8th Meeting of the Scientific Commitee (SC8)

Tenerife, Spain, 22-31 March 2023

SC-08-INFO-14

Cook Islands SIOFA fishery and data collection

Stephen Brouwer, Tiare-Renee Nicholas, and Charles Heaphy

Document type	Working paper ☐ Information paper ☑
Distribution	Public ☑ Restricted [1] ☐ Closed session document [2] ☐

Abstract

The Cook Islands has a fleet operating in the SIOFA area consisting of two trawl vessels targeting alfonsino (*Beryx splendens*) and orange roughy (*Hoplostethus atlanticus*). The fishery is extensive covering a large portion of the SIOFA area mostly south of 25^{o}S with two main areas of density one largely between 30^{o}E and 60^{o}E and the second East of 80^{o}E. The vessels collect catch and effort data as well as biological samples. This paper describes the catch and effort as well as bycatch from these vessels.
We focus the bycatch information on a detailed discussion on shark bycatch as well as a summary of the interactions with benthic organism.
Furthermore, we undertook CPUE standardisations of the alfonsino catch. This showed that an index based on all the alfonsino catch as well as separating the catch east and west of 80^{o}E all showed similar trends. These trends were similar to those presented in the 2020 stock assessment, and the trajectory since the last year of that assessment is consistent with the trend over the previous 8 years.

[1] Restricted documents may contain confidential information. Please do not distribute restricted documents in any form without the explicit permission of the SIOFA Secretariat and the data owner(s)/provider(s).
[2] Documents available only to members invited to closed sessions.

Recommendations (for proposals and working papers only)

1. The Scientific Committee note the information presented in this report.
2. The Scientific Committee note that the stock trajectory of alfonsino has not changed appreciatively since the 2020 assessment, and has fluctuated without trend over the last ten years.

Ministry of Marine Resources

GOVERNMENT OF THE COOK ISLANDS

Cook Islands SIOFA fishery and data collection

Stephen Brouwer[1], Tiare-Renee Nicholas[2], and Charles Heaphy[3]

[1]**Saggitus Limited, New Zealand**

[2]**Ministry of Marine Resources, Cook Islands**

[3]**Sealord, New Zealand**

Correspondence author: E-mail: Steve@saggitus.co.nz

Contents

1. Introduction

The Cook Islands has a fleet of trawl two vessels working in the SIOFA area targeting alfonsino (*Beryx splendens*) and orange roughy (*Hoplostethus atlanticus*). The fishery covers the SIOFA area mostly south of 25^{o}S centred around seamounts and plateaus (Figure 1) with two main areas of catch density one largely between 30^{o}E and 60^{o}E and the other East of 80^{o}E (Figure 2). The vessels collect catch and effort data as well as biological data and samples.

The data collected by the Cook Island vessels have been used in a number of biological analyses including age and growth (Brouwer et al., 2020; Brouwer et al., 2021a; Brouwer et al., 2022); maturity analysis (Brouwer et al., 2021a; Brouwer et al., 2021b). These data along with the catch data have also been used in stock assessment for alfonsino (Brandao et al., 2020) and orange roughy (Cordue, 2018; Roa-Ureta et al., 2022).

This paper attempts to summarise the information available from the Cook Islands vessels fishing in the SIOFA Area. These data include, catch, bycatch and biological information.

2. Methods

Data were collected by the vessels and entered into logsheets, and more recently elogs. These data are stored at the Cook Islands Ministry of Marine Resources and submitted annually to the SIOFA secretariat. In addition, the Cook Islands vessels have 100% observer coverage collecting catch and effort information as well as information on bycatch and seabird mitigation. Due to the COVID-19 pandemic observer coverage was suspended in 2021 and 2022. The data for this analysis were derived from an extract from the SIOFA database, although some historic data have been used that pre-date the Cook Islands entry into SIOFA.

These data were extracted from an access data set provided by the SIOFA secretariat and then imported into R (R Core Team, 2020) for analysis. The data are presented as data summaries.

An analysis of alfonsino CPUE was attempted. For this analysis species clustering was attempted using kmeans clustering to separate target sets, but no clear clusters were evident. As a result, the main target species were considered as species proportions for consideration within a General Linear model (GLM) to standardise the CPUE series. A number of different approaches were attempted using all data and all sets with positive alfonsino catch. The final model used all sets with positive alfonsino catch. A set of predictors was prepared for the GLM including calendar year; catch proportion of alfonsino (BYX), orange roughy (ORY), black cardinal fish (EPI), and pelagic armourhead (EDR); as well as Latitude, Longitude and Month with a normal distribution assumed.

Log(BYS catch) ~ year + BYS_prop + ORY_prop + EPI_prop + EDR_prop + Latitude + Longitude + Month

All analyses were diagnosed using tools outlined in Bentley et al. (2012). These include detailed analyses on the various factors effects on the CPUE trends, as well as standard model fit diagnostics for GLMs.

The same model was used for the alfonsino positive sets but separated at 80^{o}E the models derived from the full data set as well as those east and west of 80^{o}E were compared the trends to those found in Brandao and Butterworth (2020) and Brandao et al. (2020).

3. Results and Discussion

3.1. Catch and Effort

There are two trawl vessels in the Cook Islands fleet in the most recent years that fish between about 1,700 and 2,700 sets per year (Figure 3). The vessels fish throughout the year but with some inter annual fluctuation, the lowest number of sets on average occurring in the Austral Autumn between March - May (Figure 4).

Overall most of the Cook Island catch is alfonsino with catch being consistently lower in the most recent six years (Figure 5) and most alfonsino are landed from mid-water sets and orange roughy in bottom trawl sets (Figure 6). The catch distributions for the main species in the catch are shown in Figure 7 to Figure 13. Most of these species have two main areas of distribution one centred around 50^{o}E and a second around 90^{o}E. However, black oreo and smooth oreo are only caught in the western areas. These catch distributions are largely reflective of the topography and tend to occur where the seabed rises above the abyssal plains forming seamounts and plateaus between 1-2,000m deep along the Madagascar Ridge and the Southwest Indian Ridge in the west and Broken plateau in the east (Figure 1).

3.1.1. Elasmobranch catch

Trawl vessels flagged to the Cook Islands are prohibited from targeting sharks. Some sharks are caught as bycatch during the normal operations of the vessel, when this occurs sharks are required to be released and handled in a manner that affords them the best chance of survival. Relative to the target catch, sharks form a very small percentage of the catch and 91% of sets contain no sharks, 98% of mid-water sets contain no sharks and only 6% of bottom tows contain sharks (Figure 14).

The elasmobranch species reported in the highest numbers are southern lantern sharks followed by roughskin dogfish and birdbeak dogfish (Figure 15). There is some difference between the observed and reported catch where the elasmobranch species observed in the highest numbers are little sleeper sharks (Figure 16). It is not known if this difference is a real difference or a species identification issue.

A number of species such as gulper sharks, kitefin sharks and plunket sharks are caught in sets less than 1,000m while smooth lantern sharks are only caught in shallower sets while others such as bluntnose sixgill sharks and shortspine spurdogs are caught in deeper sets (Figure 17). However, separating these by set type in the reported data is not always possible as set type is often not reported in the database (Figure 18). Smooth lantern sharks are only caught in orange roughy sets while other species such as birdbeaked dogfish and kitefin sharks are caught in almost all set types (Figure 19) and all years (Figure 20). Figure 21 to Figure 42 show these catch by target, set type year and depth category for each species in the dataset. Distribution maps for each species are also presented in Appendix I (Figure AI - 1 to Figure AI - 29).

3.2. Biological data collection

Biological data have been collected from Cook Islands vessels since 2004. These data are collected by vessel crews, Cook Islands Observers, or scientists on specific voyages. Figure 43 to Figure 50 show the length frequency distributions of the nine species from which observers collect data as well as the number of otoliths and stomach samples collected. Generally, samples are sparse but samples for orange roughy and alfonsino are abundant and otolith samples are generally reflective of the size distribution (Figure 44 and Figure 48). Figure 52 and Figure 53 provide information on the maturity samples collected. These data show that over 23,000 alfonsino and 22,000 orange roughy samples have been collected. In addition, some samples pre-date these and some improvements to sampling strategies have been suggested (see Brouwer et al., 2020; Brouwer et al., 2021a; Brouwer et al., 2021b; and Brouwer et al., 2022).

3.3. Seabirds and benthic bycatch

While the seabird counts around the vessels was not excessively high in most cases, almost all sets (99%) undertaken contained seabird mitigation (Figure 54). Most observations of bird counts estimated between 20 and 30 birds around the vessel. No bird warp strikes or water strikes were recorded.

Observations by Cook Islands fisheries observers on board indicate that there have been low encounter rates with vulnerable marine benthic ecosystems (VME) by Cook Islands vessels. In 2022 a total of 282 bottom trawl shots were carried out by Cook Islands vessels and, based on provisional data from limited observer reports, no shots breached the VME threshold.

Benthic material was observed in a 13% of sets. By weight, a variety of hard corals and volcanic rock were the most abundant material (Figure 55). Almost all benthic material encounters occur in bottom sets (Figure 56). The most frequently encountered benthic material was hard corals, followed by bamboo corals and sponges. Encounters of other species are infrequent. Volcanic rock, while making up a high proportion of the weight, was encountered infrequently and was the result of few encounters with heavy material.

Cook Islands supports the protection of biodiversity, taking into account UNGA Resolution 61/105 and subsequent resolutions, which calls on states to implement measures for the high seas in accordance with the precautionary principle and ecosystem approaches to fisheries management. The Cook Islands supports the use of Benthic Protected Areas (BPA) to protect benthic invertebrates and conserve the environment, these closures meet the requirements of Resolution 61/105. Many areas in SIOFA are already identified and closed to Cook Islands vessels, In addition other areas are closed to Cook Islands vessels as a precautionary measure to maintain and protect biodiversity.

The Cook Islands Ministry of Marine Resources (MMR) has developed an advanced encounter protocol with input from industry over a number of years. This includes holistic management approach, where vessels are required either to moving off areas where encounters occurred, or more significantly by the establishment of voluntary BPAs closed to fishing. Five BPAs have been implemented by the SIOFA Meeting of the Parties (MOP) in 2018. The Cook Islands has suggested and additional seven BPA areas closed to fishing activities, and these areas remain closed to Cook Islands vessels. Cook Island flagged vessels continue to adhere to the VME encounter threshold established in CMM 20-01 Interim Bottom Fishing Measures section 12(b).

3.4. Alfonsino CPUE analysis

Two alternative data sets were considered for the alfonsino CPUE analysis. The first was the full data set that included all catch (Figure 57) and the second was only sets with positive alfonsino catch (Figure 58). The influence of removing sets with no alfonsino substantially reduced the catch proportion of orange roughy, and removed a high proportion of orange roughy target sets. This had little impact on the spatial distribution of the catch, and slightly reduced the catch proportion of spiky oreo. Due to the removal of many orange roughy target sets, the alfonsino positive sets only data set, was considered more appropriate.

This data set was then progressed for CPUE standardisation. The one step change plot (Figure 59) suggests that the standardisation did not have a large effect, with the biggest one step change occurring with the introduction of the alfonsino catch proportion and latitude, both of these lowering the index through the mid-2000s. Few other factors resulted in substantial changes to the index.

Alfonsino catch proportion has a large influence during the early period of the index but the catch remained consistently high per set throughout the time period (Figure 60). The orange roughy catch proportions remain relatively low and only had a strong negative influence on 2004 (Figure 61). The effects of both black cardinal fish and pelagic armourhead in the catch was relatively low but was consistently high towards the mid to end of the series (Figure 62 and Figure 63). The effects of latitude are relatively consistent but with a large standardisation effect in 2006 correcting for a disproportionally large proportion of the catch came from the relatively far to the north (Figure 64). The longitude effects were low but also had a strong effect in 2006, and also show a clear separation of the catch east and west of 80^{o}E (Figure 65). The effects of month was highest in the early part of the series but as the fishery stabilised catch seasonality becomes more consistent through the year and the standardisation effects are reduced (Figure 66).

The final model is presented in Figure 67. This shows a stronger standardisation effect at the start of the series. Which is likely due to the the inconsistent latitude, longitude and months fished at the start of the series. Generally speaking, the index was higher in the mid- to late-2000s but fluctuated without trend from 2010 onwards.

Separating the data east and west of 80^{o}E did not change the outcome substantially, but the series for the east was less stable probably due to the lower number of sets in that area, but both series fluctuate without trend from 2010 onwards (Figure 68).

Both the east and west indices as well as the index based on all alfonsino positive sets were very similar to those indices developed by Brandao et al. (2020) and Brandao and Butterworth (2020) (Figure 69). Generally, the analyses presented here tend toward the middle of the other five Brandao et al. (2020) models and importantly they do not deviate from the trajectory implied in the 2020 assessment (Brandao et al. (2020)), suggesting that the stock biomass has not changed appreciatively since the 2020 assessment and has been relatively stable since 2010.

4. Recommendations

1. The Scientific Committee note the information presented in this report.
2. The Scientific Committee note that the stock trajectory of alfonsino has not changed appreciatively since the 2020 assessment, and has fluctuated without trend over the last ten years.

5. Acknowledgements

The authors would like to thank the Ministry of Marine Resources, Cook Islands for funding this analysis, ORAFCO Limited Cook Islands, and Sealord New Zealand for providing the length and maturity data, as well as the fishery observers and vessel crew for collection these data.

References

Bentley, N., Kendrick, T., Starr, P. J., and Breen, P. A. (2012). Influence plots and metrics: Tools for better understanding fisheries catch-per-unit-effort standardizations. *ICES Journal of Marine Science*, 69(1):84–88.

Brandao, A. and Butterworth, D. (2020). Standardised CPUE series of the alfonsino (*Beryx splendens*) resource in the SIOFA area of the Southern Indian Ocean. Technical Report SERAWG-02-13.

Brandao, A., Butterworth, D., and Johnston, S. (2020). Age-Structured Production Model (ASPM) assessments of the Alfonsino (*Beryx splendens*) resource in the SIOFA area of the Southern Indian Ocean. Technical Report SERAWG-02-14.

Brouwer, S., Wragg, C., Dunn, A., and Saunders, R. (2022). Orange roughy age and growth in SIOFA from the Cook Island fishery. Technical Report SERAWG-04-INFO-01.

Brouwer, S., Wragg, C., Flanagan, B., and Heaphy, C. (2021a). Alfonsino growth, length and maturity estimates from fish sampled on Cook Island trawl vessels in SIOFA. Technical Report SERAWG-03-09-rev1.

Brouwer, S., Wragg, C., Flanagan, B., and Heaphy, C. (2021b). Alfonsino growth, length and maturity estimates from fishs ampled Cook Island trawl vessels in SIOFA. Technical Report SERAWG-03-09.

Brouwer, S., Wragg, C., Wichman, M., and Nicholas, T. (2020). Alfonsino age and growth - rev1. Technical Report SERAWG-02-07.

Cordue, P. (2018). Stock assessment of orange roughy in the Walter's Shoal Region. Technical Report SIOFA SERAWG.

Hood, R. R., Beal, L. M., Benway, H. M., Chandler, C. L., Coles, V. J., Cutter, G. A., Dick, H. J. B., Gangopadhyay, A., Goes, J. I., Humphris, S. E., Landry, M. R., Lloyd, K. G., McPhaden, M. J., Murtugudde, R., Subrahmanyam, B., Susanto, R. D., Talley, L. D., Wiggert, J. D., and Zhang, C. (2018). United States Contributions to the Second InternationalIndian Ocean Expedition (US IIOE-2). Technical Report 2018-08-02.

R Core Team (2020). *R: A Language and Environment for Statistical Computing*. Vienna, Austria.

Roa-Ureta, R., Wiff, R., and Flores, A. (2022). Stock Assessment of the orange roughy (*Hoplostethus atlanticus*) under management by the Southern Indian Ocean Fisheries Agreement (SIOFA):2000 to 2020. Technical Report SC-07-35.

Figures

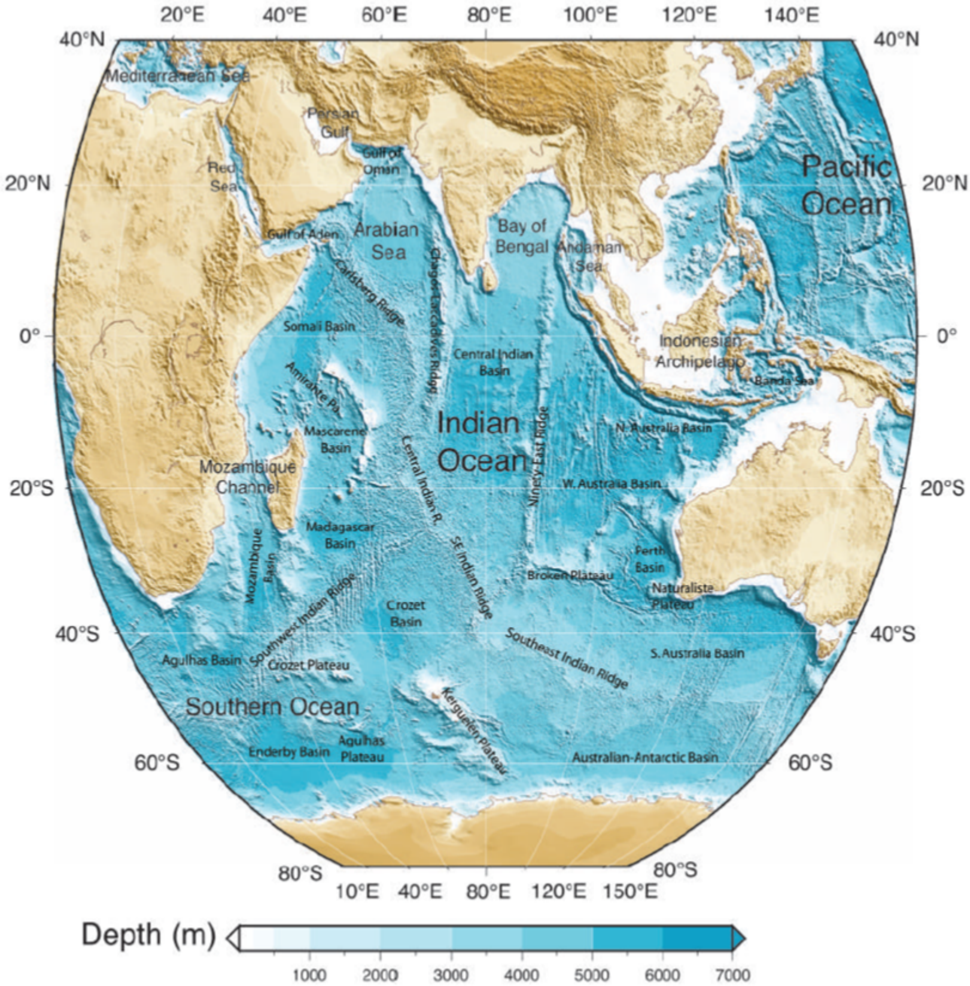

Figure 1: Map of Indian Ocean topography, derived from Etopo2 bathymetry data from NOAA NGDC from Hood et al. (2018).

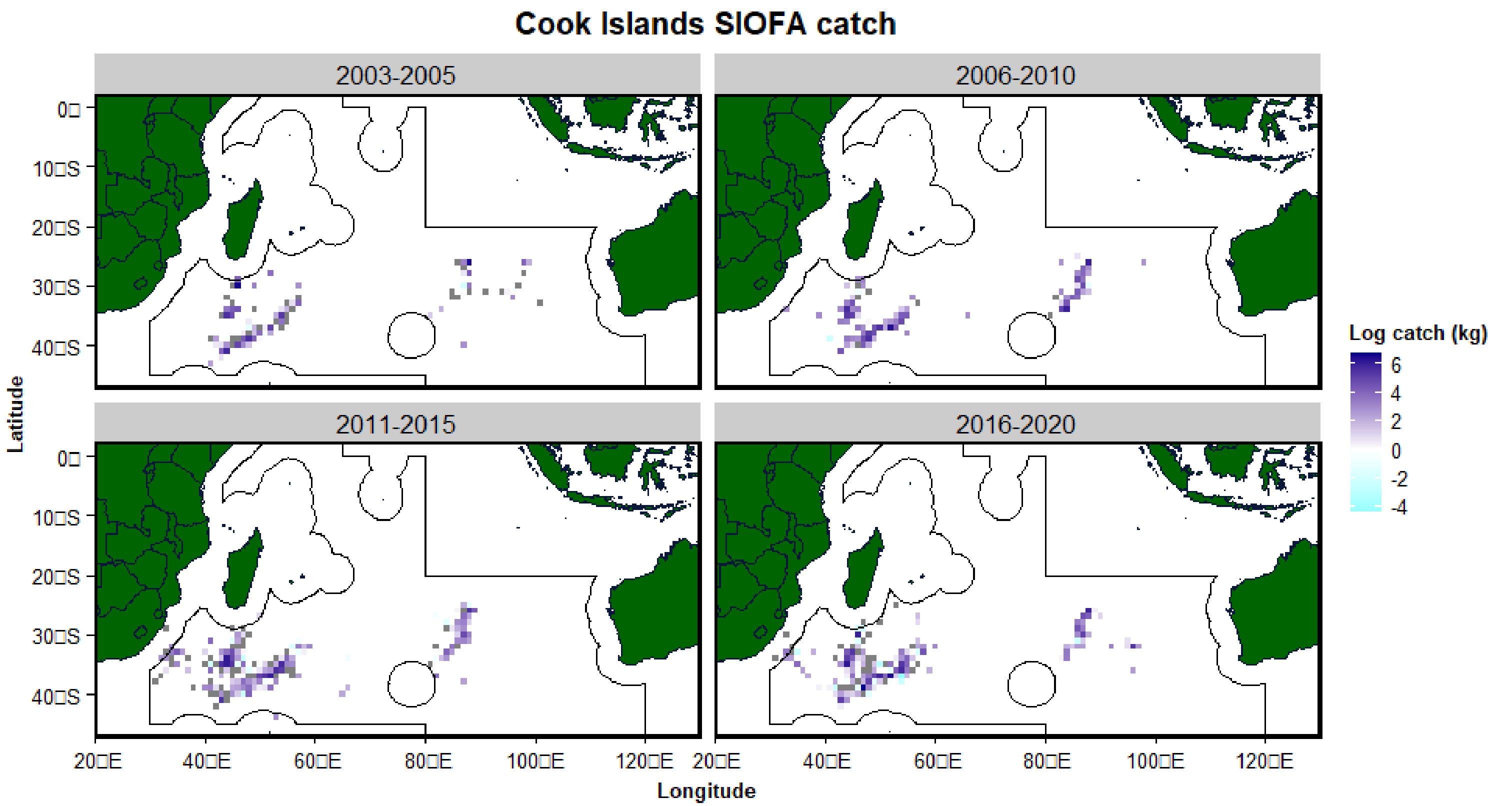

Figure 2: The Cook Islands catch distribution of all species in the SIOFA area for four different time periods.

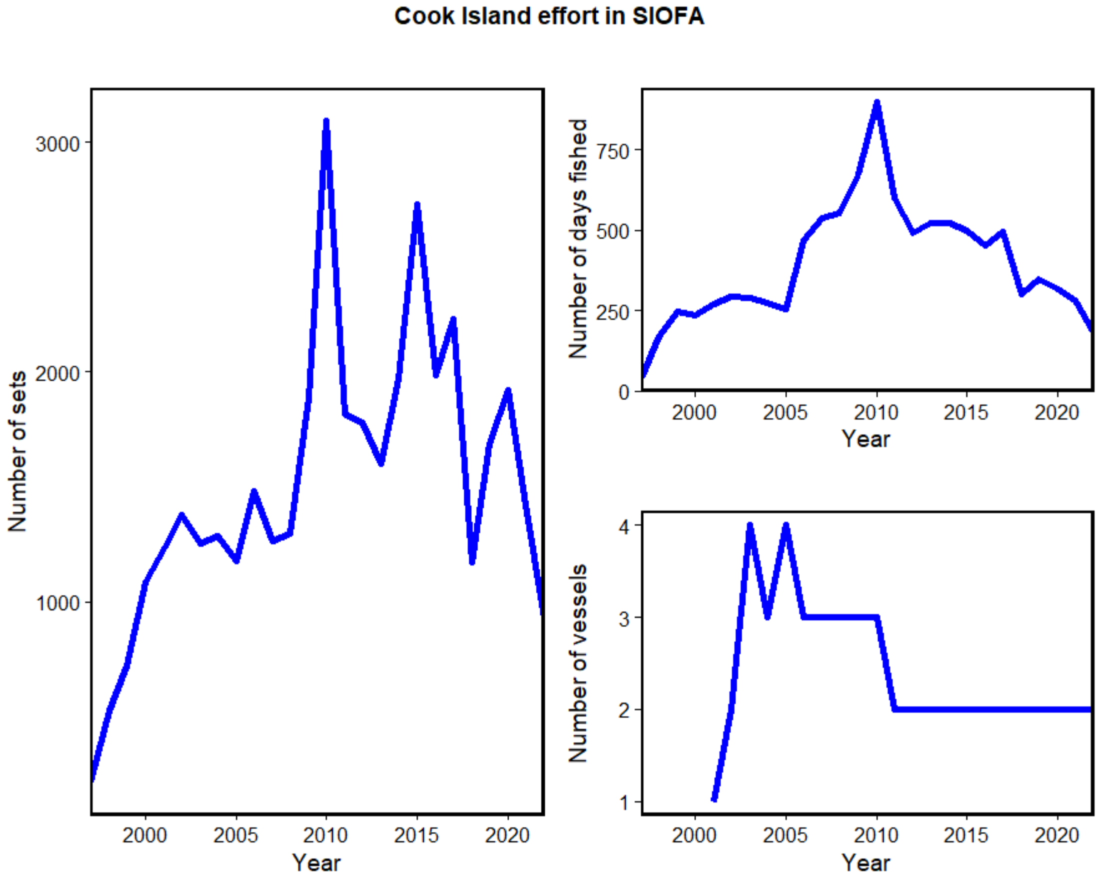

Figure 3: The number of sets made, days fished and vessels for the Cook Islands fishery in the SIOFA area from 1997-2022.

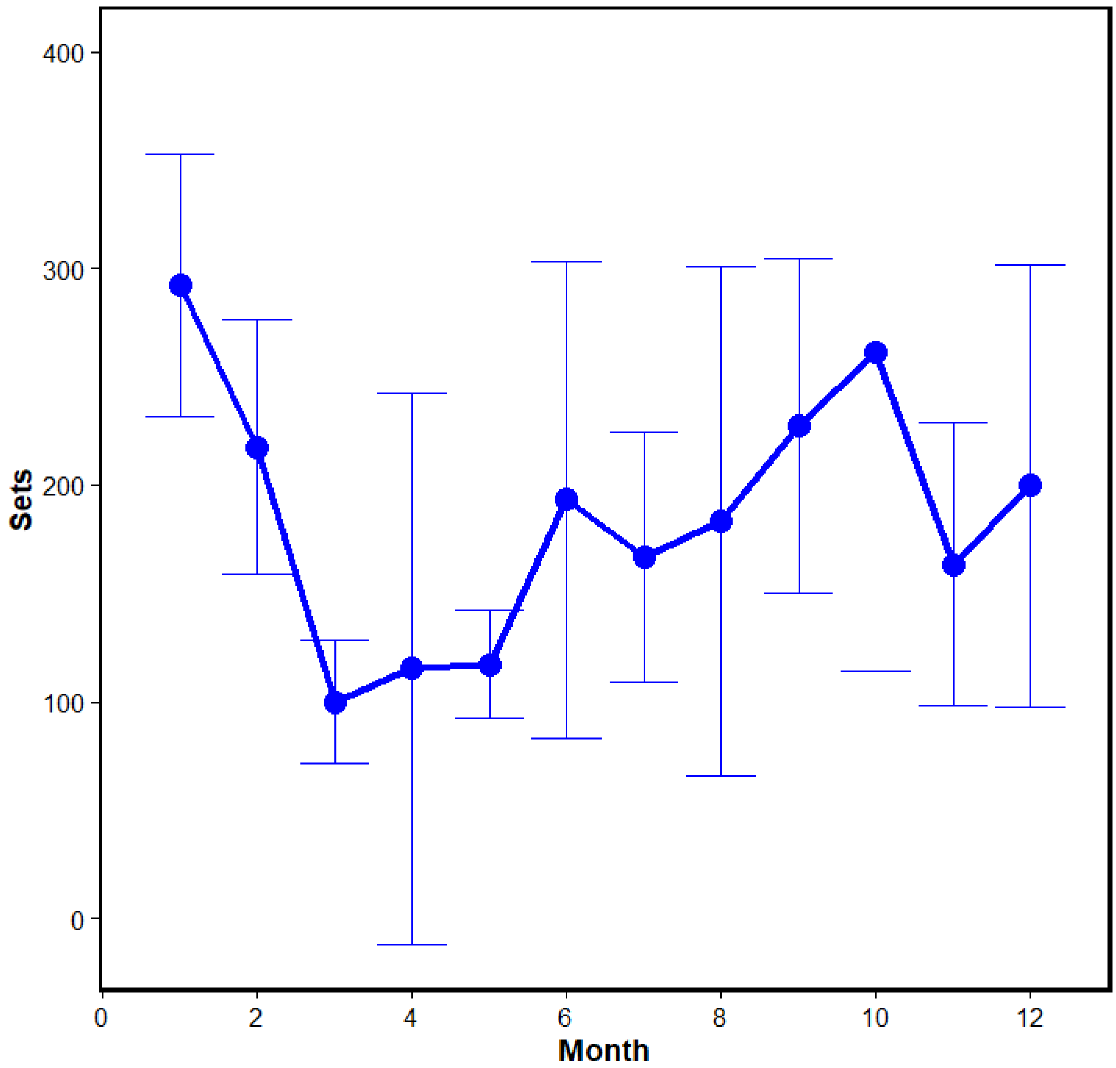

Figure 4: The average number of sets made by the Cook Islands vessels in the SIOFA area from 2018-2022.

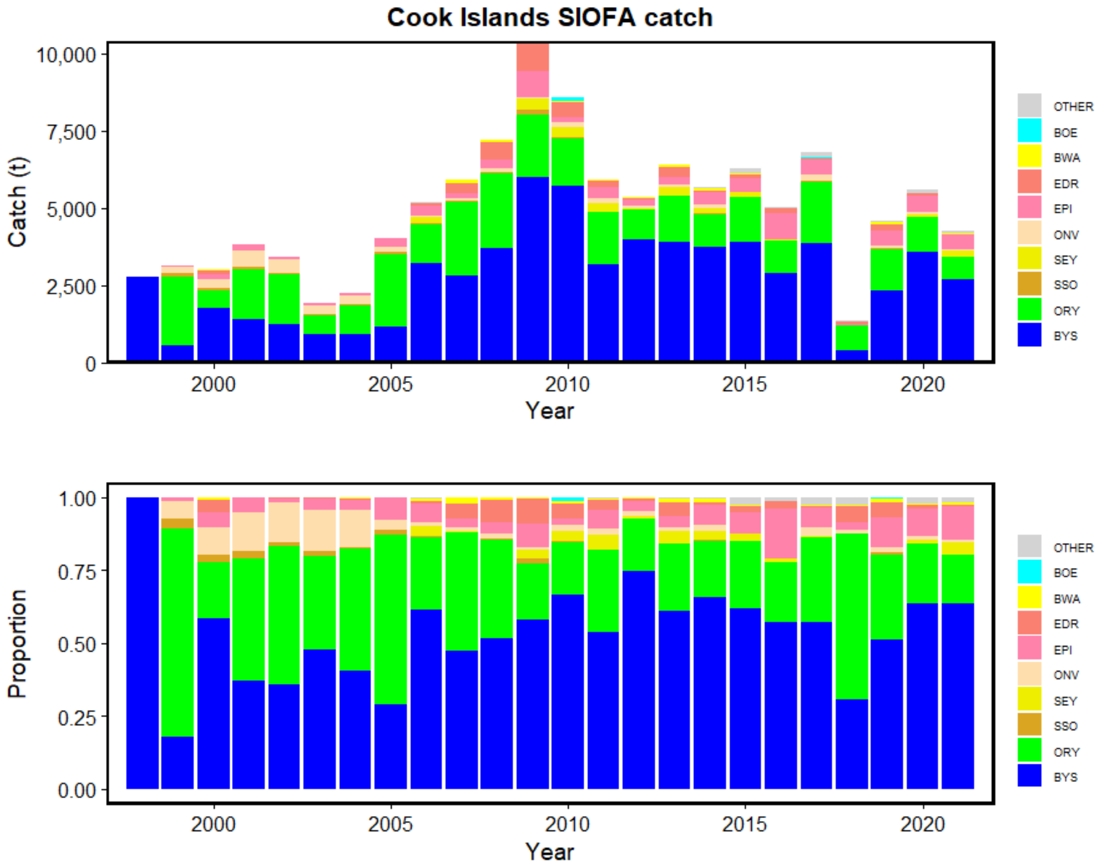

Figure 5: The Cook Islands catch (top) of the nine main species in the catch and the catch proportion (bottom).

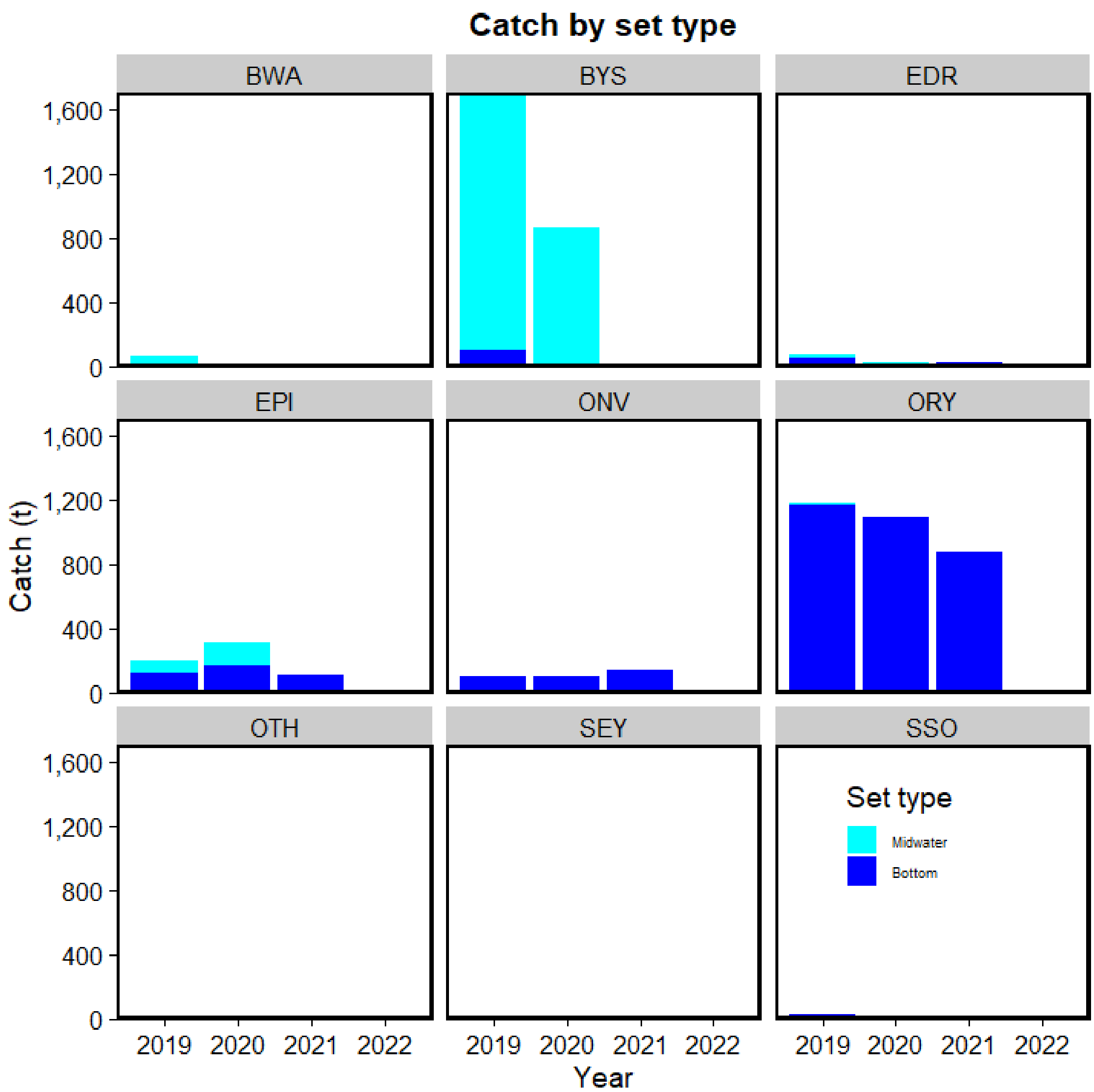

Figure 6: The Cook Islands catch of the nine main species in the catch showing the catch by set type.

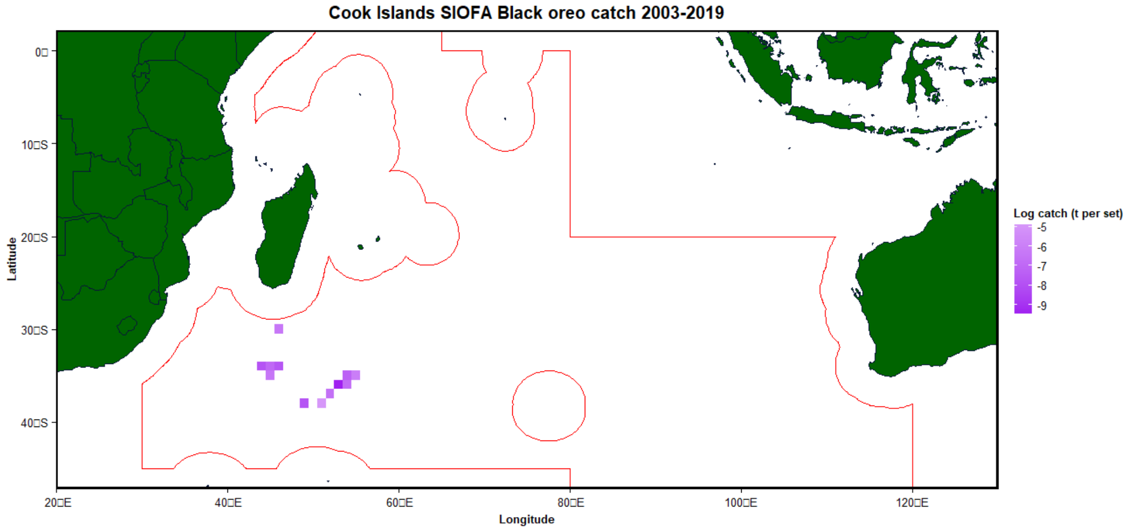

Figure 7: The Cook Islands catch of black oreo from 2003-2020.

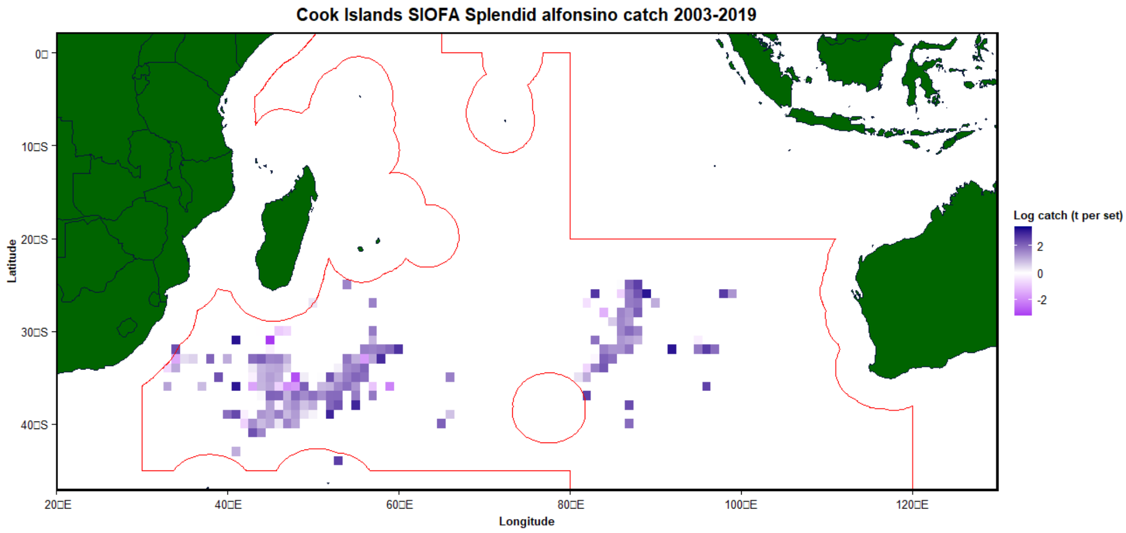

Figure 8: The Cook Islands catch of alfonsino from 2003-2020.

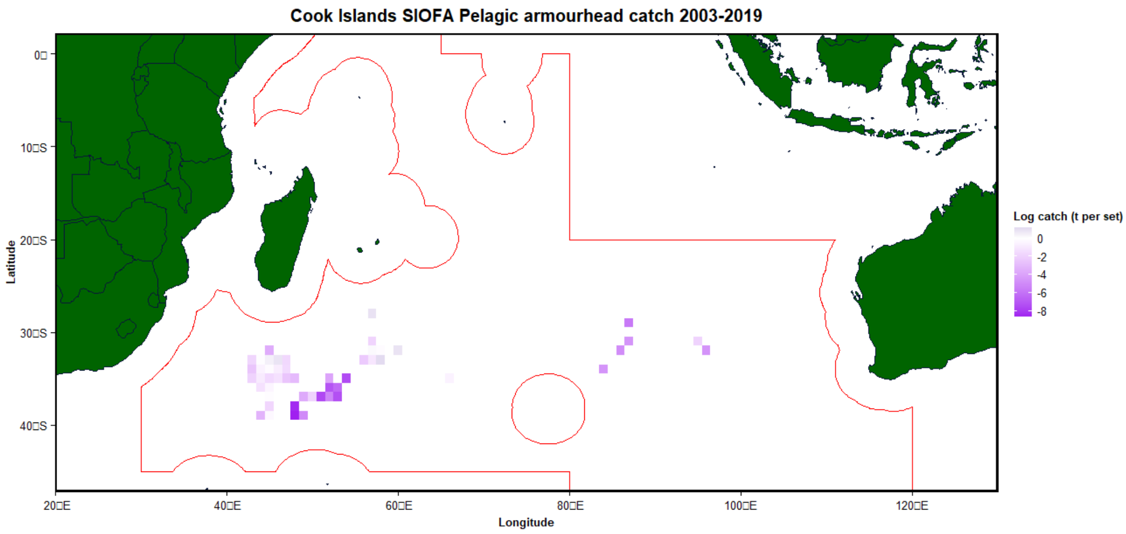

Figure 9: The Cook Islands catch of pelagic armourhead from 2003-2020.

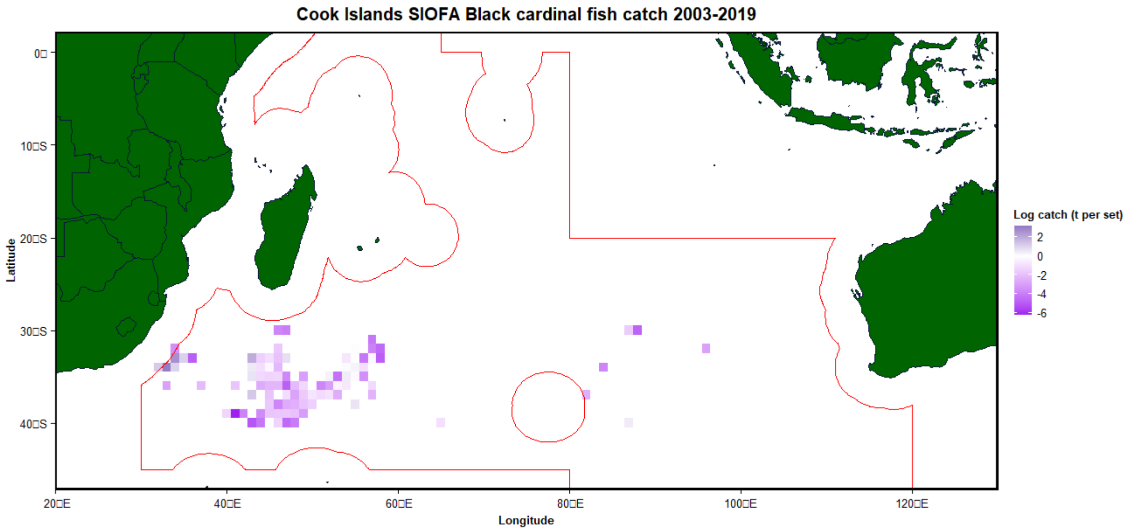

Figure 10: The Cook Islands catch of black cardinal fish from 2003-2020.

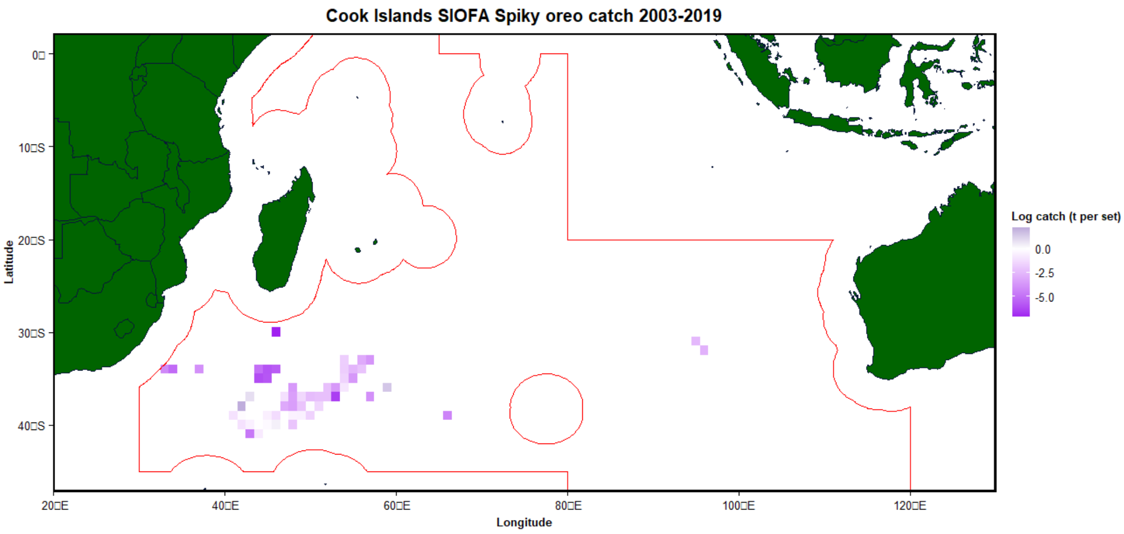

Figure 11: The Cook Islands catch of spiky oreo from 2003-2020.

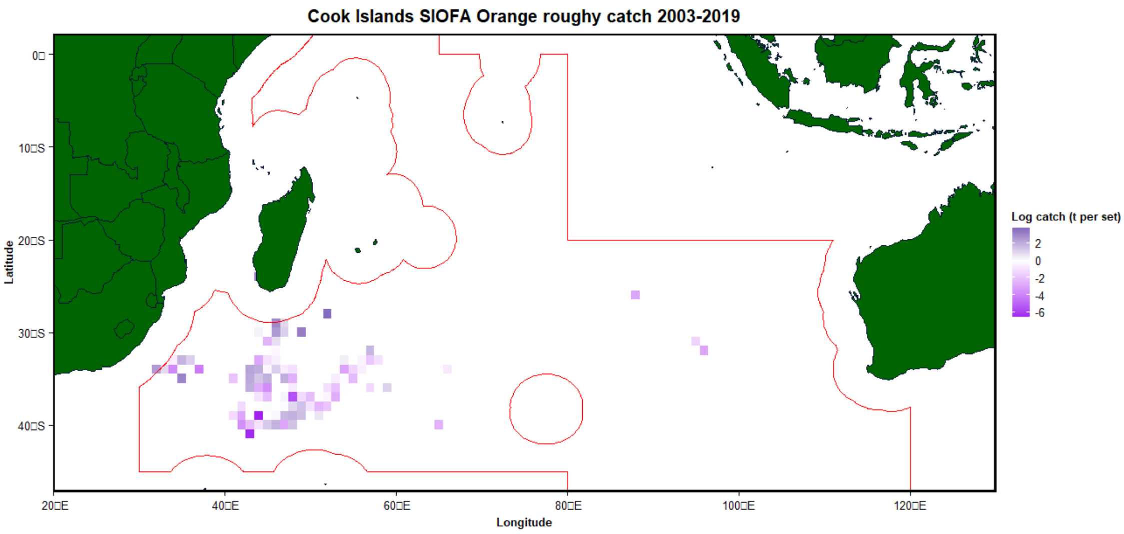

Figure 12: The Cook Islands catch of orange roughy from 2003-2020.

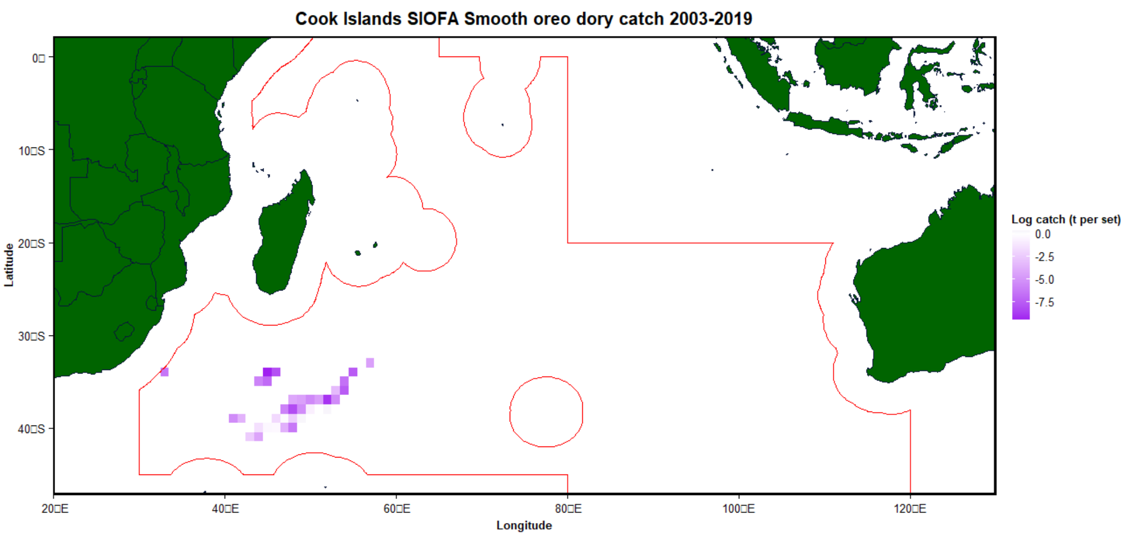

Figure 13: The Cook Islands catch of smooth oreo from 2003-2020.

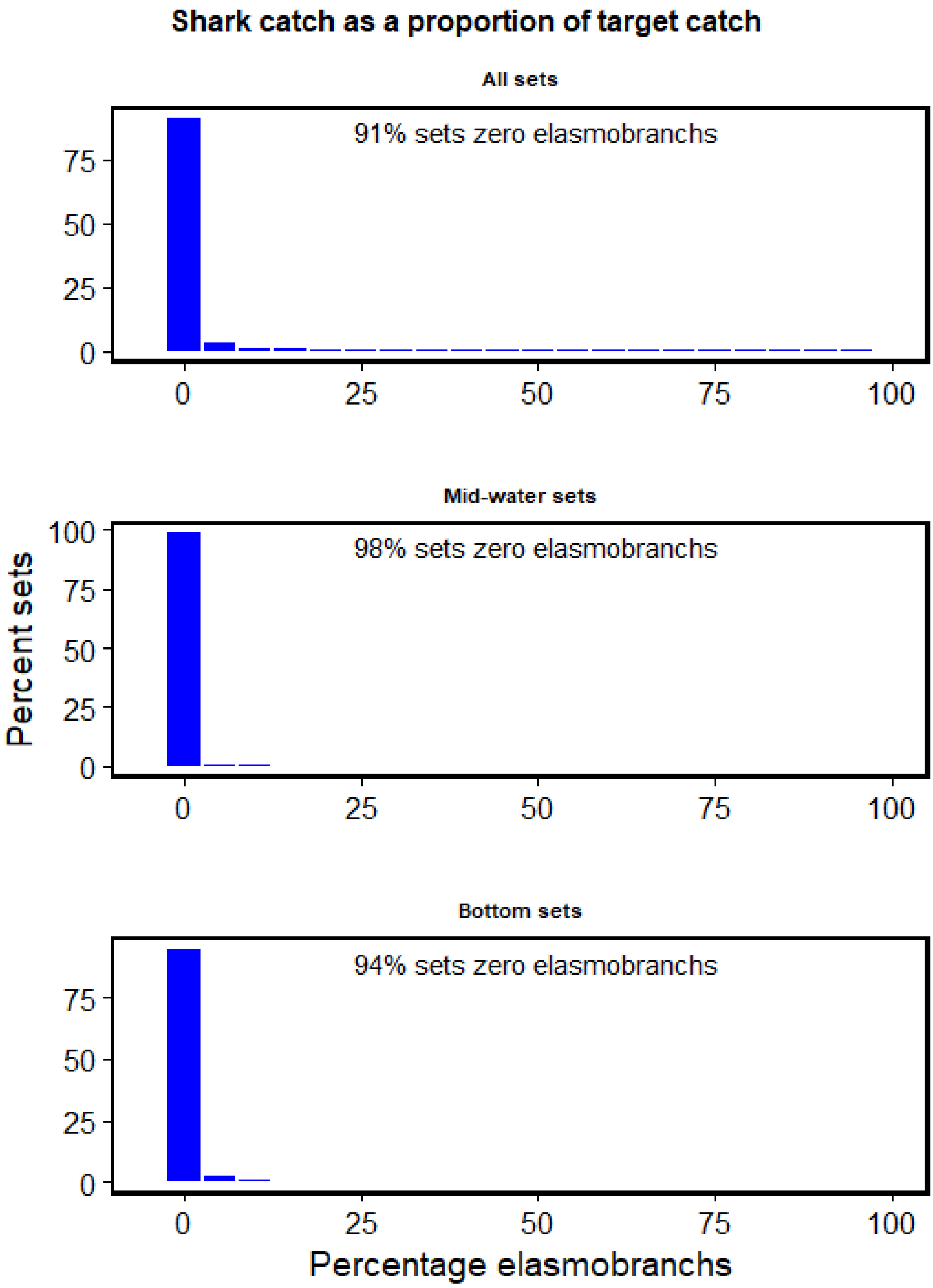

Figure 14: The percent of sets that contain sharks in the Cook Islands SIOFA sets from 2019-2022.

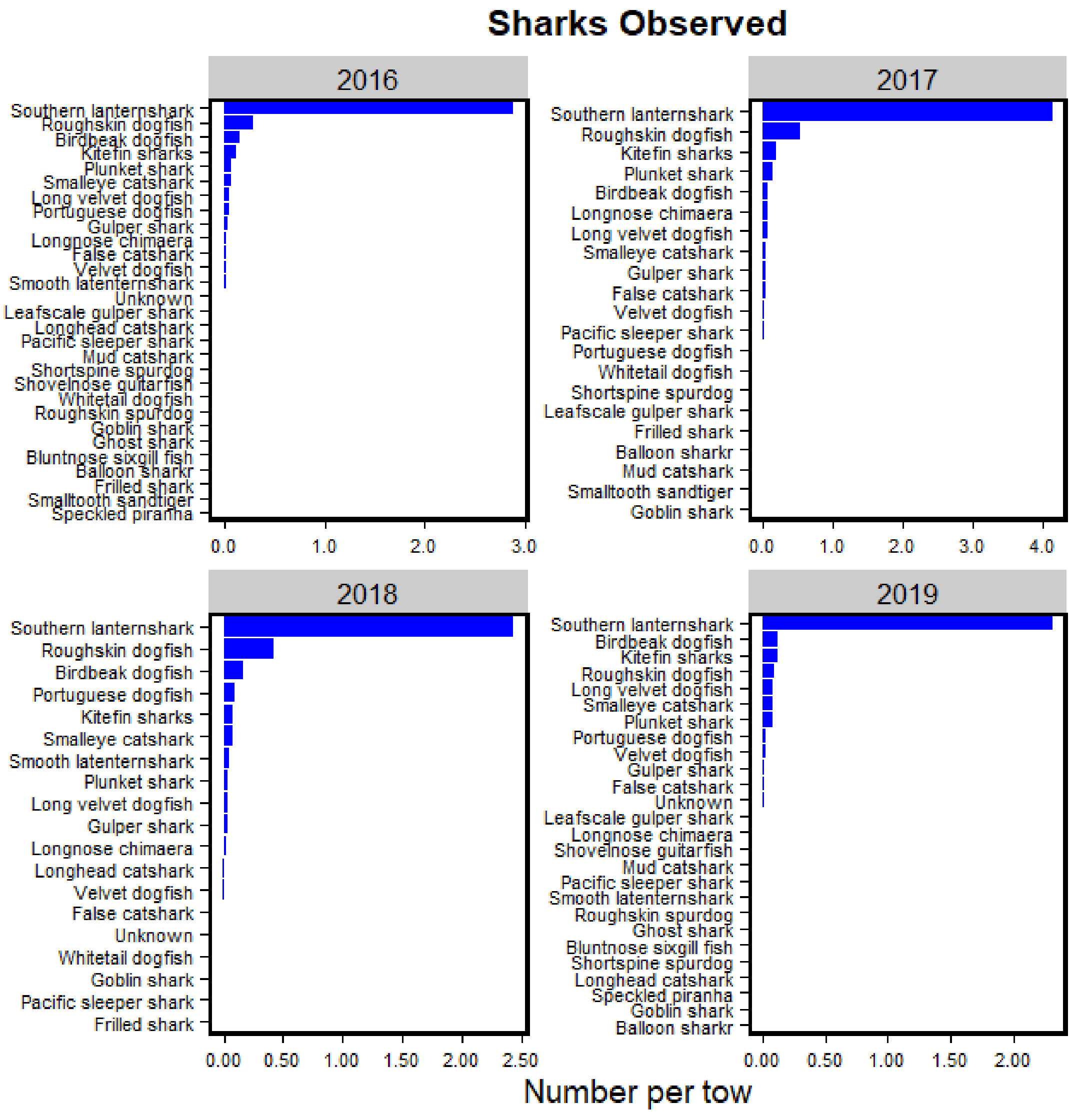

Figure 15: Sharks observed in the Cook Islands catch from 2016-2019.

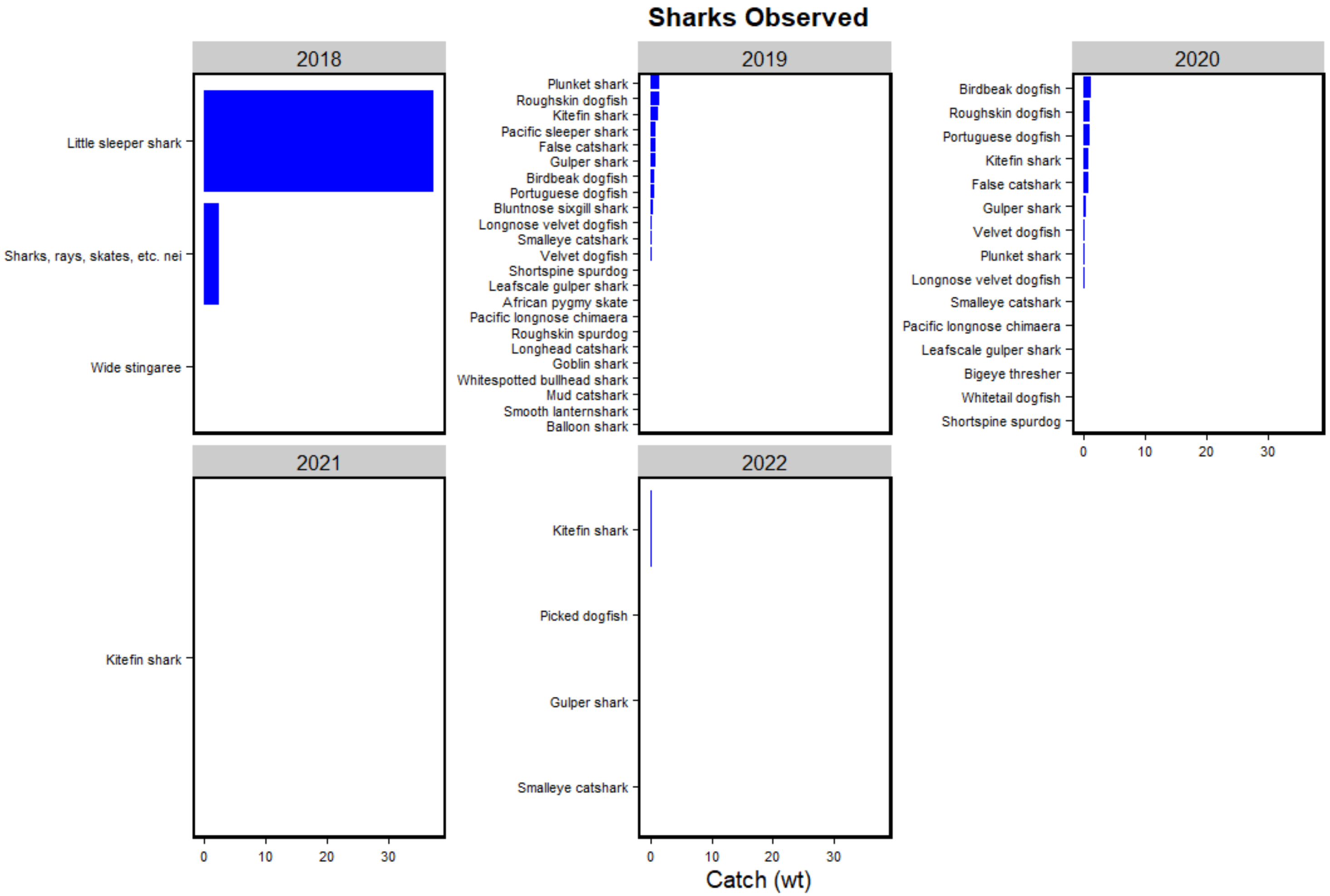

Figure 16: The observed shark catch in the Cook Islands SIOFA catch from 2019-2022.

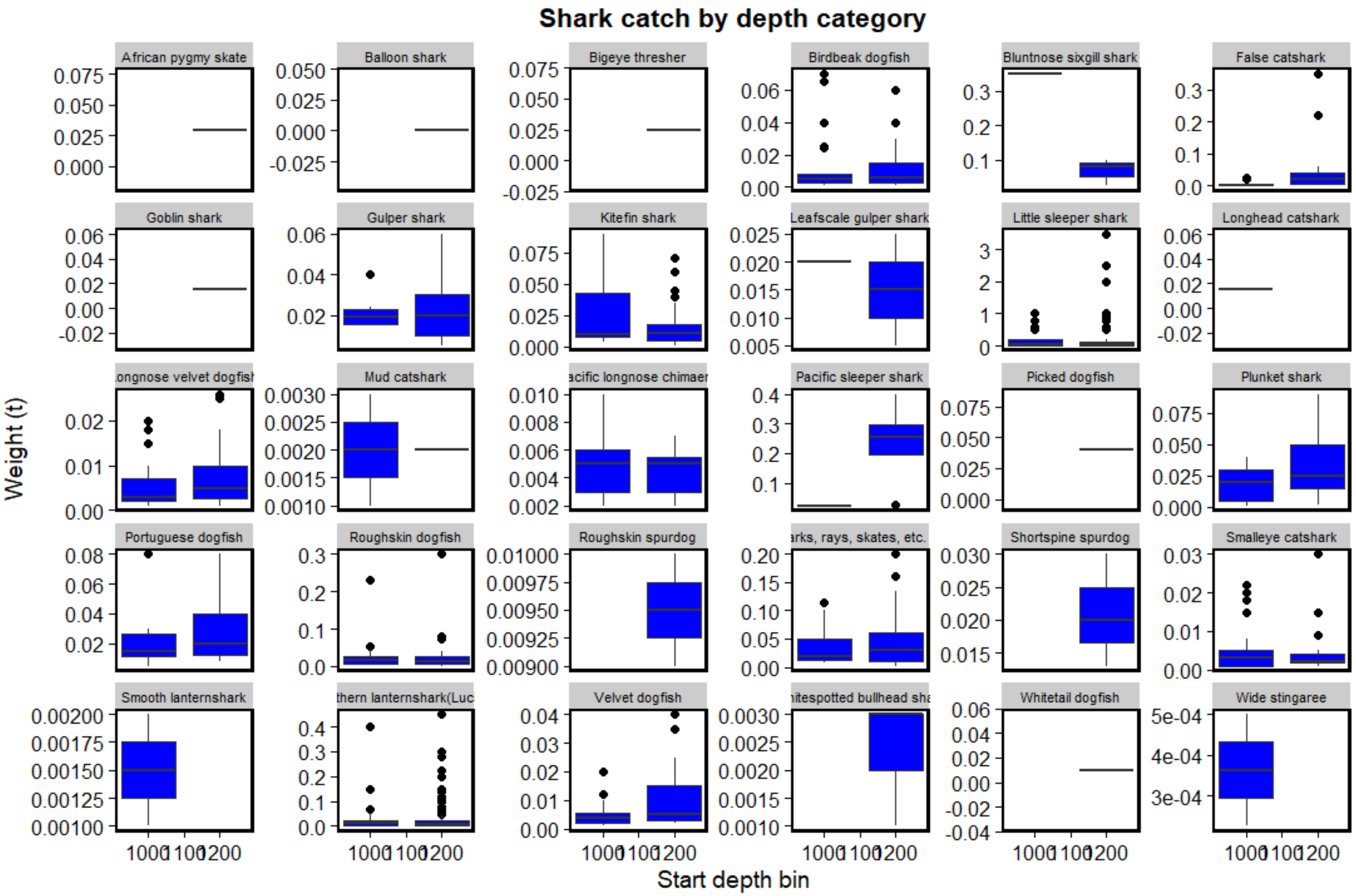

Figure 17: The observed shark catch by depth category in the Cook Islands SIOFA catch from 2019-2022.

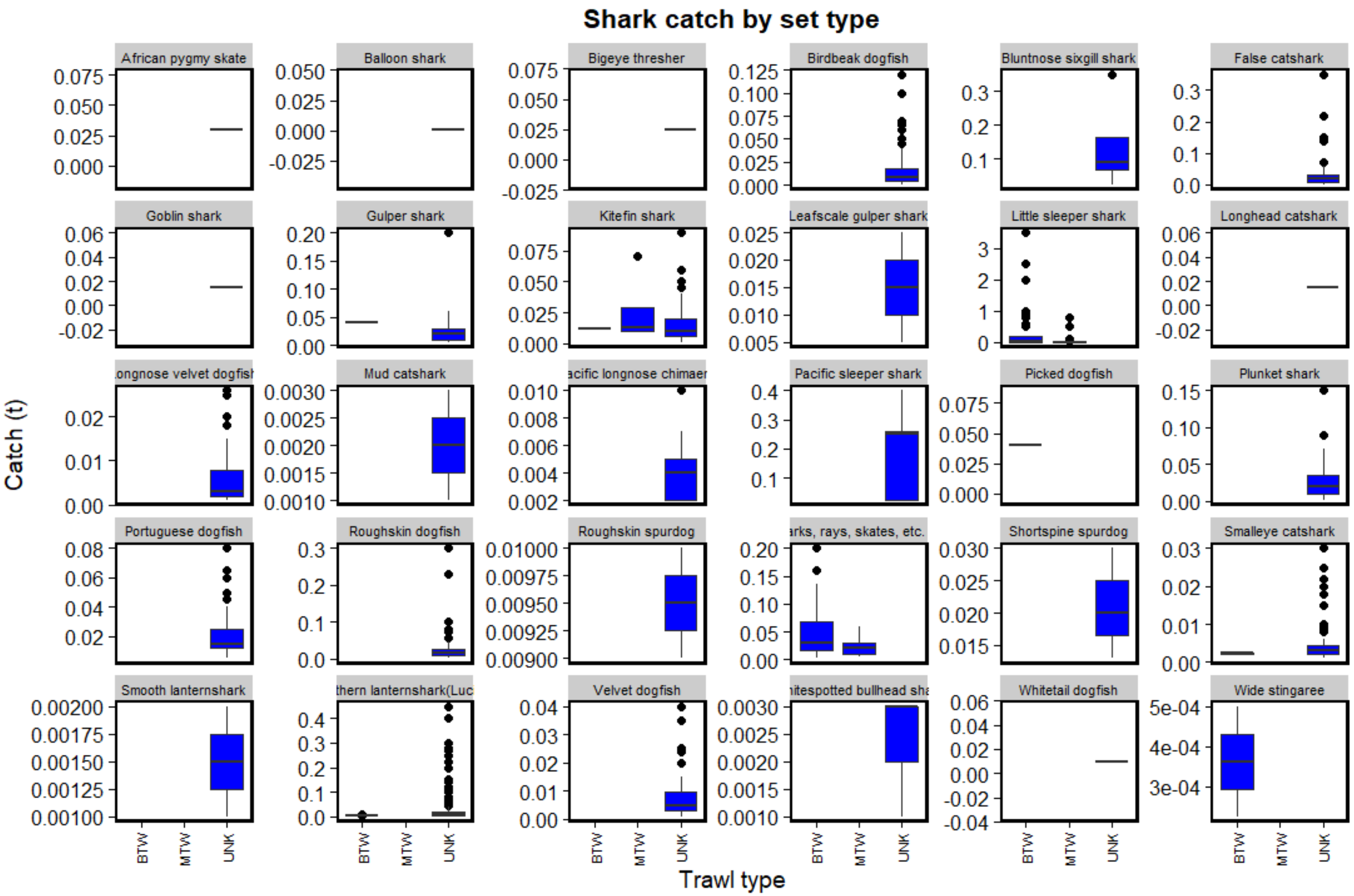

Figure 18: The observed shark catch by gear type in the Cook Islands SIOFA catch from 2019-2022.

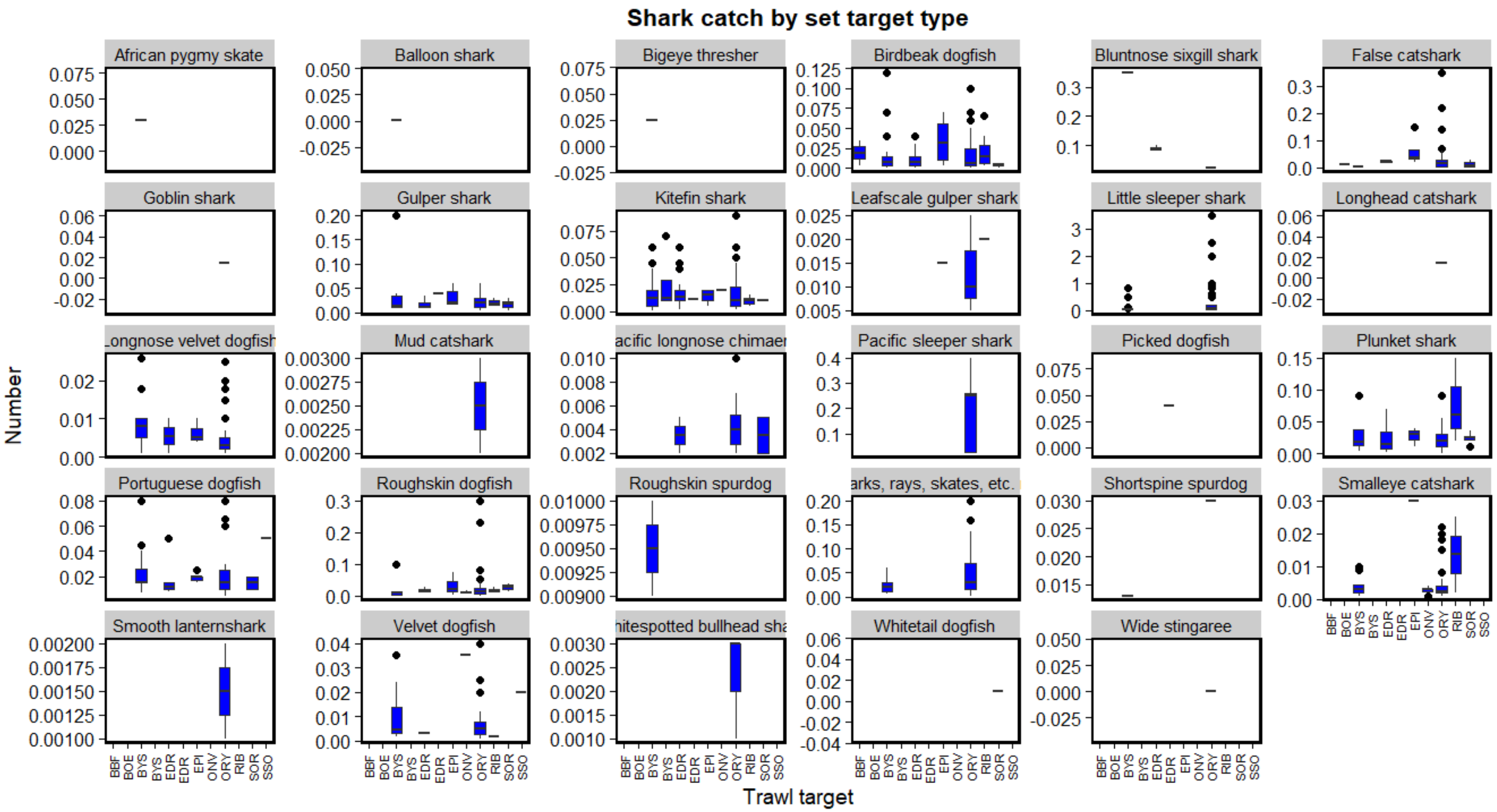

Figure 19: The observed shark catch by set target in the Cook Islands SIOFA catch from 2019-2022.

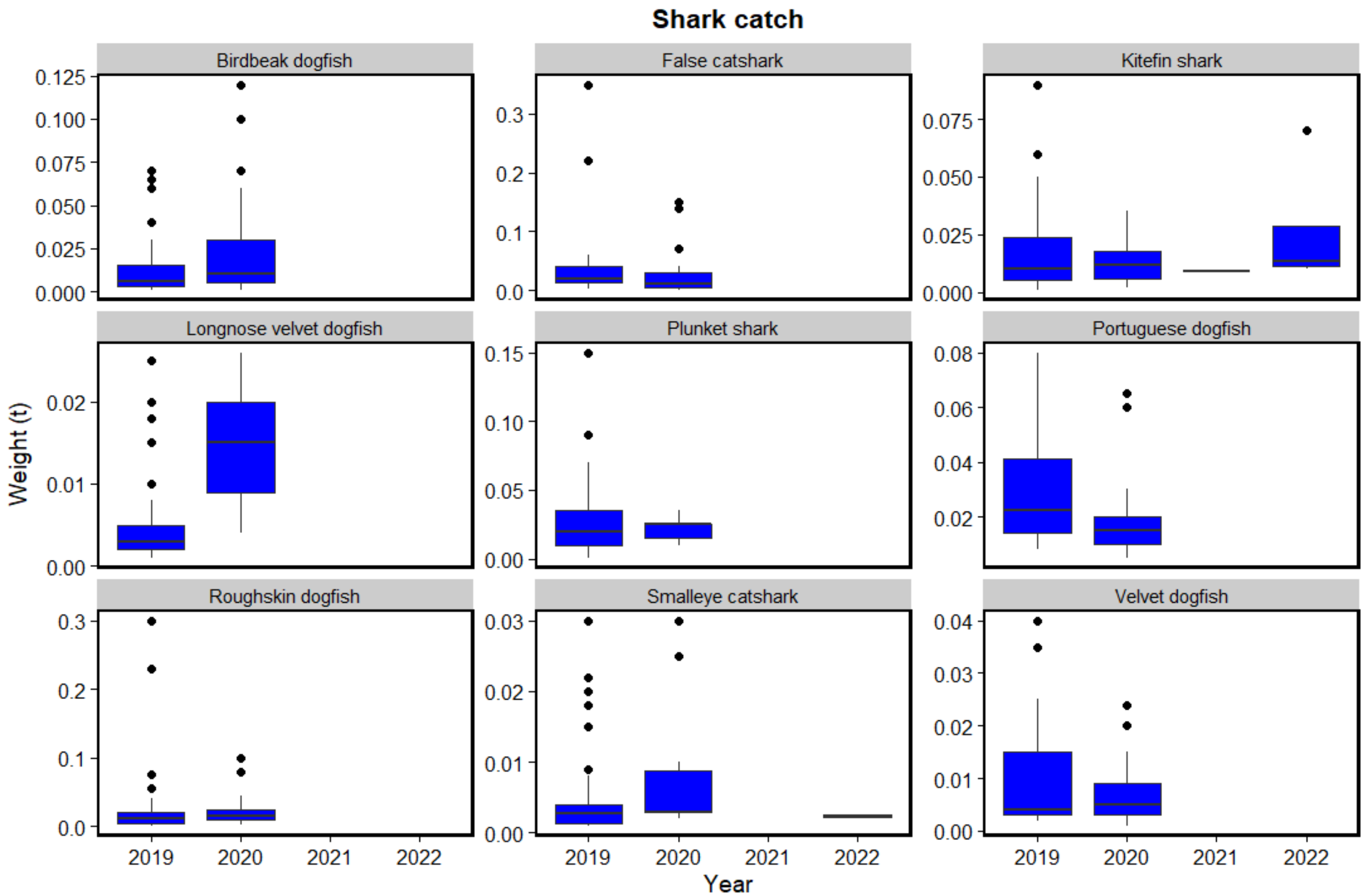

Figure 20: The observed shark catch by year in the Cook Islands SIOFA catch from 2019-2022.

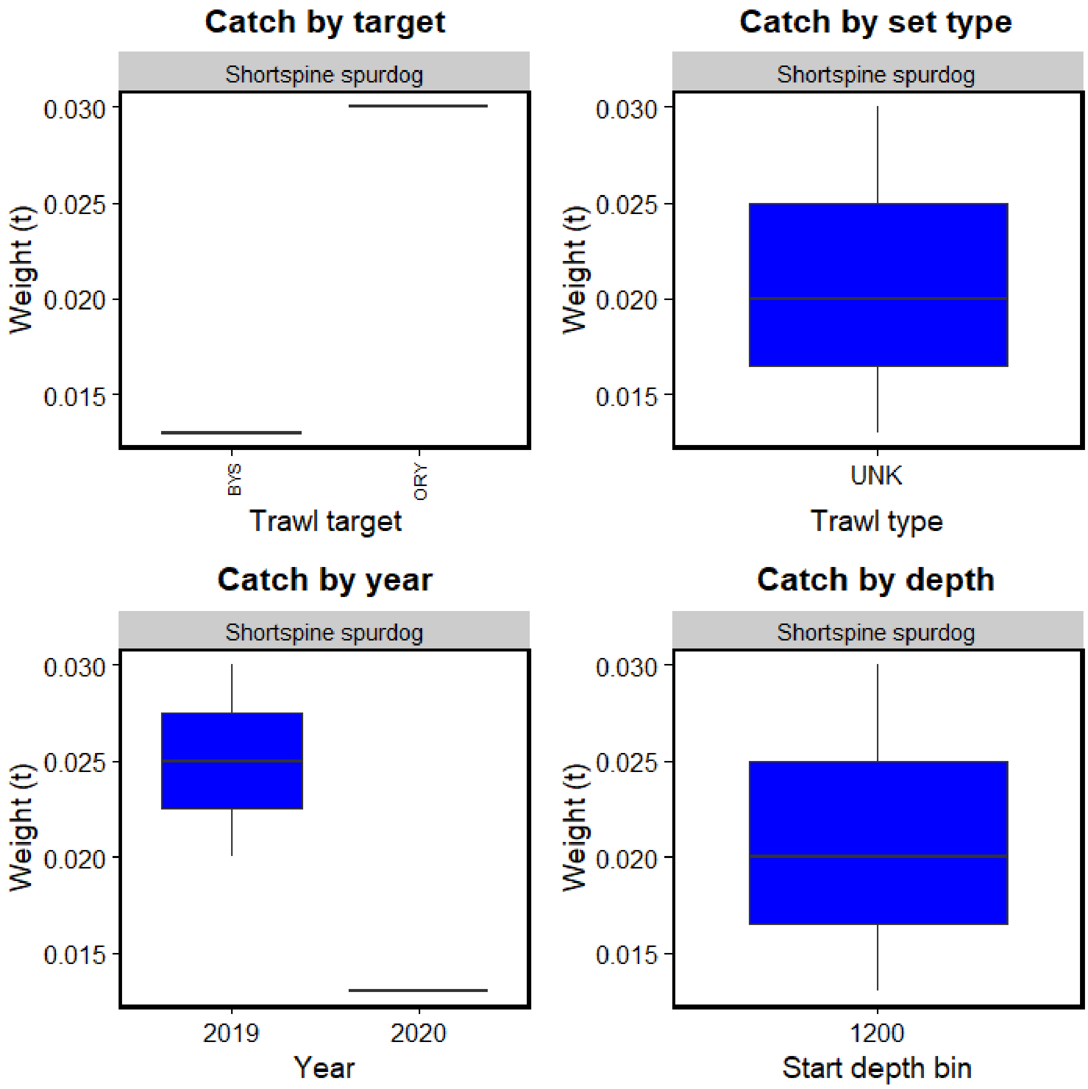

Figure 21: The observed shark catch of short spine spurdog by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

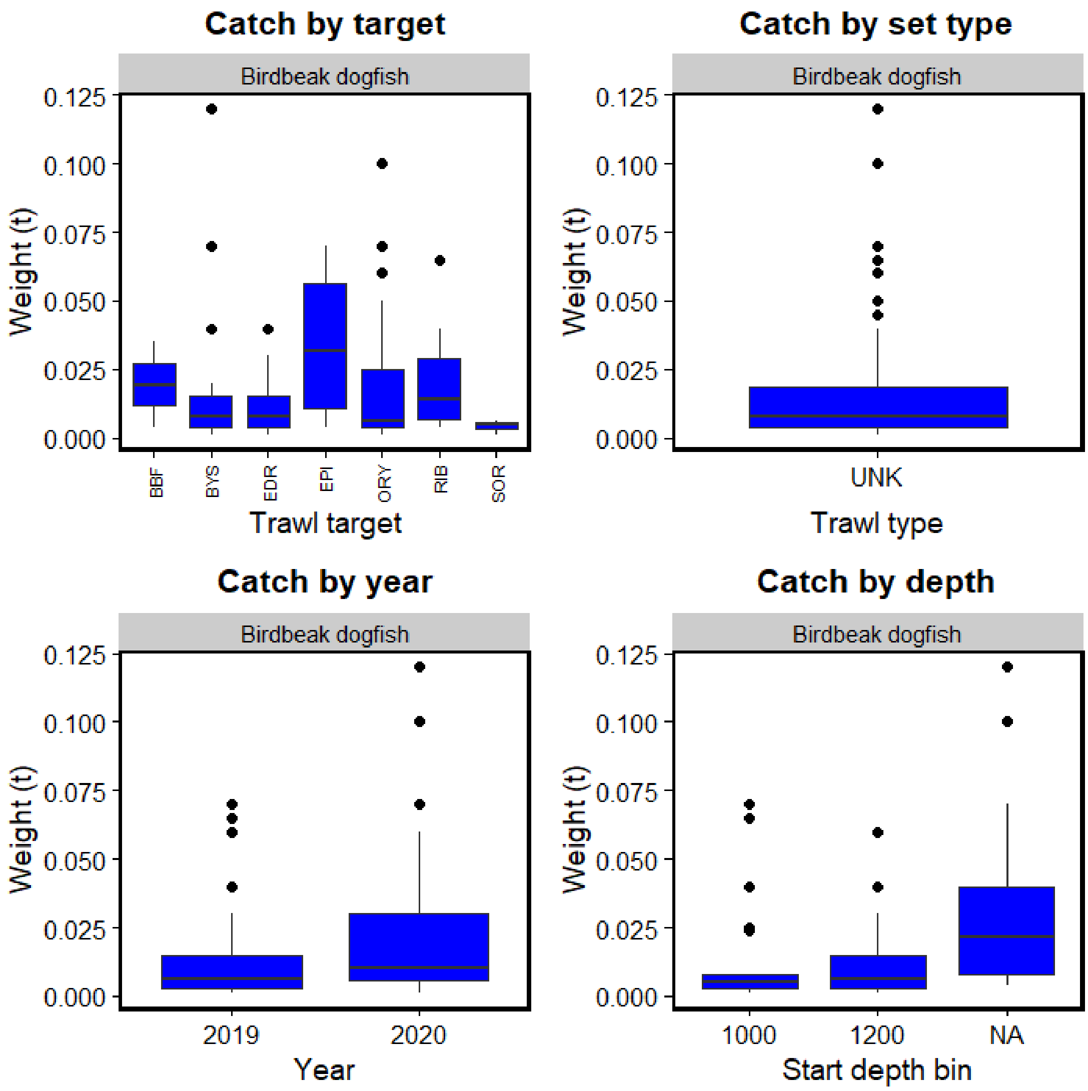

Figure 22: The observed shark catch of birdbeak dogfish by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

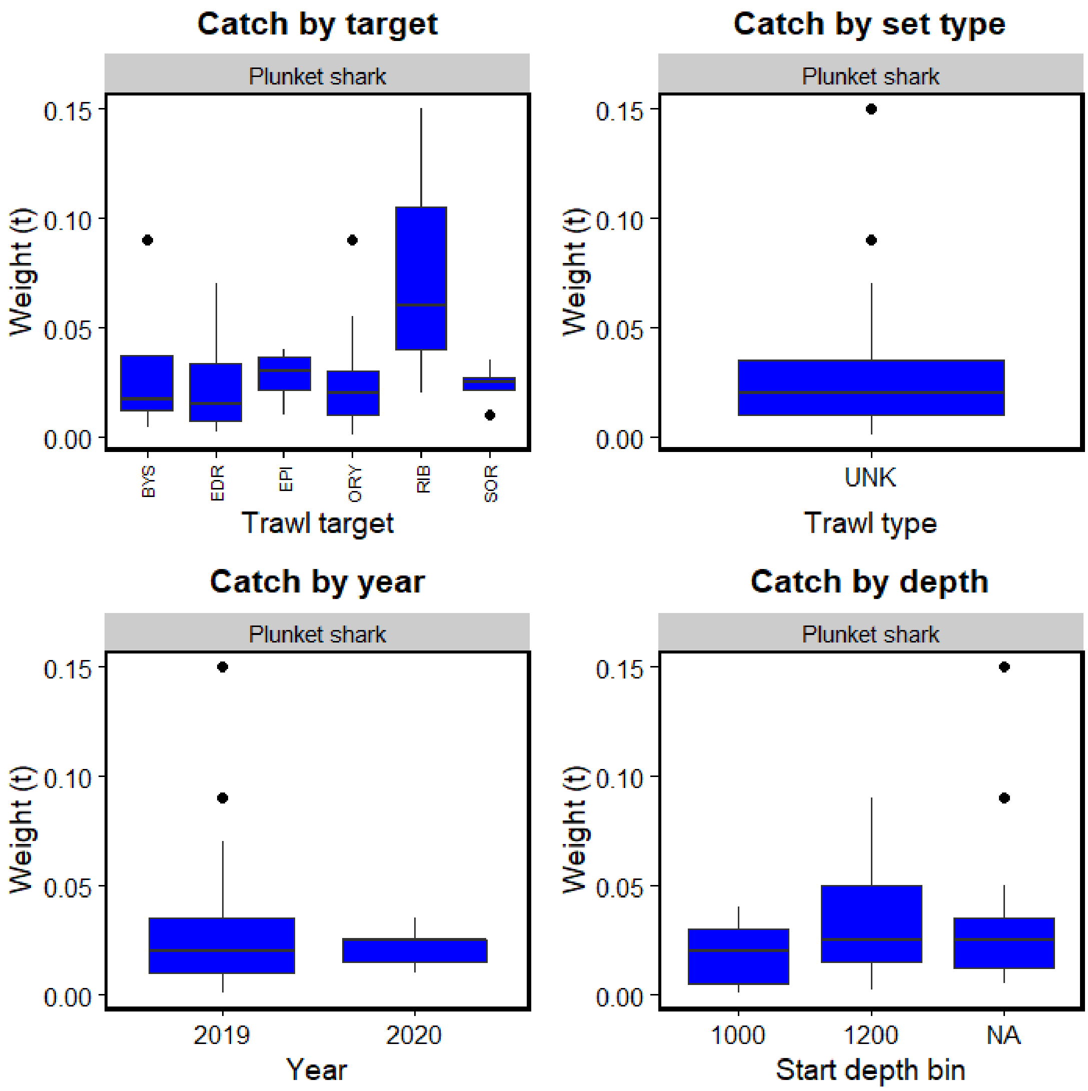

Figure 23: The observed shark catch of plunket shark by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

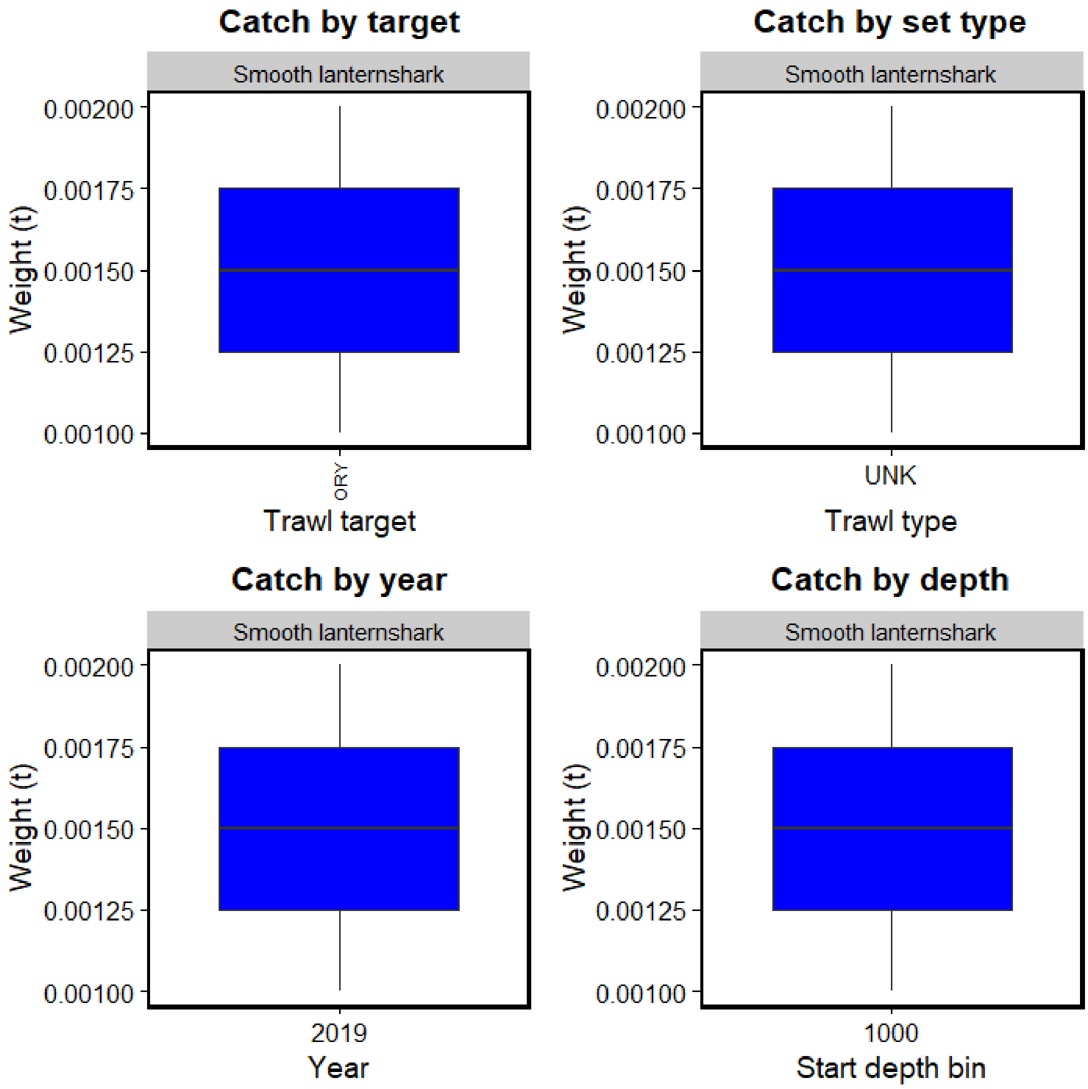

Figure 24: The observed shark catch of smooth lanternshark by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

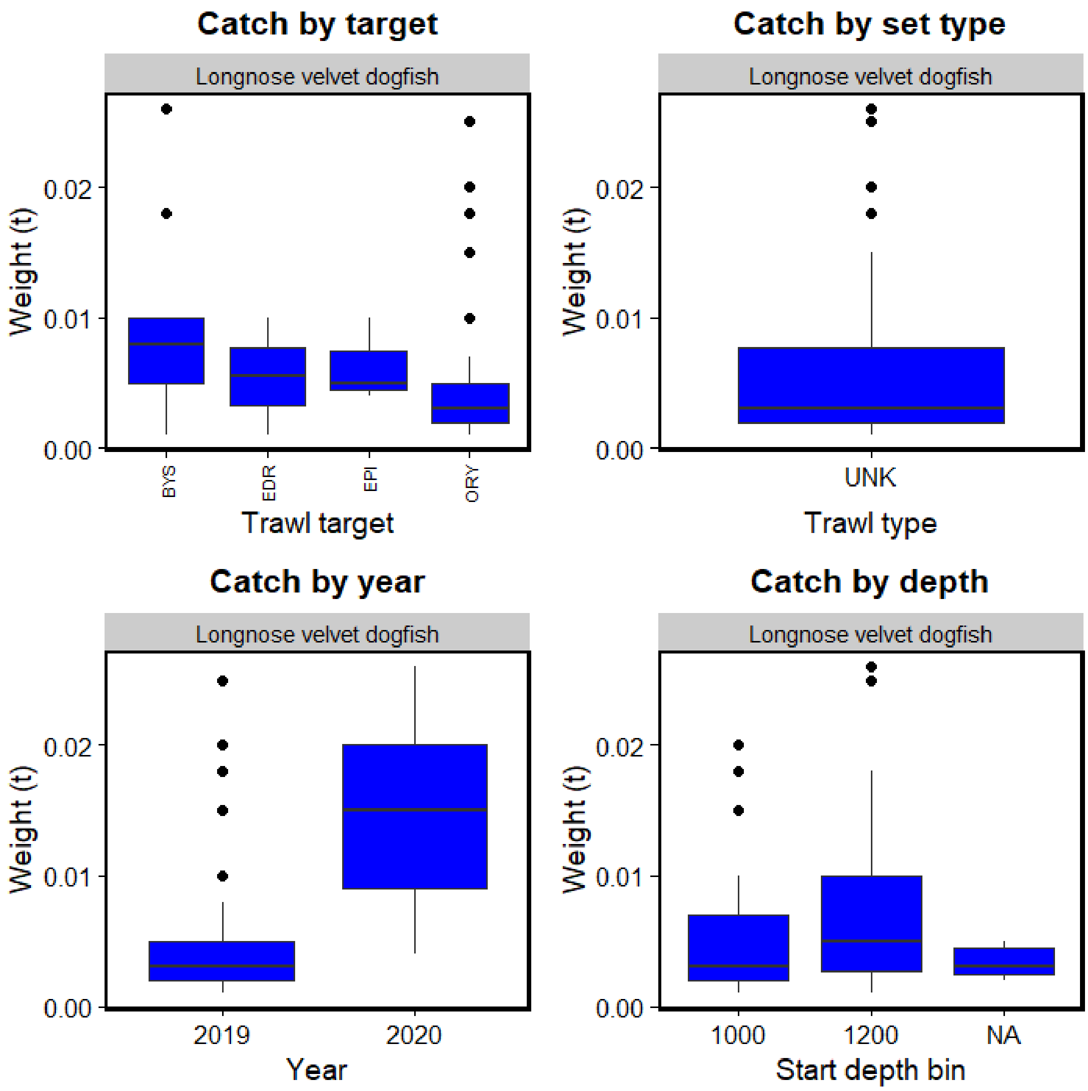

Figure 25: The observed shark catch of longnose velvet dogfish by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

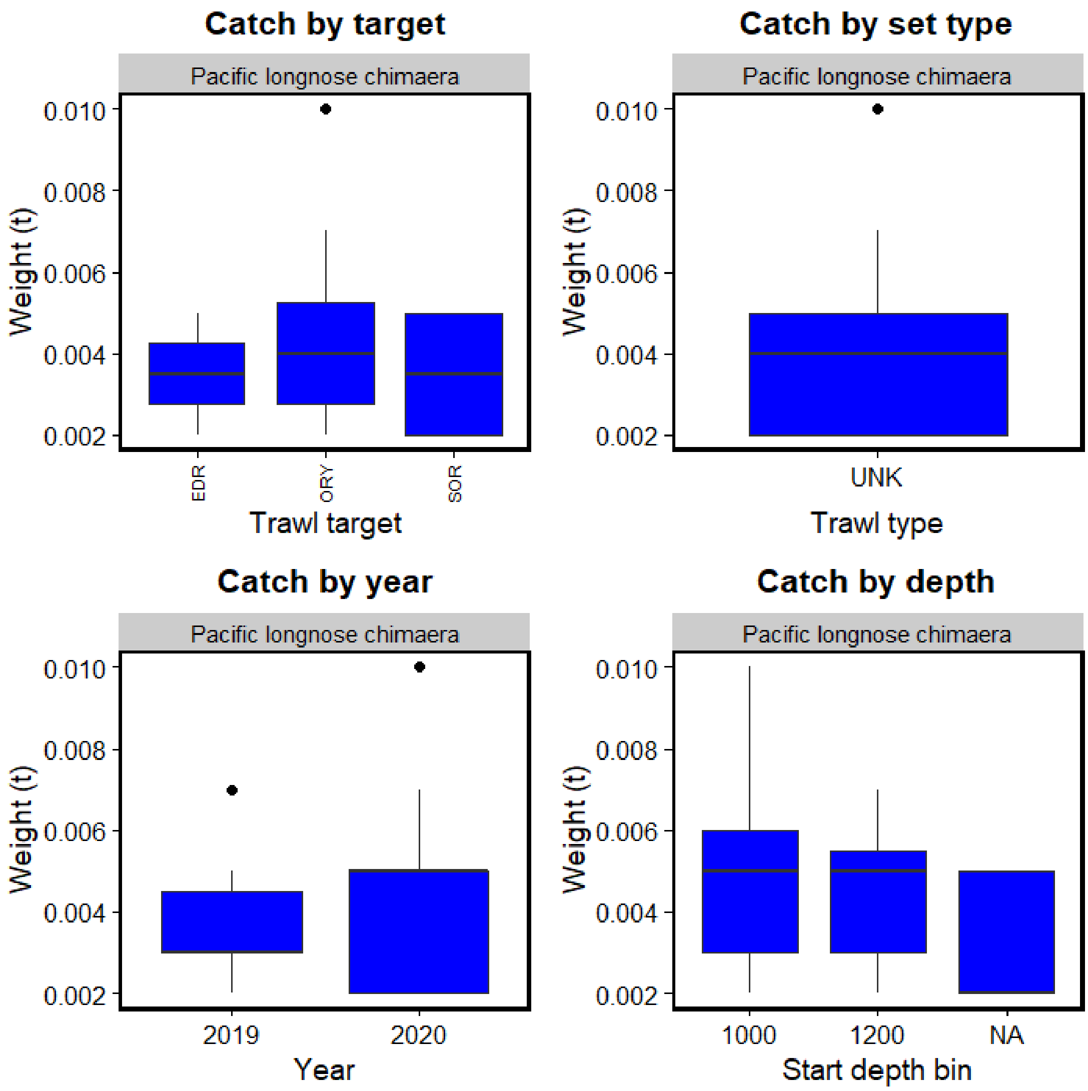

Figure 26: The observed shark catch of Pacific longnose chimera by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

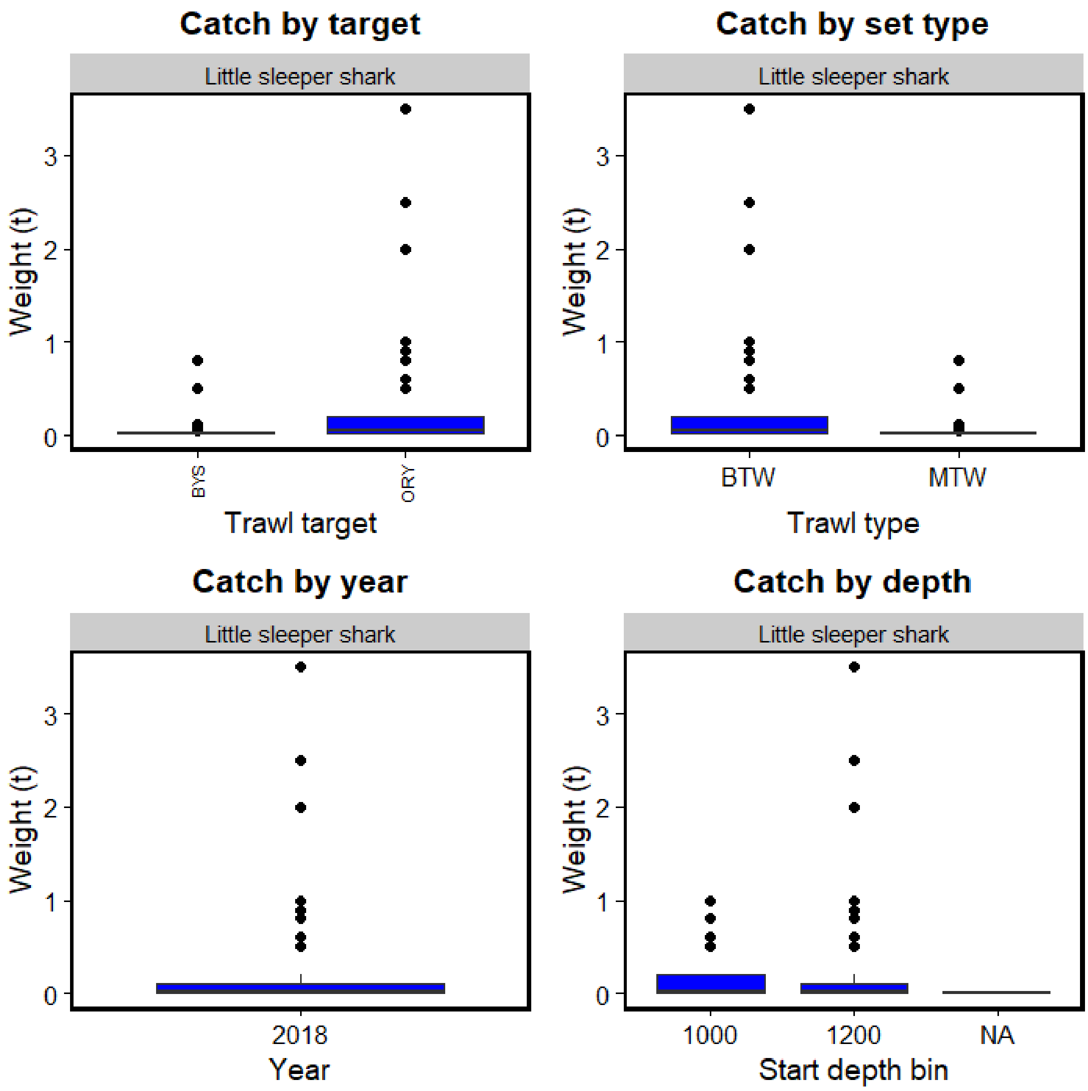

Figure 27: The observed shark catch of little sleeper shark by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

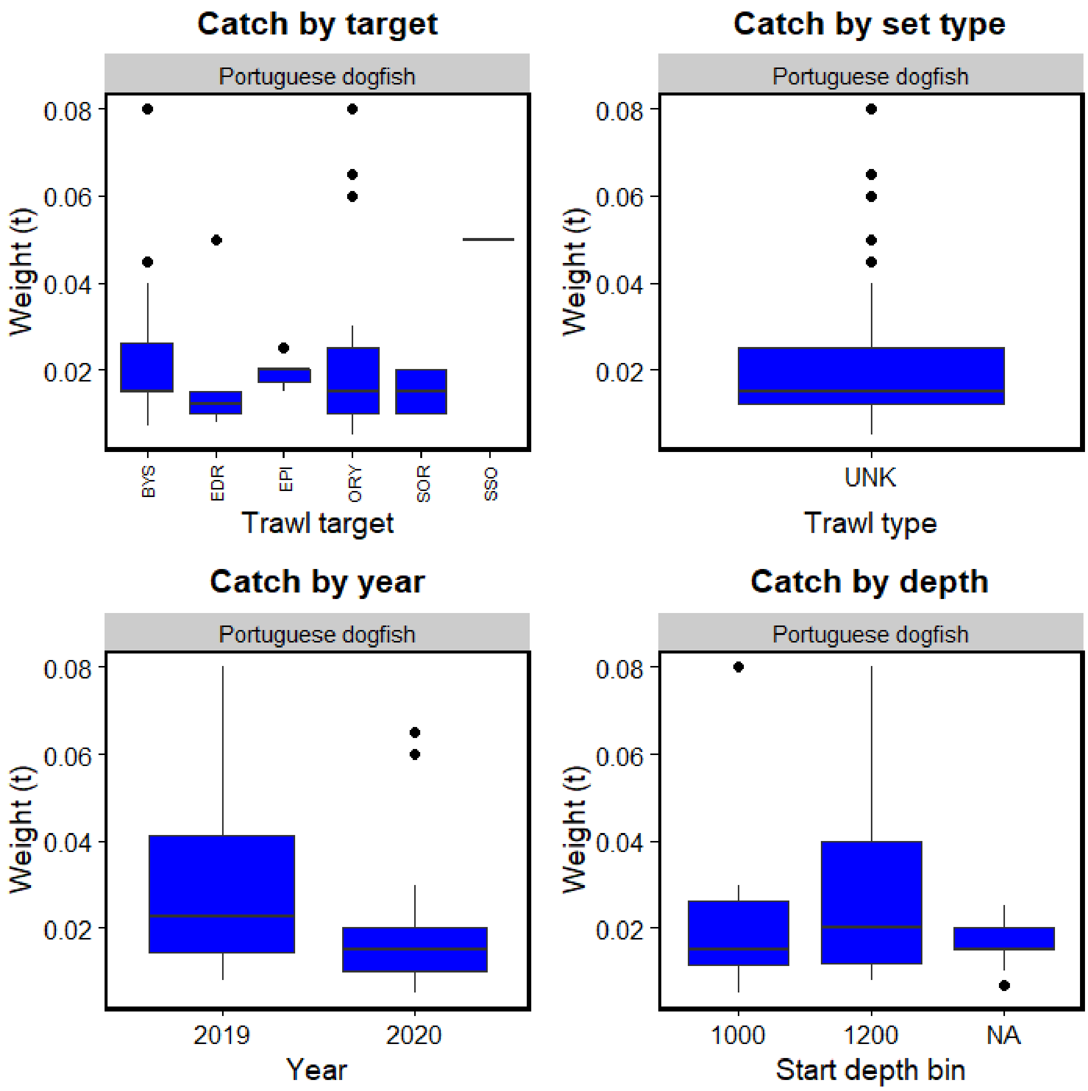

Figure 28: The observed shark catch of Portuguese dogfish by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

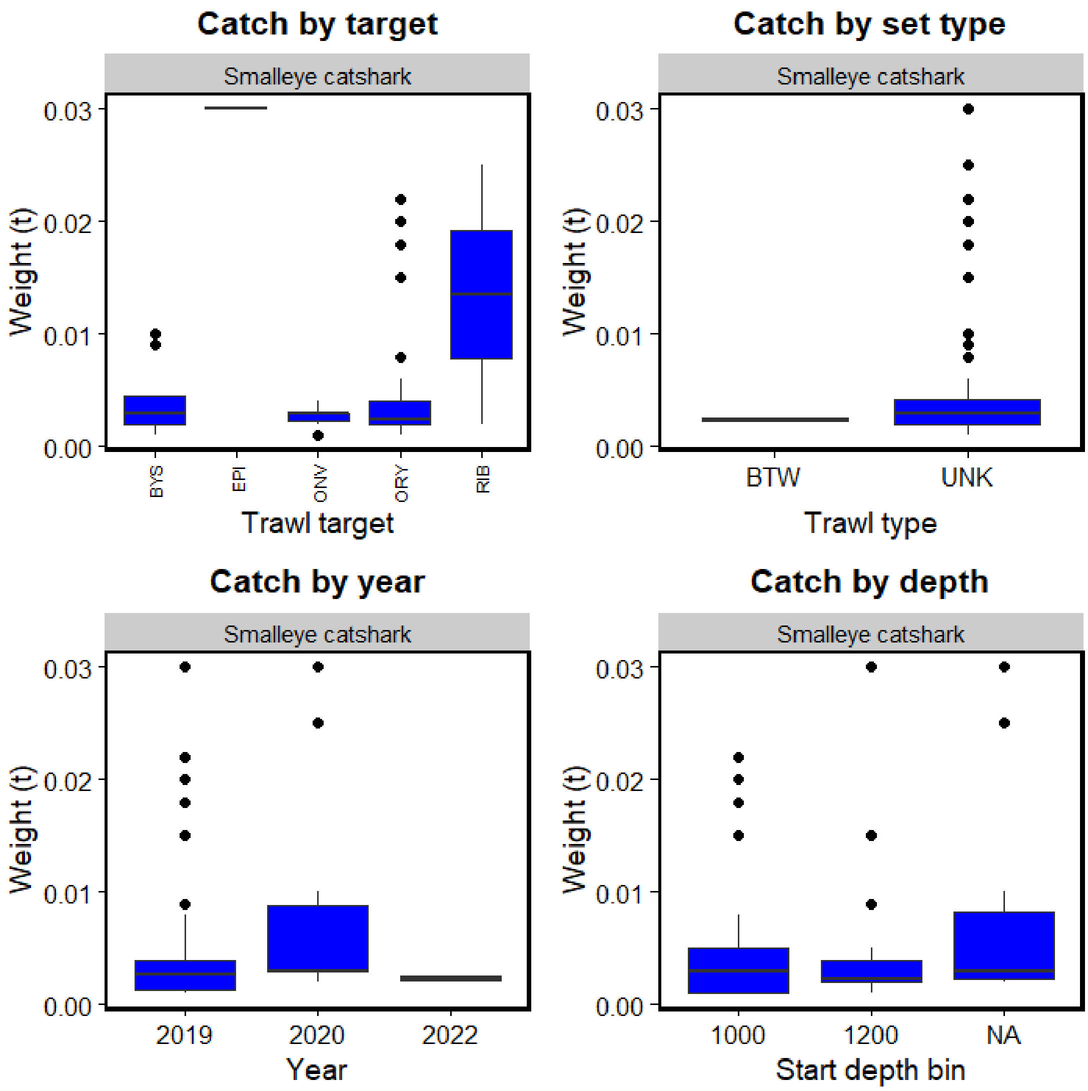

Figure 29: The observed shark catch of smalleye catchshark by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

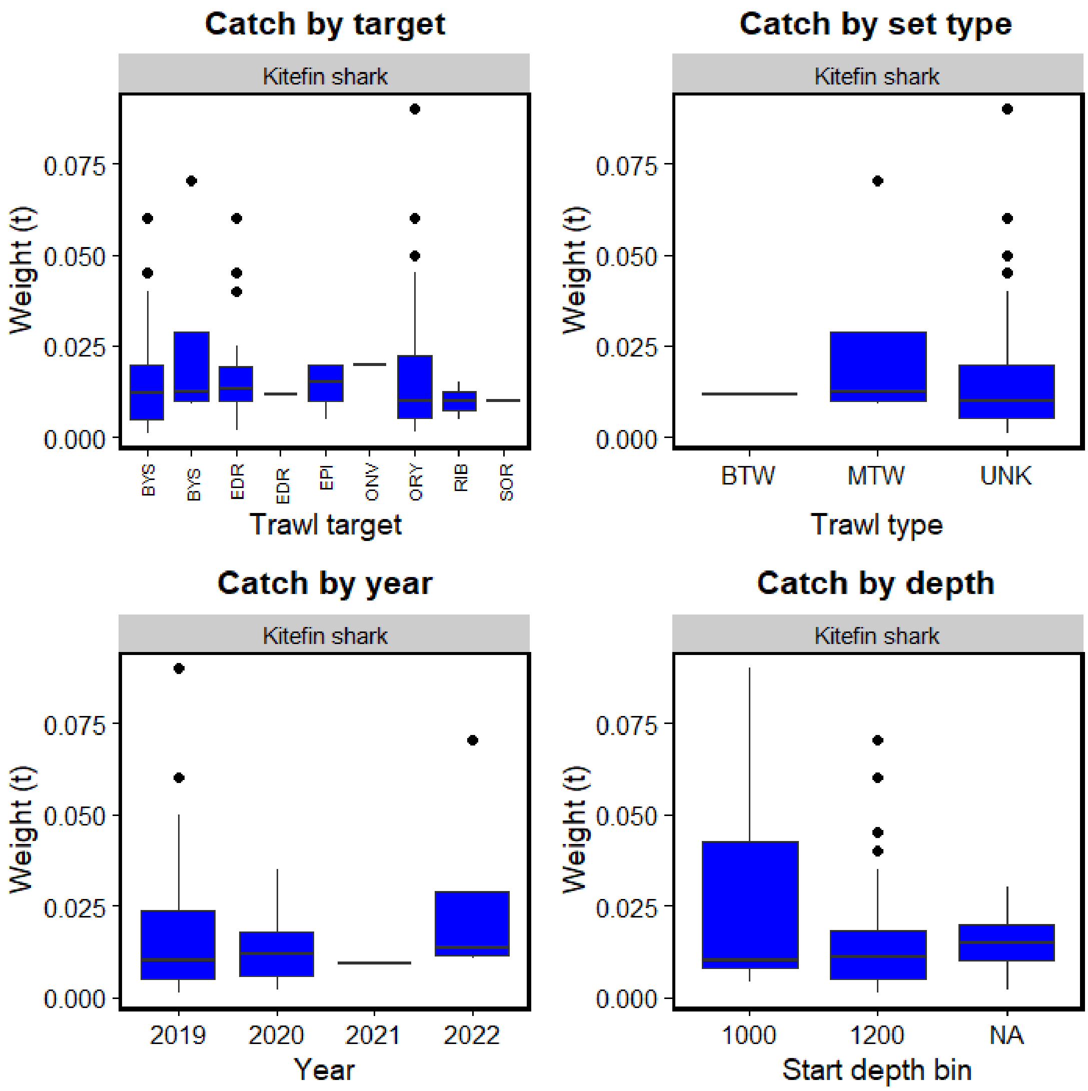

Figure 30: The observed shark catch of kitefin shark by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

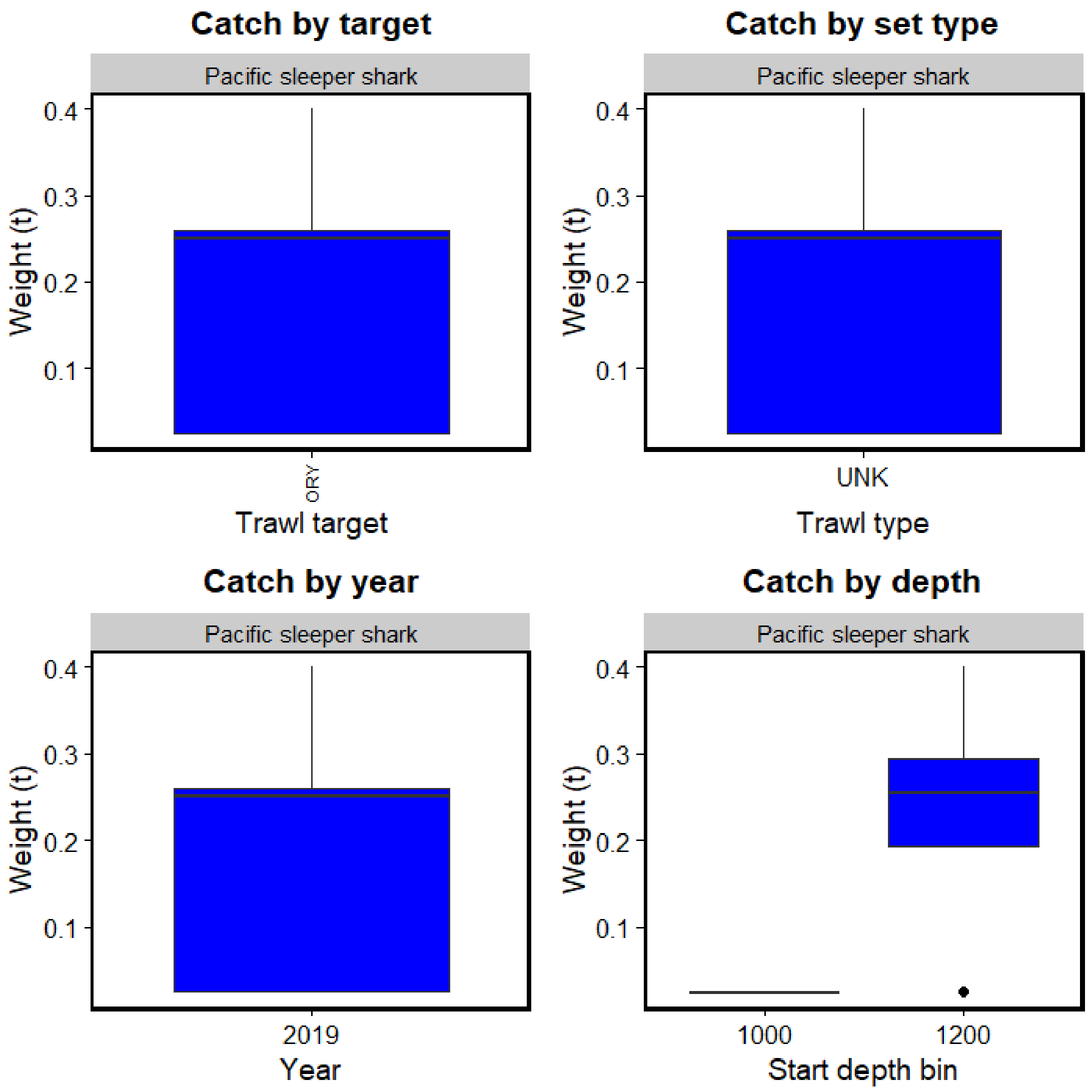

Figure 31: The observed shark catch of Pacific sleeper shark by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

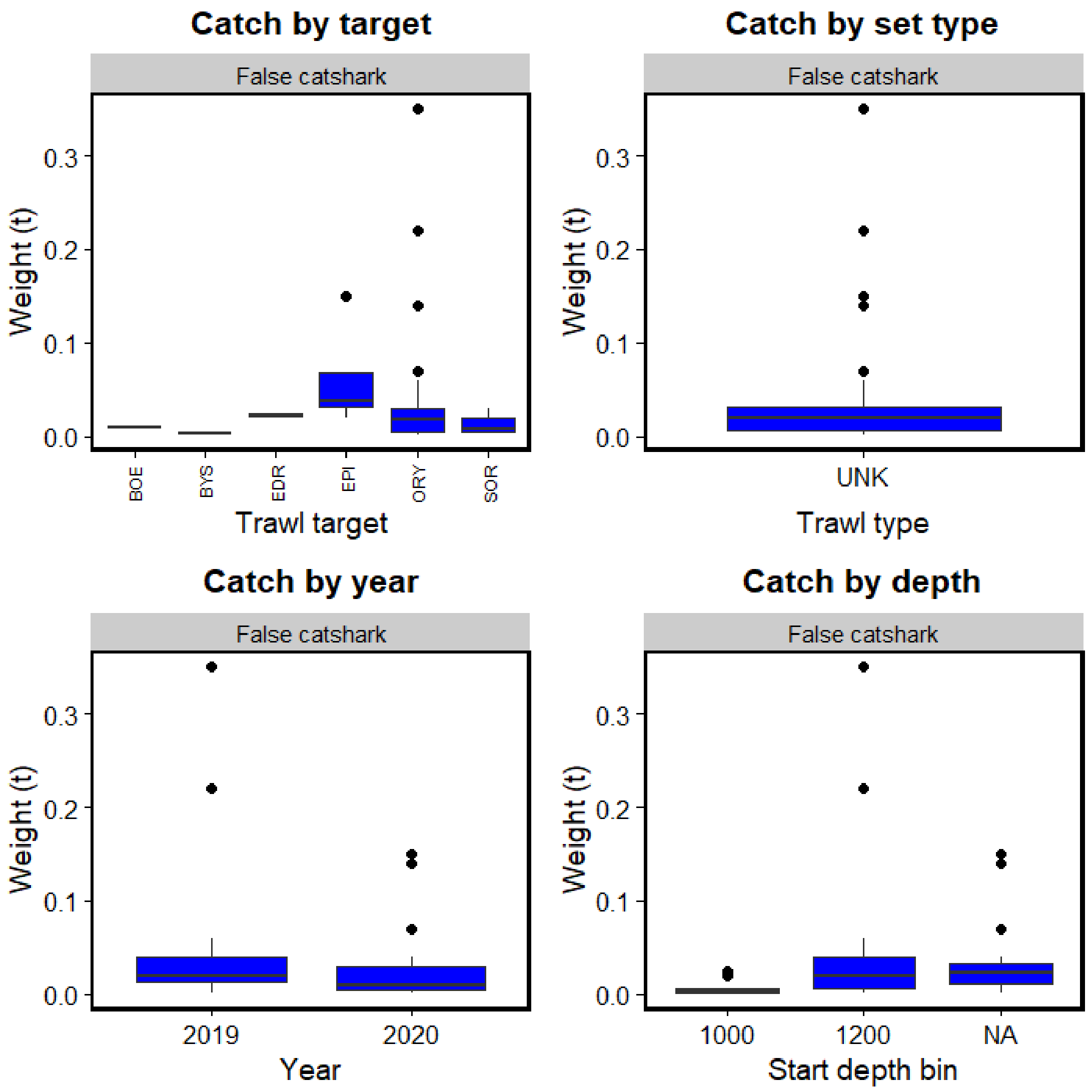

Figure 32: The observed shark catch of false catshark by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

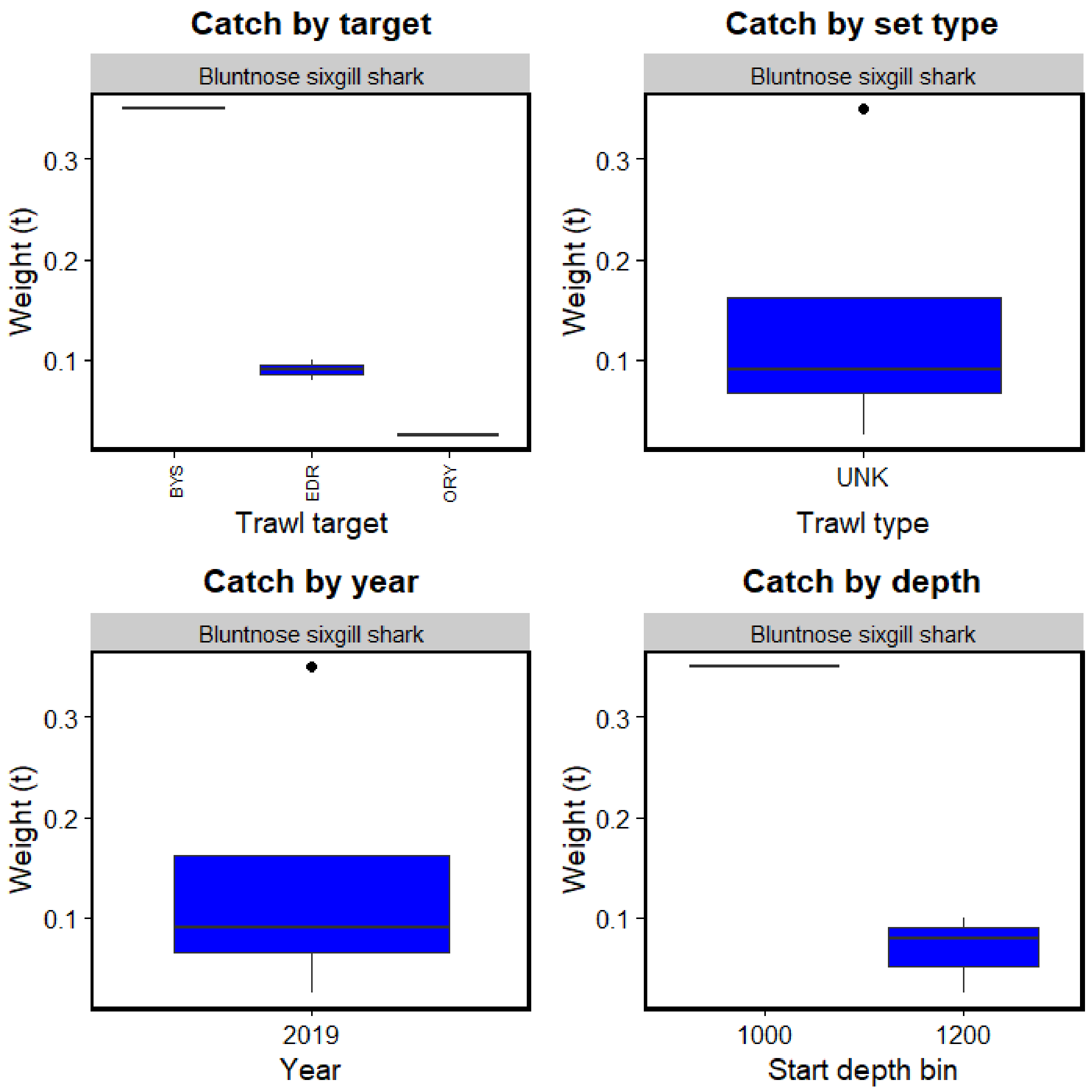

Figure 33: The observed shark catch of bluntnose sixgillshark by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

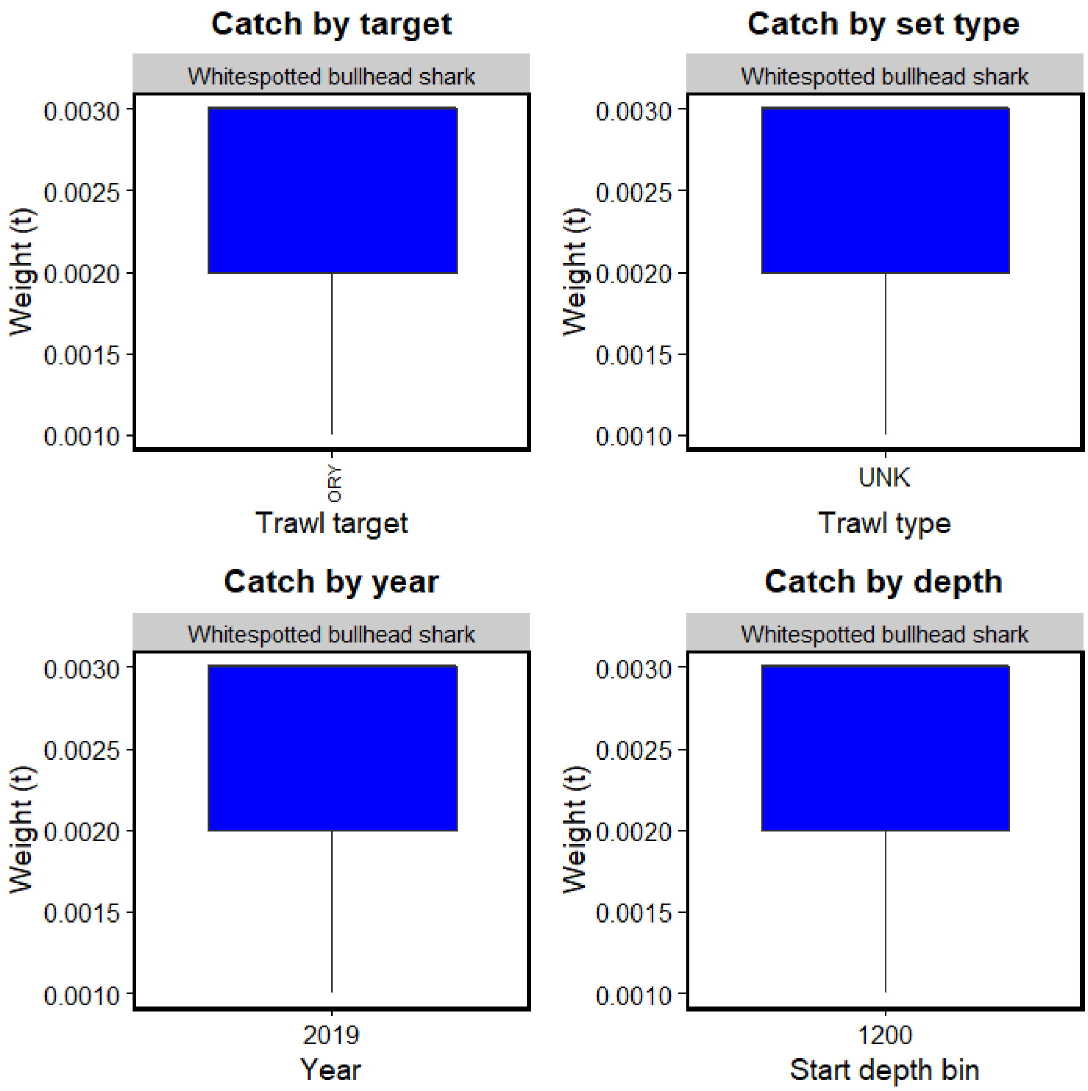

Figure 34: The observed shark catch of whitespotted bullhead shark by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

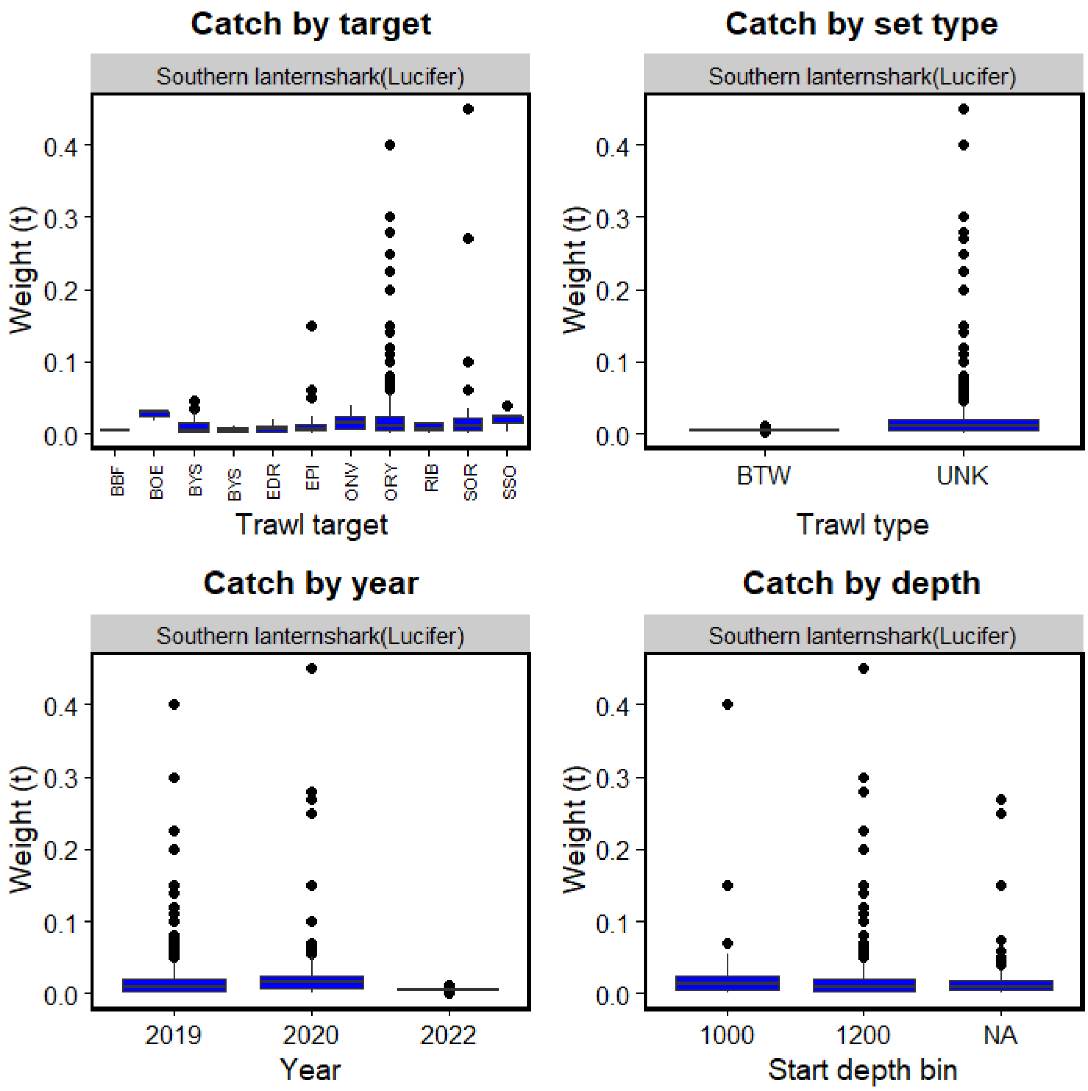

Figure 35: The observed shark catch of southern lantern shark by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

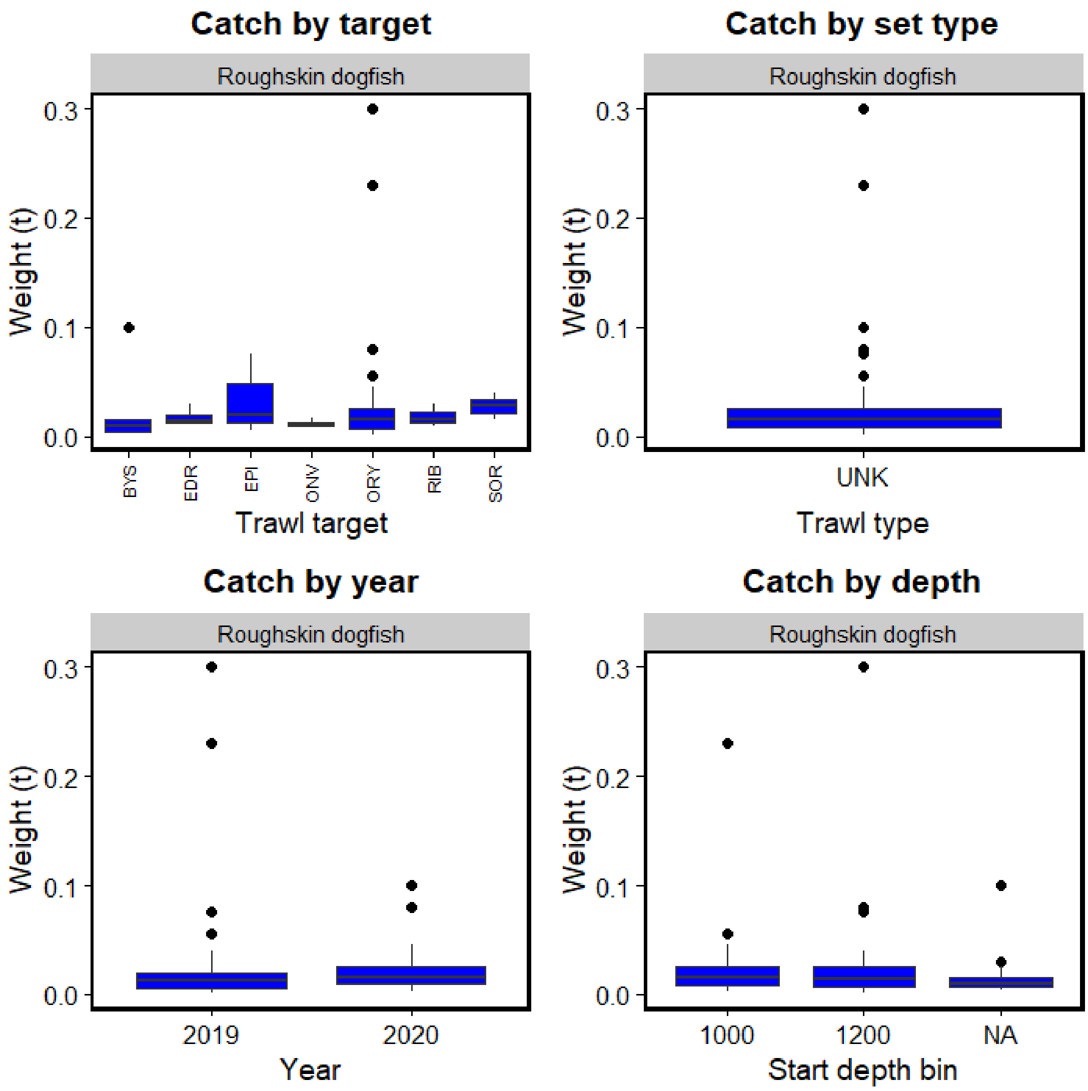

Figure 36: The observed shark catch of roughskin dogfish by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

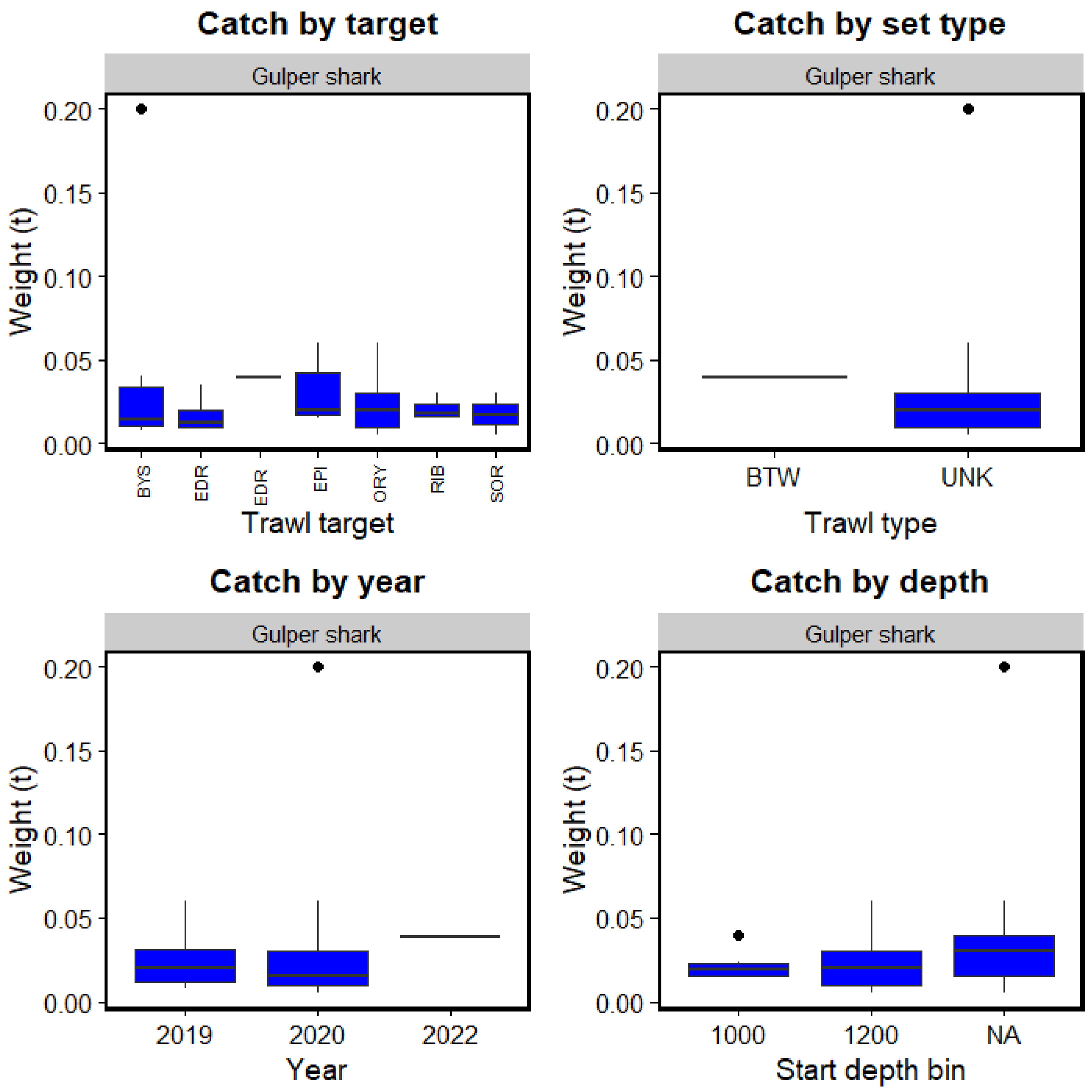

Figure 37: The observed shark catch of gulper shark by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

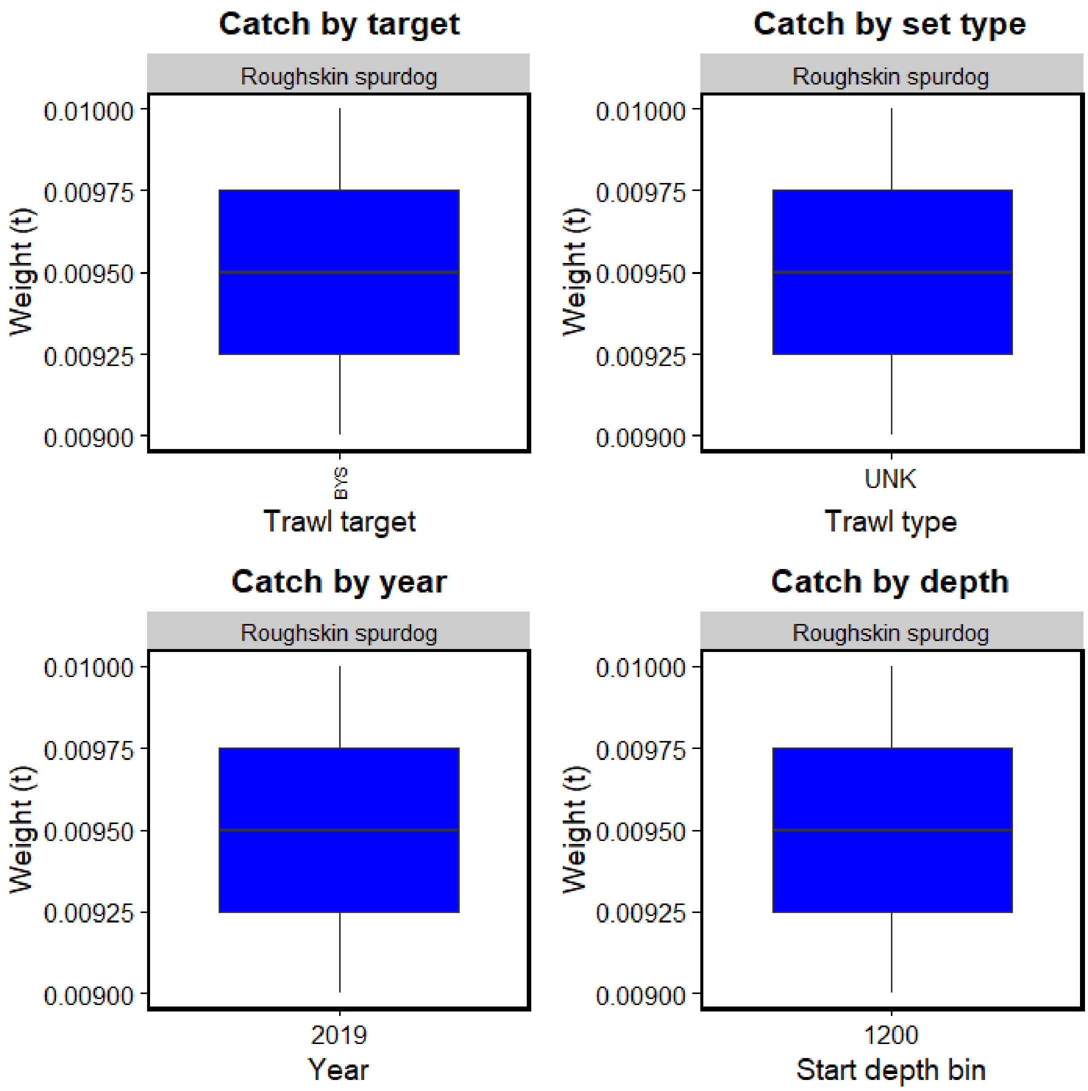

Figure 38: The observed shark catch of roughskin spurdog by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

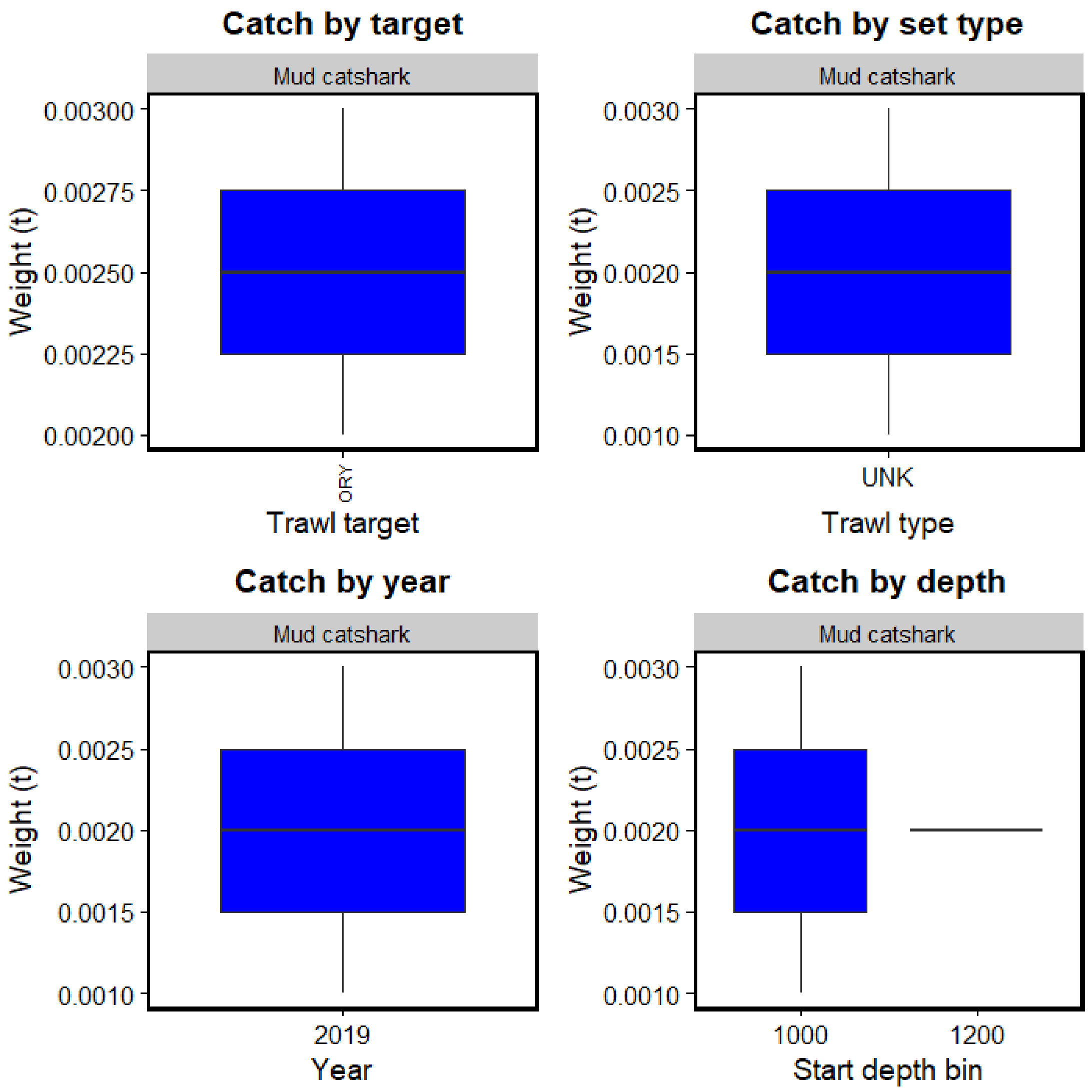

Figure 39: The observed shark catch of mud catshark by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

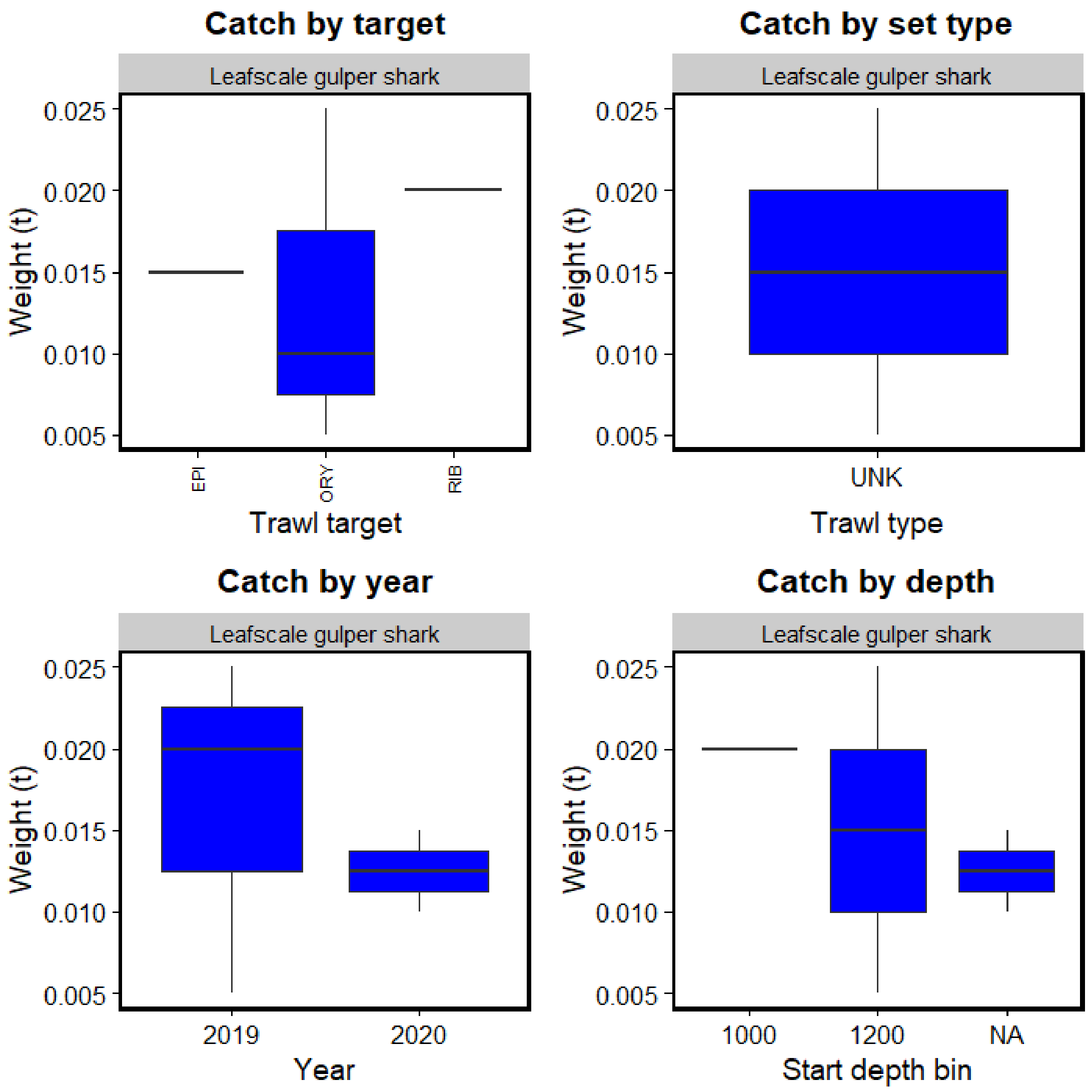

Figure 40: The observed shark catch of leafscale gulper shark by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

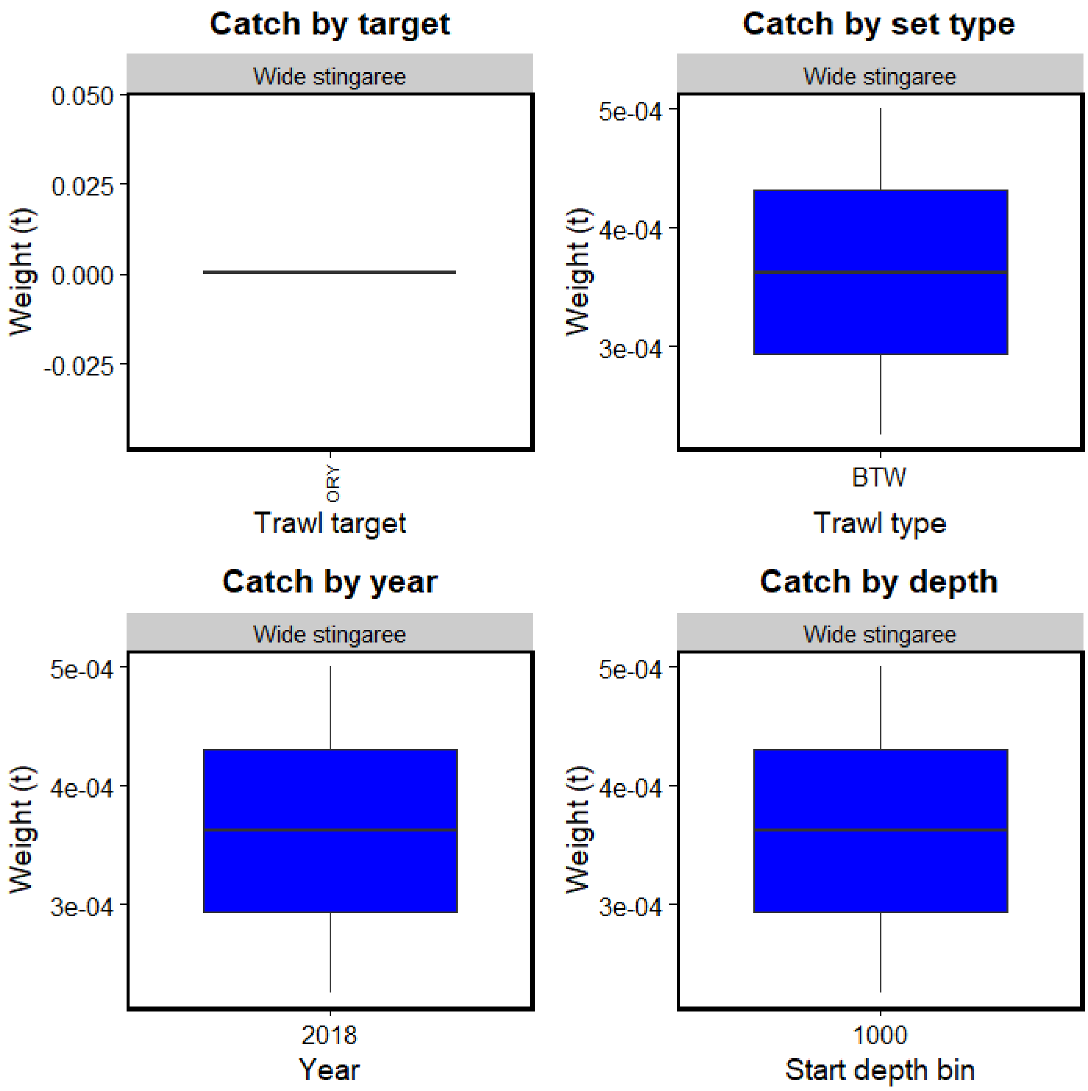

Figure 41: The observed shark catch of wide stingray by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

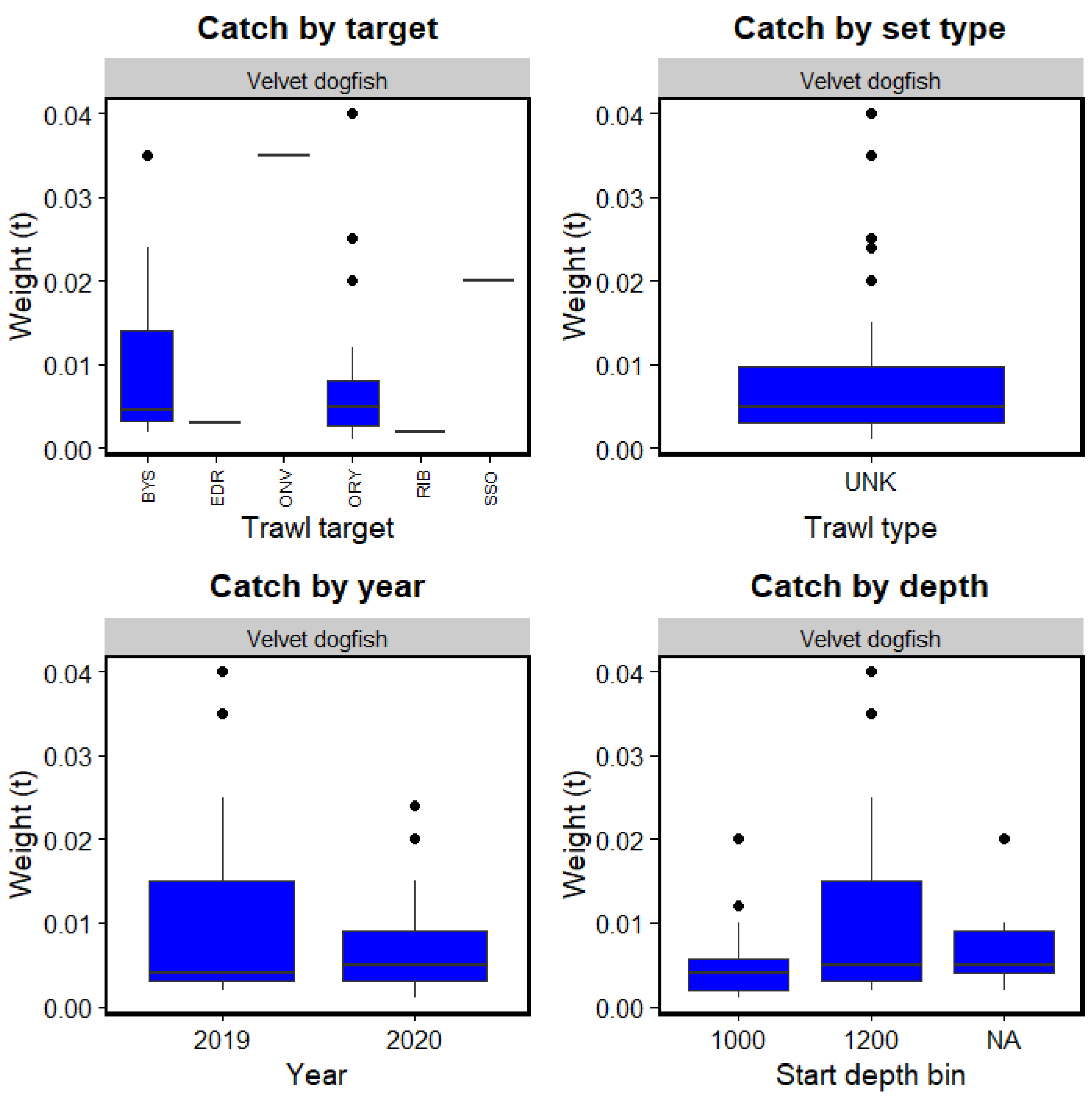

Figure 42: The observed shark catch of wide stingray by set target, trawl type, year and depth category in the Cook Islands SIOFA fishery from 2019-2022.

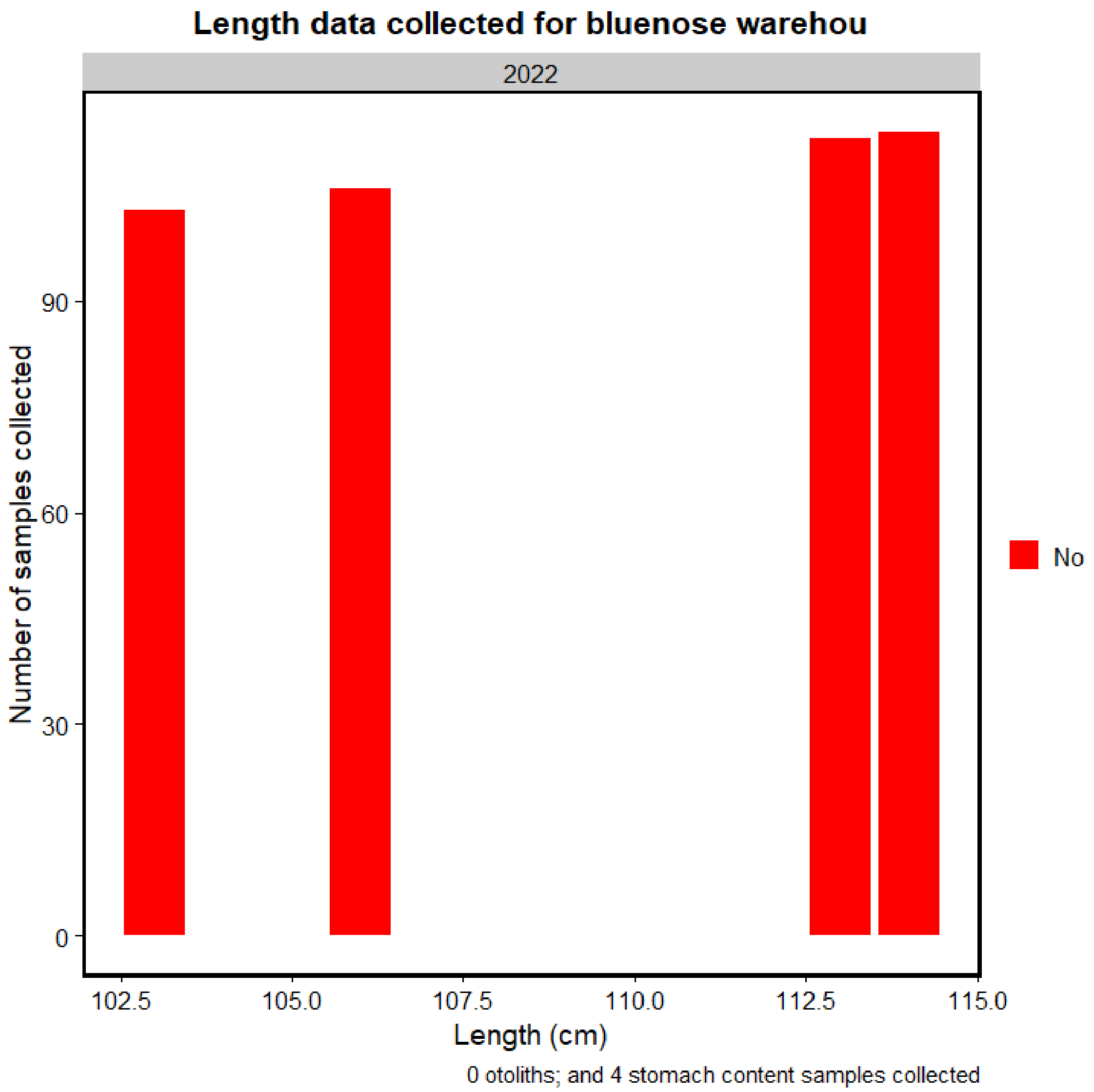

Figure 43: The length frequency sampling, otolith collection and stomach sampling collection from bluenose warehou in the Cook Islands SIOFA fishery from 2019-2022.

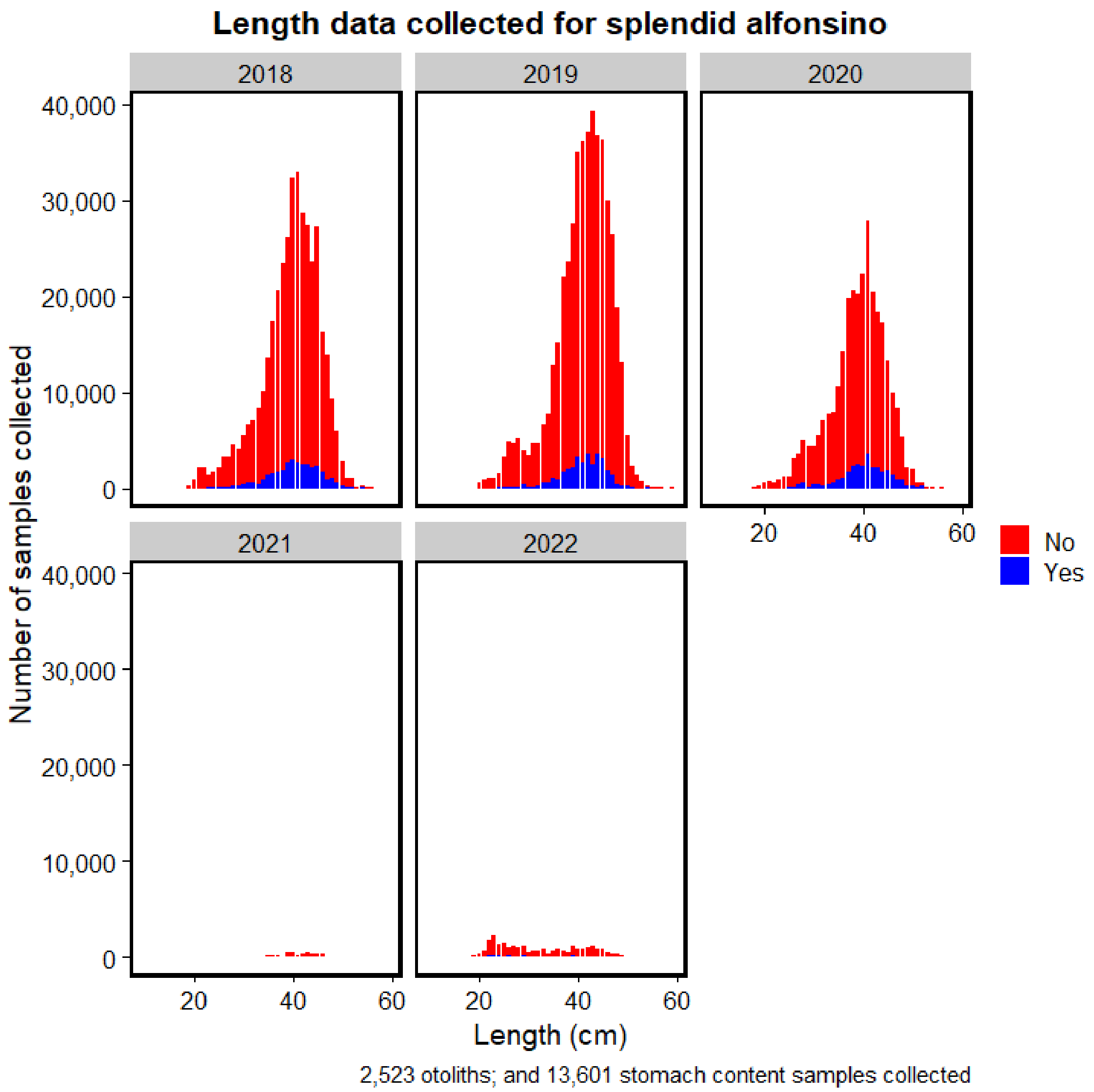

Figure 44: The length frequency sampling, otolith collection and stomach sampling collection from splendid alfonsino in the Cook Islands SIOFA fishery from 2019-2022.

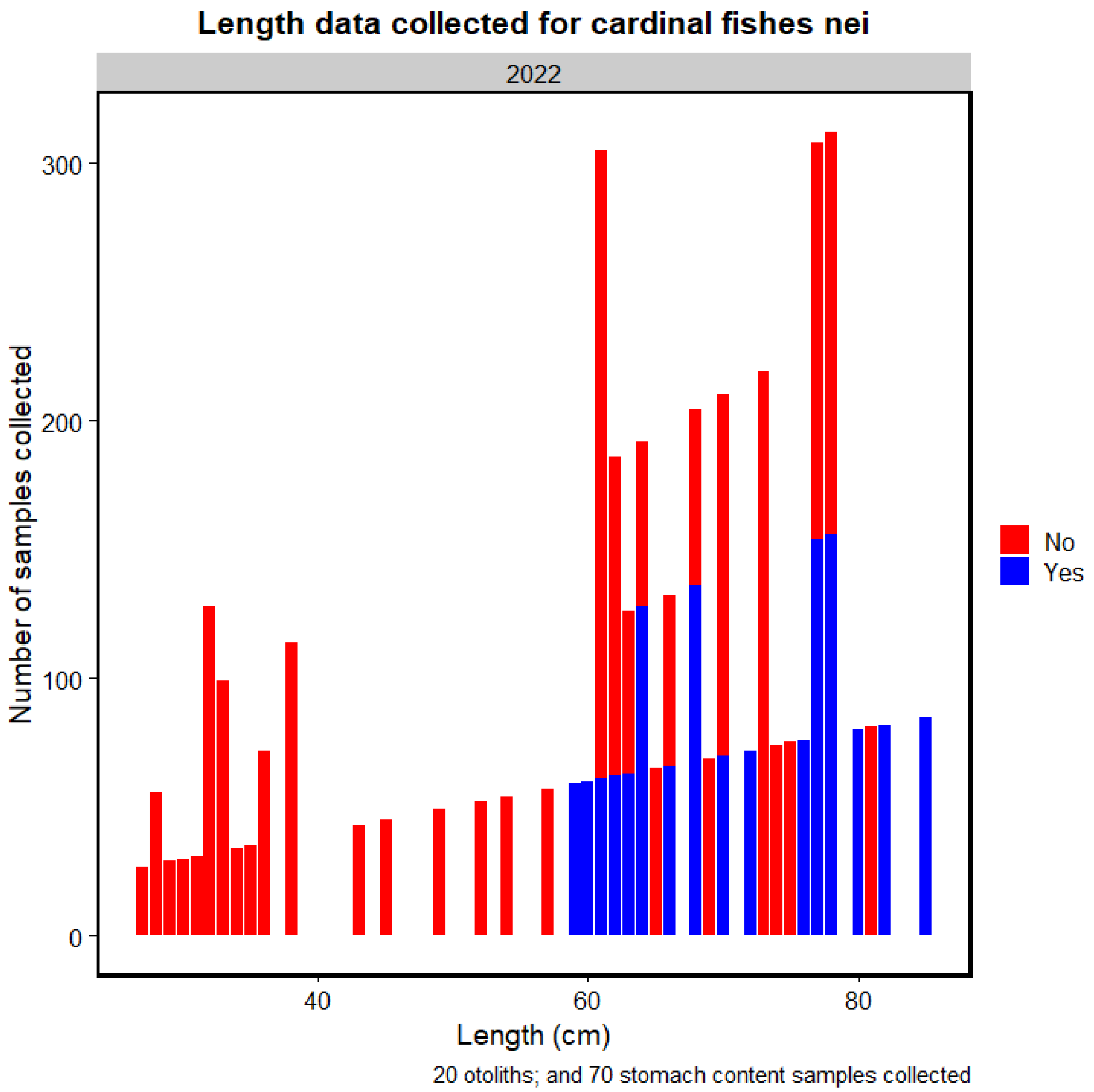

Figure 45: The length frequency sampling, otolith collection and stomach sampling collection from cardinal fishes in the Cook Islands SIOFA fishery from 2019-2022.

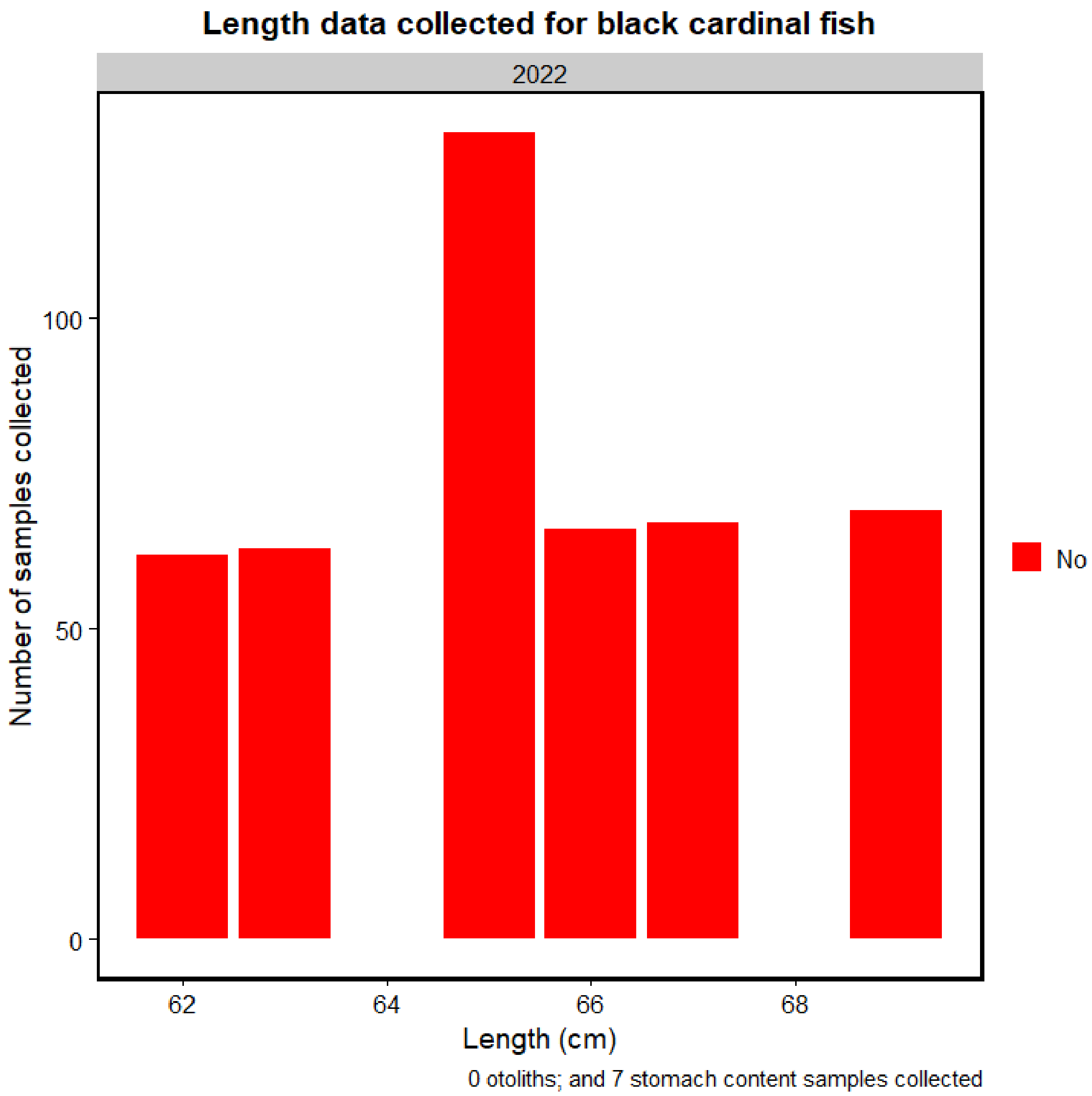

Figure 46: The length frequency sampling, otolith collection and stomach sampling collection from black cardinal fish in the Cook Islands SIOFA fishery from 2019-2022.

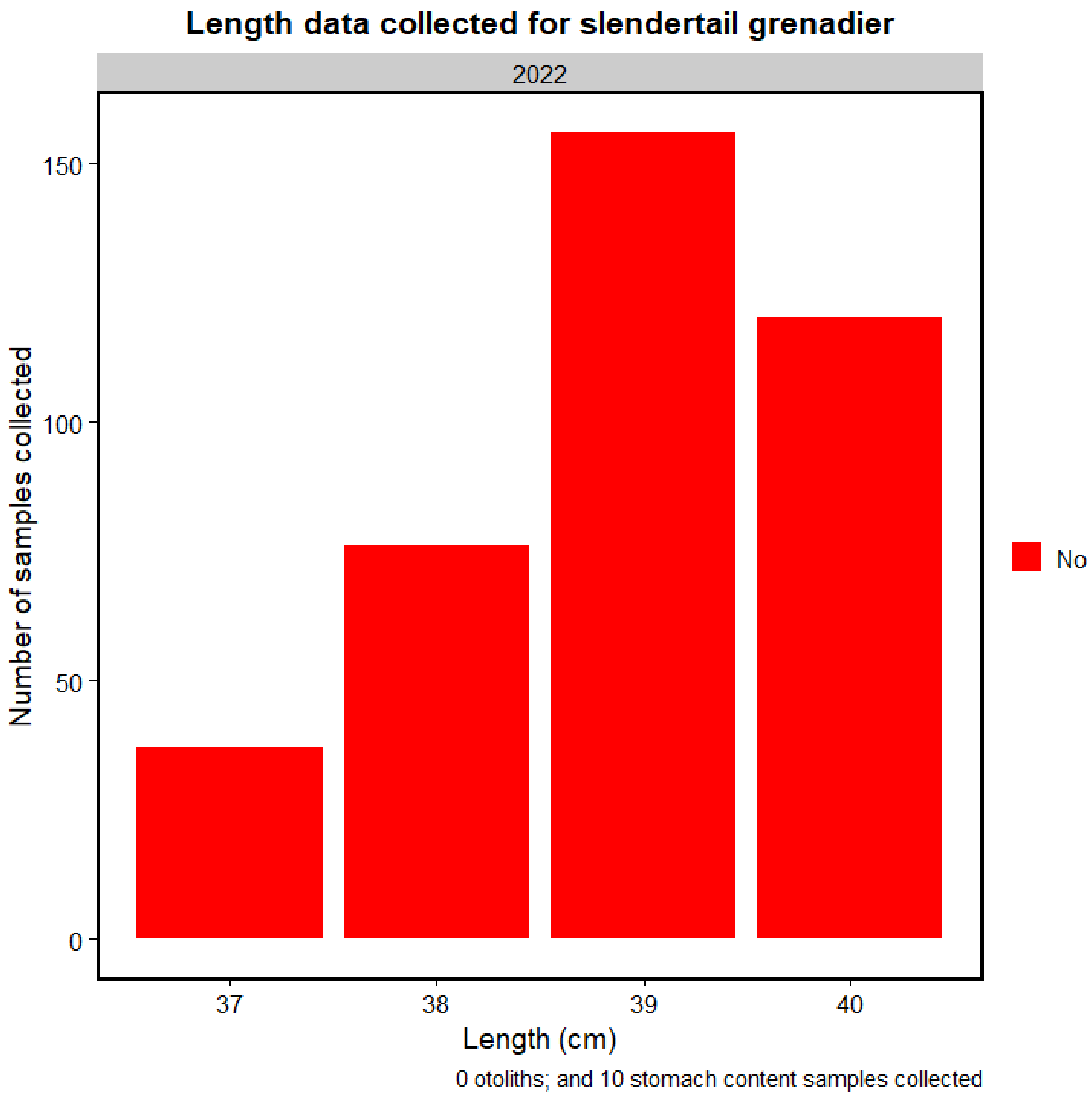

Figure 47: The length frequency sampling, otolith collection and stomach sampling collection from slender grenadier in the Cook Islands SIOFA fishery from 2019-2022.

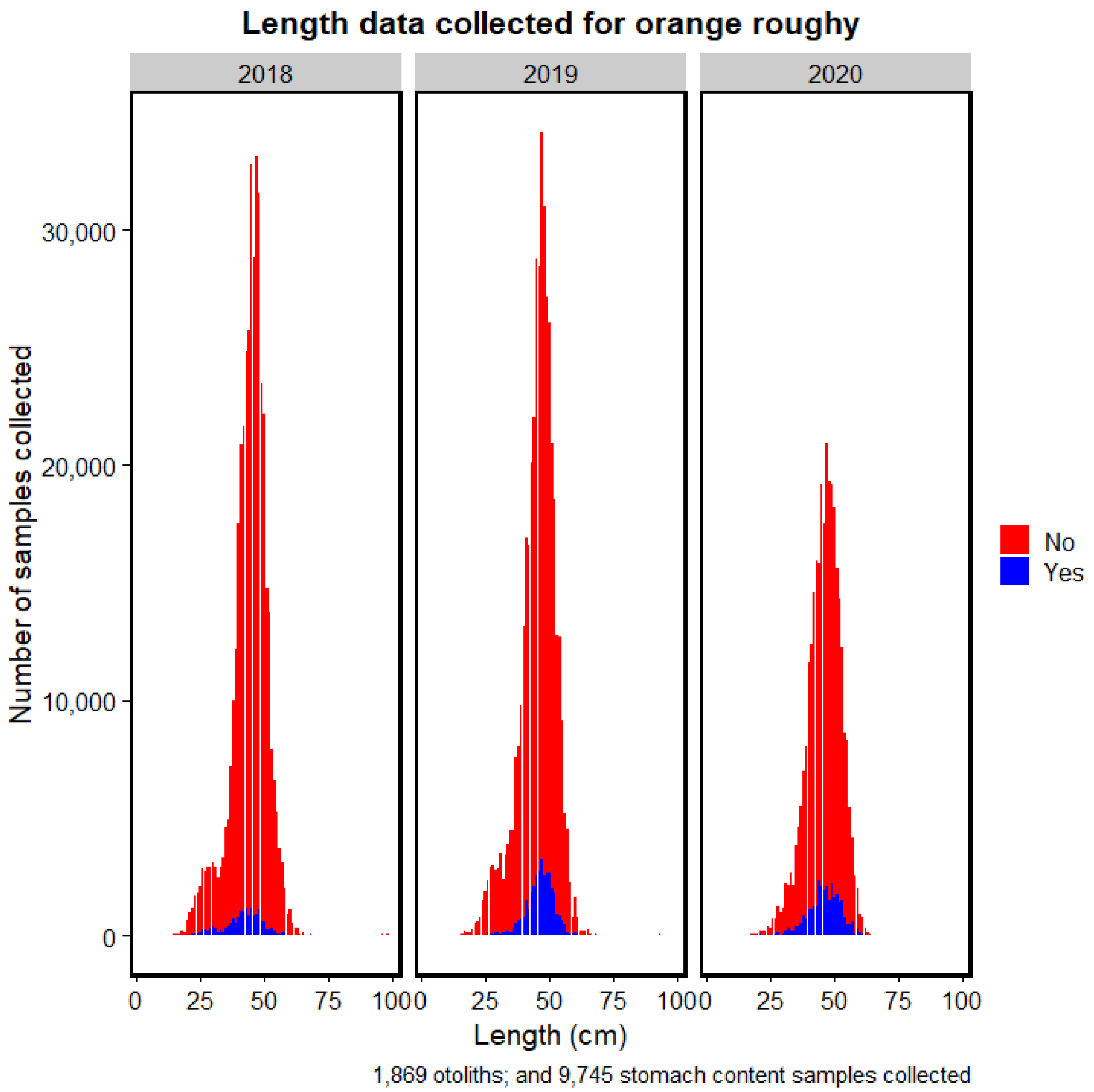

Figure 48: The length frequency sampling, otolith collection and stomach sampling collection from orange roughy in the Cook Islands SIOFA fishery from 2019-2022.

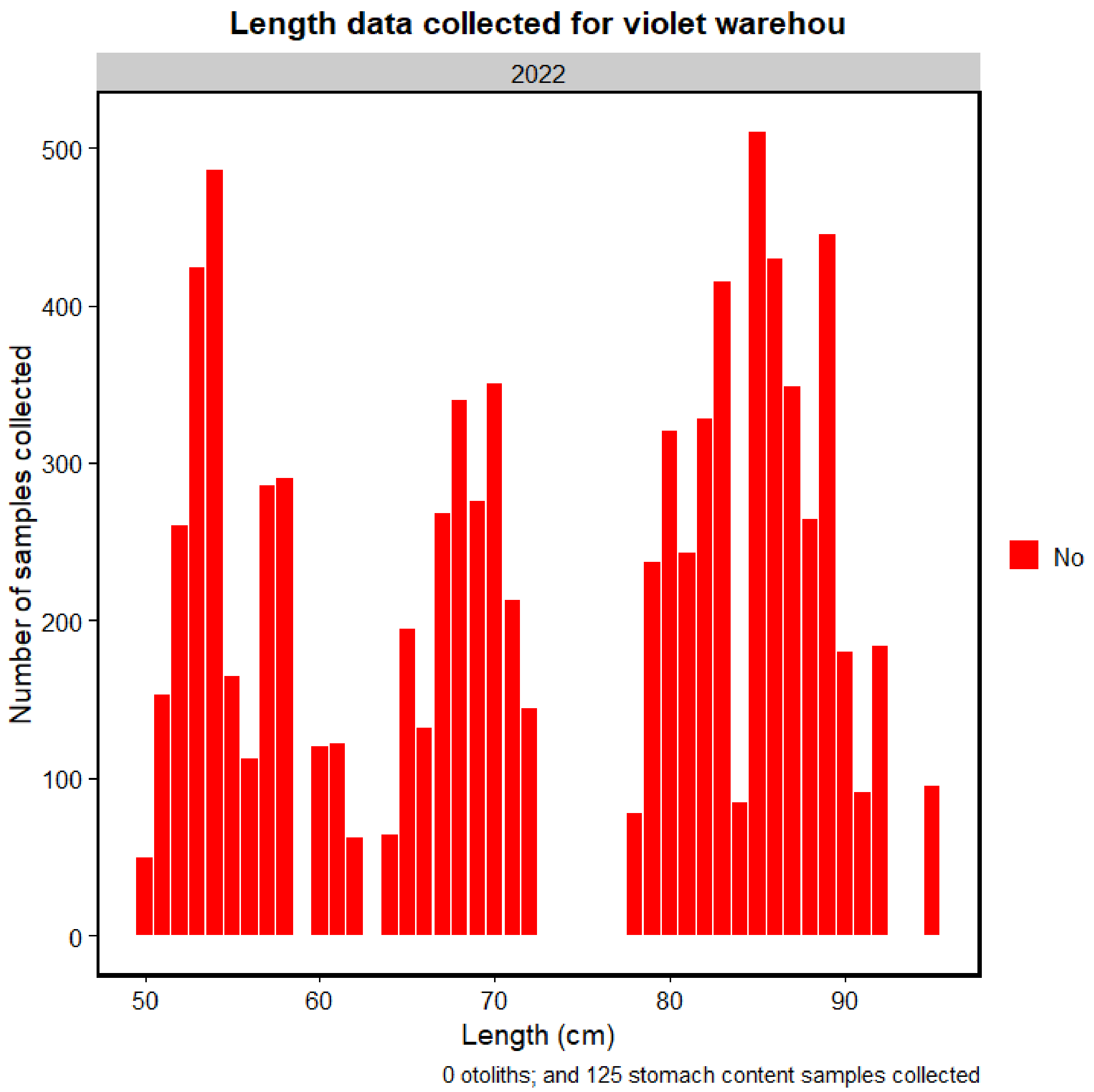

Figure 49: The length frequency sampling, otolith collection and stomach sampling collection from violet warehou in the Cook Islands SIOFA fishery from 2019-2022.

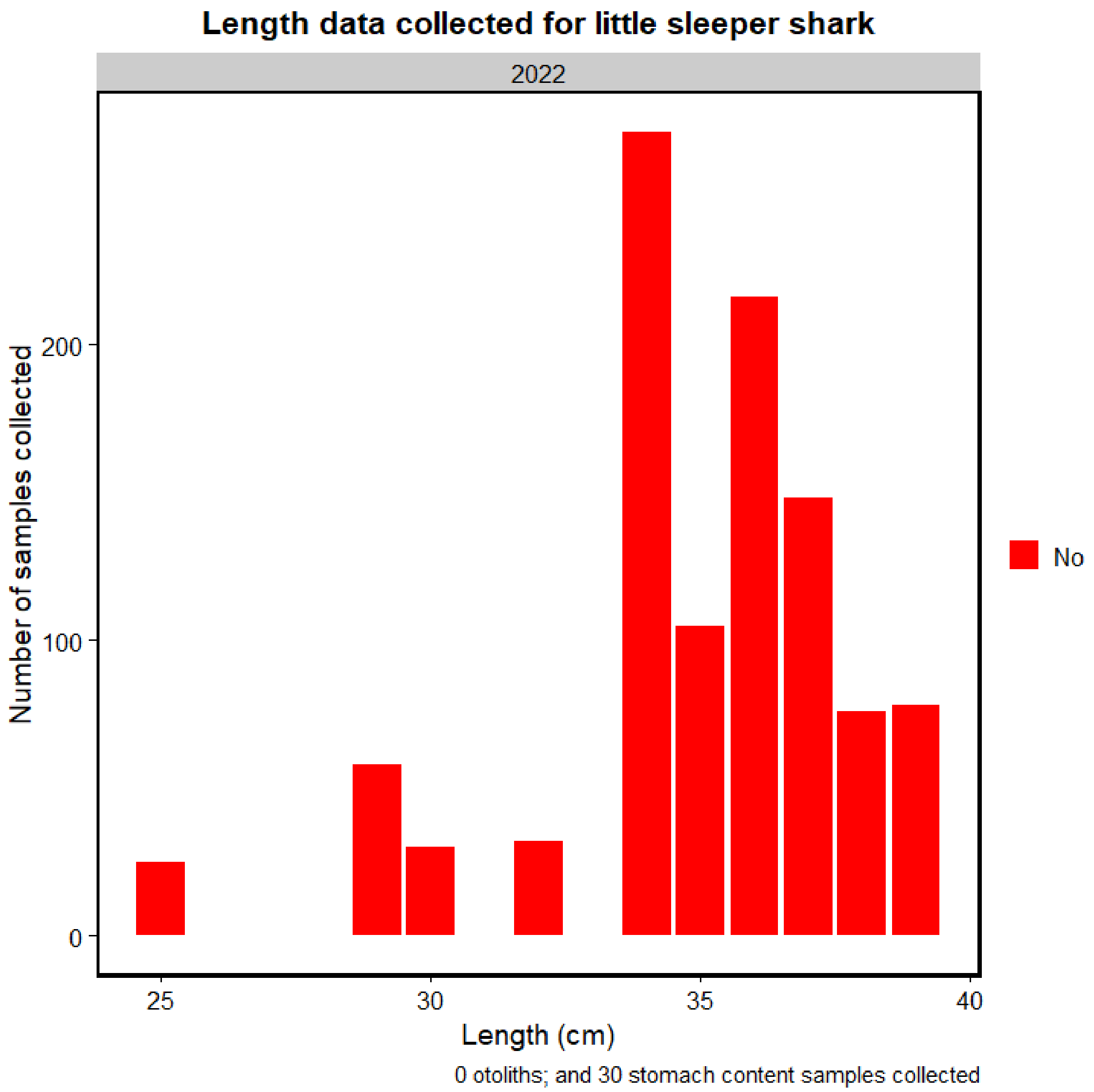

Figure 50: The length frequency sampling, otolith collection and stomach sampling collection from little sleeper shark in the Cook Islands SIOFA fishery from 2019-2022.

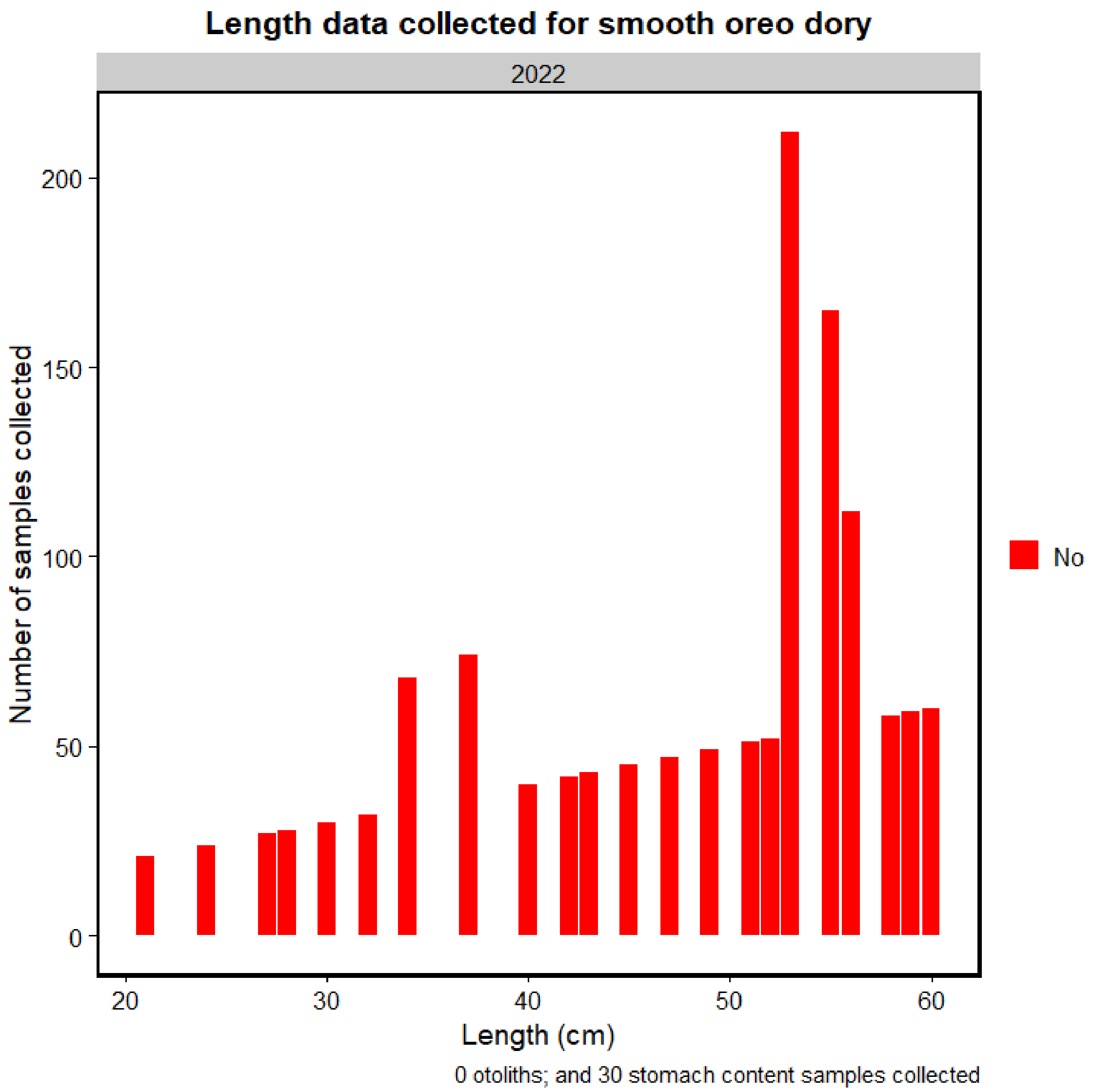

Figure 51: The length frequency sampling, otolith collection and stomach sampling collection from smooth oreo dory in the Cook Islands SIOFA fishery from 2019-2022.

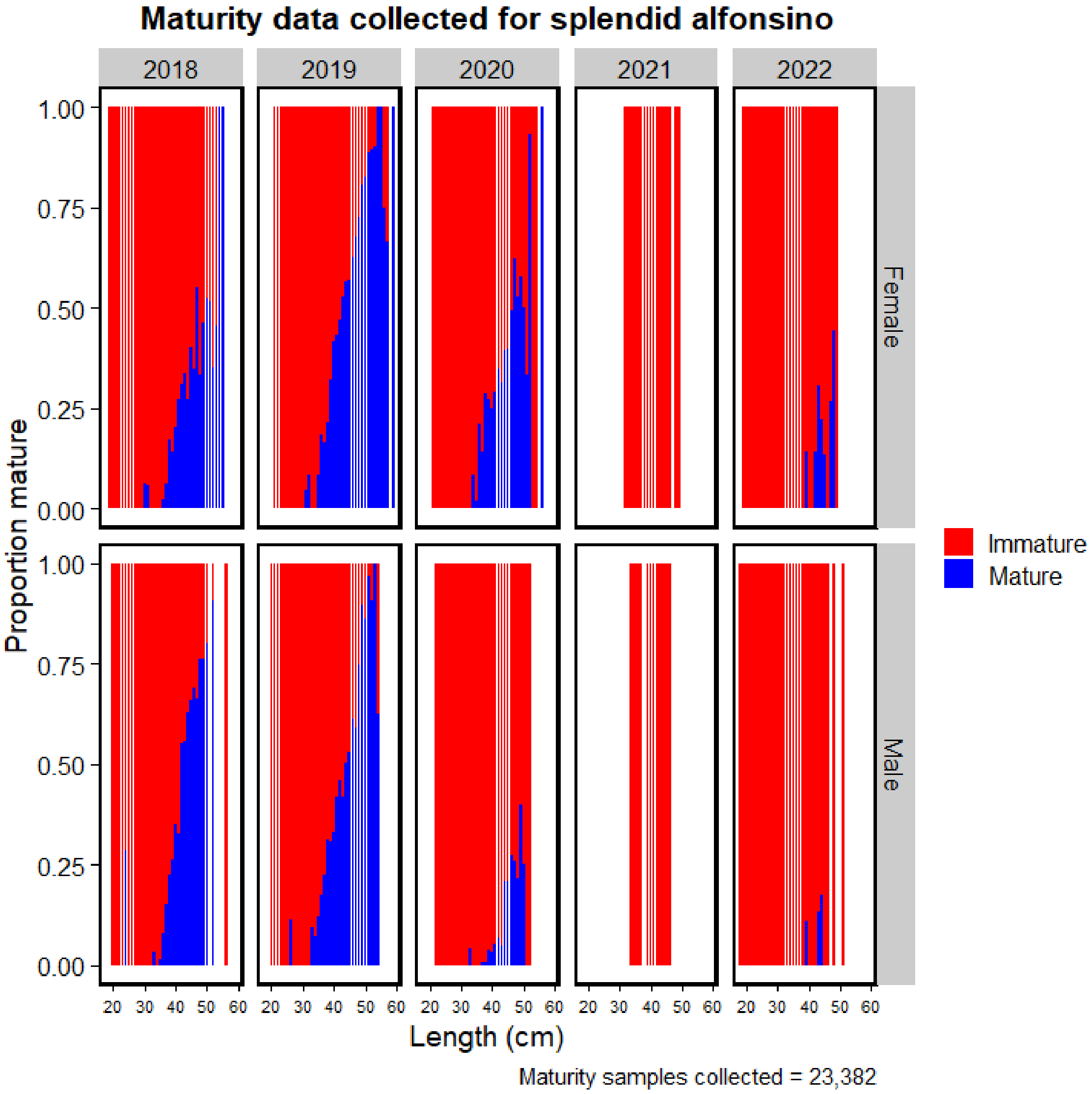

Figure 52: The maturity samples collected from splendid alfonsino in the Cook Islands SIOFA fishery from 2019-2022.

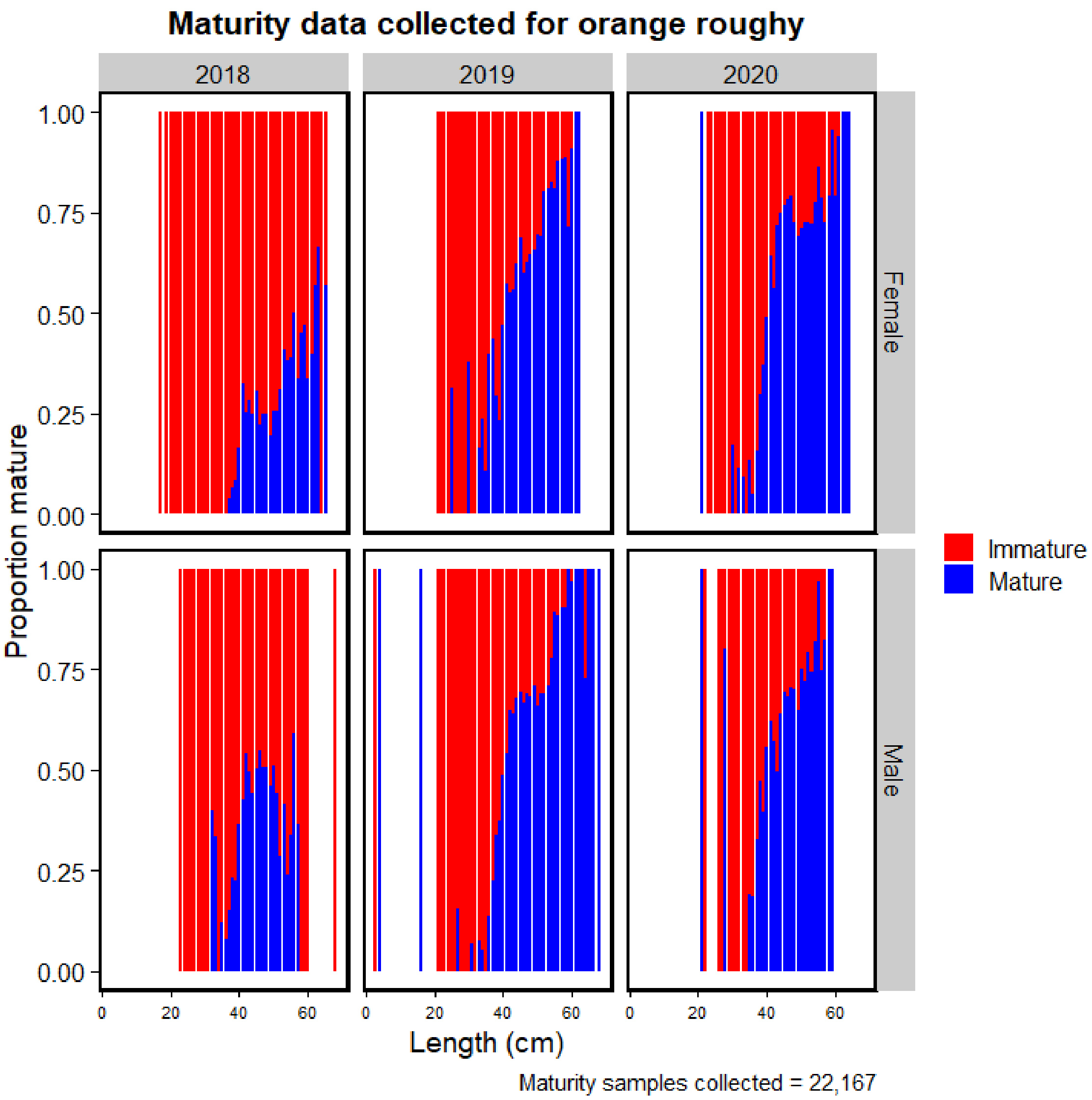

Figure 53: The maturity samples collected from orange roughy in the Cook Islands SIOFA fishery from 2019-2022.

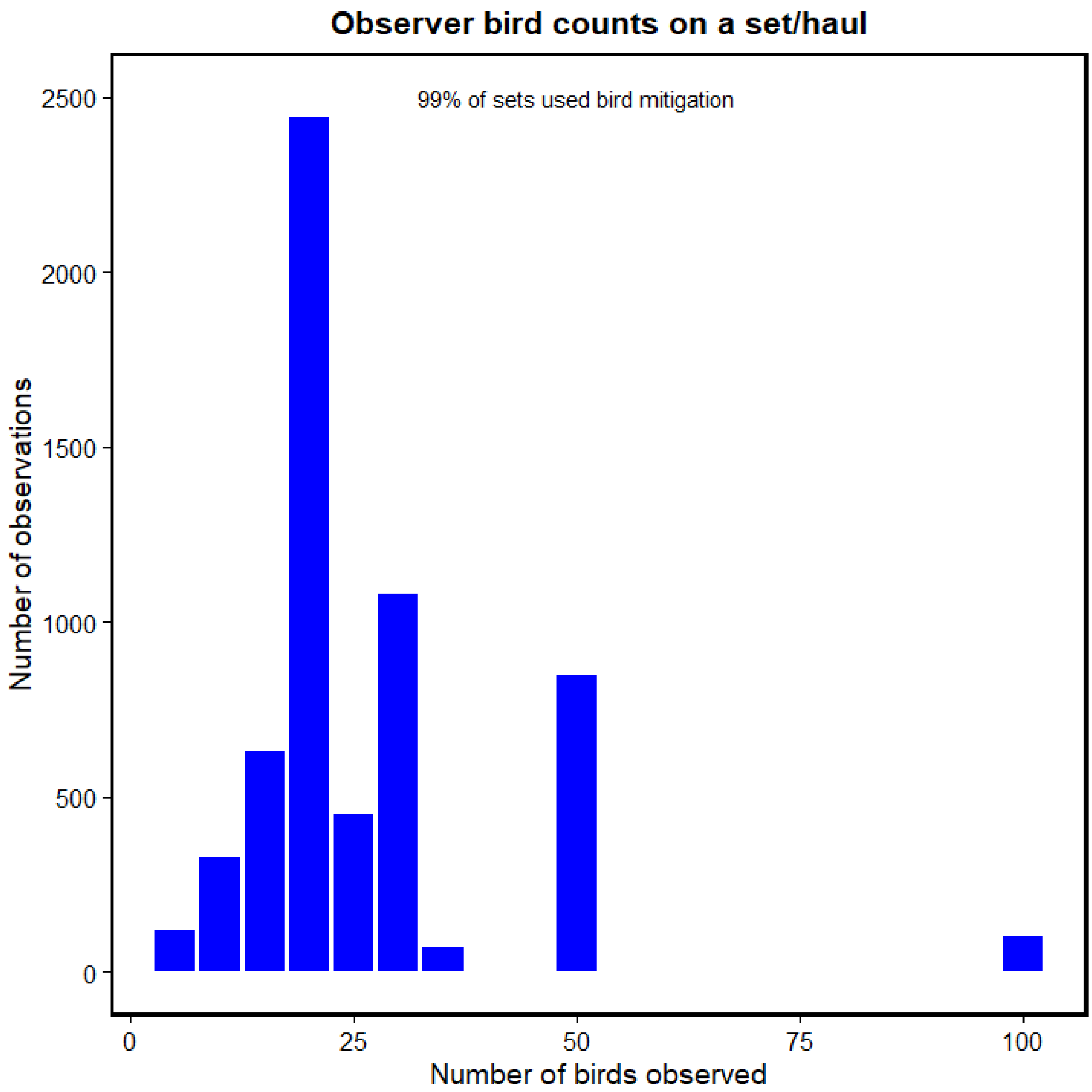

Figure 54: The observed bird counts at the set or haul, and use of bird mitigation in the Cook Islands SIOFA fishery from 2019-2022.

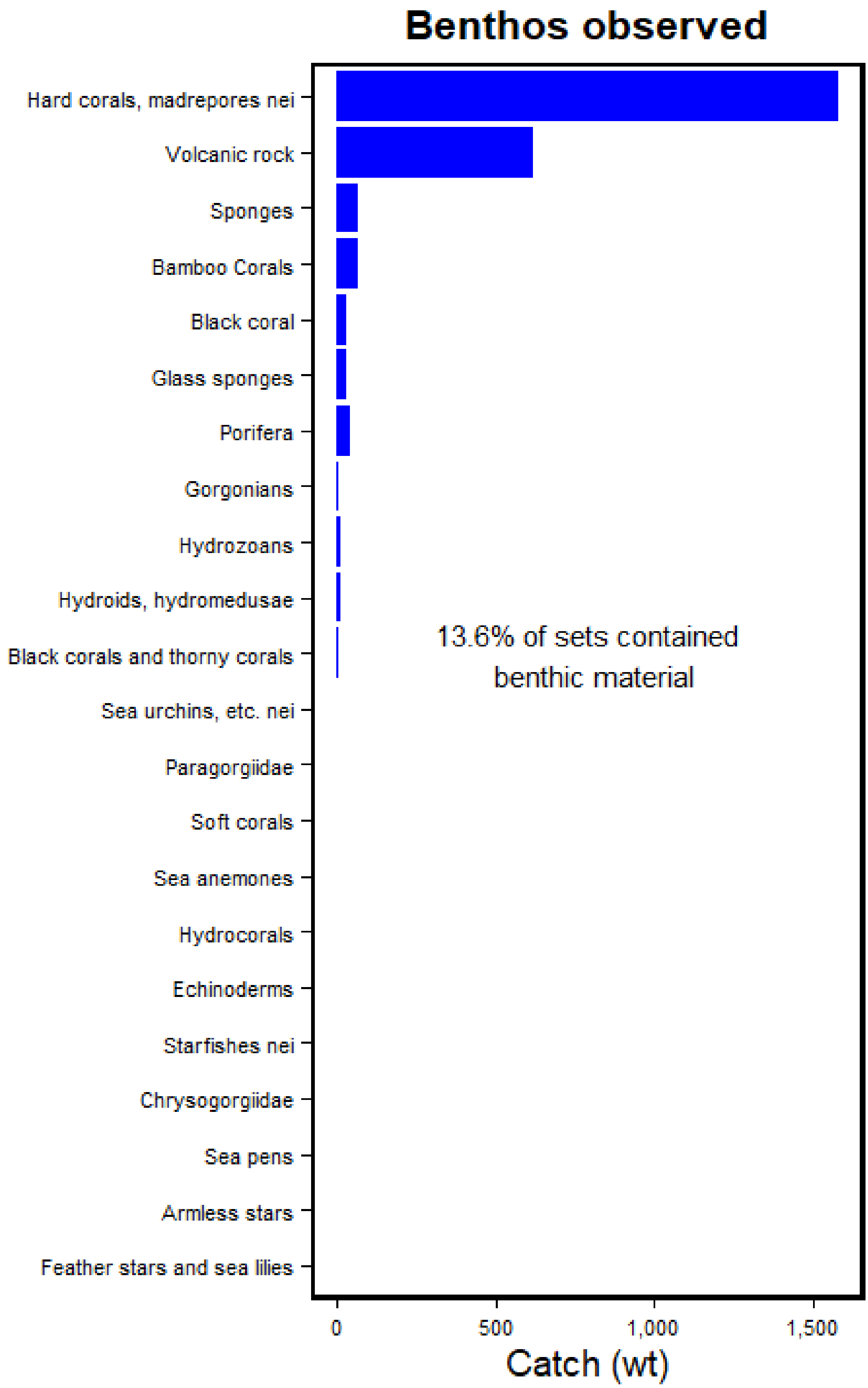

Figure 55: The observed benthic material encountered in the Cook Islands SIOFA fishery.

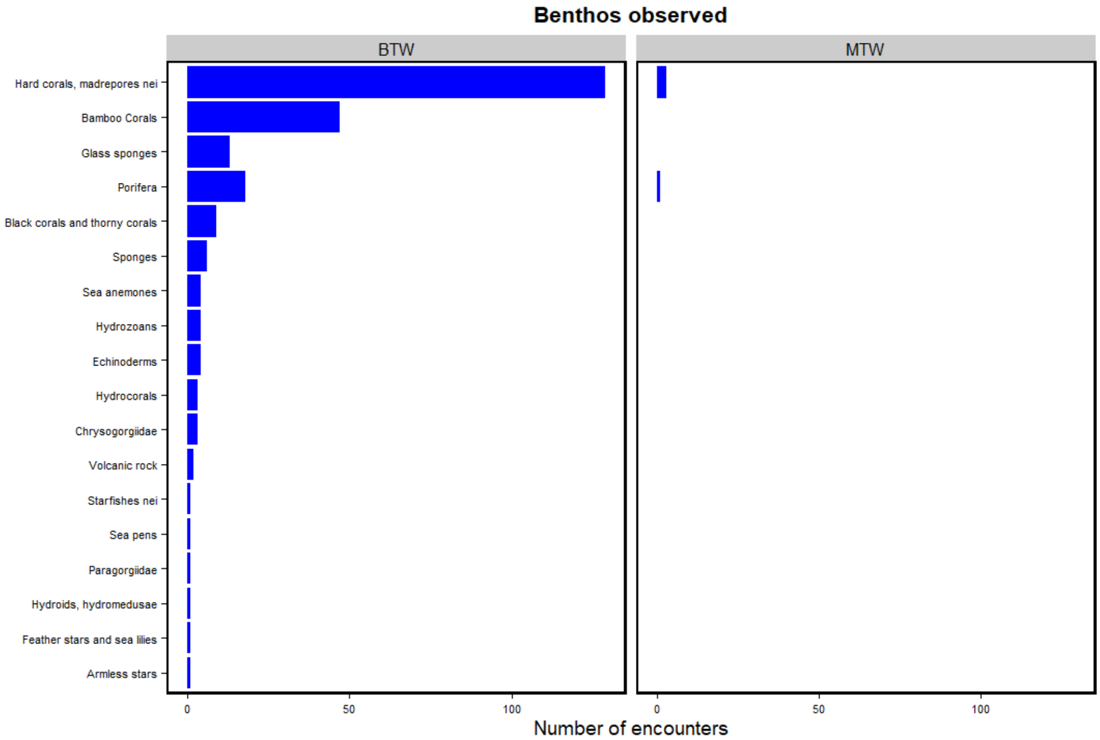

Figure 56: The observed benthic material in the Cook Islands SIOFA fishery by tow type from 2019-2022. BTW = bottom trawl; MWT = midwater trawl.

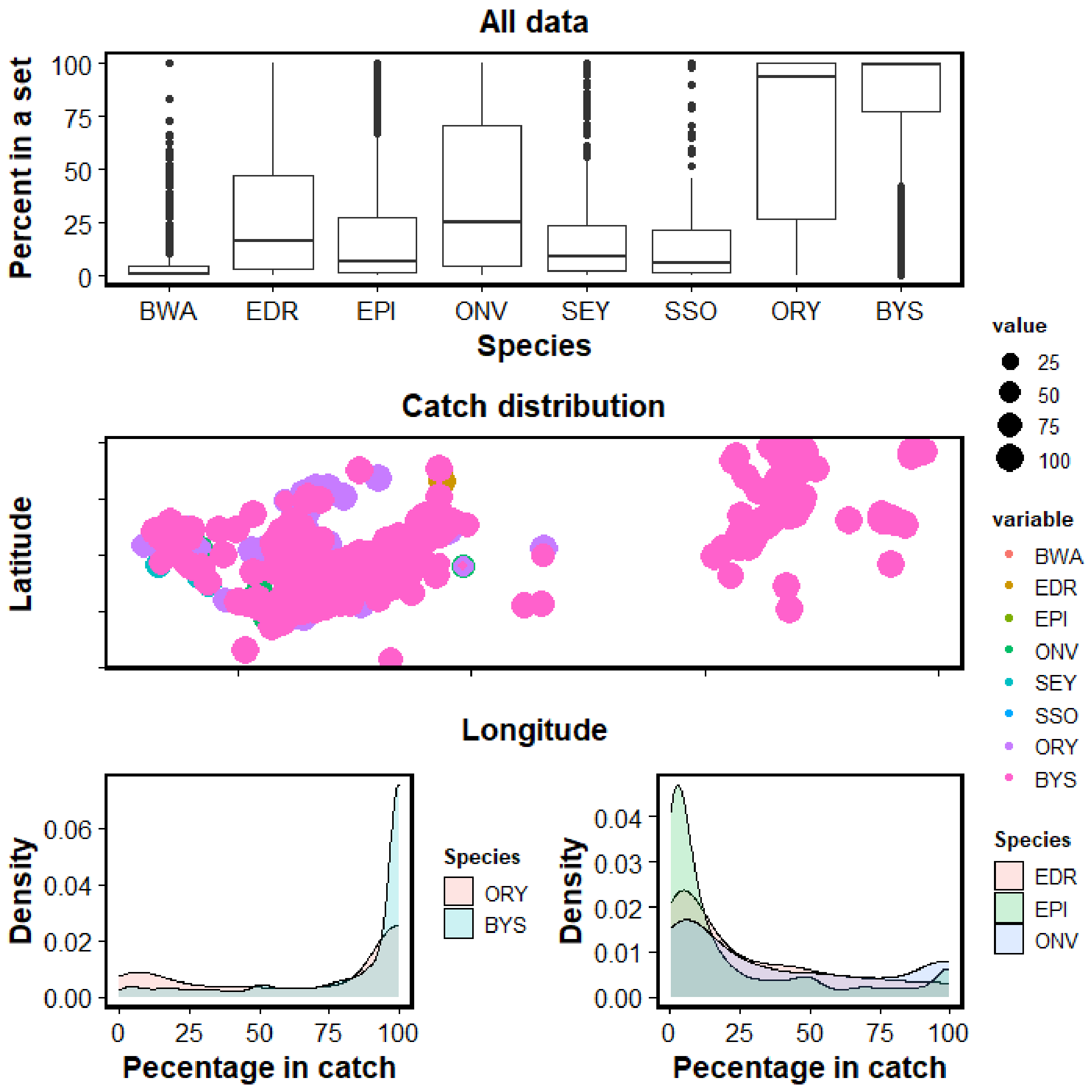

Figure 57: Plot showing the distribution of all the catch data for the main species in the Cook Islands fishery showing the percent of the catch by target species (top), the catch distribution in SIOFA (middle), the density distribution of the percent in the catch of alfonsino and orange roughy (bottom left) and the other species (bottom right). ORY = orange roughy; BYS = splendid alfonsino; EDR = pelagic armour head; EPI = black cardinal fish; ONV = spikey oreo.

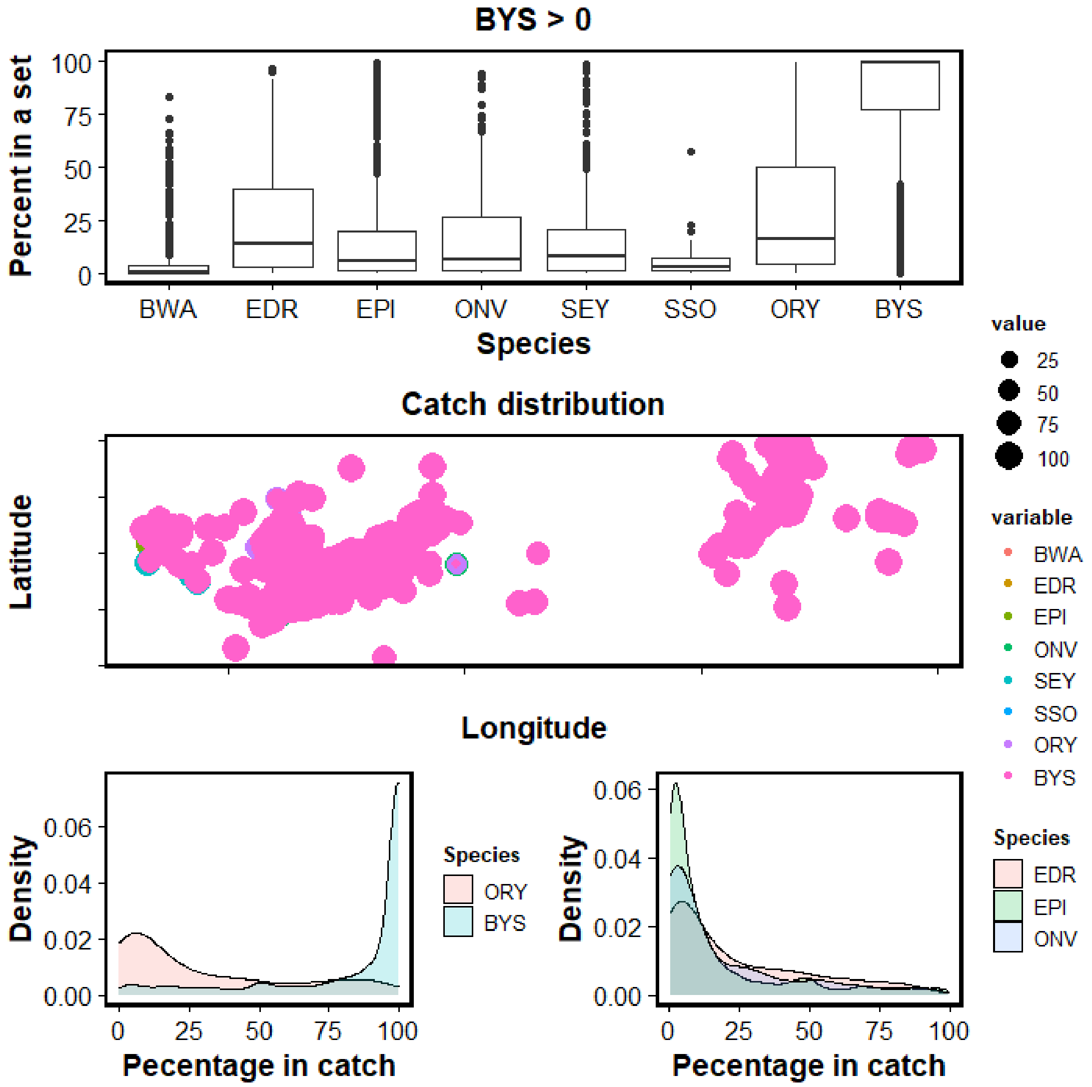

Figure 58: Plot showing the distribution of all the catch from sets that contained alfonsino in the Cook Islands fishery showing the percent of the catch by target species (top), the catch distribution in SIOFA (middle), the density distribution of the percent in the catch of alfonsino and orange roughy (bottom left) and the other species (bottom right). ORY = orange roughy; BYS = splendid alfonsino; EDR = pelagic armour head; EPI = black cardinal fish; ONV = spikey oreo.

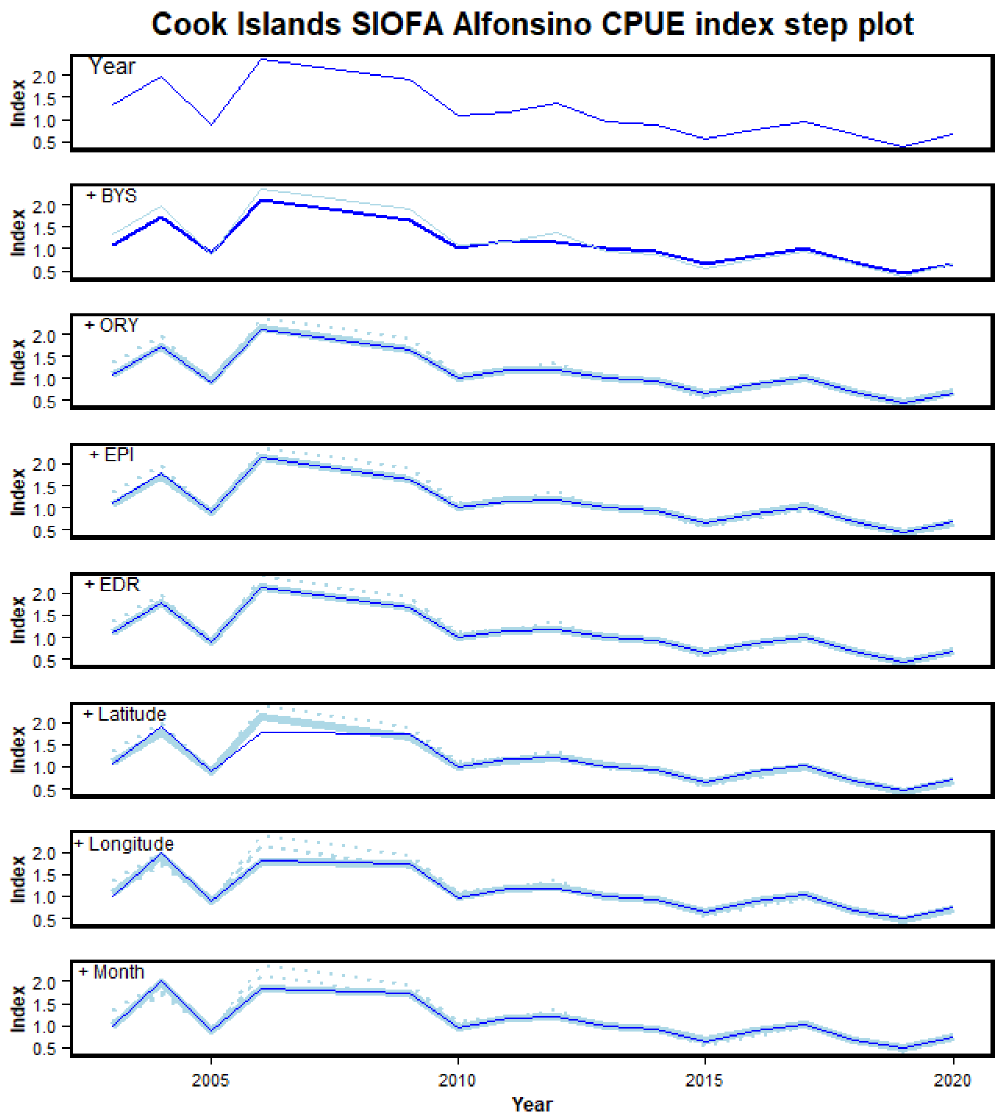

Figure 59: One change step plot showing the sequential standardisation effects. Blue line is the index, light blue and light blue dashed lines are the previous models.

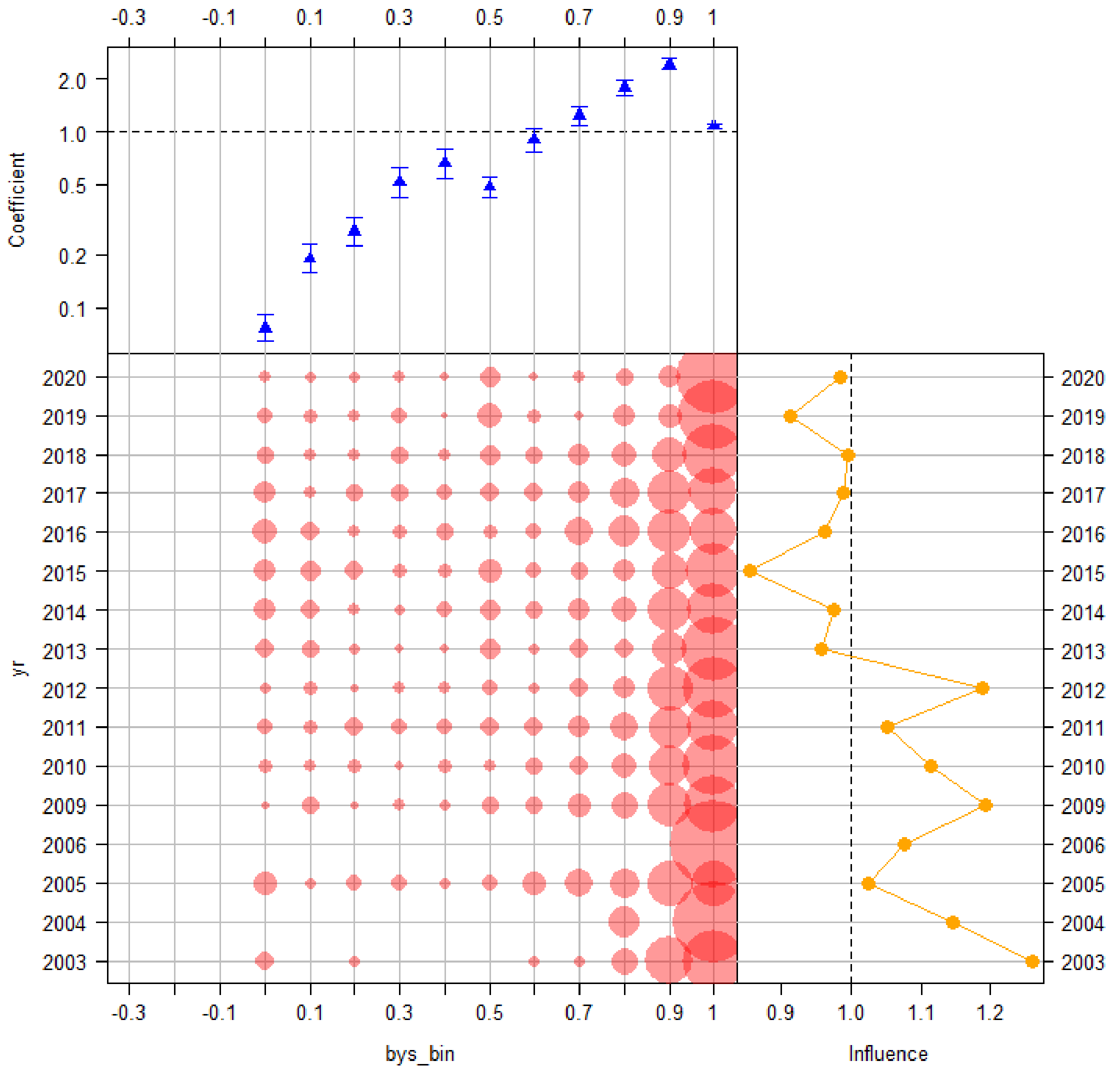

Figure 60: Influence of alfonsino catch proportion for the Cook Island fleet (bubble plot; bubbles scaled by catch) on CPUE; influence (right hand plot) shows the standardising effect (a positive effect reduces the standardised CPUE by the equivalent amount); and the estimated coefficients are provided in the top panel.

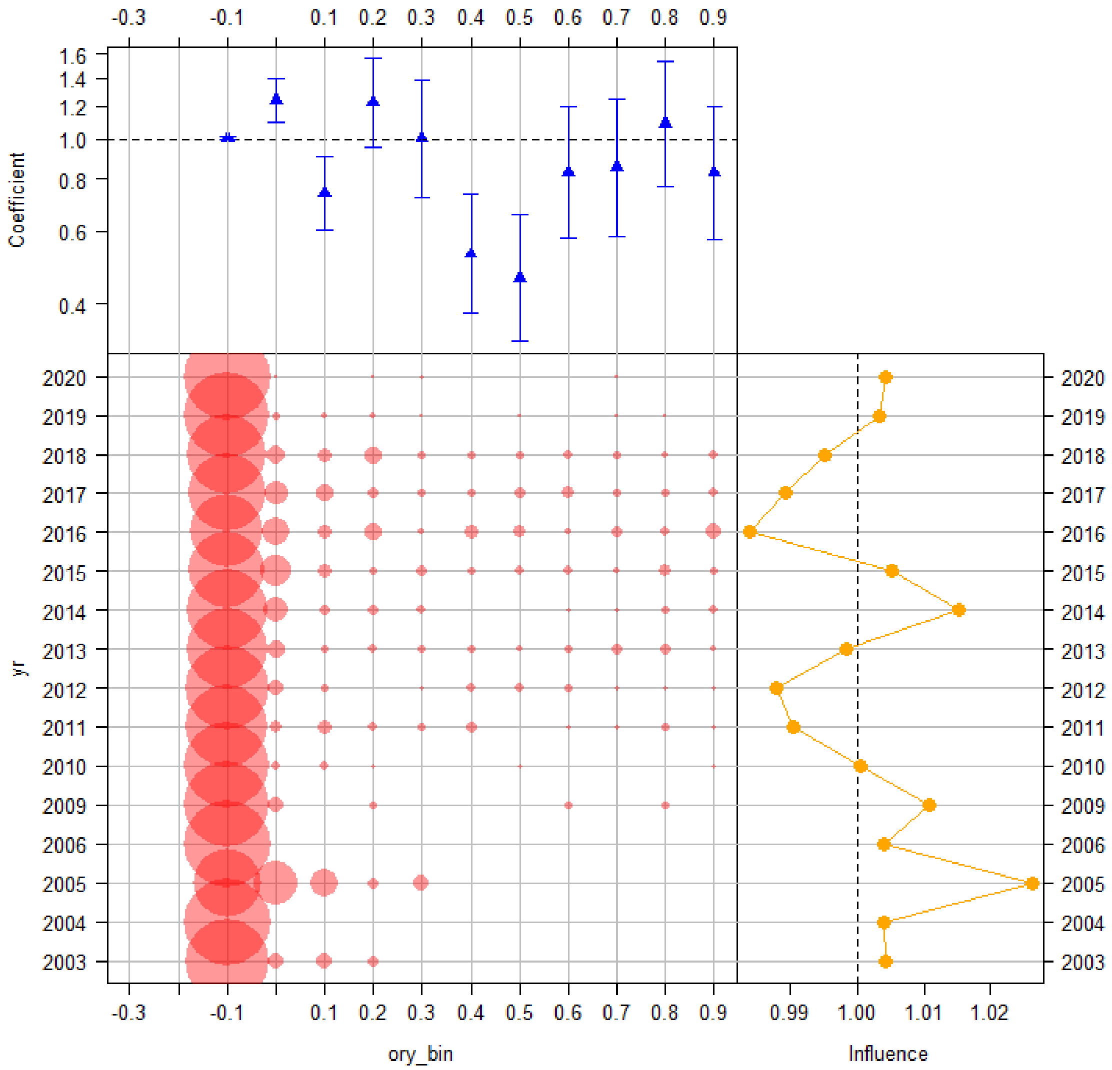

Figure 61: Influence of orange roughy catch proportion for the Cook Island fleet (bubble plot; bubbles scaled by catch) on CPUE; influence (right hand plot) shows the standardising effect (a positive effect reduces the standardised CPUE by the equivalent amount); and the estimated coefficients are provided in the top panel.

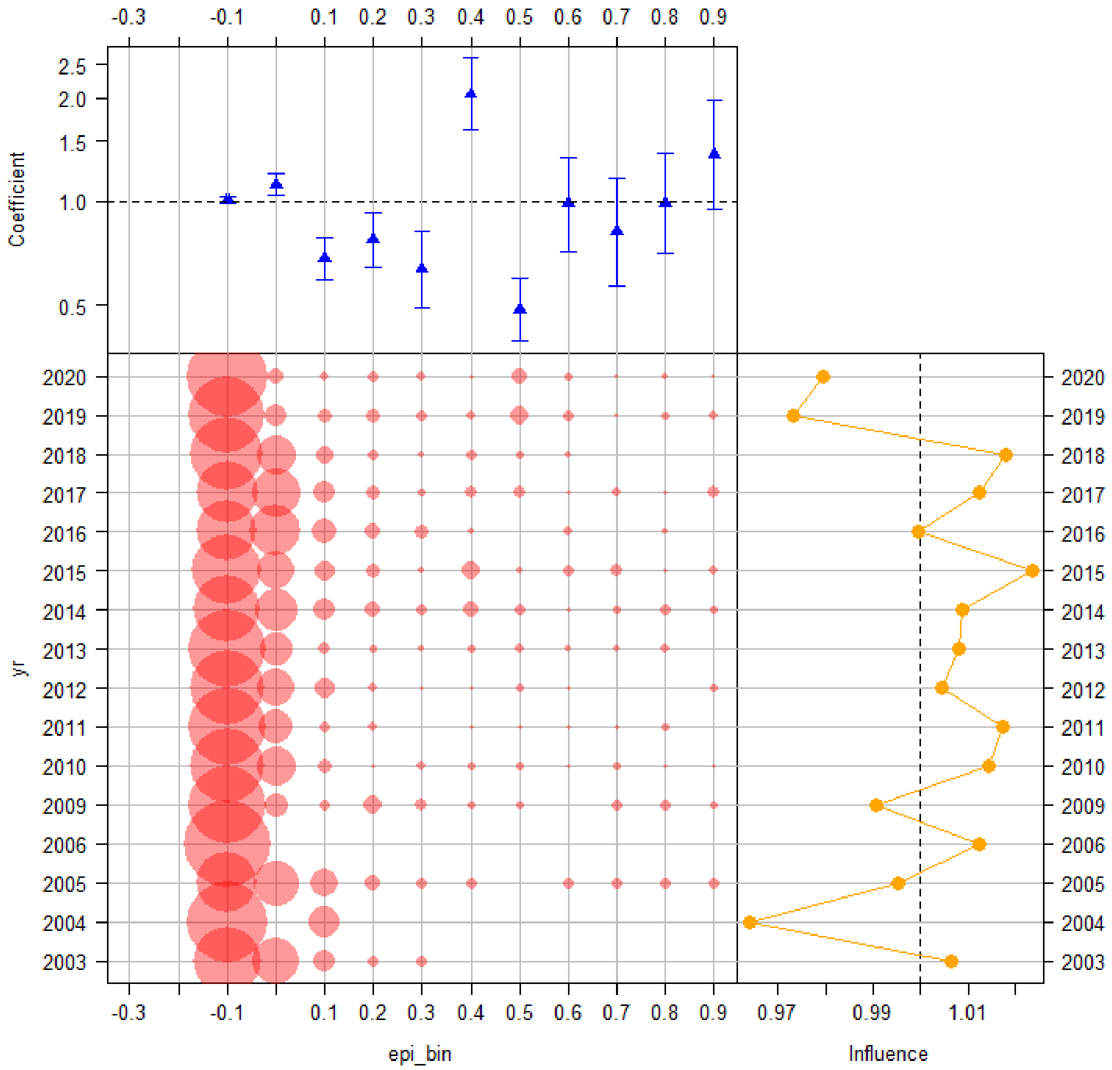

Figure 62: Influence of black cardinal fish catch proportion for the Cook Island fleet (bubble plot; bubbles scaled by catch) on CPUE; influence (right hand plot) shows the standardising effect (a positive effect reduces the standardised CPUE by the equivalent amount); and the estimated coefficients are provided in the top panel.

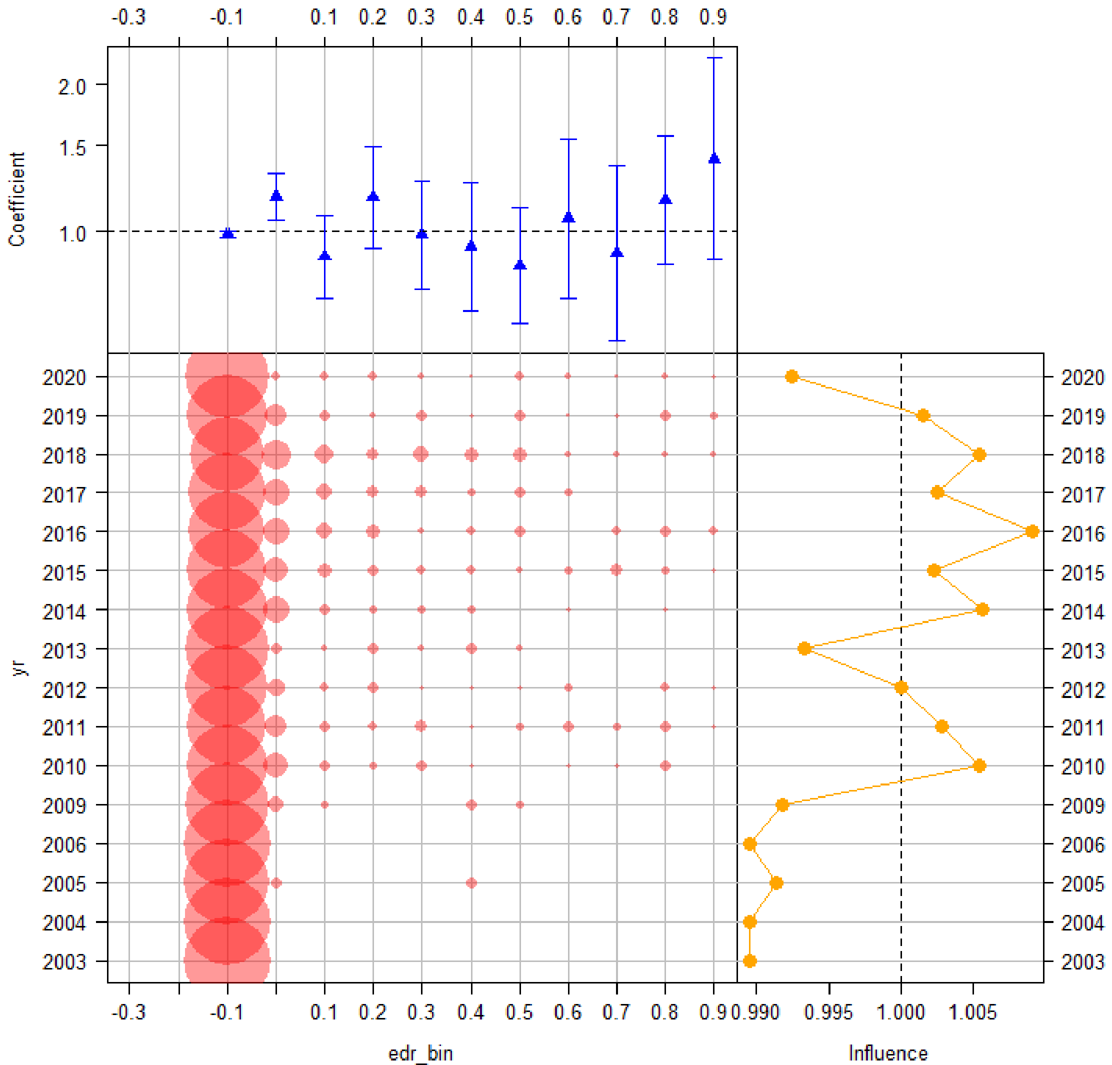

Figure 63: Influence of pelagic armourgead catch proportion for the Cook Island fleet (bubble plot; bubbles scaled by catch) on CPUE; influence (right hand plot) shows the standardising effect (a positive effect reduces the standardised CPUE by the equivalent amount); and the estimated coefficients are provided in the top panel.

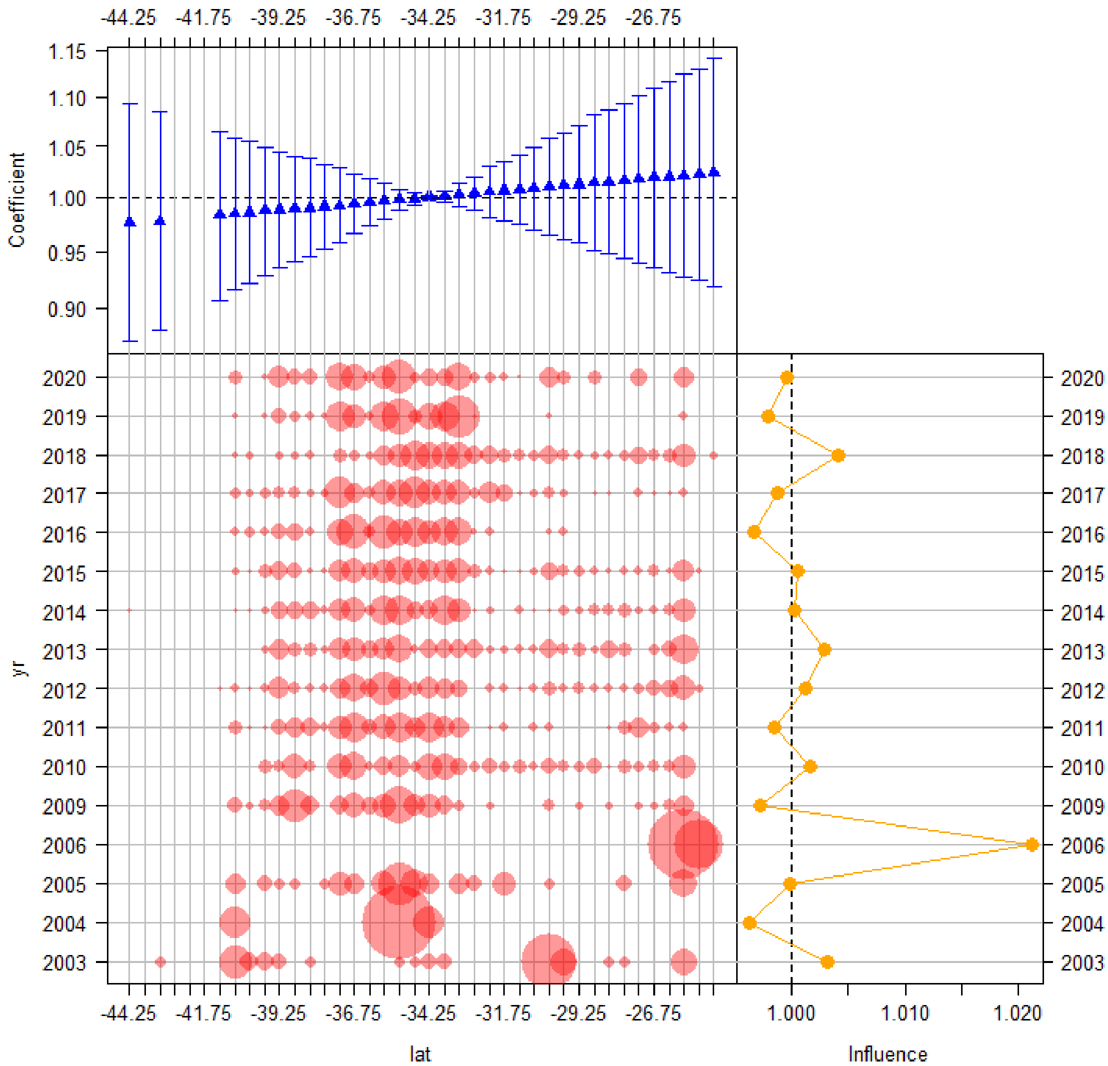

Figure 64: Influence of latitude for the Cook Island fleet (bubble plot; bubbles scaled by catch) on CPUE; influence (right hand plot) shows the standardising effect (a positive effect reduces the standardised CPUE by the equivalent amount); and the estimated coefficients are provided in the top panel.

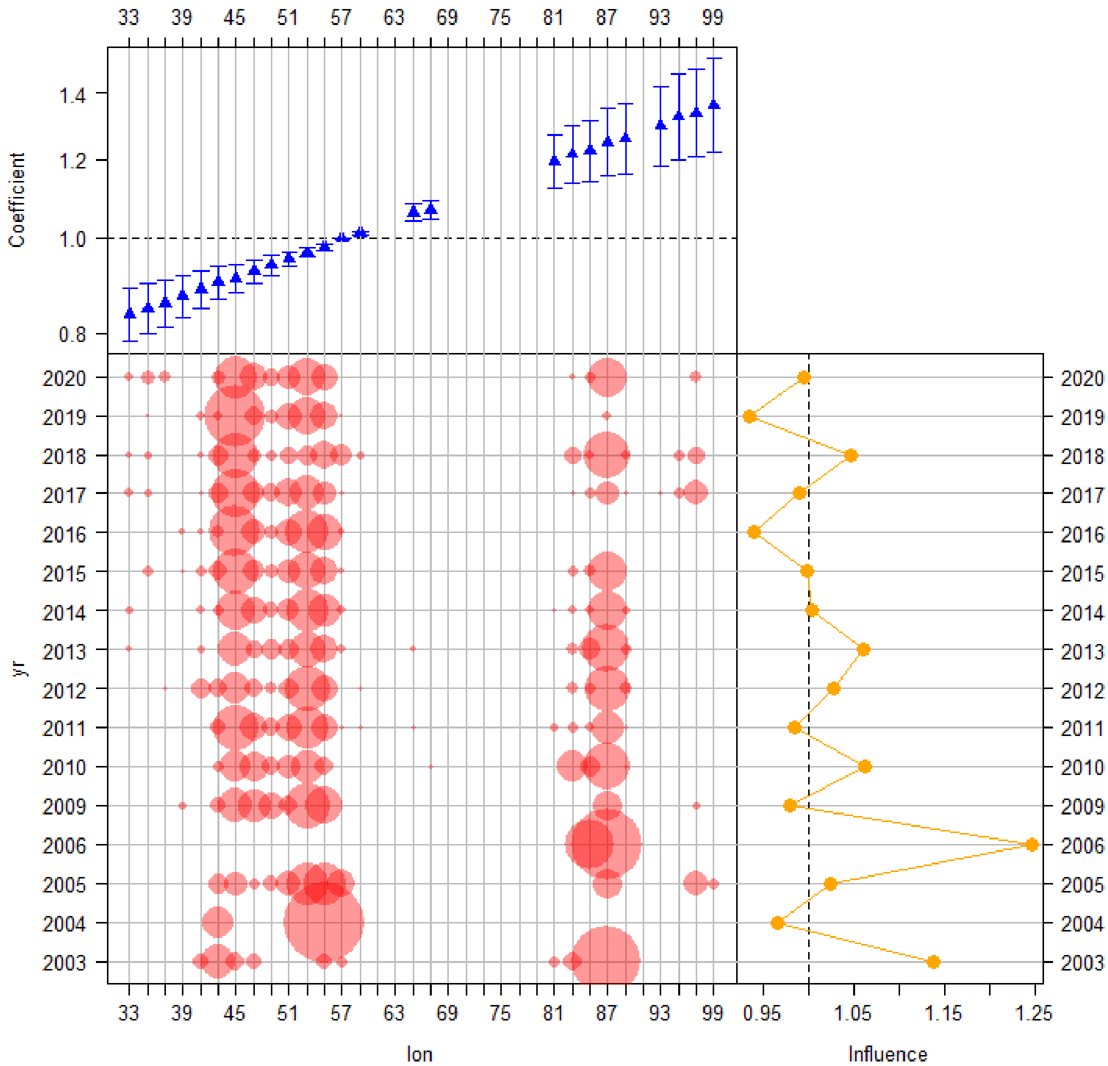

Figure 65: Influence of longitude for the Cook Island fleet (bubble plot; bubbles scaled by catch) on CPUE; influence (right hand plot) shows the standardising effect (a positive effect reduces the standardised CPUE by the equivalent amount); and the estimated coefficients are provided in the top panel.

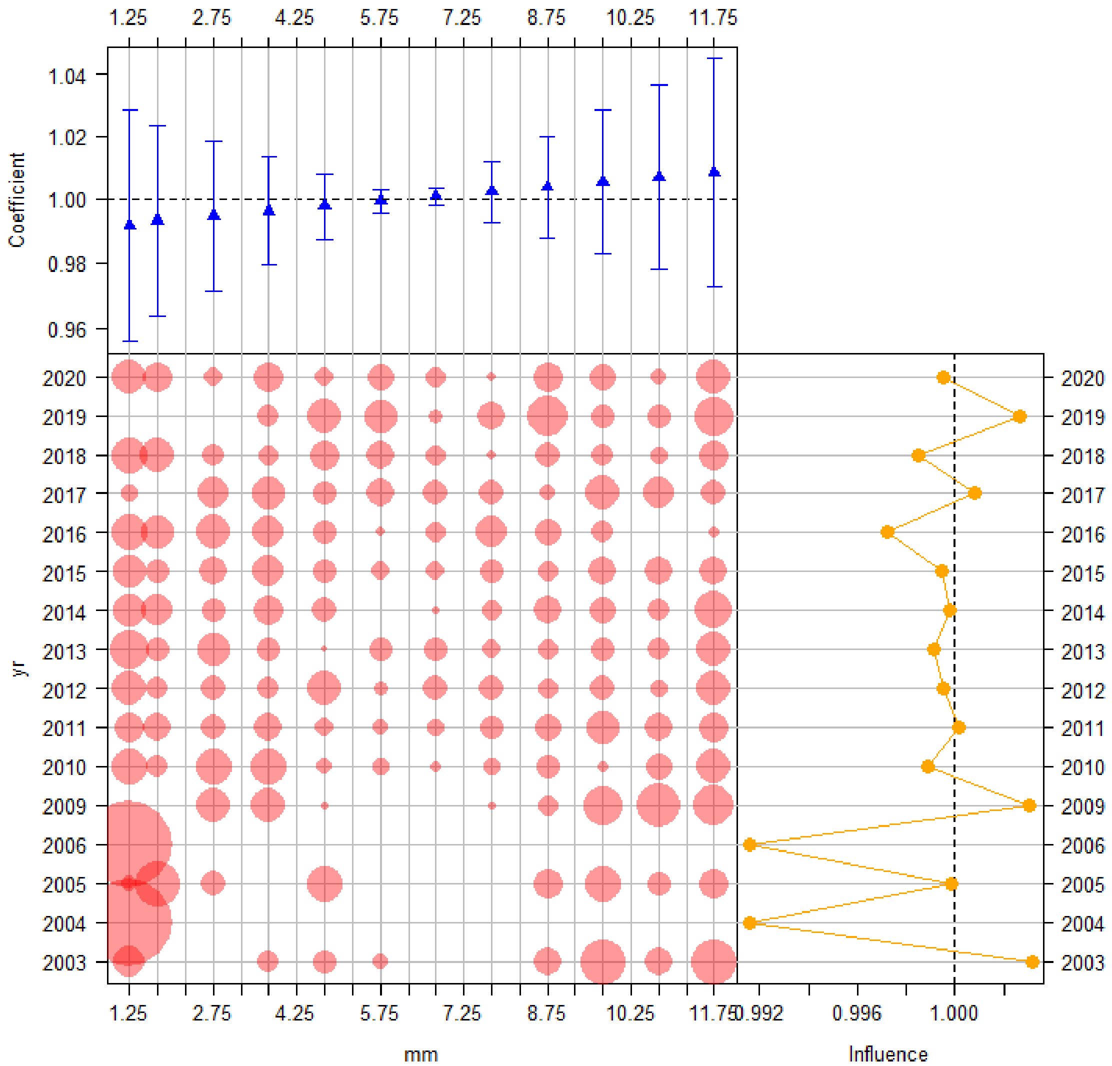

Figure 66: Influence of month for the Cook Island fleet (bubble plot; bubbles scaled by catch) on CPUE; influence (right hand plot) shows the standardising effect (a positive effect reduces the standardised CPUE by the equivalent amount); and the estimated coefficients are provided in the top panel.

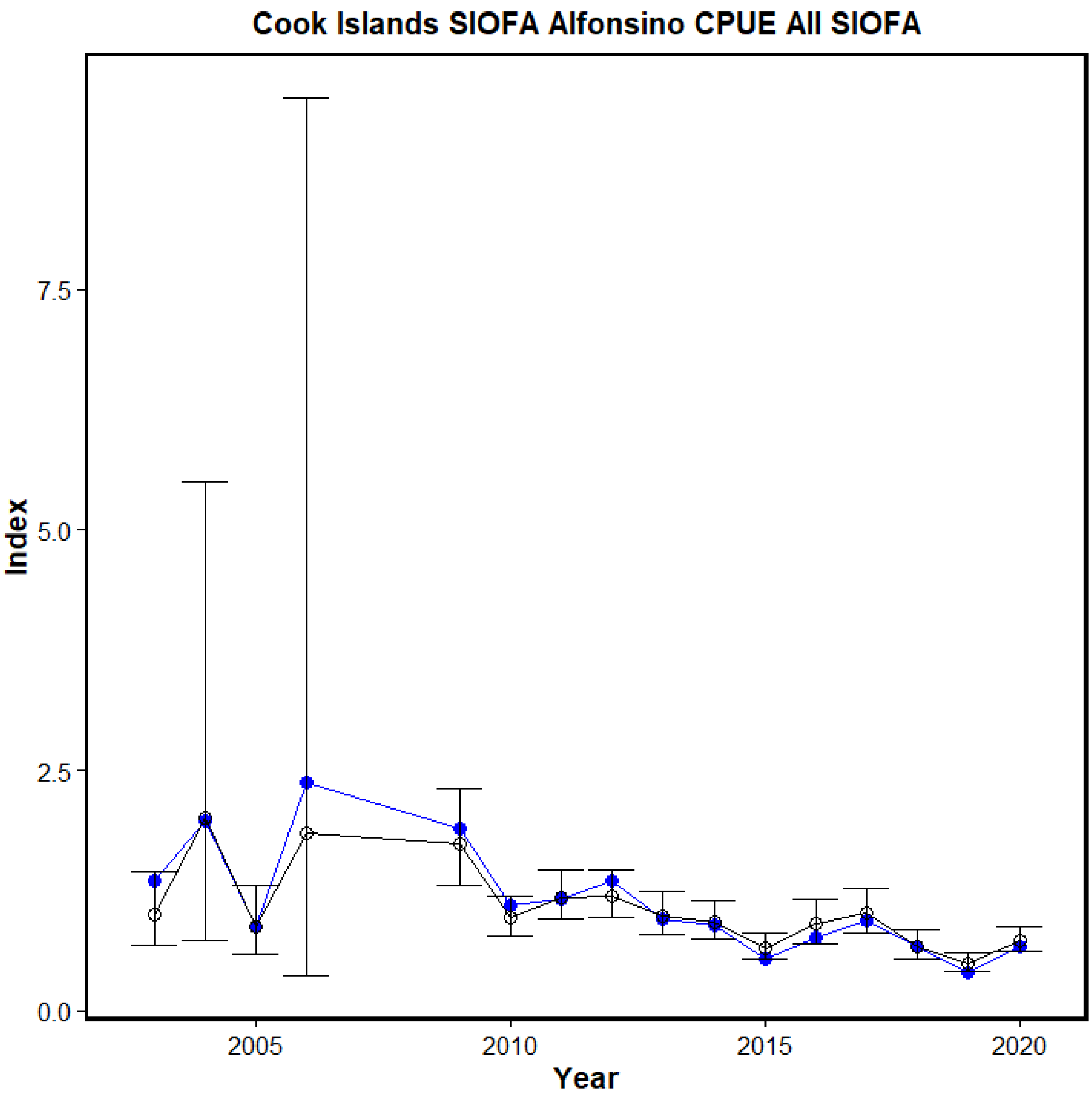

Figure 67: CPUE final model with the unstandardised (blue) and standardised (black) indices for alfonsino from the Cook Islands fleet fishing in SIOFA from 2001-2020.

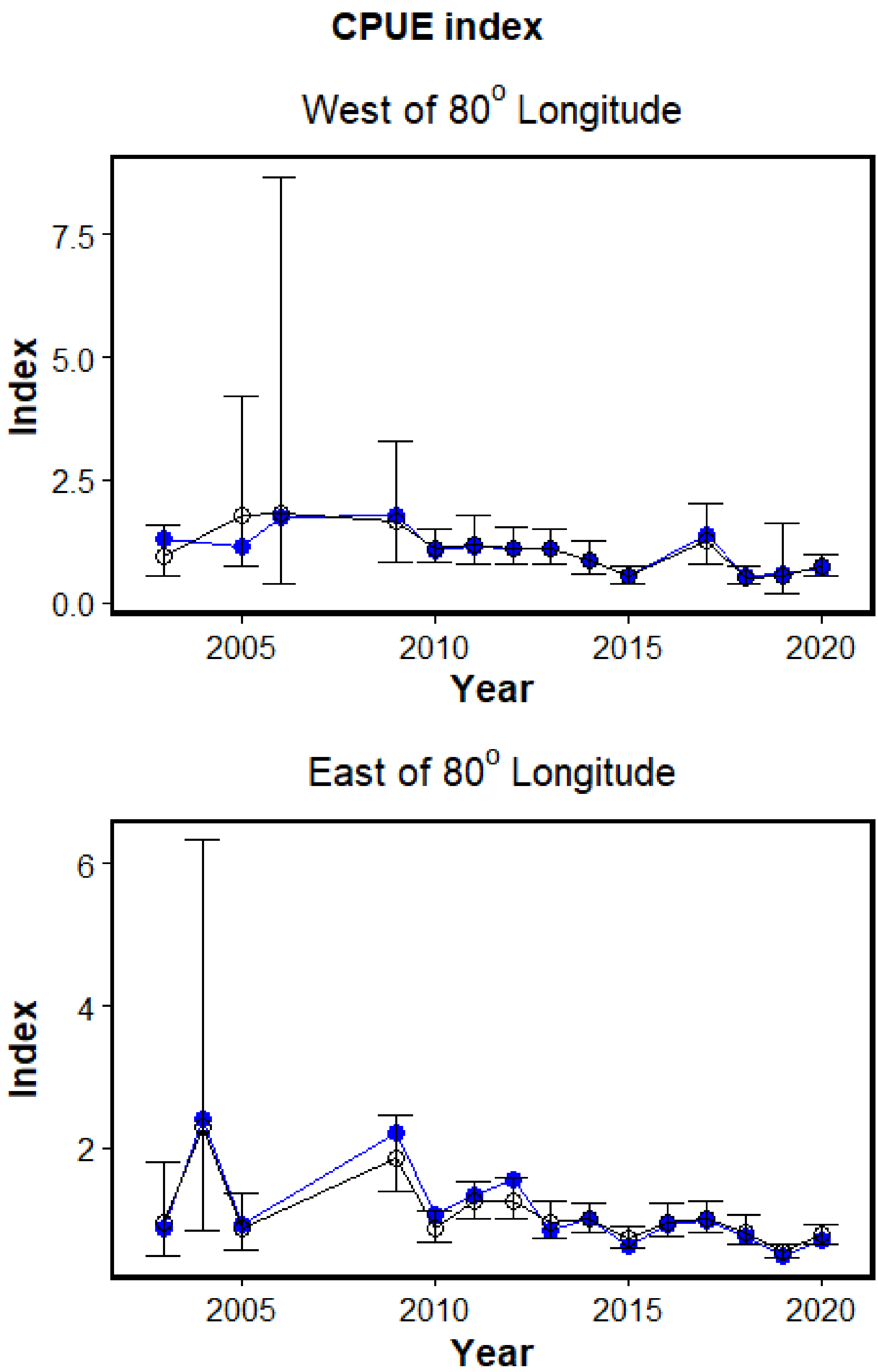

Figure 68: CPUE model showing the unstandardised (blue) and standardised (black) indices for alfonsino from the Cook Islands fleet fishing in SIOFA from 2001-2020 for the west (top) and east (bottom) areas of SIOFA (separated at 80^o of Longitude).

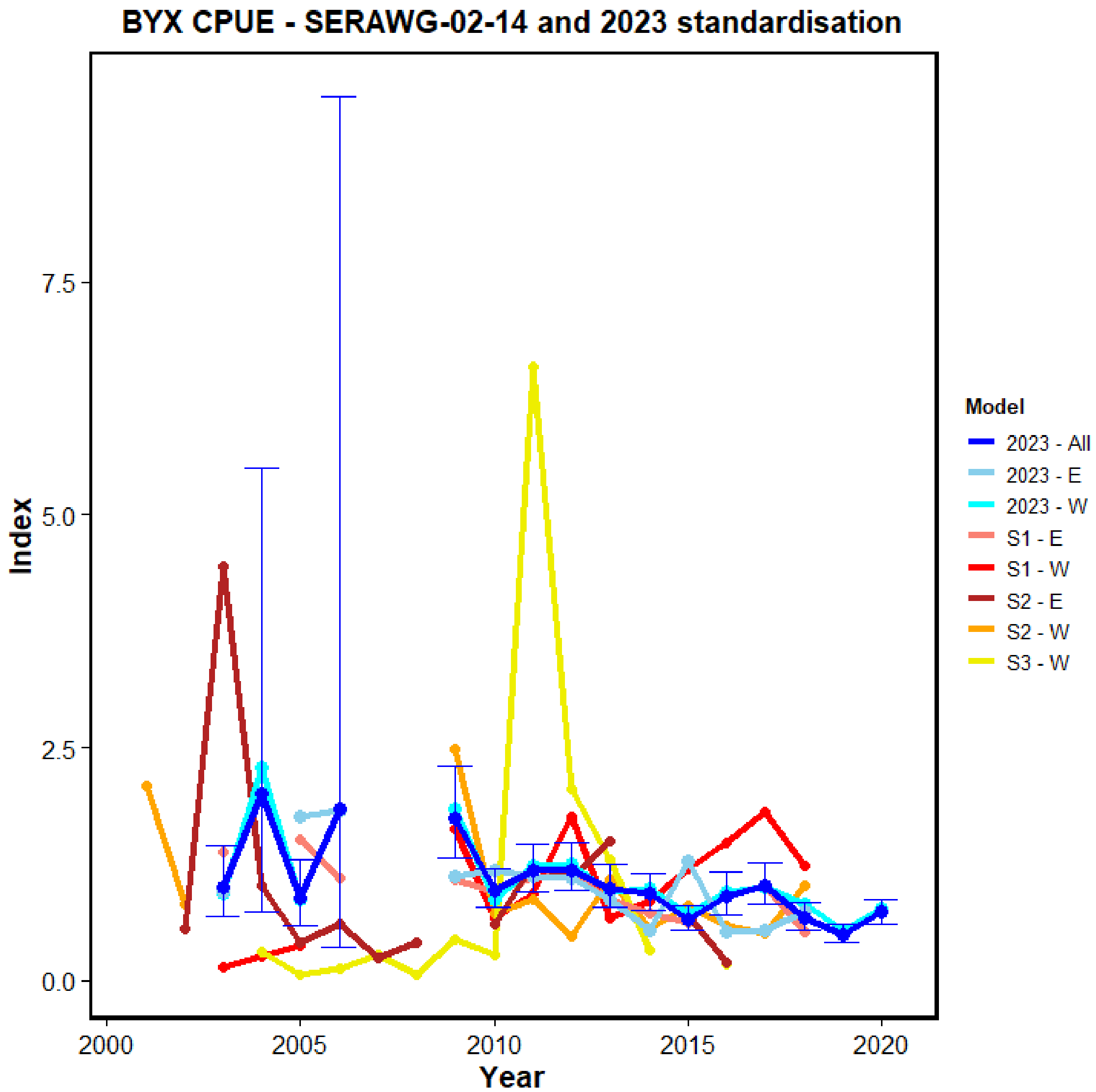

Figure 69: CPUE models from Brandao et al. (2020) that were used in the 200 alfonsino assessment as well as the 2023 alfonsino CPUE indices for all sets containing alfonsino, and those separated east and west of 80^{o}.

Appendix I

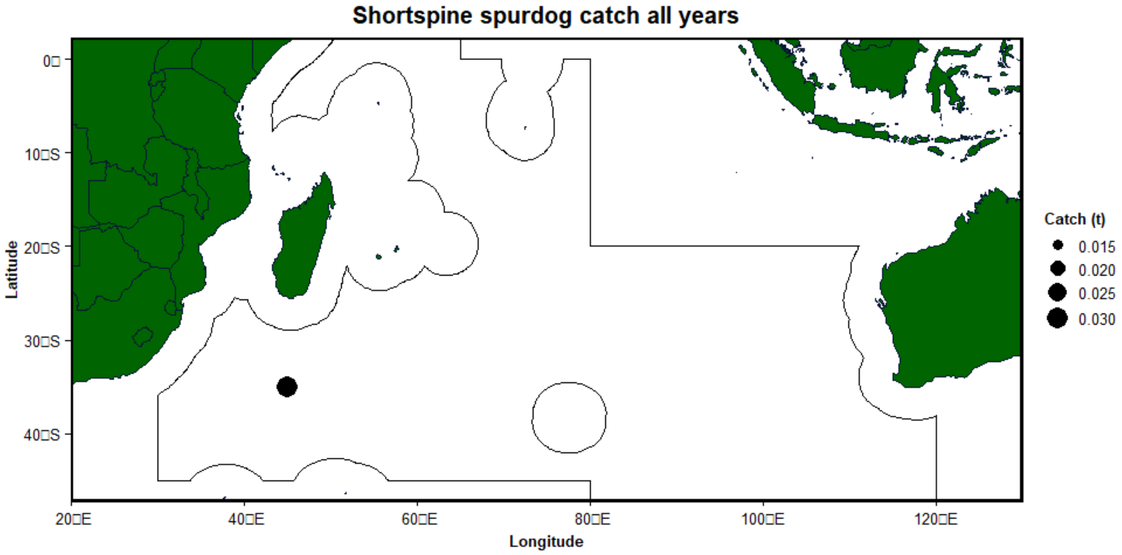

Figure AI - 1: Map of shortspine spurdog catch from 2006-2020 from the Cook Island vessels.

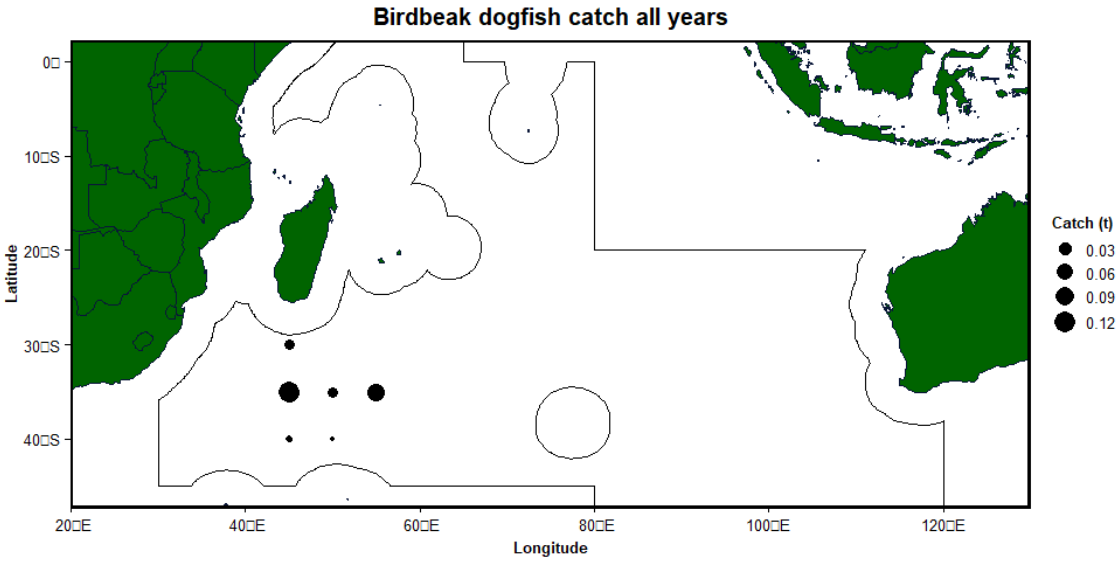

Figure AI - 2: Map of birdbeak dogfish catch from 2006-2020 from the Cook Island vessels.

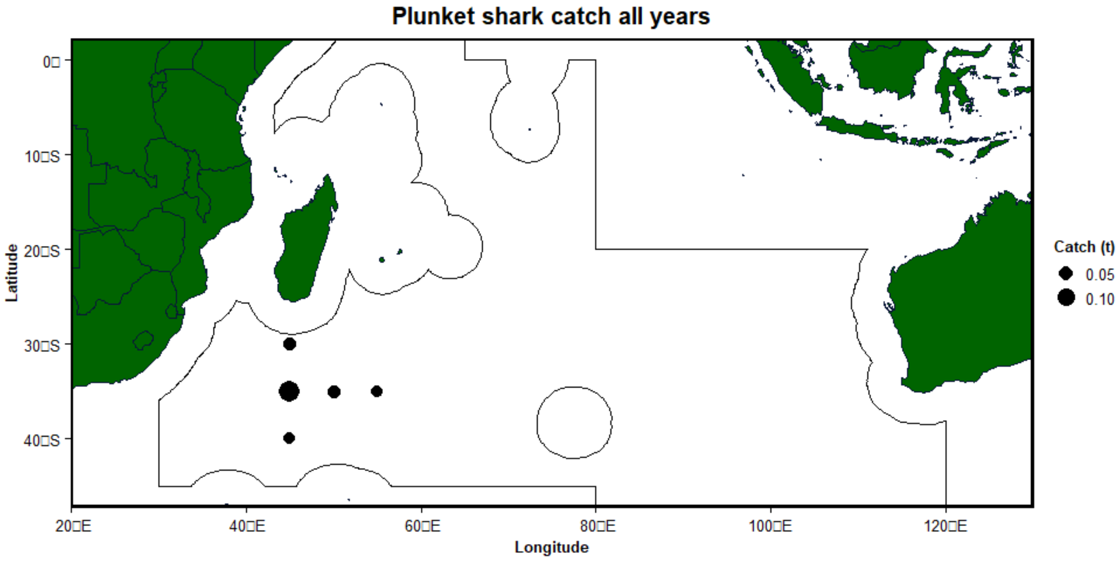

Figure AI - 3: Map of plunket shark catch from 2006-2020 from the Cook Island vessels.

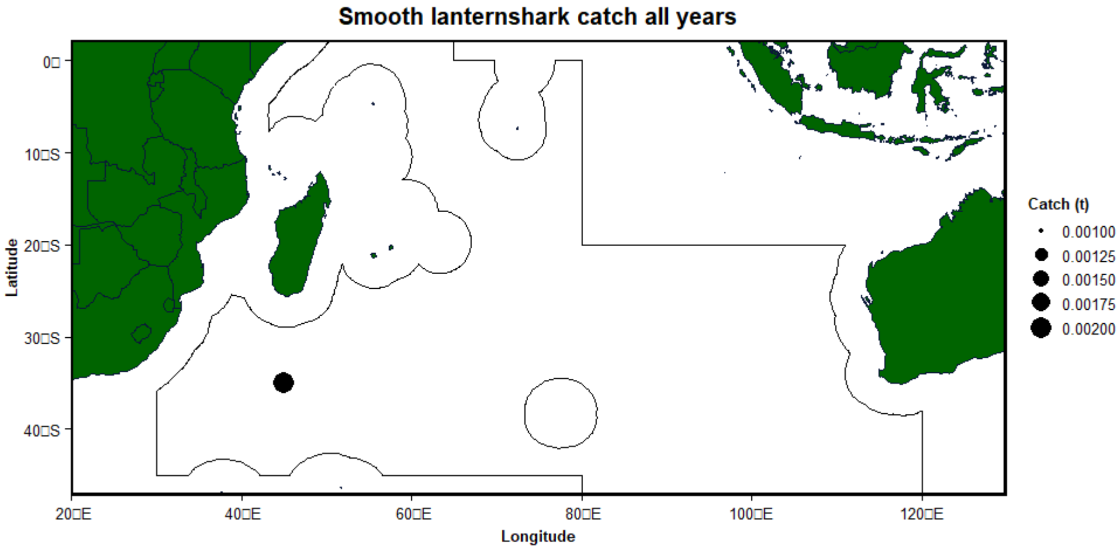

Figure AI - 4: Map of smooth lanternshark catch from 2006-2020 from the Cook Island vessels.

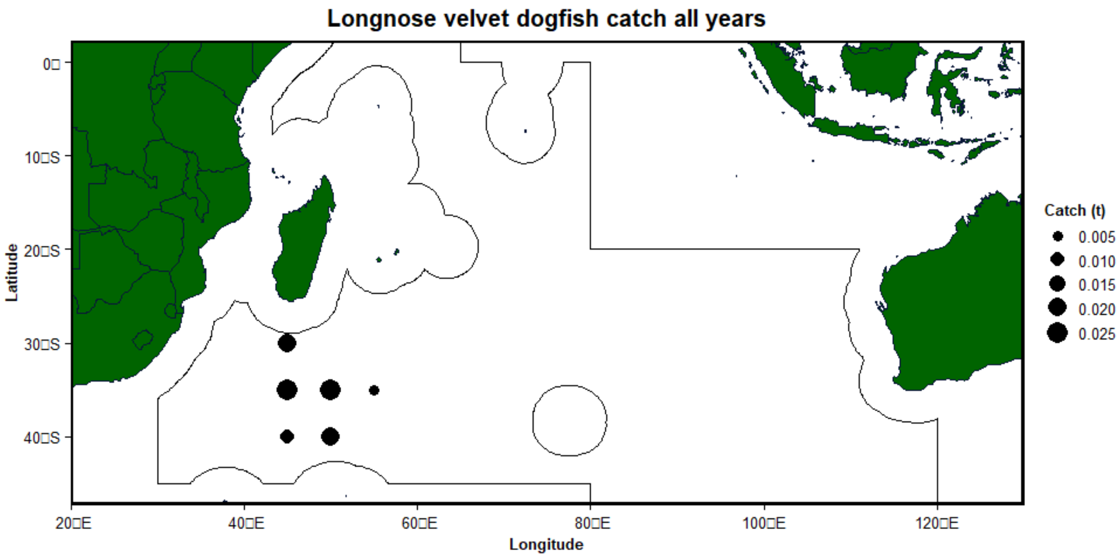

Figure AI - 5: Map of longnose valvet dogfish catch from 2006-2020 from the Cook Island vessels.

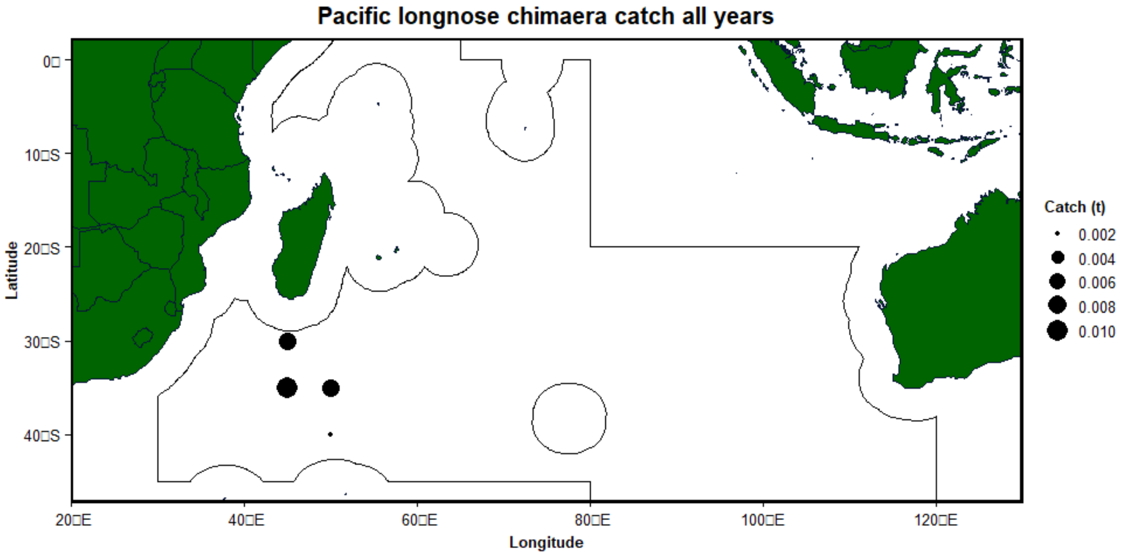

Figure AI - 6: Map of Pacific longnose chimera catch from 2006-2020 from the Cook Island vessels.

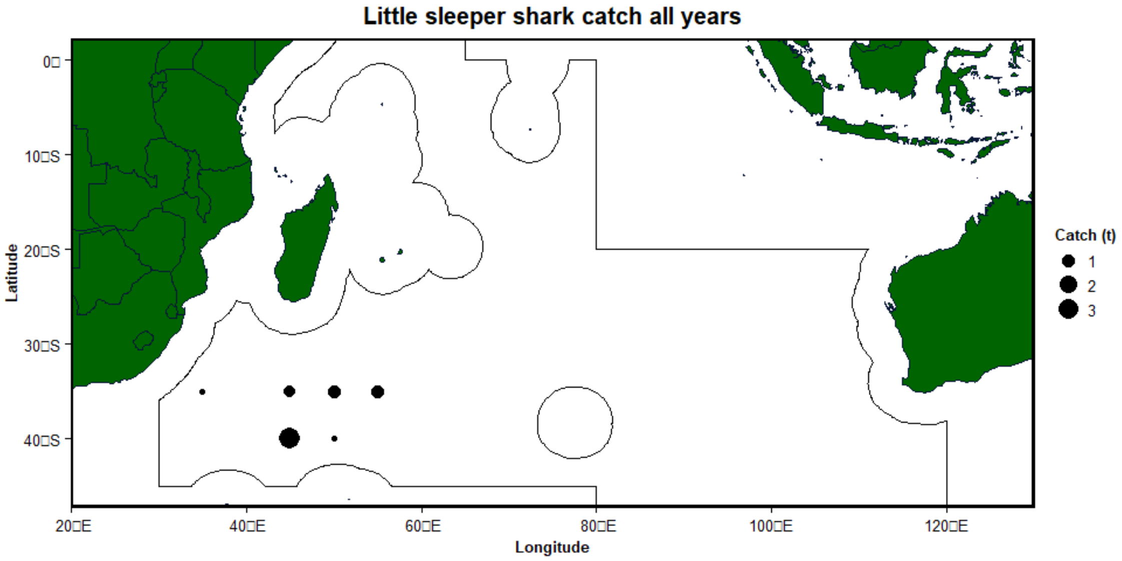

Figure AI - 7: Map of little sleeper shark catch from 2006-2020 from the Cook Island vessels.

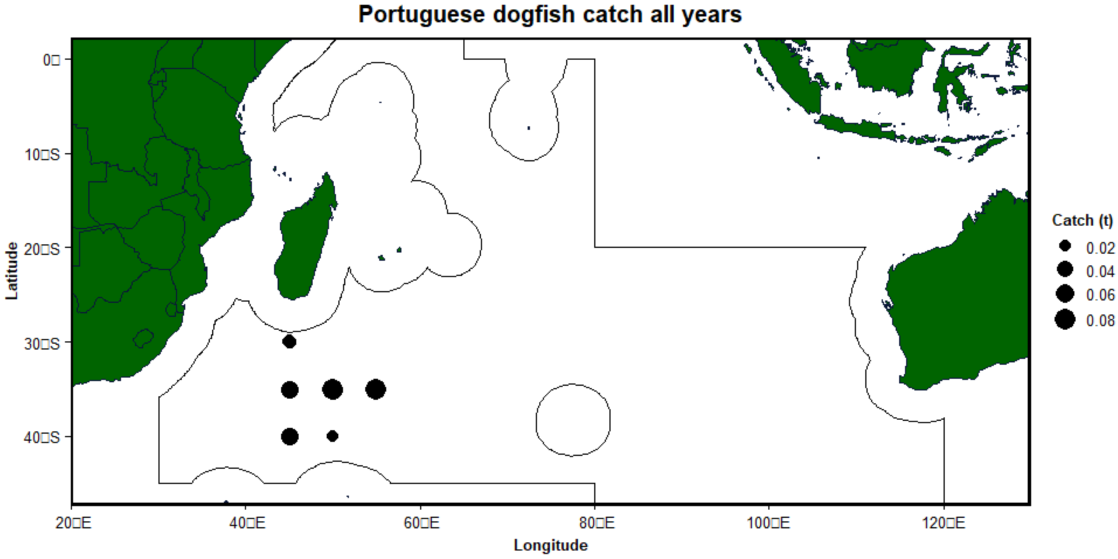

Figure AI - 8: Map of Portugese dogfish catch from 2006-2020 from the Cook Island vessels.

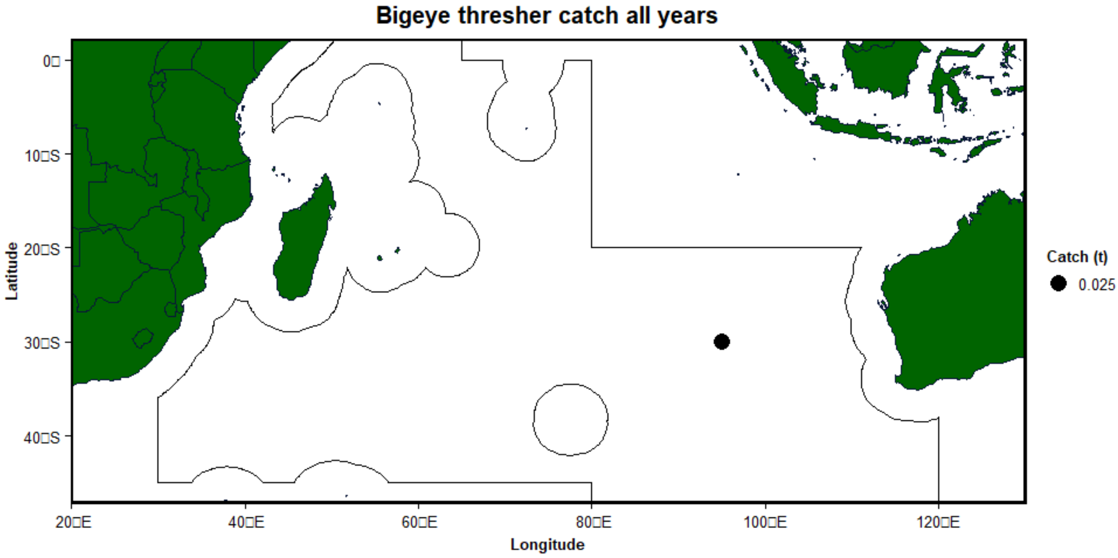

Figure AI - 9: Map of bigeye thresher shark catch from 2006-2020 from the Cook Island vessels.

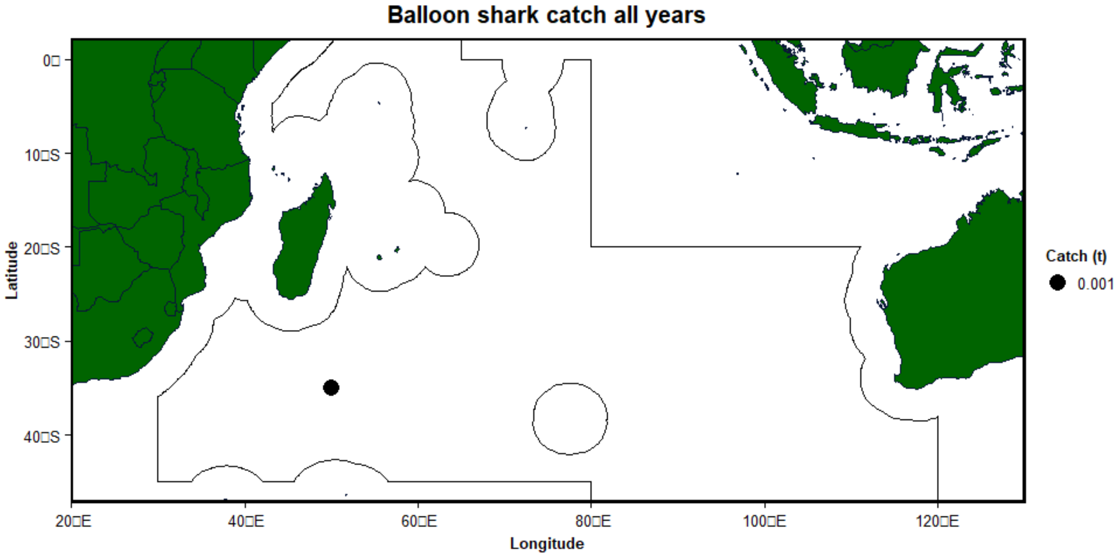

Figure AI - 10: Map of balloon shark catch from 2006-2020 from the Cook Island vessels.

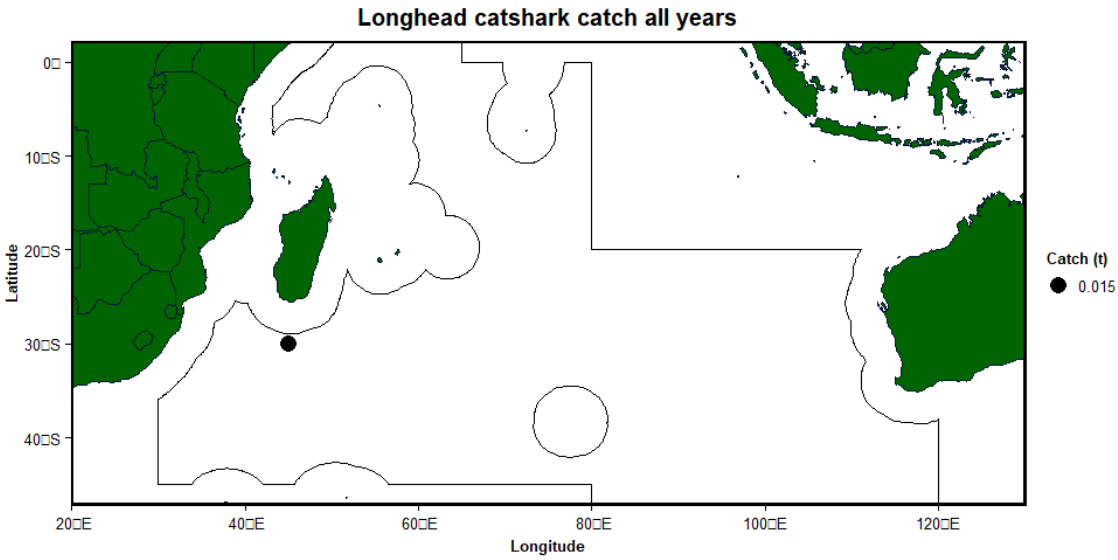

Figure AI - 11: Map of longhead catshark catch from 2006-2020 from the Cook Island vessels.

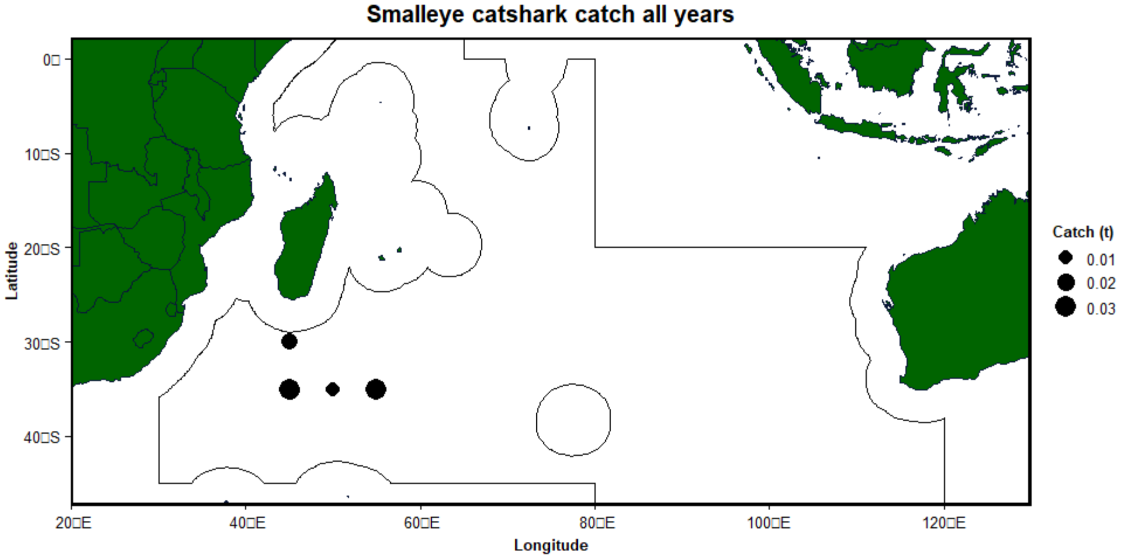

Figure AI - 12: Map of smalleye catshark catch from 2006-2020 from the Cook Island vessels.

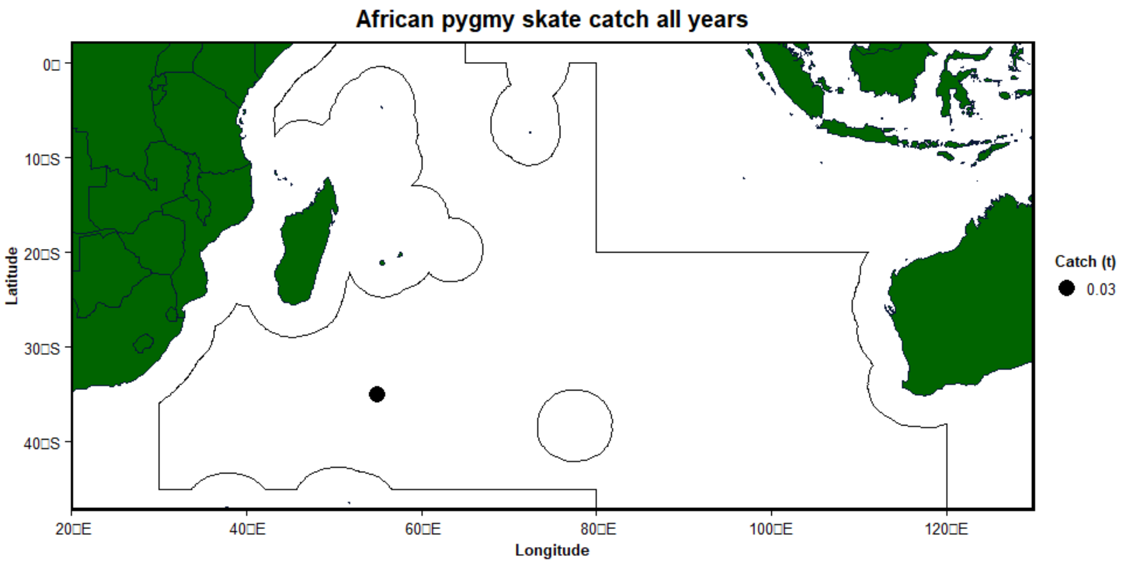

Figure AI - 13: Map of African pigmy skate catch from 2006-2020 from the Cook Island vessels.

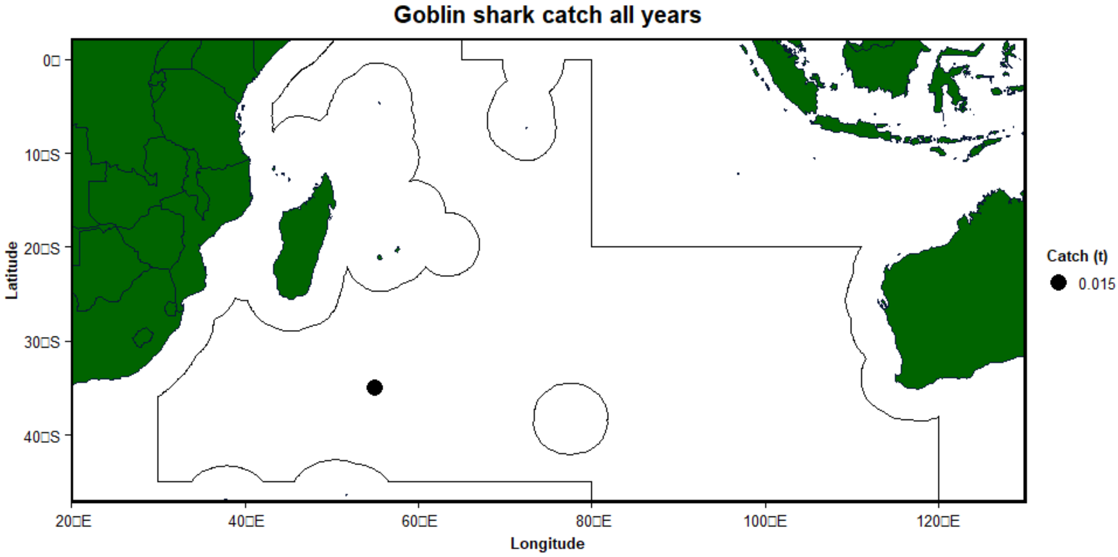

Figure AI - 14: Map of goblin shark from 2006-2020 from the Cook Island vessels.

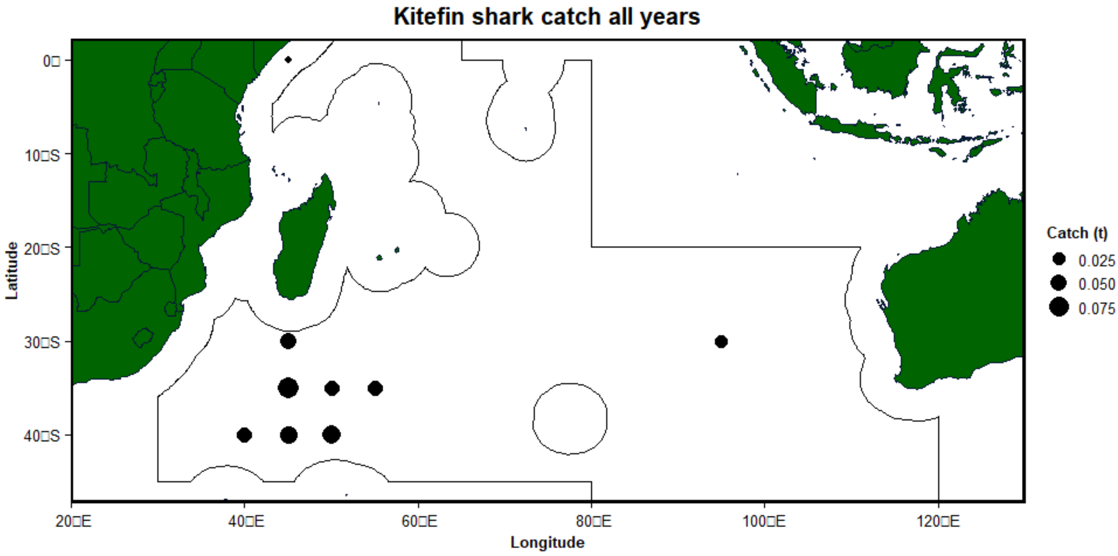

Figure AI - 15: Map of kitefin shark catch from 2006-2020 from the Cook Island vessels.

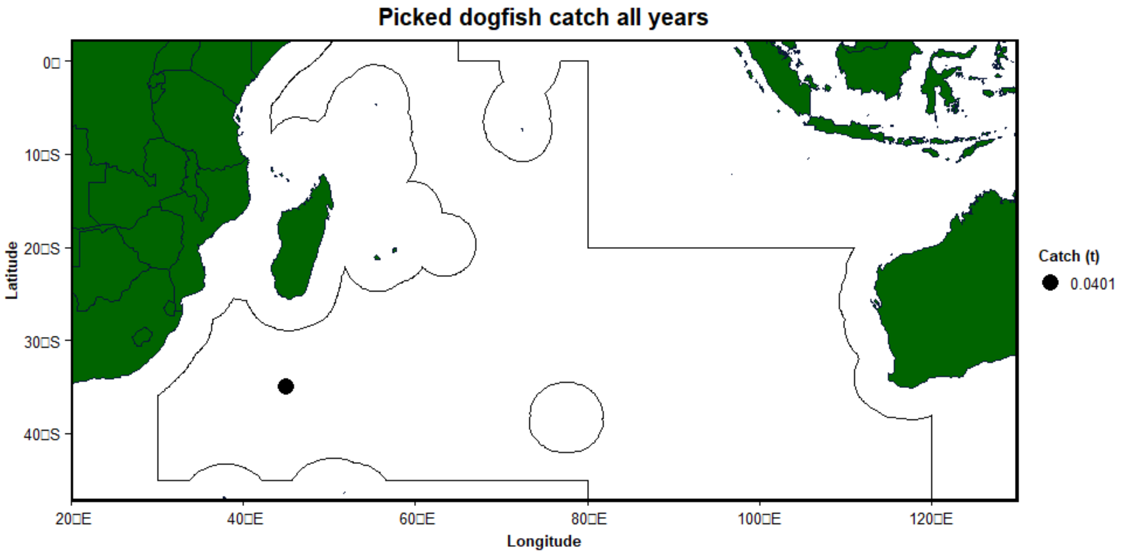

Figure AI - 16: Map of picked dogfish catch from 2006-2020 from the Cook Island vessels.

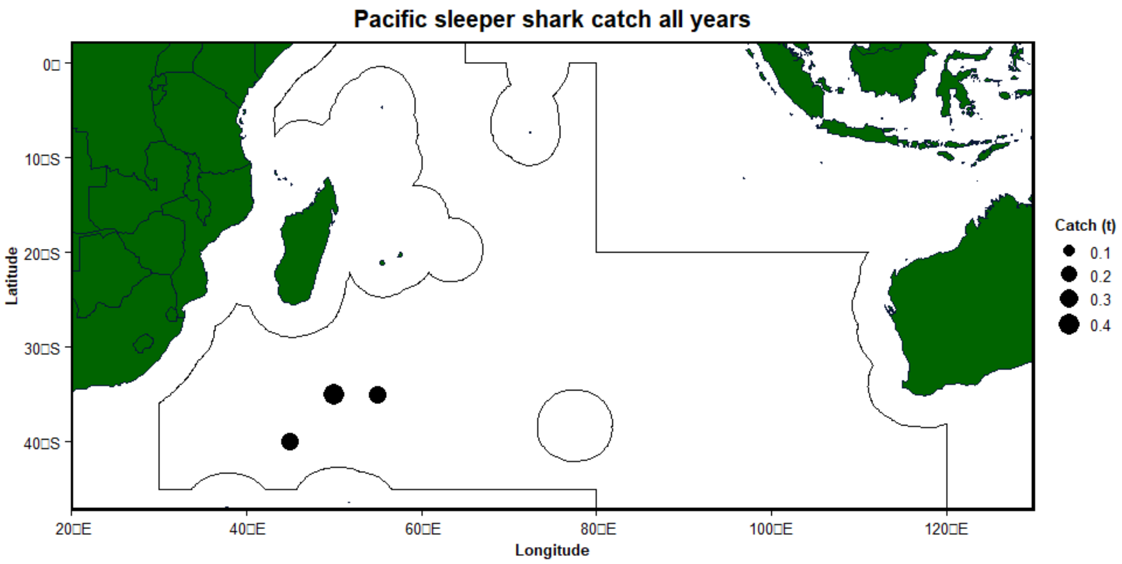

Figure AI - 17: Map of Pacific sleeper shark catch from 2006-2020 from the Cook Island vessels.

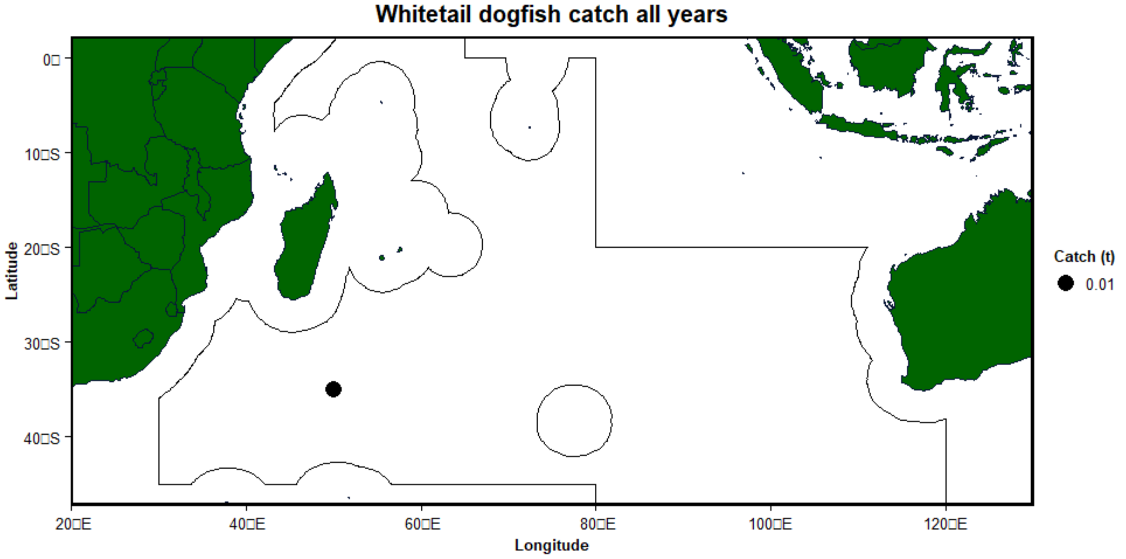

Figure AI - 18: Map of whitetail dogfish catch from 2006-2020 from the Cook Island vessels.

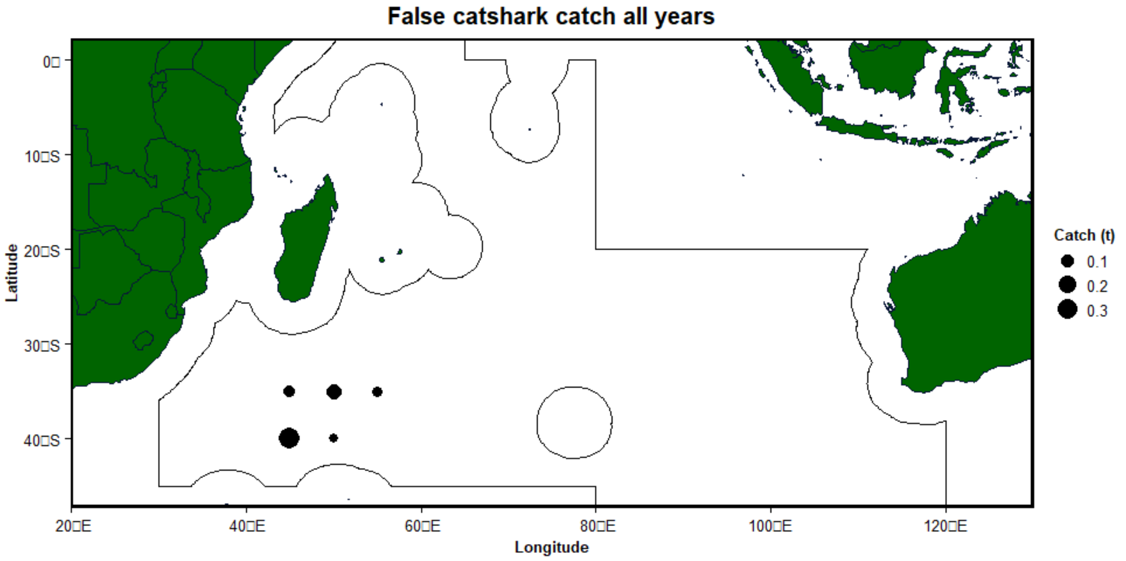

Figure AI - 19: Map of false catshark catch from 2006-2020 from the Cook Island vessels.

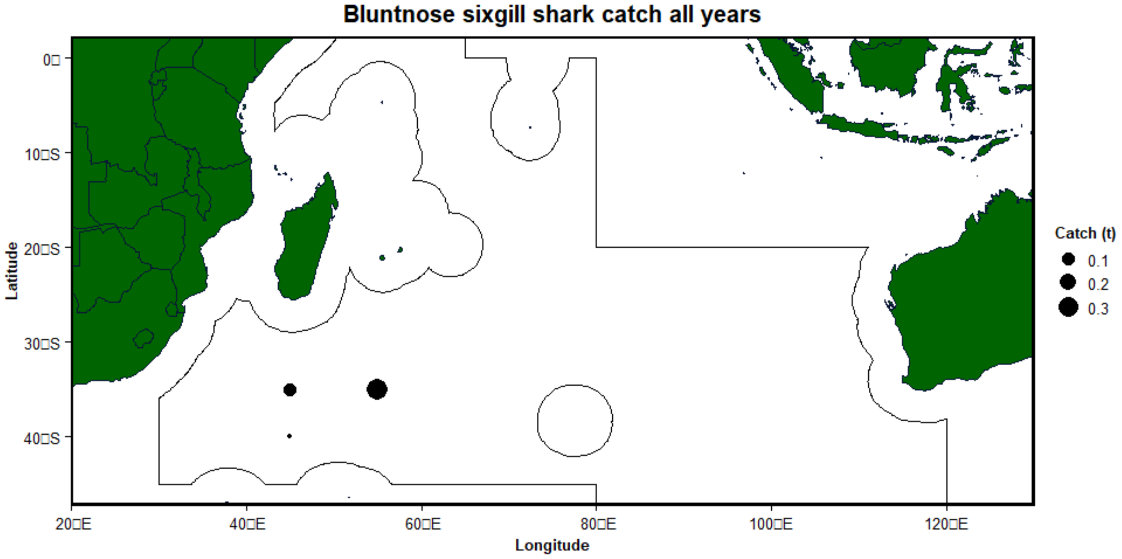

Figure AI - 20: Map of bluntnose sixgill shark catch from 2006-2020 from the Cook Island vessels.

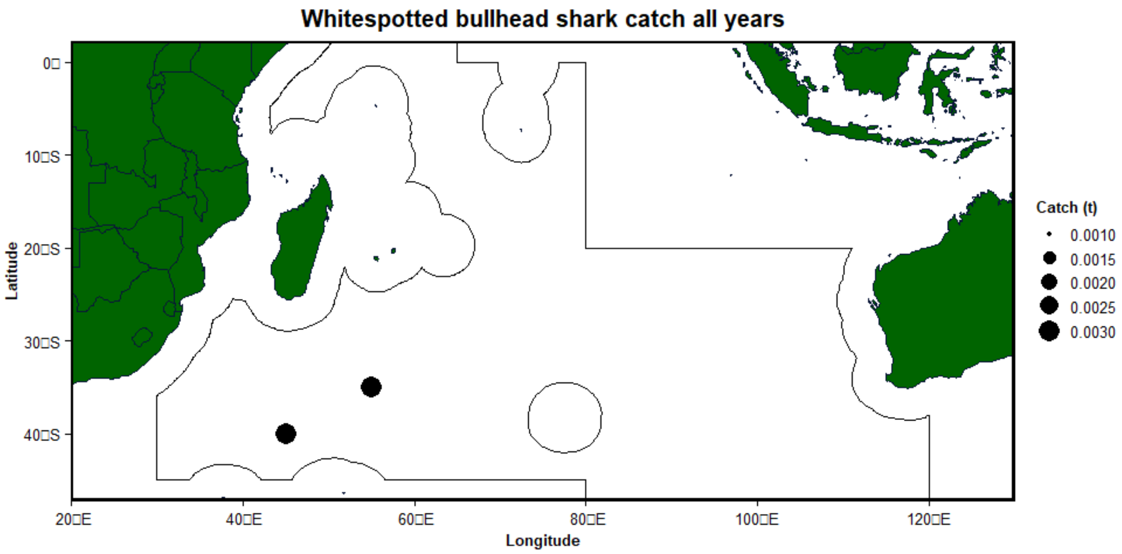

Figure AI - 21: Map of whitespotted bullhead shark catch from 2006-2020 from the Cook Island vessels.

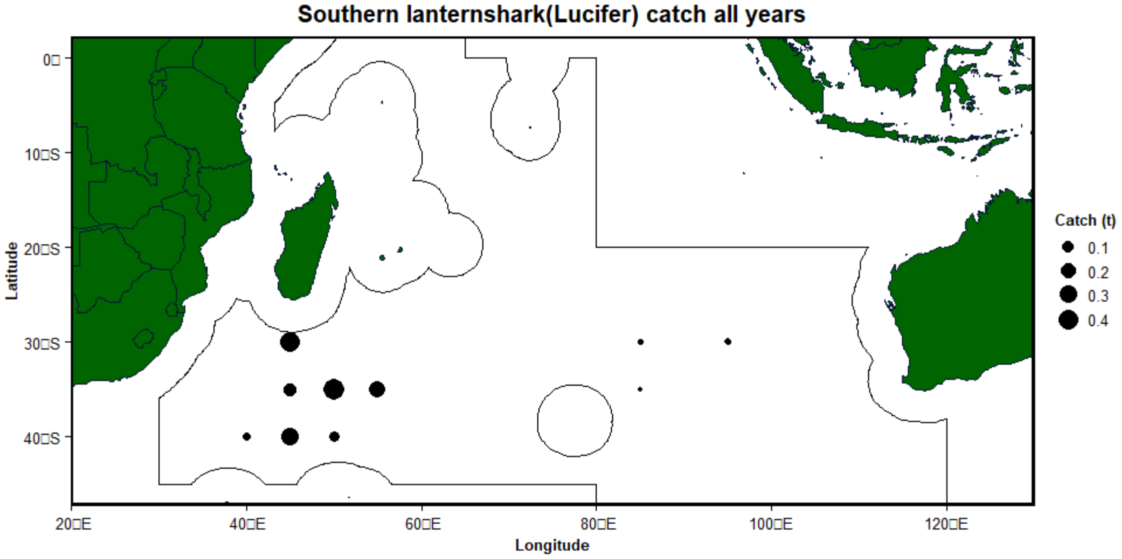

Figure AI - 22: Map of southern lanternshark catch from 2006-2020 from the Cook Island vessels.

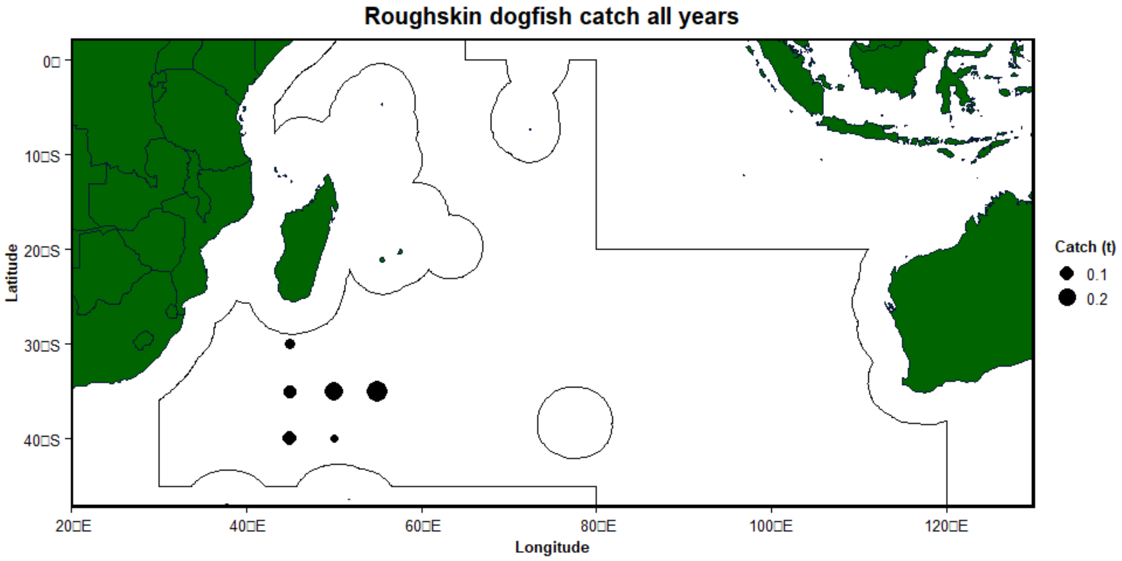

Figure AI - 23: Map of roughskin dogfish catch from 2006-2020 from the Cook Island vessels.

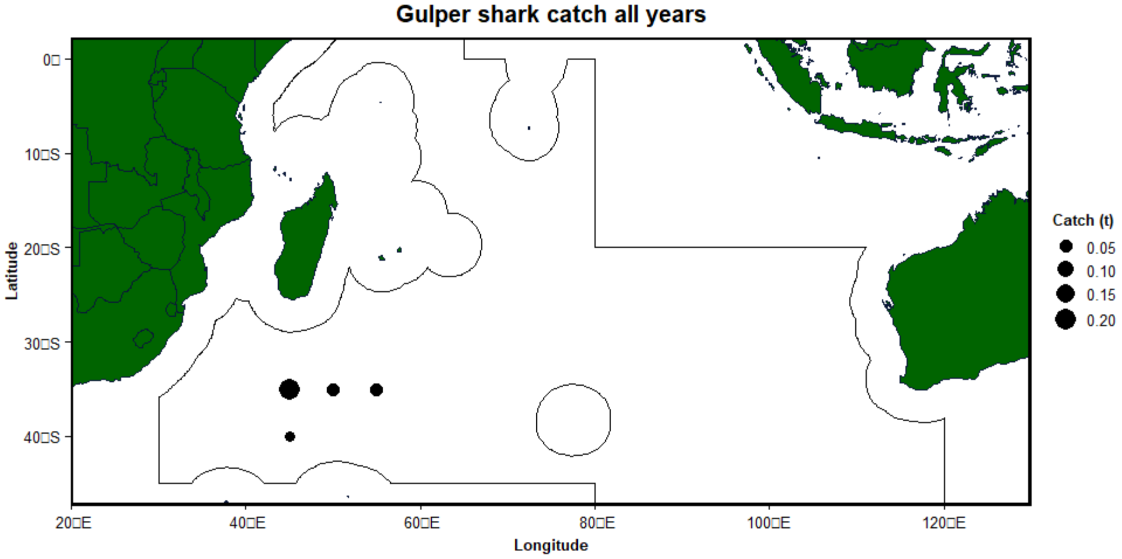

Figure AI - 24: Map of gulper shark catch from 2006-2020 from the Cook Island vessels.

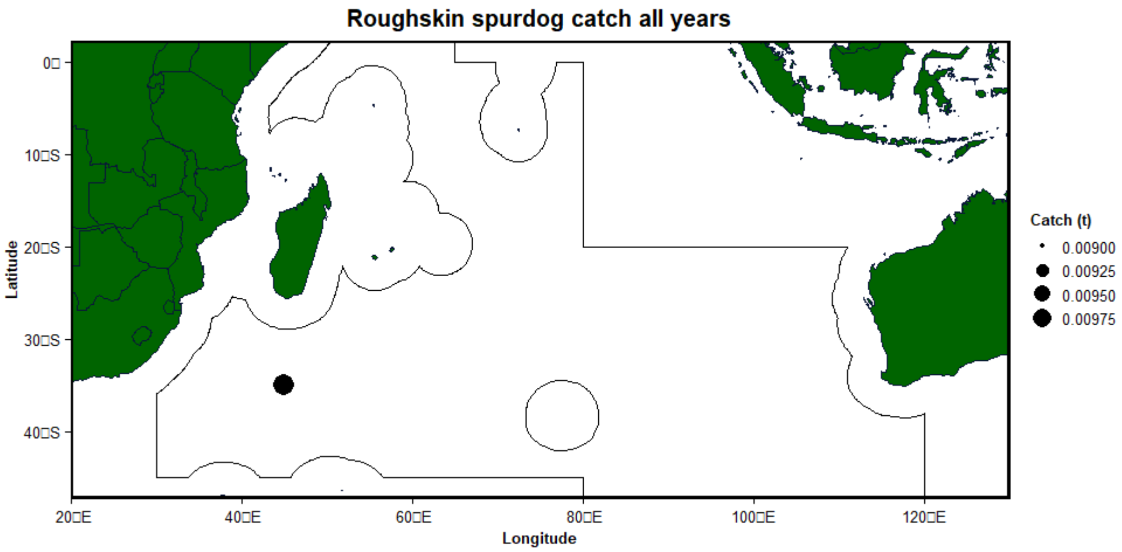

Figure AI - 25: Map of roughskin spurdog catch from 2006-2020 from the Cook Island vessels.

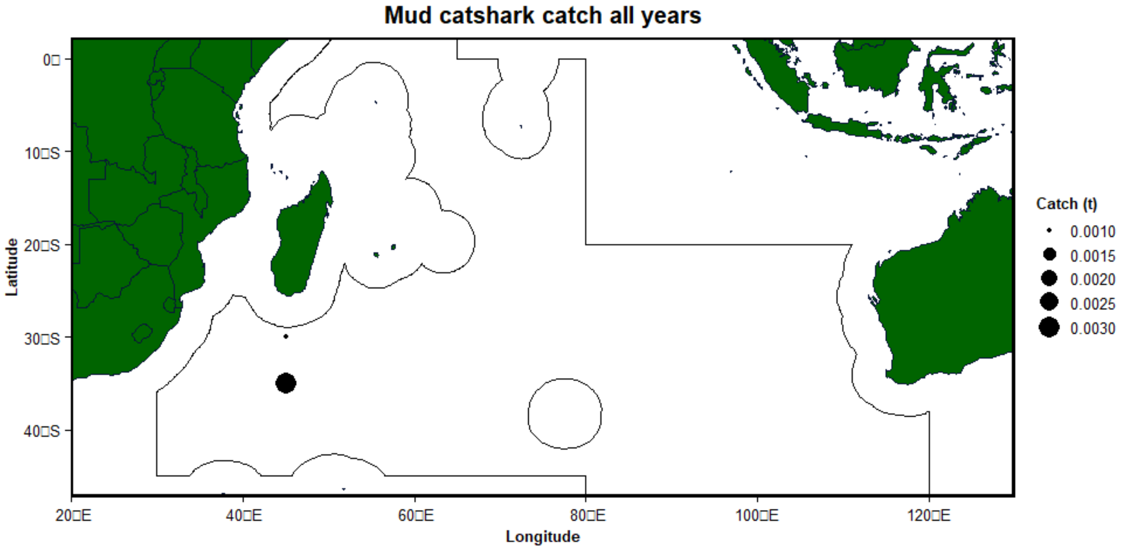

Figure AI - 26: Map of mud catshark catch from 2006-2020 from the Cook Island vessels.

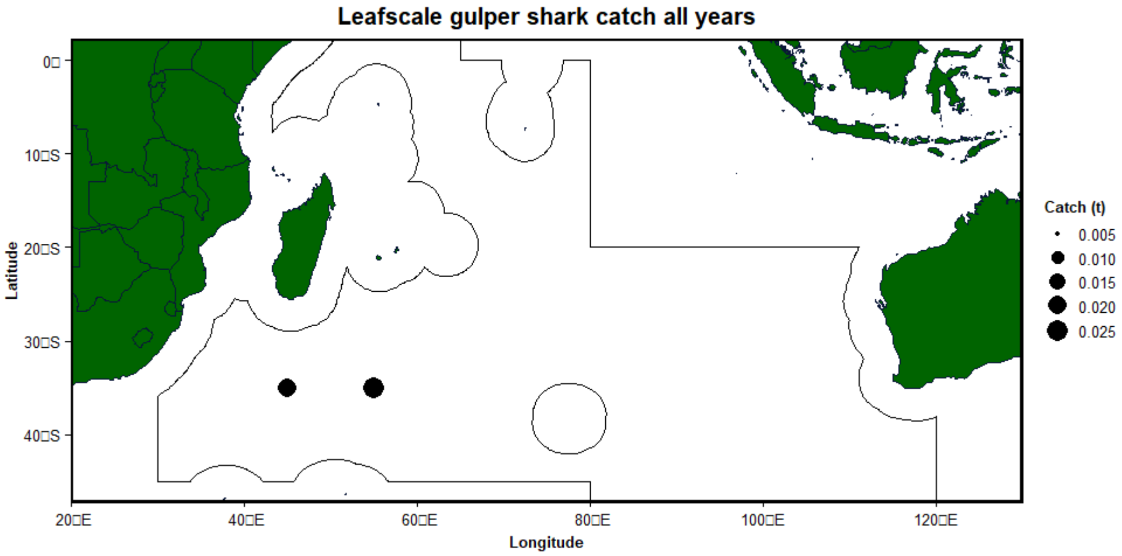

Figure AI - 27: Map of leafscale gulper shark catch from 2006-2020 from the Cook Island vessels.

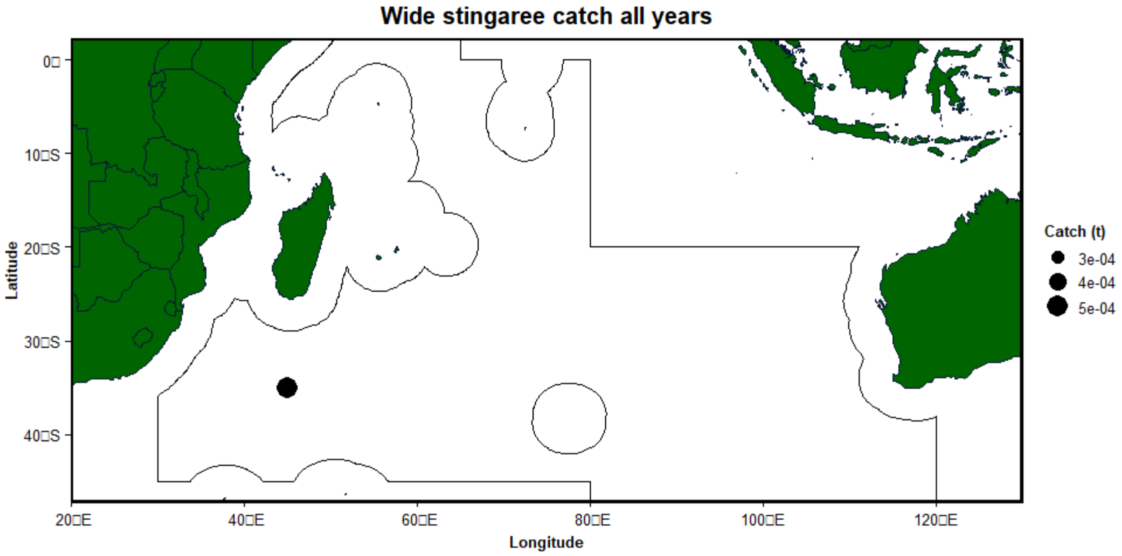

Figure AI - 28: Map of wide stingray catch from 2006-2020 from the Cook Island vessels.

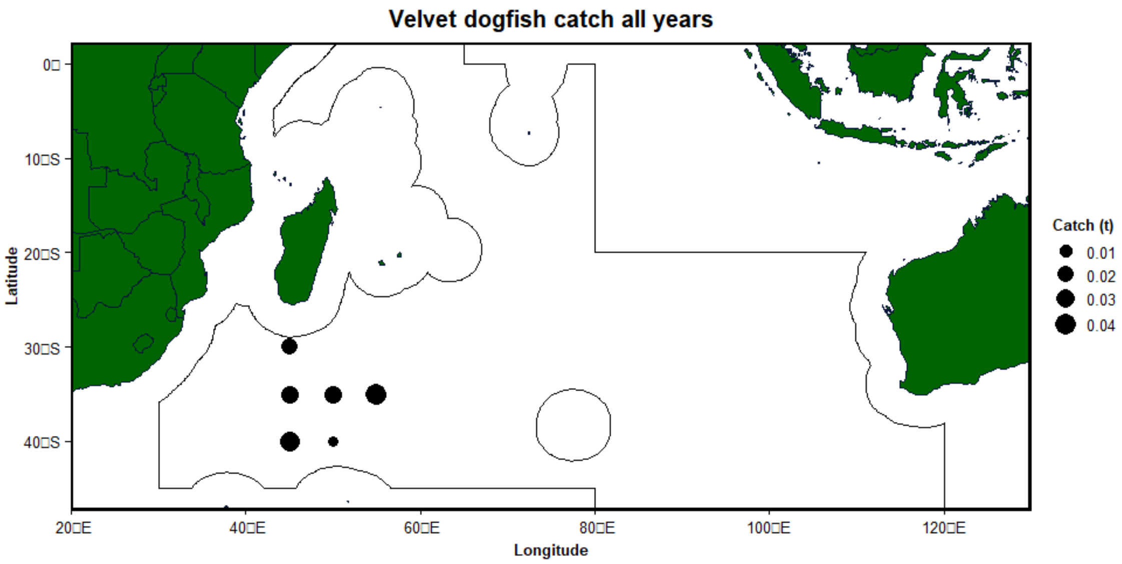

Figure AI - 29: Map of velvet dogfish catch from 2006-2020 from the Cook Island vessels.