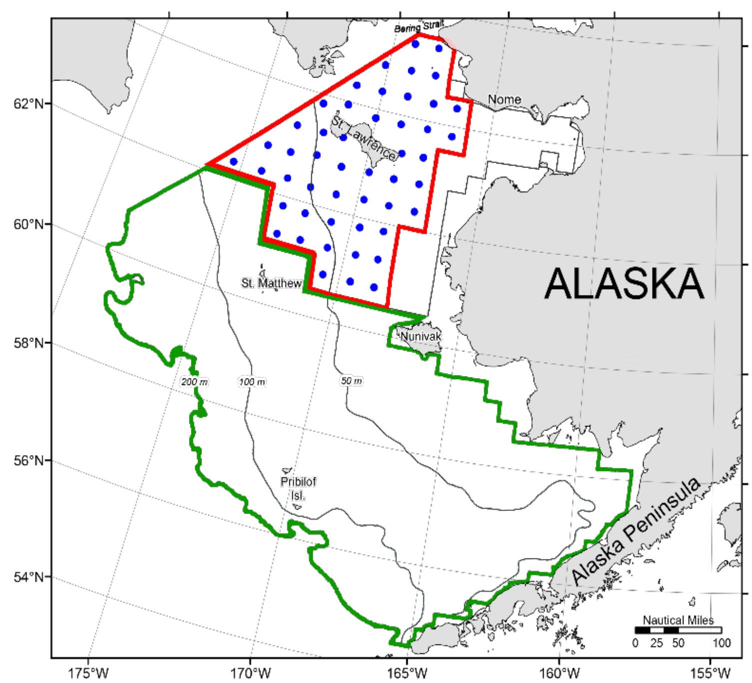
2018

Summary of Results from the Rapid Response Bottom Trawl Survey of the Northern Bering Sea Region with Comparisons to the 2010 and 2017 Northern Bering Sea Standard Surveys



Bering Sea Group

Alaska Fisheries Science Center

Bob Lauth, Lyle Britt, Liz Dawson, and Rebecca Haehn

Introduction

In 2018, the 37th annual eastern Bering Sea (EBS) shelf bottom trawl survey was extended northward to include 49 additional stations in an area bounded by the Bering Strait, Norton Sound, and the U.S.–Russia Maritime Boundary (Figure 1). This rapid response survey of the Northern Bering Sea (NBS) was conducted in response to warmer than average seafloor water temperatures and changes in historical fish and invertebrate distribution patterns observed during the EBS survey. These survey observations, when linked with reports from NBS communities of unusually warm water conditions and increased incidences of marine mammal strandings, seabird mortality events, and sightings of rare or unusual fish and invertebrate species, justified extending survey operations into the NBS region for an integrated effort to document changes over a larger extent of the Bering Sea ecosystem. The 2018 Rapid Response survey represents only the third sampling period in which our survey methodology has been used in the NBS region. Due to funding and time limitations for the 2018 survey, the standardized survey station plan implemented in 2010 and 2017 was reduced in scope and resolution. The standardized 20 x 20 nautical mile sampling grid was reduced in resolution with the use of a 30 x 30 nautical mile grid. And the survey extent was reduced by eliminating sampling in Norton Sound and near the Alaska coastline from near Nome, AK south towards Nunivak Island, AK. (Figure 1). The modified station grid resulted in 49 stations for sampling in 2018.

The Northern Bering Sea survey is a fundamental part of the Alaska Fisheries Science Center's 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. As part of the NOAA LOSI Research Plan, the NBS region is scheduled to be surveyed biennially using the same survey methods employed on the annual EBS shelf bottom trawl survey, contingent on agency funding.

As part of 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 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 2018 NBS survey with snapshot comparisons to survey results from 2010 and 2017. For comparison, historical catch numbers from the 2010 and 2017 surveys have been limited to the survey extent sampled in 2018. Thus, the values in this report for the historical surveys will not match those provided in previous reports.

Continuation of the planned biennial 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 year scheduled for the biennial survey of the NBS region is 2019.

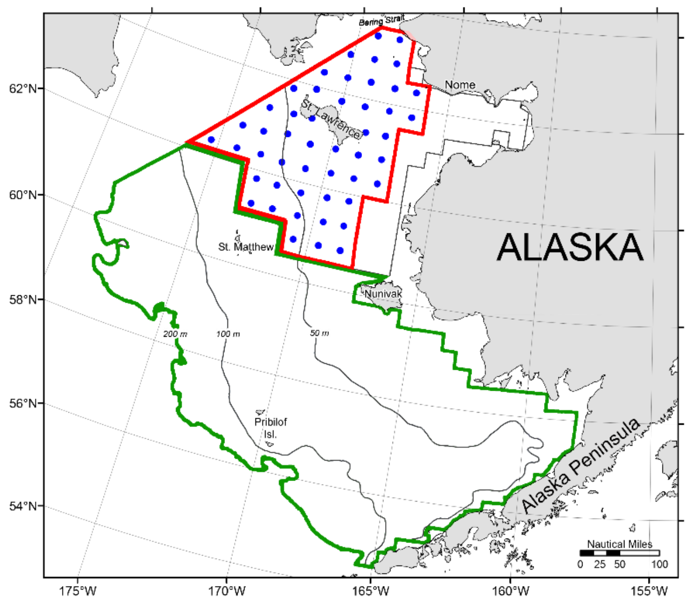


Figure 1. Survey stations sampled in 2018 during the NBS survey. The area enclosed within the green line contains the EBS shelf area that has been sampled annually since 1982, whereas the blue dots within the area outlined in red line are the NBS stations that were sampled in 2018.

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 2018, both vessels transitioned into sampling survey stations in the southwest corner of the NBS survey region. The F/V *Vesteraalen* conducted sampling in the NBS from 31 July to 3 August, and the F/V *Alaska Knight* from 01 August to 14 August.

This year's NBS survey was designed on a 30 × 30 nautical mile (nmi) sampling grid. This resulted in a systematic grid of 49 stations where each sampling station represented a geo-referenced area of 900 square nautical miles (nmi^2) distributed throughout the 46,149 nmi^2 that defined the modified NBS survey area for 2018. 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 189,855 nmi^2. The NBS stations had bottom depths ranging from 9 m to 193 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 is also the protocol for the NBS survey, shallow depths and untrawlable bottom types encountered in some grid cells required sampling locations to be moved elsewhere within a grid cell.

Scientists from the Alaska Fisheries Science Center, several National Oceanic and Atmospheric Administration contracting companies, the Alaska Department of Fish and Game, the International Pacific Halibut Commission, and a student volunteer from University of Washington participated in the survey. Lead scientist profiles can be found in Appendix A.

Both vessels were equipped with the standard research bottom trawl that has been historically used for EBS shelf, NBS, Chukchi, and Beaufort Sea surveys, called an 83/112 Eastern otter trawl (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 each of the 49 stations. The cumulative area sampled from all 49 stations covered a total area of about 0.6 nmi^2, or 0.001 % of the total area of the NBS survey area.

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

Catches of less than approximately 1,150 kg (2,500 lb) were sorted and weighed in their entirety whereas larger catches were subsampled. Fish, crab, 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 are counted and weighed. Counts are not obtained for colonial animals where individuals are difficult to define. For the predominant fish species encountered, after weighing a subsample, they were sorted by sex and 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.

For size composition estimates, the proportion of fish or crab at each 1 cm length 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 fish, crab, 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).

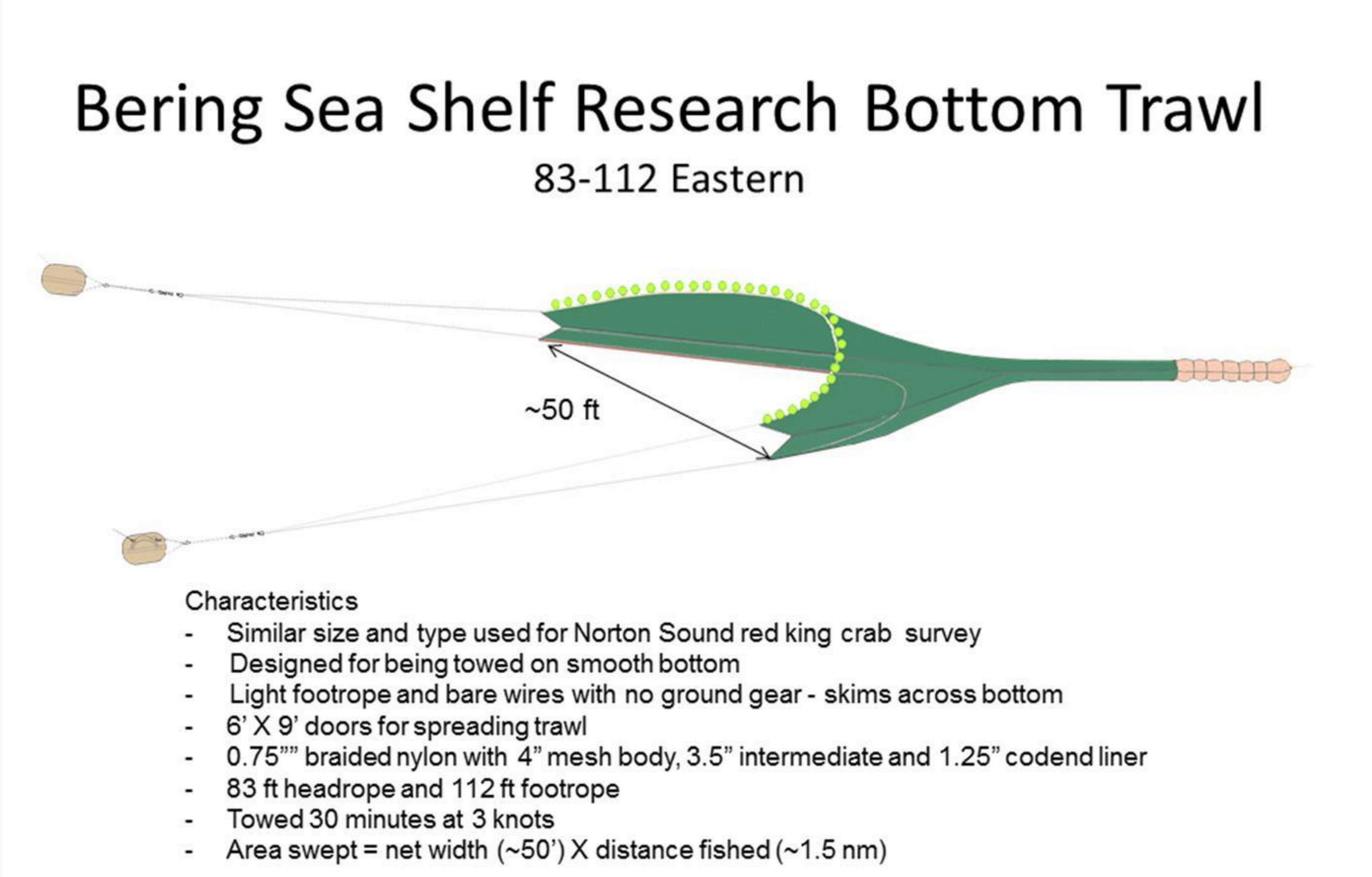


Figure 3. Diagram and specific characteristics of the 83/112 Eastern trawl net.

Survey Results with Snapshot Comparisons to previous NBS surveys

Seafloor Bottom Temperature

Seafloor bottom temperature, hereafter referred to as bottom temperature, is a major environmental driver that can affect the distribution of fishes, crabs, and other invertebrates on the shelf. Environmental conditions leading up to the summer of 2017 and 2018 were much different from those leading up to the 2010 survey (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 – 2018 were warmer than average ("warm stanza"). During the 37-year time series (1982–2018) 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 2.5°C (Figure 4A) .

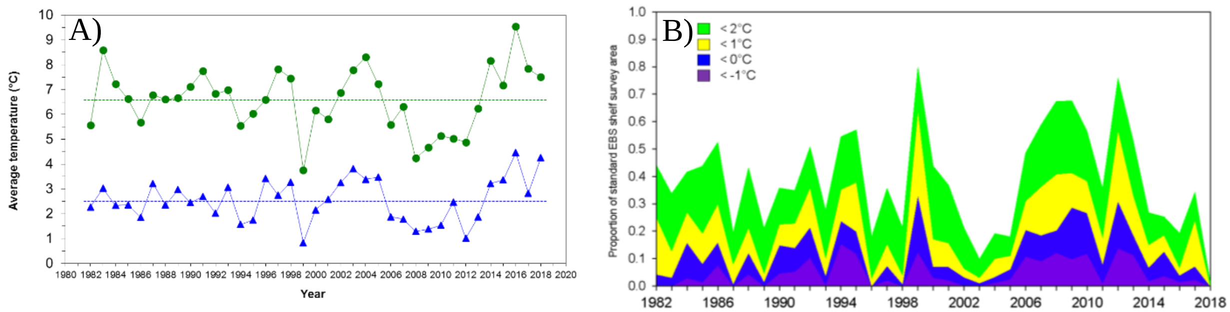


Figure 4. Mean summer bottom temperatures for the 37-year times series from the eastern Bering Sea shelf bottom trawl survey (A) and the cumulative proportion of EBS shelf area covered by each one-degree bottom isotherm range (B).

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 37-year time series, the areal coverage of the summer survey cold pool has varied greatly in size from very small to 394,000 km^2, comprising 1.4% to 80% of EBS shelf area (Figure 4B). In 2018, the 'cold pool' was confined to a very small part of standard EBS survey area, the cold pool was at the lowest areal coverage in the 37-year EBS shelf time-series, and it was the first time that bottom temperatures <0°C were not observed within the standard EBS survey area.

Bottom temperatures observed during the 2018 NBS survey ranged from 0.7° to 9.6°C (Figure 5). In 2010, the overall mean bottom temperature was cooler (2.00°C) than 2017 (4.48°C) and 2018 (3.94°C). Mean bottom temperatures on the EBS shelf were cooler in 2017 (2.66°C) and 2018 (4.16°C) than in 2016 (4.21°C). Similarly, sea surface temperatures were warmer in 2017 and 2018. Most of the NBS had a surface temperature above 10°C in 2017 and 2018, whereas only Norton Sound had sea surface temperatures above 10°C in 2010 (Figure 6). During all 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 2018 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 2018, 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 fauna. The cold pool in 2017 extended to within 50 km of the Alaska Peninsula, but bottom temperatures along the entire length of the inner shelf from Bristol Bay up to Chirikov Basin were relatively warm (>3°C). Although east-west movement of demersal fauna over much of the shelf may have been limited by the 2017 cold pool, the inner shelf was certainly an open corridor for north-south movement, especially between Nunivak Island and Chirikov Basin where bottom temperatures exceeded 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 year-round in the transboundary basin extending from the Gulf of Anadyr on the middle shelf past the west side of St. Lawrence Island. However, in 2018, even this persistent portion of the cold pool was warmer and reduced in extent to a small region just southwest of St. Lawrence Island.

Given that some fish and invertebrate species appear to actively avoid areas of colder temperatures, the location and extent of the cold pool may hinder transboundary fish movement. Recent and progressive reductions in the extent of the cold pool in 2017 and 2018 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 must adjust to sub-optimal conditions or redistribute due to the reduction in available cold pool habitat.

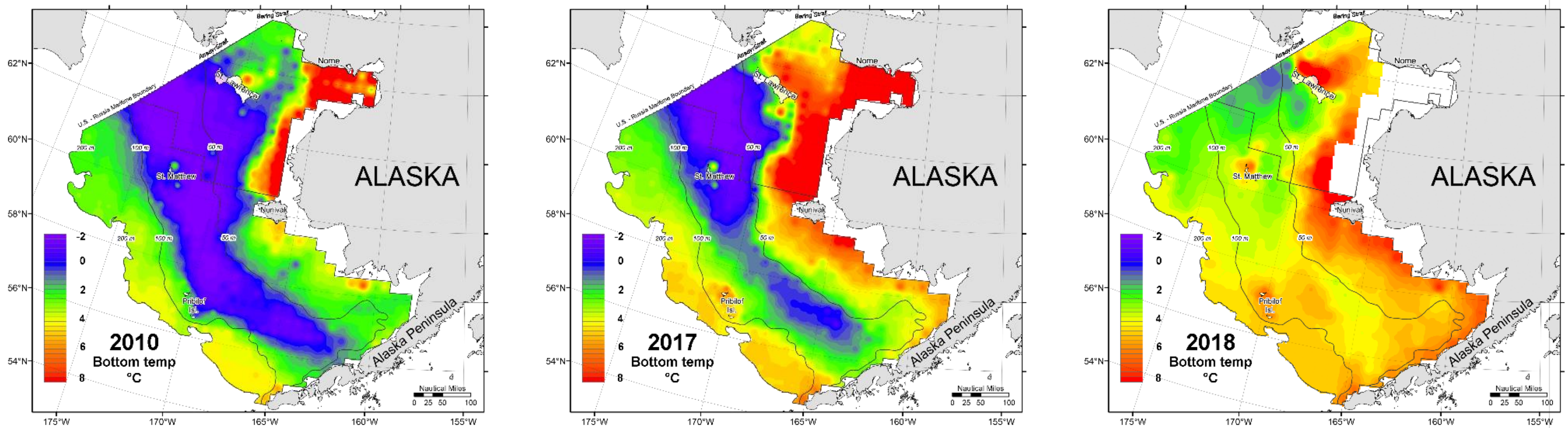


Figure 5. Distribution of survey bottom temperatures for 2010 (left), 2017 (center), and 2018 (right), the three years that the EBS survey was expanded to include the northern Bering Sea shelf.

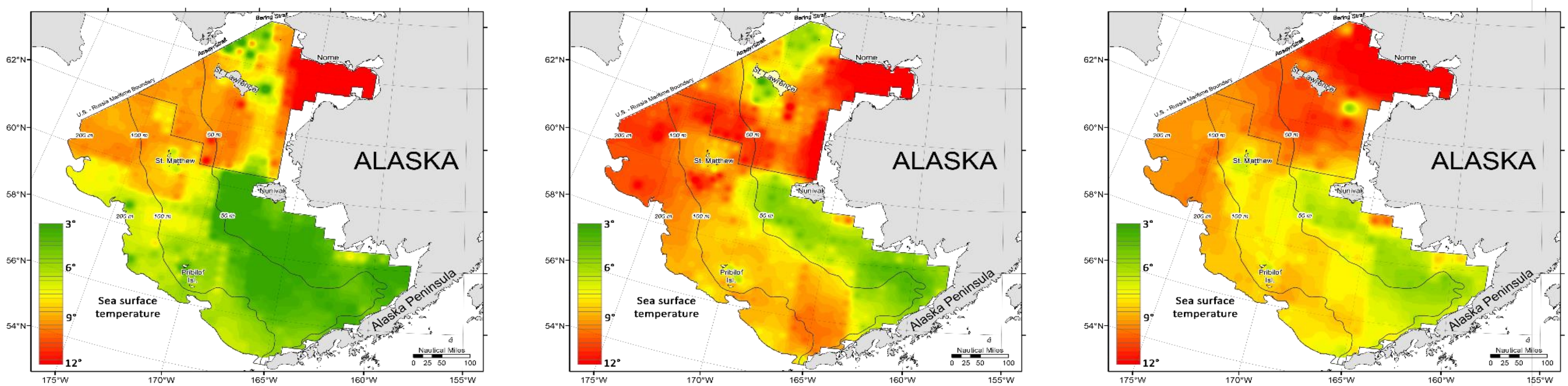


Figure 6. Sea surface temperatures (°C) recorded in the eastern Bering Sea shelf and northern Bering Sea in 2010 (left), 2017 (center), and 2018 (right).

Survey Data and Specimen Collections

From the 2018 EBS and NBS shelf trawl surveys combined, a total of 213,302 individual length measurements representing 41 fish taxa were collected. Additionally, 8,003 age structures (otoliths) were collected from 11 fish taxa, 7,285 stomach samples from 5 fish taxa, 200 Pacific cod genetic samples, and 1,179 pathobiology (blood) samples from 2 different crab taxa were collected for analysis by researchers. In addition, an IPHC sampler on board on vessel collected 411 Pacific halibut otoliths, 181 Pacific halibut tissue samples, 542 Pacific halibut fin clips, and a total of 768 tagged Pacific halibut were released.

Abundance of Fish, Crabs, and Other Invertebrates

In 2018, the total bottom-dwelling animal biomass of the EBS shelf was estimated at 12.9 million metric tons (mmt), while that of the NBS was estimated at 4.6 mmt. In 2017, our survey (amended based on the areal extent of the 2018 survey) estimated the total bottom-dwelling animal biomass of the EBS shelf at 16.3 mmt and of the NBS at 4.4 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 2.6 mmt. The percent change in biomass varied by fish and invertebrate taxon (Table 1). There were increases in biomass for 25 taxa and decreases for 16 taxa. Large increases were observed with walleye pollock (5,640%), Pacific cod (2060%), jellyfishes (162%), sea urchins (245%), northern rock sole (540%), broyozoans (437%), green sea urchins (245%), Pacific halibut (150%), red king crab (144%), Pacific herring (90%), and blue king crab (61%). when comparing the catch in 2010 (cold year) to 2018 (warm year). Decreases in biomass were observed in Arctic cod (-100%), tunicates (-60%), smelts (-98%), snailfishes (-77%), other sculpins (-69%), snow crab (-45%), eelpouts (-43%), purple-orange sea star (-34%), and pricklebacks (-31%). 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, but only represented 0.09% of the total biomass in 2018. In 2018, walleye pollock and Pacific cod together comprised 37% of the total biomass in the NBS. 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 CPUE for yellowfin sole was largely unchanged between 2010 and 2018. Arctic flounder, an arctic species, were rare and only present in the northernmost portion of the survey area in Norton Sound in 2010 and 2017. No arctic flounder were caught during 2018, likely a result of the reduced survey extent and effort in 2018. In general, overall fish biomass decreased with increasing latitude in both 2010 and 2018.

Crabs and other invertebrates (i.e., shrimps, sea squirts, sea stars, jellyfish, and urchins) made up 26% of the biomass in 2018, whereas invertebrates made up 49% of the biomass in 2010.

On average, NBS survey catches were smaller compared 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 seastars, 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. However, Arctic cod, which were more abundant in the NBS than the EBS in 2010, declined dramatically in the NBS in 2018.

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

Table 1. List of major taxa or taxonomic groups sampled in the northern Bering Sea shelf bottom trawl survey and the percentage change in biomass (mt) from 2010 to 2018.

		Biomass (mt)			
Common name	**Taxon**	**2010**	**2017**	**2018**	**Change**
walleye pollock	*Gadus chalcogrammus*	19,975	1,338,925	1,146,515	5,640 %
Pacific cod	*Gadus macrocephalus*	26,140	289,264	564,684	2,060 %
jellfishes	Scyphozoa	12,399	53,932	141,812	1,044 %
northern rock sole	*Lepidopsetta polyxystra*	18,368	55,294	117,639	540 %
bryozoans	Bryozoa	2,554	7,590	13,715	437 %
segmented worms	Polychaetes	2,638	7,743	13,717	420 %
sea anenomes	Actinaria	5,531	15,108	19,211	247 %
sea urchin	*Strongylocentrotus* sp.	44,825	168,469	154,805	245 %
other flatfishes	Pleuronectidae	3,403	7,191	11,151	228 %
poachers	Agonidae	344	1,792	911	165 %
Pacific halibut	*Hippoglossus stenolepis*	7,352	15,022	18,397	150 %
red king crab	*Paralithodes camtschaticus*	369	1,630	900	144 %
Alaska skate	*Bathyraja parmifera*	48,929	82,399	116,835	139 %
other snails	Gastropoda	41,030	70,001	96,326	135 %
Bering flounder	*Hippoglossoides robustus*	13,128	20,712	30,025	129 %
neptune whelk	*Neptunea heros*	103,591	180,659	234,996	127 %
Pacific herring	*Clupea pallasii*	21,560	36,350	41,029	90 %
plain sculpin	*Myoxocephalus jaok*	13,528	22,698	24,507	81 %
blue king crab	*Paralithodes platypus*	1,879	5,928	3,023	61 %
shorthorn (=warty) sculpi	*Myoxocephalus scorpius*	39,020	112,557	58,614	50 %
starry flounder	*Platichthys stellatus*	6,359	12,959	8,972	41 %
all shrimps		3,236	2,193	4,169	29 %
hermit crabs	Paguridae	121,136	149,861	150,180	24 %
yellowfin sole	*Limanda aspera*	310,617	368,156	373,373	20 %
other sea stars	Asteridae	94,975	97,255	113,878	20 %
other crabs		180,792	179,306	172,157	-5 %
corals	Anthozoa	11,614	8,242	11,014	-5 %
brittle stars	Ophiuridae	66,058	39,922	62,451	-5 %
clams	Bivalvia	1,984	3,810	1,874	-6 %
basket starfish	*Gorgonocephalus* sp.	65,029	39,075	58,817	-10 %
Alaska plaice	*Pleuronectes quadrituberculatus*	306,750	336,841	274,543	-10 %
saffron cod	*Eleginus gracilis*	4,402	29,533	3,915	-11 %
pricklebacks	Stichaeidae	277	204	191	-31 %
purple-orange sea star	*Asterias amurensis*	164,023	145,948	107,486	-34 %
eelpouts	Zoarcidae	10,790	9,371	6,141	-43 %
snow crab	*Chionoecetes opilio*	337,154	235,697	185,600	-45 %
tunicates	Urochordata	350,060	95,360	139,683	-60 %
other sculpins	Cottidae	9,064	8,730	2,773	-69 %
snailfishes	Liparidae	3,445	5,006	782	-77 %
smelts	Osmeridae	15,431	1,067	240	-98 %
Arctic cod	*Boreogadus saida*	34,239	4,085	11	-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 summary outlining the results. To better illustrate fish movement and distributional trends, geographic distribution and relative abundance maps were extend throughout the EBS shelf and NBS survey regions. For comparison, distribution maps and abundance-at-size plots are provided for 2010, 2017, and 2018 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.

**2018 estimates may be unreliable for some species due to the reduced survey resolution and extent in 2018. The 2018 NBS survey area may not have included areas where species were prevalent in previous years.

Yellowfin Sole (common name)

Limanda aspera (scientific name)

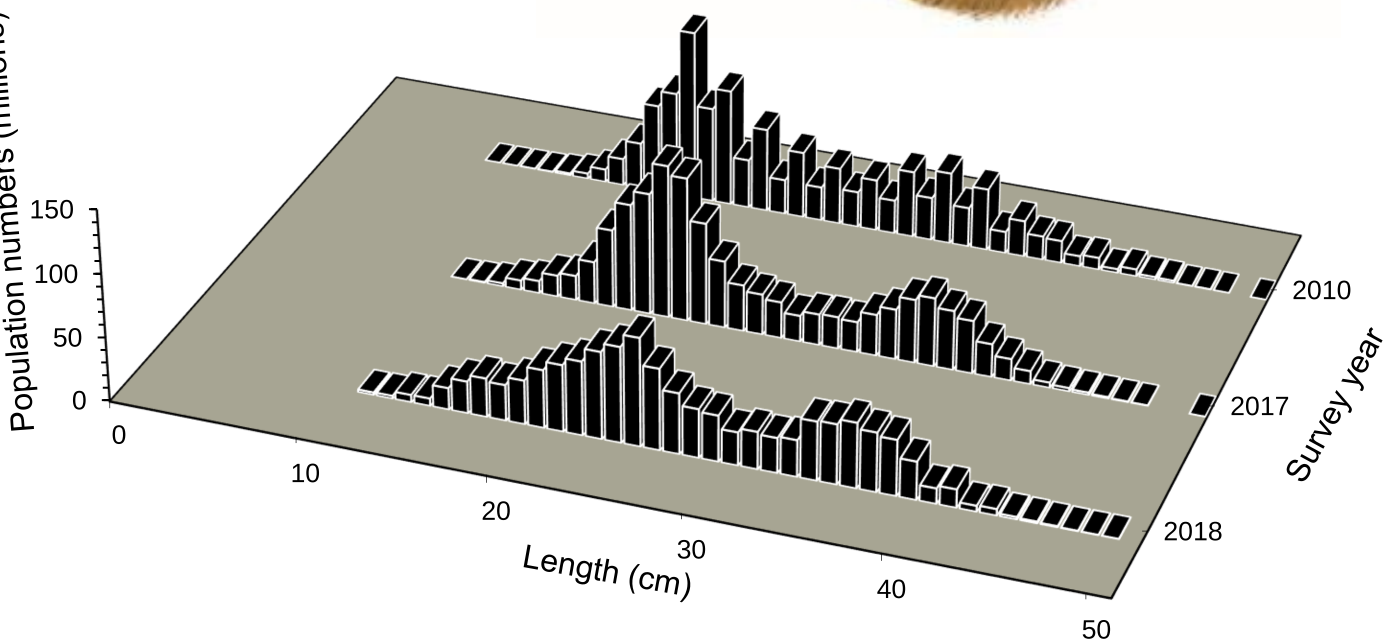


Figure 7. Total abundance-at-size of yellowfin sole in the NBS during 2010, 2017 and 2018.

Yellowfin biomass increased by 20% between 2010 and 2018. Yellowfin sole was the predominant flatfish species observed in the 2018 NBS survey, comprising 8% (373,373 mt, Table 1) of the total NBS survey area biomass. In 2010, yellowfin sole comprised 12% (310,617 mt, Table 1) of the total biomass of the NBS survey. 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 by 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. Size compositions were similar in all year with length cohort nodes around 24 cm and 36 cm (Figure 7). Spatial distribution also remained similar (Figure 8).

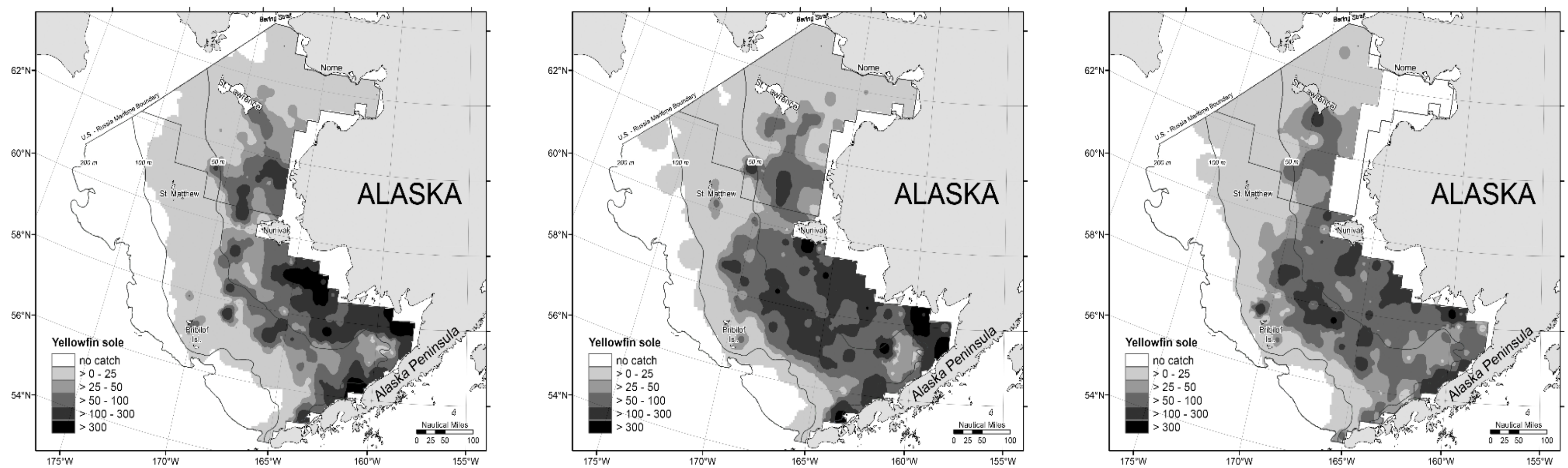


Figure 8. Distribution and relative abundance (in kg/ha) of yellow fin sole during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Snow Crab (common name)

Chionoecetes opilio (scientific name)

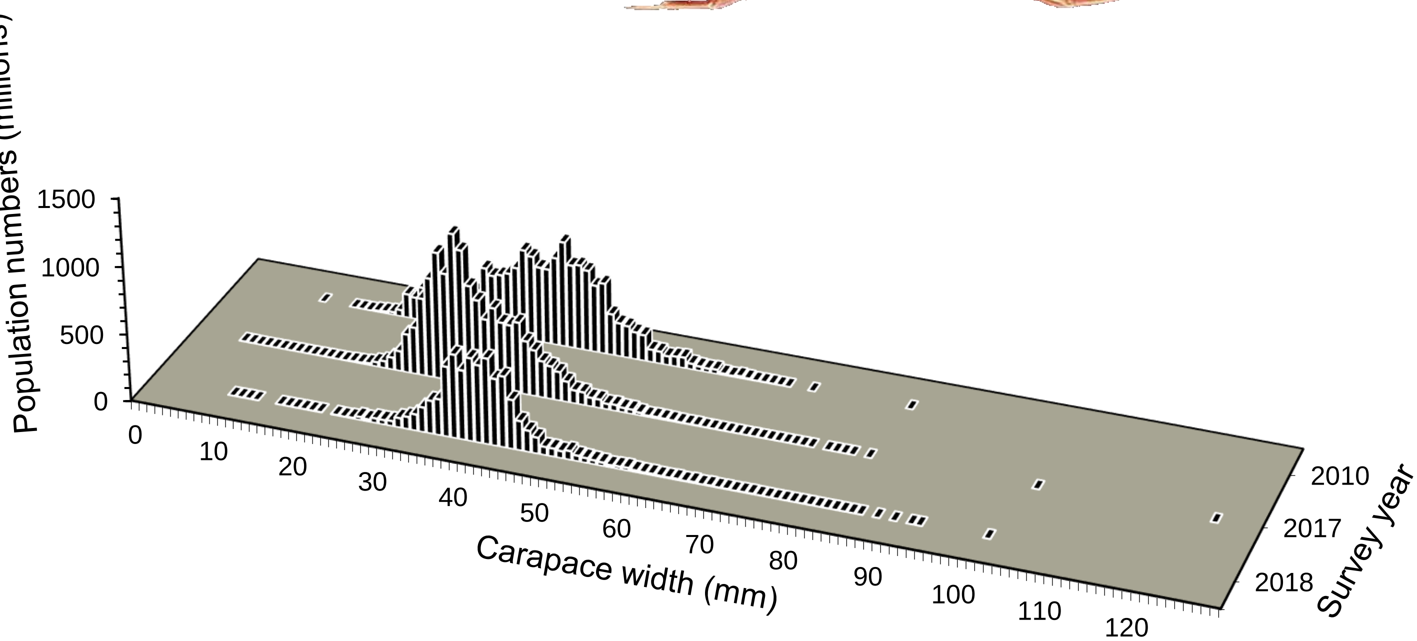


Figure 9. Total abundance-at-size of snow crab in the NBS during 2010, 2017 and 2018.

In 2018, snow crab comprised 4% (185,600 mt, Table 1) of the NBS survey biomass and was caught at 43 of the 49 NBS survey stations. In 2017, snow crab comprised 5% (227,948 mt) of the NBS survey biomass and was caught at 109 of the 144 total NBS survey stations. In 2010, snow crab comprised 11% (324,549 mt) of the survey biomass in the NBS survey area. A majority of both the male and female snow crab in the NBS were sexually immature. Less than 0.01% (less than 1.1kg) of all male snow crab caught in the NBS were ≥ 70 mm carapace width in both 2010 and 2017 (Figure 9). In 2010, highest densities of snow crab were found along the U.S.-Russia Maritime Boundary between the 50 m and 200 m contour lines, whereas in 2018, highest densities were located north and south of St. Matthew Island between the 50 m and 100 m contour line (Figure 10).

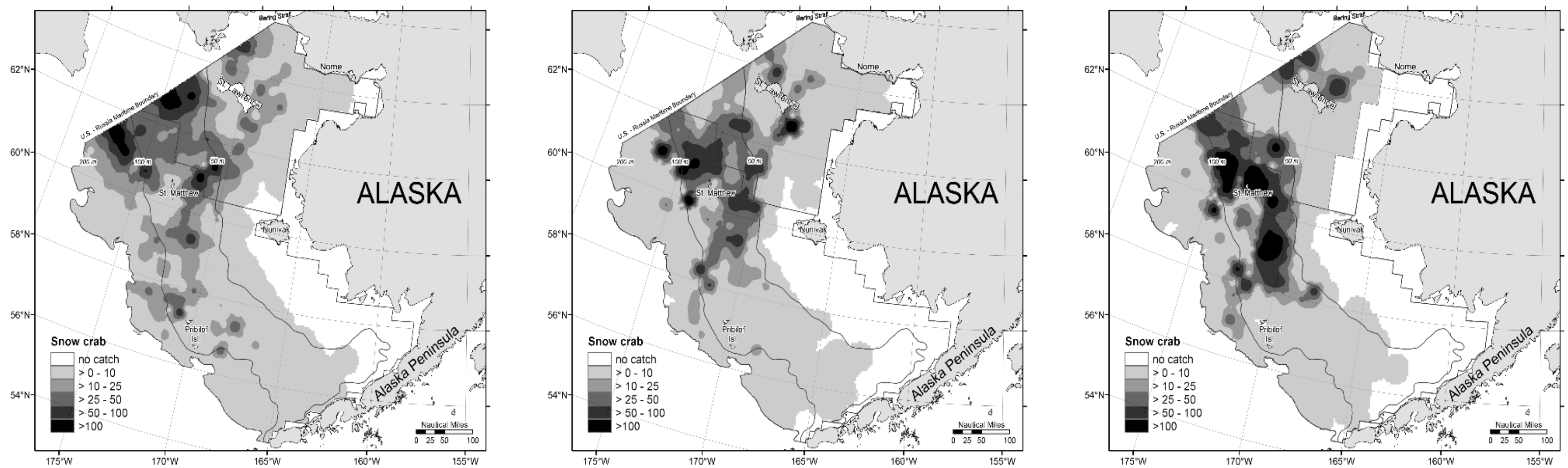


Figure 10. Distribution and relative abundance (in kg/ha) of snow crab during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Alaska Plaice (common name)

Pleuronectes quadrituberculatus (scientific name)

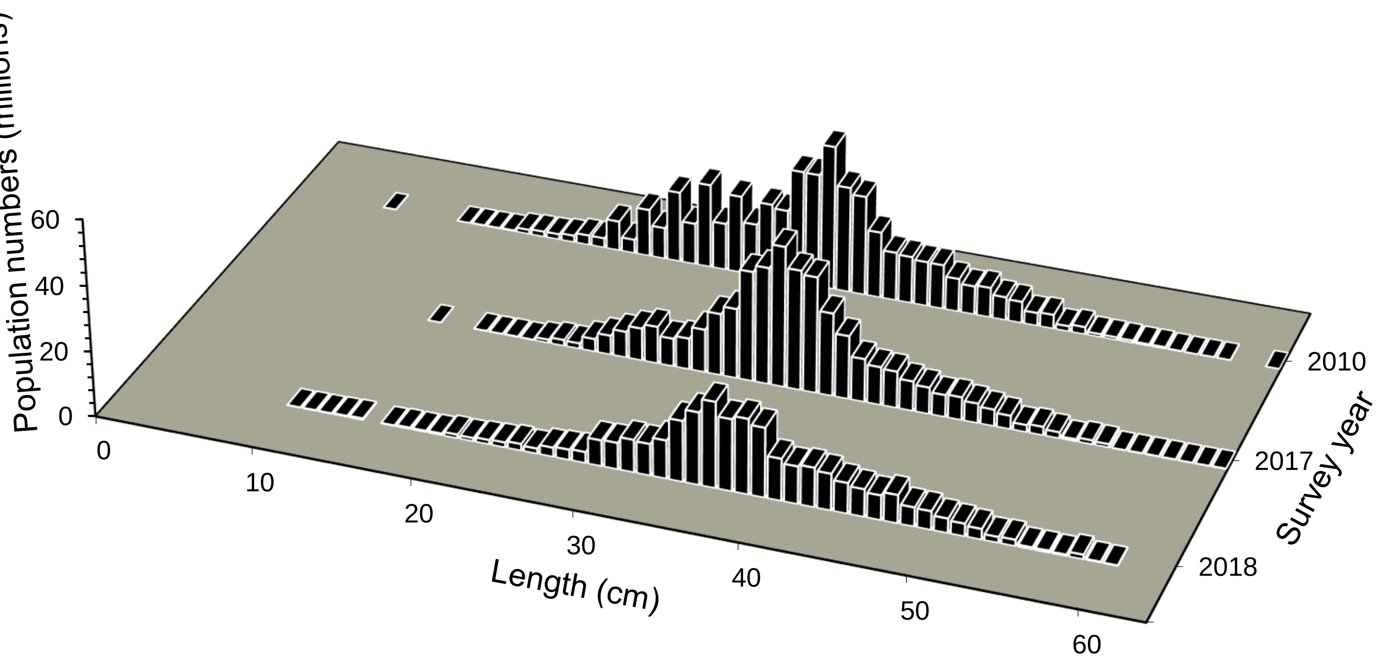


Figure 11. Total abundance-at-size of Alaska plaice in the NBS during 2010, 2017 and 2018.

In 2018, the Alaska Plaice biomass exhibited a 10% decrease (274,543 mt, Table 1) in the total NBS survey biomass compared with 2010 (206,750 mt, Table 1). Individuals that were ~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 between the 50 m and 100 m contour 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 with increasing bottom temperature.

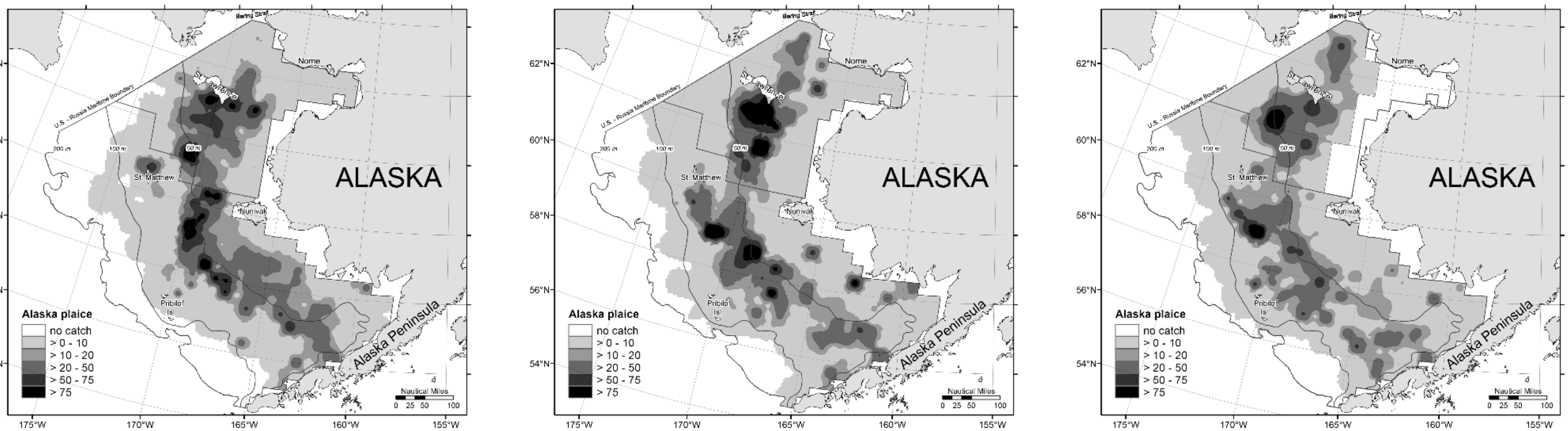


Figure 12. Distribution and relative abundance (in kg/ha) of Alaska plaice during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Purple-orange Seastar (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 2% (107,486 mt, Table 1) of the 2018 total fish and invertebrate biomass in the NBS. Biomass of the purple-orange sea star decreased by 34% between 2010 and 2018. Densities of the purple-orange sea star within the survey area were highest along the southeastern coastline up to the 100 m contour of the inner shelf. Increased densities were also noted along the north eastern boundary at the mouth of Norton Sound in the 2018 NBS Rapid Response survey (Figure 13).

**2018 estimates may be unreliable for this species due to the reduced survey resolution and extent in 2018. The 2018 NBS survey area may not have included areas where species were prevalent in previous years.

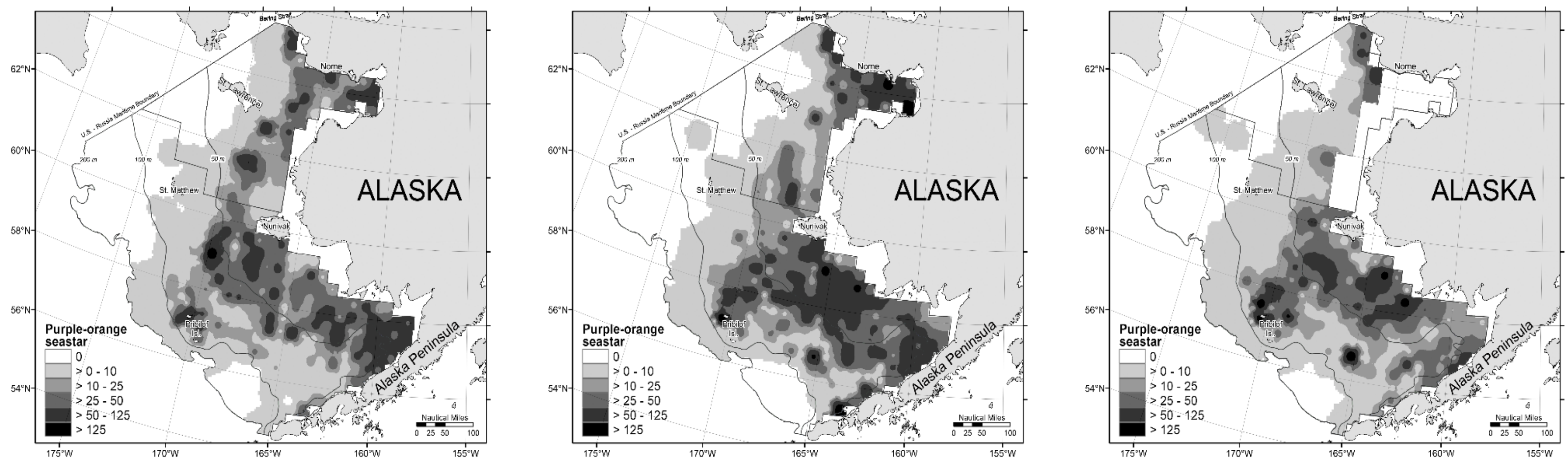


Figure 13. Distribution and relative abundance (in kg/ha) of Purple-orange seastar during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Northern Neptune Snail (common name)

Neptunea heros (scientific name)

The northern neptune snail distribution was highest around the southwest and northeast areas of St. Lawrence Island (Figure 14). The percent biomass remained stable between the 2010 and 2018 northern Bering Sea surveys (4% and 5% respectively) although total biomass for the northern neptune snail increased by 127% (Table 1).

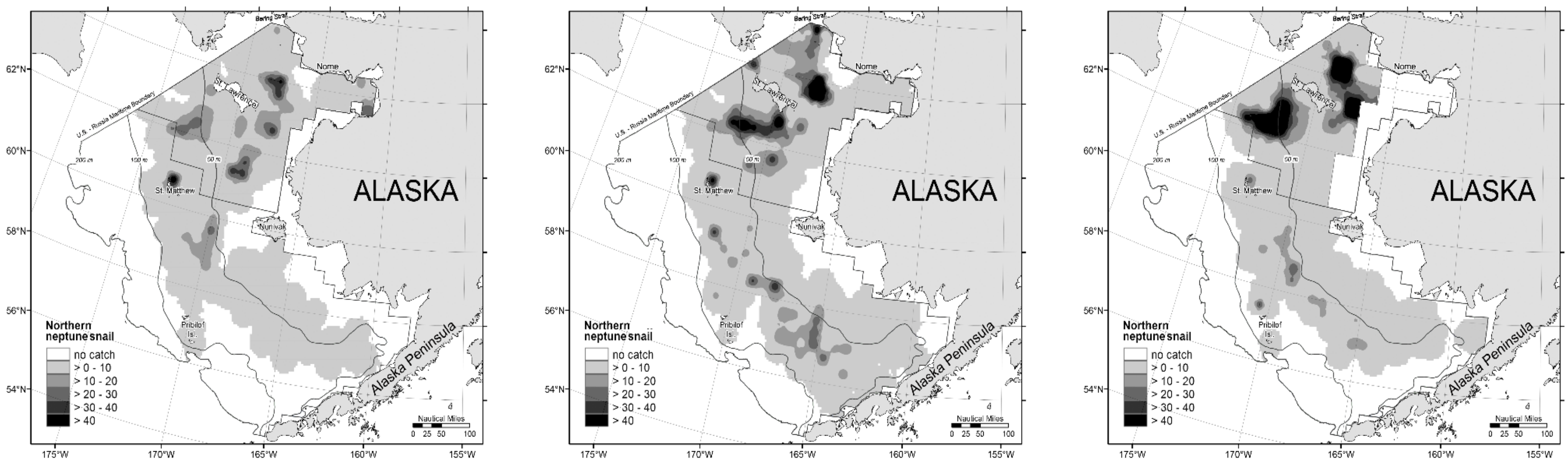


Figure 14. Distribution and relative abundance (in kg/ha) of Northern Neptune snail during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Saffron Cod (common name)

Uugaq (Inupiaq)

Eleginus gracilis (scientific name)

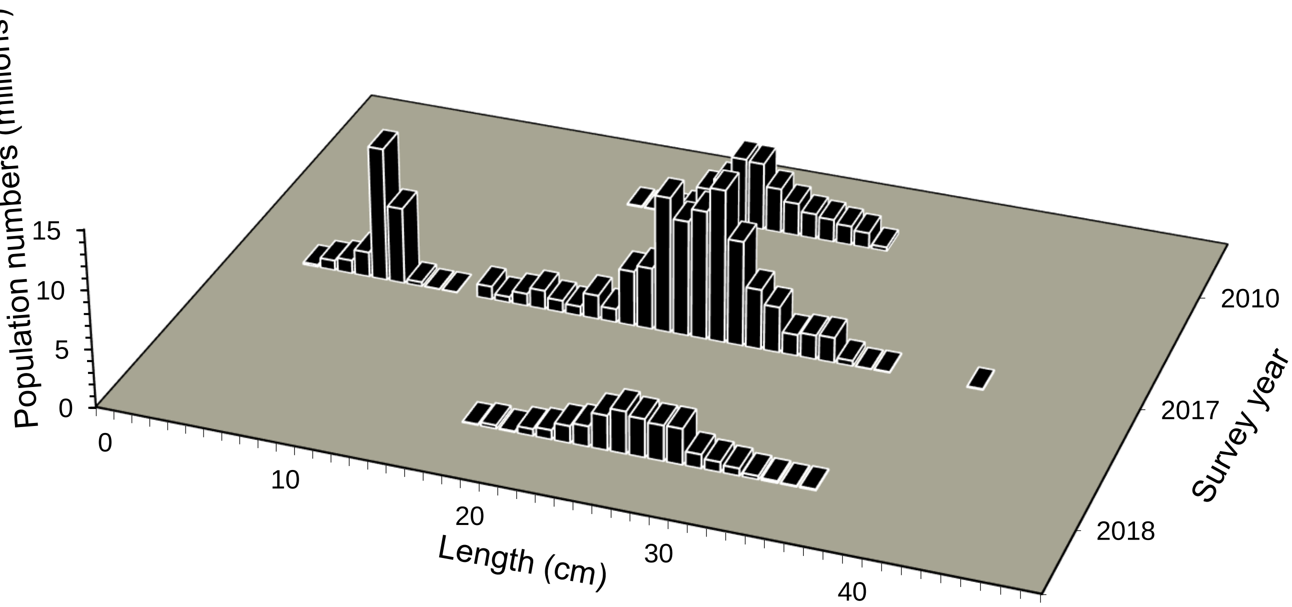


Figure 15. Total abundance-at-size of Saffron cod in the NBS during 2010, 2017 and 2018.

Saffron cod represented less than 1% of the biomass in the 2018 NBS rapid response survey. There was an 11% reduction in saffron cod biomass in 2018 from 2010 (Table 1). These fish were most dense just north of Nunivak continuing north along the east coast of St. Lawrence Island (Figure 16). Saffron cod were present at 18 of 49 stations in 2018 with depths between 24 and 51 meters. Saffron cod are considered to be a more nearshore, bottom species which includes the Norton Sound.

**2018 estimates may be unreliable for this species due to the reduced survey resolution and extent in 2018. The 2018 NBS survey area may not have included areas where species were prevalent in previous years.

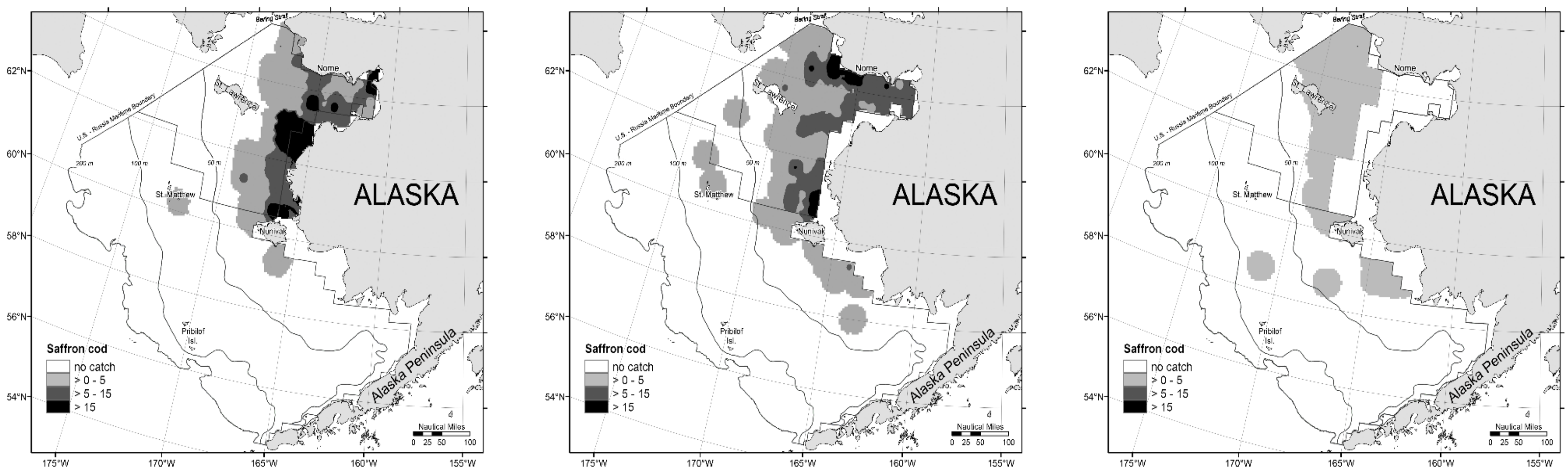


Figure 16. Distribution and relative abundance (in kg/ha) of saffron cod during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Arctic Cod (common name)

Iqalugaq (Inupiaq)

Boreogadus saida (scientific name)

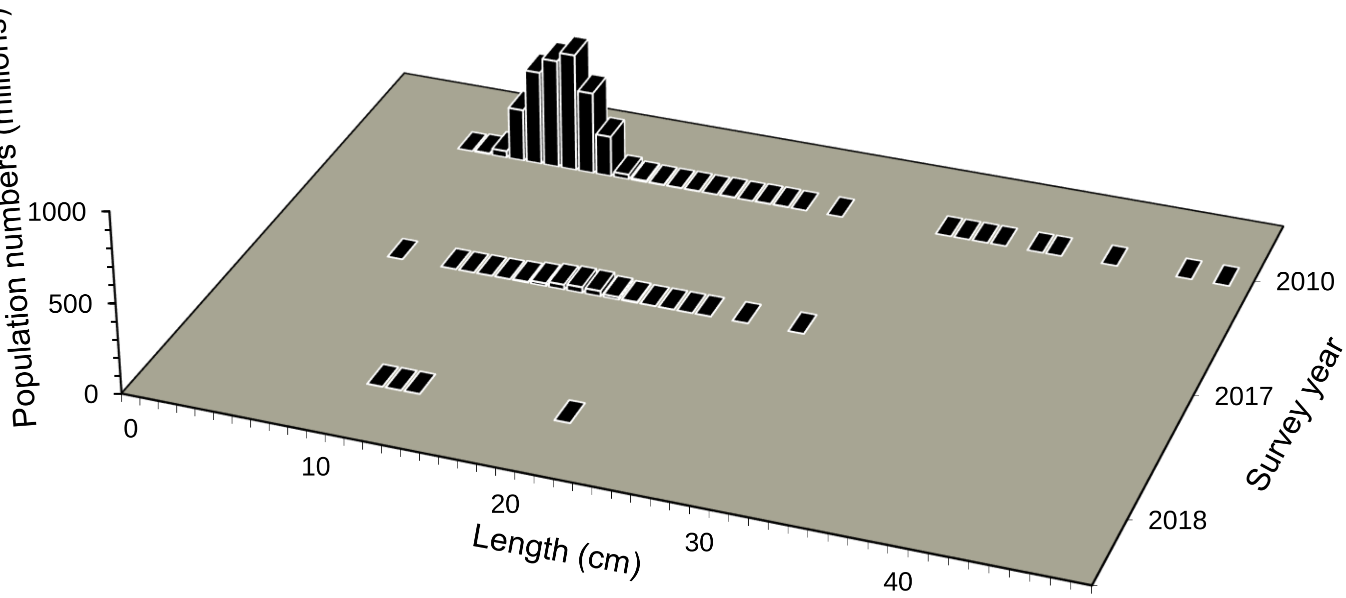


Figure 17. Total abundance-at-size of Arctic cod in the NBS 2010, 2017 and 2018.

Arctic cod represented less than 1% of the 2018 biomass and approximately 1% of the total biomass in the NBS in 2010. Between 2010 and 2018, there was a 100% reduction in Arctic cod biomass. Historically, high densities were recorded in the area of the cold pool with the lowest bottom temperatures (<-1°C). Overall spatial distribution of this forage fish decreased in 2018 (Figure 18).

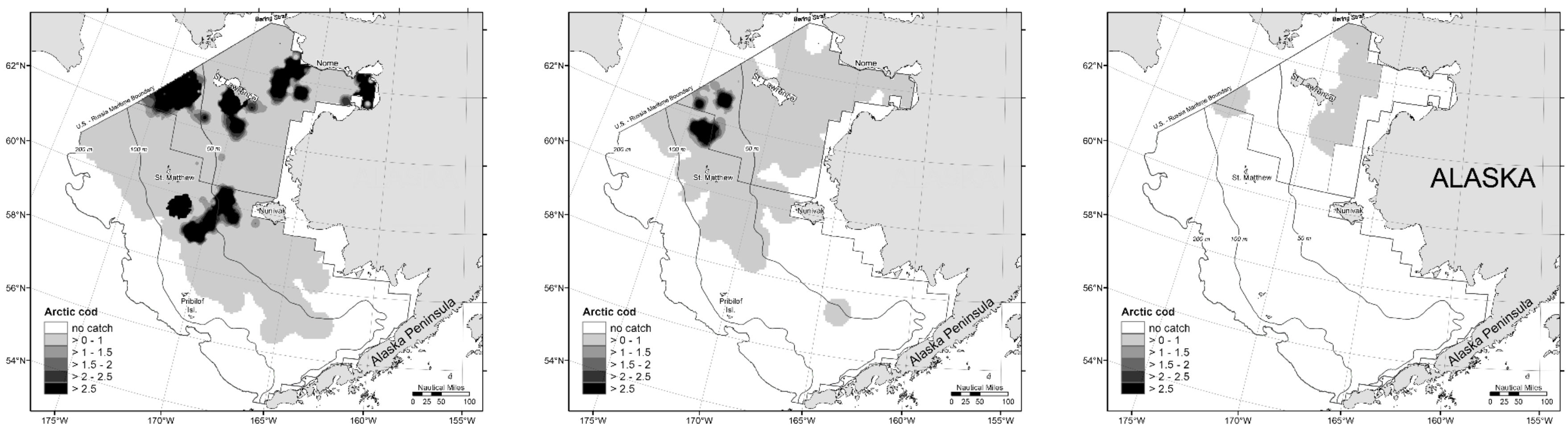


Figure 18. Distribution and relative abundance (in kg/ha) of Arctic Cod during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

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)

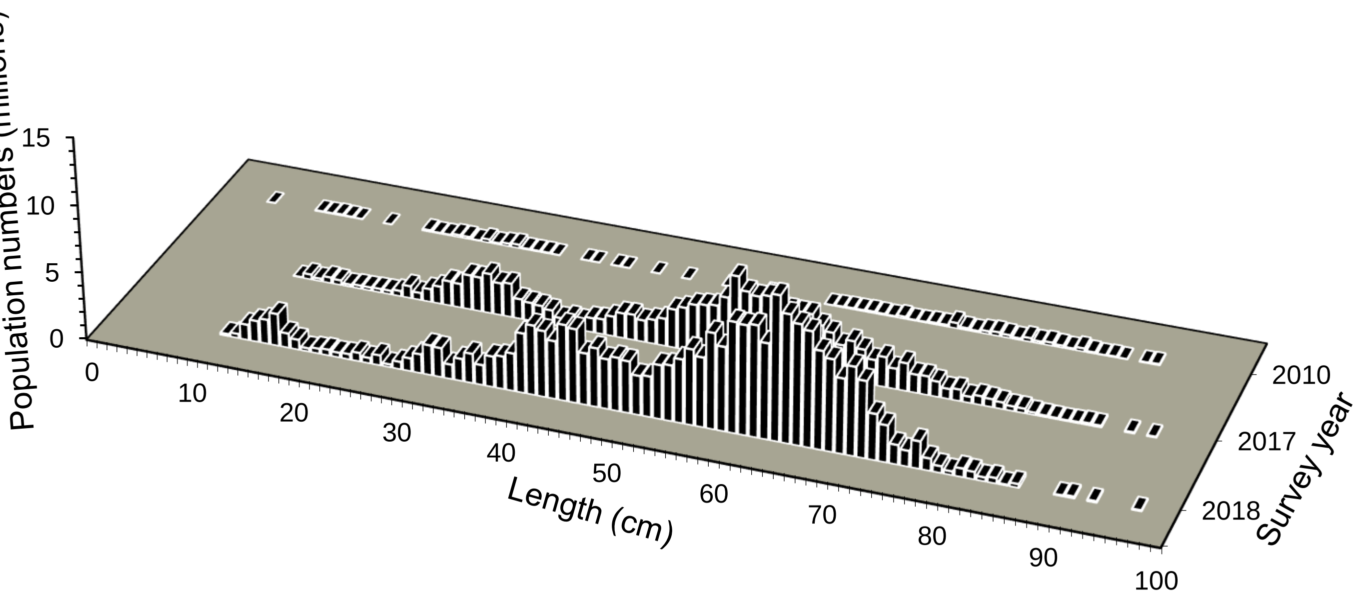


Figure 19. Total abundance-at-size of Pacific cod in the NBS during 2010, 2017 and 2018.

Pacific cod represented about 12% of the biomass in the 2018 NBS rapid response survey by weight. This represents a 2,060% increase from 2010. Pacific cod were present on the northern coastline of the Alaska Peninsula, between the 50 m and 100 m contour lines in the central area of the survey, and occurred in the highest density around St. Lawrence Island continuing to the northern boundary line of the survey (Figure 20). Pacific cod were present at every station in the NBS survey area in 2018 (Figure 20). Size composition in 2018 shows three nodes around 15 cm, 43cm, and 59 cm (Figure 19).

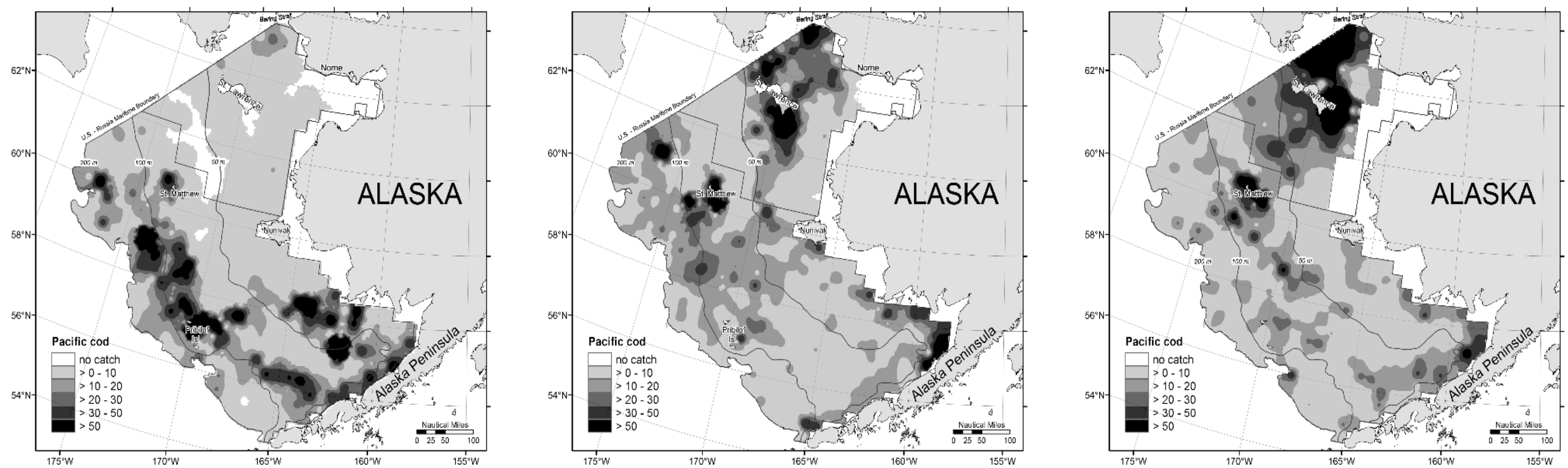


Figure 20. Distribution and relative abundance (in kg/ha) of Pacific cod during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Walleye Pollock (common name)

Gadus chalcogrammus (scientific name)

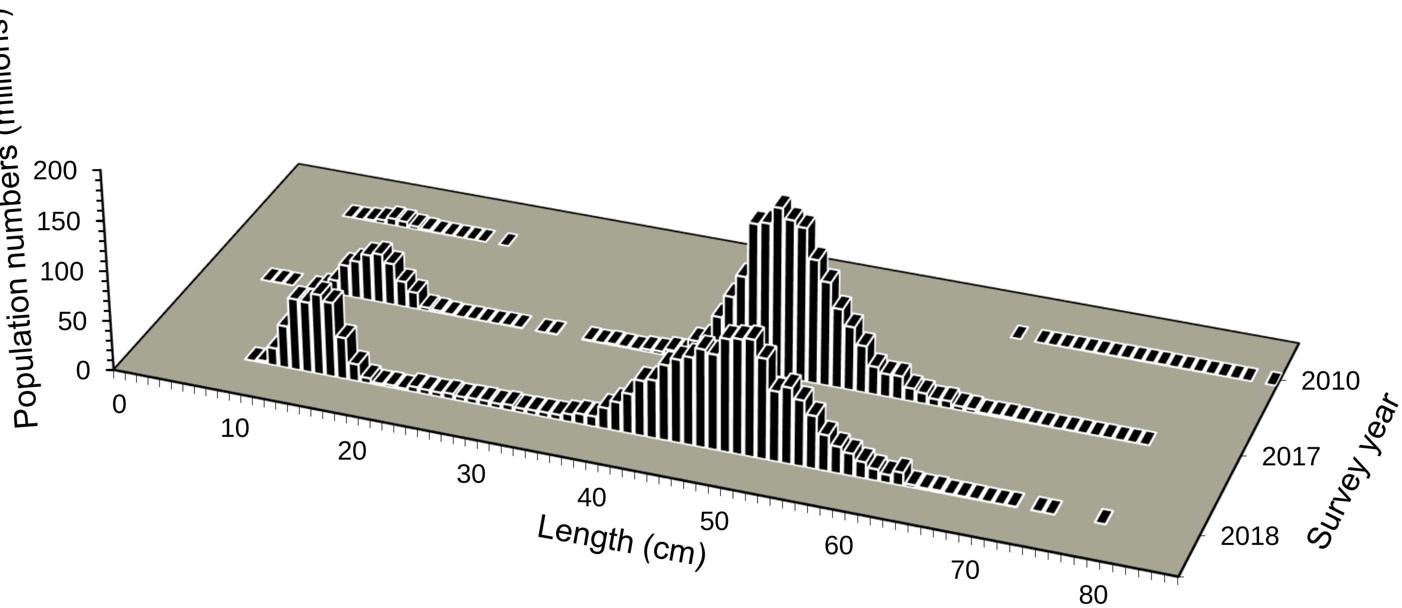


Figure 21. Total abundance-at-size of walleye pollock in the NBS during 2010, 2017 and 2018.

Walleye Pollock represented 25% of the total NBS biomass in 2018. This represents a 5,640% increase from the biomass observed in 2010. The spatial distribution was patchy throughout the eastern Bering Sea survey area, but were localized north of St. Lawrence Island in the NBS. The highest densities were located along the northwest boundary line of the survey area and north to near the Bering Strait (Figure 22). Size distributions in 2017 and 2018 are similar (Figure 21) and both years had nodes of larger fish that were not observed in 2010.

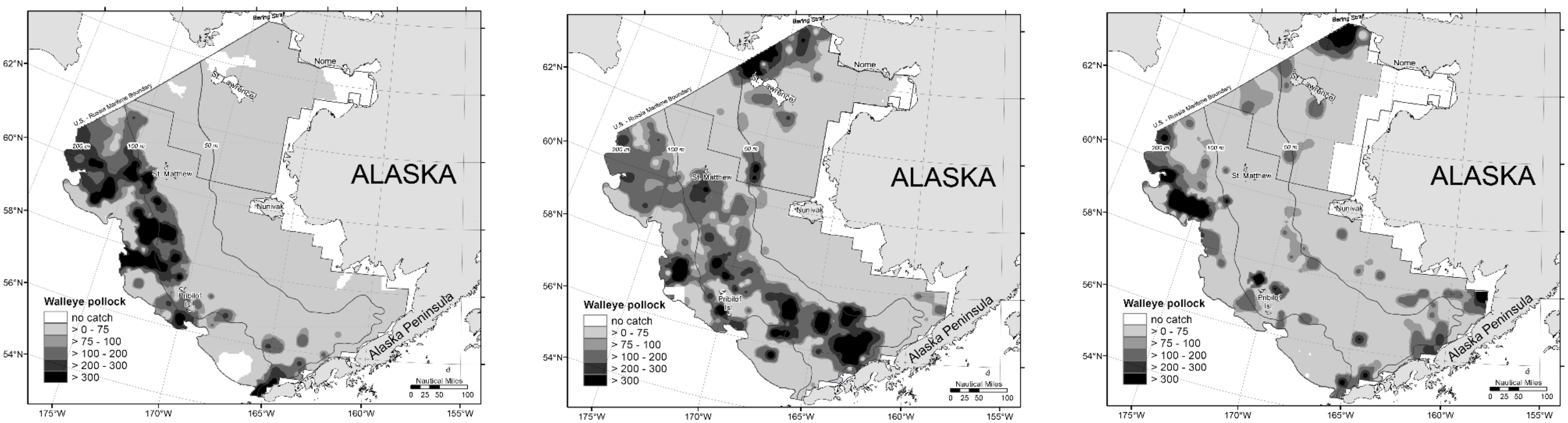


Figure 22. Distribution and relative abundance (in kg/ha) of Walleye Pollock during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Alaska Skate (common name)

Bathyraja parmifera (scientific name)

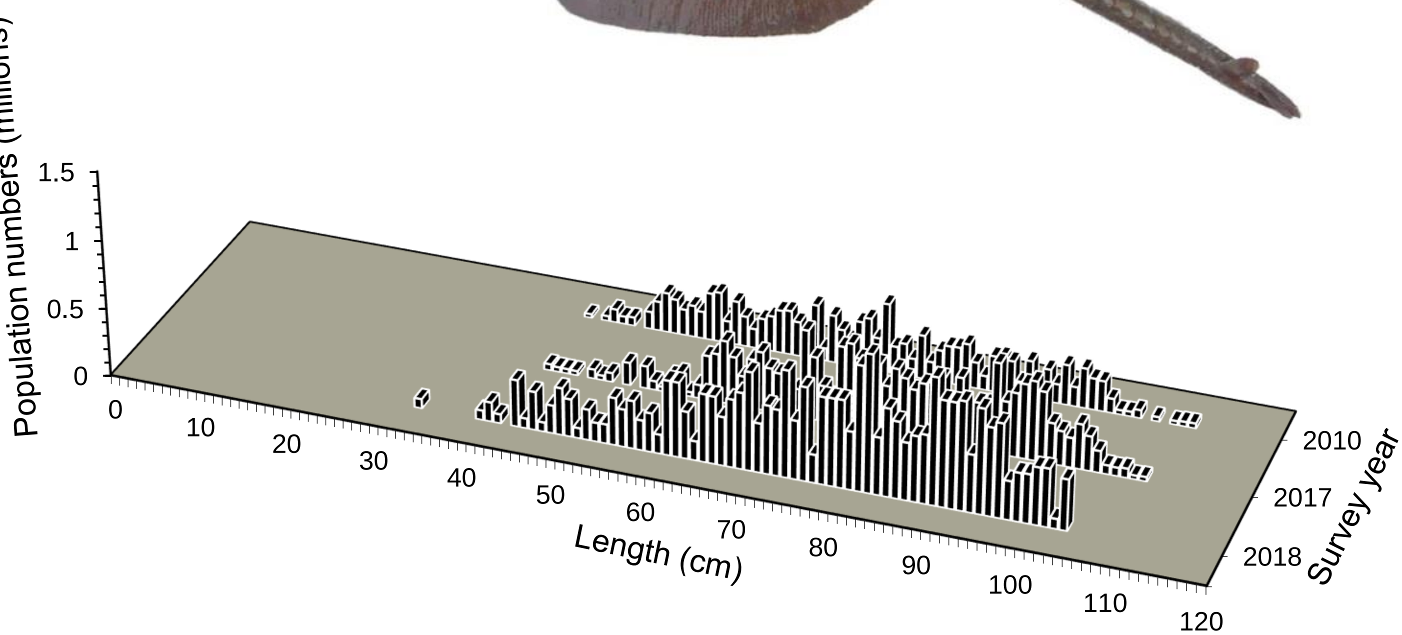


Figure 23. Total abundance-at-size of Alaska skate in the NBS during 2010, 2017 and 2018.

Alaska skate were present at 34 of the 49 stations in the NBS survey area in 2018 (Figure 27). The station depths where Alaska skate were present ranged from 24 to 78 m (Figure 27). The Alaska skate is the most abundant skate in the Bering Sea. A similar size composition was observed in 2010 and 2018 (Figure 23). Biomass of this skate increased 139% from 2010 to 2018. The distribution is consistent across the shelf in 2018, with the exception of the area north of St. Lawrence Island north to the Bering Strait (Figure 24).

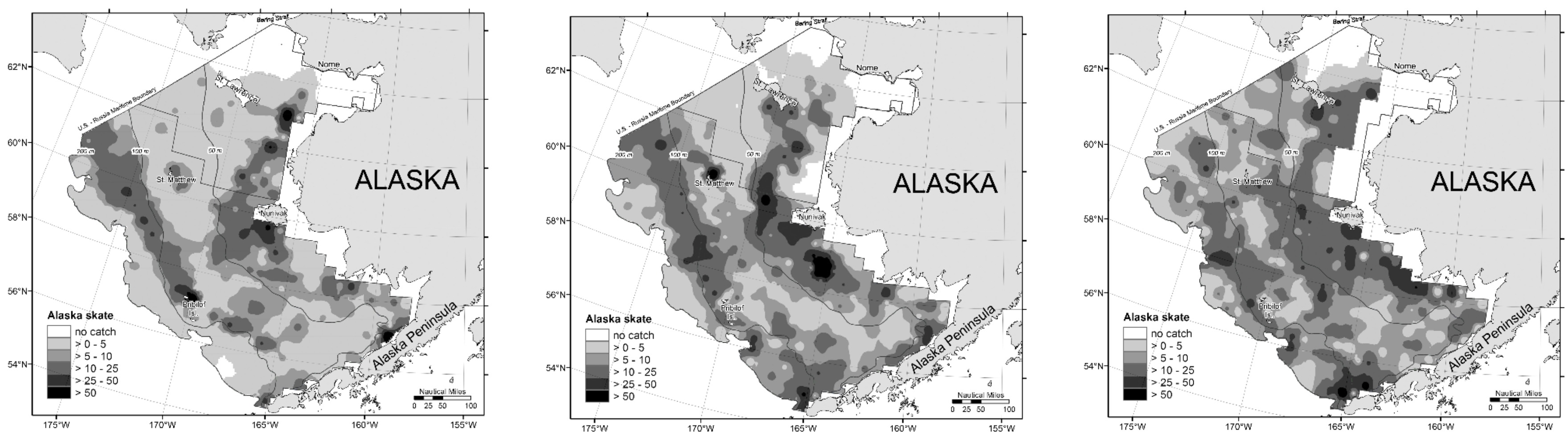


Figure 24. Distribution and relative abundance (in kg/ha) of Alaska skate during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Warty Sculpin (common name)

nertuli (St. Lawrence Island Yupik)

kanayuq (Inupiaq)

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

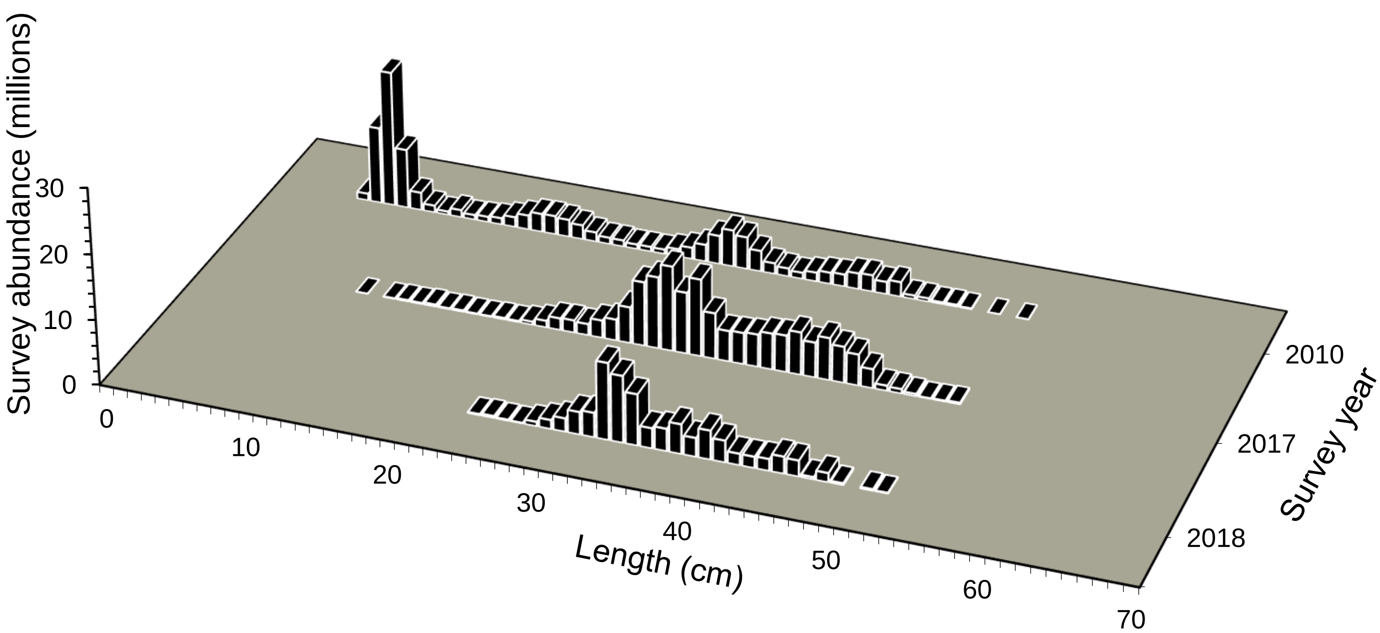


Figure 25. Total abundance-at-size of warty sculpin in the NBS during 2010, 2017 and 2018.

The NBS had a higher biomass estimate than the EBS in 2018. The highest densities of warty sculpins occurred north of St. Lawrence Island. Presence of warty sculpins occurred at stations with bottom depths between 26 and 63 m within the NBS area (Figure 26). In 2018, larger individuals were encountered in the EBS area. The trend of loss of smaller individuals continued in 2018 from what was observed in 2010 when the smaller fish were the predominant node (Figure 25).

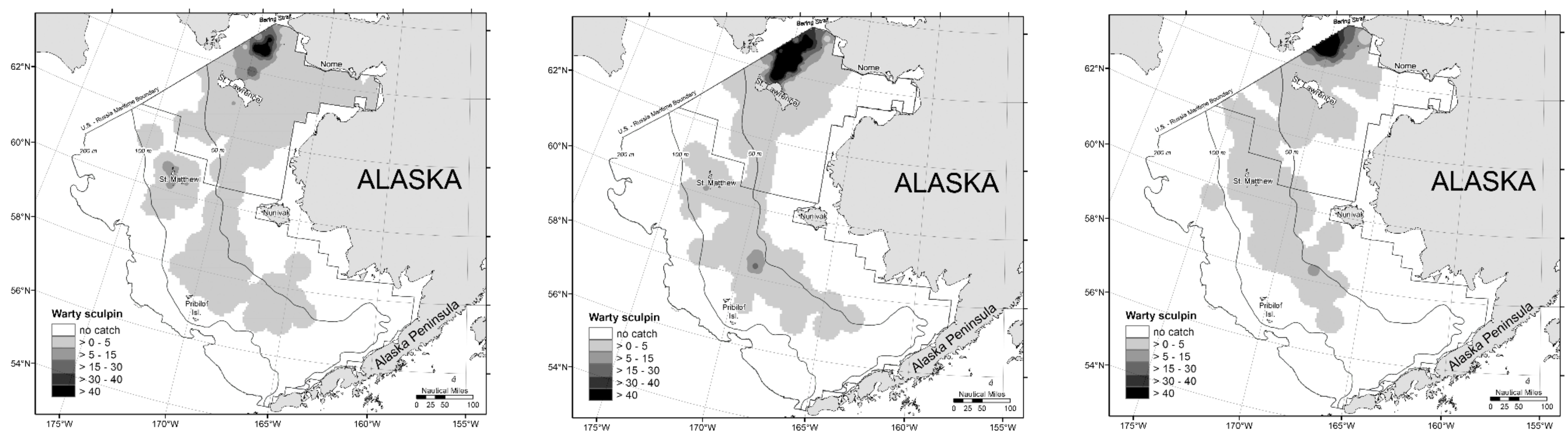


Figure 26. Distribution and relative abundance (in kg/ha) of warty sculpin during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Plain Sculpin (common name)

nertuli (St. Lawrence Island Yupik)

Myoxocephalus joak (scientific name)

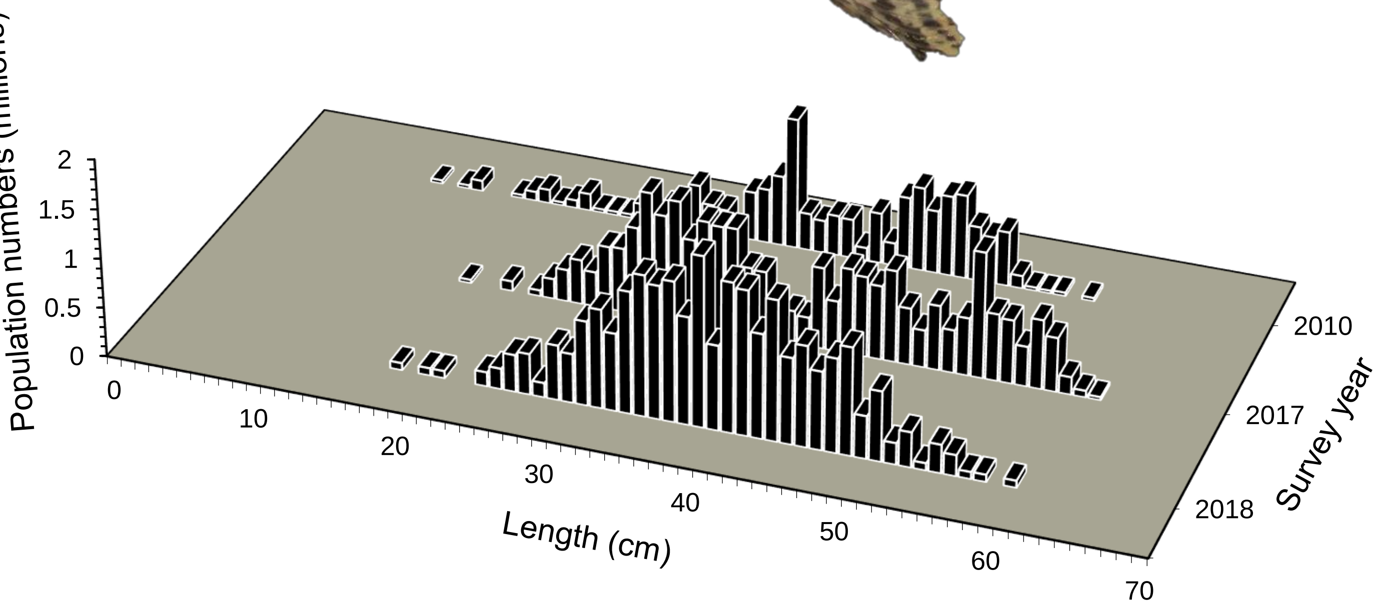


Figure 27. Total abundance-at-size of plain sculpin in the NBS during 2010, 2017 and 2018.

Plain sculpin were caught at stations with bottom depths between 21 and 62 meters, with an average depth of 41 m within the NBS area (Figure 28). Densities of plain sculpin were highest south of St. Lawrence Island and southeast of Nunivak within the 50 m contour (Figure 28).

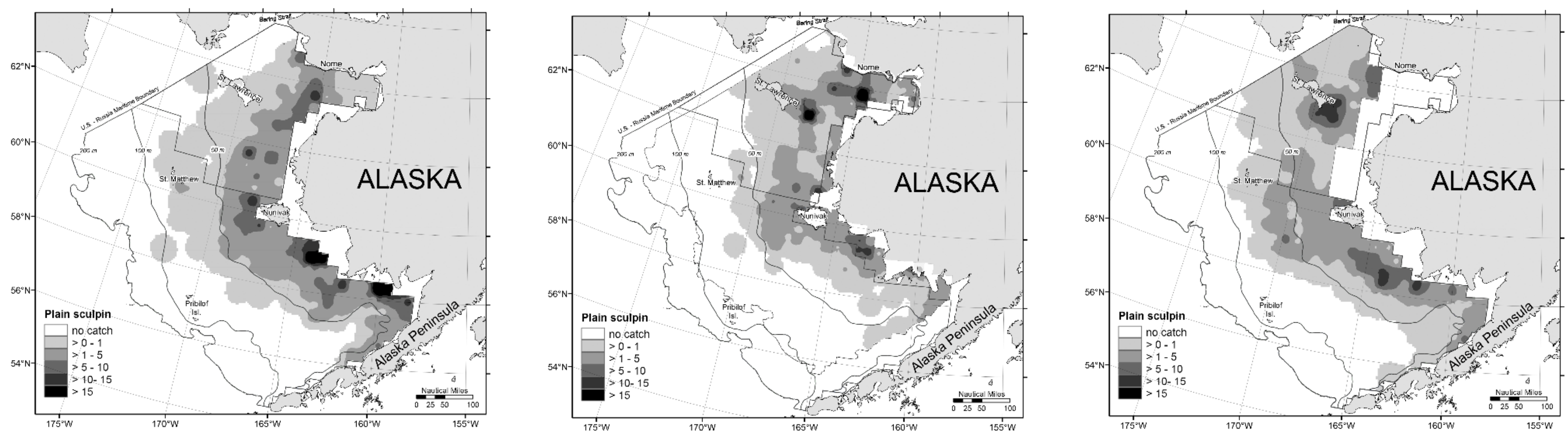


Figure 28. Distribution and relative abundance (in kg/ha) of plain sculpin during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Red King Crab (common name)

Paralithodes camtschaticus (scientific name)

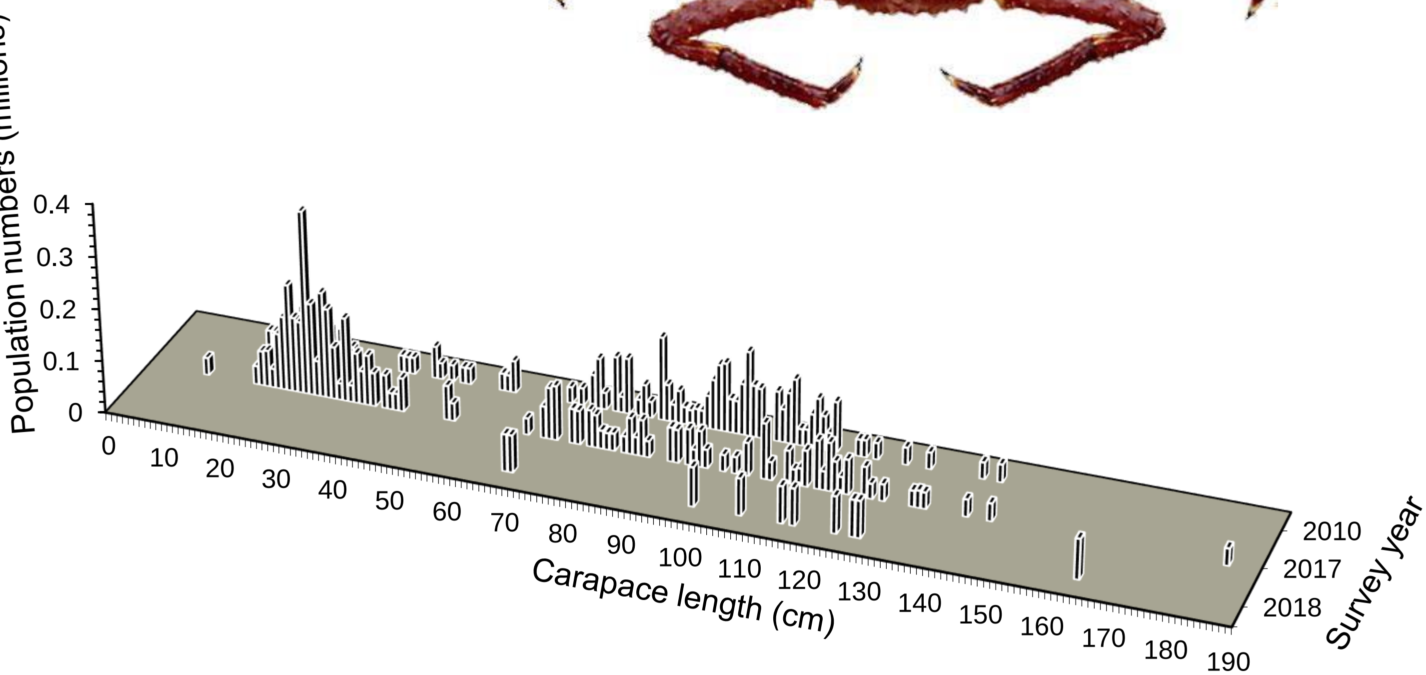


Figure 29. Total abundance-at-size of red king crab in the NBS during 2010, 2017 and 2018.

Within the NBS, red king crab occur predominantly in Norton Sound (Figure 30). The 2018 NBS rapid response survey did not include the Norton Sound area.

**2018 estimates may be unreliable for this species due to the reduced survey resolution and extent in 2018. The 2018 NBS survey area may not have included areas where species were prevalent in previous years.

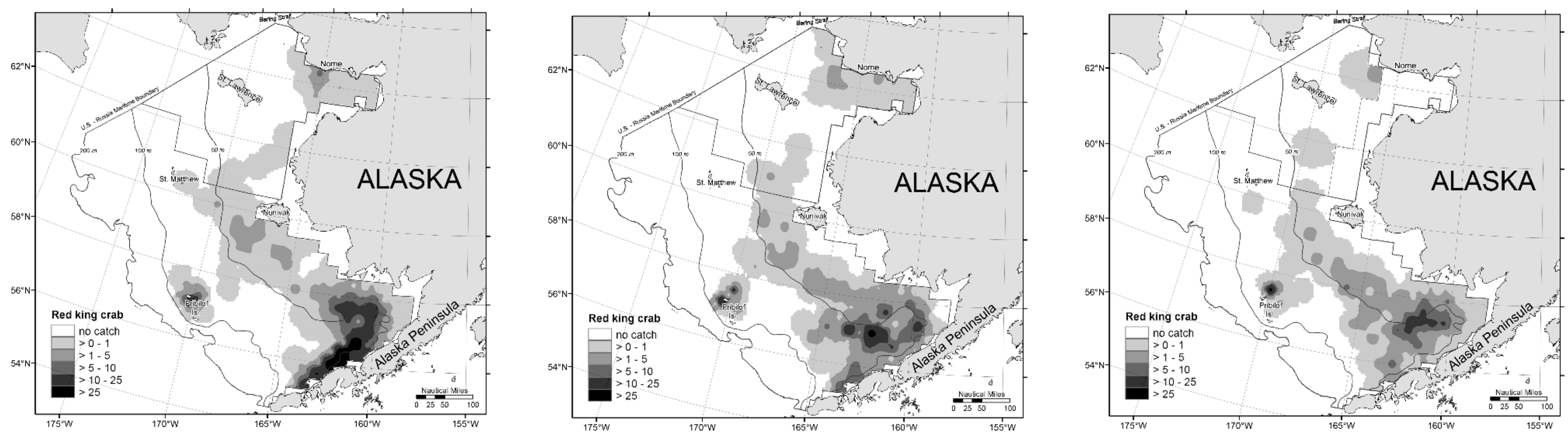


Figure 30. Distribution and relative abundance (in kg/ha) of red king crab during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Blue King Crab (common name)

Paralithodes platypus (scientific name)

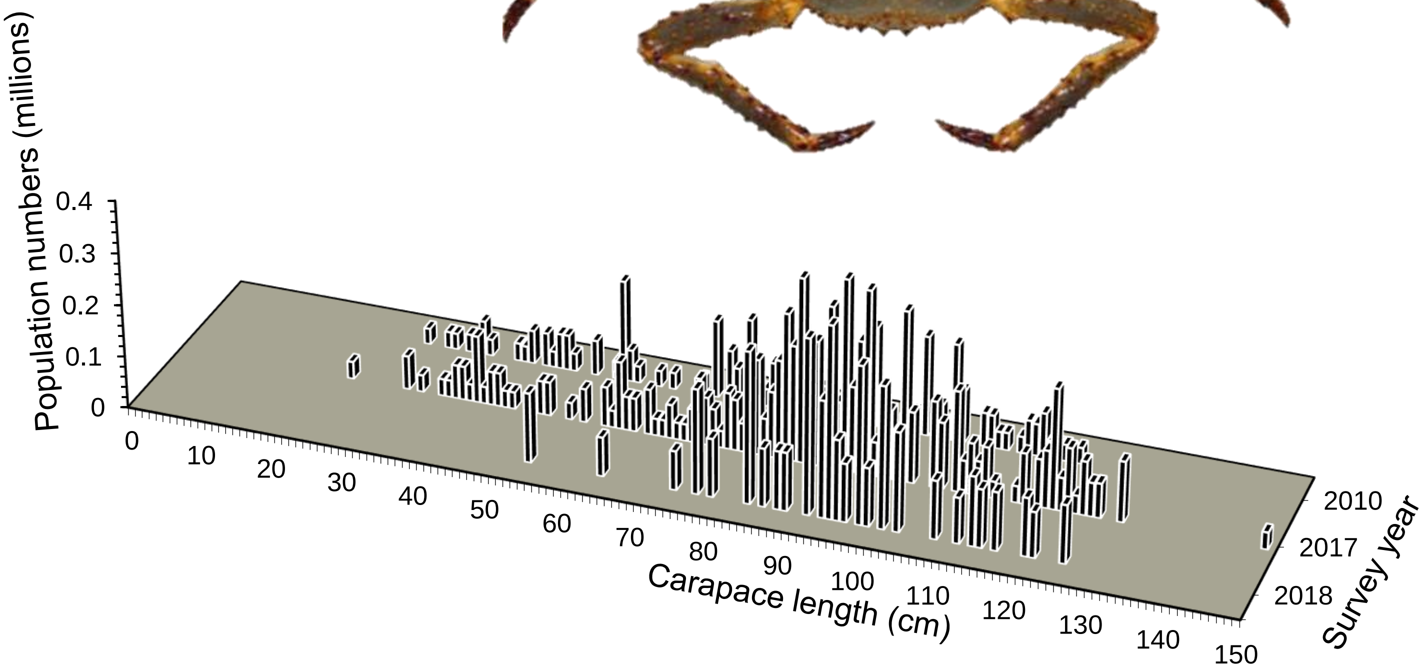


Figure 31. Total abundance-at-size of blue king crab in the NBS during 2010, 2017 and 2018.

In 2010, the majority of both mature male and female blue king crab were distributed around St. Matthew Island (Figure 32). Blue king crab biomass increase by 61% from 2010 to 2018 (Table 1). In 2018, the area of high blue king crab density was reduced in area around St. Matthew Island and high densities were encountered off of the north coast of St. Lawrence Island (Figure 32).

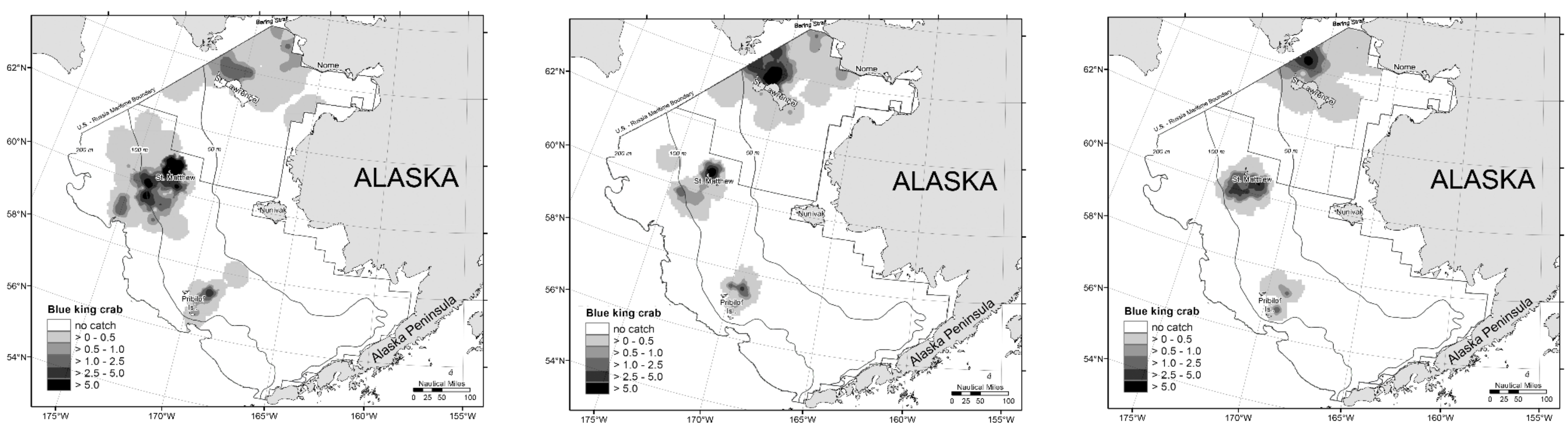


Figure 32. Distribution and relative abundance (in kg/ha) of blue king crab during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Pacific Halibut (common name)

cagiq, naternarpak (St. Lawrence Island Yupik)

Hippoglossus stenolepis (scientific name)

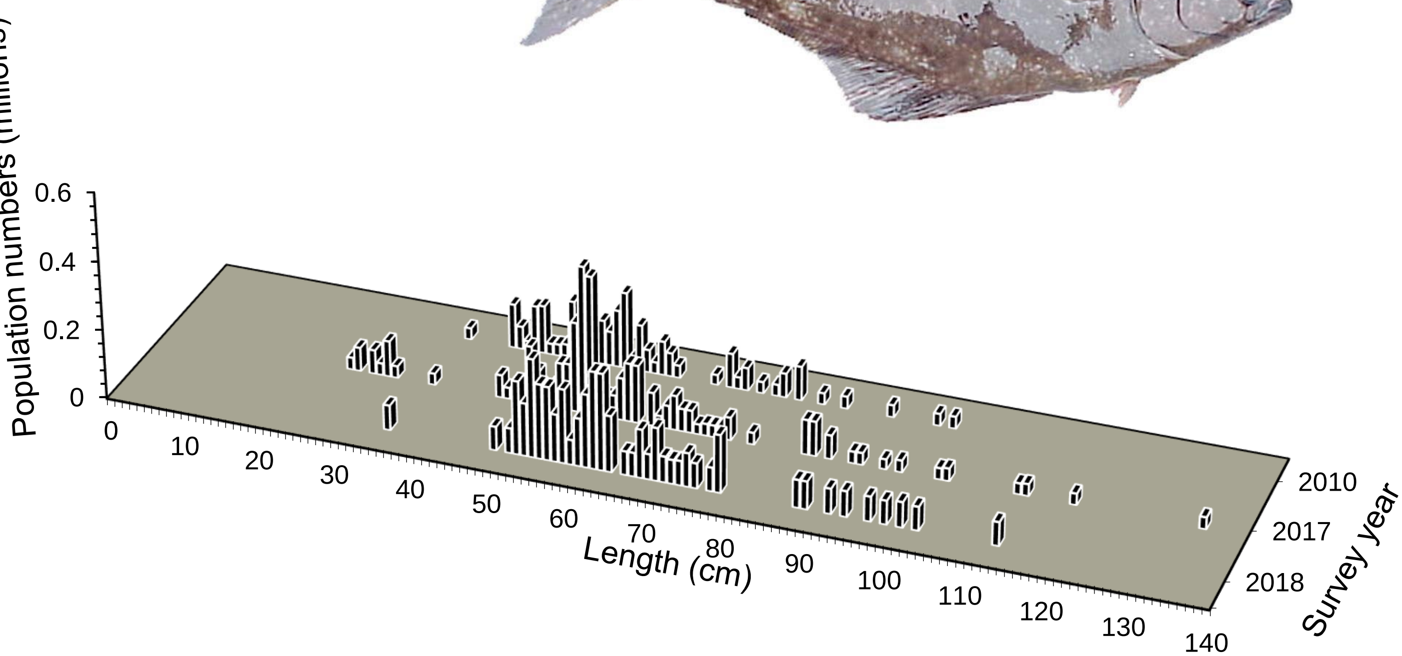


Figure 33. Total abundance-at-size of Pacific halibut in the NBS during 2010, 2017 and 2018.

In 2018, Pacific halibut were recorded at depths ranging from 21 m to 45 m in the NBS area (Figure 34). In 2018, Pacific halibut showed a large increase in total biomass (18,397 mt) from 2010 (7,352 mt, Table 1). Spatial densities were distributed shallower than the 50 m contour and from the western portion of St. Lawrence Island east to the eastern boundary of the NBS rapid response survey located at the mouth of the Norton Sound as well as in the southern area of the NBS (Figure 34). Size composition indicates an increased number of larger individuals were present in 2018 compared to 2010 (Figure 33).

**2018 estimates may be unreliable for this species due to the reduced survey resolution and extent in 2018. The 2018 NBS survey area may not have included areas where species were prevalent in previous years.

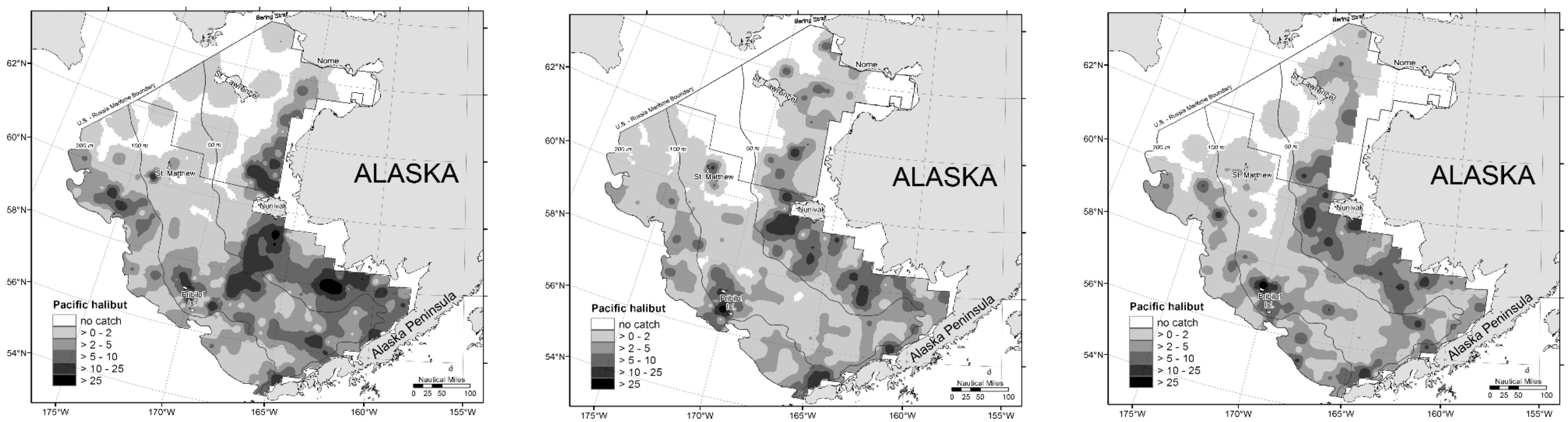


Figure 34. Distribution and relative abundance (in kg/ha) of Pacific halibut during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Bering Flounder (common name)

cagiq, sagiq (St. Lawrence Island Yupik)

Hippoglossoides robustus (scientific name)

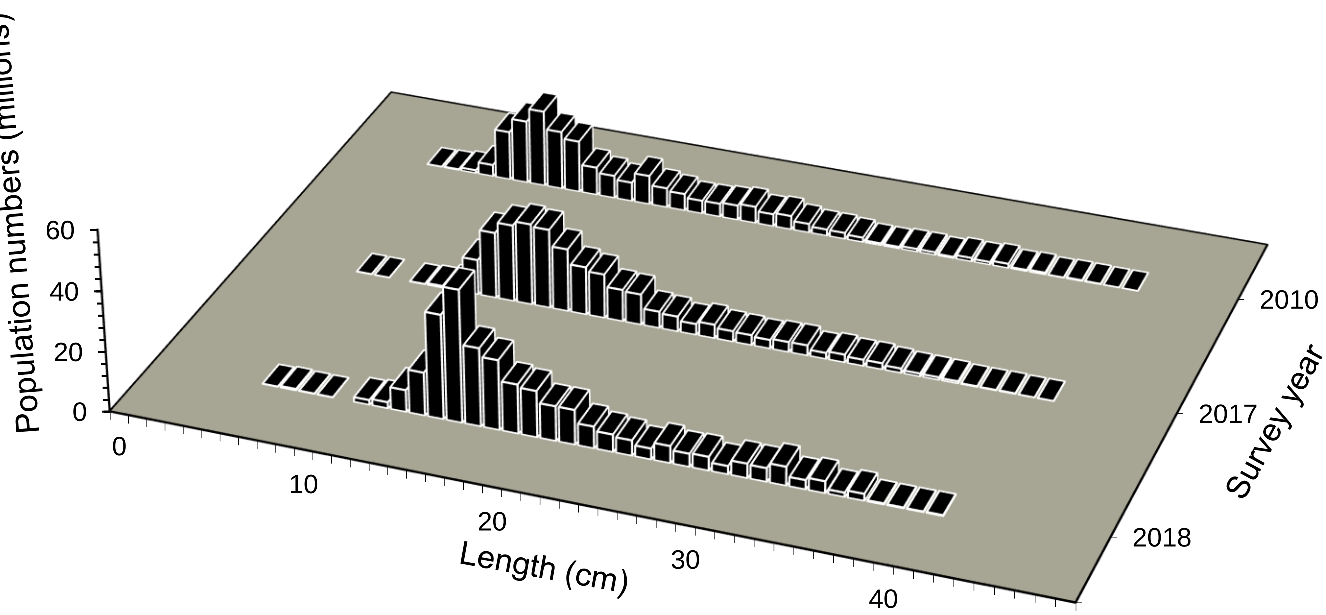


Figure 35. Total abundance-at-size of Bering flounder in the NBS during 2010, 2017 and 2018.

In the NBS, Bering flounder were recorded at depths between 21 and 76 m. The highest densities were concentrated north of St. Matthew Island north to the U.S.- Russia maritime border (Figure 36). Biomass of Bering flounder increased by 127% in 2018 (Table 1). In 2018, the greatest number of individuals was around 16 cm in length (Figure 35).

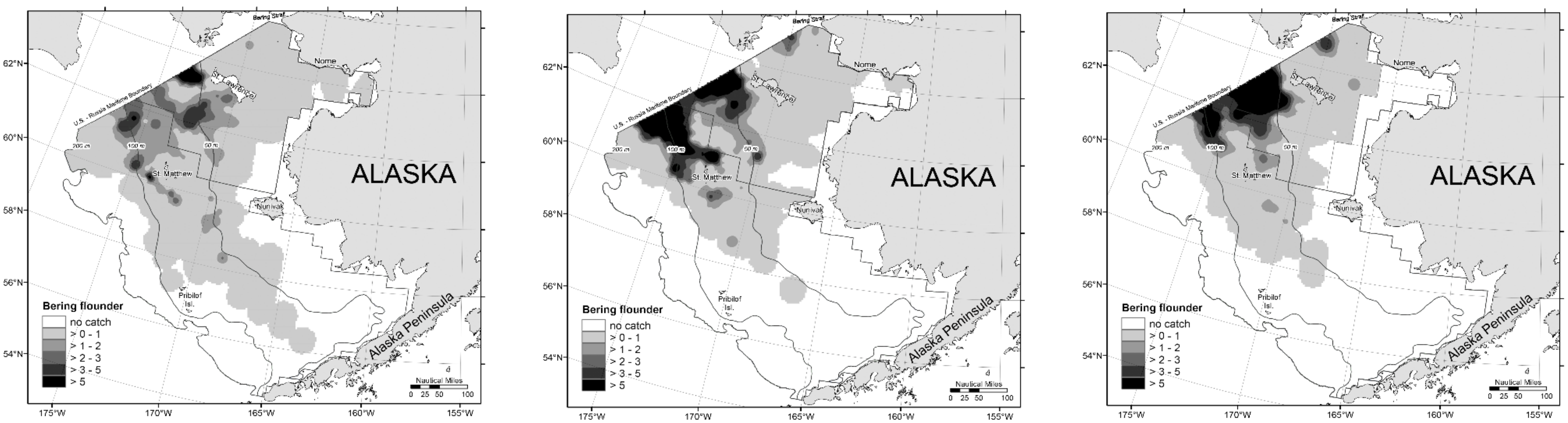


Figure 36. Distribution and relative abundance (in kg/ha) of Bering flounder during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Northern Rock Sole (common name)

cagiq, sagiq (St. Lawrence Island Yupik)

Lepidopsetta polyxystra (scientific name)

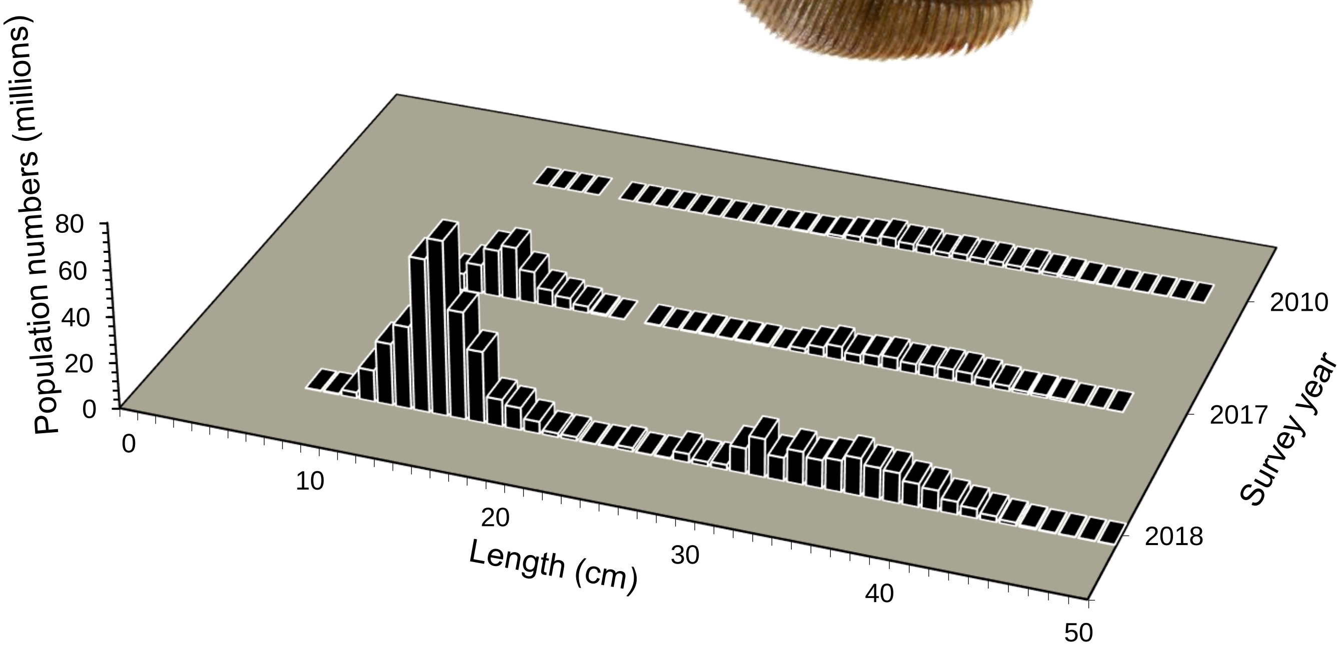


Figure 37. Total abundance-at-size of northern rock sole in the NBS during 2010, 2017 and 2018.

In 2018, the highest densites in the NBS survey area of northern rock sole were caught east of St. Lawrence Island and in an area along the 50 m contour northwest of Nunivak Island and south of St. Lawrence Island (Figure 38). In 2018, the largest number of individuals caught were around 15 cm in length while another smaller magnitude size mode existed at 37 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).

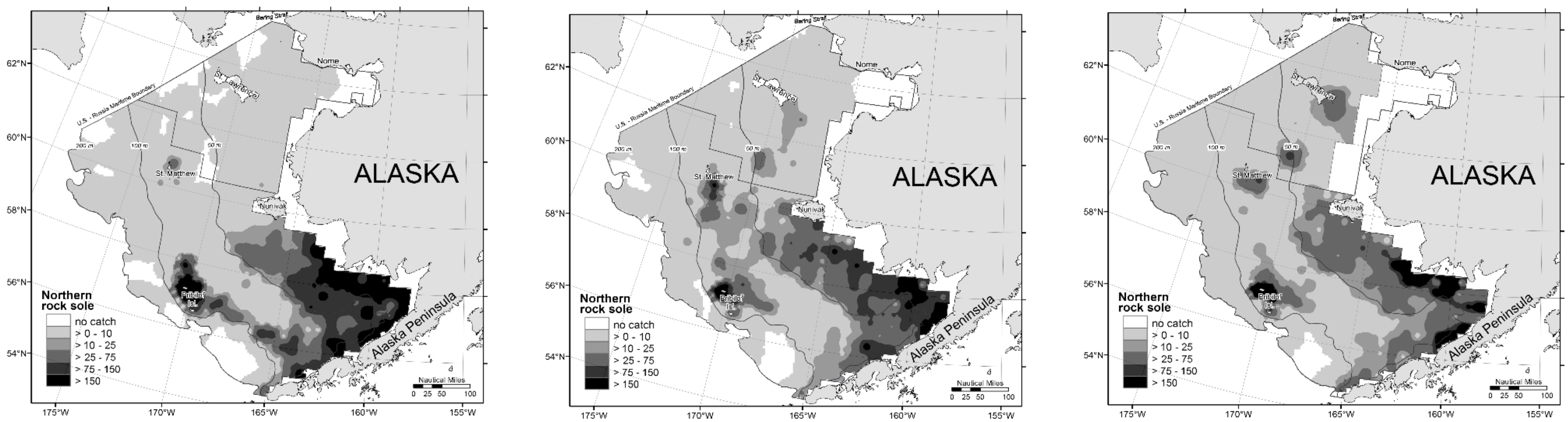


Figure 38. Distribution and relative abundance (in kg/ha) of Northern rock sole during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Pacific Herring (common name)

neqalluarpak (Central Yup'ik)

iqalluarpak, iqallugpak (St. Lawrence Island Yupik)

Uqsruqtuuq (Inupiaq)

Clupea pallasii (scientific name)

In 2018, Pacific herring were recorded at 37 of the 49 NBS stations, at depths from 21 m to 76 m. Areas of high density were located on the 50 m contour northwest of St. Matthew Island in 2018 (Figure 39). The relative Pacific herring biomass increased from 21,560 mt (2010) to 41,029 in 2018 (Table 1). Lengths of Pacific herring have not historically been recorded during the EBS and NBS surveys.

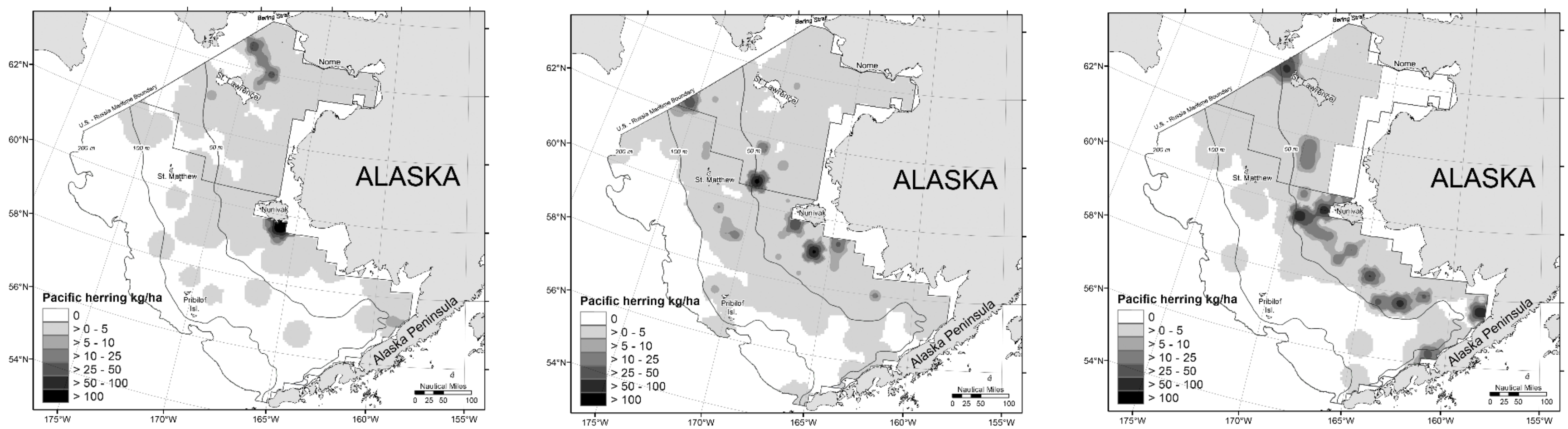
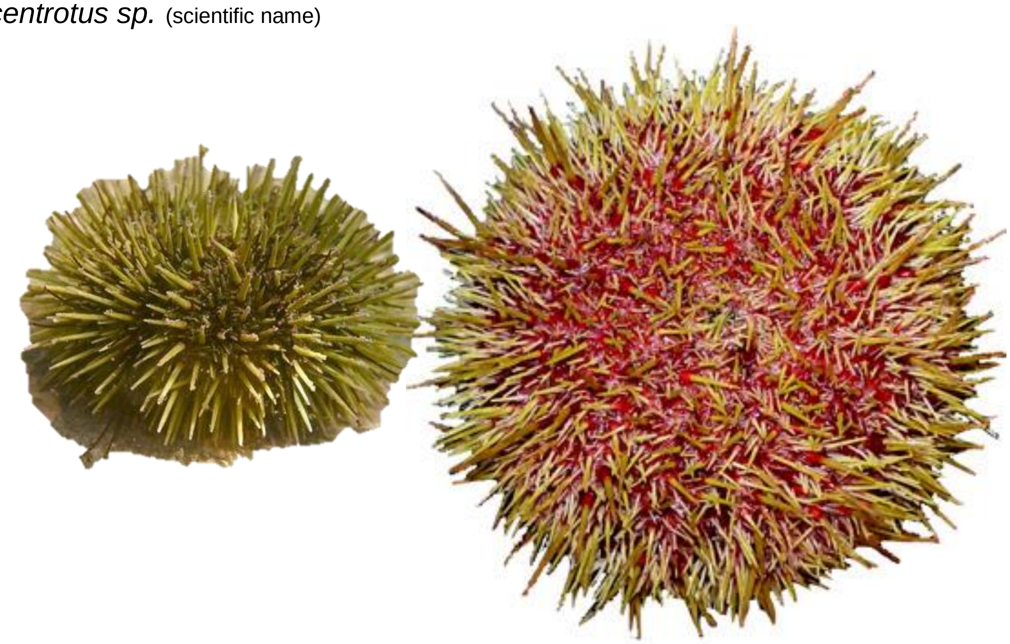


Figure 39. Distribution and relative abundance (in kg/ha) of Pacific herring during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

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 18 of the 49 stations in 2018 (Figure 40). In both 2010 and 2018, the highest densities were observed just north of St. Lawrence Island and in 2017, urchins were present throughout Norton Sound (Figure 40).

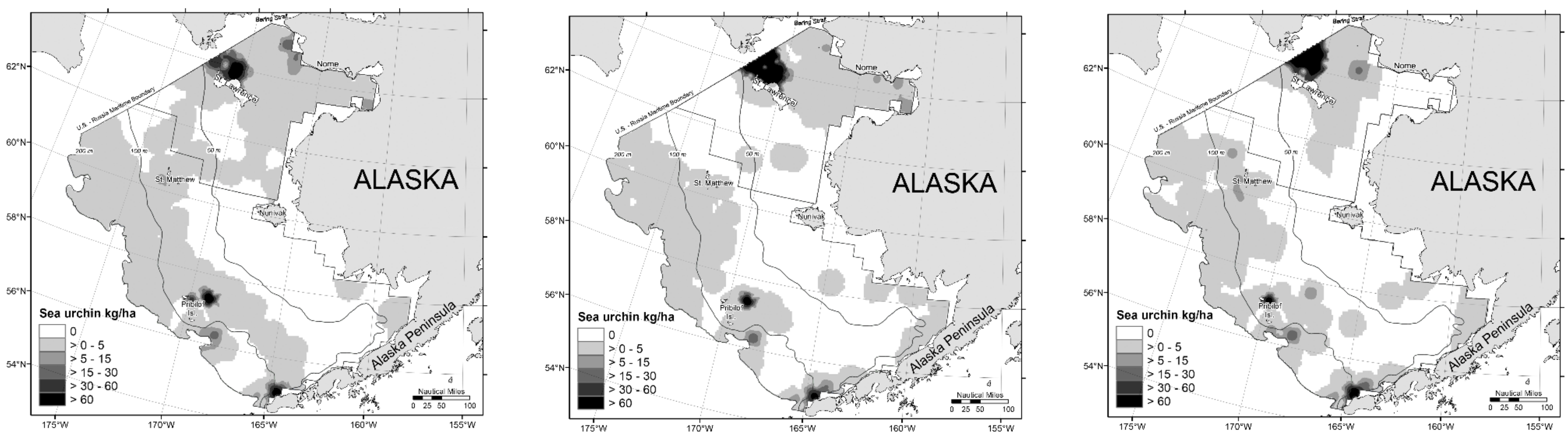


Figure 40. Distribution and relative abundance (in kg/ha) of urchins during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Jellyfishes (common name)

Scyphozoa (scientific name)




Jellyfish play an important role as both predator and prey with the ecosystem. Large jellyfish blooms can have a significant impact on the early survival of forage fishes, juvenile pollock, salmon, and the larval stages of many invertebrates, including crabs. In the NBS, the jellyfish biomass increased 1,044% between 2010 and 2018. In 2018, the largest aggregation of jellyfish was located North of and around St. Lawrence Island (Figure 41). This area also corresponds with the warmer bottom and sea surface temperatures observed. Increased species richness was also observed in 2018 compared to previous years.

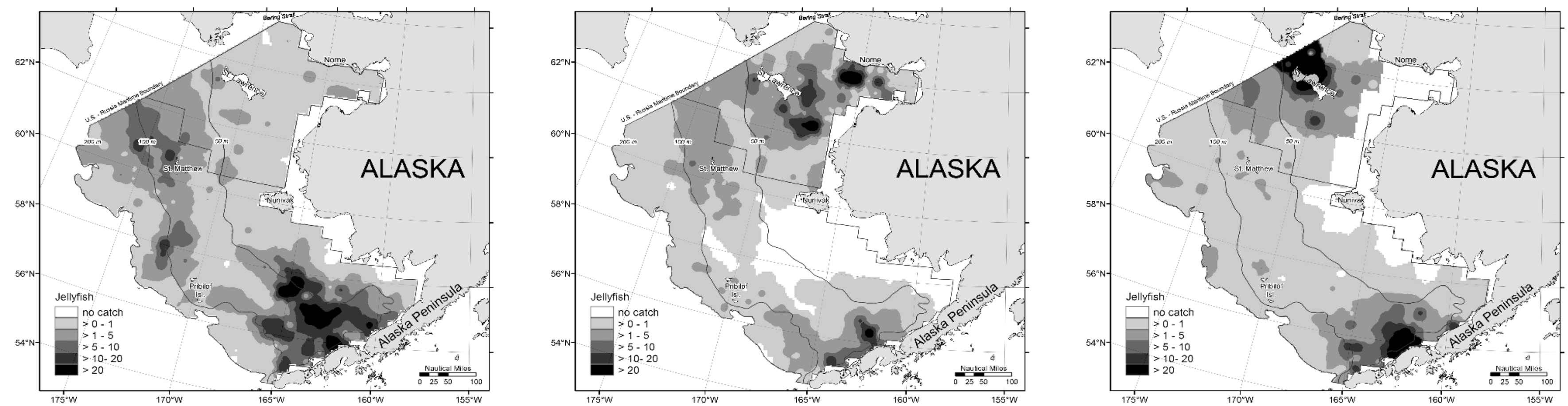


Figure 41. Distribution and relative abundance (in kg/ha) of jellyfishes during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Snailfishes (common name)

Liparidae family (scientific name)

The 2 species of snailfish most commonly encountered in the NBS survey area are the variegated snailfish (*Liparis gibbus*) and the kelp snailfish (*Liparis tunicatus*). The variegated snailfish was caught during 13 of 49 stations at depths ranging from 30 m – 49 m in the 2018 Rapid Response NBS survey west of St. Lawrence Island (Figure 42). The kelp snailfish was not caught during the 2018 NBS survey. 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 2018, a total of 16 variegated snail fish were present while 711 were caught in 2010.
Species information was added to report by request of tribal councils.

**2018 estimates may be unreliable for this species due to the reduced survey resolution and extent in 2018. The 2018 NBS survey area may not have included areas where species were prevalent in previous years.

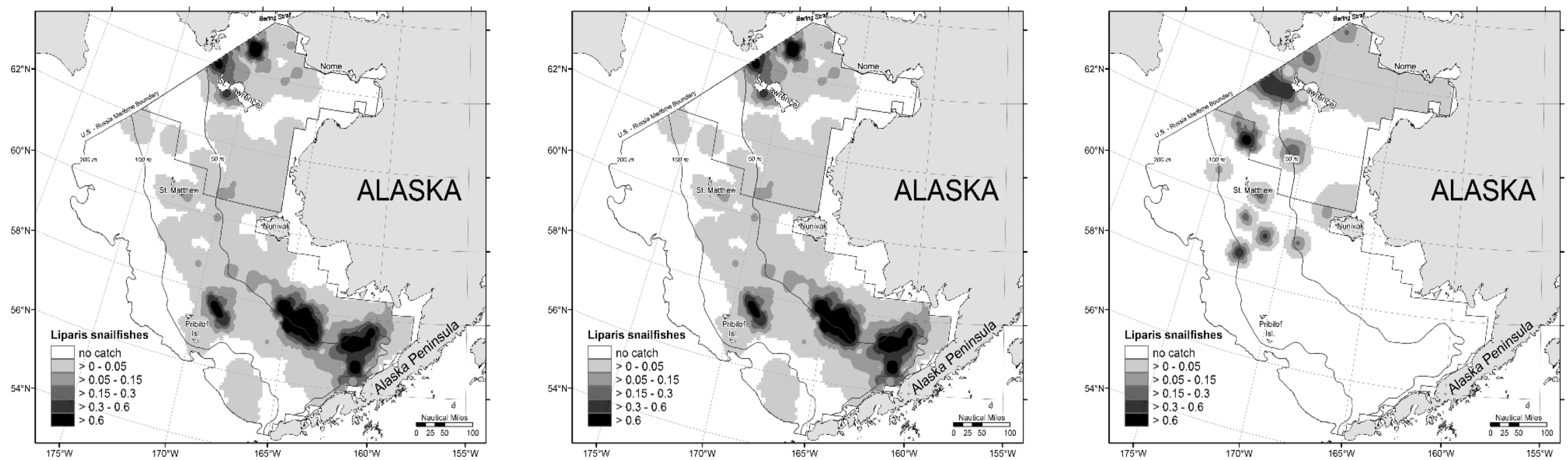


Figure 42. Distribution and relative abundance (in kg/ha) of snailfishes in the genus Liparis during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Sea onion (common name)

Genus Boltenia (scientific name)

Sea onions are a stalked, solitary ascidian, which are widely distributed in the North Atlantic, North Pacific, and Bering Sea. In 2018, in the northern Bering Sea, sea onions were found at highest density just north of St. Lawrence Island. Sea onions were caught at 10 of the 49 NBS stations, which had depths between 26 and 52 m (Figure 43).

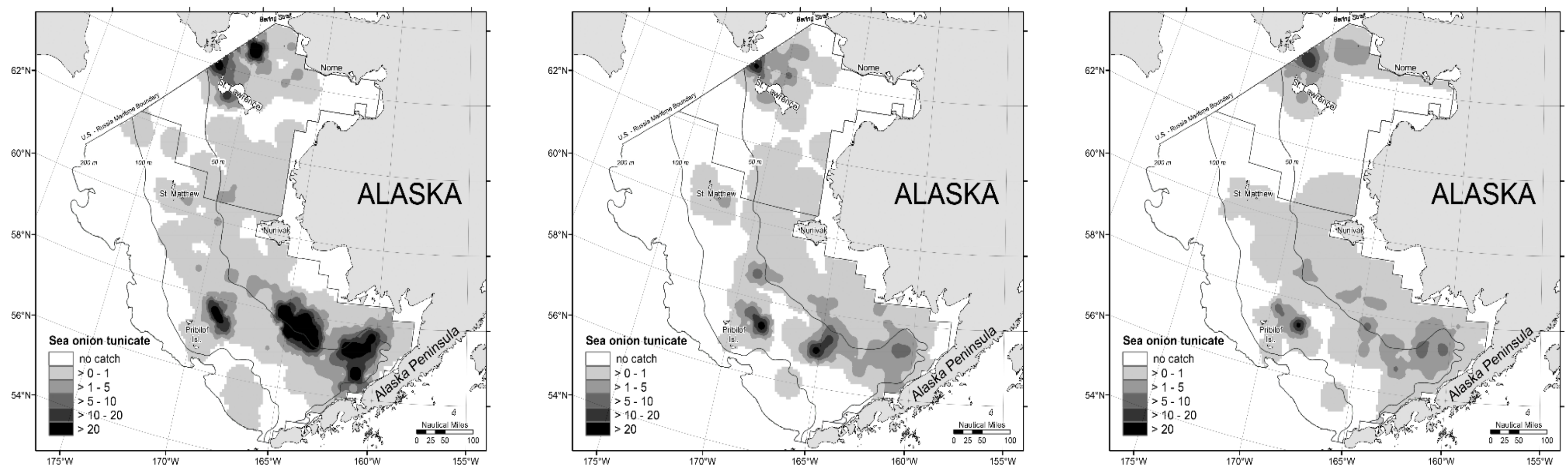


Figure 43. Distribution and relative abundance (in kg/ha) of sea onions during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

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

Sea peaches are large, solitary ascidians which are often found in groups. In 2018, in the NBS, sea peaches were found at low densities (0-10 kg/ha) north-northeast and southeast of St. Lawrence Island (Figure 44).

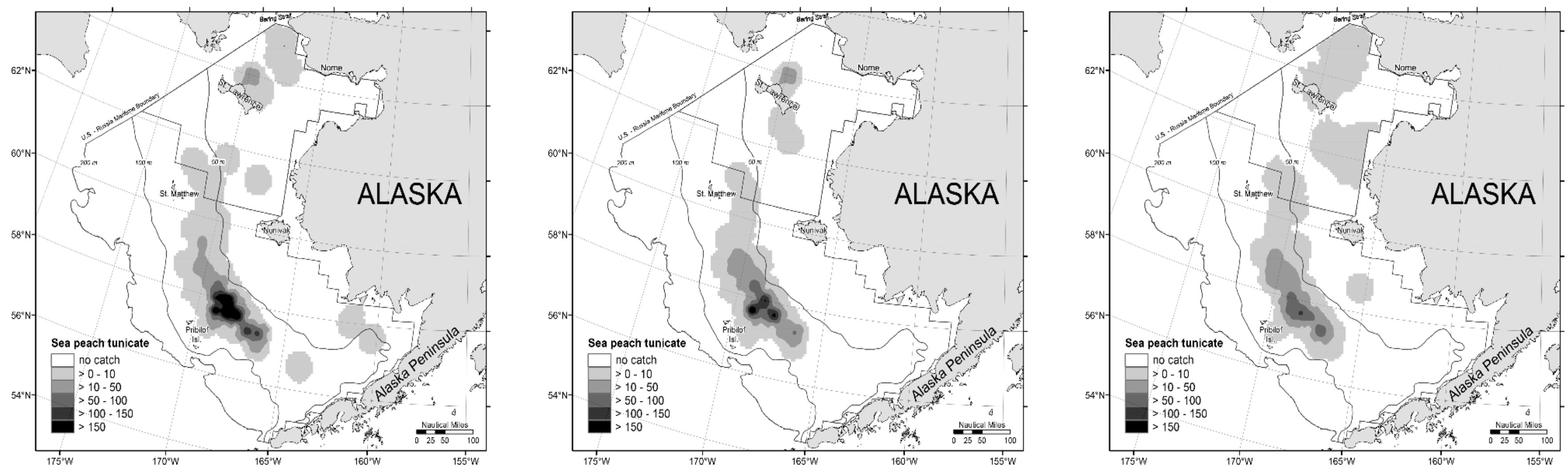


Figure 44. Distribution and relative abundance (in kg/ha) of sea peaches during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

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

The family of smelts decreased 98% from 2010 to 2018 (Table 1). Individual species information is below.

**2018 estimates may be unreliable for these species due to the reduced survey resolution and extent in 2018. The 2018 NBS survey area may not have included areas where species were prevalent in previous years.

Eulachon (common name)
Thaleicthys pacificus (scientificname)

Eulachon were not caught during the 2010 or 2018 NBS surveys. These fish were present at 2 stations during the 2017 NBS survey with depths ranging from 34 m to 35 m. The densest area was located on the southern boundary of the NBS survey area northwest of Nunivak. (Figure 45)

Capelin (common name)
Mallotus villosus (scientific name)

In 2018, capelin were present at 19 of 49 stations with depths ranging 26 – 69 m. These fish were relatively evenly distributed over the NBS Rapid Response area except the southwestern portion (Figure 46).

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

Rainbow smelt were present during the 2018 Rapid Response NBS survey at 3 stations with depths ranging from 22-33 m (Figure 47).

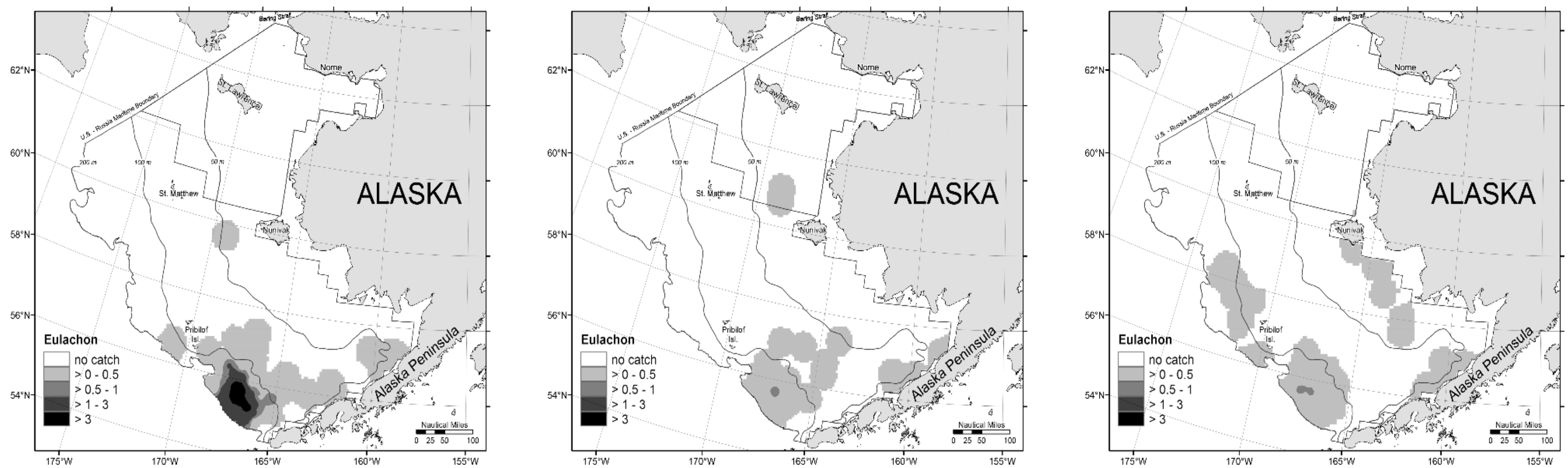


Figure 45. Distribution and relative abundance (in kg/ha) of eulachon during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

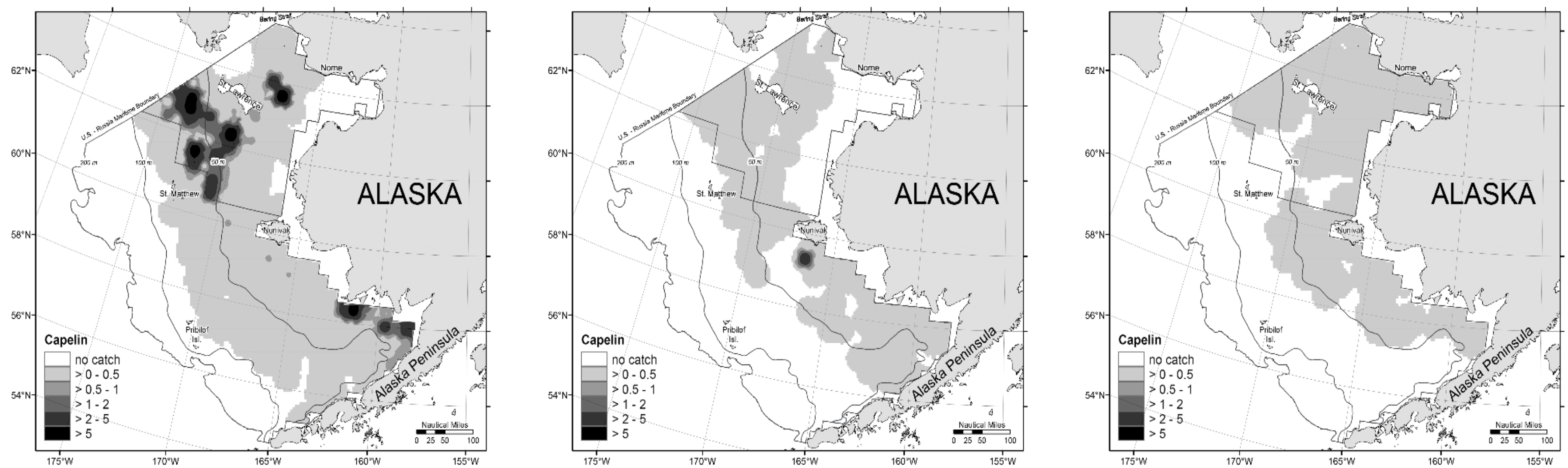


Figure 46. Distribution and relative abundance (in kg/ha) of capelin during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

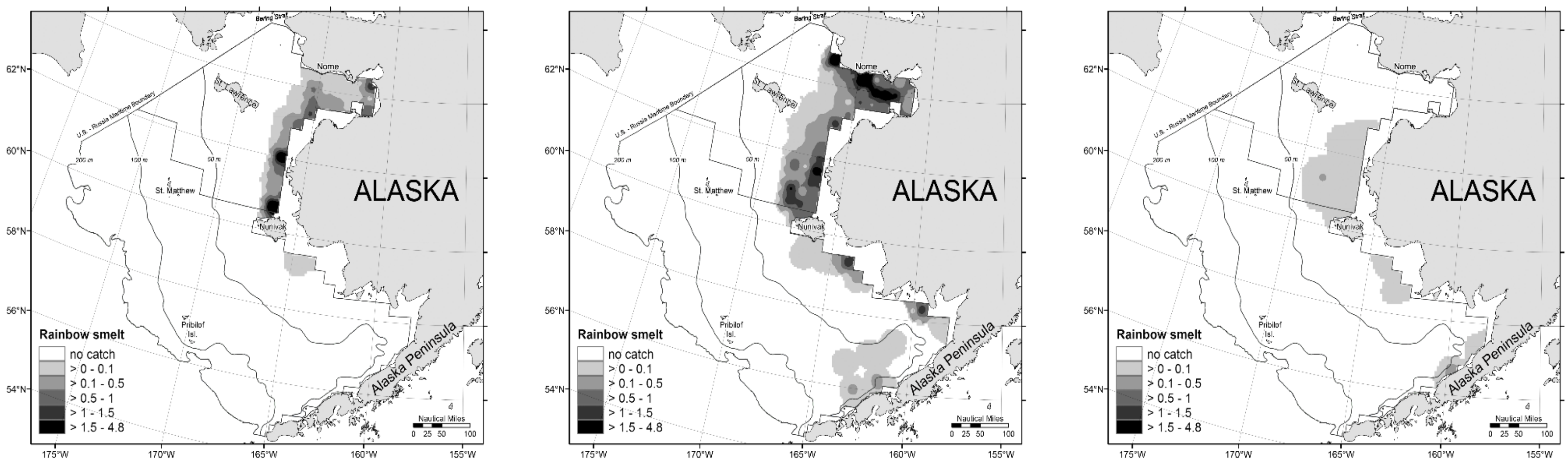
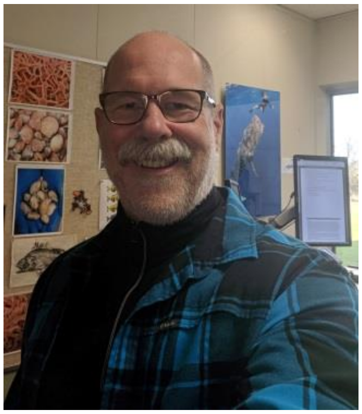


Figure 47. Distribution and relative abundance (in kg/ha) of rainbow smelt during 2010 (left), 2017 (center), and 2018 (right) NBS and EBS surveys.

Appendix A: Scientist Profiles

Meet the Scientists who conducted the survey

Bob Lauth, Research Survey Chief Scientist



Bob is a Supervisory Research Fisheries Biologist with the NOAA Fisheries Alaska Fisheries Science Center in Seattle, Washington. Bob has been with the Center for 27 years and leads a team of scientists that coordinate standardized bottom trawl surveys in the Bering Sea and Alaska Arctic regions. Bob'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). 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.

Lyle Britt, Survey Coordinator

Lyle is a Research Fisheries Biologist with the NOAA Fisheries Alaska Fisheries Science Center in Seattle, Washington. Lyle has been with the Center for 23 years where he is a survey coordinator for the eastern Bering Sea shelf and northern Bering Sea bottom trawl surveys. As the survey coordinator, he is responsible for staffing and logistics for the surveys and serves as a chief scientist on one of the vessels during survey operations. He also serves as the special projects and collections manager for these surveys, where he works with other NOAA scientists and outside researchers on the scope and design of their scientific requests to maximize the utility and scientific impact of the bottom trawl surveys. 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, Fish Biologist

Rebecca is a Fish Biologist with the NOAA Fisheries Alaska Fisheries Science Center in Seattle, Washington. Rebecca started with the group in January of 2017. She has previously conducted 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, staffing, and acts as lead deck scientist on the NBS survey. During her off time in Seattle, she enjoys hiking with her dog and friends. She is looking forward learning to snowshoe this winter.

Liz Dawson, Fish Biologist

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. In her free time, Liz enjoys backpacking, mushroom hunting, and whitewater rafting.

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

Bob Lauth Phone: (206) 526-4124 Email: bob.lauth@noaa.gov	OR	Lyle Britt Phone: (206) 526-4501 Email: lyle.britt@noaa.gov