North Pacific Fisheries Commission

NPFC-2025-SSC BFME06-WP19

VME Risk Assessment - Canada Sablefish Fishery - 2025

Christopher N. Rooper[1], Janelle M.R. Curtis[1], Devon Warawa[1],
Pamela Goddard[2], Lauri Sadorus[2], Christina Conrath[3]

02 December 2025

Contents

1 Name of Commission Member

Canada

2 Name of the fishery

Seamount longline hook and longline trap fishery

The following NPFC conservation and management measures (CMM) pertain to this fishery:

- CMM 2025-06 For Bottom Fisheries and Protection of VMEs in the NE Pacific Ocean
- CMM 2019-10 For Sablefish in the Northeastern Pacific Ocean

Available from https://www.npfc.int/active-conservation-and-management-measures

3 Status of the fishery

The seamount long-line fishery began in the 1970's and has been active in most years. Currently five seamounts (Figure 1) are fished in the Convention Area, via long-line hook and long-line trap gear, by Canadian vessels.

4 Target species

The primary target species of this fishery is sablefish (*Anoplopoma fimbria*). At times the fishery will also target and land the rougheye and blackspotted rockfish species complex (*Sebastes aleutianus/S. melanostictus*).

5 Bycatch species

The main bycatch species in this fishery are shown in Table 1. In addition to rougheye and blackspotted rockfishes, the dominant species are; crabs, including Tanner Crab (*Chionoecetes bairdi*), Scarlet King Crab (*Lithodes couesi*) and Unidentified Crabs, Unidentified Rockfishes (*Sebastes* sp.), Pacific (*Coryphaenoides acrolepis*) and Giant Grenadiers (*Albatrossia pectoralis*), Pacific Halibut (*Hippoglossus stenolepis*), Shortspine (*Sebastolobus alascanus*) and Longspine Thornyheads (*Sebastolobus altivelis*), and Skilfish (*Erilepis zonifer*).

In total, 53 different taxonomic groupings have been recorded as bycatch from 1996-2025 in the Sablefish fishery.

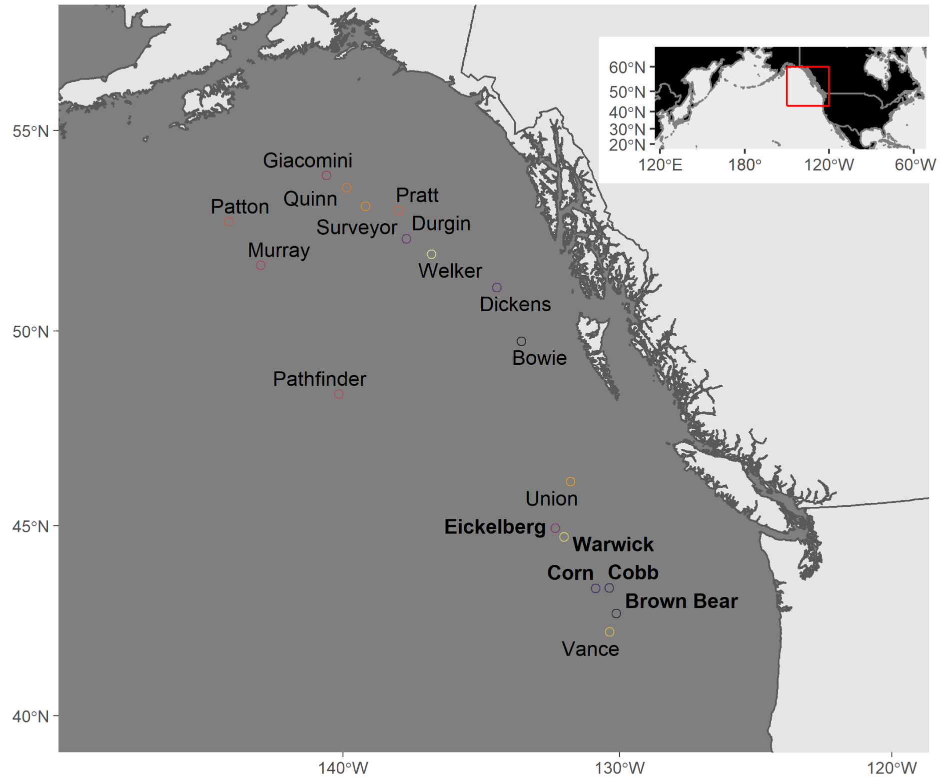

Figure 1: Map of seamounts in the NE Pacific. The five seamounts that are currently fished (Eickelberg, Warwick, Corn, Cobb and Brown Bear) are shown in bold font.

Table 1: Species of fishes and invertebrates recorded as bycatch in Canada's Sablefish fishery. The total catch is the cumulative weight from 1996-2025.

Species	Taxonomic group	Total catch (kg)
Rougheye/Blackspotted	Rougheye/Blackspotted	22196.351
Crab unidentified	Crabs	5106.283
Tanner crab	Crabs	4115.050
Rockfish unidentified	Rockfish	2671.690
Grenadier	Other fishes	2317.128
Scarlet kinng crab	Crabs	1602.596
Pacific sleeper shark	Sharks and Skates	1363.367
Pacific halibut	Flatfish	537.393
Skilfish	Other fishes	447.588
Shortspine thornyhead	Rockfish	318.884
Stripetail rockfish	Rockfish	156.489
Rosethorn rockfish	Rockfish	64.933
Splitnose rockfish	Rockfish	46.483
Octopus	Other invertebrates	38.188
Aurora rockfish	Rockfish	25.622
Longspine thornyhead	Rockfish	20.150
Pacific Ocean perch	Rockfish	15.711

Table 1: Species of fishes and invertebrates recorded as bycatch in Canada's Sablefish fishery. The total catch is the cumulative weight from 1996-2025. *(continued)*

Species	Taxonomic group	Total catch (kg)
Fish unidentified	Other fishes	15.500
Starfish	Other invertebrates	15.500
Longnose skate	Sharks and Skates	15.040
Widow rockfish	Rockfish	14.515
Thornyheads	Rockfish	12.987
Canary rockfish	Rockfish	12.131
Blue shark	Sharks and Skates	11.400
Dover sole	Flatfish	11.078
Vermillion rockfish	Rockfish	10.630
Reptantia	Other invertebrates	7.540
Shortraker rockfish	Rockfish	7.229
Arrowtooth flounder	Flatfish	5.672
Flatfish unidentified	Flatfish	5.300
Mollusc	Other invertebrates	3.700
Coral	VME indicator taxa	3.700
Redbanded rockfish	Rockfish	2.935
Sponges	VME indicator taxa	2.400
Snailfish	Other fishes	2.189
Deepsea sole	Flatfish	1.900
Chilipepper rockfish	Rockfish	1.861
Darkblotched rockfish	Rockfish	1.824
Spotted ratfish	Other fishes	1.807
Spiny dogfish	Sharks and Skates	1.427
Viperfish	Other fishes	1.172
Hydroid	Other invertebrates	0.900
Sandpaper skate	Sharks and Skates	0.868
Redstripe rockfish	Rockfish	0.597
Longfin dragonfish	Other fishes	0.500
Sea urchin	Other invertebrates	0.500
Shark unidentified	Sharks and Skates	0.425

6 Overview of the fishery and recent level of fishing effort

The Seamount Sablefish fishery is currently limited by both input and output controls. Input controls limit the amount of effort that the fishery can exert on the portion of the stock at seamounts.

- Effort is limited by a seasonal closure from October to March.
- The number of vessels that can participate in the fishery is limited to one per month during the open months (April-September).
- Only longline hook or longline trap gear is permitted for use
- Retained Sablefish must be > 55 cm in fork length to limit impact on juveniles

Output controls limit the amount of fish that can be landed during one trip. Since 2011, monthly vessel limits of:

- 34 mt (75,000 pounds) of sablefish,
- 2.3 mt (5,000 pounds) of rougheye/blackspotted rockfish, and
- 0.45 mt (1,000 pounds) of other rockfish, sole and flounder

have been in place. These limits are all in round weight. Since 2017, seamounts within Canada's EEZ have been closed to all fishing. So all seamount fishing since 2017 has been conducted at seamounts within the NPFC Convention Area.

6.1 Number of fishing vessels

The seamount fishery is managed through a lottery system in which one vessel per month is permitted to participate in the seamount fishery. Thus, in any given month from April to September, one vessel may be fishing the seamounts in the NPFC Convention Area. The vessel that wins the lottery in any given month sometimes chooses not to fish in the Convention Area. Due to the limited entry system, economics of the fishery and domestic quota available to fishers, it is possible that no vessels would choose to fish the seamounts beyond Canada's EEZ in a given year. A maximum of six vessels per year could fish these areas (one vessel per month of open fishery).

In the past 5 years (2021-2025) no vessels have chosen to fish at seamounts in the NPFC Convention Area. From 2008-2020, less than 3 vessels participated in the seamount fishery each year.

6.2 Tonnage of each fishing vessel

On average the gross volume of vessels participating in the sablefish longline hook and longline trap fishery is 443 cubic meters and the average length of these vessels is ~24.5 m.

6.3 Fishing gear

Mobile fishing gear is not permitted in the seamount fishery. Fishing is currently conducted with longlined traps, but historically, longline hooks have also been used (Figure 2). Traps must be equipped with escape holes to reduce bycatch of juvenile sablefish and rot panels to reduce ghost fishing should gear be lost.

6.4 Number of fishing days or days on the fishing ground

The number of fishing days is the number of unique calendar days during which gear was set. The number of fishing days has averaged from about 25 to greater than 100, but in most years has averaged between 50 and 75 (Figure 3). No Canadian vessels have chosen to fish for Sablefish in the Convention Area since 2020.

6.5 Fishing effort

On average 7.3 sets of either longline or traps are conducted per day, with trap sets averaging 3 km in length and 61 total traps per set. Longline sets averaged 2.3 km in length with 1241 hooks per set (Figure 4). Longline fishing with hooks in the seamount fishery in the Convention Area only occurred in 2016.

6.6 Total catch by species

Catches of Sablefish from NPFC region seamounts has ranged from an average of about 27 mt per year in 2005-2008 to about 70 mt in 2017 (Figure 5). Average annual catches were relatively low from 2002 to 2016 at NPFC seamounts and then increased in 2017-2018, with a decline to low levels in the last years. This increase in part probably reflects shifting effort due to closures of seamounts within Canada's EEZ in 2017.

Catch per unit of effort (mt/fishing days) for Sablefish has been relatively stable since 1996 (Figure 6), averaging 0.99 mt/fishing day (CV = 29%).

The annual catch of other landed species (rougheye/blackspotted, rockfishes, skilfish, thornyheads and flatfishes) have averaged 1.02 mt (Figure 7).

There has been no fishing effort at seamounts from 2021-2025 resulting in no catch.

6.7 Names of seamounts fished or to be fished

Five named seamounts in the Convention Area are actively fished by Canadian vessels. These are listed here, and shown in (Figure 1):

- Eickelberg Seamounts – Eickelberg and Eickelberg South
- Warwick Seamount
- Cobb Seamounts – Cobb, Far Cobb and Cobb South
- Corn Seamount
- Brown Bear Seamounts – Brown Bear and Brown Bear North

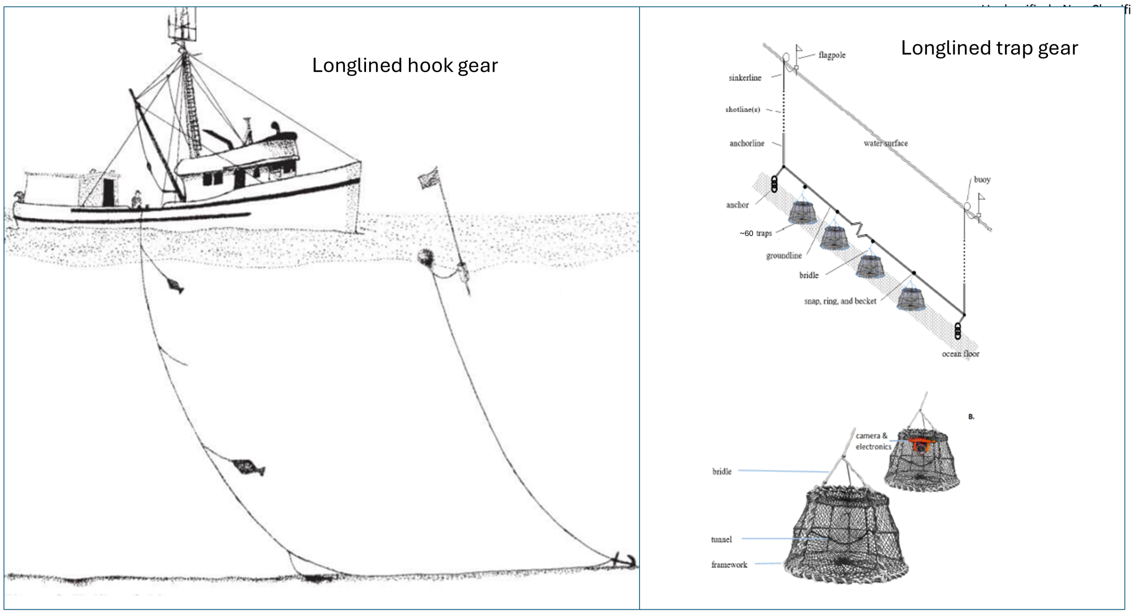

Figure 2: Longlined hook (left panel) and longlined trap (right panel) gear used by Canadian fishers in the sablefish fishery on the Cobb Seamount chain. Images courtesy of International Pacific Halibut Commission (www.iphc.int) and Lacko et al. (2023)

7 Fishing period

The Canadian seamount fishery in the Convention Area is open to one vessel per month for the months of April through September (six month season).

8 Analysis of status of fishery resources

Sablefish (*Anoplopoma fimbria*) are a highly valuable commercially harvested groundfish species in the North Pacific Ocean. They are the main target species in the eastern region of the North Pacific Fisheries Commission (NPFC) Convention Area. The goal of this status section is to summarize the current landings, assessment and management of sablefish populations in Canada, the USA and the NPFC.

8.1 Data and methods used for analysis

8.1.1 Sablefish fisheries landings

8.1.1.1 Canada domestic Canada has a commercial longline trap fishery inside its EEZ. The fishery is carried out by ~30 longline vessels and occurs throughout the year. Vessels targeting sablefish tend to be small (< 20 m in length). A small amount of sablefish is also captured by the bottom trawl sector as bycatch. Historically, sablefish fisheries on the coast of Canada have been conducted by Canadian and foreign vessels (including USA, Japanese, Russian and Korean vessels) from 1961-1981. The earliest Canadian recorded landings were in 1913. Annual landings have averaged ~4000 mt since 1980 (Figure 8).

8.1.1.2 USA domestic The Alaska sablefish fishery has been prosecuted since about 1920. The initial stages of fishery development were by US and Canadian fishers (as in other areas of the coast of North America), with other foreign vessels (primarily Japan, Korea and Russia) fishing along the coast from ~1960-1980 prior to the expansion of EEZ's. Since ~1988 all sablefish landings in Alaska have been in the domestic fishery. Landings since ~2015 have increased from 10,000 to greater than 21,000 kt (Figure 8). In Alaska, the sablefish fishery has traditionally utilized longline hook gear. However, since the legalization of pot gear in the Gulf of Alaska in 2017, fishers have moved to alternative gears such as hard and, more recently, collapsible "slinky" pots, which help eliminate whale depredation on catches. Sablefish are also incidentally captured in various bottom trawl fisheries in Alaska. The vessels fishing sablefish in Alaska are mostly small in size (< 20 m length), but there are a handful (< 10) of larger (~40-50 m) longline catcher-processor vessels that also fish for sablefish in Alaska.

On the US West Coast sablefish have been commercially captured since ~1890, with appreciable landings beginning in 1916-1919. In the 1960's and 70's foreign vessels (primarily Japan, Korea and Russia) and an increasing domestic fleet were responsible for increasing harvests. Since ~2000 annual landings have been about 10,000 mt (Figure 8). Sablefish landings have traditionally been harvested by hook and line or pot gear. However, there is also targeted catch from bottom trawl gear. Small vessels (< 20 m length) participate in the US West Coast domestic sablefish fishery.

8.1.1.3 NPFC CA In the NPFC Convention Area, sablefish are targeted only by Canadian fishers. The fishery uses longline trap gear at 1-5 seamounts in the Convention Area (CA). Since 2014, a maximum of 3 vessels per year have been allowed to fish in the CA and these have been chosen by lottery. Historically, there were significant and mostly unknown catches of sablefish and other groundfish landed in the NPFC CA by trawl and longline fishers from Canada, Japan, Korea, Russia and the USA. Since 1996 landings of sablefish in the NPFC CA have been around 10-20 mt, with some years (1996, 1998, 2017 and 2018 in particular) having larger catches (Figure 8). No fishing has occurred in the NPFC CA since 2020.

8.1.2 Fisheries Independent Surveys

8.1.2.1 Canada domestic Canada conducts two longline trap surveys in British Columbia waters. From 1990-2009 a standardized trap survey was conducted at set stations annually. From 2003 to the present DFO conducts a stratified random trap survey along the outer shelf and slope of the BC coast. Both of these surveys generated a fishery independent CPUE as well as biological data that is used in the assessment. The time series of sablefish CPUE from the current stratified random trap survey is shown in Figure (9).

8.1.2.2 USA domestic In Alaska, three survey indices are available for use in assessing the status of the sablefish population (Figure 9). There is an annual longline survey index of abundance conducted at standard survey stations since 1978 (cooperatively with Japan from 1978-1994) that samples depths from 200-1000 m. Bottom trawl surveys are conducted annually or biennially in the three main ecosystems in Alaska since 1982. These are either systematic surveys (eastern Bering Sea) or random-stratified surveys (Gulf of Alaska and Aleutian Islands). Because of limitations associated with catching sablefish with trawl gear and short survey time series in some regions (e.g., Bering Sea since 1997), only data from the Gulf of Alaska portion of the trawl survey is utilized for the Alaska stock assessment. Data from the International Pacific Halibut Commission standardized longline survey is also available, although this survey is conducted at the shallowest portion of the sablefish distribution (depths to 500 m) so it is not incorporated into the assessment. An additional longline survey conducted in the inside waters of Southeast Alaska by Alaska Department of Fish and Game is not used in the federal stock assessment because the state of Alaska assesses and manages sablefish in state waters independently from federal management.

The primary fishery independent survey index of abundance for U.S. West Coast sablefish is from the west coast groundfish bottom trawl survey, conducted from 2003-2024, over depths of 55 to ~1300 m (Figure 9). This annual bottom trawl survey follows a random-stratified survey design with four vessels (in most years). The trawl survey data is analyzed with the VAST model (Thorson 2019) to produce the index of abundance for sablefish. Historically other US West Coast bottom trawl surveys have had variable survey designs, although model based indices of abundance from these surveys (using the same VAST methods) are also included in the assessment. In the past a longline pot survey was conducted, but is not included in the stock assessment due to its limited spatial scope.

8.1.2.3 NPFC CA There is currently no survey conducted in the eastern NPFC Convention Area that captures or monitors sablefish populations.

8.1.3 Sablefish stock assessment

8.1.3.1 Canada domestic Canada uses a management strategy evaluation (MSE) process to generate recommended harvest. Underlying the MSE is a statistical catch-at-age structured operating model (stock assessment model) that gets updated on a 3 – 5 year cycle, at which time estimates of stock status are updated. Details of the operating model, as well as recent estimates of stock status relative to reference points, can be found in DFO 2020, DFO 2023, DFO 2024 and DFO 2025.

8.1.3.2 USA domestic The USA conducts two stock assessments (Alaska and the US West Coast) using age-structured models (Figure 10). The current Alaska assessment (Goethel et al. in press) and most recent USA West Coast assessments are a 2019 benchmark (Haltuch et al. 2019) and 2023 update assessment (Johnson et al. 2023) are available online (https://www.fisheries.noaa.gov/alaska/population-assessments/north-pacific-groundfish-stock-assessments-and-fishery-evaluation; https://www.pcouncil.org/stock-assessments-star-reports-stat-reports-rebuilding-analyses-terms-of-reference/groundfish-stock-assessment-documents/).

8.1.3.3 NPFC CA No stock assessment is conducted for the portion of the sablefish population found in the NPFC Convention area.

8.1.4 Sablefish management

8.1.4.1 NPFC CA The sablefish fishery in the NPFC area is managed under a Conservation and Management Measure agreed to by NPFC Members (currently CMM 2019-10 and CMM 2025-06) and the rules regulating the fishery are implemented through the conditions of licensing by DFO Fisheries Management. The allowable catch of sablefish in the eastern portion of the Convention Area is based on a long-term mean of historical catches from seamounts by Canada and assumed to be sustainable at that level (given the connection and sustainability of the coast wide population). It allows for 34 mt to be landed each month for the 6 months of the fishing season. The fishery is also managed through input controls by only allowing a single vessel to fish in each month. The Canadian vessels licensed to fish in the NPFC Convention Area are submitted to the NPFC Secretariat annually.

8.2 Results of analysis

The most recent domestic stock assessments conducted by the USA and Canada all indicate that the sablefish stock is healthy and not subject to overfishing. For all three regions the stock is well above the upper stock reference point (Figure 10), $B_{current}/B_{msy}$ is > 1.0 and $F_{current}/F_{msy} < 1.0$ (Figure 11)). In the NPFC CA there has been no fishery catch or effort since 2020.

8.3 Identification of uncertainties in data and methods, and measures to overcome such uncertainties

There is no fisheries independent survey that tracks sablefish abundance in the NPFC Convention Area. There is also no stock assessment that has been developed for this portion of the Sablefish stock.

As such, the results of this analysis are heavily dependent on the assumption that there is a single sablefish population that is contiguous in the NE Pacific Ocean (including the continental shelf and slope as well as Convention Area seamounts). In the eastern Pacific, Sablefish have traditionally been thought to form two populations based on differences in growth rate, size at maturity, and tagging studies. The northern population inhabits Alaska and northern British Columbia waters and the southern population inhabits southern British Columbia, Washington, Oregon, and California waters, with mixing of the two populations occurring off southwest Vancouver Island and northwest Washington. However, recent genetic work by Jasonowicz et al. (2017) found no population sub-structure throughout their range along the US West Coast to Alaska, and suggested that observed differences in growth and maturation rates may be due to phenotypic plasticity or are environmentally driven. Tagging evidence suggests that the sablefish inhabiting seamounts in the NPFC Convention Area are not distinct from the coast wide sablefish population (DFO 2013, Kapur et al. 2025, Figure 12).

In order to overcome these uncertainties, further data analyses could be undertaken to attempt to measure the status of the NPFC seamount Sablefish stock. These could include data-limited methods such as depletion analysis or generation of an age structured assessment model that borrows parameters and data from the coastal sablefish assessment. Currently Canada is initiating an analysis to address this gap and overcome uncertainties.

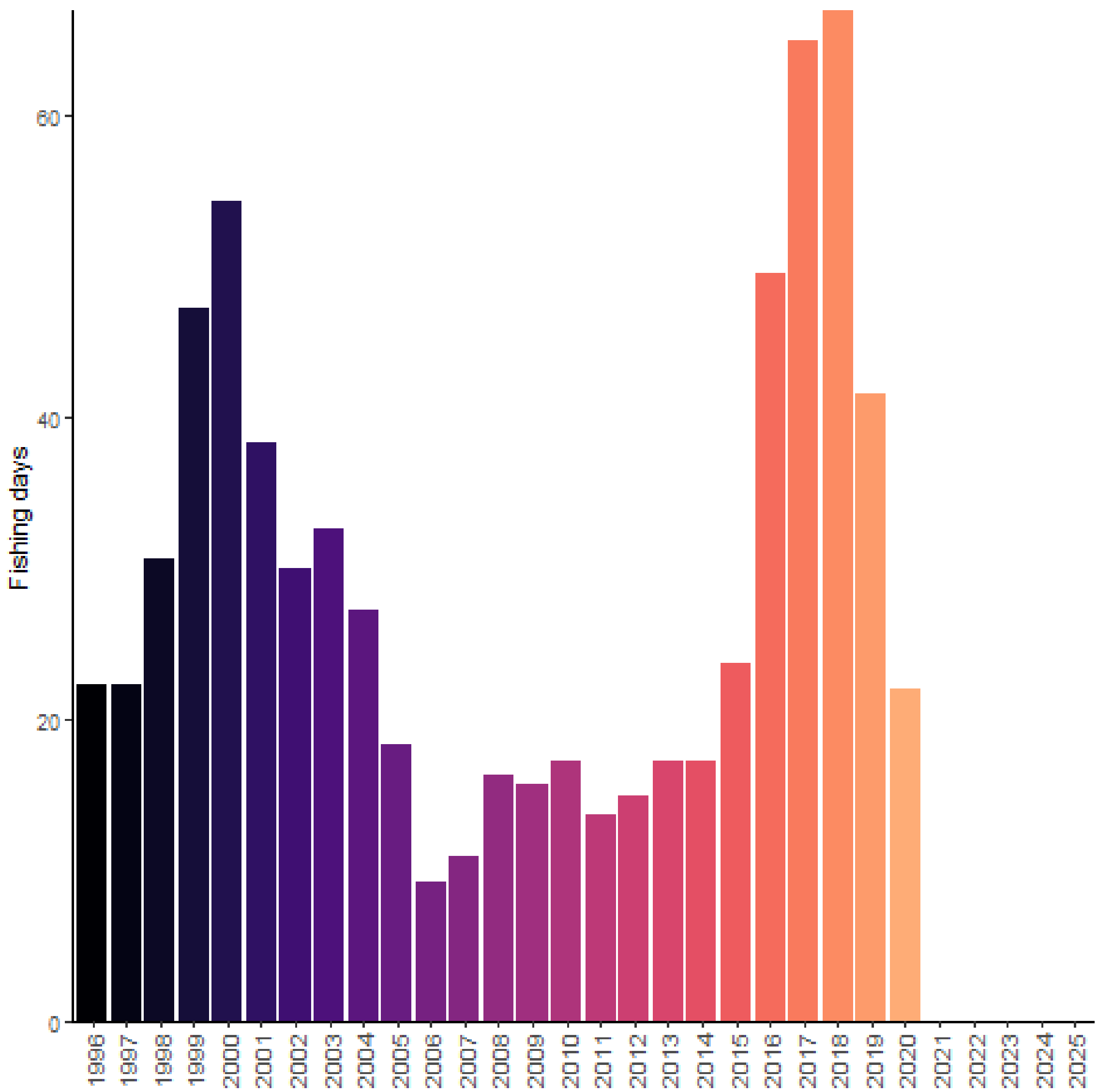

Figure 3: Fishing effort (in number of fishing days) for the Sablefish longline trap fishery conducted in NPFC waters (1996-present).Data are averaged across 3 years to comply with data privacy restrictions.

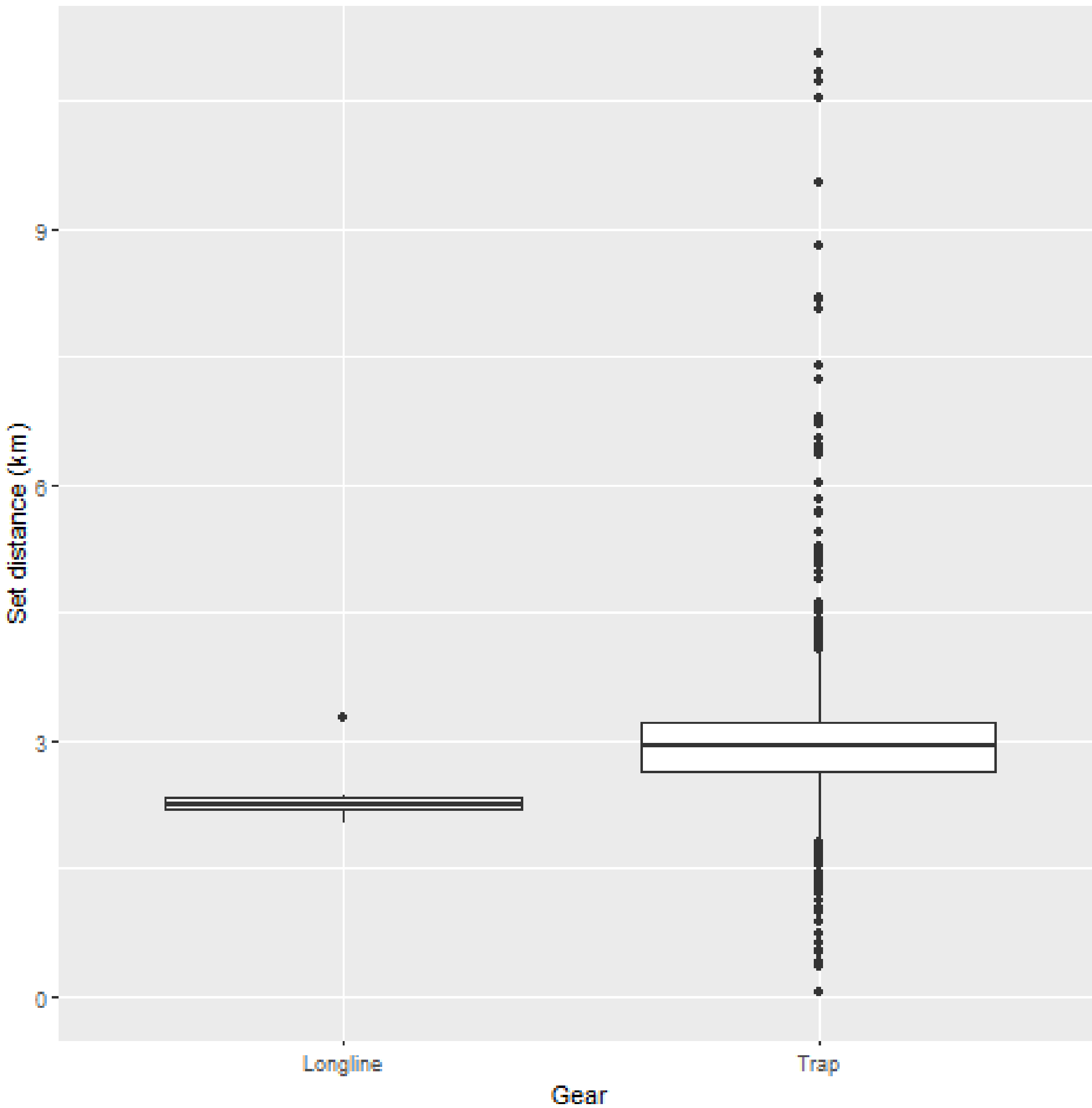

Figure 4: Average set length for trap and longline gear (km) in the Canadian seamount fishery in the NPFC Convention Area (1996-2025).

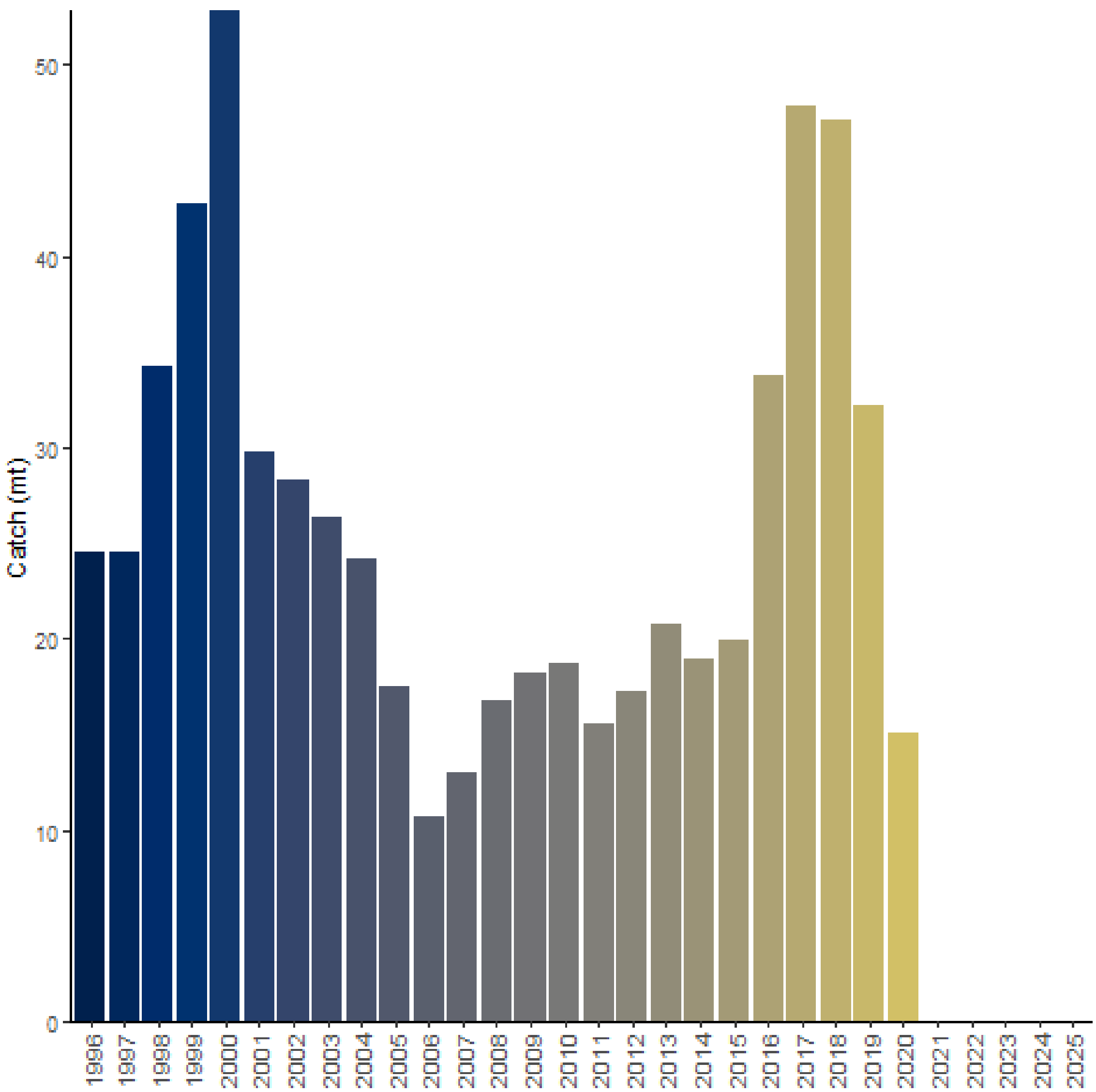

Figure 5: Landings of sablefish in the Canadian Sablefish fishery in NPFC region (1996-present).Data are averaged across 3 years to comply with data privacy restrictions.

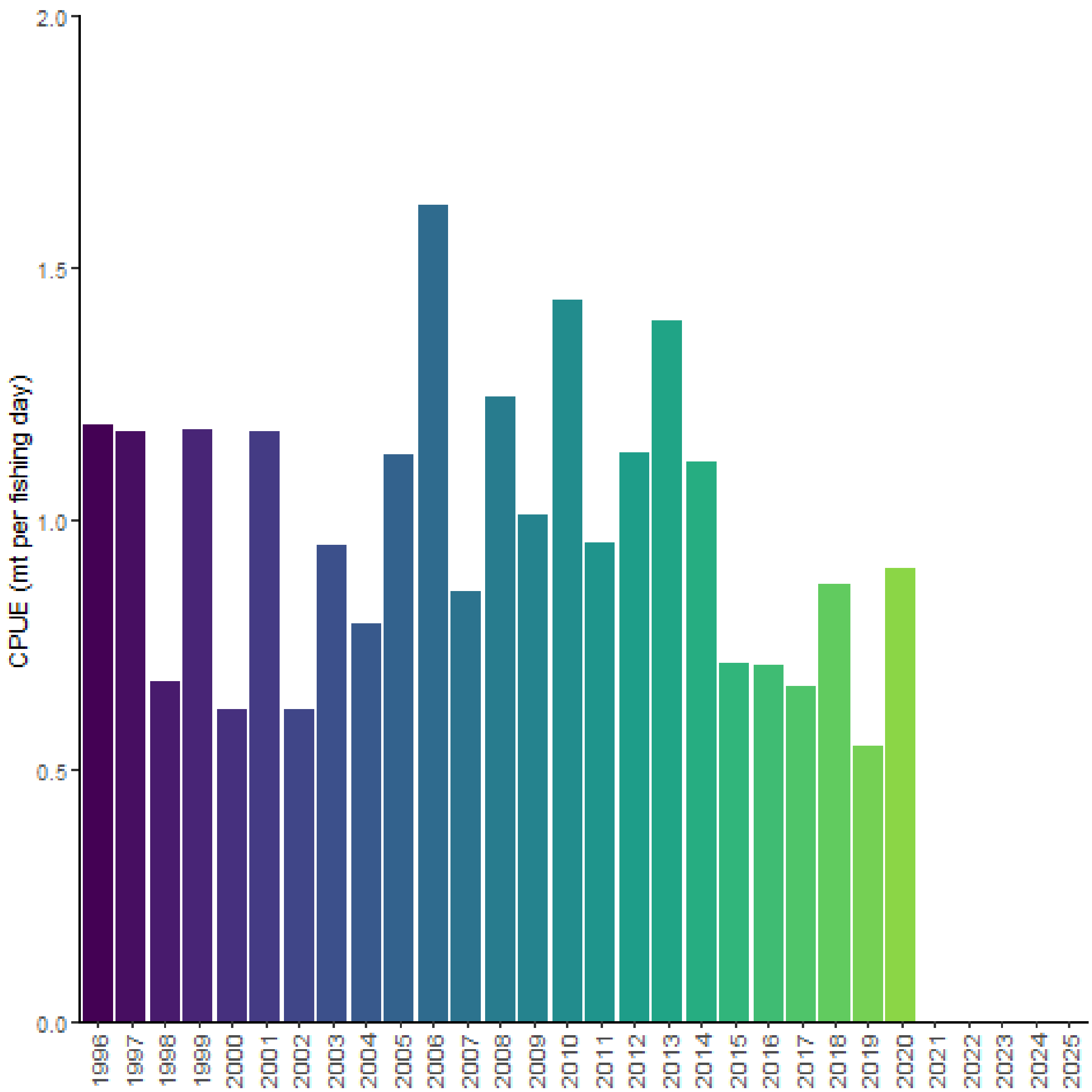

Figure 6: Catch per unit of effort for Canadian Sablefish fishery in NPFC region. Data are averaged across 3 years to comply with data privacy restrictions.

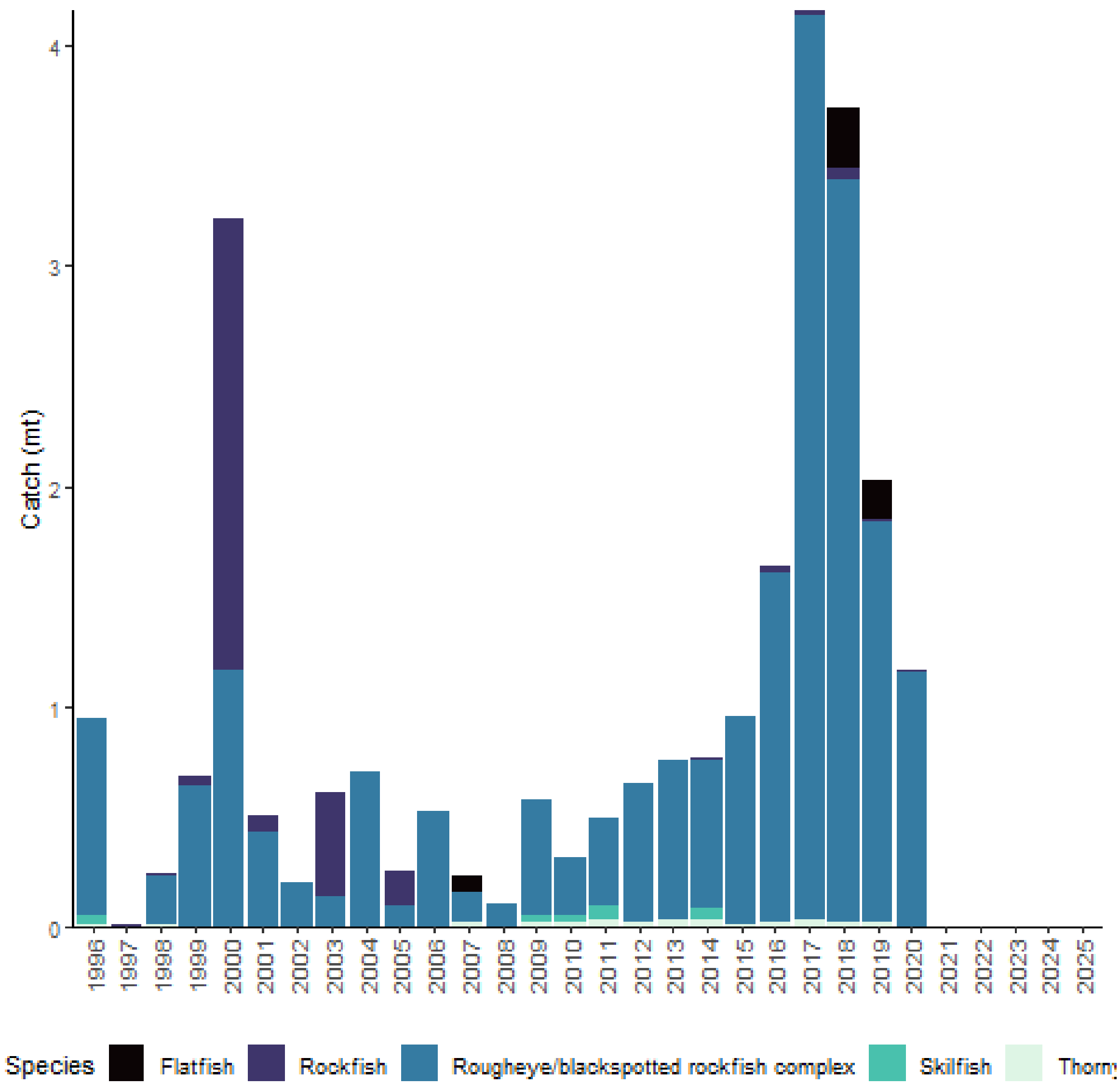

Figure 7: Catch of other landed species for Canadian Sablefish fishery in NPFC region. Data are averaged across 3 years to comply with data privacy restrictions.

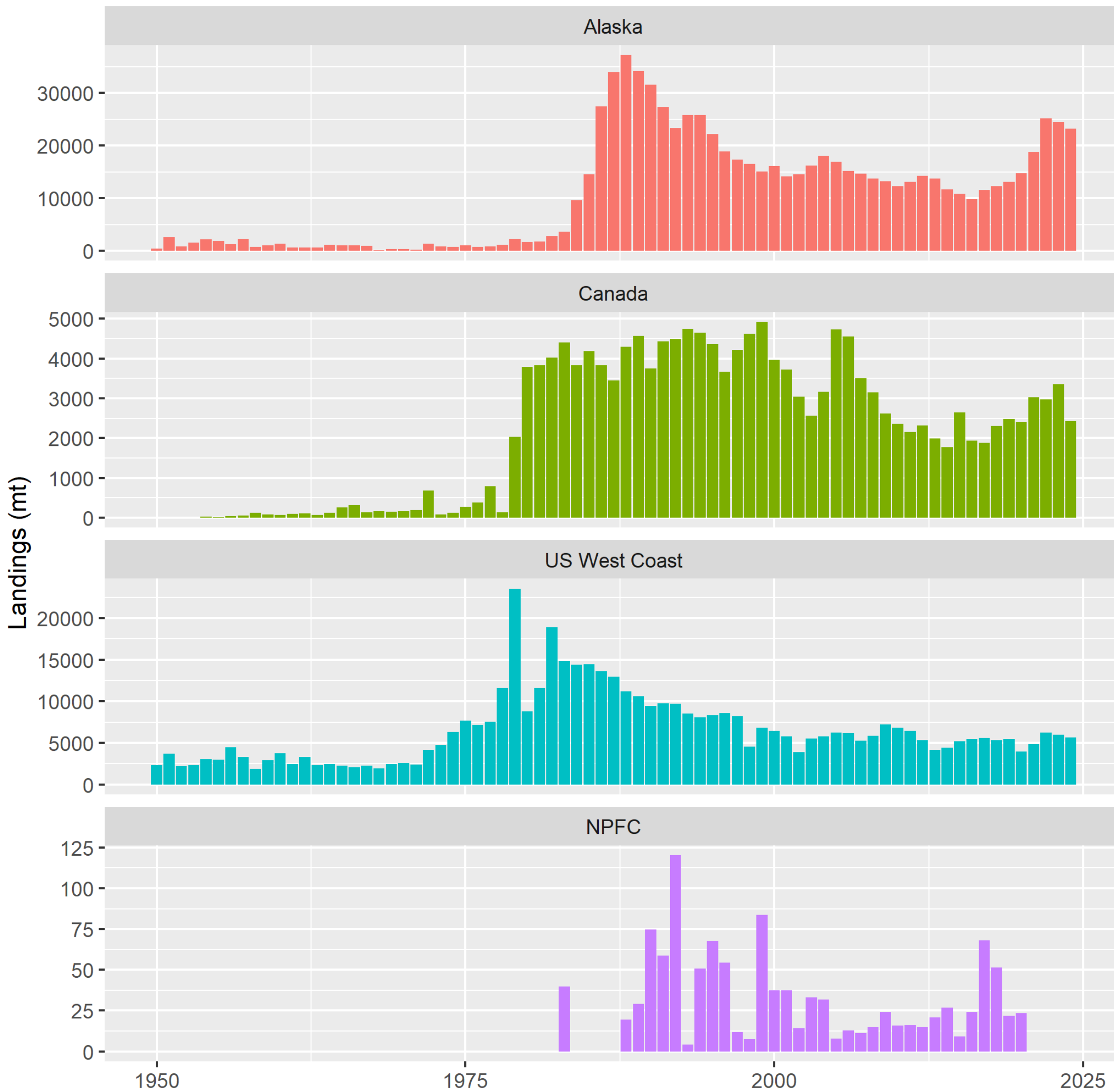

Figure 8: Historical landings of sablefish on the West Coast of North America and in the NPFC Convention Area.

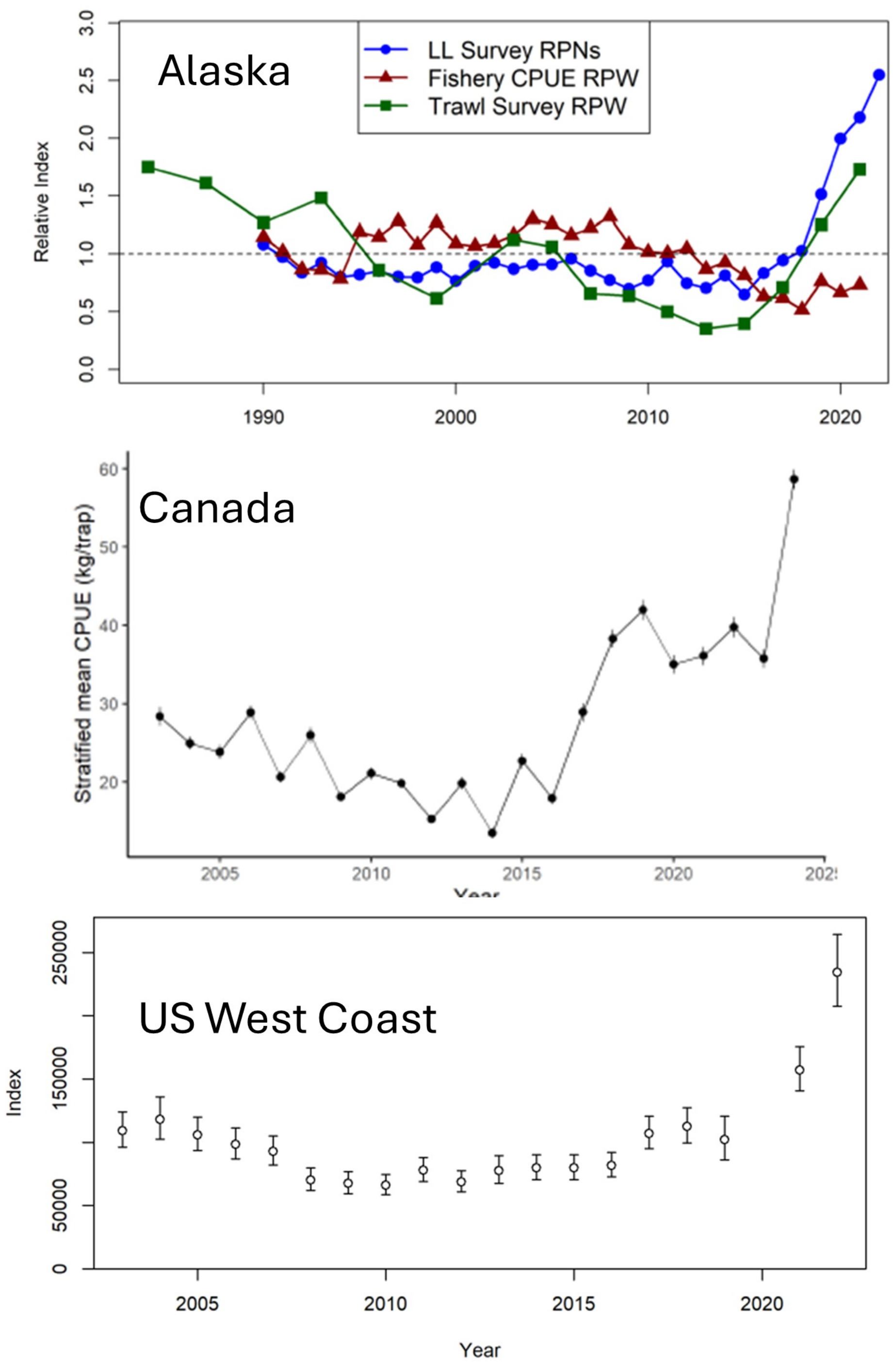

Figure 9: Survey indices of sablefish on the coast of North America (from Alaska to California).

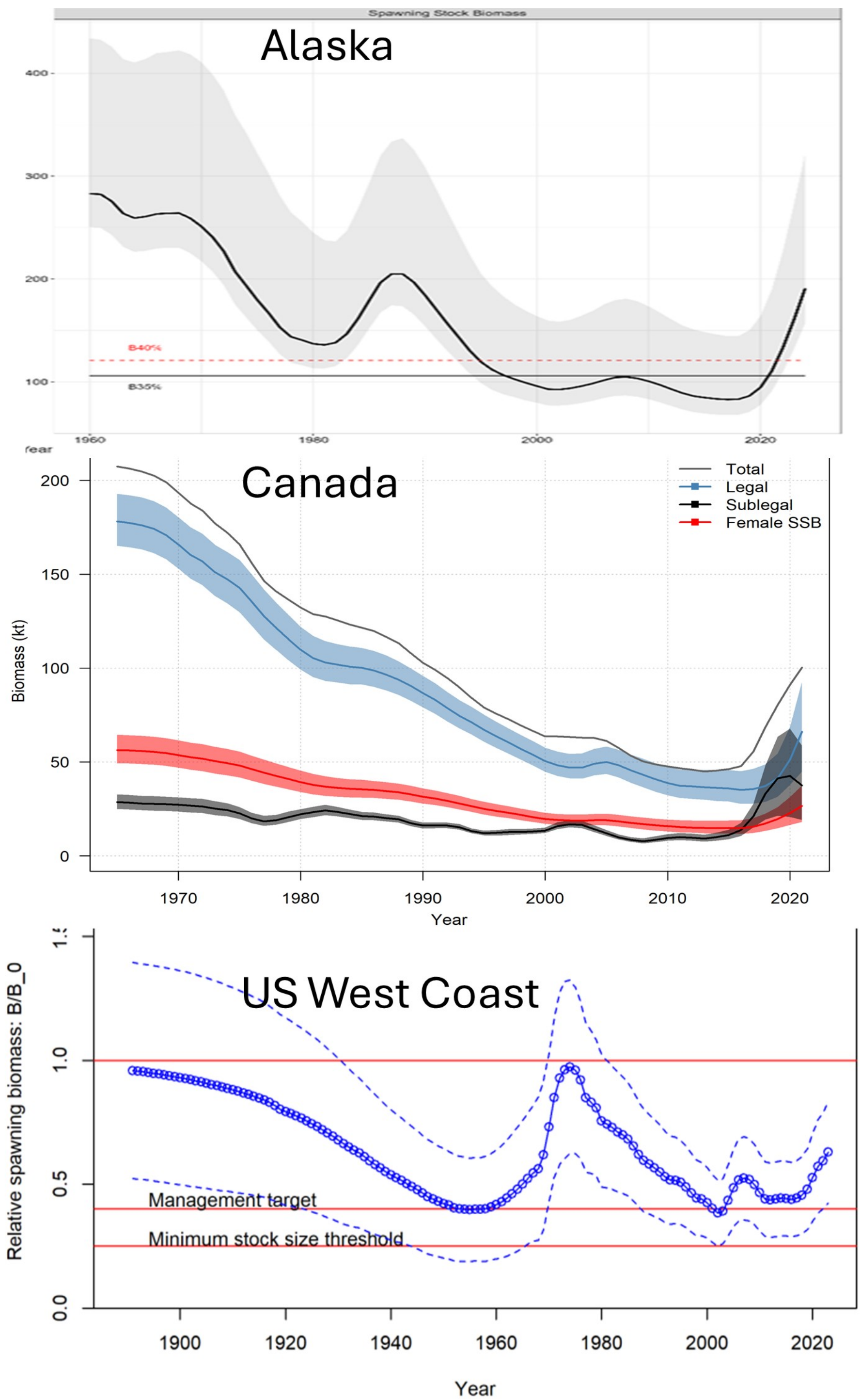

Figure 10: Time series of spawning stock biomass for Alaska (top), Canada (middle) and U.S. West Coast (bottom) sablefish. Horizontal lines represent upper and lower stock reference points.

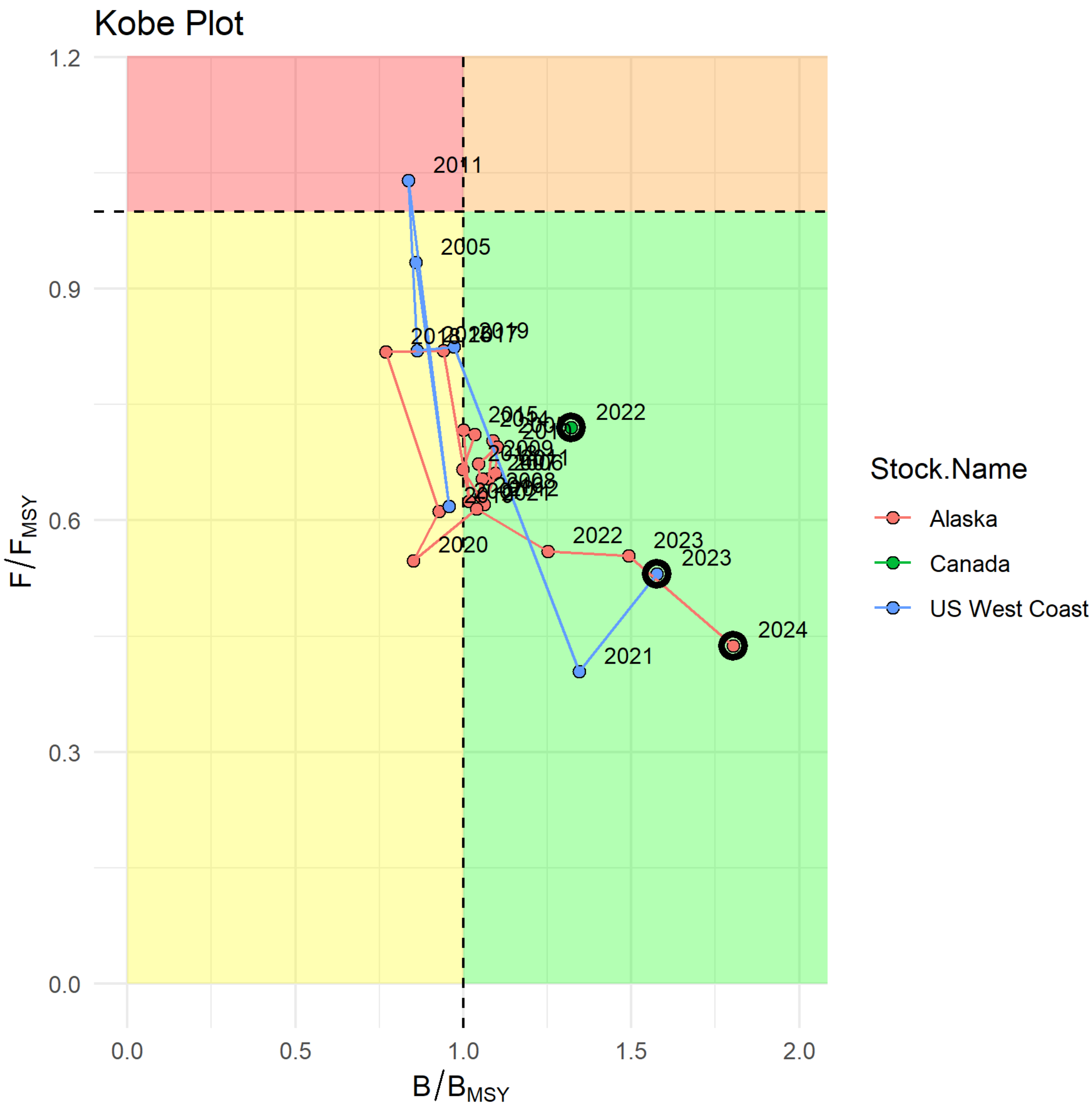

Figure 11: Kobe plot of time series reference points and status for the most recent stock assessments in Alaska, Canada and U.S. West Coast sablefish. The most recent estimates are shown in large outlined points.

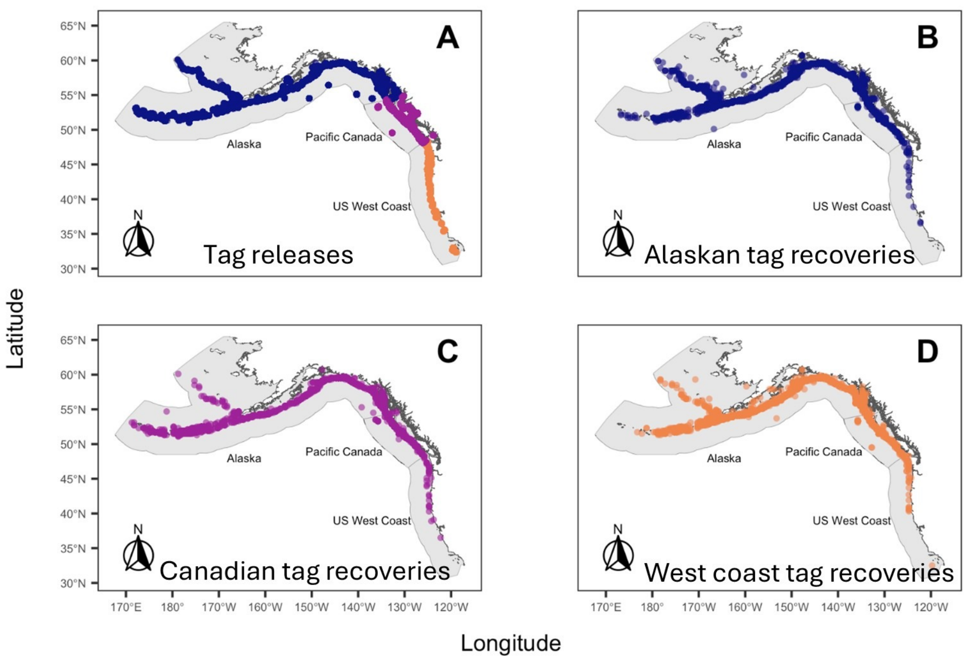

Figure 12: Historical release locations and recovery locations for eastern North Pacific Sablefish tagging programs (color coded by release location and recovery location). Image courtesy of B. Connors, DFO.

9 Analysis of status of bycatch species resources

9.1 Data and methods used for analysis

The data used for this analysis were extracted from the commercial fisheries database for seamounts in the NPFC Convention Area. Logbook data entry for all captured species has been in place throughout the history of this fishery. Since 1997 there has been 100% observer coverage on all Sablefish fishing vessels, through a combination of electronic monitoring (EM), at-sea observers and dockside monitoring (Turris 2000, DFO 2021). Data are collected and recorded on a set-by-set basis and the historical data since 1996 includes n = 2568 records. The current at-sea monitoring is conducted via EM systems where details of each fishing event including date, time, latitude, longitude and depth of the gear are captured. The EM system also video records 100 percent of both retained and released catch. Harvesters are required to keep accurate records of all fishing events and catch information in their fishing logbooks. The logbooks are then audited, by an independent service provider to ensure that it represents the most accurate record of catch. Dockside monitoring is also mandatory for vessels participating in the seamount fishery. All landings are monitored by an independent dockside validator in order to verify that the number of fish landed at the dock is equivalent to the amount recorded in the logbooks.

Data since 1996 were used in the analysis. For some species and gear types the weight of the catch was not recorded, but instead the count of individuals was recorded. For these cases, the counts of the catch were multiplied by the historical average individual weight in trap and longline fisheries to produce an estimated total weight of catch if it was available. If no historical data from the fishery was available, a historical average individual weight in fisheries independent surveys conducted on the continental shelf and slope of British Columbia.

9.2 Results of analysis

9.2.1 Historical bycatch - Fishes

Historical bycatch in the sablefish fishery has been dominated by crabs and rockfishes. Catch rates per day were generally low (< 1 kg/fishing day) with the exception of grenadiers, tanner crabs and unidentified crabs (Figure 13). Rougheye and blackspotted rockfishes were the most numerous bycatch species across all years (Figure 14). This is likely because they are targeted somewhat by the fishery as there is a market for them and they can be captured efficiently using pot gear. The second most abundant fish group in the bycatch was rockfishes. Sixteen different species of rockfish were captured (plus unidentified rockfishes) over the years (Figure 15). The most common species of rockfish were thornyheads. Other fishes included common deepsea fishes like grenadiers, skilfish and snailfishes (Figure 16). Dover sole, deepsea sole and Pacific halibut were common species of flatfish captured as bycatch (Figure 17). Very few sharks or skates were captured in bycatch on the seamounts, and the most common species was Pacific sleeper sharks (Figure 18).

9.2.2 Historical bycatch - Invertebrates

Historical bycatch of invertebrates in the sablefish fishery was dominated by crabs. Most crabs were unidentified (Figure 19), but those that were identified were either king crabs or tanner crabs (Figure 20). The catch of other types of invertebrates was low (typically less than 3 kg per year) and the most frequent catch was of octopus (Figure 21). Squat lobster (Reptantia) were also captured in some years. VME indicator taxa (corals and sponges were only captured in 1998 (Figure 22).

9.2.3 Summary

- Bycatch was low in the pot and longline fisheries since 1996
- Rockfishes (including targeted rockfishes) were the dominant bycatch
- Crabs dominated the invertebrate bycatch (king crabs and tanner crabs)
- Only two instances of VME indicator taxa were observed in the bycatch data
- There has been an increase in the bycatch of rougheye/blackspotted rockfishes, however these species are targeted by the fishery

- There appears to be no significant increasing trends in bycatch for other species over time
- Canada should continue to monitor impacts of its fisheries to species belonging to the same ecosystem as sablefish.

9.3 Identification of uncertainties in data and methods, and measures to overcome such uncertainties

There is no fisheries independent survey of abundance that can track temporal trends on seamounts for any of the bycatch species captured in the sablefish fishery. Fisheries catch data is not ideal for tracking time trends in abundance of fish stocks. Many of these bycatch species, in particular rockfish stocks, are known to have a high degree of population structure (Spencer and Rooper 2010), so it is likely that the seamount populations are somewhat isolated from coastal populations (in contrast to Sablefish populations at seamounts). This may make these species more susceptible to overharvest.

Overcoming these uncertainties would require data that tracked the abundance of bycatch species over time, such as a fisheries-independent survey.

Figure 13: Catch per day by species averaged for 1996-2024.

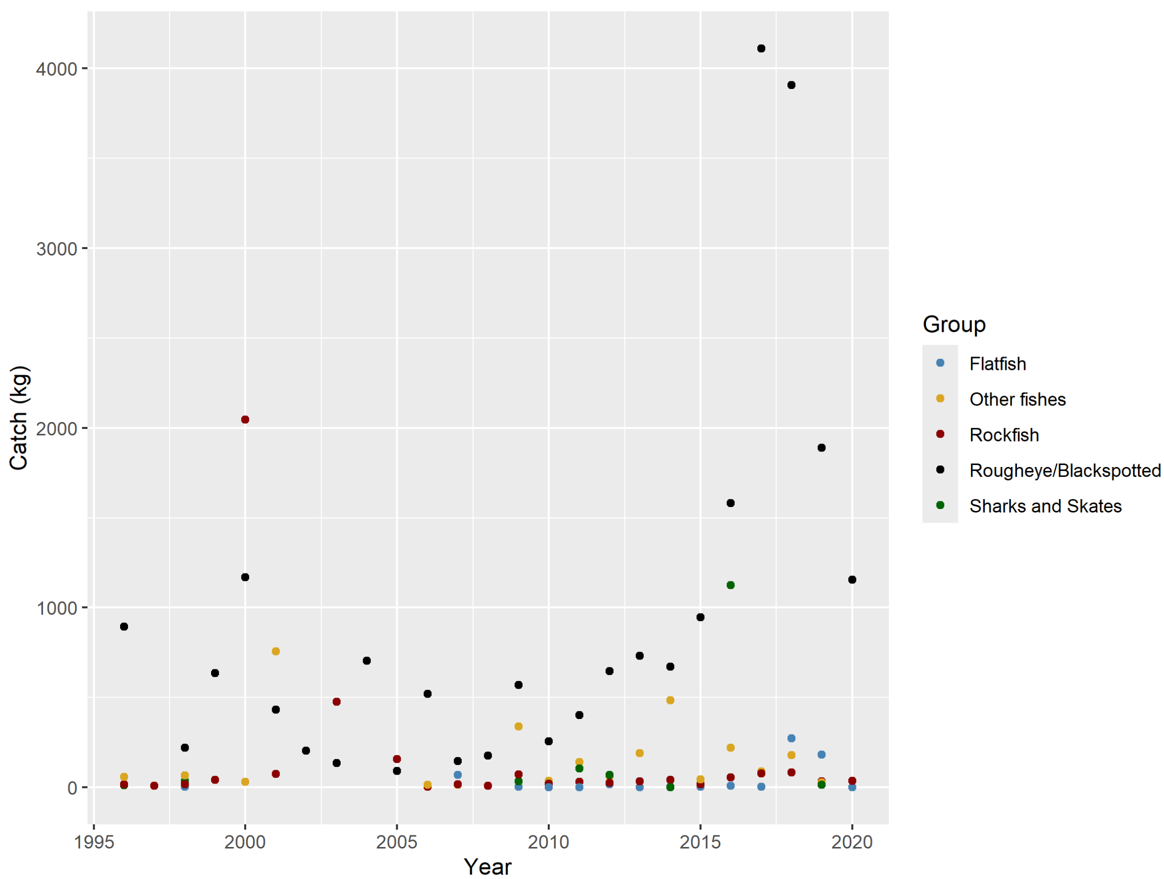

Figure 14: Bycatch of fishes by taxonomic group in the Cobb Seamount chain in the sablefish fishery by year (1996-2020).

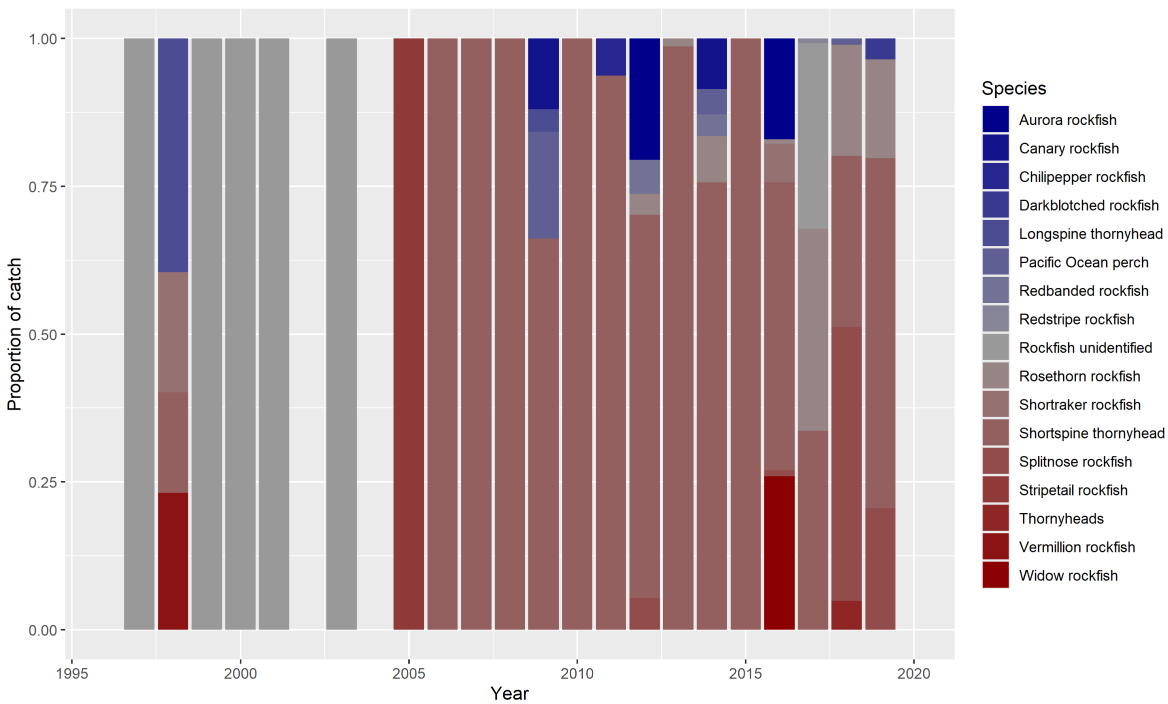

Figure 15: Bycatch of rockfishes by taxonomic group in the CObb Seamount chain in the sablefish fishery by year (1996-2020).

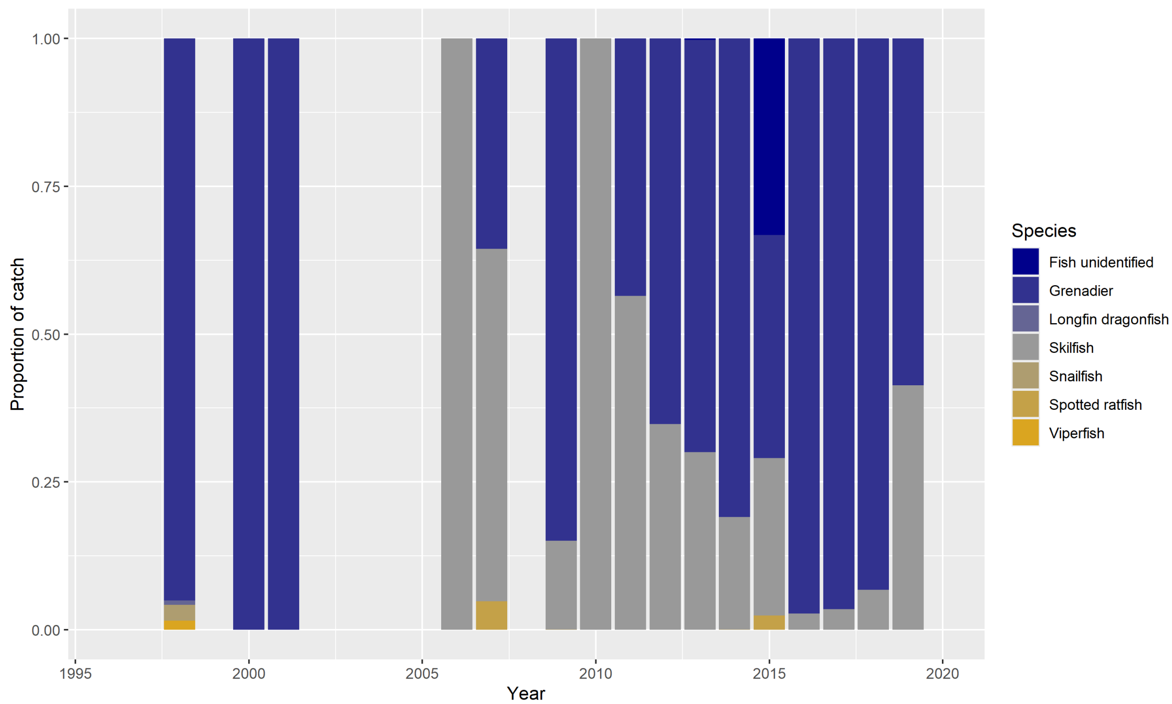

Figure 16: Proportion of other fish taxa in the catch by year (1996-2020).

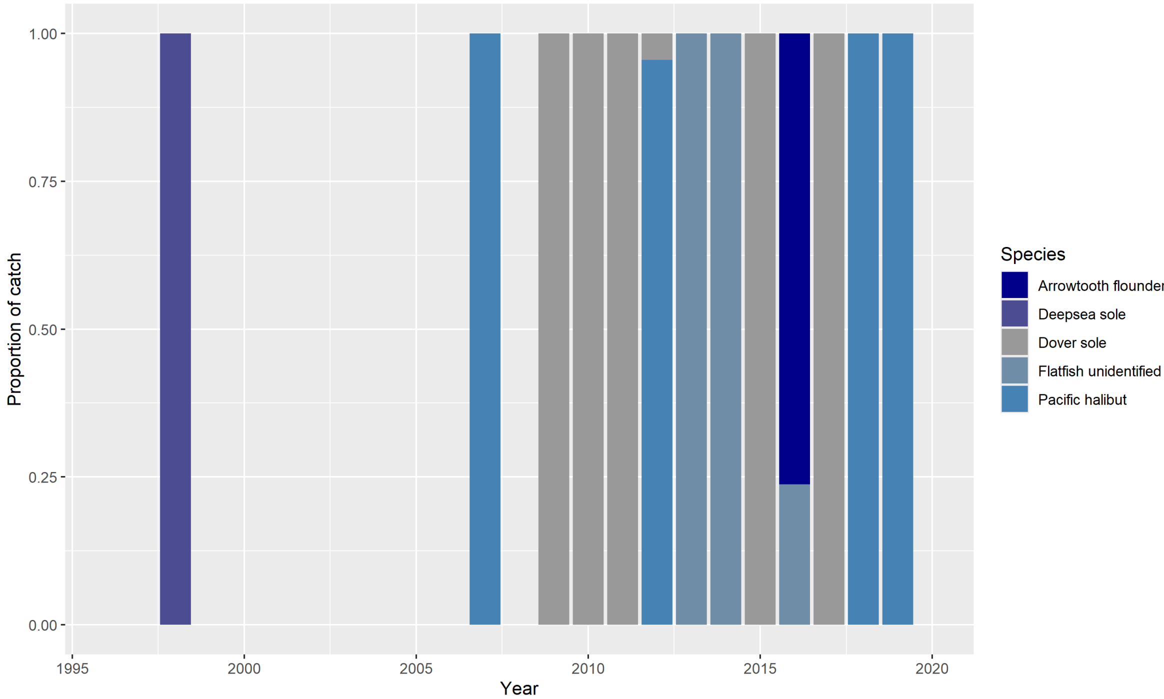

Figure 17: Proportion of flatfishes taxa in the catch by year (1996-2020).

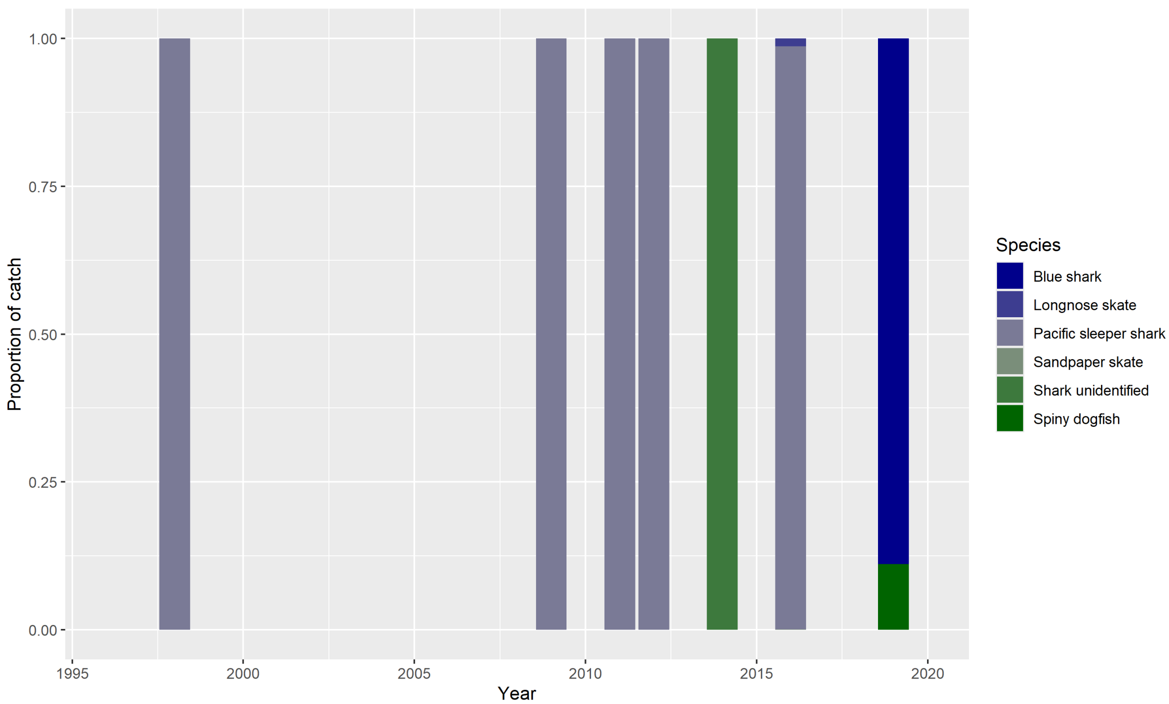

Figure 18: Proportion of flatfishes taxa in the catch by year (1996-2020).

Figure 19: Bycatch of invertebrate taxa groups in the catch by year (1996-2020).

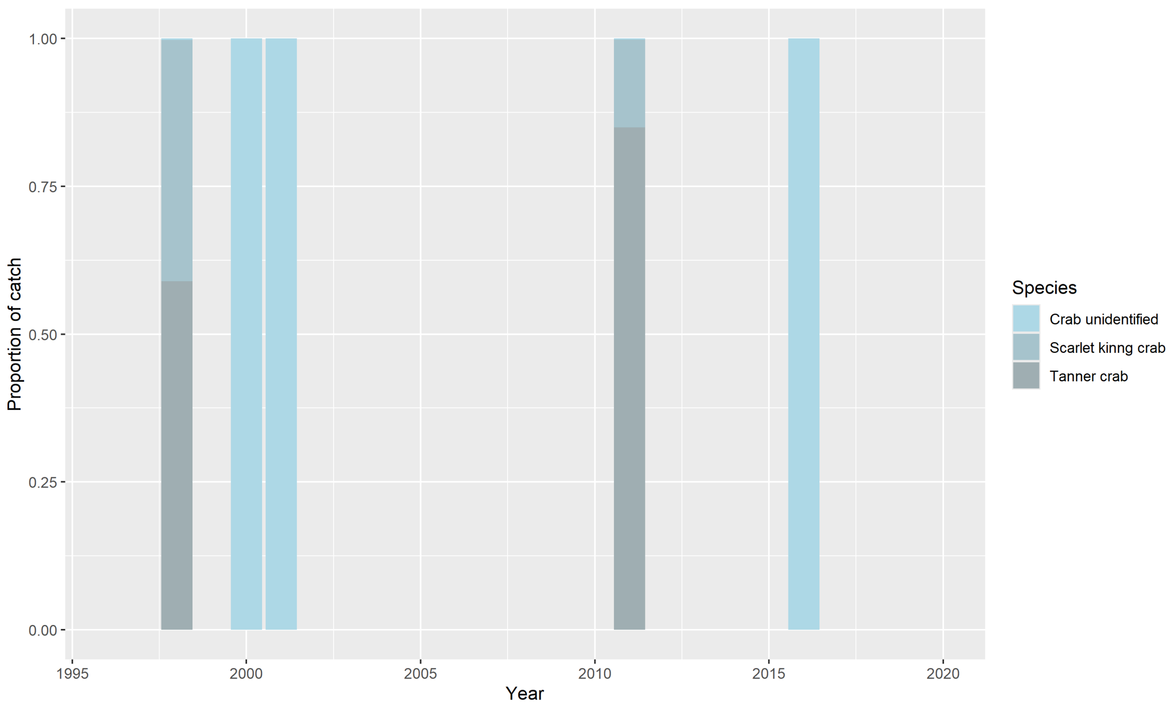

Figure 20: Proportion of crab taxa in the catch by year (1996-2020).

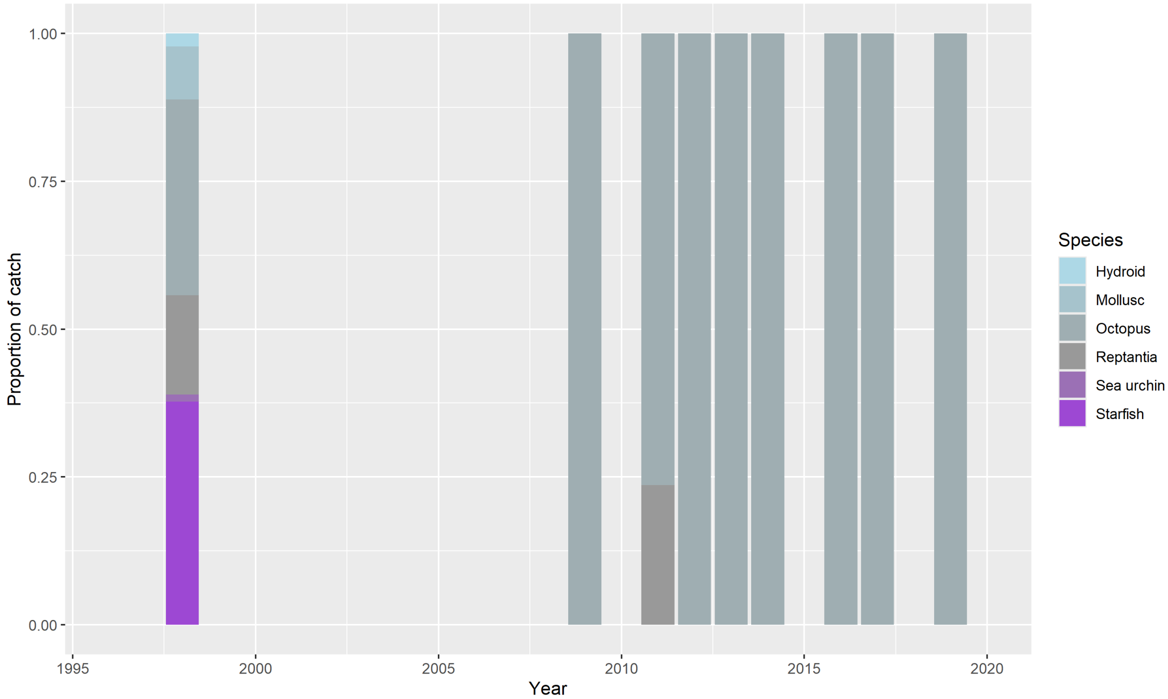

Figure 21: Proportion of other invertebrate taxa groups in the catch by year (1996-2020).

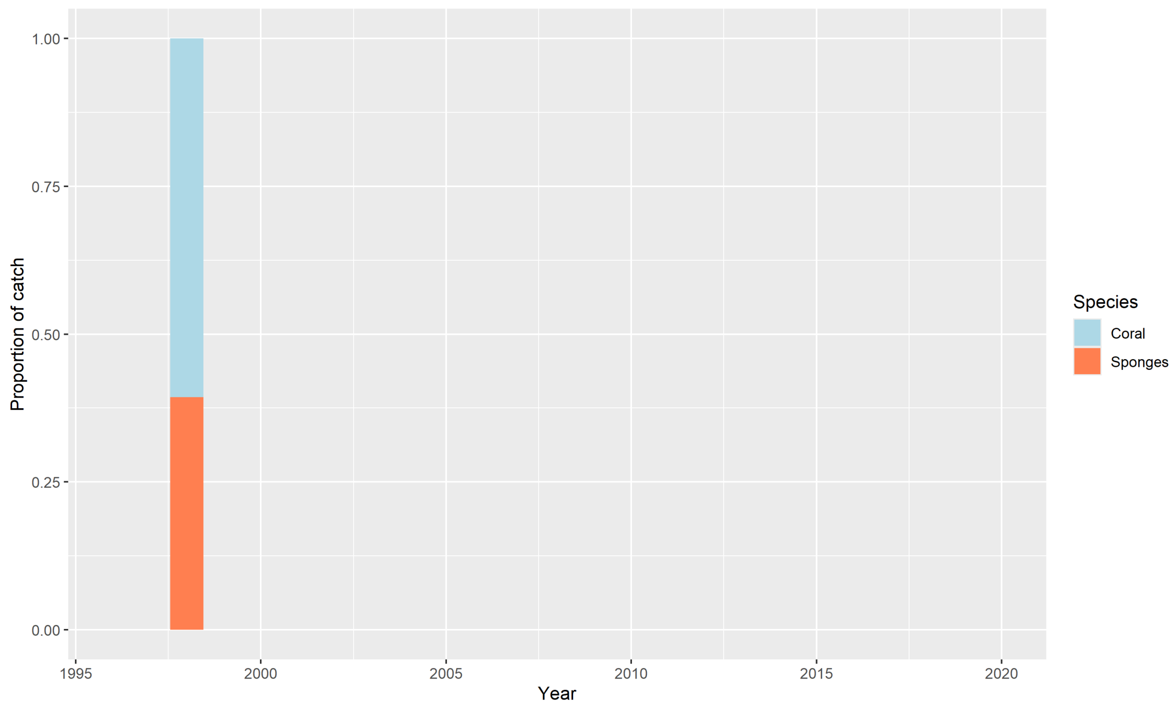

Figure 22: Proportion of VME indicator taxa in the catch by year (1996-2020).

10 Analysis of existence of VMEs in the fishing ground

10.1 Data and methods used for analysis

10.1.1 Data

As mentioned in Section 9, the trap and longline fishing gear used in the Cobb Seamount Chain does not retain VME indicator taxa. This limits the data on the existence of VME in the fishing ground to observations collected through scientific research. Since the last Risk Assessment completed by Canada (DFO 2013), significant new data has been collected on the Cobb Seamount Chain (CSC). The earlier report relied on data from historical submersible trips to Cobb Seamount that explored depths < 300 m and information from the continental shelf of Canada, as well as personal communications with taxonomic experts, and the existing scientific literature on specific corals and sponges. Most historical data and observations have been submitted and compiled into NOAA's deep-sea coral database (www.deepseacoraldata.noaa.gov). VME presence data for the CSC were queried and downloaded for use in the following analyses (queried on 10/24/2025, Table 2).

Since 2012 there have been three research cruises to the CSC that used underwater camera systems to document the occurrence of VME and VME indicator taxa in the area. The first of these cruises was completed in 2012 and used an AUV and ROV to explore Cobb Seamount. The data and results of this cruise have been published in Curtis et al. (2015). During this cruise 19 transects were carried out at depths from 34-1154 m on Cobb Seamount. They observed seventeen coral taxa, as well as sponges from the orders Hexactinellida and Demospongiae. The four AUV transects generated density estimates for VME indicator taxa which are used in the following analyses. The 15 ROV transects generated presence or absence observations for VME indicator taxa which are also used in the following analyses (Table 2).

Two other cruises were undertaken in 2022 and 2024 to the CSC. These two cruises utilized a stratified (by depth and seamount) random survey design. The main tool used in this work was the underwater stereo camera system developed during the Alaska Coral and Sponge Initiative in 2012-2015. The stereo-camera survey followed a standard protocol outlined in Rooper et al. (2016), with a target of 15 minutes of on-bottom time for each transect. Images were processed to determine substrate type, density and size of VME indicator taxa using Sebastes software (Williams et al. 2015). In 2022, 77 transects were occupied and in 2024, 58 transects were occupied covering depths from ~30 m to ~850 m. The 2022 cruise generated presence, absence, density and VME indicator taxa height observations which were used in the following analyses (Table 2). The image analysis for the 2024 data is ongoing and preliminary, so only presence or absence observations are included in the analyses for this cruise.

Data from each of these sources were compiled into a single table and observations, densities and heights were grouped into the recognized VME indicator taxa groups from the NPFC (gorgonians, soft corals, Scleractinians, sponges (Hexactinellida and Demospongiae), Antipatharians and Pennatulaceans).

10.1.2 Species distribution modeling

In addition to the new observational data, a number of species distribution models for VME indicator taxa have been derived that cover the CSC since 2010. The models that cover the CSC include three global coral models (Yesson et al. 2012 (for gorgonians and Pennatulaceans), Yesson et al. 2017 (for Antipatharia) and Tong et al. 2023 (for gorgonians, scleractinians)) and a set of regional models for Alcyonacea, Antipatharia, gorgonians, and Scleractinians from Chu et al. (2019) that were updated with new explanatory variable layers in 2023 (Warawa et al. 2023?). In addition, Rooper et al. (in prep.) developed species distribution models for probability of presence, density and VME indicator taxa height based on random stratified survey data from 2022 and 2024. These models were for Alcyonacea, Antipatharia, gorgonians, Scleractinians, Hexactinellida and Demospongiae. Finally, Warawa et al. (2025) developed a method that used the density of VME indicator taxa from AUV transects and the associated diversity of fishes and invertebrates (ala Rowden et al. 2021) to determine a threshold density to define a VME. Using that threshold, Warawa et al. (2025) classified transect segments that would be defined as VME and further used that defined VME as a dependent variable in a species distribution model that predicted the probability of occurrence of VME, rather than the occurrence of VME indicator taxa.

These models can be used to identify areas of likely VME indicator taxa presence, areas of predicted high density or areas of large VME indicator taxa. For this analysis we took a few approaches to create a weight of evidence method to identifying areas of likely VME using species distribution models and observations. For individual VME indicator taxa we created ensemble models of probability of presence. The ensembling used a weighted average to estimate a map of the probability of presence for each VME indicator taxa. The weights used were the AUC of the model predicting the 2024 survey data. This data was not used in model development for any of the ensembled species distribution models, so was an independent test of model predictions.

There was only a single density and a single height model for the CSC (Rooper et al. in prep.), so these models were considered alone (not as part of an ensemble).

There was also only a single model predicting VME distribution (Warawa et al. 2025), so this too was considered alone.

10.1.3 Analyses

Observations of presence or absence and density of VME indicator taxa were plotted for each of the five seamounts fished by Canada to show areas of high occurrence and relatively high density.

Height data from 2022 and preliminary 2024 data were used to generate estimates of size distribution of VME indicator taxa.

10.2 Results of analysis

10.2.1 Maps of VME indicator observations and models

10.2.1.1 Antipatharia Maps of Antipatharia observations (Figure 23) shows that this VME taxa group is widely distributed at depths below ~300 m. Densities where they were found tended to be relatively low, except at the deepest areas surveyed, locations on Eickelberg seamount and at AUV transects on Cobb Seamount (Figure 24). Most individuals were quite large with a median height of 34.9 cm (Figure 25). The models predicting Antipatharia height predicted larger sizes at the edges of their distribution (both shallow and deep sites, Figure 26).

10.2.1.2 Gorgonian Maps of Gorgonian observations (Figure 27) shows that this VME taxa group is also widely distributed at depths below ~300 m, with probability of presence near 1 at these depths. Densities where they were found tended to be relatively low, except at locations on Eickelberg seamount, Warwick Seamount and Corn Seamount and at AUV transects on Cobb Seamount (Figure 28). Most individuals were of medium height with a median height of 22.9 cm (Figure 25). The models predicting Gorgonian height predicted similar heights throughout most of their distribution (Figure 29).

10.2.1.3 Scleractinia Maps of Scleractinia observations (Figure 30) shows that this VME taxa group can be present at all depths on the seamounts. , with probability of presence near 1 at these depths. Densities were low, except at one AUV transect on Cobb Seamount.(Figure 31). Very few Scleractinia individuals were measured during the 2022 seamount survey (Figure 25). No models were developed predicting Scleractinian height due to the limited number of height measurements.

10.2.1.4 Alcyonacea Maps of Alcyonacea observations (Figure 32) were similar to the distribution of scleractinians (can be present at most depths on seamounts). There were no density or height models developed for Alcyonacea. Densities where they were found tended to be relatively low and most individuals were $<$ 30 cm tall with a median height of 12.2 cm (Figure 25).

10.2.1.5 Hexactinellida Maps of Hexactinellida observations (Figure 33) shows that this VME taxa group is present at most depths with high probability, except on the summits of seamounts. Densities where they were found tended to be relatively moderately low on Cobb Seamount, but generally higher at other seamounts. (Figure 34). Most individuals were $<$ 30 cm tall with a median height of 18.2 cm (Figure 25).

The models predicting Hexactinellida height predicted similar heights throughout most of their distribution (Figure 35).

10.2.1.6 Demospongiae Maps of Demospongiae observations (Figure 36) shows that this VME taxa group is distributed at depths above ~300 m on Cobb and Brown Bear Seamounts, and at deeper depths on the other seamounts. Densities where they were found tended to be relatively low, but extremely patchy (Figure 37). Most individuals were < 30 cm tall with a median height of 7.4 cm (Figure 25). The models predicting Demospongiae height predicted similar heights throughout most of their distribution (Figure 38).

10.2.1.7 Pennatulacean Maps of Pennatulacean observations (Figure 39) shows that this VME taxa group is also widely distributed at shallower depths above ~300 m on Cobb and Brown Bear Seamounts. Densities where they were found tended to be relatively low, except at AUV transects on Cobb Seamount (Figure 40). Most individuals were > 30 cm tall with a median height of 31.5 cm (Figure 25). The models predicting Pennatulacean height predicted similar heights throughout most of their distribution (Figure 41).

10.2.2 Maps of VME indicator predicted presence, density and height

Maps of combined VME indicator taxa observations (Figure 42) shows that the probability of presence of VME is quite high throughout all of the seamount area surveyed. Densities of combined VME indicator taxa were generally low, but predicted to be higher at deeper depths on all seamounts (Figure 43). The overall median height was 21.4 cm (Figure 25). The models predicting Pennatulacean height predicted similar heights throughout most of their distribution (Figure 44).

10.2.3 Maps of predicted VME probability of presence

Warawa et al. (2025) used a quantitative method to define VME using the VME indicator taxa density where there is a peak in associated diversity using the 4 AUV transects. Using this definition, Warawa et al. (2025) predicted where VME was likely to occur. These predictions are shown in Figure 45. It shows that VME is most likely in the deep areas on the North and West sides of Cobb Seamount.

10.2.4 Conclusions

- VME indicator taxa are present on most transects at depths less than 300 m on the CSC
- Densities of VME indicator taxa are generally low
- Some instances of reef building scleractians have been observed
- Is unknown how much of the VME indicator taxa habitat would be considered actual VME

10.3 Identification of uncertainties in data and methods, and measures to overcome such uncertainties

There are considerable uncertainties in the data and models presented in Section 10. It is clear however that VME indicator taxa are present and widespread (albeit patchy) at all seamounts deeper than ~300 m. Quantitative definitions are needed to determine whether the presence of VME indicator taxa constitutes a VME. This work is currently being undertaken by Canada.

Table 2: The number of observations of VME indicator taxa by observation data source. The AUV2012 and ROV2012 data are from segmented (50 m length) AUV and ROV transects conducted in 2012 on Cobb Seamount. The DSCRTP data are historical point observations from NOAA's deep-sea coral database for the CSC. The SCS 2022 and 2024 data are from a random stratified survey of five seamounts on the CSC and represent the number of transects where a VME indicator taxa occurred.

VME_group	Model	Test_AUC	Used
Antipatharia	Rooper et al. 2025	0.578	
Antipatharia	Chu et al. 2019	0.653	Yes
Antipatharia	Yesson et al. 2017	0.730	Yes
Gorgonian	Rooper et al. 2025	0.762	Yes
Gorgonian	Chu et al. 2019	0.617	Yes
Gorgonian	Yesson et al. 2012	0.767	Yes
Gorgonian	Tong et al. 2023	0.640	Yes
Scleractinia	Rooper et al. 2025	0.591	
Scleractinia	Chu et al. 2019	0.704	Yes
Scleractinia	Tong et al. 2023	0.631	Yes
Alcyonacea	Chu et al. 2019	0.642	Yes**
Hexactinellida	Rooper et al. 2025	0.833	Yes**
Demospongiae	Rooper et al. 2025	0.515	Yes**
Pennatulacean	Rooper et al. 2025	0.521	
Pennatulacean	Yesson et al. 2012	0.601	Yes

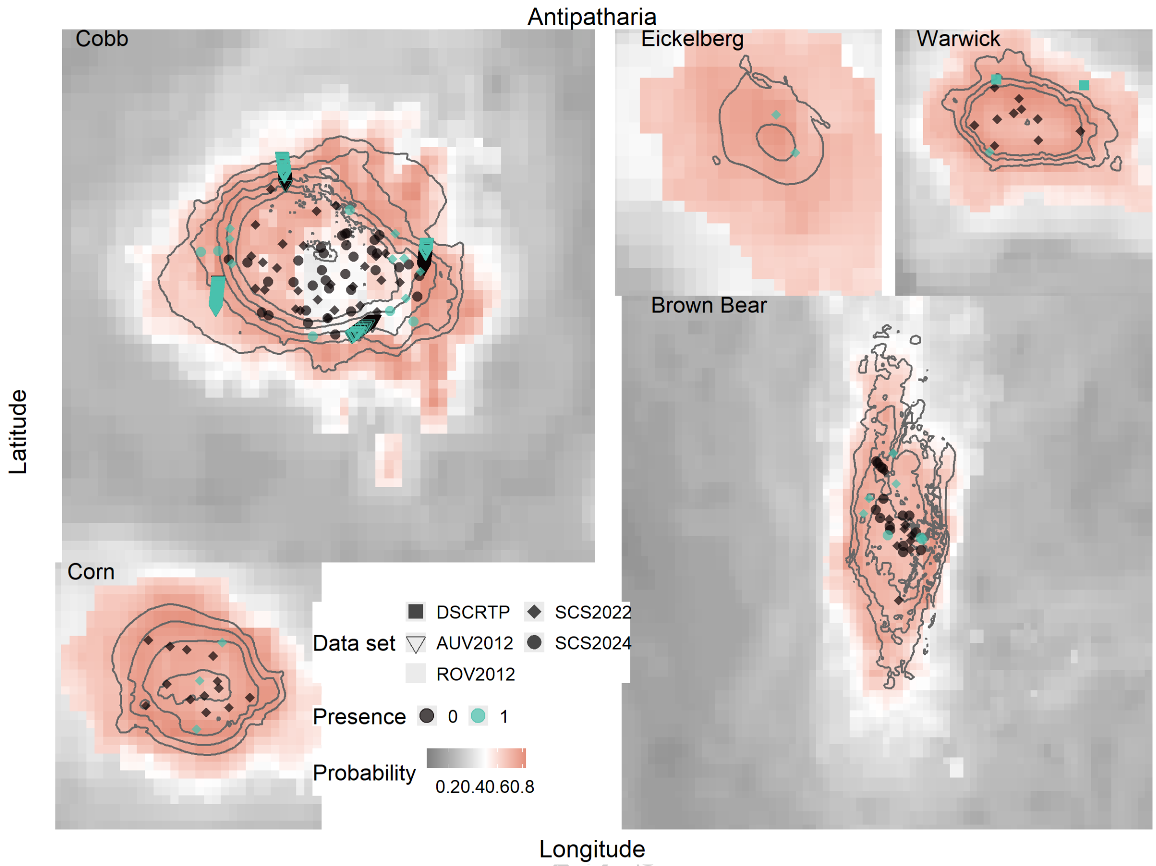

Figure 23: Observations of presence or absence of Antipatharia at seamounts in the Cobb Seamount Chain from all data sources.

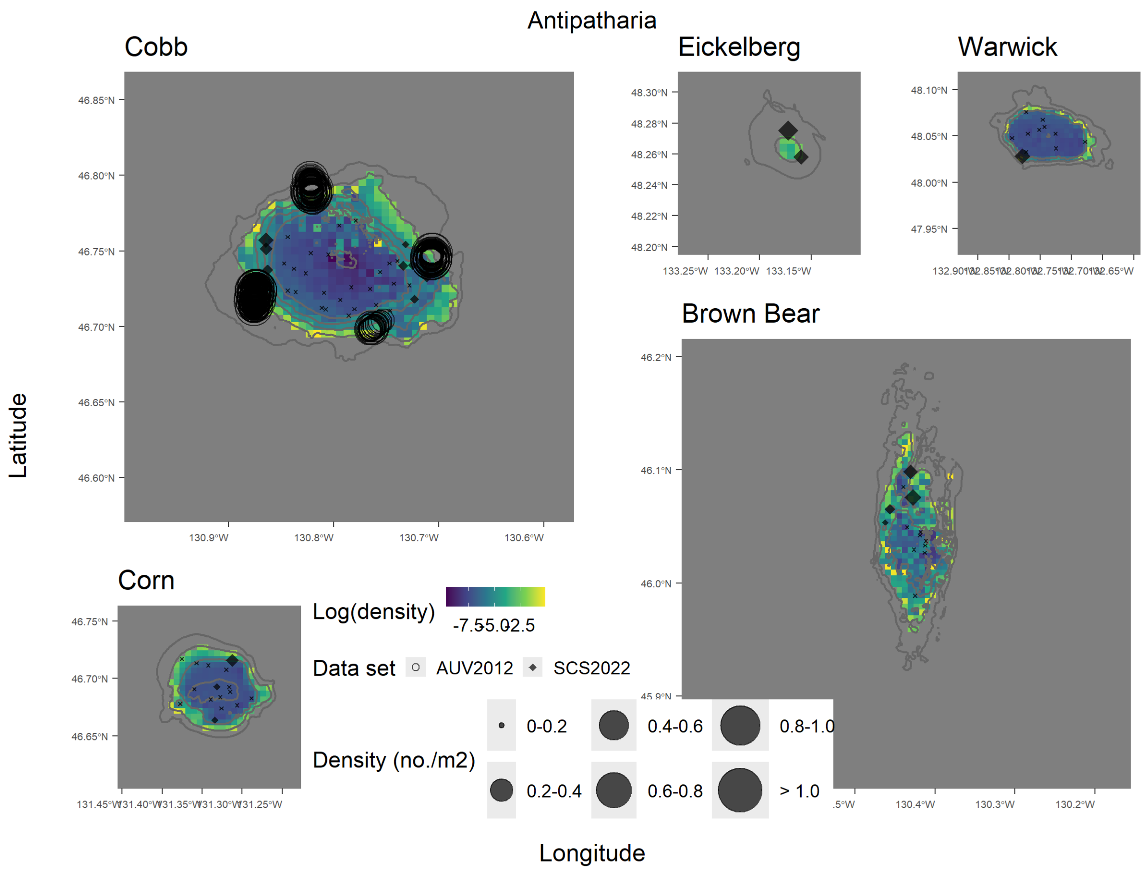

Figure 24: Observations of density $(no. * m^{-}2)$ of Antipatharia at seamounts in the Cobb Seamount Chain. Density data were only available from the 2012 AUV survey and the 2024 stereo camera survey.

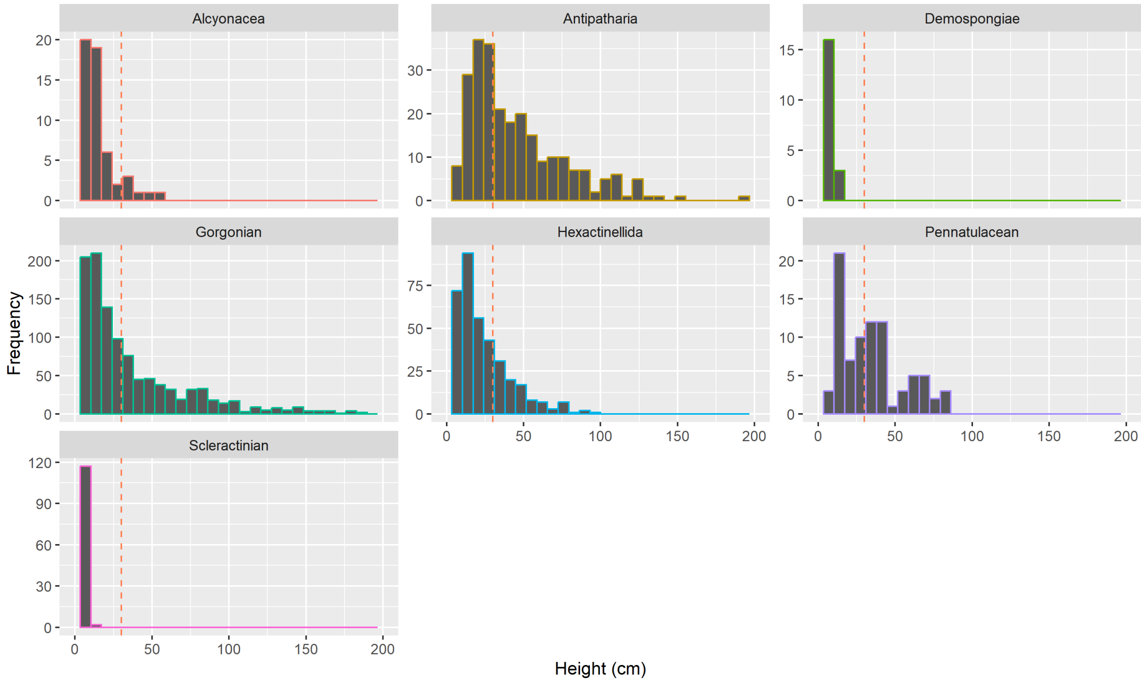

Figure 25: Height frequencies of VME indicator taxa measured using underwater stereo camera system during 2022 Cobb Seamount Chain cruise.

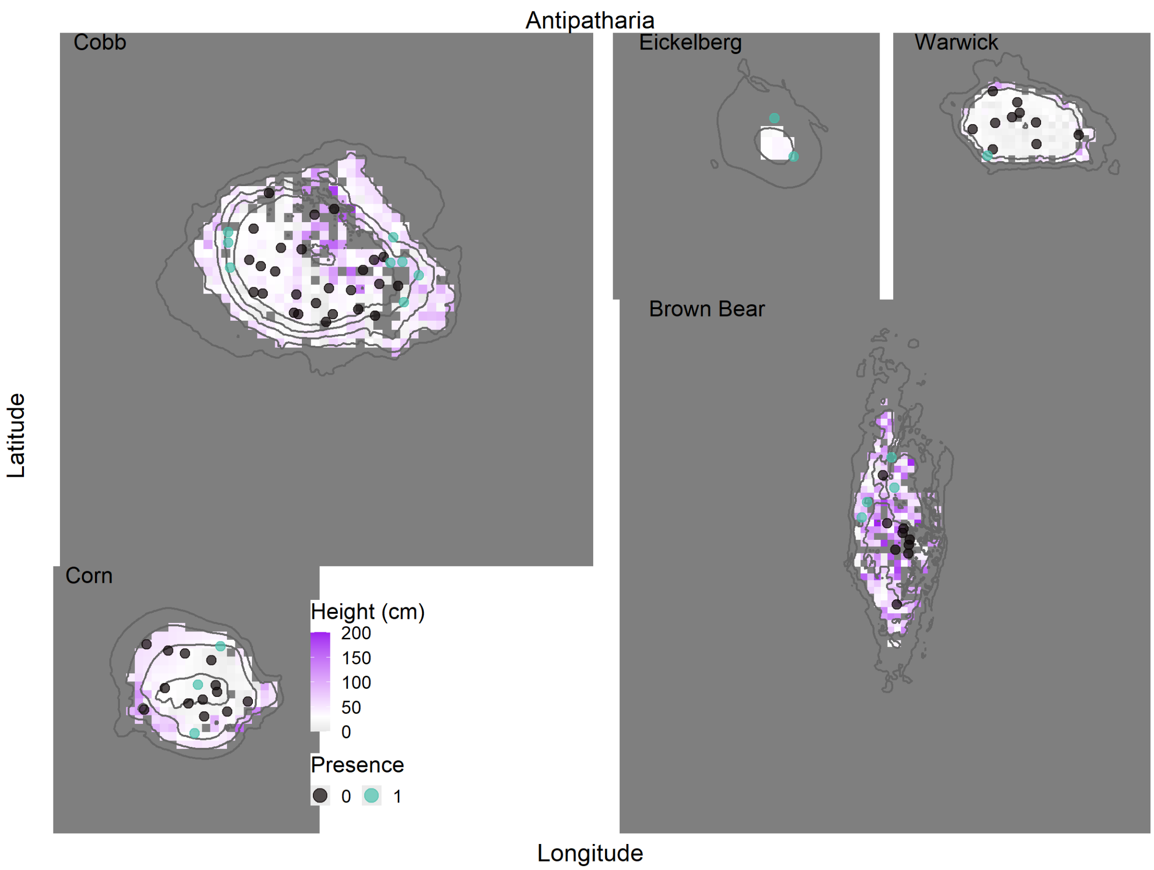

Figure 26: Predictions of height (cm) of Antipatharia at seamounts in the Cobb Seamount Chain. Height data were only available from the 2024 stereo camera survey.

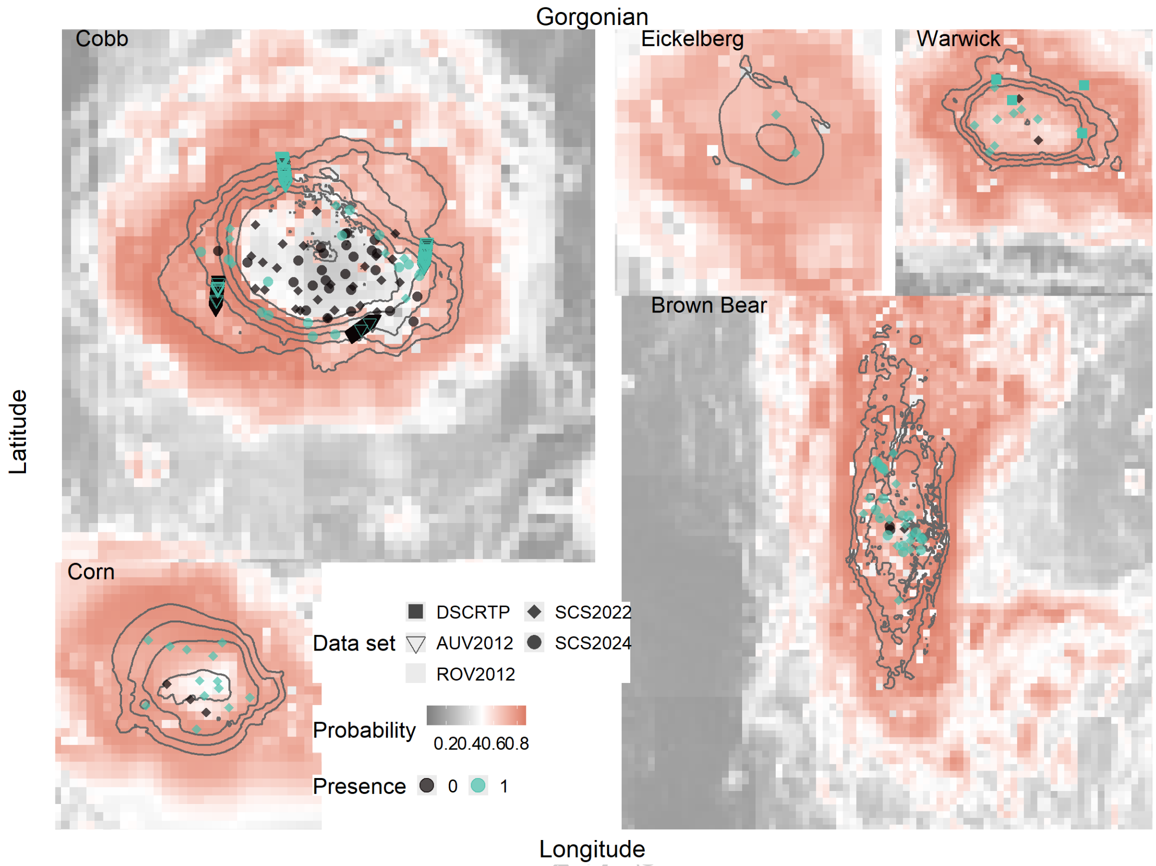

Figure 27: Observations of presence or absence of Gorgonians at seamounts in the Cobb Seamount Chain from all data sources.

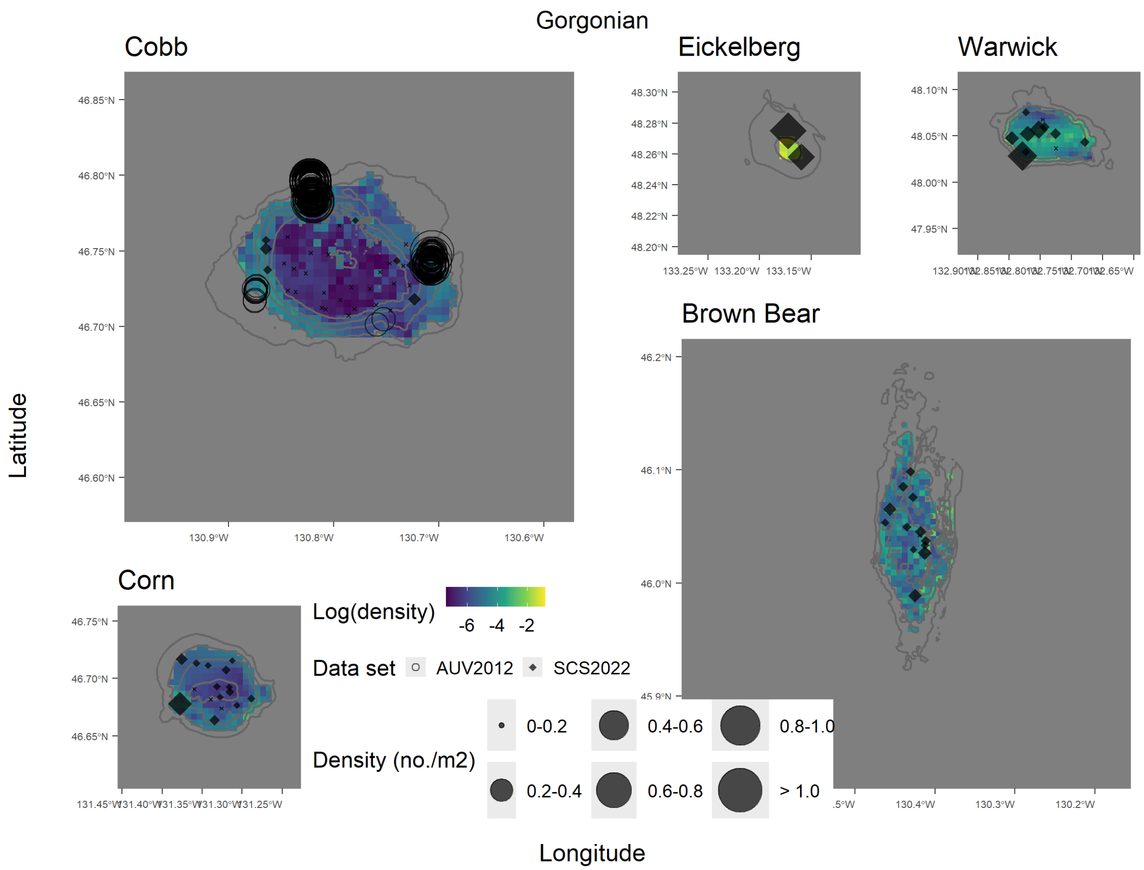

Figure 28: Observations of density ($no. * m^{-}2$) of Gorgonians at seamounts in the Cobb Seamount Chain. Density data were only available from the 2012 AUV survey and the 2024 stereo camera survey.

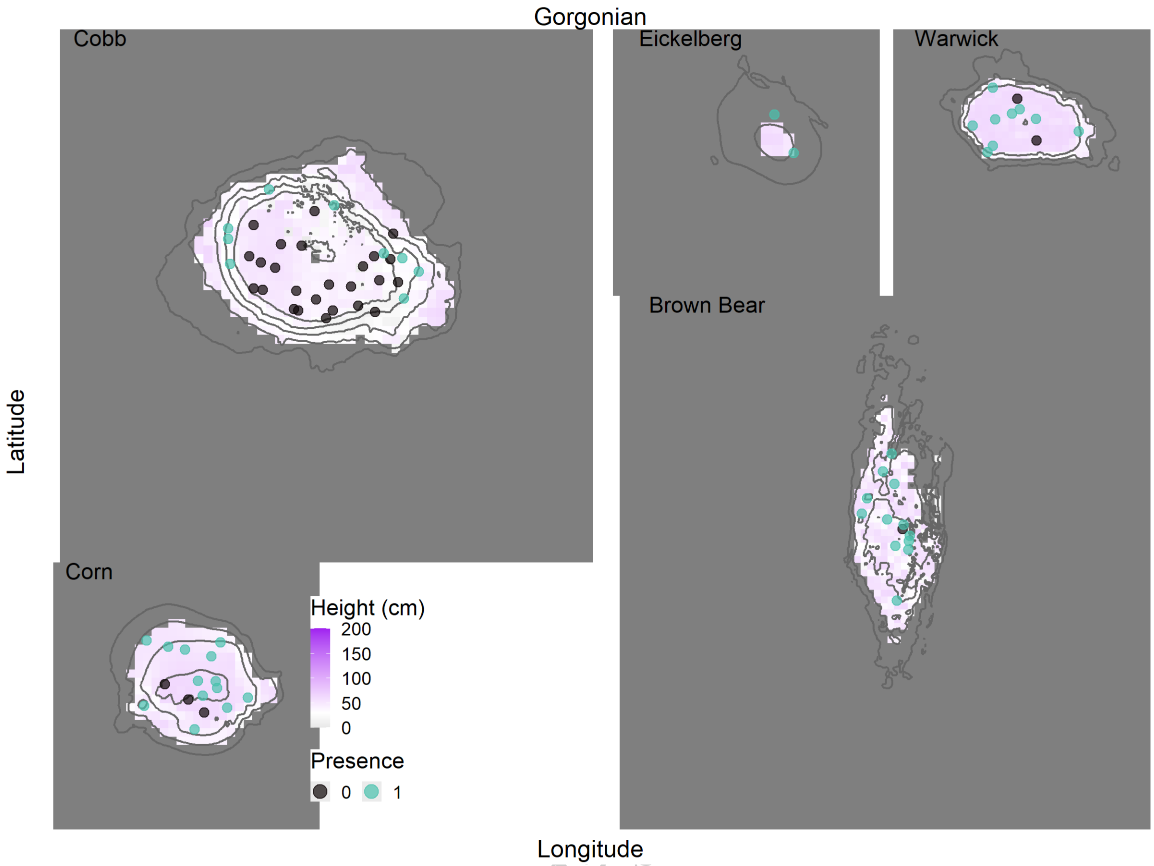

Figure 29: Predictions of height (cm) of Gorgonians at seamounts in the Cobb Seamount Chain. Height data were only available from the 2024 stereo camera survey.

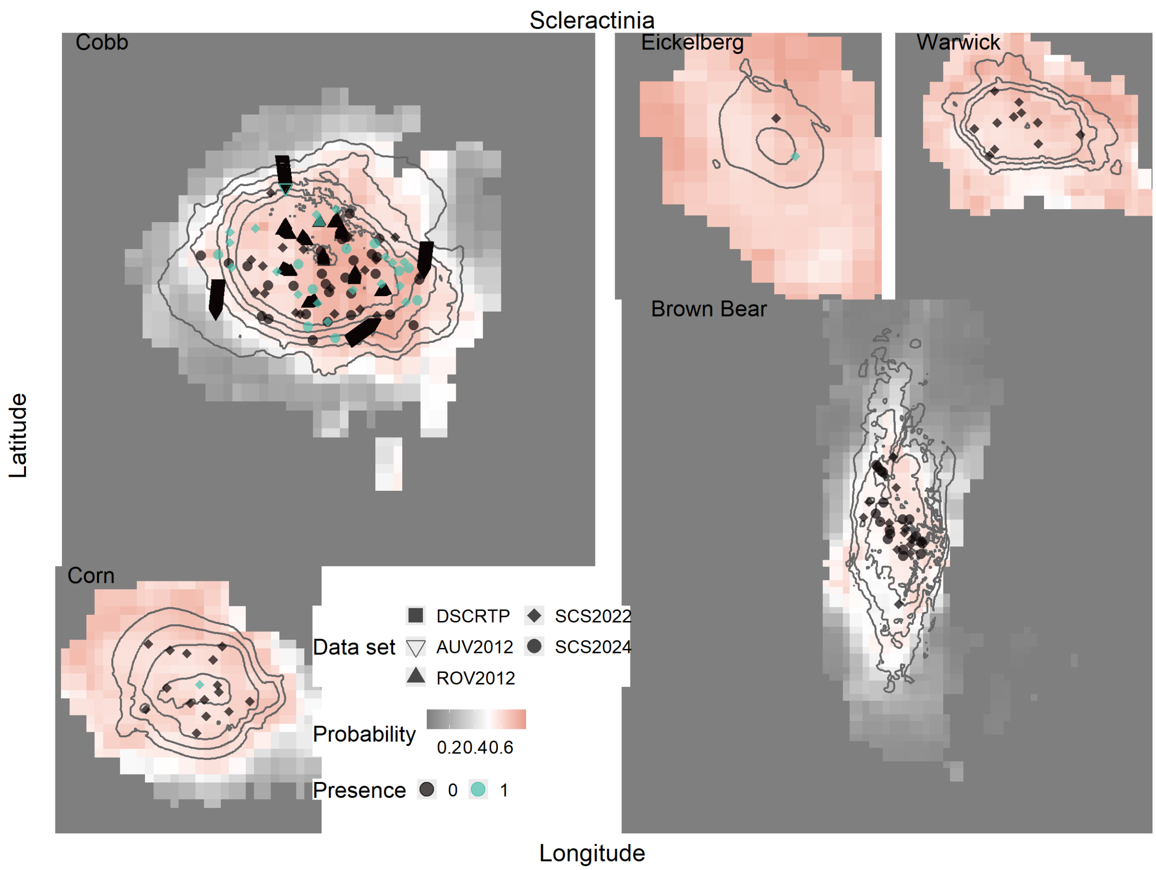

Figure 30: Observations of presence or absence of Scleractinians at seamounts in the Cobb Seamount Chain from all data sources.

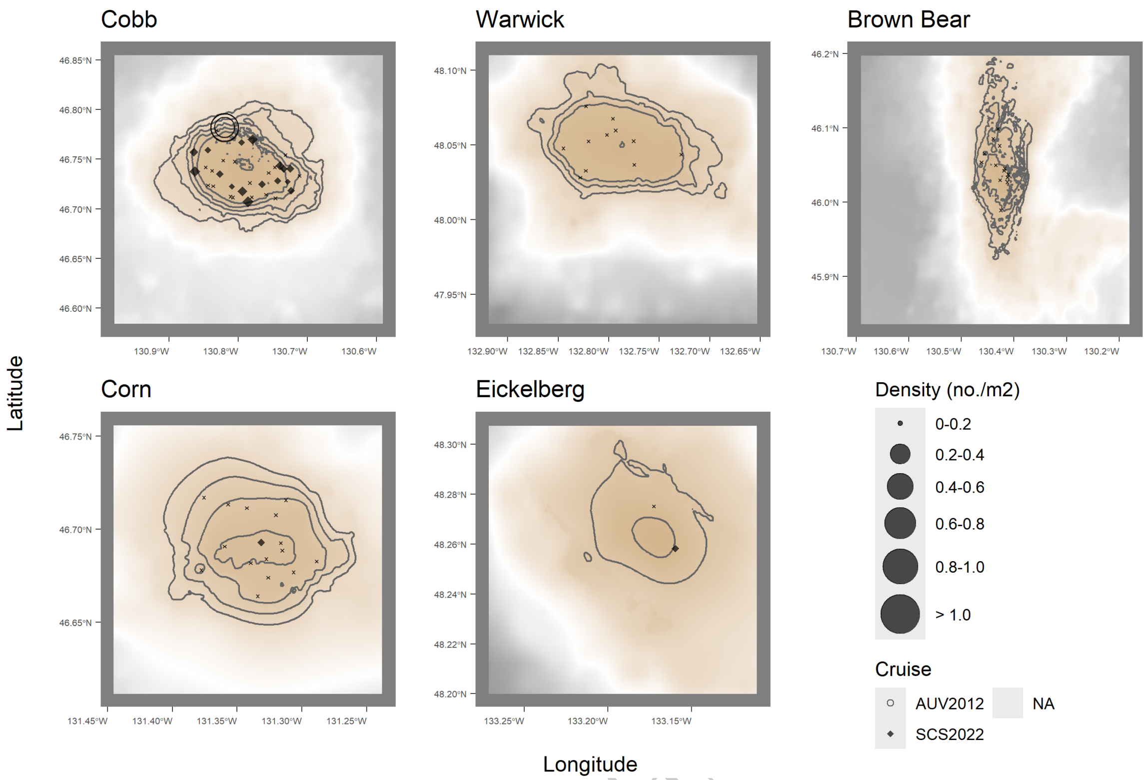

Figure 31: Observations of density ($no. * m^{-2}$) of Scleractinians at seamounts in the Cobb Seamount Chain. Density data were only available from the 2012 AUV survey and the 2024 stereo camera survey.

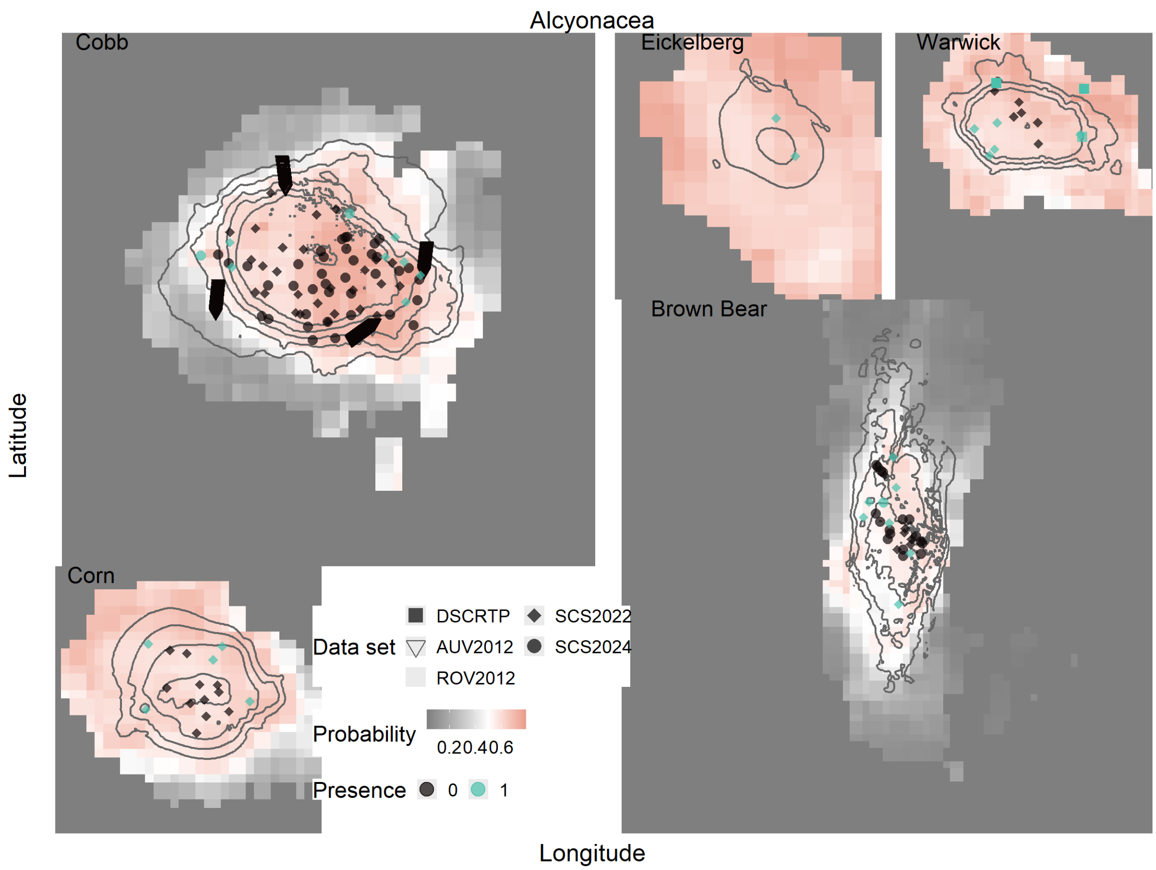

Figure 32: Observations of presence or absence of Alcyonaceans at seamounts in the Cobb Seamount Chain from all data sources.

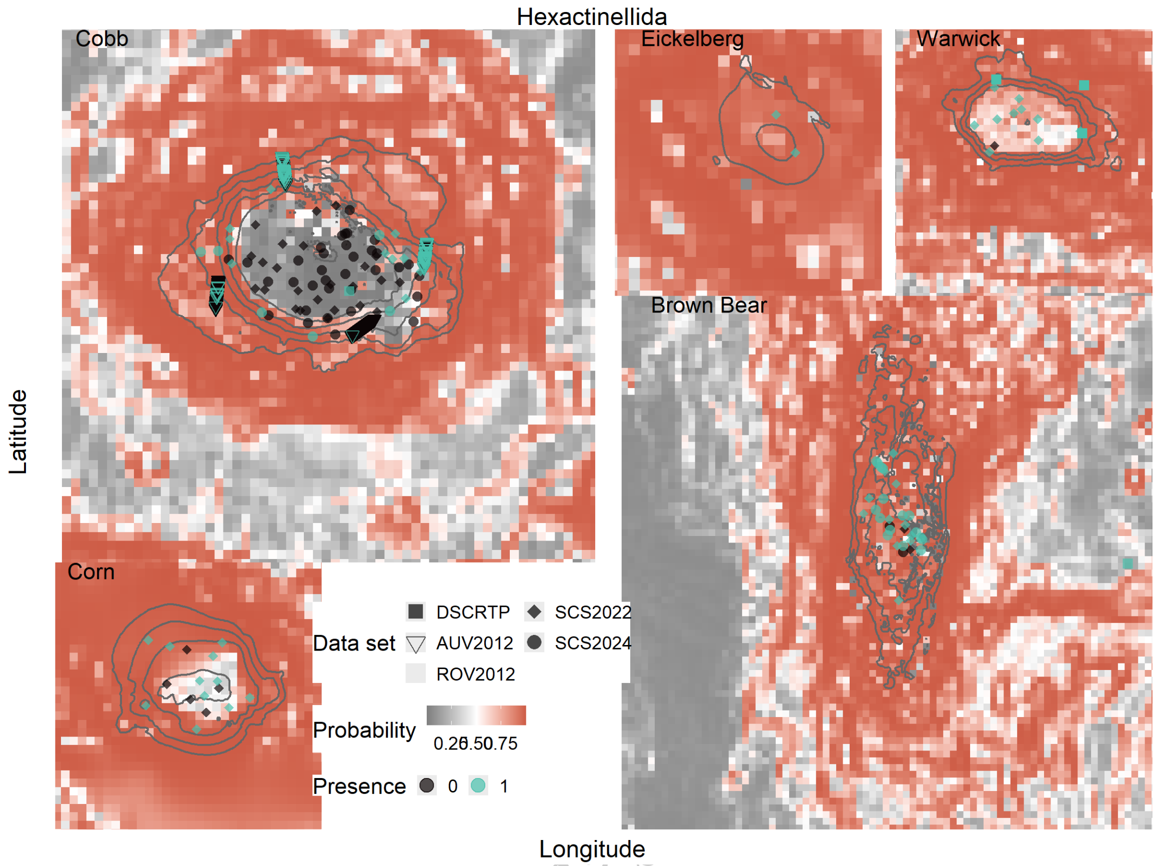

Figure 33: Observations of presence or absence of Hexactinellida at seamounts in the Cobb Seamount Chain from all data sources.

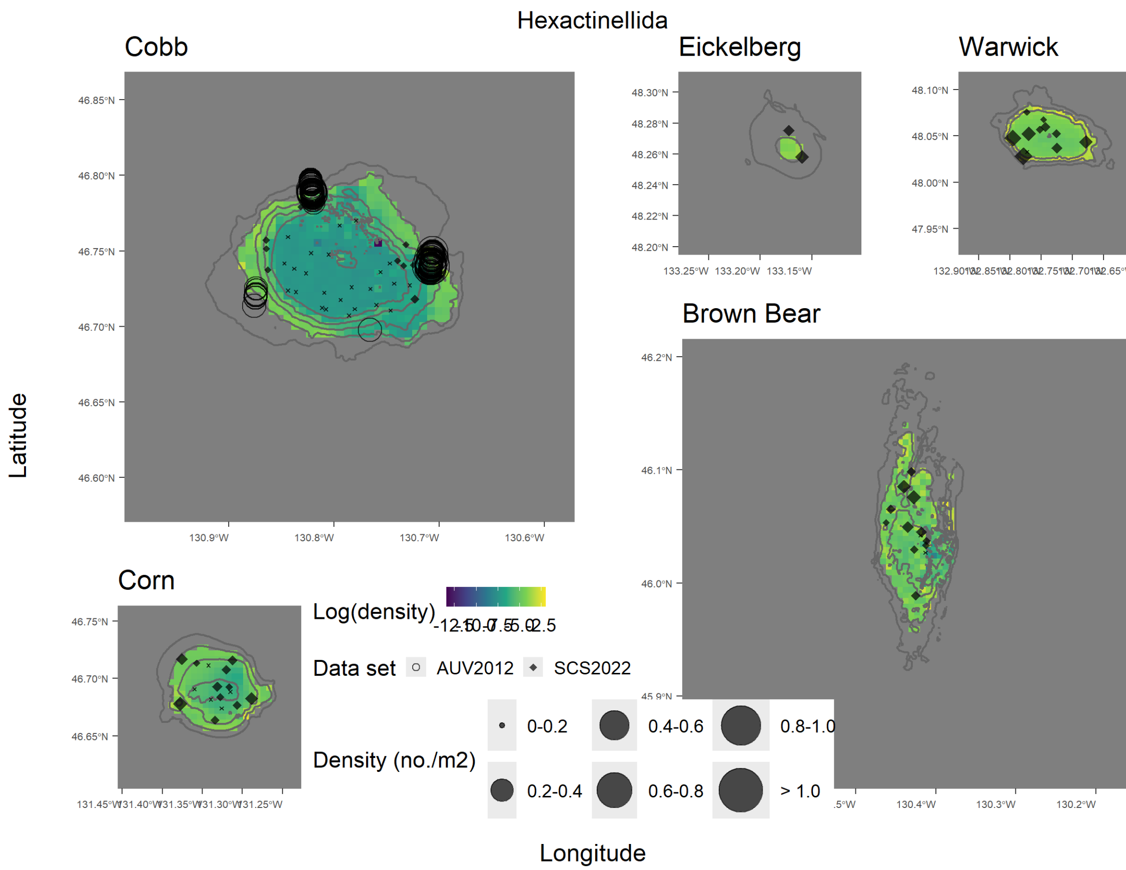

Figure 34: Observations of density ($no. * m^{-}2$) of Hexactinellida at seamounts in the Cobb Seamount Chain. Density data were only available from the 2012 AUV survey and the 2024 stereo camera survey.

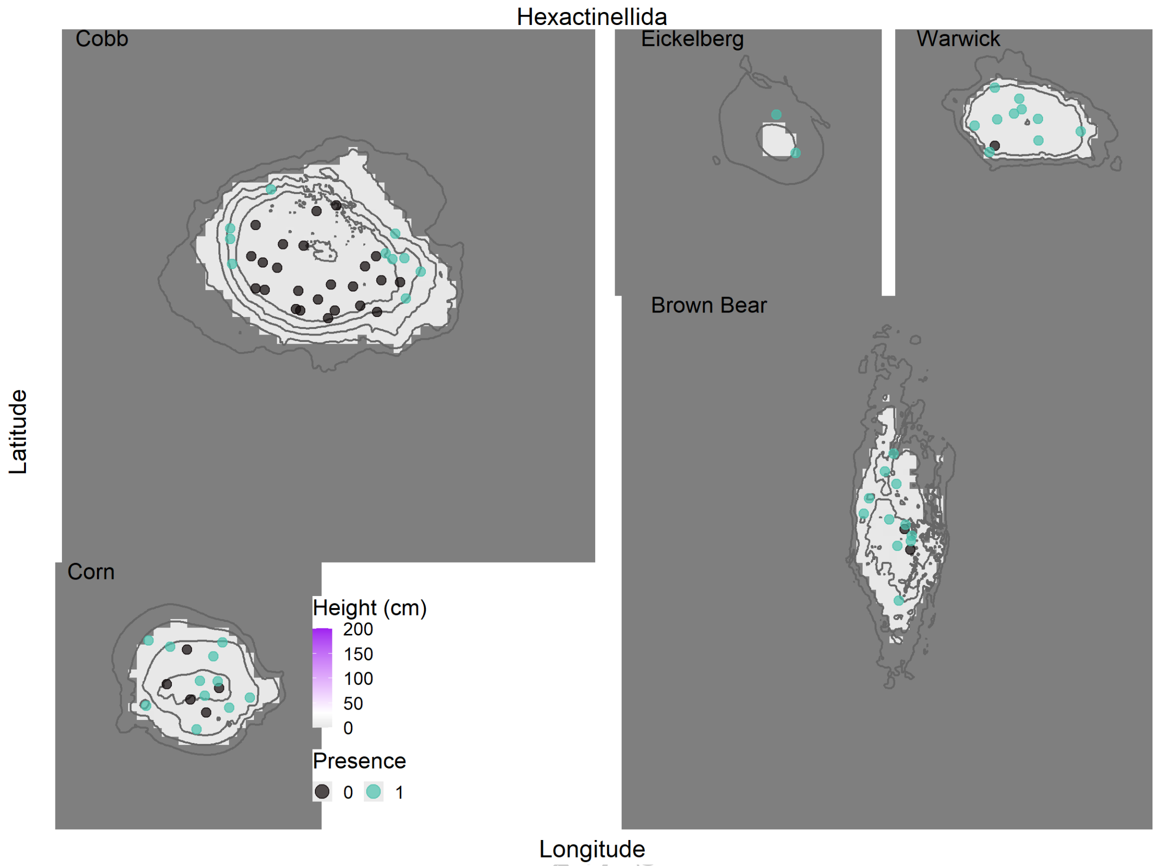

Figure 35: Predictions of height (cm) of Hexactinellida at seamounts in the Cobb Seamount Chain. Height data were only available from the 2024 stereo camera survey.

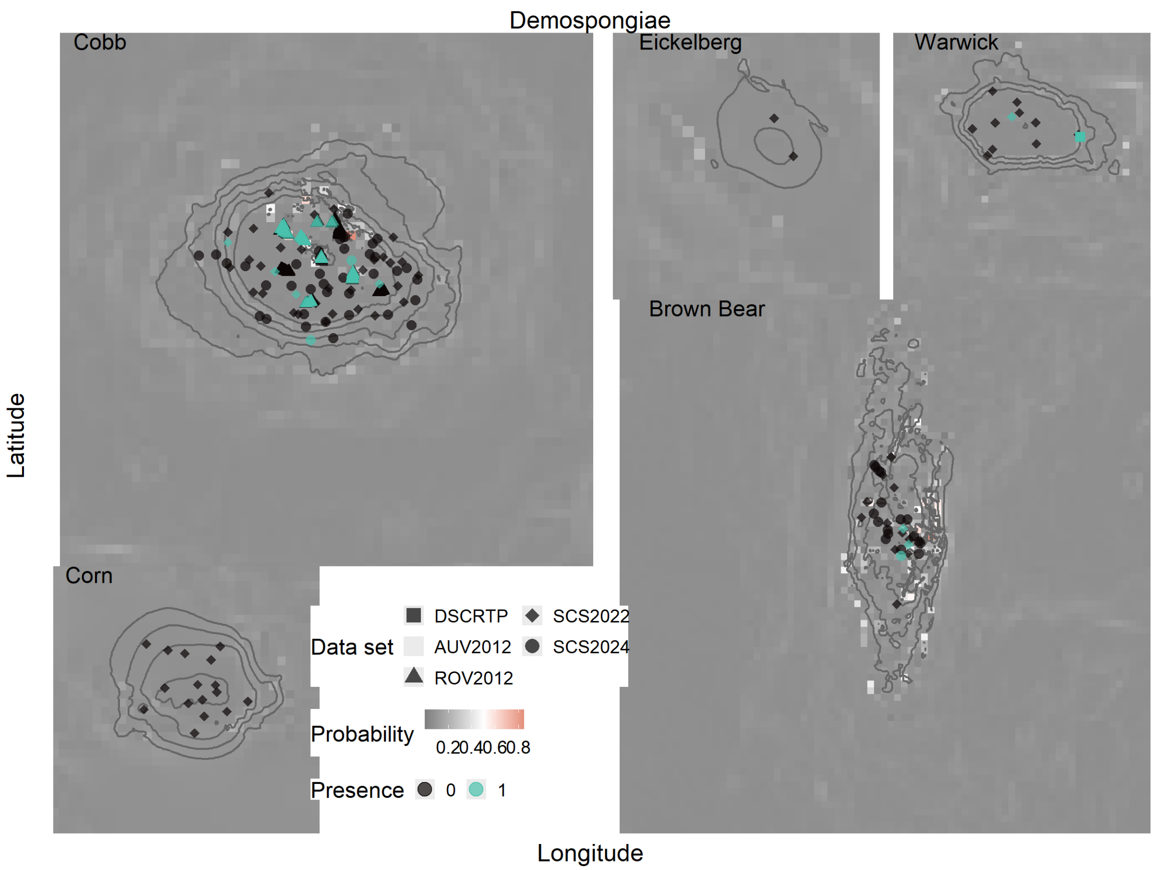

Figure 36: Observations of presence or absence of Demospongiae at seamounts in the Cobb Seamount Chain from all data sources.

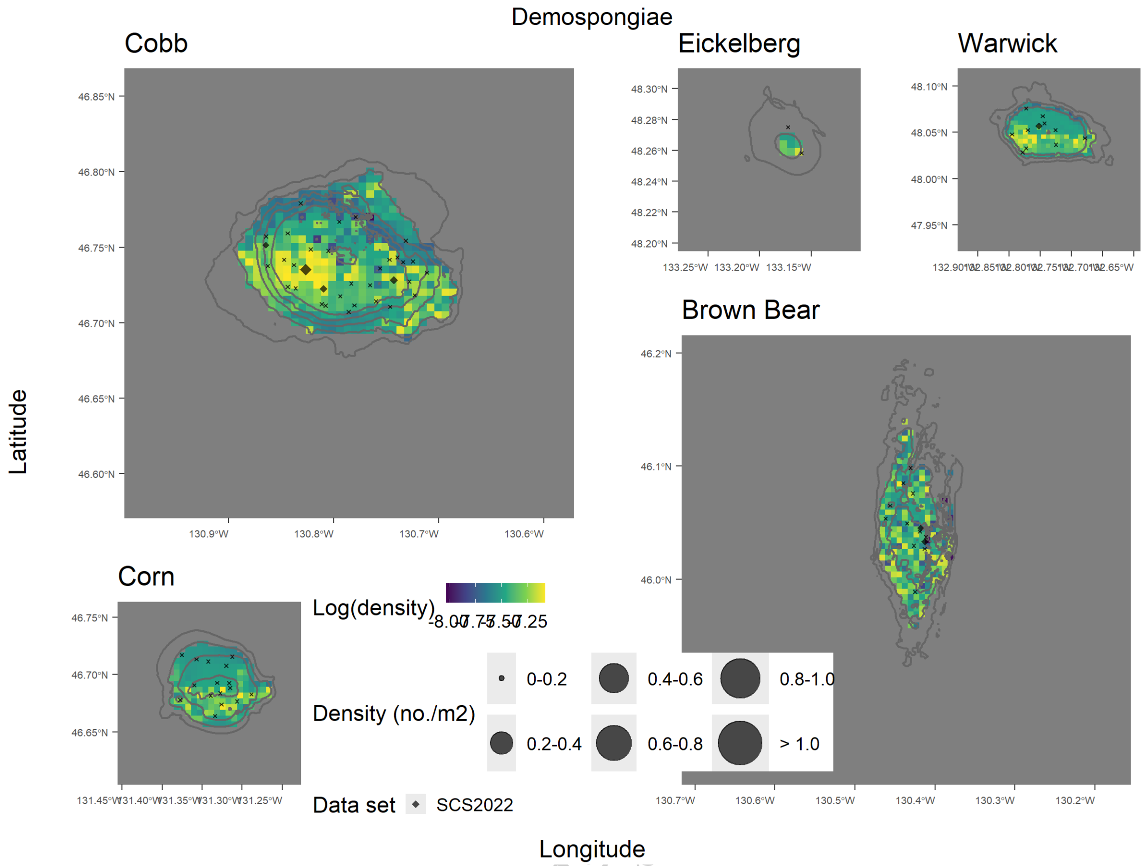

Figure 37: Observations of density ($no. * m^{-}2$) of Demospongiae at seamounts in the Cobb Seamount Chain. Density data were only available from the 2012 AUV survey and the 2024 stereo camera survey.

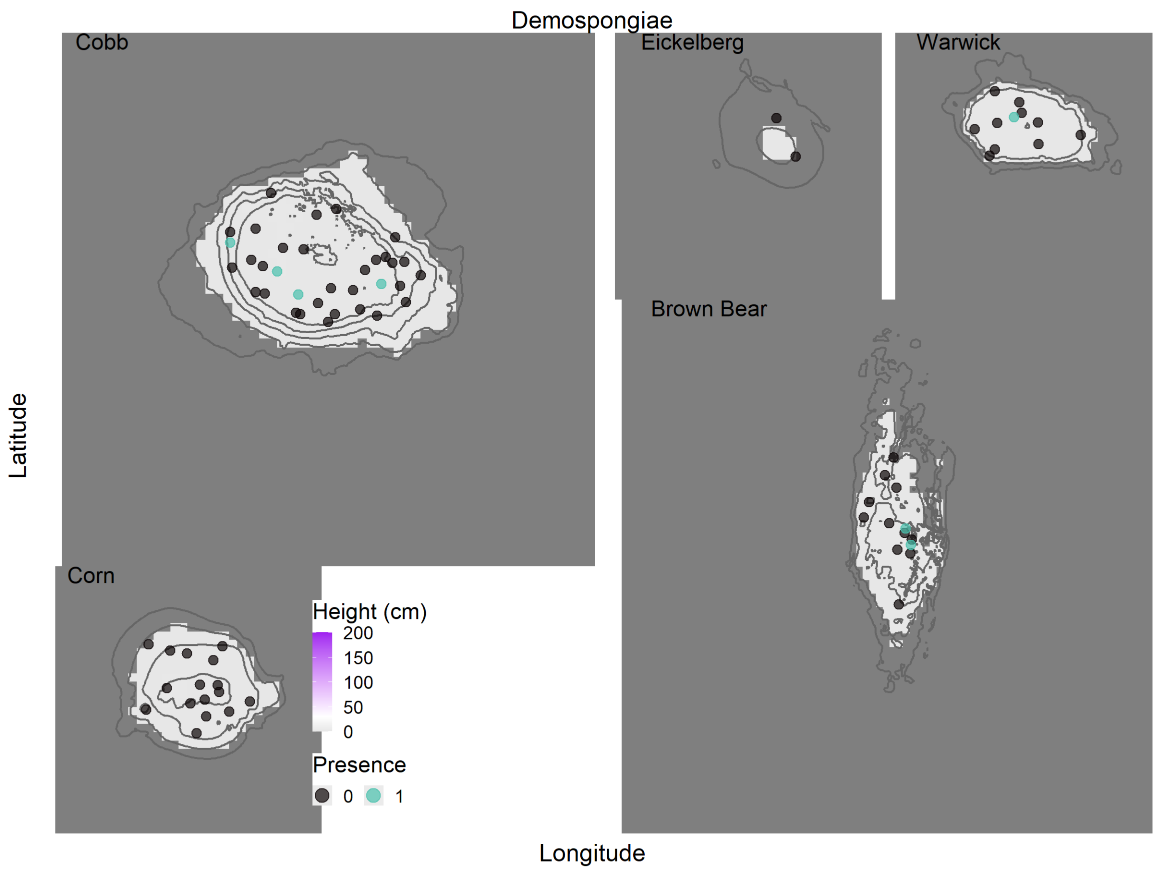

Figure 38: Predictions of height (cm) of Demospongiae at seamounts in the Cobb Seamount Chain. Height data were only available from the 2024 stereo camera survey.

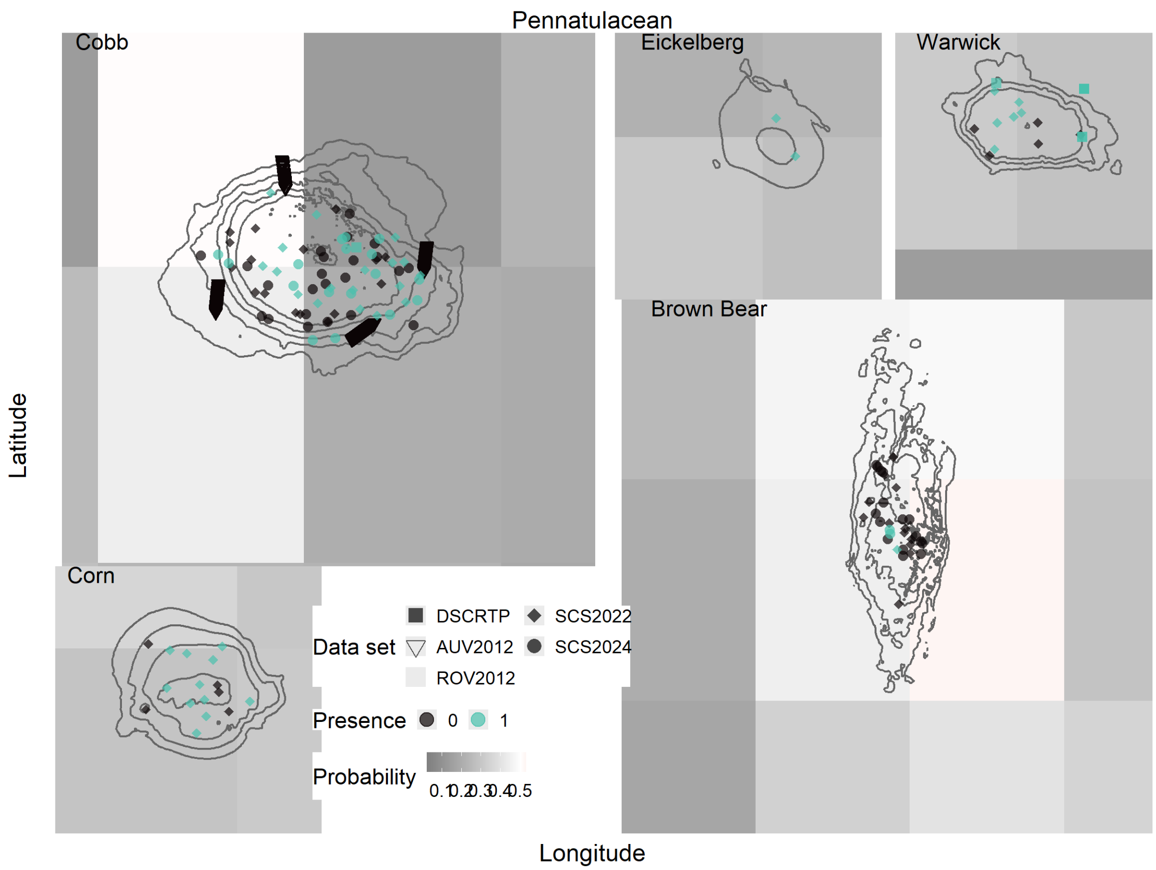

Figure 39: Observations of presence or absence of Pennatulacean at seamounts in the Cobb Seamount Chain from all data sources.

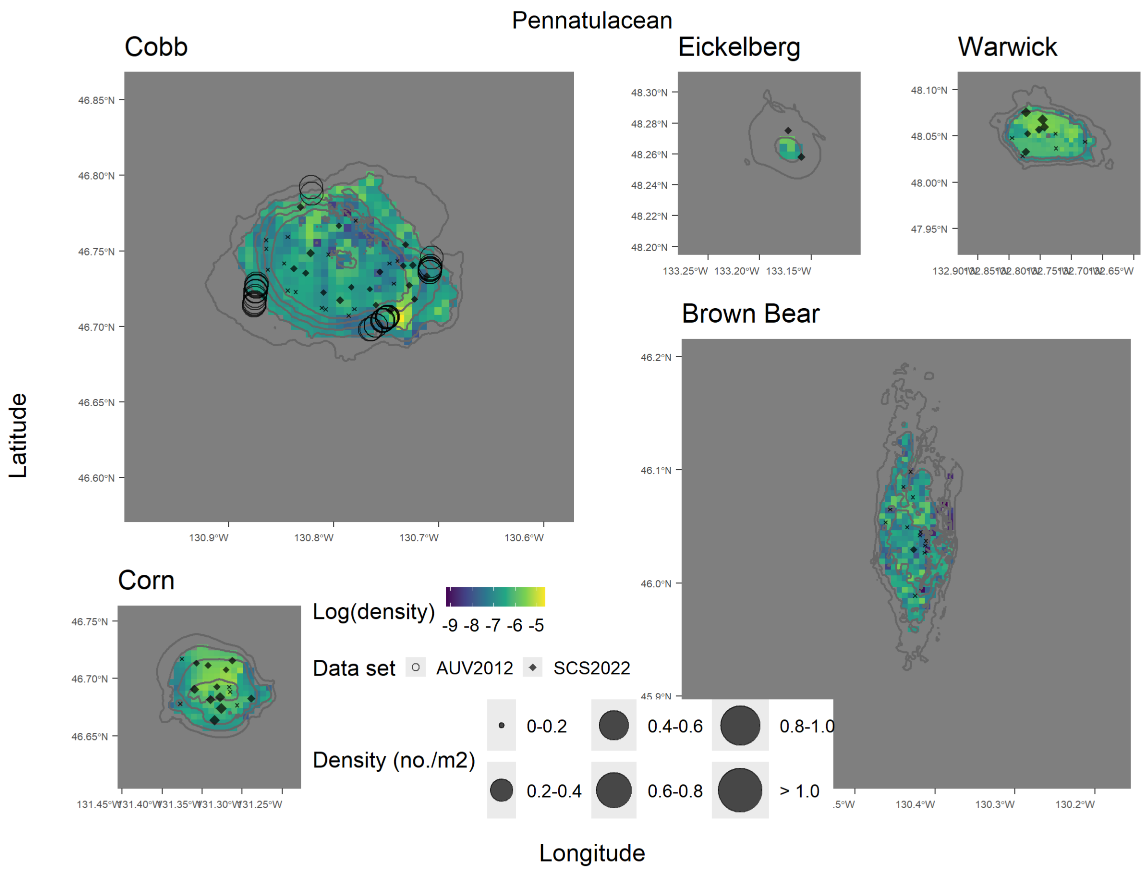

Figure 40: Observations of density ($no. * m^{-}2$) of Pennatulacean at seamounts in the Cobb Seamount Chain. Density data were only available from the 2012 AUV survey and the 2024 stereo camera survey.

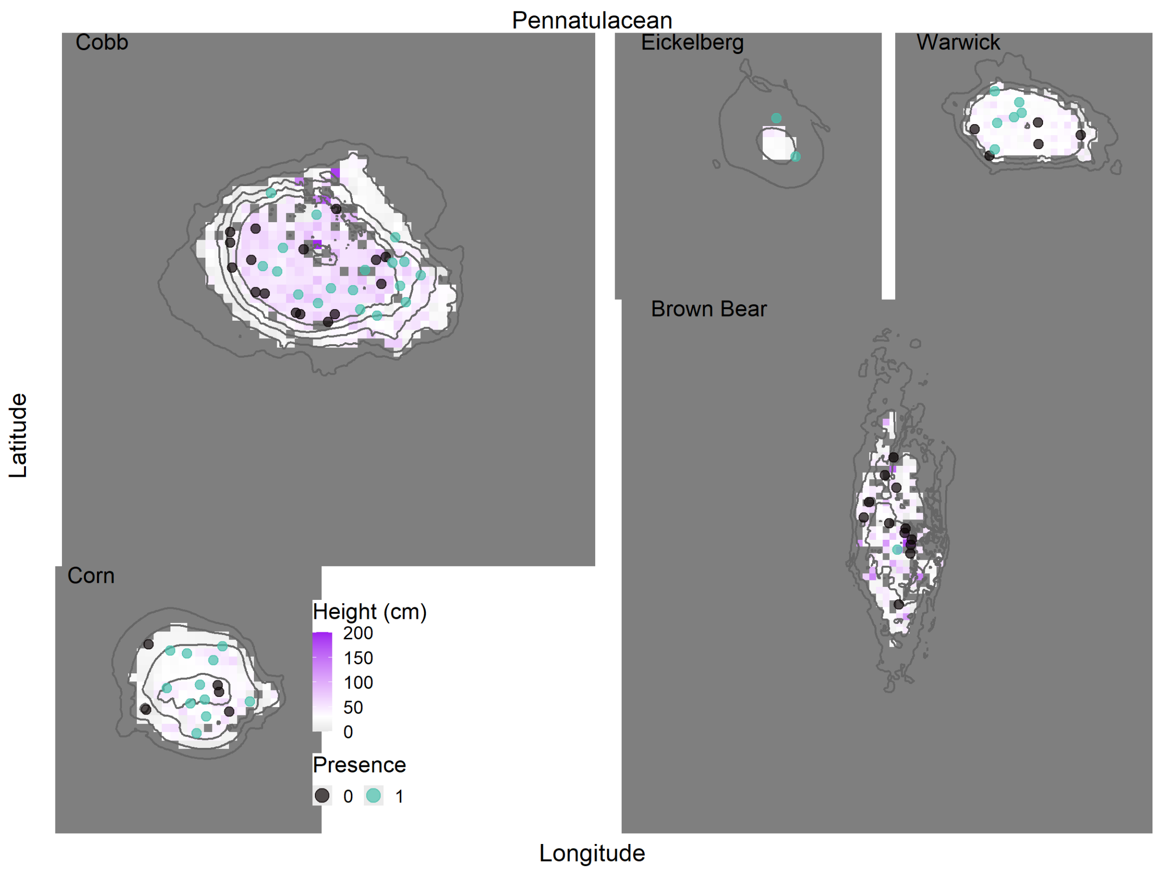

Figure 41: Predictions of height (cm) of Pennatulacean at seamounts in the Cobb Seamount Chain. Height data were only available from the 2024 stereo camera survey.

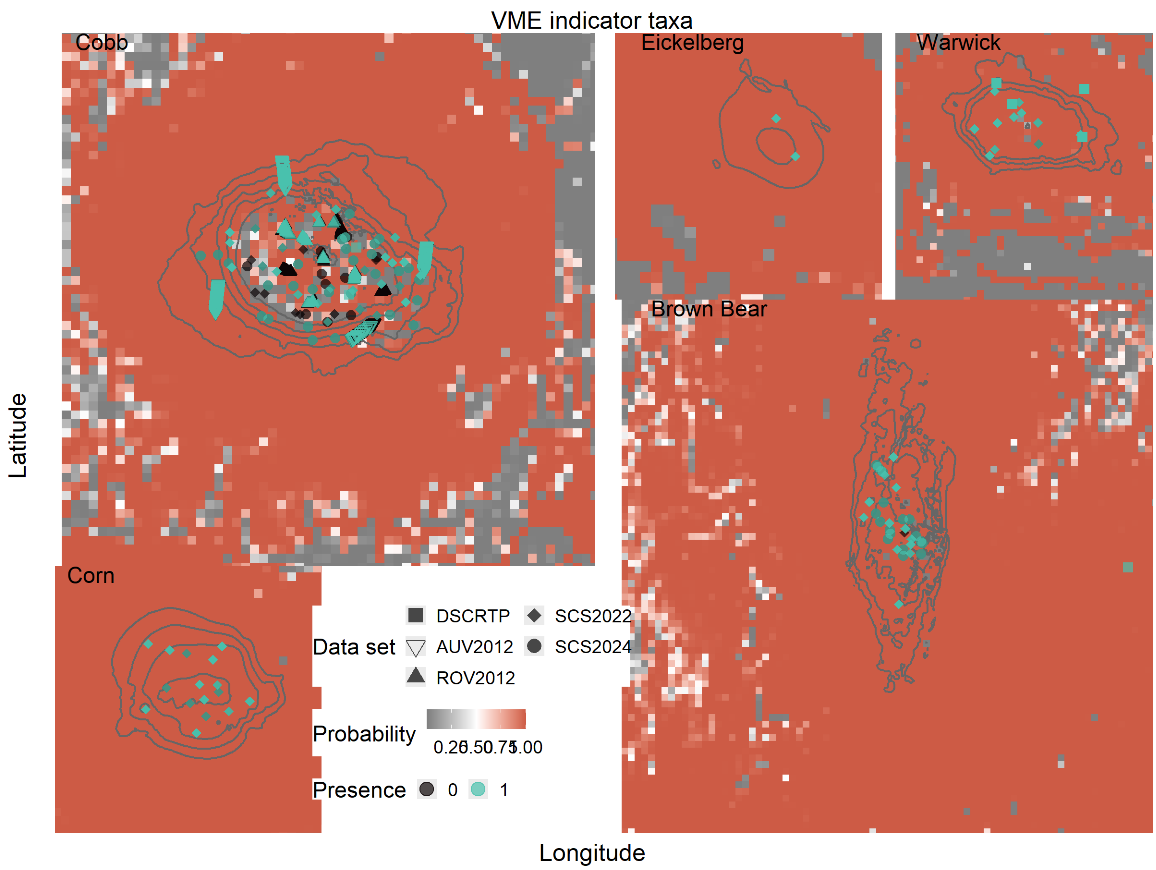

Figure 42: Observations of VME indicator taxa presence or absence at seamounts in the Cobb Seamount Chain from all data sources.

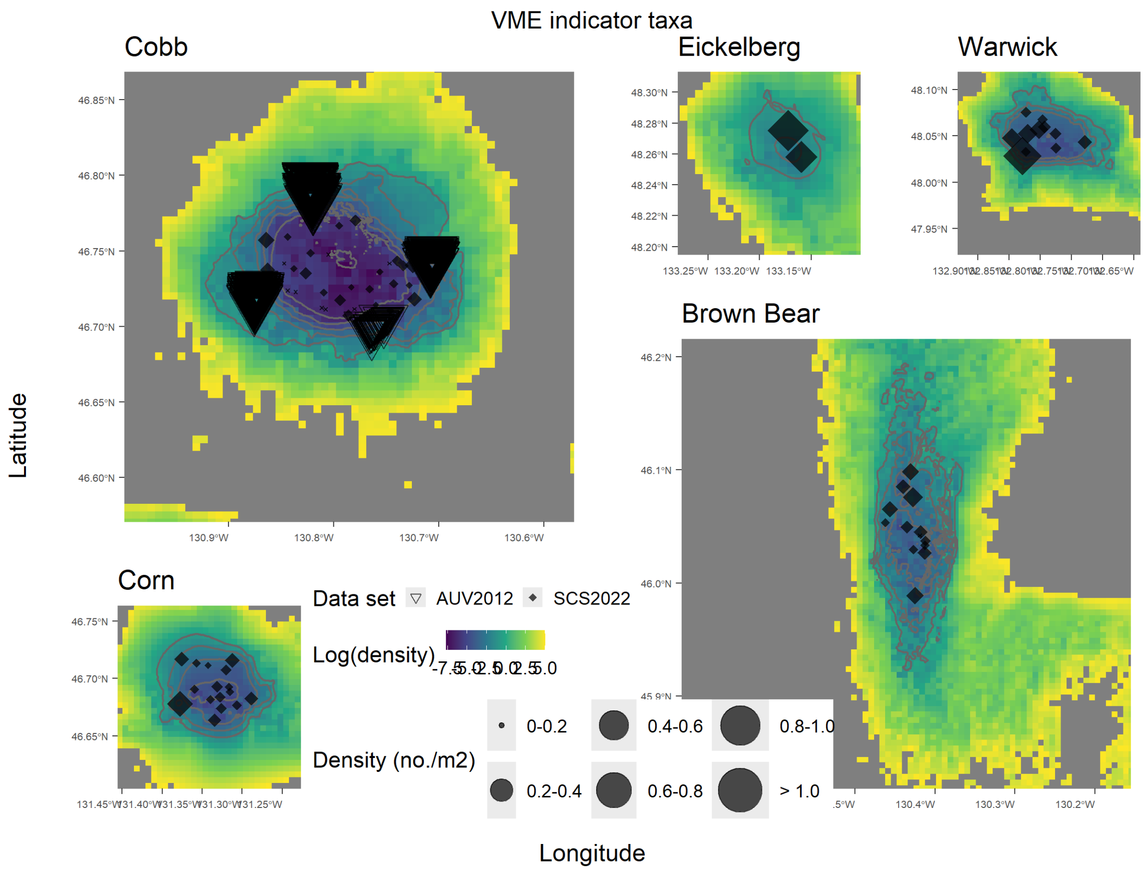

Figure 43: Observations of VME indicator taxa density ($no. * m^{-}2$) at seamounts in the Cobb Seamount Chain. Density data were only available from the 2012 AUV survey and the 2024 stereo camera survey.

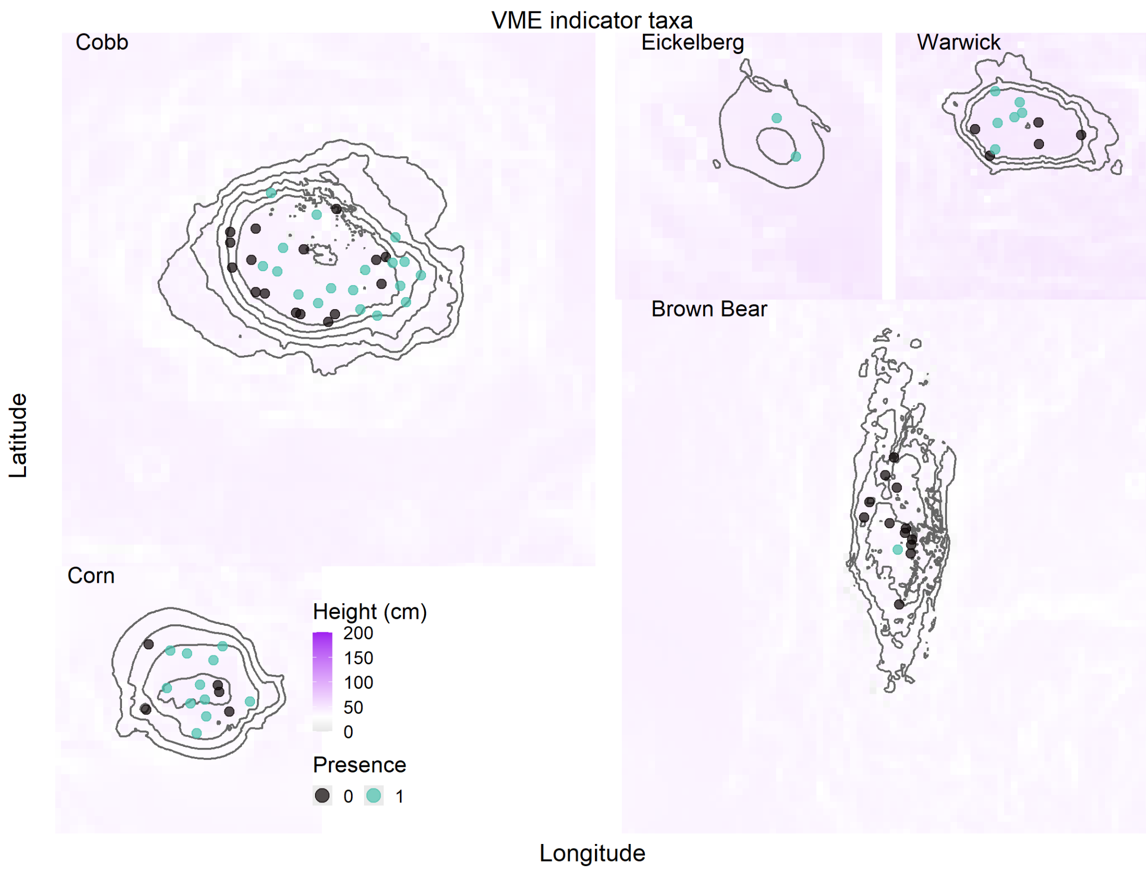

Figure 44: Predictions of VME indicator taxa height (cm) at seamounts in the Cobb Seamount Chain. Height data were only available from the 2024 stereo camera survey.

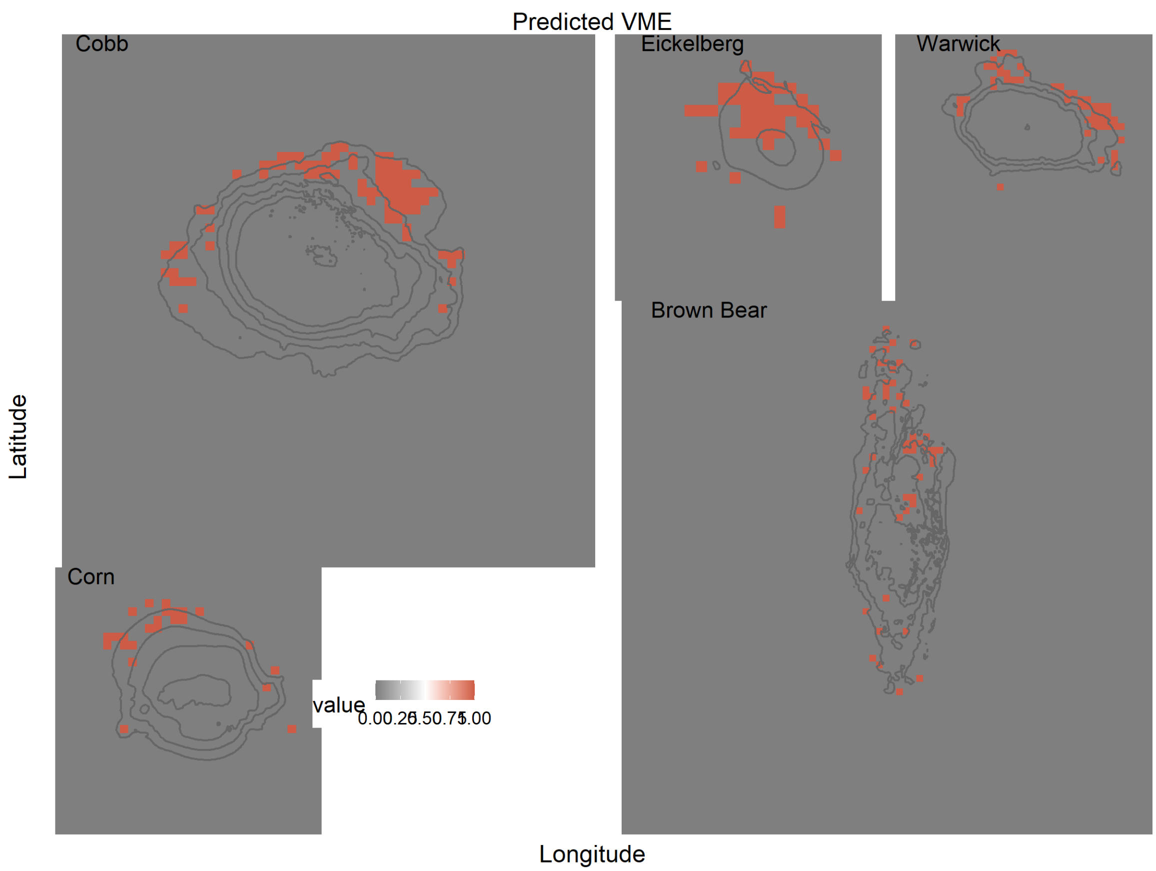

Figure 45: Predicted likely VME distribution from Warawa et al. 2025 in the Cobb Seamount Chain.

11 Impact assessment of fishing activities on VMEs

11.1 Introduction

There is a wide literature that documents the types of impacts that mobile fishing gear (such as bottom trawls and dredges) can have on vulnerable marine ecosystems (references). Much of the peer-reviewed analyses have focused on mobile fishing gear, with less information on non-mobile fishing gear (such as longlines and traps). However, in recent years a number of published analyses have attempted to fill this gap. The longlined trap gear used in the NPFC seamount fishery can impact biogenic structures (e.g., sponges, corals) through crushing or entanglement. Crushing and scouring effects can also result during deployment of the gear and during retrieval if traps are dragged across the bottom during retrieval or during periods of strong currents (e.g., storms, tides). As noted in previous sections, physical removal and retention of VME indicator taxa is uncommon.

This section attempts to use the models and data introduced in Section 10 to determine the level of risk of SAI on VME and VME indicator taxa on the Cobb Seamount Chain. Two related approaches are taken. First the historical fishing effort is used to identify areas of overlap with predicted VME indicator taxa presence, density and height. In the second approach the relative benthic status is estimated for the seamount areas based on the methodology of Pitcher et al. (2017).

11.2 Methods

11.2.1 Data available

Two types of data were used to assess the impact of Sablefish fisheries on VME in the Cobb Seamount Chain, fisheries data and data from underwater camera transects conducted in 2022 and 2024. From 1991-2020 there is logbook data, observer data and electronic monitoring data for the sablefish fishery vessels. Data collected include start and end locations, depths, longline length, trap number and trap size from each fishing event (sets; n = 4588) were recorded in logbook and observer programs and obtained from Fisheries and Oceans Canada.

The underwater camera data and models are described in detail in Section 10 of this document.

11.2.2 Analysis - Fisheries overlap approach

Estimating the fisheries overlap with VME and VME indicator taxa required knowledge of the spatial extent of VME and VME indicator taxa and the spatial extent of historical fishing. The probability of presence, density and height maps from Section 10.2.2 for combined VME indicator taxa and the maps of predicted VME presence from Section 10.2.3 were used inform the analysis about the distribution of VME and VME indicator taxa.

For the spatial extent of historical fishing (1991-2020) the annual and cumulative area touched by fishing gear in the Cobb Seamount Chain was estimated. Essentially, each 100 m by 100 m grid in the previous analyses was divided it into 25 sub grids (each representing 4% of the grid and having a 20 m by 20 m size). Then the following steps were used to estimate the area contacted by year and cumulatively:

(1) Each fishing set was overlaid on the 20 m by 20 m raster grid for each seamount. For this analysis, each set was assumed to be a straight line between the beginning latitude and longitude and the ending latitude and longitude. The lines were buffered by the 1/2 the width of the longline (6.2 m, Welsford et al. ????) or the sablefish trap (1.1 m, Doherty et al. 2019).

(2) The intersection grids were converted to a raster layer where each 20 by 20 m grid was registered as contacted or not contacted for that year. Since this method only recognizes overlap between a polygon and raster if the polygon passes through the mid-point of the cell, a buffered set line polygon that passed through the corner of one of the 20 by 20 cells might not get registered to that cell if it didn't touch the middle. To account for this, each track was additionally buffered by 10 m on each side (e.g. the trap width was now 21.1 m). This meant that if a tow passed through even a corner of a 20 by 20 cell, it was counted as occurring in that cell.

(3) In each year the grids intersected by fishing sets were summed and reclassified as a 1 if any set had passed through them and then these smaller rasters were aggregated to the 100 by 100 m cells using the sum (how many sub cells had impacts) and divided by 25. This then produced a raster for each gear type that indicates the proportion of each 100 by 100 m grid cell that has been touched by gear in a year. So for example, if a 100 by 100 m raster cell had 5 subcells where a buffered trap line had passed through, the value for that raster would by 0.20 (5/25). The resulting 100 m by 100 m rasters of cumulative (1991-2020) proportion of impacted area was overlayed on plots of species distribution models for VME indicator taxa from Section 10. These included plots of VME indicator taxa probability of presence, VME indicator taxa density, VME indicator height and predicted VME. Values were also extracted from both the model predictions and the cumulative proportion impacted to show potential regions of high risk (e.g. areas where the proportion of cumulative seafloor contacted was high and where the density of VME indicator taxa was also high).

11.2.3 Analysis - Relative benthic status approach

The second approach uses the methodology of Pitcher et al. (2017) which estimates the relative benthic status for the seafloor of the Cobb Seamount Chain. In essence, this method fits a logisitic model for each 100 m by 100 m grid cell. The equation used is:

$$B_{t+1} = B_t + B_t r(1 - B_t/K) - A_t * d_t * B_t$$

where $B_0 = 1$, K is the carrying capacity (assumed to be 1 for relative calculations), r is the intrinsic rate of population growth from Rooper et al. (2011), A is the area contacted by the gear in year t, d is the mortality rate per impacted area (assumed to be 0.9).

The model was run assuming an initial state in 1991 equal to equilibrium state (i.e. $B_t = 1$). Then fishing effort from section 11.2.2 (proportion of each 100 m by 100 m grid cell impacted each year) reduced the B_t in the impacted grid cell and in the absence of fishing effort, the B_t recovered according to r. The model was allowed to run from 1991 to 2025, resulting in a raster of the relative (scale from 0 - 1) status.

The models were also run for an additional 20 years (until 2045) in the absence of fishing (setting fishing effort to zero) to determine the capacity for recovery.

Rooper et al. (2011) provided intrinsic recovery rates for corals ($r = 0.062$) and sponges ($r = 0.107$). In the Cobb Seamount Chain, the coral recovery rate was applied to gorgonians and Antipatharians, while the faster sponge recovery rate was applied to hexactinellida. The slower coral recovery rate was used for combined VME indicator taxa.

To determine the relative benthic status by habitat (e.g. the relative benthic status of gorgonian habitat), the probability of presence models from Section 10 were converted to presence or absence layers using a threshold probability for each taxa that maximized the sensitivity and specificity. These layers (1 for presence and 0 for absence) were multiplied by the relative benthic status layers for that taxonomic group to visualize VME habitat areas with reduced predicted benthic status.

Additionally, for each taxa the percentage of habitat area by relative benthic status was summarized in a table to determine what proportion of the habitat was in a degraded state. So for example, the proportion of gorgonian habitat that was in a relative benthic state < 0.80 was computed for both the current day (2025) and in twenty years (2045) if there was no fishing.

11.3 Results

11.3.1 Direct observations of impacts

Curtis et al. (2015) documented lost fishing gear (gillnet, trawl net, longlines, trap longlines and anchors) at 13 of 19 (68%) of transects on Cobb Seamount. Impacts noted included "ghost fishing, putitive discards, dragmarks and entanglement in corals". During the 2022 camera survey longline gear (mostly groundline) was observed at ~55% of transects between 200 and 800 m on Cobb Seamount and at ~10% of transects at these depths on Warwick and Corn Seamounts. No discarded gear was observed at Brown Bear or Eickelberg Seamounts.

11.3.2 Fisheries overlap approach

The regions of higher cumulative impact generally fell within areas that had a high probability of the presence of VME indicator taxa (Figure 46). This can be seen in the impact plot (Figure 47) which shows that areas with high proportion of seafloor contacted also had high predicted probability of VME indicator taxa presence. However, most of the areas with high probability of VME indicator taxa presence had low proportions ($<$ 0.25) of the seafloor contacted.

Areas of predicted high density of VME indicator taxa generally occurred at deeper depths than the most intensive fishing (Figure 48). The impact plot shows this clearly, where the highest density areas tend to occur where cumulative fishing is less (Figure 49).

VME indicator taxa height was predicted to be greatest outside the depth bands with the heaviest fishing pressure (Figure 50). However, the impact plot shows that a significant number of grid cells with predicted VME indicator taxa height > 40 cm occurred in areas where the proportion of seafloor contacted was > 0.50 (Figure 51).

Regions of predicted VME tended to occur on the northwest side of each of the seamounts (except Brown Bear), where fishing activity was generally less (Figure 52). This can be seen in the impact plot which shows that (Figure 53) areas with high proportion of seafloor contacted had low predicted probability of VME indicator taxa presence.

11.3.3 Relative benthic status approach

Maps of the relative benthic status for Antipatharian and gorgonian habitat showed that some grid cells are currently degraded, particularly on the southeast side of Cobb Seamount (Figure 54 and Figure 56). Most of the predicted habitat for these two corals was relatively unimpacted. If fishing ceased for 20 years, most of the impacted areas would be substantially recovered, given the assumptions of the logistic model (Figure 55 and Figure 57). This can also be observed in the high proportion of habitat in condition < 0.8 (Table 3). The same patterns hold for both Hexactinellida and predicted VME indicator taxa both in 2025 (Figure 58 and Figure 60) and in 2045 (Figure 59 and Figure 61). For all four taxa examined, the proportion of habitat with condition > 0.8 relative to 1991 was ~90% and if fishing ceased for 20 years, almost 99% of taxa would be predicted to recover to 0.9 of 1991 levels.

11.4 Identification of uncertainties in data and methods, and measures to overcome such uncertainties

There are considerable uncertainties with this analysis. They include

- Uncertainty in the species distribution models. The uncertainty in model predictions was not accounted for in this analysis, but clearly some of the models fit better than others. Future research should work to refine these models and utilize better predictor variables. More data will become available in 2026, which will likely improve the models.

- Uncertainty in the spatial distribution of Sablefish fishing. The assumption of straight lines between beginning and end points is likely not correct. There may also be uncertainty in fishers logbook entries as well.
- Uncertainty in the impact and recovery rates for VME indicator taxa. A large unknown for the relative benthic status method are the impact and recovery rates of individual VME indicator taxa to the Sablefish fishery. The recovery assumptions rely heavily on work done in Alaska on a slightly different suite of species and very different ecosystem than occurs on Cobb Seamount Chain. The impact rate (0.9) used here is fairly conservative, but again better resolution of the impact rate of Sablefish traps on VME indicator taxa would be useful here.

Perhaps most importantly, there is a tremendous amount of uncertainty regarding historical fishing impacts that have occurred on these seamounts. Although the Sablefish fishing impacts can be reasonably estimated since data became available in 1991, other fisheries have operated on these seamounts prior to 1991 including foreign fishing fleets. Until 2003, a US midwater trawl fishery operated at Cobb Seamount targeting rockfish species on the summits and upper flanks of the seamounts. Although these were midwater nets, there is considerable evidence from other US rockfish fisheries that these can have substantial impacts through occasional or intermittant bottom contact of the net and a much larger occurence of door contact with the seafloor (hence the observations of discarded trawl gear and furrows from trawl impacts observed during visual surveys).

All of these factors contribute uncertainty to the results presented here. A dedicated program of routine monitoring at these seamounts using underwater cameras and vehicles would assist in documenting future impacts, tightening parameter estimates for recovery and better defining the distribuiton of VME indicator taxa and VMEs in the Cobb Seamount Chain.

Table 3: The relative benthic status of VME indicator taxa and VME from model predictions of habitat with presence of each taxa. Status is shown as the percentage of presence habitat in each category of impact. Relative benthic status is shown for the current year (2025) and projected 20 years into the future (2045) if no fishing occurred.

Time period	Status relative to inital condition (in 1991)	Antipatharia	Gorgonian	Hexactinellida	VME
Current (2025)	0.0	0.0%	0.0%	0.0%	0.0%
Current (2025)	0.1	0.0%	0.0%	0.0%	0.0%
Current (2025)	0.2	0.1%	0.0%	0.0%	0.1%
Current (2025)	0.3	0.2%	0.4%	0.0%	0.4%
Current (2025)	0.4	0.7%	1.0%	0.1%	1.1%
Current (2025)	0.5	0.9%	1.3%	0.4%	1.7%
Current (2025)	0.6	2.4%	2.7%	1.2%	3.3%
Current (2025)	0.7	5.6%	5.9%	2.6%	6.4%
Current (2025)	0.8	10.8%	11.6%	9.6%	11.9%
Current (2025)	0.9	79.3%	77.1%	86.1%	75.2%
Future (2045)	0.0	0.0%	0.0%	0.0%	0.0%
Future (2045)	0.1	0.0%	0.0%	0.0%	0.0%
Future (2045)	0.2	0.0%	0.0%	0.0%	0.0%
Future (2045)	0.3	0.0%	0.0%	0.0%	0.0%
Future (2045)	0.4	0.0%	0.0%	0.0%	0.0%
Future (2045)	0.5	0.0%	0.0%	0.0%	0.0%
Future (2045)	0.6	0.0%	0.0%	0.0%	0.0%
Future (2045)	0.7	0.1%	0.0%	0.0%	0.1%
Future (2045)	0.8	1.0%	1.4%	0.1%	1.5%
Future (2045)	0.9	99.0%	98.6%	99.9%	98.4%

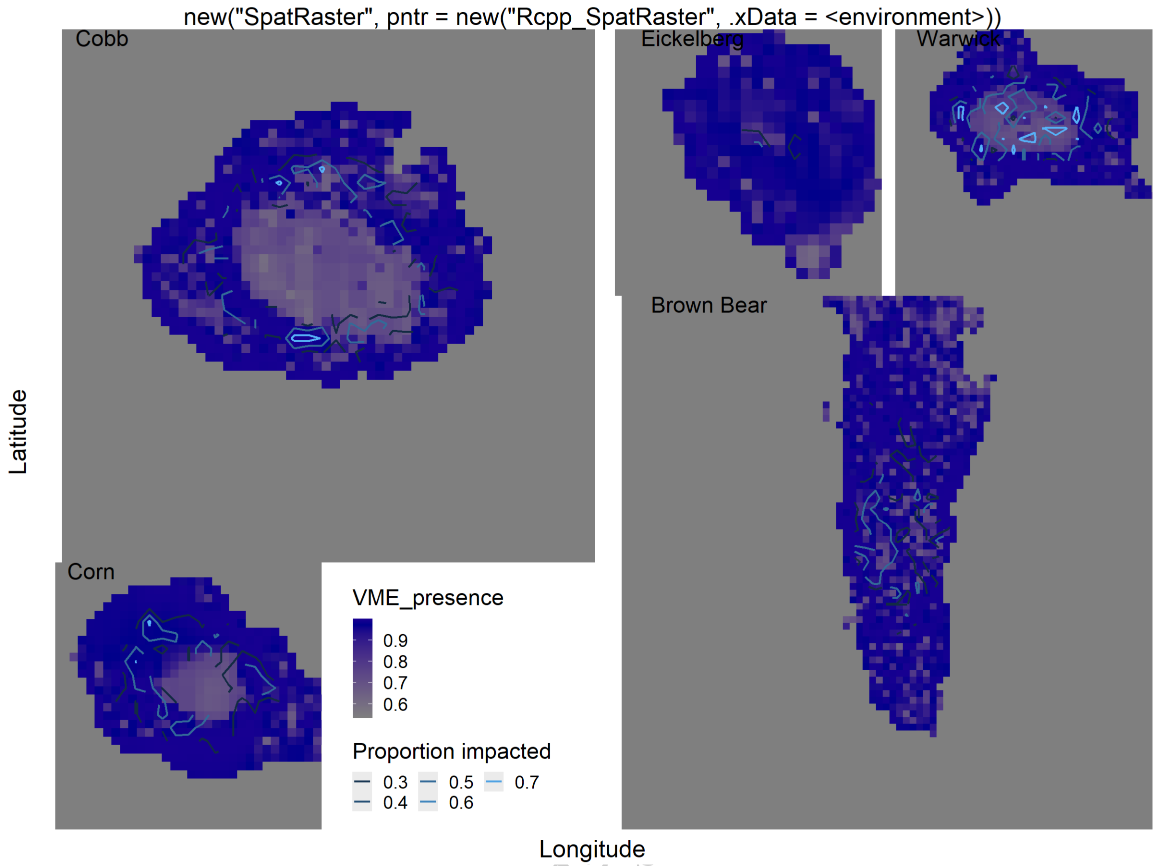

Figure 46: Area impacted by fishing from 1991-2020 overlayed on model predictions of VME indicator probability of presence at seamounts in the Cobb Seamount Chain from all data sources.

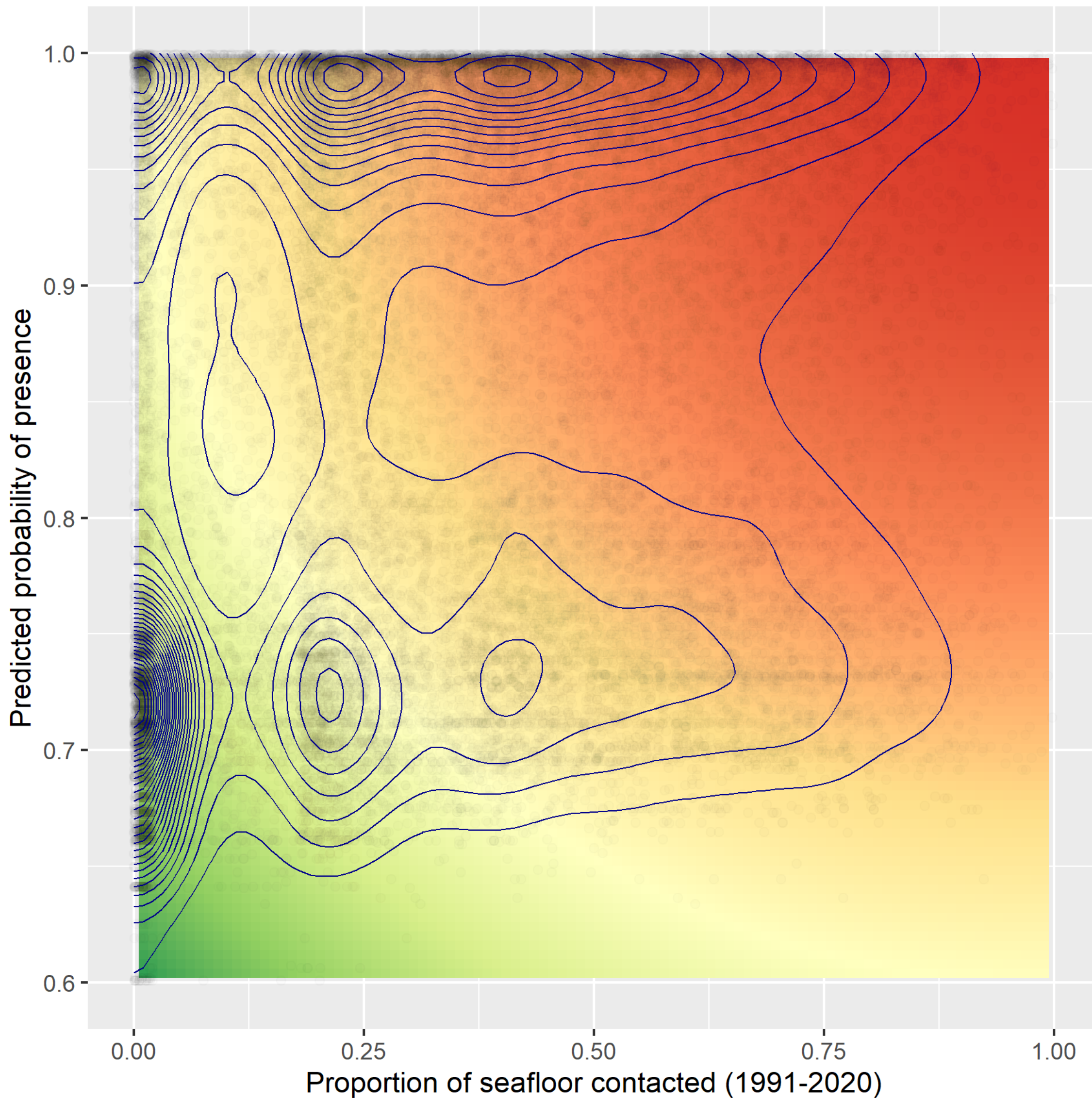

Figure 47: Presence risk at seamounts in the Cobb Seamount Chain from all data sources.

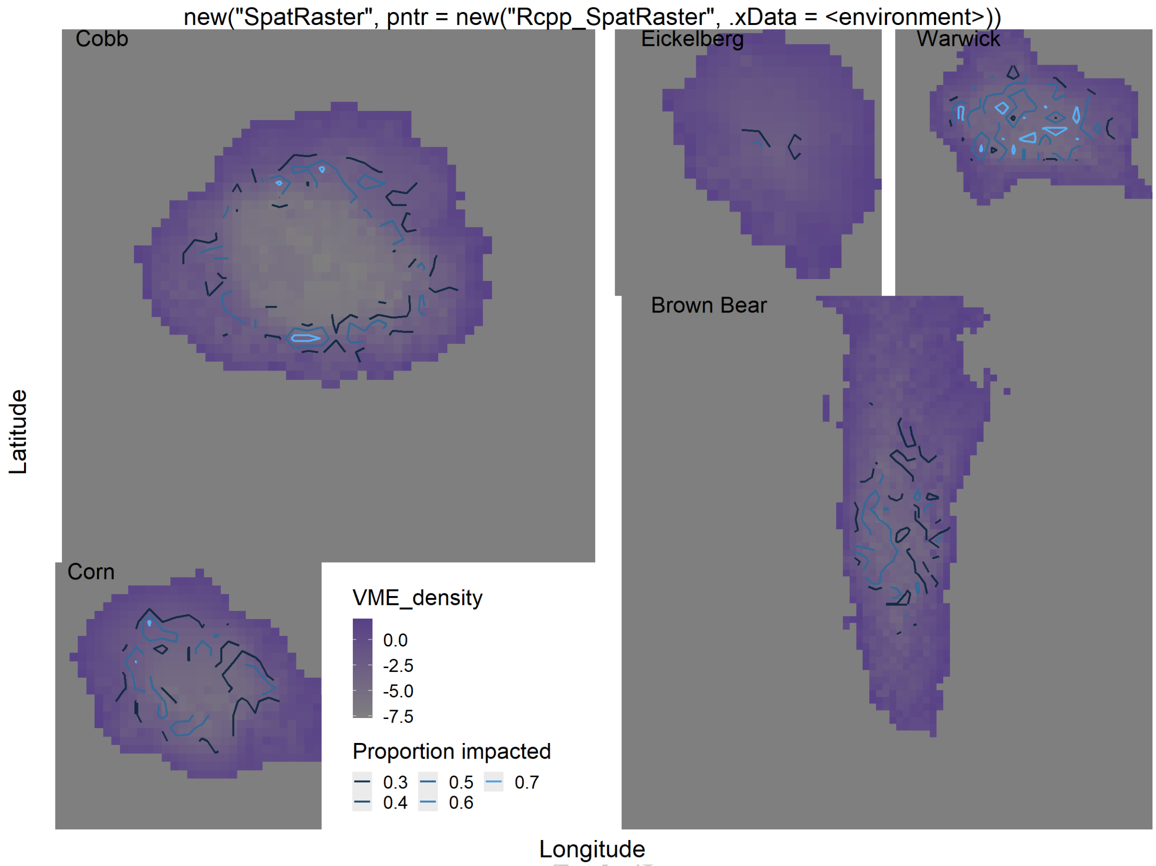

Figure 48: Area impacted by fishing from 1991-2020 overlayed on model predictions of VME indicator taxa density at seamounts in the Cobb Seamount Chain from all data sources.

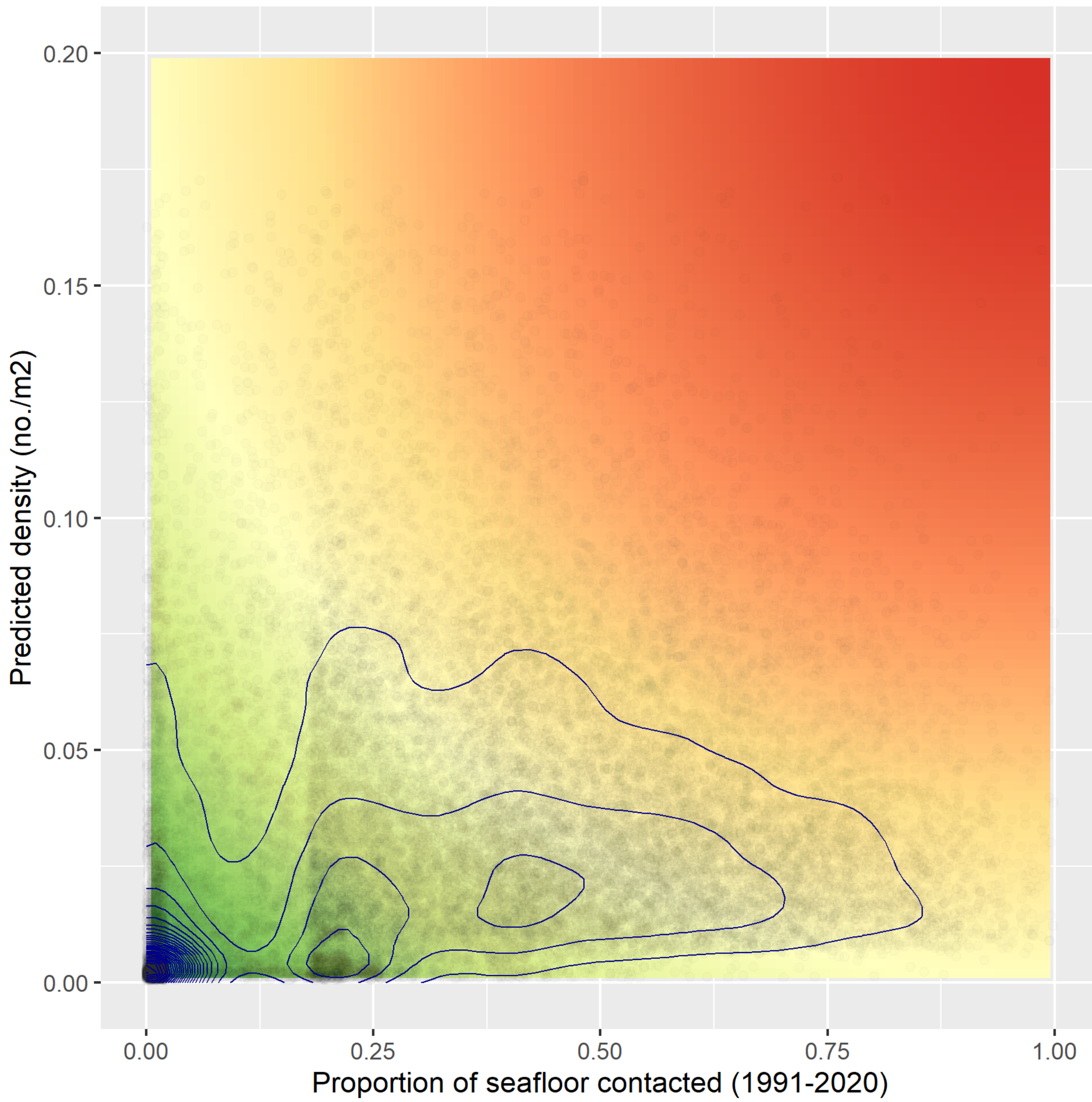

Figure 49: Density risk at seamounts in the Cobb Seamount Chain from all data sources.

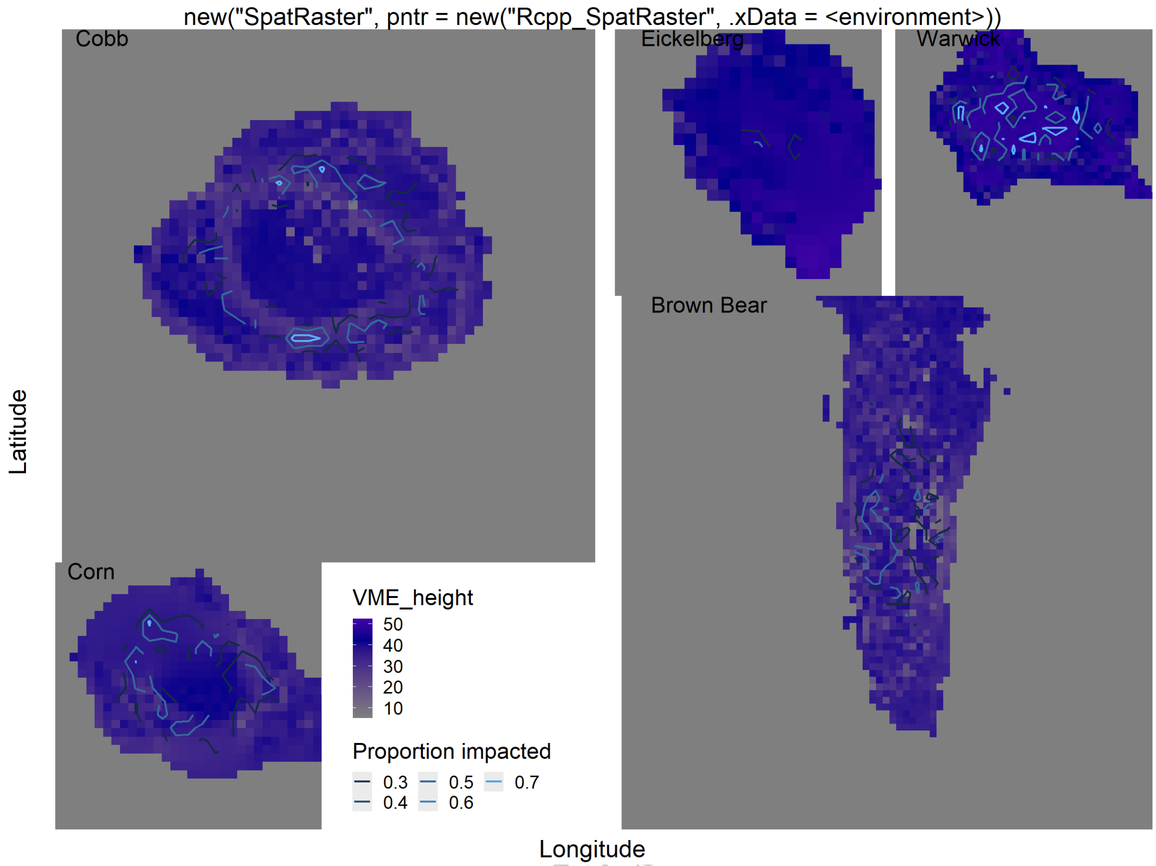

Figure 50: Area impacted by fishing from 1991-2020 overlayed on model predictions of VME indicator taxa height at seamounts in the Cobb Seamount Chain from all data sources.

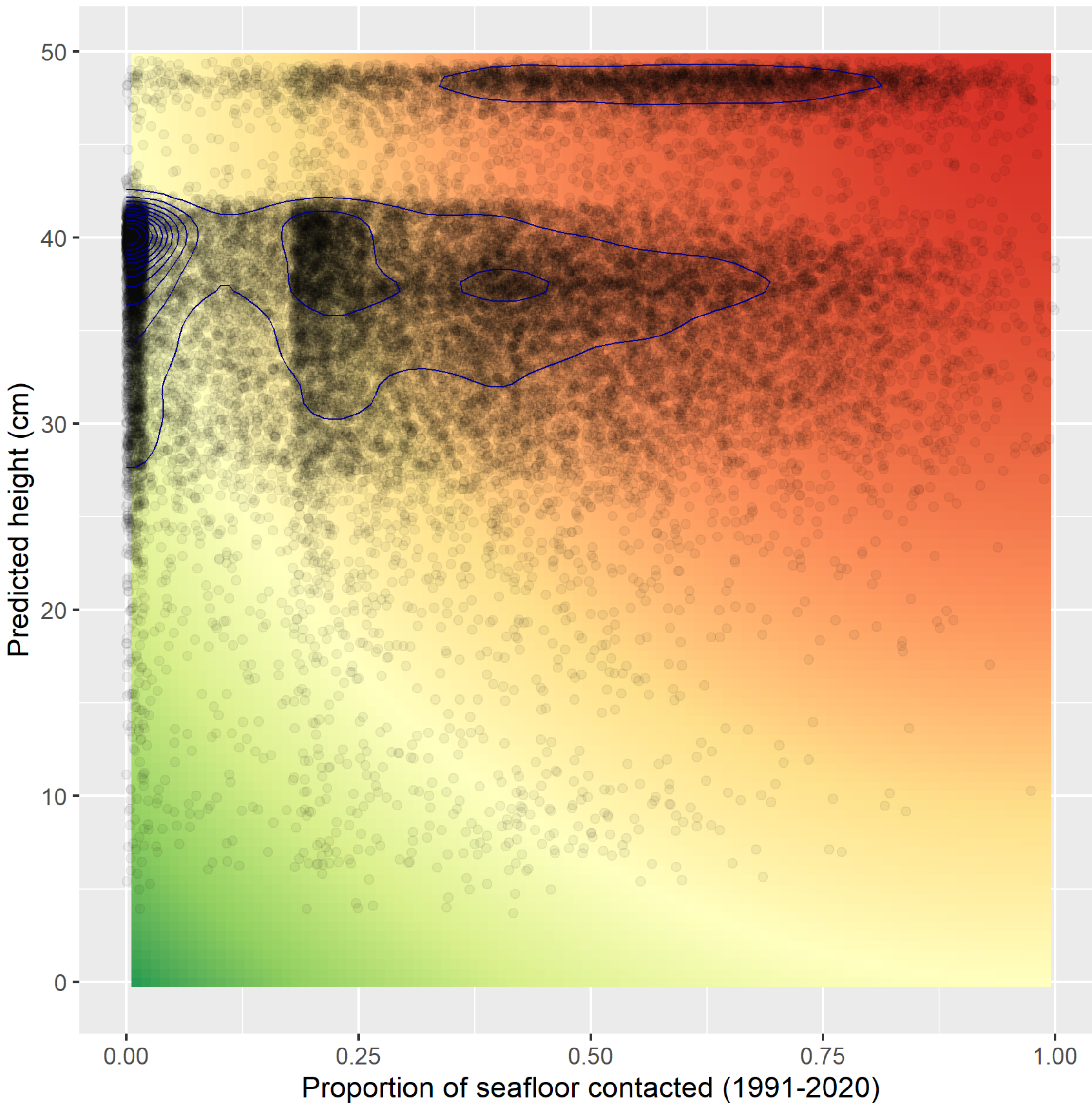

Figure 51: Height risk at seamounts in the Cobb Seamount Chain from all data sources.

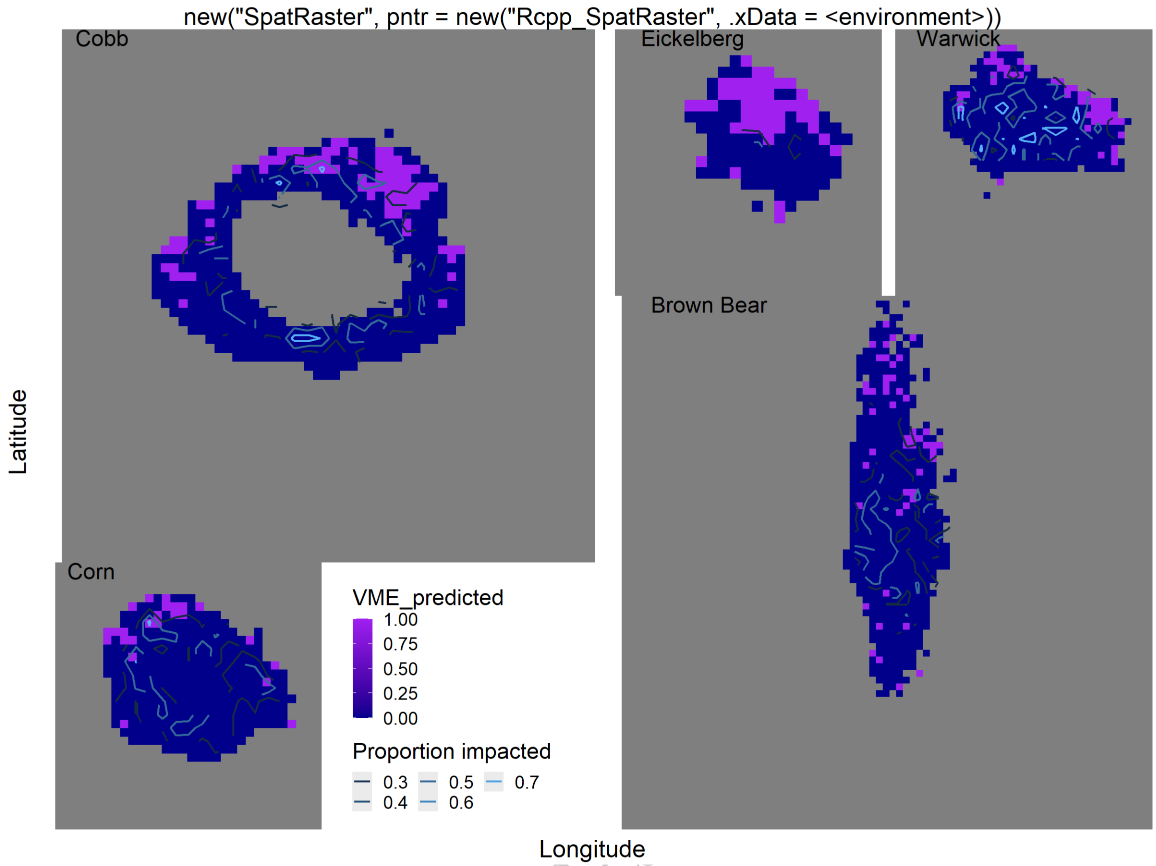

Figure 52: Area impacted by fishing from 1991-2020 overlayed on model predictions of VME at seamounts in the Cobb Seamount Chain from all data sources.

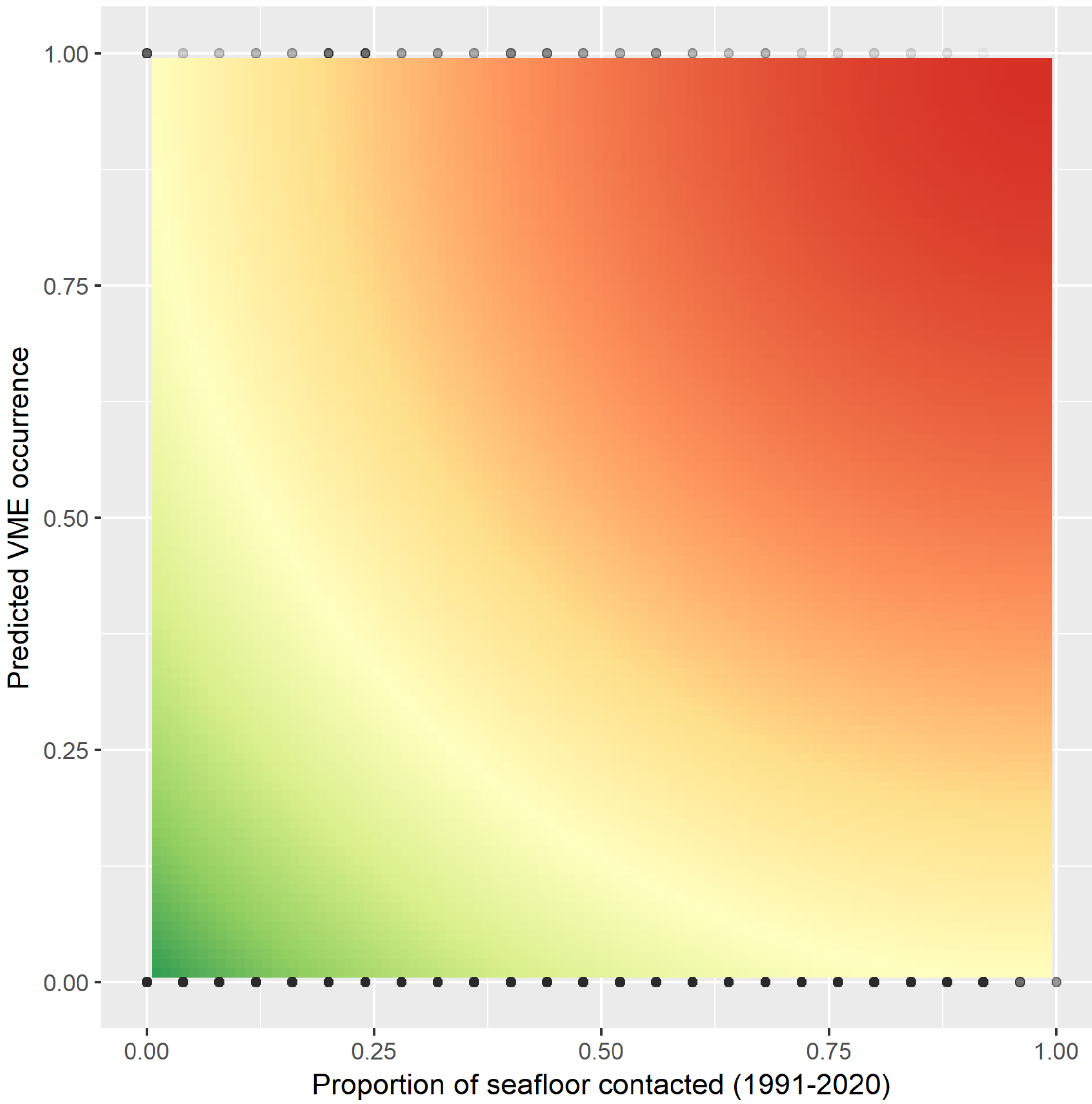

Figure 53: VME risk at seamounts in the Cobb Seamount Chain from all data sources.

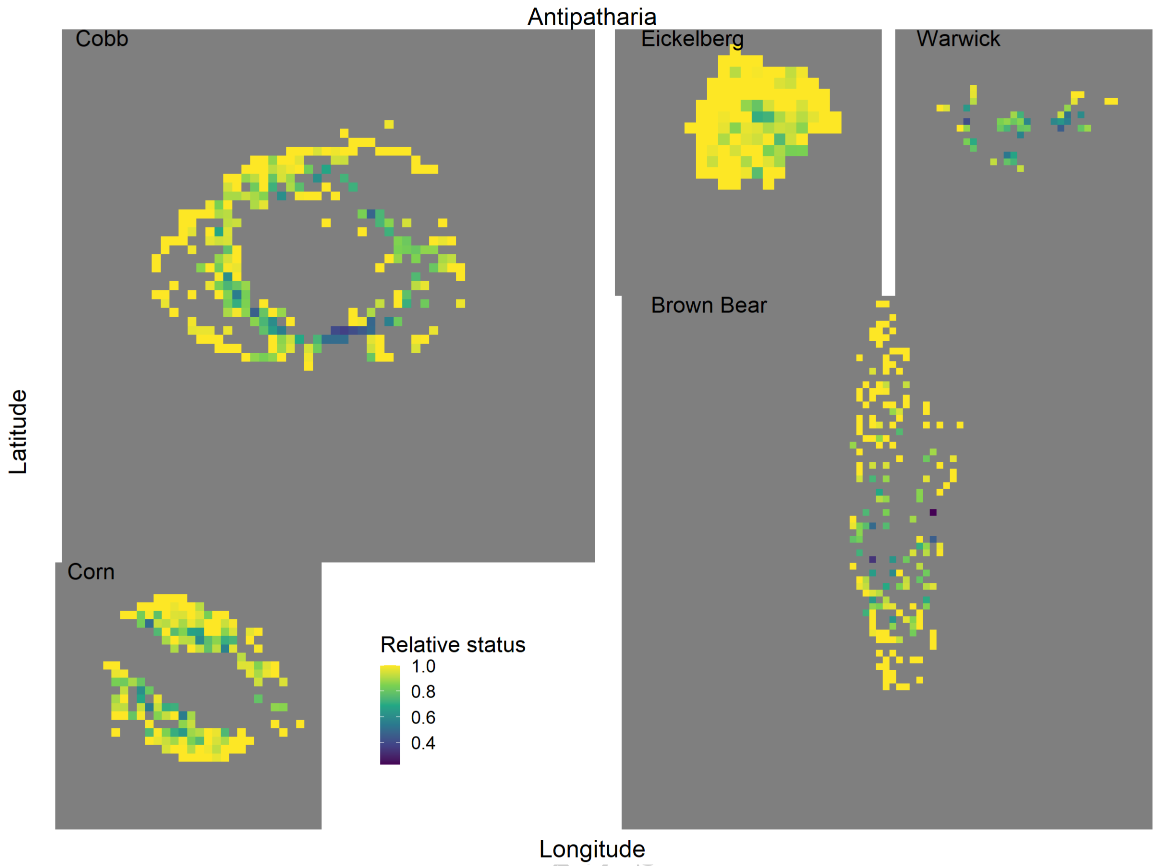

Figure 54: Relative benthic status for predicted Antipatharia at seamounts in the Cobb Seamount Chain in 2025.

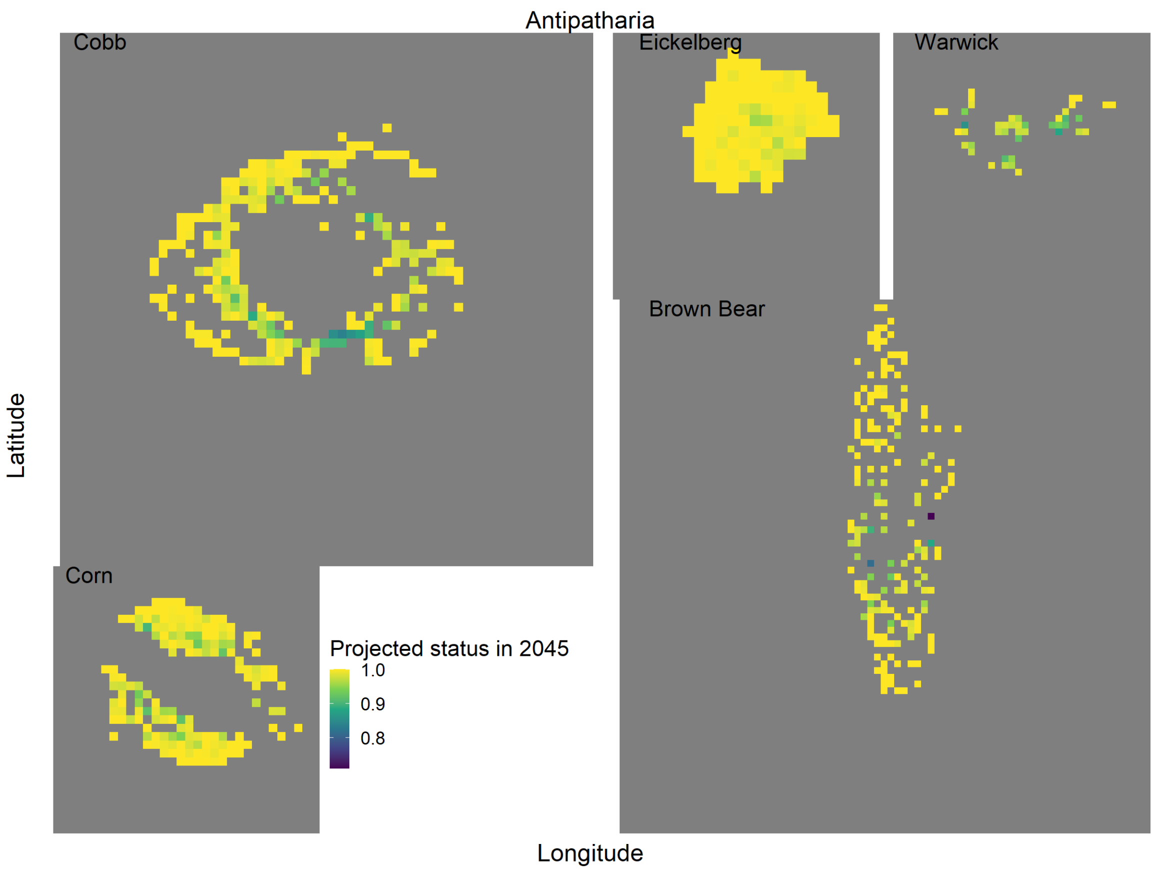

Figure 55: Relative benthic status for predicted Antipatharia at seamounts in the Cobb Seamount Chain predicted in 2045.

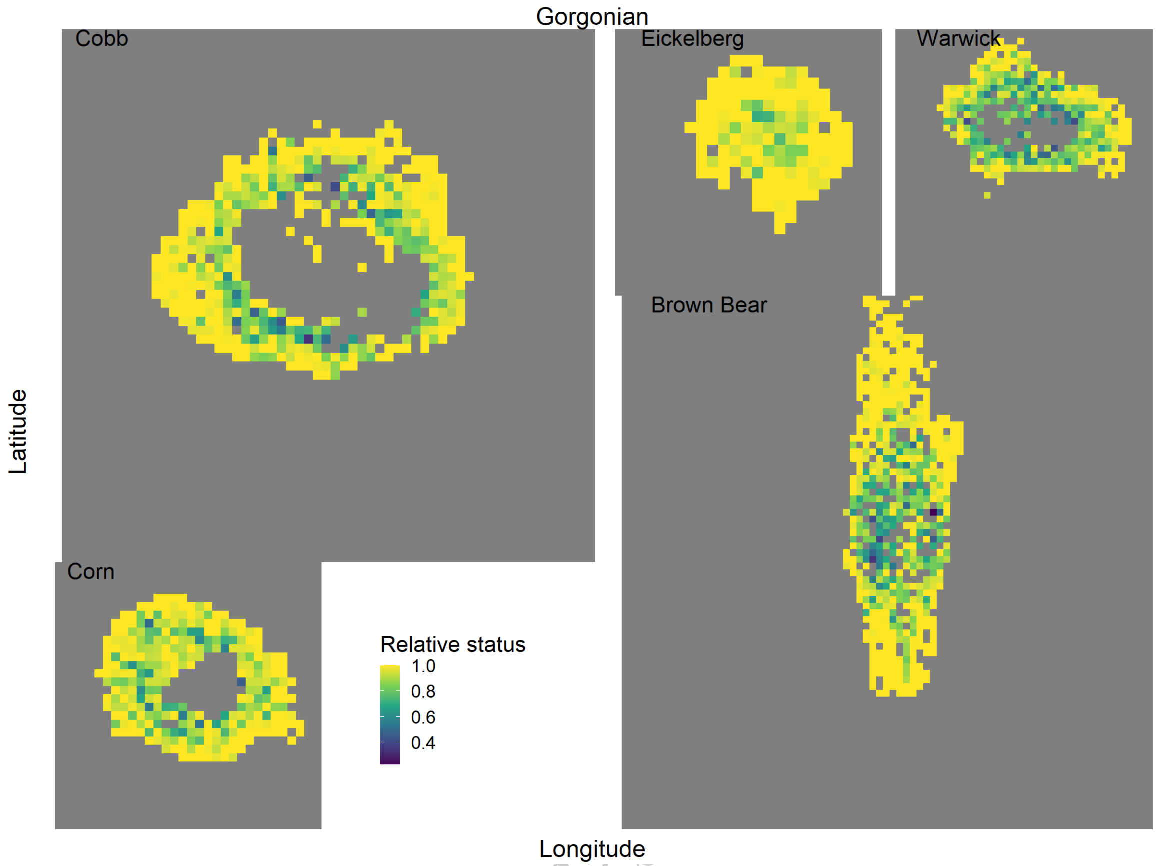

Figure 56: Relative benthic status for predicted Gorgonians at seamounts in the Cobb Seamount Chain in 2025.

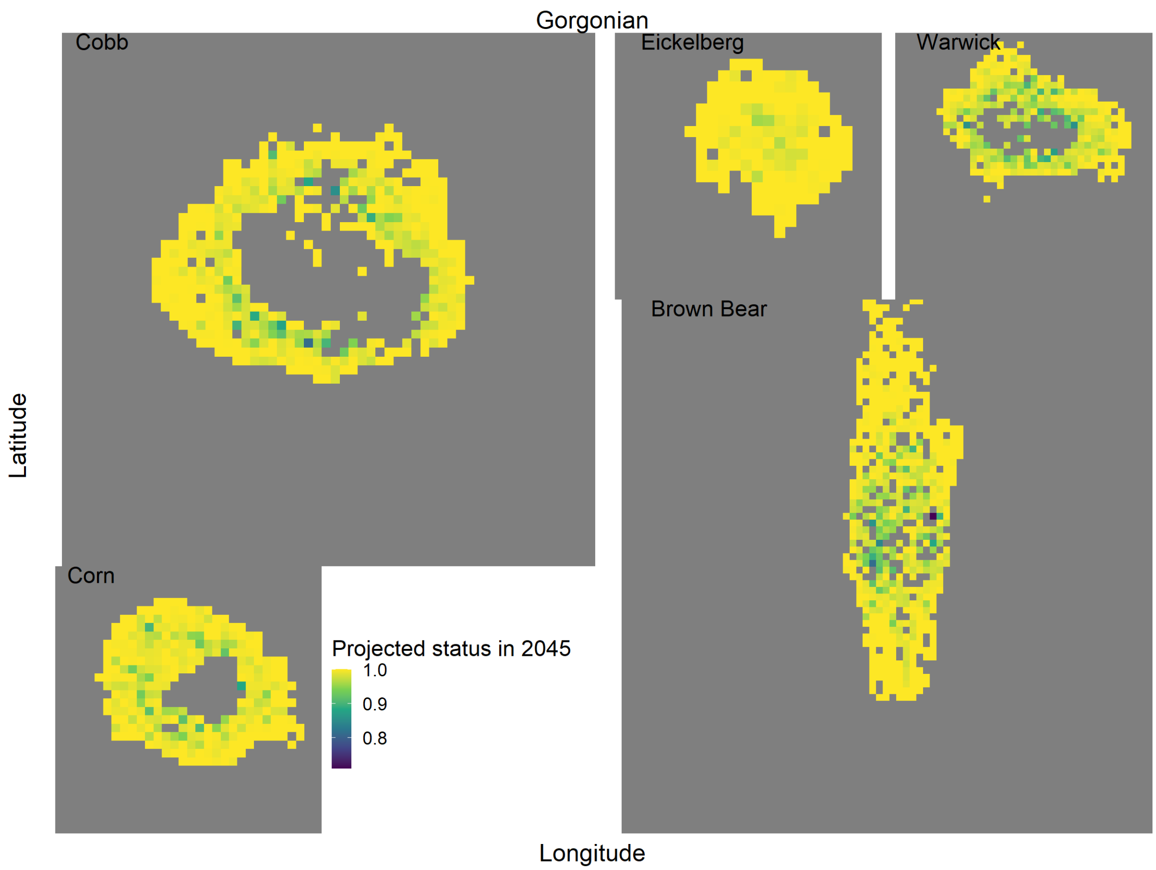

Figure 57: Relative benthic status for predicted Gorgonians at seamounts in the Cobb Seamount Chain predicted in 2045.

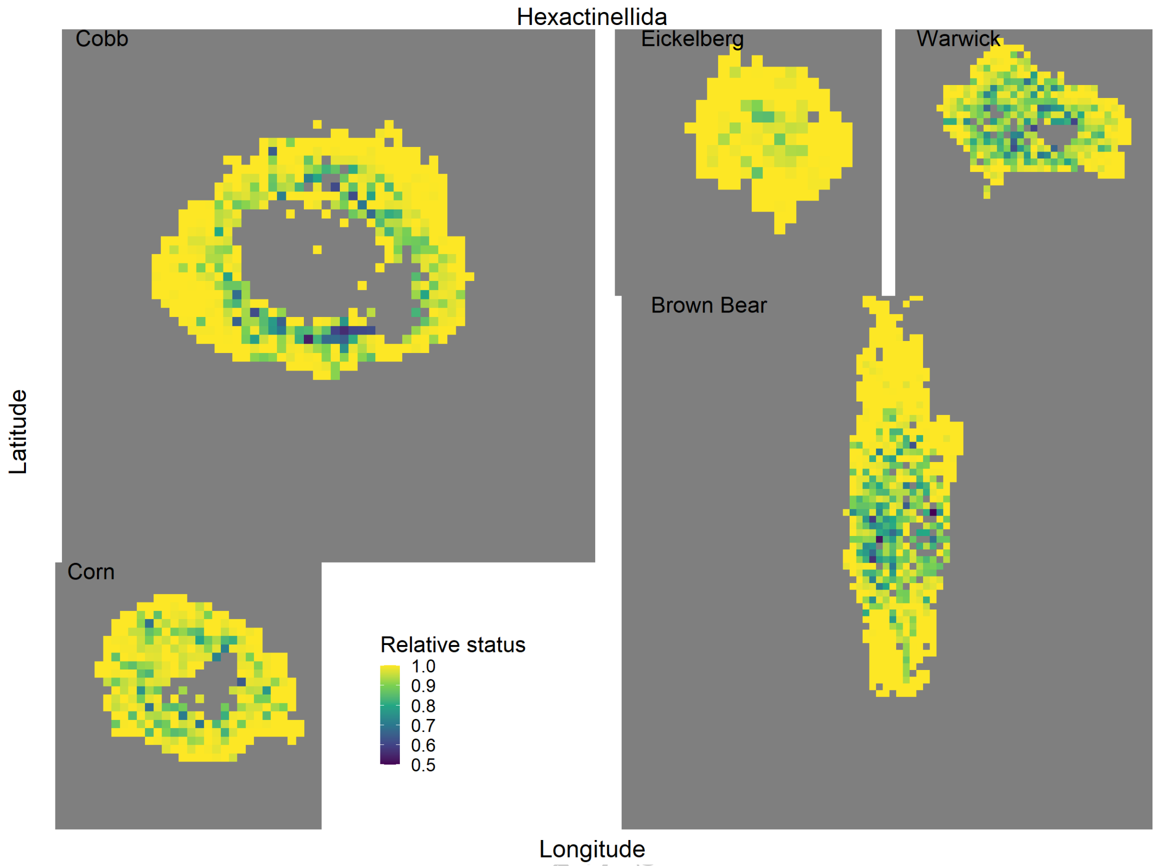

Figure 58: Relative benthic status for predicted Hexactinellids at seamounts in the Cobb Seamount Chain in 2025.

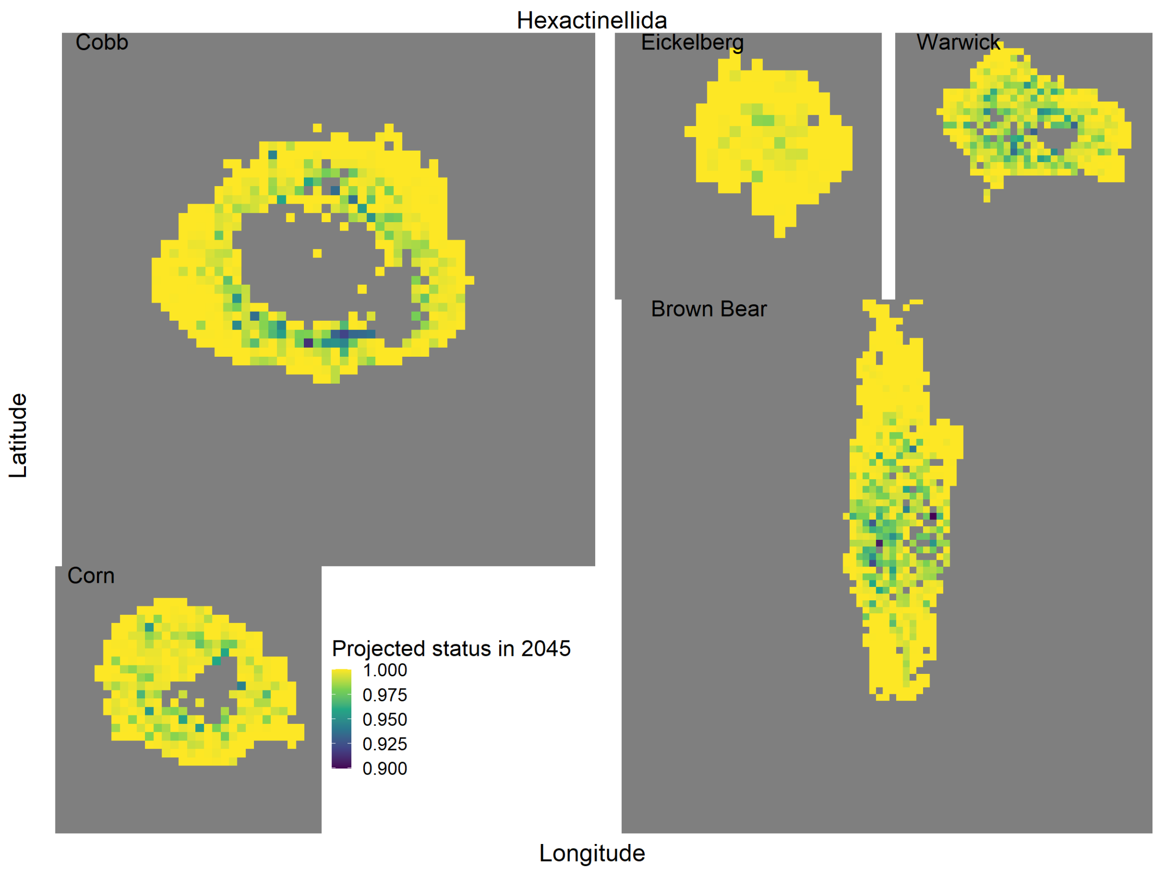

Figure 59: Relative benthic status for predicted Hexactinellids at seamounts in the Cobb Seamount Chain predicted in 2045.

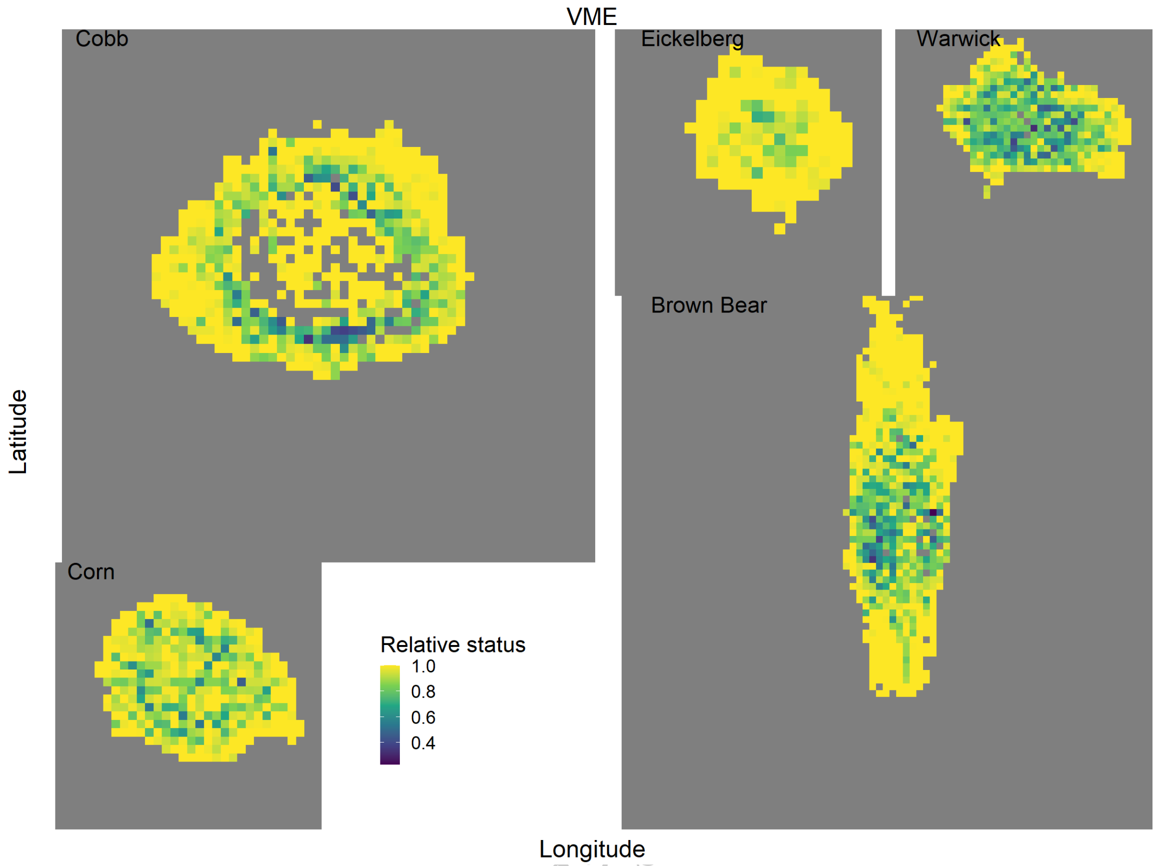

Figure 60: Relative benthic status for predicted VME indicator taxa at seamounts in the Cobb Seamount Chain in 2025.

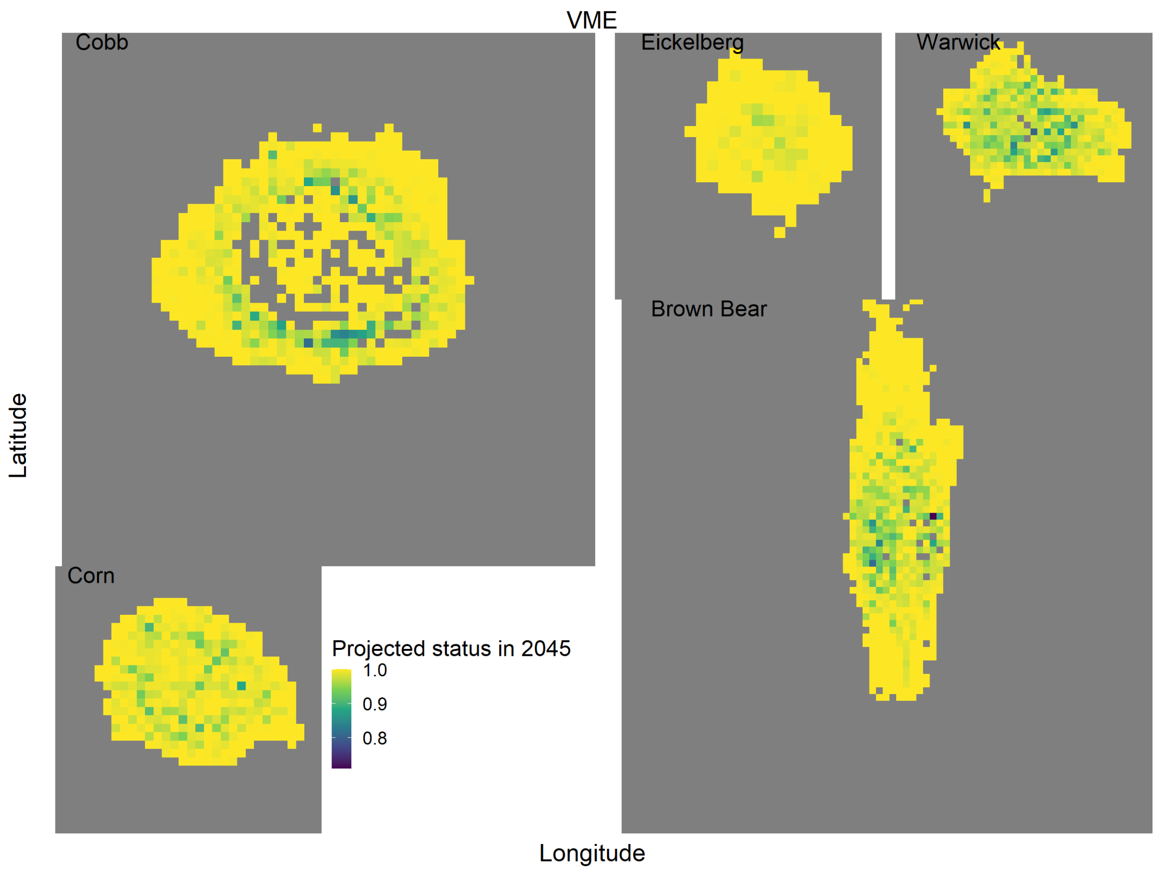

Figure 61: Relative benthic status for predicted VME indicator taxa at seamounts in the Cobb Seamount Chain predicted in 2045.

12 Other points to be addressed

Add sections on climate change impacts, cumulative impacts, etc.

Historical SAI v. Potential SAI

13 Conclusions

- The current Canadian seamount fishery does not appear to pose a conservation concern
- The sablefish population is sustainable at current harvest rates (based on domestic stock assessments)
- There is minimal bycatch of other species in the fishery
- The impact on VME at current (2017-2020) levels appears to be sustainable given the relative benthic status results (based on MSC guidelines)

14 References

Allouche, O., Tsoar, A., & Kadmon, R. (2006). Assessing the accuracy of species distribution models: Prevalence, kappa and the true skill statistic (TSS). Journal of Applied Ecology, 43, 1223–1232. https://doi.org/10.1111/j.1365-2664.2006.01214.x

Curtis, J.M.R., Du Preez, C., Davies, S.C., Pegg, J., Clarke, M.E., Fruh, E.L., Morgan, K., Gauthier, S., Gatien, G., and Carolsfeld, W. 2015. 2012 Expedition to Cobb Seamount: Survey methods, data collections, and species observations. Can. Tech. Rep. Fish. Aquat. Sci. 3124: xii + 145 p.

Etnoyer, P. J., Wagner, D., Fowle, H. A., Poti, M., Kinlan, B., Georgian, S. E., & Cordes, E. E. (2018). Models of habitat suitability, size, and age-class structure for the deep-sea black coral Leiopathes glaberrima in the Gulf of Mexico. Deep-Sea Research Part II: Topical Studies in Oceanography, 150, 218–228. https://doi.org/10.1016/j.dsr2.2017.10.008

Hijmans R. J. (2019). raster: Geographic Data Analysis and Modeling. R package version 3.0-7. https://CRAN.R-project.org/package=raster

Hosmer, D. W. Jr., Lemeshow, S., and Sturdivant, R. X. (2013). Assessing the Fit of the Model. Applied Logistic Regression, 3rd Edn. John Wiley & Sons. doi: 10.1002/9781118548387.ch5

Huff, D. D., Yoklavich, M. M., Love, M. S., Watters, D. L., Chai, F., & Lindley, S. T. (2013). Environmental factors that influence the distribution, size, and biotic relationships of the Christmas tree coral Antipathes dendrochristos in the Southern California Bight. Marine Ecology Progress Series, 494, 159–177. https://doi.org/10.3354/meps10591

R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Spencer, P.D., and C.N. Rooper. 2010. Assessment of the blackspotted and rougheye rockfish complex in the eastern Bering Sea and Aleutian Islands. In Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands region as projected for 2011, pp. 1127-1194. North Pacific Fishery Management Council, 605 W. 4th Ave, suite 306. Anchorage, AK 99501

Valavi R, Elith J, Lahoz-Monfort JJ, Guillera-Arroita G. blockCV: An R package for generating spatially or environmentally separated folds for k-fold cross-validation of species distribution models. Methods Ecol Evol. 2019; 10:225–232. https://doi.org/10.1111/2041-210X.13107

Yesson, C., Bedford, F., Rogers, A. D., & Taylor, M. L. (2017). The global distribution of deep-water Antipatharia habitat. Deep-Sea Research Part II: Topical Studies in Oceanography, 145, 79–86. https://doi.org/10.1016/j.dsr2.2015.12.004

DFO. 2016. A revised operating model for Sablefish (Anoplopoma fimbria) in British Columbia, Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/015.

DFO. 2020. Evaluating the robustness of candidate management procedures in the BC Sablefish (Anoplopoma fimbria) fpshery for 2019-2020. DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/025.

DFO. 2023. A Revised Operating Model for Sablefish in British Columbia in 2022. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2023/010.

DFO. 2023. Application of the British Columbia Sablefish (Anoplopoma fimbria) Management Procedure for the 2023-24 Fishing Year. DFO Can. Sci. Advis. Sec. Sci. Resp. 2023/009.

Goethel, D.R., Rodgveller, C.J., Echave, K.B., Shotwell, S.K., Siwicke, K.A., Hanselman, Malecha, P.W., D.H., Cheng, M., Williams, M., Omori, K.,and Lunsford, C.R. 2022. Assessment of the sablefish stock in Alaska. In "Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the GOA and BS/AI." Anchorage, AK: North Pacific Fishery Management Council.

Jasonowicz, A. J., F. W. Goetz, G. W. Goetz, and K. M. Nichols. 2017. Love the one you're with: genomic evidence of panmixia in the sablefish (Anoplopoma fimbria). Can. J. Fish. Aquat. Sci. 74:377-387.

Kapur, M.S., Lee, Q., Correa, G.M., Haltuch,M., Gertseva, V. and Hamel, O.S. 2021. Status of sablefish (Anaplopoma fimbria) along the US West Coast in 2021. Pacific Fisheries Management Council, Portland, Oregon, 196 p.

Kapur, M., Rogers, L., Goethel, D.R., Cheng, M.L.H., Hanselman, D., Echave, K., Haltuch, M.A., Holt, K.R., English, P., Berger, A.M., Connors, B. 2025. Hidden markov mark-recapture modeling highlights transboundary exchange for northeast pacific sablefish. Fisheries Research 289: 107498. https://doi.org/10.1016/j.fishres.2025.107498.

Shotwell, K., Goethel, D.R., Deary, A., Echave, K., Fenske, K., Fissel, B., Hanselman, D., Lunsford, C., Siwicke, K., and Sullivan, J. 2020. Ecosystem and socioeconomic profile of the sablefish stock in Alaska. In "Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the GOA and BS/AI." Anchorage, AK: North Pacific Fishery Management Council.

Thorson, J. 2019. Guidance for decisions using the Vector Autoregressive Spatio-Temporal (VAST) package in stock, ecosystem, habitat and climate assessments. Fisheries Research 210: 143–161. doi:10.1016/j.fishres.2018.10.013.

Wolotira, R. J. J., T. M. Sample, S. F. Noel, and C. R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. NOAA Tech. Memo. NMFS-AFSC-6. 184 pp.

Lacko, L.C., Acheson, S.M. and Holt, K.R. 2023. Summary of the annual 2021 Sablefish (Anoplopoma fimbria) trap survey, October 6 - November 21, 2021. Can. Tech. Rep. Fish. Aquat. Sci. 3530: vii + 48 p.