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An investigation of the bycatch of rebuilding species and other selected species in the Southern and Eastern Scalefish and Shark Fishery

Australian Fisheries Management Authority

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Acknowledgments

The metier analysis used to estimate the unavoidable bycatch of rebuilding and other selected species was informed by discussions with the South East Resource Assessment Group (SERAG) and Shark Resource Assessment Group (SharkRAG). Many of the figures presented in this document were developed by Malcolm Haddon (CSIRO).

This document was internally reviewed by Dr Robin Thomson and Dr Geoff Tuck.

1 Executive Summary

This version of this report has been modified to avoid identifying locations fished by less than five vessels.

Commonwealth harvest strategy policy requires that for an overfished stock that is solely managed by AFMA, a rebuilding strategy be implemented to allow stock rebuilding to above its limit reference point within a specified timeframe. The rebuilding strategies require that targeted fishing must cease and that incidental mortality be constrained. In the Southern and Eastern Scalefish and Shark Fishery (SESSF) there are currently five stocks that are managed under rebuilding strategies, Blue Warehou (*Seriolella brama*), Orange Roughy (*Hoplostethus atlanticus*), the eastern stock of Gemfish (*Rexea solandri*), eastern Redfish (*Centroberyx affinis*) and School Shark (*Galeorhinus galeus*). In addition John Dory (*Zeus faber*) and Silver Trevally (*Pseudocaranx georgianus*) were not considered to be over-fished at the beginning of 2021, however, they have been included in this report at the request of AFMA due to concerns about their sustainability. At the request of AFMA, the December 2021 version of this report includes eastern Jackass Morwong, which was assessed to be below its limit reference point in 2021 (Day et al., 2021) and the Deepwater Shark basket of species to assist in developing assessment approaches for the eastern and western stocks.

This study quantifies the unavoidable bycatch of Blue Warehou, the eastern stock of Gemfish, eastern Redfish, School Shark, John Dory, Silver Trevally, the eastern stock of Jackass Morwong and eastern and western Deepwater Sharks using a metier approach and investigates potential targeting of these stocks. Some stocks of Orange Roughy are also managed under a rebuilding strategy, however, because of the deep water nature of Orange Roughy fisheries, a specific analysis is not required to quantify unavoidable bycatch. The metier analysis uses recent logbook data to classify groups of fishing operations with common characteristics (e.g. species composition, location, depth) into metiers[1] that are then used to estimate the ratio of primary target species to bycatch species in the reported catch. Assumed target species catches for 2022 are then used to estimate the associated bycatch of Blue Warehou, eastern Gemfish, Redfish, School Shark, John Dory, Silver Trevally, eastern Jackass Morwong and Deepwater Shark. At its November 2021 meeting SERAG requested the metier analysis consider two additional scenarios of future Flathead catch of 2,000 t and 2,200 t (along with the provisional 2022 TAC of 2,407 t).

The estimation of rebuilding species bycatch from the metier analysis makes three strong assumptions about logbook reported catches, these are:

1. The metier analysis uses reported landed catches in logbooks and does not incorporate discards,
2. The distribution or abundance of the rebuilding species does not change, and
3. To estimate bycatch in 2022 the assumption is made that primary target species catches are caught by metiers in approximately the same proportions as they were in the 2019-2020 logbook data.

[1] A group of fishing operations targeting a specific assemblage of species, using a specific gear, during a precise period of the year and/or within a specific area.

While these assumptions are shared by the companion species method that has previously been used in the SESSF to estimate rebuilding species bycatch (Klaer and Smith, 2012), it is recommended that this information should be taken into account when utilising these estimates for management purposes.

Reported catches and estimated discards are summarised by gear type and year and potential targeting of bycatch species is investigated using plots of the spatial and temporal distribution of catch, fishing depth, catch per unit effort (CPUE) and annual catch by vessel. Discarded catch estimates for Blue Warehou, eastern Gemfish, eastern Redfish, John Dory, Silver Trevally and eastern and western Deepwater Shark are provided by Deng et al. (2021), however, these are quite uncertain with most coefficient of variations (CVs) >40%. Discard estimates for School Shark have not been available since there have been no observers on gillnet and line vessels since 2016. However, following an analysis by Dr Tim Emery (ABARES) presented at the SharkRAG meeting in November 2021, SharkRAG accepted that the logbook reported discards of vessels equipped with onboard electronic video monitoring were accurate hence logbook reported discards of School Shark will be incorporated into the 2022 version of this report.

Blue Warehou catches are predominately associated with the demersal trawl sector fishing on the continental shelf targeting Flathead on the east coast of Australia and a mix of species west of Tasmania. There has been little change in the spatial distribution of Blue Warehou catches even though catch has declined from 1,000 t in 1998 to <50 t in the last five years. There is no evidence of targeting and no trawl vessels have reported consistently large catches in recent years. The estimate of unavoidable Blue Warehou bycatch in 2022 is 11t (95% CI 7-18 t).

Eastern Gemfish catches are predominately associated with the demersal trawl sector fishing on the continental slope targeting Pink Ling on the east coast of Australia and Blue Grenadier and Pink Ling west of Tasmania. There is also some eastern Gemfish catch associated with the hook sector targeting Blue-eye Trevalla. While eastern Gemfish catches have varied between 20 and 200t since the late 1990s there has been little change in the spatial distribution of catch. Eastern Gemfish catch in 2019 had increased to 70.4t from 29.9t in 2018, while the catch in 2020 was 69 t. There is no evidence of targeting with no trawl vessels reporting consistently large catches in recent years. The estimate of unavoidable eastern Gemfish bycatch in 2022 is 89 t (95% CI 69-112 t).

Catches eastern Redfish are predominately associated with the demersal trawl sector fishing on the shelf targeting Flathead on the southern New South Wales (NSW) coast. The majority of the Redfish catch is taken off NSW, while there are some catches off Victoria and Tasmania these are small compared with those from NSW. Redfish catches have declined from 1,750t in the late 1990s to <50t since 2016. Two trawl vessels have consistently reported higher catches of Redfish than other vessels over the last decade. These catches are low in absolute terms and are likely from vessels operating out of southern NSW ports, which is an area of high Redfish abundance, however, they warrant further investigation by AFMA. Estimates of unavoidable Redfish bycatch in 2022 are between 27 t (95% CI 23-32 t) for the high Flathead catch scenario (i.e. 2,407 t) and 23 t (95% CI 19-27t) for the low Flathead catch scenario (i.e. 2,000 t).

Around 80% of School Shark landings are associated with the gillnet and hook sectors targeting Gummy Shark, while 15% of the School Shark landed were taken by the demersal trawl sector fishing on the slope targeting Blue Grenadier and Pink Ling west of Tasmania. The spatial distribution of School Shark landings has changed substantially since the late 1990s in response to spatial management changes in the fishery. There is considerable spatial variability in the ratio of School Shark to Gummy Shark landings in the gillnet and hook sectors. School Shark bycatch rates are highest for the gillnet sector off western Tasmania at ~61% and the hook sector off western South Australia (SA) at ~21%, however, overall School Shark catch in these areas is low at ~15t per annum due to low effort in those areas. Bycatch rates off SA and Victoria are 15-20%, in western Bass Strait they are 6-9% and for eastern Bass Strait and eastern Tasmania they are 3-6% of Gummy Shark catch. School Shark landings have remained stable between 140 t and 260 t since the introduction of individual transferable quota in 2001. There is no evidence of gillnet or hook vessels reporting consistently large landings of School Shark in recent years which may suggest that targeting is occurring. Two trawl vessels have reported higher than average catches of School Shark over the last four years. While these catches are low in absolute terms and are likely from vessels fishing on the shelf west of Tasmania they may warrant further investigation by AFMA. The estimate of unavoidable landed School Shark bycatch in 2022 is 150 t (95% CI 126-177 t).

John Dory catches are predominately associated with the demersal trawl sector on the east coast of Australia. Catches of John Dory have declined from a peak of 150 t in the late 1980s and early 1990s, to around 100 t in the mid-2000s. Catches have continued to gradually decline and for the last five years catches have been around 60 t. Estimates of unavoidable bycatch of John Dory in 2022 are between 61t (95% CI 57-66 t) for the high Flathead catch scenario (i.e. 2,407 t) and 52t (95% CI 48-56 t) for the low Flathead catch scenario (i.e. 2,000 t).

Silver Trevally catches are predominately taken by trawlers off the NSW and Victorian coasts with small catches taken by Danish seiners and gillnets. Commonwealth catch of Silver Trevally oscillated between 150 and 500 t in the period 1986-2003 but have declined since 2004 to between 4 and 55t in the last five years. State catches, predominately from NSW, comprise a substantial component of total landings and these have exceeded Commonwealth landings since 2011. The estimate of unavoidable Silver Trevally bycatch in 2022 is 23t (95% CI 17-30 t).

Jackass Morwong catches off eastern Australia are predominately taken by trawlers, with a small proportion of Danish seine and hook catches. The majority of catches are taken from southern NSW, eastern Victoria and the east coast of Tasmania. Catch of eastern Jackass Morwong has declined from between 500 and 900 t in 1990s to 85.6 t in 2020. Estimates of unavoidable bycatch of eastern Jackass Morwong in 2022 are 119 t (95% CI 107-132 t) for the high Flathead catch scenario (i.e. 2,407 t) and 100t (95% CI 90-111 t) for the low Flathead catch scenario (i.e. 2,000 t).

Deepwater Shark are not currently assessed as a rebuilding species, however, they have been included in this report to assist in developing assessment approaches for the eastern and western stocks. Deepwater Shark were reported almost exclusively by trawl, with landings of the eastern stock being around 20-30 t over the last decade and landings of the western stock being 50-100t over the same period. They were caught on the slope between 600 and 1000m from southern NSW to South Australia. The estimated landed bycatch of Deepwater Shark in 2022 is 192 t (95% CI 158-232 t) for the east and west combined.

2 Introduction

In 2019 the AFMA Commission requested companion species and targeting analyses to provide updated estimates of unavoidable bycatch for rebuilding stocks. A companion species analysis that utilised an existing metier analysis of the SESSF (Briton, 2019) was presented to the December 2019 SERAG meeting. The metier analysis was based on SESSF logbook data from 2012-2017 and did not include the most recent year of available data. SERAG considered the approach promising, however, more work was required to evaluate the impact of omitting the current year's data. Additionally, SERAG requested that the method be compared to the approach of Klaer and Smith (2012).

At the 2020 SESSFRAG Data Meeting it was agreed that CSIRO would repeat the metier analysis undertaken in 2019 using logbook data over the 2014-2019 period and undertake a targeting analysis for rebuilding species. A comparison of the metier-based approach to estimate companion species catches with the approach of Klaer and Smith (2012) was deferred to a later time. The robustness of the method to the omission of recent data was evaluated by comparing estimates of the companion species catch of Blue Warehou, eastern Gemfish and eastern Redfish obtained using logbook data from 2012 - 2017 with those obtained using logbook data from 2014 - 2019.

The metier analysis showed that the majority of the bycatch of Blue Warehou, eastern Gemfish and eastern Redfish was associated with the trawl metiers catching Blue Grenadier, Flathead and Pink Ling (Burch et al., 2021a). Bycatch of Blue Warehou and eastern Redfish was associated with fishing on the shelf targeting mostly Flathead, while eastern Gemfish bycatch was associated with fishing on the shelf for Blue Grenadier and Pink Ling. The metier analysis was sensitive to the use of recent data with the bycatch estimates for eastern Gemfish being significantly different when the metier analysis was undertaken using 2016 - 2017 data compared with 2018 - 2019 data, suggesting that the metier analysis should be revised each year to use recent logbook data. At its December 2020 meeting SERAG supported the use of a metier analysis undertaken using recent logbook data as a useful tool for understanding the level of unavoidable bycatch and to assist in setting bycatch future TACs (SERAG, 2020).

The metier analysis that included estimates of School Shark bycatch was presented to SharkRAG in December 2020. SharkRAG had concerns that the metier analysis used data from a period where there had been spatial management changes in the Gummy Shark fishery and that it did not adequately capture the spatial variability in School Shark catches, and that the effect of variable discarding and the 1:5 School Shark to Gummy Shark catch ratio rule might skew results (SharkRAG, 2020). To address these concerns the metier analysis was repeated using logbook data from 2016-2019 (a period where there has been no change in spatial management), Shark zones instead of SEF zones and a shelf/slope depth split at 183m (Burch et al., 2021a). Clusters identified by the multivariate analysis were then aggregated to form metiers only after evaluating the spatial variability in School Shark catch using shark fishing zones. At its March 2021 meeting SharkRAG supported the use of the revised metier analysis to inform the School Shark TAC for 2022 (SharkRAG, 2021).

In this report, a single bycatch analysis is undertaken for the SESSF, using SEF zones for the trawl and Danish seine sectors and shark zones for gillnet and hook sectors. As in previous reports, separate cluster analyses were undertaken for each sector (Danish seine, gillnet, hook and trawl). The trawl analysis is split into eastern and western components at 147 degrees east longitude. To quantify the spatial variability in catch composition, the Shark zonation scheme is used for the gillnet and hook sectors, while the SEF zonation scheme is used for the Danish seine and trawl sectors (Figure 1). A single zonation scheme that combines the important aspects of the Shark and SEF schemes will be developed and presented to the August 2022 SESSFRAG Data Meeting. Metiers were developed using logbook data from 2016-2020 with recent logbook data (2019-2020) used to forecast the allocation of target species catch among metiers in 2022 in order to estimate bycatch for 2022. For the gillnet, hook and trap (GHAT) sector, depth was split between shelf and slope at 183m corresponding with a management separation between the scalefish and shark components of the hook sector. In the Commonwealth trawl sector (CTS) the shelf/slope split was at 200m.

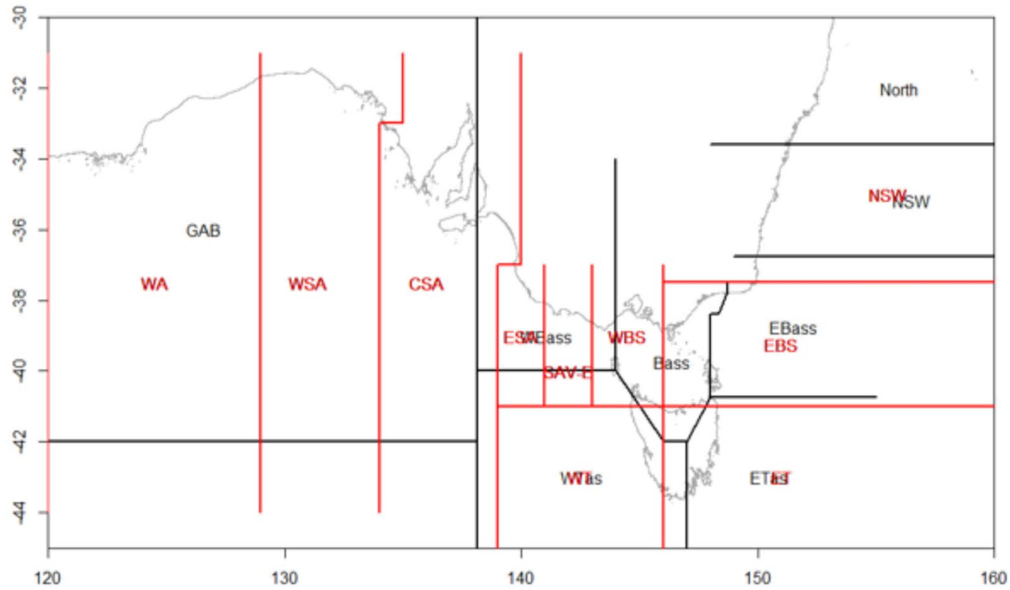

Figure 1 Map of Shark (red) and SEF (black) zonation schemes used in the metier analysis.

In addition to the metier analysis, this study also undertakes a targeting analysis to identify spatio-temporal patterns in catch and effort using a weight of evidence approach based on Haddon et al. (2016).

2.1 Changes in December 2021

This report updates the draft report that was presented to the September 2021 SERAG meeting (Burch et al., 2021b) with the following changes:

- The eastern stock of Jackass Morwong (*Nemadactylus macropterus*) and the Deepwater Shark basket of species are now included.
- Catches of eastern Redfish (*Centroberyx affinis*) reported in the GAB (SEF Zone 80) have been excluded from the targeting analysis due to likely misreporting of Bight Redfish (*Centroberyx gerrardi*).
- The unavoidable bycatch of Blue Warehou, the eastern stock of Gemfish, eastern Redfish, School Shark, John Dory, Silver Trevally, the eastern stock of Jackass Morwong and eastern and western Deepwater Sharks is quantified using a metier-based approach.

2.2 Changes in September 2021

The September 2021 report updated the report that incorporated data up to 2019 (Burch et al., 2021a) with the following changes:

- New data to 2020 were added,
- The targeting analysis now includes State catches and estimates of discarded catches (Deng et al. 2021), and
- While not currently considered to be over-fished, John Dory (*Zeus faber*) and Silver Trevally (*Pseudocaranx georgianus*) are included in this report at the request of AFMA due to concerns about their sustainability.

3 Methods

3.1 Metier analysis

This study uses a metier based approach to quantify the unavoidable bycatch of Blue Warehou, eastern Gemfish, eastern Redfish, School Shark, John Dory, Silver Trevally, eastern Jackass Morwong and Deepwater Shark. The metier analysis was undertaken using the R package vmstools (Deporte et al., 2012) using logbook data from 2016-2020 and recent price data obtained from ABARES (ABARES, 2021).

Details of the approach that was undertaken by Briton (2019) are summarised below and the components of the metier analysis that were repeated in this report are specified.

3.1.1 Defining Metiers

The metier analysis builds on the definition used by the European Data Collection Framework, which is "a group of fishing operations targeting a specific assemblage of species, using a specific gear, during a precise period of the year and/or within a specific area." A similar approach has been undertaken here, but one that is based on the species composition of the landings value rather than the landings weight since targeting is most likely to be driven by the value of the catch rather than its weight. A fleet, as defined within a stock assessment model, can be considered a group of vessels showing similar fishing patterns, in other words, operating in similar metiers. Fleets are not specifically considered in this analysis, although their presence is implied within the metiers.

The identification of metiers consists of two main steps:

1. A clustering of shots that have common characteristics using multivariate statistical methods, and
2. A post-hoc refinement of the clusters identified by the clustering algorithm in order to:
   - group clusters that do not show significant differences in terms of species composition, and
   - make sure that clusters reflect the intended targeting.

The cluster analysis undertaken by Briton (2019) used the first three steps of the workflow developed by Deporte et al. (2012), which is implemented in the R package *vmstools*:

1. Identification of the main species in the logbook data was done in order to restrict the dataset to these key species. Species were selected so that at least 90% of the total fishery value and 70% of each shot's value was represented in the final dataset used for clustering.
2. A preliminary principal component analysis (PCA) was undertaken on the dataset in order to identify groups of species that would be used to cluster the shots. The reason for applying a PCA to the dataset is that it reduces the number of variables that will be used for clustering (initially, the variables were the individual species but after running a PCA the the relevant factors from the PCA were used as variables for subsequent clustering).

3. A number of clustering algorithms and dissimilarity measures were evaluated. In order for large and small shots to be given equal importance, the clustering was done on the species contribution to the shots' value (the sum of which, across all species, is equal to 1), rather than the absolute values, as described below.

The input to the clustering algorithm is a two dimensional matrix M, with rows referring to logbook reported fishing shots (i), and columns to species (sp), with each entry $M_{i,sp}$ defined as:

$$M_{i,sp} = \frac{P_{sp} L_{i,sp}}{\sum P_{sp} L_{i,sp}},$$

where P_{sp} is the price per kg of species sp, and $L_{i,sp}$ is the landed catch weight of species sp in shot i.

The sensitivity of the clustering analysis to the number of clusters that are identified by the PCA was evaluated by setting lower thresholds of 70% and 80% of the explained variance. Setting lower thresholds failed to identify rare (but relevant) metiers such as the targeting of Orange Roughy (a fishery that was closed until 2015 in the eastern and western zones).

In addition to the sensitivity of the analysis to the number of clusters, Briton (2019) also evaluated the impact of using different clustering algorithms. Three different algorithms were evaluated HAC, K-means and CLARA. HAC and CLARA algorithms gave similar results, with both being different from K-means (consistent with tests run by Deporte et al. (2012)). The CLARA algorithm was chosen because it was more efficient for large data sets. Sensitivity of the results to the distance metric used to cluster the data was also investigated. The Euclidean and Manhattan distances are two commonly used dissimilarity measures in clustering analyses. Compared to the Euclidean distance, the Manhattan distance reduces the weight given to dimensions with large differences. However, in our case, we would like the metiers to reflect differences in targeted species, which correspond to the dimensions with the higher values. In this case, the Euclidean distance is better suited to the objective. Using the Euclidean distance allowed the identification of single species clusters (e.g. Royal Red Prawn trawling) which did not emerge when using the Manhattan distance. Since these single-species metiers are important for the fishery, Euclidean distances were used rather than Manhattan distances. The CLARA algorithm was selected as the optimal approach applied to the full data set (i.e. without prior PCA) with the Euclidean distance used as the dissimilarity metric.

Multi-species technical interactions are also sensitive to the scale at which data are analysed and working with spatially or temporally aggregated data can only increase the level of perceived interactions. Therefore, data was kept at the finest scale possible, i.e. at the shot level. This choice requires the clustering algorithm to work on a large data set which is possible using the CLARA algorithm, a variant of the Partition Around Medoids (PAM) clustering algorithm (Kaufman and Rousseeuw 2005) suited to the analysis of large data sets. In addition, separate clustering analyses were run for each of the five sectors (Danish seine, Gillnet, Hook, Trawl East and Trawl West).

Clusters were refined to metiers in two steps (Figure 2):

1. The cluster groupings that had similar species compositions and,
2. Based on expert knowledge of the fishery (mostly discussions with Simon Boag - SETFIA representative, and industry members attending SERAG meetings), clusters whose catch

composition was dominated by species that are not targeted by the fleets were assigned to a "mixed" metier as they are likely to be the result of luck rather than intended targeting.

Based on the findings of Briton (2019), subsequent repetition of the metier analysis in this study and by Burch et al. (2021a) was undertaken using the CLARA algorithm, a 90% threshold for cluster value and Euclidean distance as the dissimilarity metric. Grouping of clusters into metiers was based on the findings of Briton (2019) with some discussion at SharkRAG and SERAG in 2019 and 2020, however, this process would benefit from additional consultation with industry in the future.

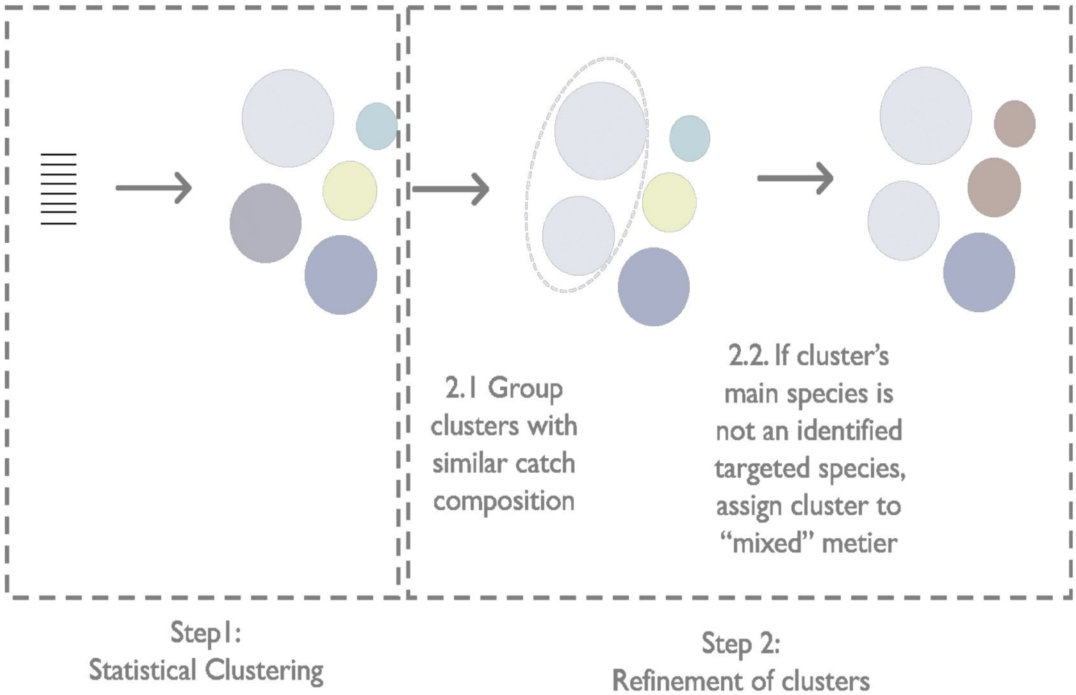

Figure 2 Steps of the metier definition.

3.1.2 Quantifying 2022 bycatch

The unavoidable bycatch of Blue Warehou, eastern Gemfish, eastern Redfish, School Shark, John Dory, Silver Trevally, eastern Jackass Morwong and Deepwater Shark in 2022 was quantified using the following steps:

1. Metiers were quantified using logbook data from 2016-2020 and recent price data following the process described above.
2. Logbook data for 2019 and 2020 was used to calculate the average annual catch of all species by metier.
3. Metiers associated with substantial catches of rebuilding species were identified along with the main target species (e.g. Flathead, Pink Ling, etc).

4. For each metier, the catch of each rebuilding species was quantified per unit of target species (e.g. 1 t of Pink Ling caught by the East Slope Trawl metier catches 1 kg of Blue Warehou, 16 kg of eastern Gemfish and 1 kg of eastern Redfish).
5. Assumed 2022 catches for target species are allocated among the metiers in the same proportion as the 2019 and 2020 data and the ratios from Step 4 are used to estimate the 2022 unavoidable bycatch of the above species.

Uncertainty in the rebuilding species bycatch estimates was quantified using a non-parametric bootstrap (i.e. resampling the data) treating the shots that comprised each metier in each year as the primary sampling unit. Confidence intervals were then constructed from the 2.5% and 97.5% quantiles of the bootstrapped data. While this allows the uncertainty within each metier to be quantified it does not account for variability in how target species catches are apportioned among metiers, however, accounting for this variability in the metier analysis potentially be investigated in the future.

To use the metier analysis to estimate the unavoidable bycatch of rebuilding and other selected species it was necessary to make assumptions about the target species catch, the allocation of target species catch among metiers and the ratio of target species catch to bycatch species catch for each metier in 2022. We assumed the following:

1. The metier analysis uses reported landed catches in logbooks and does not incorporate discards,
2. The distribution or abundance of the rebuilding species does not change, and
3. To estimate bycatch in 2022 the assumption is made that primary target species catches are caught by metiers in approximately the same proportions as they were in the 2019-2020 logbook data.

All of these assumptions also apply to the approach of Klaer and Smith (2012) and the evaluation of the potential impacts of violating any of these assumptions is beyond the scope of this study. Estimates of discarded catches are provided separately in the targeting analyses for each stock and need to be accounted for in any potential management measures.

Aggregation of Shark Zones

Some aggregation of the shark zones was undertaken to group zones that have similar rates of School Shark bycatch. The New South Wales zone (NSW) has negligible School Shark catch and remains a separate zone (NSW). Eastern Tasmania (ET) and Eastern Bass Strait (EBS) were combined into a single eastern Tasmania zone (EastTas). Central South Australia (CSA), Eastern South Australia (ESA) and Eastern South Australia / Victoria (SAV-E) were combined into a South Australia / Victoria zone (SA-Vic). Western Tasmania (WT) and Western Bass Strait (WBS) remain separate zones WestTas and WestBS. There is little reported catch in the Western Australia (WA) zone in 2016-2020 so it was combined with Western South Australia (WSA) to form WestSA.

3.2 Targeting analysis

A weight of evidence approach based on Haddon et al. (2016) was used to investigate the spatial and temporal characteristics of the incidental catches of Blue Warehou, eastern Gemfish, eastern

Redfish, School Shark, John Dory, Silver Trevally, eastern Jackass Morwong and Deepwater Shark. Plots of standardized CPUE and annual fishing depth were reproduced from Sporcic (2021a), Sporcic (2021b) and Sporcic (2021c). The spatial distribution of catches are also examined for evidence of changes in fishing behaviour or the distribution of the rebuilding species and plots of annual catch by vessel are presented.

3.2.1 Blue Warehou

Investigations in 2019 by Robin Thomson and Tamre Sarhan (AFMA) into the under reporting of Blue Warehou in logbooks compared to CDRs suggest that some operators may be reporting Blue Warehou (*Seriolella brama*) as Black Trevally (*Caranx lugubris*) in e-Logs. While Black Trevally is one of many common names for Blue Warehou, *Caranx lugubris* is a tropical species and unlikely to be caught in any great quantities in the SESSF. While AFMA have contacted operators to request they report Blue Warehou as *Seriolella brama* in logbooks, to make sure that we are not missing any logbook records relating to Blue Warehou we treat any *Caranx lugubris* reported in zones 10-60 as Blue Warehou throughout this document.

The majority of Commonwealth catch of Blue Warehou are taken by the demersal trawling and it is therefore the focus of the investigation of potential targeting of Blue Warehou. Blue Warehou are closely related to Silver Warehou and historically catches have often been reported mixed, or with all warehou species combined and referred to as Tassie trevally (Sporcic et al., 2015). This practice was most prevalent in the late 1980s when it was unclear which species was caught and recorded in Commonwealth logbooks. Consequently, logbook catches of Blue Warehou in the 1990s presented in this study should be interpreted with caution.

3.2.2 Eastern Gemfish

The majority of Commonwealth catch of eastern Gemfish are taken by demersal trawling which is therefore the focus of our investigation into potential targeting of eastern Gemfish.

3.2.3 Eastern Redfish

The majority of Commonwealth catch of eastern Redfish are taken by demersal trawling, which is therefore the focus of our investigation into potential targeting of eastern Redfish. Note that this analysis does not include Bight Redfish and any records of eastern Redfish reported in Zone 80 (the GAB) were excluded due to likely misreporting of Bight Redfish.

3.2.4 School Shark

School Shark are predominately landed as bycatch of the gillnet and hook sectors targeting Gummy Shark, however, there is also some School Shark bycatch associated with the trawl sector and the hook sector targeting Blue-eye Trevalla. Because the majority of School Shark landings are associated with Gummy Shark catch, and because the ratio of School Shark to Gummy Shark landings are legally capped to 1:5 (at the level of the quota holder), this ratio is reported.

3.2.5 John Dory

The majority of Commonwealth catch of John Dory are taken by demersal trawling, with a small amount of catch taken by Danish seine.

3.2.6 Silver Trevally

Silver Trevally catches are predominately taken by trawl with small catches taken by Danish seine and gillnets.

3.2.7 Jackass Morwong East

The eastern stock of Jackass Morwong was assessed to be below its limit reference point in 2021 (Day et al., 2021). Jackass Morwong East has been included in the December version of this report at the request of AFMA.

3.2.8 Deepwater Shark

During 2020 and 2021 difficulties in assessing the eastern and western stocks of Deepwater Shark led AFMA to request their inclusion in the December version of this report to assist in developing assessment approaches for these stocks.

4 Results

4.1 Metier analysis

4.1.1 Target Species Catches for 2022

Six target species are considered in this analysis, Blue Grenadier, Blue-eye Trevalla, Flathead, Gummy Shark, Orange Roughy and Pink Ling. The total allowable catch (TAC) for Pink Ling is split between the eastern and western stocks and there are two separate Orange Roughy management zones that support targeted fishing, the Eastern Zone (which includes Pedra Branca from the Southern Zone) and the Western Zone which is currently managed as an exploratory fishery with a research catch allowance. While some other species are targeted in the SESSF (i.e Deepwater Flathead and School Whiting) they catch little of the bycatch species of interest to this study and are not included.

Assumed target species catches in 2022 were chosen in consultation with AFMA and are based on the preliminary recommended biological catches (RBCs) from stocks being assessed in 2021, on RBCs for those stocks with existing multi-year TACs (MYTACs), and on the 2021 catch for stocks whose TAC is substantially under caught. Target species catches in 2022 to be used in the metier analysis to estimate the unavoidable bycatch of rebuilding and other selected species are provided in Table 1 and were selected based on the rationale below:

- Blue Grenadier: use the RBC from the 2021 base-case assessment, moderated by the 50% large change rule and add a 1,000 t provision for under catch in the 2021/22 season.
- Blue-eye Trevalla: assume that only 44% of the 2021/2022 TAC will be taken.
- Flathead: use the RBC for 2022 from the 2020 assessment and subtract the 2022 model estimated discards and a four year weighted mean (2017-2020) of State catches.
- Gummy Shark: use the RBC for 2022 from the 2021 assessment and subtract a four year weighted mean (2017-2020) of estimated discards and State catches.
- Pink Ling East: the estimate is based on recent catches and the likelihood of a modest increase in the TAC.
- Pink Ling West: the estimate is based on recent catches and the likelihood of a modest increase in the TAC.
- Orange Roughy Eastern: use the RBC from the 2021 base-case assessment and add a 215 t provision for under catch in the 2021/22 season.
- Orange Roughy Western: the estimate is based on 2021 catch.

At its November 2021 meeting SERAG requested that the metier analysis consider two additional scenarios of future Flathead catch of 2,000 and 2,200 t (along with the provisional 2022/23 TAC of 2,407 t).

Table 1 Assumed catch (t) of target species in 2022 used in the estimation of bycatch in 2022 (from the metier analysis), along with the RBC from MYTAC of the most recent assessment, State catch (t), Discards (t), 2021 TAC (t) and 2021 catch (t).

SPECIES	ASSUMED CATCH	RBC	STATE CATCH	DISCARDS	2021 TAC	2021 CATCH
Blue Grenadier	19,274.5		0.0		13,315.8	11,798.7
Blue-eye Trevalla	300.0		19.1	8.4	492.5	215.4
Flathead	2,407.2	2,706	117.8	181.0	2,236.2	2,045.1
Gummy Shark	1,540.8	1,727	113.5	72.7	1,854.7	1,806.0
Orange Roughy East	1,159.0	944				
Orange Roughy West	150.0					
Pink Ling			54.8		1,436.0	869.3
Pink Ling East	500.0					436.0
Pink Ling West	500.0					474.0

4.1.2 2022 bycatch estimates

The estimated 2022 bycatch of rebuilding and other selected species for the three scenarios of assumed 2022 Flathead catch are provided in Table 2. Estimates of the 2022 target species catch by metier are provided in Table 3 for the main target species metiers and Table 4 for the metiers that have little target species catch. The estimated 2022 bycatch of rebuilding and other selected species by metier is provided in Table 5 and Table 6. The small increase in School Shark and Deepwater Shark bycatch under the 2,000 t and 2,200 t Flatead catch scenarios is associated with other metiers taking the target species catch (principally Gummy Shark) that would otherwise have been taken by the Flathead metiers.

Table 2 Estimated landed bycatch (t) of rebuilding species and species of interest based on assumed 2022 target species catch (see Table 1) for three scenarios of 2022 Flathead catch. Lower 2.5% and Upper 97.5%: Lower and upper bootstrapped confidence intervals.

	Scenario 1 (2,407t Flathead catch)			Scenario 2 (2,200t Flathead Catch)			Scenario 3 (2,000t Flathead Catch)		
Species Group	**Estimate**	**lower 2.5%**	**upper 97.5%**	**Estimate**	**lower 2.5%**	**upper 97.5%**	**Estimate**	**lower 2.5%**	**upper 97.5%**
Blue Warehou	11.4	7.0	17.6	10.9	6.7	16.9	10.5	6.5	16.1
Deepwater Shark	192.4	158.0	231.5	192.5	158.0	231.5	192.5	158.0	231.6
Gemfish East	88.7	68.9	111.9	88.3	68.5	111.3	87.8	68.2	110.7
Jackass Morwong East	118.8	107.0	132.0	109.2	98.2	121.4	99.8	89.6	111.2
John Dory	61.3	56.5	66.4	56.4	51.9	61.1	51.6	47.5	56.0
Redfish	27.2	23.1	32.2	25.0	21.1	29.8	22.9	19.3	27.4
School Shark	149.8	126.1	176.9	150.1	126.3	177.2	150.4	126.6	177.5
Silver Trevally	23.0	17.1	28.9	21.0	15.6	26.4	19.1	14.2	24.0

Table 3 Estimated 2022 catch (t) for eight target species (columns) and main target species metiers (rows). Catch estimates are based on assumed 2022 catch of target species for Scenario 1 (2,407 t of Flathead being caught in 2022).

Metier	Blue Grenadier	Blue-eye Trevalla	Flathead	Gummy Shark	Orange Roughy Eastern	Orange Roughy West	Pink Ling East	Pink Ling West
Trawl East Orange Roughy	0.6	0.3	<0.1	<0.1	1132.3	<0.1	0.2	<0.1
Trawl West Orange Roughy	7.6	<0.1	<0.1	<0.1	26.2	148.6	<0.1	1.2
Danish Seine Flathead	<0.1	<0.1	1218.7	16.3	<0.1	<0.1	1.2	<0.1
Trawl East Flathead Zone10	<0.1	<0.1	154.1	4.4	<0.1	<0.1	0.6	<0.1
Trawl East Flathead Zone2060	2.1	<0.1	665.6	29.9	<0.1	<0.1	14.1	<0.1
Trawl East Flathead Zone30	9.8	<0.1	308.0	17.7	<0.1	<0.1	1.7	<0.1
Gillnet Gummy Shark East	<0.1	<0.1	0.2	615.9	<0.1	<0.1	<0.1	<0.1
Gillnet Gummy Shark SA-Vic	<0.1	<0.1	<0.1	54.5	<0.1	<0.1	<0.1	0.1
Gillnet Gummy Shark West Bass	<0.1	<0.1	<0.1	254.3	<0.1	<0.1	<0.1	<0.1
Gillnet Gummy Shark West Tas	<0.1	<0.1	<0.1	6.9	<0.1	<0.1	<0.1	<0.1
Hook Gummy Shark East	<0.1	<0.1	0.4	74.1	<0.1	<0.1	0.2	<0.1
Hook Gummy Shark SA-Vic	<0.1	0.1	0.4	275.0	<0.1	<0.1	<0.1	<0.1
Hook Gummy Shark West Bass	<0.1	<0.1	<0.1	21.8	<0.1	<0.1	<0.1	<0.1
Hook Gummy Shark West SA	<0.1	<0.1	<0.1	51.5	<0.1	<0.1	<0.1	<0.1
Hook Gummy Shark West Tas	<0.1	<0.1	<0.1	4.7	<0.1	<0.1	<0.1	0.1
Hook Blue-eye Trevalla East	2.3	113.3	<0.1	0.3	<0.1	<0.1	6.6	2.1
Hook Blue-eye Trevalla West	0.7	134.0	<0.1	0.5	<0.1	<0.1	<0.1	8.9
Hook Pink Ling East	2.3	5.2	<0.1	0.4	<0.1	<0.1	115.5	0.1
Trawl East Pink Ling	140.0	0.7	2.0	4.1	0.1	<0.1	289.2	<0.1
Hook Pink Ling West	0.7	5.7	<0.1	2.0	<0.1	<0.1	<0.1	140.0
Trawl West Mixed Slope	560.3	6.3	2.3	11.7	<0.1	0.1	<0.1	119.1
Trawl West Pink Ling	92.2	0.5	<0.1	0.7	<0.1	0.5	<0.1	167.0
Trawl East Blue Grenadier	557.3	0.5	0.2	0.5	<0.1	<0.1	39.7	<0.1

Metier	Blue Grenadier	Blue-eye Trevalla	Flathead	Gummy Shark	Orange Roughy Eastern	Orange Roughy West	Pink Ling East	Pink Ling West
Trawl West Blue Grenadier Zone50	242.7	0.3	<0.1	0.1	<0.1	0.1	<0.1	7.1
Trawl West Blue Grenadier Zone40	17615.1	1.7	<0.1	<0.1	<0.1	0.4	<0.1	22.7

Table 4 Estimated 2022 catch (t) for the eight target species (columns) and metiers (rows) corresponding to minimal target species catch. Catch estimates are based on assumed 2022 catches of target species for Scenario 1 (2,407 t of Flathead being caught in 2022).

Metier	Blue Grenadier	Blue-eye Trevalla	Flathead	Gummy Shark	Orange Roughy Eastern	Orange Roughy West	Pink Ling East	Pink Ling West
Danish Seine Mixed	<0.1	<0.1	16.8	18.3	<0.1	<0.1	0.2	<0.1
Danish Seine School Whiting	<0.1	<0.1	19.5	2.0	<0.1	<0.1	0.1	<0.1
GAB Danish Seine Deepwater Flathead	<0.1	<0.1	<0.1	6.6	<0.1	<0.1	<0.1	<0.1
GAB Trawl Bight Redfish	<0.1	<0.1	<0.1	6.1	<0.1	<0.1	<0.1	<0.1
GAB Trawl Deepwater Flathead	22.4	<0.1	<0.1	46.6	<0.1	<0.1	<0.1	<0.1
Hook Mixed Scalefish East	1.0	10.3	<0.1	0.3	<0.1	<0.1	24.4	2.9
Hook Mixed Scalefish West	1.2	13.9	<0.1	1.3	<0.1	<0.1	<0.1	24.6
Trawl East Royal Red Prawn	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.9	<0.1
Trawl East Mixed Slope	6.4	6.8	8.8	8.0	0.1	<0.1	3.8	<0.1
Trawl East School Whiting	0.1	<0.1	7.5	0.1	<0.1	<0.1	<0.1	<0.1
Trawl West Mixed Deep	6.5	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	2.2
Trawl West Mixed Shelf	3.0	<0.1	2.3	2.3	<0.1	<0.1	<0.1	0.6

Table 5 Estimated 2022 catch (t) for bycatch species (columns) and the main target species metiers (rows). Catch estimates are based on assumed 2022 catch of target species for Scenario 1 (2,407 t of Flathead being caught in 2022).

Metier	Blue Warehou	Deepwater Shark	Eastern Gemfish	Jackass Morwong East	John Dory	Eastern Redfish	School Shark	Silver Trevally
Trawl East Orange Roughy	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001
Trawl West Orange Roughy	<0.001	<0.001	0.038	<0.001	<0.001	<0.001	<0.001	<0.001
Danish Seine Flathead	0.327	0.327	<0.001	5.361	15.090	0.164	0.192	0.040
Trawl East Flathead Zone10	0.411	0.411	0.793	3.389	3.965	20.875	<0.001	21.574
Trawl East Flathead Zone2060	0.248	0.248	2.878	53.705	32.817	4.073	1.017	0.747
Trawl East Flathead Zone30	4.355	4.355	2.053	47.342	3.813	<0.001	1.269	<0.001
Gillnet Gummy Shark East	0.313	0.313	<0.001	0.025	0.047	0.001	17.099	0.003
Gillnet Gummy Shark SA-Vic	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	10.281	0.002
Gillnet Gummy Shark West Bass	<0.001	<0.001	<0.001	<0.001	0.035	<0.001	22.717	<0.001
Gillnet Gummy Shark West Tas	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	4.263	<0.001
Hook Gummy Shark East	<0.001	<0.001	0.080	0.009	<0.001	<0.001	4.626	<0.001
Hook Gummy Shark SA-Vic	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	42.454	<0.001
Hook Gummy Shark West Bass	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.388	<0.001
Hook Gummy Shark West SA	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	10.985	<0.001
Hook Gummy Shark West Tas	<0.001	<0.001	0.042	<0.001	<0.001	<0.001	0.418	<0.001
Hook Blue-eye Trevalla East	<0.001	<0.001	13.655	0.081	<0.001	0.007	1.177	0.016
Hook Blue-eye Trevalla West	<0.001	<0.001	0.411	<0.001	<0.001	<0.001	1.034	<0.001
Hook Pink Ling East	<0.001	<0.001	0.455	0.616	<0.001	<0.001	0.230	<0.001
Trawl East Pink Ling	0.002	0.002	17.280	1.245	0.149	0.156	0.344	0.010
Hook Pink Ling West	<0.001	<0.001	0.603	<0.001	<0.001	<0.001	2.127	<0.001
Trawl West Mixed Slope	3.444	3.444	10.018	<0.001	0.061	0.448	15.745	0.255
Trawl West Pink Ling	0.020	0.020	3.296	<0.001	<0.001	0.045	1.402	0.176
Trawl East Blue Grenadier	0.057	0.057	8.357	0.283	0.069	<0.001	0.183	<0.001

Metier	Blue Warehou	Deepwater Shark	Eastern Gemfish	Jackass Morwong East	John Dory	Eastern Redfish	School Shark	Silver Trevally
Trawl West Blue Grenadier Zone50	0.011	0.011	<0.001	<0.001	<0.001	0.014	0.189	<0.001
Trawl West Blue Grenadier Zone40	0.196	0.196	9.698	<0.001	0.001	<0.001	2.020	<0.001

Table 6 Estimated 2022 catch (t) for bycatch species and the metiers corresponding to minimal target species catch. Catch estimates are based on assumed 2022 catches of target species for Scenario 1 (2,407 t of Flathead being caught in 2022).

Metier	Blue Warehou	Deepwater Shark	Eastern Gemfish	Jackass Morwong East	John Dory	Eastern Redfish	School Shark	Silver Trevally
Danish Seine Mixed	0.414	<0.001	<0.001	1.203	4.134	4.134	0.074	0.004
Danish Seine School Whiting	0.077	<0.001	<0.001	0.010	0.666	0.666	0.023	0.003
GAB Danish Seine Deepwater Flathead	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
GAB Trawl Bight Redfish	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.486	<0.001
GAB Trawl Deepwater Flathead	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.973	<0.001
Hook Mixed Scalefish East	<0.001	<0.001	<0.001	0.347	<0.001	<0.001	0.221	<0.001
Hook Mixed Scalefish West	<0.001	0.037	0.037	<0.001	<0.001	<0.001	1.046	<0.001
Trawl East Royal Red Prawn	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Trawl East Mixed Slope	0.010	0.527	0.527	5.211	0.282	0.282	0.816	<0.001
Trawl East School Whiting	0.179	<0.001	<0.001	0.001	0.156	0.156	0.010	0.123
Trawl West Mixed Deep	<0.001	10.391	10.391	<0.001	<0.001	<0.001	<0.001	<0.001
Trawl West Mixed Shelf	1.348	<0.001	<0.001	<0.001	<0.001	<0.001	4.001	<0.001

4.1.3 2022 Blue Warehou bycatch by metier

Trawl sector metiers are estimated to take the vast majority of Blue Warehou bycatch (46% from Eastern Trawl and 44% from Western Trawl metiers; Table 7). The most important metiers from these sectors are the *Trawl East Flathead Zone30* metier (38% bycatch) and *Trawl West Mixed Slope* metier (30% bycatch). These metiers contribute 13% of the total Flathead catch and 24% of the total Pink Ling catch respectively (Table 7). The Danish seine and gillnet metiers contribute 7% and 3% of the Blue Warehou bycatch respectively (Table 5 and 6).

Table 7 Dominant and aggregated less-dominant metiers for Blue Warehou. Percentage of the total catch within the SESSF shown for Blue Warehou bycatch and target species. Catch estimates are based on assumed 2022 catches of target species for Scenario 1 (2,407 t of Flathead being caught in 2022).

Metier	Blue Warehou bycatch	Blue Grenadier	Blue-eye Trevalla	Flathead	Gummy Shark	Orange Roughy Eastern	Orange Roughy West	Pink Ling East	Pink Ling West
Trawl East Flathead Zone30	38.16	0.05	<0.01	12.80	1.15	<0.01	<0.01	0.34	<0.01
Trawl West Mixed Slope	30.18	2.91	2.11	0.10	0.76	<0.01	0.10	<0.01	23.88
Trawl West Mixed Shelf	11.81	0.02	0.01	0.09	0.15	<0.01	<0.01	<0.01	0.12
Eastern Trawl others	6.29	3.63	0.42	34.15	2.53	0.01	<0.01	68.78	<0.01
Gillnet combined	2.74	<0.01	<0.01	0.01	60.53	<0.01	<0.01	0.01	0.03
Hook Combined	<0.01	0.03	86.16	0.03	27.96	<0.01	<0.01	24.50	30.32
Western Trawl others	<0.01	0.28	1.74	0.25	<0.01	0.05	<0.01	0.37	<0.01
Non target others	<0.01	5.97	0.20	10.38	2.19	5.81	<0.01	0.20	6.09
Trawl West Blue Grenadier Zone40	1.72	91.39	0.56	<0.01	<0.01	<0.01	0.25	<0.01	4.55
Trawl East Orange Roughy	<0.01	<0.01	0.11	<0.01	<0.01	97.73	<0.01	0.04	<0.01
Trawl West Orange Roughy	<0.01	0.04	<0.01	<0.01	<0.01	2.26	99.08	<0.01	0.25

4.1.4 2022 Eastern Gemfish bycatch by metier

Trawl sector metiers contribute ~78% of the Gemfish bycatch, with 53% taken by eastern trawl metiers and 26% by western trawl metiers (Table 8) – note that eastern gemfish extend into western tasmania where they are available to western metiers. The two important metiers from these sectors (contribution bycatch) are the *Trawl East Pink Ling* metier (19% bycatch) and the *Trawl East Mixed Slope* metier (17% bycatch). The *Hook Blue-eye Trevalla East* metier contributes 15% of the Gemfish bycatch and is more important than the remaining trawl metiers. These three metiers contribute 58% of the total Pink Ling catch and 40% of total Blue-eye Trevalla catch.

Table 8 Dominant and aggregated less-dominant metiers for eastern Gemfish. Percentage of the total catch within the SESSF shown for eastern Gemfish bycatch and target species. Catch estimates are based on assumed 2022 catches of target species for Scenario 1 (2,407 t of Flathead being caught in 2022).

Metier	Eastern Gemfish bycatch	Blue Grenadier	Blue-eye Trevalla	Flathead	Gummy Shark	Orange Roughy Eastern	Orange Roughy West	Pink Ling East	Pink Ling West
Trawl East Pink Ling	19.48	0.73	0.24	0.08	0.27	0.01	<0.01	57.89	<0.01
Trawl East Mixed Slope	17.30	0.03	2.28	0.37	0.52	<0.01	<0.01	0.75	<0.01
Hook Blue-eye Trevalla East	15.39	0.01	37.77	<0.01	0.02	<0.01	<0.01	1.33	0.42
Trawl West Mixed Slope	11.29	2.91	2.11	0.10	0.76	<0.01	0.10	<0.01	23.88
Trawl West Blue Grenadier Zone40	10.93	91.39	0.56	<0.01	<0.01	<0.01	0.25	<0.01	4.55
Trawl East Blue Grenadier	9.42	2.89	0.16	0.01	0.03	<0.01	<0.01	7.94	<0.01
Eastern Trawl other	6.45	2.95	0.18	46.86	3.41	<0.01	<0.01	11.23	<0.01
Non target species other	4.17	21.44	19.19	21.10	20.95	21.46	21.47	20.72	21.47
Western Trawl other	3.72	1.74	0.25	<0.01	0.05	<0.01	0.37	<0.01	34.89
Hook combined	1.79	0.03	86.16	0.03	27.96	<0.01	<0.01	24.50	30.32
Trawl West Orange Roughy	0.04	0.04	<0.01	<0.01	<0.01	2.26	99.08	<0.01	0.25
Gillnet combined	<0.01	<0.01	<0.01	0.01	60.08	<0.01	<0.01	0.01	0.03
Danish Seine Flathead	<0.01	<0.01	<0.01	50.63	1.06	<0.01	<0.01	0.25	<0.01
Trawl East Orange Roughy	<0.01	<0.01	0.11	<0.01	<0.01	97.73	<0.01	0.04	<0.01

4.1.5 2022 Eastern Redfish bycatch by metier

The eastern trawl sector metiers contribute most of the eastern Redfish bycatch, with ~92% of eastern Redfish catches taken by this sector (Table 9). The metiers with the most substantial Redfish bycatch are the *Trawl East Flathead Zone10* metier (77% bycatch) and *Trawl East Flathead Zone2060* metier (15% bycatch). These metiers contribute 6% and 28% of the total Flathead catch respectively.

Table 9 Dominant and aggregated less-dominant metiers for eastern Redfish. Percentage of the total catch within the SESSF shown for eastern Redfish bycatch and target species. Catch estimates are based on assumed 2022 catches of target species for Scenario 1 (2,407 t of Flathead being caught in 2022).

Metier	Eastern Redfish bycatch	Blue Grenadier	Blue-eye Trevalla	Flathead	Gummy Shark	Orange Roughy Eastern	Orange Roughy West	Pink Ling East	Pink Ling West
Trawl East Flathead Zone10	76.67	<0.01	<0.01	6.40	0.29	<0.01	<0.01	0.12	<0.01
Trawl East Flathead Zone2060	14.96	0.01	0.01	27.65	1.94	<0.01	<0.01	2.83	<0.01
Non target species	5.28	5.70	0.21	10.39	2.28	5.96	<0.01	0.20	6.09
Western Trawl other	1.87	4.64	2.36	0.10	0.81	<0.01	0.47	<0.01	58.77
Danish Seine Flathead	0.60	<0.01	<0.01	50.63	1.06	<0.01	<0.01	0.25	<0.01
Eastern Trawl other	0.57	3.67	0.40	12.89	1.45	0.01	<0.01	66.17	<0.01
Hook combined	0.05	0.59	0.03	86.16	0.03	27.96	<0.01	<0.01	24.50
Gillnet combined	<0.01	0.02	<0.01	<0.01	0.01	60.08	<0.01	<0.01	0.01
Trawl East Orange Roughy	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	97.73	<0.01	0.04
Trawl West Blue Grenadier Zone40	<0.01	<0.01	91.39	0.56	<0.01	<0.01	<0.01	0.25	<0.01
Trawl West Orange Roughy	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	2.26	99.08	<0.01

4.1.6 2022 School Shark bycatch by metier

The hook and gillnet metiers targeting Gummy Shark contribute ~79% of the School Shark bycatch, with 36% from gillnet and ~43% from hook metiers (Table 10);as noted above, spatial differences in School Shark bycatch rates appear to be driving the differences between the gears. The most important metiers corresponding to the greatest contribution of bycatch from these sectors are the *Hook Gummy Shark SA-Vic metier* (~28% bycatch) and the *Gillnet Gummy Shark West Bass* metier (~15% bycatch). These two metiers contribute to ~18% and ~17% of the total Gummy Shark catch respectively.

Table 10 Dominant and aggregated less-dominant metiers for School Shark. Percentage of the total catch within the SESSF shown for School Shark bycatch and target species. Catch estimates are based on assumed 2022 catches of target species for Scenario 1 (2,407 t of Flathead being caught in 2022).

Metier	School Shark bycatch	Blue Grenadier	Blue-eye Trevalla	Flathead	Gummy Shark	Orange Roughy Eastern	Orange Roughy West	Pink Ling East	Pink Ling West
Hook Gummy Shark SA-Vic	28.34	<0.01	0.05	0.02	17.87	<0.01	<0.01	<0.01	<0.01
Gillnet Gummy Shark West Bass	15.16	<0.01	<0.01	<0.01	16.52	<0.01	<0.01	<0.01	0.01
Hook other	14.67	0.59	0.03	86.16	0.03	27.96	<0.01	<0.01	24.50
Gillnet Gummy Shark East	11.41	<0.01	<0.01	0.01	40.02	<0.01	<0.01	0.01	<0.01
Trawl West Mixed Slope	10.51	2.91	2.11	0.10	0.76	<0.01	0.10	<0.01	23.88
Gillnet other	9.71	<0.01	<0.01	<0.01	3.99	<0.01	<0.01	<0.01	0.02
Non target species	5.77	5.70	0.21	10.39	2.28	5.96	<0.01	0.20	6.09
Eastern Trawl others	1.88	3.68	0.42	46.94	3.68	0.01	<0.01	69.12	<0.01
Trawl West Blue Grenadier Zone40	1.35	<0.01	91.39	0.56	<0.01	<0.01	<0.01	0.25	<0.01
Western Trawl other	1.06	1.74	0.25	<0.01	0.05	<0.01	0.37	<0.01	34.89
Danish Seine Flathead	0.13	<0.01	<0.01	50.63	1.06	<0.01	<0.01	0.25	<0.01
Trawl East Orange Roughy	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	97.73	<0.01	0.04
Trawl West Orange Roughy	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	2.26	99.08	<0.01

4.1.7 2022 John Dory bycatch by metier

The eastern trawl and Danish seine metiers account for ~91% of John Dory bycatch, with 67% taken by the two eastern trawl metiers (i.e., *Trawl East Flathead Zone2060* and *Eastern Trawl other*) and ~25% by Danish seine metiers (Table 11). The metiers with the highest bycatch of John Dory are the *Trawl East Flathead Zone2060* metier (53% bycatch) and the *Danish seine Flathead* metier (25% bycatch). These metiers contribute 28% and 51% of the total Flathead catch respectively.

Table 11 Dominant and aggregated less-dominant metiers for John Dory. Percentage of the total catch within the SESSF shown for John Dory bycatch and target species. Catch estimates are based on assumed 2022 catches of target species for Scenario 1 (2,407 t of Flathead being caught in 2022).

Metier	John Dory bycatch	Blue Grenadier	Blue-eye Trevalla	Flathead	Gummy Shark	Orange Roughy Eastern	Orange Roughy West	Pink Ling East	Pink Ling West
Trawl East Flathead Zone2060	53.55	0.01	0.01	27.65	1.94	<0.01	<0.01	2.83	<0.01
Danish Seine Flathead	24.62	<0.01	<0.01	50.63	1.06	<0.01	<0.01	0.25	<0.01
Eastern Trawl other	13.05	3.67	0.41	19.29	1.74	0.01	<0.01	66.29	<0.01
Western Trawl other	0.10	4.64	2.36	0.10	0.81	<0.01	0.47	<0.01	58.77
Gillnet combined	0.13	0.02	<0.01	<0.01	0.01	60.08	<0.01	<0.01	0.01
Hook combined	<0.01	0.59	0.03	86.16	0.03	27.96	<0.01	<0.01	24.50
Non target species	8.54	5.70	0.21	10.39	2.28	5.96	<0.01	0.20	6.09
Trawl East Orange Roughy	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	97.73	<0.01	0.04
Trawl West Blue Grenadier Zone40	<0.01	<0.01	91.39	0.56	<0.01	<0.01	<0.01	0.25	<0.01
Trawl West Orange Roughy	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	2.26	99.08	<0.01

4.1.8 2022 Silver Trevally bycatch by metier

The eastern trawl sector accounts for ~97% of the Silver Trevally bycatch (Table 12). The *Trawl East Flathead Zone10* metier catches ~94% of the total Silver Trevally bycatch. This metier catches ~6% of the total Flathead catch.

Table 12 Dominant and aggregated less-dominant metiers for Silver trevally. Percentage of the total catch within the SESSF shown for John Dory bycatch and target species. Catch estimates are based on assumed 2022 catches of target species for Scenario 1 (2,407 t of Flathead being caught in 2022).

Metier	Silver Trevally bycatch	Blue Grenadier	Blue-eye Trevalla	Flathead	Gummy Shark	Orange Roughy Eastern	Orange Roughy West	Pink Ling East	Pink Ling West
Trawl East Flathead Zone10	94.00	<0.01	<0.01	6.40	0.29	<0.01	<0.01	0.12	<0.01
Eastern Trawl other	3.29	3.68	0.42	40.54	3.39	0.01	<0.01	69.00	<0.01
Western Trawl other	1.88	4.64	2.36	0.10	0.81	<0.01	0.47	<0.01	58.77
Danish Seine Flathead	0.17	<0.01	<0.01	50.63	1.06	<0.01	<0.01	0.25	<0.01
Gillnet combined	0.02	0.02	<0.01	<0.01	0.01	60.08	<0.01	<0.01	0.01
Hook combined	0.07	0.59	0.03	86.16	0.03	27.96	<0.01	<0.01	24.50
Non target species	0.56	5.70	0.21	10.39	2.28	5.96	<0.01	0.20	6.09
Trawl East Orange Roughy	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	97.73	<0.01	0.04
Trawl West Blue Grenadier Zone40	<0.01	<0.01	91.39	0.56	<0.01	<0.01	<0.01	0.25	<0.01
Trawl West Orange Roughy	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	2.26	99.08	<0.01

4.1.9 2022 Jackass Morwong East bycatch by metier

The eastern trawl sector catches almost 90% of the eastern Jackass Morwong bycatch (Table 13). The *East Flathead Zone2060* metier (~45% bycatch) and the *Trawl East Flathead Zone30* metier (~40% bycatch) have the highest catches. These two metiers contribute ~28% and ~12% the total Flathead catch respectively. The remaining eastern Jackass Morwong bycatch is taken by the *Danish Seine Flathead* metier, *Trawl East Mixed Slope* metier and the *Eastern Trawl other* metier which combined account for almost all of the remaining eastern Jackass Morwong bycatch.

Table 13 Dominant and aggregated less-dominant metiers for Jackass Morwong east. Percentage of the total catch within the SESSF shown for Jackass Morwong east bycatch and target species. Catch estimates are based on assumed 2022 catches of target species for Scenario 1 (2,407 t of Flathead being caught in 2022).

Metier	Jackass Morwong East bycatch	Blue Grenadier	Blue-eye Trevalla	Flathead	Gummy Shark	Orange Roughy Eastern	Orange Roughy West	Pink Ling East	Pink Ling West
Trawl East Flathead Zone2060	45.20	0.01	0.01	27.65	1.94	<0.01	<0.01	2.83	<0.01
Trawl East Flathead Zone30	39.84	0.05	<0.01	12.80	1.15	<0.01	<0.01	0.34	<0.01
Danish Seine Flathead	4.51	<0.01	<0.01	50.63	1.06	<0.01	<0.01	0.25	<0.01
Trawl East Mixed Slope	4.38	0.03	2.28	0.37	0.52	<0.01	<0.01	0.75	<0.01
Eastern Trawl other	4.14	3.62	0.40	6.49	0.58	0.01	<0.01	65.95	<0.01
Non target species others	1.31	94.51	7.33	0.19	4.85	2.26	99.63	0.38	34.17
Hook combined	0.59	0.03	86.16	0.03	27.96	<0.01	<0.01	24.50	30.32
Gillnet combined	0.02	<0.01	<0.01	0.01	60.53	<0.01	<0.01	0.01	0.03
Western Trawl other	<0.01	4.64	2.36	0.10	0.81	<0.01	0.47	<0.01	58.77
Trawl West Blue Grenadier Zone40	<0.01	91.39	0.56	<0.01	<0.01	<0.01	0.25	<0.01	4.55
Trawl West Orange Roughy	<0.01	0.04	<0.01	<0.01	<0.01	2.26	99.08	<0.01	0.25
Trawl East Orange Roughy	<0.01	<0.01	0.11	<0.01	<0.01	97.73	<0.01	0.04	<0.01

4.1.10 2022 Deepwater Shark bycatch by metier

The trawl sector contributes almost 100% of the Deepwater Shark bycatch, with ~88% of the bycatch caught by the western trawl sector (Table 14). The *Trawl West Orange Roughy* metier (~49% bycatch),the *Trawl West Pink Ling* metier (~17% bycatch) and the *Trawl West Blue Grenadier Zone40* metier (~16% bycatch) are the most important metiers within the western trawl sector. These metiers contribute ~100% of the western Orange Roughy, 38% the western Pink Ling and 92% of the Blue Grenadier catches respectively.

Table 14 Dominant and aggregated less-dominant metiers for Deepwater Shark. Percentage of the total catch within the SESSF shown for Deepwater Shark bycatch and target species. Catch estimates are based on assumed 2022 catches of target species for Scenario 1 (2,407 t of Flathead being caught in 2022).

Metier	Deepwater Shark bycatch	Blue Grenadier	Blue-eye Trevalla	Flathead	Gummy Shark	Orange Roughy Eastern	Orange Roughy West	Pink Ling East	Pink Ling West
Trawl West Orange Roughy	49.43	0.04	<0.01	<0.01	<0.01	2.26	99.08	<0.01	0.25
Trawl West Pink Ling	17.22	0.48	0.17	<0.01	0.04	<0.01	0.33	<0.01	33.47
Trawl West Blue Grenadier Zone40	15.74	91.39	0.56	<0.01	<0.01	<0.01	0.25	<0.01	4.55
Trawl West other	5.69	0.21	10.39	2.28	5.96	<0.01	0.20	6.09	6.08
Eastern Trawl other	3.63	3.68	0.42	46.94	3.68	0.01	<0.01	69.12	<0.01
Trawl East Orange Roughy	3.32	<0.01	0.11	<0.01	<0.01	97.73	<0.01	0.04	<0.01
Western Trawl other	<0.01	22.19	4.64	2.36	0.10	0.81	<0.01	0.47	<0.01
Gillnet combined	<0.01	<0.01	<0.01	0.01	60.08	<0.01	<0.01	0.01	0.03
Hook combined	<0.01	0.03	86.16	0.03	27.96	<0.01	<0.01	24.50	30.32
Danish Seine Flathead	<0.01	<0.01	<0.01	50.63	1.06	<0.01	<0.01	0.25	<0.01

4.2 Targeting analysis - Blue Warehou

4.2.1 Catch

Catches of Blue Warehou have declined from over 900t in 1998 to between 3 and 40 t in the last five years (Table 15). Blue Warehou catches are predominately taken by trawl with small catches taken by Danish seine and gillnets. Trawl catches summarised by year and month of fishing show that catches of Blue Warehou are higher over winter in most years (Figure 3). In recent years estimated discarded catches comprise a high component of the Blue Warehou total removals, being equal to or higher than landings in some years. Landed catches reported to the Commonwealth and State jurisdictions have declined to less than 10 t in 2020.

Table 15 Catch of Blue Warehou (t) by gear type: Danish seine, Gillnet, Hook and line, Trawl and all Other gears. Log Total (t) represents the total catch reported in logbooks, CDR (t) the total landed catch from catch disposal records, State (t) the reported State catches, Discards (t) the estimated discarded catches and TAC (t) the Commonwealth total allowable catch.

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
2020	0.3	0.4	0.0	0.0	2.0	2.7	2.6	4.0	5.9	118
2019	1.2	0.4	0.0	0.0	16.2	17.8	22.1	2.6	36.1	118
2018	3.3	0.1	0.0	0.0	35.6	39.0	47.3	5.5	27.6	118
2017	0.7	0.4	0.0	0.0	15.3	16.4	26.3	14.8	215.8	118
2016	2.2	0.1	0.0	0.0	16.5	18.8	9.1	12.5	5.7	118
2015	0.7	0.0	0.0	0.0	4.7	5.4	3.6	8.1	2.3	118
2014	0.4	0.1	0.0	0.0	14.8	15.3	14.6	5.0	1.9	118
2013	1.5	2.0	0.0	0.0	64.5	68.0	66.5	12.2	5.2	118
2012	0.6	4.4	0.0	0.0	47.3	52.3	50.7	5.0	7.6	118
2011	1.5	8.2	0.0	0.0	93.6	103.3	110.7	9.0	10.8	133
2010	2.9	3.8	0.1	0.0	122.6	129.3	131.8	25.6	3.0	183
2009	1.7	1.6	0.0	0.0	131.9	135.2	138.3	33.7	5.7	183
2008	5.4	1.1	0.0	0.0	156.7	163.3	157.5	36.9	71.2	365
2007	0.8	1.2	0.1	0.0	175.7	177.8	196.1	29.3	4.0	235
2006	0.3	0.8	0.2	0.0	378.2	379.5	387.3	26.3	4.6	650
2005	0.4	1.3	0.8	0.0	286.5	289.1	258.9	17.2	3.4	300
2004	0.4	1.3	0.0	0.0	230.8	232.4	262.0	31.1	8.6	300
2003	1.1	1.8	0.1	0.0	230.9	234.0	253.7	42.3	7.9	250
2002	1.0	4.8	0.0	0.0	284.6	290.5	317.4	71.9	12.2	246
2001	1.4	25.2	0.3	0.0	258.6	285.5	328.6	26.0	12.3	308
2000	0.5	74.1	0.7	1.6	393.3	470.2	515.4	113.5	38.2	615
1999	0.7	270.2	3.0	2.5	314.6	591.0	642.5	283.0	64.9	718

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
1998	0.6	80.5	0.1	0.6	821.4	903.2	1001.5	266.9	81.5	820
1997	0.8	270.8	1.6	3.3	658.8	935.2	291.3	190.5	40.8	700
1996	2.4	0.0	0.0	1.3	720.7	724.4	0.0	373.1	15.8	1000
1995	4.2	0.0	0.0	1.6	809.6	815.4	0.0	326.4	15.7	1000
1994	2.6	0.0	0.0	1.9	940.3	944.8	0.0	503.1	18.2	1000
1993	0.3	0.0	0.0	5.1	824.2	829.6	0.0	61.2	0.0	1000
1992	0.4	0.0	0.0	79.0	855.0	934.4	0.0	61.2	0.0	0

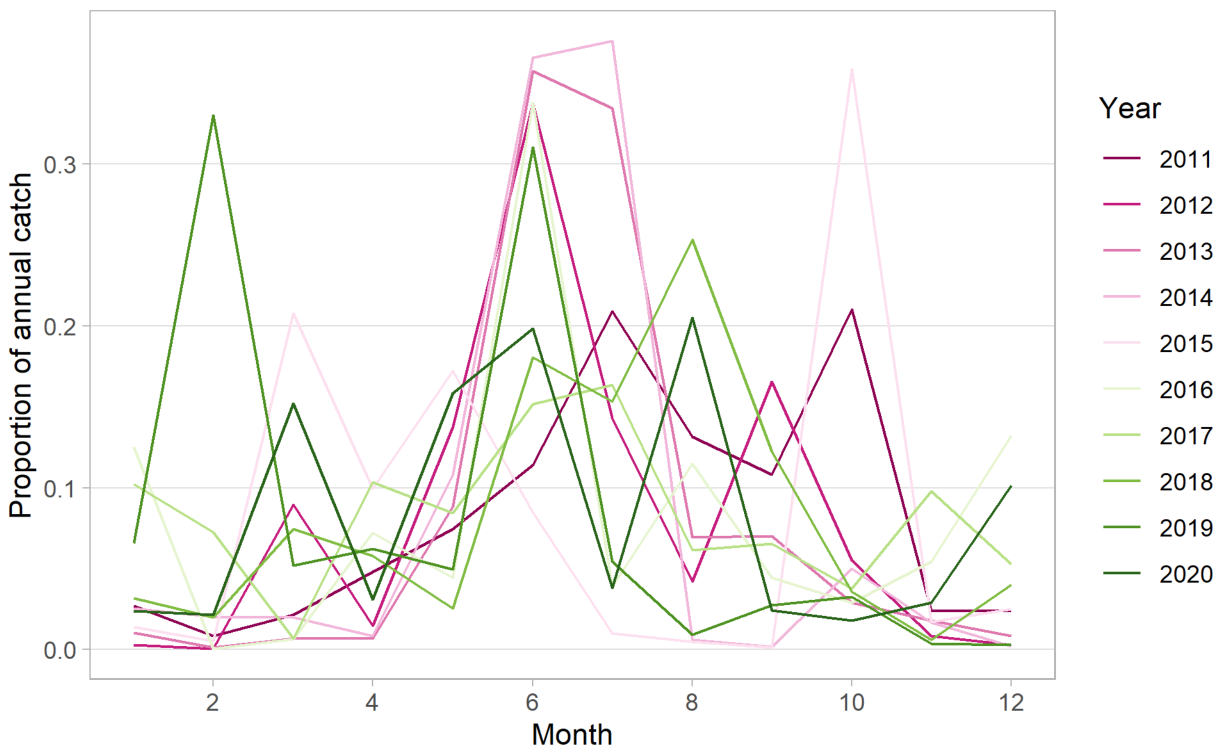

Figure 3 Monthly proportion of annual trawl catch of Blue Warehou.

4.2.2 CPUE and depth of fishing

Standardized CPUE for eastern Blue Warehou (zones 10-30) has been at a record low for over a decade (Figure 4) and the downward trend has continued in 2020 (Sporcic, 2021a). The distribution of fishing depths has been quite variable since 2013, however, the number of logbook records reporting eastern Blue Warehou has declined to less than 300 since 2013 so this variability may be associated with reduced availability of Blue Warehou rather than a change in fishing patterns (Figure 5).

Standardized CPUE for western Blue Warehou (zones 40-50) has remained well below the highs of the late 1980s and early 1990s for the last two decades (Figure 6). CPUE increased slightly in 2017, however, it subsequently resumed the downward trend to 2020 (Sporcic, 2021a). Depth of fishing for western Blue Warehou over the last decade has been shallower than preceding decades with the majority of the catch taken in approximately 200m. In 2020 one third of the landings were taken slightly deeper at depths between 300m to 400m (Figure 7; Sporcic, 2021a). Similar to the east, the number of logbook records of western Blue Warehou landings has declined substantially to an all-time low of 23t in 2020 (Figure 7).

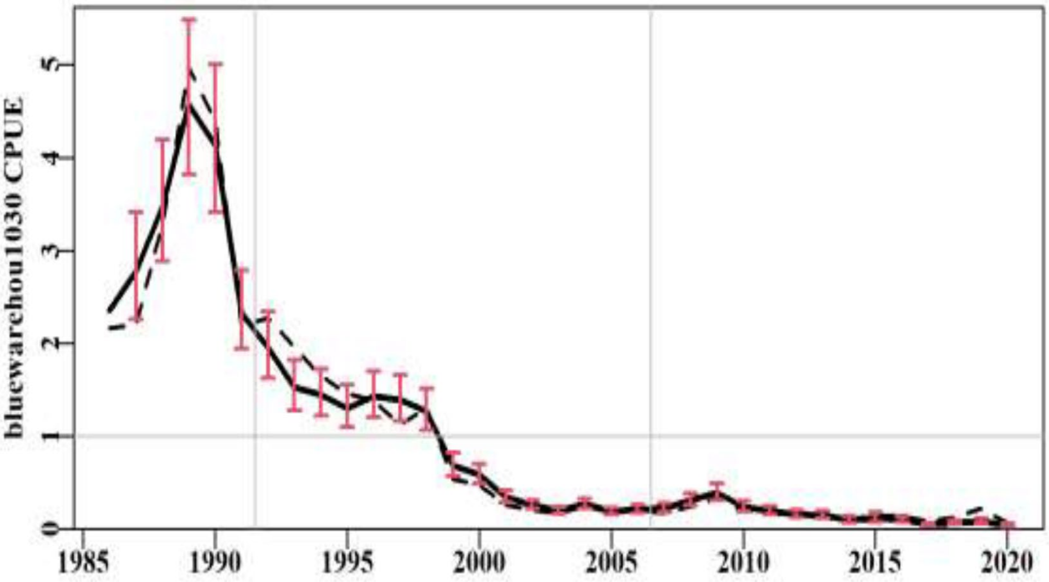

Figure 4 Standardized trawl CPUE of eastern Blue Warehou between 1986 and 2020. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series. Source: Sporcic (2021a).

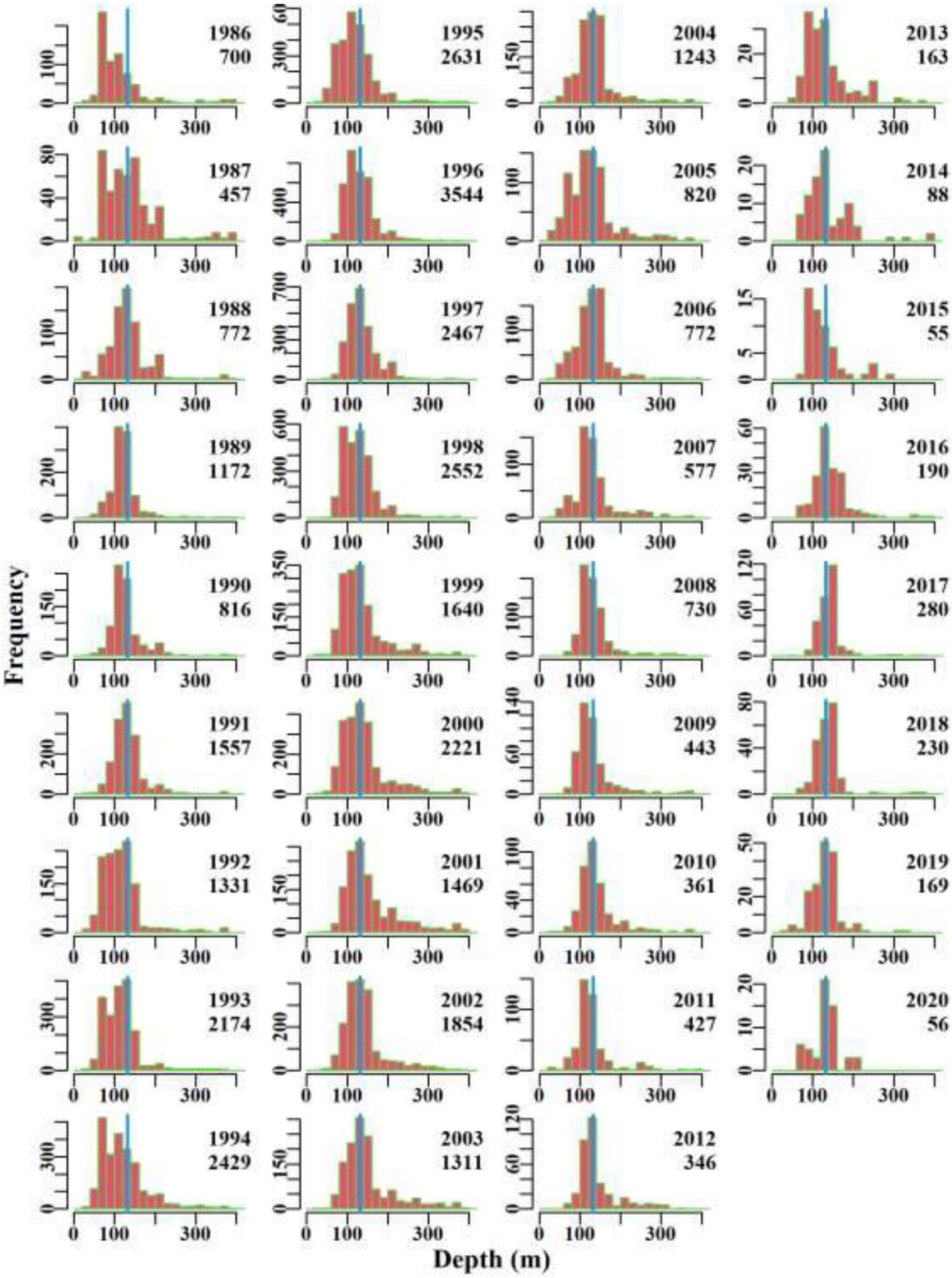

Figure 5 Histogram of annual fishing depths of eastern Blue Warehou between 1986 and 2020. Year and number of logbook records are printed on the right hand side of each plot. Blue line represents mean fishing depth. Source: Sporcic (2021a).

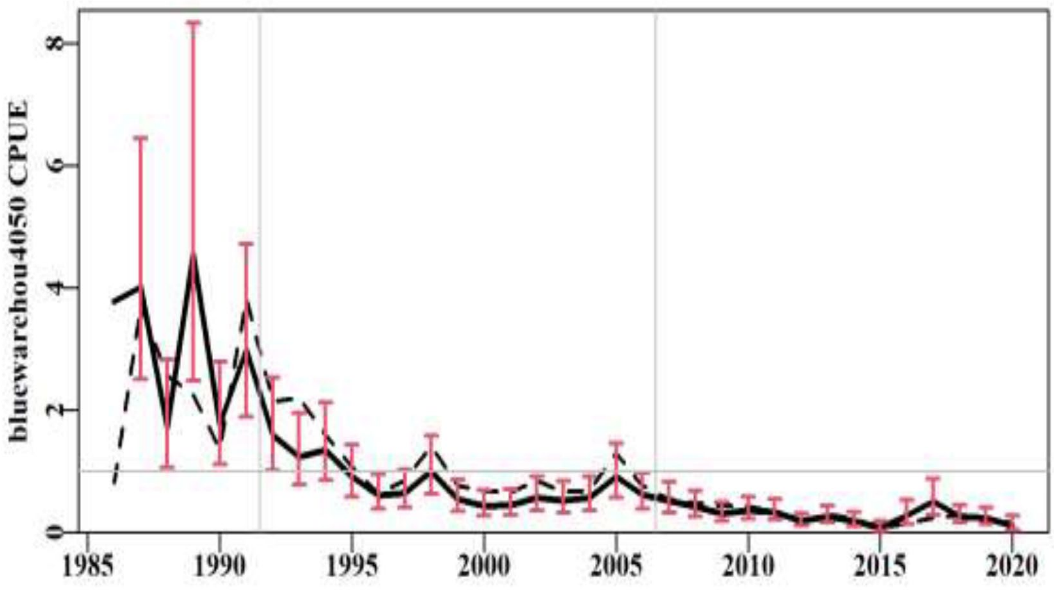

Figure 6 Standardized trawl CPUE of western Blue Warehou between 1986 and 2020. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series. Source: Sporcic (2021a).

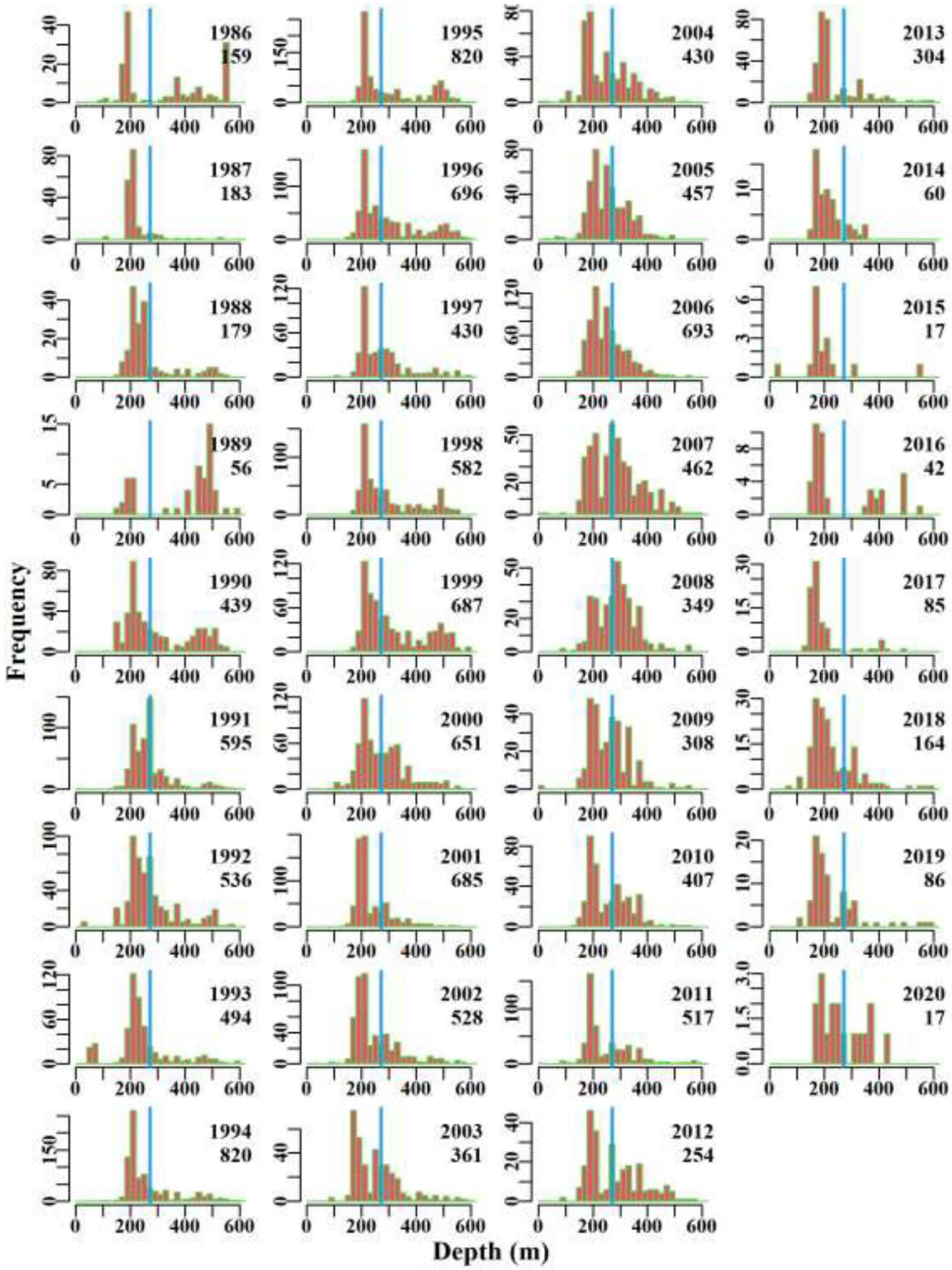

Figure 7 Histogram of annual fishing depths of western Blue Warehou between 1986 and 2020. Year and number of logbook records are printed on the right hand side of each plot. Blue line represents mean fishing depth. Source: Sporcic (2021a).

4.2.3 Spatial distribution of fishing

In the late 1990s and early 2000s large catches of Blue Warehou were taken by trawl vessels operating off the south coast of NSW, along the eastern and western coasts of Tasmania and western Victoria (Figure 8). Between 2005 and 2012, while landed catches declined from 200-350 t to 90 t the spatial pattern of catches was little changed (Figure 9). In recent years (2013-2020) catches have declined still further to be less than 50t per annum since 2013 (Figure 10). With recent landed catches at such low levels, identifying potential changes in the spatial distribution of Blue Warehou catches becomes more challenging, however, Figure 10 provides no evidence that the distribution of the stock has changed.

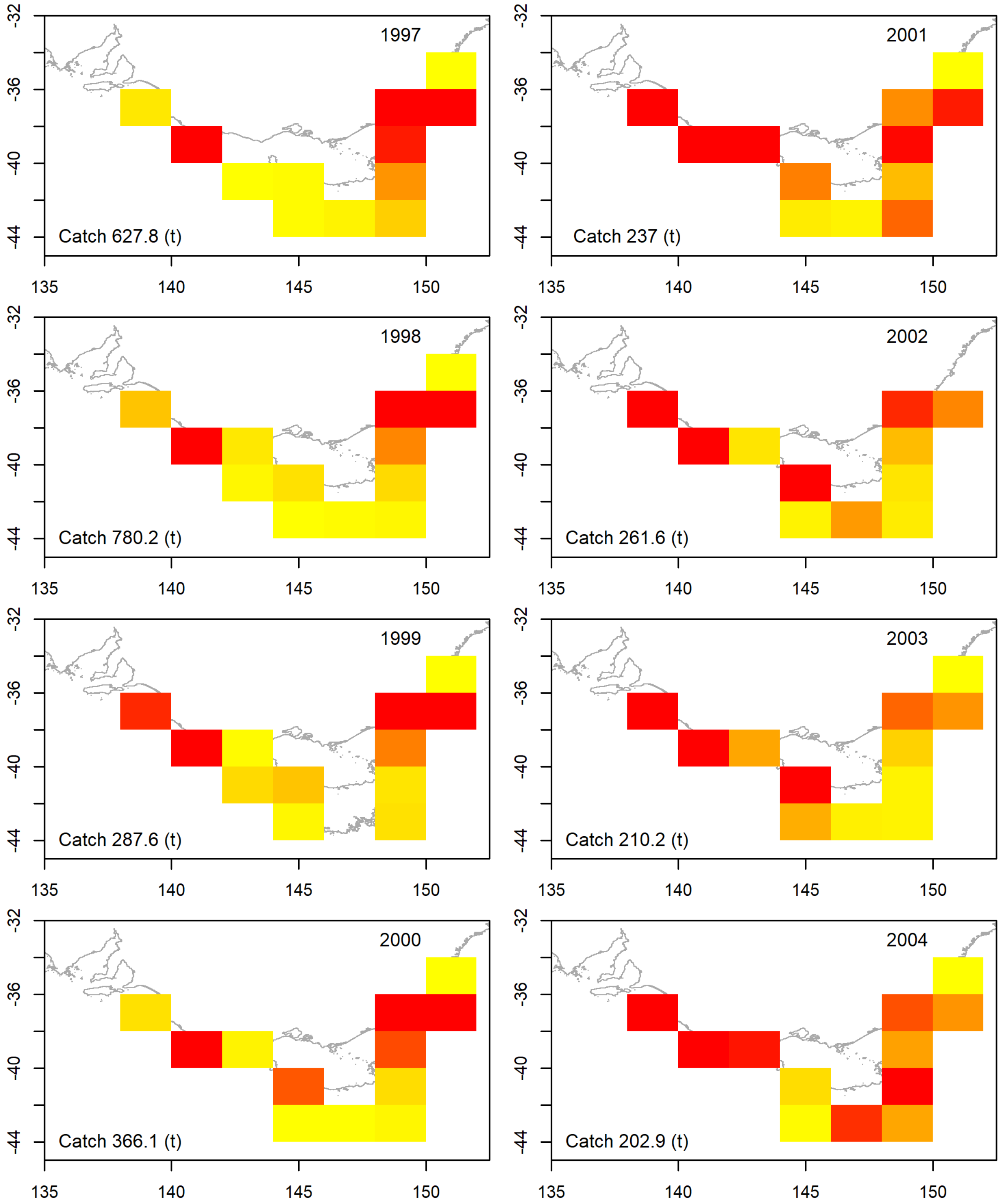

Figure 8 Spatial distribution of annual Blue Warehou catch of trawl vessels 1997 - 2004. Logbook catch is provided in the bottom left corner of each annual plot.

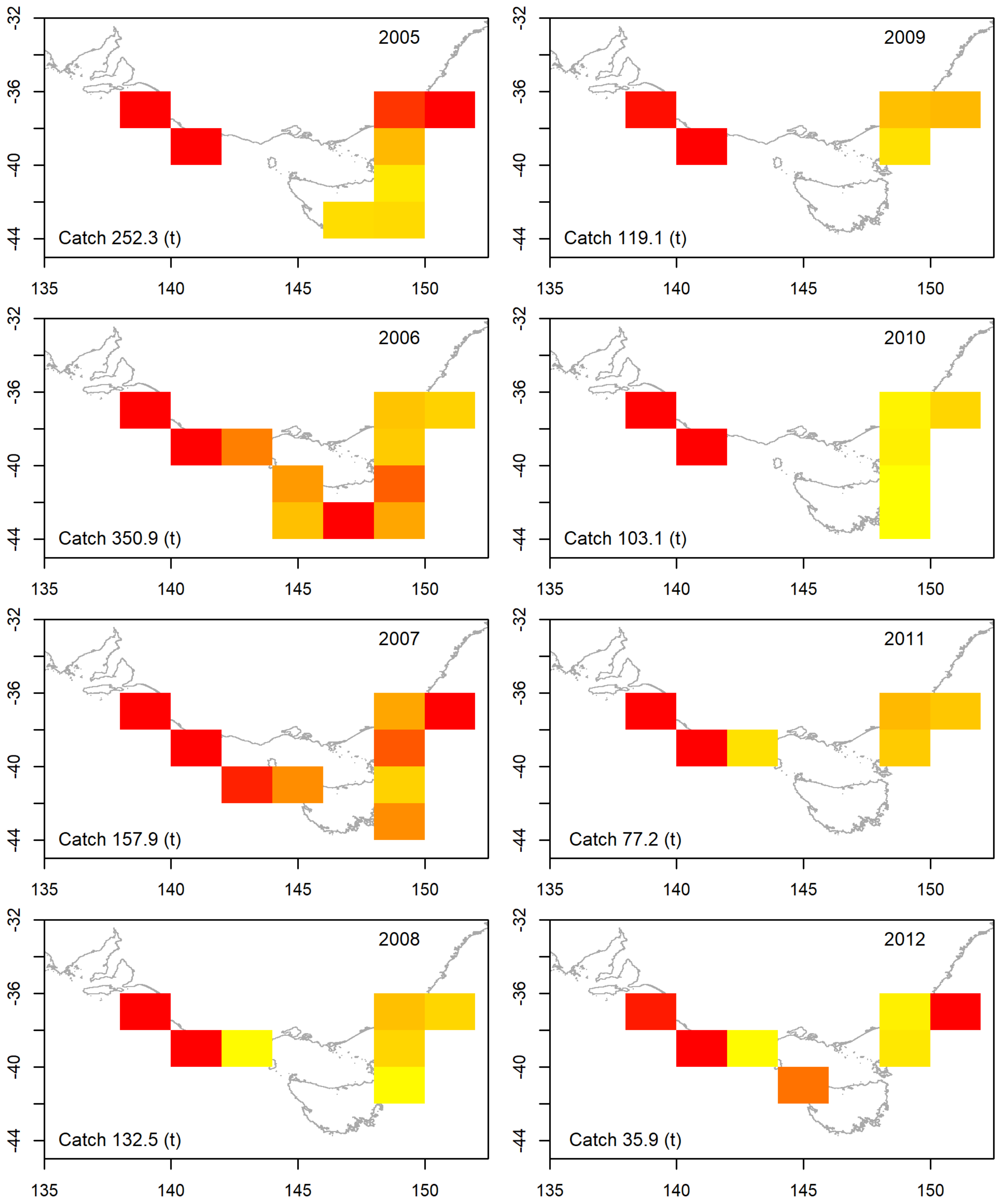

Figure 9 Spatial distribution of annual Blue Warehou catch of trawl vessels 2005 - 2012. Logbook catch is provided in the bottom left corner of each annual plot.

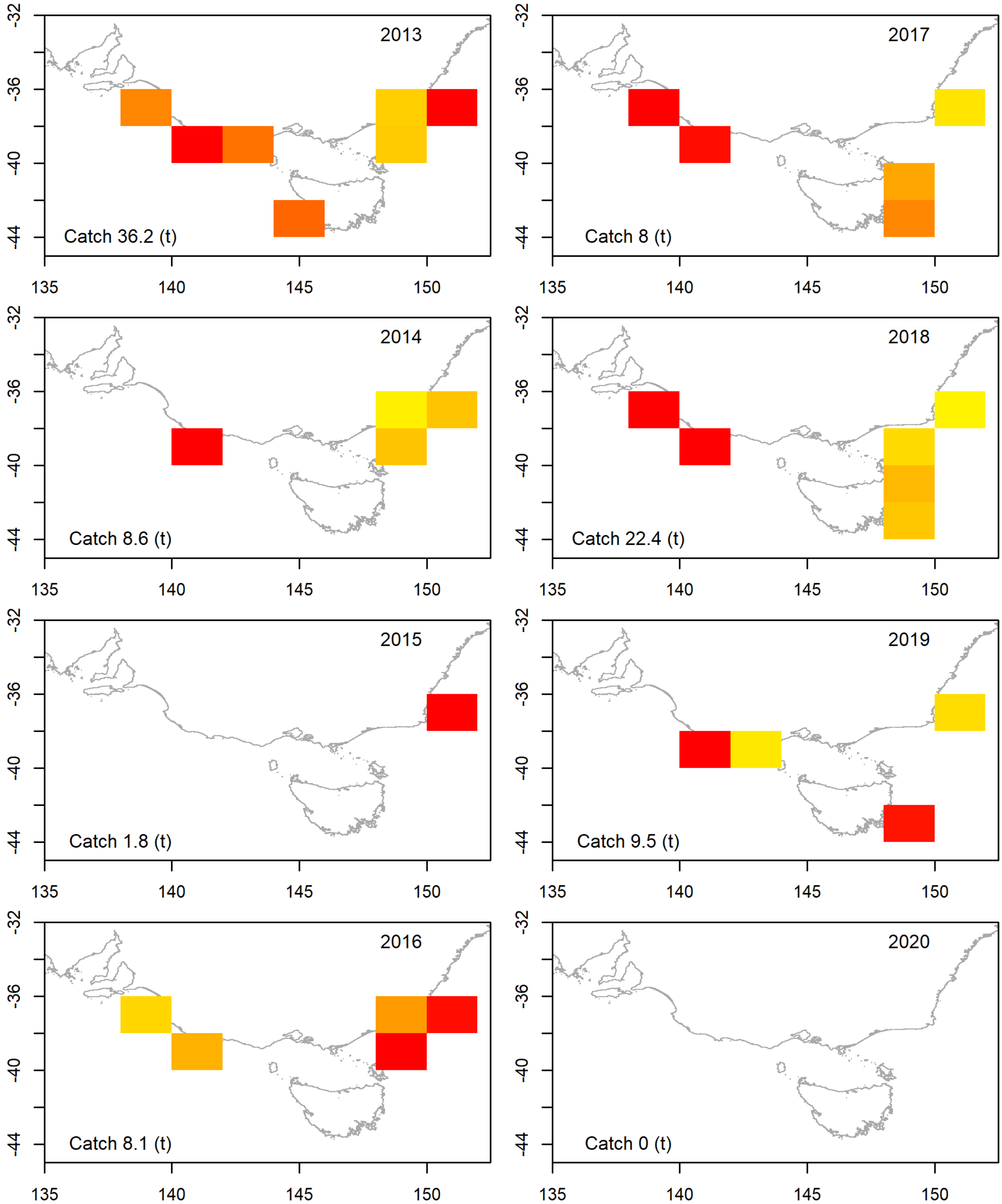

Figure 10 Spatial distribution of annual Blue Warehou catch of trawl vessels 2013 - 2020. Logbook catch is provided in the bottom left corner of each annual plot. Note all reported catches of Blue Warehou in 2020 have been masked.

4.2.4 Catch by vessel

Annual Blue Warehou catch by vessel shows no evidence of any vessels reporting consistently large catches in recent years that may suggest potential targeting of Blue Warehou (Figure 11).

Figure 11 Bubble plot of annual Blue Warehou catch of trawl vessels. Larger bubbles indicate larger annual catches. Numbers at the top of each year represent logbook catch (upper) and number of vessels reporting Blue Warehou (lower). Each row represents one vessel.

4.3 Targeting analysis - Eastern Gemfish

4.3.1 Catch

Catches of eastern Gemfish have declined from around 200t in 1998 to 25 - 50 t between 2014 and 2018 (Table 16). Eastern Gemfish catch increased to approximately 70 t in 2019 and 2020. While eastern Gemfish catches are predominately taken by trawl, 10-15% has been taken by the hook and line sector in recent years. Trawl catches summarised by year and month of fishing shows that catches of eastern Gemfish are higher over winter in most years, when gemfish aggregate to spawn (Figure 12).

Table 16 Catch of eastern Gemfish (t) by gear type: Danish seine, Gillnet, Hook and line, Trawl and all Other gears. Log Total (t) represents the total catch reported in logbooks, CDR (t) the total landed catch from catch disposal records, State (t) the reported State catches, Discards (t) the estimated discarded catches and TAC (t) the Commonwealth total allowable catch.

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
2020	0.0	0.0	21.4	0.0	47.5	68.9	61.5	1.3	38.0	100
2019	0.0	0.0	8.9	0.0	63.0	72.0	70.4	1.7	54.3	100
2018	0.1	0.0	3.3	0.0	30.4	33.8	29.9	4.1	52.7	100
2017	0.0	0.0	4.5	0.0	31.9	36.4	37.0	3.6	34.5	100
2016	0.7	0.0	4.8	0.0	18.7	24.1	22.1	3.9	22.8	100
2015	0.1	0.0	4.7	0.0	28.7	33.5	35.3	6.5	38.1	100
2014	1.0	0.0	9.8	0.0	25.2	36.0	36.1	8.2	35.4	100
2013	0.2	0.0	4.8	0.0	45.3	50.4	57.7	11.0	141.2	100
2012	0.5	0.0	7.1	0.0	57.1	64.7	71.9	11.3	29.7	100
2011	0.6	0.0	8.1	0.0	59.7	68.3	70.6	15.7	108.1	100
2010	0.0	0.0	13.0	0.0	75.5	88.5	92.5	20.3	191.2	100
2009	0.8	0.0	12.0	0.0	67.5	80.3	85.8	16.7	172.0	100
2008	1.4	0.0	14.5	0.0	110.7	126.6	107.4	11.6	164.4	100
2007	0.0	0.0	7.6	0.0	74.0	81.7	79.5	14.1	42.5	91
2006	0.1	0.0	5.1	0.0	70.6	75.8	86.9	15.3	46.5	100
2005	0.0	0.0	4.3	0.0	70.6	74.9	88.2	15.8	71.7	100
2004	0.0	0.0	3.1	0.0	60.9	64.0	75.9	17.7	79.9	100
2003	0.6	0.2	1.6	0.0	53.7	56.1	74.8	7.8	114.8	100
2002	0.0	1.9	2.1	0.0	44.2	48.3	61.7	16.2	13.6	100
2001	0.0	1.7	1.3	0.0	69.0	72.0	86.4	23.9	8.0	150
2000	0.0	1.0	1.2	0.1	72.0	74.3	93.0	30.7	29.0	200
1999	0.0	1.1	4.7	0.3	119.6	125.7	159.2	88.7	31.1	250

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
1998	0.0	2.1	1.9	0.1	191.0	195.2	210.9	127.1	20.8	300
1997	0.0	17.4	0.3	1.5	338.2	357.3	0.1	136.4	8.4	1000
1996	0.2	0.0	0.0	0.1	194.6	194.8	0.0	204.7	12.6	0
1995	0.0	0.0	0.0	0.0	74.2	74.2	0.0	157.8	9.7	0
1994	0.0	0.0	0.0	0.1	120.1	120.2	0.0	133.3	8.2	0
1993	0.3	0.0	0.0	7.7	241.8	249.8	0.0	133.3	0.0	0
1992	0.0	0.0	0.9	15.0	314.3	330.3	0.0	133.3	0.0	200

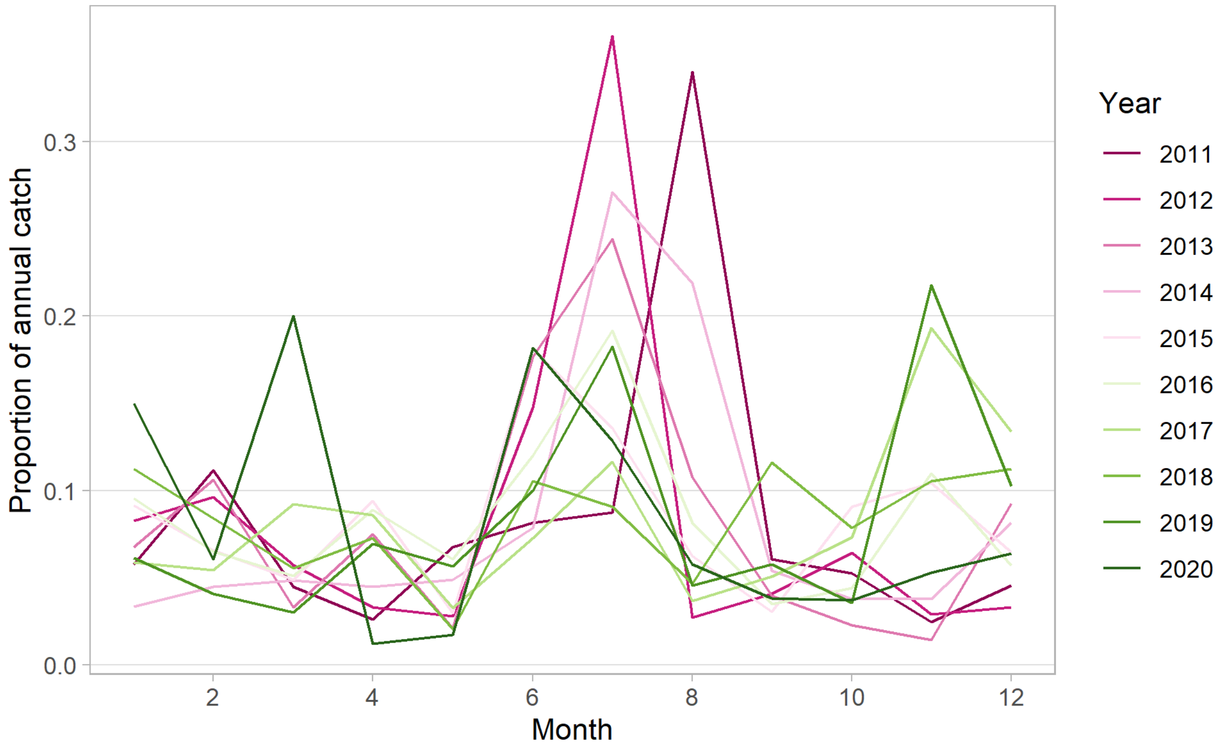

Figure 12 Monthly proportion of annual trawl catch of eastern Gemfish.

4.3.2 CPUE and depth of fishing

Standardized CPUE for the non-spawning trawl fishery for eastern Gemfish has remained relatively stable since 2014 at around 10% of the peak in 1987 and around 25% of the level in the mid-1990s (Figure 13). The distribution of fishing depths for the non-spawning fishery is bimodal in most years with eastern Gemfish caught on both the shelf and the slope (Figure 14).

Standardized CPUE for the spawning trawl fishery for eastern Gemfish has increased from its lowest point in 2016 to around half the level reached in 2008-2010 (Figure 15 and Sporcic, 2021a). The depth of fishing for the spawning fishery for eastern Gemfish shows a reduction in the proportion of shots containing eastern Gemfish shallower than 400m in the mid-2000s, compared with the 1990s and early 2000s (Figure 16). In the last three years there has been an increase in the proportion of shots shallower than 400m.

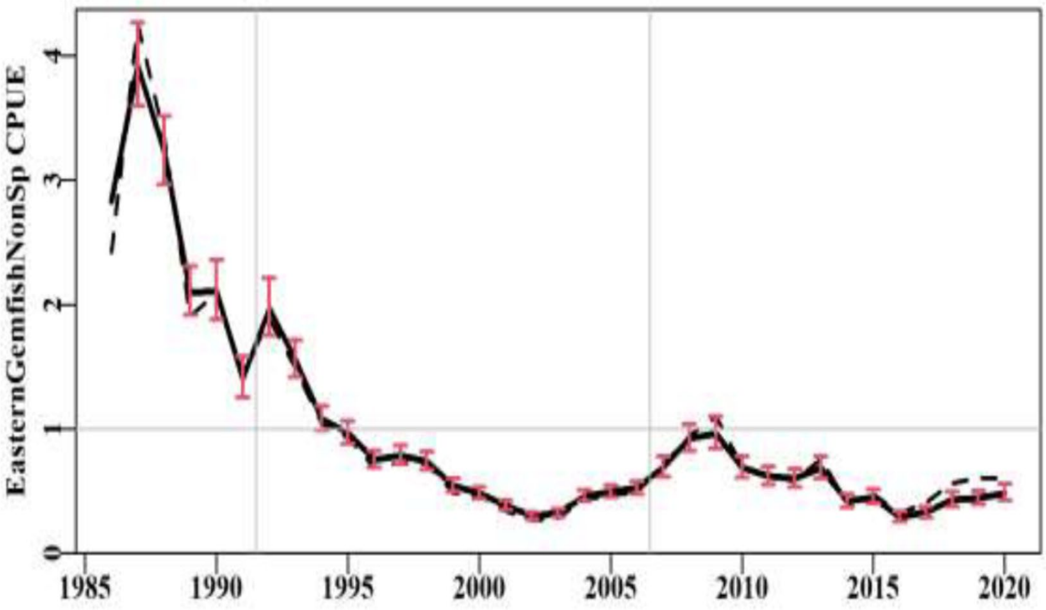

Figure 13 Standardized trawl CPUE of non-spawning eastern Gemfish between 1986 and 2020. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series. Source: Sporcic (2021a).

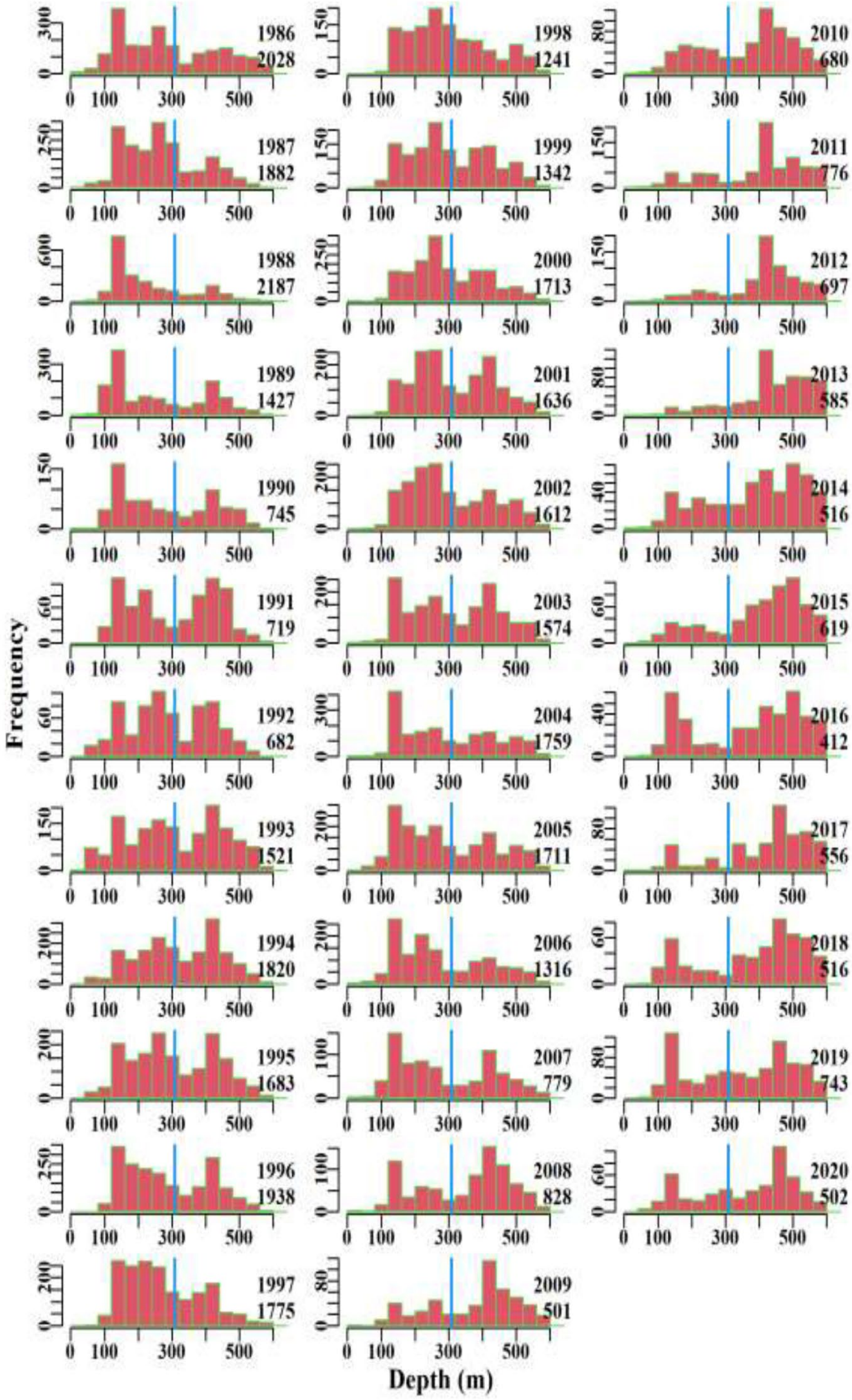

Figure 14 Histogram of annual fishing depths of non-spawning eastern Gemfish between 1986 and 2020. Year and number of logbook records are printed on the right hand side of each plot. Blue line represents mean fishing depth. Source: Sporcic (2021a).

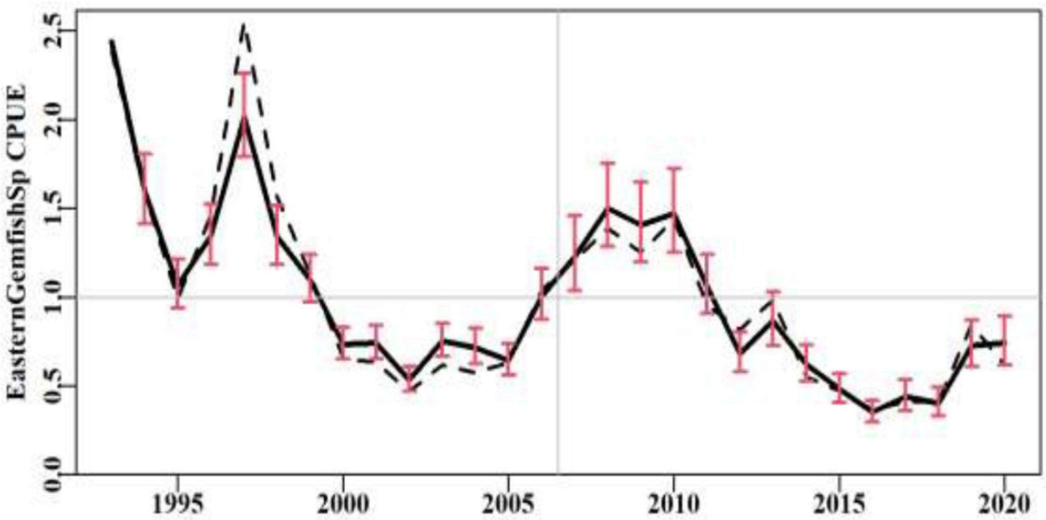

Figure 15 Standardized trawl CPUE of spawning eastern Gemfish between 1986 and 2020. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series. Source: Sporcic (2021a).

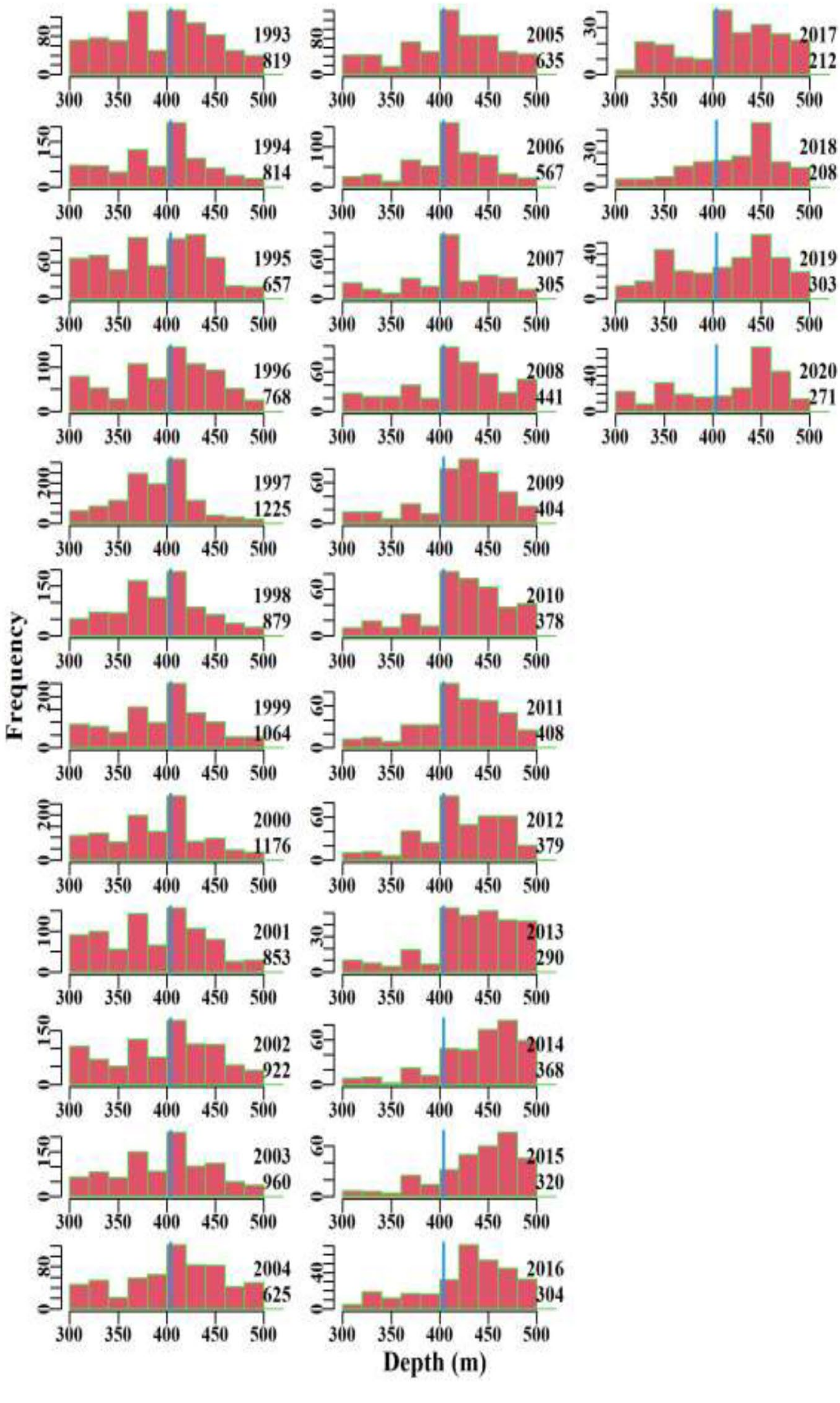

Figure 16 Histogram of annual fishing depths of spawning eastern Gemfish between 1986 and 2020. Year and number of logbook records are printed on the right hand side of each plot. Blue line represents mean fishing depth. Source: Sporcic (2021a).

4.3.3 Spatial distribution of fishing

Since the late 1990s there has been little change in the spatial distribution of eastern Gemfish catches with the majority of catches taken from NSW, eastern Victoria and the east coast of

Tasmania (Figure 17, Figure 18 and Figure 19). Some catch is also taken from the west coast of Tasmania and since 2014 the proportion of eastern Gemfish catch taken there has increased (Figure 19). Catches of Gemfish in western Victoria and South Australia are assumed to be part of the western stock and are not shown on Figures, although the species is caught in these locations.

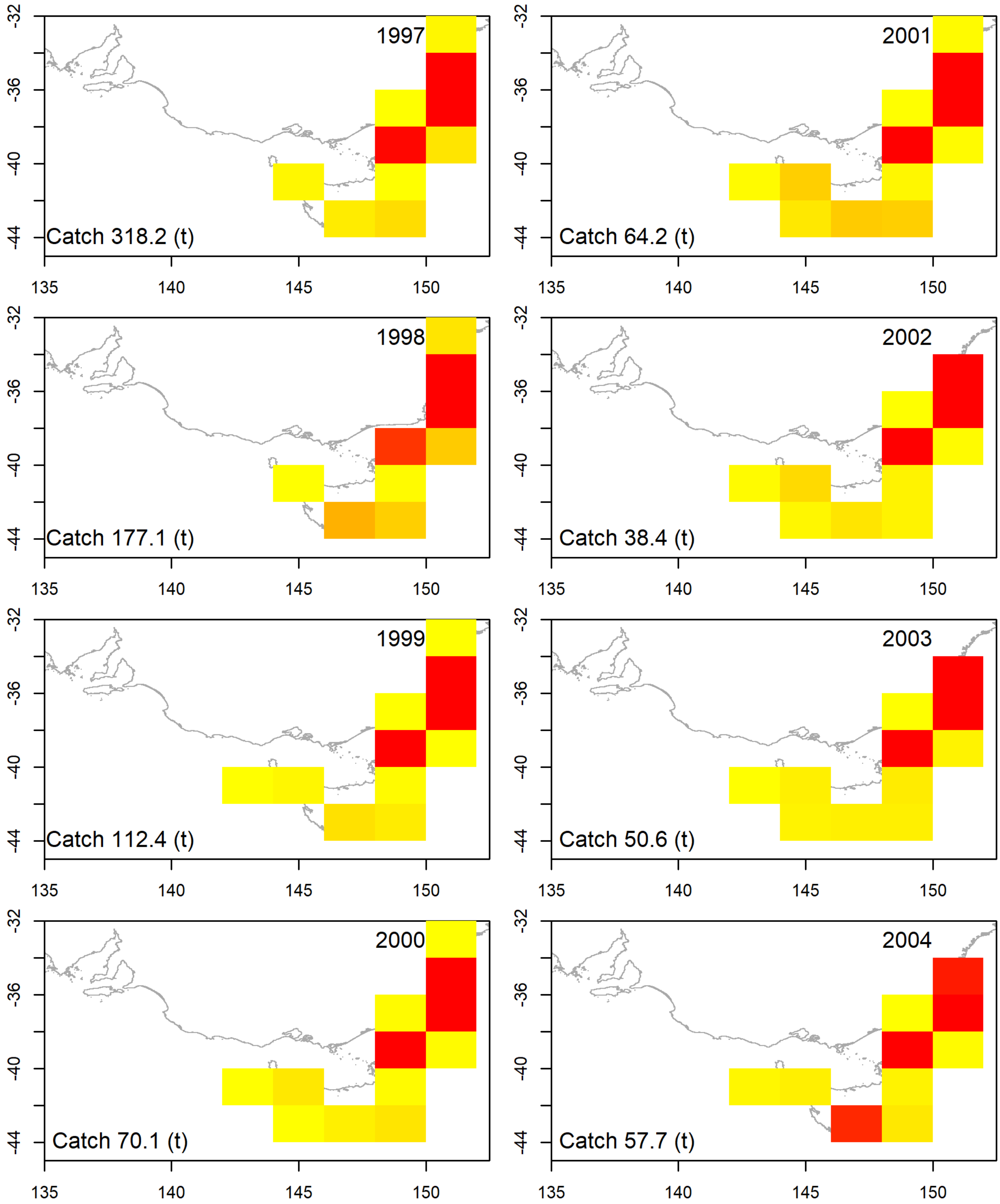

Figure 17 Spatial distribution of annual eastern Gemfish catch of trawl vessels 1997 - 2004. Logbook catch is provided in the bottom left corner of each annual plot.

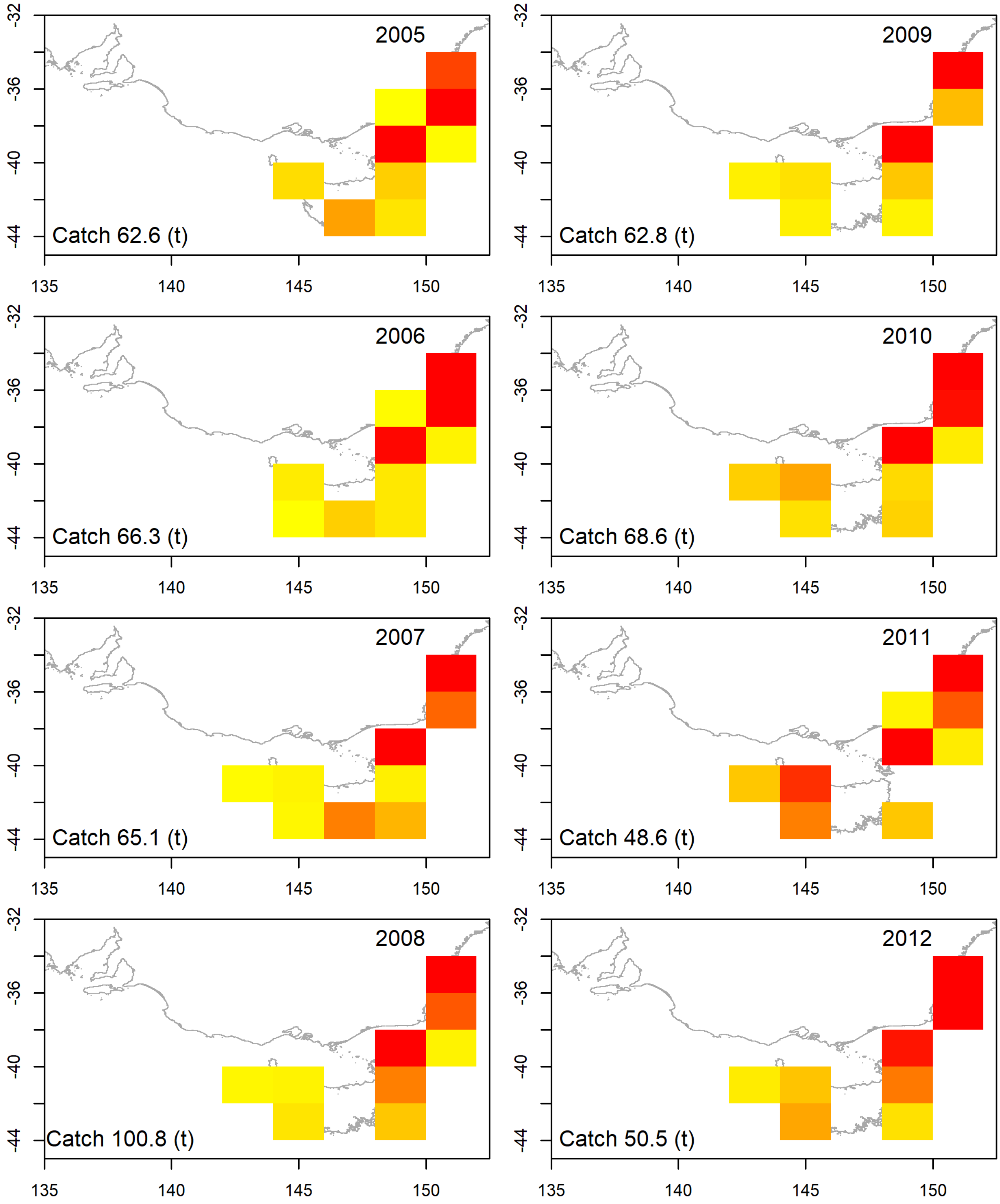

Figure 18 Spatial distribution of annual eastern Gemfish catch of trawl vessels 2005 - 2012. Logbook catch is provided in the bottom left corner of each annual plot.

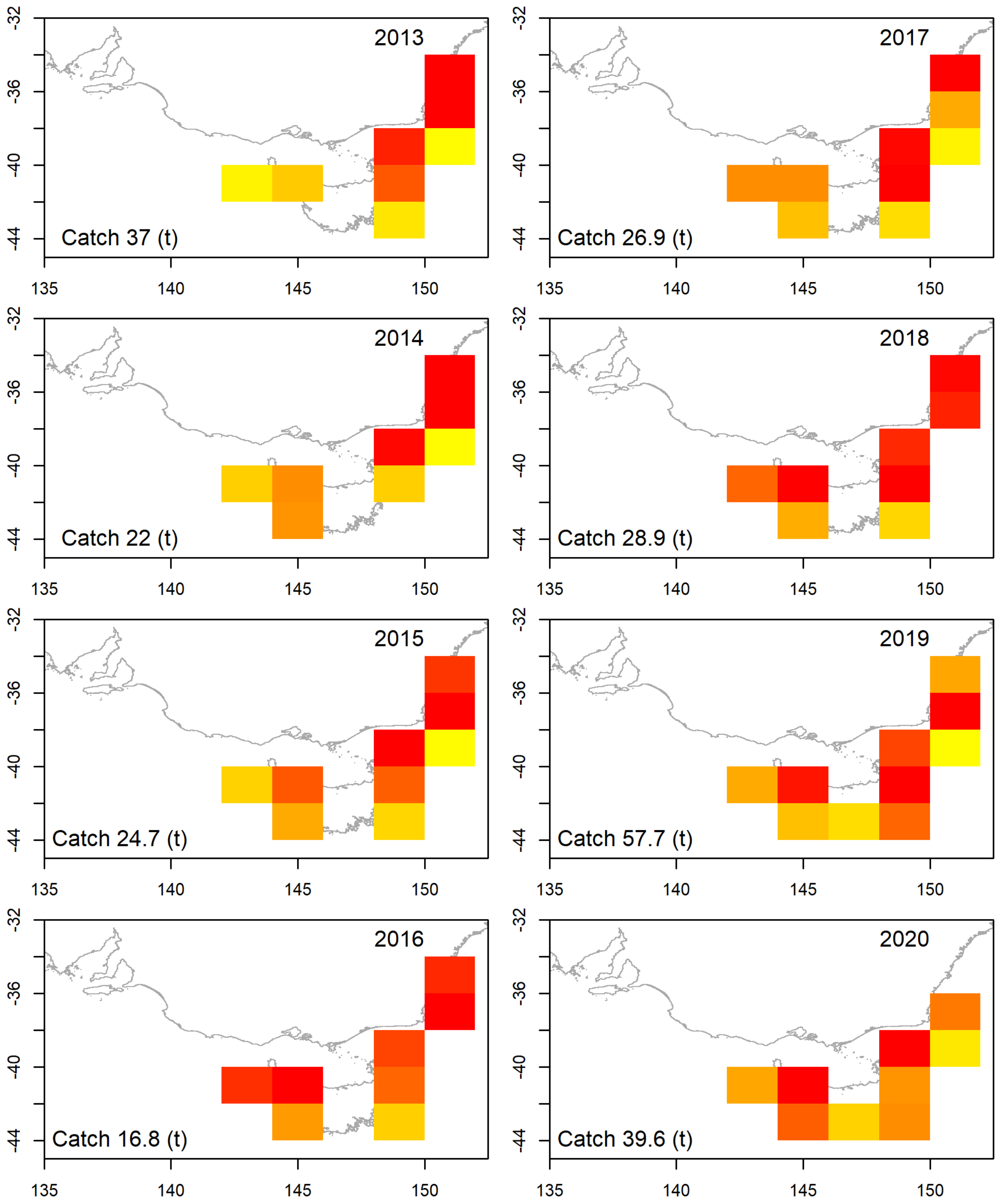

Figure 19 Spatial distribution of annual eastern Gemfish catch of trawl vessels 2013 - 2020. Logbook catch is provided in the bottom left corner of each annual plot.

4.3.4 Catch by vessel

Annual eastern Gemfish catch by vessel shows no evidence of any vessels reporting consistently large catches in recent years (Figure 20). The larger catch in 2020 appears to be relatively evenly distributed among individual trawl vessels.

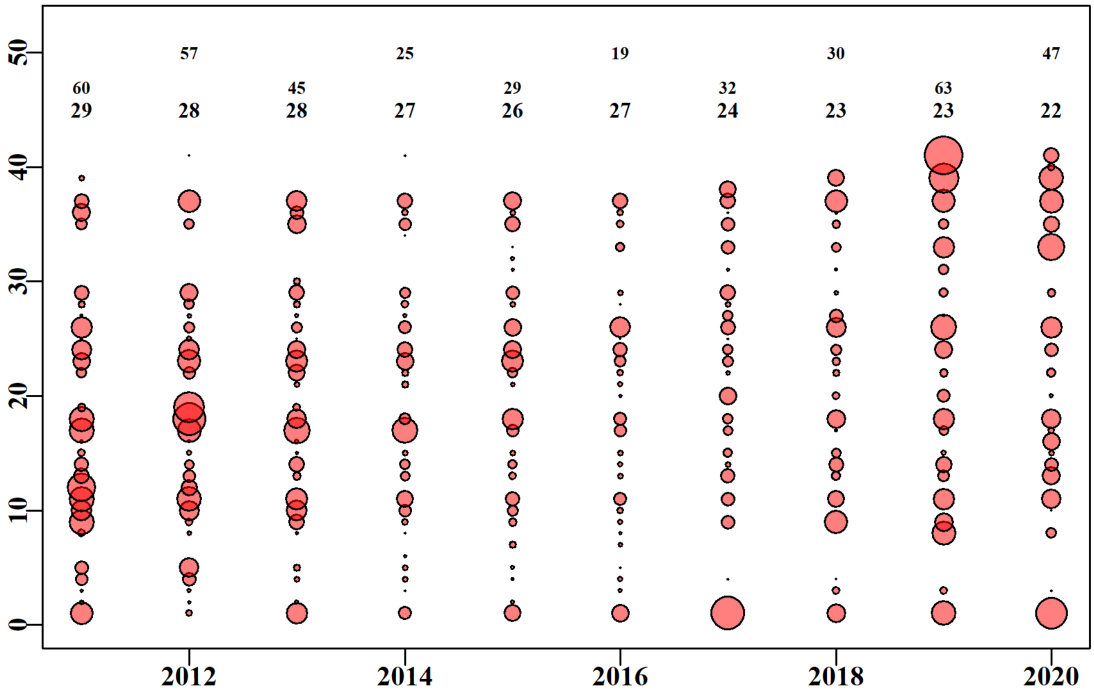

Figure 20 Bubble plot of annual eastern Gemfish catch of trawl vessels. Larger bubbles indicate larger annual catches. Numbers at the top of each year represent logbook catch (upper) and number of vessels reporting eastern Gemfish (lower). Each row represents one vessel.

4.4 Targeting analysis - Redfish

4.4.1 Catch

Catches of Redfish have declined from over 1700t in 1998 to between 25 and 47 t in the most recent four years (Table 17). Redfish catches are almost exclusively taken by trawl. Trawl catches summarised by year and month of fishing shows that catches of Redfish are higher over spring in most years, although there is variability among years (Figure 21). Note that catches of eastern Redfish (*Centroberyx affinis*) reported in the GAB (SEF Zone 80) have been excluded from this section due to likely misreporting of Bight Redfish (*Centroberyx gerrardi*).

Table 17 Catch of eastern Redfish (t) by gear type: Danish seine, Gillnet, Hook and line, Trawl and all Other gears. Log Total (t) represents the total catch reported in logbooks, CDR (t) the total landed catch from catch disposal records, State (t) the reported State catches, Discards (t) the estimated discarded catches and TAC (t) the Commonwealth total allowable catch. Note catches of eastern Redfish (*Centroberyx affinis*) reported in the GAB (SEF Zone 80) have been excluded to prevent confounding with likely misreporting of Bight Redfish (*Centroberyx gerrardi*).

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
2020	0.5	0.0	0.0	0.0	21.2	21.7	24.7	14.3	81.8	50
2019	0.4	0.0	0.0	0.0	22.5	22.9	27.1	7.4	72.4	50
2018	0.1	0.0	0.0	0.0	29.6	29.7	33.2	4.6	21.6	100
2017	0.0	0.1	0.1	0.0	24.9	25.1	27.1	8.8	20.2	100
2016	0.3	0.1	0.1	0.0	36.5	36.9	42.5	10.1	51.9	100
2015	0.0	0.0	0.0	0.0	52.0	52.0	59.0	11.5	69.6	100
2014	1.1	0.0	0.6	0.0	85.1	86.7	95.7	16.3	67.5	138
2013	0.4	0.0	0.1	0.0	61.9	62.4	66.2	16.9	30.0	276
2012	0.0	0.1	0.0	0.0	65.6	65.6	72.5	16.0	4.2	276
2011	0.0	0.2	0.0	0.0	86.3	86.6	98.9	16.6	26.9	276
2010	0.2	0.0	0.0	0.0	151.4	151.7	166.0	22.5	27.2	551
2009	0.3	0.0	0.1	0.0	158.8	159.2	182.3	27.4	233.7	678
2008	0.3	0.0	0.1	0.0	183.1	183.5	201.3	29.4	2.2	850
2007	0.1	0.0	0.0	0.0	214.8	214.9	230.6	53.7	2.7	672
2006	0.2	0.0	0.0	0.0	324.7	324.9	321.9	75.7	13.1	900
2005	1.0	0.0	0.0	0.0	482.3	483.3	532.8	46.7	126.2	1300
2004	0.6	0.0	0.0	0.0	473.7	474.3	499.3	58.1	377.4	1575
2003	28.4	0.2	0.0	0.0	586.9	615.5	678.6	48.6	347.8	1575
2002	0.2	4.6	0.4	0.0	801.8	807.1	885.0	47.0	899.8	1570
2001	0.3	2.8	0.2	0.0	738.1	741.4	795.3	52.1	738.6	1570
2000	0.6	1.5	0.6	0.1	752.8	755.5	836.1	27.4	234.0	1750

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
1999	0.3	2.2	0.6	2.8	1107.9	1113.9	1257.7	94.9	69.2	1750
1998	0.4	1.1	0.7	3.8	1544.9	1550.9	1751.7	83.3	2323.2	1750
1997	0.2	0.7	0.3	4.0	1388.4	1393.6	0.0	304.0	384.9	1700
1996	0.6	0.0	0.0	1.1	1342.4	1344.0	0.0	784.1	992.7	1700
1995	0.5	0.0	0.0	0.2	1239.9	1240.6	0.0	789.2	999.2	1700
1994	0.5	0.0	0.0	1.2	1486.1	1487.7	0.0	1343.8	1701.3	1000
1993	0.3	0.0	0.0	2.3	1918.7	1921.3	0.0	1343.8	0.0	600
1992	0.4	0.0	0.0	41.7	1594.2	1636.3	0.0	1343.8	0.0	600

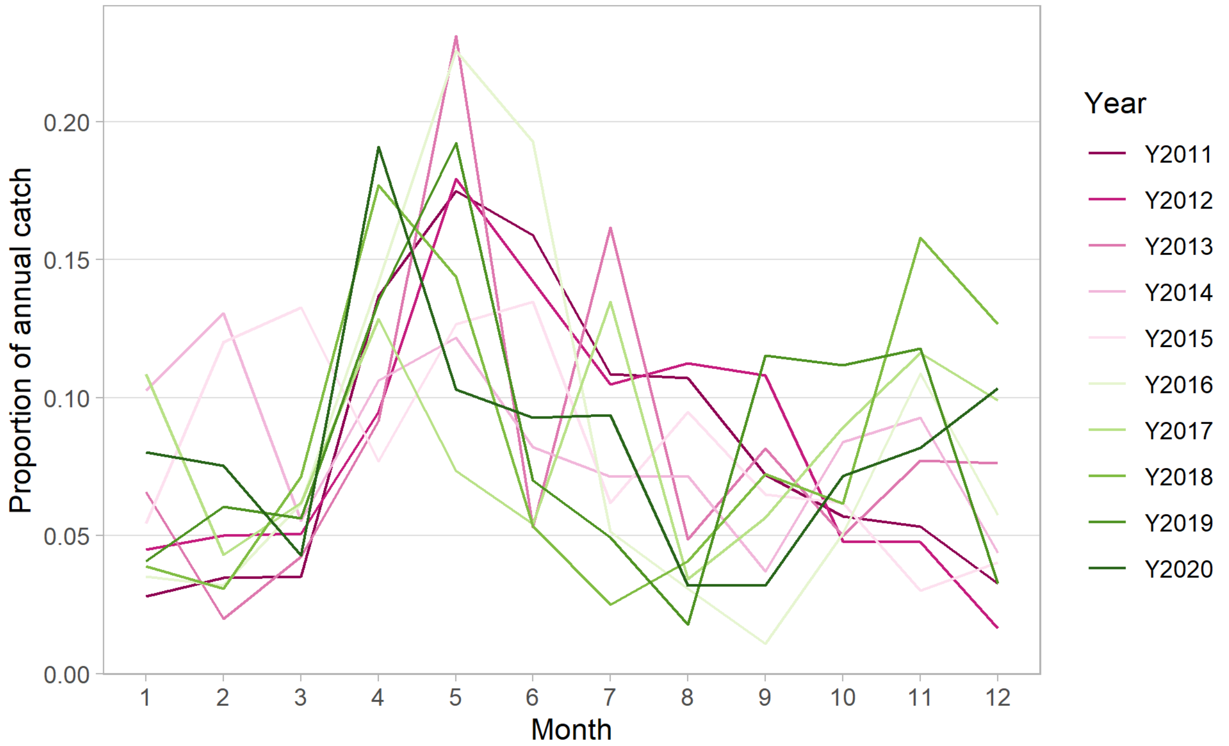

Figure 21 Monthly proportion of annual trawl catch of Redfish. Note catches of eastern Redfish (*Centroberyx affinis*) reported in the GAB (SEF Zone 80) have been excluded to prevent confounding with likely misreporting of Bight Redfish (*Centroberyx gerrardi*).

4.4.2 CPUE and depth of fishing

The standardized CPUE for Redfish (zones 10-20) peaked in 1993 and, with the exception of a brief period in the late 1990s, has steadily declined (Figure 22). Historically the majority of fishing for Redfish was shallower than 150m, however, there was some catch down to 400m (Figure 23). In the last five years the proportion of logbook records reporting Redfish deeper than 150m has declined.

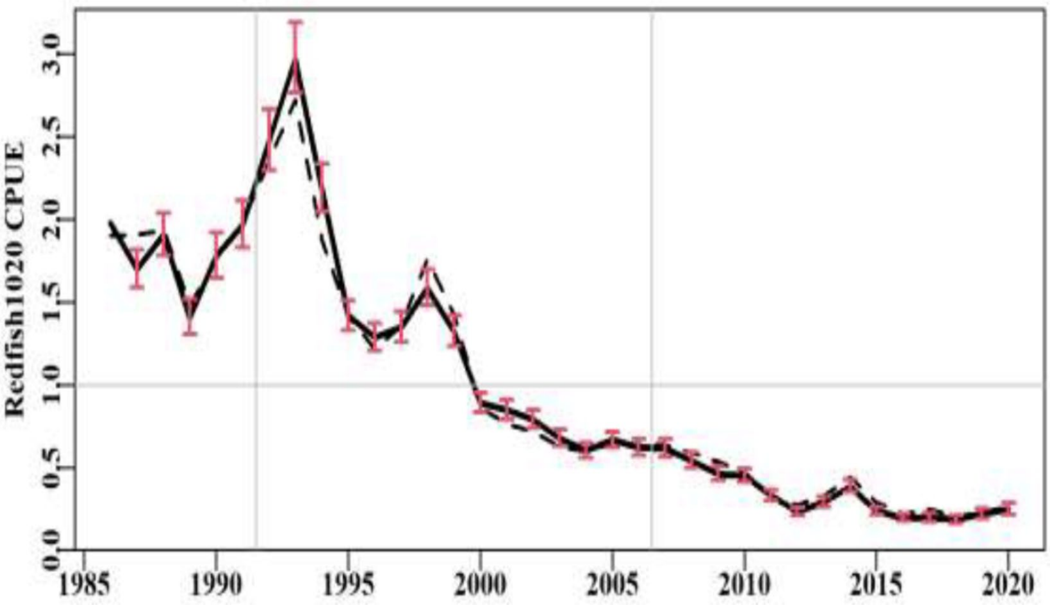

Figure 22 Standardized trawl CPUE of Redfish. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series. Source: Sporcic (2021a).

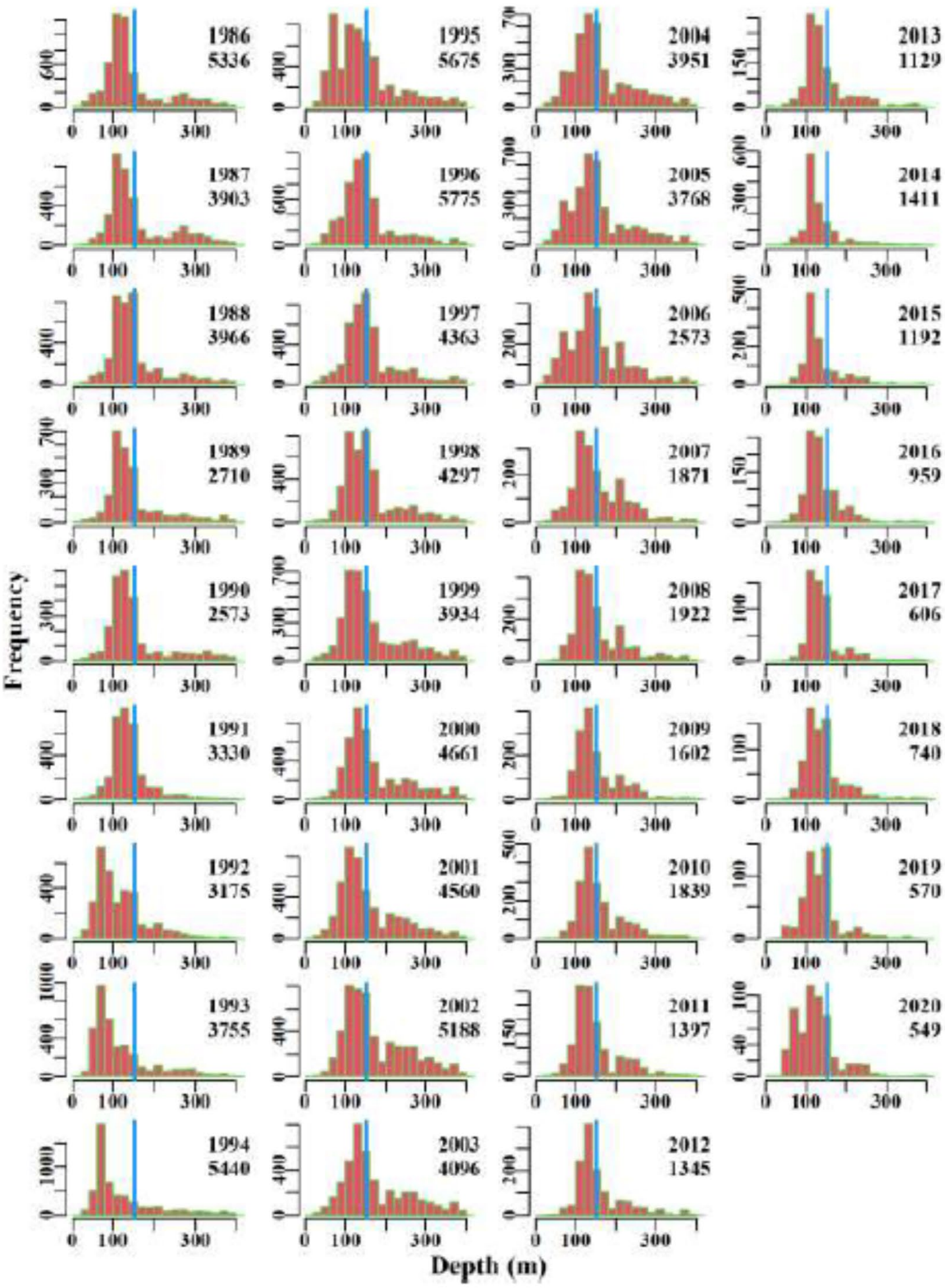

Figure 23 Histogram of annual fishing depths of Redfish between 1986 and 2020. Year and number of logbook records are printed on the right hand side of each plot. Blue line represents mean fishing depth. Source: Sporcic (2021a).

4.4.3 Spatial distribution of fishing

Since the late 1990s the majority of Redfish catch has been taken off the coast of NSW (Figure 24, Figure 25 and Figure 26). While there has been some catch off the east coast of Tasmania and in some years the west coast of Tasmania and Victoria, these catches have been small compared with the hot spot off New South Wales. Catches from west of Tasmania could be incorrect reports of Bight Redfish (*Centroberyx gerrardi*).

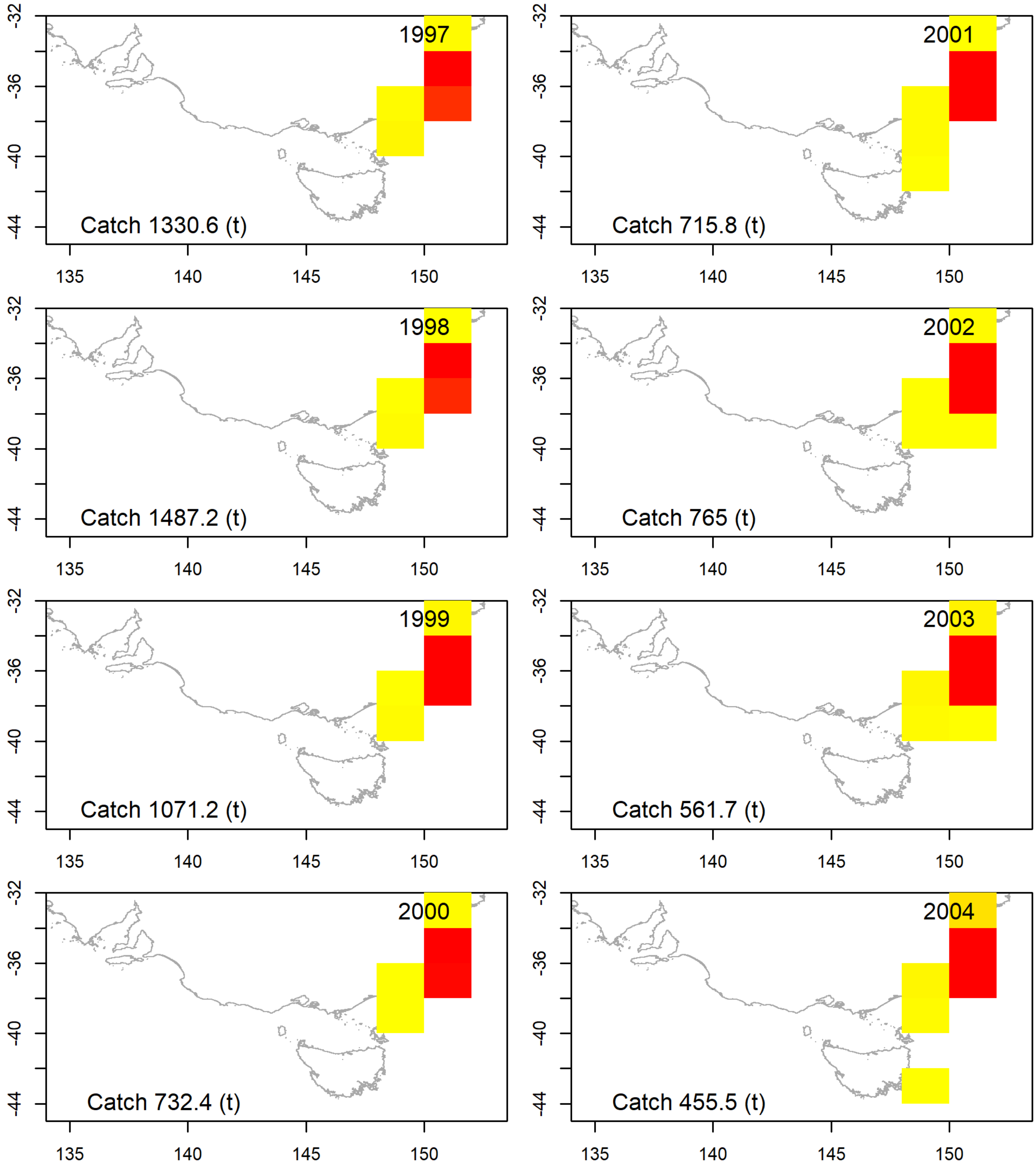

Figure 24 Spatial distribution of annual Redfish catch of trawl vessels 1997 - 2004. Logbook catch is provided in the bottom left corner of each annual plot. Note catches of eastern Redfish (*Centroberyx affinis*) reported in the GAB (SEF Zone 80) have been excluded to prevent confounding with likely misreporting of Bight Redfish (*Centroberyx gerrardi*).

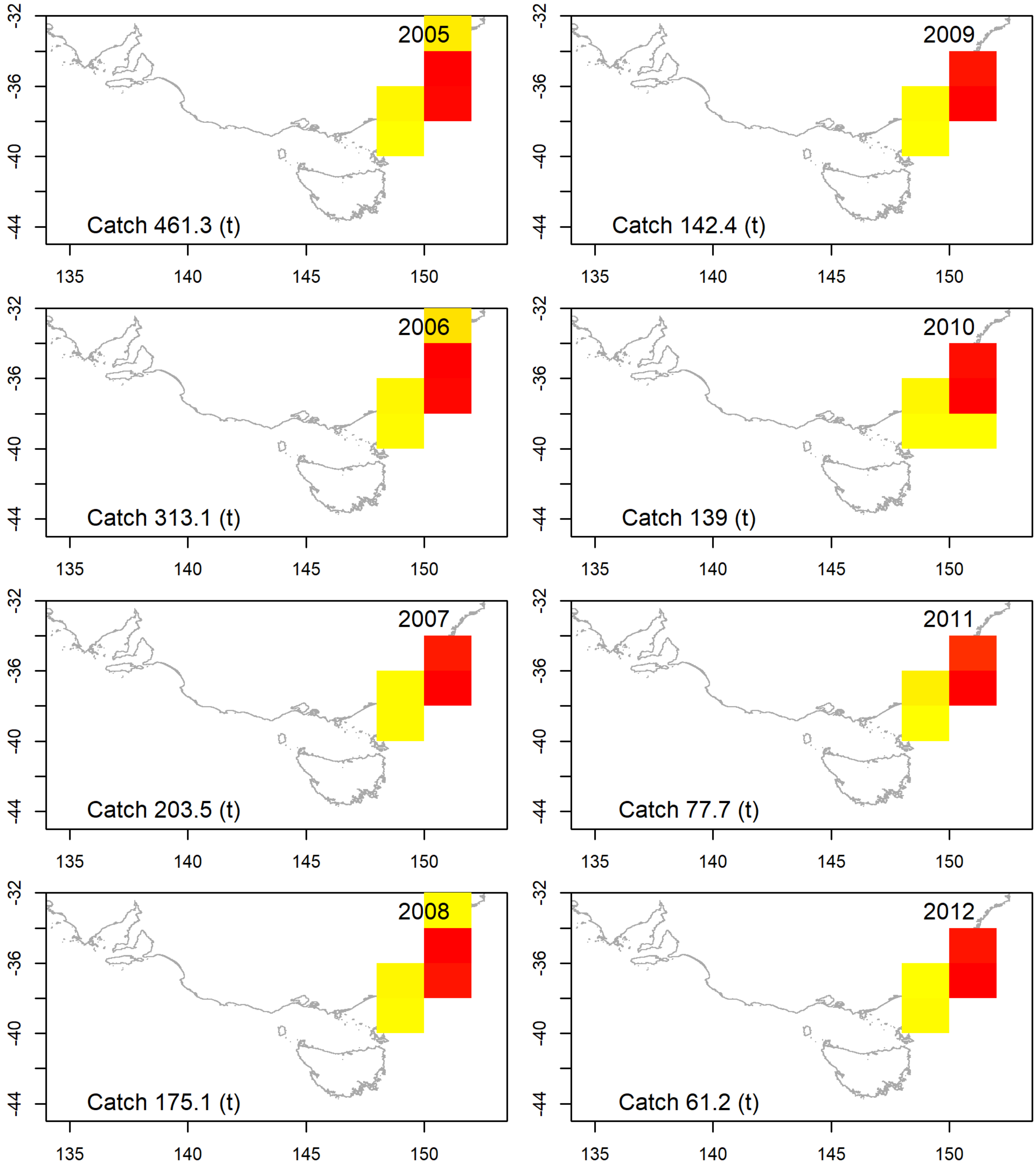

Figure 25 Spatial distribution of annual Redfish catch of trawl vessels 2005 - 2012. Logbook catch is provided in the bottom left corner of each annual plot. Note catches of eastern Redfish (*Centroberyx affinis*) reported in the GAB (SEF Zone 80) have been excluded to prevent confounding with likely misreporting of Bight Redfish (*Centroberyx gerrardi*).

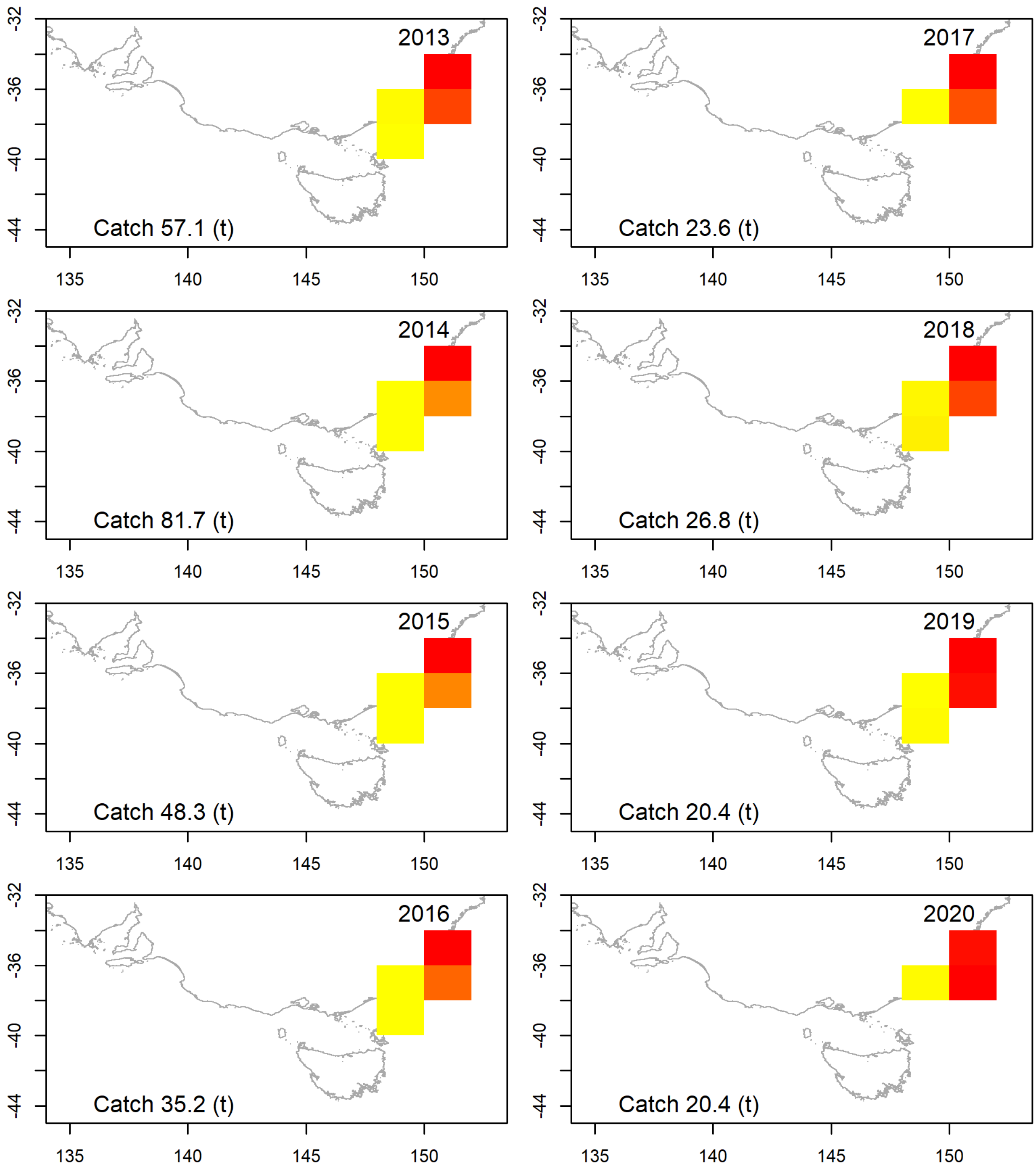

Figure 26 Spatial distribution of annual Redfish catch of trawl vessels 2013 - 2020. Logbook catch is provided in the bottom left corner of each annual plot. Note catches of eastern Redfish (*Centroberyx affinis*) reported in the GAB (SEF Zone 80) have been excluded to prevent confounding with likely misreporting of Bight Redfish (*Centroberyx gerrardi*).

4.4.4 Catch by vessel

Annual Redfish catch by vessel shows two vessels with catches that are consistently larger than other vessels over the past decade (Figure 27). While these catches remain small in absolute terms and one of these vessels did not report any Redfish catch in 2020 it may warrant further investigation.

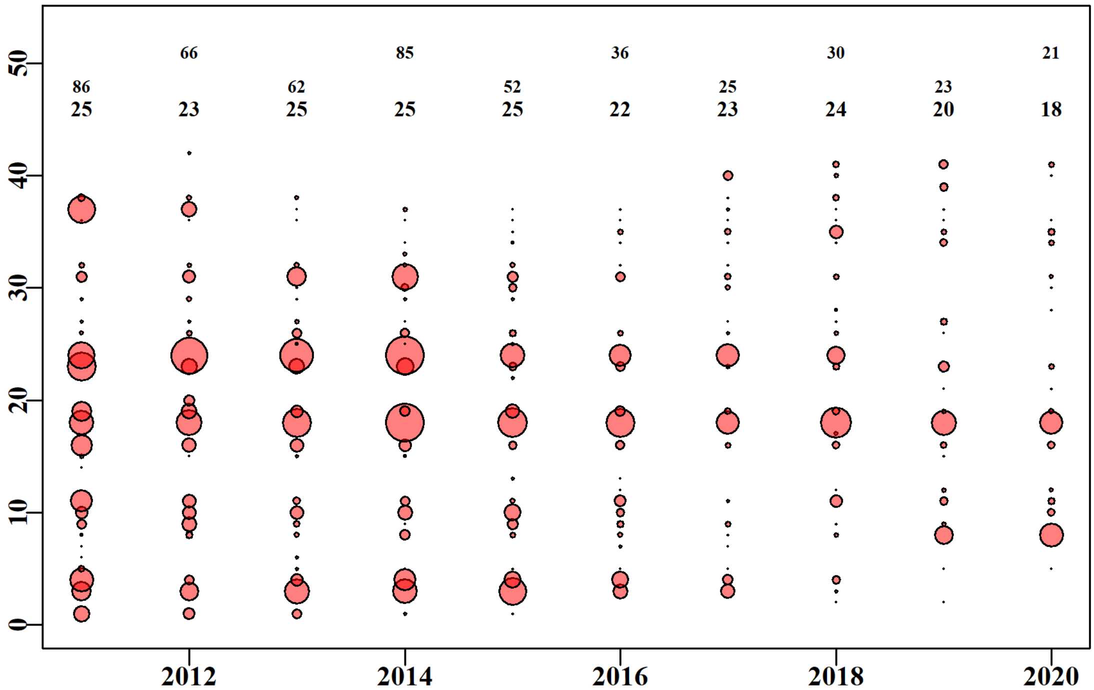

Figure 27 Bubble plot of annual Redfish catch of trawl vessels. Larger bubbles indicate larger annual catches. Numbers at the top of each year represent logbook catch (upper) and number of vessels reporting Redfish (lower). Each row represents one vessel. Note catches of eastern Redfish (*Centroberyx affinis*) reported in the GAB (SEF Zone 80) have been excluded to prevent confounding with likely misreporting of Bight Redfish (*Centroberyx gerrardi*).

4.5 Targeting analysis - School Shark

4.5.1 Catch

Landings of School Shark averaged approximately 210t between 2001 and 2009 and dropped to an average of 190t following the introduction of lower quotas from 2010 (Table 18). School shark are predominately landed by gillnet and hook gears, however, around 15% of the catch has been landed by demersal trawlers operating west of Tasmania in recent years. Gillnet catches summarised by year and month of fishing show catches of School Shark decline slightly in winter and spring but are otherwise reasonably consistent over the season (Figure 28). A similar pattern is apparent for hook catches (Figure 29). Trawl catches are highest over winter (associated with blue grenadier spawning) with little variability among years (Figure 30).

Table 18 Catch of School Shark (t) by gear type: Danish seine, Gillnet, Hook and line, Trawl and all Other gears. Log Total (t) represents the total catch reported in logbooks, CDR (t) the total landed catch from catch disposal records, State (t) the reported State catches, Discards (t) the estimated discarded catches and TAC (t) the Commonwealth total allowable catch.

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
2020	0.3	65.7	0.0	42.2	20.4	128.6	136.7	19.1	27.3	195
2019	0.2	63.1	0.1	109.6	28.7	201.8	223.9	35.0	45.7	189
2018	0.1	73.4	0.0	55.4	24.6	153.5	177.0	30.3	36.3	215
2017	0.3	108.8	0.0	95.4	21.1	225.6	259.8	28.8	50.9	215
2016	0.3	86.0	0.0	33.2	14.4	133.9	157.8	26.7	32.6	215
2015	0.6	83.1	0.2	50.4	12.6	146.9	161.6	24.5	32.9	215
2014	0.1	108.4	0.0	80.2	11.3	200.0	221.0	22.6	43.2	215
2013	0.2	79.5	0.0	51.9	18.4	150.0	157.5	20.0	29.5	215
2012	0.5	100.5	0.0	23.6	11.4	136.0	142.7	28.5	23.0	150
2011	1.1	146.5	0.0	20.7	14.1	182.4	196.6	26.5	22.1	176
2010	0.3	149.8	0.0	16.2	13.8	180.1	198.4	19.8	21.5	216
2009	0.2	227.8	0.0	11.1	13.9	253.1	258.4	19.4	27.4	240
2008	0.9	216.1	0.0	8.4	9.0	234.4	228.6	21.0	24.7	240
2007	0.5	182.0	0.0	7.7	7.7	197.8	172.1	23.9	19.3	264
2006	0.1	192.1	0.0	8.7	11.1	212.0	206.4	29.4	23.2	228
2005	0.1	193.0	0.0	7.0	8.7	208.9	205.3	26.9	22.9	243
2004	0.2	169.1	0.1	14.2	14.1	197.7	214.2	23.1	23.4	292
2003	0.1	174.0	0.0	20.2	14.0	208.3	212.8	27.4	23.8	0
2002	0.1	173.4	0.0	14.2	17.5	205.2	222.7	39.3	25.9	0
2001	0.1	153.1	0.2	11.9	17.3	182.6	189.0	52.7	23.8	0
2000	0.0	395.4	0.6	35.5	19.5	451.1	0.0	52.2	5.2	0
1999	0.1	436.0	0.9	33.1	15.5	485.6	0.0	68.4	6.8	0

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
1998	0.1	506.9	0.6	31.7	22.0	561.4	0.0	41.0	4.1	0
1997	0.4	397.3	2.5	31.1	24.4	455.8	0.0	17.4	1.7	0
1996	0.2	0.0	1.9	0.0	27.0	29.1	0.0	17.4	1.7	0
1995	0.0	0.0	0.0	0.0	2.5	2.5	0.0	17.4	1.7	0
1994	0.0	0.0	0.0	0.0	2.4	2.4	0.0	17.4	1.7	0
1993	0.0	0.0	0.0	0.0	1.4	1.4	0.0	17.4	0.0	0
1992	0.0	0.0	0.0	0.0	3.5	3.5	0.0	17.4	0.0	0

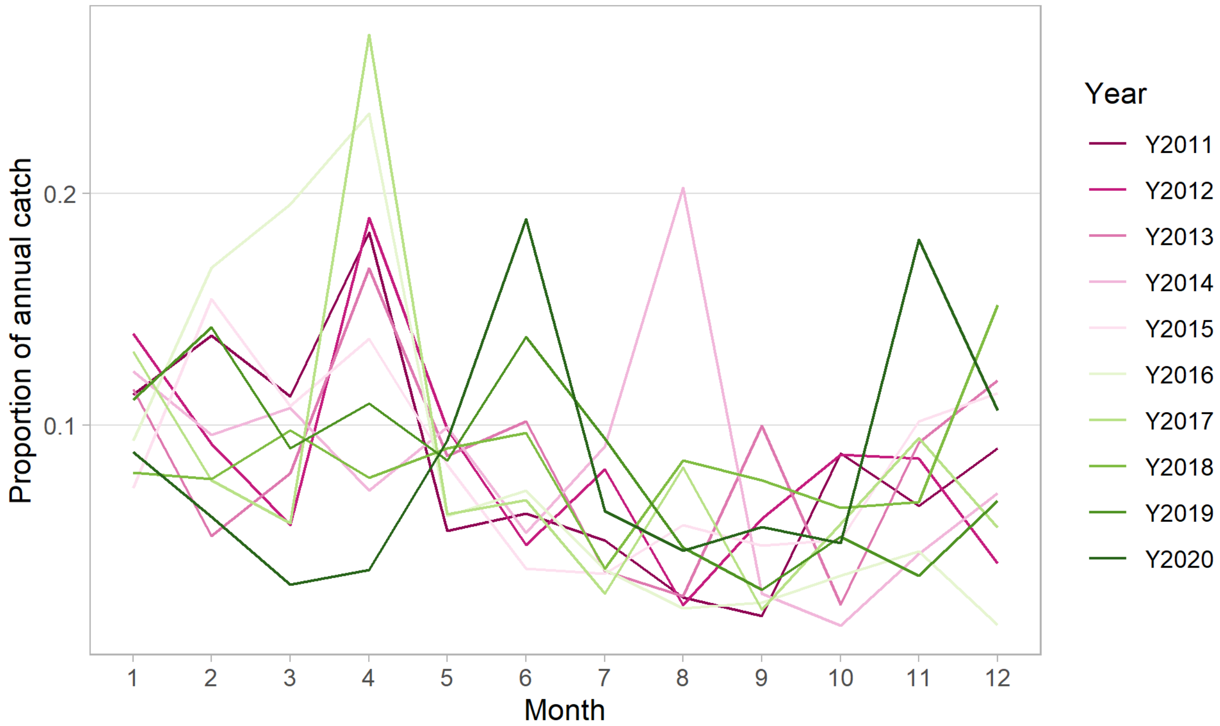

Figure 28 Monthly proportion of annual gillnet catch of School Shark.

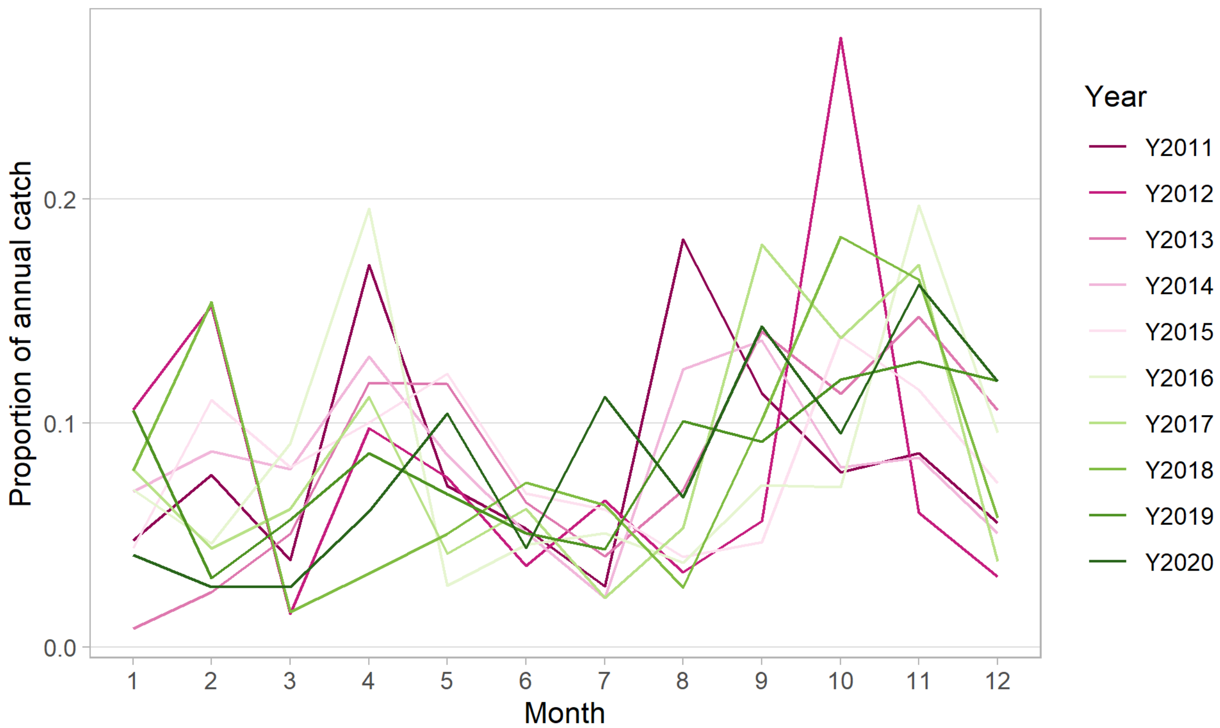

Figure 29 Monthly proportion of annual hook catch of School Shark.

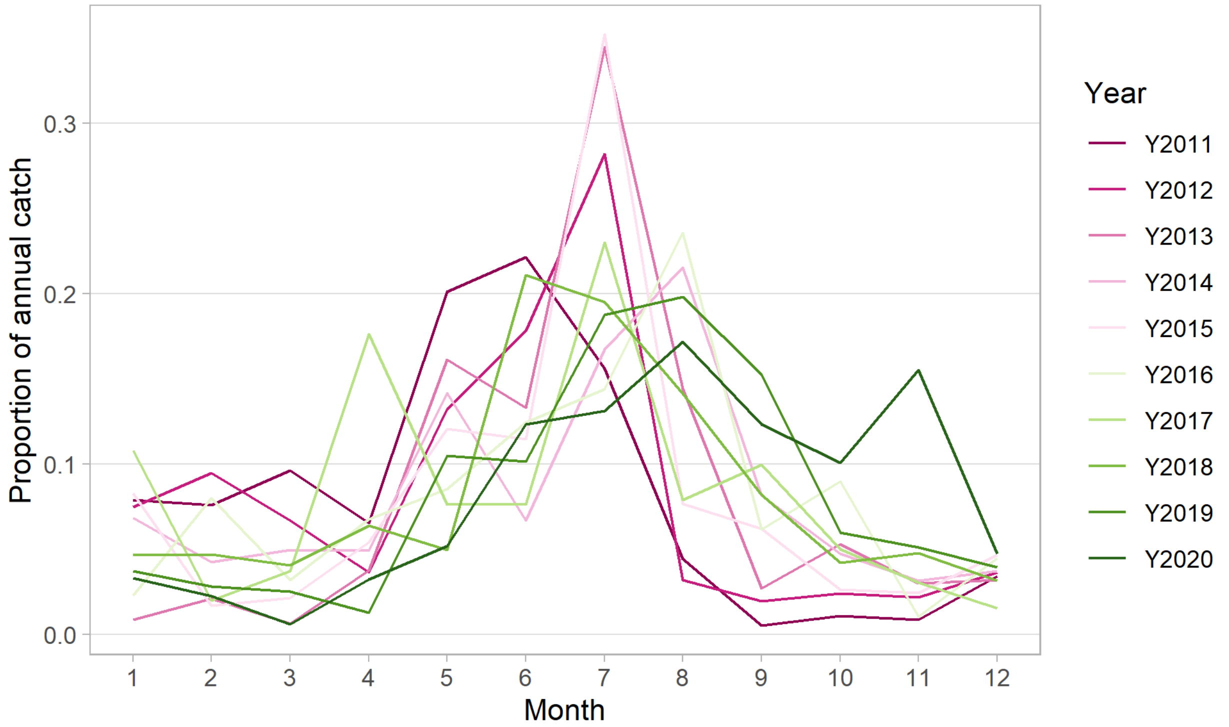

Figure 30 Monthly proportion of annual trawl catch of School Shark.

4.5.2 CPUE and depth of fishing

Gillnet CPUE is not thought to have indexed School Shark abundance since 1995 because a series of management measures, including closures, have changed fishing behaviour. The introduction of closures in South Australia to protect Australian Sea Lions lead to a shift from gillnet to hook gear in that state. Standardized trawl CPUE for School Shark has increased steadily from a low in the early to mid-2000s to reach its highest level in over two decades in recent years (Figure 31 and Sporcic, 2021b). The depth of fishing for trawl caught School Shark is bimodal with a shallow mode around 120m that has been relatively consistent over time (Figure 32). The second mode for deeper fishing is less consistent and varies between 350 and 500m.

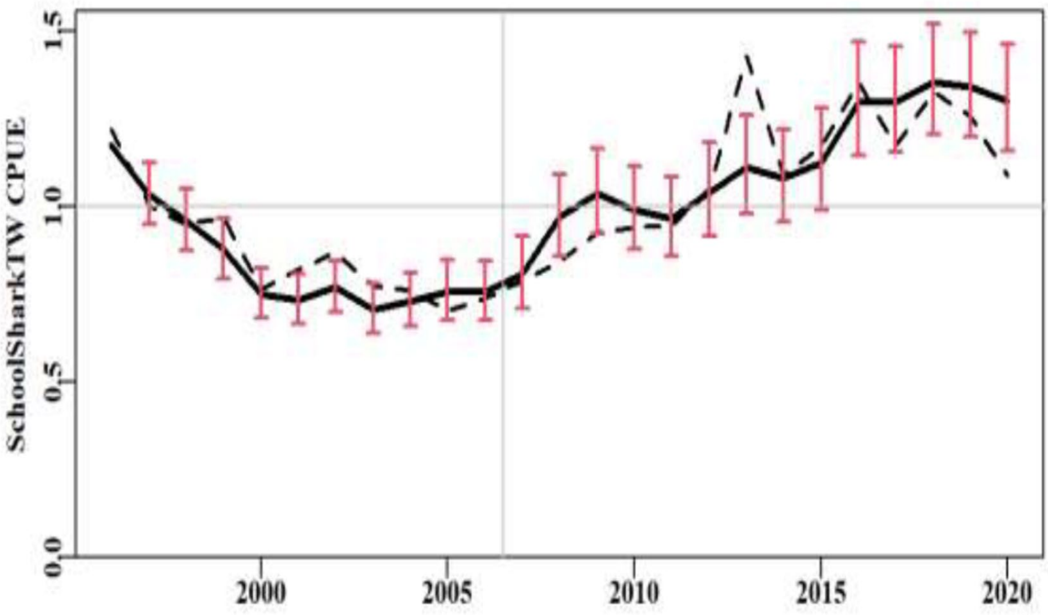

Figure 31 Standardized trawl CPUE of School shark. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series. Source: Sporcic (2021b).

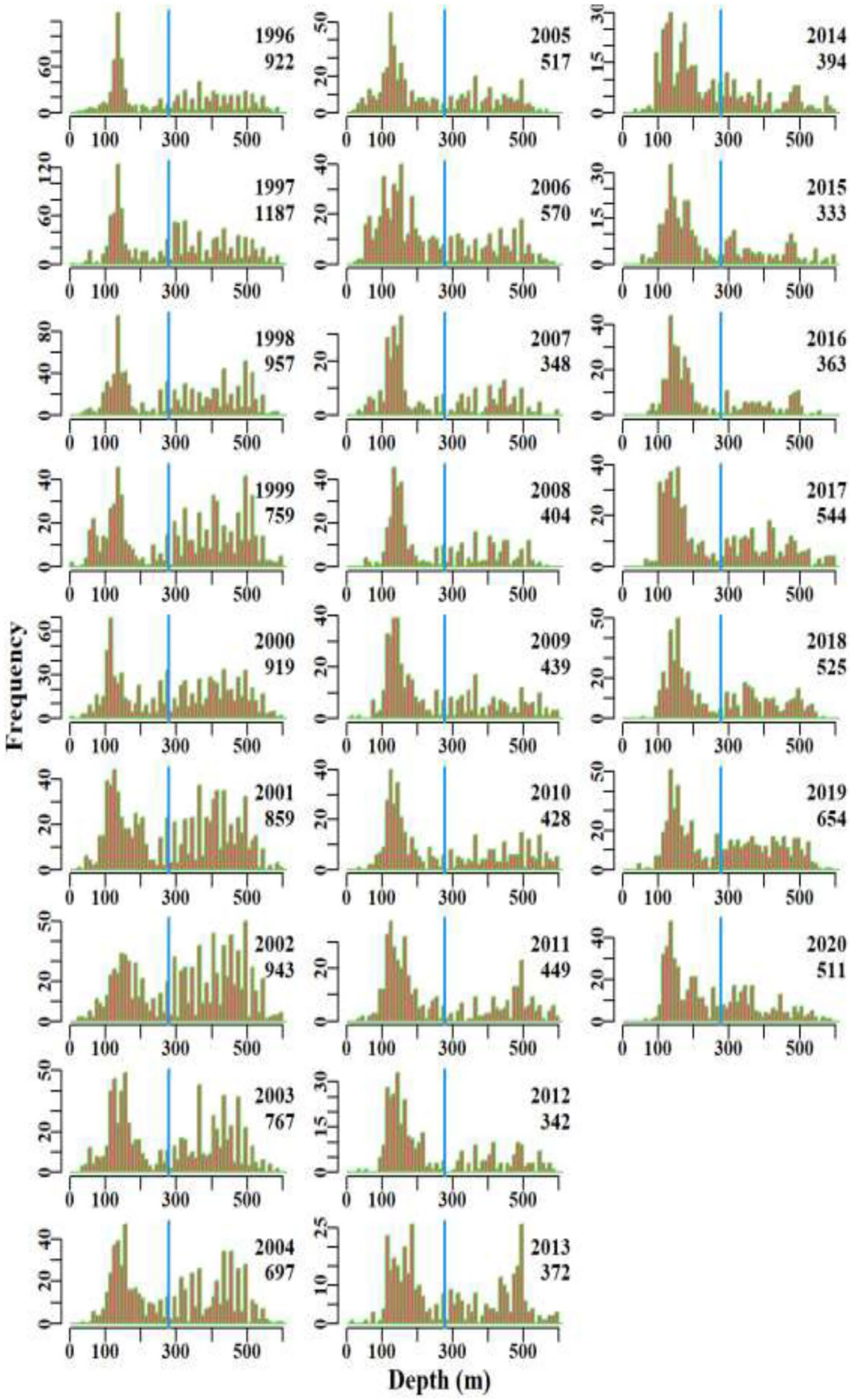

Figure 32 Histogram of annual fishing depths of School Shark between 1986 and 2020. Year and number of logbook records are printed on the right hand side of each plot. Blue line represents mean fishing depth. Source: Sporcic (2021b).

4.5.3 Spatial distribution of fishing

The spatial distribution of School Shark catches taken by gillnet vessels has contracted in recent years associated with changes in spatial management. Since 2016, gillnet catches of School Shark have been concentrated in Bass Strait, west of Tasmania to Kangaroo Island (Figure 33, Figure 34 and Figure 35). Trawl catches of School Shark have been concentrated off the west coast of Tasmania and eastern Victoria (Figure 36, Figure 37 and Figure 38). Recent catches of School Shark taken by hook and line vessels are concentrated around western and central South Australia and off the south coast of Tasmania (Figure 39).

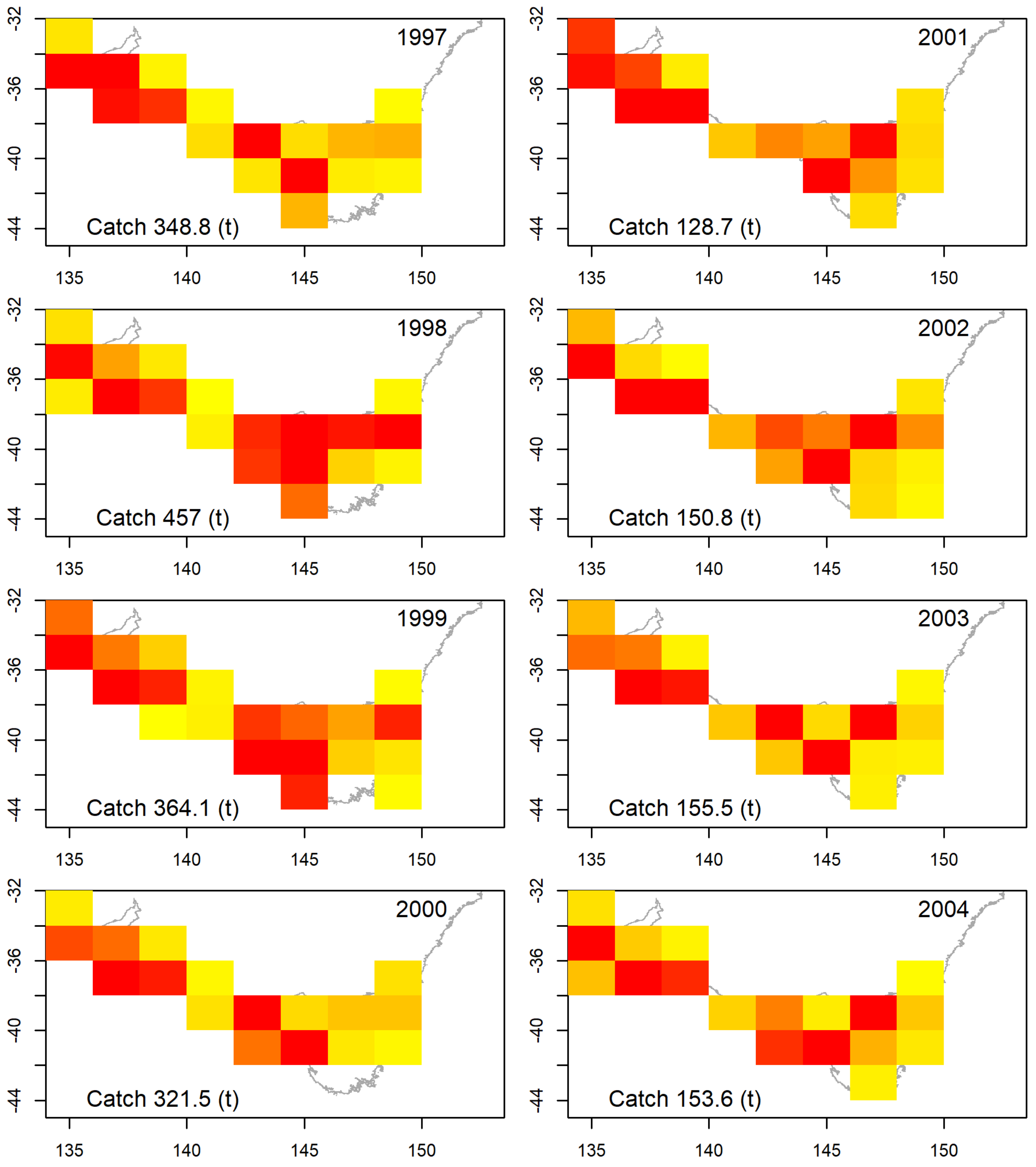

Figure 33 Spatial distribution of annual School Shark catch of gillnet vessels 1997 - 2004. Logbook catch is provided in the bottom left corner of each annual plot.

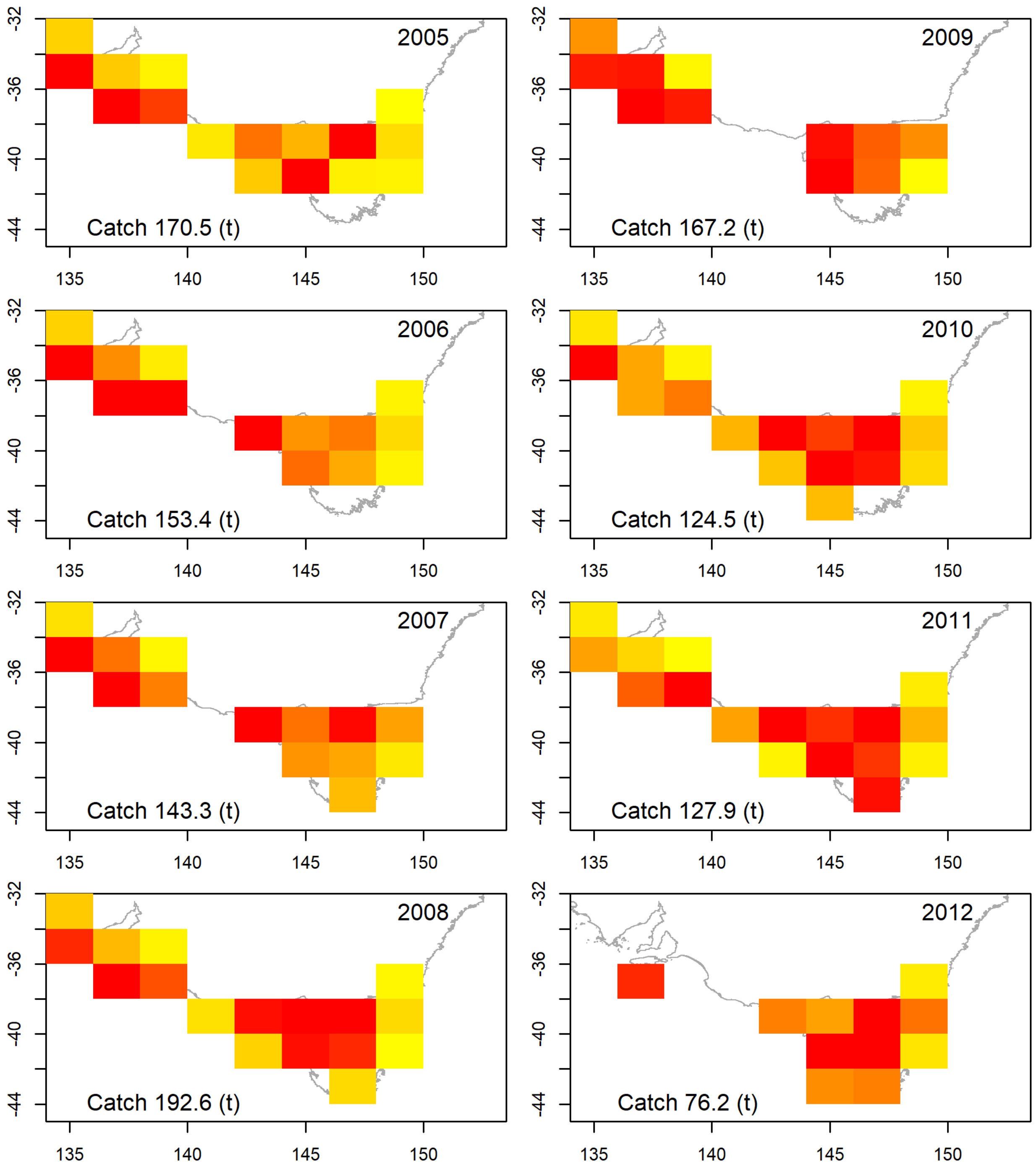

Figure 34 Spatial distribution of annual School Shark catch of gillnet vessels 2005 - 2012. Logbook catch is provided in the bottom left corner of each annual plot.

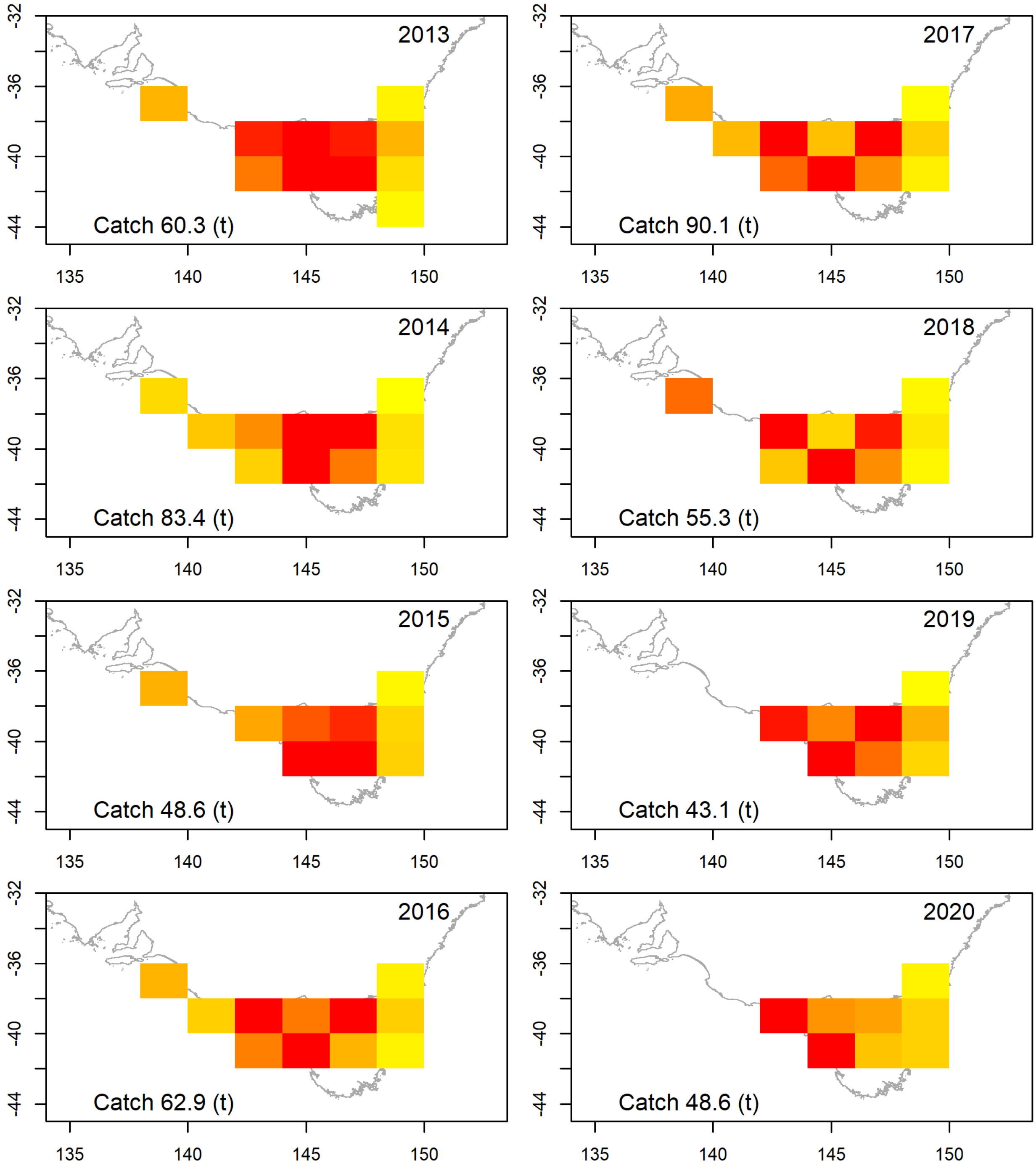

Figure 35 Spatial distribution of annual School Shark catch of gillnet vessels 2013 - 2020. Logbook catch is provided in the bottom left corner of each annual plot.

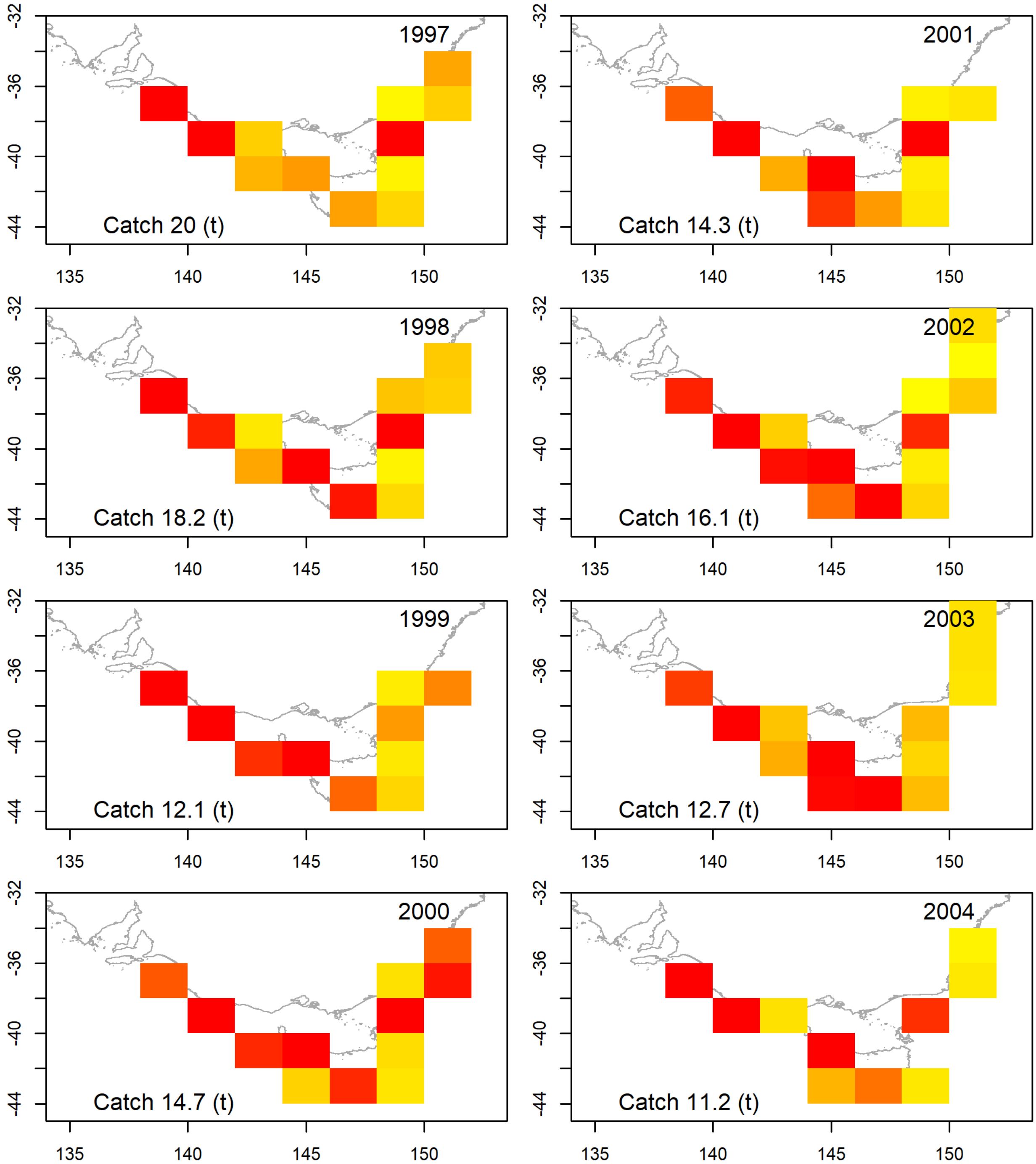

Figure 36 Spatial distribution of annual School Shark catch of trawl vessels 1997 - 2004. Logbook catch is provided in the bottom left corner of each annual plot.

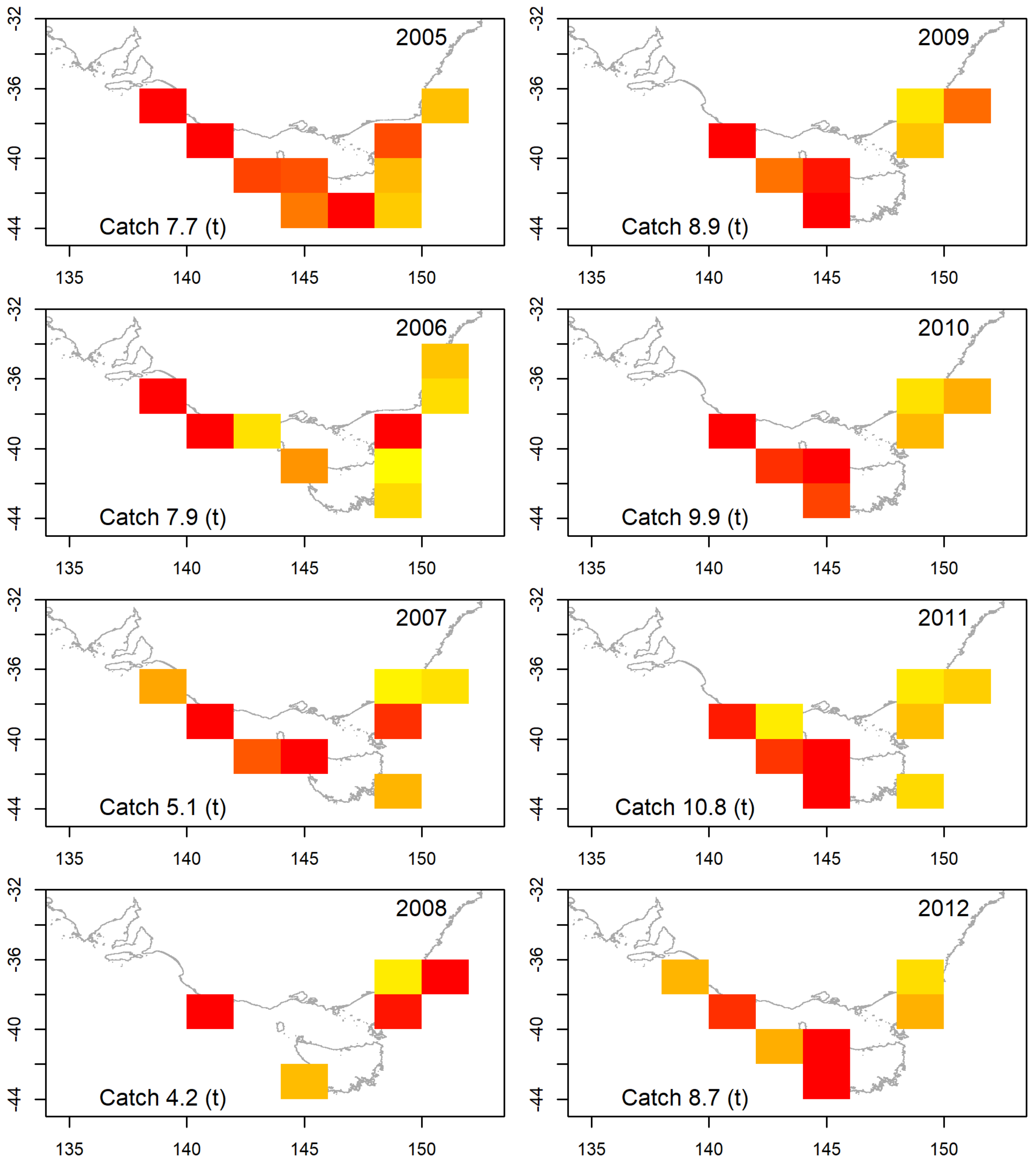

Figure 37 Spatial distribution of annual School Shark catch of trawl vessels 2005 - 2012. Logbook catch is provided in the bottom left corner of each annual plot.

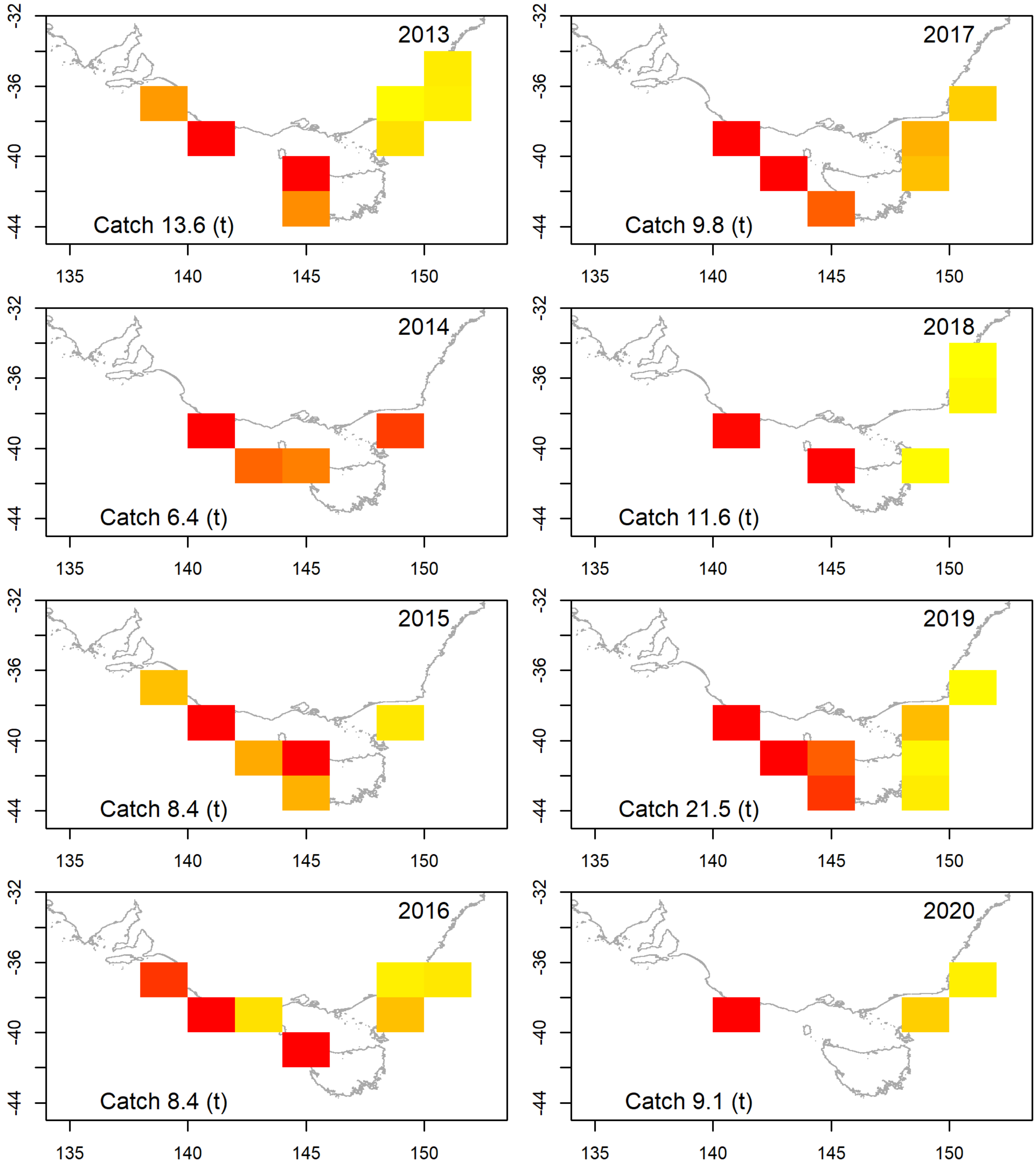

Figure 38 Spatial distribution of annual School Shark catch of trawl vessels 2013 - 2020. Logbook catch is provided in the bottom left corner of each annual plot.

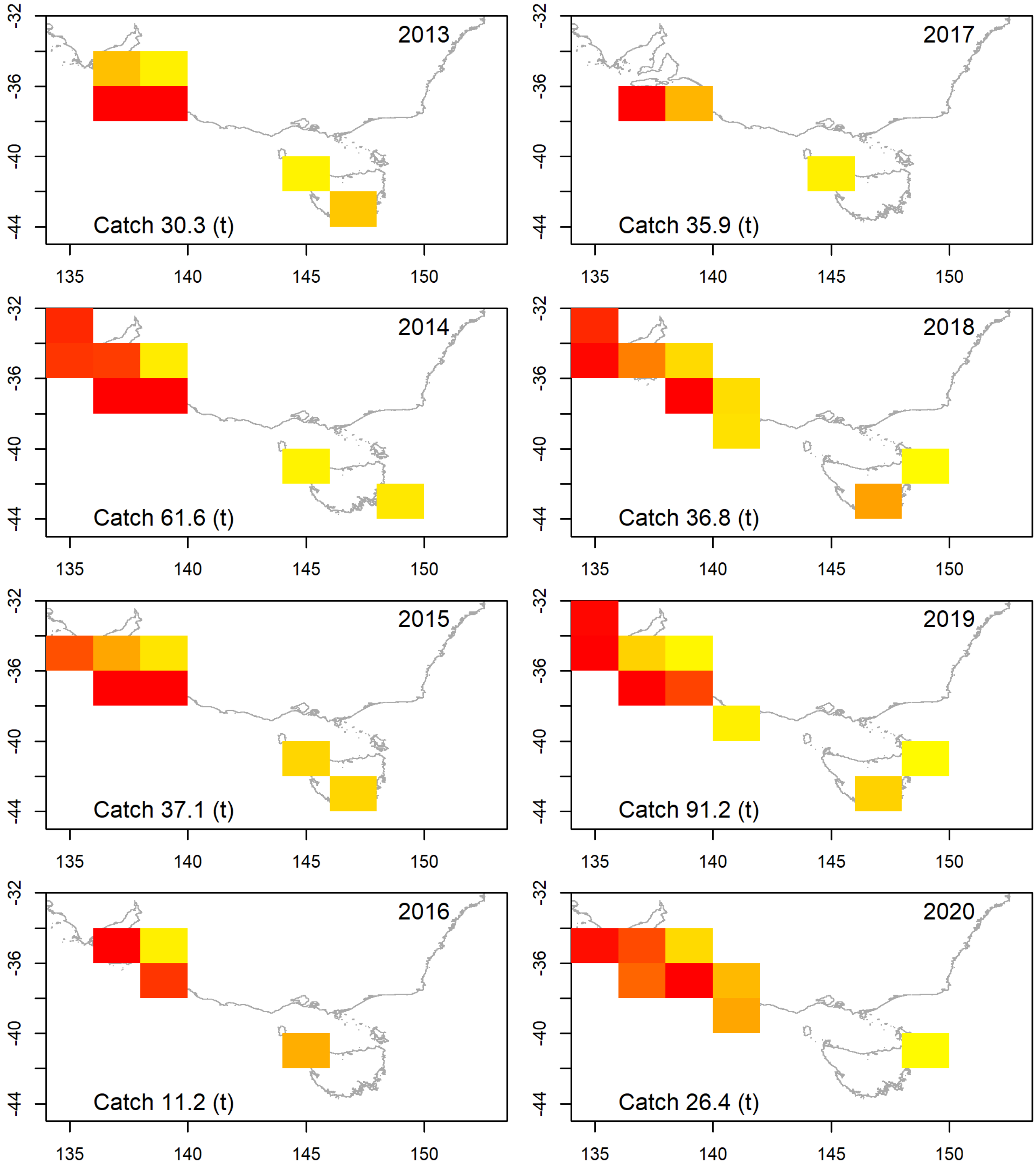

Figure 39 Spatial distribution of annual School Shark catch of hook vessels 2013 - 2020. Logbook catch is provided in the bottom left corner of each annual plot.

4.5.4 Catch by vessel

There is no evidence of gillnet or hook vessels reporting consistently large catches School Shark in recent years which therefore does not provide any evidence of targeting (Figure 40 and Figure 41). Two trawl vessels have reported higher than average landings of School Shark over the last few years (Figure 42). While these landings are low in absolute terms and are likely from vessels fishing on the shelf west of Tasmania they may warrant further investigation by AFMA.

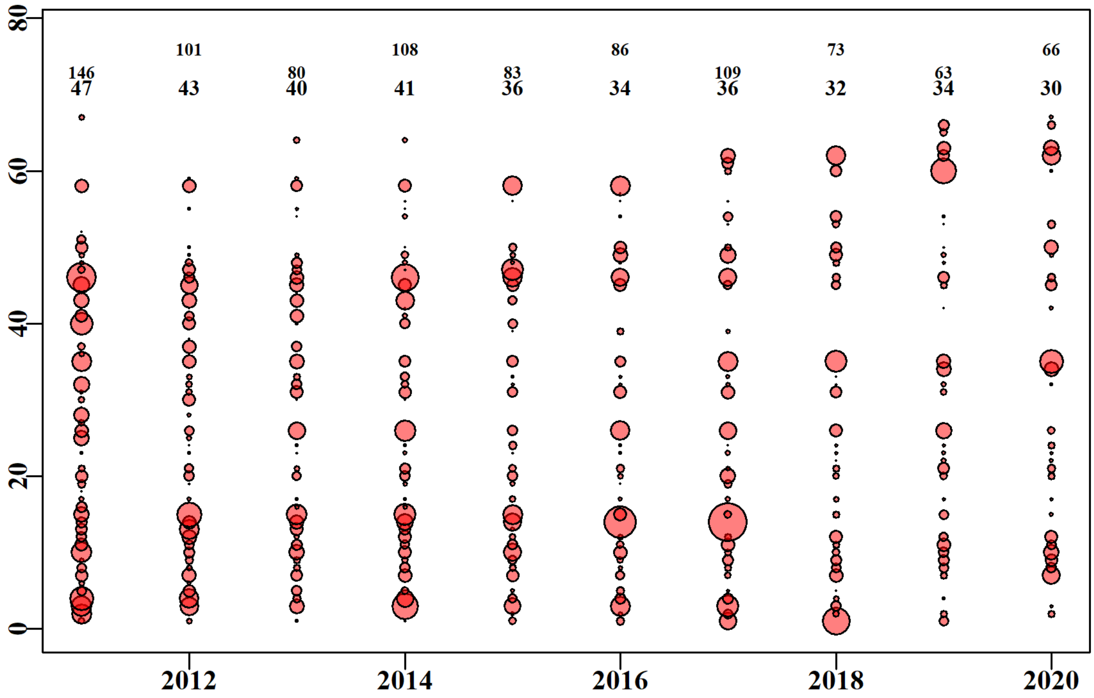

Figure 40 Bubble plot of annual School Shark catch of gillnet vessels. Larger bubbles indicate larger annual catches. Numbers at the top of each year represent logbook catch (upper) and number of vessels reporting School Shark (lower).

Figure 41 Bubble plot of annual School Shark catch of hook vessels. Larger bubbles indicate larger annual catches. Numbers at the top of each year represent logbook catch (upper) and number of vessels reporting School Shark (lower).

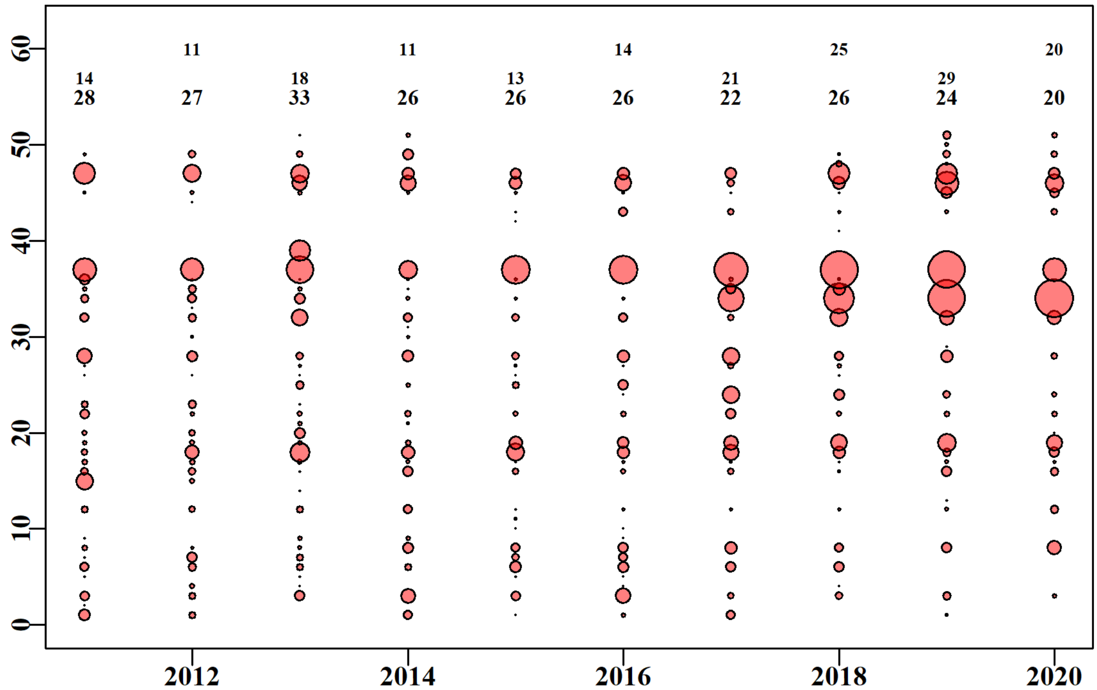

Figure 42 Bubble plot of annual School Shark catch of trawl vessels. Larger bubbles indicate larger annual catches. Numbers at the top of each year represent logbook catch (upper) and number of vessels reporting School Shark (lower). Each row represents one vessel.

4.6 Targeting analysis - John Dory

4.6.1 Catch

Commonwealth catches of John Dory have declined from a peak of 150 t in the late 1980s and early 1990s, to around 100 t in the mid 2000s. Catches have continued to gradually decline and for the last five years catches have been around 60 t (Table 19). John Dory are primarily caught by trawl in zones 10 and 20, although small catches have also been recorded by gillnet and Danish seine. Trawl catches summarised by year and month of fishing show that catches of John Dory are highest in the spring with catches increasing from winter (Figure 43).

Table 19 Catch of John Dory (t) by gear type: Danish seine, Gillnet, Hook and line, Trawl and all Other gears. Log Total (t) represents the total catch reported in logbooks, CDR (t) the total landed catch from catch disposal records, State (t) the reported State catches, Discards (t) the estimated discarded catches and TAC (t) the Commonwealth total allowable catch.

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
2020	18.6	0.2	0	0.0	39.6	58.4	68.7	7.0	8.6	452
2019	15.0	0.0	0	0.0	40.8	55.9	66.8	6.8	8.4	395
2018	14.6	0.1	0	0.0	43.1	57.8	67.9	4.7	1.2	263
2017	20.6	0.1	0	0.0	47.9	68.6	81.1	9.8	3.1	175
2016	18.1	0.1	0	0.0	48.8	66.9	78.5	7.4	1.8	167
2015	14.6	0.1	0	0.0	58.9	73.6	92.1	14.7	0.3	169
2014	7.2	0.0	0	0.0	39.3	46.6	60.8	10.1	5.5	221
2013	7.6	0.0	0	0.0	55.8	63.5	78.3	23.0	1.2	221
2012	6.2	0.0	0	0.0	60.9	67.1	79.0	18.2	1.3	221
2011	11.1	0.0	0	0.0	63.7	74.8	92.3	33.2	8.5	221
2010	4.8	0.0	0	0.0	57.1	62.0	72.4	14.6	3.0	221
2009	6.1	0.0	0	0.0	85.6	91.7	107.9	23.4	4.5	190
2008	6.9	0.1	0	0.0	109.8	116.8	136.2	41.0	0.6	190
2007	5.8	0.0	0	0.0	56.6	62.5	68.9	13.8	1.4	178
2006	6.8	0.0	0	0.0	78.6	85.4	83.6	23.6	0.6	190
2005	10.4	0.1	0	0.0	96.9	107.4	102.8	29.2	3.5	240
2004	10.5	0.1	0	0.0	155.4	166.0	166.0	29.4	1.8	240
2003	8.8	0.1	0	0.0	148.0	156.9	165.0	28.5	3.2	240
2002	8.3	0.0	0	0.0	142.7	151.0	165.0	19.5	1.7	240
2001	5.8	0.1	0	0.0	123.4	129.3	135.9	30.7	6.1	240
2000	7.1	0.1	0	0.0	156.7	164.1	169.9	39.5	17.0	240
1999	5.2	0.1	0	0.6	127.0	132.8	138.2	35.8	2.9	240

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
1998	5.1	0.1	0	0.1	103.7	109.0	115.3	39.8	3.4	240
1997	3.9	0.2	0	0.1	83.5	87.8	0.0	29.2	0.6	240
1996	4.2	0.0	0	0.2	156.3	160.8	0.0	30.0	0.6	240
1995	2.2	0.0	0	0.1	183.4	185.7	0.0	31.7	0.7	240
1994	12.4	0.0	0	0.2	255.3	267.9	0.0	36.5	0.8	240
1993	15.0	0.0	0	0.2	225.2	240.4	0.0	28.6	0.0	240
1992	6.1	0.0	0	5.8	118.9	130.8	0.0	28.6	0.0	240

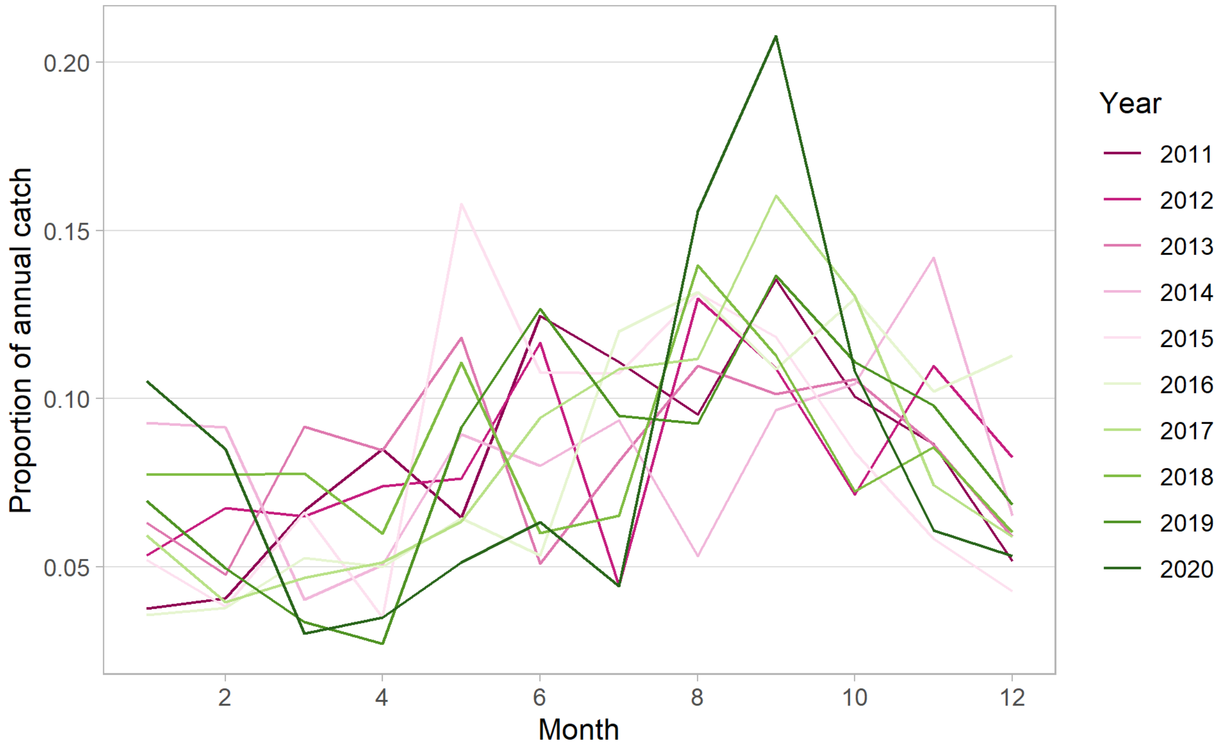

Figure 43 Monthly proportion of annual trawl catch of John Dory.

4.6.2 CPUE and depth of fishing

Standardized CPUE for eastern John Dory (zones 10-30) has been declining since the peak of the late 90s early 2000s. Apart from a small increase in 2008 and 2009 standardised CPUE has gradually declined since 1996 to the lowest level on record in 2020 (Figure 44). There has been a shift in the proportion of fishing operations from shallower depths in the early years to predominately deeper depths in the last five years (Figure 45).

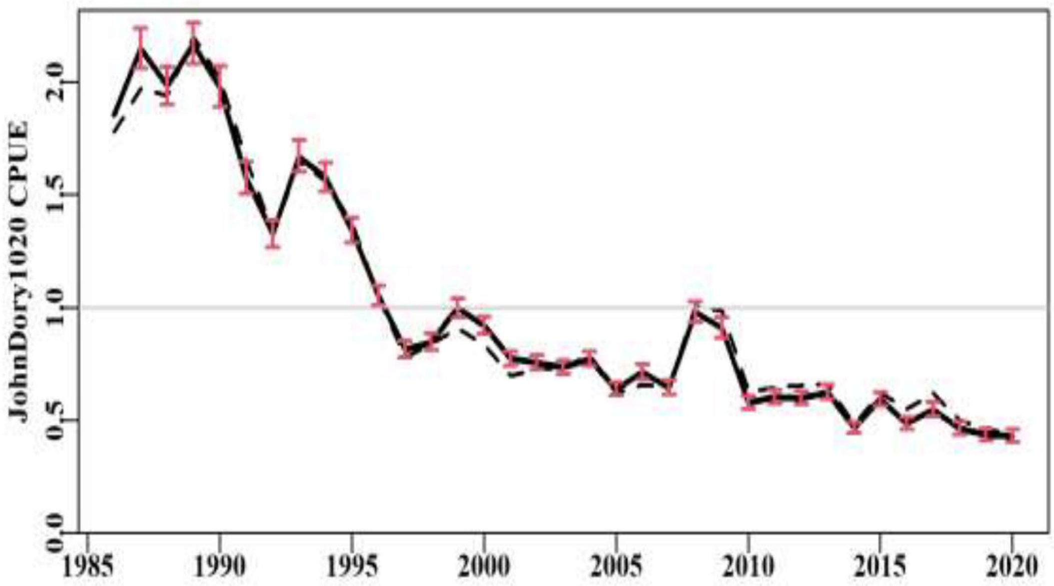

Figure 44 Standardized trawl CPUE of eastern John Dory (10 and 20) between 1986 and 2020. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series. Source: Sporcic (2021a).

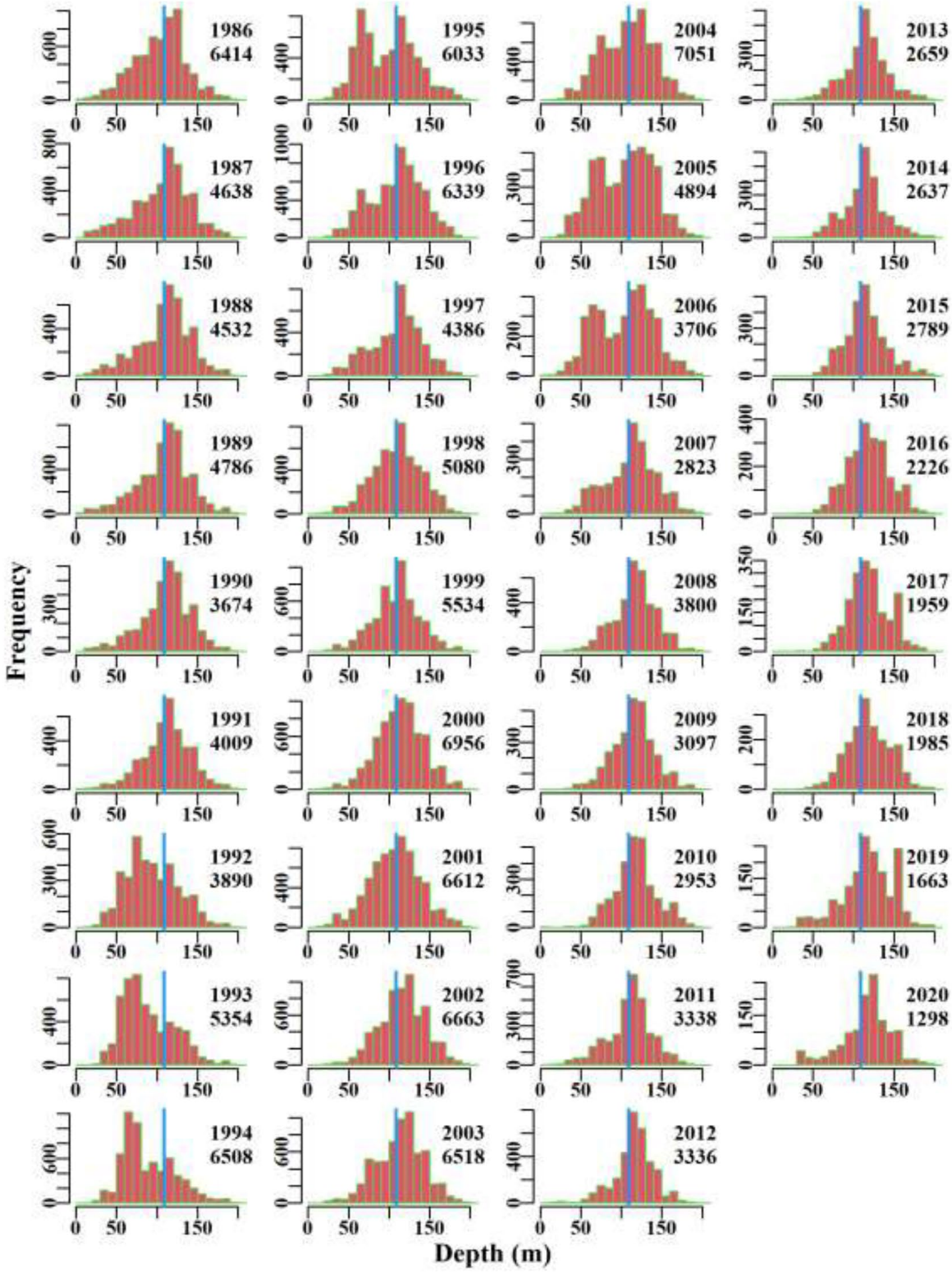

Figure 45 Histogram of annual fishing depths of eastern John Dory between 1986 and 2020. Year and number of logbook records are printed on the right hand side of each plot. Blue line represents mean fishing depth. Source: Sporcic (2021a).

4.6.3 Spatial distribution of fishing

Since the late 1990s there has been little change to the spatial distribution of John Dory catches, although as catches have declined there has been a spatial shift in where the majority of fish have been taken. In the late 1990s and early 2000s catches were spread between vessels operating within the fishery's spatial range with the majority of the catch taken by vessels operating out of the east coasts of NSW, Victoria, Tasmania and the south coast of South Australia (Figure 46). By the mid 2000s the large catches taken from vessels operating out of NSW and the Victorian east coast were reducing (Figure 47). Since 2017, landed catches have declined to ~60 t per annum and there have been no large catches from vessels operating out of the east coast of NSW or Victoria and the majority of the catch is taken by vessels operating off eastern Tasmania (Figure 48).

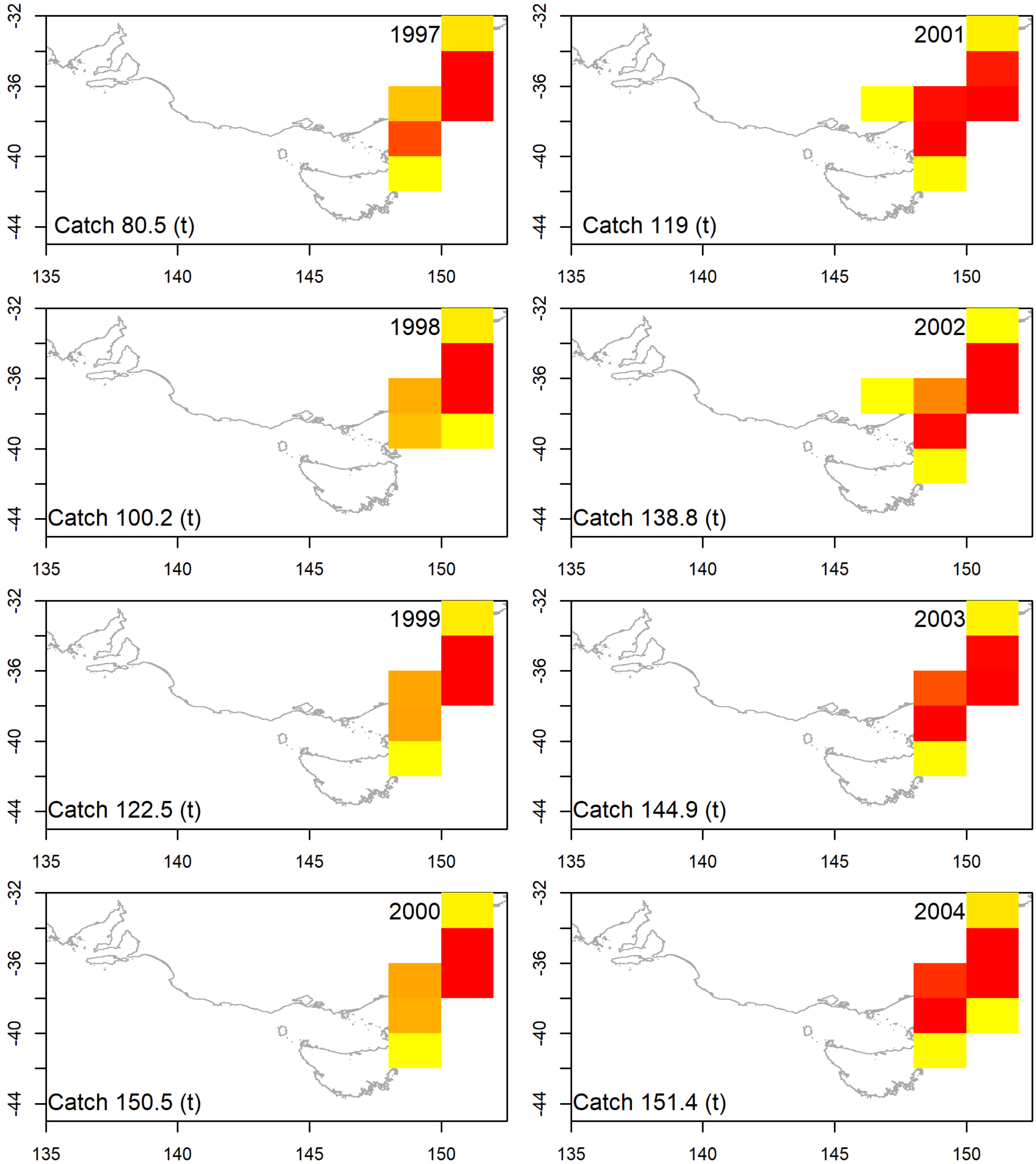

Figure 46 Spatial distribution of annual John Dory catch of trawl vessels 1997 - 2004. Logbook catch is provided in the bottom left corner of each annual plot.

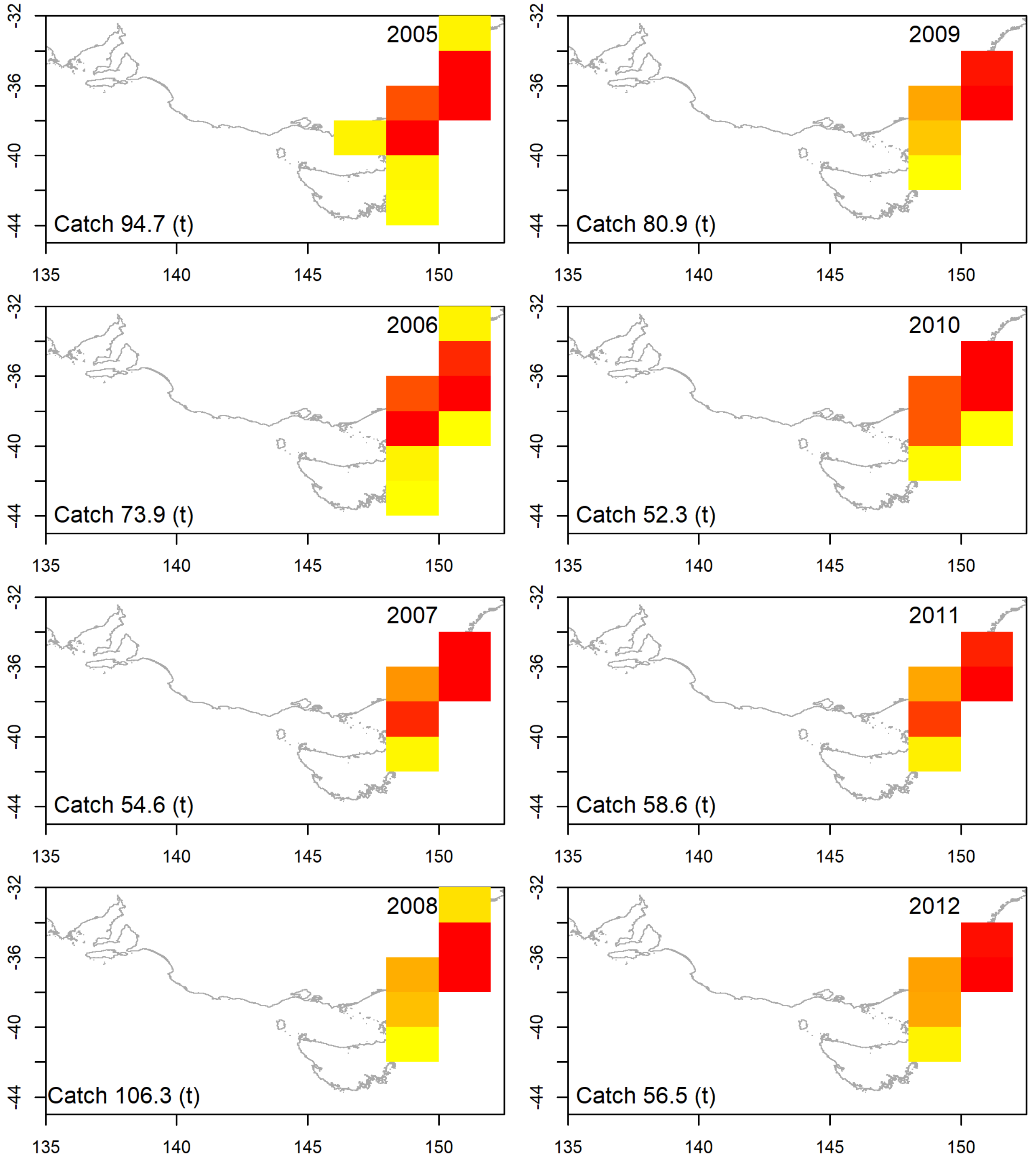

Figure 47 Spatial distribution of annual John Dory catch of trawl vessels 2005 - 2012. Logbook catch is provided in the bottom left corner of each annual plot.

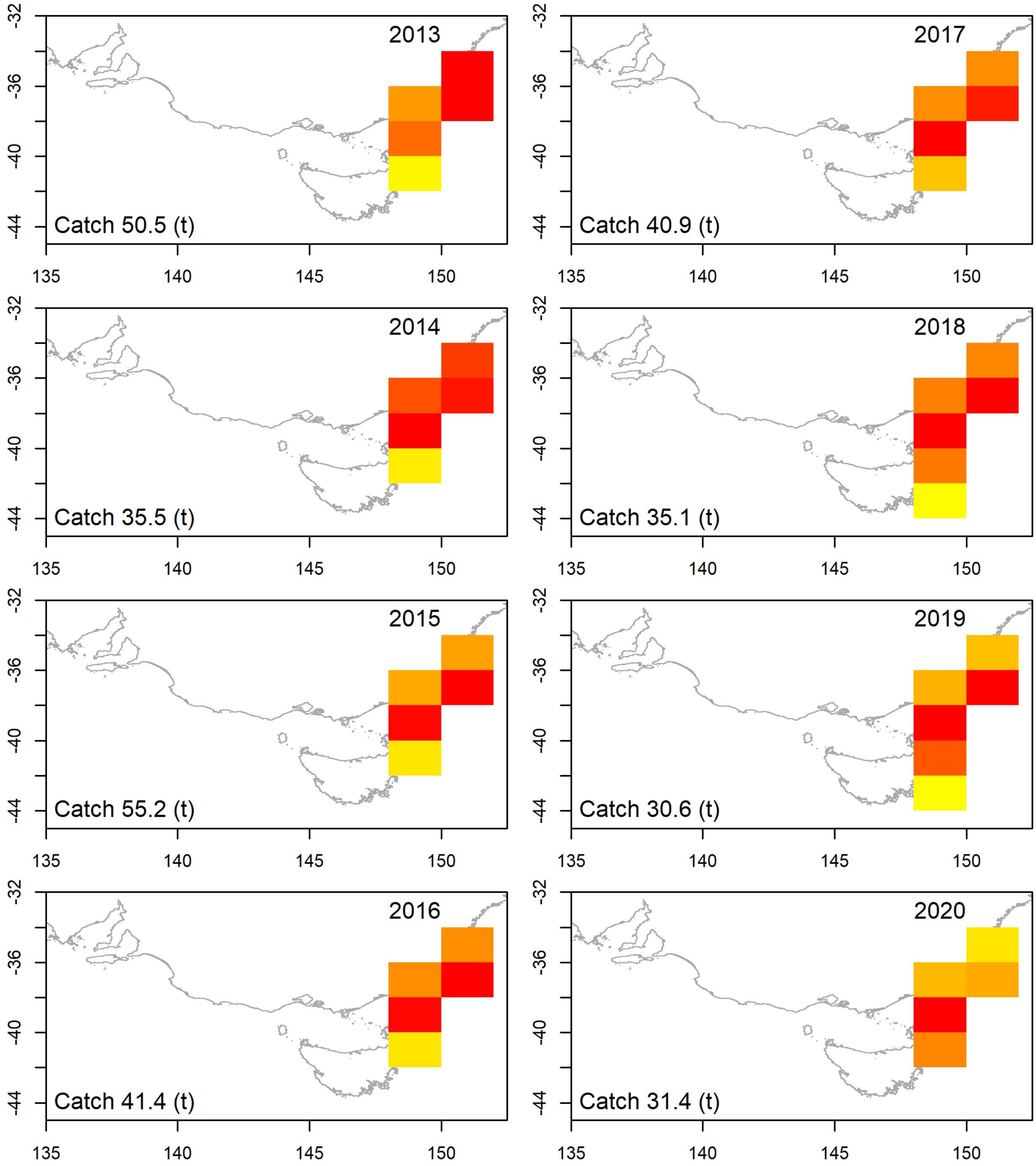

Figure 48 Spatial distribution of annual John Dory catch of trawl vessels 2013 - 2020. Logbook catch is provided in the bottom left corner of each annual plot.

4.6.4 Catch by vessel

Annual John Dory catch by vessel shows that in recent years two vessel have consistently reported large catches, one vessel since 2010 and the other since 2016. This shows some evidence that these vessels may be targeting John Dory (Figure 49). Note that targeting of John Dory is currently permitted.

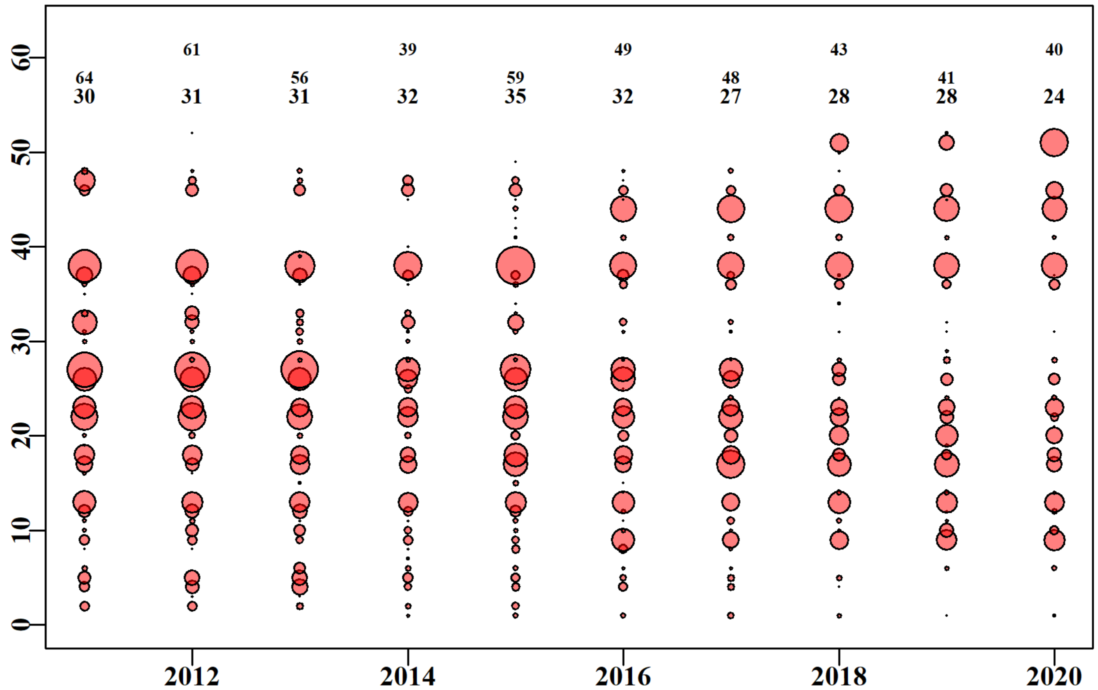

Figure 49 Bubble plot of annual John Dory catch of trawl vessels. Larger bubbles indicate larger annual catches. Numbers at the top of each year represent logbook catch (upper) and number of vessels reporting John Dory (lower). Each row represents one vessel.

4.7 Targeting analysis - Silver Trevally

4.7.1 Catch

Catches of Silver Trevally oscillated between 150 and 500t from 1986 but have been declining since 2004 to between 4 and 55 t in the last five years (Table 20). Silver Trevally catches are predominately taken by trawl with small catches taken by Danish seine and gillnets. Trawl catches summarised by year and month of fishing show that catches of Silver Trevally are higher over the spring months in most years (Figure 50).

Table 20 Catch of Silver Trevally (t) by gear type: Danish seine, Gillnet, Hook and line, Trawl and all Other gears. Log Total (t) represents the total catch reported in logbooks, CDR (t) the total landed catch from catch disposal records, State (t) the reported State catches, Discards (t) the estimated discarded catches and TAC (t) the Commonwealth total allowable catch.

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
2020	0.1	0.0	0.0	0.0	39.3	39.4	36.3	72.8	16.5	289
2019	0.0	0.0	0.5	0.0	3.3	3.8	3.0	83.2	13.0	292
2018	0.0	0.0	0.1	0.1	37.5	37.7	33.7	105.0	20.9	307
2017	0.5	0.0	0.2	0.0	52.2	52.9	51.8	135.8	28.3	613
2016	0.1	0.0	0.1	0.0	52.2	52.4	56.3	144.8	30.3	588
2015	1.7	0.0	0.0	0.0	77.7	79.5	80.3	128.4	31.5	602
2014	1.0	0.0	0.1	0.2	105.7	107.0	114.8	204.0	11.5	615
2013	0.0	0.6	0.0	0.0	122.1	122.8	132.6	197.1	0.8	781
2012	0.2	0.1	0.0	0.0	139.4	139.7	128.5	179.3	1.2	678
2011	0.2	0.2	0.0	0.1	193.1	193.5	205.6	179.4	13.9	540
2010	0.8	0.3	0.4	24.2	214.6	240.2	223.6	174.6	0.2	360
2009	0.6	0.2	0.4	0.4	162.5	164.1	156.7	172.8	0.0	360
2008	1.4	1.2	1.3	0.0	124.6	128.4	111.3	186.4	2.5	296
2007	2.0	2.4	0.3	0.0	168.0	172.7	67.6	294.3	1.6	143
2006	0.5	2.8	0.3	1.6	242.1	247.3	71.2	353.4	1.9	270
2005	0.2	0.4	0.0	0.8	289.7	291.1	96.7	412.8	0.1	320
2004	1.4	1.4	0.0	25.1	430.3	458.2	140.4	527.0	7.6	320
2003	0.4	1.6	0.0	0.0	335.9	337.9	125.8	409.6	1.5	320
2002	0.1	1.7	0.1	0.0	230.9	232.8	161.4	363.7	1.1	360
2001	0.2	1.7	0.8	0.0	267.5	270.2	156.6	501.3	9.2	450
2000	0.1	2.2	0.0	0.0	152.5	154.8	92.9	403.8	0.0	500
1999	0.0	5.7	0.0	0.3	159.9	166.0	72.9	414.8	2.0	500

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
1998	0.2	10.1	0.0	0.2	199.6	210.1	100.2	522.9	0.0	500
1997	0.1	4.1	0.0	0.4	324.2	328.8	0.0	628.7	0.0	500
1996	0.6	0.0	0.0	0.2	339.8	340.6	0.0	810.2	0.0	500
1995	0.3	0.0	0.0	0.1	413.0	413.4	0.0	803.0	0.0	500
1994	0.2	0.0	0.0	0.4	392.2	392.8	0.0	713.5	0.0	500
1993	3.6	0.0	0.0	0.1	374.0	377.7	0.0	893.1	0.0	500
1992	1.7	0.0	0.0	10.9	283.9	296.5	0.0	750.0	0.0	400

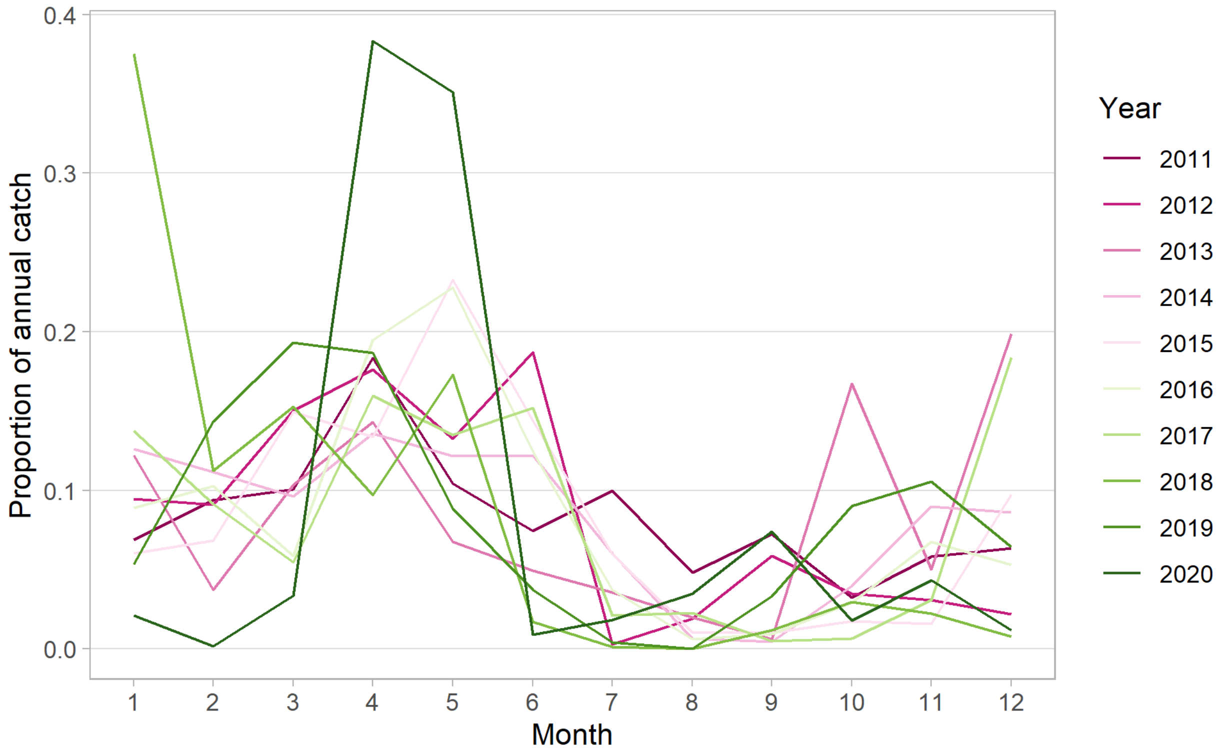

Figure 50 Monthly proportion of annual trawl catch of Silver Trevally.

4.7.2 CPUE and depth of fishing

Standardized CPUE for eastern Silver Trevally (zones 10-20) peaked in 1990, followed by a sharp decline, to remain relatively flat, albeit noisy from 1992 to 2010 (Figure 51), after which there has been a consistent downward trend until 2020 which saw a significant increase relative the previous year (Sporcic, 2021a). CPUE has been below the geometric mean since 2013. The change from the nominal geometric mean is caused by changes to the number of vessels operating, fishing depth and reduced catch. The majority of the catch is from shallower waters but is variable between years (Figure 52). The number of vessels operating in this fishery approximately halved from 39 to 22 in 2007 and reduced to seven in 2019, the increase in CPUE for 2020 was influenced by an increase to 12 operating vessels and other factors.

Standardized CPUE for No MPA Silver Trevally (zones 10-20, which includes only those areas that were never included in an MPA) peaked in 1990 and declined sharply in 1991, the trend is noisy but has generally been trending downward to 2019, with a dip in the early 2000s and flatting from 2013 to 2017. There has been an increase in CPUE for 2020 relative to the previous year (Figure 53; Sporcic, 2021a). Similar to the scenario that includes MPAs, the CPUE is lower than the geometric mean from 2013; the reasons are similar and can be attributed to changes in fishing vessels, low numbers of vessels contributing to the catch, changes in depth distribution of fishing and lower catches and number of records (Figure 54).

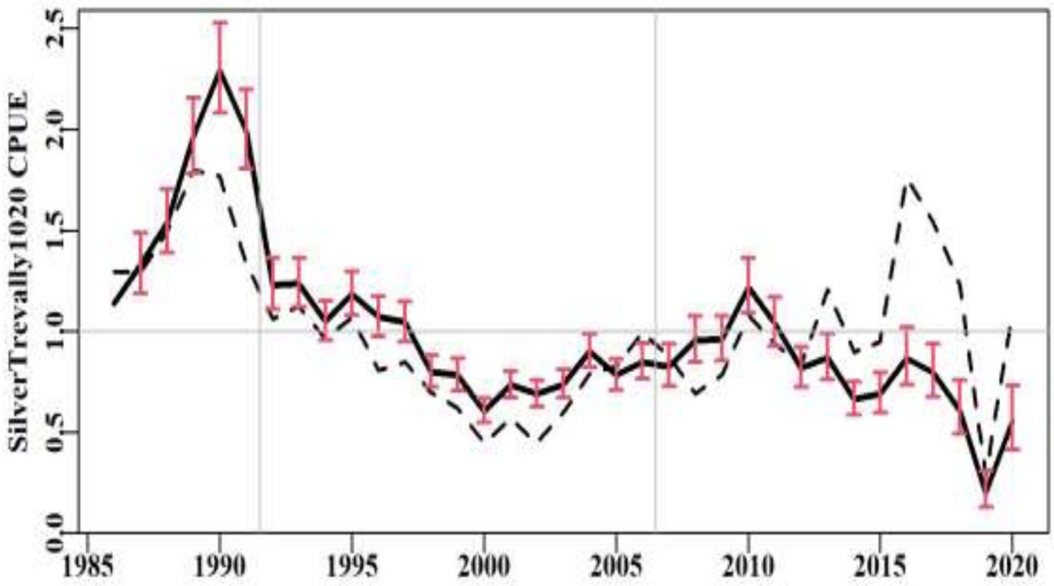

Figure 51 Standardized trawl CPUE of eastern Silver Trevally between 1986 and 2020. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series. Source: Sporcic (2021a).

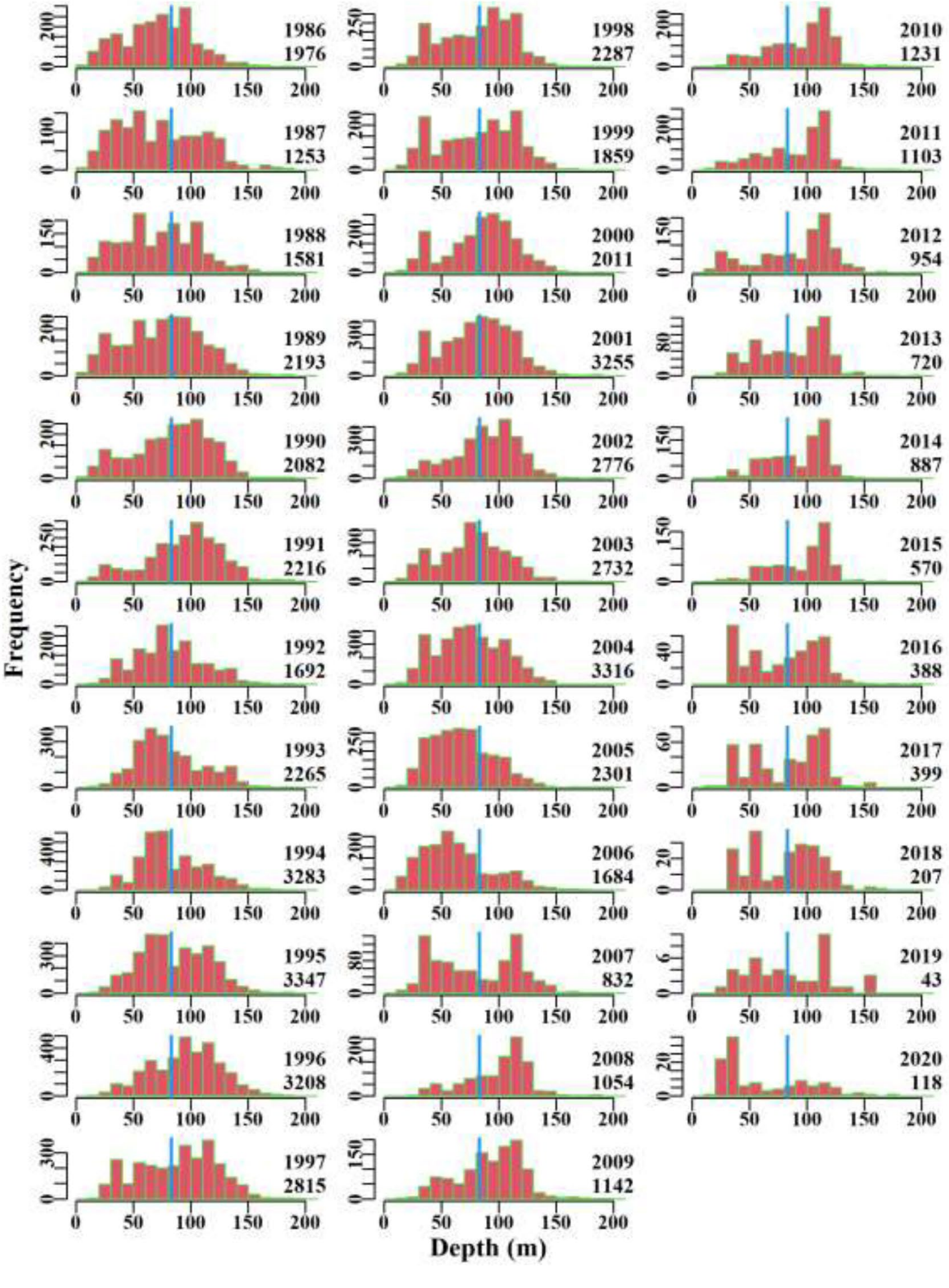

Figure 52 Histogram of annual fishing depths of eastern Silver Trevally between 1986 and 2020. Year and number of logbook records are printed on the right hand side of each plot. Blue line represents mean fishing depth. Source: Sporcic (2021a).

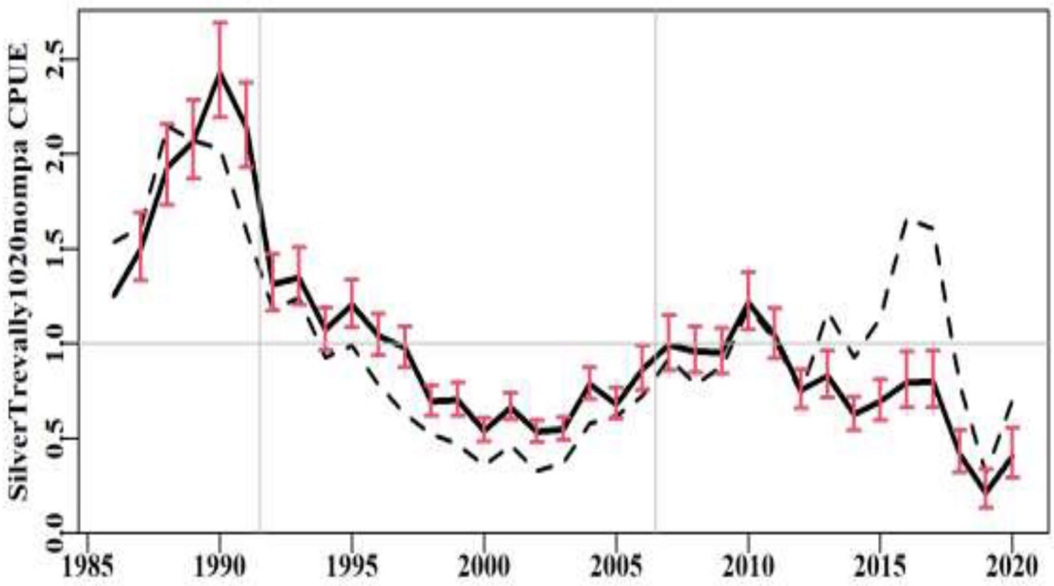

Figure 53 Standardized trawl CPUE of western Silver Trevally not including MPAs. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series. Source: Sporcic, 2021.

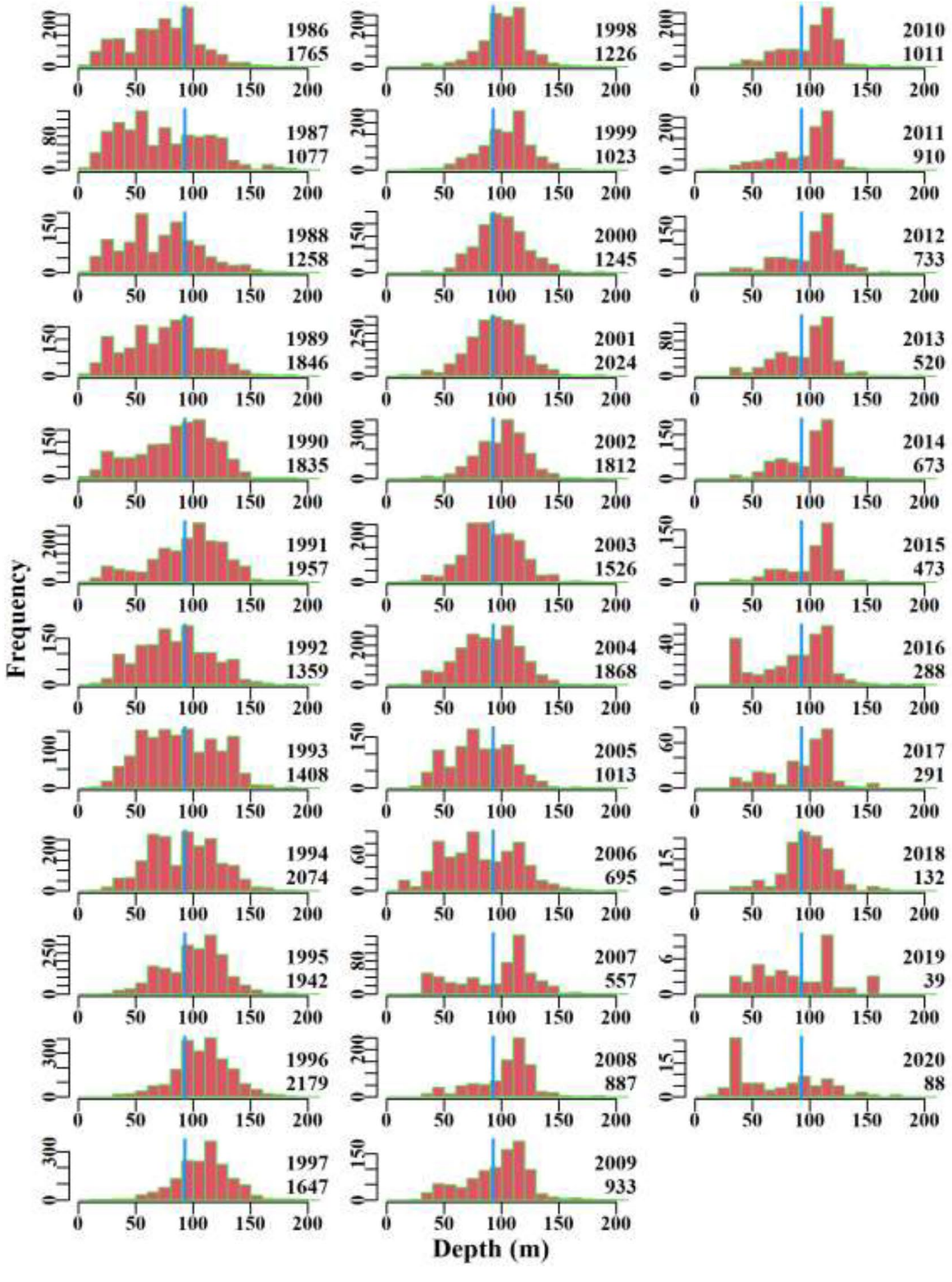

Figure 54 Histogram of annual fishing depths of eastern Silver Trevally between 1986 and 2020. Year and number of logbook records are printed on the right hand side of each plot. Blue line represents mean fishing depth.

4.7.3 Spatial distribution of fishing

In the late 1990s to the mid 2000s large catches of Silver Trevally were taken by trawl vessels operating off the south coast of NSW and the north east coast of Victoria (Figure 55). Smaller catches were taken from around Tasmania and along the south coasts of Victoria and South Australia as far west as Kangaroo Island. Landed catches peaked in 2004 at ~400 t and between 2004 to 2012 catches declined to 300-200 tonnes. While the spatial pattern remained similar, the large catches around the east coast of NSW and Victoria were reduced and large catches began to be taken from around Tasmania and along the south coast of South Australia and Victoria (Figure 56). The landed catches have continued to decrease to between 4 - 50 t in the last five years. While the spatial distribution of the Silver Trevally stock appears unchanged, catch densities have declined which means that this assumption is inconclusive (Figure 57).

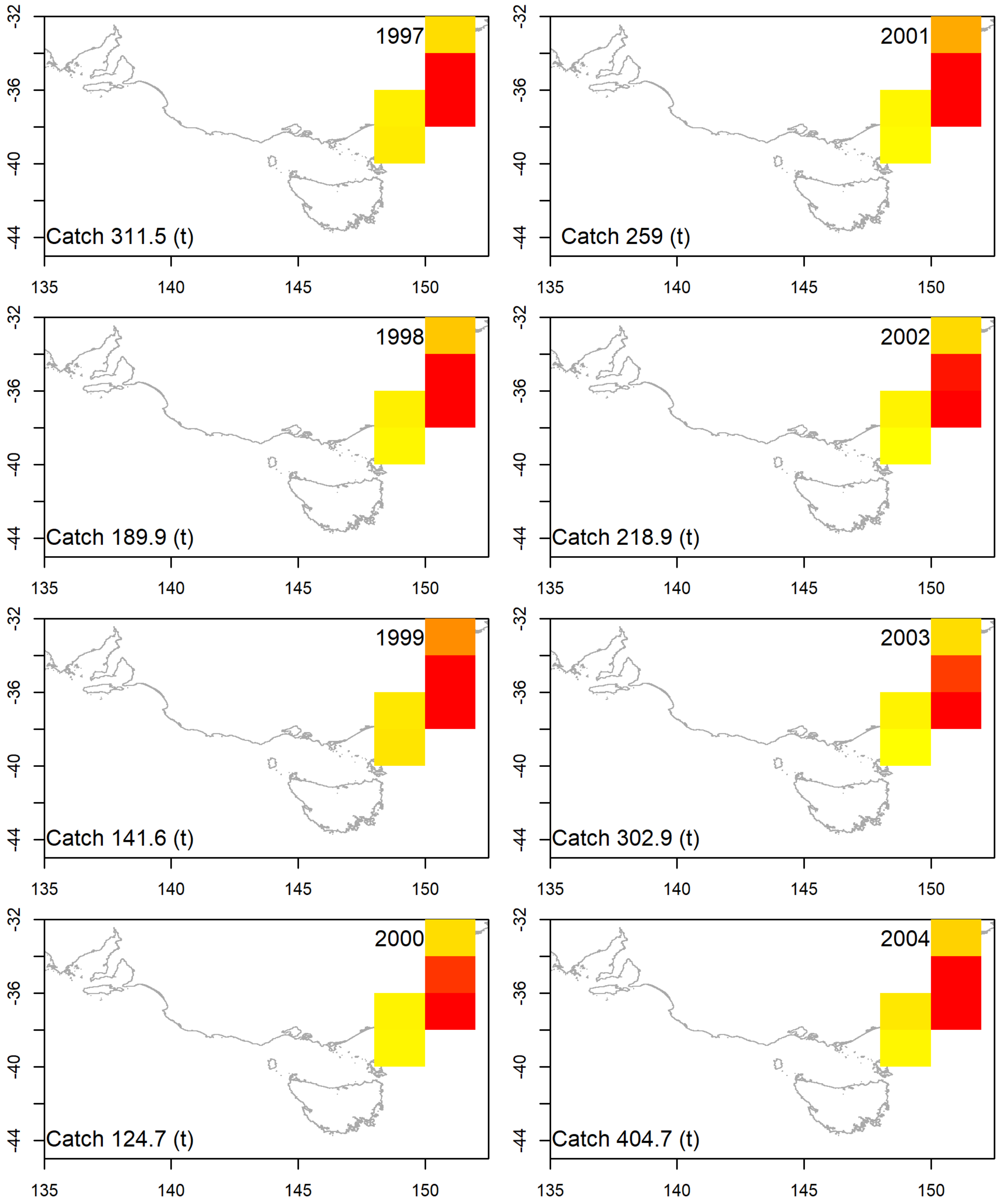

Figure 55 Spatial distribution of annual Silver Trevally catch of trawl vessels 1997 - 2004. Logbook catch is provided in the bottom left corner of each annual plot.

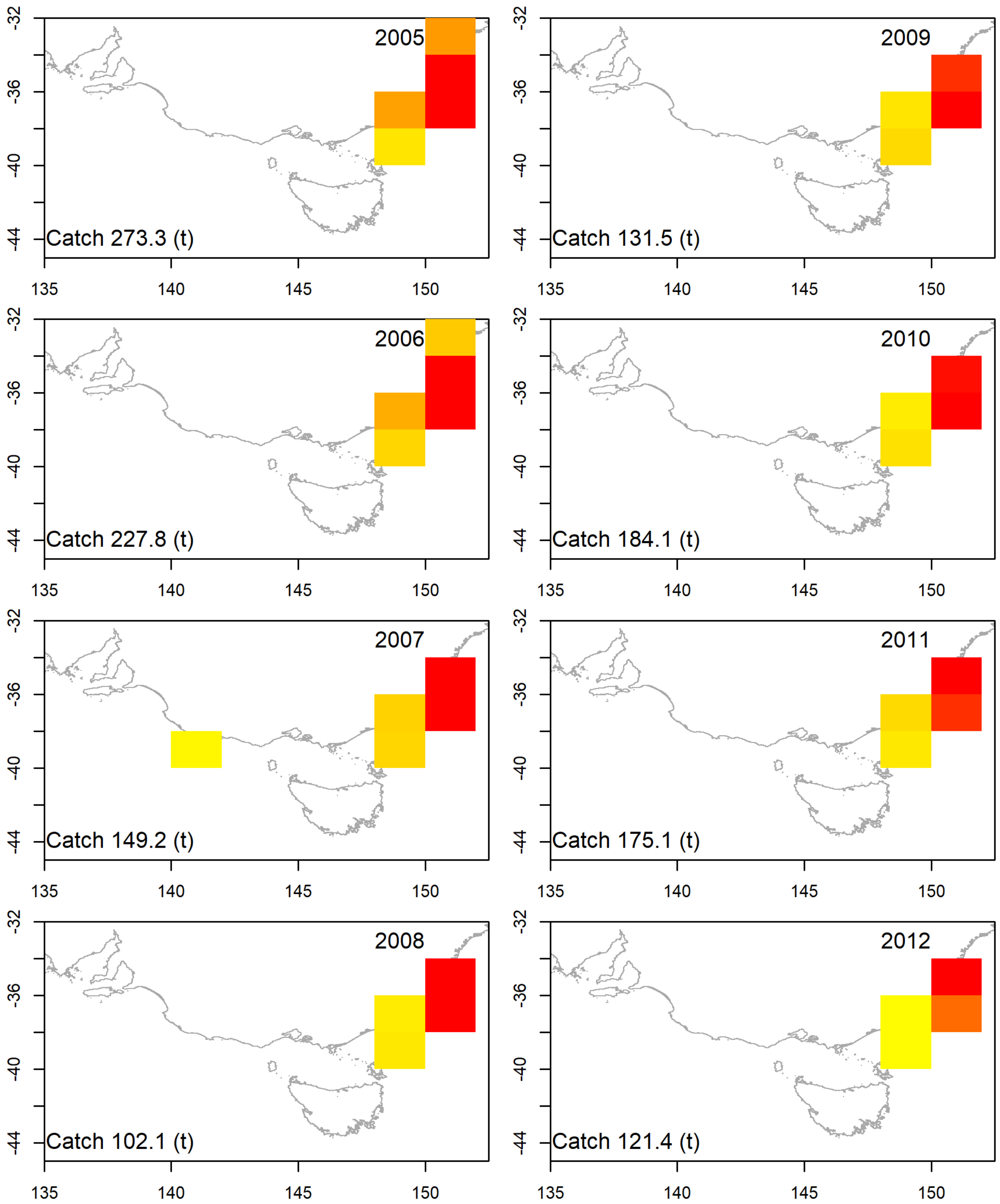

Figure 56 Spatial distribution of annual Silver Trevally catch of trawl vessels 2005 - 2012. Logbook catch is provided in the bottom left corner of each annual plot.

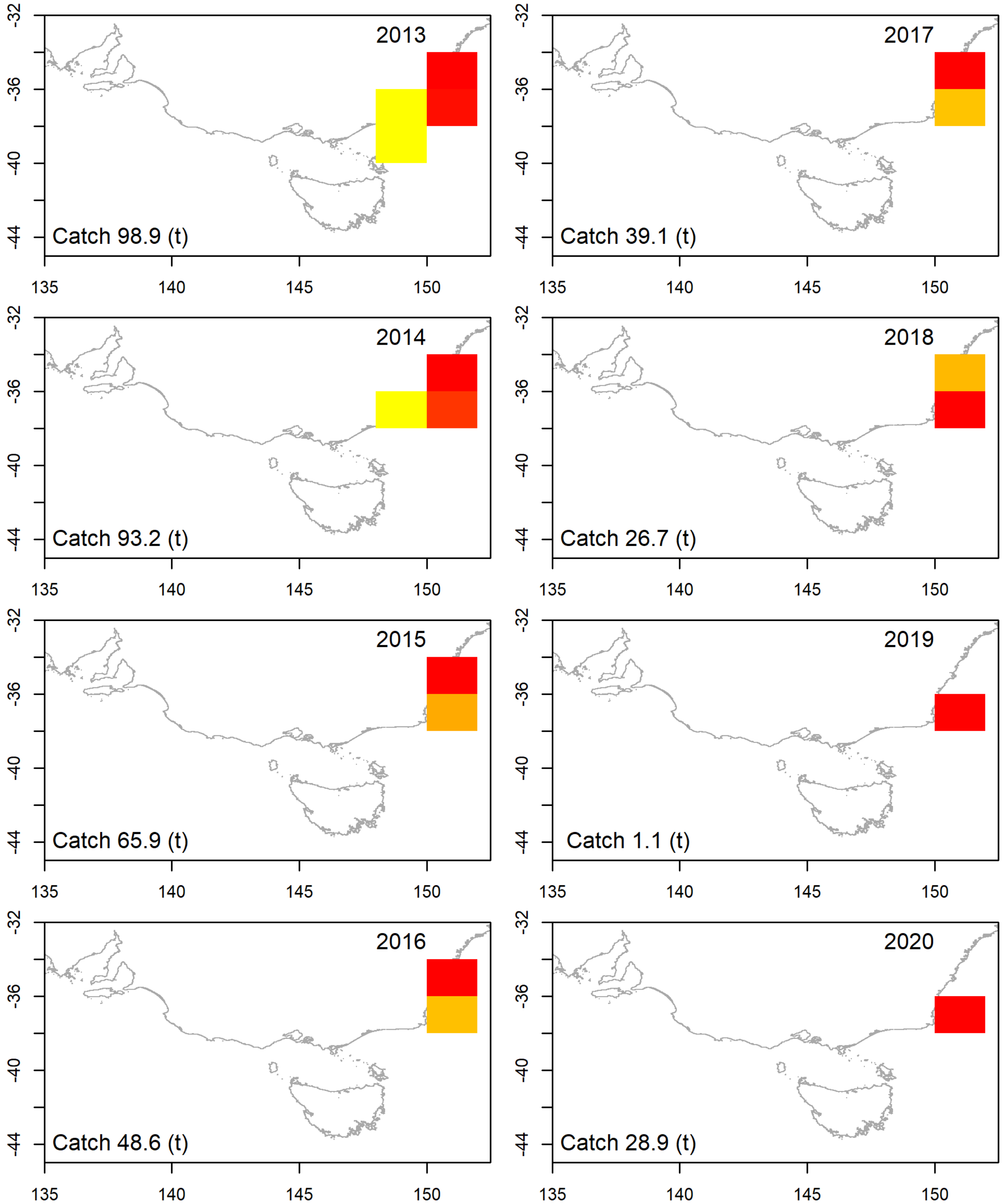

Figure 57 Spatial distribution of annual Silver Trevally catch of trawl vessels 2013 - 2020. Logbook catch is provided in the bottom left corner of each annual plot.

4.7.4 Catch by vessel

Annual Silver Trevally catch by vessel shows that there are two to three vessels that report consistently relatively large catches, although these vessels have not reported high/any catches for the last two years. These vessels may have stopped fishing or could have changed name or ownership. In 2019 catches were very small and in 2020 the two highest catches were reported from vessels that had not previously had high catches (Figure 58). Note that targeting of Silver Trevally is currently permitted.

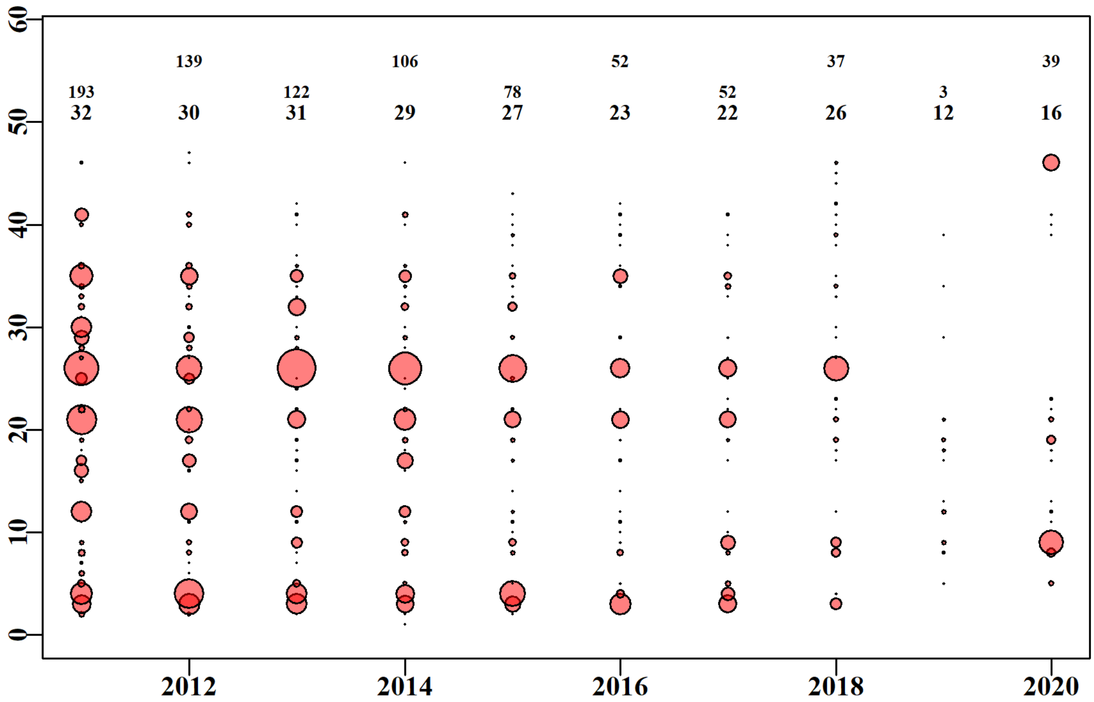

Figure 58 Bubble plot of annual Silver Trevally catch of trawl vessels. Larger bubbles indicate larger annual catches. Numbers at the top of each year represent logbook catch (upper) and number of vessels reporting Silver Trevally (lower). Each row represents one vessel.

4.8 Targeting analysis - Jackass Morwong East

4.8.1 Catch

Catches of Jackass Morwong east have declined from between 500 and 900 t in 1990s to 85.6 t in 2020 (Table 21). In the last five years 80-90% of catches have been taken by trawl with Danish seine taking around 5% and catches by the hook and line sector fluctuating between 1 and 17% of total landings. Trawl catches summarised by year and month of fishing shows that catches of Jackass Morwong east are lowest in winter months (Figure 59).

Table 21 Catch of Jackass Morwong east (t) by gear type: Danish seine, Gillnet, Hook and line, Trawl and all Other gears. Log Total (t) represents the total catch reported in logbooks, CDR (t) the total landed catch from catch disposal records, State (t) the reported State catches, Discards (t) the estimated discarded catches and TAC (t) the Commonwealth total allowable catch.

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
2020	4.0	0.0	0.4	0.2	66.5	71.1	85.6	8.2	45.0	468
2019	6.8	0.0	1.3	0.7	110.7	119.5	145.7	9.1	73.4	469
2018	4.7	0.0	18.6	0.9	105.7	129.9	129.5	4.6	14.3	505
2017	3.1	0.1	24.6	0.2	114.4	142.2	128.4	13.7	16.5	513
2016	5.7	0.0	5.4	0.0	121.1	132.1	144.4	6.9	25.5	474
2015	5.3	0.1	45.9	0.0	74.4	125.6	91.8	6.9	3.5	598
2014	9.3	0.0	29.6	0.3	132.1	171.4	167.2	4.3	60.5	568
2013	13.4	0.0	38.6	0.0	206.6	258.7	249.4	4.9	49.7	568
2012	14.8	0.1	41.5	0.1	275.4	331.9	325.6	7.7	37.7	568
2011	28.1	0.1	45.3	0.0	235.6	309.2	304.6	2.6	34.8	450
2010	16.7	0.0	18.1	0.2	258.9	293.9	318.4	4.8	18.1	450
2009	18.0	0.1	2.5	0.2	299.2	320.0	375.0	7.1	46.1	450
2008	36.4	0.1	6.2	0.0	454.9	497.5	575.6	8.9	70.5	560
2007	17.1	0.1	6.7	0.0	351.0	374.8	424.7	12.4	52.8	878
2006	16.3	0.1	6.1	0.0	474.4	496.9	557.7	28.8	70.8	1200
2005	22.9	0.1	1.9	0.0	461.4	486.4	567.4	31.6	72.3	960
2004	18.7	0.3	0.6	0.0	450.8	470.4	538.5	27.4	68.3	960
2003	28.8	15.9	0.6	0.0	452.7	498.1	544.0	21.2	68.2	960
2002	42.8	0.2	11.5	0.5	450.5	505.5	560.3	22.4	70.3	950
2001	64.0	0.5	0.2	0.2	376.7	441.5	493.8	41.8	64.6	1185
2000	42.9	0.9	75.0	4.2	623.3	746.3	746.8	33.9	94.2	1200
1999	27.4	1.4	24.8	7.2	712.0	772.8	847.0	32.3	106.1	1500

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
1998	63.6	0.9	14.2	1.6	640.9	721.2	813.7	45.2	103.7	1500
1997	41.9	1.8	1.3	4.5	890.3	939.9	0.0	65.1	7.9	1500
1996	18.1	0.0	0.0	1.4	724.1	743.6	0.0	76.0	9.2	1500
1995	4.2	0.0	0.0	0.2	653.4	657.8	0.0	145.0	17.5	1500
1994	9.4	0.0	0.0	2.0	736.4	747.9	0.0	240.1	29.0	1500
1993	4.4	0.0	0.0	2.6	929.4	936.5	0.0	166.0	0.0	1500
1992	21.6	0.0	0.0	55.6	564.8	642.1	0.0	172.0	0.0	1500

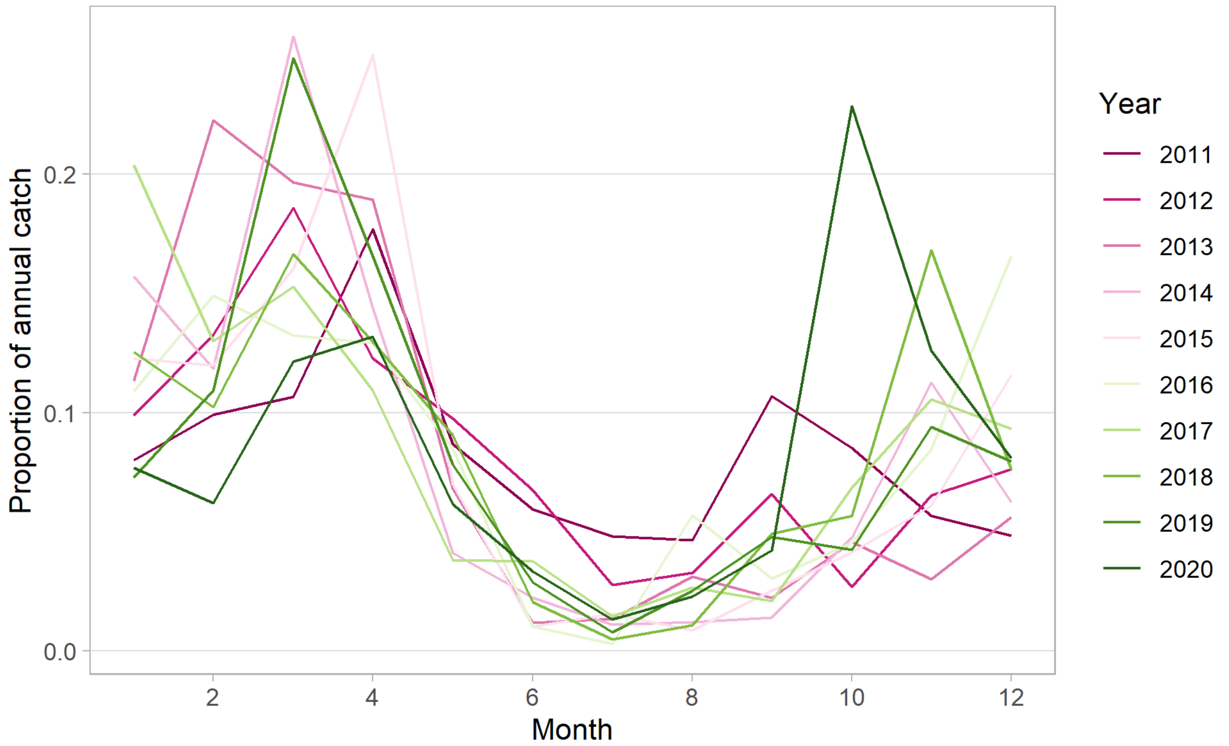

Figure 59 Monthly proportion of annual trawl catch of Jackass Morwong off eastern of Australia.

4.8.2 CPUE and depth of fishing

Standardized CPUE for the trawl fishery catching Jackass Morwong in Zones 10 and 20 has declined for most of the last three decades and is currently the lowest on record (Figure 60). The distribution of fishing depths in Zones 10 and 20 has remained relatively stable between 100 and 200 m in most years (Figure 61). Standardized CPUE trawl CPUE in Zone 30 shows a similar decline to Zones 10 and 20 (Figure 62). Depth of trawling is also similar, being between 100 and 200 m (Figure 63).

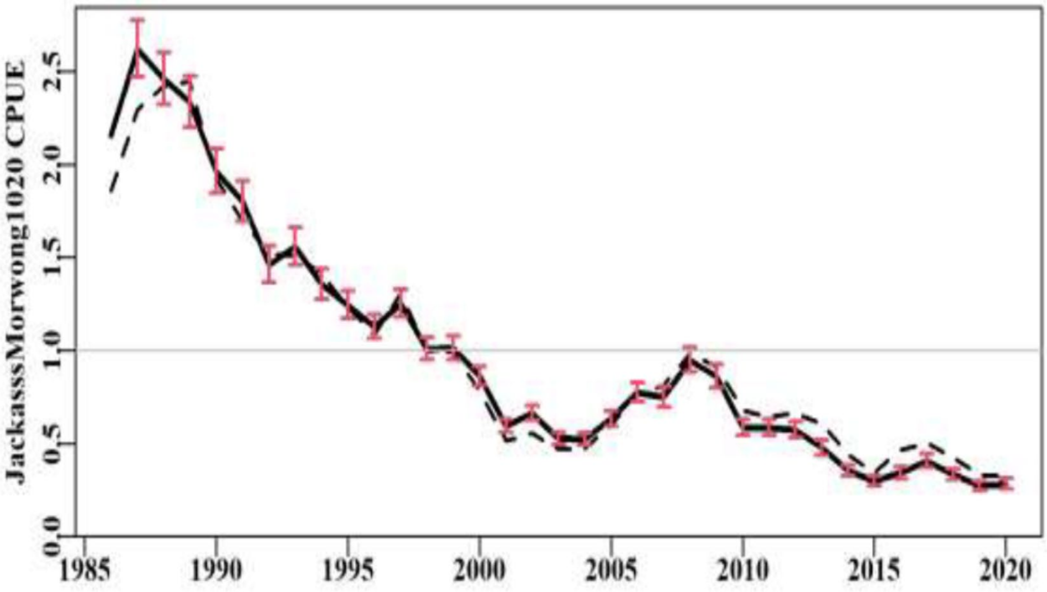

Figure 60 Standardized trawl CPUE of Jackass Morwong in Zones 10 and 20 between 1986 and 2020. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series. Source: Sporcic (2021a).

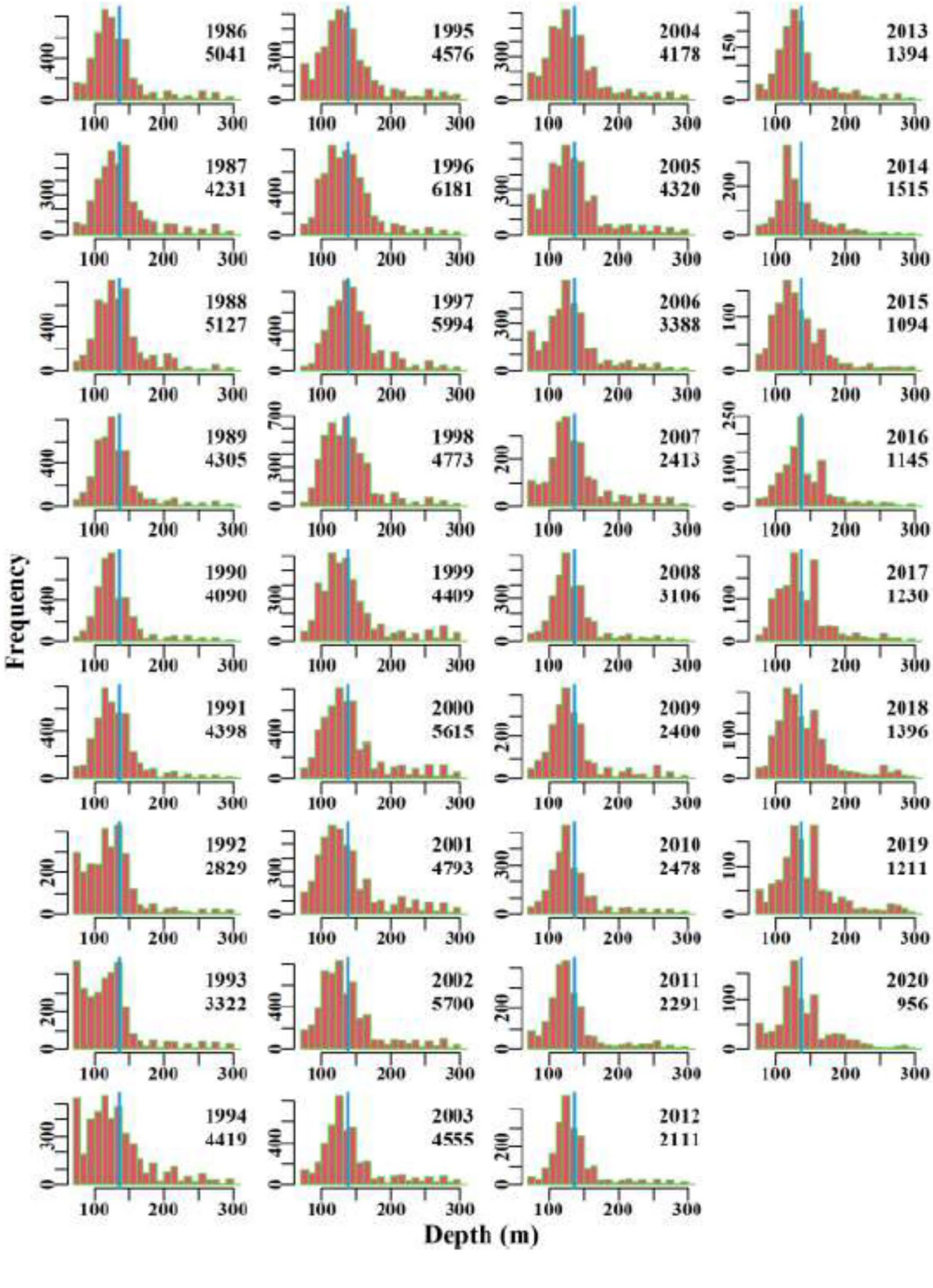

Figure 61 Histogram of annual fishing depths of Jackass Morwong in Zones 10 and 20 between 1986 and 2020. Year and number of logbook records are printed on the right hand side of each plot. Blue line represents mean fishing depth. Source: Sporcic (2021a).

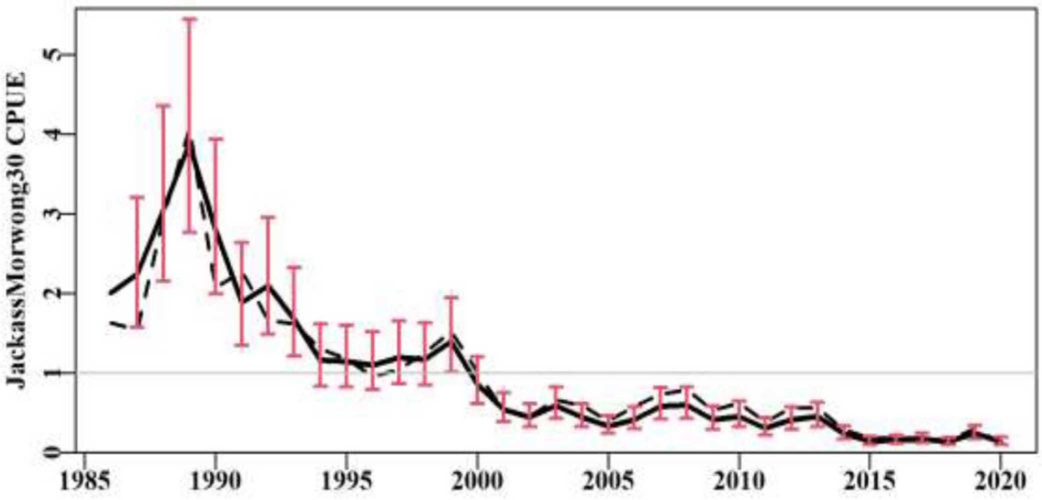

Figure 62 Standardized trawl CPUE of Jackass Morwong in Zone 30 between 1986 and 2020. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series. Source: Sporcic (2021a).

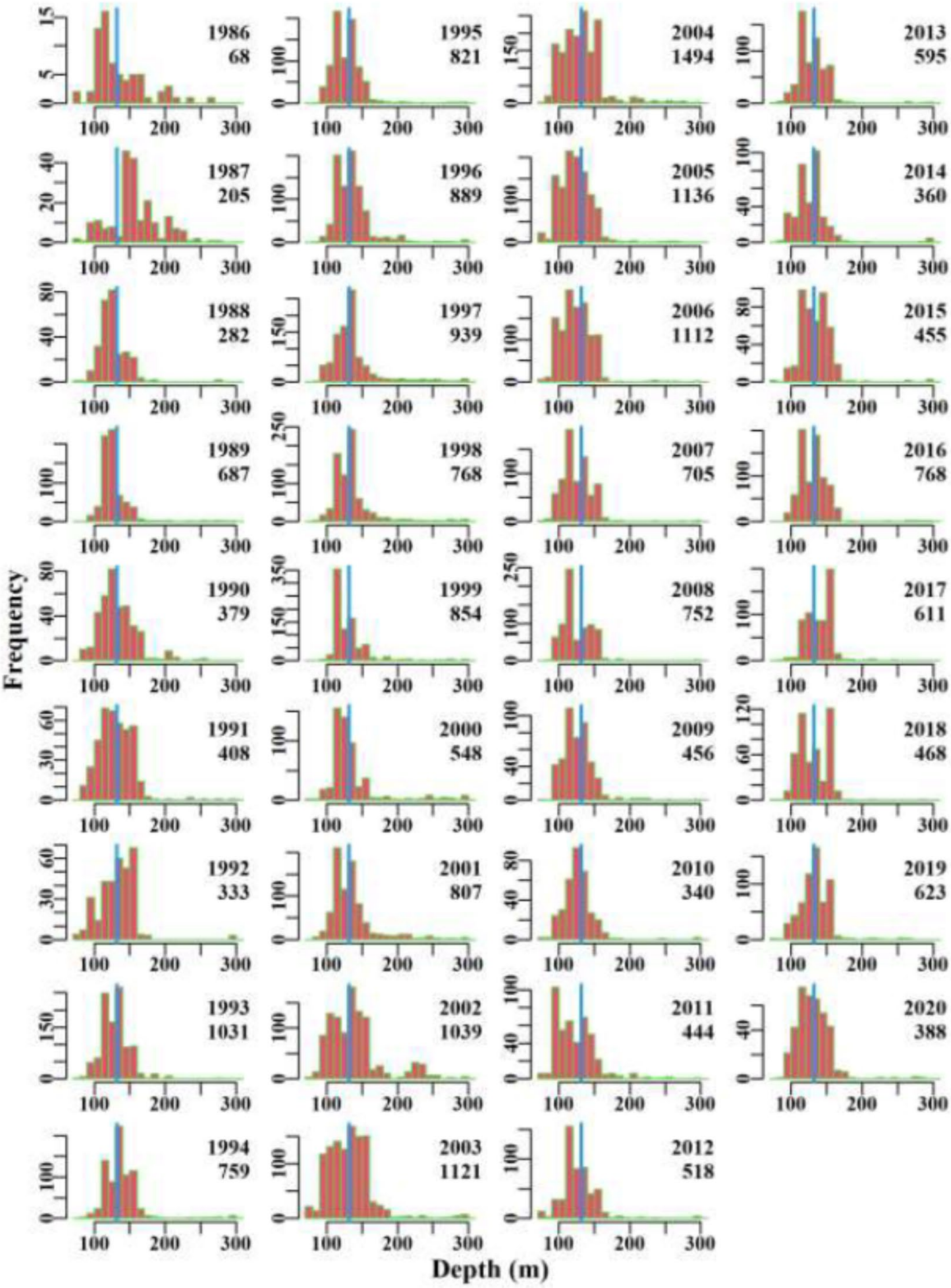

Figure 63 Histogram of annual fishing depths of Jackass Morwong in Zone 30 between 1986 and 2020. Year and number of logbook records are printed on the right hand side of each plot. Blue line represents mean fishing depth. Source: Sporcic (2021a).

4.8.3 Spatial distribution of fishing

Since the late 1990s there has been little change in the spatial distribution of Jackass Morwong catches off eastern Australia with the majority of catches taken from southern NSW, eastern

Victoria and the east coast of Tasmania (Figure 64-66). Catches of Jackass Morwong from western Victoria, South Australia and western Tasmania are assumed to be part of the western stock and are not shown.

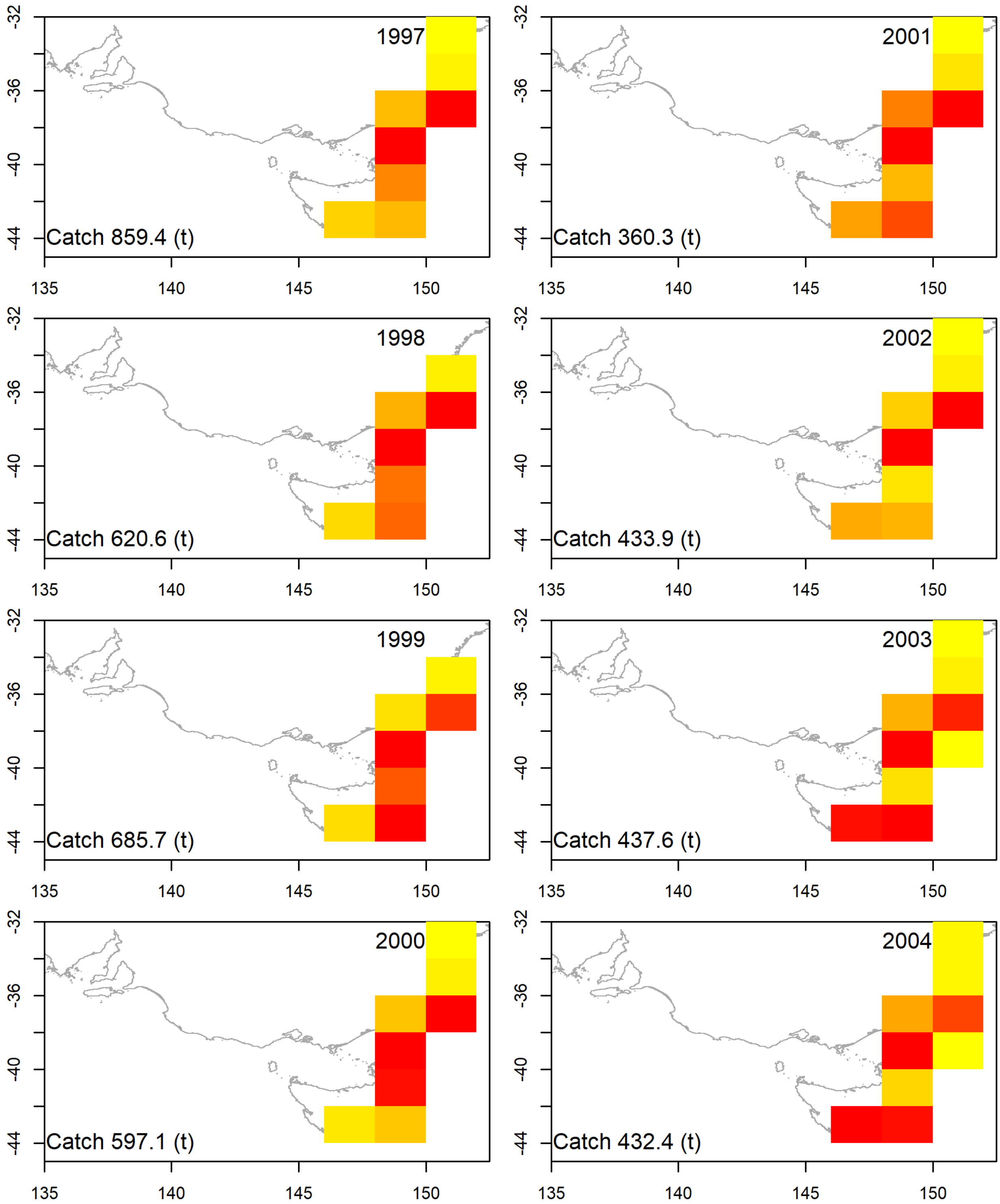

Figure 64 Spatial distribution of annual trawl catch of Jackass Morwong catch off eastern Australia 1997 - 2004. Logbook catch is provided in the bottom left corner of each annual plot.

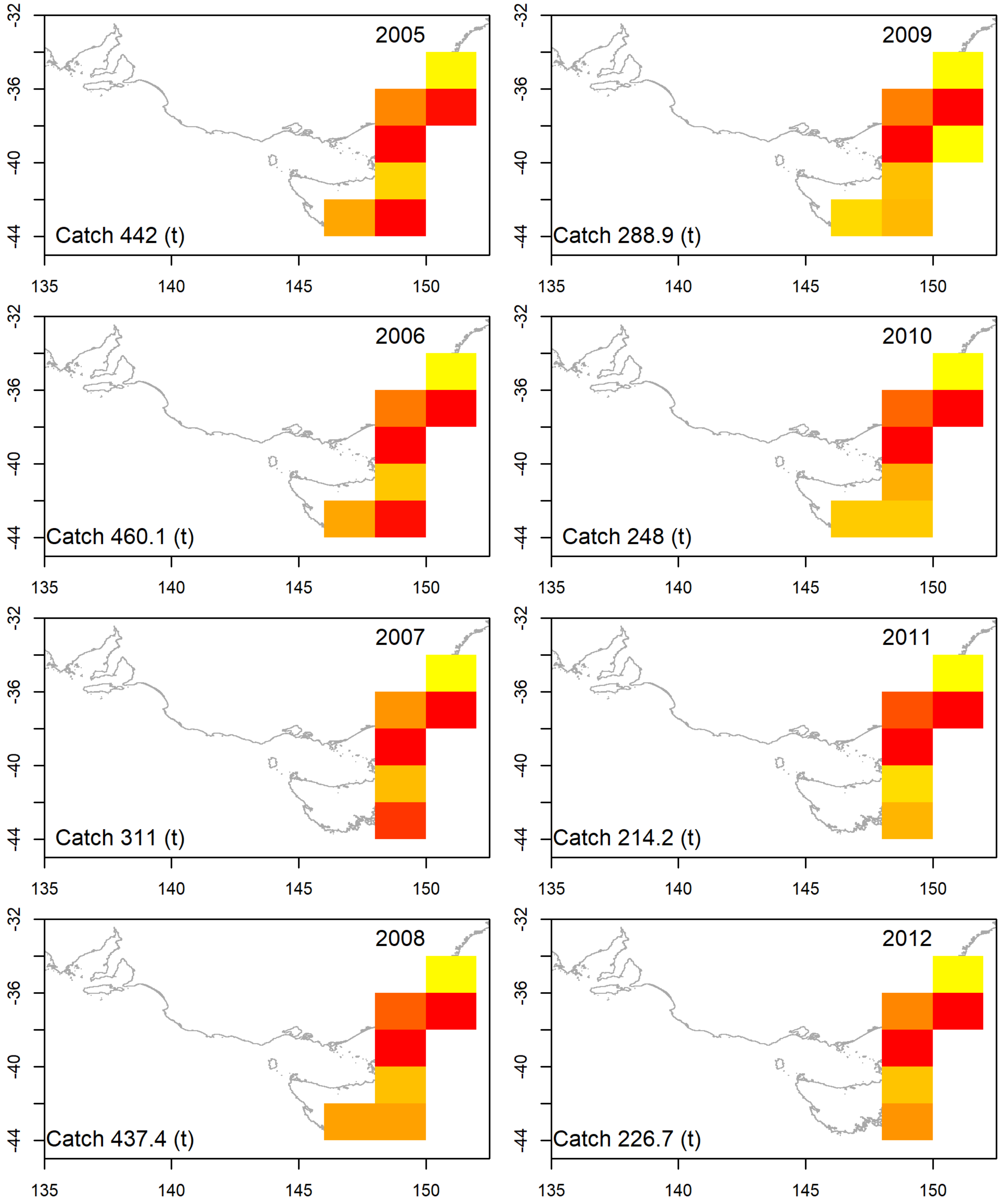

Figure 65 Spatial distribution of annual trawl catch of Jackass Morwong catch off eastern Australia 2005 - 2012. Logbook catch is provided in the bottom left corner of each annual plot.

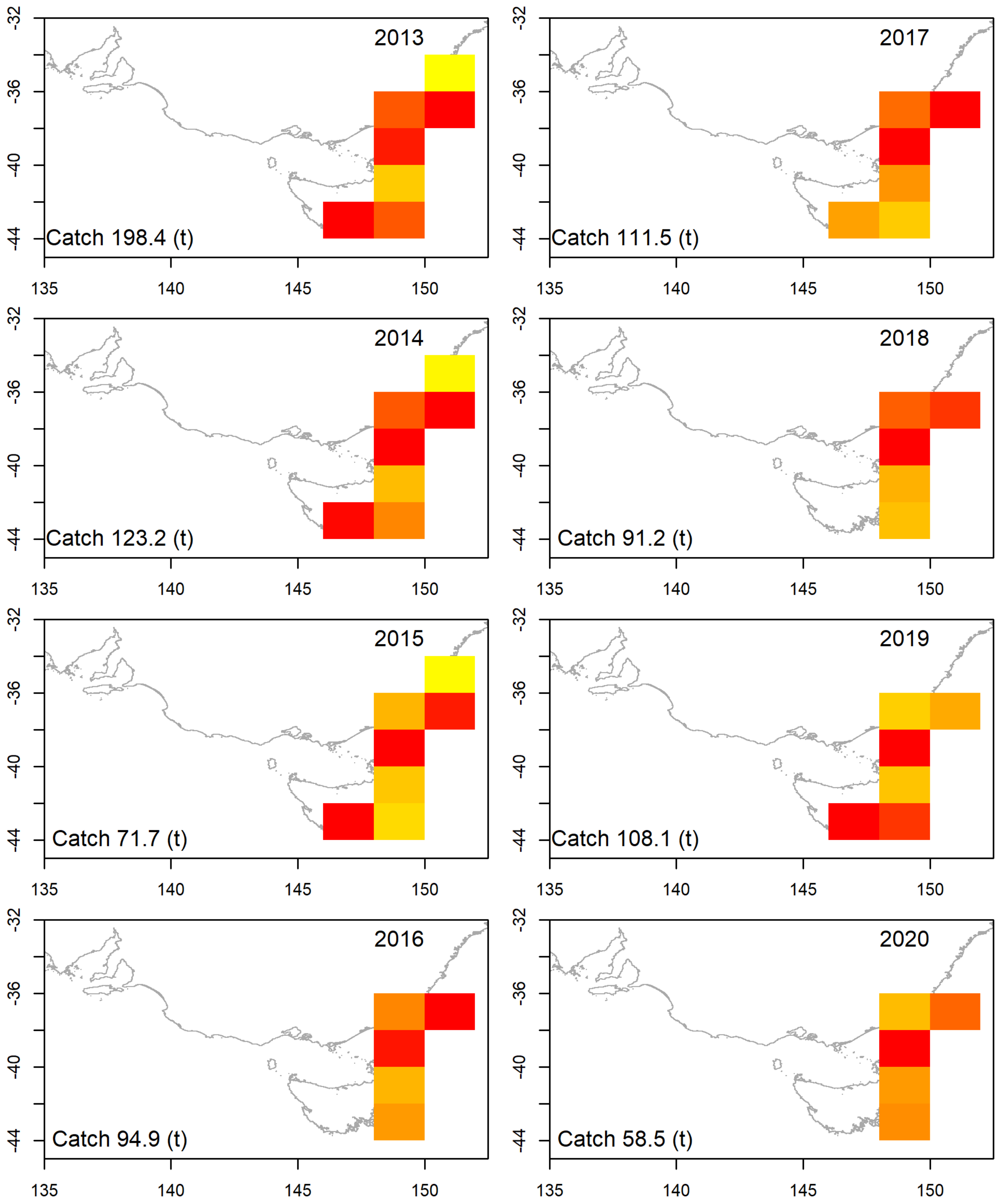

Figure 66 Spatial distribution of annual trawl catch of Jackass Morwong catch off eastern Australia 2013 - 2020. Logbook catch is provided in the bottom left corner of each annual plot.

4.8.4 Catch by vessel

Annual catch by vessel of Jackass Morwong off eastern Australia shows several vessels reporting catches that are consistently larger than other vessels in recent years (Figure 67). Note that targeting of eastern Jackass Morwong is currently permitted.

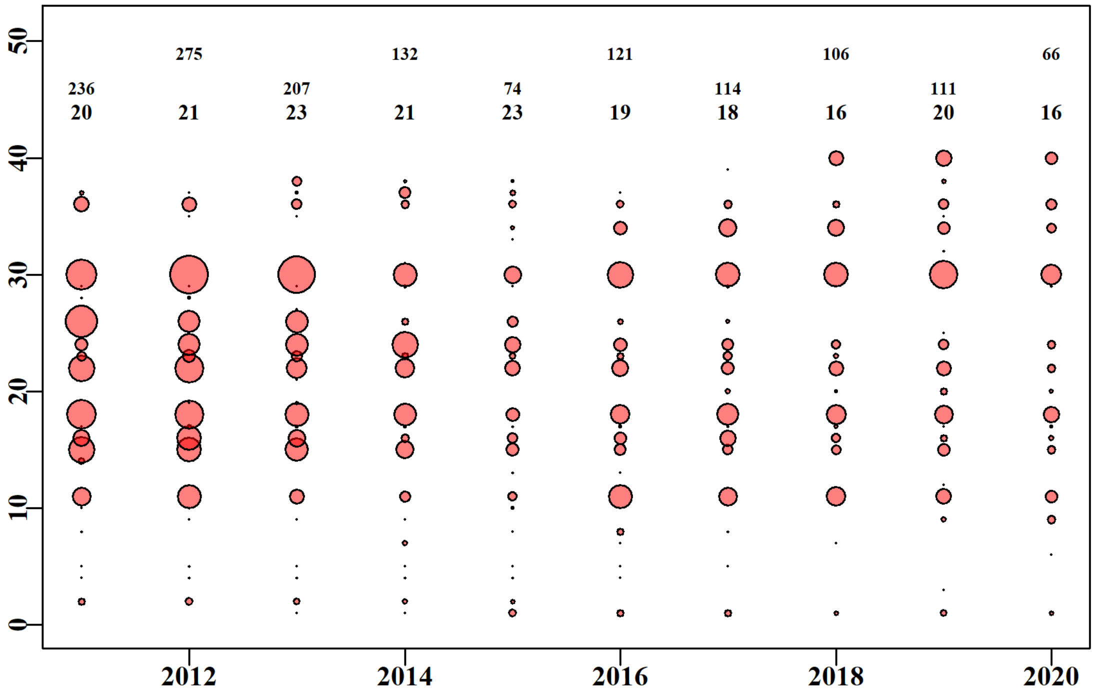

Figure 67 Bubble plot of catch by trawl vessel of Jackass Morwong off eastern Australia. Larger bubbles indicate larger annual catches. Numbers at the top of each year represent logbook catch (upper) and number of vessels reporting Jackass Morwong off eastern Australia (lower). Each row represents one vessel.

4.9 Targeting analysis - Deepwater Shark

4.9.1 Catch

Deepwater Shark are reported almost exclusively by trawlers. Catches of eastern Deepwater Shark have been around 20-30 t over the last decade (Table 22), while catches of western Deepwater Shark have been around 50-100t over the same period (Table 23). There is little evidence of seasonality in the catches of either eastern (Figure 68) or western (Figure 69) Deepwater Shark.

Table 22 Catch of eastern Deepwater Shark (t) by gear type: Danish seine, Gillnet, Hook and line, Trawl and all Other gears. Log Total (t) represents the total catch reported in logbooks, CDR (t) the total landed catch from catch disposal records, State (t) the reported State catches, Discards (t) the estimated discarded catches and TAC (t) the Commonwealth total allowable catch.

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
2020	0.0	0	0.0	0.0	10.3	10.3	15.5	0.6	0	24
2019	0.0	0	0.0	0.0	15.8	15.8	25.3	0.3	0	24
2018	0.0	0	0.0	0.0	14.3	14.3	22.5	0.6	0	23
2017	0.0	0	0.0	0.0	14.1	14.1	21.5	1.0	0	46
2016	0.0	0	0.0	0.0	15.3	15.3	26.2	0.3	0	47
2015	0.0	0	0.4	0.0	14.4	14.8	19.0	0.7	0	47
2014	0.0	0	0.2	0.0	12.3	12.4	23.2	0.6	0	47
2013	0.0	0	0.0	0.0	9.9	9.9	22.5	0.0	0	85
2012	0.0	0	0.0	0.0	9.8	9.8	30.5	0.2	0	85
2011	0.0	0	0.0	0.0	5.9	6.0	33.9	0.3	0	85
2010	0.0	0	0.0	0.0	8.2	8.2	27.3	0.0	0	85
2009	0.0	0	0.6	0.0	20.8	21.3	48.3	0.0	0	75
2008	0.0	0	0.2	0.0	7.2	7.4	18.4	0.0	0	50
2007	0.0	0	0.0	0.0	1.2	1.2	13.1	0.0	0	16
2006	0.0	0	0.0	0.0	29.2	29.2	56.6	0.0	0	92
2005	0.0	0	0.0	0.0	39.8	39.9	68.2	0.0	0	92
2004	0.0	0	0.7	0.0	58.0	58.7	0.0	0.0	0	0
2003	0.1	0	0.1	0.0	82.6	82.7	0.0	0.0	0	0
2002	0.0	0	0.0	0.0	96.8	96.8	0.0	0.0	0	0
2001	0.0	0	0.0	0.0	80.7	80.7	0.0	0.0	0	0
2000	0.0	0	0.0	0.0	98.2	98.2	0.0	0.0	0	0
1999	0.0	0	0.1	0.0	97.9	98.0	0.0	0.0	0	0

YEAR	DANISH SEINE	GILLNET	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
1998	0.0	0	0.0	0.1	110.5	110.6	0.0	0.0	0	0
1997	0.0	0	0.2	0.0	86.5	86.7	0.0	0.0	0	0
1996	0.0	0	0.0	0.0	145.3	145.3	0.0	0.0	0	0
1995	0.0	0	0.0	0.1	75.8	75.9	0.0	0.0	0	0
1994	0.0	0	0.0	0.2	84.4	84.6	0.0	0.0	0	0
1993	0.0	0	0.0	0.0	72.8	72.8	0.0	0.0	0	0
1992	0.0	0	0.0	0.0	56.5	56.5	0.0	0.0	0	0

Table 23 Catch of western Deepwater Shark (t) by gear type: Danish seine, Gillnet, Hook and line, Trawl and all Other gears. Log Total (t) represents the total catch reported in logbooks, CDR (t) the total landed catch from catch disposal records, State (t) the reported State catches, Discards (t) the estimated discarded catches and TAC (t) the Commonwealth total allowable catch.

YEAR	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
2020	0.0	0.0	124.3	124.3	88.0	0.0	53.8	235
2019	0.1	0.0	134.0	134.0	94.1	0.0	30.2	235
2018	0.0	0.0	89.6	89.6	75.3	7.3	26.4	264
2017	0.0	0.0	97.1	97.1	82.3	7.3	28.7	215
2016	0.0	0.0	93.1	93.1	71.8	7.3	25.4	215
2015	0.1	0.0	86.4	86.5	69.5	7.3	24.6	215
2014	0.4	0.0	96.1	96.5	77.9	7.3	27.3	215
2013	0.0	0.0	77.1	77.1	78.5	7.3	27.5	215
2012	0.0	0.0	47.4	47.4	47.2	7.3	17.5	215
2011	0.0	0.0	48.3	48.3	53.2	7.3	19.4	143
2010	0.0	0.0	47.5	47.5	45.4	7.3	16.9	95
2009	0.0	0.0	40.4	40.5	39.7	7.4	15.1	63
2008	0.0	0.0	23.0	23.0	22.9	3.8	8.5	50
2007	0.0	0.0	9.6	9.6	11.4	14.8	8.4	8
2006	0.0	0.0	78.0	78.0	87.4	22.8	35.3	108
2005	0.0	0.0	103.9	103.9	99.7	21.1	38.7	108
2004	0.6	0.0	254.1	254.7	0.0	26.9	8.6	0
2003	0.8	0.0	211.6	212.4	0.0	26.9	8.6	0
2002	0.0	0.0	301.2	301.2	0.0	26.9	8.6	0
2001	0.0	0.0	293.0	293.0	0.0	26.9	8.6	0
2000	0.0	0.0	355.9	355.9	0.0	26.9	8.6	0
1999	0.0	0.6	241.6	242.3	0.0	26.9	8.6	0

YEAR	HOOK	OTHER	TRAWL	LOG TOTAL	CDR	STATE	DISCARDS	TAC
1998	0.0	0.7	307.9	308.6	0.0	26.9	8.6	0
1997	0.0	0.5	176.9	177.5	0.0	26.9	8.6	0
1996	0.0	0.1	118.9	119.0	0.0	26.9	8.6	0
1995	0.0	0.0	64.5	64.5	0.0	26.9	8.6	0
1994	0.0	0.0	1.4	1.4	0.0	26.9	8.6	0
1993	0.0	0.0	0.4	0.4	0.0	26.9	0.0	0

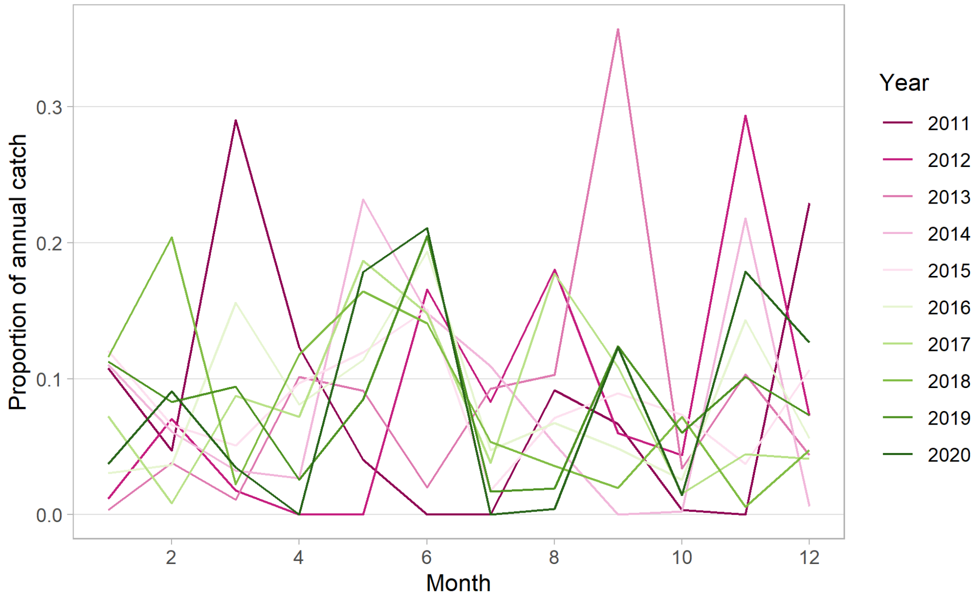

Figure 68 Monthly proportion of annual trawl catch of eastern Deepwater Shark.

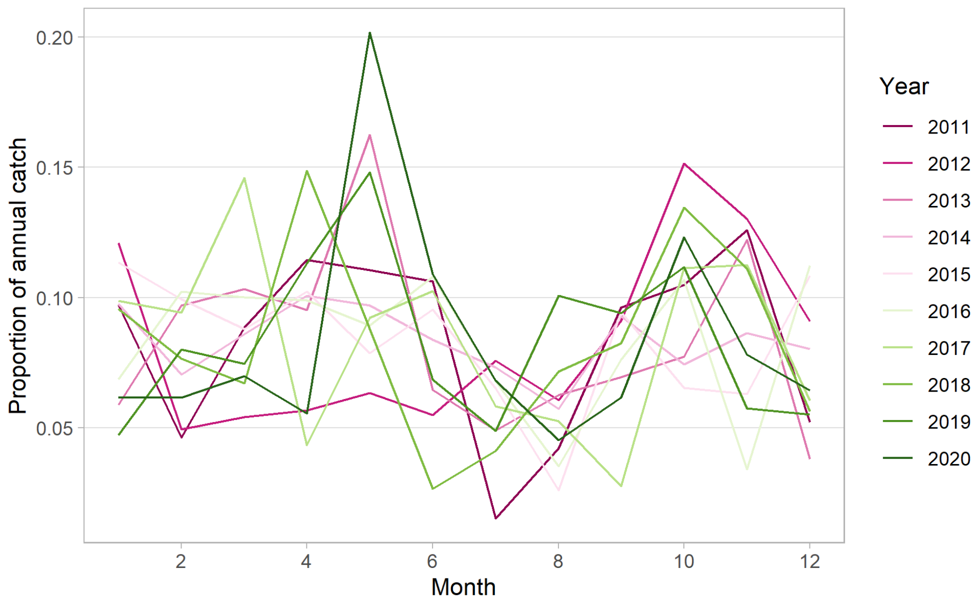

Figure 69 Monthly proportion of annual trawl catch of western Deepwater Shark.

4.9.2 CPUE and depth of fishing

Standardized CPUE for Deepwater Sharks is estimated only for areas that are not part of current deepwater closures (Sporcic, 2021c). Standardized CPUE for the trawl fishery reporting catches of eastern Deepwater Shark declined steeply in the 1990s but has been stable over the last decade at around 20% of its peak (Figure 70). The distribution of fishing depths for eastern Deepwater Shark has been stable between 600 and 1000m with the exception of 2007 and 2008 when little fishing occurred (Figure 71).

Standardized CPUE for the trawl fishery catching western Deepwater Shark has been increasing from a low in 2014 to be around the long term average in the last few years(Figure 72). The distribution of fishing depths for eastern Deepwater Shark has been stable between 600 and 1000m with the exception of 2007 - 2011 when fishing was shallower (Figure 73).

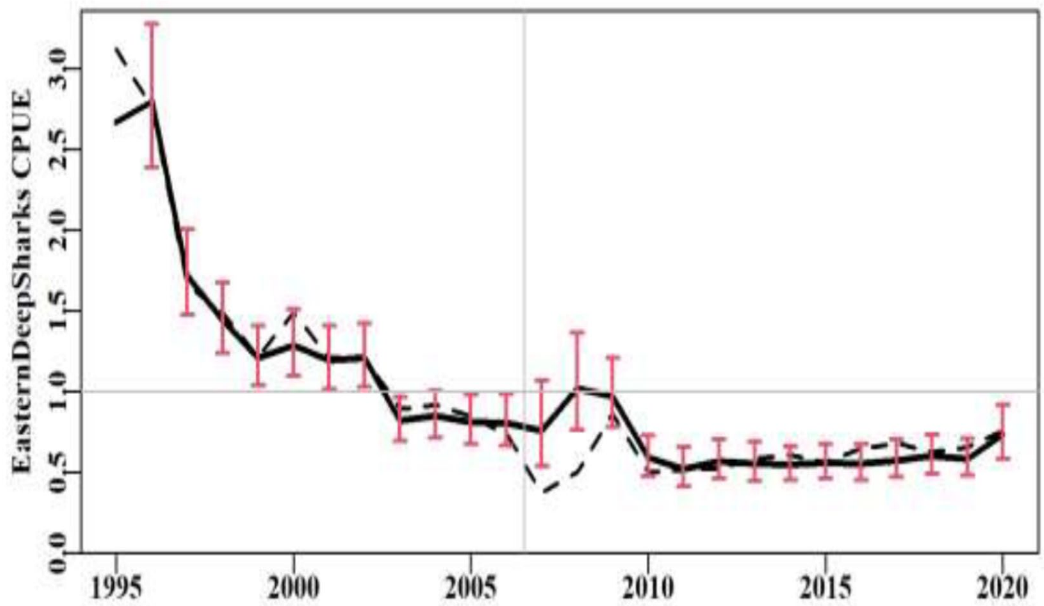

Figure 70 Standardized trawl CPUE of eastern Deepwater Shark with closures removed between 1986 and 2020. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series. Source: Sporcic (2021c).

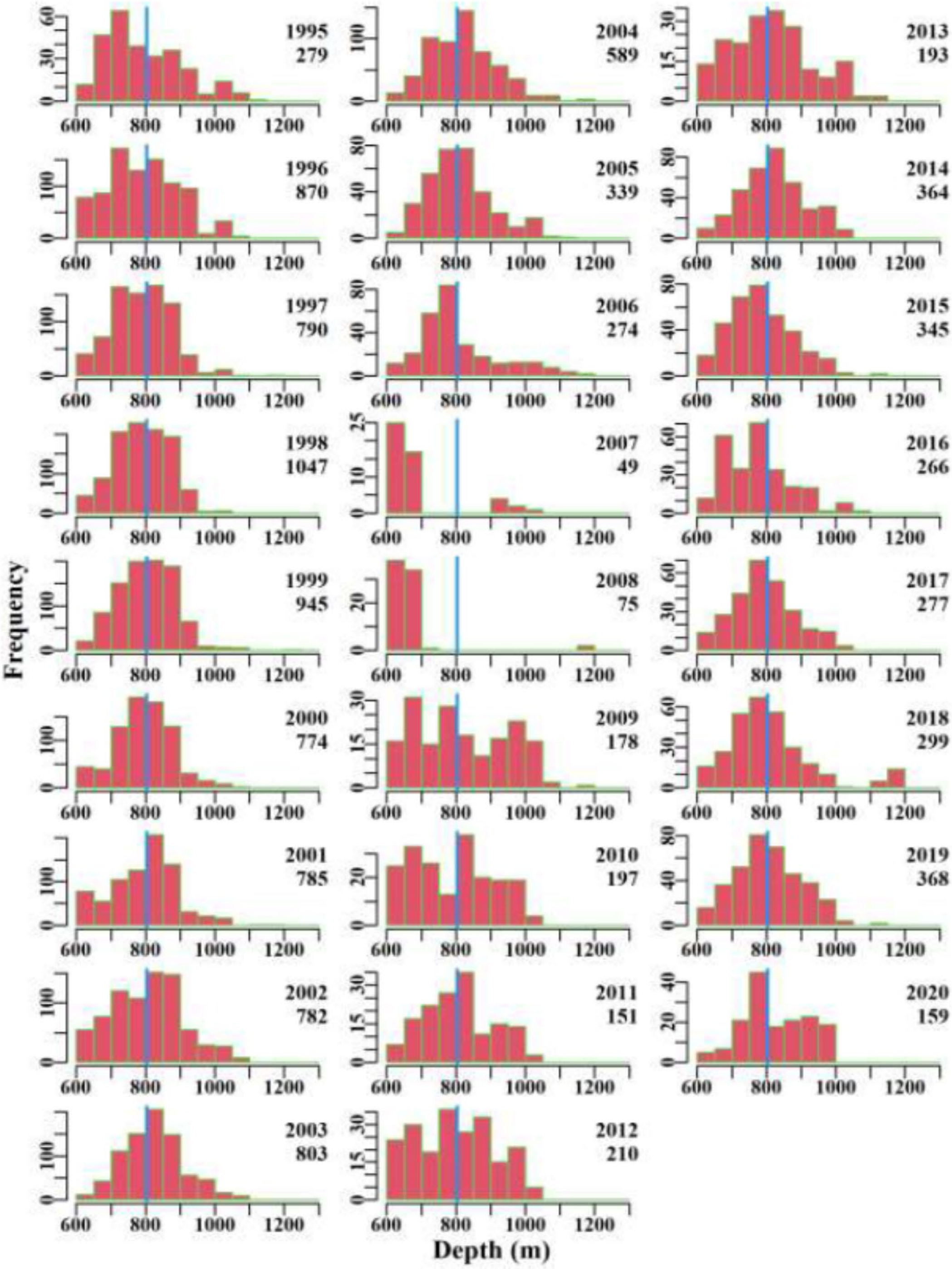

Figure 71 Histogram of annual fishing depths for eastern Deepwater Shark with closures removed between 1986 and 2020. Year and number of logbook records are printed on the right hand side of each plot. Blue line represents mean fishing depth. Source: Sporcic (2021c).

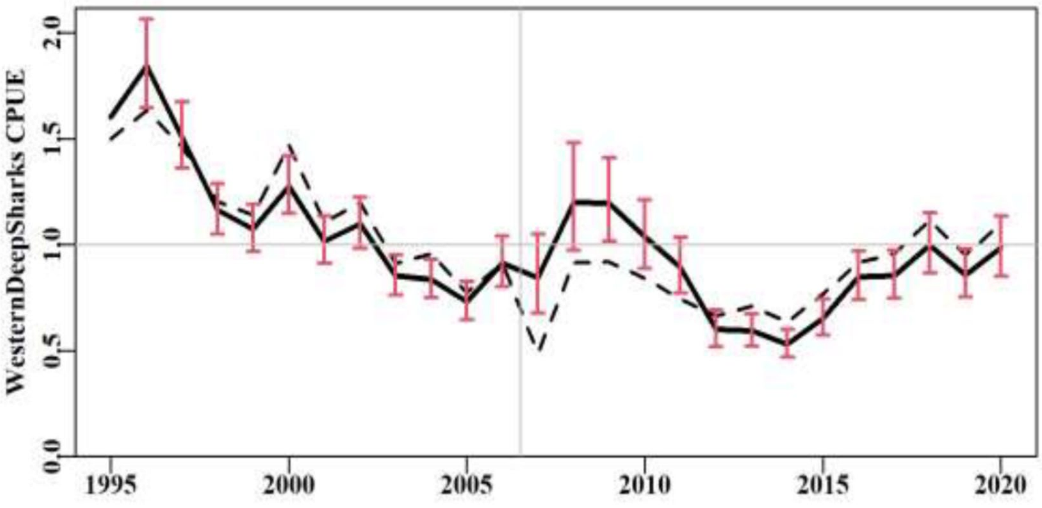

Figure 72 Standardized trawl CPUE for western Deepwater Shark with closures removed between 1986 and 2020. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series. Source: Sporcic (2021c).

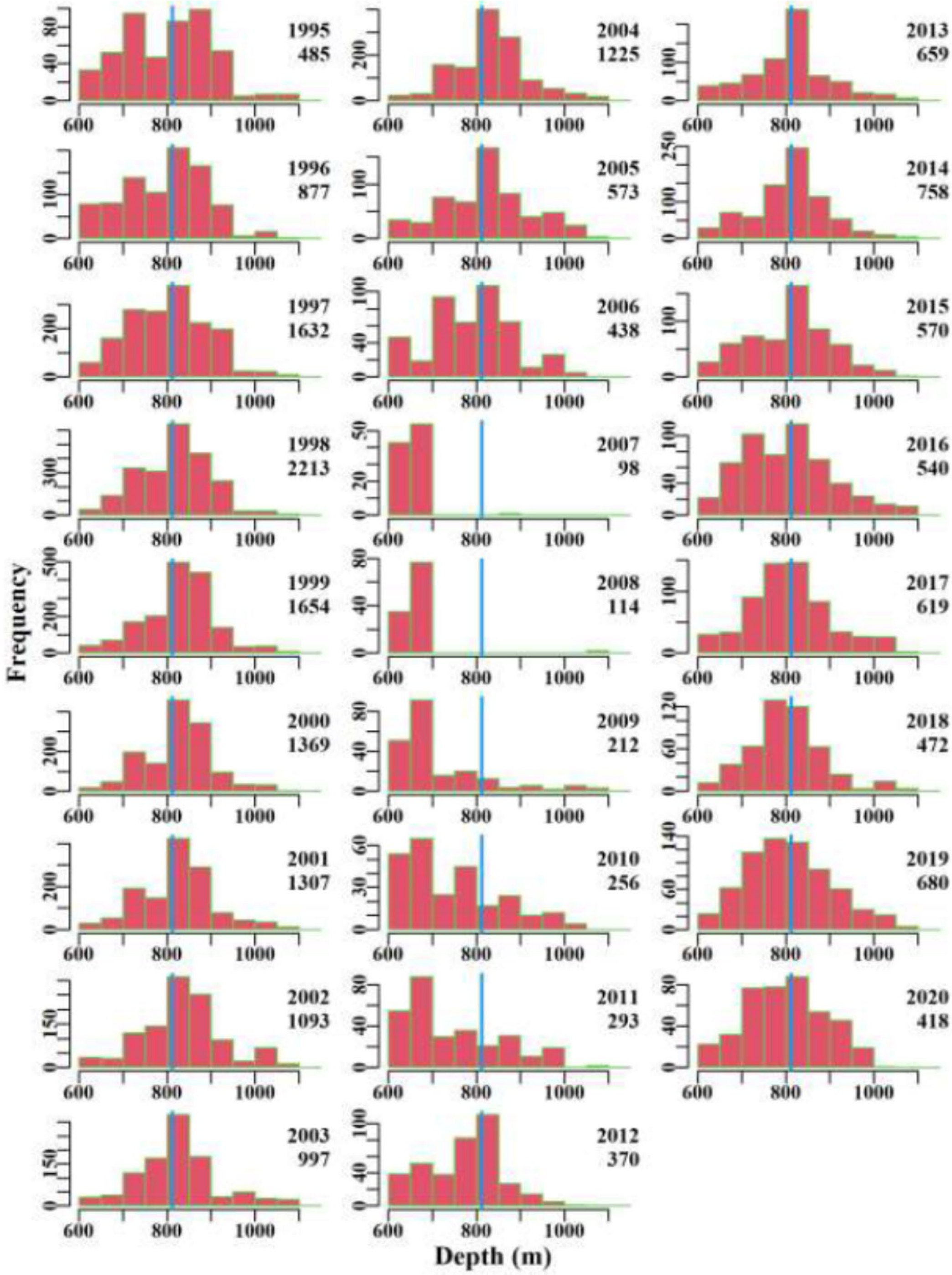

Figure 73 Histogram of annual fishing depths of western Deepwater Shark with closures removed between 1986 and 2020. Year and number of logbook records are printed on the right hand side of each plot. Blue line represents mean fishing depth. Source: Sporcic (2021c).

4.9.3 Spatial distribution of fishing

Deepwater Shark are caught on the slope from southern NSW to South Australia (Figures 74 - 76). In the last two decades reported catches from the east coast of Australia have declined substantially.

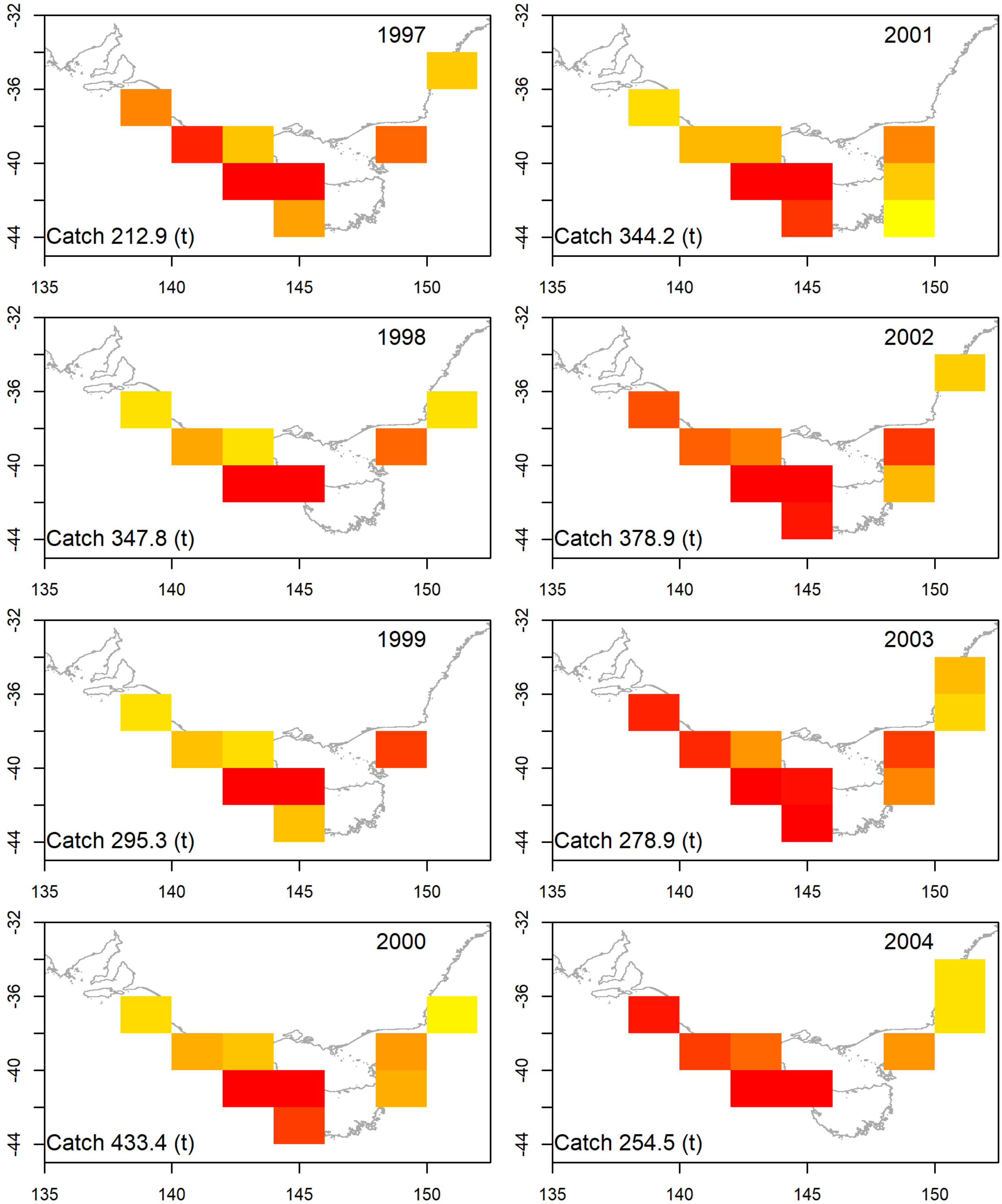

Figure 74 Spatial distribution of annual trawl catch of Deepwater Shark 1997 - 2004. Logbook catch is provided in the bottom left corner of each annual plot.

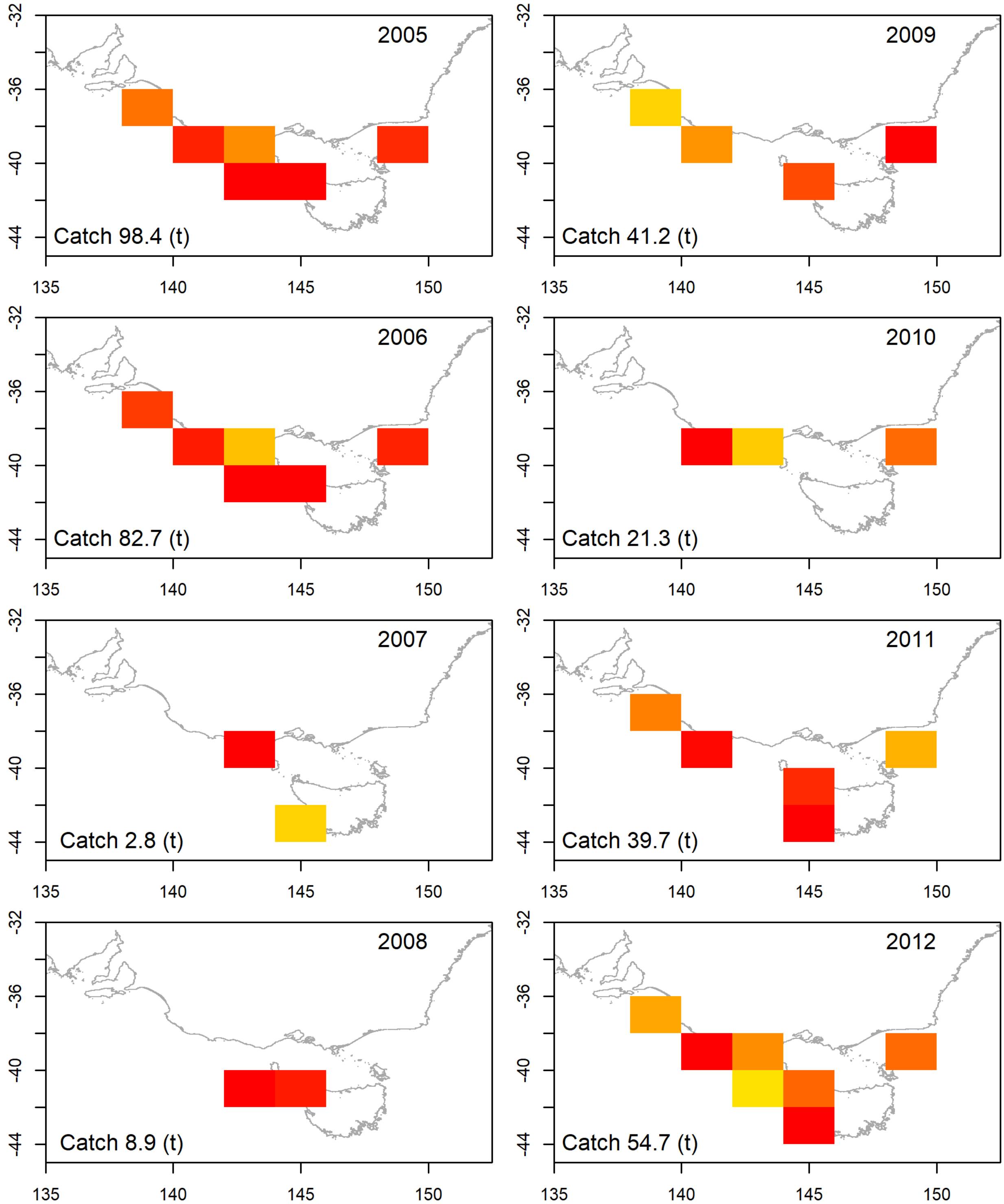

Figure 75 Spatial distribution of annual trawl catch of Deepwater Shark 2005 - 2012. Logbook catch is provided in the bottom left corner of each annual plot.

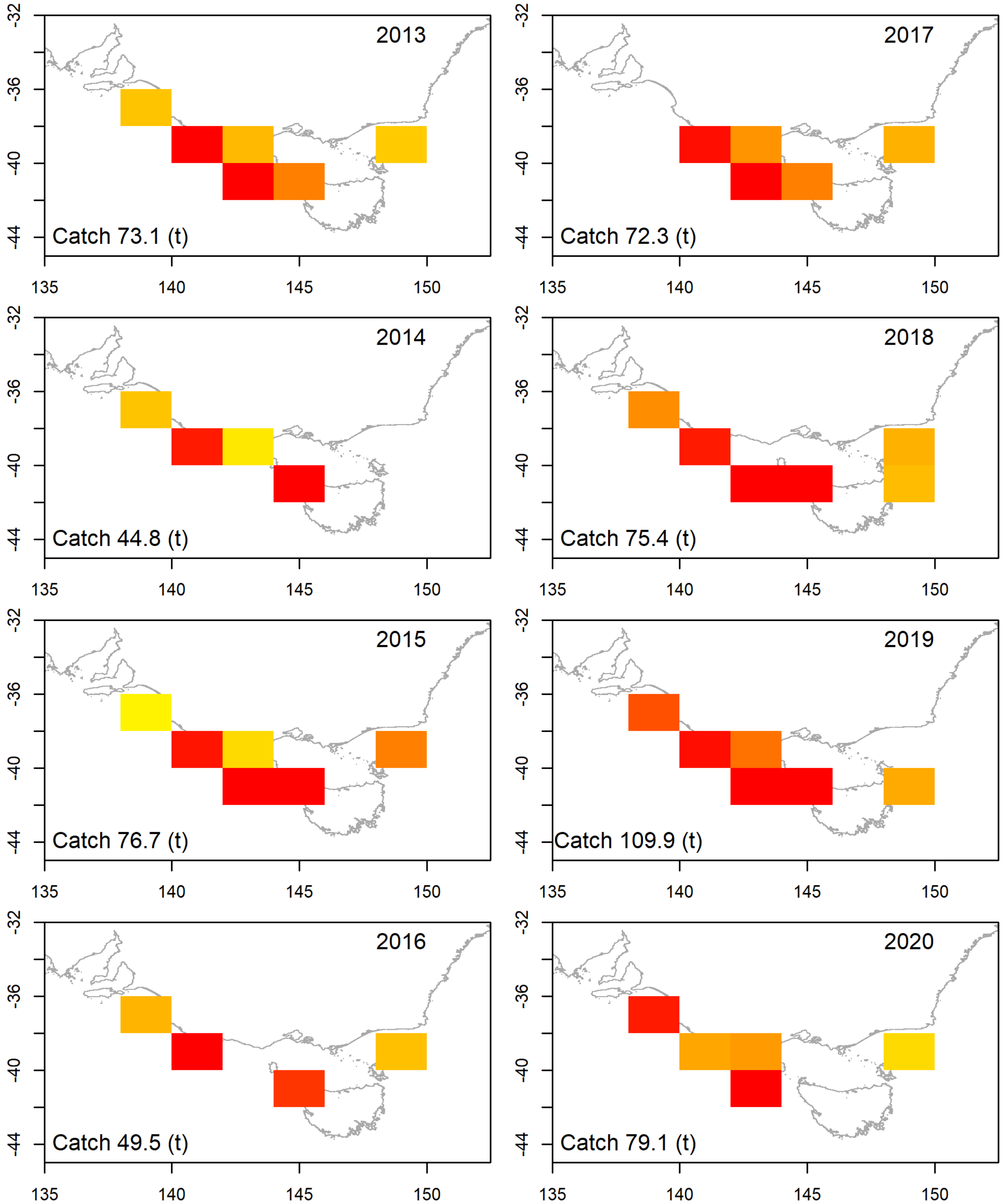

Figure 76 Spatial distribution of annual trawl catch of Deepwater Shark Australia 2013 - 2020. Logbook catch is provided in the bottom left corner of each annual plot.

4.9.4 Catch by vessel

Annual catch by vessel of eastern Deepwater Shark shows most of the catch is taken by two or three vessels (Figure 77). Similarly, most catch of western Deepwater Shark are taken by two vessels (Figure 78). Note that targeting of Deepwater Shark is currently permitted.

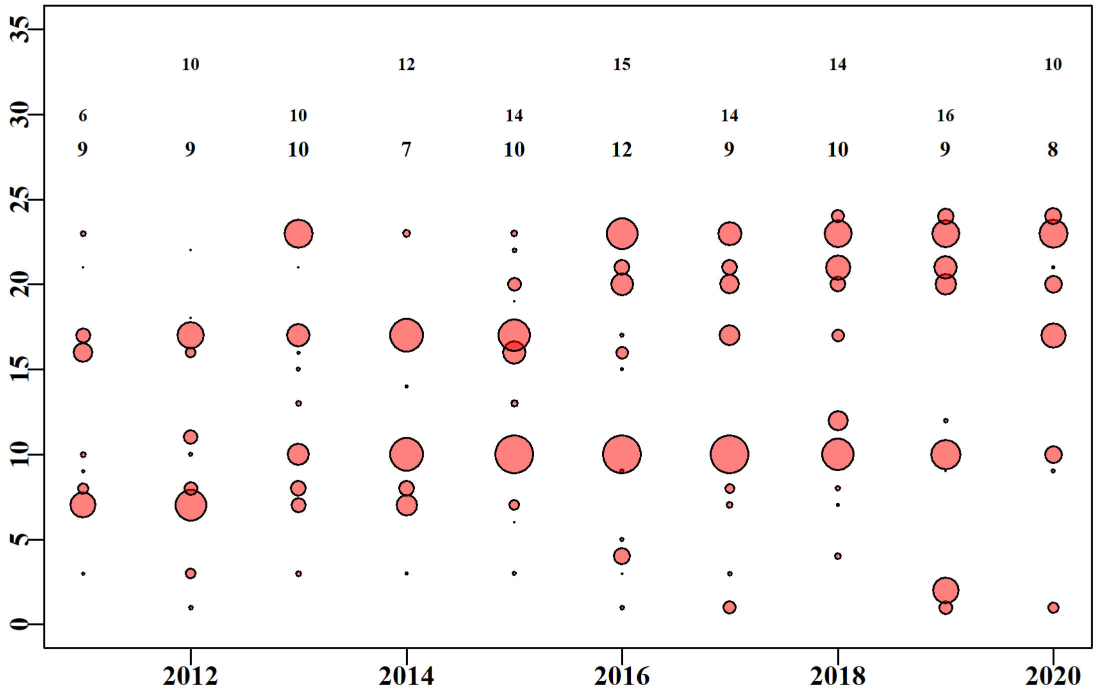

Figure 77 Bubble plot of catch by trawl vessel of eastern Deepwater Shark. Larger bubbles indicate larger annual catches. Numbers at the top of each year represent logbook catch (upper) and number of vessels reporting eastern Deepwater Shark (lower). Each row represents one vessel.

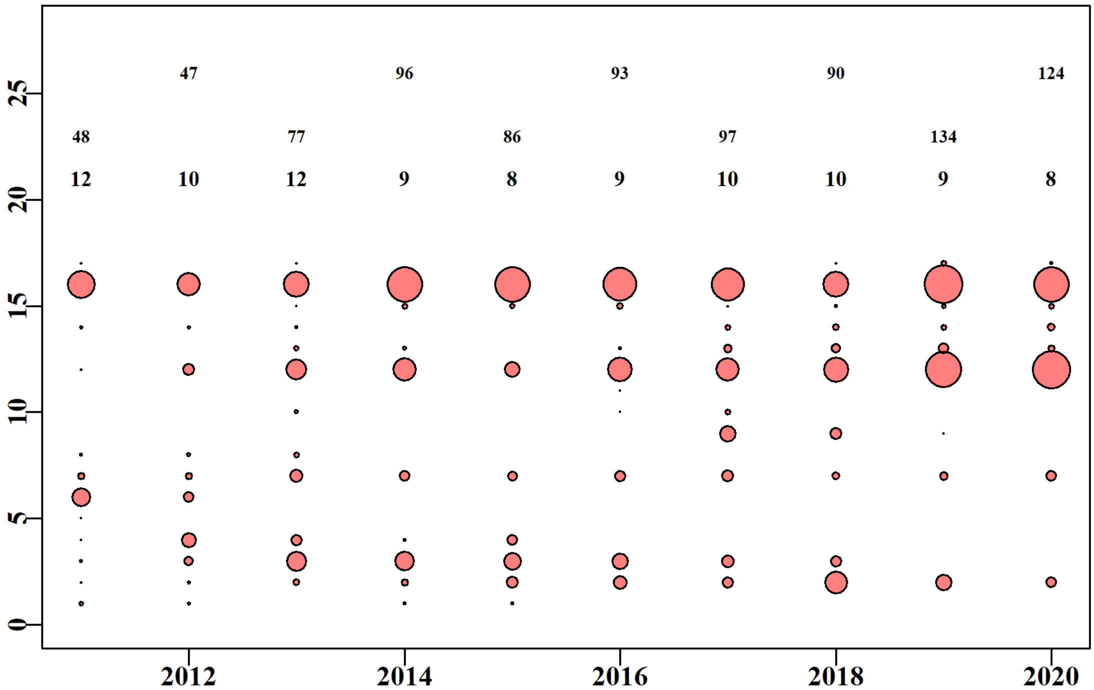

Figure 78 Bubble plot of catch by trawl vessel of western Deepwater Shark. Larger bubbles indicate larger annual catches. Numbers at the top of each year represent logbook catch (upper) and number of vessels reporting western Deepwater Shark (lower). Each row represents one vessel.

5 Discussion

This study has quantified the unavoidable bycatch of Blue Warehou, eastern Gemfish, Redfish, School Shark, John Dory, Silver Trevally, eastern Jackass Morwong and Deepwater Shark using a metier based approach. We also investigated potential targeting of these stocks using a weight of evidence approach.

The estimation of rebuilding species bycatch from the metier analysis makes three strong assumptions about catches reported in logbooks. Firstly, the metier analysis uses landed catches reported in logbooks and does not incorporate discards. Discarded catch estimates are available from Deng et al. (2021), however, they are quite uncertain with CVs >40% for many species. Following an analysis by Dr Tim Emery (ABARES) presented to its November 2021 meeting, SharkRAG accepted that logbook reported discards by vessels equipped with onboard electronic video monitoring were sufficiently accurate to replace ISMP estimates of discarding. Logbook reported discards of School Shark by these vessels will be incorporated into a future version of this report. In addition, there is the need to think more about the differences between the ISMP discard estimates and those from the Tier 1 stock assessments and how these are used for the management of rebuilding stocks. Finally, estimates of unavoidable bycatch for rebuilding and other selected species assume that the 2022 catches of primary species are caught by metiers in approximately the same proportions as they were in recent logbook data. While these assumptions are shared by other methods that have been used to estimate rebuilding species bycatch (e.g. Klaer and Smith, 2012), they need to be taken into account when utilising these estimates for management purposes.

The metier analysis of School Shark bycatch incorporating spatial location has provided useful information on how the ratio of School Shark to Gummy Shark landings change over the spatial distribution of the fishery. It is interesting that school shark are reported at higher ratios than 1:5 for some metiers, presumably reflecting that the rule is applied at a relatively high level of aggregation (i.e., not at the operation level). School to gummy ratios are consistently high in western Bass Strait and Western Tasmania with hook catches in western SA also high. There is little indication of targeting, with only two trawl vessels having higher catches of School Shark which may warrant further investigation by AFMA. For the other species considered in this report, the metiers that take the majority of the bycatch are part of the trawl sector.

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