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The interaction rate and distribution of false killer whales and rough-toothed dolphin in the PNA purse seine fishery

WCPFC-SC21-2025/EB-IP-07

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Abstract

This paper presents the trends in interaction rates and distributions of two important cetaceans false killer whales and rough-toothed dolphins. The analyses include Encounter Per Unit Effort (EPUE) trends based on observed data from 2000-2024. The data were modelled in using a general linear model to predict interaction trends. Due to the variability in the data the interaction rates were modelled in log space. The analysis includes an evaluation in trends in the distribution of both species.

The analysis showed that neither the spatial extent nor the annual encounter rate trends have changed substantially from 2000 to 2024, but the analysis showed that there is a fair amount of interannual variation.

Contents

1 Introduction

The Western and Central Pacific Ocean (WCPO) contains habitat both permanent and temporary for at least 34 different species of cetaceans including baleen whales and dolphins (Masere and Baird, 2023).

This area also contain high abundance of tuna particularly skipjack (*K*atsuwonus pelamis), yellowfin (*T*hunnus albacares) and bigeye tuna (*T*hunnus obesus) collectively as the tropical tunas which are the target of valuable fisheries. Together the WCPO catch of the skipjack and yellowfin tuna make up over 85% of the of the WCPO tuna catch and nearly 50% of the global tropical tuna catch making them the biggest tuna fishery in the world (WCPFC, 2024c). Most of the catch is skipjack tuna and from the purse seine fishery. Within the WCPO most the purse seine fishing effort for skipjack tuna takes place in the Exclusive Economic Zones (EEZs) of the PNA members states. This fishery is managed through effort limits through the PNA Vessel Day Scheme (VDS). The effort expended results in around 50,000 purse seine sets annually (WCPFC, 2024b). This activity results in interactions with unwanted species, including species of special interest (SSI) such as whale sharks, manta rays and cetaceans. While attempts are made to avoid SSI, in normal purse seine operations they are inadvertently encountered from time to time.

According to the WCPFC Secretariat during 2023, a number of cetacean interactions were reported in observer reports. These included 837 purse seine trips where 592 interactions were observed. The species encountered included a number of dolphin species such as false killer whales (*P*seudorca crassidens) and rough-toothed (*S*teno bredanensis), as well as a number of baleen whales (WCPFC, 2024a).

While some studies evaluating SSI in the WCPFC have been undertaken, the earlier analyses often focus on whale sharks (Harley et al., 2013; Clarke, 2015 and ABNJ, 2018), and a few have broadened the analyses to include cetaceans (SPC, 2011), but more recently some studies have been cetacean specific (Williams et al., 2020; Williams et al., 2021 and Masere and Baird, 2023).

This paper focuses on the interaction trends from 2000-2024 as well as the changes in distribution of false killer whales and rough-toothed dolphins. While false killer whales are considered by the International Union for Conservation of Nature (IUCN) to be near threatened, rough-toothed dolphins are listed as Least Concern `www.iucn.org`, but managing and minimising the interactions of both species is important for members of the Parties to the Nauru Agreement (PNA).

2 Methods

Within the WCPFC, and according to the PNA and Tokelau member state regulations, all vessels are required to collect the relevant catch and effort data and observers also record data independently during fishing operations. All purse seine sets are recorded on logsheets and since 2008 all purse seine vessels within PNA waters are required to have 100% observer coverage. There was a reduction in observer coverage in 2020 and 2021 due to the COVID-19 pandemic and in 2023 and 2024 observer reports have had delays in receipt and processing and as such may be incomplete at the time of collating the data for this analysis. The observers record interactions with SSI on the PS3 and GEN2 forms. These data are then checked and verified and stored on a central database held at the Pacific Community (SPC) in Noumea.

PNA member country and Tokelau data were extracted from the Pacific Community (SPC) database. Purse seine vessel logsheet and observer data from all PNA members and Tokelau EEZs as well as all PNA member country vessels fishing on the high seas were requested. The data were at the set level and the extract included all sets and all marine mammal and all whale shark interactions. The data were provided at the species level and included estimates of weight and numbers of individuals.

The data include low numbers of many species and as such the species were grouped into the two species of interest (false killer whales and rough-toothed dolphin) and eight broad categories (Dolphins, Seals, bottlenose dolphins, short-finned pilot whales, Whales, Whale sharks, Tuna and unidentified mammals). A few broad descriptive summaries were undertaken.

For false killer whales and rough-toothed dolphins the raw encounter per unit effort (EPUE) data were evaluated and these data were modelled approximating the Zhou and Griffiths (2008) SAFE methods using a General Linear Model (GLM) in R (R Core Team, 2024). There are very few factors to include in a model of purse seine data and the data were characterised by low numbers of interactions and large differences in the number of individuals encountered. As such the spatial extent of EPUE through time was estimated in log space and represented in a very simple model:

log(EPUE) year + Latitude + Longitude

Other models that included month and mean ENSO value were also attempted but were uninformative.

In addition, to evaluating trends in encounter rate, we evaluated the trends in spatial distribution. This involved evaluating the number of 1x1 degree blocks where catch was made, and evaluating trends in the spatial extent over time. These data were used to model the physical extent of the population and any changes in distribution as well as to assess if there were any obvious persistent hotspots. Due to the low encounter rate, data were grouped into 4-year bins.

3 Results

The fishing effort included in this analysis comes from all purse seine fishing effort recorded on logsheets within PNA member EEZs as well as PNA flagged vessel data from outside of PNA waters. The fishing effort is widely spread across the PNA member EEZs, some parts of the high seas as well as non-PNA member EEZs, but is concentrated in PNA member EEZs between 5^{o}N and 10^{o}S and is higher west of 180^{o} (Figure 1).

Less than 2% of observed sets contain species of special interest (SSI) (Figure 2). In sets where SSI are observed whale sharks are the most frequently observed followed by whales and false killer whales (Figure 3).

Only 0.2% of sets recorded on logsheets have SSI recorded (Figure 4). As with the observed data, in sets where SSI are recorded on logsheets whale sharks are the most frequently observed followed by whales and false killer whales (Figure 5). However, these data also demonstrate that the logsheet reporting has improved particularly from 2017 onwards.

Of the cetacean interactions, on the logsheets unidentified whales are most frequently recorded followed by false killer whales, Bryde's and sei whales and rough-toothed dolphin (Table 1). In the observed data set false killer whales, Bryde's and sei whales and rough-toothed dolphin are the species that are most frequently seen interacting with fishing operations (Table 1).

3.1 False killer whales

After whale sharks, false killer whales are the second most frequently encountered SSI species and make up 14% of the observed sets that interact with SSI.

False killer whales are widely distributed in the Pacific ocean and are encountered in all PNA member EEZs as well as by PNA member vessels fishing on the high seas, but tend to be encountered mostly between 10^{o}N and 15^{o}S. There are no obvious discernible hotspots in the encounter distribution and they appear to have a wider north-south distribution in the west of the area compared to the east but this could be reflective of the fishing effort (Figure 6).

The unstandardised observed encounter rate data are variable and characterised by low encounter numbers with highly varied numbers of individuals within each encounter (Figure 7). There was no difference between the encounter rates of associated and unassociated sets. The model standardisation of the encounter rates showed a slight decline at the start of the series, but it fluctuates without trend from 2010 to 2020, after which it increases again (Figure 8).

Overall, the area of observed encounters increased from the early to mid-2000s to around 2014 after which it has declined (Figure 9). Evaluating this spatially again did not reveal persistent hotspots through time but does suggest more frequent encounters to the west, but the encounter rate does not change substantially from east to west (Figure 10). The modelled spatial extent however seems to indicate a wider extent pre-COVID, but there is not unidirectional trend in the encounter extent (Figure 11 and Figure 12). Overall, the cumulative spatial extent of the fishery and interactions shows that as the fishery expanded in spatial extent the area where interaction took place remained low initially but then increased through to 2019 after which it has remained flat suggesting that the full spatial extent has been reached (Figure 13).

The increase in the spatial extent of the encounters at the start of the series is possibly due to an increase in reporting rather than any change on the population. The declines through to 2020 is within the normal variability of the data, but the decline thereafter may be due to changes in the observer coverage due to the COVID-19 pandemic when observer coverage declined in 2020-2022. As noted above the 2023 and 2024 data may be incomplete due to processing delays.

The false killer whale condition on capture information shows that the majority of individuals are alive and healthy on capture with a small number recorded as dead or unknown condition (Figure 14). Generally, the records of un-

known condition and alive with no health status recorded have declined, suggesting that reporting has improved since 2010.

3.2 Rough-toothed dolphin

Rough-toothed dolphins are the sixth most frequently interacted SSI species (following whale sharks, false killer whales, sei whales, bottle nose dolphins and short-finned pilot whales) and constitute only 2% of observed sets that interact with SSI.

Rough-toothed dolphins occur in all the PNA member EEZs but are rarely encountered by PNA member vessels fishing on the high seas, and tend to be encountered mostly between 10^{o}N and 10^{o}S. There are no obvious discernible hotspots in the encounter distribution (Figure 15).

The unstandardised observed encounter rate data are variable and characterised by low encounter numbers with highly varied numbers of individuals within each encounter (Figure 16). Overall, the encounter rates are more frequent and provided a more realistic trend in the FAD associated sets. The encounter rates were higher in 2013-2017 but were lower before and after that time.

The unstandardised observed encounter rate data are variable and characterised by low encounter numbers with highly varied numbers of individuals within each encounter (Figure 16). The model standardisation of the encounter rates fluctuates without trend throughout the date series (Figure 17).

Overall, the area of observed encounters increased from the early to mid-2000s to around 2013 and then declined again thereafter with a single large increase again in 2019 (Figure 18). Evaluating this spatially did not reveal persistent hotspots through time and the distribution was relatively consistent through time (Figure 19). The modelled spatial extent, however, suggests that the encounter extent is retentively consistent through time (Figure 20 and Figure 21). Overall, the cumulative spatial extent of the fishery and interactions shows that as the fishery expanded in spatial extent the area where interaction took place remained low initially but then increased from 2010 through to 2020 after which it has remained flat suggesting that the full spatial extent has been reached (Figure 22).

The rough-toothed dolphin condition on capture information shows that between 25% and 50% are recorded as dead with the remainder being alive and healthy or unknown status (Figure 23). Generally, the records of unknown condition and alive with no health status recorded have declined, suggesting that reporting has improved since 2010.

4 Discussion

SSI encounters are rare events (<2% of sets). In sets where SSI are observed whale sharks are the most frequently observed with various cetaceans or groups of cetaceans being less common than whale sharks. Williams et al. (2020) and Williams et al. (2021) provided an overview of cetacean interactions in both the purse seine and longline fisheries of the WCPO. The overall observed interaction rates with cetaceans have been influenced by changes in observer coverage as well as changes to the WCPFC conservation and management measures (Masere and Baird, 2023).

As with previous studies in the WCPO purse seine fishery (Williams et al., 2020; Williams et al., 2021 and Masere and Baird, 2023) false killer whales were the cetacean species with the highest number of interactions. Previous reports have also cited concerns about the high proportion of mortalities overall for rough-toothed dolphins since 2020 (Masere and Baird, 2023).

4.1 False killer whales

False killer whales are a tropical and warm temperate dolphin species widely distributed in the Pacific ocean, but naturally rare throughout its range (Palmer et al., 2023). They are encountered in all PNA member EEZs as well as by PNA member vessels fishing on the high seas, but tend to be encountered mostly between 10^{o}N and 15^{o}S. Whereas their biological distribution is much more extensive between 30^{o}N and 30^{o}S across the Pacific Ocean but may have a wider distribution than that in the west with records in New Zealand as far south as 50^{o}S and to northern Japan. This suggests that the PNA fishery interacts with a fairly small limited distribution of the population although Palmer et al. (2023) noted that some residential populations exist and the amount of genetic mixing between the central western tropical area and the rest of the Pacific is unknown. As we do not

know whether genetic structure exists in central western tropical Pacific false killer whales we can't be sure how much of the population is interacting with purse seine fishing gear.

In this analysis we assessed the trends in encounter rate and assume that, that is a proxy for abundance. We evaluated the actual encounter rate as well as the distribution of encounters. As we do not see a simultaneous decline in the EPUE and the spatial extent of the interactions it seems unlikely that the population is declining. This assumption seems logical noting the high survival rate in the encounters for false killer whales with purse seine gear.

4.2 Rough-toothed dolphin

Rough-toothed dolphins are a relatively small widely distributed dolphin found in deep waters in tropical, subtropical and warm temperate regions Donato et al. (2019).

As with false killer whales we assume that encounter rates are a proxy for abundance. The actual encounter rate as well as the distribution of encounters were relatively flat. As we do not see a simultaneous decline in the EPUE and the spatial extent of the interactions it seems unlikely that the population is declining. Rough-toothed dolphins are classified as least concern by the IUCN, but little is known about their population size and structure Donato et al. (2019). However, with the high mortality rates of rough-toothed dolphins when encounters with purse seine gear occur, work should be undertaken to identify ways to minimise encounters and improve survival.

Rough-toothed dolphins are one of the smallest pelagic dolphins Donato et al. (2019) and this may be a factor in their higher mortality rates during encounters. Developing an understanding of where and when in the setting operation the mortalities are occurring would help to plan strategies for mortality mitigation. The WCPFC Scientific Committee should develop a plan to assess the reasons for the higher mortality rates of rough-toothed dolphins in purse seine operations and then consider appropriate strategies to mitigate that mortality or reduce the encounter rates.

For both rough-toothed dolphins and false killer whales the populations trends evaluated here were limited in their scope. There would be value in using all Pacific purse seine and longline observer data to develop population models that better represents extent of their populations.

5 Recommendations

We recommend that the WCPFC Scientific Committee:

1. Develop population models to assess trends in rough-toothed dolphins and false killer whales using all Pacific purse seine and longline observer data.
2. Develop a plan to assess the reasons for the higher mortality rates of rough-toothed dolphins in purse seine operations; and
3. Consider developing appropriate strategies to mitigate that mortality.

Acknowledgements

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Tables

Table 1: The species composition and percentage of cetaceans interactions recorded on logsheets and observed in the PNA purse seine fishery.

Species	Reported	Observed
Aquatic mammals nei	0.38	1.53
Baleen whales nei	3.75	1.83
Beaked whales nei	0.11	0.34
Blainville's beaked whale	0.77	0.23
Blue whale	0.98	0.75
Bottlenose dolphin	0.98	1.30
Bryde's whale	18.88	28.79
Common dolphin	0.86	0.60
Dolphins nei	2.30	0.05
Dwarf sperm whale	0.22	0.03
False killer whale	20.59	29.39
Fin whale	0.00	0.80
Fraser's dolphin	0.01	0.03
Ginkgo-toothed beaked whale	0.11	0.15
Harbour seal	0.00	0.00
Humpback whale	0.11	1.34
Indo-Pacific bottlenose dolphin	0.80	0.66
Killer whale	0.11	0.03
Long-beaked common dolphin	0.04	0.23
Melon-headed whale	1.57	0.64
Minke whale	2.14	1.08
Pacific white-sided dolphin	0.11	0.00
Pantropical spotted dolphin	0.18	0.07
Pilot whales nei	0.04	0.00
Pygmy killer whale	0.78	0.47
Pygmy sperm whale	0.02	0.67
Risso's dolphin	1.75	0.97
Rough-toothed dolphin	3.11	4.84
Sei whale	5.05	17.08
Short-finned pilot whale	1.46	3.17
Sperm whale	0.67	0.33
Spinner dolphin	0.64	0.94
Spotted dolphins nei	0.05	0.06
Striped dolphin	0.02	0.15
Toothed whales nei	0.11	0.32
Whale (unidentified)	31.18	0.71

Figures

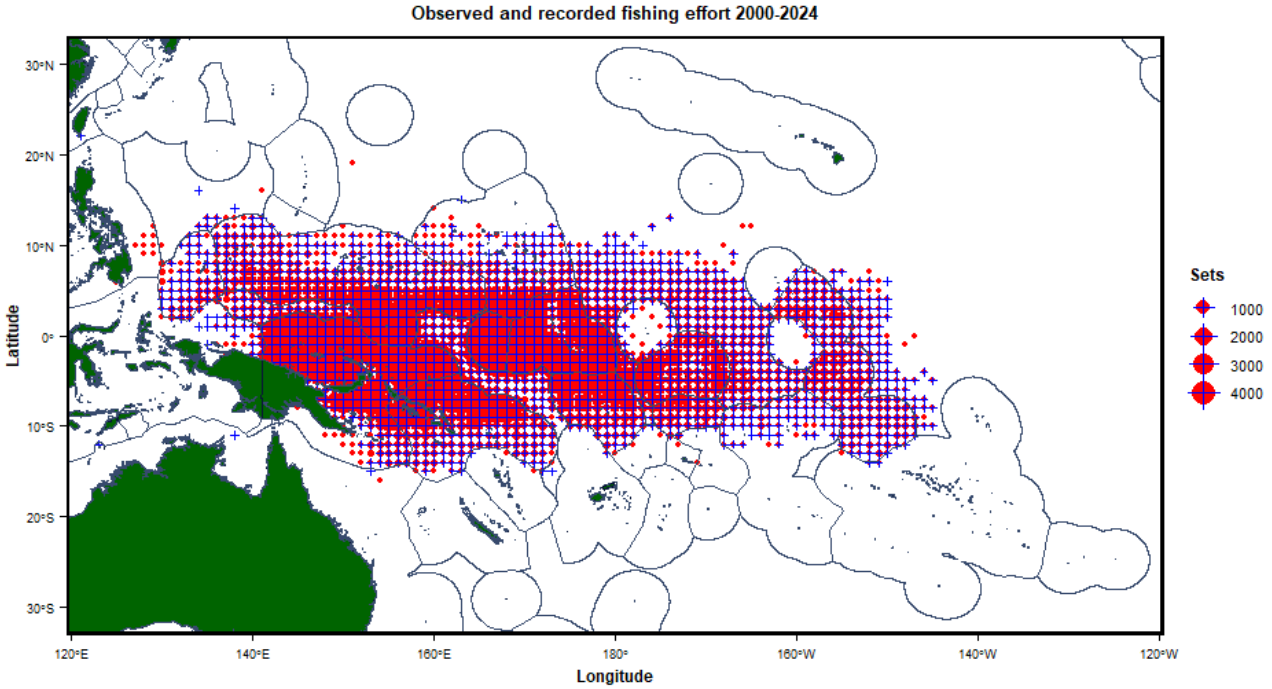

Figure 1: Fishing effort recorded on logsheets (blue crosses) and observer forms (red dots) in the PNA purse seine fishery including all sets in PNA Member EEZs and PNA Member vessels fishing outside of PNA waters.

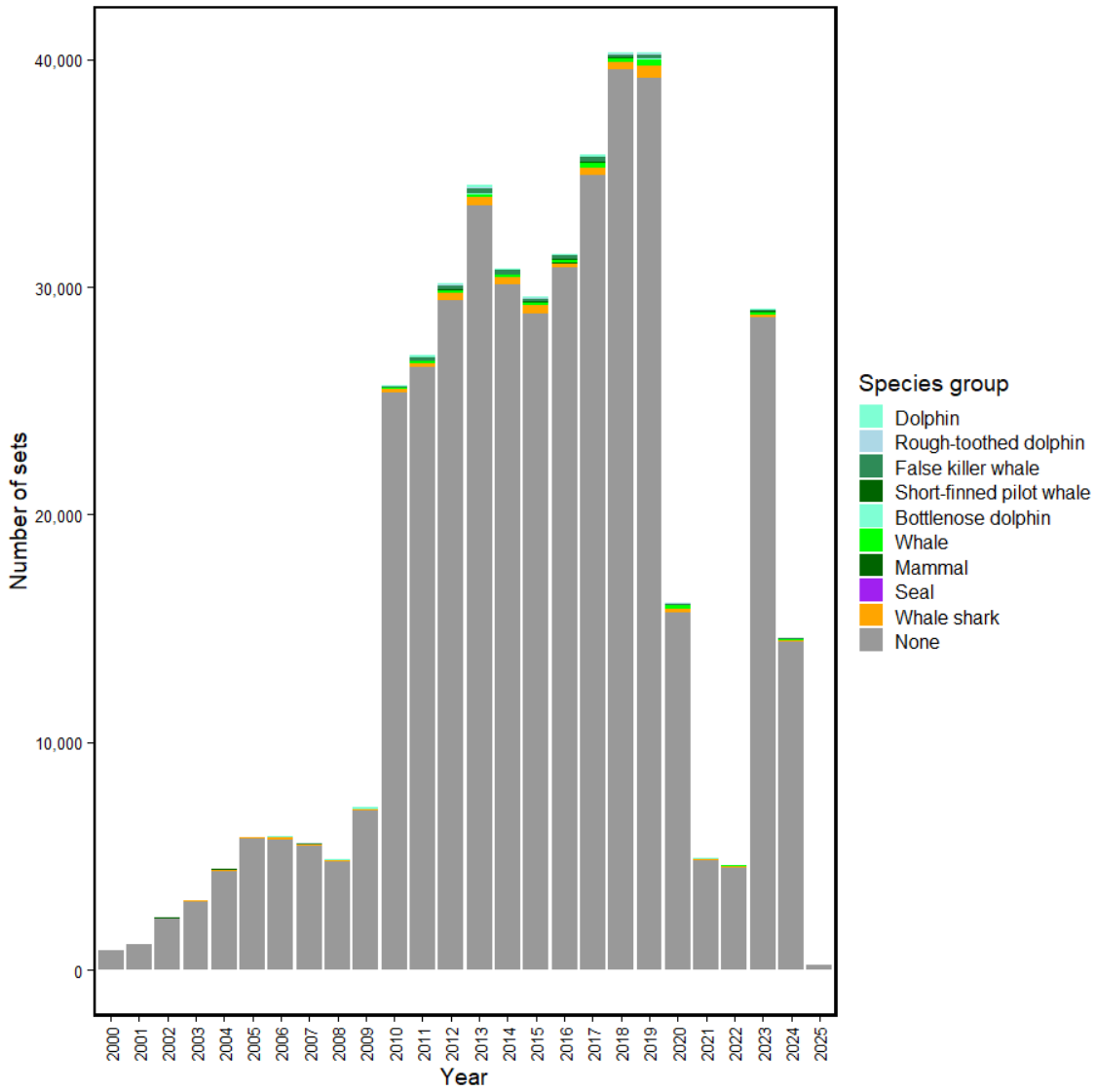

Figure 2: Observed sets in the PNA purse seine fishery showing sets with no species of special interest (SSI) interactions and sets with SSI interactions by SSI group.

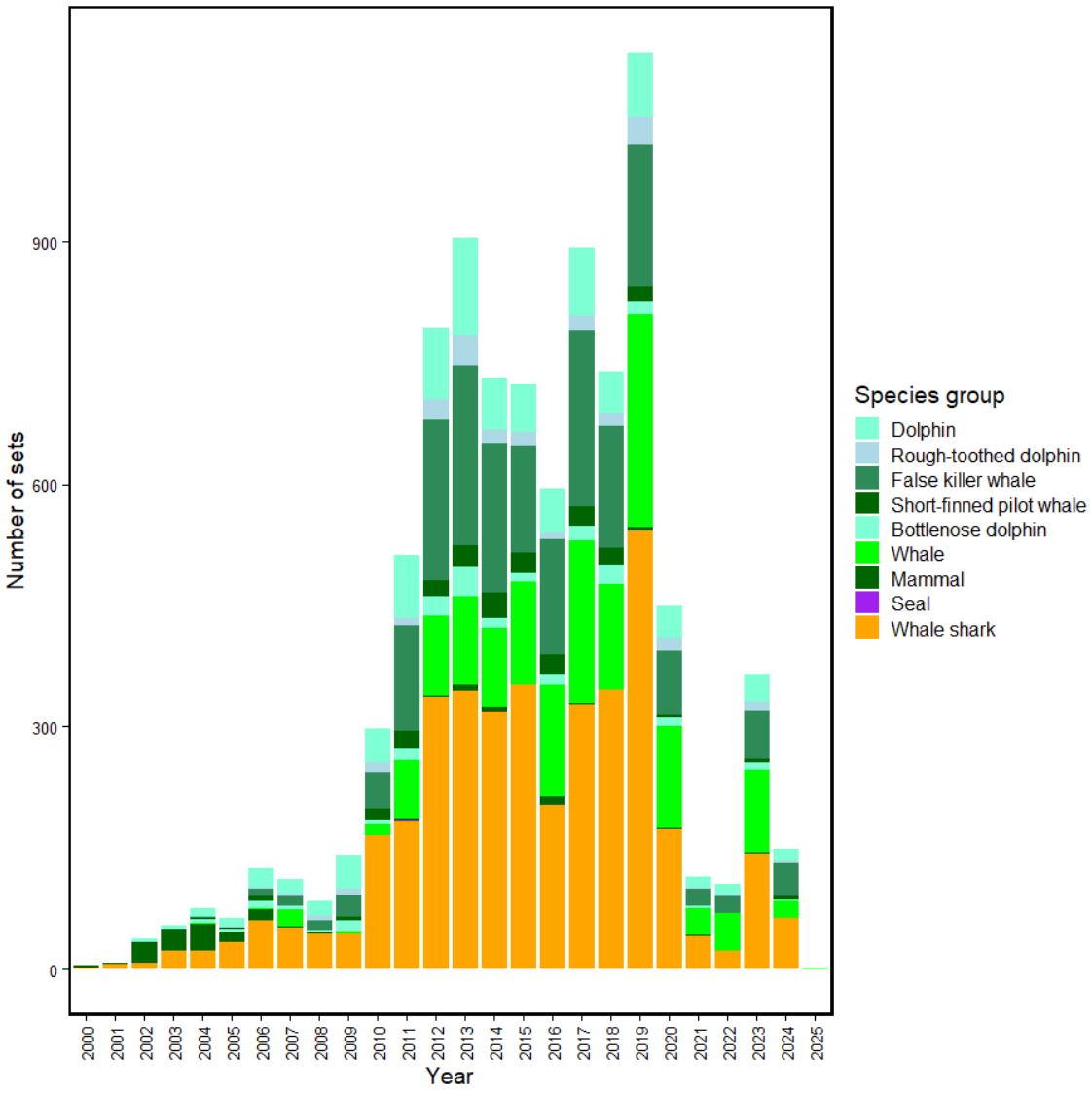

Figure 3: Observed sets in the PNA purse seine fishery showing sets interacting with species of special interest (SSI) by SSI group.

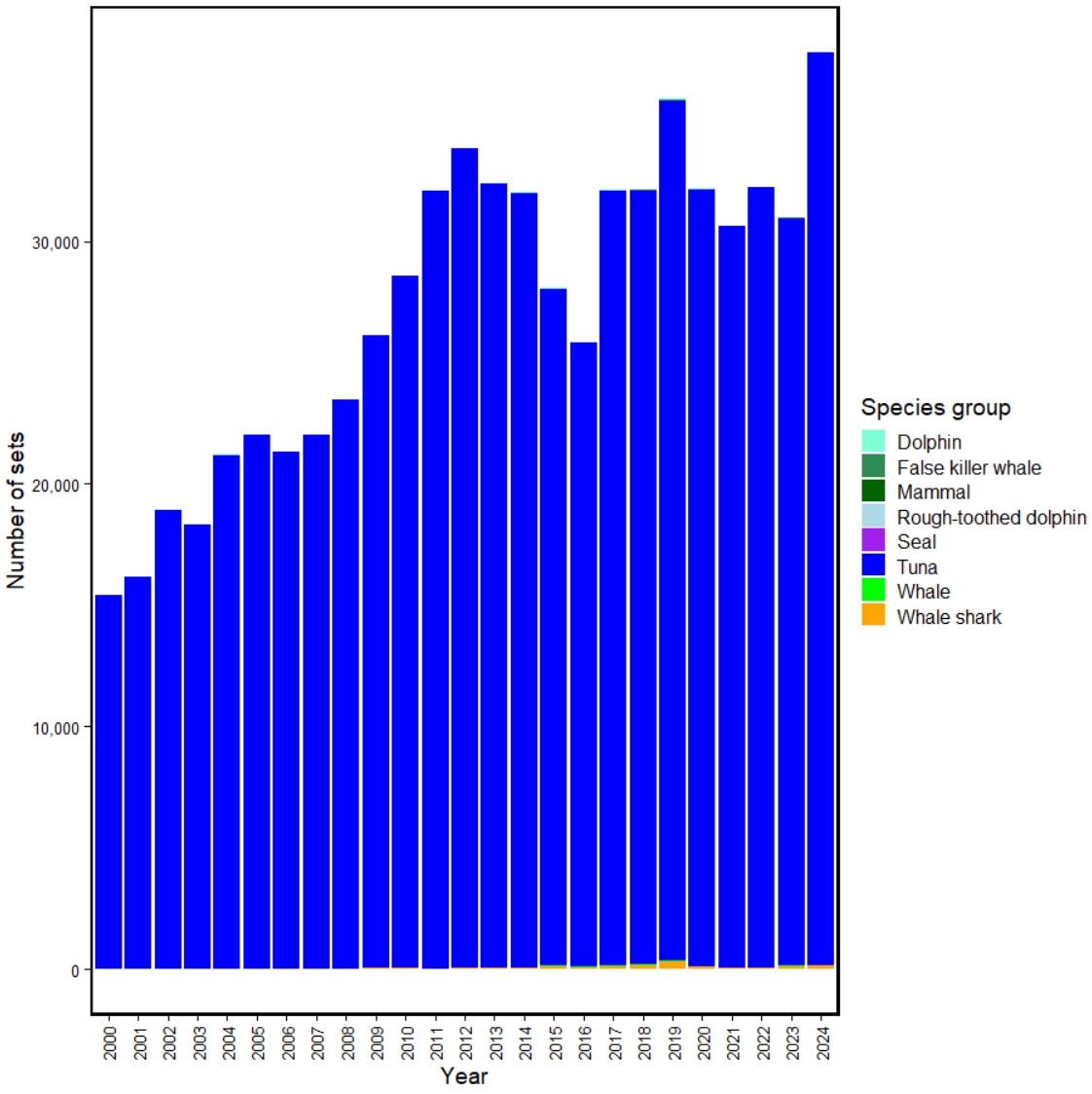

Figure 4: Reported (logsheet) sets in the PNA purse seine fishery showing sets with no species of special interest (SSI) interactions and sets with SSI interactions by SSI group.

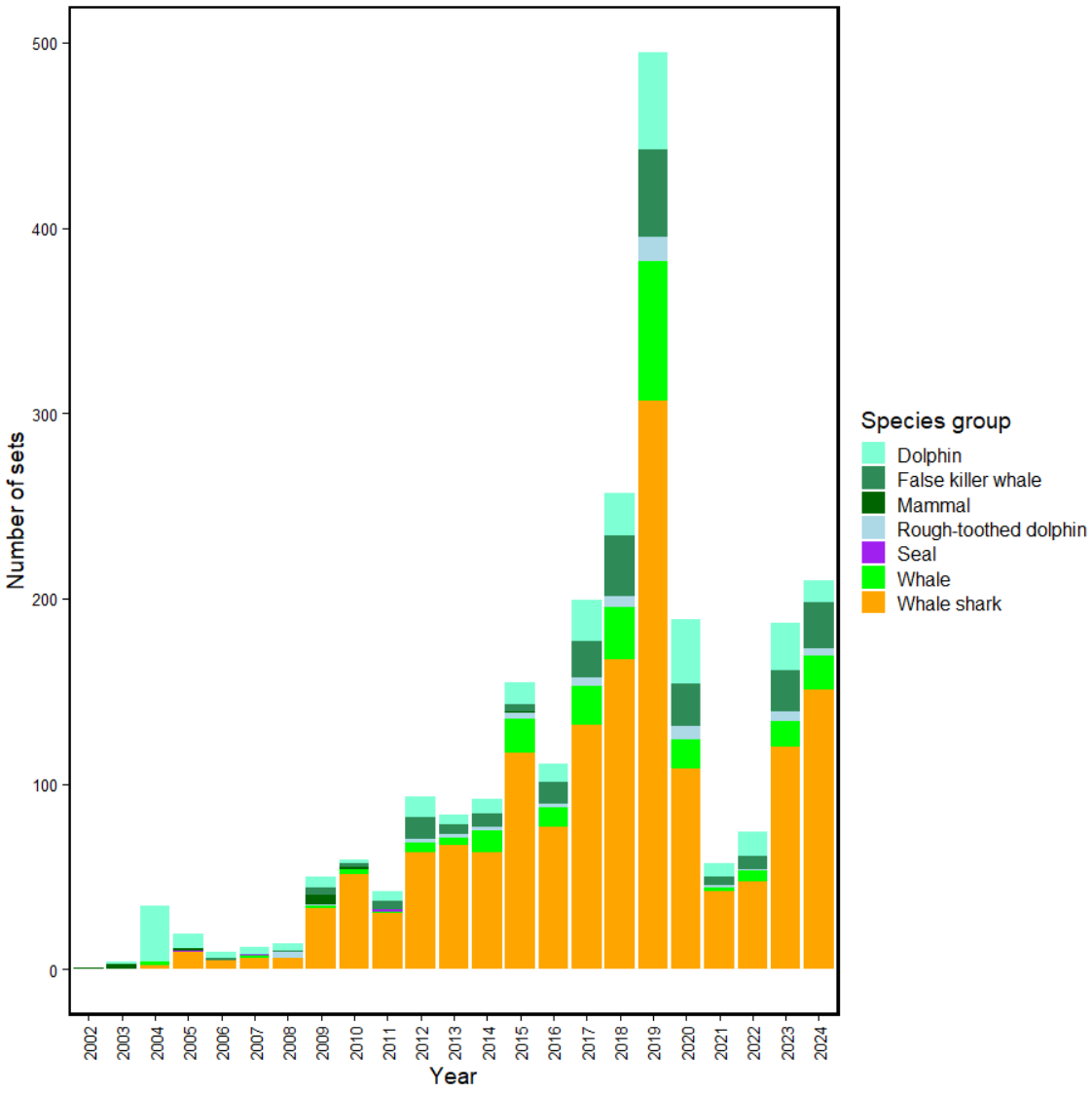

Figure 5: Reported (logsheet) sets in the PNA purse seine fishery showing sets interacting with species of special interest (SSI) by SSI group.

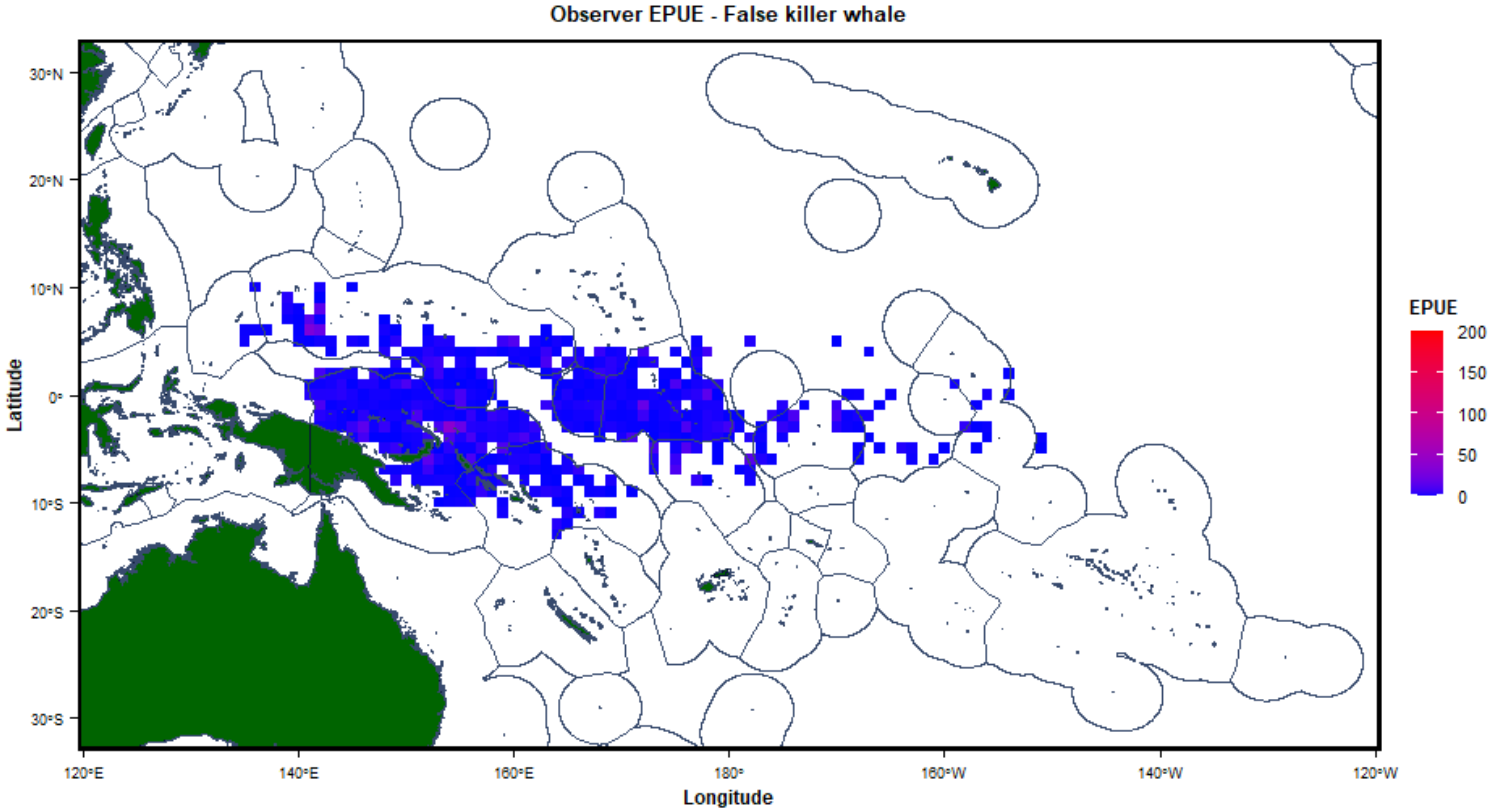

Figure 6: Observed encounter distribution of false killer whales in the PNA purse seine fishery 2000-2024.

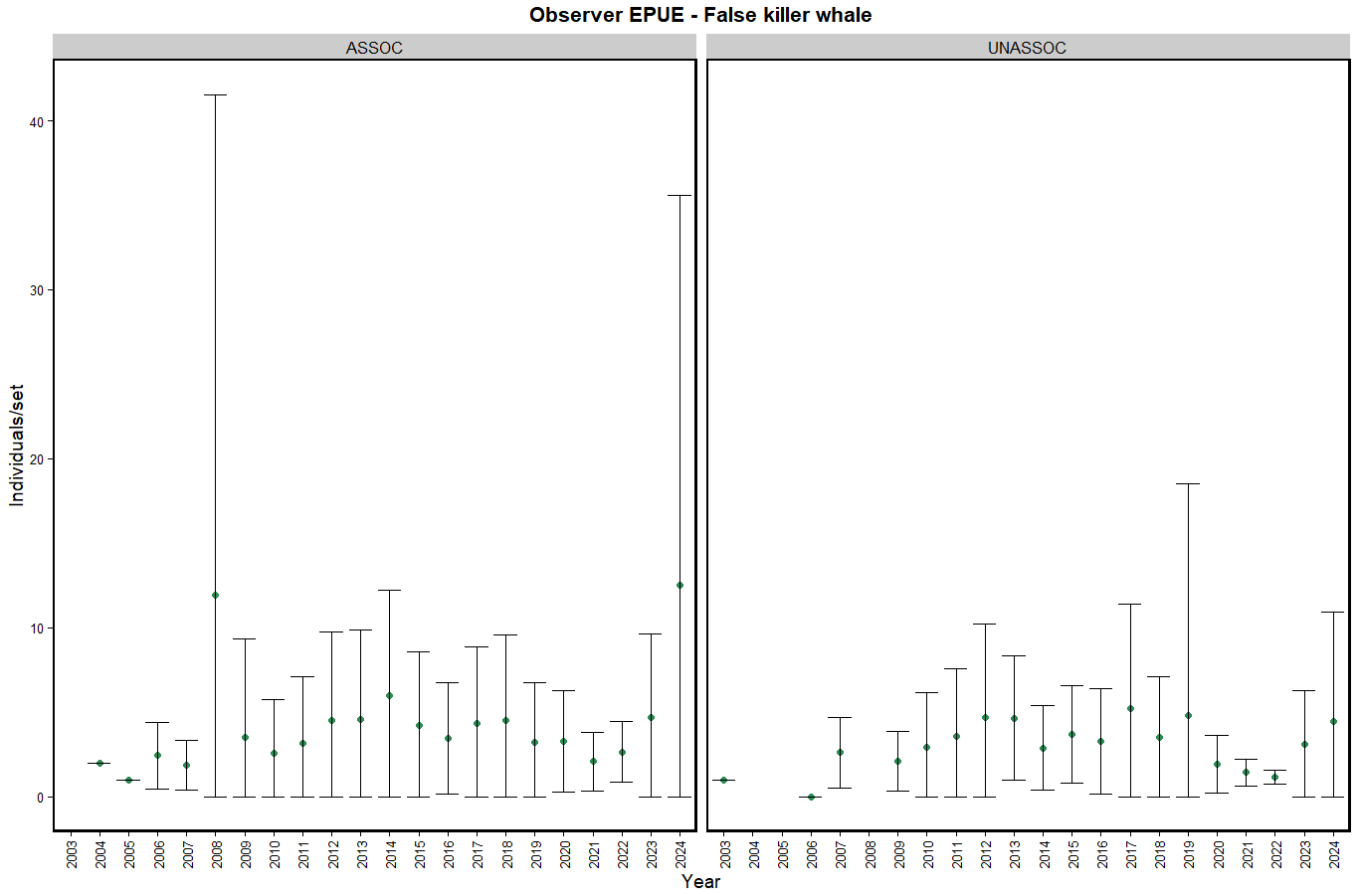

Figure 7: Unstandardised observed encounter rate of false killer whales in the PNA purse seine fishery 2000-2024 by set type. ASSOC = associated (FAD) sets, UNASSOC = unassociated (free school) sets.

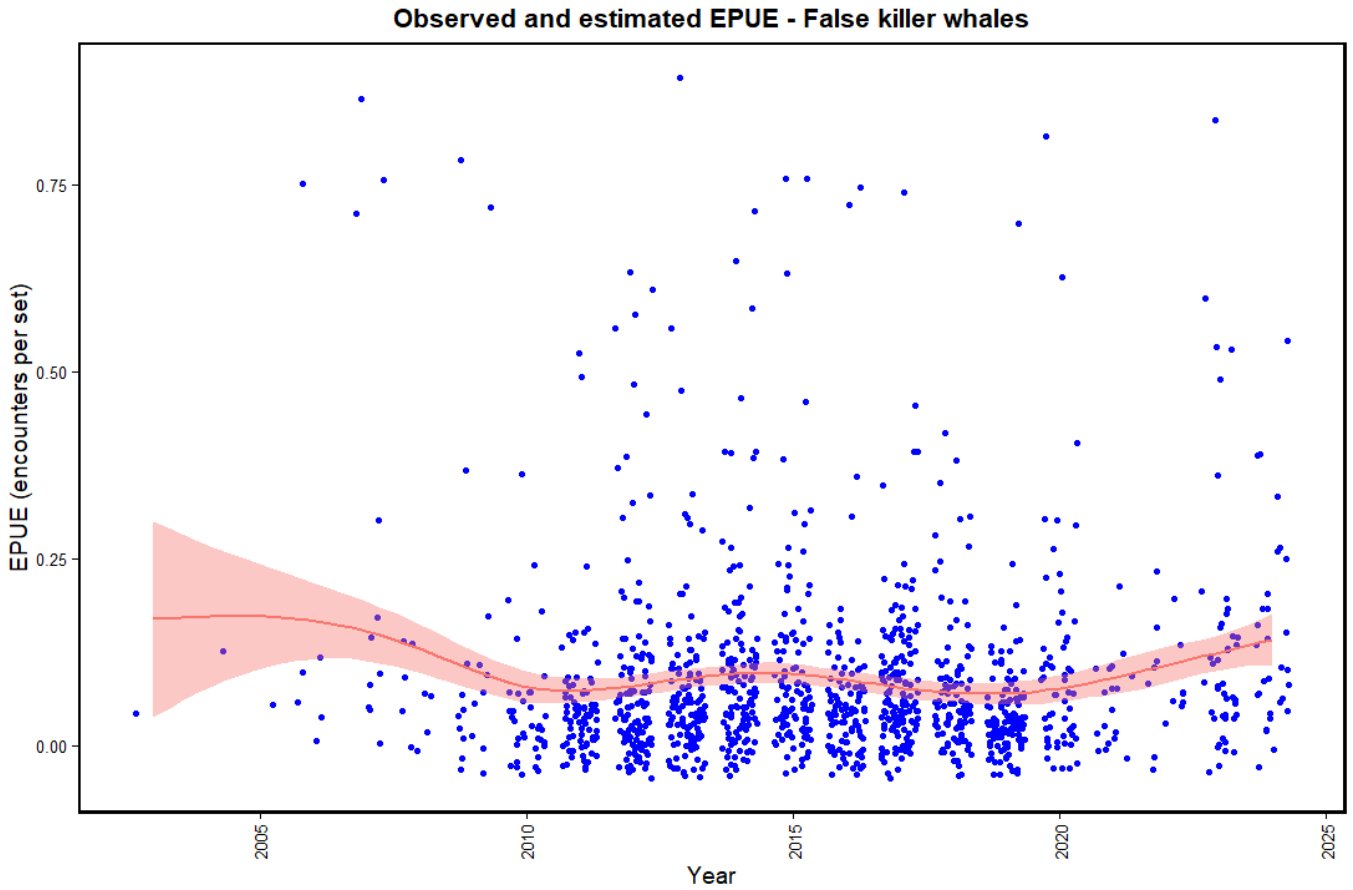

Figure 8: Standardised observed encounter rate of false killer whales in the PNA purse seine fishery 2000-2024. Points = observations red line = model fit. Note the points have been jittered for better visualisation of point densities.

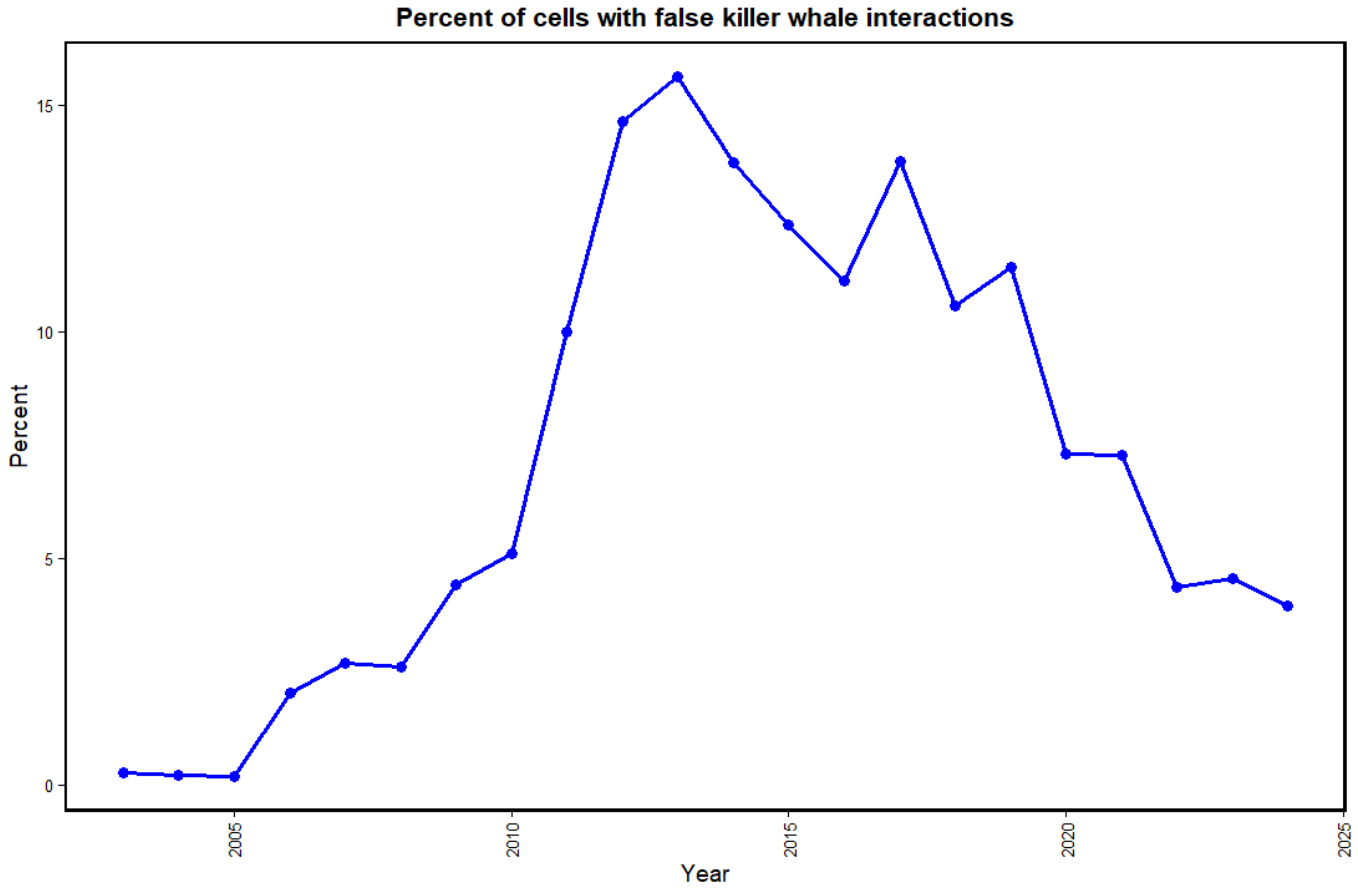

Figure 9: Observed 1x1 degree cells where interactions were recorded for false killer whales in the PNA purse seine fishery 2000-2024.

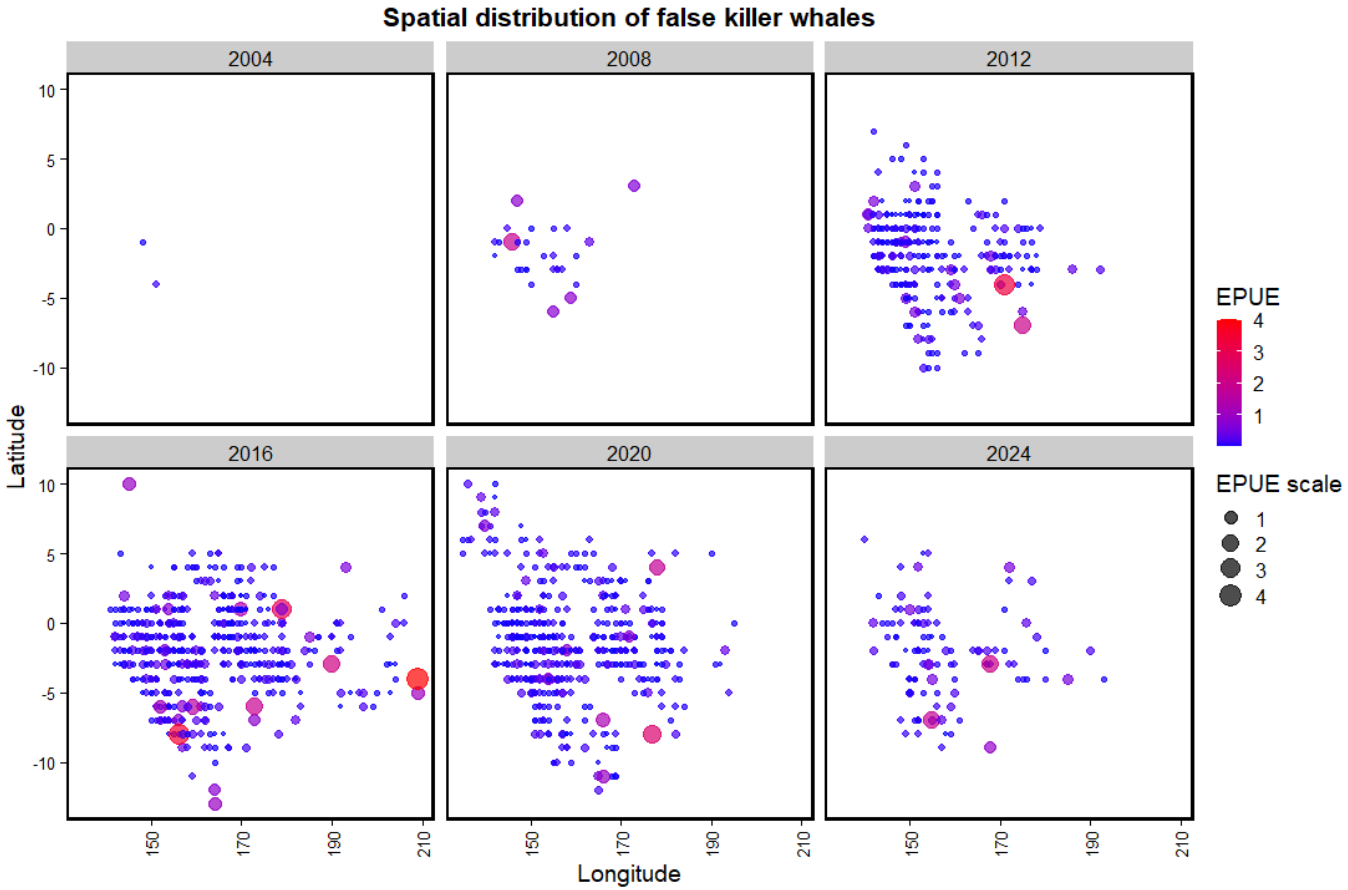

Figure 10: Mean encounter rate of observed 1x1 degree cells interactions were recorded for false killer whales in the PNA purse seine fishery 2000-2024 with years grouped into 4-year bins.

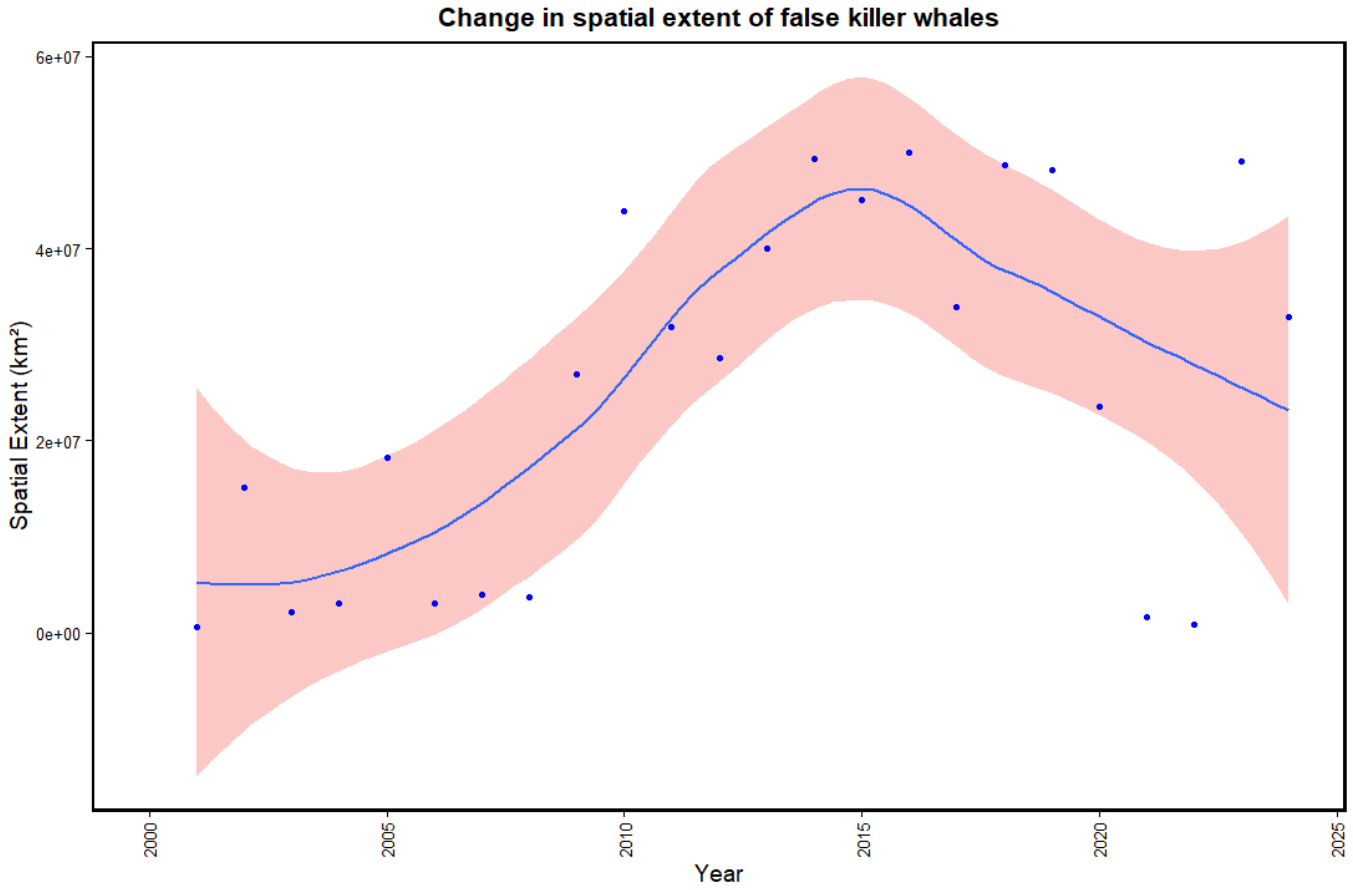

Figure 11: Estimated spatial extent of the PNA purse seine fishery interactions with false killer whales from 2000-2024.

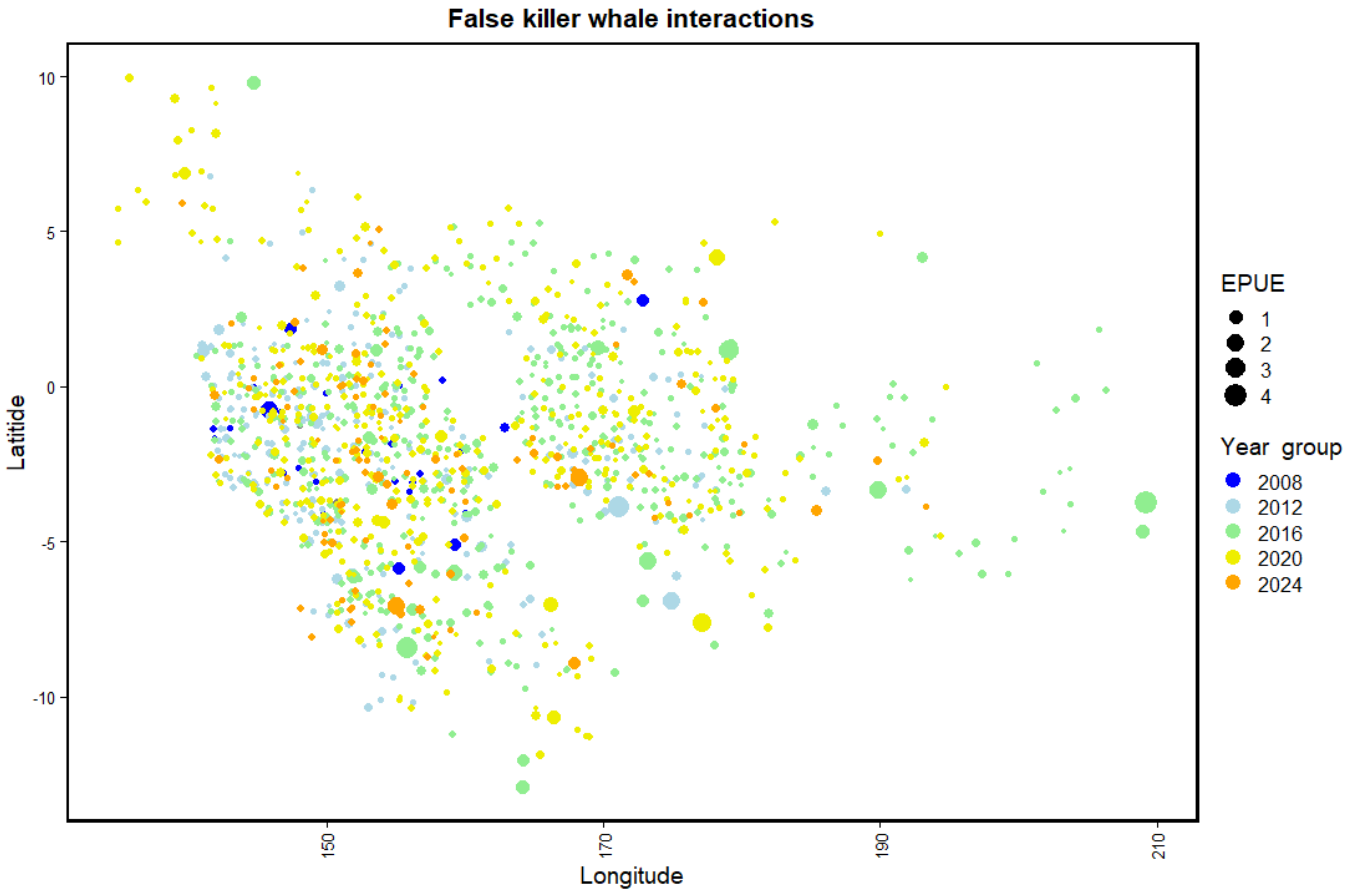

Figure 12: Mean encounter rate of observed 1x1 degree cells where positive interactions was recorded for false killer whales in the PNA purse seine fishery 2000-2024 with years grouped into 4-year bins, with points jittered to avoid overlapping points.

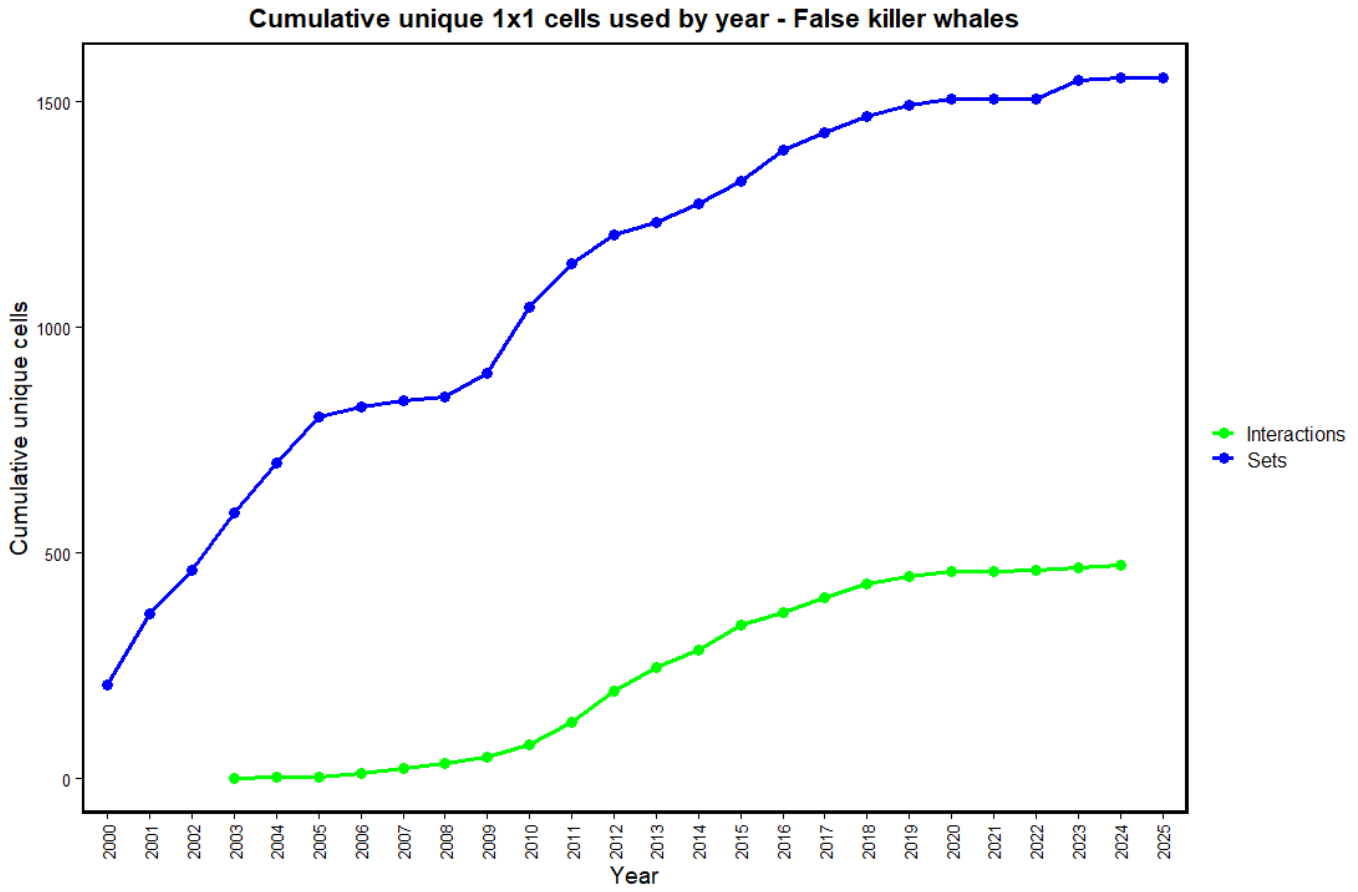

Figure 13: Cumulative extent of the PNA purse seine fishery from 2000-2025. Sets represent the cumulative number of 1x1 degree cells where sets made and interactions are the cumulative number of cells where interactions with false killer whales took place.

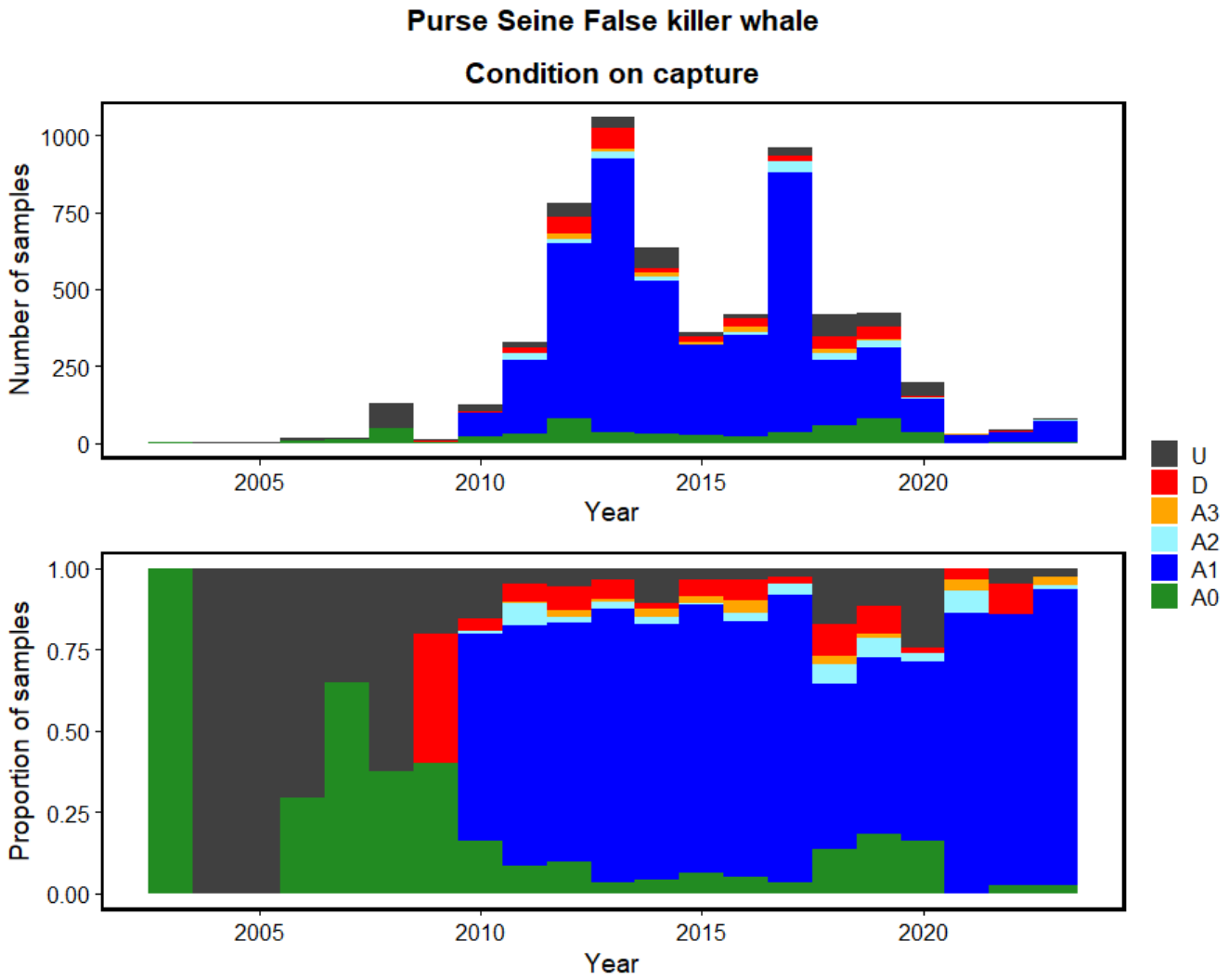

Figure 14: The observed condition on capture of false killer whales when encountered in the PNA purse seine fishery. A0 = Alive; A1 = Alive and healthy; A2 Alive and likely to survive; A3 = Alive and injured; D = Dead; U = Unknown.

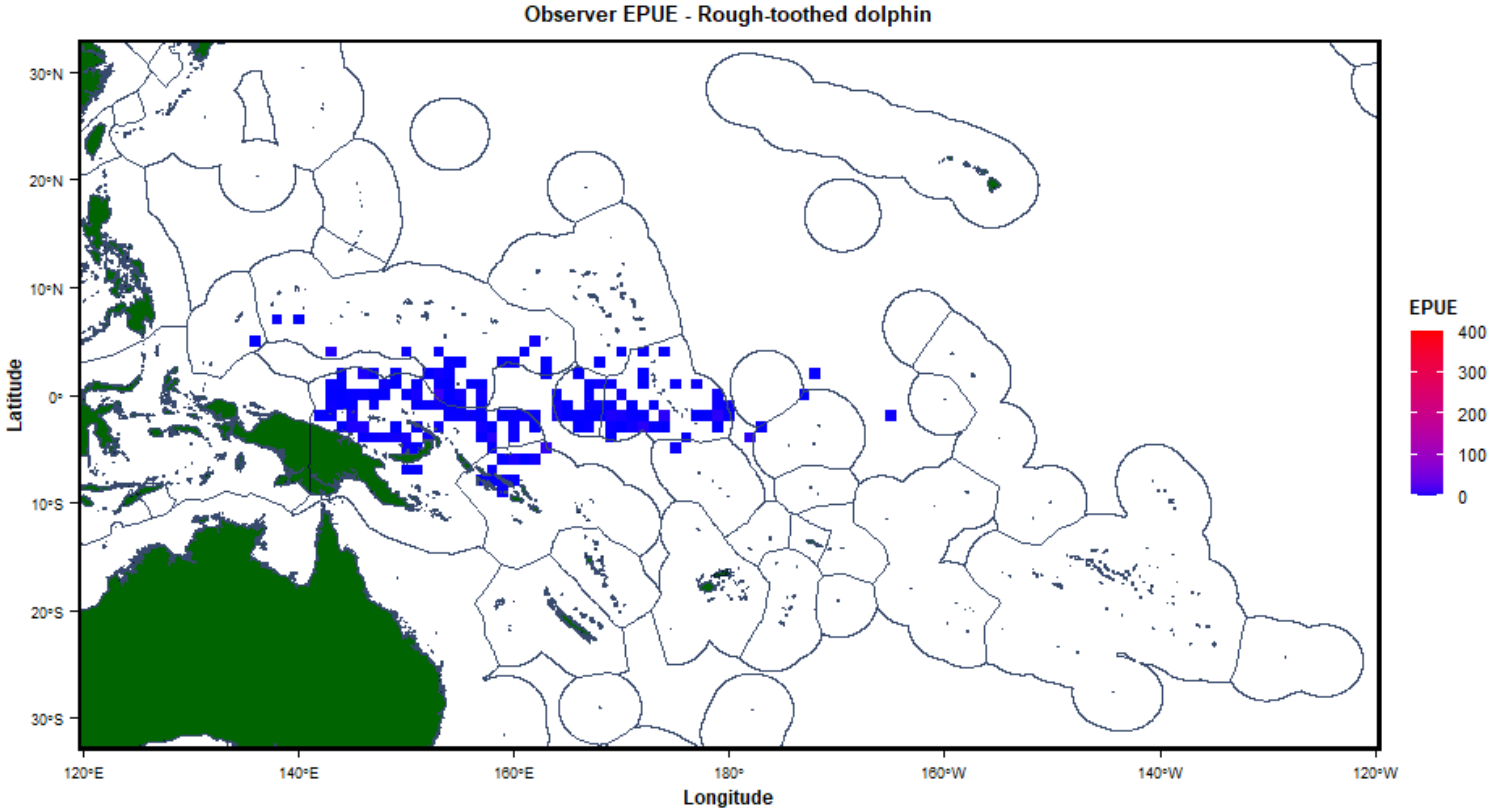

Figure 15: Observed encounter distribution of rough-toothed dolphin in the PNA purse seine fishery 2000-2024.

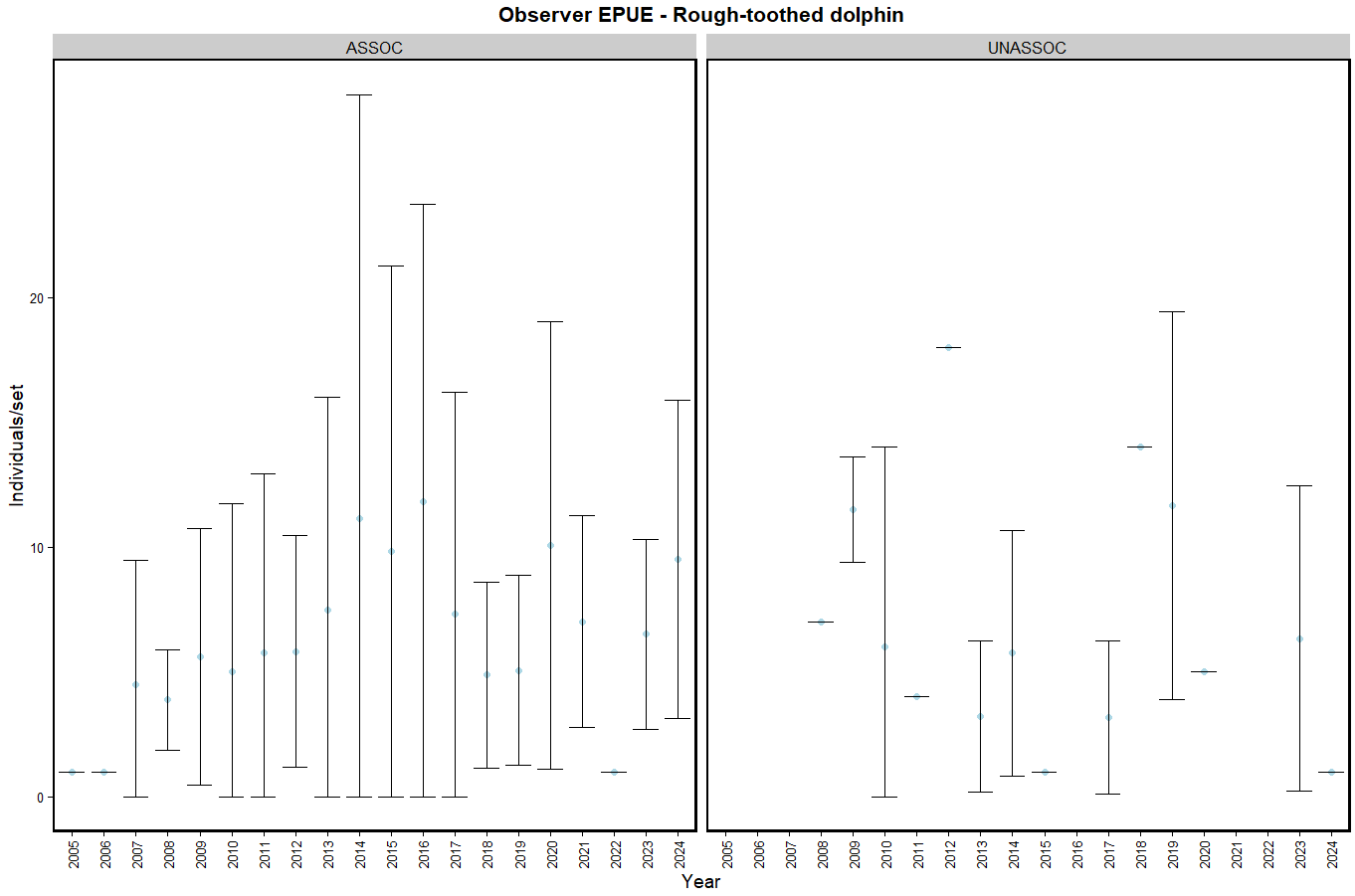

Figure 16: Unstandardised observed encounter rate of rough-toothed dolphin in the PNA purse seine fishery 2000-2024 by set type. ASSOC = associated (FAD) sets, UNASSOC = unassociated (free school) sets.

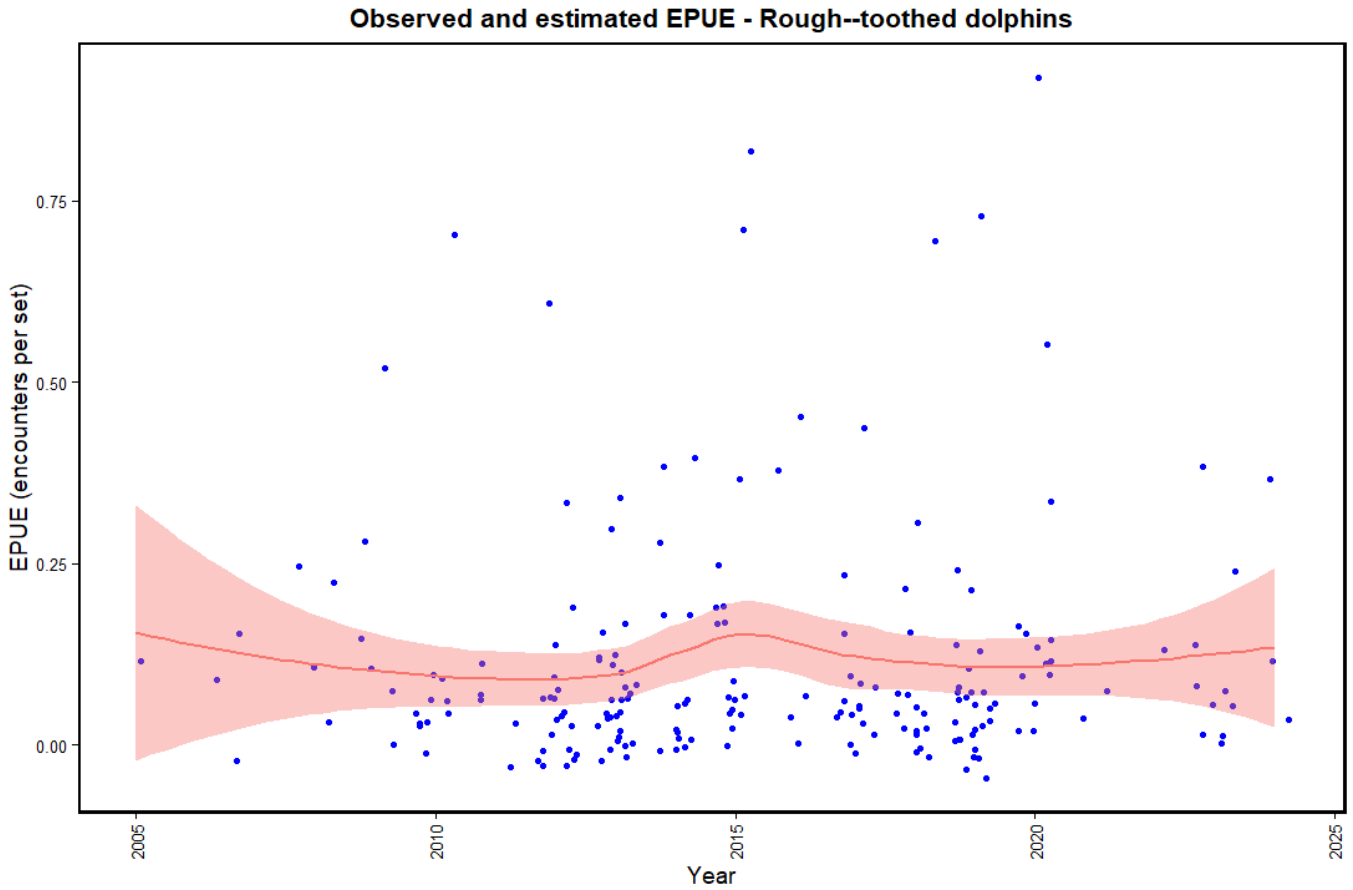

Figure 17: Standardised observed encounter rate of rough-toothed dolphins in the PNA purse seine fishery 2000-2024. Points = observations red line = model fit. Note the points have been jittered for better visualisation of point densities.

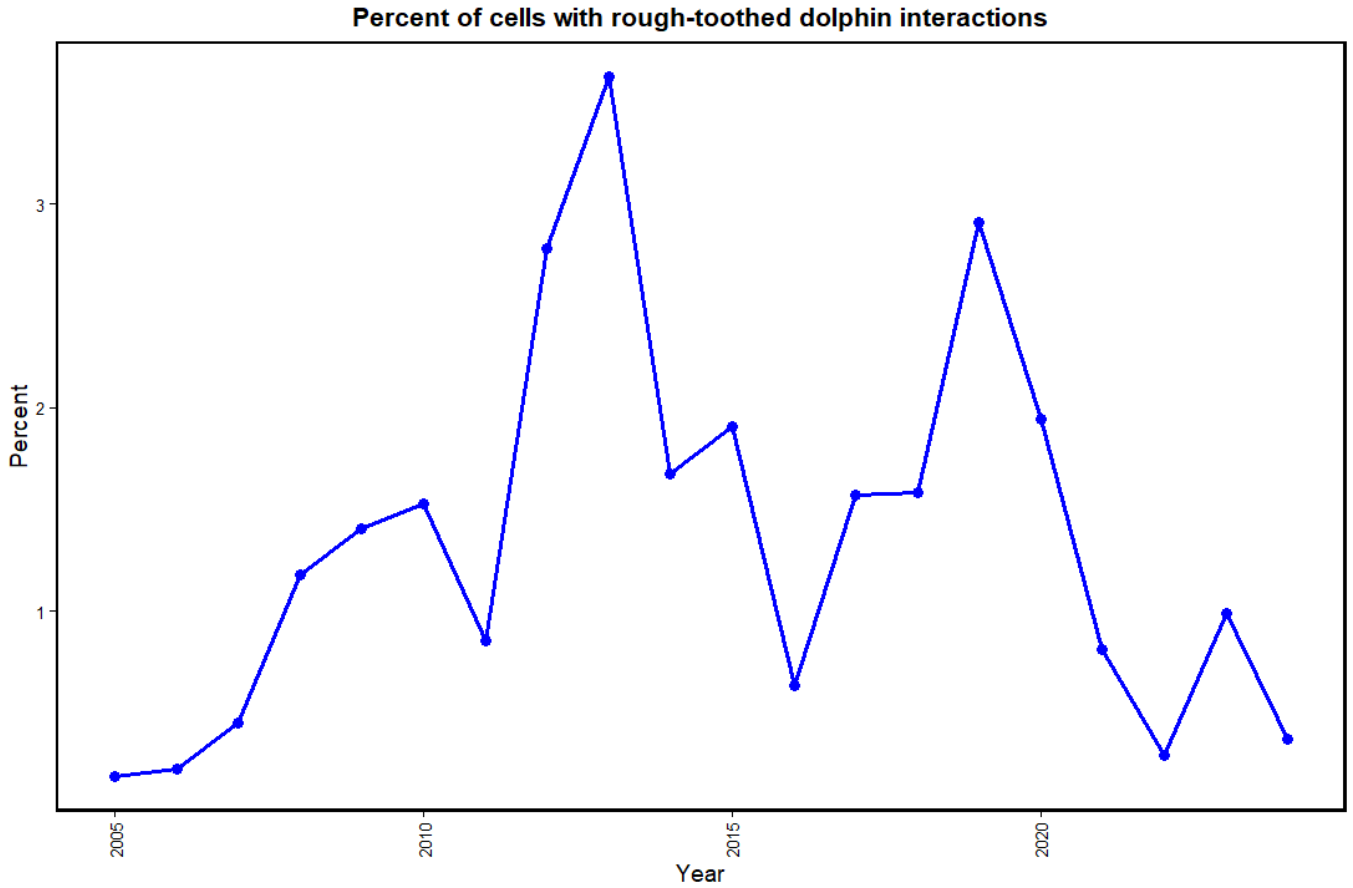

Figure 18: Observed 1x1 degree cells where interactions were recorded for rough-toothed dolphin in the PNA purse seine fishery 2000-2024.

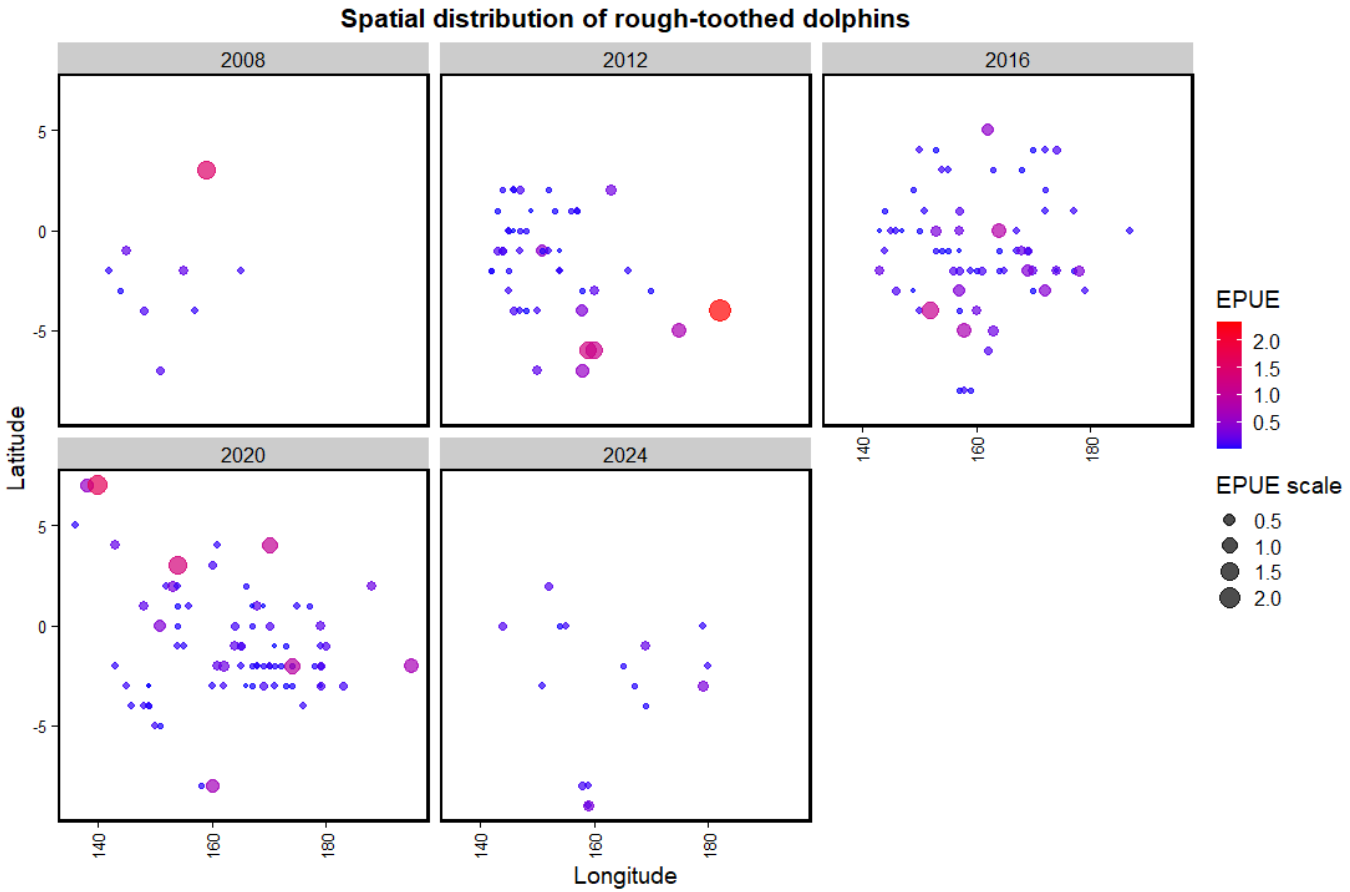

Figure 19: Mean encounter rate of observed 1x1 degree cells where interactions were recorded for rough-toothed dolphin in the PNA purse seine fishery 2000-2024 with years grouped into 4-year bins.

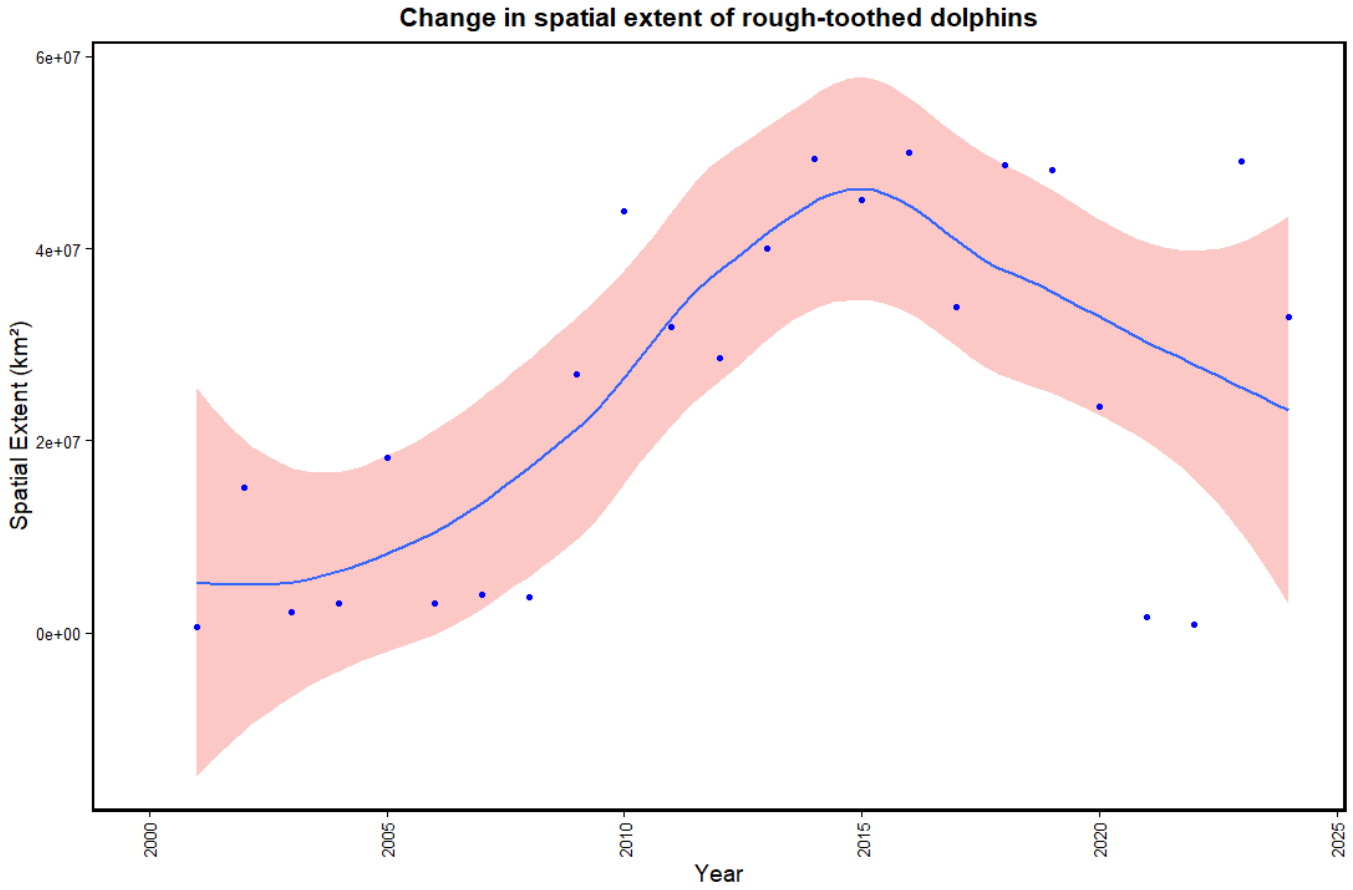

Figure 20: Estimated spatial extent of the PNA purse seine fishery interactions with rough-toothed dolphin from 2000-2024.

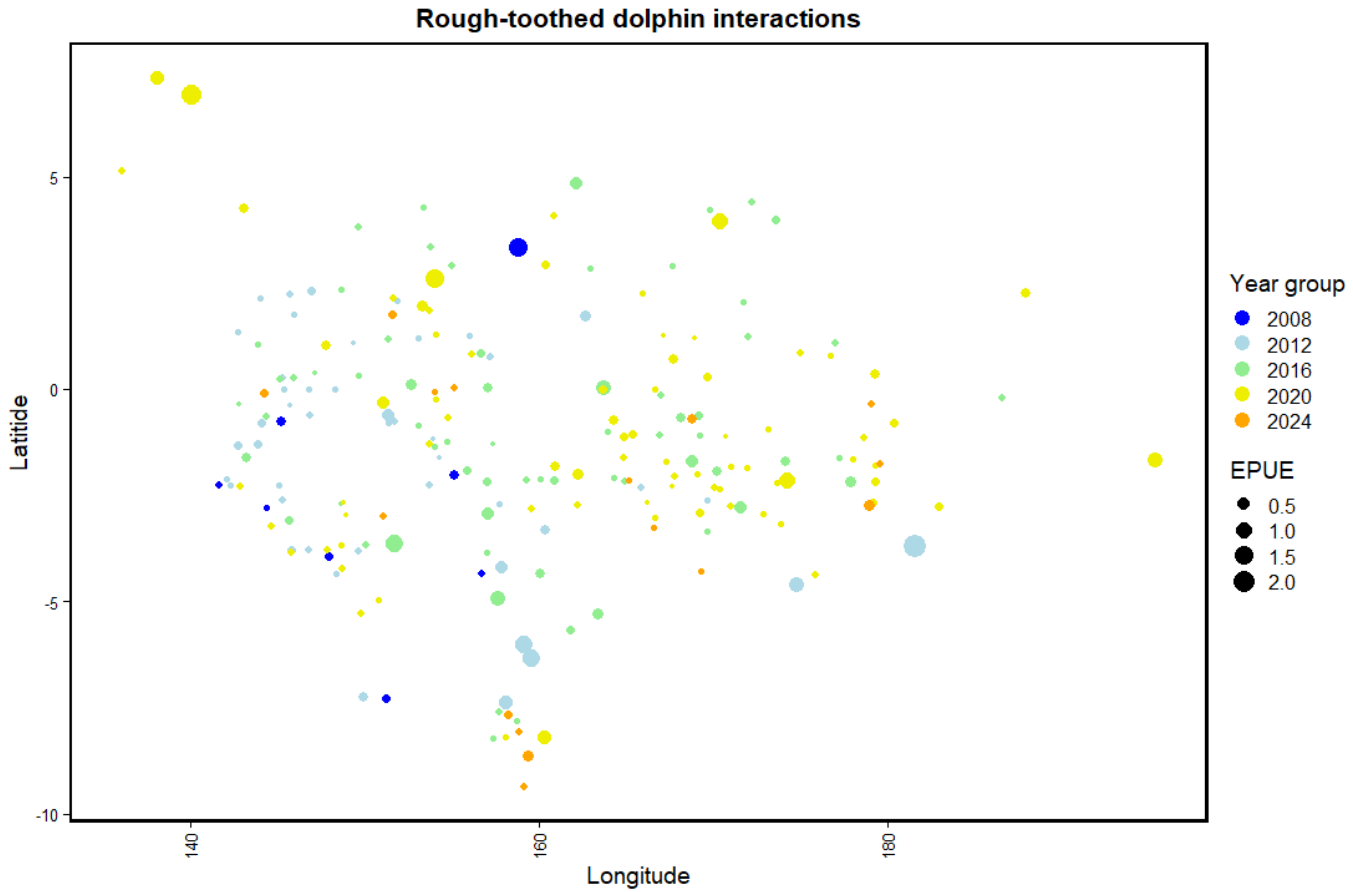

Figure 21: Mean encounter rate of observed 1x1 degree cells where interactions were recorded for rough-toothed dolphin in the PNA purse seine fishery 2000-2024 with years grouped into 4-year bins, with points jittered to avoid overlapping points.

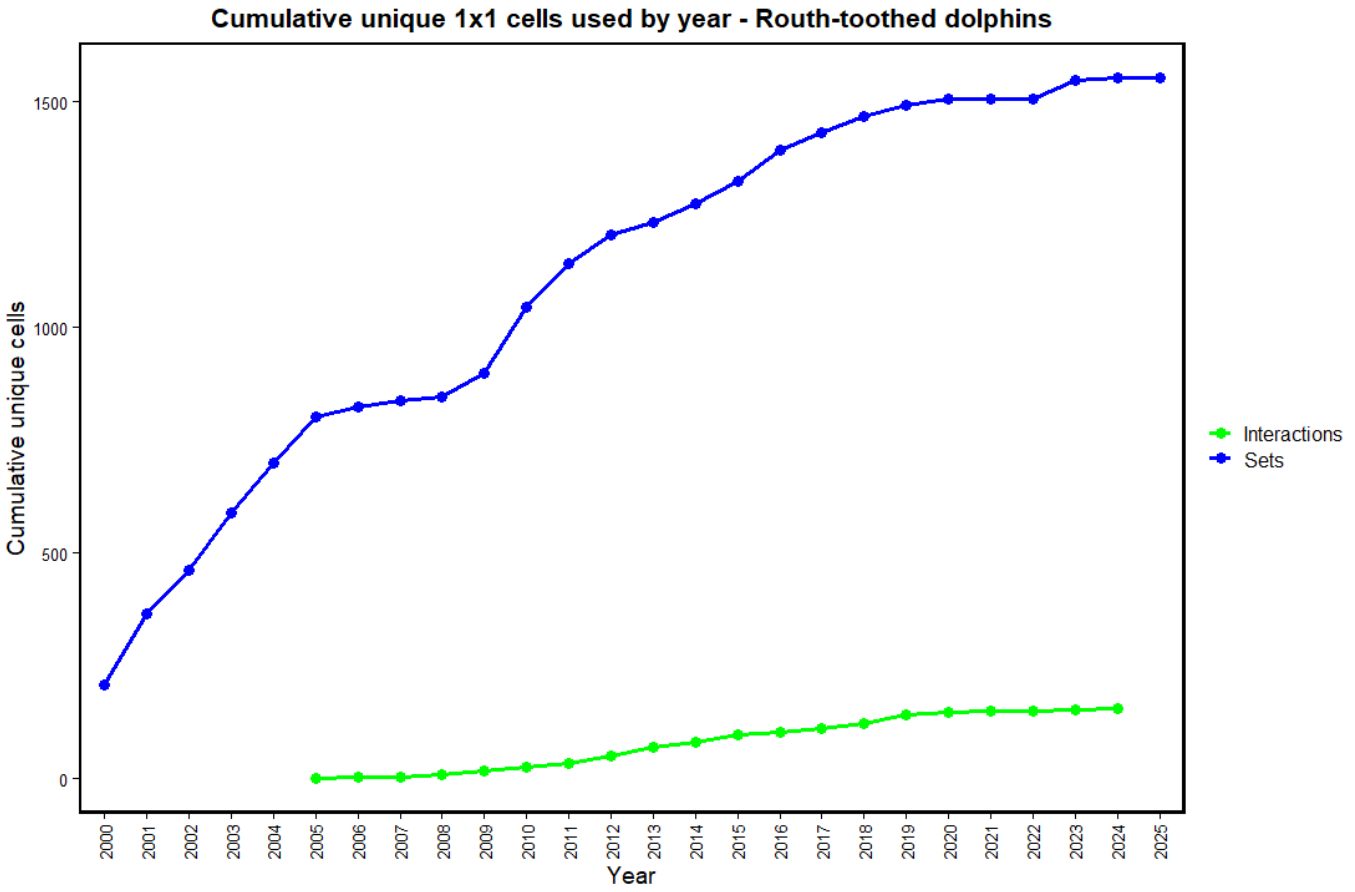

Figure 22: Cumulative extent of the PNA purse seine fishery from 2000-2025. Sets represent the cumulative number of 1x1 degree cells where sets made and interactions are the cumulative number of cells where interactions with rough-toothed dolphins took place.

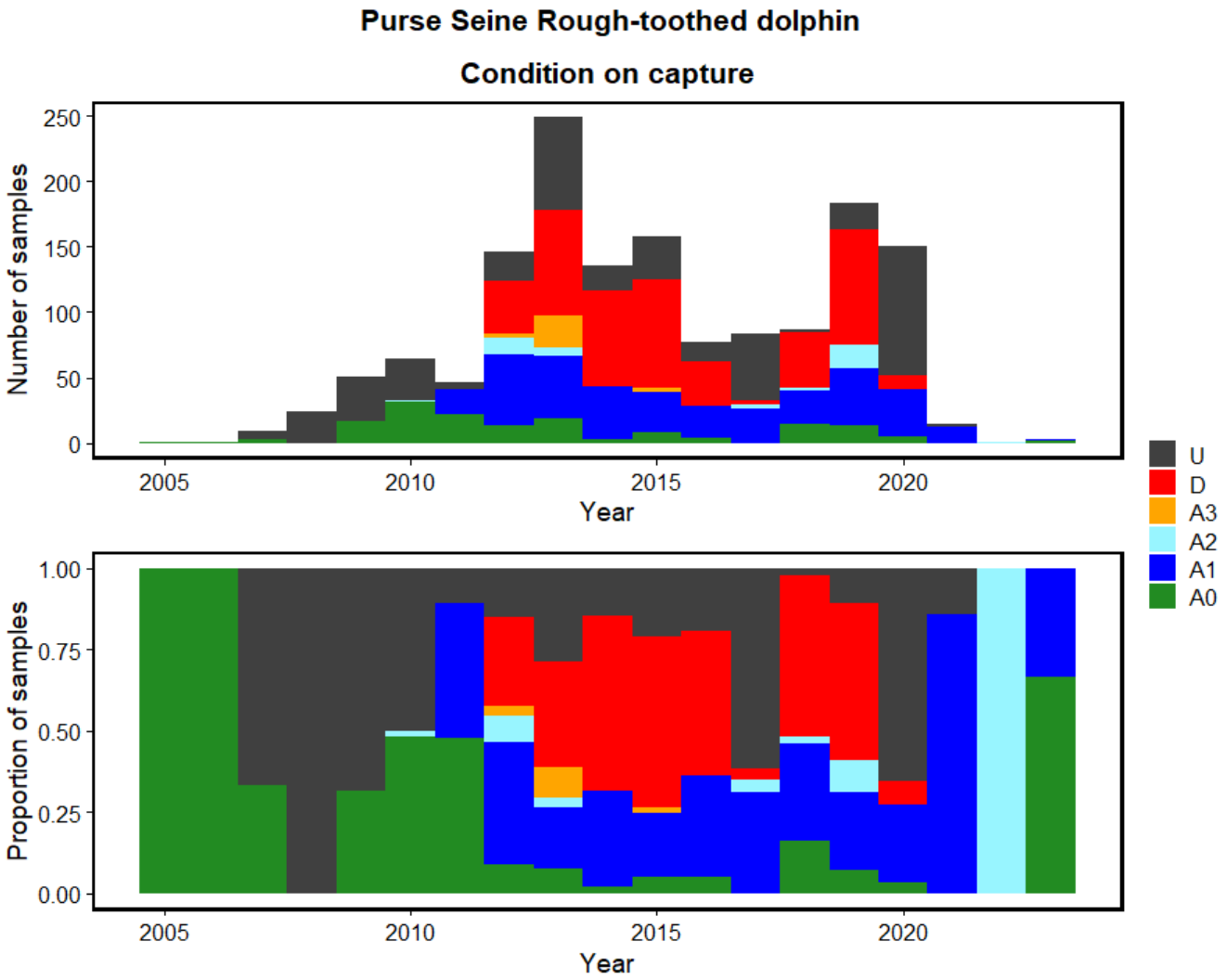

Figure 23: The observed condition on capture of rough-toothed dolphins when encountered in the PNA purse seine fishery. A0 = Alive; A1 = Alive and healthy; A2 Alive and likely to survive; A3 = Alive and injured; D = Dead; U = Unknown.