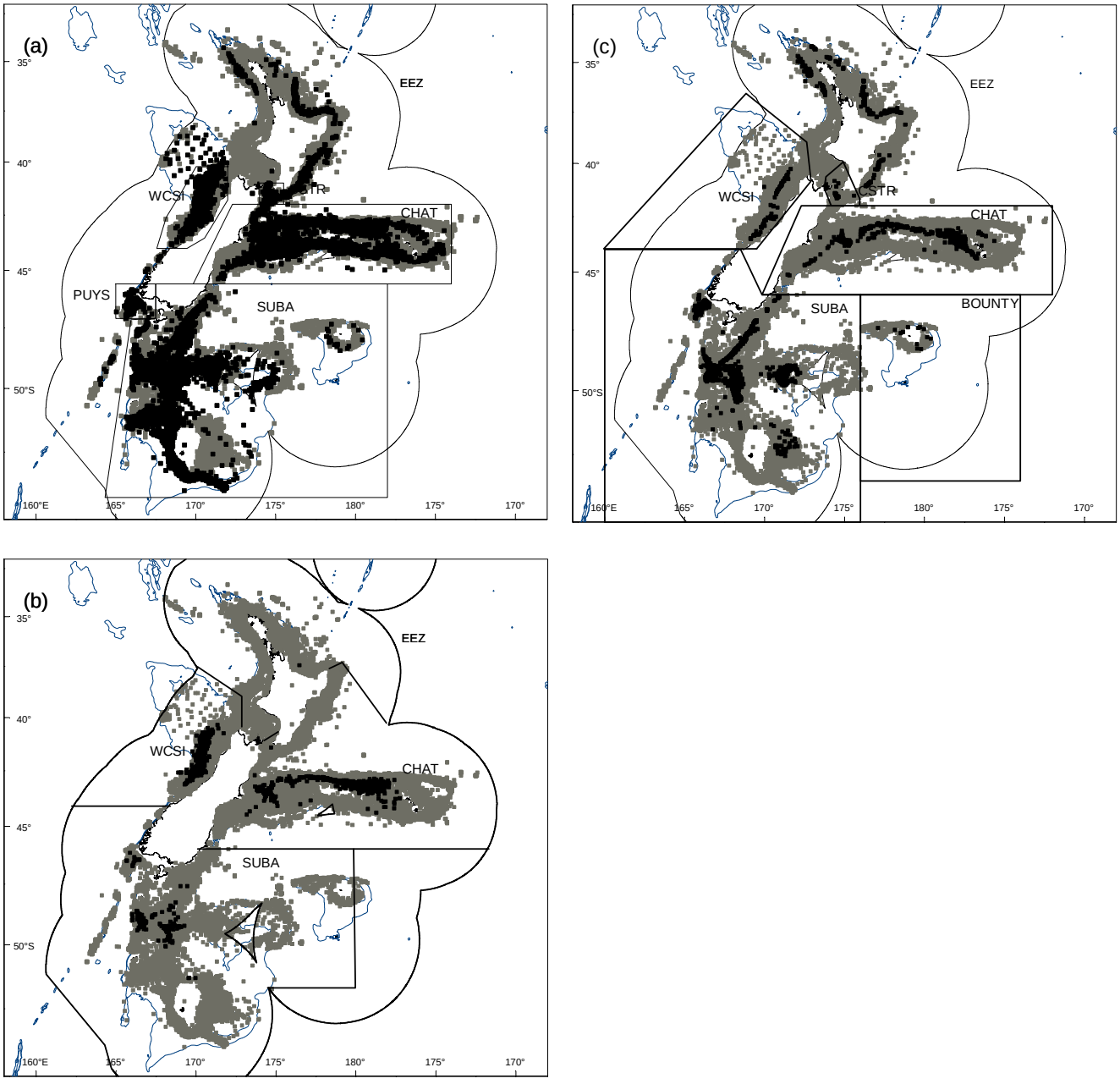


Figure 1: Distribution of all TCEPR tows from trips which caught or targeted hoki, hake, or ling for 2000–01 to 2006–07 (grey squares), and (a) target hoki, hoki areas (b) target hake, hake areas, and (c) target ling, ling areas TCEPR tows in the same period (black squares).

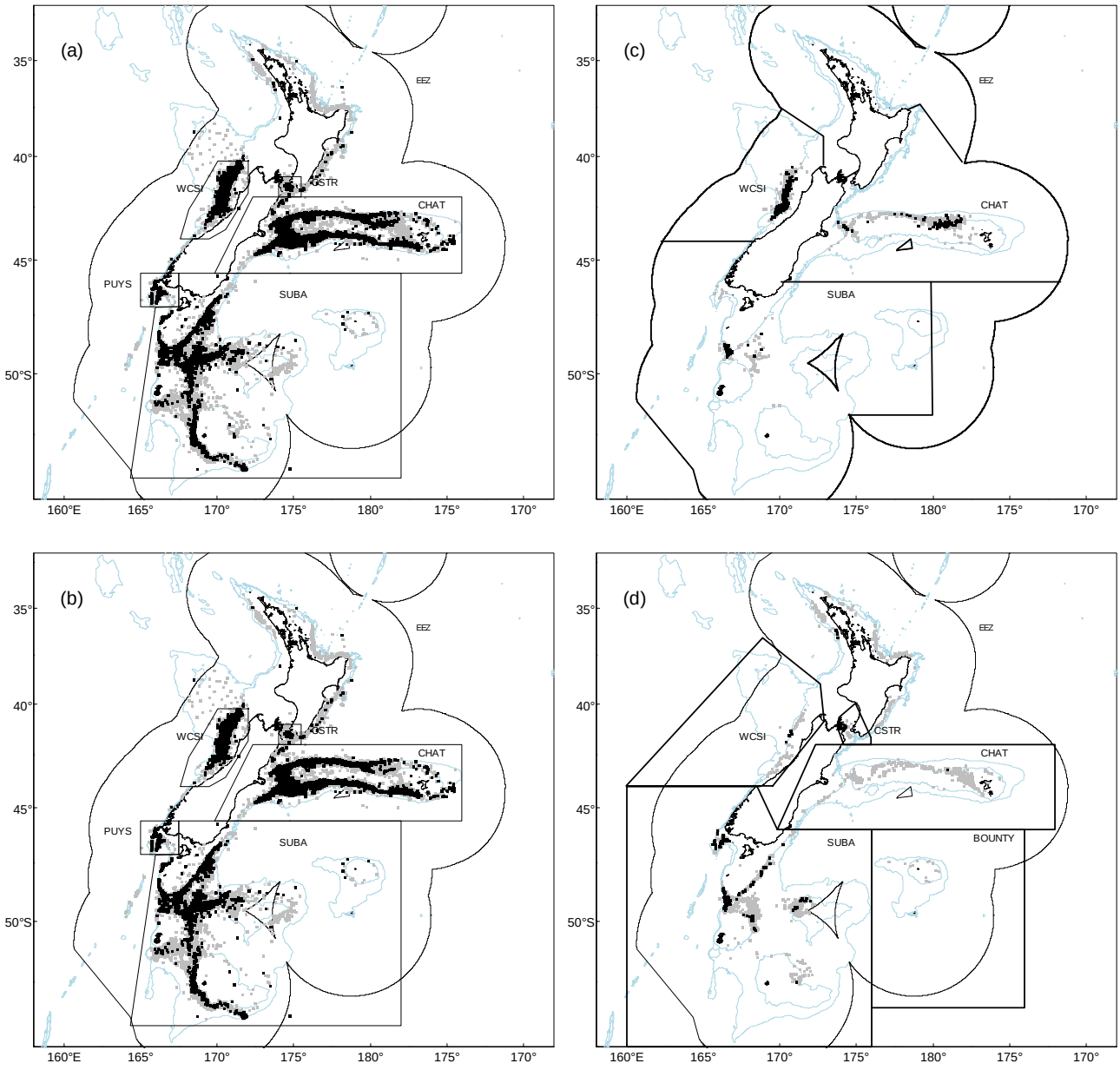


Figure 2: Distribution of tows targeting hoki, hake, or ling recorded by observers on vessels used in the analysis between 1 October 2000 and 30 September 2007 (black squares), and commercial tows targeting hoki, hake, or ling from the same dataset definition and period (grey squares). (a) Target hoki, hake or ling, hoki areas (b) target hoki, hoki areas (c) target hake, hake areas (d) target ling, ling areas.

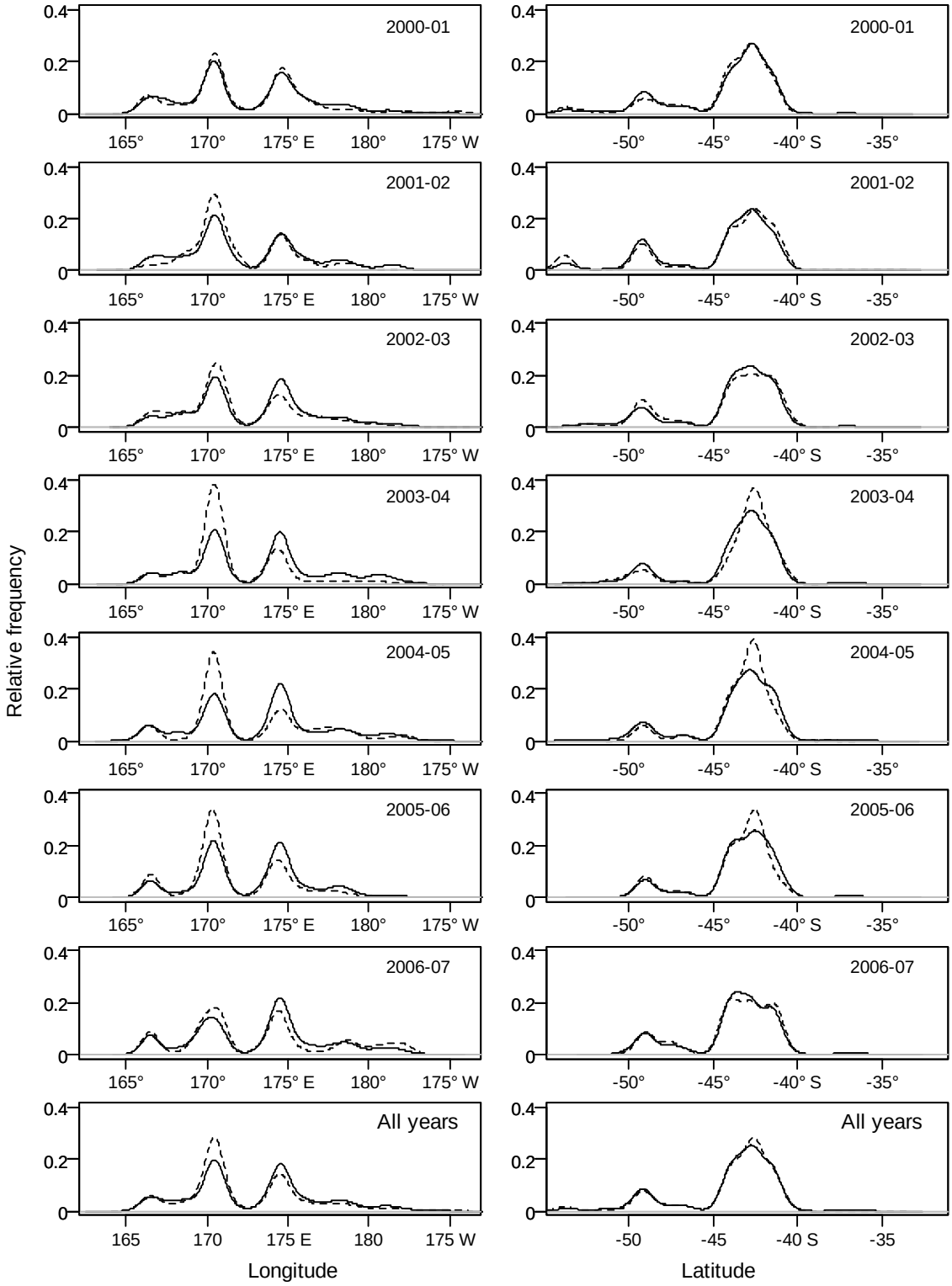


Figure 3a: Comparison of position (latitude and longitude) of target hoki, hake, and ling observed trawls (dashed lines) versus target hoki, hake, or ling trawls captured on TCEPR forms (solid line) for each fishing year from 2000–01 to 2006–07, and for all seven fishing years combined. The relative frequency was calculated from a density function which used linear approximation to estimate frequencies at a series of equally spaced points.

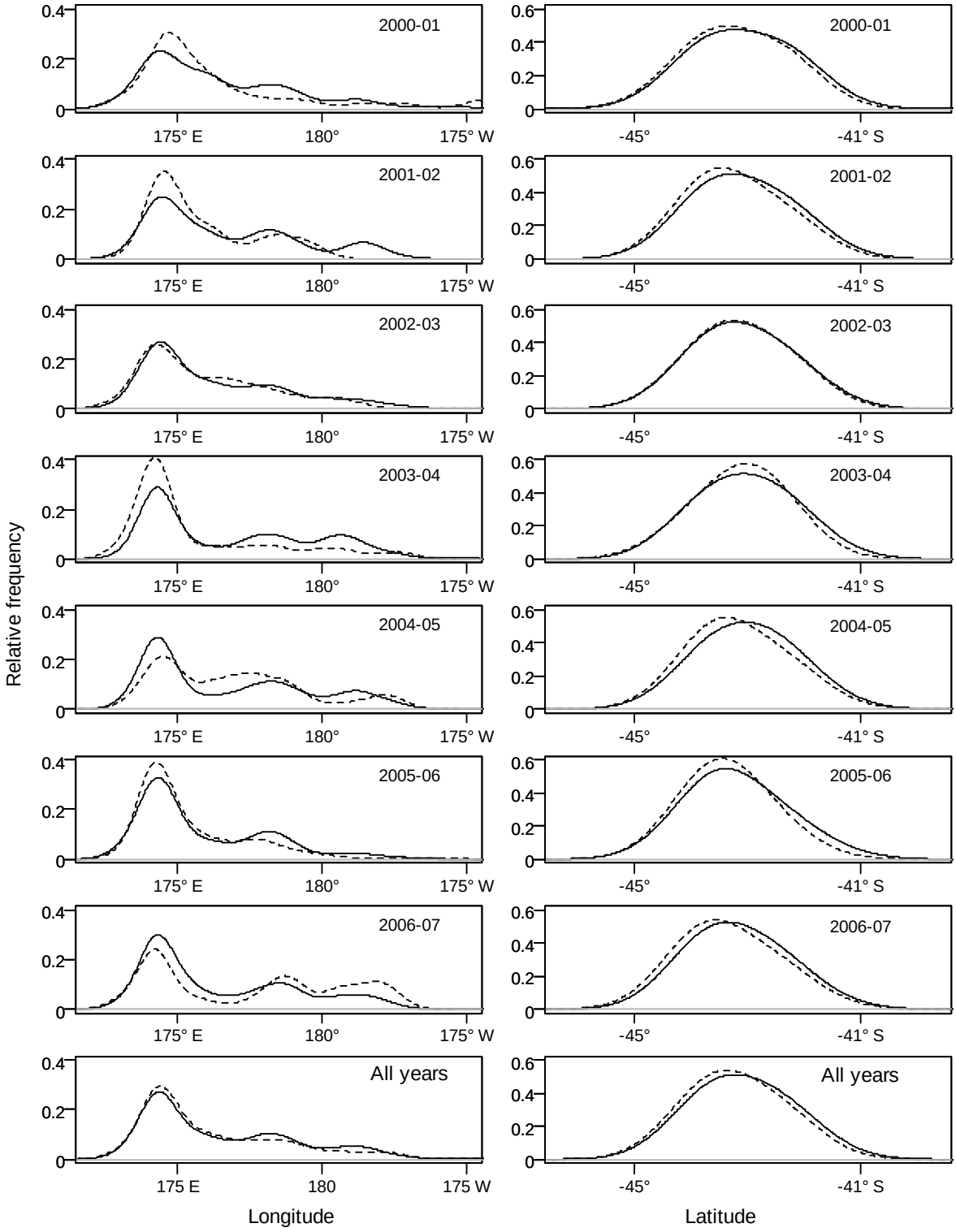


Figure 3b: Comparison of Chatham Rise position (latitude and longitude) of target hoki, hake, and ling observed trawls (dashed lines) versus target hoki, hake, or ling trawls captured on TCEPR forms (solid line) for each fishing year from 2000–01 to 2006–07, and for all seven fishing years combined. The relative frequency was calculated from a density function which used linear approximation to estimate frequencies at a series of equally spaced points.

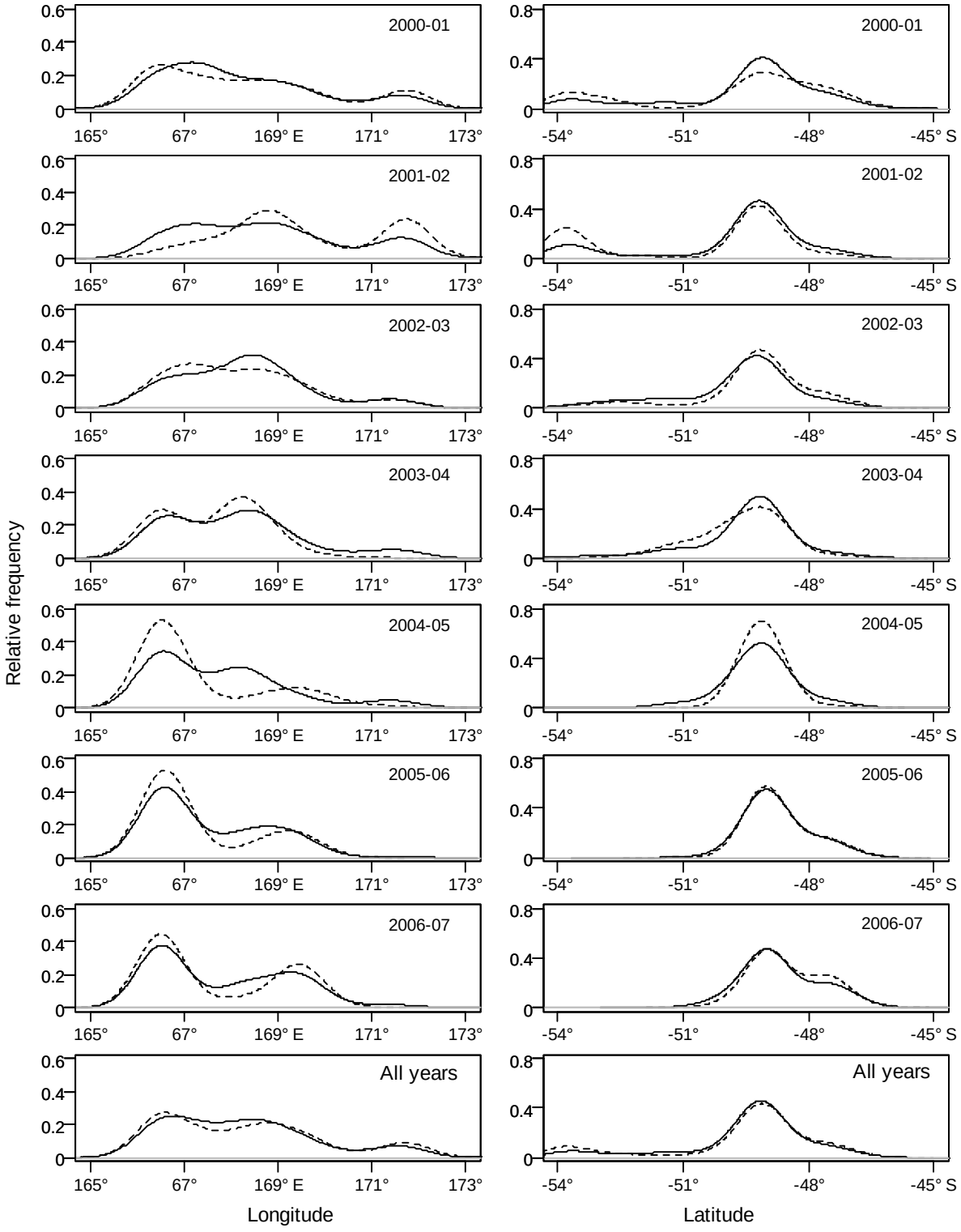


Figure 3c: Comparison of Sub-Antarctic position (latitude and longitude) of target hoki, hake, and ling observed trawls (dashed lines) versus target hoki, hake, or ling trawls captured on TCEPR forms (solid line) for each fishing year from 2000–01 to 2006–07, and for all seven fishing years combined. The relative frequency was calculated from a density function which used linear approximation to estimate frequencies at a series of equally spaced points.

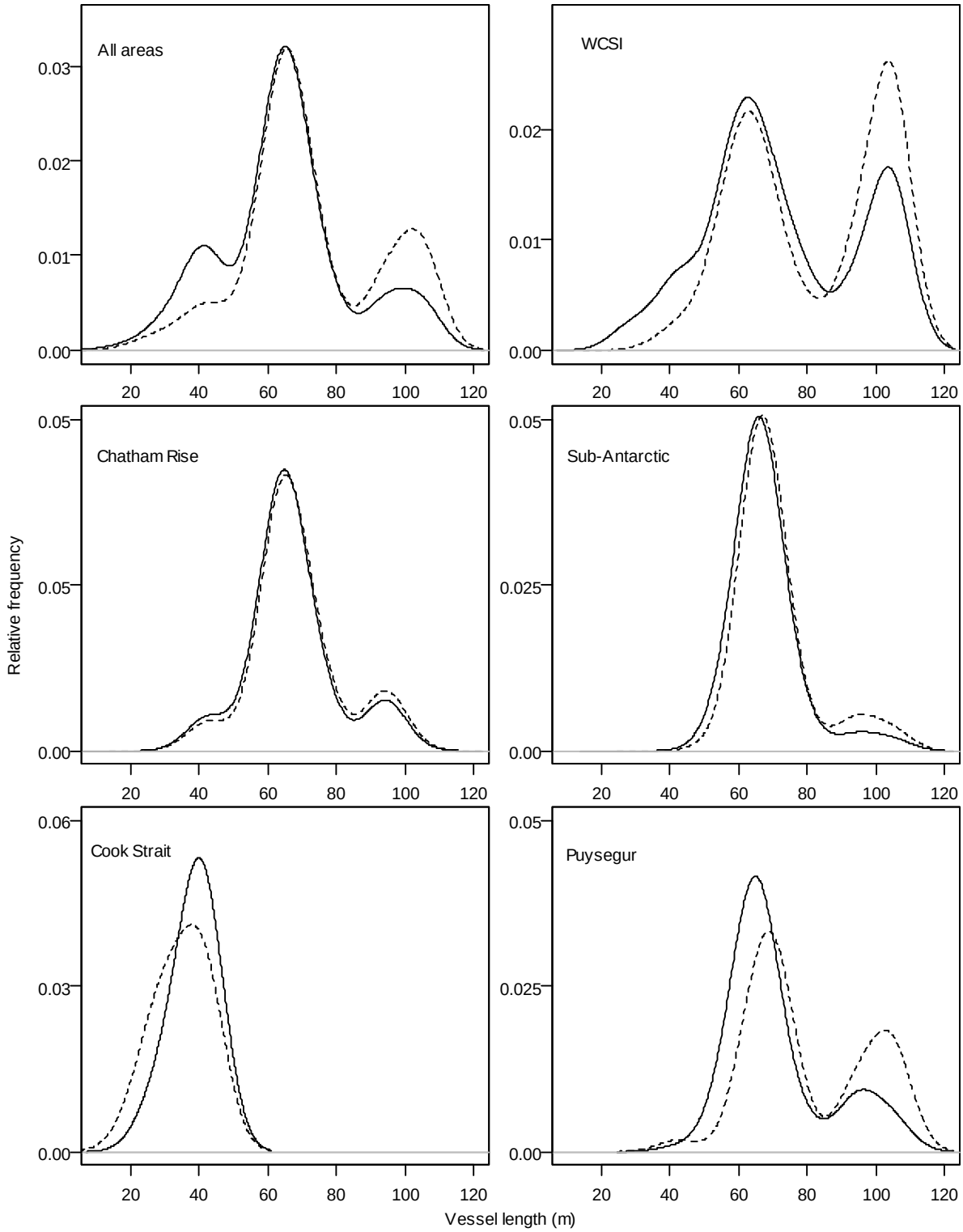


Figure 4: Comparison of vessel sizes (overall length (m)) in observed target hoki, hake, and ling trawls (dashed lines) versus target hoki, hake, and ling trawls captured on TCEPR forms (solid line) by area for all fishing years combined. The relative frequency was calculated from a density function which used linear approximation to estimate frequencies at a series of equally spaced points.

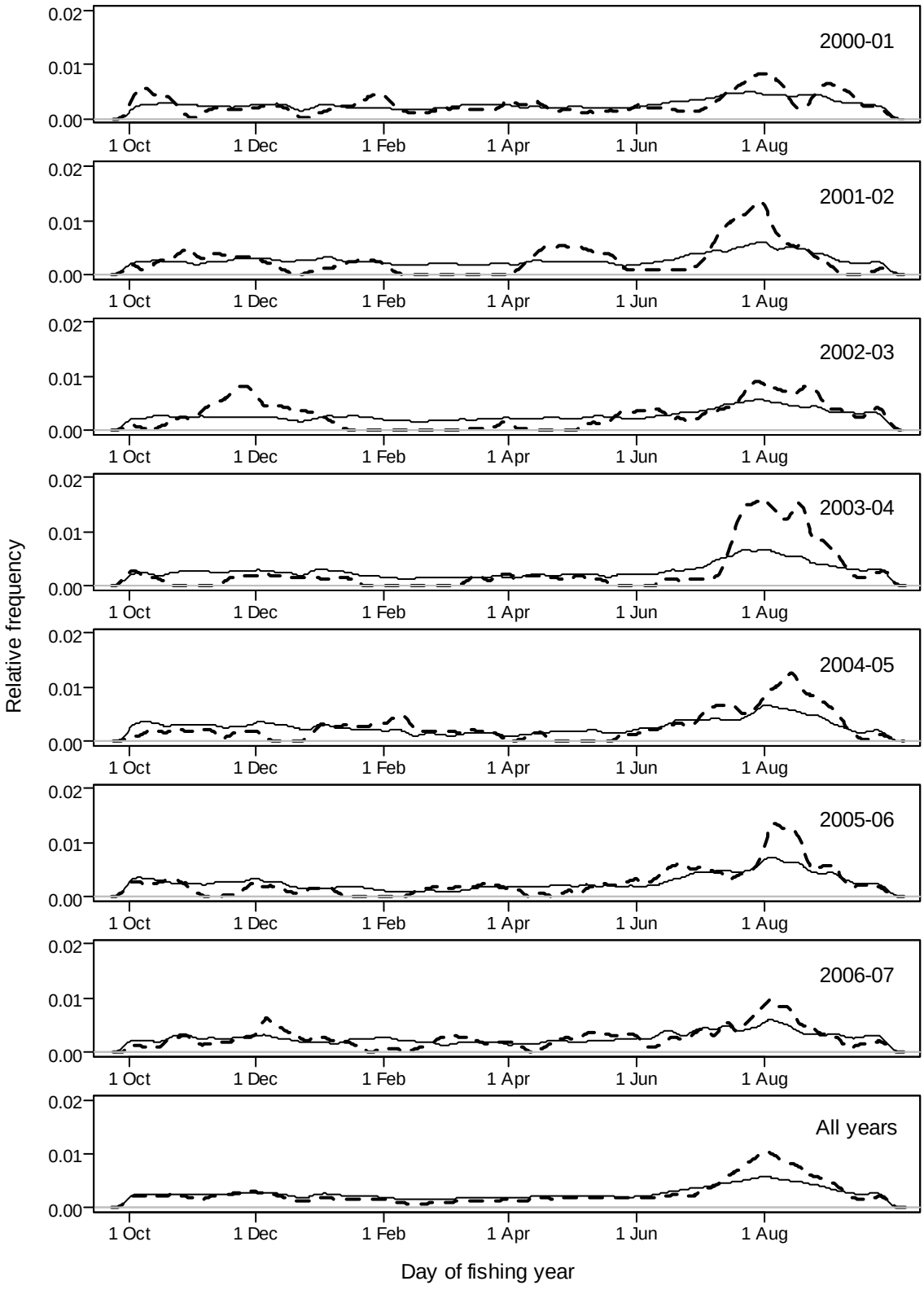


Figure 5: Comparison of the temporal spread of observed target hoki, hake, or ling trawls (dashed lines) with target hoki, hake, and ling trawls recorded on TCEPR forms (solid line) for each fishing year from 2000–01 to 2006–07, and for all seven fishing years combined. The relative frequency of the numbers of trawls was calculated from a density function which used linear approximation to estimate frequencies at a series of equally spaced points.

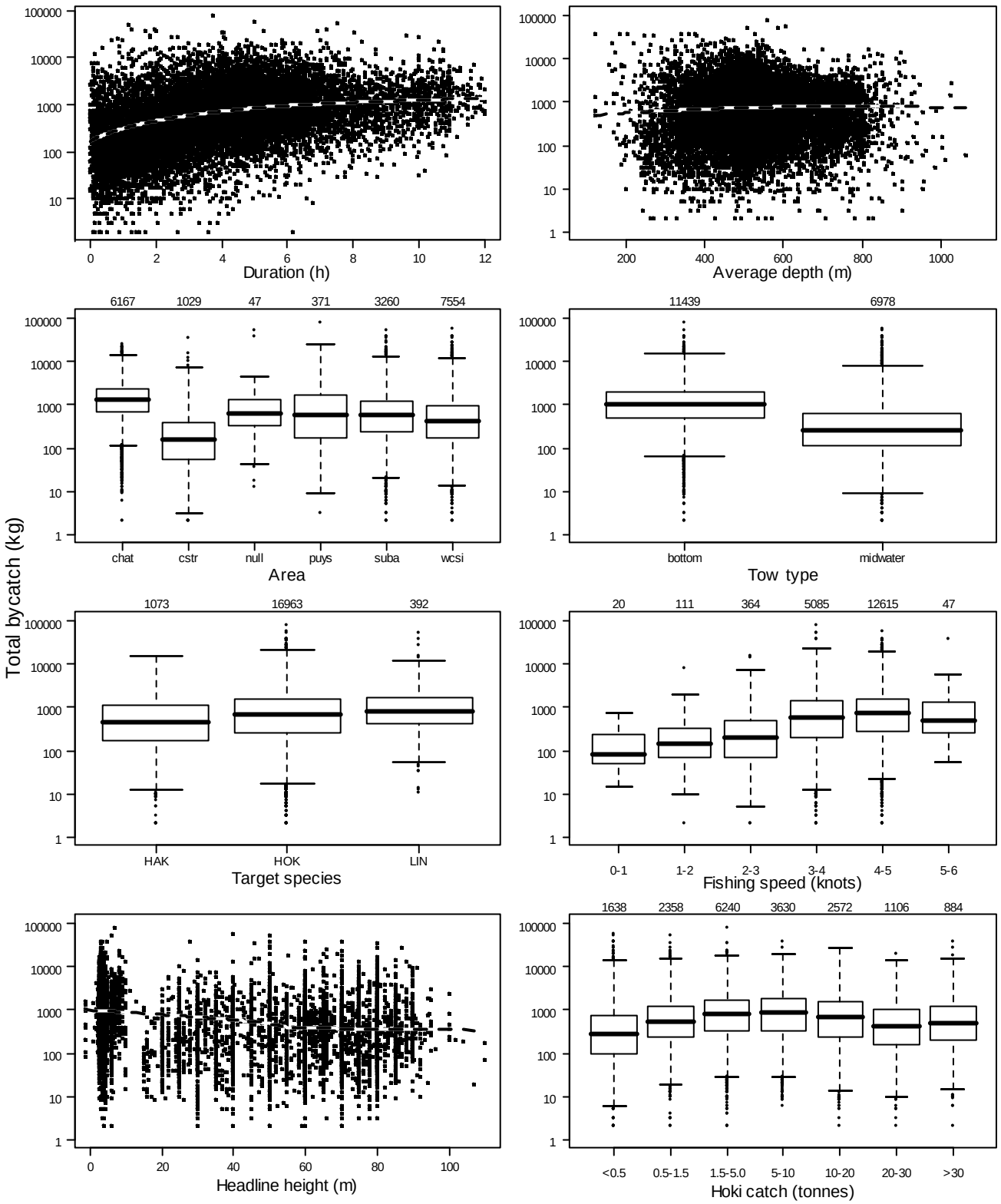
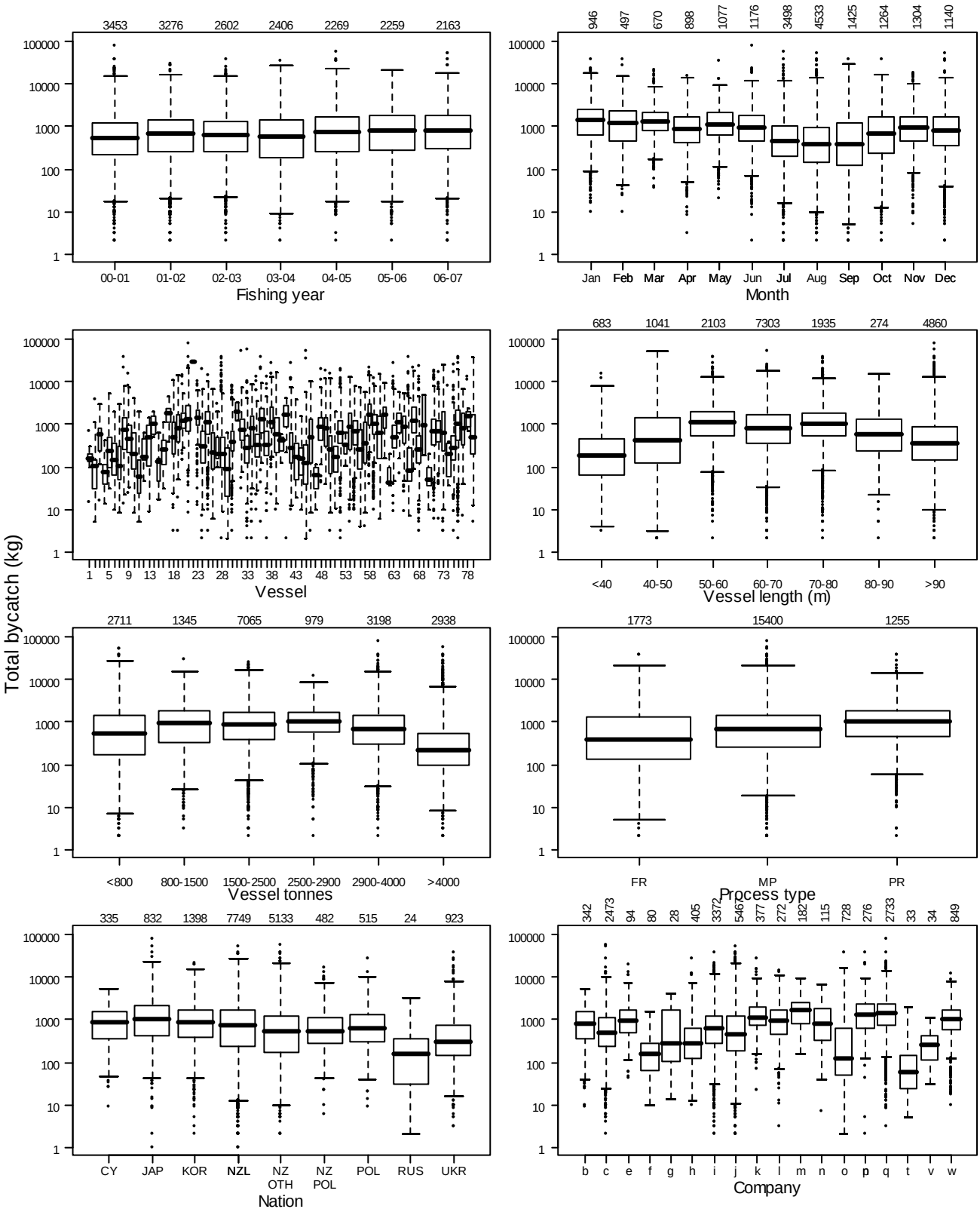


Figure 6: Total observed bycatch per tow plotted against some of the available variables for the hoki, hake, and ling target fishery. Total bycatch is plotted on a log scale. The dashed lines in the top two panels represent mean fits (using a locally weighted regression smoother) to the data. The box and whisker plots show medians and lower and upper quartiles in the box, whiskers extending up to 1.5x the interquartile range, and outliers individually plotted beyond the whiskers. The numbers above each plot indicate the number of records associated with that level of the variable. Average depth is the average of the start and finish gear depths. See Figure 1 for hoki area codes. FR, ice vessel; PR, factory vessel; MP, factory vessel with a meal plant.



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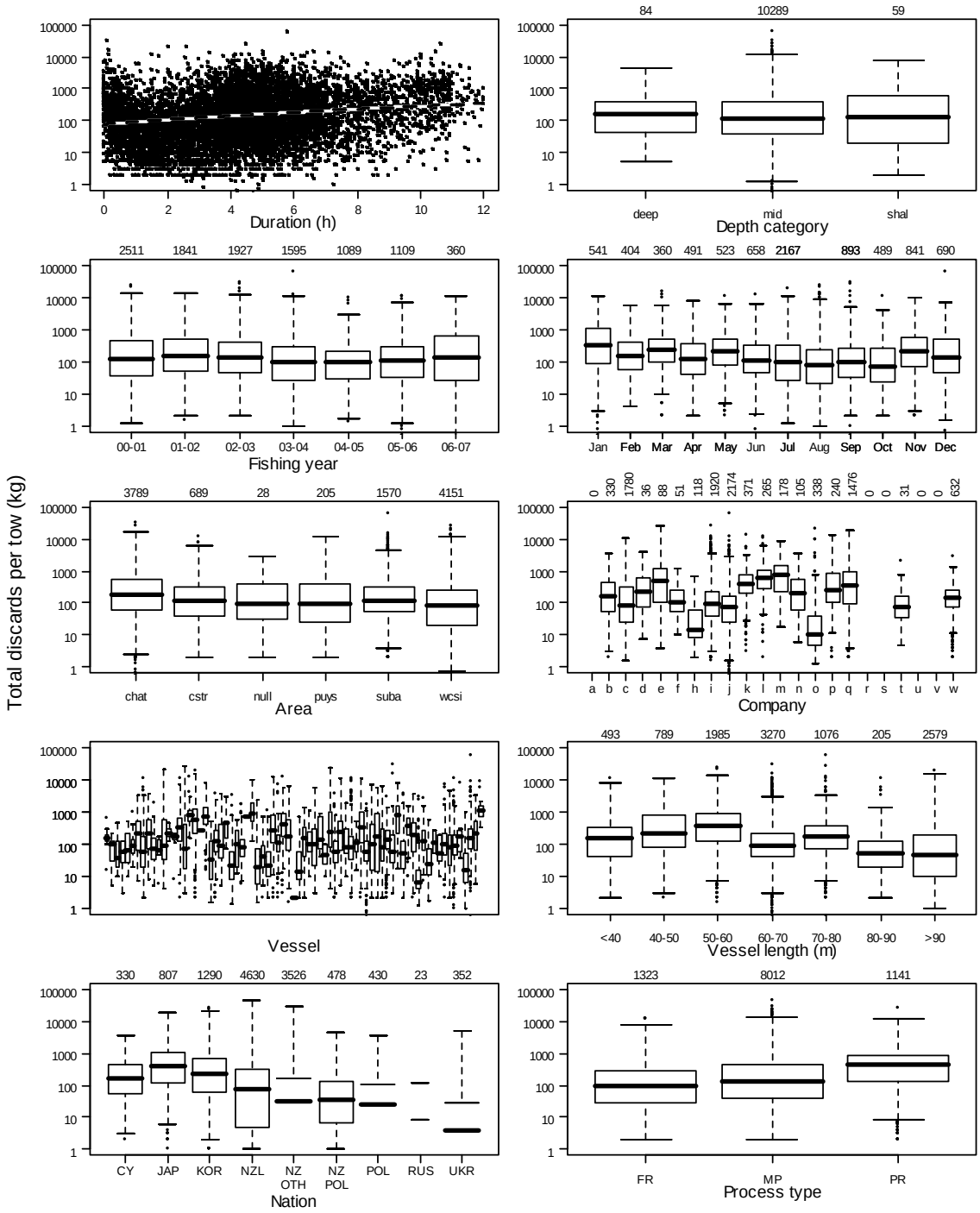


Figure 7: Total discards per tow for the target hoki, hake, and ling tow dataset (total discards per processing group divided by the number of tows in the group) plotted against some of the available variables (records with no discards excluded). Discards are plotted on a log scale. The dashed line in the top left panel represents a mean fit (using a locally weighted regression smoother) to the data. The box and whisker plots show medians and lower and upper quartiles in the box, whiskers extending up to 1.5x the interquartile range, and outliers individually plotted beyond the whiskers. Levels of variables represented by fewer than 20 records were not plotted. See Figure 1 for hoki area codes; shal, tows shallower than 200 m; mid tows 200–800 m; deep, tows 800 m or deeper. FR, ice-boat; PR, factory vessel; MP, factory vessel with a meal plant. Total discards include hoki, hake, and ling discards.

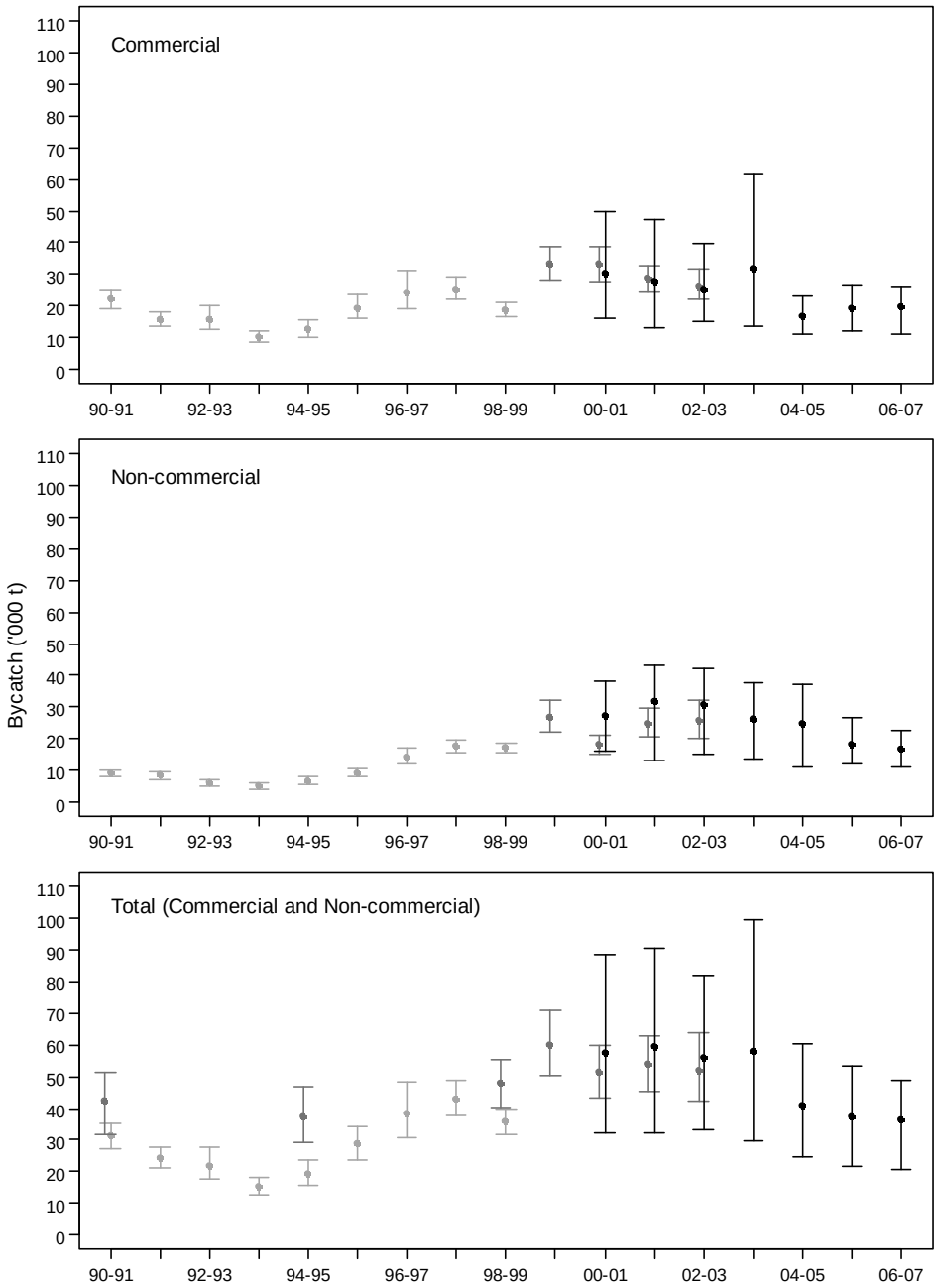


Figure 8: Annual estimates of fish bycatch in the target hoki, hake, or ling trawl fishery, calculated for commercial species, non-commercial species, and overall for 2000–01 to 2006–07 (black). Also shown (in light grey) are the COM, OTH, and TOT bycatch estimates calculated for 1990–91 to 1998–99 by Anderson et al. (2001), and COM, OTH and TOT bycatch estimates calculated for the years 1990–91, 1994–95, 1998–99 and 1999–2000 to 2002–03 by Anderson & Smith (2004), (in dark grey). Error bars show the 95% confidence intervals.

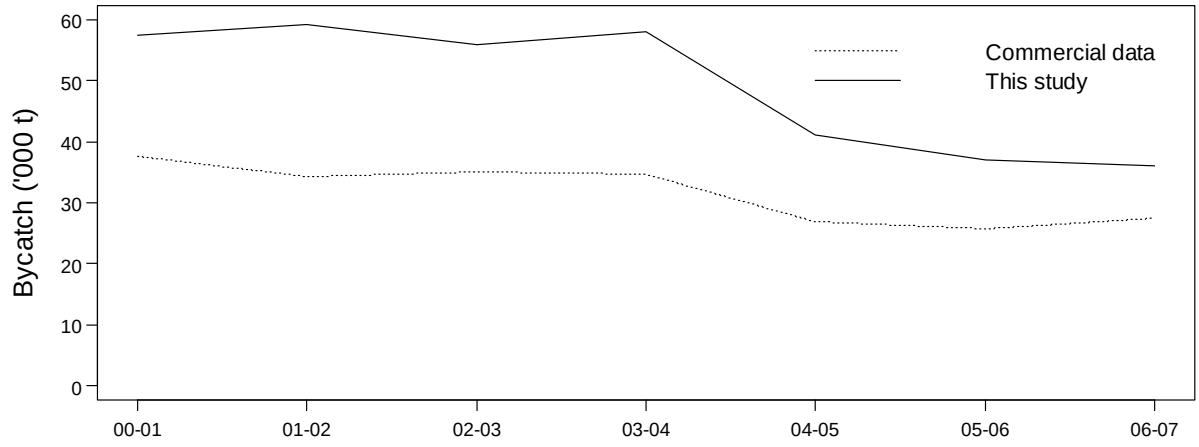


Figure 9a: Comparison of commercial (TCEPR and CELR) total bycatch in the target hoki, hake, and ling trawl fishery, with the estimated total bycatch levels calculated in this study.

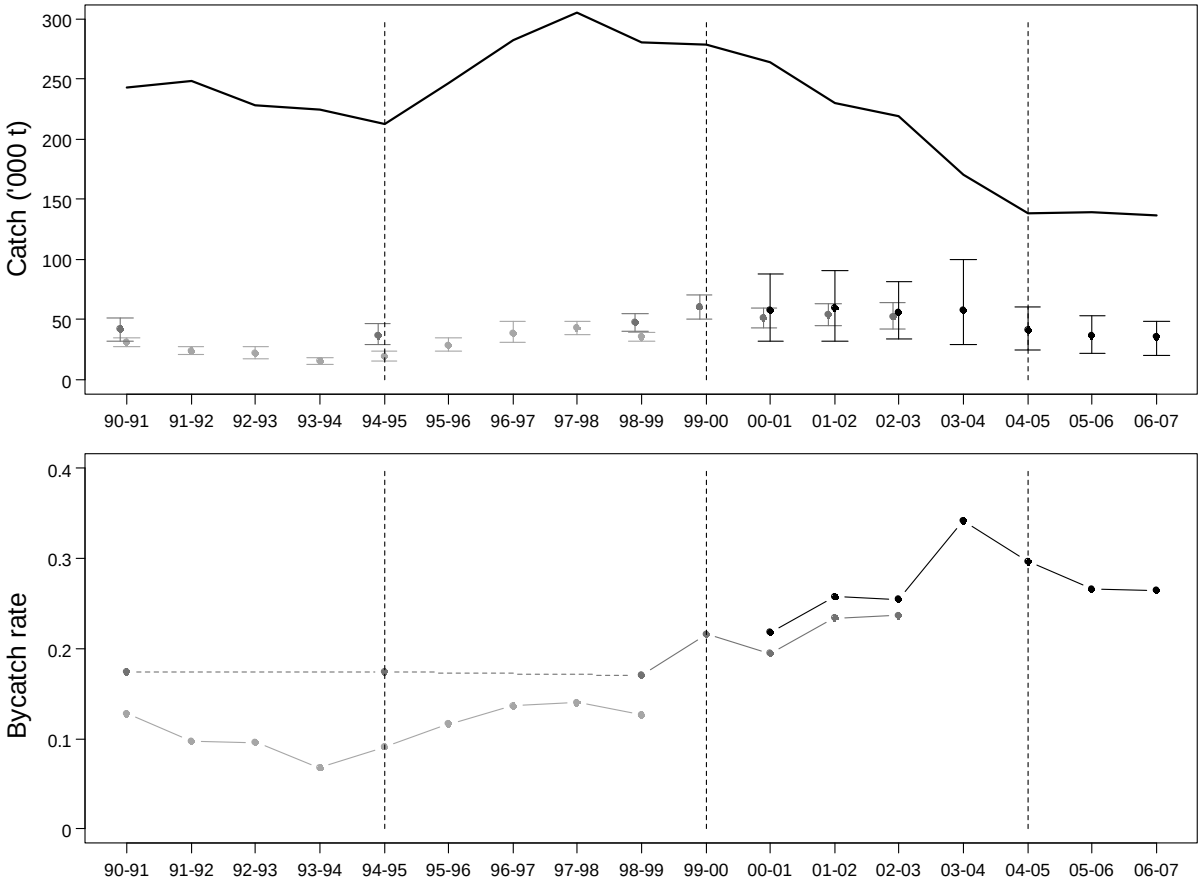


Figure 9b: Total hoki, hake, and ling catches, annual estimates of fish bycatch in the target hoki, hake, and ling trawl fishery, and bycatch rates for 1990–91 to 2006–07. Black: TOT bycatch estimates for 2000–01 to 2006–07 for the current study, Light grey: TOT bycatch estimates calculated for 1990–91 to 1998–99 by Anderson et al. (2001); Dark grey: TOT bycatch estimates calculated for the years 1990–91, 1994–95, 1998–99 and 1999–2000 to 2002–03 by Anderson & Smith (2004). Error bars show the 95% confidence intervals.

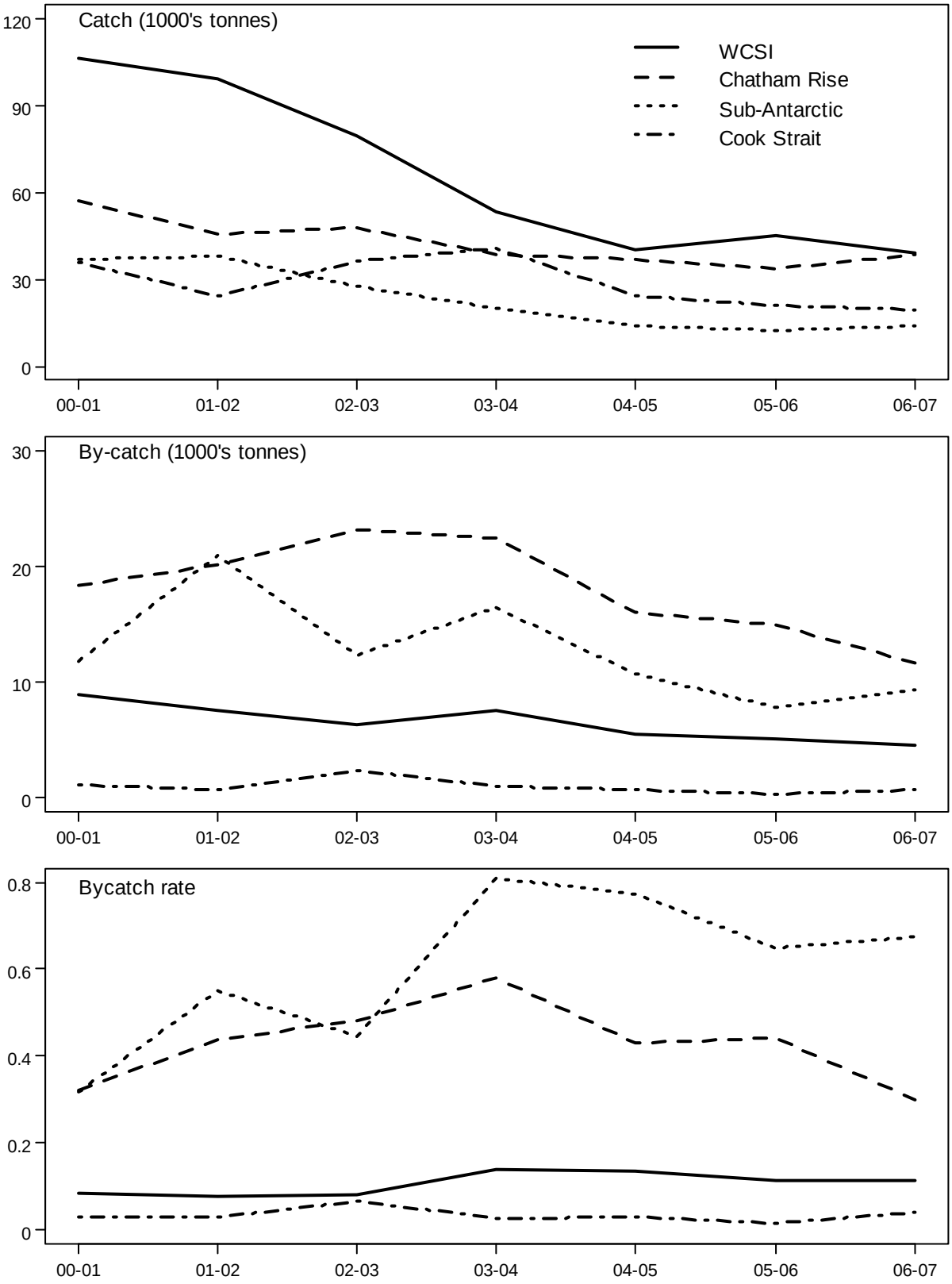


Figure 9c: Total hoki, hake, and ling catches, annual estimates of fish bycatch, and bycatch rates for 1990–91 to 2006–07 in the target hoki, hake, and ling trawl fishery for the main *hoki areas*.

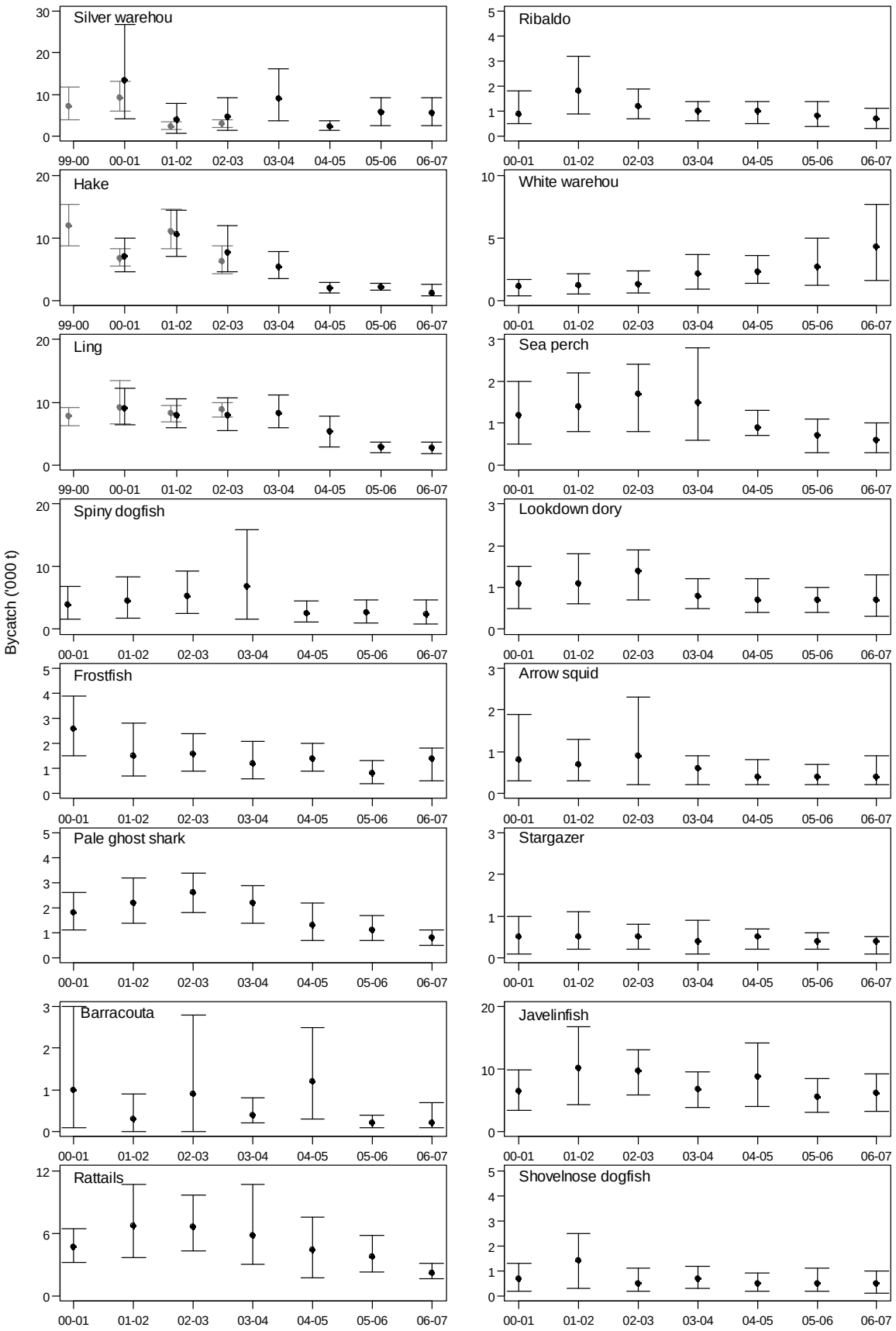


Figure 10: Annual estimates of fish bycatch calculated for various species (in the target hoki, hake, or ling trawl fishery), and hake and ling (in the target hoki trawl fishery) for 2000–01 to 2006–07 (in black). Also shown (in grey) are the silver warehou, hake, and ling bycatch estimates for 1999–2000 to 2002–03 by Anderson & Smith (2004). Error bars show the 95% confidence intervals.

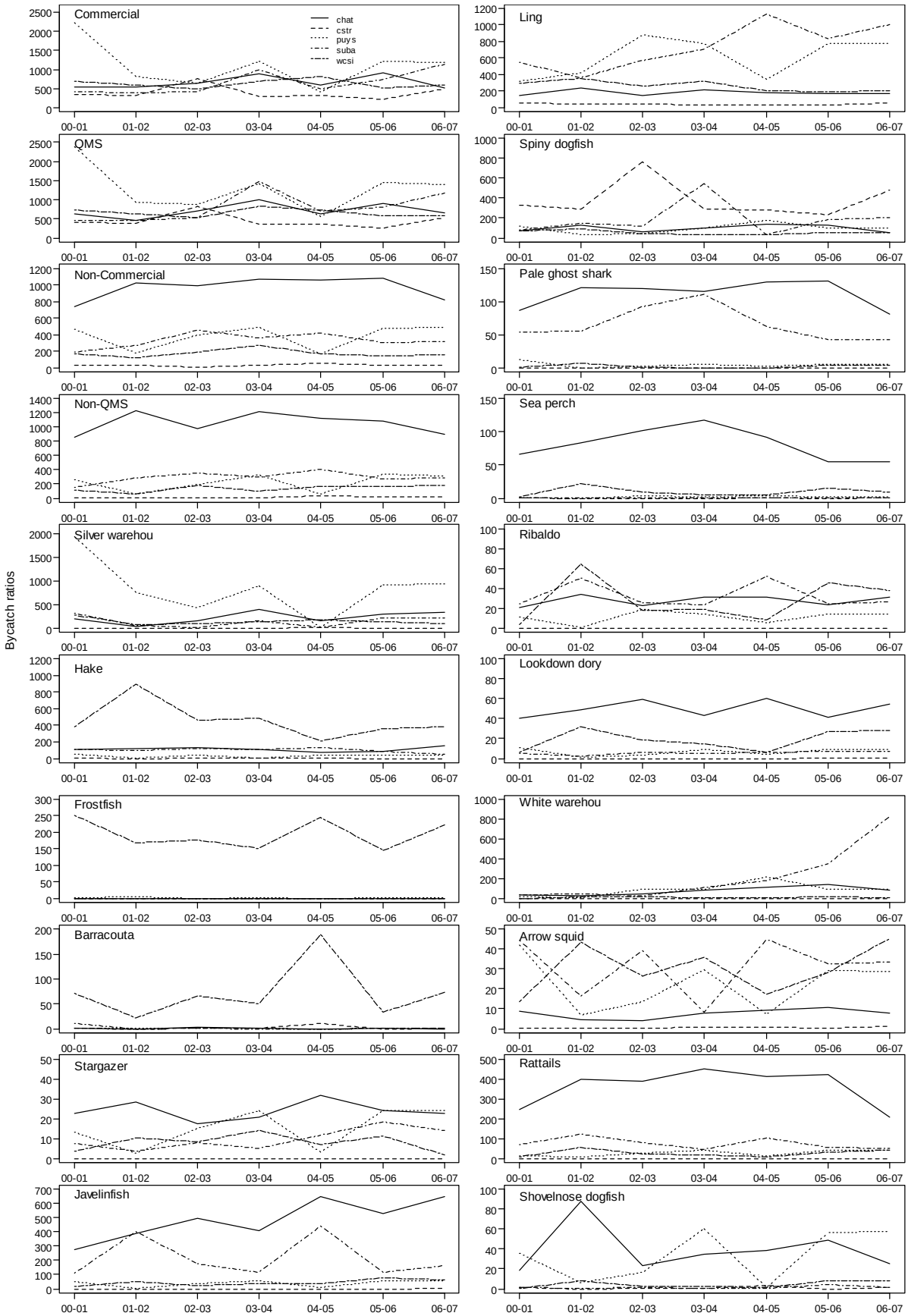


Figure 11: Annual bycatch ratios by hoki areas used for stratification for some species categories, in the hoki, hake, or ling target trawl fishery. Bycatch rates shown are the median of the bootstrap sample of 1000. Hake and ling calculated for the hoki target trawl fishery only.

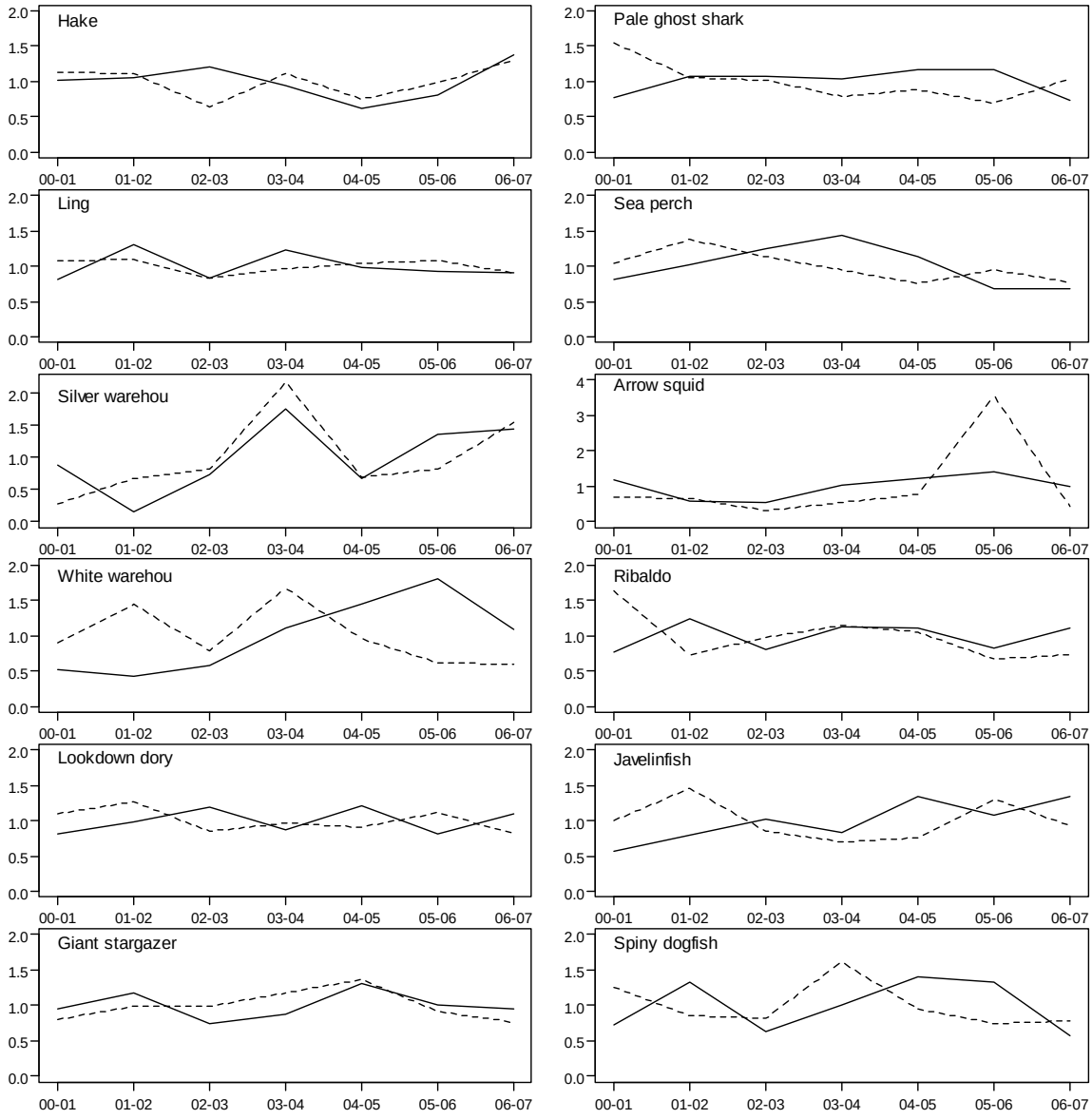


Figure 12a: Comparison of Chatham Rise *Tangaroa* January trawl standardised biomass survey estimates with standardised bycatch rates of selected species. Line, bycatch rates; dashed line, biomass survey estimates.

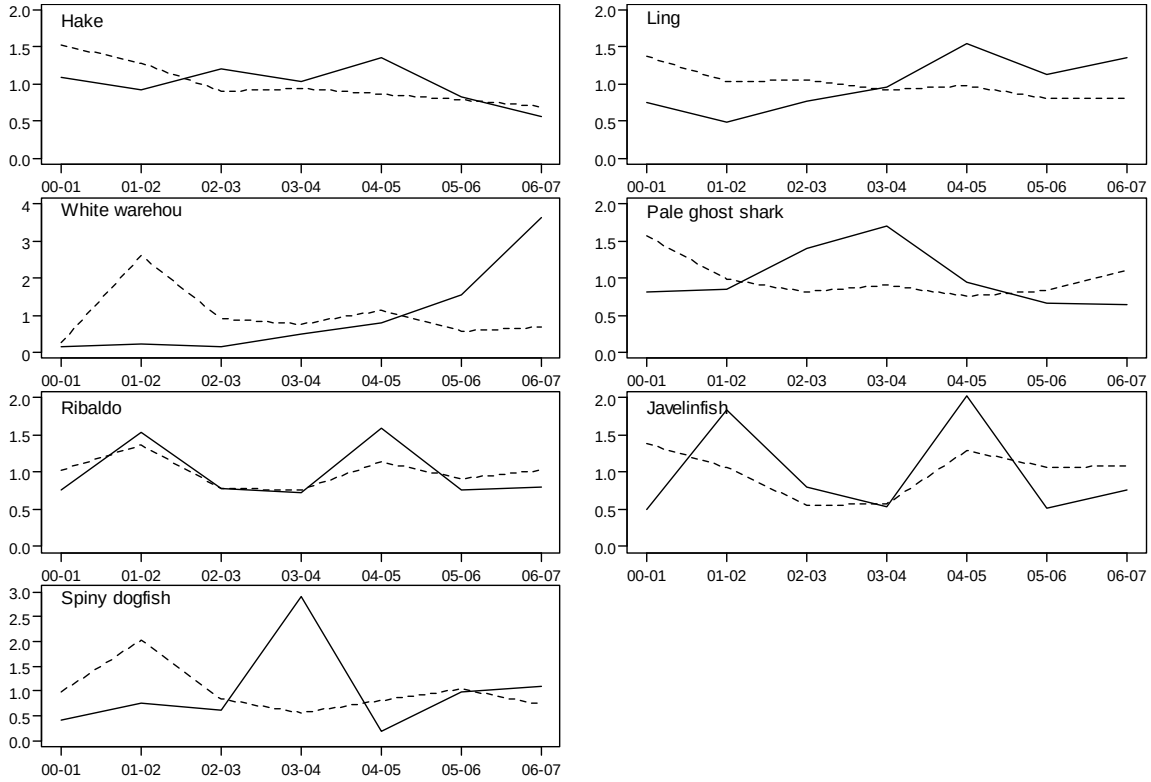


Figure 12b: Comparison of Sub-Antarctic *Tangaroa* November–December trawl standardised biomass survey estimates with standardised bycatch rates of selected species. Hake and ling biomass estimates are from core strata, others are total biomass. Line, standardised bycatch rates; dashed line, standardised biomass survey estimates.

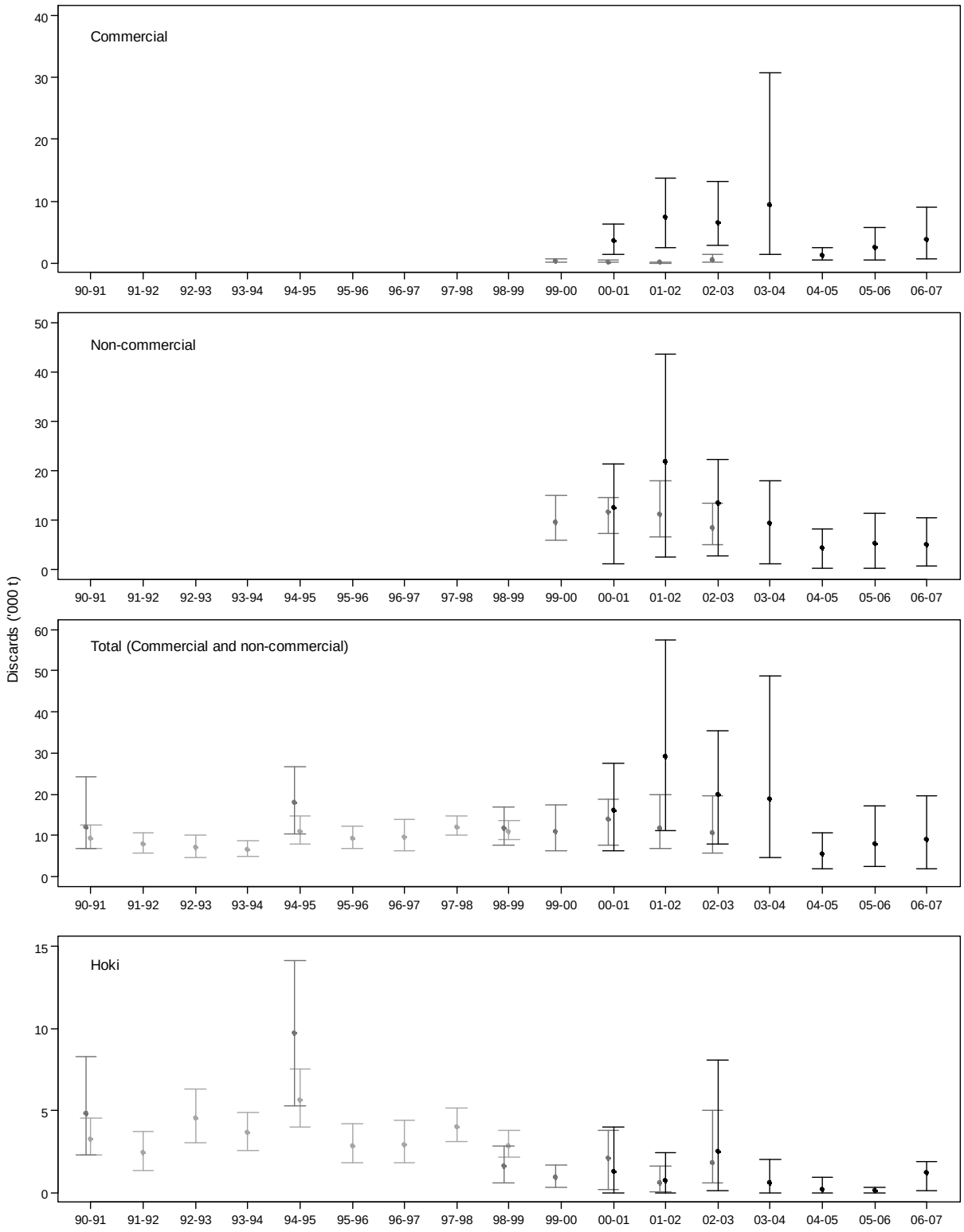


Figure 13: Annual estimates of fish discards in the target hoki, hake, and ling trawl fishery, calculated for commercial species, non-commercial species, overall and hoki for the period 2000–01 to 2006–07 (black). Also shown (in light grey) are the COM, OTH, and TOT discard estimates calculated for the period 1990–91 to 1998–99 by Anderson et al. (2001), and COM, OTH and TOT discard estimates calculated for 1990–91, 1994–95, 1998–99 and 1999–2000 to 2002–03 by Anderson & Smith (2004), (in dark grey). Error bars show the 95% confidence intervals.

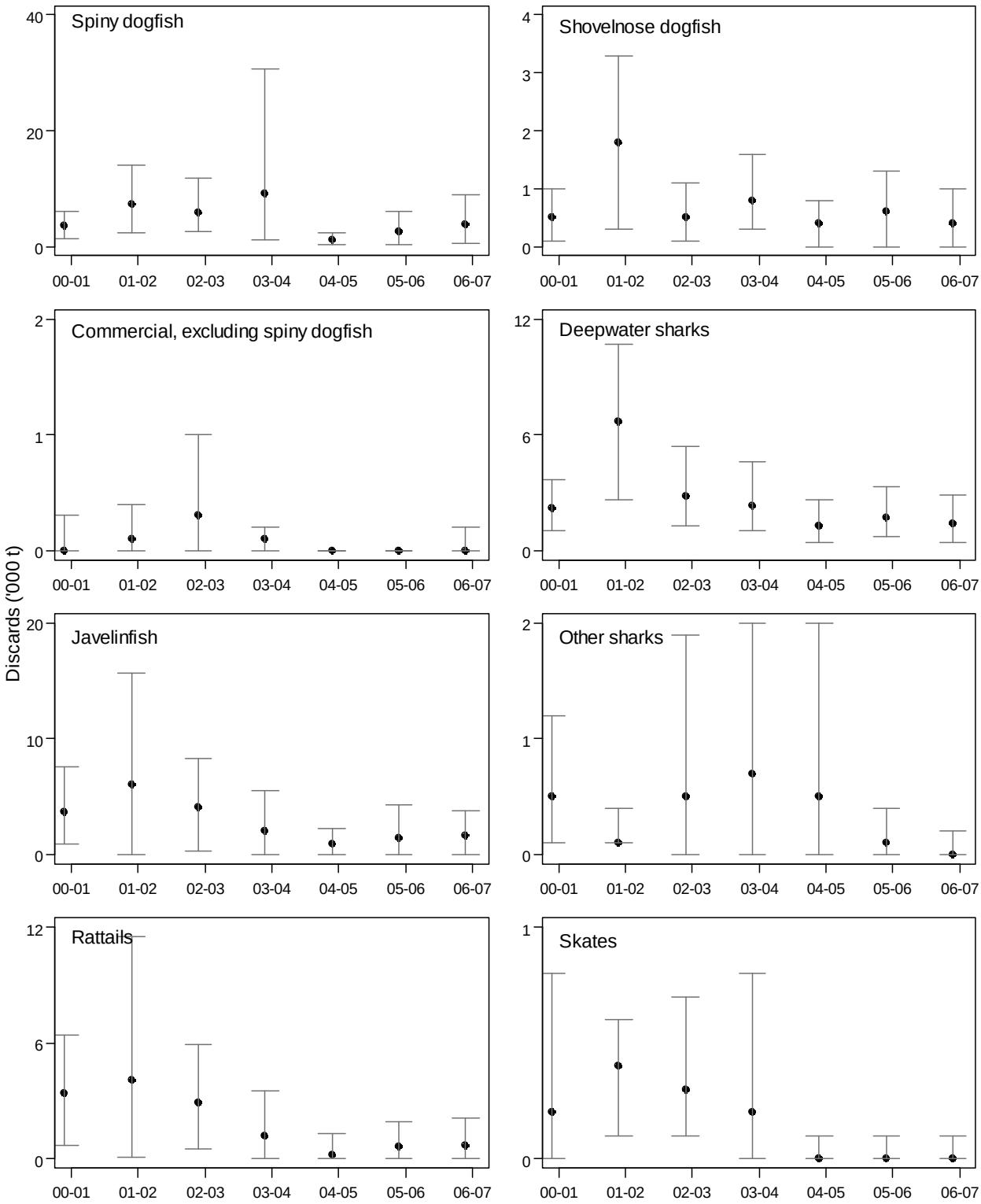


Figure 14: Annual estimates of selected species discards in the target hoki, hake, and ling trawl fishery for 2000–01 to 2006–07. Error bars show the 95% confidence intervals.

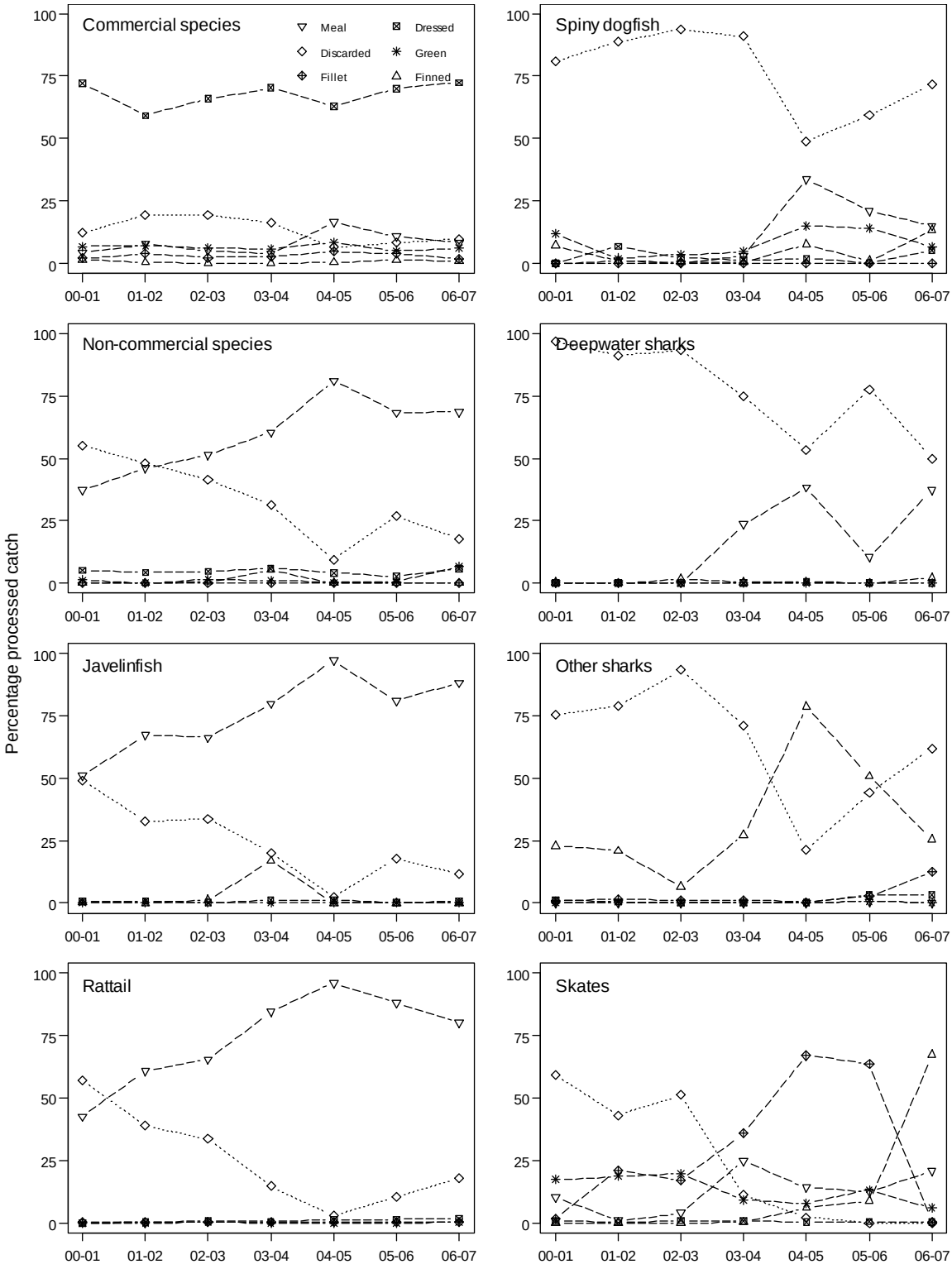


Figure 15: Observed percentage of for processed catches (processed group data) by processed state codes for selected species or species groups in the target hoki, hake, and ling fishery for 2000–01 to 2006–07.

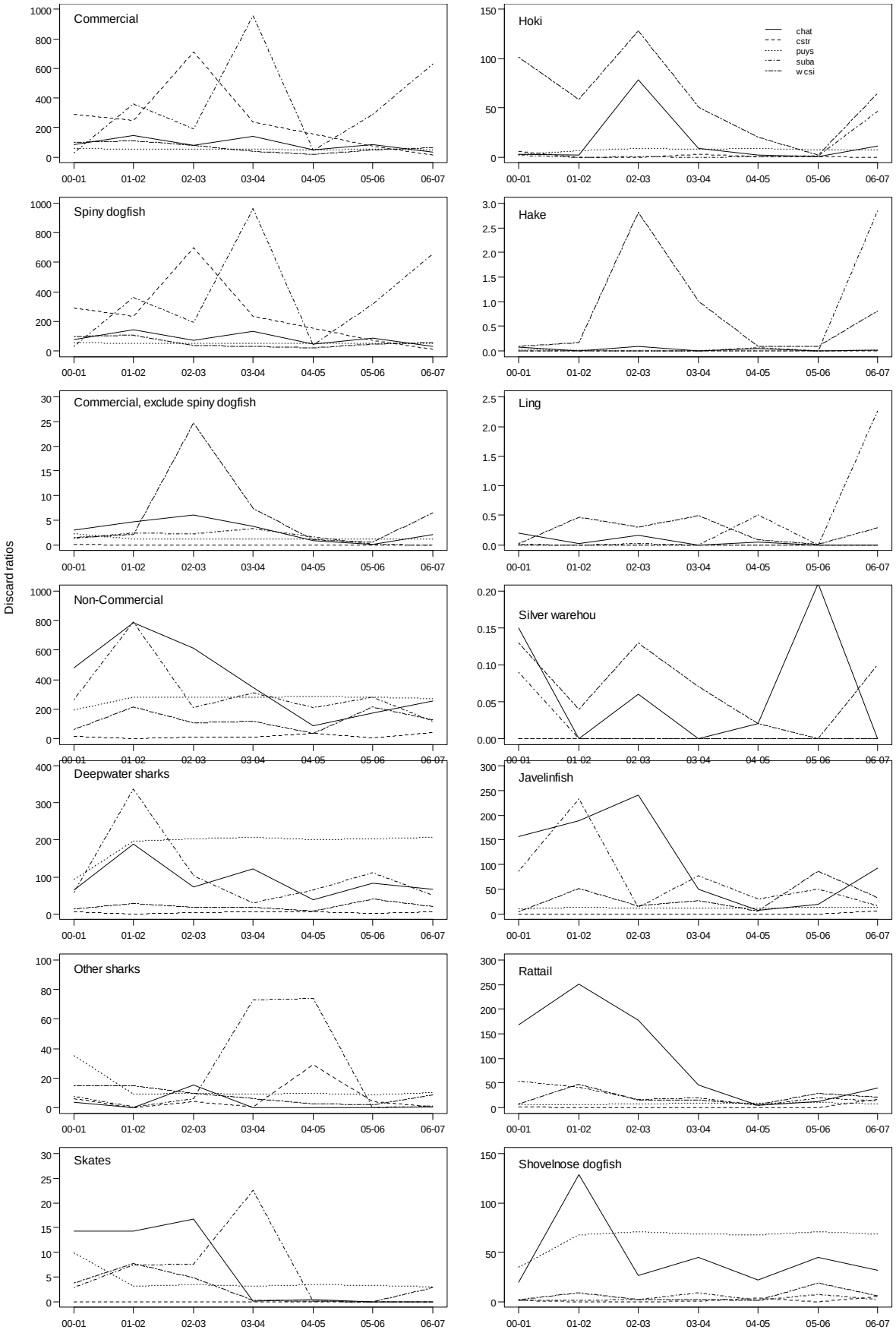


Figure 16: Annual discard ratios of selected species or species categories in the target hoki, hake, and ling trawl fishery. Hake and ling were calculated for the target hoki trawl fishery only. Discard rates shown are the median of the bootstrap sample of 1000.

Appendix 1: Species codes, common and scientific names, estimated catch weight, percentage of the total catch, and percentage of species catch discarded (to the nearest 0.01 percent), of the top species by weight down to 0.01% of the catch from all observer records for the hoki, hake, and ling target fisheries from 1 Oct 2000 to 30 Sep 2007. Catches are calculated from summed raw records, and may be unreliable if coverage is not representative. Records are ordered by decreasing percentage of catch.

(a) All areas.

Species code	Common name	Scientific name	Estimated catch (t)	% of catch	% Discarded
HOK	Hoki	*Macruronus novaezelandiae*	151915.5	77.65	0.36
HAK	Hake	*Merluccius australis*	12330.8	6.30	0.05
LIN	Ling	*Genypterus blacodes*	7721.5	3.95	0.04
JAV	Javelinfish	*Lepidorhynchus denticulatus*	4069.9	2.08	23.78
SWA	Silver warehou	*Seriolella punctata*	3409.3	1.74	0.04
RAT	Rattails	Macrouridae	2725.5	1.39	27.42
SPD	Spiny dogfish	*Squalus acanthias*	2077.1	1.06	88.58
FRO	Frostfish	*Lepidopus caudatus*	1593.0	0.81	1.50
WWA	White warehou	*Seriolella caerulea*	1223.4	0.63	0.02
GSP	Pale ghost shark	*Hydrolagus bemisi*	928.3	0.47	0.23
BAR	Barracouta	*Thyrsites atun*	593.6	0.30	2.00
SPE	Sea perch	*Helicolenus* spp	589.8	0.30	0.67
RIB	Ribaldo	*Mora moro*	521.4	0.27	0.34
LDO	Lookdown dory	*Cyttus traverse*	479.5	0.25	5.22
SQU	Arrow squid	*Nototodarus sloanii, N. gouldi*	403.2	0.21	0.69
SND	Shovelnose dogfish	*Deania calcea*	314.3	0.16	87.39
BOE	Black oreo	*Allocyttus niger*	274.1	0.14	0.01
STA	Giant stargazer	*Kathetostoma giganteum*	263.2	0.13	0.10
BSH	Seal shark	*Dalatias licha*	237.9	0.12	80.44
SKI	Gemfish	*Rexea solandri*	225.4	0.12	0.39
JMA	Jack mackerel	*Trachurus declivis, T. s. murphyi, T. novaezelandiae*	178.5	0.09	0.01
OSD	Other shark and dogs	Order selachii	174.1	0.09	61.45
BYS	Alfonsino	*Beryx splendens*	169.4	0.09	2.00
SSK	Smooth skate	*Dipturus innominatus*	165.3	0.08	15.44
ONG	Sponges	Porifera	154.2	0.08	99.95
DWD	Deepwater dogfish	-	148.8	0.08	91.17
RBM	Ray's bream	*Brama brama*	145.1	0.07	8.25
GSH	Ghost shark	*Hydrolagus novaezealandiae*	142.8	0.07	2.33
WSQ	Warty squid	*Moroteuthis* spp	123.6	0.06	89.30
BSK	Basking shark	*Cetorhinus maximus*	120.7	0.06	46.28
RCO	Red cod	*Pseudophycis bachus*	115.6	0.06	1.20
LCH	Long nosed chimaera	*Harriotta raleighana*	102.8	0.05	18.49
SBW	Southern blue whiting	*Micromesistius australi*	101.8	0.05	0.05
BEN	Scabbardfish	*Benthodesmus* spp	99.6	0.05	21.92
BBE	Banded bellowsfish	*Centriscops humerosus*	98.8	0.05	74.22
SSI	Silverside	*Argentina elongata*	93.7	0.05	50.50
SOR	Spiky oreo	*Neocyttus rhomboidalis*	90.6	0.05	0.47
ORH	Orange roughy	*Hoplostethus atlanticus*	80.6	0.04	0.02
RBT	Redbait	*Emmelichthys nitidus*	76.9	0.04	10.22
FHD	Deepsea flathead	*Hoplichthys haswelli*	67.3	0.03	50.61
RUD	Rudderfish	*Centrolophus niger*	58.7	0.03	53.53
POS	Porbeagle shark	*Lamna nasus*	55.6	0.03	54.85
BNS	Bluenose	*Hyperoglyphe antarctica*	54.9	0.03	0.65
SKA	Skate families	Rajidae and Arhynchobatidae	53.7	0.03	74.64
SSO	Smooth oreo	*Pseudocyttus maculatus*	50.0	0.03	0.03
CON	Conger eel	*Conger* spp	49.8	0.03	63.65
TOA	Toadfish	*Neophrynichthys* sp.	47.0	0.02	43.38
DEA	Dealfish	*Trachipterus trachypterus*	42.7	0.02	9.75
GLS	Glass sponge	-	36.6	0.02	100.00
SFI	Starfish	Asteroidea & Ophiuroidea	35.0	0.02	93.12

Appendix 1 (a) All areas continued.

Species code	Common name	Scientific name	Estimated catch (t)	% of catch	% Discarded
SCH	School shark	*Galeorhinus galeus*	32.6	0.02	3.99
WAR	Common warehou	*Seriolella brama*	30.8	0.02	0.00
SDO	Silver dory	*Cyttus novaezealandiae*	29.8	0.02	13.92
RSK	Rough skate	*Dipturus nasutus*	27.0	0.01	2.21
HAP	Hapuku	*Polyprion oxygeneios*	25.6	0.01	0.81
CSQ	Centrophorus squamosus	*Centrophorus squamosus*	25.3	0.01	95.89
RHY	Common roughy	*Paratrachichthys trailli*	23.4	0.01	59.88
ETL	Lucifer dogfish	*Etmopterus lucifer*	20.4	0.01	92.36
NSD	Northern spiny dogfish	*Squalus griffini*	20.2	0.01	98.89
SNA	Snapper	*Pagrus auratus*	19.7	0.01	76.06
ETM	Etmopterus sp	*Etmopterus* sp	19.6	0.01	50.41
CDL	Cardinalfish	Apogonidae	19.1	0.01	0.68
ETB	Baxter's lantern dogfish	*Etmopterus baxteri*	18.3	0.01	76.56
SLK	Slickhead	*Alepocephalidae*	18.2	0.01	69.88
HOR	Horse mussel	*Atrina zelandica*	16.3	0.01	NA
HJO	Johnson's cod	*Halargyreus johnsonii*	16.1	0.01	4.24
SSH	Slender smooth hound	*Gollum attenuatus*	16.0	0.01	99.78
SWO	Broadbill swordfish	*Xiphias gladius*	14.7	0.01	25.56
SCI	Scampi	*Metanephrops challengeri*	13.6	0.01	4.02
SCO	Swollen headed conger	*Bassanago bulbiceps*	12.4	0.01	89.43
TAR	Tarakihi	*Nemadactylus macropterus*	12.1	0.01	0.18
STN	Southern bluefin tuna	*Thunnus maccoyii*	11.1	0.01	85.73
RBY	Rubyfish	*Plagiogeneion rubiginosum*	10.6	0.01	12.34
MAK	Mako shark	*Isurus oxyrinchus*	10.5	0.01	71.61
BYX	Alfonsino and longfinned beryx	*Beryx splenden &.B decadactylus*	10.4	0.01	17.54
SHA	Shark	-	10.0	0.01	79.88
WHX	White rattail	*Trachyrincus aphyodes*	9.8	0.01	66.10

Appendix 1 (b): WCSI hoki area.

Species code	*Common name*	*Scientific name*	*Estimated catch (t)*	*% of catch*	*% Discarded*
HOK	Hoki	*Macruronus novaezelandiae*	81793.8	82.26	0.54
HAK	Hake	*Merluccius australis*	8769.7	8.82	0.07
LIN	Ling	*Genypterus blacodes*	2164.8	2.18	0.09
FRO	Frostfish	*Lepidopus caudatus*	1587.2	1.60	1.51
SWA	Silver warehou	*Seriolella punctata*	1117.8	1.12	0.08
BAR	Barracouta	*Thyrsites atun*	562.1	0.57	1.87
SPD	Spiny dogfish	*Squalus acanthias*	430.0	0.43	79.03
JAV	Javelinfish	*Lepidorhynchus denticulatus*	348.4	0.35	53.54
RIB	Ribaldo	*Mora moro*	227.2	0.23	0.74
SQU	Arrow squid	*Nototodarus sloanii, N. gouldi*	225.5	0.23	0.95
SKI	Gemfish	*Rexea solandri*	221.0	0.22	0.39
RAT	Rattails	Macrouridae	214.5	0.22	59.20
LDO	Lookdown dory	*Cyttus traverse*	142.6	0.14	7.33
JMA	Jack mackerel	*Trachurus declivis, T. s. murphyi, T. novaezelandiae*	100.7	0.10	0.03
WWA	White warehou	*Seriolella caerulea*	100.0	0.10	0.02
BEN	Scabbardfish	*Benthodesmus* spp	99.4	0.10	21.88
SPE	Sea perch	*Helicolenus* spp	77.5	0.08	4.64
SSK	Smooth skate	*Dipturus innominatus*	76.9	0.08	8.10
RBT	Redbait	*Emmelichthys nitidus*	72.7	0.07	10.28
STA	Giant stargazer	*Kathetostoma giganteum*	69.9	0.07	0.15
BSK	Basking shark	*Cetorhinus maximus*	61.8	0.06	6.58
RCO	Red cod	*Pseudophycis bachus*	58.0	0.06	1.67
OSD	Other shark and dogs	Selachii	49.9	0.05	37.13
POS	Porbeagle shark	*Lamna nasus*	43.0	0.04	52.69
CON	Conger eel	*Conger* spp	38.8	0.04	69.42
GSH	Ghost shark	*Hydrolagus novaezealandiae*	35.4	0.04	7.72
RBM	Ray's bream	*Brama brama*	34.5	0.03	6.47
SND	Shovelnose dogfish	*Deania calcea*	34.5	0.03	99.57
BSH	Seal shark	*Dalatias licha*	33.5	0.03	98.21
BNS	Bluenose	*Hyperoglyphe antarctica*	31.3	0.03	0.95
WAR	Common warehou	*Seriolella brama*	30.5	0.03	0.00
SDO	Silver dory	*Cyttus novaezealandiae*	28.3	0.03	11.15
BYS	Alfonsino	*Beryx splendens*	27.4	0.03	14.24
FHD	Deepsea flathead	*Hoplichthys haswelli*	26.1	0.03	75.38
HAP	Hapuku	*Polyprion oxygeneios*	23.9	0.02	0.97
DEA	Dealfish	*Trachipterus trachypterus*	21.7	0.02	17.11
DWD	Deep water dogfish	-	21.3	0.02	99.94
GSP	Pale ghost shark	*Hydrolagus bemisi*	19.4	0.02	2.08
RHY	Common roughy	*Paratrachichthys trailli*	19.3	0.02	69.73
NSD	Northern spiny dogfish	*Squalus griffini*	19.2	0.02	99.83
RUD	Rudderfish	*Centrolophus niger*	18.5	0.02	53.46
SSH	Slender smooth hound	*Gollum attenuatus*	15.8	0.02	99.99
SCH	School shark	*Galeorhinus galeus*	15.7	0.02	6.66
SSI	Silverside	*Argentina elongata*	15.1	0.02	94.74
SWO	Broadbill swordfish	*Xiphias gladius*	13.6	0.01	26.67
HOR	Horse mussel	*Atrina zelandica*	12.6	0.01	NA
RSK	Rough skate	*Dipturus nasutus*	12.1	0.01	1.43
SKA	Skate families	Rajidae and Arhynchobatidae	11.8	0.01	87.68
SCO	Swollen headed conger	*Bassanago bulbiceps*	11.3	0.01	90.44
RBY	Rubyfish	*Plagiogeneion rubiginosum*	10.4	0.01	12.52

Appendix 1 (b) WCSI hoki area continued.

Species code	Common name	Scientific name	Estimated catch (t)	% of catch	% Discarded
STN	Southern bluefin tuna	*Thunnus maccoyii*	9.8	0.01	91.38
SRH	Silver roughy	*Hoplostethus mediterraneus*	8.7	0.01	92.59
THR	Thresher shark	*Alopias vulpinus*	7.8	0.01	95.46
MAK	Mako shark	*Isurus oxyrinchus*	7.7	0.01	73.15
BYX	Alfonsino and longfinned beryx	*Beryx splenden &.B decadactylus*	7.2	0.01	31.89
RUB	Rubbish	-	7.1	0.01	93.87
BNE	Scabbardfish	*Benthodesmus elongatus*	6.5	0.01	2.95
WHX	White rat	*Trachyrincus aphyodes*	6.0	0.01	98.67
BBE	Banded bellowsfish	*Centriscops humerosus*	5.5	0.01	93.97
HCO	Hairy conger eel	*Bassanago hirsutus*	5.1	0.01	30.25
SFI	Starfish	*Asteroidea & ophiuroidea*	5.1	0.01	90.20
CSQ	Centrophorus squamosus	*Centrophorus squamosus*	5.1	0.01	98.49

Appendix 1 (c): Chatham Rise and ECSI hoki area.

Species code	Common name	Scientific name	Estimated catch (t)	% of catch	% Discarded
HOK	Hoki	*Macruronus novaezelandiae*	33676.3	70.07	0.25
JAV	Javelinfish	*Lepidorhynchus denticulatus*	2956.4	6.07	19.91
RAT	Rattails	Macrouridae	2210.5	4.62	24.60
LIN	Ling	*Genypterus blacodes*	1395.4	2.97	0.05
SWA	Silver warehou	*Seriolella punctata*	1354.8	3.21	0.03
HAK	Hake	*Merluccius australis*	989.1	2.12	0.02
GSP	Pale ghost shark	*Hydrolagus bemisi*	686.2	1.44	0.09
SPD	Spiny dogfish	*Squalus acanthias*	582.1	1.29	69.87
SPE	Sea perch	*Helicolenus* spp	505.3	1.04	0.07
WWA	White warehou	*Seriolella caerulea*	456.4	0.93	0.03
LDO	Lookdown dory	*Cyttus traverse*	313.9	0.67	3.91
SND	Shovelnose dogfish	*Deania calcea*	247.7	0.51	86.38
BOE	Black oreo	*Allocyttus niger*	245.9	0.53	0.01
RIB	Ribaldo	*Mora moro*	175.7	0.38	0.07
STA	Giant stargazer	*Kathetostoma giganteum*	152.1	0.32	0.09
ONG	Sponges	Porifera	147.9	0.22	99.96
BBE	Banded bellowsfish	*Centriscops humerosus*	91.9	0.19	73.18
BYS	Alfonsino	*Beryx splendens*	87.6	0.19	0.33
OSD	Other shark and dogs	Selachii	84.8	0.19	60.89
LCH	Long nosed chimaera	*Harriotta raleighana*	84.3	0.18	14.37
SOR	Spiky oreo	*Neocyttus rhomboidalis*	83.9	0.18	0.29
ORH	Orange roughy	*Hoplostethus atlanticus*	72.8	0.25	0.00
DWD	Deep water dogfish	-	66.8	0.13	84.13
BSH	Seal shark	*Dalatias licha*	66.8	0.14	68.01
SSK	Smooth skate	*Dipturus innominatus*	59.4	0.12	23.70
RBM	Ray's bream	*Brama brama*	56.5	0.12	1.44
GSH	Ghost shark	*Hydrolagus novaezealandiae*	56.4	0.14	0.43
SQU	Arrow squid	*Nototodarus sloanii, N. gouldi*	49.2	0.15	0.66
WSQ	Warty squid	*Moroteuthis* spp	42.8	0.10	80.18
TOA	Toadfish	*Neophrynichthys* sp.	42.6	0.09	42.21
FHD	Deepsea flathead	*Hoplichthys haswelli*	39.9	0.08	34.50
GLS	GLS	Glass sponge	36.2	0.03	100.00
SKA	Skate families	Rajidae and Arhynchobatidae	33.9	0.07	68.71
SSO	Smooth oreo	*Pseudocyttus maculatus*	33.5	0.13	0.00
RUD	Rudderfish	*Centrolophus niger*	29.2	0.06	56.46
SFI	Starfish	Asteroidea & Ophiuroidea	26.2	0.06	94.19
BSK	Basking shark	*Cetorhinus maximus*	23.4	0.05	78.89
SSI	Silverside	*Argentina elongata*	23.2	0.05	17.86
SNA	Snapper	*Pagrus auratus*	19.7	0.00	100.00
BAR	Barracouta	*Thyrsites atun*	18.9	0.23	4.26
ETM	Etmopterus sp	*Etmopterus* sp	16.9	0.03	45.65
DEA	Dealfish	*Trachipterus trachypterus*	16.4	0.04	3.67
SLK	Slickhead	*Alepocephalidae*	15.7	0.03	70.60
RCO	Red cod	*Pseudophycis bachus*	14.9	0.04	1.67
CDL	Cardinalfish	Apogonidae	13.4	0.03	0.22
HJO	Johnson's cod	*Halargyreus johnsonii*	12.2	0.01	6.34
SCI	Scampi	*Metanephrops challengeri*	11.9	0.02	2.04
ETL	Lucifer dogfish	*Etmopterus lucifer*	11.5	0.03	90.37
ETB	Baxter's lantern dogfish	*Etmopterus baxteri*	10.5	0.03	90.38
RSK	Rough skate	*Dipturus nasutus*	10.4	0.02	3.34

Appendix 1 (c) Chatham Rise and ECSI hoki area continued.

Species code	Common name	Scientific name	Estimated catch (t)	% of catch	% Discarded
WHE			9.2	0.02	99.46
CON	Conger eel	*Conger* spp	7.7	0.02	40.97
TAR	Tarakihi	*Nemadactylus macropterus*	6.8	0.01	0.04
SHA	Shark	-	6.8	0.01	100.00
BNS	Bluenose	*Hyperoglyphe antarctica*	6.8	0.01	0.00
SBK	Spineback	*Notacanthus sexspinis*	5.3	0.01	38.23
BEL	Bellowsfish unspecified	-	5.1	0.01	38.56
CYP	Centroscymnus crepidater	*Centroscymnus crepidater*	4.8	0.01	98.34
JMA	Jack mackerel	*Trachurus declivis, T. s. murphyi, T. novaezelandiae*	4.2	0.01	0.00
DWE	Deepwater eel	-	3.9	0.01	33.38
WHX	White rat	*Trachyrincus aphyodes*	3.8	0.01	8.53
SCH	School shark	*Galeorhinus galeus*	3.8	0.01	6.23
SCM	Large spine velvet dogfish	*Proscymnodon macracanthus*	3.7	0.01	75.38
POS	Porbeagle shark	*Lamna nasus*	3.7	0.01	32.13
BPI	Benthopecten pikei	*Benthopecten pikei*	3.5	0.01	4.69
RHY	Common roughy	*Paratrachichthys trailli*	3.5	0.01	10.93
MOD	Morid cods	Moridae	3.0	0.01	20.58
EEL	Marine eels	-	2.5	0.01	74.96
SLB	White tailed dogfish	*Scymnodalatias albicauda*	2.5	0.01	100.00
MIQ	Warty squid	*Moroteuthis ingens*	2.4	0.01	100.00

Appendix 1 (d): Sub-Antarctic hoki area.

Species code	Common name	Scientific name	Estimated catch (t)	% of catch	% Discarded
HOK	Hoki	*Macruronus novaezelandiae*	14566.3	58.59	0.13
LIN	Ling	*Genypterus blacodes*	3703.2	14.89	0.01
HAK	Hake	*Merluccius australis*	2499.5	10.05	0.01
JAV	Javelinfish	*Lepidorhynchus denticulatus*	733.9	2.95	25.02
WWA	White warehou	*Seriolella caerulea*	627.9	2.53	0.00
SPD	Spiny dogfish	*Squalus acanthias*	613.3	2.47	115.64
SWA	Silver warehou	*Seriolella punctata*	553.2	2.23	0.01
RAT	Rattails	Macrouridae	276.3	1.11	25.27
GSP	Pale ghost shark	*Hydrolagus bemisi*	218.7	0.88	0.49
BSH	Seal shark	*Dalatias licha*	127.1	0.51	81.69
SQU	Arrow squid	*Nototodarus sloanii, N. gouldi*	115.7	0.47	0.36
RIB	Ribaldo	*Mora moro*	110.3	0.44	0.00
SBW	Southern blue whiting	*Micromesistius australi*	100.2	0.40	0.05
WSQ	Warty squid	*Moroteuthis* spp	76.7	0.31	94.74
DWD	Deep water dogfish	-	56.1	0.23	95.12
SSI	Silverside	*Argentina elongata*	55.2	0.22	52.42
GSH	Ghost shark	*Hydrolagus novaezealandiae*	34.7	0.14	0.37
RBM	Ray's bream	*Brama brama*	34.4	0.14	24.80
BSK	Basking shark	*Cetorhinus maximus*	32.0	0.13	100.00
STA	Giant stargazer	*Kathetostoma giganteum*	30.0	0.12	0.09
OSD	Other shark and dogs	Selachii	28.4	0.11	94.17
BOE	Black oreo	*Allocyttus niger*	28.0	0.11	0.00
SSK	Smooth skate	*Dipturus innominatus*	26.1	0.11	15.94
RCO	Red cod	*Pseudophycis bachus*	20.7	0.08	0.70
LDO	Lookdown dory	*Cyttus traverse*	17.8	0.07	12.07
LCH	Long nosed chimaera	*Harriotta raleighana*	15.9	0.06	31.82
SSO	Smooth oreo	*Pseudocyttus maculatus*	15.8	0.06	0.01
CSQ	Centrophorus squamosus	*Centrophorus.squamosus*	10.9	0.04	95.33
BAR	Barracouta	*Thyrsites atun*	9.7	0.04	0.03
BNS	Bluenose	*Hyperoglyphe antarctica*	7.7	0.03	0.93
RUD	Rudderfish	*Centrolophus niger*	7.2	0.03	56.11
SKA	Skate families	*Rajidae Arhynchobatidae*	7.1	0.03	81.57
ETB	Baxters lantern dogfish	*Etmopterus baxteri*	6.6	0.03	49.11
ONG	Sponges	Porifera	6.3	0.03	99.88
SND	Shovelnose dogfish	*Deania.calcea*	4.4	0.02	91.52
RSK	Rough skate	*Dipturus nasutus*	3.9	0.02	2.03
SFI	Starfish	Asteroidea & Ophiuroidea	3.5	0.01	88.22
HJO	Johnson's cod	*Halargyreus johnsonii*	3.4	0.01	70.70
PDG	Prickly dogfish	*Oxynotus bruniensis*	3.4	0.01	97.70
WIT	Witch	*Arnoglossus scapha*	3.2	0.01	25.60
CRB	Crab	-	2.9	0.01	81.85
TOA	Toadfish	*Neophrynichthys* sp	2.9	0.01	41.22
SCH	School shark	*Galeorhinus galeus*	2.6	0.01	1.49
CON	Conger eel	*Conger* spp	2.5	0.01	43.81
DEA	Dealfish	*Trachipterus trachypterus*	2.4	0.01	0.20
ETL	Lucifer dogfish	*Etmopterus lucifer*	2.3	0.01	84.93
EEL	Marine eels	-	2.3	0.01	57.23
POS	Porbeagle shark	*Lamna nasus*	2.2	0.01	82.85
SPI	Spider crab	-	2.0	0.01	54.57
SOR	Spiky oreo	*Neocyttus rhomboidalis*	1.8	0.01	0.00

Appendix 1 (d) Sub-Antarctic hoki area continued.

Species code	Common name	Scientific name	Estimated catch (t)	% of catch	% Discarded
CCA	Cubehead	*Cubiceps caeruleus*	1.8	0.01	0.00
CYL	Centroscymnus coelolepis	*Centroscymnus coelolepis*	1.7	0.01	100.00
BEE	Basketwork eel	*Diastobranchus capensis*	1.6	0.01	44.03
DOG	Dogfish unspecified	-	1.4	0.01	99.56

Appendix 1 (e): Cook Strait hoki.

Species code	Common name	Scientific name	Estimated catch (t)	% of catch	% Discarded
HOK	Hoki	*Macruronus novaezelandiae*	16953.3	96.59	0.02
SPD	Spiny dogfish	*Squalus acanthias*	412.1	2.35	85.25
LIN	Ling	*Genypterus blacodes*	51.4	0.29	0.00
HAK	Hake	*Merluccius australis*	40.6	0.23	0.00
JMA	Jack mackerel	*Trachurus declivis, T. s. murphyi, T. novaezelandiae*	35.8	0.20	0.00
RCO	Red cod	*Pseudophycis bachus*	8.4	0.05	0.14
SWA	Silver warehou	*Seriolella punctata*	5.6	0.03	0.00
GSH	Ghost shark	*Hydrolagus novaezealandiae*	4.9	0.03	0.00
HOR	Horse mussel	*Atrina zelandica*	3.7	0.02	NA
POS	Porbeagle shark	*Lamna nasus*	3.6	0.02	79.58
SCH	School shark	*Galeorhinus galeus*	3.4	0.02	0.18
BNS	Bluenose	*Hyperoglyphe antarctica*	2.8	0.02	0.00
BAR	Barracouta	*Thyrsites atun*	2.3	0.01	0.00
BYS	Alfonsino	*Beryx splendens*	2.3	0.01	0.00
BSH	Seal shark	*Dalatias.licha*	2.2	0.01	57.42
RAT	Rattails	Macrouridae	2.0	0.01	98.44
SND	Shovelnose dogfish	*Deania calcea*	1.4	0.01	100.00
FUR	New Zealand furseal	*Arctocephalus forsteri*	1.0	0.01	100.00
FRO	Frostfish	*Lepidopus caudatus*	0.8	0.01	4.21

Appendix 1 (f): Puysegur hoki area.

Species code	Common name	Scientific name	Estimated catch (t)	% of catch	% Discarded
HOK	Hoki	*Macruronus novaezelandiae*	4718.7	81.29	0.29
LIN	Ling	*Genypterus blacodes*	394.4	6.79	0.01
SWA	Silver warehou	*Seriolella punctata*	376.5	6.49	0.02
SPD	Spiny dogfish	*Squalus acanthias*	39.1	0.67	50.45
WWA	White warehou	*Seriolella caerulea*	37.8	0.65	0.06
SND	Shovelnose dogfish	*Deania calcea*	23.0	0.40	92.71
JAV	Javelinfish	*Lepidorhynchus denticulatus*	22.3	0.39	20.34
RBM	Ray's bream	*Brama brama*	18.8	0.32	0.06
RAT	Rattails	*Macrouridae*	17.2	0.30	34.44
HAK	Hake	*Merluccius australis*	16.1	0.28	0.02
RCO	Red cod	*Pseudophycis bachus*	13.3	0.23	0.02
SQU	Arrow squid	*Nototodarus sloanii, N. gouldi*	11.6	0.20	0.70
GSH	Ghost shark	*Hydrolagus novaezealandiae*	11.0	0.19	5.94
OSD	Other shark and dogs	*Selachii*	10.4	0.18	81.64
STA	Giant stargazer	*Kathetostoma giganteum*	9.3	0.16	0.00
CSQ	Centrophorus squamosus	*Centrophorus squamosus*	8.5	0.15	96.69
BSH	Seal shark	*Dalatias licha*	7.5	0.13	99.43
SCH	School shark	*Galeorhinus galeus*	6.7	0.12	0.00
RIB	Ribaldo	*Mora moro*	5.5	0.10	0.68
BNS	Bluenose	*Hyperoglyphe antarctica*	4.8	0.08	0.00
DWD	Deepwater dogfish	-	3.8	0.07	107.87
RUD	Rudderfish	*Centrolophus niger*	3.6	0.06	25.70
LDO	Lookdown dory	*Cyttus traverse*	3.5	0.06	9.20
BSK	Basking shark	*Cetorhinus maximus*	3.5	0.06	100.00
POS	Porbeagle shark	*Lamna nasus*	3.0	0.05	43.19
ETL	Lucifer dogfish	*Etmopterus lucifer*	2.9	0.05	99.36
RBT	Redbait	*Emmelichthys nitidus*	2.6	0.05	0.26
FRO	Frostfish	*Lepidopus caudatus*	2.3	0.04	0.00
GSP	Pale ghost shark	*Hydrolagus bemisi*	2.2	0.04	2.11
SCM	Large spine velvet dogfish	*Centroscymnus macracanthus*	2.1	0.04	100.00
DEA	Dealfish	*Trachipterus trachypterus*	1.9	0.03	2.47
SQA	Squalus.spp	*Squalus* spp	1.5	0.03	100.00
CUB	Cubehead	*Cubiceps* spp	1.4	0.03	0.00
LHO	Omega prawn	*Lipkius holthuisi*	1.3	0.02	NA
SSK	Smooth skate	*Dipturus innominatus*	1.2	0.02	66.21
SNR	Gulper shark	*Deania hystricosa*	1.0	0.02	100.00
SPE	Sea perch	*Helicolenus* spp	1.0	0.02	2.67
DOG	Dogfish	-	0.9	0.02	100.00
CYP	Centroscymnus crepidater	*Centroscymnus crepidater*	0.8	0.01	100.00
CDL	Cardinalfish	*Apogonidae*	0.7	0.01	0.45
SDO	Silver dory	*Cyttus novaezealandiae*	0.5	0.01	0.00
CDO	Capro dory	*Capromimus abbreviatus*	0.5	0.01	100.00
SHA	Shark	-	0.5	0.01	100.00
RDO	Rosy dory	*Cyttopsis roseus*	0.4	0.01	86.52
STN	Southern bluefin tuna	*Thunnus maccoyii*	0.4	0.01	81.18
SKI	Gemfish	*Rexea solandri*	0.4	0.01	0.00
SKA	Skate families	Rajidae and Arhynchobatidae	0.3	0.01	100.00
JMA	Jack mackerel	*Trachurus declivis, T. s. murphyi, T. novaezelandiae*	0.3	0.01	0.00
SSO	Smooth oreo	*Pseudocyttus maculatus*	0.3	0.01	2.05
EPL	Bigeye cardinalfish	*Epigonus lenimen*	0.3	0.01	69.29

Appendix 1 (f) Puysegur hoki area continued.

Species code	Common name	Scientific name	Estimated catch (t)	% of catch	% Discarded
SEV	Broadnose sevengill shark	*Notorynchus cepedianus*	0.3	0.01	100.00
WSQ	Warty squid	*Moroteuthis* spp	0.3	0.01	82.67
PDG	Prickly dogfish	*Oxynotus bruniensis*	0.3	0.01	100.00
BSP	Bigscale pomfret	*Taratichthys longipinnis*	0.3	0.01	0.00
PSP	Scissortail	*Psenes pellucidus*	0.3	0.01	0.00

Appendix 1: (g) Shark and skate estimated catch (tow data) and discards (group data) for each hoki area. Percent discarded is (discard weight /calculated weight) x 100 for a species grouping and area, and discard overall percent is the (discard weight for a species grouping/all discard weights for that area) x 100.

Area	Species grouping	Estimated catch (t)	% of catch	Discarded weight (t)	% Discarded	% Discarded overall
All areas	Spiny dogfish	2089.7	1.07	1646	88.74	29.54
	Deepwater dogfish	1010.4	0.52	784.9	80.99	14.08
	Other shark and dogfish	215.8	0.11	115	55.88	2.07
	Skates	244.7	0.13	64.9	28.30	1.17
WCSI	Spiny dogfish	446.9	0.45	571.6	76.03	30.04
	Deepwater dogfish	162.2	0.16	308.6	74.23	16.22
	Other shark and dogfish	136.6	0.14	33.7	73.02	1.77
	Skates	100.6	0.10	18.2	20.32	0.96
Cook Strait	Spiny dogfish	412.1	2.35	69.9	96.10	15.68
	Deepwater dogfish	6.6	0.04	58.6	97.39	13.14
	Other shark and dogfish	7.8	0.04	7.5	96.84	1.69
	Skates	0.9	0.00	13.9	67.88	3.13
Chatham Rise	Spiny dogfish	570.1	1.29	442.2	79.74	23.98
	Deepwater dogfish	519.3	1.17	212.4	88.57	11.51
	Other shark and dogfish	28.9	0.07	37.7	36.23	2.04
	Skates	103.0	0.23	22.2	27.87	1.20
Sub-Antarctic	Spiny dogfish	609.8	2.46	529.1	100.00	42.59
	Deepwater dogfish	247.5	1.00	178.4	83.58	14.36
	Other shark and dogfish	35.2	0.14	31.7	73.66	2.55
	Skates	36.2	0.15	9.8	28.01	0.79
Puysegur	Spiny dogfish	39.2	0.68	10.3	61.91	11.74
	Deepwater dogfish	62.9	1.08	15.4	61.36	17.50
	Other shark and dogfish	7.0	0.12	3.8	98.91	4.34
	Skates	1.9	0.03	0.5	22.42	0.58

Appendix 2: Number of vessels, trips, total catch, hoki, hake, and ling catches for TCEPR, CELR and landing data for trips where hoki, hake, or ling was targeted or caught; and landing data for all trips that landed hoki, hake or ling by fishing year.

Data set		Fishing year 2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07
TCEPR data	Number of vessels	114	110	108	102	94	85	76
	Number of trips	1 641	1 569	1 518	1 508	1 297	1 217	1 049
	Total catch weight (t)	372 608.8	366 047.1	326 956.2	293 769.8	281 160.3	268 375.1	273 897.2
	Hoki hake and ling catch weight (t)	233 399.6	208 933.0	187 839.9	141 314.6	118 442.8	113 000.8	109 236.7
	Hoki catch weight (t)	210 179.4	187 198.5	166 610.3	117 341.0	95 861.5	95 604.8	89 386.5
	Hake catch weight (t)	11 988.5	10 270.3	9 959.6	12 431.7	12 073.7	8 790.4	9 697.8
	Ling catch weight (t)	11 231.6	11 464.2	11 270.0	11 541.9	10 507.6	8 605.6	10 152.4
CELR data	Number of vessels	156	147	147	146	135	131	120
	Number of trips	1 970	1 737	2 212	1 950	1 544	1 134	1 128
	Total catch weight (t)	23 716.6	16 335.9	22 088.3	24 403.0	14 106.1	12 359.8	14 337.6
	Hoki hake and ling catch weight (t)	15 574.5	9 234.5	14 292.2	16 722.9	7 260.1	5 956.1	7 682.9
	Hoki catch weight (t)	15 027.2	8 795.2	13 715.4	16 295.2	6 762.3	5 541.7	7 322.7
	Hake catch weight (t)	58.4	55.1	38.2	28.3	23.8	23.0	20.8
	Ling catch weight (t)	488.9	384.2	538.5	399.5	474.0	391.4	339.4
Landing data (trips associated with TCEPR and CELR above)	Number of vessels	266.0	253.0	248.0	243.0	225.0	213.0	191.0
	Number of trips	3600.0	3311.0	3726.0	3455.0	2840.0	2350.0	2179.0
	Total green weight (t)	431474.1	427481.2	397390.7	355394.2	329626.3	310112.7	328824.8
	Hoki hake and ling green weight (t)	259996.4	230142.9	217564.0	173558.7	140349.4	128658.6	132298.1
	Hoki green weight (t)	231137.2	204108.1	192804.9	145332.5	113364.9	107005.7	107998.6
	Hake green weight (t)	14898.0	12589.3	11242.7	14854.4	14623.6	10660.1	12078.8
	Ling green weight (t)	13961.1	13445.4	13516.4	13371.7	12360.9	10992.8	12220.6
Landing data (all trips where HOK or HAK or LIN landed)	Number of vessels	514.0	479.0	479.0	452.0	417.0	411.0	397.0
	Number of trips	9968.0	9150.0	10038.0	9376.0	8712.0	7882.0	7488.0
	Total green weight (t)	547054.4	494983.3	477441.8	449701.6	407634.6	410160.9	401913.8
	Hoki hake and ling green weight (t)	279934.6	238628.1	226480.7	181122.7	141727.3	136586.2	130361.2
	Hoki green weight (t)	241638.1	204844.8	194483.8	145329.7	110523.2	108091.3	104773.2
	Hake green weight (t)	15573.6	12576.6	11651.1	15706.1	13253.3	12370.0	10319.6
	Ling green weight (t)	22722.9	21206.6	20345.9	20086.9	17950.7	16125.0	15268.5

Appendix 3 (a): Number of ALL TCEPR vessels, tows, total catch and hoki, hake, and ling total catch by target species and fishing year.

		Fishing year						
	Target species	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07
Number of vessels	All species	112	103	104	97	90	83	76
	Hoki, hake or ling	85	81	79	74	68	65	54
	Hoki	79	76	74	73	63	61	51
	Hake	23	22	27	24	29	28	30
	Ling	29	29	30	22	34	35	35
	Non hoki, hake, ling	108	98	99	92	89	83	76
Number of tows	All species	56580	54693	53354	46826	43329	39899	37662
	Hoki, hake or ling	31166	27412	27185	22576	15982	13390	12890
	Hoki	30019	26111	25770	20507	13734	10893	9804
	Hake	801	846	944	1649	1555	1358	1606
	Ling	346	455	471	420	693	1139	1480
	Non hoki, hake, ling	25414	27281	26169	24250	27347	26509	24772
Total catch (t)	All species	372000.8	364655.5	325569.3	292946.4	280280.7	268016.7	273804.5
	Hoki, hake or ling	260166.7	232795.6	212022.6	166031.6	135896.1	128678.3	125962.3
	Hoki	248777.9	225359.8	202501.4	153404.5	118525.7	112041.7	102369.0
	Hake	8135.2	4378.1	6411.6	9269.0	12054.2	9659.8	12399.1
	Ling	3253.5	3057.6	3109.4	3358.1	5316.1	6976.7	11194.1
	Non hoki, hake, ling	111834.0	131859.8	113546.6	126914.7	144384.6	139338.4	147842.2
Hoki, hake and ling catch (t)	All species	233396.7	208926.0	187824.3	141311.0	118436.6	112996.1	109236.1
	Hoki, hake or ling	230697.5	205592.0	184741.3	138946.5	115754.7	109384.4	105178.8
	Hoki	220225.8	199330.6	176587.0	127799.4	100464.4	94966.9	86254.1
	Hake	7572.1	3966.4	5696.0	8274.2	10865.9	8864.0	10733.3
	Ling	2899.6	2295.0	2458.3	2872.9	4424.3	5553.5	8191.4
	Non hoki, hake, ling	2699.2	3334.0	3083.0	2364.5	2681.9	3611.7	4057.3
Hoki catch (t)	All species	210178.6	187195.6	166601.2	117339.8	95859.8	95602.9	89386.3
	Hoki, hake or ling	208575.2	185213.9	164789.5	116090.6	94414.5	93174.1	86701.8
	Hoki	207028.4	183640.8	163381.8	114723.6	92079.8	89694.2	82119.8
	Hake	984.3	1098.4	848.3	1100.4	1689.7	2036.8	2441.0
	Ling	562.5	474.7	559.4	266.7	645.0	1443.1	2140.9
	Non hoki, hake, ling	1603.4	1981.6	1811.7	1249.2	1445.3	2428.8	2684.6
Hake catch (t)	All species	11988.1	10267.9	9955.4	12429.9	12069.6	8788.2	9697.4
	Hoki, hake or ling	11833.2	10105.9	9812.6	12207.8	11827.3	8626.9	9576.0
	Hoki	5808.1	7541.2	5393.2	5376.6	2756.7	1870.9	1333.7
	Hake	5886.0	2497.5	4357.3	6605.3	8515.0	6587.6	7875.2
	Ling	139.0	67.2	62.2	225.9	555.6	168.4	367.0
	Non hoki, hake, ling	154.9	162.0	142.8	222.1	242.3	161.3	121.4
Ling catch (t)	All species	11230.0	11462.5	11267.7	11541.3	10507.1	8604.9	10152.4
	Hoki, hake or ling	10289.1	10272.1	10139.2	10648.1	9512.9	7583.4	8901.0
	Hoki	7389.3	8148.6	7812.0	7699.2	5627.9	3401.8	2800.5
	Hake	701.8	370.5	490.4	568.5	661.3	239.5	417.1
	Ling	2198.1	1753.1	1836.8	2380.3	3223.7	3942.0	5683.4
	Non hoki, hake, ling	940.9	1190.4	1128.5	893.3	994.2	1021.6	1251.4

Appendix 3 (b): Number of WCSI TCEPR vessels, tows, total catch and hoki, hake, and ling total catch by target species and fishing year.

		Fishing year						
	Target species	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07
Number of vessels	All species	64	58	52	51	42	40	35
	Hoki, hake or ling	63	56	51	51	39	37	34
	Hoki	63	56	51	51	38	36	32
	Hake	15	12	17	21	25	28	29
	Ling	-	-	2	1	1	2	6
	Non hoki, hake, ling	28	23	23	24	28	23	28
Number of tows	All species	9479	8431	8131	6970	5010	4701	3747
	Hoki, hake or ling	8604	7734	7630	6706	4382	4348	2993
	Hoki	8265	7541	7110	6084	3591	3176	1881
	Hake	339	193	515	605	781	1139	1067
	Ling	-	-	5	17	10	33	45
	Non hoki, hake, ling	875	697	501	264	628	353	754
Total catch (t)	All species	117976.8	107838.2	84153.5	55268.1	47124.3	49566.9	50305.9
	Hoki, hake or ling	110188.6	101348.0	79248.8	53378.0	41621.0	46213.2	40420.8
	Hoki	106674.2	100136.6	75684.8	48478.9	34887.5	38622.6	31466.3
	Hake	3514.3	1211.3	3558.8	4837.1	6715.0	7517.1	8765.9
	Ling	-	-	5.2	62.0	18.4	73.4	188.6
	Non hoki, hake, ling	7788.1	6490.2	4904.6	1890.0	5503.3	3353.6	9885.0
Hoki, hake and ling catch (t)	All species	101154.5	95009.6	74491.3	48531.2	38211.5	42647.0	37528.3
	Hoki, hake or ling	101096.9	94895.7	74281.8	48465.4	37923.7	42554.5	37147.6
	Hoki	97835.6	93782.7	71128.9	44064.4	31726.4	35604.9	29124.0
	Hake	3261.3	1113.0	3149.9	4361.1	6189.1	6895.7	7892.0
	Ling	-	-	2.9	39.9	8.3	53.8	131.6
	Non hoki, hake, ling	57.6	113.9	209.6	65.8	287.7	92.6	380.7
Hoki catch (t)	All species	92687.0	86559.9	66467.2	39499.4	30257.2	34971.6	29418.1
	Hoki, hake or ling	92649.2	86475.5	66270.9	39443.9	30014.3	34905.7	29159.3
	Hoki	92306.9	86102.1	65900.0	39075.7	29200.6	32981.5	27790.4
	Hake	342.3	373.5	369.9	351.9	812.0	1887.5	1300.2
	Ling	-	-	1.0	16.3	1.7	36.7	68.6
	Non hoki, hake, ling	37.8	84.3	196.3	55.5	242.9	65.9	258.9
Hake catch (t)	All species	6601.1	6675.0	6612.3	7459.8	6856.8	6416.3	7286.5
	Hoki, hake or ling	6589.0	6656.8	6605.4	7455.3	6852.9	6402.0	7278.6
	Hoki	3683.3	5939.0	3865.7	3498.3	1544.5	1551.7	839.0
	Hake	2905.7	717.8	2739.4	3957.0	5308.4	4850.3	6438.8
	Ling	-	-	0.4	0.0	0.0	0.0	0.7
	Non hoki, hake, ling	12.1	18.2	6.9	4.5	3.9	14.4	7.9
Ling catch (t)	All species	1866.4	1774.8	1411.8	1572.0	1097.5	1259.1	823.7
	Hoki, hake or ling	1858.7	1763.4	1405.4	1566.2	1056.5	1246.8	709.8
	Hoki	1845.4	1741.6	1363.3	1490.4	981.3	1071.7	494.6
	Hake	13.3	21.7	40.6	52.3	68.6	157.9	153.0
	Ling	-	-	1.5	23.6	6.6	17.2	62.2
	Non hoki, hake, ling	7.7	11.4	6.4	5.8	41.0	12.3	113.9

Appendix 3 (c): Number of Chatham Rise and ECSI TCEPR vessels, tows, total catch and hoki, hake, and ling total catch by target species and fishing year.

		Fishing year						
	Target species	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07
Number of vessels	All species	75	65	73	62	63	56	50
	Hoki, hake or ling	55	43	40	36	33	28	24
	Hoki	51	37	37	31	25	24	21
	Hake	13	15	17	15	17	5	13
	Ling	7	12	9	2	6	7	11
	Non hoki, hake, ling	63	55	61	51	55	51	48
Number of tows	All species	18763	16286	18586	15291	13560	13386	13410
	Hoki, hake or ling	11360	9506	10477	8568	6169	5158	5564
	Hoki	10957	8911	10163	7689	5531	5016	4908
	Hake	321	461	275	877	612	36	366
	Ling	82	134	39	2	26	106	290
	Non hoki, hake, ling	7403	6780	8109	6723	7391	8228	7846
Total catch (t)	All species	102539.3	85930.8	94154.4	80864.6	77897.8	76900.8	85031.2
	Hoki, hake or ling	68769.1	58197.2	62841.5	52564.2	48557.7	44891.7	50038.2
	Hoki	65411.5	55630.2	61458.7	49528.8	44770.6	43968.5	45723.8
	Hake	2959.6	1896.4	1167.4	3030.6	3672.7	334.2	2402.9
	Ling	397.9	670.5	215.3	4.7	114.3	589.0	1911.4
	Non hoki, hake, ling	33770.2	27733.6	31312.9	28300.3	29340.1	32009.1	34993.0
Hoki, hake and ling catch (t)	All species	56630.8	46431.2	48118.1	38508.2	37859.7	35405.0	40239.2
	Hoki, hake or ling	55737.7	45666.2	46823.2	37570.4	37029.9	33805.0	38531.7
	Hoki	52630.0	43652.7	45731.7	34983.7	33668.7	33210.6	35676.8
	Hake	2791.5	1607.4	949.0	2583.2	3290.1	281.9	1761.2
	Ling	316.2	406.1	142.5	3.4	71.0	312.5	1093.8
	Non hoki, hake, ling	893.1	765.0	1294.9	937.8	829.8	1600.0	1707.5
Hoki catch (t)	All species	51042.9	42755.5	44494.8	34300.6	33243.1	33865.9	37491.1
	Hoki, hake or ling	50372.3	42162.9	43513.6	33588.5	32587.9	32490.2	36000.2
	Hoki	49785.7	41529.4	43057.3	32871.7	31868.6	32211.5	34688.7
	Hake	502.3	576.1	419.5	715.4	704.8	118.6	996.4
	Ling	84.4	57.4	36.8	1.4	14.4	160.2	315.1
	Non hoki, hake, ling	670.6	592.6	981.2	712.2	655.2	1375.7	1490.9
Hake catch (t)	All species	3022.1	1462.2	1091.2	2207.2	3155.5	353.9	946.6
	Hoki, hake or ling	2987.6	1440.5	1059.8	2155.0	3143.2	341.2	913.5
	Hoki	932.5	510.0	647.8	542.3	775.0	214.2	269.3
	Hake	2020.6	922.3	410.8	1611.9	2367.8	117.8	606.4
	Ling	34.5	8.2	1.2	0.9	0.4	9.1	37.8
	Non hoki, hake, ling	34.5	21.8	31.4	52.2	12.3	12.8	33.1
Ling catch (t)	All species	2565.8	2213.5	2532.1	2000.3	1461.1	1185.2	1801.5
	Hoki, hake or ling	2377.8	2062.8	2249.7	1826.9	1298.8	973.6	1618.0
	Hoki	1911.8	1613.3	2026.6	1569.8	1025.1	785.0	718.8
	Hake	268.7	109.0	118.7	255.9	217.5	45.4	158.4
	Ling	197.3	340.5	104.5	1.2	56.3	143.2	740.9
	Non hoki, hake, ling	188.0	150.7	282.3	173.5	162.3	211.5	183.5

Appendix 3 (d): Number of Sub-Antarctic TCEPR vessels, tows, total catch and hoki, hake, and ling total catch by target species and fishing year.

		Fishing year						
	Target species	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07
Number of vessels	All species	61	59	56	52	51	47	44
	Hoki, hake or ling	41	38	40	31	29	27	24
	Hoki	39	38	38	30	26	20	22
	Hake	6	5	5	4	4	3	8
	Ling	13	16	14	10	18	20	19
	Non hoki, hake, ling	52	52	49	47	49	46	42
Number of tows	All species	12360	15232	12185	11976	11698	10316	9337
	Hoki, hake or ling	6439	7031	4983	3569	2170	1662	2242
	Hoki	6089	6577	4493	3100	1495	795	1216
	Hake	135	190	149	166	155	174	169
	Ling	215	264	341	303	520	693	857
	Non hoki, hake, ling	5921	8201	7202	8407	9528	8654	7095
Total catch (t)	All species	88251.5	116133.2	79098.0	101750.5	96142.4	94922.3	96947.6
	Hoki, hake or ling	41211.4	44447.6	31448.1	24652.5	16669.3	14846.9	17995.8
	Hoki	36925.2	40949.6	26980.3	20372.1	10971.6	7839.2	9193.3
	Hake	1496.9	1256.8	1653.9	1399.2	1600.2	1767.3	1196.5
	Ling	2789.3	2241.2	2813.9	2881.1	4097.5	5240.3	7605.9
	Non hoki, hake, ling	47040.1	71685.5	47649.8	77098.0	79473.0	80075.4	78951.7
Hoki, hake and ling catch (t)	All species	37894.2	39253.6	28508.9	21044.2	14873.0	13582.7	15131.3
	Hoki, hake or ling	37148.1	37830.0	27606.1	20219.6	13800.7	12176.2	13806.7
	Hoki	33188.0	34794.8	23769.4	16374.1	8955.9	6076.2	6821.8
	Hake	1421.2	1232.9	1566.7	1327.8	1325.0	1655.7	1052.0
	Ling	2538.8	1802.4	2269.9	2517.6	3519.8	4444.3	5932.9
	Non hoki, hake, ling	746.1	1423.5	902.8	824.6	1072.2	1406.5	1324.6
Hoki catch (t)	All species	30097.9	30780.6	19935.2	11456.5	6151.7	6574.3	7391.4
	Hoki, hake or ling	29752.9	30136.0	19718.2	11317.0	5919.1	5853.0	6823.9
	Hoki	29167.5	29600.2	19150.8	11063.5	5298.4	4837.9	5131.3
	Hake	125.8	139.9	55.6	32.1	169.6	19.4	135.7
	Ling	459.7	395.9	511.8	221.4	451.1	995.7	1556.9
	Non hoki, hake, ling	345.0	644.6	217.0	139.5	232.6	721.3	567.5
Hake catch (t)	All species	2194.9	2048.3	2190.0	2739.0	1944.1	1986.8	1435.0
	Hoki, hake or ling	2122.8	1932.5	2088.7	2581.1	1743.6	1859.4	1364.6
	Hoki	1143.4	1020.4	842.7	1322.5	420.7	98.6	224.6
	Hake	878.0	853.2	1185.4	1035.4	782.2	1604.6	822.4
	Ling	101.4	59.0	60.6	223.2	540.8	156.2	317.6
	Non hoki, hake, ling	72.1	115.8	101.3	157.9	200.5	127.3	70.4
Ling catch (t)	All species	5601.4	6424.6	6383.7	6848.7	6777.1	5021.7	6305.0
	Hoki, hake or ling	5272.4	5761.5	5799.2	6321.4	6138.0	4463.7	5618.2
	Hoki	2877.2	4174.2	3775.9	3988.2	3236.9	1139.7	1465.9
	Hake	417.4	239.8	325.7	260.4	373.3	31.7	93.9
	Ling	1977.7	1347.5	1697.6	2072.9	2527.9	3292.3	4058.4
	Non hoki, hake, ling	329.1	663.1	584.5	527.3	639.1	557.9	686.8

Appendix 3 (e): Number of Cook Strait TCEPR vessels, tows, total catch and hoki, hake, and ling total catch by target species and fishing year.

		Fishing year						
	Target species	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07
Number of vessels	All species	28	22	24	21	19	15	12
	Hoki, hake or ling	25	17	20	20	14	11	8
	Hoki	25	17	20	20	14	11	8
	Hake	1	-	-	-	-	-	-
	Ling	-	2	-	-	1	1	1
	Non hoki, hake, ling	13	14	9	8	11	7	10
Number of tows	All species	3336	2332	3127	3043	2605	1709	1831
	Hoki, hake or ling	3098	1990	2952	2871	2439	1557	1575
	Hoki	3097	1982	2952	2871	2436	1554	1570
	Hake	1	-	-	-	-	-	-
	Ling	-	8	-	-	3	3	5
	Non hoki, hake, ling	238	342	175	172	166	152	256
Total catch (t)	All species	29933.6	21613.7	30601.8	32344.5	21542.7	19469.2	15539.8
	Hoki, hake or ling	29147.9	20857.3	30268.7	31929.6	21278.8	19140.6	14839.8
	Hoki	29141.0	20840.1	30268.7	31929.6	21266.5	19133.0	14828.8
	Hake	6.9	-	-	-	-	-	-
	Ling	-	17.2	-	0.0	12.3	7.6	11.0
	Non hoki, hake, ling	785.6	756.4	333.1	414.8	263.8	328.5	700.0
Hoki, hake and ling catch (t)	All species	28026.9	20427.1	29261.6	30167.9	20253.2	18168.1	14055.8
	Hoki, hake or ling	27975.8	20405.9	29248.8	30159.6	20241.5	18164.7	13982.9
	Hoki	27971.7	20371.5	29248.8	30159.6	20241.2	18164.1	13979.5
	Hake	4.1	-	-	-	-	-	-
	Ling	-	34.4	-	-	0.4	0.6	3.4
	Non hoki, hake, ling	51.1	21.2	12.8	8.3	11.6	3.5	72.9
Hoki catch (t)	All species	27828.1	20272.6	29074.6	29988.6	20106.2	18068.0	13985.7
	Hoki, hake or ling	27779.9	20259.9	29068.3	29984.5	20097.6	18065.8	13919.5
	Hoki	27776.2	20252.3	29068.3	29984.5	20097.4	18065.7	13918.8
	Hake	3.7	-	-	-	-	-	-
	Ling	-	7.6	-	-	0.2	0.1	0.7
	Non hoki, hake, ling	48.1	12.8	6.2	4.1	8.6	2.2	66.2
Hake catch (t)	All species	1.7	1.0	5.6	7.2	11.1	5.0	0.4
	Hoki, hake or ling	1.6	0.9	5.6	7.0	11.1	5.0	0.3
	Hoki	1.6	0.9	5.6	7.0	11.1	5.0	0.3
	Hake	0.0	-	-	-	-	-	-
	Ling	-	0.0	-	-	0.0	0.0	0.0
	Non hoki, hake, ling	0.1	0.0	0.0	0.2	0.0	0.0	0.0
Ling catch (t)	All species	197.1	153.5	181.5	172.2	135.9	95.2	69.7
	Hoki, hake or ling	194.3	145.1	174.9	168.1	132.8	93.9	63.0
	Hoki	193.9	118.3	174.9	168.1	132.6	93.4	60.4
	Hake	0.4	-	-	-	-	-	-
	Ling	-	26.8	-	-	0.2	0.5	2.6
	Non hoki, hake, ling	2.9	8.4	6.5	4.0	3.1	1.3	6.7

Appendix 3 (f): Number of Puysegur TCEPR vessels, tows, total catch and hoki, hake, and ling total catch by target species and fishing year.

		Fishing year						
	Target species	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07
Number of vessels	All species	44	41	43	29	30	28	18
	Hoki, hake or ling	40	29	32	16	19	19	10
	Hoki	37	27	32	14	9	9	3
	Hake	2	-	-	-	-	-	-
	Ling	4	3	-	2	15	13	9
	Non hoki, hake, ling	21	24	23	19	21	21	15
Number of tows	All species	1593	1380	1893	692	821	749	365
	Hoki, hake or ling	950	567	501	191	404	275	183
	Hoki	936	557	501	145	292	108	24
	Hake	3	-	-	-	-	-	-
	Ling	11	10	-	46	106	164	157
	Non hoki, hake, ling	643	813	1392	501	417	474	182
Total catch (t)	All species	13470.2	11700.3	16416.2	4978.8	9809.9	397.5	2668.0
	Hoki, hake or ling	8714.6	6291.6	6842.2	2080.2	6821.0	458.0	1473.7
	Hoki	8559.4	6212.3	6842.2	1713.4	5708.9	530.8	187.9
	Hake	123.3	-	-	-	-	-	-
	Ling	31.9	79.3	-	366.7	1050.8	907.6	1267.0
	Non hoki, hake, ling	4755.6	5408.6	9573.9	2898.5	2988.9	939.4	1194.3
Hoki, hake and ling catch (t)	All species	7433.9	5700.5	6169.1	1912.0	6415.0	295.0	1438.9
	Hoki, hake or ling	7279.4	5596.2	6038.9	1803.0	6254.5	982.7	1087.2
	Hoki	7190.2	5565.1	6038.9	1515.8	5384.1	314.4	164.0
	Hake	64.8	-	-	-	-	-	-
	Ling	24.3	31.1	-	287.2	813.3	656.6	907.7
	Non hoki, hake, ling	154.5	104.3	130.2	109.0	160.4	312.3	351.7
Hoki catch (t)	All species	6695.1	5174.6	5632.1	1136.7	5411.7	407.2	405.2
	Hoki, hake or ling	6657.5	5114.5	5571.7	1102.7	5341.6	273.0	283.0
	Hoki	6647.0	5105.6	5571.7	1082.3	5163.6	1024.9	124.4
	Hake	7.4	-	-	-	-	-	-
	Ling	3.0	8.9	-	20.3	175.2	241.6	156.0
	Non hoki, hake, ling	37.6	60.1	60.4	34.1	70.1	134.2	122.2
Hake catch (t)	All species	124.8	12.4	28.3	10.8	92.0	11.4	21.3
	Hoki, hake or ling	103.6	10.4	25.8	4.7	67.9	5.2	12.5
	Hoki	44.1	10.4	25.8	2.9	0.9	0.6	0.3
	Hake	56.5	-	-	-	-	-	-
	Ling	3.1	0.0	-	1.8	14.4	3.1	11.0
	Non hoki, hake, ling	21.1	2.0	2.6	6.1	24.1	6.3	8.7
Ling catch (t)	All species	614.0	513.5	508.7	764.5	911.3	876.3	1012.4
	Hoki, hake or ling	518.2	471.3	441.5	695.7	845.0	704.6	791.7
	Hoki	499.1	449.1	441.5	430.6	219.6	288.9	39.4
	Hake	0.9	-	-	-	-	-	-
	Ling	18.2	22.2	-	265.1	623.7	412.0	740.8
	Non hoki, hake, ling	95.8	42.2	67.2	68.8	66.3	171.7	220.8

Appendix 4a: Estimates of bycatch (t) in the target hoki trawl fishery by fishing year and species categories COM, OTH, and overall (TOT), with 95% confidence intervals in parentheses. Rows in bold show results for the years for which estimates from Anderson & Smith (2004) were repeated. Results from this study are rounded to the nearest 100 t.

	Species category					
	COM		OTH		TOT	
Estimates from Anderson and Smith (2004)						
1990–91	–	–	–	–	42 300	(31 700–51 300)
1994–95	–	–	–	–	37 000	(29 300–46 600)
1998–99	–	–	–	–	47 700	(40 500–55 300)
1999–00	33 100	(28 000–38 700)	26 900	(22 200–32 100)	60 000	(50 200–70 800)
2000–01	**33 200**	**(27 900–38 800)**	**18 100**	**(15 200–21 000)**	**51 300**	**(43 100–59 800)**
2001–02	**28 900**	**(24 800–32 900)**	**24 900**	**(20 400–29 800)**	**53 800**	**(45 200–62 700)**
2002–03	**26 300**	**(22 000–31 700)**	**25 600**	**(20 200–32 200)**	**51 900**	**(42 200–63 900)**
Estimates from Anderson et al. (2001)						
1990–91	21 878	(19 331–24 898)	9 090	(8 035–10 249)	30 968	(27 366–35 147)
1991–92	15 748	(13 692–18 019)	8 401	(7 254–9 747)	24 148	(20 946–27 766)
1992–93	15 838	(12 475–20 254)	6 034	(5 046–7 219)	21 871	(17 521–27 474)
1993–94	10 184	(8 541–12 086)	5 011	(4 160–6 052)	15 196	(12 701–18 138)
1994–95	12 499	(9 927–15 668)	6 695	(5 654–7 915)	19 194	(15 580–23 583)
1995–96	19 322	(15 907–23 649)	9 247	(7 852–10 786)	28 569	(23 759–34 435)
1996–97	24 307	(18 978–30 946)	14 172	(11 862–17 115)	38 479	(30 840–48 061)
1997–98	25 271	(22 046–29 005)	17 443	(15 451–19 854)	42 714	(37 498–48 859)
1998–99	18 650	(16 524–20 998)	16 971	(15 439–18 695)	35 621	(31 963–39 693)

Appendix 4b : Estimates of bycatch (rounded to the nearest 100 t) in the target hoki trawl fishery by fishing year for the species categories (hake (HAK), ling (LIN), and silver warehou (SWA)) examined separately, from Anderson & Smith (2004), with 95% confidence intervals in parentheses. Rows in bold show results for the years for which estimates from Anderson and Smith (2004) were repeated.

	Species category					
	HAK		LIN		SWA	
1999–00	11 900	(8 800–15 400)	7 800	(6 300–9 100)	7 100	(4 000–11 700)
2000–01	**6 700**	**(5 500–8 200)**	**9 100**	**(6 600–13 500)**	**9 300**	**(5 900–13 100)**
2001–02	**11 000**	**(8 200–14 500)**	**8 200**	**(6 900–9 400)**	**2 400**	**(1 500–3 500)**
2002–03	**6 200**	**(4 300–8 800)**	**8 900**	**(7 600–9 900)**	**3 000**	**(2 100–4 000)**

Appendix 4c: Estimates of bycatch (rounded to the nearest 10t) in the target hoki, hake or ling trawl fishery by fishing year and species categories, with 95% confidence intervals in parentheses. Hake and ling calculated using hoki target data only.

	Commercial		Non-commercial		Species category TOT	
2000–01	30300	(16100-50000)	27100	(16300-38300)	57400	(32400-88300)
2001–02	27700	(13300-47200)	31500	(19100-43500)	59200	(32400-90700)
2002–03	25000	(15200-39800)	30800	(18200-42000)	55800	(33400-81800)
2003–04	31700	(13600-61700)	26300	(15900-37700)	58000	(29500-99400)
2004–05	16400	(11300-23000)	24600	(13500-37200)	41000	(24800-60200)
2005–06	19000	(12000-26700)	18000	(9800-26500)	37000	(21800-53200)
2006–07	19400	(11000-25900)	16600	(9500-22700)	36000	(20500-48600)

	QMS		Non-QMS		Species category TOT	
2000–01	38600	(19100-60500)	20900	(14000-30500)	59500	(33100-91000)
2001–02	31700	(14100-53500)	28800	(18700-41800)	60500	(32800-95300)
2002–03	31300	(17300-47700)	22800	(14300-33100)	54100	(31600-80800)
2003–04	36700	(21400-54700)	23900	(15500-35500)	60600	(36900-90200)
2004–05	24200	(15000-33500)	16700	(8200-29300)	40900	(23200-62800)
2005–06	22500	(13800-30900)	14000	(7700-22000)	36500	(21500-52900)
2006–07	22200	(12300-30700)	14000	(8600-22400)	36200	(20900-53100)

	SPD		FRO		Species category GSP	
2000–01	3900	(1600-6800)	2600	(1500-3900)	1800	(1100-2600)
2001–02	4500	(1700-8400)	1500	(700-2800)	2200	(1400-3200)
2002–03	5300	(2500-9300)	1600	(900-2400)	2600	(1800-3400)
2003–04	6800	(1600-15900)	1200	(600-2100)	2200	(1400-2900)
2004–05	2500	(1200-4500)	1400	(900-2000)	1300	(700-2200)
2005–06	2600	(1000-4700)	800	(400-1300)	1100	(700-1700)
2006–07	2400	(800-4700)	1400	(500-1800)	800	(500-1100)

	BAR		RIB		Species category WWA	
2000–01	1000	(100-3000)	900	(500-1800)	1100	(400-1700)
2001–02	300	(0-900)	1800	(900-3200)	1200	(500-2100)
2002–03	900	(0-2800)	1200	(700-1900)	1300	(600-2400)
2003–04	400	(200-800)	1000	(600-1400)	2100	(900-3700)
2004–05	1200	(300-2500)	1000	(500-1400)	2300	(1400-3600)
2005–06	200	(100-400)	800	(400-1400)	2700	(1200-5000)
2006–07	200	(100-700)	700	(300-1100)	4300	(1600-7700)

	SPE		LDO		Species category SQU	
2000–01	1200	(500-2000)	1100	(500-1500)	800	(300-1900)
2001–02	1400	(800-2200)	1100	(600-1800)	700	(300-1300)
2002–03	1700	(800-2400)	1400	(700-1900)	900	(200-2300)
2003–04	1500	(600-2800)	800	(500-1200)	600	(200-900)
2004–05	900	(700-1300)	700	(400-1200)	400	(200-800)
2005–06	700	(300-1100)	700	(400-1000)	400	(200-700)
2006–07	600	(300-1000)	700	(300-1300)	400	(200-900)

Appendix 4c: continued.

	Species category					
	STA		JAV		RAT	
2000–01	500	(100-1000)	6400	(3400-9900)	4700	(3200-6400)
2001–02	500	(200-1100)	10100	(4300-16800)	6700	(3700-10700)
2002–03	500	(200-800)	9700	(5900-13100)	6600	(4300-9700)
2003–04	400	(100-900)	6700	(3900-9600)	5800	(3000-10700)
2004–05	500	(200-700)	8800	(4000-14200)	4400	(1700-7500)
2005–06	400	(200-600)	5500	(3000-8500)	3800	(2300-5800)
2006–07	400	(100-500)	6200	(3200-9200)	2200	(1600-3100)

	Species category	
	SND	
2000–01	700	(200-1300)
2001–02	1400	(300-2500)
2002–03	500	(200-1100)
2003–04	700	(300-1200)
2004–05	500	(200-900)
2005–06	500	(200-1100)
2006–07	500	(100-1000)

Appendix 5: Bycatch ratios in the hoki, hake or ling target combined fisheries by fishing year and area for species categories examined. Standard deviations calculated from bootstrap samples are shown in parentheses. See Figure 1 for area boundaries. Hake and ling data calculated using only target hoki data.

Commercial

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	555.11 (123.90)	334.02 (52.73)	223.48 (38.85)	2219.76 (1266.62)	428.86 (586.48)	683.09 (151.07)
2001–02	544.81 (98.86)	310.84 (119.24)	222.25 (39.39)	808.42 (451.09)	392.64 (1329.38)	590.04 (105.86)
2002–03	650.48 (228.68)	776.67 (244.45)	224.28 (40.50)	649.00 (234.51)	421.14 (322.38)	489.67 (117.11)
2003–04	892.07 (320.72)	289.82 (61.46)	222.30 (35.82)	1218.41 (434.82)	987.87 (1240.12)	683.76 (264.84)
2004–05	587.98 (289.44)	314.89 (90.79)	221.52 (39.52)	425.87 (135.18)	502.39 (219.70)	823.45 (171.28)
2005–06	907.15 (273.80)	231.96 (37.99)	224.76 (39.57)	1222.65 (433.07)	740.06 (663.85)	510.84 (200.84)
2006–07	527.72 (232.84)	487.60 (260.03)	222.69 (40.95)	1183.04 (432.05)	1146.93 (816.76)	600.14 (154.92)

Non-commercial

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	742.59 (113.67)	38.07 (6.08)	974.52 (399.87)	464.51 (114.39)	191.44 (262.00)	175.27 (76.69)
2001–02	1028.55 (203.12)	30.13 (8.61)	1002.12 (393.91)	182.83 (45.05)	269.40 (432.73)	129.91 (174.51)
2002–03	986.89 (316.80)	16.25 (9.48)	988.16 (380.40)	394.51 (122.27)	450.63 (107.01)	193.86 (70.06)
2003–04	1066.45 (404.72)	36.18 (35.12)	999.12 (377.72)	488.61 (113.75)	360.32 (207.99)	269.80 (176.01)
2004–05	1062.10 (455.51)	51.99 (11.29)	999.86 (391.69)	165.93 (29.62)	422.58 (544.02)	165.93 (77.25)
2005–06	1078.60 (316.33)	29.30 (9.81)	986.02 (391.37)	478.01 (117.08)	306.61 (254.51)	147.62 (193.72)
2006–07	816.28 (234.09)	37.47 (10.43)	985.69 (358.66)	487.34 (114.20)	319.11 (123.50)	159.95 (176.24)

QMS (All QMS species)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	624.52 (184.82)	399.88 (69.24)	548.05 (218.30)	2375.42 (1301.65)	462.01 (658.73)	733.85 (459.21)
2001–02	468.08 (132.24)	385.15 (133.68)	547.02 (221.85)	936.94 (453.34)	457.13 (1323.96)	623.31 (168.39)
2002–03	694.02 (190.94)	821.10 (246.76)	550.00 (221.63)	880.92 (263.59)	520.88 (322.93)	522.31 (268.38)
2003–04	998.68 (288.73)	349.97 (63.19)	542.08 (225.51)	1423.81 (448.67)	1474.32 (560.52)	817.00 (296.70)
2004–05	636.91 (248.60)	350.24 (99.47)	548.82 (213.79)	560.67 (149.45)	700.72 (674.93)	736.04 (222.23)
2005–06	907.06 (246.04)	263.00 (39.66)	550.83 (219.15)	1444.04 (452.70)	798.45 (649.85)	590.11 (255.77)
2006–07	654.09 (185.29)	531.19 (235.33)	543.55 (224.73)	1407.31 (455.76)	1178.76 (783.74)	591.42 (253.76)

Appendix 5: continued.

Non-QMS (All non-QMS species)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	853.28 (161.25)	8.13 (2.21)	706.82 (326.08)	265.60 (81.26)	149.60 (247.37)	113.21 (33.67)
2001–02	1233.00 (315.61)	9.86 (4.75)	704.49 (323.29)	58.40 (19.52)	280.70 (409.62)	65.39 (164.64)
2002–03	974.65 (279.39)	4.98 (3.12)	710.95 (319.99)	198.05 (117.92)	353.04 (88.60)	185.86 (73.02)
2003–04	1217.57 (346.93)	7.04 (3.42)	692.46 (315.89)	324.38 (110.47)	302.17 (262.20)	102.71 (149.53)
2004–05	1124.51 (474.74)	35.26 (10.02)	716.47 (318.09)	57.67 (16.52)	402.45 (581.71)	166.15 (229.11)
2005–06	1088.47 (325.99)	14.65 (9.81)	702.14 (338.44)	334.43 (108.39)	277.19 (245.56)	171.86 (153.53)
2006–07	902.12 (260.62)	15.63 (8.12)	714.74 (332.29)	319.13 (113.32)	282.96 (249.94)	175.08 (133.28)

SWA (Silver warehou)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	200.55 (138.78)	4.08 (5.96)	15.39 (4.91)	1933.69 (1226.44)	322.21 (144.10)	281.21 (154.78)
2001–02	33.58 (18.91)	0.43 (0.35)	15.58 (4.79)	764.43 (473.10)	64.61 (61.71)	84.86 (28.98)
2002–03	166.18 (298.90)	0.19 (0.11)	15.20 (5.03)	438.55 (273.08)	30.26 (21.59)	107.14 (30.58)
2003–04	399.08 (114.68)	0.03 (0.03)	15.65 (4.87)	900.99 (429.61)	155.60 (145.29)	147.95 (215.71)
2004–05	151.85 (43.18)	14.79 (7.07)	15.47 (4.75)	18.60 (5.42)	26.82 (11.18)	177.47 (157.79)
2005–06	309.09 (225.89)	0.12 (0.11)	15.46 (4.76)	921.18 (419.29)	222.42 (68.07)	130.23 (71.26)
2006–07	329.61 (294.19)	8.77 (8.76)	15.10 (5.01)	937.59 (426.41)	211.22 (84.83)	101.05 (78.34)

HAK (Hake)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	111.75 (79.06)	0.74 (0.49)	83.81 (63.20)	51.79 (29.11)	109.44 (68.00)	379.05 (331.94)
2001–02	114.62 (44.72)	0.18 (0.09)	86.40 (65.65)	9.20 (2.66)	91.67 (98.94)	893.53 (565.42)
2002–03	131.28 (44.36)	1.06 (0.42)	92.70 (66.80)	34.75 (26.41)	120.06 (45.77)	459.61 (647.75)
2003–04	103.79 (48.91)	0.41 (0.22)	89.28 (66.13)	9.78 (4.94)	103.87 (53.76)	483.75 (315.52)
2004–05	68.74 (36.08)	1.91 (0.52)	94.97 (63.93)	36.55 (12.90)	136.23 (94.59)	213.26 (171.61)
2005–06	87.69 (70.49)	0.08 (0.11)	89.27 (64.04)	35.55 (13.07)	82.96 (47.25)	357.36 (279.37)
2006–07	150.34 (91.23)	0.23 (0.16)	86.63 (66.50)	35.92 (12.53)	56.87 (69.10)	378.85 (170.11)

Appendix 5: continued.

LIN (Ling)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	148.04 (55.74)	61.83 (14.72)	83.84 (19.88)	321.35 (63.61)	547.63 (526.23)	293.85 (176.77)
2001–02	236.59 (64.47)	44.36 (8.68)	82.34 (19.74)	420.90 (97.13)	361.82 (465.10)	348.31 (187.50)
2002–03	152.44 (89.99)	41.26 (12.13)	82.01 (19.61)	877.99 (486.76)	572.16 (170.84)	261.85 (144.16)
2003–04	221.48 (112.31)	30.46 (4.51)	82.47 (19.35)	770.99 (277.18)	711.78 (690.05)	316.82 (270.30)
2004–05	178.38 (67.90)	30.31 (7.73)	82.20 (19.20)	340.68 (131.80)	1133.60 (986.89)	205.97 (286.90)
2005–06	169.18 (40.43)	29.78 (6.61)	82.51 (20.28)	774.08 (288.43)	828.24 (429.92)	188.96 (204.32)
2006–07	165.65 (56.74)	59.06 (31.42)	82.03 (19.23)	774.55 (287.58)	1004.66 (473.62)	210.82 (97.65)

SPD (Spiny dogfish)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	68.97 (17.88)	329.68 (52.88)	5.94 (1.91)	121.62 (88.31)	80.90 (36.42)	74.03 (30.93)
2001–02	125.66 (30.11)	292.75 (120.18)	5.88 (1.79)	28.82 (16.90)	143.42 (90.18)	88.29 (19.11)
2002–03	59.46 (11.75)	763.95 (248.47)	5.91 (1.79)	40.98 (18.36)	118.32 (70.41)	41.56 (7.72)
2003–04	96.46 (23.56)	287.60 (61.07)	5.96 (1.81)	96.20 (40.17)	550.91 (440.80)	35.64 (11.78)
2004–05	133.97 (30.70)	283.39 (96.44)	5.78 (1.88)	178.30 (111.74)	35.44 (20.90)	35.32 (12.45)
2005–06	125.46 (38.64)	228.99 (35.32)	5.95 (1.83)	99.60 (37.50)	184.50 (113.49)	55.31 (17.82)
2006–07	54.83 (8.43)	481.41 (267.32)	5.78 (1.83)	100.33 (39.03)	207.75 (131.68)	50.03 (10.22)

GSP (Pale ghost shark)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	86.23 (14.96)	0.00 (0.00)	9.59 (4.87)	12.37 (9.59)	53.61 (17.36)	0.88 (0.70)
2001–02	120.40 (16.06)	0.00 (0.00)	9.23 (4.68)	0.00 (0.00)	56.20 (19.96)	7.06 (3.53)
2002–03	120.08 (18.43)	0.00 (0.00)	9.36 (4.71)	2.42 (1.83)	92.37 (11.02)	0.83 (0.36)
2003–04	114.82 (11.85)	0.03 (0.02)	9.32 (4.70)	5.46 (3.29)	111.33 (30.66)	0.57 (0.34)
2004–05	129.31 (27.56)	0.00 (0.00)	9.41 (4.82)	2.77 (2.09)	62.03 (21.93)	0.12 (0.09)
2005–06	130.69 (24.61)	0.00 (0.00)	9.07 (4.98)	5.49 (3.18)	43.11 (10.67)	4.13 (2.11)
2006–07	81.12 (12.63)	0.01 (0.02)	9.37 (4.75)	5.44 (3.33)	42.28 (11.80)	4.02 (2.00)

Appendix 5: continued.

BAR (Barracouta)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	0.63 (0.57)	0.08 (0.08)	2.76 (1.34)	0.11 (0.08)	10.31 (8.83)	71.79 (73.09)
2001–02	0.01 (0.02)	0.03 (0.03)	2.72 (1.30)	0.08 (0.11)	0.00 (0.00)	22.71 (28.54)
2002–03	3.42 (22.68)	1.88 (2.14)	2.83 (1.40)	0.07 (0.06)	0.22 (0.28)	64.65 (59.10)
2003–04	0.13 (0.11)	0.08 (0.03)	2.70 (1.26)	0.20 (0.18)	0.00 (0.00)	49.77 (19.76)
2004–05	0.03 (0.05)	10.04 (4.59)	2.71 (1.39)	0.00 (0.00)	0.00 (0.00)	188.22 (104.05)
2005–06	0.10 (0.08)	0.00 (0.00)	2.73 (1.35)	0.21 (0.19)	0.06 (0.04)	32.96 (14.77)
2006–07	0.05 (0.07)	1.58 (0.93)	2.76 (1.33)	0.21 (0.18)	1.02 (0.83)	72.38 (36.66)

RIB (Ribaldo)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	21.33 (5.19)	0.03 (0.04)	55.66 (17.84)	11.68 (6.23)	25.10 (7.52)	3.45 (1.48)
2001–02	34.64 (7.50)	0.00 (0.00)	55.52 (17.76)	0.92 (1.10)	50.53 (16.19)	64.51 (30.67)
2002–03	22.86 (5.61)	0.01 (0.02)	56.22 (17.50)	19.36 (19.65)	25.74 (6.59)	18.07 (5.11)
2003–04	31.79 (4.57)	0.00 (0.00)	55.17 (17.74)	14.57 (4.42)	24.00 (3.56)	19.32 (7.17)
2004–05	30.96 (7.20)	0.00 (0.00)	56.22 (18.38)	5.32 (2.65)	52.22 (10.36)	8.14 (5.37)
2005–06	23.31 (5.62)	0.00 (0.00)	56.61 (17.02)	14.09 (4.48)	25.04 (4.88)	45.87 (24.54)
2006–07	31.19 (8.51)	0.37 (0.46)	55.96 (18.35)	14.01 (4.60)	26.49 (3.72)	37.96 (20.00)

WWA (White warehou)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	40.36 (9.65)	0.00 (0.0)	2.09 (1.19)	15.58 (20.38)	36.65 (14.28)	0.97 (0.59)
2001–02	33.13 (4.52)	0.00 (0.0)	2.06 (1.15)	5.67 (4.90)	52.40 (31.58)	18.34 (5.98)
2002–03	45.88 (13.57)	0.00 (0.0)	2.05 (1.20)	97.27 (82.45)	32.07 (7.52)	15.89 (6.92)
2003–04	86.21 (17.58)	0.00 (0.0)	2.13 (1.20)	98.31 (27.90)	114.57 (61.11)	8.66 (3.35)
2004–05	113.77 (20.73)	0.00 (0.0)	2.18 (1.18)	217.46 (58.29)	182.51 (46.46)	7.23 (6.18)
2005–06	141.23 (82.96)	0.00 (0.0)	2.12 (1.23)	96.50 (27.77)	351.45 (75.92)	23.62 (9.94)
2006–07	85.73 (27.28)	3.32 (3.9)	2.13 (1.28)	97.43 (29.11)	823.03 (340.82)	12.27 (5.34)

Appendix 5: continued.

SPE (Sea perch)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	66.34 (15.91)	0.22 (0.33)	38.63 (13.04)	1.08 (0.61)	0.09 (0.09)	2.68 (1.29)
2001–02	83.16 (17.68)	0.00 (0.05)	39.27 (12.89)	0.00 (0.00)	0.10 (0.09)	22.30 (10.17)
2002–03	101.28 (20.81)	0.00 (0.00)	39.10 (13.05)	3.11 (3.92)	0.10 (0.06)	9.32 (2.93)
2003–04	117.01 (43.08)	0.00 (0.00)	39.14 (12.81)	2.44 (1.49)	0.17 (0.17)	5.44 (1.73)
2004–05	92.33 (11.22)	0.09 (0.07)	38.68 (12.97)	2.92 (1.98)	0.13 (0.13)	4.79 (2.15)
2005–06	55.03 (13.34)	0.00 (0.00)	38.85 (12.74)	2.45 (1.48)	0.07 (0.03)	14.61 (6.71)
2006–07	55.07 (11.18)	0.26 (0.27)	39.30 (13.05)	2.45 (1.46)	0.56 (0.33)	9.06 (4.15)

LDO (Lookdown dory)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	40.37 (6.20)	0.00 (0.00)	43.71 (13.69)	11.06 (7.83)	5.44 (1.93)	5.88 (2.05)
2001–02	49.29 (7.96)	0.00 (0.00)	43.41 (13.61)	1.04 (1.00)	1.99 (0.92)	31.38 (9.59)
2002–03	59.71 (12.91)	0.01 (0.01)	43.67 (13.26)	3.70 (3.09)	5.80 (1.11)	18.76 (4.19)
2003–04	43.46 (5.67)	0.00 (0.00)	43.05 (12.79)	8.87 (3.04)	5.45 (1.91)	14.74 (3.14)
2004–05	60.44 (12.30)	0.00 (0.00)	43.03 (13.54)	4.07 (1.82)	6.27 (1.59)	6.63 (2.59)
2005–06	41.08 (6.13)	0.03 (0.03)	43.00 (13.52)	8.91 (3.13)	7.15 (1.90)	27.04 (8.64)
2006–07	55.04 (20.11)	0.09 (0.11)	43.65 (12.48)	9.16 (3.21)	7.19 (2.32)	28.03 (10.19)

SQU (Arrow squid)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
8.92 (2.35)	8.92 (2.35)	0.08 (0.04)	5.04 (2.74)	41.86 (27.79)	44.53 (29.37)	13.65 (3.37)
4.59 (0.85)	4.59 (0.85)	0.06 (0.04)	4.82 (2.84)	6.70 (3.01)	16.16 (8.06)	43.61 (15.31)
4.06 (0.95)	4.06 (0.95)	0.26 (0.08)	4.78 (2.76)	13.72 (8.00)	39.25 (38.82)	26.27 (5.75)
7.86 (1.73)	7.86 (1.73)	0.53 (0.18)	4.72 (2.82)	29.48 (10.74)	8.24 (3.75)	35.95 (11.61)
9.46 (2.75)	9.46 (2.75)	0.88 (0.23)	4.82 (2.73)	7.19 (2.08)	44.91 (9.40)	17.13 (6.95)
10.84 (4.00)	10.84 (4.00)	0.17 (0.09)	5.00 (2.78)	29.18 (10.66)	32.47 (9.59)	28.31 (9.34)
7.65 (2.70)	7.65 (2.70)	1.24 (0.60)	4.89 (2.84)	28.55 (10.61)	33.33 (13.53)	45.18 (14.00)

Appendix 5: continued.

STA (Stargazer)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	22.72 (5.61)	0.13 (0.10)	11.22 (8.25)	13.19 (7.35)	7.61 (2.84)	3.96 (2.18)
2001–02	28.27 (8.79)	0.03 (0.03)	11.09 (8.24)	2.84 (2.59)	3.61 (1.69)	10.55 (3.18)
2002–03	17.73 (3.99)	0.00 (0.00)	11.16 (8.26)	15.12 (9.99)	7.91 (1.49)	8.35 (1.69)
2003–04	20.99 (5.35)	0.00 (0.00)	11.23 (8.20)	24.03 (7.70)	5.42 (2.37)	14.48 (5.57)
2004–05	31.71 (6.19)	0.00 (0.00)	10.64 (7.68)	3.27 (2.57)	11.91 (2.81)	6.90 (3.08)
2005–06	24.22 (3.29)	0.00 (0.00)	11.55 (8.36)	24.35 (7.53)	18.62 (5.04)	11.56 (4.28)
2006–07	22.68 (4.26)	0.07 (0.06)	11.03 (7.92)	24.32 (7.55)	14.16 (2.75)	1.81 (0.61)

FRO (Frostfish)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	0.11 (0.06)	0.35 (0.16)	2.56 (1.18)	2.82 (1.31)	0.23 (0.48)	249.82 (59.08)
2001–02	0.01 (1.32)	0.40 (0.24)	2.56 (1.14)	4.54 (3.09)	0.00 (0.00)	168.06 (57.31)
2002–03	0.07 (0.07)	0.93 (0.44)	2.53 (1.14)	0.11 (0.14)	0.02 (0.03)	177.22 (41.07)
2003–04	0.82 (0.99)	0.18 (0.08)	2.48 (1.10)	4.32 (5.57)	0.00 (0.00)	151.72 (49.93)
2004–05	0.17 (0.14)	1.12 (0.36)	2.48 (1.20)	0.08 (0.08)	0.00 (0.00)	244.59 (52.67)
2005–06	0.03 (0.03)	0.09 (0.07)	2.57 (1.15)	4.10 (5.79)	0.01 (0.02)	144.82 (40.21)
2006–07	0.02 (0.02)	1.13 (0.64)	2.47 (1.17)	3.59 (5.92)	0.00 (0.00)	222.60 (54.43)

RAT (Rattails)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	245.98 (32.23)	1.95 (0.86)	63.98 (14.46)	13.06 (4.80)	69.21 (21.87)	11.69 (3.76)
2001–02	397.22 (116.01)	0.22 (0.18)	63.10 (14.28)	9.19 (7.57)	121.84 (16.06)	56.31 (17.90)
2002–03	391.70 (85.25)	0.81 (0.66)	64.79 (14.43)	26.38 (22.26)	83.08 (10.52)	25.42 (3.27)
2003–04	449.59 (152.05)	0.87 (0.31)	64.34 (14.40)	44.25 (21.75)	49.36 (19.52)	19.26 (5.56)
2004–05	415.32 (152.03)	0.19 (0.11)	64.44 (14.33)	13.24 (5.51)	104.22 (28.36)	11.30 (3.44)
2005–06	423.46 (89.74)	0.30 (0.33)	64.37 (15.22)	43.93 (21.30)	57.79 (23.00)	32.07 (12.85)
2006–07	210.65 (24.74)	1.33 (0.60)	64.35 (15.08)	42.97 (22.20)	54.59 (13.40)	44.84 (17.63)

Appendix 5: continued.

JAV (Javelinfish)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	274.43 (49.32)	0.04 (0.05)	165.97 (53.13)	47.04 (29.85)	110.83 (49.26)	17.34 (5.94)
2001–02	385.74 (69.55)	0.00 (0.00)	168.07 (54.29)	6.36 (3.95)	401.17 (167.22)	52.92 (23.56)
2002–03	498.11 (85.24)	0.01 (0.02)	169.12 (55.63)	37.63 (28.84)	173.15 (20.04)	26.10 (4.78)
2003–04	406.76 (57.57)	0.00 (0.00)	167.16 (55.09)	58.43 (22.13)	117.36 (49.30)	33.54 (13.31)
2004–05	651.49 (180.37)	0.01 (0.01)	169.83 (55.02)	9.35 (3.88)	443.46 (142.42)	38.52 (7.45)
2005–06	525.77 (103.82)	0.00 (0.00)	165.41 (56.92)	56.76 (22.37)	114.84 (51.81)	79.28 (42.16)
2006–07	646.87 (131.79)	1.26 (2.09)	168.17 (55.07)	57.89 (22.17)	165.18 (52.32)	64.15 (20.49)

SND (Shovelnose dogfish)

	Median bycatch ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	18.84 (5.54)	1.38 (0.76)	32.02 (17.97)	35.37 (35.49)	1.42 (0.69)	0.62 (0.38)
2001–02	87.94 (44.85)	0.00 (0.00)	31.16 (18.21)	6.00 (7.18)	0.52 (0.47)	8.25 (2.51)
2002–03	23.57 (7.41)	0.06 (0.05)	32.53 (17.85)	16.80 (15.57)	0.99 (0.52)	2.28 (0.85)
2003–04	34.50 (10.17)	0.24 (0.20)	30.90 (17.69)	60.09 (33.75)	0.16 (0.18)	1.99 (1.39)
2004–05	38.54 (8.35)	3.63 (2.25)	32.85 (17.86)	1.47 (0.66)	0.84 (0.60)	1.27 (0.57)
2005–06	49.14 (12.25)	0.00 (0.10)	31.83 (16.76)	56.19 (33.29)	3.97 (1.97)	7.82 (3.54)
2006–07	25.58 (12.81)	1.00 (0.73)	31.48 (17.37)	57.48 (32.92)	1.62 (0.53)	8.29 (2.63)

Appendix 6a: Estimates of discards (t) in the target hoki trawl fishery by year, for the species categories HOK, COM, OTH, and overall (TOT), with 95% confidence intervals in parentheses. Rows in bold show results for the years for which estimates from Anderson & Smith (2004) were repeated. Results from this study are rounded to the nearest 10 or 100 t.

	Species category					
Fishing year	HOK		COM		OTH		TOT	
Estimates from Anderson & Smith (2004)								
1990–91	4 800	(2 300–8 300)	–	–	–	–	12 100	(6 900–24 300)
1994–95	9 700	(5 300–14 100)	–	–	–	–	17 900	(10 300–26 700)
1998–99	1 580	(600–2 800)	–	–	–	–	11 800	(7 600–17 000)
1999–00	900	(300–1 700)	300	(100–700)	9 700	(6 000–15 100)	10 900	(6 400–17 500)
2000–01	**2 100**	**(200–3 800)**	**200**	**(100–400)**	**11 600**	**(7 300–14 700)**	**13 900**	**(7 600–18 800)**
2001–02	**600**	**(10–1 600)**	**70**	**(10–140)**	**11 200**	**(6 700–18 100)**	**11 800**	**(6 700–19 800)**
2002–03	**1 800**	**(600–5 000)**	**400**	**(40–1 300)**	**8 500**	**(5 000–13 400)**	**10 700**	**(5 700–19 700)**
Estimates from Anderson et al. (2001)								
1990–91	3258	(2 281–4 512)	–	–	–	–	9 178	(6 729–12 529)
1991–92	2397	(1 343–3 696)	–	–	–	–	7 873	(5 691–10 507)
1992–93	4511	(3 069–6 305)	–	–	–	–	7 103	(4 668–10 129)
1993–94	3626	(2 572–4 897)	–	–	–	–	6 628	(4 939–8 662)
1994–95	5636	(4 010–7 517)	–	–	–	–	10 896	(7 886–14 670)
1995–96	2846	(1 820–4 200)	–	–	–	–	9 187	(6 786–12 133)
1996–97	2893	(1 781–4 413)	–	–	–	–	9 484	(6 234–13 823)
1997–98	4023	(3 135–5 114)	–	–	–	–	12 123	(10155–14 609)
1998–99	2862	(2 159–3 816)	–	–	–	–	10 962	(8 869–13 627)

Appendix 6b: Estimates of discards in the target hoki, hake, and ling trawl fishery by year, for various species categories with 95% confidence intervals in parentheses. Estimates are rounded to the nearest 100 t for all discard estimates except ling, hake and silver warehou which are rounded to nearest t. Hake and ling are calculated using the hoki target data set. 2006–07 data are incomplete.

	Commercial		Non-commercial		Species category TOT	
2000–01	3500	(1300-6200)	12600	(5100-21200)	16100	(6300-27600)
2001–02	7300	(2500-13800)	21900	(8600-43700)	29200	(11100-57500)
2002–03	6500	(2800-13200)	13500	(5200-22400)	20000	(8000-35500)
2003–04	9400	(1300-30700)	9300	(3300-18000)	18700	(4600-48700)
2004–05	1200	(400-2400)	4300	(1500-8300)	5500	(1900-10700)
2005–06	2500	(400-5800)	5400	(2000-11400)	7900	(2400-17200)
2006–07	3800	(700-9000)	5100	(1300-10500)	8900	(2000-19500)

	QMS		Non-QMS		Species category TOT	
2000–01	4100	(1700-6900)	11800	(4200-20700)	15900	(5900-27600)
2001–02	7500	(2600-14400)	21500	(8400-42100)	29000	(11000-56500)
2002–03	6800	(2800-13300)	13200	(5000-22000)	20000	(7800-35300)
2003–04	9700	(1400-30400)	8700	(3200-17800)	18400	(4600-48200)
2004–05	1200	(600-2700)	4100	(1400-8000)	5300	(2000-10700)
2005–06	2600	(500-6200)	5200	(1700-11300)	7800	(2200-17500)
2006–07	3800	(600-8400)	5100	(1300-10100)	8900	(1900-18500)

	HOK		HAK		LIN		Species category SWA	
2000–01	1300	(0-4000)	5	(0-18)	9	(0-36)	10	(0-42)
2001–02	700	(0-2400)	2	(0-6)	5	(0-18)	1	(0-2)
2002–03	2500	(100-8100)	32	(0-103)	6	(0-19)	2	(0-7)
2003–04	600	(0-2000)	9	(0-23)	5	(0-14	1	(0-2)
2004–05	200	(0-900)	2	(0-6)	5	(0-16)	0	(0-2)
2005–06	100	(0-300)	1	(0-2)	0	(0-1)	2	(0-8)
2006–07	1200	(100-1900)	17	(0-52)	14	(0-41)	1	(0-2)

	JAV		Rattail		SND		Species category Skates	
2000–01	3700	(900-7600)	3400	(700-6400)	500	(100-1000)	200	(0-800)
2001–02	6000	(0-15700)	4100	(100-11500)	1800	(300-3300)	400	(100-600)
2002–03	4100	(300-8300)	2900	(500-5900)	500	(100-1100)	300	(100-700)
2003–04	2000	(0-5500)	1200	(0-3500)	800	(300-1600)	200	(0-800)
2004–05	900	(0-2300)	200	(0-1300)	400	(0-800)	0	(0-100)
2005–06	1400	(0-4300))	600	(0-1900)	600	(0-1300)	0	(0-100)
2006–07	1600	(0-3800)	700	(0-2100)	400	(0-1000)	0	(0-100)

	SPD		Commercial excl SPD		DW sharks		Species category Other sharks	
2000–01	3500	(1300-6000)	0	(0-200)	2200	(1000-3700)	500	(100- 1200)
2001–02	7300	(2400-14100)	100	(0-400)	6700	(2600-10700)	100	(100- 400)
2002–03	5900	(2600-11700)	500	(0-1300)	2800	(1300-5400)	500	(0-1900)
2003–04	9200	(1100-30600)	100	(0-200)	2300	(1000-4600)	700	(0-2000)
2004–05	1200	(400-2400)	0	(0-0)	1300	(400-2600)	500	(0-2000)
2005–06	2500	(400-6100)	0	(0-0)	1700	(700-3300)	100	(0-400)
2006–07	3700	(600-8900)	0	(0-200)	1400	(400-2900)	0	(0-200)

Appendix 7: Discard ratios in the hoki, hake, and ling target combined fishery by fishing year and area for species categories examined. Standard deviations calculated from bootstrap samples are shown in parentheses. See Figure 1 for hoki area boundaries. 2006–07 data is incomplete.

Commercial

	Median discard ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	83.00 (33.18)	289.48 (47.45)	1.62 (1.39)	57.88 (39.14)	30.44 (10.01)	99.07 (46.47)
2001–02	145.71 (41.65)	249.74 (149.26)	1.52 (1.36)	52.93 (18.86)	359.70 (179.26)	109.79 (37.08)
2002–03	77.70 (14.43)	709.93 (201.17)	1.65 (1.41)	51.91 (19.33)	194.09 (135.52)	79.47 (38.68)
2003–04	140.32 (59.44)	235.67 (45.63)	1.56 (1.40)	52.18 (19.43)	958.02 (912.77)	38.19 (12.32)
2004–05	48.44 (11.72)	153.96 (86.21)	1.56 (1.40)	50.32 (19.93)	45.28 (29.11)	20.37 (8.63)
2005–06	86.15 (30.71)	72.59 (40.71)	1.61 (1.39)	53.24 (19.19)	285.94 (255.57)	48.01 (18.95)
2006–07	31.17 (13.29)	12.24 (2.97)	1.54 (1.38)	51.14 (18.47)	631.88 (563.71)	65.41 (12.72)

Spiny dogfish

	Median discard ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	78.89 (33.18)	289.33 (48.16)	1.45 (1.39)	55.48 (36.64)	28.82 (9.91)	99.82 (45.86)
2001–02	141.31 (38.29)	235.97 (151.33)	1.43 (1.44)	52.35 (19.53)	360.20 (182.39)	109.76 (35.50)
2002–03	71.32 (14.26)	698.11 (196.82)	1.41 (1.42)	50.71 (18.60)	195.28 (131.23)	36.11 (7.47)
2003–04	132.25 (57.08)	235.01 (48.22)	1.41 (1.42)	52.89 (19.02)	963.44 (914.76)	30.82 (11.33)
2004–05	46.52 (11.06)	155.78 (92.09)	1.45 (1.43)	51.58 (19.44)	42.34 (27.89)	19.53 (8.59)
2005–06	88.06 (31.40)	73.07 (43.58)	1.39 (1.43)	52.37 (20.08)	313.99 (250.57)	48.14 (19.21)
2006–07	28.84 (12.55)	12.39 (2.91)	1.37 (1.44)	49.35 (19.22)	658.24 (544.91)	55.28 (11.32)

Commercial, excluding spiny dogfish

	Median discard ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	3.08 (2.34)	0.07 (0.11)	0.12 (0.12)	2.31 (1.63)	1.31 (1.33)	1.58 (1.38)
2001–02	4.76 (4.03)	0.00 (0.00)	0.12 (0.12)	1.22 (0.81)	2.30 (2.06)	2.04 (1.75)
2002–03	5.90 (2.69)	0.00 (0.00)	0.12 (0.12)	1.23 (0.85)	2.25 (2.84)	42.79 (35.42)
2003–04	3.84 (2.97)	0.00 (0.00)	0.12 (0.12)	1.24 (0.82)	3.29 (1.58)	7.23 (3.93)
2004–05	0.83 (1.03)	0.00 (0.00)	0.12 (0.13)	1.19 (0.84)	0.17 (2.09)	0.96 (0.91)
2005–06	0.03 (0.44)	0.00 (0.00)	0.12 (0.12)	1.22 (0.81)	0.04 (0.51)	0.47 (0.55)
2006–07	2.08 (2.54)	0.00 (0.00)	0.12 (0.12)	1.23 (0.81)	0.02 (0.06)	9.46 (6.93)

Appendix 7: continued.

QMS

	Median discard ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	89.62 (35.44)	296.34 (47.36)	6.18 (3.75)	78.59 (46.17)	44.55 (15.61)	117.17 (44.90)
2001–02	154.01 (43.05)	238.37 (144.93)	6.51 (3.89)	62.04 (22.68)	371.09 (180.61)	126.15 (37.43)
2002–03	84.75 (14.85)	700.28 (200.46)	6.66 (3.99)	62.73 (22.39)	200.52 (134.14)	92.80 (40.59)
2003–04	139.07 (61.13)	240.15 (47.43)	6.29 (3.83)	60.86 (22.89)	977.02 (891.46)	47.10 (12.80)
2004–05	47.81 (11.55)	155.97 (89.18)	6.40 (3.92)	61.29 (22.54)	44.46 (30.04)	25.51 (8.55)
2005–06	88.14 (30.63)	82.77 (45.48)	6.32 (4.01)	61.55 (22.64)	336.49 (253.63)	51.20 (18.85)
2006–07	31.14 (13.11)	12.46 (2.95)	6.64 (3.71)	61.75 (22.30)	652.93 (493.96)	75.00 (12.79)

HOK (Hoki)

	Median discard ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	2.82 (3.39)	5.83 (7.57)	0	2.92 (2.45)	1.82 (1.83)	101.16 (97.78)
2001–02	1.66 (1.39)	0.00 (0.00)	0	6.75 (53.23)	0.00 (0.03)	58.52 (69.39)
2002–03	78.09 (91.59)	0.00 (0.92)	0	9.14 (51.80)	0.14 (0.21)	128.06 (105.99)
2003–04	9.05 (13.15)	3.08 (2.47)	0	8.05 (53.23)	0.00 (0.00)	51.05 (42.33)
2004–05	1.79 (2.14)	0.20 (0.34)	0	8.88 (53.70)	0.28 (0.37)	20.70 (18.79)
2005–06	0.14 (0.20)	0.67 (0.89)	0	7.23 (53.10)	0.88 (1.35)	1.79 (1.73)
2006–07	11.29 (12.12)	0.00 (0.00)	0	7.53 (51.33)	46.61 (45.71)	64.53 (31.12)

HAK (Hake)

	Median discard ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	0.08 (0.08)	0	0	0.03 (0.05)	0.00 (0.00)	0.09 (0.39)
2001–02	0.00 (0.00)	0	0	0.01 (0.02)	0.00 (0.00)	0.17 (0.19)
2002–03	0.09 (0.12)	0	0	0.00 (0.02)	0.00 (0.00)	2.81 (3.24)
2003–04	0.00 (0.00)	0	0	0.00 (0.02)	0.00 (0.00)	1.01 (0.74)
2004–05	0.04 (0.07)	0	0	0.00 (0.02)	0.07 (0.10)	0.10 (0.12)
2005–06	0.00 (0.00)	0	0	0.00 (0.02)	0.00 (0.00)	0.09 (0.09)
2006–07	0.02 (0.03)	0	0	0.01 (0.02)	2.84 (3.06)	0.81 (0.64)

Appendix 7: continued.

LIN (Ling)

	Median discard ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	0.20 (0.54)	0	0	0 (0.24)	0.01 (0.01)	0.02 (0.24)
2001–02	0.02 (0.02)	0	0	0 (0.11)	0.00 (0.01)	0.46 (0.54)
2002–03	0.16 (0.21)	0	0	0 (0.10)	0.02 (0.04)	0.30 (0.25)
2003–04	0.00 (0.00)	0	0	0 (0.10)	0.00 (0.00)	0.49 (0.45)
2004–05	0.05 (0.09)	0	0	0 (0.10)	0.51 (0.62)	0.08 (0.07)
2005–06	0.00 (0.00)	0	0	0 (0.10)	0.00 (0.02)	0.01 (0.02)
2006–07	0.00 (0.02)	0	0	0 (0.09)	2.26 (2.87)	0.29 (0.15)

SWA (Silver warehou)

	Median discard ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	0.15 (0.19)	0	0	0	0.09 (0.14)	0.13 (0.80)
2001–02	0.00 (0.00)	0	0	0	0.00 (0.00)	0.04 (0.05)
2002–03	0.06 (0.08)	0	0	0	0.00 (0.00)	0.13 (0.10)
2003–04	0.00 (0.00)	0	0	0	0.00 (0.00)	0.07 (0.07)
2004–05	0.02 (0.04)	0	0	0	0.00 (0.00)	0.02 (0.03)
2005–06	0.00 (0.33)	0	0	0	0.00 (0.00)	0.00 (0.01)
2006–07	0.00 (0.00)	0	0	0	0.00 (0.00)	0.10 (0.12)

Non-commercial

	Median discard ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	478.67 (126.00)	15.16 (3.62)	303.56 (148.42)	192.21 (68.66)	263.56 (114.61)	63.17 (17.39)
2001–02	787.76 (360.06)	1.88 (2.10)	303.70 (137.68)	282.77 (112.94)	789.83 (322.36)	214.79 (108.44)
2002–03	610.76 (199.50)	9.26 (6.53)	294.19 (149.20)	279.40 (118.07)	208.25 (48.29)	106.30 (21.09)
2003–04	344.62 (118.82)	8.31 (3.45)	303.95 (144.65)	283.32 (112.42)	311.92 (141.79)	119.98 (54.50)
2004–05	86.26 (22.21)	36.00 (9.40)	314.38 (149.63)	285.42 (112.17)	211.67 (94.45)	37.47 (13.57)
2005–06	172.88 (43.65)	5.32 (6.11)	302.55 (147.39)	280.77 (111.98)	280.48 (203.17)	216.79 (114.08)
2006–07	255.09 (153.96)	43.00 (14.80)	302.41 (149.36)	271.10 (112.59)	118.15 (37.12)	130.27 (35.36)

Appendix 7: continued.

Non-QMS

Median discard ratios kg.tow^{-1}

Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	477.50 (128.70)	6.17 (2.01)	297.00 (147.67)	173.14 (68.73)	241.80 (116.47)	44.34 (14.34)
2001–02	760.38 (343.75)	1.40 (1.72)	300.05 (147.89)	266.85 (113.31)	778.76 (323.26)	195.07 (105.44)
2002–03	612.88 (196.57)	4.06 (3.24)	297.56 (149.08)	272.32 (120.33)	200.81 (48.94)	94.40 (18.24)
2003–04	340.04 (118.20)	5.93 (3.47)	293.80 (151.42)	272.76 (113.08)	290.98 (142.10)	115.68 (54.84)
2004–05	86.19 (23.40)	32.83 (9.83)	312.36 (140.62)	273.80 (114.18)	215.99 (91.63)	31.92 (13.43)
2005–06	171.80 (41.65)	0.72 (0.61)	300.48 (145.20)	273.35 (115.26)	277.17 (185.87)	213.10 (122.97)
2006–07	261.55 (144.52)	40.73 (14.55)	297.09 (152.48)	266.32 (119.86)	116.17 (36.77)	117.71 (35.09)

Deepwater sharks

Median discard ratios kg.tow^{-1}

Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	65.00 (18.38)	6.21 (2.58)	42.97 (20.37)	93.50 (56.93)	57.44 (16.64)	14.40 (6.34)
2001–02	187.76 (55.26)	0.00 (0.72)	44.32 (19.14)	197.38 (103.72)	336.70 (111.40)	28.40 (7.67)
2002–03	73.55 (15.14)	3.21 (2.53)	43.66 (19.69)	202.38 (110.16)	102.83 (49.69)	16.70 (4.61)
2003–04	120.62 (42.77)	4.88 (3.21)	42.27 (19.58)	207.61 (106.63)	29.44 (26.38)	17.17 (4.83)
2004–05	37.06 (13.59)	5.21 (2.44)	43.15 (18.83)	201.92 (110.46)	65.11 (27.42)	7.19 (2.60)
2005–06	83.76 (31.85)	0.45 (0.54)	44.54 (19.93)	203.29 (105.76)	112.07 (27.10)	40.49 (12.69)
2006–07	65.53 (50.10)	6.16 (2.31)	44.07 (19.15)	206.55 (104.85)	50.82 (14.06)	20.24 (3.16)

Other sharks

Median discard ratios kg.tow^{-1}

Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	3.78 (5.00)	6.22 (2.04)	2.74 (3.07)	35.31 (32.71)	7.52 (8.02)	14.81 (4.93)
2001–02	0.11 (0.15)	0.00 (0.66)	2.77 (3.14)	9.43 (17.35)	0.51 (0.66)	14.92 (3.70)
2002–03	15.14 (24.78)	4.15 (3.65)	2.74 (3.01)	9.49 (16.44)	6.36 (9.49)	9.96 (6.06)
2003–04	0.11 (0.15)	0.78 (0.67)	2.70 (3.02)	9.21 (16.81)	72.70 (58.31)	5.94 (3.07)
2004–05	0.01 (0.01)	28.90 (9.58)	2.64 (3.00)	9.50 (16.62)	74.07 (91.75)	2.68 (1.41)
2005–06	0.00 (0.00)	4.29 (6.24)	2.64 (3.01)	8.74 (17.63)	0.00 (25.14)	2.14 (1.28)
2006–07	0.42 (0.36)	0.51 (0.47)	2.66 (3.01)	10.37 (17.60)	1.18 (1.59)	8.81 (1.81)

Appendix 7: continued.

Skates

Median discard ratios kg.tow^{-1}

Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	14.27 (7.73)	0.01 (0.02)	7.00 (3.93)	9.90 (8.18)	2.87 (1.22)	3.83 (2.32)
2001–02	14.25 (6.29)	0.00 (0.00)	6.76 (3.86)	3.21 (3.30)	7.50 (1.67)	7.78 (2.51)
2002–03	16.82 (4.47)	0.00 (0.00)	6.77 (3.79)	3.44 (3.31)	7.57 (5.51)	4.90 (1.99)
2003–04	0.04 (0.04)	0.00 (0.00)	6.87 (3.75)	3.09 (3.20)	22.51 (27.31)	0.18 (0.14)
2004–05	0.36 (0.40)	0.00 (0.00)	6.61 (3.86)	3.38 (3.40)	0.14 (0.15)	0.05 (0.09)
2005–06	0.00 (0.00)	0.00 (0.00)	6.47 (3.85)	3.26 (3.07)	0.00 (0.00)	0.00 (0.02)
2006–07	0.00 (0.00)	0.00 (0.00)	7.16 (3.86)	3.04 (3.09)	0.00 (0.00)	2.79 (0.83)

Javelinfish

Median discard ratios kg.tow^{-1}

Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	157.16 (47.09)	0.05 (0.05)	111.57 (66.68)	9.35 (7.69)	86.66 (66.21)	3.42 (1.68)
2001–02	189.09 (161.28)	0.00 (0.00)	110.46 (67.03)	13.16 (14.20)	232.69 (169.77)	51.33 (31.28)
2002–03	241.02 (123.45)	0.00 (0.02)	114.07 (67.44)	11.28 (13.96)	13.76 (10.96)	16.42 (5.64)
2003–04	50.30 (41.56)	0.00 (0.00)	117.06 (66.23)	11.42 (13.45)	77.58 (59.87)	27.63 (17.15)
2004–05	7.52 (6.89)	0.09 (0.26)	111.40 (67.22)	12.22 (13.77)	29.73 (38.29)	5.71 (3.29)
2005–06	19.49 (18.40)	0.00 (0.00)	114.22 (67.13)	12.56 (14.91)	50.15 (76.06)	86.93 (68.12)
2006–07	92.69 (75.54)	5.51 (4.75)	112.54 (64.89)	13.09 (13.45)	15.48 (13.56)	32.44 (13.75)

Rattail

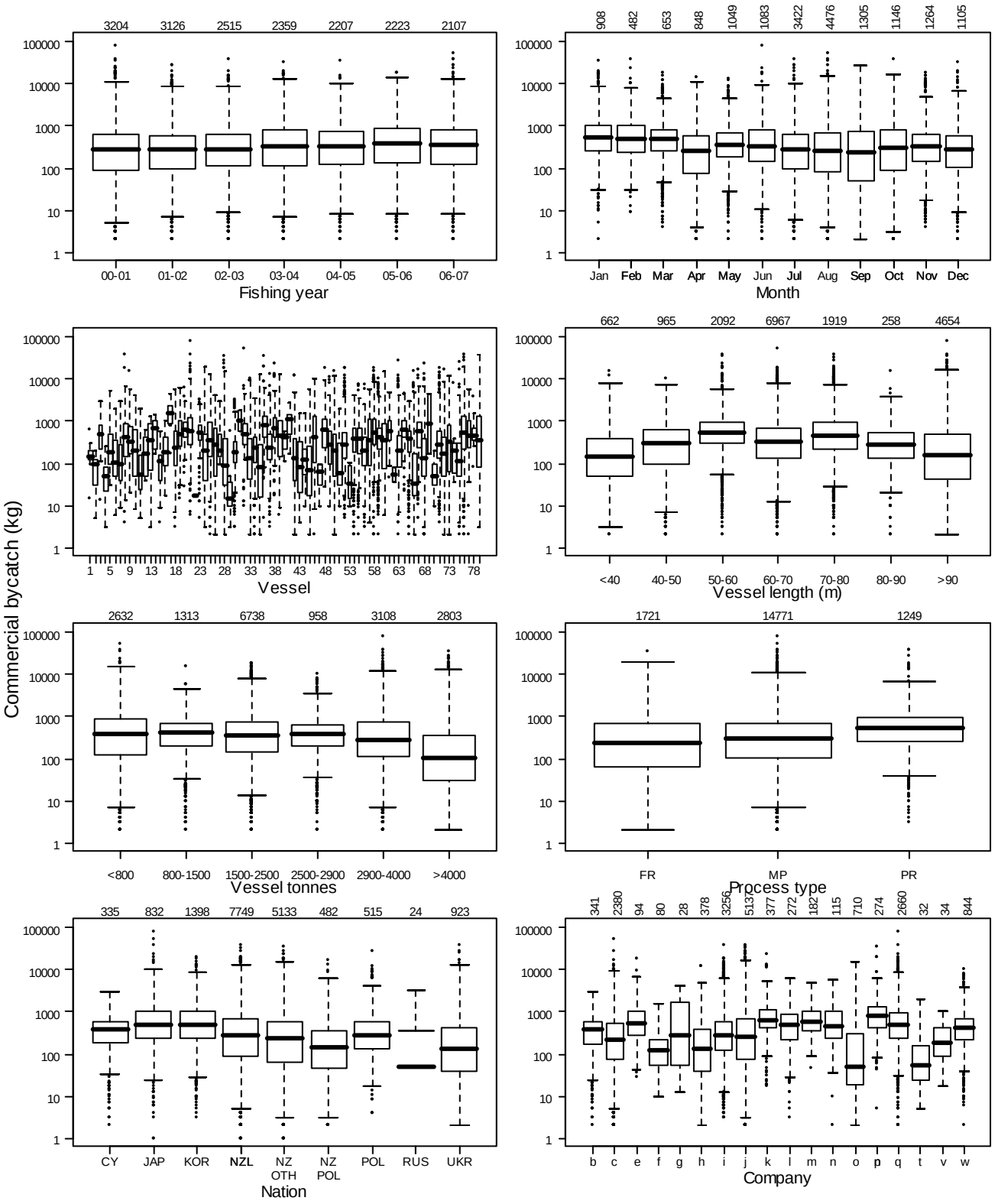
Median discard ratios kg.tow^{-1}

Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	167.60 (57.77)	1.67 (0.84)	56.20 (43.01)	5.91 (4.31)	53.83 (27.36)	7.07 (4.55)
2001–02	251.55 (208.33)	0.31 (0.27)	56.21 (43.61)	6.93 (20.82)	41.17 (23.40)	47.91 (24.63)
2002–03	176.77 (71.19)	0.65 (0.65)	58.54 (43.32)	8.40 (22.51)	16.25 (14.22)	15.88 (4.38)
2003–04	46.57 (41.22)	0.90 (0.30)	55.56 (44.84)	9.04 (22.79)	20.44 (16.69)	15.76 (7.54)
2004–05	4.07 (3.06)	0.76 (0.63)	57.94 (43.45)	8.58 (21.95)	5.03 (5.92)	6.47 (4.04)
2005–06	12.89 (10.74)	0.04 (0.04)	54.87 (43.68)	10.15 (23.18)	19.85 (29.04)	28.98 (16.26)
2006–07	40.59 (32.76)	16.89 (5.12)	57.27 (42.97)	8.17 (22.28)	13.47 (13.15)	21.66 (7.30)

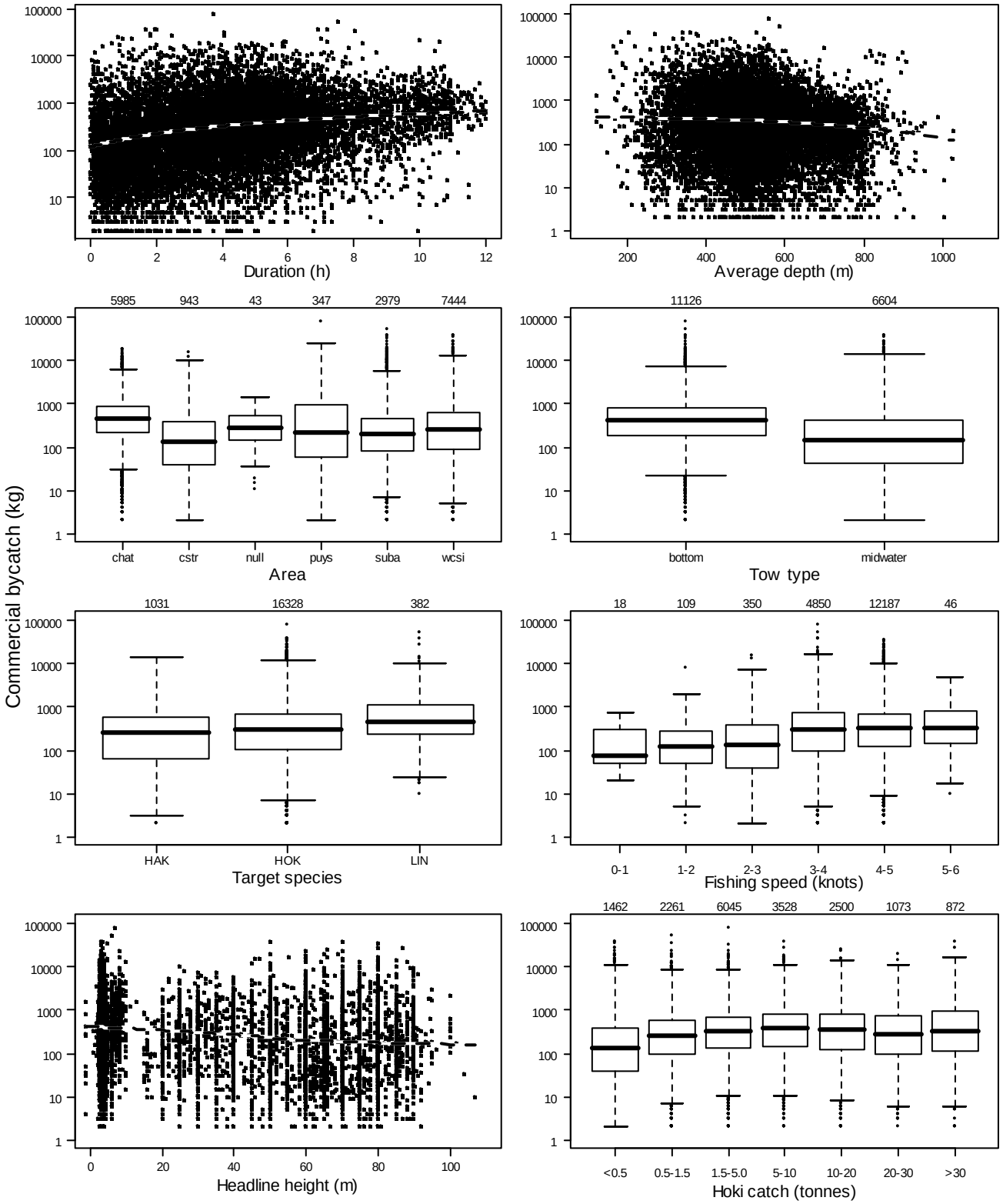
Appendix 7: continued.

Shovelnose dogfish

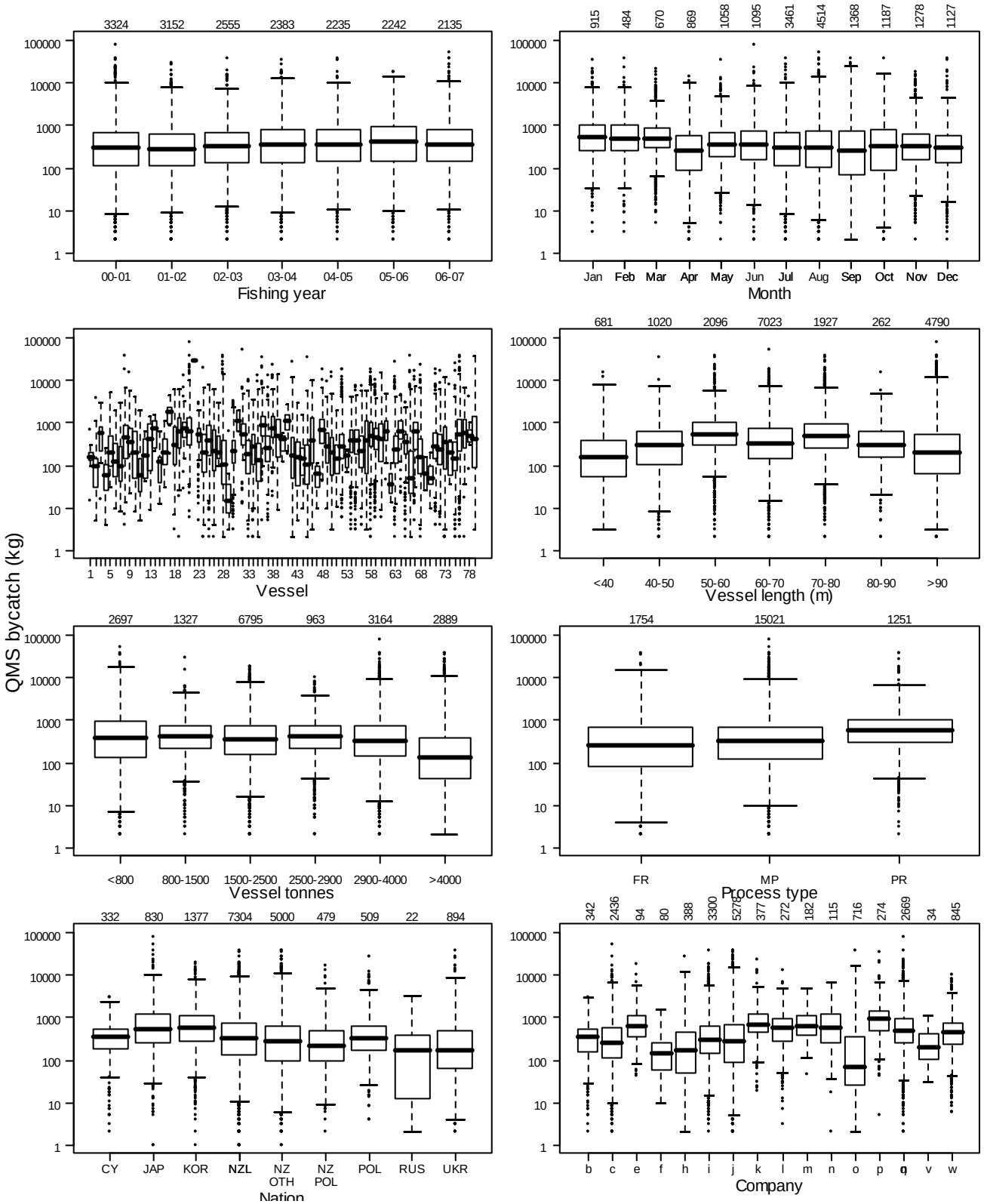
	Median discard ratios kg.tow^{-1}					
Fishing year	chat	cstr	null	puys	suba	wcsi
2000–01	19.35 (7.75)	1.33 (0.75)	13.84 (5.51)	35.05 (36.05)	1.15 (1.05)	1.96 (1.14)
2001–02	129.06 (61.58)	0.00 (0.00)	13.96 (5.66)	67.82 (49.34)	1.05 (0.96)	8.80 (2.98)
2002–03	26.80 (9.47)	0.06 (0.05)	14.26 (5.61)	70.88 (48.16)	2.12 (0.72)	2.36 (0.78)
2003–04	44.47 (9.19)	0.26 (0.20)	14.09 (5.51)	68.29 (50.10)	9.25 (13.52)	2.36 (1.69)
2004–05	21.77 (9.71)	3.76 (2.12)	14.48 (5.79)	68.00 (47.17)	1.05 (0.96)	1.06 (0.59)
2005–06	44.50 (20.94)	0.00 (0.11)	14.58 (5.61)	70.42 (49.74)	7.70 (5.77)	19.09 (7.68)
2006–07	31.85 (25.35)	5.12 (2.29)	14.03 (5.36)	68.67 (49.83)	2.10 (1.61)	5.46 (1.22)



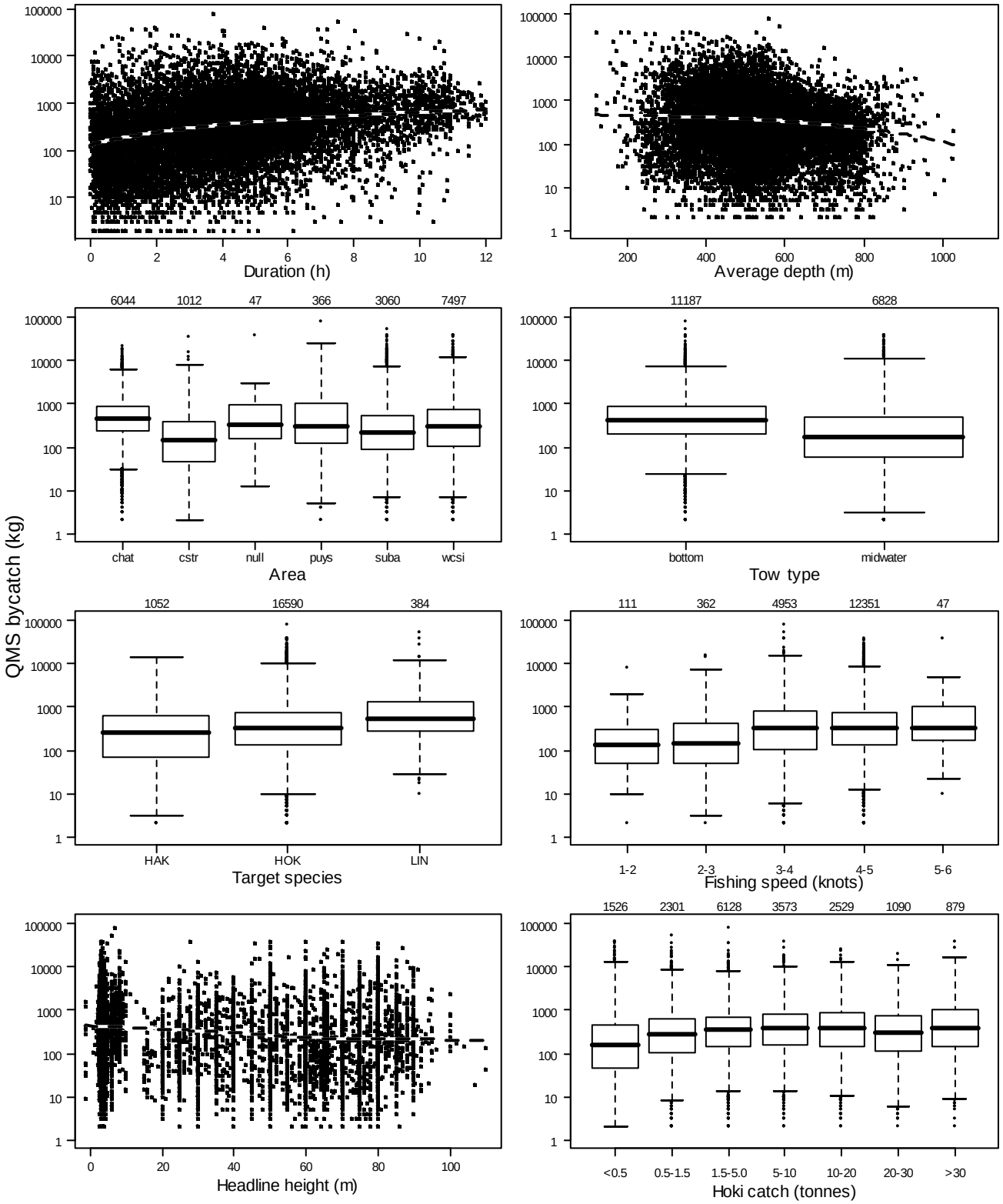
Appendix8, Figure 1a: Observed commercial species bycatch per tow plotted against some of the available variables for the hoki, hake, or ling target fishery. Total bycatch is plotted on a log scale. The dashed lines in the top two panels represent mean fits (using a locally weighted regression smoother) to the data. The box and whisker plots show medians and lower and upper quartiles in the box, whiskers extending up to 1.5x the interquartile range, and outliers individually plotted beyond the whiskers. The numbers above each plot indicate the number of records associated with that level of the variable. Average depth is the average of the start and finish gear depths. See Figure 1 for hoki area codes. FR, fresher; PR, factory vessel; MP, factory vessel with a meal plant.



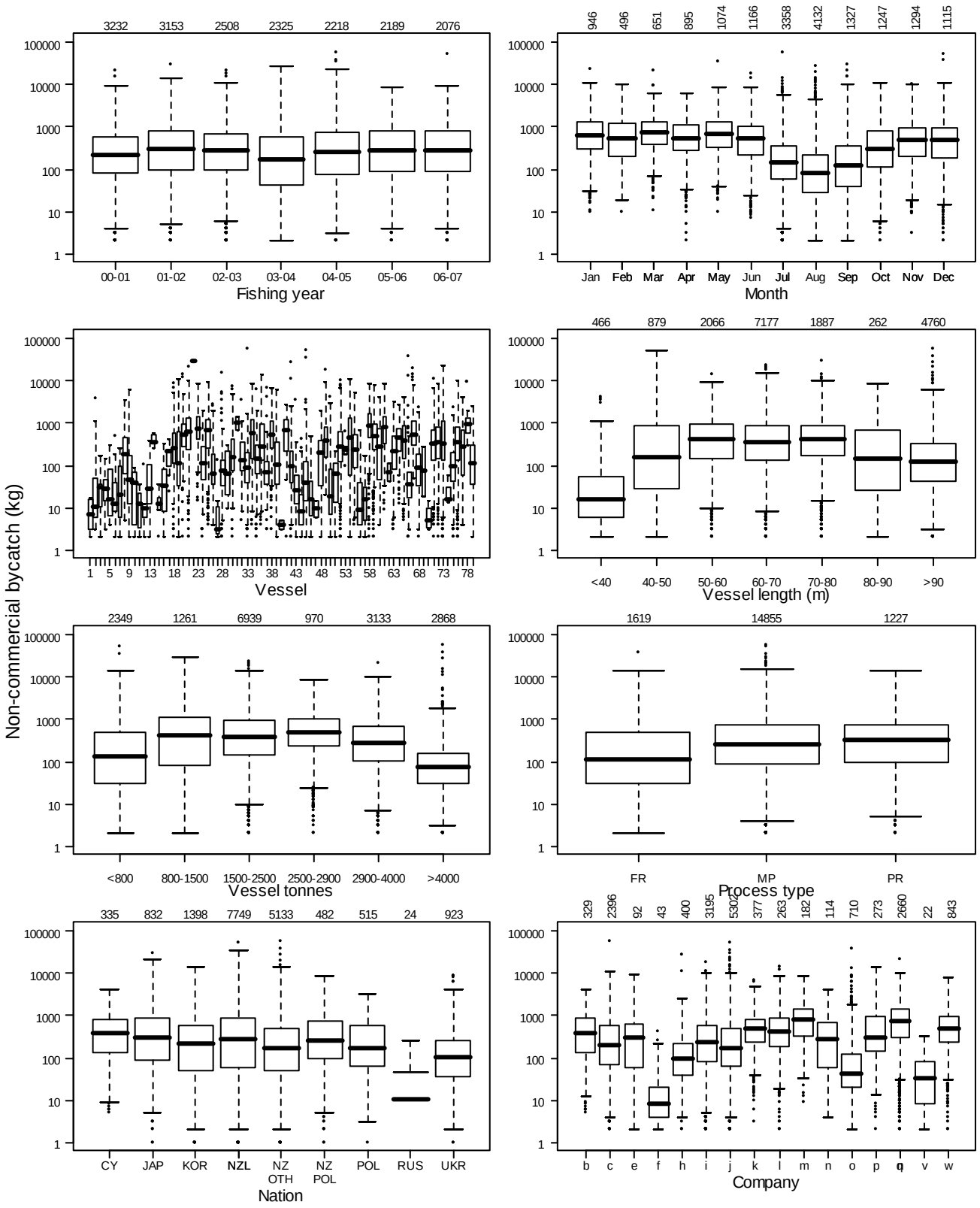
Appendix8, Figure 1a: continued.



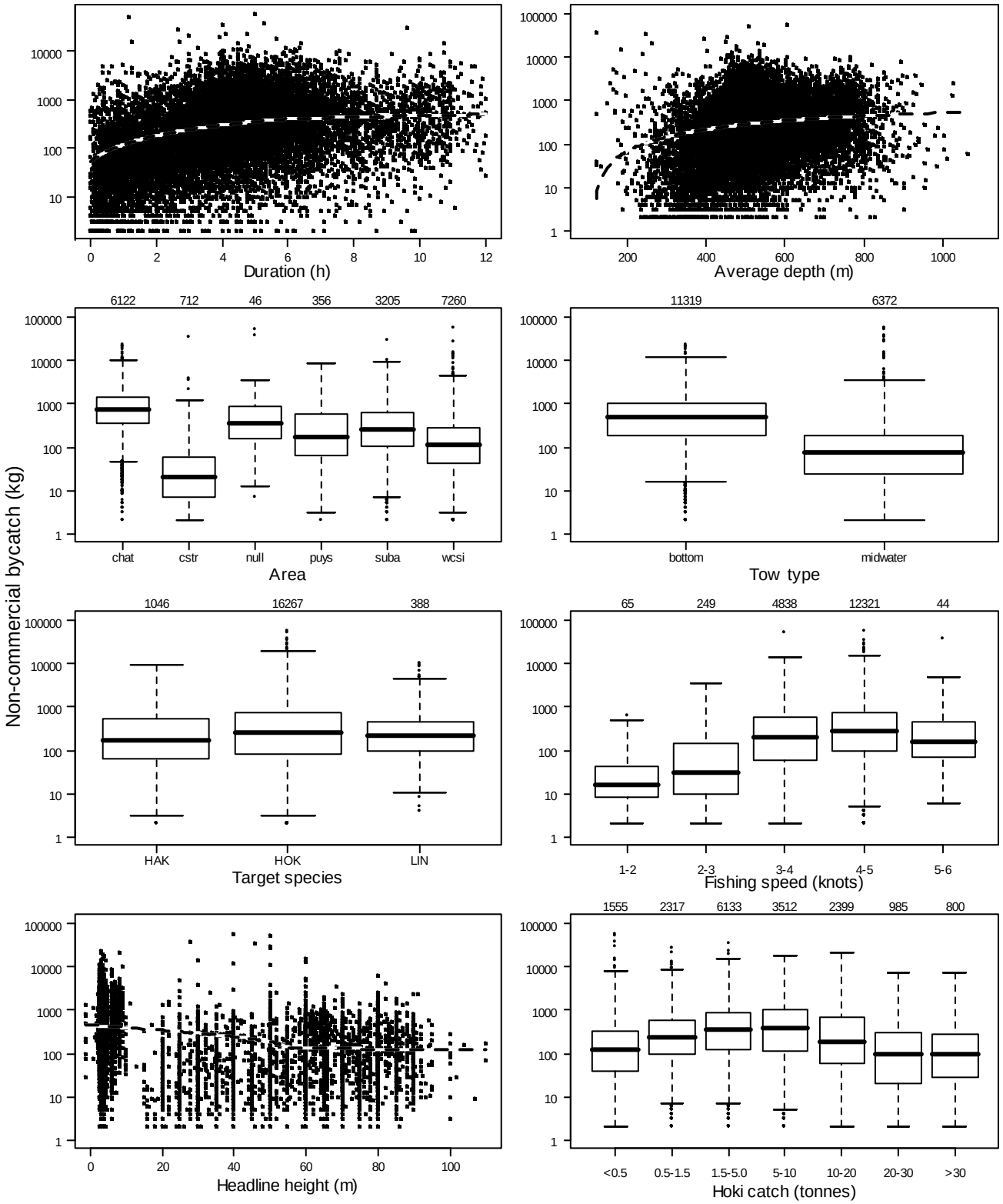
Appendix 8, Figure 1b: Observed QMS species bycatch per tow plotted against some of the available variables for the hoki, hake, or ling target fishery. Total bycatch is plotted on a log scale. The dashed lines in the top two panels represent mean fits (using a locally weighted regression smoother) to the data. The box and whisker plots show medians and lower and upper quartiles in the box, whiskers extending up to 1.5x the interquartile range, and outliers individually plotted beyond the whiskers. The numbers above each plot indicate the number of records associated with that level of the variable. Average depth is the average of the start and finish gear depths. See Figure 1 for hoki area codes. FR, fresher; PR, factory vessel; MP, factory vessel with a meal plant.



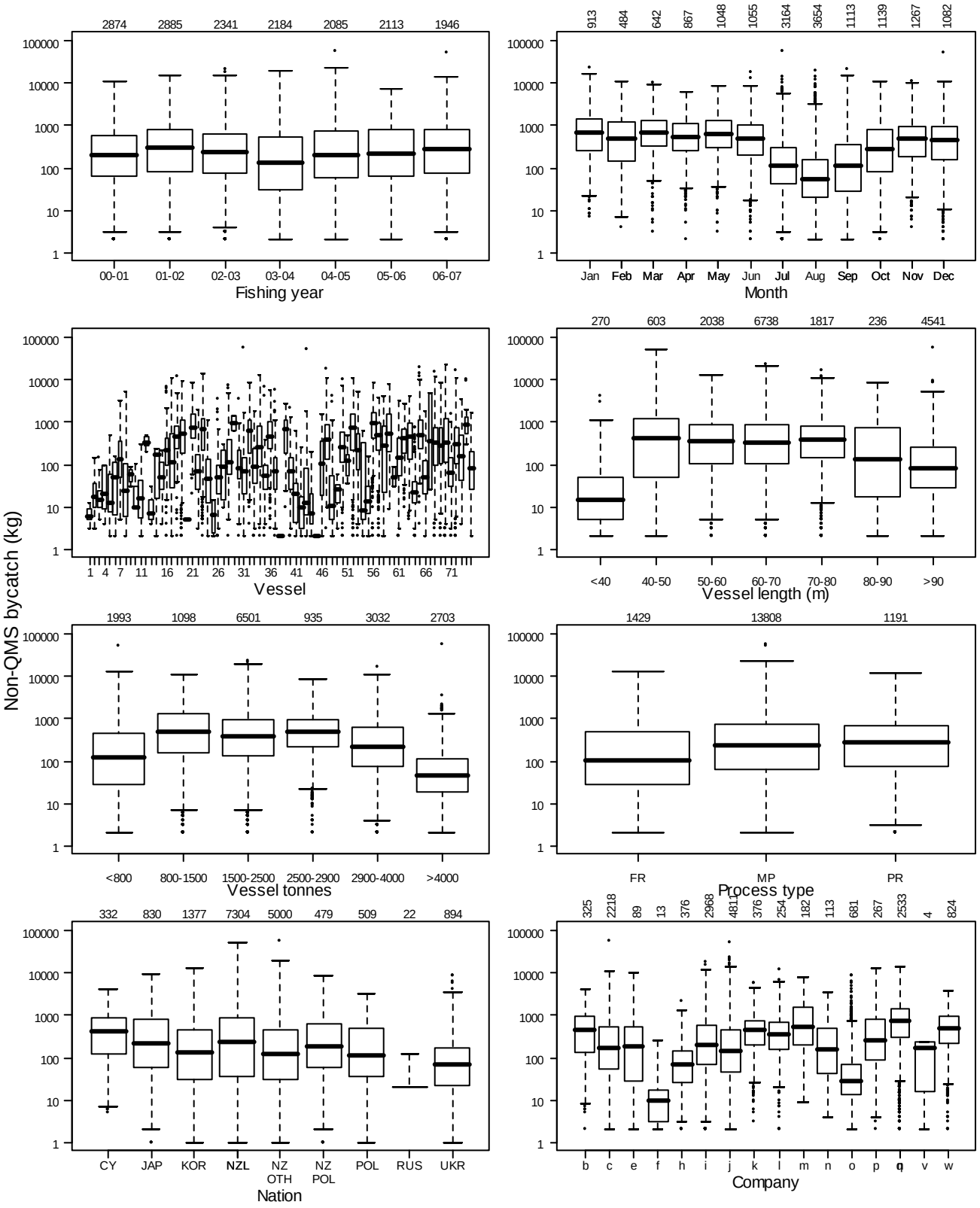
Appendix 8, Figure 1b: continued.



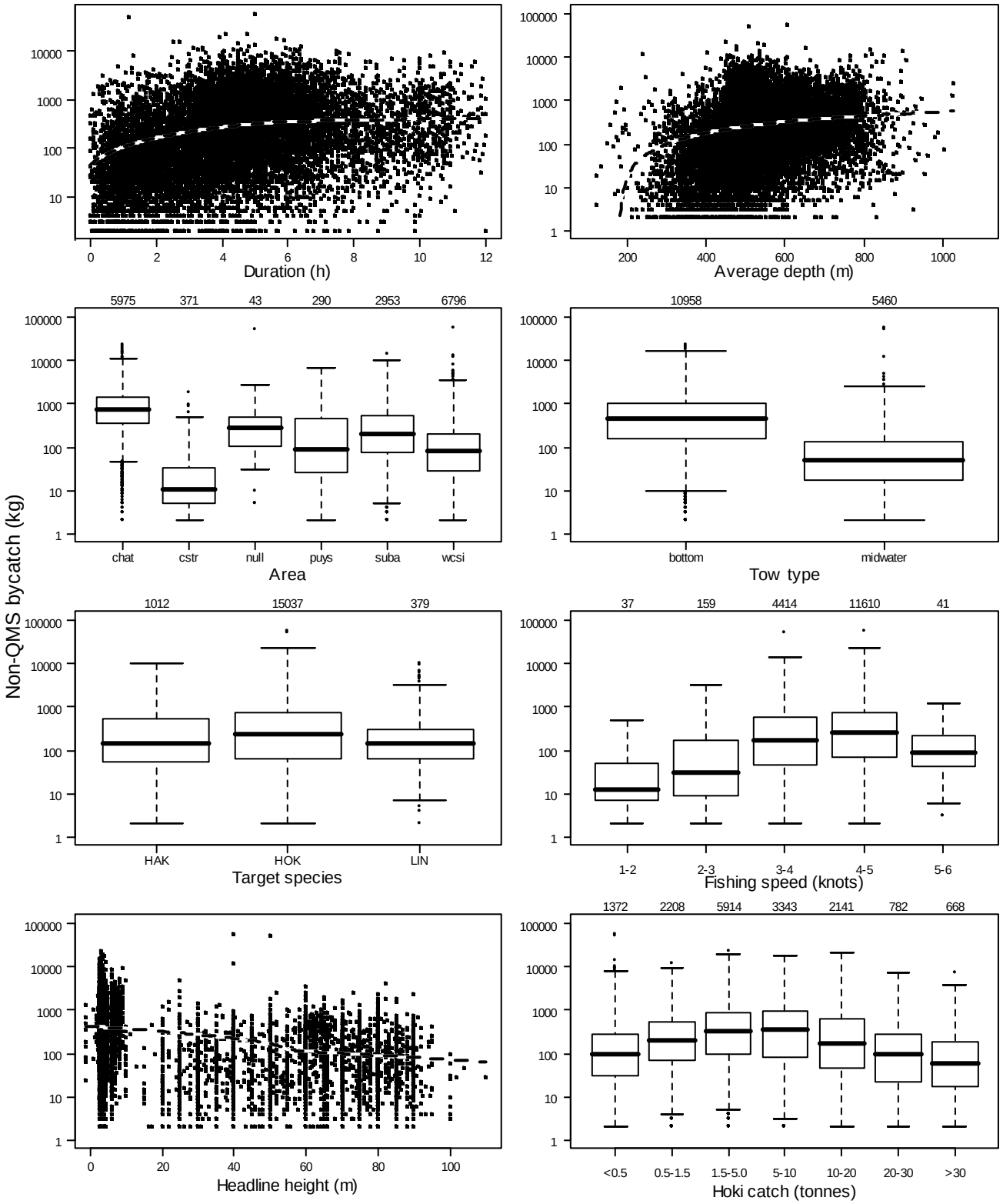
Appendix 8, Figure 1c: Observed non-commercial species bycatch per tow plotted against some of the available variables for the hoki, hake, or ling target fishery. Total bycatch is plotted on a log scale. The dashed lines in the top two panels represent mean fits (using a locally weighted regression smoother) to the data. The box and whisker plots show medians and lower and upper quartiles in the box, whiskers extending up to 1.5x the interquartile range, and outliers individually plotted beyond the whiskers. The numbers above each plot indicate the number of records associated with that level of the variable. Average depth is the average of the start and finish gear depths. See Figure 1 for hoki area codes. FR, fresher; PR, factory vessel; MP, factory vessel with a meal plant.



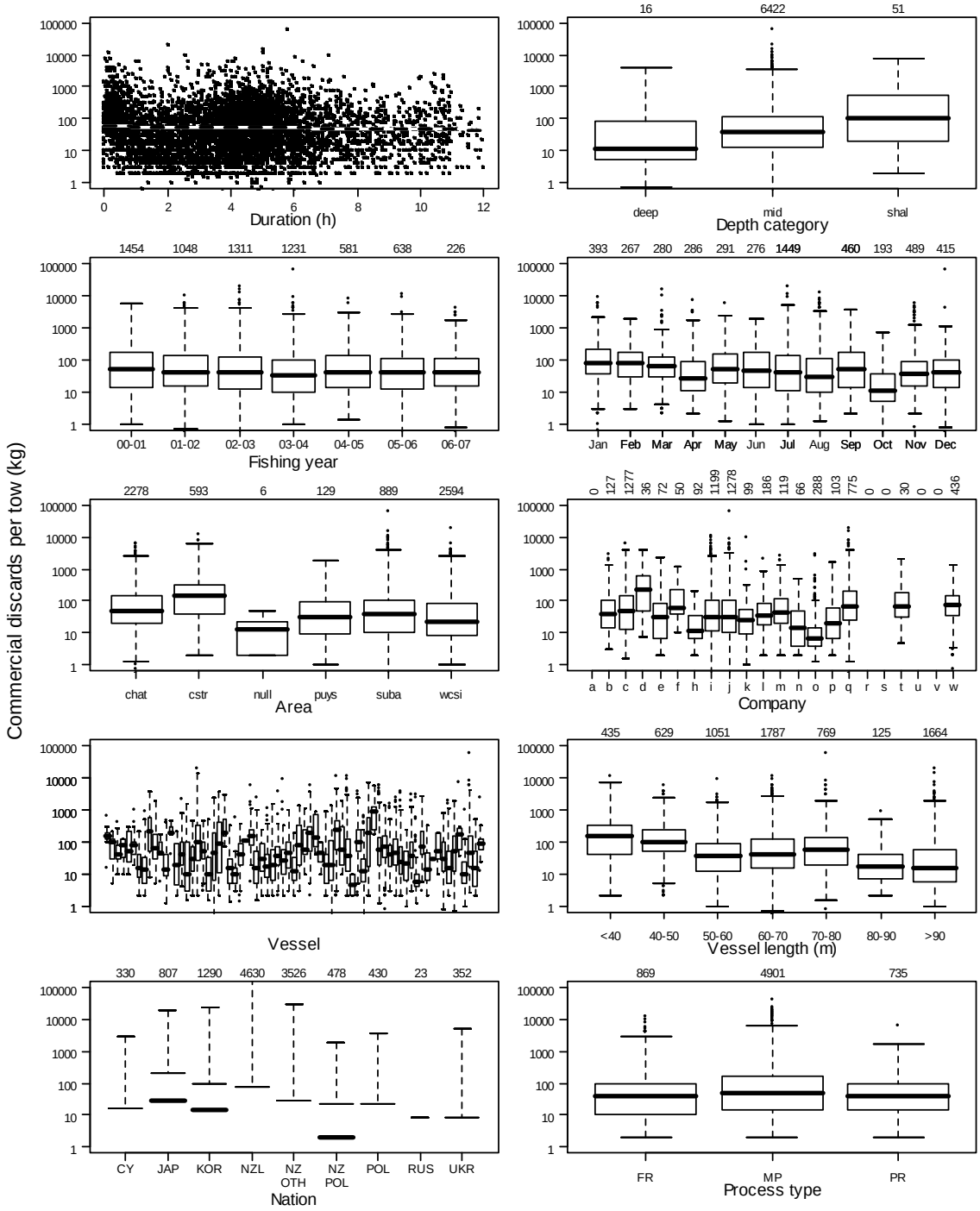
Appendix 8, Figure 1c: continued.



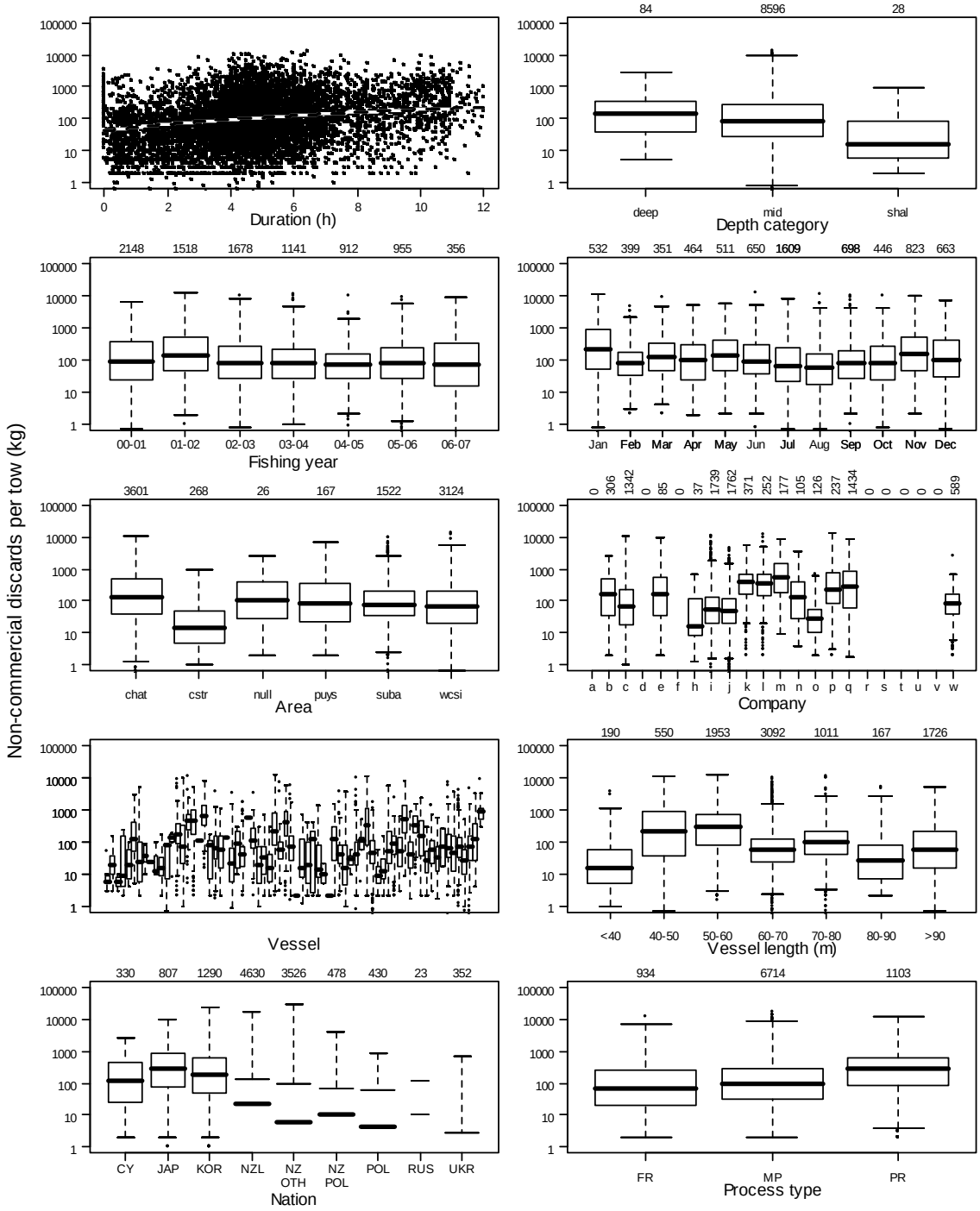
Appendix 8, Figure 1d: Observed non-QMS species bycatch per tow plotted against some of the available variables for the hoki, hake, or ling target fishery. Total bycatch is plotted on a log scale. The dashed lines in the top two panels represent mean fits (using a locally weighted regression smoother) to the data. The box and whisker plots show medians and lower and upper quartiles in the box, whiskers extending up to 1.5x the interquartile range, and outliers individually plotted beyond the whiskers. The numbers above each plot indicate the number of records associated with that level of the variable. Average depth is the average of the start and finish gear depths. See Figure 1 for hoki area codes. FR, fresher; PR, factory vessel; MP, factory vessel with a meal plant.



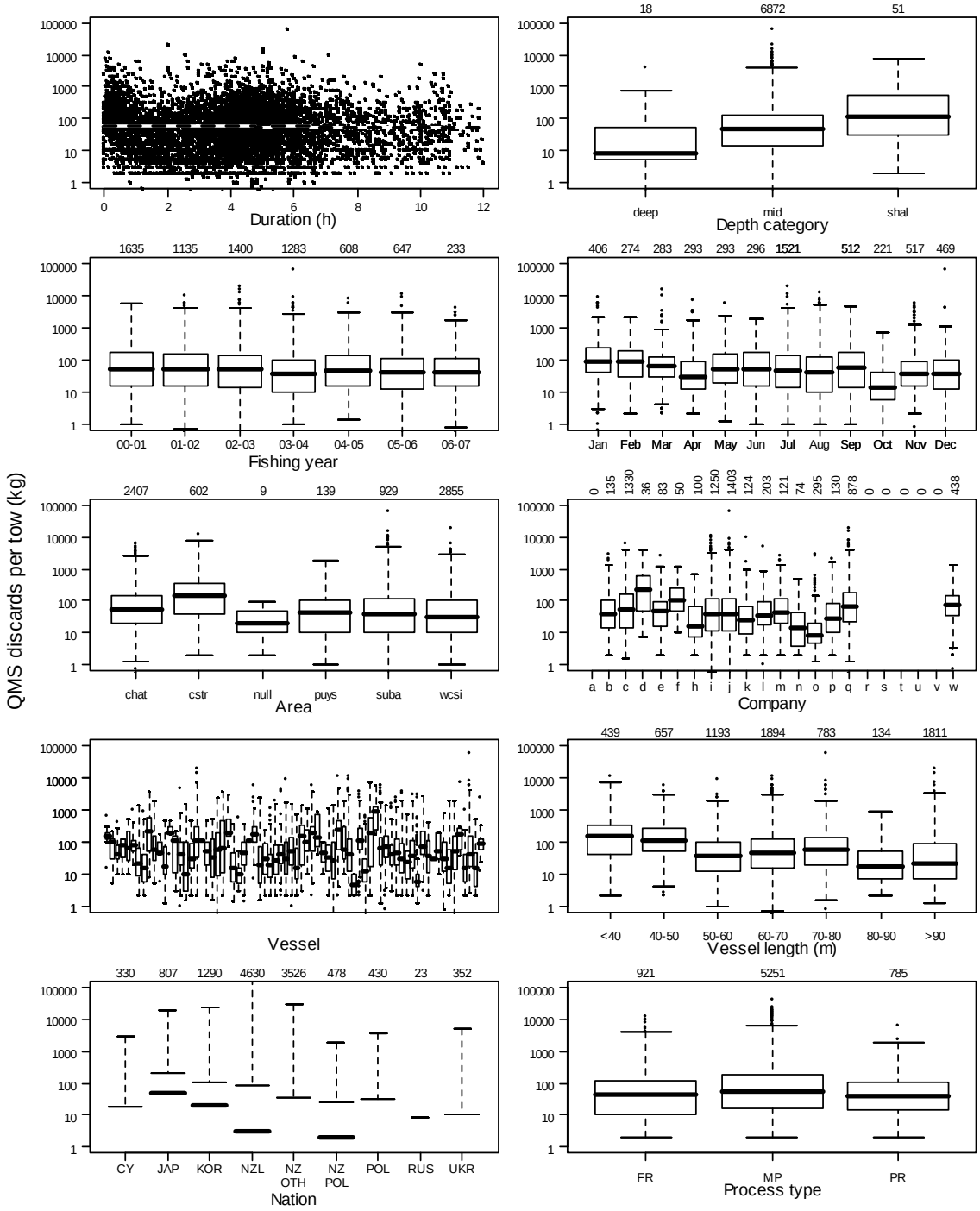
Appendix 8, Figure 1d: continued.



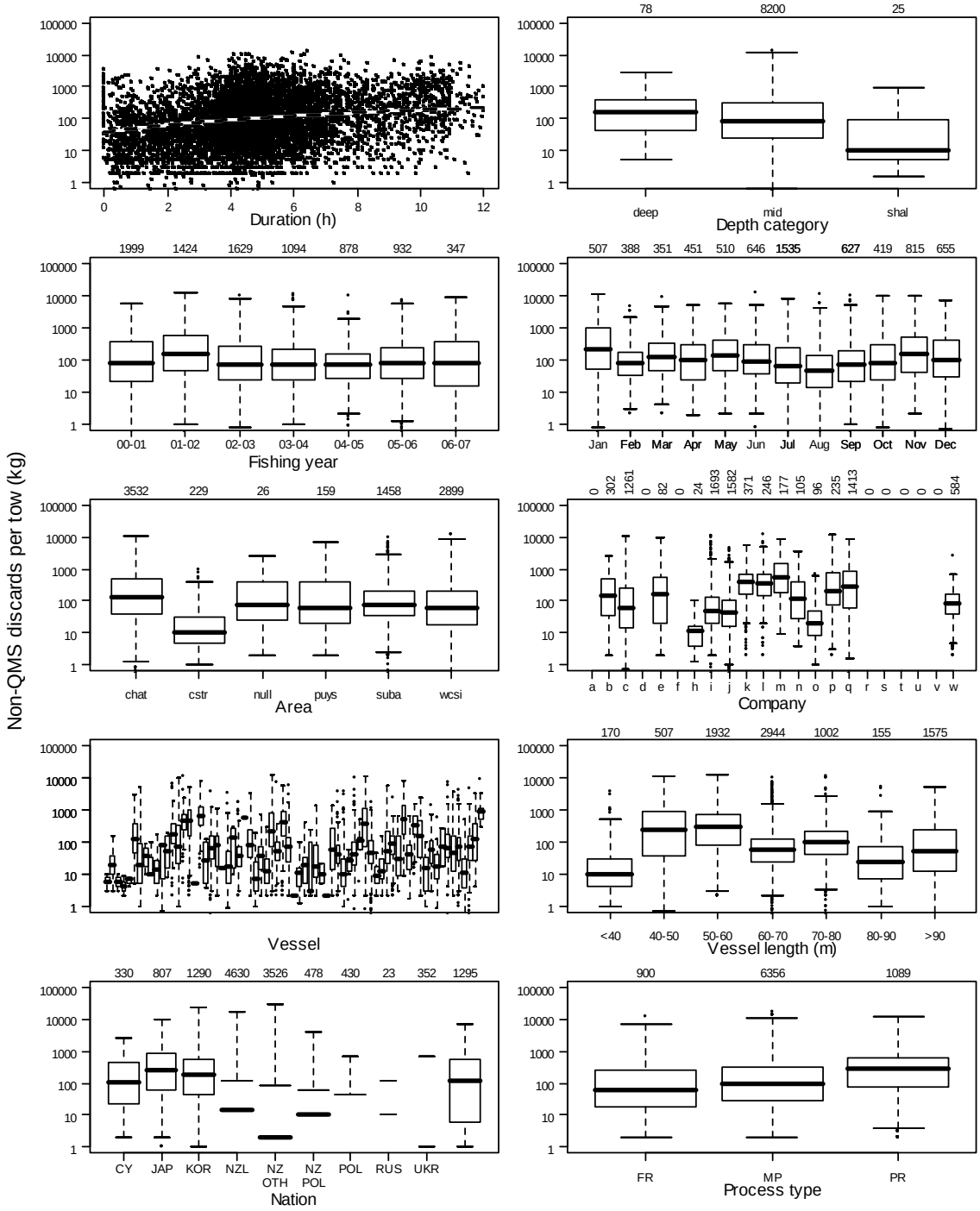
Appendix 8, Figure 2a: Commercial species discards per tow for the target hoki, hake, and ling tow dataset (total discards per processing group divided by the number of tows in the group) plotted against some of the available variables (records with no discards excluded). Discards are plotted on a log scale. The dashed line in the top left panel represents a mean fit (using a locally weighted regression smoother) to the data. The box and whisker plots show medians and lower and upper quartiles in the box, whiskers extending up to 1.5x the interquartile range, and outliers individually plotted beyond the whiskers. Levels of variables represented by fewer than 20 records were not plotted. See Figure 1 for hoki area codes; shal, tows shallower than 200 m; mid tows 200–800 m; deep, tows 800 m or deeper. FR, fresher; PR, factory vessel; MP, factory vessel with a meal plant



Appendix 8, Figure 2b: Non-commercial species discards per tow for the target hoki, hake, and ling tow dataset (total discards per processing group divided by the number of tows in the group) plotted against some of the available variables (records with no discards excluded). Discards are plotted on a log scale. The dashed line in the top left panel represents a mean fit (using a locally weighted regression smoother) to the data. The box and whisker plots show medians and lower and upper quartiles in the box, whiskers extending up to 1.5x the interquartile range, and outliers individually plotted beyond the whiskers. Levels of variables represented by fewer than 20 records were not plotted. See Figure 1 for hoki area codes; shal, tows shallower than 200 m; mid tows 200–800 m; deep, tows 800 m or deeper. FR, fresher; PR, factory vessel; MP, factory vessel with a meal plant.



Appendix 8, Figure 2c: QMS species discards per tow for the target hoki, hake, and ling tow dataset (total discards per processing group divided by the number of tows in the group) plotted against some of the available variables (records with no discards excluded). Discards are plotted on a log scale. The dashed line in the top left panel represents a mean fit (using a locally weighted regression smoother) to the data. The box and whisker plots show medians and lower and upper quartiles in the box, whiskers extending up to 1.5x the interquartile range, and outliers individually plotted beyond the whiskers. Levels of variables represented by fewer than 20 records were not plotted. See Figure 1 for hoki area codes; shal, tows shallower than 200 m; mid tows 200–800 m; deep, tows 800 m or deeper. FR, fresher; PR, factory vessel; MP, factory vessel with a meal plant



Appendix 8, Figure 2d: Non-QMS species discards per tow for the target hoki, hake, and ling tow dataset (total discards per processing group divided by the number of tows in the group) plotted against some of the available variables (records with no discards excluded). Discards are plotted on a log scale. The dashed line in the top left panel represents a mean fit (using a locally weighted regression smoother) to the data. The box and whisker plots show medians and lower and upper quartiles in the box, whiskers extending up to 1.5x the interquartile range, and outliers individually plotted beyond the whiskers. Levels of variables represented by fewer than 20 records were not plotted. See Figure 1 for hoki area codes; shal, tows shallower than 200 m; mid tows 200–800 m; deep, tows 800 m or deeper. FR, fresher; PR, factory vessel; MP, factory vessel with a meal plant.