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Tini a Tangaroa

Identification and mapping of habitats of significance for sharks

New Zealand Aquatic Environment and Biodiversity Report No. 361

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PLAIN LANGUAGE SUMMARY

The aim of this project was to review existing literature and analyse data to identify areas that may be further identified as a habitat of particular significance (HoPS) for chondrichthyans (sharks, rays, and chimaeras). This project proposed 30 HoPS for 20 species of interest: six of the 20 species had at least one potential HoPS for spawning purposes identified and 10 species had at least one suspected potential HoPS identified. There were four species (blue shark, mako, porbeagle, basking shark) where potential HoPS could not be identified. No proposed HoPS is completely closed to fishing, and 22 proposed HoPS are completely open to fishing. All species evaluated here need further information to reduce knowledge gaps. Focal species and areas for future research, and alternative opportunities to collect data are discussed.

EXECUTIVE SUMMARY

Finucci, B.[1]; Bennion, M.[2]; Chin, C.[1]; Duffy, C.A.J.[3]; Morrison, M.[4]; Struthers, C.[5] (2025). Identification and mapping of habitats of significance for sharks.

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There are currently 113 recognised species of chondrichthyans (sharks, rays, chimaeras) in New Zealand waters, of which about 20% are endemic to the region. Some species are of commercial and cultural importance, some have cultural value as taonga or kaitiaki, and some are protected and/or recognised in New Zealand or globally as threatened. Many chondrichthyans are susceptible to overexploitation from fishing because of their low biological productivity (e.g., slow growing, long-lived, late maturing, low fecundity). Identifying and protecting habitats of importance to chondrichthyans will enable fisheries managers and resource management agencies to make more informed decisions that lead to improved outcomes for these species, which in turn maintains biodiversity and healthy ecosystem function, helping to meet management objectives throughout the ecosystem under an Ecosystem Based Fisheries Management (EBFM) approach.

The aim of this project was to review the existing literature and analyse fishery-dependent and fisheries-independent available data to identify areas that may be further identified as HoPS for chondrichthyans. This project proposed 30 HoPS for 20 species of interest: six of the 20 species had at least one potential HoPS for spawning purposes identified and 10 species had at least one suspected potential HoPS identified. There were four species (blue shark, mako, porbeagle, basking shark) where potential HoPS could not be identified. No proposed HoPS is completely closed to fishing, and 22 proposed HoPS are completely open to fishing.

All species evaluated here need further research to reduce knowledge gaps. This project focused on a small percentage (15%) of the overall chondrichthyan diversity and only HoPS for reproductive purposes. The HoPS guidelines also defined HoPS to include feeding area, migratory corridors, and specific areas to which species are highly restricted. There will be many more chondrichthyan HoPS in New Zealand waters when considering these other focal areas, and with improved knowledge. Focal species and areas for future research, and alternative opportunities to collect data are discussed.

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[2] NIWA, Hamilton
[3] Auckland Museum, Auckland
[4] NIWA, Auckland
[5] Te Papa, Wellington

1. INTRODUCTION

There are currently 113 recognised species of chondrichthyans (sharks, rays, chimaeras) in New Zealand waters (Duffy et al. in press). About 20% of these are endemic to the New Zealand region (Finucci et al. 2019). Some species are of commercial and cultural importance (e.g., school shark, *Galeorhinus galeus*, rig, *Mustelus lenticulatus*), some have cultural value as taonga or kaitiaki (e.g., mako, *Isurus oxyrinchus*, white shark, *Carcharodon carcharias*) and some are protected and/or recognised in New Zealand or globally as threatened (e.g., basking shark, *Cetorhinus maximus*). More than 70 species have been recorded captured in fisheries in New Zealand (Francis 2015a). Many chondrichthyans are susceptible to overexploitation from fishing because of their low biological productivity (e.g., slow growing, long-lived, late maturing, low fecundity) (Dulvy et al. 2021). Identifying and protecting habitats of importance to chondrichthyans will enable fisheries managers and resource management agencies to make more informed decisions that lead to improved outcomes for these species, which in turn maintains biodiversity and healthy ecosystem function (Dedman et al. 2024), helping to meet management objectives throughout the ecosystem under an Ecosystem Based Fisheries Management (EBFM) approach.

In 2025, Fisheries New Zealand published guidelines for identifying habitats of particular significance (HoPS) for fisheries management (Fisheries New Zealand 2025). The initial priority for HoPS identification is nursery and spawning or egg-laying habitat, and these areas have long been considered some of the most critical for chondrichthyan conservation since they provide habitat for key components of the population (e.g., neonates, juveniles, reproductively active females) that are particularly important for the long-term persistence of these species.

The aim of this project is to review the existing literature and analyse available fishery-dependent and fisheries-independent data to identify areas that may be further identified as HoPS for chondrichthyans. The identification of these areas needs to be consistent with Fisheries New Zealand’s guidance for identifying, and definition of, habitats of particular significance for fisheries management. Expected outputs include identification and mapping of new areas critical to chondrichthyans, identification and risk of potential adverse effects on the habitats, and a prioritisation of specific areas that could be selected for future investigation.

1.1 Objectives

This report was prepared as an output from the Ministry for Primary Industries (MPI) project BYC2023-03 “Identification and mapping of habitats of significance for sharks” which had the following objectives.

Overall objective

To identify and map habitats of significance for chondrichthyan species.

Specific objectives

- Objective 1: Review existing literature and analyse fisheries-dependent and fisheries-independent data to identify habitats of significance for chondrichthyan species.
- Objective 2: Produce maps and a prioritisation of specific areas that could be selected for future investigation and methodologies that could be used for these investigations.
- Objective 3: Identify opportunities to increase data collection to improve identification of habitats of significance (and potential adverse effects on them) for chondrichthyan species.

2. METHODS

2.1 Species selection

The following 20 chondrichthyans were selected for this project in consultation with Fisheries New Zealand (Table 1). These included species managed under the Quota Management System (QMS, n=11), species protected under the Wildlife Act 1953 (n=2), and species identified as being at high risk (n=7) from commercial fisheries by a qualitative risk assessment analysis for New Zealand cartilaginous fishes (Ford et al. 2015, 2018).

A literature review was completed for each species to summarise current knowledge of relevant information on habitat use (i.e., reproduction, spawning cycle, population structure, and areas known to be important for spawning purposes), and to identify knowledge gaps in New Zealand.

Table 1: Species of interest, their three-letter reporting code, and the rationale for including the species in this project. QMS = Quota Management Species.

Species	Scientific name	Species code	Rationale
Elephantfish	*Callorhinchus milii*	ELE	QMS
Dark ghost shark	*Hydrolagus novaezealandiae*	GSH	QMS
Pale ghost shark	*Hydrolagus bemisi*	GSP	QMS
Rig	*Mustelus lenticulatus*	SPO	QMS
School shark	*Galeorhinus galeus*	SCH	QMS
Spiny dogfish	*Squalus acanthias*	SPD	QMS
Blue shark	*Prionace glauca*	BWS	QMS
Mako	*Isurus oxyrinchus*	MAK	QMS
Porbeagle	*Lamna nasus*	POS	QMS
Smooth skate	*Dipturus innominatus*	SSK	QMS
Rough skate	*Zearaja nasuta*	RSK	QMS
White shark	*Carcharodon carcharias*	WPS	Protected
Basking shark	*Cetorhinus maximus*	BSK	Protected
Carpet shark	*Cephaloscyllium isabella*	CAR	High risk
Plunket's shark	*Scymnodon macracanthus*	PLS	High risk
Baxter's dogfish	*Etmopterus granulosus*	ETB	High risk
Seal shark	*Dalatias licha*	BSH	High risk
Shovelnose dogfish	*Deania calcea*	SND	High risk
Longnose velvet dogfish	*Centroselachus crepidater*	CYP	High risk
Leafscale gulper shark	*Centrophorus squamosus*	CSQ	High risk

2.2 Habitats of Particular Significance (HoPS)

Environmental principles in the Fisheries Act 1996 (the Act) support taking into account the wider environment within which fishing occurs when making fisheries management decisions. All people exercising or performing functions, duties, or powers under the Act in relation to the utilisation of fisheries resources or ensuring sustainability must take into account the three environmental principles in section 9 of the Act. The third principle (section 9(c)) requires taking into account that habitat of particular significance for fisheries management should be protected. The term "habitat of particular significance for fisheries management" is not defined in the Act. To support taking account of section 9(c), Fisheries New Zealand developed and published a definition for HoPS and guidelines to support their identification (Fisheries New Zealand 2025). The definition for HoPS is:

"an area or areas, and their attributes, that are important for fisheries management in that they are of especially great importance in supporting life-history stages of fisheries resources, including nursery areas for larvae and juveniles, adult feeding areas, spawning areas, migratory corridors, and specific areas to which species are highly restricted".

The above definition of HoPS recognises the disproportionate contribution certain habitats make in supporting the productivity of fisheries resources and sets these habitats and their function apart from other habitats that species may utilise more generally (Figure 1). The occurrence of a species in a particular habitat does not equate to that habitat being particularly significant (e.g., observing a shark feeding in a location does not make the location a feeding HoPS and observing a juvenile fish does not make the location a nursery HoPS). Similarly, the presence of a habitat "type" with a widely accepted ecological role does not make that area a HoPS (e.g., not all kelp beds are expected to be HoPS).

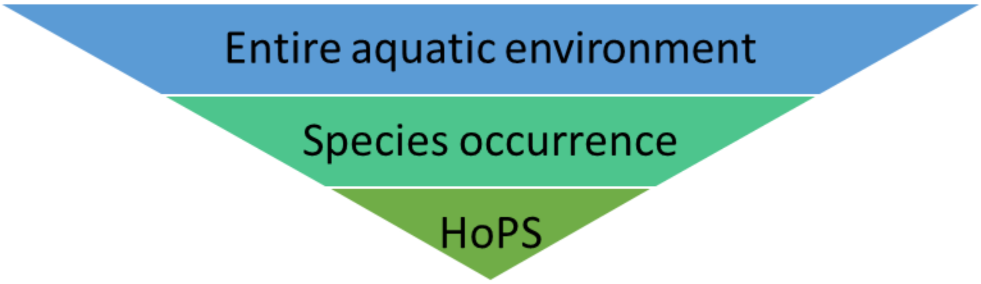


Figure 1: HoPS are a subset of where a species generally occurs and are particularly significant in supporting one or more life-history stages.

Information to support the identification of HoPS and the association between HoPS and fisheries resources can come from a number of sources, including mātauranga Māori[6], traditional/local ecological knowledge, and Western science, and can include:

- habitat type;
- mātauranga that kaitiaki[7] share relating to particularly significant habitat for taonga[8] species;
- the nature of the association between the fisheries resources and the habitat (e.g., if there are particular life history aspects associated with the habitat such as spawning ground, juvenile fish nursery area), including the timing of the species' reliance on a specific habitat (e.g., seasonal or year round);
- the location, depth, spatial extent, and relative distribution of the habitat (i.e., connection of the habitat with other habitats, or proximity to other habitats that are important to other life stages); and
- the specific attributes of the habitat on which species rely (e.g., habitat structure, settlement substrate, temperature, depth, persistent hydrological features, abundance/diversity of food available, etc.).

2.3 Habitats of importance to chondrichthyans

There have been considerable knowledge advances globally to understand and define habitat use and habitats of importance to chondrichthyans. These have included broad overviews (e.g., nursery habitats, Heithaus 2007, Heupel et al. 2007, Heupel et al. 2018), defining habitat criteria for specific species groups (e.g., batoid nursery habitats, Martins et al. 2018), descriptions of how chondrichthyans use their environment (Kanno et al. 2023), and defining specific behavioral criteria (e.g., Papastamatiou et al. 2022, McInturf et al. 2023), which can be used to then infer important habitat where these behaviours occur. There is also a growing focus on the threats and stressors that can impact these important habitats (e.g., Speed et al. 2010, Jones et al. 2015, Crear et al. 2020).

[6] Māori knowledge, wisdom, understanding, skill
[7] guardianship
[8] treasured

Within New Zealand, HoPS for some commercially important inshore sharks have been identified (e.g., Francis et al. 2012); other areas are suspected to be of importance for these species, but comprehensive data are lacking, and further investigation is required (e.g., Morrison et al. 2014a, b).

Global efforts are underway to identify and improve knowledge of areas of importance to chondrichthyans through the Important Shark and Ray Areas (ISRA) project (Hyde et al. 2022). The globally recognised ISRA approach provides a standardised framework to identify discrete, three-dimensional habitats important for one or more shark, ray, or chimaera species. The ISRA Criteria can be applied to all environments where sharks occur (marine, estuarine, and freshwater) and consider the diversity of species, their complex behaviours and ecology, and biological needs.

There are four broad ISRA Criteria (Figure 2):

- **Vulnerability**: Criterion A refers to species vulnerability (e.g., threatened species)
- **Range Restricted**: Criterion B refers to restricted ranges within the scale of Large Marine Ecosystems (LMEs) as defined by the Global Environment Facility
- **Life-History**: Criterion C refers to areas that sharks use to carry out vital functions across their life cycle (e.g., reproductive areas, feeding areas)
- **Special Attributes**: Criterion D refers to areas where distinct biological, behavioural, or ecological attributes occur and/or support important diversity of species

The ISRA Criteria ensure that the habitats of importance that are identified are persistent and regular occurrences (i.e., occurring over multiple years), and do not include one-off observations that may not reflect true habitat use.

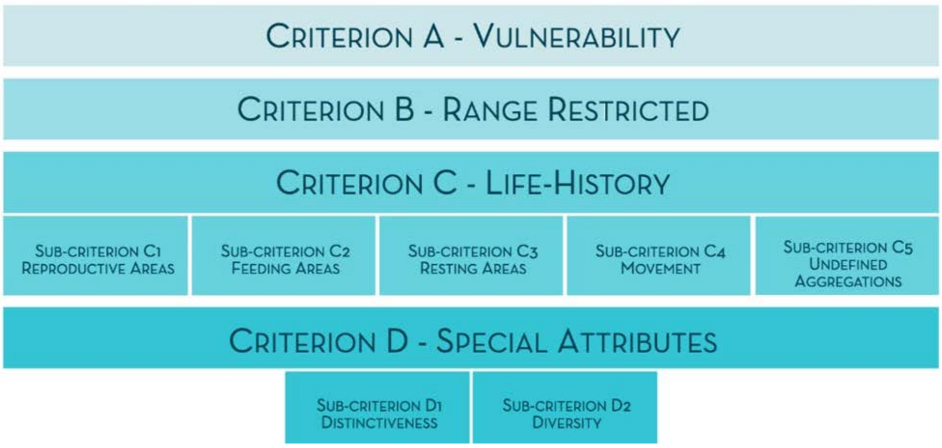


Figure 2: Overview of the Important Shark and Ray Area (ISRA) Criteria (IUCN SSG 2024).

Aspects of the ISRA Criteria were integrated here to identify HoPS in New Zealand because 1) it provides a globally recognised and standardised framework for identifying HoPS (reducing the need to reinvent the wheel); 2) it has been designed by shark researchers and defined specifically for sharks; and 3) it was designed to be aligned with other biogeographical conservation planning approaches (e.g., Key Biodiversity Areas, BirdLife International 2023).

Broadly, reproductive areas for chondrichthyans are defined as "areas which are important for sharks to mate, gestate, give birth, lay eggs, or provide refuge or other advantages to the young" (IUCN SSG 2024).

Reproductive areas can be defined as sites (pupping areas, nursery areas) that are important for neonate (<1 month old) or young-of-the-year (i.e., <1 year old) for both viviparous (live-bearing) and oviparous (egg-laying) species. Additionally, reproductive areas can include 'egg nursery areas', sites that are important for egg-laying and development until hatching for oviparous species. Species may use discrete nursery areas for different development stages (one for egg laying, embryo development (egg case nursery), one for newly hatched juveniles (juvenile nursery) (Hoff 2016)). These areas provide advantages to vulnerable life history stages such as predator avoidance and access to food sources.

To qualify for a pupping, nursery, or egg laying area, at least two of the following criteria need to be met, following guidelines by Heupel et al. (2007) and Martins et al. (2018):

- Sharks are more commonly encountered in the area than other areas
- Sharks have a tendency to remain or return for extended periods (weeks or months)
- The area of habitat is repeatedly used across years

Here, emphasis was given to the first and third criteria where data was most likely to be available. Criteria two would require sufficient knowledge of species movement through tagging studies (conventional, acoustic, or satellite tracking) which are largely unavailable for most New Zealand species.

Reproductive areas can also be defined as areas where mature sharks are regularly and/or predictably present. Evidence for these areas can include:

- Observations of mating (including courtship behaviour)
- Where females show evidence of recent mating (e.g., mating scars)
- Where gravid females aggregate to avoid aggressive males, conserve energy during mating/gestation, take advantage of environmental conditions (e.g., thermal advantage), or to give birth

The presence of pregnant females on its own is not sufficient to meet the ISRA criteria, given that for many viviparous species, mature females are almost always pregnant. Here however, the evidence mentioned above is virtually unknown for New Zealand chondrichthyans so the presence of reproductively active females was used to identify an area of interest, given that for some species, there are very few records of mature females (e.g., Francis et al. 2018, Finucci et al. 2021a, Finucci et al. 2022).

2.4 Life history parameters

To identify HoPS to specific life history stages (e.g., nursery areas), life history parameters, specifically size at birth, size of young-of-the-year (YOY), and female size at maturity, were required. Life history parameters were collated and based on New Zealand published literature, where possible (Table 2). YOY lengths were extracted from published literature or estimated from growth curves in growth studies. Where possible, length at 50% maturity was reported, however, this estimate was not available for some species or not defined in the available literature.

Table 2: Life history parameters (size at birth, size of young-of-the-year (YOY), and female size at maturity), measurement length (FL = fork length; CL = chimaera length; TL = total length; PL = pelvic length), and reference. See Table 1 for species codes. *indicates a non-New Zealand reference.

Species	Female maturity (cm)	Size at birth (cm)	Young-of-the-year (cm)	Measurement	Maturity Reference	YOY Reference
ELE	70	10–14	30	FL	Francis (1997a); Kemper et al. (2015)	Francis (1997a); Kemper et al. (2015)
GSH	62	5–10	20	CL	Horn (1997)	Horn (1997); Barnett et al. (2009)*; Berio et al. (2024)*
GSP	69	5–10	20	CL	Horn (1997)	Horn (1997); Barnett et al. (2009)*; Berio et al. (2024)*
SPO	100	25–30	46	TL	Francis & Francis (1992); Francis & Ó Maolagáin (2000)	Francis & Francis (1992); Francis & Ó Maolagáin (2000); Francis et al. (2012)
SCH	135–140	30	50	TL	Francis & Mulligan (1998)	Duffy (2015a); Francis & Mulligan (1998)
SPD	73	18	30	TL	Hanchet (1986)	Hanchet (1986)
BWS	180	40	75	FL	Francis & Duffy (2005)	Francis & Ó Maolagáin (2016)
MAK	280	70–80	90	FL	Francis & Duffy (2005); Duffy (2015b)	Bishop (2006); Francis (2016)
POS	175	69–80	90	FL	Francis & Duffy (2005); Duffy (2015b)	Francis & Stevens (2000); Francis (2015b)
SSK	112	20	30	PL	Francis et al. (2001); Francis et al. (2004)	Francis et al. (2001); Francis et al. (2004)
RSK	59	10–15	30	PL	Francis et al. (2001)	Francis et al. (2001); Last & Stewart (2015a); Bianchi (2024)*
WPS	450–500	150	180	TL	Francis (1996); Finucci & Ó Maolagáin (2022)	Francis (1996); Finucci & Ó Maolagáin (2022)
BSK	800	150	200	TL	Ebert et al. (2021)*	Pauly (2002)*
CAR	76	16–17	30	TL	Horn (2016); Francis et al. (2018)	Francis et al. (2018)
PLS	130	30–34	50	TL	Garrick (1959a); Francis et al. (2018)	Parker & Francis (2012, as proxy); Francis et al. (2018)
ETB	64	20	25	TL	Wetherbee (1996); Irvine et al. (2006a)*	Irvine et al. (2006a)*
BSH	133	37.5	50	TL	Francis et al. (2018)	da Silva (1988)*; Parker & Francis (2012, as proxy)
SND	106	33–45	50	TL	Parker & Francis (2012)	Parker & Francis (2012)
CYP	87	30	40	TL	Francis et al. (2018)	Irvine et al. (2006b)*; Francis et al. (2018)
CSQ	119	30–45	50	TL	Parker & Francis (2012)	Parker & Francis (2012)

2.5 Data selection

Under the ISRA Criteria, species may be identified as Qualifying (species that satisfy one or more of the ISRA Criteria) or Supporting Species (species that are present within an ISRA but that do not satisfy any of the ISRA Criteria) if they occur regularly or predictably within the area of interest based on contemporary information (collected in the last 15 years).

ISRAs are defined using the best available data, and must include observational data (e.g., sightings, movement data, fisheries independent and -dependent data, and biological studies). Information on chondrichthyan catches from the New Zealand Exclusive Economic Zone (EEZ) were obtained from the sources outlined below. Research trawl data were extracted for the calendar years 2000 to 2024, providing a longer temporal scale for the HoPS than what is accepted as contemporary by the ISRA Criteria. This departure was necessary here due to data paucity. Non-observational data (e.g., modelled distributions) are not considered under the ISRA Criteria as they project where a species *may* occur (but not necessarily where it does occur).

Sufficient details on specific biological data (e.g., length, sex, maturation) were required to identify areas of importance to specific life histories (e.g., nursery and pupping grounds). These data are routinely collected by research trawl surveys but are not collected by fisher-reported data and infrequently collected by observer-reported data. A previous review of deepwater shark data collected by observers found few biological data (Finucci et al. 2021a) and collection of data on pelagic sharks collected by observers has diminished significantly in recent years (Francis & Finucci 2019, Moore & Finucci 2024). Thus, fisheries-independent data were used to identify HoPS. Observer and commercial-reported data were used largely to support the research trawl observations and guide the identification of ‘hot-spots’ for future investigation, particularly for the protected species (i.e., white shark and basking shark).

Research trawl

Data were extracted from the *trawl* database for the calendar years 2000 to 2024 and groomed for spatial outliers (obvious errors in location data). Tows beyond the New Zealand EEZ were removed. Position was defined as the mid-point of the start and end latitude and longitude. Depth (m) was defined as the mean of the minimum and maximum depths recorded per tow. Errors were corrected where possible, or the record was omitted if not. Data were available from different surveys with different gear and/or operational procedures (e.g., net size, tow duration) that may affect species' catchability; to maximise records available for this work, survey records were amalgamated together.

Biological and length-frequency data were extracted for the species of interest identified in Section 2.1. Records were groomed to ensure that data were accurate for the species of interest (e.g., occurring within known depth ranges, size lengths). Errors were corrected where possible, if not, the record was omitted.

Within the biological dataset, particular attention was given to reproductively active females, either ‘gravid’ (females allocated stages 4 and 5 of NIWA’s standard Macroscopic Staging Key, Appendix 1) or ‘post-partum’ (stage 6), given that these life history stages were a primary focus of the project. Mature males and females were defined as stage 3, and juveniles (males and females) were defined as stages 1 and 2. Small individuals were defined as YOY if they measured equal to, or less than, the YOY estimate in Table 2. The biological data for YOY and reproductively active females was used to identify areas of importance to these life history stages as these were individuals with measured size and maturity data, as opposed to individuals where only length was recorded (see below).

In the length-frequency data, when only a subset of each catch was measured (when catches were large), the length-frequency distribution of measured individuals was scaled up to the total catch. Length-frequency data were assigned as ‘YOY’, ‘juvenile’, or ‘mature’ based on the life history parameters in Table 2. The length-frequency data was used to identify areas of importance to juveniles (i.e., immature males and females) as this life history stage is often caught in large numbers and is subsampled. The length-frequency data for estimated YOY and reproductively active females was plotted to complement the biological data and possibly highlight additional areas where these life history stages may occur but was not considered for the kernel density estimation (see Section 2.7) as some individuals of these life history stages (particularly females maturing at a smaller size) may not have been accounted for because maturity was not assessed.

Observer-reported data

The Centralised Observer Database or '*cod'* contains data collected by Fisheries New Zealand observers on fishing vessels and is managed by NIWA for Fisheries New Zealand. The database was searched for all records containing the three-letter species codes for the species listed in Table 1 and associated fishing event data, including any species-specific information on size and sex, for the calendar years 2000 to 2024. Species identification, particularly for deepwater species, improved after the introduction of specific field identification guides (McMillan et al. 2011a, 2011b). These observed records are hereafter referred to as observer-reported records.

Fisher-reported data

The Enterprise Data Warehouse (EDW) database (previously *Warehou*) contains catch and effort data received from commercial fishers and is managed by Fisheries New Zealand. The database was searched for all records containing the three-letter species codes for the species listed in Table 1 and associated fishing event data for the calendar years 2000 to 2024. These records are hereafter referred to as fisher-reported records.

Protected species

Information on protected species (i.e., white shark and basking shark) interactions was extracted from previous projects (BYC2021-02, BYC2022-02) and updated to the end of 2024. These data are obtained from the fisher reported Non-Fish Protected Species Catch Returns (NFPS). There was one observer-reported and six fisher-reported basking shark records, and 35 fisher-reported white shark records added here.

2.6 Additional data sources

Additional data sources were also obtained to support the trawl survey, observer- and fisher-reported data, and to identify areas, species, and/or life history stages that are not otherwise sampled or commercially fished. For example, egg cases are not often captured or reported in research trawl surveys but are important for identifying egg-laying areas for oviparous species. These additional data sources included species-specific surveys (e.g., Francis et al. 2012), the Adaptive Management Programme (AMP), community observations (e.g., iNaturalist 2024), and collection material from the Museum of New Zealand Te Papa Tongarewa (hereafter Te Papa) and the Auckland War Memorial Museum (hereafter Auckland Museum). These data were used as supportive information (see Appendix 4) and not used in the mapping.

2.7 Kernel density estimation

Visualizing the density of occurrence (point-location) records can be misleading, especially when there are a high number of occurrence records in close proximity, limiting the ability to accurately discern high and low densities. This limitation is compounded by datasets which record numerous individual records at a single location; wherein a single point-location could represent a high density of unique records. Kernel density estimation (KDE) calculates the density of features in a neighborhood around those features, allowing for the creation of a spatial dataset (in this case raster grid format) representing the density of targets (Kenchington et al. 2014, Lees et al. 2016). In a spatially explicit context, KDE is calculated for a given cell, with the size of the 'neighborhood' (i.e., number of adjoining cells) determined by a preselected bandwidth (also known as search radius). When calculating a spatial KDE, an underlying raster dataset is required to set the resolution and extent of the KDE. Here, a spatial dataset for bathymetry (depth in metres) was used, with a grid resolution (i.e., cell size) of 1 km × 1 km, with the extent of the New Zealand Exclusive Economic Zone (EEZ). The KDE function converts 'count per cell' to a density value based on cell area. The algorithm calculates values referred to as 'expected density per cell', but the value provided by the function is cell area specific (in this case 1 km × 1 km or 1 km^2). KDEs have been used to map the distribution and habitat use of marine species in New Zealand waters previously, including seabirds (Dunphy et al. 2020) and marine mammals (Rayment et al. 2009, Brough et al. 2019).

To calculate KDEs to inform shark HoPS development, occurrence information from research trawl surveys was subset by development stage (YOY, juveniles, and reproductively active females) for each shark species (Table 1). The grid supplied was bathymetry at the extent of the EEZ (1 km by 1 km), while the bandwidth used was 10 km. Various approaches were used to investigate an appropriate bandwidth. These included testing a series of bandwidth values (20 km and 10 km), as well as applying recognized statistical approaches, drawing on the Silverman Rule of Thumb (Silverman 1986). The bandwidths derived from statistical approaches were deemed too large to be ecologically relevant. Ultimately, the bandwidth chosen was 10 km, based on the visualization of tested bandwidths and informed by research on broad-scale shark core habitat size (Druon et al. 2022). Using this search radius, KDEs were deemed to be useful, not too broad or too computationally demanding. Data manipulation was achieved using R packages *dplyr* and *tidyr* (Wickham et al. 2019), and handling of spatial data and calculation of KDEs was supported by the *raster* (Hijmans et al. 2015), *terra* (Hijmans et al. 2022) and *spatialKDE* (Caha 2014) packages in RStudio (RStudio 2020).

To support like-for-like comparison of shark KDEs (across species and development stages) regardless of magnitude, all calculated KDEs were standardized (0–1). This process allows for 'equal weighted' comparison between disparate datasets / densities, but it should be noted that hotspots (high densities) across standardized KDEs are not directly comparable; high density of rare species and highly abundant common species will both be represented with KDE values approaching 1.

2.8 Location and feature combinations of KDEs

Species and development stage KDEs were used to create heatmaps to visualize the density distribution of relevant development stage occurrences. Almost 50 maps were created. To streamline the identification of areas of importance for multiple shark species (and thus support creation of shark HoPS polygons), multiple species KDEs were combined (see Appendix 3). Expert knowledge of location or region use by different sharks was used to inform which species KDEs should be combined. For the East Coast South Island region for example, the KDEs for GSH, SPD, SSK, and SCH were summed to produce a single heatmap for the region. All KDEs were standardized (0–1) prior to summing to equally-weight species included in the combination. Location-specific KDE combinations were generated for 24 different regions or specific underwater topographical features (like Mernoo Bank and Snares Shelf). To complement location-specific species KDE combinations, for each development stage all species KDEs were summed to provide an overarching heatmap of occurrence densities for all YOY, juveniles, and reproductively active individuals. All combined standardized KDEs were mapped, by each location used to inform the grouping, so that hotspots of shark densities could be visualized in areas anticipated to contain shark HoPS.

2.9 Zonation prioritisations

The combination approach of summing KDEs is useful for identifying areas important for several species (i.e., for identifying areas with overlapping high density). However, the approach of summing KDEs can reduce the signal of species that have a comparatively different or unique distribution or smaller geographic ranges, or niche breadth compared to other species included in each combination. This is a similar limitation to that experienced by stacked species distribution models (Brough et al. 2025). To complement combined species maps produced by summing, a Zonation approach was used to cross-check representativity of species of combined KDEs. Zonation is a decision-support tool, that produces conservation planning solutions where biodiversity value is maximized, and when included, costs are minimized. It was developed to assist the identification of areas important for retaining habitat quality and connectivity. The power of Zonation comes from its ability to handle extensive complementary datasets, allowing for scenario testing (Rowden et al. 2019). Zonation has been used extensively in New Zealand, for identifying spatial conservation priorities for vulnerable marine ecosystems (VMEs) in the high seas (Rowden et al. 2019), for identifying optimal areas for biodiversity conservation throughout the New Zealand EEZ (Jefferson et al. 2023) and to support spatial planning in the Hauraki Gulf Marine Park (Bennion et al. 2023, Tablada et al. 2022).

The hierarchical prioritization algorithm of Zonation works by progressively removing cells of lower value until the minimum area, providing the maximum value (incorporating costs) remains (Di Minin et al. 2014). For example, 'value' here refers to KDE where a higher density of shark occurrence is considered higher value. Zonation settings used in this analysis were: core area cell removal, *warp factor* (defines how many cells removed each iteration) set to 1000, *edge removal* set to 1 (Zonation gives lower priority to cells from the edges of remaining landscape), and *z* (the exponent of the species area curve, $S = cAz$, used to calculate the extinction risk of taxa as their distribution decreases) set to 0.25 (default setting). Given the absence of a statistical measure of uncertainty, the *use info-gap* weights function was not used; default settings for other Zonation options were set to 0 (i.e., not used). For all Zonation prioritisation scenarios carried out for this project, the core-area Zonation cell removal algorithm was used. In this algorithm, cell removal minimises biological loss by picking the cell that has the lowest KDE for the most valuable feature over all biodiversity features in the cell. Therefore, if even one species has a high proportion of its relative occurrence found there, the cell gets a high value. When running the analysis, the programme analyses all cells and calculates a value for each cell based on the feature that has the highest weighted proportion of distribution remaining in that specific cell. The cell which has the lowest value will then be removed. Zonation peer-reviewed literature provides more details on model equations and model options (Di Minin et al. 2014, Moilanen 2007, Moilanen et al. 2008).

The Zonation algorithm produces a rank priority (0–1) with cells approaching 1 representing areas of high rank importance and areas approaching 0 representing areas less important for included biodiversity features. As opposed to the summing approach, the rank priority attempts to maintain high value for all the biodiversity input layers. For instance, if one species exhibited a comparatively unique core habitat distribution (indicated by KDE), the Zonation algorithm would ensure that high value areas (although only high value for one species) were indicated as high priority. In this way, caution should be used when interpreting the Zonation rank priority, as areas that are indicated as high priority, may only represent areas of high biodiversity value (high KDE) for one or two species rather than all species (biodiversity features) included.

For this analysis shark species were divided into two groups based on their known depth distribution: inshore and deepwater. The inshore group contained the following species: elephantfish, carpet shark, school shark, rig, spiny dogfish, rough skate, and smooth skate. The deepwater group contained: dark ghost shark, pale ghost shark, spiny dogfish, leafscale gulper shark, shovelnose dogfish, longnose velvet dogfish, Baxter's dogfish, Plunket's shark, and seal shark. Spiny dogfish was considered in both groups because of their abundance in both inshore and deepwater environments (Hanchet 1986, Roberts et al. 2015). The pelagic (mako, porbeagle, and blue shark) and protected (basking shark, white shark) species were not considered here because of a lack of research trawl survey records (see individual species sections for more details). The Zonation approach detailed above was then run for each development stage separately (YOY, juveniles, reproductively active females). Final 'all combined' runs were constructed with all species (both inshore and deepwater) for each development stage. Given the small area covered by KDE hotspots (relative to the size of the EEZ), the Zonation rank priority output (0–1) was not very informative in places where values were <0.95, given large swaths of the EEZ obtained low-moderate rank priority (as expected as Zonation attempts to prioritise the full extent of the study area). For this reason, all Zonation rank priority maps were limited to the top 1% (>0.99), indicating the areas of highest biodiversity value only.

2.10 Developing potential Habitats of particular significance (HoPS) for sharks

More than 145 maps were used to inform the placement of shark HoPS polygons. Habitats of particular significance boundaries were hand drawn on maps of species and development stage location-specific KDEs. Images of hand drawn boundaries were imported into ArcGIS Pro, and georeferenced. Georeferencing uses control reference point locations to scale an image and correctly locate it on a map. GIS polygons could then be manually drawn, using the hand drawn shapes for reference. A series of depth cut-offs were then applied to certain shark HoPS polygons. Depth cut-offs were specific to each HoPS and were based on a combined depth range of the species relevant to a given shark HoPS. Species known depth ranges within New Zealand waters were derived from research trawl data, summarized in McMillan et al. (2019). See Table 3 for the depth ranges used to reshape the boundaries of shark HoPS polygons.

2.11 Describing the habitats of significance

To understand the similarities between the different HoPS polygons, environmental descriptions were derived. The method used to derive environmental descriptions is akin to that used by Bennion et al. (2023) to describe 'trawl corridor' scenarios (referred to as 'post-accounting' therein), and by Stephenson et al. (2023) to describe the New Zealand seafloor bioregionalisation. An intersect analysis was used to reveal the environmental conditions present within HoPS polygons. Spatially explicit static estimates of environmental conditions were used at the scale of the EEZ (1 km × 1 km resolution). The environmental datasets used are described in Stephenson et al. (2022) and include: depth, bottom temperature, bathymetric position index-broad (BPI-broad), percent gravel, percent mud, particulate organic carbon (POC), roughness, percent sand, slope, sea surface temperature (SST), and tidal current speed. Depth and water temperature (bottom and SST) were reported in the final outputs (see Appendix 4) as these two environmental parameters are frequently shown to be key drivers of shark distributions (e.g., Vedor et al. 2021, Pardo & Dulvy 2022). At the same time, a representation of fishing pressure (a 30-year swept area ratio, SAR) was also included in the intersect analysis. Annual trawling intensity datasets for combined inshore and deep-sea fisheries, within the New Zealand EEZ were produced by Rowden et al. (2024). Trawl swept areas were derived from start and end positions and trawl widths (for 24 separate categories of fishing gear) and used to calculate total swept area ratio for each 1 km × 1 km grid cell as the total accumulated swept area (in km^2) of all trawls centred in the cell divided by the area of the cell (1 km^2). The total accumulated swept area ratio is used as the fishing intensity for each HoPS.

Various summary statistics were calculated to aid descriptions of the environmental conditions within the shark HoPS polygons, including mean, median, interquartile range, minimum and maximum values.

A second version of the intersect analysis used above was employed, using management boundaries of several protected areas, which were used to describe the level of protection currently afforded to the derived shark HoPS polygons. The protected areas used include Type I and Type II Marine Protected Areas (MPAs; including marine reserves and cable protection zones), the benthic protection areas (BPAs), and seamount closures. Spatial layers representing management area boundaries were all sourced from the LINZ data service (https://data.linz.govt.nz/). The proportion of shark HoPS polygons inside and outside of protected areas was calculated. This method mirrors the approach used in previous benthic fisheries impact assessments conducted in New Zealand, referred to as 'post-accounting' (SPRFMO 2020).

2.12 Limitations of the KDE approach

KDEs are wholly limited by the completeness of the data used to generate them. For instance, if a species' entire niche or home range is not represented in the sampling regime, KDE hotspots may not fully represent core habitat use. In the case of this study, most of the data available is derived from research trawl surveys that monitor commercial fish stocks. The distribution of occurrence records is biased to areas that are fished commercially. Caution should therefore be placed on the distribution of KDE hotspots; they should be interpreted with the knowledge that areas outside of the fishing footprint are less certain. Furthermore, as the occurrence data was gathered with fishing gear, the selectivity of the various gears used (i.e., catchability) and effort (length of tows and number of tows) can have a large impact on the density of records from a given location. Areas are also not sampled throughout the year, so any seasonality in occurrence cannot be captured. Statistical methods are sometimes used to account for effort when calculating KDEs (e.g., weighting by catch or sighting per unit effort) (Brough et al. 2019), however the quality and quantity of data available by species and by development stage, did not allow for implementation of these methods. When interpreting hotspots, it should therefore be noted that effort could be inflating the density estimates in some places. Density estimates may alternatively be underestimated if a species catchability in certain gear types is low (e.g., pelagic sharks in trawl fisheries). Nevertheless, the data available, and the KDEs generated, represent the best available information to inform the placement of shark HoPS, in combination with expert knowledge of shark distribution and habitat use in New Zealand waters.

Table 3: Depth ranges used to reshape the shark HoPS polygons.

Shark HoPS	Minimum depth (m)	Maximum depth (m)
North Cape	0	-100
Puysegur	-200	-1500
Snares shelf	0	-1500
Auckland Islands East	0	-1100
Auckland Islands North	0	-1100
East Coast South Island	-150	-400
Hokitika	0	-1500
Chatham Rise North 1	-200	-1300
Chatham Rise North 2	-200	-1300
Chatham Rise North 3	-200	-1300
Chatham Rise North 4	-200	-1300
Chatham Rise South 1	-200	-1500
Mernoo Bank	-400	-1100
Veryan Bank	-100	-600
Canterbury Bight	0	-50
Pegasus Bay	0	-50

2.13 Proposed HoPS description

Each proposed HoPS was described with a profile entry, found in Appendix 4. The profile for each proposed HoPS contains the following details:

- Habitat name
    - The location of the proposed HoPS
- Species of interest
    - Species of interest, as well as other species known to occur in the habitat. Species were identified as:
        - 1) Primary species: species of interest where the habitat has been identified as a proposed HoPS
        - 2) Supporting species: species of interest that occur in the habitat but were not identified to use the habitat as a proposed HoPS
        - 3) Other chondrichthyans known to occur in the habitat (but were not a focal species for this project)
- Attributes of habitat
    - Description of the habitat using the Coastal and Marine Ecological Classification Standard (CMECS) (see NOAA 2012)

    - Depth and temperature range (see Section 2.11)
    - The Marine Bioregion(s) the proposed HoPS overlaps with (see Stephenson et al. 2023)
- Reason(s) for particular significance
    - The function of the habitat (e.g., nursery area), known or suspected
- Risks/potential adverse effects of fishing
    - Identification of fishing stressors, known and potential
        - *Fishing using bottom-contact methods across the habitat* was identified for each HoPS, whether that risk/potential adverse effect be ongoing or potential. The environmental impacts and natural disturbance of community composition and function of habitats caused by fishing (any gear type) on the seabed, benthic communities, are well documented in New Zealand and elsewhere (e.g., Johnson et al. 2015, Van Denderen et al. 2015, Clark et al. 2016, Collie et al. 2017, Clark et al. 2019). The timeframe for this risk (historical, contemporary, or future) was not identified because information may have been unavailable (historical, or contemporary for some gear types), may occur in only part of the identified HoPS (contemporary), or cannot be predicted (future).
        - *Resuspension of sediment by bottom-contact fishing* was identified for each HoPS, whether that risk/potential adverse effect be ongoing or potential for the reasons above. This is of particular importance for HoPS where oviparous species were identified as Primary Species. Oviparous chondrichthyans either lay their egg cases directly on the seabed, or attach egg cases to benthic substrate (e.g., coral) (e.g., Armstrong 2022, Finucci et al. 2024a). Regular water flow, well-oxygenated water, and low sedimentation is required for embryo development and to avoid suffocation (e.g., Henry et al. 2016, Phillips et al. 2021, Maguire et al. 2023). Resuspension of sediment may impact the benthic substrate these species use for breeding purposes, or may altogether smother egg cases, leading to embryo impairment or death.
        - *Fishing using pelagic methods across the habitat* was identified as a risk/potential adverse effect of fishing for HoPS where pelagic species were identified as Primary Species. The primary habitat for species of interest is identified in the species' accounts (see Section 3.1). Fishing in pelagic/oceanic environments can lead to changes in community trophodynamics and reduce biodiversity and ecosystem resilience (Ortuño Crespo & Dunn 2017).
    - Estimated sum Swept Area Ratio (SAR) (see Section 2.11)
    - The proportion of the proposed HoPS closed to fishing (see Section 2.11)
- Risks/potential adverse effects of other activities
    - Identification of non-fishing stressors, known and potential
        - *Increased human activities in the water* was identified as a risk/potential adverse effect for HoPS that were readily accessible to people (i.e., coastal habitats within 12 nautical miles of shore). Exponential human population growth and increased interest in water-based activities is increasing human presence in the marine environment, which is leading, or may lead to, impacts such as habitat disturbance and degradation (e.g., Halpern et al. 2019, Rex et al. 2023).
        - *Climate change effects* was identified as a risk/potential adverse effect for all HoPS. The impacts of climate change, including changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, and reduced habitat quality have already been identified as adverse effects on coastal marine environments (e.g., Harley et al. 2006). Climate change will also affect the deep ocean, if it is not already; though impacts are not well defined, many of the impacts on coastal marine environments mentioned

above (except for freshwater run off) are likely to impact the deep ocean as well (e.g., Levin & Le Bris 2015).

        - *Coastal modification and development* was identified as a risk/potential adverse effect for coastal HoPS. Coastal population growth leads to increased land usage and known or suspected impacts on the marine environment, including increased turbidity, sedimentation, eutrophication, and ultimately, habitat loss (e.g., Crain et al. 2009, Halpern et al. 2019).
        - *Pollution* was identified as a risk/potential adverse effect for coastal HoPS for the same reasons as *Increased human activities in the water* and *Coastal modification and development.* Adverse effects may include high nutrient and contamination loading (e.g., Crain et al. 2009, Halpern et al. 2019). *Pollution* was also selected for Chatham Rise because of interest in phosphorite nodule mining which may result in the release of contaminants from sediment plumes into the marine environment (Kaikkonen et al. 2025).

- Evidence (References)
    - Information sources used to support the identification of the proposed HoPS. These sources may include published and unpublished data

3. RESULTS

3.1 Species knowledge inventory

Elephantfish (*Callorhinchus milii*)

Elephantfish are found in New Zealand and Australian waters. In New Zealand, the species is demersal, known from nearshore to the continental slopes at depths of at least 200 m (Kemper et al. 2015). Elephantfish are recorded predominately from around the South Island of New Zealand; they are uncommon off the North Island but are occasionally recorded from the eastern Bay of Plenty, south of East Cape, and on the west coast, and sometimes as far north as the Kaipara Harbour (Kemper et al. 2015). Elephantfish prefer soft sediment substrate (Francis 1997a, Braccini et al. 2008).

Spawning

Elephantfish are oviparous, laying egg cases on the sediment (sand or mud) where embryos develop for an estimated 5–8 months before hatching (at approximately 10 cm fork length) (Lyon et al. 2011, Kemper et al. 2015). Average annual fecundity is estimated to be 20 egg cases. It is thought that elephantfish prefer to deposit egg cases on bare, soft sediment in shallow areas with minimal wave disturbance and tidal current movement (Braccini et al. 2008, Barnett et al. 2019). In Australia, large numbers of elephantfish egg cases and neonates were reported from the outer margins of subtidal areas on sandy sediment and seagrass (*Halophila australis*) meadows (Braccini et al. 2008).

Major coastal spawning sites in New Zealand include harbours, bays, and estuaries in Marlborough Sounds (Queen Charlotte and Pelorus Sounds), Canterbury Bight (north and south of Timaru), and west of Foveaux Strait (Te Waewae Bay) (Francis 1997a, Lyon et al. 2011, Morrison et al. 2014a). High catches of neonates were also recorded between Oamaru and Banks Peninsula, especially off Lake Ellesmere, in depths 10–50 m. Off the North Island, egg cases, juveniles, and adults have been reported around Wellington Harbour, Porirua Harbour, and Pāuatahanui Inlet but these areas are not well defined (Jones & Hadfield 1985, Francis 1997a, Lyon et al. 2011).

Embryonic development (egg laying to neonate hatching) is highly temperature dependent. In the Canterbury Bight, embryonic development is approximately 26 weeks (with hatching and the presence of juveniles in catches between April and July), and 32 weeks in the Marlborough Sounds (estimated mid-November hatching but could be as late as January with an extended spawning period) (Francis 1997a, Lyon et al. 2011).

Juvenile habitats

Juvenile elephantfish have been recorded in research trawl surveys in Pegasus Bay and along the Canterbury Bight. Tagging studies have shown that juveniles generally remain within nursery areas for up to three years and may move further offshore as they mature (Francis 1997a, Beentjes & Stevenson 2000).

Adult habitat, migrations and movements

Mating grounds, movement patterns, and/or seasonal changes in distribution of adults are not well defined throughout their range. Acoustic tagging data from Australia suggests that elephantfish are highly mobile (Barnett et al. 2019). In New Zealand, adult elephantfish aggregate in shallow inshore waters (including harbours, bays and estuaries) on the east coast of the South Island (ECSI) to engage in inshore spawning migrations during the spring-summer months (November to February) (Jones & Hadfield 1985, Francis 1997a). Large migrations of mature female elephantfish are known to enter the Pegasus Bay area in spring each year to lay their eggs (Gorman 1963, Sullivan 1977). In the Marlborough Sounds, spawning is thought to take place from mid-March to June, with a peak in April. In Te Waewae Bay, spawning occurs between December and March, with a peak in January. Off Wellington, elephantfish are most abundant during late summer months (February, March) (Francis 1997a, Lyon et al. 2011). After spawning, adults are suspected to move back offshore into deeper water during the summer months and remain at deeper depths during winter.

Population connectivity
Population structure within New Zealand and between New Zealand and Australia is suspected based on ongoing research (B. Finucci unpublished data).

Research trawl data
Since 2000, reproductively active female elephantfish have been recorded in three years (2012, 2016, 2018), with 20 records across three trips. These females measured 70.6 to 92.1 cm FL (median=81.1 cm FL). Mature females (n=250) were recorded from depths of 15–136 m (median=33 m) and reproductively active females were recorded from similar depths of 19–80 m (median=32 m) (Figure 3). Juveniles (n=2603) were found at a similar depth range to mature females (range=15–138 m, median=28 m) while mature males (n=606) were generally found at deeper depths (range=15–128 m, median=56 m) (Figure 3).

Reproductively active females were recorded in Pegasus Bay and along Canterbury Bight, as well as Taiaroa Canyon (Figure 4). Additional female elephantfish (n=1805) not assessed for maturity but measuring at least known length-at-maturity (70 cm FL) were recorded in large numbers along ECSI (north and south of Banks Peninsula to just north of Dunedin), the west coast of the South Island (WCSI), with a few scattered records around Stewart Island and Tasman and Golden bays (Figure 4).

Estimated YOY (<30 cm FL) were recorded in seven years. There were 532 biologically measured (depth range=15 to 52 m, median=26 m) and 4508 length-measured (depth range=8 to 52 m, median=22 m) individuals. Records were largely confined to south of Banks Peninsula to Timaru, with an additional record north of Banks Peninsula and off Greymouth (Figure 4). Most biological records occurred in April-June (n=467), and the remaining records were in December (n=65).

The kernel density estimates for elephantfish showed juveniles and YOY were mostly reported along the Canterbury coastline. Reproductively active females were mostly recorded at Taiaroa Canyon (Figure 5, Appendix 2), and in April (n=6) and May (n=14), which is reflective of sampling efforts.

Observer and commercial data
No elephantfish have been measured by observers since 2000. Observed catch was limited to trawl and set net fisheries, largely along Banks Peninsula (Figure 6). Some observed catch was also reported from Foveaux Strait (Figure 6). Fisher-reported catch was mostly recorded around Banks Peninsula to Timaru, southwest Chatham Rise, and to a lesser extent, the Otago Peninsula and WCSI in trawl, bottom longline, and set net fisheries (Figure 7).

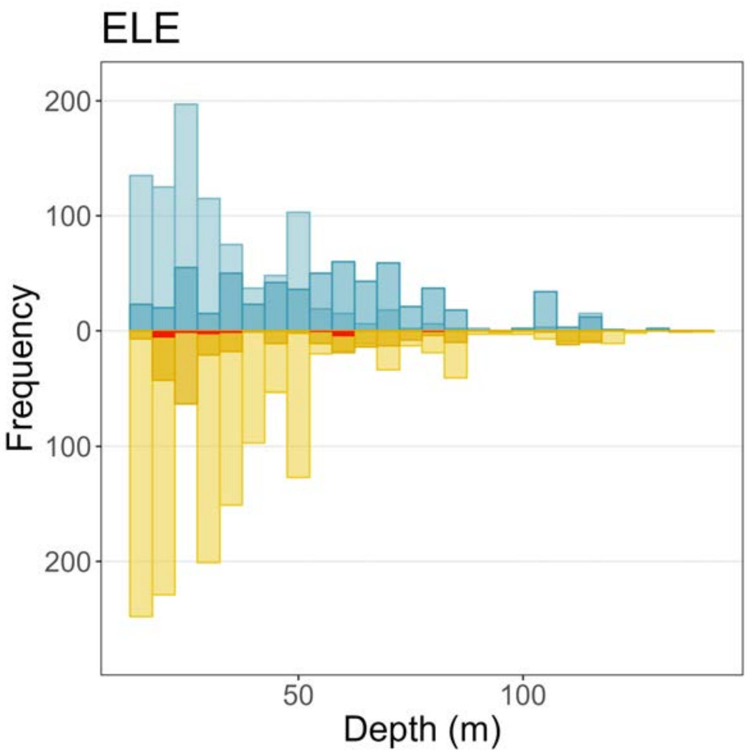


Figure 3: Depth distribution of elephantfish biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively active females are identified in red.

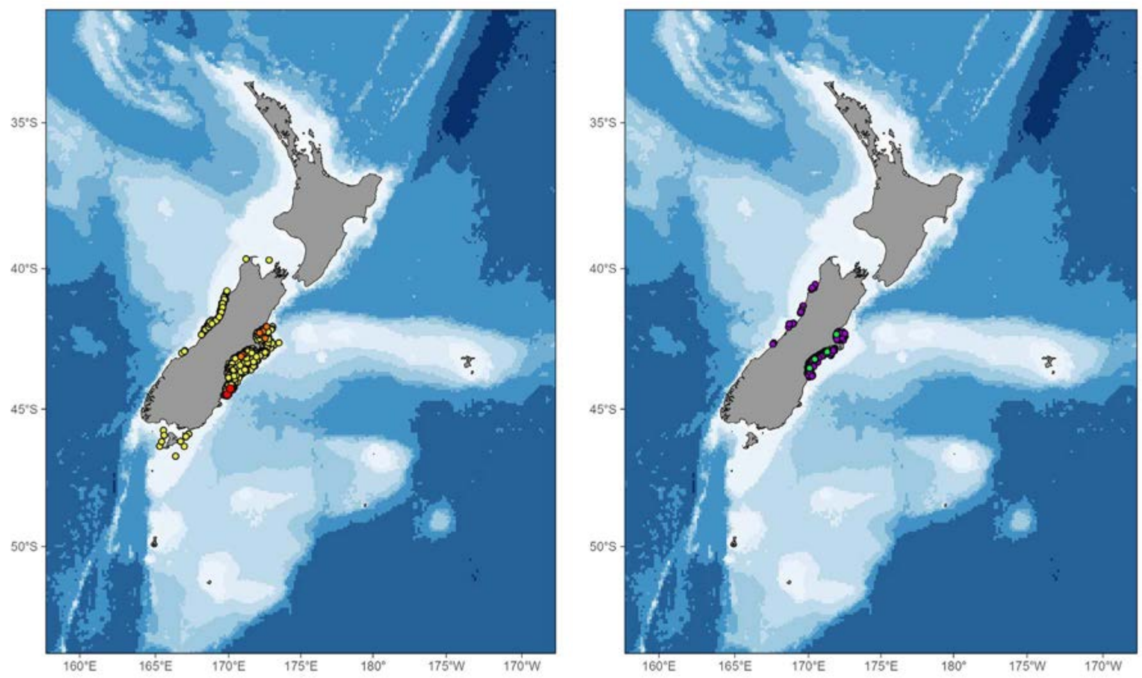
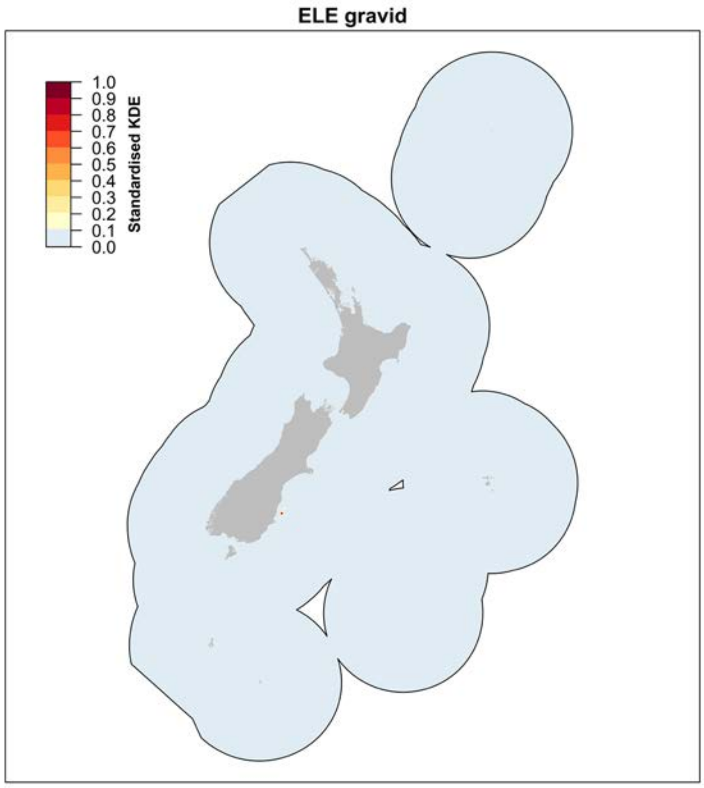


Figure 4: Research trawl survey records for elephantfish from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements only (purple).



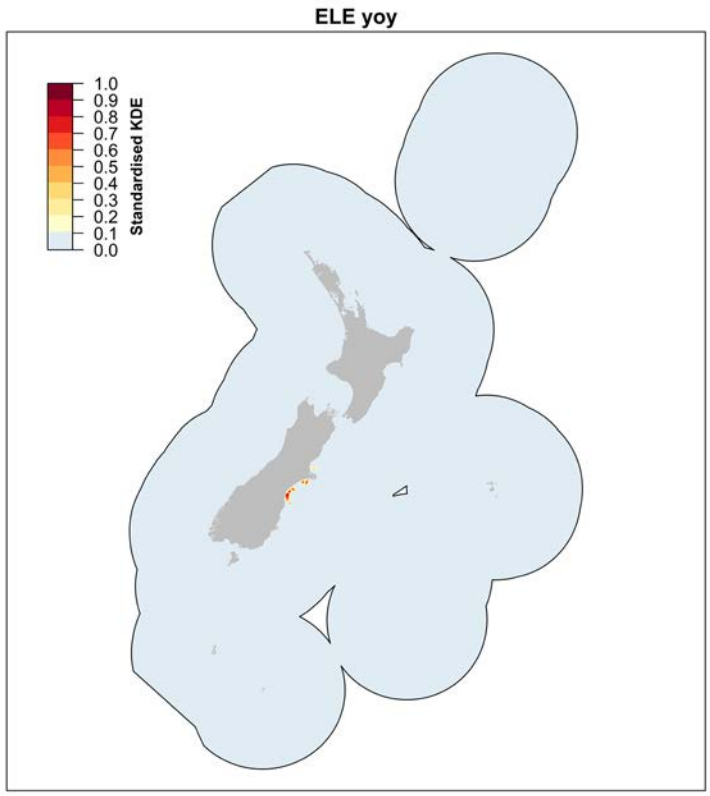


Figure 5: Kernel density estimate (KDE) for research trawl survey records for elephantfish from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year 'YOY'. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

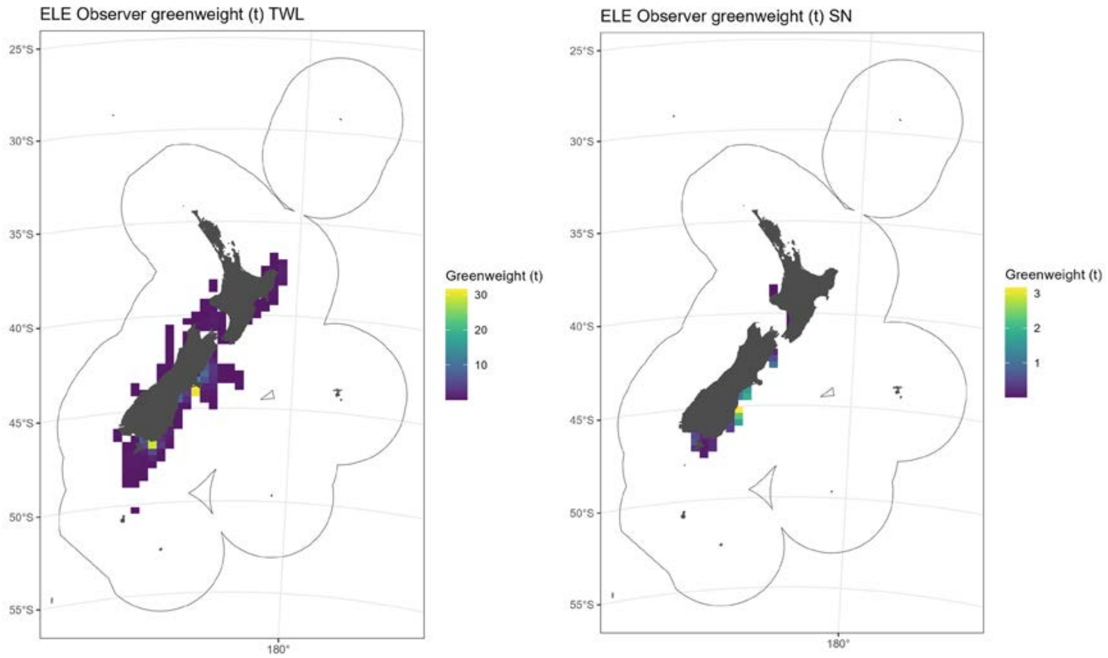


Figure 6: Distribution of elephantfish catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; SN=set net.

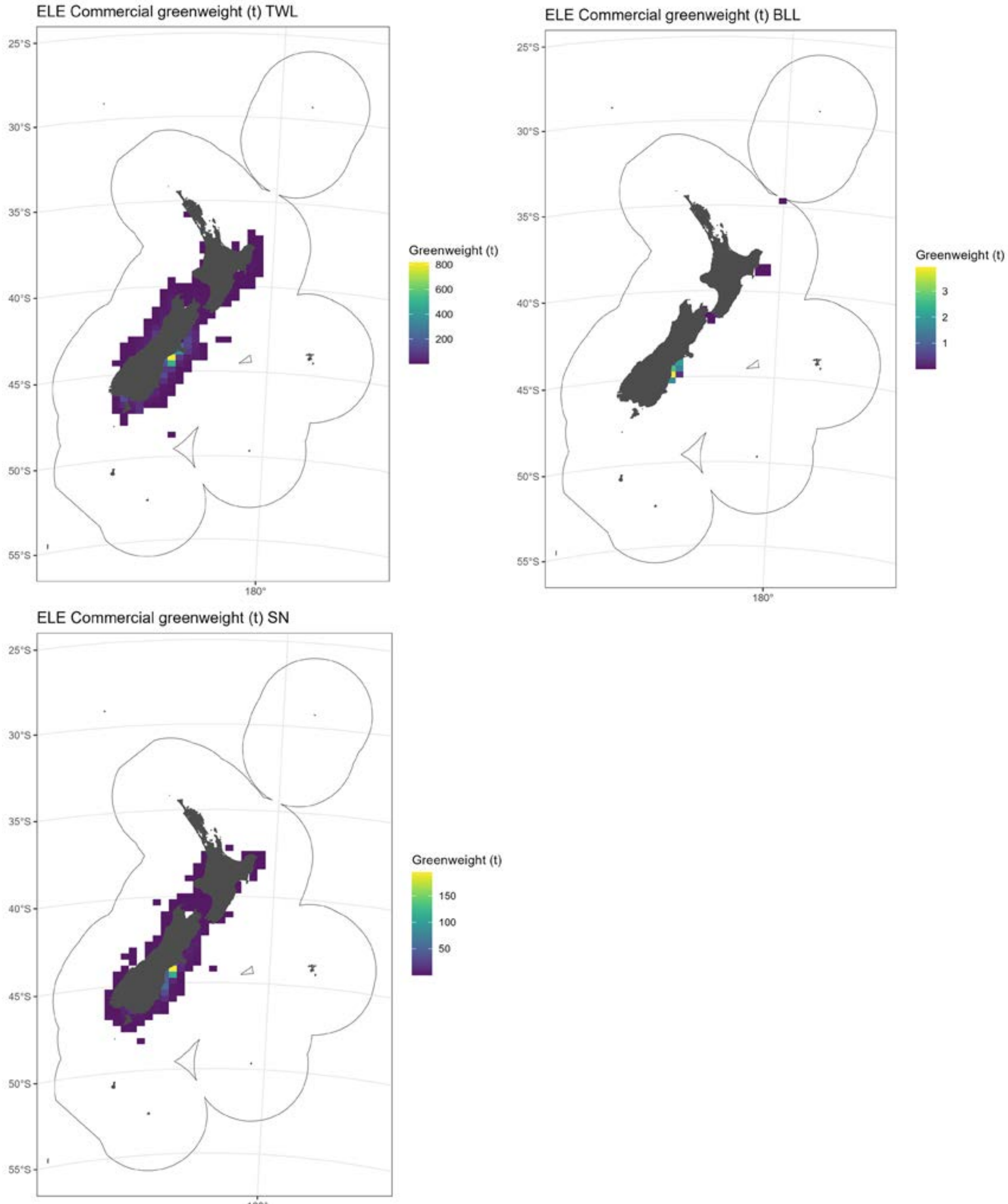


Figure 7: Distribution of elephantfish catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net.

Dark ghost shark *(Hydrolagus novaezealandiae)*

The dark ghost shark is endemic to New Zealand waters. The species is demersal along the outer continental shelf and upper slope at depths of 32–800 m but is most common between 150 and 500 m. Dark ghost shark are distributed throughout New Zealand waters but are most frequently reported on Chatham Rise and Campbell Plateau at latitudes south of 40°S (MacGibbon & Fu 2013, Kemper et al. 2015). Dark ghost sharks are generally found at shallower depths than pale ghost sharks. Habitat preference is unclear. On Chatham Rise, larger fish occur in warmer waters and appear to consume more crabs, whereas smaller fish were found more often in cooler waters and eat more polychaetes (Dunn et al. 2010). Ghost sharks (Chimaeridae) in New Zealand appear to be found more often on muddy sediment or sandy bottom habitat, and at temperatures of 8.6–12.1°C, based on video observations (Armstrong 2022, Te Papa unpublished data).

Spawning

Spawning season, spawning frequency, and egg laying grounds are not known. Dark ghost sharks are oviparous, laying two egg cases at a time on the sediment where embryos develop for a prolonged period before hatching. Fecundity, incubation duration, and spawning season are not known, but based on captive observations of the related Spotted Ratfish (*Hydrolagus colliei*), female dark ghost sharks may lay two eggs every two weeks throughout most of the year (McCutcheon 1980, Berio et al. 2024). Estimated incubation to hatching duration is around one year for other *Hydrolagus* species (Berio et al. 2024), which may fluctuate depending on water temperature (Dean 1906, Lyon et al. 2011, Berio et al. 2024).

Juvenile habitats

Nursery grounds are not known. Smaller sharks (under 40 cm chimaera length, CL) are more abundant in waters shallower than 200 m, particularly in the Canterbury Bight (Fisheries New Zealand 2024). Small ghost sharks and egg capsules have been observed on NIWA's Deep Towed Imaging System (DTIS) video on Pukaki Rise and Campbell Plateau (Armstrong 2022). These individuals appeared to be associated with high densities of seastars (class Asteroidea) and brittle stars (class Ophiuroidea). Other oviparous chondrichthyans have been reported to have separate nursery areas – one for egg deposition and embryo development and another for newly emergent juveniles (Hoff 2016). It is possible that ghost sharks also engage in this behaviour.

Adult habitat, migrations and movements

Mating grounds, movement patterns, and/or seasonal changes in distribution are not known. Large catches of ghost sharks have been reported on south Canterbury Bight in May–June and the Stewart-Snares shelf in February–March (Horn 1997). Dark ghost sharks aggregate in large numbers off ECSI and Mernoo Bank (Horn 1997). The presence of large mature females, as well as small individuals, including neonates and young of the year suggest that this is an important breeding area. Mature and gravid female dark ghost sharks have also been caught in small numbers on Chatham Rise, Sub-Antarctic, and WCSI RV *Tangaroa* surveys, and at a higher relative abundance in the ECSI RV *Kaharoa* survey.

Population connectivity

Population structure is not known. Land masses, sea features, and areas of narrow continental shelf may provide natural barriers. The deep water separating the Bounty Platform from the Campbell Plateau may also be a barrier to mixing, and these areas may hold separate stocks (Horn 1997). Overseas, distinct genetic populations of the related Rabbitfish (*Chimaera monstrosa*) have been identified between the Northeast Atlantic Ocean and Mediterranean Sea and were attributed to the shallow depths of the Strait of Gibraltar (Catarino et al. 2017).

Research trawl data

Since 2000, reproductively active female dark ghost sharks have been regularly recorded in research trawl surveys (14/23 years), with 456 records across 27 trips. These females measured 51.0 to 73.2 cm CL (median=63.6 cm CL). Mature females (n=2692) were largely reported from shallower depths (range=64–675 m, median=137 m) and reproductively active females were recorded deeper from depths of 66–648 m (median=261 m) (Figure 8). Juveniles (n=8890) and mature males (n=3996) were more often found at deeper depths than females (range=72–656 m, median=359 m; range=64–712 m, median=332 m, respectively) (Figure 8).

Reproductively active females were mostly recorded along the ECSI, with scattered records throughout Chatham Rise, and a cluster of observations from WCSI, the southern edge of the Snares Shelf, and southeast of the Auckland Islands (Figure 9). Additional female dark ghost shark (n=15 174) not assessed for maturity but measuring at least known length-at-maturity (62 cm CL) were more widely distributed, recorded in large numbers in these areas, as well as Puysegur and in smaller numbers on the Campbell Rise, and northwest North Island (Figure 9). Reproductively active females were recorded in most months except spring (October and November), and most observations were in January (n=200) and May (n=159). While sampling is dependent on when and where research surveys take place, the presence of reproductively active females throughout most of the year may suggest that reproduction occurs year-round.

Estimated YOY (<20 cm CL) have also been recorded in four years (2001, 2016, 2018, 2023) in January (n=3), March (n=1), and May (n=2). There were six biologically measured (depth range=305 to 384 m, median=322 m) and 53 length-measured (depth range=231 to 411 m, median=363 m) individuals. Most of these records were off Canterbury Bight, with two records near the Chatham Islands, a few scattered records from WCSI and around Auckland Islands and one record in the Cook Strait (Figure 9).

The kernel density estimates for dark ghost shark showed that most reproductively active females, juveniles, and YOY records were reported along the ECSI (Figure 10). Juveniles were also recorded in high densities at Mernoo Bank (Appendix 2).

Observer and commercial data
No dark ghost shark have been measured by observers since 2000. Observed catch was recorded mostly in trawl fisheries along the ECSI slope, with some observed catch recorded in bottom longline mostly on the Chatham Rise, west of the Chatham Islands, and in set net fisheries along the Otago Peninsula coastline (Figure 11). There were a small (n=12) number of records reported in Danish seine fisheries (not shown here). Fisher-reported catch was mostly recorded in trawl fisheries in the Cook Strait (Figure 12). Fisher-reported catch in bottom longline was recorded west of the Chatham Islands and catch in set net was recorded near Kaikoura (Figure 12).

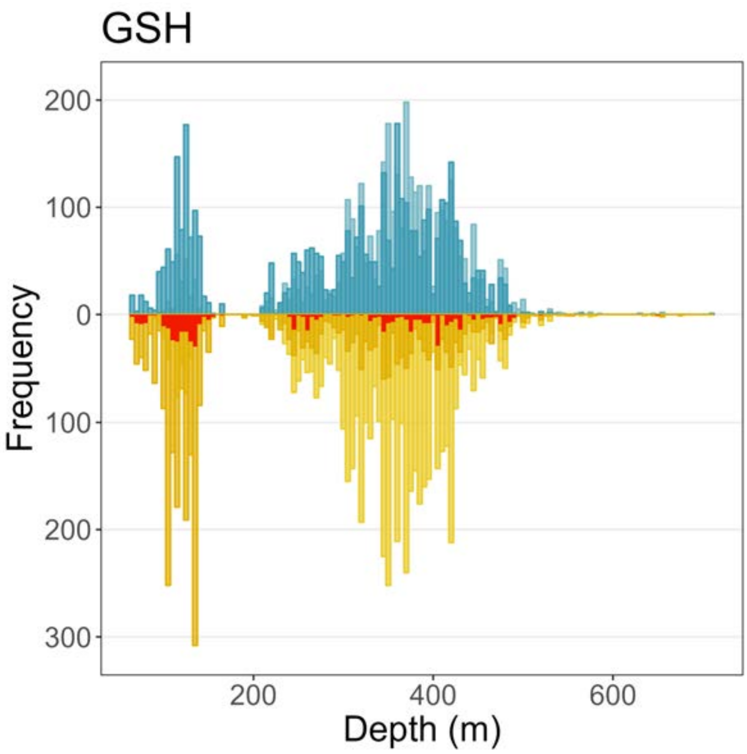


Figure 8: Depth distribution of dark ghost shark biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively active females are identified in red.

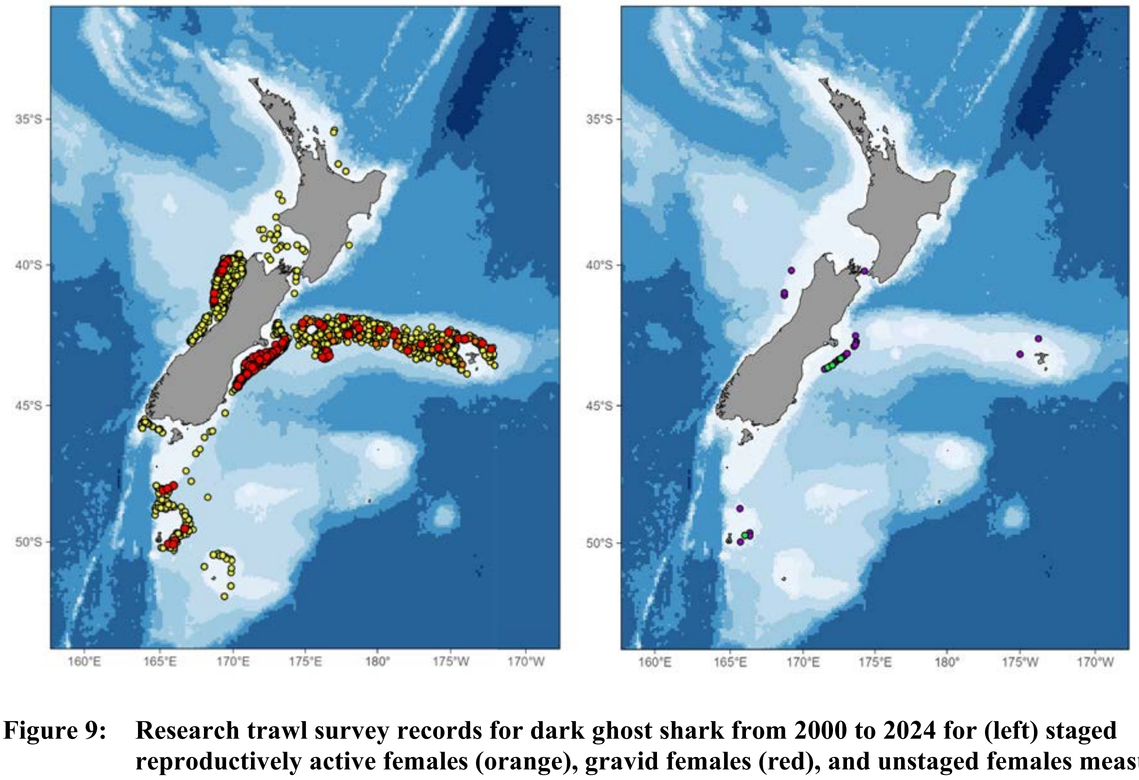
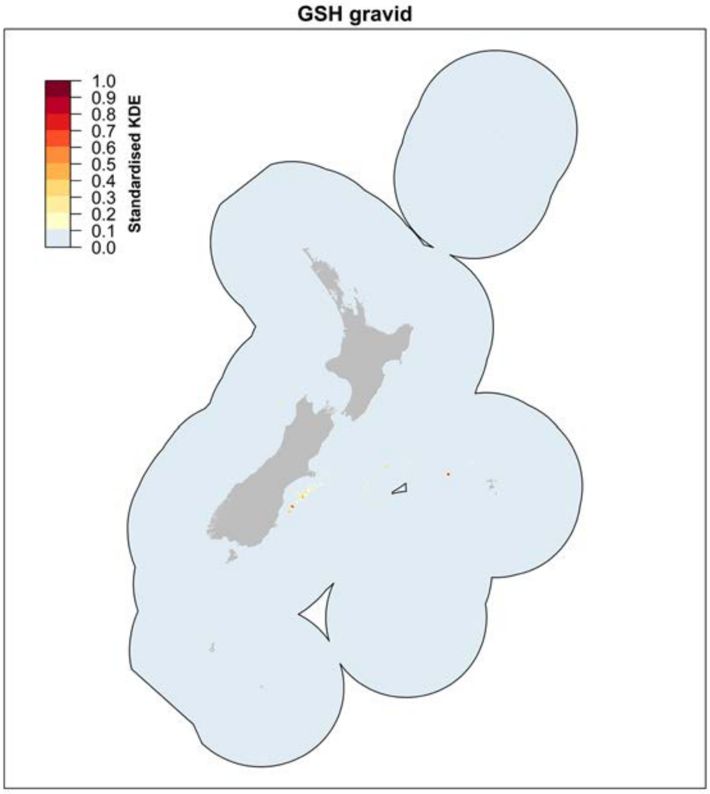


Figure 9: Research trawl survey records for dark ghost shark from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements (purple).



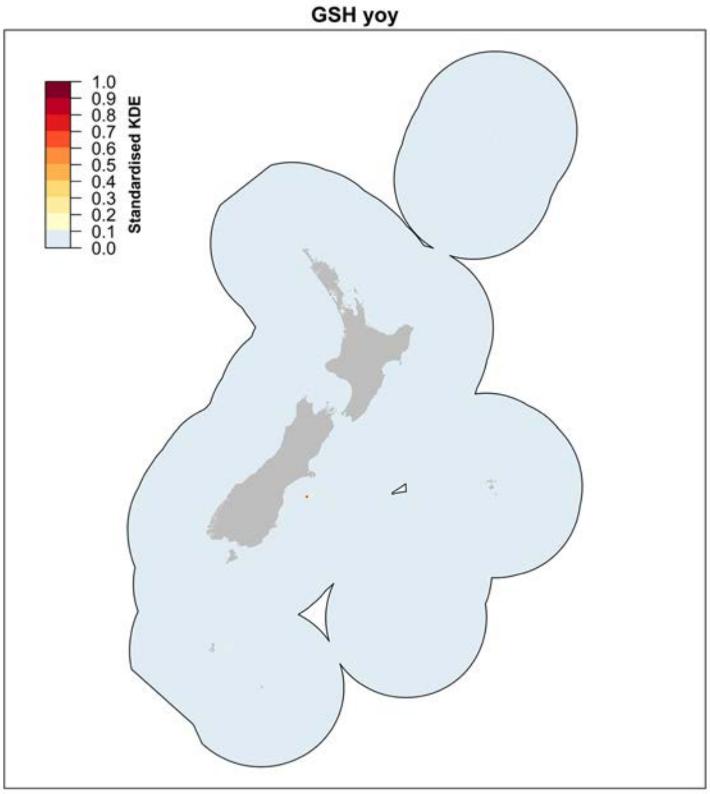


Figure 10: Kernel density estimate (KDE) for research trawl survey records for dark ghost shark from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

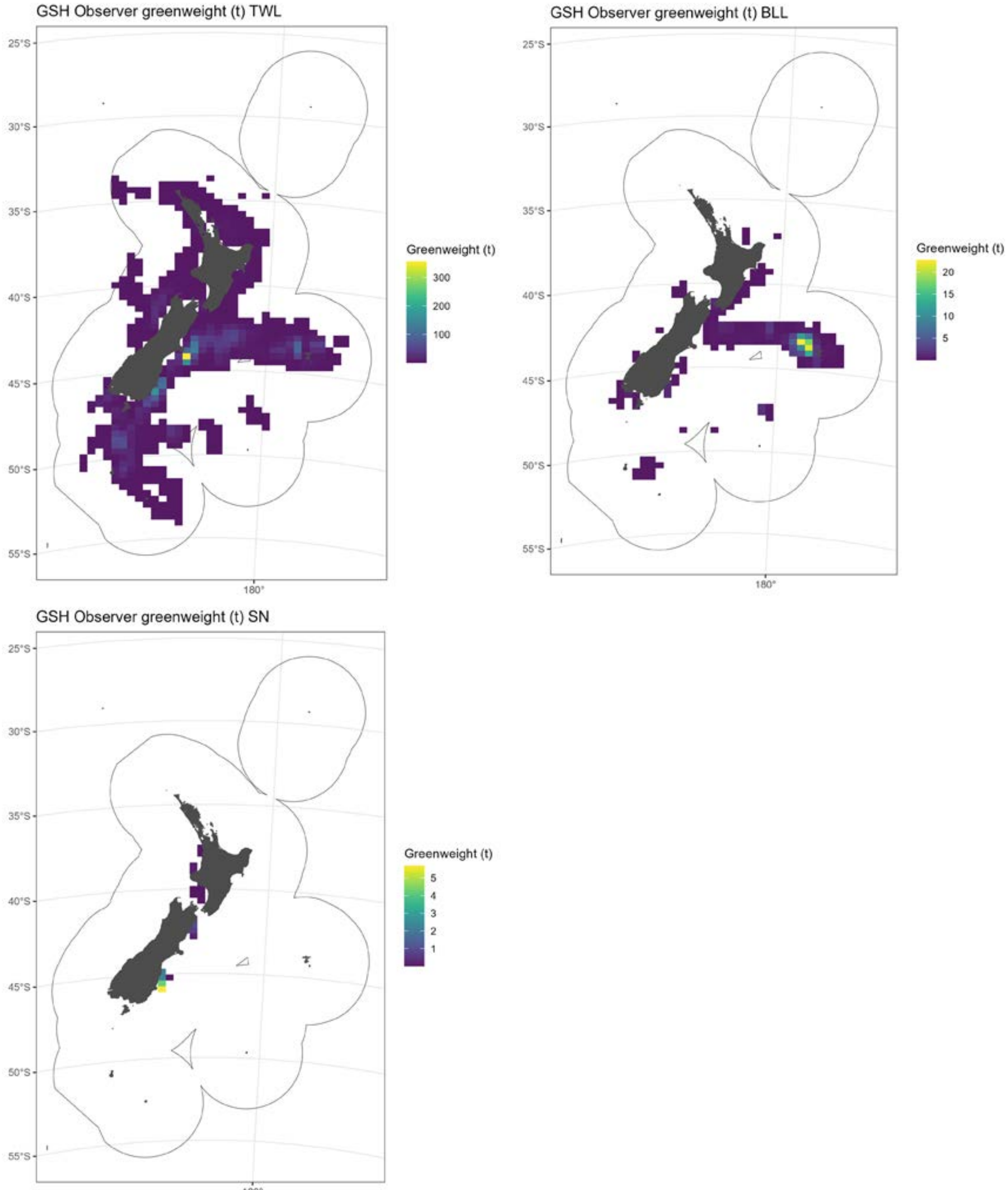


Figure 11: Distribution of dark ghost shark catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net.

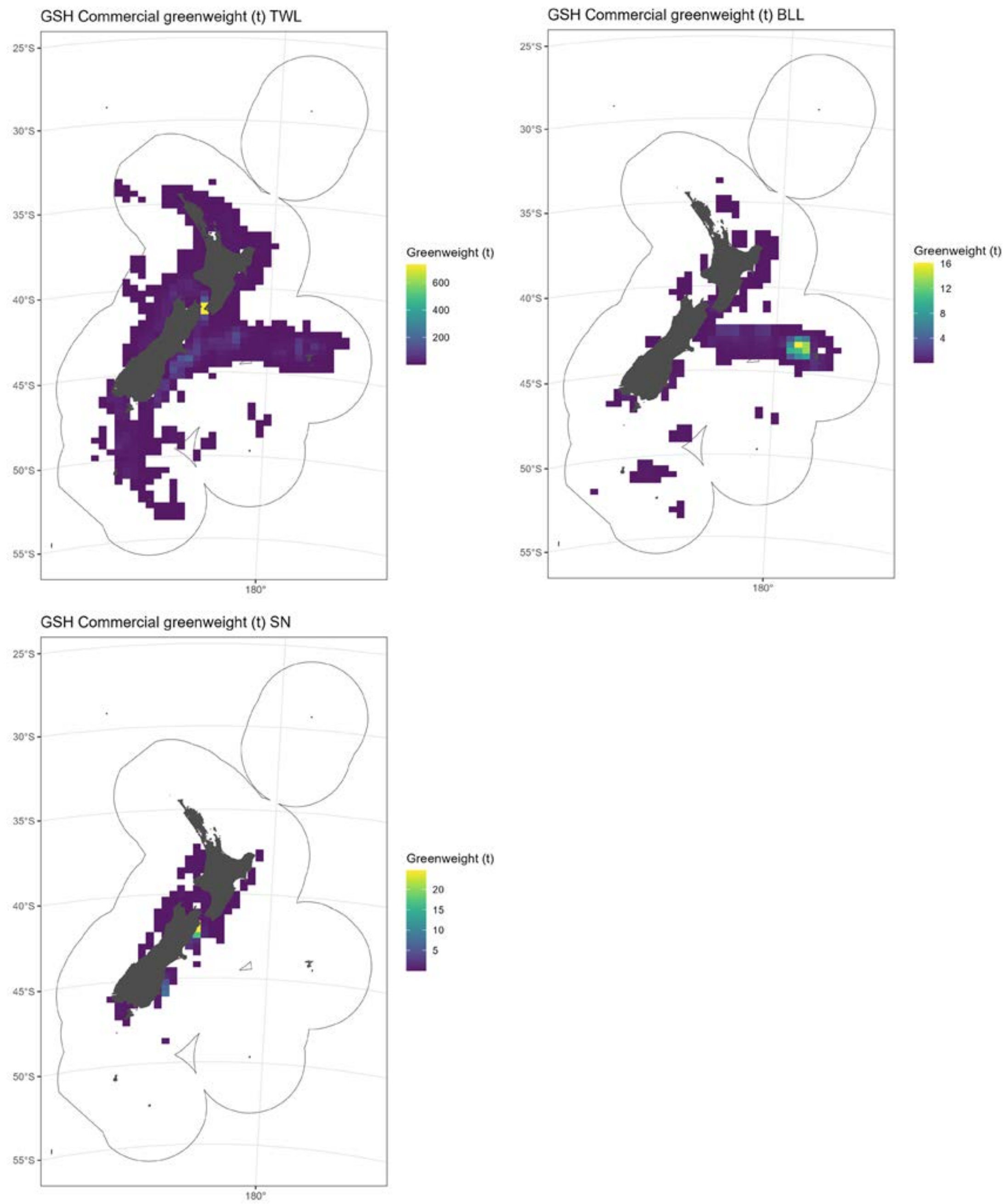


Figure 12: Distribution of dark ghost shark catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net.

Pale ghost shark (*Hydrolagus bemisi*)

The pale ghost shark is endemic to New Zealand, where they are distributed throughout New Zealand waters but most frequently reported on Chatham Rise and Campbell Plateau at latitudes south of 40°S (Kemper et al. 2015). The species is demersal along the continental slopes and plateaus at depths of 400–1000 m but are most common around 600 m. Pale ghost shark overlaps with dark ghost shark but is generally found at deeper depths. Habitat preference is unclear. On Chatham Rise, larger fish in warmer waters appear to consume more crabs, whereas smaller fish in cooler waters eat more polychaetes (Dunn et al. 2010). Ghost sharks (Chimaeridae) in New Zealand appear to be found more often on muddy sediment or sandy bottom habitat, and at temperatures of 6.1–7.2°C, based on video observations (Armstrong 2022, Te Papa unpublished data).

Spawning

Spawning season, spawning frequency, and egg laying grounds are not known. Pale ghost sharks are oviparous, laying two egg cases at a time on the sediment where embryos develop for a prolonged period before hatching. Fecundity, incubation duration, and spawning season are not known, but based on captive observations of the related Spotted Ratfish (*Hydrolagus colliei*), female pale ghost sharks may lay two eggs every two weeks throughout most of the year (McCutcheon 1980, Berio et al. 2024). Estimated incubation to hatching duration is around one year for other *Hydrolagus* species (Berio et al. 2024), which may fluctuate depending on water temperature (Dean 1906, Lyon et al. 2011, Berio et al. 2024).

Juvenile habitats

Nursery grounds are not known. Pale ghost sharks less than 30 cm CL have been very rarely caught (Fisheries New Zealand 2024). Small ghost sharks and egg capsules have been observed on DTIS video on Pukaki Rise and Campbell Plateau (Armstrong 2022). These individuals appeared to be associated with high densities of seastars (class Asteroidea) and brittle stars (class Ophiuroidea). Other oviparous chondrichthyans have been reported to have separate nursery areas – one for egg deposition and embryo development and another for newly emergent juveniles (Hoff 2016). It is possible that ghost sharks also engage in this behaviour.

Adult habitat, migrations and movements

Mating grounds, movement patterns, and/or seasonal changes in distribution are not known. Pale ghost sharks have been documented to aggregate on Chatham Rise (including the Mernoo Bank), the eastern Stewart-Snares Shelf, Campbell Island Rise, and the Auckland Islands Shelf (Horn 1997, MacGibbon & Fu 2013). The presence of large mature females, sometimes gravid, suggest that these areas may be important breeding areas. Mature and gravid female pale ghost sharks have been caught in small numbers on Chatham Rise, Sub-Antarctic, and west coast South Island RV *Tangaroa* surveys.

Population connectivity

Population structure is not known. Land masses, sea features, and areas of narrow continental shelf may provide natural barriers. The deep water separating the Bounty Platform from the Campbell Plateau may also be a barrier to mixing, and these areas may hold separate stocks (Horn 1997). Overseas, distinct genetic populations of the related Rabbitfish (*Chimaera monstrosa*) have been identified between the Northeast Atlantic Ocean and Mediterranean Sea and were attributed to the shallow depths of the Strait of Gibraltar (Catarino et al. 2017).

Research trawl data

Since 2000, reproductively active female pale ghost sharks have been recorded in 12/23 years, with 291 records across 22 trips. These females measured 61.5 to 85.5 cm CL (median=73.4 cm CL). Mature females (n=1761) were largely reported at depths from 322–1105 m (median=538 m) and reproductively active females were recorded from similar depths of 328–957 m (median=547 m) (Figure 13). Juveniles (n=7576) and mature males (n=4546) were more often found at deeper depths (range=252–1178 m, median=651 m; range=351–1279 m, median=567 m, respectively) (Figure 13).

Reproductively active females were mostly recorded along the ECSI slope and shelf, with scattered records throughout Chatham Rise, and a cluster of observations from WCSI, Puysegur, and throughout Campbell Plateau (Figure 14). Additional female pale ghost shark (n=9751) that were not assessed for maturity but measuring at least the known length-at-maturity (69 cm CL) were recorded in large numbers in these areas, as well as a few records from Bounty Plateau, Challenger Plateau, and along Hikurangi Trench (Figure 14). Reproductively active females were mostly recorded in spring-summer (November, n=11, December, n=50, and January, n=225), with a few records in August (n=5), which may be reflective of sampling efforts.

Estimated YOY (<20 cm CL) were recorded in three years (2011, 2012, 2015) in January (n=2) and August (n=1). There were three biologically measured (depth range=528 to 682 m, median=663 m) and 21 length-measured (depth range=462 to 728 m, median=602 m) individuals. Most of these records were on the western Chatham Rise and a few records on Campbell Rise (Figure 14).

The kernel density estimates for pale ghost shark showed that most reproductively active females, juveniles, and YOY records were reported at Mernoo Bank and on the southern Chatham Rise (Figure 15). Juveniles were also recorded in high densities along the Snares Shelf (Appendix 2).

Observer and commercial data

No pale ghost shark have been measured by observers since 2000. Observer and fisher-reported catch was recorded mostly in trawl fisheries east of Banks Peninsula, south of Otago Peninsula, and on the Campbell Plateau (Figure 16). In bottom longline fisheries, pale ghost shark catch was recorded by observers and fishers on the Bounty Plateau (Figure 16, Figure 17). Small amounts of pale ghost shark were also reported by fishers in set net fisheries operating at Puysegur and along the west coast of the North Island (Figure 17).

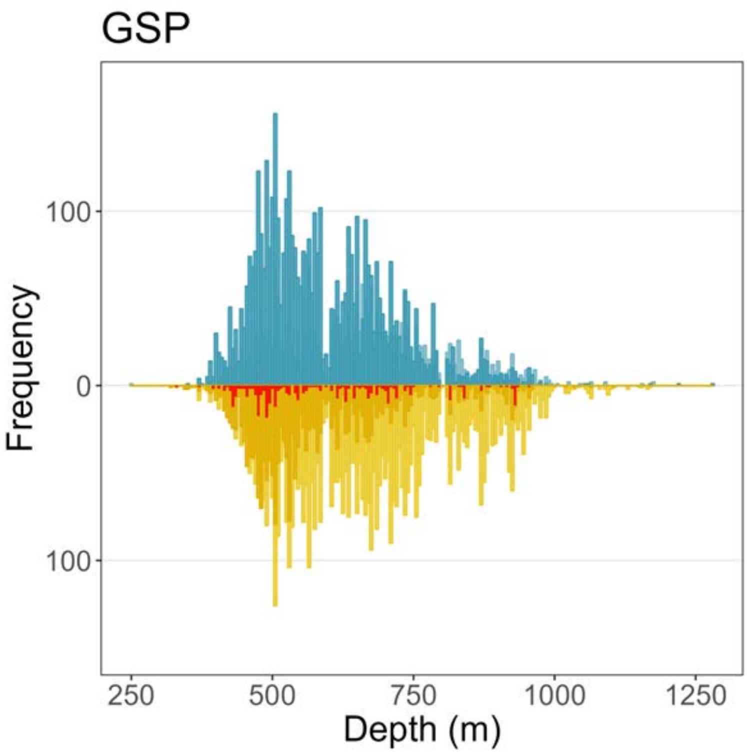


Figure 13: Depth distribution of pale ghost shark biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively active females are identified in red.

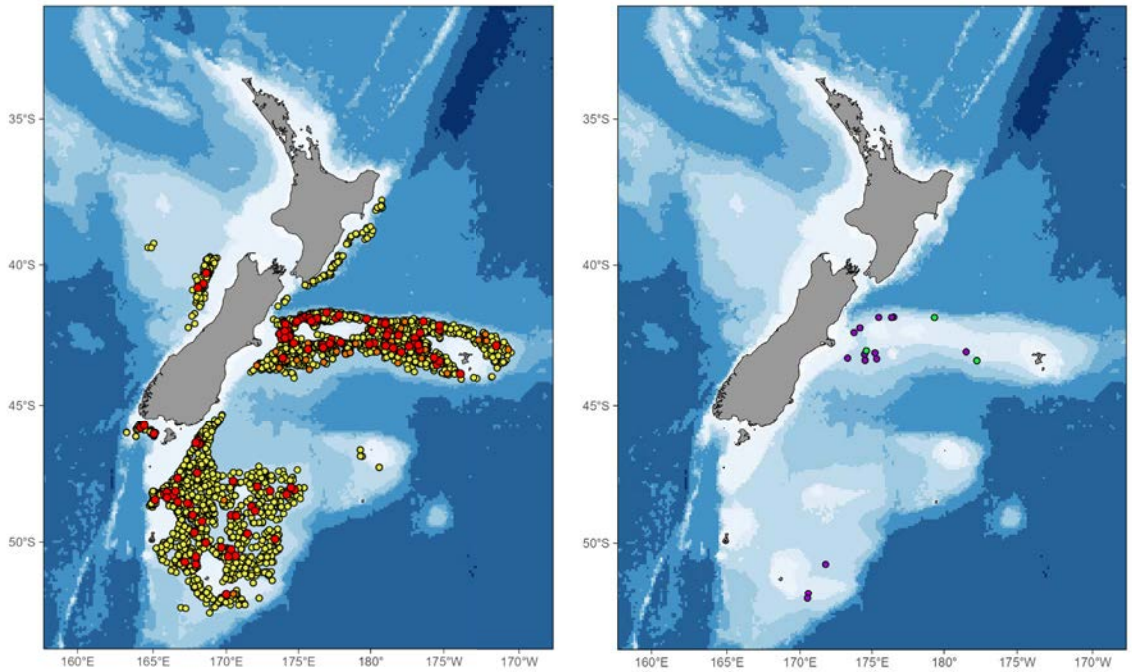
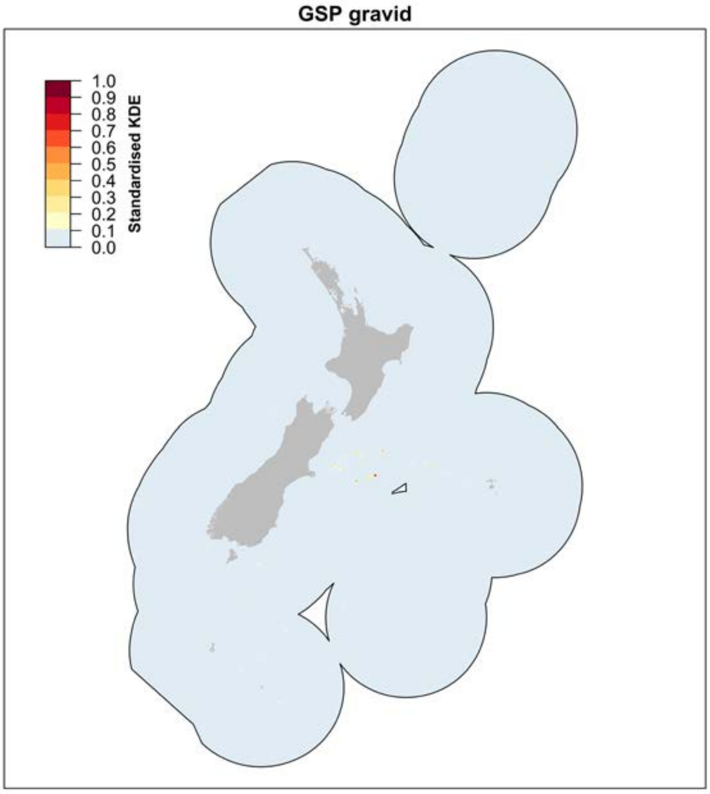


Figure 14: Research trawl survey records for pale ghost shark from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements (purple).



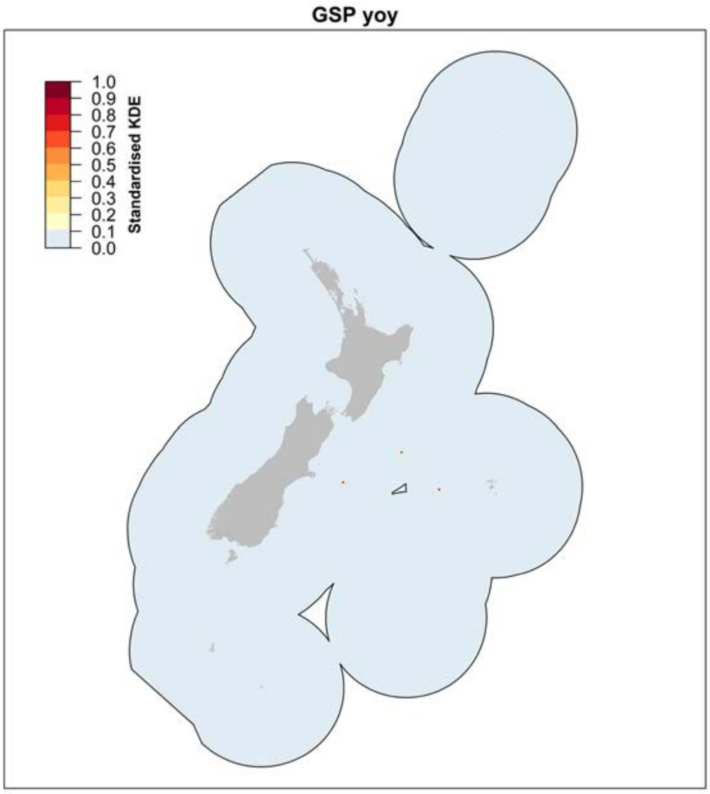


Figure 15: Kernel density estimate (KDE) for research trawl survey records for pale ghost shark from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

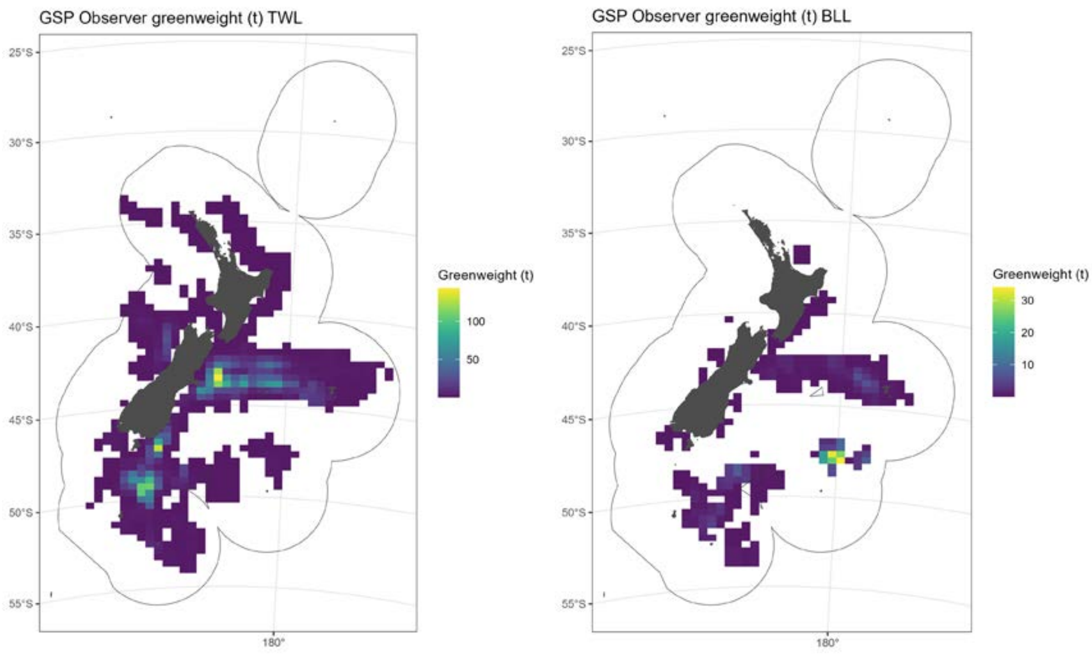


Figure 16: Distribution of pale ghost shark catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline.

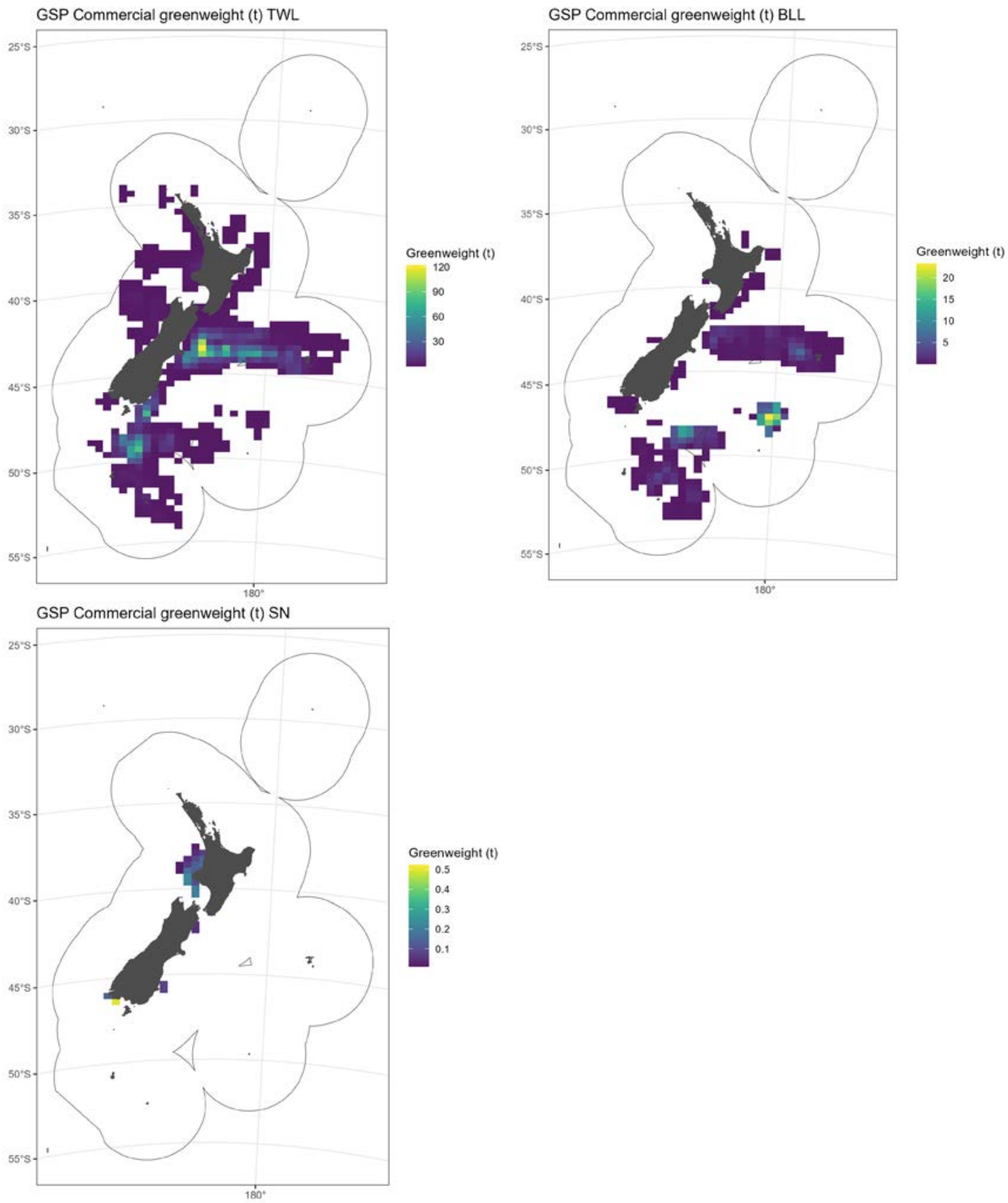


Figure 17: Distribution of pale ghost shark catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net.

Basking shark (*Cetorhinus maximus*)

Basking sharks are globally distributed and highly migratory in temperate and tropical waters. The species was once widely reported throughout New Zealand waters, often in large numbers along the ECSI (Finucci et al. 2021b). Most basking shark records are now confined to small numbers reported as bycatch in Sub-Antarctic fisheries. The species is pelagic, mostly recorded at depths from 600–1100 m in New Zealand waters and has been recorded to depths of 1262 m overseas (Gore et al. 2008, Finucci et al. 2021b). Basking sharks are capable of long-distance migrations, having been recorded crossing the Atlantic Ocean both from east to west and from north to south (Gore et al. 2008). Their movements in the South Pacific are not known.

Spawning

Spawning season, spawning frequency, and pupping grounds are not known. Reproduction is viviparous and oophagous with litter sizes of up to six pups (Ebert et al. 2021). Gestation is estimated to be between 12–36 months with a likely resting period of two years between litters (Pauly 1978, 2002). Globally, there is only one record of a gravid female basking shark (Sund 1943) and few neonate or juvenile records.

Juvenile habitats

Nursery grounds are not known. There are several reports of small (~3 m TL) basking sharks from around New Zealand, including off the WCSI. Historical captures of juvenile basking sharks (180–310 cm TL) in international waters east and north-east of Chatham Rise were reported by Japanese drift net vessels fishing near the sea surface at shallow (10 m) depths (Yatsu 1995).

Adult habitat, migrations and movements

Mating grounds, movement patterns, and/or seasonal changes in distribution are not known. When basking sharks were observed in the Canterbury Bight, ‘nose-to-tail’ following behaviour, a suspected mating behaviour, was observed in early summer (Roberts et al. 2015). In the eastern North Atlantic Ocean, combined-sex groups of up to 23 individuals have been observed engaging in a rotating ‘torus’ during late summer (August) and this behaviour is considered to be for courtship purposes (Sims et al. 2022).

Population connectivity

Population genetics have indicated one global population (Lieber et al. 2020).

Research trawl data

There was one record of a basking shark in the research trawl data (TAN2014). This individual was captured in December 2020 and was estimated to be 7 m in length (Finucci et al. 2022). This record is not included here.

Observer, commercial, and opportunistic sightings data

There were 208 basking shark records since 2000. Most records were from trawl fisheries (n=151), or sightings (including aerial surveys) and strandings (n=23). When depth was recorded (n=108), basking sharks were recorded between 128 and 1024 m (mean=412 m). Basking sharks were recorded throughout New Zealand waters, but were most frequently recorded off ECSI, Snares Shelf, near the Auckland Islands, and around Puysegur (Figure 18). Basking sharks were mostly (n=134) recorded in summer and autumn months (December-May).

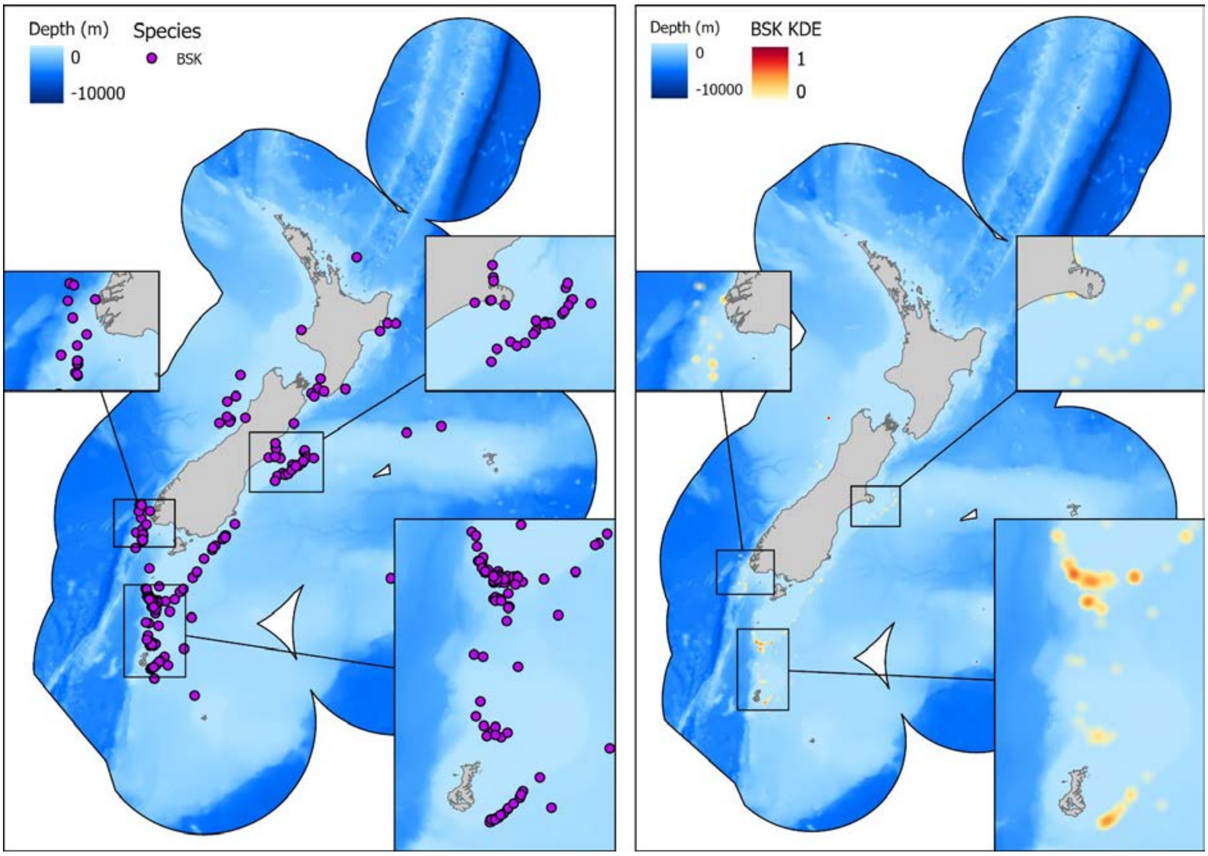


Figure 18: Basking shark records by fishers and observers, as well as opportunistic sightings between 2000 and 2024 (left) and kernel density estimate (KDE) for the data (right).

White shark (*Carcharodon carcharias*)

White shark is a wide-ranging coastal and pelagic shark, occurring throughout most temperate and tropical oceans. In New Zealand, white sharks are widespread, occurring from the Kermadec Islands in the north to Campbell Island and the northern Macquarie Ridge in the south (Duffy 2015a). White sharks are reported from shallow coastal waters including estuaries and tidal reaches of river mouths, and the open ocean, at depths from the surface to over 1200 m (Francis et al. 2015a). Movement studies have shown that white sharks are highly migratory, with juveniles and adults moving from temperate New Zealand waters to subtropical and tropical waters of Australia, the Coral Sea, and southwestern Pacific Islands during the austral autumn, winter, and spring (Duffy et al. 2012).

Spawning

Reproduction is aplacental viviparous with oophagy and histotrophy, with litter sizes of 2–17 and a suspected two-to-three-year reproductive cycle (Francis 1996, Mollet & Cailliet 2002, Bruce 2008). Gestation is estimated to be 18 months. Pupping occurs in relatively shallow, inner shelf waters around the upper North Island (including in or around Kaipara and Manukau Harbours) during spring and early summer. Pregnant females containing near-term or full-term embryos have been caught in Hauraki Gulf and Great Exhibition Bay, while neonates have been recorded in the entrance to Kaipara Harbour and off Ninety Mile Beach (C. A. J. Duffy unpublished data).

Juvenile habitats

Juvenile white sharks have only been recorded around the upper North Island (north of about 38° S), including North Cape, Ninety Mile Beach, Manukau and Kaipara harbours, Tauranga, and the Bay of Plenty (C. A. J. Duffy unpublished data).

Adult migrations and movements

Mating grounds are not known. Tagging data (primarily sub-adult and adult males) shows that most New Zealand white sharks make annual migrations during the winter months to tropical waters (Great Barrier Reef in Australia, the Coral Sea, New Caledonia, Vanuatu, Norfolk Island, Fiji, and Tonga) (Duffy et al. 2012, Francis et al. 2015a). Some of these sharks have been tracked returning to their initial tagging locations – Chatham Islands and Stewart Island. These two aggregation sites for New Zealand white sharks are not related to mating, and are most likely driven by the presence of large fur seal colonies (Francis et al. 2015a). Movement patterns of mature female white sharks are not known.

Population connectivity

Tagging and population genetics studies have shown that white shark movement is largely restricted to local ocean basins, with limited population genetic structuring within ocean basins and considerable genetic structuring between ocean basins (Clark et al. 2025). Genetic population structuring indicates separate northeast Pacific, northwest Pacific, and Western Australian populations, with white sharks in New Zealand and eastern Australia forming a single population (Hillary et al. 2018). Genetic analyses indicate that mature females are philopatric with gene flow between populations likely to be male mediated (Pardini et al. 2001). Movements of white sharks satellite tagged in New Zealand and Australia are consistent with regular seasonal mixing of the species between New Zealand and East Australia and the Southwest Pacific islands.

Research trawl data

There were no records of white shark in the trawl survey data.

Observer, commercial, and opportunistic sightings data

There were 204 white shark records since 2000. Most records were from trawl (n=60), set net (n=61), or bottom longline (n=36) fisheries. When depth was recorded (n=108), white sharks were recorded between 23 and 520 m (mean=153 m). White sharks were recorded throughout New Zealand waters but were most frequently recorded around the northern North Island, particularly North Cape, Hauraki Gulf and outside Kaipara Harbour, in Foveaux Strait, and around the Auckland Islands (Figure 19). About half of the records were in summer and early autumn months (December–March, n=98).

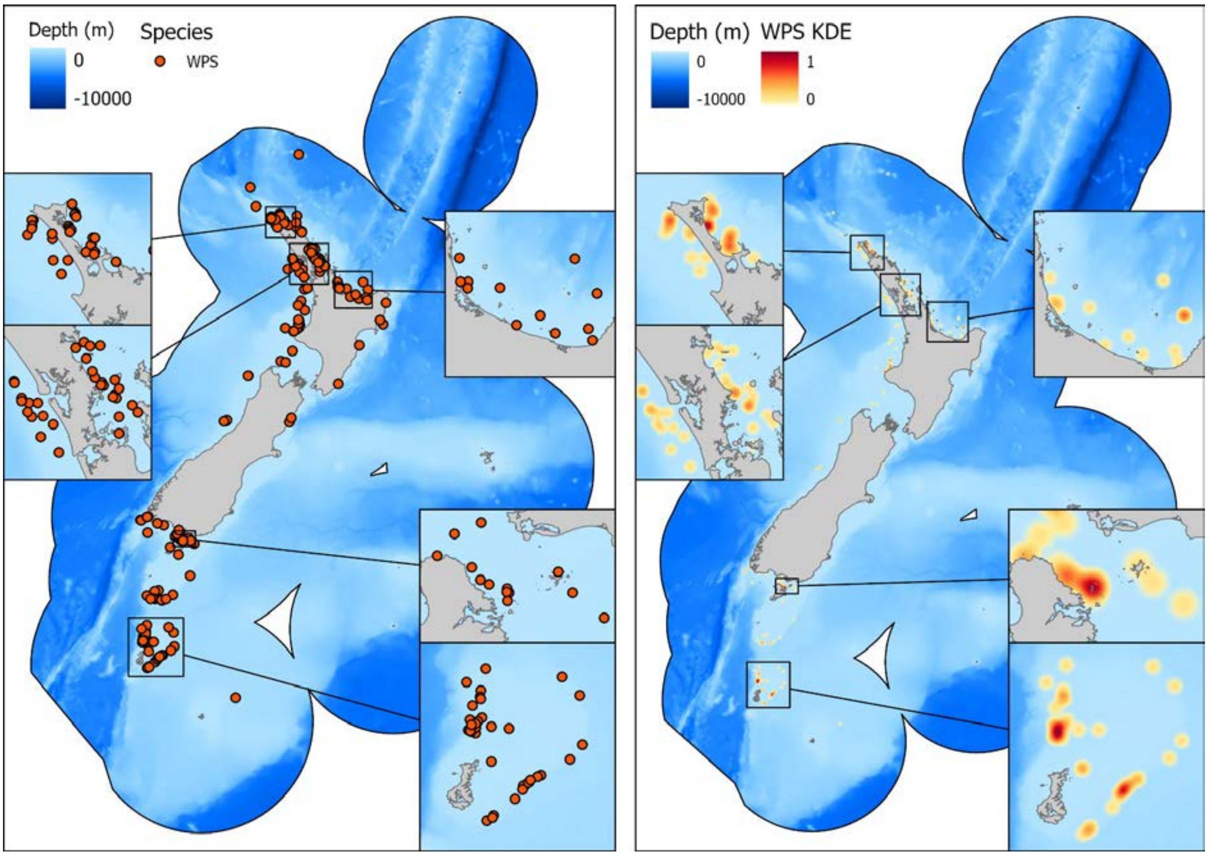


Figure 19: White shark records by fishers and observers, as well as opportunistic sightings between 2000 and 2024 (left) and kernel density estimate (KDE) for the data (right).

Mako (*Isurus oxyrinchus*)

Mako is globally distributed and highly migratory in temperate and tropical waters. It is commonly reported in coastal and pelagic waters across New Zealand to at least 49°S (Duffy 2015a). The species occupies a broad thermal niche, occurring in waters from ~3 °C to 26 °C, and in surface waters to depths ~900 m, with occasional dives recorded as deep as 1400 m (Francis et al. 2023). In New Zealand, tagged sharks spent most of their time in water temperatures of 14–27 C (Francis et al. 2019). Makos exhibit "resident" and "travel" behavioural states, with residency periods of several months. Resident behaviour showed sharks stay along shallow shelf locations (median depth=105 m) whereas oceanic travel occurs over deep waters (median=2239 m) (Francis et al. 2019). Sharks may occur further north in autumn-spring, but there appears to be no clear distinction in seasonal behaviour in small and large sharks. Mako are one of several sharks capable of thermoregulation, allowing them to utilise environments different to most species.

Spawning

Pupping areas are not known. Mako are viviparous and oophagous, with litter sizes ranging from 4–25 pups, rarely more than 18, and average litter size increases with maternal size (Ebert et al. 2021). Gestation is estimated to be 15–24 months. It has been suggested that mako have an extended parturition period (possibly year-round) and peak parturition may occur in late winter-spring, based on estimated embryonic and juvenile growth rates (Duffy & Francis 2001, Duffy 2015a). There is only one known record of a gravid female mako reported from New Zealand (Duffy & Francis 2001). This shark was caught off Hawke Bay in the summer, and it is suspected that females may give birth near or over the outer shelf. Free swimming YOY and neonates have been observed from North Cape to Central Hawke Bay, mainly over the mid-outer shelf (C. A. J. Duffy pers. obs.).

Juvenile habitats

Nursery areas are not known. The mid-outer shelf and near-shelf waters all around the upper North Island are likely to be important juvenile habitat. Tagged mako in New Zealand have been primarily juveniles (Holdsworth et al. 2016, Holdsworth 2021, Francis et al. 2019, 2023). Mako may engage in site fidelity; conventional tagging has shown that some sharks were recaptured near their initial tagging site after 1–3 years at liberty (Holdsworth et al. 2016, Holdsworth 2021). The satellite tagged individuals showed return migration and extensive use of shelf waters (Francis et al. 2019).

Adult habitat, migrations and movements

Mating grounds are not known and movement patterns and/or seasonal changes in distribution are not well defined. Adults are mostly encountered over the upper continental slope and further offshore (i.e., >200 m depth).

Population connectivity

Mako likely comprise one global stock, with some genetic structuring between ocean basins. Tagging (satellite and conventional) has shown that mako can travel extensively around the Southwest Pacific Ocean (Australia, New Caledonia, Tonga, Vanuatu, Norfolk Island, Fiji, Solomon Islands, French Polynesia) (Holdsworth et al. 2016, Holdsworth 2021, Francis et al. 2019, 2023).

Research trawl data

There are few research trawl records of mako. Three individuals were measured for length (91–117 cm TL from 1995 and 1996) and there were 32 catch records, with six post-2000 (2000, 2001, 2012, 2017) on Chatham Rise, northern North Island, and ECSI. These records are not included here.

Observer and commercial data

A total of 2605 mako have been measured for length by observers (range: 43–350 cm FL, median=142 cm FL) since 2000. The number of mako measured by observers has steadily declined; between 2003 and 2018, there was between ~500 to 1377 mako measured annually, 439 sharks were measured in 2019, followed by 197 and 125 in 2020 and 2021, respectively. In 2022 and 2023, a total of 57 individuals were measured. Female mako recorded in surface longline fisheries estimated to be at size of maturity were mostly recorded off East Cape, with scattered records north of New Zealand (including the Kermadec region) and off southern WCSI (Figure 20). Estimated YOY were mostly recorded off East Cape and the Bay of Plenty (Figure 20).

Observer-reported catch of mako in surface longline fisheries showed that the largest individuals were reported off North Cape, in FMA 10, and off the southern coast of the South Island (Figure 21). Small mako were recorded further offshore on the Challenger Plateau, as well as along northeast North Island (Figure 21). Observer-reported catch of mako in trawl fisheries was mostly recorded off WCNI (Figure 22). Fisher-reported catch of mako in surface longline fisheries was highest off East Cape and eastern Bay of Plenty, as well as off WCSI (Figure 21). Fisher-reported catch of mako in trawl fisheries was mostly recorded off WCSI, as well as Snares Shelf, and WCNI (Figure 22).

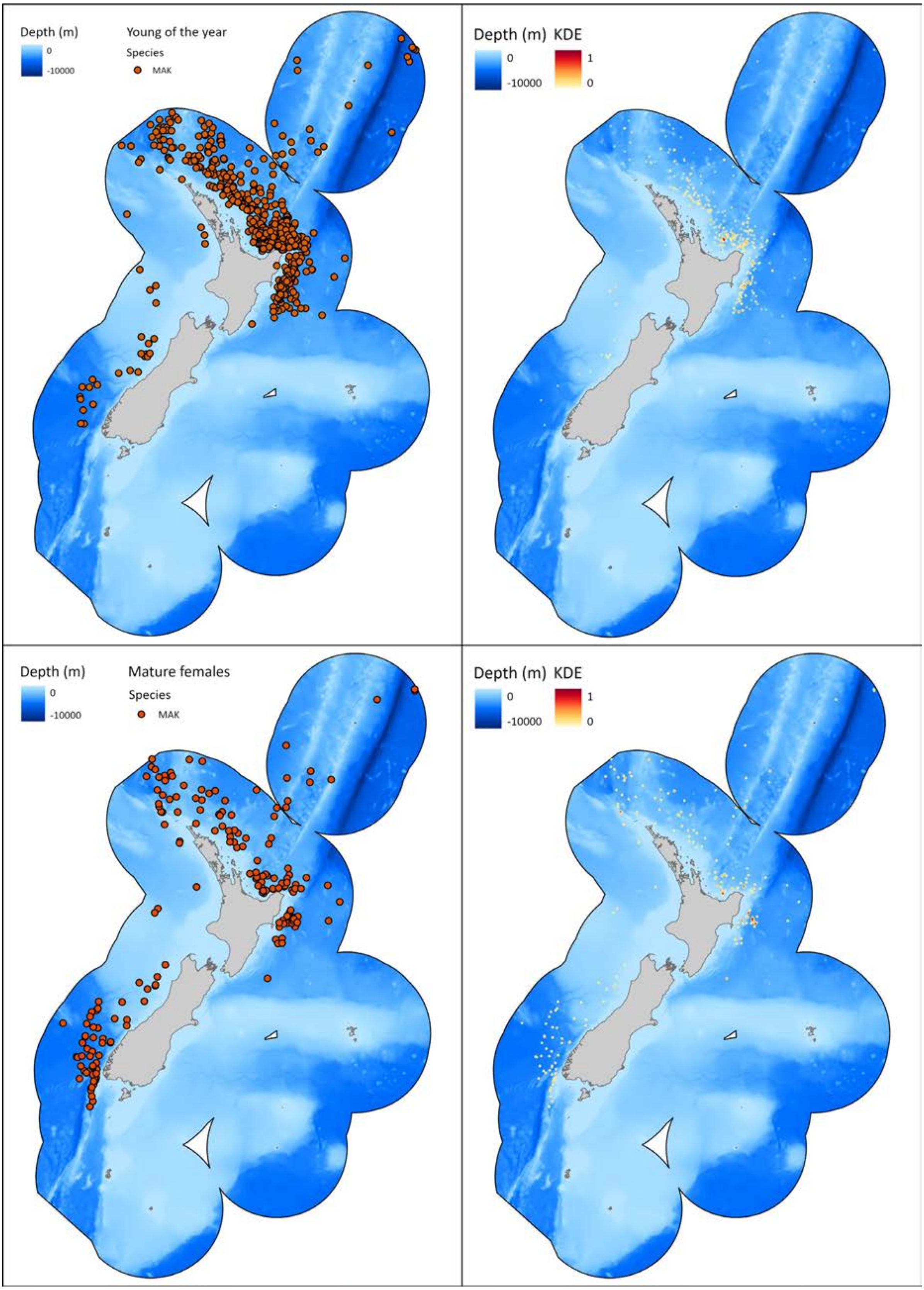


Figure 20: Mako recorded in surface longline fisheries from 2000 to 2024 estimated to be young of the year (YOY) (top left) and the KDE for the data (top right) and females estimated to be at or larger than size at maturity (bottom left) and the kernel density estimate (KDE) for the data (bottom right).

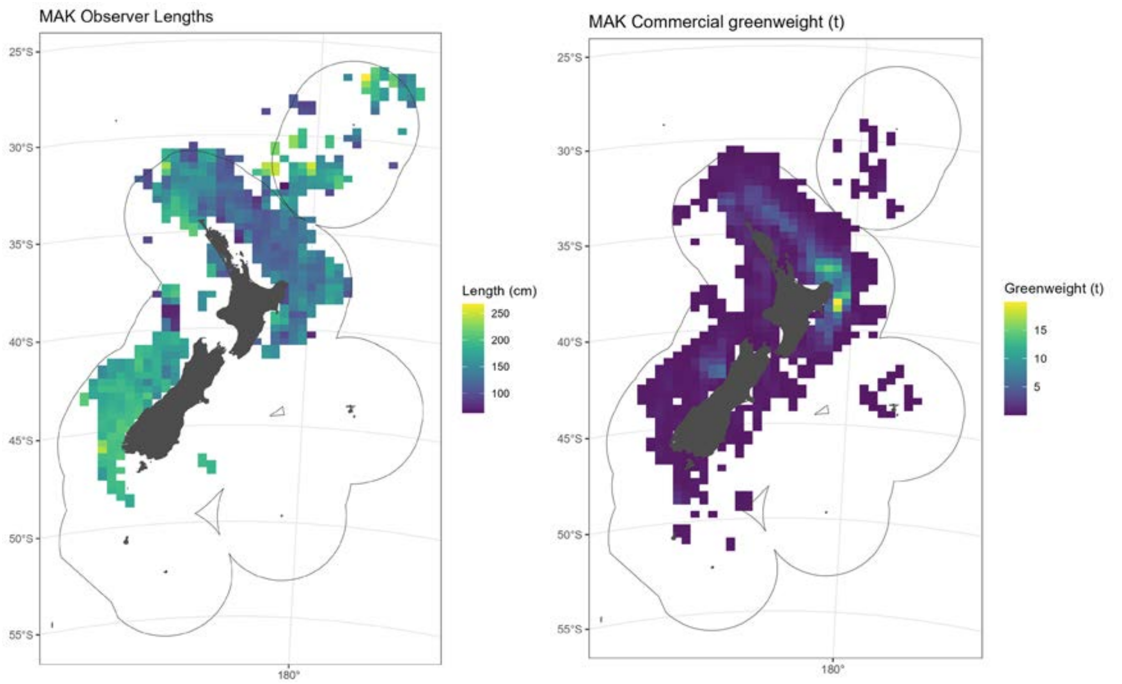


Figure 21: Distribution of mako catch for observer-reported (cm, mean fork length per cell) and fisher-reported (cumulative greenweight, t) records in surface longline fisheries from 2000 to 2024.

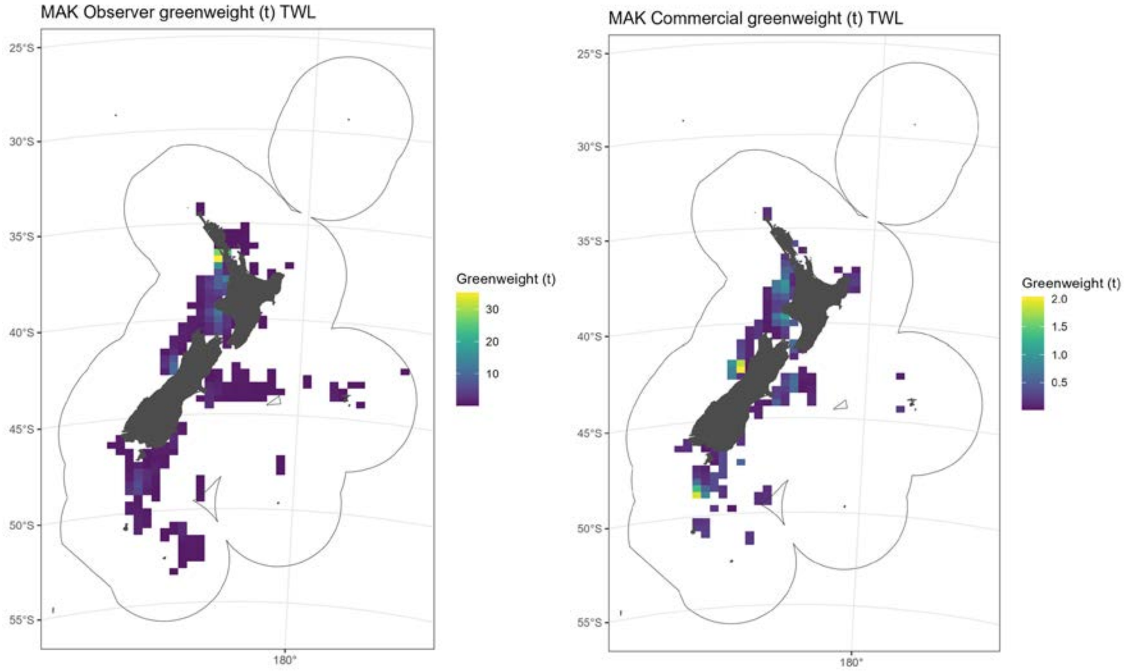


Figure 22: Distribution of mako catch for observer- and fisher-reported (greenweight, t) records in trawl fisheries from 2000 to 2024.

Porbeagle (*Lamna nasus*)

Porbeagle is found in temperate and cold-temperate pelagic waters in the North Atlantic and Southern Hemisphere. It is widespread in New Zealand waters but most abundant south of Cook Strait in shelf waters and over the upper slope (Duffy 2015a). This species prefers cooler waters with temperatures below 18°C and occurs at depths from the surface to ~1800 m. Tagged sharks spend most of their time during the day at depths 200–600 m in the open ocean, and the maximum recorded diving depth in New Zealand is 1024 m (Francis et al. 2015b). In the South Pacific Ocean between New Zealand and Chile, mean body weight increased with declining sea surface temperature (southward). Porbeagles are endothermic and large sharks may have a higher tolerance for colder waters (Francis et al. 2015b).

Spawning

Gestation, spawning season, spawning frequency, and pupping grounds are not known. Reproduction is viviparous with oophagy, and litter sizes range from one to five pups (Ebert et al. 2021). In New Zealand, parturition may occur over autumn and winter (April–Sept) and peak in June–July, and pups may be born in northern waters (Francis & Stevens 2000, Francis et al. 2015b). In the North Atlantic Ocean, mature female porbeagle migrate to the Sargasso Sea, a highly productive area, to give birth and provide neonates with rich feeding opportunities (Campana et al. 2010).

Juvenile habitats

Nursery areas are not known. Areas of importance to juveniles have not been identified.

Adult habitat, migrations and movements

Mating grounds, movement patterns, and/or seasonal changes in distribution are not known. There are several records of gravid or recently pupped females from Sub-Antarctic waters, suggesting that large porbeagle may inhabit more southern latitudes. Tagged mature females (n=3, two believed to be gravid) showed strong seasonal movement patterns, occurring mostly at 46–48°S in summer and 35–38°S in winter–spring (Francis et al. 2015b). Mature males may remain within New Zealand waters based on tagging data, but the sample size is only two individuals (Francis et al. 2015b).

Porbeagle are capable of large distance migrations and there appears to be a seasonal north-south migration, with sharks remaining relatively close to the New Zealand plateau and EEZ (Francis et al. 2015b).

Population connectivity

There are two subpopulations of porbeagle: the North Atlantic population and the Southern Hemisphere population.

Research trawl data

There are few records of porbeagle in the research trawl data. Two sharks were biologically measured: one in September of 2002, a mature male of 166 cm TL caught at 348 m on Campbell Plateau; and a maturing male of 124 cm TL in August of 2021 at 326 m off WCSI. There were eight length-frequency measurements for porbeagle; five recorded on Campbell Plateau, two on WCSI, and one on Chatham Rise. All but one of these records were male. The one female was caught on Chatham Rise at a depth of 70 m, whereas the males were recorded much deeper from 326 to 583 m. These records are not reported further.

Observer and commercial data

A total of 4380 porbeagle have been measured for length by observers (range: 37–244 cm FL, median=102 cm FL) since 2000. The number of porbeagle measured by observers has steadily declined since 2000, with 90 to 477 individuals measured annually up to 2017, 57 sharks measured in 2018, but no more than six sharks measured annually from 2019 onwards (last record in 2021). Female porbeagle recorded in surface longline fisheries estimated to be at size of maturity were mostly recorded along Puysegur Trench and Snares Shelf (Figure 23). Additional records were scattered off southern WCSI and offshore, north of the North Island. Estimated YOY were mostly recorded off East Cape and the Bay of Plenty, and along the WCSI and Puysegur Trench (Figure 23).

Observer-reported catch of porbeagle in surface longline fisheries showed that the largest individuals were recorded off North Cape, east of East Cape, and off southern South Island (Figure 24). Small porbeagle were also recorded off ECNI and on Challenger Plateau. Observer-reported catch of porbeagle in trawl fisheries was mostly recorded off eastern Bay of Plenty and East Cape, and WCSI (Figure 25). Fisher-reported catch of porbeagle in surface longline fisheries was highest off eastern Bay of Plenty and East Cape, as well as off WCSI (Figure 24). Fisher-reported catch of porbeagle in trawl fisheries was mostly recorded off WCSI.

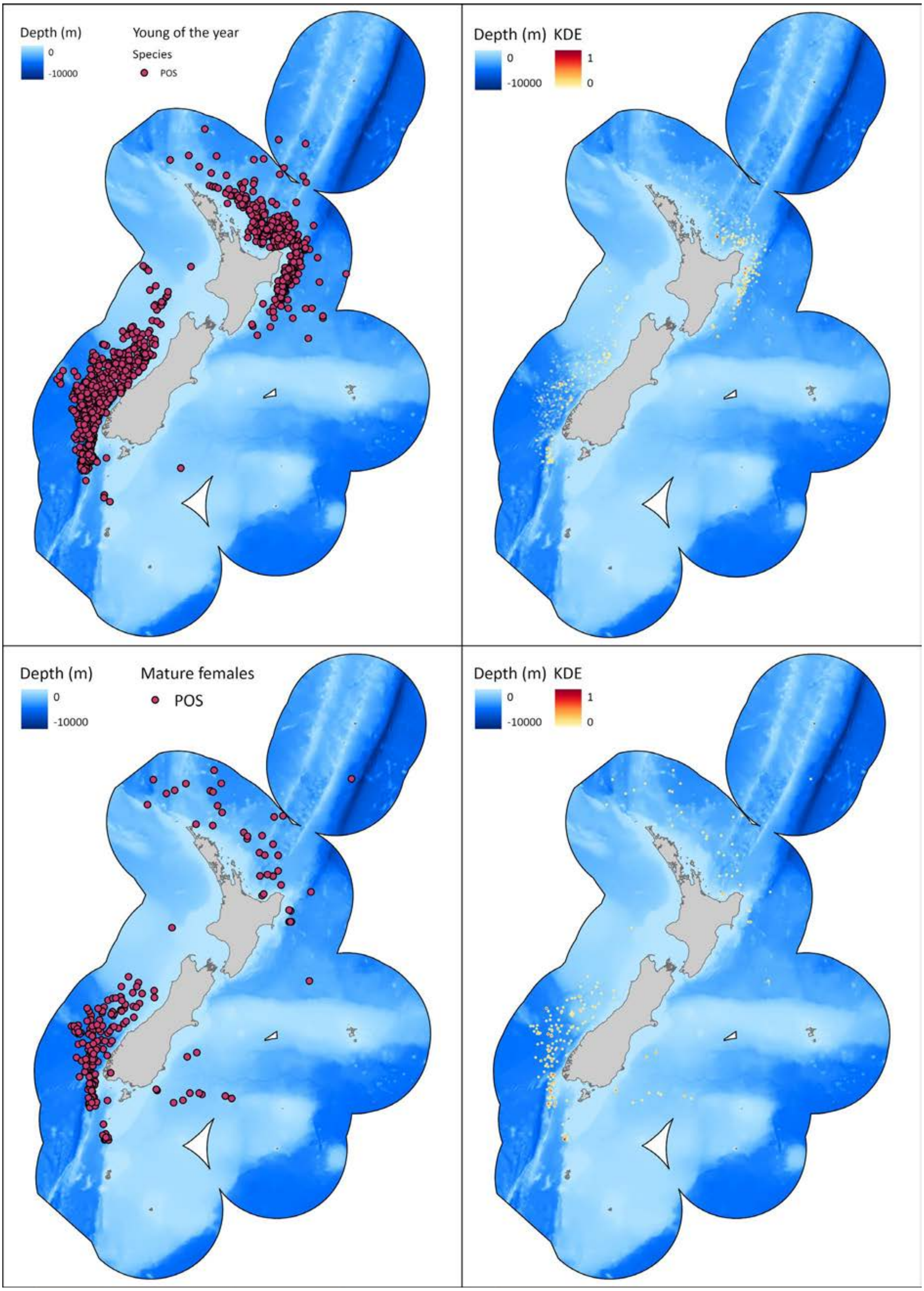


Figure 23: Porbeagle recorded in surface longline fisheries from 2000 to 2024 estimated to be young of the year (YOY) (top left) and the KDE for the data (top right) and females estimated to be at or larger than size at maturity (bottom left) and the kernel density estimate (KDE) for the data (bottom right).

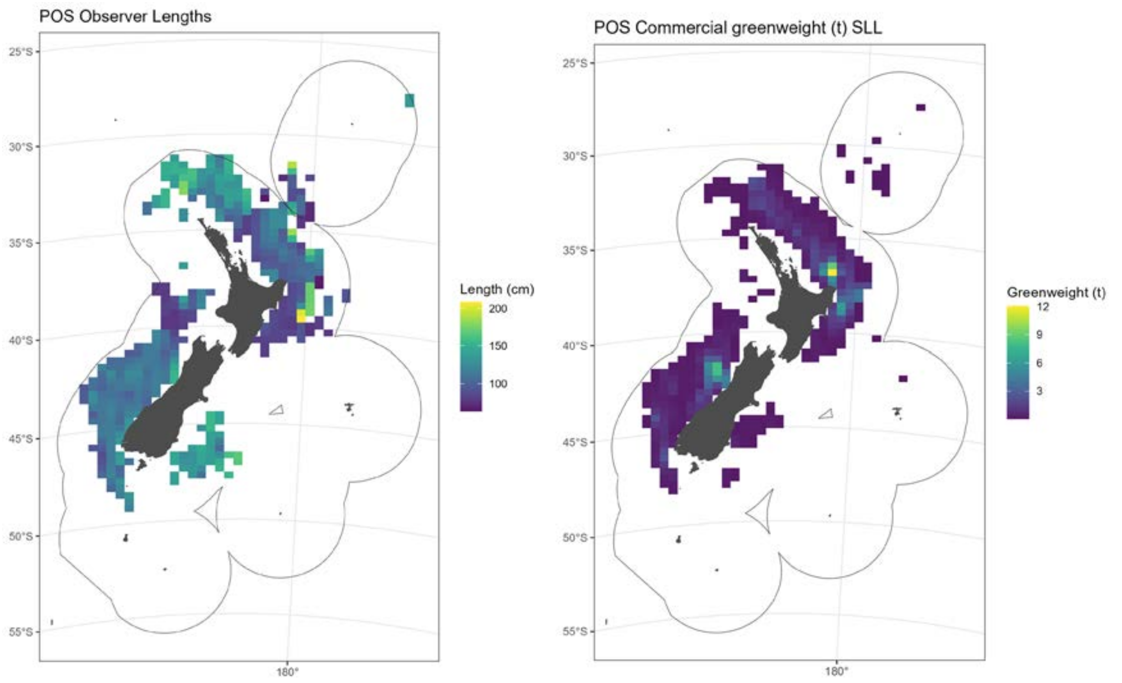


Figure 24: Distribution of porbeagle catch for observer-reported (cm, mean fork length per cell) and fisher-reported (cumulative greenweight, t) records in surface longline fisheries from 2000 to 2024.

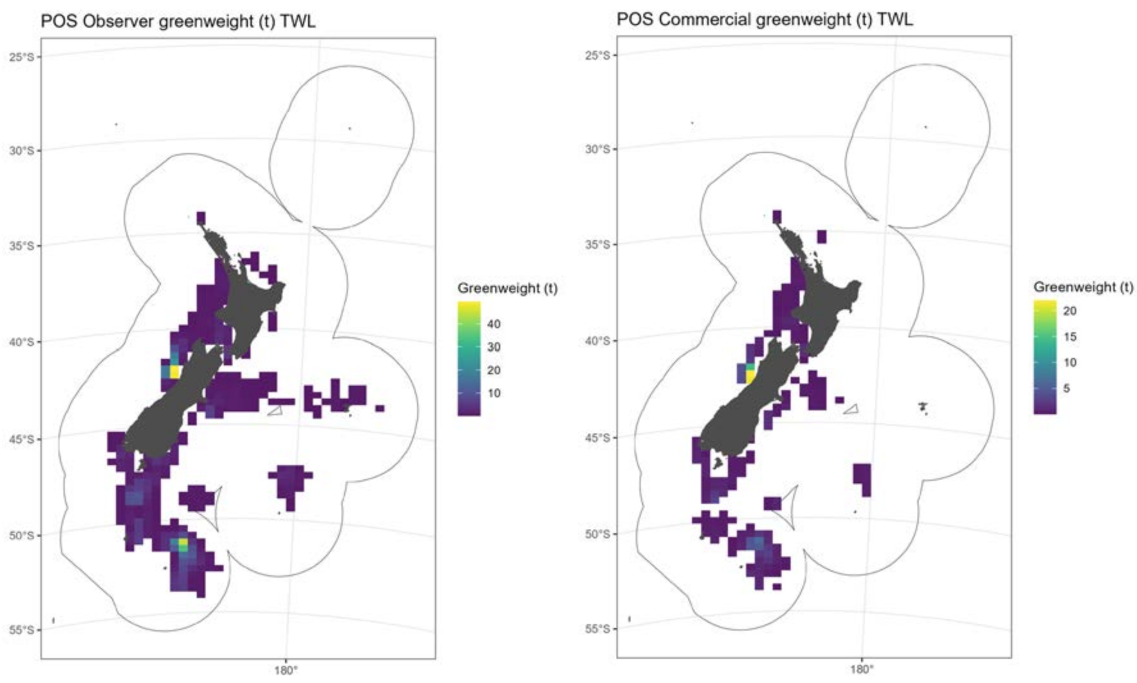


Figure 25: Distribution of porbeagle catch for observer- and fisher-reported (greenweight, t) records in trawl fisheries from 2000 to 2024.

Carpet shark (*Cephaloscyllium isabella*)

Carpet shark is endemic to New Zealand waters. The species is demersal in coastal waters around New Zealand, including Stewart Island, Snares Island, and Chatham Islands at depths from the surface to 700 m, and usually shallower than 400 m (Nakaya et al. 2015). Their overall depth distribution deepens with decreasing latitude, indicating a distribution moderated by water temperature (Horn 2016). Where data are available, they are recorded at bottom temperatures of 6.5–19.7°C (mean 12.5°C) and appear to undergo stress when water temperature is above 20°C (Horn 2016). The species appears to occur across a wide range of habitats from shallow, almost intertidal rocky reefs to deep soft sediment habitats. Carpet shark have been observed over coarse sand (shells, debris, gravel), muddy and sandy sediment, and pebble dominated substrates with or without epifauna, and at temperatures of 8.5–15.3°C (Te Papa unpublished data). A cryptic, undescribed species has been recorded from deepwater off the Bay of Plenty to Northland, Kermadec Ridge, and West Norfolk Ridge (C. A. J. Duffy unpublished data).

Spawning

Spawning season, spawning frequency, and egg laying grounds are not known. Reproduction is oviparous, and carpet sharks lay two egg cases at a time around substratum structures. Spawning may be year-round, and egg-laying may peak in the summer months. Incubation and hatching may be prolonged and is likely to be between nine and 12 months (Horn 2016). Carpet shark egg cases have been observed on video in the Marlborough Sounds (M. Morrison, unpublished data). Egg cases have also been reported infrequently in the following locations around the North Island: Little Omaha Bay, Stanmore Bay, Whangaparāoa Peninsula, Rahotu (Taranaki), Wellington Harbour, Kapiti, Riversdale Beach, and around the South Island: Rarangi Beach, Blenheim, Canterbury, Timaru to Lower Nevis and Foveaux Strait, Gaer Arm, and Bradshaw (Fiordland) (iNaturalist 2024).

Juvenile habitats

Nursery areas are not known. Areas of importance to juveniles have not been identified. Small individuals exist in museum collections and may offer some insight into habitat preference (C. A. J. Duffy unpublished data).

Adult habitat, migrations and movements

Mating grounds, movement patterns, and/or seasonal changes in distribution are not known. Carpet shark is relatively abundant in inshore waters. *Cephaloscyllium* sharks often hunt at night, and shelter in caves or reefs during the day (Awruch et al. 2012). Carpet shark may spend part of their time in a similar environment, but they are often recorded in research trawl surveys (which operate during the day). No information is available on carpet shark density in rocky areas relative to flat soft seabed (Horn 2016).

Population connectivity

Population structure is not known.

Research trawl data

Since 2000, reproductively active female carpet sharks have been recorded in 6/23 years (2012, 2013, 2015–2017, 2021), with 24 records across six trips. These females measured 69.7 to 92.1 cm TL (median=83.0 cm TL). Mature females (n=39) were reported from depths of 38–431 m (median=118 m) and reproductively active females were recorded from similar depths of 38–326 m (median=99 m) (Figure 26). Juveniles (n=198) were found at similar depth ranges (range=27–423 m, median=85 m) and mature males (n=170) were generally found at deeper depths (range=28–458 m, median=206 m) (Figure 26).

Reproductively active females were mostly recorded on WCSI and Tasman and Golden Bay, and two records occurred east of Stewart Island (depths of 123 and 132 m) (Figure 27). Additional female carpet shark (n=145) not assessed for maturity but measuring at least known length-at-maturity (76 cm TL) were also recorded along the ECSI and Mernoo Bank, near Chatham Islands, off Otago

Peninsula, near Stewart Island, and off WCNI (Figure 27). Reproductively active females were recorded in February–April (n=20) and July–August (n=4).

There was one record of an estimated YOY (<30 cm TL). This record was in January 2022 off Chatham Islands (44.19°S, 183.05°W) at a depth of 238 m. There were 24 length-measured individuals (depth range=34 to 238 m, median=49 m). Records were largely confined to Tasman and Golden Bay, with a few additional scattered records on ECSI and one off the ECNI (Figure 27).

The kernel density estimates for carpet shark showed most reproductively active females along the WCSI and juveniles in Tasman Bay (Figure 28, Appendix 2).

Observer and commercial data
No carpet shark have been measured by observers since 2000. Observed catch was mostly reported in trawl fisheries off Otago Peninsula (Figure 29). Catches were highest along Snares Shelf, but the validity of these records remains unclear. Carpet shark was also recorded by observers off northwest Chatham Rise on longline and off Otago Peninsula in set net fisheries (Figure 29). Fisher-reported carpet shark catches were mostly in Tasman/Golden Bay trawl fisheries, northwest Chatham Rise and Whangarei region in bottom longline fisheries, and Tasman/Golden Bay, Taranaki, and Otago Peninsula in set net fisheries (Figure 30). Small amounts of carpet shark were also recorded by fishers in other fisheries (e.g., pot fisheries).

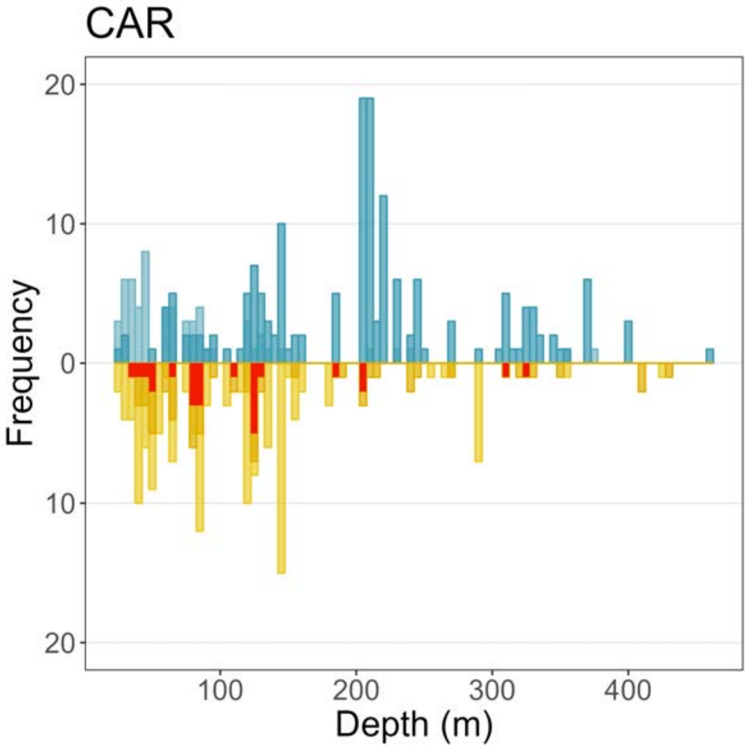


Figure 26: Depth distribution of carpet shark biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively active females are identified in red.

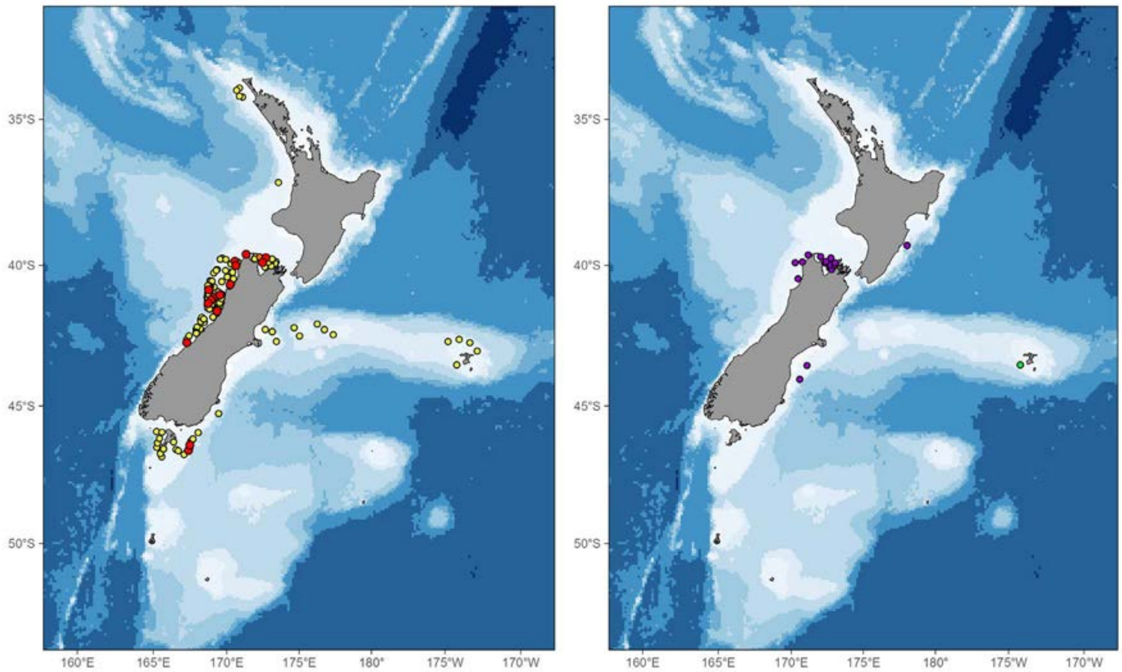
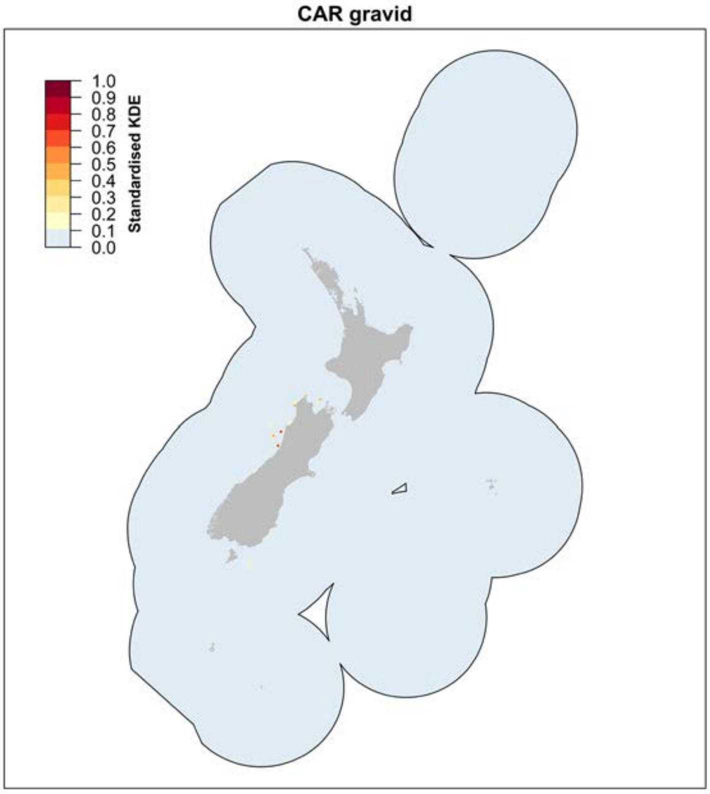


Figure 27: Research trawl survey records for carpet shark from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements (purple).



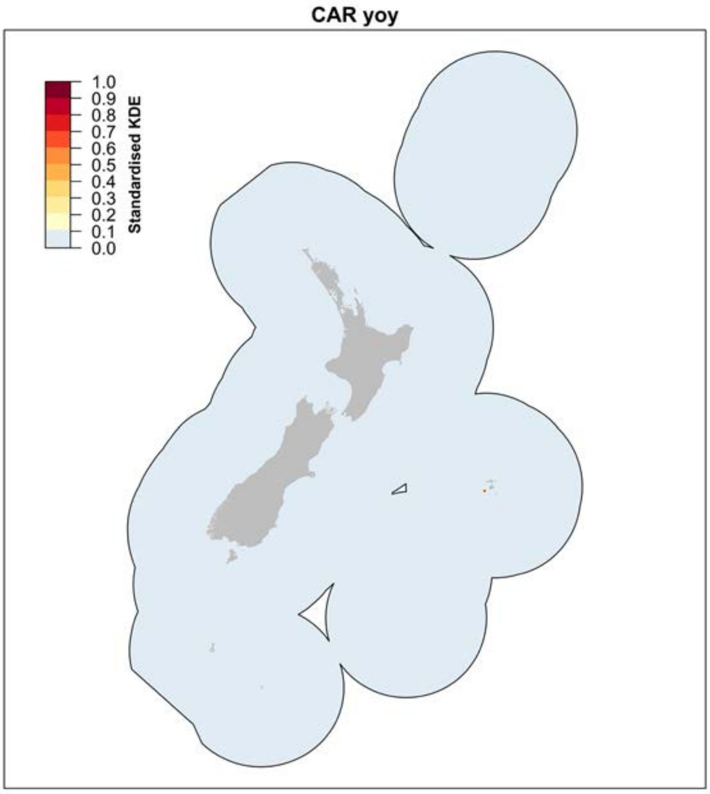


Figure 28: Kernel density estimate (KDE) for research trawl survey records of carpet shark from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

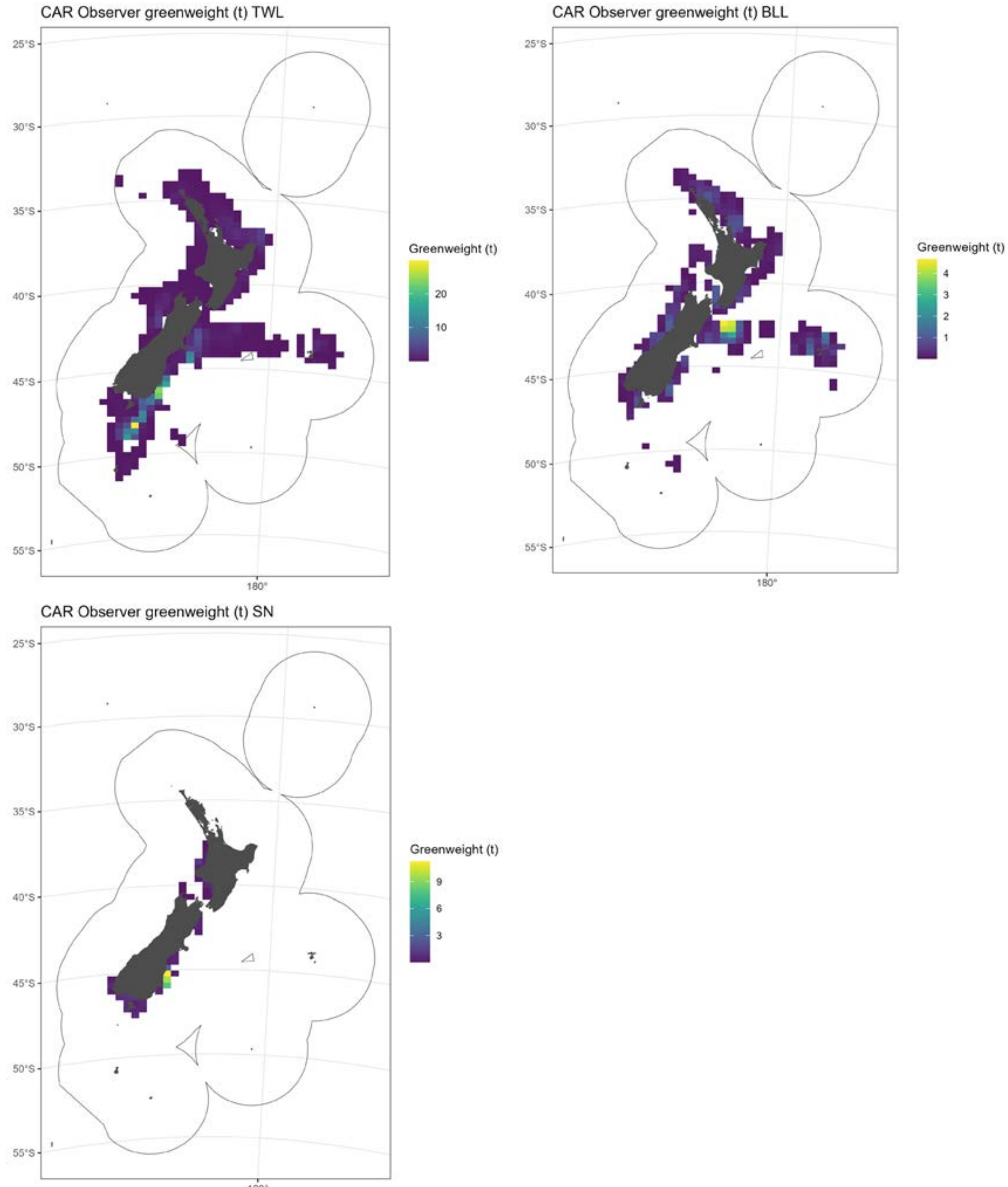


Figure 29: Distribution of carpet shark catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net.

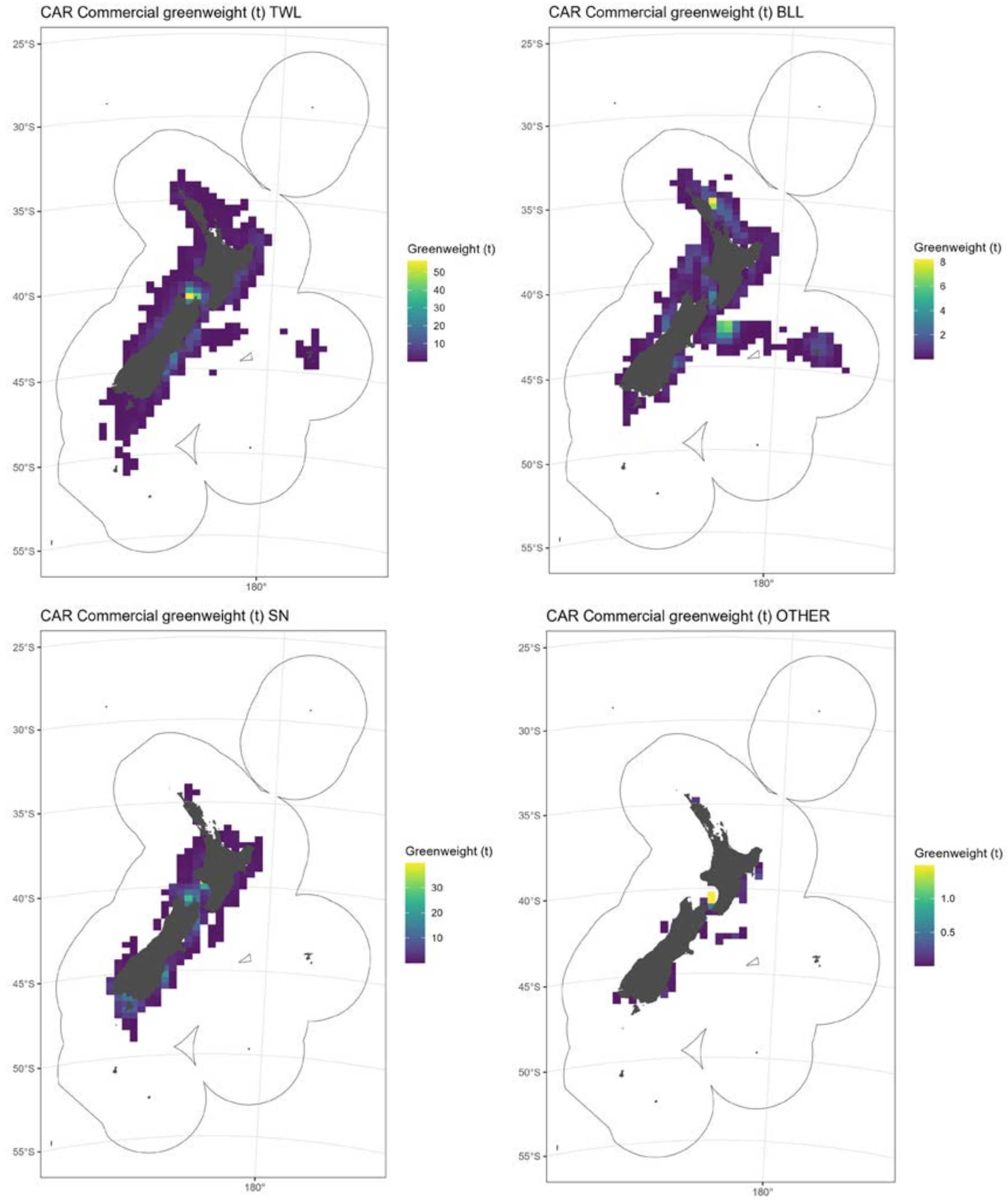


Figure 30: Distribution of carpet shark catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net; OTHER=other gear types.

School shark (*Galeorhinus galeus*)

School shark is found in cold to temperate waters in both the Northern and Southern hemisphere (Ebert et al. 2021). The species is widespread in New Zealand; it is demersal and pelagic across the shelf and upper continental slope and reported from depths near shore to 1100 m (Duffy 2015b). School shark have been observed over hard and soft substrates, including reef habitat with epifauna, and at temperatures of 10.2–16.6°C (Te Papa unpublished data).

Spawning

Spawning frequency and pupping grounds are not well defined. Reproduction is aplacental viviparous with litter sizes of 6–52 pups that increase with maternal size (Ebert et al. 2021). Reproduction is thought to be triennial with a 12-month gestation (Duffy 2015b). Female school shark give birth in coastal waters during spring and early summer (November–January) but there are limited data outside of the Kaipara Harbour (Morrison et al. 2014a, C. A. J. Duffy unpublished data). Gravid school sharks are infrequently reported in New Zealand, but large aggregations of mature females have been documented in Kaipara and Manukau (Papakura Channel) harbours (C. A. J. Duffy unpublished data).

Juvenile habitats

Juvenile habitat includes harbours, shallow bays, and sheltered coasts. Reported nursery areas are restricted to mainland coastal waters in the North Island (Hauraki Gulf and Kaipara Harbour) and South Island (Oamaru and Jackson Bay) (Morrison et al. 2014a). Smaller juveniles have also been recorded from Kenepuru Sound (Marlborough), Lyttleton and Akaroa Harbours, Blueskin Bay, Manukau Harbour, Raglan Harbour, and Fiordland (Francis et al. 2012, Morrison et al. 2014a, B. Finucci pers. obs., C. A. J. unpublished data). Juvenile school shark remain in these shallow habitats for one to two years before dispersing across the shelf (Morrison et al. 2014a).

Adult habitat, migrations and movements

Mating grounds, movement patterns and/or seasonal changes in distribution are not well defined. Mating is thought to occur offshore in deep water during the winter months (May to July), however, mature males have also been previously reported inshore during summer to early winter (late October to March) (Olsen 1954, Morrison et al. 2014a). Movements vary by size and sex, females are likely to travel longer distances than males, and some tagged sharks have been recaptured in Australia (Hurst et al. 1999, Francis 2010a, B. Finucci unpublished data). School sharks are commonly observed at the Chatham Islands (C. A. J. Duffy unpublished data); this area is suspected to be important for reproductive purposes, but no data are available.

Population connectivity

Tagging and population genetics studies have shown school shark in New Zealand and Australia form a single population (Hurst et al. 1999, Hernández 2013, Devloo-Delva et al. 2019).

Research trawl data

Since 2000, reproductively active female school shark have been recorded in 2/23 years, with four records across four trips. These females measured 126.5 to 158.5 cm TL (median=144.2 cm TL). Mature females (n=2) were reported from depths of 393 and 480 m and reproductively active females (n=4) were recorded from depths of 238–452 m (median=311 m) (Figure 31). Juveniles (n=3742) and mature males (n=105) were found at shallower depths (range=13–527 m, median=62 m and range=37–490 m, median=278 m for juveniles and mature males, respectively) (Figure 31).

Reproductively active females were recorded mostly near the Chatham Islands (Figure 32). Additional female school shark (n=111) not assessed for maturity but measuring at least known length-at-maturity (135 cm TL) were recorded across the Chatham Rise, WCSI, Puysegur, Snares Shelf, and along the west coast of the North Island (Figure 32). Reproductively active females were recorded in January.

Estimated YOY (<50 cm TL) were recorded in 10 years. There were 886 biologically measured (depth range=13–91 m, median=29 m) and 2694 length-measured (depth range=12–236 m, median=33 m) individuals. Records occurred from March to June and were confined to ECSI, WCSI, and Tasman and Golden Bays (Figure 32).

The kernel density estimates for school shark showed that YOY and juveniles were mostly reported along the Canterbury coastline and Tasman and Golden Bays (Figure 33, Appendix 2). The kernel density estimates for the reproductively active females represent the four locations where these females were recorded and do not show any trend in occurrence.

Observer and commercial data

Observer-reported catch was recorded mostly along the Snares Shelf and Puysegur in trawl and bottom longline fisheries, and along the southern South Island in set net fisheries (Figure 34). Fisher-reported catch was recorded at North Cape and Kapiti in trawl fisheries, at Chatham Islands and Taranaki in bottom longline fisheries, at Stewart Island in set net fisheries, and in the Cook Strait in small numbers in other gear types (Figure 35). Large female school sharks from observer-reported catch in the surface longline fishery were mostly recorded off the southern WCSI (Figure 36).

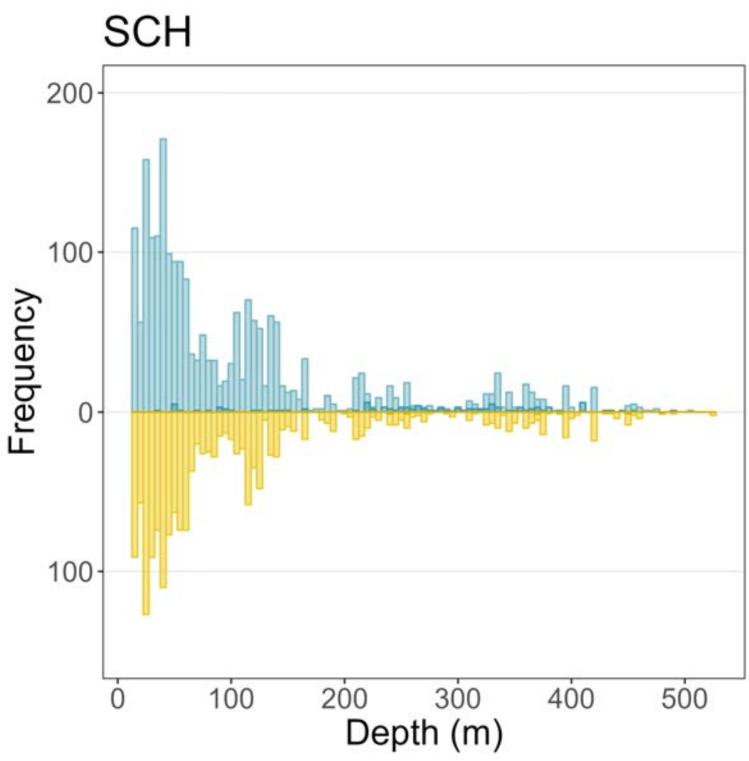


Figure 31: Depth distribution of school shark biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature).

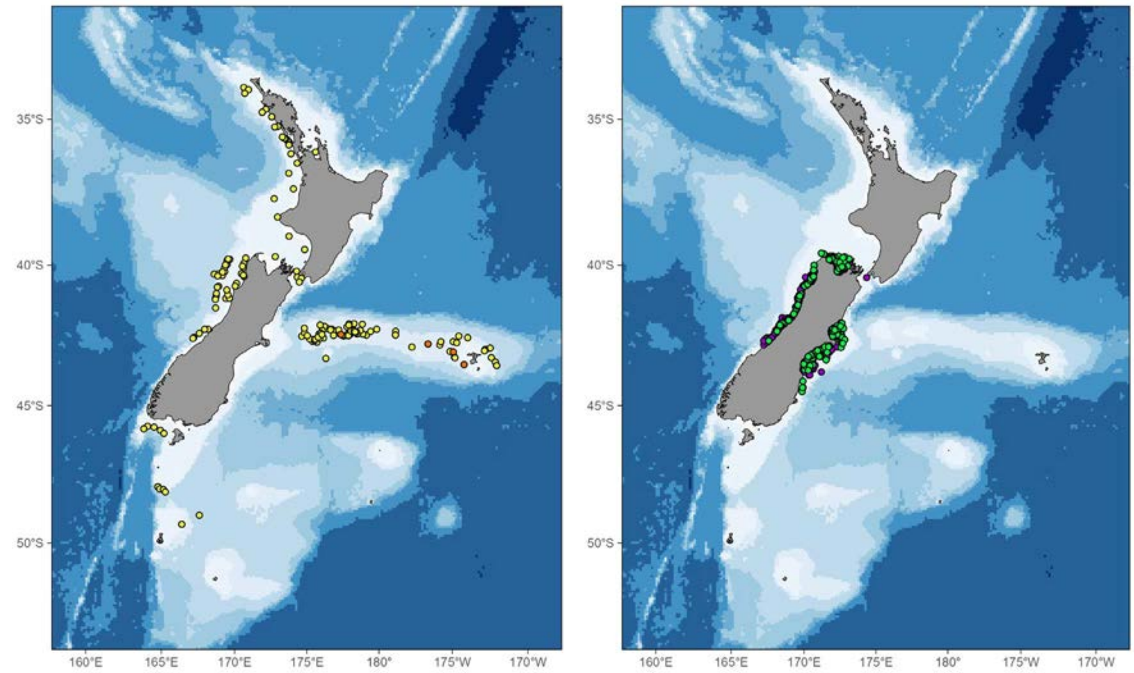


Figure 32: Research trawl survey for school shark records from 2000 to 2024 for (left) staged reproductively active females (orange), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements (purple).

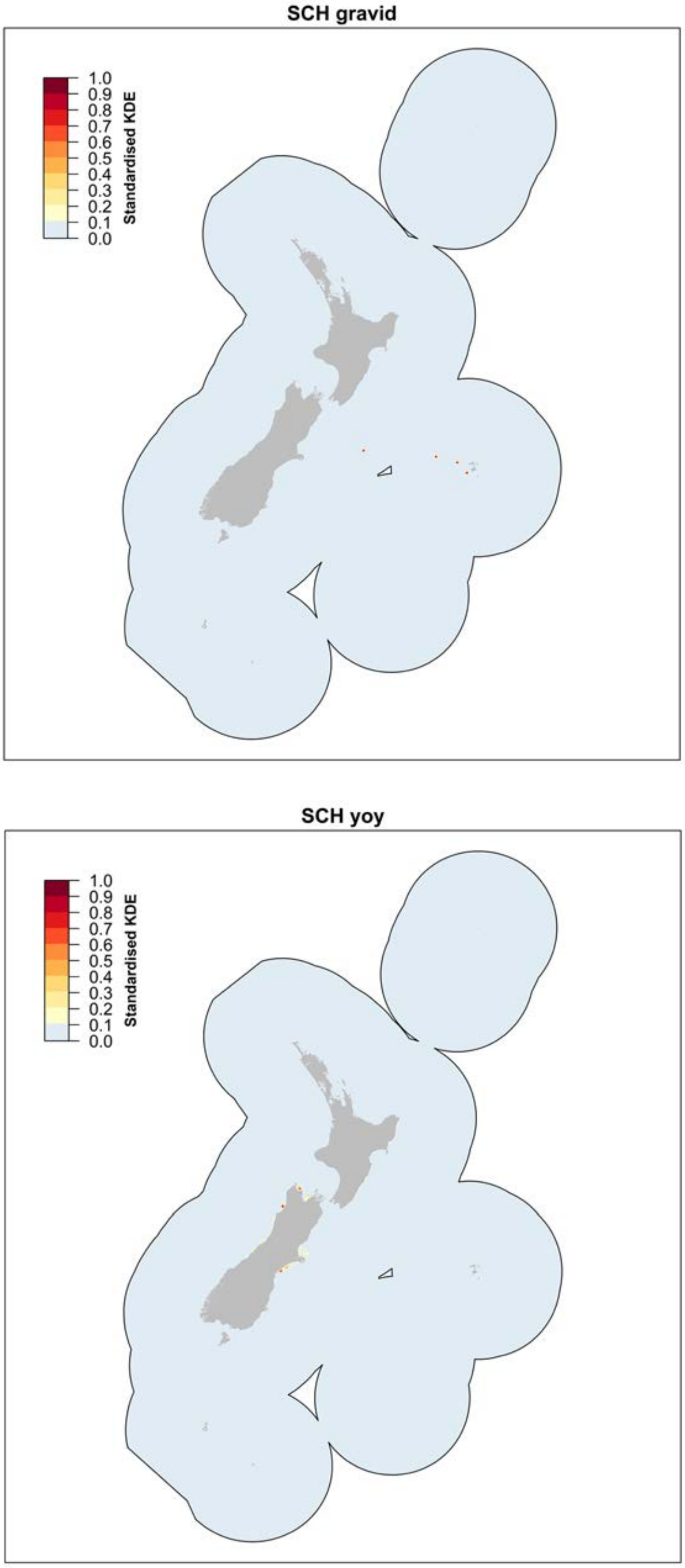


Figure 33: Kernel density estimate (KDE) for research trawl survey records for school shark from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

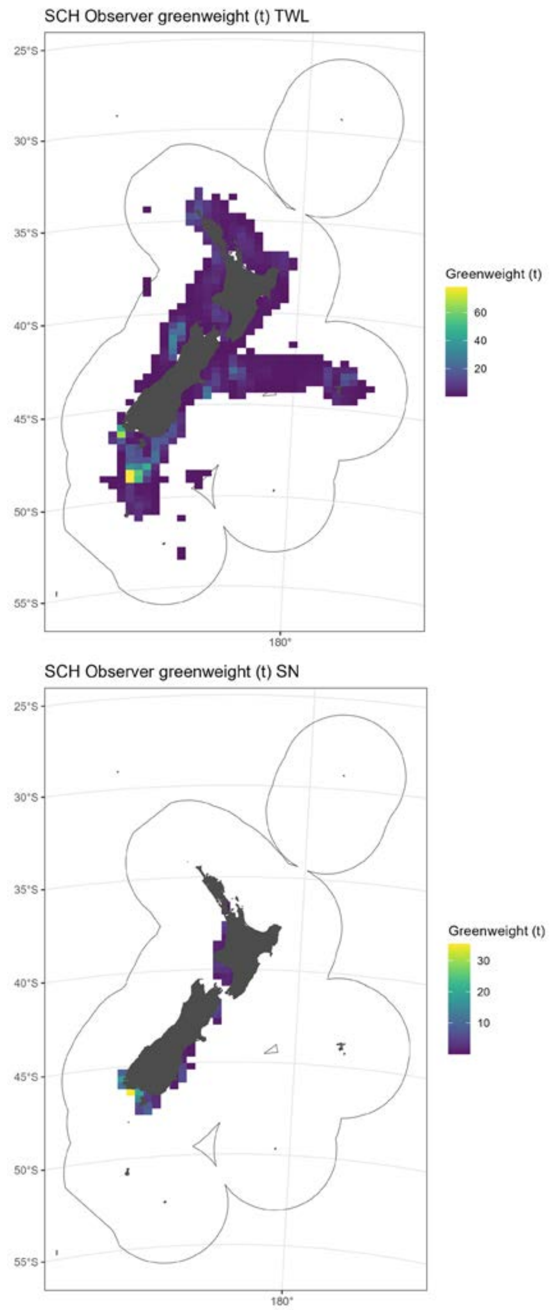


Figure 34: Distribution of school shark catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; SN=set net.

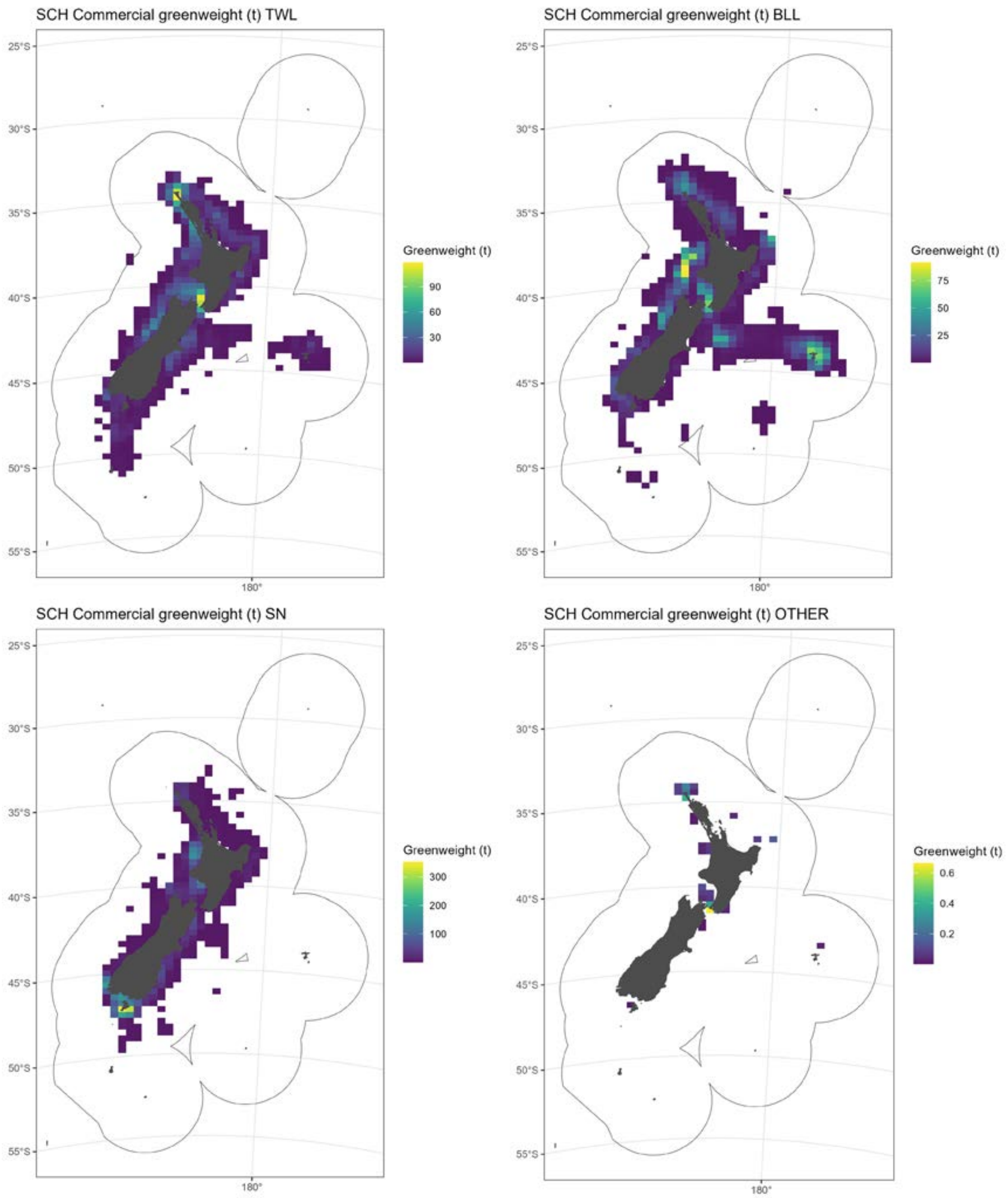


Figure 35: Distribution of school shark catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net; OTHER=other gear types.

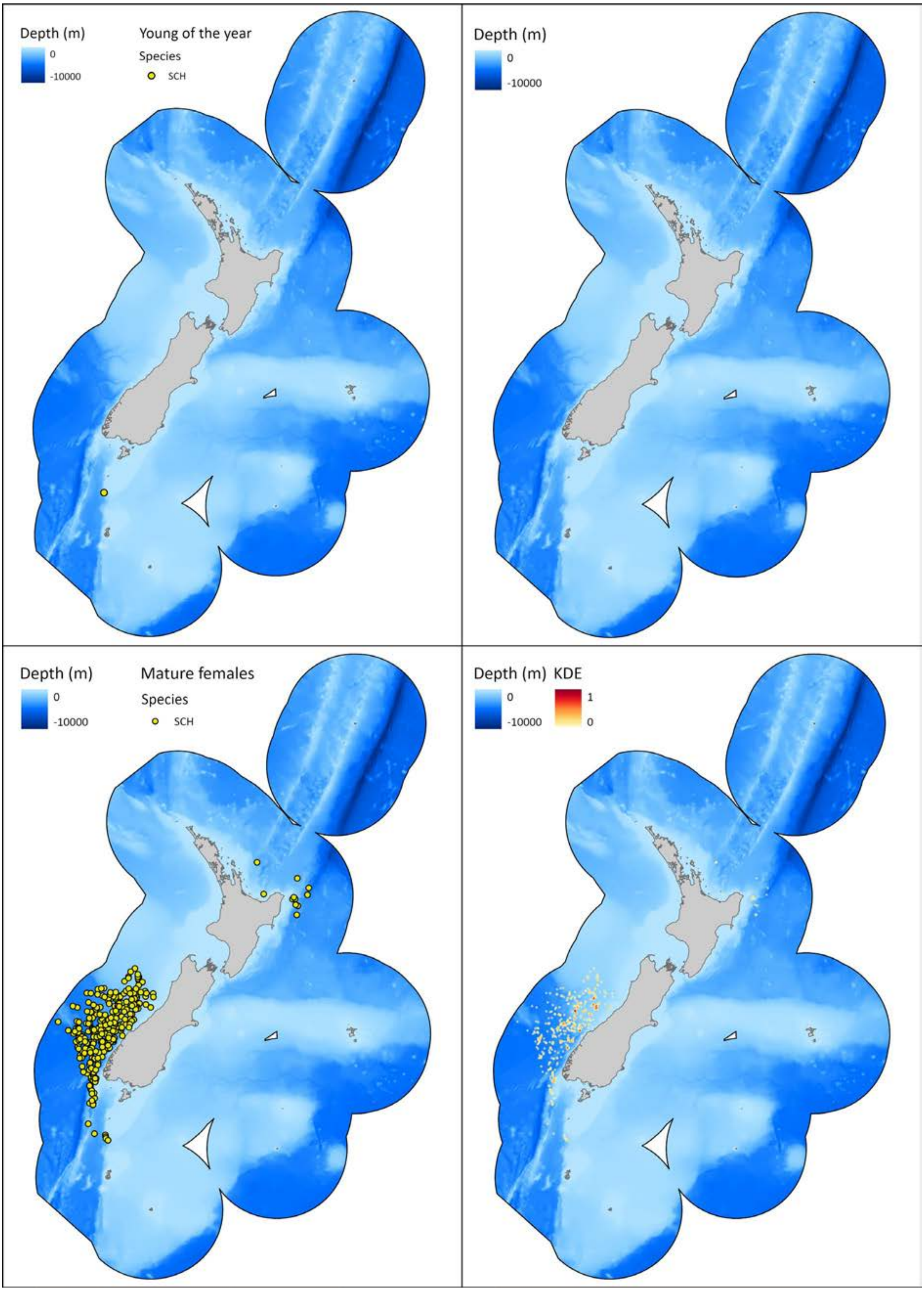


Figure 36: School shark recorded in surface longline fisheries from 2000 to 2024 estimated to be at least female size at maturity (top left) and the kernel density estimate (KDE) for the data (top right); and estimated young of the year school shark (bottom left) and the KDE for the data (top right).

Rig (*Mustelus lenticulatus*)

Rig are endemic to New Zealand. The species is demersal along the coastline from the Three Kings to the southern edge of the Snares Shelf within estuaries to the upper continental slope (Duffy 2015b). The species is recorded from shore to 400 m depth but is most common between 100 and 200 m outside of their breeding season (Duffy 2015b, see below). Rig are found mainly over soft sediment habitat (Duffy 2015b). Rig movement and distribution in harbours and estuaries is influenced by salinity and changes in water temperature (Lyon 2021).

Spawning

Reproduction is aplacental viviparous with litter sizes of 2–37 pups, and fecundity increases with maternal size (Francis & Mace 1980). Gestation is believed to be around 10–11 months (Graham 1956, Francis & Mace 1980). Once females have pupped (November–December) it is thought that a rest period of about one month before mating occurs (King & Clark 1984). The exact locations of pupping grounds are not known. Rig are born either in shallow, sheltered estuaries or large coastal harbours, or they make their way into these places after being born in nearby coastal waters (King & Clark 1984, Blackwell & Francis 2010).

Juvenile habitats

High densities of juvenile rig have been repeatedly identified at specific locations throughout the North Island, including Kaipara Harbour, Waitemata Harbour, and Porirua Harbour, indicating that females give birth in these general areas (e.g., Francis et al. 2012). Other regions, such as Wellington, Poverty Bay, Hawke Bay, the Hauraki Gulf, Tasman and Golden Bays report smaller numbers of juveniles (King & Clark 1984, Hendry 2004, Hurst et al. 2000). Juveniles have also been observed in Manukau Harbour (C. A. J. Duffy unpublished data). Juveniles remain within these areas through summer-autumn (to May in Porirua Harbour) and depart for the open sea when water temperature starts to drop and they reach a length ~50 cm TL in autumn-winter (approximately 6–8 months) (Francis & Francis 1992, Francis 2013). Acoustically tagged juveniles in Porirua Harbour spent most of their time in large basins and on shallow sand and mud flats around the margins (Francis 2013).

No site has been identified from the South Island, despite three nationwide surveys conducted in 1985, 2001, and 2009 (Francis 2013). Francis & Mace (1980) identified 'The Banks' an area of shallow (<8 m depth) water on the inside of Farewell Spit as an area where exclusively mature females were caught around the time of pupping suggesting that this area may be important but was missed by previous sampling efforts.

Adult migrations and movements

Adult rig undergo seasonal inshore–offshore migrations from the continental shelf into shallow coastal waters to give birth and mate; this occurs during the spring-summer months (September to December). Mating is thought to occur shortly after parturition, possibly at or near these areas (Francis 2013). The winter habitat of rig is unclear but may be in deeper waters across the continental shelf (e.g., Hikurangi Trench, Waitaki Canyon near Timaru and Oamaru) (Francis & Mace 1980, Francis 1988). Tag and recapture studies show that female rig travel farther than males, and mature females have larger movements than immature individuals (Francis 1988). Males appear to remain relatively close to where they were initially caught (remaining within one Quota Management Area (QMA)), even after years at liberty. One rig was reported to travel 1159 km from the Snares Islands to Golden Bay. A small number of tagged rig have shown movement between the North and South Islands, and from the east coast and west coast of the South Island (Francis 1988). There is some tagging evidence to support adult site philopatry in Pauatahanui inlet which is likely to be associated with mating and/or spawning purposes (Lyon 2021).

Population connectivity

Population structure is not clear. Genetic studies, growth rates, length at age and weight, the location of nursery grounds and vertebral counts provided little information suggesting the existence of separate stocks (Blackwell & Francis 2010). However, it has been suggested that northern rig stocks may mature at a smaller size than South Island stocks, and that movement of rig between the two islands may be limited (Blackwell & Francis 2010). The current QMAs for rig are considered appropriate for management purposes based on the low movement of adults (Francis 2010a).

Research trawl data

Since 2000, reproductively active female rig have been recorded in 11/23 years (every year since 2011 except 2014 and 2020), with 92 records across 15 trips. These females measured 77.8 to 130.0 cm TL (median=94.6 cm TL). Mature females (n=34) were reported from depths of 16–344 m (median=56 m) and reproductively active females were found across a similar depth range (14–407 m), but more often found slightly shallower (median=17 m) (Figure 37). Juveniles (n=2205) and mature males (n=410) were found at similar but deeper depth ranges (range=13–334 m, median=32 m, range=13–352 m, median=42 m, respectively) (Figure 37).

Reproductively active females were mostly recorded on ECSI (north and south of Banks Peninsula), Golden and Tasman Bay, with a few scattered records on WCSI and WCNI (Figure 38). Additional female rig (n=171) not assessed for maturity but measuring at least known length-at-maturity (100 cm TL) were also recorded from these areas, with additional records around the North Island.

Estimated YOY (<46 cm TL) were recorded in 14/23 years (in every year from 2008 onwards, except for 2010). There were 531 biologically measured (depth range=14 to 91 m, median=25 m) and 1408 length-measured (depth range=12 to 91 m, median=29 m) individuals. Most biological records occurred from March (n=129), April (n=141), and May (n=256), with a few additional records from June (n=3), and October (n=2). Records were largely confined to ECSI (north and south of Banks Peninsula to Timaru), WCSI, Tasman and Golden Bays, and a few scattered records off northwest North Island, Hauraki Gulf and one from Bay of Plenty (Figure 38).

The kernel density estimates for rig showed most YOY, juveniles, and reproductively active females in Tasman and Golden Bays, and YOY and juveniles were also along ECSI (Figure 39, Appendix 2). Reproductively active females were recorded throughout most of the year, with most records occurring in autumn (March–May, n= 83).

Observer and commercial data

No rig have been measured by observers since 2000. Observer-reported catch was recorded mostly along the Snares Shelf in trawl fisheries, at Chatham Islands in bottom longline fisheries, and along the Otago Peninsula in set net fisheries. The trawl and bottom longline records are questionable (Figure 40). Fisher-reported catch was throughout most of the coast of the South Island, as well as off Napier in the North Island in trawl and set net fisheries, off Otago Peninsula in bottom longline fisheries, and off East Cape in small numbers in other gear types (Figure 41, Figure 38).

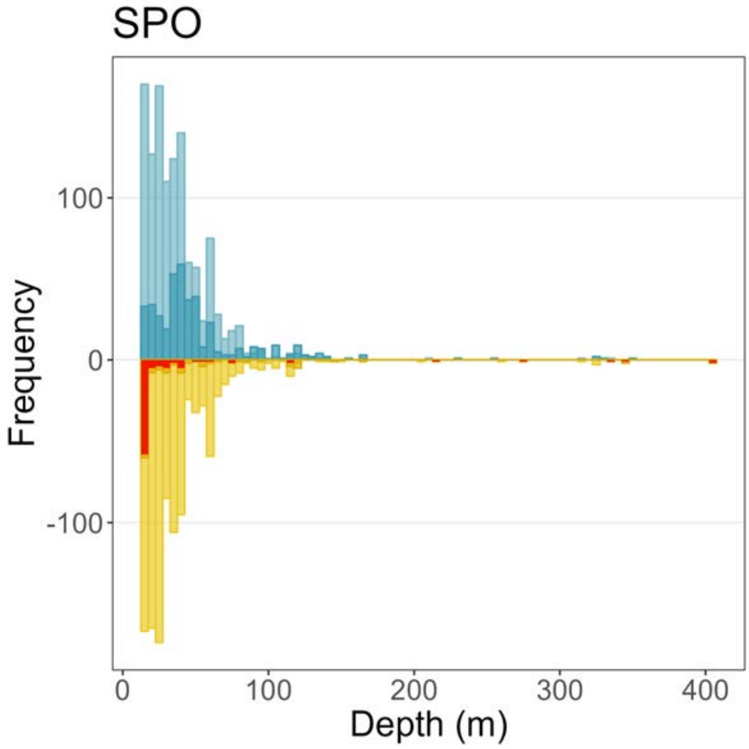


Figure 37: Depth distribution of rig biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively active females are identified in red.

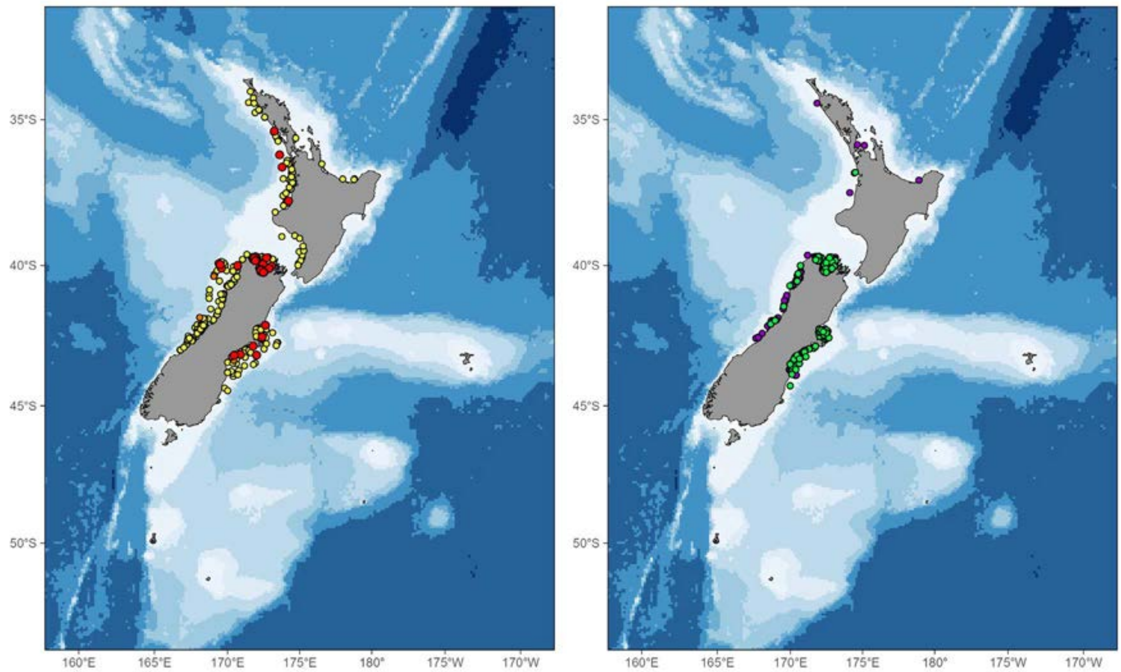


Figure 38: Research trawl survey records for rig from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements (purple).

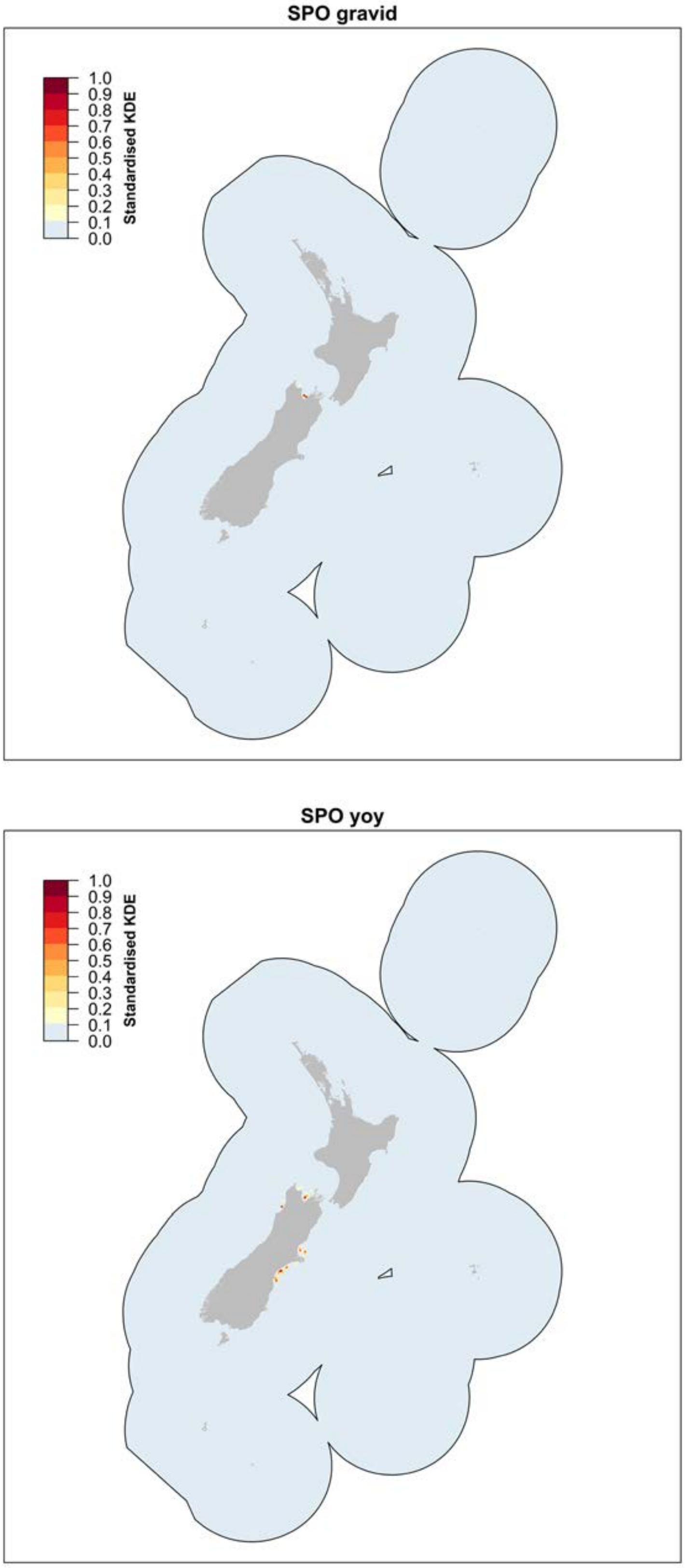


Figure 39: Kernel density estimate (KDE) for research trawl survey records for rig from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

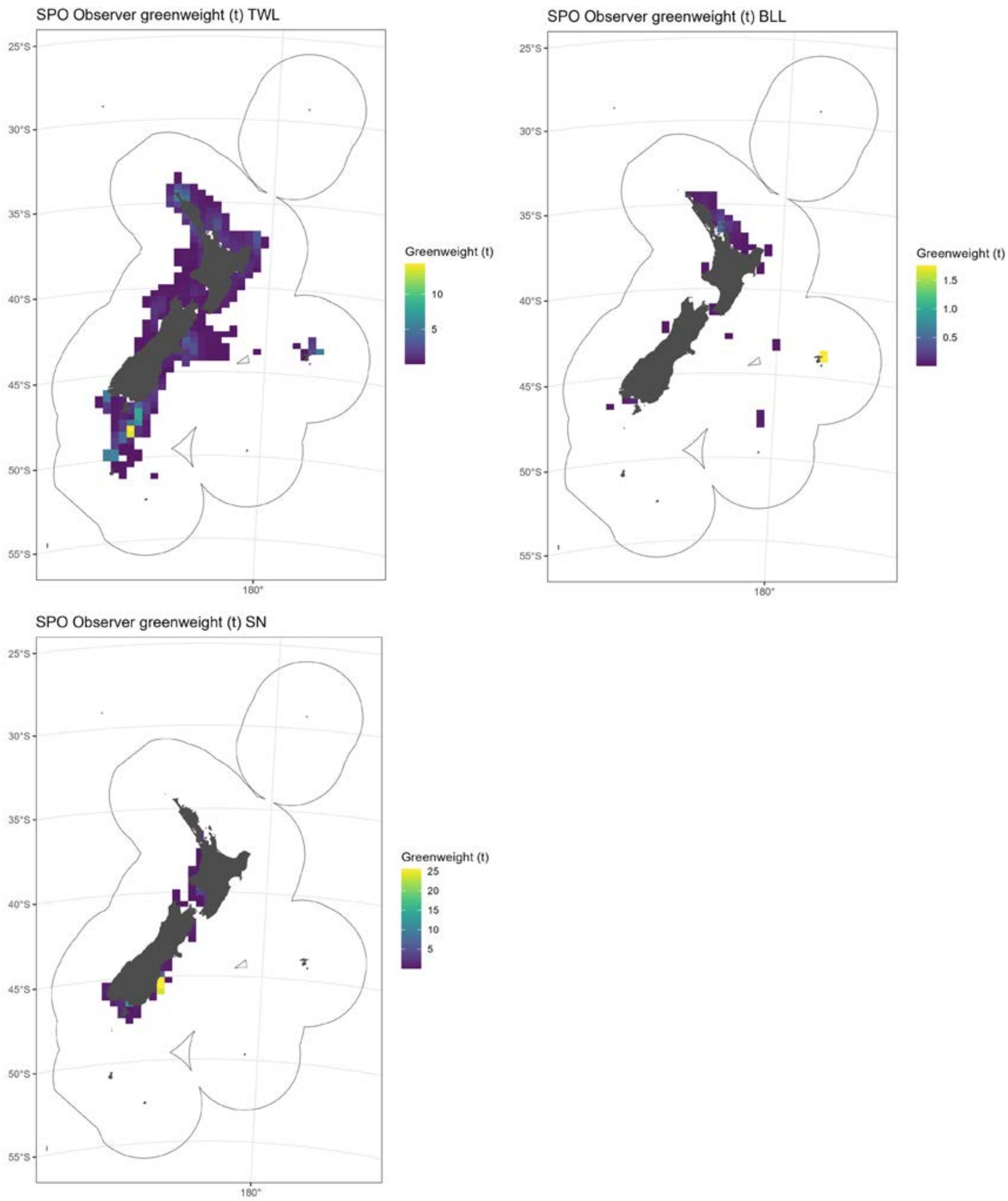


Figure 40: Distribution of rig catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net.

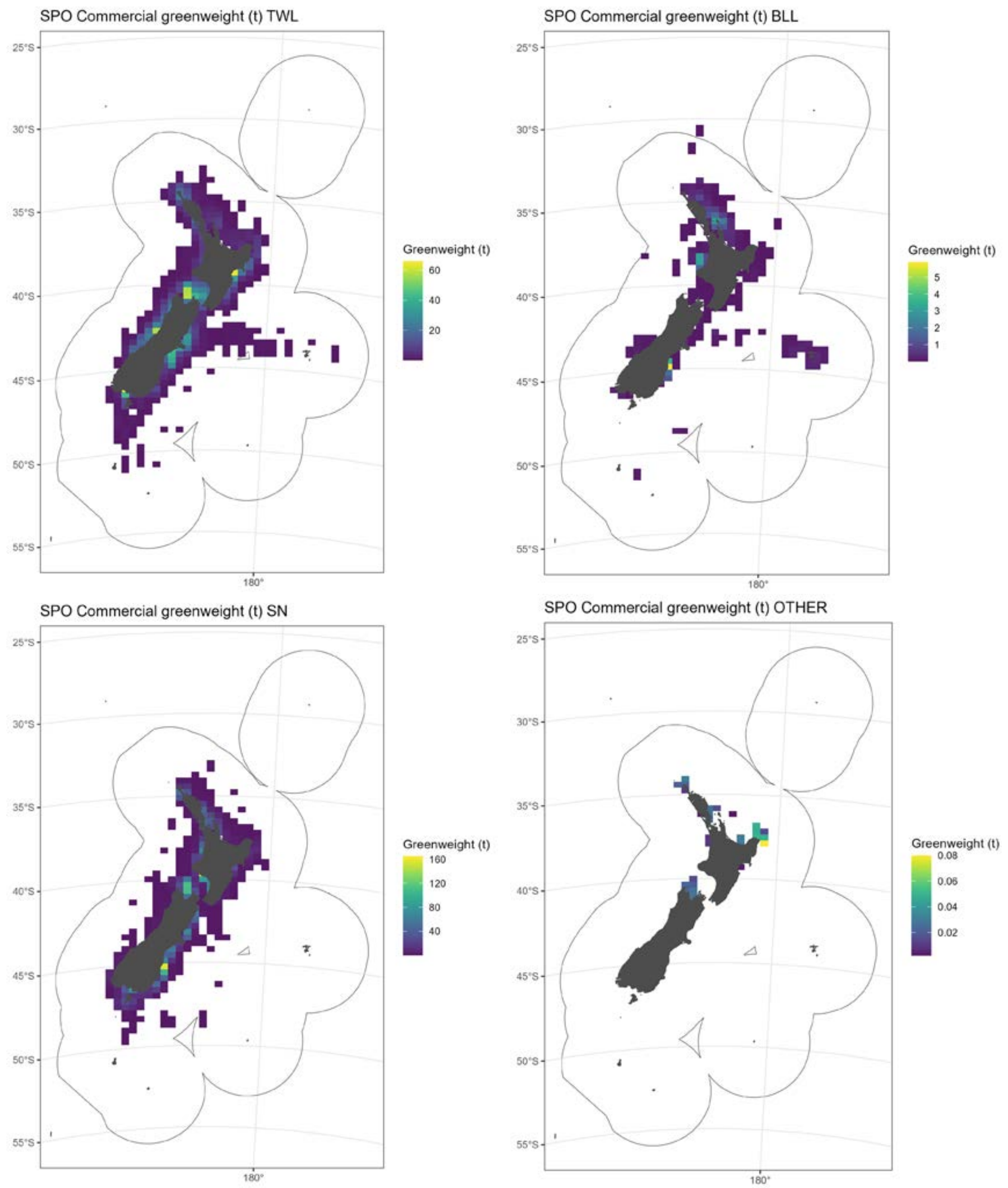


Figure 41: Distribution of rig catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net; OTHER=other gear types.

Blue shark (*Prionace glauca*)

Blue shark is globally distributed in temperate and tropical waters. It is commonly reported in coastal and pelagic waters across New Zealand to at least 49°S (Duffy 2015c). The species occupies a broad thermal niche, occurring in waters from about 12 °C to 29 °C (generally between 15.5° to 20°C), and in surface waters to depths of ~1000 m (Duffy 2015c, Druon et al. 2022). The deepest recorded depth from New Zealand is 1364 m (Elliott et al. 2022). Blue sharks move inshore and towards higher latitudes in spring-summer months, and offshore to the tropics in autumn-winter. Blue sharks occur at depths generally of 100–600 m when foraging, particularly at lower latitudes where surface waters are oligotrophic (Vedor et al. 2021); latitudinal patterns in ocean productivity can influence spatial distribution (Neubauer et al. 2021). Different size classes have been shown to prefer different sea surface temperature ranges (Vandeperre et al. 2016, Druon et al. 2022).

Spawning

Blue shark are aplacental viviparous, with litter sizes ranging from 4–135 pups (Ebert et al. 2021). Gestation is 9–12 months. Reproduction is believed to be an annual cycle based on information outside of New Zealand (Kohler et al. 2002) and may occur during the summer months in New Zealand (Elliott et al. 2022). Pupping grounds are not well defined but are thought to include the Bay of Plenty, Hawke Bay, Three Kings, and Wanganella Bank; neonates have been observed off Hawke Bay over 500 m depth, and gravid females have been observed off Cape Kidnappers (C. A. J. Duffy, pers. obs.). Length composition data for the wider South Pacific region shows smaller individuals at higher latitudes, with a high proportion of mature females, suggesting that higher latitudes act as nursery areas (Neubauer et al. 2021).

Juvenile habitats

Nursery areas are not known. Juveniles appear to remain close to the New Zealand coastline and spend much of their time at depths <500 m (and mostly <150 m) (Elliott et al. 2022). Elsewhere, juvenile blue sharks have shown preferences to areas with higher net primary productivity and environmental conditions that provide good habitat throughout the year to support rapid growth without the need to relocate over large distances (Vandeperre et al. 2016). Juveniles appear to prefer areas in the vicinity of topographic features, such as seamounts and oceanic islands, but this preference can differ widely depending on shark size. A global review of blue shark distribution showed that the species tends to shift from mesotrophic and temperate surface waters as juveniles to oligotrophic and warm surface waters as adults (Druon et al. 2022).

Adult habitat, migrations and movements

Mating grounds are not known and movement patterns and/or seasonal changes in distribution are not well defined. The species may engage in site fidelity; tagged blue sharks have returned to their initial tagging location after a year of foraging offshore (Elliott et al. 2022). Mature females appear to remain resident in New Zealand waters, with mature males travelling farther distance (beyond EEZ) (Elliott et al. 2022).

Population connectivity

A global genomic population structure study is currently ongoing. Initial genomics suggest that blue shark comprise of two groups, a Northern population (Mediterranean Sea and northern Atlantic Ocean) and a Southern population (Indo-west Pacific) (Nikolic et al. 2023). Blue sharks tagged in New Zealand waters travelled to New Caledonia, Vanuatu, and Tonga (Holdsworth et al. 2016, Holdsworth 2021).

Research trawl data

There are no records of blue shark in the research trawl data.

Observer and commercial data

A total of 43 882 blue shark have been measured for length by observers (range: 30–310 cm FL, median=132 cm FL). The number of blue shark measured by observers has steadily declined since

2000, with between ~1200 to almost 5200 individuals measured annually to 2017 (with the exception of 2016 where 173 sharks were measured), 241 sharks measured in 2018, only 5 sharks in 2019, and 24 and 45 in 2020 and 2021, respectively. There was 1 shark measured in 2022 and 3 in 2023. Female blue shark recorded in surface longline fisheries estimated to be at size of maturity were mostly recorded at the Kermadec Islands, northeast North Island and off southern WCSI (Figure 42). Estimated YOY blue shark were mostly recorded off East Cape and Hokitika Trench, with additional records in the Bay of Plenty and southern WCSI (Figure 42).

Observer-reported catch of blue shark in surface longline fisheries showed that the largest individuals were recorded in FMA10, north of the Kermadec Islands (Figure 43). Smaller blue sharks were recorded at more southern latitudes. Fisher-reported catch of blue shark in surface longline fisheries was highest off East Cape and the Bay of Plenty, as well as off WCSI (Figure 43).

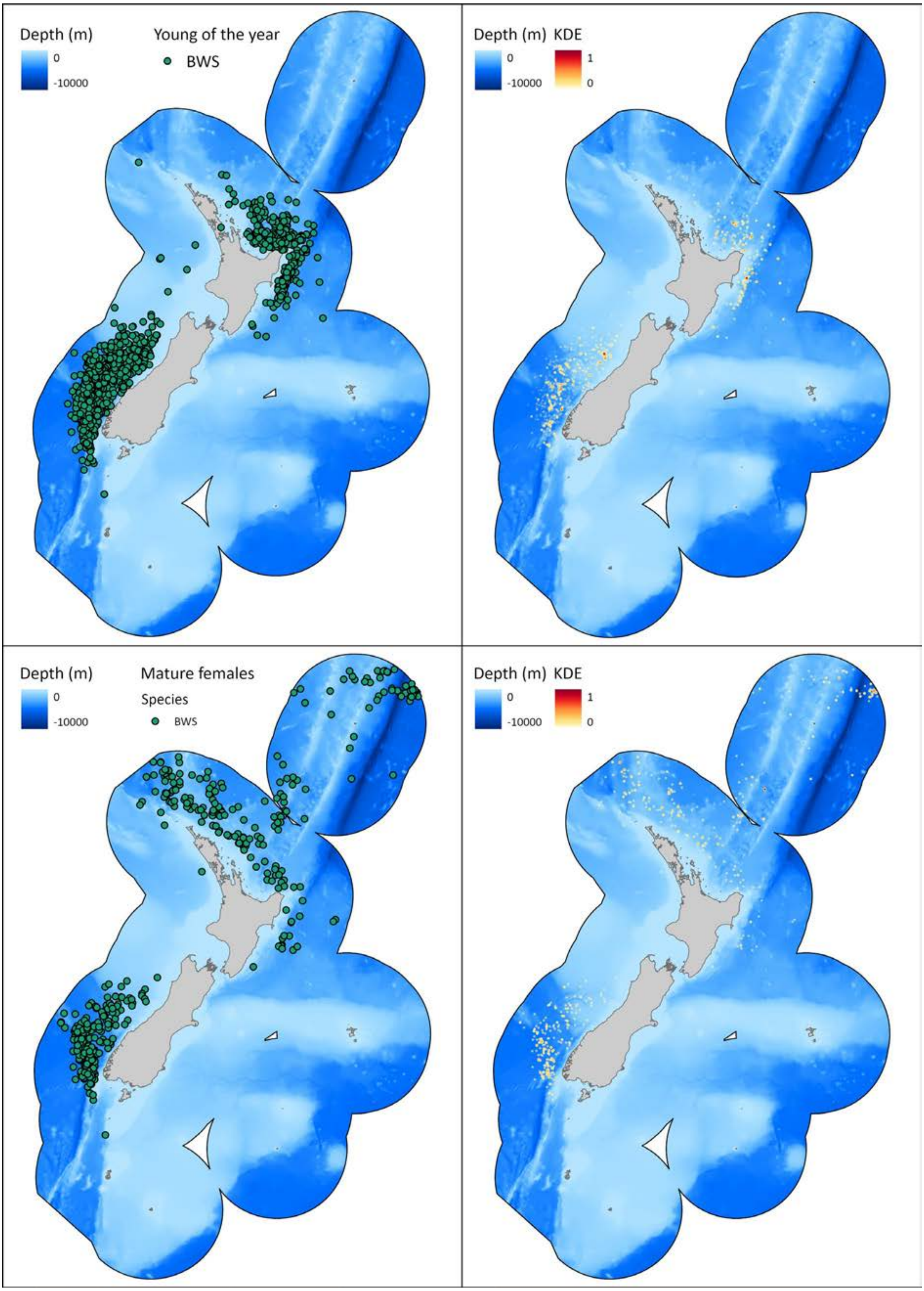


Figure 42: Blue shark recorded in surface longline fisheries from 2000 to 2024 estimated to be young of the year (YOY) (top left) and the KDE for the data (top right) and females estimated to be at or larger than size at maturity (bottom left) and the kernel density estimate (KDE) for the data (bottom right).

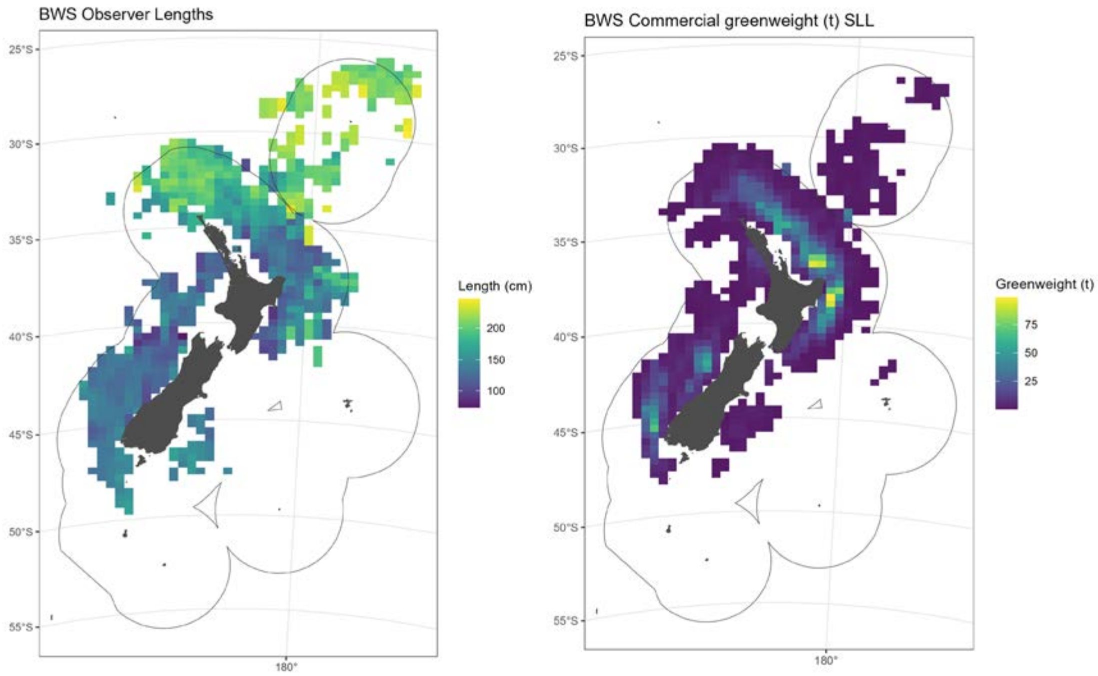


Figure 43: Distribution of blue shark catch for observer-reported (cm, mean fork length per cell) and fisher-reported (cumulative greenweight, t) records in surface longline fisheries from 2000 to 2024.

Spiny dogfish (*Squalus acanthias)*

Spiny dogfish are widespread in temperate waters in the North Atlantic, Mediterranean and Black Seas, South Atlantic, and Southeast Pacific around New Zealand and Australia (Ebert et al. 2021). Spiny dogfish are demersal and mesopelagic throughout New Zealand waters at depths from the shore to up to 700 m (mostly 50–150 m) (Duffy & Last 2015). The species is most abundant on the continental shelf and upper slope on East Coast South Island and Stewart-Snares Shelf. Spiny dogfish appear to prefer water temperatures between 9 and 13°C (Hanchet 1986). Overseas, spiny dogfish abundance has been linked to depth, temperature, salinity, and ocean productivity, with differing preferences between the sexes (Dell-Apa et al. 2017). Spiny dogfish have been observed over hard (coarse sand, shell debris, gravel, pebble) and soft (muddy, sandy) substrates, and at temperatures of 8.0–13.4°C (Te Papa unpublished data).

Spawning

Reproduction is aplacental viviparous with litter sizes of up to 32 pups (Ebert et al. 2021). Gestation is estimated to be 24 months. Spawning on ECSI is relatively well defined (Banks Peninsula to the Otago Peninsula); pupping occurs in deeper waters (200–300 m) along the edge of the continental shelf during autumn-winter months (April to September) (Hanchet 1986, Hanchet 1988). Spawning habitats are not well defined elsewhere across the species' New Zealand distribution.

Juvenile habitats

Shortly after birth in deep waters, juveniles are suspected to move into shallow and mid-water depths, and possibly in pelagic waters over the continental shelf (Hanchet 1986). Spiny dogfish slowly move into deep waters as they grow but remain in size-segregated schools comprising up to 2 or 3 age classes.

Adult habitat, migrations and movements

Mating grounds, movement patterns and/or seasonal changes in distribution are not well defined or known beyond ECSI. Adult spiny dogfish are abundant and one of the dominant species throughout their New Zealand range. Movement is triggered by changes in water temperature (Manning et al. 2004, Manning 2009), with both mature male and female spiny dogfish undergoing inshore and offshore migrations associated with spawning once maturity is reached (6–10 years of age); males move offshore in winter and females move inshore during summer (Hanchet 1986, 1988). Female spiny dogfish in early-stage pregnancies (with candled embryos) move into shallow waters of 100 m or less during summer and autumn (November to April), where they remain for a year before moving into deeper waters to pup and mate (Hanchet 1986, 1988). On ECSI, mating is suspected to occur between May and August. There is some evidence to suggest north-south migrations along ECSI during autumn and spring (Hanchet 1986) but limited tagging to determine individual rates of movement.

Population connectivity

Spiny dogfish in New Zealand are genetically distinct from individuals in the North Atlantic Ocean (Veríssimo et al. 2010).

Research trawl data

Since 2000, reproductively active female spiny dogfish have been recorded in 17/23 years, with 9475 records across 52 trips. These females measured 57.2 to 106.0 cm TL (median=77.1 cm TL). Mature females (n=1273) were reported from depths of 13–703 m (median=289 m) and reproductively active females were recorded from similar depths of 17–776 m (median=300 m) (Figure 44). Juveniles (n=11 840) and mature males (n=12 341) were found across similar but also deeper depths to mature females, but had a shallower median depth (juveniles, range=13–836 m, median=100 m, and mature males, range=13–949 m, median=110 m) (Figure 44).

Reproductively active females were mostly recorded along the continental shelf of ECSI and WCSI (Figure 45). Additional female spiny dogfish (n=31 503) not assessed for maturity but measuring at least the known length-at-maturity (73 cm TL) were recorded throughout New Zealand waters, particularly along the Chatham Rise, Snares Shelf, and WCSI (Figure 45). Reproductively active females were recorded throughout the year, particularly January to August (n=9033), with fewer records in September to December (n=422). While sampling is dependent on when and where research surveys take place, the presence of reproductively active females throughout most of the year suggests that reproduction occurs year-round.

Estimated YOY (<30 cm TL) were recorded in 14 years. There were 198 biologically measured (depth range=15 to 85 m, median=22 m) and 1845 length-measured (depth range=14 to 607 m, median=25 m) individuals. Records were largely confined to ECSI and WCSI (Figure 45). Most biological records occurred in April–May (n=191).

The kernel density estimates for spiny dogfish showed YOY and juveniles were mostly recorded along the Canterbury coastline including Pegasus Bay and South Canterbury Bight (Figure 46, Appendix 2). The kernel density estimates for reproductively active spiny dogfish were mostly recorded along the shelf and slope of the ECSI and WCSI, and throughout Chatham Rise.

Observer and commercial data
Six spiny dogfish have been measured by observers since 2000. Most observer and fisher reported catch was in trawl fisheries (Figure 47, Figure 48). Observer- and fisher-reported trawl catch was mostly on ECSI, Snares Shelf, Hokitika Trench, and Cook Strait. In longline fisheries, spiny dogfish was recorded at Chatham Islands, and in set net fisheries, along the ECSI in small amounts (Figure 47, Figure 48).

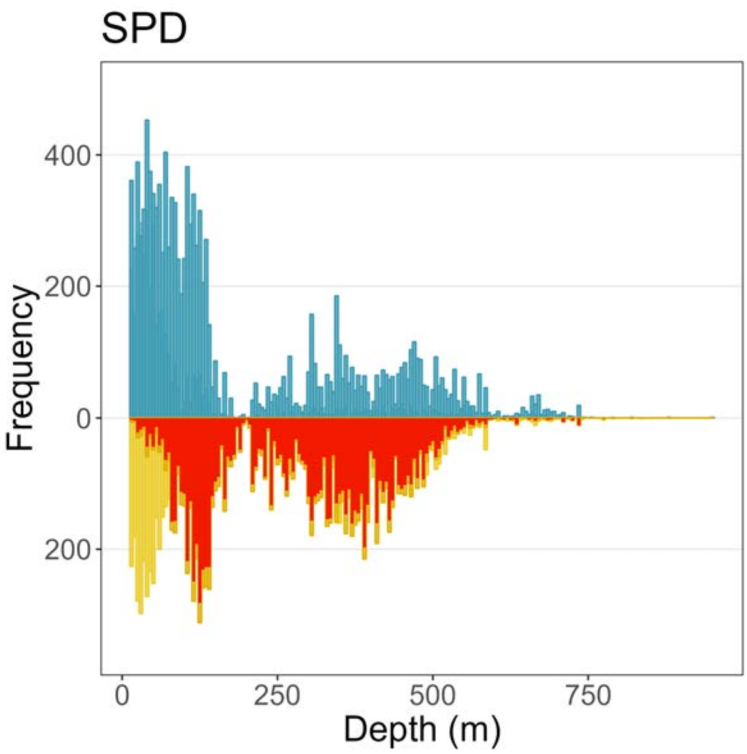


Figure 44: Depth distribution of spiny dogfish biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively active females are identified in red.

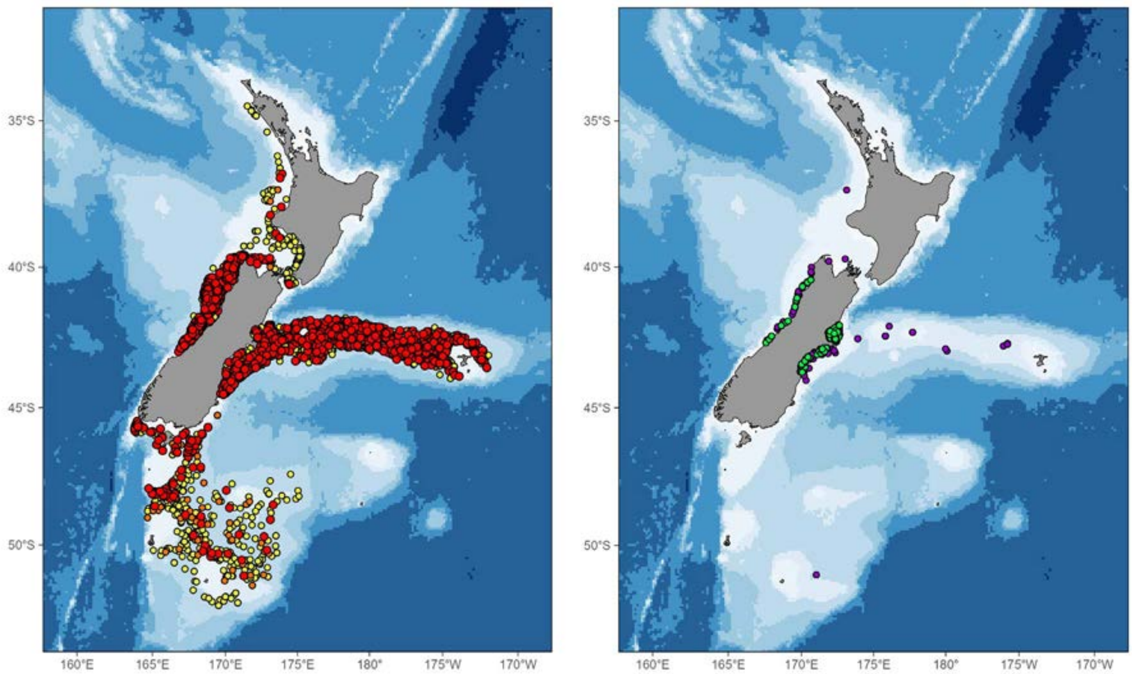


Figure 45: Research trawl survey records for spiny dogfish from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements (purple).

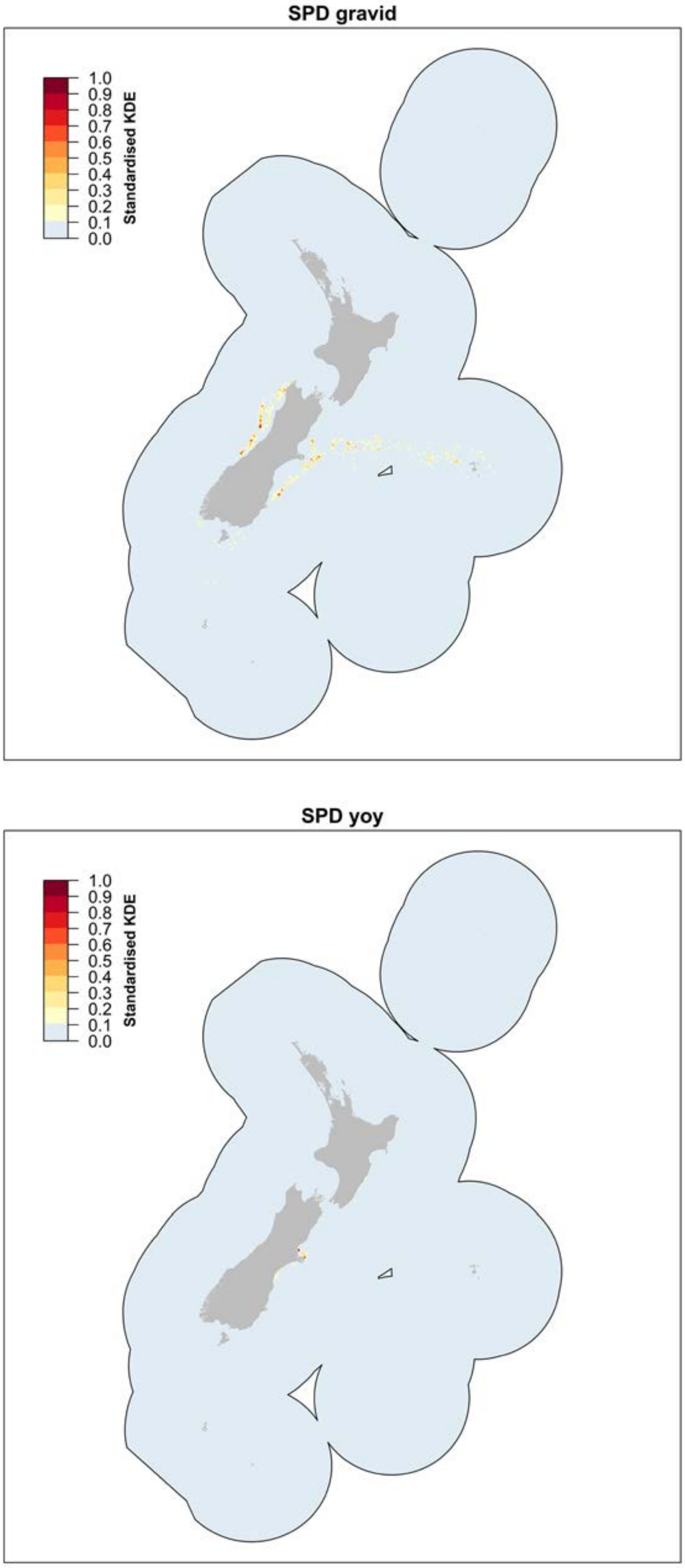


Figure 46: Kernel density estimate (KDE) for research trawl survey records for spiny dogfish from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

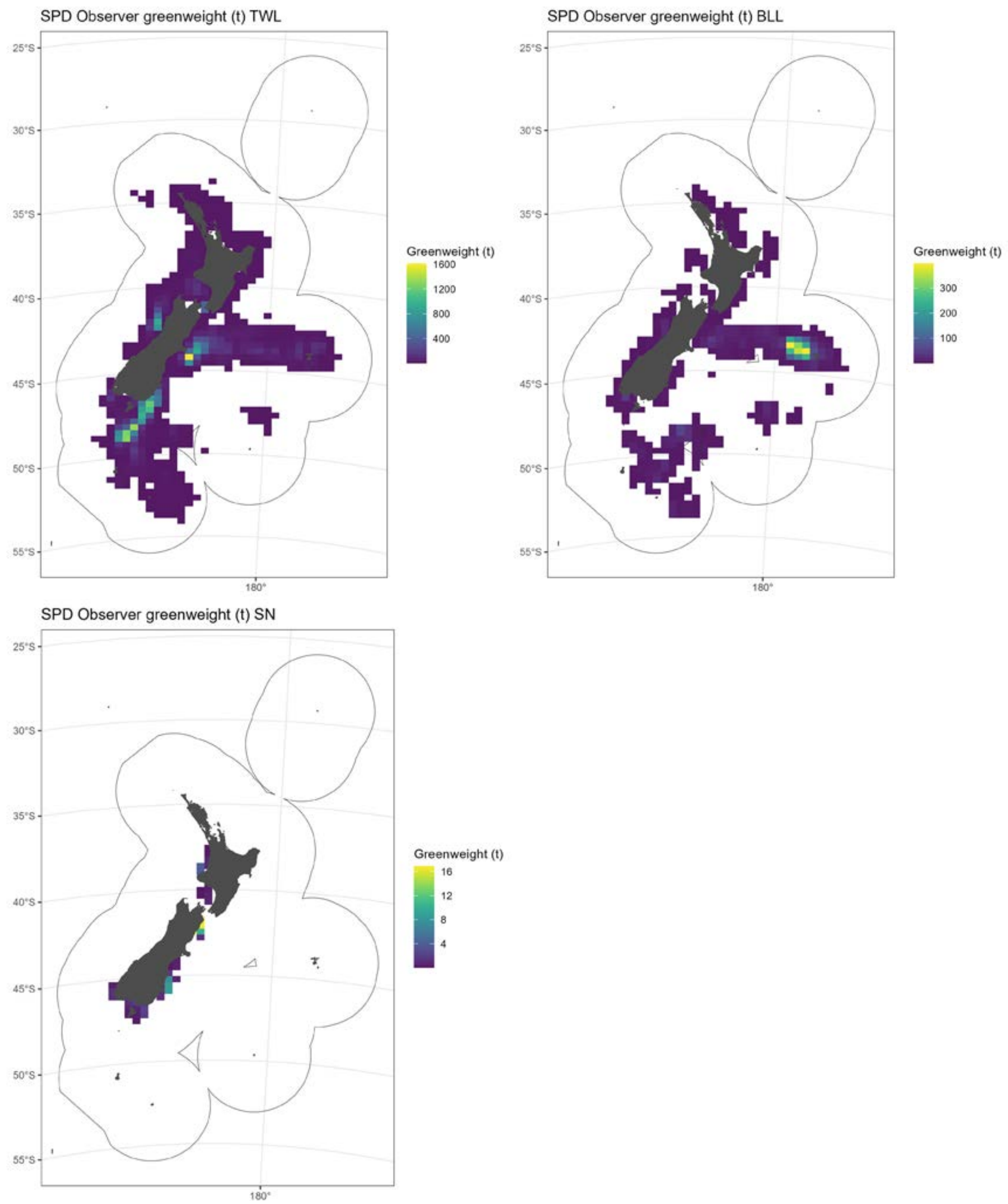


Figure 47: Distribution of spiny dogfish catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net.

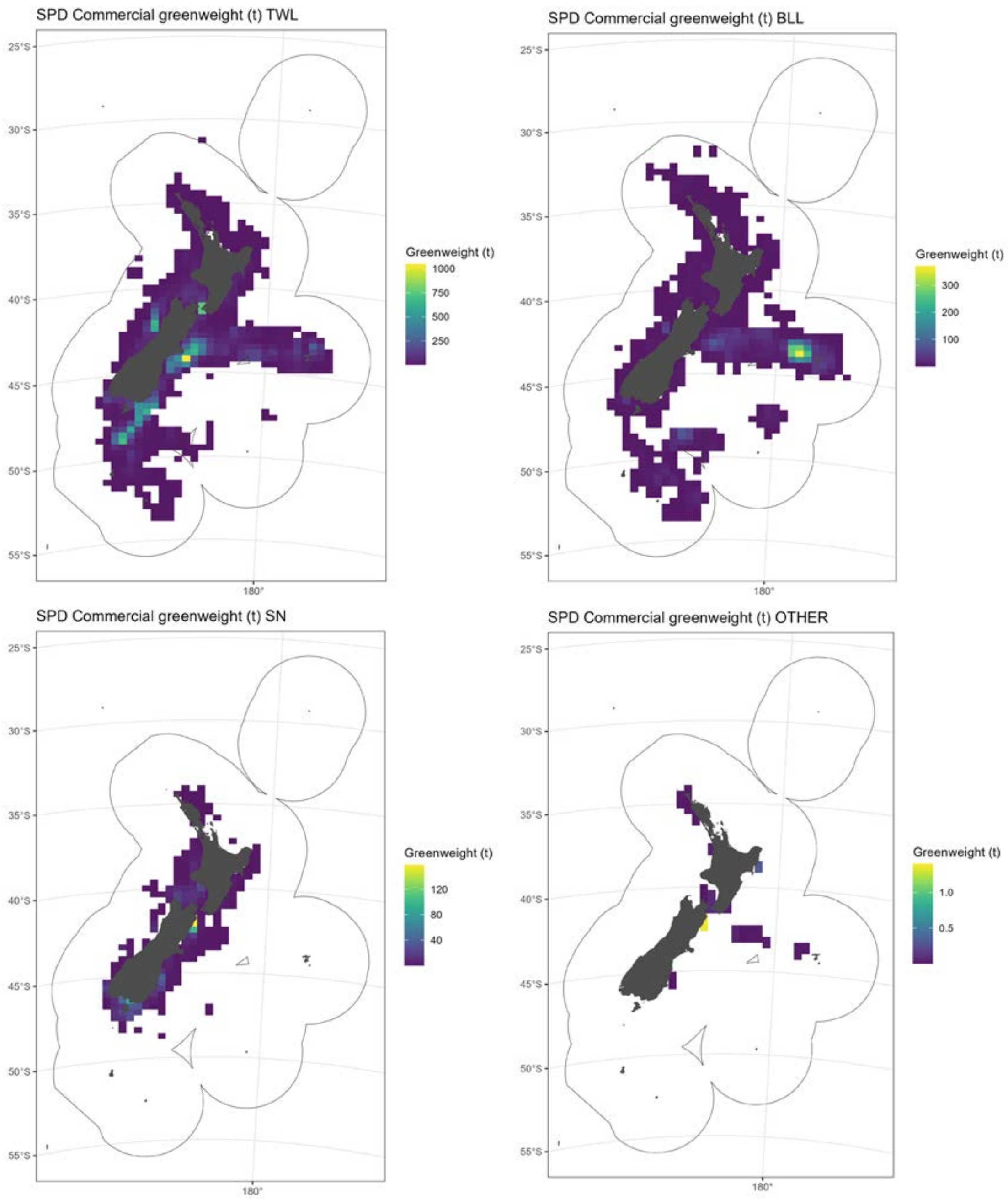


Figure 48: Distribution of spiny dogfish catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net; OTHER=other gear types.

Leafscale gulper shark (*Centrophorus squamosus*)

Leafscale gulper shark has a widespread, yet patchy, global distribution across the Indo-Pacific Ocean and Atlantic Ocean. The species is demersal on continental and insular shelves and slopes to the abyss at depths to 3366 m, and mostly at depths >200 m (Duffy et al. 2015, Ebert et al. 2021). Leafscale gulper shark is distributed throughout New Zealand waters, from the West Norfolk Ridge to the southern margin of Campbell Plateau at depths of 260–1440 m (Duffy et al. 2015). Habitat preference is unclear. Deepwater shark distribution appears to be influenced by environmental variables including depth, water temperature, and salinity, and segregation by sex, size, and maturity stage is common (Moura et al. 2014, Rodriguez-Cabello & Sanchez 2014, Daley et al. 2015, O'Hea et al. 2020). Leafscale gulper shark have been observed on video over soft (muddy, muddy-sand, and sandy) and hard substrates with or without features, and at temperatures of 4.4–8.1°C (Te Papa unpublished data).

Spawning

Gestation, spawning season, spawning frequency, and pupping grounds are not known. Reproduction is aplacental viviparous with litter sizes of 5–8 pups (Ebert et al. 2021). Spawning cycle is suspected to be asynchronous and continuous (i.e., parturition is quickly followed by ovulation) (Girard & Du Buit 1999, Figueiredo et al. 2008, Graham & Daley 2011).

Juvenile habitats

Nursery areas are not known. Areas of importance to juveniles have not been identified. However, Puysegur has long been suspected to be an important habitat for small leafscale gulper shark given their prevalence there in research trawl survey data (Parker & Francis 2012, Moura et al. 2014, Finucci et al. 2021a).

Adult habitat, migrations and movements

Mating grounds, movement patterns and/or seasonal changes in distribution are not known. Reports of gravid females are generally rare and isolated events (e.g., Bañón et al. 2008, Severino et al. 2009, Parker & Francis 2012). Mature and post-natal females have been shown to be associated with shallower depths and warmer waters, with clear associations with submarine features such as the Mid Atlantic Ridge and Tore-Madeira Ridge, Rockall Trough and Rockall Bank (Girard & Du Buit 1999, Severino et al. 2009, Moura et al. 2014). Mature males appear to be confined to Puysegur and the northeast Campbell Plateau in New Zealand waters (Moura et al. 2014).

Tagging studies (both sexes) observed movements over several months with individuals travelling several hundred kilometres; one individual was observed migrating from the Cantabrian Sea to the Porcupine Bank (Rodríguez-Cabello & Sánchez 2014, Rodríguez-Cabello et al. 2016). Such distances could be akin to movements between Puysegur and the west coast of the North Island, for example. Satellite tagged leafscale gulper shark off Challenger Plateau showed limited movement (approximately 200 km) over 60 days, although the primary purpose of these tags is to report on post-release survival (B. Finucci unpublished data). Satellite tagged sharks have been shown to engage in regular diel movement patterns (B. Finucci unpublished data).

Population connectivity

Population structure within New Zealand is not known. Population genetics have indicated low genetic variability and migration of individuals between populations, although long-term genetic divergence between the Northeast Atlantic Ocean and New Zealand was reported (Veríssimo et al. 2012). This same study also showed that females were less dispersive than males and possibly philopatric.

Research trawl data

Since 2000, reproductively active female leafscale gulper shark have been recorded in 13/23 years, with 79 records across 22 trips. These females measured 85.6 to 143.0 cm TL (median=131.6 cm TL). The 86 cm TL shark may have been misidentified or improperly staged, given that this individual was much smaller than estimated length-at-maturity (119 cm TL). However, given that this shark was identified as gravid (stage 4), it has been retained at this time. Mature females (n=296) were reported from depths of 419–1198 m (median=679 m) and reproductively active females were more often recorded from deeper depths of 437–1009 m (median=793 m) (Figure 49). Juveniles (n=819) were found at a similar depth range to reproductively active females (range=356–1238 m, median=766 m) while mature males (n=244) were found at similar depth to mature females generally (range=445–1036 m, median=658 m) (Figure 49).

Reproductively active females were mostly recorded along the central northern Chatham Rise, Puysegur, Snares slope, and WCSI, with a few scattered records from the North Island (Figure 50). Additional female leafscale gulper shark (n=760) not assessed for maturity but measuring at least known length-at-maturity (119 cm TL) were recorded in large numbers in these areas, as well as along the eastern slope of Chatham Rise, the southern margin of Campbell Plateau and a discrete location on Challenger Plateau (Figure 50). Reproductively active females were recorded throughout the year, with most records occurring in summer (December=14, January=24) and winter (July=23, August=12), which are likely reflective of available sampling efforts. However, the presence of reproductively active females throughout most of the year may suggest reproduction occurs year-round.

Estimated YOY (<50 cm TL) were recorded in 13/23 years. There were 221 biologically measured (depth range=360 to 1047 m, median=794 m) and 512 length-measured (depth range=360 to 1047 m, median=819 m) individuals. Most biological records occurred from November (n=49), December (n=99), and January (n=47), while the remaining records occurred June to August (n=26). Records were largely confined to northern Chatham Rise, Puysegur, and Cook Strait Canyon (Figure 50).

Kernel density estimates for YOY and juveniles were mostly recorded at Puysegur (Figure 51, Appendix 2). The kernel density estimates for reproductively active leafscale gulper shark were recorded in one discrete location off the northwest coast of the North Island, but this is likely to be reflective of low sample size (Figure 51).

Observer and commercial data
One leafscale gulper shark has been measured by observers since 2000. Most observer- and fisher-reported catch was in trawl fisheries. Observer- and fisher-reported trawl catch was mostly on the Snares Shelf and Puysegur, and Hokitika Trench in smaller amounts (Figure 52, Figure 53). Smaller amounts of bottom longline catch was recorded from southwest Chatham Rise and west of Puysegur (Figure 52, Figure 53).

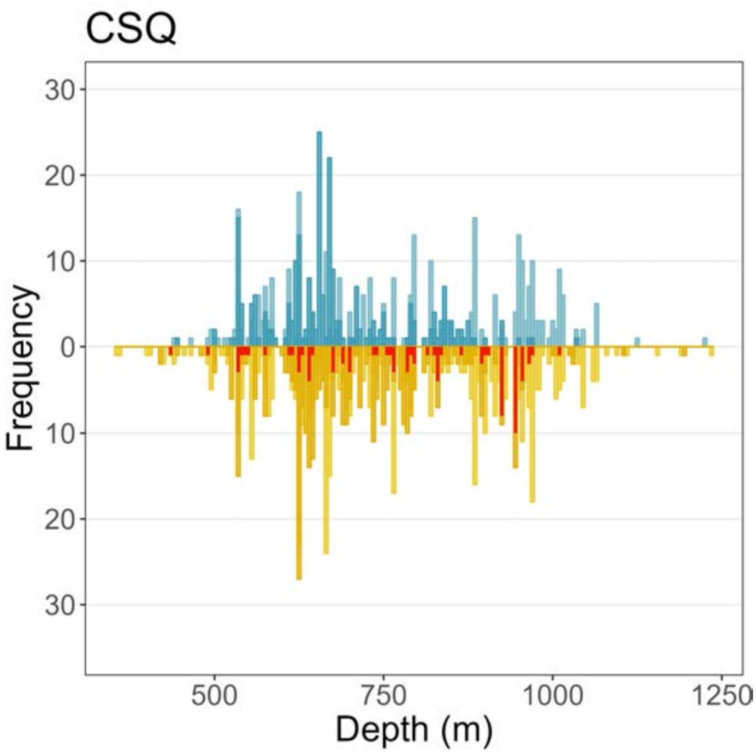


Figure 49: Depth distribution of leafscale gulper shark biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively active females are identified in red.

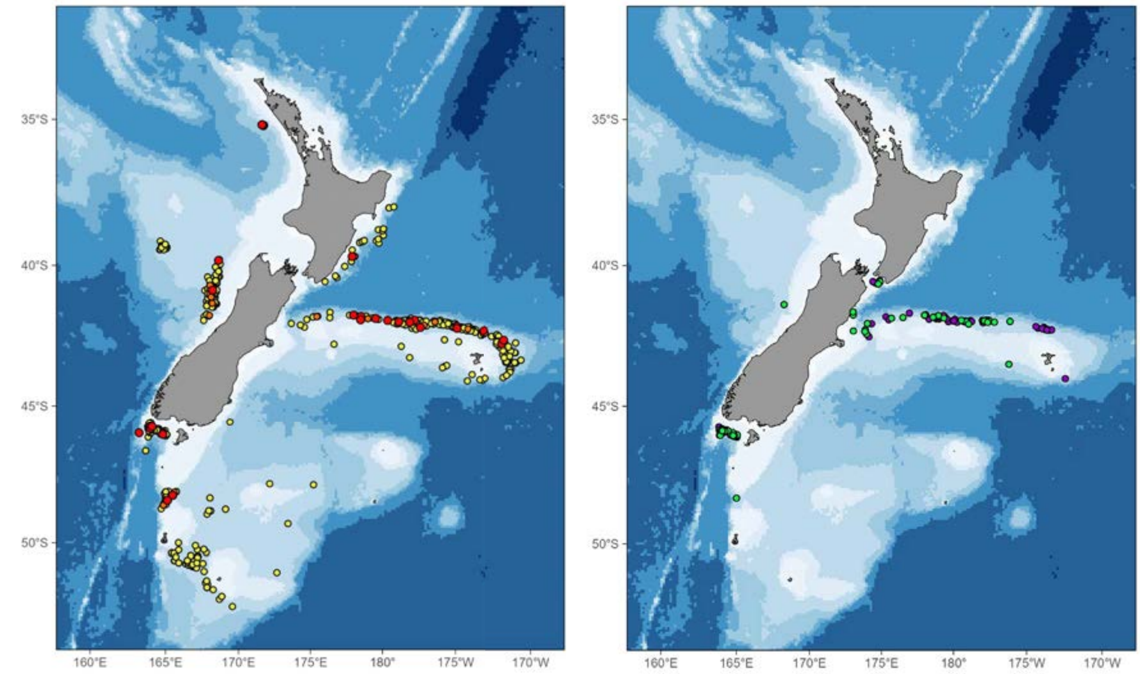


Figure 50: Research trawl survey records for leafscale gulper shark from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements (purple).

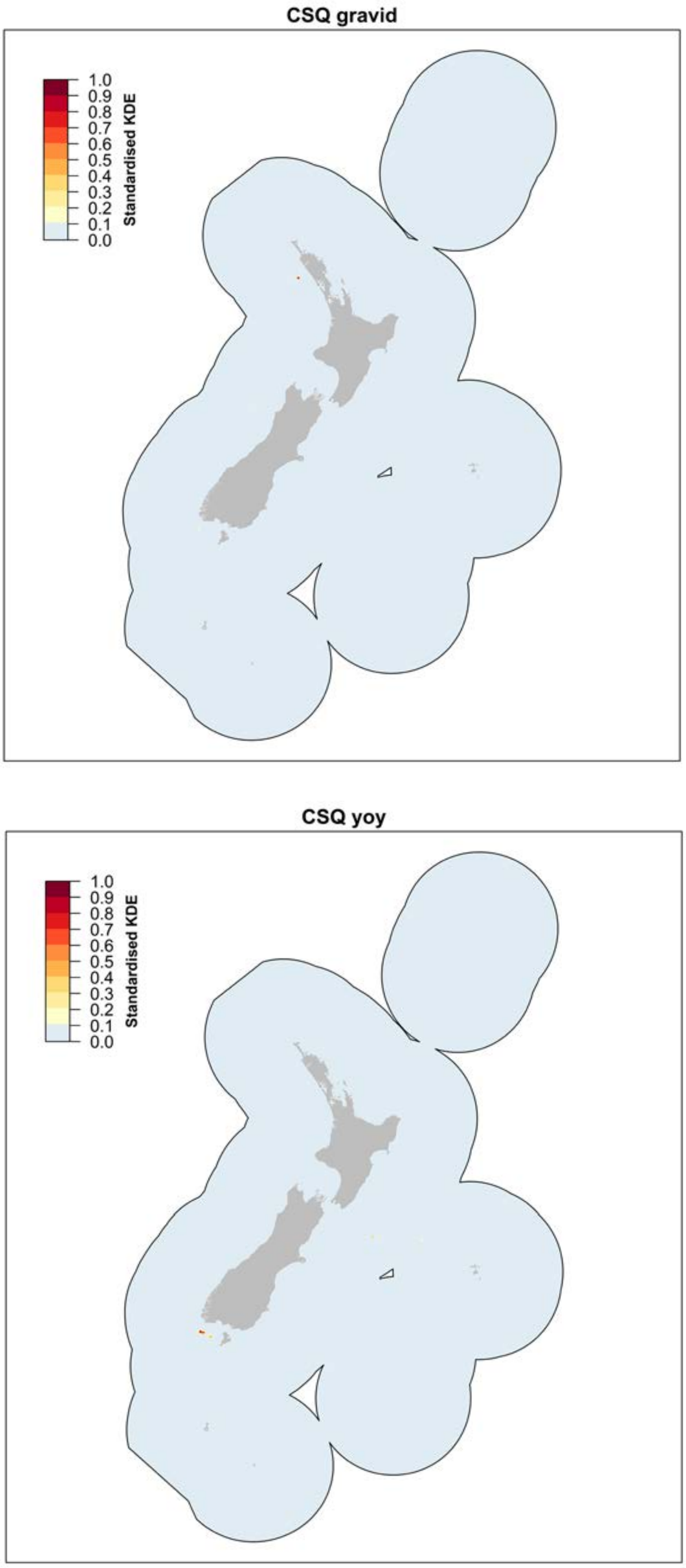


Figure 51: Kernel density estimate (KDE) for research trawl survey records for leafscale gulper shark from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

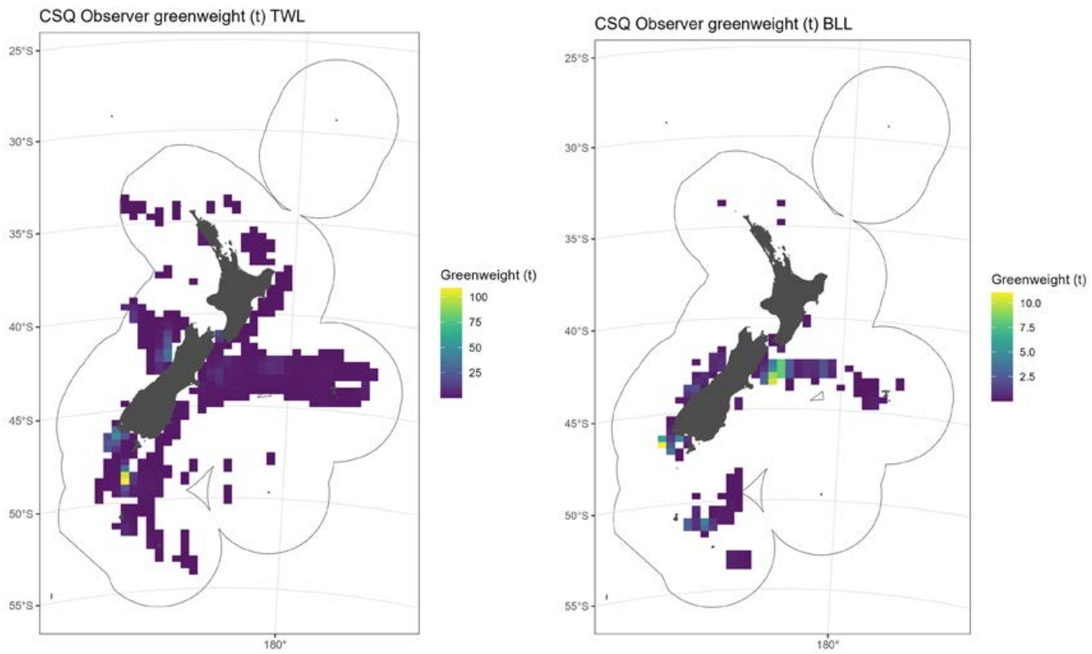


Figure 52: Distribution of leafscale gulper shark catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline.

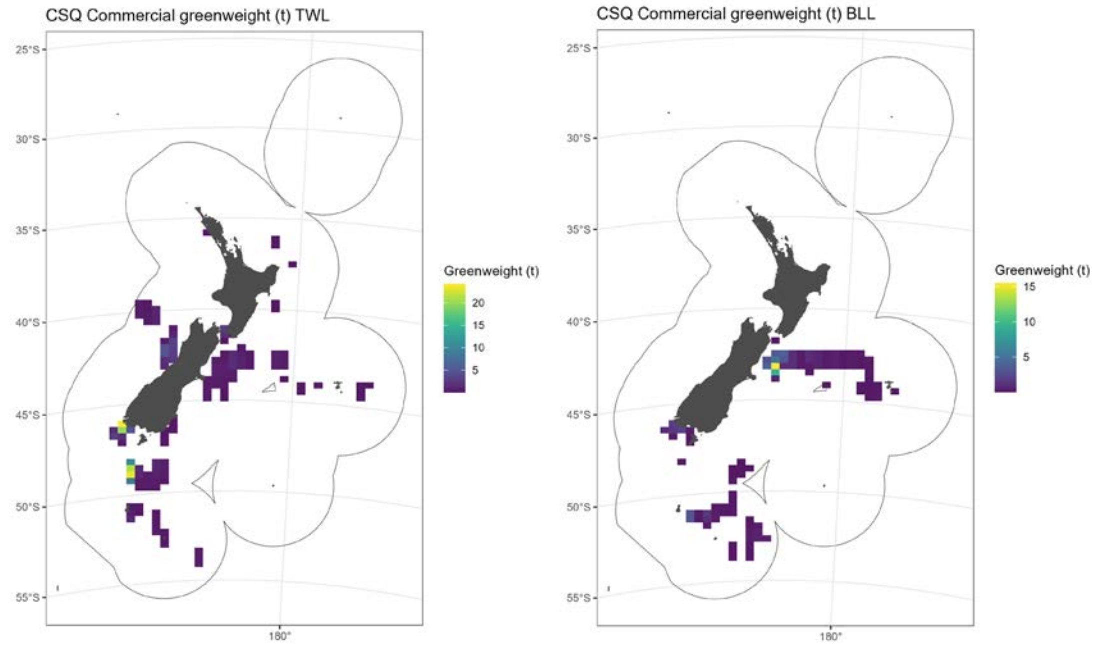


Figure 53: Distribution of leafscale gulper shark catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline.

Shovelnose dogfish (*Deania calcea*)

Shovelnose dogfish has a widespread, yet patchy, global distribution across the Indo-Pacific Ocean and east Atlantic Ocean. The species is demersal on continental and insular shelves and slopes at depths of 60–1500 m, with most individuals recorded at depths >400 m (Duffy et al. 2015, Ebert et al. 2021). Shovelnose dogfish is distributed throughout New Zealand waters, from Lord Howe Rise, northern ridges, and off North Cape to the Snares Shelf at depths of 30–1340 m, and usually 600–900 m (Duffy et al. 2015). Habitat preference is unclear. Deepwater shark distribution appears to be influenced by environmental variables including depth, water temperature, and salinity, and segregation by sex, size, and maturity stage is common (Moura et al. 2014, Rodríguez -Cabello & Sanchez 2014, Daley et al. 2015, O'Hea et al. 2020). Shovelnose dogfish have been observed on video over soft (muddy, sandy) ground with no features, and at temperatures of 5.6–8.4°C (Te Papa unpublished data).

Spawning

Gestation, spawning season, spawning frequency, and pupping grounds are not known. Reproduction is aplacental viviparous with litter sizes of 6–12 pups (Ebert et al. 2021). Spawning cycle is asynchronous (Irvine et al. 2012) and a resting period of up to four years has been estimated (Clark & King 1989, Parker & Francis 2012).

Juvenile habitats

Nursery areas are not known. Areas of importance to juveniles have not been identified. High numbers of juveniles have been reported from the northern slopes of Chatham Rise and Puysegur Bank (Moura et al. 2014).

Adult habitat, migrations and movements

Mating grounds, movement patterns and/or seasonal changes in distribution are not known. Reports of gravid females are found to be uncommon and geographically isolated (e.g., Moura et al. 2014). Mature and post-natal females from multiple regions including New Zealand have been shown to be associated with shallower depths and warmer waters (Moura et al. 2014). Life history stages appear to be strongly spatially segregated.

Population connectivity

Population genetics have indicated some genetic variability between populations on a global scale (Keggin 2017).

Research trawl data

Since 2000, reproductively active female shovelnose dogfish have been recorded in 12/23 years, with 174 records across 22 trips. These females measured 90.1 to 117.6 cm TL (median=105.8 cm TL). Mature females (n=597) were reported from depths of 445–1366 m (median=678 m) and reproductively active females were recorded from similar depths of 424–1173 m (median=704 m) (Figure 54). Juveniles (n=6872) were found at a similar depth range to reproductively active females (range=330–1345 m, median=697 m) while mature males (n=3733) were found at deeper depths (range=330–1434 m, median=831 m) (Figure 54).

Reproductively active females were mostly recorded along the northern and eastern slope of the Chatham Rise, Puysegur, WCSI, Cook Strait Canyon, and along the Hikurangi Trench (Figure 55). Additional female shovelnose dogfish (n=1583) not assessed for maturity but measuring at least known length-at-maturity (106 cm TL) were also recorded in large numbers in these areas, as well as along the southern margin of Campbell Plateau (Figure 55). Reproductively active females were recorded throughout the year, but mostly in January (n=111) and August (n=30).

Estimated YOY (<50 cm TL) were recorded in 16/23 years. There were 314 biologically measured (depth range=336 to 1174 m, median=697 m) and 2147 length-measured (depth range=336 to 1174 m, median=679 m) individuals. Most records occurred in January (n=220) and March (n=42), with an additional smaller number of records (<20 per month) throughout the year. Records occurred along the northern Chatham Rise Slope, Puysegur, Cook Strait Canyon, and along the Hikurangi Trench, with a few records off WCSI and Challenger Plateau (Figure 55).

The kernel density estimates for shovelnose dogfish showed YOY records were mostly recorded along northwest Chatham Rise while juveniles were found throughout northern and eastern Chatham Rise, as well as Puysegur (Figure 56, Appendix 2). Reproductively active females were mostly recorded at Hokitika Trench and Puysegur (Figure 56).

Observer and commercial data
Only one shovelnose dogfish has been measured by observers. Observer- and fisher-reported trawl catch was predominately reported from northwest Chatham Rise, with some observer-reported catches also recorded off northeast Chatham Rise, Hokitika Trench, and Puysegur (Figure 57, Figure 58). Observer-reported bottom longline catch was mostly at Puysegur, while fisher-reported bottom longline catch was mostly at Hikurangi Trench, northern Chatham Rise, Puysegur, and northwest coast of North Island (Figure 57). There were small amounts of fisher-reported catch in set net fisheries around Kaikoura Canyon (Figure 58).

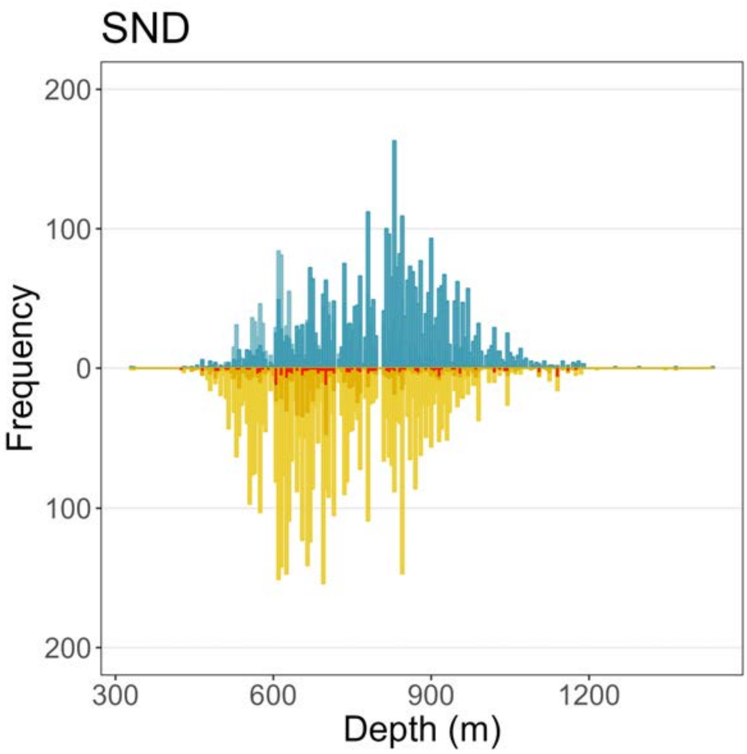


Figure 54: Depth distribution of shovelnose dogfish biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively active females identified in red.

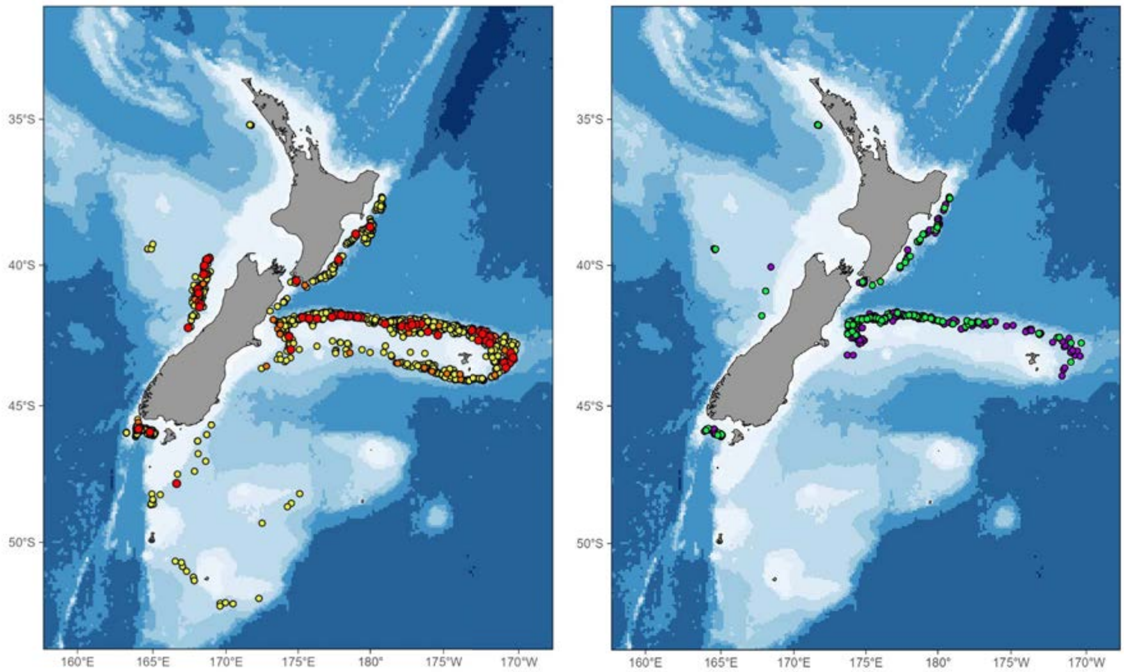


Figure 55: Research trawl survey records for shovelnose dogfish from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow) and (right) estimated young of the year with staging data (green) and length measurements (purple).

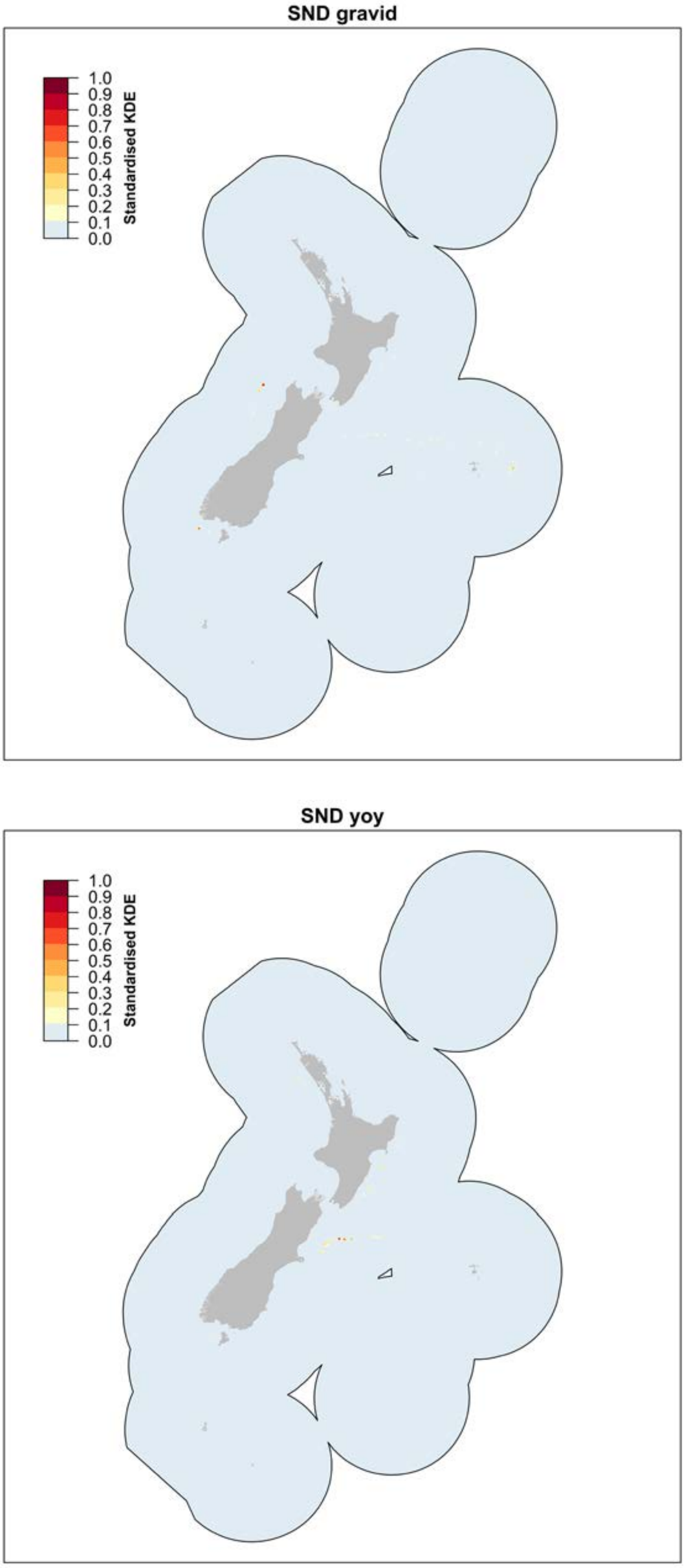


Figure 56: Kernel density estimate (KDE) for research trawl survey records for shovelnose dogfish from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

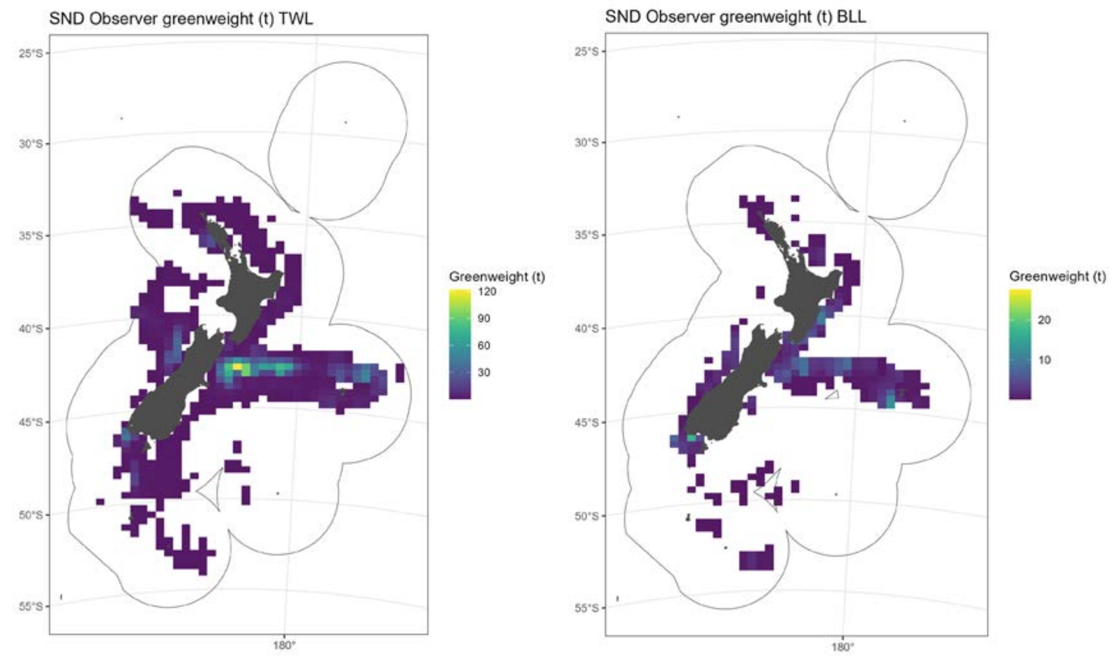


Figure 57: Distribution of shovelnose dogfish catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline.

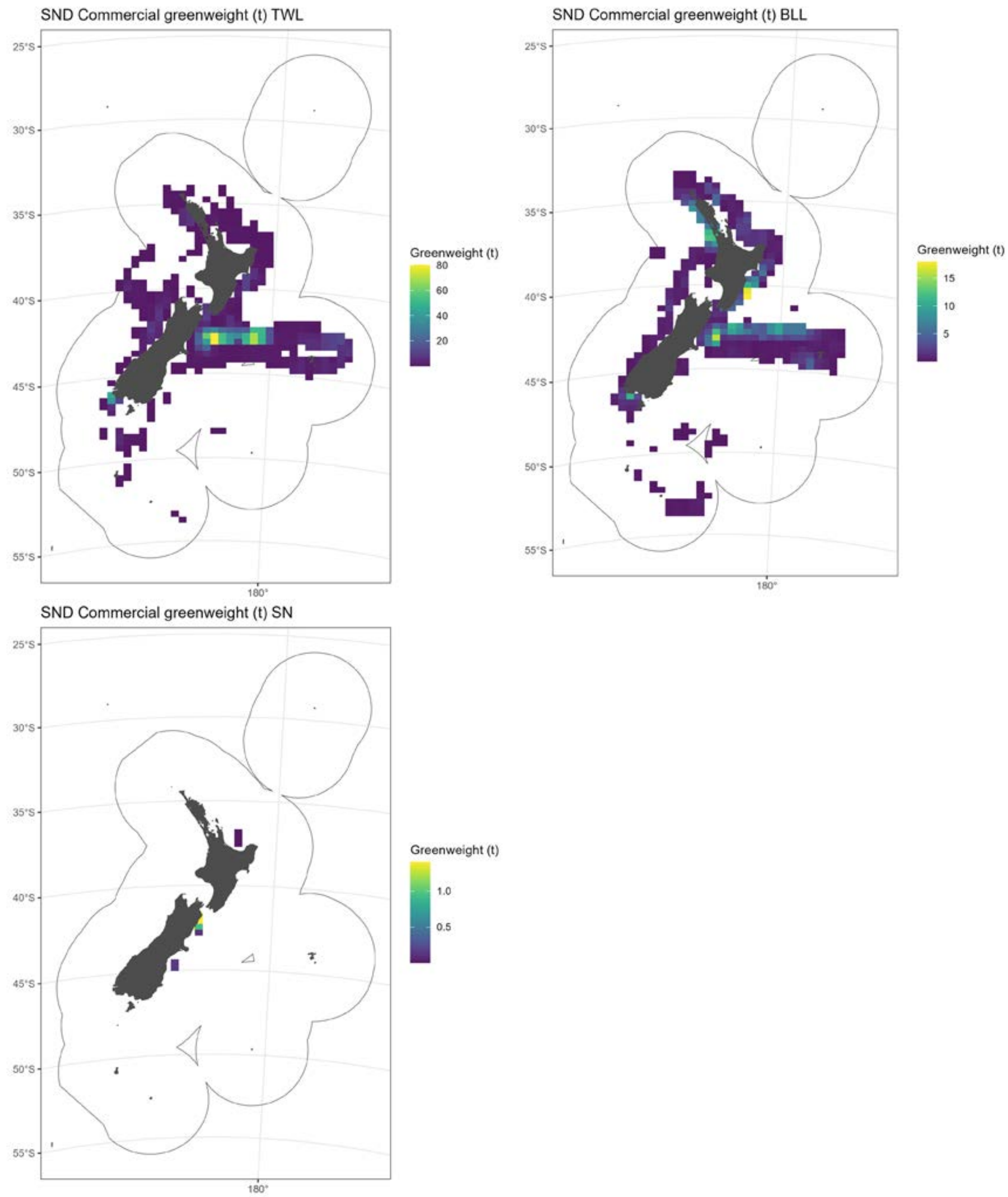


Figure 58: Distribution of shovelnose dogfish catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net.

Longnose velvet dogfish (*Centroselachus crepidater*)

Longnose velvet dogfish has a widespread, yet patchy, global distribution in the east Atlantic and Indo-Pacific Oceans. The species is demersal on the continental slope at depths of 200–2080 m, and mostly at depths >500 m (Ebert et al. 2021). Longnose velvet dogfish is distributed throughout New Zealand waters, from off the North Island to the Campbell Plateau at depths of 270–2080 m, and usually 780–1110 m (Stewart & Last 2015a). Habitat preference is unclear. Deepwater shark distribution appears to be influenced by environmental variables including depth, water temperature, and salinity, and segregation by sex, size, and maturity stage is common (Moura et al. 2014, Rodríguez -Cabello & Sanchez 2014, Daley et al. 2015, O'Hea et al. 2020). Few observations of longnose velvet dogfish have been recorded on video, with individuals occurring over muddy substrate at temperatures of 6.9–7.6°C (Te Papa unpublished data).

Spawning

Gestation, spawning frequency, and pupping grounds are not known. Reproduction is aplacental viviparous with litter sizes of up to nine pups (Ebert et al. 2021). Spawning cycle is asynchronous and non-continuous (Daley et al. 2002), and a resting period of two years or more has been estimated (Irvine et al. 2006b).

Juvenile habitats

Nursery areas are not known. Areas of importance to juveniles have not been identified. Juveniles are commonly caught in trawl surveys all around New Zealand (Francis et al. 2018), with highest densities found on the western end of Chatham Rise (Finucci et al. 2021a).

Adult habitat, migrations and movements

Mating grounds, movement patterns and/or seasonal changes in distribution are not known. Reproductively active females have been reported as uncommon but larger mature females occurred in highest numbers at the eastern end of the Chatham Rise, Puysegur and across the Campbell Plateau (Francis et al. 2018, Finucci et al. 2021a).

Population connectivity

Population structure is not known. Preliminary genetic analyses show Atlantic Ocean-Pacific Ocean differentiation and the possible existence of present-day gene flow barriers between the two ocean basins (Cunha et al. 2012, Keggin 2017). Fine-scale population differences were also reported in the Northeast Atlantic along two spatially similar sampling sites in the Rockall Trough (Hebrides North and South) and the Mid Atlantic Ridge, separated by approximately 2000 km (Keggin 2017).

Research trawl data

Since 2000, reproductively active female longnose velvet dogfish have been recorded in 15/23 years, with 412 records across 27 trips. These females measured 71.3 to 102.9 cm TL (median=88.7 cm TL). Mature females (n=667) were reported from depths of 568–1192 m (median=877 m), reproductively active females were recorded at depths of 464–1211 m, but occurred more often from shallower depths (median=853 m) (Figure 59). Juveniles (n=5098) were found at a similar depth range to reproductively active females (range=414–1442 m, median=864 m) while mature males (n=1198) were found at similar depths to mature females generally (range=330–1267 m, median=844 m) (Figure 59).

Reproductively active females were mostly recorded along the northern and eastern slope of the Chatham Rise, the northern margin of Campbell Plateau, Puysegur, WCSI, and Cook Strait Canyon (Figure 60). Additional female longnose velvet dogfish (n=5500) not assessed for maturity but measuring at least known length-at-maturity (87 cm TL) were also recorded in large numbers in these areas, as well as along the southern slope of Chatham Rise and the southern margin of Campbell Plateau (Figure 60). Reproductively active females were recorded mostly in November (n=32), December (n=67), and January (n=303), with a few additional records in July–August (n=10).

Estimated YOY (<40 cm TL) were recorded in 15/23 years. This includes 673 biologically measured (depth range=437 to 1200 m, median=814 m) and 2466 length-measured (depth range=437 to 1200 m, median=813 m) individuals. Most biological records occurred from November (n=48), December (n=67), and January (n=474). Records occurred along the entirety of the Chatham Rise Slope, the northern and southern margin of Campbell Plateau, Puysegur, WCSI, Cook Strait Canyon and along the Hikurangi Trench (Figure 60).

The kernel density estimates for longnose velvet dogfish showed YOY and juveniles were mostly recorded along northwest Chatham Rise and Puysegur (Figure 61, Appendix 2). Reproductively active females were mostly recorded at east Chatham Rise and Puysegur (Figure 61).

Observer and commercial data
Only four longnose velvet dogfish have been measured by observers. Observer- and fisher-reported trawl catch was recorded mostly at northwest Chatham Rise, and observer-reported trawl catch was also recorded northeast Chatham Rise (Figure 62, Figure 63). Very small amounts of observer-reported bottom longline catch was recorded off Timaru, Puysegur, and WCSI (Figure 62).

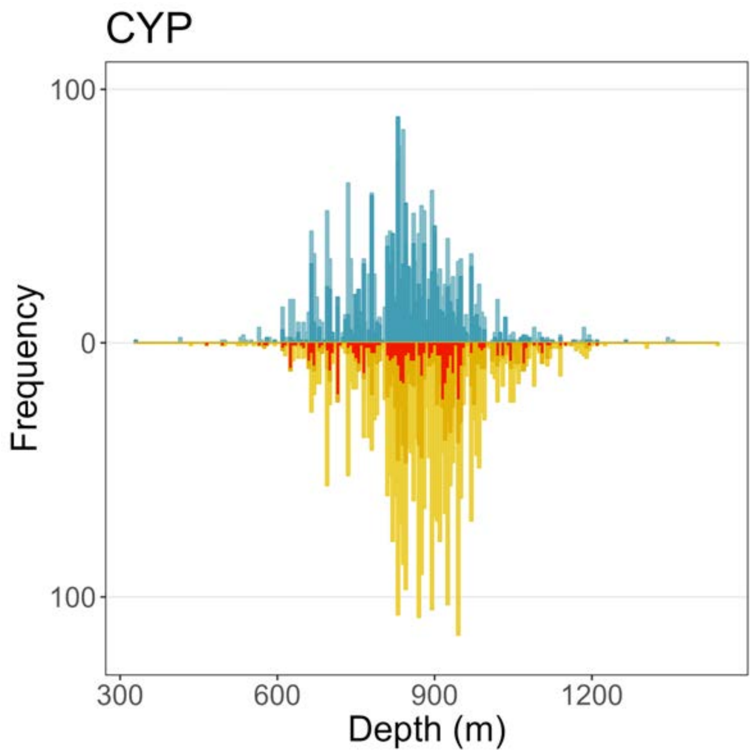


Figure 59: Depth distribution of longnose velvet dogfish biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively active females are identified in red.

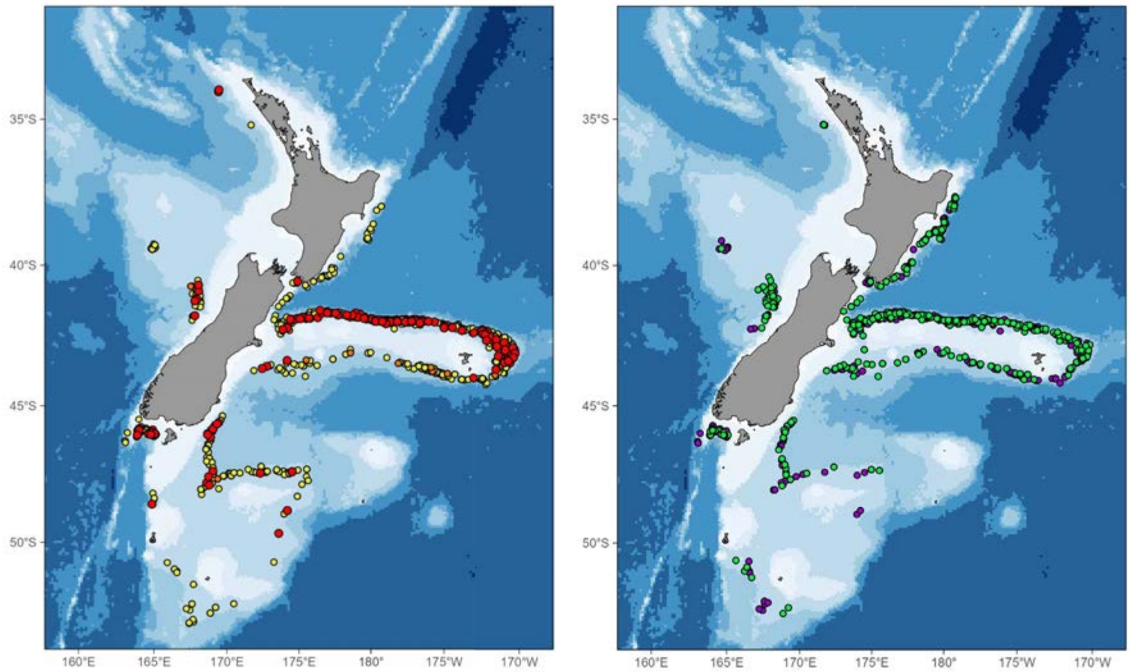
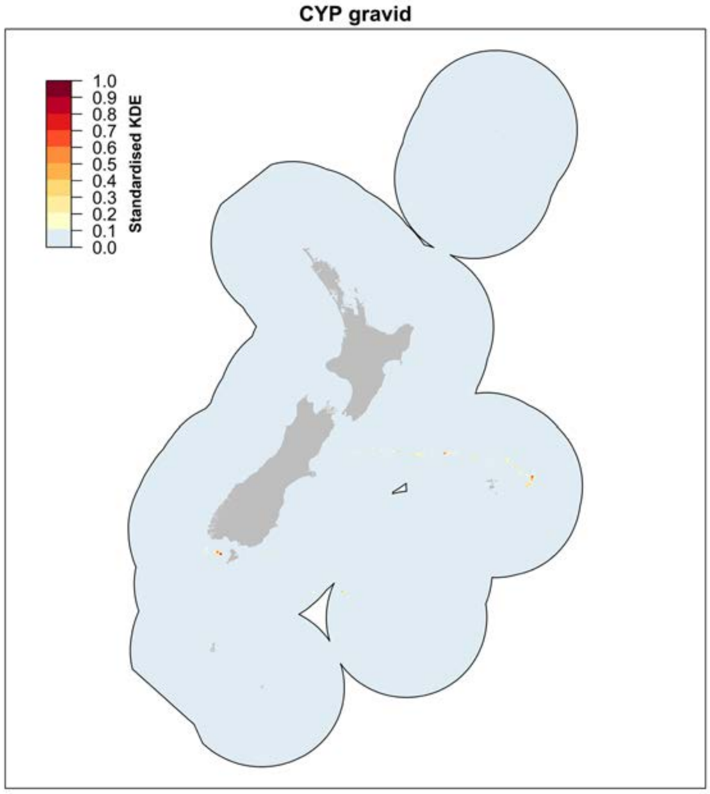


Figure 60: Research trawl survey records for longnose velvet dogfish from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements (purple).



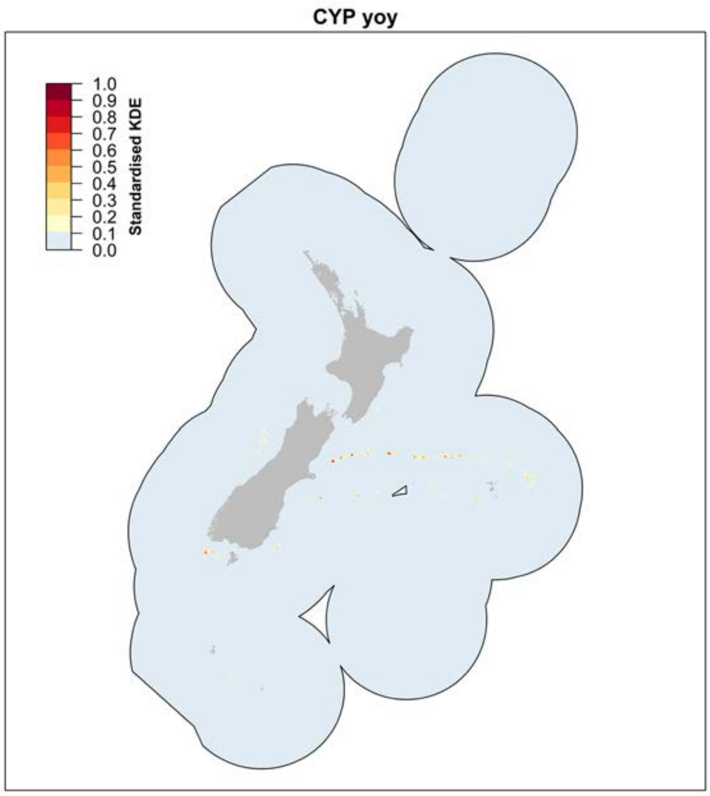


Figure 61: Kernel density estimate (KDE) for research trawl survey records for longnose velvet dogfish from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

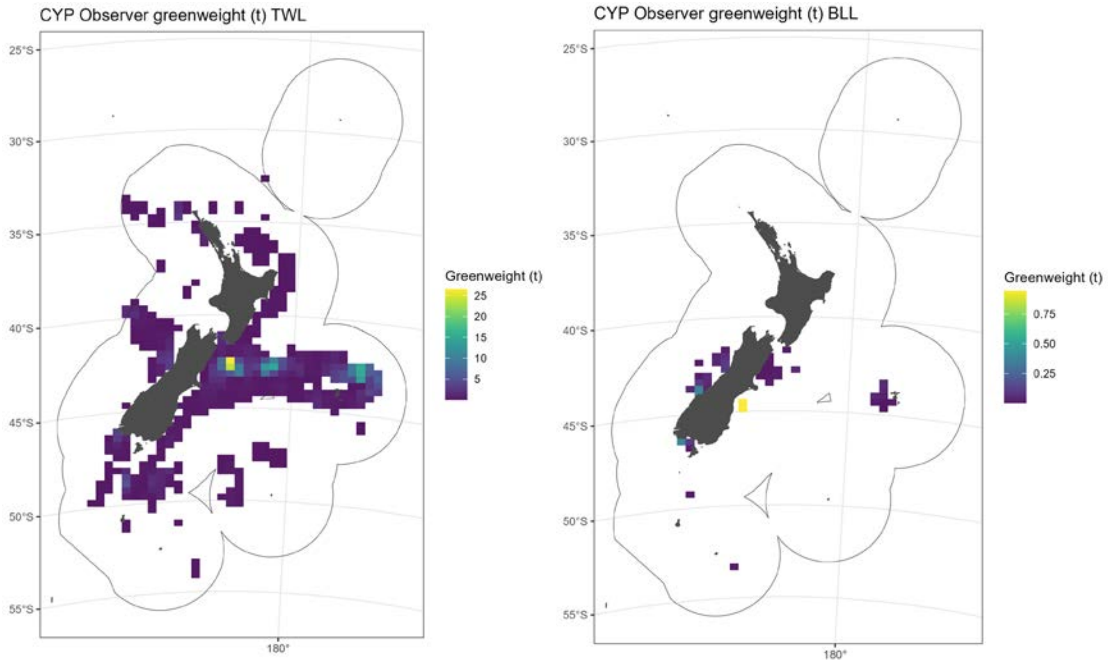


Figure 62: Distribution of longnose velvet dogfish catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline.

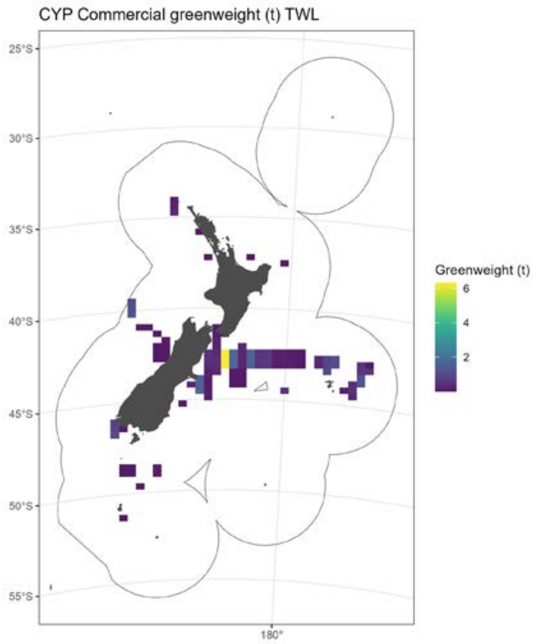


Figure 63: Distribution of longnose velvet dogfish catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl.

Baxter’s dogfish (*Etmopterus granulosus*)

Baxter’s dogfish has a circumpolar distribution in the Southern Hemisphere in the Atlantic and Indo-Pacific Oceans. The species is demersal on upper continental and insular slopes, and seamounts at depths of 220–1500 m, but is more common at depths >600 m (Ebert et al. 2021). Baxter’s dogfish is distributed throughout New Zealand waters, from Northland to the Campbell Plateau at depths of 367–1638 m and is most abundant at 800–1200 m depth (Last & Stewart 2015b). Habitat preference is unclear, but Baxter’s dogfish appears to have high affinity to seamounts (Daley et al. 2002, Tracey et al. 2012, Nehmens 2019). Deepwater shark distribution appears to be influenced by environmental variables including depth, water temperature, and salinity, and segregation by sex, size, and maturity stage is common (Moura et al. 2014, Rodríguez -Cabello & Sanchez 2014, Daley et al. 2015, O’Hea et al. 2020). Baxter’s dogfish have been observed on video over soft (muddy, muddy-sand, and sandy) and hard substrates (coarse sand, rocky bottom without relief), sometimes with epifauna, and at temperatures of 3.0–8.3°C (Te Papa unpublished data).

Spawning

Gestation, spawning season, spawning frequency, and pupping grounds are not known. Reproduction is aplacental viviparous with litter sizes of 6–16 pups, and an average of 10 (Daley et al. 2002). Spawning cycle is suspected to be asynchronous (Wetherbee 1996, Daley et al. 2002). Young of the year have been reported in small numbers on Chatham Rise (Wetherbee 1996).

Juvenile habitats

Nursery areas are not known. Areas of importance to juveniles have not been identified.

Adult habitat, migrations and movements

Mating grounds, movement patterns and/or seasonal changes in distribution are not known. Mature females are common on Chatham Rise, but gravid females are infrequently recorded (Wetherbee 1996, Finucci et al. 2021a).

Population connectivity

Population structure is not known. Weak but significant genetic differentiation was reported between Chilean and New Zealand samples of Baxter’s dogfish, suggesting that gene flow may be limited across the South Pacific (Straube et al. 2011). Subsequent studies suggest there is some mixing of stocks across the Southern Hemisphere (Straube et al. 2015).

Research trawl data

Since 2000, reproductively active female Baxter’s dogfish have been recorded in 13/23 years (every year from 2009 onwards except for 2017 and 2023), with 558 records across 26 trips. These females measured 55.3 to 81.7 cm TL (median=70.4 cm TL). Mature females (n=634) were reported from depths of 468–1386 m (median=913 m) and reproductively active females were recorded from similar depths of 444–1358 m (median=815 m) (Figure 64). Juveniles (n=4200) and mature males (n=1766) were also found across similar depth ranges, but mature males were more often reported from a shallower depth (range=359–1504 m, median=872 m; range=427–1386 m, median=788 m, respectively) (Figure 64).

Reproductively active females were recorded throughout the slope of Chatham Rise, south to the Campbell Plateau (most records on the southern Snares Shelf), with some additional records off Puysegur, WCSI, Cook Strait Canyon, and along the Hikurangi Trench (Figure 65). Additional female Baxter’s dogfish (n=8593) not assessed for maturity but measuring at least known length-at-maturity (64 cm TL) were also recorded from these areas. Reproductively active females were recorded throughout most of the year, with most records from November (n=67), December (n=148), and January (n=288). The presence of reproductively active females throughout most of the year may suggest reproduction occurs year-round.

Estimated YOY (<25 cm TL) were recorded in 12 years (in years 2009 onwards) from 21 trips. There were 101 biologically measured (depth range=524 to 1386 m, median=748 m) and 496 length-measured (depth range=378 to 1386 m, median=728 m) individuals. Most biological records occurred in December (n=12) and January (n=64), with fewer records at other times of the year. Records were largely confined to northwest and southwest Chatham Rise, with some additional records from southeast Chatham Rise and scattered along the Snares Shelf, Puysegur, WCSI, and Hikurangi Trench (Figure 65).

The kernel density estimates for Baxter's dogfish showed most reproductively active females occurring along Snares Shelf, and juveniles, and YOY records from Snares Shelf and along southern Chatham Rise (Figure 66, Appendix 2).

Observer and commercial data

Only one Baxter's dogfish has been measured by observers since 2000. Observed catch in trawl fisheries was reported mid-Campbell Plateau and along southern Chatham Rise (Figure 67). In bottom longline fisheries, some observed catch was reported at Bounty Plateau as well (Figure 67). Fisher-reported catch followed a similar pattern to observer-reported catch (Figure 68).

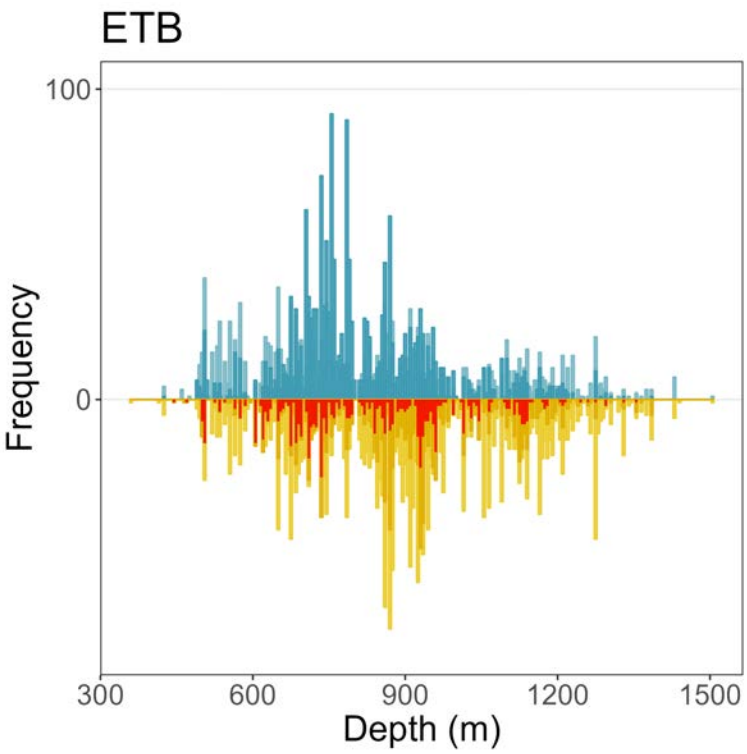
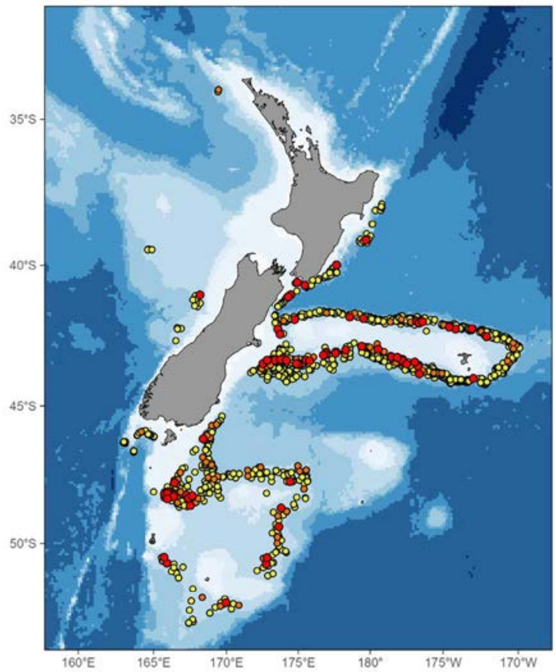


Figure 64: Depth distribution of Baxter's dogfish biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively active females identified are in red.



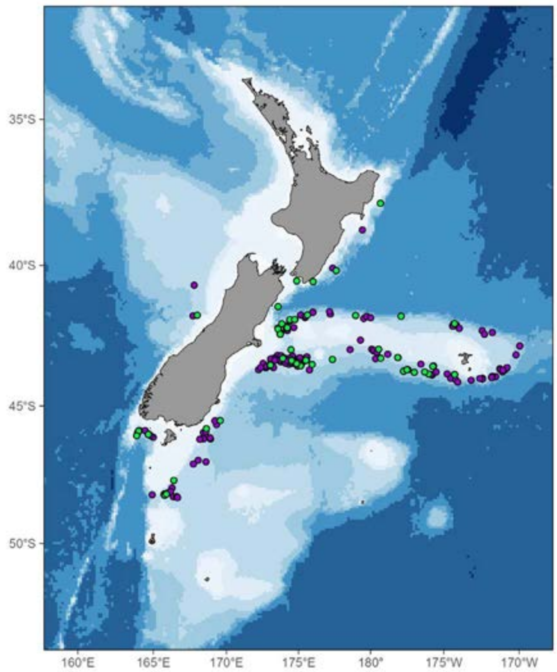
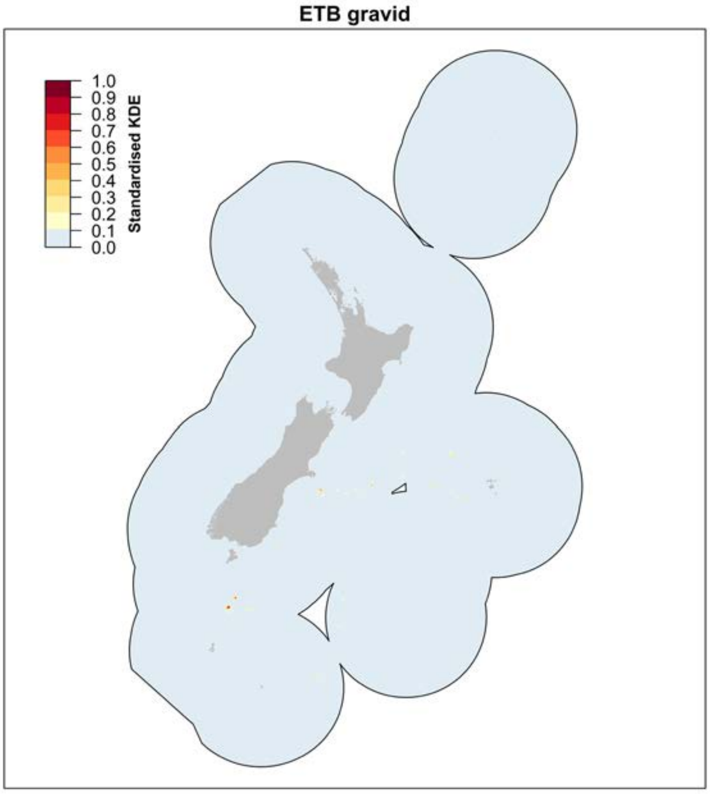


Figure 65: Research trawl survey records for Baxter's dogfish from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements (purple).



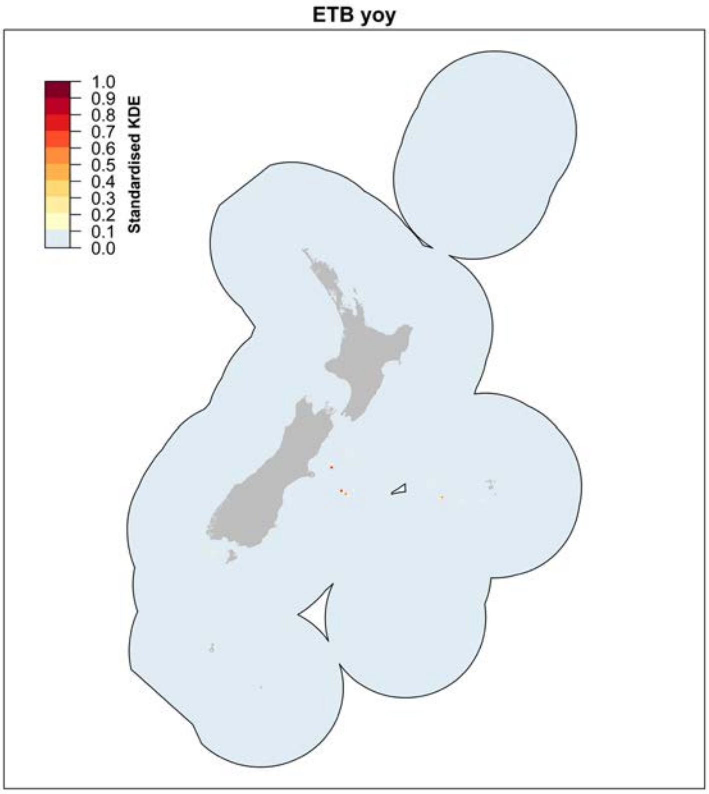


Figure 66: Kernel density estimate (KDE) for research trawl survey records for Baxter's dogfish from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

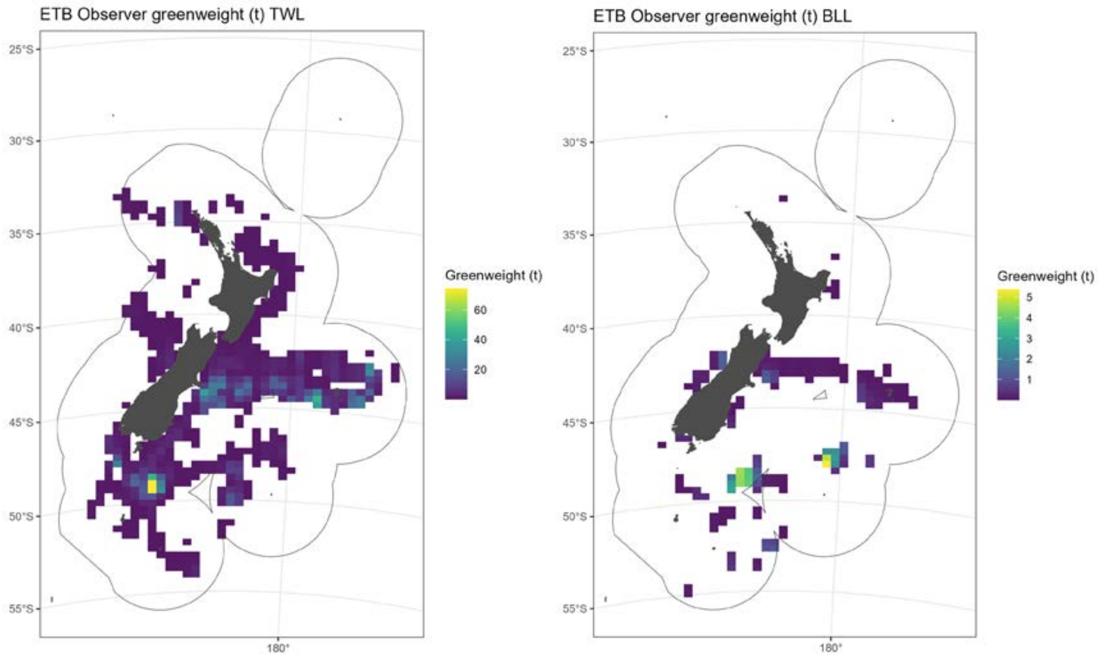


Figure 67: Distribution of Baxter's dogfish catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline.

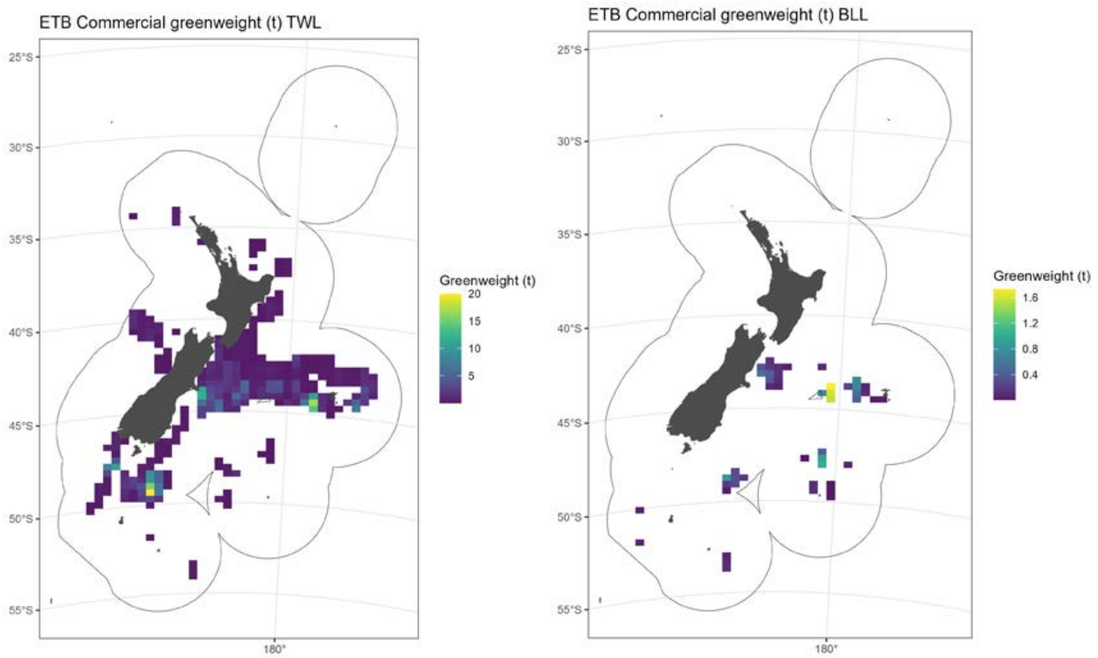


Figure 68: Distribution of Baxter's dogfish catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline.

Plunket's shark (*Scymnodon macracanthus*)

Plunket's shark has a widespread yet patchy distribution in the Southern Hemisphere, from Chile to southern Australia and New Zealand, and parts of the western Indian Ocean (Stewart & Last 2015a). The species is demersal and distributed throughout New Zealand waters, from the Lord Howe Rise to the northern Campbell Plateau at depths of 180–1550 m, and usually below 600 m (Stewart & Last 2015a). Habitat preference is unclear. Deepwater shark distribution appears to be influenced by environmental variables including depth, water temperature, and salinity, and segregation by sex, size, and maturity stage is common (Moura et al. 2014, Rodríguez -Cabello & Sanchez 2014, Daley et al. 2015, O'Hea et al. 2020). Plunket's shark have been observed on video over soft (muddy and sandy) and hard substrates, often with epifauna, and at temperatures of 3.2–9.0°C (Te Papa unpublished data).

Spawning
Gestation, spawning season, spawning frequency, and pupping grounds are not known. Reproduction is aplacental viviparous with litter sizes of up to 36 pups (Garrick 1959a). Spawning cycle is suspected to be asynchronous and non-continuous with a long resting phase (Daley et al. 2002, Irvine 2004).

Juvenile habitats
Nursery areas are not known. Areas of importance to juveniles have not been identified. Relatively higher numbers of juveniles have been reported at Puysegur (Francis et al. 2018).

Adult habitat, migrations and movements
Mating grounds, movement patterns, and/or seasonal changes in distribution are not known. Historical catches from New Zealand and Australia suggest the species aggregates in certain locations at certain times of year (Garrick 1959a, Daley et al. 2002). Plunket's shark was previously caught off Cook Strait, Kaikoura, and Banks Peninsula, sometimes in large numbers. For example, catches from a line-fisher operating off Kaikoura for a month reported sufficient specimens to yield 3300 1bs of liver, equating to 300–400 sharks (Garrick 1959a).

Population connectivity
Population structure is not known.

Research trawl data
Since 2000, reproductively active female Plunket's shark have been recorded in four research trawl surveys (2009, 2011, 2013, 2018), with just six records. These females measured 89 to 150 cm TL (median=144 cm TL). The 89 cm TL shark (4.9 kg) is questionable, given that this individual was much smaller than estimated length-at-maturity (130 cm TL), and weighed considerably less (e.g., a female measuring 150 cm TL weighed 23.4 kg). It is possible this shark was misidentified or improperly staged or weighed. However, given that this shark was identified as gravid (stage 4), it has been retained at this time. Mature females (n=3) were reported from depths of 726–931 m (median=570 m) and reproductively active females were recorded from shallower depths of 377–578 m (median=440 m) (Figure 69). Juveniles (n=231) and mature males (n=45) were found at similar depth ranges (range=464–1105 m, median=736 m; range=301–921 m, median=633 m, respectively) (Figure 69).

Reproductively active females were recorded on Chatham Rise (n=2), southern Snares Shelf (n=3), and Challenger Plateau (n=1) (Figure 70). Additional female Plunket's shark (n=22) not assessed for maturity but measuring at least known length-at-maturity (130 cm TL) were recorded in scattered locations along Chatham Rise, Campbell Plateau, off WCSI, and the Hikurangi Trench (Figure 70).

Estimated YOY (<50 cm TL) were recorded in five years (2009, 2010–2012, 2024) from five trips. There were 36 biologically measured (depth range=571 to 1059 m, median=950 m) and 65 length-measured (depth range=445 to 1059 m, median=919 m) individuals. Most biological records occurred in December (n=32), with a few records in January (n=4). Records were largely confined to Puysegur, with some scattered records along the northern and eastern Chatham Rise) (Figure 70).

The kernel density estimates for Plunket's shark showed most reproductively active females were recorded along the Snares Shelf, while YOY and juveniles were recorded mostly at Puysegur (Figure 71, Appendix 2). Reproductively active females were recorded in January (n=2), July (n=1), and December (n=3).

Observer and commercial data
No Plunket's shark have been measured by observers since 2000. Observed catch was reported in trawl fisheries in the Hokitika Trench and Snares Shelf (Figure 72). Some observer-reported catch in bottom longline fisheries has also been recorded (Figure 72). Fisher-reported trawl catch was mostly along Snares Shelf and bottom longline catch was mostly on western Chatham Rise (Kaikoura Canyon) (Figure 73).

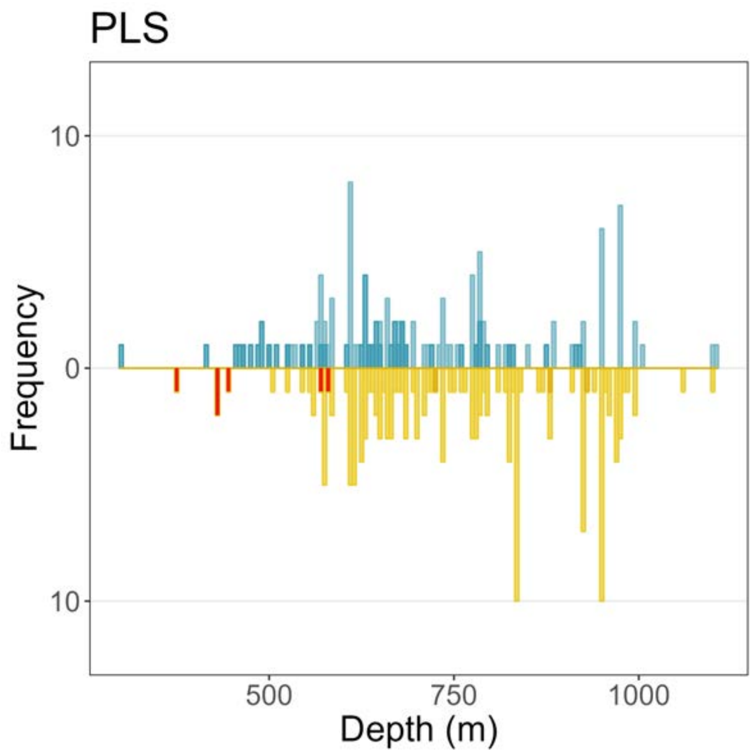


Figure 69: Depth distribution of Plunket's shark biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively active females are identified in red.

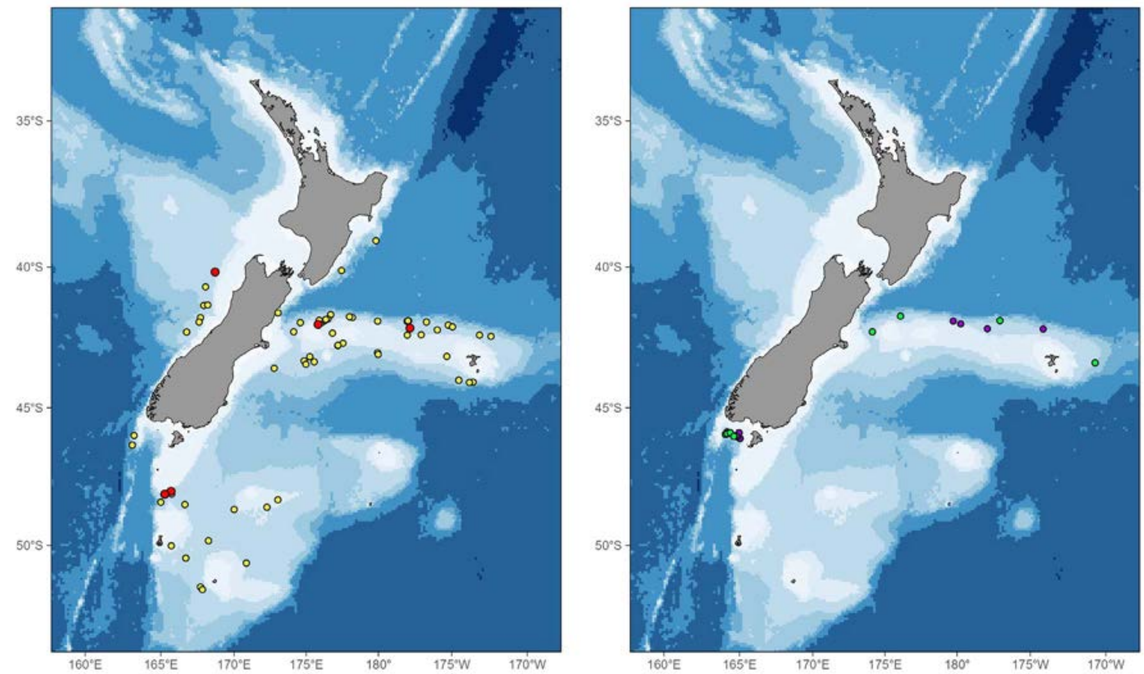
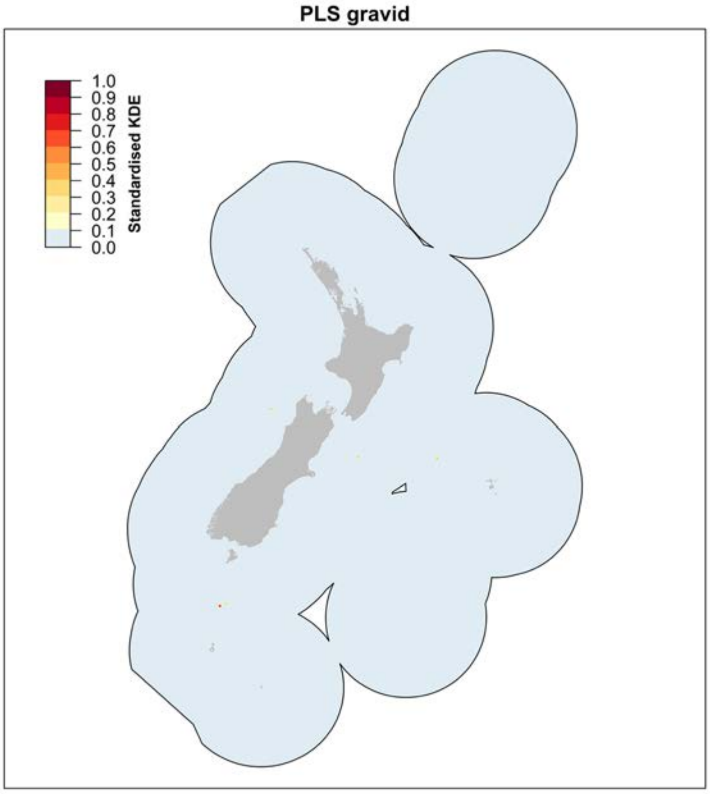


Figure 70: Research trawl survey records for Plunket's shark from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements (purple).



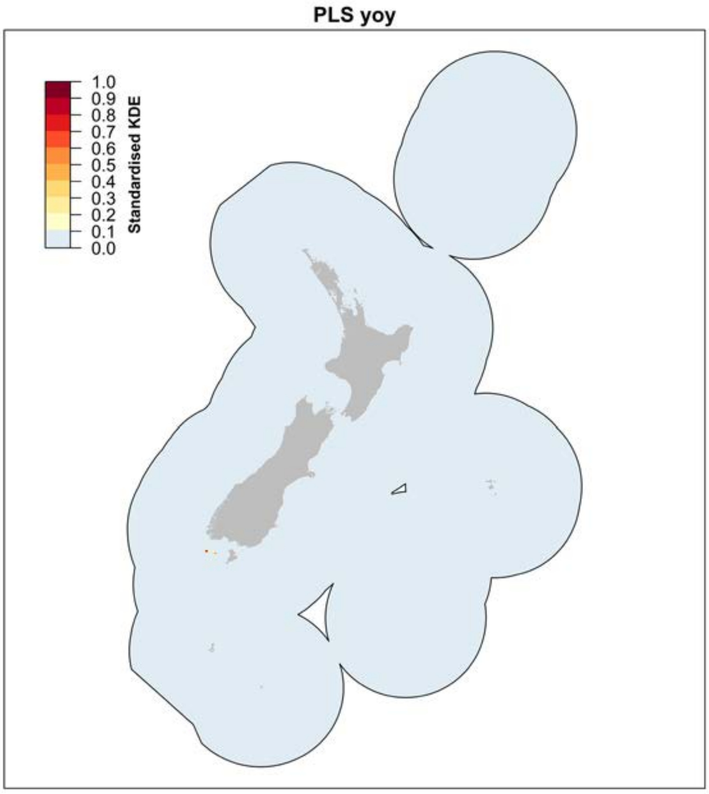


Figure 71: Kernel density estimate (KDE) for research trawl survey records for Plunket's shark from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

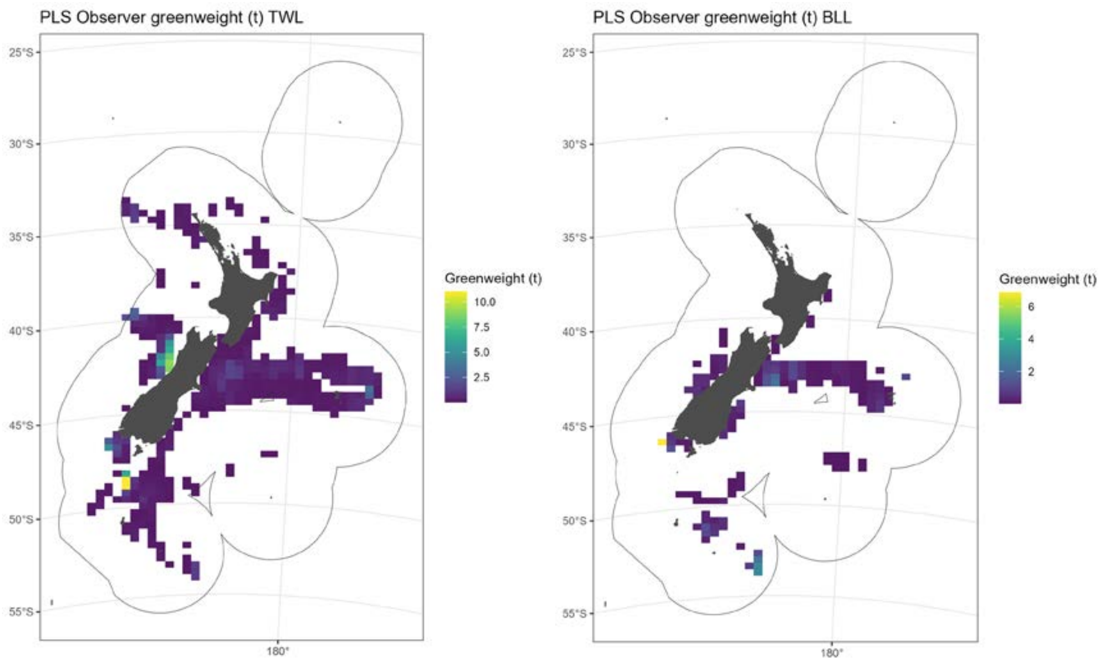


Figure 72: Distribution of Plunket's shark catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline.

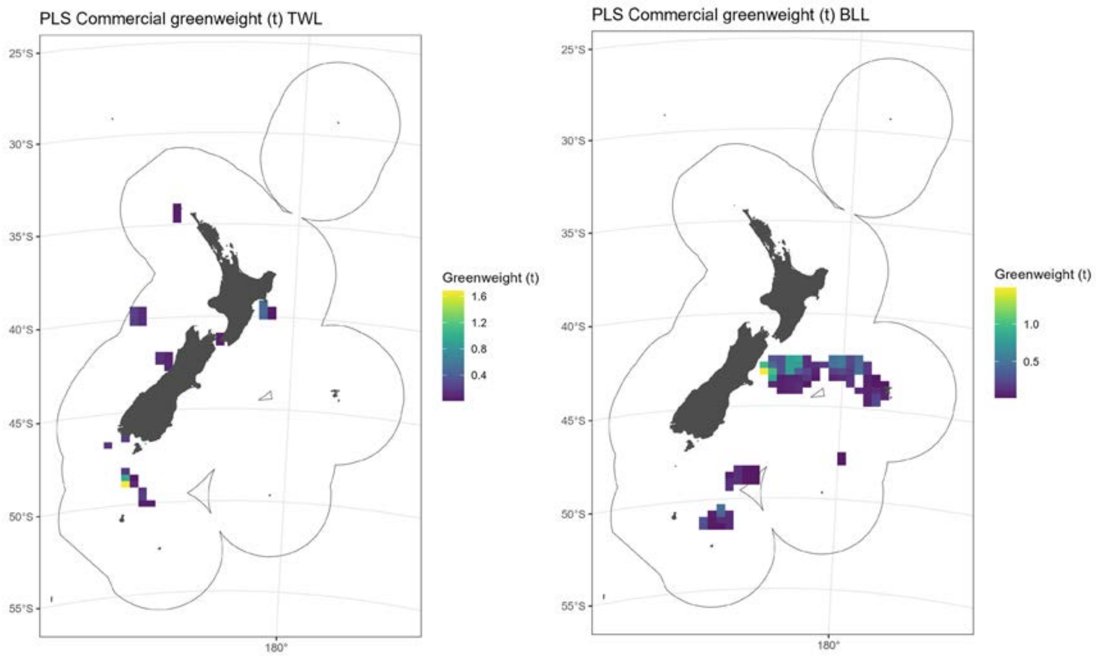


Figure 73: Distribution of Plunket's shark catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline.

Seal shark (*Dalatias licha*)

Seal shark has a widespread yet patchy distribution in the Atlantic and Indo-West Central Pacific Oceans. The species is demersal and mesopelagic on continental and insular shelves and slopes at depths from 37–1800 m, and mostly at depths >200 m (Ebert et al. 2021). Seal shark is distributed throughout New Zealand waters, from off North Cape to the Puysegur region at depths of 50–1000 m, and mostly below 300 m on the continental slope (Stewart & Last 2015b). Habitat preference is unclear. Deepwater shark distribution appears to be influenced by environmental variables including depth, water temperature, and salinity, and segregation by sex, size, and maturity stage is common (Moura et al. 2014, Rodríguez -Cabello & Sanchez 2014, Daley et al. 2015, O'Hea et al. 2020). Seal sharks have been observed on video generally over soft (muddy and sandy) substrates, with or without features, and at temperatures of 6.2–8.1°C (Te Papa unpublished data).

Spawning

Gestation, spawning season, spawning frequency, and pupping grounds are not known. Reproduction is aplacental viviparous with litter sizes of 3–16 pups (average 6–8) (Ebert et al. 2021). There is some evidence to suggest seasonality in the reproductive cycle (Francis et al. 2018), and that breeding is non-continuous (Daley et al. 2002).

Juvenile habitats

Nursery areas are not known. Areas of importance to juveniles have not been identified. Most historical survey records are of juvenile and immature specimens (Francis et al. 2018).

Adult habitat, migrations and movements

Mating grounds, movement patterns, and/or seasonal changes in distribution are not known. There are anecdotal reports of historic high catch rates of at least some mature specimens from Cook Strait and the Kaikoura Canyon (Garrick 1960a), but very few records were reported previously from trawl surveys (Francis et al. 2018). Off the Azores, preliminary results from fine-scale acoustic telemetry suggest that seal shark are highly resident and reside on island slopes and surrounding seamounts (L. Fauconnet, Instituto do Mar, pers. comm.). Large mature individuals tend to be recorded from longline gear types (Henderson et al. 2003, Fauconnet et al. 2019, Finucci et al. 2021a, Finucci 2022), suggesting that trawl surveys may not be appropriate to monitor large individuals of this species.

Population connectivity

Population structure is not known.

Research trawl data

Since 2000, reproductively active female seal shark have been recorded in 5/23 years (2010, 2011, 2013, 2022, 2024), with eight records across six trips. These females measured 129 to 151.2 cm TL (median=137.9 cm TL). Mature females (n=19) were reported from depths of 553–1006 m (median=713 m) and reproductively active females were recorded from similar depths of 497–961 m (median=777 m) (Figure 74). Juveniles (n=736) and mature males (n=25) were generally recorded from shallower (range=270–1180 m, median=624 m) and deeper (range=292–1055 m, median=852 m) depths, respectively (Figure 74).

Reproductively active females were recorded along northern Chatham Rise (n=5), Puysegur (n=1), Cook Strait Canyon (n=1), and Hikurangi Trench (n=1) (Figure 75). Additional female seal shark (n=96) not assessed for maturity but measuring at least known length-at-maturity (133 cm TL) were recorded along the northern and eastern slope of Chatham Rise, Puysegur, and a few scattered records occurred on Snares Shelf, WCSI and Challenger Plateau, and Hikurangi Trench (Figure 75). There was also one record off northwest North Island. Reproductively active females were recorded throughout the year, with records in January (n=4), and one record each in March, April, June, and November. Only one gravid (stage 4) female has been recorded in January 2011 on Chatham Rise (42.73°S, 177.82°E) at a depth of 852 m.

Estimated YOY (<50 cm TL) were regularly recorded in 15/23 years. There were 297 biologically measured (depth range=369 to 1067 m, median=566 m) and 611 length-measured (depth range=369 to 1067 m, median=562 m) individuals. Most biological records occurred from November (n=21), December (n=42), and January (n=191), with additional records in March–April (n=3), and July–August (n=40). Records were from northern and eastern Chatham Rise, Puysegur, Snares Shelf, WCSI, and Cook Strait Canyon (Figure 75).

The kernel density estimates for seal shark showed YOY, juveniles, and reproductively active females in discrete locations along northern Chatham Rise, Cook Strait, and Puysegur (Figure 76, Appendix 2). Juveniles were most prevalent at Puysegur (Appendix 2).

Observer and commercial data

Only three seal sharks have been measured by observers since 2000. Observed catch in trawl fisheries was reported in southeast Chatham Rise, Hokitika Trench, Snares Shelf, and Campbell Plateau, while observed bottom longline catch was mostly in Cook Strait (Figure 77). Fisher-reported trawl catch was also reported in southeast Chatham Rise and Campbell Plateau (Figure 78). Fisher-reported bottom longline catch was reported mostly along the west coast of the North Island, from the Manukau Heads northwards (Figure 78). Observer- and fisher-reported set net catch was recorded near Kaikoura (Figure 77, Figure 78).

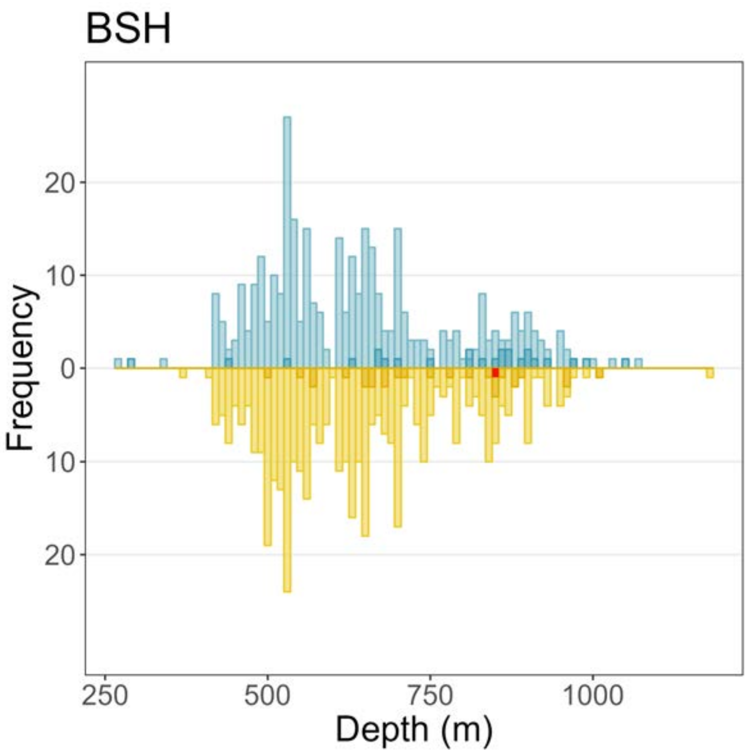


Figure 74: Depth distribution of seal shark biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively active females are identified in red.

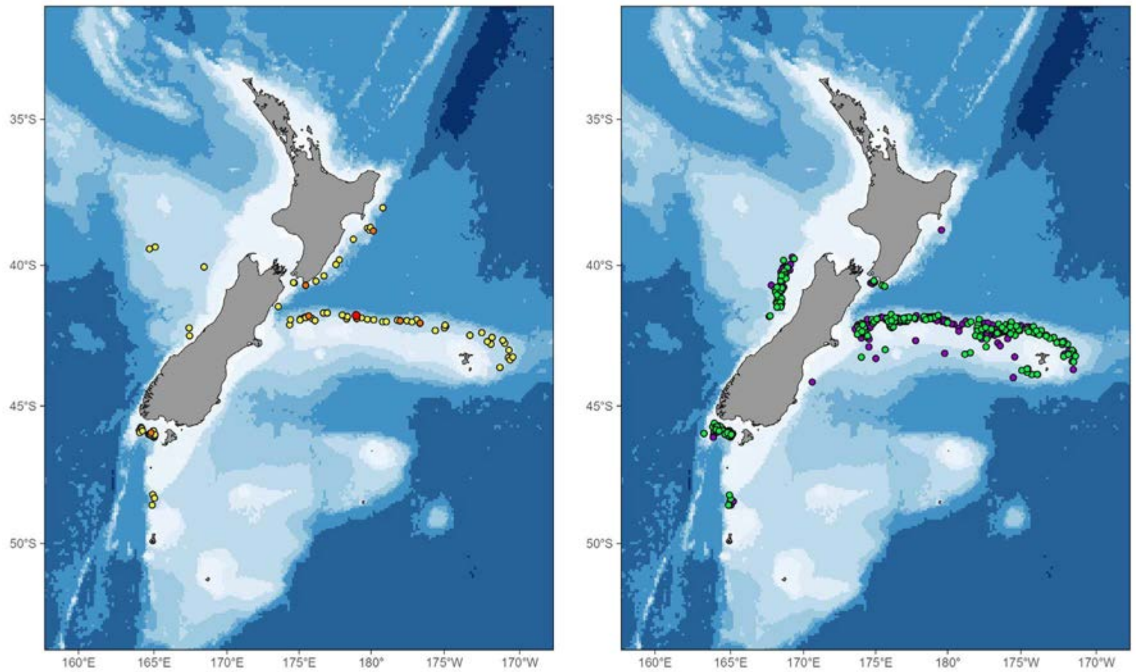
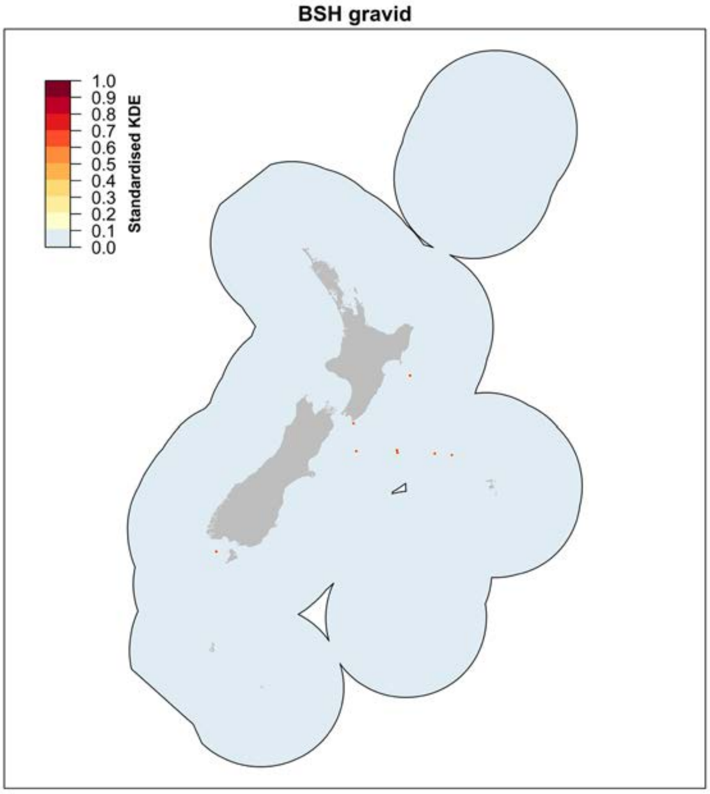


Figure 75: Research trawl survey records for seal shark from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements (purple).



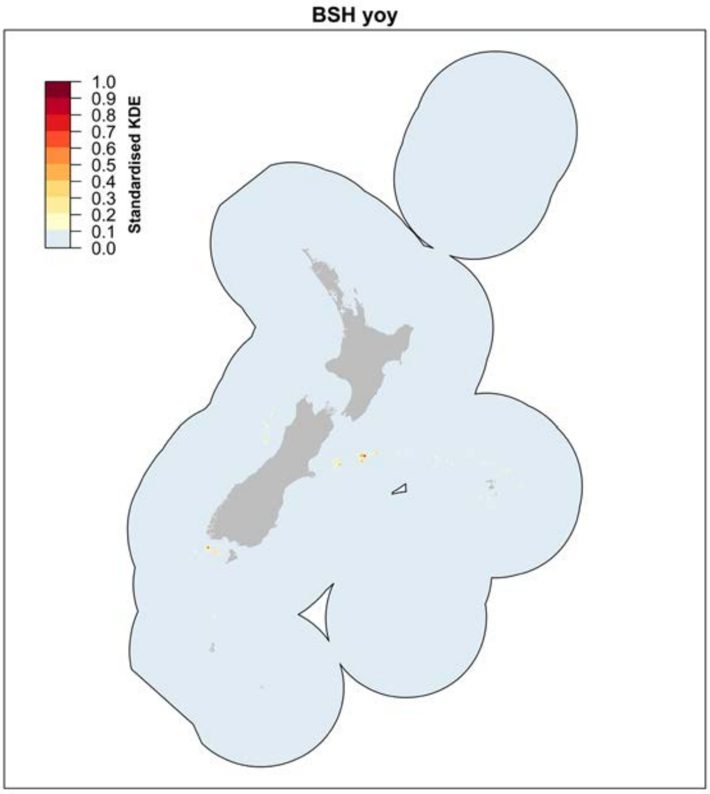


Figure 76: Kernel density estimate (KDE) for research trawl survey records for seal shark from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked

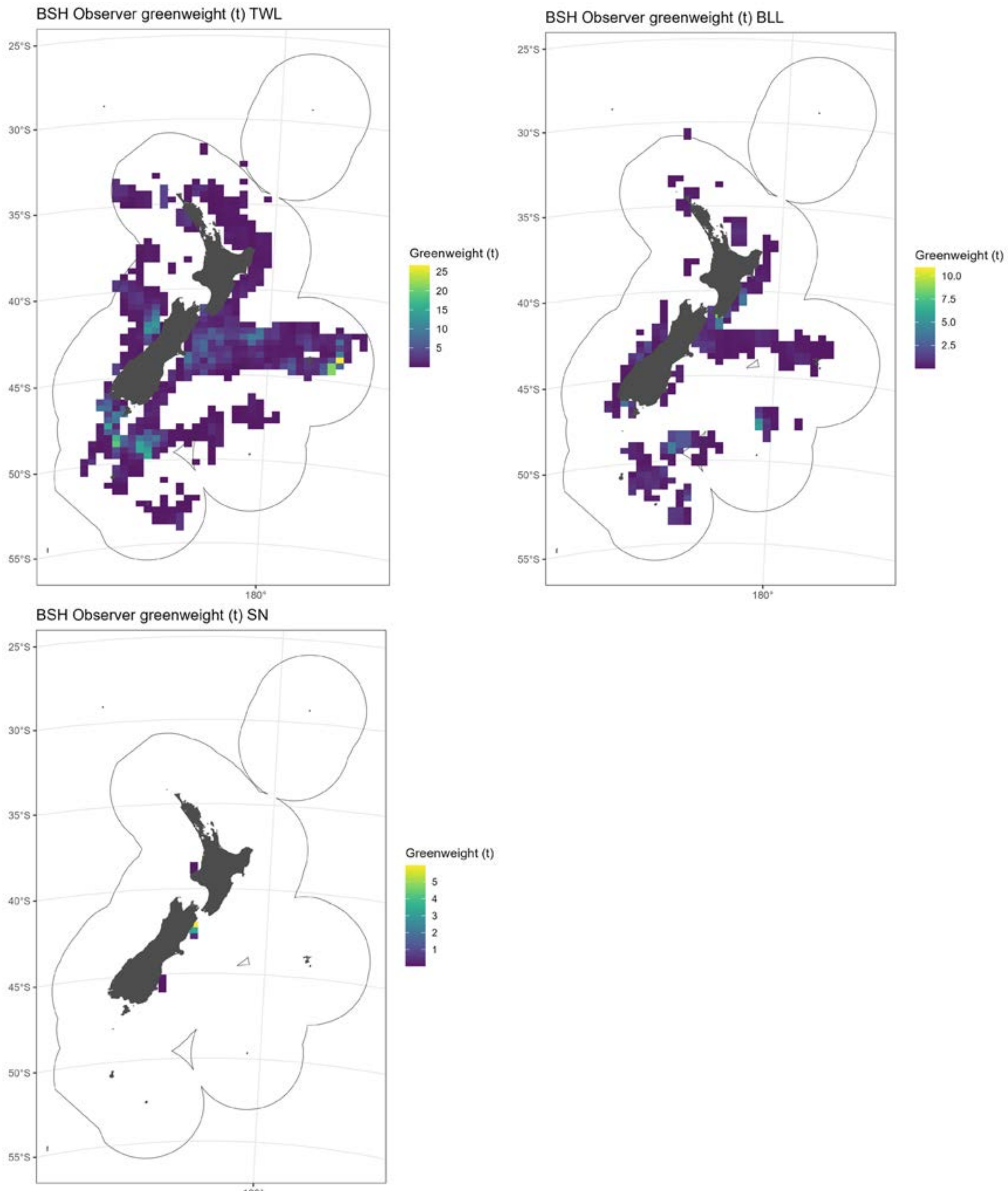


Figure 77: Distribution of seal shark catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net.

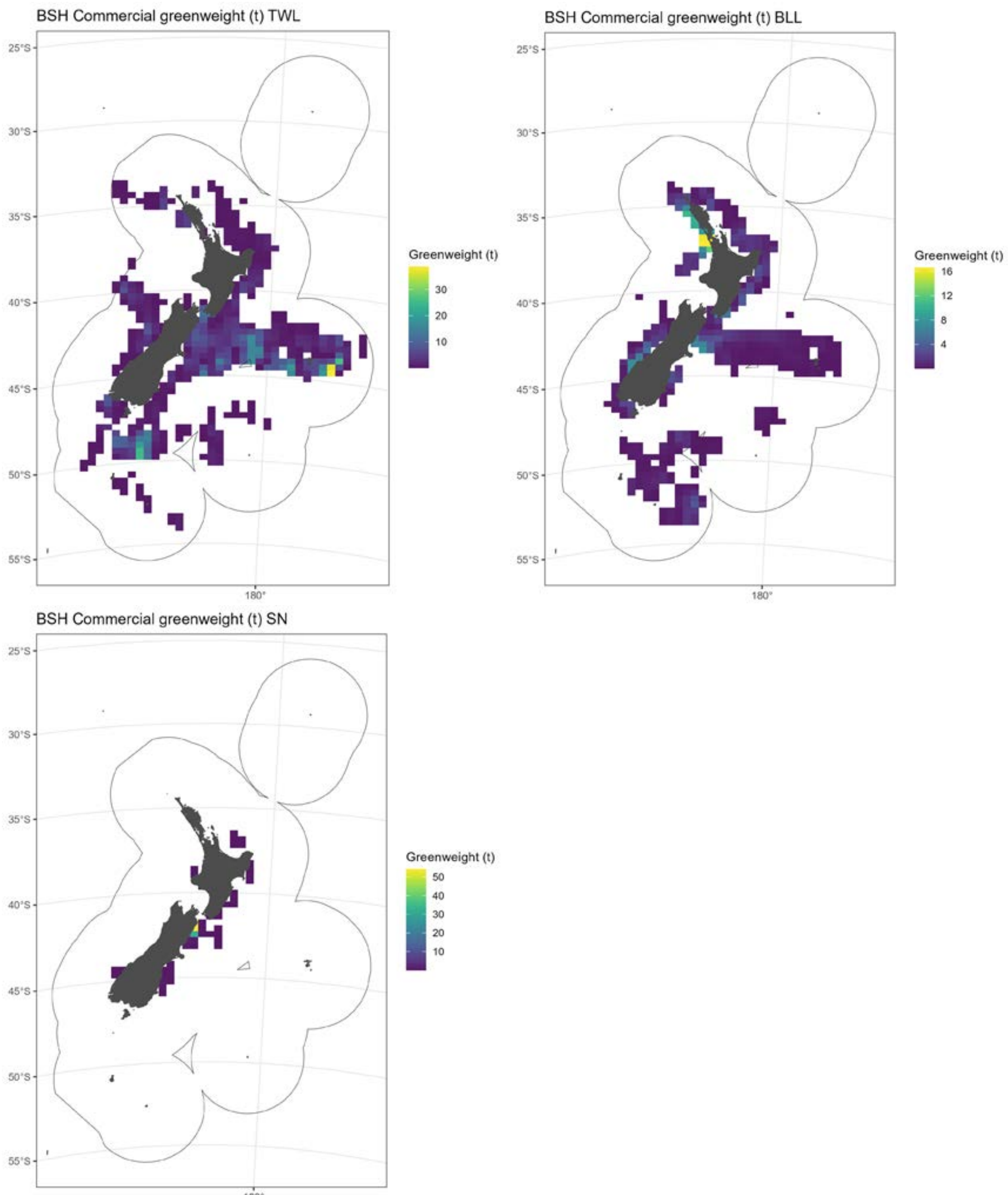


Figure 78: Distribution of seal shark catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net.

Smooth skate (*Dipturus innominatus*)

Smooth skate is endemic to New Zealand waters. The species is demersal along the mid to outer continental shelf throughout New Zealand waters, including West Norfolk Ridge, and from North Cape to the northern Campbell Plateau at depths from the surface to 500 m, and possibly as deep as 1300 m (Last & Stewart 2015a). Habitat preference is unclear. Skates (Rajidae) are mostly found over soft sediment habitats including mud, sand and gravel substrates (Last et al. 2016). Smooth skate are generally found at deeper depths than rough skate. Smooth skates have been observed on video over soft (muddy and sandy) substrates, and at temperatures of 6.5–14.5°C (Te Papa unpublished data).

Spawning

Gestation, spawning season, and spawning frequency are not known, and egg laying areas are not well defined. Reproduction is oviparous, and smooth skates lay two eggs at a time in the sediment, possibly at shallow depths during spring and summer (Francis 1997b). Incubation and hatching may be prolonged and has been estimated for *Dipturus* species to vary from about eight to 16 months (Parent et al. 2008, Concha et al. 2018, Benjamins et al. 2021) and is likely to be dependent on water temperature (Benjamins et al. 2021). Egg cases have been reported from Hawke Bay and Foveaux Strait, and at the Chatham Islands (Francis 1997b). Other oviparous chondrichthyans have been reported to have separate nursery areas – one for egg deposition and embryo development and another for newly emergent juveniles (Hoff 2016). It is possible that smooth skates also engage in this behaviour.

Juvenile habitats

Nursery grounds are not known. Juvenile smooth skate have been recorded in shallow depths around the South Island, Stewart-Snares Shelf, and in areas where adults have not been recorded, including the east and west coasts of the North Island with highest catch rates in the Hauraki Gulf and south of Banks Peninsula (O'Driscoll et al. 2003, Morrison et al. 2014a).

Adult habitats, migrations, and movements

Mating grounds, movement patterns, and/or seasonal changes in distribution are not known. A skate tagging programme was implemented on research trawl surveys but was discontinued due to low tag returns. The data has not been analysed.

Population connectivity

Population structure is not known.

Research trawl data

Since 2000, reproductively active female smooth skate have been recorded in three years (2010, 2018, 2024), with six records across four trips. These females measured 54 to 155 cm pelvic length (PL, median=112 cm PL). There were two records from ECSI that were relatively small (54 and 61 cm PL, May 2018) and unlikely to be mature, however, both individuals were reported to be reproductively active. It is unclear if these skates were misidentified or measured or staged incorrectly. The remaining four records occurred on Chatham Rise (January at 380 m), Hikurangi Trench (May at 675 m) and WCSI (July at 362 and 537 m).

Mature females (n=27) were reported from depths of 24–562 m (median=137 m) and reproductively active females were recorded from deeper depths of 28–675 m (median=371 m) (Figure 79). Juveniles (n=1513) were generally found at an intermediate depth (range=27–1123 m, median=240 m) and mature males (n=242) were found at shallow depths (range=16–853 m, median=128 m) (Figure 79). Additional female smooth skate (n=209) not assessed for maturity but measuring at least known length-at-maturity (112 cm PL) were recorded throughout Chatham Rise, WCSI, and some scattered records on Campbell Plateau (Snares Shelf, Auckland Islands, Campbell Rise) (Figure 80).

Estimated YOY (<30 cm PL) were recorded in 12/23 years (2000, 2001, 2011–2018, 2021, 2022). There were 120 biologically measured (depth range=28 to 390 m, median=114 m) and 295 length-measured (depth range=28 to 693 m, median=111 m) individuals. Most biological records occurred from April (n=30) and May (n=66), with a few records from June (n=7), and January (n=17). Records were confined to ECSI and WCSI, Tasman and Golden Bay, a few records from Northland and two on Chatham Rise (Figure 80).

The kernel density estimates for smooth skate showed YOY and juveniles were mostly recorded along the Canterbury shelf (Figure 81, Appendix 2). Reproductively active females were recorded in multiple locations, including Canterbury shelf, WCSI, Chatham Rise, and Hikurangi Trench (Figure 81).

Observer and commercial data
No smooth skate have been measured by observers since 2000. Observer-reported smooth skate was recorded in trawl fisheries mostly around Hokitika Trench, in bottom longline fisheries on Bounty Plateau, and in set net fisheries in small quantities near Kaikoura, Otago Peninsula, and Foveaux Strait (Figure 82). Fisher-reported smooth skate was similar to the observer-reported catch, with additional trawl catch along the Canterbury coastline and bottom longline catch in the interior of Chatham Rise (Figure 83).

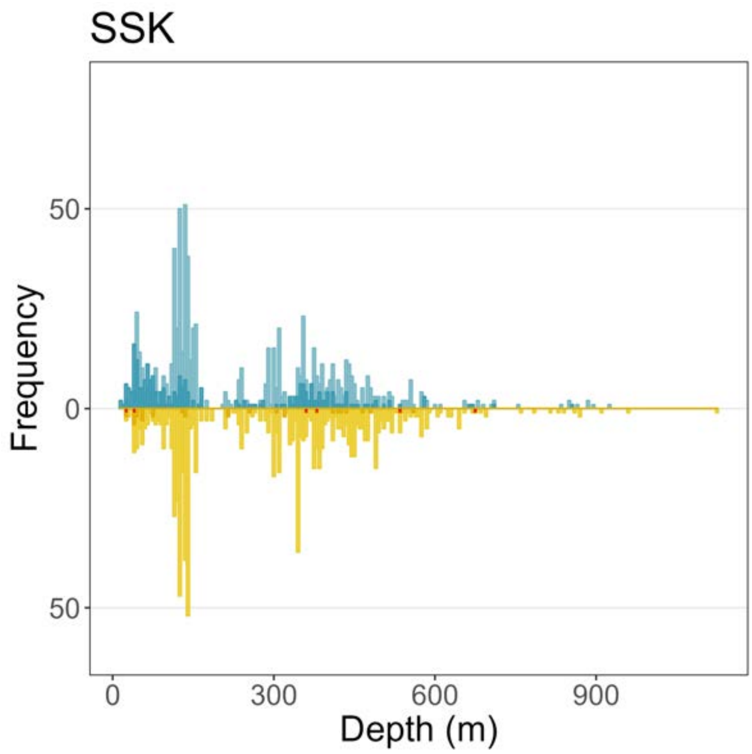


Figure 79: Depth distribution of smooth skate biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively are active females identified in red.

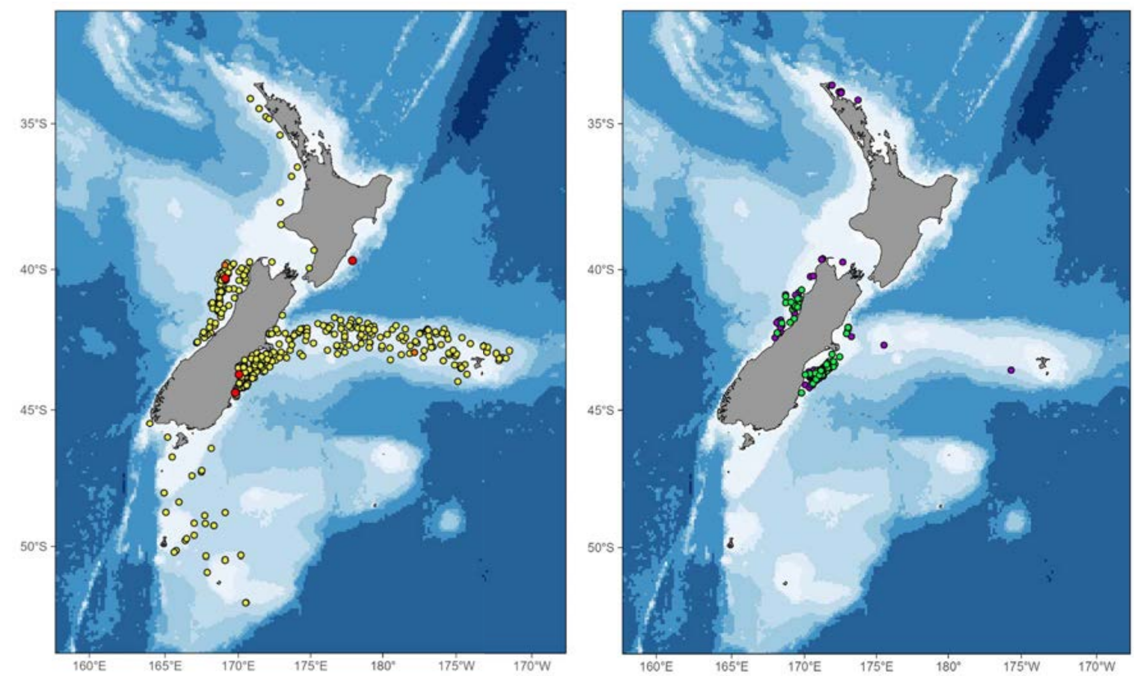
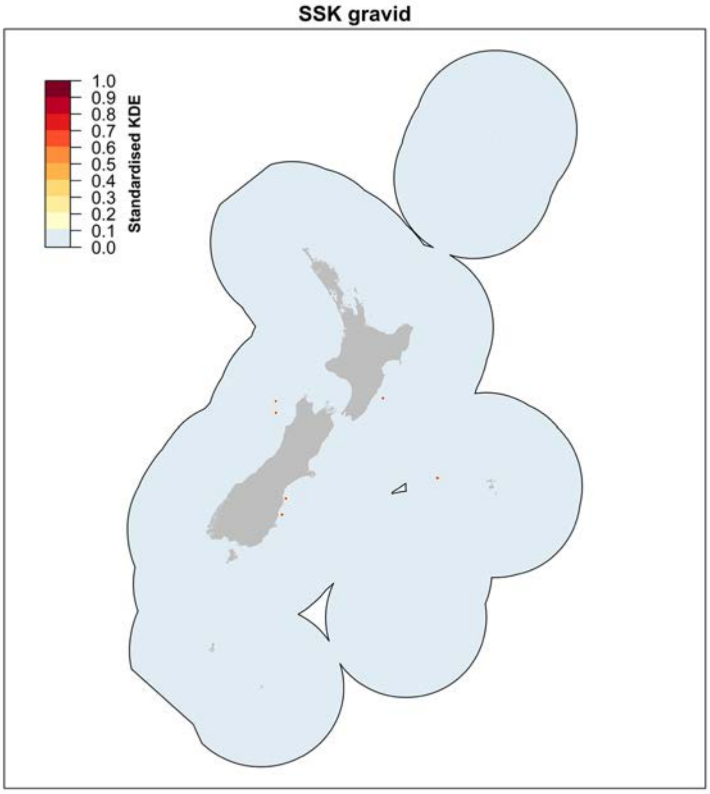


Figure 80: Research trawl survey records for smooth skate from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements (purple).



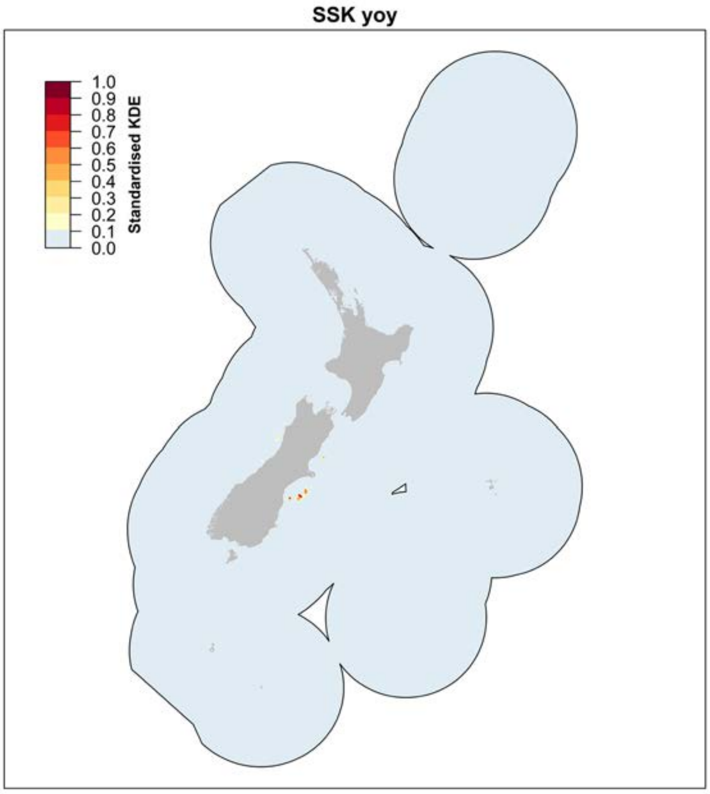


Figure 81: Kernel density estimate (KDE) for research trawl survey records for smooth skate from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

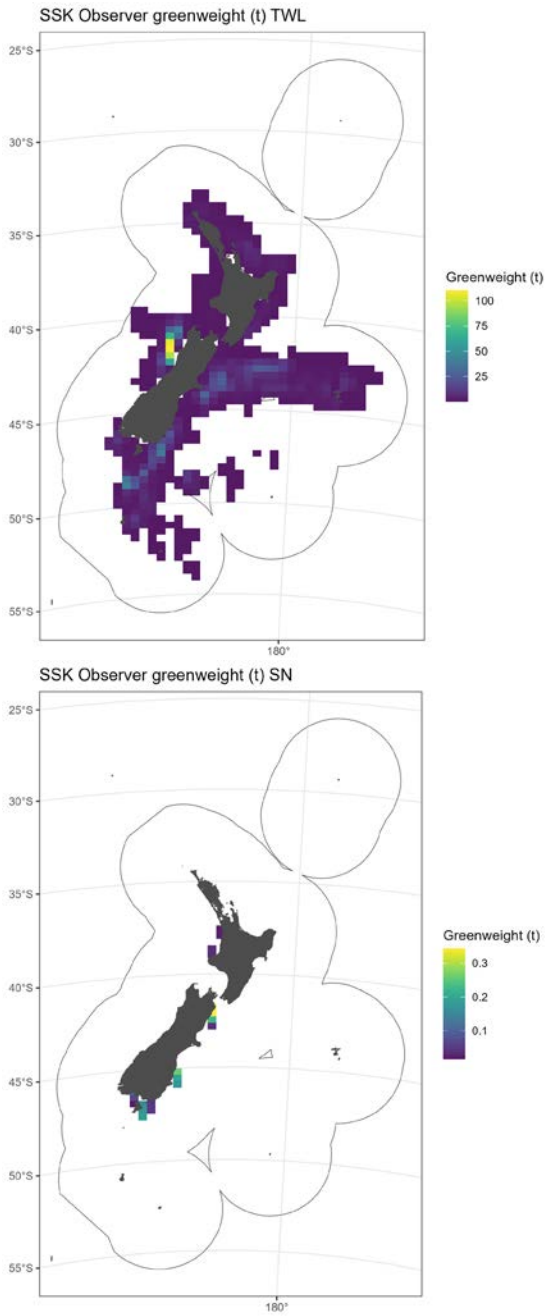


Figure 82: Distribution of smooth skate catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net.

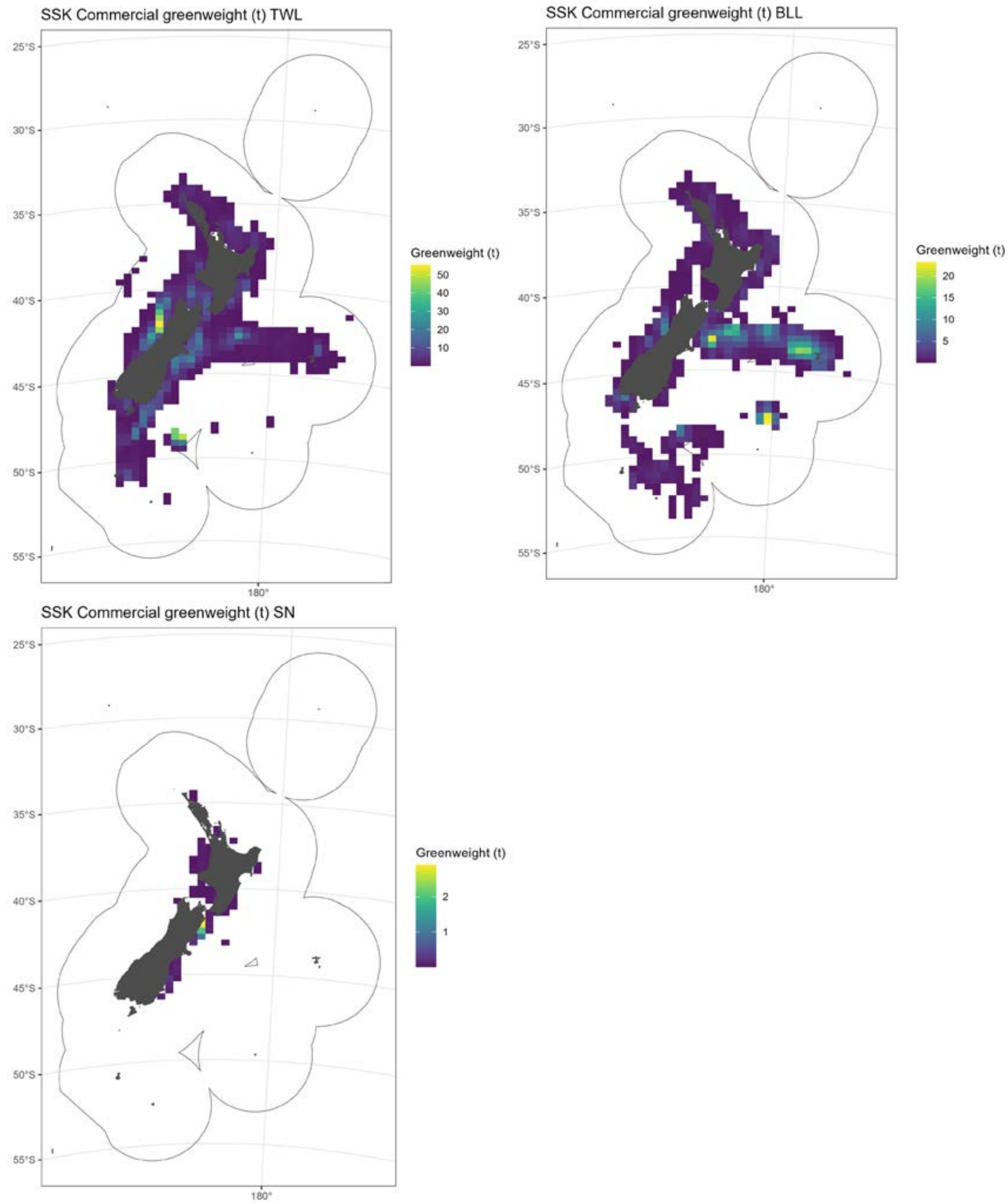


Figure 83: Distribution of smooth skate catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net.

Rough skate (*Zearaja nasuta)*

Rough skate is endemic to New Zealand waters. The genus *Zearaja* is recognized by four regionally endemic species in the Southern Hemisphere (Australia, New Zealand, and South America) (Last et al. 2016). The species is demersal along the mid to outer continental shelf throughout New Zealand waters but is most abundant around the South Island down to depths of 500–600 m, and as deep as 1500 m. They are less common on the Campbell Plateau, around the Sub-Antarctic Islands, and on the Challenger and Chatham Rise (Last & Stewart 2015a). Skates (Rajidae) are most often found over soft sediment habitats including mud, sand and gravel substrates. Rough skates are generally found at shallower depths than smooth skate. Rough skates have been observed on video over soft (muddy and sandy) and hard (coarse sand, shell debris, gravel) substrates, and at temperatures of 8.5–15.1°C (Te Papa unpublished data).

Spawning

Gestation, spawning season, spawning frequency, and egg laying areas are not well defined. Reproduction is oviparous, and rough skates lay two eggs at a time in the sediment, possibly at shallow depths during spring and summer (Graham 1939, Francis 1997b). Incubation and hatching may be prolonged, at least five months or more (Graham 1956, Concha et al. 2018), and is likely to be dependent on water temperature (Benjamins et al. 2021). The highest densities of rough skate in egg-laying condition were reported from south of Banks Peninsula (O'Driscoll et al. 2003). Egg cases have been reported from Blueskin Bay in spring to summer (October–January, Graham 1939), in the Marlborough Sounds (Port Underwood; inner Queen Charlotte Sound, entrance to Ngakuta Bay, Grove Arm), Paterson Inlet and Wellington Harbour, particularly along the Eastbourne coast (Smith et al. 2005, Morrison et al. 2014a, C. A. J. Duffy, pers. obs.). Rough skates in aquarium settings have laid up to 30 egg cases in a six-week period, with hatching taking place after 4 to 4.5 months (Graham 1956). Other oviparous chondrichthyans have been reported to have separate nursery areas – one for egg deposition and embryo development and another for newly emergent juveniles (Hoff 2016). It is possible that rough skates also engage in this behaviour.

Juvenile habitats

Nursery grounds are not known. High numbers of juvenile rough skate have been recorded on ECSI (between Banks Peninsula and Otago), WCNI, and WCSI, and around Wairarapa appears to be an area where particularly high numbers of juvenile rough skate are recorded (O'Driscoll et al. 2003, Morrison et al. 2014a).

Adult habitat, migrations and movements

Mating grounds, movement patterns, and/or seasonal changes in distribution are not known. A skate tagging programme was implemented on research trawl surveys but was discontinued due to low tag returns. The data has not been analysed.

Population connectivity

Population structure is not known.

Research trawl data

Since 2000, reproductively active female rough skate have been frequently recorded in research trawl surveys (9/23 years), with 60 records across 11 trips. These females measured 51.0 to 78.3 cm PL (median=60.8 cm PL). Mature females (n=363) were largely reported from shallower depths (range=13–565 m, median=42 m) and reproductively active females were recorded from depths of 17–565 m (median=39 m), with most (77%) at depths less than 200 m (Figure 84). Juveniles (n=2059) and mature males (n=888) were found at similar depth ranges (range=13–969 m, median=43 m; range=13–540 m, median=46 m, respectively) (Figure 84). It is plausible that some of these records, particularly those found at deeper depths were mistaken for smooth skate.

Reproductively active females were mostly recorded along the ECSI, with scattered records from WCSI, and Tasman and Golden Bay (Figure 85). Additional female rough skate (n=712) not assessed for maturity but measuring at least known length-at-maturity (59 cm PL) were recorded in large numbers in these areas, with additional scattered records along Chatham Rise, Campbell Plateau (Snares Shelf, Auckland Islands, Campbell Rise, Pukaki Rise), and the west coast of the North Island (Kapiti, Taranaki, Northland) (Figure 85). Reproductively active females were recorded in the first half of the year (January to August, not February or July), and most records were in April (n=12) and May (n=38).

Estimated YOY (<40 cm PL) have also been recorded in ten years. There were 234 biologically measured (depth range=15 to 368 m, median=34 m) and 505 length-measured (depth range=15 to 392 m, median=35 m) individuals. Most biological records occurred from March to June (n=230), with occasional records in August (n=1), December (n=2), and January (n=1). Records were confined to ECSI and WCSI, Tasman and Golden Bay, and a few scattered records on the Campbell Plateau (Figure 85).

The kernel density estimates for rough skate showed YOY, juveniles, and reproductively active females were mostly recorded along the Canterbury coastline (Figure 86, Appendix 2). YOY were also recorded in Tasman and Golden Bay (Figure 86).

Observer and commercial data
No rough skate have been measured by observers since 2000. Observer-reported rough skates were mostly recorded along Snares Shelf in trawl fisheries, at Bounty Plateau in bottom longline fisheries, in smaller quantities along Otago Peninsula in set net fisheries, and in the Bay of Plenty in other fishing gear types (Figure 87). Fisher-reported rough skates were recorded along the Canterbury Bight in trawl and set net fisheries, at Bounty Plateau in bottom longline fisheries, and off northern North Island in other gear types in small quantities (Figure 88).

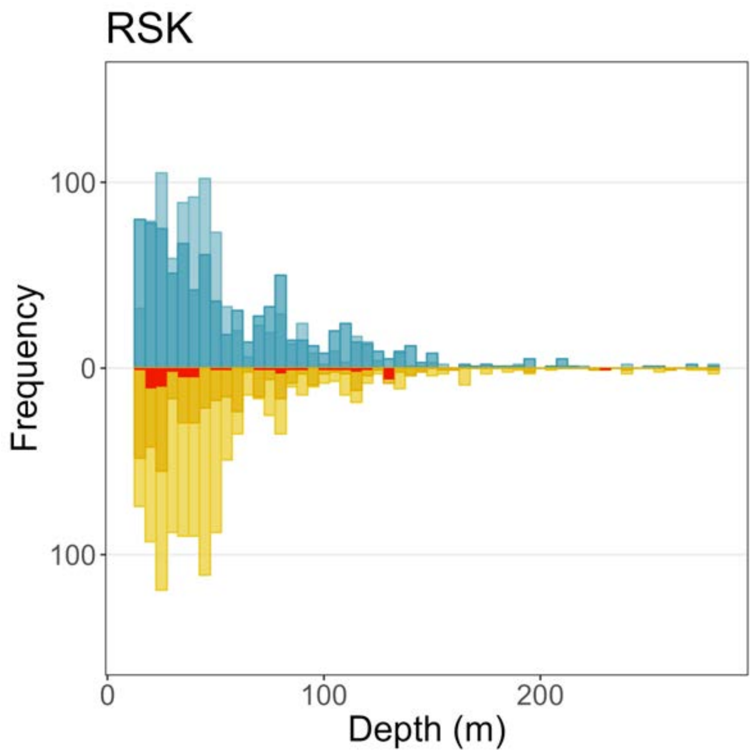


Figure 84: Depth distribution of rough skate biological data by sex (blue=male, yellow=female) and life history status (lighter shade=immature, darker shade=mature). Reproductively active are females identified in red.

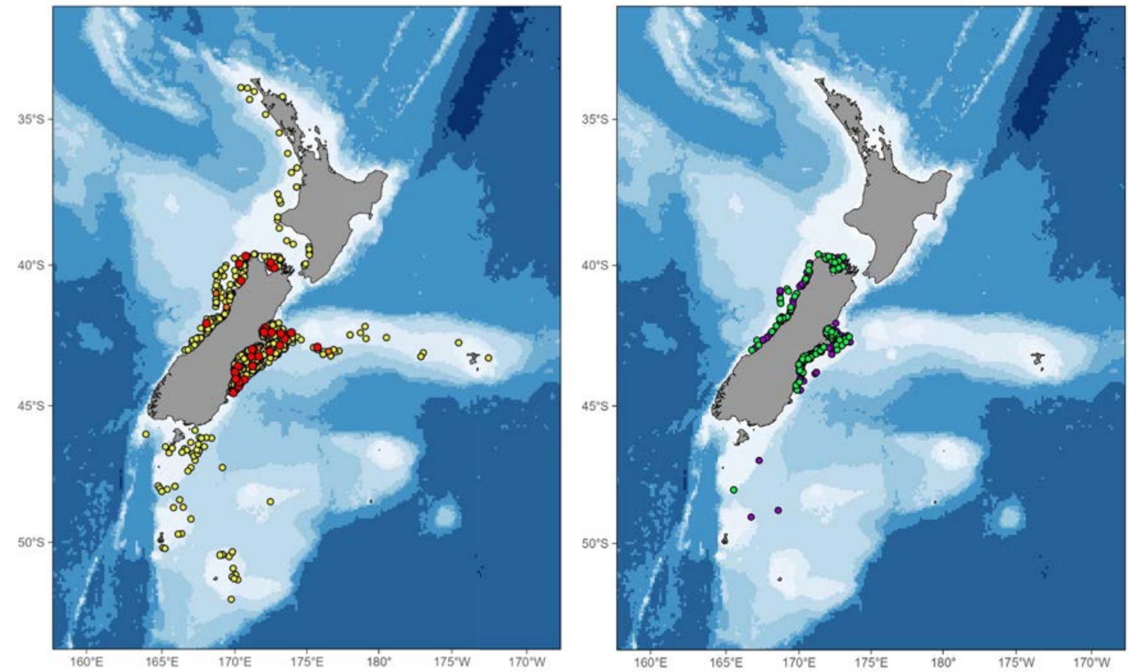
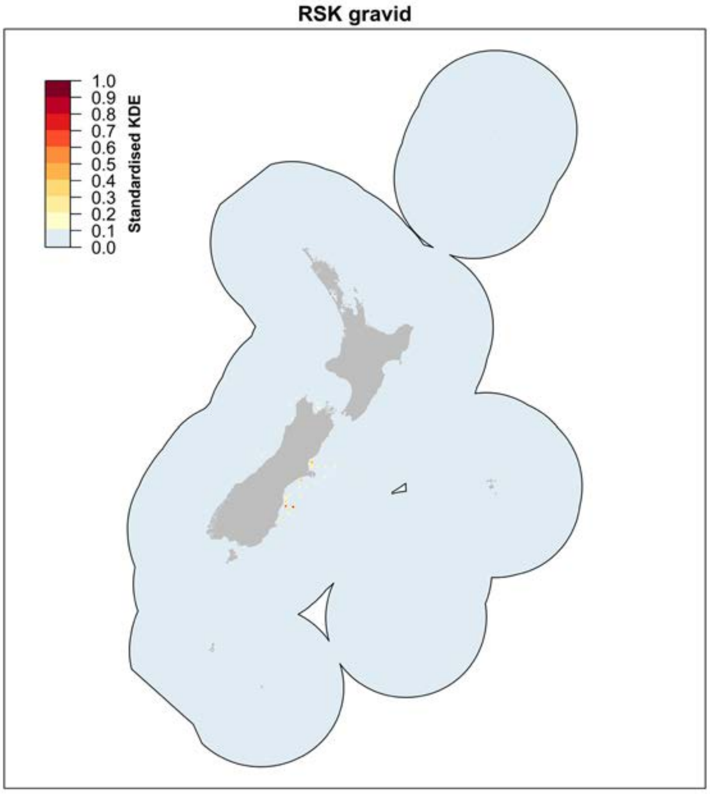


Figure 85: Research trawl survey records for rough skate from 2000 to 2024 for (left) staged reproductively active females (orange), gravid females (red), and unstaged females measuring at least size-at-maturity (yellow); and (right) estimated young of the year with staging data (green) and length measurements (purple).



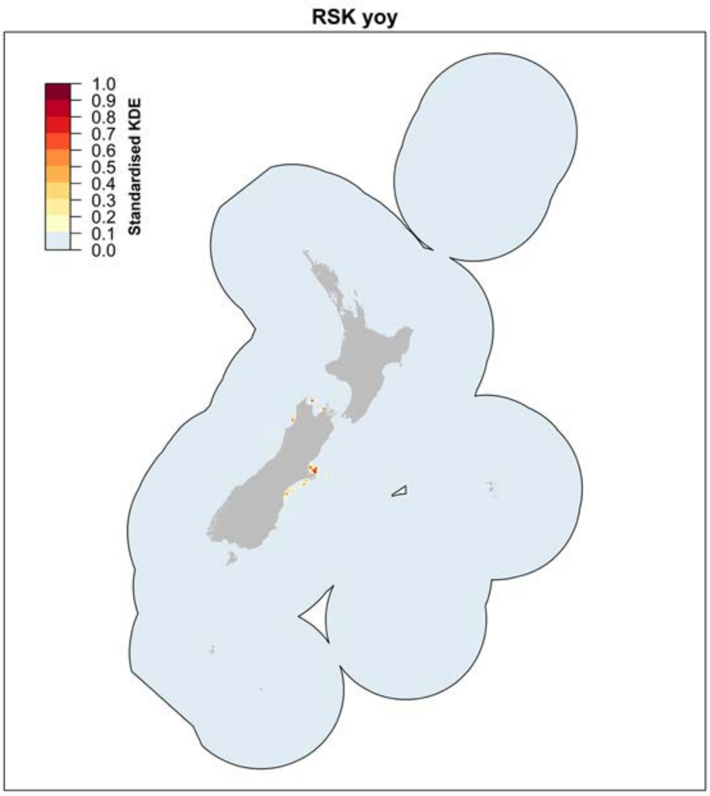


Figure 86: Kernel density estimate (KDE) for research trawl survey records for rough skate from 2000 to 2024 for (top) staged reproductively active 'gravid' females (stages 4–6, see Section 2.5); and (bottom) estimated young of the year. KDE for juveniles is found in Appendix 2. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

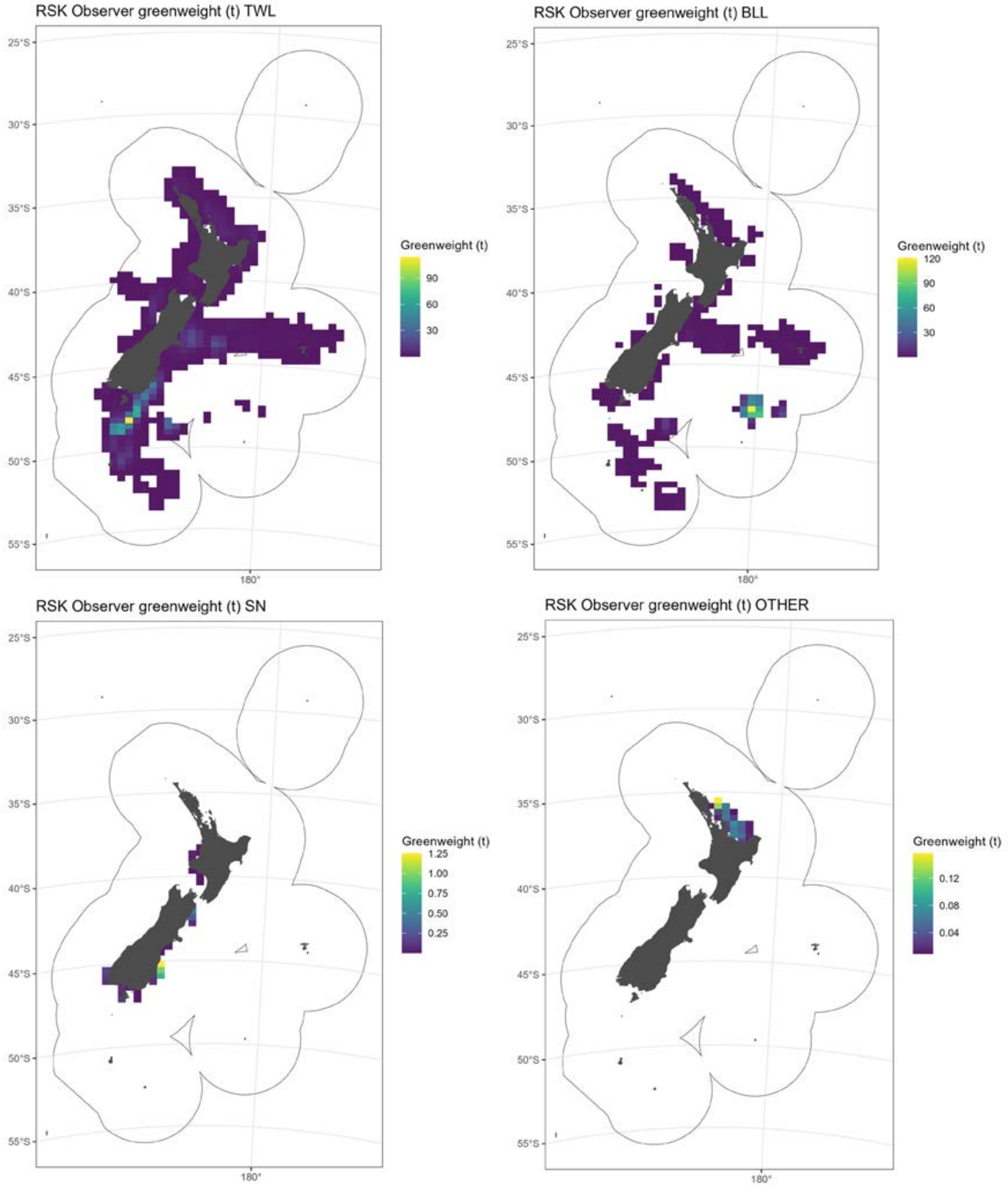


Figure 87: Distribution of rough skate catch (greenweight, t) for observer-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net; OTHER=other fishing gears.

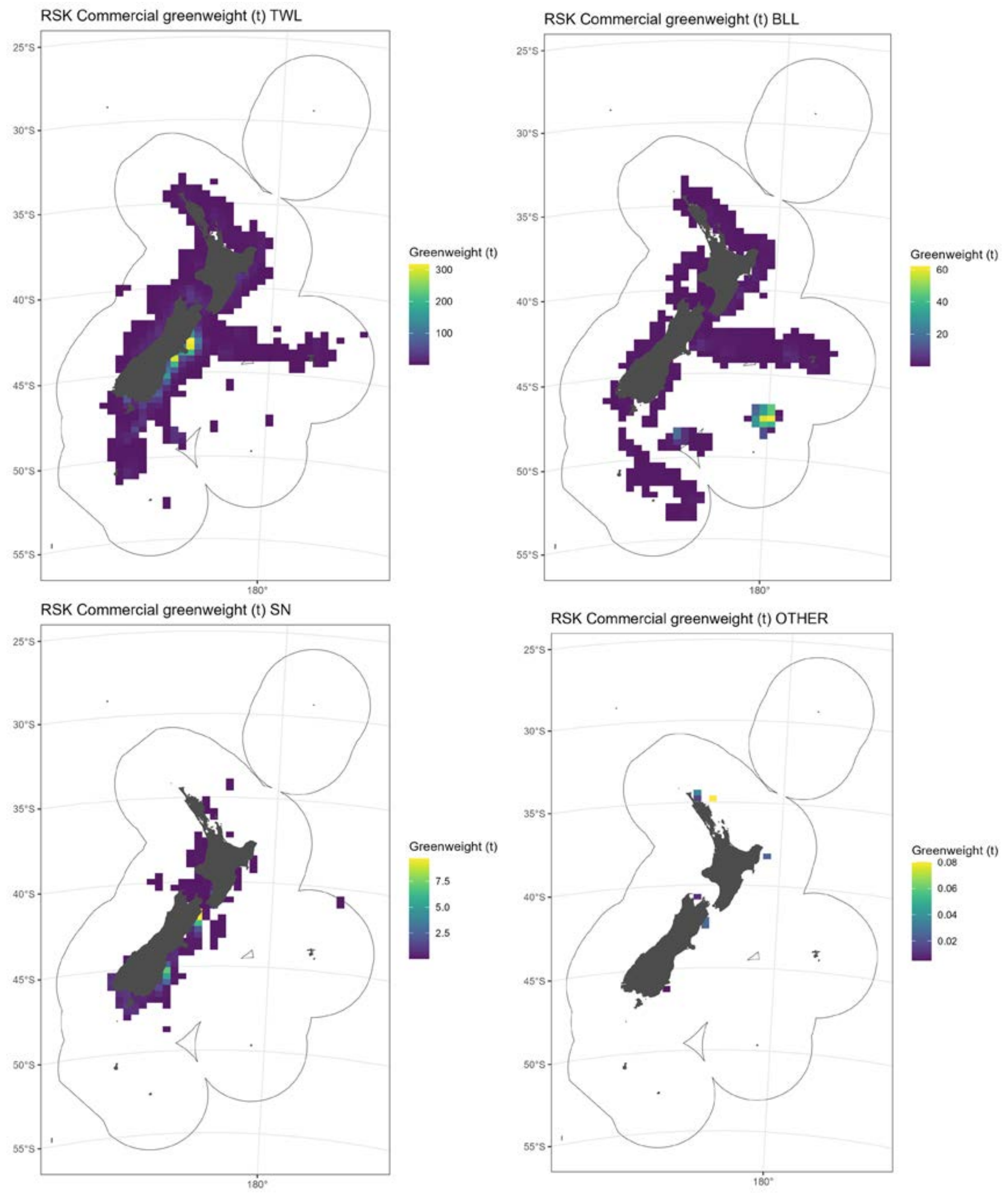


Figure 88: Distribution of rough skate catch (greenweight, t) for fisher-reported records by fishing gear type from 2000 to 2024. TWL=trawl; BLL=bottom longline; SN=set net; OTHER=other fishing gears.

3.2 Additional data sources

Rig surveys

In February and March 2011, 14 major harbours and estuaries were sampled in a nationwide set net survey to define and rank the importance of rig nurseries (Francis et al. 2012). Results showed that Kaipara and Raglan harbours were considered of 'very high value' to juvenile (0+ age class) rig. Waitemata, Tamaki, Manukau, Tauranga, and Porirua harbours were all considered of 'high value'. There was not sufficient evidence to show that any of the South Island harbours were important rig nurseries. To date, it is the only dedicated surveying effort to comprehensively evaluate habitats of importance for a New Zealand chondrichthyan species.

Here, Kaipara and Raglan harbours, as well as Manukau and Porirua harbours, and Tamaki Estuary were considered areas of importance to highlight for one or more of the following reasons: 1) there has been additional research completed in the area to show its importance to rig (e.g., Porirua Harbour, Lyon 2021); 2) additional contemporary records were found, showing the continued use of the area by rig (e.g., Tamaki Estuary, iNaturalist 2024); or 3) the area has been shown to be important to other chondrichthyans as well (e.g., Kaipara and Manukau for white shark, C. A. J. Duffy unpublished data).

Adaptive Management Programme (AMP)

Between 1995 and 2013, biological information (length, sex, and some maturity data) was collected by commercial fisheries in conjunction with the associated detailed catch and effort data (Fisheries New Zealand 2024). There were some fisheries and areas of relevance here, including the shark set net logbook (SPO 3, SCH 3, SCH 5, ELE 3, ELE 5), and the FMA 3 ELE trawl logbook programme. Data from 2000 onwards was reviewed, with some minor grooming (e.g., implausible lengths). Data were collected throughout the year, providing information for these species that is otherwise not captured in research trawl surveys, and records were divided into seasons (summer, December to February; autumn, March to May; winter, June to August; spring, September to November).

Information for three species – elephantfish, school shark, and rig – was available in the AMP dataset (Table 4). While some maturity staging data was collected for males, there was virtually no maturity information collected for females. Using published length at maturity estimates and the recorded lengths at capture, measured individuals were assigned an estimated life history stage.

For elephantfish (n=5087), estimated mature females (n=3654) were recorded along the ECSI, specifically Timaru to Taiaroa Canyon, and mostly during the spring and summer months (Figure 89). There were no records during the winter months and few in autumn, suggesting that these animals move elsewhere during that time of year. There were no estimated YOY elephantfish recorded in the AMP data.

For school shark (n=24 780), estimated mature females (n=1044) were recorded along the ECSI, north of Dunedin, in the spring and summer months, with some records north of Stewart Island in autumn and winter (Figure 90). Estimated YOY (n=333) were recorded along ECSI (Timaru) and WCSI (Haast) during the summer months, but only WCSI in autumn (Figure 91). There were relatively few estimated YOY records during the winter and spring.

For rig (n=28 667), estimated mature females (n=8769) were recorded in Tasman and Golden Bays throughout the year, and were highest in summer and autumn, and additional individuals were recorded along WCSI (Haast) in the winter (Figure 92). Two rig were assessed as 'gravid'. Estimated YOY (n=232) were recorded along WCSI (Greymouth) throughout the year in low numbers (Figure 93).

Table 4: Data for commercially-fished chondrichthyans collected during the Adaptive Management Programme between 2000 and 2013.

Species	Number of individuals measured	Estimated young of the year (YOY)	Estimated juveniles	Estimated mature (females)	Gravid female
Elephantfish	5 087	0	239	4 858 (3 654)	0
School shark	24 780	333	23 271	1 509 (1 044)	0
Rig	28 667	232	9 893	18 774 (8 769)	2

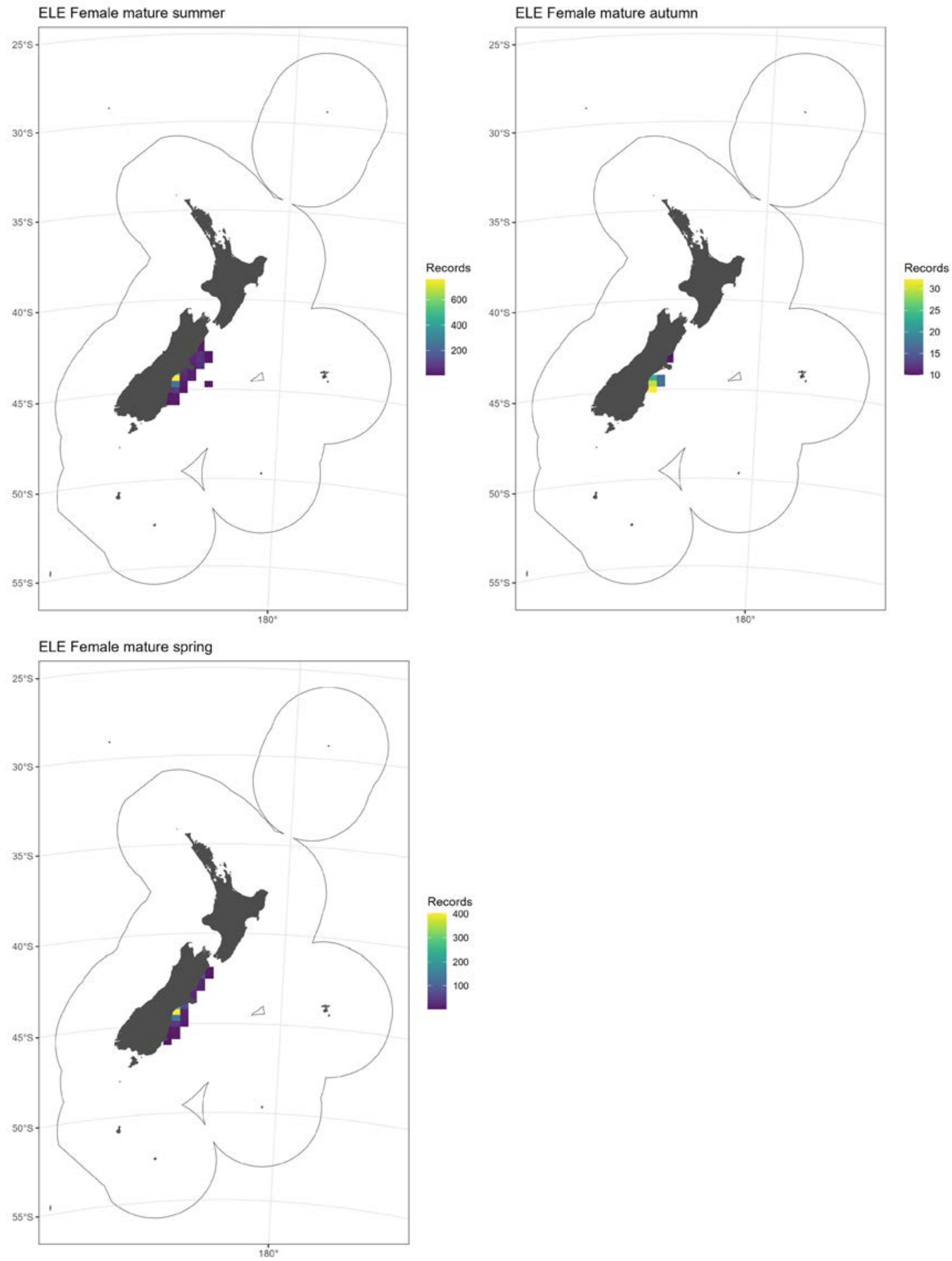


Figure 89: Seasonal distribution of estimated mature female elephantfish catch collected during the Adaptive Management Programme between 2000 and 2013. No elephantfish were measured during the winter months.

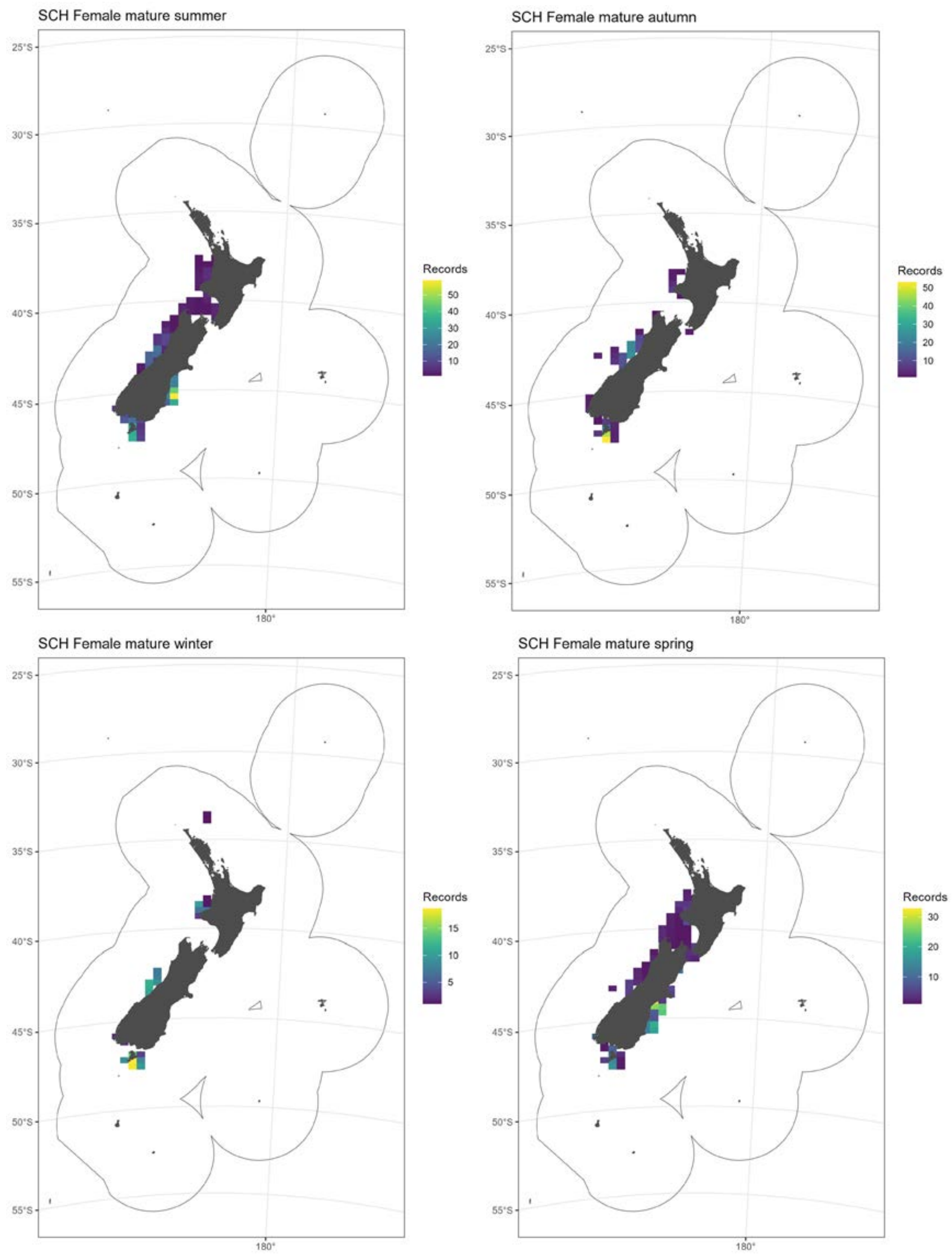


Figure 90: Seasonal distribution of estimated mature female school shark catch collected during the Adaptive Management Programme between 2000 and 2013.

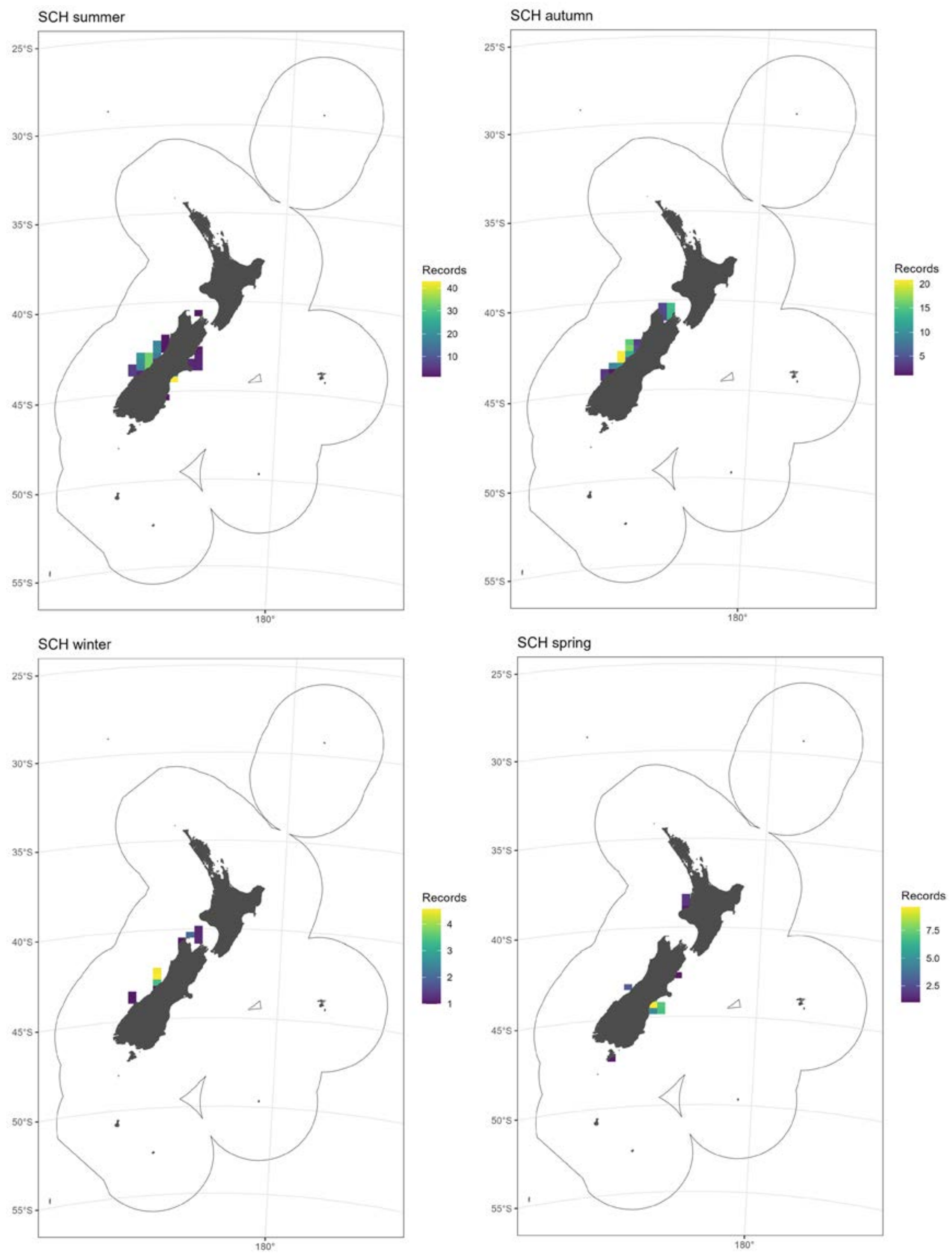


Figure 91: Seasonal distribution of estimated young of the year school shark catch collected during the Adaptive Management Programme between 2000 and 2013.

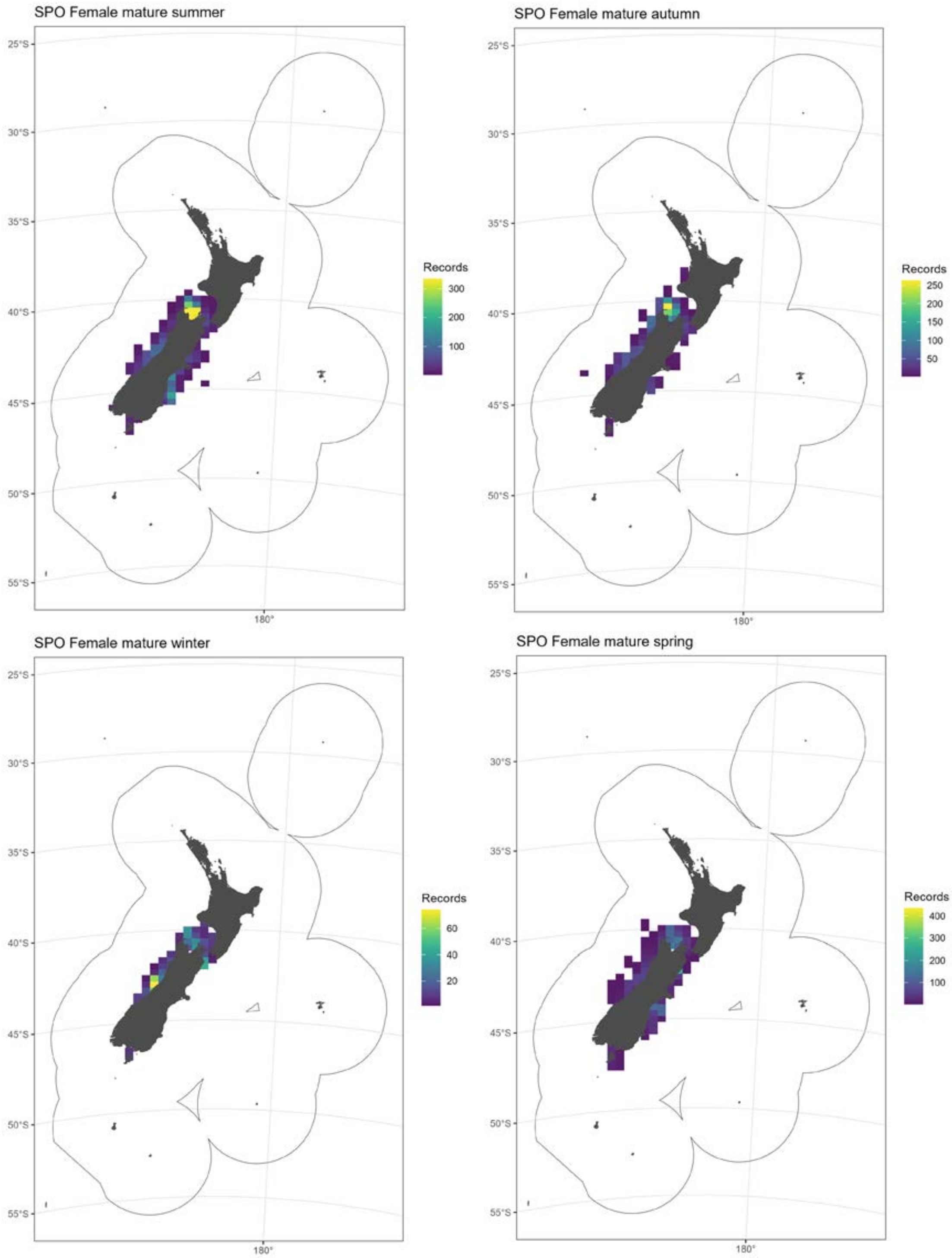


Figure 92: Seasonal distribution of estimated mature female rig catch collected during the Adaptive Management Programme between 2000 and 2013.

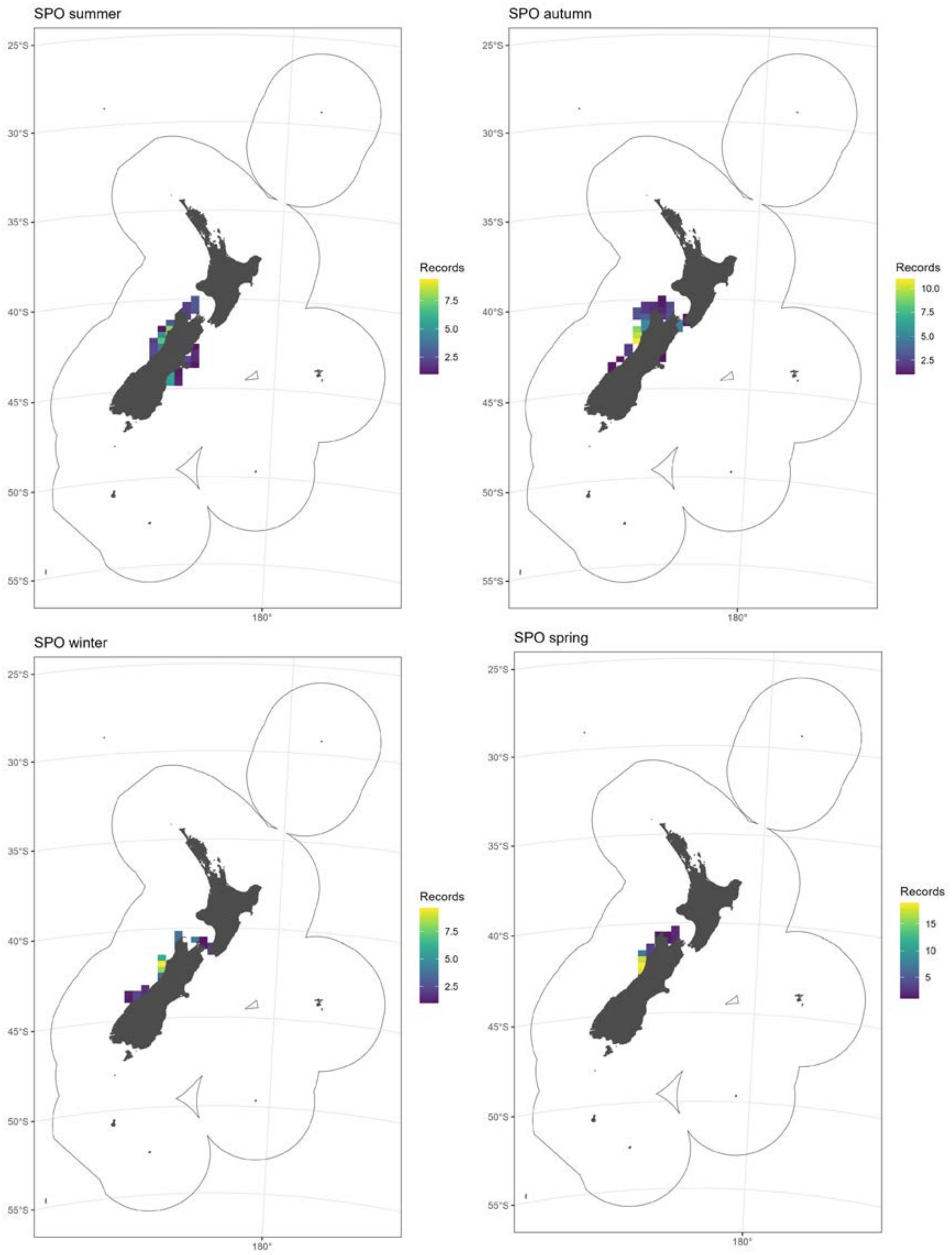


Figure 93: Seasonal distribution of estimated young of the year rig catch collected during the Adaptive Management Programme between 2000 and 2013.

Museum collections – egg cases

Te Papa holds material for five species of interest: elephantfish, n=10 records for a total of 12 egg cases; dark ghost shark, n=3 records and egg cases, carpet shark, n=26 records and 39 egg cases; rough skate, n=9 records and egg cases; and smooth skate, n=1 record and egg case (Table 5, Figure 94, Figure 95). One elephantfish egg case was recorded on the Campbell Rise in 1976. Upon further inspection, this egg case was found to belong to a chimaera species in the Rhinochimaeridae family. These egg cases were collected from 1905 to 2013, and about 85% of samples were collected prior to 2000.

Table 5: Summary of Te Papa egg case collection material for the species of interest.

	Elephantfish	Dark ghost shark	Carpet shark	Smooth skate	Rough skate
pre-1950	1	1	4	0	0
1950s	2	2	3	0	1
1960s	3	0	4	0	1
1970s	0	0	3	1	1
1980s	2	0	2	0	3
1990s	0	0	0	0	0
2000s	0	0	2	0	0
2010s	0	0	2	0	2
2020s	0	0	0	0	0
Year Unknown	2	0	6	0	1
Total Records	10	3	26	1	9
Total Egg Cases	12	3	39	1	9

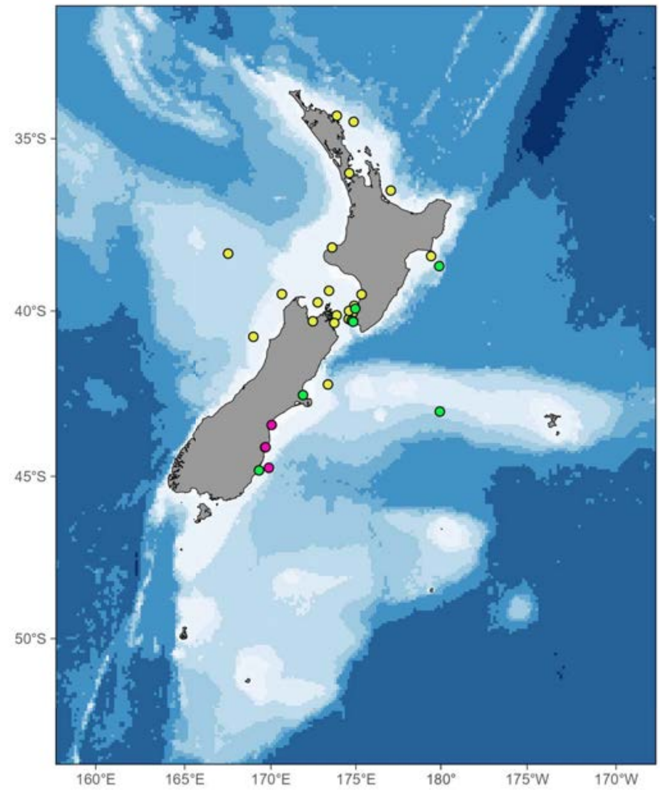


Figure 94: Location of Te Papa egg case collection material for elephantfish (green), dark ghost shark (pink), and carpet shark (yellow).

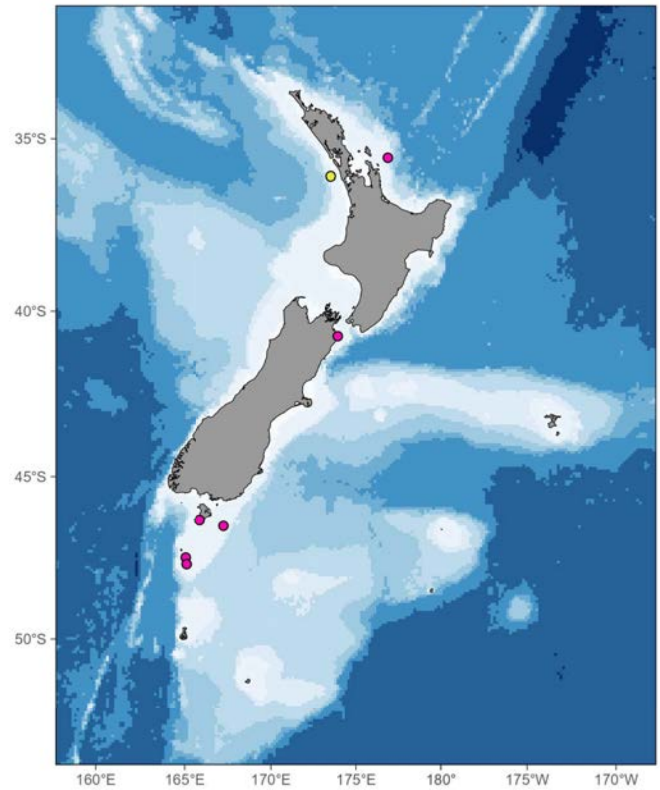


Figure 95: Location of Te Papa egg case collection material for smooth skate (yellow) and rough skate (pink).

Egg cases were also available for at least two species of interest at the Auckland Museum. There were five records and 10 egg cases for carpet shark and four records and five egg cases for rough skate (Table 6). An additional six records for a total of 16 egg cases belong to unidentified skates. These egg cases have been collected between 1969 and 2022, and only four of these records have been collected post-1981.

The carpet shark egg cases were collected at Cavalli Island, Cape Karikari, and off Timaru (Figure 96). The rough skate egg cases were collected at Aldermen Island, Whangamata Beach, and south of Banks Peninsula (Figure 96). The unidentified skate egg cases were collected mostly in northern New Zealand, at Aldermen Island, Mayor Island, and Hen and Chicken Islands (Figure 96). An additional record was also collected mid-Campbell Plateau.

Table 6: Summary of Auckland Museum egg case collection material for the species of interest.

	Carpet shark	Rough skate	Skates (unidentified)
1960s	0	1	3
1970s	1	0	2
1980s	1	1	0
1990s	0	0	0
2000s	0	1	0
2010s	0	0	0
2020s	2	1	0
Year Unknown	1	0	1
Total Records	5	4	6
Total Egg Cases	10	5	16

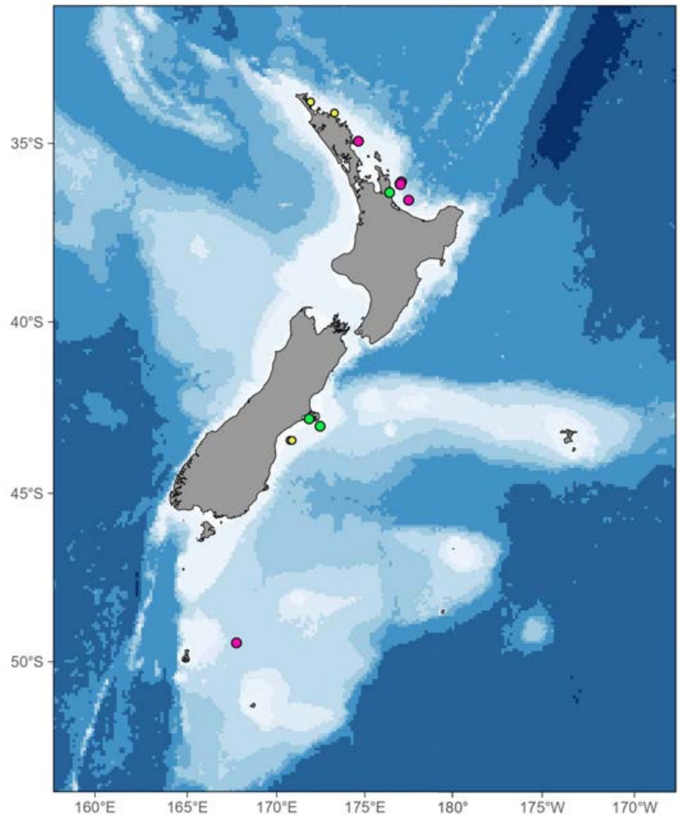


Figure 96: Location of Auckland Museum egg case collection material for carpet shark (yellow), rough skate (green), and unidentified skates (pink).

3.3 Proposed Habitats of Particular Significance (HoPS)

The following section briefly describes each of the proposed HoPS identified in Figure 97. The profile for each HoPS can be found in Appendix 4.

No proposed HoPS is completely closed to fishing (Table 7). Four of the proposed HoPS have 0–1% of their area closed to fishing (Tasman and Golden Bays, WCSI, Titi/Stewart Island, north Auckland Islands), two have 1–5% of their area closed to fishing (east Auckland Islands, Chatham Rise N3), the Hauraki Gulf has 12.8% of its areas closed to fishing, and 25.3% of Chatham Rise N4 is closed to fishing. The remaining 22 proposed HoPS are open to fishing (Table 7).

The sum Swept Area Ratio (SAR) for two proposed HoPS (Raglan Harbour, Tamaki Estuary) was zero, <1 for five proposed HoPS (Marlborough Sounds 1&2, Manukau Harbour, Wellington Harbour, Porirua Harbour), and <100 for four proposed HoPS (Chatham Rise N4, Chatham Islands, Veryan Bank, Stewart Island) (Table 7). The highest sum SAR values were for Chatham Rise N1 (6112.97), Shares Shelf (3277.11), Hokitika (2736.67), Chatham Rise S1 (2701.0), and Auckland Islands E (1673.54).

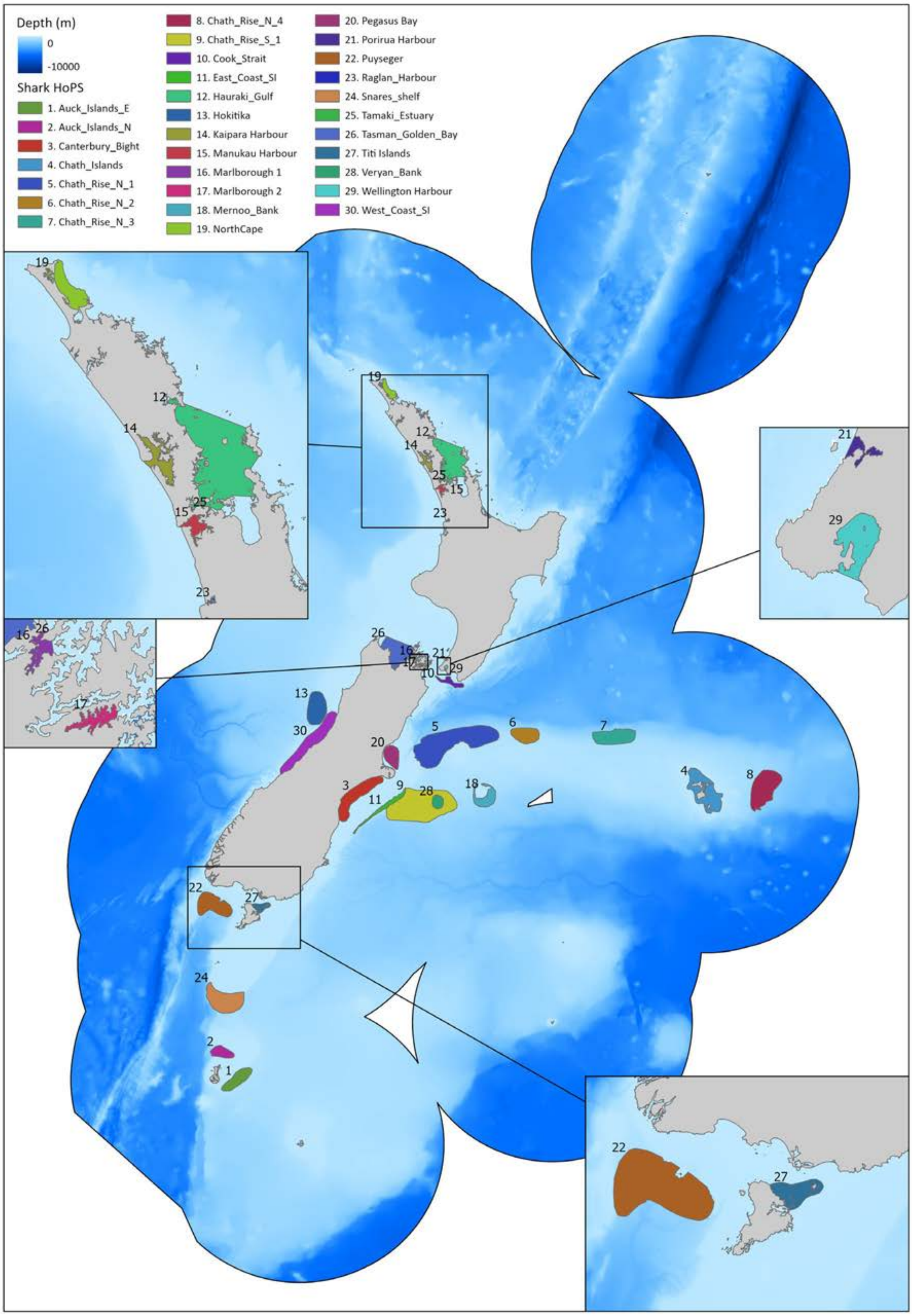


Figure 97: Proposed Habitats of Particular Significance (HoPS) for the 20 chondrichthyan species of interest.

Table 7: Proposed Habitats of Particular Significance (HoPS), the percentage of each HoPS closed to fishing, and the sum Swept Area Ratio (SAR) within each HoPS.

Proposed HoPS	Area (km^2)	Percentage (%) in closed area	Swept Area Ratio (SAR)
1. Auck_Islands_E	2 229	4.98	1 673.54
2. Auck_Islands_N	1 340	0.97	649.05
3. Canterbury_Bight	4 335	0.00	1 298.08
4. Chath_Islands	4 938	0.00	55.55
5. Chath_Rise_N_1	12 229	0.00	6 112.97
6. Chath_Rise_N_2	2 455	0.00	1 618.39
7. Chath_Rise_N_3	3 701	1.57	143.98
8. Chath_Rise_N_4	5 531	25.26	83.22
9. Chath_Rise_S_1	11 522	0.00	2 701.00
10. Cook_Strait	693	0.00	226.53
11. East_Coast_SI	598	0.00	798.87
12. Hauraki_Gulf	5 347	12.75	1 623.61
13. Hokitika	3 594	0.00	2 736.67
14. Kaipara.Harbour	375	0.00	1.71
15. Manukau.Harbour	164	0.00	0.47
16. Marlborough.1	12	0.00	0.49
17. Marlborough.2	20	0.00	0.49
18. Mernoo_Bank	1 746	0.00	279.34
19. North Cape	759	0.00	156.23
20. Pegasus Bay	1 789	0.00	346.97
21. Porirua.Harbour	4	0.00	0.08
22. Puyseger	3 788	0.00	782.72
23. Raglan_Harbour	4	0.00	0.00
24. Snares_shelf	4 808	0.00	3 277.11
25. Tamaki_Estuary	1	0.00	0.00
26. Tasman_Golden_Bay	3 683	0.57	1 427.49
27. Titi Islands	646	0.46	24.46
28. Veryan_Bank	811	0.00	27.57
29. Wellington.Harbour	48	0.00	0.32
30. West_Coast_SI	4 980	0.94	1 640.14

Auckland Islands (1. Auck_Islands_E; 2. Auck_Islands_N)

Auckland Islands is important for one or more of the life history stages for the following species: white shark and basking shark. White shark and basking shark are frequently reported as fisheries bycatch in this area, although the reason for their aggregating behaviour here is unknown. This area may prove to be important to other species of interest in this project, as well as other chondrichthyan diversity, with further research. Other supporting species known to occur in the area include dark and pale ghost shark, school shark, leafscale gulper shark, Plunket's shark, among others. There are several other chondrichthyans also known to occur here (e.g., Dawson's catshark *Bythaelurus dawsoni*, prickly dogfish *Oxynotus bruniensis*, and skates, Rajidae).

The depth of this habitat is delineated from 110 to 1088 m, with surface temperatures ranging from 8.9–9.6°C and bottom temperatures ranging from 4.8–9.2°C. The habitat is at risk from adverse effects of fishing using bottom-contact and pelagic methods and resuspension of sediment by bottom-contact fishing, the estimated sum SAR is 1673.5 and 649.0 in the east and west, respectively, and the percentage of the HoPS closed to fishing is 4.9 (east) and 0.9 (north). The HoPS is also at risk from adverse effects from non-fishing activities including climate change.

Canterbury Bight and Pegasus Bay (3. Canterbury_Bight; 20. Pegasus Bay)

Canterbury Bight and Pegasus Bay is important for one or more of the life history stages for the following species: elephantfish, rig, school shark, spiny dogfish, and rough skate. This area has been routinely sampled by inshore research trawl surveys (Beentjes et al. 2010, 2013, 2015, 2016, 2022, 2023, MacGibbon et al. 2019b). There is sufficient evidence to show its importance as an egg-laying and nursery area for elephantfish and a pupping and nursery area for spiny dogfish. It is suspected to be an egg-laying and nursery area for rough skate, and a pupping and nursery area for rig and school shark based on research trawl catches and beach-cast egg cases (iNaturalist 2024). Other supporting species known to occur in the area include basking shark, white shark, porbeagle, mako, carpet shark, blue shark, and smooth skate. There are a number of other chondrichthyans also known to occur here (e.g., thresher shark *Alopias vulpinus*, electric ray *Tetronarce fairchildi*, and stingrays, *Bathytoshia* spp.).

The depth of this habitat is delineated from 3 to 50 m, with surface temperatures ranging from 10.0–16.0°C and bottom temperatures ranging from 11.0–12.6°C in Canterbury Bight, and from 12.7–14.6°C and bottom temperatures ranging from 10.8–12.3°C in Pegasus Bay. The habitat is at risk from adverse effects of fishing using bottom-contact and pelagic methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 1298.1 and 346.9 in Canterbury Bight and Pegasus Bay, respectively, and no part of the HoPS is completely closed to fishing. The HoPS is also at risk from adverse effects from non-fishing activities including climate change, coastal modification, and pollution.

Chatham Islands (4. Chath_Islands)

Chatham Islands is important for one or more of the life history stages for the following species: white shark. There is sufficient independent tagging to show that the area is used as a seasonal aggregation site for the species (Duffy et al. 2012, Francis et al. 2015a, iNaturalist 2024). This area may prove to be important to other species of interest in this project (e.g., carpet shark, school shark), as well as other chondrichthyan diversity (e.g., broadnose sevengill shark, *Notorynchus cepedianus*), with further research. Other supporting species known to occur in the area include school shark, mako, porbeagle, carpet shark, blue shark, and spiny dogfish. There are a number of other chondrichthyans also known to occur here (e.g., broadnose sevengill shark, northern spiny dogfish *Squalus griffini*, and short-tail stingray *Bathytoshia brevicaudata*).

The depth of this habitat is delineated from 3 to 127 m, with surface temperatures ranging from 12.9–13.2°C and bottom temperatures ranging from 11.3–13.3°C. The habitat is at risk from adverse effects of fishing using bottom-contact and pelagic methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 55.6 and no part of the HoPS is closed to fishing. The HoPS is also at risk from adverse effects from non-fishing activities including increased human activities in the water, climate change, and coastal modification.

Chatham Rise (5. Chath_Rise_N_1; 6. Chath_Rise_N_2; 7. Chath_Rise_N3; 8. Chath_Rise_N_4; 9. Chath_Rise_S_1)

Chatham Rise is important for one or more of the life history stages for the following species: leafscale gulper shark, shovelnose dogfish, longnose velvet dogfish, seal shark (along northern Chatham Rise, 5. Chath_Rise_N_1; 6. Chath_Rise_N_2; 7. Chath_Rise_N3; 8. Chath_Rise_N_4), and Baxter's dogfish (along southern Chatham Rise, 9. Chath_Rise_S_1). This area has been sampled by offshore research trawl surveys (O'Driscoll et al. 2011; Stevens et al. 2012, 2013, 2014, 2015, 2017, 2018, 2021, 2023). It is a suspected pupping and nursery area for the aforementioned species based on research trawl catches. Chatham Rise has a high diversity of chondrichthyans and is likely to be an area of importance to many other species. Other supporting species known to occur in the area include the ghost sharks, school shark, spiny dogfish, Plunket's shark, amongst others. There are many other chondrichthyans that also occur here.

The depth of this habitat is delineated from 194 to 1369 m in the north (5. Chath_Rise_N_1; 6. Chath_Rise_N_2; 7. Chath_Rise_N3; 8. Chath_Rise_N_4) and 202 to 1244 m in the south (9. Chath_Rise_S_1). In the north, surface temperatures range from 12.3–14.6°C and bottom temperatures range from 3.8–11.2°C; in the south, surface temperatures range from 10.8–12.0°C and bottom temperatures range from 3.2–9.0°C. The habitat is at risk from adverse effects of fishing using bottom-contact methods and resuspension of sediment by bottom-contact fishing, the estimated sum SAR ranges from 83.2–6112.9 in the north and 2701.0 in the south. The percentage of the HoPS in closed areas to fishing ranges from 0 (5. Chath_Rise_N_1; 6. Chath_Rise_N_2, and 9. Chath_Rise_S_1) to 25.3 (8. Chath_Rise_N_4). The HoPS is also at risk from adverse effects from non-fishing activities including climate change and pollution (including from mineral deposit extraction).

Cook Strait Canyon (10. Cook_Strait)

Cook Strait Canyon may be important for one or more of the life history stages for the following species: leafscale gulper shark, Baxter's dogfish, longnose velvet dogfish, and seal shark. There is some general knowledge of species occurring in this area, but no empirical work or contemporary studies exist (Garrick 1955, 1957, 1959a, 1959b, 1960a, 1960b, 1960c), Gaskin & Cawthorn 1967, Garrick & Moreland 1968, Livingston 1990, Escobar-Flores & O'Driscoll 2022, Escobar-Flores et al. 2024). Other supporting species known to occur in the area include dark ghost shark, white shark, mako, school shark, blue shark, spiny dogfish, and shovelnose dogfish. There are a number of other chondrichthyans also known to occur here (e.g., thresher shark, prickly shark *Echinorhinus cookei*, and bluntnose sixgill shark *Hexanchus griseus*).

The depth of this habitat is delineated from 116 to 1298 m, with surface temperatures ranging from 13.6–14.1°C and bottom temperatures ranging from 4.0–11.7°C. The habitat is at risk from adverse effects of fishing using bottom-contact methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 226.5 and no part of the HoPS is closed to fishing. The HoPS is also at risk from adverse effects from non-fishing activities including climate change.

Canterbury Shelf Break (11. East_Coast_SI)

The ECSI shelf and slope is important for one or more of the life history stages for the following species: dark ghost shark, school shark, spiny dogfish, and smooth skate. This area has been routinely sampled by inshore research trawl surveys (Beentjes et al. 2010, 2013, 2015, 2016, 2022, 2023, MacGibbon et al. 2019b). There is sufficient evidence to show its importance as a pupping and nursery area for spiny dogfish. It is suspected to be an egg-laying and nursery area for dark ghost shark and smooth skate, and a pupping and nursery area for school shark based on research trawl catches. Other supporting species known to occur in the area include elephantfish, pale ghost shark, mako, porbeagle, carpet shark, blue shark, Baxter's dogfish, and rough skate. There are a number of other chondrichthyans also known to occur here (e.g., broadnose sevengill shark, prickly dogfish, and skates).

The depth of this habitat is delineated from 150 to 397 m, with surface temperatures ranging from 11.4–12.1°C and bottom temperatures ranging from 7.5–9.5°C. The habitat is at risk from adverse effects of fishing using bottom-contact and pelagic methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 798.9 and no part of the HoPS is closed to fishing. The HoPS is also at risk from adverse effects from non-fishing activities including climate change.

Hauraki Gulf (12. Hauraki_Gulf)

The Hauraki Gulf is important for one or more of the life history stages for the following species: white shark, school shark, and rig. There is sufficient independent surveying and local knowledge to show that this harbour is used as a pupping and nursery area by each species (Hurst et al. 2000, Morrison et al. 2002, 2003, Beston 2003, Hendry 2004, Francis et al. 2012, iNaturalist 2024, C. A. J. Duffy unpublished data). The Hauraki Gulf is also a suspected egg-laying and nursery area for carpet shark and rough skate based on video observations and museum collection material (M. Morrison unpublished data, Te Papa unpublished data). Other supporting species known to occur in the area include mako and blue shark, and there are a number of other chondrichthyans also known to occur here (e.g., threshers, smooth hammerhead *Sphyrna zygaena*, oceanic manta ray *Mobula birostris*).

The depth of this habitat is delineated from 39 to 101 m, with surface temperatures ranging from 13.6–14.1°C and bottom temperatures ranging from 4.0–11.7°C. The habitat is at risk from adverse effects of fishing using bottom-contact and pelagic methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 1623.6 and the percentage of the HoPS closed to fishing is 12.8. The HoPS is also at risk from adverse effects from non-fishing activities including increased human activities, climate change, coastal modification, and pollution.

Hokitika Canyon (13. Hokitika)

Hokitika Canyon is important for one or more of the life history stages for the following species: spiny dogfish, leafscale gulper shark, shovelnose dogfish, longnose velvet dogfish, seal shark, and smooth skate. This area has been sampled by offshore research trawl surveys (O'Driscoll et al. 2014, 2015, O'Driscoll & Ballara 2018, 2019; Devine et al. 2022). It is suspected to be an egg-laying and nursery area for smooth skate, and a pupping and nursery area for spiny dogfish, leafscale gulper shark, shovelnose dogfish, longnose velvet dogfish, and seal shark based on research trawl catches. Other supporting species known to occur in the area include dark and pale ghost shark, basking shark, Plunket's shark, and others. There are a number of other chondrichthyans also known to occur here (e.g., slender smoothhound *Gollum attenuatus*, bramble shark *Echinorhinus brucus*, and bluntnose sixgill shark).

The depth of this habitat is delineated from 171 to 697 m, with surface temperatures ranging from 15.1–15.6°C and bottom temperatures ranging from 7.3–13.1°C. The habitat is at risk from adverse effects of fishing using bottom-contact methods and resuspension of sediment by bottom-contact fishing, the estimated sum SAR is 2736.7 and no part of the HoPS is closed to fishing. The HoPS is also at risk from adverse effects from non-fishing activities including climate change.

Kaipara Harbour (14. Kaipara Harbour)

Kaipara Harbour is important for one or more of the life history stages for the following species: white shark, school shark, and rig. There is sufficient independent surveying and local knowledge to show that this harbour is used as a pupping and nursery area by each species (Paul & Sanders 2001, Hendry 2004, Francis et al. 2012, Morrison et al. 2014b, iNaturalist 2024, C. A. J. Duffy unpublished data). There are a number of other chondrichthyans also known to occur here (e.g., bronze whaler *Carcharhinus brachyurus*, smooth hammerhead, and stingrays).

The depth of this habitat is delineated from 15 to 25 m, with surface temperatures ranging from 15.6–23.6°C and bottom temperatures ranging from 16.9–17.3°C. The habitat is at risk from adverse effects of fishing using bottom-contact and pelagic methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 1.71 and no part of the HoPS is closed to fishing but set netting at the harbour entrance is prohibited. The HoPS is also at risk from adverse effects from non-fishing activities including increased human activities, climate change, coastal modification, and pollution.

Manukau Harbour (15. Manukau Harbour)

Manukau Harbour is important for one or more of the life history stages for the following species: white shark, school shark, and rig. There is sufficient independent surveying and local knowledge to show that this harbour is used as a pupping and nursery area by each species (Francis et al. 2012, Hernández 2013, Hernández et al. 2014, Finucci & Ó Maolagáin 2022, iNaturalist 2024, C. A. J. Duffy unpublished data 2024). There are a number of other chondrichthyans also known to occur here (e.g., bronze whaler, smooth hammerhead, and stingrays).

The depth of this habitat is delineated from the surface to 38 m, with surface temperatures ranging from 16.4–25.0°C and bottom temperatures ranging from 17.4–17.6°C. The habitat is at risk from adverse effects of fishing using bottom-contact and pelagic methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 0.47 and no part of the HoPS is closed to fishing but trawling and set netting at the harbour entrance is prohibited. The HoPS is also at risk from adverse effects from non-fishing activities including increased human activities, climate change, coastal modification, and pollution.

Marlborough Sounds (16. Marlborough 1; 17. Marlborough 2)

Marlborough Sounds (Iwirua Point, Grove Arm, Queen Charlotte Sound; Kumutoto Bay, Queen Charlotte Sound; Fitzroy Bay, Hallam Cove, Pelorus Sound) is important for one or more of the life history stages for the following species: elephantfish, carpet shark, and rough skate. Dive surveys, video surveys, and beach-cast egg cases show that there is sufficient evidence that this area is used as an egg-laying area for the aforementioned species and is also a suspected nursery area (Didier et al. 1998, Hurst et al. 2000, Lyon et al. 2011, Davidson et al. 2018, Davidson et al. 2019, iNaturalist 2024, C. A. J. Duffy pers. obs., M. Morrison, unpublished data). Other supporting species known to occur in the area include school shark, rig, and spiny dogfish. There are a number of other chondrichthyans also known to occur here (e.g., broadnose sevengill shark, short-tail stingray, and eagle ray *Myliobatis tenuicaudatus*).

The depth of this habitat is delineated from the surface to 60 m, with surface temperatures ranging from 15.6–18.2°C and bottom temperatures ranging from 14.3–17.3°C. The habitat is at risk from adverse effects of fishing using bottom-contact methods and resuspension of sediment by bottom-contact fishing, the estimated sum SAR is 0.49 and no part of the HoPS is closed to fishing. The HoPS is also at risk from adverse effects from non-fishing activities including increased human activities, climate change, coastal modification, and pollution.

Mernoo and Veryan Bank (18. Mernoo_Bank; 28. Veryan Bank)

Mernoo and Veryan Banks are important for one or more of the life history stages for the following species: dark ghost shark and pale ghost shark. This area has been sampled by offshore research trawl surveys (Horn 1997, MacGibbon 2016, O'Driscoll et al. 2011, Stevens et al. 2012, 2013, 2014, 2015, 2017, 2018, 2021, 2023). It is a suspected egg-laying and nursery area for the aforementioned species based on research trawl catches. Other supporting species known to occur in the area include basking shark, white shark, mako, porbeagle, blue shark, and spiny dogfish.

The depth of this habitat is delineated from 403 to 1021 m for Mernoo Bank and 621 to 829 m for Veryan Bank. Surface temperatures range from 11.3–12.3°C and bottom temperatures range from 4.1–8.2°C for Mernoo Bank and 11.2–11.6°C and 5.1–6.3°C for surface and bottom temperatures, respectively, for Veryan Bank. The habitat is at risk from adverse effects of fishing using bottom-contact methods and resuspension of sediment by bottom-contact fishing, the estimated sum SAR is 279.3 and 27.8 for Mernoo and Veryan, respectively, and no part of the HoPS is closed to fishing. The HoPS is also at risk from adverse effects from non-fishing activities including climate change.

North Cape (19. NorthCape)

North Cape is important for one or more of the life history stages (reproductively active females, juveniles, and YOY) for the following species: white shark. There is evidence to show it is a pupping and nursery area for the species based on local knowledge, beach cast specimens, and fisheries catch (Francis 1996, C. A. J. Duffy unpublished data). North Cape is also a suspected egg-laying and nursery area for carpet shark based on museum collection material (Auckland Museum unpublished data). Commercial catches show school shark also occur here in large numbers, but the reason for this is unknown. Other supporting species known to occur in the area include rig, mako, blue shark, and spiny dogfish, and there are a number of other chondrichthyans also known to occur here (e.g., bronze whaler, broadnose sevengill shark, and eagle ray).

The depth of this habitat is delineated from 9 to 100 m, with surface temperatures ranging from 16.0–21.9°C and bottom temperatures ranging from 15.0–17.5°C. The habitat is at risk from adverse effects of fishing using bottom-contact and pelagic methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 156.2 and no part of the HoPS is closed to fishing. The HoPS is also at risk from adverse effects from non-fishing activities including increased human activities, climate change, coastal modification, and pollution.

Porirua Harbour (21. Porirua Harbour)

Porirua Harbour is important for one or more of the life history stages for the following species: rig. There is sufficient independent surveying and tagging to show that this harbour is used as a pupping and nursery area by rig (Jones & Hadfield 1985, Francis & Francis 1992, Hendry 2004, Francis et al. 2012, Francis 2013, Lyon 2021, iNaturalist 2024). Other supporting species known to occur in the area include elephantfish, carpet shark, and spiny dogfish, and there are a number of other chondrichthyans also known to occur here (e.g., short-tail stingray and eagle ray).

The depth of this habitat is delineated from the surface to 3 m, with surface temperatures ranging from 16.2–17.8°C and a bottom temperature of 14.3°C. The habitat is at risk from adverse effects of fishing using bottom-contact methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 0.08 and no part of the HoPS is completely closed to fishing. Fishing (except crab potting) is prohibited just outside of the HoPS inside a straight line from West Head (at 41°05.444′S and 174°51.187′E) to East Head (at 41°04.980′S and 174°51.850′E) under the Fisheries (Central Area Commercial Fishing) Regulations 1986 Section 9A. It is not known what impact, if any, this prohibition has for rig, but rig are presumably using the area as a migratory corridor as they move in and out of the harbour. The HoPS is also at risk from adverse effects from non-fishing activities including increased human activities, climate change, coastal modification, and pollution.

Puysegur (22. Puysegur)

Puysegur is important for one or more of the life history stages for the following species: leafscale gulper shark, shovelnose dogfish, longnose velvet dogfish, Plunket’s shark, and seal shark. This area has been sampled by offshore research trawl surveys (Bagley et al. 2013, 2014, 2017, O’Driscoll et al. 2018, MacGibbon et al. 2019a Stevens et al. 2022, 2024). It is suspected to be a pupping and nursery area for the aforementioned species based on research trawl catches. Other supporting species known to occur in the area include dark and pale ghost shark, school shark, spiny dogfish, Baxter’s dogfish, and smooth skate. There are a number of other chondrichthyans also known to occur here (e.g., Australasian narrow-nose spookfish *Harriotta avia*, lucifer dogfish *Etmopterus lucifer*, and Owston’s dogfish *Centroscymnus owstonii*).

The depth of this habitat is delineated from 213 to 1495 m, with surface temperatures ranging from 12.3–12.9°C and bottom temperatures ranging from 3.0–11.1°C. The habitat is at risk from adverse effects of fishing using bottom-contact methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 782.7 and no part of the HoPS is closed to fishing. The HoPS is also at risk from adverse effects from non-fishing activities including climate change.

Raglan Harbour (23. Raglan_Harbour)

Raglan Harbour is important for one or more of the life history stages for the following species: rig. There is sufficient independent surveying to show that this harbour is used as a pupping and nursery area by rig (Francis et al. 2012). Other supporting species known to occur in the area include white shark (C. A. J. Duffy, unpublished data), and there are a number of other chondrichthyans also known to occur here (e.g., bronze whaler, smooth hammerhead, and stingrays).

The depth of this habitat is delineated from the surface to 9 m, with surface temperatures ranging from 17.4–19.6°C and a bottom temperature of 17.6°C. The habitat is at risk from adverse effects of fishing using bottom-contact methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is zero and no part of the HoPS is closed to fishing. The HoPS is also at risk from adverse effects from non-fishing activities including increased human activities, climate change, coastal modification, and pollution.

Snares Shelf (24. Snares_shelf)

Snares Shelf and the surrounding slope is important for one or more of the life history stages for the following species: pale ghost shark, spiny dogfish, leafscale gulper shark, Baxter's dogfish, Plunket's shark, and seal shark. This area has been sampled by offshore research trawl surveys (Bagley et al. 2013, 2014, 2017, O'Driscoll et al. 2018, MacGibbon et al. 2019a, Stevens et al. 2022, 2024). It is suspected to be to be an egg-laying and nursery area for pale ghost shark, and a pupping and nursery area for spiny dogfish, pale ghost shark, leafscale gulper shark, Baxter's dogfish, Plunket's shark, and seal shark based on research trawl catches. White shark and basking shark are frequently reported as fisheries bycatch in this area as well (Finucci et al. 2022), although the reason for their aggregating behaviour here is unknown. Other supporting species known to occur in the area include school shark, shovelnose dogfish, smooth and rough skate. There are a number of other chondrichthyans also known to occur here (e.g., giant chimaera *Chimaera lignaria*, prickly dogfish, and skates).

The depth of this habitat is delineated from 151 to 1490 m, with surface temperatures ranging from 9.7–11.2°C and bottom temperatures ranging from 3.1–10.5°C. The habitat is at risk from adverse effects of fishing using bottom-contact and pelagic methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 3277.1, and no part of the HoPS is closed to fishing. The HoPS is also at risk from adverse effects from non-fishing activities including climate change.

Tamaki Estuary (25. Tamaki_Estuary)

Tamaki Estuary is important for one or more of the life history stages for the following species: rig. There is sufficient independent surveying and local knowledge to show that this harbour is used as a pupping and nursery area by rig (Francis et al. 2012, iNaturalist 2024). There are a number of other chondrichthyans also known to occur here (e.g., smooth hammerhead and eagle ray).

The depth of this habitat is delineated from the surface to 3 m, with a surface temperature of around 19.9°C and bottom temperature of around 17.5°C. The habitat is at risk from adverse effects of fishing using bottom-contact methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is zero and no part of the HoPS is closed to fishing. The HoPS is also at risk from adverse effects from non-fishing activities including increased human activities, climate change, coastal modification, and pollution.

Tasman and Golden Bays (26. Tasman_Golden_Bay)

Tasman and Golden Bays are important for one or more of the life history stages for the following species: carpet shark, school shark, rig, and rough skate. This area has been routinely sampled by inshore research trawl surveys (Stevenson & Hanchet 2010, Stevenson 2012, MacGibbon & Stevenson 2013, Stevenson & MacGibbon 2015, 2018, MacGibbon 2019, MacGibbon et al. 2022, 2024). It is suspected to be an egg-laying and nursery area for carpet shark and rough skate, and a pupping and nursery area for rig and school shark based on research trawl catches and set net survey data. Other supporting species known to occur in the area include elephantfish, dark ghost shark, white shark, mako, spiny dogfish, and smooth skate. There are a number of other chondrichthyans also known to occur here (e.g., thresher shark, bronze whaler, and eagle ray).

The depth of this habitat is delineated from the surface to 70 m, with surface temperatures ranging from 13.4–21.1°C and bottom temperatures ranging from 13.3–15.1°C. The habitat is at risk from adverse effects of fishing using bottom-contact and pelagic methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 1427.5 and the percentage of the HoPS closed to fishing is 0.57. The HoPS is also at risk from adverse effects from non-fishing activities including increased human activities, climate change, coastal modification, and pollution.

Titi Islands and Ruapuke (Stewart Island) (27. Titi Islands)

Titi Islands and Ruapuke (Stewart Island) are important for one or more of the life history stages for the following species: white shark. There is sufficient independent tagging to show that area is used as a seasonal aggregation site for the species (Duffy et al. 2012, Francis et al. 2015a, iNaturalist 2024). This area may prove to be important to other species of interest in this project, as well as other chondrichthyan diversity (e.g., broadnose sevengill shark), with further research. Other supporting species known to occur in the area include mako, porbeagle, carpet shark, school shark, blue shark, spiny dogfish, and rough skate. There are a number of other chondrichthyans also known to occur here (e.g., thresher shark and broadnose sevengill shark).

The depth of this habitat is delineated from the surface to 51 m, with surface temperatures ranging from 10.2–14.8°C and bottom temperatures ranging from 11.7–12.7°C. The habitat is at risk from adverse effects of fishing using bottom-contact and pelagic methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 24.5 and the percentage of the HoPS closed to fishing is 0.46. The HoPS is also at risk from adverse effects from non-fishing activities including increased human activities in the water, climate change, and coastal modification.

Wellington Harbour (29. Wellington Harbour)

Wellington Harbour (Oriental Parade, Balaena Bay, Breaker Bay, Robinson Bay, Scorching Bay, Hataitai Beach, Days Bay, Lyall Bay) is important for one or more of the life history stages for the following species: elephantfish and rig. General knowledge of this area and public observations provide some evidence to show it is an egg-laying area and suspected nursery area for elephantfish, and a suspected pupping and nursery area for rig (Jones & Hadfield 1985, iNaturalist 2024, B. Finucci pers. obs., C. A. J. Duffy pers. obs.). Other supporting species known to occur in the area include carpet shark, school shark, spiny dogfish, and rough skate, and there are a number of other chondrichthyans also known to occur here (e.g., electric ray, short-tail stingray, and eagle ray).

The depth of this habitat is delineated from 4 to 22 m, with surface temperatures ranging from 14.2–17.7°C and bottom temperatures ranging from 14.1–14.2°C. The habitat is at risk from adverse effects of fishing using bottom-contact methods and resuspension of sediment by bottom-contact fishing, the estimated sum SAR is 0.32 and no part of the HoPS is closed to fishing. Commercial netting is prohibited in parts of Wellington Harbour, including Oriental Bay, south of Matiu/Somes Island, and Palmer Head to Pencarrow Head under the Fisheries (Central Area Commercial Fishing) Regulations 1986 Section 9. The HoPS is also at risk from adverse effects from non-fishing activities including increased human activities, climate change, coastal modification, and pollution.

West Coast South Island (30. West_Coast_SI)

The West Coast South Island is important for one or more of the life history stages for the following species: elephantfish, dark ghost shark, carpet shark, school shark, rig, and spiny dogfish. This area has been sampled by inshore research trawl surveys (Stevenson & Hanchet 2010; Stevenson 2012; MacGibbon & Stevenson 2013; Stevenson & MacGibbon 2015, 2018; MacGibbon 2019; MacGibbon et al. 2022, 2024). It is suspected to be an egg-laying and nursery area for elephantfish, dark ghost shark, carpet shark, and smooth skate, and a pupping and nursery area for school shark and spiny dogfish based on research trawl catches. Other supporting species known to occur in the area include mako, porbeagle, carpet shark, blue shark, spiny dogfish, and rough skate. There are a number of other chondrichthyans also known to occur here (e.g., thresher shark, sevengill sharks, and northern spiny dogfish).

The depth of this habitat is delineated from the surface to 524 m, with surface temperatures ranging from 13.7–17.6°C and bottom temperatures ranging from 9.3–15.2°C. The habitat is at risk from adverse effects of fishing using bottom-contact and pelagic methods and resuspension of sediment by bottom-contact fishing. The estimated sum SAR is 1640.1 and the percentage of the HoPS closed to fishing is 0.94. The HoPS is also at risk from adverse effects from non-fishing activities including increased human activities, climate change, coastal modification, and pollution.

3.4 Zonation approach

The Zonation approach to identifying HoPS for the species of interest provided similar results to the KDE method. For the inshore species group (ELE, SPO, SCH, SPD, RSK, SSK, CAR), the primary areas of interest (for YOY, juveniles, and reproductively active females combined) included Pegasus Bay and Canterbury Bight, Mernoo Bank, Puysegur, Tasman and Golden Bays, and WCSI (Figure 98). When reproductive development stages were assessed independently, Canterbury Bight and Tasman and Golden Bays were particularly important for all three life history stages (Appendix 5).

For the deepwater species group (GSH, GSP, PLS, ETB, BSH, SND, CYP, CSQ, SPD), the primary areas of interest (for YOY, juveniles, and reproductively active females combined) included ECSI slope and shelf, Puysegur, Snares Shelf, and the northern and eastern slope of Chatham Rise (Figure 99). When development stages were assessed independently, Puysegur was particularly important for all three life history stages, while the eastern Chatham Rise was more important for reproductively active females, and northern Chatham Rise and ECSI were particularly important for YOY and juveniles (Appendix 5).

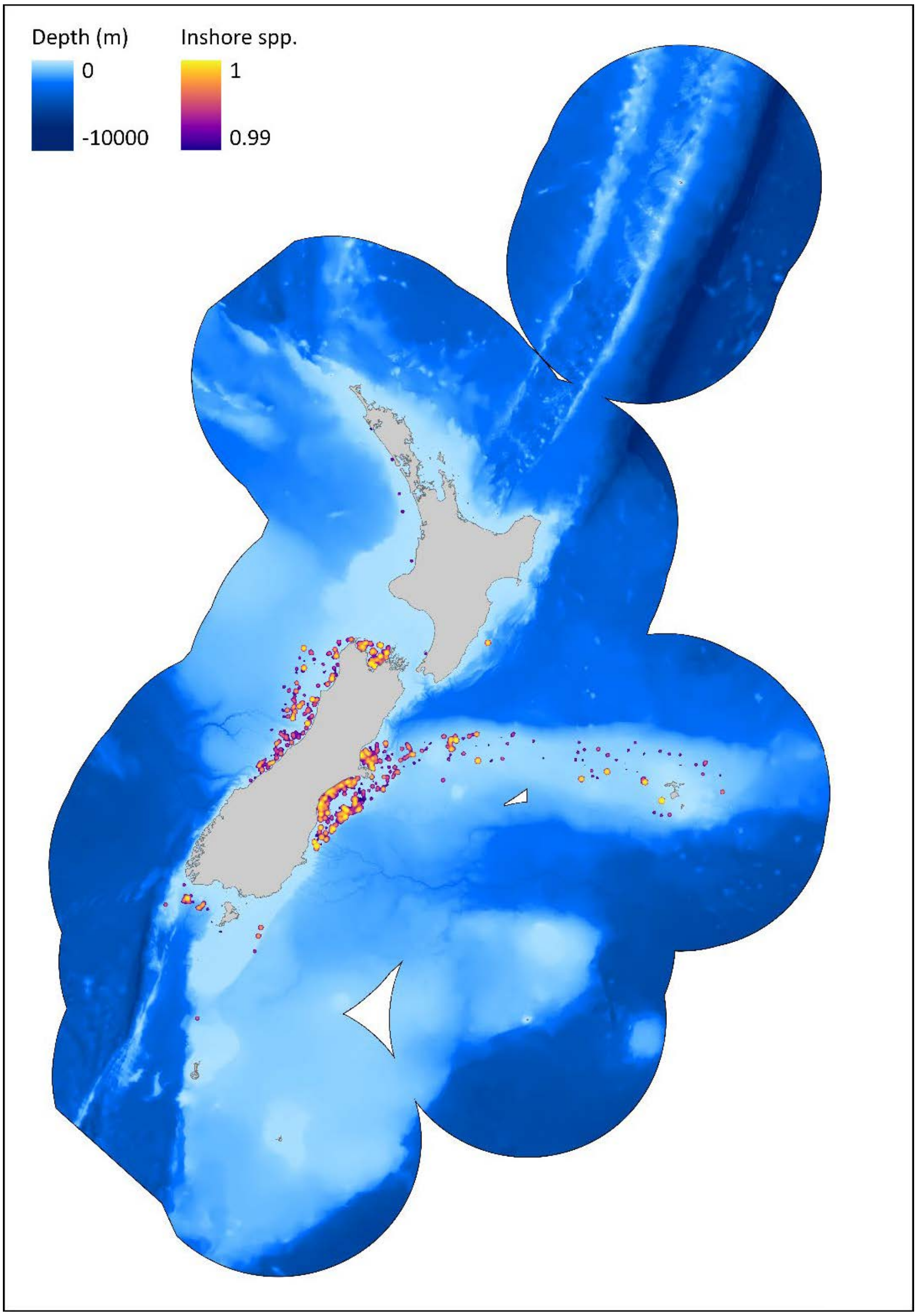


Figure 98: Zonation prioritisation (rank priority) for inshore species. Prioritisation created using the kernel density estimates (KDEs) for YOY, juvenile, and reproductively active development stages for ELE, SPO, SCH, SPD, RSK, SSK, CAR (see Table 1 for species names). Rank priority shown is restricted to the top 1% of value. Individual zonation prioritisation for YOY, juvenile, and reproductively active development stages are in Appendix 5.

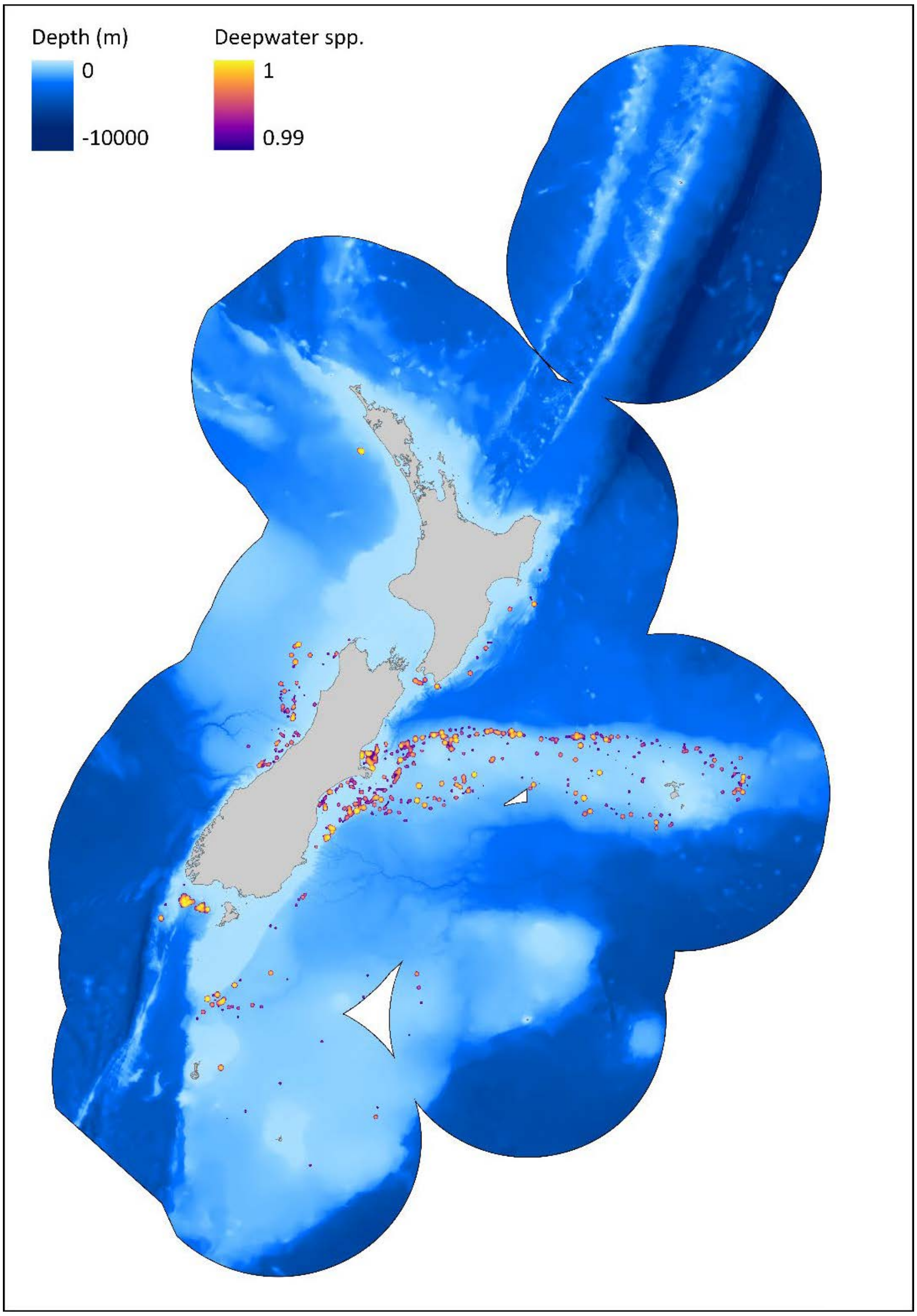


Figure 99: Zonation prioritisation (rank priority) for deepwater species. Prioritisation created using the kernel density estimates (KDEs) for YOY, juvenile, and reproductively active development stages for GSH, GSP, PLS, ETB, BSH, SND, CYP, CSQ, SPD (see Table 1 for species names). Rank priority shown is restricted to the top 1% of value. Individual zonation prioritisation for YOY, juvenile, and reproductively active development stages are in Appendix 5.

4. DISCUSSION

This project proposed 30 HoPS for the species of interest using the best current information available. Six of the 20 species had at least one potential HoPS for spawning purposes identified and 10 species had at least one suspected potential HoPS identified. There were four species (blue shark, mako, porbeagle, basking shark) where potential spawning HoPS could not be identified (Table 8). These species had a lack of records for the life histories of interest (reproductively active females, young-of-the-year) and/or had inconsistent and sparse records over wide areas. This project focused on a small percentage (15%) of the overall chondrichthyan diversity and only HoPS for reproductive purposes. The HoPS guidelines also defined HoPS to include feeding area, migratory corridors, and specific areas to which species are highly restricted. There will be many more chondrichthyan HoPS in New Zealand waters when considering these other focal areas, and with improved knowledge. Chondrichthyans are relatively wide-ranging species and HoPS should be expected to be relatively large in area when compared to other marine species (e.g., sessile species). The size and location of HoPS could possibly be refined with improved data collection.

Table 8: Summary of proposed HoPS by species, where dark green indicates that at least one potential spawning HoPS was identified for a species, light green indicates at least one suspected potential spawning HoPS was identified, and orange indicates that no HoPS could be identified.

Species	One or more spawning HoPS identified	Proposed HoPS
ELE	Yes	3. Canterbury_Bight 16. Marlborough 1 17. Marlborough 2 20. Pegasus 29. Wellington Harbour 30. West_Coast_SI
GSH	Suspected	11. East_Coast_SI 18. Mernoo_Bank 28. Veryan Bank
GSP	Suspected	18. Mernoo_Bank 24. Snares_shelf 28. Veryan Bank 30. West_Coast_SI
SPO	Yes	3. Canterbury_Bight 11. East_Coast_SI 12. Hauraki_Gulf 14. Kaipara Harbour 15. Manukau Harbour 20. Pegasus 21. Porirua Harbour 23. Raglan_Harbour 25. Tamaki_Estuary 26. Tasman_Golden_Bay 29. Wellington Harbour 30. West_Coast_SI
SCH	Yes	3. Canterbury_Bight 11. East_Coast_SI 12. Hauraki_Gulf 14. Kaipara Harbour 15. Manukau Harbour 20. Pegasus 26. Tasman_Golden_Bay 30. West_Coast_SI

Species	One or more spawning HoPS identified	Proposed HoPS
SPD	Yes	3. Canterbury_Bight 11. East_Coast_SI 13. Hokitika 20. Pegasus 24. Snares_shelf 30. West_Coast_SI
BWS	No	
MAK	No	
POS	No	
SSK	Suspected	11. East_Coast_SI 13. Hokitika
RSK	Suspected	3. Canterbury_Bight 16. Marlborough 1 17. Marlborough 2 20. Pegasus 26. Tasman_Golden_Bay
WPS	Yes	1. Auck_Islands_E 2. Auck_Islands_N 4. Chath_Islands 12. Hauraki_Gulf 14. Kaipara Harbour 15. Manukau Harbour 19. NorthCape 27. Titi Islands
BSK	No	1. Auck_Islands_E 2. Auck_Islands_N
CAR	Yes	16. Marlborough 1 17. Marlborough 2 26. Tasman_Golden_Bay 30. West_Coast_SI
PLS	Suspected	22. Puysegur 24. Snares_shelf
ETB	Suspected	9. Chath_Rise_S_1 10. Cook_Strait 24. Snares_shelf
BSH	Suspected	5. Chath_Rise_N_1 6. Chath_Rise_N_2 7. Chath_Rise_N3 8. Chath_Rise_N_4 10. Cook_Strait; 13. Hokitika 22. Puysegur 24. Snares_shel
SND	Suspected	5. Chath_Rise_N_1 6. Chath_Rise_N_2 7. Chath_Rise_N3 8. Chath_Rise_N_4 13. Hokitika 22. Puysegur
CYP	Suspected	5. Chath_Rise_N_1 6. Chath_Rise_N_2 7. Chath_Rise_N3 8. Chath_Rise_N_4 10. Cook_Strait 13. Hokitika 22. Puysegur

Species	One or more spawning HoPS identified	Proposed HoPS
CSQ	Suspected	5. Chath_Rise_N_1 6. Chath_Rise_N_2 7. Chath_Rise_N3 8. Chath_Rise_N_4 10. Cook_Strait 13. Hokitika 22. Puysegur 24. Snares_shelf

4.1 Challenges and opportunities associated with data collection for chondrichthyans

Lack of biological knowledge

Most species are still lacking basic biological information that will help inform HoPS identification. Mating grounds, movement patterns, and population structure, in particular, are not known for most species (Table 9, Table 10, Table 11). The deepwater species (seal shark, leafscale gulper shark, longnose velvet dogfish, Baxter's dogfish, Plunket's shark, and shovelnose dogfish) are particularly data deficient (Table 11). Only one species is considered to have sufficient fisheries-independent tracking data (white shark), which has provided useful information on habitat use and seasonal movements within and beyond New Zealand for sub-adults and mature males (Duffy et al. 2012, Francis et al. 2015a), although this information is not specifically related to spawning purposes. Other species, such as blue shark, mako, porbeagle, and school shark, have been tagged (with conventional and/or electronic tags) in small numbers which has provided some information on movement patterns (e.g., Francis et al. 2015b, Francis et al. 2019, Francis et al. 2023), but data are insufficient at this time to confirm habitats of particular significance. Tagging programmes can provide insight into seasonal patterns of movement or use and residency periods within specific habitats, which are largely unknown for juveniles and females of reproductive size for all species. There is limited knowledge of how chondrichthyans use the water column, which can become important for delineating important habitat for deepwater species (e.g., some species engage in diel migrations) and pelagic species that may regularly dive deep, presumably for foraging purposes (Andrzejaczek et al. 2022). Given the rarity of reproductively active female observations for many species and the general intrinsic sensitivity of chondrichthyans to fishing (Cortés 2016, Pardo et al. 2016, Finucci et al. 2024b), non-lethal sampling methods should be explored, where possible, to improve some of the knowledge gaps identified (e.g., blood chemistry to study reproductive cycles, e.g., Mechaly et al. 2025).

Historical data limitations

Many of the potential HoPS identified here have been identified in previous studies (e.g., Hurst et al. 2000, O'Driscoll et al. 2003, Morrison et al. 2014a, Moura et al. 2014, Finucci et al. 2021a). Aside from ongoing research trawl surveys and limited tagging studies, our knowledge of habitat use for chondrichthyans is largely dated (over 25 years old) and would no longer be accepted in global practices (e.g., ISRAs) as it cannot be determined if these areas are still important to the species. Of the species evaluated here, only one, rig, has had targeted surveying for habitats of importance for nursery areas, and this study occurred in 2011 (Francis et al. 2012). This study identified several harbours in the Auckland region were important nursery areas for rig (Francis et al. 2012). Environmental threats and stressors to those nursery areas was also considered, documenting catchment land use, impervious cover, water quality, sedimentation rates and pollution at the time (Jones et al. 2015). Since the completion of the survey, the population of Auckland has risen by about 340 000 people by 2024 – an increase of ~20% (StatsNZ 2025). The impact of this growth on the magnitude of those stressors and rig habitat is not known.

Survey limitations

Opportunities to collect new, and relevant, data have become increasingly limited. Information required to identify HoPS (e.g., size, sex, maturity stage) for chondrichthyans is largely reliant on fisheries independent research trawl surveys. However, these surveys are infrequent (e.g., most surveys are biennial) and occur at the same time of year, thus they do not capture any seasonality in species' occurrence (e.g., the Chatham Rise survey always occurs in January). These surveys also take place in specific areas (e.g., virtually no sampling outside of the core areas of interest to fisheries) and were not designed to detect important chondrichthyan habitat, nor are they appropriate for some species (e.g., pelagic sharks). Alternative data collection methods (outlined in Section 4.2) are required to complement survey efforts.

Observer programme potential

The observer programme is an underutilized opportunity for data and sample collection. Presently, there is virtually no data collection for most chondrichthyans through the observer programme, which has been highlighted here and in previous research (Parker & Francis 2012, MacGibbon 2016, Finucci et al. 2021a, Moore & Finucci 2024). Some information for pelagic species (mako, porbeagle, blue shark) was previously recorded by fisheries observers on the surface longline fleet, however, this data collection has since ceased with the removal of most observers from this fishery (Moore & Finucci 2024). Unlike the research trawl surveys, the observer programme can sample year-round and in places where the research surveys do not sample. There is also opportunity here to sample other gear types that may be more appropriate given the rarity of some species in trawl surveys (e.g., seal shark, skates). For example, large catches of some species are recorded by both fishers and observers in deepwater longline fisheries (e.g., Bounty Plateau for smooth and rough skate), but are limited in research trawl catches. A rotating 'species of interest' protocol for sampling (similar to the Ross Sea region bycatch monitoring, Moore et al. 2022) could be employed here to maximize sample collection without overburdening the observer programme.

Threatening processes

Fishing is the primary threat to most chondrichthyans (Dulvy et al. 2021). The potential impact of commercial fishing to the proposed HoPS here was evaluated as the sum Swept Area Ratio (SAR). The sum SAR output highlights that some proposed HoPS are more exposed to commercial fishing than other areas. However, it is important to note that the sum SAR is influenced by the size of the proposed HoPS, as it is simply the sum of the SAR in cells within a given HoPS. SAR is only a measure of bottom trawling impact, and some HoPS are likely to be impacted by other gear types, e.g., set net fishing in harbours and estuaries, and probably by recreational fishing as well. Additionally, certain species within some of the proposed HoPS are also impacted by these other gear types, e.g., white sharks and set net fisheries at Titi Islands. However, there is limited information available on fishing impacts beyond the commercial bottom trawl fisheries.

There are additional non-fishing threats likely to impact species, but information is largely unavailable. These threats include habitat loss and alteration, non-fishing extractive activities (e.g., mining), increased human activity on the water (e.g., recreational fishing, boat strikes, noise disturbance), pollution, and environmental climate change (Gelsleichter & Walker 2010, Francis & Lyon 2013, Drymon & Scyphers 2017, Crear et al. 2020, Dulvy et al. 2021, Womersley et al. 2022, Nieder et al. 2023, Morrison et al. 2023, Brown & Puschendorf 2025). Rig is the only New Zealand species where non-fishing threats and stressors to nursery areas have been reviewed (Jones et al. 2015), however, no long-term monitoring of abundance and the health of juveniles in these known nursery habitats exists.

Table 9: Summary of current knowledge for chondrichthyans managed under the Quota Management System. Dark green indicates sufficient data are available in at least part of the species range; light green indicates there is some data available for the species, and orange indicates no data are available. ? = uncertainty in the current available knowledge; * data available in the *trawl* database. Areas are not specific to proposed Habitats of Particular Significance. See Table 1 for species names.

	Endemic	Reproductively active female observations *	YOY observations	Pupping grounds	Egg laying grounds	Nursery grounds	Mating grounds	Movement patterns	Population structure	Research gaps
ELE	No?	Yes (<10)	Yes	NA	Yes	Yes	Yes? ECSI	Yes? ECSI, some conventional tagging	Work ongoing	Wellington Harbour; ECSI winter habitat; Taiaroa Canyon; WCSI; Te Waewae Bay
SPO	Yes	Yes (<100)	Yes	Yes	NA	Yes	Yes? Porirua	Yes (acoustic tagging within Porirua), some conventional tagging	Yes	South Island (TBGB, Otago Peninsula)
SCH	No	No	Yes	Yes	NA	Yes	No	Satellite tagging ongoing for NI, some conventional tagging	Yes	WCSI, southern NZ
RSK	Yes	Yes (<50)	Yes	NA	Yes? Queen Charlotte Sound, Blueskin Bay	Yes? Otago Peninsula	No	No	No	North Island; TBGB; Canterbury Bight to Otago Peninsula; Bounty Plateau; WCSI
SSK	Yes	Yes (<5)	Yes (<150)	NA	Yes? Hawke Bay, Foveaux Strait	Yes? Hauraki Gulf	No	No	No	North Island; ECSI shelf (south of Banks Peninsula); WCSI; Hokitika Canyon; Pukaki Rise

	Endemic	Reproductively active female observations *	YOY observations	Pupping grounds	Egg laying grounds	Nursery grounds	Mating grounds	Movement patterns	Population structure	Research gaps
GSH	Yes	Yes	Yes (<10)	NA	No	No	No	No	No	North Island; ECSI shelf; WCSI; Hokitika Canyon; Pukaki Rise
GSP	Yes	Yes	Yes (<5)	NA	No	Yes? Mernoo Bank	No	No	No	North Island; Mernoo Bank; Snares Shelf
SPD	No	Yes	Yes	Yes? ECSI shelf	NA	Yes? ECSI shelf	Yes? ECSI shelf	No	No	North Island; Blueskin Bay, Otago Harbour; WCSI; Hokitika Canyon

Table 10: Summary of current knowledge for chondrichthyans managed under the Quota Management System (blue shark, mako, porbeagle) and protected species (white shark, basking shark). Dark green indicates sufficient data are available in at least part of the species range; light green indicates there is some data available for the species, and orange indicates no data are available. ? = uncertainty in the current available knowledge; * data available in the *trawl* database. Areas are not specific to proposed Habitats of Particular Significance. See Table 1 for species names.

	Endemic	Reproductively active female observations	YOY observations	Pupping grounds	Egg laying grounds	Nursery grounds	Mating grounds	Movement patterns	Population structure	Research gaps
BWS	No	No	Yes	Yes? Bay of Plenty, Hawke Bay, Three Kings, Wanganella Bank	NA	No	No	Yes (<10 sharks satellite tagged, some conventional tagging)	Work ongoing	southwest South Island; Kermadec region; East Cape
MAK	No	Yes (one)	Yes	No	NA	No	No	Yes (<50 sharks satellite tagged, some conventional tagging)	No	Bay of Plenty; East Cape
POS	No	Yes (few)	No	No	NA	No	No	Yes (10 sharks satellite tagged, some conventional tagging)	Yes	Puysegur Trench; Snares Shelf; Bay of Plenty; East Cape
WPS	No	Yes (two?)	Yes	Yes	NA	Yes	No	Yes (63 sharks satellite or acoustically tagged)	Yes	North Cape; Hauraki Gulf; Auckland Islands

	Endemic	Reproductively active female observations	YOY observations	Pupping grounds	Egg laying grounds	Nursery grounds	Mating grounds	Movement patterns	Population structure	Research gaps
BSK	No	No	No	No	NA	Yes? WCSI, NW Chatham Islands	No	No	Yes	Auckland Islands; Snares Shelf; WCSI

Table 11: Summary of current knowledge for non-Quota Management System chondrichthyans assessed at high risk from fishing (Ford et al. 2018). Dark green indicates sufficient data are available in at least part of the species range; light green indicates there is some data available for the species, and orange indicates no data are available. ? = uncertainty in the current available knowledge; * data available in the *trawl* database. Areas are not specific to proposed Habitats of Particular Significance. See Table 1 for species names.

	Endemic	Reproductively active female observations *	YOY observations	Pupping grounds	Egg laying grounds	Nursery grounds	Mating grounds	Movement patterns	Population structure	Research gaps
CAR	Yes	Yes (<25)	Yes (one)	NA	Yes? Marlbor. Sounds	Yes? TBGB	No	No	No	North Island; TBGB; Otago Peninsula; WCSI
BSH	No	Yes (one)	Yes	No	NA	No	No	No	No	North Island; Cook Strait Canyon; NE Chatham Rise; Hokitika Canyon; Snares Shelf
CSQ	No	Yes (<75)	Yes	Yes? Puysegur	NA	Yes? Puysegur	No	No	No	North Island; Cook Strait Canyon; Hokitika Canyon; Snares Shelf; southern Campbell Plateau; southwest Challenger Plateau
CYP	No	Yes	Yes	No	NA	No	No	No	No	North Island; Cook Strait Canyon; Hokitika Canyon
ETB	No	Yes	Yes (<150)	No	NA	No	No	No	No	North Island; Cook Strait Canyon; Snares Shelf
PLS	No	Yes (<10)	Yes (<50)	No	NA	No	No	No	No	North Island; Kaikoura Canyon; Puysegur; Snares Shelf
SND	No	Yes (100)	Yes	Yes? ECNI	NA	No	No	No	No	North Island; Hokitika Canyon

4.2 Alternative data sources

Underwater video sources

Underwater video observations can be used to collect information on community composition, species abundance, and if collected over a prolonged time, can also be used as an indication of population trends (Whitmarsh et al. 2017, Simpfendorfer et al. 2023). Baited underwater video (BUV) or baited remote underwater video (BRUV) are underwater video censuses that are increasingly popular for studying the marine environment. Remote drift underwater video (DUV) and towed-video (CoastCam, DTIS) have also collected data on the species of interest in this project (see below and Appendix 6). One of the primary advantages of underwater video surveys is their ability to monitor and document marine species in their natural habitats without disturbance, allowing the opportunity to capture real-time species interactions, feeding behaviours, and reproductive activities in real-time (Whitmarsh et al. 2017, Parton et al. 2023). Underwater video surveys are also beneficial in that they can cover challenging terrains that might be difficult to explore through conventional means (Zintzen et al. 2012, Zintzen et al. 2017). This capability is crucial for studying diverse habitats, such as rocky reef habitat, kelp forests, and deep-sea environments, where access can be limited, and physical sampling may not be feasible. By accurately documenting species presence and habitat conditions, underwater video surveys can support the identification of critical habitats and biodiversity hotspots (Osgood et al. 2019).

Underwater video surveys have been conducted throughout the country, from the Kermadec region to Fiordland to the Auckland Islands, often for evaluating and monitoring general ecosystem composition (e.g., Zintzen et al. 2012, Zintzen et al. 2017). These studies include projects funded by the Department of Conservation, projects incorporated into wider university-driven studies or part of community-driven initiatives (e.g., SharkSpy). Many of these studies are ongoing. Studies often opportunistically come across species of interest in this project, as well as a diversity of other chondrichthyans. At least ten species of interest – elephantfish, carpet shark, rig, school shark, spiny dogfish, blue shark, white shark, mako, porbeagle, and rough skate – have been observed (Appendix 6).

It is unclear at this time how comparable these studies may be, and if they could be combined into larger analysis. National guidelines should be developed so that video data collections can be standardised and comparable. It should also be determined if video surveys are appropriate for monitoring species of interest. Some species, including chimaeras, appear to avoid camera detection, and this avoidance behaviour can underestimate species diversity and abundance (McIntrye et al. 2015, Whitmarsh et al. 2018). Identifying morphological features of chondrichthyans *in-situ* can also be challenging without ground truth data (i.e., specimen collections), particularly if the field of view is poor at the time of observation (Armstrong 2022).

Deep Towed Imaging System (DTIS)

NIWA's Deep Towed Imaging System has collected towed video throughout the New Zealand EEZ and in the Ross Sea, Antarctica, dating back to 2006. Efforts are made to identify all species observed to the lowest possible taxon, but identification is dependent on viewers' taxonomic knowledge and survey objectives when the video is collected. Chondrichthyans are often observed, as well as egg cases, most have not been identified to any taxonomic level. Using DTIS footage, one skate egg case nursery has been described in the Ross Sea (Finucci et al. 2024a), and another yet to be characterised has been observed on Epilogue Seamount on Chatham Rise (Armstrong 2022). DTIS footage can provide some insight into habitat association; for example, deepwater catshark (*Apristurus* spp) egg cases have been observed on stony branching coral (*Solenosmilia variabilis*) (Armstrong 2022). Data on size, sex, and maturity is not available at this time, though additional analysis may be able to provide insight into at least individual sizes.

A query for records of chondrichthyans between 2006 and 2022 revealed 2463 observations, with records for 10 species of interest and seven other species or species groups (Table 12). Records were available throughout the New Zealand EEZ, as well as beyond. Some places sampled here that are not well sampled, or not sampled at all by research trawl surveys include the Kermadec Trench, southern Hikurangi margin, Kaikoura Canyon, Challenger Plateau, and Macquarie Ridge (beyond the New Zealand EEZ) (Figure 100).

Table 12: Observations of chondrichthyans recorded by Deep Towed Imaging System (DTIS) between 2006 and 2022. See Table 1 for species names. LCH=Australasian Long-nose Spookfish (*Harriotta avia*); ETL=Lucifer dogfish (*Etmopterus lucifer*).

	2006	2007	2008	2009	2010	2011	2012	2013	2015	2016	2017	2018	2020	2021	2022
Species of interest															
GSH	0	0	0	0	0	4	0	20	0	2	73	0	0	0	0
POS	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
CAR	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0
SCH	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SPD	0	0	0	0	0	0	0	1	0	0	4	0	0	0	0
SND	0	0	0	0	0	0	0	0	0	0	6	0	2	0	2
ETB	0	0	21	0	0	0	0	0	0	0	65	0	127	0	0
PLS	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
SSK	0	0	0	0	0	1	0	1	0	0	5	0	0	0	0
RSK	0	0	0	0	0	0	0	0	0	0	6	0	11	0	1
Other species, species groups															
LCH	0	0	0	0	0	0	0	0	0	0	16	0	5	0	0
ETL	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0
Shark	0	56	76	11	243	2	37	182	79	5	372	0	161	0	23
Skates	0	0	0	0	0	0	0	0	0	1	34	4	0	2	6
Chimaera	0	13	1	0	0	0	1	88	0	0	143	0	63	0	7
Dogfish	0	0	0	0	0	0	0	0	2	0	38	0	52	0	0
Lanternshark	6	14	0	0	0	0	0	115	0	0	110	0	17	0	21

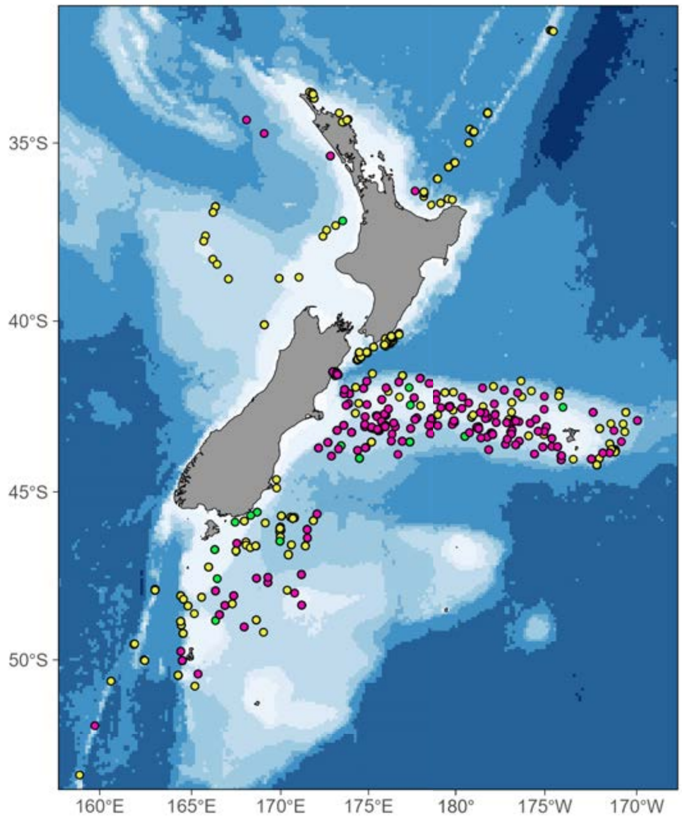


Figure 100: Location of shark (yellow), ray (green), and chimaera (pink) observations collected on NIWA's Deep Towed Imaging System between 2006 and 2022.

Museum collections

Te Papa holds a large number of egg cases for at least 13 additional species not evaluated in this project (Table 13). Many of these egg cases have not been identified to the species level yet. Of those identified to the species level, egg cases for a number of deepwater catsharks and skates are available, including some skates that occur in the Ross Sea. There are some chimaera egg cases for the Australasian long-nose spookfish, as well as 15 chimaera egg cases not identified to any species level. About 75% of the collection material was collected prior to 2000.

Table 13: Additional egg case collection material held at Te Papa. *indicate species that occur in the Ross Sea.

	Number of records	Number of eggs
*Amblyraja georgiana**	7	7
Amblyraja hyperborea	8	8
Apristurus exsanguis	2	2
Apristurus garricki	2	2 (at least)
Arhynchobatis asperrimus	4	4
*Bathyraja arctowskii**	5	5
*Bathyraja eatonii**	1	1
Bathyraja richardsoni	2	3
Brochiraja asperula	1	1
Brochiraja microspinifera	11	16
Bythaelurus dawsoni	3	4
Dichichthys satoi	2	4
Harriotta avia	2	3 (at least)
Catshark	3	4
Chimaera	12	15
Skates*	30	38
Total	95	117

Aerial surveys

Like underwater video analysis, aerial surveys (e.g., unmanned aerial vehicles UAVs, drones) can be used to study behaviour, distribution, and population dynamics of some marine species (Hodgson et al. 2013). Aerial surveys can cover vast areas of habitats quickly and efficiently, unlike boat-based surveys which can be time-consuming and limited in their geographic reach. Aerial surveys are non-lethal and non-invasive; removing any adverse effects caused by human presence that may inadvertently disrupt natural behaviours (Witt et al. 2009). Aerial observations allow for detailed studies without physical disturbance, thereby yielding more accurate representations of species and their interactions within ecosystems. Aerial surveys would be particularly useful for species occurring in coastal habitats (e.g., beaches, estuaries, shallow inlets) and have been used to monitor Smooth hammerheads and oceanic manta rays in New Zealand waters (Francis 2010b, Setyawan et al. 2022).

Community driven research

Community driven research, often referred to as citizen science, offers an alternative solution to gather critical data, while raising public awareness and fostering community engagement. The Great Eggcase Hunt (Shark Trust Great Eggcase Hunt), for example, is an initiative that first began in the United Kingdom in 2003 and encourages the public to report chondrichthyan egg cases found on beaches and observed underwater through a locally developed app (Shark Trust 2020). Since its inception, over 375 000 egg cases have been reported, and the initiative is now available in 30 countries, including Australia. Data collected in this project has been fed into scientific reports and publications and has assisted in improving ecological knowledge of egg cases (Gordon et al. 2016) and describing habitats of importance for oviparous species (Ellis et al. 2024).

In New Zealand, iNaturalist is a popular online tool for the public to record their observations of the natural world. There are presently around 3200 observations across 33 chondrichthyan species (iNaturalist 2024) some of which were utilized in this study to provide evidence of contemporary occurrence of some species (e.g., elephantfish, school shark, white shark). These observations are well curated due to interest from chondrichthyan taxonomists, and in the case of iNaturalist, these observations are given a 'research grade' status to highlight their validity.

The Tindale Marine Research Charitable Trust (https://tindaleresearch.org.nz/) has established a nation-wide inshore tagging programme to encourage tag and release of recreationally caught fish, and reporting of recaptures, including several inshore chondrichthyans, to monitor seasonal movements, habitat use, and capture growth data.

While citizen science projects offer an opportunity to fill in some knowledge gaps, there is a level of quality control required to ensure data are accurate and data collected cannot generally be used for robust quantitative analysis due to biases in data collection (e.g., spatially and temporally patchy coverage, observed effort is likely to be higher in easily accessible locations or during holiday periods) (Dickinson et al. 2010).

5. POTENTIAL RESEARCH

5.1 Focal species for future research

All species evaluated here need further research to improve our knowledge and fill gaps. There are several avenues that could be taken to improve knowledge and better inform the identification of HoPS for these species:

1) **High risk species**: There are several approaches that can be used to inform risk and prioritise research for species considered to be more susceptible to human activities. These approaches include national fisheries risk assessments (e.g., Ford et al. 2015, 2018, Edwards 2025, Edwards et al. 2025), national threat status evaluated through the New Zealand Threat Classification System (Duffy et al. in press), or global threat status determined by the IUCN Red List of Threatened Species (IUCN 2025). Generally, species considered most at-risk and at an elevated threat status are consistent across the approaches, and include basking shark, leafscale gulper shark, Plunket's shark, and seal shark.
2) **New Zealand endemic species**: These are species that are not found anywhere else, so HoPS must be located somewhere in New Zealand waters (as well as other similar applications such as ISRAs). These species include the ghost sharks (Pale ghost shark, dark ghost shark), carpet shark, and skates (smooth skate, rough skate).
3) **Accessible species**: There are several coastal species where a similar study to Francis et al. (2012) could be replicated to explore suspected HoPS and quantify the importance of these HoPS. These species include elephantfish, school shark, carpet shark, and possibly rough skate. A re-evaluation of the Francis et al. (2012) study for rig is also warranted given that this study is now 14 years old and some of the 'high-value' habitats identified in 2011 are likely to have undergone considerable human impact since the completion of that project. A targeted study here would allow for some quantification of habitat importance (i.e., are all habitats of equal value?).
4) **Data poor species:** There were four species identified in this project where no potential HoPS could be identified, basking shark, mako, porbeagle, and blue shark. These species are all considered highly migratory and are known to occur beyond New Zealand waters (i.e., Areas Beyond National Jurisdiction or ABNJ). International collaboration in the wider South Pacific region would be needed to identify habitat use, seasonality, and movement patterns so that HoPS could be sufficiently identified.

It is also important to note that many chondrichthyans (~90 species) occurring in New Zealand waters were not evaluated in this project. Some species have overlapping distribution with the species of interest here (see Appendix 4) and may also be considered for inclusion in the proposed HoPS with further evaluation of data availability. Others, such as Eagle ray and Smooth hammerhead, have considerable habitat overlap with anthropogenic activities; their habitats are likely to be highly impacted and should be considered in future analysis.

5.2 Focal areas for future research

The New Zealand marine environment is vast, and there are many areas that could not be considered here due to a lack of data, or a lack of recent data. Some suggestions are provided below, but this list is not exhaustive:

1) **North Island (generally):** The hiatus in inshore trawl surveys in this region from 2000 until relatively recently (2018) means that there are few contemporary data available for inshore waters surrounding the North Island. The deep-sea environment is also particularly data poor. East Cape and the eastern Bay of Plenty were identified as areas of interest for blue shark and mako and should be investigated.
2) **Coastal habitats (e.g., estuaries, harbours):** These habitats are used by many inshore species, but there are few quantitative data available to assess their use over time and their relative importance (i.e., are some areas of 'higher value' than others).
3) **West Coast South Island, Hokitika Trench:** These areas appear to be important, particularly for commercially important species like school shark, and possibly for basking shark as well, where several small (3–3.5 m) individuals have been reported as fisheries bycatch or washed up on shore. Contemporary tagging studies would be useful to show species' movement and habitat use in this region.
4) **Bounty Plateau:** There are relatively high commercial catches of smooth and rough skate from this region, as previously identified in Francis (2015a). There are no biological data to inform the importance, if any, of this habitat to these species.
5) **Snares Shelf:** There are relatively high numbers of commercial fishing interactions with protected species (white shark, basking shark) in this area and it is unclear why these species occur here. Other high-risk species, such as Plunket's shark, are also reported from this area.
6) **Cook Strait Canyon, Kaikoura Canyon:** There are few contemporary data available here, but these were areas of interest for deepwater species, including Plunket's shark and seal shark (amongst others), for some of the earliest studies conducted on deepwater chondrichthyans in New Zealand (e.g., Garrick 1959a).

5.3 Reference material: egg case identification guide

Many (~40%) of New Zealand chondrichthyans are oviparous, meaning that the first life stage for these species occurs in an egg case. This sedentary life stage can be extensive, with some deepwater skate embryos estimated to have up to a four-year development stage before hatching (Hoff 2008). This is arguably the most vulnerable life stage, where embryos are exposed to predation, extreme weather events, and anthropogenic disturbance. There is insufficient knowledge to determine if all oviparous species have 'egg-laying' grounds (i.e., specific areas where egg cases are dropped), however, there are some observations of large numbers of egg cases in defined areas within New Zealand waters (e.g., elephantfish egg cases in Marlborough Sounds), suggesting that at least some species do engage in this behaviour. However, it is difficult, if not impossible, to identify egg cases to the species level because there is a lack of sufficient reference material.

There are many egg cases currently held in museum collections, although most material was collected decades ago (pre-1980s) and is often misidentified, or identified to a more generic category (e.g., skate egg case, Rajidae). For example, an egg case (P.006782) held at Te Papa was collected on the Campbell Rise in 1976 and labelled as an elephantfish egg case at the time of collection. Upon further inspection, it was determined this egg case belongs to the family Rhinochimaeridae (species cannot be identified at this time). Egg cases are also occasionally picked up by research trawl surveys, and if they are recorded, they are recorded under a generic egg case code (EGC), making it impossible to conclude anything beyond the fact that a chondrichthyan egg case was collected at a specific location and depth. Identification guides have become invaluable resources for fisheries independent and dependent data collection, and an egg case guide specific to New Zealand chondrichthyans would be helpful in collecting information on where, and when, these species are laying their eggs. To create a guide, there would be a need to increase museum collection material, which would require gravid females and the egg cases to confirm species identification. Reference genetic sequences would also be useful.

6. FULFILMENT OF BROADER OUTCOMES

As required under Government Procurement rules[9], Fisheries New Zealand considered broader outcomes (secondary benefits such as environmental, social, economic or cultural benefits) that would be generated by this project. The following broader outcomes were delivered:

Building capacity and capability in the research sector
The team working on the project brought together a diverse range of skill sets and experience levels, including early career researchers (ECRs), and building capacity in fisheries science and spatial management.

[9] https://www.procurement.govt.nz/procurement/principles-charter-and-rules/government-procurement-rules/planning-your-procurement/broader-outcomes/

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9. APPENDIX 1: NIWA's Macroscopic Staging Key for chondrichthyans

Table Appendix 1 NIWA's Macroscopic Staging Key for chondrichthyans

Stage	Name	Male	Female	Class for this project
1	Immature	Claspers shorter than pelvic fins, soft and uncalcified, unable or difficult to splay open	Ovaries small and undeveloped. Oocytes not visible, or small (pin-head sized) and translucent whitish	Young-of-the-year or juvenile, depending on size
2	Maturing	Claspers longer than pelvic fins, soft and uncalcified, unable or difficult to splay open or rotate forwards	Some oocytes enlarged, up to about pea-sized or larger, and white to cream	Juvenile
3	Mature	Claspers longer than pelvic fins, hard and calcified, able to splay open and rotate forwards to expose clasper spine	Some oocytes large (greater than pea-sized) and yolky (bright yellow)	Mature
4	Gravid I	Not applicable	Uteri contain eggs or egg cases but no embryos are visible	Reproductively active
5	Gravid II	Not applicable	Uteri contain visible embryos. Not applicable to oviparous species	Reproductively active
6	Post-partum	Not applicable	Uteri flaccid and vascularised indicating recent birth	Reproductively active

10. APPENDIX 2: Distribution and kernel density estimate (KDE) for juveniles

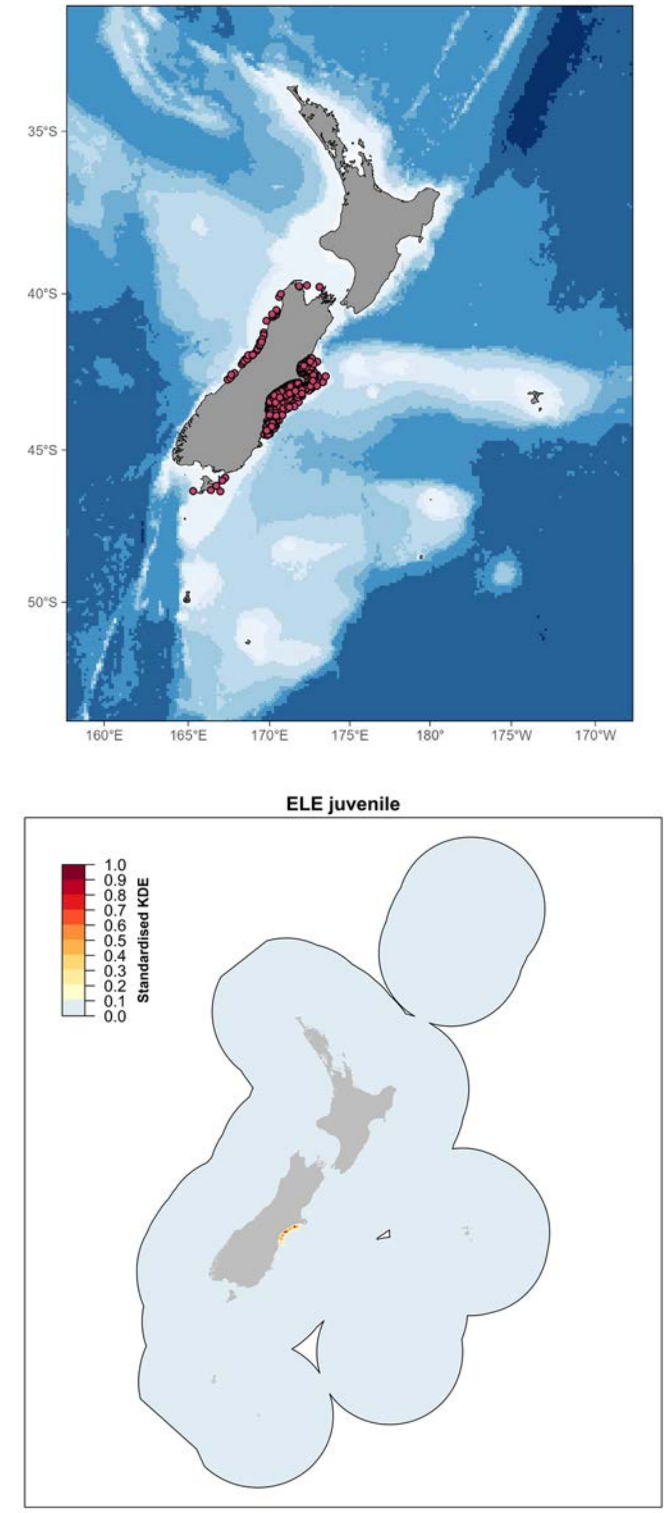
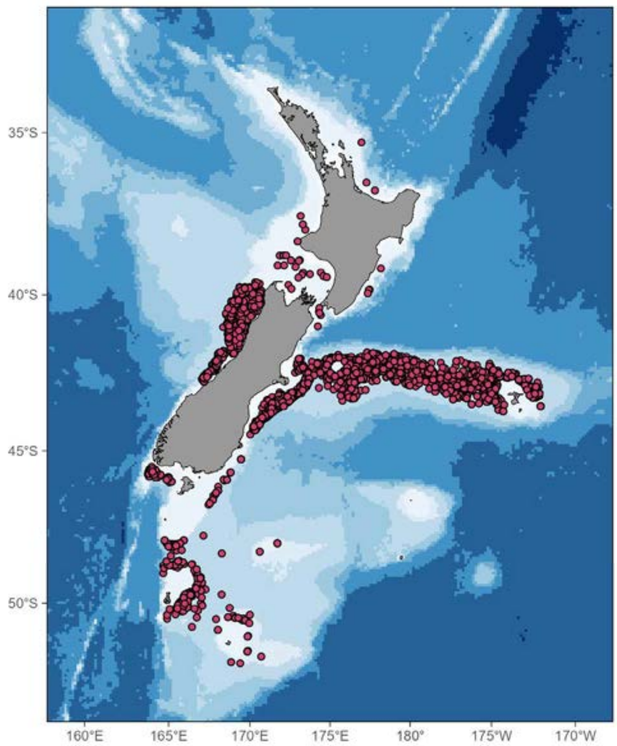


Figure Appendix 1: Research trawl survey records for elephantfish from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.



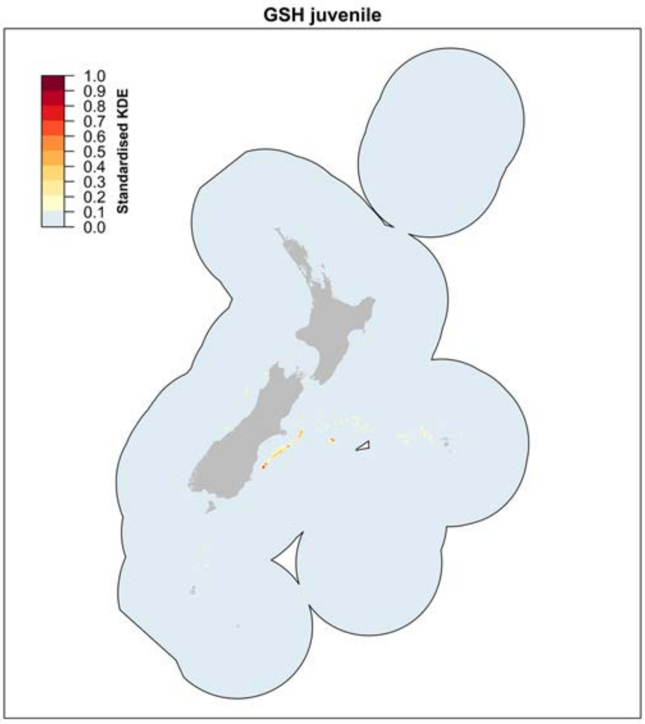
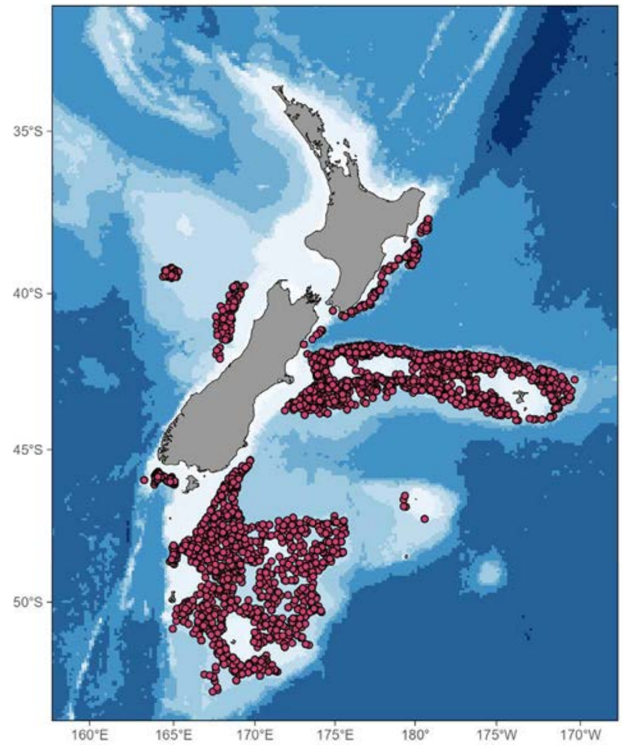


Figure Appendix 2: Research trawl survey records for dark ghost shark from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.



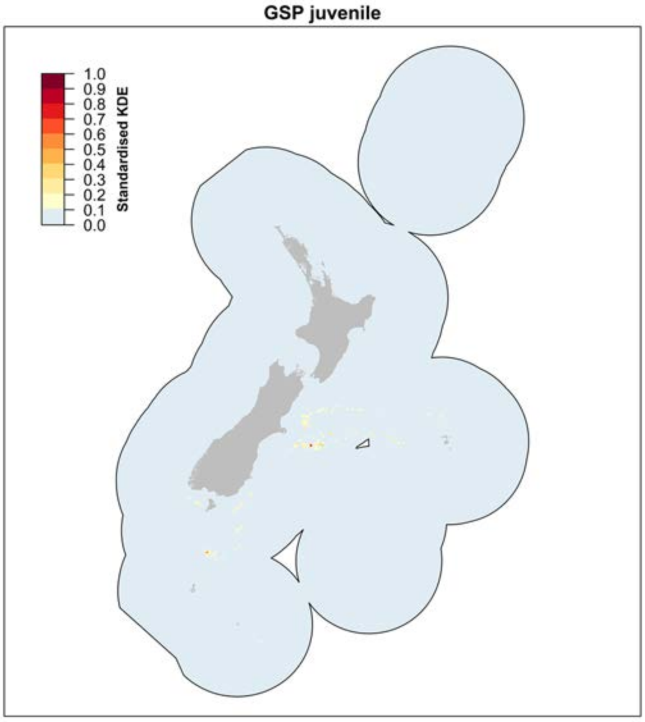
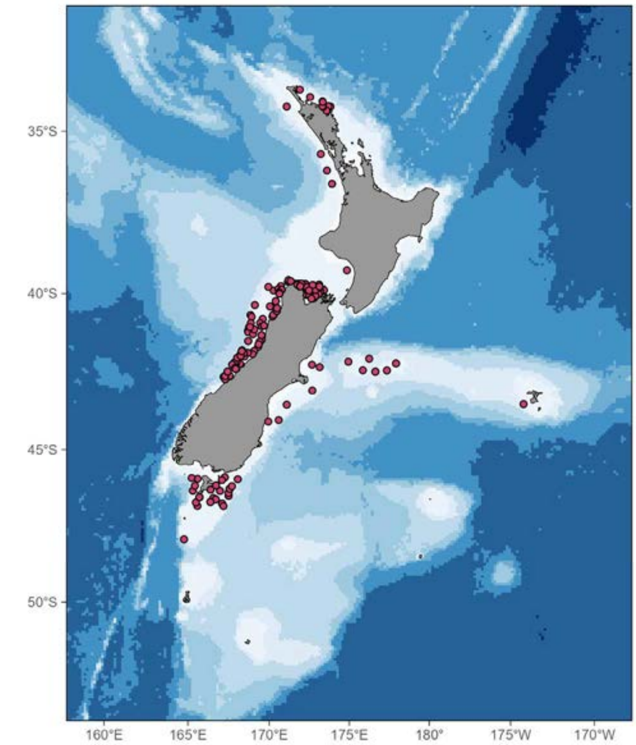


Figure Appendix 3: Research trawl survey records for pale ghost shark from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.



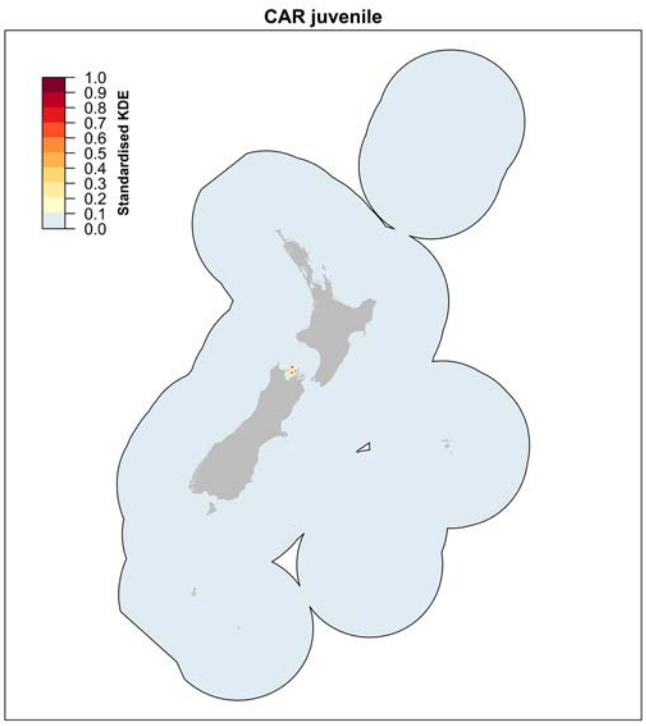
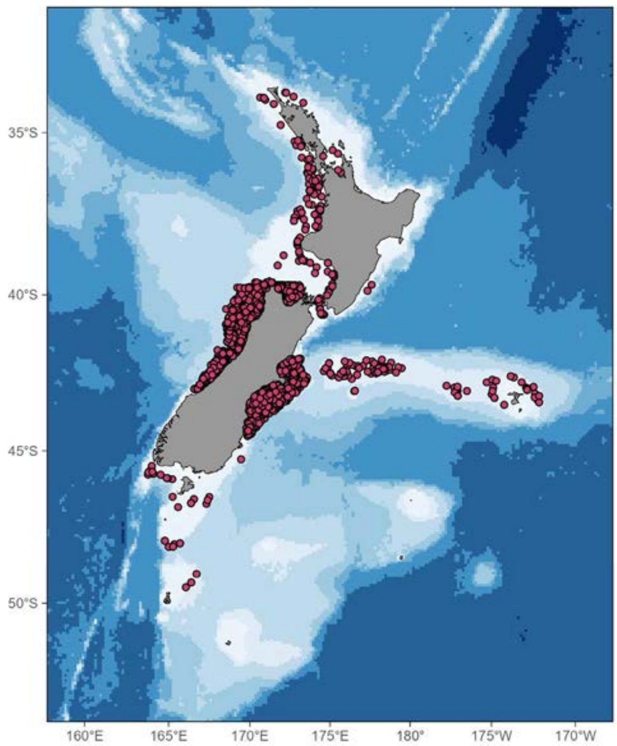


Figure Appendix 4: Research trawl survey records for carpet shark from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.



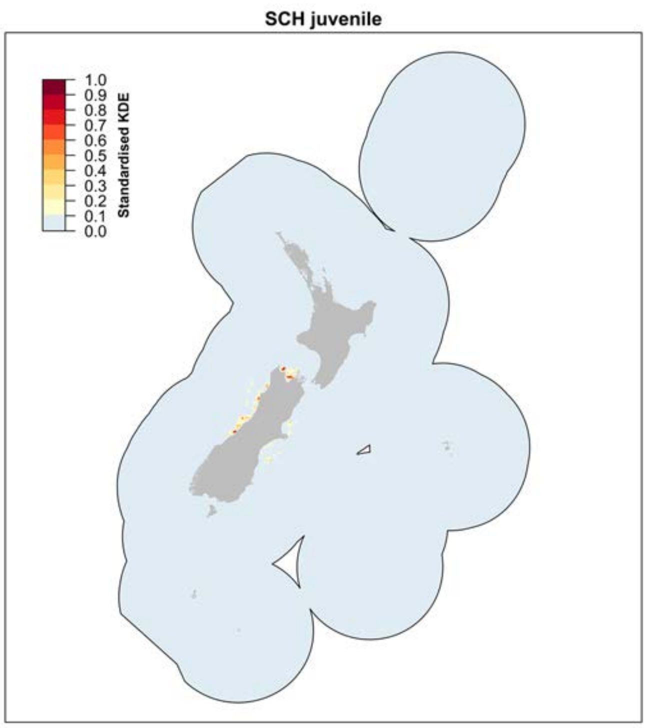
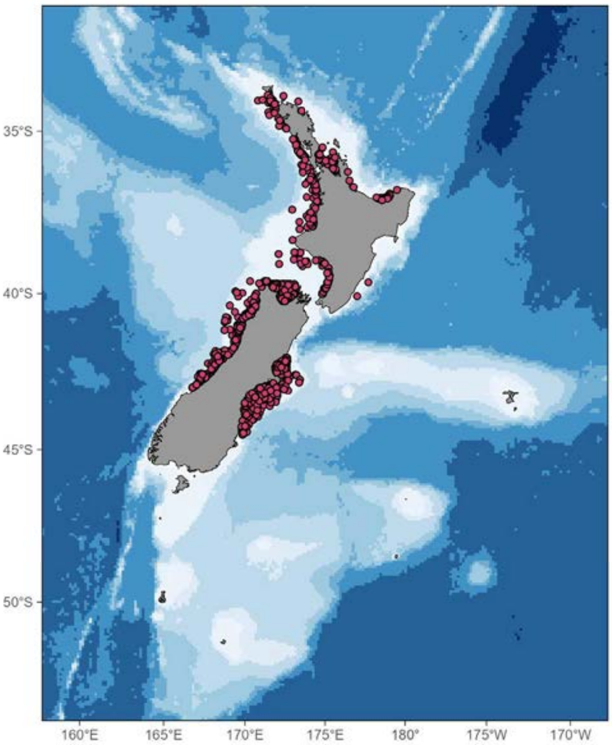


Figure Appendix 5: Research trawl survey records for school shark from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.



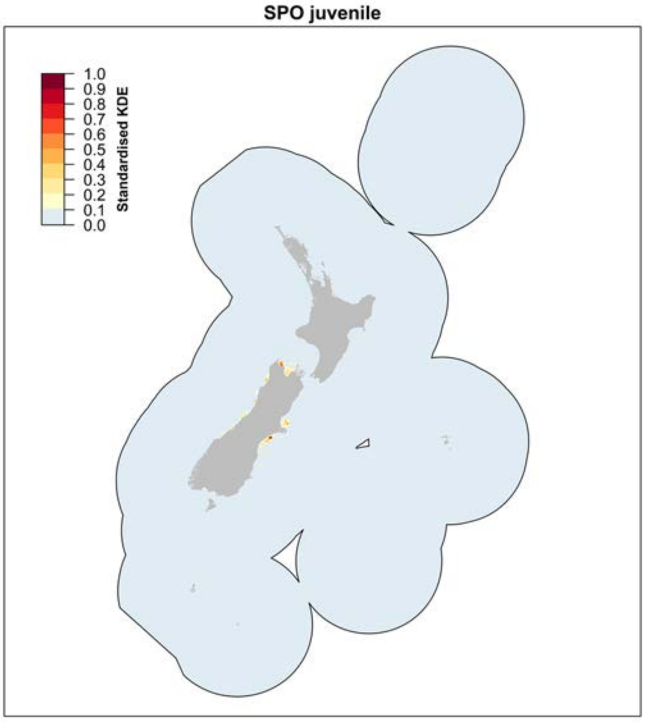
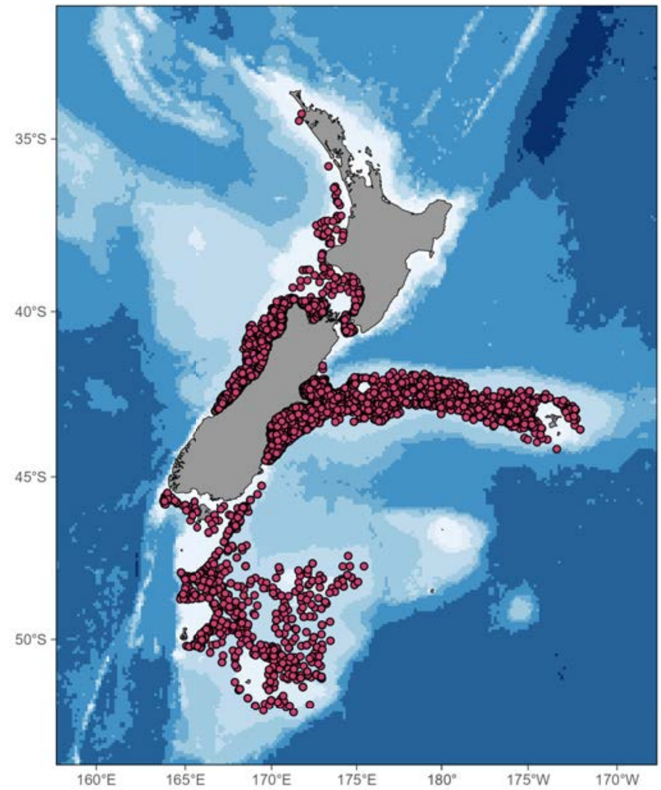


Figure Appendix 6: Research trawl survey records for rig from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.



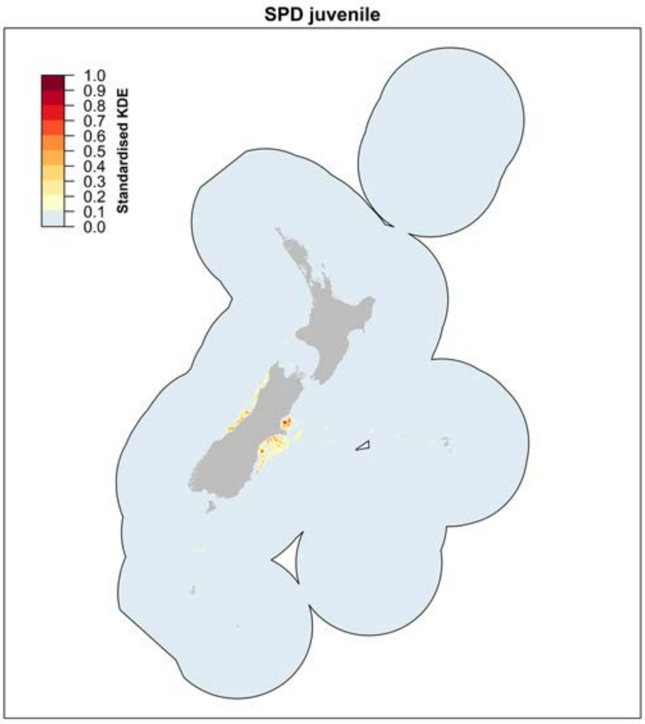


Figure Appendix 7: Research trawl survey records for spiny dogfish from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

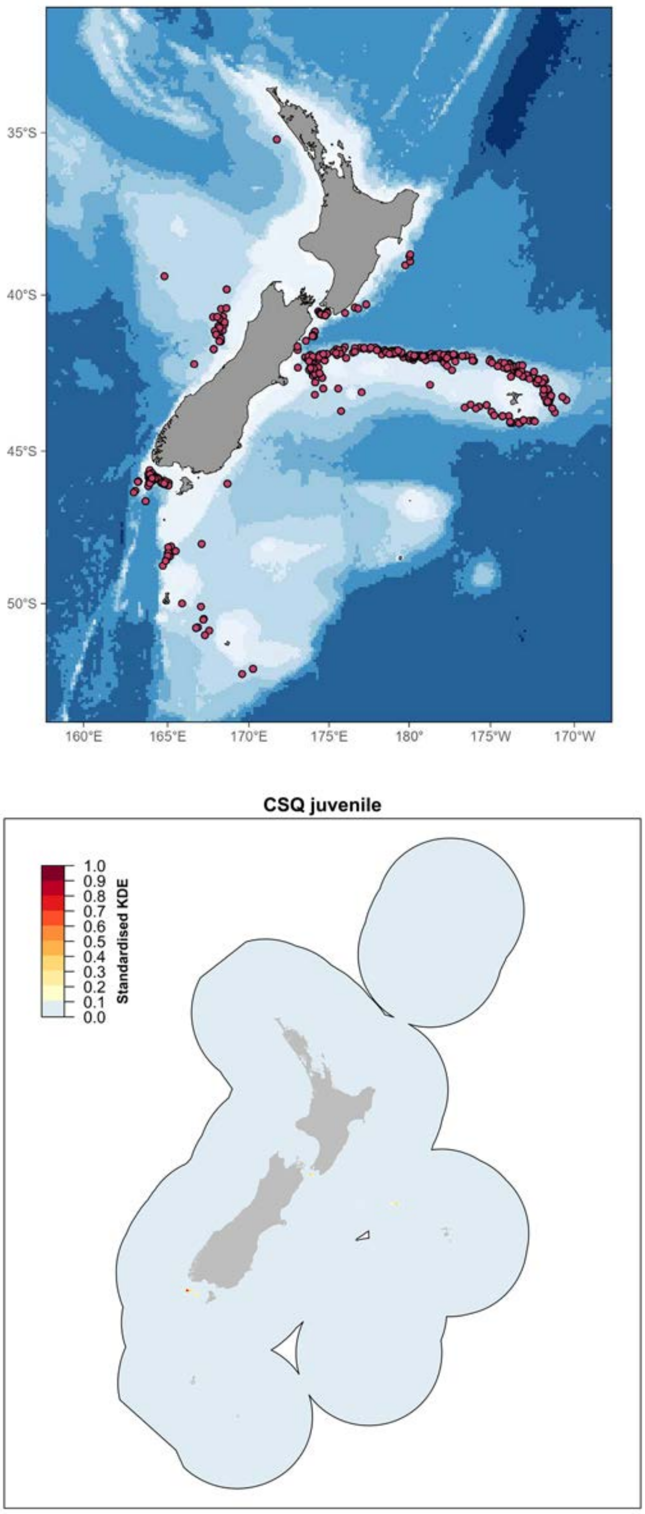
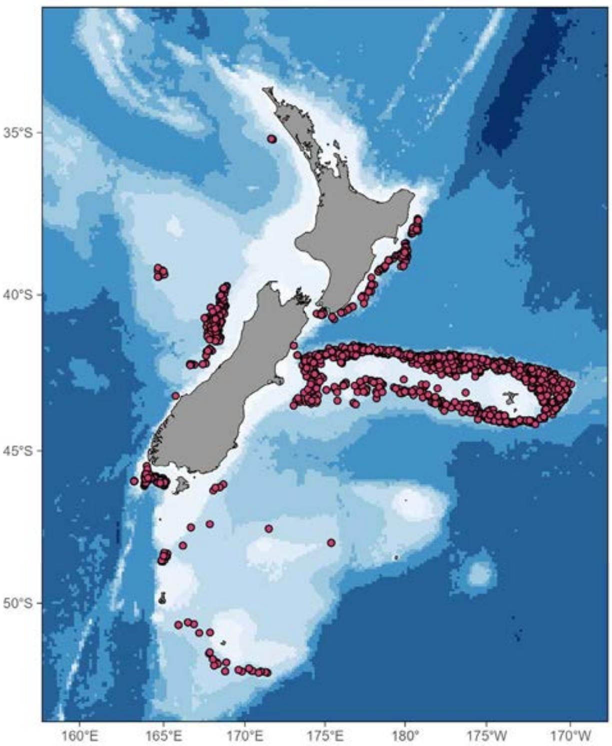


Figure Appendix 8: Research trawl survey records for leafscale gulper shark from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.



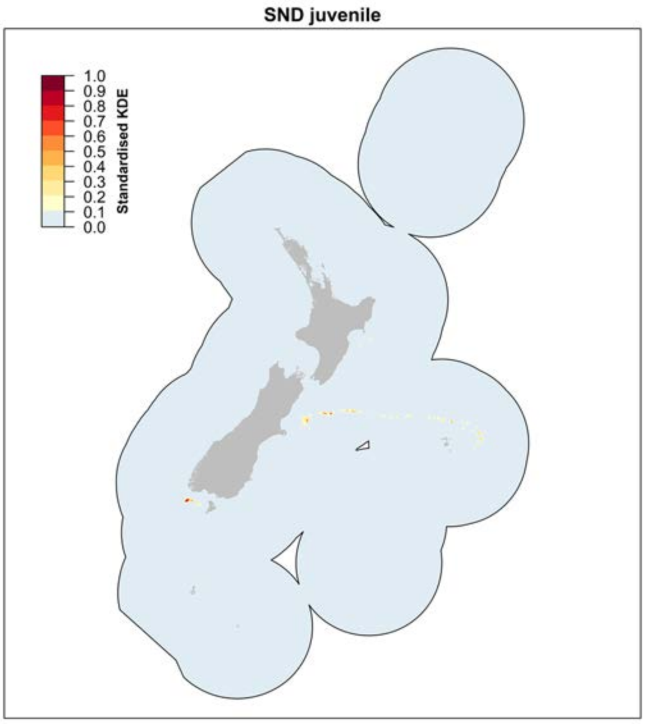
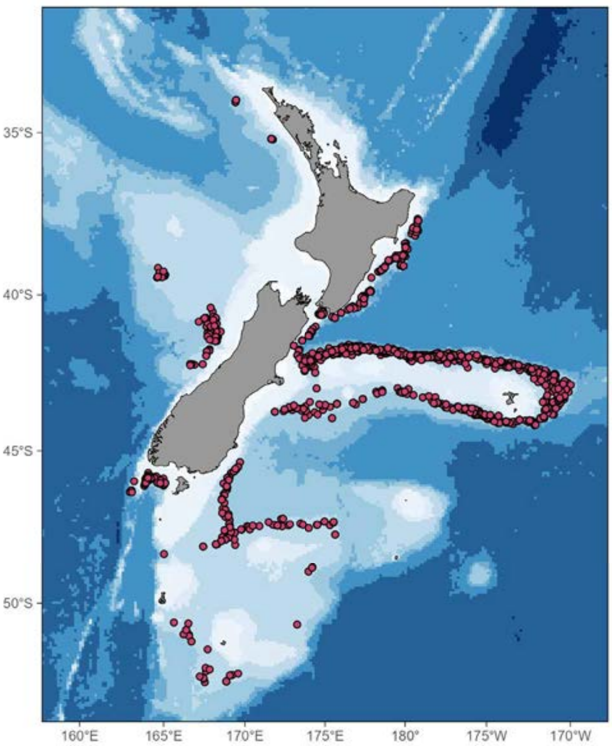


Figure Appendix 9: Research trawl survey records for shovelnose dogfish from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.



CYP juvenile

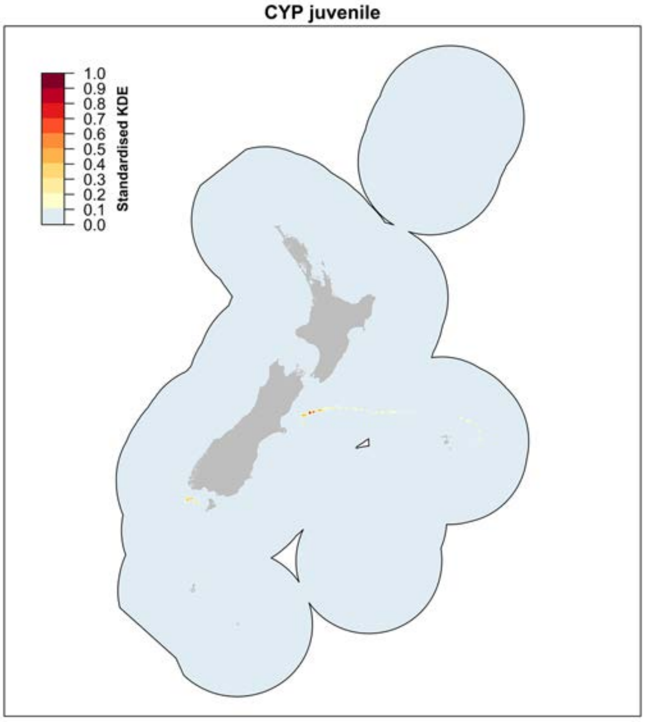
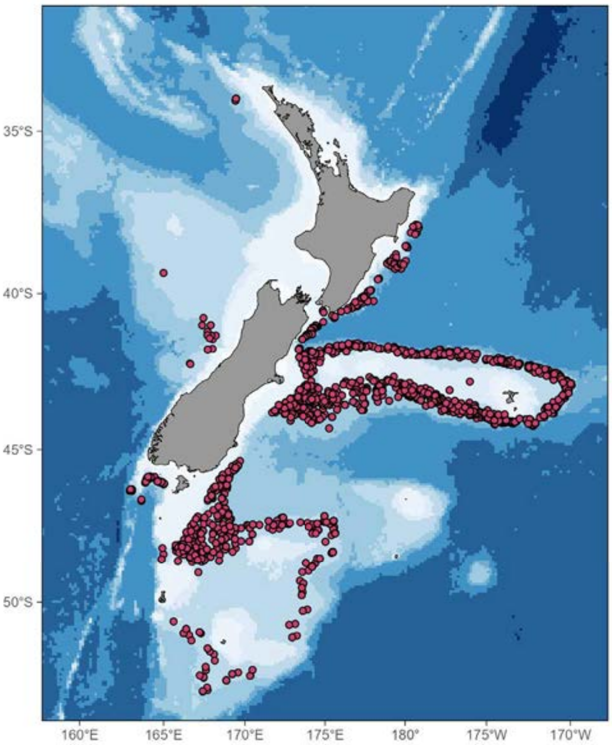


Figure Appendix 10: Research trawl survey records for longnose velvet dogfish from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.



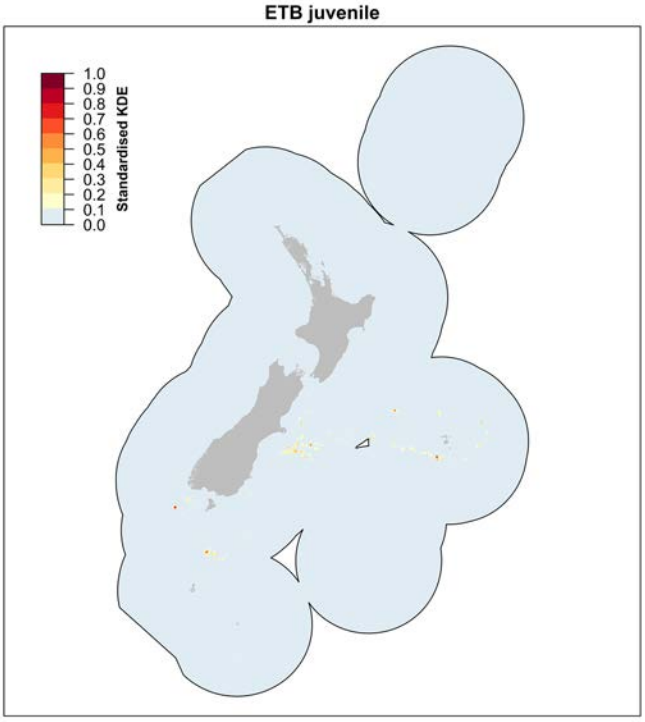


Figure Appendix 11: Research trawl survey records for Baxter's dogfish from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

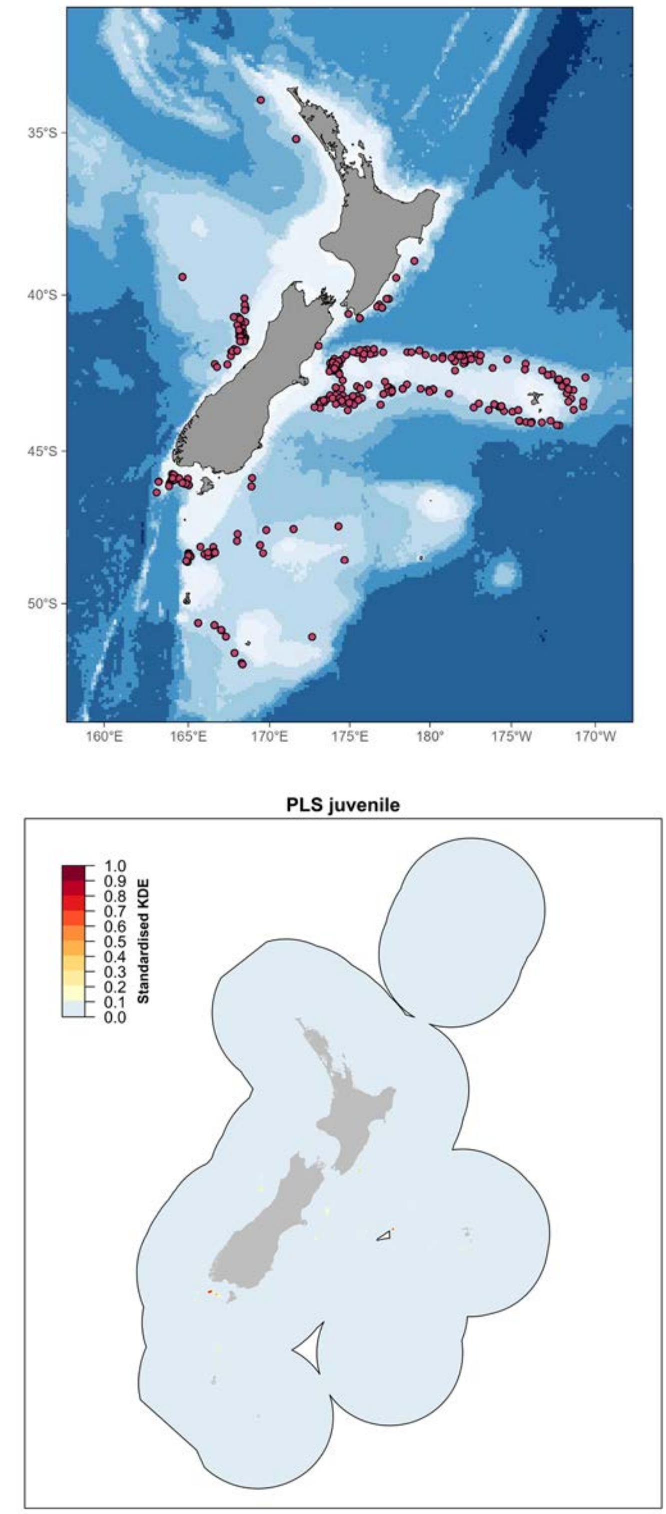


Figure Appendix 12: Research trawl survey records for Plunket's dogfish from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

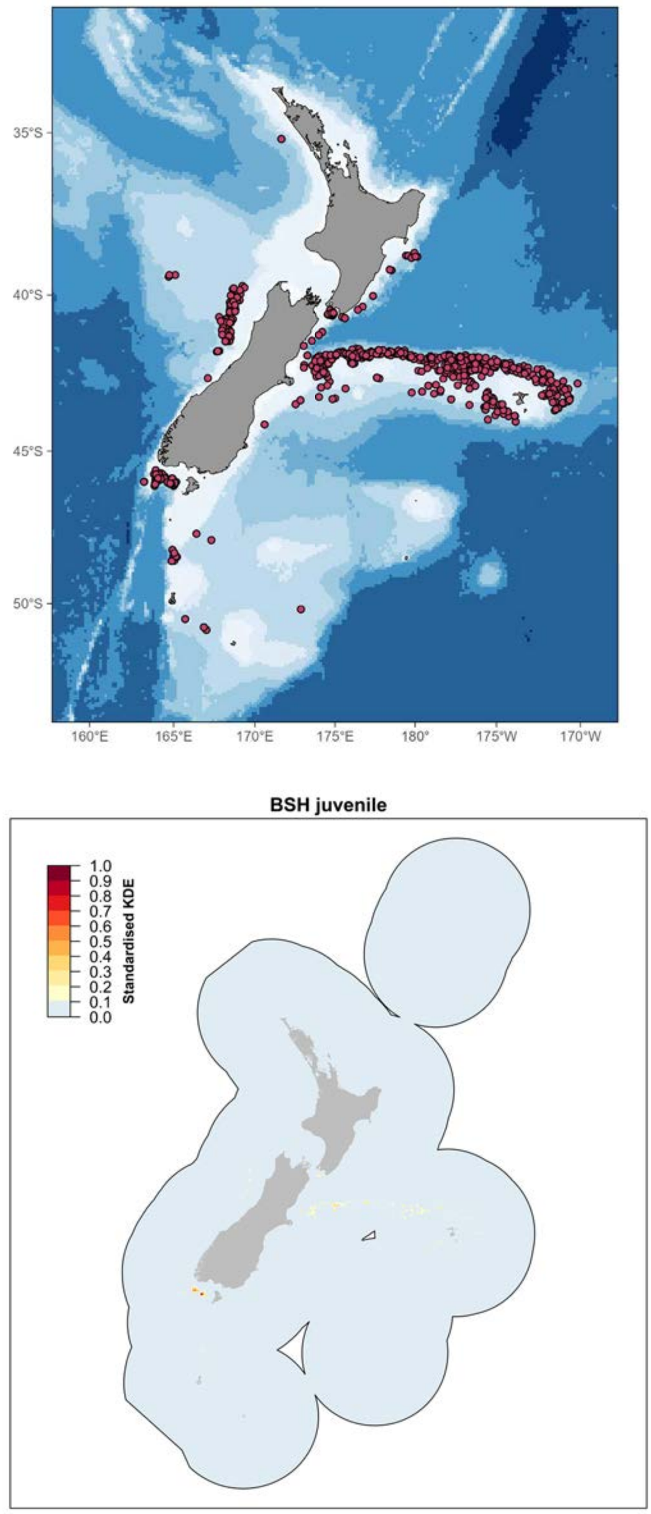


Figure Appendix 13: Research trawl survey records for seal shark from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

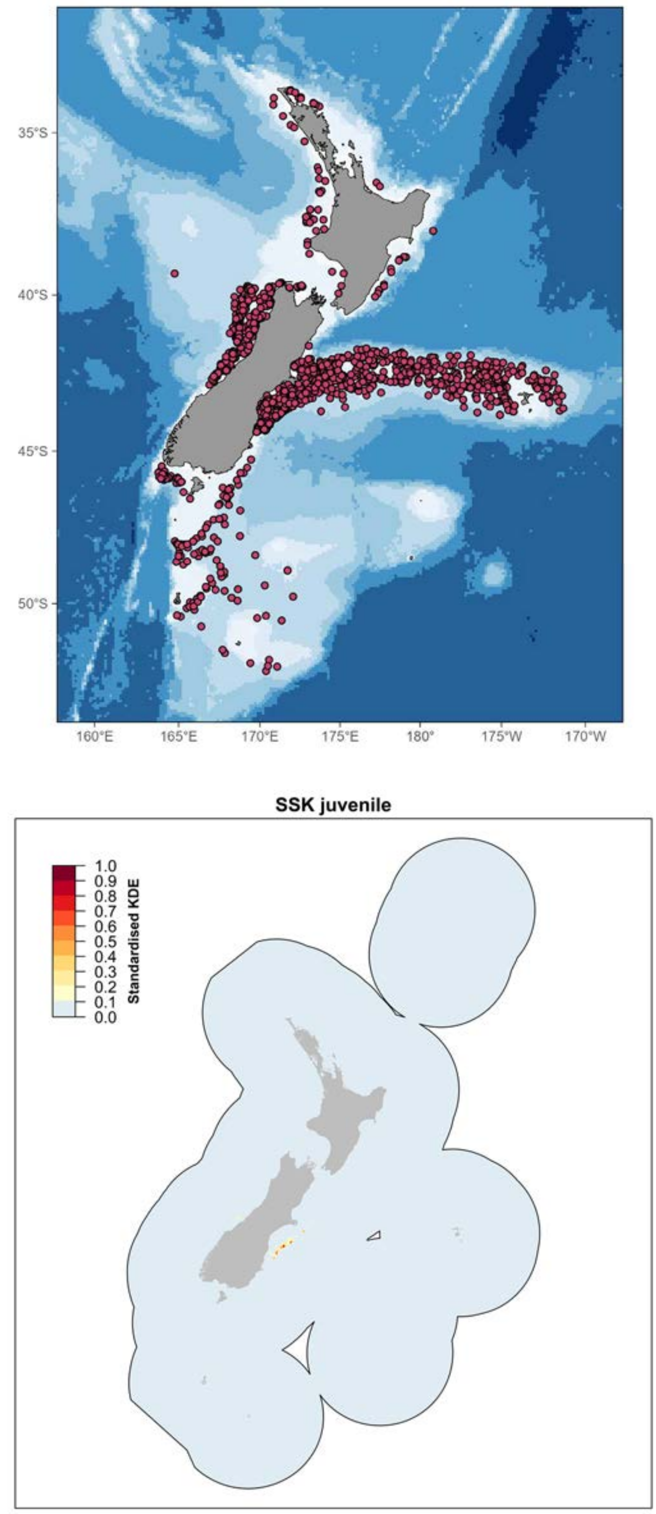
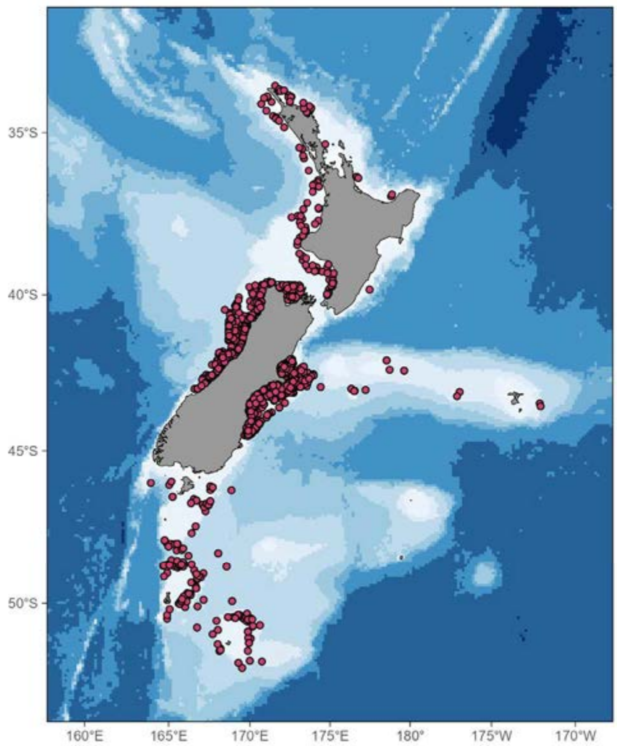


Figure Appendix 14: Research trawl survey records for smooth skate from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.



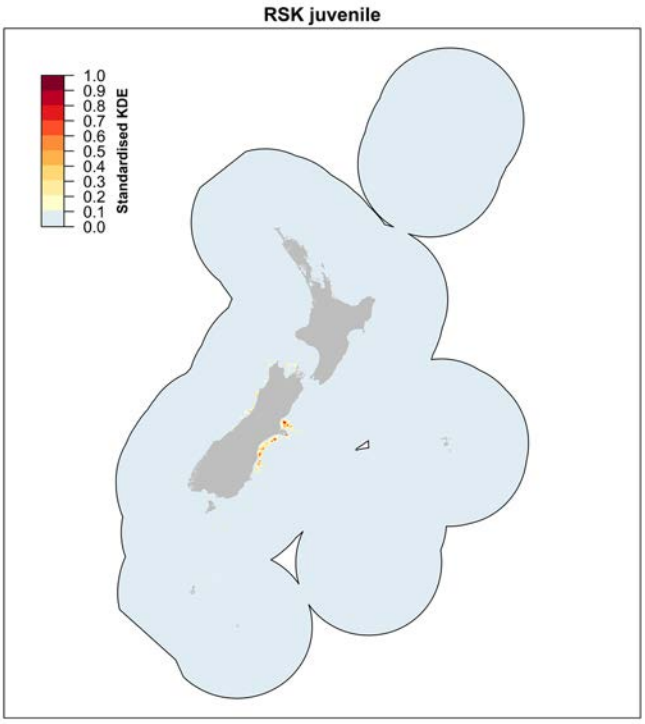


Figure Appendix 15: Research trawl survey records for rough skate from 2000 to 2024 for (top) juveniles and (bottom) kernel density estimate (KDE) for research trawl survey records. Note: standardised KDE values between 0–0.1 are represented as blue to place emphasis on areas with moderate to high KDE i.e., the signal of single occurrences is masked.

11. APPENDIX 3: KDEs for combined species observations

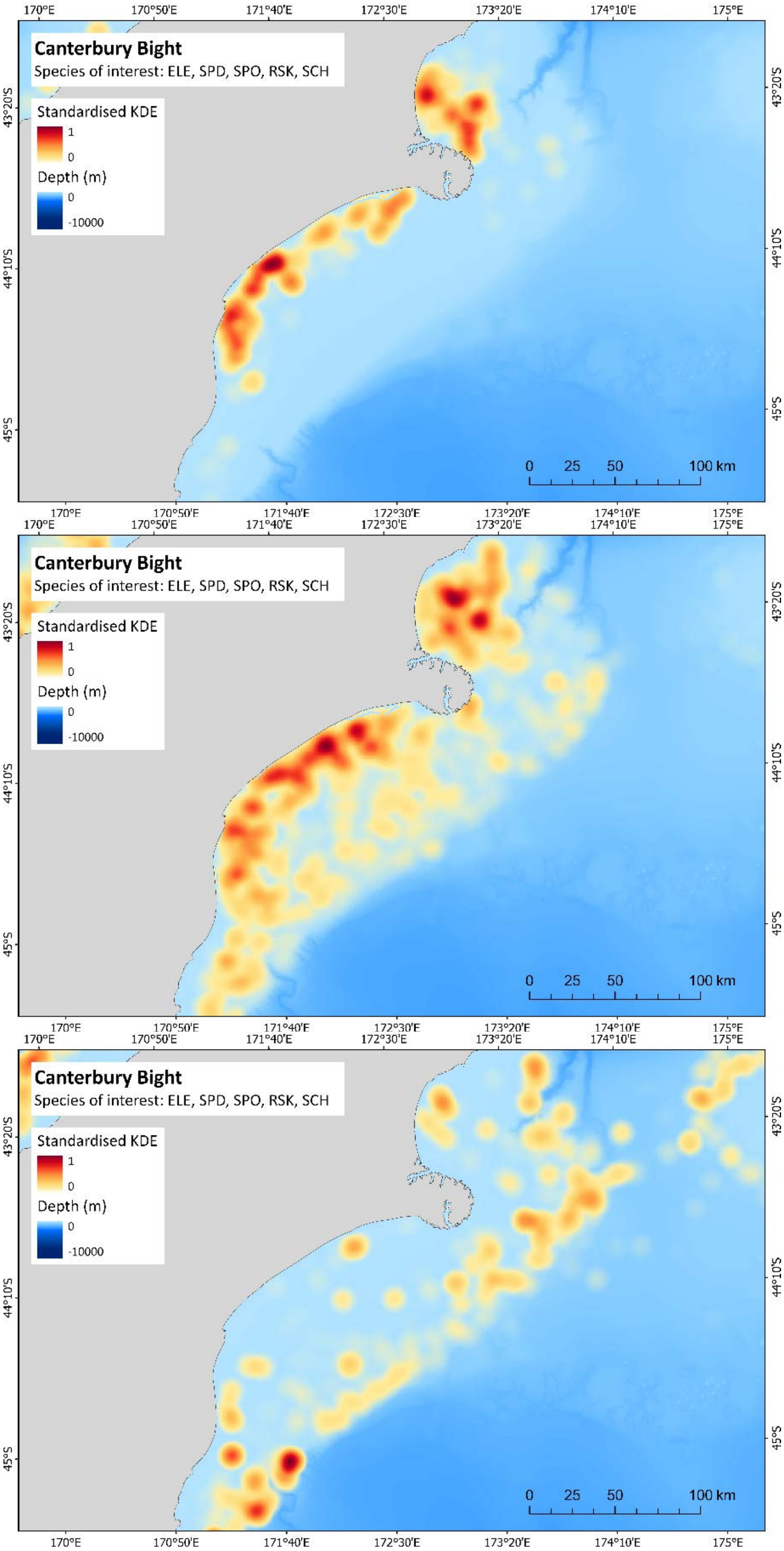


Figure Appendix 16: Kernel density estimate (KDE) for combined species observations of young-of-the-year (top panel), juveniles (middle panel), and reproductively active females (bottom panel) for Canterbury Bight and Pegasus Bay (3. Canterbury_Bight; 20. Pegasus Bay). Species of interest are: elephantfish (ELE), spiny dogfish (SPD), rig (SPO), rough skate (RSK), and school shark (SCH).

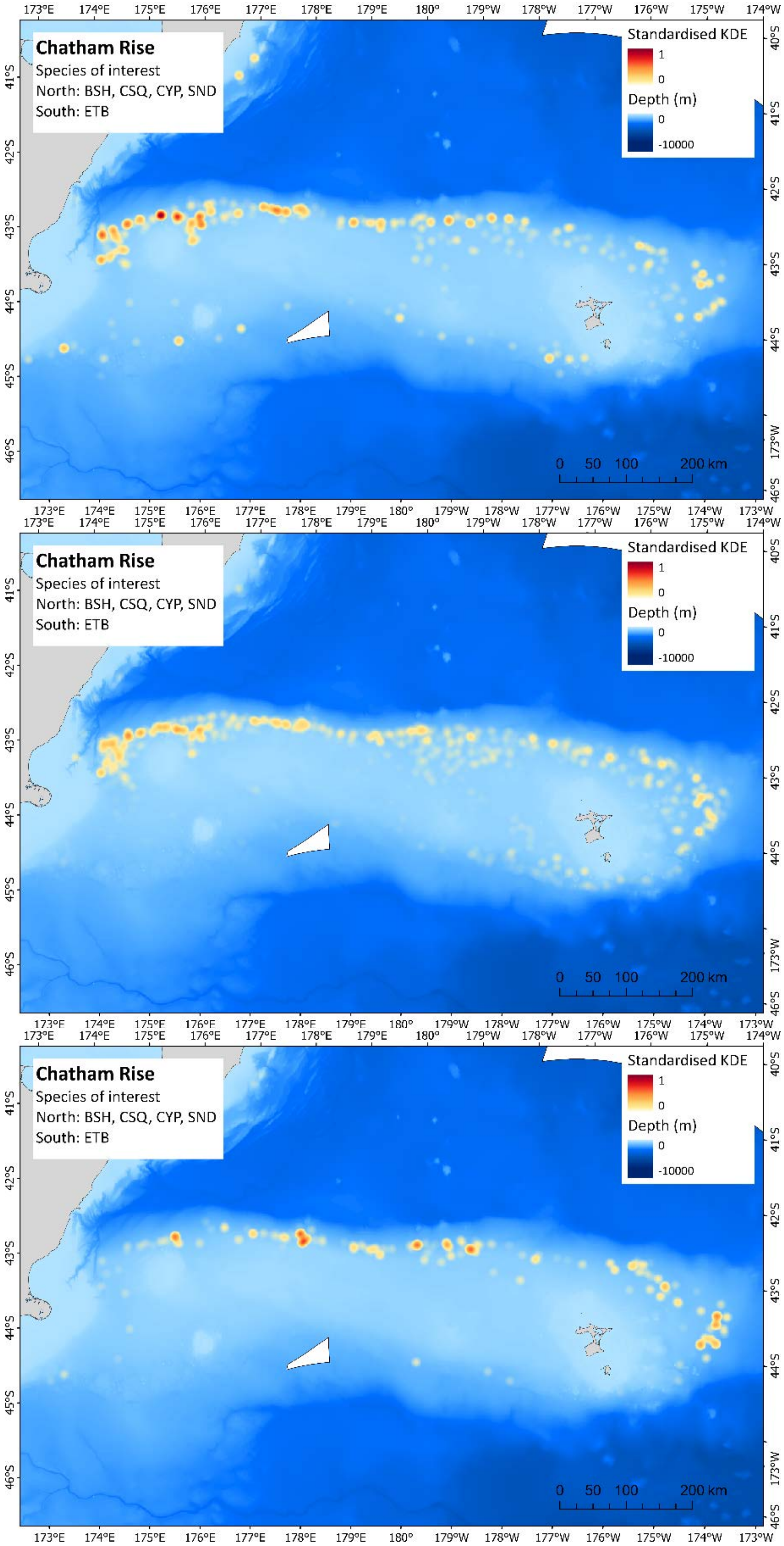


Figure Appendix 17: Kernel density estimate (KDE) for combined species observations of young-of-the-year (top panel), juveniles (middle panel), and reproductively active females (bottom panel) for Chatham Rise North (5. Chath_Rise_N_1; 6. Chath_Rise_N_2; 7. Chath_Rise_N3; 8. Chath_Rise_N_4). Species of interest are: seal shark (BSH), leafscale gulper shark (CSQ), longnose velvet dogfish (CYP), and shovelnose dogfish (SND).

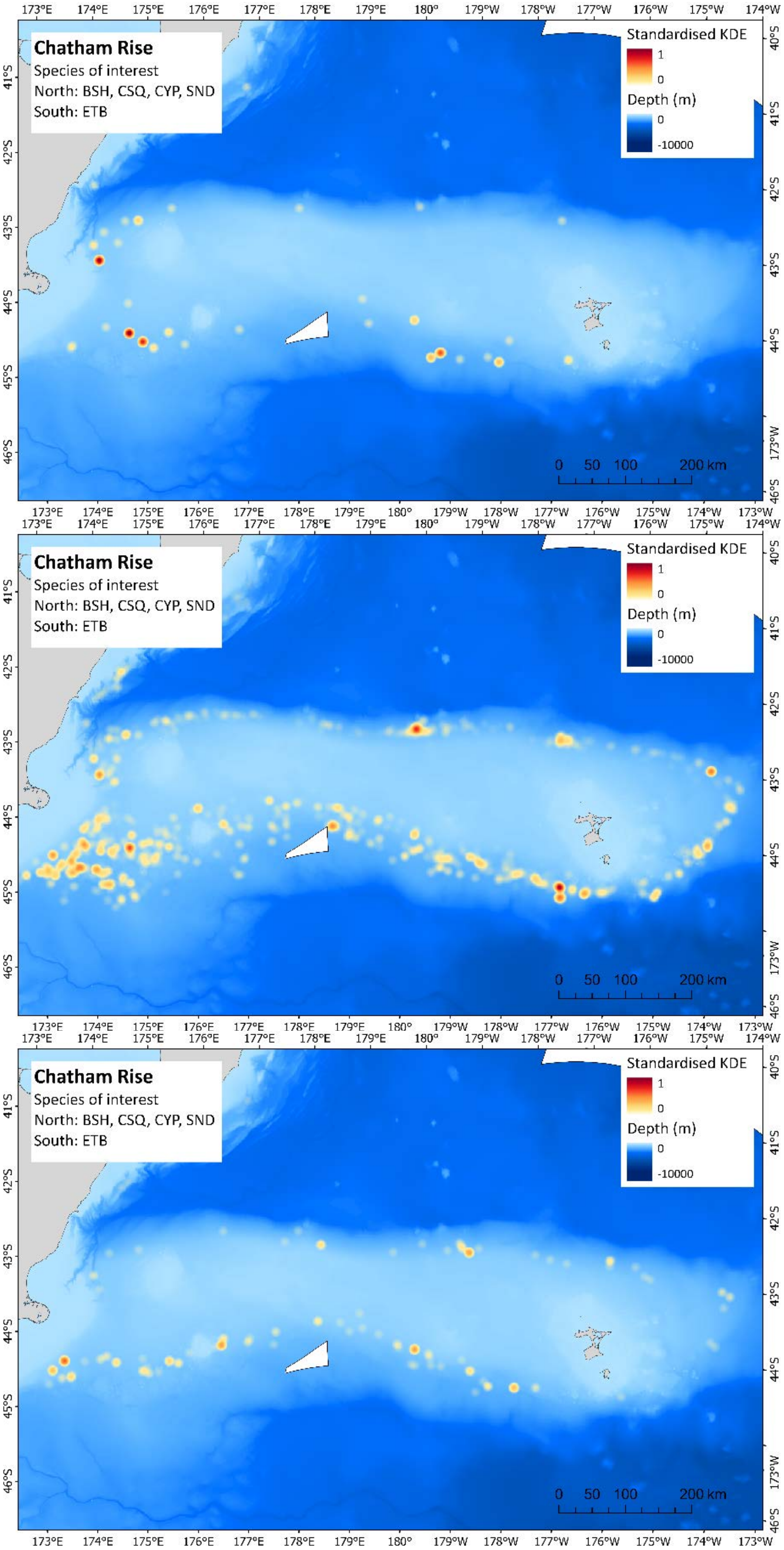


Figure Appendix 18: Kernel density estimate (KDE) for combined species observations of young-of-the-year (top panel), juveniles (middle panel), and reproductively active females (bottom panel) for Chatham Rise South (9. Chath_Rise_S_1). Species of interest are: Baxter's dogfish (ETB).

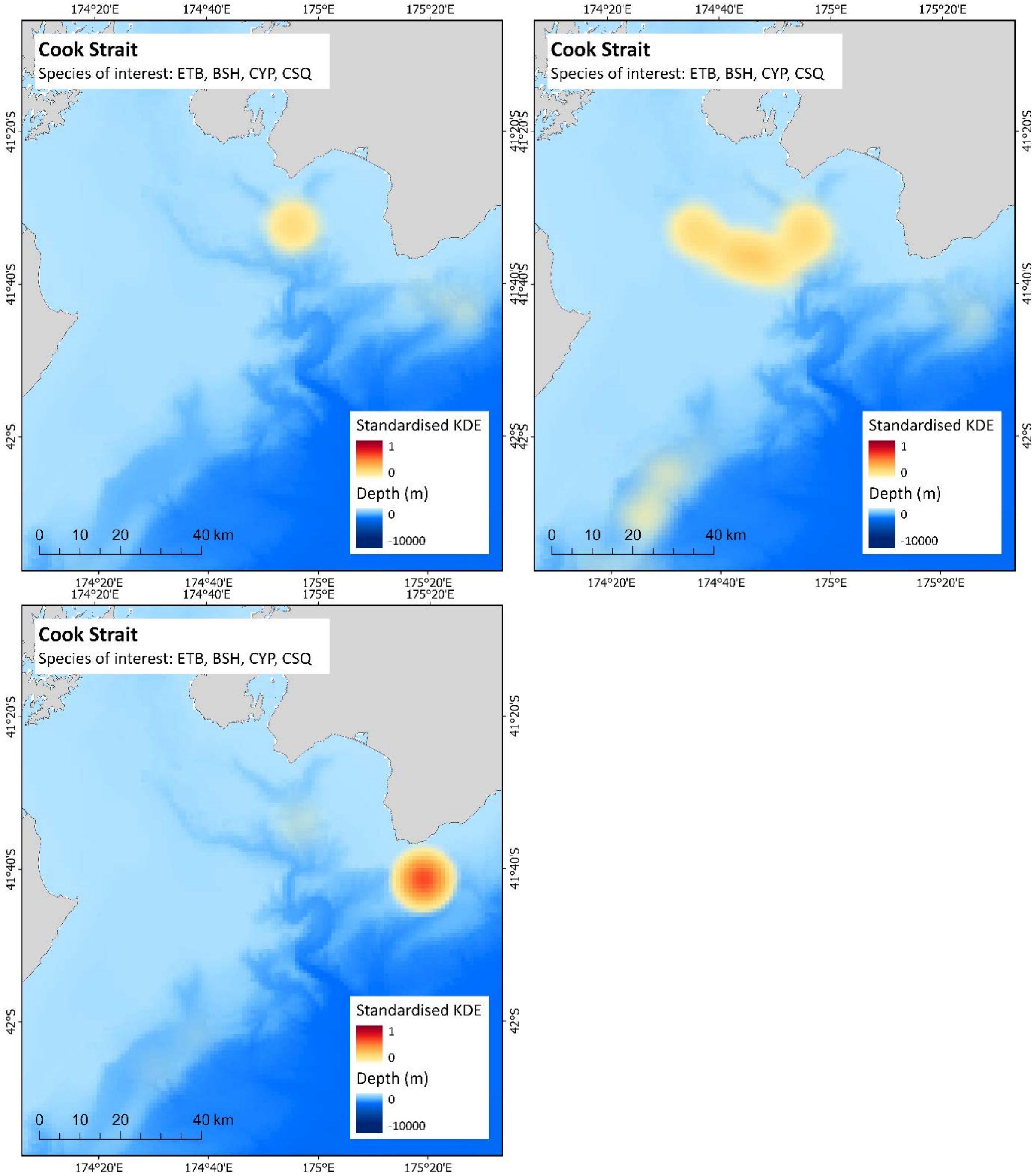


Figure Appendix 19: Kernel density estimate (KDE) for combined species observations of young-of-the-year (top panel), juveniles (middle panel), and reproductively active females (bottom panel) for Cook Strait (10. Cook_Strait). Species of interest are: Baxter's dogfish (ETB), seal shark (BSH), longnose velvet dogfish (CYP), and leafscale gulper shark (CSQ).

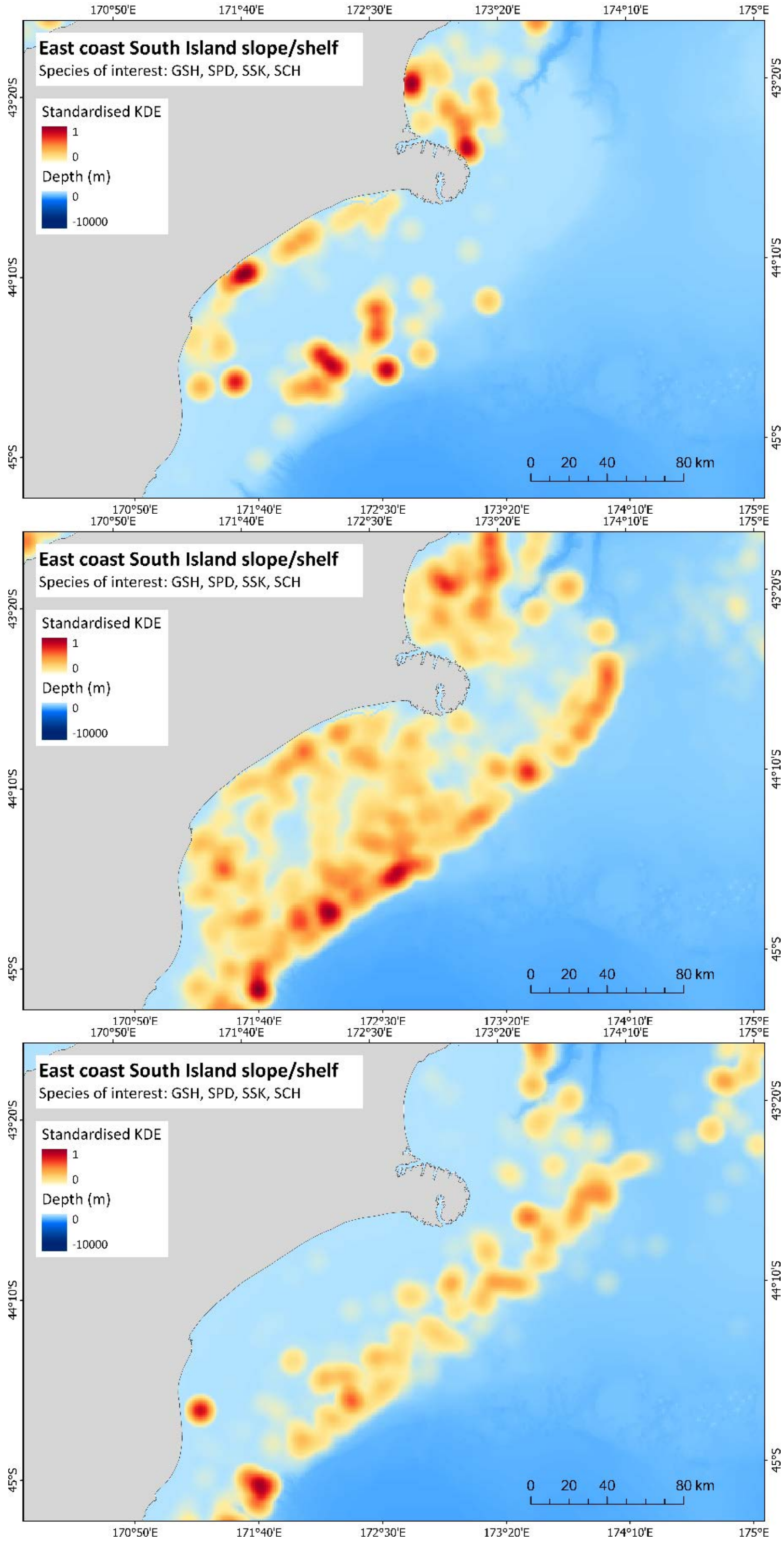


Figure Appendix 20: Kernel density estimate (KDE) for combined species observations of young-of-the-year (top panel), juveniles (middle panel), and reproductively active females (bottom panel) for Canterbury Shelf Break (11. East_Coast_SI). Species of interest are: dark ghost shark (GSH), spiny dogfish (SPD), smooth skate (SSK), and school shark (SCH).

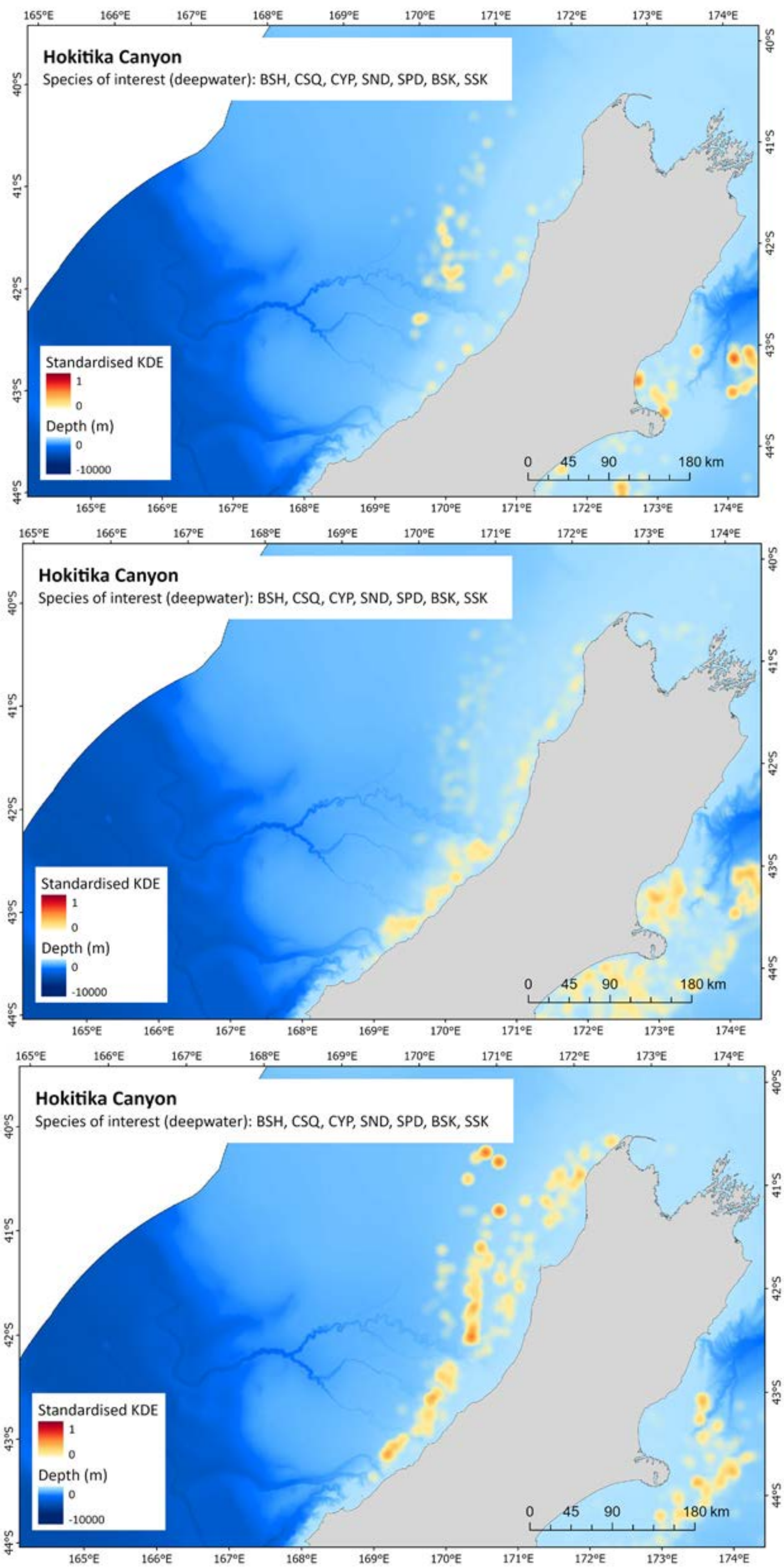


Figure Appendix 21: Kernel density estimate (KDE) for combined species observations of young-of-the-year (top panel), juveniles (middle panel), and reproductively active females (bottom panel) for Hokitika Canyon (13. Hokitika). Species of interest are: seal shark (BSH), leafscale gulper shark (CSQ), longnose velvet dogfish (CYP), shovelnose dogfish (SND), spiny dogfish (SPD), basking shark (BSK), and smooth skate (SSK).

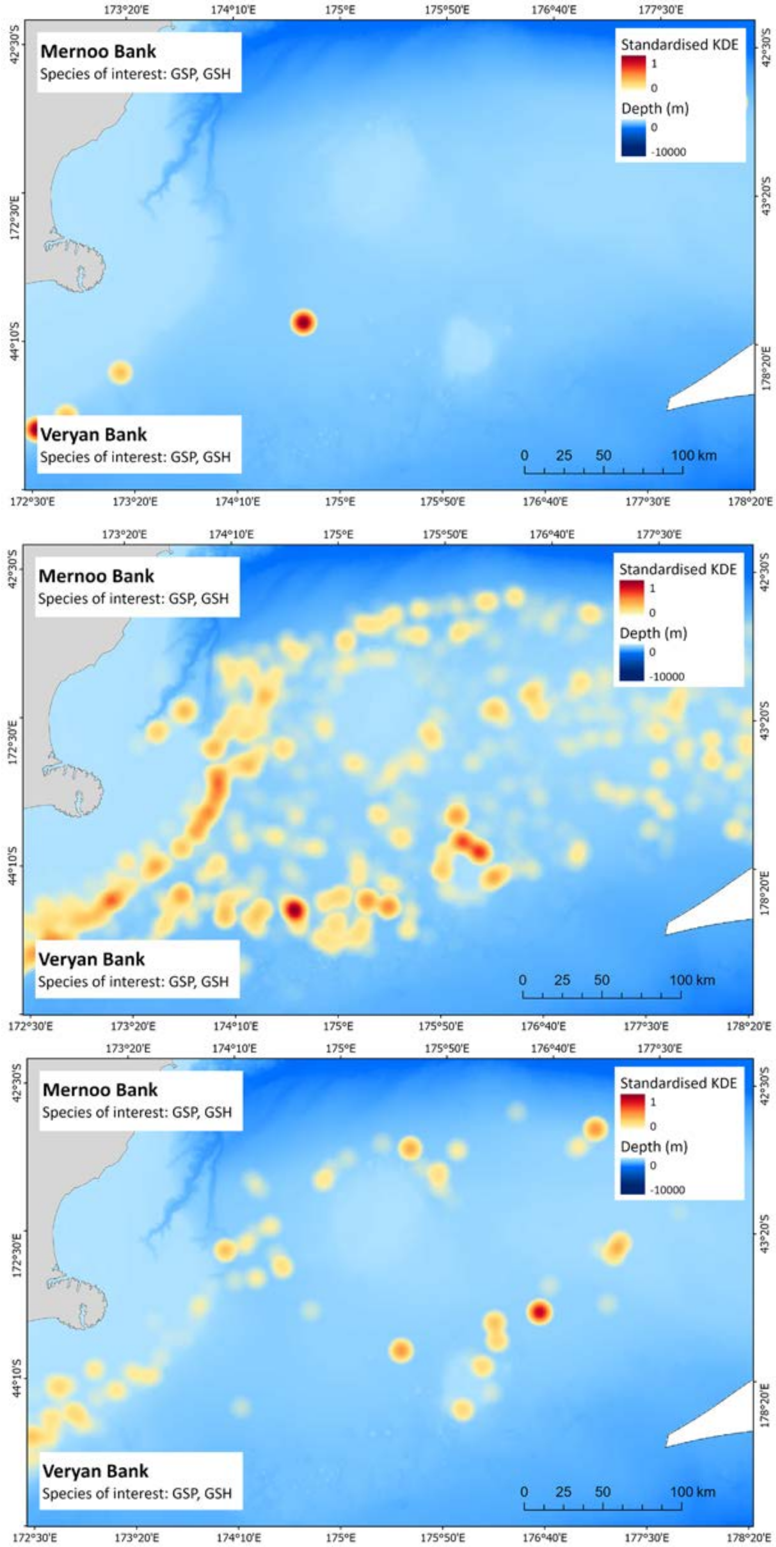


Figure Appendix 22: Kernel density estimate (KDE) for combined species observations of young-of-the-year (top panel), juveniles (middle panel), and reproductively active females (bottom panel) for Mernoo and Veryan Bank (18. Mernoo_Bank; 28. Veryan_Bank). Species of interest are: pale ghost shark (GSP) and dark ghost shark (GSH).

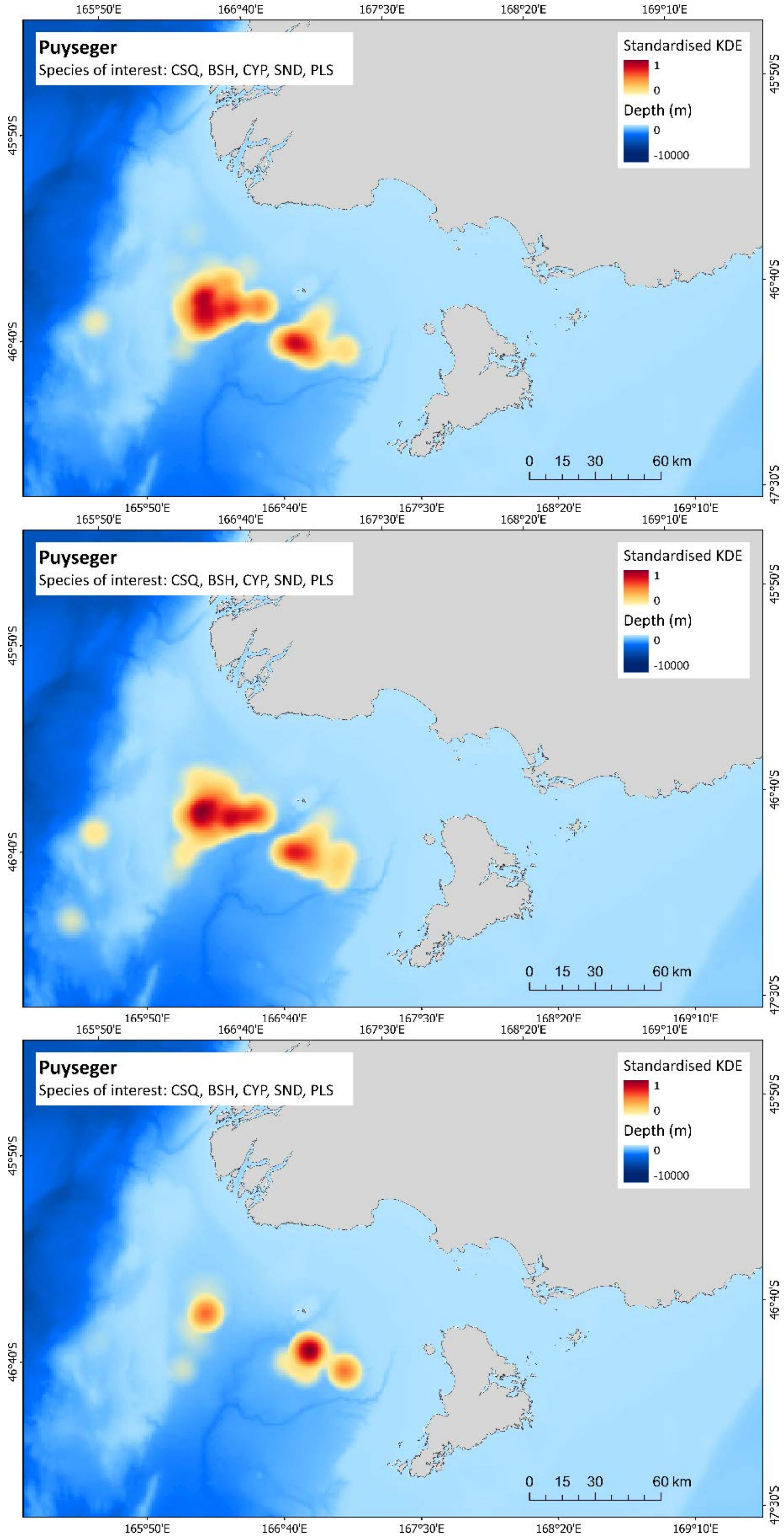


Figure Appendix 23: Kernel density estimate (KDE) for combined species observations of young-of-the-year (top panel), juveniles (middle panel), and reproductively active females (bottom panel) for Puysegur (22. Puysegur). Species of interest are: leafscale gulper shark (CSQ), seal shark (BSH), longnose velvet dogfish (CYP), shovelnose dogfish (SND), and Plunket's shark (PLS).

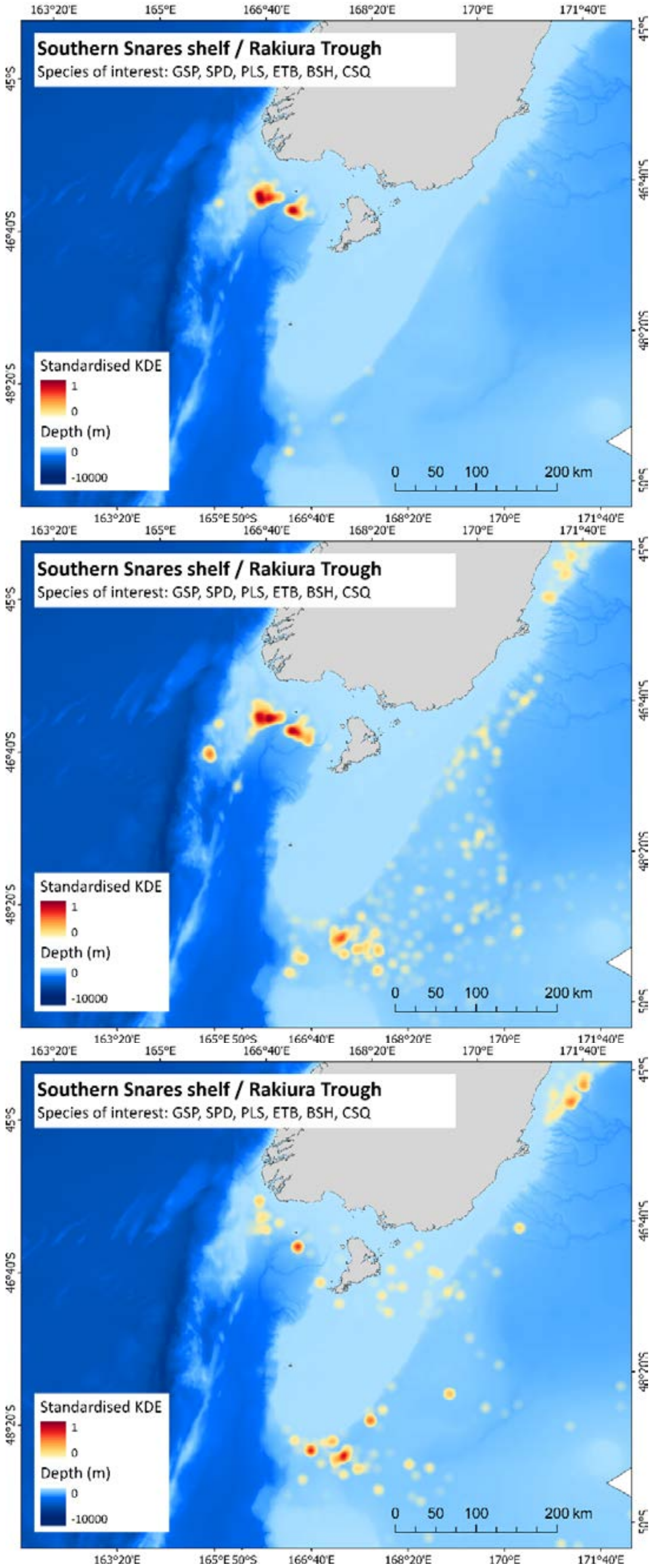


Figure Appendix 24: Kernel density estimate (KDE) for combined species observations of young-of-the-year (top panel), juveniles (middle panel), and reproductively active females (bottom panel) for Snares Shelf (24. Snares_shelf). Species of interest are: pale ghost shark (GSP), spiny dogfish (SPD), Plunket's shark (PLS), Baxter's dogfish (ETB), seal shark (BSH), and leafscale gulper shark (CSQ).

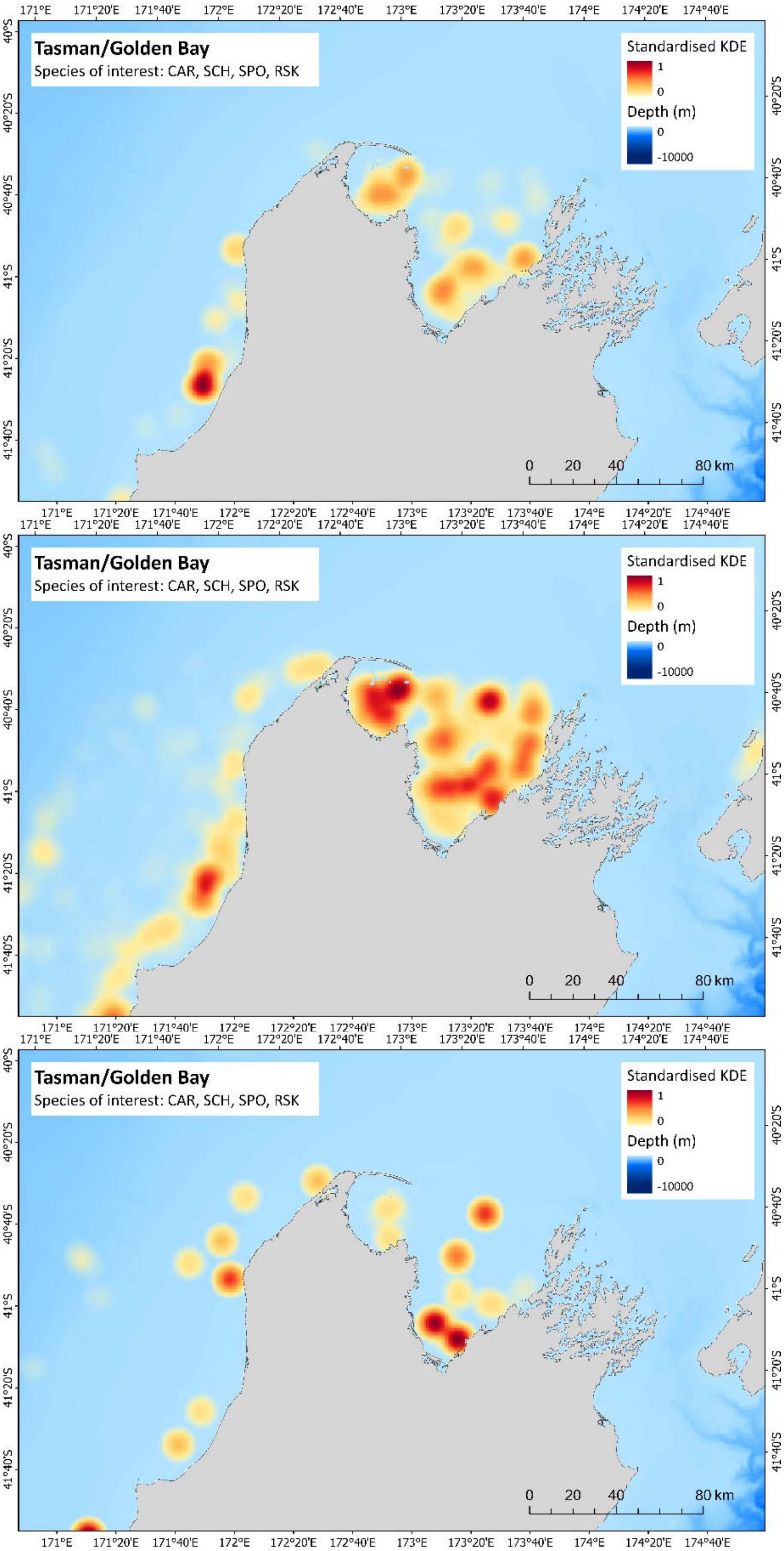


Figure Appendix 25: Kernel density estimate (KDE) for combined species observations of young-of-the-year (top panel), juveniles (middle panel), and reproductively active females (bottom panel) for Tasman and Golden Bays (26. Tasman_Golden_Bay). Species of interest are: carpet shark (CAR), school shark (SCH), rig (SPO), and rough skate (RSK).

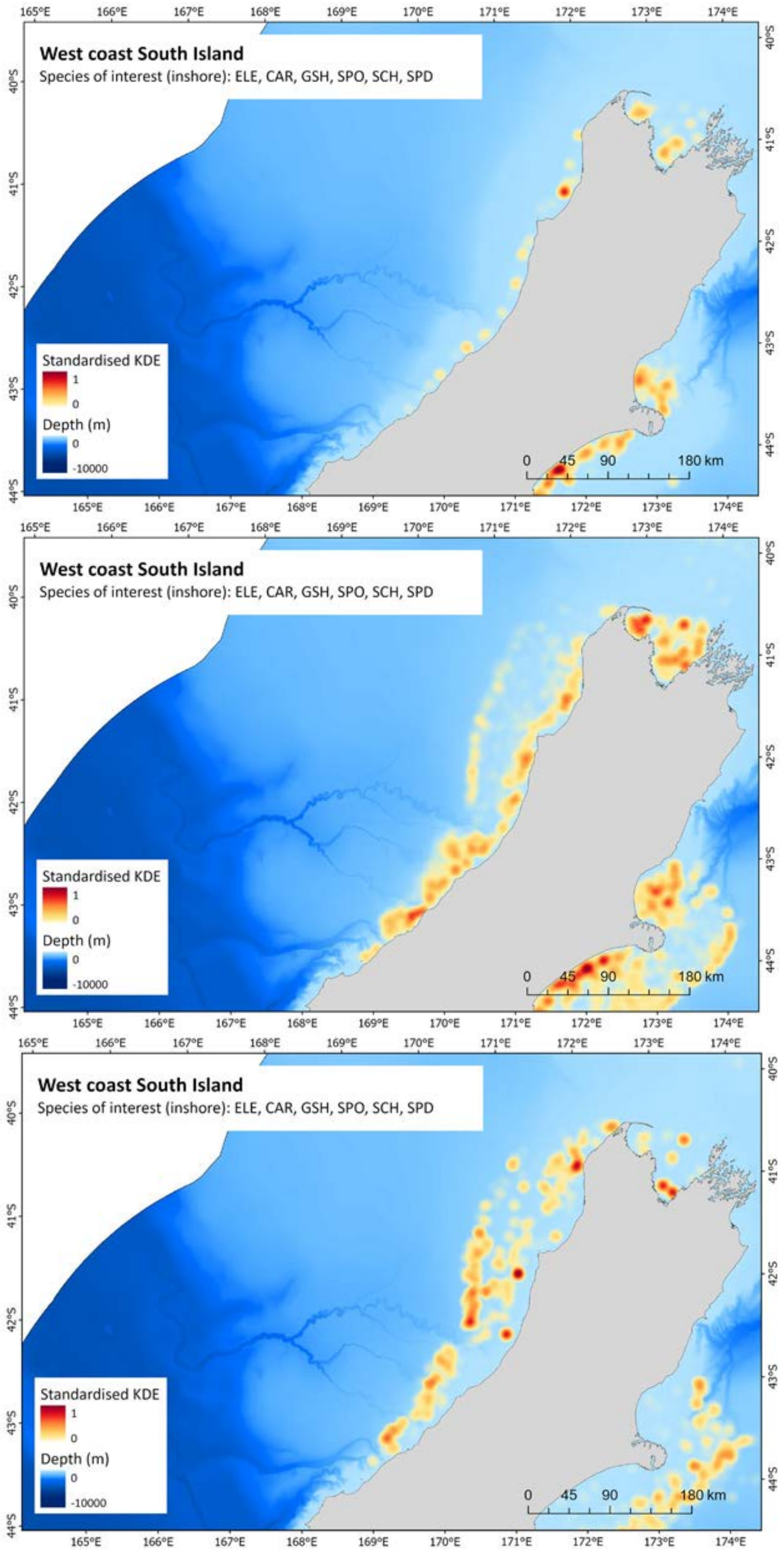


Figure Appendix 26: Kernel density estimate (KDE) for combined species observations of young-of-the-year (top panel), juveniles (middle panel), and reproductively active females (bottom panel) for West Coast South Island (30. West_Coast_SI). Species of interest are: elephantfish (ELE), carpet shark (CAR), dark ghost shark (GSH), rig (SPO), school shark (SCH), and spiny dogfish (SPD).

12. APPENDIX 4: HoPS profiles

Table Appendix 2: Proposed Habitats of Particular Significance (HoPS) profiles

HABITAT	**Auckland Islands (1. Auck_Islands_E; 2. Auck_Islands_N)**
Fish species	**Primary species** • Basking shark (BSK) • White shark (WPS) **Supporting species** • Pale ghost shark (GSP) • Dark ghost shark (GSH) • School shark (SCH) • Spiny dogfish (SPD) • Leafscale gulper shark (CSQ) • Shovelnose dogfish (SND) • Baxter's dogfish (ETB) • Plunket's shark (PLS) • Seal shark (BSH) • Smooth skate (SSK) • Rough skate (RSK) **Other species in the region** • Australasian narrow-nose spookfish • Dawson's catshark • Lucifer dogfish • Prickly dogfish • Smooth deepsea skate • Prickly deepsea skate
Attributes of habitat	**Area (km^2):** 2 229 (E); 1 340 (N) **Aquatic Setting** • System: Marine • Subsystem: Marine Offshore; Marine Oceanic **Water Column Component** • Water Column Layer: Marine Offshore Upper Water Column; Marine Offshore Lower Water Column; Marine Oceanic Epipelagic Upper Layer; Marine Oceanic Mesopelagic Layer; Marine Oceanic Bathypelagic Layer • Temperature Regime: Cold Water • Depth: 110–517 m (E); 110–1088 m (N) • Bottom Temperature: 7.6–9.1°C (E); 4.8–9.2°C (N) • Sea Surface Temperature: 8.9–9.1°C (E); 9.2–9.6°C (N) **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Continental/Island Shelf; Continental/Island Slope **Marine Bioregion** • 3 (Intermediate depth) • 8 (Shelf depth – Southern distribution)
Reasons for particular significance	• Aggregation site, reason unknown (BSK, WPS)

Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Fishing using pelagic methods across the habitat • Swept Area Ratio=1673.5 (E); 649.0 (N) • Percentage of HoPS in area closed to fishing=4.9% (E); 0.9% (N)
Risks/potential adverse effects of other activities	**Climate change effects:** increased temperature, reduced oxygen availability, reduced habitat quality
References	Finucci et al. 2022; Fisheries New Zealand (unpublished data)

HABITAT	**Canterbury Bight (3. Canterbury_Bight, CB; 20. Pegasus Bay, PB)**
Fish species	**Primary species** • Elephantfish (ELE) • School shark (SCH) • Rig (SPO) • Spiny dogfish (SPD) • Rough skate (RSK) **Supporting species** • Basking shark (BSK) • White shark (WPS) • Porbeagle (POS) • Mako (MAK) • Carpet shark (CAR) • Blue shark (BWS) • Smooth skate (SSK) **Other species** • Thresher shark • Broadnose sevengill shark • Electric ray • Short-tail stingray • Long-tail stingray
Attributes of habitat	**Area (km^2):** 4 335 (CB); 1 789 (PB) **Aquatic Setting** • System: Marine • Subsystem: Marine Nearshore; Marine Offshore **Water Column Component** • Water Column Layer: Marine Nearshore Upper Water Column; Marine Nearshore Lower Water Column; Marine Offshore Upper Water Column; Marine Offshore Lower Water Column • Temperature Regime: Cool to Moderate Water • Depth: 3–50 m (CB); 13–50 m (PB) • Bottom Temperature: 11.0–12.6°C (CB); 10.8–12.3°C (PB) • Sea Surface Temperature: 10.0–16.0°C (CB); 12.7–14.6°C (PB) **Geoform Component** • Tectonic Setting: Divergent Active Continental Margin • Physiographic Setting: Bight **Marine Bioregion** • 9 (Shallow coastal – Southern distribution)
Reasons for particular significance	• Egg-laying and nursery area (ELE) • Pupping and nursery area (SPD) • Suspected egg-laying and nursery area (RSK) • Suspected pupping and nursery area (SPO, SCH)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing

	- Fishing using pelagic methods across the habitat - Swept Area Ratio=1298.1 (CB); 346.9 (PB) - Percentage of HoPS in area closed to fishing=0.0%
Risks/potential adverse effects of other activities	**Climate change effects:** changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss **Pollution:** high nutrient and contamination loading
References	Francis 1997a; Beentjes et al. 2010, 2013, 2015, 2016, 2022; 2023; MacGibbon et al. 2019b; iNaturalist 2024

HABITAT	**Chatham Islands (4. Chath_Islands)**
Fish species	**Primary species** • White shark (WPS) **Supporting** • School shark (SCH) • Mako (MAK) • Porbeagle (POS) • Carpet shark (CAR) • Blue shark (BWS) • Spiny dogfish (SPD) **Other species in the region** • Broadnose sevengill shark • Northern spiny dogfish • Short-tail stingray
Attributes of habitat	**Area (km^2):** 4 938 **Aquatic Setting** • System: Marine • Subsystem: Marine Nearshore; Marine Offshore **Water Column Component** • Water Column Layer: Marine Nearshore Upper Water Column; Marine Nearshore Lower Water Column; Marine Offshore Upper Water Column; Marine Offshore Lower Water Column • Temperature Regime: Cool Water • Depth: 3–127 m • Bottom Temperature: 11.3–13.3°C • Sea Surface Temperature: 12.9–13.2°C **Geoform Component** • Tectonic Setting: Divergent Active Continental Margin • Physiographic Setting: Continental/Island Shelf **Marine Bioregion** • 8 (Shelf depth – Southern distribution)
Reasons for particular significance	• Aggregation site, reason unknown (WPS)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Fishing using pelagic methods across the habitat • Swept Area Ratio=55.6 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Increased human activities in the water:** habitat disturbance, habitat degradation **Climate change effects:** changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss
References	Duffy et al. 2012; Francis et al. 2015a; iNaturalist 2024

HABITAT	**Chatham Rise** **(5. Chath_Rise_N 1; 6. Chath_Rise_N_2; 7. Chath_Rise_N_3; 8. Chath_Rise_N_4): incl. Kaikoura Canyon to north Mernoo Bank; Graveyard Knolls, Andes Knolls** **(9. Chath_Rise_S_1): incl. Urry Knolls**

Fish species

Primary species

- Leafscale gulper shark (CSQ) (north)
- Shovelnose dogfish (SND) (north)
- Longnose velvet dogfish (CYP) (north)
- Seal shark (BSH) (north)
- Baxter's dogfish (ETB) (south)

Supporting species

- Pale ghost shark (GSP)
- Dark ghost shark (GSH)
- White shark (WPS)
- Mako (MAK)
- Porbeagle (POS)
- Carpet shark (CAR)
- School shark (SCH)
- Spiny dogfish (SPD)
- Plunket's shark (PLS)
- Smooth skate (SSK)
- Rough skate (RSK)

Other species in the region

- Australasian narrownose spookfish
- Pacific spookfish
- Brown chimaera
- Giant chimaera
- Black ghost shark
- Frilled shark
- Catsharks (*Apristurus* spp)
- Dawson's catshark
- Bluntnose sixgill shark
- Lucifer dogfish
- Owston's dogfish
- Prickly dogfish
- Torpedo ray
- Longnose deepsea skate
- Smooth deepsea skate
- Prickly deepsea skate

Attributes of habitat

Area (km^2): 12 229 (N1); 2 455 (N2); 3 701 (N3); 5 531 (N4); 11 522 (S1)

Aquatic Setting

- System: Marine
- Subsystem: Marine Oceanic

Water Column Component

- Water Column Layer: Marine Oceanic Epipelagic Upper Layer; Marine Oceanic Mesopelagic Layer; Marine Oceanic Bathypelagic Layer
- Temperature Regime: Very Cold to Cool Water
- Depth: North (194–1369 m); South (202–1244 m)

	• Bottom Temperature: North (3.8–11.2°C); South (3.2–9.0°C) • Sea Surface Temperature: North (12.3–14.6°C); South (10.8–12.0°C) **Geoform Component** • Tectonic Setting: Divergent Active Continental Margin • Physiographic Setting: Continental/Island Rise **Marine Bioregion** • 2 (Deep water) • 3 (Intermediate depth) • 5 (Shelf depth – Northern distribution)
Reasons for particular significance	• Suspected pupping and nursery area (CSQ, SND, CYP, ETB, BSH)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Swept Area Ratio= North (83.2–6112.9); South (2701.0) • Percentage of HoPS in area closed to fishing =0.0% (N1, N2, S1); 1.6% (N3); 25.3% (N4)
Risks/potential adverse effects of other activities	**Climate change effects:** changes in storm frequency, increased temperature, reduced oxygen availability, reduced habitat quality **Pollution:** high nutrient and contamination loading (mineral deposit extraction)
References	O'Driscoll et al. 2011; Stevens et al. 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2021, 2023

HABITAT	**Cook Strait Canyon (10. Cook_Strait)**
Fish species	**Primary species** • Leafscale gulper shark (CSQ) • Baxter's dogfish (ETB) • Longnose velvet dogfish (CYP) • Seal shark (BSH) **Supporting species** • Dark ghost shark (GSH) • White shark (WPS) • Mako (MAK) • School shark (SCH) • Blue shark (BWS) • Spiny dogfish (SPD) • Shovelnose dogfish (SND) **Other species in the region** • Thresher shark • Dawson's catshark • Frilled shark • Prickly shark • Sharpnose sevengill shark • Bluntnose sixgill shark • Broadnose sevengill shark • Northern spiny dogfish • Lucifer dogfish
Attributes of habitat	**Area (km^2):** 693 **Aquatic Setting** • System: Marine • Subsystem: Marine Offshore; Marine Oceanic **Water Column Component** • Water Column Layer: Marine Offshore Lower Water Column; Marine Oceanic Mesopelagic Layer; Marine Oceanic Bathypelagic Layer • Temperature Regime: Cold to Cool Water • Depth: 116–1298 m • Bottom Temperature: 4.0–11.7°C • Sea Surface Temperature: 13.6–14.1°C **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Submarine Canyon **Marine Bioregion** • 2 (Deep water) • 3 (Intermediate depth)
Reasons for particular significance	• Aggregation site, reason unknown (CSQ, ETB, CYP, BSH)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Swept Area Ratio=226.5

	• Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Climate change effects:** increased temperature, reduced oxygen availability, reduced habitat quality
References	Garrick 1955, 1957, 1959a, 1959b, 1960a, 1960b, 1960c; Gaskin & Cawthorn 1967; Garrick & Moreland 1968; Livingston 1990; Escobar-Flores & O’Driscoll 2022; Escobar-Flores et al. 2024

HABITAT	**Canterbury Shelf Break (11. East_Coast_SI)**

Fish species

Primary species
- Dark ghost shark (GSH)
- School shark (SCH)
- Spiny dogfish (SPD)
- Smooth skate (SSK)

Supporting species
- Elephantfish (ELE)
- Pale ghost shark (GSP)
- Mako (MAK)
- Porbeagle (POS)
- Carpet shark (CAR)
- Blue shark (BWS)
- Baxter's dogfish (ETB)
- Rough skate (RSK)

Other species in the region
- Australasian narrow-nosed spookfish
- Thresher shark
- Dawson's catshark
- Broadnose sevengill shark
- Lucifer dogfish
- Prickly dogfish
- Electric ray
- Smooth deepsea skate
- Prickly deepsea skate

Attributes of habitat

Area (km^2): 598

Aquatic Setting
- System: Marine
- Subsystem: Marine Offshore; Marine Oceanic

Water Column Component
- Water Column Layer: Marine Offshore Upper Water Column; Marine Offshore Lower Water Column; Marine Oceanic Epipelagic Upper Layer; Marine Oceanic Mesopelagic Layer
- Temperature Regime: Cold to Cool Water
- Depth: 150–397 m
- Bottom Temperature: 7.5–9.5°C
- Sea Surface Temperature: 11.4–12.1°C

Geoform Component
- Tectonic Setting: Divergent Active Continental Margin
- Physiographic Setting: Continental/Island Shelf; Continental/Island Slope; Shelf Break

Marine Bioregion
- 3 (Intermediate depth)
- 8 (Shelf depth – Southern distribution)

Reasons for particular significance
- Pupping and nursery area (SPD)
- Suspected egg-laying and nursery area (GSH, SSK)
- Suspected pupping and nursery area (SCH)

Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Fishing using pelagic methods across the habitat • Swept Area Ratio=798.9 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Climate change effects:** increased temperature, reduced oxygen availability, reduced habitat quality
References	Beentjes et al. 2010, 2013, 2015, 2016, 2022, 2023; MacGibbon et al. 2019b

HABITAT	**Hauraki Gulf (12. Hauraki_Gulf)**
Fish species	**Primary species** • White shark (WPS) • School shark (SCH) • Rig (SPO) **Supporting species** • Mako (MAK) • Carpet shark (CAR) • Blue shark (BWS) • Rough skate (RSK) **Other species in the region** • Thresher shark • Bigeye thresher shark • Tiger shark • Bronze whaler • Smooth hammerhead • Broadnose sevengill shark • Northern spiny dogfish • Electric ray • Short-tail stingray • Long-tail stingray • Oceanic manta ray • Eagle ray
Attributes of habitat	**Area (km^2):** 5 347 **Aquatic Setting** • System: Marine • Subsystem: Marine Nearshore; Marine Offshore **Water Column Component** • Water Column Layer: Marine Offshore Upper Water Column; Marine Offshore Lower Water Column • Temperature Regime: Cold to Cool Water • Depth: 39–101 m • Bottom Temperature: 4.0–11.7°C • Sea Surface Temperature: 13.6–14.1°C **Geoform Component** • Tectonic Setting: Divergent Active Continental Margin • Physiographic Setting: Embayment/Bay **Marine Bioregion** • 6 (Shallow coastal – Northern distribution) • 7 (Very shallow coastal)
Reasons for particular significance	• Pupping and nursery area (WPS, SCH) • Suspected pupping and nursery area (SPO) • Suspected egg-laying and nursery area (CAR)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Fishing using pelagic methods across the habitat • Swept Area Ratio=1623.6

	• Percentage of HoPS in area closed to fishing =12.8%
Risks/potential adverse effects of other activities	**Increased human activities in the water:** habitat disturbance, habitat degradation **Climate change effects:** changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss **Pollution:** high nutrient, contamination loading
References	Beston 2003; Hurst et al. 2000; Morrison et al. 2002, 2003; Hendry 2004; Francis et al. 2012; iNaturalist 2024; C. A. J. Duffy (unpublished data)

HABITAT	**Hokitika Canyon (13. Hokitika)**

Fish species

Primary species
- Spiny dogfish (SPD)
- Leafscale gulper shark (CSQ)
- Shovelnose dogfish (SND)
- Longnose velvet dogfish (CYP)
- Seal shark (BSH)
- Smooth skate (SSK)

Supporting species
- Dark ghost shark (GSH)
- Pale ghost shark (GSP)
- Basking shark (BSK)
- Mako (MAK)
- Porbeagle (POS)
- Carpet shark (CAR)
- School shark (SCH)
- Rig (SPO)
- Blue shark (BWS)
- Plunket's shark (PLS)
- Rough skate (RSK)

Other species in the region
- Australasian narrow-nosed spookfish
- Pacific spookfish
- Bramble shark
- Slender smoothhound
- Sharpnose sevengill shark
- Bluntnose sixgill shark
- Northern spiny dogfish
- Lucifer dogfish
- Portuguese dogfish
- Owston's dogfish
- Electric ray
- Pacific blonde skate
- Smooth deepsea skate

Attributes of habitat

Area (km^2): 3 594

Aquatic Setting
- System: Marine
- Subsystem: Marine Oceanic

Water Column Component
- Water Column Layer: Marine Oceanic Epipelagic Upper Layer; Marine Oceanic Mesopelagic Layer
- Temperature Regime: Cool to Moderate Water
- Depth: 171–697 m
- Bottom Temperature: 7.3–13.1°C
- Sea Surface Temperature: 15.1–15.6°C

Geoform Component
- Tectonic Setting: Convergent Active Continental Margin
- Physiographic Setting: Submarine Canyon

Marine Bioregion

	• 2 (Deep water) • 3 (Intermediate depth)
Reasons for particular significance	• Suspected pupping and nursery area (BSH, CSQ, CYP, SND, SPD) • Suspected egg-laying and nursery area (SSK)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Swept Area Ratio=2736.7 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Climate change effects:** increased temperature, reduced oxygen availability, reduced habitat quality
References	O'Driscoll et al. 2014, 2015, O'Driscoll & Ballara 2018, 2019; Devine et al. 2022

HABITAT	**Kaipara Harbour (14. Kaipara Harbour)**
Fish species	**Primary species** • White shark (WPS) • School shark (SCH) • Rig (SPO) **Other species in the region** • Bronze whaler • Smooth hammerhead • Broadnose sevengill shark • Short-tail stingray • Long-tail stingray • Eagle ray
Attributes of habitat	**Area (km^2):** 375 **Aquatic Setting** • System: Marine • Subsystem: Estuarine Open Water; Marine Nearshore; Marine Offshore **Water Column Component** • Water Column Layer: Estuarine Open Water Upper Water Column; Estuarine Open Water Lower Water Column; Marine Nearshore Upper Water Column; Marine Nearshore Lower Water Column • Temperature Regime: Moderate to Warm Water • Depth: 15–25 m • Bottom Temperature: 16.9–17.3°C • Sea Surface Temperature: 15.6–23.6°C **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Embayment/Bay **Marine Bioregion** • 7 (Very shallow coastal)
Reasons for particular significance	• Pupping and nursery area (WPS, SCH, SPO)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Fishing using pelagic methods across the habitat • Swept Area Ratio=1.71 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Increased human activities in the water:** habitat disturbance, habitat degradation **Climate change effects:** changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss **Pollution:** high nutrient, contamination loading
References	Paul & Sanders 2001; Hendry 2004; Francis et al. 2012; Morrison et al. 2014a; iNaturalist 2024; C. A. J. Duffy (unpublished data)

HABITAT	**Manukau Harbour (15. Manukau Harbour)**
Fish species	**Primary species** • White shark (WPS) • School shark (SCH) • Rig (SPO) **Other species in the region** • Bronze whaler • Smooth hammerhead • Broadnose sevengill shark • Short-tail stingray • Long-tail stingray • Eagle ray
Attributes of habitat	**Area (km^2):** 164 **Aquatic Setting** • System: Marine • Subsystem: Estuarine Open Water; Marine Nearshore; Marine Offshore **Water Column Component** • Water Column Layer: Estuarine Open Water Surface Layer; Estuarine Open Water Upper Water Column; Estuarine Open Water Lower Water Column; Marine Nearshore Surface Layer; Marine Nearshore Upper Water Column; Marine Nearshore Lower Water Column; Marine Offshore Surface Layer; Marine Offshore Upper Water Column; Marine Offshore Lower Water Column • Temperature Regime: Moderate to Warm Water • Depth: 0–38 m • Bottom Temperature: 17.4–17.6°C • Sea Surface Temperature: 16.4–25.0°C **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Embayment/Bay **Marine Bioregion** • 7 (Very shallow coastal)
Reasons for particular significance	• Pupping and nursery area (WPS, SCH, SPO)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Fishing using pelagic methods across the habitat • Swept Area Ratio=0.47 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Increased human activities in the water:** habitat disturbance, habitat degradation **Climate change effects:** changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss

	Pollution: high nutrient, contamination loading
References	Francis et al. 2012; Hernández 2013; Hernández et al. 2014; Finucci & Ó Maolagáin 2022; iNaturalist 2024; C. A. J. Duffy (unpublished data 2024)

HABITAT	**Marlborough Sounds (16. Marlborough 1; 17. Marlborough 1 2)** (1) Iwirua Point, Grove Arm, Queen Charlotte Sound; Kumutoto Bay, Queen Charlotte Sound (2) Fitzroy Bay, Hallam Cove, Pelorus Sound)
Fish species	**Primary species** • Elephantfish (ELE) • Carpet shark (CAR) • Rough skate (RSK) **Supporting species** • School shark (SCH) • Rig (SPO) • Spiny dogfish (SPD) **Other species in the region** • Broadnose sevengill shark • Short-tail stingray • Eagle ray
Attributes of habitat	**Area (km^2):** 12 (M1); 20 (M2) **Aquatic Setting** • System: Marine • Subsystem: Marine Nearshore; Marine Offshore **Water Column Component** • Water Column Layer: Marine Nearshore Surface Layer; Marine Nearshore Upper Water Column; Marine Nearshore Lower Water Column; Marine Offshore Surface Layer; Marine Offshore Upper Water Column; Marine Offshore Lower Water Column • Temperature Regime: Cool to Warm Water • Depth: 0–60 m (M1); 0–54 m (M2) • Bottom Temperature: ~14.3°C(M1); 15.1–17.3°C (M2) • Sea Surface Temperature: 16.4–25.0°C(M1); 15.6–18.2°C (M2) **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Sound **Marine Bioregion** • 6 (Shallow coastal – Northern distribution)
Reasons for particular significance	• Egg-laying area, nursery area (ELE, CAR) • Suspected egg-laying area, nursery area (RSK)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Swept Area Ratio=0.49 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Increased human activities in the water:** habitat disturbance, habitat degradation

	Climate change effects: changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss **Pollution:** high nutrient, contamination loading
References	Francis 1997a; Didier et al. 1998; Hurst et al. 2000; Lyon et al. 2011; Davidson et al. 2018, 2019; iNaturalist 2024

HABITAT	**Mernoo Bank (18. Mernoo Bank)**
Fish species	**Primary species** • Pale ghost shark (GSP) • Dark ghost shark (GSH) **Supporting species** • Basking shark (BSK) • White shark (WPS) • Mako (MAK) • Porbeagle (POS) • Blue shark (BWS) • Spiny dogfish (SPD)
Attributes of habitat	**Area (km^2):** 1 746 **Aquatic Setting** • System: Marine • Subsystem: Marine Oceanic **Water Column Component** • Water Column Layer: Marine Oceanic Mesopelagic Layer; Marine Oceanic Bathypelagic Layer • Temperature Regime: Cold to Cool Water • Depth: 403–1021 m • Bottom Temperature: 4.1–8.2°C • Sea Surface Temperature: 11.3–12.3°C **Geoform Component** • Tectonic Setting: Divergent Active Continental Margin • Physiographic Setting: Ocean Bank/Plateau **Marine Bioregion** • 8 (Shelf depth – Southern distribution)
Reasons for particular significance	• Suspected egg-laying area and nursery area (GSH, GSP)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Swept Area Ratio=279.3 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Climate change effects:** increased temperature, reduced oxygen availability, reduced habitat quality
References	Horn 1997; MacGibbon 2016; O'Driscoll et al. 2011; Stevens et al. 2012, 2013, 2014, 2015, 2017, 2018, 2021, 2023

HABITAT	**North Cape (19. NorthCape)**
Fish species	**Primary species** • White shark (WPS) **Supporting species** • Rig (SPO) • School shark (SCH) • Carpet shark (CAR) • Mako (MAK) • Blue shark (BWS) • Spiny dogfish (SPD) **Other species in the region** • Bronze whaler • Dusky shark • Broadnose sevengill shark • Short-tail stingray • Long-tail stingray • Oceanic manta ray • Eagle ray
Attributes of habitat	**Area (km^2):** 759 **Aquatic Setting** • System: Marine • Subsystem: Marine Nearshore; Marine Offshore **Water Column Component** • Water Column Layer: Marine Nearshore Upper Water Column; Marine Nearshore Lower Water Column; Marine Offshore Upper Water Column; Marine Offshore Lower Water Column • Temperature Regime: Moderate to Warm Water • Depth: 9–100 m • Bottom Temperature: 15.0–17.5°C • Sea Surface Temperature: 16.0–21.9°C **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Embayment/Bay **Marine Bioregion** • 5 (Shelf depth – North distribution) • 6 (Shallow coastal – Northern distribution)
Reasons for particular significance	• Pupping and nursery area (WPS) • Suspected egg-laying and nursery area (CAR) • Aggregation site, reason unknown (SCH)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Fishing using pelagic methods across the habitat • Swept Area Ratio=156.2 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Increased human activities in the water:** habitat disturbance, habitat degradation

	Climate change effects: changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss **Pollution:** high nutrient, contamination loading
References	Francis 1996; C. A. J. Duffy (unpubl. data)

HABITAT	**Porirua Harbour (Pāuatahanui and Onepoto) (21. Porirua Harbour)**
Fish species	**Primary species** • Rig (SPO) **Supporting species** • Elephantfish (ELE) • Carpet shark (CAR) • Spiny dogfish (SPD) **Other species in the region** • Short-tail stingray • Eagle ray
Attributes of habitat	**Area (km^2):** 4 **Aquatic Setting** • System: Estuarine • Subsystem: Estuarine Open Water **Water Column Component** • Water Column Layer: Estuarine Open Water Upper Water Column; Estuarine Open Water Lower Water Column • Temperature Regime: Cool to Moderate Water • Depth: 10–14 m • Bottom Temperature: 14.3°C • Sea Surface Temperature: 16.2–17.8°C **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Riverine Estuary **Marine Bioregion** • 6 (Shallow coastal – Northern distribution)
Reasons for particular significance	• Pupping and nursery area (SPO)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Swept Area Ratio=0.08 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Increased human activities in the water:** habitat disturbance, habitat degradation **Climate change effects:** changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss **Pollution:** high nutrient, contamination loading
References	Jones & Hadfield 1985; Francis & Francis 1992; Hendry 2004; Francis et al. 2012; Francis 2013; Lyon 2021; iNaturalist 2024

HABITAT	**Puysegur (22. Puysegur)**
Fish species	**Primary species** • Leafscale gulper shark (CSQ) • Shovelnose dogfish (SND) • Longnose velvet dogfish (CYP) • Plunket's shark (PLS) • Seal shark (BSH) **Supporting species** • Pale ghost shark (GSP) • Dark ghost shark (GSH) • School shark (SCH) • Spiny dogfish (SPD) • Baxter's dogfish (ETB) • Smooth skate (SSK) **Other species in the region** • Australasian narrow-nose spookfish • Pacific spookfish • Lucifer dogfish • Portuguese dogfish • Owston's dogfish
Attributes of habitat	**Area (km^2):** 3 788 **Aquatic Setting** • System: Marine • Subsystem: Marine Oceanic **Water Column Component** • Water Column Layer: Marine Oceanic Mesopelagic Layer; Marine Oceanic Bathypelagic Layer • Temperature Regime: Very Cold to Cool Water • Depth: 213–1495 m • Bottom Temperature: 3.0–11.1°C • Sea Surface Temperature: 12.3–12.9°C **Geoform Component** • Tectonic Setting: Tectonic Trench • Physiographic Setting: Continental/Island Shelf; Continental/Island Slope **Marine Bioregion** • 2 (Deep water) • 3 (Intermediate depth) • 8 (Shelf depth – Southern distribution)
Reasons for particular significance	• Suspected pupping and nursery area (CSQ, SND, CYP, PLS, BSH)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Swept Area Ratio=782.7 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Climate change effects:** increased temperature, reduced oxygen availability, reduced habitat quality

References	Bagley et al. 2013, 2014, 2017; O’Driscoll et al. 2018; MacGibbon et al. 2019a; Stevens et al. 2022, 2024

HABITAT	**Raglan Harbour (23. Raglan Harbour)**
Fish species	**Primary species** • Rig (SPO) **Supporting species** • White shark (WPS) **Other species in the region** • Bronze whaler • Smooth hammerhead • Broadnose sevengill shark • Short-tail stingray • Long-tail stingray • Eagle ray
Attributes of habitat	**Area (km^2):** 4 **Aquatic Setting** • System: Marine • Subsystem: Estuarine Open Water; Marine Nearshore; Marine Offshore **Water Column Component** • Water Column Layer: Estuarine Open Water Upper Water Column; Estuarine Open Water Lower Water Column; Marine Nearshore Upper Water Column; Marine Nearshore Lower Water Column • Temperature Regime: Moderate Water • Depth: 1–9 m • Bottom Temperature: 17.6°C • Sea Surface Temperature: 17.4–19.6°C **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Embayment/Bay **Marine Bioregion** • 7 (Very shallow coastal)
Reasons for particular significance	• Pupping and nursery area (SPO)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Swept Area Ratio=0.0 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Increased human activities in the water:** habitat disturbance, habitat degradation **Climate change effects:** changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss **Pollution:** high nutrient, contamination loading
References	Francis et al. 2012

HABITAT	**Snares Shelf (24. Snares_Shelf)**
Fish species	**Primary species** • Pale ghost shark (GSP) • Basking shark (BSK) • White shark (WPS) • Spiny dogfish (SPD) • Leafscale gulper shark (CSQ) • Baxter's dogfish (ETB) • Plunket's shark (PLS) • Seal shark (BSH) **Supporting species** • School shark (SCH) • Shovelnose dogfish (SND) • Smooth skate (SSK) • Rough skate (RSK) **Other species in the region** • Australasian narrow-nose spookfish • Giant chimaera • Dawson's catshark • Prickly dogfish • Smooth deepsea skate
Attributes of habitat	**Area (km^2):** 4 808 **Aquatic Setting** • System: Marine • Subsystem: Marine Oceanic **Water Column Component** • Water Column Layer: Marine Oceanic Epipelagic Upper Layer; Marine Oceanic Mesopelagic Layer; Marine Oceanic Bathypelagic Layer • Temperature Regime: Very Cold to Cool Water • Depth: 151–1490 m • Bottom Temperature: 3.1–10.5°C • Sea Surface Temperature: 9.7–11.2°C **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Continental/Island Shelf; Continental/Island Slope **Marine Bioregion** • 2 (Deep water) • 3 (Intermediate depth) • 8 (Shelf depth – Southern distribution)
Reasons for particular significance	• Suspected pupping and nursery area (SPD, CSQ, PLS, ETB, BSH) • Suspected egg-laying and nursery area (GSP) • Aggregation site, reason unknown (BSK)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Fishing using pelagic methods across the habitat

	• Swept Area Ratio=3277.1 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Climate change effects:** increased temperature, reduced oxygen availability, reduced habitat quality
References	Bagley et al. 2013, 2014, 2017; O'Driscoll et al. 2018; MacGibbon et al. 2019a; Finucci et al. 2022, Stevens et al. 2022; Stevens et al. 2024

HABITAT	**Tamaki Estuary (25. Tamaki_Estuary)**
Fish species	**Primary species** • Rig (SPO) **Other species in the region** • Smooth hammerhead • Electric ray • Eagle ray
Attributes of habitat	**Area (km^2):** 1 **Aquatic Setting** • System: Marine • Subsystem: Estuarine Open Water **Water Column Component** • Water Column Layer: Estuarine Open Water Surface Layer; Estuarine Open Water Upper Water Column; Estuarine Open Water Lower Water Column • Temperature Regime: Moderate Water • Depth: 0–3 m • Bottom Temperature: 17.5°C • Sea Surface Temperature: 19.9°C **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Riverine Estuary **Marine Bioregion** • 6 (Shallow coastal – Northern distribution)
Reasons for particular significance	• Pupping and nursery area (SPO)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat (set netting is prohibited) • Resuspension of sediment by bottom-contact fishing • Swept Area Ratio=0.0 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Increased human activities in the water:** habitat disturbance, habitat degradation **Climate change effects:** changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss **Pollution:** high nutrient, contamination loading
References	Francis et al. 2012; iNaturalist 2024

HABITAT	**Tasman and Golden Bays (26. Tasman_Golden_Bay)**
Fish species	**Primary species** • Carpet shark (CAR) • School shark (SCH) • Rig (SPO) • Rough skate (RSK) **Supporting species** • Elephantfish (ELE) • Dark ghost shark (GSH) • White shark (WPS) • Mako (MAK) • Spiny dogfish (SPD) • Smooth skate (SSK) **Other species in the region** • Thresher shark • Bronze whaler • Broadnose sevengill shark • Electric ray • Short-tail stingray • Eagle ray
Attributes of habitat	**Area (km^2):** 3 683 **Aquatic Setting** • System: Marine • Subsystem: Marine Nearshore; Marine Offshore **Water Column Component** • Water Column Layer: Marine Nearshore Surface Layer; Marine Nearshore Upper Water Column; Marine Nearshore Lower Water Column; Marine Offshore Surface Layer; Marine Offshore Upper Water Column; Marine Offshore Lower Water Column • Temperature Regime: Cool to Warm Water • Depth: 0–70 m • Bottom Temperature: 13.3–15.1°C • Sea Surface Temperature: 13.4–21.1°C **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Embayment/Bay **Marine Bioregion** • 6 (Shallow coastal – Northern distribution)
Reasons for particular significance	• Suspected pupping and nursery area (SPO, SCH) • Suspected egg-laying and nursery area (CAR, RSK)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Fishing using pelagic methods across the habitat • Swept Area Ratio=1427.5 • Percentage of HoPS in area closed to fishing =0.57%

Risks/potential adverse effects of other activities	**Increased human activities in the water:** habitat disturbance, habitat degradation **Climate change effects:** changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss **Pollution:** high nutrient, contamination loading
References	Stevenson & Hanchet 2010; Stevenson 2012; MacGibbon & Stevenson 2013; Stevenson & MacGibbon 2015, 2018; MacGibbon 2019; MacGibbon et al. 2022, 2024

HABITAT	**Titi Islands & Ruapuke (27. Titi Islands)**
Fish species	**Primary species** • White shark (WPS) **Supporting species** • Mako (MAK) • Porbeagle (POS) • Carpet shark (CAR) • School shark (SCH) • Blue shark (BWS) • Spiny dogfish (SPD) • Rough skate (RSK) **Other species in the region** • Thresher shark • Broadnose sevengill shark
Attributes of habitat	**Area (km^2):** 646 **Aquatic Setting** • System: Marine • Subsystem: Marine Nearshore; Marine Offshore **Water Column Component** • Water Column Layer: Marine Nearshore Surface Layer; Marine Nearshore Upper Water Column; Marine Nearshore Lower Water Column; Marine Offshore Surface Layer; Marine Offshore Upper Water Column; Marine Offshore Lower Water Column • Temperature Regime: Cool Water • Depth: 0–51 m • Bottom Temperature: 11.7–12.7°C • Sea Surface Temperature: 10.2–14.8°C **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Continental/Island Shelf **Marine Bioregion** • 8 (Shelf depth – Southern distribution)
Reasons for particular significance	• Aggregation site, suspected feeding area (WPS)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Fishing using pelagic methods across the habitat • Swept Area Ratio=24.5 • Percentage of HoPS in area closed to fishing =0.46%
Risks/potential adverse effects of other activities	**Increased human activities in the water:** habitat disturbance, habitat degradation **Climate change effects:** changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss

References	Duffy et al. 2012; Francis et al. 2015a; iNaturalist 2024

HABITAT	Veryan Bank (28. Veryan_Bank)
Fish species	**Primary species** • Pale ghost shark (GSP) • Dark ghost shark (GSH) **Supporting species** • Basking shark (BSK) • White shark (WPS) • Mako (MAK) • Porbeagle (POS) • Blue shark (BWS) • Spiny dogfish (SPD)
Attributes of habitat	**Area (km^2):** 811 **Aquatic Setting** • System: Marine • Subsystem: Marine Oceanic **Water Column Component** • Water Column Layer: Marine Oceanic Mesopelagic Layer • Temperature Regime: Cold to Cool Water • Depth: 621–829 m • Bottom Temperature: 5.1–6.3°C • Sea Surface Temperature: 11.2–11.6°C **Geoform Component** • Tectonic Setting: Divergent Active Continental Margin • Physiographic Setting: Ocean Bank/Plateau **Marine Bioregion** • 3 (Intermediate depth)
Reasons for particular significance	• Suspected egg-laying area and nursery area (GSH, GSP)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Swept Area Ratio=27.8 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Climate change effects:** increased temperature, reduced oxygen availability, reduced habitat quality
References	MacGibbon 2016; O'Driscoll et al. 2011; Stevens et al. 2012, 2013, 2014, 2015, 2017, 2018, 2021, 2023

HABITAT	**Wellington Harbour (29. Wellington Harbour)** (Oriental Parade, Balaena Bay, Breaker Bay, Robinson Bay, Scorching Bay, Hataitai Beach, Days Bay, Lyall Bay)
Fish species	**Primary species** • Elephantfish (ELE) • Rig (SPO) **Supporting species** • Carpet shark (CAR) • School shark (SCH) • Spiny dogfish (SPD) • Rough skate (RSK) **Other species in the region** • Electric ray • Short-tail stingray • Eagle ray
Attributes of habitat	**Area (km^2):** 48 **Aquatic Setting** • System: Marine • Subsystem: Marine Nearshore; Marine Offshore **Water Column Component** • Water Column Layer: Marine Nearshore Upper Water Column; Marine Nearshore Lower Water Column • Temperature Regime: Cool to Moderate Water • Depth: 4–22 m • Bottom Temperature: 14.1–14.2°C • Sea Surface Temperature: 14.2–17.7°C **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Embayment/Bay **Marine Bioregion** • 6 (Shallow coastal – Northern distribution)
Reasons for particular significance	• Egg-laying area, suspected nursery area (ELE) • Suspected pupping and nursery area (SPO)
Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Swept Area Ratio=0.32 • Percentage of HoPS in area closed to fishing =0.0%
Risks/potential adverse effects of other activities	**Increased human activities in the water:** habitat disturbance, habitat degradation **Climate change effects:** changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss **Pollution:** high nutrient, contamination loading
References	Jones & Hadfield 1985; iNaturalist 2024; B. Finucci (pers. obs.); C. A. J. Duffy (pers. obs.)

HABITAT	West Coast South Island (30. West_Coast_SI)
Fish species	**Primary species** • Elephantfish (ELE) • Dark ghost shark (GSH) • Carpet shark (CAR) • School shark (SCH) • Rig (SPO) • Spiny dogfish (SPD) **Supporting species** • Mako (MAK) • Porbeagle (POS) • Blue shark (BWS) • Smooth skate (SSK) • Rough skate (RSK) **Other species in the region** • Thresher shark • Sharpnose sevengill shark • Bluntnose sixgill shark • Broadnose sevengill shark • Northern spiny dogfish • Torpedo ray • Short-tail stingray
Attributes of habitat	**Area (km^2):** 4 980 **Aquatic Setting** • System: Marine • Subsystem: Marine Nearshore; Marine Offshore **Water Column Component** • Water Column Layer: Marine Nearshore Surface Layer; Marine Nearshore Upper Water Column; Marine Nearshore Lower Water Column; Marine Offshore Surface Layer; Marine Offshore Upper Water Column; Marine Offshore Lower Water Column; Marine Oceanic Epipelagic Upper Layer; Marine Oceanic Mesopelagic Layer • Temperature Regime: Cold to Moderate Water • Depth: 0–524 m • Bottom Temperature: 9.3–15.2°C • Sea Surface Temperature: 13.7–17.6°C **Geoform Component** • Tectonic Setting: Convergent Active Continental Margin • Physiographic Setting: Bight **Marine Bioregion** • 5 (Shelf depth – Northern distribution) • 6 (Shallow coastal – Northern distribution)
Reasons for particular significance	• Suspected pupping and nursery area (SCH, SPD) • Suspected egg-laying and nursery area (ELE, GSH, CAR, SSK)

Risks/potential adverse effects of fishing	• Fishing using bottom-contact methods across the habitat • Resuspension of sediment by bottom-contact fishing • Fishing using pelagic methods across the habitat • Swept Area Ratio=1640.1 • Percentage of HoPS in area closed to fishing =0.94%
Risks/potential adverse effects of other activities	**Increased human activities in the water:** habitat disturbance, habitat degradation **Climate change effects:** changes in storm frequency, freshwater run off, increased temperature, reduced oxygen availability, reduced habitat quality **Coastal modification and development:** increased turbidity, sedimentation, eutrophication, habitat loss **Pollution:** high nutrient, contamination loading
References	Stevenson & Hanchet 2010; Stevenson 2012; MacGibbon & Stevenson 2013; Stevenson & MacGibbon 2015, 2018; MacGibbon 2019; MacGibbon et al. 2022, 2024

15. APPENDIX 5: Zonation prioritisation

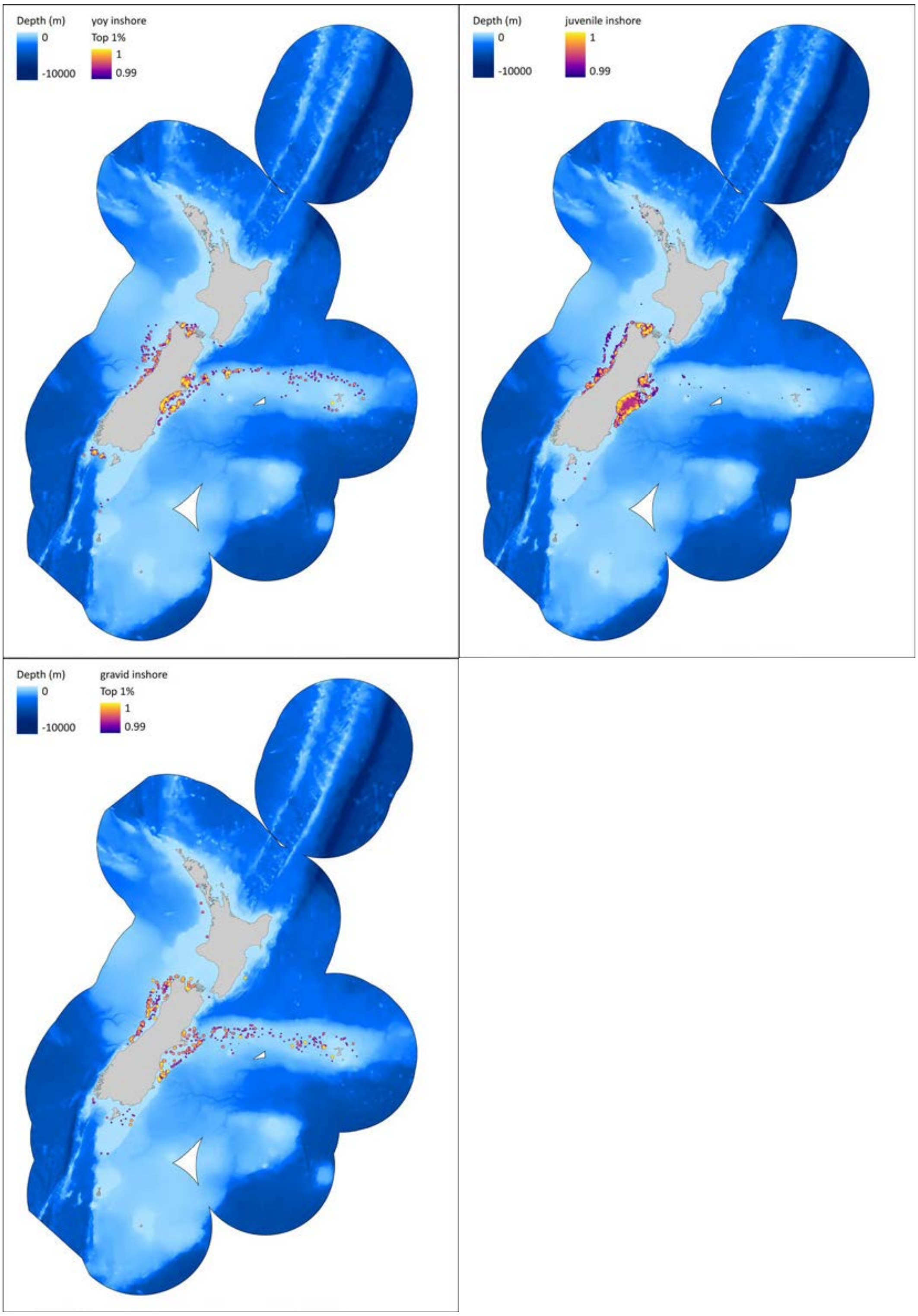


Figure Appendix 27: Zonation prioritisation (rank priority) for inshore species. Prioritisation created using the kernel density estimates (KDEs) for YOY, juvenile, and reproductively active development stages for ELE, SPO, SCH, SPD, RSK, SSK, CAR (see Table 1 for species names). Rank priority shown is restricted to the top 1% of value.

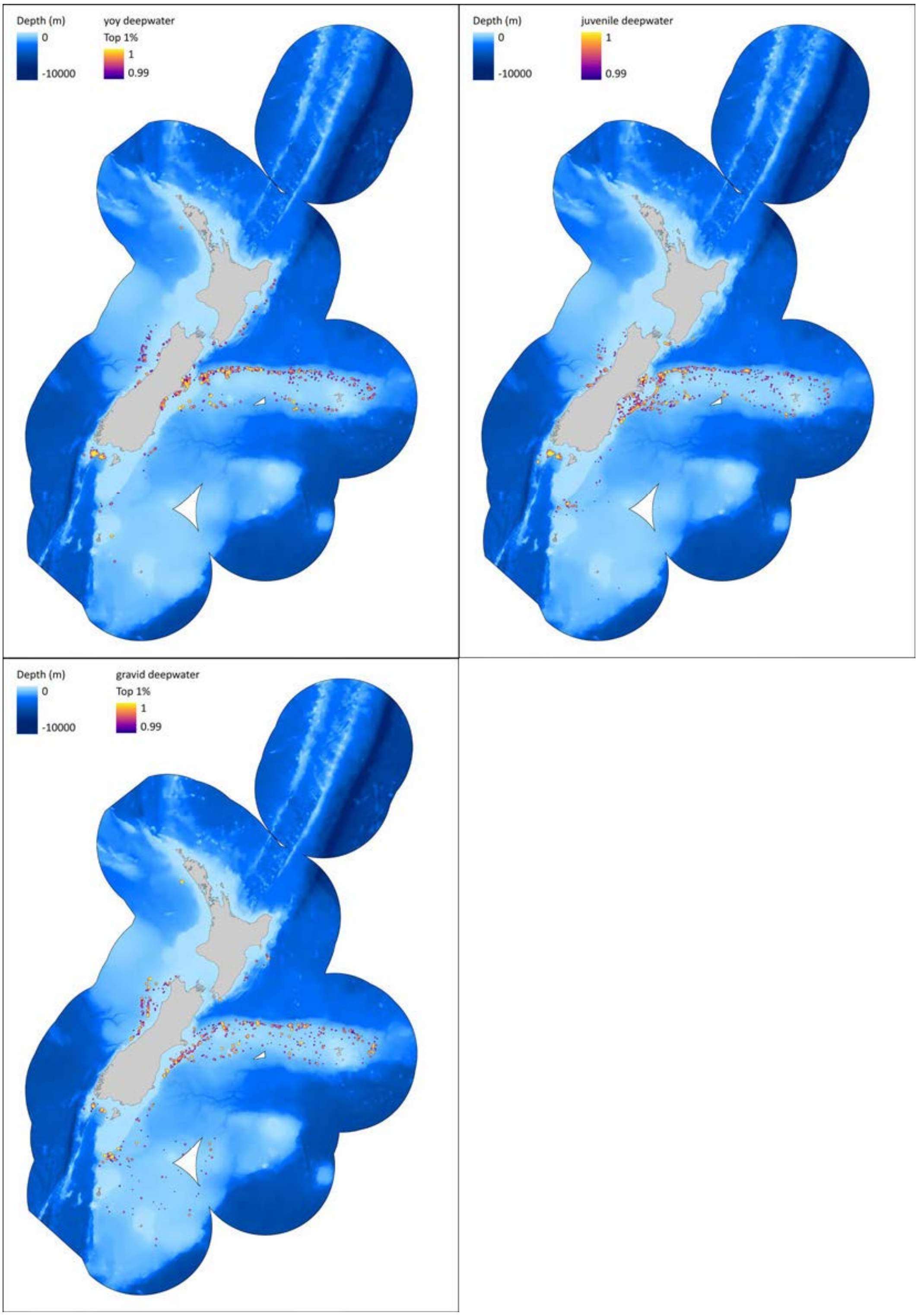


Figure Appendix 28: Zonation prioritisation (rank priority) for deepwater species. Prioritisation created using the kernel density estimates (KDEs) for YOY, juvenile, and reproductively active development stages for GSH, GSP, PLS, ETB, BSH, SND, CYP, CSQ, SPD (see Table 1 for species names). Rank priority shown is restricted to the top 1% of value.

16. APPENDIX 6: Video survey summary

Table Appendix 3: Summary of previous and ongoing underwater video surveys conducted in New Zealand waters. This list is not exhaustive but provides some examples of where research has taken place, and the species observed on video. Species of interest for this project are bolded.

Reference	Location	Gear	Depth (m)	Year sampling	***Callorhinchus milii***	***Cephaloscyllium isabellum***	***Mustelus lenticulatus***	***Galeorhinus galeus***	*Notorynchus cepedianus*	***Squalus acanthias***	*Squalus griffini*	*Carcharhinus brachyurus*	*Carcharhinus galapagensis*	***Prionace glauca***	*Alopias vulpinus*	***Carcharodon carcharias***	***Isurus oxyrinchus***	***Lamna nasuta***	*Sphyrna zygaena**	*Myliobatis tenuicaudatus*	***Zearaja nasuta***	*Bathytoshia lata*	*Bathytoshia brevicaudata*	Unidentified ray	Unidentified shark
Carbines & Cole (2009)	Foveaux Strait	remote drift underwater video (DUV)	NA	2002						x															
Denny & Babcock (2004)	Mimiwhangata Marine Park	BRUV (benthic)	up to 40	2002																x		x			
Morrison e& Carbines (2006)	Mahurangi Harbour	DUV	5–26	2004																x					
Langlois (2007)	Great Barrier Island, Hauraki Island	remote BUV/ stereo-BRUV	120	2006		x		x			x														
Simpfendorfer et al. (2023)	Kermadec region (Raoul and Macauley Island)	BRUV	12–33	2017									x			x			x			x	x		
Lewis et al. (2020, 2023)	Sawdust Bay, Paterson Inlet, Rakiura	stereo-BUV (midwater)	5–10	2016–2017		x	x		x	x											x				

Reference	Location	Gear	Depth (m)	Year sampling	***Callorhinchus milii***	***Cephaloscyllium isabellum***	***Mustelus lenticulatus***	***Galeorhinus galeus***	*Notorynchus cepedianus*	***Squalus acanthias***	*Squalus griffini*	*Carcharhinus brachyurus*	*Carcharhinus galapagensis*	***Prionace glauca***	*Alopias vulpinus*	***Carcharodon carcharias***	***Isurus oxyrinchus***	***Lamna nasuta***	*Sphyrna zygaena**	*Myliobatis tenuicaudatus*	***Zearaja nasuta***	*Bathytoshia lata*	*Bathytoshia brevicaudata*	Unidentified ray	Unidentified shark
Bell (2018)	Doubtful, Breaksea, Dusky Sounds	BUV/ROV	30–309	2018		x		x	x	x	x														
Heldsinger et al. (2023)	Fiordland (Gaer Arm, Elizabeth Island, Wet Jacket Arm, Five Fingers, Long Sound)	stereo-BRUV (benthic)	10–30	2018–2019		x	x	x	x	x	x														
M. Kellet unpublished	Matakana Is, Plate Is, Papamoa	BRUV (midwater and benthic)	7–53	2020		x		x				x					x			x			x		
Jaksons et al. (2022)	inner Queen Charlotte Sound	BRUV	53	2017–2020	x	x	x	x	x	x										x	x		x		
Morrison et al. (2022)	Pātea Bank, South Taranaki	towed-video CoastCam stereo-BUV (benthic),	32–38	2021		x	x													x		x		x	x
Project Reef (unpublished)	Pātea Shoals, South Tarankai	in-situ camera	20–23	2017–ongoing			x	x	x	x											x				
Lewis (2019)	Otago Harbour, Oamaru Harbour, Catlins Estuary	stereo-BUV (benthic)	5–30	2019–ongoing			x	x	x	x	x					x			x			x			
Lewis & Carson (2021)	North Taranaki (Sugar Loaf Is to Waitara Beach)	stereo-BUV (benthic)	5–30	2019–ongoing			x		x	x	x		x		x	x		x							

Reference	Location	Gear	Depth (m)	Year sampling	***Callorhinchus milii***	***Cephaloscyllium isabellum***	***Mustelus lenticulatus***	***Galeorhinus galeus***	*Notorynchus cepedianus*	***Squalus acanthias***	*Squalus griffini*	*Carcharhinus brachyurus*	*Carcharhinus galapagensis*	***Prionace glauca***	*Alopias vulpinus*	***Carcharodon carcharias***	***Isurus oxyrinchus***	***Lamna nasuta***	*Sphyrna zygaena**	*Myliobatis tenuicaudatus*	***Zearaja nasuta***	*Bathytoshia lata*	*Bathytoshia brevicaudata*	Unidentified ray	Unidentified shark
A. Smith (Sea Through Science, unpublished data)	Hauraki Gulf (inner and outer Gulf, Poor Knights/Mokohinau Is, Aldermen Is)	stereo-BRUV (benthic)	9–96	2019–ongoing			x		x	x			x					x					x	x	
J. Crawshaw (BoP Regional Council, unpublished)	Motiti Island & associated offshore reefs (Bay of Plenty)	BUV/ROV	5–40	2021–ongoing					x																
A. Smith (Sea Through Science, unpublished data)	Fiordland	stereo-BRUV (benthic)	10–95	2021–ongoing			x	x	x	x	x	x									x				x
A. Rogers unpublished data	Breaksea, Dusky Sound	stereo-BRUV (benthic)	20–145	2022–ongoing			x		x	x	x														
S. Van Olst unpublished data	Dusky Sound	stereo-BRUV (benthic)	15–40	ongoing			x	x	x	x													x		
J. Grimshaw, unpublished data*	North Island (Hauraki Gulf, Auckland region, East Cape, Northland)	stereo-BRUV (benthic)	90–1450	ongoing		x		x	x	x		x				x	x								

*Additional species of interest to the project include Leafscale gulper shark, Shovelnose dogfish, Baxter's dogfish, Plunket's shark, Seal shark