

2022 Gulf of Alaska forage report

Cody Szuwalski

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Executive summary

This forage species report for the Gulf of Alaska (GOA) region is prepared and presented to the GOA Plan Team and the North Pacific Fishery Management Council (NPFMC) in even years. This report is not a formal stock assessment; it is a presentation of the available data on trends in abundance and distribution of forage populations and a description of their interactions with federal fisheries through bycatch.

Forage species are a fundamental component of the GOA ecosystem, so there is overlap between the information presented here and in the Ecosystem Considerations report (<https://access.afsc.noaa.gov/reem/ecoweb/index.php>). This forage report primarily displays data from the GOA bottom trawl surveys. The Ecosystem Considerations report contains surface-trawl surveys, euphausiid abundances from acoustic surveys, and indirect indicators of forage species abundance such as seabird breeding success and groundfish predator diets.

Estimated capelin abundance and biomass from the NMFS bottom trawl surveys were near all time highs in 2021; eulachon saw slight increases in 2021 compared to 2019. Magistrate armhook squid estimated abundance and biomass during 2021 were up from all-time lows in 2017. Estimated abundance and biomass of unidentified shrimp were at all-time highs in 2021 and sidestripe shrimp were slightly higher than average. Total incidental catches of the FMP forage group were low in 2020 and 2021 compared to historical observations. Total shrimp catches during 2020 were the second highest observed, but 2021 was the lowest observed. Prohibited species catch of herring was higher than average in 2020 and 2022.

A. Forage species and their management

Defining ‘forage species’ can be difficult. Small, energy-rich schooling fishes like sardines or herring are the classic ‘forage fish’, but most fish species experience predation in their life cycle. Forage species can be thought of as those whose primary ecosystem role is as prey and serve as a link between lower and upper trophic levels. The following species or groups are defined as components of the forage base in the GOA: members of the ‘forage fish group’ listed in the GOA Fishery Management Plan, squids, shrimps, Pacific herring (*Clupea pallasii*), and juvenile groundfishes and salmon.

Forage fish groups

Forage fishes in the GOA were either managed as part of the Other Species group (non-target species caught incidentally in commercial fisheries) or were classified as “non-specified” in the Fishery Management Plan (FMP), with no conservation measures prior to 1998. Amendment 36 to the GOA FMP created a separate forage fish category in 1998, with conservation measures that included a ban on directed fishing. Members of this forage fish group (the “FMP forage group” in this report) are considered “Ecosystem Components” beginning in 2011. The group is large and diverse, containing over fifty species from these taxonomic groups (see the appendix at the end of this report for a full list of species), but some of the key groups include:

- Osmeridae (smelts; eulachon *Thaleichthys pacificus* and Pacific capelin *Mallotus catevarius* are the principal species)
- Ammodytidae (sand lances; Pacific sand lance *Ammodytes personatus* is the only species commonly observed in the GOA and BSAI)
- Trichodontidae (sandfishes; Pacific sandfish *Trichodon trichodon* is the main species)
- Stichaeidae (pricklebacks)
- Pholidae (gunnels)
- Myctophidae (lanternfishes)
- Bathylagidae (blacksmelts)
- Gonostomatidae (bristlemouths)
- Euphausiacea (krill; these are crustaceans, not fish, but are considered essential forage)

The primary motivation for the creation of the FMP forage group was to prevent fishing-related impacts to the forage base in the GOA. This was an early example of ecosystem-based fisheries management (Livingston et al. 2011). Two key management measures for the group are specified in section 50 CFR 679b20.doc of the federal code: a closure to direct fishing and a prohibition of the sale, barter, trade or processing of forage species. Fishmeal production and sale from forage species is allowed provided it does not exceed the maximum retainable bycatch. Catches are limited to a maximum retention allowance (MRA) of 2% by weight of the retained target species.

It appears the figure of ‘2%’ was chosen to accommodate existing levels of catch that were believed to be sustainable (Federal Register, 1998, vol. 63(51), pages 13009-13012), which suggests the intent of amendment 36 was to prevent an increase in forage fish removals, not to reduce existing levels of catch. In 1999, the state of Alaska adopted a statute with the same taxonomic groups and limitations, except that no regulations were passed regarding the processing of forage fishes. This exception has caused some confusion regarding the onshore processing of forage fishes for human consumption (J. Bonney, pers. comm., Alaska Groundfish Databank, Kodiak, Alaska).

Squids

Several species of squid inhabit the GOA, mainly along the shelf break. Squids were managed as part of the ‘Other Species’ complex before 2011; starting in 2011, they were managed as a target stock complex with annual harvest specifications. However, in June 2017, the NPFMC amended the FMP for the Bering Sea

and Aleutian Islands (BSAI; Amendment 117) and GOA (Amendment 106) to move the squid stock complex into the Ecosystem Component category. The rationales for this decision included: the lack of a directed fishery for squid, low risk of overfishing given high productivity and no directed fishery, and small incidental fishing mortality.

The amendments were implemented in the Federal Register with an effective date of August 8, 2018 (Federal Register, Volume 83, Number 130, July 6 2018, pages 31460-31470). The amendments placed squid in the Ecosystem Component category, prohibited a directed fishery for squid, established a 20% maximum retention allowance, and established record keeping requirements. The new management regime was implemented in January 2019.

Shrimp

Many shrimp species occur in the GOA, with four species targeted by commercial fisheries: northern (*Pandalus borealis*), coonstripe (*Pandalus hypsinotis*), spot (*Pandalus playcros*), and sidestripe (*Pandalopsis dispar*). Relatively large fisheries of mainly northern shrimp used to occur in the GOA. However, the fisheries have been closed since 1984 following population declines. Currently almost all catch occurs in Southeast Alaska and detailed information on shrimp fisheries in Alaskan waters is available from the Alaska Department of Fish & Game (ADFG). This report only includes incidental catch data of shrimp in federal fisheries.

Pacific herring

Herring are abundant in Alaskan waters and commercial fisheries managed by ADFG exist throughout the GOA, primarily for herring roe and bait. Herring stocks in Prince William Sound declined following the Exxon Valdez Oil Spill and have yet to recover to levels that would allow a directed fishery. However, herring populations in other regions of the GOA do have directed fisheries with notably large recruitment events in recent years, such as Southeast Alaska and Kodiak. Pacific herring are managed as Prohibited Species in federal groundfish species and consequently no directed fishing occurs and all bycatch must be returned to the sea immediately. Data regarding incidental catches of herring in federal fisheries are include here.

Juvenile groundfishes and salmon

Juvenile groundfish, particularly age 0 and age 1 walleye pollock (*Theragra chalcogramma*), are key forage species in the GOA. Yong Chinook, chum, and sockeye salmon are also important. Information regarding these species is available in the Ecosystem Considerations chapter, NPFMC stock assessments, and ADFG reports.

B. Trends in biomass, abundance, prevalence, and distribution

Information content of data sources

The primary data source for this report is the bottom trawl survey, but this survey is not aimed at sampling the water column (where many forage species reside) and is not designed to capture small fish. Furthermore, the sampling does not include very shallow or very deep waters in the GOA. Consequently, measures of abundance, prevalence, and distribution are uncertain. The goal of this report is to present the data from the bottom trawl survey for forage species while understanding the potential shortcomings of the survey for this task.

Methods

Data for many of the species listed above as ‘forage species’ are available in the bottom trawl survey data (Figure 1). However, for many of these species, a large fraction of the available observations are associated with life stages that are not ‘forage’ sized. Filtering out tows in which the average weight of an individual was greater than 0.5 kilograms focuses on the fraction of tows in which only forage sized animals were present (Figure 2). This is an overly restrictive filter because tows with average weights higher than 0.5 kilograms could have forage sized fish in them. However, it is also clear that not filtering the data would lead to distributions and abundances that include primarily adult fish. The actual distribution of forage sized individuals of given species is likely somewhere between filtered and unfiltered data set. After the application of this filter, eulachon, capelin, squid, and shrimp are the primary species that appear to be at least marginally well sampled by the bottom trawl, so they will be the primary focus of this report.

Pacific capelin

Pacific capelin are an important forage species in the GOA for which information from both the bottom trawl and acoustic surveys exist. Acoustic survey data are not presented here, but will be included in the next iteration of the GOA forage report. Previous forage reports have noted the similarity in the trends of abundance between the acoustic and trawl survey. Estimates of both biomass and abundance of capelin during 2021 in the GOA were near the historical highs seen in 2003, however, there is considerable uncertainty associated with these estimates (Figure 3). Capelin were observed in ~22% of the 2021 bottom trawl samples, which was the second highest frequency of occurrence (the previous high occurring in 2013 at 25%; Figure 4). Historically, capelin are observed widely throughout the GOA (Figure 5), but the largest survey estimates have been observed in the Kodiak area in shallow water (Figure 6).

Eulachon

Eulachon are larger than capelin and distributed closer to the seafloor, which allows them to be more efficiently sampled by the bottom trawl survey. Eulachon lack swim bladders, so they are not detected in acoustic surveys. Abundance and biomass estimates of eulachon during 2021 were higher than in 2019, but lower than those observed from 2001-2015 (Figure 3). Eulachon were observed in ~36% of the 2021 bottom trawl samples, which was the third highest frequency of occurrence in the time series (Figure 4). Like capelin, eulachon are observed widely throughout the GOA (Figure 7), but the largest survey estimates have been observed in the Kodiak area in water 100-300 meters deep (Figure 8).

Squid

Observations of two groups of squid are reported from the bottom trawl survey: magistrate armhook squid (*Berryteuthis magister*) and unidentified squid. Adult *B. magister* are regularly encountered by the bottom trawl survey because of their relatively large size (maximum mantle length of ~28 cm; Sealifebase.com). Smaller species and juvenile squid are mainly found near surface waters. Estimated abundance and biomass for magistrate armhook squid during 2021 were substantially higher than 2019 estimates, but abundance estimates for unidentified squids were less than average (Figure 9). The historical trends of the prevalence of occurrence for both *B. magister* and unidentified squid are increasing, but the 2021 prevalence for each species was closer to the mean over time than the 2019 data (~17% and 7%, respectively; Figure 10). *B. magister* is distributed throughout the GOA (Figure 11), but the largest biomasses have been observed in Kodiak, Chirikof, and Shumagin at depths of 200-300 meters (Figure 12).

Shrimp

Observations of two groups of shrimp are reported from the bottom trawl survey: sidestripe shrimp (*Pandalopsis dispar*) and unidentified shrimp. *P. dispar* can reach 8 inches in length and were seen in ~23% of survey samples in 2021; unidentified shrimp were observed in ~36% of samples (Figure 13). The estimated abundance of unidentified shrimp was at all-time highs in 2021 and the estimated biomass was the second highest on record (Figure 14). The trend in sidestripe shrimp abundance and biomass has been positive since the GOA survey began in the 1980s, but 2021 estimates declined from the all-time highs seen in 2019 (Figure 14). Sidestripe shrimp are observed in shallower waters the farther east into the GOA the survey progresses (Figure 15).

C. Bycatch and other conservation issues

FMP forage group

Incidental catch data for the FMP forage group are available starting in 2003. Prior to 2005, species identification by observers was unreliable and many smelt catches were recorded as ‘other osmerid’. Identification has improved since then, but smelts are often too damaged for accurate identification and much of the catch is still reported as other osmerid. Osmerids regularly make up the vast majority of FMP forage fish group catches (Figure 16). Eulachon are the most abundant osmerid catch and it is likely that they make up the majority of the ‘other osmerid’ catch. Osmerid catches (and consequently total FMP forage group catches) have been low relative to historical levels since 2015 (Figure 17). Other osmerids accounted for almost all of the incidental catch in 2021.

Squid

Squid catches are generally relatively low compared to biomass estimates from trawl surveys, but in 2006 there was a large catch of 1,516 t. Recent squid catches are low compared to catches observed beginning in 2005 (Figure 18). The 2006 catch occurred in the bottom trawl fisheries for pollock, but the catches from midwater trawls for pollock have been consistently higher than the bottom trawls since 2008 (Figure 18). Almost all of the squid catch occurs in the central GOA (Figure 18).

Shrimp

Bycatch of pandalid shrimp in federal fisheries is generally low and all is discarded (Figure 19). Catches in 2019 and 2020 were the highest in the time series, but 2021 and 2022 catches were the lowest. Recently, the arrowtooth flounder fishery accounts for nearly all of the bycaught shrimp in the GOA and those catches primarily occur in the Central GOA (Figure 19).

Pacific herring

Pacific herring are a prohibited species and data on catches in federal fisheries are available beginning in 1991. The Prohibited Species Catch (PSC) of herring is generally low, with occasional larger catches (e.g. 1994, 2004, and 2016; Figure 20). Herring PSC in 2022 was above the long-term mean. Most of the herring bycatch occurs in the midwater trawls for walleye pollock in the Central GOA (Figure 20).

D. Future research directions

Given the change in authorship for the forage report, the goal for this year's report was only to replicate the previous report with updated data with some small additions. However, future efforts will be aimed at developing synthetic (i.e. incorporating multiple data sources) indices of forage base and linking spatio-temporal changes in these indices to environmental variables. I also hope to explore the potential for more quantitative, model-based assessments of forage species that include indices of the biomass of their predators as seen through diet data.

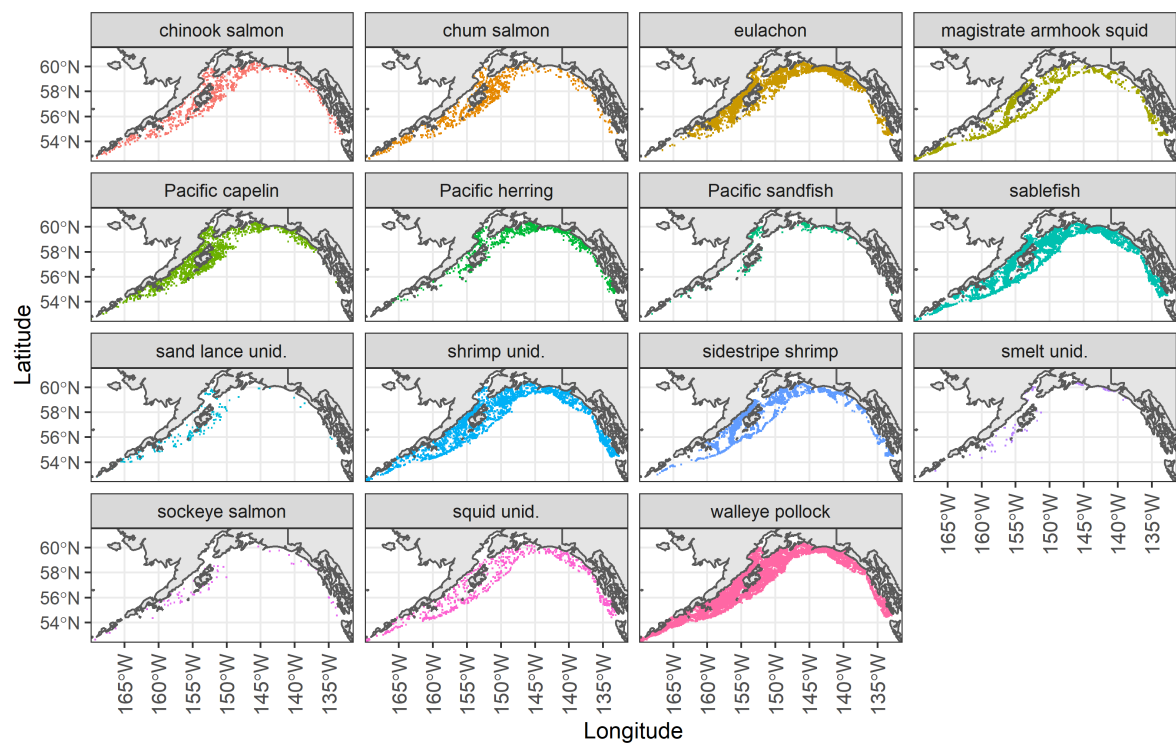


Figure 1: All non-zero tows for select forage species.

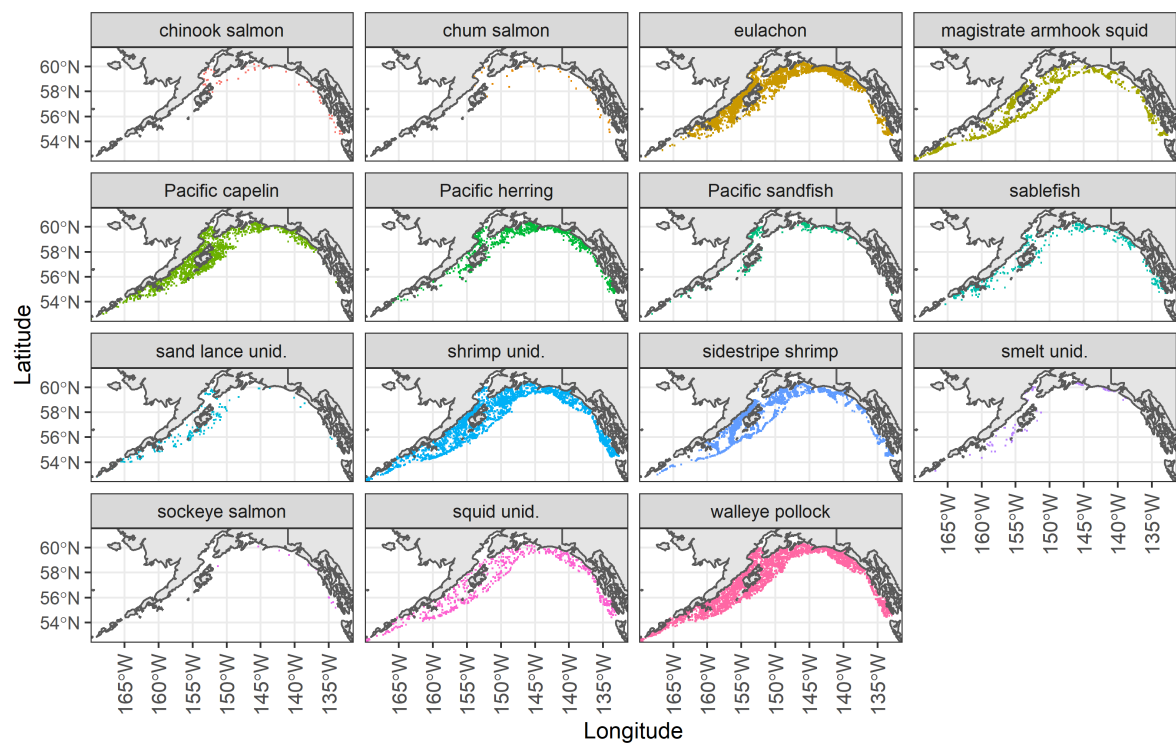


Figure 2: All non-zero tows for select forage species filtered for tows that have an average weight less than 0.5 kilograms.

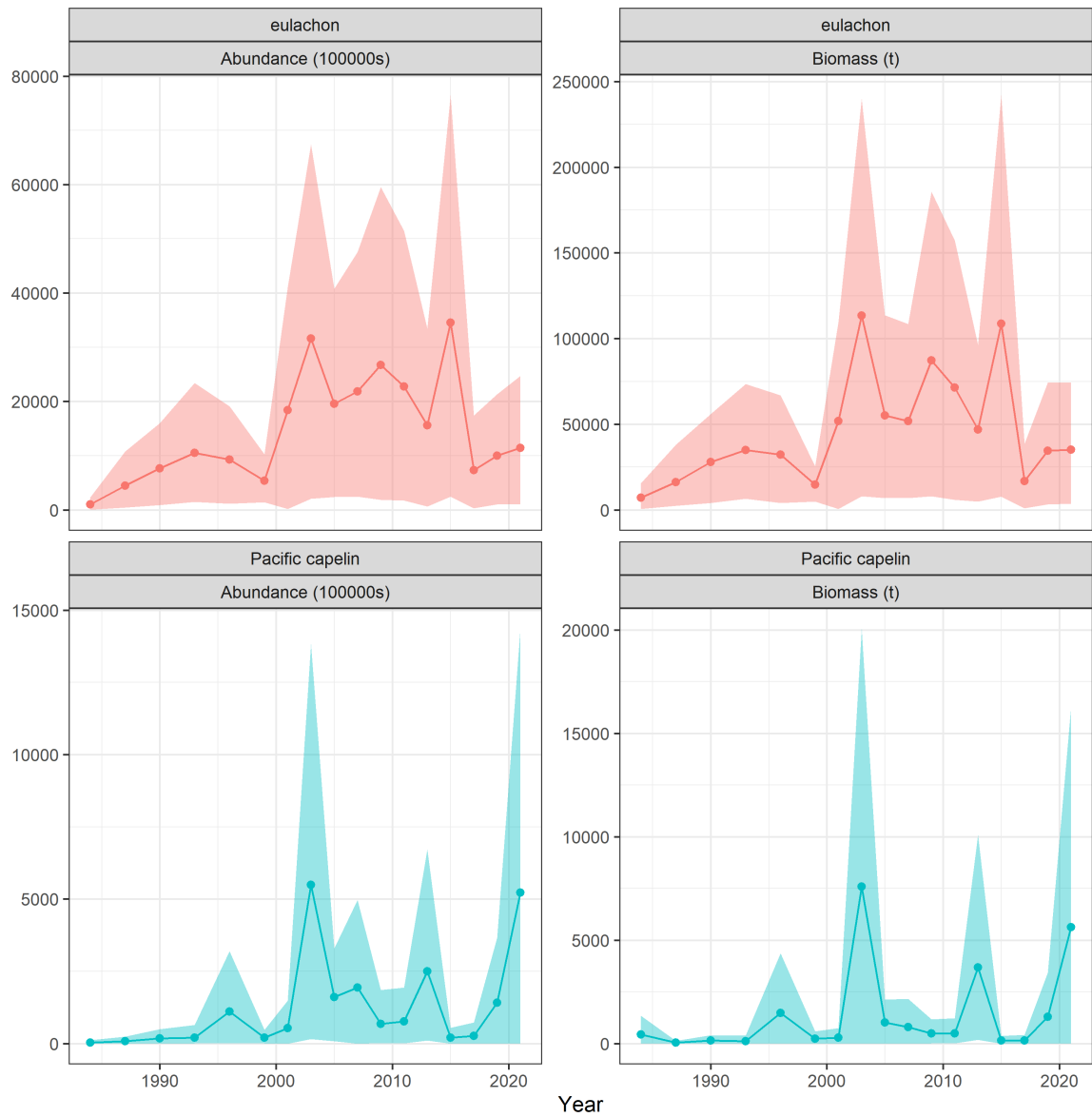


Figure 3: Estimated biomass and abundance of eulachon and Pacific capelin in the Gulf of Alaska with 95% confidence intervals.

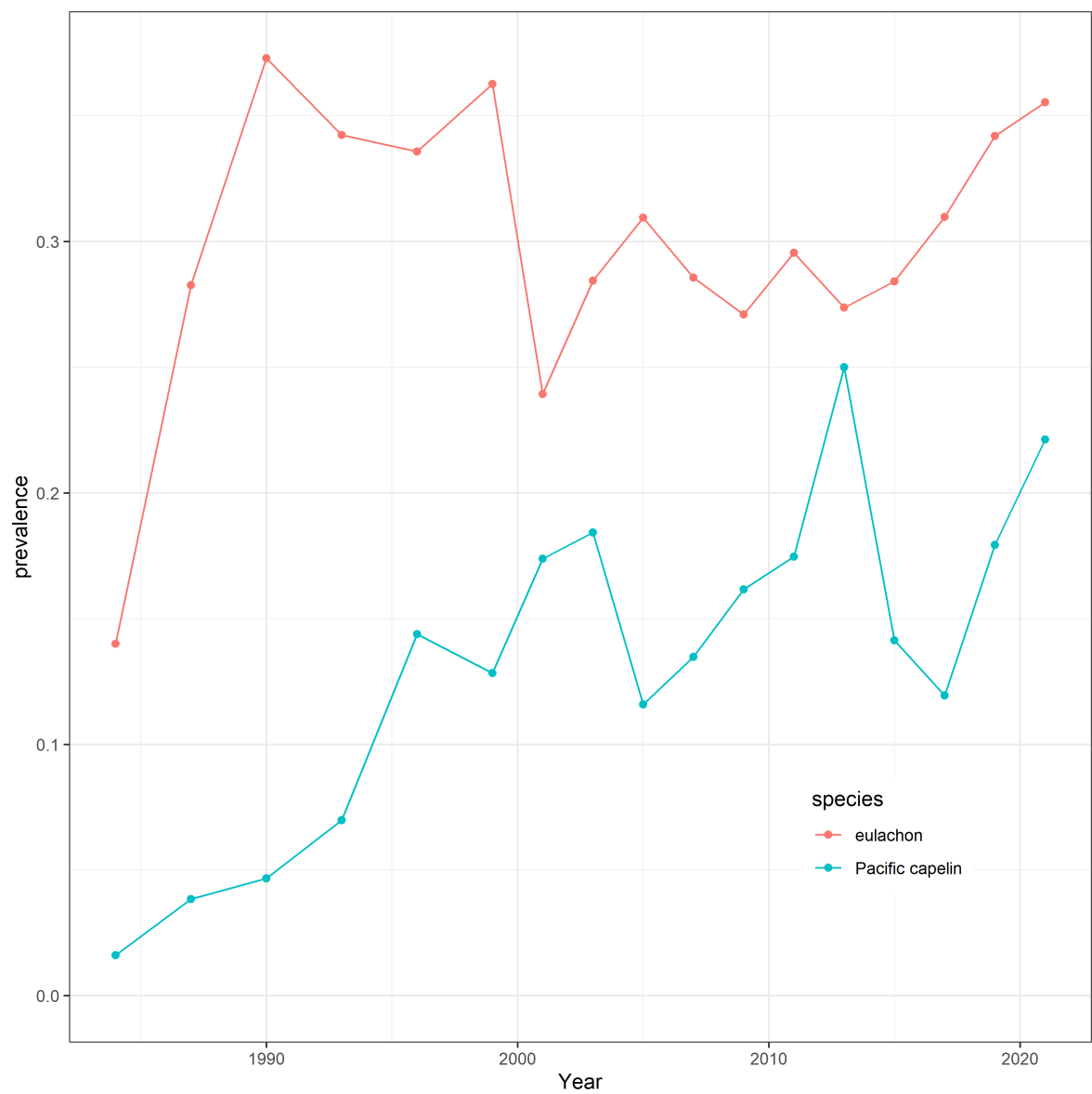


Figure 4: Frequency of occurrence of eulachon and Pacific capelin in the Gulf of Alaska bottom trawl survey.

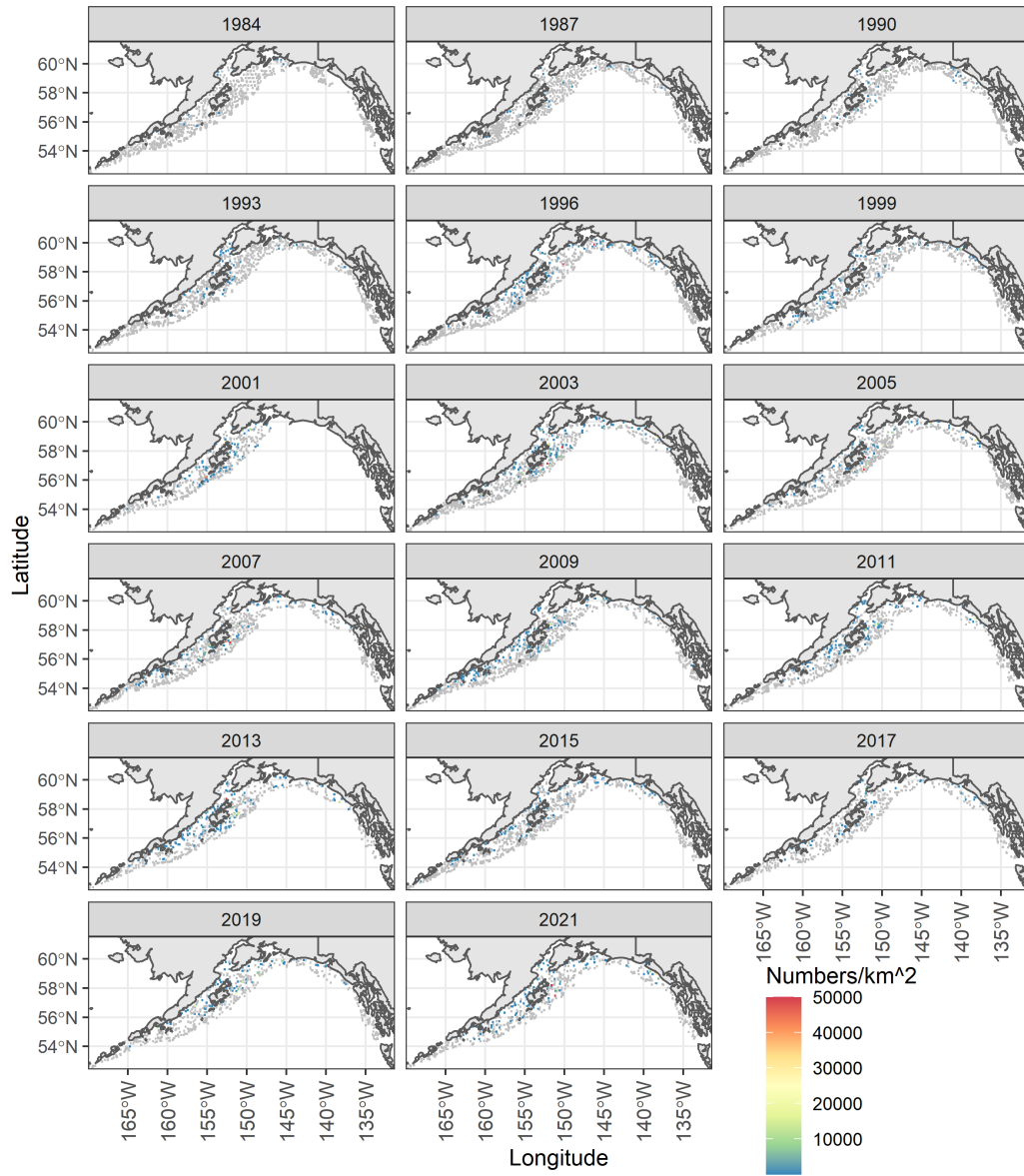


Figure 5: Map of distribution of prevalence and density from the all GOA surveys for Pacific capelin. Grey squares indicate surveyed stations at which no capelin were observed. (zoom for detail)

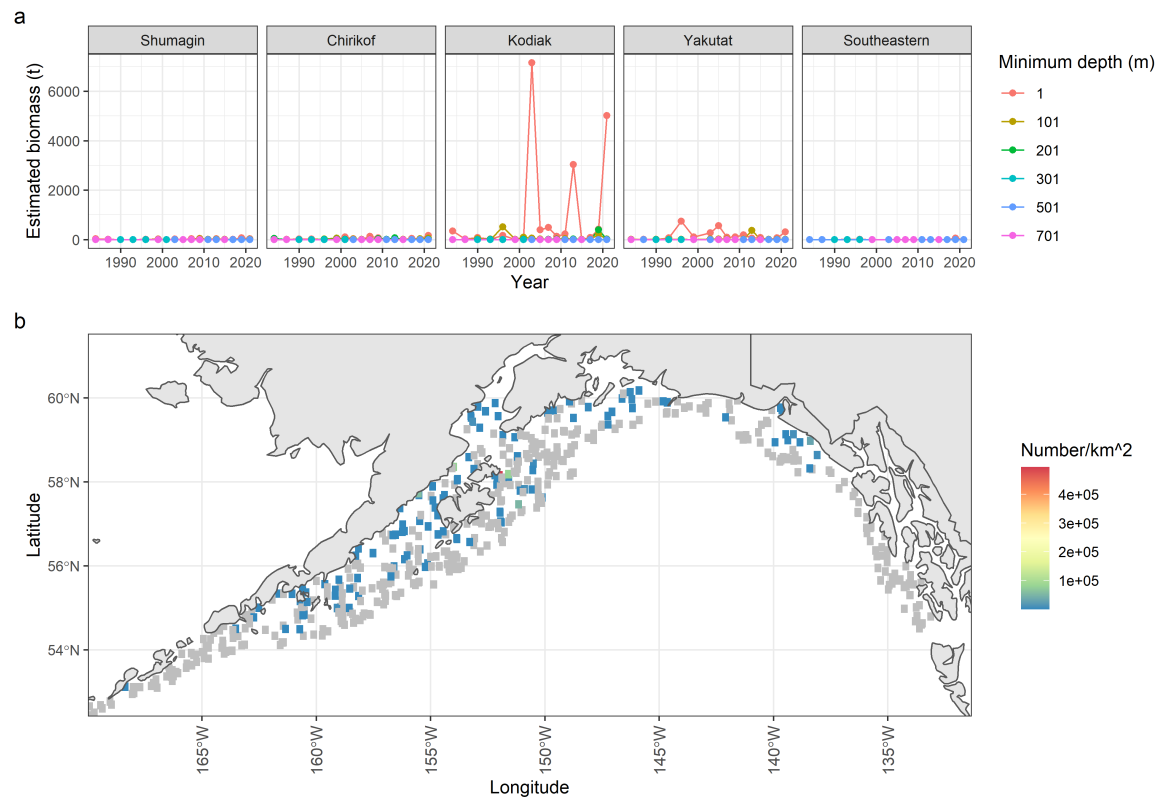


Figure 6: Estimated biomass of Pacific capelin by INFPC area and depth over time in the Gulf of Alaska (top) and map of distribution of prevalence and density from the most recent GOA survey (bottom). Grey squares indicate surveyed stations at which no capelin were observed.

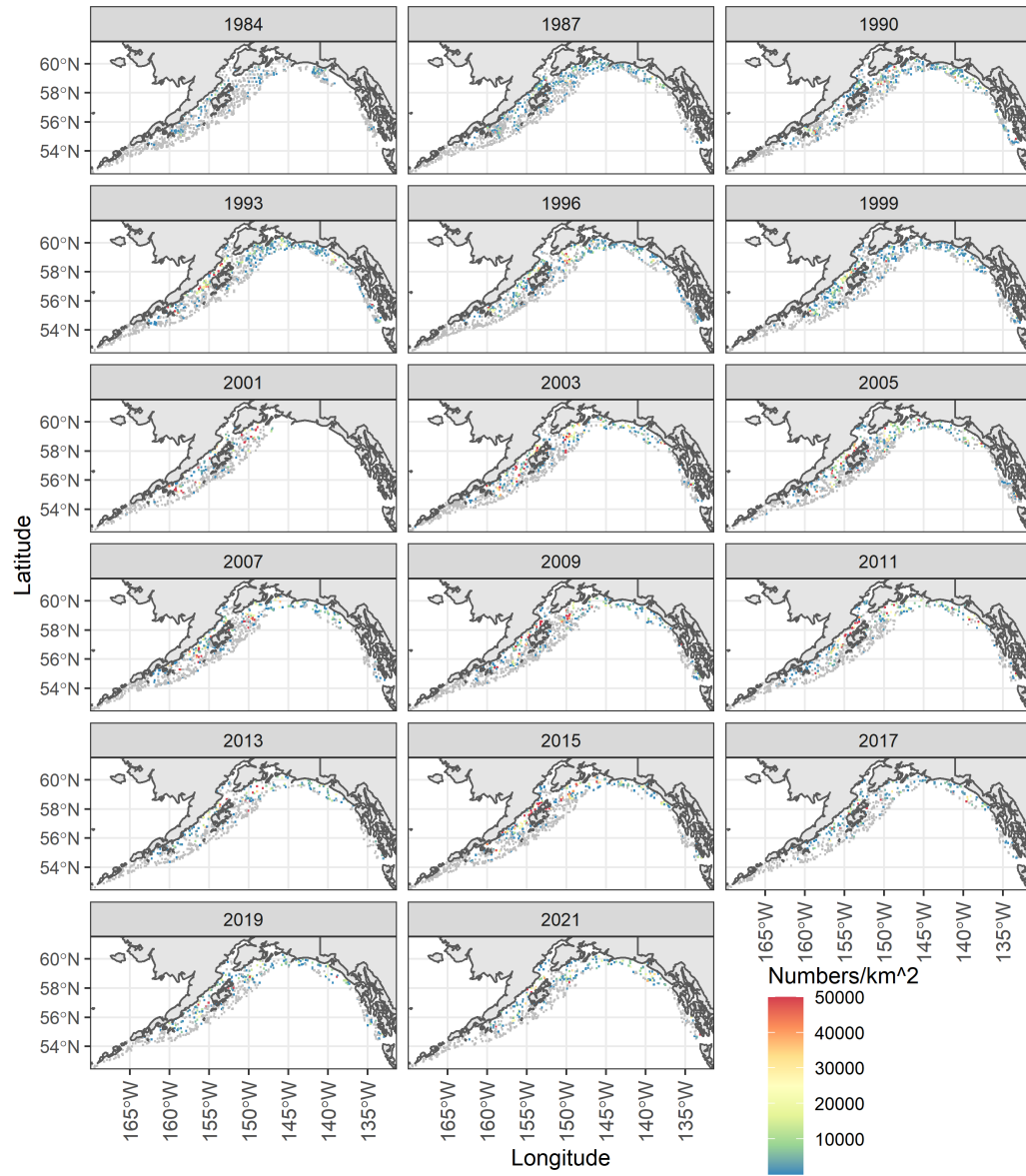


Figure 7: Map of distribution of prevalence and density from the all GOA surveys for eulachon. Grey squares indicate surveyed stations at which no eulachon were observed.

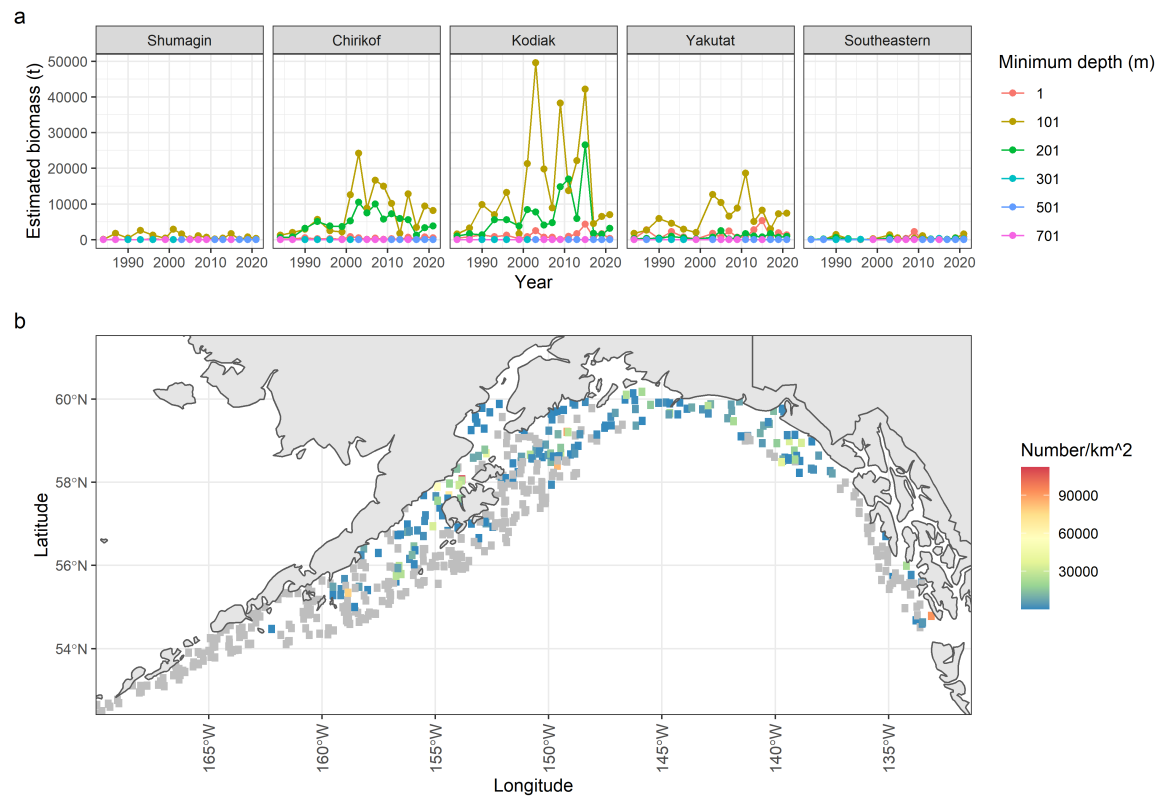


Figure 8: Estimated biomass of eulachon by INFPC area and depth over time in the Gulf of Alaska (top) and map of distribution of prevalence and density from the most recent GOA survey (bottom). Grey squares indicate surveyed stations at which no eulachon were observed.

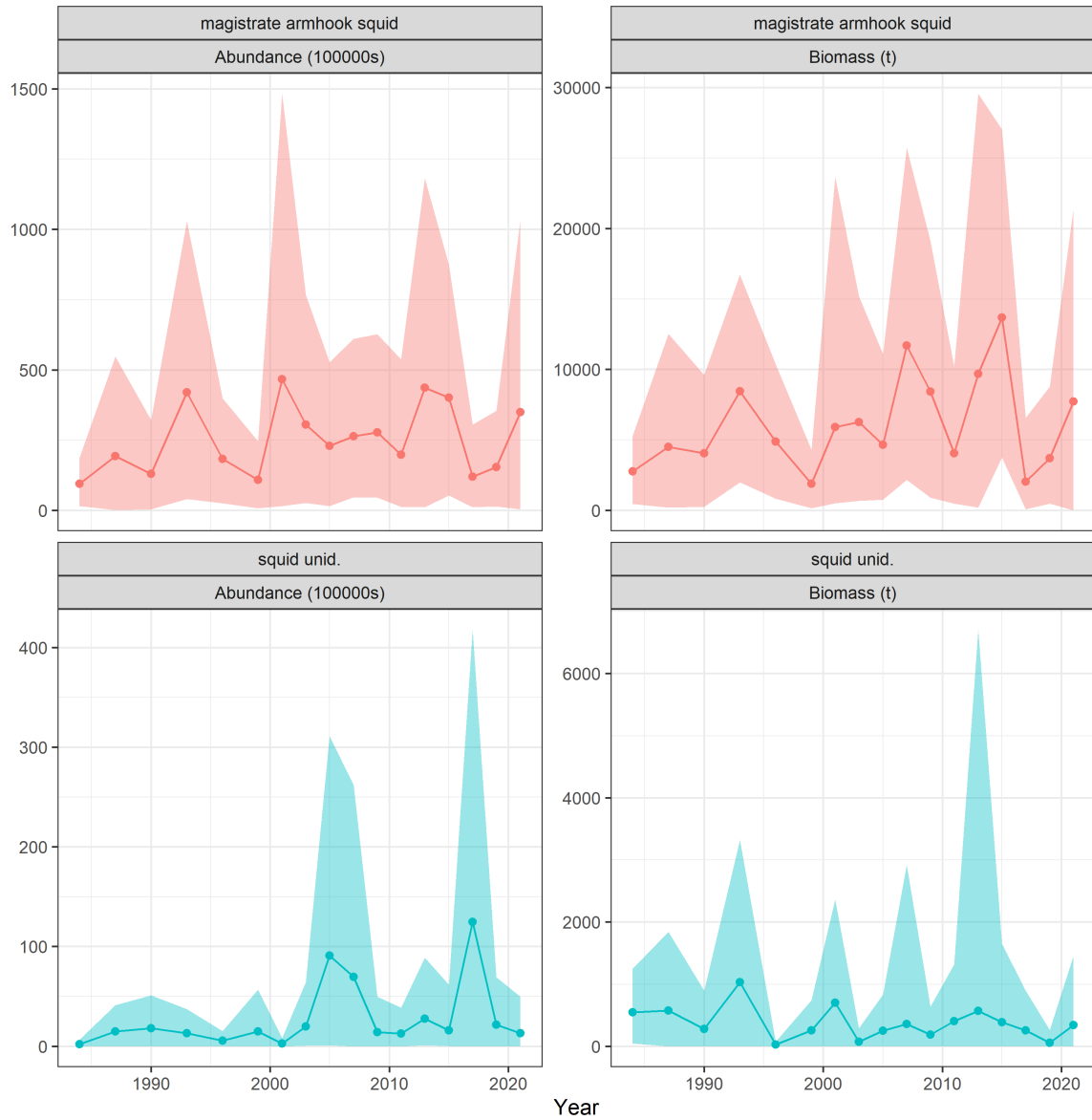


Figure 9: Estimated biomass and abundance of magistrate armhook squid and unidentified squid in the Gulf of Alaska with 95% confidence intervals.

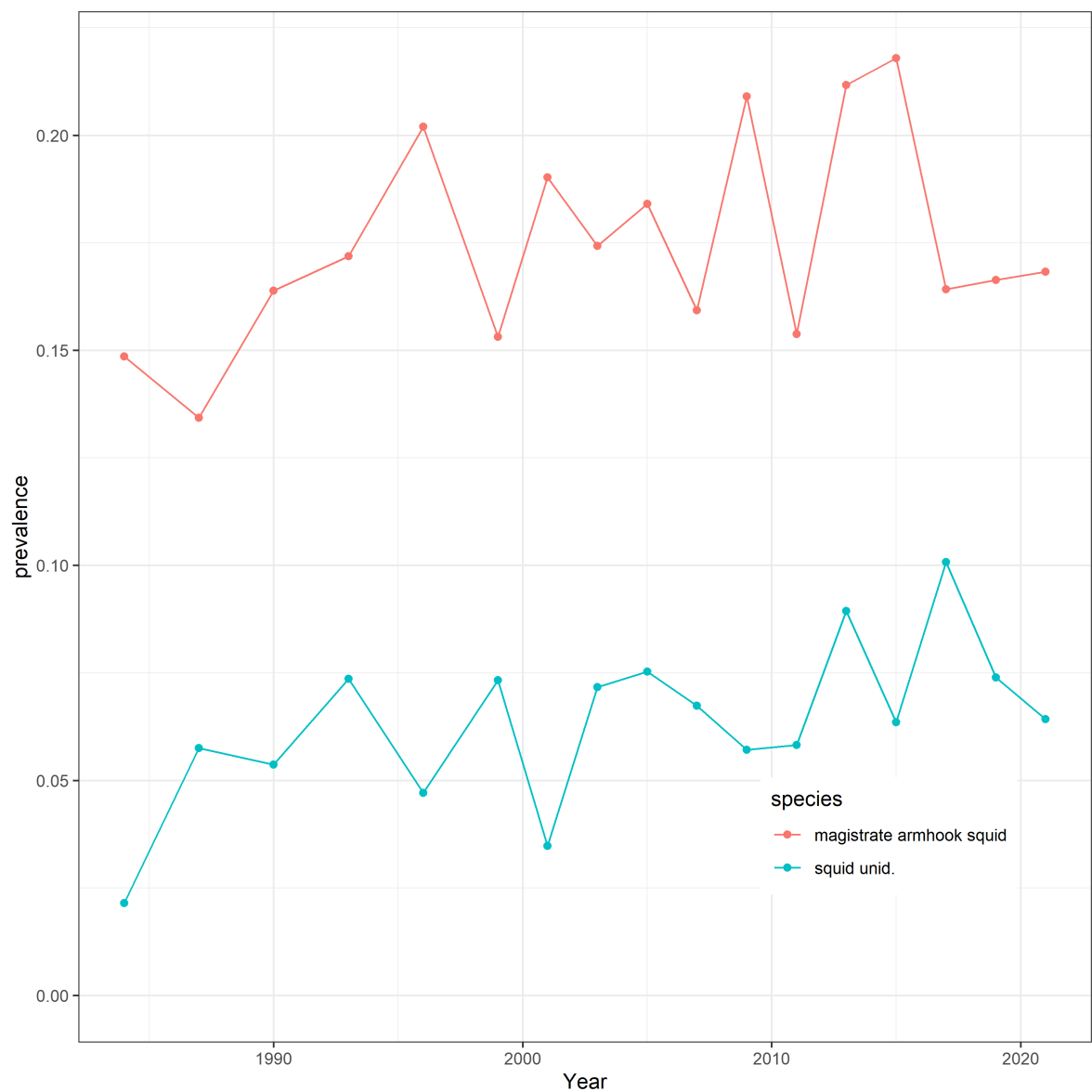


Figure 10: Frequency of occurrence of magistrate armhook squid and unidentified squid in the Gulf of Alaska bottom trawl survey.

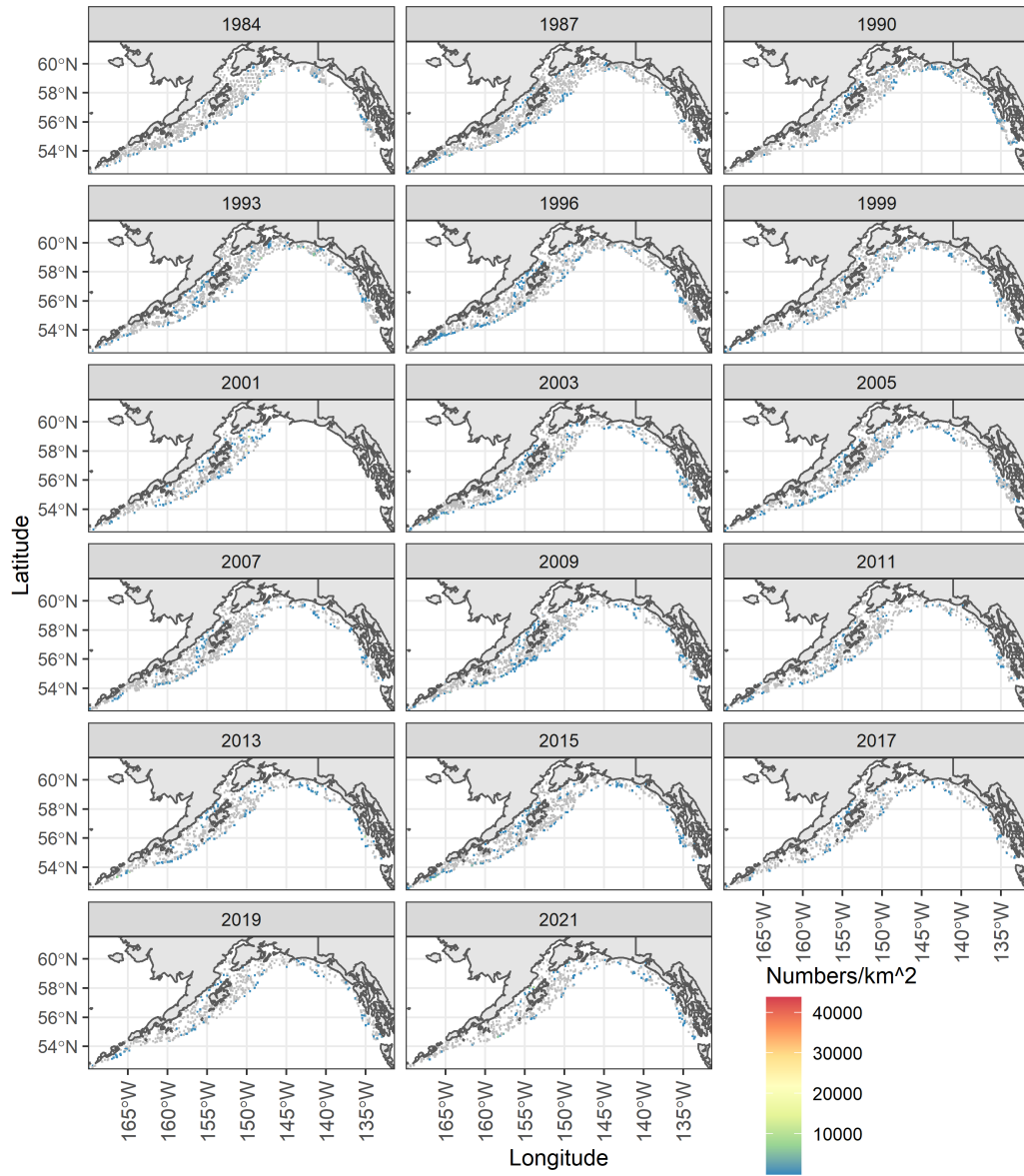


Figure 11: Map of distribution of prevalence and density from the all GOA surveys for magistrate armhook squid. Grey squares indicate surveyed stations at which no squid were observed.

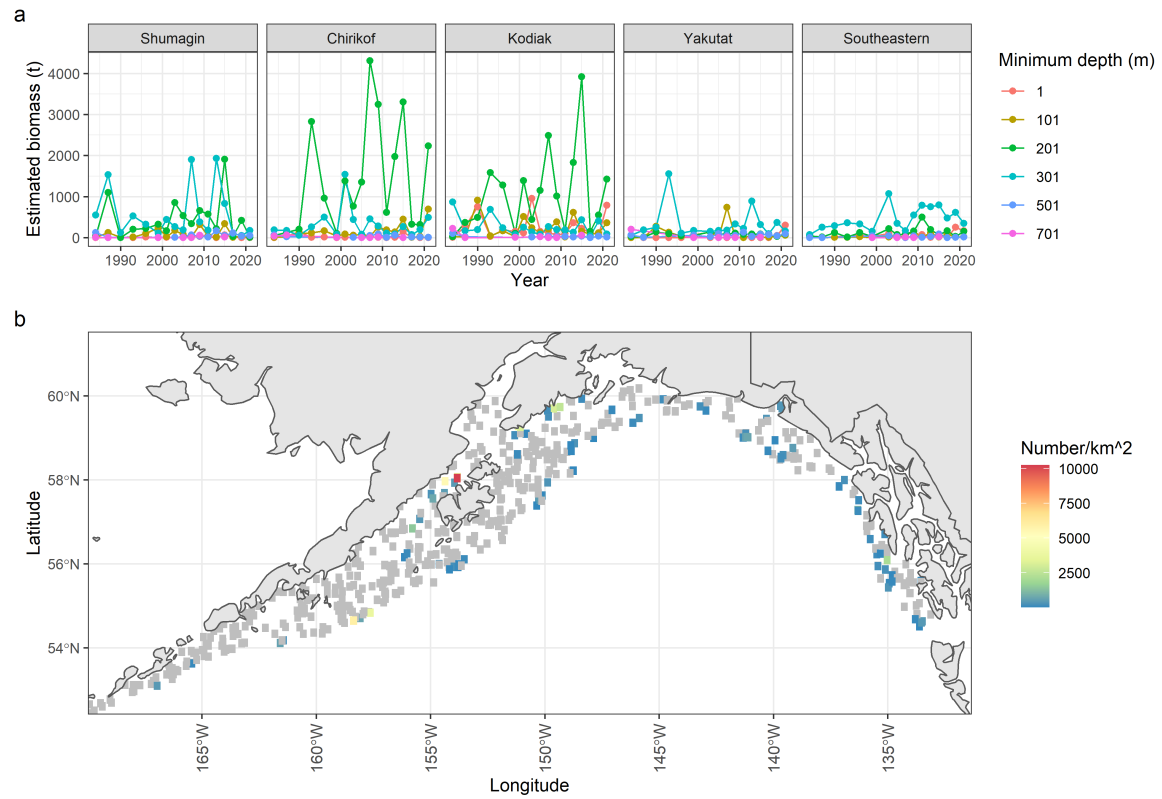


Figure 12: Estimated biomass of magistrate armhook squid by INFPC area and depth over time in the Gulf of Alaska (top) and map of distribution of prevalence and density from the most recent GOA survey (bottom). Grey squares indicate surveyed stations at which no squid were observed.

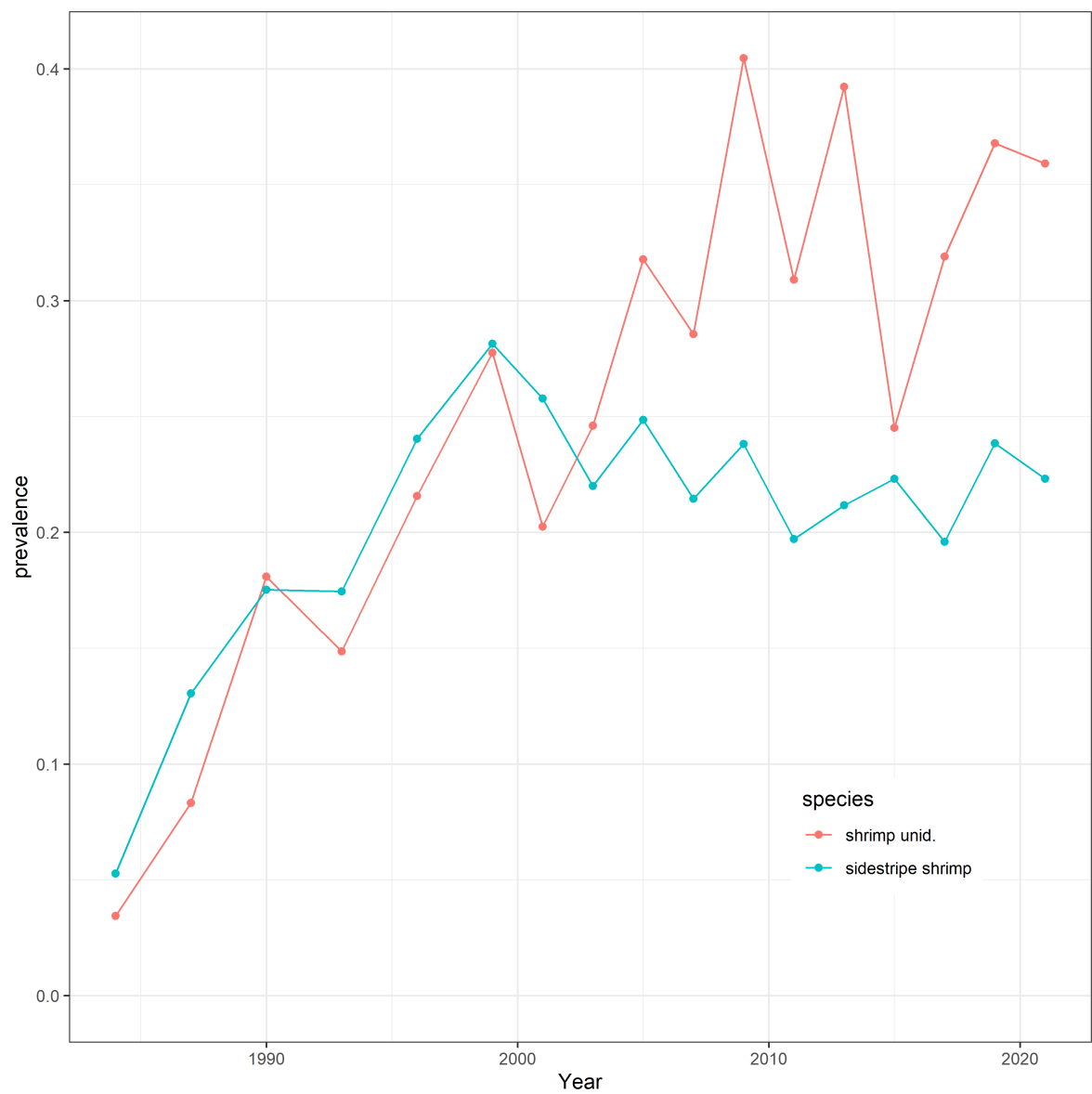


Figure 13: Frequency of occurrence of sidestripe shrimp and unidentified shrimp in the Gulf of Alaska bottom trawl survey.

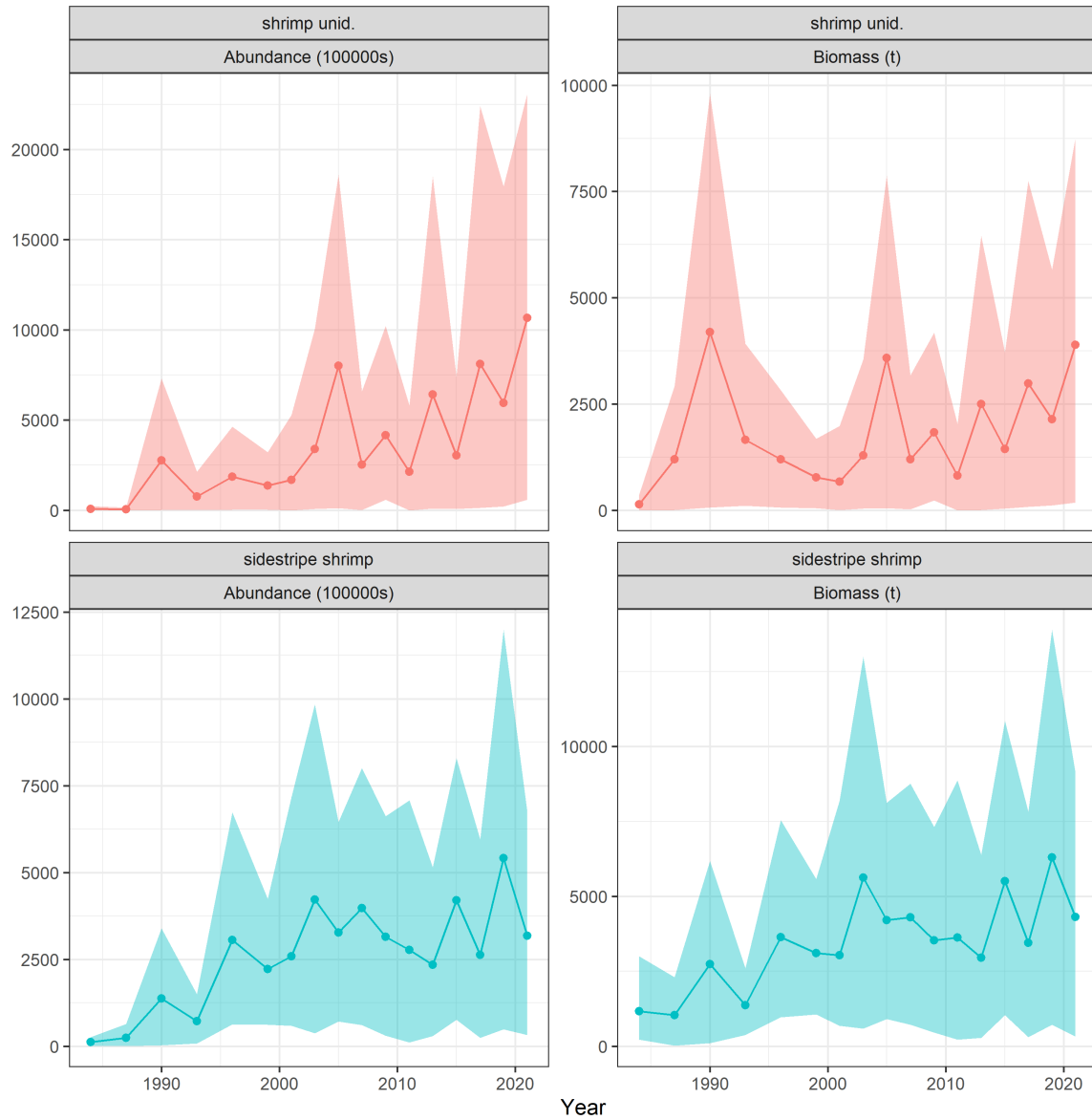


Figure 14: Estimated biomass and abundance of sidestripe shrimp and unidentified shrimp in the Gulf of Alaska with 95% confidence intervals.

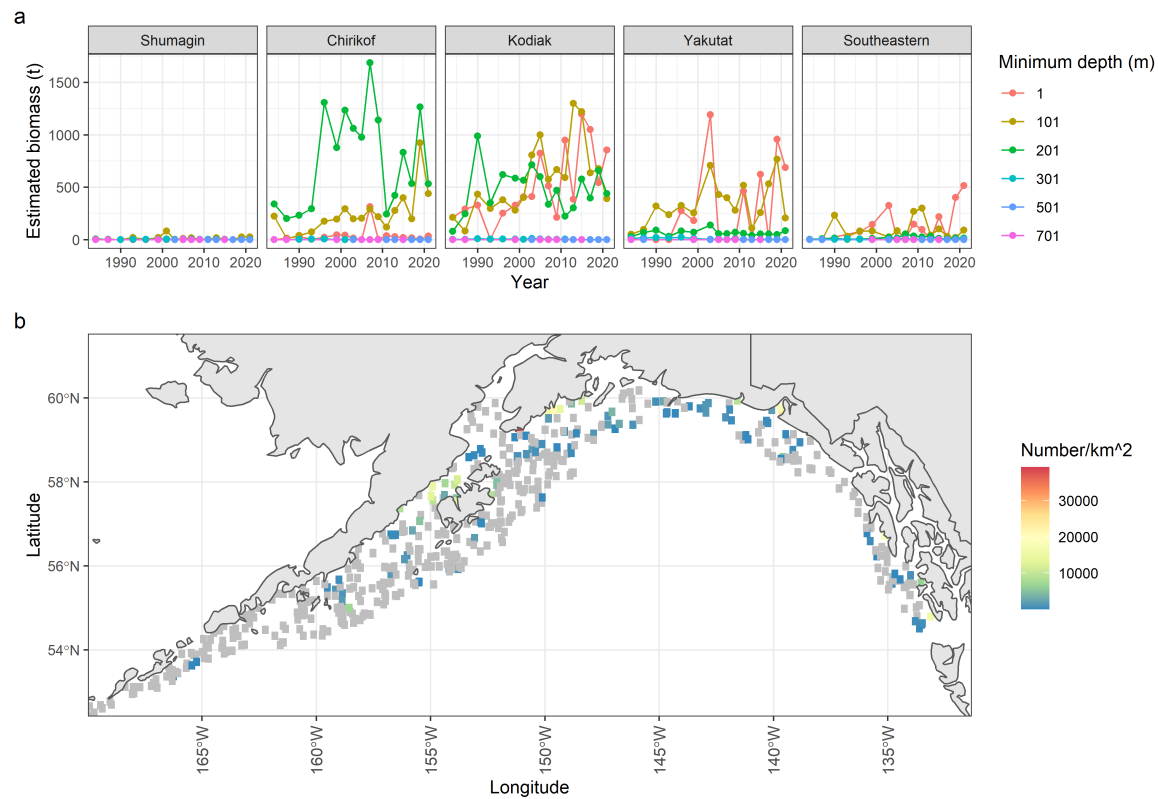


Figure 15: Estimated biomass of sidestrip shrimp by INFPC area and depth over time in the Gulf of Alaska (top) and map of distribution of prevalence and density from the most recent GOA survey (bottom). Grey squares indicate surveyed stations at which no shrimp were observed.

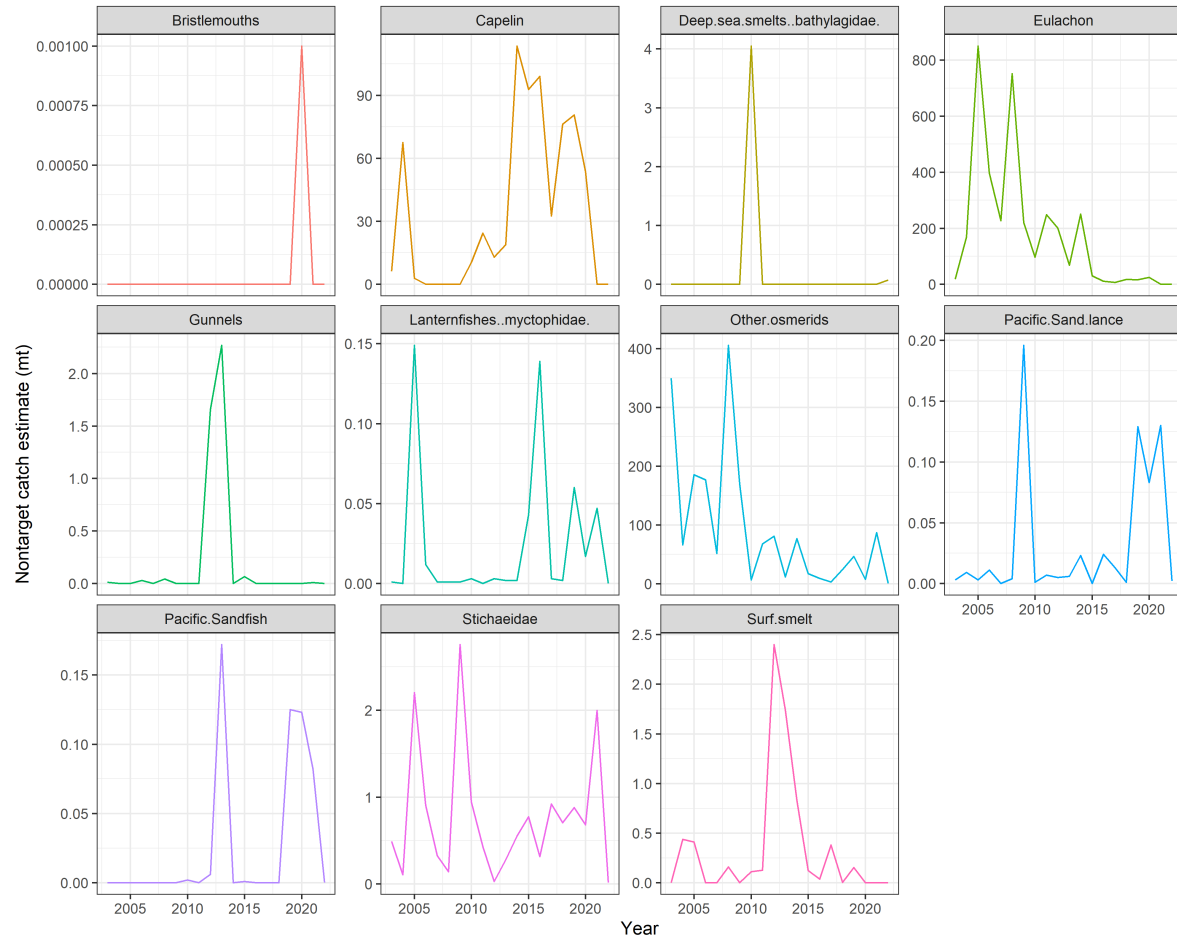


Figure 16: Incidental catches of fishes in the GOA FMP forage group (2003-2021).

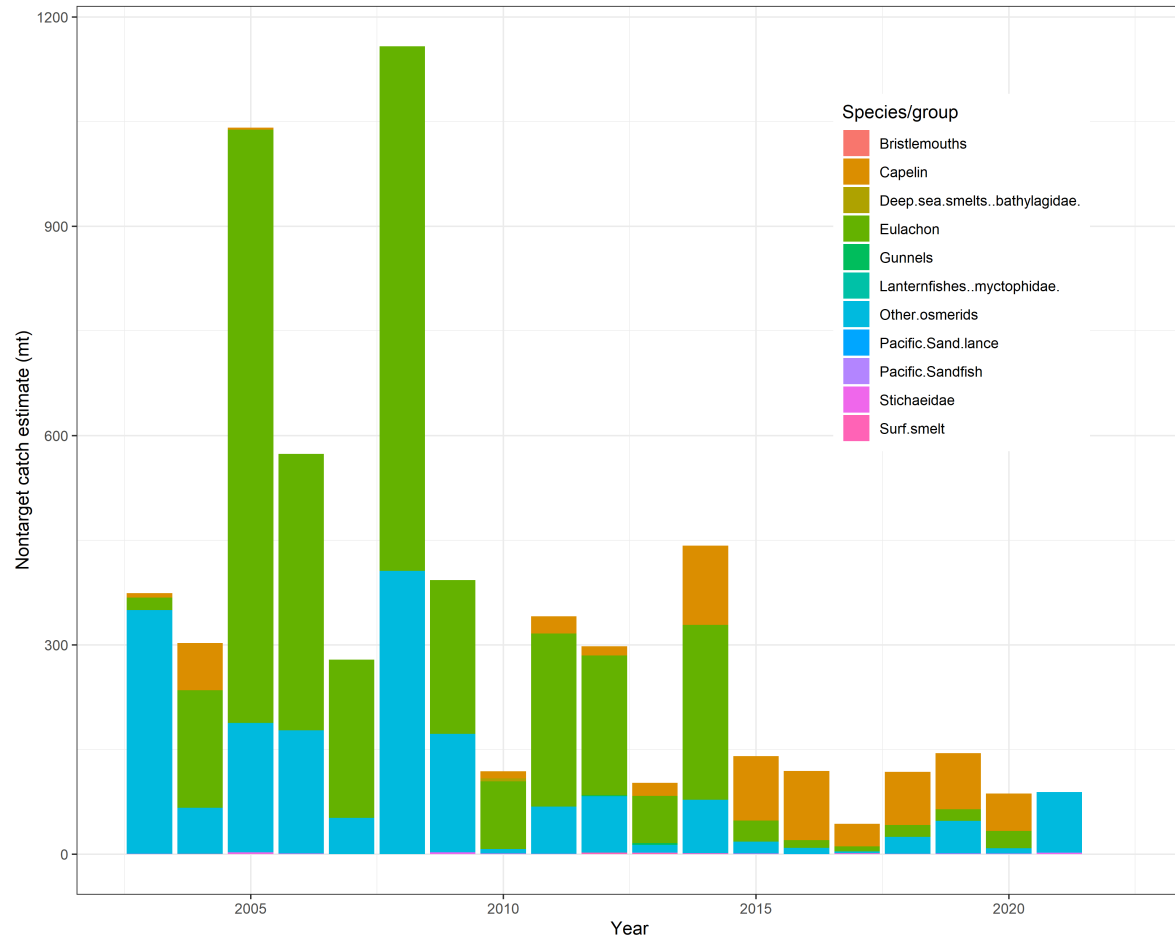


Figure 17: Incidental catches of fishes in the GOA FMP forage group (2003-2021).

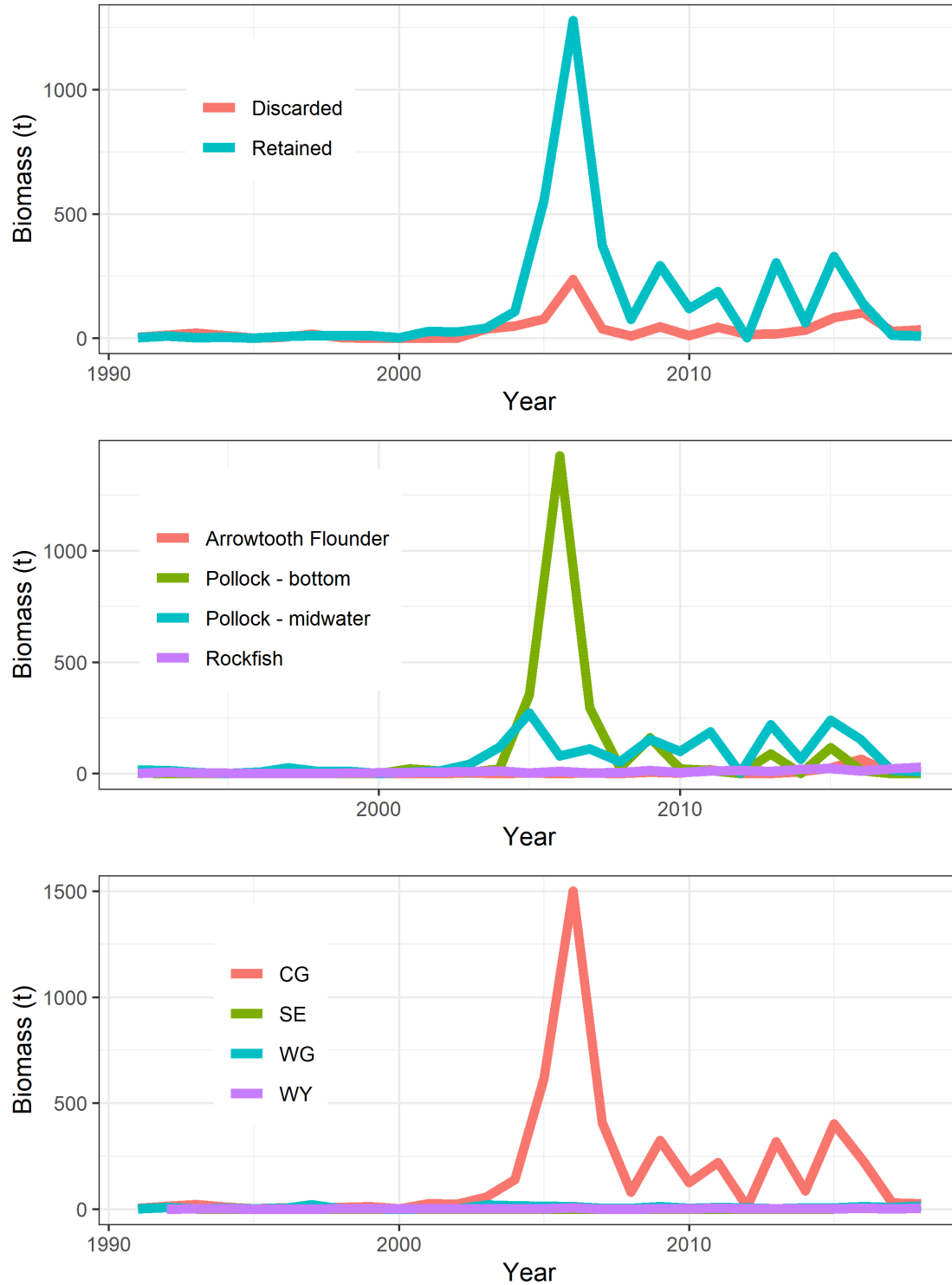


Figure 18: Catches of squid in the GOA that were discarded vs. retained (top). Biomass of squid caught by target fishery (middle). Location of squid caught in the GOA (bottom).

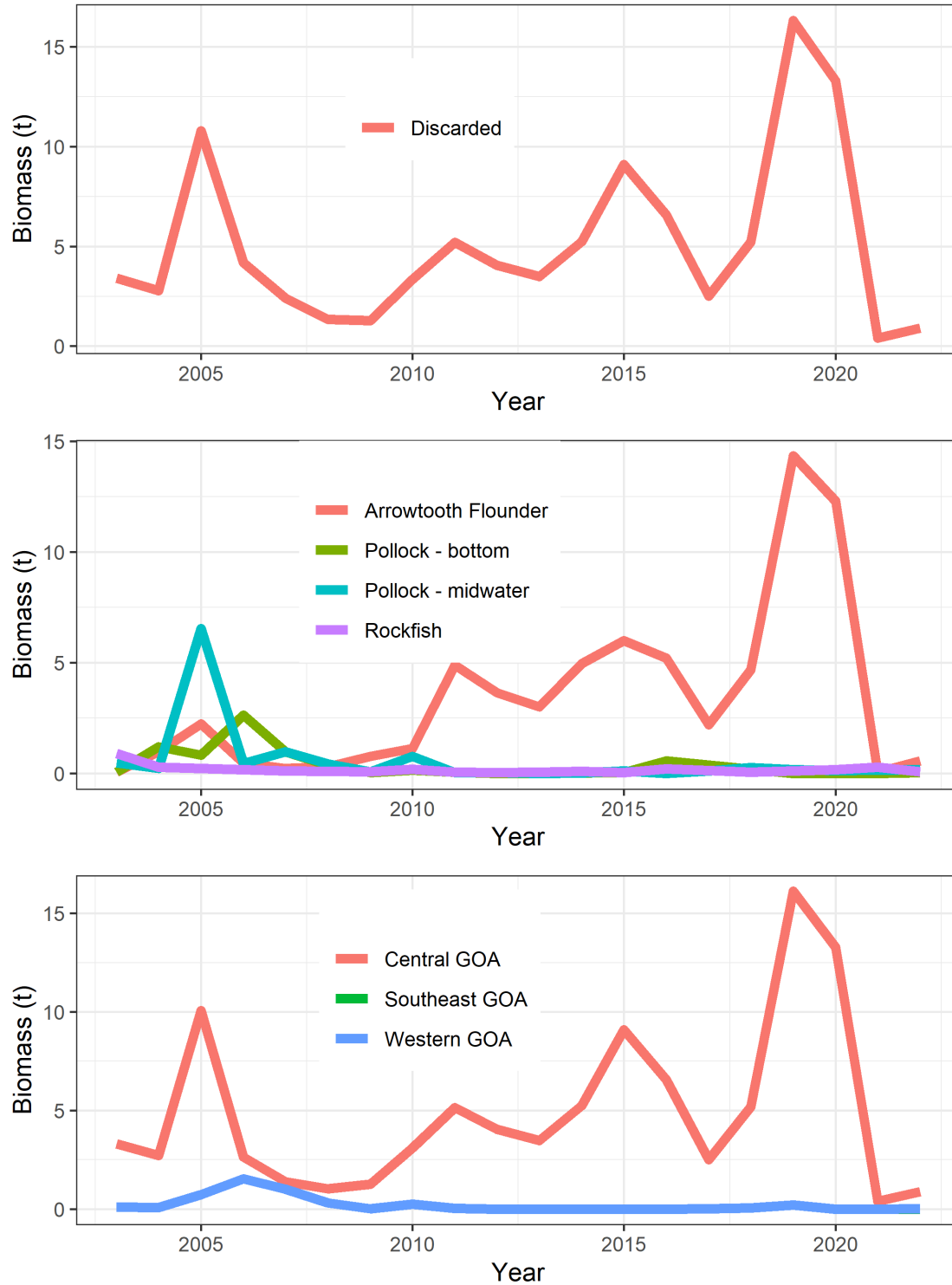


Figure 19: Catches of shrimp in the GOA that were discarded vs. retained (top). Biomass of shrimp caught by target fishery (middle). Location of shrimp caught in the GOA (bottom).

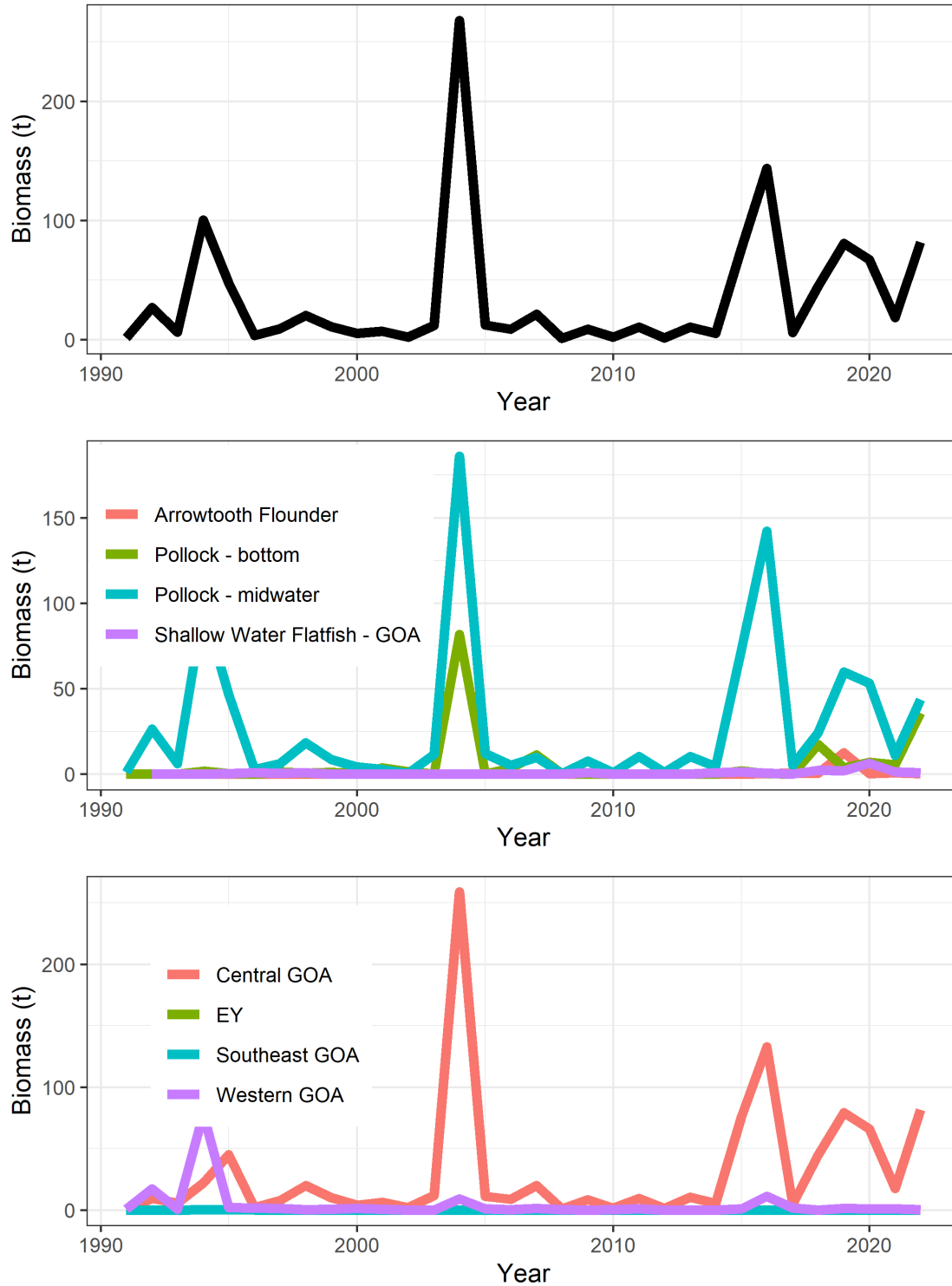


Figure 20: Catches of herring in the GOA (top). Prohibited species catch of herring caught by target fishery (middle). Location of herring caught in the GOA (bottom).