Ministry for Primary Industries
Manatū Ahu Matua

Fish and invertebrate bycatch and discards in New Zealand hoki, hake, or ling trawl fisheries from 1990–91 until 2012–13

New Zealand Aquatic Environment and Biodiversity Report No. 163

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ISSN 1179-6480 (online)
ISBN 978-1-77665-111-5 (online)

November 2015

New Zealand Government

Growing and Protecting New Zealand

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EXECUTIVE SUMMARY

Ballara, S.L.; O'Driscoll, R.L. (2015). Fish and invertebrate bycatch and discards in New Zealand hoki, hake, and ling fisheries from 1990–91 until 2012–13. ***New Zealand Aquatic Environment and Biodiversity Report No. 163.*** **120 p.**

Commercial catch-effort data and fisheries observer records of catch and discards by species were used to estimate the rate and level of fish bycatch and discards in the target hoki, hake, and ling trawl fishery for each fishing year from 1990–91 to 2012–13. Separate estimates, along with estimates of precision, were made for the following categories of catch and discards: all QMS species combined, all non-QMS species combined, all invertebrate species combined. In addition, estimates were made of the annual bycatch of a wide range of individual species.

Linear mixed-effect models (LMEs) were used to identify key factors influencing variability in the observed rates of bycatch and discarding. These models consistently identified the hoki fishery areas as having the greatest influence on bycatch rates, therefore area was used to stratify the calculation of annual bycatch and discard totals in each catch category, although the WCSI was further split by fishing method.

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 two ratio estimators were applied, based on number of tows and duration respectively. Annual estimates of bycatch and discards calculated with the two forms of the estimator tended to be similar. Estimated ratios were then multiplied by the total number of trawls in each area stratum, derived from commercial catch-effort data, to make annual estimates for the target hoki, hake, or ling fishery as a whole. Multi-step bootstrap methods, taking into account the effect of auto-correlation between trawls in the same observed trip and area stratum, were used to estimate the variance in the rates and provide confidence intervals for the annual bycatch and discard estimates.

Since 1990–91 the annual combined total landed catch of hoki, hake, and ling was between 109 600 and 301 600 t. Hoki, hake and ling have accounted for an average of 91% of the total estimated catch weight recorded by observers in these target fisheries. The remainder of the observed catch comprised mainly two QMS species, silver warehou (1.4% of the total catch), and spiny dogfish (0.9%), and the non-QMS javelinfish (1.4% of the total catch), and rattails (1.1%). Invertebrate species made up only a very small fraction of the overall catch, with arrow squid (0.1% of the total catch) the main species caught. All but a few edible invertebrates (crustaceans and molluscs) were discarded.

Total bycatch in the hoki, hake, and ling fishery ranged from about 12 020 t to 37 730 t per year. The main bycatch species were silver warehou, javelinfish, rattails, and spiny dogfish. Bycatch ratios of QMS species were highest in Puysegur and lowest in Cook Strait. Bycatch ratios of non-QMS species were highest on the Chatham Rise and lowest for Cook Strait. Bycatch of invertebrates was low in all areas.

Total annual discard estimates ranged from about 3699 to 16 633 t per year. Discards increased in the 1990s, peaked in 2000, and have since decreased. The main species being discarded were spiny dogfish, rattails, javelinfish, hoki, and shovelnose dogfish. Discard ratios of QMS species were highest in Cook Strait and the Sub-Antarctic and discard ratios of non-QMS and invertebrate species were lowest in Cook Strait. Discarding of hoki, hake, and ling accounted for 0.7% of total observed discards. There was an average of 0.05 kg of observed species discarded per kilogram of observed hoki, hake, and ling caught.

The annual catch of 225 individual bycatch species was estimated using the same methods as for the combined species categories, and trends examined. A total of 40 species showed a decreasing trend and 19 species an increasing trend over time, although in some cases detection of trends was confounded by apparent changes over time in the species codes used by observers. Significant trends in bycatch ratios were not strongly supported by trends in relative biomass estimated from Sub-Antarctic and Chatham trawl survey time-series, although overall QMS and invertebrate groups showed some correlation with Chatham Rise trawl survey biomass trends for these species.

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. 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. Changes in bycatch ratios could be compared in more detail to survey biomass estimates for some species on the Chatham Rise and in the Sub-Antarctic, but further validation is required to determine whether estimates of commercial bycatch could provide long-term monitoring approaches for low-value species.

1. INTRODUCTION

The Ministry for Primary Industries (MPI) National Deepwater Plan includes the following Environment Outcome related management objective MO2.4: "Identify and avoid or minimise adverse effects of deepwater and middle-depth fisheries on incidental bycatch species". This project addresses this objective by quantifying the level of bycatch of species or groups of species not managed separately in the QMS system. Significant changes in the relative catch of a species may be used to infer changes in abundance - although these may be due to other causes, such as changes in fishing practices. Bycatch species identified in this way as being in decline can be monitored and remedial action planned. The scampi (*Metanephrops challengeri*) trawl fishery was assessed in the first year of the programme (Anderson 2012), followed by the arrow squid (*Nototodarus* spp.) trawl fishery (Anderson 2013), and the ling (*Genypterus blacodes*) bottom longline fishery (Anderson 2014a) in the second and third years respectively. The hoki (*Macruronus novaezelandiae*)/hake (*Merluccius australis*)/ling (*Genypterus blacodes*) trawl fishery is the main subject of this report. Similar analyses will be carried out in subsequent years for each of the other Ministry for Primary Industries Tier-1 fisheries: jack mackerel (*Trachurus* spp.) trawl; southern blue whiting (*Micromesistius australis*) trawl; and orange roughy (*Hoplostethus atlanticus*)/oreo (Oreosomatidae) trawl. 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.

The hoki fishery has historically been New Zealand's largest, with total reported catches of between 90 000 t and 213 000 t per year for the fishing years 1990–91 to 2012–13 (Ballara & O'Driscoll 2014). The hake and ling trawl fisheries are considerably smaller, but together account for between 20 000–30 000 t of landed fish per year. Total reported catches in 2012–13 were 131 570 t of hoki, 7 690 t of hake, and 14 330 t of ling (Ministry for Primary Industries 2014), with export earnings in 2013 (calendar year) of about NZD $187M, $14M, and $53M respectively (http://www.seafoodindustry.co.nz/). 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 8000–36 000, 3000–7000, and 1000–7000 trawls targeting hoki, hake, and ling respectively each year within the New Zealand Exclusive Economic Zone (EEZ).

Hoki are widely distributed throughout the EEZ, mainly between 200 m and 800 m deep (Ministry for Primary Industries 2014). 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 & O'Driscoll 2014). Smaller spawning fisheries occur in Puysegur and off the east coast of the South Island (Ballara & O'Driscoll 2014), 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 was increased for a while, 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, and an industry Code of Practice (COP) for hoki target trawling, introduced in 2001 with the initial aim of protecting small fish (less than 60 cm) by: 1) restricting fishing in waters shallower than 450 m; 2) requiring vessels to 'move on' if there are more than 10% small hoki in the catch; and 3) seasonal and area closures in spawning fisheries (Ballara & O'Driscoll, 2014). The COP was superseded by Operational Procedures for Hoki Fisheries, also introduced by the fishing industry from 1 October 2009 which aimed to manage and monitor fishing effort within four

industry Hoki Management areas, where there are thought to be high abundances of juvenile hoki. These areas are closed to trawlers over 28 m targeting hoki, with increased monitoring when targeting species other than hoki. There is also a general recommendation that vessels move from areas where catches of juvenile hoki (now defined as less than 55 cm total length) comprise more than 20% of the hoki catch by number. There have also been agreed annual catch splits between eastern and western stocks since 2001 (Ballara & O'Driscoll, 2014).

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 and has generally consisted of bycatch in the much larger hoki fishery, but it has undergone a number of changes over time (Devine 2009) including changes to the TACCs of both hake and hoki, and also changes in fishing practices such as gear used, tow duration, and strategies to limit hake bycatch in the hoki target fishery. 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 (Ballara 2012). 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, around the Norwegian Hole, and between the Snares and Auckland Islands in the Sub-Antarctic (Devine 2009).

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. 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. Until 2000, up to a third of ling landings were taken by bottom longliners, but since then there has been a declining trend in catches taken by line vessels in most areas, offset, to some extent, by increased trawl landings (Horn et al., 2013). Ling are mainly caught by large trawlers at Puysegur Bank, the slope of the Stewart-Snares shelf, and in the Auckland Islands area. Small domestic vessels tend to fish for ling on the WCSI and the east coast of both main islands south of East Cape (Horn et al., 2013).

The most recent analysis of bycatch and discards in the hoki, hake, and ling trawl fishery (Ballara et al. 2010) used a number of tows-based estimator and covered the period 2003–04 to 2006–07. That report estimated total annual bycatch in the hoki, hake, and ling fishery for the period ranged from 36 000 t to 58 000 t and total annual discards from about 5500 t to 29 000 t per year. The principal bycatch species were javelinfish (*Lepidorhynchus denticulatus*), silver warehou (*Seriolella punctata*), rattails, and spiny dogfish (*Squalus acanthias*) (Ballara et al. 2010). Estimates of the rate of discarding averaged 0.03 kg of discards for every 1 kg of hoki, hake, and ling landed. Earlier studies to estimate the level of bycatch and discards in the hoki fishery were from 1999–2000 to 2002–03 (Anderson & Smith 2005) and from 1990–91 to 1998–99 (Anderson et al. 2001).

In this report, new estimates of annual bycatch and discards were made for all years from 1990–91 to 2012–13, using a revised estimator, and the methods used in previous work were extended by examining temporal trends in more detail. The report was prepared as an output from the Ministry for Primary Industries project DAE2010-02 "Bycatch monitoring and quantification of deepwater stocks" which has the following objectives.

Overall objective:

To estimate the level of non-target fish catch and discards of target and non-target fish species in New Zealand deepwater fisheries.

Specific objectives for year-4

1. To estimate the quantity of non-target fish species caught, and the target and non-target fish species discarded in the hoki, hake, or ling trawl fishery, for the fishing years since the last review, using data from Ministry for Primary Industries Observers and commercial fishing returns.

2. To compare estimated rates and amounts of bycatch and discards from this study with previous projects on bycatch in the hoki, hake, or ling trawl fishery.

3. To compare any trends apparent in bycatch rates in the hoki, hake, or ling trawl fishery with relevant fishery independent trawl surveys.

4. To provide annual estimates of bycatch for nine Tier-1 species fisheries (SQU, SCI, HAK, HOK, JMA, ORH, OEO, LIN, SBW). This objective is reported on in a separate report (Ballara, 2015), and repeated here for HOK, HAK, LIN only.

2. METHODS

2.1 Definition of terms

For this study *non-target fish species catch* is equivalent to *bycatch*, defined by McCaughran (1992) as all fish caught that were not the stated target species for that tow (hoki, hake or ling in this case), whether or not they were discarded. *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 Observer data

Ministry for Primary Industries observers have been making detailed records of catch and discards by species or species group, for each trawl or (frequently for discards) group of trawls, for a portion of the hoki, hake, or ling fleet in each year since 1990–91. The allocation of observers on commercial vessels takes into account a range of data collection requirements and compliance issues for multiple fisheries. It has therefore not always been possible to achieve an even or random spread of observer effort in each fishery. Observer coverage in the hoki, hake, or ling target trawl fishery has varied through time, with 7–19 % of target catch and 2–15% of target tows observed from 1990–91 to 2005–06 (Table 1). Since 2006–07 coverage has increased, and in 2012–13 45% of the target catch and 38% of target tows were sampled. Overall, there was a considerable amount of observer data available for this analysis, with about 1600–5060 observed trawls annually (Table 1).

2.2.1 Data preparation and grooming

For the analysis of the hoki, hake, or ling target trawl fishery, two datasets were prepared from the Ministry for Primary Industries observer databases *obs* and *cod*, based on all observed trawls targeting hoki, hake, or ling since 1990–91, one comprising bycatch data and the other discard data. The *cod* database, which superseded the older *obs* database, was used to construct the bycatch dataset as this contains a complete set of catch by species for all relevant trawls. The discard dataset required data from both *obs* and *cod* to produce a complete set of discards by species for the years required, because of the lack of linkage in *cod* between processing data and station data in records from before about mid-2007. The *obs* database has this linkage, but contains no relevant data after April 2008.

After grooming, a total of 61 839 observed trawls targeting hoki, hake, or ling were available for the analysis of bycatch. Because of variability in the recording of fish processing data (see below), there were fewer observed trawls (39 182) available for the analysis of discards. Data grooming was carried out in the same way for each dataset.

Trawl distance was calculated from the recorded start and finish positions. Records in which a start or finish position was missing were identified and groomed using median imputation. This process substitutes the missing value with an approximate one calculated from the median latitude or longitude for other trawls by the same vessel on the same day, if any exist. Long tows (over 50 km, approximately the 99th percentile of the distribution of observed trawl distances) were accepted if in approximate agreement with the tow distance calculated from the recorded tow duration and trawling speed. Records with missing position data that could not be resolved were removed from the dataset. Trawl distances were then recalculated from a combination of the corrected positions and values derived from the recorded duration and trawling speed.

Trawl durations were derived from the difference between the start and finish times, less the period (recorded by observers) between those times when the net was not fishing, e.g., when the net was lifted off the bottom to avoid foul ground, brought to the surface during turning, or was temporarily left hanging in the water due to equipment malfunction. These trawl durations were then cross-checked with estimates based on the recorded fishing speed and calculated trawl distance. Missing fishing speed values and speeds less than 2 knots or greater than 6 knots (about 1.9% of the records) were substituted with values estimated by median imputation.

Fishing depth was calculated from the average of the recorded start and finish net depths where possible. For the records where one or both of these values was not recorded, bottom depth was taken from the remaining value or from the seabed depth (average of start and finish values where possible). About 60% of observed trawls used bottom trawls, and of the midwater trawls, 49% were within 5 m of the seabed. Most observed trawls (72%) followed a straight line or constant depth contour, and most of the remainder followed an "out and back", zig-zag or closed loop track.

Observers estimated the amounts "total greenweight on surface" and "total greenweight on board", and these would sometimes differ if fish were lost from the net, either at or below the surface, but also simply because the observer may revise their estimate of the total catch once the net is aboard. Losses of fish from the net come about through a mixture of burst codends, burst windows/escape panels, and rips in the belly of the net. Valid differences in these values were interpreted here as lost fish and included as part of the discards from the trawl, with corrections made for any obvious recording errors. 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 it was clearly due to a transposition of the two values. These and any other differences in the two recorded values were interpreted as valid fish losses only if they were accompanied by an appropriate code

identifying the cause of the loss. Genuine observed cases of lost fish were uncommon in this fishery, occurring in only 201 observed tows, with an average of about 29 t of lost fish in total.

Each record was assigned to an area based on hoki areas (see Figure 1): WCSI, CHAT (Chatham Rise), SUBA (Sub-Antarctic), CSTR (Cook Strait), PUYS (Puysegur Bank) and were similar to those used in the previous review (Ballara, et al. 2010). Areas outside these defined areas, including hoki spawning area Pegasus Bay and Conway Trough in the ECSI, were combined into a single NULL area category, and were retained for use in analyses and calculations where area was not relevant. The number of observed trawls in each area over the 23 years is shown in Table 2.

Observer data were available from 154 vessels ranging in length from 15 to 105 m. No vessel or company is identified in this report, and alpha-numeric codes are used to differentiate between vessels where necessary.

To create the dataset used to estimate discards, the weights of each species retained and discarded in each "processing group" were obtained from the observer databases. The processing group is the level at which observers record information on the processing of fish on board, including those discarded, and although usually represented by a single trawl, processing data from two or more trawls are frequently combined into one processing group. This grouping of processing data stems from the difficulty of keeping track of the catch from individual trawls in the factory or processing area of a vessel. In order to examine how discard levels varied with fishing depth, area, season, and other factors that can vary between tows within a trip, either these variables can be summarised over all trawls within each processing group, or processing groups representing more than one trawl can be disregarded. In this case the latter approach was adopted (which avoids also having to account for the effects of differences in discard variability between groups with one tow and groups with multiple tows), therefore data from the *obs* database disregards about 4691 records (or 6% of total records) and 1820 t of observed discards (15% of total observed discards). An examination was made to investigate whether the practice of combining multiple tows into single groups was related to the level of discards per tow, e.g., discards being tallied and recorded only when several small amounts had been accumulated. For *obs* data there was no clear pattern, with median discards per tow slightly lower for groups comprising a single tow (442 kg tow^{-1}) compared with groups comprising two or three tows (536 kg tow^{-1} and 554 kg tow^{-1}, respectively), and lower again for groups comprising 4–9 tows (103–257 kg tow^{-1}).

For discard data from the *cod* database, processing group is not entered into fishing event information, so the discard data cannot be linked directly to fishing events to choose target hoki, hake, or ling discards, unless the processing group comprises a single tow. In addition, the field *tow_range* sometimes has a "P" in it, e.g. "137P–138" which means part of tow 137 and all of tow 138, further complicating the relationship between groups of tows from tow-level information and discard data. For *cod* data 8.3% of the total observed discarded catch (due to missing *tow_min* data or processing groups with more than one tow where the data came from a trip that targeted hoki, hake, or ling, and may have targeted other species) was excluded from the analysis.

Using the datasets described above, the weights of species caught and species discarded in each trawl were calculated for the following species categories.

- All Quota Management System species combined (QMS) as defined at the time of analysis. Observers recorded 124 QMS species in total.
- All non-QMS species combined, excluding invertebrates (non-QMS).
- All non-QMS invertebrate species combined (INV).

The above abbreviations (QMS, non-QMS, and INV) are used throughout the remainder of this report. Bycatch and discards were estimated separately for each of these combined species categories.

Summaries of the observed catch and percentage discarded of individual species and species groups are tabulated in Tables A1–A3. The catch in these appendices is based on the greenweight catch (Section 7) recorded in the observer catch effort logbook form (Table A4), but the discards are based on a comparison of catch and discards from the "processed catch" and "all other fish" sections of the form (Sections 8 and 9). This is because the less common species are recorded in better detail (especially in terms of their fate, retained or discarded) in these sections. This is further complicated by the allowance in the forms for Sections 8 and 9 to apply to a different range of tows; to overcome this, summaries of fractions discarded by species were based on data from entire trips but, necessarily, only those trips in which hoki, hake, or ling were the only species targeted. Care needs to be taken with interpretation of bycatch as in section 7, observers should record all species caught in the tow, including all species discarded for this tow. As the discards recorded in section 9 can be for individual tows, or groups of tows with sometimes part tows, there is not a direct link with fish caught in a tow and discards, and the bycatch section may be under-represented and therefore biased. Bycatch can also be underrepresented when there is a one-group to one-tow relationship between if catches are not included in section 7.

For Objective 4, the total catch and frequency of capture of each bycatch species in the hoki, hake, ling target trawl fishery was examined, and those for which there was a total of less than 10 kg of observed catch over the entire 23-year period, or which were observed caught on fewer than five occasions, were ignored. It was considered that either the capture of such species was so rare as to be irrelevant, or the species code may have been incorrectly recorded by the observer.

2.3 Commercial fishing return data

Catch-effort, daily processed, and landed data were requested from the MPI catch-effort database "warehou" as extract 9171 (Table A5). The data consist of all fishing and landing events associated with a set of fishing trips that reported a positive catch or landing of hoki, hake, or ling between 1 October 1989 and 30 September 2013. This included all fishing recorded on Trawl Catch, Effort and Processing Returns (TCEPRs); Trawl Catch Effort returns (TCERs); Catch, Effort and Landing Returns (CELRs) and excluded high seas versions of these forms. As the data extraction was done in mid-December 2013, a small amount of data from the 2012–13 fishing year may still not have been entered into the database. Data are analysed by fishing year (1 October to 30 September), referred to as, for example, 1991 for the 1990–91 fishing year. The fields from the database tables requested are listed in Table A5. Data were groomed for errors using simple checking and imputation algorithms developed in the statistical software package 'R' (R Development Core Team 2013). Tow positions, trawl length and duration, fishing speed, and depths were all groomed in this manner, primarily employing median imputation and range checks to identify and deal with missing or unlikely values and outliers (Table 3). These records, representing 533 995 trawls, were assigned to the areas defined in Figure 1, as was done for the observer data, using the recorded position coordinates.

It is possible to use these commercial catch data to directly estimate the total annual non-target catch in this fishery, as for each trawl or group of trawls (CELR records) the total catch as well as the catch of the target species (unless it is outside of the top five species by weight and therefore generally negligible) is recorded. Such estimates are provided here for comparison with the observer-based estimates and are somewhat appealing because (in contrast to the observer-based estimates) no scaling is required. However, a study of the New Zealand ling longline fishery, comparing commercial catch reports between observed and unobserved vessels, indicated that under-reporting and non-reporting of bycatch species was common and only a quarter of the catch of the main bycatch species (spiny dogfish, *Squalus acanthias*) was reported between 2001 and 2004 (Burns & Kerr 2008). This method also has the limitation that, because only the top five or eight species by weight are recorded, it is not possible to properly estimate the bycatch of individual species or groups of species.

2.4 Analysis of factors influencing bycatch and discards

Regression analyses were used to identify the most useful strata for the calculations to scale up from the observer records to the whole fishery. Several potentially influential variables are recorded by observers for each observed trawl, but not all are useful for stratification of commercial data. For example, vessel and trip have been shown in previous analyses to be useful factors for predicting rates of bycatch and discards. But, since only a subset of the vessels and trips in any fishery are observed, it is problematic to calculate rates for those that were not. The influence of trip was, however, taken into account in this analysis. This was done by using linear mixed-effects models (LMEs), in which the trip variable was treated as a random effect (whereby the trip associated with each record is assumed to be randomly selected from a population of trips), and the other variables were treated as fixed effects. The fixed effect variables considered in the models for each species category were: trawl duration (h); depth (average of start and finish depth, m); month or fishing day (day of the fishing year, 1 to 366); headline height; start time (0–24); fishing year; area (see Figure 1); vessel overall length; fishing speed; nationality; and gear code (bottom, midwater net, midwater net within 5 m of the seabed). The presence or absence of a meal plant on vessels was not used in the regression analysis as this data was not available on a tow-by-tow basis. The extent of the error introduced by the lack of temporal resolution of the data is being discussed with MPI in order to investigate whether it can or should be routinely included in the future.

Each species category (QMS, non-QMS, INV, (and HOK, HAK, LIN discards only)) was examined separately and normal mixed-effect regression models constructed which enabled an examination of factors influencing the *level* of a bycatch or discard. The normal model was fitted to records where the species category occurred in the bycatch (or discards) and the response variable was the log of the bycatch/discards. LME models were run for both catch per tow and catch per hour. From these regressions, summary tables were produced to show the order of variable selection in each model. Regressions were run for all data, and by each hoki area to see what other variables may explain bycatch or discards. The WCSI data was also split by fishing method (bottom and midwater tows) as a large amount of catch is caught by each fishing method. Hoki area was chosen as the most suitable stratification (with the WCSI further split by gear type - midwater or bottom tow) and area-based strata were applied to both catch per tow and catch per hour estimates for both bycatch and discards. Hoki areas (with the exception of the WCSI split by fishing method) were not further partitioned as there was not enough data. Strata chosen was mainly motivated by logistics, i.e. area is largely how these fleets are managed, and also for comparability over time, rather than statistical treatment of the data.

2.5 Calculation of bycatch and discard rates

For each species category, the observed weights of bycatch and discards were summed within each stratum determined from regression analysis. Similarly, the target species catches and trawl durations were summed within strata. From this, the "discard rate", $\widehat{DR}$, was derived, with the following form,

$$\hat{DR} = \frac{\sum_{i=1}^{m} d_i}{m}$$

where m trawls were sampled from a stratum and d_i is the weight of discarded catch from the ith trawl sampled. As in previous analyses (e.g. Ballara & Anderson 2009) two other forms of the discard rate were considered, based on the catch of hoki, hake, and ling and trawl duration within a stratum instead of the number of trawls. Comparison of the precision of the estimates for hoki, hake, and ling produced from each of the alternative rates, using sets of trial data, showed that the trawl

duration and number of trawls-based estimates performed in a similar manner, and so both of these are used in this analyses.

Using these rate estimators, estimates of $\widehat{DR}$ were derived for each stratum in each fishing year and variances were estimated by a multi-step bootstrapping procedure that allowed for correlation of discards between trawls within an observed trip.

Separate rates were calculated only for fishing year/strata cells with 50 records or more. For strata with fewer than 50 records in the year, additional records were taken from the adjacent two years (the previous and subsequent year) or single year if at the start or end of the series (Table A6). If there were still fewer than 50 records the next two adjacent years were included, and this process was continued until 50 records or more were available. If there were fewer than 50 records across all strata for the year an overall rate based on all years for the stratum was substituted. The discard rate calculated for each cell was then multiplied by the total number of trawls or duration in the cell, from commercial catch records for the target hoki, hake, or ling fishery, to estimate total discards $\hat{D}$:

$$(1) \qquad \hat{D} = \sum_j \hat{DR}_j \times M_j$$

where M_j is the number of trawls or fishing duration in fishing year/strata cell j.

To obtain a 95% confidence interval for the total discards that takes into account vessel to vessel differences and variability in the total amount of fishing effort per trip, and allows for correlation between trawls within a trip, 1000 bootstrap samples were generated from the trawls within each cell using a three-step sequential sampling procedure.

First a trip was chosen at random, then a bootstrap sample was taken of the trawls from that trip that were in the cell. These steps were repeated until the effective number of trawls was approximately equal to the effective number of observed trawls for the cell. The effective number of trips in the bootstrap sample was then calculated. If this was within 5% of the effective number of observed trips in the cell, 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 trawls and the effective number of trips was calculated from the effort (number of trawls or total duration) and reflected the contributions to the variance of the discard rate $\hat{D}$. from the variance of the discards and the covariance between pairs of discards within the same trip and cell. Matching a bootstrap sample to the cell 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 within a fishing year, and the 95% confidence interval was obtained from the 2.5% and 97.5% quantiles.

Bycatch estimates were calculated in a similar same manner to discards. Bootstrapping was carried out using the statistical software package R (R Development Core Team 2013).

2.6 Analysis of temporal trends in bycatch and discards

Annual estimates of bycatch and discards in each species category and overall, with confidence intervals, were plotted for the whole time-series. Locally weighted regression lines were calculated and shown on the same plots to highlight overall patterns of change over time.

2.7 Comparison of trends in bycatch with data from trawl surveys

The detection of a possible trend or pattern in the bycatch of the species categories assessed is one of the primary aims of this research. If such a pattern were detected, corroborative evidence from an independent source would greatly enhance its credibility and assist fishery managers to take appropriate action if required.

Bottom trawl surveys in waters within the depth range of hoki, hake and ling are summarised in this section. The surveys are part of standardised time series with potential use to monitor middle depth species abundance, and mainly optimised for hoki, hake, and ling. Note that years referred to in the research survey section are calendar years. The following *Tangaroa* trawl survey series were analysed using NIWA's research trawl survey analysis program "SurvCalc" (Francis & Fu 2012): Chatham Rise (core strata of 200–800 m); summer Sub-Antarctic (core strata of 300–800 m); and WCSI (core strata of 300–650 m, all strata 200–800 m).

1. *Chatham Rise* (1992–2013) hoki and middle depth species trawl survey time series (O'Driscoll et al. 2011, Stevens et al. 2014). The main aim of this series is to provide relative biomass estimates of adult and juvenile hoki. Other middle depth species including hake and ling, as well as a wide range of non-commercial fish and invertebrate species are also monitored by this survey time series. All surveys cover depths of 200–800 m on the Chatham Rise with additional deeper strata also surveyed in 2000, 2002, 2007, 2008, and 2010.

2. *Southland and Sub-Antarctic* (1991–1993, 2010–2009, 2011–2012) trawl survey of middle depth species (Bagley et al. 2013). This series was also primarily aimed at surveying hoki, hake, and ling. All individual surveys cover depths of 300–800 m, with additional 800–1000 m strata also surveyed from 2000. One additional stratum at Puysegur in 800 to 1000 m was included with the core strata to cover known hake distribution. The Bounty Platform was also surveyed in 1992 and 1993, but not from 2000 onwards.

3. *WCSI* (2000, 2012–2013) trawl surveys of middle depth species (O'Driscoll et al. 2014a, O'Driscoll et al. 2014b). Trawl surveys were carried out on the WCSI during July–August in 2000 and 2012–2013. The 2000 survey was part of a series of acoustic surveys of WCSI hoki spawning areas. The 2012 and 2013 surveys are a new time series of trawl estimates for middle depth species from the WCSI, with results that could be compared to the random daytime trawl component from the 2000 WCSI survey for 300–650 m core strata. The trawl survey design was changed in 2012 by adding strata in the north to cover the depth range of other key species (200–800 m).

Another *Tangaroa* trawl survey series was carried out in waters around the Stewart–Snares shelf and off Puysegur (known as the "Southland" series) during February–March of years 1993–96. These Southland surveys were conducted in depths of 30–600 m and were optimised for 10 species which included hoki, hake and ling (Hurst & Bagley 1997). The core survey area is appropriate although sampling intensity may not be adequate in the 400–600 m depth range, and as this survey was discontinued in 1996, it was considered to be of little use for assessing long term changes in hoki, hake and ling bycatch species in the area.

2.8 Discard information from Catch Landing Returns

The disposal of all catch taken by vessels in the hoki, hake, and ling fishery is recorded on Catch Landing Returns (CLRs). Codes used on this form under *destination_type* which may provide information on discarding include:

A	Accidental loss
D	Discarded (non-ITQ)
M	QMS species returned to sea (those in Part 6A of the Fisheries (Reporting) Regulations 2001, this code currently only applies to spiny dogfish)

X QMS species (those listed in Schedule 6 of the Fisheries Act1996) returned to sea - that the species is likely to survive on return; and the return takes place as soon as practicable after the species is taken - but excluding those in Part 6A of the Fisheries (Reporting) Regulations 2001 (spiny dogfish).

Although these returns are designed to capture information on the disposal of all catch recorded in catch/effort forms, in reality there appears to have been more of a focus on fish physically landed onshore, with discarded bycatch not fully recorded in all cases. In addition, these returns relate to the catch from several days or from whole trips rather than from individual tows, and so they may relate to more than one target fishery. Despite these caveats, a summary of this information is made to gauge the level of reported discarding, in particular the discarding of QMS species, which is permitted for species listed in Schedule 6 of the Fisheries Act (1996) and for species not so listed when an observer is on board the vessel and approves it.

2.9 Observer-authorised discarding

Section 72 of the Fisheries Act (1996) allows for the legal discarding of QMS species not listed in Schedule 6 if authorised by an observer (or fishery officer) who is present at the time. Such discarding is recorded at sea on an "Authority to return or abandon fish to the sea" form. These forms are returned to Ministry for Primary Industries where they are stored, but not recorded in any electronic database. In addition, observers provide a summary of all approved discarding for each trip in their trip report, but again this is not recorded in a database. A complicating factor with the data from both of these sources (if they were to be incorporated into this study) is that usually the records relate to the combined discards from several tows, or the entire trip, and could not be properly reconciled with the catch from individual tows or processing groups.

3. RESULTS

3.1 Distribution and representativeness of observer data

The density of all observed trawls in the target hoki, hake, or ling trawl fishery from 1990–91 to 2012–13 is compared with the distribution of all trawls recorded on commercial fishing returns from the same period in Figures 1 and 2. Observer coverage was spread over the geographical range of the combined fishery, with high sampling throughout WCSI, Chatham Rise, and Sub-Antarctic fishing grounds from 1997–98 (Table 2, Figure 1 and 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, although 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. Distribution of effort in the main fisheries from 1991 to 2013 has remained stable (Figure 2).

One hundred and fifty-four vessels were observed during the 23-year period, with 17–43 vessels observed in any one year (Table 1). From 1990–91 the annual number of observed tows increased to over 3000 for 1997–98 to 2001–02, and then decreased to between 2134–2823 from 2002–03 to 2011–12, with a large increase to 5058 tows in 2012–13. The percentage of the fishery observed ranged from 3–37% during the period (Table 1). The percentage of catch covered for each year was above the nominal 10%, considered sufficient to be representative of a fishery for all years except 1996–97, although the figure for overall coverage is slightly misleading as coverage of hoki in the Sub-Antarctic, and inside the 25 n. mile line in WCSI and Cook Strait is unrepresentative of the commercial fleet in some years (Ballara & O'Driscoll 2014), 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.

A spatial comparison of observed trawls with all commercial trawls was produced using density plots (Figure 3). Overall, the longitudinal and latitudinal extent of observed trawls matched the spread of commercial trawls throughout much of the 23-year period examined (Figure 3). Longitudes 168–172° E were well sampled each year, reflecting concentrated observer sampling on the WCSI. By latitude, the Chatham Rise was relatively well sampled (although in some years the eastern side was under-sampled, and in other years the western side was under-sampled), and the Sub-Antarctic has been under-sampled or not representatively sampled in some years (Ballara & O'Driscoll 2014). When all years are considered together, the WCSI is shown to have been slightly oversampled and Cook Strait, the Chatham Rise, and Sub-Antarctic under-sampled relative to the distribution of fishing effort.

Comparisons made between vessel sizes in the commercial fleets and the observed portion of the fleet showed that a very wide size range of vessels operate in this fishery, from just a few hundred tonne GRT (Gross Registered Tonnage) to over 4000 t, and from 20 to 120 m overall length (Figure 4). 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, especially in Cook Strait and on the WCSI (Ballara & O'Driscoll, 2014).

Comparison of the distribution of fishing depths between the observed tows and all commercial tows shows good correspondence (Figure 5). The distribution of fishing depths shows a close to normal distribution.

The spread of observer effort throughout each fishing year was compared with the spread of total effort in the fishery by applying a density function to the numbers of trawls per day (Figure 6). 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 outside the hoki spawning season was more 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, and inside the 25 n. mile line on the WCSI and in Cook Strait (Ballara & O'Driscoll 2014).

3.2 Comparison of estimators

Using observer data, the target (hoki, hake, and ling) estimated catch-based (catch of hoki, hake, and ling in each trawl), tow-based (number of hoki, hake, and ling tows), and tow duration-based (trawl duration for hoki, hake, and ling tows) 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 QMS, non-QMS species, INV, and HOK, HAK, LIN (discards only) categories, without any stratification, and coefficients of variation (CV) estimated by bootstrapping.

All estimated CVs were low, ranging from 0.9 to 1.9% for bycatch estimators and 1.8 to 4.7% for discard estimators (Table 4). Differences in CVs between the three forms of the ratio estimator were small, but the tow-duration provided a lower CV than the tow-based or catch-based estimators in most cases (Table 4), however tow-based estimator CVs were almost as low. Therefore the tow-duration and tow-based estimators were selected for all subsequent bycatch and discard calculations. As Anderson (2013) found the precision of the estimates produced from tow-based and duration-based rates showed that the tow-based rate performed consistently better, and has now become the standard form for use in these analyses, tow-based estimators are in the main report and tow-duration based estimators are in Appendix B for comparison.

3.3 Bycatch data (excluding discards)

3.3.1 Overview of raw bycatch data

Over 470 species or species groups were identified as bycatch by observers in the hoki, hake, or ling target fishery, most being non-QMS species, including invertebrate species, caught in low numbers (see Tables A1–A3). Hoki, hake, and ling accounted for 91% (81.9%, 5.5%, and 3.4% respectively) of the total observed catch from trawls targeting hoki, hake, and ling between 1 October 1990 and 30 September 2013. The main bycatch species (excluding discards) was silver warehou (1.4%) followed by javelinfish (1.4%), rattails (1.1%), and spiny dogfish (0.9%); only some of which was discarded (Figure 7).

When combined into broader taxonomic groups (Table A3), bony fish (excluding rattails, tuna, flatfish, and eels) contributed the most bycatch (95% of the total catch), followed by sharks and dogfish (1.4%), javelinfish (1.4%), and rattails (1.1%). The combined bycatch of all other fish (tuna, rays and skates, chimaeras, flatfish, and eels) accounted for 0.6% of the total catch. About 65% of the sharks and dogfish and 75% of eels were discarded, whereas more than half of the rattails, javelinfish, flatfish, tuna, rays and skates, chimaeras, and other fish not in any of these groups were retained. Of the invertebrates, 84% of octopuses, 20% of squid, 22% of crustaceans, and 43% of other molluscs were discarded. In the calculations for Tables A1–A3, discards of species or species groups expected to have been 100% discarded in this fishery, e.g., jellyfish, sometimes came to less than 100% suggesting (most likely incorrectly) that some were retained. This is partly due to the "destination" being assumed to be "retained" rather than "discarded" when this field was missing on the observer forms—a correct assumption in most, but not all, cases. Also, however, some species generally not considered commercial were occasionally recorded by observers as having been processed to meal.

Many invertebrates, in particular corals, echinoderms, and crustaceans, were identified to species, especially in the more recent records. This is due to improving knowledge of the New Zealand marine invertebrate fauna, both in general and specifically by fisheries scientists and observers, and the use of invertebrate identification guides (e.g. Tracey et al. 2011) which have become available to observers.

Exploratory plots of QMS species, non-QMS species, and total bycatch were prepared to examine bycatch per trawl (plotted on a log scale) with respect to the available variables (Figures 8–10). Total bycatch was highly variable between trawls, ranging from 0 t to 240 t (Figure 8), with the highest bycatch in the early 1990s. Most trawls were between 1 and 10 h long, with a median of 4 h. Bycatch per trawl showed an increasing trend with increasing trawl duration for total bycatch, QMS, and non-QMS species (Figures 8–10).

The observed tows had an average depth of mostly between 200 and 800 m, with a median of 510 m. Total bycatch increased only very slightly with increasing bottom depth, but the increase was much greater for non-QMS species, and QMS species showed a slight decrease in bycatch with increasing depth. Overall median bycatch of non-QMS species was 124 kg per trawl, however for depths of less than 400 the median was 2 kg per trawl and over 400 m was about 189 kg per trawl. The net type used made a difference to bycatch also, with bottom trawls catching more than midwater trawls in each catch category, especially for non-QMS species.

There was substantial variation in bycatch between the 40 vessels represented by more than 500 records, with total bycatch medians ranging from about 160–1700 kg per trawl, QMS bycatch medians from about 100–950 kg per trawl, and non-QMS bycatch medians from about 0–620 kg per trawl. There was little trend in total bycatch by fishing year, although there was a slight indication of an increasing trend in non-QMS species bycatch in recent years. By month there was little trend for total bycatch for QMS species, however there was a decrease in non-QMS bycatch in the hoki spawning months especially in July and August.

The observed trawls were spread amongst 13 nations comprising charter vessels (e.g. NZPOL, Polish vessels under charter to New Zealand fishing companies); foreign licenced vessels (e.g. POL, Poland); and domestic vessels (NZL). There were some differences in bycatch between nations for each catch category, with bycatch being lower for Chinese, Russian and Ukrainian vessels in all categories and generally higher for Korean, and Japanese vessels.

There were some differences in bycatch levels in each catch category between the five main areas examined. Median total bycatch varied between hoki areas with a range of 0.3–0.5 t tow^{-1}, although Cook Strait had a lower bycatch level (median 0.15 t tow^{-1}) and Chatham Rise a much higher level (1.07 t tow^{-1}). For Cook Strait this is due to lower catches of QMS species (median 0.11 t tow^{-1}) and very low non-QMS species catches (median 0.001 t tow^{-1}), while the Chatham Rise had the highest levels of QMS species catch (median 0.36 t tow^{-1}) and non-QMS species catch (median 0.55 t tow^{-1}).

3.3.2 Regression modelling and stratification of bycatch data

The dependent variable in the LME models was the bycatch rate, expressed as the log of catch (kg) per trawl or catch (kg) per hour. There was a fraction of records with no bycatch of non-QMS species and invertebrate species, but these were excluded and only log-linear models were constructed to enable identification of factors affecting the level of bycatch in these categories.

In each of the models bycatch rates were influenced strongly by fishery *area*, *depth*, *gear code*, and *duration* (catch per tow only) (Table 5). For catch per tow, *area*, *depth*, *duration*, and *gear code* were the most important variables, and for catch per hour *area*, *depth*, *month*, and *gear code* or *headline height* tended to be the most important variables (Table B1). Most of the other variables tested also had some degree of influence in some or all of the models, especially *headline*, *fishing year*, and *month*. Vessel *nationality* and vessel *speed* had little or no influence in any of the models.

Although trawl duration clearly has an influence on catch rates in each species category, the quantity of available observer data in this fishery limits the amount of stratification that can practically be used in the calculation of bycatch estimates. As most target catch is hoki and comes from the hoki area fisheries, a hoki area breakdown of bycatch is more useful for managers, and due to this and the influence of area in each of the bycatch categories, this variable was used to stratify all bycatch calculations (with the WCSI further split by gear type - midwater or bottom tow), to enable the same suitable comparisons between catch per tow and catch per hour estimates for bycatch estimates.

3.4 Discard data

3.4.1 Overview of raw discard data

Because the top fourteen observed bycatch species were all QMS species, except for javelinfish and rattails, discard rates were generally low (Table A1). 17–18% of javelin and rattail catch was discarded. The individual species most discarded in the hoki, hake, or ling target fishery was spiny dogfish, which was introduced into the QMS in October 2004 but at the same time added to the 6th schedule of the Fisheries Act 1996, allowing it to be legally discarded at sea (see also Section 3.5.5 for a discussion of observer-authorised QMS species discards). Spiny dogfish was the fourth most common bycatch species (after silver warehou, rattails and javelinfish) and 69% of the 6640 t of the observed catch was discarded (see Table A1). Discarding of target species hoki, hake or ling occurred in only 0.5%, 0.1% and 0.1% of processing groups observed respectively, and 0.2% of silver warehou catch was recorded as discarded. Jack mackerel were sometimes discarded (16%). Of the non-QMS species, most were discarded, including shovelnose dogfish (58%), deepwater dogfish

(82%), seal sharks (70%); and other sharks and dogs (56%) were also usually discarded (Table A1). Few of the major invertebrate bycatch species were retained, exceptions being arrow squid (*Nototodarus* sp) (2.1% discarded), and warty squid (53.4% discarded) (*Onykia* spp); with most of the observed catch of crab species, other crustaceans, echinoderms, squids, and unidentified invertebrates less than 0.01% retained (see Table A2 for details).

Exploratory plots were prepared to examine the variability in the level of discards per trawl for QMS species, non-QMS species and all species combined, with respect to some of the available variables (Figures 11–13). The level of total discards was highly variable between trawls, ranging from 0 t to 103 t (Figure 11). The quantity of discards increased slightly with trawl duration for non-QMS species, and overall (Figures 11–13), but did not change for QMS species. Overall median discards increased from 0.1 t for tows less than 5 hours duration, to 0.2 t for tows 5–8 hours, and 0.6 t for durations longer than 8 hours. Similarly, discards increased slightly with increasing depth overall and for non-QMS species, but decreased for QMS species.

There was substantial variation in discards between vessels (those represented by more than 500 records), with total discard medians ranging from about 10–600 kg tow^{-1}, QMS discard medians from about 0–84 kg tow^{-1}, and non-QMS discard medians from about 0–530 kg tow^{-1}. Although the presence and use of meal plants on vessels is not well recorded, those vessels in Figure 11 with lower discard rates tended to be larger vessels on which meal plants were known to be installed. There was some variation in discard rates between years in each species category and, as for bycatch, an indication of increasing discards of non-QMS species over the last several years (note that due to problems with the observer databases there is no discard data available for 1997–98).

Discards were similar between *hoki areas* (105–225 kg tow^{-1}). Cook Strait had higher discards than other areas for QMS species, and lower discards than other areas for non-QMS species, and the Chatham Rise had the highest total and non-QMS discards. Total discards were greatest for Chinese, Japanese and Korean vessels and least for Russian and Ukrainian vessels with patterns similar for QMS and non-QMS categories. Bottom trawls resulted in more discarding than midwater trawls overall and for non-QMS species, with the median total discards per tow for bottom trawls about 260 kg, compared with about 60 kg tow^{-1} for midwater trawls near the bottom, and 90 kg tow^{-1} for other midwater trawls. There was no trend in discards with *month*. There were more discards of QMS species in shallow tows, and more discards of non-QMS species in deeper tows.

3.4.2 Regression modelling and stratification of discard data

The dependent variable in the discard LME models was the discard rate, expressed as the log of discards (kg) per trawl or discards (kg) per hour. Records with no discards (51%, 47%, 72%, and 72% of tows had no discards for QMS, non-QMS, invertebrate, or hoki, hake and ling species respectively) were excluded and only log-linear models were constructed to enable identification of factors affecting the level of discards in these categories.

In each of the models discard rates were strongly correlated with *depth*, *gear code*, and *duration* (catch per tow only) (Table 6, Table B2). *Area* was present in most dataset models but lower in the list. Most of the other variables tested also had some degree of influence in some or all of the models, especially *headline*, *fishing year*, and *month*. Vessel *nationality* and vessel *speed* had little or no influence in any of the models. For the same reasons that area was used as the stratification in the calculation of bycatch estimates, and to be consistent with those calculations, this variable (along with WCSI further split by gear type - midwater or bottom tow) was used in the discard calculations.

3.5 Estimation of retained bycatch

3.5.1 Bycatch rates

Bycatch rates by stratum and year were calculated for each species category from the observer data. The six strata (WCSI bottom tows, WCSI midwater tows, Cook Strait, Chatham Rise, Sub-Antarctic, and Puysegur), together accounted for over 99% of the total hoki, hake, and ling catch. Average bycatch rates across all strata in each year were calculated to apply to fishing effort in other areas. The variance associated with these estimates was calculated using the bootstrap methods described in Section 2.4.

As well as providing the basis from which annual bycatch can be determined by application to target fishery effort totals, these rates also provide some insight as to how bycatch varies between the different regions of the target hoki, hake, or ling fishery (Figures 14 and B1, Table A7 and B3). Limitations in the data in a few years (represented as no dots in Figures 14 and B1), especially in the spread of observer effort across areas in each year, meant that bycatch rates for some year/area combinations included data from adjacent years, or from all areas for the year, as described in Section 2.4.

Median bycatch rates of QMS species in the six hoki areas (excluding the null area) ranged from 52–2276 kg tow^{-1} (Figure 14, Table A7), with Puysegur or WCSI midwater having the highest bycatch rates in a few years, and Cook Strait generally having the lowest bycatch ratios. Median bycatch rates of QMS species were consistently low in Cook Strait, showing a decreasing trend, and were the lowest in the first four years, and last few years. WCSI midwater bycatch rates were high from 1993–94 to 1997–98 (946–1455 kg tow^{-1}) but have since decreased. Chatham Rise showed an increasing trend from 1993–94 to 2003–04 (320–1273 kg tow^{-1}) and subsequently levelled off. The Sub-Antarctic had lower bycatch rates in earlier years. In other areas bycatch rates of QMS species were variable.

Bycatch rates of non-QMS species ranged from 4 to 1877 kg tow^{-1}. The Chatham Rise had the highest non-QMS bycatch rates and showed an increasing trend. Bycatch rates for WCSI midwater and Cook Strait (which is also mainly fished with midwater trawls) were the lowest. Bycatch rates for WCSI bottom tows, Sub-Antarctic, and Puysegur were low until about 1995–96 (usually less than 300 kg tow^{-1}) and then increased over time with bycatch rates ranging from 49 to 1084 kg tow^{-1}.

Bycatch rates of invertebrate species were low, ranging from 0.1–160 kg tow^{-1}. For WCSI bottom tows bycatch rates of invertebrates were high in 1991–92, 1993–94, and 1994–95. For other areas bycatch rates were less than 40 kg tow^{-1} up to the mid-1990s and then increased after 1999–2000. In contrast, invertebrate bycatch rates remained consistently low in Cook Strait—generally less than 2 kg tow^{-1} in each year. The increase in bycatch rates of invertebrate species was especially strong in the Sub-Antarctic, where the observed catch of unspecified crab species, giant spider crabs (*Jaquinotia edwardsii*), and smooth red swimming crabs all increased after about 2000.

Even though the spread of effort either as number of tows or duration by stratum showed similar trends (Figure 15), bycatch rates calculated for the duration based estimator tended to be lower for most areas especially for non-QMS and invertebrate species (Figures 17 and B2).

To investigate whether standardised bycatch rates might provide estimates of abundance for some species the bycatch ratios were compared with trawl survey relative biomass indices from *Tangaroa* surveys of the Chatham Rise, Sub-Antarctic, and WCSI (Figure 16). Indices appear to show similar patterns for QMS and INV species on the Chatham Rise (Figure 16a), within the limits of uncertainty of both bycatch and trawl estimates. Correlation for indices for the Sub-Antarctic core survey area and bycatch rates was low (Figure 16b), [Note: Glass sponges were excluded from the invertebrate category for the Sub-Antarctic in tan0617 as biomass was large 33 513 t (CV 93%) so

would have obscured the trend.] and for the WCSI bottom tow daytime tows indices were very low or negative (Figure 16c).

Differences in observer and survey bycatch data make comparisons difficult. For example: for surveys every species is recorded in the catch for every tow; the identification skills of scientific staff on surveys and Observers will be different; the tows on a trawl survey are at a slower standard speed, so species such as warehou or jack mackerel are less likely to be caught; survey vessels such as *Tangaroa* use 60 mm codend, while commercial vessels use larger codend mesh; surveys are wide area whereas commercial fishing is localised; surveys have a dispensation to trawl in benthic protected areas, which have been closed to commercial trawling since 2007; deeper water is not always well covered by survey core strata which may reduce hake bycatch; survey tows are all during the daytime; and surveys are from a discrete time of the year whereas observer data is collected at variable times of the year.

3.5.2 Annual bycatch levels

Annual bycatch in each species category was estimated by multiplying the rates calculated from observer data for each area and year stratum by the number of trawls in the target hoki, hake, or ling target fishery for the equivalent stratum, as described in Section 2.4. The precision of the estimates was determined from the variability in the bootstrap samples of 1000 rates (Table 7, Figure 17).

The annual bycatch of QMS species ranged from 7050 t to 23 930 t (Table 7) with an increasing trend to 2000–01 followed by a decreasing trend. QMS bycatch was higher from 1995–96 to 2003–04 (16 360 to 23 900 t), and was much lower from 2004–05 to 2012–13 (7050 to 12 400 t). The 95% confidence intervals around the QMS bycatch overlap between all adjacent years (Figure 17), and years with higher annual bycatch levels tended to have wider confidence intervals. Estimates of annual bycatch of QMS species made by Ballara et al. (2010) for 1999–2000 to 2005–06 showed similar patterns to those from this study, with confidence intervals all overlapping, although the estimates in this study for 2000–01 to 2003–04 were much higher.

The estimated annual bycatch of non-QMS species was lower than that of QMS species except for in 2001–02, 2008–09, and 2009–10, was at a peak in 2001–02 at 17 020 t, and then generally decreased slightly each year to 5930 t in 2011–12, with a slight increase in 2012–13 (Table 7, Figure 17). Non-QMS estimates made by Ballara et al. (2010) for 1999–2000 to 2005–06 were higher than those from this study, with confidence intervals all overlapping, and showed the same pattern of higher levels between 2000–01 and 2003–04.

Invertebrate species were only a very small component of the total annual bycatch, usually less than 1000 t, and showed the same trend as QMS and non-QMS species with the greatest amounts caught in the middle part of the period, from 1998–99 to 2003–04, when 1190–1550 t per year was caught (Table 7, Figure 17).

Total annual bycatch (all categories combined) showed a similar pattern to QMS, non-QMS and invertebrate species bycatch – decreasing from 1990–91 to 1992–93, increasing to 1999–2000, and then decreasing to a lower level from 2004–05 to 2011–12, with a slight increase in 2012–13 (Figure 17). Total bycatch appears to have been highest in the five years from 1999–2000 to 2003–04. Total estimates of Ballara et al. (2010) showed similar patterns to those from this study, with confidence intervals all overlapping, although the Ballara et al. (2010) estimates of total bycatch for 2000–01 to 2003–04 were higher.

The reduction in bycatch from the early 2000s was not due to lower bycatch rates but to a much reduced level of effort – as shown in the lower panel of Figure 17. Changes in total levels of bycatch

reflect changes in the total catches in the target fishery, notably serial reductions in the hoki TACC from 2001–02. Total hoki, hake, and ling catches decreased from 305 000 to 112 363 t from 1997–98 to 2008–09 (Ministry for Primary Industries, 2014).

Annual estimates of bycatch for the duration-based estimator were generally similar to those from the tow-based estimator (Table B4, Figure B2).

Estimates of total bycatch from this study based on observed ratios both by number of tows and duration was substantially higher than estimates of bycatch calculated directly from commercial data (total TCEPR, TCER and CELR catch minus the TCEPR, TCER and CELR catch of hoki, hake, and ling from the target hoki, hake, and ling fishery), but both indices showed similar trends (Table 8, Figures 18 and B3) with effort having generally decreased in this fishery after 2001–02. Overall, the total catch record-based annual bycatch for the 23-year period was about 78% of the observer data-based bycatch for the tow estimator and 75% for the duration estimator.

3.6 Estimation of discards

3.6.1 Discard rates

Discard rates by area and year were calculated for each species category from the observer data (Figure 19, Table A8). Median discard rates of hoki, hake, or ling for the tow-based estimator were variable between years and areas, with the highest discard rates (100–1000 kg tow^{-1}) generally observed before 1996–97, and generally less than 200 kg tow^{-1} in most areas and in later years (Figure 19, Table A8).

Annual discard rates of QMS species were also variable, and ranged from 0.4 to 641 kg tow^{-1} (Figure 19, Table A8), with WCSI midwater tows (8–291 kg tow^{-1}), Cook Strait (40–641 kg tow^{-1}) and Sub-Antarctic (0.4–453 kg tow^{-1}) having the highest discard rates in most years. Rates of discarding for QMS species were lower on the Chatham Rise (10–168 kg tow^{-1}), Puysegur (9–110 kg tow^{-1}), and WCSI bottom tows (3–243 kg tow^{-1}) respectively. Annual median discard ratios of the QMS species were mainly driven by discarding of spiny dogfish, as once spiny dogfish were removed from the QMS species category in the previous analysis, bycatch ratios were very low (Ballara et al, 2010).

Discard rates of non-QMS species were also variable, and ranged from 0.7–1126 kg tow^{-1}, with the lowest discard rates in Cook Strait (0.7–70 kg tow^{-1}), and the higher discard rates on the Chatham Rise (46–1126 kg tow^{-1}), the Sub-Antarctic (29–276 kg tow^{-1}), and for WCSI bottom tows (20–694 kg tow^{-1}) (Figure 19, Table A8).

Annual discard rates of invertebrate species were mostly less than 100 kg tow^{-1} in all areas, except for the Chatham Rise in 1999–2000 and 2001–02 (Figure 19, Table A8). Invertebrate discard rates were consistently the lowest in Cook Strait and for WCSI midwater tows, and were higher on the Chatham Rise and Sub-Antarctic. As with bycatch of invertebrates, patterns of discard rates may have been influenced by changes in observer recording practices over time.

Duration-based discard rates tended to be lower than tow-based estimators, with the main exception being a higher estimate for Cook Strait QMS species (Table B5, Figure B4).

3.6.2 Annual discard levels

The level of annual discards in each species category was estimated by multiplying the ratios calculated from observer data for each area and year stratum by the number of trawls in the target hoki, hake, or ling fishery for the equivalent stratum, and precision of the estimates was determined

from the variability in the bootstrap samples of 1000 rates, as described in Section 2.4 (Table 9, Figure 20). Estimates of total annual discards ranged from 3699 in 2011–12 to 16 633 t in 1996–97 and, like bycatch, were generally lower after 2003–04 (Table 9, Figure 20). The estimates for 2000–01 to 2006–07 generally match well with those of Ballara et al. (2010), with considerable overlap of confidence intervals in most years, but are lower than these earlier estimates (Figure 20). Total discards do not show a similar pattern to hoki, hake, and ling, QMS, non-QMS, or invertebrate discards, rather a combination of their trends with a slight increase in total discards to 1996–97, followed by a decrease to 2006–07, and a then low stable discards (Figure 20).

Estimated discards of hoki, hake, or ling discards decreased from a high in 1994–95 of 9347t to the lowest discard level of 104 t in 2007–08. These estimates were within the range calculated by Ballara et al. (2010) for overlapping years.

Discards of QMS species were variable but showed a slight increasing trend up to 2000–01, and then a decrease (Table 9, Figure 20). Discards were high from 1995–96 to 2002–03 ranging from 3433 to 6471 t y^{-1}. Estimates of QMS species discards by Ballara et al (2010) were similar to the estimates for this period in the current study, with confidence intervals for the pairs of estimates all overlapping to some degree (Figure 20), although the estimate for 2003–04 is higher.

Discards of non-QMS species ranged from 829 to 10 555 t y^{-1}, and tended to be higher than those of QMS species, although they were slightly lower from 1992–93 to 1998–99. The fitted line in Figure 20 shows an increasing trend in non-QMS discards to 2000–01 followed by a decreasing trend, and a levelling off from 2006–07. The estimates show a similar trend to those of Ballara et al (2010) (Figure 20), but are higher.

Annual discards of invertebrate species were a very small component of the total annual discards, usually less than 500 t, although discard rates were higher from 1998–99 to 2002–03 when 634–1838 t y^{-1} was caught (Table 9, Figure 20). Annual discards of invertebrates showed a similar pattern to bycatch as most of the catch in this category is discarded.

In Ballara et al. (2010) spiny dogfish were the major contributor to discards making up 95% of observed discards of QMS species and once spiny dogfish were excluded discards were very low. The apparent decrease in discards may also be related to vessel processing practice, as it was found that decreases in discards are associated with increases in javelinfish, rattails, deepwater sharks, and skates processed to meal (Ballara et al. 2010).

Annual estimates of discards for the duration-based estimator were generally similar to the tow-based estimator except that the duration-based estimates of discards for hoki, hake, and ling were higher from 1990–91 to 1996–97 and estimated discards of QMS species were higher in most years (Table B6, Figure B5).

3.6.3 Discard information from Catch Landing Returns

Catch Landing Return data were examined from all trips which were mainly targeting hoki, hake, or ling, i.e., greater than 50% of tows/days. Recorded accidental losses of fish ranged from 94–602 t per year (except for 980 t in 1990–91 and 2172 t in 1999–2000). Discarding of non-QMS species ranged from 224–7375 t per year (Table 10), and was considerably greater from 1998–99 to 2003–04. Destination types M and X are more recent codes, introduced in 2004–05 and 2007–08 respectively. These show little recorded discarding of Schedule 6 QMS species but larger amounts of Part 6A (spiny dogfish) discards (434–1227 t per year).

The codes listed in Table 10 are the only destination type codes available in this study for recording discards, and there is no code provided to record observer/fishery officer approved discards. Such

discards are therefore unaccounted for by Catch Landing Records. The total discards calculated from these returns are much lower than estimated from observer records, less than half in most years, but excluding the first few years represent a relatively constant fraction of them. From 2013–14 a new destination code J for observer/fishery officer approved discards (OADs) in Catch Landing Returns was introduced and will better quantify these discards. Destination type A may have in the past at least partially accounted for OADs (Tiffany Bock, MPI, pers. comm.).

3.6.4 Observer-authorised discarding

An examination was made of the trip reports from a random selection of 20 of the 866 observed trips since 1996 in this study. About half of these recorded no authorised QMS species discarding and the remaining recorded authorised discards of between 60 kg and 49 t per trip. Most of the discards comprised hoki (60 kg to 45 t) which were considered too small or too damaged to process, or the meal plant was broken. Occasionally large amounts of barracouta (up to about 49 t), jack mackerel, squid, hake, ling, silver warehou, and red cod were discarded—for the same reasons.

Observer authorised discarding clearly has the potential to bias estimation of discards which are based on observed discard ratios. Ideally such discards would be ignored in the calculation of these ratios but this could be done only by assuming that all QMS species discards in the observer databases were properly approved. Disregarding these discards would lead to a discard ratio of zero and infer zero discarding of (non-Schedule 6, or fish smaller then MLS) QMS species in the unobserved portion of the fishery. The annual QMS species discard estimates presented in this report therefore make the assumption that the level of discarding of QMS species not listed in Schedule 6 and MLS of the Fisheries Act 1996 is unaffected by the presence of an observer on the vessel. This assumption is known to be incorrect and the observer code OAD available in the observer data from August 2013, and commercial code J code were introduced to deal with this in the future.

3.7 Efficiency of the hoki, hake, or ling trawl fishery

Annual bycatch and discard estimates in the hoki, hake, or ling target trawl fishery were divided by the estimated annual catch of ling and the total annual bycatch, to provide measures of the efficiency of the fisheries (Table 11).

The annual bycatch fraction (kg of bycatch/kg of hoki, hake and ling catch) ranged from 0.06 in 1992–93 to 0.23 in 2003–04, and was low in the early 1990s, and generally higher from 2000–01 to 2010–11. The annual discard fraction (kg of discards/kg of hoki, hake and ling catch) ranged from 0.03 in 2004–05 and 2011–12 to 0.08 in 1994–95 and 2002–03, with an overall value for the 23-year period of 0.05. Although quite variable, the discard fraction was generally higher in the 1990s and decreased from the mid-2000s. Between 15% and 88% of the annual bycatch was discarded, with higher percentages in the 1990s, and with lower percentages of discards generally seen from 2003–04. Duration-based estimators generally produced similar trends (Table B7).

3.8 Annual retained bycatch by individual species

A table of annual bycatch estimates for individual species is given in Table A9. In some cases the apparent increase or decrease in bycatch of a species is likely to be due to improvements in species identification, or changes in recording habits, over time. For example, observers may have switched from the genus-level code CON (*Conger* spp.) to the more specific code HCO (hairy conger, *Bassanago hirsutus*) resulting in an apparent increase in HCO catch and a decrease in CON catch over time; and a change from SKA (skate) to the more specific RSK (rough skate) and SSK (smooth skate) may be responsible for the apparent decrease in bycatch of SKA.

Based on these estimates, the most commonly caught bycatch species over the entire commercial fishery were (in decreasing order) silver warehou (SWA), javelinfish (JAV), unspecified rattails (Macrouridae, RAT), spiny dogfish (SPD), frostfish (FRO), and white warehou (WWA).

Of the 225 bycatch species examined, 40 have shown a significant decrease in catch over time and 19 an increase in catch over time (the remaining species showing no change at the 1% level of significance). Among the species showing declines were skates (SKA), combined jack mackerel species (JMA, JMM, and JMN), and dogfishes (*Etmopterus* spp., ETM), and species showing an increase included Tam O shanter urchins (Echinothurioida, TAM), umbrella octopus (*Opisthoteuthis* spp., OPI), and floppy tubular sponge (*Hyalascus* sp., HYA) (Figure 21).

Annual estimates of main bycatch species in the hoki, hake, or ling target trawl fishery show that most of these species had higher catches in the early to mid-2000s, although some show higher catches in earlier years (such as frostfish, jack mackerel, barracouta, and dark ghostshark) (Table A9, Figure 22). White warehou shows an increasing trend to 2007, with a subsequent decreasing trend.

3.8.1 Comparison of trends in individual species bycatch in the hoki, hake, and ling trawl fishery with relevant trawl surveys

The time-series of trawl surveys in the sub-Antarctic (Bagley et al. 2013) and on the Chatham Rise (O'Driscoll et al. 2011) overlap substantially with the depth range and the spatial extent of the hoki, hake, and ling trawl fishery so it is useful to compare trends in catch rates of the main bycatch species. Annual relative biomass estimates were calculated for a wide range of species in each survey time-series and summarised in two comprehensive reports; these cover the years 1991 to 2009 in the sub-Antarctic (Bagley et al. 2013), and 1992 to 2010 on the Chatham Rise (O'Driscoll et al. 2011). The confidence in the biomass estimates in these reports was defined as follows: **very well** estimated, mean CV < 20%; **well** estimated, mean CV 20–30%; **moderately well** estimated, mean CV 30–40%, **poorly** estimated, mean CV > 40% (O'Driscoll et al. 2011). Definitions of trends used a bootstrapping technique based on ranks for survey data split into three time periods (see O'Driscoll et al. 2011 for full details). For WCSI surveys O'Driscoll et al. (2014b) presents a summary biomass table of some main species caught in this survey, and CVs were well estimated for LDO, SPE, JAV and SQU (mean CV < 20%), and were moderately estimated or poorly estimated for the other species listed in this section.

Silver warehou (SWA)

According to the present study, silver warehou was the most commonly caught bycatch species (by weight) in the hoki, hake, and ling trawl fishery. This species was reported as being **poorly** estimated in the Sub-Antarctic and Chatham Rise surveys; relative biomass showed **a decrease then increase** in the Sub-Antarctic survey time-series, but **increased** in the Chatham Rise surveys. The WCSI trawl survey showed an increasing trend in biomass (O'Driscoll et al. 2014b). Bycatch rates by fishing year and area showed variable trends with higher bycatch rates for WCSI midwater trawls in the 1990s, WCSI bottom trawls in most years, and on the Chatham Rise from 2004, and very low bycatch rates in Cook Strait (Table A10, Figure 23).

Javelinfish (JAV)

Javelinfish was the second most commonly caught bycatch species (by weight) in the fishery. This species was reported as being **very well** estimated in the Sub-Antarctic and Chatham Rise surveys; relative biomass showed **no clear trend** in the Sub-Antarctic survey time-series, but **increased** in the Chatham Rise surveys. The WCSI trawl survey showed no trend in biomass (O'Driscoll et al. 2014b). Bycatch rates by fishing year and area showed variable trends with high increasing bycatch rates on

the Chatham Rise, and increasing bycatch rates for WCSI for bottom trawls and for the Sub-Antarctic, with very low bycatch rates in Cook Strait (Table A10, Figures 23 and 24).

Unspecified rattails (Macrouridae, RAT)

Rattails were the third most caught bycatch species (by weight) in the fishery. Rattails are recorded to species level in the research surveys so there are no overall descriptions of the species code RAT in trawl survey reports. Bycatch rates by fishing year and area showed variable trends with high increasing bycatch rates on the Chatham Rise, and increasing bycatch rates for WCSI for bottom trawls and for the Sub-Antarctic, with very low bycatch rates in Cook Strait and for WCSI midwater trawls (Table A10, Figure 23).

Spiny dogfish (SPD)

Spiny dogfish was reported as being **well** estimated in the survey area of the Sub-Antarctic survey and **very well** estimated in the Chatham Rise surveys; relative biomass showed **no clear trend** in the Sub-Antarctic survey time-series, but **increased** in the Chatham Rise surveys. The WCSI trawl survey showed a variable trend in biomass with higher biomass in the 2012 and 2013 surveys (O'Driscoll et al. 2014b). Bycatch rates by fishing year and area showed increasing then decreasing bycatch rates in Cook Strait (Appendix 13, Figure 23). Higher bycatch rates were seen on the WCSI for both bottom and midwater tows during the 1990s, for WCSI bottom tows in 2012 and 2013, and for the Sub-Antarctic from 2002 (Table A10, Figures 23 and 24).

Frostfish (FRO)

Frostfish was **poorly** estimated in the Chatham Rise surveys and biomass showed **no clear trend**. There is no summary information for frostfish for the Sub-Antarctic or WCSI surveys. Bycatch rates for frostfish were low in all areas except for WCSI midwater tows up until 2009 (Table A10, Figure 23).

White warehou (WWA)

White warehou was reported as being **moderately well** estimated in both the Sub-Antarctic and Chatham Rise surveys with relative biomass showing **no clear trend** for both time-series. There was no summary information for the WCSI survey. Bycatch rates by fishing year and area were variable with higher bycatch rates in the Sub-Antarctic and Puysegur from 2005 (Table A10, Figures 23 and 24).

Pale ghost shark (GSP)

Pale ghost shark was reported as being **very well** estimated in the Sub-Antarctic and Chatham Rise surveys and relative biomass showed **no clear trend** in either time-series. There was no summary information for the WCSI survey. Bycatch rates by fishing year and area were variable with higher bycatch rates in the Sub-Antarctic and on the Chatham Rise in most years (Table A10, Figures 23 and 24).

Combined jack mackerel species (JMA, JMM, and JMN)

Jack mackerel are recorded as JMD and JMM in the Chatham Rise survey, both of which are **poorly** estimated; for JMD biomass has **increased**, and for JMM biomass has **decreased**. There is no summary information for jack mackerel for the Sub-Antarctic or WCSI surveys. Bycatch rates by fishing year and area were variable with higher bycatch rates in the WCSI midwater tows until 2000 (Table A10, Figure 23).

Ribaldo (RIB)

Ribaldo was reported as being **very well** estimated in both the Sub-Antarctic surveys and the Chatham Rise survey areas and relative biomass has showed **no clear trend** in either time-series, with the Chatham Rise trend matching well for both data sources. Ribaldo showed a decreasing trend in biomass on the WCSI (O'Driscoll et al. 2014b). Bycatch rates by fishing year and area were variable with higher bycatch rates for WCSI bottom tows from 2000 (Table A10, Figures 23 and 24).

Sea perch (SPE)

Sea perch was reported as being **poorly** estimated in the Sub-Antarctic surveys but **very well** estimated in the Chatham Rise surveys; relative biomass showed **no clear trend** in the sub-Antarctic time-series, but **increased** in the Chatham Rise time-series, with the Chatham Rise trend matching well for both data sources. Sea perch showed no trend in biomass on the WCSI (O'Driscoll et al. 2014b). Bycatch rates by fishing year and area were variable with higher bycatch rates for Chatham Rise and WCSI bottom tows (Table A10, Figures 23 and 24).

Lookdown dory (LDO)

Lookdown dory was reported as being **well** estimated in the Sub-Antarctic surveys and **very well** estimated in the Chatham Rise surveys; relative biomass **increased then decreased** in the sub-Antarctic time-series, but showed **no clear trend** in the Chatham Rise time-series. Lookdown dory showed a variable trend in biomass on the WCSI, although was higher in 2013 (O'Driscoll et al. 2014b). Bycatch rates by fishing year and area were variable with higher bycatch rates for Chatham Rise and WCSI bottom tows (Table A10, Figures 23 and 24).

Barracouta (BAR)

Barracouta was reported as being **poorly** estimated in the Sub-Antarctic and Chatham Rise survey areas, and relative biomass showed **no clear trend** in these time-series. Barracouta showed no trend in biomass on the WCSI (O'Driscoll et al. 2014b). Bycatch rates by fishing year and area were relatively low and variable in all areas except for WCSI midwater tows (Table A10, Figure 23).

Arrow squid (SQU)

Arrow squid species was reported as being **poorly** estimated in the Sub-Antarctic survey area but **well** estimated in the Chatham Rise surveys; relative biomass showed **no clear trend** in the Sub-Antarctic time-series, but **decreased and then increased** in the Chatham Rise time-series. There is no summary information for arrow squid for the WCSI survey (O'Driscoll et al. 2014b). Bycatch rates by fishing year and area were variable and showed higher bycatch rates for WCSI bottom tows, the Sub-Antarctic and Puysegur (Table A10, Figures 23 and 24).

Black oreo (BOE)

Black oreo was reported as being **poorly** estimated in the Sub-Antarctic surveys but **moderately well** estimated in the Chatham Rise surveys; relative biomass showed **no clear trend** in the Sub-Antarctic time-series, but **increased and then decreased** in the Chatham Rise time-series. There is no summary information for black oreo for the WCSI survey (O'Driscoll et al. 2014b). Bycatch rates were variable and higher in the Chatham Rise (Table A10, Figures 23 and 24).

Dark ghost shark (GSH)

Dark ghost shark was reported as being **poorly** estimated in the Sub-Antarctic surveys but **very well** estimated in the Chatham Rise surveys; relative biomass showed **no clear trend** in the sub-Antarctic time-series, but **increased** in the Chatham Rise time-series. Dark ghost shark showed no trend in biomass on the WCSI (O'Driscoll et al. 2014b). Bycatch rates by fishing year and area were variable

and generally showed higher bycatch rates for Sub-Antarctic and Chatham Rise (Table A10, Figures 23 and 24).

Shovelnose dogfish (SND)

Shovelnose dogfish was reported as being **well** estimated Sub-Antarctic surveys and Chatham Rise surveys; relative biomass has showed **no clear trend** in the Chatham Rise time-series, but **decreased** then **increased** in the Sub-Antarctic time-series. Shovelnose dogfish showed a trend in biomass on the WCSI (O'Driscoll et al. 2014b). Bycatch rates by fishing year and area were variable and showed higher bycatch rates on the Chatham Rise and in Puysegur in most years (Table A10, Figures 23 and 24).

4. SUMMARY AND DISCUSSION

Annual estimates of bycatch and discards were based on observed bycatch and discard rates so the precision of these estimates was strongly dependent on the quality (level and spread) of the observer coverage. The level of observer coverage in the hoki, hake and ling fishery has been lower than some of the other deepwater fisheries for which bycatch and discard levels are assessed. The long-term level of observer coverage was over 40% for southern blue whiting by weight of the target fishery catch, about 22% for the arrow squid fishery, 13% for the ling longline fishery; and 11–12% for jack mackerel and scampi fisheries (Anderson 2004a, 2007, 2012, 2014a). Coverage in the hoki, hake, and ling trawl fishery has been highly variable, but less than 10% coverage was achieved in 1994–95 to 1998–99, 1999–2000, 2002–03 and 2003–04. Although observer coverage 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. Consequently estimates of bycatch and discard ratios for some strata vary, and the larger the confidence intervals show lower confidence.

The rate estimator used in the analysis is the same as used in recent assessments of other Tier-1 fisheries (e.g., Anderson 2009b). This "per tow" estimator is preferred to the alternatives ("per trawl duration" or per "hoki, hake, and ling catch") mainly because of the reduced possibility of measurement error and the better precision achievable. However the tow-duration estimator generally provided a lower CV in the hoki, hake, and ling trawl fishery than the tow-based estimator, so the tow-duration and tow-based estimator for bycatch and discard calculations were both used.

Overall, *area* was the most critical factor influencing bycatch and discard rates in this fishery and although *depth*, *gear code*, and *duration* were also important, there was insufficient observer data to stratify by more than two variables, i.e., area and fishing year. Therefore due to the influence of area, this variable was used to stratify all bycatch and discard calculations (with the WCSI further split by gear type - midwater or bottom tow), to enable the same suitable comparisons between the tow-duration- and tow-based estimators for bycatch and discard calculations.

Estimation of bycatch and discards focussed on three broad categories of catch; QMS species, non-QMS species, and invertebrates. The QMS species were defined as at the present time, and there could be a bias in the results with the addition of species into the QMS, due to reporting and targeting behaviours of fishers. Only the first two of these categories match those previously assessed, and these only in the most recent assessment (Ballara et al. 2010), limiting comparisons between studies to the 2000–01 to 2006–07 period. The repeated estimates were in most cases lower than the earlier estimates. Slight differences in data grooming methods, especially in assembling discard data in different formats from two separate databases, and the revised procedure used for dealing with data poor strata will also have contributed.

Eight of the top ten bycatch species are QMS species, and therefore direct controls exist to limit their overall catch. Spiny dogfish is the fourth main bycatch species and, despite being a QMS species, is mostly discarded. Although the extent of discards by species were not estimated, annual bycatch of

spiny dogfish was 650–6930 t and observer data show an overall discard rate of 69% for this species. From 2000–01 to 2006–07 spiny dogfish was found to be 91–100 % of commercial species discards and 21–49 % of total discards (Ballara et al. 2010), so it is therefore recommended that spiny dogfish be analysed as a separate category for future analyses of the extent of bycatch by species in trawl fisheries. Spiny dogfish are also a major component of the bycatch and discards in the arrow squid, scampi, southern blue whiting, and jack mackerel trawl fisheries, and the ling longline fishery (Anderson 2007, 2009b, 2012, 2013, 2014a), and indeed much of the total annual catch of this species has historically been discarded due to its low commercial value (Manning et al. 2004). Despite this, there is no evidence that spiny dogfish abundance has declined, and stock sizes may actually be increasing (Ministry for Primary Industries 2014).

The species most at risk from the adverse effects of the hoki, hake, and ling fishery are likely to be those not under the management of the QMS. As a group, javelinfish and rattails form the largest non-QMS bycatch categories and, according to observer records, these comprise only about 1.4% and 1.1% of the catch respectively in the target hoki, hake, and ling trawl fishery. The shovelnose dogfish (*Deania calcea*) is another non-QMS species with substantial levels of bycatch (and which is usually discarded), comprising about 0.1% of the total catch and regularly observed caught in large amounts, and the bycatch of this species was shown to have decreased over time. A recent summary has shown that, across all eight of the deepwater fisheries monitored, there is a mixture of increasing and decreasing bycatch of shovelnose dogfish (Anderson 2013, Anderson 2014b, Ballara, in press). The authors recommend that the overall impact of the deepwater fisheries on this species should be assessed.

The catch of invertebrates in this fishery is small compared to the fish bycatch. Arrow squid are the most common invertebrate, comprising about 0.13% of the total catch. Observers may have become more diligent over time, or been more diligent at times, in recording of invertebrates, but this cannot be assessed. Observers have always been required to record invertebrate catch and the main improvement in this area is likely to have been in the taxonomic resolution of the catch species.

There was consistency in the trends between observer-based estimates of total bycatch and estimates obtained directly from TCEPR, TCER and CELR data (see Figure 18). This was reassuring. As expected, the estimates of total bycatch (12 020 to 37 730 t per year) were higher than that from the direct analysis of TCEPR, TCER, and CELR (10 708–27 046 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. In addition, there is a general bias towards underestimation on the forms of the total catch compared to that of the target species.

Overall, the total catch record-based annual bycatch for the 23-year period was about 78% of the observer data-based bycatch for the tow estimator and 74% for the duration estimator, and the general pattern over time was similar between the two estimates.

Bycatch in QMS, non-QMS, invertebrate species, for bycatch and discards, and total bycatch, all showed an increasing then decreasing pattern over the 23-year period. Although bycatch of non-commercial species is clearly undesirable, the analysis indicates that it was increasing effort rather than increased rates of bycatch and discards, which was primarily responsible for these patterns, suggesting that overall abundance within these species categories may not have decreased. Discards of hoki, hake, and ling in the hoki, hake, ling fishery was higher in earlier years, and then generally lower, and changes over time in total discards reflect a combination of differing trends in discards across the three separate species categories, with a slight increase in total discards to 1996–97, followed by a decrease to 2006–07, and then low stable discards.

Annual estimates of bycatch and discards calculated with the two forms of the estimator tended to be similar, except the QMS bycatch was lower with the duration-based estimator in 1999–1996 and higher in 1998–2009. Annual estimates of discards for the duration-based estimator were also generally similar to those from the tow-based estimator except that the duration based estimates of

discards for hoki, hake, and ling were higher from 1990–91 to 1996–97 and those for QMS discards were higher from 1998–99 to 2012–13. The relative sizes of the confidence intervals for the tow-based estimator were narrower than the duration-based estimator. Both estimates show similar trends as effort either as number of tows or duration in hours by stratum showed similar trends.

Total bycatch in the hoki, hake, and ling fishery ranged from about 12 020 to 37 730 t per year (compared to the combined total landed catch of hoki, hake, and ling of 109 600 to 301 600 t). Bycatch ratios of QMS species were highest in Puysegur and lowest in Cook Strait. Bycatch ratios of non-QMS species were highest on the Chatham Rise and lowest in Cook Strait. Bycatch of invertebrates was low in all areas, but lowest in Cook Strait. The reduction of effort in the past (due to reduced TACCs) was skewed to the WCSI with more of the reduction in effort in the WCSI, and therefore it might be possible that the WCSI distributed bycatch species were disproportionately less affected.

Total annual estimates of discards ranged from about 3699 to 16 633 t with the main species discarded including spiny dogfish, rattails, javelinfish, hoki, and shovelnose dogfish. Discarding of hoki, hake, and ling accounted for 0.7% of total observed discards. The discard dataset used in this analysis is a subset of the total observed discard data.

From 1991 to 2013, an average of 0.05 kg of fish was discarded per kilogram of hoki, hake, and ling caught, higher than the 0.03 kg figure calculated by Ballara et al (2010). This current rate is higher than that seen in the southern blue whiting (0.005 kg), oreo (0.03 kg), and orange roughy (0.04 kg), fisheries, and is lower than that of the jack mackerel (0.06 kg), arrow squid (0.06 kg), ling longline (0.29 kg) and scampi (4.2 kg) fisheries (Anderson 2007, 2009b, 2011, 2012, 2013, 2014a). Fish lost from the net during landing accounted for a small percentage (0–28%) of the total fish discards each year in the hoki, hake and ling fishery, with most percentages less than 7% in each year since 1999.

The hoki fishery has been considered to have low discard ratios relative to other fisheries, both in New Zealand and internationally (Ballara et al. 2010), but the levels of discards could potentially be reduced further. 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, Anderson & Smith 2005, Ballara et al. 2010). Some 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 (Ballara et al. 2010). 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-QMS species such as javelinfish and rattails that were previously discarded are now processed as meal (Ballara et al. 2010). Lower levels of discarding from 2004–05 were mainly a result of more vessels using meal plants, with discards of non-QMS species by factory vessels without meal plants up to twice the level of discards for vessels with meal plants (Ballara et al. 2010).

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 (Ballara et al. 2010). 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 the 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.

The estimation of bycatch for the main bycatch species in the hoki, hake, and ling trawl fishery has provided an initial overview of both the level of this catch and the changes in catch over time. This may provide initial evidence of, or supporting evidence for, non-target species which are being adversely affected by this fishery. Patterns in relative biomass estimates for individual bycatch species from trawl survey time series in the Sub-Antarctic, WCSI, and the Chatham Rise showed little support for species identified in this study as having strongly declining or increasing catch over time, although care needs to be taken in interpretation of regression slopes, especially for data poor species and years with no data.

The inshore commercial trawl fleet has recently moved from CELR forms to TCER forms. This has increased reporting precision due to an increase in the number of species that can be reported (up to eight species per tow, and multiple tows a day) relative to the older CELR format (maximum five species per day/statistical area/target species). If there is more than one tow recorded in a day the estimated catch of up to 20–30 species may be reported for a day of fishing on a TCER form. To remove any bias, in the future, a 'top5 filter' could be applied to individual fishing events, to drop catches from any species in excess of the five most abundant (by weight) in the catch. This may also affect the definition of target species for these forms as target species reported by inshore fishermen can be based on the largest catch to avoid reporting difficulties (Roux, 2015). It is also known that fishing (particularly target fishing) and reporting practices have varied over time based on quotas, catches, species entering the QMA, etc, and this could have biased the data.

These analyses would benefit from better identification of bycatch species, especially of the highly diverse rattails (which, apart from javelinfish, have been almost universally identified by observers only to family level) and of invertebrates. Although improvements in this area have been made in recent years, particularly with the availability of new field guides such as those of McMillan et al. (2011a, 2011b, 2011c) and Tracey et al. (2011), observers still require a level of training as well as sufficient time alongside their other duties while at sea to carry out accurate species identifications.

There is 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. Changes in bycatch ratios could be compared in more detail to survey biomass estimates for some species on the Chatham Rise and in the Sub-Antarctic, but further validation is required to determine whether estimates of commercial bycatch could provide long-term monitoring approaches for low-value species. Linking of catch landing data to observer data could be explored to get better information on use of meal plants by trip.

5. ACKNOWLEDGMENTS

We would like to thank the observers of the Ministry for Primary Industries for their dedication and continued efforts over a long period to collect the high quality data that made this analysis possible. Thanks also to Neil Bagley and Owen Anderson for useful advice, and to Owen Anderson (NIWA) for his review of the report. Members of the Aquatic Environment Working Group, Richard Ford (MPI) in particular, also provided valuable feedback on initial drafts of the report. This work was funded by the Ministry for Primary Industries (Project DAE2010-02D).

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TABLES

Table 1: Summary of effort and estimated catch in the target trawl fishery for hoki, hake, or ling, for observed trawls and overall, by fishing year. Trips include those with any recorded targeting of hoki, hake, or ling.

Fishing year	Number of trawls		Number of vessels		Number of trips		Hoki, hake, ling catch (t)		Percentage observed (%)	
	Observed	All	Observed	All	Observed	All	Observed	All	Catch	Trawls
1991	2 674	23 310	23	165	24	1 330	38 185	220 911	17.3	11.5
1992	2 943	23 461	21	170	25	1 166	34 657	217 810	15.9	12.5
1993	2 486	24 501	24	168	36	1 116	27 986	202 028	13.9	10.1
1994	2 996	23 086	27	167	43	1 530	42 243	192 613	21.9	13.0
1995	1 580	29 560	17	171	20	1 633	30 942	199 204	15.5	5.3
1996	2 133	34 717	27	168	33	2 052	27 836	223 930	12.4	6.1
1997	1 255	39 547	22	184	25	2 121	18 302	250 469	7.3	3.2
1998	3 147	39 325	43	169	52	1 992	35 448	280 471	12.6	8.0
1999	3 516	33 617	40	144	49	1 572	37 780	258 930	14.6	10.5
2000	3 300	34 181	38	119	45	1 655	34 662	264 500	13.1	9.7
2001	3 493	33 262	42	121	73	1 571	33 416	251 393	13.3	10.5
2002	3 306	28 652	37	112	49	1 159	31 152	218 560	14.3	11.5
2003	2 621	29 369	33	115	43	1 399	20 676	201 133	10.3	8.9
2004	2 429	24 758	30	109	36	1 436	18 906	155 478	12.2	9.8
2005	2 282	17 301	31	96	41	861	19 147	125 235	15.3	13.2
2006	2 310	14 715	28	91	39	861	23 007	118 600	19.4	15.7
2007	2 197	13 863	33	81	47	787	22 850	113 649	20.1	15.8
2008	2 536	12 543	31	80	48	816	24 701	98 197	25.2	20.2
2009	2 134	11 355	34	78	51	777	24 362	98 072	24.8	18.8
2010	2 562	11 978	32	81	54	912	29 405	110 099	26.7	21.4
2011	2 058	12 369	26	82	49	965	24 631	121 439	20.3	16.6
2012	2 823	12 918	32	83	64	941	36 823	134 339	27.4	21.9
2013	5 058	13 500	31	77	113	943	62 222	139 474	44.6	37.5
All years	61 839	541 888	154	468	1 008	29 259	699 339	4 196 535	16.7	11.4

Table 2: Number of observed trawls targeting hoki, hake, or ling by area (see Figure 1 for area boundaries) and fishing year. ECSI areas Pegasus Bay and Conway Trough are included in the NULL area.

Fishing year	WCSI	CSTR	CHAT	SUBA	PUYS	NULL	TOTAL
1991	1 253	-	834	475	110	2	2 674
1992	851	-	482	830	198	-	2 361
1993	1 410	14	262	662	131	7	2 486
1994	1 626	38	896	365	57	14	2 996
1995	840	-	501	218	21	-	1 580
1996	1 053	40	735	223	64	18	2 133
1997	694	-	419	99	32	11	1 255
1998	906	205	1 621	329	-	86	3 147
1999	1 111	294	1 238	763	29	81	3 516
2000	1 162	162	756	1 155	32	33	3 300
2001	1 097	263	1 301	703	107	22	3 493
2002	1 333	143	950	806	50	24	3 306
2003	953	133	781	587	54	113	2 621
2004	1 381	128	503	292	32	93	2 429
2005	1 084	139	779	186	59	35	2 282
2006	1 131	65	680	326	49	59	2 310
2007	673	226	867	398	20	13	2 197
2008	774	200	773	708	12	69	2 536
2009	704	168	569	611	-	82	2 134
2010	788	357	636	727	7	47	2 562
2011	677	89	737	507	9	39	2 058
2012	1 061	192	948	529	61	32	2 823
2013	2 097	198	1 490	1 115	79	79	5 058

Table 3: Numbers of missing values or outliers in commercial fishing return effort data, by form type for daily summary CELR form and tow-by-tow TCER and TCEPR forms.

Field (range)	CELR	TCER	TCEPR
All rows	14 703	8 382	506 346
Missing/outlying start longitude (< 157° E or < 167° W)	13 889	-	428
Missing/outlying end longitude (< 157° E or < 167° W)	14 703	8 382	415
Missing/outlying start latitude (58° S)	13 889	-	396
Missing/outlying end latitude (58° S)	14 703	8 382	392
Calculated distance missing or > 100 km	14 703	8 382	609
Missing/outlying gear depths (1000 m)	14 703	126	786
Missing/outlying bottom depth (1000 m)	14 703	96	4 212
Missing/outlying fishing duration (>15 h)	479	5	2 150
Missing/outlying fishing speed (4.0 knots)	14 703	75	75

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	CV (%)
Bycatch	QMS	Target catch	0.050	1.14
		Number of tows	674.2	1.09
		Tow duration	2786.0	1.07
	non-QMS	Target catch	0.039	1.12
		Number of tows	436.8	0.91
		Tow duration	107.8	0.85
	INV	Target catch	0.003	2.02
		Number of tows	30.2	1.87
		Tow duration	7.5	1.91
Discards	QMS	Target catch	0.009	4.69
		Number of tows	100.5	4.59
		Tow duration	24.0	4.57
	non-QMS	Target catch	0.018	2.02
		Number of tows	205.4	1.83
		Tow duration	48.6	1.83
	INV	Target catch	0.001	3.75
		Number of tows	13.0	3.69
		Tow duration	3.1	3.63

Table 5: Summary of LME normal modelling of bycatch (catch per tow) in the target hoki, hake, or ling trawl fishery. The numbers denote the order in which the variable entered the model. Variables: *gear code*, bottom or midwater trawls; *Day of yr:* day of fishing year. *, crashes at this point, beyond computer capability; –, not accepted by the model; NA, not assessed.

Species cat.	Dataset	Variable											
		Area	*Depth*	*Duration*	*Gear code*	*Month*	*Headline height*	*Start time*	*Nation*	*Day of yr*	*Vessel length*	*Fishing year*	*Vessel speed*
QMS	All years	–	1	2	3*	NA	NA	NA	NA	NA	NA	NA	NA
	2003–2013	–	2	3	1	4	5	7	8	9	6	–	–
	WCSI	–	1	2	3	8	5	–	6	4	–	7*	_
	WCSI.MW	–	1	2	–	9	4	7	5	3	8	6	10
	WCSI.BT	–	1	2	–	5	7	3	4	6	–	–	–
	CHAT	–	3	2	7	4	1	5	6	–	8	–	9
	SUBA	–	1	2	7	4	3	6	5	–	_	–	–
	CSTR	–	1	–	6	2	3	–	–	–	–	–	–
Non-QMS	All years	1*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2003–2013	1	4	2	3	7	6	9	5	12	8	10	11
	WCSI	–	2	3	1	5	4	8	6	10	9	7	–
	WCSI.MW	–	1	1	–	3	2		5	6	7	4	–
	WCSI.BT	–	2	1	–	–	6	4	3	8	7	5	–
	CHAT	–	3	1	2	5	8	4	NA	NA	7*	6	NA
	SUBA	–	2	1	–	5	3	7	4	–	–	–	–
	CSTR	–	2	1	–	3	4	–	–	–	5	–	–
INV	All years	3*	NA	2	1	NA	NA	NA	NA	NA	NA	NA	NA
	2003:2013	2	–	3	1	4	6	7	5	_	8	–	–
	WCSI	–	–	3	5	2	1	4	7	6	–	–	–
	WCSI.MW	–	4	1	–	2	3	7	5	6	–	–	–
	WCSI.BT	–	2	5	–	6	–	3	4	1	–	7	
	CHAT	–	8	1	2	3	–	6	4	7	–	–	5
	SUBA	–	5	1		3	4	6	2	–	–	–	–
	CSTR	–	–	–	–	–	2	3	–	1	4	–	–

Table 6: Summary of LME normal modelling of discards (catch per tow) in the target hoki, hake, or ling trawl fishery. The numbers denote the order in which the variable entered the model. Variables: *gear code*, bottom or midwater trawls; *Day of yr:* day of fishing year. Species category HHL: HOK, HAK, LIN discards.

Species cat.	Dataset	Variable											
		Area	*Depth*	*Duration*	*Gear code*	*Month*	*Headline height*	*Start time*	*Nation*	*Day of yr*	*Vessel length*	*Fishing year*	*Vessel speed*
HHL	All years	4	1	2	7	3	–	8	5	–	–	6	
	WCSI	–	1	2	–	4	8	10	3	–	6	5	9
	WCSI.MW	–	1	2	7	–	–	–	–	–	–	–	–
	WCSI.BT	–	1	4		3	–	7	2	–	8	5	6
	CHAT	–	6	1	3	2	–	–	5	–	–	4	–
	SUBA	–	2	1		3	5	6	4	–	–	–	–
	CSTR	–	4	–	2	–	–	–	–	–	3	1	–
QMS	All years	8	1	3	2	9	5	7	4	–	–	6	–
	WCSI	–	1	4	2	6	7	8	5	–	–	3	–
	WCSI.MW	–	1	2	–	4	6	–	3	7	8	5	–
	WCSI.BT	–	1	–	–	5	–	2	4	–	–	3	6
	CHAT	–	1	3	2	5	–	4	6	–	7	–	–
	SUBA	–	1	5	2	4	–	3	4	–		–	–
	CSTR	–	1	7	5	2	6	–	–	–	4	3	–
Non-QMS	All years	4	3	2	1	6	9	8	5	–	–	7	–
	WCSI	–	2	3	1	6	7	5	4	–	–	8	–
	WCSI.MW	–	1	2	–	4	5	–	3	–	–	–	–
	WCSI.BT	–	4	3	–	7	6	2	1	–	–	5	–
	CHAT	–	2	1	–	7	–	8	3	–	6	5	–
	SUBA	–	2	1	5	4	–	6	3	–	–	–	–
	CSTR	–	2	1	–	3	5		–	–	4	–	–
INV	All years	4	1	2	7	3	–	8	5	–	–	6	–
	WCSI	–	1	2	7	4	8	10	3	–	6	5	9
	WCSI.MW	–	1	2	–	–	–	–	–	–	–	–	–
	WCSI.BT	–	1	4	–	3	–	7	2	–	8	5	6
	CHAT	–	6	1	3	2	–		5	–	–	4	–
	SUBA	–	2	1	–	3	5	6	4	–	–	–	–
	CSTR	–	4	–	2	–	–	–	–	–	3	1	–

Table 7: Estimates of total annual bycatch (rounded to the nearest 10 t) in the hoki, hake, or ling target trawl fishery for the species categories QMS, non–QMS, invertebrates, and overall, based on observed catch rates; 95% confidence intervals in parentheses (calculated using the tow-based estimator).

Fishing year	QMS	non-QMS	Invertebrate	Total bycatch
1991	13 940 (10 940–17 300)	5 470 (4 710–6 060)	440 (360– 560)	19 850 (16 010–23 920)
1992	11 950 (10 060–14 470)	6 520 (5 150–8 040)	750 (490–1 170)	19 220 (15 700–23 680)
1993	7 940 (5 360–11 090)	3 670 (2 570–4 790)	410 (200– 680)	12 020 (8 130–16 560)
1994	11 710 (9 200–15 290)	2 630 (2 040–3 390)	430 (290– 610)	14 770 (11 530–19 290)
1995	17 600 (13 850–22 600)	5 600 (3 990–8 230)	590 (490– 690)	23 790 (18 330–31 520)
1996	20 540 (16 030–25 860)	6 650 (3 570–10 840)	340 (220– 490)	27 530 (19 820–37 190)
1997	21 200 (16 420–27 270)	10 150 (7 420–13 560)	260 (160– 380)	31 610 (24 000–41 210)
1998	22 360 (18 180–28 080)	13 450 (10 680–16 710)	460 (370– 570)	36 270 (29 230–45 360)
1999	17 160 (14 760–19 910)	12 890 (10 300–15 850)	700 (480–1 070)	30 750 (25 540–36 830)
2000	23 590 (19 870–27 710)	12 950 (10 270–17 010)	1 190 (470–2 420)	37 730 (30 610–47 140)
2001	23 930 (18 900–29 370)	11 390 (9 360–13 410)	1 310 (810–2 010)	36 630 (29 070–44 790)
2002	16 360 (13 220–20 280)	17 020 (12 550–22 380)	1 550 (1 140–2 040)	34 930 (26 910–44 700)
2003	19 160 (15 400–23 450)	14 900 (11 520–18 610)	880 (610–1 490)	34 940 (27 530–43 550)
2004	22 370 (17 890–27 820)	13 130 (11 170–16 290)	900 (630–1 400)	36 400 (29 690–45 510)
2005	12 400 (10 100–15 560)	10 900 (6 960–16 130)	500 (380– 710)	23 800 (17 440–32 400)
2006	11 470 (9 780–13 110)	8 670 (6 620–10 860)	460 (360– 610)	20 600 (16 760–24 580)
2007	11 220 (9 230–13 460)	7 530 (5 780–9 240)	380 (280– 490)	19 130 (15 290–23 190)
2008	9 700 (7 950–12 110)	9 400 (7 810–11 570)	420 (340– 500)	19 520 (16 100–24 180)
2009	7 050 (5 990–8 370)	9 260 (7 320–11 620)	250 (200– 300)	16 560 (13 510–20 290)
2010	8 140 (6 170–10 480)	10 800 (7 910–14 050)	370 (300– 460)	19 310 (14 380–24 990)
2011	7 640 (6 220–9 400)	7 130 (5 660–8 970)	440 (300– 620)	15 210 (12 180–18 990)
2012	8 070 (6 950–9 610)	5 930 (4 740–7 280)	330 (270– 390)	14 330 (11 960–17 280)
2013	8 950 (7 340–10 770)	8 730 (7 510–10 200)	480 (390– 590)	18 160 (15 240–21 560)

Table 8: Total annual bycatch estimates for the target hoki, hake, or ling fishery, based on catch effort records, compared with the observer-based estimates. Estimates are derived by summing the difference between the recorded total catch and hoki, hake, and ling combined catch for each TCER or TCEPR trawl or group of CELR trawls.

Fishing year	Total catch effort bycatch (t)	% of observer-based estimate
1991	14 513	136.8
1992	12 429	154.6
1993	10 708	112.3
1994	17 705	83.4
1995	18 637	127.6
1996	21 403	128.6
1997	27 319	115.7
1998	23 702	153.0
1999	20 457	150.3
2000	25 365	148.7
2001	24 358	150.4
2002	23 645	147.7
2003	25 612	136.4
2004	27 046	134.6
2005	19 897	119.6
2006	19 134	107.7
2007	19 919	96.0
2008	17 428	112.0
2009	15 578	106.3
2010	13 549	142.5
2011	14 882	102.2
2012	13 749	104.2
2013	12 823	141.6
All years	439 856	128.0

Table 9: Estimates of total annual discards (rounded to the nearest tonne) in the hoki, hake, or ling trawl fishery for the species categories HOKHAKLIN, QMS, non–QMS, invertebrates, and overall, based on observed discard rates for the tow-based estimator; 95% confidence intervals in parentheses.

Fishing year	HOKHAKLIN	QMS	non-QMS	Invertebrate	Total discards
1991	7 828 (4 260–11 759)	2 165 (1 125–3 565)	3 810 (2 983–4 380)	180 (152– 238)	13 984 (8 520–19 942)
1992	4 392 (2 301–7 875)	1 922 (1 273–2 786)	6 799 (6 019–7 705)	272 (23– 973)	13 385 (9 616–19 339)
1993	7 509 (2 905–13 892)	2 123 (1 549–2 733)	829 (624–1 936)	102 (72– 142)	10 562 (5 149–18 703)
1994	7 576 (4 092–12 225)	3 097 (2 145–4 196)	1 697 (1 154–2 244)	252 (112– 458)	12 622 (7 503–19 123)
1995	9 347 (5 775–14 508)	3 384 (1 942–5 569)	2 170 (1 225–3 665)	271 (230– 343)	15 172 (9 172–24 085)
1996	6 623 (3 387–10 939)	5 247 (3 012–12 602)	3 652 (1 313–7 461)	27 (11–82)	15 549 (7 724–31 084)
1997	6 363 (2 953–12 299)	5 661 (3 283–9 352)	4 423 (1 187–7 519)	186 (22– 386)	16 633 (7 445–29 556)
1998	- -	- -	- -	- -	- -
1999	1 611 (512–2 950)	5 242 (3 668–7 106)	4 575 (2 765–6 612)	634 (373–1 082)	12 062 (7 318–17 751)
2000	668 (222–1 743)	6 471 (4 752–8 207)	8 025 (7 051–11 283)	1 838 (1 364–2 726)	17 002 (13 388–23 959)
2001	1 368 (310–3 382)	3 686 (2 725–4 860)	7 257 (5 201–9 738)	770 (326–1 625)	13 081 (8 562–19 604)
2002	626 (101–1 750)	3 433 (2 124–5 502)	10 555 (4 892–19 060)	1 589 (1 141–2 095)	16 204 (8 258–28 407)
2003	1 758 (467–4 148)	5 258 (3 520–7 615)	8 452 (6 511–11 034)	465 (324– 644)	15 933 (10 822–23 440)
2004	1 183 (461–2 266)	2 822 (2 232–3 584)	4 398 (2 524–7 012)	229 (118– 541)	8 632 (5 335–13 403)
2005	603 (101–1 363)	1 174 (766–1 867)	1 663 (1 121–2 473)	192 (71– 375)	3 632 (2 058–6 078)
2006	440 (104–1 042)	1 845 (736–3 141)	2 893 (1 655–4 644)	188 (74– 411)	5 366 (2 569–9 237)
2007	816 (269–1 673)	1 241 (515–2 194)	2 119 (838–3 696)	57 (25– 100)	4 233 (1 648–7 663)
2008	104 (21– 308)	706 (541– 890)	2 527 (1 676–4 072)	123 (73– 200)	3 460 (2 311–5 469)
2009	288 (85– 675)	666 (429– 972)	3 687 (1 935–6 362)	86 (54– 125)	4 727 (2 504–8 134)
2010	805 (289–1 854)	595 (363– 860)	5 876 (2 531–9 350)	106 (54– 163)	7 382 (3 236–12 227)
2011	1 427 (596–2 622)	544 (381– 763)	3 635 (1 700–5 969)	140 (74– 231)	5 747 (2 750–9 585)
2012	630 (370–1 058)	1 353 (953–1 796)	1 645 (953–2 671)	70 (46– 107)	3 699 (2 322–5 633)
2013	729 (419–1 091)	1 187 (898–1 599)	4 195 (2 789–5 794)	105 (69– 152)	6 216 (4 176–8 637)

Table 10: Summary of discard and loss weights (t) by destination type and fishing year, from hoki, hake, and ling fishery Catch Landing Returns. Catch Landing Return data only includes trips which targeted hoki, hake, or ling for more than 50% of tows/days. A, Accidental loss; D, Discarded (NON-ITQ); M, QMS species returned to sea (Part 6A, currently only spiny dogfish); X, QMS species returned to sea alive (not Part 6A, i.e., excluding spiny dogfish).

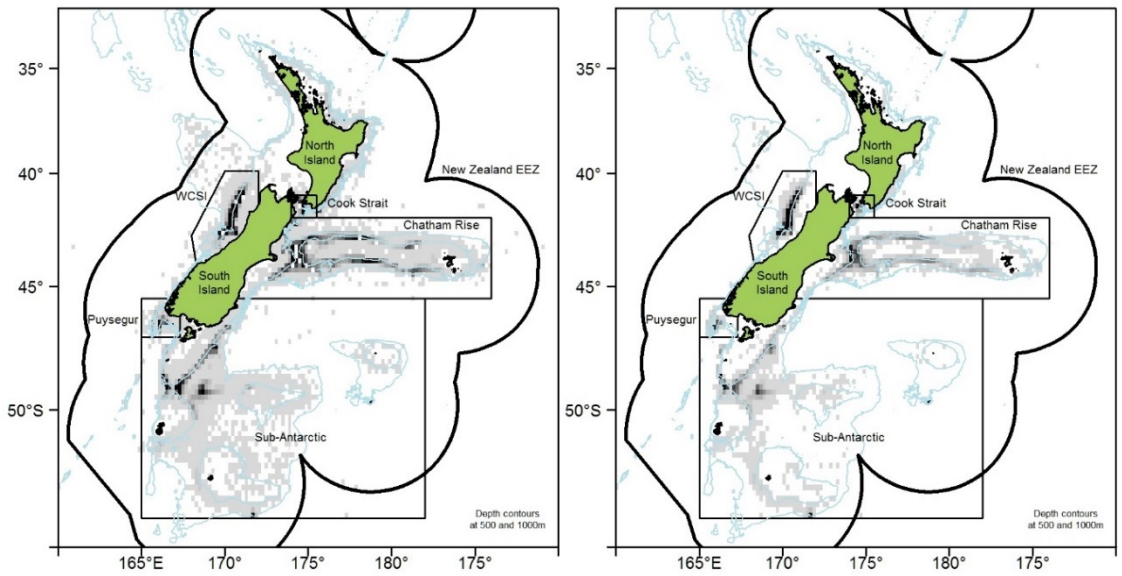
	Destination type			
Fishing year	**A**	**D**	**M**	**X**
1991	980	224	-	-
1992	305	492	-	-
1993	321	899	-	-
1994	350	1 303	-	-
1995	106	1 502	-	-
1996	276	1 670	-	-
1997	494	2 265	-	-
1998	509	3 655	-	-
1999	363	5 867	-	-
2000	2 172	6 180	-	-
2001	287	6 568	-	-
2002	136	7 375	-	-
2003	288	5 841	-	-
2004	241	4 998	-	-
2005	123	1 789	1 227	-
2006	193	1 999	1 021	-
2007	190	1 821	784	2
2008	125	2 505	882	1
2009	94	2 650	507	2
2010	263	2 129	510	4
2011	211	1 591	434	2
2012	309	1 383	834	4
2013	602	1 602	650	23

Table 11: Estimated annual target hoki, hake, or ling trawl catch (t), total bycatch (t), and total discards (t), in the target hoki, hake, or ling trawl fishery; bycatch fraction (kg of total bycatch per kg of hoki, hake, or ling caught); discard fraction (kg of total discards per kg of hoki, hake, or ling caught); and discards as a fraction of bycatch (calculated using the tow-based estimator).

Fishing year	Hoki, Hake, and Ling estimated catch	Total bycatch	Total discards	Bycatch fraction	Discard fraction	Discards / bycatch
1991	220 911	19 850	13 984	0.09	0.06	0.70
1992	217 810	19 220	13 385	0.09	0.06	0.70
1993	202 028	12 020	10 562	0.06	0.05	0.88
1994	192 613	14 770	12 622	0.08	0.07	0.85
1995	199 204	23 790	15 172	0.12	0.08	0.64
1996	223 930	27 530	15 549	0.12	0.07	0.56
1997	250 469	31 610	16 633	0.13	0.07	0.53
1998	280 471	36 270	-	0.13	-	-
1999	258 930	30 750	12 062	0.12	0.05	0.39
2000	264 500	37 730	17 002	0.14	0.06	0.45
2001	251 393	36 630	13 081	0.15	0.05	0.36
2002	218 560	34 930	16 204	0.16	0.07	0.46
2003	201 133	34 940	15 933	0.17	0.08	0.46
2004	155 478	36 400	8 632	0.23	0.06	0.24
2005	125 235	23 800	3 632	0.19	0.03	0.15
2006	118 600	20 600	5 366	0.17	0.05	0.26
2007	113 649	19 130	4 233	0.17	0.04	0.22
2008	98 197	19 520	3 460	0.20	0.04	0.18
2009	98 072	16 560	4 727	0.17	0.05	0.29
2010	110 099	19 310	7 382	0.18	0.07	0.38
2011	121 439	15 210	5 747	0.13	0.05	0.38
2012	134 339	14 330	3 699	0.11	0.03	0.26
2013	139 474	18 160	6 216	0.13	0.04	0.34

FIGURES

(a) Target hoki, hake, or ling



(b) Target hoki

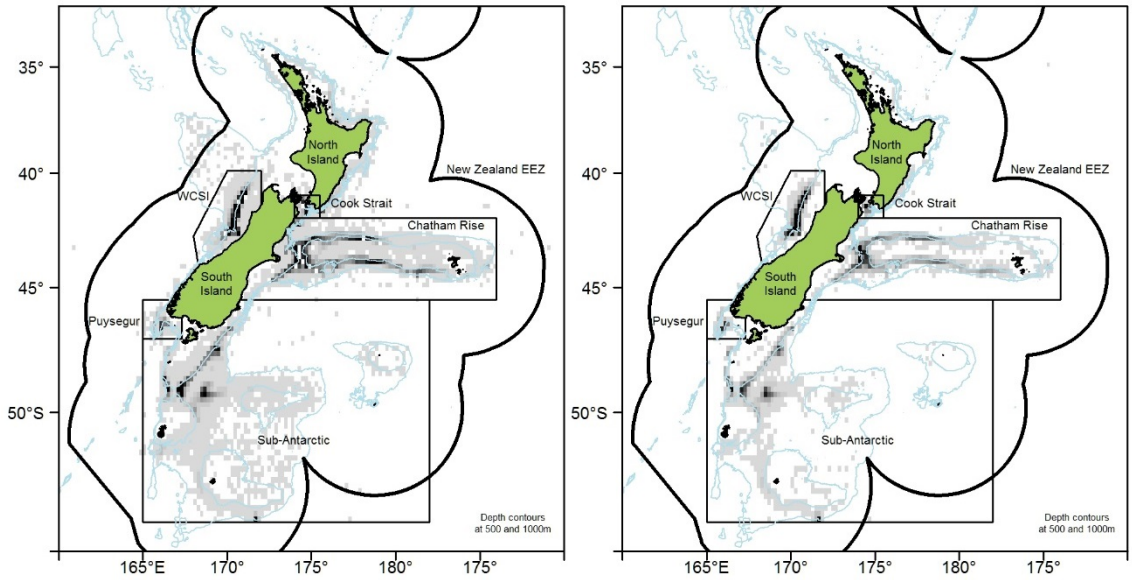
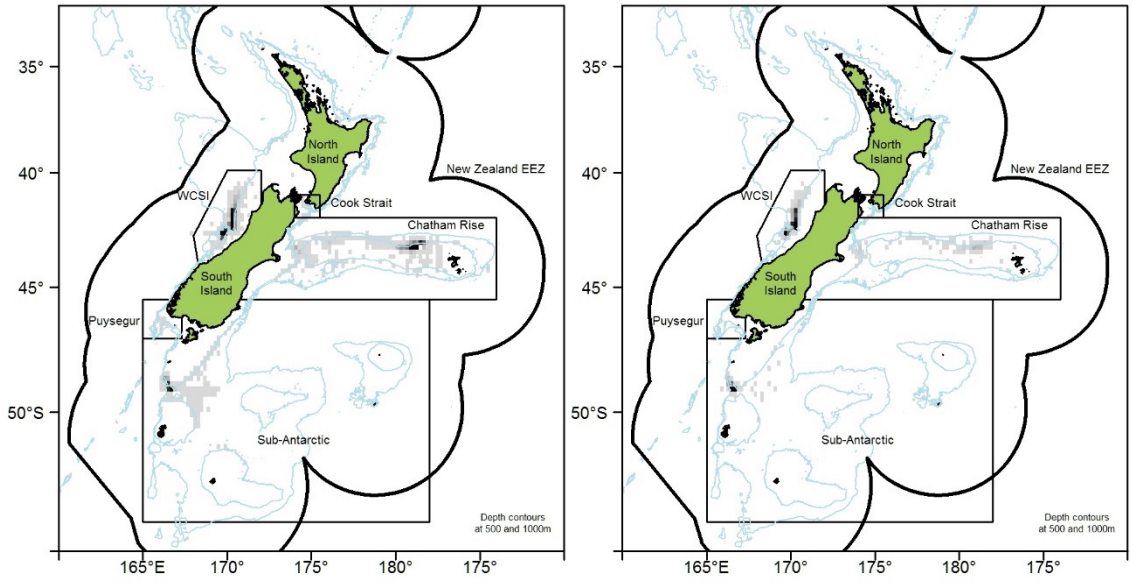


Figure 1: Density plots showing the distribution of: a) all commercial (left) and observed (right) trawls with position data targeting hoki, hake, or ling; and b) targeting hoki only, for all trawls from 1990–91 to 2012–13. Area divisions used in the analyses are shown. a) Target hoki, hake, or ling: left, darkest pixels represent 1921–17 927 trawls, and right, darkest pixels are 470–5602 trawls. b) Target hoki: left, darkest pixels represent 1842–17 927 trawls, and right, darkest pixels are 392–5371 trawls.

(c) Target hake



(d) Target ling

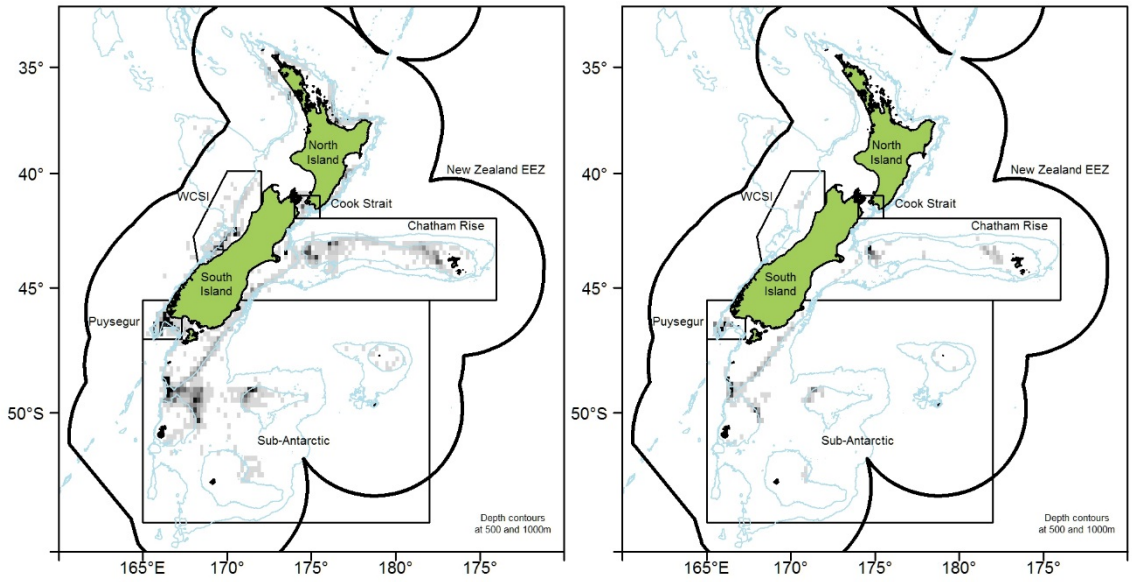


Figure 1: continued. Density plots showing the distribution of all commercial (left) and observed (right) trawls with position data targeting: c) hake only; or d) ling only. For all trawls from 1990–91 to 2012–13. Area divisions used in the analyses are shown. c) Target hake: left, darkest pixels represent 681–1601 trawls, and right, darkest pixels are 237–426 trawls. d) Target ling: left, darkest pixels represent 164–1992 trawls, and right, darkest pixels are 39–508 trawls.

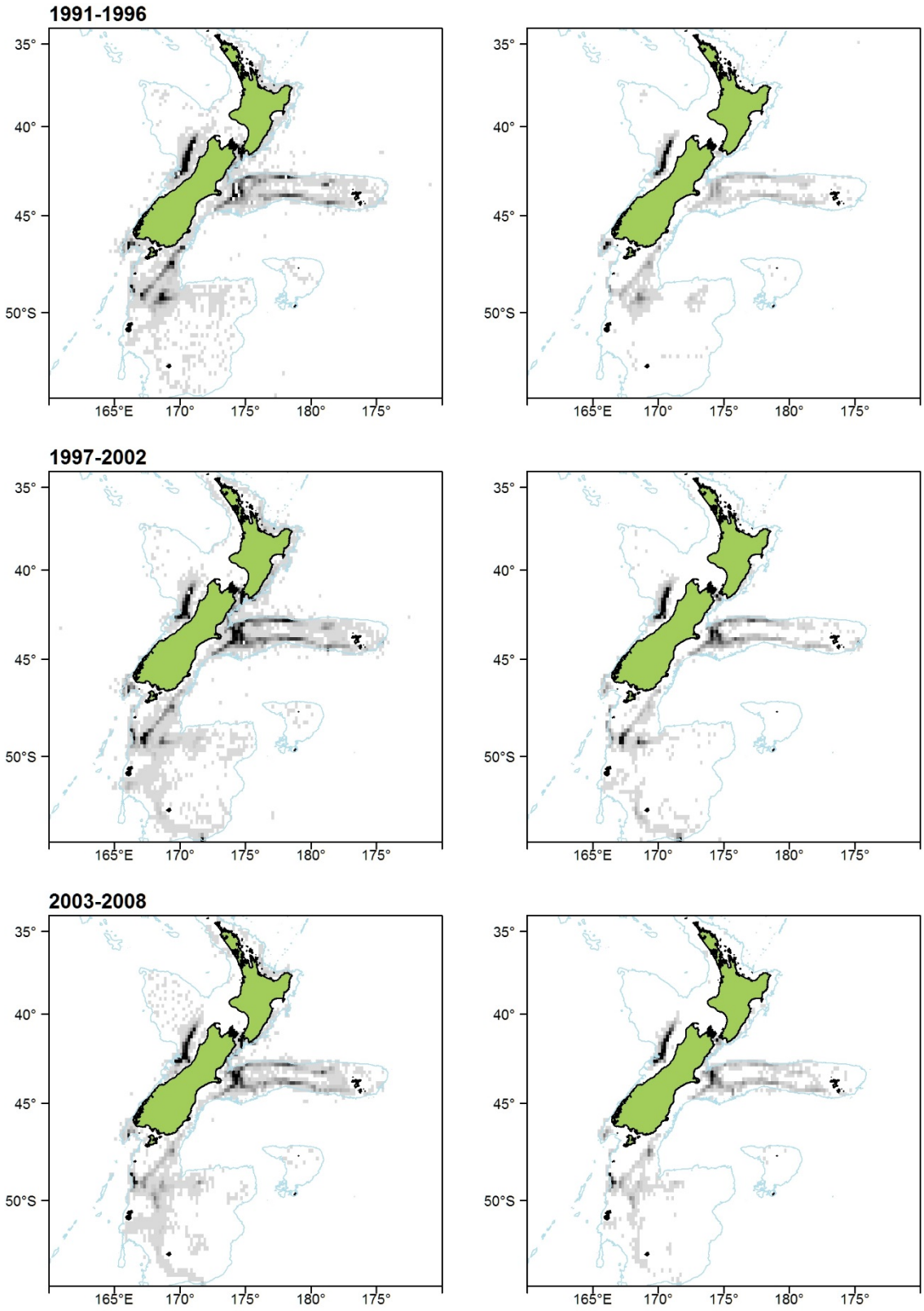


Figure 2: Density plots showing the distribution of all commercial trawls with position data targeting hoki, hake, or ling (left) and all trawls recorded by observers on vessels targeting hoki, hake, or ling (right), for 1990–91 to 2012–13, by groups of years. 1991, fishing year 1990–91, etc.

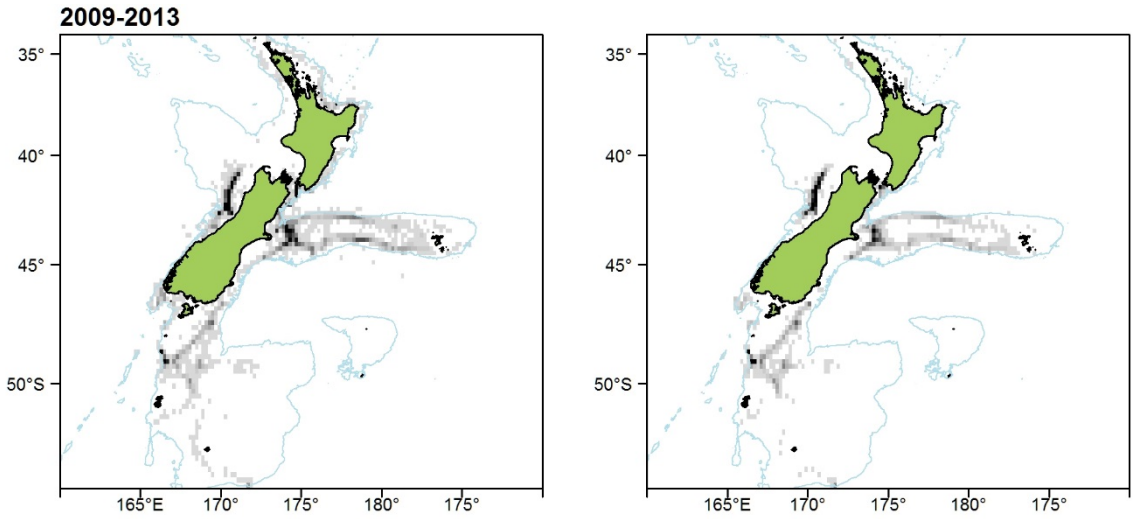


Figure 2—*Continued*

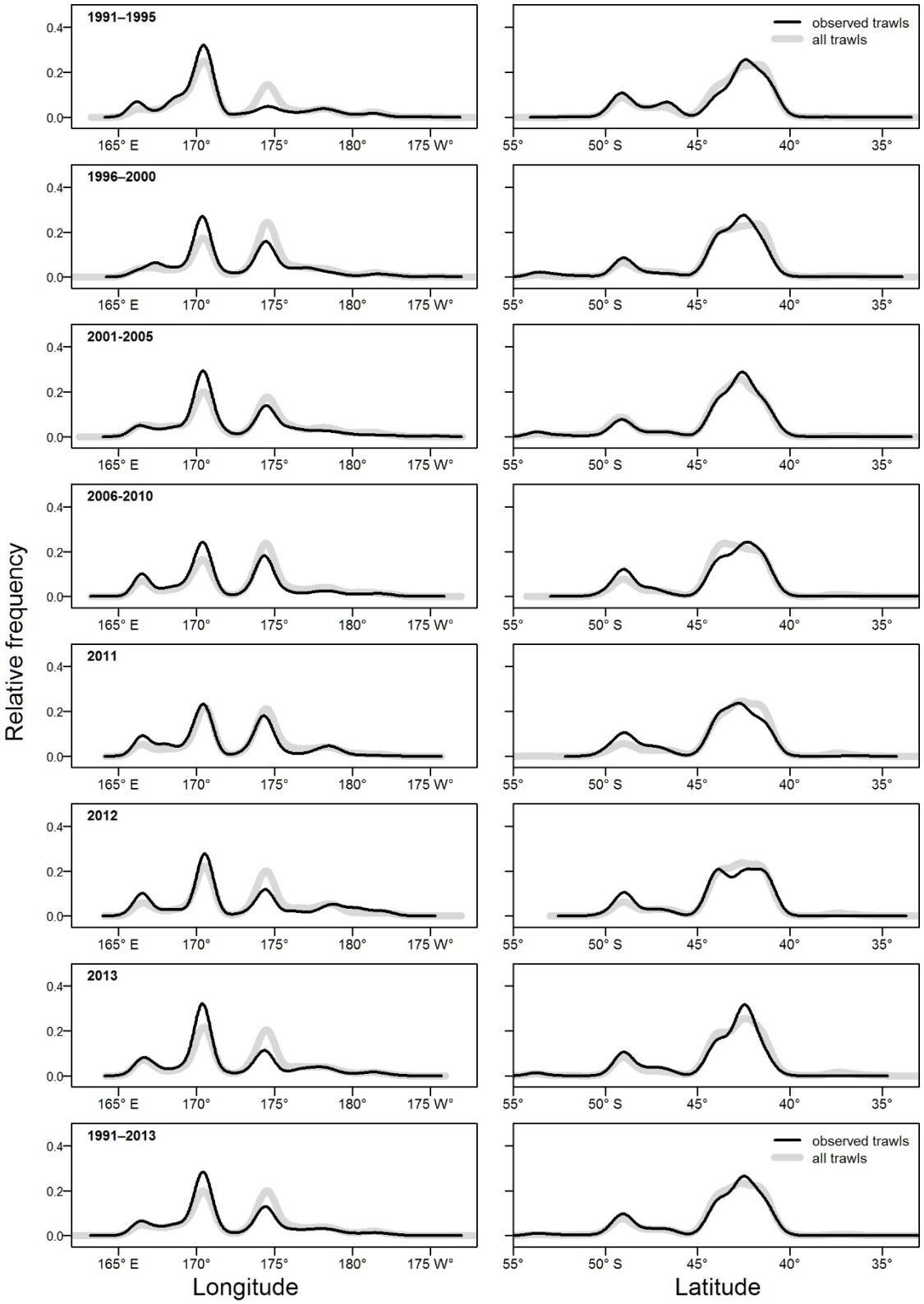


Figure 3: Hoki, hake, or ling target fishery. Comparison of start positions (latitude and longitude) of observed trawls with those of all commercial trawls. Fishing years 1990–91 to 2009–2010 are shown in 5 year groups, fishing years 2010–11 to 2012–13 are shown by individual year and, in the bottom panel, all 23 fishing years are shown combined. The relative frequency was calculated from a density function which used linear approximation to estimate frequencies at a series of equally spaced points.

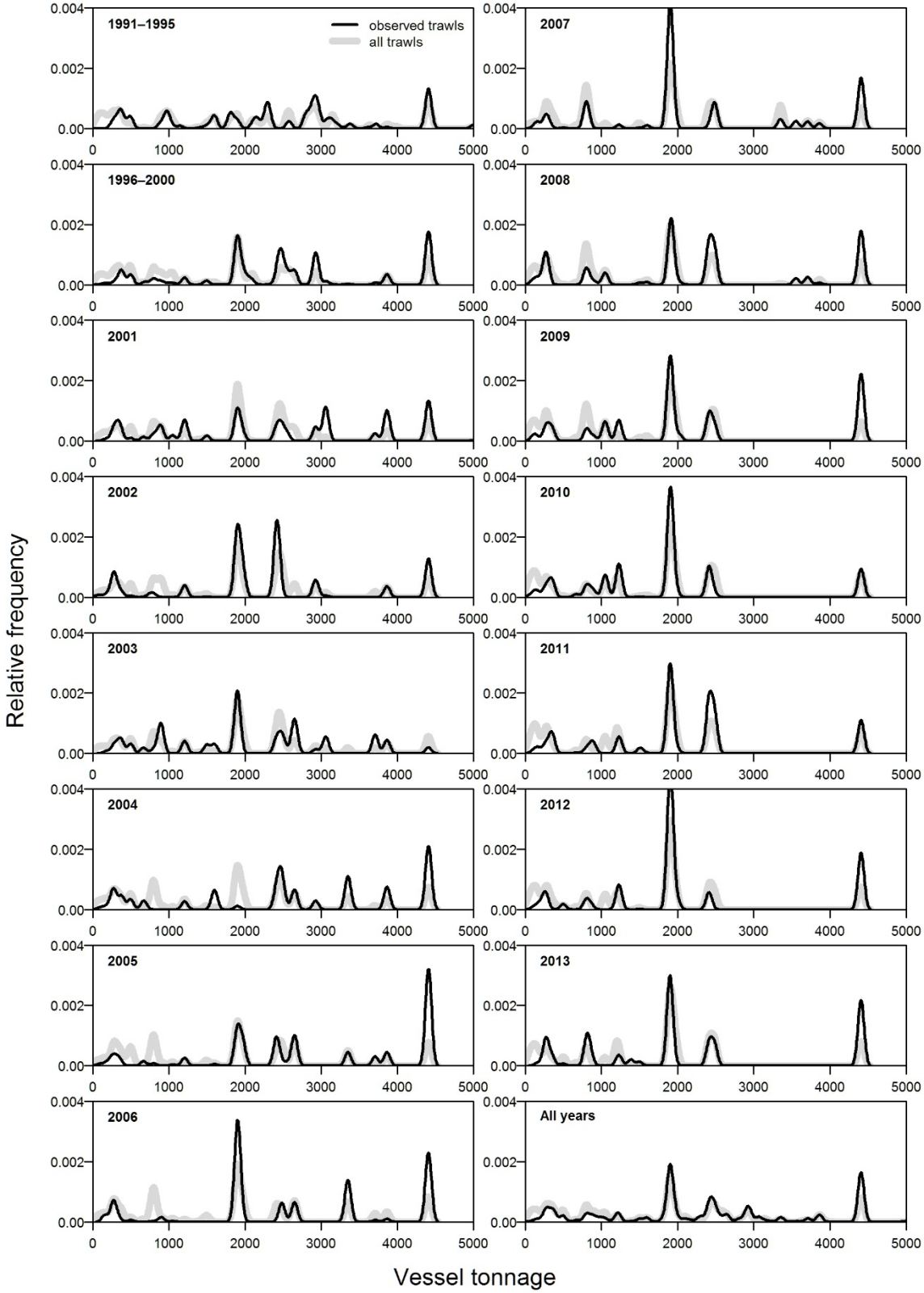


Figure 4a: Hoki, hake, or ling target fishery. Comparison of vessel sizes (gross registered tonnage) of observed trawls with those of all commercial trawls. Fishing years 1990–91 to 1999–2000 are shown in 5 year groups, fishing years 2000–01 to 2012–13 are shown by individual year and, in the bottom panel, all 23 fishing years are shown combined. The relative frequency was calculated from a density function which used linear approximation to estimate frequencies at a series of equally spaced points.

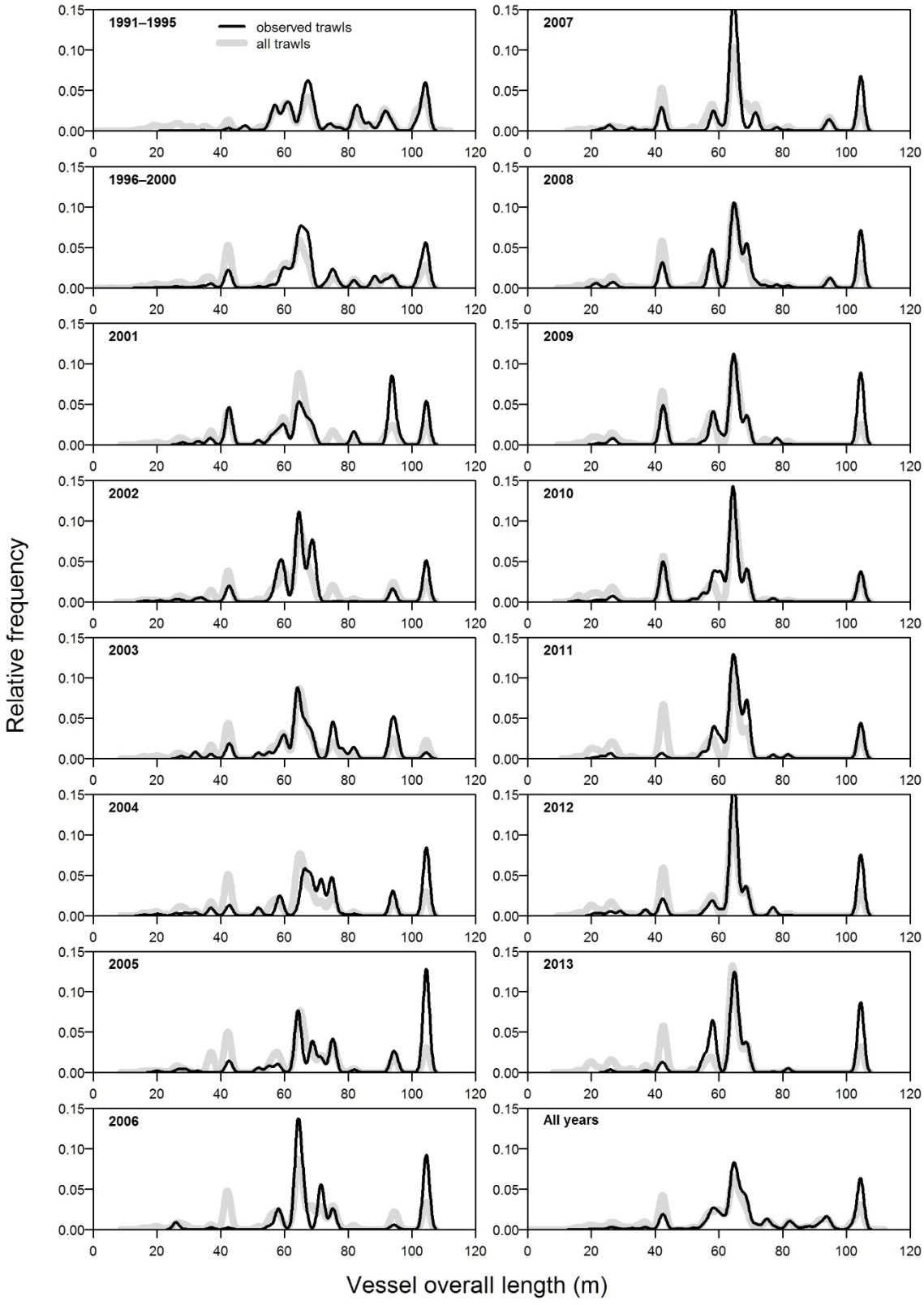


Figure 4b: Hoki, hake, or ling target fishery. Comparison of vessel sizes (overall length) of observed trawls with those of all commercial trawls. Fishing years 1990–91 to 1999–2000 are shown in 5 year groups, fishing years 2000–01 to 2012–13 are shown by individual year and, in the bottom panel, all 23 fishing years are shown combined. The relative frequency was calculated from a density function which used linear approximation to estimate frequencies at a series of equally spaced points

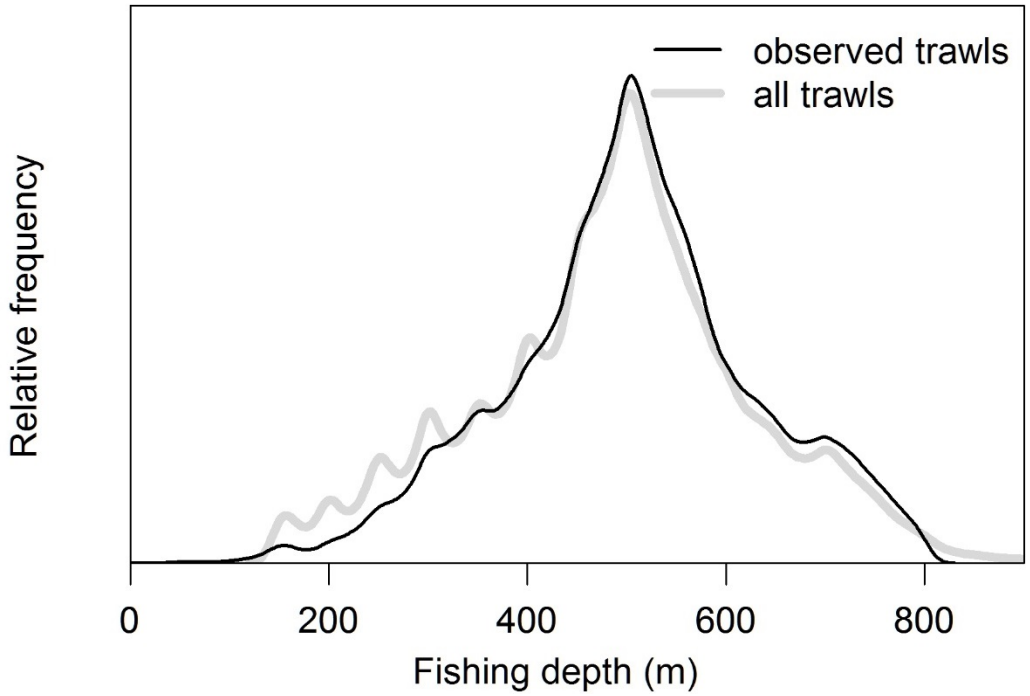


Figure 5: Comparison of fishing depth in observed trawls versus all recorded commercial trawls for the period 1 October 1990 to 30 September 2013, in the hoki, hake, or ling target fishery. The relative frequency was calculated from a density function which used linear approximation to estimate frequencies at a series of equally spaced points.

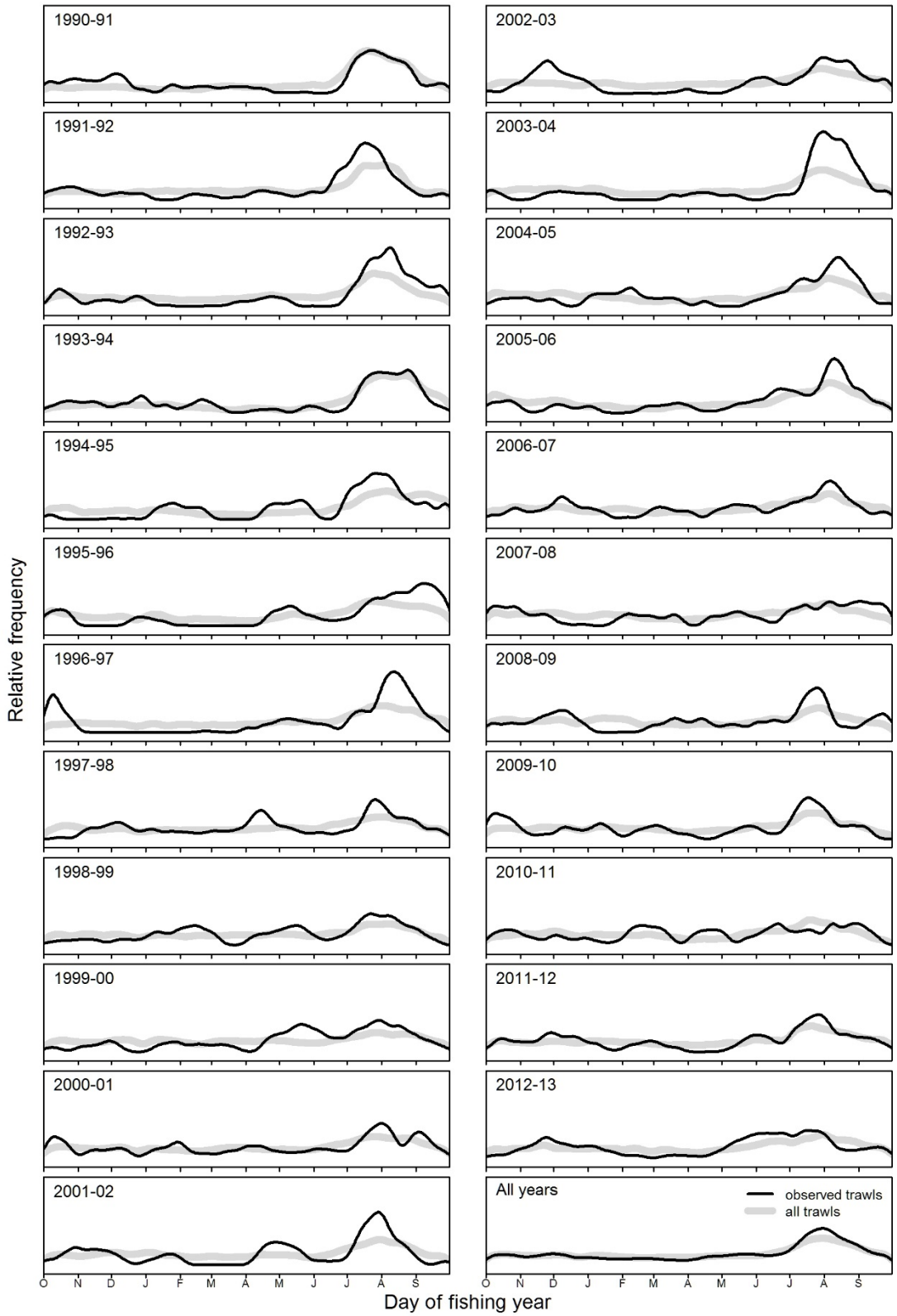
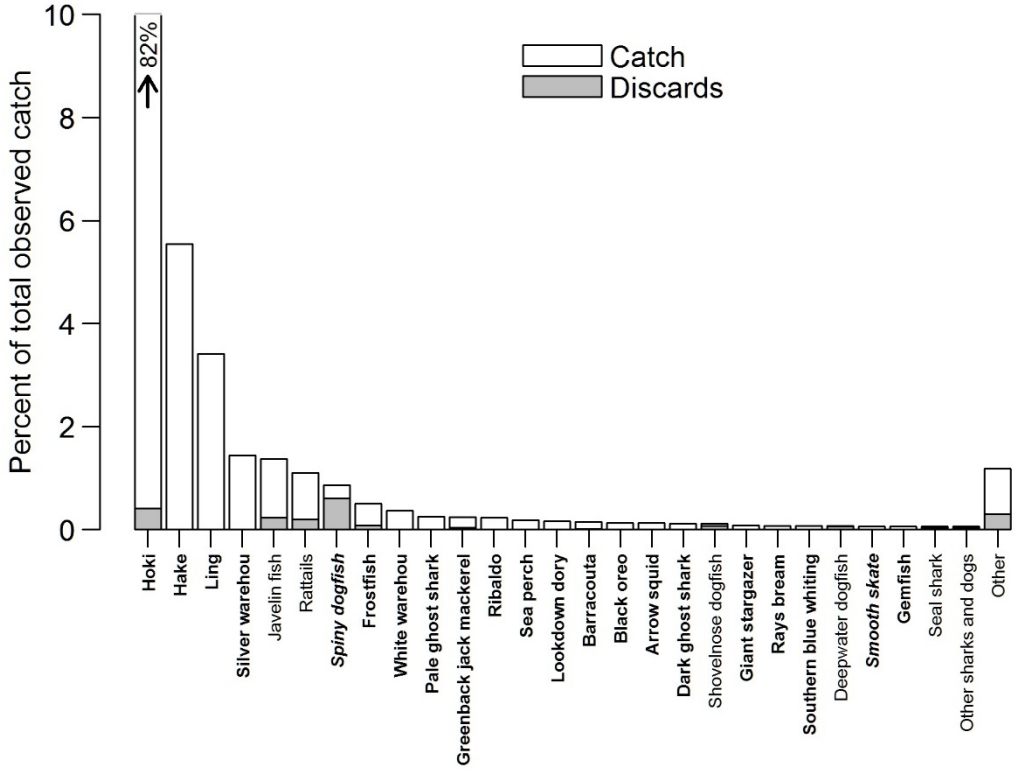


Figure 6: Hoki, hake, or ling target fishery: Comparison of the temporal spread of observed trawls with all recorded commercial trawls for 1990–91 to 2012–13, and for all fishing years combined. The relative frequency of the numbers of trawls was calculated from a density function which used linear approximation to estimate frequencies at a series of equally spaced points.

(a) 1991–2013



(b) 2009–2013

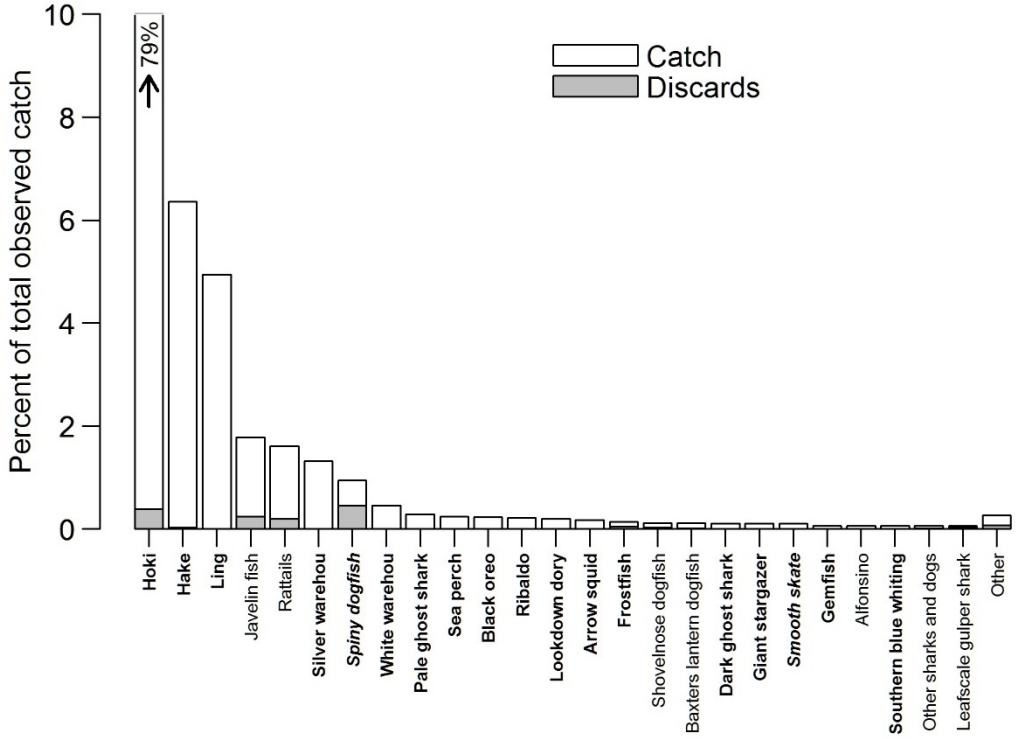


Figure 7: Percentage of the total catch contributed by the main bycatch species (those representing 0.05% or more of the total catch) in the observed portion of the hoki, hake, or ling fishery, and the percentage discarded from (a) 1990–91 to 2012–13, and (b) 2008–09 to 2012–13. The "Other" category is the sum of all bycatch species representing less than 0.05% of the total catch. Names in bold are QMS species, names in italics are QMS species which can be legally discarded under Schedule 6 of the Fisheries Act (1996).

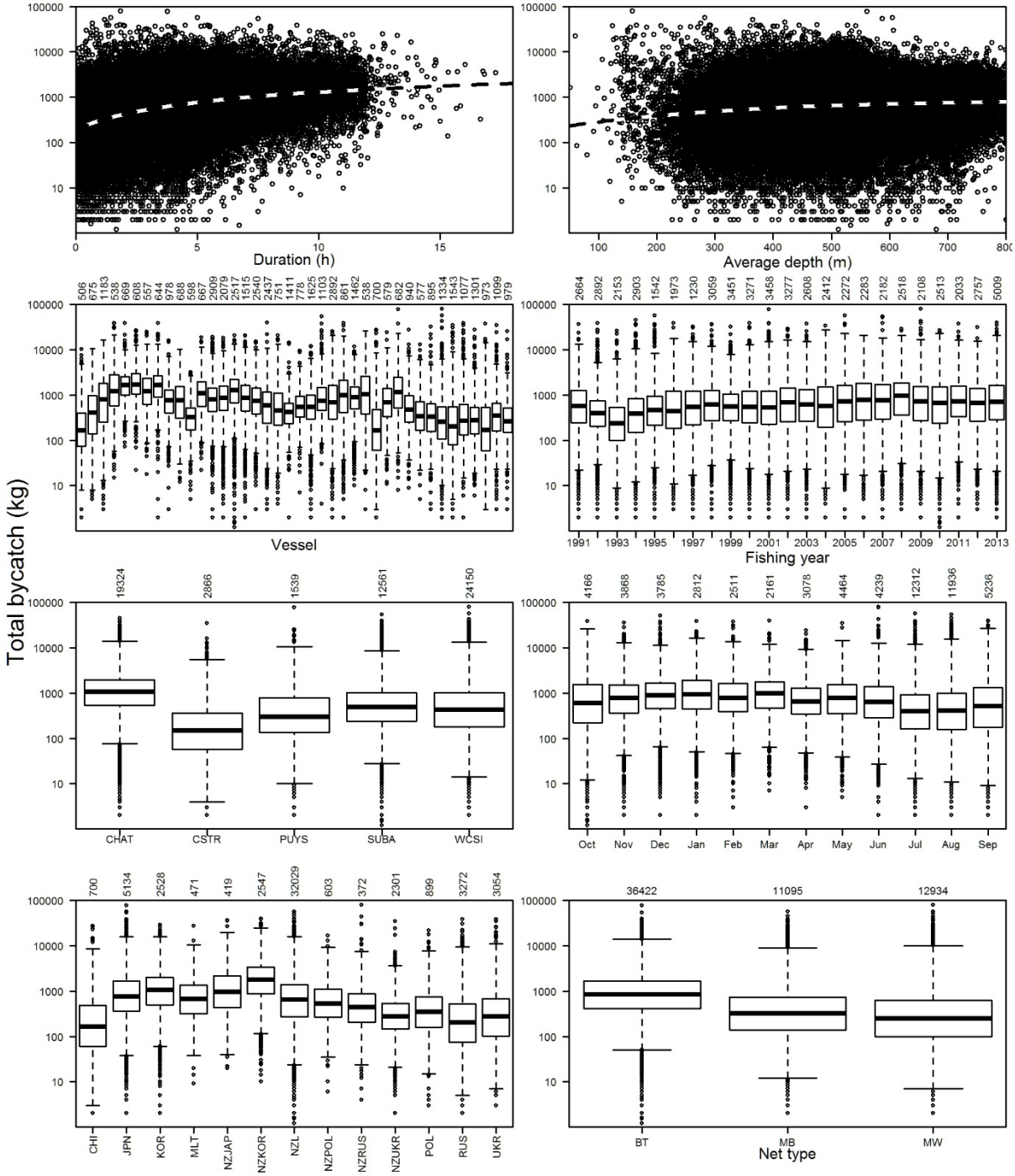


Figure 8: Total bycatch (all species) per trawl plotted against selected variables in the hoki, hake, or ling target fishery. Total bycatch is plotted on a log scale. The dashed lines in the top panels represent mean fits (using a locally weighted regression smoother) to the data. The box and whisker plots show medians and lower and upper quartiles in the box, whiskers extending up to 1.5 times the interquartile range, and outliers individually plotted. The numbers above the plots indicate the number of records associated with that level of the variable. In the vessel plot, vessels are ordered by size, from shortest to longest; and vessels represented by fewer than 500 records were not plotted. Average depth is the average of the start and finish gear depth. Nations: CHI, China; JPN, Japan; KOR, Korea; MLT, Malta; NZL, New Zealand; POL, Poland; RUS, Russia; UKR, Ukraine. Area codes: CHAT: Chatham Rise; CSTR: Cook Strait; PUYS: Puysegur; SUBA: Sub-Antarctic; WCSI. Net types: BT: bottom trawl; MB: midwater trawl within 5 m of the seabed; MW: midwater trawl. Maximum catch is 240 t, plots are truncated to 100 t.

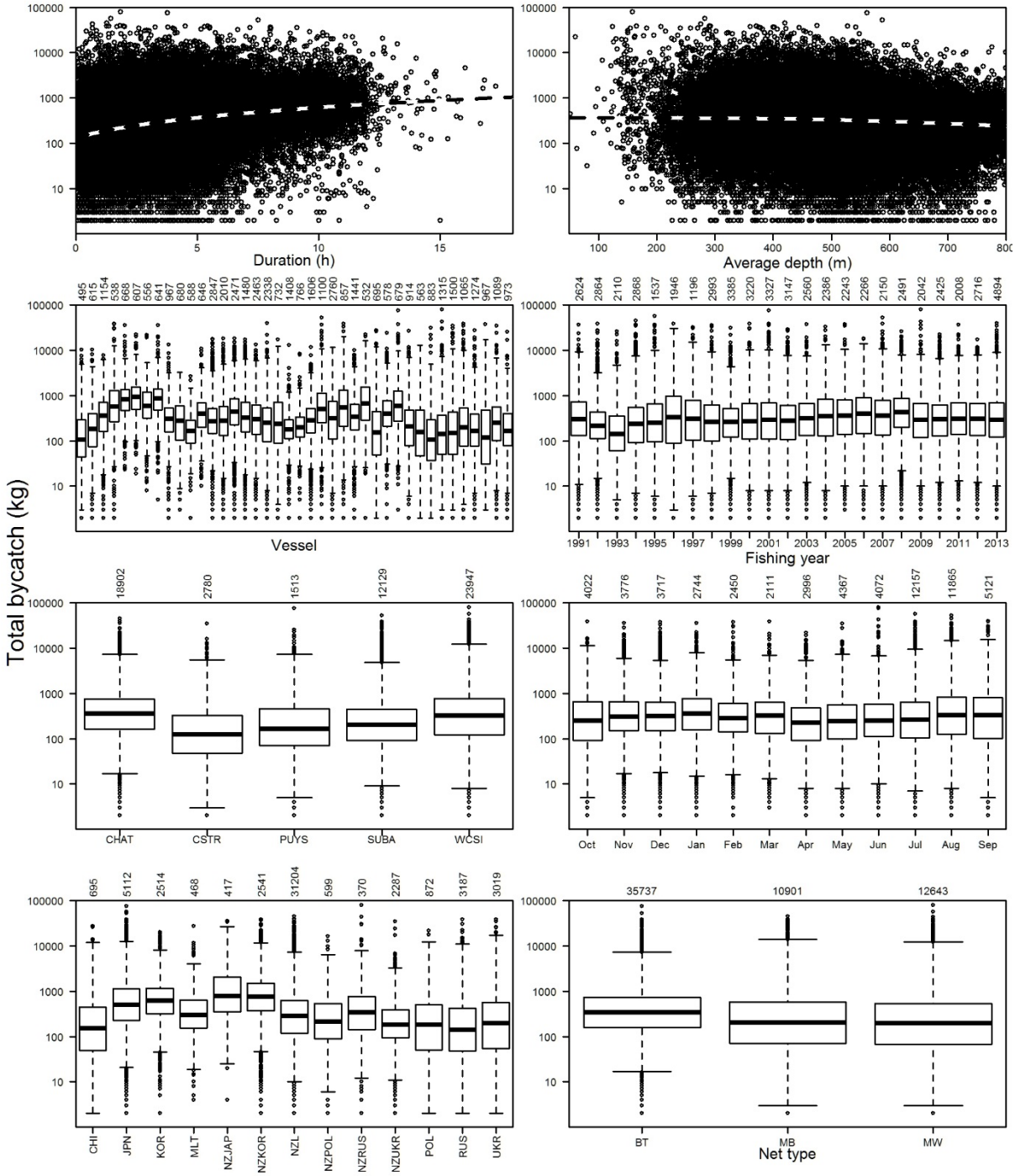


Figure 9: QMS species bycatch per trawl plotted against selected variables in the hoki, hake, or ling target fishery. See Figure 8 for further details.

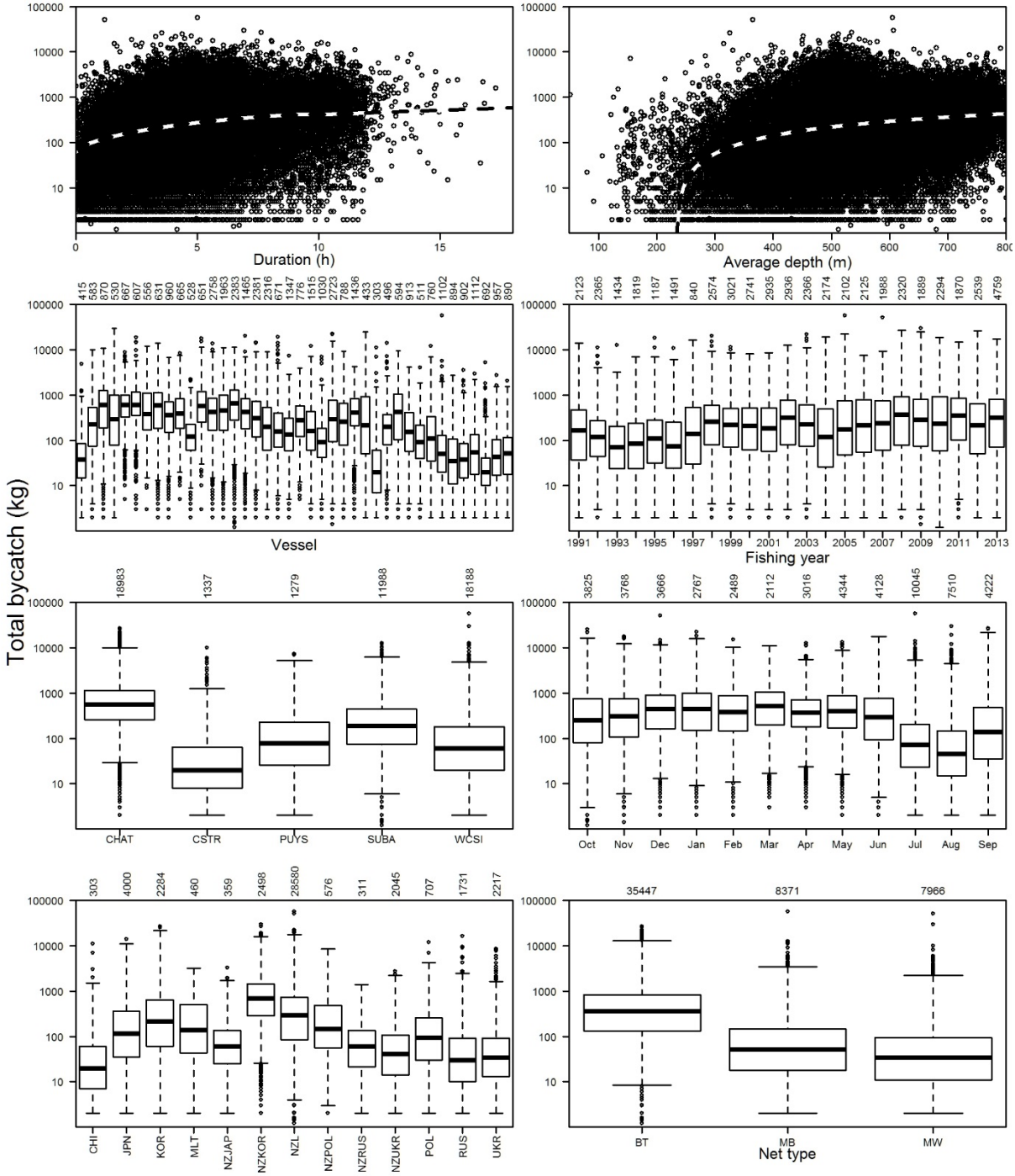


Figure 10: Non-QMS species bycatch per trawl plotted against selected variables in the hoki, hake, or ling target fishery. See Figure 8 for further details.

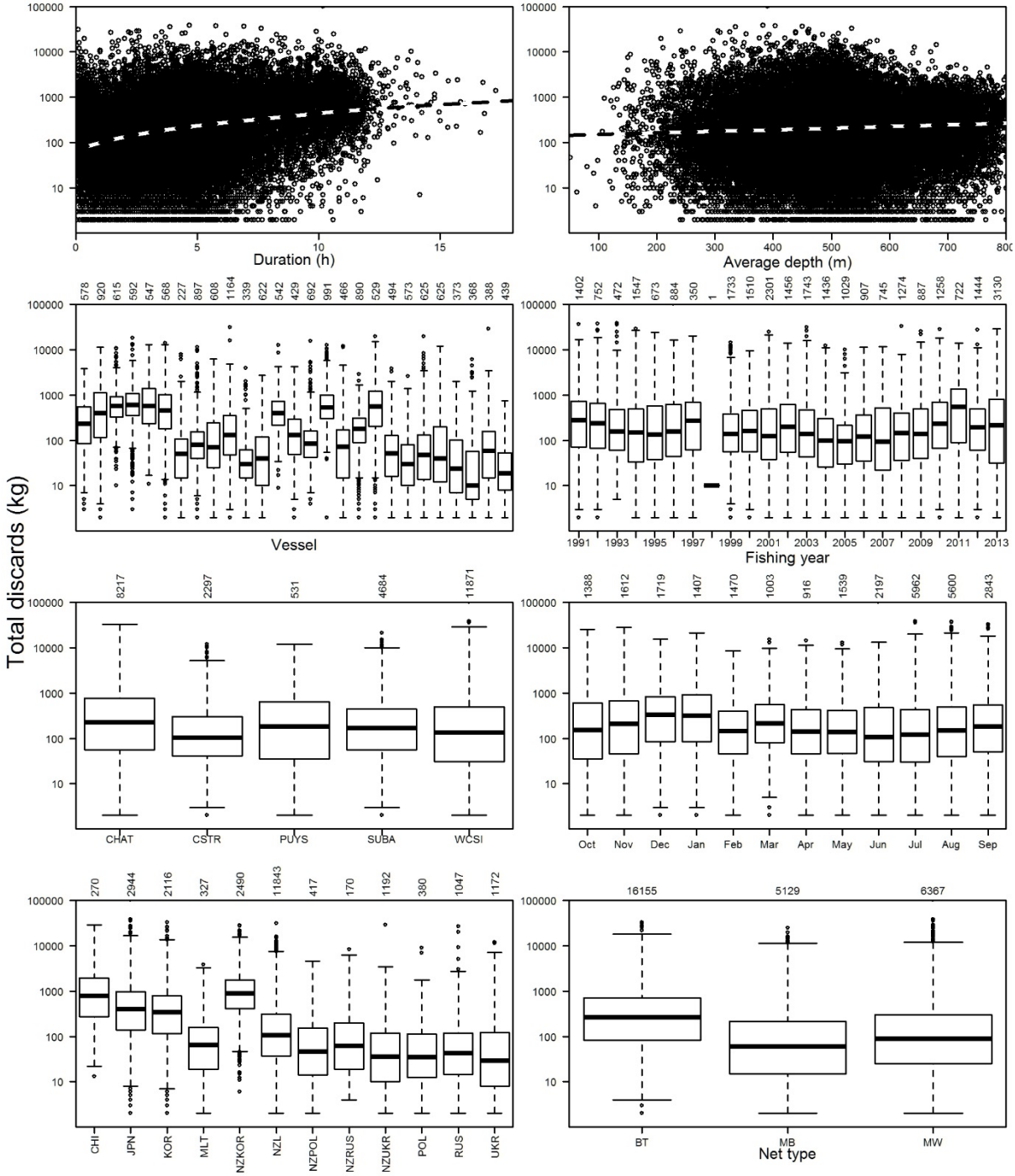


Figure 11: Total discards (all species) per trawl plotted against selected variables in the hoki, hake, or ling target fishery. Total discards are plotted on a log scale. The dashed lines in the top panels represent mean fits (using a locally weighted regression smoother) to the data. The box and whisker plots show medians and lower and upper quartiles in the box, whiskers extending up to 1.5 times the interquartile range, and outliers individually plotted. The numbers above the plots indicate the number of records associated with that level of the variable. In the vessel plot, vessels are ordered by size, from shortest to longest; and vessels represented by fewer than 500 records were not plotted. Average depth is the average of the start and finish gear depth. Nations: CHI, China; JPN, Japan; KOR, Korea; MLT, Malta; NZL, New Zealand; POL, Poland; RUS, Russia; UKR, Ukraine. Area codes: CHAT: Chatham Rise; CSTR: Cook Strait; PUYS: Puysegur; SUBA: Sub-Antarctic; WCSI. Net types: BT: bottom trawl; MB: midwater trawl within 5 m of the seabed; MW: midwater trawl. No data for 1997–98 due to linkage error in database tables.

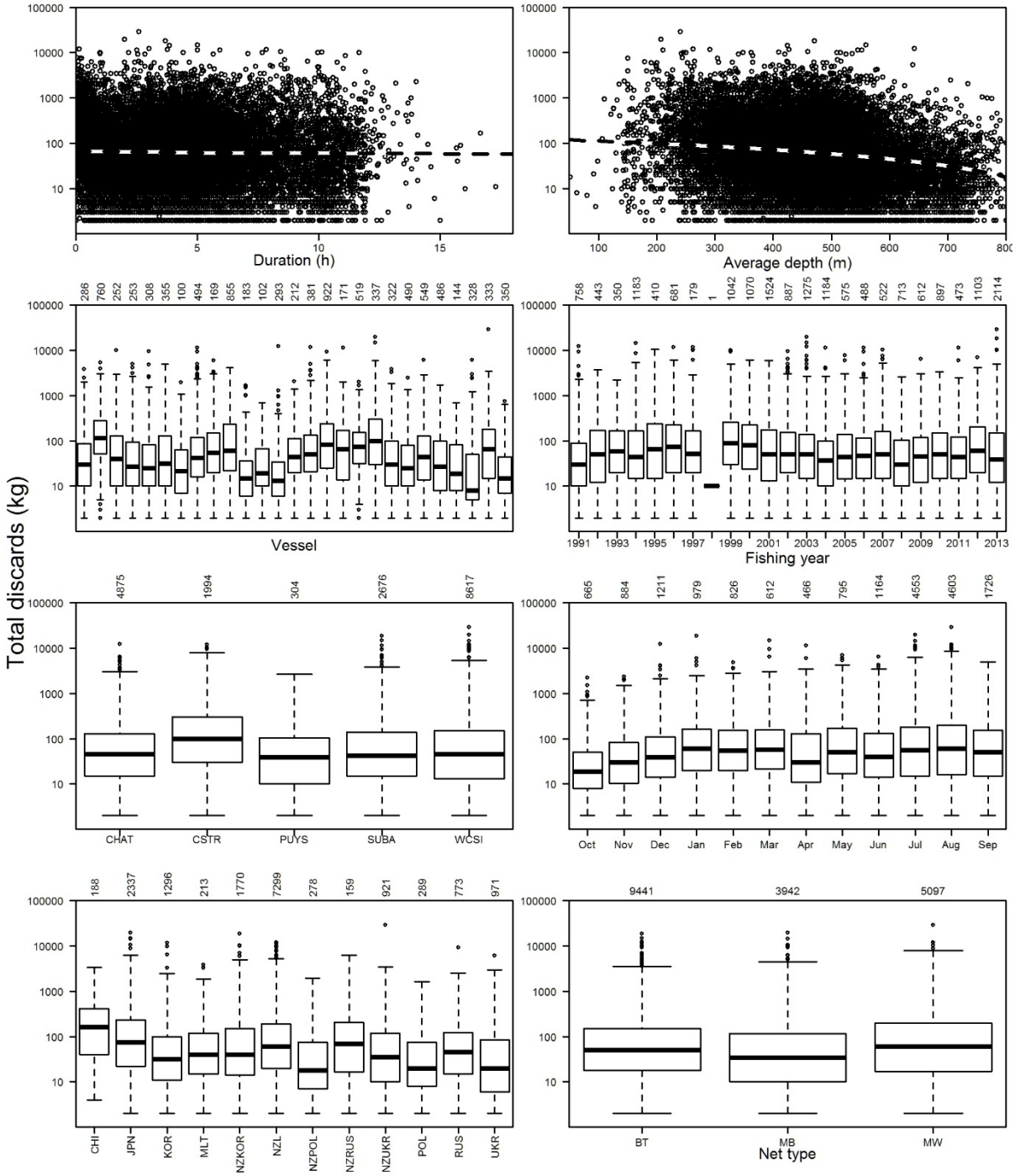


Figure 12: QMS species discards per trawl plotted against selected variables in the hoki, hake, or ling target fishery. See Figure 11 for further details.

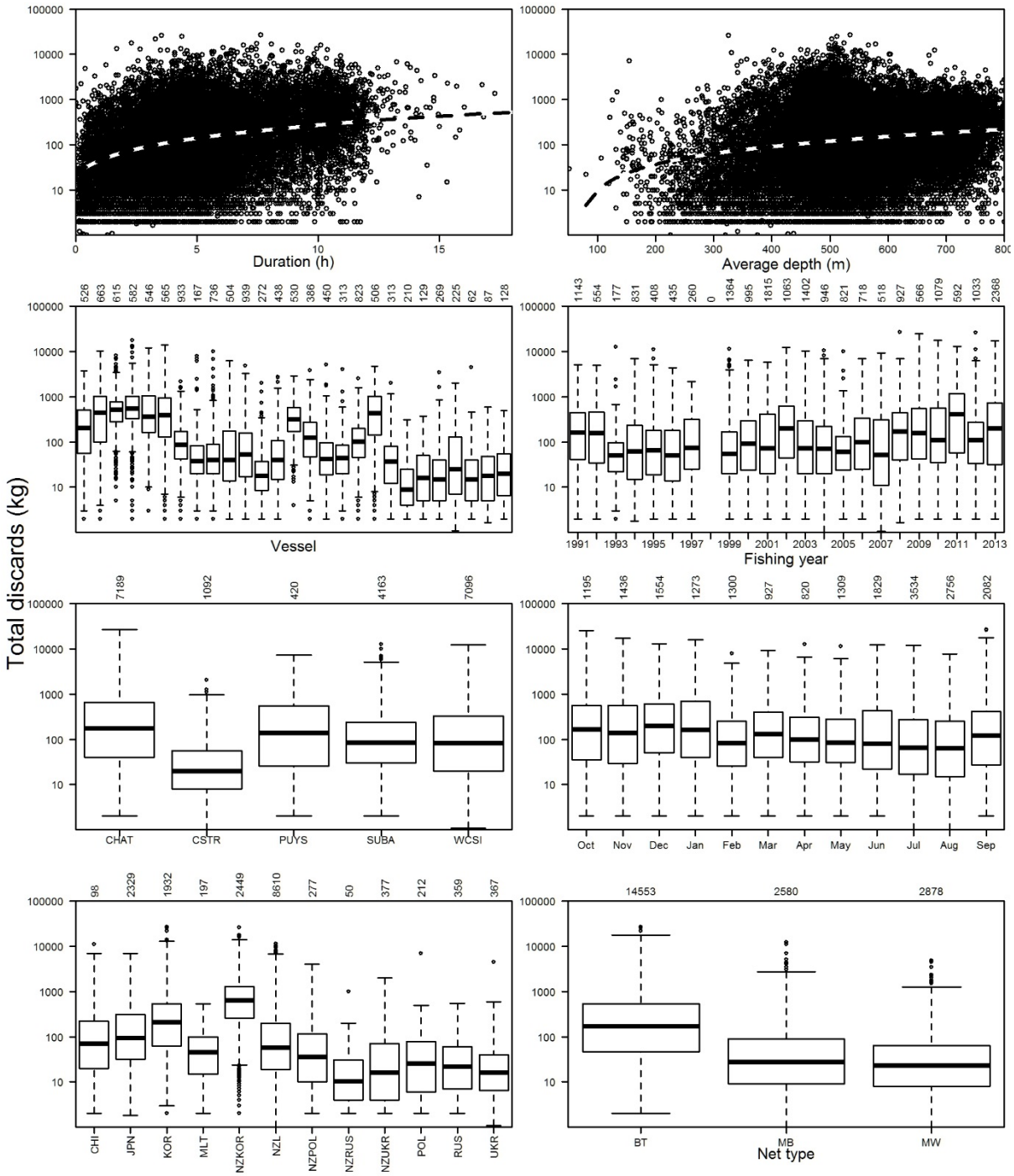


Figure 13: Non-QMS species discards per trawl plotted against selected variables in the hoki, hake, or ling target fishery. See Figure 11 for further details.

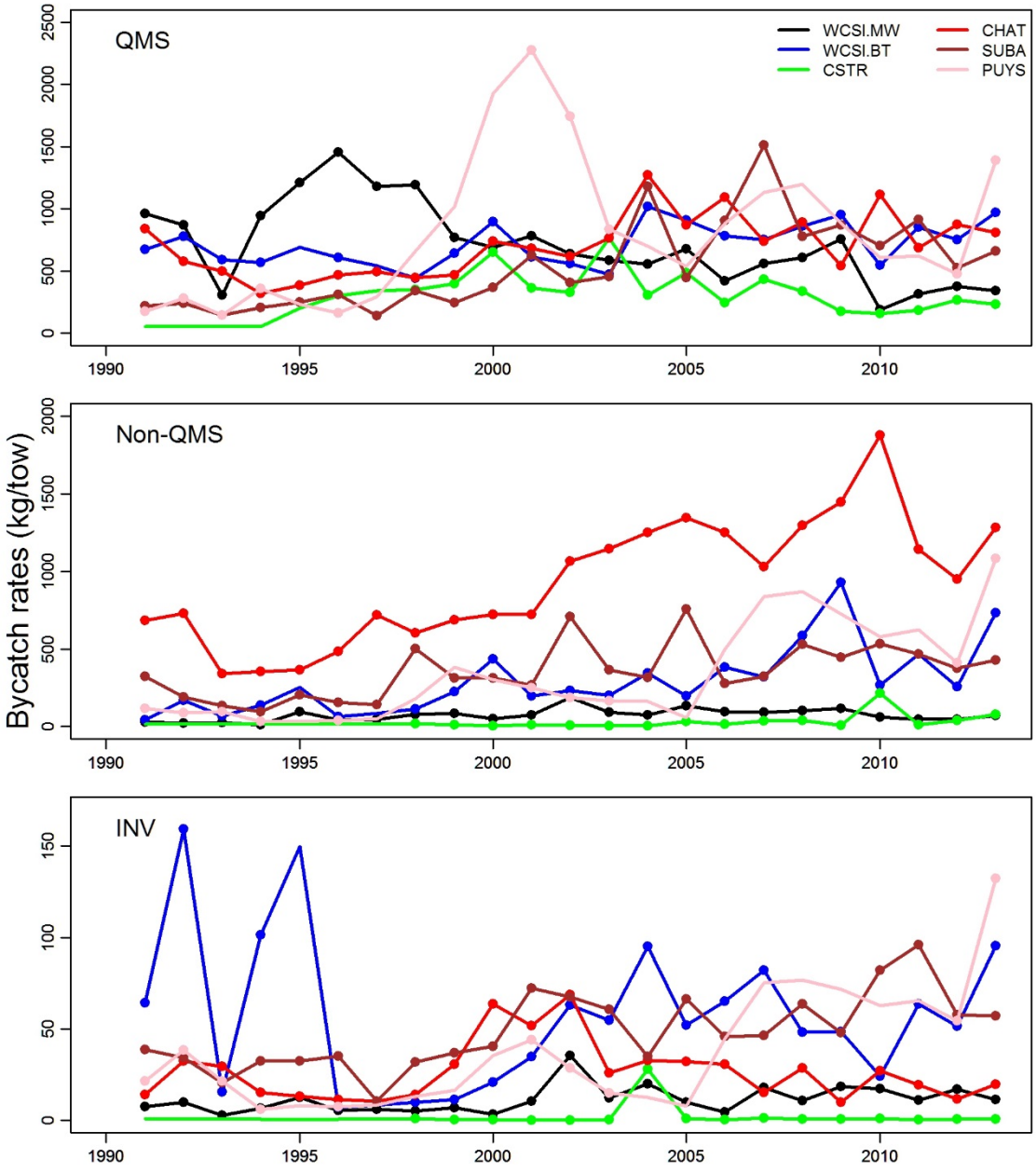


Figure 14: Annual bycatch rates (calculated using the number of tows estimator) by species category and areas used for stratification, in the hoki, hake, or ling target trawl fishery. Bycatch rates are the median of the bootstrap sample of 1000. Dots indicate years in which there were sufficient observed tows (i.e. at least 50) to calculate an individual bycatch rate for the area; for years with no dot bycatch rates were calculated using additional records from between 2 and 7 adjacent years (see Appendix 5) as required to obtain at least 50 records.

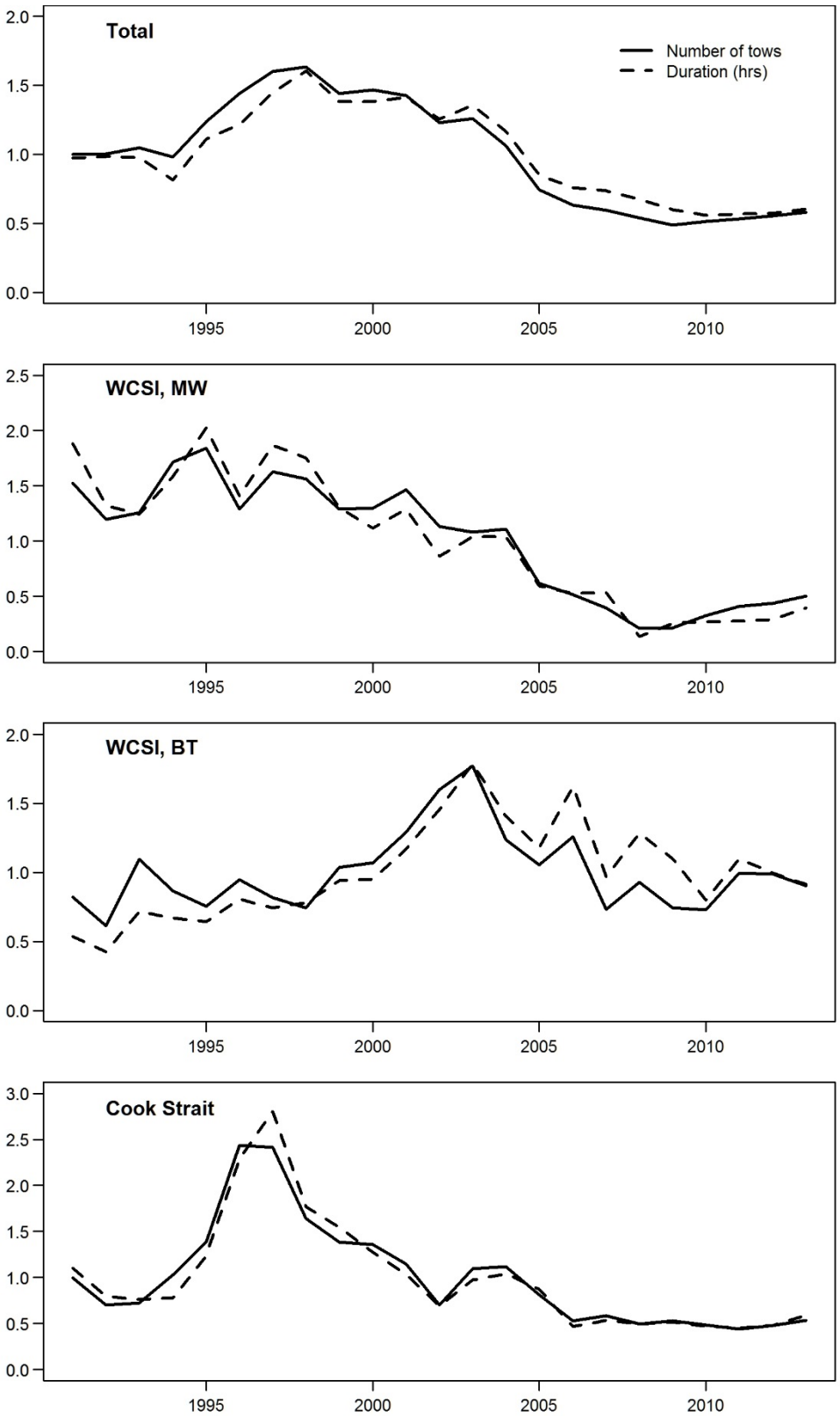


Figure 15: Comparison of effort (number of tows, and duration in hours) scaled to mean of 1 for all areas (total) and by area.

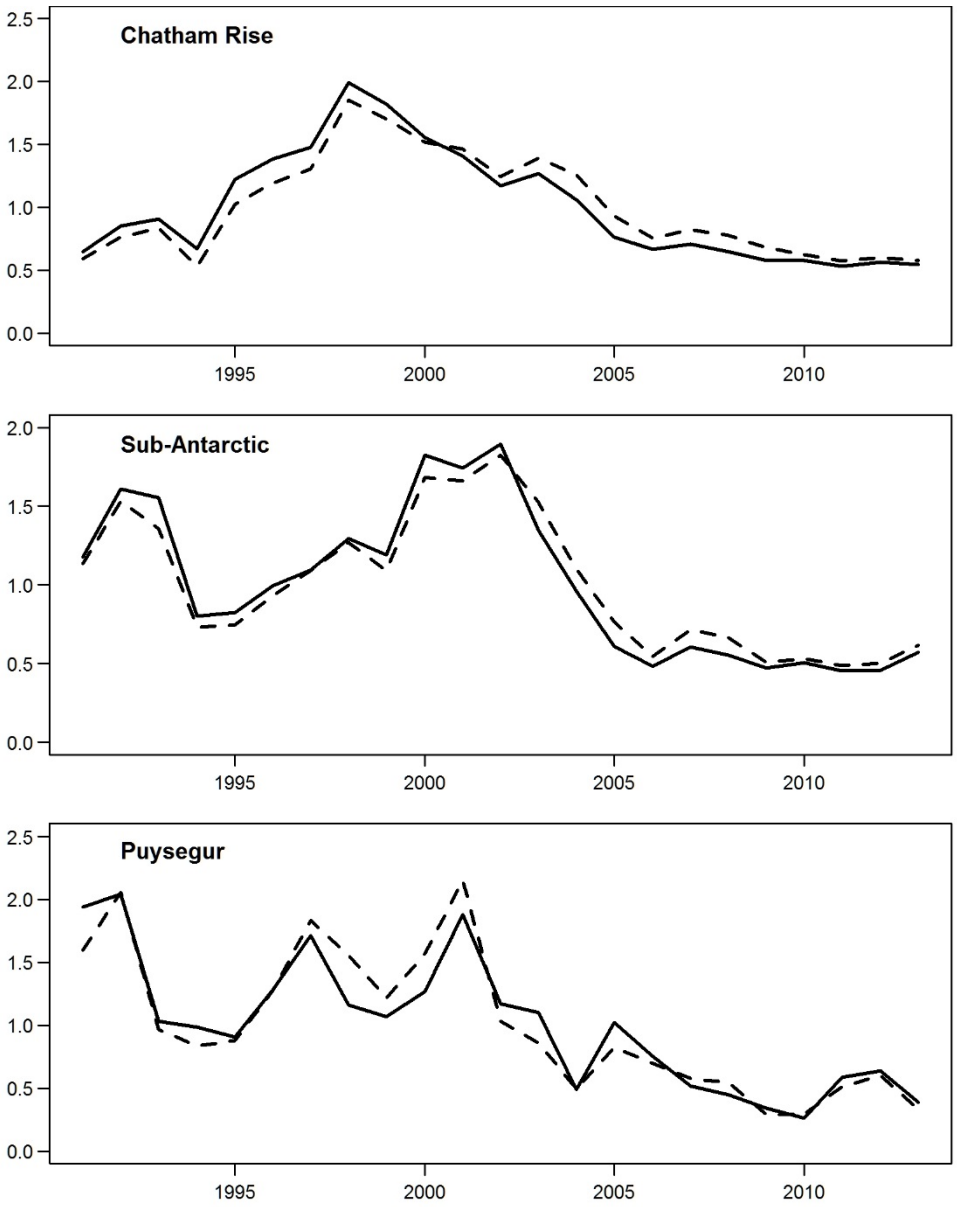


Figure 15: continued.

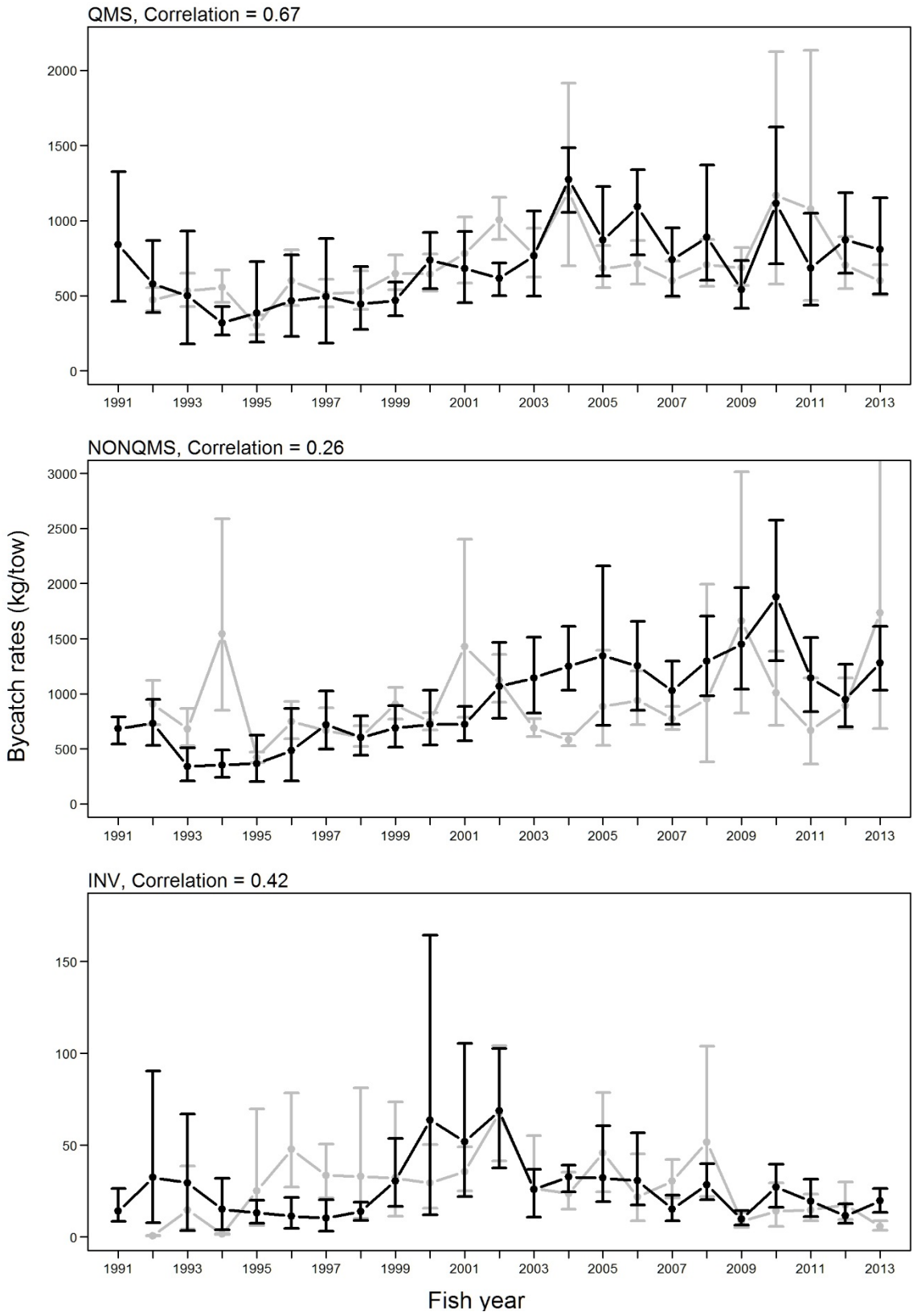


Figure 16a: Comparison of annual bycatch rates (calculated using the tow-based estimator) by species category in the hoki, hake, or ling target trawl Chatham Rise fishery (black) with relative biomass estimates from the Chatham Rise *Tangaroa* January trawl surveys (grey). Bycatch rates are the median of the bootstrap sample of 1000. Biomass is scaled to bycatch rates.

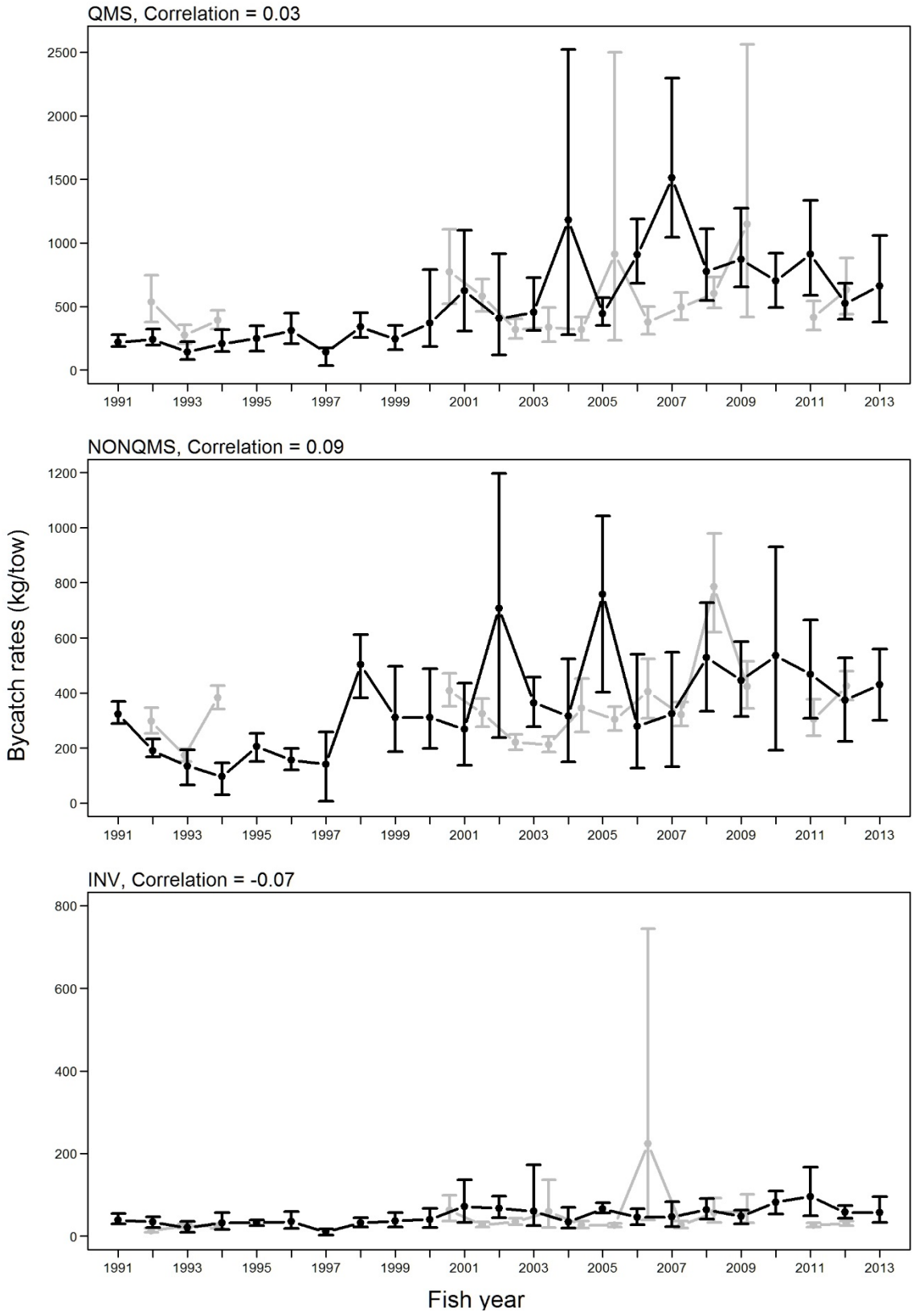


Figure 16b: Comparison of annual bycatch rates (calculated using the tow-based estimator) by species category in the hoki, hake, or ling target trawl Sub-Antarctic fishery (black) with biomass from the Sub-Antarctic *Tangaroa* November–December trawl surveys (grey). Bycatch rates are the median of the bootstrap sample of 1000. Biomass is scaled to bycatch rates.

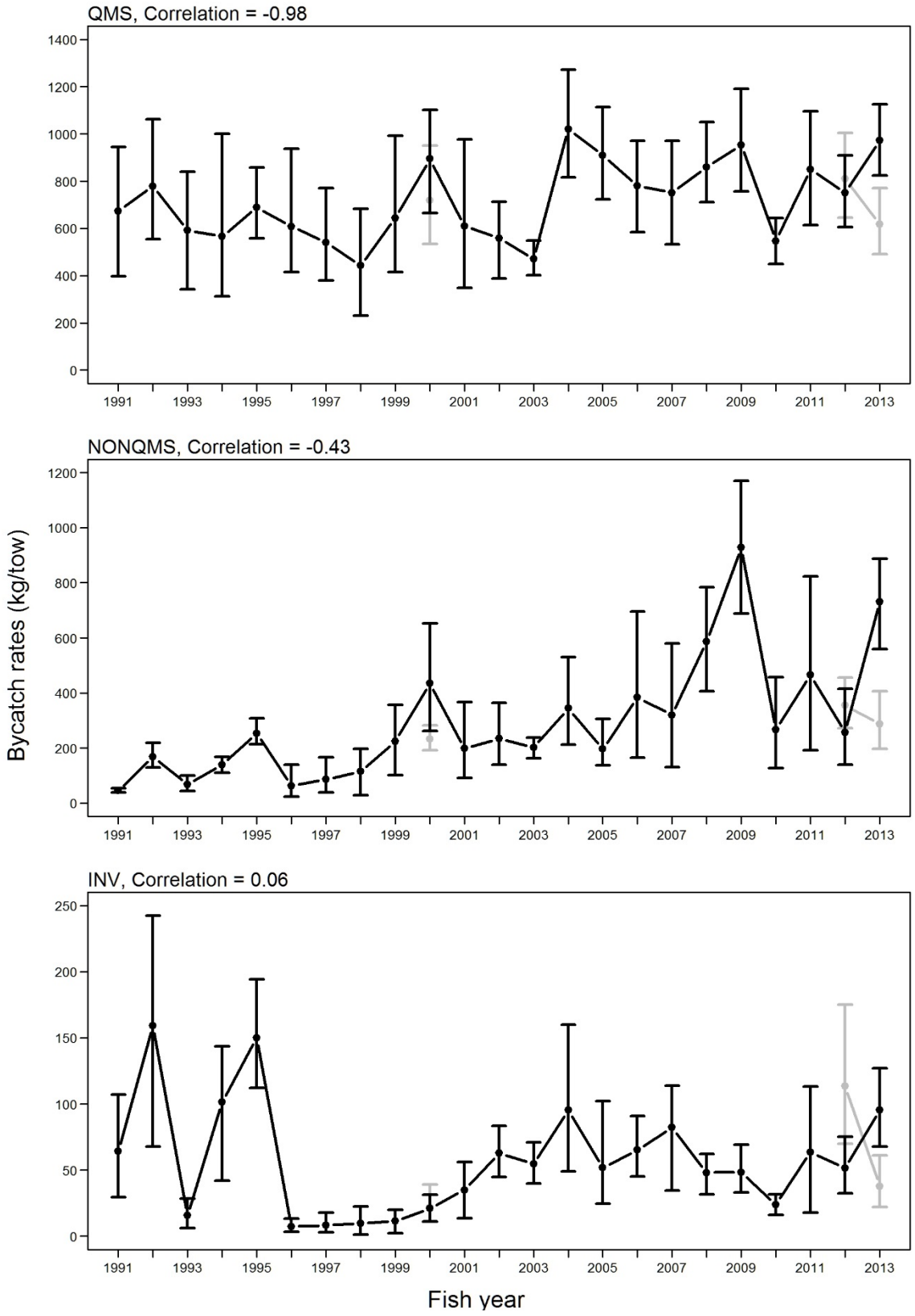


Figure 16c: Comparison of annual bycatch rates (calculated using the tow-based estimator) by species category in the hoki, hake, or ling target trawl WCSI fishery (black) with biomass from the WCSI *Tangaroa* winter trawl surveys (grey). Bycatch rates are the median of the bootstrap sample of 1000. Biomass is scaled to bycatch rates.

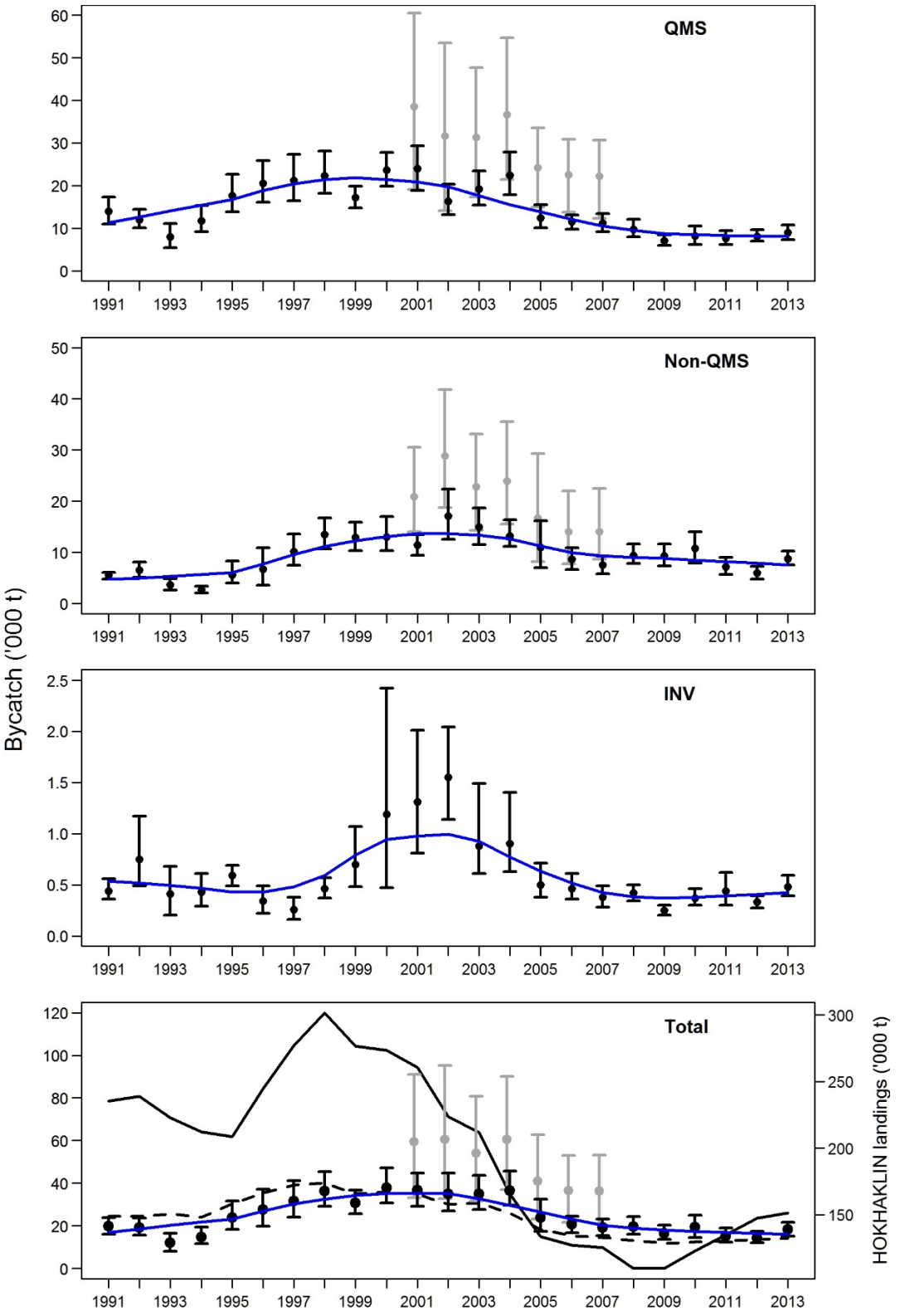


Figure 17: Annual estimates (calculated using the number of tows estimator) of bycatch in the hoki, hake, or ling target trawl fishery, for QMS species, non-QMS species, invertebrates (INV), and overall for 1990–91 to 2012–13. Also shown (in grey) are estimates of bycatch in each category (excluding INV) calculated for 2000–01 to 2006–07 (Ballara et al. 2010). Error bars indicate 95% confidence intervals. The blue lines show the fit of a locally-weighted polynomial regression to annual bycatch. In the bottom panel the solid black line shows the total annual reported trawl-caught landings of hoki, hake, or ling (Ministry for Primary Industries 2014) and the dashed line shows annual effort (scaled to have mean equal to that of total bycatch).

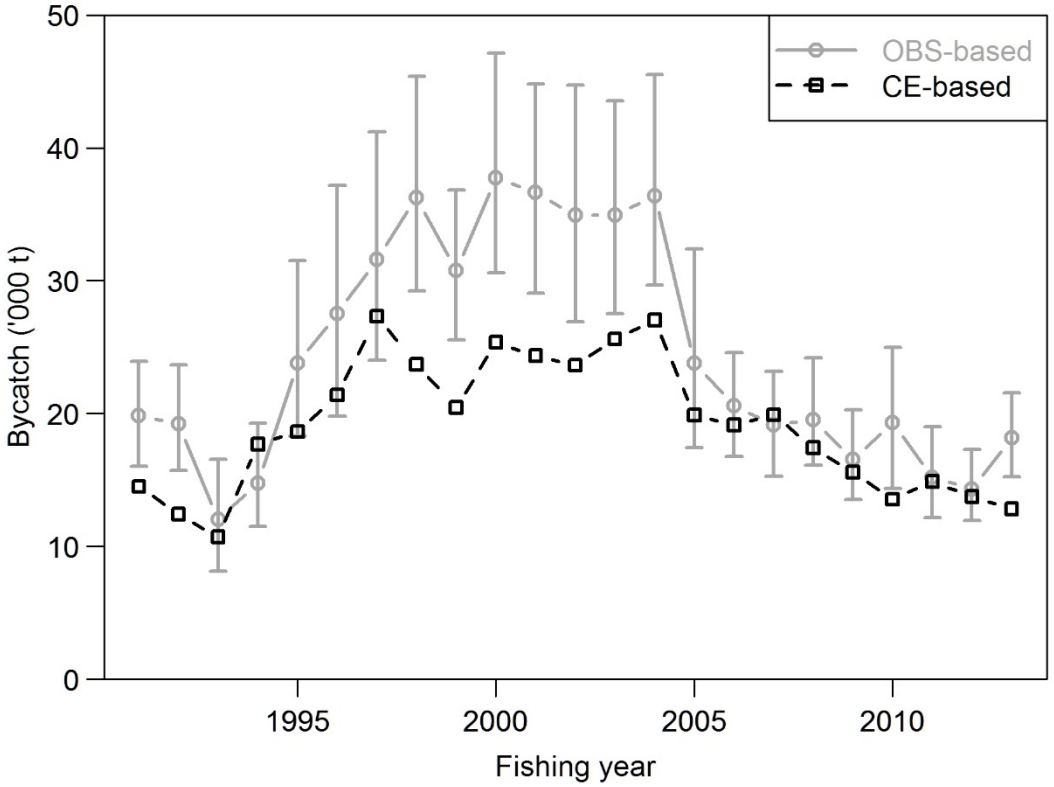


Figure 18: Total annual bycatch (calculated using the tow-based estimator) in the hoki, hake, or ling target fishery from scaled up observer catch rates and commercial catch effort records.

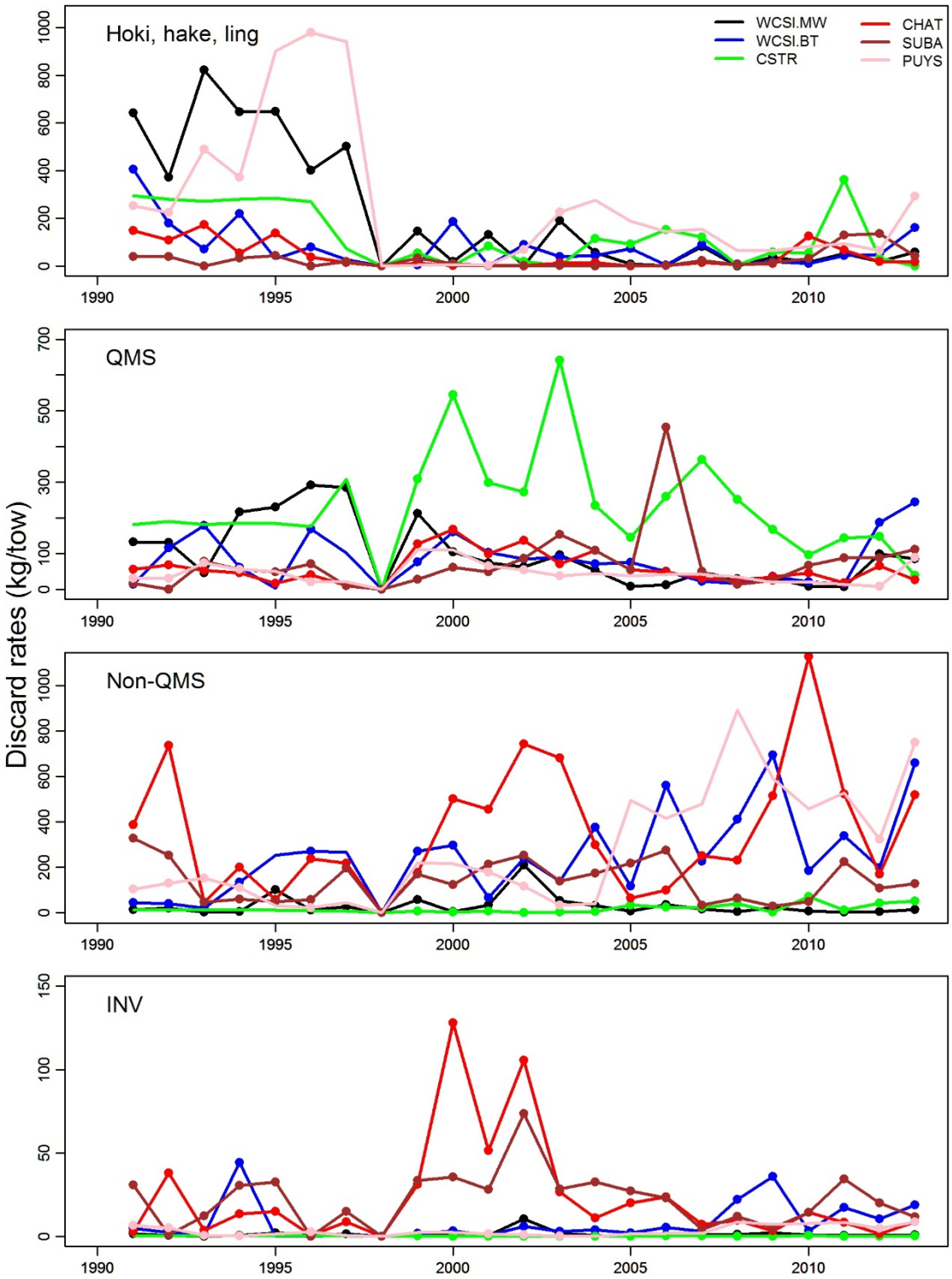


Figure 19: Annual discard rates (calculated using the tow-based estimator) by species category and areas used for stratification, in the hoki, hake, or ling target trawl fishery. Discard rates are the median of the bootstrap sample of 1000. Dots indicate years in which there were sufficient observed tows (i.e. at least 50) to calculate an individual discard rate for the area; for years with no dot discard rates were calculated using additional records from between 2 and 7 adjacent years (see Appendix A6) as required to obtain at least 50 records.

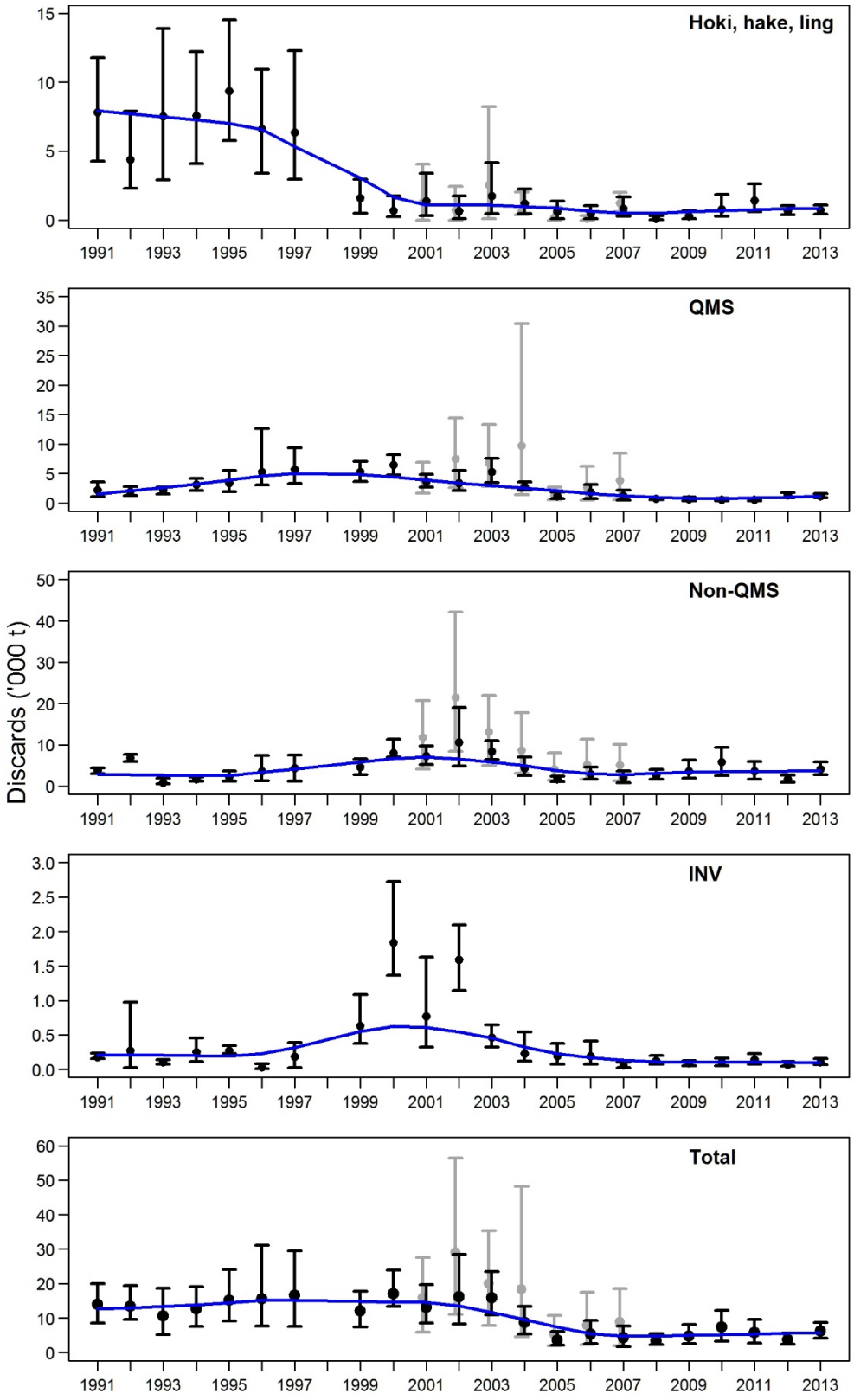


Figure 20: Annual estimates of discards (calculated using the tow-based estimator) in the hoki, hake, or ling target trawl fishery, for hoki, hake, or ling target (HOKHAKLIN), QMS species, non-QMS species, invertebrates (INV), and overall for 1990–91 to 2012–13. Also shown (in grey) are estimates of discards in each category (excluding INV) calculated for 2000–01 to 2006–07 (Ballara et al. 2010). Error bars indicate 95% confidence intervals. The blue lines show the fit of a locally-weighted polynomial regression to annual discards.

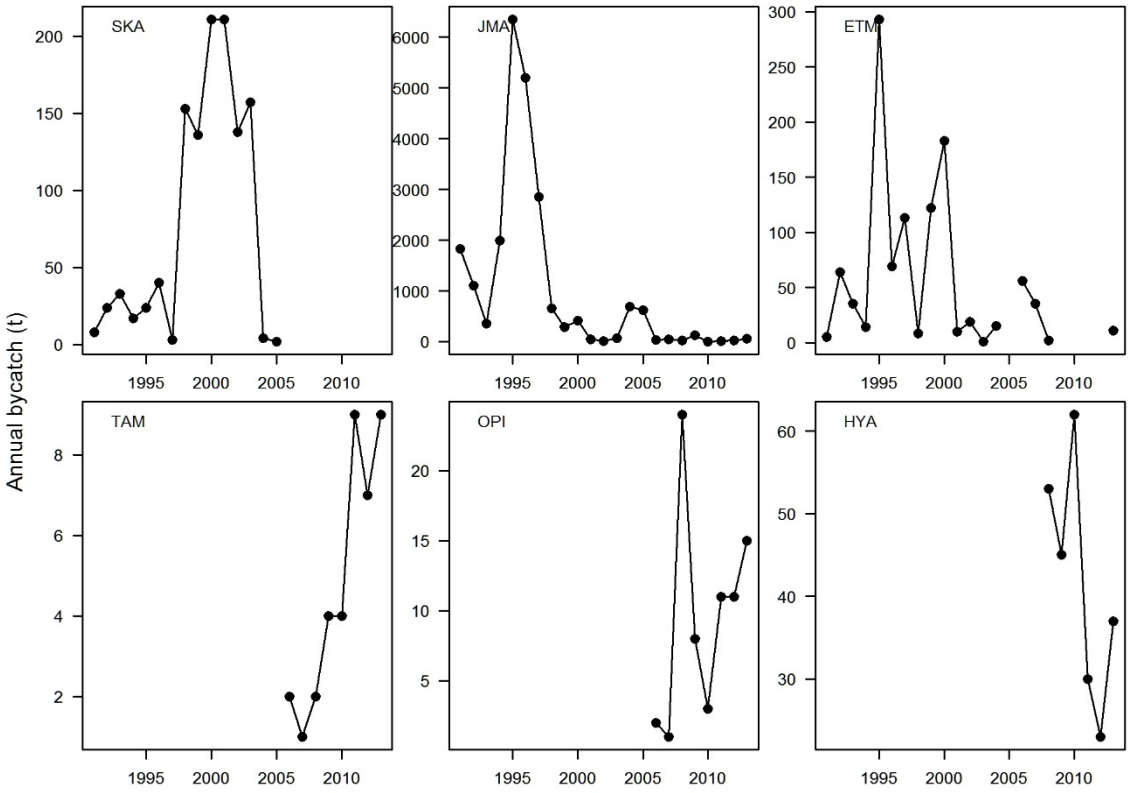


Figure 21: Annual bycatch estimates in the hoki, hake, and ling trawl fishery for the species which have shown the greatest decrease (top) and greatest increase (bottom) between 1990–91 and 2012–13. See text above for explanation of the species codes.

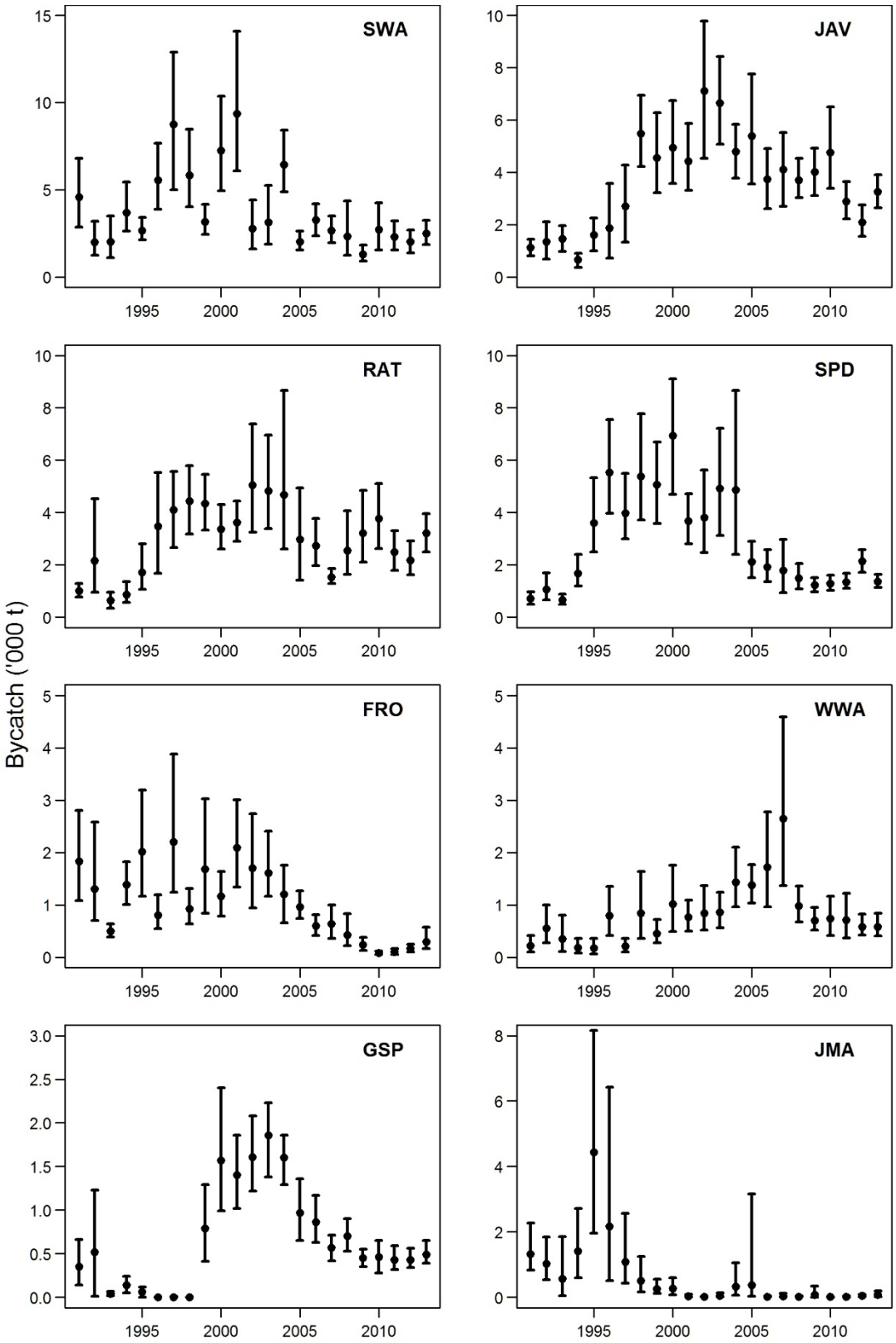


Figure 22: Annual estimates (calculated using the tow-based estimator) of bycatch in the hoki, hake, or ling target trawl fishery, for main bycatch species. Error bars indicate 95% confidence intervals.

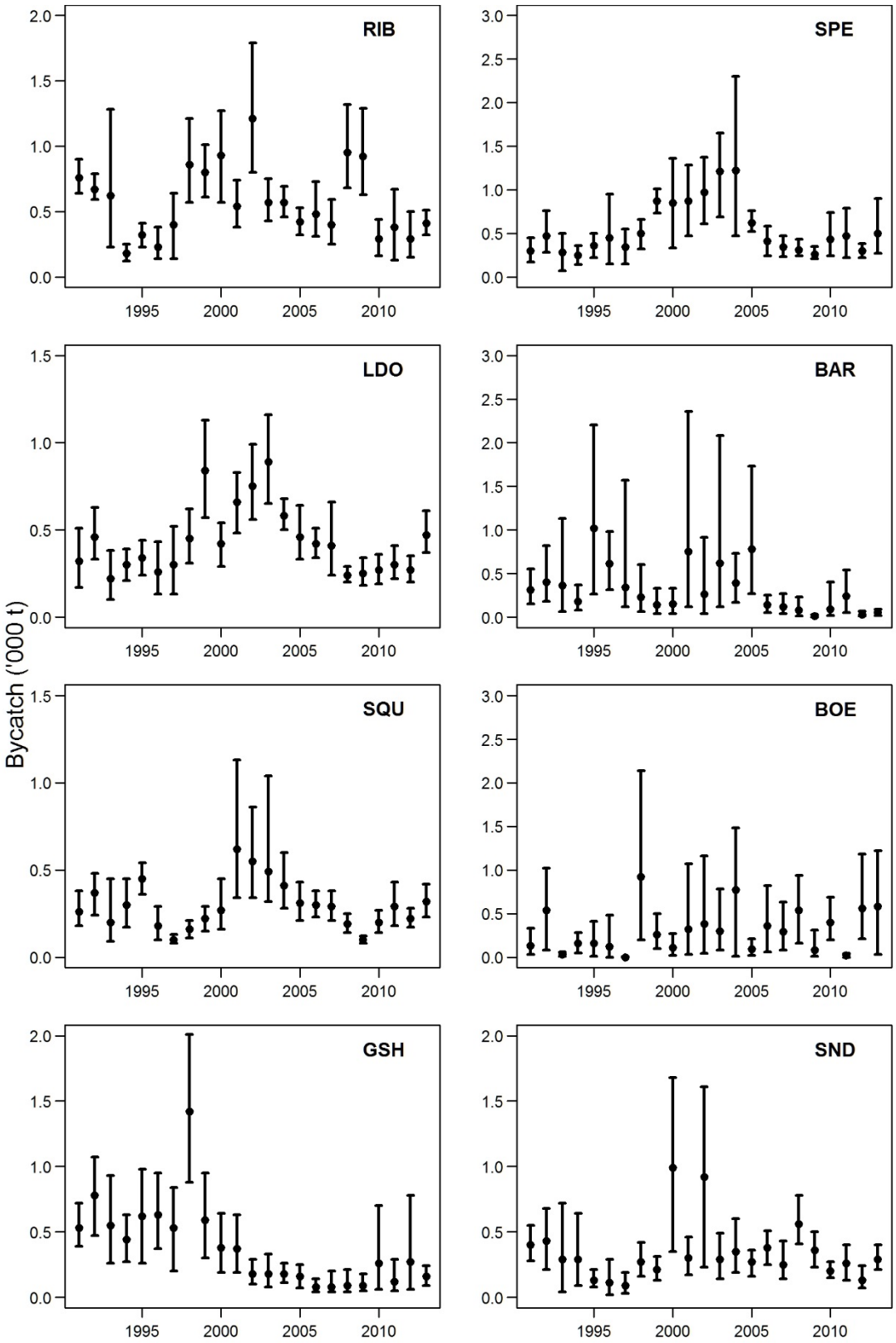


Figure 22: continued.

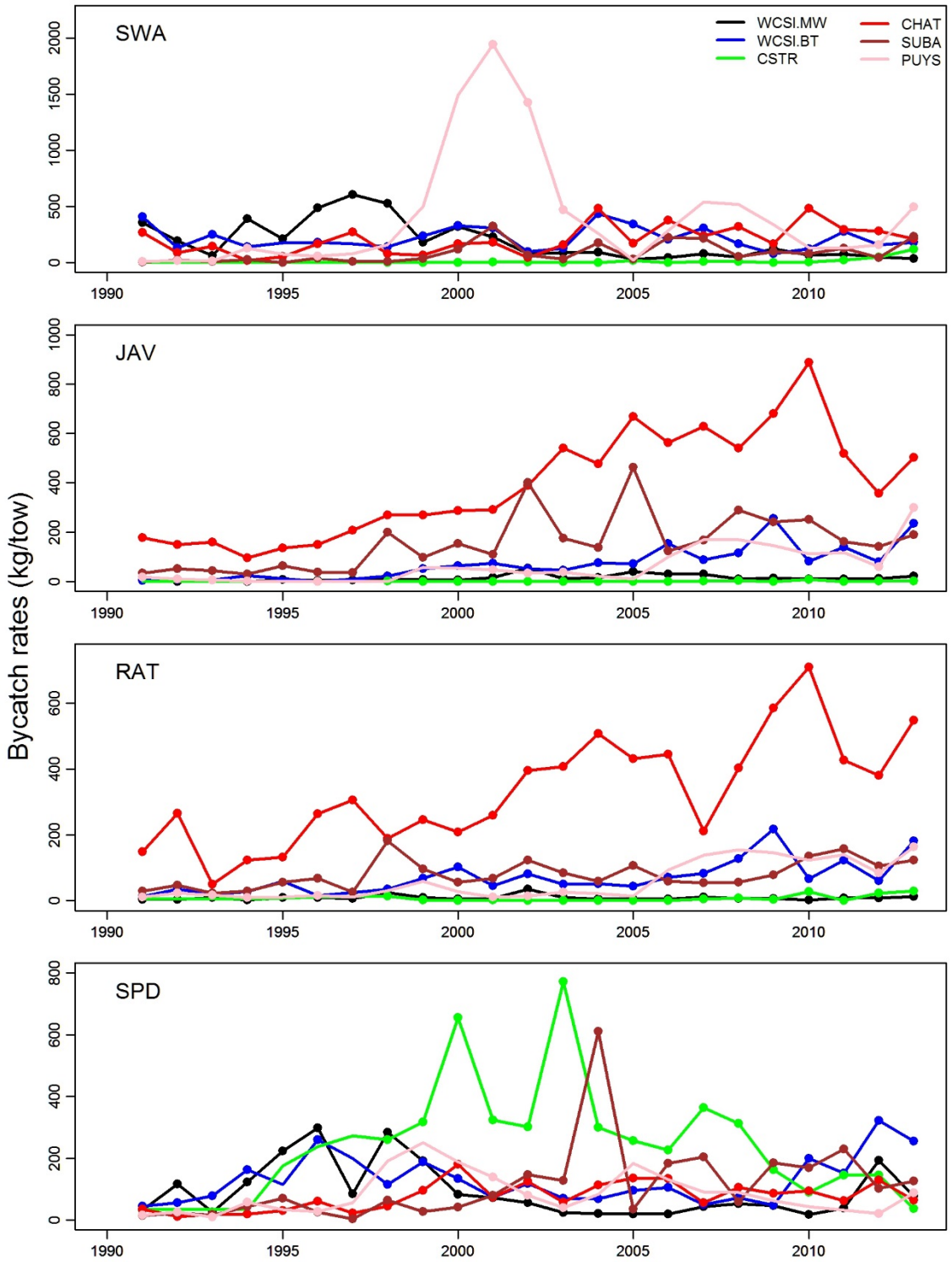


Figure 23: Annual bycatch rates (calculated using the tow-based estimator) for main bycatch species by area areas used for stratification, in the hoki, hake, or ling target trawl fishery. Bycatch rates are the median of the bootstrap sample of 1000. Dots indicate years in which there were sufficient observed tows (i.e. at least 50) to calculate an individual bycatch rate for the area; for years with no dot bycatch rates were calculated using additional records from between 2 and 7 adjacent years (see Appendix A6) as required to obtain at least 50 records.

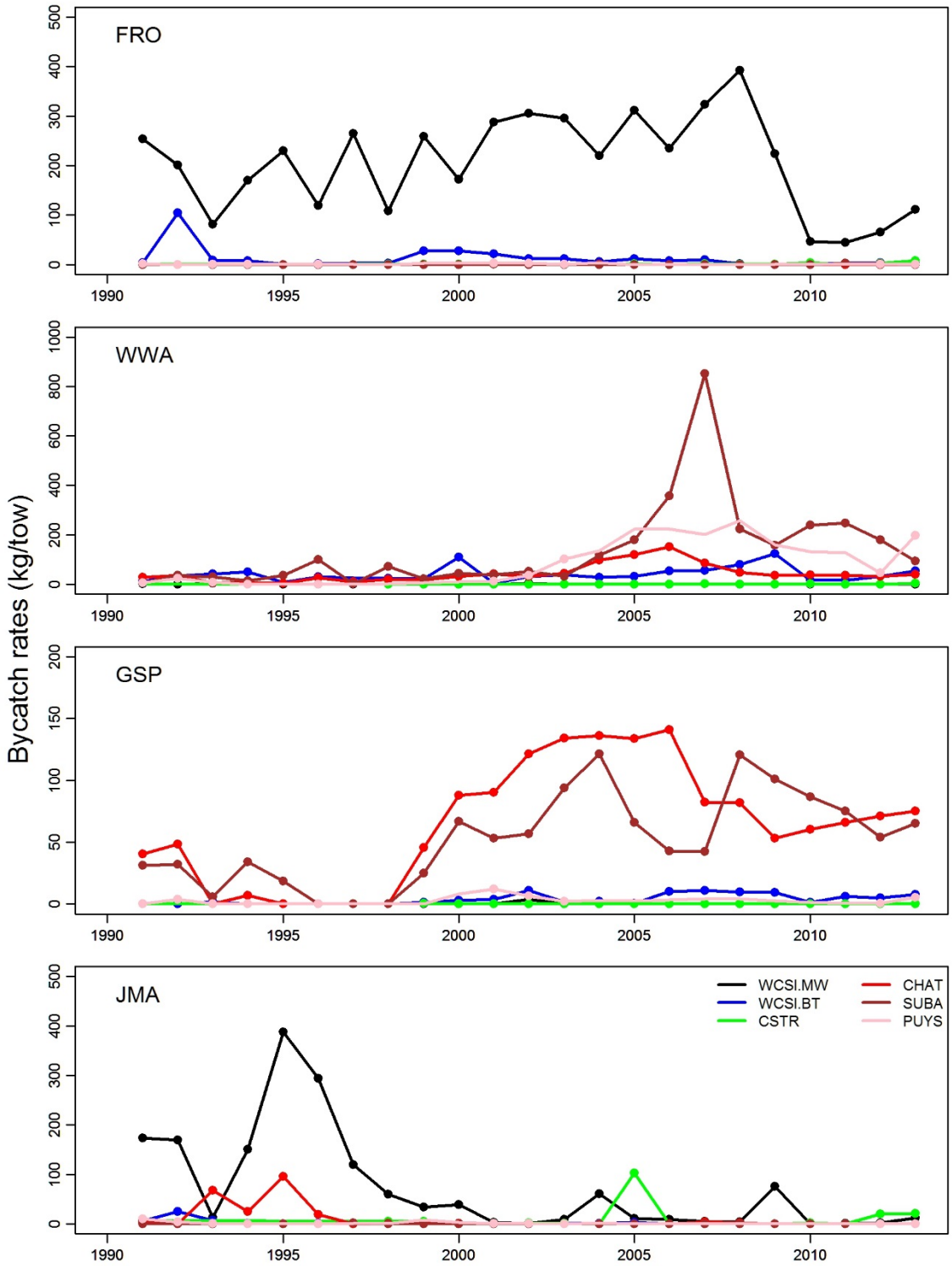


Figure 23: continued.

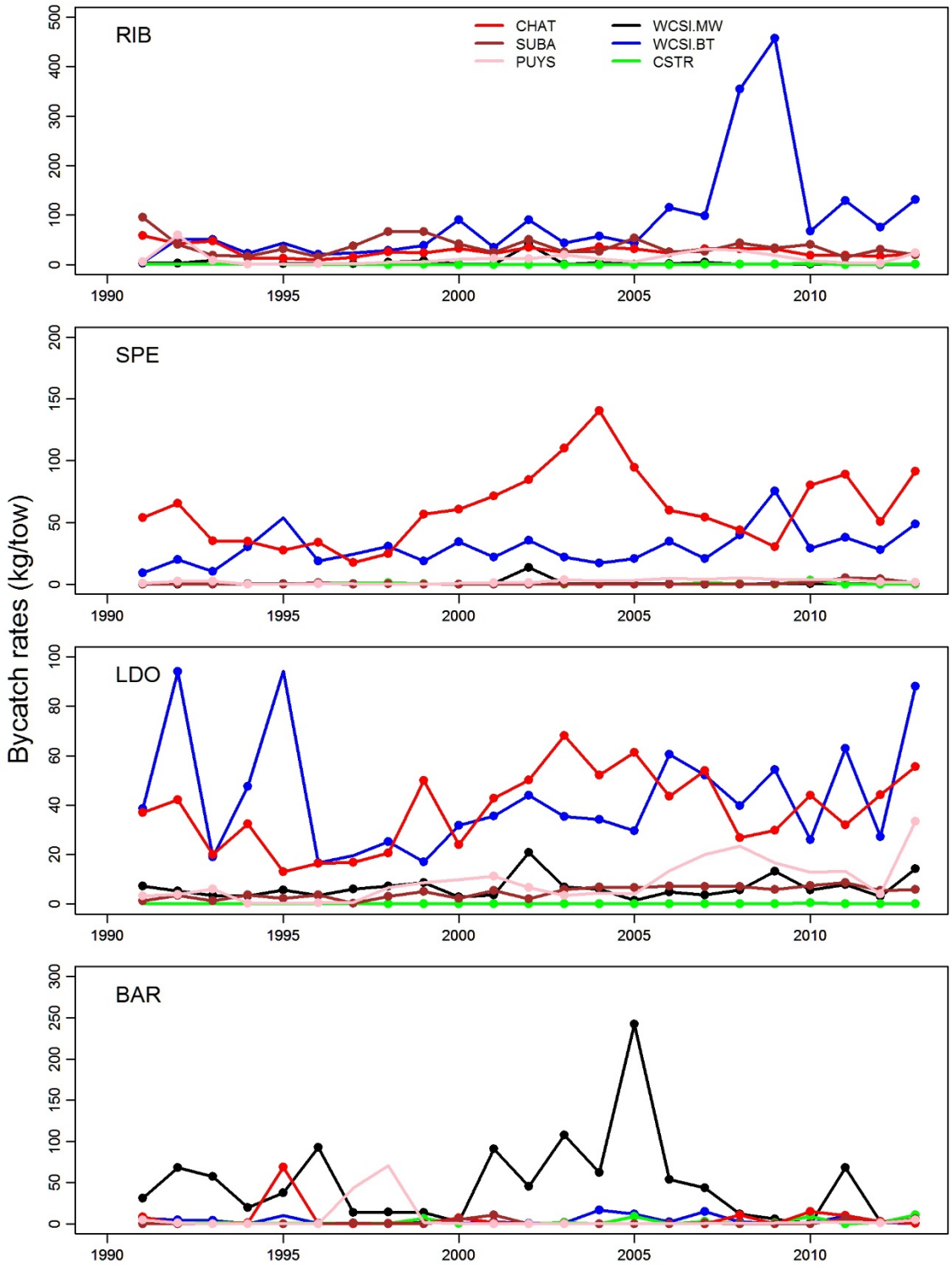


Figure 23: continued.

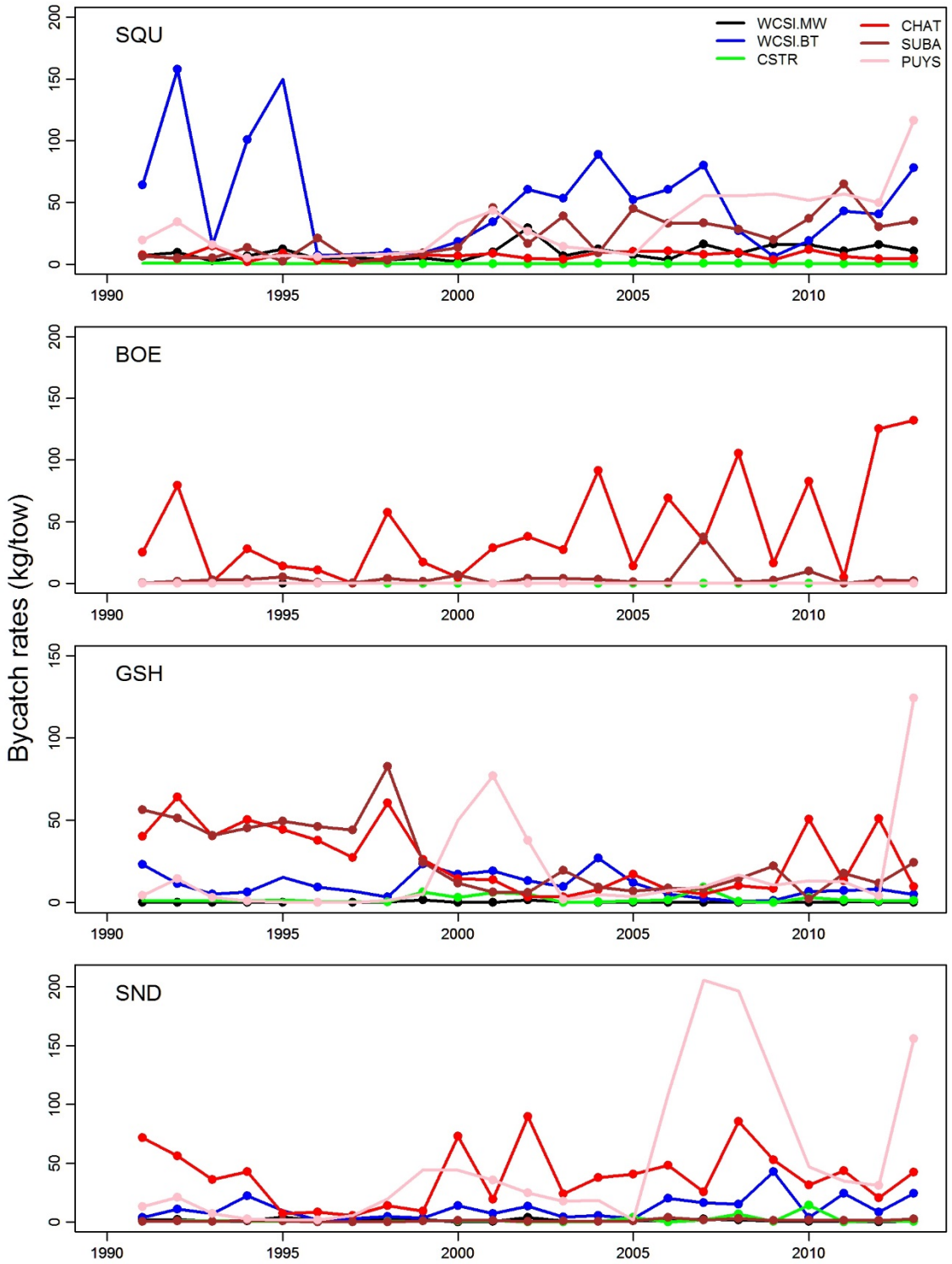


Figure 23: continued.

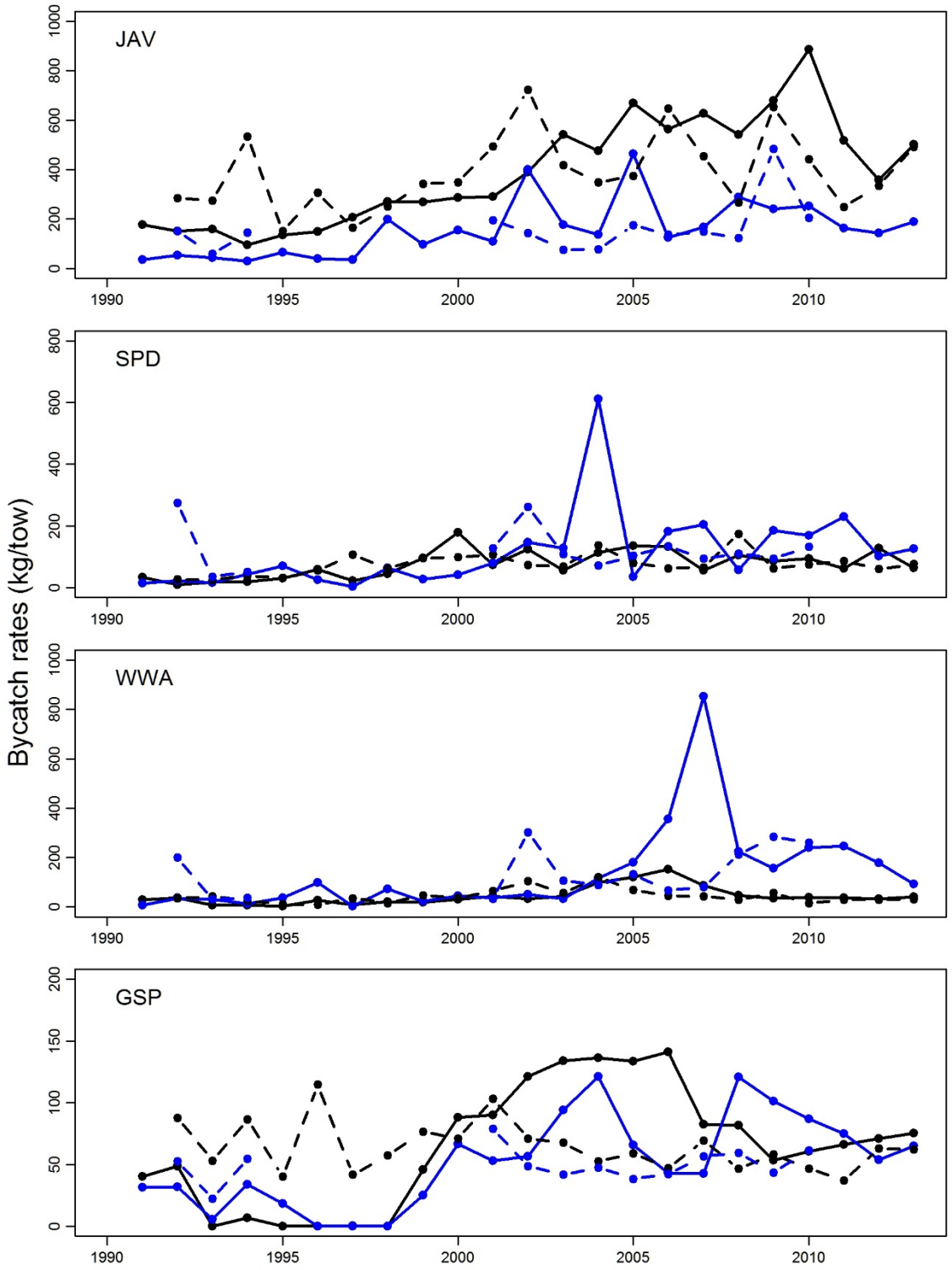


Figure 24: Comparison of bycatch rates (calculated using the tow-based estimator) by species where biomass is at least moderately well estimated in the hoki, hake, or ling target trawl Chatham Rise (black solid) and Sub-Antarctic (blue solid) fisheries with biomass from the *Tangaroa* Chatham Rise (black dashed) and Sub-Antarctic (blue dashed) summer trawl surveys. Bycatch rates are the median of the bootstrap sample of 1000. Biomass is scaled to bycatch rates.

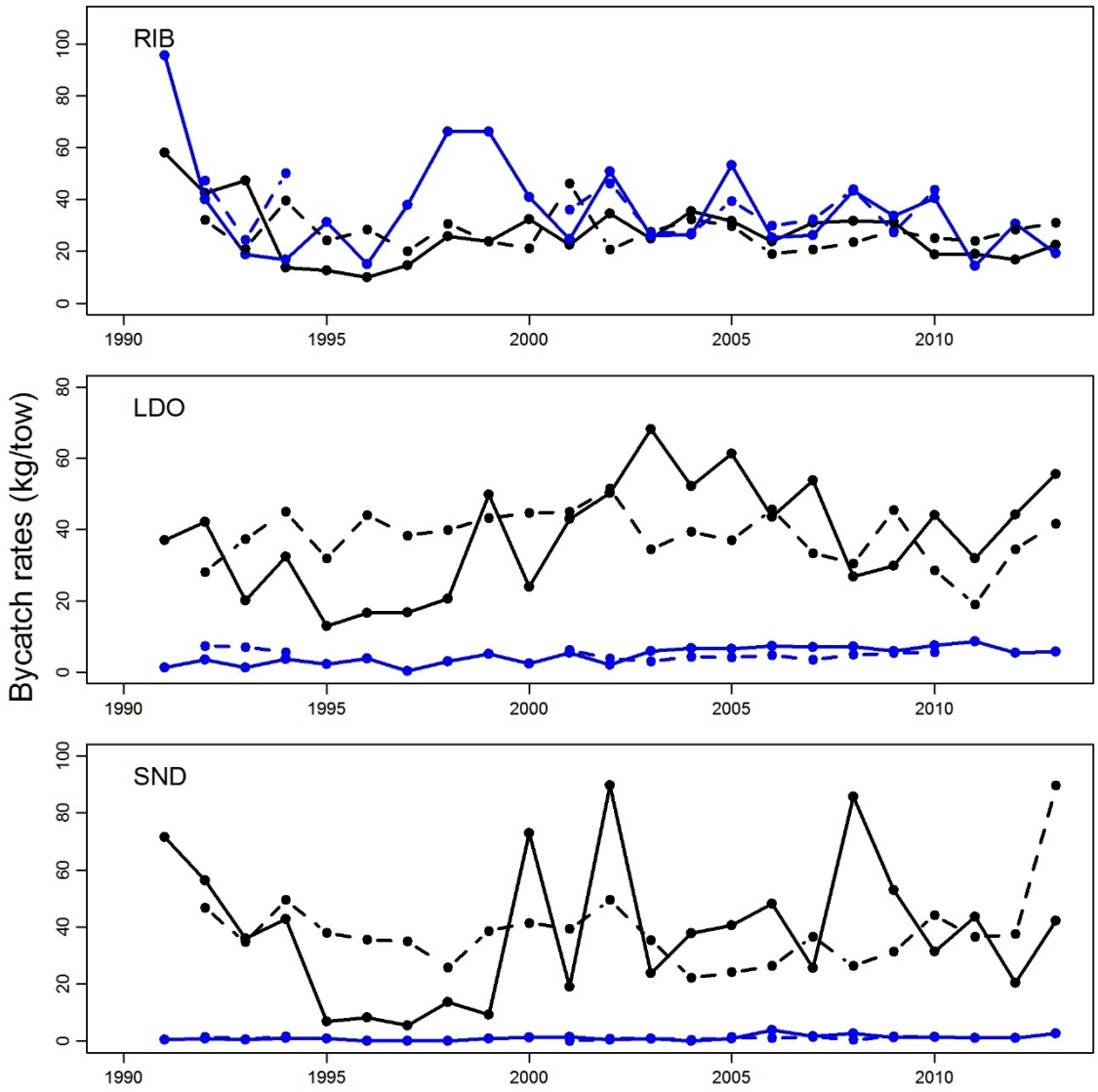


Figure 24: continued.

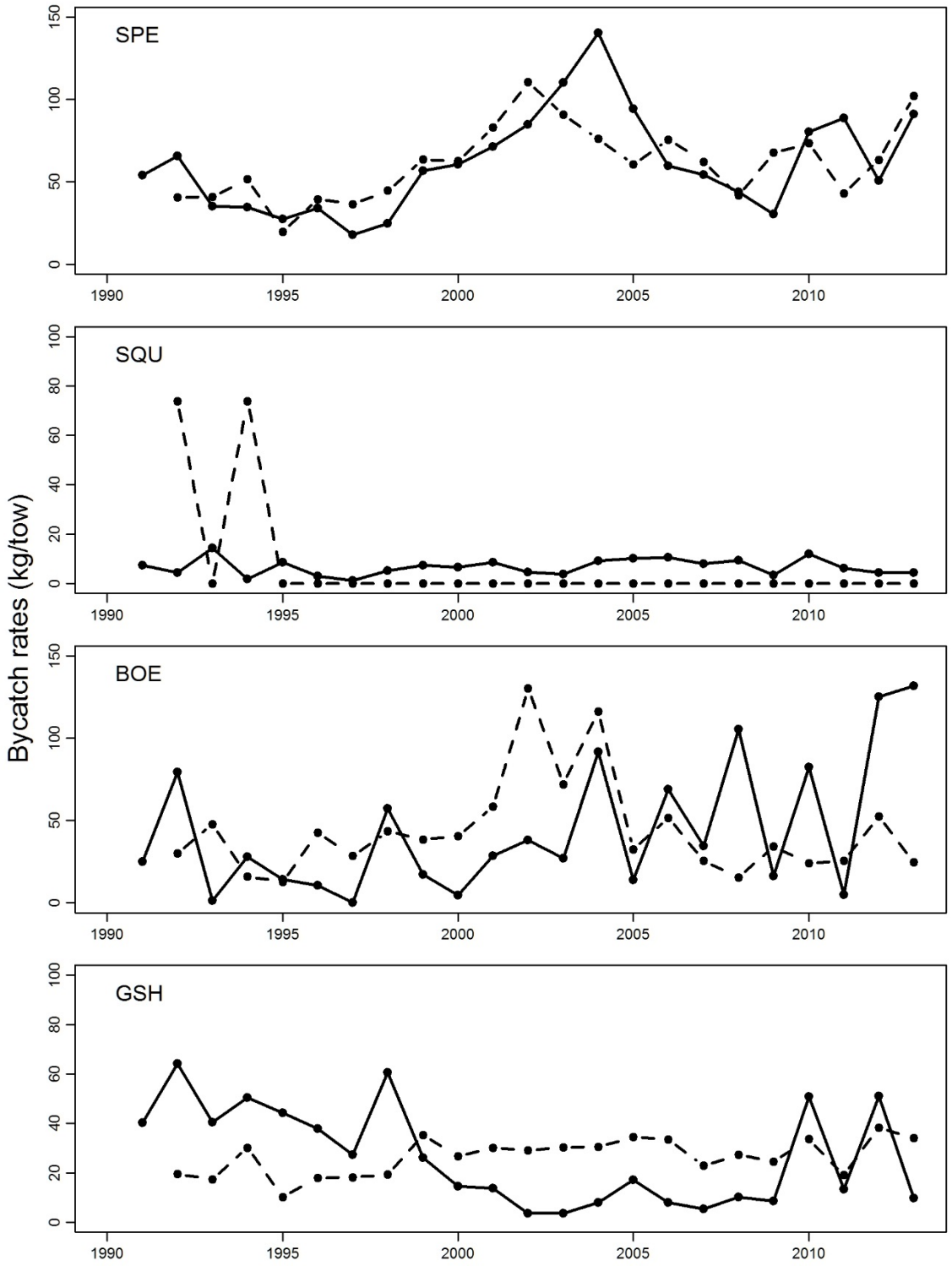


Figure 24: continued.

APPENDIX A

Table A1: Observed fish bycatch. Species codes, common and scientific names, estimated catch, percentage of total catch, and overall percentage discarded of the top 100 fish species or species groups by weight from observer records for the hoki, hake or ling target fishery from 1 Oct 1990 to 30 Sep 2013. Records are ordered by decreasing percentage of catch, codes in bold are QMS species; 1 = Schedule 6 QMA species; 2 = species with a minimum legal size. Estimated catches are based on all observed target hoki, hake or ling tows; discards are based on all trips where hoki, hake or ling was the sole target species.

Species code	Common name	Scientific name	Observed catch (t)	% of catch	% discarded
HOK	Hoki	*Macruronus novaezelandiae*	626 859	81.92	0.5
HAK	Hake	*Merluccius australis*	42 357	5.54	0.1
LIN	Ling	*Genypterus blacodes*	26 153	3.42	0.1
SWA	Silver warehou	*Seriolella punctata*	11 044	1.44	0.2
JAV	Javelin fish	*Lepidorhynchus denticulatus*	10 544	1.38	17.1
RAT	Rattails	*Macrouridae*	8 431	1.10	18.0
SPD [1]	Spiny dogfish	*Squalus acanthias*	6 640	0.87	69.1
FRO	Frostfish	*Lepidopus caudatus*	3 809	0.50	16.1
WWA	White warehou	*Seriolella caerulea*	2 866	0.37	0.0
GSP	Pale ghost shark	*Hydrolagus bemisi*	2 006	0.26	0.1
JMA	Greenback jack mackerel	*Trachurus declivis*	1 855	0.24	15.9
RIB	Ribaldo	*Mora moro*	1 753	0.23	0.7
SPE	Sea perch	*Helicolenus spp.*	1 470	0.19	1.5
LDO	Lookdown dory	*Cyttus traversi*	1 259	0.16	3.7
BAR	Barracouta	*Thyrsites atun*	1 144	0.15	7.6
BOE	Black oreo	*Allocyttus niger*	1 003	0.13	3.5
GSH	Dark ghost shark	*Hydrolagus novaezealandiae*	955	0.12	1.0
SND	Shovelnose dogfish	*Deania calcea*	936	0.12	58.0
GIZ	Giant stargazer	*Kathetostoma spp.*	704	0.09	0.0
RBM	Rays bream	*Brama brama*	514	0.07	4.9
SBW	Southern blue whiting	*Micromesistius australis*	511	0.07	0.4
DWD	Deepwater dogfish	-	501	0.07	82.0
SSK [1]	Smooth skate	*Dipturus innominatus*	489	0.06	9.5
RSO	Gemfish	*Rexea spp.*	485	0.06	0.0
BSH	Seal shark	*Dalatias licha*	455	0.06	70.1
OSD	Other sharks and dogs	*Selachii*	437	0.06	55.9
RCO [2]	Red cod	*Pseudophycis bachus*	400	0.05	2.4
ETB	Baxters lantern dogfish	*Etmopterus baxteri*	339	0.04	10.7
BYS	Alfonsino	*Beryx splendens*	333	0.04	2.2
MIX	Mixed fish	-	333	0.04	77.4
ORH	Orange roughy	*Hoplostethus atlanticus*	330	0.04	0.1
BSK	Basking shark	*Cetorhinus maximus*	329	0.04	99.9
WAR	Common warehou	*Seriolella brama*	285	0.04	0.0
SOR	Spiky oreo	*Neocyttus rhomboidalis*	278	0.04	0.6
RBT	Redbait	*Emmelichthys nitidus*	276	0.04	38.8
SSI	Silverside	*Argentina elongata*	268	0.03	14.7
LCH	Long.nosed chimaera	*Harriotta raleighana*	262	0.03	11.6
BNS	Bluenose	*Hyperoglyphe antarctica*	260	0.03	1.0
POS [1]	Porbeagle shark	*Lamna nasus*	222	0.03	66.7
RUD	Rudderfish	*Centrolophus niger*	199	0.03	42.6
BBE	Banded bellowsfish	*Centriscops humerosus*	197	0.03	62.1
CON	Conger eel	*Conger spp.*	179	0.02	83.5
CSQ	Leafscale gulper shark	*Centrophorus squamosus*	176	0.02	52.8
BYX	Alfonsino & long.finned beryx	*Beryx splendens & B. decadactylus*	162	0.02	7.2
BEN	Scabbardfish	*Benthodesmus spp.*	159	0.02	24.1
FHD	Deepsea flathead	*Hoplichthys haswelli*	153	0.02	55.9
DEA	Dealfish	*Trachipterus trachypterus*	150	0.02	13.2
SSO	Smooth oreo	*Pseudocyttus maculatus*	143	0.02	0.3
SKA	Skate	*Rajidae Arhynchobatidae (Families)*	115	0.02	81.4
SCH [1]	School shark	*Galeorhinus galeus*	103	0.01	12.4

Table A1 — *Continued*

Species code	Common name	Scientific name	Observed catch (t)	% of catch	% discarded
RHY	Common roughy	*Paratrachichthys trailli*	102	0.01	75.9
SDO	Silver dory	*Cyttus novaezealandiae*	102	0.01	28.5
RSK [1]	Rough skate	*Zearaja nasuta*	96	0.01	8.0
ETM	Etmopterus sp	*Etmopterus sp.*	95	0.01	85.4
TOA	Toadfish	*Neophrynichthys sp.*	81	0.01	32.5
ETL	Lucifer dogfish	*Etmopterus lucifer*	78	0.01	42.4
SWO [1]	Broadbill swordfish	*Xiphias gladius*	63	0.01	7.5
CYP	Longnose velvet dogfish	*Centroscymnus crepidater*	63	0.01	35.4
SSH	Slender smooth.hound	*Gollum attenuatus*	53	0.01	83.5
SCO	Swollenhead conger	*Bassanago bulbiceps*	50	0.01	84.6
CDL	Cardinalfish	*Epigonidae*	50	0.01	7.0
HAP	Hapuku	*Polyprion oxygeneios*	44	0.01	1.2
SNA [2]	Snapper	*Pagrus auratus*	43	0.01	60.9
HAG	Hagfish	*Eptatretus cirrhatus*	41	0.01	90.9
NSD	Northern spiny dogfish	*Squalus griffini*	39	0.01	69.5
SRH	Silver roughy	*Hoplostethus mediterraneus*	36	<0.01	70.6
BEL	Bellowsfish	*Centriscops spp.*	34	<0.01	44.4
SLK	Slickhead	*Alepocephalidae*	33	<0.01	69.4
NMP [2]	Tarakihi	*Nemadactylus macropterus & N. sp. (King tarakihi)*	31	<0.01	0.0
THR	Thresher shark	*Alopias vulpinus*	30	<0.01	86.8
RBY	Rubyfish	*Plagiogeneion rubiginosum*	30	<0.01	12.3
SBK	Spineback	*Notacanthus sexspinis*	29	<0.01	35.9
CBO	Bollons rattail	*Coelorinchus bollonsi*	28	<0.01	100.0
MAK [1]	Mako shark	*Isurus oxyrinchus*	28	<0.01	61.7
HJO	Johnson's cod	*Halargyreus johnsonii*	26	<0.01	2.2
STN [1]	Southern bluefin tuna	*Thunnus maccoyii*	25	<0.01	17.6
WHX	White rattail	*Trachyrincus aphyodes*	24	<0.01	84.0
SCM	Largespine velvet dogfish	*Centroscymnus macracanthus*	22	<0.01	72.3
ERA	Electric ray	*Torpedo fairchildi*	21	<0.01	83.3
COL	Olivers rattail	*Coelorinchus oliverianus*	21	<0.01	0.0
PLS	Plunket's shark	*Proscymnodon plunketi*	20	<0.01	41.8
SPO [12]	Rig	*Mustelus lenticulatus*	19	<0.01	21.7
SHA	Shark	-	18	<0.01	82.0
PDG	Prickly dogfish	*Oxynotus bruniensis*	17	<0.01	50.7
BEE	Basketwork eel	*Diastobranchus capensis*	16	<0.01	57.7
DSK	Deepwater spiny skate (arctic skate)	*Amblyraja hyperborea*	15	<0.01	81.4
EPT	Deepsea cardinalfish	*Epigonus telescopus*	15	<0.01	2.4
HCO	Hairy conger	*Bassanago hirsutus*	15	<0.01	38.1
EPL	Bigeye cardinalfish	*Epigonus lenimen*	14	<0.01	74.7
MOO	Moonfish	*Lampris guttatus*	14	<0.01	43.0
DWE	Deepwater eel	-	12	<0.01	38.8
WIT	Witch	*Arnoglossus scapha*	12	<0.01	14.6
TOP	Pale toadfish	*Ambophthalmos angustus*	12	<0.01	47.6
MOD	Morid cods	*Moridae*	12	<0.01	15.1
WHR	Unicorn rattail	*Trachyrincus longirostris*	12	<0.01	0.0
RDO	Rosy dory	*Cyttopsis roseus*	11	<0.01	74.6
EMA	Blue mackerel	*Scomber australasicus*	11	<0.01	6.8
CYO	Smooth skin dogfish	*Centroscymnus owstoni*	11	<0.01	62.0
APR	Catshark	*Apristurus spp.*	10	<0.01	15.3
LAN	Lantern fish	*Myctophidae*	10	<0.01	55.5

Table A2: Observed invertebrate catch. Species codes, common and scientific names, estimated catch, percentage of total catch, and overall percentage discarded of the top 100 invertebrate species or species groups by weight from observer records for the hoki, hake or ling target fishery from 1 Oct 1990 to 30 Sep 2013. Records are ordered by decreasing percentage of catch, codes in bold are QMS species; 1 = Schedule 6 QMA species; 2 = species with a minimum legal size. Estimated catches are based on all observed target hoki, hake or ling tows; discards are based on all trips where hoki, hake or ling was the sole target species.

Species code	Common name	Scientific name	Observed catch (t)	% of catch	% discarded
SQU	Arrow squid	*Nototodarus sloanii & N. gouldi*	997	0.13	2.1
WSQ	Warty squid	*Onykia spp.*	356	0.05	53.4
ONG	Sponges	*Porifera (Phylum)*	333	0.04	99.8
SFI	Starfish	*Asteroidea & Ophiuroidea*	69	0.01	62.7
HYA	Floppy tubular sponge	*Hyalascus sp.*	57	0.01	100.0
MIQ	Warty squid	*Onykia ingens*	52	0.01	5.8
GLS	Glass sponges	*Hexactinellida (Class)*	43	0.01	100.0
SCI	Scampi	*Metanephrops challengeri*	34	<0.01	15.1
OPI	Umbrella octopus	*Opisthoteuthis spp.*	17	<0.01	94.5
HOR	Horse mussel	*Atrina zelandica*	17	<0.01	0.0
SQX	Squid	-	15	<0.01	52.4
RSQ	Ommastrephes bartrami	*Ommastrephes bartrami*	13	<0.01	94.9
GSQ	Giant squid	*Architeuthis spp.*	13	<0.01	72.8
WHE	Whelks	-	10	<0.01	53.0
OCT	Octopus	*Pinnoctopus cordiformis*	10	<0.01	62.9
TSQ	Todarodes filippovae	*Todarodes filippovae*	9	<0.01	12.8
BSQ	Broad squid	*Sepioteuthis australis*	9	<0.01	93.5
TAM	Tam O shanter urchin	*Echinothuriidae & Phormosomatidae*	8	<0.01	78.2
DWO	Deepwater octopus	*Graneledone spp.*	7	<0.01	81.9
FMA	Fusitriton magellanicus	*Fusitriton magellanicus*	7	<0.01	33.1
CRB	Crab	-	7	<0.01	70.7
VSQ	Violet squid	*Histioteuthis spp.*	7	<0.01	88.0
ACS	Deepsea anemone	*Actinostolidae*	6	<0.01	89.8
GSC [1]	Giant spider crab	*Jacquinotia edwardsii*	4	<0.01	2.2
ECH	Echinoderms	*Echinodermata* (Phylum)	4	<0.01	99.4
ANT	Anemones	*Anthozoa*	4	<0.01	94.4
SPI	Spider crab	-	4	<0.01	50.8
BPI	Benthopecten pikei	*Benthopecten pikei*	4	<0.01	0.0
MOL	Molluscs	-	3	<0.01	55.4
GAS	Gastropods	*Gastropoda*	3	<0.01	85.3
PSI	Geometric star	*Psilaster acuminatus*	2	<0.01	65.4
PKN	Abyssal star	*Plutonaster knoxi*	2	<0.01	0.4
CPA	Pentagon star	*Ceramaster patagonicus*	2	<0.01	7.4
ZOR	Rat.tail star	*Zoroaster spp.*	2	<0.01	7.0
URO	Sea urchin other	-	2	<0.01	95.9
LHO	Omega prawn	*Lipkius holthuisi*	2	<0.01	60.4
LNV	Rock star	*Lithosoma novaezelandiae*	2	<0.01	11.6
CJA	Sun star	*Crossaster multispinus*	2	<0.01	48.6
GRM	Sea urchin	*Gracilechinus multidentatus*	1	<0.01	4.5
KIC [1]	King crab	*Lithodes murrayi Neolithodes brodiei*	1	<0.01	1.2
SUR [1]	Kina	*Evechinus chloroticus*	1	<0.01	45.3
HTR	Trojan starfish	*Hippasteria phrygiana*	1	<0.01	15.4
LMU	Murray's king crab	*Lithodes murrayi*	1	<0.01	0.0
JFI	Jellyfish	-	1	<0.01	85.7
HMT	Deepsea anemone	*Hormathiidae*	1	<0.01	91.1
HTH	Sea cucumber	*Holothurian unidentified*	1	<0.01	9.1
CTU	Cooks turban shell	*Cookia sulcata*	1	<0.01	0.0
DMG	Dipsacaster magnificus	*Dipsacaster magnificus*	1	<0.01	22.2
SSP	Scallop spat	*Pecten novaezelandiae*	1	<0.01	0.0
PLT	Plutonaster spp	*Plutonaster spp.*	1	<0.01	0.0

Table A2 — *Continued*

Species code	Common name	Scientific name	Observed catch (t)	% of catch	% discarded
PSQ	Large red scaly squid	*Pholidoteuthis massyae*	1	<0.01	47.0
ASR	Asteroid (starfish)	-	1	<0.01	42.7
GOR	Gorgonocephalus spp	*Gorgonocephalus spp.*	1	<0.01	65.0
COU	Coral (unspecified)	*Alcyonacea Gorgonacea Scleractinia Antipatharia (Orders) & Stylasteridae (Family)*	1	<0.01	99.2
PRA	Prawn	-	1	<0.01	57.5
CRU	Crustacea	-	1	<0.01	100.0
SOT	Solaster torulatus	*Solaster torulatus*	1	<0.01	16.7
TLD	Furry oval sponge	*Tetilla leptoderma*	1	<0.01	0.0
ECT	Echinothuriidae (family)	*Echinothuriidae (family)*	1	<0.01	80.0
SDM	Pagurid	*Sympagurus dimorphus*	1	<0.01	33.3

Table A3: Observed bycatch by species group. Estimated catch, percentage of total catch, and overall percentage discarded by species group from observer records for the hoki, hake, or ling target trawl fishery for fishing years 1990–2013 and 2009–2013 . Estimated catches are based on all observed target hoki, hake, or ling tows; discards are based on all trips where hoki, hake, or ling was the target species. Fish (other) includes hoki, hake, and ling.

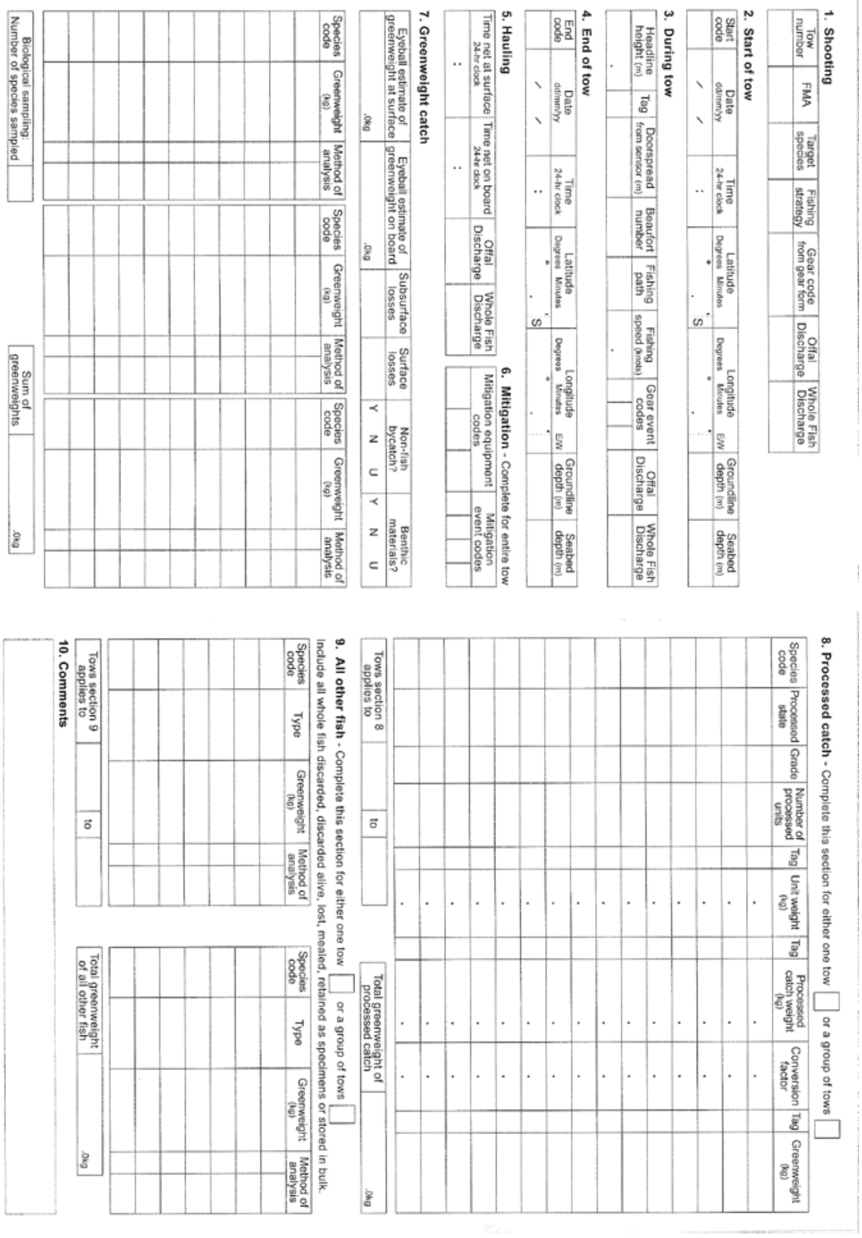
(a) 1991–2013

Group	Observed catch (t)	% of catch	% discarded
Fish			
Fish (other)	728 808	95.33	0.70
Sharks & dogfish	10 703	1.40	64.60
Javelinfish	10 544	1.38	17.10
Rattails	8 431	1.10	18.00
Chimaeras	3 233	0.42	1.70
Rays & Skates	769	0.10	28.10
Eels	311	0.04	75.00
Tuna	51	0.01	19.00
Flatfish	23	<0.01	9.10
Invertebrates			
Squid	1 472	0.19	20.30
Crustacea	56	0.01	22.60
Other molluscs	42	0.01	42.90
Octopuses	34	<0.01	84.00
Sponges	-	<0.01	<0.01
Polychaetes	-	<0.01	<0.01
Echinoderms	-	<0.01	<0.01
Cnidaria	-	<0.01	<0.01

(b) 2009–2013

Group	Observed catch (t)	% of catch	% discarded
Fish			
Fish (other)	159 434	94.19	0.70
Javelinfish	3 008	1.78	13.60
Rattails	2 721	1.61	12.40
Sharks & dogfish	2 501	1.48	42.10
Chimaeras	758	0.45	1.50
Rays & Skates	251	0.15	9.20
Eels	126	0.07	75.20
Tuna	12	0.01	<0.01
Flatfish	6	<0.01	<0.01
Invertebrates			
Squid	413	0.24	7.00
Octopuses	19	0.01	76.50
Crustacea	13	0.01	8.30
Other molluscs	3	<0.01	40.00
Sponges	-	<0.01	<0.01
Polychaetes	-	<0.01	<0.01
Echinoderms	-	<0.01	<0.01
Cnidaria	-	<0.01	<0.01

Table A4: The observer catch effort logbook form version 0308.



1. Shooting

Tow number	FMA	Target species	Fishing strategy	Gear code from gear form	Offal Discharge	Whole Fish Discharge

2. Start of tow

Start code	Date dd/mm/yy	Time 24-hr clock	Latitude Degrees Minutes	Longitude Degrees Minutes E/W	Groundline depth (m)	Seabed depth (m)
	/ /	:	° . S	° .		

3. During tow

Headline height (m)	Tag	Doorspread from sensor (m)	Beaufort number	Fishing path	Fishing speed (knots)	Gear event codes	Offal Discharge	Whole Fish Discharge
.					.			

4. End of tow

End code	Date dd/mm/yy	Time 24-hr clock	Latitude Degrees Minutes	Longitude Degrees Minutes E/W	Groundline depth (m)	Seabed depth (m)
	/ /	:	° . S	° .		

5. Hauling

Time net at surface 24-hr clock	Time net on board 24-hr clock	Offal Discharge	Whole Fish Discharge
:	:		

6. Mitigation - Complete for entire tow

Mitigation equipment codes	Mitigation event codes

7. Greenweight catch

Eyeball estimate of greenweight at surface	Eyeball estimate of greenweight on board	Subsurface losses	Surface losses	Non-fish bycatch?	Benthic materials?
.0kg	.0kg			Y N U	Y N U

Species code	Greenweight (kg)	Method of analysis	Species code	Greenweight (kg)	Method of analysis	Species code	Greenweight (kg)	Method of analysis

Biological sampling: Number of species sampled | Sum of greenweights .0kg

8. Processed catch - Complete this section for either one tow ☐ or a group of tows ☐

Species code	Processed state	Grade	Number of processed units	Tag	Unit weight (kg)	Tag	Processed catch weight (kg)	Conversion factor	Tag	Greenweight (kg)
					.		.	.		

Tows section 8 applies to ___ to ___ | Total greenweight of processed catch .0kg

9. All other fish - Complete this section for either one tow ☐ or a group of tows ☐

Include all whole fish discarded, discarded alive, lost, mealed, retained as specimens or stored in bulk.

Species code	Type	Greenweight (kg)	Method of analysis	Species code	Type	Greenweight (kg)	Method of analysis

Tows section 9 applies to ___ to ___ | Total greenweight of all other fish .0kg

10. Comments

Table A5. List of tables and fields requested in the MPI extract 9171.

Fishing_events table

Event_Key	Effort_total_num	Column_a
Version_seqno	Effort_width	Column_b
DCF_key	Effort_speed	Column_c
Start_datetime	Total_net_length	Column_d
End_datetime	Total_hook_num	Display_fishyear
Primary_method	Set_end_datetime	Start_stats_area_code
Target_species	Haul_start_datetime	Vessel_key
Fishing_duration	Start_latitude (full accuracy)	Form_type
Catch_weight	Start_longitude (full accuracy)	Trip
Effort_depth	End_latitude (full accuracy)	Literal_yn
Effort_height	End_longitude (full accuracy)	Interp_yn
Effort_num	Pair_trawl_yn	Resrch_yn
Effort_num_2	Bottom_depth	
Effort_seqno		

Landing_events table

Event_Key	Destination_type	Trip_key
Version_seqno	Unit_type	Trip_start_datetime
DCF_key	Unit_num	Trip_end_datetime
Landing_datetime	Unit_weight	Vessel_key
Landing_name	Conv_factor	Form_type
Species_code	Green_weight	Literal_yn
Species_name	Green_weight_type	Interp_yn
Fishstock_code (ALL fish stocks)	Processed_weight	Resrch_yn
	Processed_weight_type	
State_code	Form_type	

Estimated subcatch table

Event_Key	Species_code (ALL species for each fishing event)	Literal_yn
Version_seqno		Interp_yn
DCF_key	Catch_weight	Resrch_yn

Process data table

Event_Key	Unit_type	Processed_weight_type
Version_seqno	Unit_num	Vessel_key
DCF_key	Unit_weight	Form_type
Spec_prod_action_type	Conv_factor	Trip_key
Processed_datatime	Green_weight	Literal_yn
Species_code	Green_weight_type	Interp_yn
State_code	Processed_weight	Resrch_yn

Vessel_history table

Vessel_key	Engine_kilowatts	History_start_datetime
Flag_nationality_code	Gross_tonnes	History_end_datetime
Built_year	Overall_length_metres	

Table A6: Number of years of observer data required to provide more than 50 records for bycatch and discard rate calculations.

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	1	1	4	1	1	1	7
1992	1	1	4	1	1	1	7
1993	1	1	3	1	1	1	7
1994	1	1	3	1	1	1	7
1995	1	1	3	1	1	3	7
1996	1	1	5	1	1	1	5
1997	1	3	3	1	1	3	3
1998	1	1	1	1	1	3	1
1999	1	1	1	1	1	5	1
2000	1	1	1	1	1	3	3
2001	1	1	1	1	1	1	3
2002	1	1	1	1	1	1	3
2003	1	1	1	1	1	1	1
2004	1	1	1	1	1	3	1
2005	1	1	1	1	1	1	3
2006	1	1	1	1	1	3	1
2007	1	1	1	1	1	3	3
2008	1	1	1	1	1	5	1
2009	1	1	1	1	1	7	1
2010	1	1	1	1	1	5	3
2011	1	1	1	1	1	3	3
2012	1	1	1	1	1	1	3
2013	1	1	1	1	1	1	1

Table A7: Bycatch rates (t tow^{-1}) of species groups in the hoki, hake, or ling target trawl fishery, by area and fishing year, based on observed catch data. Bycatch rates are the median of the bootstrap sample of 1000, rounded to the nearest whole number. Some rates based on additional records from adjacent years (see Table A6).

(a) QMS fish species (t tow^{-1})

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	962.5	673.4	52.5	840.9	218.7	173.9	668.9
1992	871	779.3	52.1	578.7	240.2	280.1	674.6
1993	303.9	591.5	51.7	499.3	141.8	142.9	505.5
1994	945.6	566.1	52.1	320.5	206.4	357.3	611.5
1995	1209	689.4	200.4	384.9	249.4	231.4	625.4
1996	1453.6	608.7	301.9	466.5	309.9	162.2	699.5
1997	1178.3	540.1	340.3	493.5	140	292	568.3
1998	1191.9	442.4	350.1	444	339.4	660.1	663
1999	770.6	642.8	396.2	467.9	244.8	1019.8	603.5
2000	689.2	894.5	649.3	738	368.9	1927.8	858.7
2001	781.1	610.7	363.8	681	622.9	2276.7	892.4
2002	639	558.8	327.5	616.5	405.1	1745.3	722.6
2003	586.5	470.9	764.2	764	453.6	834.8	668.1
2004	554.9	1020.3	305.4	1273.7	1181.3	700.5	765.8
2005	677.7	909.8	483.9	869.4	443.6	535.3	647.3
2006	420.5	780	244.9	1091.3	906.5	883.1	773.5
2007	561	751.5	430.2	739.8	1510.9	1133.5	836.8
2008	606.1	860	334.9	890.9	776.7	1196.7	737.9
2009	757.8	952.6	173.6	540.3	870.5	881	636.3
2010	189.2	546.8	155.9	1112.7	703	606	517.6
2011	314.1	850	183.8	685.3	912.5	622.3	571.7
2012	376.8	750.7	266.6	872	525.5	475.4	607.1
2013	342.2	972.2	229.5	808.1	660.5	1390.9	855.5

Table A7: continued.

(b) **non-QMS fish species (t tow^{-1})**

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	31.1	45.1	15.5	683.1	323.3	118.3	218.5
1992	22.2	168.2	15.8	730.4	190.1	87.5	219.3
1993	27.3	67.4	15.4	341.6	134.7	94.7	143.5
1994	10.9	138.9	15.3	354.2	96.1	34.8	136.9
1995	96.7	253.3	16.4	365.7	204.8	33.3	201.7
1996	42.9	63.1	14	483	155.7	39.1	174.8
1997	48.2	85.7	15.3	720	141.3	49.4	216.2
1998	79.8	114.9	19.3	603.6	502.5	181	283.5
1999	86.4	223.9	11.3	687.4	311.6	384.5	350.6
2000	51.9	435.1	4.1	723.6	311.4	301.1	359
2001	74.1	198.8	10.8	721.1	268.9	248.7	317.7
2002	185.9	234.1	8.4	1066.3	707.8	187.4	430.9
2003	91.9	202.2	4	1144.7	364.5	165.8	357.1
2004	76.5	344.1	6	1250.2	316.8	161	380.6
2005	134.1	196.9	32.2	1344	757.4	57	429.8
2006	97.7	383.8	14.6	1251.5	278.7	497.2	445
2007	94.3	319.9	35.9	1028.5	324.3	837.1	498.9
2008	104.8	585.7	40	1297.4	528.4	870.2	571.4
2009	117.8	928.2	9.1	1447.2	445.8	725.5	587.6
2010	61.5	266.4	214.1	1877.5	534.7	579.4	595.7
2011	46	465.4	12.4	1141.4	467.7	625.9	506.4
2012	46.2	256.7	40.8	947.8	374.7	410.3	383.2
2013	72	731.5	77.6	1280.9	429.4	1083.9	613.3

(c) Invertebrate species (t tow^{-1})

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	7.5	64.3	0.8	14.1	38.6	21.3	26.1
1992	9.7	159.3	0.8	32.4	34.2	38.5	45.2
1993	2.7	15.6	0.8	29.4	20.4	21.5	18.7
1994	6.7	101.5	0.8	15.2	32.5	6	28.3
1995	12.4	149.9	0.4	13.2	32.4	8.1	32.4
1996	5.4	7.2	0.7	11.4	35.1	7.6	10.9
1997	6.1	8.4	0.7	10.3	10.4	8.4	7.7
1998	5.2	9.8	0.8	14	31.8	13	12.1
1999	6.9	11.4	0.4	30.6	36.8	16.5	20
2000	3.4	20.9	0.2	63.7	40.5	35.4	28.1
2001	10.3	34.9	0.1	51.9	72.1	44.1	33.3
2002	35.5	63	0.1	68.6	67.5	28.5	40.2
2003	12.1	54.6	0.3	26	60.5	15	26.4
2004	20	95.3	28.1	32.7	34.9	12.4	34.9
2005	9.8	51.9	1	32.1	66.2	7.8	26.4
2006	4.5	65.2	0.2	30.6	45.7	44.5	31.5
2007	18	82.2	1.2	15.3	46.4	75.1	36.2
2008	10.7	48.1	0.6	28.5	63.7	76.7	33.7
2009	18.4	48.4	0.6	9.7	47.8	71.7	29.1
2010	17.2	24	0.9	27.2	82.1	62.7	32
2011	11	63.6	0.2	19.5	96	65.4	38
2012	17	51.5	0.6	11.6	57.8	54.5	28.9
2013	11.4	95.5	0.5	19.7	57.1	132.3	47.4

Table A8: Discard rates (kg tow^{-1}) of species groups in the hoki, hake, or ling target trawl fishery, by area and fishing year, based on observed discard data. Discard rates are the median of the bootstrap sample of 1000, rounded to the nearest whole number

(a) Hoki, hake or ling (kg tow^{-1})

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	641.2	405.2	293.4	147.6	38	252.1	269.1
1992	371.7	179.1	279.1	107.2	38.5	223	187.2
1993	823.2	69.7	272.1	173.4	0	488.9	278.2
1994	647	219.5	279.6	53.3	33	371.1	241.5
1995	649	30.3	284.7	137.2	44	901.9	307.1
1996	401.4	78.7	268.7	35.8	0	979.8	265.3
1997	501.9	25.4	72.1	14.4	18.5	941.9	236.6
1998	0	0	0	0	0	0	0
1999	146	2.5	53.6	10.8	33.5	2.4	41.1
2000	17.3	185.7	1.6	1.7	8.6	2.4	34.8
2001	131	0.6	82.6	3.4	2	3.3	33.4
2002	2.2	89.1	17.8	2	0	67.9	84.8
2003	190.4	38.3	0.6	11.3	0.6	226.2	147.6
2004	55.1	43.4	114.8	13	0	274.8	86.1
2005	7.4	73.3	92	0.1	1.1	188.1	85.7
2006	0.8	3.6	151.7	0.2	1.5	144.5	115.2
2007	79.8	88.7	120.6	12.8	21.6	154.3	78.4
2008	0	7.8	2.7	5.1	4.6	65	14.1
2009	36	17.3	57.7	9.5	14.6	63.8	31.9
2010	15.5	10.4	53.6	123.8	30.1	81.6	51.7
2011	51.8	43.6	360.5	66.3	128	92.8	116
2012	17.1	47.4	32.4	17.2	134.9	64.3	51.5
2013	57	160	0	16.1	41.6	293.1	83.2

(b) QMS fish species (kg tow^{-1})

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	132.5	13.7	181.8	56.3	17.3	30.1	89.2
1992	131.9	115.3	190.1	68.1	0.4	30.6	102.8
1993	46.7	179.3	181.8	53.3	78	74.1	115.6
1994	215.9	60.8	185.9	46	55.8	56.1	115.4
1995	229.8	3.2	184.4	16.4	49.6	50.7	103.8
1996	291.3	169.6	175.4	41.1	70.8	20.6	155
1997	284.1	101.5	308	10.9	9.8	21.6	134.7
1998	0	0	0	0	0	0	0
1999	211.7	76.2	308.2	127.1	27.4	110.3	153
2000	104.5	160.1	544	168.2	61.5	109.8	191.7
2001	74.5	103.1	299.4	98.9	48.8	65.1	112.3
2002	63.4	84.7	272.2	137.1	86.6	54.3	115.9
2003	95.7	89.9	641	71.6	153.3	37.9	175.6
2004	52.7	71.8	234.9	108.6	109.5	45.1	94
2005	8.7	75.1	145.4	54.6	53.9	38	60.4
2006	12.1	50	260.1	49.5	453.4	41.4	129.2
2007	47.5	22.8	362.7	30.5	50	42.2	82.7
2008	29.6	16.3	251.2	24.3	13.8	34.4	53.8
2009	31.8	36.1	167	34.8	24.6	19.8	47.6
2010	8.9	20.9	96.8	46.8	66.6	20.7	38.5
2011	7.6	15.9	144	17.5	87.7	13.9	42.1
2012	98.6	186.8	147.9	65.2	88	9.1	87.9
2013	85.1	243.7	39.8	26.1	111.9	88.7	90.5

Table A8: continued.

(c) non-QMS fish species (kg tow^{-1})

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	13.2	44	11.7	387.7	328.4	104.7	153.9
1992	19.7	40.3	11.1	735.6	253	131.1	200.1
1993	3.1	20.3	11.4	46.4	47.1	152.2	69.8
1994	6.3	134.6	11.4	200.6	60.6	111.7	103.4
1995	101.3	252.8	11.4	57.8	48.4	32.6	102.6
1996	11.5	269.9	10.8	237.2	58.8	22.5	111.8
1997	27.5	266.1	7.6	218.6	197.2	44.4	132
1998	0	0	0	0	0	0	0
1999	58.8	270.1	7	176.4	169.6	221.2	161.9
2000	4.8	296.8	2.4	502.2	123.5	216.6	196
2001	33.8	65.8	8.5	454.3	213	178.1	158.4
2002	208.8	239.1	0.7	742.7	252.3	116.2	229.7
2003	52.9	138.9	3.7	681.4	139.9	33	154.7
2004	30.7	376.5	6.3	299.8	173.6	40.9	149.2
2005	8.1	117.2	34.4	63.9	218	495.5	150.6
2006	36	559.9	24.1	99.8	276.2	416.7	228
2007	15.9	227.1	23.6	251.2	34.3	478.2	189
2008	5.2	412.1	39.8	231	64.8	891.3	284.1
2009	22.3	694.2	3.5	514.9	29.6	590.7	321.2
2010	7.5	186.2	70.8	1126.2	48.7	456.5	341.7
2011	3.5	338.4	11.8	522.5	224.7	527	302.2
2012	4.4	198.6	43.5	170.7	108.1	324.1	136.3
2013	14.6	660.1	50.6	518.7	128.8	748.1	309.9

(d) Invertebrate species (kg tow^{-1})

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	1.4	4.7	0.3	2.7	30.6	6.6	7.7
1992	0.6	2.3	0.4	37.9	1	5	7.7
1993	0	1.3	0.4	3.5	12.1	0.6	3.6
1994	0.5	44.2	0.3	13.5	30.4	0.3	13.8
1995	2	0	0.3	15	32.7	1.6	8.6
1996	1.3	0	0.3	0.6	0	2.6	1.7
1997	1.4	1	0.2	8.6	15	0.7	4.9
1998	0	0	0	0	0	0	0
1999	1.9	1.5	0.2	31.1	33.5	2.5	11.9
2000	0.6	3.4	0	128.1	35.6	2.4	25.8
2001	0.6	0.4	0	51.4	28	1.4	12.6
2002	10.4	6	0	105.5	73.7	0.9	28.9
2003	1.6	2.9	0	26.6	28.3	0.2	9.7
2004	0.5	3.9	0	11.1	32.6	0	7.3
2005	0.1	1.9	0	20	27.1	1.5	7.7
2006	0.8	5.5	0.2	23.5	23	1.9	8.3
2007	0.8	3.1	0.3	7	4.3	1.8	2.8
2008	1.3	22	0.1	9.6	12	8.6	8.1
2009	2.1	35.7	0.1	3.4	5.2	7.1	8.6
2010	0.8	3.2	0.4	14.2	14.2	7.8	6.5
2011	0.4	17.4	0	8.3	34.3	8.5	10.3
2012	0.5	10.5	0	1.5	20	4.7	5.6
2013	0.8	18.9	0.2	8.6	11.5	8.7	7

Table A9: Hoki, hake, and ling trawl fishery. Total annual bycatch estimates (t) calculated using the tow-based estimator (with estimated CVs in parentheses where available—see text) for individual species, based on observer catch rates. Species are ordered by decreasing total catch. The slope of a linear regression through the data points is shown on the last line. See http://marlin.niwa.co.nz for species code definitions).

Fishing	Species									
year	SWA	JAV	RAT	SPD	FRO	WWA	GSP	JMA	RIB	SPE
1991	4 580 (21)	1 120 (14)	1 000 (13)	700 (18)	1 830 (24)	220 (36)	350 (35)	1 320 (28)	760 (9)	300 (23)
1992	2 000 (24)	1 350 (26)	2 160 (42)	1 060 (26)	1 300 (39)	550 (34)	520 (55)	1 020 (33)	670 (7)	470 (24)
1993	2 020 (30)	1 460 (18)	630 (25)	650 (15)	500 (13)	350 (51)	40 (32)	560 (92)	620 (44)	280 (40)
1994	3 690 (21)	660 (21)	860 (24)	1 670 (18)	1 390 (15)	180 (43)	140 (32)	1 410 (39)	180 (18)	250 (23)
1995	2 660 (13)	1 610 (21)	1 710 (26)	3 590 (21)	2 020 (26)	170 (51)	60 (61)	4 430 (36)	320 (15)	360 (20)
1996	5 540 (17)	1 860 (40)	3 460 (29)	5 530 (17)	800 (21)	790 (31)	- (-)	2 170 (72)	230 (27)	450 (47)
1997	8 740 (23)	2 700 (28)	4 100 (19)	3 970 (16)	2 200 (32)	210 (32)	- (-)	1 080 (53)	400 (30)	340 (32)
1998	5 840 (20)	5 480 (13)	4 430 (15)	5 370 (19)	920 (19)	840 (39)	- (-)	510 (56)	860 (20)	500 (17)
1999	3 160 (14)	4 560 (17)	4 330 (13)	5 070 (16)	1 680 (35)	450 (26)	790 (28)	260 (42)	800 (13)	870 (8)
2000	7 240 (19)	4 950 (16)	3 360 (13)	6 930 (16)	1 160 (19)	1 020 (32)	1 570 (23)	270 (52)	930 (20)	850 (30)
2001	9 360 (22)	4 420 (15)	3 610 (11)	3 680 (13)	2 090 (21)	770 (19)	1 400 (15)	30 (75)	540 (17)	870 (21)
2002	2 780 (26)	7 110 (19)	5 040 (21)	3 800 (21)	1 700 (28)	840 (27)	1 610 (13)	10 (53)	1 210 (22)	970 (19)
2003	3 140 (27)	6 640 (13)	4 830 (20)	4 920 (22)	1 610 (20)	860 (20)	1 860 (11)	50 (63)	570 (15)	1 210 (18)
2004	6 430 (14)	4 800 (11)	4 670 (30)	4 860 (36)	1 200 (23)	1 430 (21)	1 600 (9)	330 (83)	570 (10)	1 220 (38)
2005	2 010 (13)	5 380 (20)	2 970 (31)	2 110 (17)	960 (15)	1 380 (14)	970 (17)	370 (271)	420 (13)	620 (9)
2006	3 260 (14)	3 730 (16)	2 720 (17)	1 910 (16)	600 (17)	1 720 (28)	860 (17)	20 (34)	480 (24)	410 (21)
2007	2 670 (15)	4 110 (18)	1 530 (10)	1 780 (30)	640 (26)	2 650 (31)	570 (14)	30 (104)	400 (23)	340 (18)
2008	2 320 (36)	3 700 (11)	2 540 (25)	1 480 (17)	420 (39)	980 (19)	700 (14)	20 (56)	950 (17)	310 (16)
2009	1 300 (18)	4 010 (12)	3 210 (21)	1 230 (12)	240 (26)	700 (16)	450 (12)	80 (134)	920 (18)	260 (14)
2010	2 710 (25)	4 760 (17)	3 760 (17)	1 280 (12)	80 (22)	740 (27)	460 (22)	10 (14)	290 (25)	430 (31)
2011	2 310 (19)	2 890 (12)	2 480 (16)	1 340 (12)	100 (28)	710 (31)	430 (16)	10 (109)	380 (38)	470 (31)
2012	2 010 (16)	2 090 (15)	2 170 (15)	2 140 (10)	160 (25)	580 (18)	430 (13)	40 (44)	290 (33)	300 (13)
2013	2 480 (14)	3 250 (10)	3 200 (11)	1 360 (10)	290 (38)	580 (20)	490 (14)	70 (67)	410 (12)	500 (32)
slope	-0.03	0.05	0.03	-0.01	-0.11	0.06	0.18	-0.22	0.00	0.00

Fishing	Species									
year	LDO	BAR	SQU	BOE	GSH	SND	SHA	GIZ	SBW	RBM
1991	320 (26)	310 (33)	260 (19)	130 (61)	530 (15)	400 (17)	- (-)	320 (32)	- (-)	40 (16)
1992	460 (17)	400 (41)	370 (16)	540 (45)	780 (19)	430 (29)	- (-)	320 (25)	40 (59)	40 (30)
1993	220 (34)	360 (82)	200 (48)	30 (47)	550 (32)	290 (64)	10 (234)	140 (46)	- (-)	250 (27)
1994	300 (15)	180 (44)	300 (23)	160 (35)	440 (21)	290 (51)	- (-)	60 (18)	- (-)	160 (23)
1995	340 (15)	1 020 (55)	450 (10)	160 (74)	620 (29)	130 (27)	10 (103)	140 (25)	50 (81)	170 (27)
1996	260 (30)	610 (30)	180 (27)	120 (114)	630 (24)	110 (67)	- (-)	320 (39)	- (-)	480 (27)
1997	300 (35)	340 (125)	100 (13)	- (-)	530 (30)	90 (45)	- (-)	180 (42)	- (-)	780 (42)
1998	450 (18)	230 (62)	160 (17)	920 (60)	1 420 (20)	270 (25)	10 (44)	240 (13)	30 (69)	550 (33)
1999	840 (17)	140 (54)	220 (16)	260 (40)	590 (28)	210 (22)	20 (115)	330 (12)	20 (80)	410 (58)
2000	420 (15)	150 (49)	270 (29)	110 (62)	380 (29)	990 (38)	- (-)	210 (13)	50 (52)	500 (32)
2001	660 (13)	750 (82)	620 (34)	320 (88)	370 (31)	300 (25)	70 (48)	410 (18)	80 (47)	550 (26)
2002	750 (15)	260 (94)	550 (26)	380 (85)	180 (27)	920 (43)	- (-)	380 (24)	50 (67)	140 (26)
2003	890 (15)	620 (82)	490 (41)	300 (60)	180 (35)	290 (30)	- (-)	330 (14)	290 (48)	320 (30)
2004	580 (8)	390 (37)	410 (20)	770 (47)	180 (21)	350 (28)	10 (91)	360 (14)	220 (65)	180 (41)
2005	460 (16)	780 (50)	310 (19)	90 (54)	160 (28)	270 (20)	- (-)	290 (14)	20 (143)	70 (17)
2006	420 (11)	140 (37)	300 (13)	360 (57)	80 (30)	380 (17)	- (-)	270 (11)	- (-)	30 (35)
2007	410 (28)	120 (51)	290 (15)	290 (48)	80 (53)	250 (30)	- (-)	200 (12)	10 (51)	30 (21)
2008	240 (9)	80 (74)	190 (15)	540 (38)	90 (51)	560 (18)	- (-)	190 (13)	400 (60)	60 (31)
2009	250 (17)	10 (77)	100 (10)	80 (105)	90 (39)	360 (20)	- (-)	140 (24)	420 (68)	50 (37)
2010	270 (16)	90 (122)	200 (16)	400 (31)	260 (63)	200 (15)	- (-)	220 (25)	20 (80)	60 (21)
2011	300 (17)	240 (52)	290 (21)	20 (54)	120 (50)	260 (24)	- (-)	170 (16)	160 (41)	80 (21)
2012	270 (13)	30 (54)	220 (13)	560 (44)	270 (76)	130 (34)	- (-)	150 (41)	60 (53)	60 (19)
2013	470 (14)	50 (39)	320 (15)	580 (55)	160 (24)	290 (16)	- (-)	210 (14)	40 (61)	60 (15)
slope	0.00	-0.10	0.00	0.06	-0.09	0.00	-0.10	0.00	0.24	-0.07

Table A9: Hoki, hake, and ling trawl fishery. — *continued.*

Fishing	Species									
year	RSO	SSK	BSH	RCO	WSQ	ETB	BYS	ONG	BSK	ORH
1991	210 (59)	120 (20)	70 (20)	200 (31)	150 (11)	180 (19)	- (-)	10 (50)	130 (96)	480 (49)
1992	110 (20)	150 (22)	70 (30)	200 (25)	160 (31)	80 (56)	- (-)	200 (76)	90 (186)	210 (79)
1993	120 (29)	40 (22)	120 (46)	90 (25)	110 (63)	10 (96)	- (-)	- (-)	- (-)	200 (80)
1994	200 (22)	110 (44)	50 (48)	140 (35)	80 (23)	- (-)	10 (53)	40 (91)	110 (110)	250 (86)
1995	50 (32)	180 (13)	30 (24)	290 (23)	130 (14)	- (-)	320 (158)	- (-)	30 (230)	90 (102)
1996	90 (24)	140 (40)	20 (32)	350 (22)	100 (20)	- (-)	10 (49)	- (-)	- (-)	190 (107)
1997	90 (27)	80 (35)	30 (35)	150 (25)	70 (34)	- (-)	- (-)	60 (90)	140 (108)	10 (86)
1998	80 (31)	150 (28)	230 (44)	190 (43)	240 (18)	100 (76)	- (-)	80 (53)	640 (67)	10 (68)
1999	- (-)	110 (31)	470 (39)	280 (28)	170 (17)	40 (71)	40 (69)	390 (37)	290 (56)	40 (87)
2000	80 (53)	70 (53)	270 (38)	120 (38)	210 (26)	10 (96)	60 (62)	850 (57)	30 (87)	380 (89)
2001	50 (27)	160 (34)	220 (22)	120 (27)	190 (24)	- (-)	210 (31)	180 (37)	110 (71)	20 (104)
2002	70 (24)	190 (35)	1 120 (32)	70 (24)	410 (24)	- (-)	10 (26)	890 (28)	10 (169)	50 (36)
2003	240 (14)	240 (25)	260 (49)	70 (17)	180 (18)	30 (50)	220 (91)	130 (37)	190 (116)	480 (77)
2004	560 (12)	240 (18)	120 (29)	250 (40)	200 (11)	50 (46)	30 (33)	20 (128)	250 (71)	70 (56)
2005	390 (23)	140 (12)	210 (46)	190 (27)	90 (20)	20 (60)	230 (107)	80 (96)	300 (96)	50 (111)
2006	160 (31)	220 (18)	90 (29)	90 (17)	60 (13)	10 (84)	20 (28)	70 (100)	- (-)	20 (112)
2007	30 (23)	130 (19)	80 (24)	170 (23)	50 (15)	40 (58)	160 (57)	10 (84)	- (-)	60 (80)
2008	10 (35)	140 (14)	140 (19)	60 (21)	70 (12)	340 (58)	90 (47)	30 (54)	- (-)	90 (61)
2009	30 (33)	130 (20)	90 (28)	40 (28)	40 (14)	80 (26)	20 (26)	40 (117)	- (-)	110 (113)
2010	30 (28)	150 (14)	40 (33)	60 (31)	80 (12)	220 (44)	330 (33)	20 (50)	- (-)	10 (55)
2011	160 (55)	180 (14)	70 (26)	90 (35)	40 (15)	100 (27)	40 (73)	40 (105)	20 (135)	- (-)
2012	30 (28)	130 (14)	10 (36)	120 (41)	50 (21)	120 (26)	10 (39)	10 (47)	- (-)	10 (100)
2013	140 (22)	240 (12)	40 (19)	110 (29)	80 (10)	230 (19)	90 (70)	50 (62)	10 (280)	30 (73)
slope	-0.02	0.03	-0.02	-0.04	-0.05	0.21	0.26	0.09	-0.21	-0.14

Fishing	Species									
year	SOR	SSI	BNS	LCH	RBT	POS	WAR	RUD	BBE	CSQ
1991	180 (25)	10 (48)	130 (26)	60 (17)	- (-)	40 (23)	220 (44)	50 (34)	20 (62)	20 (116)
1992	110 (46)	70 (31)	90 (17)	110 (22)	10 (42)	30 (28)	280 (72)	30 (55)	20 (52)	50 (56)
1993	120 (49)	150 (26)	100 (19)	20 (39)	130 (96)	50 (24)	10 (65)	110 (22)	50 (44)	20 (73)
1994	50 (49)	20 (73)	60 (37)	40 (27)	120 (75)	50 (38)	50 (30)	50 (28)	10 (17)	- (-)
1995	20 (35)	40 (29)	70 (20)	60 (28)	10 (47)	70 (26)	170 (170)	100 (17)	40 (43)	10 (58)
1996	30 (75)	20 (51)	290 (28)	50 (42)	20 (62)	110 (26)	100 (47)	120 (41)	90 (56)	20 (64)
1997	10 (47)	20 (47)	190 (29)	40 (54)	10 (336)	170 (18)	70 (69)	90 (21)	20 (77)	20 (80)
1998	130 (41)	200 (45)	340 (22)	80 (27)	80 (366)	280 (15)	90 (167)	80 (23)	50 (53)	20 (89)
1999	190 (54)	90 (52)	100 (17)	90 (25)	- (-)	160 (21)	10 (51)	80 (20)	70 (39)	- (-)
2000	330 (38)	30 (38)	140 (50)	150 (25)	20 (35)	210 (15)	- (-)	140 (22)	50 (43)	10 (89)
2001	160 (26)	20 (21)	80 (21)	60 (32)	100 (38)	160 (17)	150 (124)	130 (21)	80 (46)	10 (73)
2002	160 (52)	60 (36)	50 (30)	140 (26)	40 (45)	100 (22)	- (-)	50 (22)	70 (46)	10 (73)
2003	60 (44)	150 (21)	40 (21)	200 (17)	40 (95)	70 (29)	10 (28)	90 (18)	140 (42)	20 (134)
2004	70 (33)	140 (49)	50 (15)	220 (13)	60 (155)	30 (26)	10 (26)	80 (22)	360 (66)	10 (62)
2005	160 (62)	60 (32)	50 (20)	180 (30)	60 (33)	30 (26)	- (-)	70 (30)	90 (30)	30 (55)
2006	40 (77)	100 (57)	70 (16)	110 (24)	50 (21)	30 (40)	- (-)	40 (19)	50 (40)	70 (36)
2007	100 (36)	160 (71)	50 (22)	70 (22)	30 (53)	10 (35)	- (-)	30 (24)	140 (63)	60 (27)
2008	180 (42)	120 (44)	30 (27)	100 (15)	40 (52)	10 (28)	- (-)	40 (20)	20 (27)	140 (16)
2009	40 (28)	50 (17)	30 (15)	50 (14)	70 (94)	20 (28)	- (-)	40 (28)	30 (40)	110 (20)
2010	40 (22)	50 (62)	50 (54)	50 (22)	40 (22)	20 (27)	80 (184)	70 (21)	70 (48)	60 (19)
2011	70 (26)	50 (59)	30 (19)	50 (24)	20 (37)	20 (17)	20 (99)	40 (14)	80 (56)	80 (13)
2012	60 (19)	50 (39)	20 (26)	100 (14)	40 (15)	20 (30)	- (-)	40 (21)	10 (46)	110 (12)
2013	50 (32)	50 (32)	30 (25)	80 (12)	110 (19)	30 (21)	- (-)	60 (15)	80 (39)	160 (14)
slope	-0.01	0.04	-0.08	0.02	0.11	-0.08	-0.31	-0.02	0.03	0.15

Table A9: Hoki, hake, and ling trawl fishery. — *continued.*

Fishing year	Species CON	BYX	BEN	FHD	DEA	SSO	SKA	SCH	RHY	ETM
1991	10 (45)	60 (103)	- (-)	10 (14)	20 (26)	60 (52)	10 (37)	20 (37)	- (-)	10 (56)
1992	20 (50)	50 (50)	- (-)	30 (27)	30 (27)	60 (34)	30 (55)	20 (22)	- (-)	80 (66)
1993	20 (50)	50 (43)	- (-)	10 (24)	300 (37)	10 (48)	30 (59)	20 (57)	- (-)	40 (29)
1994	10 (17)	110 (52)	- (-)	10 (22)	70 (54)	30 (100)	20 (32)	10 (28)	- (-)	20 (27)
1995	- (-)	70 (46)	30 (172)	30 (13)	80 (32)	10 (42)	40 (52)	20 (17)	- (-)	310 (20)
1996	10 (53)	150 (90)	10 (107)	40 (69)	50 (41)	- (-)	40 (67)	30 (27)	10 (28)	70 (53)
1997	20 (45)	160 (84)	- (-)	10 (84)	40 (18)	60 (88)	10 (119)	30 (29)	- (-)	130 (54)
1998	30 (40)	740 (71)	- (-)	30 (39)	300 (56)	10 (26)	140 (32)	30 (38)	- (-)	10 (47)
1999	10 (42)	20 (80)	20 (89)	30 (26)	50 (36)	10 (73)	130 (21)	100 (40)	- (-)	90 (56)
2000	10 (66)	10 (103)	90 (43)	20 (37)	90 (38)	110 (45)	240 (21)	80 (34)	- (-)	150 (58)
2001	20 (29)	20 (108)	80 (75)	40 (29)	200 (30)	40 (92)	210 (20)	60 (40)	10 (100)	10 (50)
2002	110 (52)	- (-)	30 (103)	100 (41)	10 (33)	90 (103)	130 (18)	40 (26)	30 (69)	20 (88)
2003	80 (31)	20 (42)	150 (60)	110 (20)	30 (16)	110 (67)	160 (17)	40 (27)	10 (32)	- (-)
2004	60 (25)	- (-)	130 (32)	120 (24)	30 (64)	30 (87)	- (-)	40 (19)	40 (88)	10 (65)
2005	40 (35)	- (-)	50 (44)	80 (27)	10 (99)	10 (127)	- (-)	40 (27)	20 (103)	- (-)
2006	20 (41)	- (-)	90 (35)	60 (22)	10 (28)	20 (41)	- (-)	30 (19)	20 (21)	70 (81)
2007	40 (57)	10 (49)	10 (45)	50 (32)	10 (26)	70 (88)	- (-)	30 (40)	10 (64)	30 (98)
2008	170 (19)	- (-)	10 (32)	60 (31)	10 (39)	40 (58)	- (-)	30 (35)	20 (17)	- (-)
2009	130 (21)	10 (274)	10 (54)	60 (19)	10 (39)	- (-)	- (-)	20 (24)	30 (13)	- (-)
2010	50 (33)	20 (78)	40 (18)	50 (29)	10 (20)	20 (54)	- (-)	40 (36)	60 (92)	- (-)
2011	80 (66)	10 (24)	20 (30)	50 (24)	20 (16)	- (-)	- (-)	30 (21)	10 (37)	- (-)
2012	40 (42)	50 (92)	10 (32)	30 (23)	20 (19)	20 (107)	- (-)	40 (17)	150 (127)	- (-)
2013	100 (33)	10 (46)	20 (11)	70 (19)	20 (23)	120 (72)	- (-)	40 (17)	30 (27)	10 (125)
slope	0.13	-0.18	0.24	0.07	-0.10	-0.04	-0.36	0.02	0.34	-0.28

Fishing year	Species SDO	RSK	TOA	ETL	ASR	CYP	CDL	SWO	HYA	SSH
1991	20 (61)	10 (45)	- (-)	- (-)	- (-)	20 (117)	10 (50)	10 (59)	- (-)	- (-)
1992	- (-)	10 (53)	10 (22)	50 (73)	- (-)	10 (10)	- (-)	10 (52)	- (-)	10 (44)
1993	- (-)	10 (52)	- (-)	- (-)	- (-)	- (-)	20 (56)	20 (49)	- (-)	- (-)
1994	- (-)	10 (33)	- (-)	- (-)	- (-)	- (-)	10 (58)	10 (40)	- (-)	- (-)
1995	- (-)	10 (33)	- (-)	10 (26)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1996	- (-)	- (-)	10 (66)	30 (61)	- (-)	10 (50)	- (-)	- (-)	- (-)	- (-)
1997	10 (30)	- (-)	20 (51)	30 (83)	- (-)	- (-)	- (-)	10 (101)	- (-)	- (-)
1998	40 (40)	20 (91)	30 (20)	10 (47)	- (-)	20 (77)	20 (76)	40 (38)	- (-)	- (-)
1999	70 (64)	50 (101)	40 (22)	20 (48)	- (-)	- (-)	- (-)	50 (27)	- (-)	- (-)
2000	10 (51)	- (-)	50 (16)	20 (27)	- (-)	- (-)	30 (42)	50 (25)	- (-)	10 (56)
2001	30 (49)	- (-)	50 (21)	20 (39)	- (-)	10 (58)	30 (377)	60 (28)	- (-)	10 (45)
2002	30 (44)	- (-)	50 (33)	40 (51)	- (-)	- (-)	20 (20)	10 (41)	- (-)	20 (102)
2003	50 (43)	- (-)	100 (25)	50 (44)	- (-)	30 (66)	20 (43)	20 (42)	- (-)	30 (46)
2004	20 (39)	100 (29)	110 (23)	10 (42)	- (-)	20 (49)	10 (26)	10 (42)	- (-)	20 (80)
2005	30 (23)	40 (37)	90 (37)	10 (62)	- (-)	- (-)	- (-)	- (-)	- (-)	40 (29)
2006	10 (26)	40 (39)	50 (31)	20 (42)	- (-)	10 (35)	10 (20)	- (-)	- (-)	- (-)
2007	10 (65)	20 (19)	10 (60)	30 (23)	- (-)	20 (34)	10 (36)	- (-)	- (-)	- (-)
2008	40 (131)	50 (73)	20 (21)	30 (16)	- (-)	70 (55)	10 (26)	10 (28)	60 (42)	10 (48)
2009	10 (66)	20 (19)	10 (36)	30 (20)	10 (53)	10 (56)	10 (39)	10 (20)	60 (88)	- (-)
2010	60 (103)	40 (20)	20 (34)	40 (31)	- (-)	40 (26)	10 (65)	10 (32)	60 (143)	10 (51)
2011	20 (54)	20 (37)	20 (26)	20 (32)	- (-)	10 (26)	20 (77)	10 (52)	20 (98)	20 (45)
2012	20 (63)	20 (32)	10 (36)	10 (22)	- (-)	30 (50)	10 (44)	10 (37)	20 (48)	20 (35)
2013	30 (37)	40 (17)	20 (17)	60 (17)	- (-)	40 (31)	10 (39)	20 (22)	40 (38)	50 (36)
slope	0.22	0.12	0.19	0.16	0.03	0.18	0.12	-0.01	0.30	0.20

Table A9: Hoki, hake, and ling trawl fishery. — *continued.*

Fishing	Species									
year	MIQ	SCO	HAP	GLS	SNA	NSD	SRH	SCI	BEL	SLK
1991	20 (56)	- (-)	10 (79)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1992	30 (50)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (35)	- (-)
1993	50 (56)	10 (55)	10 (65)	- (-)	- (-)	- (-)	- (-)	10 (64)	- (-)	- (-)
1994	10 (28)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	10 (26)	10 (41)	- (-)	- (-)	10 (75)	- (-)	- (-)	- (-)	- (-)
1996	- (-)	- (-)	10 (64)	- (-)	- (-)	- (-)	- (-)	40 (80)	- (-)	- (-)
1997	- (-)	- (-)	10 (68)	- (-)	- (-)	- (-)	- (-)	10 (63)	10 (69)	- (-)
1998	- (-)	- (-)	10 (72)	- (-)	170 (120)	- (-)	- (-)	20 (38)	10 (44)	- (-)
1999	- (-)	- (-)	10 (54)	- (-)	- (-)	- (-)	- (-)	20 (30)	50 (97)	- (-)
2000	- (-)	- (-)	20 (28)	- (-)	20 (98)	- (-)	- (-)	20 (39)	10 (71)	10 (50)
2001	10 (101)	- (-)	30 (23)	- (-)	160 (115)	10 (49)	- (-)	40 (26)	10 (62)	- (-)
2002	- (-)	- (-)	30 (34)	- (-)	- (-)	20 (239)	10 (74)	20 (21)	- (-)	20 (42)
2003	- (-)	10 (26)	20 (24)	- (-)	- (-)	30 (55)	10 (28)	20 (35)	- (-)	30 (81)
2004	- (-)	10 (52)	60 (26)	70 (72)	- (-)	10 (57)	10 (24)	20 (25)	20 (73)	110 (91)
2005	10 (75)	- (-)	20 (20)	- (-)	- (-)	30 (30)	- (-)	10 (24)	- (-)	10 (26)
2006	- (-)	50 (84)	10 (10)	210 (95)	- (-)	10 (91)	20 (68)	10 (33)	10 (72)	10 (35)
2007	- (-)	- (-)	10 (39)	10 (150)	- (-)	20 (35)	- (-)	- (-)	- (-)	- (-)
2008	10 (114)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (10)	40 (58)	30 (25)
2009	20 (44)	10 (70)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (10)	10 (37)	20 (40)
2010	40 (68)	- (-)	10 (32)	- (-)	- (-)	10 (69)	10 (67)	10 (22)	10 (63)	- (-)
2011	10 (52)	40 (91)	- (-)	- (-)	- (-)	20 (44)	20 (25)	10 (22)	10 (448)	- (-)
2012	10 (32)	- (-)	- (-)	30 (49)	- (-)	10 (26)	10 (32)	- (-)	10 (33)	- (-)
2013	10 (47)	60 (36)	10 (44)	- (-)	- (-)	20 (32)	40 (31)	10 (26)	- (-)	- (-)
slope	0.05	0.12	-0.06	0.12	-0.05	0.23	0.23	0.08	0.10	0.11

Fishing	Species									
year	NMP	THR	RBY	SBK	CBO	MAK	HJO	STN	WHX	SCM
1991	10 (68)	10 (33)	30 (154)	- (-)	10 (55)	- (-)	- (-)	- (-)	- (-)	- (-)
1992	10 (56)	10 (78)	10 (75)	10 (102)	80 (81)	- (-)	10 (39)	- (-)	- (-)	- (-)
1993	- (-)	- (-)	10 (161)	30 (42)	10 (28)	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	- (-)	10 (35)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	10 (20)	20 (40)	10 (36)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1996	20 (25)	30 (32)	10 (17)	- (-)	- (-)	60 (87)	- (-)	- (-)	- (-)	10 (73)
1997	20 (32)	30 (46)	10 (87)	- (-)	- (-)	60 (88)	- (-)	- (-)	- (-)	- (-)
1998	20 (26)	10 (30)	30 (94)	- (-)	- (-)	70 (69)	10 (68)	- (-)	- (-)	50 (92)
1999	10 (57)	60 (32)	- (-)	- (-)	- (-)	20 (43)	10 (96)	- (-)	- (-)	- (-)
2000	10 (45)	- (-)	10 (89)	10 (35)	- (-)	10 (35)	- (-)	10 (36)	- (-)	10 (82)
2001	70 (54)	30 (44)	- (-)	- (-)	- (-)	20 (44)	- (-)	10 (64)	10 (70)	30 (75)
2002	- (-)	20 (39)	10 (151)	10 (107)	- (-)	10 (66)	80 (113)	10 (75)	40 (102)	- (-)
2003	- (-)	10 (35)	10 (128)	10 (44)	- (-)	20 (43)	30 (54)	10 (88)	- (-)	- (-)
2004	10 (52)	- (-)	20 (44)	10 (32)	- (-)	10 (68)	10 (82)	20 (51)	10 (71)	10 (47)
2005	10 (51)	- (-)	20 (63)	10 (49)	- (-)	10 (49)	- (-)	10 (41)	- (-)	20 (58)
2006	- (-)	- (-)	- (-)	10 (42)	- (-)	10 (28)	- (-)	- (-)	20 (58)	10 (79)
2007	- (-)	- (-)	- (-)	10 (24)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (39)
2008	- (-)	- (-)	- (-)	10 (40)	40 (111)	- (-)	10 (97)	- (-)	50 (89)	10 (60)
2009	- (-)	- (-)	- (-)	20 (28)	- (-)	10 (33)	10 (57)	- (-)	- (-)	- (-)
2010	- (-)	- (-)	- (-)	10 (28)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (58)
2011	- (-)	- (-)	- (-)	10 (39)	- (-)	- (-)	- (-)	- (-)	10 (64)	10 (62)
2012	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2013	- (-)	- (-)	- (-)	20 (28)	30 (76)	- (-)	- (-)	20 (37)	- (-)	- (-)
slope	-0.21	-0.23	-0.27	0.16	-0.06	-0.05	0.00	0.07	0.10	0.10

Table A9: Hoki, hake, and ling trawl fishery. — *continued.*

Fishing	Species									
year	ERA	COL	PLS	SPO	OPI	HOR	PDG	BEE	HCO	SQX
1991	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1992	- (-)	30 (82)	- (-)	40 (128)	- (-)	- (-)	- (-)	10 (20)	10 (26)	- (-)
1993	- (-)	- (-)	10 (26)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	10 (10)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (41)	- (-)	- (-)
1996	10 (82)	- (-)	- (-)	190 (142)	- (-)	- (-)	10 (88)	- (-)	- (-)	- (-)
1997	10 (26)	- (-)	- (-)	240 (121)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1998	10 (14)	- (-)	- (-)	190 (119)	- (-)	10 (71)	- (-)	- (-)	10 (42)	20 (42)
1999	- (-)	- (-)	- (-)	20 (66)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (44)
2000	10 (28)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	30 (35)	10 (58)
2001	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2002	- (-)	- (-)	10 (55)	- (-)	- (-)	- (-)	- (-)	10 (62)	10 (37)	10 (39)
2003	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	30 (90)	10 (44)	- (-)	- (-)
2004	10 (17)	- (-)	- (-)	- (-)	- (-)	140 (125)	- (-)	- (-)	- (-)	20 (23)
2005	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	20 (61)	- (-)
2007	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (44)	- (-)
2008	10 (14)	40 (74)	- (-)	- (-)	20 (30)	- (-)	- (-)	10 (32)	- (-)	- (-)
2009	10 (17)	30 (181)	10 (36)	- (-)	20 (64)	- (-)	- (-)	20 (34)	- (-)	- (-)
2010	- (-)	- (-)	10 (32)	- (-)	- (-)	- (-)	10 (52)	- (-)	- (-)	- (-)
2011	10 (41)	- (-)	20 (38)	- (-)	10 (57)	- (-)	10 (17)	10 (79)	- (-)	10 (39)
2012	- (-)	20 (78)	10 (22)	- (-)	10 (72)	- (-)	10 (57)	- (-)	- (-)	- (-)
2013	10 (28)	10 (64)	10 (26)	- (-)	10 (33)	- (-)	10 (14)	- (-)	- (-)	10 (39)
slope	0.05	0.12	0.17	-0.19	0.20	0.00	0.15	0.03	-0.03	0.06

Fishing	Species									
year	DSK	MOO	EPL	RSQ	GSQ	TOP	MCA	WHR	WIT	MOD
1991	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	40 (98)	- (-)	- (-)
1992	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	20 (57)	- (-)	- (-)	- (-)
1993	- (-)	10 (22)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	20 (25)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	10 (41)	- (-)	- (-)	- (-)	- (-)	40 (65)	- (-)	- (-)	- (-)
1996	- (-)	- (-)	- (-)	- (-)	10 (39)	- (-)	- (-)	- (-)	- (-)	- (-)
1997	- (-)	- (-)	- (-)	- (-)	10 (49)	- (-)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	10 (52)	- (-)	- (-)	10 (44)	- (-)	- (-)	- (-)	- (-)	- (-)
1999	- (-)	- (-)	- (-)	- (-)	10 (55)	10 (68)	- (-)	- (-)	- (-)	- (-)
2000	- (-)	10 (32)	- (-)	20 (50)	- (-)	- (-)	- (-)	20 (101)	- (-)	10 (64)
2001	- (-)	10 (24)	- (-)	- (-)	10 (52)	10 (28)	- (-)	- (-)	- (-)	- (-)
2002	- (-)	10 (20)	10 (77)	- (-)	- (-)	10 (28)	- (-)	- (-)	10 (30)	- (-)
2003	- (-)	- (-)	- (-)	- (-)	10 (42)	- (-)	- (-)	- (-)	- (-)	- (-)
2004	10 (40)	- (-)	- (-)	- (-)	10 (48)	10 (33)	- (-)	- (-)	10 (95)	20 (71)
2005	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (49)
2007	10 (40)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2008	10 (36)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (69)	10 (37)	10 (37)	10 (37)
2009	20 (29)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (40)	10 (49)	- (-)	10 (20)
2010	10 (42)	- (-)	10 (17)	10 (37)	- (-)	10 (62)	- (-)	- (-)	10 (32)	- (-)
2011	- (-)	- (-)	20 (37)	10 (41)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2012	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (79)	- (-)
2013	10 (46)	- (-)	10 (24)	- (-)	- (-)	10 (37)	- (-)	- (-)	- (-)	10 (35)
slope	0.18	-0.15	0.13	0.07	-0.07	0.08	-0.04	-0.02	0.12	0.13

Table A9: Hoki, hake, and ling trawl fishery. — *continued.*

Fishing										Species
year	DWE	RDO	EEL	HAG	EMA	CYO	APR	WHE	OCT	LAN
1991	- (-)	- (-)	- (-)	- (-)	10 (30)	10 (56)	- (-)	- (-)	- (-)	- (-)
1992	- (-)	- (-)	10 (22)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1993	- (-)	- (-)	- (-)	- (-)	10 (88)	- (-)	- (-)	- (-)	- (-)	20 (100)
1994	- (-)	- (-)	- (-)	- (-)	20 (82)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	- (-)	10 (22)	- (-)	- (-)	10 (109)	- (-)	- (-)	- (-)	- (-)
1996	- (-)	- (-)	- (-)	- (-)	10 (62)	- (-)	- (-)	- (-)	- (-)	- (-)
1997	- (-)	- (-)	- (-)	- (-)	10 (199)	- (-)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (169)	- (-)	- (-)	- (-)
1999	- (-)	10 (107)	10 (82)	- (-)	10 (95)	- (-)	- (-)	- (-)	10 (14)	- (-)
2000	- (-)	- (-)	20 (49)	- (-)	- (-)	- (-)	- (-)	- (-)	20 (26)	40 (75)
2001	- (-)	- (-)	20 (48)	- (-)	- (-)	- (-)	- (-)	80 (90)	10 (17)	10 (66)
2002	10 (99)	- (-)	30 (57)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (66)	- (-)
2003	30 (26)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2004	- (-)	10 (69)	- (-)	- (-)	- (-)	10 (100)	10 (51)	- (-)	- (-)	- (-)
2005	10 (88)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	10 (45)	- (-)	- (-)	- (-)	10 (42)	- (-)	- (-)	- (-)	- (-)
2007	10 (36)	- (-)	10 (102)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2008	- (-)	- (-)	- (-)	- (-)	- (-)	10 (30)	- (-)	- (-)	- (-)	- (-)
2009	- (-)	- (-)	- (-)	- (-)	- (-)	10 (33)	- (-)	- (-)	- (-)	- (-)
2010	- (-)	10 (122)	- (-)	- (-)	- (-)	- (-)	20 (56)	- (-)	- (-)	- (-)
2011	- (-)	10 (39)	- (-)	- (-)	- (-)	10 (20)	- (-)	- (-)	- (-)	- (-)
2012	10 (47)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (33)	- (-)	- (-)	- (-)
2013	- (-)	- (-)	- (-)	10 (122)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
slope	0.09	0.09	-0.08	0.05	-0.20	0.05	0.08	-0.01	-0.03	-0.06

Fishing										Species
year	TSQ	HPB	TAM	RAG	PHO	BSQ	HEX	PSK	CDO	CYL
1991	- (-)	20 (36)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1992	10 (41)	10 (40)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1993	- (-)	10 (55)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	10 (50)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	20 (24)	- (-)	10 (58)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1996	- (-)	20 (37)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1997	- (-)	10 (17)	- (-)	- (-)	130 (154)	- (-)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	10 (14)	- (-)	20 (71)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1999	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2000	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2001	- (-)	- (-)	- (-)	- (-)	10 (85)	- (-)	- (-)	10 (37)	- (-)	- (-)
2002	- (-)	10 (32)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2003	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2004	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (108)	- (-)
2005	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (65)
2007	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (39)
2008	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (79)
2009	10 (37)	- (-)	10 (14)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2010	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (71)	- (-)	- (-)
2011	- (-)	- (-)	10 (24)	- (-)	- (-)	- (-)	10 (32)	10 (95)	- (-)	10 (61)
2012	10 (14)	- (-)	10 (14)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (89)
2013	10 (14)	- (-)	10 (30)	10 (58)	- (-)	- (-)	10 (44)	- (-)	- (-)	- (-)
slope	0.08	-0.29	0.17	0.00	-0.04	0.00	0.09	0.07	0.01	0.16

Table A9: Hoki, hake, and ling trawl fishery. — *continued.*

Fishing										Species
year	OAR	FMA	STU	OPE	CRB	CSH	DWO	BNE	STG	VSQ
1991	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	40 (44)	- (-)
1992	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1993	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1996	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1997	10 (84)	- (-)	- (-)	10 (138)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1999	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2000	- (-)	- (-)	10 (47)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2001	10 (101)	- (-)	- (-)	10 (49)	10 (30)	- (-)	- (-)	30 (69)	- (-)	10 (81)
2002	- (-)	- (-)	- (-)	- (-)	10 (99)	10 (66)	- (-)	10 (114)	- (-)	- (-)
2003	- (-)	- (-)	- (-)	- (-)	10 (114)	- (-)	- (-)	- (-)	- (-)	- (-)
2004	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (47)
2005	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2007	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2008	- (-)	20 (58)	- (-)	20 (118)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2009	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2010	- (-)	- (-)	- (-)	- (-)	- (-)	10 (33)	- (-)	- (-)	- (-)	- (-)
2011	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	20 (61)	- (-)	- (-)	10 (56)
2012	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2013	10 (143)	- (-)	- (-)	- (-)	- (-)	10 (45)	- (-)	- (-)	- (-)	- (-)
slope	0.02	0.03	-0.01	0.00	0.00	0.09	0.05	-0.01	-0.06	0.05

Fishing										Species
year	ACS	YBO	CAR	MAN	AGR	OEO	BAS	POR	TOR	SRI
1991	- (-)	- (-)	- (-)	10 (10)	10 (35)	- (-)	- (-)	- (-)	- (-)	- (-)
1992	- (-)	- (-)	- (-)	10 (14)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1993	- (-)	- (-)	- (-)	- (-)	- (-)	30 (84)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1996	- (-)	- (-)	- (-)	- (-)	- (-)	40 (147)	- (-)	- (-)	- (-)	- (-)
1997	- (-)	- (-)	- (-)	- (-)	30 (131)	- (-)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	- (-)	- (-)	- (-)	10 (51)	- (-)	- (-)	- (-)	- (-)	- (-)
1999	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (92)	- (-)	- (-)
2000	- (-)	- (-)	- (-)	10 (48)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2001	- (-)	- (-)	10 (39)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2002	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2003	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (30)	- (-)	- (-)	- (-)
2004	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (20)	- (-)	- (-)	- (-)
2005	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (44)	80 (32)
2006	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2007	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2008	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2009	10 (33)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2010	10 (36)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2011	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2012	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2013	- (-)	10 (20)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
slope	0.07	0.05	0.00	-0.10	-0.10	-0.09	0.01	-0.01	0.01	0.02

Table A9: Hoki, hake, and ling trawl fishery. — *continued.*

Fishing year	BSL	SEE	SQA	OSK	MOK	MDO	EUC	ECH	PDS	GSC
	Species									
1991	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1992	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1993	- (-)	- (-)	- (-)	- (-)	20 (176)	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (26)
1996	- (-)	- (-)	- (-)	- (-)	40 (155)	- (-)	- (-)	- (-)	- (-)	- (-)
1997	- (-)	- (-)	- (-)	- (-)	10 (114)	10 (17)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	- (-)	- (-)	- (-)	10 (99)	10 (20)	- (-)	- (-)	- (-)	- (-)
1999	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2000	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	20 (70)	- (-)	- (-)
2001	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2002	10 (73)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (59)	- (-)	- (-)
2003	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (102)	- (-)
2004	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2005	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	- (-)	20 (39)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2007	- (-)	- (-)	10 (36)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2008	- (-)	- (-)	10 (41)	- (-)	- (-)	- (-)	10 (49)	- (-)	- (-)	- (-)
2009	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2010	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2011	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2012	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2013	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
slope	0.00	0.00	0.07	0.00	-0.12	-0.04	0.03	-0.01	0.00	-0.03

Fishing year	SUN	SPI	ANT	BSP	CCX	BPI	HEP	PIG	BTS	BTH
	Species									
1991	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1992	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1993	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1996	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1997	- (-)	10 (42)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1999	- (-)	- (-)	10 (77)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2000	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (81)	- (-)	- (-)
2001	- (-)	10 (33)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2002	- (-)	10 (51)	10 (59)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2003	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2004	- (-)	- (-)	10 (72)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2005	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2007	- (-)	- (-)	- (-)	- (-)	- (-)	20 (107)	- (-)	- (-)	- (-)	- (-)
2008	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (14)
2009	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2010	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2011	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2012	- (-)	- (-)	- (-)	- (-)	10 (147)	- (-)	- (-)	- (-)	- (-)	- (-)
2013	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (59)	- (-)
slope	0.00	-0.03	0.00	0.00	0.05	0.03	0.00	-0.01	0.05	0.03

Table A9: Hoki, hake, and ling trawl fishery. — *continued.*

Fishing	Species									
year	**RAY**	**SLB**	**BWS**	**SNR**	**BER**	**LSK**	**FOR**	**GAS**	**EPR**	**SEV**
1991	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1992	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1993	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1996	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1997	- (-)	- (-)	10 (40)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	- (-)	10 (48)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1999	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2000	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2001	- (-)	- (-)	- (-)	10 (76)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2002	- (-)	- (-)	- (-)	10 (44)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2003	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2004	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2005	- (-)	20 (88)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (45)	- (-)	- (-)
2007	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2008	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2009	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (20)	10 (24)	- (-)
2010	- (-)	- (-)	- (-)	- (-)	- (-)	10 (49)	- (-)	- (-)	- (-)	- (-)
2011	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2012	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2013	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
slope	0.00	0.02	-0.04	0.00	0.00	0.04	0.00	0.05	0.03	0.00

Fishing	Species									
year	**MOL**	**FLA**	**BCA**	**SNI**	**HYD**	**PSI**	**EMO**	**PKN**	**RSN**	**NEX**
1991	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1992	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1993	- (-)	- (-)	10 (69)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1996	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1997	10 (32)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	- (-)	10 (36)	- (-)	- (-)	- (-)	- (-)	- (-)	20 (144)	- (-)
1999	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2000	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2001	- (-)	10 (73)	- (-)	20 (42)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2002	20 (77)	- (-)	- (-)	- (-)	10 (40)	- (-)	- (-)	- (-)	- (-)	- (-)
2003	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2004	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (91)
2005	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2007	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2008	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (87)	- (-)	- (-)
2009	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2010	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2011	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2012	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2013	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
slope	-0.02	0.00	-0.06	0.00	0.00	0.00	0.00	0.03	-0.02	0.01

Table A9: Hoki, hake, and ling trawl fishery. — *continued.*

Fishing	Species									
year	SOP	TVI	CPA	CUB	OFH	BYD	CHG	ECN	SMI	ZOR
1991	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1992	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1993	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1996	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1997	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1999	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2000	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2001	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2002	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (35)	- (-)	- (-)	- (-)
2003	- (-)	- (-)	- (-)	20 (131)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2004	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2005	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2007	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2008	- (-)	10 (59)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2009	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2010	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2011	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2012	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2013	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
slope	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Fishing	Species									
year	CCA	RCH	SBR	SHE	BTA	LHO	TOD	YFN	CHI	CPD
1991	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1992	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1993	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (22)	- (-)
1996	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1997	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1999	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (66)
2000	- (-)	- (-)	- (-)	10 (105)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2001	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2002	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2003	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2004	- (-)	20 (91)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2005	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2007	- (-)	- (-)	- (-)	- (-)	- (-)	10 (60)	- (-)	- (-)	- (-)	- (-)
2008	- (-)	- (-)	- (-)	- (-)	- (-)	10 (52)	- (-)	- (-)	- (-)	- (-)
2009	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2010	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (49)	- (-)	- (-)	- (-)
2011	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2012	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2013	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
slope	0.00	0.01	0.00	-0.01	0.00	0.05	0.04	0.00	-0.03	-0.01

Table A9: Hoki, hake, and ling trawl fishery. — *continued.*

Fishing	Species									
year	PAL	GON	CAS	CCO	LNV	CJA	GRM	SUR	HTR	KIC
1991	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1992	- (-)	- (-)	10 (108)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1993	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1996	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1997	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (86)	- (-)	- (-)
1999	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2000	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2001	10 (81)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2002	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2003	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2004	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2005	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2007	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2008	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (42)	- (-)	- (-)	- (-)
2009	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2010	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2011	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2012	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2013	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
slope	0.00	0.00	-0.05	0.00	0.00	0.00	0.03	-0.02	0.00	0.00

Fishing	Species									
year	LMU	HTH	HMT	JFI	SBO	RIS	BCO	BCR	BDA	CTU
1991	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1992	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1993	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1996	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (75)	- (-)	- (-)
1997	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
1999	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (88)
2000	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2001	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	10 (94)	- (-)
2002	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2003	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2004	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2005	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2007	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2008	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2009	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2010	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2011	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2012	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
2013	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
slope	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.03	0.00	-0.01

Table A9: Hoki, hake, and ling trawl fishery. — *continued.*

Fishing	Species				
year	DMG	MRL	SNE	BFI	COD
1991	- (-)	- (-)	- (-)	- (-)	- (-)
1992	- (-)	- (-)	- (-)	- (-)	- (-)
1993	- (-)	- (-)	- (-)	- (-)	- (-)
1994	- (-)	- (-)	- (-)	- (-)	- (-)
1995	- (-)	- (-)	- (-)	- (-)	- (-)
1996	- (-)	- (-)	- (-)	- (-)	- (-)
1997	- (-)	- (-)	- (-)	- (-)	- (-)
1998	- (-)	- (-)	- (-)	- (-)	10 (125)
1999	- (-)	- (-)	- (-)	- (-)	- (-)
2000	- (-)	- (-)	- (-)	- (-)	- (-)
2001	- (-)	- (-)	- (-)	- (-)	- (-)
2002	- (-)	10 (87)	- (-)	- (-)	- (-)
2003	- (-)	- (-)	- (-)	- (-)	- (-)
2004	- (-)	- (-)	- (-)	- (-)	- (-)
2005	- (-)	- (-)	- (-)	- (-)	- (-)
2006	- (-)	- (-)	- (-)	- (-)	- (-)
2007	- (-)	- (-)	- (-)	- (-)	- (-)
2008	- (-)	- (-)	- (-)	- (-)	- (-)
2009	- (-)	- (-)	- (-)	- (-)	- (-)
2010	- (-)	- (-)	- (-)	- (-)	- (-)
2011	- (-)	- (-)	- (-)	- (-)	- (-)
2012	- (-)	- (-)	- (-)	- (-)	- (-)
2013	- (-)	- (-)	- (-)	- (-)	- (-)
slope	0.00	0.00	0.00	0.00	-0.02

Table A10: Bycatch rates (kg tow^{-1}) of main bycatch species in the hoki, hake, or ling target trawl fishery, by area and fishing year, calculated using the tow-based estimator. Bycatch rates are the median of the bootstrap sample of 1000, rounded to the nearest whole number. Species are ordered by decreasing total catch.

(a) SWA

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	353.5	406.1	0	264.6	1.1	6.8	156.8
1992	189.1	128.6	0	84.7	21.4	16.4	74.6
1993	60.5	249.1	0	142.7	7.7	9.6	79.5
1994	389.5	137.1	0	16.8	26.2	127.5	111.9
1995	207	174.3	0	52.8	0.1	72.3	87.2
1996	486.8	176.1	0	164.9	38.2	53.4	147.5
1997	604.3	166.4	0	270.2	7.5	76.8	179.6
1998	525.9	140.5	0	76.5	8.7	157.8	147.2
1999	178	234.4	0.1	62.5	32.4	499.6	174.7
2000	319.5	325.6	0	163.1	118.6	1488	377.1
2001	224.7	305.4	4.2	178.9	322.1	1940.8	471.7
2002	76.1	93.5	0.4	43.9	63.3	1424	284
2003	86	124.7	0.2	155.6	29.7	465.8	164.1
2004	89.4	434	0	479.2	173.6	255.9	221.1
2005	30.5	338.6	16.4	167.7	27.6	18.5	131.1
2006	41.3	202.6	0.1	376.1	223	284.9	295.7
2007	75.2	306.6	7.5	235.2	212.3	537	262.5
2008	45.5	165.7	6.3	319.9	52.1	514.7	186.7
2009	121.1	79	0	167.1	93.7	335.9	118.5
2010	66	119.2	2.7	483	78.5	131.9	130.5
2011	73.3	273.8	21	292.7	125.9	125.8	147.6
2012	45.3	157.7	45.4	279.2	43.8	155.2	206.5
2013	33.4	176.6	118.4	208.5	231.4	496.1	365.9

(b) JAV

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	4.1	3.4	0	177.3	34.7	17.2	37.4
1992	0.7	8.7	0	149.9	52.6	10.2	35.1
1993	5.1	5.6	0	159.6	43.9	5.7	35.2
1994	0.4	23	0	95.5	29.9	2.1	25
1995	7.2	12	0	135.1	64.4	0.8	45.3
1996	4.6	0.6	0.4	149.2	38.6	0	43.1
1997	5.1	9.9	0.6	207.1	36.1	0.1	52.6
1998	9.9	21.9	1.4	270.2	199.6	0.3	90.9
1999	8.7	51.7	0.1	268.9	97.3	58.2	106.2
2000	5.7	64.2	0	286.3	154.3	53.2	115.6
2001	15.1	73.9	0	291.2	109.7	47.8	118.1
2002	54.8	52.4	0	389.2	400	33.8	164.8
2003	12	46.6	0	541.4	176.2	37.6	137.9
2004	15.2	76.5	0	476.3	137.8	22.8	123.7
2005	39.3	71.5	0.2	669	463.7	9.4	200.6
2006	29.3	153.4	0	563	124.3	99.5	172.3
2007	29.4	87.4	1.4	627.7	166.7	169.9	182
2008	10.2	116.1	3.2	541	289.1	169.8	187.9
2009	14.8	256.1	0.5	679.3	240.7	144.9	209.6
2010	9.1	81.7	7.4	886.7	251.8	111.2	213.4
2011	10.5	139.3	0	518.1	162.4	118.5	158.6
2012	11.8	79.1	1.6	357.8	142.6	58.9	112.1
2013	21.7	234.7	2.4	501.7	188.9	299.8	199.6

Table A10: Bycatch rates (kg tow^{-1}) of main bycatch species in the hoki, hake, or ling target trawl fishery continued.

(c) RAT

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	4.2	13.1	5.5	149.2	28.9	11.8	52.4
1992	3.1	34.8	5.8	265.2	47.3	23.8	78.9
1993	9	20.5	5.4	49.7	22.7	16.5	39.2
1994	2.1	27	5.8	123.4	28.7	9.3	50.4
1995	9.6	59.7	7.9	131.8	56.3	11.1	71.3
1996	10.2	16	11	264	67.9	15.1	87.5
1997	6.4	25.1	11.9	305.2	26.3	11.1	91.8
1998	24.9	34.9	14.7	188.7	181.2	30.2	103.1
1999	10.2	67.4	2.8	245.8	96.3	58.5	124.4
2000	5	101.8	1	208.6	56.1	27	103.6
2001	7.4	45.9	1.9	259.9	68.1	11.3	97.9
2002	34.4	82	0.2	395.2	122.7	14.7	133.8
2003	9.2	49.6	0.7	406.9	85	26.6	120.8
2004	4.9	51.5	0.9	507.5	59.1	21.3	119.8
2005	5	43.7	0.8	431.3	106.4	13.6	110.9
2006	5.5	70.4	0.3	444.6	58.4	92.9	125.9
2007	11.7	83	4.8	211.6	54.4	138.8	106.3
2008	6.9	128.3	8.9	403.6	56.6	154.8	148.4
2009	7.3	218.2	3.5	584.9	78.6	145.5	162.1
2010	2.1	66	27.1	709.6	135.3	122.9	195.4
2011	8.4	123	1.3	427.6	158	140.4	191.1
2012	7.8	61.1	22.9	380	105.5	84.8	148.1
2013	12.7	181.7	29.1	548.2	123	164	205.3

(d) SPD

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	31	43.9	33.4	34.1	14	15.3	30.3
1992	115.6	55.2	33.3	10.4	22.2	25.8	43.1
1993	25.4	77.5	33.1	18.2	15.8	8.8	31.2
1994	122	162.5	33.1	19.6	42.6	57.9	67.4
1995	222.4	114.5	175.7	29.8	70	33.4	100.6
1996	298.8	260.4	237	59.8	25	26.9	140.6
1997	84.9	199.2	271.9	22.4	3.1	56.3	100.4
1998	283.6	114.9	259.7	45.2	63.6	192	147.9
1999	190.7	187.6	317	95.1	26.5	250	182.6
2000	82.8	134.4	655.4	179.4	41.7	187.4	206.1
2001	71.9	72.4	323.7	73.4	80	138.2	126
2002	56.5	117.7	301.2	123.8	147.4	80.2	132.4
2003	23.1	70.5	771.5	56.6	128.1	39.3	169.2
2004	20.9	67.7	299.6	113.3	611.3	82.2	179.8
2005	18.5	95.4	256.9	135.3	34.5	182.5	111.3
2006	18.6	105.1	226.1	133.2	182.6	130.3	122.1
2007	42.7	48.5	363.7	55.5	203.6	91.5	118.9
2008	52.4	71.5	313.1	104.7	58.2	89.8	100.2
2009	46.6	47.5	162.3	86.5	185.2	61.5	87.8
2010	18	198.7	88.6	93.8	168.4	42.6	89.8
2011	37.6	151.6	145.6	61.9	229.4	30.9	98
2012	193	322.2	144.6	128.3	102	19.8	138.4
2013	76.1	254.5	36.2	63.1	126.3	87.5	104.4

Table A10: Bycatch rates (kg tow^{-1}) of main bycatch species in the hoki, hake, or ling target trawl fishery continued.

(e) FRO

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	253.8	3.3	0.5	0.1	0	1.7	39.8
1992	201.3	104.4	0.5	0	0	0	48.9
1993	81.4	8.2	0.5	0	0	0.3	15.2
1994	170	7.7	0.5	0	0	0.6	28
1995	230.1	0.9	0.3	0	0	0.4	53.5
1996	119.3	1.8	0.2	0	0	0.3	39
1997	264.4	2.4	0.2	0.1	0	0.2	62.8
1998	108.3	2.8	0.2	0	0	0	47.1
1999	259	27.4	0.7	0	0	2.2	42.4
2000	172.2	27.9	0.8	0.1	0	2.5	30.1
2001	287.4	21.6	0.4	0.1	0.2	2.7	45
2002	305.9	11.1	0.4	0	0	2.6	46
2003	295.6	11.9	0.9	0	0	0.1	44.5
2004	220.3	5.9	0.2	0.2	0	3.6	34.4
2005	311.6	11.3	1.9	0	0	0.1	46.8
2006	235.3	7.8	0.1	0	0	0.1	34.9
2007	323.3	9.7	1.3	0	0	0.1	47.8
2008	392.3	2	0.8	0	0	0.1	56.8
2009	223.5	0.2	0.2	0	0	0.2	32.1
2010	46.3	1.1	3.1	0.1	0	0.4	7.5
2011	44.4	2.3	0	0	2.5	0.4	7.5
2012	65.3	3.5	3	0	1.2	0.5	10.8
2013	111.7	1.4	7.1	0	0	0.2	17.4

(f) WWA

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	1.8	12.8	0	28.2	6.8	6.3	9.2
1992	0.7	34.3	0	36	35.4	24	20.2
1993	4.3	42.7	0	6.8	30.6	8.7	14.4
1994	0.5	50.4	0	6.5	13.8	0.2	11.2
1995	0.1	7	0	3.4	36.2	0.1	11.5
1996	0.2	29.5	0	26.5	99.6	0.1	28.4
1997	0.8	26.1	0	9.2	2.1	0.3	11.2
1998	1	23	0	19.9	72.5	2.1	25.6
1999	0.3	22.6	0.1	18.7	22.8	5.3	16.7
2000	0.1	110.5	0	31.1	44.2	10	35.1
2001	0.2	4.9	0	41.8	37.3	12.1	20
2002	4.8	32.9	0	32.4	51.2	36.1	30.5
2003	0.1	38.2	0	43.2	32.7	101	38.9
2004	0.4	27.5	0	98.3	117.5	135.9	60.8
2005	0.1	31.4	0	120.3	179.7	222.9	84.1
2006	0.4	53.7	0	151.7	356.3	223.9	114.8
2007	1.6	56.7	2.9	86.6	851.6	201.9	180.9
2008	0.1	79	0	47.3	224.1	256.5	97.7
2009	0.2	124.5	0	35.4	157.3	159.7	73.8
2010	0.1	16.4	2.8	38.8	239.4	132.4	75
2011	0.3	16.2	0	35.9	246.5	128.1	77.6
2012	0	32.8	0.3	31.9	179.2	45.4	48
2013	0	54.6	4.2	40.5	92.8	196.9	57.5

Table A10: Bycatch rates (kg tow^{-1}) of main bycatch species in the hoki, hake, or ling target trawl fishery continued.

(g) GSP

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	0	0	0	40.4	31.4	0.2	10.4
1992	0	0	0	48.5	31.9	3.8	12.1
1993	0	1.9	0	0	5.7	0	1.1
1994	0	0	0	6.8	34	0	5.8
1995	0	0	0	0	18.4	0	2.6
1996	0	0	0	0	0	0	0
1997	0	0	0	0.2	0	0	0
1998	0	0	0	0	0	0	0
1999	0	1.5	0.6	45.7	25	0.1	17.4
2000	0	2.9	0	88	66.7	8.1	31.8
2001	0.3	3.9	0	90.2	53.1	12.2	32.2
2002	3.9	10.9	0	121.4	56.6	6.6	34.4
2003	0	1.9	0	134	94	2.3	36.3
2004	0	2	0	136.3	121.4	2.8	41.5
2005	0	0.4	0	133.7	65.9	2.8	33.5
2006	0	10.3	0	141.1	43	3.3	33.3
2007	0.1	10.9	0.2	82.4	42.5	4.2	23.4
2008	0.1	9.8	0.2	81.9	120.8	4	33.4
2009	0	9.5	0.3	53.4	101.1	2.4	25.5
2010	0	1.5	0.1	60.5	86.8	1.2	23.6
2011	0.1	6	0	66.1	75.1	0.8	23.9
2012	0	5.1	0.3	71.1	54	0.7	21.2
2013	0.2	7.7	0	75.4	65.1	5.5	23.9

(h) JMA

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	173.2	5.6	6.2	4.4	0.2	9.6	31
1992	169.1	24.7	6.4	0.3	0	3.8	32.9
1993	12.5	7.2	6.3	67.3	0.4	0.8	14.9
1994	150.8	0.6	6.5	25.3	0	0.3	29.5
1995	387.5	5.3	4.7	95.7	0	0.1	73.3
1996	293.8	1.1	4.9	18.4	0	0	47.7
1997	119.1	0.8	4.6	0.4	2.1	0.4	20.2
1998	60.1	0.3	5.1	1.1	0	0.6	10
1999	33.8	4.1	4.4	0.4	0	7.6	7.9
2000	38.9	1.3	0.7	0.7	0.1	3.1	6.7
2001	3.1	0.4	0.6	0.2	0.1	0.7	1
2002	1.4	0.2	1.8	0	0	0.4	0.7
2003	8.4	1	0.9	0.1	0	0.1	1.8
2004	60.6	0.9	0.4	0	0	1.6	9.1
2005	11	2.7	102.6	0.1	0	0.4	32.2
2006	9.2	0	0	0	0	0.2	1.4
2007	5.3	0.1	1.1	3.6	0	0	1.4
2008	3.6	0.8	1.3	2	0	0	1.3
2009	76.1	0	0.1	0	0	0	10.9
2010	0.1	0	2.3	0.1	0	0	0.4
2011	1	0.2	0	0	0	0	0.6
2012	1.9	0.1	20.1	0.3	0	0	3.6
2013	12.2	0	20.9	0.1	0.1	0	5

Table A10: Bycatch rates (kg tow^{-1}) of main bycatch species in the hoki, hake, or ling target trawl fishery continued.

(i) RIB

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	2.4	4.7	0.2	58.1	95.6	5.4	25.6
1992	2.7	51	0.2	42.4	40	59.1	29.7
1993	8.2	50.9	0.2	47.3	18.8	8.8	21.2
1994	1	22.5	0.2	13.8	16.8	1.1	9.8
1995	2	43.1	0.1	12.7	31.3	0.9	14.6
1996	1.9	20.4	0	10	15.1	1.1	8.4
1997	1.6	23.9	0	14.5	37.8	1.5	12.1
1998	5.1	28.3	0	25.8	66.2	4.5	20.2
1999	7.2	38.9	0.1	23.9	66.2	5.5	22.5
2000	0.2	90.3	0	32.3	41	10.5	27.9
2001	0.8	34.4	0	22.5	24.7	12.1	17.7
2002	40.1	90.2	0	34.6	50.9	11.8	35.2
2003	0.8	43	0	24.9	26	19.9	18.5
2004	3.3	57.4	0	35.4	26.4	11.2	22.4
2005	0.6	42.4	0	31.7	53.2	5.4	21.8
2006	1.7	115.4	0	23.7	25.3	19.7	29.6
2007	4.3	97.8	0.3	31.1	26.3	31	31
2008	0.2	354.9	0.7	31.8	43.4	28.8	70.8
2009	1.1	456.9	0.1	31.2	33.6	18.3	80.9
2010	0.4	67.7	2.9	18.8	40.4	8	22.5
2011	0.2	129.7	0	19	14.3	3.4	25.4
2012	0	75.8	0.4	16.9	30.7	2.4	19.2
2013	0.7	131.7	0.8	22.4	19.2	23.9	29.2

(j) SPE

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	0.2	9.2	0	54	0.1	0.8	14.1
1992	0.1	19.8	0	65.6	0.5	2.3	17.8
1993	0.1	10.2	0	35.1	0.1	2.2	11.7
1994	0.2	30.5	0	34.7	0.2	0	14.1
1995	0.3	53.8	0	27.5	0.1	0	22.1
1996	0.2	18.8	0.8	34.1	1.2	0.6	19.1
1997	0.4	24.3	1	17.7	0	0.4	18.5
1998	0.8	30.7	1.2	24.7	0.3	0.1	21.6
1999	0.6	18.9	0.3	56.8	0.1	0.1	15.3
2000	0.2	34.3	0	60.7	0.1	0.8	18.6
2001	0.7	22.1	0.2	71.3	0.1	1.1	19.2
2002	13.4	35.3	0	84.7	0.1	1.4	24.7
2003	0.5	22.1	0	110.3	0.3	3.6	25.4
2004	0.3	17.1	0	140.4	0.2	2.8	24.5
2005	0.2	20.7	0.1	94.6	0.1	3	19.7
2006	0.3	34.6	0	59.8	0.1	4.7	18.3
2007	0.1	20.8	1.3	54.3	0.6	4.1	19.1
2008	0.2	40	0.3	43.8	0.1	5.1	23.6
2009	0.6	75.2	0	30.5	0.3	4.1	19.4
2010	0.4	29.1	3	80.3	1.5	3.8	21.2
2011	0.4	38.1	0	88.8	5.4	4.2	24.9
2012	0.3	28	0.2	50.7	4.3	1.8	15.6
2013	0.6	48.8	0	91.2	1.3	1.8	23.3

Table A10: Bycatch rates (kg tow^{-1}) of main bycatch species in the hoki, hake, or ling target trawl fishery continued.

(k) LDO

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	7.3	38.5	0.1	37	1.4	3.3	13.8
1992	5.2	94.1	0.1	42.1	3.5	4	22.8
1993	3.4	19	0	20.1	1.3	6	8.4
1994	3.4	47.5	0.1	32.4	3.6	0.3	13.6
1995	5.7	94.2	0	13	2.2	0.4	17.5
1996	3.5	16.6	0	16.5	3.8	0.5	6.9
1997	6	19.7	0	16.8	0.4	0.6	7.4
1998	7.3	25.2	0	20.5	3	6.8	10
1999	8.7	17	0	49.9	5.1	8.8	15.1
2000	2.9	31.8	0	24	2.4	9.9	13.7
2001	3.6	35.6	0	42.9	5.5	11.2	19.4
2002	20.9	44	0	50.2	2.1	6.8	19.7
2003	7	35.3	0	68.2	5.9	3.5	18.5
2004	6	34.1	0	52.1	6.8	4.4	16
2005	1.5	29.6	0	61.3	6.6	4	16.1
2006	5	60.6	0	43.5	7.3	13.5	20
2007	3.7	52.2	0.1	53.9	7	20.1	21
2008	5.7	39.7	0.1	26.8	7.2	23.4	15.6
2009	13.3	54.3	0	29.8	5.9	16.7	18
2010	5.6	26.1	0.5	44	7.5	12.9	14.8
2011	8	63	0	32	8.7	13.2	19.7
2012	3	27.2	0.1	44.2	5.5	4.2	13.2
2013	14.2	88.1	0.2	55.6	5.8	33.5	29.2

(l) BAR

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	31.3	6.4	1	8.2	0.1	4.9	16.1
1992	68.2	4.5	1	0.1	0.1	1.2	20.7
1993	57.2	4	1	0.1	0.2	0	19.1
1994	19.4	0	1	1.1	0.1	0.2	12.6
1995	37.7	9.8	0.7	68.7	0	0.1	25.2
1996	92.5	0.7	0.7	0.1	0	0	22.1
1997	13.7	0.4	0.6	0	1	43.9	20.6
1998	14.3	0.1	0.7	0.7	0	70.6	19.2
1999	13.6	1.6	6.6	0.8	0.2	1.8	5.3
2000	2.3	0.5	0.2	6.9	5.5	0.6	3.8
2001	91	2.4	0.1	1.8	10.5	0	16.4
2002	45.5	0.6	0	0	0	0.1	19.7
2003	107.8	1	1.6	0.2	0.2	0.1	36.8
2004	62.1	16.5	0.1	0.1	0	0.1	11.9
2005	242.3	11.7	8.9	0	0	0	37.7
2006	54	2	0	0.1	0.1	0.2	8.2
2007	43.4	14.7	3	0	0.9	0.2	9.7
2008	11.9	2.2	0.3	10.9	0	0.2	5.1
2009	6.2	0.4	1.3	0	0	1.3	3.9
2010	0.1	1	9.2	15.2	0.2	1.9	5.7
2011	67.8	9.8	0	9.9	6.8	2.4	15.4
2012	2.2	1.7	2	3.1	1.2	1.3	1.9
2013	0.7	0.7	10.7	0.3	5.8	4.5	3.8

Table A10: Bycatch rates (kg tow^{-1}) of main bycatch species in the hoki, hake, or ling target trawl fishery continued.

(m) SQU

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	7.2	64.2	0.8	7.5	6.3	19.4	19.7
1992	9.4	157.9	0.7	4.4	4.9	34.3	35.2
1993	2.5	15.4	0.8	14.4	5.1	15.7	13.9
1994	6.8	100.7	0.8	1.8	13.4	5.2	22.6
1995	12	150	0.4	8.6	2.1	6.9	26.7
1996	4.3	7	0.7	3	20.9	5.8	6.8
1997	5.3	7.7	0.6	1.1	2.2	6.8	4.3
1998	3.5	9.2	0.7	5.1	3	8.4	5.1
1999	5.1	8.9	0.2	7.3	9.1	10.7	8.2
2000	1.7	18.1	0.2	6.5	13.4	32.4	12.6
2001	9.8	34.1	0.1	8.6	45.6	43.5	21.6
2002	29.2	60.3	0.1	4.7	16.5	26.4	21.1
2003	6.6	53.4	0.2	3.9	38.8	14.2	17.8
2004	12.3	88.9	0.5	9.3	9.1	11.6	19.2
2005	7.5	52	0.9	10.1	45	7.3	18.4
2006	3.3	60.5	0.2	10.5	32.9	34.9	22.6
2007	16.2	80.1	0.8	7.9	33.5	55.2	29
2008	8.5	26.9	0.5	9.3	28.2	55.3	19
2009	16.3	6.4	0.4	3.4	19.6	56.8	14.9
2010	15.7	18.8	0.4	11.9	37	51.7	20.1
2011	10.4	43.1	0.2	6.2	64.9	57	27.4
2012	15.9	40.6	0.5	4.4	30.1	49.6	21
2013	10.5	78	0.3	4.5	35	116.4	36.1

(n) BOE

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	0	0	0	25	0.3	0	3.6
1992	0	0	0	79.4	1.6	0	11.6
1993	0	0	0	1.4	2.7	0	0.6
1994	0	0	0	27.9	3.3	0	4.4
1995	0	0	0	14.1	5.2	0	2.8
1996	0	0	0	10.7	0.9	0	1.6
1997	0	0	0	0	0.5	0.2	0.1
1998	0	0	0	57.3	4	0.3	8.9
1999	0	0	0	17.3	1.7	0	2.8
2000	0	0	0	4.7	7	0	1.8
2001	0	0	0	28.6	0	0	4.9
2002	0	0	0	38	4.1	0	6.3
2003	0	0	0	27.2	4.1	0	4.6
2004	0	0.1	0	91.5	3	0	13.6
2005	0	0.1	0	13.9	1.1	0	2.5
2006	0	0	0	68.8	0.7	0	10
2007	0	0	0	34.6	37.7	0	10.7
2008	0	0	0	105.4	1.1	0	15.2
2009	0	0	0	16.3	2.3	0	2.7
2010	0	0	0	82.5	10.2	0	13.3
2011	0	0	0	4.9	0.1	0	0.7
2012	0	0	0	125.1	2.8	0	18.3
2013	0	0	0	131.9	2	0	19.2

Table A10: Bycatch rates (kg tow^{-1}) of main bycatch species in the hoki, hake, or ling target trawl fishery continued.

(o) GSH

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	0	23.2	1.1	40.3	56.5	4.3	28.3
1992	0.1	11.4	1.1	64.1	51.4	14.6	30.3
1993	0.1	5.1	1	40.5	41	3.1	23.3
1994	0	6.5	1.1	50.4	45.2	1	26.2
1995	0	15.3	1.8	44.3	49.6	0.4	17.8
1996	0	9.4	0.8	37.8	46.1	0	15.2
1997	0	7	0.6	27.3	44	0	12.5
1998	0.3	3.5	0.4	60.5	82.6	1.5	22.8
1999	1.5	23.4	6.6	26.1	24.4	5.3	14.4
2000	0.2	17.1	3.1	14.6	11.8	50.2	15.8
2001	0.1	19.3	6	13.8	6.3	76.9	19.9
2002	1.6	13.3	5.3	3.5	6.2	37.8	10.8
2003	0.3	9.6	0.2	3.6	19.7	1.9	6
2004	0	27	0.3	8	9.4	4.8	7.4
2005	0	12.1	0.9	17.2	7.1	3.6	6.3
2006	0.1	5.1	1.7	7.9	8.7	7.3	4.9
2007	0.1	2.5	9.3	5.3	8.3	9.8	6.1
2008	0	0.6	0.7	10.2	14.5	16.9	6.8
2009	0	1.3	0	8.5	22.2	10.6	7.1
2010	0.1	6.8	3.2	50.7	2.1	13.2	11.8
2011	0.5	7.5	1.7	13.4	17.7	12.8	9.4
2012	0.4	8.3	1	51	11.8	4	12.2
2013	0.2	4.9	1.3	9.8	24.3	124.2	25.6

(p) SND

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	1.4	3.7	0.6	71.4	0.6	12.8	17.8
1992	1.9	10.7	0.6	56.3	0.8	20.9	17.9
1993	0.5	7	0.6	36	0.4	6.9	12.7
1994	1	22.3	0.6	42.7	1.1	2.3	15.4
1995	4	9.5	0.5	6.9	1	1.5	8.4
1996	1.3	1.5	0.2	8.2	0	1.6	4
1997	0.9	2.8	0.1	5.4	0.1	5.3	3.6
1998	2	4.5	0.2	13.7	0	19.6	8
1999	2.2	3.1	0.6	9.2	1	44.5	12.5
2000	0.1	13.7	1	72.8	1.3	43.8	23.9
2001	0.3	7.3	1.3	19.1	1.4	35.4	13.4
2002	3.5	13.4	0	89.7	0.6	24.8	25.7
2003	0.9	4.2	0.1	23.7	1	17.5	13
2004	0.6	5.6	0.2	37.8	0.2	18.3	13.8
2005	0.8	2.8	3.6	40.5	0.9	1.5	12.6
2006	1.4	20	0	48.2	3.9	108.9	34.7
2007	2.5	16.3	1.5	25.6	1.6	205.8	44.2
2008	1.7	15.2	6.8	85.6	2.8	196.6	53
2009	0.7	42.6	0.4	52.9	1.2	122.8	47.3
2010	0.5	3.8	14.1	31.3	1.4	47.1	26.8
2011	0.3	24.1	0	43.6	1	34.7	23.1
2012	0	8.1	1	20.4	1.1	31.1	14.5
2013	0.9	24.3	0.3	42.2	2.6	155.8	35

APPENDIX B

Table B1: Summary of LME normal modelling of bycatch (catch per hr) in the target hoki, hake, or ling trawl fishery. The numbers denote the order in which the variable entered the model. Variables: *gear code*, bottom or midwater trawls; *Day of yr:* day of fishing year. *, crashes at this point, beyond computer capability; –, not accepted by the model; NA, not assessed.

Species cat.	Dataset	Variable										
		Area	*Depth*	*Gear code*	*Month*	*Headline height*	*Start time*	*Nation*	*Day of yr*	*Vessel length*	*Fishing year*	*Vessel speed*
QMS	All years	NA	1	4*	3	2	NA	NA	NA	NA	NA	NA
	2003–2013	NA	1	NA	NA	2*	NA	NA	NA	NA	NA	NA
	WCSI	NA	NA	2	3	4	NA	5	NA	NA	6	7*
	WCSI.MW	–	1	–	2	3	7	4	6	–	5	–
	WCSI.BT	–	1	–	3	6	2	5	4	–	–	–
	CHAT	–	2	6	3	1	4	5	–	–	–	7
	SUBA	–	1	6	3	2	4	5	–	–	–	–
	CSTR	–	1	6	2	4	–	–	–	5	3	–
Non-QMS	All years	1	3	2	5	4	NA	NA	NA	NA	6*	NA
	2003–2013	1	3	2	5	4	6	7	–	8	9	–
	WCSI	–	2	1	5	3	6	7	9	8	4	–
	WCSI.MW	–	1	–	3	2	–	5	6	8	4	7
	WCSI.BT	–	4	–	–	–	1	3	–	5	2	–
	CHAT	–	2	1	4	6	3	7	–	8	5	–
	SUBA	–	1	–	4	3	6	2	–	–	5	–
	CSTR	–	2	–	4	1	5	–	–	3	–	–
INV	All years	1	4	5*	3	2	NA	NA	NA	NA	NA	NA
	2003:2013	2	7	6	3	1	4	5	8	–	–	–
	WCSI	–	4	5	6	1	3	7	2	–	–	–
	WCSI.MW	–	6	–	1	2	5	3	4	–	–	–
	WCSI.BT	–	1	–	5	–	3	–	2	–	4	6
	CHAT	–	5	3	1	–	4	2	6	7	–	8
	SUBA	–	4	–	2	3	5	1	6	–	–	–
	CSTR	–	2	–	1	–	3	5	–	–	–	–

Table B2: Summary of LME normal modelling of discards (catch per hour) in the target hoki, hake, or ling trawl fishery. The numbers denote the order in which the variable entered the model. Variables: *gear code*, bottom or midwater trawls; *Day of yr:* day of fishing year. Species category HHL: HOK, HAK, LIN discards. *, crashes at this point, beyond computer capability; –, not accepted by the model; NA, not assessed.

Species cat.	Dataset	Variable										
		Area	*Depth*	*Gear code*	*Month*	*Headline height*	*Start time*	*Nation*	*Day of yr*	*Vessel length*	*Fishing year*	*Vessel speed*
HHL	All years	4	1	2	5	7	3	6		–	–	–
	WCSI	–	1	5	3	7	2	4	6	–	–	–
	WCSI.MW	–	2	–	1	5	3	4	6	–	–	–
	WCSI.BT	–	2	–	–	3	1	–	4	5	–	–
	CHAT	–	–	–	–	1	2	–	–	–	–	–
	SUBA	–	7	6	3	5	1	4	2	–	–	–
	CSTR	–	–	–	–	–	–	–	–	–	1	–
QMS	All years	3	1	NA	5	2	7*	4	NA	NA	6	NA
	2003–2013	2	1	8	6	3	5	4	–	9	7	–
	WCSI	–	1	2	5	6	7	3	9	8	4	–
	WCSI.MW	–	1	–	3	5	–	2	7	6	4	–
	WCSI.BT	–	1	2	4	–	–	–	–	–	3	5
	CHAT	–	1	2	5	–	3	4	–	–	–	–
	SUBA	–	1	2	4	–	3	–	–	–	–	–
	CSTR	–	1	–	2	–	–	–	–	–	3	–
Non-QMS	All years	3	2	1	7*	NA	NA	4	NA	NA	6	NA
	2003–2013	2	4	1	6	–	–	3	–	–	8	9
	WCSI	–	2	1	5	6	3	4	–	–	7	–
	WCSI.MW	–	1	–	4	3	2		–	–	–	–
	WCSI.BT	–	6	–	5	4	1	2	–	3	–	–
	CHAT	–	1	–	6	5	7	2	–	4	3	–
	SUBA	–	1	4	3		5	2	–		–	–
	CSTR	–	1	–	2	3	–	–	–	4	6	–
INV	All years	3	2	7	1	–	6	5	–	8	4	–
	WCSI	–	1	–	4	–	5	2	–	–	3	6
	WCSI.MW	–	1	–	–	–	–	3	4	–	2	
	WCSI.BT	–	1	–	3	–	2	–	–	6	4	5
	CHAT	–	4	2	1	–	–	–	–	–	3	5
	SUBA	–	1	–	2	4	5	3	–	–	–	–
	CSTR	–	–	2	–	–	–	–	–	–	1	3

Table B3: Bycatch rates (t hr^{-1}) of species groups in the hoki, hake, or ling target trawl fishery, by area and fishing year, based on observed catch data. Bycatch rates are the median of the bootstrap sample of 1000, rounded to the nearest whole number.

(a) QMS fish species (t hr^{-1})

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	192.8	151	43.6	219.8	48.2	46.7	203.4
1992	205.8	148.4	43.7	140.8	57.1	84.5	198.8
1993	92.1	138	43.5	114.1	38.5	40.6	178.8
1994	306.7	128.9	43.5	98.4	57.2	111	217.6
1995	244.1	107.4	180.4	112.4	60.7	85.8	178
1996	368.2	174.9	288.8	133.7	97.8	61.4	233.4
1997	272.4	144.1	335.1	120.7	45.6	112.5	195
1998	301.2	109.3	311.7	111	76.1	227.9	212.5
1999	192.9	146.6	402.2	112.7	64.6	257	198.3
2000	251.5	193.8	1240.3	172.7	96.5	531.3	385
2001	220.4	130	502.6	148.2	166.1	684.7	296.9
2002	183.7	114.7	563.6	146.2	114.6	457.9	265.7
2003	112.5	87.6	1730.8	158.5	94.7	205.3	379.7
2004	138.8	174	573.1	241.5	255	248.7	250.4
2005	245.2	141.4	687.3	179.8	91.2	345.3	269.9
2006	117.5	127.9	544.5	234.8	245.3	322.5	269.7
2007	130	165.1	402.9	164.3	388.3	299.9	253
2008	260.2	115.4	462.1	200.2	163.5	295.6	240.2
2009	206.9	111.2	402	115.4	191.4	218.2	192.7
2010	58.5	112.7	131.6	202.9	153.7	144.5	131
2011	135.4	166	384.5	138.3	185.6	139.5	184.2
2012	149.8	156.9	237.9	189.7	108.8	123.3	184.4
2013	117.6	130.9	132.3	155.7	143.6	336.3	219.1

(b) non-QMS fish species (t hr^{-1})

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	6.4	10	13.6	178.5	71.8	30.2	63.2
1992	5.2	33.1	13.4	178.5	45.5	26.4	61.6
1993	8.4	16.6	13.5	77.2	36.9	28	44.2
1994	3.4	30.5	13.4	107.8	27.3	7.5	46.3
1995	19.6	39.4	16.1	98.6	52	12.5	54.7
1996	10.4	18.2	14.7	136.2	49.2	14.8	55.4
1997	10.9	23.4	15.8	172.9	46.8	20.4	61.8
1998	19.6	29.1	20.8	151.2	115.5	64.6	78.3
1999	21	51.5	12.2	163.9	81.8	95.8	91.8
2000	19.2	98	7.7	167.3	87.1	81	92.3
2001	20.9	43.8	15.9	157.5	69.9	68.8	81
2002	56.4	47.6	12.5	249.6	188.4	48.6	116.1
2003	16.7	37.8	10.3	246	76.5	42.2	87.1
2004	19.5	59.4	12.3	237	66.7	57.5	91.2
2005	39.3	31.4	43.6	283.4	156.4	36.7	110.7
2006	26.2	65.4	29.9	271.5	78.5	185.3	119.8
2007	21.3	78.8	33.2	228.5	85	223.8	132.6
2008	44	78.2	56.5	286.3	111.9	216.7	144.2
2009	34.6	107.2	21.8	305.7	97.8	184.3	134.3
2010	18.9	58.5	192.4	337.2	118.5	143	157.2
2011	19.2	96.7	25.4	223.2	95.9	152	124.3
2012	18.2	55.3	37.4	201.8	78	107.8	100.2
2013	24.4	97.9	45.5	250.6	89.8	264.4	140.1

Table B3: continued.

(c) Invertebrate species (t hr^{-1})

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	1.5	14.4	0.6	3.7	8.5	5.5	7.2
1992	2.3	33.1	0.6	9.2	8.2	11.4	11.8
1993	0.8	3.6	0.6	6.5	5.7	6.2	5.7
1994	2.2	22.7	0.7	4.8	9.1	1.6	8.3
1995	2.5	23.4	0.4	3.5	8.3	3	6.3
1996	1.4	2	0.7	3.2	10.7	3	3.5
1997	1.4	2.3	0.7	2.6	3.5	3.2	2.4
1998	1.3	2.5	0.7	3.6	7.4	4.7	3.3
1999	1.7	2.7	0.4	7.4	9.5	4	5.2
2000	1.3	4.7	0.4	14.3	10.9	9.7	7.1
2001	2.8	7.6	0.2	11.2	19.7	13.1	8.6
2002	10.8	13.3	0.1	16.2	18.1	8	10.2
2003	2.2	10.5	0.6	5.5	12.7	3.7	5.8
2004	6.1	17.1	43.4	6.3	7.3	4.2	12.7
2005	3.5	8.4	1.4	6.6	14	5	6.4
2006	1.2	10.5	0.4	6.5	13.2	16.1	8.2
2007	4.3	19.2	1.1	3.4	11.7	19.3	9.1
2008	4.5	6.5	1	6.4	13.3	19.3	7.6
2009	5.1	5.3	1.4	2	10.5	17.1	6.4
2010	5.3	4.8	0.8	4.9	18.2	14.4	7.4
2011	4.6	13.2	0.5	3.9	19.9	14.6	8.7
2012	6.7	10.8	0.6	2.5	11.8	13.3	7
2013	3.9	13	0.3	3.9	12.6	32.5	10

Table B4: Estimates of total annual bycatch (rounded to the nearest 10 t) in the hoki, hake, or ling target trawl fishery for the species categories QMS, non–QMS, invertebrates, and overall, based on observed catch rates; 95% confidence intervals in parentheses (calculated using the duration-based estimator).

Fishing year	QMS	non-QMS	Invertebrate	Total bycatch
1991	12 770 (10 080–16 190)	5 360 (4 730–5 890)	400 (320– 500)	18 530 (15 130–22 580)
1992	11 030 (9 180–13 250)	6 220 (4 880–7 250)	700 (470–1 130)	17 950 (14 530–21 630)
1993	7 610 (5 440–9 810)	3 450 (2 540–4 310)	380 (190– 580)	11 440 (8 170–14 700)
1994	12 340 (9 640–15 480)	2 730 (2 100–3 440)	450 (310– 610)	15 520 (12 050–19 530)
1995	15 300 (12 190–19 310)	5 170 (3 270–7 240)	490 (390– 580)	20 960 (15 850–27 130)
1996	21 650 (17 300–26 440)	7 150 (4 450–10 310)	370 (260– 520)	29 170 (22 010–37 270)
1997	22 560 (16 960–28 890)	9 760 (7 450–12 120)	280 (170– 390)	32 600 (24 580–41 400)
1998	23 340 (19 000–29 060)	13 630 (10 550–17 170)	480 (390– 590)	37 450 (29 940–46 820)
1999	17 670 (14 870–21 200)	12 540 (10 160–15 200)	700 (450–1 080)	30 910 (25 480–37 480)
2000	29 010 (24 040–34 270)	13 030 (10 130–17 600)	1 160 (490–2 560)	43 200 (34 660–54 430)
2001	25 450 (19 930–31 510)	11 340 (9 480–13 510)	1 350 (830–2 070)	38 140 (30 240–47 090)
2002	17 750 (14 210–22 460)	18 110 (14 490–22 540)	1 620 (1 210–2 090)	37 480 (29 910–47 090)
2003	23 340 (18 170–30 370)	14 910 (11 440–18 730)	860 (590–1 370)	39 110 (30 200–50 470)
2004	23 720 (18 590–29 160)	12 880 (10 480–16 510)	1 000 (650–2 220)	37 600 (29 720–47 890)
2005	15 060 (12 280–18 690)	12 230 (7 880–17 210)	550 (420– 740)	27 840 (20 580–36 640)
2006	13 650 (11 430–15 820)	9 560 (7 400–11 700)	530 (410– 680)	23 740 (19 240–28 200)
2007	13 820 (11 160–17 020)	8 940 (7 110–10 690)	510 (360– 720)	23 270 (18 630–28 430)
2008	11 220 (9 380–13 450)	10 630 (8 560–13 120)	450 (370– 540)	22 300 (18 310–27 110)
2009	7 990 (6 580–10 120)	9 700 (8 030–11 960)	250 (210– 290)	17 940 (14 820–22 370)
2010	7 610 (6 340–9 090)	9 700 (7 960–11 570)	360 (300– 420)	17 670 (14 600–21 080)
2011	8 230 (7 140–9 570)	6 900 (5 750–8 140)	450 (310– 600)	15 580 (13 200–18 310)
2012	8 310 (7 150–9 780)	5 920 (4 810–7 340)	330 (280– 390)	14 560 (12 240–17 510)
2013	7 870 (6 500–9 410)	7 650 (6 700–8 640)	410 (340– 490)	15 930 (13 540–18 540)

Table B5: Discard rates (kg hr^{-1}) of species groups in the hoki, hake, or ling target trawl fishery, by area and fishing year, based on observed discard data. Discard rates are the median of the bootstrap sample of 1000, rounded to the nearest whole number.

(a) Hoki, hake or ling (kg hr^{-1})

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	119	82.6	279.3	37.4	8.3	60.2	90.9
1992	92.7	38.3	258	25.9	9.3	56.6	73.7
1993	239.6	14.7	269	32.5	0	115.8	101.8
1994	186.2	56.1	265	17.1	8.4	86.8	97.7
1995	139.5	4.7	270	38.8	12.1	360.7	125.5
1996	115.8	14.7	216.1	9.4	0	397.7	115.7
1997	102.5	4.3	77.2	3.3	5.8	340.2	80.1
1998	0	0	0	0	0	0	0
1999	31.1	0.5	54.8	2.5	9	0.6	15.8
2000	6.5	40.4	3.1	0.4	2	0.6	8.5
2001	32.6	0.1	112.1	0.8	0.5	0.9	21.6
2002	0.6	15.6	22.2	0.5	0	18.8	31.4
2003	37	7.1	0	2.9	0.1	62.9	47.1
2004	14.8	6.7	206.1	2.5	0	71.6	48.1
2005	3	12.5	117	0	0.2	51.2	38
2006	0.2	0.6	152.7	0	0.3	35.6	53.6
2007	18.4	19.7	127.5	2.6	5.4	41.4	33.4
2008	0	0.9	0	1.6	1	15.6	4.1
2009	9.7	2	145.4	1.6	3.3	14.8	25.2
2010	5	2.3	39.5	21	6.5	19.2	15.6
2011	22.2	8.2	722.4	12	26.4	23.6	119.2
2012	6	10.1	35.1	3.5	27.4	16.5	15.8
2013	19.5	21.4	0	3.1	8.6	72.6	18.4

(b) QMS fish species (kg hr^{-1})

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	24.5	2.7	166.7	12.7	3.9	7.5	39.2
1992	31.1	23.7	166.8	15.9	0.1	7.5	42.9
1993	12.4	37.7	169.7	9.5	24.5	17.8	46.9
1994	62.7	16.1	167.1	15	14.4	15.7	49.8
1995	47.1	0.5	171.6	4.9	13.4	20.2	44.6
1996	83.3	28.4	134.8	10.7	20.1	7.9	55.7
1997	56.4	20.1	320.7	2.6	3.3	8.3	68.5
1998	0	0	0	0	0	0	0
1999	45.3	14.7	305.4	30.2	8.1	29.2	68.5
2000	36.2	30.5	1042.8	40	13.3	29.4	177.6
2001	16.7	23.5	413.4	22.1	13.2	17.3	76.2
2002	16.4	17.2	358	32.4	23.9	13.8	70.9
2003	18.1	16.9	1265.6	14.7	31.3	10.6	201
2004	13.4	10.7	423.3	19.5	26.7	12.8	73.8
2005	3.2	10.8	160.9	10.6	10.8	10.2	31.2
2006	3.2	6.8	257.5	10.7	87.2	11.3	55.4
2007	10	5.2	336.9	6.3	11.9	11.5	55.8
2008	12.9	2.1	460.4	5.2	3.1	7.6	70.3
2009	8.3	4.2	379.4	6.8	5.1	4.5	59.4
2010	2.7	4.5	77.8	8.8	15	5	16.4
2011	3.1	3	305.5	3.2	17.8	3.4	48.4
2012	36.3	37	130.8	14.1	18.1	2.5	34.6
2013	31.2	33.4	20.7	4.5	23	22.6	21

Table B5: continued.

(c) non-QMS fish species (kg hr^{-1})

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	2.6	8.6	10.6	97.4	71.6	25.8	39.7
1992	4.5	9	11.3	175.7	60.9	31.6	51.2
1993	0.8	4.3	10.8	8.6	14.7	37.9	20.6
1994	1.9	34.2	10.5	63.8	15.6	34.5	31.9
1995	23	39.2	10.4	13.8	13.1	13.1	25.4
1996	3.2	45.2	8.1	69.5	16.9	8.9	30.1
1997	5.9	49	7.5	53.5	62.9	18	36.2
1998	0	0	0	0	0	0	0
1999	12.7	52.1	7.6	42.1	49.9	60	40.1
2000	1.8	64.4	4.5	121.8	26.4	57.6	48.4
2001	8.4	15.6	12.6	100.6	56.2	51.3	40.9
2002	58.9	43.3	1	171.2	70.7	32	57.7
2003	10	25.6	7.3	137.3	27.7	9	32.4
2004	8	58.7	11.9	50.6	40.3	10.8	31.4
2005	2.9	17	44.7	12.5	45.4	147.4	44.6
2006	8	76.9	26.9	21.1	58.8	119.4	50.5
2007	3.7	61.4	22.2	49.5	8.9	127.1	51.7
2008	2.2	50.4	73.6	50	13.7	198.8	75
2009	6	79.2	8.2	96.7	6.7	145.1	75.5
2010	2.4	40.4	60.4	202.1	10.3	114.4	86.1
2011	1.5	71.8	23.6	94.1	47	129.5	75.9
2012	1.1	42.4	37.4	34.7	22.7	86.3	37.3
2013	5	88.9	26.9	100.5	26.5	183	63.4

(d) Invertebrate species (kg hr^{-1})

Fishing year	WCSI.MW	WCSI.BT	CSTR	CHAT	SUBA	PUYS	NULL
1991	0.3	0.9	0.3	0.7	6.7	1.7	1.9
1992	0.1	0.5	0.3	9.2	0.2	1.2	2
1993	0	0.3	0.3	0.6	3.7	0.1	1.1
1994	0.2	11.2	0.3	4.4	7.9	0.1	3.8
1995	0.4	0	0.3	4.2	8.7	0.6	2.4
1996	0.3	0	0.3	0.4	0	0.3	0.5
1997	0.3	0.2	0.2	2	5.1	1.1	1.6
1998	0	0	0	0	0	0	0
1999	0.4	0.3	0.2	7.2	9	0.6	3
2000	0.2	0.8	0	30.9	7.6	0.6	6.1
2001	0.1	0.1	0	11.3	7.3	0.4	3
2002	3	1.1	0	24.5	20.6	0.3	7.3
2003	1.2	0.5	0	5.3	5.9	0	2
2004	0.1	0.6	0	2	8.2	0	1.7
2005	0	0.3	0	4	5.6	0.5	1.6
2006	0.2	0.8	0.2	5.3	4.8	0.6	1.8
2007	0.2	0.8	0.3	1.5	1.1	0.5	0.7
2008	0.6	2.8	0.2	2.1	2.5	1.9	1.6
2009	0.6	3.8	0.2	0.6	1.1	1.7	1.6
2010	0.2	0.7	0.4	2.6	3.1	2	1.5
2011	0.2	3.7	0	1.6	7.2	2	2.2
2012	0.2	2.4	0	0.3	4.1	1.3	1.2
2013	0.3	2.5	0.1	1.7	2.5	2.1	1.3

Table B6: Estimates of total annual discards (rounded to the nearest tonne) in the hoki, hake, or ling trawl fishery for the species categories HOKHAKLIN, QMS, non–QMS, invertebrates, and overall, based on observed discard rates; 95% confidence intervals in parentheses (calculated using the duration-based estimator).

Fishing year	HOKHAKLIN	QMS	non-QMS	Invertebrate	Total discards
1991	7 100 (4 223–10 886)	2 123 (1 161–3 484)	3 559 (2 729–4 191)	160 (131– 209)	12 941 (8 244–18 771)
1992	4 626 (2 402–7 788)	1 908 (1 283–2 830)	6 415 (5 671–7 306)	258 (22– 751)	13 207 (9 378–18 674)
1993	7 411 (3 247–14 211)	2 097 (1 511–2 860)	772 (598–2 141)	104 (76– 144)	10 383 (5 432–19 355)
1994	7 365 (3 937–12 964)	3 020 (2 049–4 371)	1 807 (1 103–2 558)	266 (120– 503)	12 457 (7 210–20 397)
1995	9 130 (5 916–13 221)	3 069 (1 921–4 978)	1 873 (1 008–3 353)	272 (233– 348)	14 345 (9 078–21 900)
1996	7 618 (4 061–15 088)	5 521 (3 009–13 804)	3 780 (1 301–7 557)	32 (10–84)	16 951 (8 382–36 532)
1997	6 804 (3 343–11 275)	7 166 (3 472–12 612)	4 522 (1 559–7 398)	211 (53– 396)	18 704 (8 426–31 682)
1998	- -	- -	- -	- -	- -
1999	1 537 (585–2 824)	5 598 (3 592–8 508)	4 491 (2 875–6 378)	616 (376–1 098)	12 242 (7 428–18 808)
2000	680 (251–1 379)	10 360 (7 136–13 915)	8 093 (6 988–11 558)	1 825 (1 363–2 882)	20 958 (15 737–29 733)
2001	1 426 (357–3 094)	4 534 (3 158–6 249)	7 270 (5 124–9 340)	769 (312–1 721)	13 999 (8 951–20 404)
2002	637 (117–1 534)	4 144 (2 238–7 146)	11 013 (5 478–18 266)	1 727 (1 222–2 303)	17 522 (9 055–29 250)
2003	1 409 (406–2 973)	8 673 (5 547–13 945)	7 951 (5 942–10 417)	432 (304– 595)	18 464 (12 198–27 930)
2004	1 721 (601–3 883)	4 004 (2 743–5 399)	4 148 (2 688–6 185)	242 (139– 476)	10 115 (6 171–15 943)
2005	837 (143–2 268)	1 434 (807–2 843)	1 758 (1 235–2 467)	210 (70– 404)	4 240 (2 255–7 983)
2006	529 (102–1 409)	1 897 (710–3 467)	2 870 (1 528–4 088)	196 (81– 396)	5 492 (2 421–9 361)
2007	1 031 (316–2 281)	1 448 (604–2 487)	2 457 (1 348–3 468)	66 (40–96)	5 002 (2 307–8 332)
2008	128 (28– 352)	1 473 (1 094–1 953)	2 780 (1 805–4 493)	130 (79– 211)	4 510 (3 005–7 008)
2009	547 (87–2 008)	1 354 (817–1 893)	3 500 (1 681–6 398)	76 (48– 115)	5 477 (2 633–10 414)
2010	720 (261–1 530)	593 (376– 831)	5 175 (3 246–7 016)	96 (57– 141)	6 584 (3 940–9 518)
2011	2 594 (611–7 292)	1 039 (766–1 419)	3 460 (2 221–5 025)	144 (76– 228)	7 237 (3 674–13 964)
2012	632 (347–1 232)	1 384 (890–1 906)	1 664 (1 011–2 574)	73 (45– 104)	3 753 (2 293–5 816)
2013	614 (397– 888)	1 025 (773–1 414)	3 544 (2 635–4 634)	91 (62– 128)	5 274 (3 867–7 063)

Table B7: Estimated annual target hoki, hake, or ling trawl catch (t), total bycatch (t), and total discards (t), in the target hoki, hake, or ling trawl fishery; discard fraction (kg of total discards per kg of hoki, hake, or ling caught); and discards as a fraction of bycatch (calculated using the duration-based estimator).

Fishing year	Hoki, Hake, and Ling estimated catch	Total bycatch	Total discards	Discard fraction	Discards / bycatch
1991	220 911	18 530	12 941	0.06	0.70
1992	217 810	17 950	13 207	0.06	0.74
1993	202 028	11 440	10 383	0.05	0.91
1994	192 613	15 520	12 457	0.06	0.80
1995	199 204	20 960	14 345	0.07	0.68
1996	223 930	29 170	16 951	0.08	0.58
1997	250 469	32 600	18 704	0.07	0.57
1998	280 471	37 450	-	-	-
1999	258 930	30 910	12 242	0.05	0.40
2000	264 500	43 200	20 958	0.08	0.49
2001	251 393	38 140	13 999	0.06	0.37
2002	218 560	37 480	17 522	0.08	0.47
2003	201 133	39 110	18 464	0.09	0.47
2004	155 478	37 600	10 115	0.07	0.27
2005	125 235	27 840	4 240	0.03	0.15
2006	118 600	23 740	5 492	0.05	0.23
2007	113 649	23 270	5 002	0.04	0.21
2008	98 197	22 300	4 510	0.05	0.20
2009	98 072	17 940	5 477	0.06	0.31
2010	110 099	17 670	6 584	0.06	0.37
2011	121 439	15 580	7 237	0.06	0.46
2012	134 339	14 560	3 753	0.03	0.26
2013	139 474	15 930	5 274	0.04	0.33

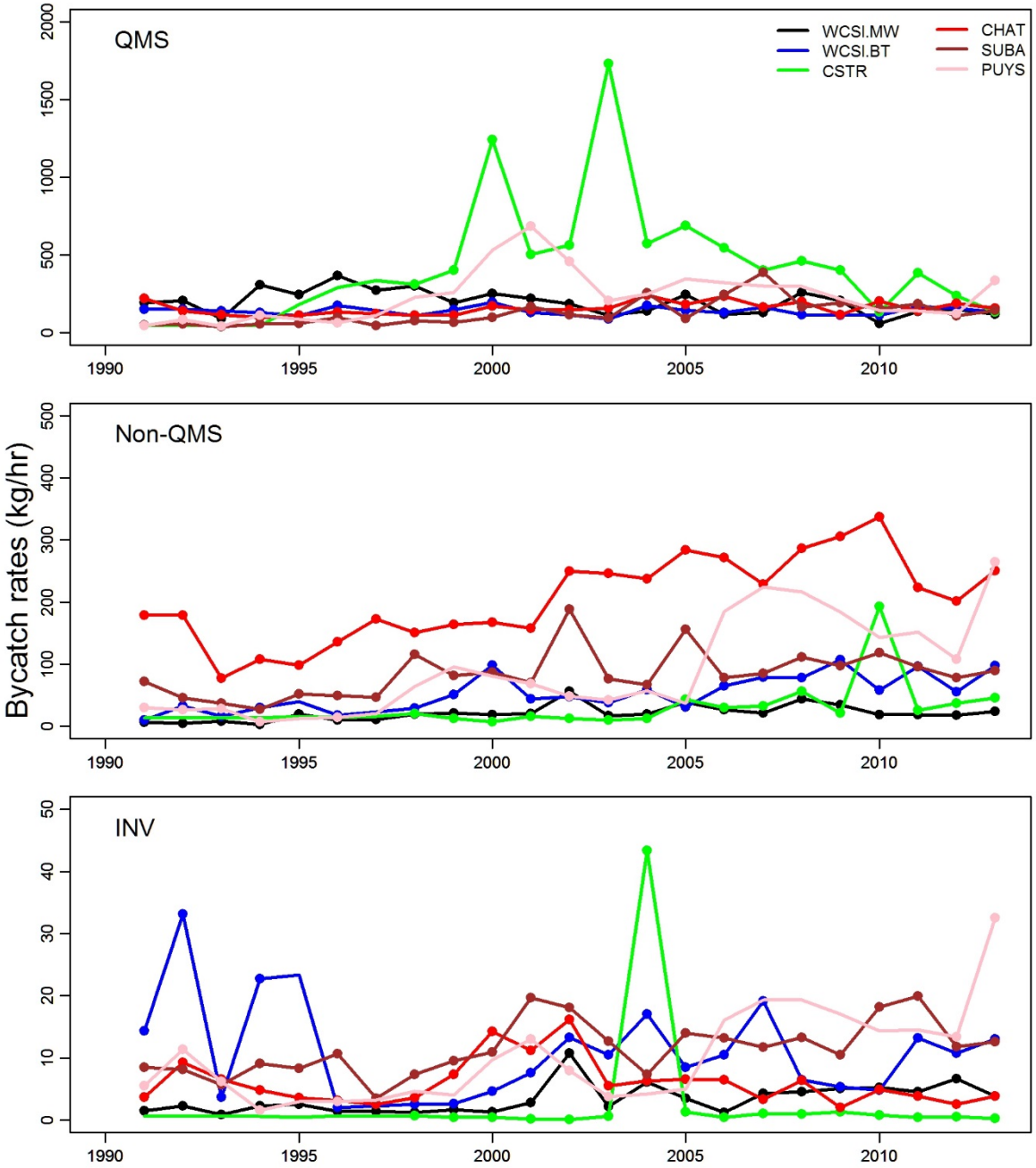


Figure B1: Annual bycatch rates (calculated using the duration-based estimator) by species category and areas used for stratification, in the hoki, hake, or ling target trawl fishery. Bycatch rates are the median of the bootstrap sample of 1000. Dots indicate years in which there were sufficient observed tows (i.e. at least 50) to calculate an individual bycatch rate for the area; for years with no dot bycatch rates were calculated using additional records from between 2 and 7 adjacent years (see Appendix A6) as required to obtain at least 50 records.

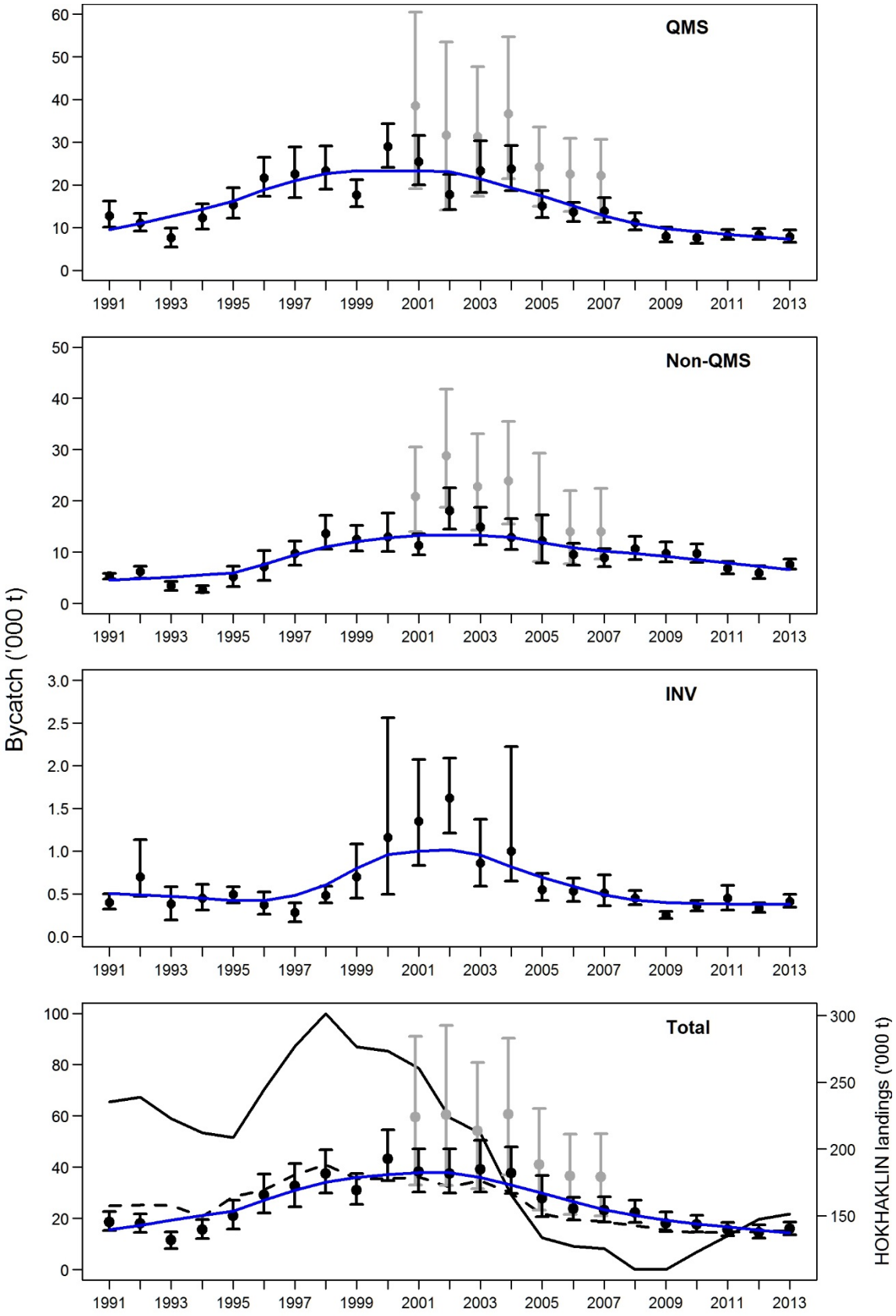


Figure B2: Annual estimates (calculated using the duration-based estimator) of bycatch in the hoki, hake, or ling target trawl fishery, for QMS species, non-QMS species, invertebrates (INV), and overall for 1990–91 to 2012–13. Also shown (in grey) are estimates of bycatch in each category (excluding INV) calculated for 2000–01 to 2006–07 (Ballara et al. 2010). Error bars indicate 95% confidence intervals. The blue lines show the fit of a locally-weighted polynomial regression to annual bycatch. In the bottom panel the solid black line shows the total annual reported trawl-caught landings of hoki, hake, or ling (Ministry for Primary Industries 2014) and the dashed line shows annual effort (scaled to have mean equal to that of total bycatch).

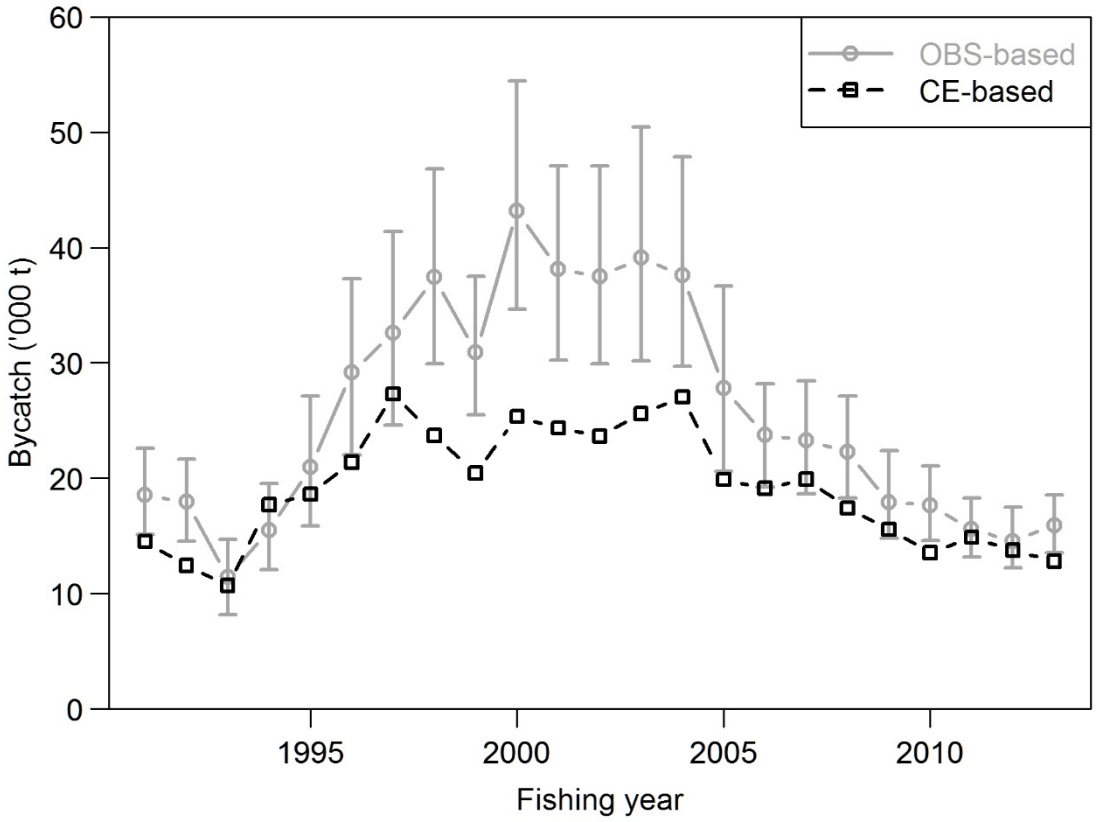


Figure B3: Total annual bycatch (calculated using the duration-based estimator) in the hoki, hake, or ling target fishery from scaled up observer catch rates and commercial catch effort records.

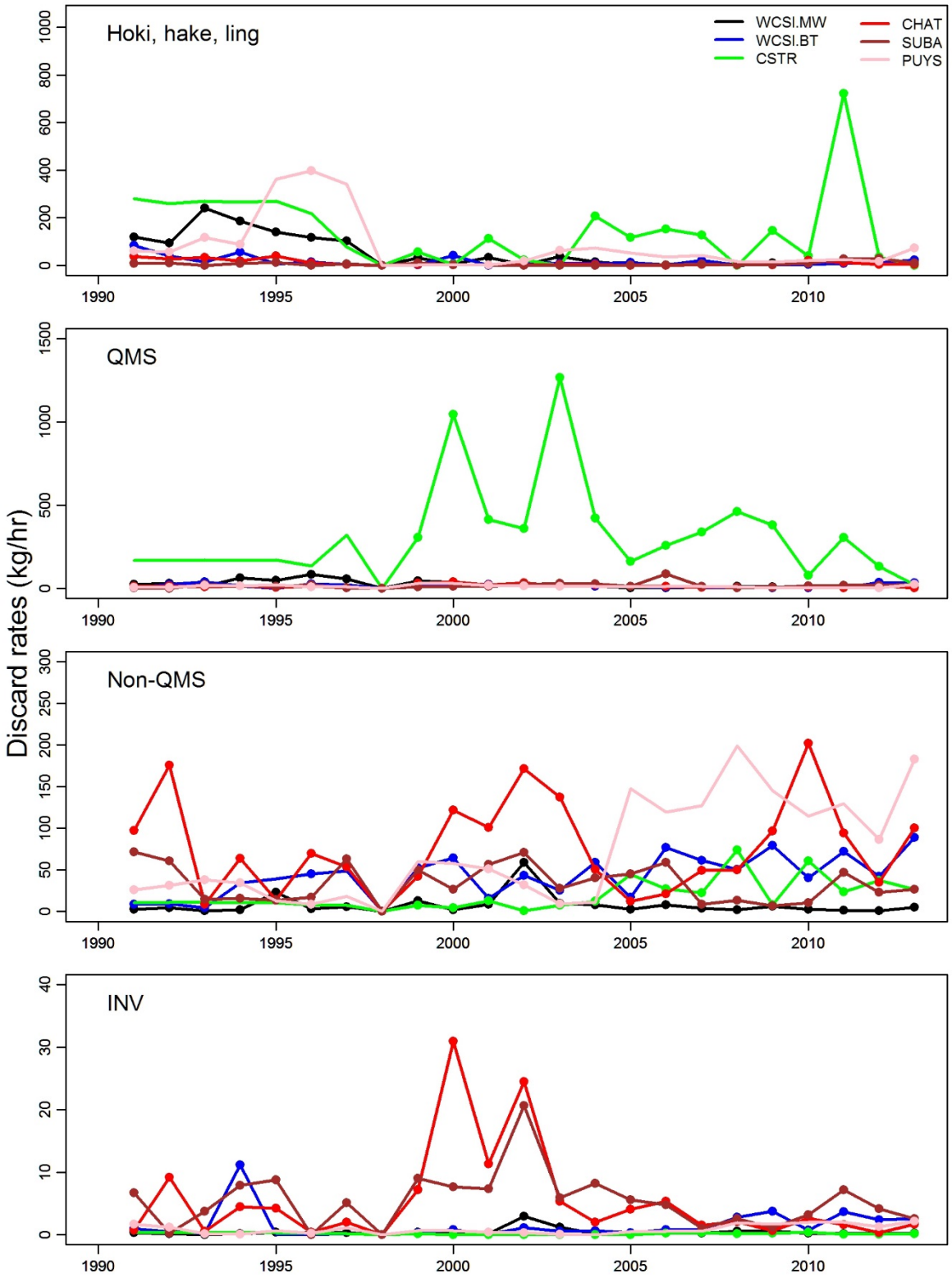


Figure B4: Annual discard rates (calculated using the duration-based estimator) by species category and areas used for stratification, in the hoki, hake, or ling target trawl fishery. Discard rates are the median of the bootstrap sample of 1000. Dots indicate years in which there were sufficient observed tows (i.e. at least 50) to calculate an individual discard rate for the area; for years with no dot discard rates were calculated using additional records from between 2 and 7 adjacent years (see Appendix A6) as required to obtain at least 50 records.

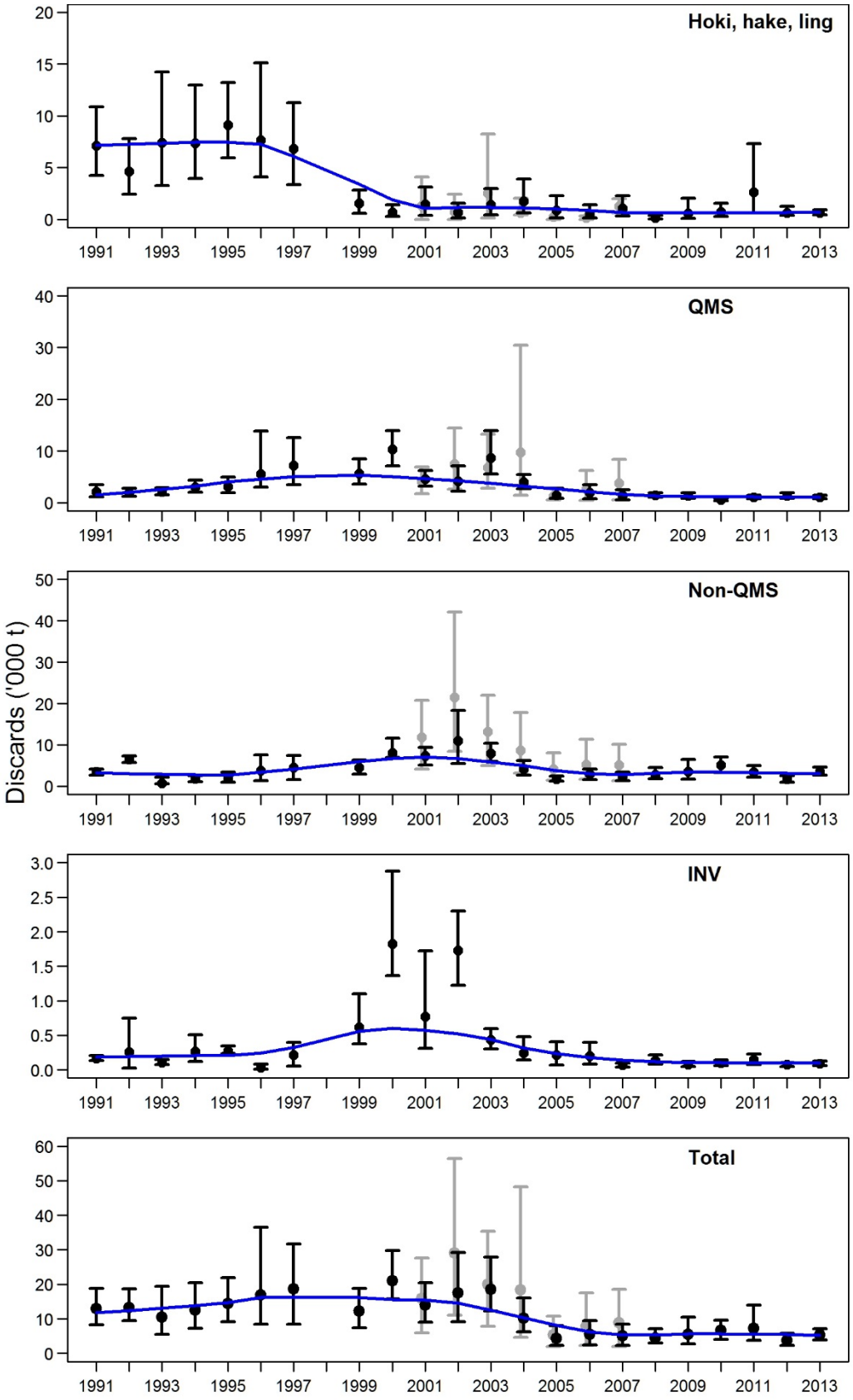


Figure B5: Annual estimates of discards (calculated using the duration-based estimator) in the hoki, hake, or ling target trawl fishery, for hoki, hake, or ling target (HOKHAKLIN), QMS species, non-QMS species, invertebrates (INV), and overall for 1990–91 to 2012–13. Also shown (in grey) are estimates of discards in each category (excluding INV) calculated for 2000–01 to 2006–07 (Ballara et al. 2010). Error bars indicate 95% confidence intervals. The blue lines show the fit of a locally-weighted polynomial regression to annual discards.