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Characterisation analyses for blue mackerel (*Scomber australasicus*) in EMA 1, 2, 3, and 7, 1989–90 to 2013–14

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Contents

EXECUTIVE SUMMARY

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This report is part of a series of middle depth fishery characterisations for species or stocks for which no robust stock assessment has been developed. It follows the standardised format used in previous reports, with additional information and analyses where appropriate. This report is an update of the most recent characterisation of blue mackerel fisheries that was carried out with data from 1990 to 2010.

Reliable records of blue mackerel (*Scomber australasicus*) catches are available annually since the 1990 fishing year. The commercial catch is caught by a variety of methods in all QMAs, and most is caught north of latitude 43° S. The largest, most consistent catches across fishing years are by purse seine vessels targeting blue mackerel schools in EMA 1, and midwater trawl catches targeting jack mackerels in EMA 7. Blue mackerel entered the Quota Management System on 1 October 2002, with a Total Allowable Commercial Catch (TACC) of 7630 t in EMA 1, 180 t in EMA 2, 390 t in EMA 3, and 3350 t in EMA 7.

The landings for EMA 1 peaked at over 10 600 t in 1992 and 1993, and since then have fluctuated between 3000 and 8000 t in most years. The landings in 2010 and 2012 exceeded the TACC, and were just under TACC in 2013 and 2014. Almost all the catch from EMA 1 was taken by the purse seine fishery, mostly as a target species, operating mainly off the northeast coast of North Island and in northern Bay of Plenty between July and December. The annual commercial catch in EMA 2 and EMA 3 is very small and under the TACC. Blue mackerel in EMA 2 was mostly taken by inshore purse seine vessels off the east coast of North Island targeting a mixture of species. Blue mackerel in EMA 3 was mostly taken by midwater trawls targeting jack mackerel near Mernoo Bank. The annual landings for EMA 7 before 1996 were mostly less than 2000 t but then increased to be generally between 2500 t and 5000 t, and peaked in 1999 at about 8800 t. The landings exceeded the TACC in 2003, 2005, 2006, and 2009, and have been less than the TACC since 2010. Blue mackerel in EMA 7 is mostly taken as bycatch from the midwater target jack mackerel trawl fishery, and sometimes as a target species from the purse seine fishery. The midwater trawl fishery operated off the west coast of South Island through most of the 1990s, but since then there has been a shift of effort to the north over time where a fishery has developed in the North Taranaki Bight and further north off the west coast of North Island.

A standardised catch per unit effort (CPUE) analysis was carried out using the catch effort data from the midwater trawl fishery in EMA 7 where jack mackerel was targeted. Because there was a change in the composition of the fleet that occurred during the mid to late 1990s, separate CPUE indices were calculated for an early time series (1990 to 1998) and a late time series (1997 to 2014). For the early time series, the CPUE indices showed a generally flat trend; for the late time series, the CPUE indices showed a decline from 2000 of more than 50% but indices are relatively flat in recent years, and this series appears to provide reliable indices of abundance.

Blue mackerel are encountered in various trawl surveys series but none are optimised to estimate biomass for this species, and too few fish are measured to provide useful length distributions. Data cannot be used to develop time series of length distribution or biomass indices. Observer sampling in EMA 7 and market sampling in EMA 1 have provided consistent length frequency and age distributions. An increase in the abundance of small fish has been observed on the West coast since 2010. The development of appropriate monitoring schemes for blue mackerel from EMA 1 and EMA 7 is recommended.

A stock assessment for EMA 7 should be run once ageing of two years of sampling has been completed (suggested years were 2007 and 2014). In EMA 3 catch is less than a third of the TACC; catch rates show large variability and no abundance series was possible.

1. INTRODUCTION

This report is part of a series of middle depth fishery characterisations for species or stocks for which no robust stock assessment has been developed. It follows the standardised format used in previous reports, with additional information and analyses where appropriate. This report is an update of the most recent characterisation of blue mackerel fisheries that was carried out with data from 1989–90 to 2009–10 (Fu 2013).

Blue mackerel is generally caught by purse seine or midwater fishing in depths of less than 300 m, but are also taken by a variety of methods including bottom longline, bottom pair trawl, beach-seine, bottom trawl, drift net, dip net, Danish seine, handline, lampara, lobster pot, ring net, surface longline, setnet, and troll, although the catches from these other methods are low (Fu 2013). Most catch is taken north of latitude 43° S with the largest and most consistent catches from the target purse seine fishery in EMA 1, 2 and 7, and as non-target catch in the jack mackerel mid-water trawl fishery in EMA 7 (Fu 2013). Most blue mackerel purse seine catch comes from the Bay of Plenty and East Northland, where it is mainly taken between July and December (Fu 2013). Purse seine fishing effort on blue mackerel has been strongly influenced by the availability and market value of other pelagic species, especially skipjack tuna and kahawai, with effort increasing as limits have been placed on the purse seine catch of kahawai (Fu 2013).

Research has focused on stock monitoring by commercial catch-sampling in both EMA 1 and 7 during 1998 (Morrison et al. 2001a), 2003 (Manning et al. 2006), 2004 (Manning et al. 2007a), 2005 (Manning et al. 2007b), 2006 (Devine et al. 2009), 2007 and 2008 (M.H. Smith & P. Taylor, unpublished results from research project EMA2007/01). Age validation was attempted using radioisotope dating methods, which provided support for the age estimates produced in the catch-sampling series (M. Manning, unpublished results from research project EMA2005/02). The age validation study also investigated optimal market sampling designs and some causes of imprecision in the age estimates produced, resulting in improved protocols for preparing and interpreting blue mackerel otoliths (Manning & Marriott 2006). Associated biological relationships for New Zealand blue mackerel such as length-at-age, weight-at-length, and length- and age-at-maturity have also been quantified (Manning et al. 2006, 2007a, 2007b). The method for estimating blue mackerel ages was reviewed and refined (Marriot & Manning 2011), and age error investigated (McKenzie & Manning 2011).

Catch histories (domestic and foreign) of commercial inshore finfish and shellfish were developed by Management Area from 1931 to 1982 where available, and for blue mackerel catch histories have been summarised for calendar years 1974 to 1982 (Francis & Paul 2013).

Relative abundance indices derived from aerial sightings data produced by pilots supporting purse seine fishing operations have been developed (Taylor 2015), although most of the data are concentrated in EMA 1 off the northeast coast of the North Island. Recent research has shown that indices of relative abundance of blue mackerel from the aerial sighting data are unreliable over small areas as there is high inter-annual variation, suggesting varying levels of immigration/emigration into the survey area, and indicating that the indices may be reflecting only part of a much larger stock (Taylor 2014). Bradford & Taylor (1995) produced several indices, including a presence/absence or binomial index, annual medians of the number of schools, and total tonnage sighted. They found some conflict between the indices and little change throughout the time series apart from a peak in the late 1980s. Annual means of total tonnage and number of schools were used as indices by Taylor (1999, unpublished results), but an independent examination of the aerial sightings data by Sampson (2000) has found that that they are not a reliable measure of relative abundance because they are not standardised by the amount of flying time. The feasibility of fishery-independent aerial surveys for blue mackerel and other small pelagic species in the New Zealand EEZ has also been investigated (Taylor 2015), but no fishery-independent surveys using aerial overflights or other methods have yet been carried out. Taylor (2015) investigated a multi-purpose aerial method for surveying inshore pelagic finfish species and concluded that it would be of no use for blue mackerel as it would yield very high CVs for this species.

The commercial catch of blue mackerel in the New Zealand EEZ varies greatly between fishing years. Inter-annual variation in catches is thought to reflect variable market demand rather than changes in stock abundance (Morrison et al. 2001a). For example, blue mackerel has become a more valuable alternative to jack mackerel as a replacement for kahawai during the skipjack tuna off-season in EMA 1. The catch per unit effort (CPUE) of the northern purse seine fishery was examined by Morrison et al. (2001b). This data source held little or no information that would be useful in a stock assessment. Some of the basic assumptions required for the application of CPUE analyses were also violated, due to the fishery targeting surface schools, and variability in fishing effort due to market forces, and the availability of other target purse seine species, independent of blue mackerel abundance.

Taylor (2002) suggested that CPUE indices are likely to be unreliable indicators of changes in abundance for blue mackerel as the fish are highly mobile, both vertically within the water column and geographically between areas, and have the tendency to school by size, and that irregular fluctuations in catch may have indicated a lack of concurrence in availability of fish to main gear types (trawl or purse seine) rather than providing evidence of years of high or low abundance. Catch seasonality showed inversely correlated patterns for the purse seine and midwater trawl methods in EMA 7: purse seine catches were taken in most months except between June and August; midwater trawl catches were low for most of the year with a large peak in July and August. Taylor (2002) examined patterns in aerial sighting data and found that a large proportion of blue mackerel in EMA 7 is absent from surface schools during winter, but is present in subsurface schools mixed with jack mackerel; though these data were too patchy to provide a definitive seasonal pattern. He argued that blue mackerel change their behaviour in June–August and thus become more vulnerable to the midwater fleet, or that the fleet switch their strategy to take advantage of the change in fish behaviour. Other factors also influence catch and thus reduce the validity of using catch as an indicator of abundance; for example: the low abundance of skipjack tuna in 1999 was considered to be the key factor that resulted in high catches of blue mackerel in both the purse seine and midwater trawl fisheries (Fu 2013).

For the purse seine fleet, there is a tendency for fishers to target blue mackerel by size and for catch rates to remain high when abundance is low. For the midwater trawl fleet where blue mackerel is taken as bycatch in the jack mackerel target fishery, the preference for blue mackerel catch is driven by market conditions and also differs by fishing company depending on the amount of blue mackerel quota each company owns (Devine et al. 2009). However, fishers have suggested that the sounder-mark for jack mackerel schools has the same appearance as a mark for mixed schools of jack mackerel and blue mackerel (Taylor 2002), which indicates that the blue mackerel catch is largely beyond the control of vessel operators and will fluctuate according to both the abundance and fishing effort present in the fishery. Fu & Taylor (2007) developed standardised CPUE indices based on commercial catch-per-unit-effort associated with the midwater trawl fishery for blue and jack mackerels (*Trachurus* spp.) in EMA 7. The standardised indices were updated in 2010 using fishery data up to 2009 and then to 2010 (Fu & Taylor 2011; Fu 2013). Concerns over inter-annual variation in the indices led the Deepwater Fisheries Assessment Working Group to conclude that the extent to which these indices provide information on the true level of stock abundance was uncertain.

Fu (2013) characterised the blue mackerel fisheries up to the fishing year 2010, and found the largest catches are by purse seine vessels in EMA 1, with catches by midwater trawl in EMA 7 also important. The catch in EMA 2 and EMA 3 was very small and the TACC was not fully caught in either stock. The inter-annual variation in blue mackerel catches is thought to reflect market demand. The CPUE indices in EMA 7 showed a declining trend through to the early 2000s, and then remained relatively flat. From this study, the Deepwater Fisheries Assessment Working Group identified that CPUE could be used to monitor the EMA 7 fishery, and that the recent northern west coast of the South Island (WCSI) fishery should be considered separately from the WCSI fishery in early years.

Under the 10 year National Fisheries Plan for Deepwater and Middle-depth Fisheries (Ministry of Fisheries 2010) the blue mackerel fishery is to be characterised every four years, in 2009–10, 2013–14 and 2017–18. This report summarises the analyses carried out for the Ministry for Primary Industries under project DEE201007EMAD "Characterisation and fishery monitoring of deepwater and middle depth species" which, for blue mackerel, includes the following objectives:

- To characterise the fisheries by analysis of commercial catch and effort data up to 2013–14;
- To carry out standardised CPUE analyses for the major fisheries (Fishstocks) where appropriate;
- To review the indices from CPUE analyses, all relevant research trawl surveys and observer logbooks to determine any trends in biomass, size frequency distributions or catch rates;
- To review stock structure using data accessed above and any other relevant biological or fishery information;
- To assess the availability and utility of developing a series of age frequency distributions from otoliths collected by researchers on trawl surveys or by observers on commercial fishing vessels.

- To make recommendations on future data requirements (including recommendations for annual levels of observer sampling) and methods for monitoring the stocks.

The report contains sections of text and tables that can be transferred to the MPI Plenary report as appropriate. Some topics present in plenary reports were not reported on in this report but the headings are listed in the appropriate place in grey. Tables and figures are provided in four Appendices: A, Survey data; B, Observer data; C. Fishery Characterisation; and D, Catch-per-unit-effort analyses. Data are analysed by fishing year (1 October to 30 September), referred to as, for example, 1990 for the 1989–1990 fishing year.

2. REVIEW OF THE FISHERIES

2.1 Commercial fishery

Blue mackerel are taken by a variety of methods in all QMAs, including bottom longline, bottom pair trawl, beach-seine, bottom trawl, drift net, dip net, Danish seine, handline, lampara, mid-water trawl, purse seine, lobster pot, ring net, surface longline, setnet, and troll (Fu 2013). However, for many of these methods the catch is very low. The commercial catch is caught mainly north of latitude 43° S (Morrison et al. 2001a). The largest and most consistent catches have been from the target purse seine fishery in EMA 1, 2 and 7, and as non-target catch in the jack mackerel mid-water trawl fishery in EMA 7 (Figure 1). In EMA 7, catches are mainly by midwater trawl vessels targeting jack mackerels. Most of the purse seine catch comes from the Bay of Plenty and east Northland, and the target purse seine catch in EMA 1 is the single largest component of the catch by any method in any QMA (Morrison et al. 2001a). Historical estimated and recent reported blue mackerel landings, and TACCs, are shown in Tables 1–3, while Figure 2 shows the landings and TACC values for these three main stocks.

The purse seine catch is taken primarily between July and December (Taylor 2008). Since 1984 the catch of blue mackerel in New Zealand waters has grown substantially, primarily in the purse seine fishery in EMA 1 (Table 1). Total catches peaked in 1992 at more than 15 000 t, of which 60–70% was taken by purse seine (Morrison et al. 2001a). More recently, commercial landings of over 12 500 t were taken in 1999, 2001 and 2005, with the highest landings recorded in EMA 1 and EMA 7. EMA 1 landings exceeded the TACC in 2005, 2007, 2010 and 2012. The purse seine fishery accounted for 92% of the total EMA 1 landings in 2005.

EMA 7 landings in 2005, 2006, and 2009 also exceeded the TACC (Table 1), and in these years landings from EMA 2 and EMA 3 were well below the TACC and at levels near the lowest recorded since 1984. There was an increase in EMA 3 catch from 2006, but to levels still well below the TACC. The blue mackerel catch from EMA 7 is principally non-target catch from the jack mackerel mid-water trawl fishery and, in 2005, represented about 85% of total landings in that Fishstock with most of the balance taken by purse seine (12%).

Manning et al. (2007b) and Taylor (2008) suggested that inter-annual variations in catch may reflect variable market demand and fishing effort rather than changes in stock abundance. In the purse seine fishery, blue mackerel has become the second most preferred species because of decreased TACCs on kahawai. Skipjack tuna is the preferred species and blue mackerel are seldom targeted once the skipjack season has begun in late-spring, early summer. Thus, the early arrival of skipjack can result in reduced volumes of blue mackerel being landed. Management of company quota is also complicated by the relative timing of the fishing season and the fishing year and this, along with the timing of the main market, may influence whether the blue mackerel TACC can all be taken in a particular year (Fu 2013). The fishing season usually begins in about July–August and finishes in about November. The main market for purse seined blue mackerel takes up to 80% of the catch and requires premium fish to be available from early spring. To meet the demands of this market and to minimise the costs of storing fish for many months, fishing companies retain some proportion of their quota in a given year until late in the fishing year when fish become available. If availability is delayed until after October 1, only 10% of the total quota can then be carried over into the new fishing year.

As blue mackerel in QMAs 7, 8 and 9 is taken principally as bycatch in the jack mackerel TCEPR target fishery in JMA 7, factors influencing the targeting of jack mackerel also affect blue mackerel landings. Other bycatch species taken in this fishery including barracouta (*Thyrsites atun*), red gurnard (*Chelidonichthys kumu*), John dory (*Zeus faber*), kingfish (*Seriola lalandi*), and snapper (*Pagrus auratus*), and, although non-availability of ACE is unlikely to be constraining in the first three of these, the same is not true of kingfish and snapper (Fu 2013). Fishing company spokespersons have stated that known hotspots of snapper are avoided. Other factors in this fishery include strategies to avoid the catch of marine mammals, and a voluntary code of practice requires that gear is not deployed between 2 a.m. and 4 a.m. It is unknown whether this affects total landing volumes.

2.2 Recreational fishery

Blue mackerel does not rate highly as a recreational target species although it is popular as bait (Ministry for Primary Industries 2015). There is some uncertainty with all recreational harvest estimates for blue mackerel and there is some confusion between blue and jack mackerels in the recreational data. The harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and, c) the 2000 and 2001 estimates are implausibly high for many important fisheries.

Recreational catch in the northern region (EMA 1) was estimated at 114 000 fish annually by a diary survey in 1994 (Bradford 1996), 47 000 fish in a national recreational survey in 1996 (Bradford 1998), 84 000 fish (CV 42%) in the 2000 survey (Boyd & Reilly 2005) and 58 000 fish (CV 27%) in the 2001 survey (Boyd et al 2004). The surveys suggest a harvest of 35–90 t per year for EMA 1, insignificant in the context of the commercial catch. Estimates from other areas are very low (between 500 and 3000 fish annually) and are likely to be insignificant in the context of the commercial catch.

2.3 Māori customary fisheries

There is no quantitative information available on Māori customary harvest of blue mackerel.

2.4 Illegal and misreported catch

There is no known illegal catch of blue mackerel.

2.5 Other sources of mortality

There is no information on other sources of mortality.

2.6 Regulations affecting the fishery

Current and historical limits on catch for blue mackerel are described in Section 2.1. Minimum codend mesh-size regulations that currently apply to the trawl fisheries specify 60 mm for Sub-Antarctic (FMA 6) fisheries and FMA 5 south of 48°S; and 100 mm elsewhere. Previously, the codend mesh-size change took effect at the boundary between the Snares and Auckland Islands fisheries (the old EEZ area F/E boundary), which was at 48° 30’S. However, since 1 October 1983 the codend mesh size change takes effect at latitude 48°S to allow for targeting of squid around the Snares Islands (Hurst 1988).

Protection of bycatch species in multi-species fisheries is mainly through the QMS, with quotas currently set for 628 fishstocks. Catches of protected species such as corals, seabirds, and marine mammals are monitored through the government observer programme and all trawl vessels over 28 m have been required to deploy seabird mitigation devices to minimise interactions with trawl warps since April 2006 (Ministry of Fisheries 2011).

3. BIOLOGY AND DISTRIBUTION

3.1 Distribution and stock structure

Blue mackerel are widespread in North Island and northern South Island waters. Bagley et al. (2000) presented summary distributions of blue mackerel from various datasets, and found that catches were from North and South Taranaki Bights, northern WCSI southwards to the Hokitika Trench, and around Mernoo Bank. Taylor (2002) found that blue mackerel were distributed over most of the range covered by aerial sightings supporting purse seine vessels, from the Three Kings Islands around the entire coastline of the North Island, and from the Kahurangi Shoals, outer Golden and Tasman Bays to Kaikoura. The highest densities were seen on the east coast from North Cape to Hawke Bay, and in the area including the South Taranaki Bight to Kahurangi and the outer Golden and Tasman Bays. The distribution at the surface is seasonal and differs from its known geographical range as during summer, surface schools are found in Northland, Bay of Plenty, South Taranaki Bight, and Kaikoura, but they disappear during winter, when only occasional individuals are found in Northland and the Bay of Plenty (Taylor 2002). This winter disappearance may coincide with the peak in bycatch of blue mackerel in the winter jack mackerel mid-water trawl fishery in EMA 7 (Fu 2013). This suggests an increased partitioning of the population in deeper water at this time of the year, reflecting an observed behavioural characteristic of the related Atlantic mackerel (*Scomber scombrus*) (Sette, 1950). Summaries from aerial sightings data show that blue mackerel can be found in mixed schools with jack mackerel, kahawai, skipjack tuna and trevally, and that its appearance in mixed schools varies seasonally (Taylor 2002).

Sampling of eggs, larvae, and spawning blue mackerel indicate at least three spawning areas for this species: Northland-Hauraki Gulf; Western Bay of Plenty; and South Taranaki Bight (Crossland 1981, 1982). Nothing is known of migratory patterns or the fidelity of fish to a particular spawning area. Examination of mitochondrial DNA shows no geographical structuring between New Zealand and Australian fish (Smith et al. 2005). Meristic characters show significant regional differentiation within New Zealand fisheries waters and, combined with parasite markers and meristic characters, and based on their differences between areas, Smith et al. (2005) showed that blue mackerel in the New Zealand EEZ are subdivided into at least three stocks: in EMA 1, EMA 2, and EMA 7.

Using recorded commercial and research catches, Taylor (2002) found that the geographical distribution and habitat of blue mackerel vary with life history stage. Hurst et al. (2000) summarised life history stages from the research trawl and found that juvenile and immature blue mackerel are northerly in their distribution around the North Island and into Golden and Tasman Bay, whereas adults are recorded around both the North and South Islands to Stewart Island and across the Chatham Rise almost to the Chatham Islands (Figure A1). Sporadic catches of small numbers of yearling blue mackerel have been made by bottom trawl in shallow waters (Hurst et al. 2000).

3.2 Spawning

Blue mackerel are serial spawners, releasing eggs in batches over several months (Jones, 1983). Based on gonad condition, sexual maturity for both sexes of blue mackerel taken in the Great Australian Bight between January 1979 and December 1980 was estimated to be about 28 cm fork length (FL), which translates to an age of about 2 years (Taylor, 2002). Eggs are pelagic and development rate is dependent on temperature. In plankton surveys, blue mackerel eggs have been found from North Cape to East Cape, with highest concentrations from Northland, the Hauraki Gulf, and the Western Bay of Plenty (Crossland, 1981). Eggs have been described throughout the Hauraki Gulf from November to the end of January, at surface temperatures in the range 15–23°C.

Smith et al. (2005) reported that two spawning concentrations have been noted for blue mackerel. Crossland (1981, 1982) used egg and larval surveys to identify spawning in the Hauraki Gulf and east Northland. Hurst et al. (2000) produced spatial distribution maps of fish in "ripe and running ripe" and "spent" condition using gonad staging data and showed spawning blue mackerel from a few tows off Tasman Bay and Taranaki in EMA 7 and in the Bay of Plenty in EMA 1.

Gonad staging data of blue mackerel collected from the research trawl and observer databases provide information on the presence and timing of spawning. These data provided some evidence that spawning took place in EMA 7 in June and from October to January (Figures C1–C3). However, Taylor (2002) cautioned that the reliability of the gonad staging data is unknown and there may be some difficulty in distinguishing between immature and resting gonads and early stage maturing.

3.3 Age and growth

No new information on ageing or growth parameters is available since the previous characterisation (Fu 2013). A comprehensive description of the methods to prepare and interpret blue mackerel otoliths for ageing is available (Marriott & Manning 2011).

Morrison et al. (2001a) estimated von Bertalanffy growth curves using otoliths collected from the Tauranga purse seine fishery, and from archived otoliths from the west coast of the North Island (WCNI), the Hauraki Gulf, and the Bay of Plenty (see table 4, Morrison et al. 2001a).

Manning et al. (2006) estimated von Bertalanffy growth curves from the age and length data collected from the EMA 1 purse fishery and reported that the estimates were consistent with those of Morrison et al. (2001a). Both studies found no apparent difference in growth rate between sexes. Differences in growth between EMA 1 and EMA 7 fish were found to be less than differences in growth of fish in New Zealand versus Australian waters (Devine et al. 2009).

The Bay of Plenty results have a much broader distribution, with a maximum age of 24 years, and a mode in the data around 8 to 10 years (Manning et al., 2006). Growth parameters estimated in the Bay of Plenty study are given in Table 4. Following a quantitative test of competing growth models in the Bay of Plenty study, no evidence was found of statistically significant differences in growth between the sexes in Bay of Plenty blue mackerel.

Age and growth studies suggest a difference in the age structures of catches taken in the Bay of Plenty (EMA 1) and New South Wales (Australia) (Rohde, 1987). For fish from the New South Wales study, a peak was found at 1 year that accounted for more than 55% of the fish sampled, with a maximum age of 7 years. Australian studies may underestimate the ages of larger, older blue mackerel in their catch as the Australian ageing method was based on reading otoliths whole in oil, whereas the New Zealand method was based on otolith thin-sections. Results from the New South Wales study suggest that blue mackerel 25–40 cm FL may be 3–7 years old. Using the New Zealand method, fish in this length range could be as old as 16 years. Australian scientists, reading whole otoliths, may be missing opaque zones near the margin, which are visible in sectioned otoliths, and although the Australian study validated the timing of the first opaque zone in blue mackerel otoliths, the results do not cover the complete life history defined using either the Australian or New Zealand method (Marriot et al. 2010). A standard and validated age estimation method for blue mackerel is an important topic of future research for New Zealand blue mackerel.

A feasibility study on validating the New Zealand growth zone counting method used to estimate blue mackerel ages using lead-radium dating was performed (Marriott et al. 2010). Initial radiometric results showed that analysis of otolith cores was impractical, given the difficulties associated with extraction in a cost-effective manner. An alternative method using pooled whole otoliths relied on assumptions of otolith mass growth through time, resulting in less precise age determinations. However, the method did indicate that blue mackerel in New Zealand are a relatively long lived small pelagic species, living to at least 17 to 49 years, with the real age most likely nearer the lower value (Marriott et al. 2010). While this range of age estimates is less than desirable for the validation of the growth zone counting method for this species, the findings are consistent with the New Zealand method where traditional otolith ageing studies from commercial catches have blue mackerel living to at least 24 years.

3.4 Natural mortality

No new information on natural mortality is available since the previous characterisation (Fu 2013). Morrison et al. (2001a) estimated instantaneous natural mortality (M) for both male and female fish using the method of Hoenig (1983). Based on age estimates from otoliths collected during the mid 1980s when fishing pressure was presumably light, natural mortality estimates of 0.22 for males and 0.20 for females were derived.

3.5 Length-weight relationships

No new information on length weight parameters is available since the previous characterisation (Fu 2013). The length–weight relationship for blue mackerel was estimated from a linear regression of log-transformed length and weight data from EMA 1 fishery (Manning et al. 2007b).

3.6 Feeding and trophic status

In New Zealand, the diet of blue mackerel has been described as zooplankton, which consists mainly of copepods, but also includes larval crustaceans and molluscs, fish eggs and fish larvae (Ministry for Primary Industries, 2015). Feeding involves both filtering of the water and active pursuit of prey, with blue mackerel feeding on much smaller animals than other fish such as kahawai.

4. CURRENT AND ASSOCIATED RESEARCH PROGRAMMES

4.1 Ministry for Primary Industries

Blue mackerel is one of 18 species included on a list to be regularly characterised under the Ministry for Primary Industries 'Deepwater 10-year Plan'. There are no specific research programmes for blue mackerel. Bottom research trawl surveys have been conducted since the early 1990s using either the *Tangaroa* (Chatham Rise survey or Sub-Antarctic Survey) or the *Kaharoa* (east coast of the South Island (ECSI), east coast of the North Island (ECNI), WCSI, WCNI). Some of those surveys encounter blue mackerel, but these surveys are not optimised to estimate biomass for this species.

5. FISHERY INDEPENDENT OBSERVATIONS

5.1 Research surveys

5.1.1 Biomass indices, length frequency distributions, and gonad stage data, length and age frequency distributions

Bottom trawl surveys in waters within the depth range of blue mackerel are summarised in this section. The surveys are part of standardised time series with potential use to monitor blue mackerel abundance, although these surveys are not optimised to estimate biomass for this species. The relevant trawl survey outputs are summarised in Appendix A. Note that years referred to in the research survey section are calendar years. The trawl survey series were analysed using NIWA's research trawl survey analysis program "SurvCalc" (Francis & Fu 2012). The length data collected from those research trawl voyages throughout New Zealand waters are summarised in Table A1. Length data of blue mackerel sampled in some of the early exploratory surveys conducted in the 1970s by other vessels (*Ikatere* and *James Cook*) were summarised by Taylor (2002).

Fish length was generally between 5 and 50 cm FL, with smaller fish likely to be in waters around the north Island, especially in EMA 1 and 2 (Figure A2). Unscaled length frequency distributions of blue mackerel sampled from trawl surveys in EMA 1, 2, and 7 are shown in Figure A3 (only surveys with more than 50 fish sampled are shown). In most years the length data were too few to provide useful length distributions, and most fish caught during the surveys were juvenile fish less than 20 cm. The length distributions from the 1990 survey in EMA 7 showed modes centred at about 20, 30, and 45 cm, although sample sizes were small (Fu 2013).

6. FISHERY DEPENDENT OBSERVATIONS

6.1 Commercial catch length data (observer and market sampling data)

Length and age sampling

Commercial catches of blue mackerel were sampled from a number of sources. Length and age data of blue mackerel were collected during limited sampling of purse seine catch in EMA 1 during 1998 (Morrison et al. 2001a) and 2003 (Manning et al. 2006). A new sampling programme was developed under the Ministry of Fisheries research project EMA200401 with the aim of representatively sampling the target purse seine catch in EMA 1 and the target purse seine catch and catches by midwater trawl vessels targeting jack mackerel in EMA 7 from 2004 onwards.

Landings by purse seine vessels targeting blue mackerel in EMA 1 and EMA 7 were sampled in fish processing factories in Tauranga using a stratified scheme in 2004 (Manning et al. 2007a), 2005 (Manning et al. 2007b), and 2006 (Devine et al. 2009), although there was no formal spatial or temporal allocation of sampling effort. Samples were systematically collected from the vessel-hold strata for each landing, where about 100 fish were randomly sampled from each hold at a rate of up to three samples per hold per day. Most samples were from EMA 1; for EMA 7 the sample size was generally small, with only 2–3 landings sampled each year (Table B1). The spatial and temporal distribution of the catch and sampling effort suggested that sampling data collected from EMA 1 may be representative of the fishery, and data collected from EMA 7 may be not representative — at least for some years (Devine et al. 2009). In 2004 no target purse seine vessels operated in EMA 7. Samples were taken from inshore trawlers as bycatch of fishing effort directed at other preferred species (Manning et al. 2007b).

The representativeness of observer sampling of blue mackerel was evaluated by plotting the proportion of landed catch for each year by area and by month, statistical area, depth range, and vessel length as circles, and overlaying this with the proportion of the observed catch for those same circles as crosses (Figure C4). If the proportions are the same, the plots align; if over- or under-sampling has occurred, the crosses are either larger or smaller than the circles. Observed length frequency samples by area are representative of catches from WCSI and WCNI (Figure C4).

Blue mackerel catches by midwater-trawl vessels in EMA 3 on the Chatham Rise have been sampled at sea by the Ministry for Primary Industry Observer Programme mainly from Statistical Area 021, and are patchily sampled by year, month, and by vessel size (Tables C1–C3, Figure C4a). Since 1993, 60 tows have been sampled and 16 630 fish measured, with at least 100 measured in each year since 2011 (Table C2 and C3).

Blue mackerel catches by midwater-trawl vessels targeting jack mackerel in EMA 7 have been sampled at sea by the Ministry for Primary Industry Observer Programme since 1987. The sampling scheme was described in full by Sutton (2002). Typically, about 100 fish were randomly sampled from the catch every two to three days during each fishing trip for length measurements. Samples were collected more frequently when larger catches of blue mackerel were made. However, observers were assigned to vessels opportunistically with no formal spatial or temporal allocation of sampling effort. The sample size was small in the early years, with generally fewer than 500 fish sampled each year. The sampling effort has significantly increased since 2004, with more tows sampled and over 2000 fish measured each year (Tables C2 and C3). The midwater jack mackerel fishery in EMA 7 appears to be sampled adequately with respect to area, month, and depth, and the data collected are thought to be representative of the fishery in EMA 7 since 2004 (Table C2, Figure C4b and C4c).

Length and age frequency distributions

Scaled length frequency distributions were estimated for each of the fisheries using NIWA's catch-at-age software (Bull & Dunn 2002). For the purse seine fishery, the catch samples were scaled up to each landed catch, and summed over all landings. For the midwater trawl fishery, the length frequency of fish from each tow were scaled up to the tow catch weight, summed over all tows, scaled up to the total catch in each trip, and then summed across the all trips, to yield overall length frequency distributions.

The length distributions of observed blue mackerel for all years combined show that smaller (under 40 cm FL) blue mackerel are more likely to be found in the WCNI regions (Figure C5).

Length distributions of blue mackerel sampled in EMA 1 ranged from 30–55 cm, with the mode roughly centred around 45 cm in most years (Figure B1a), whereas blue mackerel ranged from 40–55 cm in EMA 2 and EMA 3 (Figures B1b and C6a).

From 2002 to 2009 length distributions of blue mackerel sampled from in EMA 7 from both the WCSI and WCNI generally ranged from 40 cm to 55 cm and were strongly unimodal, with the mode roughly centred around 48 cm in most years (Figures B1c, C6b and C6c). The purse seine target fishery in EMA 7 did not sample any fish outside the 30–55 cm size range, and the fish caught during 2005 and 2006 were smaller than those during 2004 (samples in 2004 were from non-target catch). The trawl bycatch fishery in EMA 7 caught few fish in the 30–40 cm size range, but caught slightly more large fish before 2004. There appears to be no sign of mode progression present over time in the length distribution in any of the fisheries in the 2000s. From 2010 length distributions showed a range of small fish from 25 to 45 cm along with the strong mode from 40 to 55 cm in both the WCNI and WCSI, especially in 2010, 2013 and 2014 (Figures C6b and C6c). In 2014 two modes of smaller fish were present at 28 and 37 cm on the WCNI, and one at 34 cm on the WCSI which appear to be the same cohort at different sizes at different times of the year.

Otoliths were also collected from sampled landings, by observers on observed fishing trips between 2002 and 2014 in EMA 1 and 7 (Tables B2 and C4). Scaled age distributions for the EMA 1 purse seine fishery and EMA 7 purse seine fishery and the midwater trawl fishery were estimated by applying the age-length key to the scaled length frequency for 2003, 2004, 2005, and 2006 fishing years (see figure 11 of Manning et al. 2006, figure 9 of Manning et al. 2007a, figure 8 of Manning et al. 2007b, and figure 10 of Devine et al. 2009). The age distribution generally ranged between 2 and 25 years with slightly more young fish caught in the purse seine fisheries relative to the trawl fisheries. The age distribution of the catch from the midwater trawl fishery had a slightly broader range (Fu 2013).

Female maturity

The female maturity data are summarised here using the observer five stage reproductive scale: immature and resting, maturing, ripe, running ripe, and spent. The relative proportions of the reproductive stage data are shown in Figure C3 by area, and the numbers of fish sampled are given in Table C5.There were few data available before 2000. After 2003, more data became available from the observer programme, especially on the WCNI where generally over 1000 fish were sampled each year. These data show that ripe or running ripe females mostly occur between September and February on the WCNI, June to October on the WCSI, and throughout most of the year on the Chatham Rise (Figure C3). Spent fish were reported throughout most of the year (Figure C3.

7. DESCRIPTIVE ANALYSIS OF CATCH

7.1 Catch and effort data sources

Catch-effort, daily processed, and landed data were requested from the MPI catch-effort database "warehou" as extract 9843. The data consist of all fishing and landing events associated with a set of fishing trips that reported a positive catch or landing of blue mackerel in EMA fish stock areas (see Figure 1) between 1 October 1989 and 30 September 2014. Data are analysed by fishing year. The requested fields from the database tables are listed in Table D1.

The estimated catches associated with the fishing events were reported on the Ministry for Primary Industries Catch Effort Landing Returns (CELR), Trawl Catch Effort Returns (TCER), Trawl Catch Effort and Processing Return (TCEPR), and Netting Catch Effort Returns (NCER). The greenweight associated with landing events was reported on the bottom part of the CELRs or NCERs, or where fishing was reported on the two other forms it was recorded on the associated Catch Landing Return (CLR). TCEPR and TCER forms record tow-by-tow data with the estimated catch (by weight) of the top five species (TCEPRs) or the top eight species (TCERs) in each individual tow. CELR forms record estimated daily catches for the top five species, which are further stratified by statistical area, method of capture, and target species. Greenweight data associated with landing events are reported on the bottom part of the CELR forms, or on CLR forms for fishing reported on TCEPRs and TCERs. NCER forms record set-by-set data and summarise the estimated catch for the top eight species (by weight) for individual sets. Before 1 October 2007, trawl vessels less than 28 m in length could use either CELR or TCEPR forms whereas trawl vessels over 28 m used TCEPR forms. From 1 October 2007 TCER forms were used by vessels over 6 m and less than 28 m (if less than 6 m the CELR is still used). NCER forms were introduced on 1 October 2006 for set net vessels over 6 m (if less than 6 m the CELR is still used).

Information on total harvest levels is provided via the Quota Management Report/Monthly Harvest Return (QMR/MHR) system, but only at the resolution of Quota Management Area. The data were groomed and restratified to derive the datasets required for the characterisation and CPUE analyses using a variation of the method developed by Starr (2007) as implemented by Manning et al. (2004), with refinements by Blackwell et al. (2005) and Manning (2007), and further modifications for this study. The method allows catch-effort and landings data collected using different form types that record data with different spatial and temporal resolutions to be combined. It also overcomes the main limitation of the CELR and TCEPR reporting systems (frequent non-reporting of species that make up only a minor component of the catch). The procedure was developed for monitoring bycatch species in the Adaptive Management Programme. The major steps are as follows.

Step 1: The fishing effort, estimated catch, and landings data are groomed separately. Outlier values in key variables that fail a range check are corrected using median imputation. This involves replacing missing or outlier values with a median value calculated over some subset of the data. Where grooming fails to find a replacement, all fishing and landing events associated with the trip will be excluded.

Step 2: The fishing effort within each valid trip is then restratified by statistical area, method, and target species.

Step 3: The greenweight landings for each fish stock for each trip are then allocated to the effort data. The greenweight landings are mapped to the effort strata using the relationship between the statistical area for each effort stratum and the statistical areas contained within each fish stock and trip ID.

Step 4: The greenweight landings are then allocated to the effort strata using the total estimated catch in each effort stratum as a proportion of the total estimated catch for the trip. If estimated catches are not recorded for the trip, but a landing was recorded for the trip, then the total fishing effort in each effort stratum as a proportion of the total fishing effort for the trip is used to allocate the greenweight landings.

Step 5: The original intent of the merging process was to allow trip level landings data to be mapped to CELR effort strata. However, many species are captured in fisheries reporting using a combination of form types, and some may use TCEPR forms almost exclusively. The grooming and merging process also allows an evaluation of the amount of catch and effort that is not captured using TCEPR and TCER forms at the fishing event level. If this is substantial, the best characterisation dataset is likely to be the merged trip level data. But if the amount of lost catch and effort is predictable, minor, and stable over time and area, the estimated catch at the level of the fishing event provides a much more detailed dataset for characterisation and CPUE analysis.

Processed product and landed weights in New Zealand fisheries are converted to greenweight catches using species and product-form-specific conversion factors (multiplicative constants). Product form conversion factors for many New Zealand species have changed several times since the full implementation of the QMS. This means that different amounts of greenweight catch are associated with the same amount of processed catch for particular product forms throughout the database. These changes are standardised relative to the latest conversion factor defined for each product state and apply the catch-consistency checking algorithm designed by Blackwell et al. (2005). This algorithm systematically compares the different catch weights recorded for a particular fishing trip against one another and returns the single most consistent catch type for each trip and explicitly and rigorously accounts for conversion factor changes.

The landings data provide a verified greenweight landed for a fish stock on a trip basis. However, landings data include all final landing events – where a vessel offloads catch to a Licensed Fish Receiver, as well as interim landing events, where catch is transferred or retained, and may therefore appear subsequently as a final landing event (SeaFIC 2007). The procedure of Starr (2007) separates final and interim landings based on the landing destination code, and only landings with destination codes that indicate a final landing are retained (see table 2 in Starr (2007)).

7.2 Summary of catches

All tables and figures relating to characterisation of blue mackerel fisheries are contained in Appendix D (Tables D1–12, Figures D1–40). Table D1 provides a summary of the data requested from MPI for this characterisation, and Table D12 contains a list of species codes used.

The reported QMR/MHR landings, ungroomed catch-effort landings, and TACCs (set since 2003) for all EMA fish stocks 1990–2014 are shown in Figure D1. MHR landings and TACCs are also presented earlier in Tables 1 and 3. In general, the catch-effort landings in the raw dataset conform closely with the reported MHR landings. The landings for EMA 1 peaked at just less than 11 000 t in 1992 and 1993, and since then have fluctuated between 3000 and 8000 t in most years. The landings in 2009 were the lowest over the last 20 years. In 2010 and 2012 landings exceeded the TACC (8538 and 8080 t respectively), but landings were just under the TACC in 2013 and 2014. The annual commercial catch in EMA 2 and EMA 3 was very small and under the TACC. The total annual reported landings for EMA 2 and EMA 3 have been below 200 t since 2001, and the catch in EMA 2 was less than 15 t in nine of the last ten years. The annual landings for EMA 7 before 1996 were mostly below 2000 t but increased since then ranging generally between 2500 t and 5000 t. The peak landing, in 1999, was at about 8800 t. The TACC for EMA 7 was initially set at 3350 t in 2003 and has remained unchanged. The landings overran the TACC in 2003, 2005, 2006, and 2009, and have been less than the TACC since 2010.

The weight, number of records, and description of each potential destination type is given in Table D2, and Table D3 summarises the number of landing events for the major destination codes for each stock by fishing year and form type. Most landing events are recorded as “L” (Landed), however substantial numbers were recorded under “T” (transferred to another vessel) and “R” (retained on board) destination codes (both are defined as interim landing events by Starr (2007)). For EMA 7, the “T” events accounted for about 5% of the total reported landings and most of them appeared in the early part of the series through to the late 1990s. The actual destination of the “T” events is unknown as the transferred catches could be landed by foreign vessels to ports outside New Zealand. These interim events accounted for more than half of the annual landings in some of the early years and excluding them from the dataset would lead to retained landings falling short of the MHR by more than 50%. Also there is a large number of trips with estimated catch, but no reported landings, and annual estimated catch exceeds retained landings by up to 40% in some years. It is therefore prudent to retain the “T” landing events (Fu 2013), but other interim landing events (retained as bait, in holding receptacles, or on board) were dropped (after Starr 2007). The conversion factor “J” (observer authorised discard) was introduced in 2013 which will better quantify discarding of blue mackerel, however no observer authorised discard landings were recorded in 2014. Destination code “A” may have in the past at least partially accounted for observer authorised discards (Tiffany Bock, MPI, pers. comm.).

The grooming process excluded a small number of trips with invalid codes in fishing method, target species, statistical area, and trip date which could not be fixed using the median imputation method. The estimated catch and landings removed from the dataset in this process were generally insignificant over the time series. The reported QMR/MHR landings (the ratio of the annual estimated catch to the retained landings in the groomed and merged dataset) do not match well with the retained landings for a number of fishing years, particularly in the 1990s (Table D4, Figure D2). The estimated catches appeared to track the retained landings reasonably well over time and they have captured the majority of the harvest reported via the MHR/QMR system over recent years for all stocks (Table D4). For EMA 1, the retained landings during the 1993 fishing year were about 3000 t less than the reported landings. Fu (2013) found that about 1360 t of the catches were taken from trips that fished in Statistical Areas 037, 040–042, and 045–047 (outside EMA 1), and about 2140 t were from trips that had used both the CLR and CELR forms (the catch appeared to have been equally split between the two forms). For EMA 2, 120 t of landings in 2003 were reported under destination code ‘R’ (retained on board) (Fu 2013). For EMA 7, the retained landings were short of the reported MHR in the early 1990s, but match closely for the later part of the time series.

The estimated catches and retained landings by form type for each fish stock are shown in Figure D3. For EMA 7 and EMA 3, the bulk of catches were recorded on the CLR forms, and a small proportion was from the CELR forms. For EMA 1 and 2 almost all the catches were recorded on the CELR forms. For EMA 1, where most vessels used CELR forms, the ratio of estimated catch to the retained landings was generally about 90% (Figure D1). For EMA 2, 7 t of estimated catches were recorded during the 2007 fishing year and the reported landing was about 130 t. At the trip level, there appears to be a reasonably close match between estimated catch and the reported landings. For EMA 7, the ratio of estimated catch to landings was generally above 80% for the TCEPR forms, but appeared to be more variable for the CELR forms (Figure D1). During the 1997 fishing year, the landings reported on the CELR forms were about 310 t, but the associated estimated catch was only about 3 t; between 2001 and 2003, many CELR records appeared to have recorded the catch in wrong units (i.e. 100 t was recorded as 100 rather than 100 000 kg) (Fu 2013).

The retained landings adjusted for the changes in conversion factors were allocated to the effort strata based on the statistical areas within each fish stock. For this study, the "centroid method" was used in which the midpoint of each statistical area is used to allocate it to the larger fish stock area, for example, Statistical Areas 018 and 032 were allocated to EMA 7, and Statistical Area 019 was allocated to EMA 3. This resulted in a closer relationship between QMR/MHR landings, merged landings, and estimated catch for most stocks. EMA 1, 2, 3, and 9 generally had a mixture of blue mackerel landed as green or dressed. The main processed state for retained landings of blue mackerel in EMA 3 and 7 was "DRE" (includes "dressed", "headed and gutted", and "trunked") with smaller amounts landed green or made into fishmeal (Figure D4). A small proportion of catches were landed green in recent years, but that proportion was higher in early years, and some catches were processed to "Head and Gutted" state (HGU) before 2003. The conversion factor for the "DRE" state was decreased from 1.80 to 1.50 from 1 October 1996. This means that different amounts of greenweight catch are associated with the same amount of processed catch for particular product forms throughout the database. Therefore the greenweights were standardised using the most recent conversion factor for each processed state which assumes that the changes in conversion factors reflect improving estimates of the actual conversion factor when processing blue mackerel, rather than real changes in processing methodology across the fleet. The adjustment has slightly decreased the greenweight in the early years. For EMA 1 and 2, almost all the catches were landed as 'green'. The "OAD" ("observer authorised discard") code introduced on 1 October 2013 with a conversion factor of 1 did not appear in the data.

The percentage of TCEPR forms recording a zero estimated catch in the tow-by-tow data ranged from about 14–100%, although this was much lower in stocks with higher TCEPR catch: EMA 1 (50–100%), EMA 2 (67–100%), EMA 3 (14–100%), and EMA 7 (25–74%), (Table D5). On CELR/TCER recorded trips, the percentage is generally lower in each stock with 22–92% of trips recording no estimated catch on CELR/TCER forms. Some of the differences between the estimated and MHR/QMR catches could also be explained by the large numbers of trips that reported non-zero landings but zero estimated catch, and the proportions of such trips were usually above 50% in most years (Table D5). However, landings from those trips were generally very small (less than 1 t, although there were exceptions), and accounted for an insignificant proportion of the total catch.

7.3 Fishery summary

The spatial distribution of the total blue mackerel commercial catch is shown in Figure D5. The highest catches were from EMA 1 and EMA 7 (Table D6, Figures D5 and D6), with most of the trawl catch from EMA 7, and the purse seine fishery mainly from EMA 1 and EMA 7 (Figures D5 and D6).

Across all areas, blue mackerel are caught primarily by midwater trawling and purse seine fishing (Figure D6a). A variety of other fishing methods are also reported to catch blue mackerel but catch is negligible. The trawl catch is mainly taken from June to October as non-target catch in the jack mackerel mid-water trawl fishery in EMA 7 (Figure D6b). Most blue mackerel purse seine catch comes from EMA 1 in the Bay of Plenty and East Northland, mainly between July and December from target fishing (Figure D6c). Most blue mackerel catch was caught by New Zealand vessels, with a large proportion of the remainder from Ukrainian and Russian vessels (Table D7, Figure D7). Most vessels are either less than 40 m or large vessels over 90 m (Figure D7).

In this characterisation section, finer scale areas are used to review the hypothesised stock structure as a prelude to developing CPUE analyses that might be useful for monitoring the major fisheries. The fisheries are summarised in more detail by stock (EMA 1, 2, 3, and 7).

7.3.1 EMA 1

The EMA 1 region contributed an estimated 161 000 t of blue mackerel, about 67% of the total blue mackerel catch for 1990–2014 (Table D8, Figure D6a). Purse seine was the dominant fishing method in EMA 1, accounting for nearly all the blue mackerel catches (Table D8, Figure D8). A small amount of blue mackerel was caught by Danish seine in 1991, 2011 and 2012 but these were less than 1% of the total catch. Other fishing methods are also reported to catch blue mackerel but catch is negligible. All the purse seine catches were recorded on the CELR forms (Figure D8). Within a fishing year, catches were usually highly seasonal and the purse seine fishery typically operated between September and December before the summer skipjack season (Table D8, Figure D8).

The purse seine fishery mainly operated in the inshore areas with catches mostly taken from the northern ECNI and in the northern area of the Bay of Plenty (Figure D9). Statistical Areas 002, 003, 008, and 009 accounted for 21%, 35%, 9%, and 25% of the total catch respectively, but the catch exhibited large inter-annual variability over the last two decades (Table D8, Figure D8). There were high catches in Statistical Area 005 in 2012–2014 with 48–66% of the EMA 1 catch taken in these years. Catches have dropped considerably in Statistical Areas 002 and 008 since 2008, with less than 5% of the catch taken in each year since then.

The purse seine fishery in EMA 1 is largely a target fishery and over 90% of the annual catches were taken as a target species (Table D8). About 3–14% of catches were taken by jack mackerel effort; other target species included skipjack or kahawai, but catches of blue mackerel from these target fisheries were minor. Target blue mackerel catches are taken mainly from September to December in Statistical Areas 002, 003, 005, 008, and 009, whereas target jack mackerel catches are taken throughout the year in Statistical Areas 002, 003, 008, and 009 (Figures D10 and D11).

Most of the northern ECNI blue mackerel catch was targeted, whereas most purse seine sets in the Bay of Plenty targeted jack mackerel (Figure D12). In both areas, the mean catch rates for sets targeting blue mackerel fluctuated over time but were generally over 50 t per set. The catch rates of blue mackerel for effort targeting jack mackerel were usually less than 2–10 t per set. Blue mackerel was caught throughout EMA 1 from fishing effort by both these target species (Figure D13).

7.3.2 EMA 2

The commercial catch in EMA 2 is very small, with annual catches below 200 t since 1995, and less than 5 t in each of the last seven years (Table D9). Catch was mostly taken using purse seine nets by inshore vessels off the ECNI from East Cape to Cape Palliser, and although catches were widely distributed, most catches were concentrated in Statistical Areas 013 and 014 (Table D9, Figures D14 and 15).

In the early 1990s, most catches were taken by effort targeted at kahawai, but since the mid-1990s, catches were taken from a mixture of target species including kahawai, blue mackerel, and jack mackerel (Table D9, Figure D14). The temporal distributions were patchy with most catches taken in October and November, and almost no catches in June and July (Table D9, Figure D14). Target blue mackerel and jack mackerel catches are taken patchily from October to May in Statistical Areas 013–015, whereas target kahawai catches are mainly from October to December in Statistical Areas 013–014 (Figures D16 and D17). Both effort and catch rates have exhibited large inter-annual variability, and fewer than 30 sets were made annually since 2004 (Figure D18). Blue mackerel was caught throughout EMA 2 from fishing for target species jack mackerel and kahawai, but mainly from Statistical Areas 013 and 014 when targeting blue mackerel (Figure D19).

7.3.3 EMA 3

The commercial catch in EMA 3 is also very small, with annual catches below 100 t in most years (Table D10). Blue mackerel in EMA 3 are mainly caught by trawling, with 80% and 19% of the catch by midwater and bottom trawling respectively (Table D10, Figure D20), and with most of the catch taken by midwater trawl near Mernoo Bank in Statistical Area 021 (Figure D21). Jack mackerel targeted trawl catches are taken throughout the fishing year generally in depths of less than 300 m (Figures D22–D24). Target species hoki and squid catches were mainly taken in Statistical Area 021 in depths of less than 300 m, in December, January, and April (for hoki), and March–June (for squid), whereas target barracouta tows occurred throughout the year mainly in Statistical Areas 029, 049, and 050 in depths of less than 300 m (Figures D22–D24).

Trawling effort for target jack mackerel decreased from 1994 to 1999 and effort in this fishery varied considerably over the last nine years (Figure D25). Catch rates of blue mackerel from the jack mackerel targeted tows exhibited large inter-annual variability but was generally less than 0.5 t per tow. Catches from effort for barracouta, hoki, and squid were low, and catch rates of blue mackerel from these fisheries also exhibited wide inter-annual variability (Figure D25). Blue mackerel was mainly caught near Mernoo Bank when target fishing for barracouta, hoki, jack mackerel, and squid, despite these target species being caught in wider areas (Figure D26).

7.3.4 EMA 7

The West coast region contributed an estimated 75 000 t of blue mackerel, about 31% of the total blue mackerel catch for 1990–2014 (Table D11). Most blue mackerel catch was taken by midwater trawl and purse seine (Table D11, Figures D27a–c). Midwater trawls accounted for about 79% of the total catch between 1990 and 2014, and purse seine accounted for 19% (Table D11). Before 1999, some catches were taken by bottom trawling, which accounted for 15–16% of the annual catch from 1991 to 1993. A minor portion of catch was taken by bottom pair trawl, set-net, and Danish seine. In 2010 and 2014 almost all catches were taken by midwater trawl. All the catches taken by midwater trawlers were recorded on the TCEPR forms, and those by purse seine were recorded on the CELR forms (Figures D27b–c).

Blue mackerel catches in EMA 7 were widely distributed. Midwater catches were taken from the North and South Taranaki Bights, and from the northern WCSI southward to the Hokitika Trench, with most effort targeting jack mackerel (Figures D27b and D28). The purse seine fishery operated mostly in the South Taranaki Bight and in the outer waters of Golden Bay and Tasman Bay, and was mainly a target fishery (Figures D27c and D28).

Midwater trawl fishery

Blue mackerel are caught predominantly by midwater trawling mainly targeting jack mackerel (Table D11, Figure D27b). In 1990 the annual catch was about 50 t, but increased from 1991, and was over 1000 t in most years since then, and over 2000 t from 1998 to 2010, and in 2012 and 2013 (Table D11). Overall, the trawl catch was taken throughout the year, with higher catches in June and July, and from Statistical Areas 035 and 041 (Table D11, Figure D27b).

Blue mackerel catch from midwater trawling was taken mostly as bycatch in the jack mackerel target fishery (Table D11, Figure D27b). The target catch of blue mackerel was usually small and also variable, and, since 2003, there has been an increase in the target catch, which has accounted for 5–63% of the annual catches from midwater trawling (Table D11, Figure D27b). Other target species in the fishery included hoki, barracouta, and kahawai. Before 1997, hoki target tows accounted for 1–28% of annual catches of blue mackerel by midwater trawl.

Catches of blue mackerel from the midwater trawl fishery exhibited a clear seasonal pattern, with catches mostly in the winter period with peaks in June to September from target blue mackerel, hoki, and barracouta target catches (Figure D29). The jack mackerel target fishery is spread over more of the year with peaks in June and July, although fishing from October and January has increased since 2000 (Figure D29).

Fishing effort producing blue mackerel catch has shifted from the south to the north over time (Figures D30 and D31). This appears to be the result of a northward movement of midwater trawl jack mackerel targeted effort in JMA 7 (McKenzie 2008). Blue mackerel and jack mackerels can be considered separate elements of a single mixed-species midwater trawl fishery in the EMA 7 and JMA 7 areas (Fu 2013). Before 2000, catches were mainly taken in Statistical Areas 034–037 by target hoki and jack mackerel fishing (and to a much smaller extent barracouta and blue mackerel targeting in some years). From 2000, the fishery developed off the WCNI in Statistical Areas 040–042 and 045, and offshore in Statistical Area 801. The catches in Statistical Area 041 (north Taranaki Bight) have been consistently high from 2003 to 2013, and are from a mixture of target blue mackerel and jack mackerel fishing; 69–76% of catch was taken from Statistical Area 041 alone in 2009, 2010, and 2012. Target fishing for blue mackerel by midwater trawl was confined to smaller areas in the North Taranaki Bight and off the northern WCSI (Figure D31). Blue mackerel was generally caught in depths of less than 300 m (Figure D32).

Unstandardised catch rates (kg per tow) of blue mackerel were variable for all the main target species (Figure D33). Target catches of blue mackerel by midwater trawl were sporadic and infrequent before the early 2000s. Between 2005 and 2009, 30 to 40 tows each year consistently targeted blue mackerel and the average catch rates were about 15 to 25 t per tow (Figure D33). The mean catch rate increased to about 40 t per tow in 2010, but has decreased since then, even though effort was high in 2012 and 2013. Data for target barracouta were variable and patchy, with high catch rates in some years. For the hoki fishery, unstandardised catch rates of blue mackerel were variable and decreased to 2002, with little effort after that (Figure D33). Unstandardised catch rates from target jack mackerel midwater trawls were high from 1999 to 2002, but then decreased to 2013 (Figure D33). For blue mackerel caught in the midwater trawl jack mackerel target fishery off the WCSI (Statistical Areas 034, 035, and 036), there was generally an increasing trend in catch rates through the late 1990s, followed by a declining trend from 2000 to 2004. The catch rates appear lower in Statistical Area 036, where it appears most annual effort has been in last 14 years. In South Taranaki Bight (Statistical Areas 037, 039, and 040), there was an overall decreasing trend in catch rates through the time series, with the effort increasing through the early 2000s (Figure D34). In North Taranaki Bight and areas off the WCNI, there was little fishing before 2000. In Statistical Area 041, where most fishing effort was concentrated, the catch rate was exceptionally high in 2002, but dropped dramatically in the following year, and since then has remained relatively flat (Figure D34).

Average tow duration midwater hoki and jack mackerel tows was usually around 2–4 h; the average duration for target jack mackerel tows has increased since 2000 (Figure D35). Target blue mackerel and barracouta fishing durations were more variable. The depth of midwater trawl fishing for jack mackerel is generally less than 200 m, and appears to have decreased since the late 1990s (Figure D36). Target hoki midwater tows had widely variable average depths from 200–500 m (Figure D36).

The distributions for data describing midwater trawl gear width (wingspread), gear height, distance towed, and vessel speed, tonnage, and length by target (when blue mackerel catches were reported) are shown in Figure D37. Most effort variables were variable in the early years, but they have become more stable in recent years, reflecting the consistency of the Ukrainian fleet targeting jack mackerel in those years (Figure D37). Vessels targeting blue mackerel or jack mackerel with midwater gear mainly reported an effort width distribution narrowly focussed on 110 m, whereas vessels targeting hoki with midwater gear mainly reported effort widths of about 60–90 m, and vessels targeting barracouta were mainly between 60–120 m (Figure D37). For midwater tows, headline heights averaged 5 m, effort speed was 4–4.5 kts, and distances towed averaged 15–25 km, although there were some longer distances (Figure D37). Vessels that caught blue mackerel were generally large with most being more than 2000 GRT and 80 m in length (Figure D37).

Purse seine fishery

The purse seine fishery in EMA 7 is largely a target fishery and target fishing has accounted for 84–100% of the annual purse seine catch from 1998 to 2013 (Table D11, Figure D27c). Before 1998, a large proportion of the catch was taken when the effort was directed at jack mackerel and kahawai, but those catches varied considerably between years (Table D11, Figure D27c). Blue mackerel was also caught occasionally when skipjack was the target species, as occurred in 2007 when this fishery accounted for about 10% of the blue mackerel catch by purse seine (Table D11, Figure D27c). The purse seine fishery for blue mackerel did not operate during 2010 or 2014. Most blue mackerel catches in the purse seine fishery were from February–May, although target jack mackerel and kahawai catches were sporadic in other months, with little catch since 2000 (Figure D38).

The spatial distribution of purse seine catches is patchy (Figure D39). Target fishing was concentrated in areas between Tasman and Golden Bays and the South Taranaki Bight (Statistical Areas 037–041), and occurred as far north as the top of North Island (Statistical Area 047). The target jack mackerel or kahawai fisheries also operated off the north-eastern coast of the South Island from Cloudy Bay to Kaikoura during the early 1990s (Statistical Areas 017 and 018), but this fishery ceased by the end of 1990s. The exceptionally high catch in 1999 was mostly taken in Statistical Area 037 by target fishing.

The catch rates of blue mackerel by the purse seine method generally ranged between 0 and 100 t per set, but catches over 100 t from a single set were not uncommon. Before 1997, most effort was directed at jack mackerel and kahawai, and catch rates of blue mackerel were low (Figure D40). Between 1999 and 2003 more effort was directed at blue mackerel. Since 2005 total effort in the fishery has decreased considerably although the target catch rates appear to have increased.

8. CPUE ANALYSES

The focus of this analysis is on the West Coast fishery area, where deepwater vessels operate using midwater trawl. All tables and figures relating to CPUE analyses for blue mackerel are contained in Appendix E (Tables E1–E5, Figures E1–E8). Taylor (2002) suggested that catch and effort data from the purse seine fishery was unlikely to provide a reliable set of abundance indices for blue mackerel, as the distribution of the catch and effort was patchy in time and space, and also because the effective effort cannot be easily measured when the species school at the surface and are bulk-caught in purse seine nets with assistance of spotter planes. Fu & Taylor (2007) developed standardised CPUE indices for the midwater trawl fishery in EMA 7, based on the bycatch of blue mackerel from jack mackerel targeted effort. The standardised indices were updated to 2009 (Fu & Taylor, 2011), to 2010 (Fu 2013), and are further updated in this report to the 2014 fishing year.

Annual unstandardised (raw) CPUE indices were calculated as the mean of the catch per hour (in kilograms per hour) for TCEPR estimated data. Estimates of relative year effects were obtained from a stepwise multiple regression method, where the data were fitted using a lognormal model using log transformed non-zero catch-effort data. A forward stepwise multiple-regression fitting algorithm (Chambers & Hastie 1991) implemented in the R statistical programming language (R Development Core Team 2015) was used to fit all models. The algorithm generates a final regression model iteratively and used the year term as the initial or base model in all cases. The reduction in residual deviance (denoted R2) was calculated for each single term added to the base model. The term that resulted in the greatest reduction in the residual deviance was then added to the base model, where the change was at least 1%. The algorithm was then repeated, updating the base model, until no more terms were added. A stopping rule of 1% change in residual deviance was used because this results in a relatively parsimonious model with moderate explanatory power. Alternative stopping rules or error structures were not investigated.

The variable year was treated as a categorical value so that the regression coefficients of each year could vary independently within the model. The relative year effects calculated from the regression coefficients represent the change in CPUE through time, all other effects having been taken into account, and represents a possible index of abundance. Year indices were standardised to the mean and were presented in canonical form (Francis 1999).

Categorical and continuous variables offered to the model are listed in Table E1. Fits to continuous variables were modelled as third-order polynomials, although a fourth-order polynomial was also offered to the models for *duration* in catch per tow and catch per km models. In each analysis, *statistical area* and *latitude* or *longitude* were not allowed to enter the same model at the same time because they were correlated.

Vessel was incorporated into the CPUE standardisation to allow for differences in fishing power between vessels. Vessels not involved in the fishery for at least three consecutive years should be excluded because they provided little information for the standardisations, which could result in model over-fitting (Francis 2001). Thus, CPUE analyses were undertaken for “core” vessels that were determined for each area using gear- and area-specific criteria based on approximately 80% of positive blue mackerel catch, the number of years of vessel participation, and the number of tows per vessel-year (Table E2, Figure E1).

The influence of each variable accepted into the lognormal models was described by coefficient–distribution–influence (CDI) plots (Bentley et al. 2012). These plots show the combined effect of (a) the expected log catch for each level of the variable (model coefficients) and (b) the distribution of the levels of the variable in each year, and therefore describe the influence that the variable has on the unstandardised CPUE and that is accounted for by the standardisation.

Model fits to the lognormal component of the combined model were investigated using standard residual diagnostics. For each model, a plot of residuals against fitted values and a plot of residuals against quantiles of the standard normal distribution were produced to check for departures from the regression assumptions of homoscedasticity and normality of errors in log-space (i.e., log-normal errors).

Following Fu (2013), the CPUE dataset comprised tows that targeted jack mackerel with blue mackerel caught as bycatch. Tows that targeted blue mackerel were not considered as they constituted a small amount of catch and effort (about 30 tows each year for the last 10 years by all vessels) and they were confined to a few areas in the fishery and were directed at large sub-surface schools of blue mackerel. As vessels mainly fished off WCSI early in the fishery and gradually moved towards the north later in the series (Fu & Taylor 2011), the CPUE dataset was split into two time series, one extending from 1990 to 1998 and the other from 1997 to 2014. Separate CPUE indices also account for the dramatic change in the composition of the fleet that occurred during the mid- to late 1990s (a shift from a bottom-trawl fishery executed by vessels about 3000 gross tonnes to a midwater trawl fishery executed by vessels about 4000 gross tonnes). Only standardised indices for the late series were updated here; standardised indices for the early series from Fu & Taylor (2011) for 1990 to 1999 are re-presented.

Fu & Taylor (2011) fitted standardisation models using estimated catch from the tow by tow data, and also investigated an alternative model based on the allocated green weight landings of the stratified data. Standardised CPUE indices from the two models showed very similar trends. For standardised CPUE analyses of trawl catches, the use of tow-by-tow data allows for the trend in catch rates to be modelled using smaller spatial and temporal scales, and also enables additional factors influencing CPUE to be included (such as tow distance or bottom depth). In this analysis, as for Fu (2013), standardisation analysis was carried out for the TCEPR tow by tow data using the estimated catch.

Fu & Taylor (2011) investigated incorporating zero catches (a zero is a tow with no estimated catch of blue mackerel) in the standardisation by fitting the binomial-lognormal model to the data and found that the indices for the proportions of zeros had a flat trend, and that the combined indices were very close to the indices for the positive catches. Therefore Fu (2013) only used the positive catches, and this method was adopted for the current analysis.

The dependent variable was the log-transformed estimated catch per hour. The use of catch per tow in the standardisations was investigated in a previous CPUE analysis (Fu & Taylor 2011); however, variable *fishing duration* was not selected into the final model and the resulting CPUE showed less of a decline. Given that the tow duration in this fishery had decreased to 1990 and then increased (see Figure D35), the use of catch per hour as a measure of CPUE allows for the effect of fishing duration to be incorporated in the standardisations. Catch per tow and catch per km were also investigated.

The data constraints for the lognormal model applied to the target jack mackerel west coast midwater trawl fishery from fishing years 1997 to 2014 presented here are given in Table E2. The dependent variable was either the log-transformed estimate of catch per hour, catch per tow, or catch per km. The following target jack mackerel catch per hour models for midwater trawl fishery were also run: WCSI 1997–2014 (year as May–October; Statistical Areas 034–036); and WCNI 1997–2014 (year as fishing year; Statistical Areas 040–045, 801). There were no twin trawl or precision harvesting tows to identify or exclude from the dataset.

A total of 43 unique vessels (range 7–22 vessels each year) using midwater tows caught 33 900 t of blue mackerel since 1997, from 32 331 tows (Table E3). The proportion of zero tows was variable, ranging from 0.4 to 0.8. Core vessels for the tow-by-tow estimated index were defined as those participating in the fishery for five or more years, and reporting at least 20 tows per vessel-year (Table E2, Figures E1 and E2). Seven core vessels (range 4–7 per year) caught 31 345.9 t of blue mackerel, representing 92% of the total catch during 1997–2014, with catches for core vessels ranging from 351–3580 t annually (Table E3). There has been a temporal change in the fleet composition: most of the vessels that fished in the early 1990s dropped out of the fishery by 1998, and since then the fishery has been dominated by these seven vessels (Fu 2013) which are Ukrainian vessels over 100 m in length and over 4000 t in tonnage. The early vessels are much smaller in size and power.

Five variables were selected into the lognormal model, resulting in a total R2 of 35.4%, with *statistical area* explaining 22.5% of the residual deviance (Table E4). The other variables selected were *distance*, *vessel*, and *month*. The standardised indices fluctuated in the first three years, then declined to 2004, and since then have remained relatively flat (Table E5, Figure E3).The index in 2014 is the lowest in the series and about 23% of the level in 1998. This catch index matches the unstandardised index reasonably well except for the first few years, and there is little effect in the addition of retained variables in the lognormal model (Figure E4). The overall trend of the standardised indices did not change whether the dependent variable was the log-transformed estimated catch per hour, catch per tow or catch per km (Figure E5). The overall trend for West Coast, WCSI, or WCNI indices, (Figure E5), suggested that the changes in relative abundance were likely to be similar between WCSI and WCNI. The current analysis showed a similar trend to the previous indices produced by Fu (2013) (Figure E5).

The effects of the selected variables on the expected catch rates of blue mackerel in the lognormal catch models are shown in the CDI plots in Figure E6. For *statistical area* and *vessel*, trends are related to changes in fishing behaviour by core vessels around 2000. Before 2000, the core vessels fished in more southern areas, towed shorter distances, and caught blue mackerel almost exclusively during winter seasons; after 2000, the core vessels fished mostly in the northern areas, towed longer distances, and caught blue mackerel throughout the year. The loss of vessel 1 in the core dataset from 2001 to 2014 has a negative impact on the index. Predicted CPUE by statistical area generally followed the overall lognormal CPUE trend, although there were some exceptions in some individual year-area combinations (e.g. Statistical Area 036 in 1997, or 037 in 1999) (Figure E7). This suggested that the changes in relative abundance were likely to be similar between statistical areas within EMA 7.

Diagnostic plots of residuals against fitted values and residuals against quantiles of the standard normal distribution suggested no apparent departures from model assumption of homoscedasticity and normality of errors in log-space (Figure E8).

9. PRINCIPLES FOR STOCK ASSESSMENT

9.1 Annual model cycle
9.2 Landings (catch history)
9.3 Exploitation rates

10. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

10.1 Benthic impact (sea-bed disturbance)
10.2 Incidental catch (fish and invertebrates)
10.3 Incidental catch (seabirds and mammals)
10.4 Community and trophic structure
10.5 Spawning disruption
10.6 Habitats of special significance
10.7 Biodiversity

11. AQUACULTURE AND ENHANCEMENT

12. SUMMARY AND RECOMMENDATIONS

12.1 Biology

Blue mackerel are considered to consist of at least three biological stocks in EMA 1, 2, and 7 (Smith et al. 2005). The data presented here suggest that there is no reason to revise this. The observer data show that spawning females are found over summer on the WCNI, ripe females are found on the WCSI in June–October, and ripe females throughout most of the year on ECSI, and ripe and running ripe females around Chatham Islands in December. Spawning was recorded in the Hauraki Gulf and east Northland in EMA 1 during egg and larval surveys (Crossland 1981, 1982).

Length frequency distributions from observer and research trawl data show differences in size ranges: length frequency distributions showed wider length ranges for the research trawl data (about 9–50 cm FL) with a predominance of small fish, while those from observer data had a narrower range (30–55 cm), except in 2014 on the WCNI. Taylor (2002) suggested that the distribution of small fish is more coastal, resulting in them not being vulnerable to the TCEPR fleet fishing outside 12 miles. There is also likely to be a mesh selection effect as trawl survey vessels use 60 mm mesh codends, and therefore retain more small fish than the 100 mm of commercial vessels (Jones, 1990). More small fish have been found on the WCSI and WCNI since 2010. Collection of length, weight, and gonad data in EMA 1 and EMA 7 from market samples could increase knowledge of length-weight relationships, spawning biology and areas, and potential stock relationships.

Catch sampling from 2002 to 2007 indicates that catch-at-length and catch-at-age are relatively stable between years in EMA 1.

12.2 Status of the stocks

Little is known about the status of blue mackerel stocks and no estimates of current and reference biomass, reference fishing mortalities, or yield, are available for any blue mackerel area (Ministry for Primary Industries 2015). It is not known if recent catch levels are sustainable or at levels that will allow the stocks to move towards a size that will support the *MSY*.

Recent fishing effort has been interdependent on several pelagic species (Fu 2013). A large proportion of blue mackerel catch is by purse seine, and catch restrictions for kahawai (which traditionally received greater effort) first set in the early 1990s, shifted fishing effort towards blue mackerel. A significant component of the catch is also taken as non-target catch when targeting other pelagic species, e.g. jack mackerels, skipjack.

Although rates of total mortality in EMA 1 are poorly understood, the relatively stable age composition between years and the number of year-classes that compose the catch-at-age within fishing years, suggest that blue mackerel may be capable of sustaining current commercial fishing mortality in EMA 1, at least in the short-term. In EMA 7, the broad spread of age classes seen in the catch from the trawl fishery and, in recent years, from the observer data is not consistent with the large decline in CPUE from 1999 to 2014. However, there has been little evidence in the commercial catch sampling data to support this decline of abundance as there has been no great change in the length distribution. However it has been noted that there appear to have been more large fish in the catch before 2003, and more small fish in the catch from 2010, although the sample size was generally too low in the early years to draw any firm conclusion (Fu 2013).

The standardised CPUE in the WCNI and WCSI jack mackerel trawl fishery appears to provide reliable indices of abundance. The series shows a decline from 2000 of more than 50% but indices are relatively flat in recent years. A stock assessment for EMA 7 should be run once ageing of two years of sampling has been completed (suggested years from the DWWG were 2007 and 2014).

In EMA 3 catch is less than a third of the TACC; catch rates show large variability and no abundance series was possible.

12.2 Observer Programme and market sampling

In EMA 1, almost all the catches are taken as a target species. In EMA 7, most catch records are captured on TCEPR forms and the fisheries encountering blue mackerel have several dominant vessels. Observer sampling in EMA 7 and market shed sampling in EMA 1 have provided consistent length frequency and age distributions. The biology is reasonably well understood, but a directed study of reproductive development would enable robust maturity ogives to be determined (Ministry for Primary Industries 2015). For future possible stock assessment one limiting factor is that no biomass estimates are available from existing fishery independent surveys, as none are optimised for this species (Ministry for Primary Industries 2015).

12.3 Future data needs and research requirements

1. A standardised CPUE analysis was not attempted for the blue mackerel midwater target fishing in EMA 7 as the number of tows is low. If the quantity of records increases it would be appropriate, therefore, to develop a CPUE series for this fishery to monitor the EMA 7 stock.

2. Biological information from market and observer sampling could be enhanced, with the goal of developing appropriate monitoring tools, as follows:
    - Collect market samples EMA 1 and EMA 7 to monitor size changes, as small observed fish have been observed in EMA 7 since 2010.
    - Continued opportunistic collection of biological information from trawl surveys and by the observer programme, including length, weight, sex, gonad data, and otoliths.

3. A stock assessment for EMA 7 should be run once ageing of two years of sampling has been completed (suggested years in the deepwater working group meeting were 2007 and 2014).

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Table 1: Recreational and customary non-commercial allowances, TACCs and TACs for blue mackerel by Fishstock. From Ministry for Primary Industries (2015).

Fishstock	Recreational Allowance	Customary Non-Commercial Allowance	TACC	TAC
EMA 1	40	20	7 630	7 690
EMA 2	5	2	180	187
EMA 3	1	1	390	392
EMA 7	1	1	3 350	3 352
EMA 10	0	0	0	0
Total	47	24	11 550	11 621

Table 2: Reported landings (t) for the main QMAs from 1974 to 1982. From Ministry for Primary Industries (2015).

Year	EMA 1	EMA 2	EMA 3	EMA 7
1974	38	8	0	6
1975	10	0	0	2
1976	50	49	0	0
1977	34	135	0	0
1978	14	55	0	128
1979	185	31	0	317
1980	752	32	0	407
1981	459	49	0	1 363
1982	305	0	0	791

Notes
1. Calendar years.
2. Data are from fishing returns
3. Data for the period 1974 to 1982 are based on reported landings by harbour and are likely to be underestimated as a result of under-reporting and discarding practices. Data includes both foreign and domestic landings.

Table 3: Reported landings (rounded to the nearest tonne) of blue mackerel by QMA, and where area was unspecified (Unsp) from 1983–84 to 2013–14. (Source: Ministry for Primary Industries (2015). Landings reported from EMA 10 are probably attributable to Statistical Area 010 in the Bay of Plenty (i.e., QMA 1). *, FSU data.†, CELR data, ‡, QMS data.

QMA	EMA 1	EMA 2	EMA 3	EMA 7	EMA 10	Unsp	Total
1983–84*	480	259	44	245	0	1	1 029
1984–85*	565	222	18	865	0	73	1 743
1985–86*	618	30	190	408	0	51	1 297
1986–87†	1 431	7	424	489	0	49	2 400
1987–88†	2 641	168	864	1 896	0	58	5 627
1988–89†	1 580	<1	1 141	1 021	0	469	4 211
1989–90†	2 158	76	518	1 492	0	<1	4 245
1990–91†	5 783	94	478	3 004	0	0	9 359
1991–92†	10 926	530	65	3 607	0	0	15 128
1992–93†	10 684	309	133	1 880	0	0	13 006
1993–94†	4 178	218	223	1 402	5	0	6 026
1994–95†	6 734	94	154	1 804	10	149	8 945
1995–96†	4 170	119	173	1 218	0	1	5 681
1996–97†	6 754	78	340	2 537	0	<1	9 710
1997–98†	4 595	122	78	2 310	0	<1	7 106
1998–99†	4 505	186	62	8 756	0	4	13 513
1999–00†	3 602	73	3	3 169	0	0	6 847
2000–01†	9 738	113	6	3 278	0	<1	13 136
2001–02‡	6 368	177	49	5 101	0	0	11 695
2002–03‡	7 609	115	88	3 563	0	0	11 375
2003–04‡	6 523	149	1	2 701	0	0	9 374
2004–05‡	7 920	8	<1	4 817	0	0	12 746
2005–06‡	6 713	13	133	3 784	0	0	10 643
2006–07‡	7 815	133	42	2 698	0	0	10 688
2007–08‡	5 926	6	122	2 929	0	0	8 983
2008–09‡	3 147	2	88	3 503	0	0	6 740
2009–10‡	8 538	3	14	3 260	0	0	11 815
2010–11‡	6 630	2	9	1 996	0	0	8 638
2011–12‡	8 080	2	28	2 707	0	0	10 817
2012–13‡	7 213	3	100	2 401	0	0	9 716
2013–14‡	6 860	4	29	1 200	0	0	8 092

Table 4: Von Bertalanffy growth parameters for Bay of Plenty (EMA 1) blue mackerel (from Manning et al. 2006).

	Males	Females	Both sexes
L_∞	52.49	53.10	52.79
K	0.15	0.15	0.15
t_0	-3.29	-3.18	-3.19
Age range	1.8–21.9	1.8–21.9	1.8–21.9
N	240	269	509

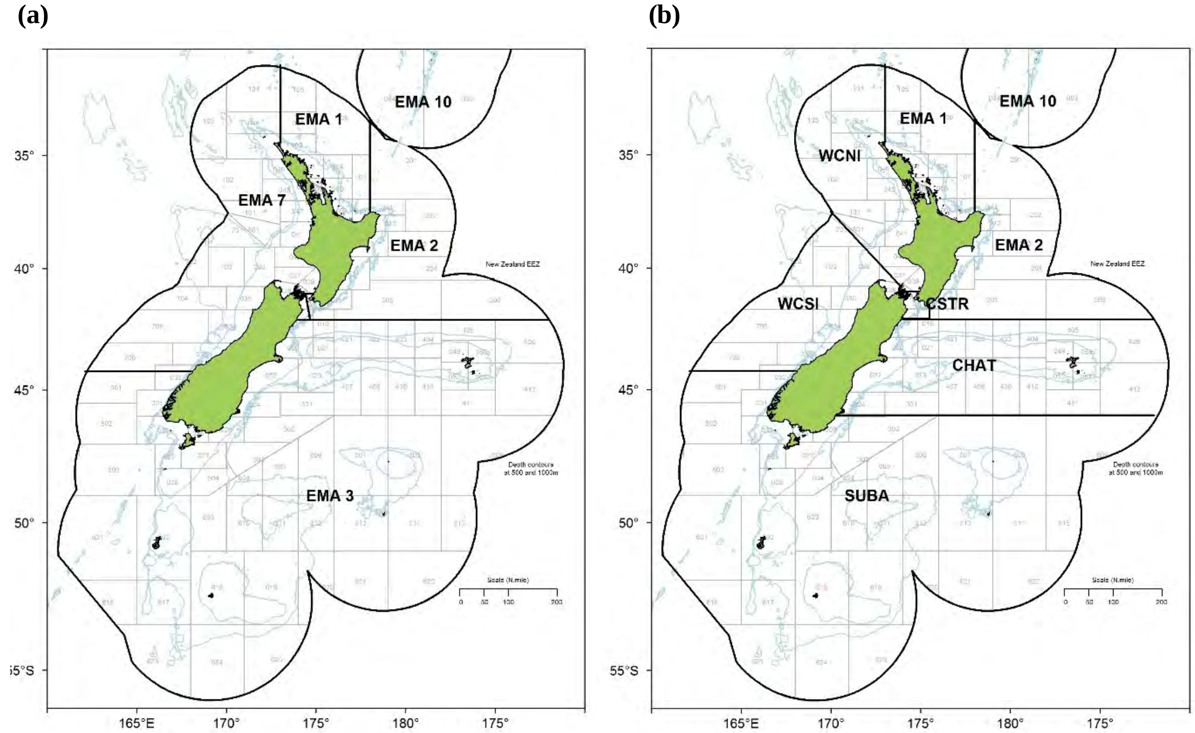


Figure 1: Maps showing (a) administrative fishstock boundaries for EMA 1, EMA 2, EMA 3, EMA 7 and EMA 10, including statistical areas, and the 500 m and 1000 m depth contours, and (b) areas used in this analysis, including statistical areas, and the 500 m and 1000 m depth contours. CHAT, east coast South Island and the Chatham Rise; CSTR, Cook Strait; WCSI, west coast South Island; WCNI, west coast North Island; and SUBA, Sub-Antarctic.

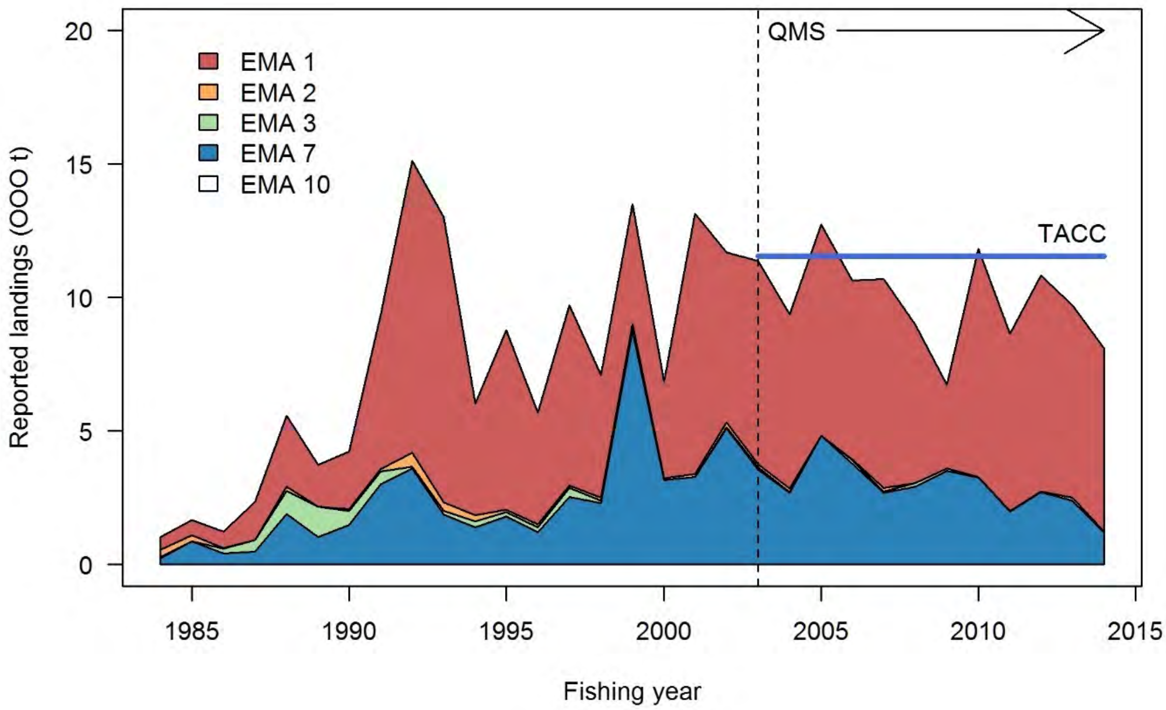


Figure 2: Total reported landings by QMA, and the total TACC, for 1983–84 (1984) to 2013–14 (2014).

APPENDIX A: TRAWL SURVEY SUMMARIES

Table A1: Sources of fish length data and key information of blue mackerel collected from research trawl surveys in EMA 1, EMA 2, EMA 3, and EMA 7 since 1981–82.

Fishing year	Trip code	Vessel	Min length (cm FL)	Max length (cm FL)	No. of fish measured	Female	Male
EMA 1							
1981–82	kah8203	Kaharoa	9	43	55	0	0
1982–83	kah8303	Kaharoa	8	15	233	0	0
1983–84	kah8413	Kaharoa	13	22	22	0	0
1984–85	kah8421	Kaharoa	23	23	1	0	0
1984–85	kah8506	Kaharoa	11	43	101	0	0
1985–86	kah8517	Kaharoa	19	46	15	0	0
1985–86	kah8609	Kaharoa	8	23	384	0	0
1986–87	kah8613	Kaharoa	16	24	28	0	0
1986–87	kah8711	Kaharoa	7	26	74	0	0
1987–88	kah8716	Kaharoa	15	42	109	0	0
1988–89	kah8810	Kaharoa	17	47	50	0	0
1989–90	kah8917	Kaharoa	17	28	99	0	0
1989–90	kah9004	Kaharoa	15	15	1	0	0
1990–91	kah9016	Kaharoa	17	35	27	0	0
1991–92	kah9202	Kaharoa	6	11	73	0	0
1992–93	kah9212	Kaharoa	14	35	95	0	1
1992–93	kah9302	Kaharoa	9	75	153	0	2
1993–94	kah9311	Kaharoa	12	36	568	0	1
1994–95	kah9411	Kaharoa	19	44	25	0	0
1995–96	kah9601	Kaharoa	9	10	2	0	0
1997–98	kah9720	Kaharoa	14	28	97	0	0
1998–99	kah9902	Kaharoa	11	42	17	0	0
2000–01	kah0012	Kaharoa	10	30	75	0	0
2008–09	kah0907	Kaharoa	16	27	46	4	5
EMA 2							
1981–82	kah8211	Kaharoa	51	53	2	0	0
1982–83	kah8313	Kaharoa	51	51	1	0	0
1984–85	jco8420	James Cook	53	53	1	1	0
1993–94	kah9402	Kaharoa	5	47	131	0	2
1994–95	kah9502	Kaharoa	32	53	2	1	0
1995–96	kah9602	Kaharoa	10	47	11	0	0
2000–01	tan0111	Tangaroa	52	53	2	0	0
2001–02	kah0209	Kaharoa	49	49	1	0	0
2004–05	kah0506	Kaharoa	54	54	1	0	0
2005–06	kah0611	Kaharoa	45	53	2	1	1

Table A1: continued.

Fishing year	Trip code	Vessel	Min length (cm FL)	Max length (cm FL)	No. of fish measured	Female	Male
EMA 3							
1990–91	kah9105	Kaharoa	51	51	2	2	0
1991–92	kah9205	Kaharoa	52	56	3	1	2
1991–92	tan9106	Tangaroa	43	43	1	0	1
1992–93	kah9306	Kaharoa	51	53	4	2	2
1992–93	tan9301	Tangaroa	46	46	1	0	1
1993–94	kah9406	Kaharoa	51	51	1	1	0
1993–94	tan9401	Tangaroa	41	41	1	1	0
1993–94	tan9402	Tangaroa	44	44	1	1	0
1994–95	tan9502	Tangaroa	45	45	1	0	0
1995–96	kah9606	Kaharoa	49	52	2	1	1
1995–96	tan9601	Tangaroa	48	48	1	0	1
1996–97	tan9701	Tangaroa	48	48	1	0	1
1997–98	tan9801	Tangaroa	47	48	2	1	1
2001–02	tan0201	Tangaroa	49	49	1	1	0
2002–03	tan0301	Tangaroa	39	50	12	4	8
2004–05	tan0501	Tangaroa	42	48	5	5	0
2005–06	tan0601	Tangaroa	35	37	3	1	2
2006–07	kah0705	Kaharoa	53	53	1	1	0
2007–08	kah0806	Kaharoa	53	53	1	0	1
2007–08	tan0801	Tangaroa	40	51	3	2	1
2008–09	kah0905	Kaharoa	52	52	1	1	0
2009–10	tan1001	Tangaroa	43	47	11	4	7
2011–12	kah1207	Kaharoa	51	52	2	2	0
EMA 7							
1981–82	kah8205	Kaharoa	16	30	6	0	0
1982–83	jco8306	James Cook	46	51	5	3	2
	kah8216	Kaharoa	17	18	2	0	0
1983–84	jco8415	James Cook	47	51	6	0	6
1984–85	jco8420	James Cook	53	53	1	1	0
1986–87	kah8612	Kaharoa	15	27	68	0	0
1987–88	kah8715	Kaharoa	20	20	2	0	0
1989–90	cor9001	Cordella	15	53	313	100	189
1991–92	kah9111	Kaharoa	48	51	2	0	0
	kah9204	Kaharoa	46	49	2	1	0
1994–95	kah9410	Kaharoa	13	22	73	0	13
	kah9504	Kaharoa	46	51	12	3	8
	kah9507	Kaharoa	18	18	1	0	0
1995–96	kah9608	Kaharoa	10	21	325	0	0
1996–97	kah9615	Kaharoa	12	26	39	0	0
	kah9701	Kaharoa	47	50	5	3	2
1999–00	kah0004	Kaharoa	48	50	5	2	3
	kah9915	Kaharoa	15	48	183	3	2
2002–03	kah0304	Kaharoa	47	49	3	0	1
2004–05	kah0503	Kaharoa	49	49	3	0	2
2006–07	kah0704	Kaharoa	49	49	1	0	1
2010–11	kah1104	Kaharoa	15	22	8	0	0
2011–12	tan1202	Tangaroa	50	50	3	1	2

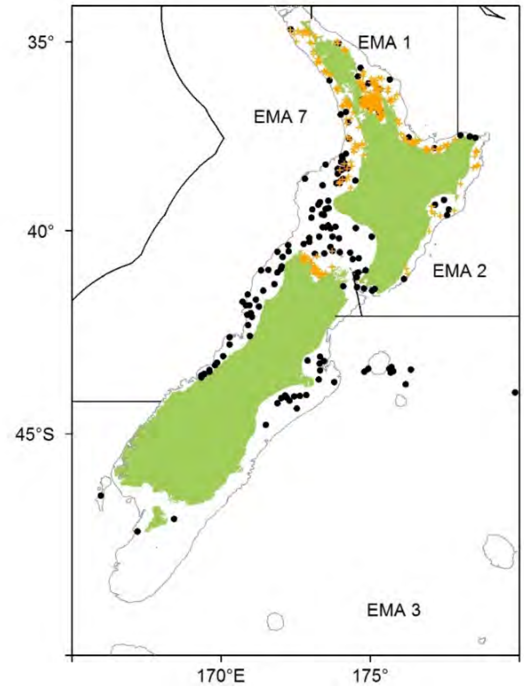


Figure A1: Distribution of blue mackerel from all research fishing in the *trawl* database to 2014. Black circles represent fish greater than or equal to 30 cm FL; orange crosses represent fish less than 30 cm FL.

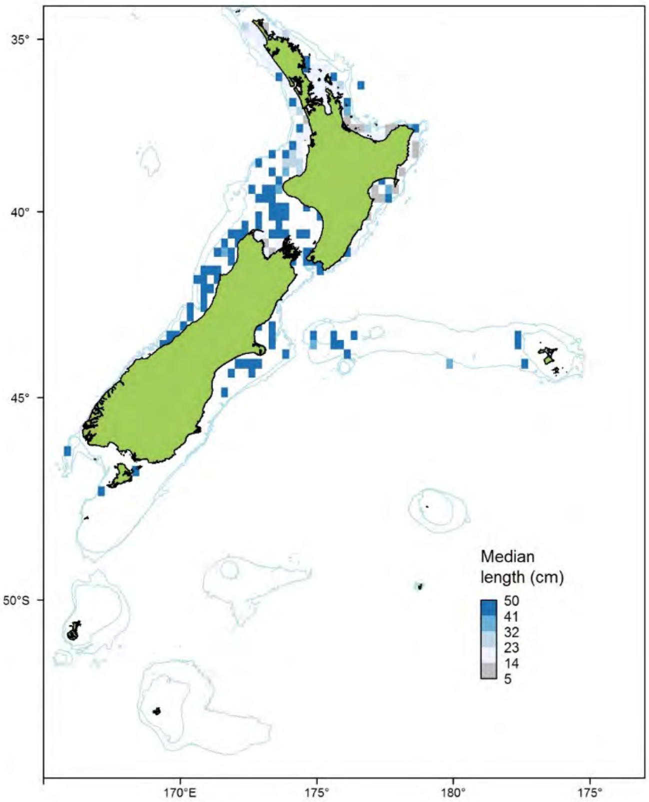


Figure A2: Distribution of lengths (median per 0.25° latitude × longitude cell) from 4143 blue mackerel caught during trawl surveys completed between 1961 and 2014.

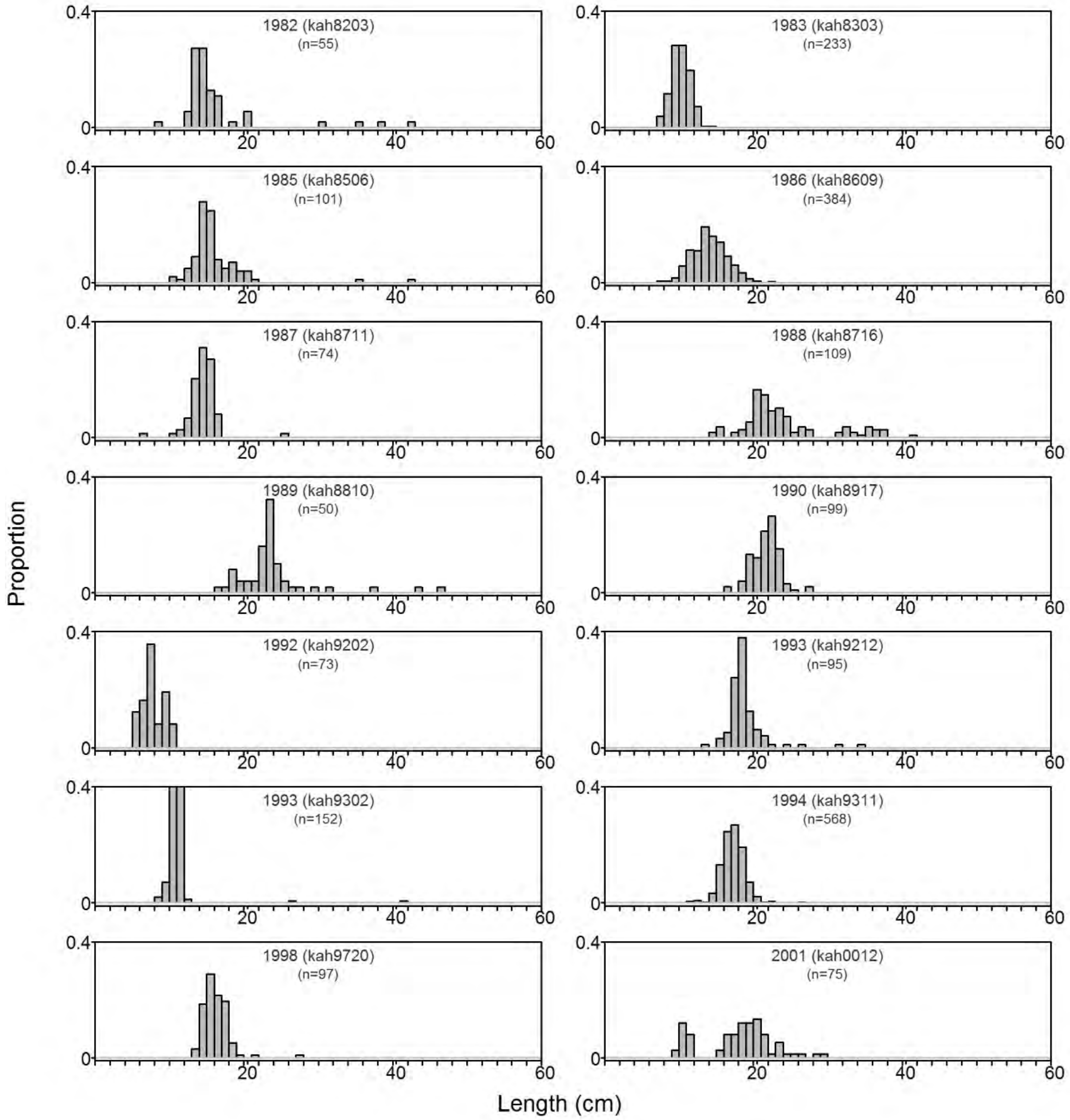


Figure A3a: Unscaled length frequency distributions of blue mackerel from research trawls in EMA 1 since the 1981–82 fishing year. Surveys where sample size was less than 50 were excluded.

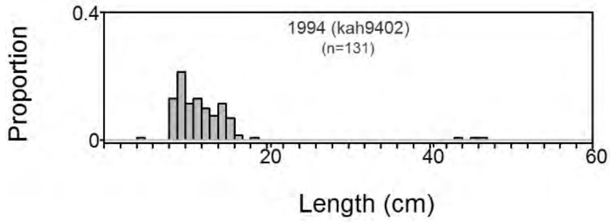


Figure A3b: Unscaled length frequency distribution of blue mackerel from research trawls in EMA 2, in the 1993–94 fishing year. Years where sample size was less than 50 were excluded.

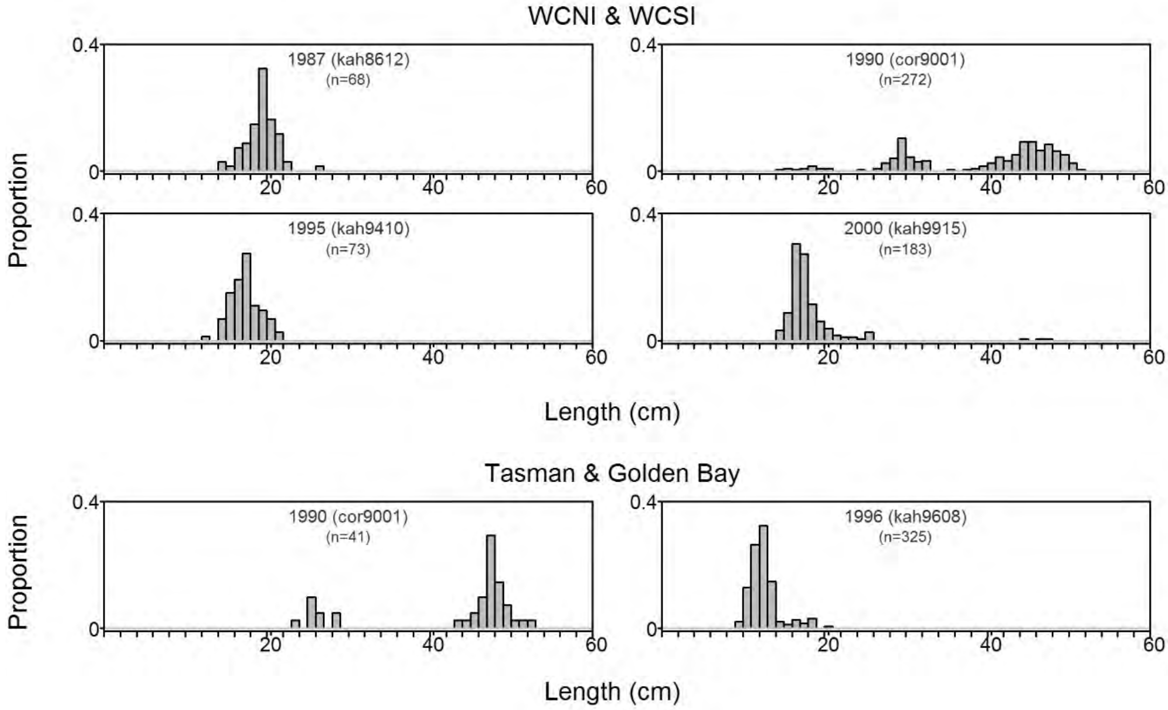


Figure A3c: Unscaled length frequency distributions of blue mackerel from research trawls in EMA 7 by fishing year. Length frequency distributions are shown for Tasman and Golden Bays and the West coast of the North and South Islands separately. Surveys where sample size was less than 50 were excluded.

APPENDIX B: MARKET DATA

Table B1: Number of landings, and fish measured for length for blue mackerel collected from market sampling programme in EMA 1, EMA 2, and EMA 7 since 1996–97 fishing year.

EMA 1				
Fishing year	Landings	Males	Females	Total
1997	1	315	213	528
1998	9	3 604	3 763	7 367
2002	7	2 442	2 382	4 824
2003	44	18 418	18 607	37 026
2004	27	4 704	4 720	9 424
2005	33	5 320	6 854	12 174
2006	34	6 344	6 619	12 963
2007	33	12 904	14 409	29 880
2008	1	-	-	956
EMA 2				
Fishing year	Landings	Males	Females	Total
2007	1	189	184	373
EMA 7				
Fishing year	Landings	Males	Females	Total
2004	3	30	26	56
2005	2	200	224	424
2006	2	105	95	200

Table B2: Number of otolith pairs collected from market samples by stock for calendar years 1992–2014. Note: in 2002, 509 SMP otoliths from EMA 1 (area AKE) were aged.

Year	EMA 1	EMA 2	EMA 3	EMA 7
2002	704	-	-	-
2003	508	-	-	-
2004	471	1	50	363
2005	1 208	80	-	176
2006	703	-	-	123
Total	3 594	81	50	662

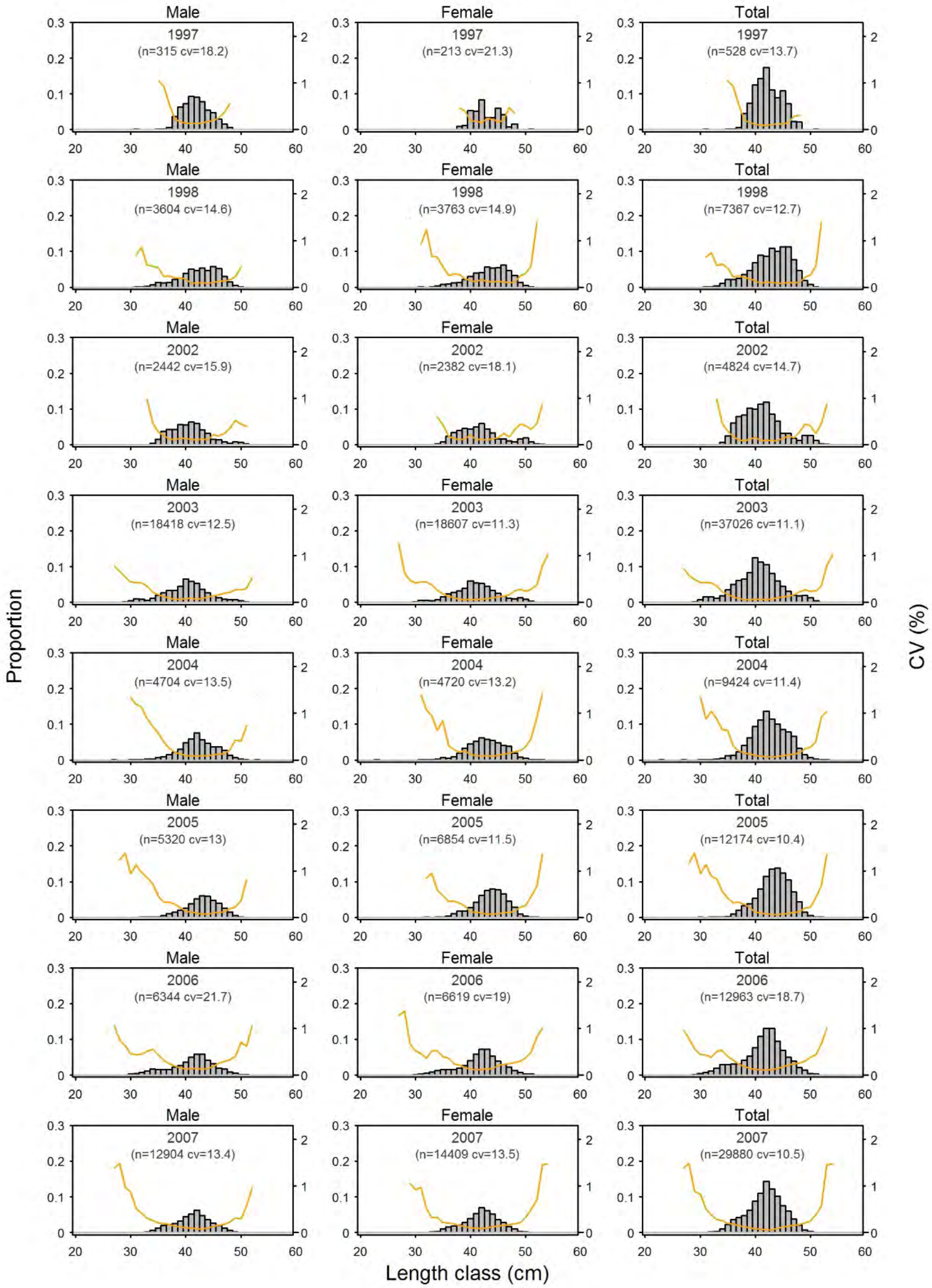


Figure B1a: Scaled length frequency distributions of blue mackerel from market sampling in EMA 1 1997–2007.

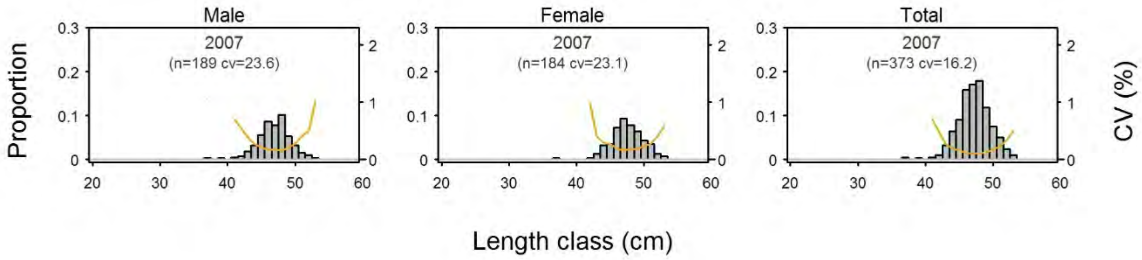


Figure B1b: Scaled length frequency distributions of blue mackerel from market sampling in EMA 2 2007.

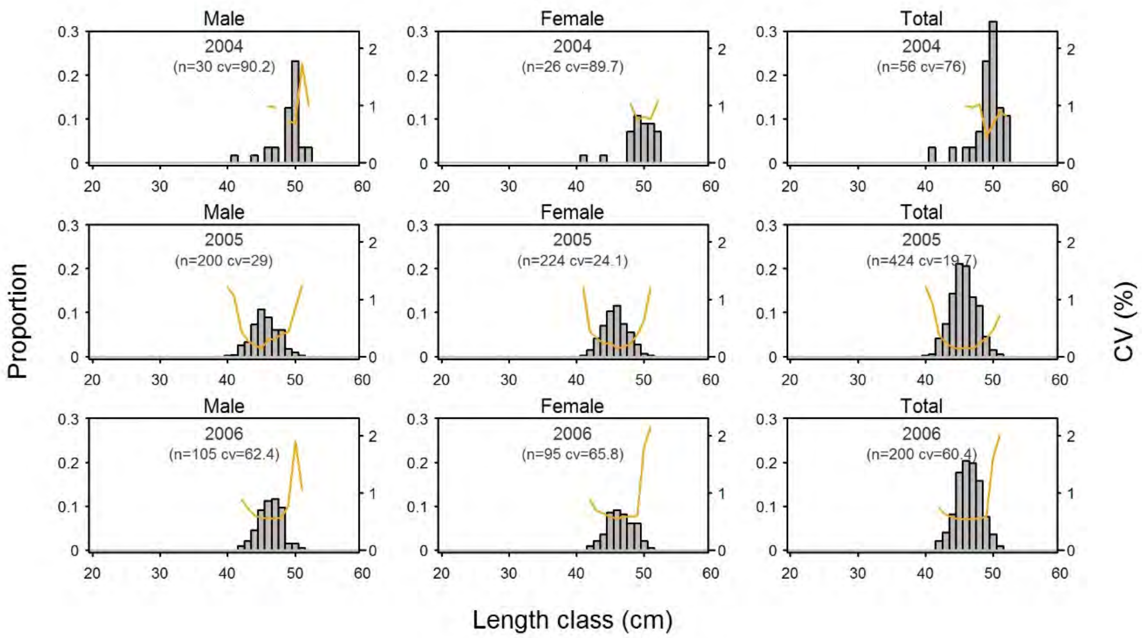


Figure B1c: Scaled length frequency distributions of blue mackerel from market sampling in EMA 7 2004–2006.

APPENDIX C: OBSERVER DATA

Table C1: Total number of observed trawl catches and tows sampled for blue mackerel, by area for fishing years 1991 to 2014. Areas are defined in Figure 1.

(a) Tows

Fishing year	CHAT	CSTR	EMA 1	EMA 2	SUBA	WCNI	WCSI	Other	Total
1990–91	6	-	-	-	3	189	66	-	264
1991–92	1	-	-	1	3	159	84	-	248
1992–93	104	-	-	-	2	220	47	-	373
1993–94	25	-	-	-	1	195	164	-	385
1994–95	9	-	1	-	-	301	19	-	330
1995–96	52	-	-	-	4	68	61	-	185
1996–97	1	-	-	-	2	138	108	-	249
1997–98	1	1	-	1	3	186	27	-	219
1998–99	8	2	-	-	1	53	268	-	332
1999–00	4	-	-	1	3	61	29	-	98
2000–01	4	-	-	-	1	64	62	-	131
2001–02	54	-	-	-	3	88	40	-	185
2002–03	9	-	-	-	1	154	36	-	200
2003–04	1	4	-	-	-	116	7	-	128
2004–05	-	-	-	2	-	403	26	-	431
2005–06	29	-	-	-	2	270	11	-	312
2006–07	24	4	4	-	-	403	170	-	605
2007–08	53	2	4	-	-	479	85	-	623
2008–09	2	-	-	-	-	423	79	-	504
2009–10	27	1	-	-	1	473	26	-	528
2010–11	19	-	-	1	-	363	28	-	411
2011–12	34	1	2	-	3	800	79	-	919
2012–13	124	1	2	-	8	1 023	162	-	1 320
2013–14	125	1	16	3	12	1 170	168	1	1 496
Total	716	17	29	9	53	7 799	1 852	1	10 476

(b) Catches (t) (0, < 0.5 t; - no data)

Fishing year	CHAT	CSTR	EMA 1	EMA 2	SUBA	WCNI	WCSI	Other	Total
1990–91	1	-	-	-	0	181	287	-	468
1991–92	0	-	-	0	0	38	150	-	188
1992–93	21	-	-	-	0	137	48	-	205
1993–94	9	-	-	-	0	40	157	-	206
1994–95	0	-	0	-	-	240	1	-	241
1995–96	11	-	-	-	0	9	26	-	47
1996–97	0	-	-	-	0	25	269	-	294
1997–98	32	0	-	0	0	94	176	-	301
1998–99	4	0	-	-	0	23	1 453	-	1 480
1999–00	0	-	-	0	0	29	35	-	64
2000–01	0	-	-	-	0	17	217	-	234
2001–02	14	-	-	-	0	234	101	-	350
2002–03	0	-	-	-	0	61	16	-	77
2003–04	0	0	-	-	-	257	0	-	257
2004–05	-	-	-	0	-	731	61	-	792
2005–06	18	-	-	-	0	833	31	-	882
2006–07	1	0	0	-	-	605	239	-	844
2007–08	46	0	0	-	-	559	147	-	753
2008–09	1	-	-	-	-	1 240	164	-	1 404
2009–10	9	0	-	-	0	1 107	70	-	1 186
2010–11	8	-	-	0	-	313	63	-	383
2011–12	10	0	0	-	0	1 112	277	-	1 400
2012–13	72	0	0	-	0	1 743	132	-	1 947
2013–14	26	0	0	0	3	792	175	0	996
Total	282	0	0	0	3	10 420	4 295	0	15 000

Table C2: Number of observed tows sampled for blue mackerel, by area and month, for fishing years 1992 to 2014. Areas defined in Figure 1.

(a) EMA 2 (Chatham Rise)

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1992–93	-	-	-	-	-	-	2	-	-	-	-	-	2
2000–01	-	-	-	-	1	-	-	-	-	-	-	-	1
2001–02	-	-	-	-	-	-	4	4	-	-	-	-	8
2002–03	-	-	-	-	-	-	-	-	-	-	-	1	1
2005–06	-	-	-	-	-	1	-	-	-	-	-	-	1
2006–07	2	-	-	-	-	-	3	-	-	-	-	-	5
2007–08	-	-	-	-	-	-	-	-	-	-	1	3	4
2009–10	-	-	-	-	-	-	-	-	-	-	-	4	4
2010–11	-	-	1	-	-	-	-	-	-	-	-	-	1
2011–12	-	-	-	-	-	-	-	-	-	-	-	1	1
2012–13	-	-	1	-	-	-	5	8	7	-	1	-	22
2013–14	-	-	3	1	5	1	-	-	-	-	-	-	10
Total	2	-	5	1	6	2	14	12	7	-	2	9	60

(b) EMA 7 (WCNI)

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1994–95	-	-	2	3	-	-	-	-	-	-	-	-	5
1997–98	-	-	-	4	1	-	-	-	-	-	-	-	5
2001–02	15	-	-	-	-	-	-	-	-	-	-	2	17
2002–03	30	1	-	-	-	-	5	-	-	-	-	-	36
2003–04	3	-	27	1	-	-	-	-	-	-	3	5	39
2004–05	-	10	4	-	-	-	2	-	-	13	-	-	29
2005–06	-	4	40	-	-	-	-	-	7	18	-	-	69
2006–07	12	2	19	47	-	-	3	-	1	6	7	4	101
2007–08	21	10	79	3	-	-	-	-	10	7	-	1	131
2008–09	29	10	56	10	-	-	-	-	16	-	-	-	121
2009–10	48	3	52	1	-	-	-	1	18	1	-	-	124
2010–11	6	9	14	1	-	-	5	4	24	-	-	-	63
2011–12	1	13	72	29	-	-	-	2	25	-	2	10	154
2012–13	12	14	60	35	-	14	35	-	36	1	-	-	207
2013–14	8	10	33	18	2	1	21	12	45	11	-	-	161
Total	185	86	458	152	3	15	71	19	182	57	12	22	1 262

(c) EMA 7 (WCSI)

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1993–94	-	-	-	-	-	-	-	-	1	-	-	-	1
1996–97	-	-	-	-	-	-	-	-	-	1	-	-	1
1997–98	-	-	-	-	-	-	-	-	-	2	-	-	2
1999–00	-	-	-	-	-	-	-	-	-	1	-	-	1
2001–02	-	-	-	-	-	-	-	-	-	4	1	5	10
2002–03	16	-	-	-	-	-	-	-	-	-	2	3	21
2004–05	-	-	-	-	-	-	-	-	-	6	-	-	6
2005–06	-	-	-	-	-	-	-	-	-	2	1	-	3
2006–07	-	-	-	-	-	-	-	-	14	23	-	1	38
2007–08	-	-	-	-	-	-	-	-	23	3	8	-	34
2008–09	2	-	-	-	-	-	-	-	6	4	3	-	15
2009–10	2	-	-	-	-	-	-	-	-	-	-	-	2
2010–11	2	-	-	-	-	-	-	-	2	-	-	-	4
2011–12	1	-	-	-	-	-	-	-	6	2	5	-	14
2012–13	3	-	-	-	-	-	-	2	26	8	3	-	42
2013–14	-	-	-	-	-	-	-	4	31	7	1	-	43
Total	26	-	-	-	-	-	-	6	109	63	24	9	237

Table C3: Total number of blue mackerel measured, by area and month, for fishing years 1992 to 2014, where data exist collected by the Observer Programme. Note: Areas defined in Figure 1.

(a) EMA 2 (Chatham Rise)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1992–93	-	-	-	-	-	-	184	-	-	-	-	-	184
2000–01	-	-	-	-	2	-	-	-	-	-	-	-	2
2001–02	-	-	-	-	-	-	50	41	-	-	-	-	91
2002–03	-	-	-	-	-	-	-	-	-	-	-	5	5
2005–06	-	-	-	-	-	20	-	-	-	-	-	-	20
2006–07	51	-	-	-	-	-	30	-	-	-	-	-	81
2007–08	-	-	-	-	-	-	-	-	-	-	10	47	57
2009–10	-	-	-	-	-	-	-	-	-	-	-	80	80
2010–11	-	-	61	-	-	-	-	-	-	-	-	-	61
2011–12	-	-	-	-	-	-	-	-	-	-	-	100	100
2012–13	-	-	112	-	-	-	160	148	160	-	81	-	661
2013–14	-	-	195	5	70	18	-	-	-	-	-	-	288
Total	51	-	368	5	72	38	424	189	160	-	91	232	1 630

(b) EMA 7 (WCNI)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1994–95	-	-	77	58	-	-	-	-	-	-	-	-	135
1997–98	-	-	-	150	37	-	-	-	-	-	-	-	187
2001–02	160	-	-	-	-	-	-	-	-	-	-	23	183
2002–03	254	10	-	-	-	-	60	-	-	-	-	-	324
2003–04	29	-	1 351	15	-	-	-	-	-	-	304	301	2 000
2004–05	-	729	70	-	-	-	5	-	-	2 386	-	-	3 190
2005–06	-	162	1 584	-	-	-	-	-	254	1 408	-	-	3 408
2006–07	676	52	934	605	-	-	20	-	20	304	486	234	3 331
2007–08	1 032	337	3 212	60	-	-	-	-	140	635	-	41	5 457
2008–09	1 500	458	2 792	526	-	-	-	-	1 475	-	-	-	6 751
2009–10	3 371	178	2 074	158	-	-	-	64	962	58	-	-	6 865
2010–11	189	385	345	52	-	-	656	362	3 039	-	-	-	5 028
2011–12	47	485	3 057	1 381	-	-	-	129	1 460	-	19	625	7 203
2012–13	451	262	2 373	1 537	-	435	1 007	-	2 148	20	-	-	8 233
2013–14	165	334	1 101	547	40	20	578	300	1 105	395	-	-	4 585
Total	7 874	3 392	18 970	5 089	77	455	2 326	855	10 603	5 206	809	1 224	56 880

(c) EMA 7 (WCSI)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1993–94	-	-	-	-	-	-	-	-	24	-	-	-	24
1996–97	-	-	-	-	-	-	-	-	-	41	-	-	41
1997–98	-	-	-	-	-	-	-	-	-	240	-	-	240
1999–00	-	-	-	-	-	-	-	-	-	97	-	-	97
2001–02	-	-	-	-	-	-	-	-	-	121	10	64	195
2002–03	116	-	-	-	-	-	-	-	-	-	20	97	233
2004–05	-	-	-	-	-	-	-	-	-	113	-	-	113
2005–06	-	-	-	-	-	-	-	-	-	20	81	-	101
2006–07	-	-	-	-	-	-	-	-	580	1 182	-	2	1 764
2007–08	-	-	-	-	-	-	-	-	639	252	630	-	1 521
2008–09	30	-	-	-	-	-	-	-	546	189	241	-	1 006
2009–10	253	-	-	-	-	-	-	-	-	-	-	-	253
2010–11	51	-	-	-	-	-	-	-	299	-	-	-	350
2011–12	31	-	-	-	-	-	-	-	269	37	349	-	686
2012–13	115	-	-	-	-	-	-	40	588	278	100	-	1 121
2013–14	-	-	-	-	-	-	-	75	803	350	20	-	1 248
Total	596	-	-	-	-	-	-	115	3 748	2 920	1 451	163	8 993

Table C4: Number of otolith pairs collected by observers by fishstock for calendar years 1995–2014.

Year	EMA 1	EMA 2	EMA 3	EMA 7
1995	-	-	-	1
1996	-	-	-	-
1997	-	-	-	-
1998	-	-	-	31
1999	-	-	-	-
2000	-	-	-	6
2001	-	-	-	149
2002	-	-	-	414
2003	-	-	-	78
2004	-	-	-	254
2005	-	-	-	467
2006	-	-	10	503
2007	67	-	41	1 277
2008	35	-	8	1 155
2009	-	-	-	1 137
2010	-	-	15	394
2011	-	-	-	565
2012	-	-	-	990
2013	-	-	91	1 823
2014	2	-	67	1 261
Total	104	-	232	10 505

Table C5: Number of blue mackerel female gonad stages collected by the Observer Programme.

(a) EMA 2 (Chatham Rise)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1992–93	-	-	-	-	-	-	53	-	-	-	-	-	53
2001–02	-	-	-	-	-	-	24	27	-	-	-	-	51
2002–03	-	-	-	-	-	-	-	-	-	-	-	3	3
2005–06	-	-	-	-	-	13	-	-	-	-	-	-	13
2006–07	25	-	-	-	-	-	4	-	-	-	-	-	29
2007–08	-	-	-	-	-	-	-	-	-	-	5	16	21
2009–10	-	-	-	-	-	-	-	-	-	-	-	44	44
2010–11	-	-	47	-	-	-	-	-	-	-	-	-	47
2011–12	-	-	-	-	-	-	-	-	-	-	-	53	53
2012–13	-	-	49	-	-	-	81	115	95	-	43	-	383
2013–14	-	-	97	2	29	11	-	-	-	-	-	-	139
Total	25	-	193	2	29	24	162	142	95	-	48	116	836

(b) EMA 7 (WCNI)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1994–95	-	-	64	38	-	-	-	-	-	-	-	-	102
1997–98	-	-	-	80	20	-	-	-	-	-	-	-	100
2001–02	78	-	-	-	-	-	-	-	-	-	-	10	88
2002–03	123	7	-	-	-	-	19	-	-	-	-	-	149
2003–04	12	-	796	13	-	-	-	-	-	-	118	121	1 060
2004–05	-	358	43	-	-	-	1	-	-	11	-	-	413
2005–06	-	118	779	-	-	-	-	-	101	588	-	-	1 586
2006–07	348	26	455	372	-	-	9	-	10	150	251	71	1 692
2007–08	424	217	2 058	28	-	-	-	-	63	317	-	27	3 134
2008–09	695	375	1 495	295	-	-	-	-	681	-	-	-	3 541
2009–10	1 552	94	1 341	101	-	-	-	30	448	24	-	-	3 590
2010–11	92	212	228	46	-	-	335	166	1 576	-	-	-	2 655
2011–12	25	326	1 961	670	-	-	-	76	919	-	6	234	4 217
2012–13	209	190	1 359	889	-	214	589	-	979	8	-	-	4 437
2013–14	72	167	599	253	19	7	233	124	521	139	-	-	2 134
Total	3 630	2 090	11 178	2 785	39	221	1 186	396	5 298	1 237	375	463	28 898

(c) WCSI

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1997–98	-	-	-	-	-	-	-	-	-	46	-	-	46
1999–00	-	-	-	-	-	-	-	-	-	41	-	-	41
2001–02	-	-	-	-	-	-	-	-	-	41	10	42	93
2002–03	72	-	-	-	-	-	-	-	-	-	10	58	140
2004–05	-	-	-	-	-	-	-	-	-	33	-	-	33
2005–06	-	-	-	-	-	-	-	-	-	11	22	-	33
2006–07	-	-	-	-	-	-	-	-	266	416	-	2	684
2007–08	-	-	-	-	-	-	-	-	310	117	311	-	738
2008–09	17	-	-	-	-	-	-	-	259	88	110	-	474
2009–10	122	-	-	-	-	-	-	-	-	-	-	-	122
2010–11	24	-	-	-	-	-	-	-	173	-	-	-	197
2011–12	18	-	-	-	-	-	-	-	131	21	154	-	324
2012–13	53	-	-	-	-	-	-	18	284	134	71	-	560
2013–14	-	-	-	-	-	-	-	28	436	179	9	-	652
Total	306	-	-	-	-	-	-	46	1 859	1 127	697	102	4 137

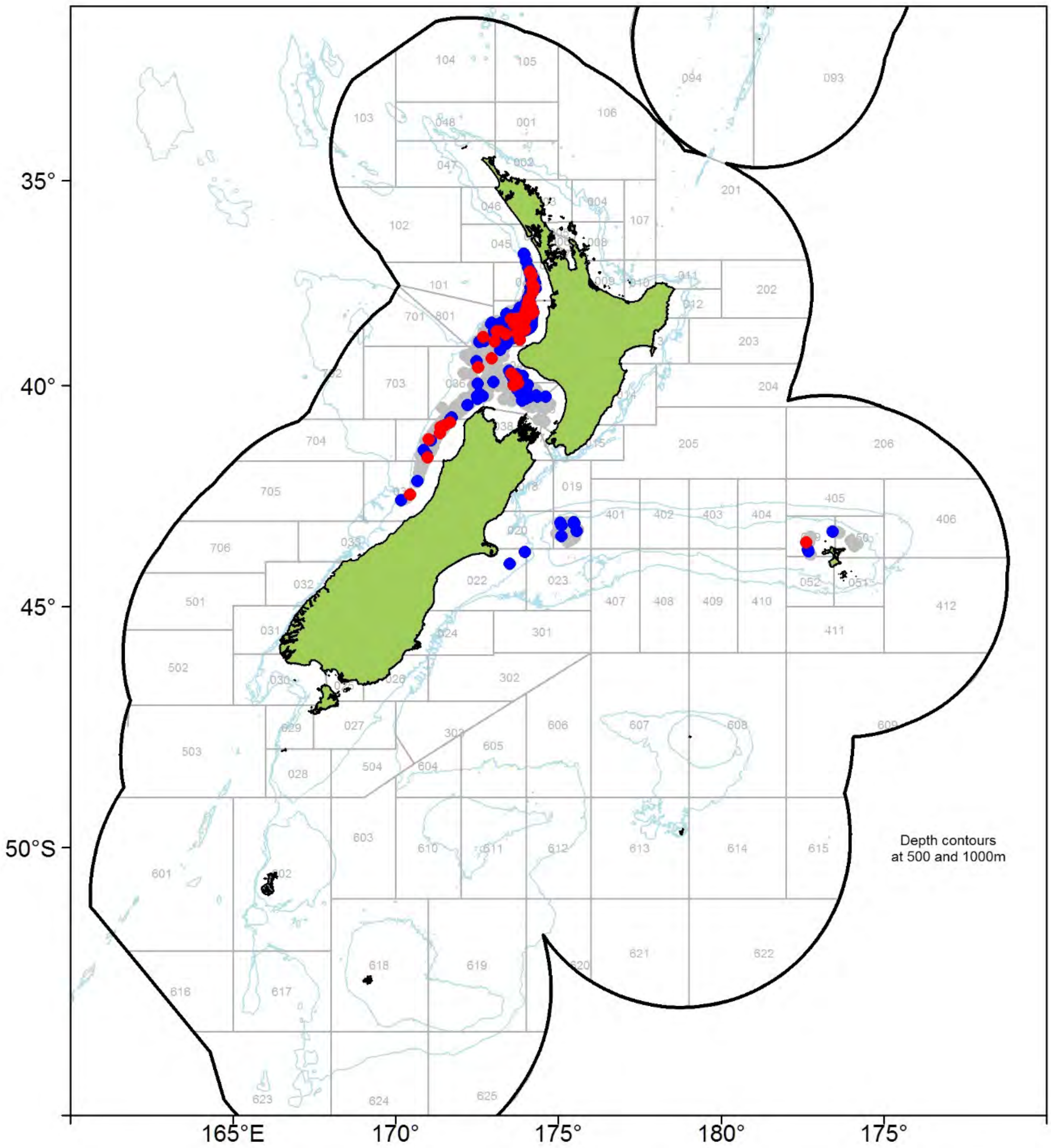


Figure C1: Location of female blue mackerel gonad stages sampled by the Observer Programme. Grey = stage 1 (immature), stage 2 (maturing), and stage 5 (spent); blue = stage 3 (ripe), red = stage 4 (running ripe).

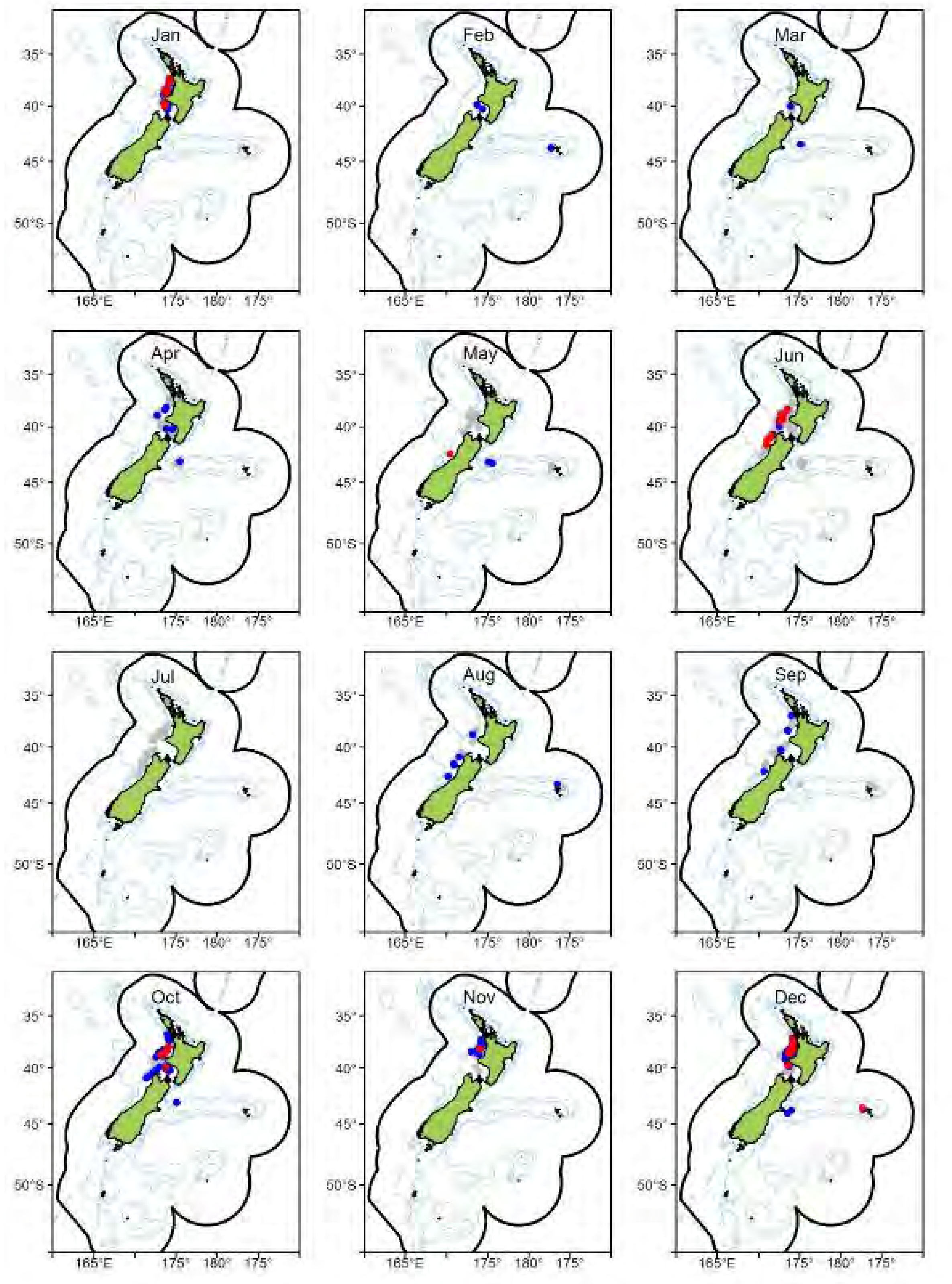


Figure C2: Location of female blue mackerel gonad stages sampled by observers, by month. Grey: stage 1 (immature), stage 2 (maturing), or stage 5 (spent); blue = stage 3 (ripe), red = stage 4 (running ripe).

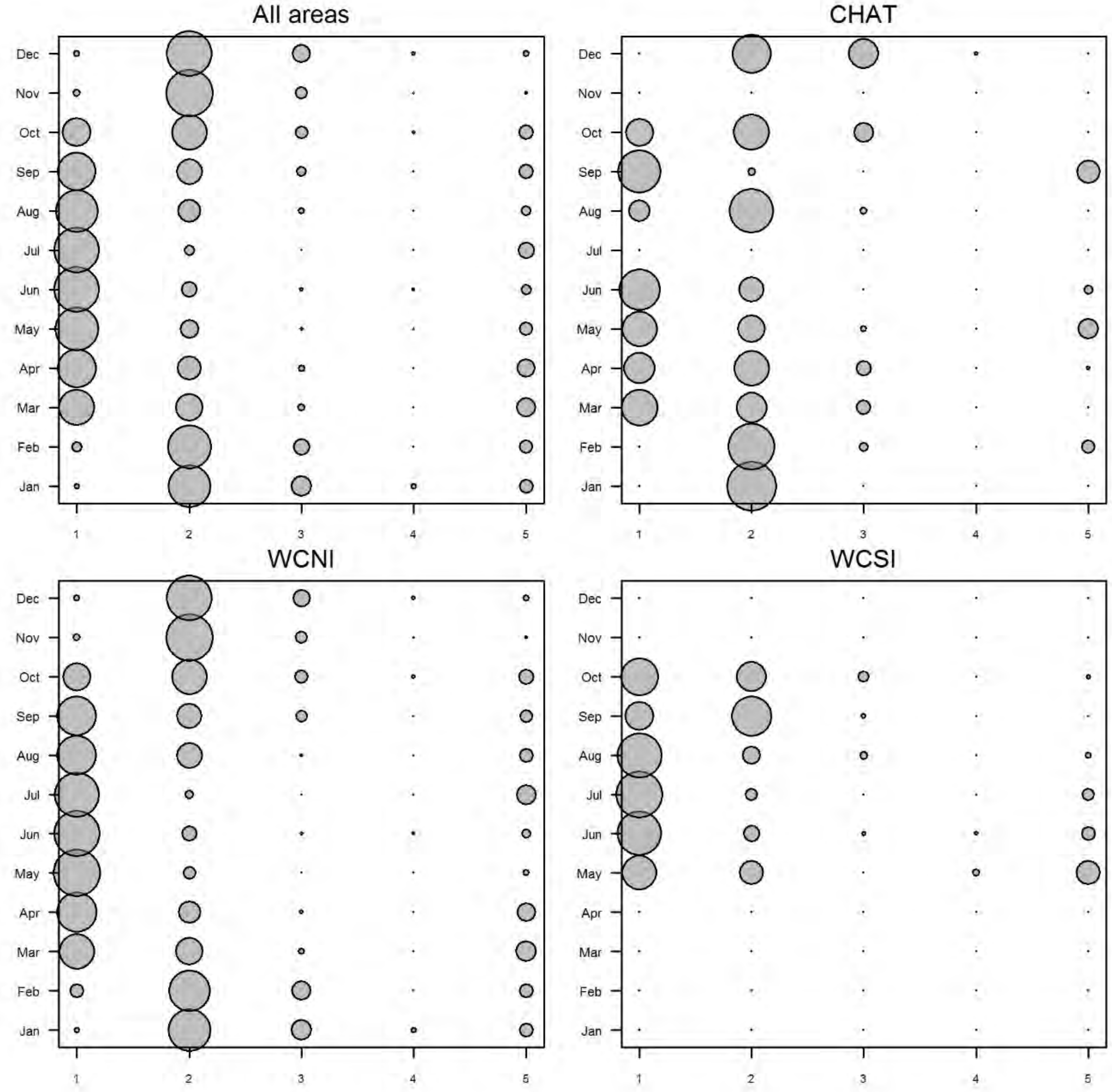


Figure C3: Proportion of gonad stages of female blue mackerel by month sampled by observers from commercial catches, by month and area. Stages are: 1, resting/immature; 2, maturing; 3, ripe; 4, running ripe; 5, spent.

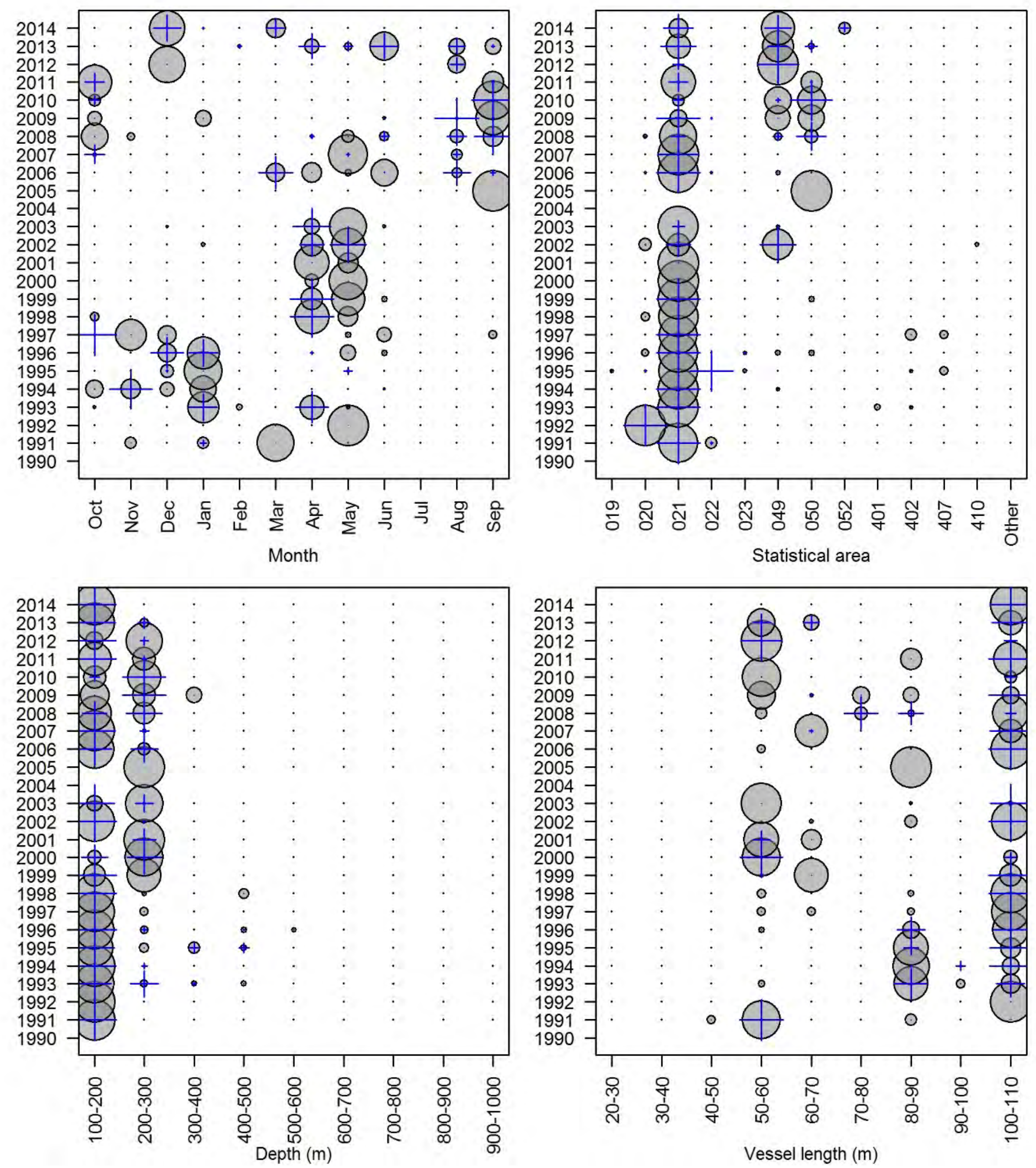


Figure C4a: Representativeness of observer sampling of blue mackerel EMA 3 (Chatham Rise) catch by fishing year and month, statistical area, depth (m), and vessel size (m). Circles show the proportion of catch by month within a year; crosses show the proportion of observed catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter.

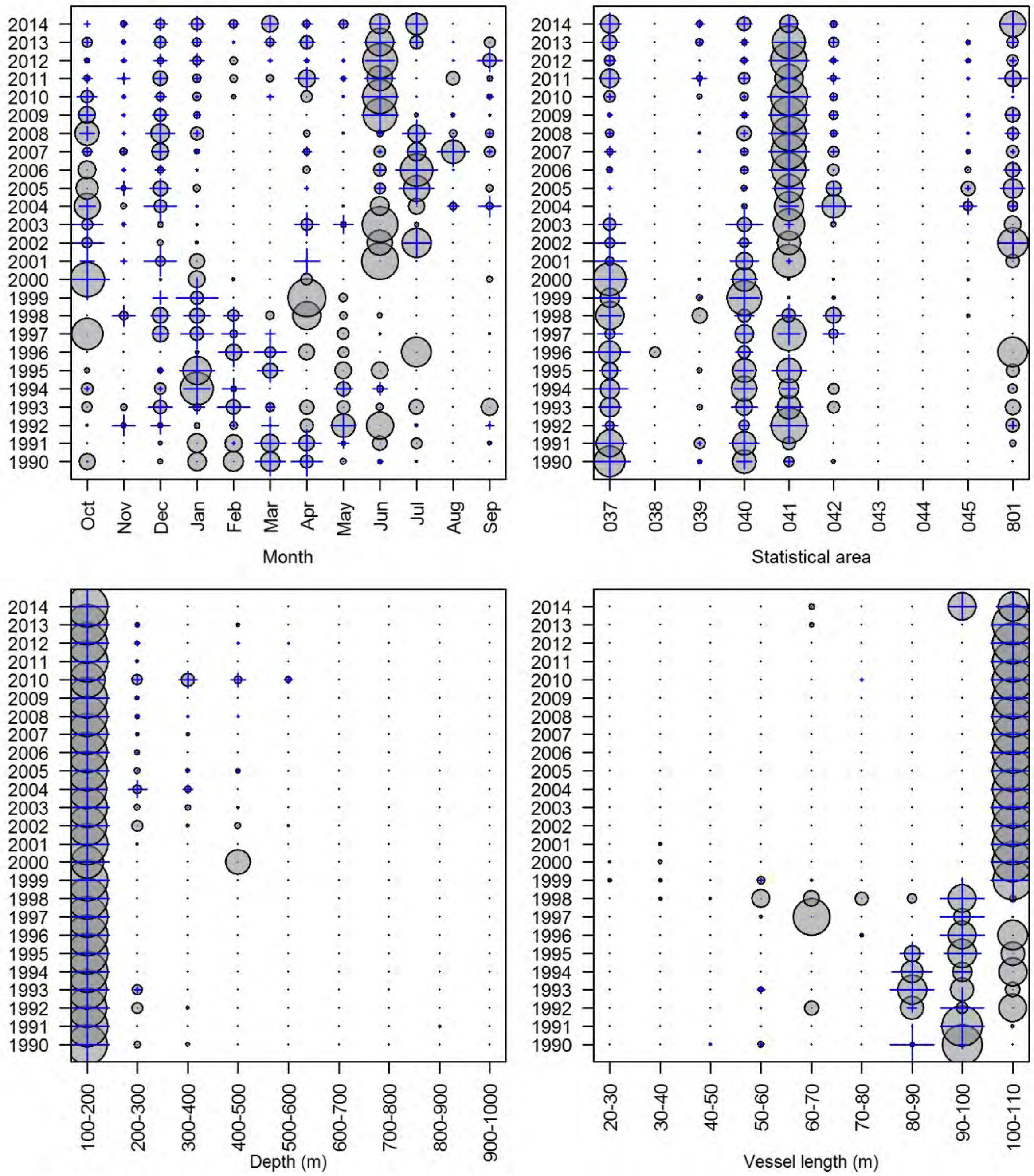


Figure C4b: Representativeness of observer sampling of blue mackerel EMA 7 (WCNI) catch by fishing year and month, statistical area, depth (m), and vessel size (m). Circles show the proportion of catch by month within a year; crosses show the proportion of observed catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter.

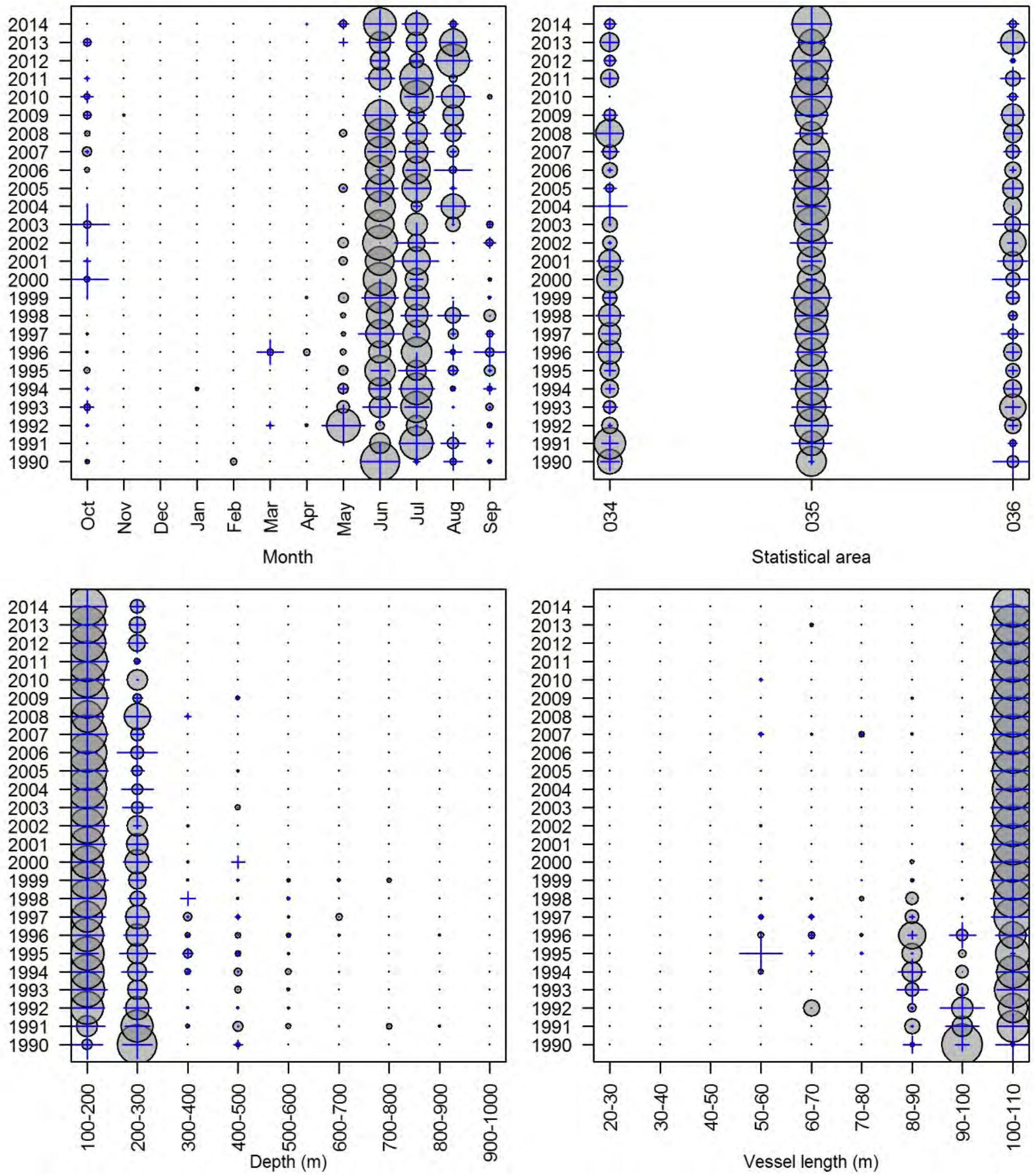


Figure C4c: Representativeness of observer sampling of blue mackerel EMA 7 (WCSI) catch by fishing year and month, statistical area, depth (m), and vessel size (m). Circles show the proportion of catch by month within a year; crosses show the proportion of observed catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter.

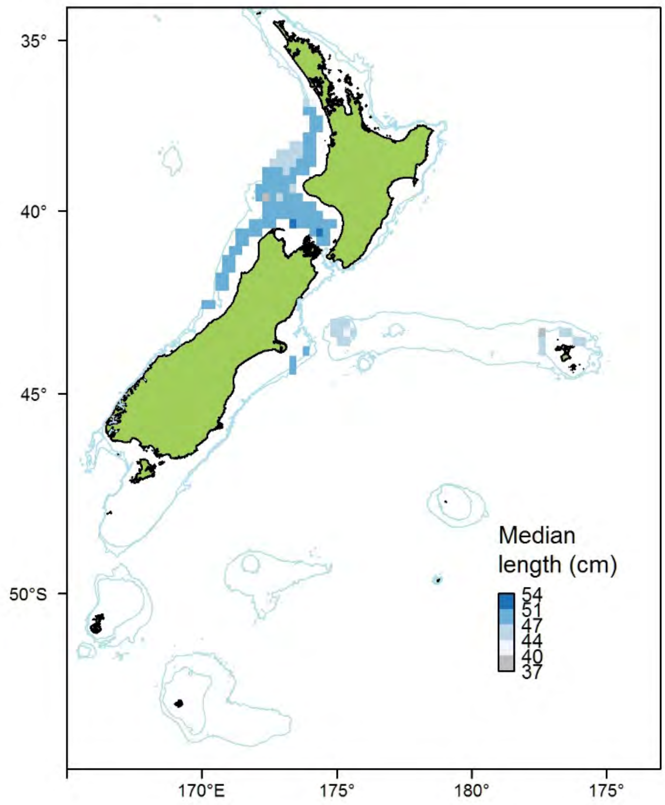


Figure C5: Median length of observed blue mackerel (n = 67 503) for 0.25° cells (all years combined).

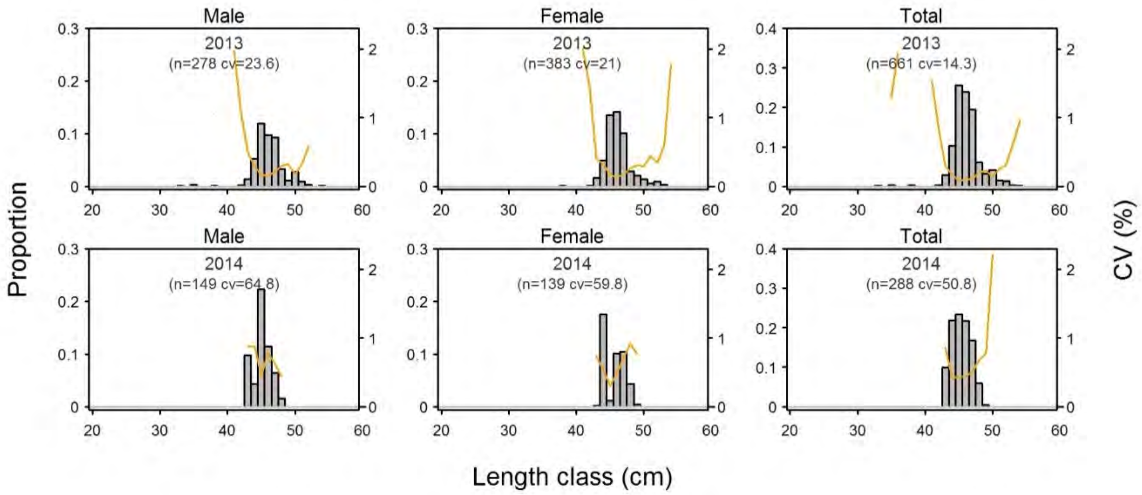


Figure C6a: Scaled length frequency distributions of blue mackerel from observer sampling programme in EMA 3 (Chatham Rise) 2013–2014.

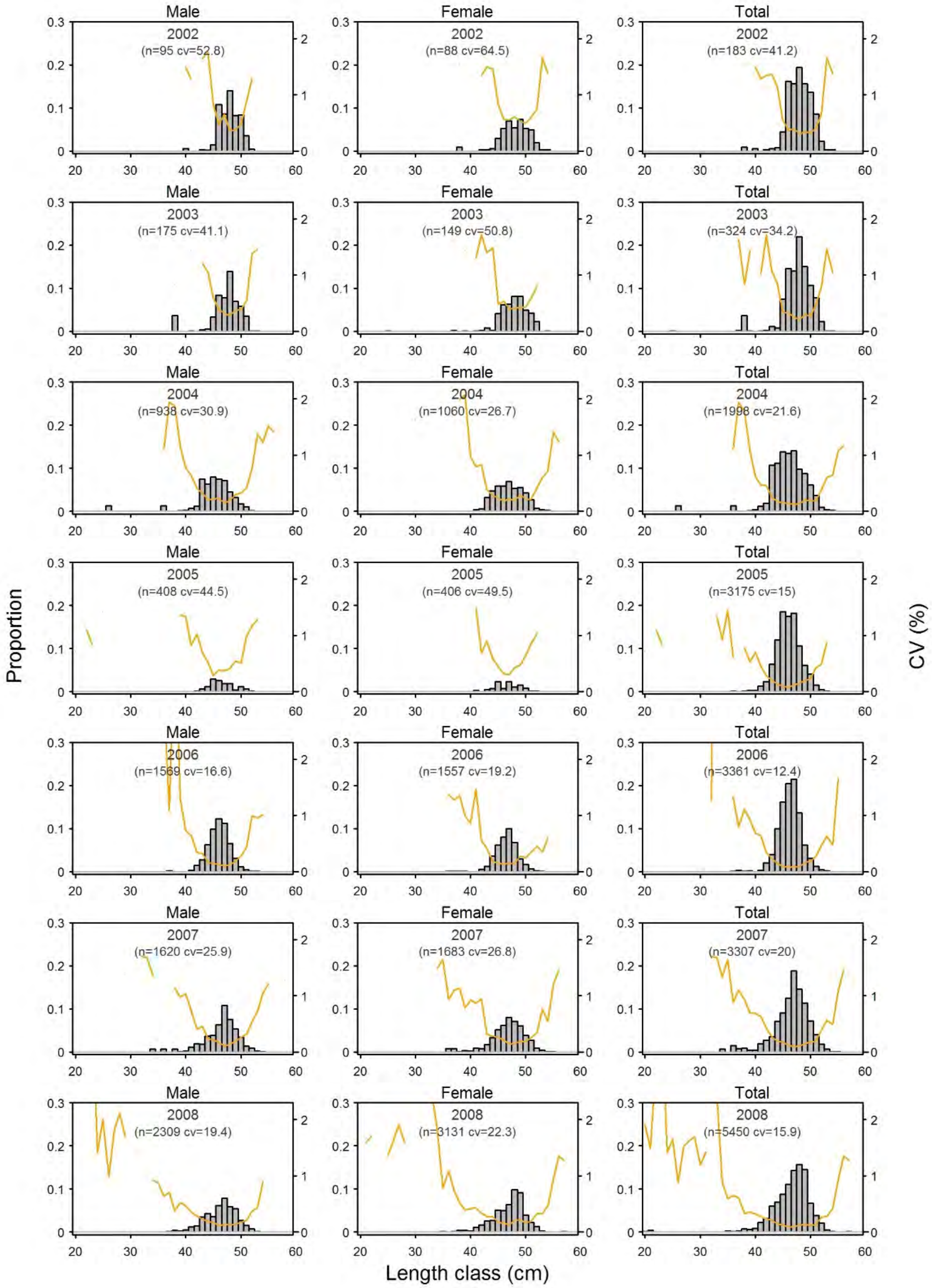


Figure C6b: Scaled length frequency distributions of blue mackerel from observer sampling programme in EMA 7 (WCNI) 2002–2008.

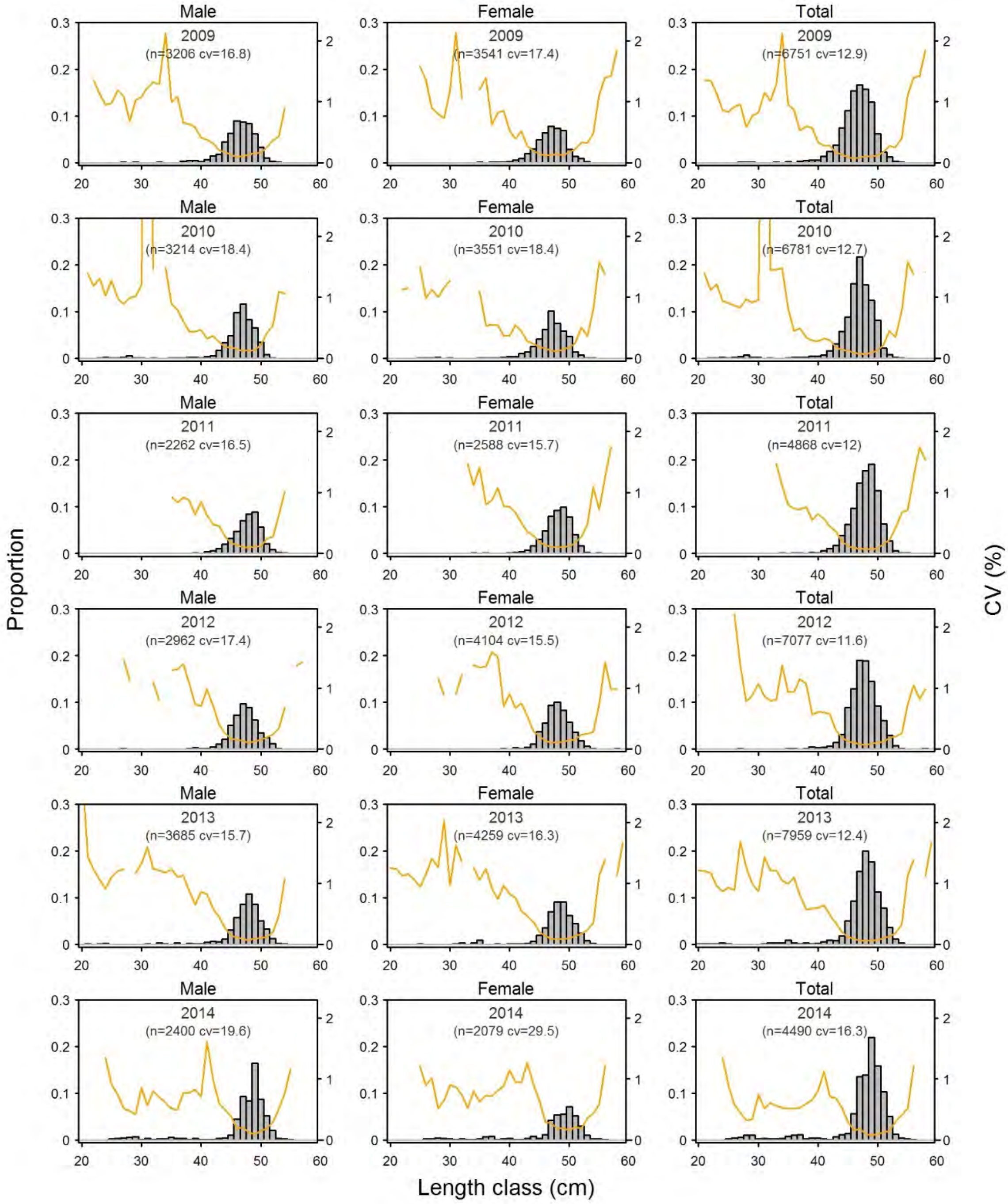


Figure C6b: continued. Scaled length frequency distributions of blue mackerel from observer sampling programme in EMA 7 (WCNI) 2009–2014.

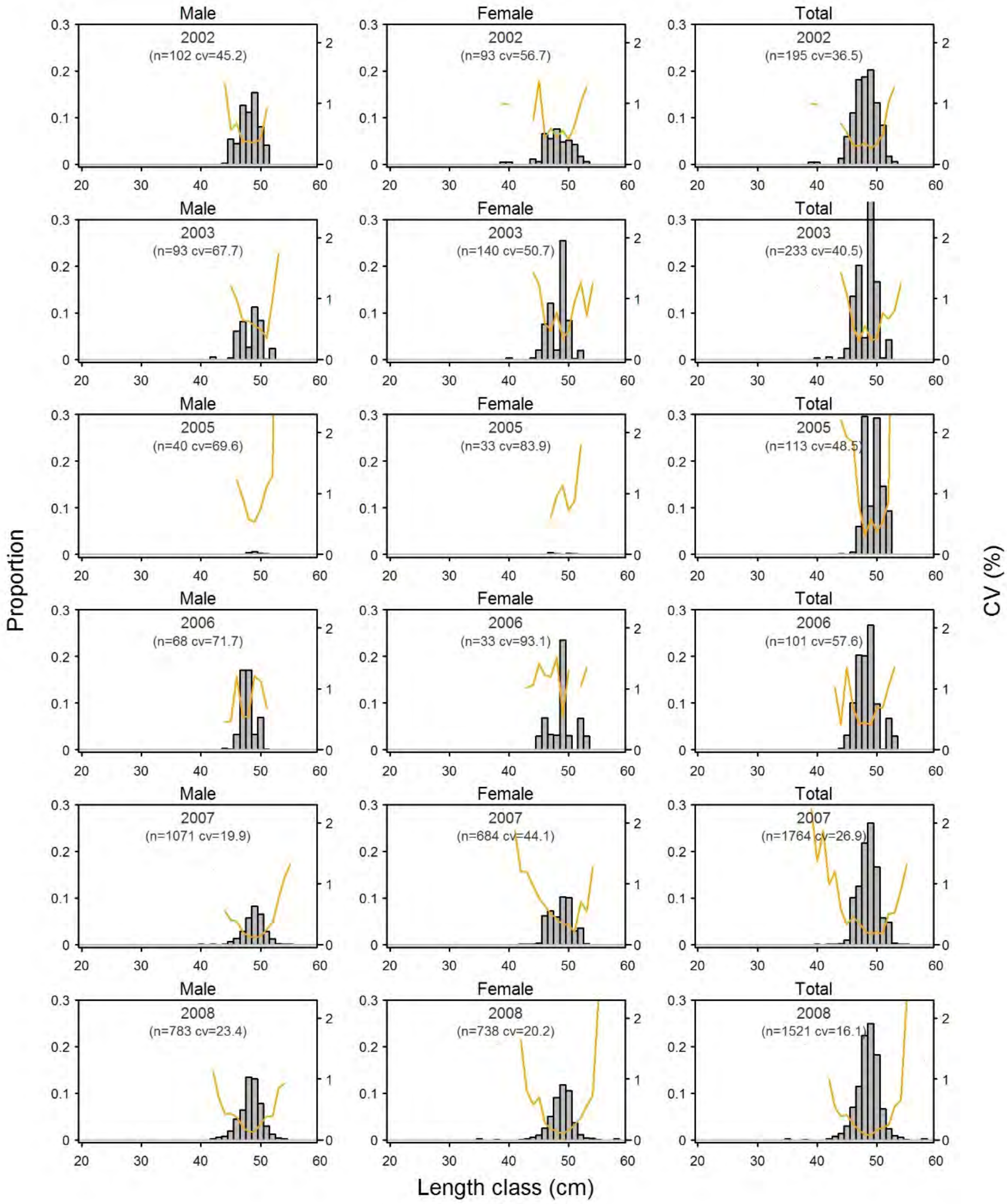


Figure C6c: Scaled length frequency distributions of blue mackerel from observer sampling programme in EMA 7 (WCSI) 2002–2008.

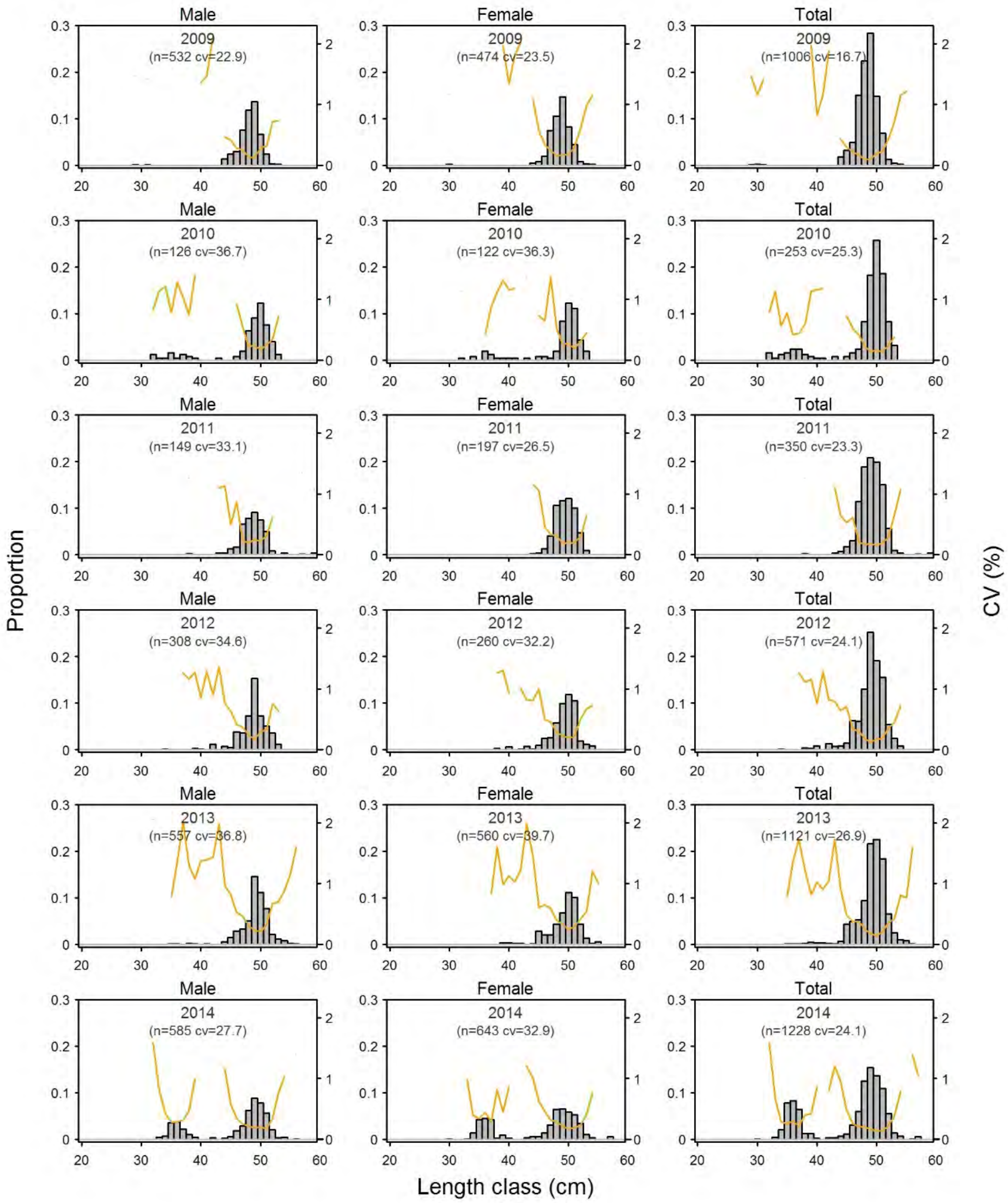


Figure C6c: continued. Scaled length frequency distributions of blue mackerel from observer sampling programme in EMA 7 (WCSI) 2009–2014.

APPENDIX D: CHARACTERISATION

Table D1: List of tables and fields requested in the Ministry for Primary Industries extract 9843.

Fishing_events table

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

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	Processed_weight	Resrch_yn
(ALL fish stocks)	Processed_weight_type	
State_code	Form_type	

Estimated subcatch table

Event_Key	Species_code (ALL species for	Literal_yn
Version_seqno	each fishing event)	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	Gross_tonnes
Flag_nationality_code	Overall_length_metres
Built_year	History_start_datetime
Engine_kilowatts	History_end_datetime

Table D2: Destination codes, total landing weight, number of landings, and whether the records were kept or dropped, for all blue mackerel catch reported for fishing years 1990–2014, by EMA stock.

EMA 1

Destination code	Greenweight (t)	No. records	Description	Action
L	163 296.91	10 298	Landed in New Zealand to a Licensed Fish Receiver	Keep
T	1 936.40	47	Transferred to another vessel	Keep
A	39.59	40	Accidental loss	Keep
U	3.32	195	Used as bait	Keep
W	2.42	222	Sold at wharf	Keep
F	1.63	65	Recreational catch	Keep
D	0.69	16	Discarded	Keep
E	0.45	9	Eaten	Keep
H	0.05	1	Loss from holding pot	Keep
O	0.02	1	Conveyed outside New Zealand	Keep
S	0.02	2	Seized by the Crown	Keep
C	0.00	1	Disposed to the Crown	Keep
R	450.62	85	Retained on board	Drop
Null	399.89	23	Missing destination type code	Drop
Q	17.77	469	Holding receptacle on land	Drop
B	7.90	217	Stored `as bait	Drop
P	0.02	2	Holding receptacle in the water	Drop

EMA 2

Destination code	Greenweight (t)	No. records	Description	Action
L	2 355.46	1 538	Landed in New Zealand to a Licensed Fish Receiver	Keep
T	121.75	2	Transferred to another vessel	Keep
U	0.82	2	Used as bait	Keep
W	0.06	8	Sold at wharf	Keep
F	0.04	12	Recreational catch	Keep
D	0.01	1	Discarded	Keep
S	0.00	1	Seized by the Crown	Keep
R	165.23	12	Retained on board	Drop
B	1.23	51	Stored as bait	Drop
Q	0.44	32	Holding receptacle on land	Drop

Table D2: continued.

EMA 3

Destination code	Greenweight (t)	No. records	Description	Action
L	2 906.71	1 516	Landed in New Zealand to a Licensed Fish Receiver	Keep
O	8.55	2	Conveyed outside New Zealand	Keep
T	7.54	18	Transferred to another vessel	Keep
E	7.11	233	Eaten	Keep
A	0.17	8	Accidental loss	Keep
U	0.07	9	Used as bait	Keep
D	0.03	4	Discarded	Keep
W	0.03	1	Sold at wharf	Keep
S	0.01	2	Seized by the Crown	Keep
F	0.00	1	Recreational catch	Keep
R	334.17	41	Retained on board	Drop
B	4.74	45	Stored as bait	Drop
Q	4.44	166	Holding receptacle on land	Drop
Null	0.01	1	Missing destination type code	Drop

EMA7

Destination code	Greenweight (t)	No. records	Description	Action
L	69 769.13	6 395	Landed in New Zealand to a Licensed Fish Receiver	Keep
T	3 811.49	257	Transferred to another vessel	Keep
O	127.52	29	Conveyed outside New Zealand	Keep
E	45.78	698	Eaten	Keep
D	30.82	43	Discarded	Keep
A	3.46	9	Accidental loss	Keep
U	1.70	37	Used as bait	Keep
S	0.20	2	Seized by the Crown	Keep
F	0.12	14	Recreational catch	Keep
H	0.02	1	Loss from holding pot	Keep
C	0.01	1	Disposed to the Crown	Keep
W	0.00	1	Sold at wharf	Keep
R	2 351.90	327	Retained on board	Drop
B	23.20	282	Stored as bait	Drop
Q	1.72	49	Holding receptacle on land	Drop
Null	0.21	1	Missing destination type code	Drop

Table D3: Number of landing events by major destination code and form type for EMA stocks for fishing years 1990–2014. CLR is Catch Landing Return; CELR is Catch Effort Landing Return; L: landed to NZ; Q: Holding receptacle on land; W: Sold at wharf; B: Stored as bait; U: Used as bait; R: retained on board. Note: the Total column includes counts of destination codes other than L, Q, W, B, U, R.

EMA 1

	CLR form						CELR and NCELR form							
	L	Q	B	U	R	Total	L	Q	W	B	U	R	Total	Total
1990	-	-	-	-	-	-	135	-	-	6	3	1	145	145
1991	2	-	-	-	-	2	350	-	3	34	14	-	401	403
1992	27	-	-	-	-	27	478	-	2	16	38	5	539	566
1993	20	-	-	-	-	20	550	-	7	49	24	8	638	658
1994	13	-	-	-	-	13	453	-	-	33	23	-	509	522
1995	25	-	-	-	-	25	444	-	7	8	13	-	472	497
1996	40	-	-	-	-	40	452	-	11	4	4	1	472	512
1997	56	-	-	-	-	56	491	-	1	13	2	-	507	563
1998	103	-	-	-	-	103	528	-	9	3	10	1	551	654
1999	53	-	-	-	-	53	258	-	1	3	-	-	262	315
2000	85	-	-	-	-	85	243	-	13	1	1	-	258	343
2001	60	-	-	-	-	60	291	-	3	5	1	-	300	360
2002	111	-	-	-	-	111	282	-	3	-	2	2	289	400
2003	114	-	-	-	-	114	247	2	40	1	-	1	291	405
2004	66	-	-	-	-	66	241	3	24	5	1	-	274	340
2005	78	-	-	-	-	78	259	3	-	3	2	29	296	374
2006	109	-	-	-	-	109	289	15	2	2	-	2	310	419
2007	92	-	-	-	-	92	280	47	26	8	8	-	369	461
2008	115	-	1	9	-	125	223	16	3	-	-	4	246	371
2009	107	-	1	1	-	109	230	65	24	2	-	7	328	437
2010	127	-	1	4	1	133	326	113	27	1	-	4	471	604
2011	175	-	-	4	2	181	289	23	6	4	-	3	325	506
2012	108	3	-	7	-	118	308	14	4	2	-	1	329	447
2013	106	1	5	6	-	118	361	89	6	1	-	-	457	575
2014	140	5	3	15	-	163	358	70	-	2	3	13	446	609
Total	1 932	9	11	46	3	2 001	8 366	460	222	206	149	82	9 485	11 486

EMA 2

	CLR form						CELR and NCELR form							
	L	Q	B	U	R	Total	L	Q	W	B	U	R	Total	Total
1990	1	-	-	-	-	1	16	-	-	12	-	-	28	29
1991	1	-	-	-	-	1	37	-	-	22	-	-	59	60
1992	7	-	-	-	3	10	20	-	1	14	-	-	35	45
1993	6	-	-	-	-	6	31	-	-	-	-	-	31	37
1994	4	-	-	-	-	4	40	-	-	1	-	-	41	45
1995	5	-	-	-	-	5	39	-	1	-	-	-	40	45
1996	33	-	-	-	-	33	53	-	-	-	-	2	55	88
1997	34	-	-	-	-	34	37	-	-	-	1	1	39	73
1998	16	-	-	-	-	16	21	-	-	-	-	-	21	37
1999	28	-	-	-	-	28	37	-	-	-	-	-	37	65
2000	10	-	-	-	-	10	22	-	-	-	-	-	22	32
2001	19	-	-	-	-	19	40	-	-	-	-	-	40	59
2002	18	-	-	-	-	18	38	-	-	-	-	2	40	58
2003	29	-	-	-	-	29	39	6	-	1	-	-	46	75
2004	23	-	-	-	-	23	36	5	-	-	-	-	41	64
2005	16	-	-	-	-	16	34	10	-	-	-	-	44	60
2006	13	-	-	-	-	13	30	3	-	-	-	-	33	46
2007	16	-	-	-	-	16	35	1	-	1	1	-	38	54
2008	14	-	-	-	-	14	69	3	-	-	-	1	73	87
2009	18	-	-	-	-	18	102	1	-	-	-	1	104	122
2010	27	-	-	-	1	28	84	2	6	-	-	1	93	121
2011	23	-	-	-	-	23	55	-	-	-	-	-	55	78
2012	20	-	-	-	-	20	66	1	-	-	-	-	67	87
2013	21	-	-	-	-	21	59	-	-	-	-	-	59	80
2014	32	-	-	-	-	32	64	-	-	-	-	-	64	96
Total	434	-	-	-	4	438	1 104	32	8	51	2	8	1 205	1 643

Table D3: continued.

EMA 3

	CLR form						CELR and NCELR form							
	L	**Q**	**B**	**U**	**R**	**Total**	**L**	**Q**	**W**	**B**	**U**	**R**	**Total**	**Total**
1990	11	-	-	-	-	11	135	-	-	-	-	-	135	146
1991	4	-	-	-	-	4	86	-	1	-	-	-	87	91
1992	1	-	-	-	-	1	33	-	-	-	-	-	33	34
1993	23	-	-	-	-	23	64	-	-	1	-	-	65	88
1994	29	-	-	-	4	33	28	-	-	-	-	-	28	61
1995	24	-	-	-	2	26	28	-	-	3	-	-	31	57
1996	17	-	-	-	-	17	78	-	-	18	-	2	98	115
1997	18	-	-	-	2	20	36	-	-	1	-	6	43	63
1998	21	-	-	-	-	21	9	-	-	2	-	-	11	32
1999	10	-	-	-	-	10	10	-	-	1	-	-	11	21
2000	4	-	-	-	-	4	21	-	-	4	-	-	25	29
2001	6	-	-	-	1	7	25	-	-	-	-	-	25	32
2002	25	-	-	-	-	25	7	-	-	1	-	-	8	33
2003	15	-	-	-	1	16	25	-	-	-	-	-	25	41
2004	6	-	-	-	1	7	2	-	-	6	-	-	8	15
2005	3	-	-	-	-	3	8	-	-	-	2	1	11	14
2006	30	-	-	-	1	31	41	-	-	-	2	-	43	74
2007	15	-	-	-	3	18	55	-	-	-	1	-	56	74
2008	31	-	-	-	6	37	41	-	-	-	-	-	41	78
2009	21	-	-	-	1	22	31	12	-	-	1	2	46	68
2010	20	-	-	-	-	20	44	29	-	-	-	-	73	93
2011	20	-	-	-	2	22	71	30	-	-	-	-	101	123
2012	30	-	-	-	3	33	57	31	-	-	-	2	90	123
2013	47	-	-	-	1	48	47	29	-	6	3	-	85	133
2014	45	-	-	-	-	45	58	35	-	2	-	-	95	140
Total	476	-	-	-	28	504	1 040	166	1	45	9	13	1 274	1 778

EMA7

	CLR form						CELR and NCELR form							
	L	**Q**	**B**	**U**	**R**	**Total**	**L**	**Q**	**W**	**B**	**U**	**R**	**Total**	**Total**
1990	17	-	-	-	34	51	119	-	-	14	6	-	139	190
1991	22	-	-	-	42	64	141	-	-	7	-	-	148	212
1992	32	-	-	1	42	75	182	-	-	18	4	-	204	279
1993	29	-	-	-	34	63	363	-	-	37	6	-	406	469
1994	58	-	-	-	46	104	344	-	-	26	5	-	375	479
1995	83	-	-	-	13	96	264	-	1	35	-	1	301	397
1996	65	-	-	-	2	67	151	-	-	11	5	4	171	238
1997	96	-	-	-	14	110	94	-	-	17	1	5	117	227
1998	155	-	-	-	11	166	41	-	-	13	2	-	56	222
1999	203	-	-	-	7	210	85	-	-	-	2	1	88	298
2000	176	-	-	-	2	178	73	-	-	9	-	-	82	260
2001	186	-	-	-	2	188	62	-	-	10	3	-	75	263
2002	265	-	-	-	6	271	26	2	-	12	-	1	41	312
2003	200	-	-	-	1	201	71	7	-	5	-	-	83	284
2004	170	-	-	-	7	177	30	3	-	19	-	3	55	232
2005	197	-	-	-	1	198	29	2	-	12	-	1	44	242
2006	155	-	-	-	5	160	32	1	-	9	-	1	43	203
2007	184	-	-	-	9	193	52	-	-	8	1	-	61	254
2008	202	-	-	-	7	209	69	6	-	12	-	-	87	296
2009	150	-	-	-	9	159	120	2	-	3	-	-	125	284
2010	160	-	-	-	3	163	109	-	-	-	1	-	110	273
2011	170	-	-	-	4	174	109	-	-	2	-	-	111	285
2012	161	-	-	-	5	166	108	8	-	2	-	-	118	284
2013	175	-	-	-	3	178	115	12	-	1	-	-	128	306
2014	175	-	-	-	1	176	120	6	-	-	-	-	126	302
Total	3 486	-	-	1	310	3 797	2 909	49	1	282	36	17	3 294	7 091

Table D4: The reported Quota Management Report (QMR) or Monthly Harvest Return (MHR) catch, annual retained landings in the groomed and unmerged dataset, and retained landings in the groomed and merged dataset, and estimated catches in the groomed and merged dataset for EMA stocks for fishing years 1990–2014. All catch and landings data are in tonnes.

EMA 1

Year	MHR	Unmerged landings	Merged landings	Estimated catch	Percent MHR
1990	2 158	2 158	2 153	2 110	98
1991	5 783	5 791	5 687	5 104	88
1992	10 926	11 209	11 198	10 485	96
1993	10 684	9 271	7 630	6 240	58
1994	4 178	4 096	4 067	4 441	106
1995	6 734	6 386	6 072	5 175	77
1996	4 170	3 957	3 748	3 575	86
1997	6 754	6 754	6 743	6 514	96
1998	4 595	4 594	4 575	4 619	101
1999	4 505	4 506	4 505	4 138	92
2000	3 602	3 601	3 601	3 197	89
2001	9 738	9 738	9 738	9 486	97
2002	6 368	6 685	6 664	6 298	99
2003	7 609	7 752	7 748	7 574	100
2004	6 523	6 571	6 564	6 173	95
2005	7 920	7 904	7 899	6 742	85
2006	6 713	6 586	6 586	5 711	85
2007	7 815	8 026	8 025	9 053	116
2008	5 926	6 154	6 154	5 183	87
2009	3 147	3 310	3 310	2 895	92
2010	8 539	8 859	8 859	8 297	97
2011	6 630	6 846	6 846	6 183	93
2012	8 080	8 311	8 311	7 549	93
2013	7 213	7 347	7 346	6 867	95
2014	6 860	7 001	6 996	6 499	95

EMA 2

Year	MHR	Unmerged landings	Merged landings	Estimated catch	Percent MHR
1990	76	76	76	45	59
1991	94	93	93	96	102
1992	530	407	285	302	57
1993	309	284	284	223	72
1994	218	218	218	204	94
1995	94	94	94	94	100
1996	119	119	119	166	139
1997	78	78	75	51	65
1998	122	122	105	118	97
1999	186	186	172	34	18
2000	73	74	74	46	63
2001	113	113	113	63	56
2002	177	160	160	96	54
2003	115	115	115	81	70
2004	149	109	109	80	54
2005	8	9	9	3	38
2006	13	13	13	-	-
2007	133	133	133	7	5
2008	6	33	4	1	17
2009	2	2	2	3	150
2010	3	3	2	1	33
2011	2	2	2	2	100
2012	2	2	2	1	50
2013	3	3	3	-	-
2014	4	4	4	1	25

Table D4: continued.

EMA 3

Year	MHR	Unmerged landings	Merged landings	Estimated catch	Percent MHR
1990	518	518	453	425	82
1991	478	479	427	478	100
1992	65	65	65	41	63
1993	133	126	94	91	68
1994	223	216	196	160	72
1995	154	154	124	122	79
1996	173	162	118	203	117
1997	340	341	336	243	71
1998	78	76	37	16	21
1999	62	61	29	21	34
2000	3	3	3	2	67
2001	6	4	4	2	33
2002	49	48	49	39	80
2003	88	88	94	83	94
2004	1	3	1	-	-
2005	1	1	1	-	-
2006	133	133	141	112	84
2007	42	19	20	15	36
2008	122	103	101	83	68
2009	88	97	104	84	95
2010	14	37	39	35	250
2011	9	13	13	9	100
2012	28	12	12	4	14
2013	100	114	121	77	77
2014	29	28	30	7	24

EMA7

Year	MHR	Unmerged landings	Merged landings	Estimated catch	Percent MHR
1990	1 492	1 489	1 236	1 464	98
1991	3 004	2 555	2 032	2 095	70
1992	3 607	3 468	2 972	2 954	82
1993	1 880	1 475	1 367	1 133	60
1994	1 402	1 236	1 143	1 010	72
1995	1 804	1 658	1 505	1 379	76
1996	1 218	1 026	961	641	53
1997	2 537	2 308	2 431	1 898	75
1998	2 310	2 315	2 436	2 082	90
1999	8 756	8 761	8 924	7 452	85
2000	3 169	3 169	3 339	2 922	92
2001	3 278	3 278	3 450	2 636	80
2002	5 101	5 086	5 346	4 338	85
2003	3 563	3 317	3 403	2 514	71
2004	2 701	2 565	2 730	2 330	86
2005	4 817	4 946	5 225	4 698	98
2006	3 784	3 662	3 886	3 367	89
2007	2 698	2 714	2 868	2 520	93
2008	2 929	2 851	2 948	2 528	86
2009	3 503	3 221	3 403	2 941	84
2010	3 260	3 249	3 461	2 928	90
2011	1 996	2 016	2 134	1 657	83
2012	2 707	2 573	2 710	2 183	81
2013	2 401	2 276	2 411	1 755	73
2014	1 200	1 161	1 210	806	67

Table D5: Total number of trips, number of trips with zero estimated catch, and proportion of trips with zero estimated catch, by form type for EMA stocks for fishing years 1990–2014. Areas are shown in Figure 1.

EMA 1

	CELR/TCE estimated catch			TCEPR estimated catch		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1990	125	68	0.54	2	-	-
1991	344	169	0.49	2	1	0.50
1992	483	213	0.44	7	6	0.86
1993	550	201	0.37	3	2	0.67
1994	456	218	0.48	11	10	0.91
1995	419	195	0.47	24	23	0.96
1996	394	194	0.49	33	32	0.97
1997	467	233	0.50	54	48	0.89
1998	484	247	0.51	103	93	0.90
1999	252	158	0.63	50	50	1.00
2000	250	144	0.58	85	79	0.93
2001	285	105	0.37	57	53	0.93
2002	280	132	0.47	110	106	0.96
2003	285	93	0.33	113	106	0.94
2004	261	93	0.36	66	64	0.97
2005	237	87	0.37	69	65	0.94
2006	255	97	0.38	106	101	0.95
2007	207	61	0.29	81	75	0.93
2008	169	41	0.24	73	71	0.97
2009	132	47	0.36	63	58	0.92
2010	200	63	0.32	68	68	1.00
2011	213	61	0.29	81	77	0.95
2012	193	60	0.31	70	68	0.97
2013	227	93	0.41	42	41	0.98
2014	258	112	0.43	57	54	0.95

EMA 2

	CELR/TCE estimated catch			TCEPR estimated catch		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1990	16	4	0.25	1	1	1.00
1991	37	8	0.22	1	1	1.00
1992	21	8	0.38	9	6	0.67
1993	31	8	0.26	4	4	1.00
1994	40	30	0.75	3	3	1.00
1995	40	20	0.50	5	5	1.00
1996	43	20	0.47	25	25	1.00
1997	31	20	0.65	35	32	0.91
1998	17	8	0.47	16	16	1.00
1999	33	11	0.33	28	28	1.00
2000	22	13	0.59	10	10	1.00
2001	38	23	0.61	18	17	0.94
2002	34	21	0.62	18	17	0.94
2003	38	21	0.55	29	27	0.93
2004	33	21	0.64	21	19	0.90
2005	31	22	0.71	16	15	0.94
2006	29	26	0.90	13	12	0.92
2007	15	9	0.60	15	13	0.87
2008	17	11	0.65	6	6	1.00
2009	25	12	0.48	9	9	1.00
2010	31	17	0.55	15	15	1.00
2011	36	18	0.50	11	11	1.00
2012	52	31	0.60	11	11	1.00
2013	49	30	0.61	4	4	1.00
2014	38	30	0.79	11	11	1.00

Table D5: continued.

EMA 3

	CELR/TCE estimated catch			TCEPR estimated catch		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1990	132	74	0.56	12	11	0.92
1991	86	48	0.56	10	6	0.60
1992	33	25	0.76	1	1	1.00
1993	62	45	0.73	21	3	0.14
1994	28	19	0.68	24	10	0.42
1995	27	22	0.81	21	6	0.29
1996	65	49	0.75	20	6	0.30
1997	23	19	0.83	20	6	0.30
1998	7	2	0.29	21	5	0.24
1999	9	4	0.44	11	5	0.45
2000	21	16	0.76	7	5	0.71
2001	24	19	0.79	9	5	0.56
2002	7	5	0.71	22	19	0.86
2003	25	17	0.68	22	9	0.41
2004	2	1	0.50	8	7	0.88
2005	8	5	0.62	4	3	0.75
2006	42	29	0.69	25	14	0.56
2007	9	8	0.89	20	13	0.65
2008	4	1	0.25	29	15	0.52
2009	3	1	0.33	22	11	0.50
2010	6	3	0.50	19	11	0.58
2011	18	4	0.22	23	18	0.78
2012	14	10	0.71	26	18	0.69
2013	8	6	0.75	37	22	0.59
2014	12	7	0.58	32	21	0.66

EMA7

	CELR/TCE estimated catch			TCEPR estimated catch		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1990	111	42	0.38	44	20	0.45
1991	138	75	0.54	47	14	0.30
1992	186	112	0.60	55	14	0.25
1993	368	123	0.33	41	11	0.27
1994	338	136	0.40	51	16	0.31
1995	263	116	0.44	67	16	0.24
1996	127	73	0.57	57	24	0.42
1997	88	58	0.66	74	25	0.34
1998	46	28	0.61	111	31	0.28
1999	69	20	0.29	151	95	0.63
2000	65	38	0.58	133	92	0.69
2001	60	30	0.50	126	93	0.74
2002	27	19	0.70	142	93	0.65
2003	66	34	0.52	134	87	0.65
2004	30	18	0.60	104	70	0.67
2005	27	14	0.52	130	80	0.62
2006	31	25	0.81	93	49	0.53
2007	18	8	0.44	106	53	0.50
2008	32	25	0.78	94	48	0.51
2009	28	19	0.68	89	52	0.58
2010	35	30	0.86	80	37	0.46
2011	41	37	0.90	93	60	0.65
2012	16	10	0.62	91	52	0.57
2013	34	29	0.85	84	43	0.51
2014	38	35	0.92	67	22	0.33

Table D6: Total catch (t) for each stock from groomed and merged data, for fishing years 1990–2014. Stock areas are shown in Figure 1. 0: catch < 0.1 t.

Year	EMA 1	EMA 2	EMA 3	EMA 7	Total
1990	2 153	76	2	1 687	3 919
1991	5 687	93	12	2 447	8 239
1992	11 198	285	1	3 035	14 520
1993	7 630	284	70	1 391	9 375
1994	4 067	218	162	1 177	5 624
1995	6 072	94	112	1 517	7 794
1996	3 748	119	52	1 028	4 947
1997	6 743	75	34	2 733	9 585
1998	4 575	105	9	2 464	7 152
1999	4 505	172	23	8 930	13 631
2000	3 601	74	2	3 340	7 016
2001	9 738	113	2	3 452	13 305
2002	6 664	155	18	5 382	12 219
2003	7 748	114	93	3 403	11 359
2004	6 564	109	1	2 730	9 404
2005	7 899	9	0	5 225	13 133
2006	6 586	13	140	3 887	10 626
2007	8 025	133	19	2 869	11 047
2008	6 154	4	100	2 949	9 206
2009	3 310	2	103	3 403	6 818
2010	8 859	2	39	3 461	12 362
2011	6 846	2	11	2 136	8 995
2012	8 311	2	12	2 711	11 035
2013	7 346	3	121	2 411	9 881
2014	6 996	4	29	1 210	8 239
Total	161 023	2 260	1 167	74 980	239 430

Table D7: Total catch (t) by vessel nationality from groomed and merged data, for fishing years 1990–2014. 0: catch < 0.1 t.

Year	NZ	Ukraine	Russian	Unknown	Vanuatu	Japan	Belize	Other	Total
1990	2 783	-	1	975	-	155	-	5	3 919
1991	5 051	-	654	1 821	-	703	-	9	8 239
1992	8 061	130	652	3 608	-	2 057	-	12	14 520
1993	7 960	32	489	526	-	354	1	13	9 375
1994	4 163	192	543	468	0	251	-	6	5 624
1995	5 940	19	917	415	11	352	1	137	7 794
1996	4 220	12	456	131	14	62	4	48	4 947
1997	7 147	316	1 446	285	293	26	-	73	9 585
1998	4 563	665	919	155	424	202	35	190	7 152
1999	8 872	2 165	1 240	82	384	0	856	31	13 631
2000	4 055	1 263	1 127	74	494	0	0	3	7 016
2001	9 876	2 097	374	530	426	0	-	2	13 305
2002	7 108	3 237	863	240	760	4	-	7	12 219
2003	8 651	1 513	512	229	360	2	-	94	11 359
2004	6 430	1 357	783	301	533	0	-	0	9 404
2005	8 055	2 869	698	430	1 079	-	-	1	13 133
2006	6 425	1 906	776	439	1 076	0	-	5	10 626
2007	8 428	1 434	583	93	458	17	-	34	11 047
2008	6 491	1 629	460	1	592	-	-	32	9 206
2009	3 767	1 790	598	3	575	-	-	87	6 818
2010	8 858	2 287	495	8	674	-	-	41	12 362
2011	7 079	1 200	405	2	306	-	-	5	8 995
2012	8 496	1 873	374	11	269	-	-	11	11 035
2013	7 612	1 304	553	1	370	-	-	39	9 881
2014	7 485	520	150	1	82	-	-	1	8 239
Total	167 577	29 810	16 065	10 829	9 180	4 185	898	886	239 430

Table D8: Proportion of blue mackerel catch reported from the EMA 1 stock, by month, statistical area, method, and target species for fishing years 1990–2014.

(a) Month

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990	-	0.25	0.34	0.01	-	-	-	0.22	-	-	-	0.18	2 153
1991	0.38	0.27	0.13	-	-	0.01	0.03	0.03	-	0.02	-	0.13	5 687
1992	0.32	0.23	0.23	0.07	0.04	0.03	0.07	-	-	-	-	-	11 198
1993	0.32	0.17	0.12	0.18	0.12	0.02	0.02	0.03	-	-	0.01	-	7 630
1994	0.09	0.44	0.28	-	0.01	0.09	0.05	-	0.01	-	0.01	0.02	4 067
1995	0.26	0.24	0.10	0.15	0.11	0.10	0.01	0.02	-	-	0.01	-	6 072
1996	0.19	0.56	0.10	-	0.07	0.03	-	-	-	0.01	0.03	0.02	3 748
1997	0.13	0.42	0.22	0.04	-	-	0.08	0.09	-	-	-	0.01	6 743
1998	0.18	0.57	0.21	-	-	0.01	-	-	-	-	0.01	0.02	4 575
1999	0.22	0.57	0.20	-	-	-	-	-	-	-	-	0.01	4 505
2000	0.01	0.76	0.13	0.02	-	0.08	-	-	-	-	-	0.01	3 601
2001	0.16	0.32	0.22	0.20	0.02	-	-	-	-	-	-	0.07	9 738
2002	0.27	0.36	0.13	0.01	-	-	-	-	-	0.02	-	0.21	6 664
2003	0.33	0.43	0.13	0.04	0.04	-	-	-	-	-	-	0.02	7 748
2004	0.27	0.41	0.07	0.02	-	0.05	0.03	0.02	-	-	0.01	0.12	6 564
2005	0.29	0.25	0.24	0.08	0.01	0.04	0.03	-	0.01	-	0.03	0.01	7 899
2006	0.05	0.02	0.18	0.10	-	0.09	0.03	-	0.04	0.05	0.03	0.39	6 586
2007	0.44	0.30	0.13	-	0.04	0.01	0.01	0.01	-	-	0.01	0.04	8 025
2008	0.29	0.20	0.02	0.15	0.05	-	0.01	0.01	0.03	0.15	0.03	0.07	6 154
2009	0.13	0.25	0.01	0.01	-	-	-	0.05	0.02	0.09	-	0.45	3 310
2010	0.10	0.43	0.01	0.02	0.15	0.02	0.06	0.14	0.02	0.03	0.01	0.01	8 859
2011	0.09	0.05	0.04	0.01	0.02	0.02	-	0.09	0.15	0.26	0.27	0.01	6 846
2012	0.57	0.21	0.04	0.03	0.02	0.01	-	0.02	0.02	0.01	0.05	0.02	8 311
2013	0.53	0.19	0.08	0.02	0.02	0.04	0.04	0.02	-	0.02	0.02	0.01	7 346
2014	0.57	0.14	0.02	0.01	0.04	0.02	-	0.05	-	0.02	0.06	0.06	6 996
Total	0.27	0.30	0.13	0.06	0.04	0.03	0.02	0.03	0.01	0.03	0.03	0.06	161 023

(b) Statistical area (Statistical areas are shown in Figure 1).

Year	001	002	003	004	005	006	007	008	009	010	106	Total
1990	-	0.03	-	0.01	-	-	-	0.26	0.70	-	-	2 153
1991	0.04	0.44	0.13	-	-	0.01	-	0.07	0.28	-	0.02	5 687
1992	-	-	0.65	-	-	-	0.01	0.12	0.22	0.01	-	11 198
1993	-	0.70	0.14	-	-	-	-	0.03	0.13	-	-	7 630
1994	-	0.26	0.45	0.04	-	-	-	-	0.23	-	0.01	4 067
1995	-	0.28	0.34	-	-	-	-	0.15	0.22	-	-	6 072
1996	-	0.22	0.61	-	-	-	-	0.05	0.11	-	-	3 748
1997	-	0.04	0.72	-	-	0.01	-	0.06	0.16	-	-	6 743
1998	-	0.83	-	0.01	-	-	-	0.06	0.09	-	0.01	4 575
1999	-	0.24	0.18	-	-	-	-	0.13	0.44	-	-	4 505
2000	-	0.53	-	-	-	-	-	0.11	0.36	-	-	3 601
2001	-	0.15	0.24	-	-	-	-	0.15	0.46	-	-	9 738
2002	-	0.27	0.59	-	-	-	-	0.06	0.08	-	-	6 664
2003	-	0.11	0.78	-	-	-	-	0.01	0.08	0.02	-	7 748
2004	-	0.44	0.35	-	-	-	-	0.05	0.15	0.01	-	6 564
2005	-	0.32	0.43	-	-	-	-	0.10	0.15	-	-	7 899
2006	-	0.46	0.10	-	-	-	-	0.13	0.20	0.10	-	6 586
2007	-	0.18	0.71	-	-	-	-	0.02	0.08	-	-	8 025
2008	-	0.04	0.36	-	-	-	-	0.13	0.48	-	-	6 154
2009	-	0.01	0.26	-	-	-	-	0.36	0.31	0.01	0.05	3 310
2010	-	0.01	0.50	-	-	-	-	0.02	0.47	-	-	8 859
2011	-	-	0.06	-	-	-	-	0.24	0.70	-	-	6 846
2012	-	-	0.33	-	0.48	-	-	0.02	0.16	0.01	-	8 311
2013	-	-	0.14	-	0.66	-	-	0.02	0.17	0.01	-	7 346
2014	-	0.02	0.02	-	0.64	-	-	0.05	0.25	-	-	6 996
Total	-	0.21	0.35	-	0.08	-	-	0.09	0.25	0.01	-	161 023

Table D8: continued.

(c) Method. DS: Danish seine; PS: Purse seine.

	DS	PS	Other	Total
1990	-	1	-	2 153
1991	0.03	0.97	-	5 687
1992	-	1	-	11 198
1993	-	1	-	7 630
1994	-	1	-	4 067
1995	-	1	-	6 072
1996	-	1	-	3 748
1997	-	1	-	6 743
1998	-	1	-	4 575
1999	-	1	-	4 505
2000	-	1	-	3 601
2001	-	1	-	9 738
2002	-	1	-	6 664
2003	-	1	-	7 748
2004	-	1	-	6 564
2005	-	1	-	7 899
2006	-	1	-	6 586
2007	-	1	-	8 025
2008	-	0.99	0.01	6 154
2009	-	0.99	0.01	3 310
2010	-	1	-	8 859
2011	0.01	0.99	-	6 846
2012	0.02	0.98	-	8 311
2013	-	1	-	7 346
2014	-	1	-	6 996
Total	<0.01	1	<0.01	161 023

(d) Target species. (Target species codes are defined in Table D12).

Year	EMA	JMA	KAH	SKJ	TRE	Other	Total
1990	0.96	-	0.02	0.01	-	-	2 153
1991	0.91	0.08	0.01	-	-	-	5 687
1992	0.91	0.04	-	0.01	-	0.03	11 198
1993	0.90	0.06	0.01	0.02	-	-	7 630
1994	0.93	0.05	-	0.01	-	-	4 067
1995	0.88	0.12	-	-	-	-	6 072
1996	0.89	0.07	-	0.03	-	-	3 748
1997	0.98	0.02	-	-	-	-	6 743
1998	0.94	0.05	-	-	0.01	-	4 575
1999	0.95	0.04	-	-	-	-	4 505
2000	0.92	0.06	-	-	0.01	-	3 601
2001	0.97	0.03	-	-	-	-	9 738
2002	0.95	0.03	-	-	0.01	-	6 664
2003	0.93	0.06	-	-	-	-	7 748
2004	0.85	0.12	0.02	0.01	-	-	6 564
2005	0.89	0.10	0.01	-	-	-	7 899
2006	0.92	0.07	-	-	-	-	6 586
2007	0.93	0.06	-	-	-	-	8 025
2008	0.86	0.11	-	0.02	-	0.01	6 154
2009	0.82	0.14	-	0.01	0.03	0.01	3 310
2010	0.92	0.07	-	-	-	-	8 859
2011	0.87	0.10	0.01	0.02	0.01	-	6 846
2012	0.89	0.09	0.01	-	-	-	8 311
2013	0.94	0.05	-	0.01	-	-	7 346
2014	0.91	0.08	-	-	-	-	6 996
Total	0.91	0.07	<0.01	0.01	<0.01	<0.01	161 023

Table D9: Proportion of blue mackerel catch reported from the EMA 2 stock, by month, statistical area, method, and target species for fishing years 1990–2014.

(a) Month

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990	0.77	0.22	-	-	-	-	-	-	-	-	-	-	76
1991	-	-	0.15	0.01	-	-	-	-	-	-	0.29	0.55	93
1992	0.96	-	-	-	-	-	-	-	-	-	0.01	0.02	285
1993	-	0.99	-	0.01	-	-	-	-	-	-	-	-	284
1994	0.26	0.04	0.64	0.03	-	-	-	0.04	-	-	-	-	218
1995	0.03	0.53	-	0.03	-	0.19	0.21	-	-	-	-	-	94
1996	0.52	-	-	0.01	-	-	0.45	-	-	-	-	-	119
1997	0.97	0.01	0.01	-	-	-	-	-	-	-	-	-	75
1998	0.98	-	-	-	-	-	-	-	-	-	-	0.02	105
1999	0.52	0.05	-	0.01	-	-	-	-	-	0.02	0.07	0.33	172
2000	0.72	0.01	-	-	-	-	-	0.23	-	-	-	0.03	74
2001	0.63	0.01	-	0.27	0.07	0.01	-	-	-	-	-	-	113
2002	-	-	-	-	-	0.04	0.95	-	-	-	-	-	155
2003	0.13	0.35	0.01	-	-	0.43	-	0.08	-	-	-	-	114
2004	0.12	0.14	-	0.44	0.26	-	-	0.02	-	-	-	0.01	109
2005	-	0.67	-	0.02	0.02	-	-	0.01	0.01	0.05	-	0.21	9
2006	0.95	-	0.02	-	-	-	-	0.03	-	-	-	-	13
2007	-	-	0.21	-	-	0.68	0.04	-	-	-	0.06	0.01	133
2008	0.72	0.16	0.01	0.02	0.03	-	-	0.01	0.01	-	-	0.03	4
2009	0.14	0.10	0.02	0.02	0.49	0.02	0.01	0.06	0.01	0.01	0.02	0.09	2
2010	0.08	0.07	0.73	0.02	0.04	0.02	0.01	0.01	0.01	-	-	0.01	2
2011	0.74	0.10	0.05	0.02	0.01	-	0.05	0.01	0.02	0.01	-	-	2
2012	0.04	0.02	0.64	0.02	0.02	0.02	0.09	0.02	0.01	0.02	0.02	0.09	2
2013	0.01	0.16	0.56	0.04	0.09	0.10	0.01	-	0.02	-	-	-	3
2014	-	0.03	0.01	0.87	0.05	-	0.01	0.01	-	0.01	-	0.01	4
Total	0.39	0.19	0.08	0.04	0.02	0.07	0.10	0.02	<0.01	<0.01	0.02	0.05	2 260

(b) Statistical area (Statistical areas are shown in Figure 1).

Year	011	012	013	014	015	016	Other	Total
1990	-	-	0.98	0.01	-	-	-	76
1991	-	-	0.26	0.74	-	0.01	-	93
1992	-	-	0.01	0.99	-	-	-	285
1993	-	-	0.91	0.09	-	-	-	284
1994	-	-	0.64	0.36	-	-	-	218
1995	-	-	0.57	0.25	0.01	-	0.18	94
1996	-	-	0.44	0.54	0.01	0.01	-	119
1997	-	-	0.12	0.35	0.52	0.01	-	75
1998	-	-	0.02	0.98	-	-	-	105
1999	-	-	-	0.89	0.10	-	-	172
2000	-	-	-	1	-	-	-	74
2001	0.14	0.01	0.01	0.84	-	0.01	-	113
2002	-	-	-	0.11	0.89	-	-	155
2003	-	-	-	0.48	0.51	-	-	114
2004	0.42	0.02	0.41	0.14	-	-	-	109
2005	0.01	0.02	0.46	0.47	0.01	0.02	-	9
2006	-	-	0.03	0.93	-	0.04	-	13
2007	0.01	-	0.74	0.20	0.04	0.01	-	133
2008	-	-	0.17	0.75	0.05	0.02	-	4
2009	-	0.01	0.57	0.07	0.23	0.12	-	2
2010	0.18	0.01	0.56	0.11	0.09	0.06	-	2
2011	-	-	0.68	0.20	0.05	0.06	-	2
2012	0.01	0.04	0.74	-	0.01	0.20	-	2
2013	-	0.15	0.32	0.37	0.03	0.13	-	3
2014	-	0.02	0.89	0.01	0.03	0.04	-	4
Total	0.03	<0.01	0.34	0.50	0.12	<0.01	0.01	2 260

Table D9: continued.

(c) Method. BT: bottom trawl; MB: midwater trawl within 5 m of the seabed; MW: midwater trawl; DS: Danish seine; PS: Purse seine; SN: Setnet.

Year	BT	MB	MW	PS	SN	Other	Total
1990	-	-	-	0.99	0.01	-	76
1991	-	-	-	0.98	0.01	-	93
1992	-	0.01	-	0.98	-	-	285
1993	-	-	-	0.99	0.01	-	284
1994	-	-	-	1	-	-	218
1995	-	-	-	0.99	0.01	-	94
1996	-	0.01	-	0.97	0.01	-	119
1997	0.01	-	-	0.97	0.01	-	75
1998	-	-	-	1	-	-	105
1999	-	-	-	0.99	0.01	-	172
2000	-	-	-	0.99	-	-	74
2001	0.01	-	-	0.98	0.01	0.01	113
2002	-	-	-	1	-	-	155
2003	-	-	-	0.99	-	-	114
2004	0.01	-	-	0.98	-	-	109
2005	0.04	0.03	0.01	0.88	0.04	-	9
2006	-	-	0.01	0.95	0.03	-	13
2007	-	-	-	0.99	-	-	133
2008	0.01	-	-	0.89	0.10	-	4
2009	0.03	0.02	0.03	0.51	0.41	-	2
2010	0.02	-	-	0.72	0.25	-	2
2011	0.04	-	-	0.76	0.19	-	2
2012	0.07	0.04	0.01	0.67	0.18	0.04	2
2013	0.03	-	-	0.67	0.30	-	3
2014	0.05	-	-	0.84	0.12	-	4
Total	<0.01	<0.01	<0.01	0.99	0.01	<0.01	2 260

(d) Target species. (Target species codes are defined in Table D12).

Year	EMA	JMA	KAH	SKJ	Other	Total
1990	-	-	0.99	-	0.01	76
1991	-	-	0.98	-	0.02	93
1992	0.12	-	0.86	-	0.02	285
1993	-	-	0.99	-	0.01	284
1994	-	0.06	0.94	-	-	218
1995	0.18	0.09	0.52	0.20	0.01	94
1996	0.44	0.01	0.52	0.01	0.03	119
1997	-	0.01	0.96	-	0.03	75
1998	0.75	0.18	0.07	-	-	105
1999	0.21	0.23	0.55	-	0.01	172
2000	-	0.23	0.76	-	-	74
2001	0.07	-	0.90	0.01	0.02	113
2002	0.62	0.19	0.19	-	-	155
2003	0.47	0.01	0.51	-	0.01	114
2004	0.37	0.22	0.36	0.04	0.02	109
2005	-	-	0.88	-	0.12	9
2006	-	-	0.95	-	0.05	13
2007	0.62	-	0.37	-	0.01	133
2008	-	-	0.89	-	0.11	4
2009	-	-	0.52	-	0.48	2
2010	-	-	0.74	-	0.26	2
2011	-	0.04	0.72	-	0.24	2
2012	-	-	0.67	-	0.33	2
2013	-	-	0.66	0.01	0.33	3
2014	-	-	0.84	-	0.16	4
Total	0.22	0.07	0.69	0.01	0.01	2 260

Table D10: Proportion of blue mackerel catch reported from the EMA 3 stock, by month, statistical area, method, and target species for fishing years 1990–2014.

(a) Month

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990	0.11	0.06	0.08	0.01	0.03	0.32	0.07	0.25	0.04	-	0.03	0.01	2
1991	0.19	-	0.43	0.28	-	-	0.08	-	-	-	-	-	12
1992	-	0.20	0.25	0.05	0.07	0.01	0.13	-	-	0.04	0.24	-	1
1993	0.01	-	-	0.55	0.03	-	0.31	0.01	0.07	-	-	-	70
1994	0.34	0.05	0.52	0.06	0.02	-	-	-	-	-	-	-	162
1995	-	-	0.43	0.55	-	-	-	0.01	-	-	-	-	112
1996	-	-	0.66	0.02	-	-	0.13	0.18	0.02	-	-	-	52
1997	0.50	0.26	0.04	0.01	-	-	-	0.02	0.13	-	-	0.04	34
1998	0.10	-	-	-	-	0.02	0.69	0.19	-	-	-	-	9
1999	-	-	-	-	-	-	0.26	0.73	0.01	-	-	-	23
2000	-	-	-	-	-	-	0.96	-	-	-	-	0.02	2
2001	0.01	-	0.01	0.01	0.01	0.01	0.59	0.35	-	-	-	0.01	2
2002	-	-	0.02	0.04	0.01	0.03	0.35	0.52	-	-	-	0.03	18
2003	-	-	-	-	-	-	0.15	0.83	0.01	-	-	-	93
2004	-	0.01	-	-	0.03	-	0.92	0.01	-	-	-	0.03	1
2005	-	-	-	-	-	-	-	-	-	-	-	0.99	<0.5
2006	-	-	-	-	-	0.37	0.18	0.27	0.13	-	0.05	-	140
2007	0.01	-	-	-	0.07	0.06	0.02	0.76	-	-	0.07	-	19
2008	0.50	-	-	-	-	-	0.01	0.07	-	-	0.15	0.26	100
2009	0.10	-	-	0.15	-	-	-	-	-	-	-	0.74	103
2010	0.09	-	-	-	-	-	-	-	-	-	-	0.90	39
2011	0.51	-	-	-	-	0.01	0.03	-	-	-	-	0.44	11
2012	0.03	0.12	0.63	0.01	0.01	-	0.03	-	-	-	0.15	0.03	12
2013	-	-	-	-	0.01	0.08	0.28	0.15	0.23	-	0.11	0.12	121
2014	0.02	-	0.54	0.10	0.24	0.10	-	-	-	-	-	-	29
Total	0.13	0.02	0.17	0.12	0.01	0.06	0.11	0.17	0.05	<0.01	0.03	0.14	1 167

(b) Statistical area (Statistical areas are shown in Figure 1).

Year	020	021	022	028	049	050	407	602	Other	Total
1990	0.04	-	0.51	0.06	-	-	-	0.01	0.38	2
1991	0.04	0.23	0.50	0.11	-	-	-	-	0.12	12
1992	-	0.02	0.01	-	-	-	-	0.09	0.89	1
1993	-	0.87	-	-	-	-	-	-	0.13	70
1994	-	0.95	-	0.02	0.01	-	0.01	0.01	0.01	162
1995	0.01	0.93	-	-	-	-	0.03	-	0.02	112
1996	0.10	0.71	0.01	-	0.01	0.02	0.01	0.09	0.06	52
1997	-	0.83	-	0.01	-	0.01	0.04	-	0.11	34
1998	0.10	0.86	0.02	-	-	-	-	-	0.02	9
1999	-	0.76	0.02	-	-	0.01	-	-	0.21	23
2000	-	0.83	0.05	-	-	0.01	-	-	0.10	2
2001	-	0.93	0.01	0.01	0.01	-	-	-	0.03	2
2002	0.07	0.26	0.06	0.03	0.47	-	-	0.03	0.08	18
2003	-	0.99	-	-	0.01	-	-	-	-	93
2004	0.01	-	0.84	0.08	-	-	-	0.02	0.05	1
2005	0.11	0.04	-	-	-	0.83	-	-	0.02	-
2006	-	0.98	-	-	0.01	-	-	-	-	140
2007	-	0.84	0.01	0.08	-	-	-	-	0.06	19
2008	-	0.76	-	-	0.07	0.16	-	-	0.01	100
2009	-	0.18	-	-	0.37	0.44	-	-	-	103
2010	-	0.09	-	-	0.43	0.47	-	-	-	39
2011	-	0.52	0.01	0.01	-	0.44	-	0.02	-	11
2012	0.01	0.04	0.02	-	0.60	0.02	-	-	0.30	12
2013	0.02	0.44	0.05	0.01	0.40	0.02	-	0.03	0.02	121
2014	0.02	0.12	0.13	0.05	0.55	-	-	0.08	0.05	29
Total	0.01	0.71	0.02	0.01	0.13	0.08	0.01	0.01	0.03	1 167

Table D10: continued.

(c) Method. MB: midwater trawl within 5 m of the seabed; MW: midwater trawl; PS: Purse seine; SN: Setnet.

Year	BT	MB	MW	PS	SN	Total
1990	0.99	-	0.01	-	-	2
1991	0.80	0.19	-	-	0.01	12
1992	0.99	-	-	-	0.01	1
1993	0.07	0.27	0.66	-	-	70
1994	-	0.73	0.27	-	-	162
1995	-	0.32	0.68	-	-	112
1996	0.10	0.33	0.57	-	-	52
1997	0.04	0.18	0.77	-	-	34
1998	0.14	0.61	0.25	-	-	9
1999	0.55	0.01	0.23	0.21	-	23
2000	0.95	-	0.05	-	-	2
2001	0.98	0.01	0.01	-	-	2
2002	0.16	0.70	0.14	-	-	18
2003	0.87	0.13	-	-	-	93
2004	0.86	0.13	0.01	-	-	1
2005	0.86	0.14	-	-	-	<0.5
2006	0.04	0.64	0.32	-	-	140
2007	0.57	0.41	0.01	-	-	19
2008	0.15	0.84	-	-	-	100
2009	0.26	0.67	0.07	-	-	103
2010	0.01	0.99	-	-	-	39
2011	0.01	0.98	0.01	-	-	11
2012	0.93	0.05	0.01	-	-	12
2013	0.23	0.43	0.32	0.01	-	121
2014	0.01	0.73	0.26	-	-	29
Total	0.19	0.52	0.28	0.01	<0.01	1 167

(d) Target species. (Target species codes are defined in Table D12).

Year	BAR	FLA	HOK	JMA	LIN	RCO	SQU	SWA	Other	Total
1990	0.58	0.05	0.10	-	0.02	0.04	0.06	0.02	0.13	2
1991	0.68	0.01	0.08	0.03	-	0.06	0.10	0.01	0.03	12
1992	-	-	0.22	-	-	0.17	-	-	0.60	1
1993	0.11	0.02	0.18	0.64	-	0.01	0.01	0.03	-	70
1994	-	-	0.10	0.88	-	-	0.02	-	-	162
1995	-	-	0.08	0.90	-	-	0.01	-	-	112
1996	0.04	-	0.30	0.55	-	-	0.11	-	-	52
1997	0.04	-	0.07	0.88	-	-	0.01	-	-	34
1998	-	0.01	0.10	0.85	-	0.01	0.03	-	-	9
1999	0.03	-	0.01	0.44	-	-	0.52	-	-	23
2000	0.01	0.01	0.06	0.05	0.01	-	0.86	-	0.01	2
2001	0.02	0.02	-	-	-	-	0.96	-	-	2
2002	0.48	-	0.01	0.34	0.03	-	0.13	0.01	-	18
2003	-	-	-	0.89	-	-	0.11	-	-	93
2004	0.84	-	-	0.01	0.01	0.02	0.09	-	0.04	1
2005	0.83	-	0.17	-	-	-	-	-	-	-
2006	0.01	-	-	0.96	-	-	0.04	-	-	140
2007	0.07	-	-	0.84	-	-	0.07	-	0.01	19
2008	0.15	-	-	0.69	0.07	-	0.06	0.01	-	100
2009	0.29	-	-	0.54	0.15	-	-	0.01	-	103
2010	0.01	-	-	0.98	-	-	-	-	0.01	39
2011	0.44	-	-	0.52	-	-	0.03	-	-	11
2012	0.50	0.01	0.33	-	0.01	-	-	0.08	0.06	12
2013	0.32	-	-	0.62	-	-	0.03	-	0.03	121
2014	0.56	-	-	0.31	-	-	0.11	0.01	0.02	29
Total	0.12	-	0.05	0.73	0.02	-	0.05	0.01	0.01	1 167

Table D11: Proportion of blue mackerel catch reported from the EMA 7 stock, by month, statistical area, method, and target species for fishing years 1990–2014.

(a) Month

Trawl

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990	-	-	-	0.24	0.14	0.22	0.02	0.02	0.29	-	0.02	0.05	160
1991	-	-	-	0.07	0.01	0.06	0.04	0.01	0.33	0.34	0.13	0.01	1 509
1992	-	0.01	0.01	0.02	0.01	-	0.11	0.41	0.35	0.07	-	0.01	2 852
1993	0.02	0.03	0.02	0.04	0.08	0.01	0.08	0.06	0.28	0.30	-	0.09	826
1994	-	-	0.08	0.10	0.06	-	-	0.08	0.33	0.32	0.01	0.01	832
1995	0.02	-	0.13	0.03	-	0.07	-	0.18	0.45	0.05	0.05	0.02	1 327
1996	-	-	-	-	0.02	0.01	0.04	0.04	0.60	0.19	0.07	0.02	544
1997	-	0.01	0.01	-	-	-	-	0.01	0.54	0.37	0.03	0.03	1 866
1998	-	0.02	0.02	0.02	0.01	0.01	0.05	0.02	0.44	0.24	0.11	0.06	2 434
1999	-	-	0.01	-	-	-	0.02	0.19	0.66	0.12	-	-	4 668
2000	0.04	-	0.02	-	-	-	-	0.02	0.88	0.03	-	0.01	2 906
2001	-	0.01	0.06	-	-	-	-	0.16	0.59	0.17	-	-	2 903
2002	0.06	-	0.03	-	-	-	-	0.05	0.54	0.32	-	0.01	4 860
2003	0.07	-	0.03	-	-	-	0.09	0.01	0.70	0.10	-	0.01	2 389
2004	0.40	0.04	0.12	-	-	-	-	0.02	0.32	0.03	0.08	-	2 674
2005	0.25	0.09	0.11	-	-	-	-	-	0.15	0.34	-	0.05	4 652
2006	0.15	0.02	0.02	-	-	0.01	0.02	-	0.17	0.60	0.01	0.01	3 624
2007	0.06	0.11	0.05	0.01	-	-	0.03	-	0.31	0.11	0.28	0.06	2 508
2008	0.16	0.10	0.15	0.07	-	-	0.02	-	0.12	0.20	0.06	0.12	2 615
2009	0.14	0.03	0.10	0.01	-	-	-	-	0.63	0.02	0.03	0.04	2 946
2010	0.08	0.03	0.08	0.03	-	-	0.08	0.24	0.39	0.02	0.01	0.02	3 459
2011	0.03	0.07	0.15	0.02	0.06	-	0.16	0.15	0.21	0.07	0.08	0.01	1 905
2012	0.02	0.03	0.07	0.01	0.03	-	0.01	0.02	0.61	0.01	0.08	0.10	2 517
2013	0.08	0.07	0.09	0.03	-	0.12	0.04	-	0.42	0.08	0.02	0.06	2 200
2014	0.01	0.08	0.10	0.05	0.03	0.12	0.05	0.04	0.34	0.18	0.01	-	1 207
Total	0.08	0.03	0.06	0.02	0.01	0.01	0.03	0.08	0.44	0.18	0.04	0.03	60 383

Purse-seine

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990	-	-	-	0.12	0.24	0.26	0.23	0.02	0.01	0.01	-	0.10	1 521
1991	-	-	-	0.02	0.27	0.56	0.14	0.01	-	-	-	-	934
1992	-	-	-	0.25	0.05	0.18	0.23	0.01	-	-	-	0.28	179
1993	-	-	0.01	0.03	0.62	0.33	0.01	-	-	-	-	-	553
1994	0.78	0.09	0.05	-	0.02	0.01	0.05	-	-	-	-	-	329
1995	0.01	-	0.28	-	0.07	0.01	0.01	0.63	-	-	-	-	170
1996	-	-	-	-	0.19	0.36	0.44	0.01	-	-	-	-	478
1997	-	-	0.30	0.20	-	-	0.49	-	-	-	-	-	607
1998	-	-	-	-	-	-	-	1	-	-	-	-	28
1999	-	-	-	-	-	0.41	0.29	0.28	0.01	-	-	-	3 992
2000	-	-	-	0.02	-	-	0.37	0.46	0.14	-	-	-	432
2001	-	-	0.20	-	0.01	0.18	0.57	0.04	-	-	-	-	545
2002	0.93	-	-	-	-	0.01	-	0.06	0.01	-	-	-	522
2003	-	-	-	-	0.20	0.71	0.09	-	-	-	-	-	1 012
2004	-	-	-	-	-	1	-	-	-	-	-	-	55
2005	-	-	-	-	-	-	0.94	0.06	-	-	-	-	572
2006	-	-	-	-	0.45	-	-	0.55	-	-	-	-	260
2007	-	-	-	-	-	0.17	0.83	-	-	-	-	-	359
2008	-	-	-	-	-	0.59	-	0.41	-	-	-	-	332
2009	-	-	-	0.02	-	0.51	0.48	-	-	-	-	-	454
2010	-	-	-	-	0.83	0.17	-	-	-	-	-	-	<0.1
2011	-	-	-	-	-	-	1	-	-	-	-	-	224
2012	-	-	-	-	-	0.68	0.02	-	-	-	0.29	-	190
2013	-	-	-	-	-	-	-	1	-	-	-	-	209
2014	-	-	0.02	-	0.10	0.54	0.34	-	-	-	-	-	<0.1
Total	0.05	<0.01	0.03	0.03	0.10	0.32	0.29	0.15	0.01	<0.01	<0.01	0.01	13 958

Table D11: continued.

(b) Statistical area (Statistical areas are shown in Figure 1).
Trawl

	034	035	036	037	038	039	040	041	042	045	801	Total
1990	0.11	0.16	0.03	0.43	-	0.01	0.23	0.03	-	-	-	160
1991	0.44	0.27	0.05	0.12	-	0.01	0.07	0.02	-	-	0.01	1 509
1992	0.07	0.29	0.10	0.03	-	-	0.05	0.40	-	-	0.06	2 852
1993	0.07	0.36	0.23	0.09	-	0.01	0.08	0.12	-	-	0.04	826
1994	0.16	0.43	0.14	0.11	-	-	0.10	0.05	-	-	0.01	832
1995	0.13	0.39	0.14	0.06	-	-	0.12	0.13	-	-	0.03	1 327
1996	0.38	0.36	0.18	0.03	0.01	-	0.01	-	-	-	0.04	544
1997	0.32	0.61	0.04	-	-	-	-	0.01	-	-	-	1 866
1998	0.23	0.58	0.05	0.05	-	0.02	0.02	0.02	0.03	-	-	2 434
1999	0.13	0.74	0.11	-	-	-	0.02	-	-	-	-	4 668
2000	0.39	0.43	0.12	0.04	-	-	0.02	-	-	-	-	2 906
2001	0.21	0.31	0.16	0.02	-	-	0.06	0.19	-	-	0.04	2 903
2002	0.03	0.09	0.13	0.05	-	-	0.04	0.23	-	-	0.42	4 860
2003	0.03	0.16	0.05	0.08	-	-	0.10	0.43	0.01	-	0.14	2 389
2004	-	0.01	0.02	-	-	-	0.02	0.47	0.35	0.06	0.06	2 674
2005	-	0.03	0.04	-	-	-	0.02	0.45	0.14	0.11	0.21	4 652
2006	0.03	0.18	0.03	0.02	-	-	0.03	0.52	0.06	0.02	0.11	3 624
2007	0.03	0.19	0.03	0.02	-	-	0.03	0.56	0.05	0.01	0.07	2 508
2008	0.08	0.06	0.04	0.04	-	-	0.12	0.54	0.02	-	0.09	2 615
2009	0.01	0.07	0.05	0.01	-	-	0.02	0.69	0.04	0.01	0.11	2 946
2010	-	0.03	0.01	0.08	-	0.02	0.05	0.76	0.05	-	-	3 459
2011	0.03	0.10	0.04	0.19	-	0.02	0.07	0.39	0.05	-	0.11	1 905
2012	0.01	0.11	-	0.06	-	-	0.02	0.70	0.02	0.02	0.06	2 517
2013	0.01	0.03	0.03	0.16	-	0.03	0.03	0.56	0.07	0.02	0.08	2 200
2014	0.01	0.19	0.03	0.17	-	0.02	0.11	0.15	0.07	-	0.25	1 207
Total	0.09	0.23	0.07	0.05	<0.01	<0.01	0.04	0.35	0.05	0.01	0.10	60 383

Purse-seine

	017	018	036	037	038	039	040	041	042	047	Total
1990	0.34	0.42	0.02	0.16	0.05	-	0.01	-	-	-	1 521
1991	0.02	0.79	-	-	0.08	0.11	-	-	-	-	934
1992	0.04	0.65	0.04	-	-	-	-	-	-	0.16	179
1993	0.08	0.10	-	0.04	-	-	-	-	-	0.78	553
1994	0.01	0.10	0.02	0.02	-	-	-	-	-	0.84	329
1995	0.01	0.07	-	0.01	-	-	0.28	-	-	0.63	170
1996	0.05	0.81	-	0.14	-	-	-	-	-	-	478
1997	-	0.49	-	0.04	-	-	0.46	-	-	-	607
1998	-	1	-	-	-	-	-	-	-	-	28
1999	-	-	0.02	0.75	-	0.06	0.17	-	-	-	3 992
2000	0.03	-	-	0.97	-	-	-	-	-	-	432
2001	0.22	-	-	0.52	-	-	0.25	-	-	-	545
2002	0.01	0.06	-	-	-	-	0.01	-	-	0.93	522
2003	0.03	-	0.01	0.91	-	-	0.05	-	-	-	1 012
2004	-	-	-	0.98	-	-	-	0.01	0.01	-	55
2005	-	-	-	0.71	-	0.29	-	-	-	-	572
2006	-	-	0.03	0.07	-	0.45	-	-	-	-	260
2007	0.01	-	-	0.05	-	-	0.67	0.11	-	0.17	359
2008	-	-	-	0.40	-	0.39	-	-	0.21	-	332
2009	-	-	-	0.29	-	-	0.70	-	-	0.02	454
2010	-	-	-	-	-	-	-	0.17	0.83	-	<0.5
2011	-	-	-	1	-	-	-	-	-	-	224
2012	-	-	-	0.02	0.68	-	-	-	-	0.29	190
2013	-	-	-	1	-	-	-	-	-	-	209
2014	-	-	0.15	0.05	0.02	-	0.09	0.48	0.19	0.02	<0.5
Total	0.06	0.17	0.01	0.44	0.02	0.05	0.13	<0.01	0.01	0.10	13 958

Table D11: continued.

(c) Method. BT: bottom trawl; MB: midwater trawl within 5 m of the seabed; MW: midwater trawl; PS: Purse seine.

Year	BT	MB	MW	PS	Other	Total
1990	0.06	0.01	0.02	0.90	-	1 687
1991	0.15	0.23	0.24	0.38	-	2 447
1992	0.16	0.34	0.44	0.06	-	3 035
1993	0.15	0.23	0.21	0.40	0.01	1 391
1994	0.06	0.39	0.26	0.28	0.01	1 177
1995	0.02	0.38	0.47	0.11	0.01	1 517
1996	0.05	0.18	0.30	0.46	0.01	1 028
1997	0.01	0.28	0.39	0.22	0.10	2 733
1998	0.12	0.21	0.65	0.01	-	2 464
1999	-	0.16	0.36	0.45	0.03	8 930
2000	0.01	0.30	0.56	0.13	-	3 340
2001	-	0.50	0.34	0.16	-	3 452
2002	-	0.56	0.34	0.10	-	5 382
2003	-	0.54	0.16	0.30	-	3 403
2004	-	0.60	0.38	0.02	-	2 730
2005	-	0.62	0.27	0.11	-	5 225
2006	-	0.72	0.21	0.07	-	3 887
2007	-	0.54	0.33	0.13	-	2 869
2008	-	0.55	0.34	0.11	-	2 949
2009	-	0.46	0.41	0.13	-	3 403
2010	-	0.30	0.70	-	-	3 461
2011	-	0.42	0.47	0.10	-	2 136
2012	-	0.29	0.64	0.07	-	2 711
2013	-	0.22	0.69	0.09	-	2 411
2014	-	0.43	0.56	-	-	1 210
Total	0.02	0.40	0.39	0.19	0.01	74 980

(d) Target species. (Target species codes are defined in Table D12).

Trawl

Year	BAR	EMA	HOK	JMA	Other	Total
1990	0.01	-	0.01	0.98	-	160
1991	-	0.25	0.21	0.54	-	1 509
1992	-	0.02	0.01	0.97	-	2 852
1993	0.07	-	0.12	0.81	0.01	826
1994	-	-	0.28	0.72	-	832
1995	0.03	-	0.10	0.87	0.01	1 327
1996	0.03	-	0.28	0.69	-	544
1997	0.01	0.01	0.06	0.93	-	1 866
1998	0.04	0.03	-	0.93	-	2 434
1999	-	0.07	-	0.93	-	4 668
2000	-	-	-	0.99	0.01	2 906
2001	0.01	-	-	0.99	-	2 903
2002	0.01	-	-	0.98	0.01	4 860
2003	-	0.05	-	0.95	-	2 389
2004	0.04	0.05	-	0.90	-	2 674
2005	0.10	0.09	-	0.80	-	4 652
2006	-	0.22	-	0.78	0.01	3 624
2007	0.02	0.15	-	0.83	-	2 508
2008	0.01	0.11	-	0.86	0.01	2 615
2009	-	0.17	-	0.83	-	2 946
2010	-	0.29	-	0.70	-	3 459
2011	-	0.04	-	0.96	-	1 905
2012	-	0.63	-	0.37	-	2 517
2013	-	0.49	-	0.50	0.01	2 200
2014	0.03	0.06	-	0.91	-	1 207
Total	0.02	0.12	0.02	0.84	<0.01	60 383

Purse-seine

Year	EMA	JMA	KAH	Other	Total
1990	0.51	0.13	0.36	-	1 521
1991	0.83	0.07	0.11	-	934
1992	0.28	0.49	0.23	-	179
1993	0.78	0.18	0.04	-	553
1994	0.64	0.33	0.03	-	329
1995	0.63	0.08	0.29	-	170
1996	0.64	0.34	0.02	-	478
1997	0.49	0.30	0.21	-	607
1998	-	1	-	-	28
1999	0.99	0.01	-	-	3 992
2000	0.97	-	0.03	-	432
2001	0.96	-	0.04	-	545
2002	0.93	0.07	0.01	-	522
2003	0.92	0.03	0.06	-	1 012
2004	0.98	-	-	0.02	55
2005	0.94	-	0.06	-	572
2006	0.97	-	0.03	-	260
2007	0.84	-	0.06	0.11	359
2008	1	-	-	-	332
2009	0.98	-	-	0.02	454
2010	-	-	-	1	<0.5
2011	1	-	-	-	224
2012	0.95	-	0.05	-	190
2013	1	-	-	-	209
2014	0.02	0.12	0.10	0.77	<0.5
Total	0.84	0.07	0.08	<0.01	13 958

Table D12: Species codes used in the report.

Code	Common name	Scientific name
BAR	Barracouta	*Thyrsites atun*
EMA	Blue mackerel	*Scomber australasicus*
FLA	Flatfishes or flounders	-
HOK	Hoki	*Macruronus novaezelandiae*
JMA	Jack mackerels	*Trachurus declivis, T. novaezelandiae, T. symmetricus murphyi*
KAH	Kahawai	*Arripis trutta, A. xylabion*
LIN	Ling	*Genypterus blacodes*
RBT	Redbait	*Emmelichthys nitidus*
RCO	Red cod	*Pseudophycis bachus*
SKJ	Skipjack tuna	*Katsuwonus pelamis*
SQU	Arrow squid	*Nototodarus gouldi, N. sloanni*
SWA	Silver warehou	*Seriolella punctata*
TAR	Tarakihi	*Nemadactylus macropterus*
TRE	Trevally	*Pseudocaranx dentex*

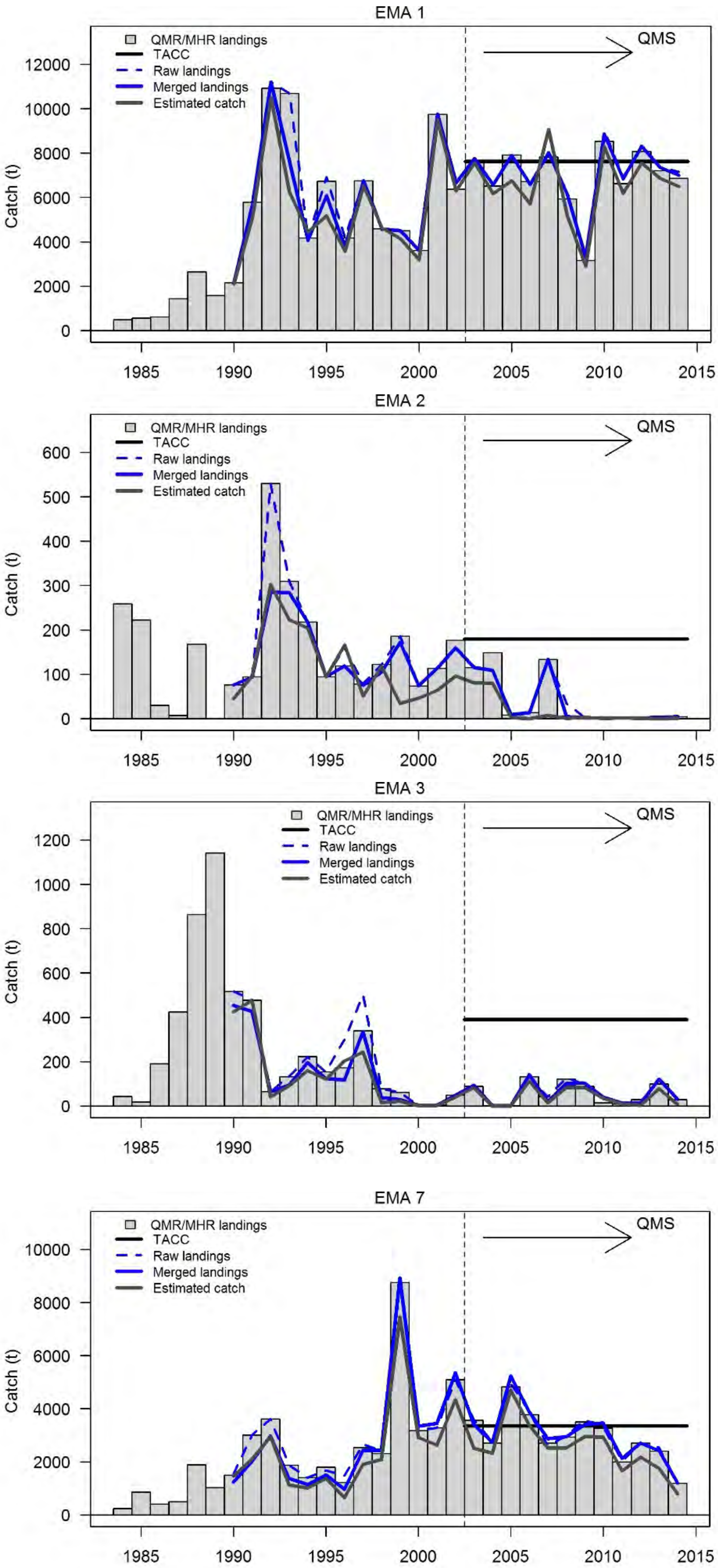


Figure D1: QMR/MHR landings, raw landings, groomed and merged landings, groomed and merged estimated catch, and TACC for EMA stocks for fishing years 1984–2014.

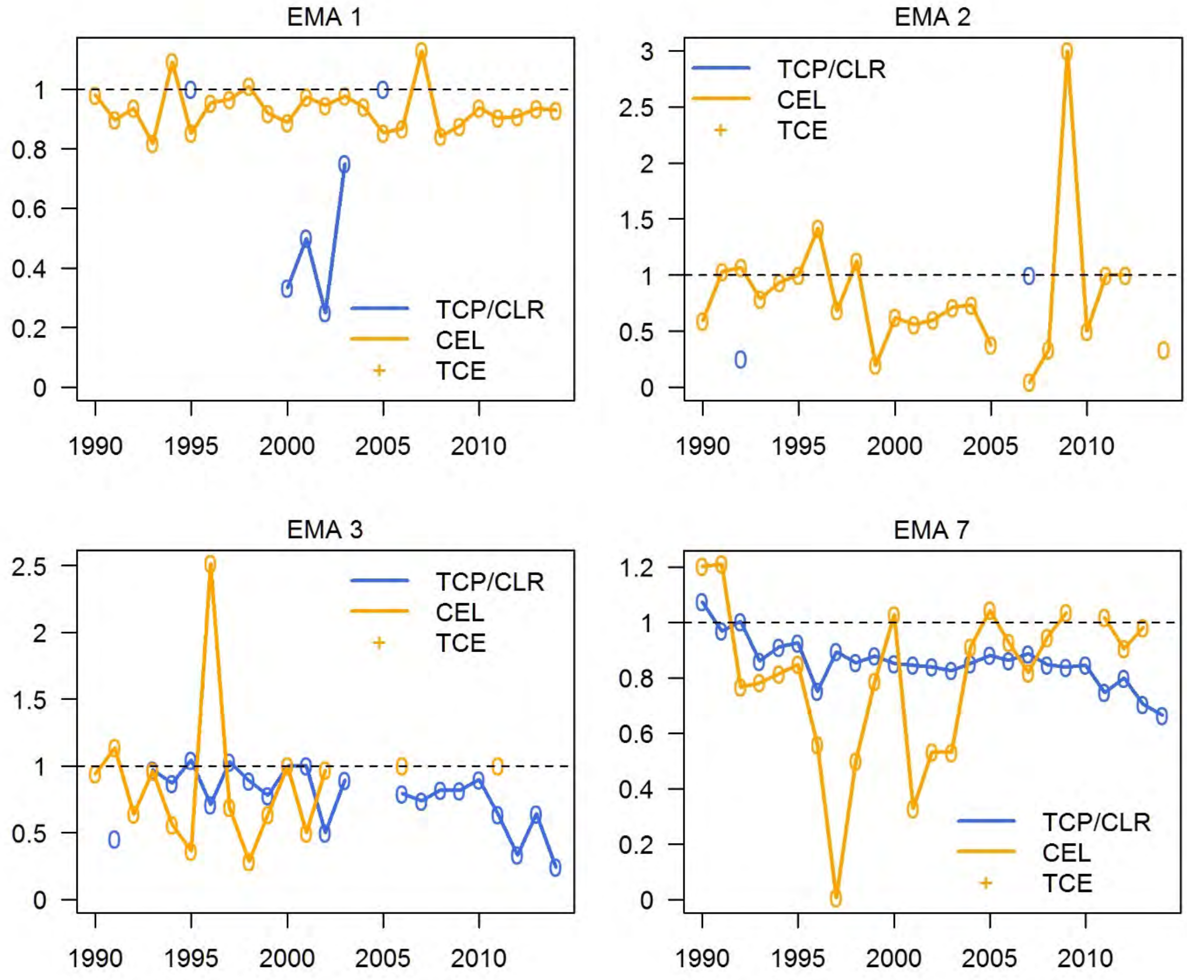


Figure D2: The reporting rate, defined as the ratio of the estimated catch as a proportion of retained landings in the groomed and merged dataset, for EMA stocks for fishing years 1990–2014. The reporting rates for each stock were calculated by form type, where TCP is Trawl Catch Effort Processing Return; CLR is Catch Landing Return; CEL is Catch Effort Landing Return; and TCE is Trawl Catch Effort Return.

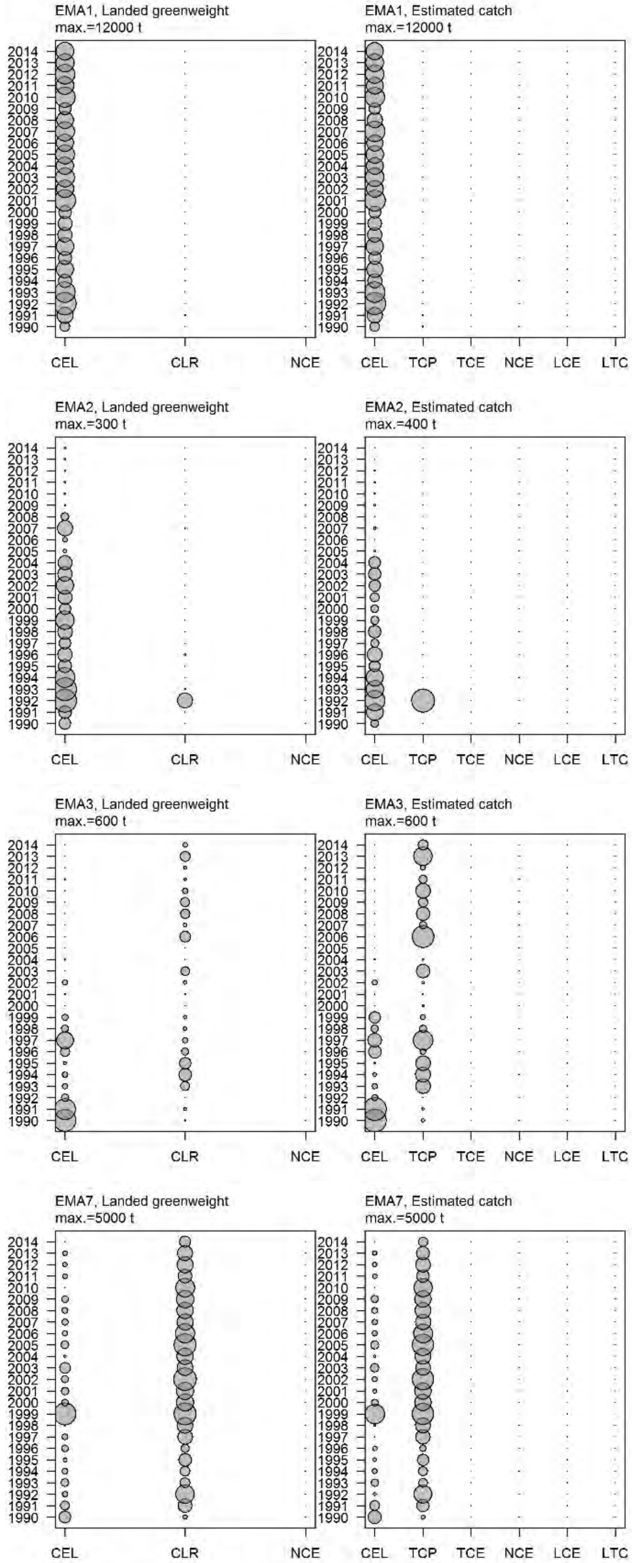


Figure D3: Landings by form type in the groomed and unmerged dataset, and estimated catches by form type in the groomed and merged dataset, for EMA stocks for fishing years 1990–2014, where CEL is Catch, Effort, Landing Return; CLR is Catch Landing Return; TCP is Trawl, Catch, Effort, and Processing Return; TCE is Trawl, Catch, Effort Return; NCE is Netting Catch Effort Return; LCE is Lining Catch Effort return; and LTC is Lining Trip Catch, Effort return. The area of the circle is proportional to the annual catches (only comparable within each panel).

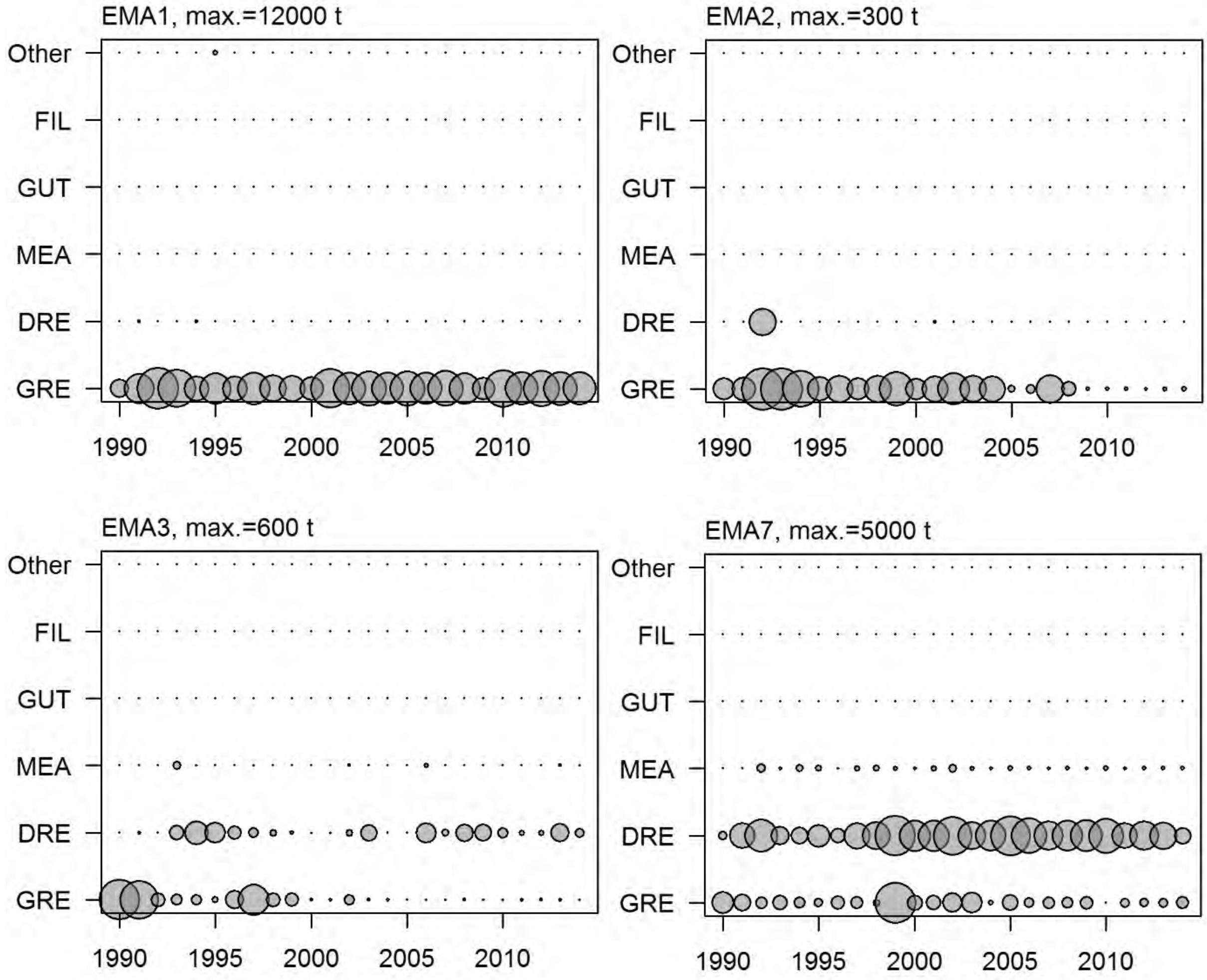


Figure D4: Retained landings (greenweight in tonnes) by processed state for EMA stocks for fishing years 1990–2014 in the groomed and unmerged dataset. GRE, Green; DRE, dressed or headed, gutted, and tailed; GUT, gutted; FIL, filleted or skin off filleted; MEA, mealed.

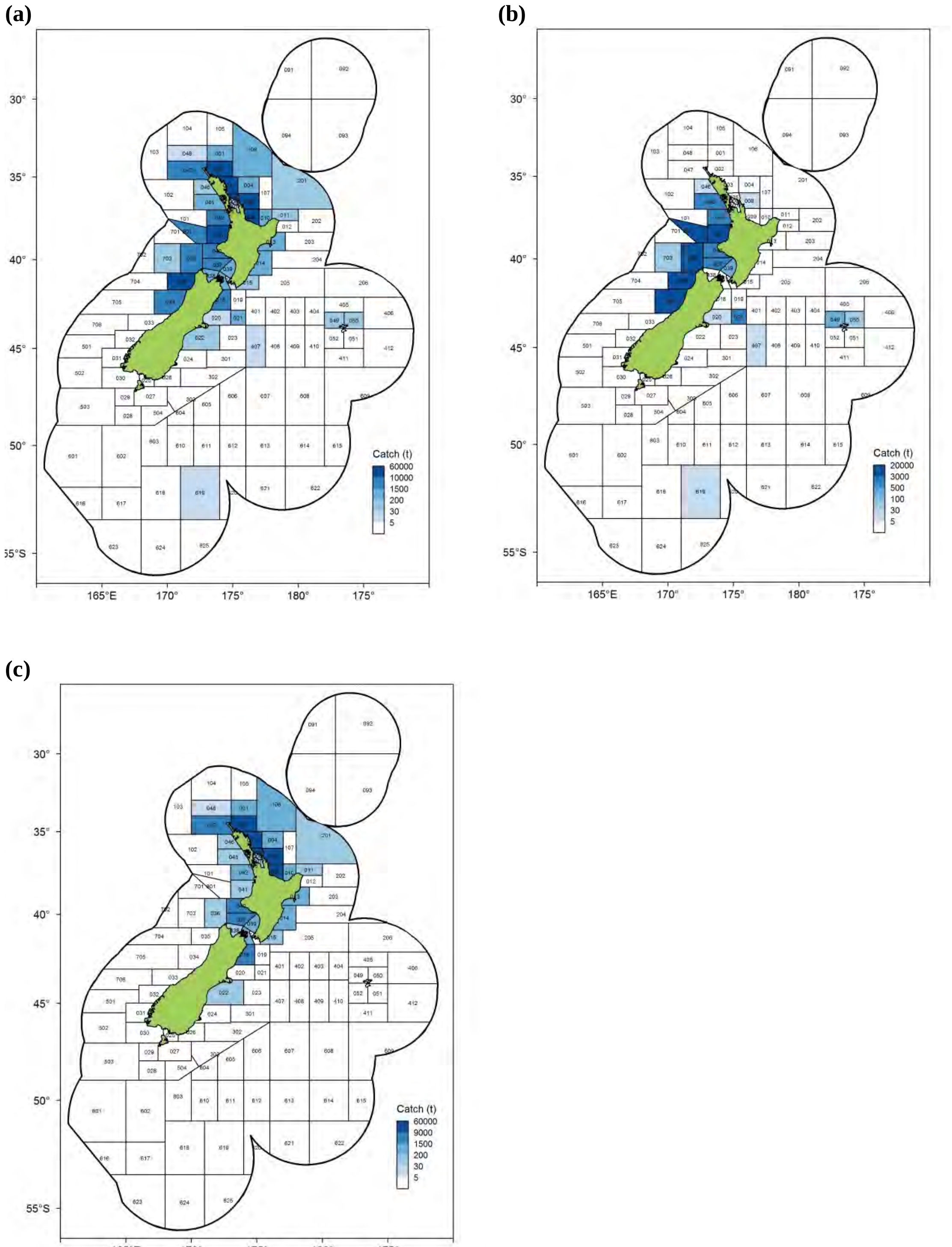


Figure D5: Annual commercial blue mackerel catches (in tonnes) by statistical area over all fishing years 1990–2014 (a) for all forms and methods (b) TCEPR trawl catch, and (c) purse seine catch.

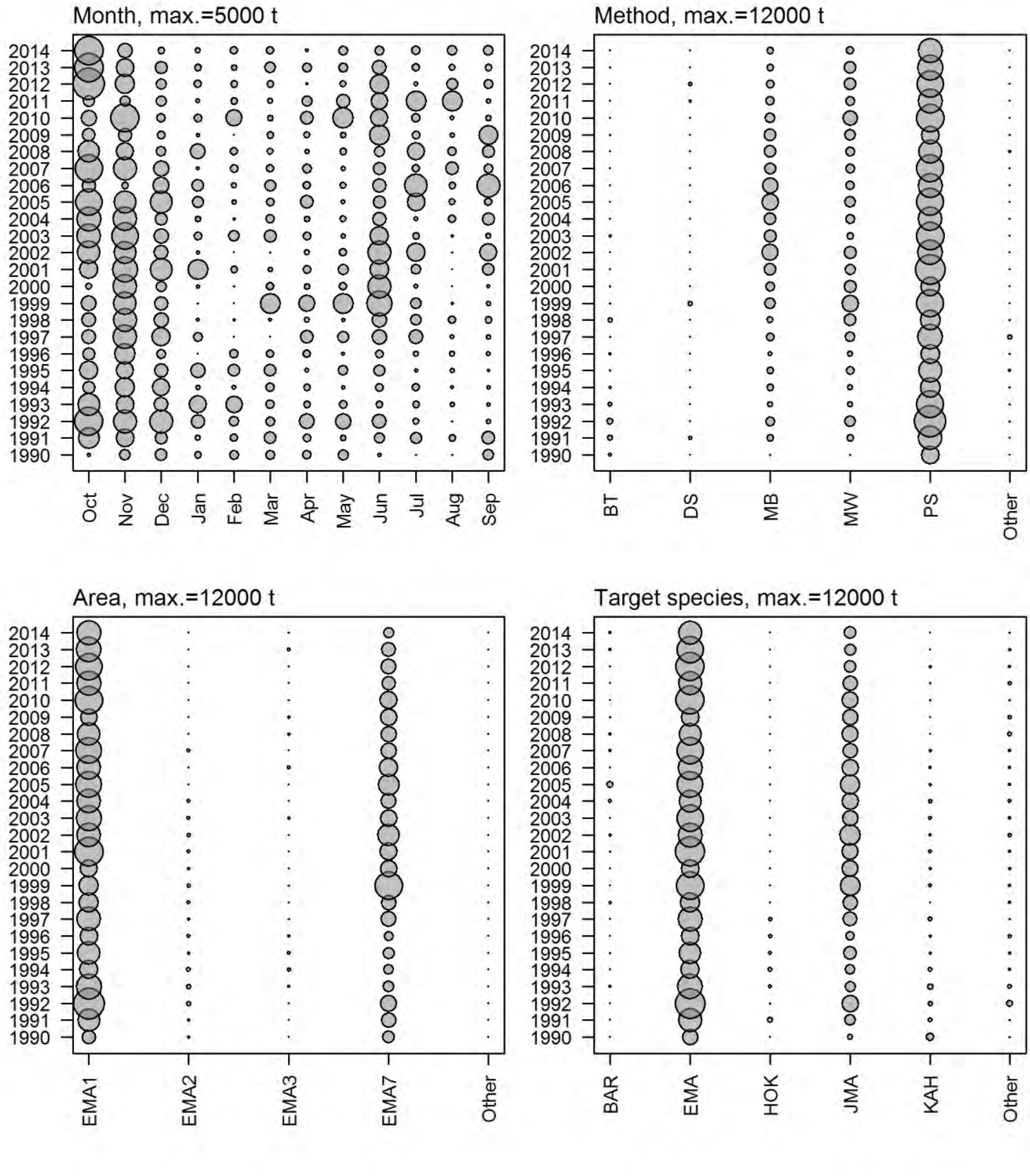


Figure D6a: Distribution of annual blue mackerel catch (t) by month, area, method, and target species for all merged data for fishing years 1990–2014. Circle size is proportional to catch; maximum circle size is indicated on each plot. Statistical areas are shown in Figure 1. BT is bottom trawl; DS is Danish seine; MB is midwater trawl within 5 m of the seabed; MW is midwater trawl; PS is purse seine. Target species codes are defined in Table D12.

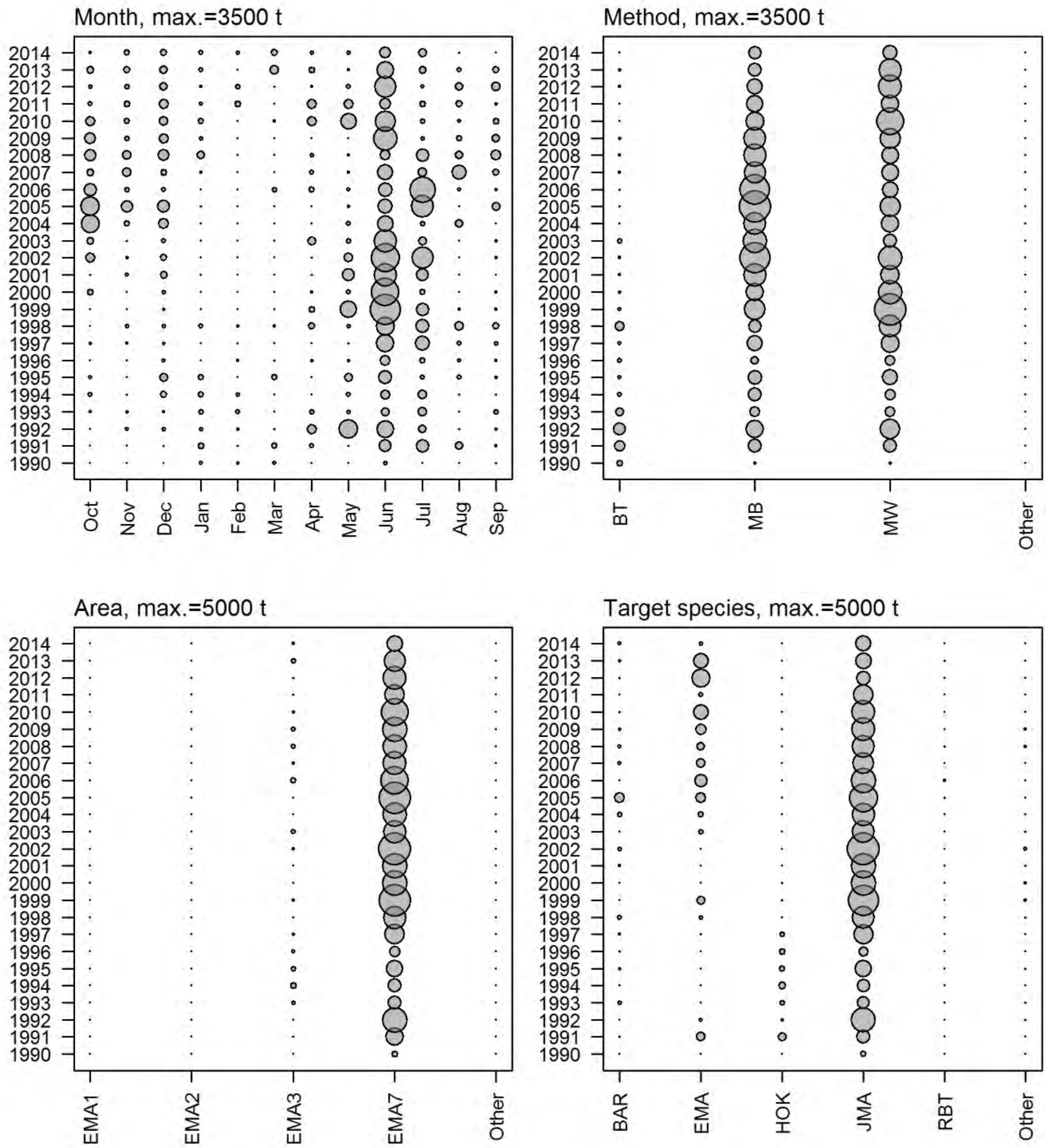


Figure D6b: Distribution of annual blue mackerel catch (t) by month, area, method, and target species for all merged trawl data for fishing years 1990–2014. Circle size is proportional to catch; maximum circle size is indicated on each plot. Statistical areas are shown in Figure 1. BT is bottom trawl; MB is midwater trawl within 5 m of the seabed; MW is midwater trawl. Target species codes are defined in Table D12.

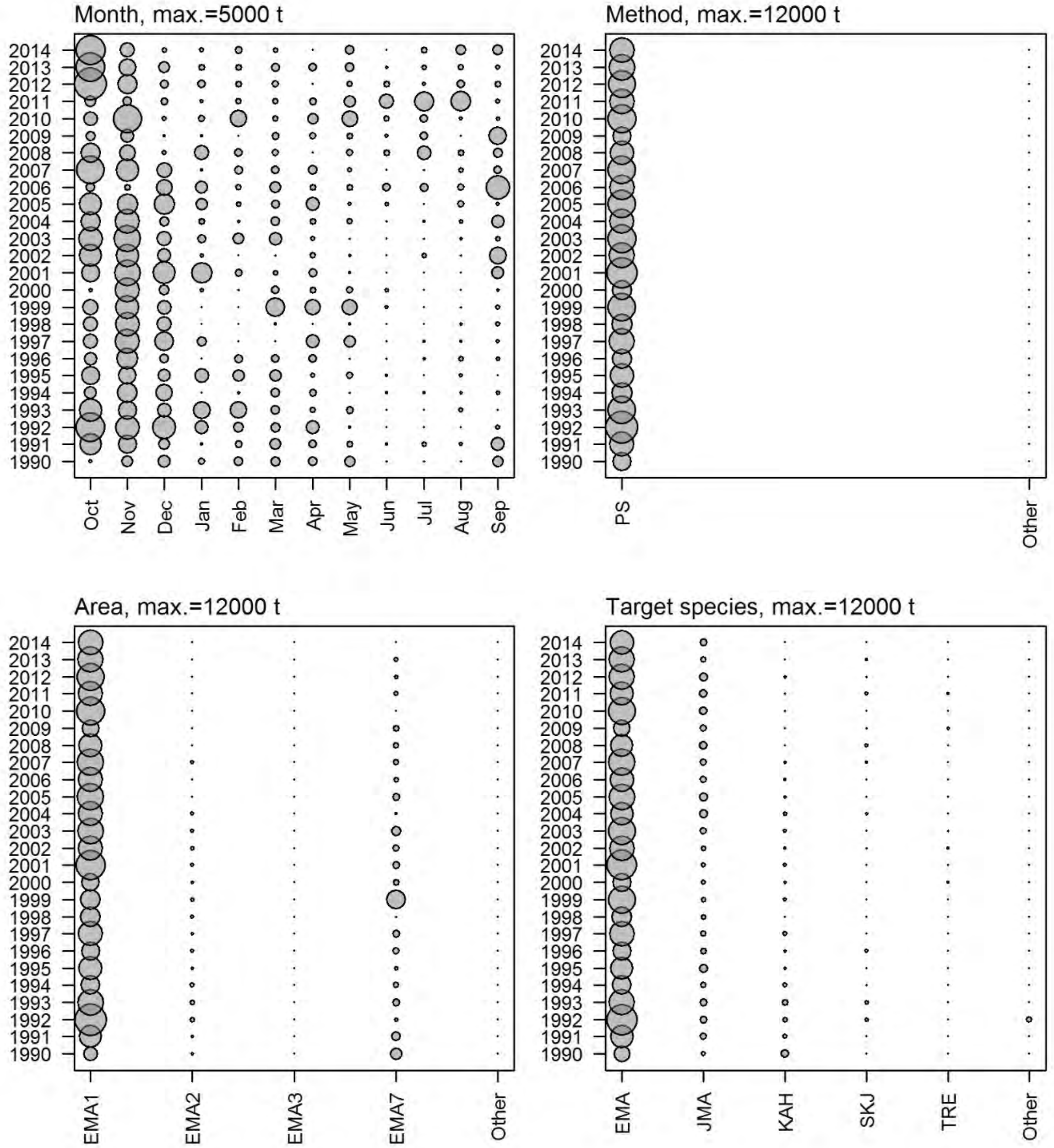


Figure D6c: Distribution of annual blue mackerel catch (t) by month, area, method, and target species for all merged purse seine data for fishing years 1990–2014. Circle size is proportional to catch; maximum circle size is indicated on each plot. Statistical areas are shown in Figure 1. PS is purse seine. Target species codes are defined in Table D12.

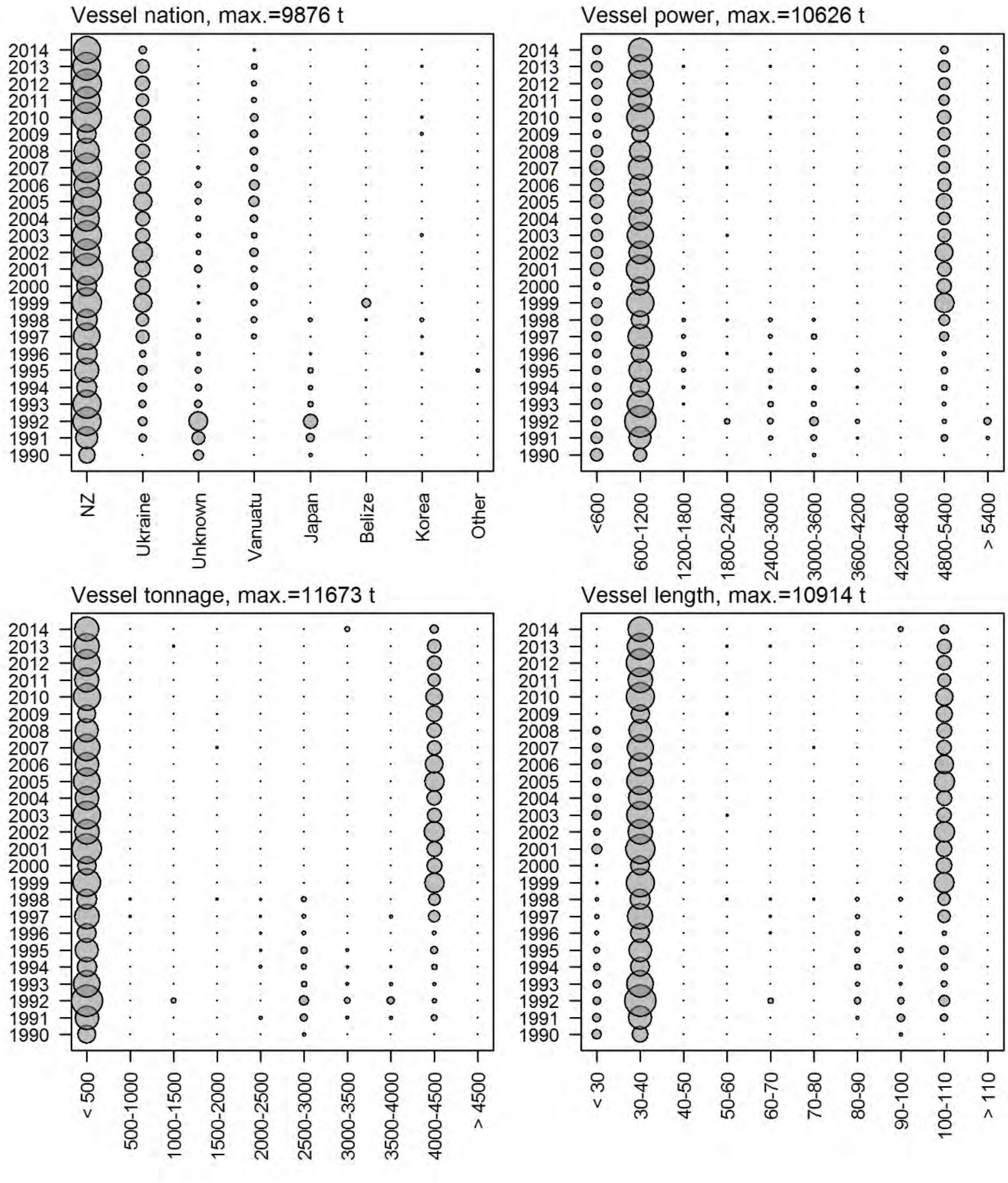


Figure D7: Distribution of annual blue mackerel catch (t) by nationality, vessel power (kW), vessel gross tonnage, and vessel length (m) for all estimated merged data for fishing years 1990–2014. Circle size is proportional to catch; maximum circle size is indicated on each plot.

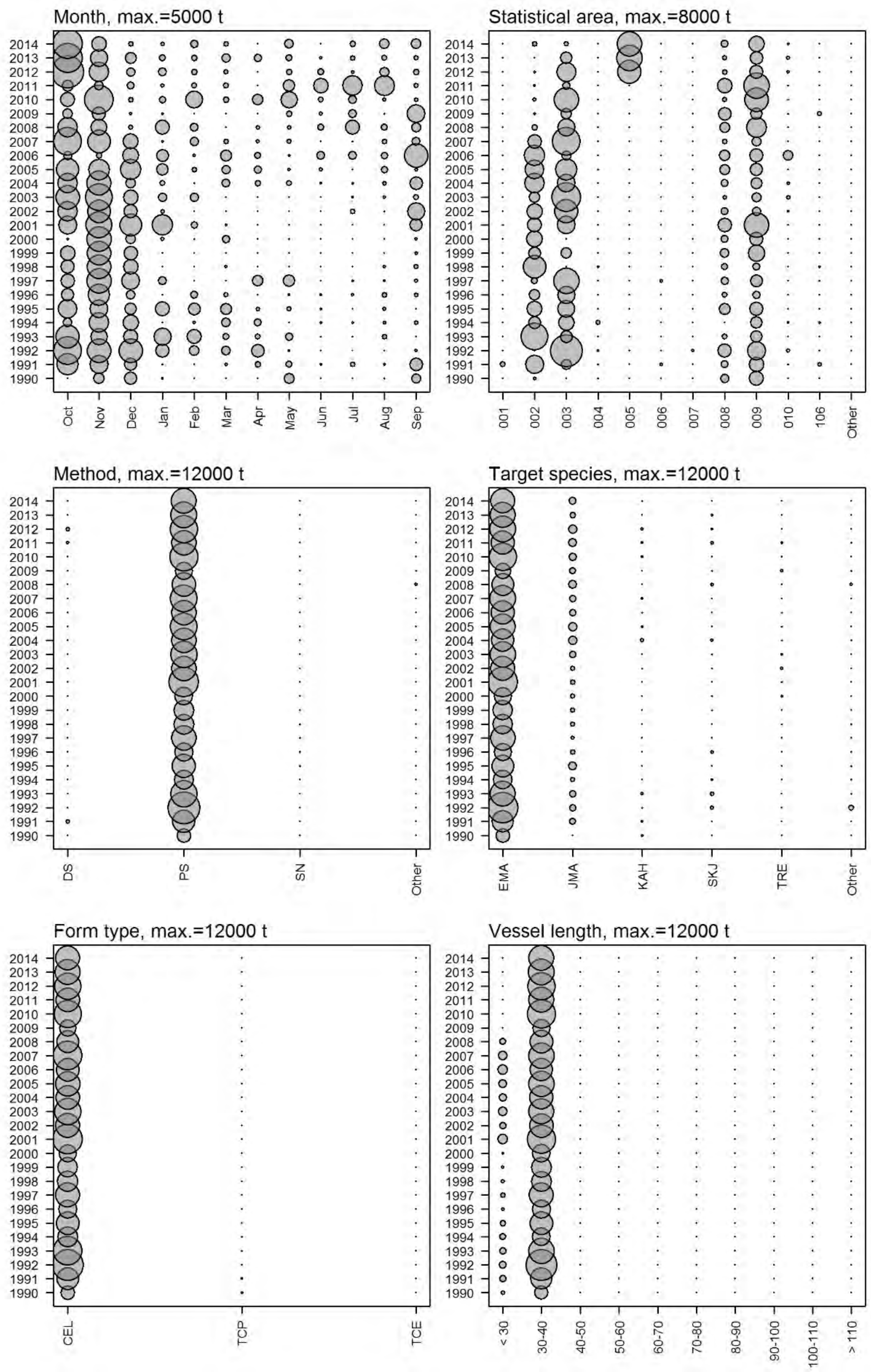


Figure D8: Distribution of annual estimated blue mackerel catch (t) by month, statistical area, method, target species, form type, and vessel length for EMA 1 merged data for fishing years 1990–2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. DS is Danish seine; PS is purse seine; SN is Setnet; target species codes are given in Table D12; and form types are defined in Figure D3.

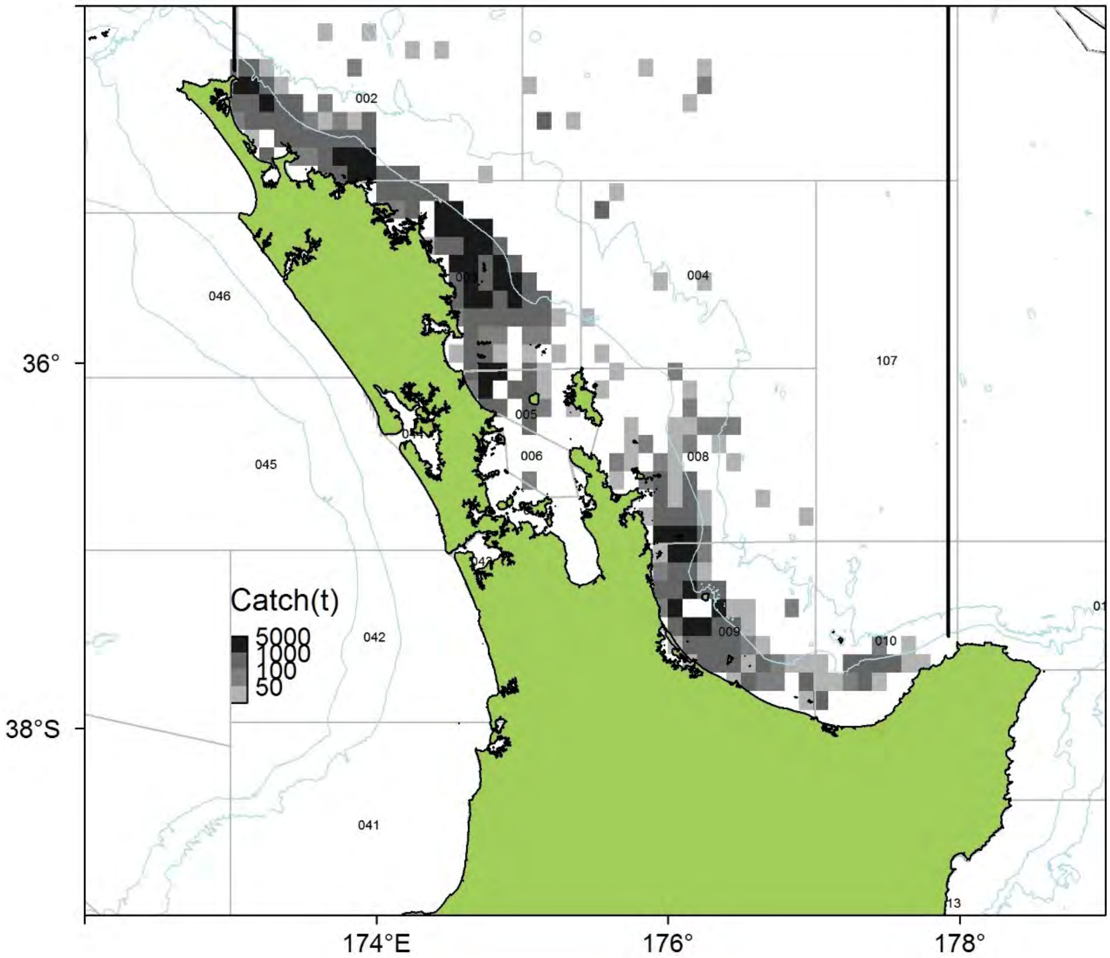


Figure D9: Distribution of blue mackerel catch by 0.2 degree grid for the purse seine fishery in EMA 1, for fishing years 1990–2014.

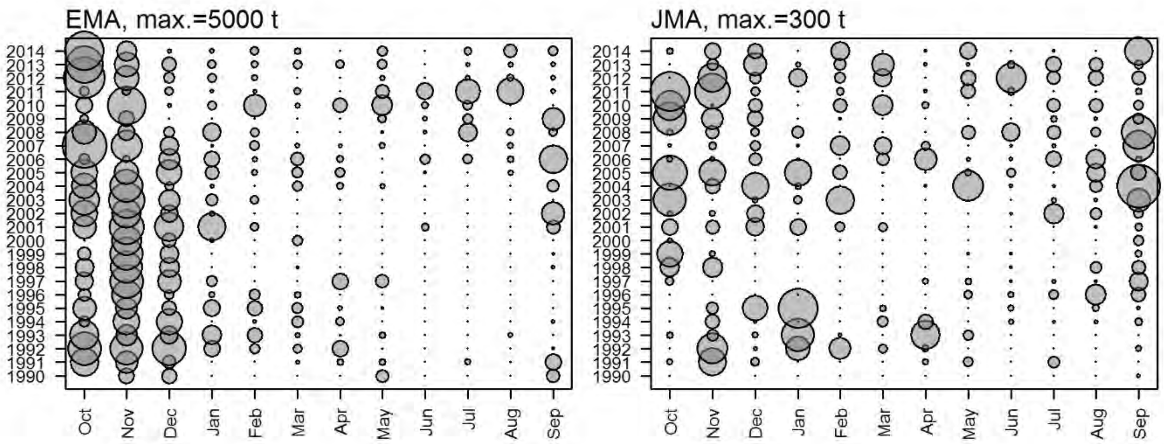


Figure D10: Distribution of blue mackerel catch by month for main target species in the purse-seine fishery in EMA 1, for fishing years 1990–2014. Target species codes are given in Table D12.

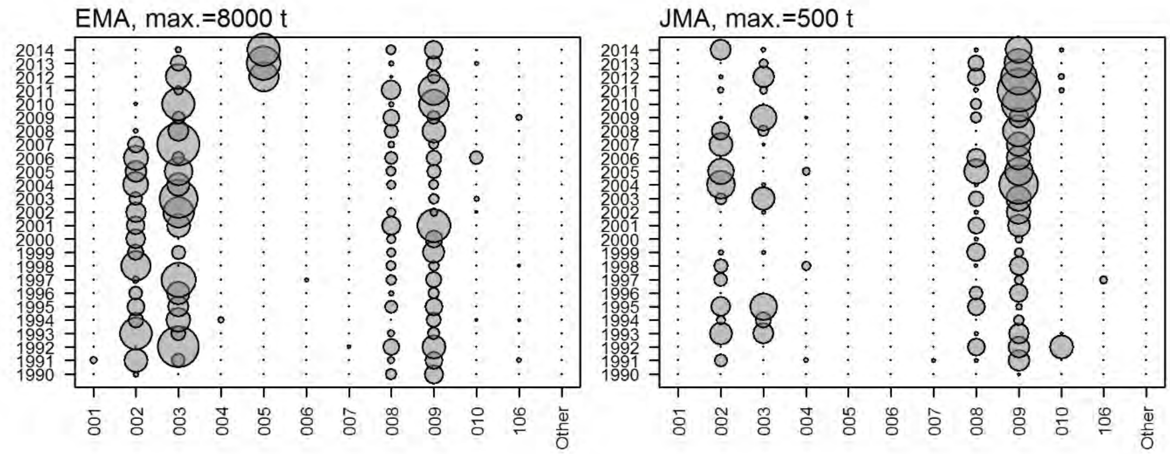


Figure D11: Distribution of blue mackerel catch by statistical area for the main target species in the purse-seine fishery in EMA 1, for fishing years 1990–2014. Target species codes are given in Table D12.

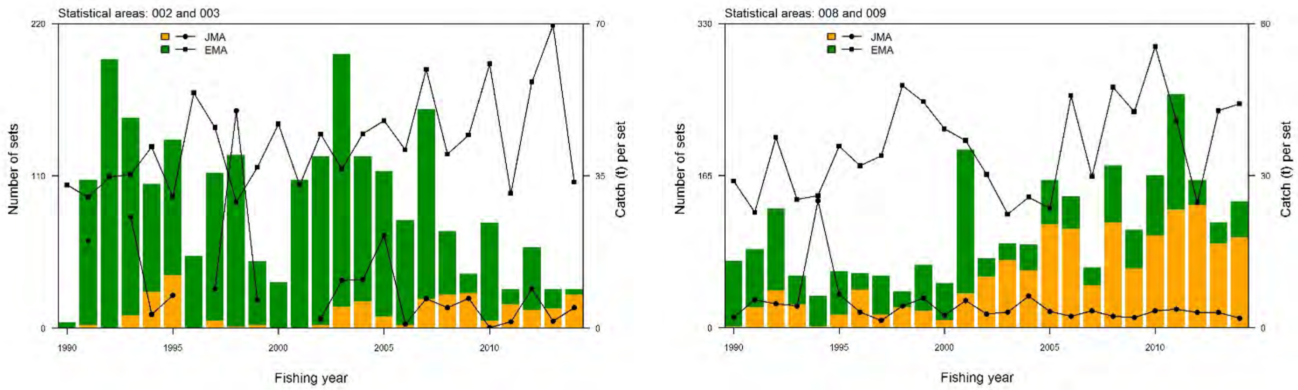


Figure D12: Number of sets (bars) and catch per set (lines) by target species for the purse-seine fishery in EMA 1 for fishing years 1990–2014. Left panel is for catch and effort from Statistical Areas 002 and 003; right panel is for Statistical Areas 008 and 009. Target species codes are given in Table D12.

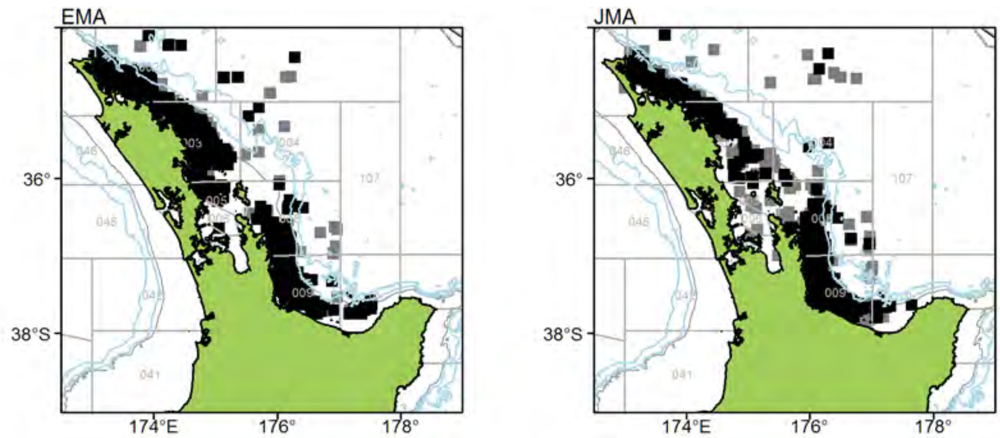


Figure D13: EMA 1 statistical areas and bathymetry showing the distribution of purse seine fishing by target species in the merged processed data (grey) where blue mackerel was caught (black) for the main target species for all years combined for fishing years 1990–2014. Target species codes are given in Table D12.

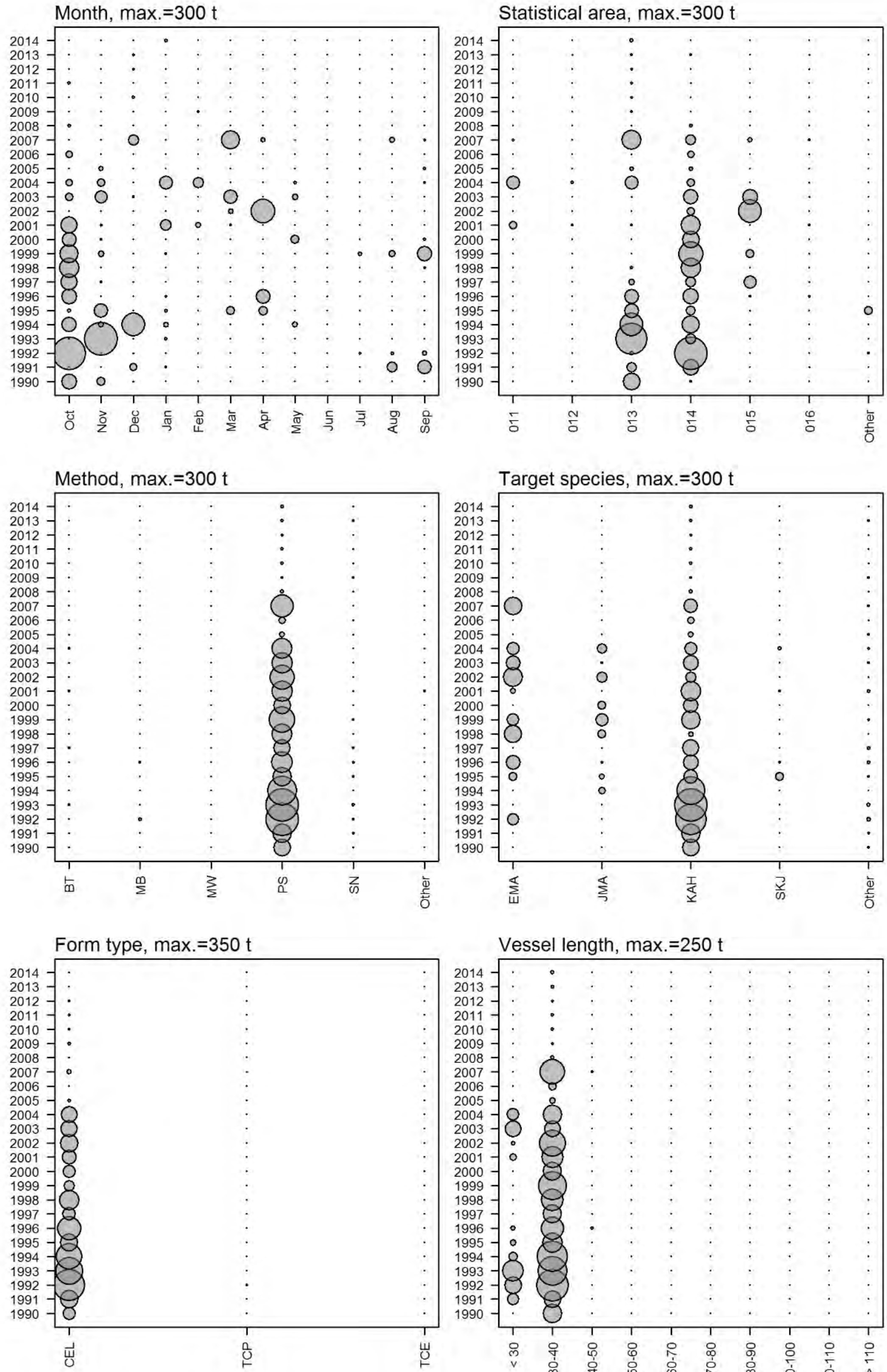


Figure D14: Distribution of annual estimated catch (t) by month, statistical area, method, target species, form type, and vessel length for EMA 2 merged data for fishing years 1990–2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. BT is bottom trawl; MB is midwater trawl within 5 m of the seabed; MW is midwater trawl; PS is purse seine; SN is Setnet; target species codes are given in Table D12; and form types are defined in Figure D3.

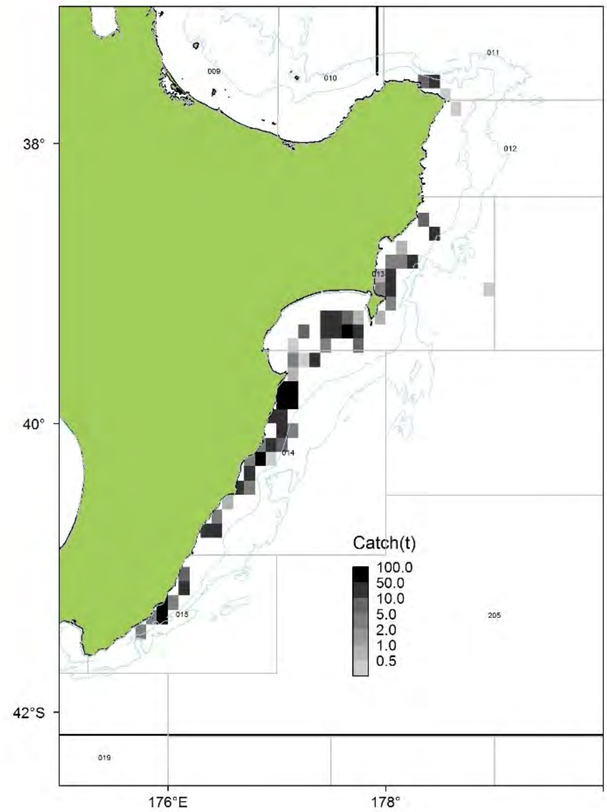


Figure D15: Distribution of blue mackerel catch by 0.2 degree grid for the purse seine fishery in EMA 2, for fishing years 1990–2014.

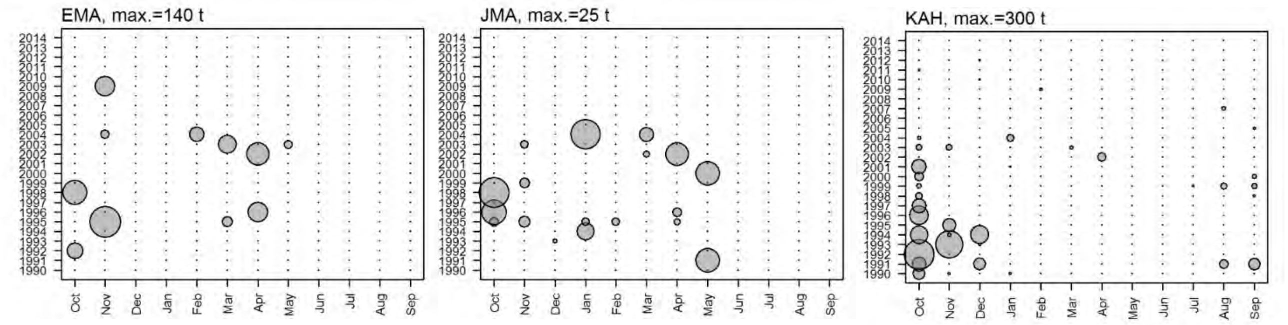


Figure D16: Distribution of blue mackerel catch by month for main target species in the purse-seine fishery in EMA 2, for fishing years 1990–2014. Target species codes are given in Table D12.

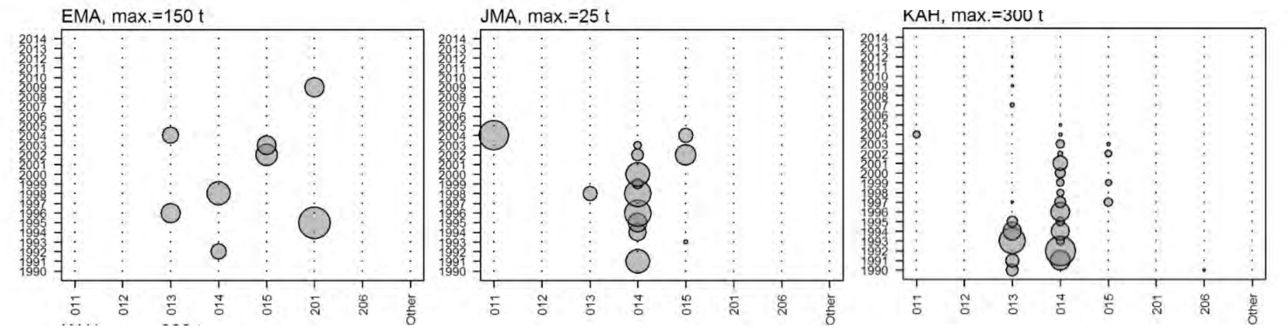


Figure D17: Distribution of blue mackerel catch by statistical area for the main target species in the purse-seine fishery in EMA 2, for fishing years 1990–2014. Target species codes are given in Table D12.

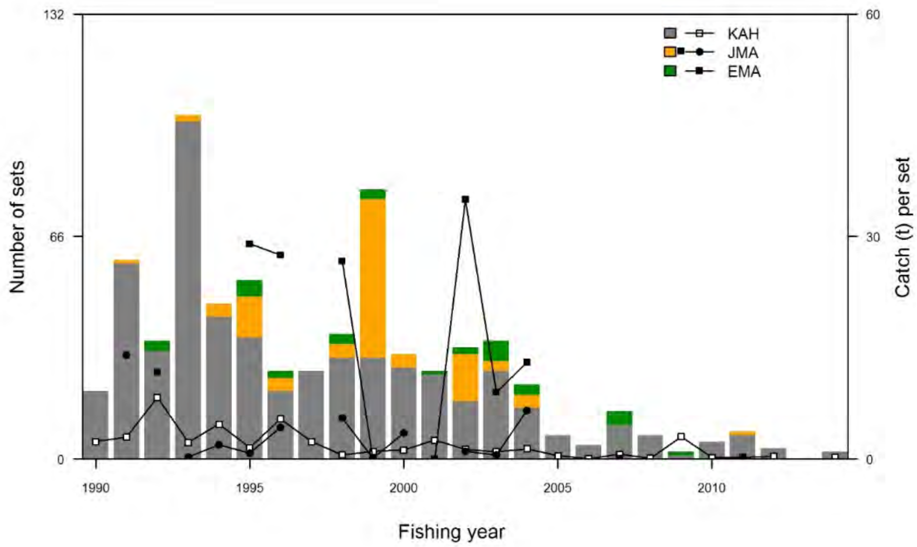


Figure D18: Number of sets (bars) and catch per set (lines) by target species for the purse-seine fishery in EMA 2 for fishing years 1990–2014. Target species codes are given in Table D12.

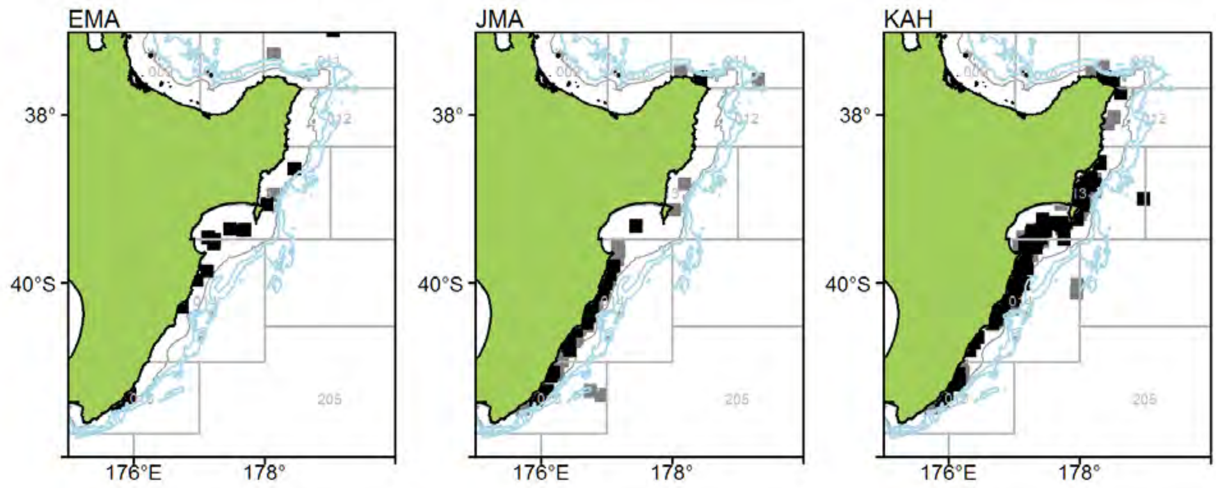


Figure D19: EMA 2 statistical areas and bathymetry showing the distribution of purse seine fishing by target species in the merged processed data (grey) where blue mackerel was caught (black) for the main target species for fishing years 1990–2014 combined. Target species codes are given in Table D12.

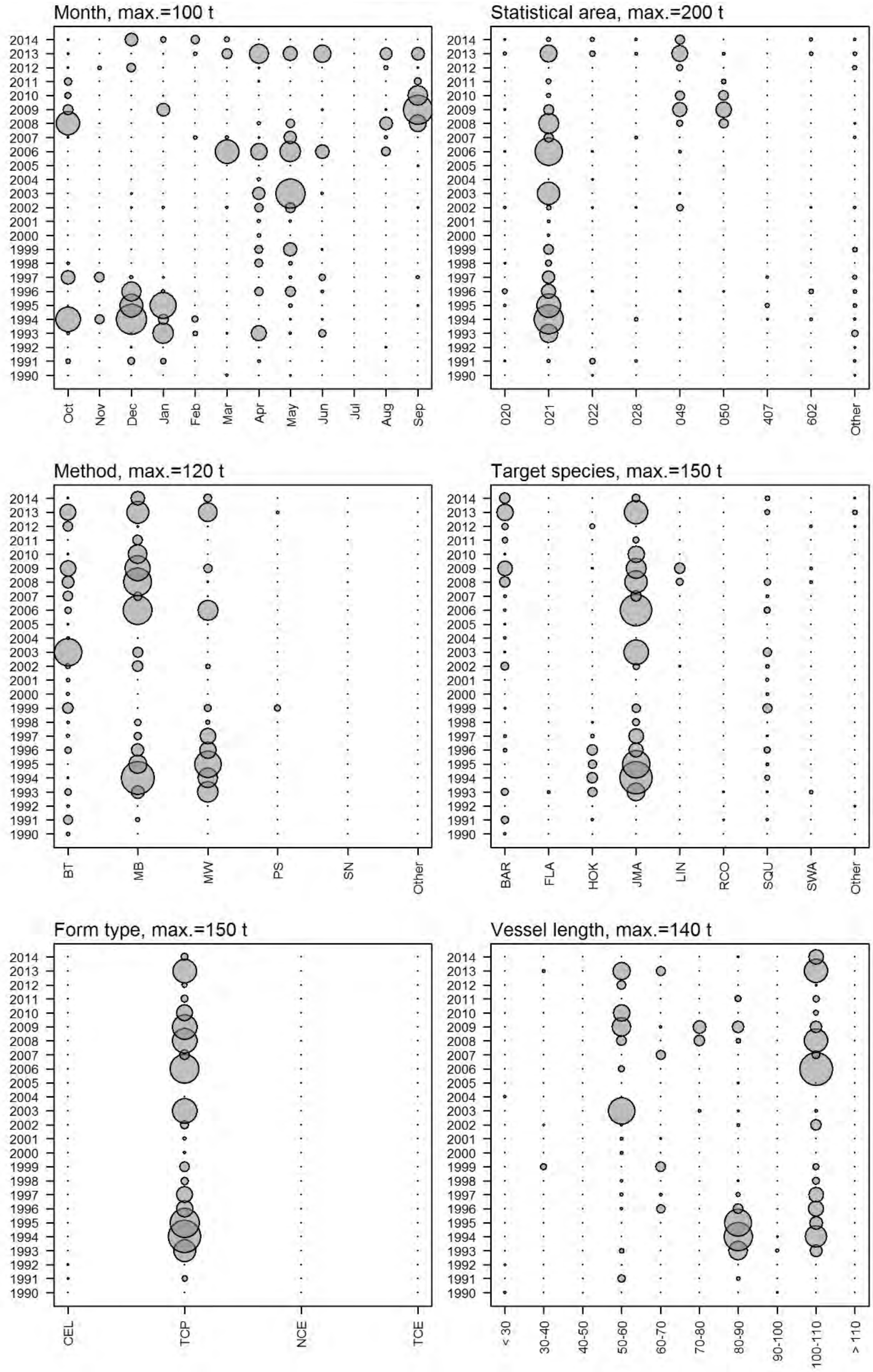


Figure D20: Distribution of annual estimated catch (t) by month, statistical area, method, target species, form type, and vessel length for EMA 3 merged data for fishing years 1990–2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. BT is bottom trawl; MB is midwater trawl within 5 m of the seabed; MW is midwater trawl; PS is purse seine; SN is Setnet; target species codes are given in Table D12; and form types are defined in Figure D3.

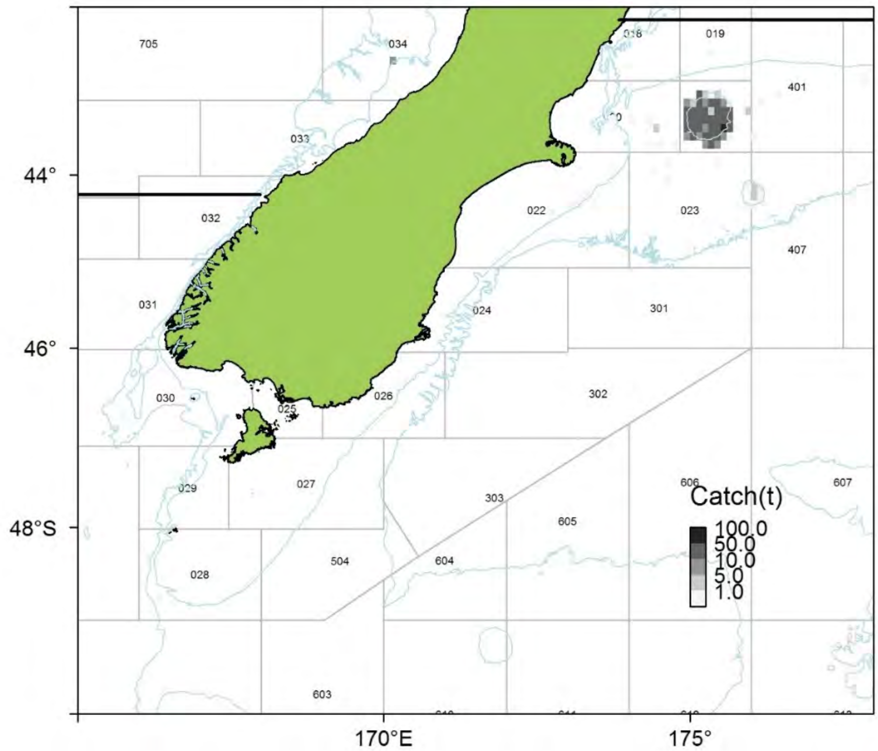


Figure D21: Distribution of blue mackerel catch by 0.2 degree grid for the trawl fishery in EMA 3, for fishing years 1990–2014.

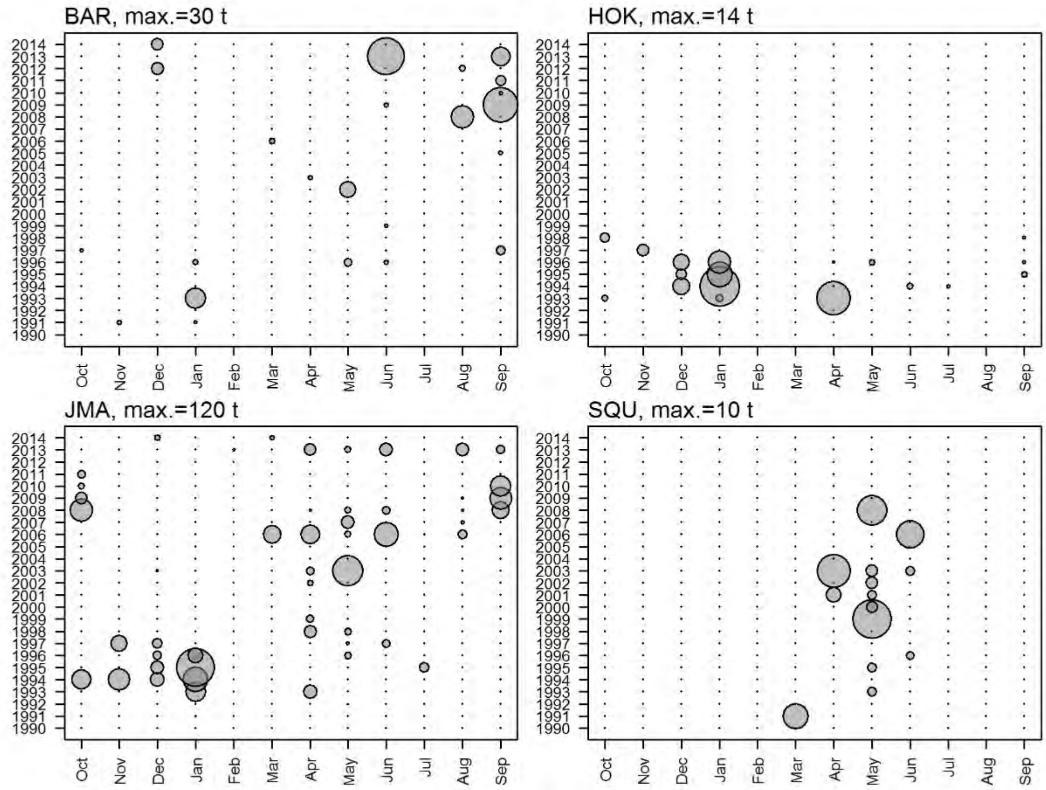


Figure D22: Distribution of blue mackerel catch by month for main target species in the trawl fishery in EMA 3, for fishing years 1990–2014. Target species codes are given in Table D12.

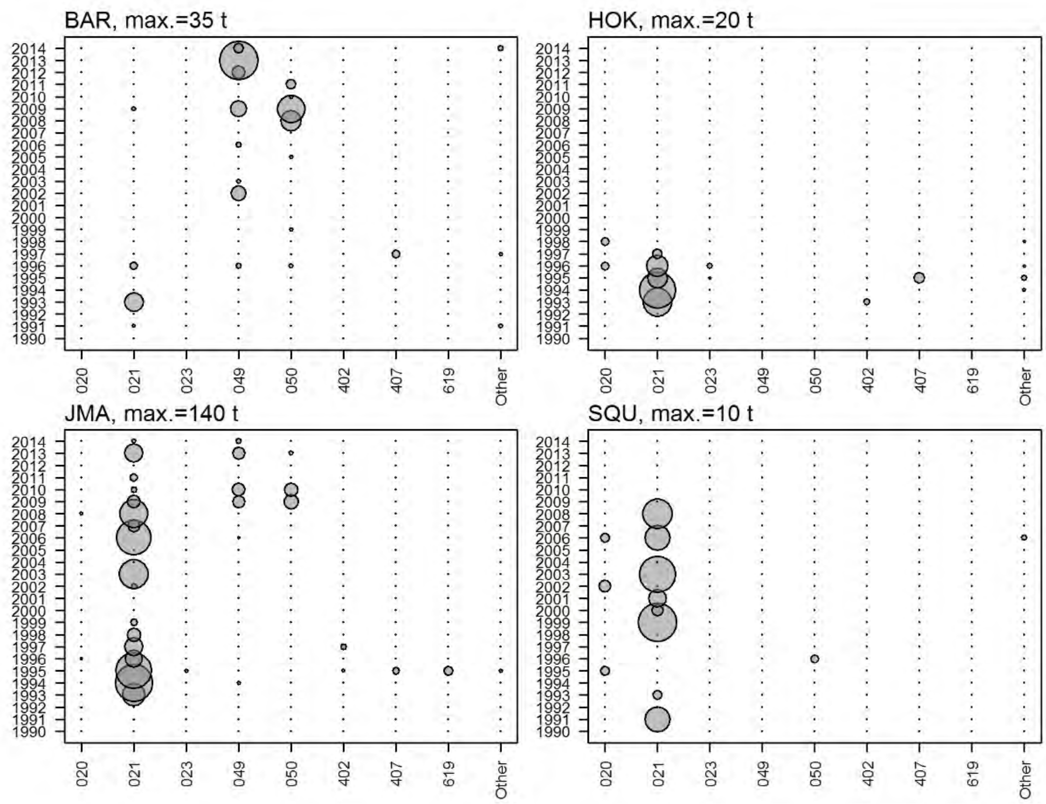


Figure D23: Distribution of blue mackerel catch by statistical area for the main target species in the trawl fishery in EMA 3, for fishing years 1990–2014. Target species codes are given in Table D12.

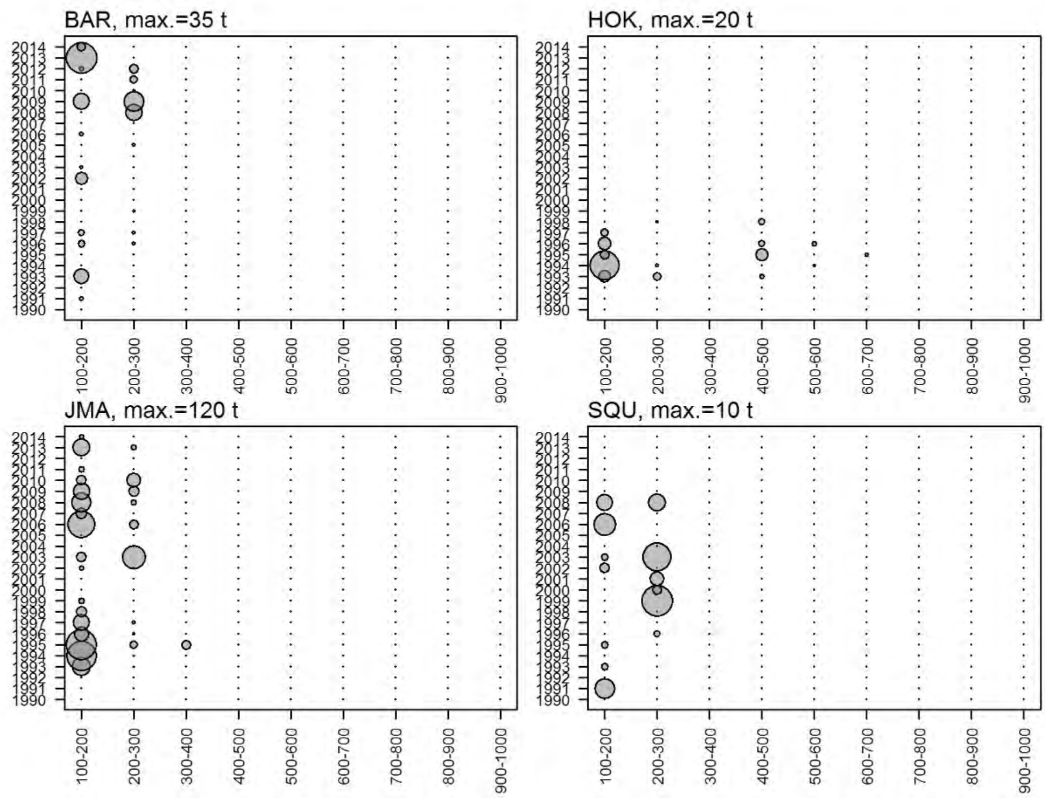


Figure D24: Distribution of blue mackerel catch by statistical area by depth in the trawl fishery in EMA 3, for fishing years 1990–2014. Target species codes are given in Table D12.

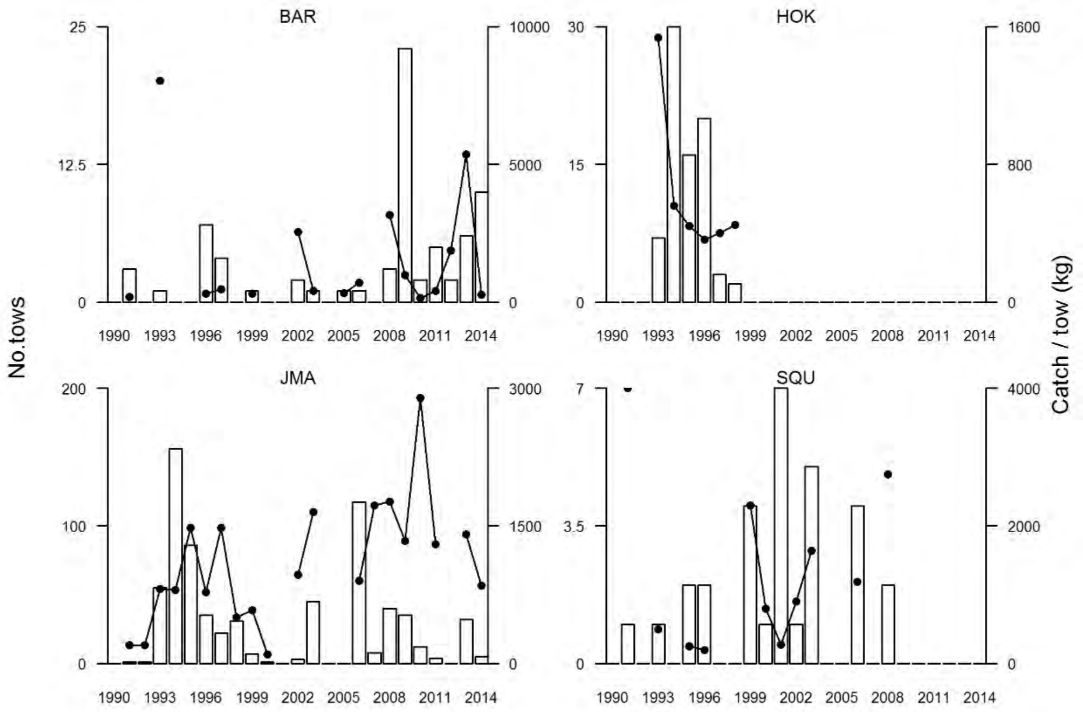


Figure D25: Unstandardised catch rate (kg/tow) of blue mackerel (lines), and the number of tows (bars) for EMA 3, by main target species for unmerged estimated TCEPR trawl data for fishing years 1990–2014. Target species codes are given in Table D12.

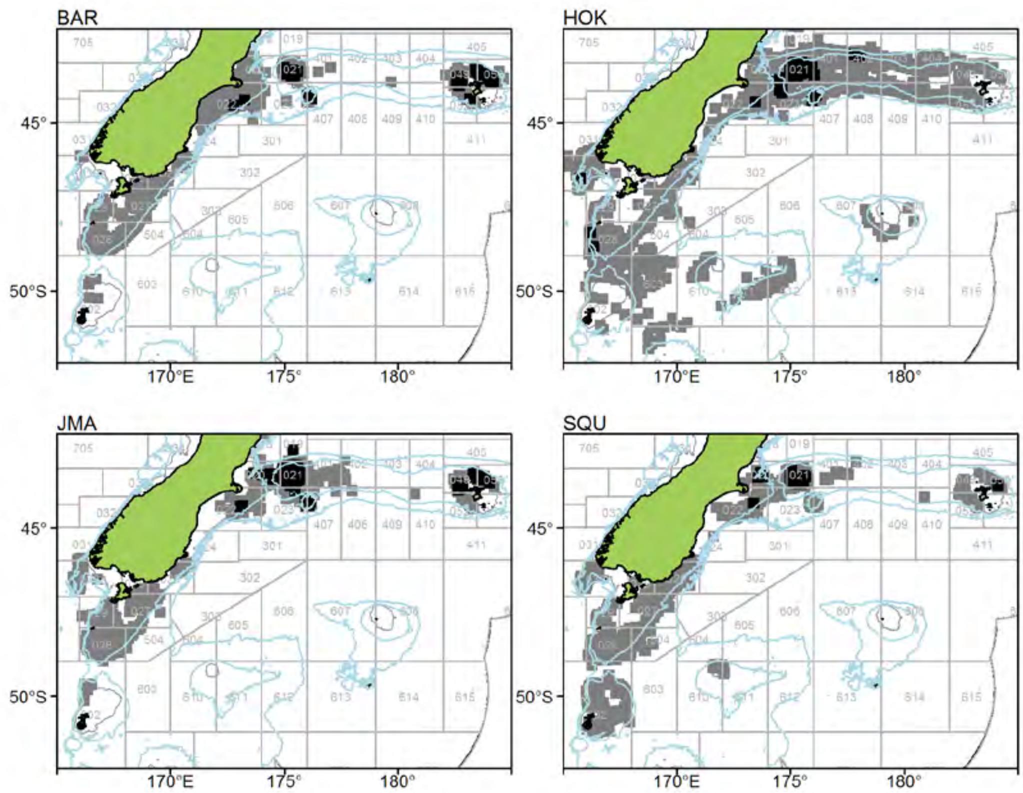


Figure D26: EMA 3 statistical areas and bathymetry showing the distribution of TCEPR trawls by target species (grey) in the merged estimated data and trawls by target species where blue mackerel was caught (black) for the main target species for fishing years 1990–2014 combined. Target species codes are given in Table D12.

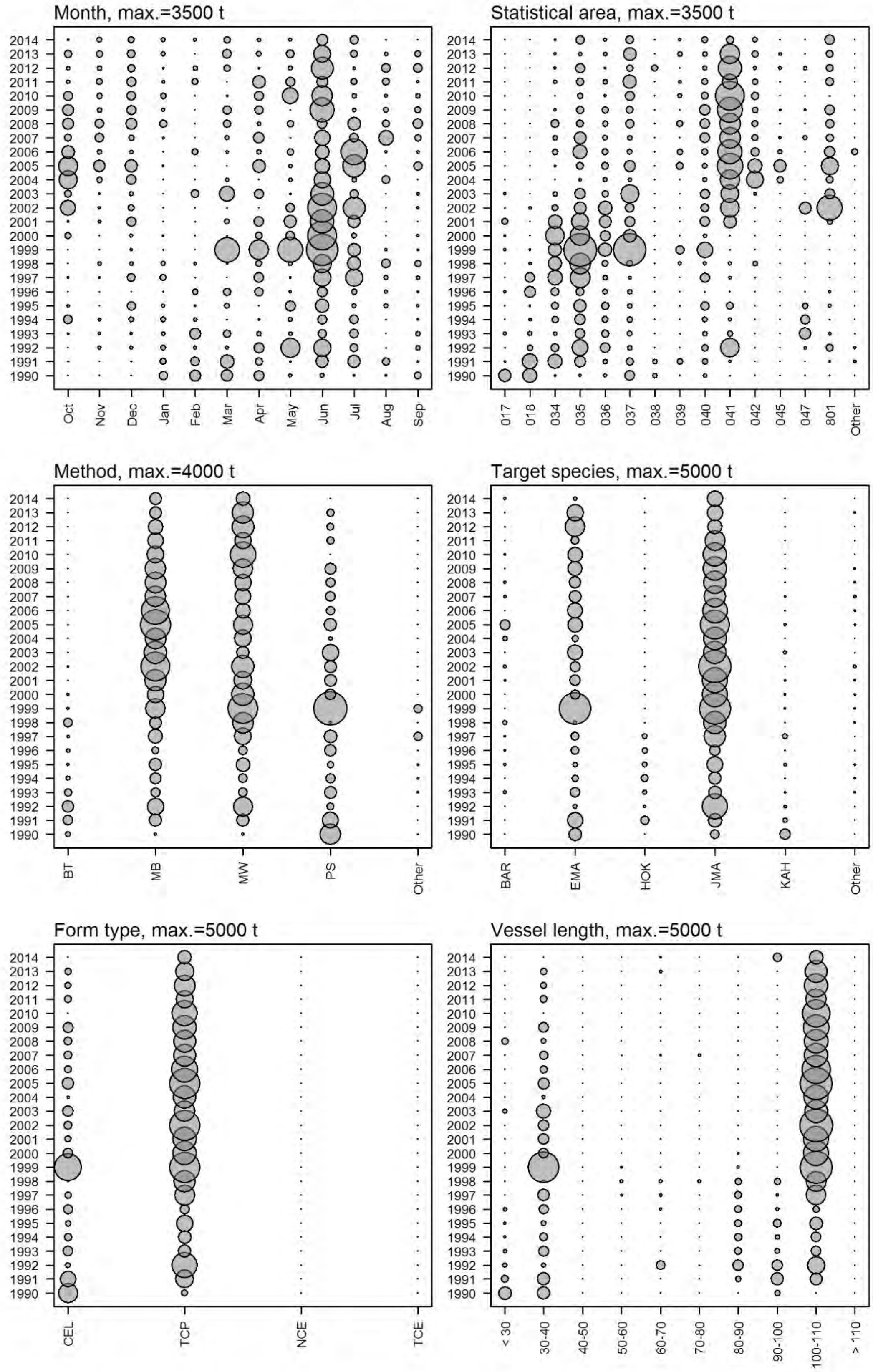


Figure D27a: Distribution of annual estimated catch (t) by month, statistical area, method, target species, form type, and vessel length for EMA 7 merged data for fishing years 1990–2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. BT is bottom trawl; MB is midwater trawl within 5 m of the seabed; MW is midwater trawl; DS is Danish seine; PS is purse seine; target species codes are given in Table D12; and form types are defined in Figure D3.

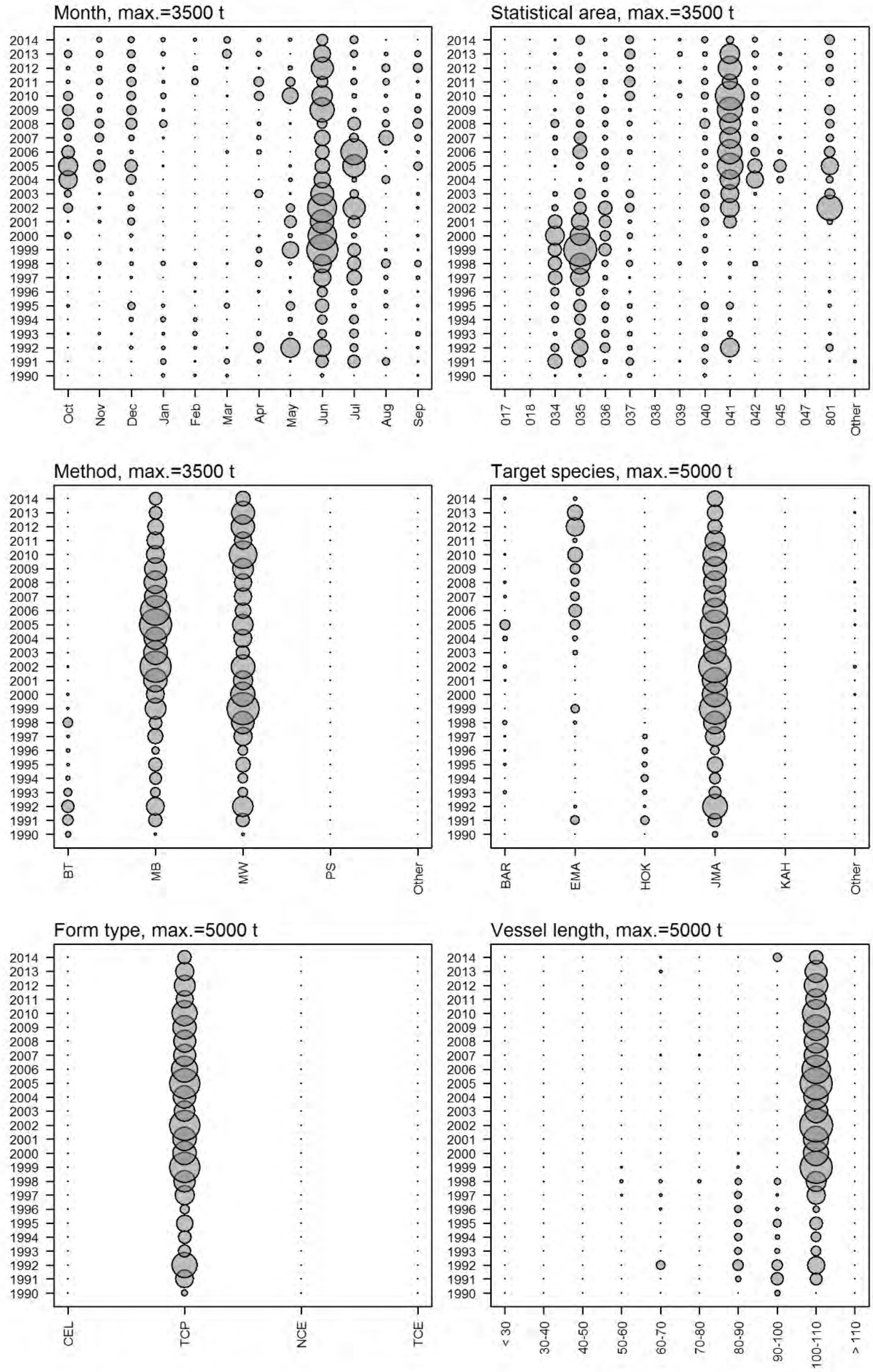


Figure D27b: Distribution of annual estimated catch (t) by month, statistical area, method, target species, form type, and vessel length for EMA 7 trawl merged data for fishing years 1990–2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. BT is bottom trawl; MB is midwater trawl within 5 m of the seabed; MW is midwater trawl; DS is Danish seine; PS is purse seine; target species codes are given in Table D12; and form types are defined in Figure D3.

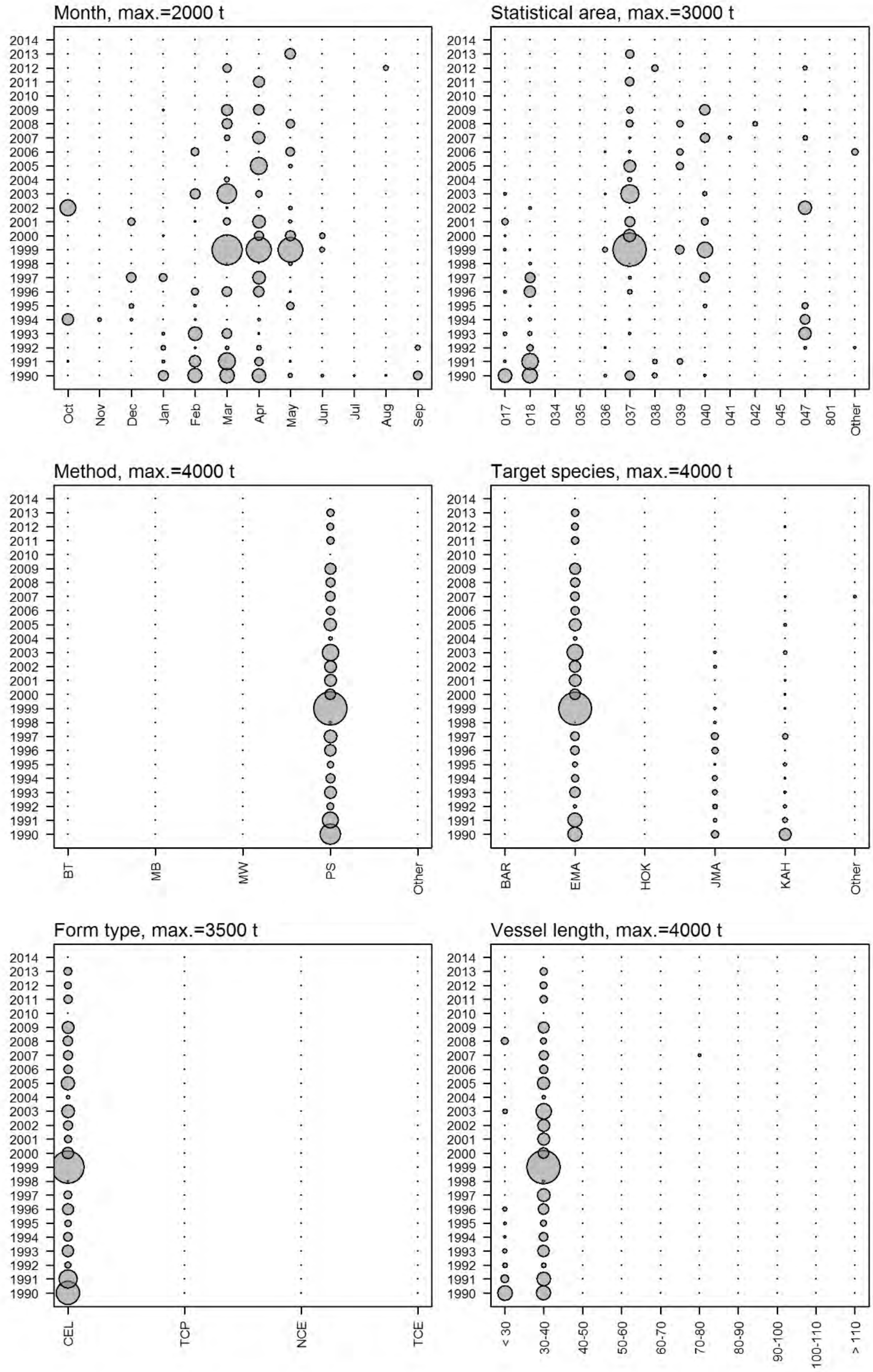


Figure D27c: Distribution of annual estimated catch (t) by month, statistical area, method, target species, form type, and vessel length for EMA 7 purse seine merged data for fishing years 1990–2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. BT is bottom trawl; MB is midwater trawl within 5 m of the seabed; MW is midwater trawl; PS is purse seine; target species codes are given in Table D12; and form types are defined in Figure D3.

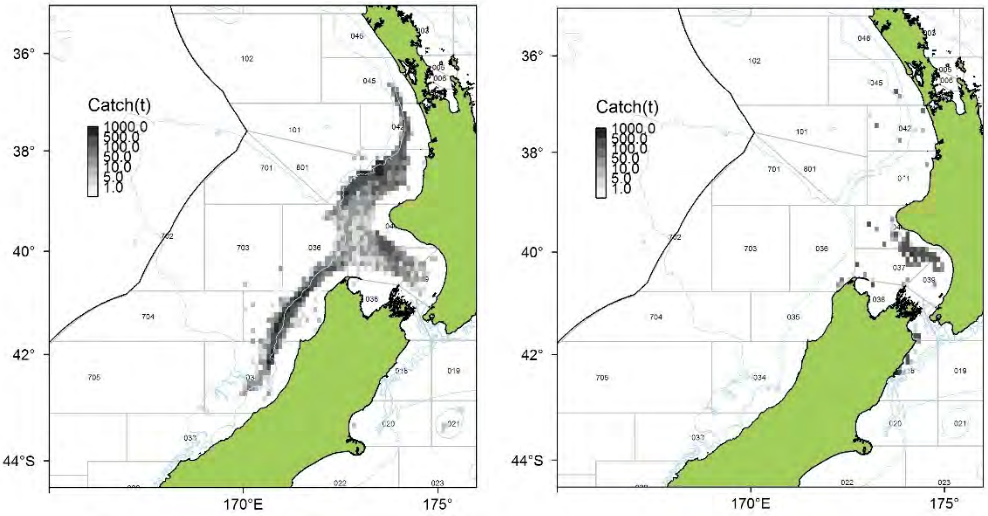


Figure D28: Distribution of blue mackerel catch by 0.2 degree grid for the midwater trawl (left) and purse seine (right) fisheries in EMA 7, for fishing years 1990–2014 combined.

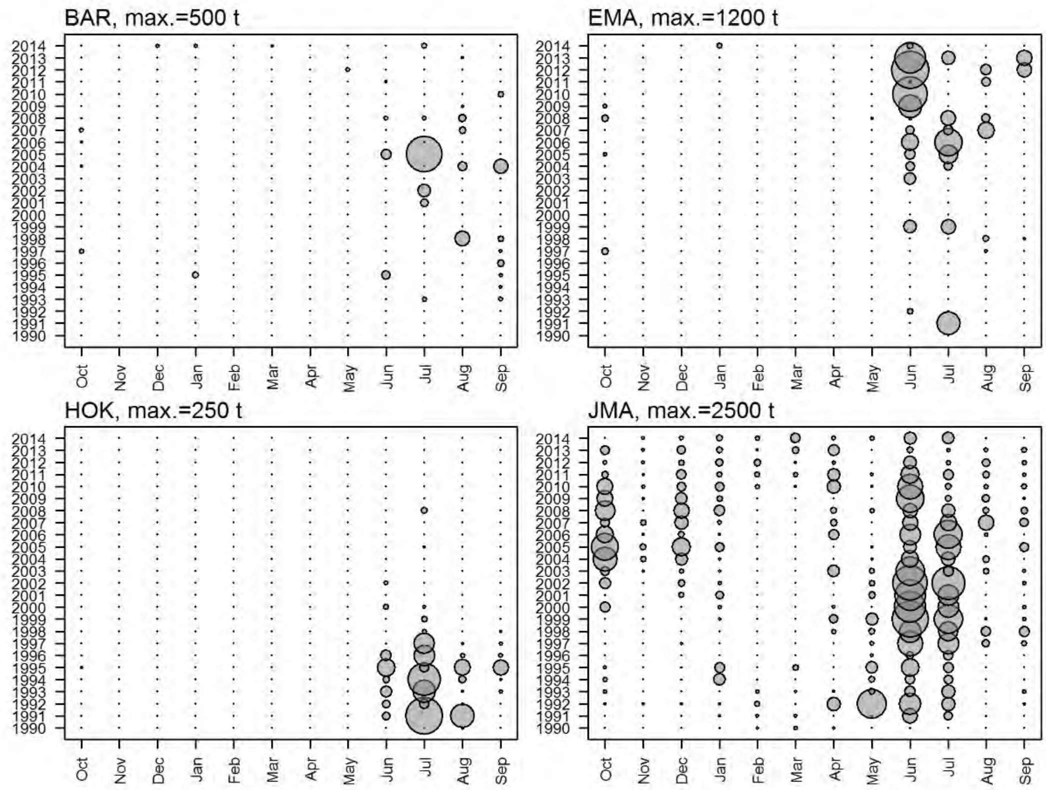


Figure D29: Distribution of blue mackerel catch by month for main target species in the midwater trawl fishery in EMA 7, for fishing years 1990–2014. Target species codes are given in Table D12.

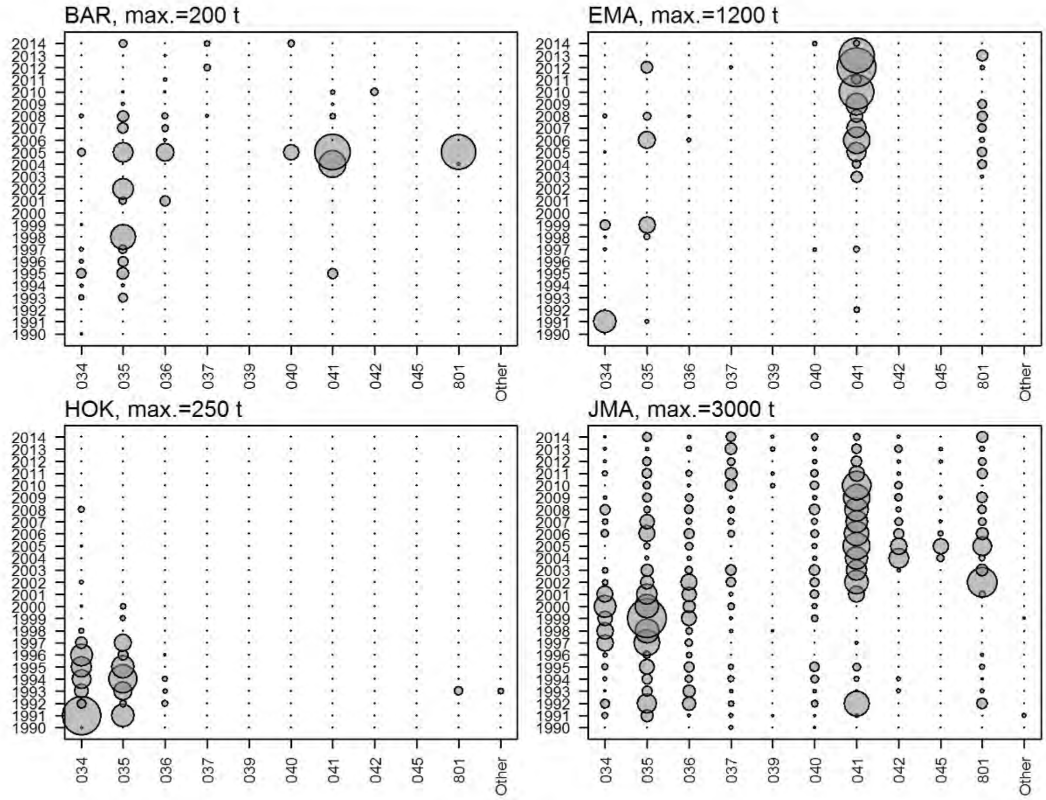


Figure D30: Distribution of blue mackerel catch by statistical area for the main target species in the midwater trawl fishery in EMA 7, for fishing years 1990–2014. Target species codes are given in Table D12.

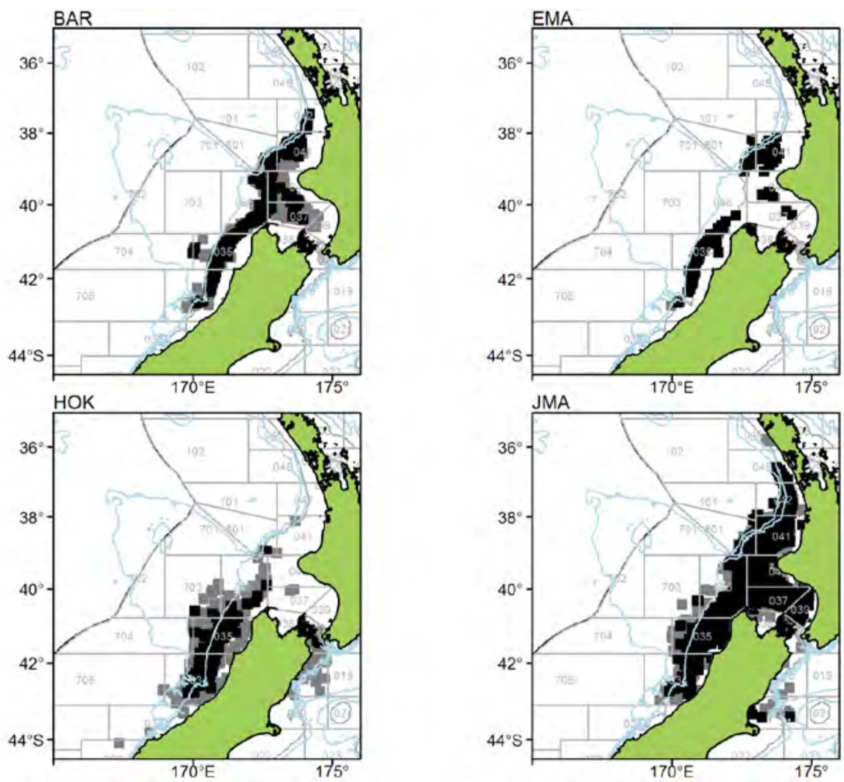


Figure D31: EMA 7 statistical areas and bathymetry showing the distribution of TCEPR midwater trawls by target species (grey) in the merged estimated data and midwater trawls where blue mackerel was caught (black) for the main target species for fishing years 1990–2014 combined. Target species codes are given in Table D12.

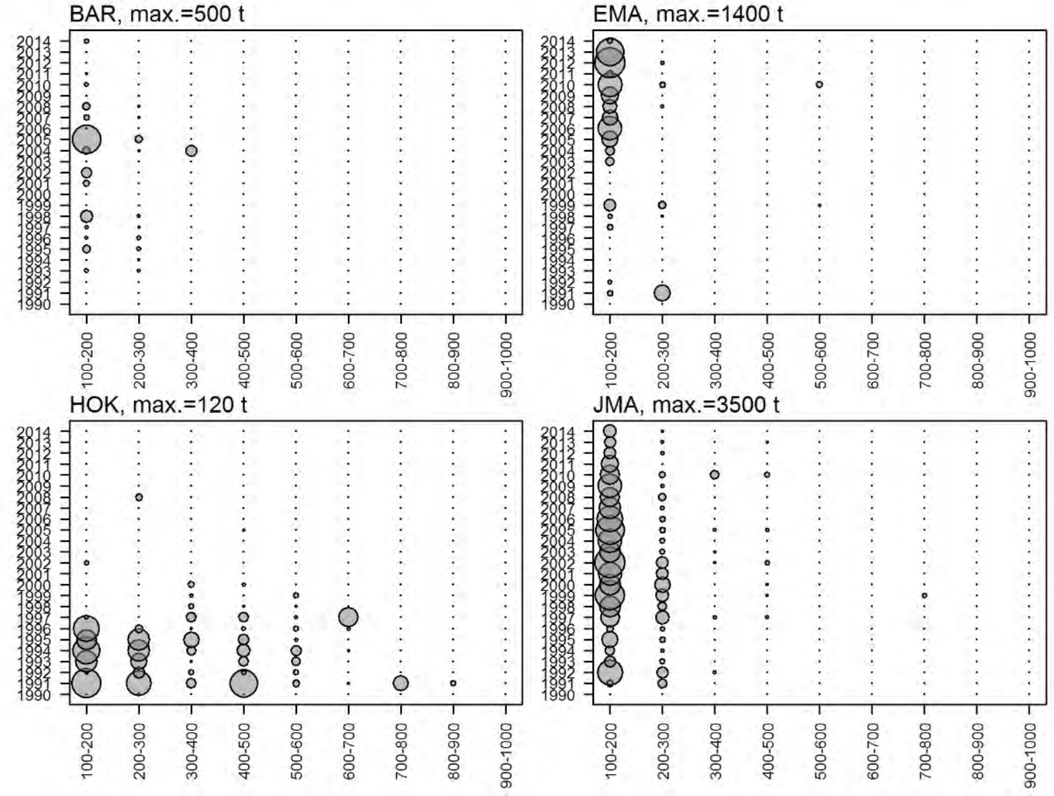


Figure D32: Distribution of blue mackerel catch by target species by depth in the midwater trawl fishery in EMA 7, for fishing years 1990–2014. Target species codes are given in Table D12.

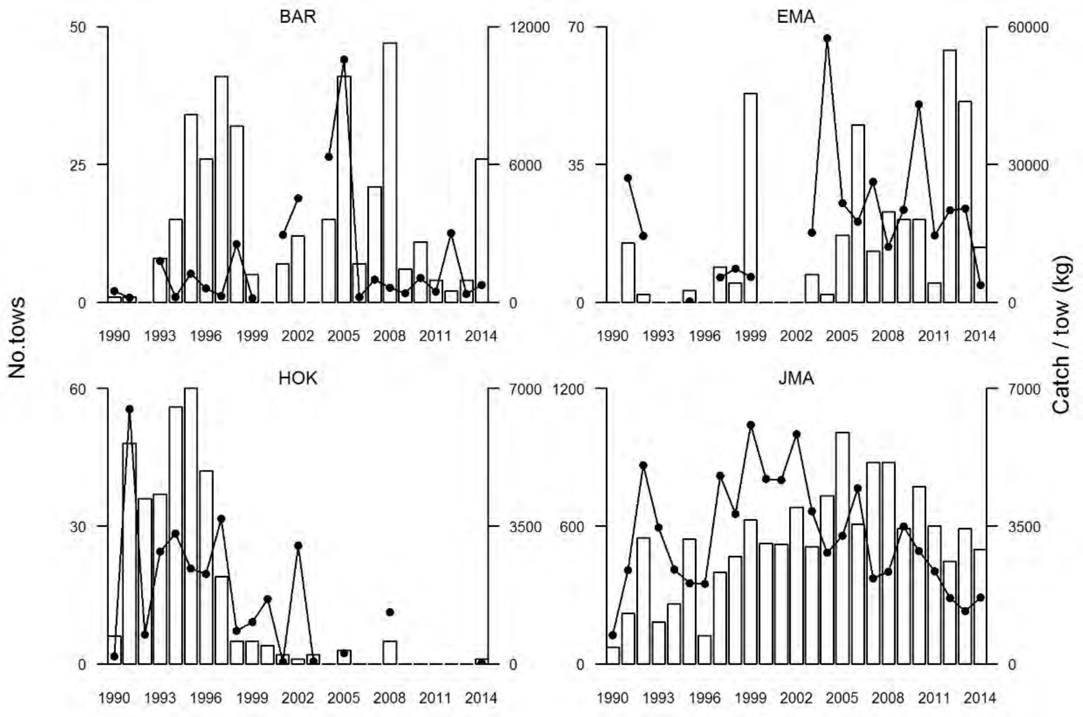


Figure D33: Unstandardised catch rate (kg/tow) of blue mackerel (lines), and the number of tows (bars) for EMA 7, by main target species for unmerged estimated TCEPR midwater trawl data for fishing years 1990–2014. Target species codes are given in Table D12.

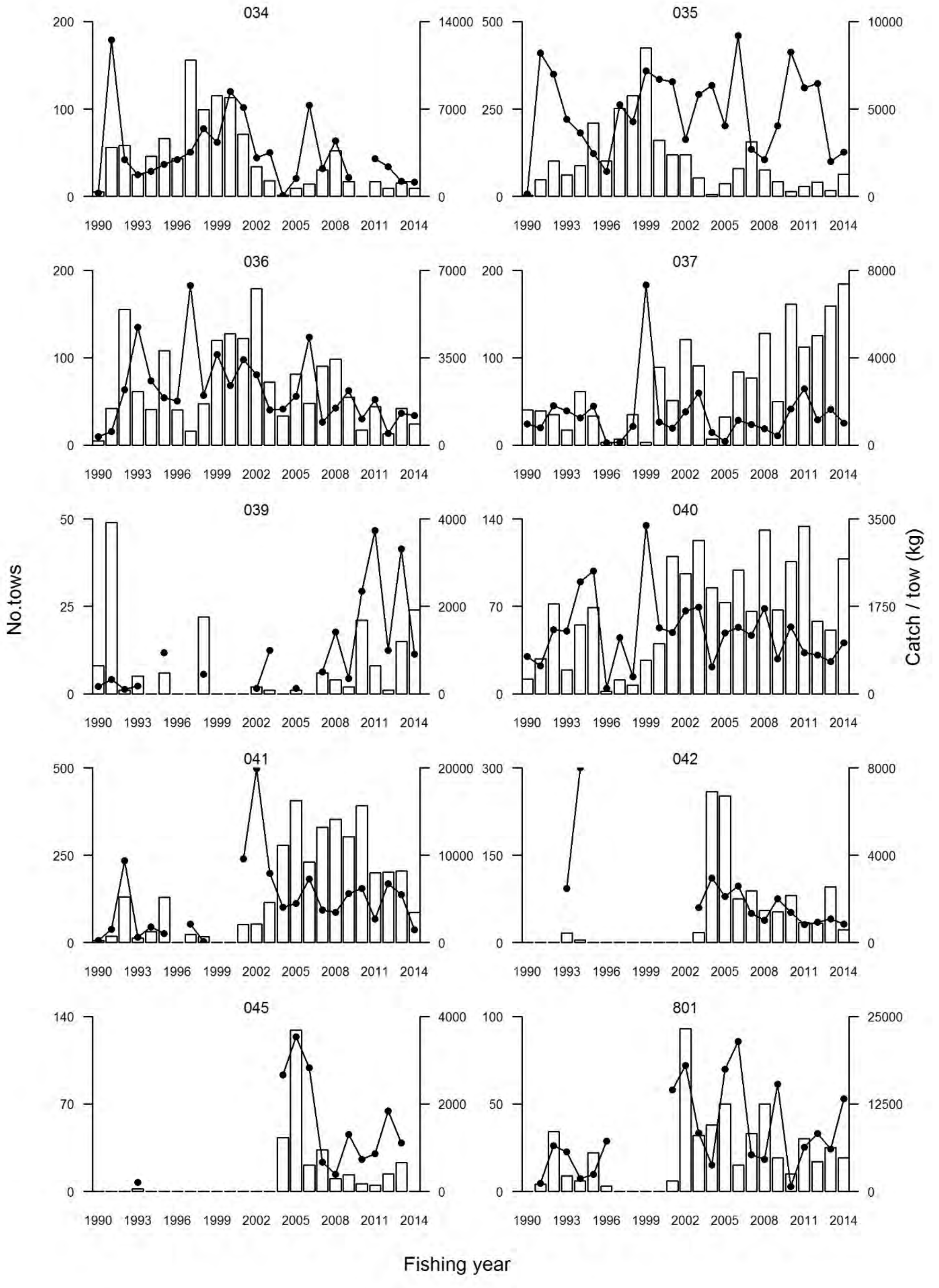


Figure D34: Unstandardised target jack mackerel catch rate (kg/tow) of blue mackerel (lines), and the number of tows (bars) for EMA 7, by main statistical areas for unmerged estimated TCEPR midwater trawl data for fishing years 1990–2014. Statistical areas are given in Figure 1.

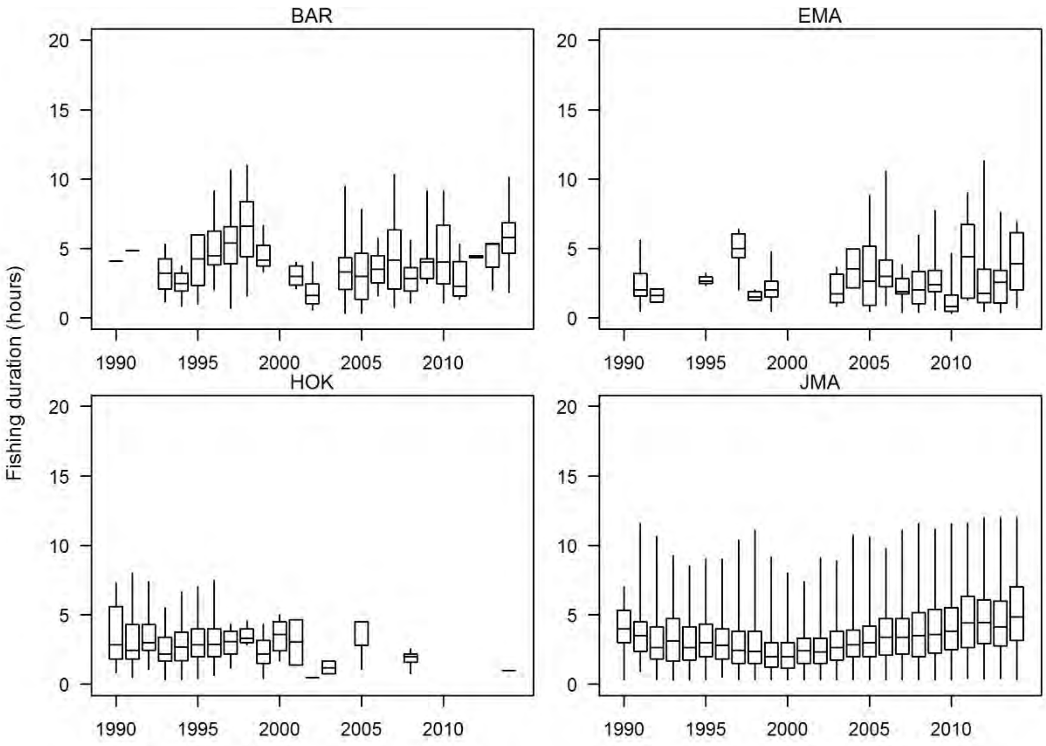


Figure D35: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for fishing duration during unmerged estimated TCEPR midwater trawls that caught blue mackerel in EMA 7, by main target species and fishing year for fishing years 1990–2014. Target species codes are given in Table D12.

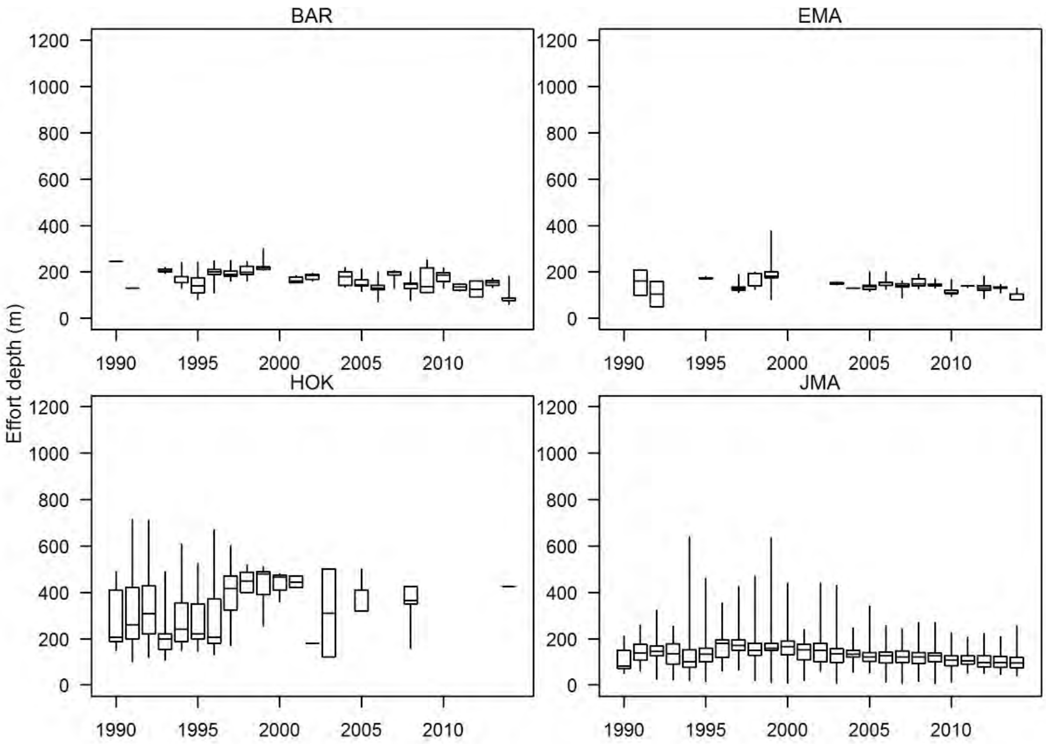


Figure D36: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for depths (m) fished during unmerged estimated TCEPR midwater trawls that caught blue mackerel in EMA 7, by main target species and for fishing years 1990–2014. Target species codes are given in Table D12.

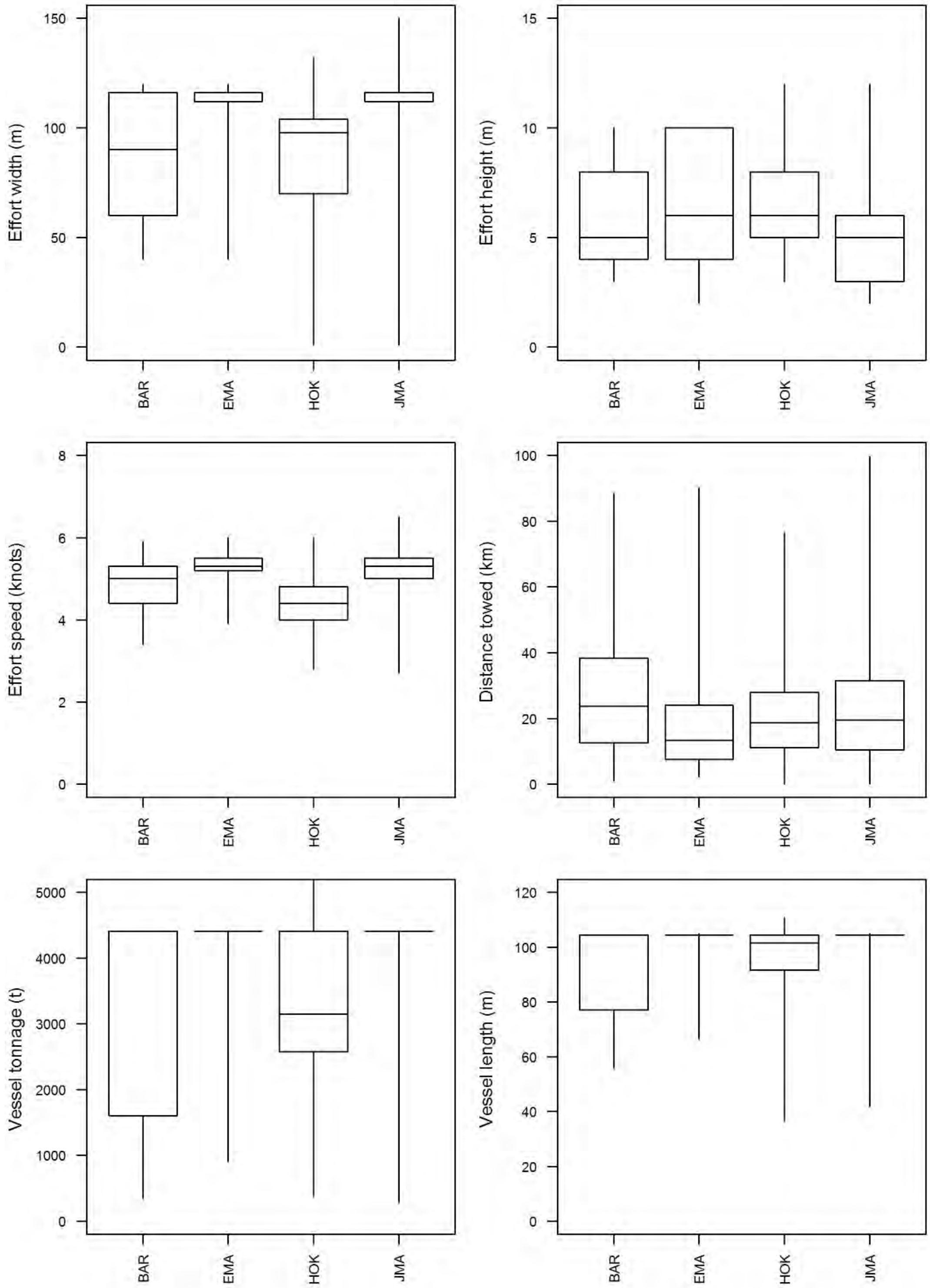


Figure D37: Distribution of fishing effort variables and vessel characteristics for EMA 7 for unmerged estimated TCEPR midwater fishing that caught blue mackerel by main target species for fishing years 1990–2014. Target species codes are given in Table D12.

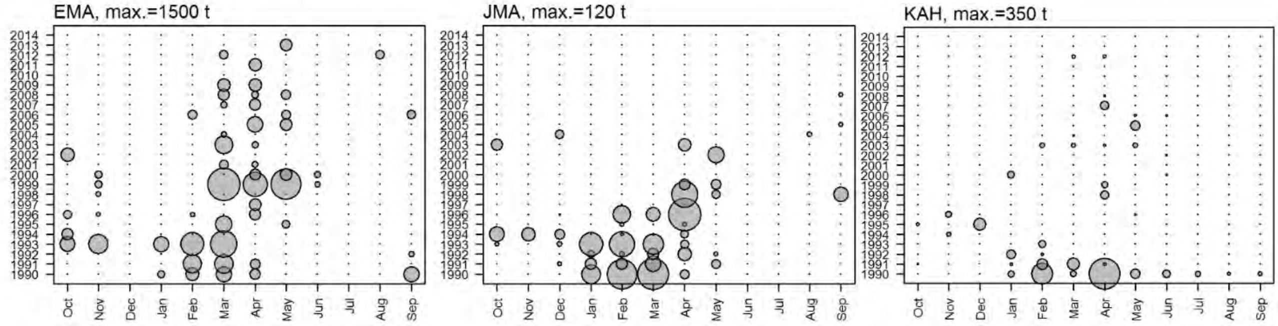


Figure D38: Distribution of blue mackerel catch by month in the purse-seine fishery in EMA 7, by main target species for fishing years 1990–2014. Target species codes are given in Table D12.

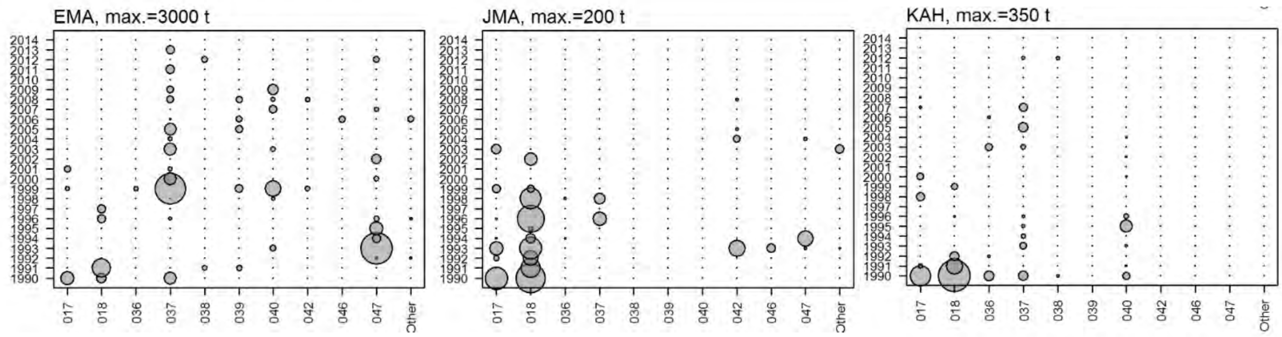


Figure D39: Distribution of blue mackerel catch by statistical area for the main target species in the purse-seine fishery in EMA 7, for fishing years 1990–2014. Target species codes are given in Table D12.

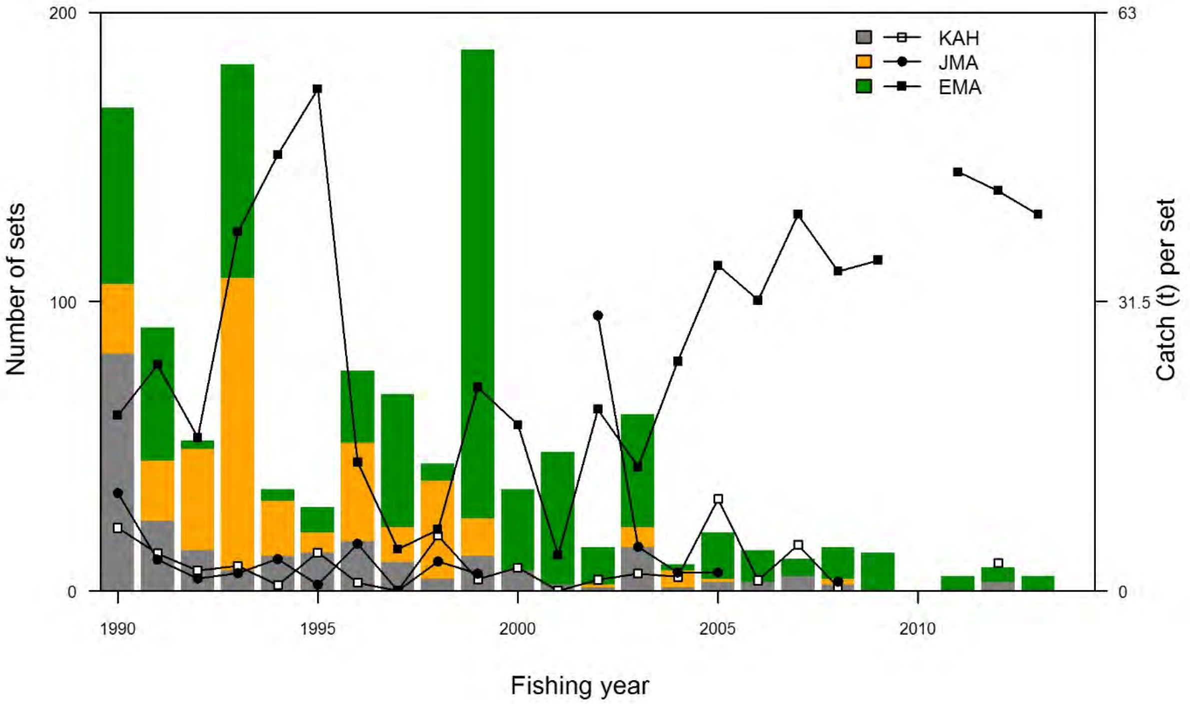


Figure D40: Number of sets (bars) and catch per set (lines) by target species for the purse-seine fishery in EMA 7 for fishing years 1990–2014. Target species codes are given in Table D12.

APPENDIX E: CATCH-PER-UNIT-EFFORT ANALYSIS

Table E1: Description of variables and their type used in the CPUE analysis for the TCEPR data. Continuous variables were fitted as third order polynomials except for tow duration which was offered as both third and fourth order polynomials.

Variable	Type	Description
Year	Categorical	Fishing year (Oct–Sep)
Vessel	Categorical	Unique (encrypted) vessel identification number
Statistical area	Categorical	Statistical area
Catch	Continuous	Estimated green weight of blue mackerel (t) caught from a tow
Date	Continuous	Start date of tow
Month	Categorical	Month of the year
Fday	Continuous	Day of the year
Time start	Continuous	Start time of tow
Time mid	Continuous	Mid time of tow
Tow distance	Continuous	Distance of tow (kt)
Distance2	Continuous	Distance (as speed*duration) of tow (kt)
Headline height	Continuous	Headline height (m) of the net for a tow
Bottom depth	Continuous	Seabed depth (m) for a tow
Net depth	Continuous	Net depth (m) for a tow
Speed	Continuous	Vessel speed (knots) for a tow
Longitude	Continuous	Longitude of the vessel for a tow
Latitude	Continuous	Latitude of the vessel for a tow

Table E2: CPUE data constraints for the West coast TCEPR tow-by-tow data.

Data source	TCEPR estimated tow-by-tow data
Year range	1997–2014 (October–September)
Statareas	≥ 50 tows: 031, 032, 034 – 037, 039, 040, 801, 041, 042, 045 – 048
Method	Midwater tows
Target species	JMA
Core vessel selection	≥ 5 years vessel participation, ≥ 20 tows per vessel-year
Catch	< 50 t
Other	50–800 m; 0.2–15 hours; latitude 36°–43.5°; longitude 169°–175.5°

Table E3: Summary of West coast TCEPR tow-by-tow, target JMA data used in the analyses of estimated CPUE for all vessels and core vessels for fishing years 1990–2014. Vessels, number of unique vessels fishing; Effort, number of tow records fished with a non-zero catch; Zeros, proportion of tows that caught zero catch; Catch, estimated catch; CPUE, unstandardised CPUE as catch/hr from the non-zero tow-by-tow data.

	All vessels					Core vessels				
Fishing year	No. vessels	Catch	No. tows	Prop. zeros	CPUE	No. vessels	Catch	No. tows	Prop. zeros	CPUE
1997	18	1 512.3	869	0.60	0.55	4	727.2	293	0.57	1.25
1998	22	1 742.9	963	0.53	0.60	5	1 234.8	419	0.45	1.48
1999	15	3 749.6	1 025	0.40	1.61	5	2 876.6	762	0.39	1.82
2000	9	2 329.1	924	0.44	1.15	6	2 310.8	878	0.43	1.22
2001	11	2 412.1	1 450	0.64	0.66	7	2 411.8	1 436	0.64	0.66
2002	12	3 580.2	1 996	0.66	0.65	7	3 579.1	1 908	0.65	0.71
2003	9	1 756.2	2 488	0.81	0.23	7	1 754.9	2 454	0.81	0.24
2004	7	1 938.6	2 206	0.67	0.30	7	1 938.6	2 206	0.67	0.30
2005	9	3 043.0	2 424	0.59	0.40	7	3 043.0	2 416	0.59	0.40
2006	7	2 240.3	2 150	0.76	0.30	7	2 240.3	2 150	0.76	0.30
2007	9	1 683.5	2 388	0.65	0.19	7	1 547.6	2 278	0.66	0.18
2008	8	1 769.4	2 319	0.66	0.21	7	1 769.3	2 317	0.66	0.21
2009	9	1 678.2	1 861	0.69	0.23	7	1 678.2	1 855	0.69	0.23
2010	9	1 347.2	2 258	0.70	0.15	7	1 342.7	2 211	0.70	0.15
2011	7	1 230.3	1 660	0.66	0.16	6	1 230.3	1 654	0.66	0.16
2012	7	668.4	1 619	0.75	0.09	6	668.4	1 614	0.75	0.09
2013	8	660.2	1 791	0.72	0.08	6	641.1	1 632	0.72	0.09
2014	9	565.8	1 940	0.80	0.06	5	351.4	1 200	0.80	0.07

Table E4: Variables retained in order of decreasing explanatory value from the catch/hr West coast TCEPR tow-by-tow target JMA lognormal model and the corresponding total r^2 (R-squared) values.

Variable	**R-squared**
Year	14.11
Statistical area	22.48
Distance	28.43
Vessel	33.16
Month	35.37

Table E5: Standardised lognormal CPUE catch/hr indices for the core West coast TCEPR tow-by-tow target JMA data indices for fishing years 1990–2014. The Standardised CPUE indices for the early series is from 1990 to 1998 (see table B2 from Fu & Taylor 2011) and for the late series from 1997 to 2014. Only the late series was updated in this report.

Fishing year	Indices	CV	Indices	CV
1990	0.67	0.20		
1991	0.87	0.10		
1992	1.24	0.11		
1993	1.01	0.13		
1994	0.99	0.09		
1995	1.05	0.07		
1996	0.87	0.11		
1997	1.34	0.08	2.27	0.09
1998	1.13	0.08	1.99	0.07
1999			2.22	0.05
2000			2.03	0.05
2001			1.66	0.05
2002			1.73	0.04
2003			1.17	0.05
2004			0.80	0.04
2005			0.70	0.04
2006			0.86	0.04
2007			0.60	0.04
2008			0.69	0.04
2009			0.84	0.04
2010			0.71	0.04
2011			0.75	0.04
2012			0.55	0.05
2013			0.57	0.05
2014			0.52	0.06

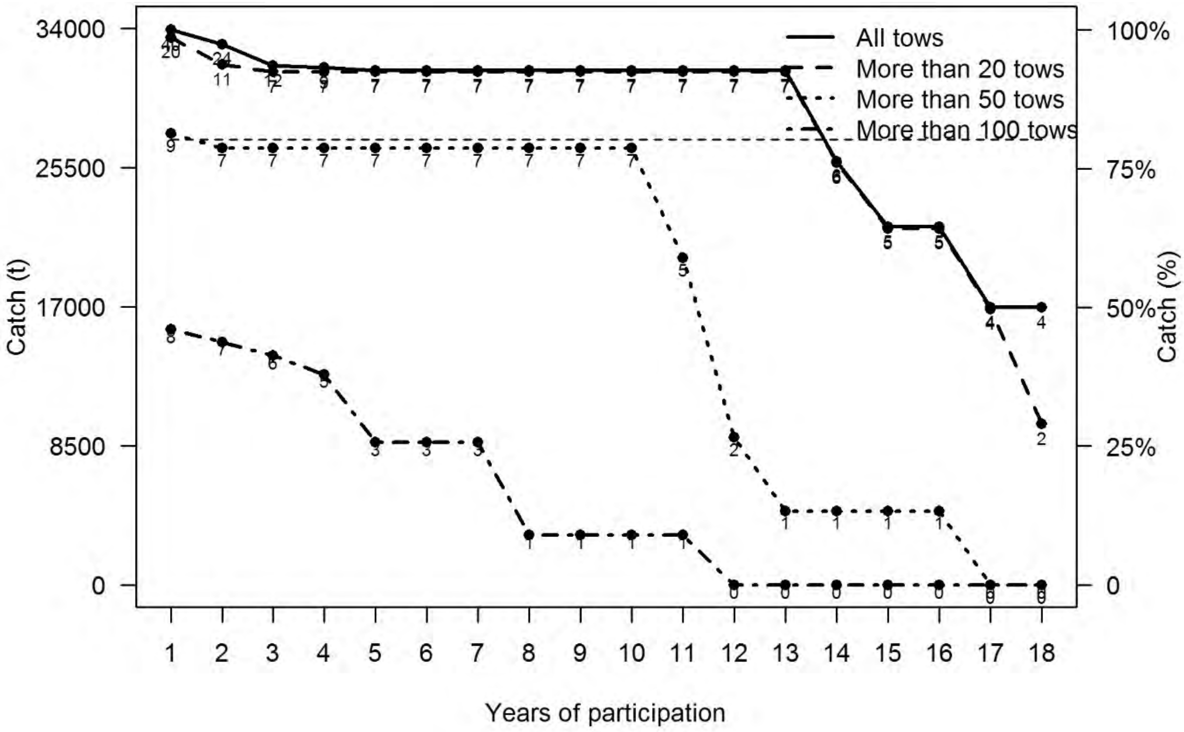
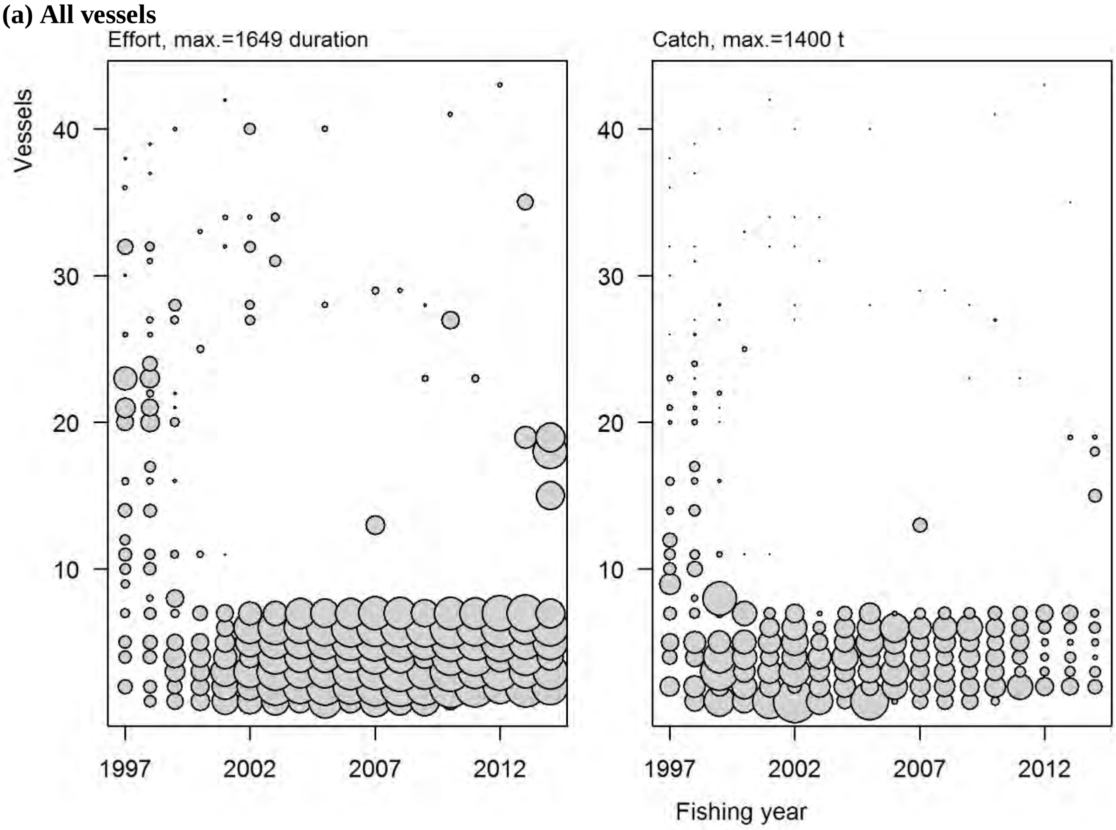


Figure E1: Relationship between years of vessel participation and total blue mackerel catch by dataset. The number under each circle indicates the number of vessels with the corresponding years of participation. Dotted horizontal line represents 80% of catch.

(a) All vessels



(b) Core vessels

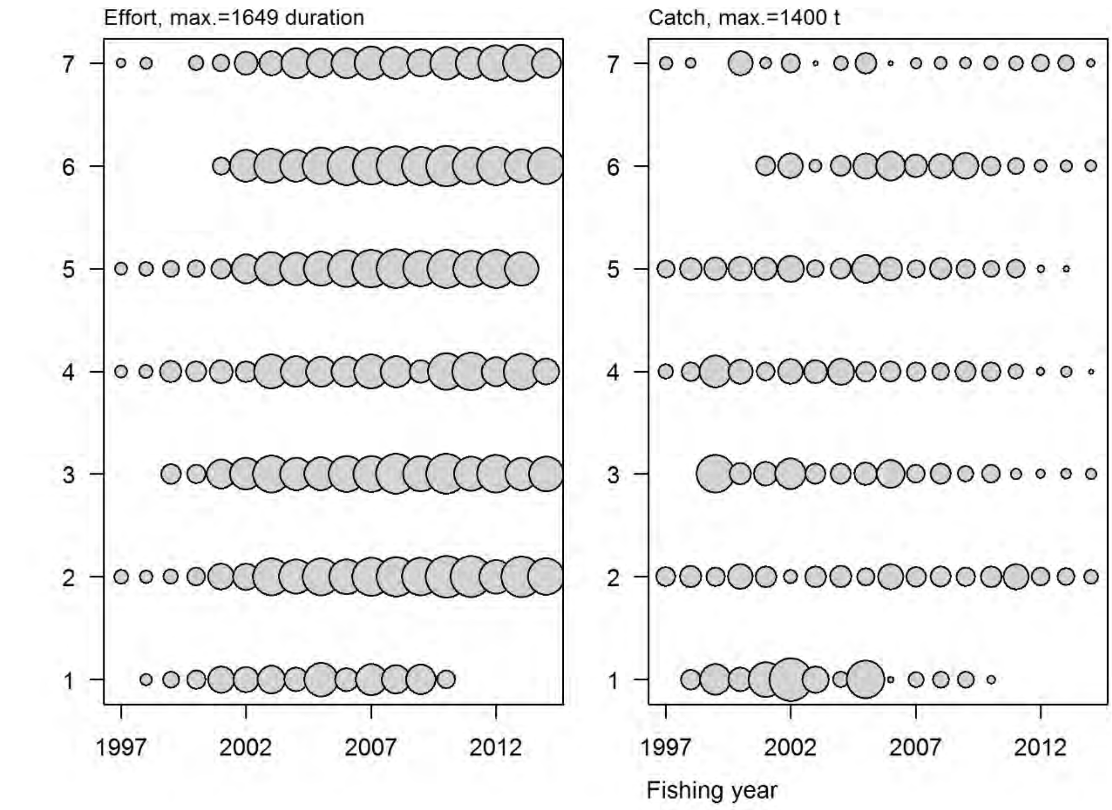


Figure E2: TCEPR tow-by-tow analysis. Summary of effort (number of tows) and estimated blue mackerel catch for fishing years 1990–2014 from (a) all TCEPR BT tows and (b) TCEPR BT core vessels. Symbol area is proportional to either number of tows or annual catch, and maximum circle size is shown in the label on the plot.

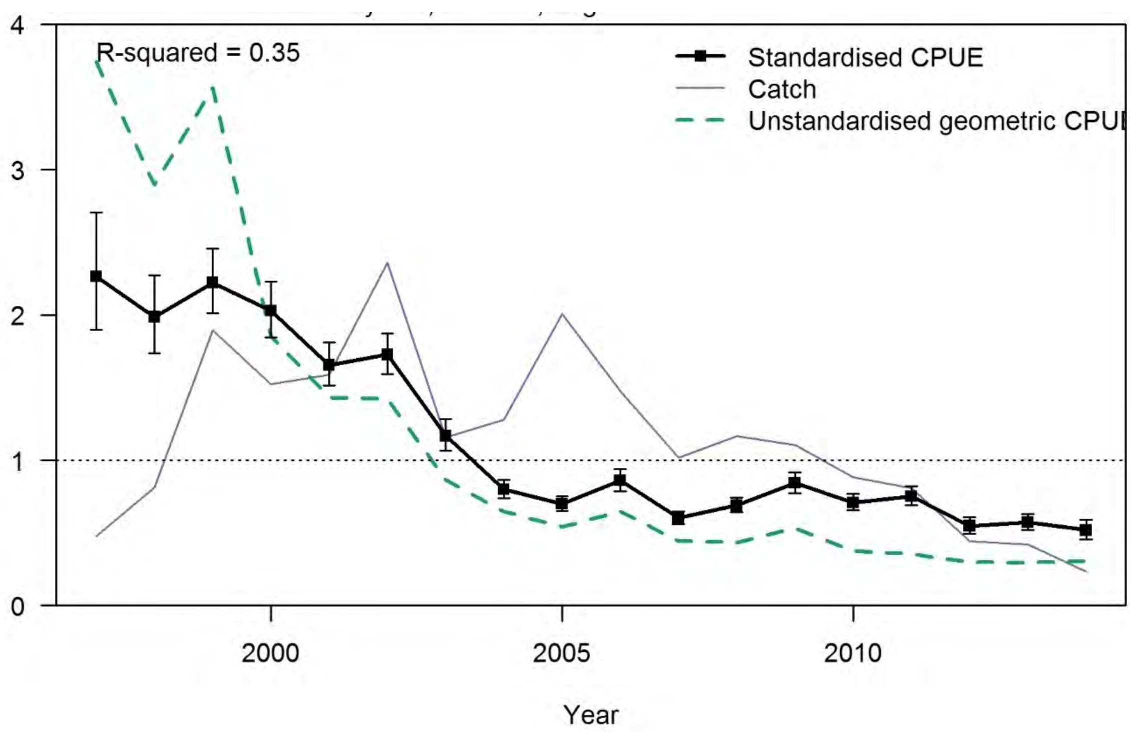


Figure E3: CPUE lognormal indices showing catches (scaled to same mean as indices), and lognormal standardised and un-standardised indices for fishing years 1990–2014. Bars indicate 95% confidence intervals. Year defined as October − September.

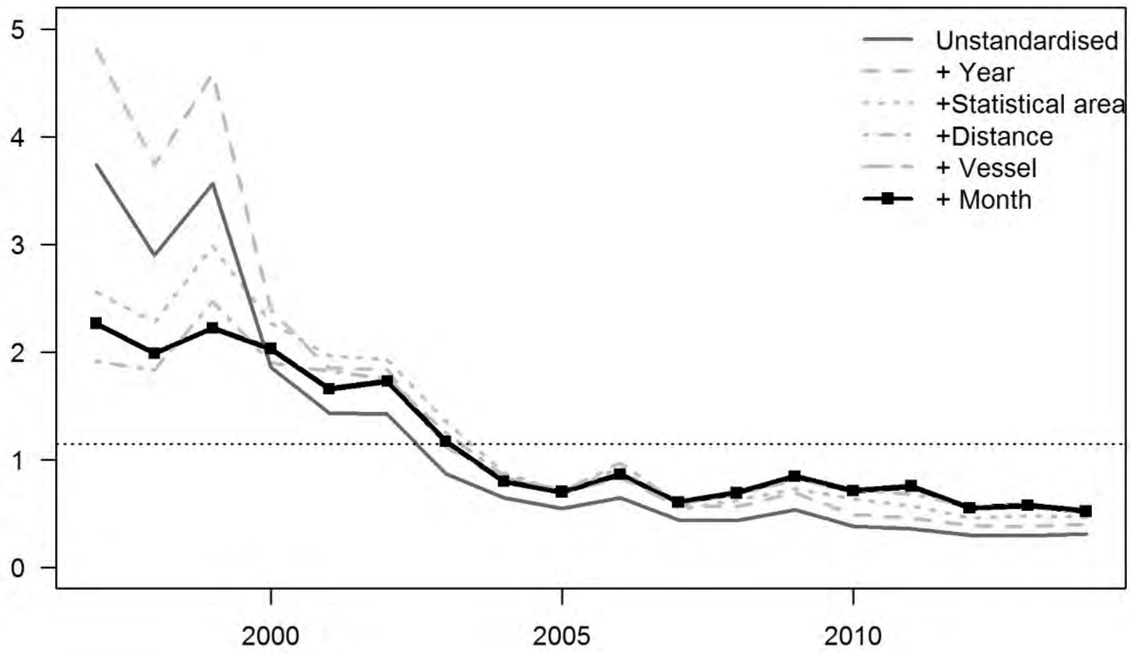
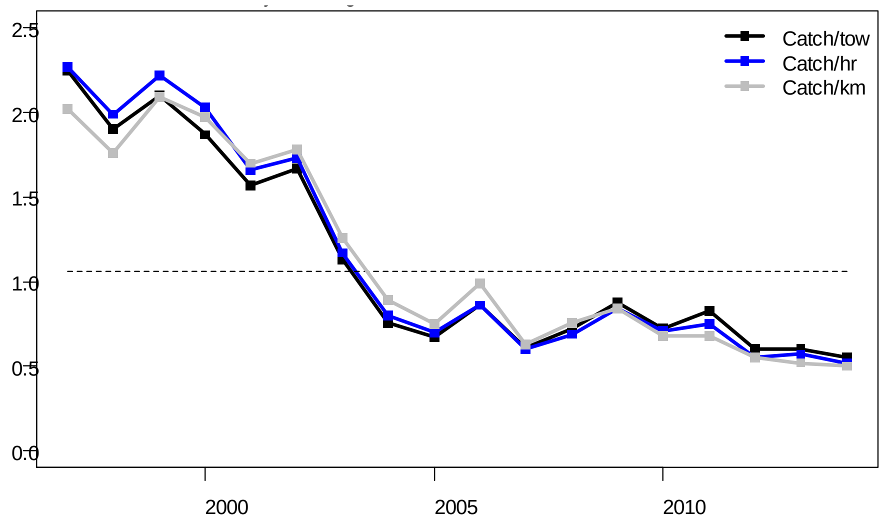
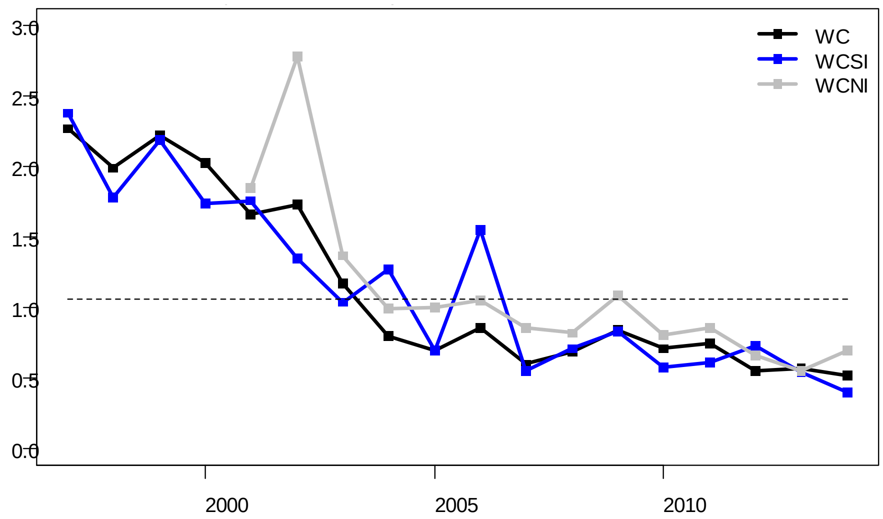


Figure E4: Addition of variables into the CPUE lognormal CPUE model for each fishery for fishing years 1990–2014. Year defined as October to September.

(a)



(b)



(c)

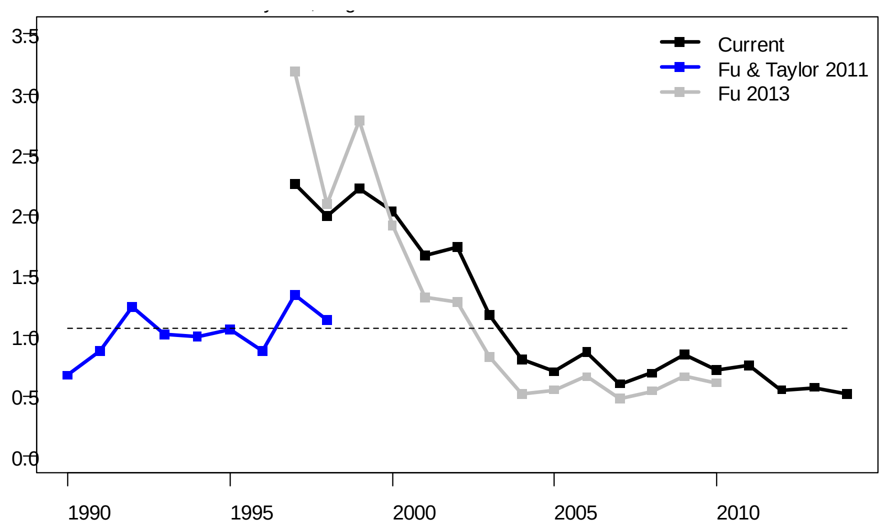


Figure E5: Comparison of indices for the TCEPR tow-by-tow datasets for fishing years 1990–2014 for blue mackerel: (a) West coast catch/tow, Catch/hr, and catch/km CPUE indices; (b) West coast (WC); WCSI, and WCNI catch/hr CPUE indices; (c) West coast catch/hr current analysis with CPUE indices from Fu (2013) and Fu & Taylor (2011). Indices have been standardised to have a mean of one.

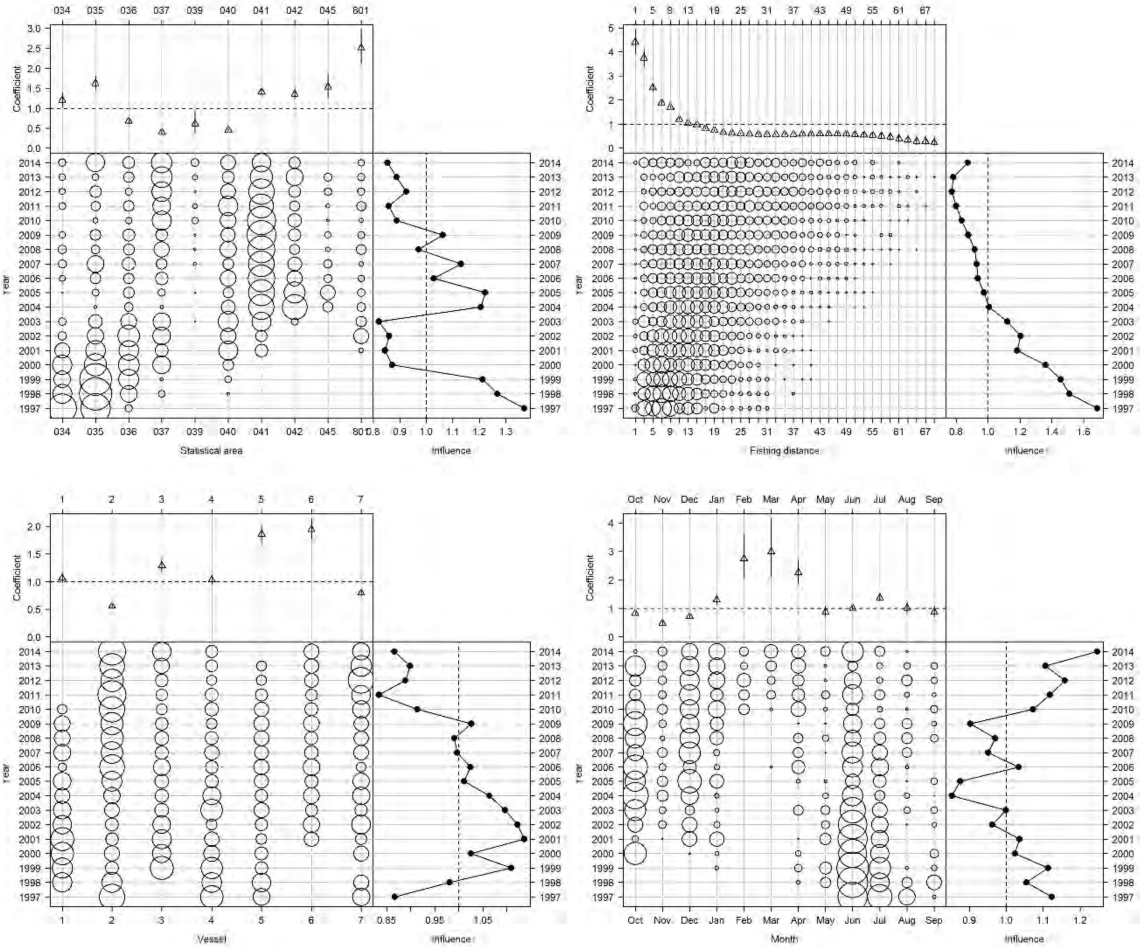


Figure E6: TCEPR tow-by-tow analysis. Effect and influence of variable in the lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

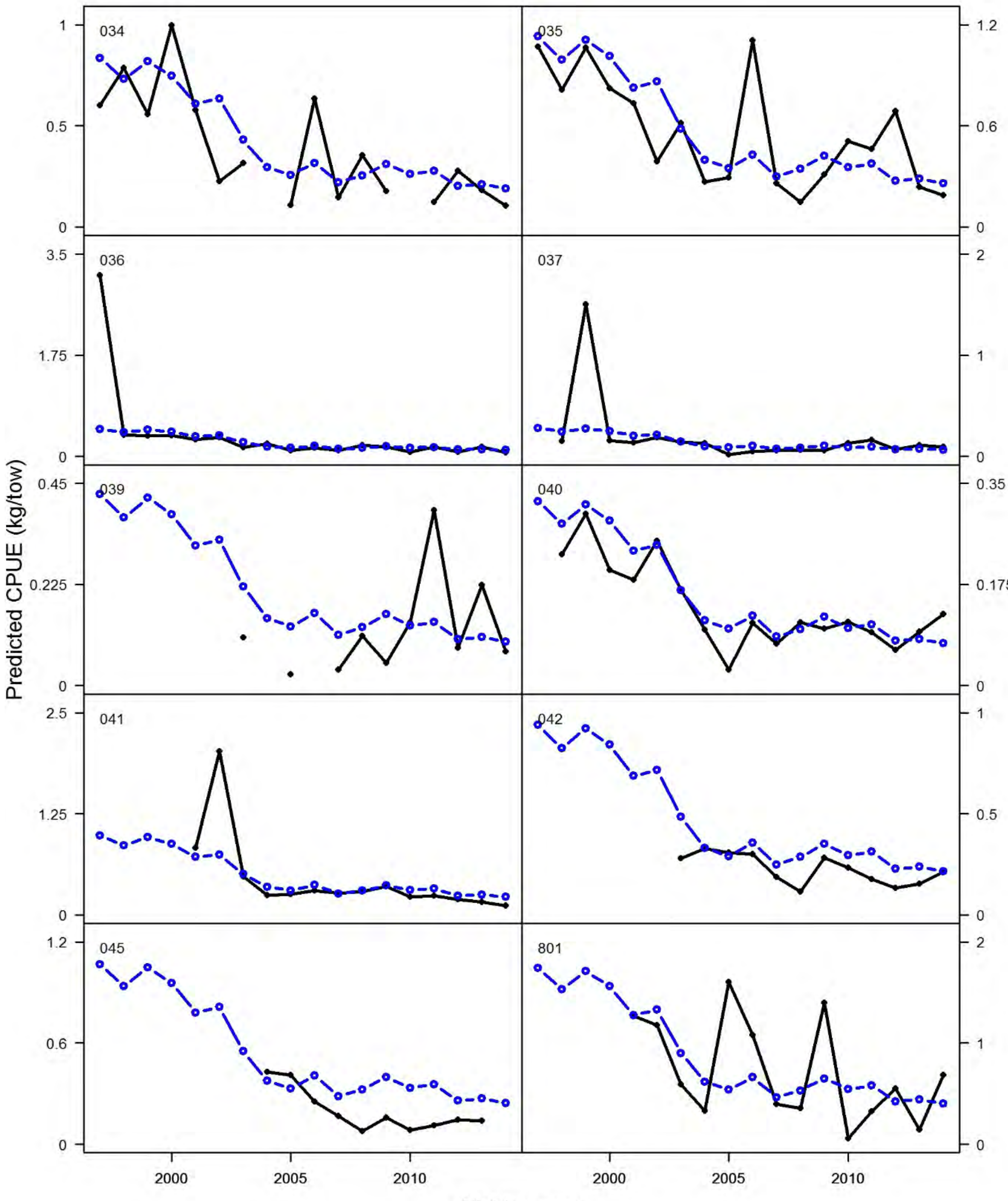


Figure E7: Predicted CPUE by statistical area for the TCEPR tow-by-tow lognormal model showing model with year-statistical area interaction (black) and without year-statistical area interaction (blue).

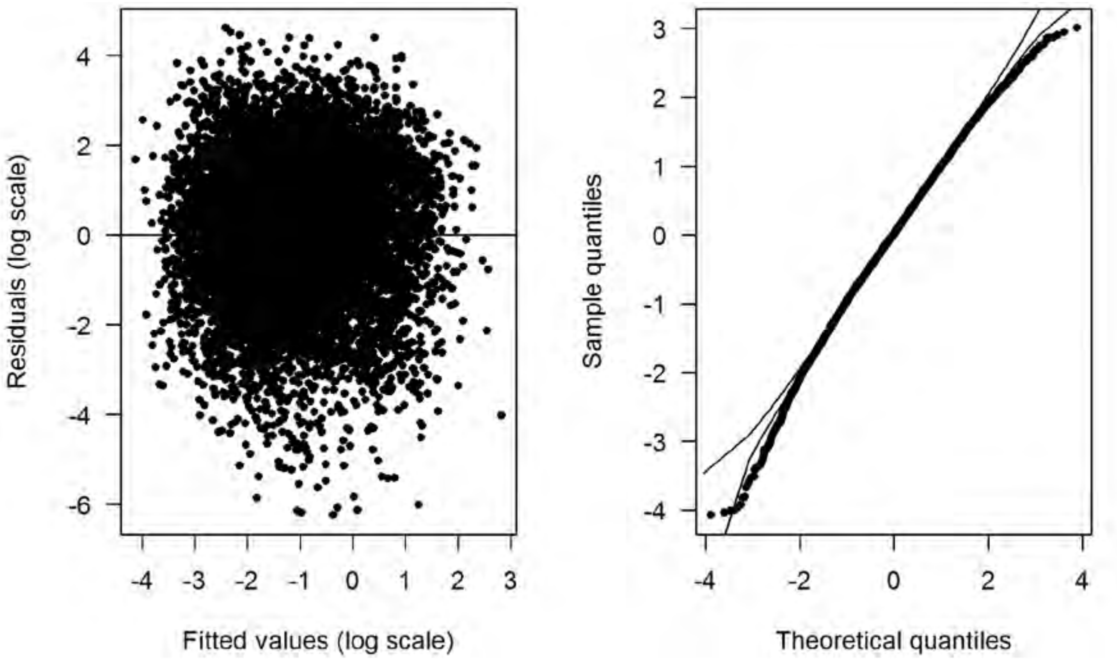


Figure E8: Distribution of the standardised residuals against fitted values (left) and quantile-quantile plot of the residuals (right) for lognormal models.