# 2019

# Northern Bering Sea Groundfish and Crab Trawl Survey Highlights

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NOAA FISHERIES

Alaska Fisheries Science Center

Resource Assessment and Conservation Engineering

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# Harmful Algal Bloom Toxins in Alaska Seabirds

**USGS Alaska Region**
**Alaska Science Center**
**USGS National Wildlife Health Center and**
**USFWS Alaska Region**
**Migratory Bird Management**

**September 2018**

Photos: Common Murres, Northern Fulmar, Common Murres; S. Schoen, USGS.

## Seabird die-offs

Unusually large numbers of dead seabirds have been found on shorelines and lakes throughout Alaska during 2015-2018. More than 45,000 dead Common Murres (*Uria aalge*) were counted in the Gulf of Alaska in 2015-2016, and many dead birds have been reported from the Bering and Chukchi seas in 2017-2018. Seabird die-offs occur irregularly, but recent die-offs were unusual due to the large number and variety of species affected, the long die-off duration, and the large spatial extent. Coastal residents and scientists have been monitoring the size and scope of these die-offs, as well as investigating potential causes.

## Why did the birds die?

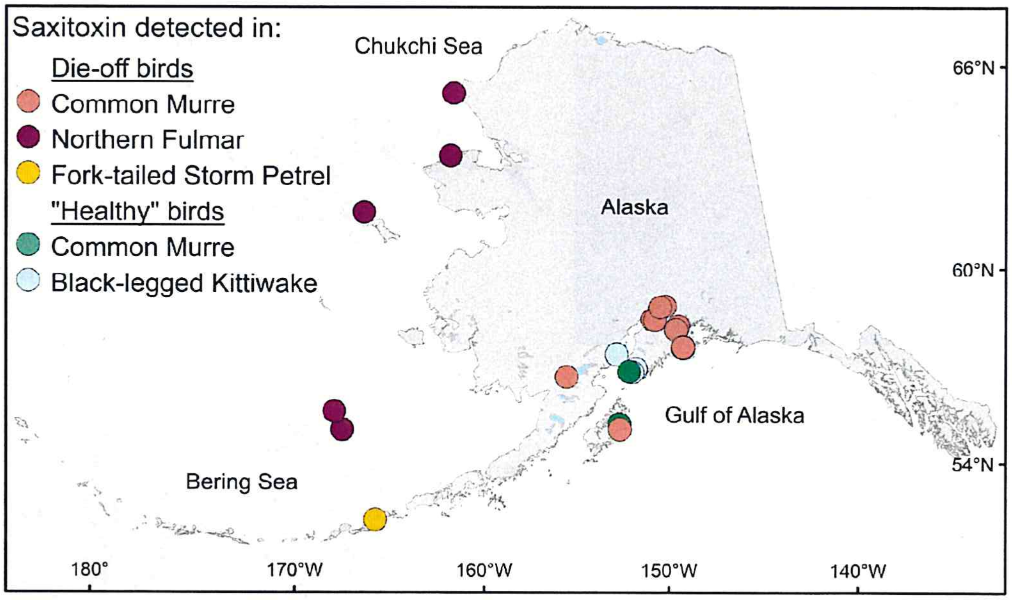


**Figure 1.** The distribution of sampled seabirds with detectable levels of saxitoxin in Alaska from 2015-2017. Detectable levels of saxitoxin (>1-2 µg/100g) were found in both die-off (31 of 69) and "healthy" (22 of 63) birds.

Necropsy information from more than 200 birds examined by the U.S. Geological Survey (USGS) National Wildlife Health Center (NWHC) and the USGS Alaska Science Center (ASC) found that birds starved to death. This finding was presumably related to changes in prey availability associated with persistently warm ocean temperatures. Preliminary tests by the National Ocean and Atmospheric Association (NOAA) also detected saxitoxin, a harmful algal bloom (HAB) neurotoxin, in some birds, prompting further study. To evaluate whether HAB toxins may have contributed to seabird deaths, the ASC, in collaboration with NOAA and other partners, tested birds from multiple locations during 2015-2017 for saxitoxin and domoic acid. Samples included tissues from die-off carcasses harvested during necropsies, as well as tissues from apparently healthy (hereafter "healthy") birds captured live via noose pole or collected at colonies (Figure 1).

## What are harmful algal blooms?

Harmful algal blooms are large growths of algae that produce potentially harmful toxins. These toxins are produced by certain phytoplankton species, and can cause severe illness or death in animals if ingested in high enough concentrations. The primary HAB neurotoxins in Alaska are saxitoxin and domoic acid. Little is known about what levels of these toxins could cause illness or death in seabirds.

**U.S. Department of the Interior**
**U.S. Geological Survey**
**U.S. Fish and Wildlife Service**

## HAB toxins in Alaska seabirds

Saxitoxin was common in both die-off (45%) and "healthy" (35%) birds across different seabird species, locations, seasons, and years. Concentrations also varied by tissue type. Trace levels of domoic acid were found in only 1% of the 86 seabirds tested.

The occurrence of saxitoxin differed by species. We found detectable levels of saxitoxin in about one-third of: "healthy" Black-legged Kittiwakes (*Rissa tridactyla*), "healthy" murres, and die-off murres. In contrast, saxitoxin was detected in almost 90% of die-off Northern Fulmars (*Fulmarus glacialis*). Quantifiable levels of saxitoxin were highest in fulmars, followed by die-off murres (Figure 2). All saxitoxin levels were below advisory limits for human consumption of shellfish (80 µg/100 g); however, these limits do not apply to seabirds, and thus we cannot advise on human harvest or consumption at this time. The NWHC and ASC are currently investigating the impacts of low-level exposure of HAB toxins on birds.

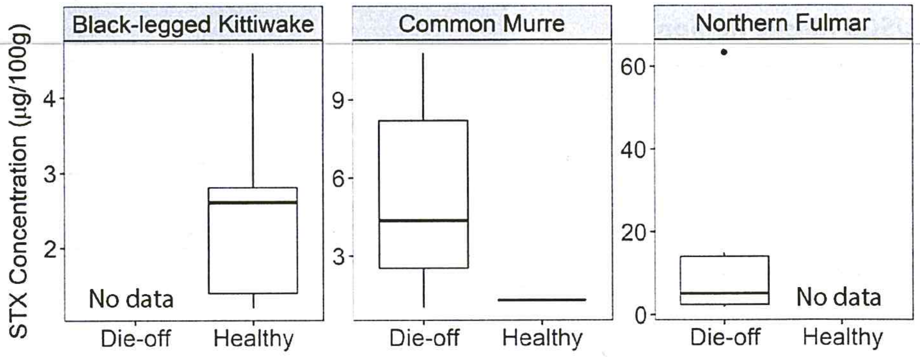
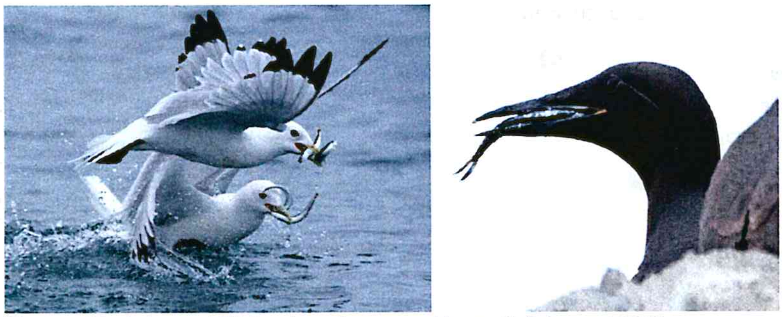


**Figure 2.** Die-off and apparently healthy birds from 2015–2017 with quantifiable levels of saxitoxin (STX). In each boxplot the horizontal line is the median, the box represents the first and third quartiles, the whiskers extend to the highest and lowest values within 1.5x the inter-quartile range, and points denote outliers.



Photos: Black-legged Kittiwakes, Common Murre; S. Schoen, USGS.

## HAB toxins in forage fish & invertebrates

The ASC also tested forage fish and invertebrates, the typical prey of seabirds, for HAB toxins. We found that they also contained detectable levels of saxitoxin (31% of 85 samples) and domoic acid (12% of 34 samples). Studies to better understand how HAB toxins move through the marine ecosystem are currently underway.

## Conclusions

- Unusual seabird die-offs have occurred throughout Alaska since 2015.
- The direct cause of death was attributed to starvation.
- Saxitoxin was found in both die-off and apparently healthy seabirds.
- There is no evidence that seabirds died from acute toxicity, but little is known about the effects of low-level saxitoxin exposure on seabirds.

Photos: Common Murres; S. Schoen, USGS.

## What should you do if you find dead or dying seabirds or have questions?

- Report observations of sick/dead birds to the U.S. Fish & Wildlife Service (1-866-527-3358; AK_MBM@fws.gov).
- Participate in monitoring efforts on your local beaches with the Coastal Observation and Seabird Survey Team (COASST; www.coasst.org).
- Contact Caroline Van Hemert (907-786-7167; cvanhemert@usgs.gov) or Sarah Schoen (907-786-7467; sschoen@usgs.gov) with questions.

**Acknowledgments**

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# Results of seawater monitoring for cesium-137 and cesium-134 near Saint Lawrence Island

Sea Grant
Alaska

## Background

Since the damage of the Fukushima nuclear power plant in 2011, many Alaskans have expressed concerns about the presence of radiation in seawater and marine wildlife. Measurable amounts of radioactive substances have been present in oceans and seas, including the Bering Sea, for long periods of time. These come from a combination of naturally occurring and man-made sources (e.g., nuclear weapons tests, and accidental releases from nuclear reactors). Two types of radioactive substances cesium-137 and cesium-134 are byproducts of nuclear fission and were among the radioactive isotopes released when the Fukushima nuclear reactor was damaged. The Woods Hole Oceanographic Institution has been tracking the spread of cesium-134 and -137 in ocean currents that flow from Japan to the western US and Canadian coastlines. Historically, levels of cesium-137 in the Pacific Ocean are very low, generally **below 2.0 becquerels per cubic meter**[1] (Bq/m$^3$). For comparison, the US Environmental Protection Agency (EPA) considers drinking water levels of cesium-137 of up to 7,400 Bq/m$^3$ to be safe for human consumption (Figure 1) which is approximately 3,700 times higher than any background levels measured.

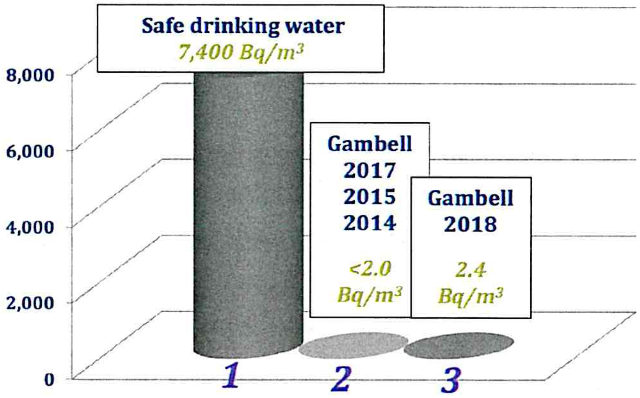

Figure 1. (1) Cesium-137 level allowable in safe drinking water, (2) cesium-137 levels in seawater sampled during 2014, 2015, 2017, and (3) cesium-137 level in the 2018 seawater sample. All listed units are Bq/m$^3$.

## Expectation and Results

Based on their knowledge of ocean currents, residents of Saint Lawrence Island anticipated an increase in the levels of cesium-137 in seawater after the Fukushima Daiichi accident. Seawater samples collected during 2014, 2015, 2017, and 2018 were collected and analyzed for cesium-137 and cesium-134 by the Woods Hole Oceanographic Institution Center for Marine and Environmental Radiation. No seawater sample was collected during 2016. Results of 2014, 2015, and 2017 samples showed that cesium-137 was still being detected at background (pre-accident) levels, ≤ 2.0 Bq/m$^3$ (Table 1).

Table 1. Collection date and levels (Bq/m$^3$) of cesium-137 and 134 measured in seawater near Gambell during 2014–2018.

| Year | Date | Cesium-137 (Bq/m$^3$) | Cesium-134 (Bq/m$^3$) |
|---|---|---|---|
| **2018** | August 3 | **2.4*** | not detected |
| **2017** | April 2 | **1.8** | not detected |
| **2016** | N/A | no sample available | no sample available |
| **2015** | August 5 | **1.2** | not detected |
| **2014** | April 25 | **1.3** | not detected |

*Indicates an increase in cesium-137 levels in seawater (above pre-accident levels) that is attributed to Fukushima-related contamination. Cesium-134 was not detected in any seawater sample. All sampling results are publically accessible via http://ourradioactiveocean.org/results.html.

The level of cesium-137 measured in the 2018 seawater sample was found to be 2.4 Bq/m$^3$, which is slightly higher than pre-accident levels. Scientists at Woods Hole attribute this slight increase to Fukushima-related contamination, which has been detected at various locations along the west coast of the US and Canada. Despite the 0.4 Bq/m$^3$ increase of cesium-137 in seawater samples from 2018, it is important to note that the levels are still thousands of times lower than the level considered of concern in drinking water by the EPA. The other isotope that was screened for (cesium-134) was not detected in any seawater samples collected near Gambell.

## Conclusions

- Seawater in the Bering Strait region has been monitored for many years by residents of Saint Lawrence Island. Very low levels of cesium-137 have consistently been found.
- Saint Lawrence Island residents anticipated an increase in cesium-137 after the Fukushima disaster, based on their understanding of ocean currents.
- A slight (0.4 Bq/m$^3$) increase in cesium-137 was confirmed in a seawater sample collected near Gambell in 2018, which has been attributed to the arrival of the northern edge of the Fukushima plume.
- Cesium-137 in seawater in the Bering Strait region continues to be **extremely low** and is **not considered a health concern**.
- Cesium-134 was not detected in any seawater samples near Saint Lawrence Island.
- Residents of Saint Lawrence Island desire expansion of cesium-137 monitoring efforts in the northern Bering Sea/Bering Strait region.

## For more information

You can also learn more about radiation and health at these websites.

DHSS: http://dhss.alaska.gov/dph/Epi/eph/Pages/radiation/default.aspx
Alaska DEC: https://dec.alaska.gov/eh/radiation/
US FDA: https://www.fda.gov/newsevents/publichealthfocus/ucm247403.htm
CDC/ATSDR: https://www.atsdr.cdc.gov/phs/phs.asp?id=575&tid=107
Woods Hole Oceanographic Institute: http://www.whoi.edu/oceanus/feature/heath-risks

## Acknowledgements

Teamwork was essential to document the status of cesium-137 and cesium-134 in the seawater near Saint Lawrence Island, and included Native Village of Gambell, Native Village of Savoonga, Woods Hole Oceanographic Institution, State of Alaska Dept. of Epidemiology, Norton Sound Regional Health Corporation, and Alaska Sea Grant. Funding for seawater analyses was provided by Alaska Native Tribal Health Consortium, Alaska Sea Grant, Norton Sound Economic Development Corporation, and a private donation.

## Literature cited

[1] Kamenik, J., Dulaiova, H., Sebesta, F., Stastna, K., "Fast concentration of dissolved forms of cesium radioisotopes from large seawater samples," *Journal of Radioanalytical and Nuclear Chemistry* 296(2012): 841–846.

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## Introduction

In 2019, the NOAA Fisheries, Alaska Fisheries Science Center conducted two surveys within U.S. territorial waters of the Bering Sea; the southeastern Bering Sea (EBS) shelf bottom trawl survey and the northern Bering Sea (NBS) bottom trawl survey. This was the 38th annual survey of the EBS region and the third year in which the NBS region was surveyed following standardized sampling protocols. A rapid response survey was also conducted in the NBS region in 2018 using a modified spatial extent and sampling procedure and will not be covered in this report. The NBS survey region contains 144 stations in an area bounded by the Bering Strait, Norton Sound, and the U.S.–Russia Maritime Boundary (Figure 1). This region is a fundamental part of the Alaska Fisheries Science Center Loss of Sea Ice (LOSI) Research Plan, the primary purpose of which is to study the impacts of diminished sea ice on the marine ecosystem. The 2019 survey represents the third sampling year for the new standardized time series of the NBS region. While the NBS region has been surveyed sporadically in the past, the inaugural year in which the region was sampled using the same standardized sampling methods as the EBS shelf survey, creating a formative new time series, was 2010.

In the NOAA LOSI research plan, the NBS was identified as a region of critical importance for increased scientific monitoring because this area may undergo rapid change with a changing climate. This survey represents one component of a multi-faceted research plan to create a long-term time series designed to identify and track environmental and ecological change throughout the Bering Sea. Beyond the potential impacts of climate change, the scale and extent of fish and crab movements can also vary from year to year in response to a variety of biological or environmental processes causing changes in distribution and abundance that extend beyond

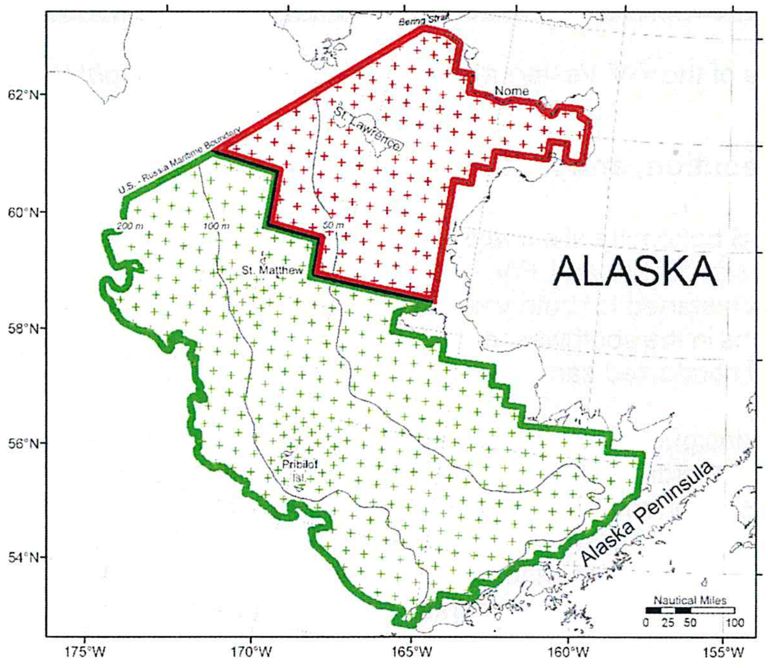


**Figure 1**. Survey stations sampled in 2019 during the EBS and NBS survey. The area enclosed within the green line contains the EBS shelf stations that have been sampled annually since 1982, whereas the area outlined in the red line are the NBS stations that were sampled in 2019. The plus signs indicate each station location.

the traditional survey boundaries (e.g. EBS), creating an additional need for survey data that provides comprehensive coverage of the entire Bering Sea.

In this summary report, we provide some of the results of the 2019 NBS survey and provide some snapshot comparisons to what was observed in 2010 and 2017 when the region was also surveyed using the same methods.

Continuation of the survey effort for a combined EBS and NBS bottom trawl survey will provide more comprehensive snapshots for investigating how different fishes, crabs and other bottom dwellers respond to biological and environmental processes on large space and time scales. The next survey of the NBS region is partially funded for 2020.

**Figure 2**. Photographs of the F/V *Vesteraalen* (left) and F/V *Alaska Knight* (right).

## Survey Design, Execution, and Analysis

The EBS shelf and NBS bottom trawl surveys were conducted aboard the chartered commercial stern-trawlers F/V *Alaska Knight* and F/V *Vesteraalen* (Figure 2). After the completion of the EBS shelf survey, which started for both vessels on 3 June 2019, both vessels transitioned into sampling survey stations in the southwest corner of the NBS survey region. The F/V *Vesteraalen* and F/V *Alaska Knight* conducted sampling in the NBS from 29 July to 20 August.

The NBS survey was designed as a continuation of the systematic 20 × 20 nautical mile (nmi) sampling grid that was coordinated along latitudinal and longitudinal axes and established for the annual EBS shelf survey and has been used since 1982. This resulted in a systematic grid of 144 stations where each sampling station represented a geo-referenced area of 400 square nautical miles (nmi$^2$) distributed throughout the 58,371 nmi$^2$ that defined the NBS survey area. For reference, the EBS shelf survey area contains 376 stations distributed over 143,706 nmi$^2$. The addition of the NBS survey expanded the overall survey coverage in the Bering Sea to 202,077 nmi$^2$. The NBS stations had bottom depths ranging from 12 m to 80 m. All stations were sampled during daylight hours. For the EBS shelf survey, a fixed sampling station located at the center of each grid cell was typically sampled. While this approach was also used for the NBS survey, shallow depths and untrawlable bottom types were encountered in some grid cells requiring the sampling location to be moved elsewhere within the cell.

Scientists from the Alaska Fisheries Science Center, Alaska Department of Fish and Game, International Pacific Halibut Commission, Norton Sound Economic Development Corporation, and volunteers from the University of Washington and the College of Charleston participated in the survey. Lead scientist profiles can be found in Appendix B.

Both vessels were equipped with the standard 83/112 Eastern otter trawl that has been historically used for EBS shelf, Chukchi, and Beaufort Sea surveys (Figure 3). This trawl is significantly smaller and lighter in weight than commercial trawls used for fishing in Alaska. One 30-minute tow, at a vessel speed of 3 knots, was conducted at 144 stations. This year, we permanently added one station that is just north of St. Lawrence Island to the survey, while removing one station in Norton Sound from the survey due to untrawlability. The cumulative area sampled by trawls at the 144 stations was about 1.85 nmi$^2$, only 0.003 % of the total area of the NBS.

Catches of less than approximately 1,150 kg (2,500 lbs.) were sorted and weighed in their entirety, whereas larger catches were subsampled. Fishes, crabs, and other invertebrates were identified and sorted to species to the extent possible. In cases where species identification was unknown, specimens were collected and returned to the lab for dissemination to experts for identification. After sorting, all species caught were counted and weighed. Counts were not obtained for colonial animals because individuals are difficult to define. For the predominant fish species encountered, a subsample was weighed, then sorted by sex, and the fork length of all specimens in the subsample was measured to the nearest centimeter (cm). For the predominant crab species encountered, carapace width (snow crab) or length (king crabs) was measured to the nearest millimeter (mm).

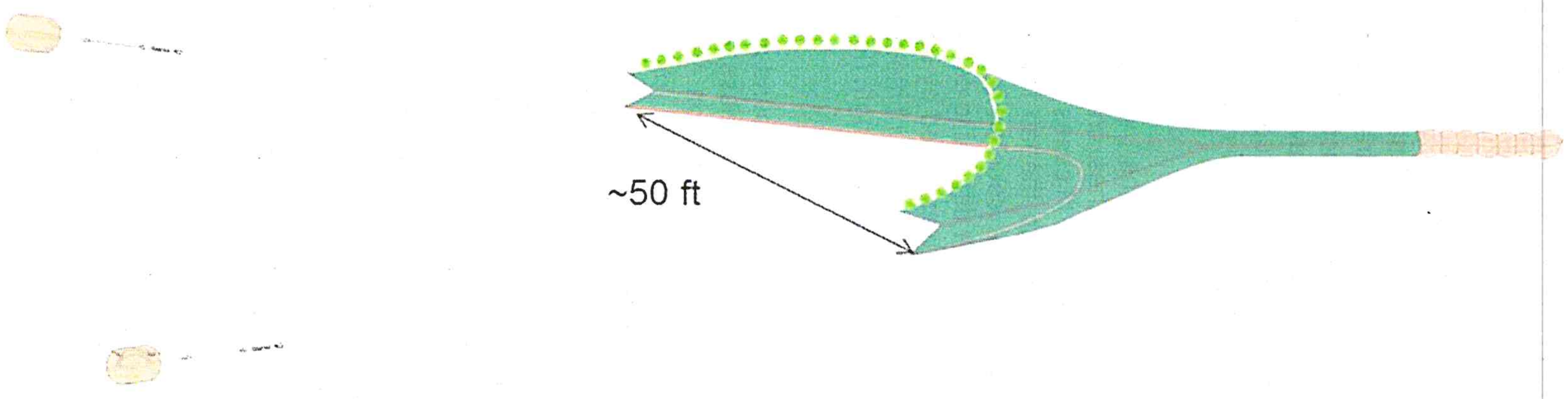
Trawl survey catch data were used to estimate 1) relative abundance; 2) population biomass; 3) population numbers; and 4) population abundance by size class for measured species. Some of the species caught were grouped to higher taxa (common names for an assemblage of species) for analysis because the catch size was very small for individual species or due to questionable identification. Relative abundance was represented using mean catch-per-unit-effort (CPUE) values for each species. CPUE was calculated in kilograms (kg) or number of individuals per hectare (1 ha = 10,000 m$^2$ = 0.003 nmi$^2$) based on the area sampled by the bottom trawl. The area sampled, or area swept, was computed as the distance the trawl was towed multiplied by the mean width of the net during the tow. Net width during the tow was measured by acoustic sensors attached to the net. Mean CPUE values were calculated for the overall NBS survey area. Biomass and population estimates were derived for the NBS survey area by multiplying the mean CPUE by the total survey area.

For size composition estimates, the proportion of fish at each 1-cm length interval or crab at each 1-3m width interval (collected from subsamples at each station) was weighted based upon the mean CPUE (number of fish or crab per hectare), and then expanded to the total population for the NBS survey area.

Additionally, samples of fishes, crabs, and other invertebrates were retained to gather additional information that included their size, weight, sex, age, reproductive state, genetics, health, and stomach content/diet. Environmental data, including water temperature (°Celsius), depth (meters), salinity (parts per thousand), and underwater ambient light (micro-Einsteins per square meter per second) were also recorded at each sampling station. Water column profiles of temperature and salinity at each trawl location were measured using a trawl-mounted Conductivity, Temperature, and Depth profiler (CTD).

# Bering Sea Shelf Research Bottom Trawl

## 83-112 Eastern



Characteristics

- Similar size and type used for Norton Sound red king crab survey
- Designed for being towed on smooth bottom
- Light footrope and bare wires with no ground gear - skims across bottom
- 6' X 9' doors for spreading trawl
- 0.75"" braided nylon with 4" mesh body, 3.5" intermediate and 1.25" codend liner
- 83 ft headrope and 112 ft footrope
- Towed 30 minutes at 3 knots
- Area swept = net width (~50') X distance fished (~1.5 nm)

**Figure 3**. Diagram and specific characteristics of the 83/112 Eastern trawl net.

## 2019 Survey Results with Snapshot Comparisons to 2017

### *Seafloor Bottom Temperature*

Bottom temperature is a major environmental driver that can affect the distribution of fishes, crabs, and other invertebrates on the shelf (Figure 4). Using the long-term time series of bottom temperatures from the EBS shelf survey as reference, the years 2006 – 2013 were colder than average ("cold stanza") and the years 2014 – 2019 were warmer than average ("warm stanza"). During the 38-year time series (1982–2019) of the annual EBS shelf bottom trawl survey, mean summer bottom temperatures were highly variable, ranging from 0.8°C to 4.5°C, with a grand mean for all years of 2.6°C (Figure 4A) .

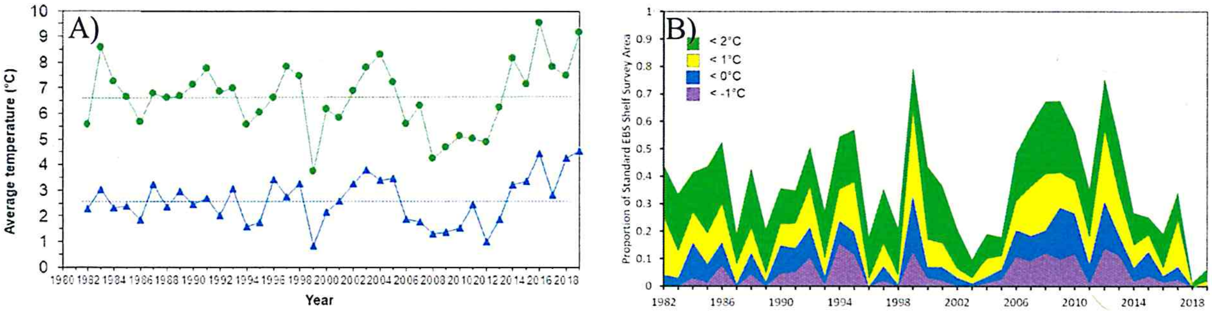


**Figure 4.** Mean summer surface and bottom temperatures for the 38-year times series from the eastern Bering Sea shelf bottom trawl survey (A) and the cumulative proportion of EBS shelf area covered by each one-degree bottom isotherm range (B).

The highly variable survey bottom temperatures are related to the variability of the summer cold pool, defined by the extent of bottom temperatures below 2°C. During the coldest years recorded, the cold pool can extend southward on the middle shelf from the northern edge of the EBS survey box south into Bristol Bay and near the Alaska Peninsula. The size of the cold pool each summer depends on sea ice coverage from the previous winter and the timing of its retreat during the spring and early summer. Over the period of the 38-year time series, the areal coverage of the summer survey cold pool has varied greatly in size, from 6,924 km$^2$ in 2018 to 394,000 km$^2$ in 1999, comprising 1.4% to 80% of EBS shelf area, respectively (Figure 4B). In 2019, the cold pool covered 6.3% of the EBS shelf survey area, which was the second lowest areal coverage in the 38-year EBS shelf time-series.

Water temperatures, recorded both at the surface and at the bottom, were relatively warm in the NBS in 2019. Bottom temperatures measured during the 2019 NBS survey ranged from -0.6° to 15.3°C (Figure 5). In 2010, the overall mean bottom temperature was cooler (2.00°C) than in 2017 and 2019 (4.48°C and 5.73°C, respectively) in the NBS. Sea surface temperatures were also warm in 2019, and temperatures above 10°C were recorded at 78% of the stations in the NBS. Similarly, most of the NBS had a surface temperature above 10°C in 2017, whereas only Norton Sound had sea surface temperatures above 10°C in 2010 (Figure 6). During all NBS survey years, the region north of St. Lawrence Island had the coolest sea surface temperatures. This is likely due to the strong currents in this region reducing stratification of the water mass.

The 2010, 2017, and 2019 NBS surveys provided a much broader view of the spatial pattern of bottom temperatures across the shelf and how they might affect distribution patterns or potential migration pathways available to fishes, crabs, and other invertebrates. The cold pool in 2010 was more extensive compared to 2017 and 2019, and was composed of colder water that impinged on Chirikov Basin, Nunivak Island, and the Alaska Peninsula (Figure 5), potentially restricting east-west and north-south movements of the fauna. The cold pool in 2019 extended to just south of St. Matthew Island. However, bottom temperatures along the entire length of the inner shelf from Bristol Bay to Chirikov Basin were warm (>6°C). The warm temperatures may have potentially allowed for more northward and shoreward fish movement. Historically, regardless of the size of the cold pool or mean summer bottom temperatures, a portion of the cold pool has persisted throughout the year in the transboundary basin extending from the Gulf of Anadyr on the middle shelf to beyond the west side of St. Lawrence Island.

Some fish and invertebrate species appear to actively avoid areas of colder temperatures, therefore the location and extent of the cold pool may affect transboundary fish movement. Recent and progressive reductions in the extent of the cold pool in 2017 and 2019 reduced a significant boundary to movement throughout the region for sub-Arctic fishes and invertebrates. Conversely, Arctic species that utilize the cold pool as a habitat refuge were forced to adjust to sub-optimal conditions or redistribute due to the reduction in available cold pool habitat.

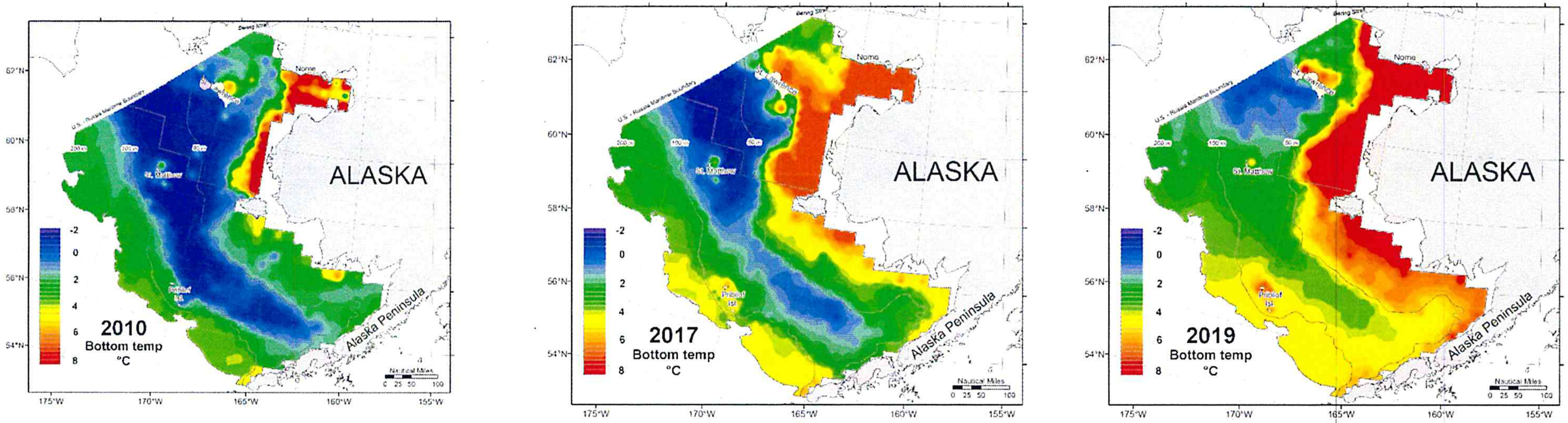


**Figure 5.** Distribution of survey bottom temperatures for 2010 (left), 2017 (center), and 2019 (right), the three years that the EBS survey was expanded to include the northern Bering Sea shelf.

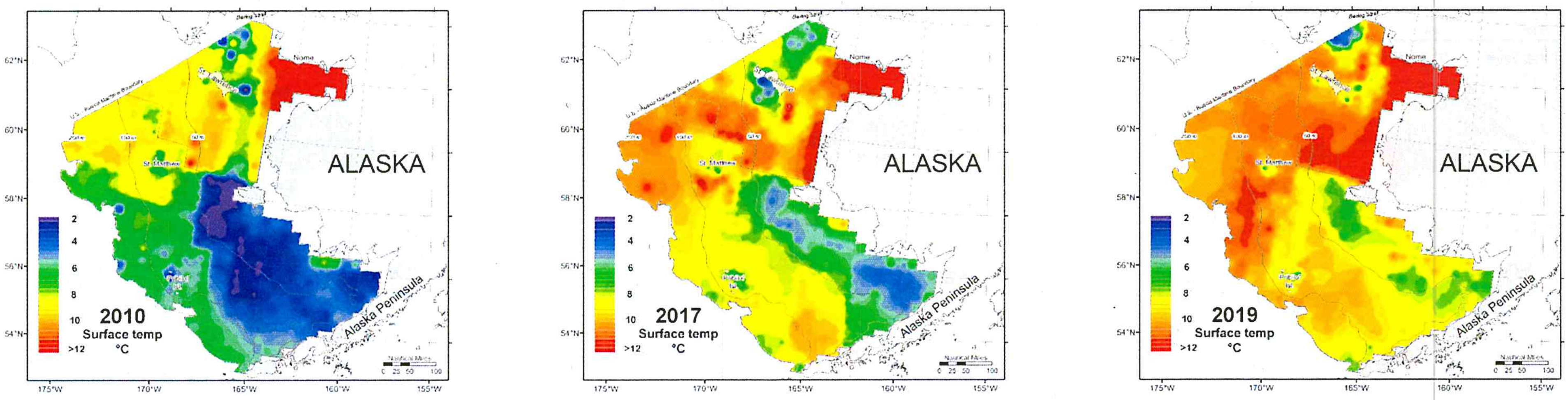


**Figure 6**. Sea surface temperatures (°C) recorded in the eastern Bering Sea shelf and northern Bering Sea in 2010 (left), 2017 (center), and 2019 (right).

### *Survey Data and Specimen Collections*

From the EBS and NBS shelf trawl surveys combined, a total of 529,666 individual fish length measurements representing 46 fish taxa were collected. Additionally, 9,295 age structures (otoliths) were collected from 11 fish taxa, 6,398 stomach samples from 4 fish taxa, 469 fecundity and maturity (ovary) samples from one fish taxon, 143 genetic samples from two fish taxa, and 1,727 pathobiology (blood) samples from 2 crab taxa were collected for analysis by researchers after the survey.

### *Abundance of Fishes, Crabs, and Other Invertebrates*

In 2019, the total bottom-dwelling animal biomass of the EBS shelf was estimated at 15.1 million metric tons (mmt), while that of the NBS was estimated at 4.3 mmt. In 2017, our survey estimated the total bottom-dwelling animal biomass of the EBS shelf at 16.3 mmt and of the NBS at 4.5 mmt. In 2010, our survey estimated the total bottom-dwelling animal biomass of the EBS shelf at 15.2 mmt, and of the NBS at 2.8 mmt. The percent change in biomass varied by fish and invertebrate taxon (Table 1). Calculated biomass increased for 26 taxa and decreased for 16 taxa from 2010 (cold year) to 2019. Some of the largest increases in biomass from 2010 to 2019 were observed in walleye pollock (5,421%), bryozoans (3,213%), Pacific cod (1,153%), brittle stars & sand dollars (751%), jellyfishes (590%), northern rock sole (366%), Pacific herring (282%), and the clams, mussels, scallops group (169%). Decreases in biomass were observed in Arctic cod (-100%), tunicates (-93%), eelpouts (-84%), corals (-78%), snailfishes (-76%), and smelts (-70%).

Species groups that previously exhibited a decreasing trend in biomass from 2010 to 2017 but have increased biomass in 2019 are Pacific halibut, red king crab, and brittle stars. Conversely, species groups that exhibited increasing biomass trends from 2010 to 2017, but decreasing biomass in 2019 are blue king crab, warty sculpin, snailfishes, shrimps, and other sculpins.

In 2019, walleye pollock and Pacific cod together comprised 36% of the total biomass in the NBS and yellowfin sole represented 12%. In 2010 walleye pollock comprised 0.8% and flatfishes (i.e., yellowfin sole, Alaska plaice, and other flounders) comprised 32% of the total biomass in the NBS. Walleye pollock and Pacific cod together accounted for only 2% of the total biomass in the NBS in 2010. Other cod taxa, saffron cod and Arctic cod, accounted for 1.5% of the total biomass in the NBS in 2010 and represented 1.9% of the total biomass in 2019. While the large increase in walleye pollock and Pacific cod results in a proportional decrease in the observed biomass for all of the other species observed, it should be noted that the mean CPUE, a measure of fish density, for several species did not see as much change between survey years. For instance, the mean CPUEs for Alaska plaice and Pacific halibut were largely unchanged between 2010 and 2019. However, species such as Pacific herring and yellowfin sole had increases in CPUE throughout the NBS region. Arctic flounder, an arctic species, were rare and only present in the northernmost portion of the survey area in Norton Sound in 2010, 2017, and 2019. Crabs and other invertebrates (i.e., shrimps, sea squirts, sea stars, jellyfish, and urchins) made up 33% of the biomass in 2019, whereas invertebrates made up 49% of the biomass in 2010.

On average, NBS survey catches were smaller compared to those from the EBS, but distributions of some of the predominant species such as Alaska plaice, Bering flounder, yellowfin sole, northern rock sole, walleye pollock, Alaska skate, Pacific cod, Pacific halibut, purple-orange sea stars, and snow crab extended throughout much of both survey regions. Several key forage fish species were found in the NBS in greater numbers than the EBS, including Pacific herring, capelin, and saffron cod.

Detailed summary profiles outlining several of the species showing ecologically significant trends are discussed below.

**Table 1.** List of the major taxa sampled in the NBS bottom trawl survey and the percentage change in biomass (metric tons) from 2010 to 2019, in descending order of % change.

| Common name | Taxon | 2010 | 2017 | 2019 | Change |
|---|---|---|---|---|---|
| walleye pollock | *Gadus chalcogrammus* | 21,141 | 1,319,062 | 1,167,099 | 5,421% |
| bryozoans | Bryozoa | 2,802 | 7,645 | 92,808 | 3,213% |
| Pacific cod | *Gadus macrocephalus* | 29,124 | 287,535 | 364,982 | 1,153% |
| brittle stars and sand dollars | | 1,082 | 5,347 | 9,211 | 751% |
| jellyfishes | Scyphozoa | 12,861 | 66,292 | 88,791 | 590% |
| northern rock sole | *Lepidopsetta polyxystra* | 21,256 | 55,466 | 99,040 | 366% |
| Pacific herring | *Clupea pallasii* | 23,011 | 34,914 | 87,918 | 282% |
| poachers | Agonidae | 416 | 2,027 | 1,346 | 224% |
| clams, mussels, scallops | Bivalvia | 2,474 | 4,992 | 6,662 | 169% |
| other flatfishes | Pleuronectidae | 3,476 | 8,620 | 7,532 | 117% |
| sea urchins | *Strongylocentrotus* sp. | 50,252 | 166,745 | 89,954 | 79% |
| pricklebacks | Stichaeidae | 1,129 | 2,967 | 2,015 | 78% |
| starry flounder | *Platichthys stellatus* | 15,802 | 31,430 | 26,472 | 68% |
| Bering flounder | *Hippoglossoides robustus* | 12,355 | 19,803 | 18,526 | 50% |
| plain sculpin | *Myoxocephalus jaok* | 28,274 | 36,206 | 41,636 | 47% |
| purple-orange sea star | *Asterias amurensis* | 296,846 | 331,261 | 414,423 | 40% |
| neptune whelk | *Neptunea heros* | 110,916 | 178,930 | 146,344 | 32% |
| misc. worms | | 205 | 278 | 253 | 24% |
| Alaska skate | *Bathyraja parmifera* | 76,942 | 83,255 | 95,102 | 24% |
| yellowfin sole | *Limanda aspera* | 427,375 | 434,086 | 520,029 | 22% |
| red king crab | *Paralithodes camtschaticus* | 2,507 | 2,256 | 2,827 | 13% |
| other snails | Gastropoda | 42,471 | 73,187 | 47,511 | 12% |
| Pacific halibut | *Hippoglossus stenolepis* | 23,333 | 18,507 | 25,722 | 10% |
| sea anenomes | Actiniaria | 9,438 | 20,920 | 10,377 | 10% |
| Alaska plaice | *Pleuronectes quadrituberculatu* | 302,976 | 330,728 | 321,571 | 6% |
| hermit crabs | Paguridae | 133,104 | 162,368 | 139,243 | 5% |
| saffron cod | *Eleginus gracilis* | 90,299 | 76,238 | 81,269 | -10% |
| other sea stars | Asteroidea | 106,605 | 103,116 | 84,661 | -21% |
| all shrimps | | 3,802 | 4,118 | 2,436 | -36% |
| blue king crab | *Paralithodes platypus* | 2,133 | 5,830 | 1,212 | -43% |
| basket starfish | *Gorgonocephalus eucnemis* | 70,643 | 40,455 | 36,653 | -48% |
| snow crab | *Chionoecetes opilio* | 347,025 | 223,216 | 167,124 | -52% |
| other sculpins | Cottidae | 10,415 | 10,393 | 4,862 | -53% |
| other crabs | | 62,762 | 33,866 | 27,908 | -56% |
| sea cucumbers | Holothuroidea | 7,116 | 3,413 | 2,564 | -64% |
| warty sculpin | *Myoxocephalus scorpius* | 39,824 | 111,350 | 14,159 | -64% |
| smelts | Osmeridae | 16,377 | 5,260 | 4,891 | -70% |
| snailfishes | Liparidae | 3,305 | 4,864 | 777 | -76% |
| corals | Anthozoa | 12,626 | 8,519 | 2,823 | -78% |
| eelpouts | Zoarcidae | 10,666 | 9,759 | 1,707 | -84% |
| tunicates | Urochordata | 368,169 | 102,585 | 27,260 | -93% |
| Arctic cod | *Boreogadus saida* | 37,861 | 3,906 | 47 | -100% |

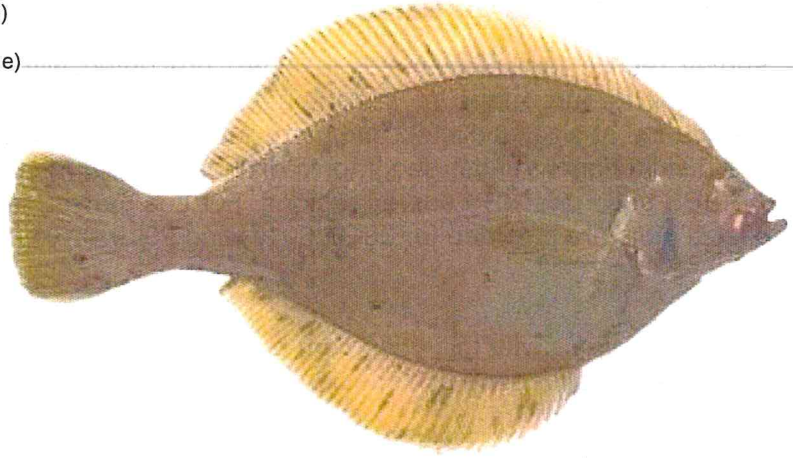
## Summary Results for Select Major Taxa

Survey results for select major taxa are presented with a photograph of the species or taxonomic group, maps of geographic distribution and relative abundance, plots of total abundance-at-size, and a text summary outlining the results. To better illustrate fish movement and distributional trends, geographic distribution and relative abundance maps include both the EBS shelf and NBS survey regions. For comparison, distribution maps and abundance-at-size plots are provided for 2010, 2017, and 2019 survey results.

*You can help us with this document by providing names in local language(s) and cultural or traditional uses for each fish species.

## **Yellowfin Sole** (common name)

*Limanda aspera* (scientific name)



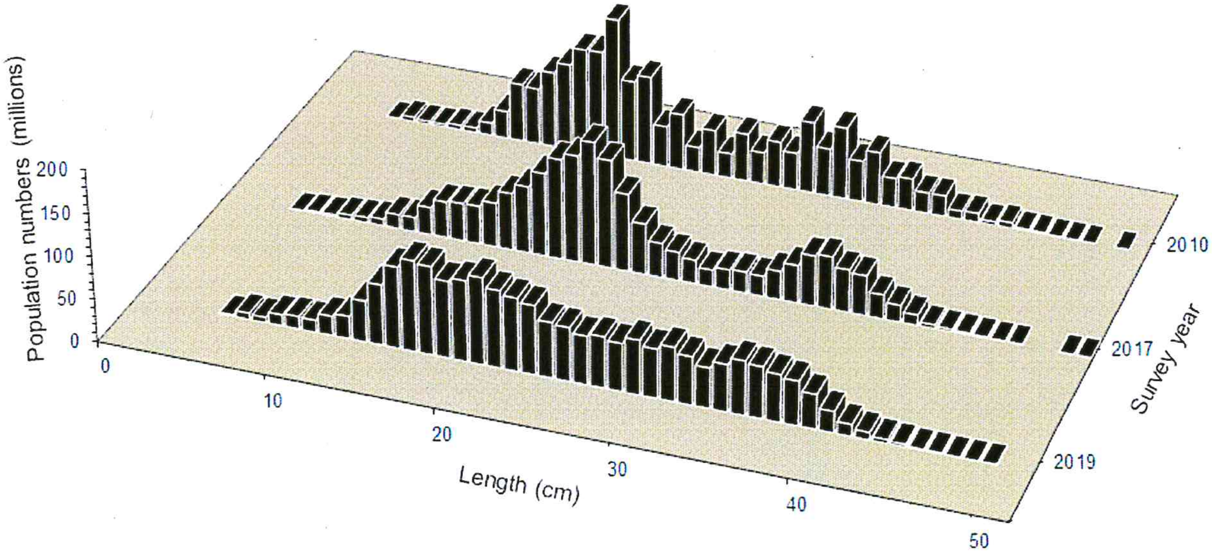


**Figure 7**. Total abundance-at-size of yellowfin sole in the NBS during 2010, 2017 and 2019.

Yellowfin sole biomass increased by 22% between 2017 and 2019 in the NBS area. Yellowfin sole was the predominant flatfish species observed in the 2019 NBS survey, comprising 12% (520,029 mt; Table 1) of the total NBS survey area biomass. Sexually mature yellowfin sole adults undergo an annual spawning migration to nearshore waters during the spring and summer. Younger and sexually immature individuals undergo an ontogenetic (age-based) migration rather than a spawning migration, moving deeper as they get older. Length or age at sexual maturity differs for males and females causing further size segregation among spawning and non-spawning portions of the population. In 2010 and 2017, size compositions were similar with length cohort modes around 24 cm and 36 cm, while in 2019 the size class modes are less distinct and the smallest size class mode appears from 18-22cm (Figure 7). Spatial distribution also remained similar, although a denser aggregation appears just south of St. Lawrence Island in 2019 (Figure 8).

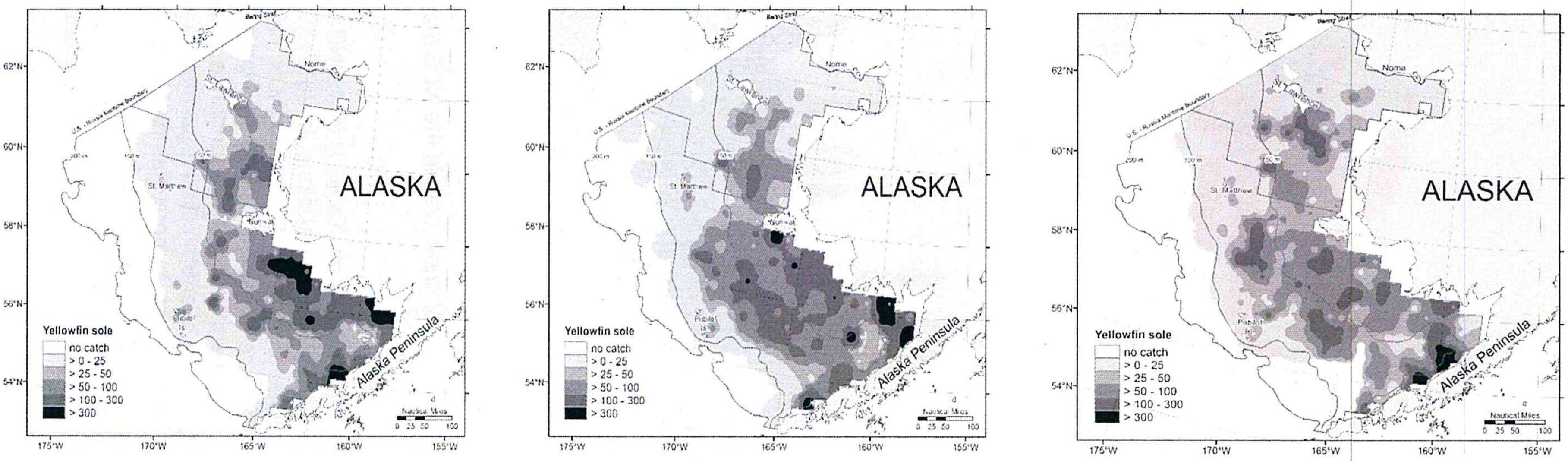


**Figure 8.** Distribution and relative abundance (in kg/ha) of yellow fin sole during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

**Snow Crab** (common name)

*Chionoecetes opilio* (scientific name)

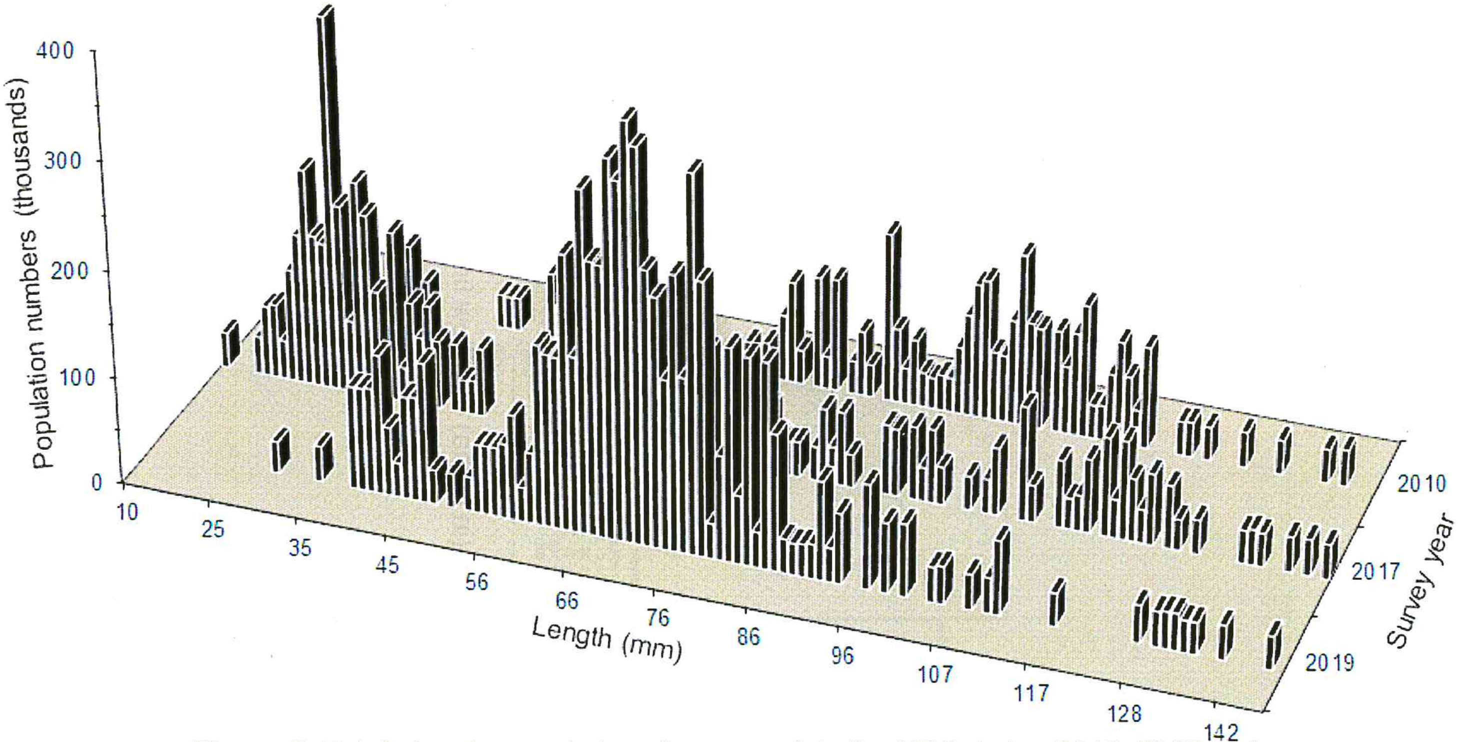


**Figure 9**. Total abundance-at-size of snow crab in the NBS during 2010, 2017 and 2019.

In 2019, snow crab comprised 4% (167,124 mt, Table 1) of the NBS survey biomass and was caught at 102 of 144 stations) NBS survey stations. In 2017, snow crab comprised 5% (223,216 mt) of the NBS survey biomass and was caught at 102 of the 144 total NBS survey stations. In 2010, snow crab comprised 12% (347,025 mt) of the survey biomass in the NBS survey area. While the overall estimated abundance of snow crab was less in 2019 than in 2017 or 2010, there were over 65 million legal males (>78mm carapace width) estimated in the NBS in 2019, which is more than previously seen. In 2010, highest densities of snow crab were found along the U.S.-Russia Maritime Boundary between 50 m and 200 m depth, whereas in 2017 and 2019, highest densities were located north and south of St. Matthew Island, in areas where bottom depths were between 50 m and 100 m (Figure 10).

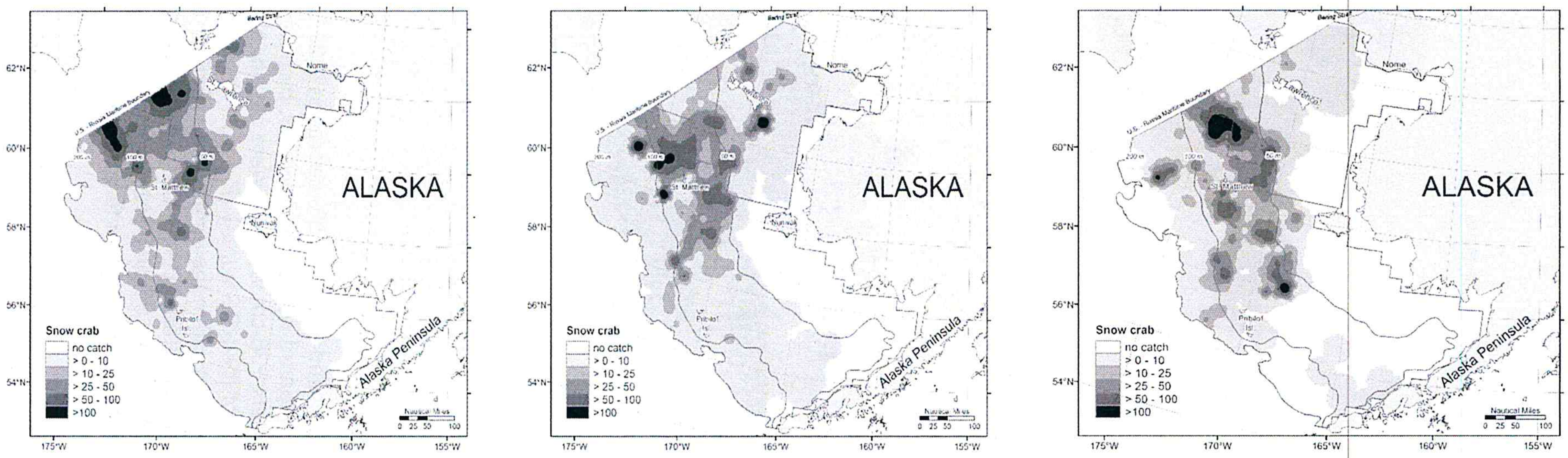


**Figure 10.** Distribution and relative abundance (in kg/ha) of snow crab during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## **Alaska Plaice** (common name)

*Pleuronectes quadrituberculatus* (scientific name)

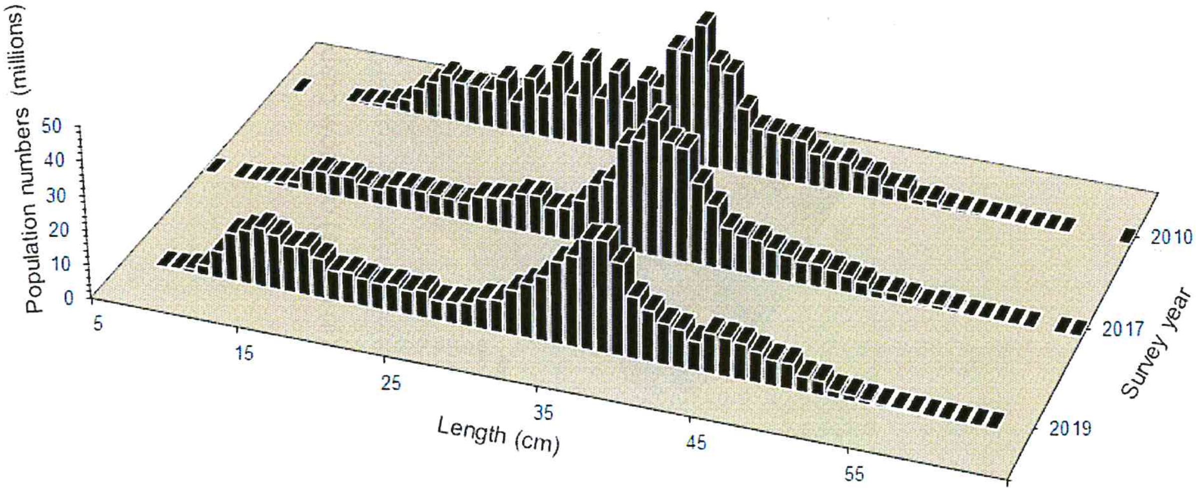


**Figure 11**. Total abundance-at-size of Alaska plaice in the NBS during 2010, 2017 and 2019.

In 2019, the Alaska plaice exhibited a slight 0.8% decrease (321,571 mt; Table 1) in the total NBS survey biomass compared with 2017; however, biomass in 2019 was 24% greater than in 2010. Individuals ~36 cm in length were caught at a higher rate than other sizes for all three years of the NBS survey (Figure 11). Their distribution was highest at depths less than 100 m within the survey area (Figure 12). Alaska plaice have a type of protein in their blood that acts as antifreeze allowing them to inhabit shelf areas where bottom temperatures are below freezing. However, their distribution did not appear to change much with increasing bottom temperature.

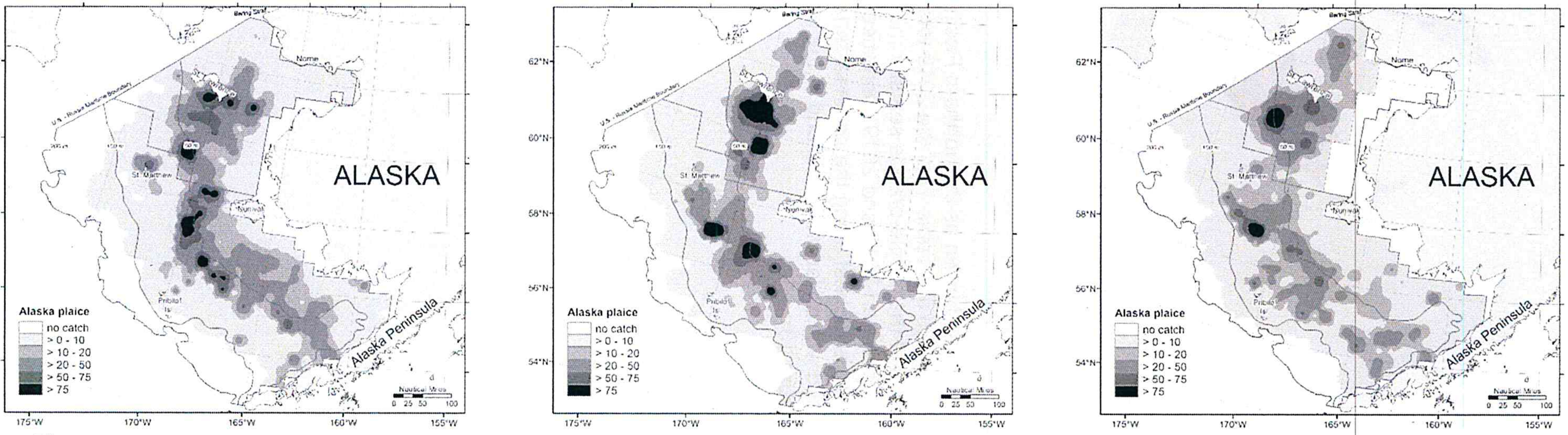
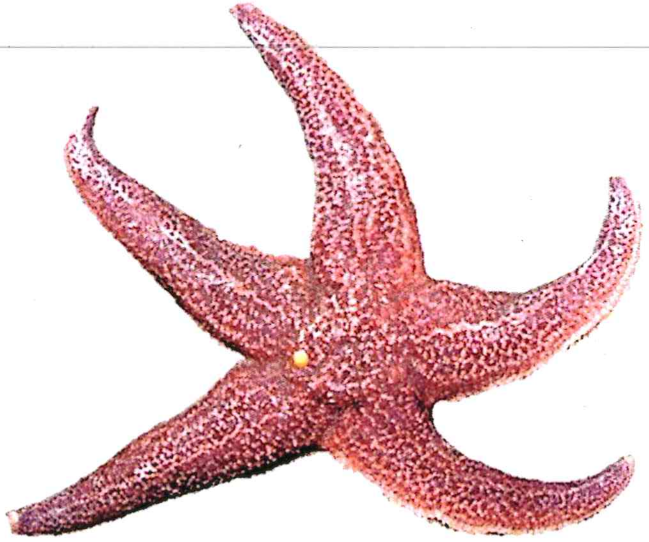


**Figure 12.** Distribution and relative abundance (in kg/ha) of Alaska plaice during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## **Purple-orange Sea Star** (common name)
*Asterias amurensis* (scientific name)



The purple-orange sea star is also known as the northern Pacific sea star. This species of sea star made up 10% (414,423 mt, Table 1) of the 2019 total fish and invertebrate biomass in the NBS. Biomass of the purple-orange sea star increased by 26% between 2017 and 2019 and by 40% between 2010 and 2019. Densities of the purple-orange sea star within the survey area were highest along the southeastern coastline to depths of 100 m on the inner shelf, and within Norton Sound and to the north and south of Norton Sound along the coast (Figure 13).

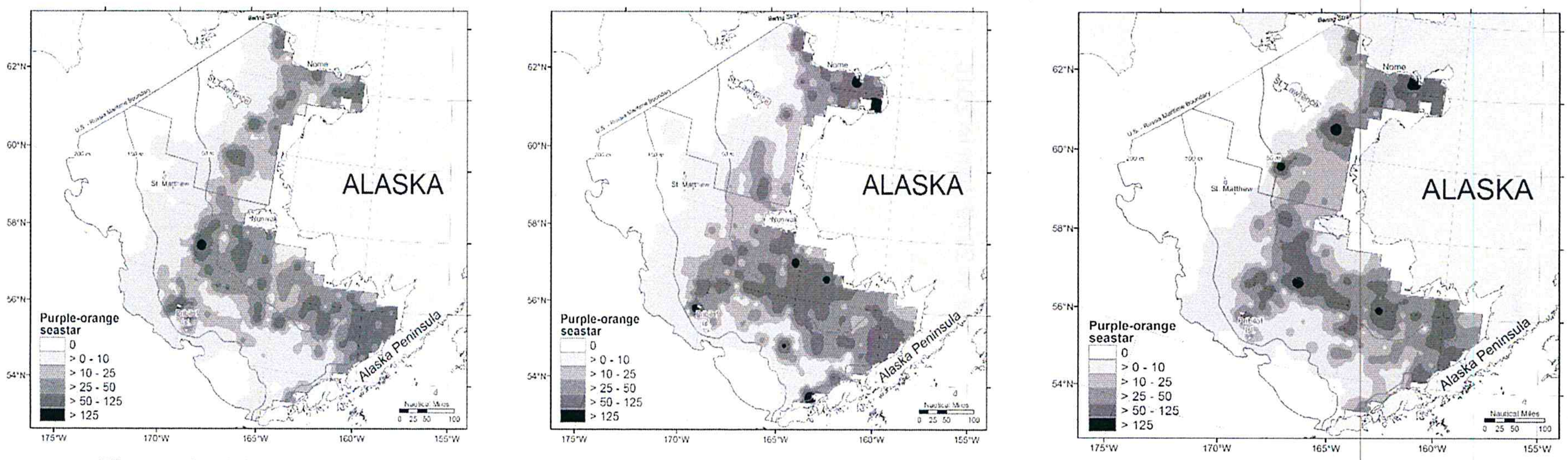
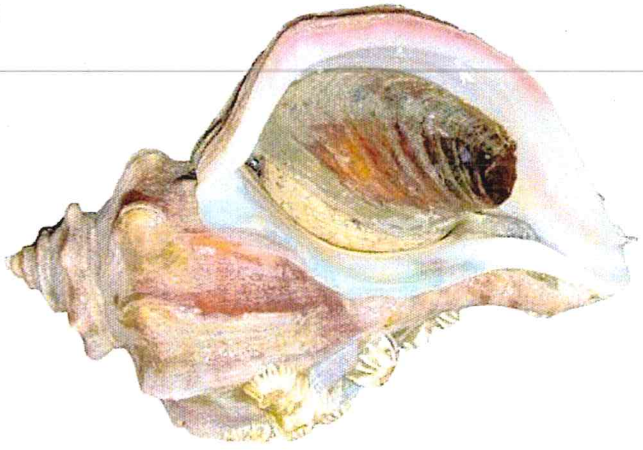


**Figure 13.** Distribution and relative abundance (in kg/ha) of Purple-orange sea star during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## **Northern Neptune Snail** (common name)

*Neptunea heros* (scientific name)



The northern Neptune snail distribution was highest to the northeast and to the south of St. Lawrence Island (Figure 14). The estimated biomass of the northern Neptune snail decreased by 18% (Table 1) between 2017 (327,678 mt) and 2019 (146,344 mt). However, the biomass was 32% greater in 2019 than in 2010.

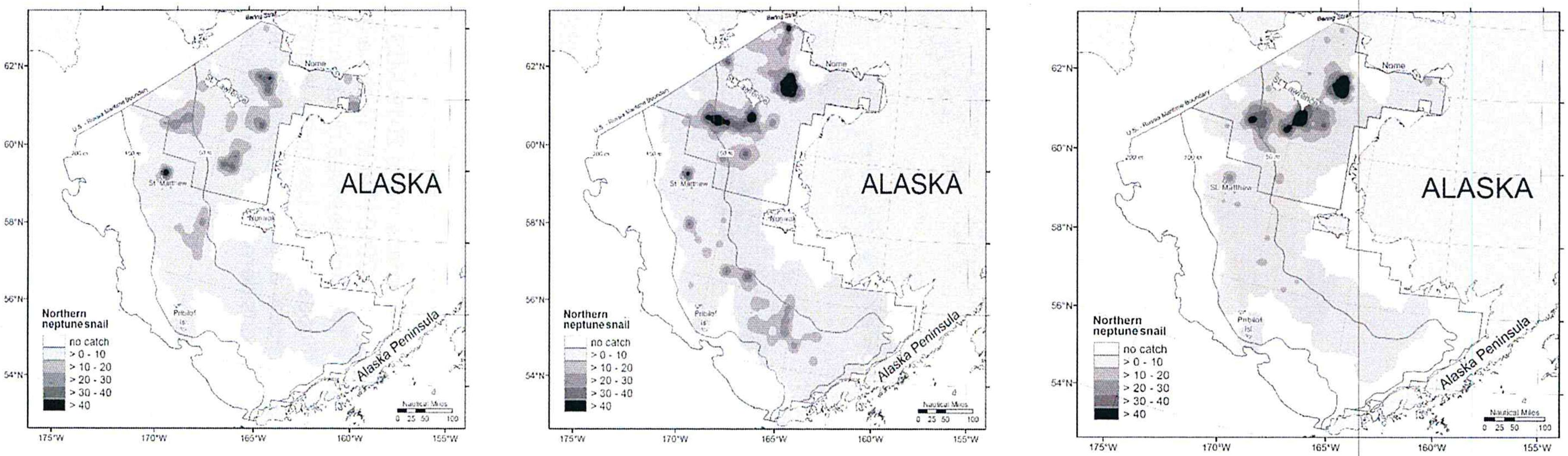
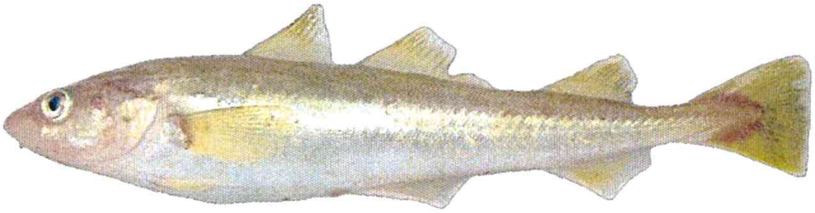


**Figure 14.** Distribution and relative abundance (in kg/ha) of Northern Neptune snail during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## Saffron Cod (common name)

Uugaq (Inupiaq)

*Eleginus gracilis* (scientific name)



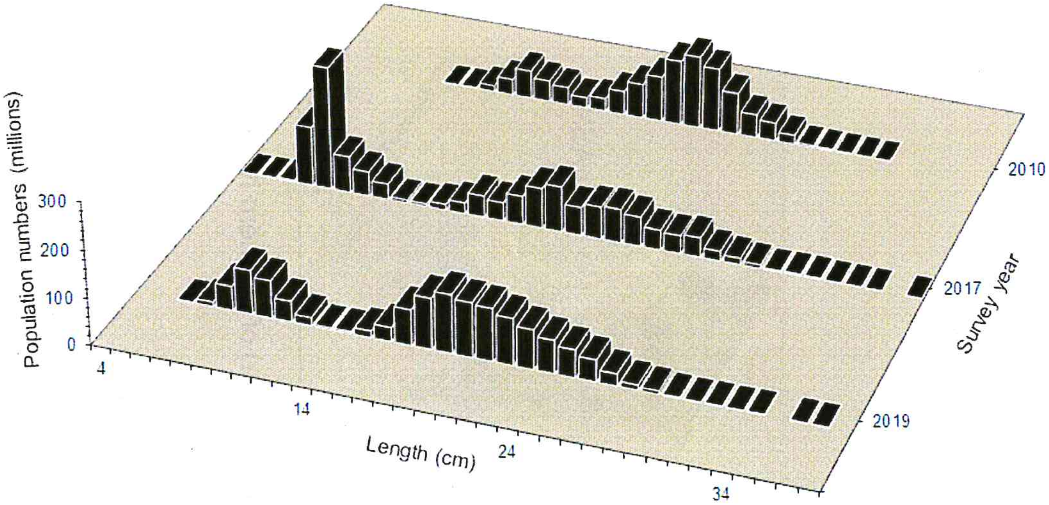


**Figure 15**. Total abundance-at-size of Saffron cod in the NBS during 2010, 2017 and 2019.

Saffron cod represented almost 2% of the biomass in the 2019 NBS. There was a 10% reduction in saffron cod biomass in 2019 from 2010 (Table 1), but a 6% increase in saffron cod biomass from 2017 to 2019. This species was most abundant just north of Nunivak continuing north along the east coast of St. Lawrence Island and into Norton Sound (Figure 16). Saffron cod were present at 84 of 144 stations in 2019 with depths between 12 and 53 m. Saffron cod are considered to be a nearshore, bottom species.

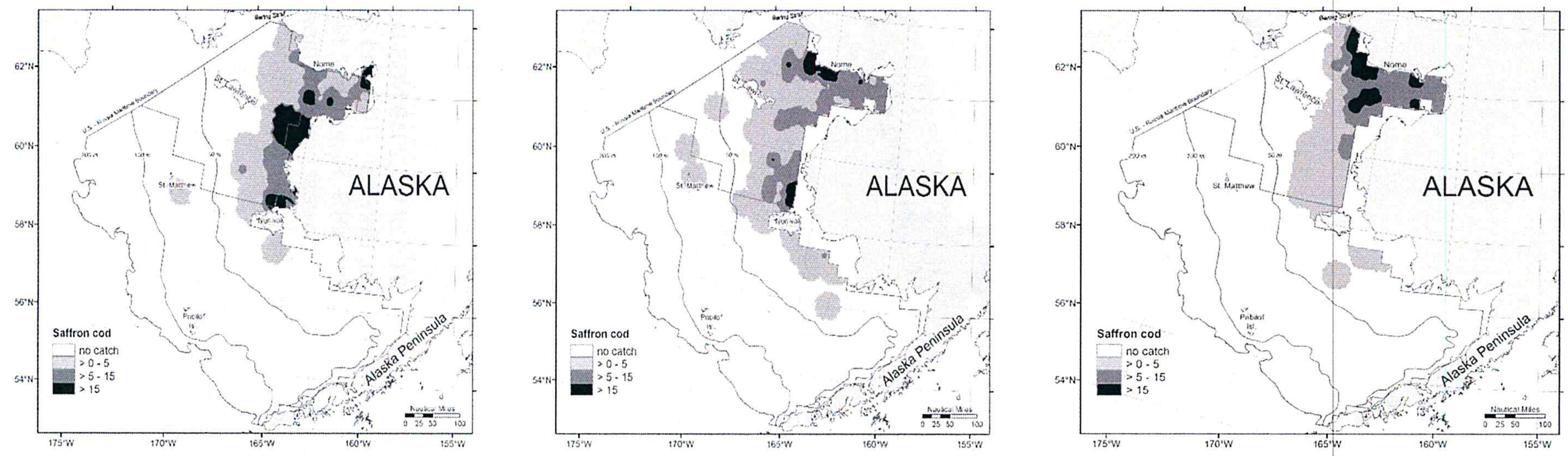
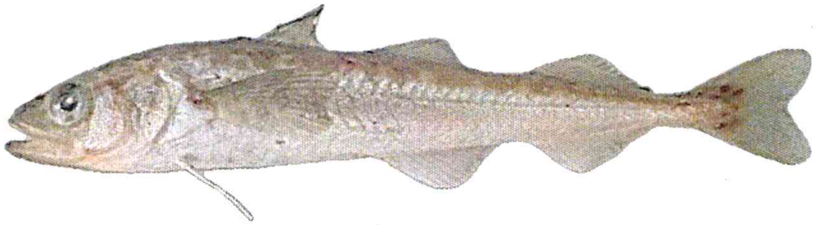


Figure 16. Distribution and relative abundance (in kg/ha) of saffron cod during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## **Arctic Cod** (common name)

Iqalugaq (Inupiaq)

*Boreogadus saida* (scientific name)



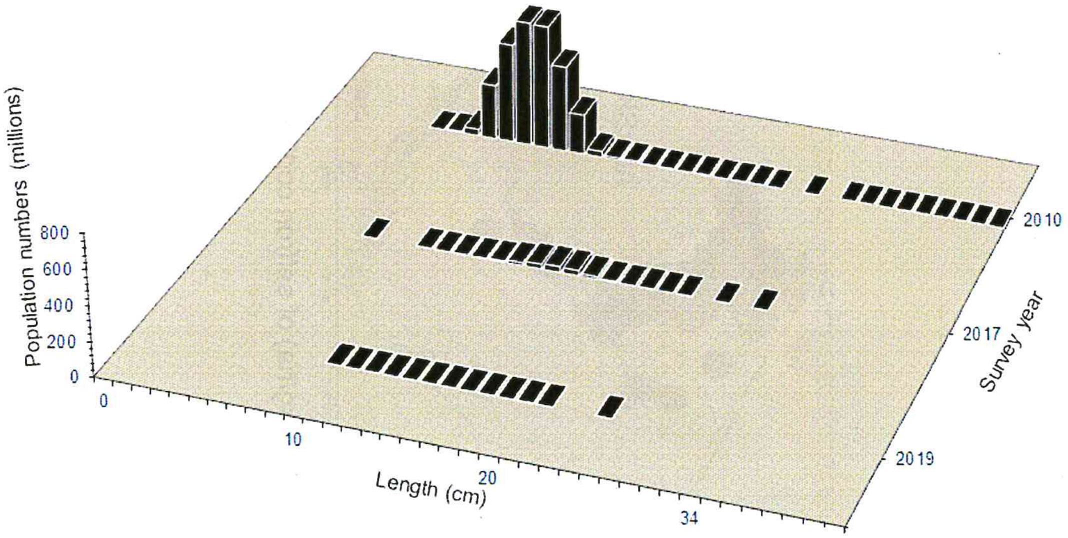


**Figure 17**. Total abundance-at-size of Arctic cod in the NBS 2010, 2017 and 2019.

Arctic cod represented approximately 0.001% of the 2019 NBS biomass, 0.1% of the 2017 biomass and 1% of the 2010 biomass. Between 2010 and 2019, there was a 99.8% reduction in Arctic cod biomass in the NBS. Historically, high densities were recorded in the area of the cold pool with the lowest bottom temperatures (<-1°C). Spatial distribution of this forage fish has been decreasing throughout the Bering Sea since 2017 (Figure 18).

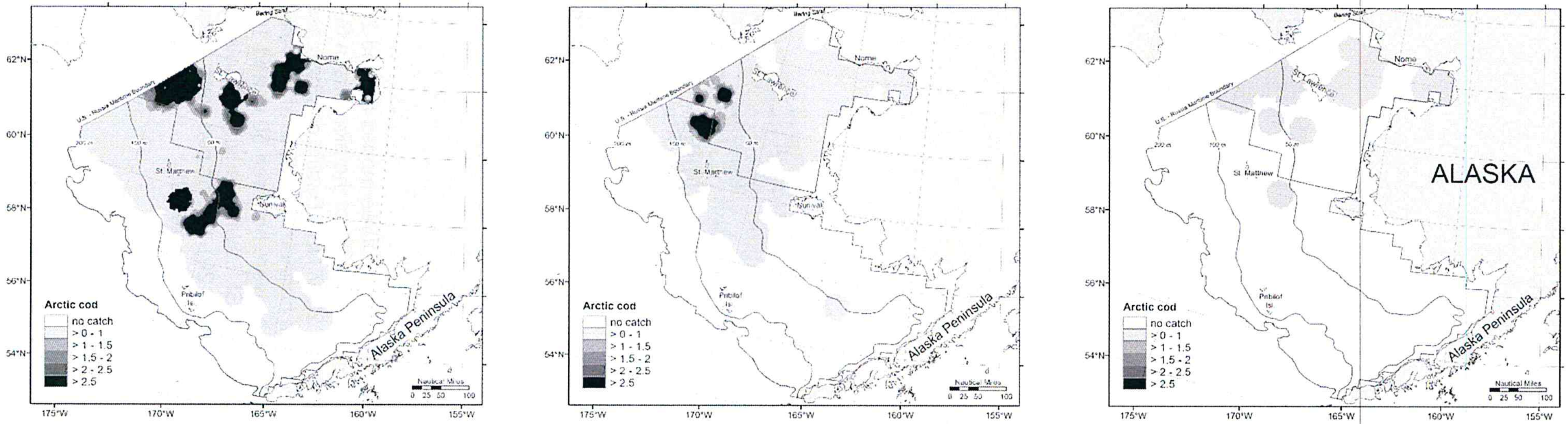
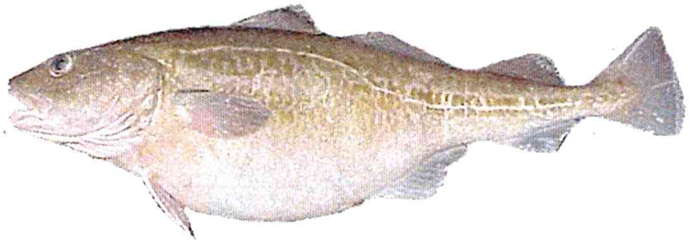


**Figure 18.** Distribution and relative abundance (in kg/ha) of Arctic Cod during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

**Pacific Cod** (common name)
atigiaq (Bristol Bay Yup'ik)
atgiiyaq (Nunivak Island Yup'ik)
centurrnaq (Central Yup'ik)
iqalluaq (Yukon, Hooper Bay, Chevak, Nunivak Island Yup'ik)
*Gadus macrocephalus* (scientific name)



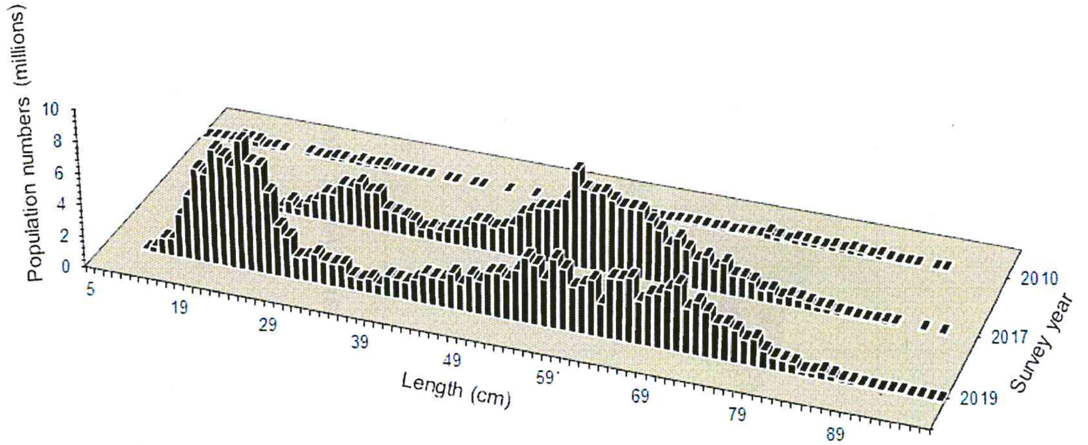


**Figure 19**. Total abundance-at-size of Pacific cod in the NBS during 2010, 2017 and 2019.

Pacific cod size composition in 2019 shows three modes around 24 cm, 58cm, and 71 cm (Figure 19). Pacific cod represented about 9% of the biomass in the 2019 NBS survey; this represents a 29% increase from 2017 NBS Pacific cod biomass. Pacific cod were present in highest densities along the northern coastline of the Alaska Peninsula, in the EBS survey area where bottom depths were between 50 m and 100 m, and occurred in the highest density in the NBS around St. Lawrence Island continuing to the northern boundary line of the survey area (Figure 20). Pacific cod were present at 114 of the 144 stations in the NBS survey area in 2019 (Figure 20).

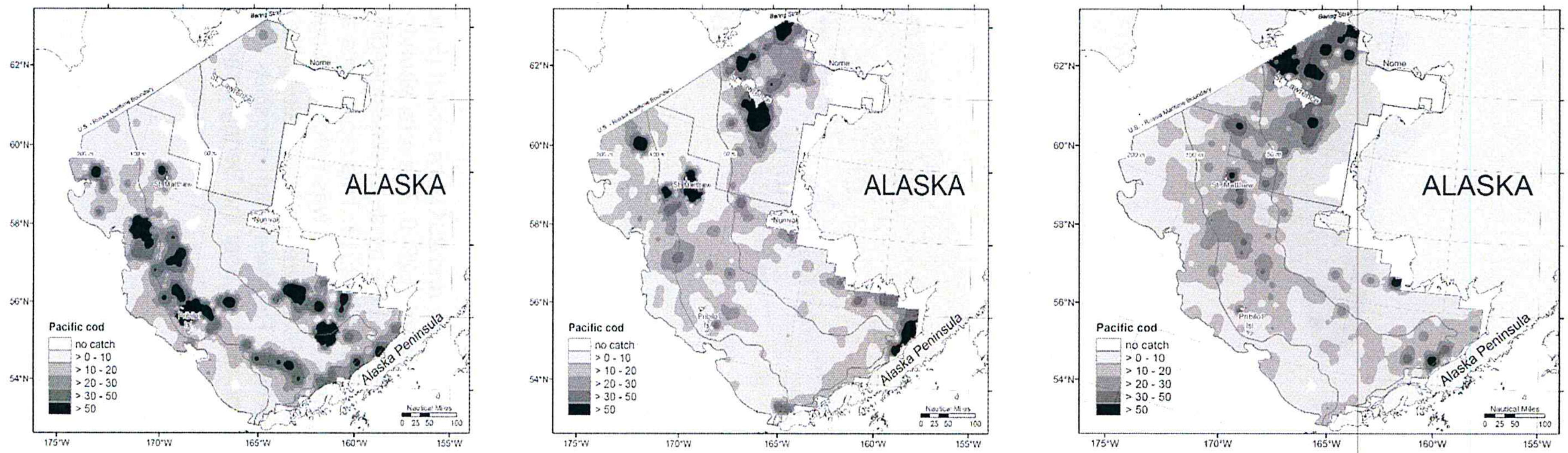
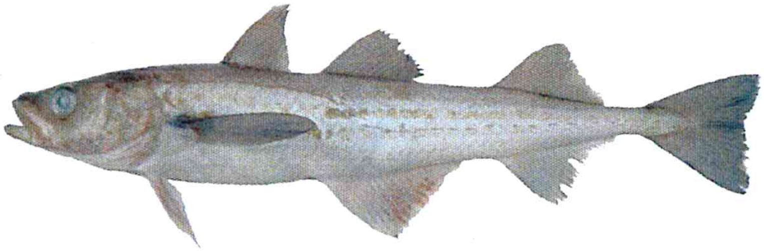


**Figure 20.** Distribution and relative abundance (in kg/ha) of Pacific cod during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## **Walleye Pollock** (common name)

*Gadus chalcogrammus* (scientific name)



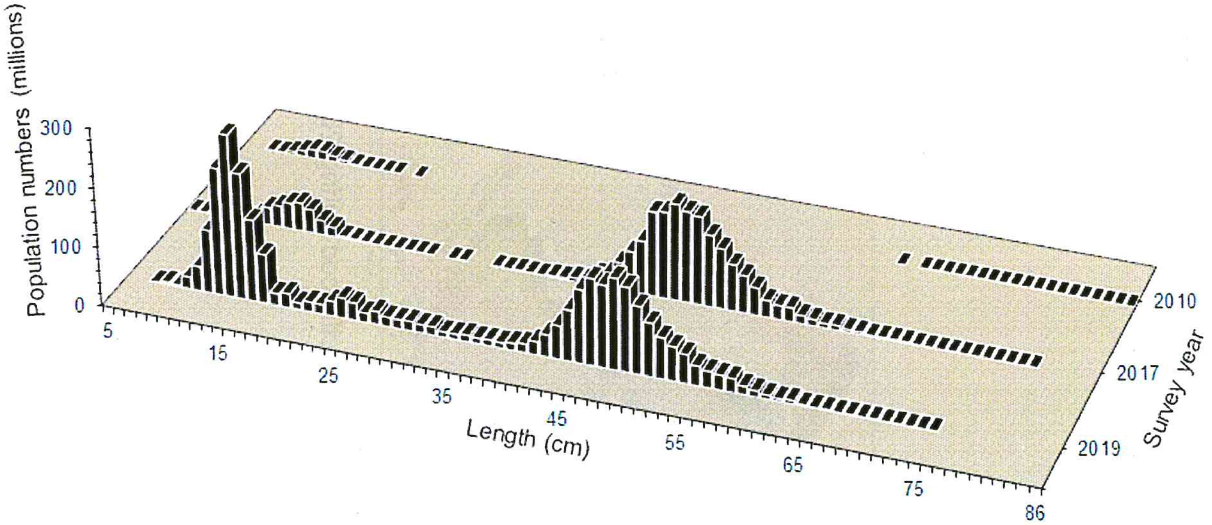


**Figure 21**. Total abundance-at-size of walleye pollock in the NBS during 2010, 2017 and 2019.

Size distributions of walleye pollock in 2019 and 2017 are similar (Figure 21) and both years had modes of larger fish that were not observed in 2010. The total abundance of fish in the mode present around 15 cm in 2019 is much greater than the mode of similar length pollock in 2017. Walleye pollock represented 27% of the total NBS biomass in 2019. This represents a 5,421% increase from the biomass observed in 2010. The spatial distribution was patchy throughout the eastern Bering Sea survey area, but was localized north of St. Lawrence Island along the northwest boundary line and south of St. Lawrence Island in the NBS. Relatively high densities were located along the northwest boundary line of the survey area and north to near the Bering Strait (Figure 22).

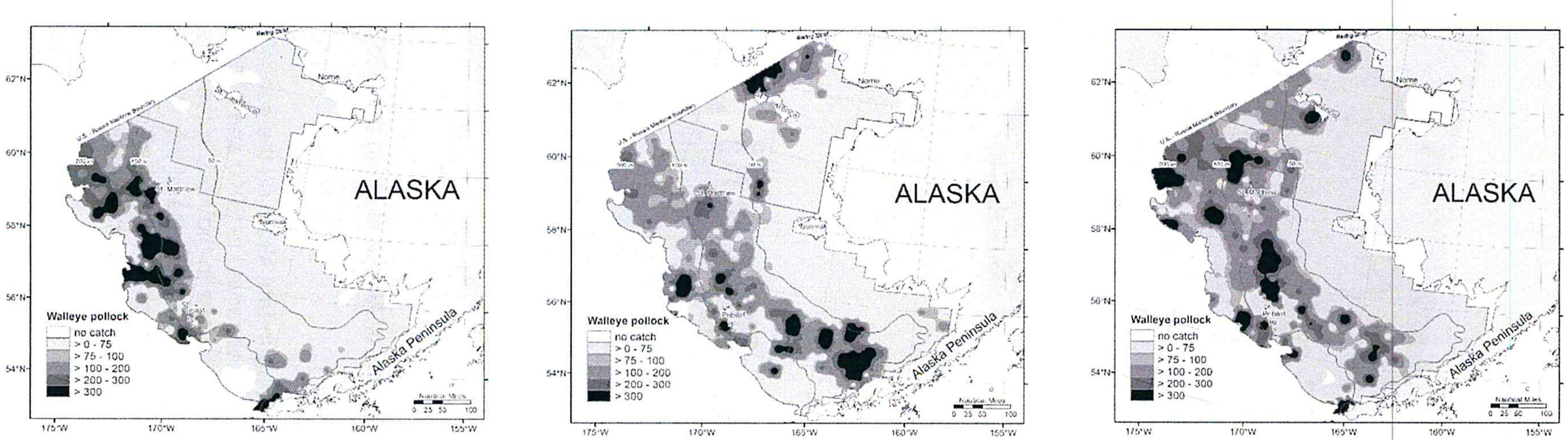
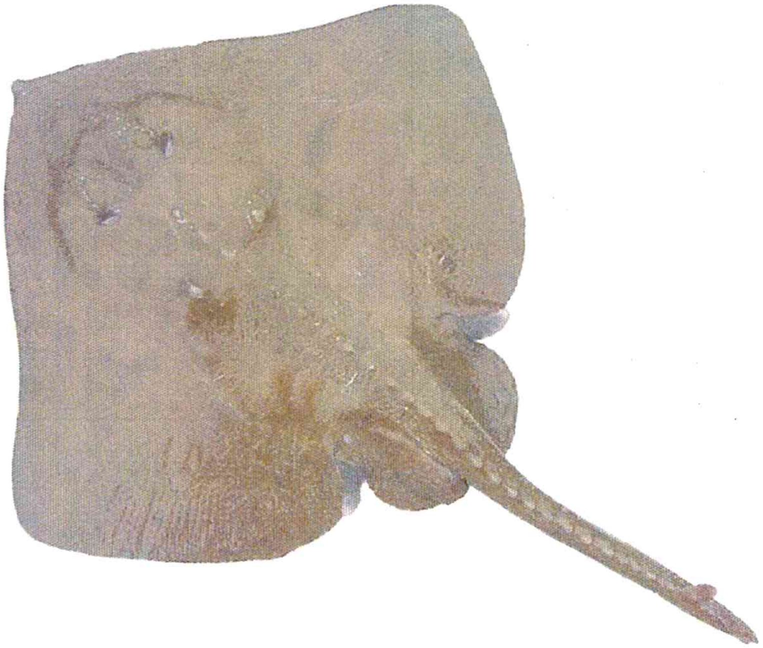


**Figure 22.** Distribution and relative abundance (in kg/ha) of Walleye pollock during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## **Alaska Skate** (common name)

*Bathyraja parmifera* (scientific name)



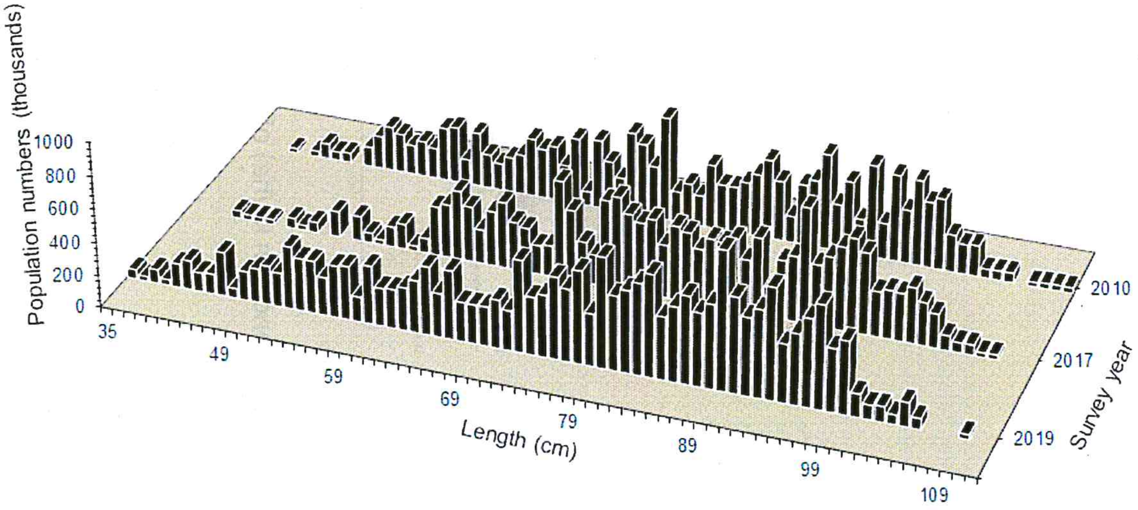


**Figure 23**. Total abundance-at-size of Alaska skate in the NBS during 2010, 2017 and 2019.

The Alaska skate is the most abundant skate on the continental shelf of the Bering Sea. A similar size composition was observed in 2010 and 2017 (Figure 23). Alaska skates were present at 73 of the 144 stations in the NBS survey area in 2019, at depths ranging from 27 to 80 m (Figure 24). Biomass of this skate increased 24% from 2010 to 2019. The distribution is consistent across the shelf in 2019, with the exception of the area north of St. Lawrence Island north to the Bering Strait (Figure 24), where the species was not encountered.

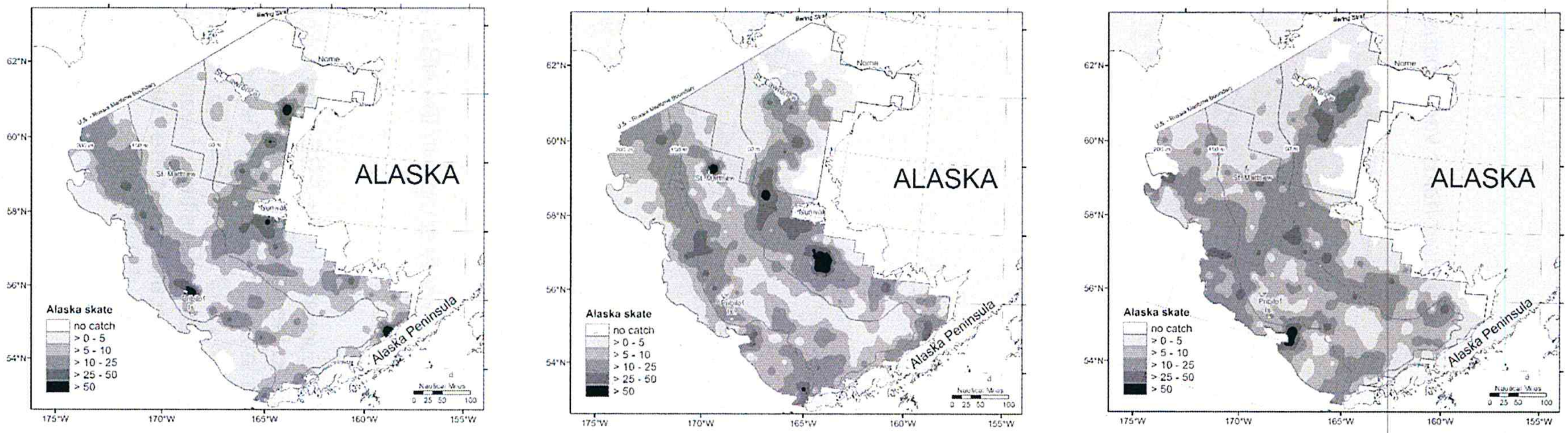


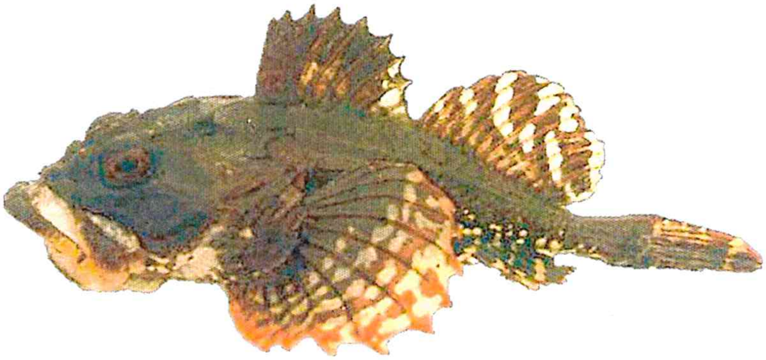
**Figure 24.** Distribution and relative abundance (in kg/ha) of Alaska skate during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

**Warty Sculpin** (common name)

nertuli (St. Lawrence Island Yupik)

kanayuq (Inupiaq)

*Myoxocephalus scorpius* (previously *Myoxocephalus verrucosus*) (scientific name)



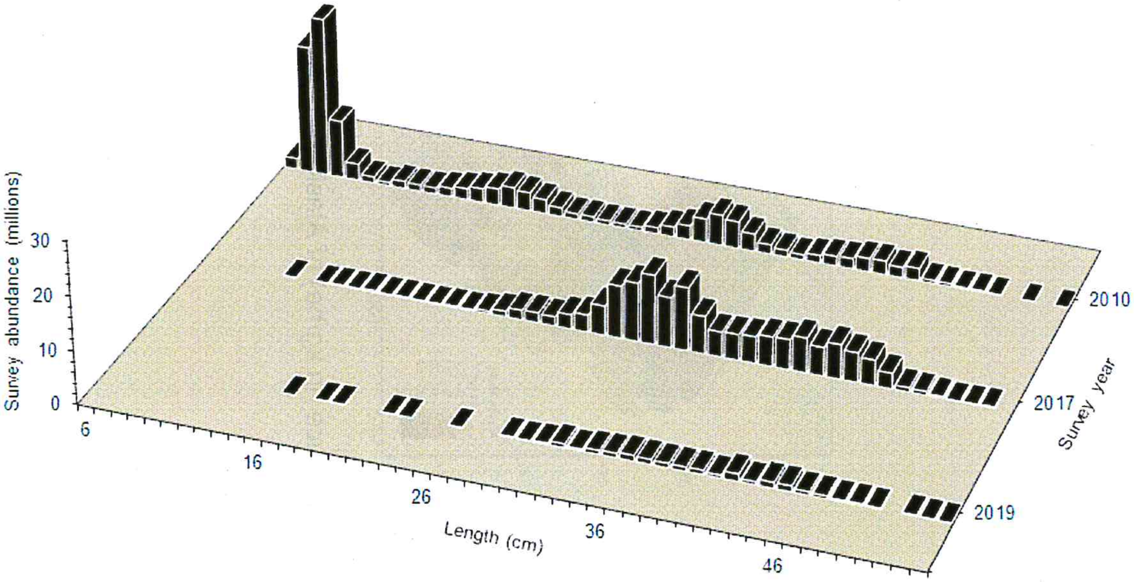


**Figure 25**. Total abundance-at-size of warty sculpin in the NBS during 2010, 2017 and 2019.

In 2019, larger individuals were encountered in the EBS area. Likewise in the NBS, larger individuals continued to be present in the size distribution from 2017 to 2019. In contrast, smaller fish (length < 15 cm) mode in 2010 (Figure 25). Despite an 87% decrease in estimated biomass between 2017 and 2019 in the NBS, the NBS had a higher biomass estimate than the EBS in 2019. The highest densities of warty sculpins occurred north of St. Lawrence Island. Presence of warty sculpins occurred at stations with bottom depths between 23 and 69 m within the NBS area (Figure 26).

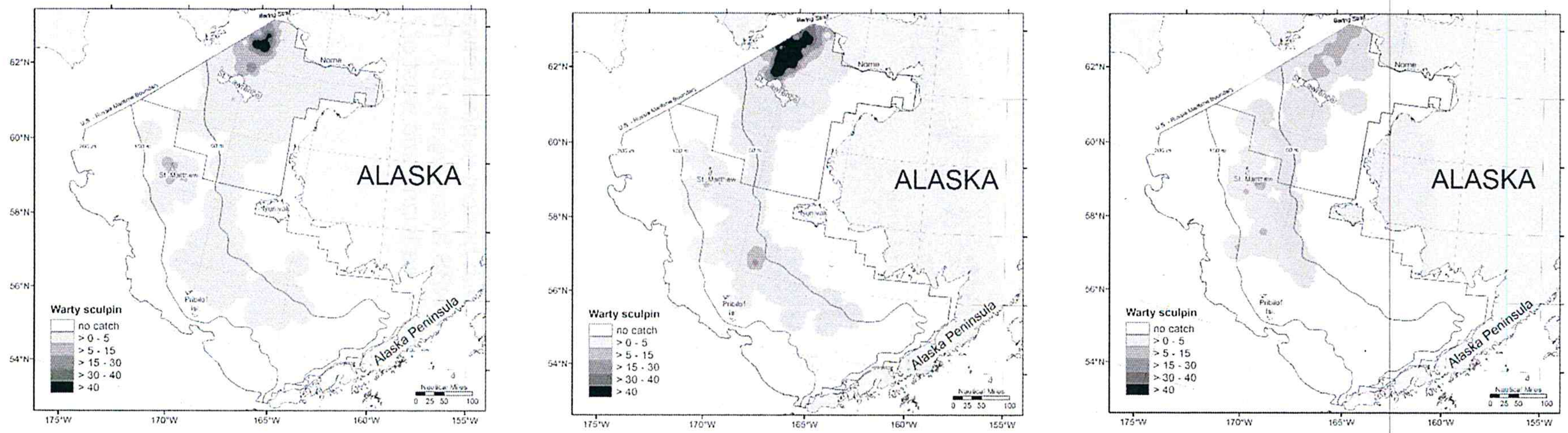
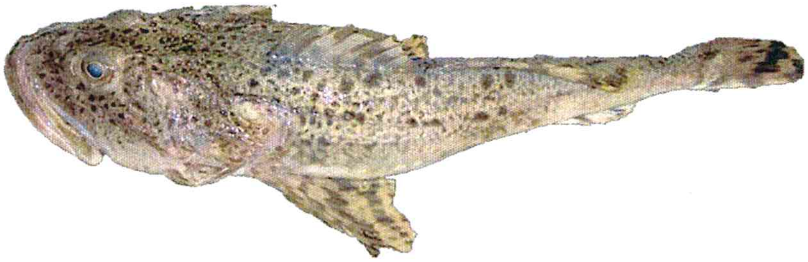


**Figure 26.** Distribution and relative abundance (in kg/ha) of warty sculpin during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## **Plain Sculpin** (common name)

nertuli (St. Lawrence Island Yupik)

*Myoxocephalus jaok* (scientific name)



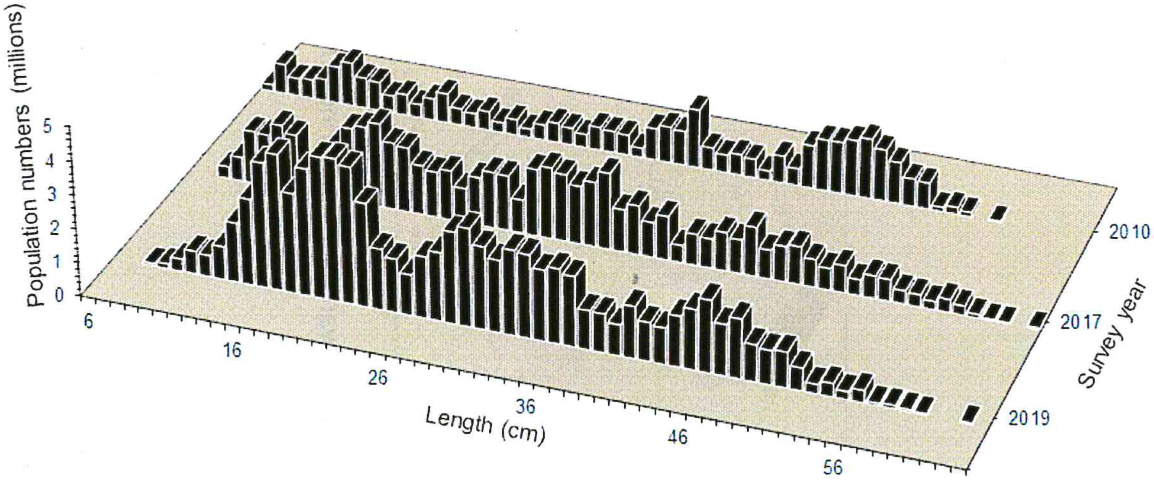


**Figure 27**. Total abundance-at-size of plain sculpin in the NBS during 2010, 2017 and 2019.

Plain sculpins were caught at stations with bottom depths between 12 and 66 meters, with an average depth of 33.6 m within the NBS area (Figure 28). The density of plain sculpins was highest north and east of St. Lawrence Island and west of Nunivak at depths less than 50 m (Figure 28).

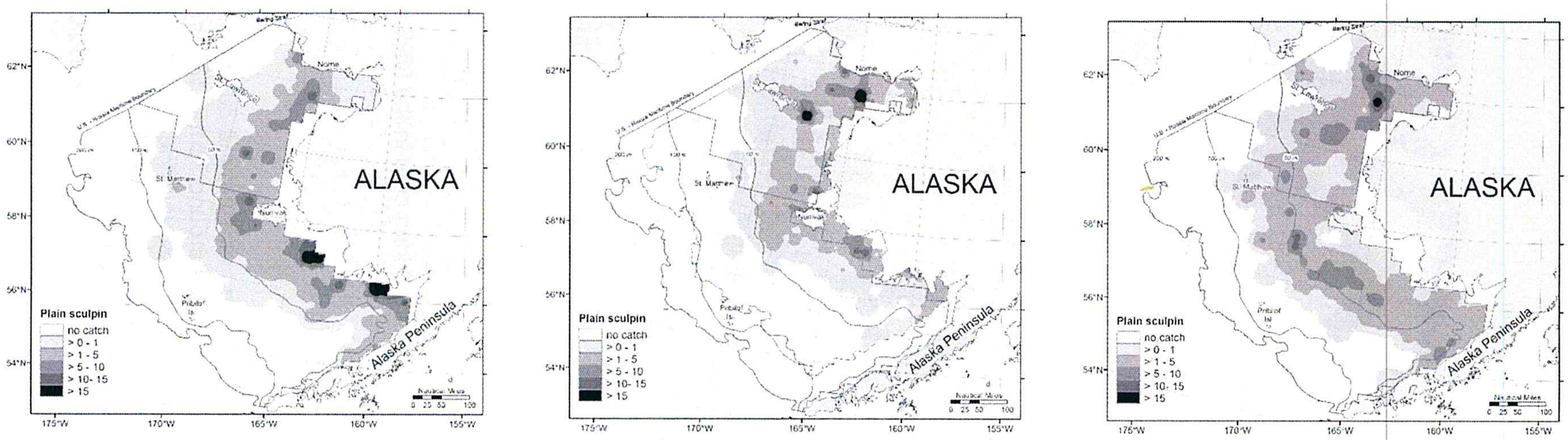
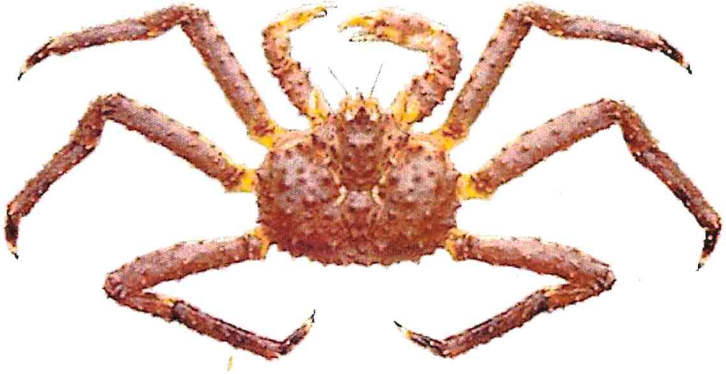


**Figure 28.** Distribution and relative abundance (in kg/ha) of plain sculpin during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## **Red King Crab** (common name)

*Paralithodes camtschaticus* (scientific name)



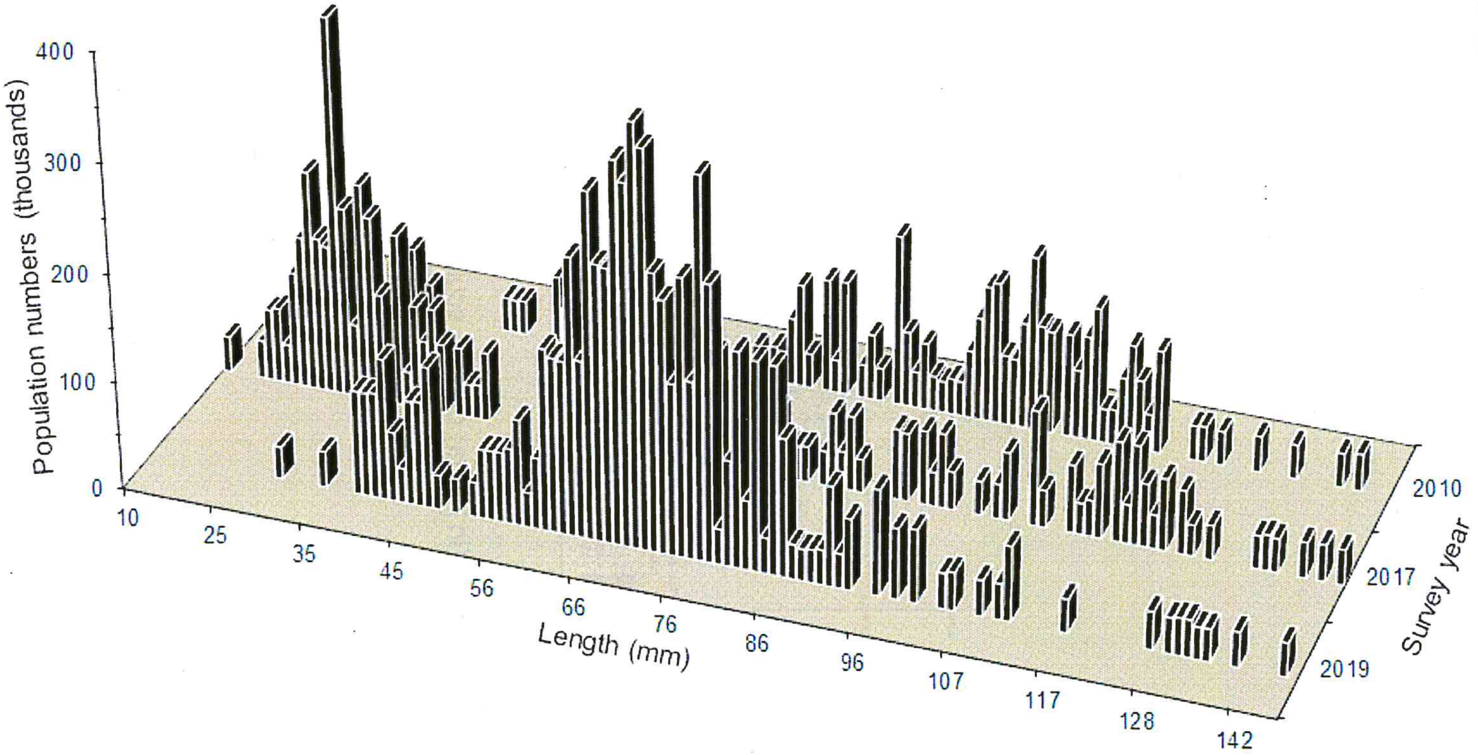


**Figure 29**. Total abundance-at-size of red king crab in the NBS during 2010, 2017 and 2019.

A strong mode was present for red king crabs around 30 mm carapace length in 2017, while in 2019 a strong mode was present around 70 mm (Figure 29). Within the NBS, red king crabs occur predominantly in Norton Sound (Figure 30). Red king crabs were caught at 23 of the 144 total stations within the NBS survey area in 2019 (Figure 30), and there was a 25% increase (2,827 mt) in the estimated biomass of red king crab compared to 2017 (2,256 mt). The increase in biomass in 2019 relative to 2010 was slightly less (13%) (Table 1).

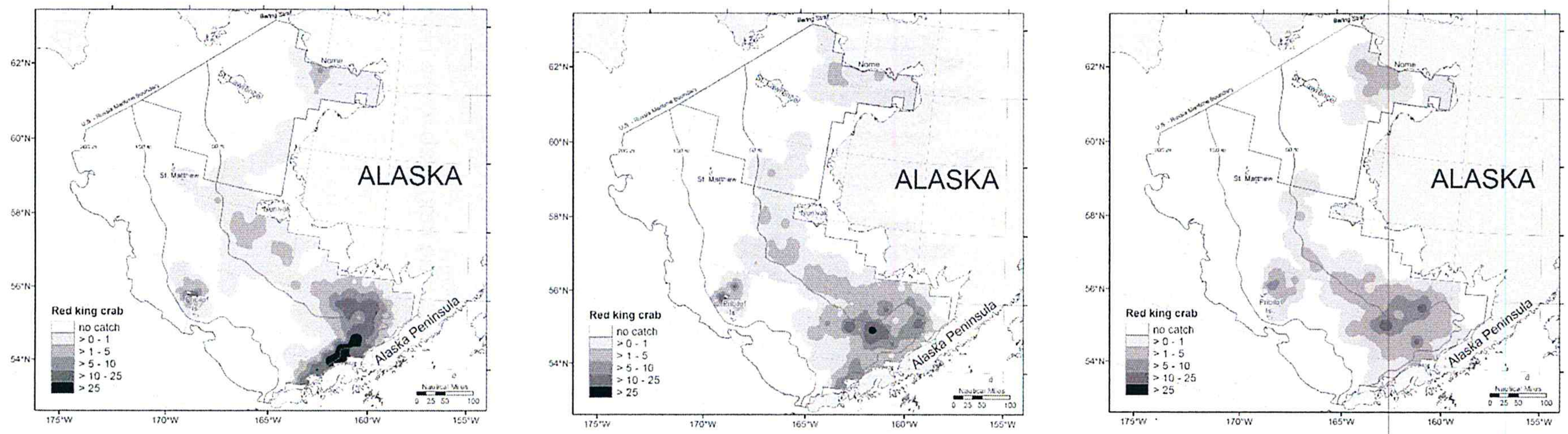
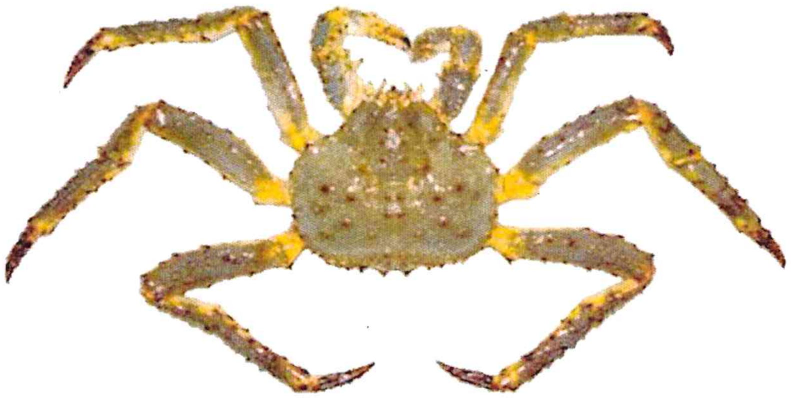


**Figure 30.** Distribution and relative abundance (in kg/ha) of red king crab during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## **Blue King Crab** (common name)

*Paralithodes platypus* (scientific name)



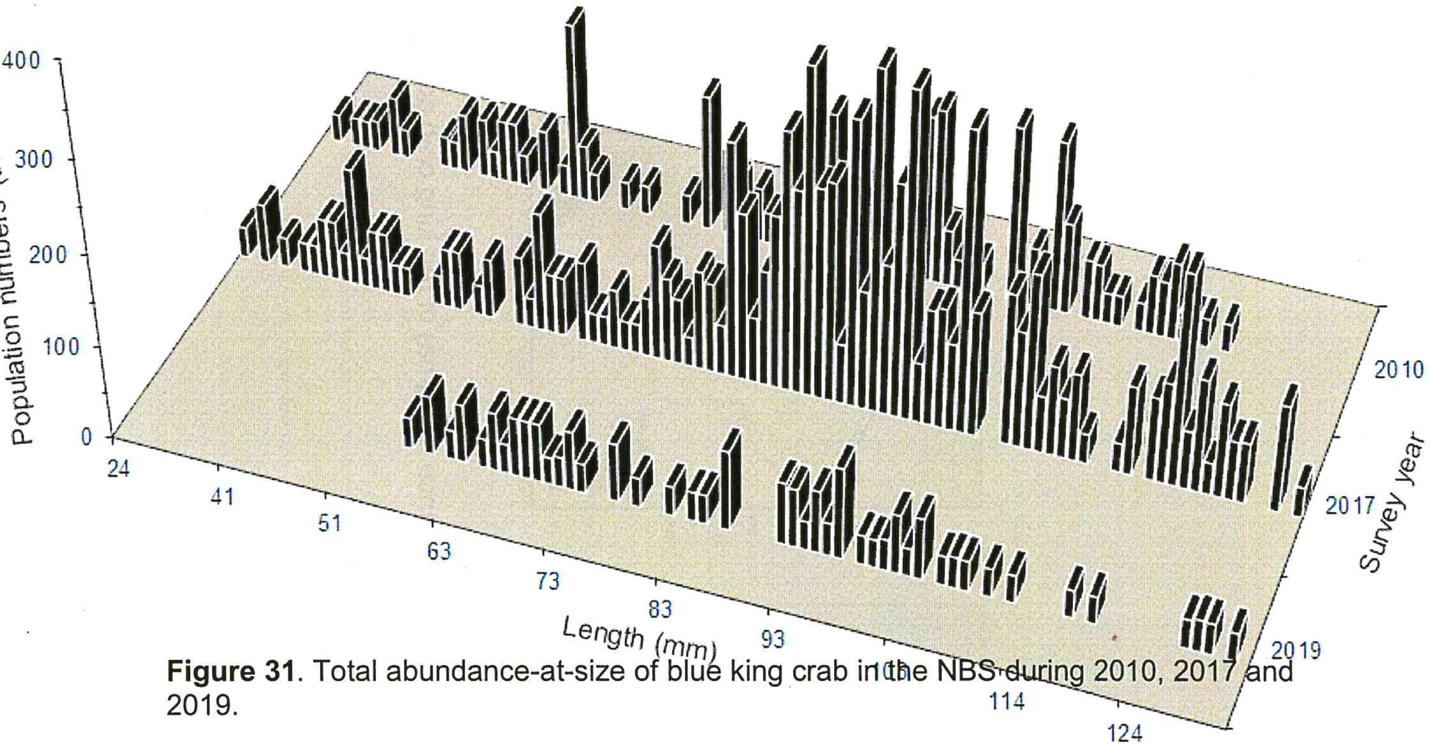


**Figure 31**. Total abundance-at-size of blue king crab in the NBS during 2010, 2017 and 2019.

In 2019, the majority of blue king crabs were distributed around St. Matthew Island, the Pribilof Islands, and north of St. Lawrence Island (Figure 32). In 2017, the area of high blue king crab density was reduced around St. Matthew Island and high densities were encountered off of the north coast of St. Lawrence Island (Figure 32). Blue king crab biomass decreased by 79% from 2017 to 2019. Biomass in 2019 (1,212 mt) was more similar to 2010 (2,133 mt) (Table 1).

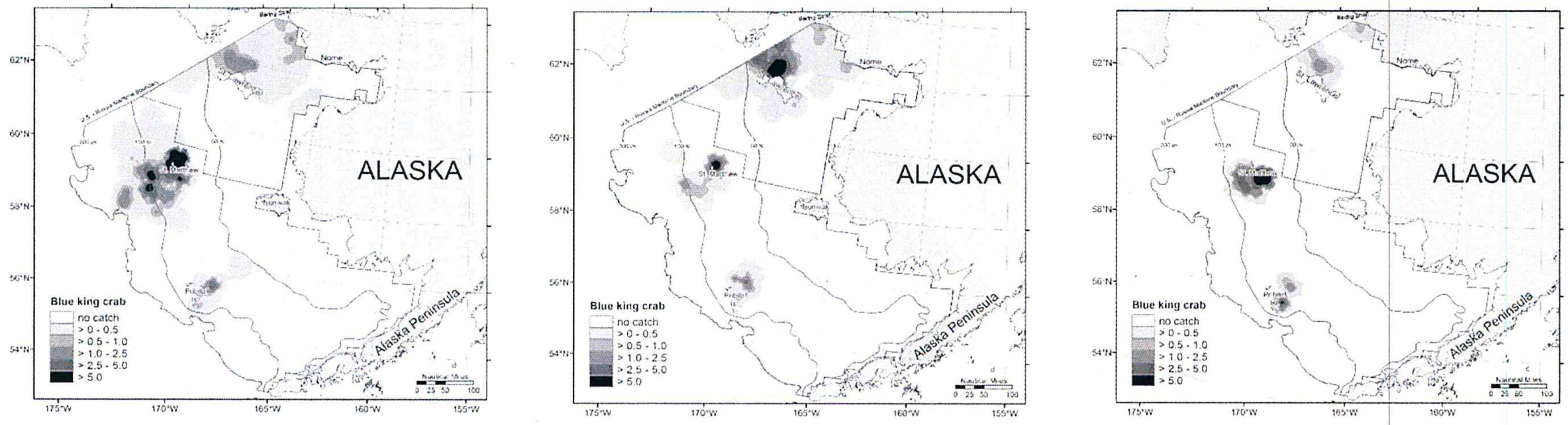


**Figure 32.** Distribution and relative abundance (in kg/ha) of blue king crab during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## Pacific Halibut (common name)

cagiq, naternarpak (St. Lawrence Island Yupik)

*Hippoglossus stenolepis* (scientific name)

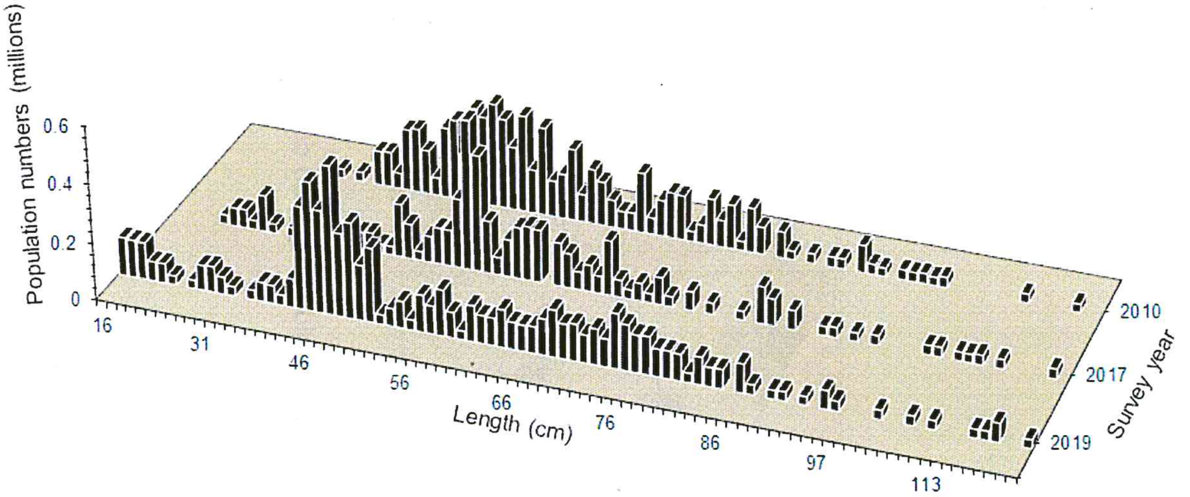


**Figure 33**. Total abundance-at-size of Pacific halibut in the NBS during 2010, 2017 and 2019.

Pacific halibut size composition indicates a decreasing number of larger individuals were present in 2019 than 2017 or 2010 (Figure 33). As a result, the average size of halibut in the NBS was smaller in 2019 (57.9 cm) than 2017 (62.4 cm) and 2010 (61.8 cm). In 2019, Pacific halibut were recorded at depths ranging from 14 m to 63 m in the NBS area (Figure 34). Pacific halibut showed an estimated 42% increase in total biomass from 2017 (18,507 m) to 2019 (25,722 mt; Table 1). However, the 2019 biomass increased by 10% from 2010. Highest spatial densities were distributed shallower than 50 m, from the western portion of St. Lawrence Island east to the mouth of the Norton Sound, as well as in the southern portion of the NBS (Figure 34).

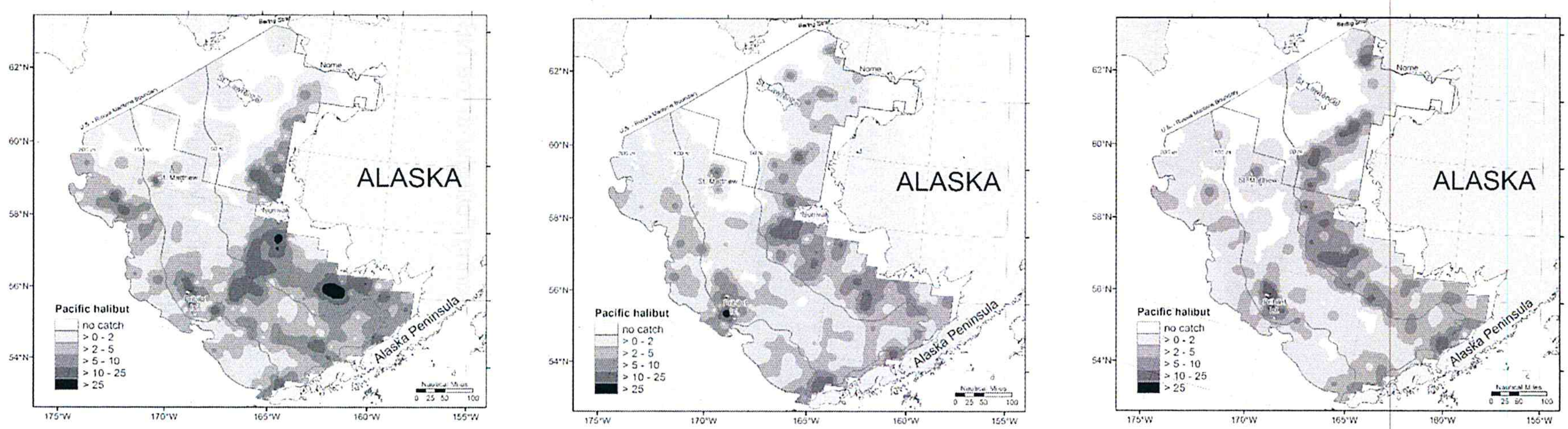
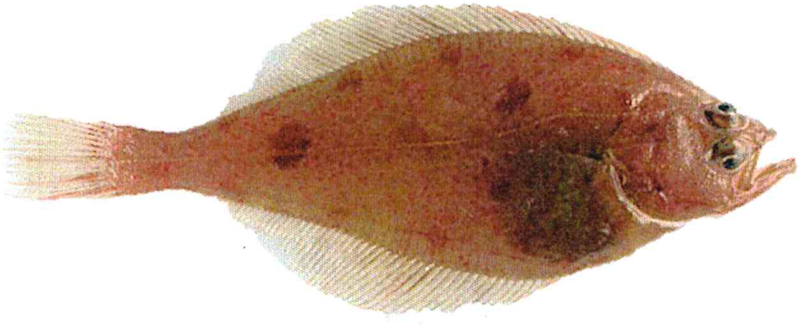


**Figure 34.** Distribution and relative abundance (in kg/ha) of Pacific halibut during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## **Bering Flounder** (common name)

cagiq, sagiq (St. Lawrence Island Yupik)

*Hippoglossoides robustus* (scientific name)



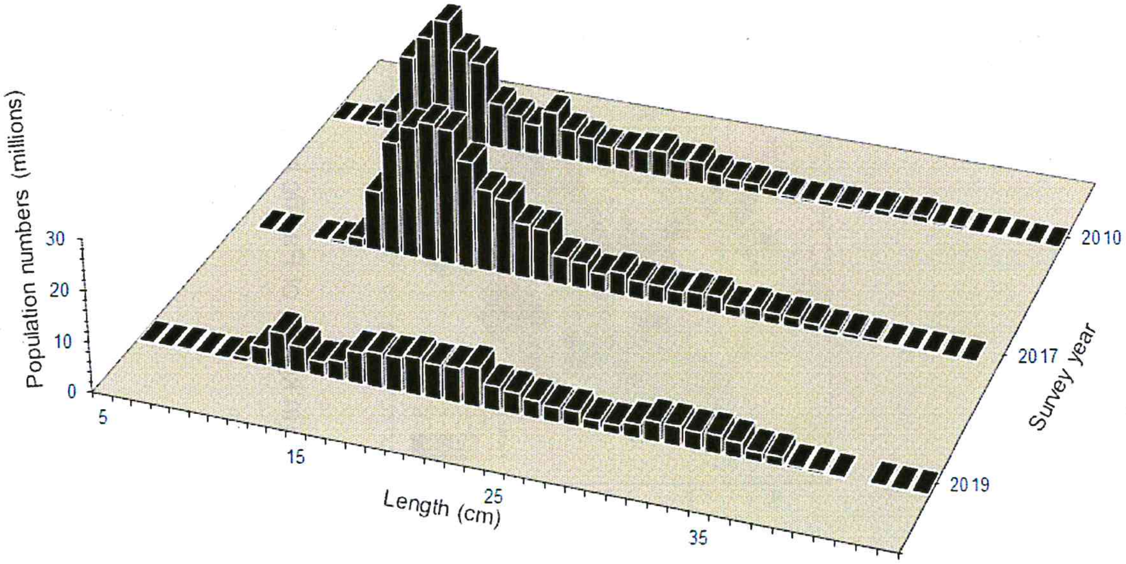


**Figure 35**. Total abundance-at-size of Bering flounder in the NBS during 2010, 2017 and 2019.

In 2019, the greatest number of Bering flounder individuals were around 19 and 22 cm in length (Figure 35).Bering flounder were recorded at depths between 15 and 76 m. The highest densities were concentrated from St. Matthew Island north to the U.S.- Russia maritime border (Figure 36). Biomass of Bering flounder increased by 50% between 2010 and 2019 (12,355 mt to 18,526 mt; Table 1).

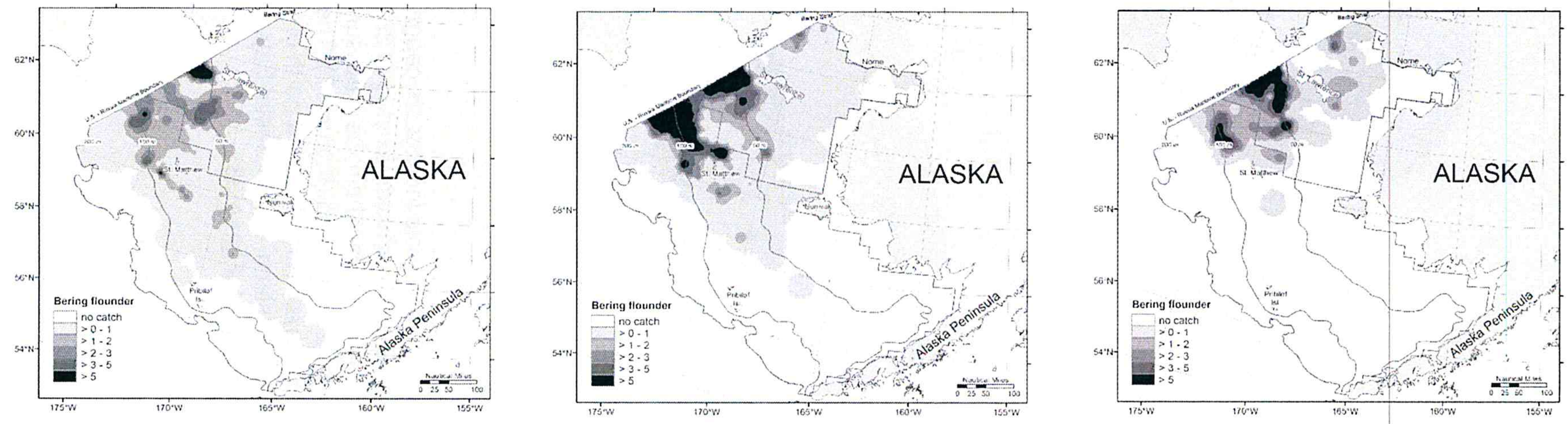


**Figure 36.** Distribution and relative abundance (in kg/ha) of Bering flounder during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## **Northern Rock Sole** (common name)
cagiq, sagiq (St. Lawrence Island Yupik)
*Lepidopsetta polyxystra* (scientific name)

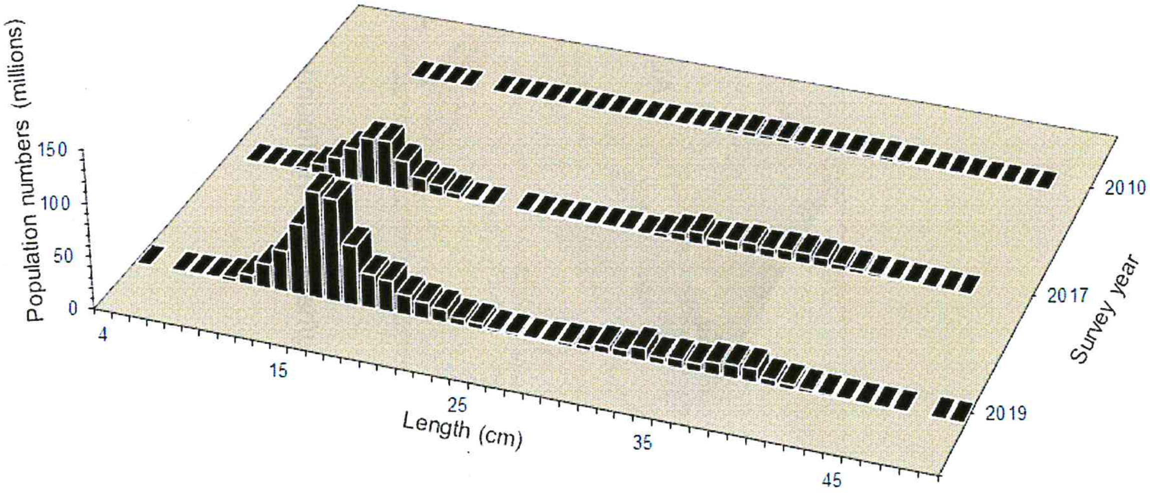


**Figure 37**. Total abundance-at-size of northern rock sole in the NBS during 2010, 2017 and 2019.

In 2019, the largest number of northern rock sole individuals caught were around 15 cm in length while another smaller magnitude size mode existed at 38 cm (Figure 37). In 2010, relatively few northern rock sole were caught in the NBS survey, but the majority of those that were caught were around 31 cm long (Figure 37). The highest densities of northern rock sole in the NBS survey area were recorded north of the Pribilof Islands, directly west and southwest of Nunivak Island, and in Bristol Bay, as well as along the 50 m contour south of St. Lawrence Island (Figure 38).

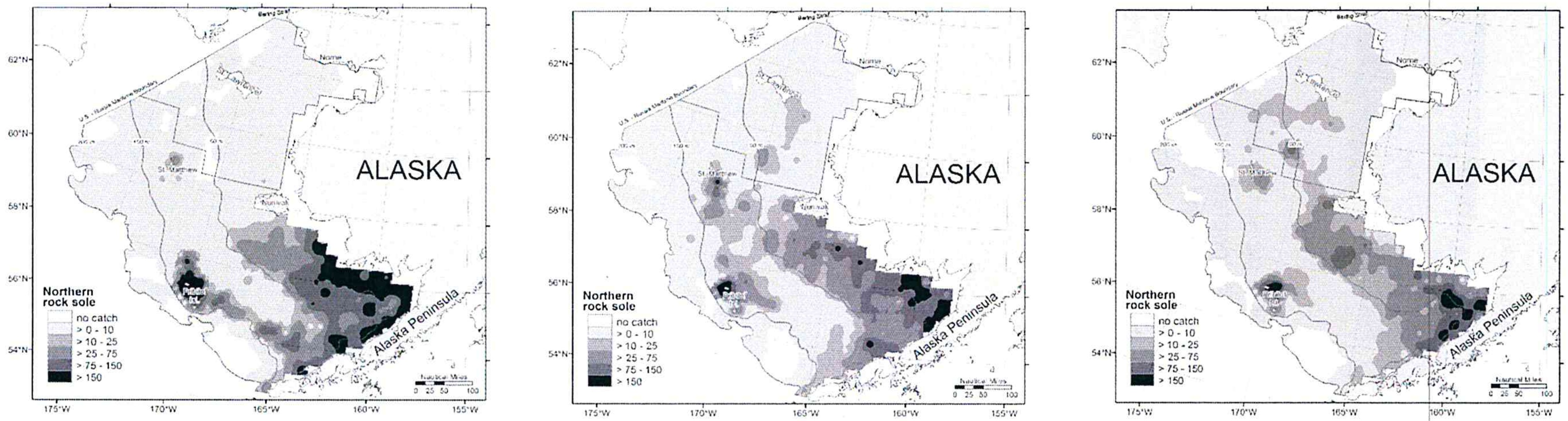


**Figure 38.** Distribution and relative abundance (in kg/ha) of Northern rock sole during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

**Pacific Herring** (common name)

neqalluarpak (Central Yup'ik)

iqalluarpak, iqallugpak (St. Lawrence Island Yupik)

Uqsruqtuuq (Inupiaq)

*Clupea pallasii* (scientific name)

In 2019, Pacific herring were recorded at 94 of 144 NBS stations in depths ranging from 12 m to 80 m. Areas of high density were located on the middle shelf southwest of St. Lawrence Island, east of St. Matthew Island, and west and southwest of Nunivak Island in 2019 (Figure 39). The relative Pacific herring biomass increased 282% from 23,011 mt in 2010 to 87,918 mt in 2019 (Table 1). Lengths of Pacific herring have not historically been recorded during the EBS and NBS surveys.

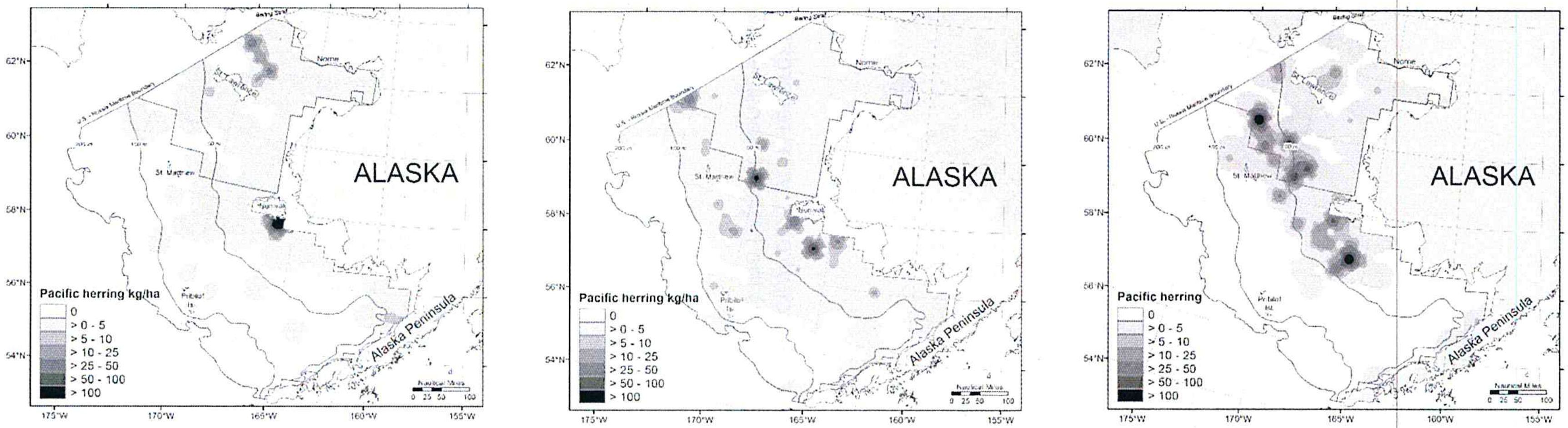
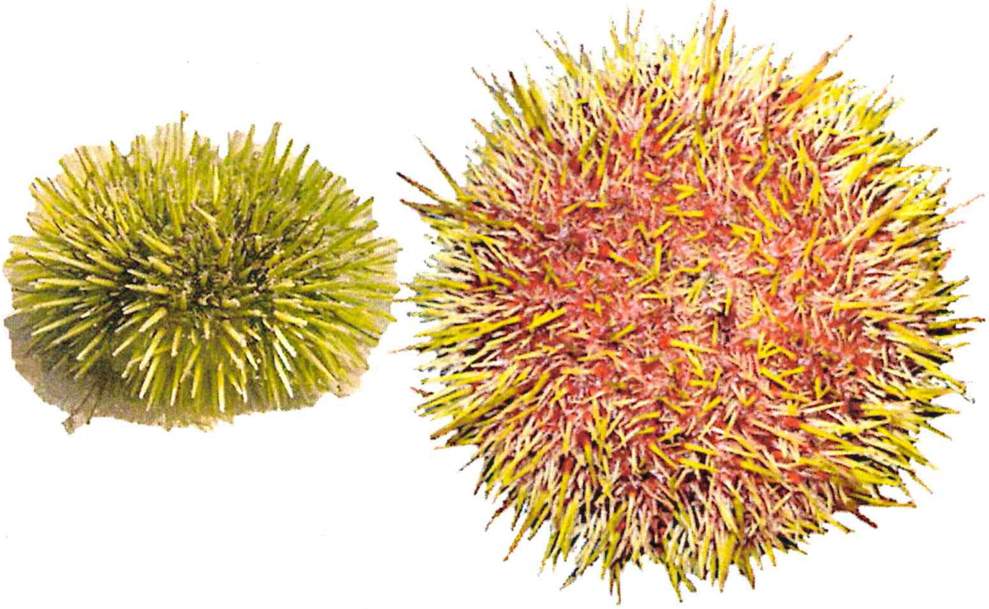


**Figure 39.** Distribution and relative abundance (in kg/ha) of Pacific herring during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

**Urchins** (common name)
kemagnaq, uutuk (Central Yup'ik)
Kemagnaq, uutuk (St. Lawrence Island Yupik)
*Strongylocentrotus* sp. (scientific name)



Sea urchins within the genus *Strongylocentrotus* were recorded at 75 stations in 2019. In all three surveys (2010, 2017, and 2019) the highest densities were observed just north of St. Lawrence Island (Figure 40).

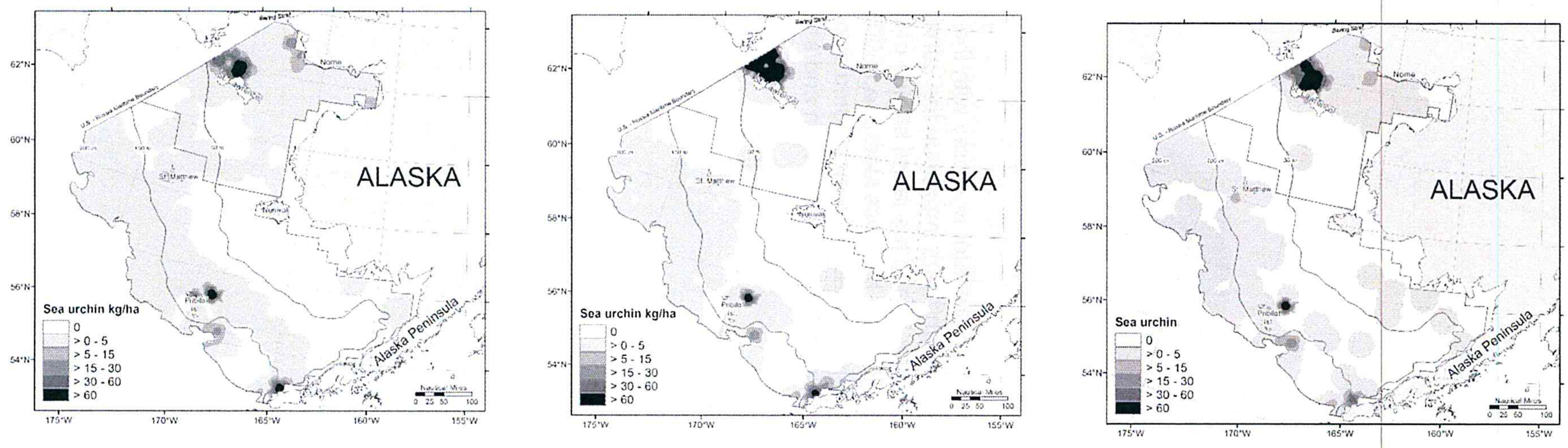
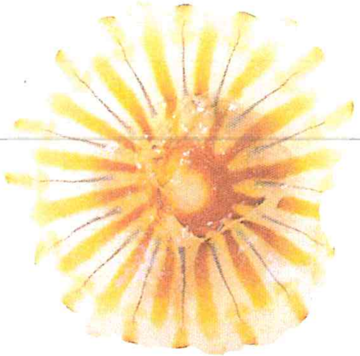


**Figure 40.** Distribution and relative abundance (in kg/ha) of urchins during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## **Jellyfishes** (common name)

Scyphozoa (scientific name)



Jellyfish play important roles as both predator and prey with the Bering Sea ecosystem. Large jellyfish blooms can have a significant impact on the survival of larval and juvenile forage fishes, juvenile pollock, salmon, and the larval stages of many invertebrates, including crabs. In the NBS, the jellyfish biomass increased 590% between 2010 and 2019. In 2019, dense patches of jellyfishes were distributed throughout the NBS (Figure 41). This area also corresponds with the warmer bottom and sea surface temperatures observed.

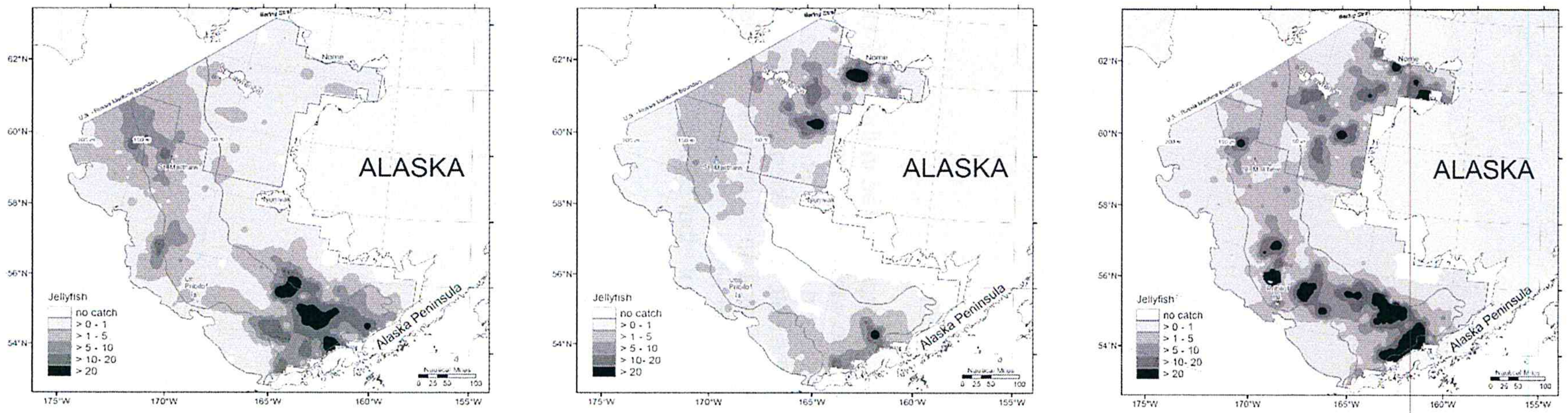
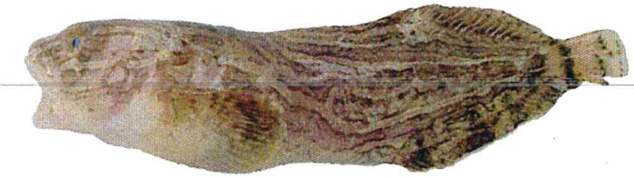
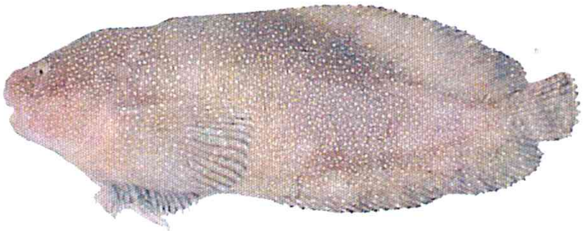


**Figure 41.** Distribution and relative abundance (in kg/ha) of jellyfishes during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

**Snailfishes** (common name)

Liparidae family (scientific name)





The species of snailfish most commonly encountered in the 2019 NBS survey area is the variegated snailfish (*Liparis gibbus*). The variegated snailfish was caught at 8 stations at depths ranging from 16 m to 77 m west and north of St. Lawrence Island (Figure 42). The 2010 NBS survey encountered both the kelp and variegated snailfish species as well as the festive snailfish (*Liparis marmoratus*) and an unidentified *Liparis* species. In 2019, a total of 18 variegated snailfish were caught while 711 were caught in 2010. Species information was added to report by request of tribal councils.

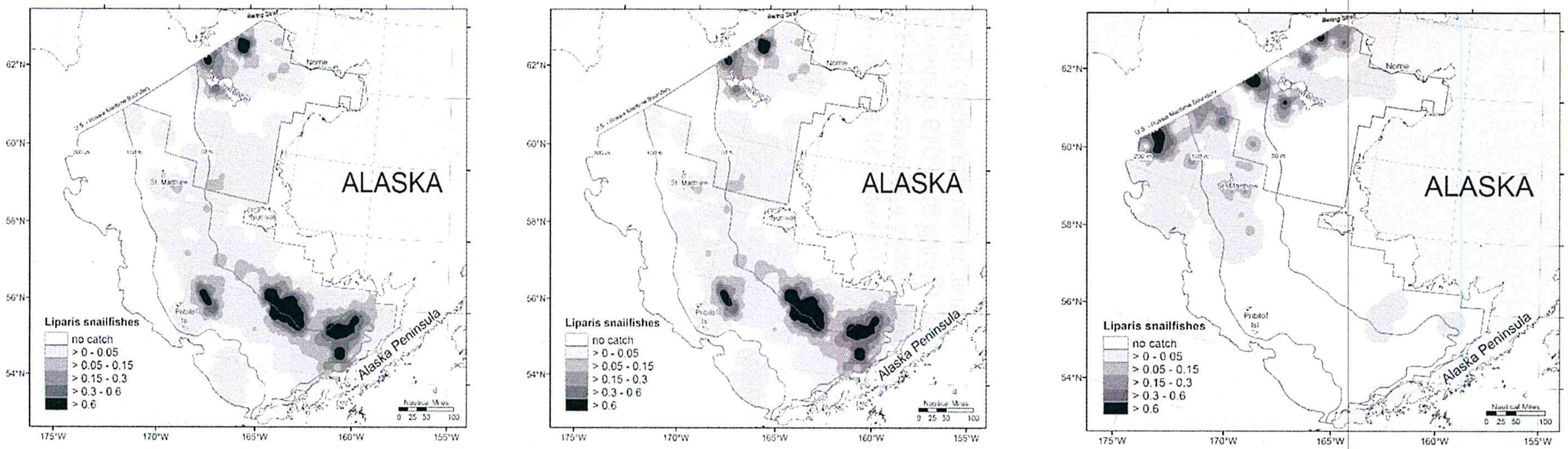


**Figure 42.** Distribution and relative abundance (in kg/ha) of snailfishes in the genus *Liparis* during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

**Sea onion** (common name)
Genus *Boltenia* (scientific name)

Sea onions are stalked, solitary ascidians, which are widely distributed in the North Atlantic, North Pacific, and Bering Sea. During the 2019 survey of the northern Bering Sea, sea onions were found at highest density just north of St. Lawrence Island. They were caught at 24 NBS stations, at depths between 15 and 50 m (Figure 43).

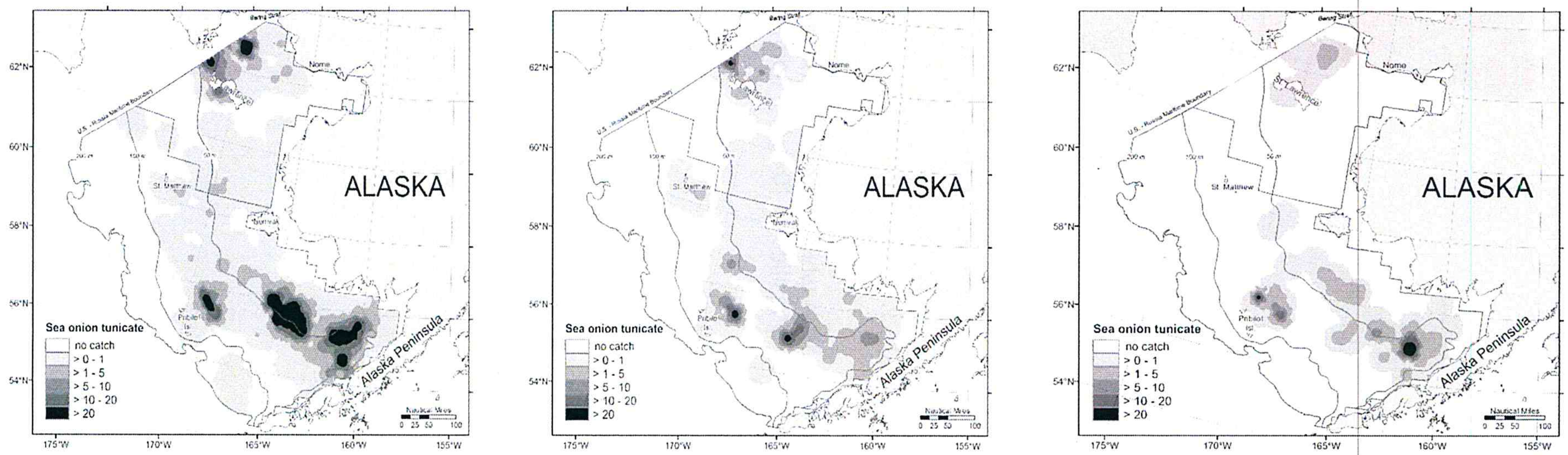


**Figure 43.** Distribution and relative abundance (in kg/ha) of sea onions during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

**Sea peach** (common name)
Genus *Halocynthia* (scientific name)

Sea peaches are large, solitary ascidians which are often found in groups. In 2019, in the NBS, sea peaches were found at low densities (0-10 kg/ha) north-northeast and southeast of St. Lawrence Island (Figure 44).

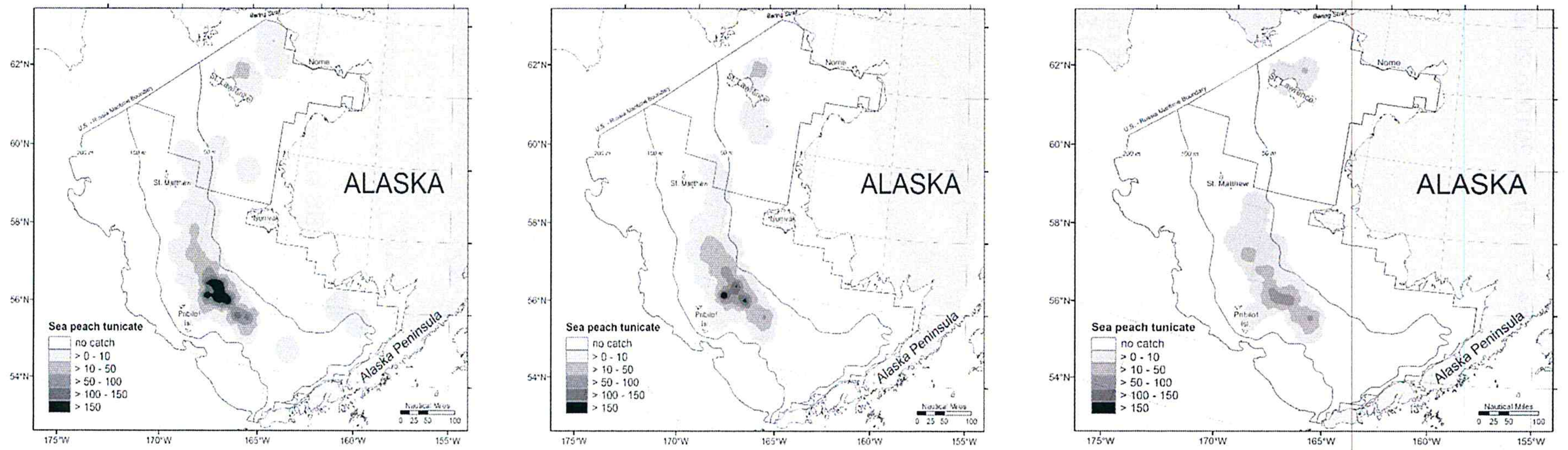


**Figure 44.** Distribution and relative abundance (in kg/ha) of sea peaches during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

## Smelts (Osmeridae) include eulachon, capelin, and rainbow smelt

The family of smelts biomass decreased 70% from 2010 to 2019 (Table 1). Individual species information is below.

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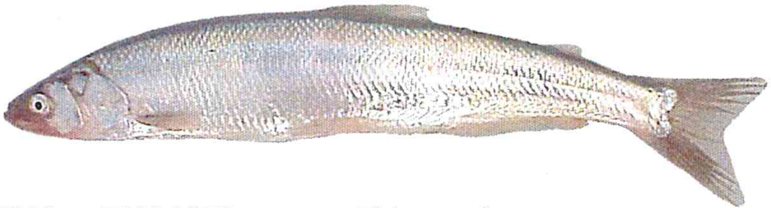
**Eulachon** (common name)
*Thaleicthys pacificus* (scientific name)

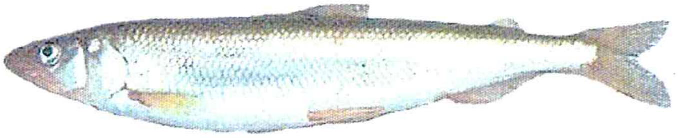


Eulachon were not caught during the 2010 or 2019 NBS surveys. This species was present at 2 stations during the 2017 NBS survey with depths ranging from 34 m to 35 m. The distribution of eulachon in 2019 was south of Nunivak and St. Matthew Island in the eastern Bering Sea (Figure 45).

**Capelin** (common name)
*Mallotus villosus* (scientific name)

In 2019, capelin were present at 22 stations with depths of 31–67 m. These fish were relatively evenly distributed through the central area of the NBS (Figure 46).

**Rainbow Smelt** (common name)
*Osmerus mordax* (scientific name)



Rainbow smelt were present during the 2019 NBS survey at 64 of 144 stations with depths of 9–45 m (Figure 47).

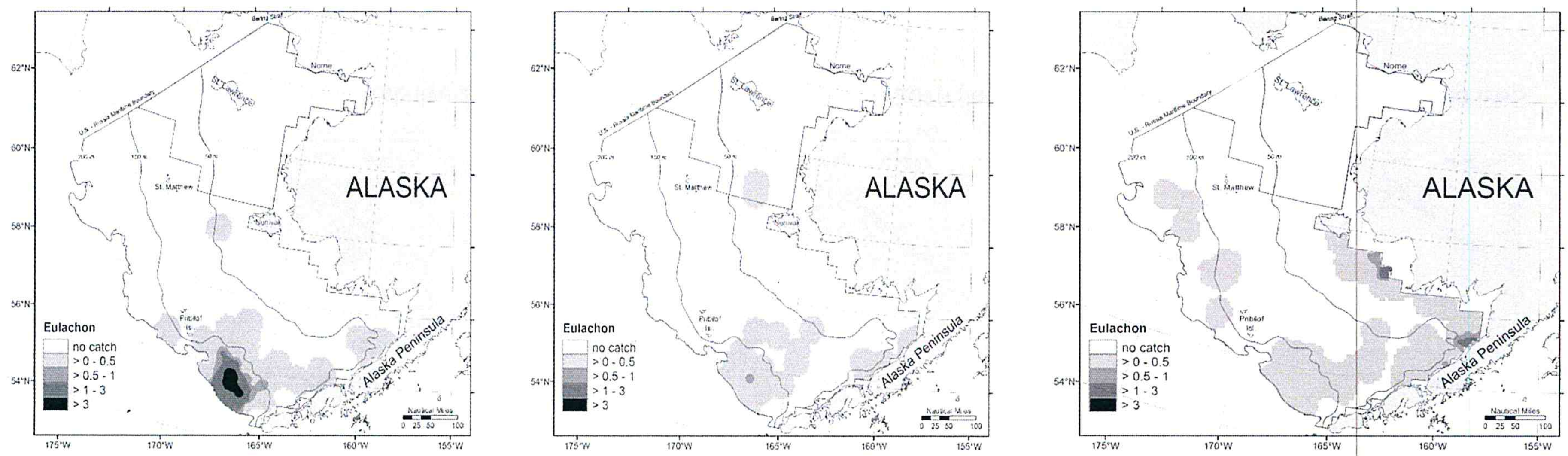


**Figure 45.** Distribution and relative abundance (in kg/ha) of eulachon during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

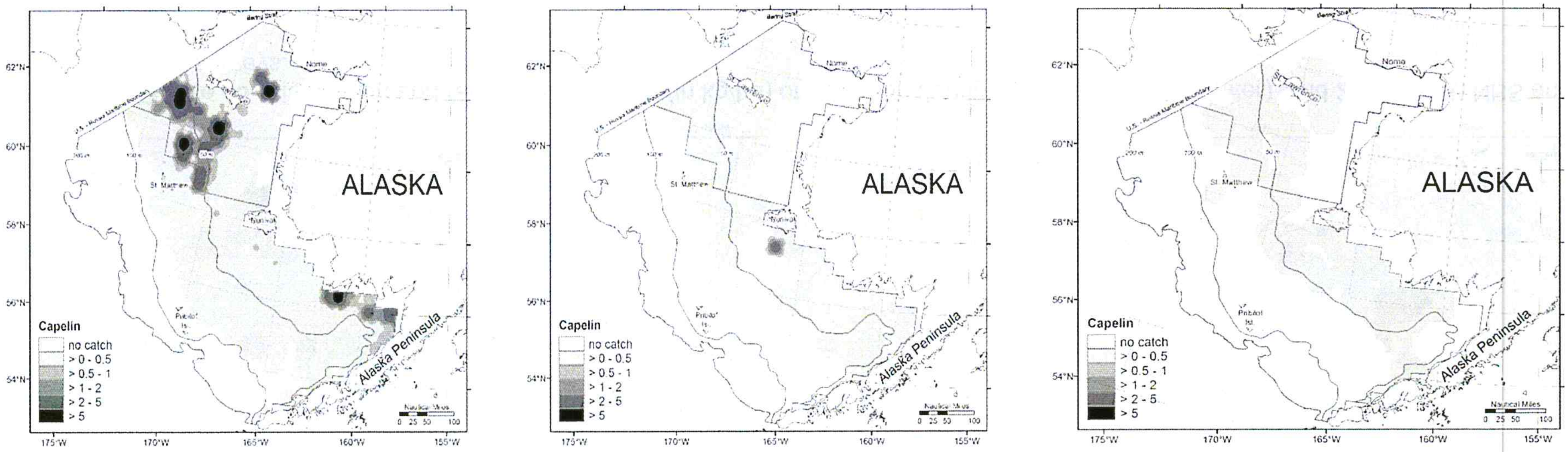


**Figure 46.** Distribution and relative abundance (in kg/ha) of capelin during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

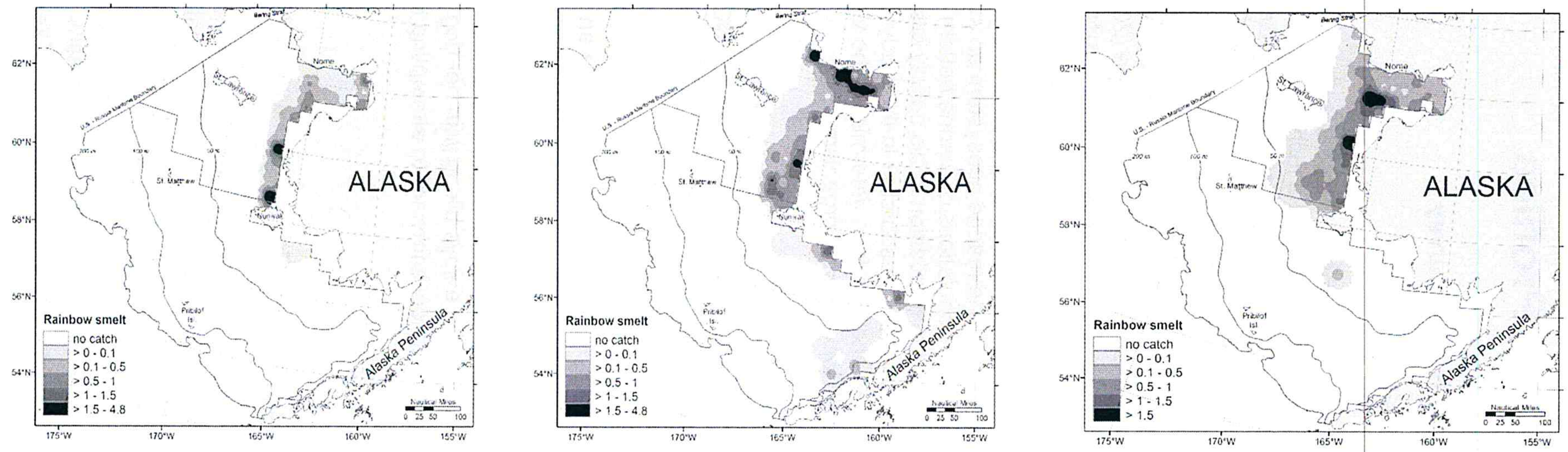
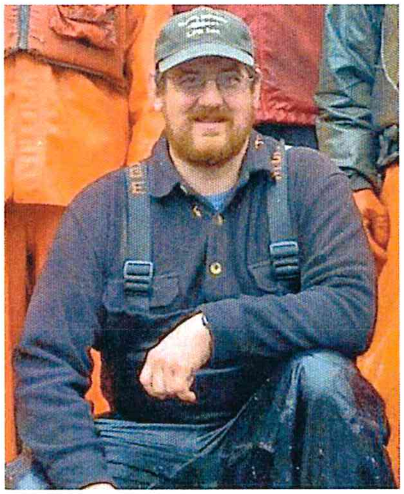


**Figure 47.** Distribution and relative abundance (in kg/ha) of rainbow smelt during 2010 (left), 2017 (center), and 2019 (right) NBS and EBS surveys.

# Appendix B: Scientist Profiles

## Meet the Scientists who conducted the survey

### Lyle Britt, Research Survey Chief Scientist



Lyle is a Supervisory Research Fisheries Biologist with the NOAA Fisheries Alaska Fisheries Science Center in Seattle, Washington. Lyle has been with the Center for 24 years and leads a team of scientists that coordinate standardized bottom trawl surveys in the Bering Sea and Alaska Arctic regions. Lyle's team conducts annual surveys of the eastern Bering Sea shelf (10 – 200 m) and biennial surveys of the Bering Sea upper continental slope (200 -1,200 m) and Northern Bering Sea. He is also responsible for managing the time-series of legacy survey data from the Bering Sea and providing results from survey analyses to all interested individuals or groups. Survey results are essential for monitoring the marine ecosystem as well as for assessing trends in populations of marine bottom fishes, crabs and other marine life. In addition to his survey responsibilities, Lyle is also a leading researcher in the study of light and optics in the ocean and its role in determining the visual capability and behavior of marine organisms.

### Rebecca Haehn, Bering Sea Group

Rebecca is a Fish Biologist with the NOAA Fisheries Alaska Fisheries Science Center in Seattle, Washington. Rebecca joined the Bering Sea group in 2017 and has previously participated with coastal fisheries research in New York, Alaska, southern California, Florida and Mississippi. With the AFSC, Rebecca is responsible for assisting senior scientists with survey logistics and staffing, and acts as field party chief and deck scientist on the NBS survey. During her off time in Seattle, she enjoys hiking with her dog, her friends and their dogs, and looks forward to attempting to snowshoe this winter.

### Liz Dawson, Bering Sea Group

Liz has been a Fish Biologist with NOAA Fisheries Alaska Fisheries Science Center in Seattle, Washington since January 2017. Prior to beginning her position in Seattle, Liz worked as a contractor for the National Marine Fisheries Service in Arcata, California on Endangered Species Act consultations. In her current position, Liz participates in the annual Bering Sea surveys and helps senior scientists in the Bering Sea group with survey logistics, packing and planning, and analyzing and writing up the survey results. Liz grew up snowmobiling and ice fishing in Minnesota. In her free time, Liz enjoys backpacking, mushroom hunting, and whitewater rafting.

**Duane Stevenson, Research Survey Chief Scientist**

Duane is a Research Fishery Biologist with the NOAA Fisheries Alaska Fisheries Science Center in Seattle, Washington, and has been working with the AFSC in the Bering Sea for 18 years. He is an expert in the taxonomy and evolutionary relationships of marine fishes, and his research focuses on the identification and distribution of fishes in Alaska's marine ecosystems. Duane also works closely with the North Pacific Observer Program, where he has been training observers to identify fishes and invertebrates for over 20 years. More recently, he is responsible for developing training materials for fishery observers working throughout Alaska, designing and implementing quality control measures, and analyzing patterns in observer-collected fishery data.

If you have any questions or would like more information, please contact:

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Email: lyle.britt@noaa.gov