2017

Northern Bering Sea Groundfish and Crab Trawl Survey Highlights

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Introduction

In 2017, the 36th annual eastern Bering Sea (EBS) shelf bottom trawl survey was extended northward to include 144 additional stations in an area bounded by the Bering Strait, Norton Sound, and the U.S.–Russia Maritime Boundary (Figure 1). This "Northern Bering Sea" (NBS) extension of the survey 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. 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. The 2017 survey represents the second sampling year for a new 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.

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

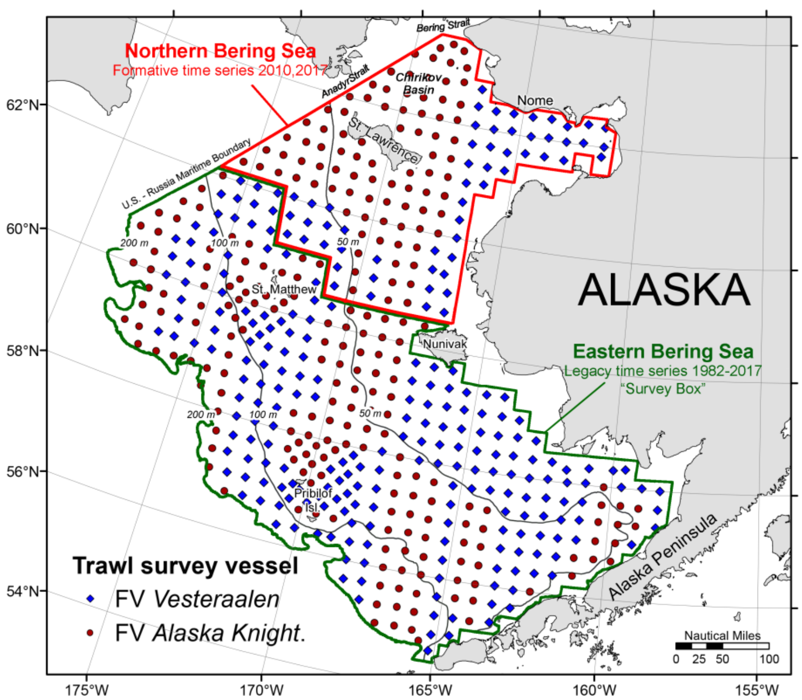

Figure 1. Survey stations sampled in 2017 during both the EBS shelf survey and the NBS survey. The area enclosed within the green line contains the EBS shelf stations that have been sampled annually since 1982, whereas the area outlined in red line are the NBS stations that were sampled for the second time since 2010.

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.

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 2017, 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 06 August to 27 August, and the F/V *Alaska Knight* from 09 August to 2 September.

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 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 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 grid cell.

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

Both vessels were equipped with the standard research bottom trawl that has been historically used for EBS shelf, 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 144 stations. The cumulative area sampled from all 144 stations covered a total area of about 1.8 nmi^2, only 0.003 % of

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

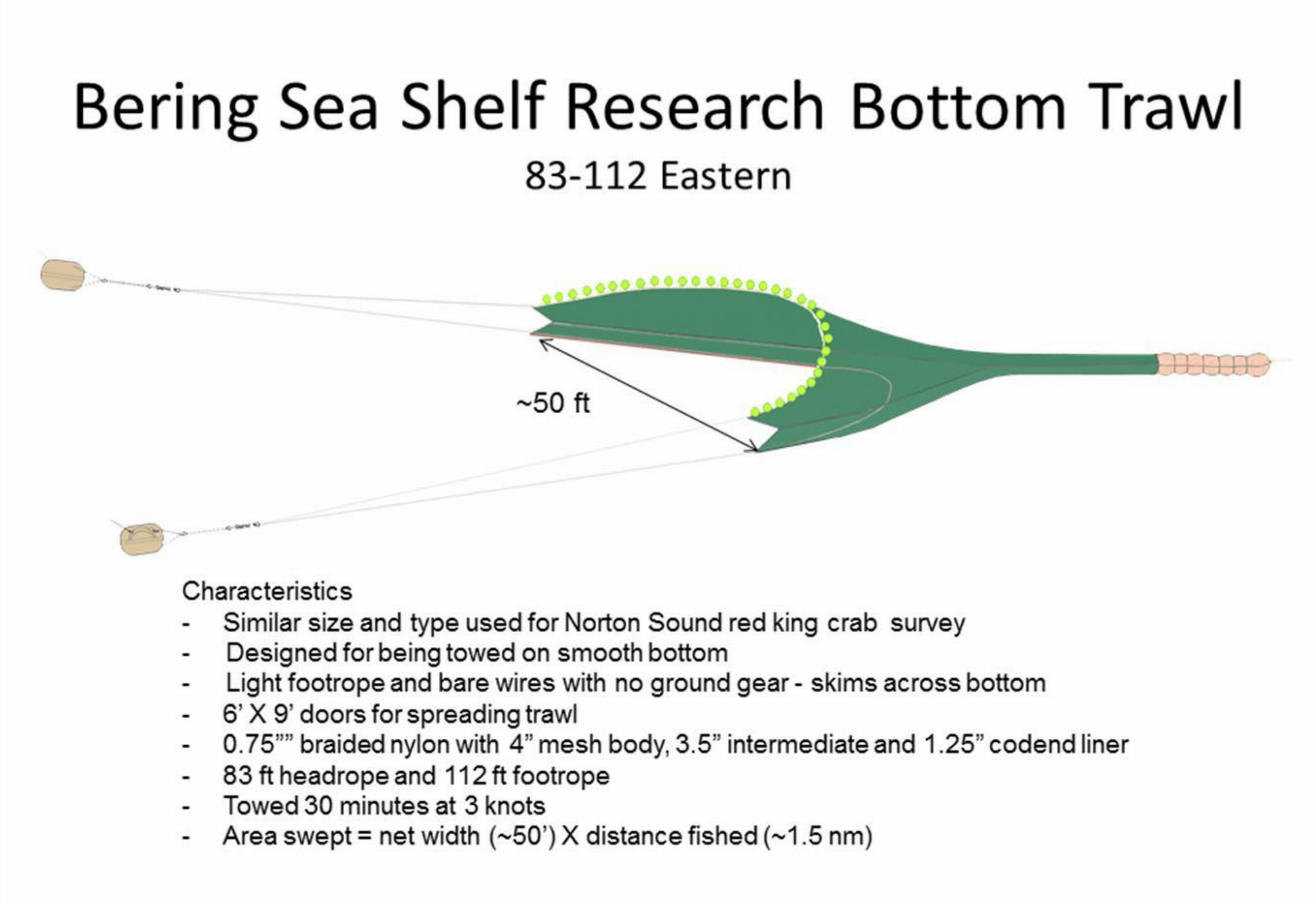

Figure 3. Diagram and specific characteristics of the 83/112 Eastern trawl net.

the total area of the NBS.

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 caught 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. Relative abundance was portrayed 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, called the 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 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).

2017 Survey Results with Snapshot Comparisons to 2010

Bottom Temperature

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 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 – 2017 were warmer than average (“warm stanza”). During the 36-year time series (1982–2017) 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) .

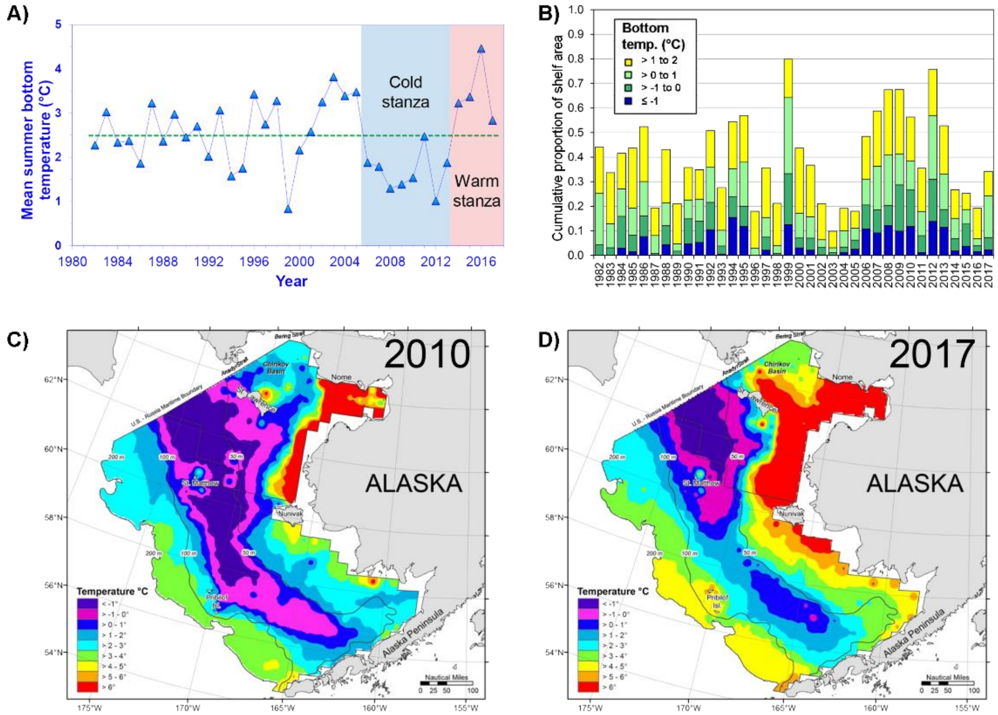

Figure 4. Mean summer bottom temperatures for the 36-year times series from the eastern Bering Sea shelf bottom trawl survey (A) and the cumulative proportion of EBS shelf area covered by each one-degree bottom isotherm range (B). Distribution of survey bottom temperatures for 2010 (C) and 2017 (D), the two years that the EBS survey was expanded to include the northern Bering Sea shelf.

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 36-year time series, the areal coverage of the summer survey cold pool has varied in size from 48,000 to 394,000 km^2, comprising 10% to 80% of EBS shelf area (Figure 4B).

Bottom temperatures measured during the 2017 NBS survey ranged from -1.6° to 13.4°C (Figure 4D). In 2010, the overall mean bottom temperature was cooler (2.00°C) than in 2017 (4.48°C). Mean bottom temperatures on the EBS shelf were cooler in 2017 (2.66°C) than in 2016 (4.21°C). Similarly, sea surface temperatures were warmer in 2017. 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 5). During both 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 and 2017 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 was composed of colder water that impinged on Chirikov Basin, Nunivak Island, and the Alaska Peninsula (Figure 4C and 4D), potentially restricting east-west and north-south

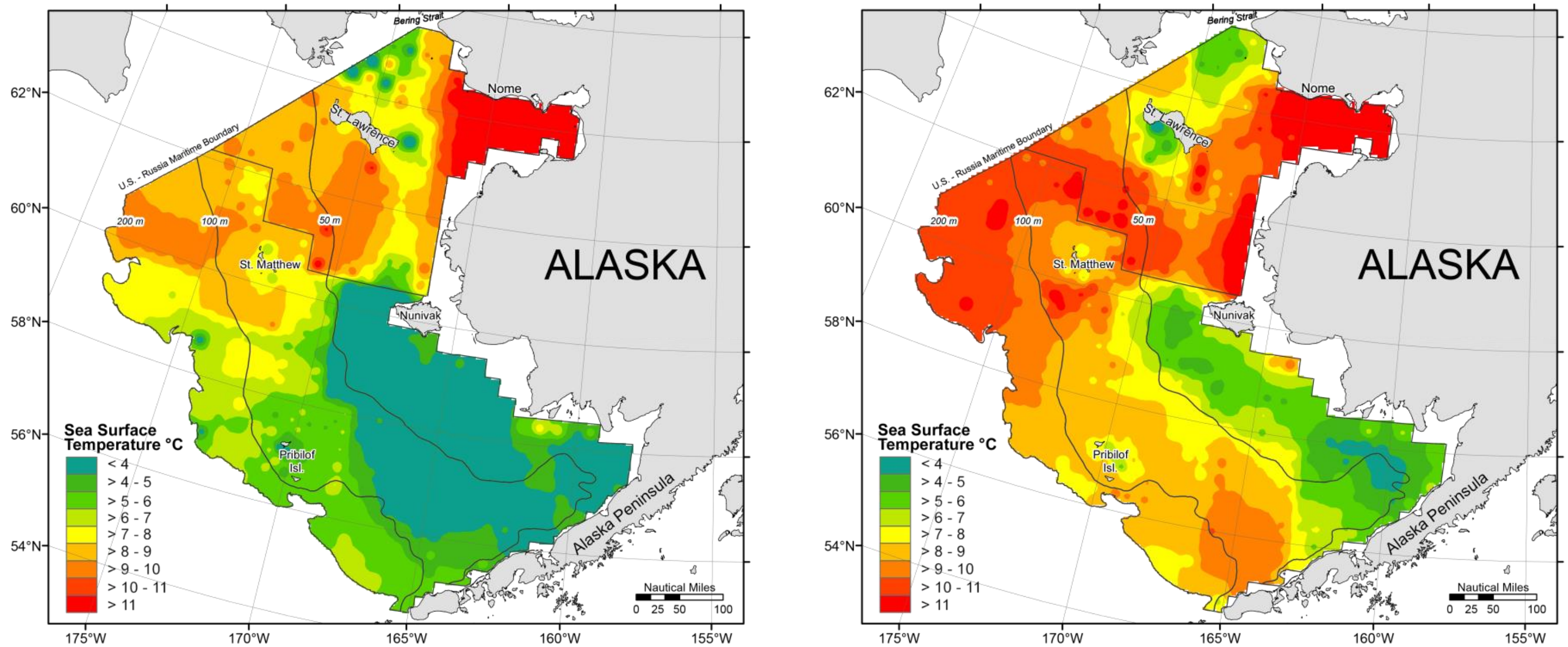

Figure 5. Sea surface temperatures recorded in the eastern Bering Sea shelf and northern Bering Sea in 2010 (left) and 2017

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. Regardless of the size of the cold pool or mean summer bottom temperatures, a portion of the cold pool persists year-round in the transboundary basin extending from the Gulf of Anadyr on the middle shelf past the west side of St. Lawrence Island. Given that some fish species appear to actively avoid areas of colder temperatures, the location of this year-round cold pool may hinder transboundary fish movement along the inner shelf through Anadyr Strait. Considering how water temperatures below freezing (<0°C) could slow down food digestion and body metabolism, such an environment would not be optimal during the summer when feeding and growth are vital. The outer shelf appears to be less of a hindrance because bottom temperatures are generally always warmer (>3°C) and the shelf is relatively broad where it crosses the transboundary basin towards Cape Navarin.

Survey Data and Specimen Collections

From the EBS and NBS shelf trawl surveys combined, a total of 418,357 individual length measurements representing 42 fish taxa were collected. Additionally, 9,333 age structures (otoliths) were collected from 12 fish taxa, 8,333 stomach samples from 15 fish taxa, 838 fecundity and maturity (ovaries) samples from two fish taxa, 567 genetic samples from six different fish and invertebrate taxa, and 1,210 pathobiology (blood) samples from 2 different crab taxa were collected for analysis by researchers after the survey.

Abundance of Fish, Crabs, and Other Invertebrates

In 2017, total bottom-dwelling animal biomass of the EBS shelf was estimated at 16.5 million metric tons (mmt), while that of the NBS was estimated at 4.6 mmt. In 2010, our survey estimated the total bottom-dwelling animal biomass of the EBS shelf at 15.4 mmt, and of the NBS at 2.9 mmt, corresponding to a 7% decrease in the overall biomass for the EBS and a 59% increase in the overall biomass in the NBS. The percent change in biomass varied by fish and invertebrate taxon (Table 1). There were notable increases in biomass for 27 taxa, decreases for 13 taxa, and no change for one taxon, the yellowfin sole. Dramatic increases were observed with walleye pollock (6,157%), Pacific cod (907%), jellyfishes (405%), sea urchins (233%), blue king crab (199%), shorthorn sculpin (185%), and northern rock sole (162%). Significant decreases in biomass were observed in Arctic cod (-90%), tunicates (-72%), smelts (-69%), basket seastars (-45%), brittle stars (-42%), corals (-32%), snow crab (-30%), Pacific halibut (-22%), saffron cod (-17%), and red king crab (-8%). In 2010, walleye pollock comprised 0.8% and flatfishes (i.e., yellowfin sole, Alaska plaice, and other flounders) comprised 32% of the total biomass (Figure 6). In 2017, the overall fish biomass was composed of mostly walleye Pollock (31%) and flatfishes (20%; Figure 7). 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 4.5% of the total biomass in the NBS in 2010, but only represented 1.7% of the total biomass in 2017. In 2017, walleye pollock and Pacific cod together comprised 37% of the total biomass in the NBS (Figures 6, 7). 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 2017 (Figures 8 and 9), but their proportional contribution to the total biomass dropped 64%. Arctic flounder, an arctic species, were rare and only present in the northernmost portion of the survey area. However, in general, overall fish biomass decreased with increasing latitude in both 2010 and 2017.

Table 1. List of the major taxa or taxonomic groups sampled in the NBS bottom trawl survey and the percentage change in biomass (mt) from 2010 to 2017.

		Biomass (mt)		
Common name	**Taxon**	**2010**	**2017**	**Change**
walleye pollock	*Gadus chalcogrammus*	20,977	1,312,620	6,157%
Pacific cod	*Gadus macrocephalus*	28,425	286,310	907%
jellfishes	Scyphozoa	13,112	66,166	405%
poachers	Agonidae	422	2,040	384%
green sea urchin	*Strongylocentrotus* sp.	49,263	164,277	233%
blue king crab	*Paralithodes platypus*	1,940	5,795	199%
shorthorn (=warty) sculpin	*Myoxocephalus scorpius*	38,172	108,753	185%
bryozoans	Bryozoa	2,747	7,463	172%
northern rock sole	*Lepidopsetta polyxystra*	21,379	56,093	162%
other flatfishes	Pleuronectidae	3,549	8,715	146%
pricklebacks	Stichaeidae	1,553	3,609	132%
sea anenomes	Actinaria	9,381	21,330	127%
clams	Bivalvia	2,531	5,374	112%
starry flounder	*Platichthys stellatus*	15,319	31,103	103%
other snails	Gastropoda	27,102	54,963	103%
Pacific herring	*Clupea pallasii*	22,289	35,365	59%
Bering flounder	*Hippoglossoides robustus*	12,661	20,022	58%
neptune whelk	*Neptunea heros*	115,325	178,443	55%
snailfishes	Liparidae	3,316	4,842	46%
plain sculpin	*Myoxocephalus jaok*	28,338	36,819	30%
hermit crabs	Paguridae	134,417	162,475	21%
purple-orange sea star	*Asterias amurensis*	298,087	353,314	19%
all shrimps		3,777	4,462	18%
Alaska plaice	*Pleuronectes quadrituberculatu*	309,523	333,947	8%
Alaska skate	*Bathyraja parmifera*	78,972	84,267	7%
segmented worms	Polychaetes	124	130	5%
other sculpins	Cottidae	10,219	10,422	2%
yellowfin sole	*Limanda aspera*	438,548	439,801	0%
other sea stars	Asteridae	103,392	101,312	(2%)
red king crab	*Paralithodes camtschaticus*	2,453	2,254	(8%)
eelpouts	Zoarcidae	11,313	9,842	(13%)
saffron cod	*Eleginus gracilis*	91,593	76,455	(17%)
Pacific halibut	*Hippoglossus stenolepis*	23,806	18,538	(22%)
snow crab	*Chionoecetes opilio*	324,549	227,948	(30%)
corals	Anthozoa	12,343	8,429	(32%)
brittle stars	Ophiuridae	69,653	40,697	(42%)
basket starfish	*Gorgonocephalus* sp.	68,662	39,878	(42%)
Other crabs		60,972	33,575	(45%)
smelts	Osmeridae	16,745	5,273	(69%)
tunicates	Urochordata	358,440	101,083	(72%)
Arctic cod	*Boreogadus saida*	37,981	3,963	(90%)

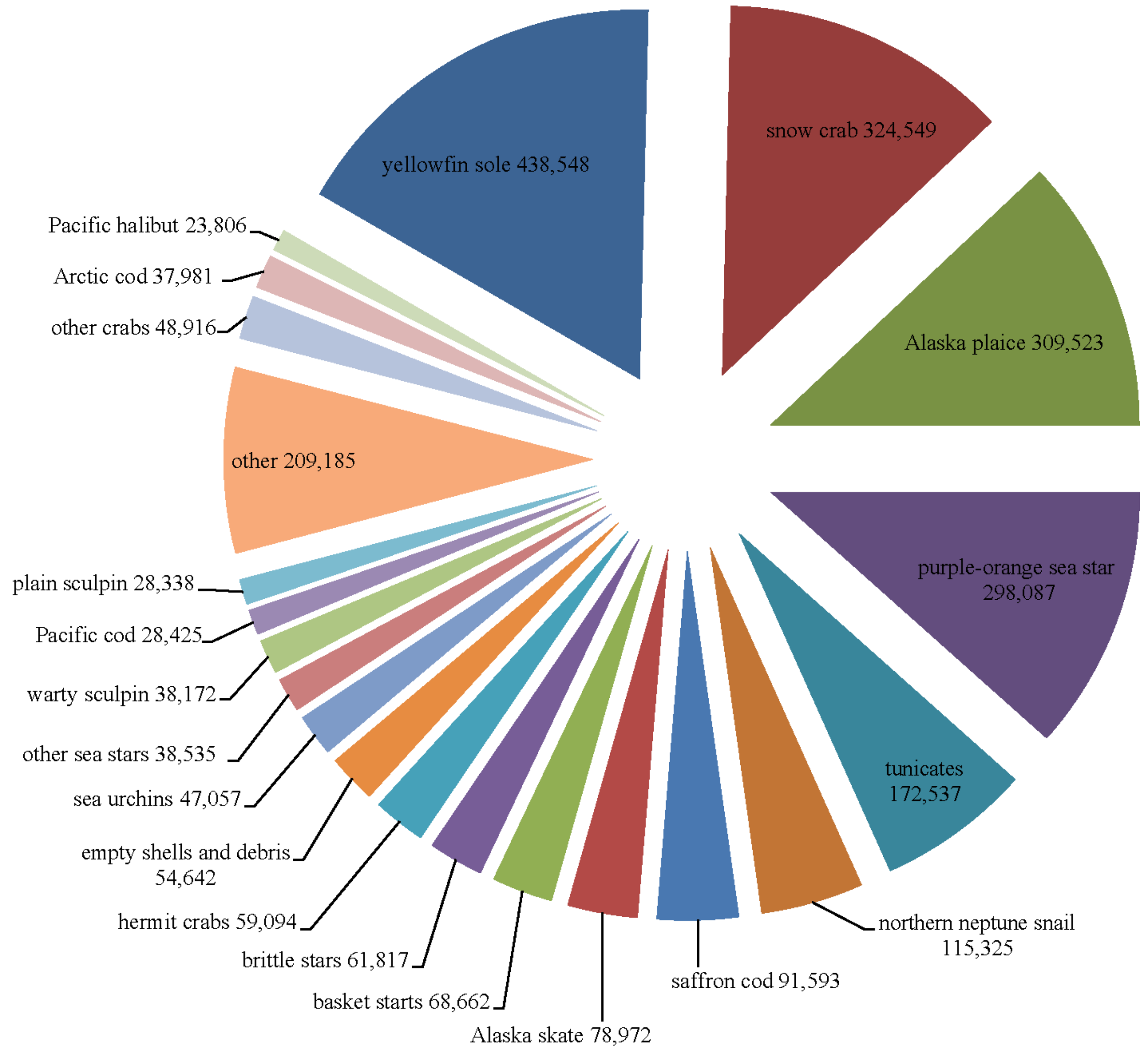

Figure 6. Proportional species composition based on estimated population biomass in metric tons (mt) for the 20 most abundant taxa observed during the 2010 NBS survey. Taxa not represented in the top 20 are listed in Appendix Table A1.

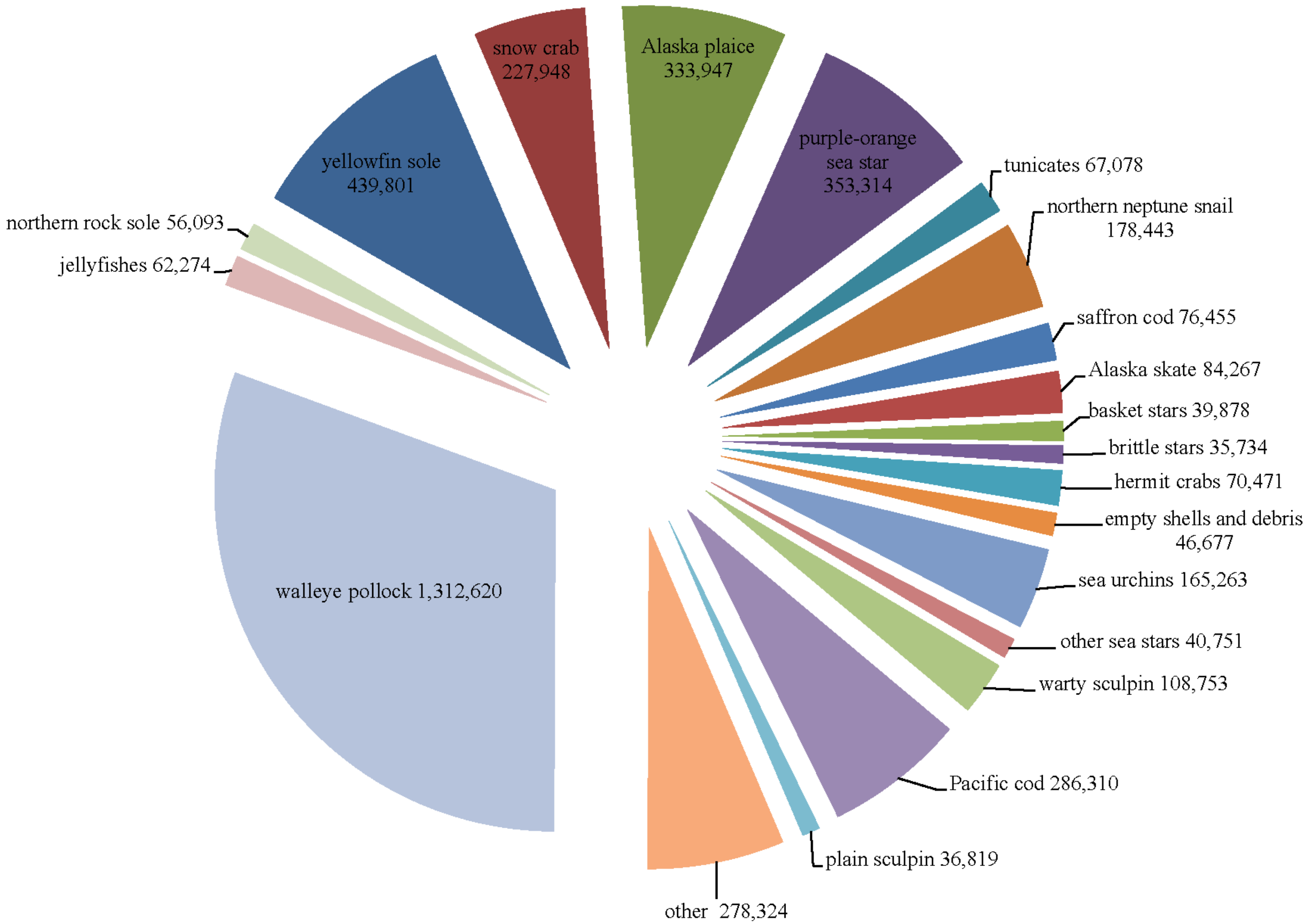

Figure 7. Proportional species composition based on estimated population biomass in metric tons (mt) for the 20 most abundant taxa observed during the 2017 NBS survey. Taxa not represented in the top 20 are listed in Appendix Table A1.

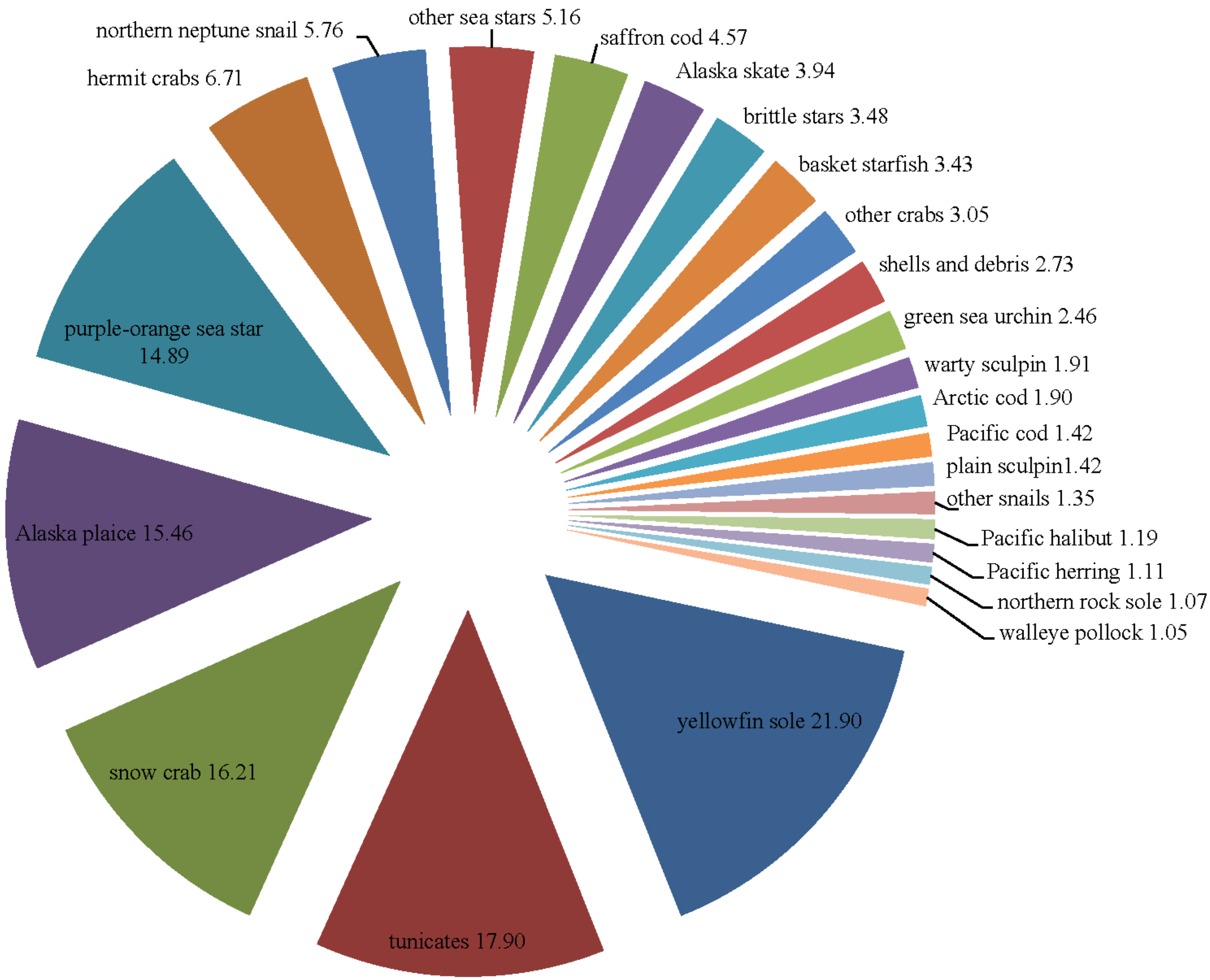

Figure 8. Proportional relative abundance for the most abundant taxa observed during the 2010 NBS survey based upon mean CPUE (in kg/ha). Taxa with a CPUE less than 1.0 kg/ha are can be found in Appendix Table A2.

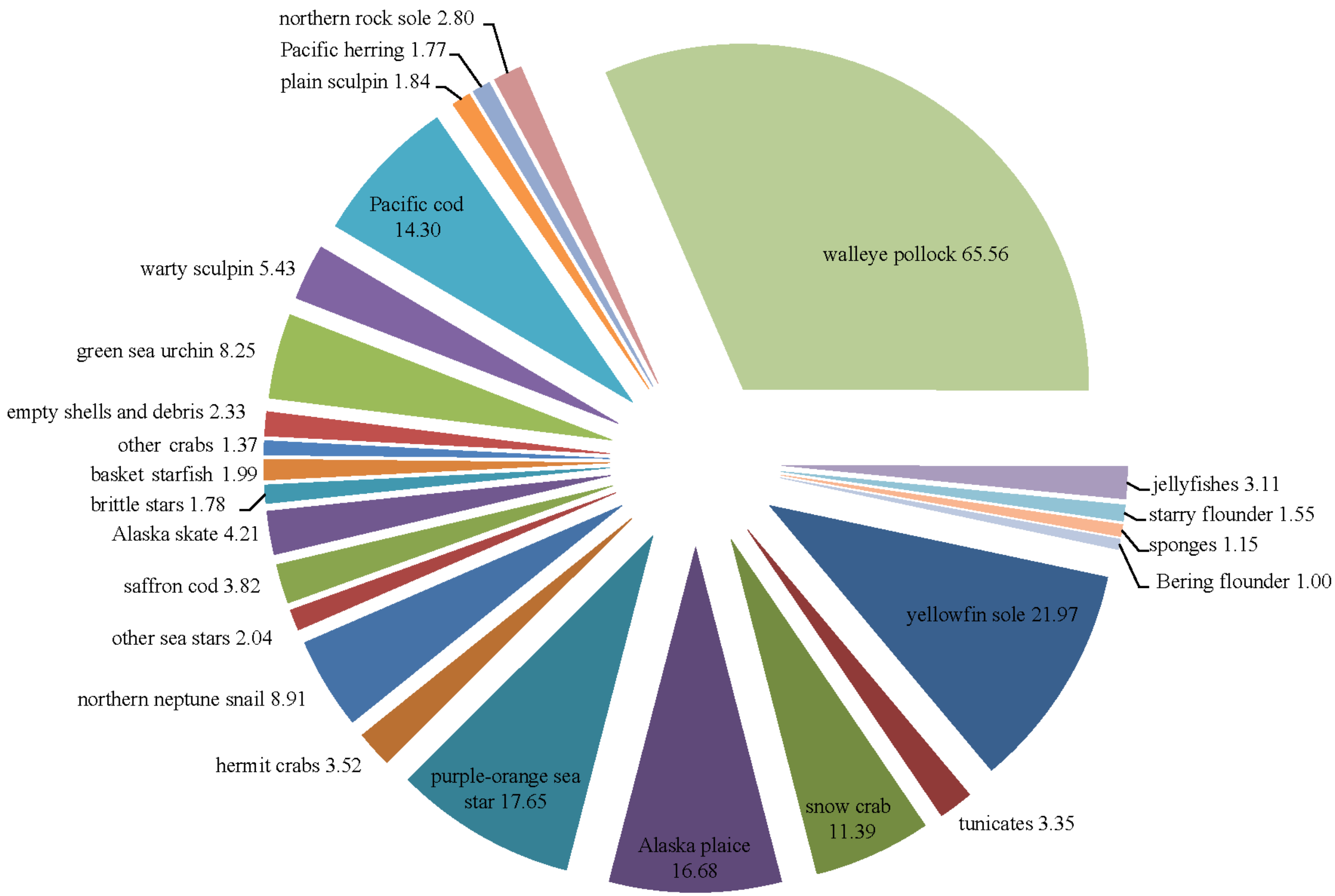

Figure 9. Proportional relative abundance for the most abundant taxa observed during the 2017 NBS survey based on mean CPUE (in kg/ha). Taxa with a CPUE less than 1.0 can be found in Appendix Table A2.

Crabs and other invertebrates (i.e., shrimps, sea squirts, sea stars, jellyfish, and urchins) made up 32% of the biomass in 2017, whereas invertebrates made up 51% of the biomass in 2010 (Figures 6 & 7). In 2017, echinoderms (seastars, urchins, basket stars, sand dollars, and sea cucumbers) and crustaceans (crabs and shrimps) were the major invertebrate taxa, together comprising 71% of the total invertebrate biomass, and similarly accounted for 73% of the total invertebrate biomass in 2010.

Overall, 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 2017.

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

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 and 2017 survey results.

*Please help us with this document by providing names for each fish species in local language(s), or correcting names if they are incorrect.

Yellowfin Sole

common name

?

Central Yup'ik

?

St. Lawrence Island Yupik

?

Inupiaq

Limanda aspera

scientific name

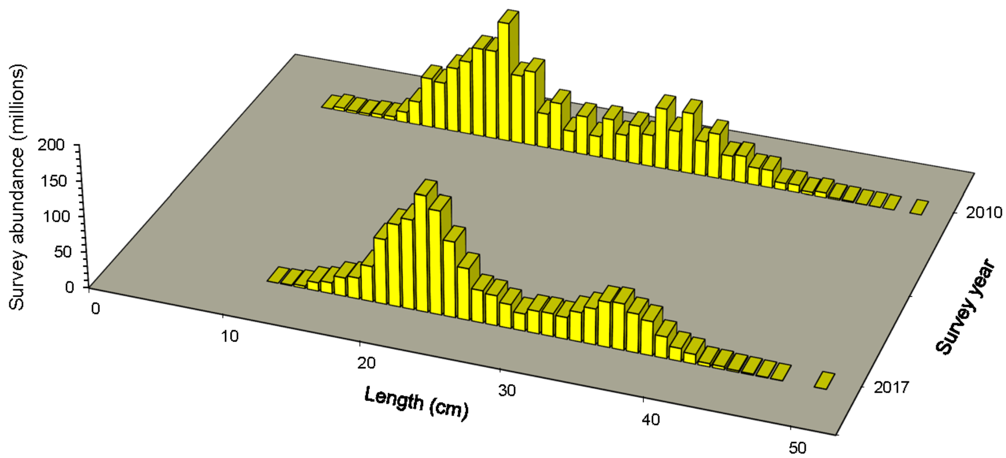

Figure 10. Total abundance-at-size of yellowfin sole in the NBS during 2010 and 2017.

Yellowfin biomass remained relatively stable between 2010 and 2017. Yellowfin sole was the 2nd most predominant species in the 2017 NBS survey, comprising 10% (439,801 mt, Figure 7) of the total NBS survey area biomass. Yellowfin sole were caught at 132 of the 144 NBS survey stations. In 2010, yellowfin sole comprised 15% (438,548 mt, Figure 6) 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. In 2010 and 2017, size compositions were similar with two length cohort nodes around 24 cm and 36 cm (Figure 10). Spatial distribution also remained similar between 2010 and 2017 (Figure 11).

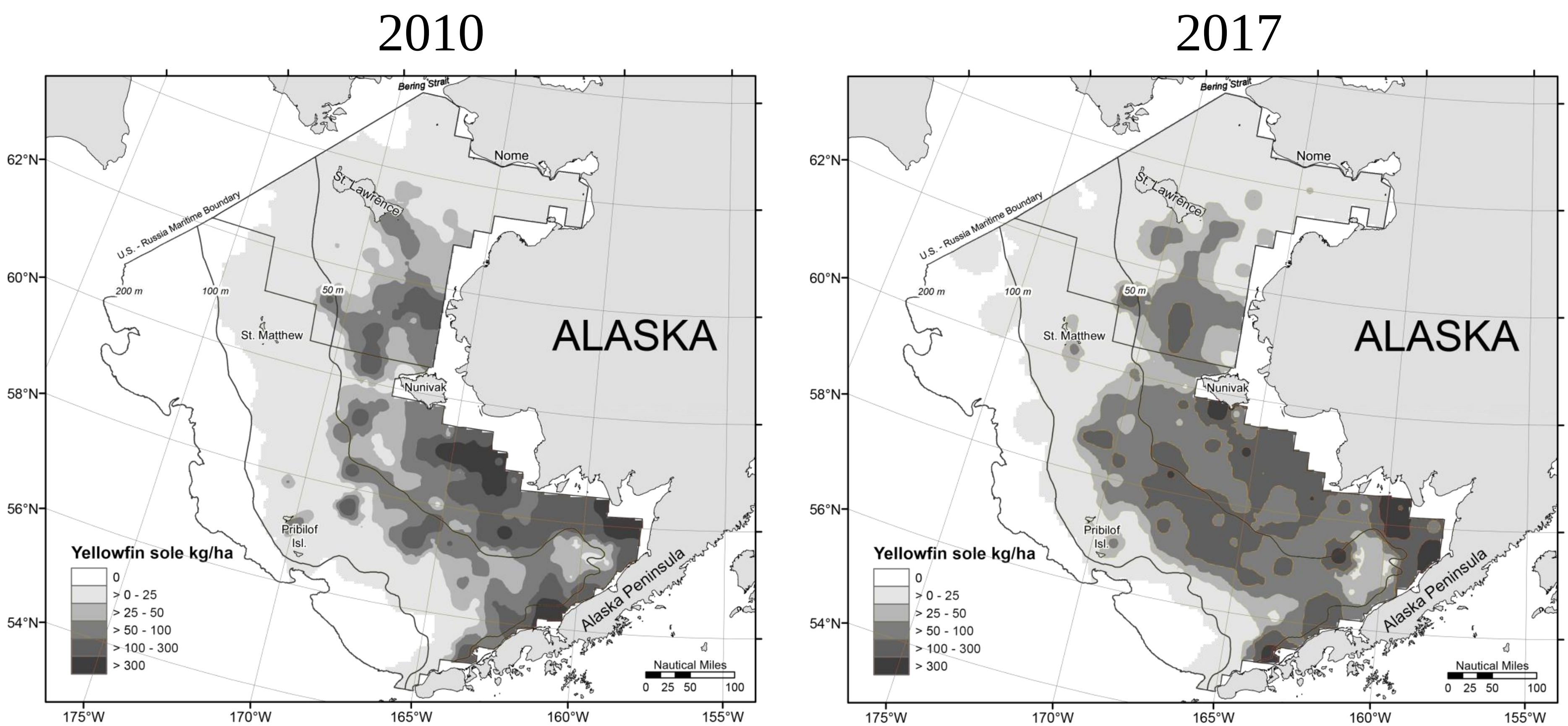

Figure 11. Distribution and relative abundance of yellowfin sole during 2010 (left) and 2017 (right) NBS and EBS surveys.

Snow Crab

common name

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Central Yup'ik

?

St. Lawrence Island Yupik

?

Inupiaq

Chionoecetes opilio

scientific name

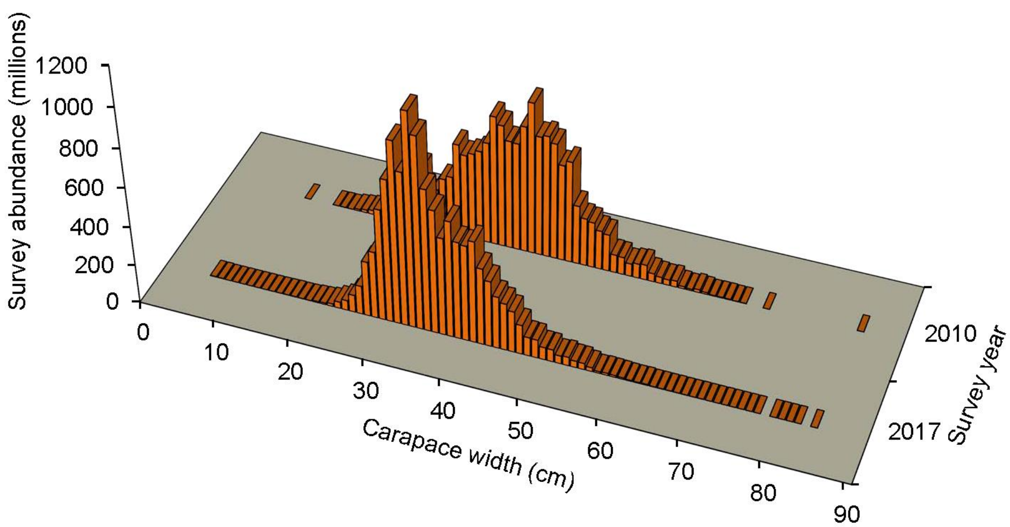

Figure 12. Total abundance-at-size of snow crab in the NBS during 2010 and 2017.

In 2017, Snow crab comprised 5% (227,948 mt, Figure 7) 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, Figure 6) 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 12). 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 2017, highest densities were located along the 100 m contour line and just south of St. Lawrence Island (Figure 13).

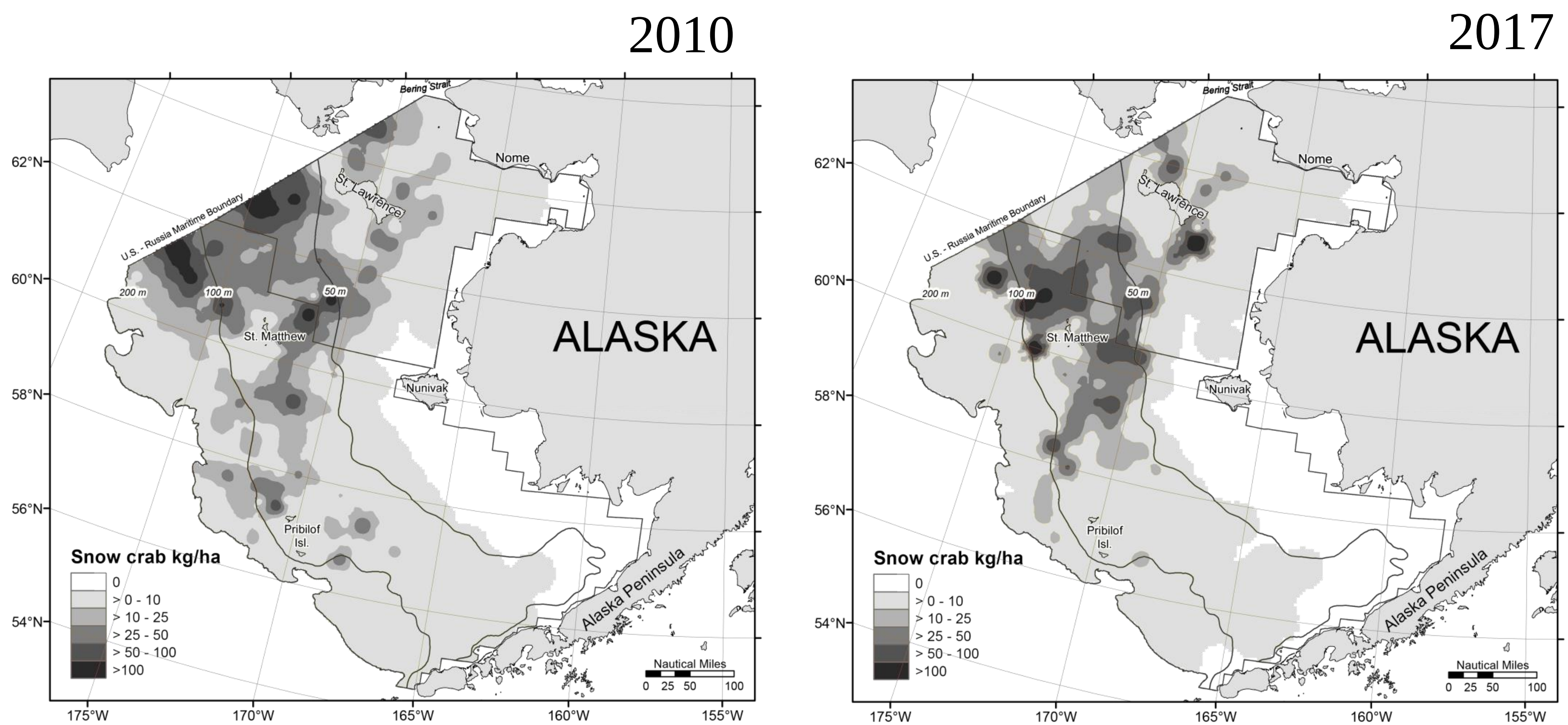

Figure 13. Distribution and relative abundance of snow crab during 2010 (left) and 2017 (right) NBS and EBS surveys.

Alaska Plaice

common name

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Central Yup'ik

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St. Lawrence Island Yupik

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Inupiaq

Pleuronectes quadrituberculatus

scientific name

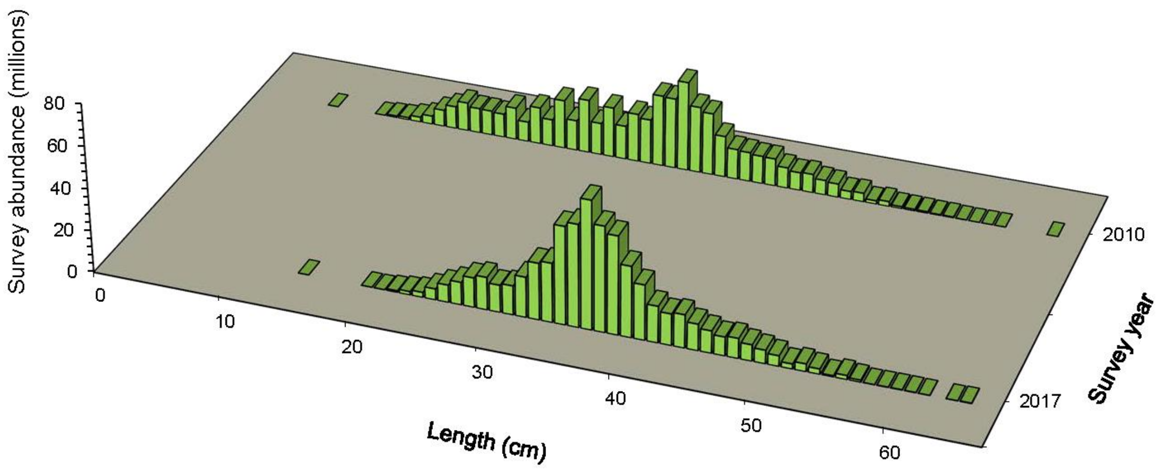


Figure 14. Total abundance-at-size of Alaska plaice in the NBS during 2010 and 2017.

In 2017, Alaska Plaice biomass exhibited a slight decrease to 8% (333,947 mt, Figure 7) of the total NBS survey biomass from 2010 (10%, 309,523 mt, Figure 6). Alaska plaice biomass increased by 8% in 2017. Their distribution was highest between the 50 m and 100 m contour inside the cold pool (Figure 15). 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. The longest Alaska Plaice measured in 2017 was 64 cm (25") in fork length (Figure 14).

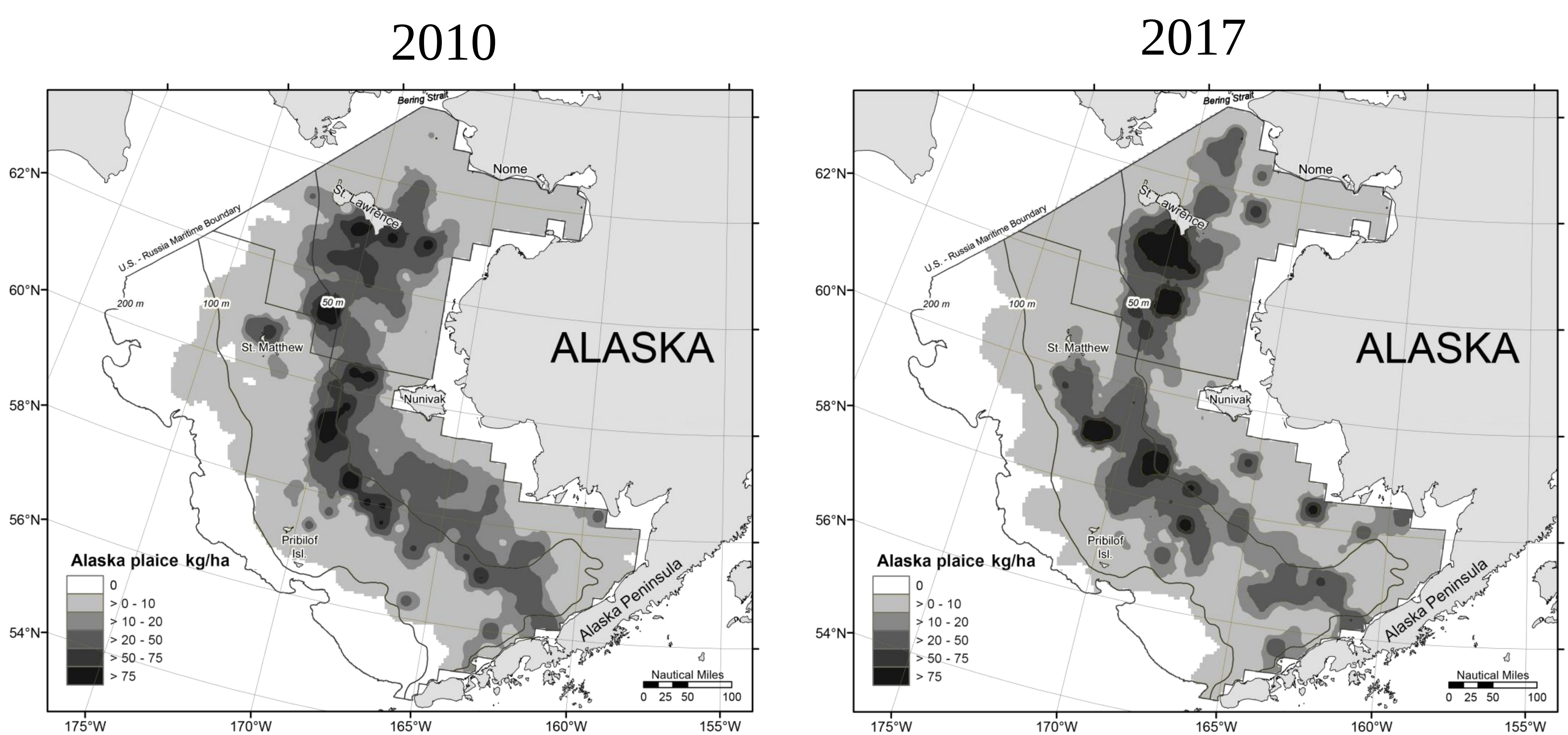


Figure 15. Distribution and relative abundance of Alaska plaice during 2010 (left) and 2017 (right) NBS and EBS surveys.

Purple-orange seastar

common name

?

Central Yup'ik

?

St. Lawrence Island Yupik

?

Inupiaq

Asterias amurensis

scientific name

The purple-orange sea star is also known as the northern Pacific sea star. This species of seastar made up 8% (353,314 mt, Figure 7) of the total fish and invertebrate biomass in the NBS. Biomass of the purple-orange sea star increased by 19% between 2010 and 2017. Catch rates for the purple sea star were highest in the survey area along and inside the 50 m contour of the inner shelf from the Alaska Peninsula to Port Clarence as well as in Norton Sound (Figure 16). The purple-orange seastar prefers warmer water and increase in biomass in 2017 may be due to warm water temperatures during warm stanza.

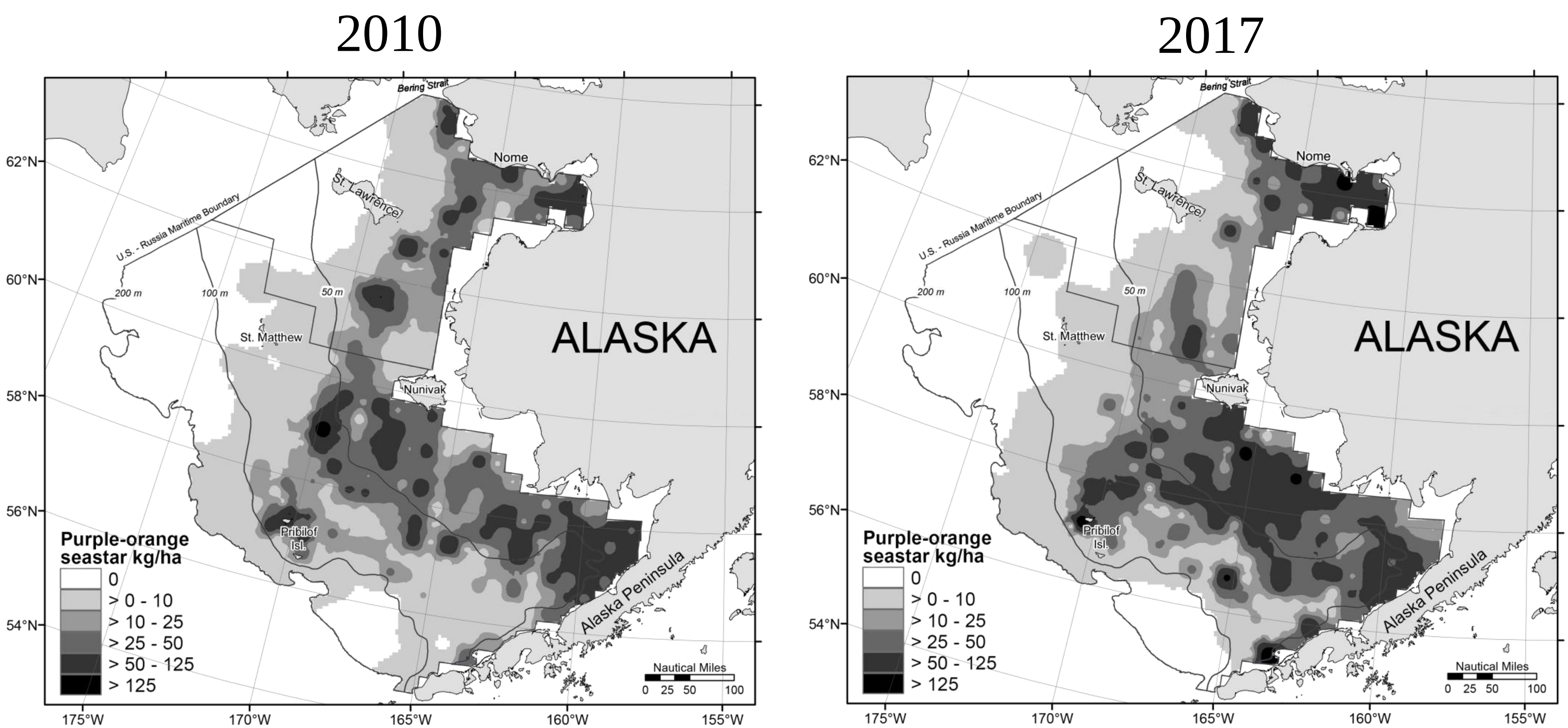


Figure 16. Distribution and abundance of purple-orange seastar during 2010 (left) and 2017 (right) NBS and EBS surveys.

Northern neptune snail

common name

?

Central Yup'ik

?

St. Lawrence Island Yupik

?

Inupiaq

Neptunea heros

scientific name

The northern neptune snails were caught in waters between 12 and 58 meters deep along the northern Bering Sea shelf. Highest concentrations were found around St. Lawrence Island (Figure 17). The percent biomass remained stable at 4% between the 2010 and 2017 northern Bering Sea surveys although total biomass for the northern neptune snail increased by 63,118 mt.

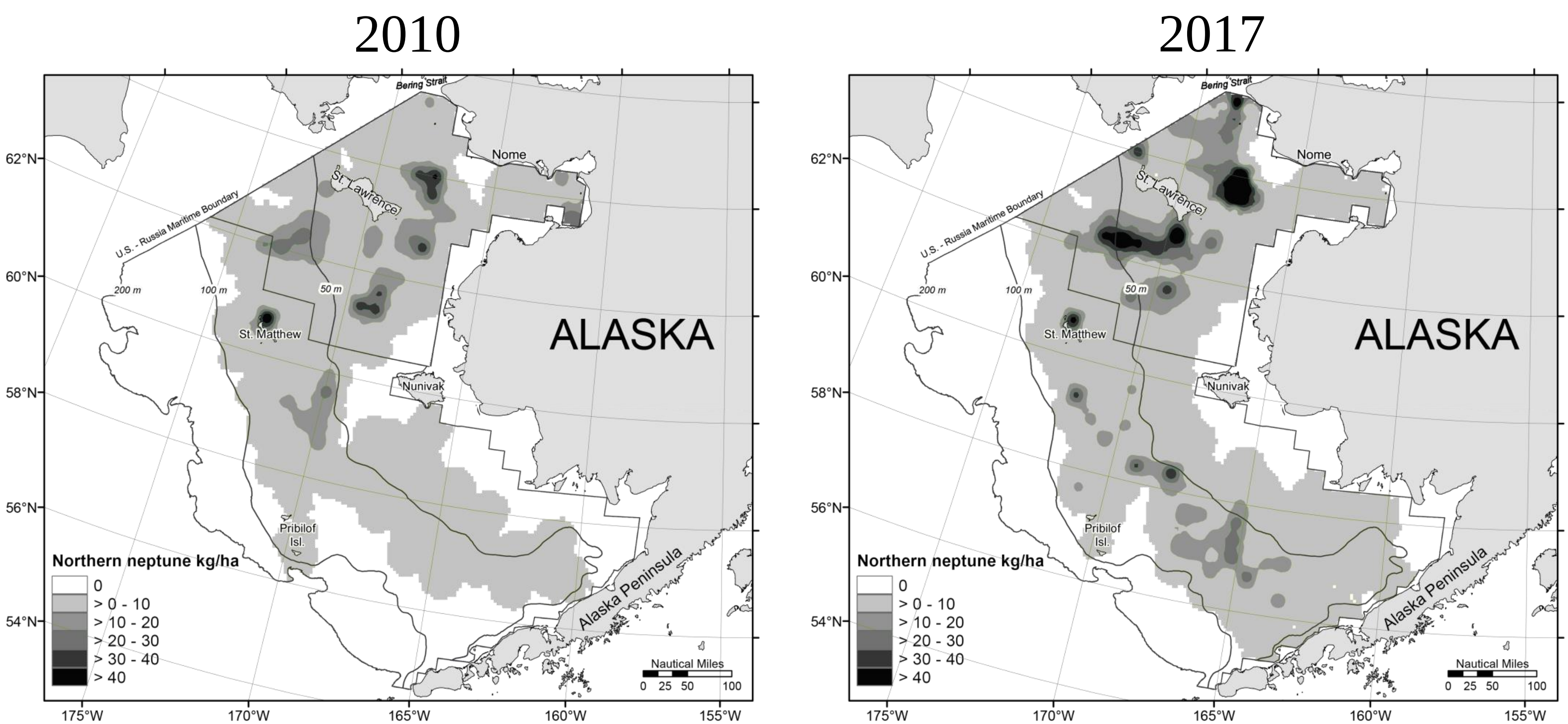


Figure 17. Distribution and abundance of northern Neptune snail during 2010 (left) and 2017 (right) NBS and EBS surveys.

Saffron Cod

common name

?

Central Yup'ik

?

St. Lawrence Island Yupik

Uugaq

Inupiaq

Eleginus gracilis

scientific name

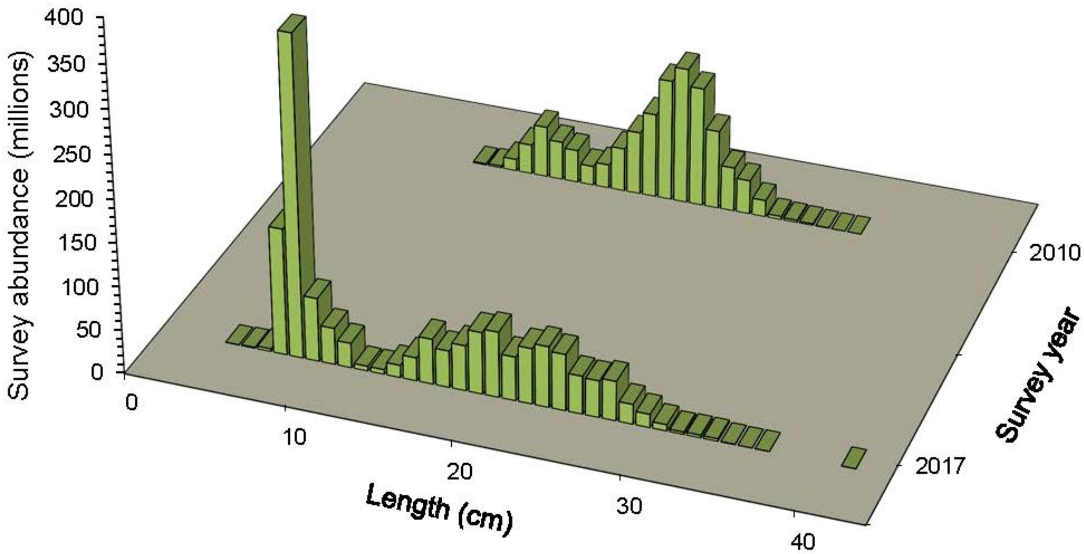


Figure 18. Total abundance-at-size of saffron cod in the NBS during 2010 and 2017.

Saffron cod represented about 3% of the total biomass in the 2017 NBS survey. There was a 17% reduction in saffron cod biomass in 2017. These forage fish were most dense just north of Nunivak island, southeast of St. Lawrence Island and up through Norton Sound (Figure 19). Saffron cod were present at 82 of 144 stations in 2017 with depths between 20 and 54 meters (Figure 19). Saffron cod are considered to be a more nearshore, bottom species. The size distribution in 2017 showed a large increase in the overall number of smaller (<10 cm) individuals (juveniles) caught in the northern Bering Sea area (Figure 18).

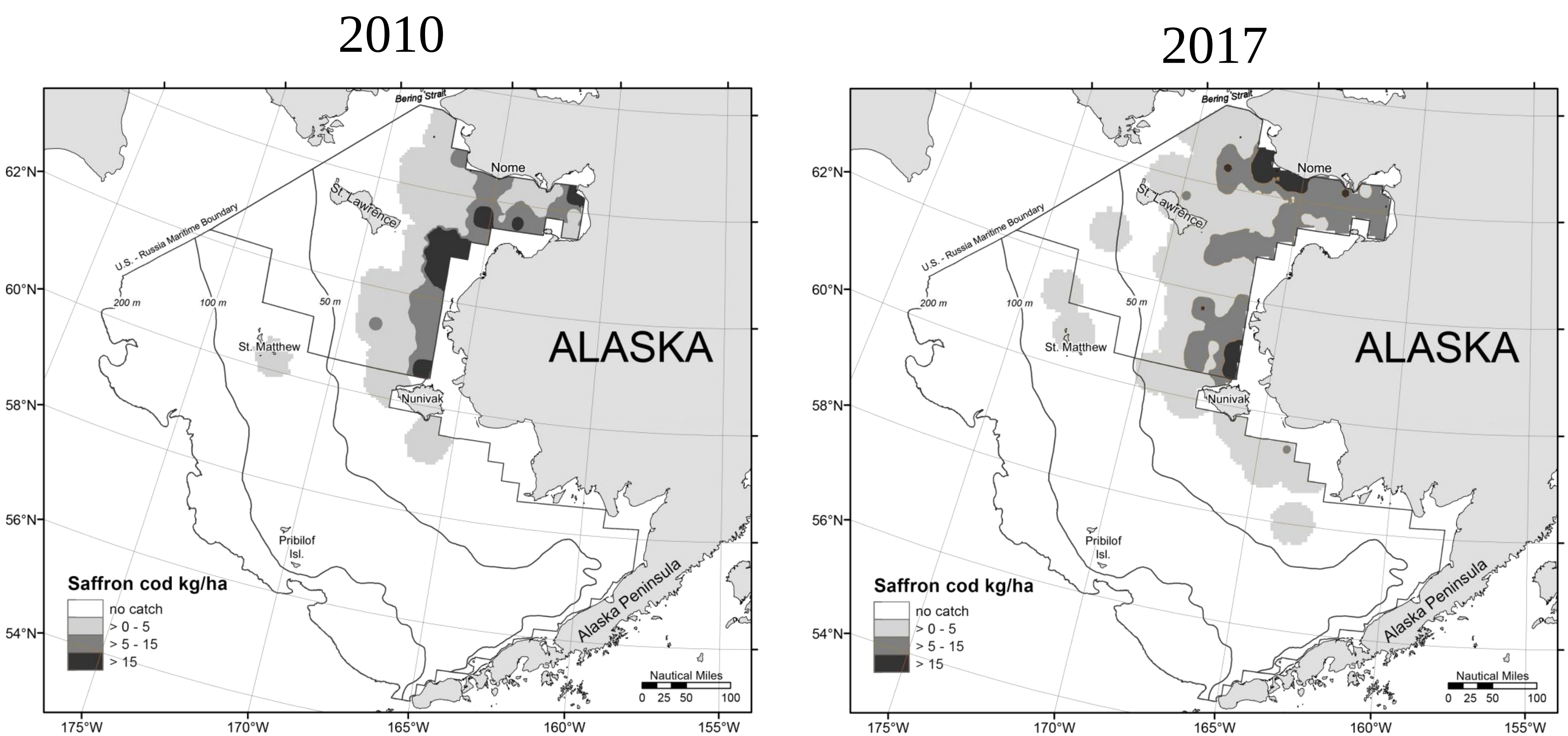


Figure 19. Distribution and relative abundance of saffron cod during 2010 (left) and 2017 (right) NBS and EBS surveys.

Arctic Cod

common name

?

Central Yup'ik

?

St. Lawrence Island Yupik

Iqalugaq

Inupiaq

Boreogadus saida

scientific name

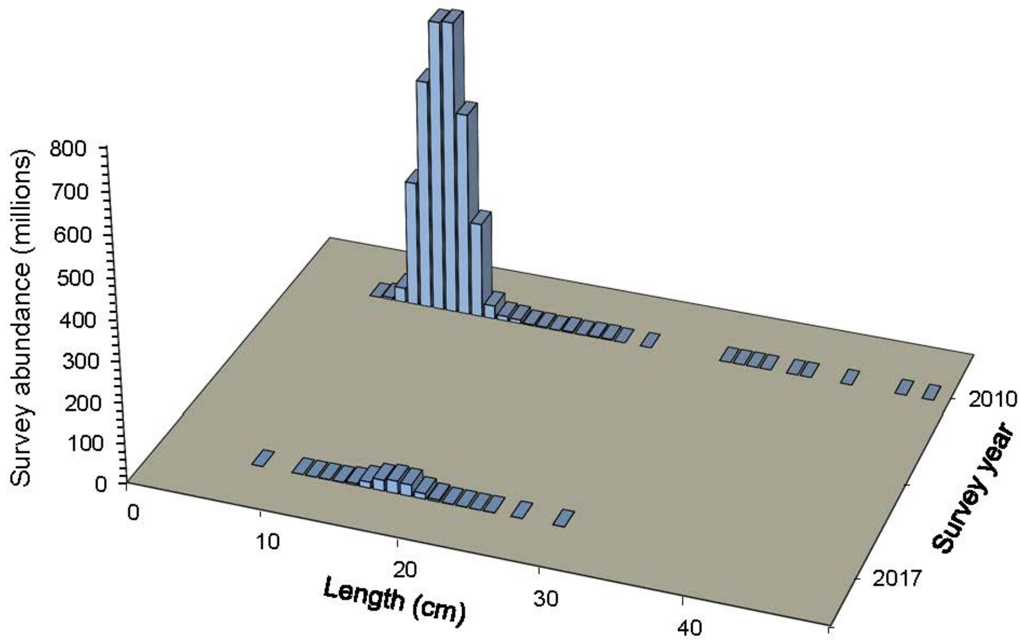


Figure 20. Total abundance-at-size of Arctic cod in the NBS during 2010 and 2017.

Arctic cod represented about 1% of the total biomass in the NBS in 2017. Between 2010 and 2017, there was a 90% reduction in Arctic cod biomass. The CPUE decreased from 1.9 kg/ha in 2010 to 0.02 kg/ha in 2017. The highest densities were recorded in the area of the cold pool with the lowest bottom temperatures (<-1°C; Figure 21). Overall spatial distribution of this forage fish decreased in 2017 (Figure 21). In 2010, a large node existed at lengths between 8 and 15 cm, whereas in 2017, the node magnitude was much smaller and existed at lengths between 15 and 21 cm (Figure 20).

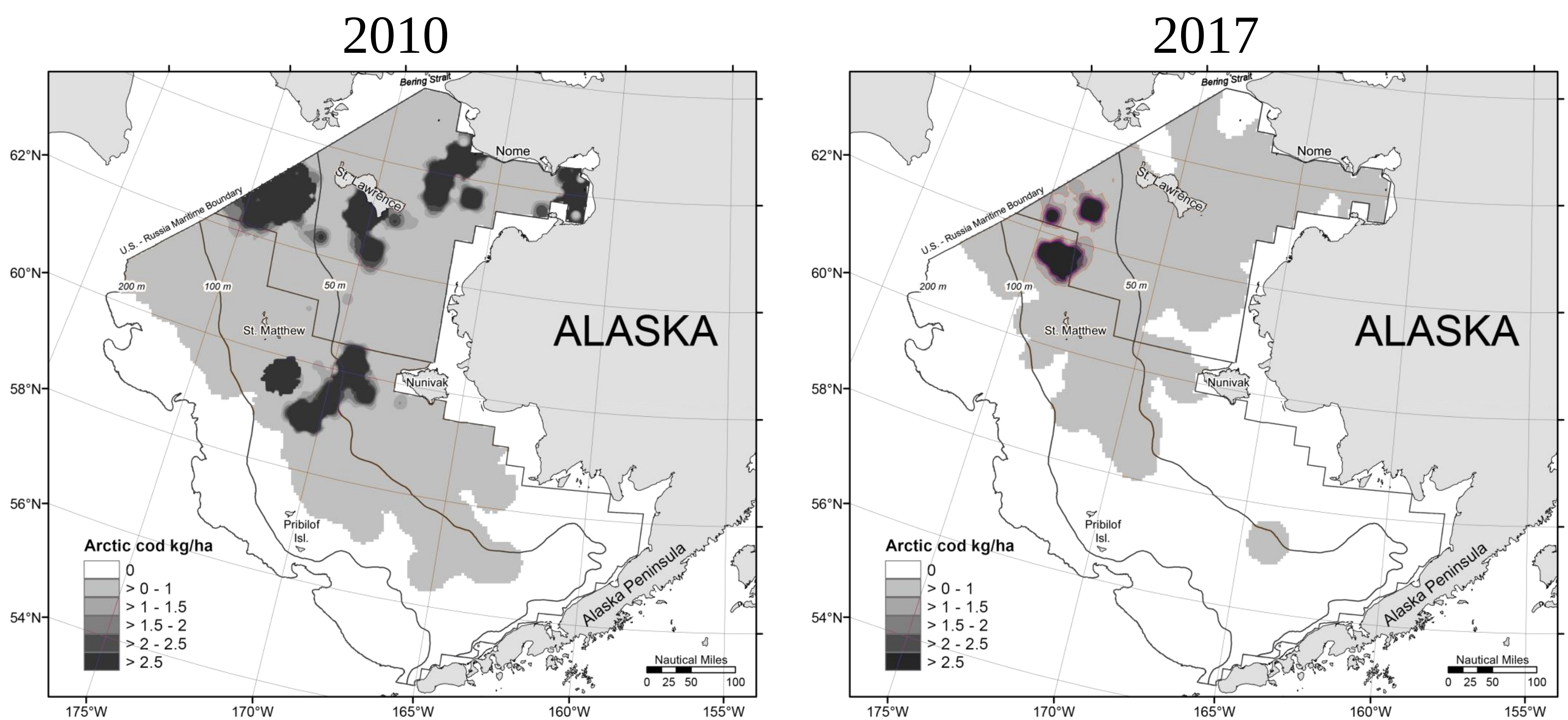


Figure 21. Distribution and relative abundance of Arctic cod during 2010 (left) and 2017 (right) NBS and EBS surveys.

Pacific Cod

common name

?

Central Yup'ik

atigiaq (Bristol Bay)

atgiiyaq (Nunivak Island)

centurrnaq

iqalluaq (Yukon, Hooper Bay, Chevak, Nunivak Island)

St. Lawrence Island Yupik

?

Inupiaq

Gadus macrocephalus

scientific name

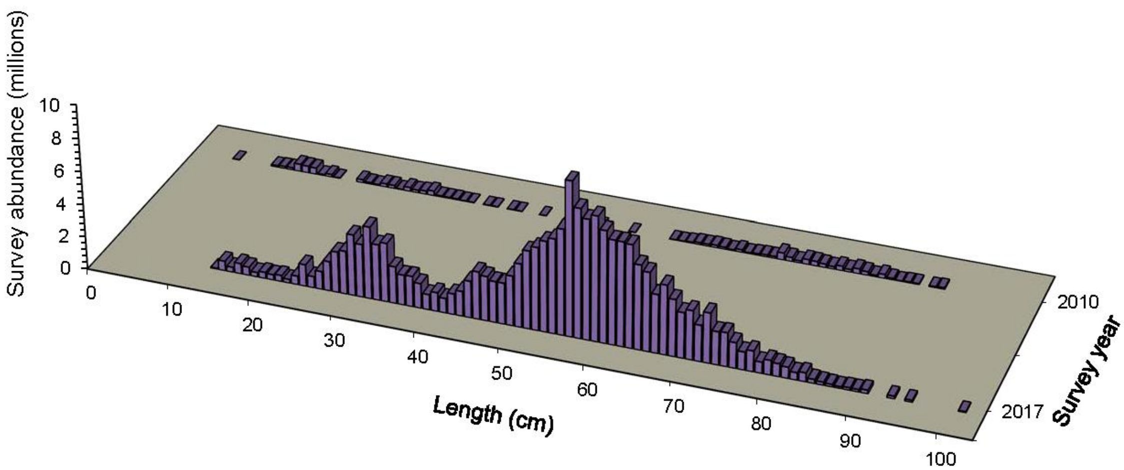


Figure 22. Total abundance-at-size of Pacific cod in the NBS during 2010 and 2017.

Pacific cod represented about 1% of the total catch in the NBS by weight. This is an increase from 0.01% in 2010. Pacific cod were broadly distributed across the shelf and the highest densities were recorded on the northeastern and northwestern edges of the cold pool in the NBS (Figure 23). Pacific cod were present at 113 of 144 stations in the NBS survey area and were found to be less abundant where bottom temperatures were less than 1°C (Figure 23). Size composition in 2017 shows three nodes around 34 cm, 47cm, and 58 cm (Figure 22).

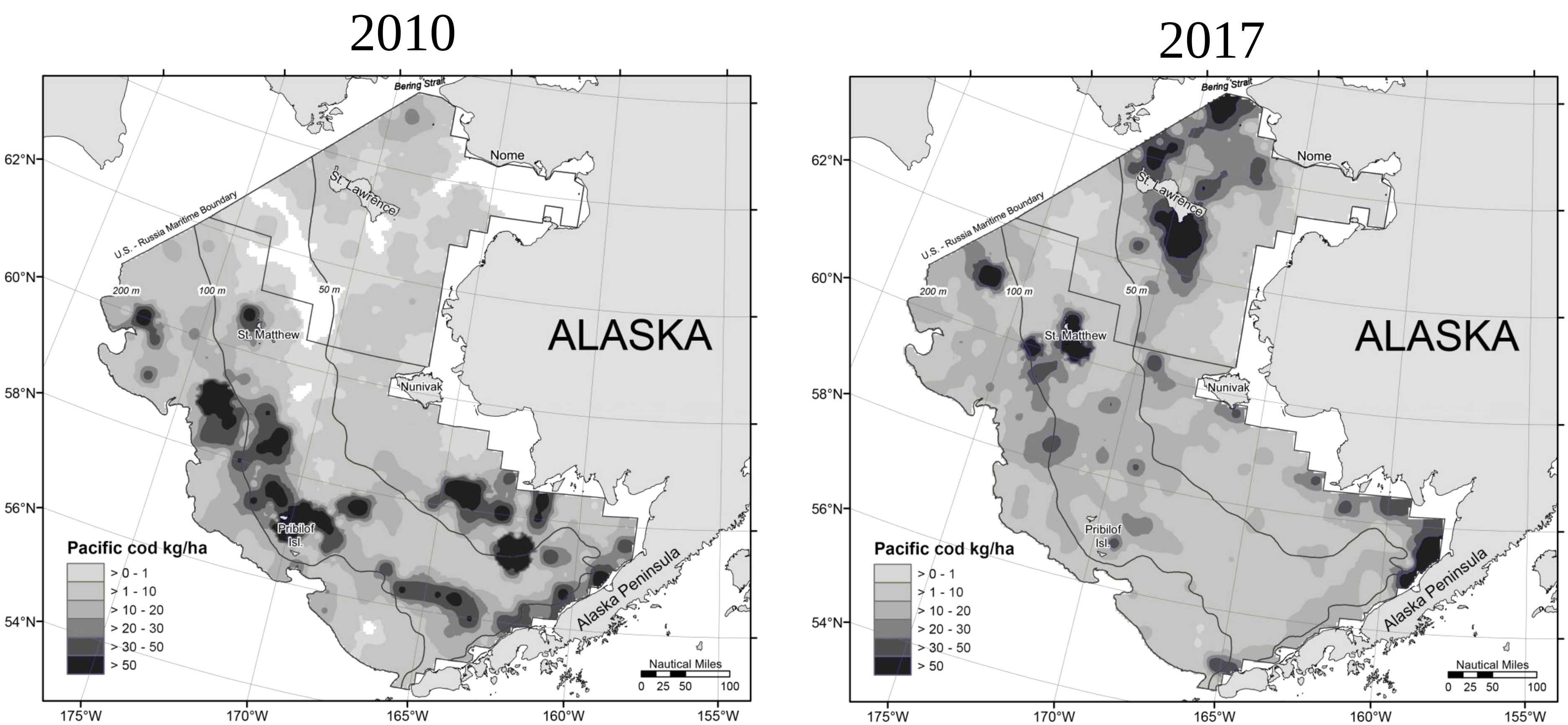


Figure 23. Distribution and relative abundance of Pacific cod during 2010 (left) and 2017 (right) NBS and EBS surveys.

Walleye Pollock
common name

?

Central Yup'ik

?

St. Lawrence Island Yupik

?

Inupiaq

Gadus chalcogrammus

scientific name

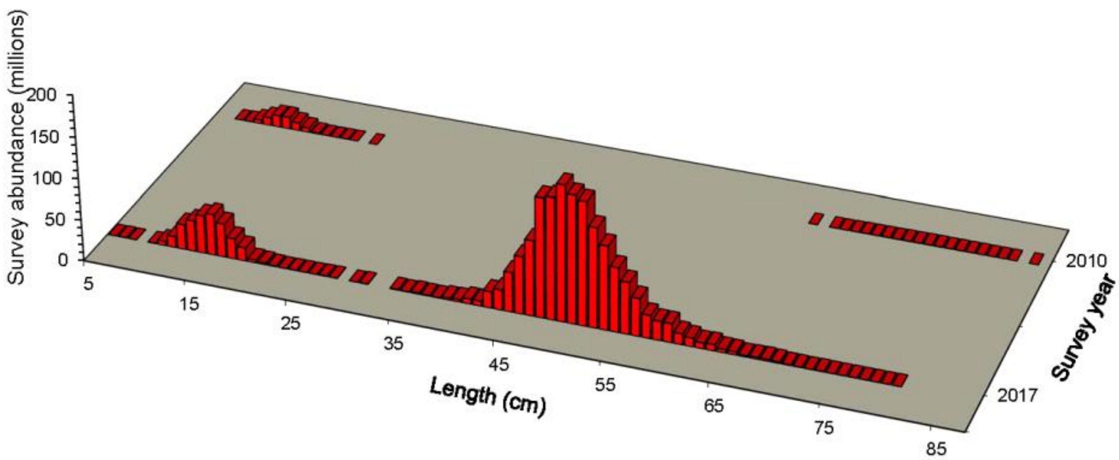


Figure 24. Total abundance-at-size of walleye pollock in the NBS during 2010 and 2017.

Walleye Pollock represented 31% of the total NBS biomass in 2017. The spatial distribution was highest on the eastern edge of the U.S.-Russian maritime border and extended south of St. Lawrence Island (Figure 25). In 2017, walleye pollock were present at 136 of 144 stations in the NBS compared to 89 of 142 in 2010 (Figure 25). A significant increase in number of pollock at lengths 45 to 55 cm was observed in 2017 (Figure 24).

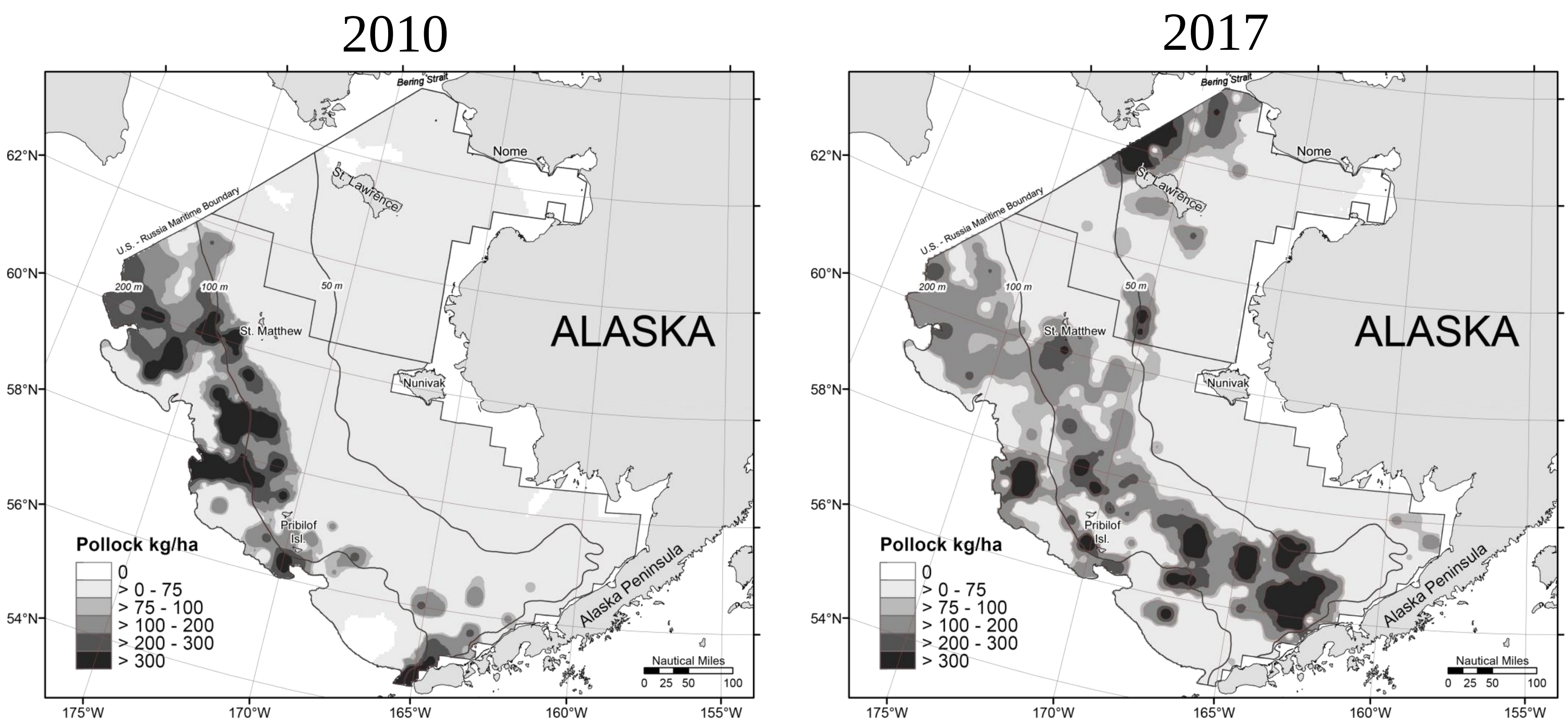


Figure 25. Distribution and relative abundance of walleye pollock during 2010 (left) and 2017 (right) NBS and EBS surveys.

Alaska Skate

common name

?

Central Yup'ik

?

St. Lawrence Island Yupik

?

Inupiaq

Bathyraja parmifera

scientific name

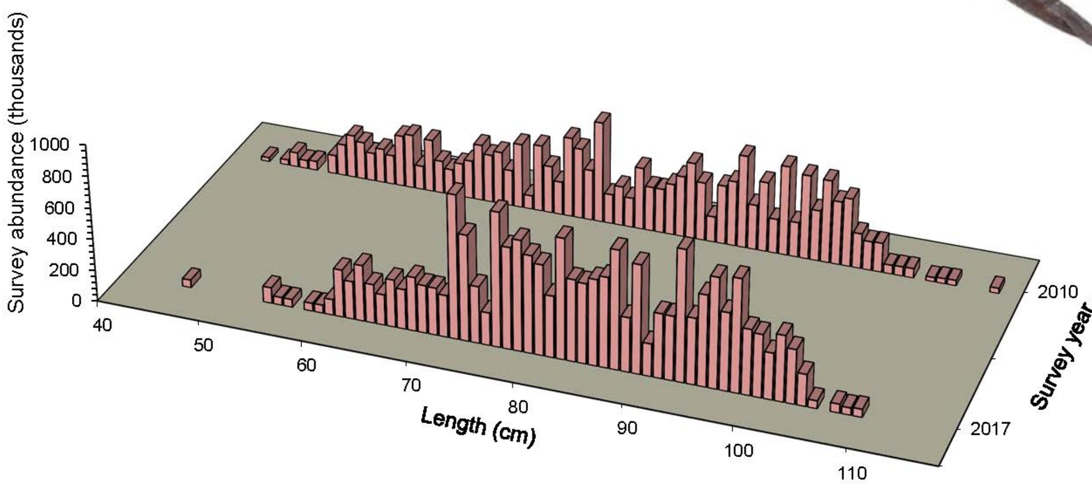


Figure 26. Total abundance-at-size of Alaska skate in the NBS during 2010 and 2017.

Alaska skate were found at 84 of the 144 stations in the NBS survey area in 2017 (Figure 27). These skates were present at station depths ranging from 23 to 79 m (Figure 27). The Alaska skate is the most abundant skate in the Bering Sea. A similar size composition was observed in 2010 and 2017 (Figure 26).

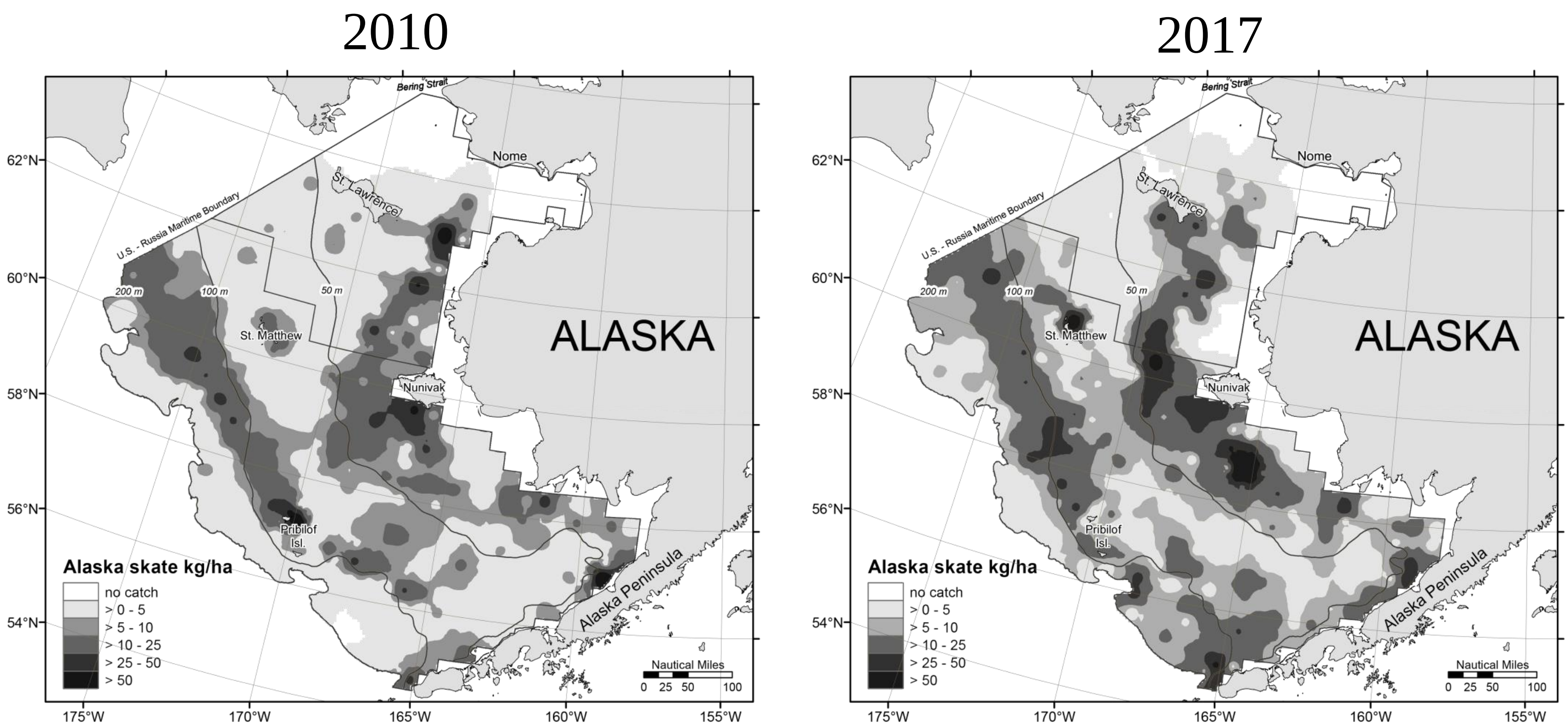


Figure 27. Distribution and relative abundance of Alaska skate during 2010 (left) and 2017 (right) NBS and EBS surveys.

Warty Sculpin

common name

?

Central Yup'ik

nertuli

St. Lawrence Island Yupik

kanayuq

Inupiaq

Myoxocephalus scorpius

(previously *Myoxocephalus verrucosus*)

scientific name

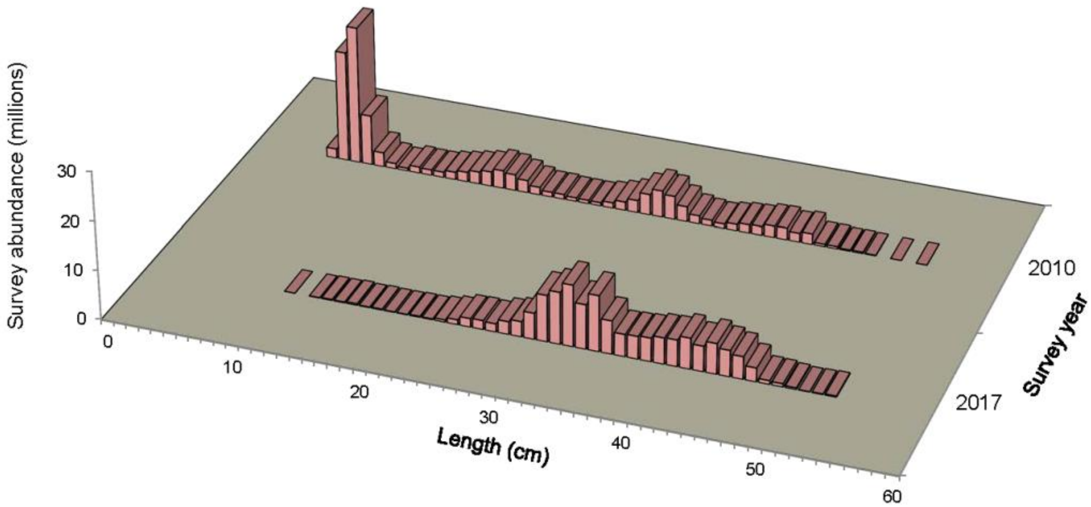


Figure 28. Total abundance-at-size of warty sculpin in the NBS during 2010 and 2017.

Warty sculpin were more numerous in the NBS than the EBS. The highest densities of warty sculpins occurred north of St. Lawrence Island (Figure 29). Presence of warty sculpins occurred at stations with bottom depths between 27 and 65 m (Figure 29). In 2017, more, larger individuals were present in the NBS (Figure 28).

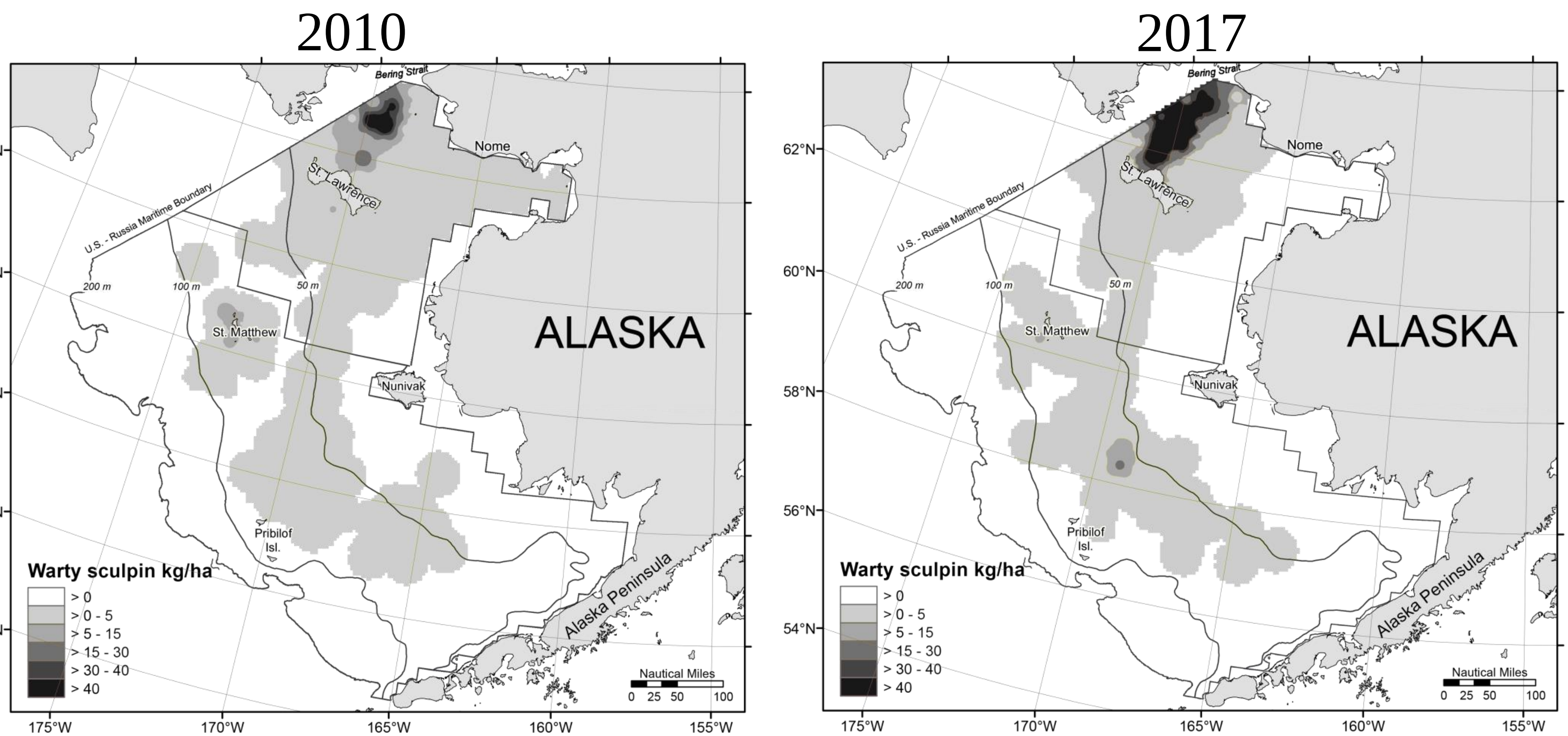


Figure 29. Distribution and relative abundance of warty sculpin during 2010 (left) and 2017 (right) NBS and EBS surveys.

Plain Sculpin

common name

?

Central Yup'ik

nertuli

St. Lawrence Island Yupik

?

Inupiaq

Myoxocephalus joak

scientific name

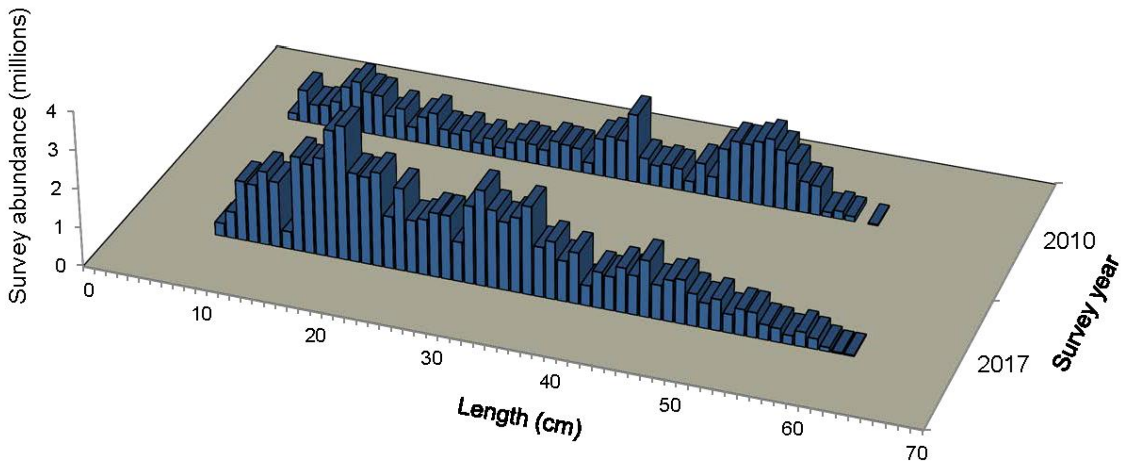


Figure 30. Total abundance-at-size of plain sculpin in the NBS during 2010 and 2017.

Plain sculpin were caught at bottom depths between 12 and 74 meters, with an average depth of 39 m (Figure 31). Densities of plain sculpin were highest south of St. Lawrence Island and in the center of the Norton Sound inlet (Figure 31). In both 2010 and 2017, several weak nodes existed in the size composition plot (Figure 30).

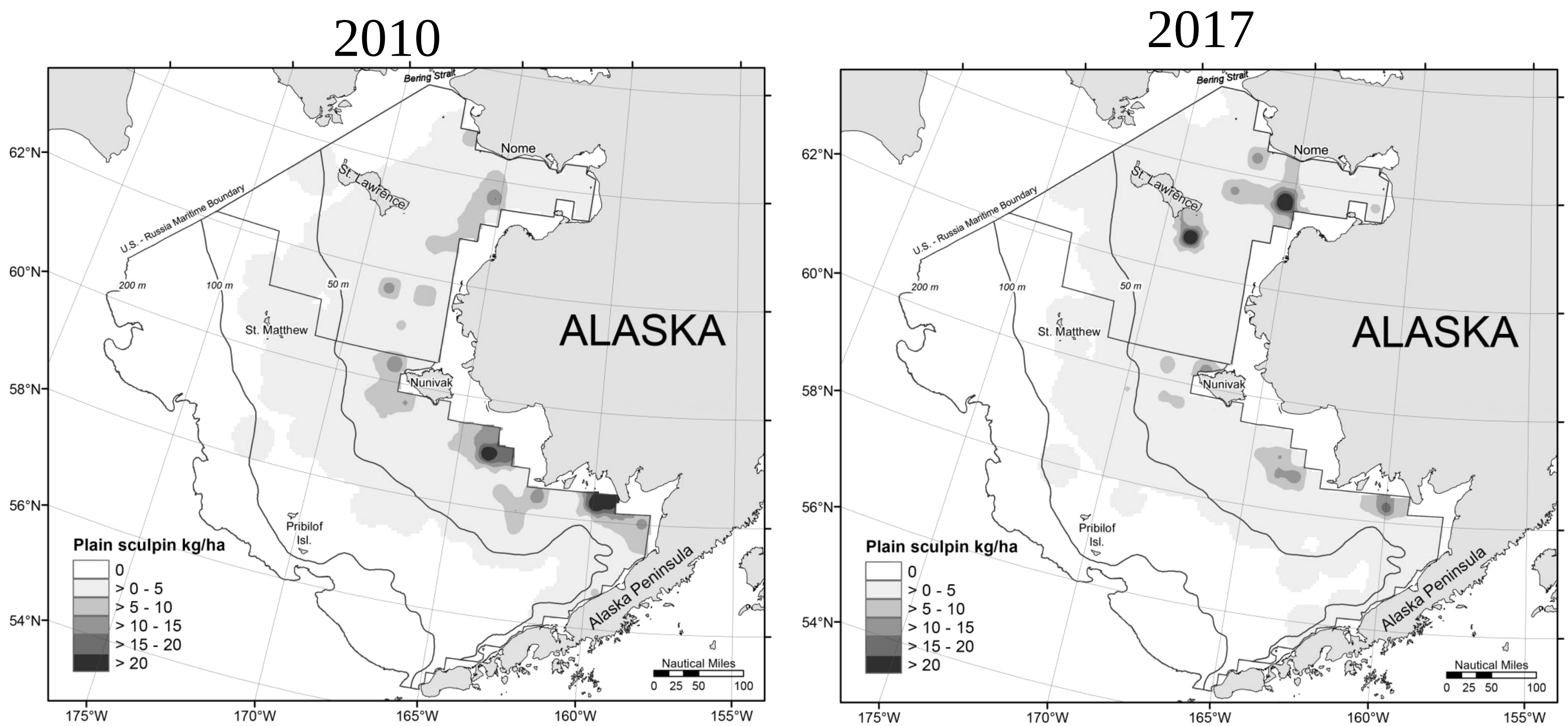


Figure 31. Distribution and relative abundance of plain sculpin during 2010 (left) and 2017 (right) NBS and EBS surveys.

Red King Crab

common name

?

Central Yup'ik

?

St. Lawrence Island Yupik

?

Inupiaq

Paralithodes camtschaticus

scientific name

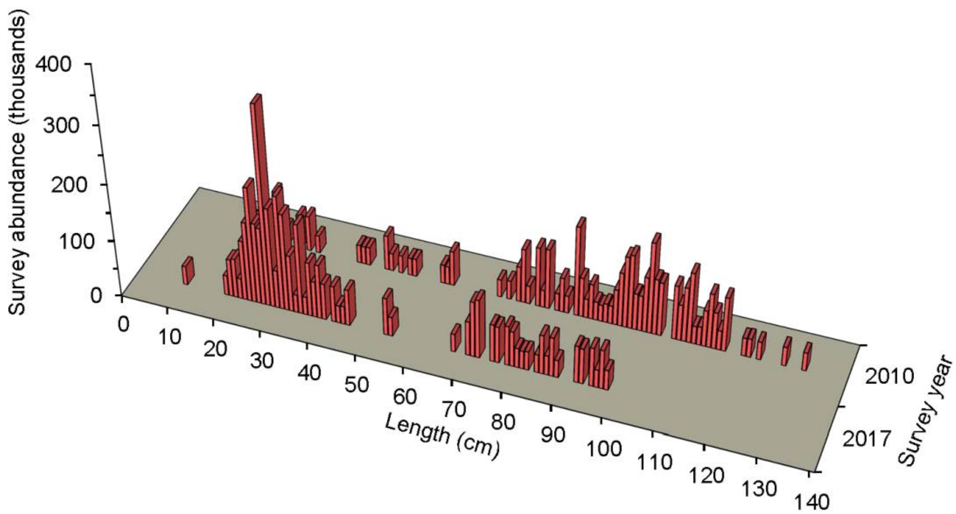


Figure 32. Total abundance-at-size of red king crab in the NBS during 2010 and 2017.

Within the NBS, red king crab occurred predominantly in Norton Sound (Figure 33). Red king crab were caught at 22 of the 44 total stations within the Norton Sound portion of the survey area in 2010 (Figure 33). In 2017, a greater overall number of red king crab was observed, but there was decrease in biomass because the red king crabs were smaller in size. A strong node was present around 30 mm lengths in 2017.

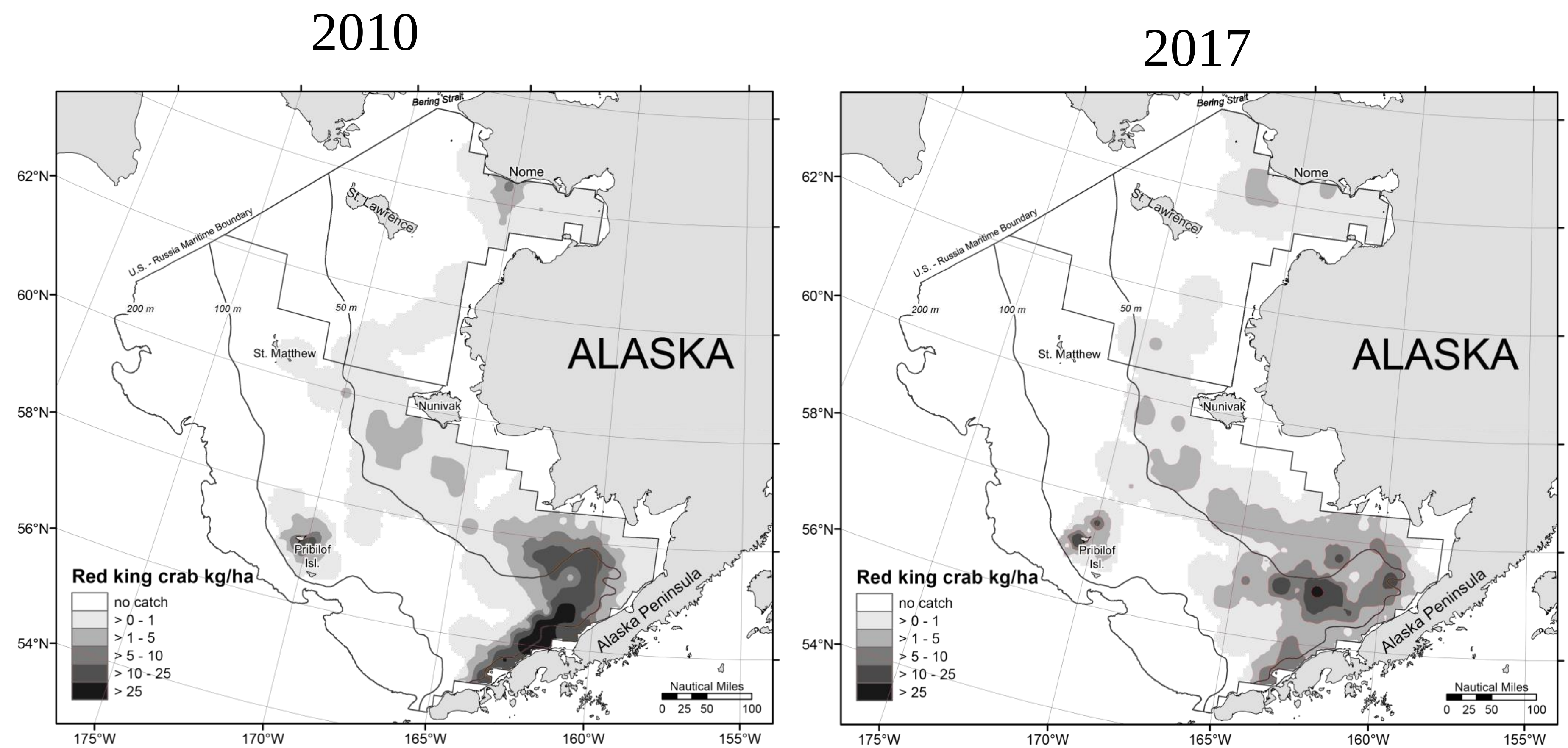


Figure 33. Distribution and relative abundance of red king crab during 2010 (left) and 2017 (right) NBS and EBS surveys.

Blue King Crab

common name

?

Central Yup’ik

?

St. Lawrence Island Yupik

?

Inupiaq

Paralithodes platypus

scientific name

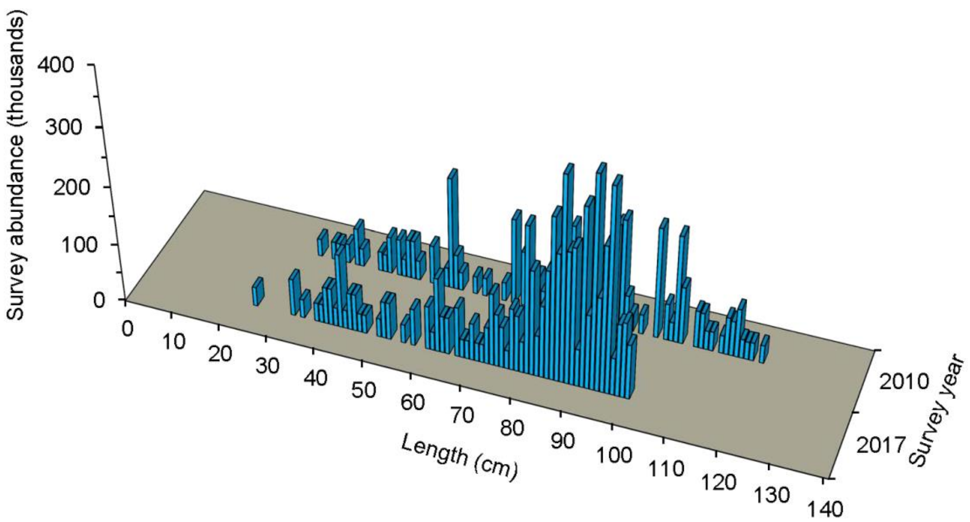


Figure 34. Total abundance-at-size of blue king crab in the NBS during 2010 and 2017.

In 2010, the majority of both mature male and female blue king crab were distributed off the northwest coast of St. Lawrence Island and in shallow water south of the Bering Strait (Figure 35). In 2017, a higher density of blue king crabs were distributed off the northwest coast of St. Lawrence Island (Figure 35). Red king crab size composition was similar in 2010 and 2017, except there were more larger individuals (>100 mm) in 2010 (Figure 34).

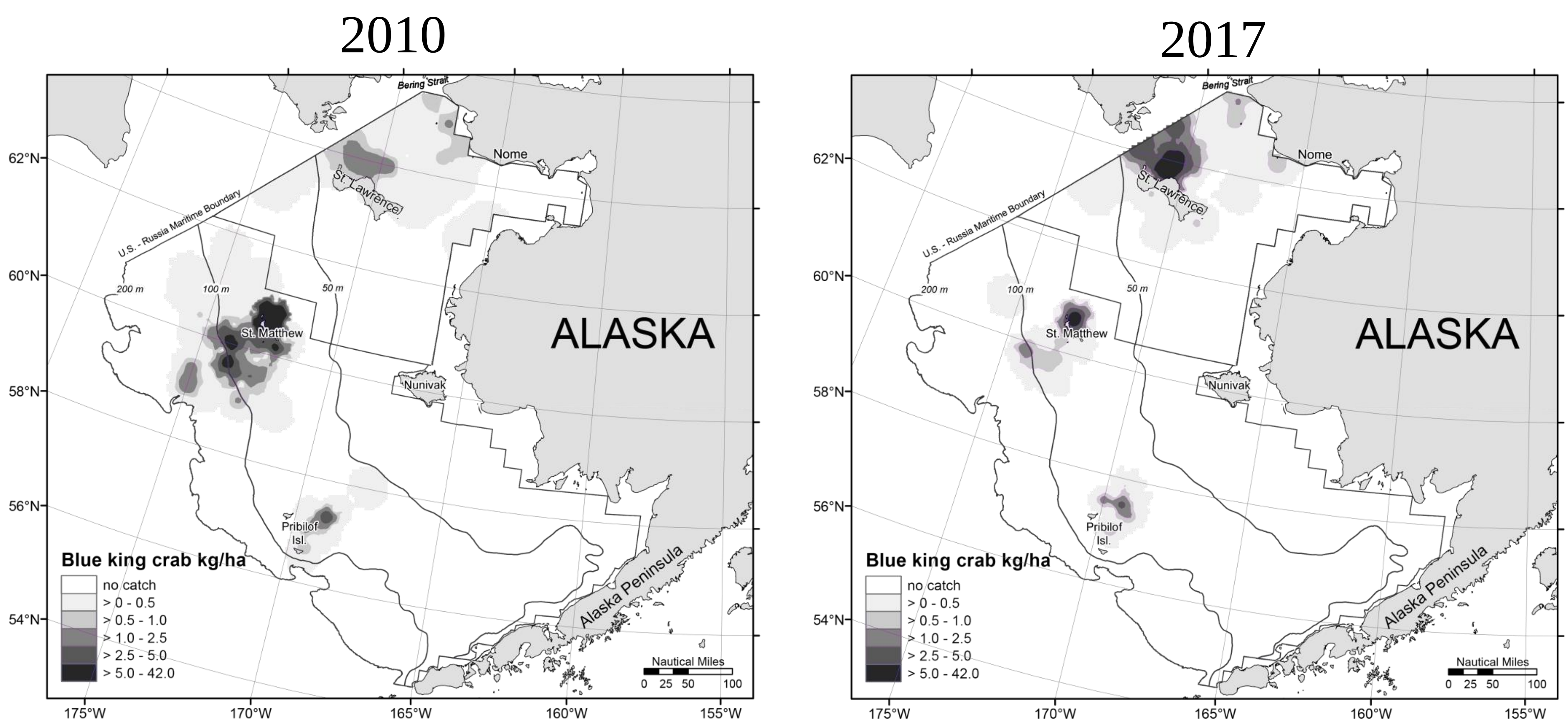


Figure 35. Distribution and relative abundance of blue king crab during 2010 (left) and 2017 (right) NBS and EBS surveys.

Pacific halibut

common name

?

Central Yup'ik

cagiq, naternarpak

St. Lawrence Island Yupik

?

Inupiaq

Hippoglossus stenolepis

scientific name

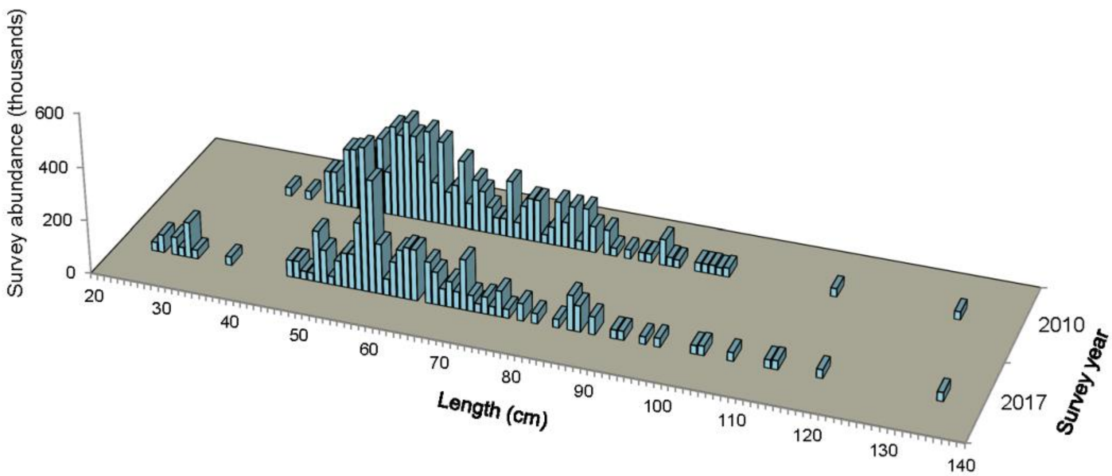


Figure 36. Total abundance-at-size of Pacific halibut in the NBS during 2010 and 2017.

In 2017, Pacific halibut were recorded at a total of 39 of the 144 NBS survey stations, which had depths ranging from 18 m to 43 (Figure 37). In 2017, Pacific halibut exhibited decreased total biomass (18,538 mt) from 2010 (23,806 mt). Spatial densities were distributed shallower than the 50 m contour and through the eastern side of St. Lawrence Island and the western portion of the Norton Sound (Figure 37). Size composition shows smaller individuals were present in 2017 (Figure 36).

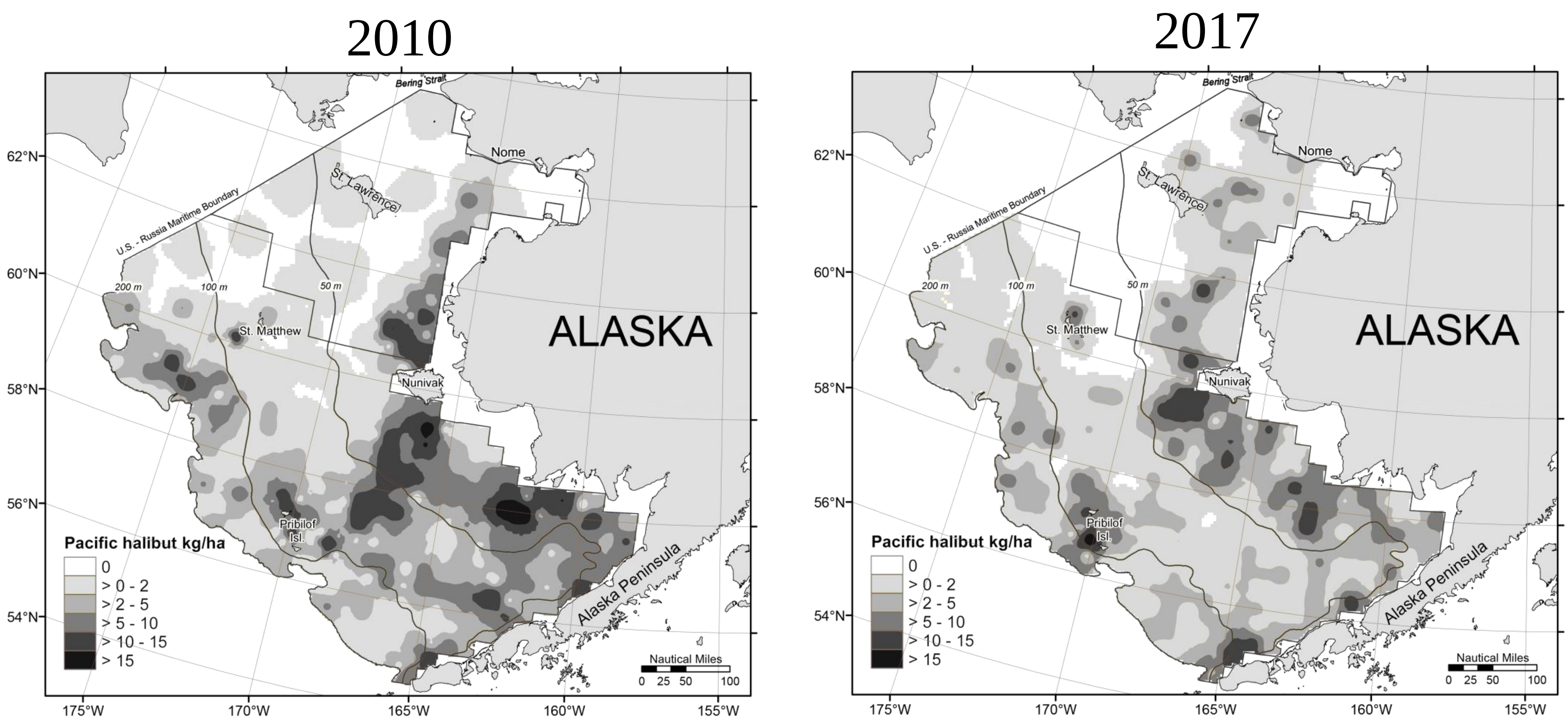


Figure 37. Distribution and relative abundance of Pacific halibut during 2010 (left) and 2017 (right) NBS and EBS surveys.

Bering Flounder

common name

?

Central Yup'ik

cagiq, sagiq

St. Lawrence Island Yupik

?

Inupiaq

Hippoglossoides robustus

scientific name

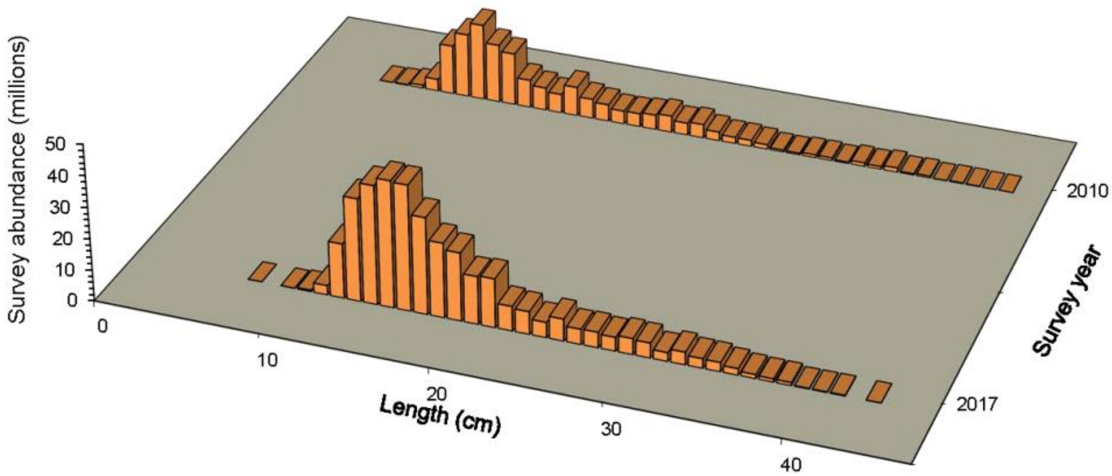


Figure 38. Total abundance-at-size of Bering flounder in the NBS during 2010 and 2017.

In the NBS, Bering flounder were recorded at depths between 19 and 79 m (Figure 39). The highest densities were concentrated in the cold pool, between the 50 m contour and the U.S. Russia maritime border southwest of St. Lawrence Island (Figure 39). In both 2010 and 2017, the greatest number of individuals was around 15 cm in length (Figure 38).

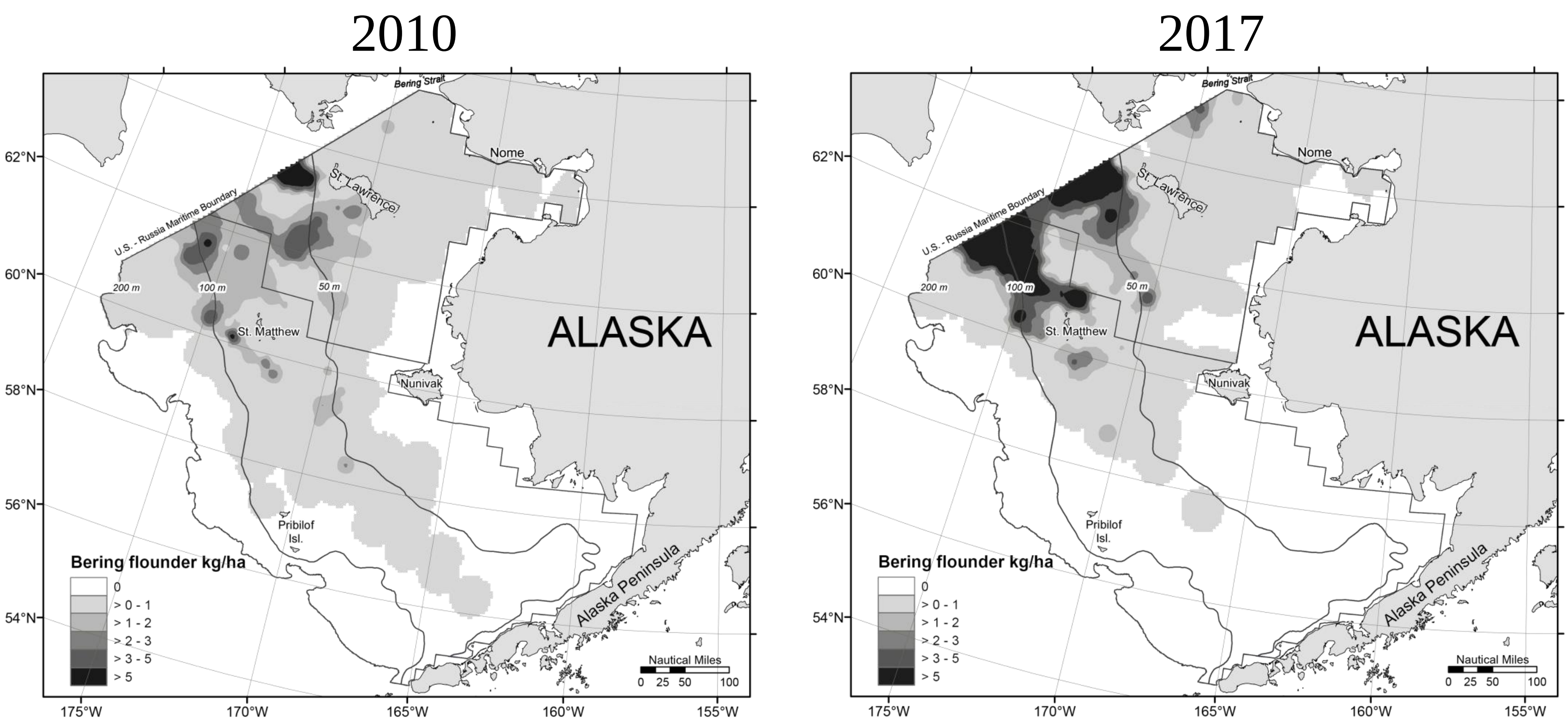


Figure 39. Distribution and relative abundance of Bering flounder during 2010 (left) and 2017 (right) NBS and EBS surveys.

Northern Rock Sole

common name

?

Central Yup'ik

cagiq, sagiq

St. Lawrence Island Yupik

?

Inupiaq

Lepidopsetta polyxystra

scientific name

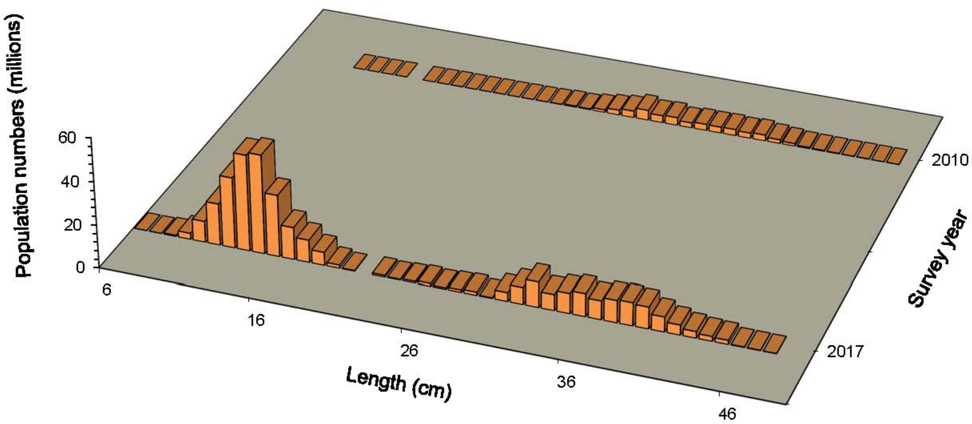


Figure 40. Total abundance-at-size of northern rock sole in the NBS during 2010 and 2017.

In 2017, many small northern rock sole were caught in the NBS survey just south of St. Lawrence Island (Figures 40 & 41). The largest number of individuals caught were around14 cm in length while other smaller magnitude size modes existed at lengths of 32cm, 35cm, and 38cm (Figure 40). In 2010, relatively few northern rock sole were caught in the NBS survey, but the majority of those that were caught were around 33 cm long (Figure 40). The northern rock sole were found in highest density in a small area north of Nunivak Island (Figure 41).

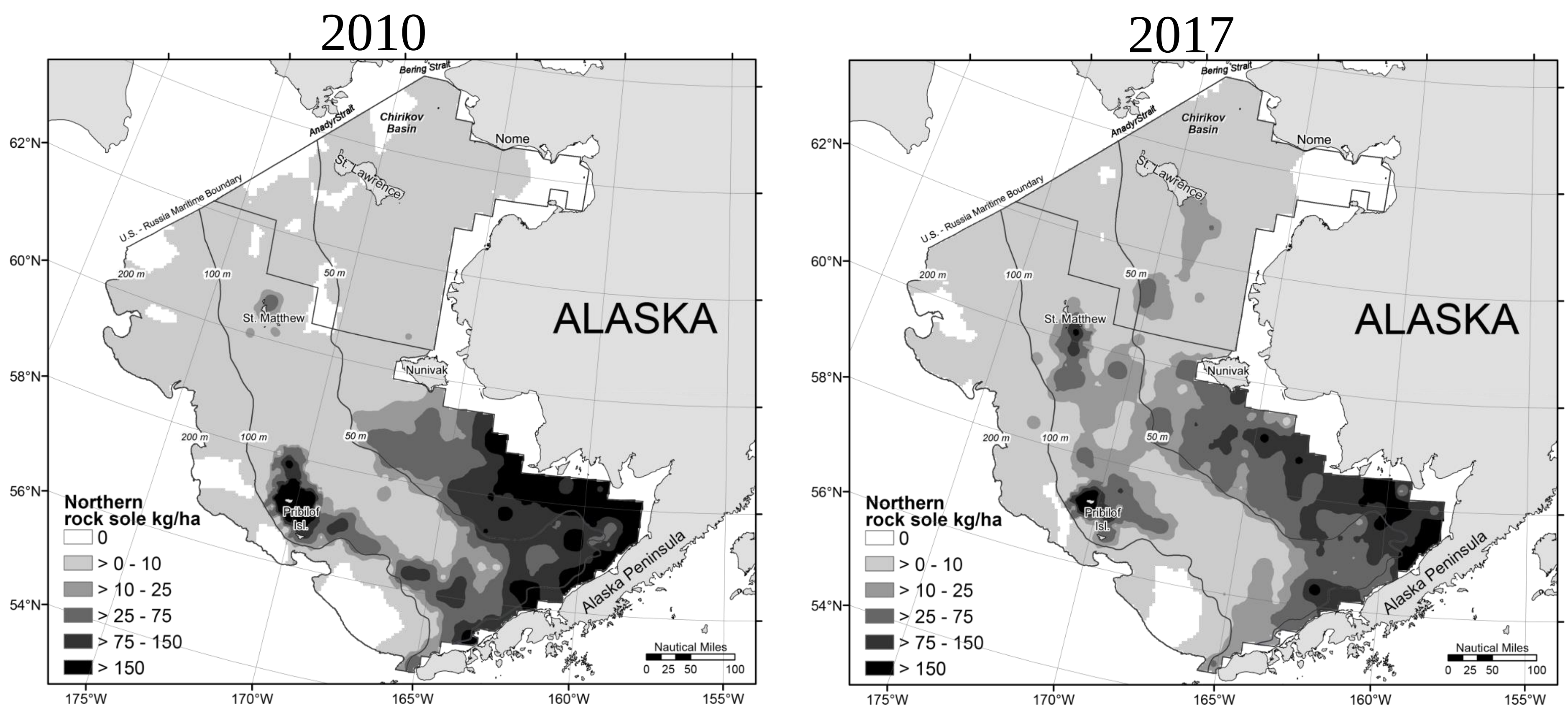


Figure 41. Distribution and relative abundance of Northern Rock Sole during 2010 (left) and 2017 (right) NBS and EBS surveys.

Pacific Herring

common name

neqalluarpak

Central Yup'ik

iqalluarpak, iqallugpak

St. Lawrence Island Yupik

Uqsruqtuuq

Inupiaq

Clupea pallasii

scientific name

In 2017, Pacific herring were recorded at 86 of 144 stations in the northern Bering sea at depths from 12 m to 79 m (Figure 42). Highest densities were located on the 50 m contour northwest of St. Matthew Island (Figure 42). The Pacific herring biomass increased from 22,289 mt (2010, Figure 6) to 35,365 mt in 2017 (Figure 7). Lengths of Pacific herring have not historically been recorded during the EBS and NBS surveys.

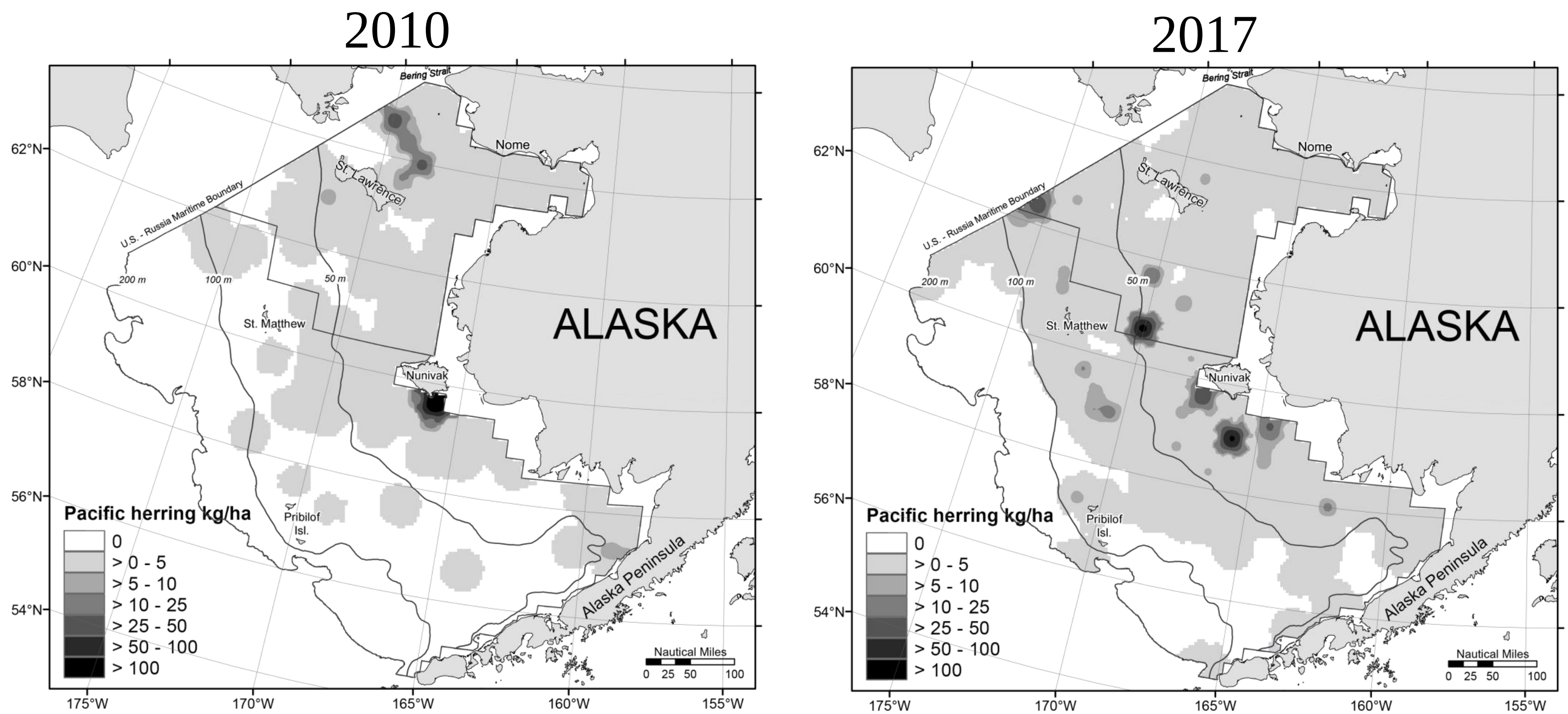


Figure 42. Distribution and relative abundance of Pacific herring during 2010 (left) and 2017 (right) NBS and EBS surveys.

Urchins

common name

kemagnaq, uutuk

Central Yup'ik

Kemagnaq, uutuk

St. Lawrence Island Yupik

?

Inupiaq

Strongylocentrotus sp.

scientific name

Sea urchins within the genus *Strongylocentrotus* were recorded at 49 of 144 stations in the northern Bering Sea in 2017 (Figure 43). The highest density was observed just north of St. Lawrence Island and urchins were present throughout the Norton Sound (Figure 43).

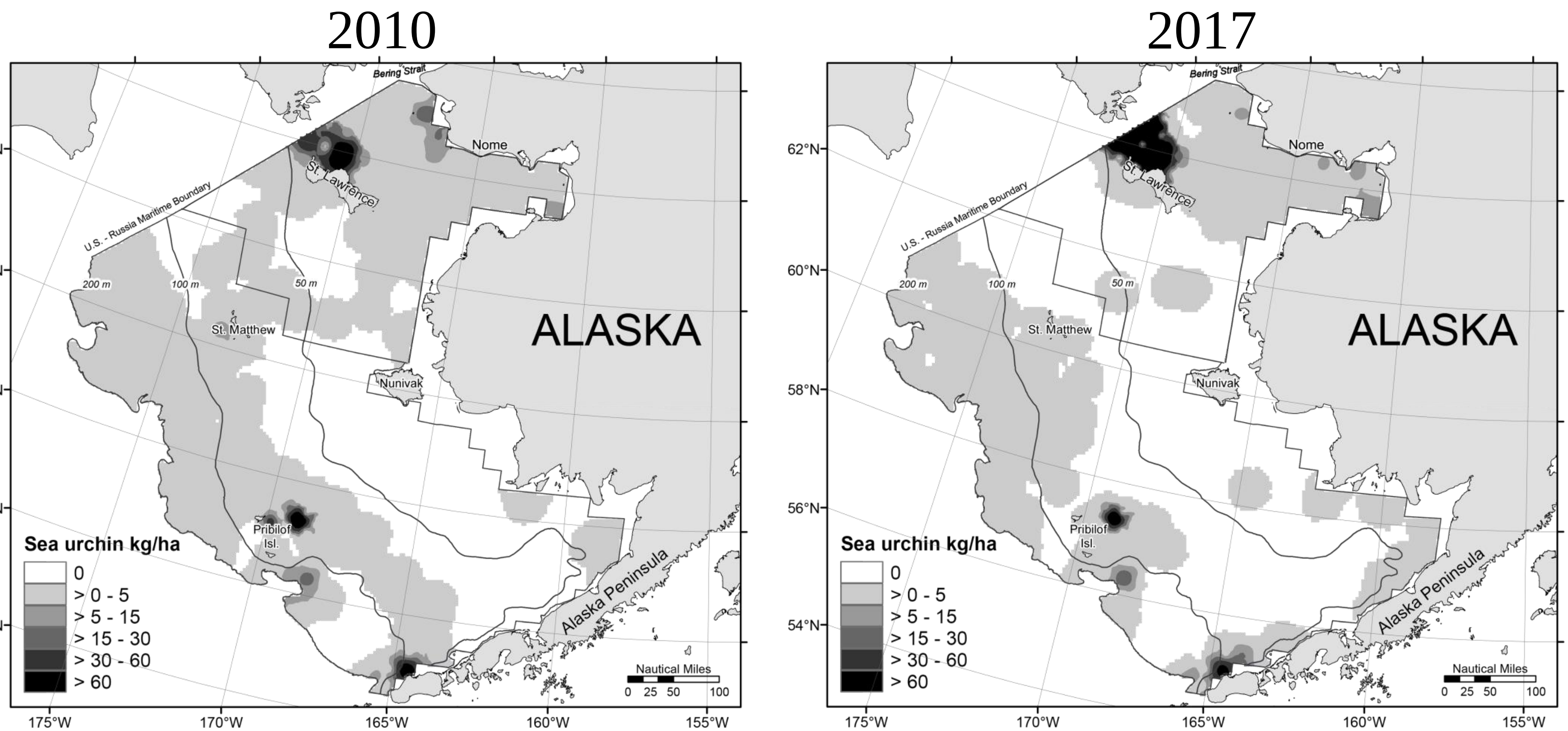


Figure 43. Distribution and relative abundance of urchin (*Strongylocentrotus sp.*) during 2010 (left) and 2017 (right) NBS and EBS surveys.

Jellyfishes

common name

?

Central Yup'ik

?

St. Lawrence Island Yupik

?

Inupiaq

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. Jellyfish populations are monitored in the EBS survey region, where 2017 had an 18% increase compared to 2016. However, jellyfish biomass in 2016-17 was the lowest observed since 1989. In the NBS, the jellyfish biomass increased 405% between 2010 and 2017 and most of this increase was observed in Norton Sound and south towards Nunivak Island (Figure 44). This area also corresponds with the warmer bottom and sea surface temperatures observed.

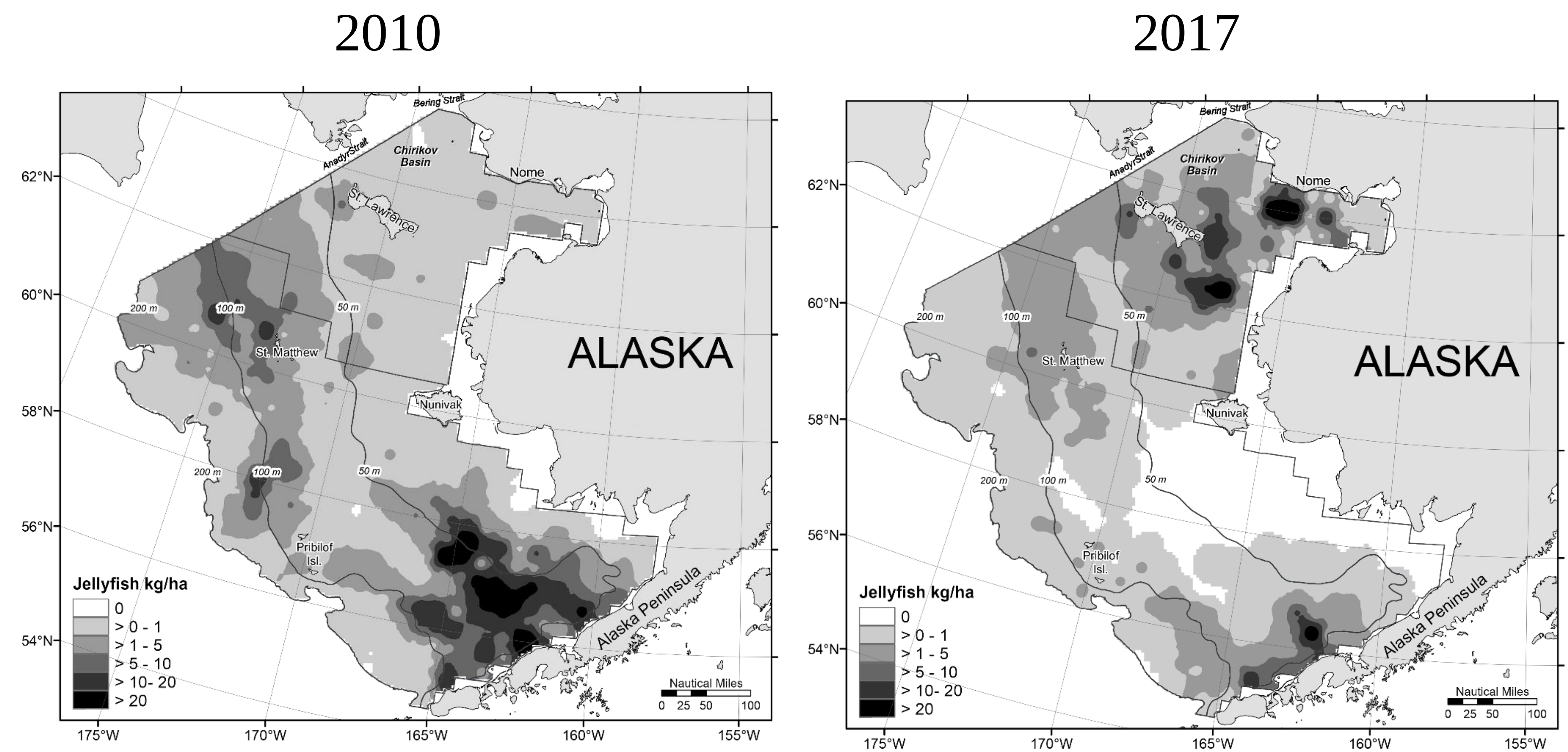


Figure 44. Distribution and relative abundance of jellyfish during 2010 (left) and 2017 (right) NBS and EBS surveys.

Appendix A: Tables

Table A1. Biomass (mt) of fish and invertebrate taxa or taxonomic group in 2010 and 2017 that were not in the top 20 based on biomass. (*Denotes a taxa or group that is listed in top 20 for a given year.)

Taxa or Taxonomic Group	2010	2017
Pacific herring	22,289.35	35,365.09
smelts	16,512.48	5,273.34
starry flounder	15,318.90	31,103.39
sponges	15,200.46	23,039.55
Bering flounder	12,660.61	20,021.96
corals	12,342.99	8,428.98
other snails	9,842.62	17,987.75
eelpouts	9,339.97	8,970.22
sea anemones	7,319.52	18,615.16
other sculpins	5,109.34	5,019.15
other flatfishes	2,753.91	7,425.74
snailfishes	2,721.52	4,648.00
red king crab	2,452.96	2,253.89
clams and mussels	2,164.81	4,051.74
shrimps	2,016.23	3,045.47
blue king crab	1,940.36	5,795.37
pricklebacks	1,336.64	3,149.78
Bering wolffish	1,143.70	92.89
poachers	369.54	1,538.12
octopuses	193.37	57.32
polychaetes	119.59	125.99
whitespotted greenling	33.86	351.56
lumpsuckers	13.74	1.64
sand lance sp.	3.61	4.91
amphipods	2.64	1.22
salmonids	653.91	672.28
sand dollars	114.16	4,428.49
sea cucumbers	6,545.09	3,316.08
worms	2,307.86	6,765.39
bryozoans	2,294.45	6,801.52
northern rock sole	21,378.95	*
walleye pollock	20,977.03	*
jellyfishes	11,710.51	*
other crabs	*	2,7470.17
Pacific halibut	*	1,8538.19
Arctic cod	*	3,963.37

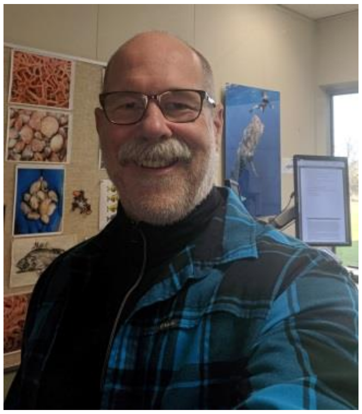
Table A2. Relative abundance based on mean CPUE (kg/ha) of fish and invertebrate taxa or taxonomic group in 2010 and 2017 where the CPUE was less than 1.0 kg/ha. (*Denotes a taxa or group that was above 1.0 kg/ha for a given year.)

Taxa or Taxonomic Group	2010	2017
smelts	0.84	0.26
corals	0.62	0.42
eelpouts	0.57	0.45
other sculpins	0.51	0.25
other snails	0.49	0.90
sea anemones	0.47	0.93
sea cucumbers	0.33	0.17
shrimp	0.19	0.15
other flatfishes	0.18	0.37
snailfishes	0.17	0.23
bryozoans	0.14	0.34
clams and mussels	0.13	0.20
red king crab	0.12	0.11
worms	0.12	0.34
blue king crab	0.10	0.29
pricklebacks	0.08	0.16
Bering wolffish	0.06	<0.00
poachers	0.02	0.08
sand dollars	0.01	0.22
polychaetes	0.01	0.01
octopuses	0.01	<0.00
salmon	<0.00	0.03
whitespotted greenling	<0.00	0.02
amphipods	<0.00	<0.00
sand lances	<0.00	<0.00
lumpsuckers	<0.00	<0.00
Pacific halibut	*	0.93
Arctic cod	*	0.20
sponges	0.80	*
starry flounder	0.77	*
jellyfishes	0.65	*
Bering flounder	0.63	*

Appendix B: 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 22 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, Bering Sea Group

Rebecca is a Fish Biologist with the NOAA Fisheries Alaska Fisheries Science Center in Seattle, Washington. Rebecca is a recent addition to the group 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, staffing and acts as lead 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, 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:

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Email: bob.lauth@noaa.gov		Email: lyle.britt@noaa.gov