2021

Northern Bering Sea Groundfish and Crab Trawl Survey Highlights

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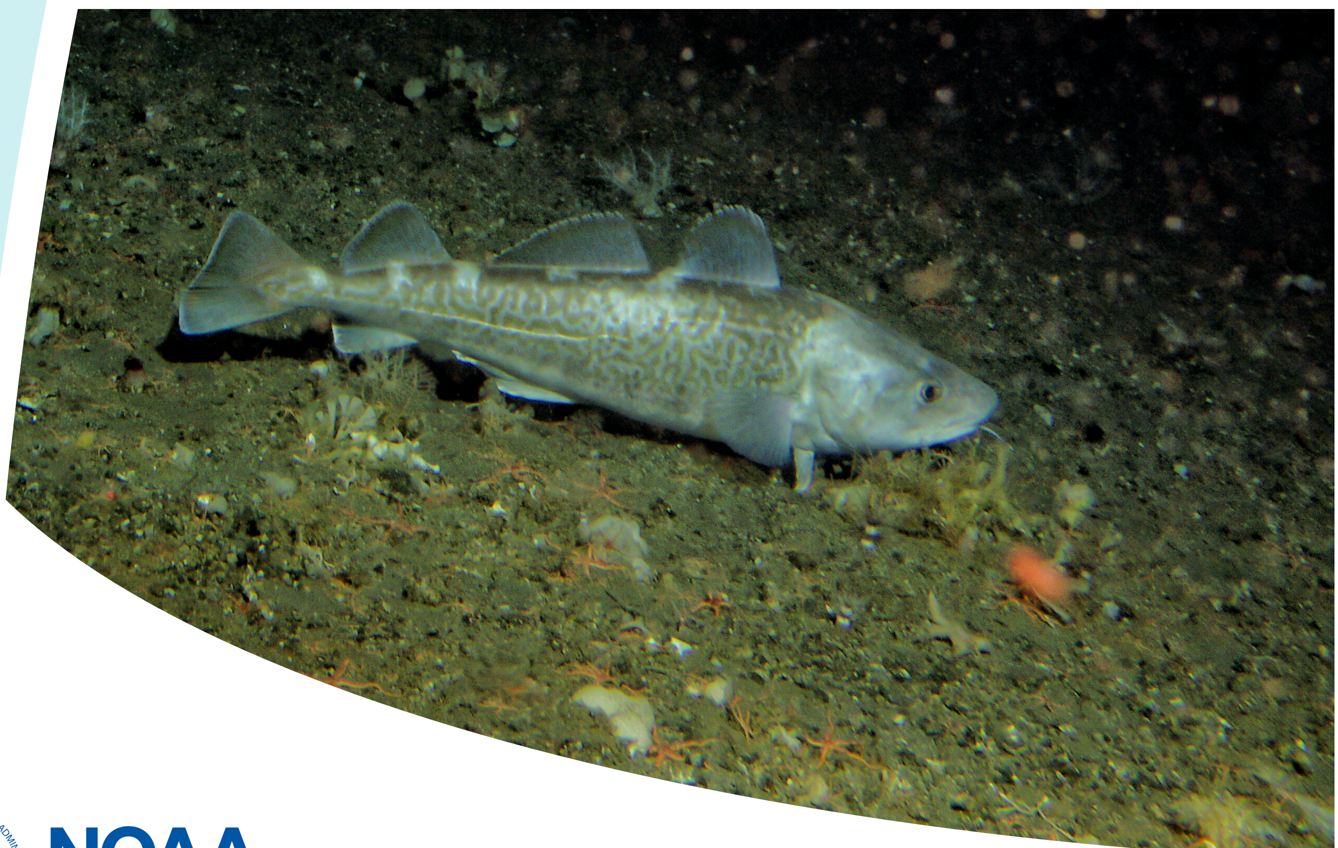

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Introduction

In 2021, the NOAA Fisheries, Alaska Fisheries Science Center conducted two surveys within U.S. territorial waters of the Bering Sea: the southeastern Bering Sea (EBS) shelf bottom trawl survey and the northern Bering Sea (NBS) bottom trawl survey. This year was the 39th annual survey of the EBS region and the fourth year in which the NBS region was surveyed following standardized sampling protocols. A rapid response survey was also conducted in the NBS region in 2018 using a modified spatial extent and sampling procedure and will not be covered in this report. The NBS survey region contains 144 stations in an area bounded by the Bering Strait, Norton Sound, and the U.S.–Russia Maritime Boundary (Figure 1). This region is a fundamental part of the Alaska Fisheries Science Center Loss of Sea Ice (LOSI) research plan, the primary purpose of which is to study the impacts of diminished sea ice on the marine ecosystem. While the NBS region has been surveyed sporadically in the past, the inaugural year in which the region was sampled using the same standardized sampling methods as the EBS shelf survey, creating a formative new time series, was 2010.

In the NOAA LOSI research plan, the NBS was identified as a region of critical importance for increased scientific monitoring because this area may undergo rapid change with a changing climate. This survey represents one component of a multi-faceted research plan to create a long-term time series designed to identify, as well as 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. These movements cause changes in distribution and abundance that extend beyond the traditional survey boundaries (e.g., EBS) and ultimately create 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 2021 NBS survey and offer some snapshot comparisons to what was observed in 2010, 2017, and 2019 when the region was also surveyed using the same methods.

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

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). For the EBS shelf survey, the F/V *Alaska Knight* started on June 01, 2021 and ended on July 22, 2021; the F/V *Vesteraalen* started on May 31, 2021 and ended on July 21, 2021. After the completion of the EBS shelf survey, both vessels transitioned into sampling survey stations in the southwest corner of the NBS survey region. The NBS shelf survey started on July 23, 2021 for the F/V *Alaska Knight* and on July 22, 2021 for the F/V *Vesteraalen* and ended for both vessels on August 16, 2021. After the NBS survey was completed, both vessels returned to Dutch Harbor to offload survey equipment and specimens. The NBS shelf was divided into three strata: one including the area north of St. Lawrence Island and Norton Sound and two others south of St. Lawrence Island separated by the 50-m (164-ft) isobath.

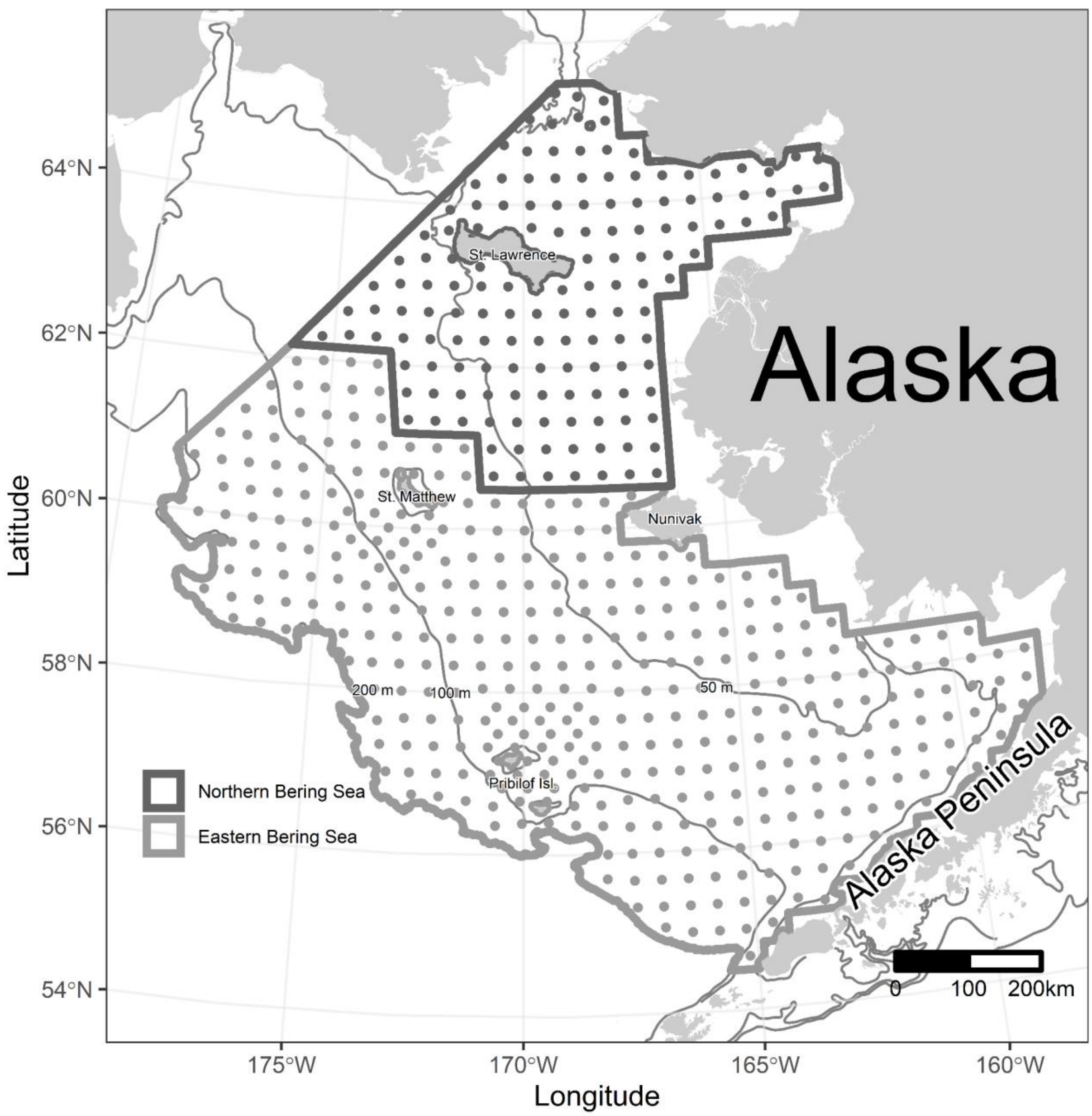

Figure 1. Map of the Bering Sea survey stations sampled in 2021 during the EBS and NBS survey. The area enclosed within the light gray line contains the EBS shelf stations that have been sampled annually since 1982, whereas the area outlined in the dark gray line are the NBS stations that were sampled in 2021. The dots within each area indicate each station location.

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

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 design resulted in a systematic grid of 144 stations in which each sampling station represents a geo-referenced area of 400 square nautical miles (nmi^2; 1,372 km^2) distributed throughout the 57,978 nmi^2 (198,858 km^2) that defines the NBS survey area. For reference, the EBS shelf survey area contains 376 stations distributed over 143,706 nmi^2 (492,897 km^2).

The addition of the NBS survey expanded the overall survey coverage in the Bering Sea to 201,684 nmi^2 (691,755 km^2). The NBS stations had bottom depths ranging from 36.1 ft (11 m) to 259.2 ft (79 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, which required the sampling location to be moved elsewhere within the cell.

Scientists from the Alaska Fisheries Science Center, Alaska Department of Fish and Game, A.I.S. Inc., and a volunteer from Alaska Pacific University participated in the survey. Lead scientist profiles can be found in Appendix A.

Both vessels were equipped with the standard 83/112 Eastern otter trawl that has been historically used for EBS shelf, Chukchi, and Beaufort Sea surveys (Figure 3). This trawl is significantly smaller and lighter in weight than commercial trawls used for commercial fishing in Alaska. One 30-minute tow, at a vessel speed of 3 knots, was conducted at 144 stations. The cumulative area sampled by trawls at the 144 stations was about 1.86 nmi^2 (6.4 km^2), covering 0.003% of the total area of the NBS.

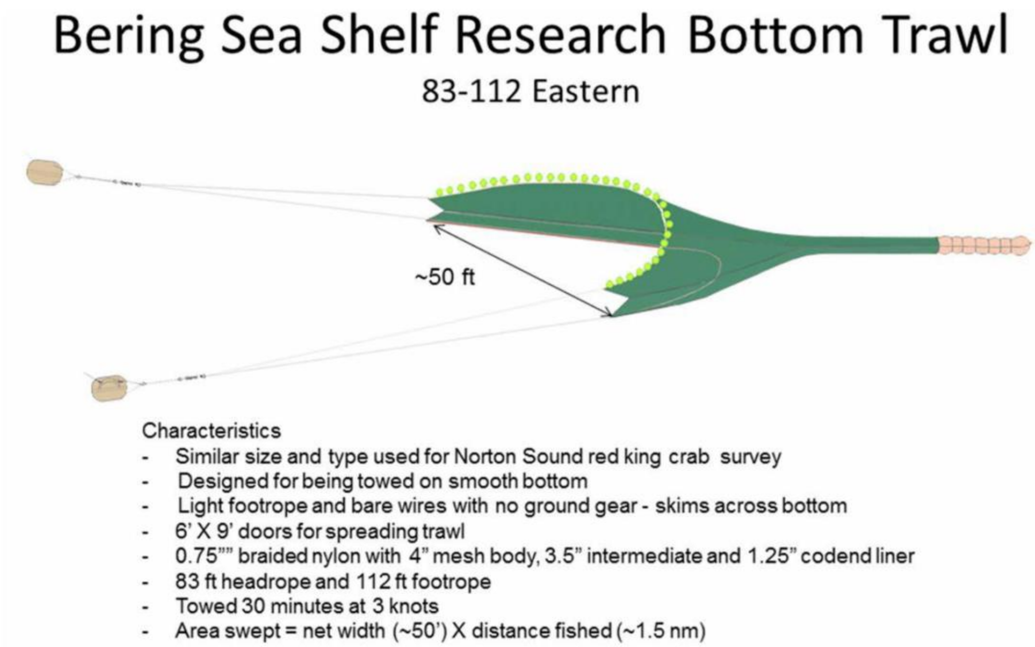

Figure 3. Diagram and specific characteristics of the 83/112 Eastern trawl net.

In 2021, we surveyed the same NBS stations as in 2019. Catches of less than approximately 1,200 kg (2,500 lbs.) were sorted and weighed in their entirety, whereas larger catches were subsampled. Fishes, crabs, and other invertebrates were identified and sorted to species to the greatest extent possible. In cases where species identification was unknown, specimens were collected and returned to the lab for expert identification. After sorting, all species caught were counted and weighed. Counts were not obtained for colonial animals because individuals are difficult to define. For the predominant fish species encountered, a subsample was weighed, sorted by sex, and the fork length of all specimens in the subsample was measured to the nearest centimeter (cm). For the predominant crab species encountered, carapace width (snow crab) or length (king crabs) was measured to the nearest millimeter (mm).

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

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

Additionally, samples of fishes, crabs, and other invertebrates were retained to gather additional information that included their size, weight, sex, age, reproductive state, genetics, health (condition factor), 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).

2021 Survey Results with Snapshot Comparisons to 2019

Seafloor Bottom Temperature

Bottom temperature is a major environmental driver that can affect the distribution of fishes, crabs, and other invertebrates on the shelf (Figures 4 and 5). 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 2002-2005 and 2014-2019 were warmer than average ("warm stanza"). During the 39-year time series (1982–2021) of the annual EBS shelf bottom trawl survey, mean summer bottom temperatures were variable, ranging from 0.7°C (33.3°F) to 4.4°C (39.9°F), with a grand mean for all years of 2.5°C (36.5°F) (Figure 4).

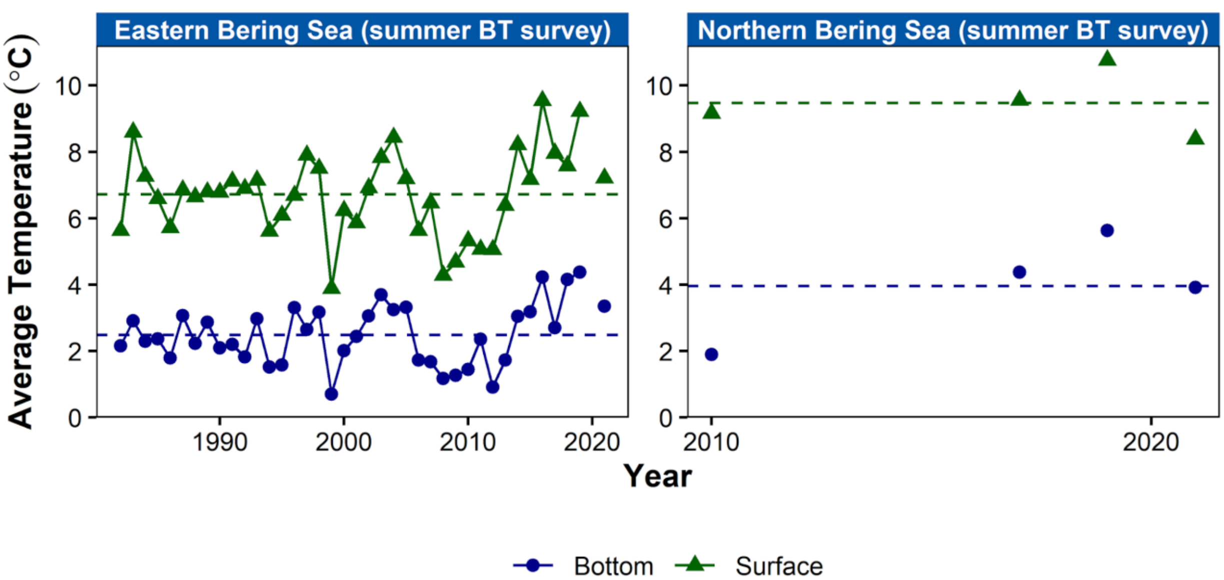

Figure 4. Average summer surface (green triangles) and bottom (blue circles) temperatures (°C) on the EBS shelf (left) based on data collected during standardized summer bottom trawl surveys from 1982–2021 and NBS shelf based (right) on data collected during standardized summer bottom trawl surveys from 2010, 2017, 2019, and 2021. Dashed lines represent the time series mean.

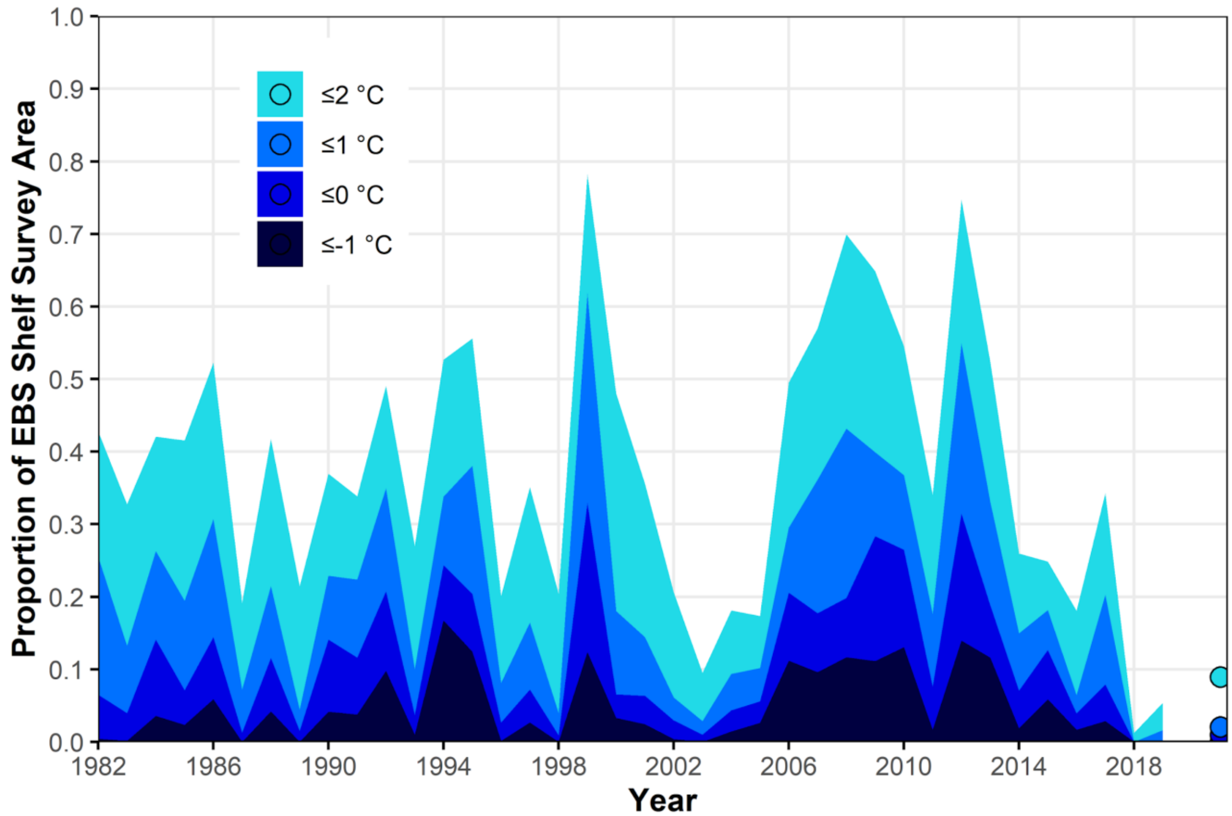

Figure 5. Graph showing annual cold pool extent in the EBS, based on observations from the EBS bottom trawl survey. Extent of the cold pool is shown in proportion to the total southern EBS shelf survey area. Shading denotes bottom temperatures ≤ 2°C (aqua blue), ≤ 1°C (cerulean blue), ≤ 0°C (cobalt blue), and ≤ -1°C (dark navy blue).

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 (35.6°F). During the coldest years recorded, the cold pool has extended 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 39-year time series, the areal coverage of the summer survey cold pool has varied greatly in size, from 1,808 nmi^2 (6,202 km^2) in 2018 to 111,974 nmi^2 (384,062 km^2) in 1999, respectively comprising 1.3% to 77.9% of EBS shelf area (Figure 5). In 2021, the cold pool covered 12% of the EBS shelf survey area (17,273 nmi^2; 59,243 km^2), which was the fourth lowest areal coverage in the 39-year EBS shelf time series.

Bottom temperatures measured during the 2021 NBS survey ranged from -1.7°C to 12.5°C (Figure 6). In the NBS 2021 survey, the overall mean bottom temperature (3.91°C) was warmer than in 2010 (1.89°C), but colder than in 2017 and 2019 (4.38°C and 5.63°C, respectively). Sea surface temperatures were colder in 2021 than in previous years, while temperatures above 10°C were found throughout 5% of the NBS. In past years, 5% of the NBS area in 2010, 24% of the NBS area in 2017, and 39% of the NBS area in 2019 had temperatures above 10°C (Figure 7).

During all NBS survey years, the region north of St. Lawrence Island had the coolest sea surface temperatures. This finding is likely due to the strong currents in this region reducing stratification of the water mass.

The 2010, 2017, 2019, and 2021 NBS surveys provide 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 2021 was more extensive compared to 2017 and 2019, and was composed of colder water that impinged on Chirikov Basin, Nunivak Island, and the Alaska Peninsula (Figure 6), potentially restricting east-west and north-south movements of the fauna. The cold pool in 2021 extended south of St. Matthew Island. However, bottom temperatures from Nunivak Island north to Chirikov Basin were warm (>6°C). The warm temperatures may have potentially allowed for more northward fish movement. Historically, regardless of the size of the cold pool or mean summer bottom temperatures, a portion of the cold pool has persisted throughout the year in the transboundary basin, which extends from the Gulf of Anadyr on the middle shelf to beyond the west side of St. Lawrence Island.

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

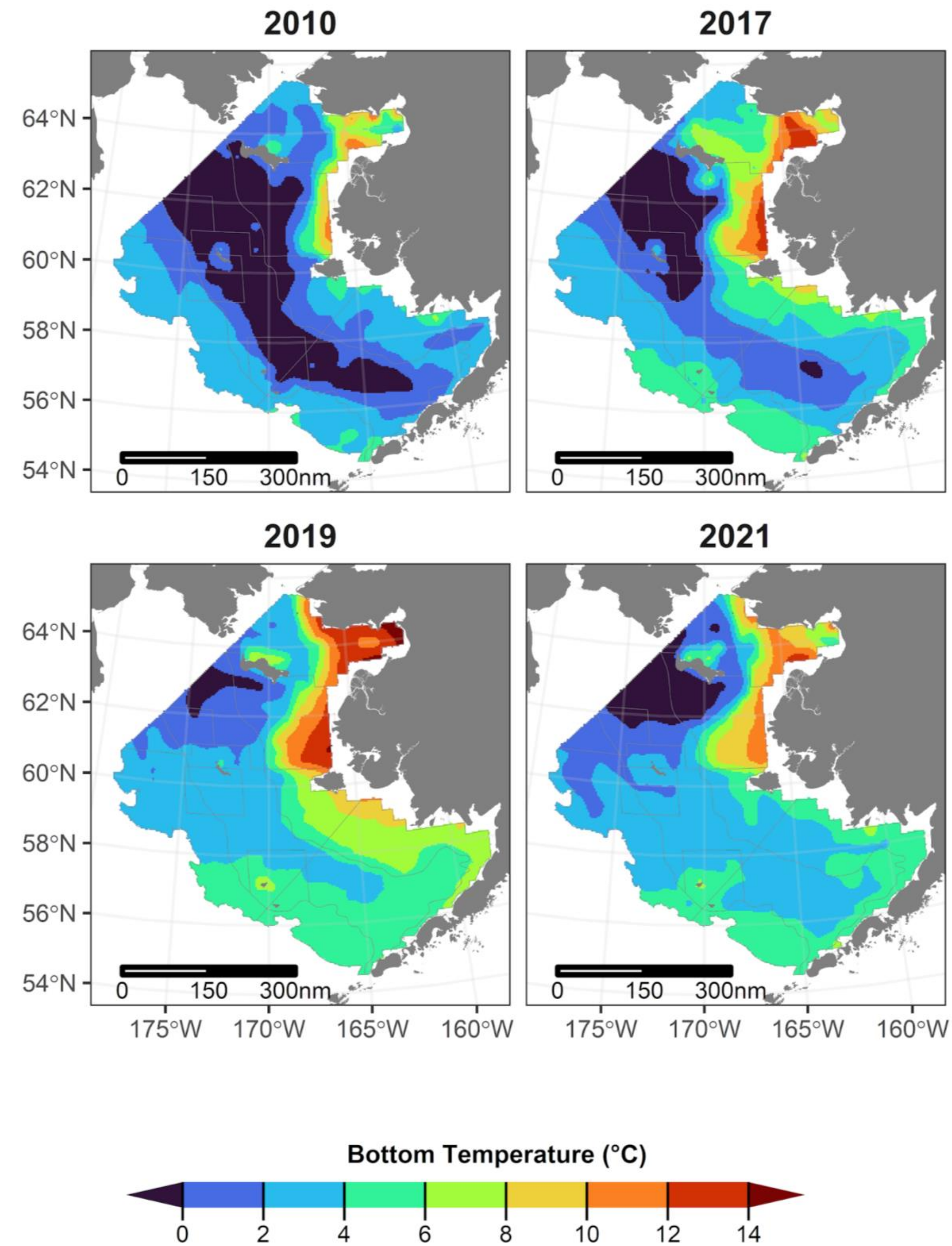

Figure 6. Map showing bottom temperatures (°C) in the NBS and EBS during the 2010, 2017, 2019, and 2021 surveys, which are the years when the survey included the full NBS shelf.

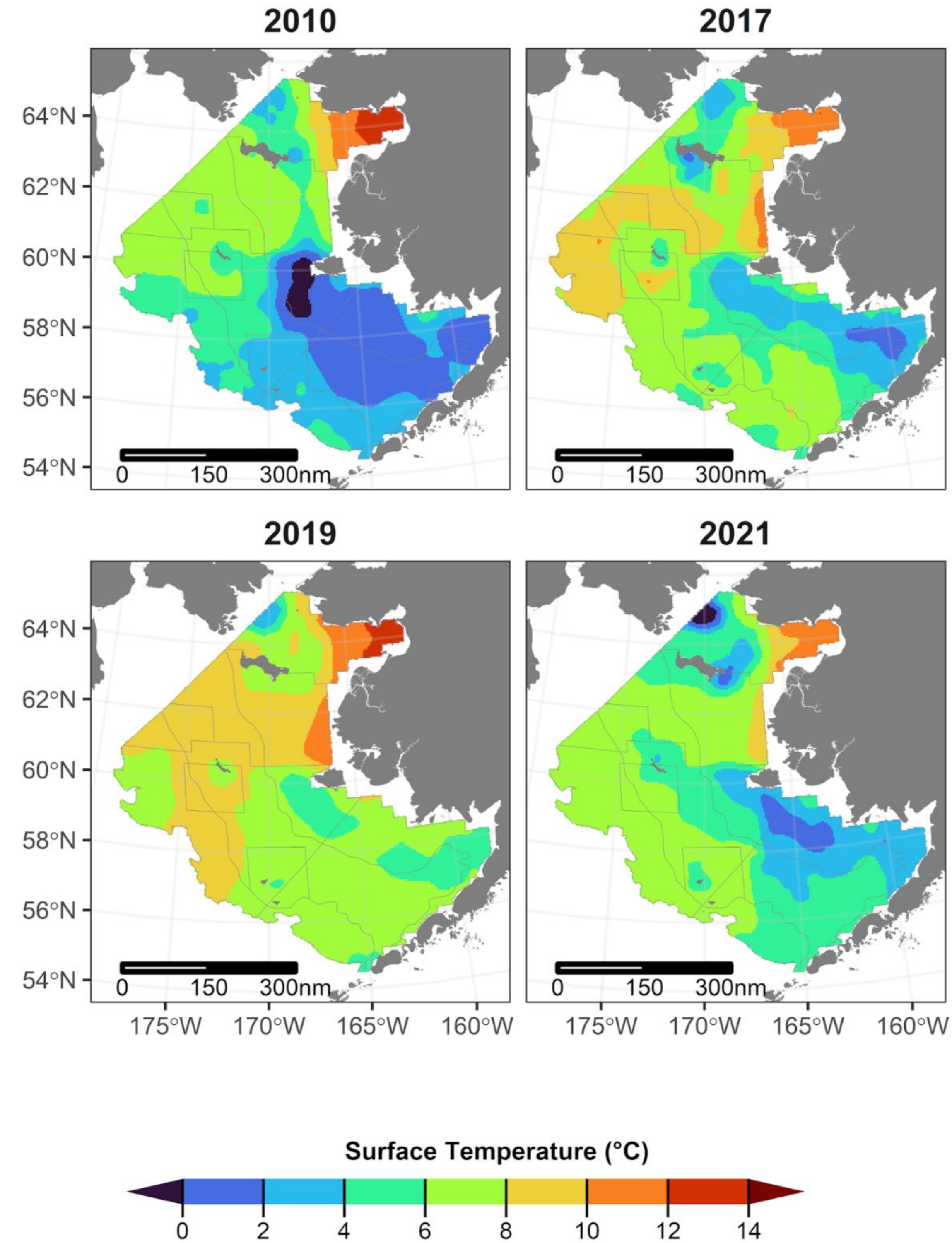

Figure 7. Map showing surface temperatures (°C) in the NBS and EBS during the 2010, 2017, 2019, and 2021 surveys, which are the years when the survey included the full NBS shelf.

Survey Data and Specimen Collections

From the EBS and NBS shelf trawl surveys combined, a total of 89,346 individual fish length measurements representing 50 fish taxa were collected. Additionally, 10,301 age structures (otoliths) were collected from 11 fish taxa; 7,320 stomach samples were collected from four fish taxa; 126 genetic samples were collected from two fish taxa; one genetic sample was collected from a shark; 137 condition (muscle and liver tissue) samples were collected from Pacific cod; and 107 condition (muscle and liver tissue) samples were collected from walleye pollock.

Abundance of Fishes, Crabs, and Other Invertebrates

In 2021, the total bottom-dwelling animal biomass of the EBS shelf was estimated at 12.1 million metric tons (mmt) and the NBS shelf was estimated at 3 mmt. Likewise, the total bottom-dwelling animal biomass of the 2019 EBS shelf was estimated at 15.3 mmt, 2019 NBS shelf was estimated at 4.4 mmt, 2017 EBS shelf was estimated at 16.5 mmt, 2017 NBS shelf was estimated at 4.5 mmt, 2010 EBS shelf was estimated at 15.4 mmt, and 2010 NBS shelf was estimated at 2.9 mmt. The percent change in biomass varied by fish and invertebrate taxon (Table 1). Calculated biomass decreased for 35 taxa, did not change for two taxa, and increased for 12 taxa from 2019 (warm year) to 2021. Some of the largest increases in biomass from 2019 to 2021 were observed in tunicates (182%), corals (105%), sea onion (98%), other crabs (94%), and all shrimps (87%). Decreases in biomass were observed in jellyfishes (-75%), miscellaneous worms (-79%), brittle stars and sand dollars (-88%), saffron cod (-88%), and Atka mackerel (-100%).

Species groups that previously exhibited a decreasing trend in biomass from 2017 to 2019 but an increasing trend in biomass from 2019 to 2021 include tunicates, corals, sea onion, other crabs, all shrimps, Arctic cod, Pacific capelin, starry flounder, sea cucumbers, and Alaska plaice. Species groups that previously exhibited an increasing trend in biomass from 2017 to 2019 but a decreasing trend in biomass from 2019 to 2021 include yellowfin sole, Alaska skate, northern rock sole, Pacific herring, purple-orange sea star, bryozoans, Pacific cod, plain sculpin, clams, mussels, scallops, jellyfishes, brittle stars and sand dollars, and saffron cod.

In 2021, yellowfin sole (17%), walleye pollock (16%), Alaska plaice (12%), and purple-orange sea star (9%) together comprised over 50% of the total estimated biomass in the NBS. Previously, in 2019, walleye pollock (27%), yellowfin sole (12%), purple-orange sea star (10%), and Pacific cod (8%); in 2017, walleye pollock (29%), yellowfin sole (10%), purple-orange sea star (7%), Alaska plaice (7%), and Pacific cod (6%); and in 2010, yellowfin sole (15%), tunicates (12%), snow crab (11%), Alaska plaice (10%), and purple-orange sea star (10%) together comprised over 50% of the total estimated biomass in the NBS. Other cod taxa (saffron cod and Arctic cod) accounted for 0.3% of the total biomass in 2021, 1.9% of the total biomass in 2019, 1.8% of the total biomass in 2017, and 4.4% of the total biomass in 2010. Crabs and other invertebrates (i.e., shrimps, sea squirts, sea stars, jellyfish, and urchins) made up 35% of the biomass in 2021, 33% of the biomass in 2019, 35% of the biomass in 2017, and 58% of the biomass in 2010.

Catch per unit effort (CPUE) is an estimated measure of fish density. From 2019 to 2021, 18 fishes and 12 invertebrates experienced decreasing CPUE, five fishes and eight invertebrates experienced increasing CPUE, and seven fishes and nine invertebrates experienced no marked change in CPUE (within ±25% change from the previous survey year). Between 2021 and 2019, the largest increases in CPUE were seen in tunicates (182%), corals (104%), skate egg cases (100%), sea onion (98%), and other crabs (94%); the largest decreases in CPUE were seen in salmonids (-84%), brittle stars and sand dollars (-88%), saffron cod (-88%), greenlings (-89%), Atka mackerel (-100%), and lumpsuckers (-100%). A few prominent fish species exhibited no change between 2019 and 2021, including Alaska plaice, Pacific halibut, yellowfin sole, Alaska skate, wolffishes, northern rock sole, and other sculpins (within 0b125% change from the previous survey year) in CPUE.

On average, NBS survey catches were smaller compared to those from the EBS, but distributions of some of the predominant species, such as Alaska plaice, Alaska skate, basket starfish, empty shells and debris, hermit crabs, jellyfishes, northern Neptune whelk, northern rock sole, other sea stars, other snails, Pacific cod, Pacific halibut, Pacific herring, plain sculpin, purple-orange sea star, snow crab, starry flounder, tunicates, walleye pollock, and yellowfin sole, extended throughout much of both survey regions. Several key fish species were found in the NBS in greater numbers than the EBS, including Alaska plaice, Arctic cod, Bering flounder, Pacific capelin, Pacific herring, plain sculpin, pricklebacks, rainbow smelt, saffron cod, sand lances, shorthorn sculpin, snailfishes, starry flounder, and wolffishes.

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

Summary Results for Select Major Taxa[1]

Survey results for select major taxa are presented with a photograph of the species or taxonomic group, maps of geographic distribution and relative abundance, plots of total abundance-at-size, and a text summary outlining the results. To better illustrate fish movement and distributional trends, geographic distribution and relative abundance maps include both the EBS shelf and NBS survey regions. For comparison, distribution maps and abundance-at-size plots are provided for 2010, 2017, 2019, and 2021 survey results.

[1] You can help us with this document by providing names in local language(s) and cultural or traditional uses for each fish and invertebrate species reviewed in this report.

Table 1. Major taxa sampled in the NBS bottom trawl survey for 2010, 2017, 2019, and 2021, and the percentage change in biomass (metric tons) from 2019 to 2021 in descending order of percent (%) change.

Common name		**2010**	**2017**	**2019**	**2021**	**Change (2021, 2019)**
Tunicates	Urochordata	339,401	88,457	23,681	66,860	182%
Corals	Anthozoa	12,626	8,519	2,823	5,776	105%
Sea Onion	*Boltenia ovifera*	19,747	6,794	1,623	3,221	98%
Other Crabs		62,756	33,858	27,908	54,160	94%
All Shrimps		3,802	4,118	2,436	4,561	87%
Arctic Cod	*Boreogadus saida*	37,861	3,906	47	83	77%
Pacific Capelin	*Mallotus villosus*	14,632	179	50	76	52%
Starry Flounder	*Platichthys stellatus*	15,802	31,430	26,472	39,010	47%
Sea Cucumbers	Holothuroidea	7,116	3,413	2,564	3,356	31%
Red King Crab	*Paralithodes camtschaticus*	2,496	2,228	2,865	3,601	26%
Alaska Plaice	*Pleuronectes quadrituberculatus*	302,976	330,728	321,571	344,578	7%
Pacific Halibut	*Hippoglossus stenolepis*	23,333	18,507	25,722	25,995	1%
Yellowfin Sole	*Limanda aspera*	427,375	434,086	520,029	496,038	-5%
Other Sea Stars	Asteroidea	106,605	103,116	84,661	79,310	-6%
Other Snails	Gastropoda	42,471	73,187	47,511	44,470	-6%
Blue King Crab	*Paralithodes platypus*	2,025	5,928	1,228	1,083	-12%
Alaska Skate	*Bathyraja parmifera*	76,942	83,255	95,102	80,207	-16%
Sea Anemones	Actiniaria	9,438	20,920	10,377	8,710	-16%
Basket Starfish	*Gorgonocephalus eucnemis*	70,643	40,455	36,653	30,082	-18%
Northern Neptune Whelk	*Neptunea heros*	110,916	178,930	146,344	114,179	-22%
Northern Rock Sole	*Lepidopsetta polyxystra*	21,256	55,466	99,040	76,630	-23%
Hermit Crabs	Paguridae	133,104	162,368	139,243	107,054	-23%
Other Sculpins	Cottidae	10,415	10,393	4,862	3,725	-23%
Sea Peach	*Halocynthia* sp.	9,021	7,334	1,955	1,425	-27%

Common name		**2010**	**2017**	**2019**	**2021**	**Change (2021, 2019)**
Pacific Herring	*Clupea pallasii*	23,011	34,914	87,918	60,929	-31%
Other Flatfishes	Pleuronectidae	3,476	8,620	7,532	5,171	-31%
Purple-Orange Sea Star	*Asterias amurensis*	296,846	331,261	414,423	270,632	-35%
Bryozoans	Bryozoa	2,802	7,645	92,808	60,060	-35%
Pacific Cod	*Gadus macrocephalus*	29,124	287,535	364,982	227,577	-38%
Urchins	*Strongylocentrotus* spp.	50,252	166,745	89,954	54,744	-39%
Poachers	Agonidae	416	2,027	1,346	779	-42%
Shorthorn Sculpin	*Myoxocephalus scorpius*	39,824	111,350	14,159	7,626	-46%
Sticklebacks		0	0	1	1	-48%
Plain Sculpin	*Myoxocephalus jaok*	28,274	36,206	41,636	20,651	-50%
Snow Crab	*Chionoecetes opilio*	319,816	225,941	159,359	73,994	-54%
Bering Flounder	*Hippoglossoides robustus*	12,355	19,803	18,526	8,384	-55%
Snailfishes	Liparidae	3,305	4,864	777	329	-58%
Walleye Pollock	*Gadus chalcogrammus*	21,141	1,319,062	1,167,099	474,448	-59%
Rainbow Smelt	*Osmerus mordax*	1,745	5,054	4,841	1,873	-61%
Pricklebacks	Stichaeidae	1,129	2,967	2,015	757	-62%
Clams, Mussels, Scallops	Bivalvia	2,474	4,992	6,662	2,416	-64%
Eelpouts	Zoarcidae	10,666	9,759	1,707	425	-75%
Jellyfishes	Scyphozoa	12,861	66,292	88,791	21,959	-75%
Miscellaneous Worms		205	278	253	54	-79%
Brittle Stars And Sand Dollars		1,082	5,347	9,211	1,131	-88%
Saffron Cod	*Eleginus gracilis*	90,299	76,238	81,269	9,973	-88%
Atka Mackerel	*Pleurogrammus monopterygius*	0	0	19	0	-100%

Yellowfin Sole (*Limanda aspera*)

Yellowfin sole comprised 17% (496,038 mt; Table 1) of the total 2021 NBS biomass. When compared with the biomass in 2019 (520,029 mt; Table 1), this species experienced a 5% decrease. Previously, yellowfin sole biomass increased by 20% from 2017 (434,086 mt; Table 1) to 2019. Sexually mature yellowfin sole adults complete an annual spawning migration to nearshore waters during the spring and summer. Younger and sexually immature individuals complete an ontogenetic (age-based) migration rather than a spawning migration, moving deeper as they get older. Length or age at sexual maturity differs for males and females, causing further size segregation among spawning and non-spawning portions of the population (Nichol et al. 2019; Nichol 1997). In 2021, the length cohort size class modes are small and not highly distinctive, with values around 16 cm and 21 cm (Figure 8). This finding is similar to 2019, when the smallest size class mode range appears from 18-22 cm. Spatial distribution also remained similar from 2019 to 2021, although less dense aggregations in the NBS were observed south of St. Lawrence Island in 2021 (Figure 9).

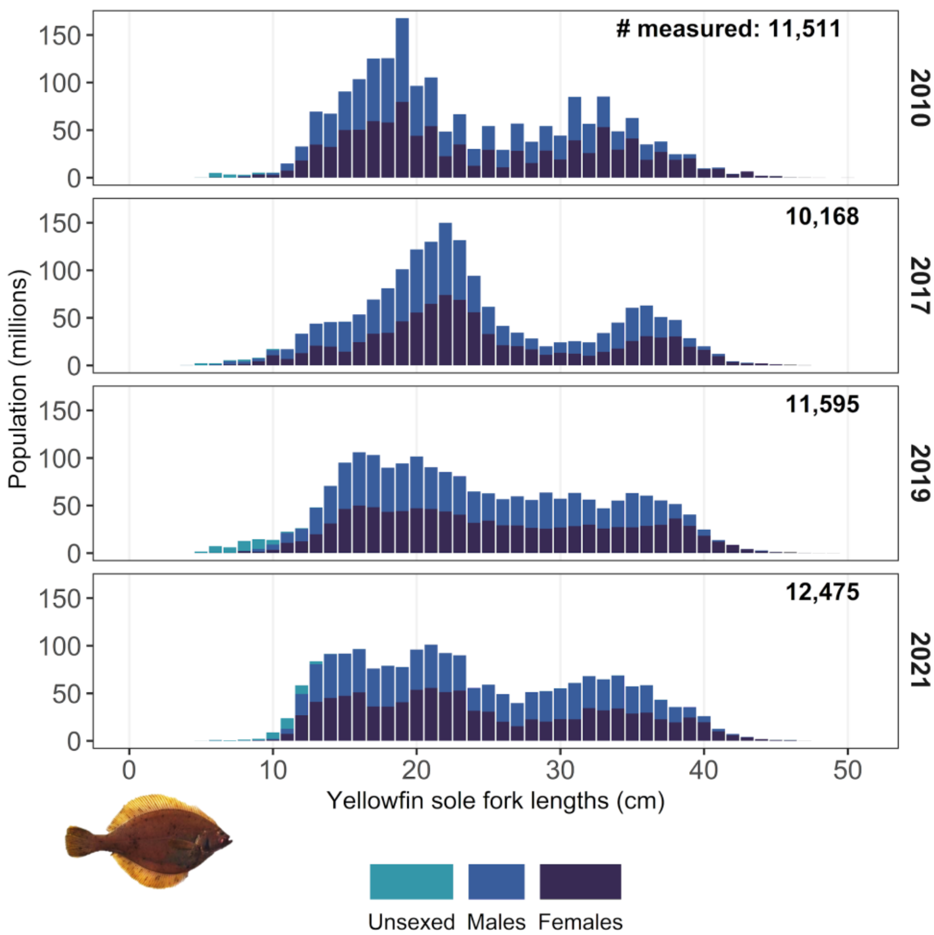

*Figure 8. Total abundance-at-size of yellowfin sole (*Limanda aspera*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

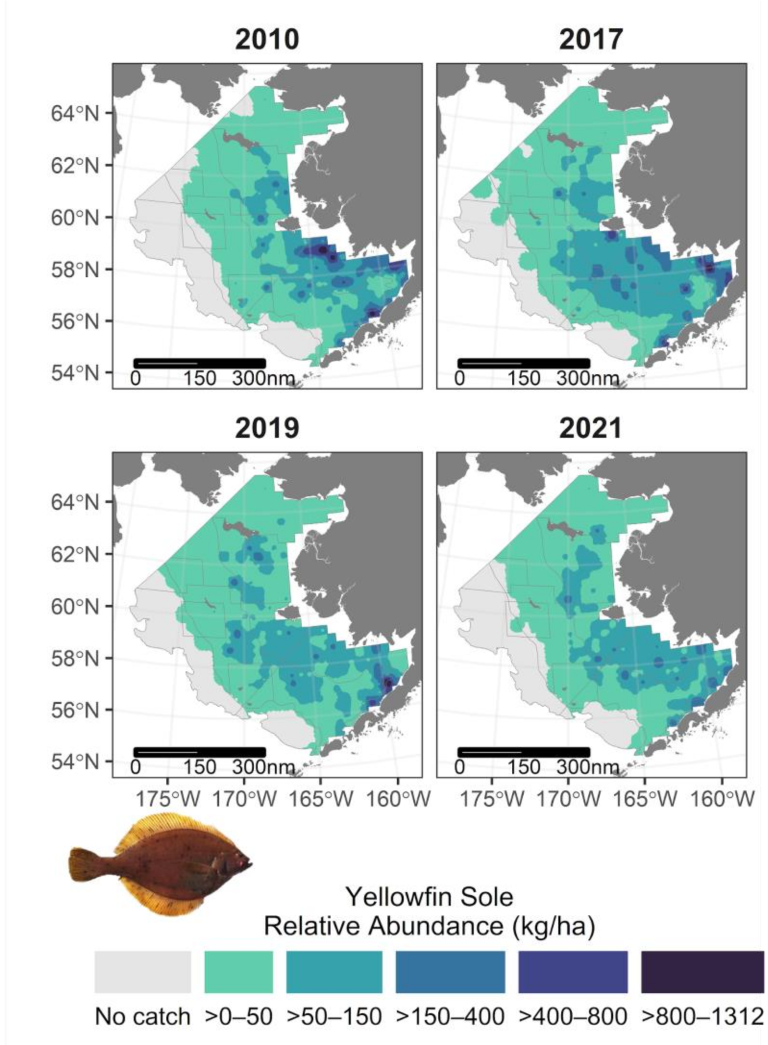

*Figure 9. Distribution and relative abundance (in kg/ha) of yellowfin sole (*Limanda aspera*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

References

Nichol, Daniel G. 1997. "Effects of Geography and Bathymetry on Growth and Maturity of Yellowfin Sole, Pleuronectes Asper, in the Eastern Bering Sea." Journal Article. *Oceanographic Literature Review* 12 (44): 1548.

Nichol, Daniel G, Stan Kotwicki, Thomas K Wilderbuer, Robert R Lauth, and James N Ianelli. 2019. "Availability of Yellowfin Sole Limanda Aspera to the Eastern Bering Sea Trawl Survey and Its Effect on Estimates of Survey Biomass." Journal Article. *Fisheries Research* 211: 319–30.

Snow Crab (*Chionoecetes opilio*)

In 2021, snow crab were caught at 102 of the 144 total NBS stations and comprised 3% (73,994 mt; Table 1) of the NBS survey biomass. Compared with 2019 (159,359 mt; Table 1), snow crab biomass experienced a 54% decrease. Previously, snow crab biomass experienced a 29% decrease from 2017 (225,941 mt; Table 1) to 2019. The highest length cohort size class range is 31-34 mm for both males and immature females in 2021. While the overall estimated abundance of snow crab for that size range has increased since 2019, the number of legal males (greater than 78 mm carapace width) has notably decreased (Figure 10). Highest densities of snow crab from 2017 to 2019 were located north and south of St. Matthew Island, in areas where bottom depths are between 50 m and 100 m (Figure 11). In 2021, the highest snow crab densities were observed just west of St. Matthew Island (Figure 11).

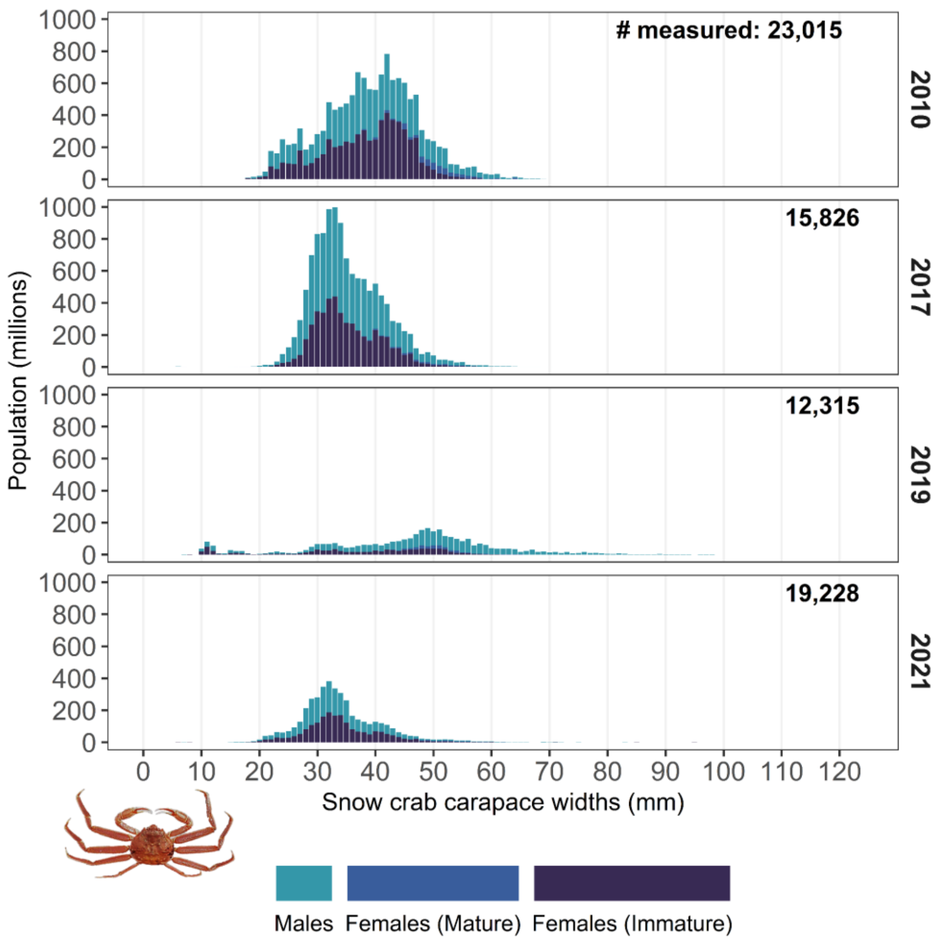

*Figure 10. Total abundance-at-size of snow crab (*Chionoecetes opilio*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

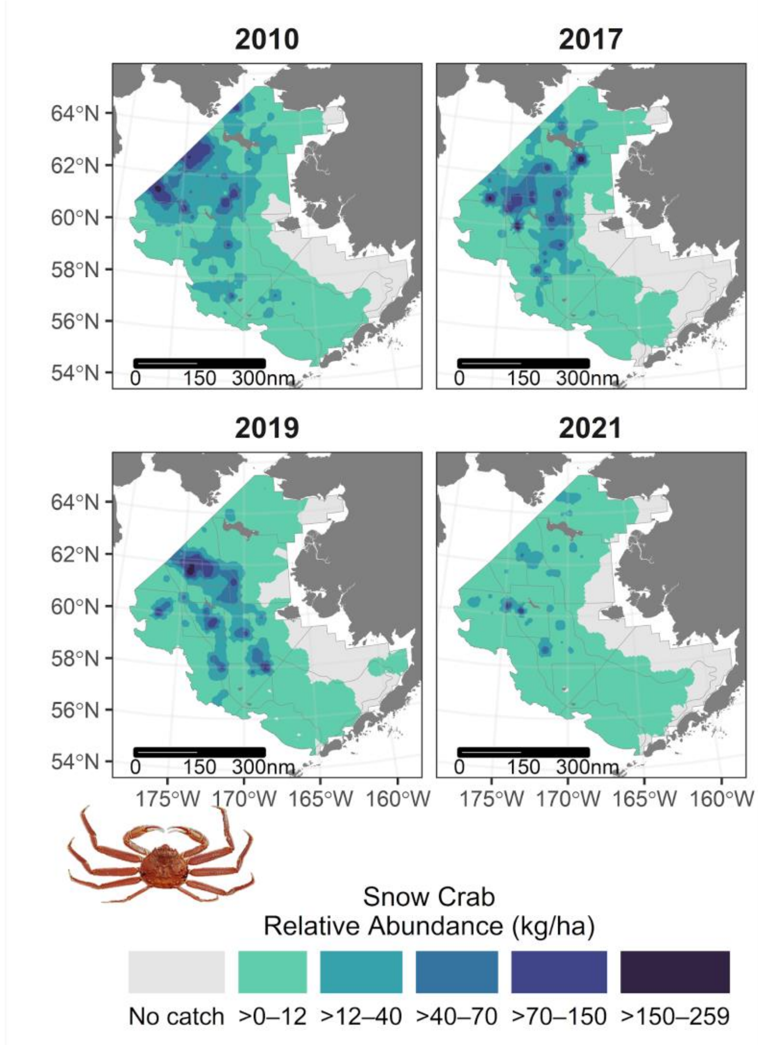

*Figure 11. Distribution and relative abundance (in kg/ha) of snow crab (*Chionoecetes opilio*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Alaska Plaice (*Pleuronectes quadrituberculatus*)

In 2021, Alaska plaice biomass (344,578 mt; Table 1) experienced a 7% increase when compared to biomass in 2019 (321,571 mt; Table 1). Previously, Alaska plaice biomass experienced a 3% decrease from 2017 (330,728 mt; Table 1) to 2019. 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 (Knight, Cheng, and DeVries 1991). Consequently, this species was found in bottom temperatures as warm as 12.5°C and as cold as -1.7°C. Alaska plaice also comprised approximately 12% of the total NBS survey biomass in 2021. Individuals ~36 cm in length were caught at a higher rate than other sizes in the most recent four years of the NBS survey (Figure 12). Spatial distribution was similar from 2019 to 2021, with highest relative abundance located south of St. Lawrence Island (Figure 13).

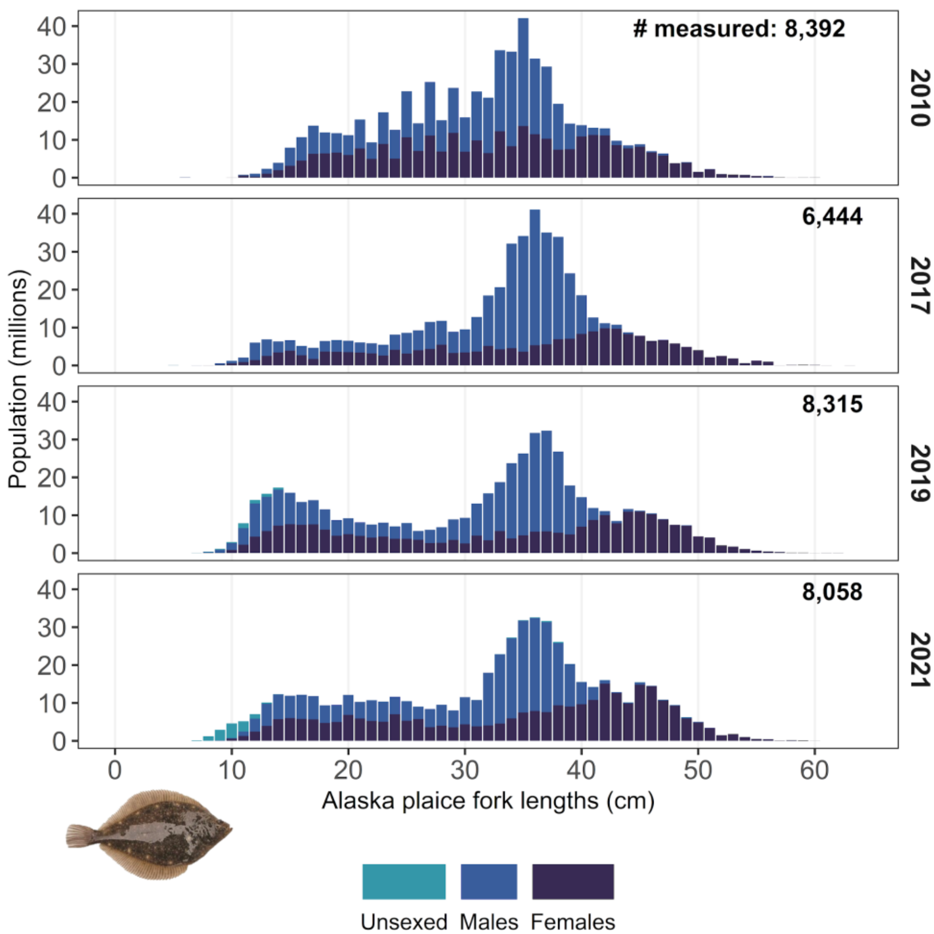

*Figure 12. Total abundance-at-size of Alaska plaice (*Pleuronectes quadrituberculatus*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

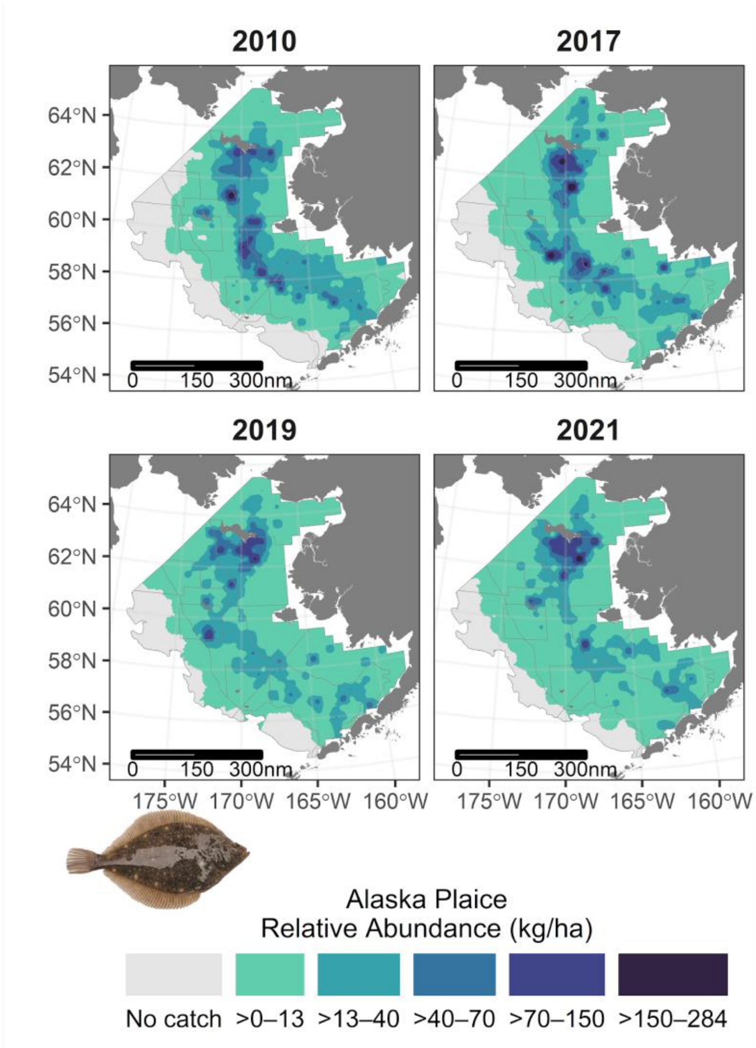

*Figure 13. Distribution and relative abundance (in kg/ha) of Alaska plaice (*Pleuronectes quadrituberculatus*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

References

Knight, CA, CC Cheng, and AL DeVries. 1991. "Adsorption of Alpha-Helical Antifreeze Peptides on Specific Ice Crystal Surface Planes." Journal Article. *Biophysical Journal* 59 (2): 409–18.

Purple-Orange Sea Star (*Asterias amurensis*)

The purple-orange sea star, also known as the northern Pacific sea star, comprised 9% (270,632 mt; Table 1) of the total 2021 NBS survey biomass. This sea star species also accounted for 10% (414,423 mt; Table 1) of the total 2019 NBS survey biomass. Between 2019 and 2021, biomass of the purple-orange sea star decreased by 35%. Previously, this species' biomass in 2019 experienced a 25% increase when compared to that of 2017, as well as an overall 40% increase between 2010 and 2019. Densities of the purple-orange sea star within the NBS survey area were highest along the southeastern coastline of Norton Sound (Figure 14).

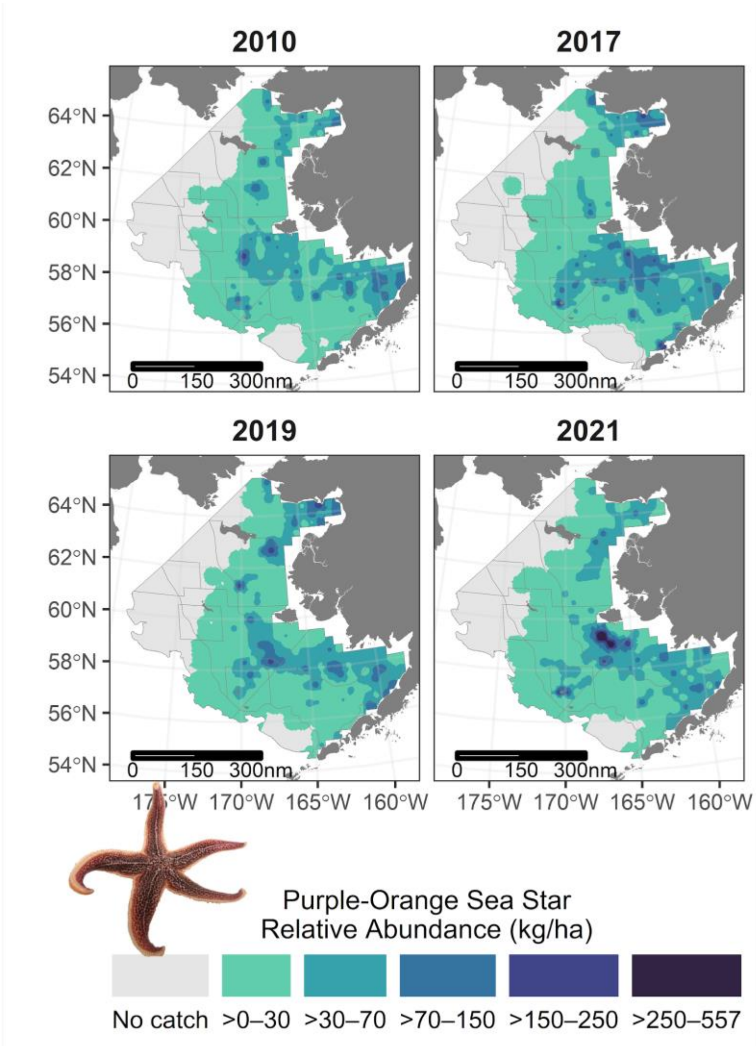

*Figure 14. Distribution and relative abundance (in kg/ha) of purple-orange sea star (*Asterias amurensis*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Northern Neptune Whelk (*Neptunea heros*)

In 2021, the northern Neptune whelk accounted for 4% (114,179 mt; Table 1) of the total NBS survey biomass. Previously, the species comprised 3% (146,344 mt; Table 1) of the 2019 NBS survey biomass. When comparing the above biomass numbers, the northern Neptune whelk experienced a 22% decrease from 2019 to 2021. This decrease follows an 18% decline in biomass from 2017 (178,930 mt; Table 1) to 2019. Northern Neptune whelk were present in bottom temperatures as warm as 12.5°C and as cold as -1.7°C. Density of this species was highest to the northeast and to the south of St. Lawrence Island (Figure 15) in 2021.

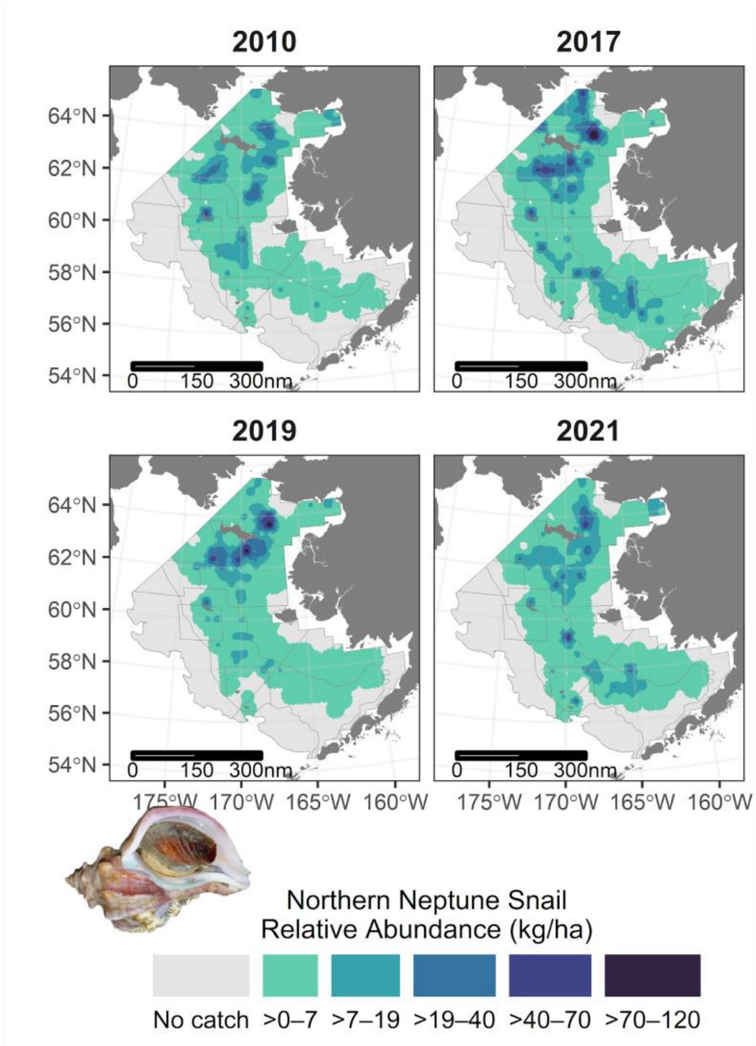

*Figure 15. Distribution and relative abundance (in kg/ha) of northern Neptune whelk (*Neptunea heros*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Saffron Cod (*Eleginus gracilis*)

Inupiaq: Uugaq

Saffron cod is considered to be a nearshore, bottom-dwelling species and represented 0.3% (9,973 mt; Table 1) of the NBS biomass in 2021. When compared with biomass estimates in 2019 (81,269 mt; Table 1), this species experienced an 88% decrease. Previously, saffron cod biomass increased by 7% from 2017 (76,238; Table 1) to 2019. This species was most abundant just north of Nunivak, continuing north along the east coast of St. Lawrence Island, and into Norton Sound (Figure 17). In 2021, saffron cod were present at 57 of 144 NBS stations at depths between 11 and 53 m.

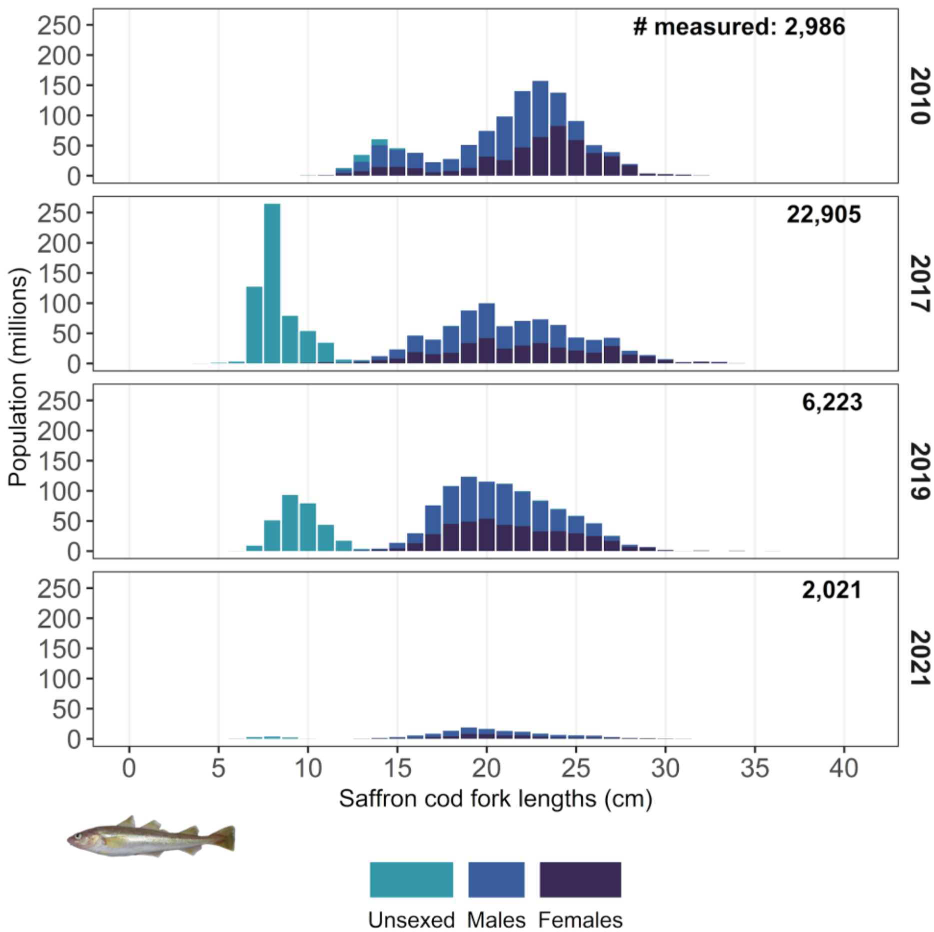

*Figure 16. Total abundance-at-size of saffron cod (*Eleginus gracilis*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

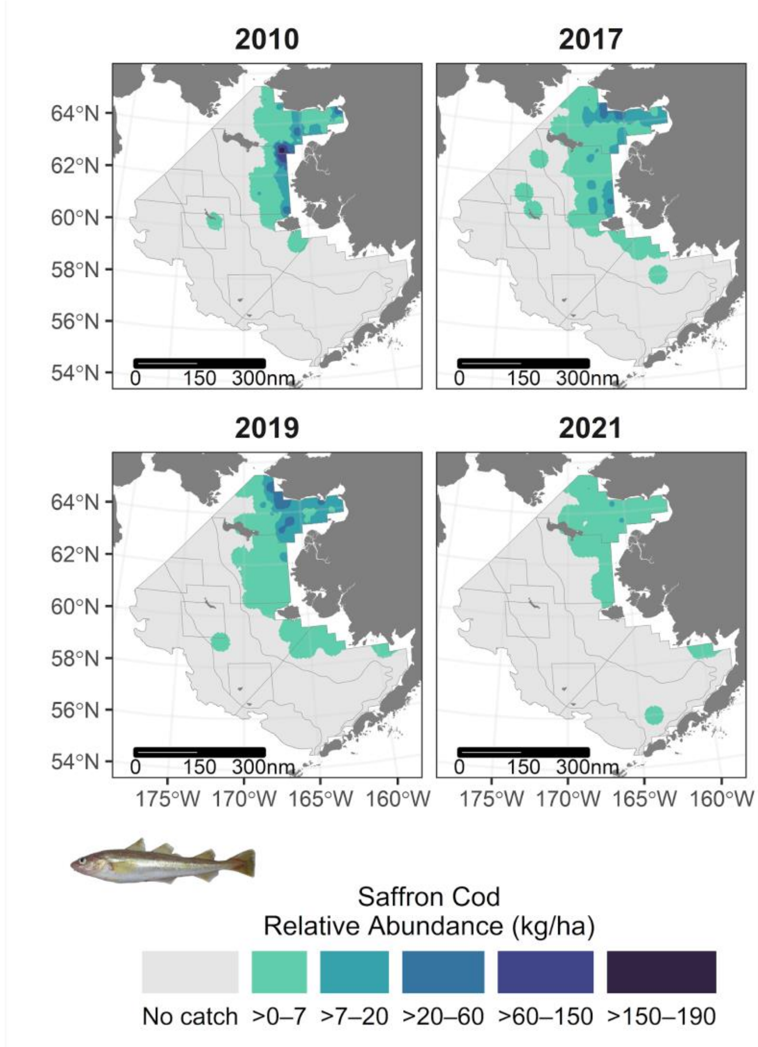

*Figure 17. Distribution and relative abundance (in kg/ha) of saffron cod (*Eleginus gracilis*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Arctic Cod (*Boreogadus saida*)

Inupiaq: Iqalugaq

Arctic cod comprised only 83 mt (Table 1) of the total 2021 NBS survey biomass. In 2019, this species comprised 47 mt (Table 1) of the total NBS survey biomass. High densities of Arctic cod were previously observed in the area of the cold pool with the lowest bottom temperatures (less than -1°C). Between 2010 and 2019, however, NBS Arctic cod biomass declined by 99.8%. Spatial distribution of this forage fish has been decreasing throughout the Bering Sea since 2017 (Figure 19).

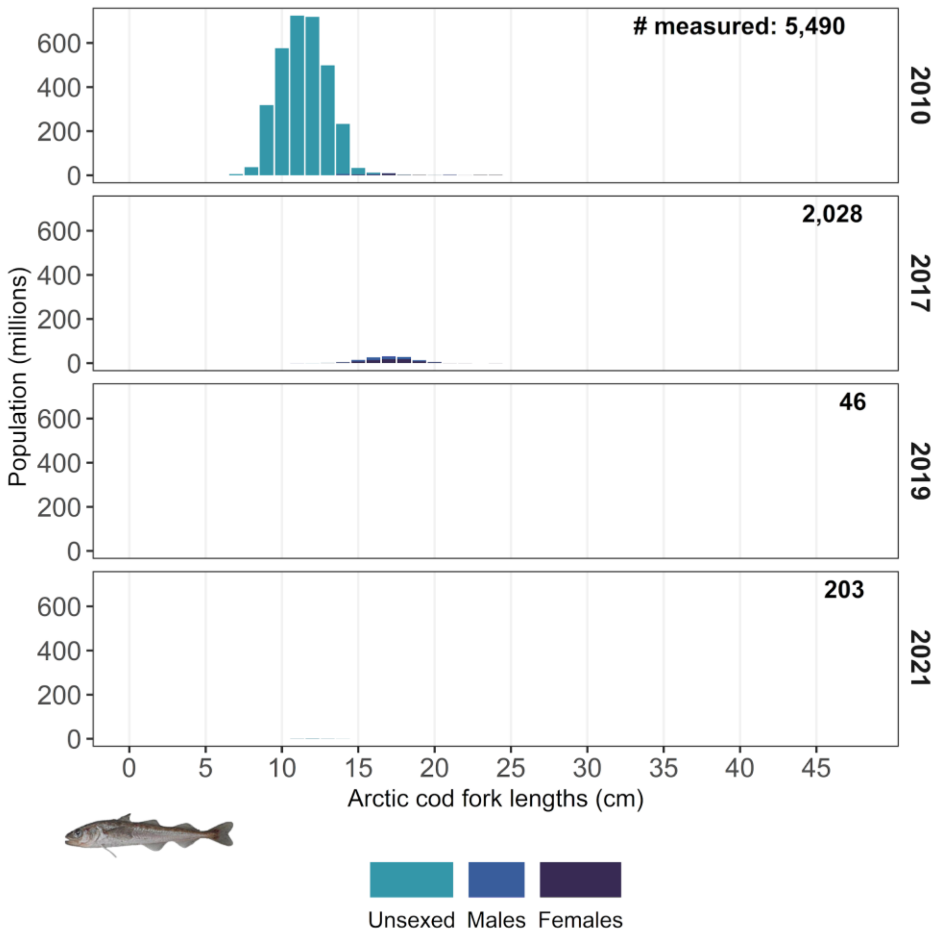

*Figure 18. Total abundance-at-size of Arctic cod (*Boreogadus saida*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

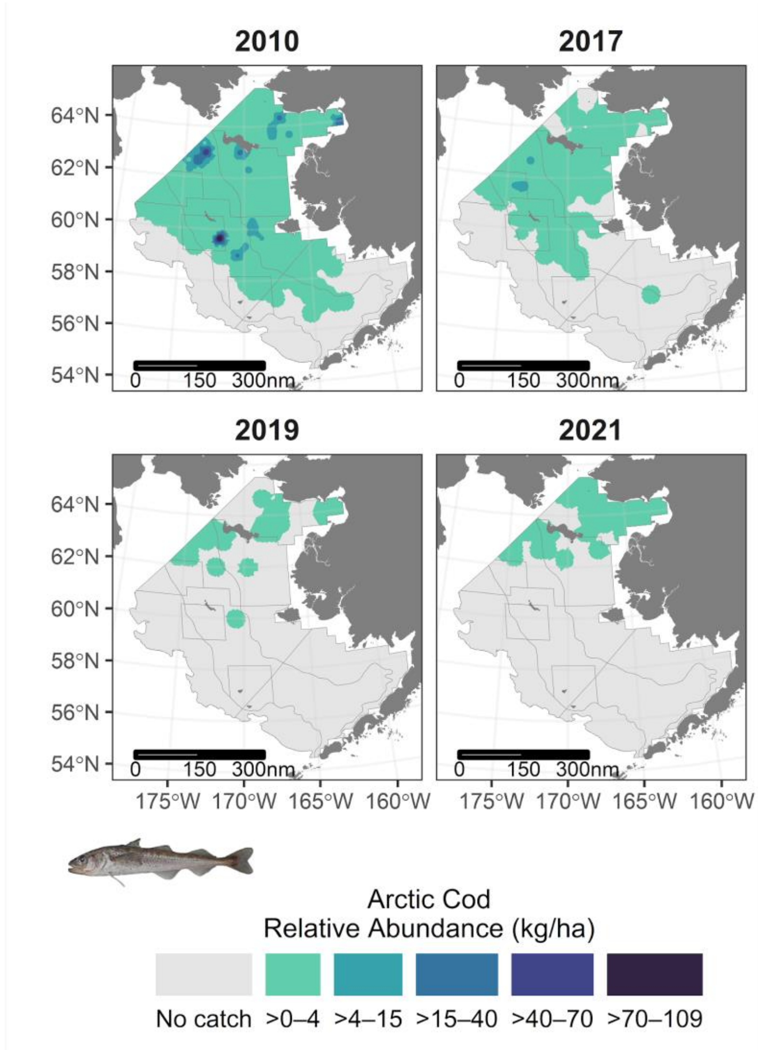

*Figure 19. Distribution and relative abundance (in kg/ha) of Arctic cod (*Boreogadus saida*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Pacific Cod (*Gadus macrocephalus*)

Bristol Bay Yup'ik: atigiaq

Nunivak Island Yup'ik: atgiiyaq

Central Yup'ik: centurrnaq

Yukon, Hooper Bay, Chevak, Nunivak Island Yup'ik: iqalluaq

Pacific cod represented about 8% (227,577 mt; Table 1) of the 2021 NBS survey biomass, which is a 38% decrease from 2019 NBS Pacific cod biomass (364,982 mt; Table 1). Previously, Pacific cod biomass experienced a 27% increase from 2017 (287,535 mt; Table 1) to 2019. Pacific cod size composition in 2021 shows two distinct modes around 8 cm and 41 cm, as well as another approximate mode around 65 cm (Figure 20). The highest NBS densities of this species were present just southeast of St. Lawrence Island and north of St. Matthew Island (Figure 21). Pacific cod were present at 109 of the 144 NBS stations (75.7%) in 2021.

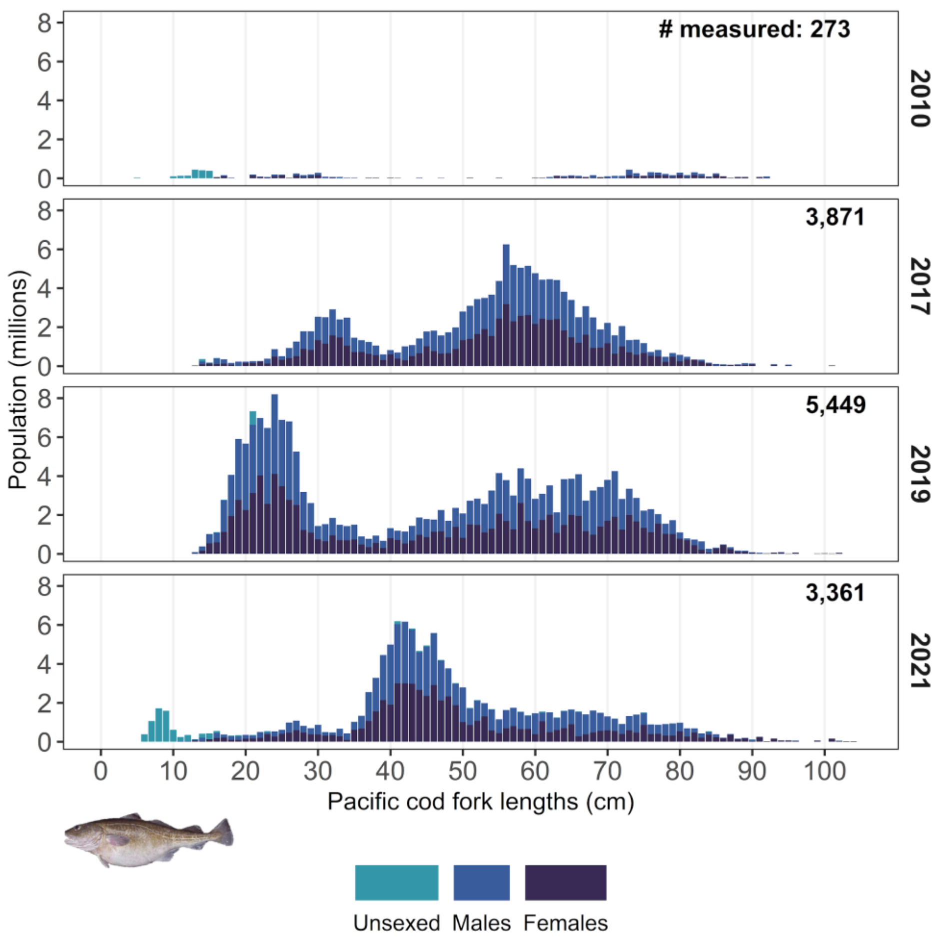

*Figure 20. Total abundance-at-size of Pacific cod (*Gadus macrocephalus*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

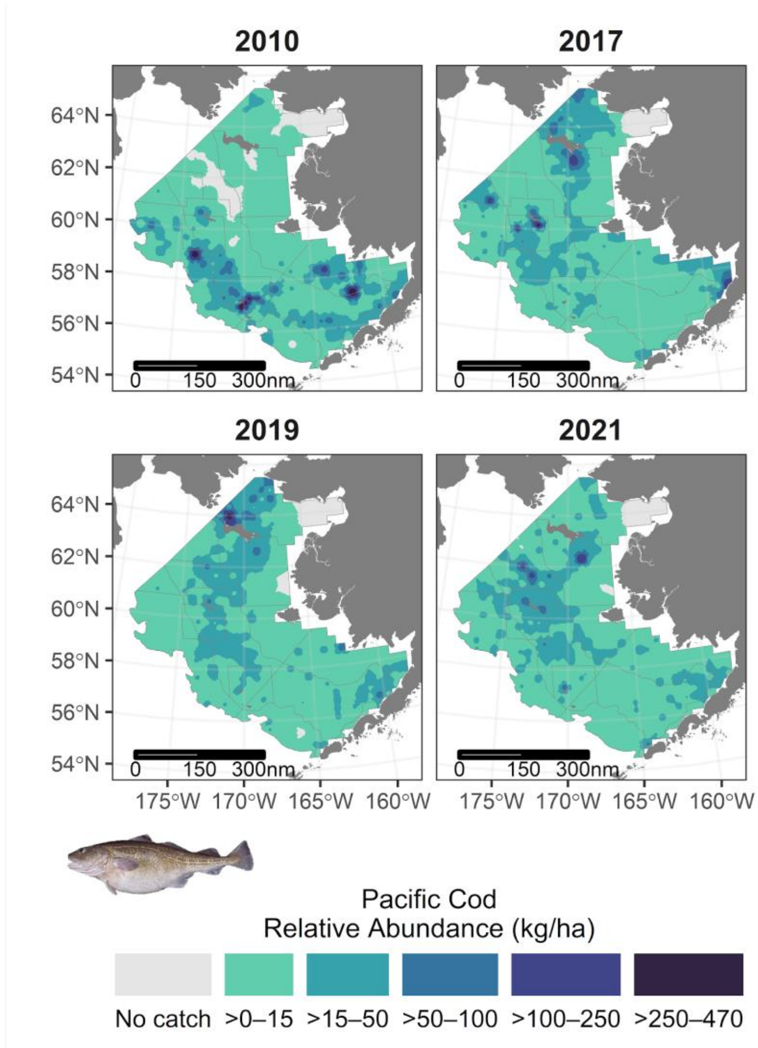

*Figure 21. Distribution and relative abundance (in kg/ha) of Pacific cod (*Gadus macrocephalus*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Walleye Pollock (*Gadus chalcogrammus*)

Size distributions of walleye pollock in 2021 is similar to that of 2017 and 2019 (Figure 22) and all three years had modes of larger fish that were not observed in 2010. The total abundance of fish in 2021 in both modes is much smaller than that in 2017 and 2019. Compared with 2019, walleye pollock biomass in the NBS in 2021 experienced a 59% decrease. Walleye pollock represented 16% of the total NBS biomass in 2021. In 2021, walleye pollock were present at 135 of 144 survey stations in the NBS, at depths from 16 to 79 m. The spatial distribution was relatively consistent throughout the EBS survey area, with a few areas of relatively higher densities along the western boundary line of the survey area and north of St. Lawrence Island (Figure 23).

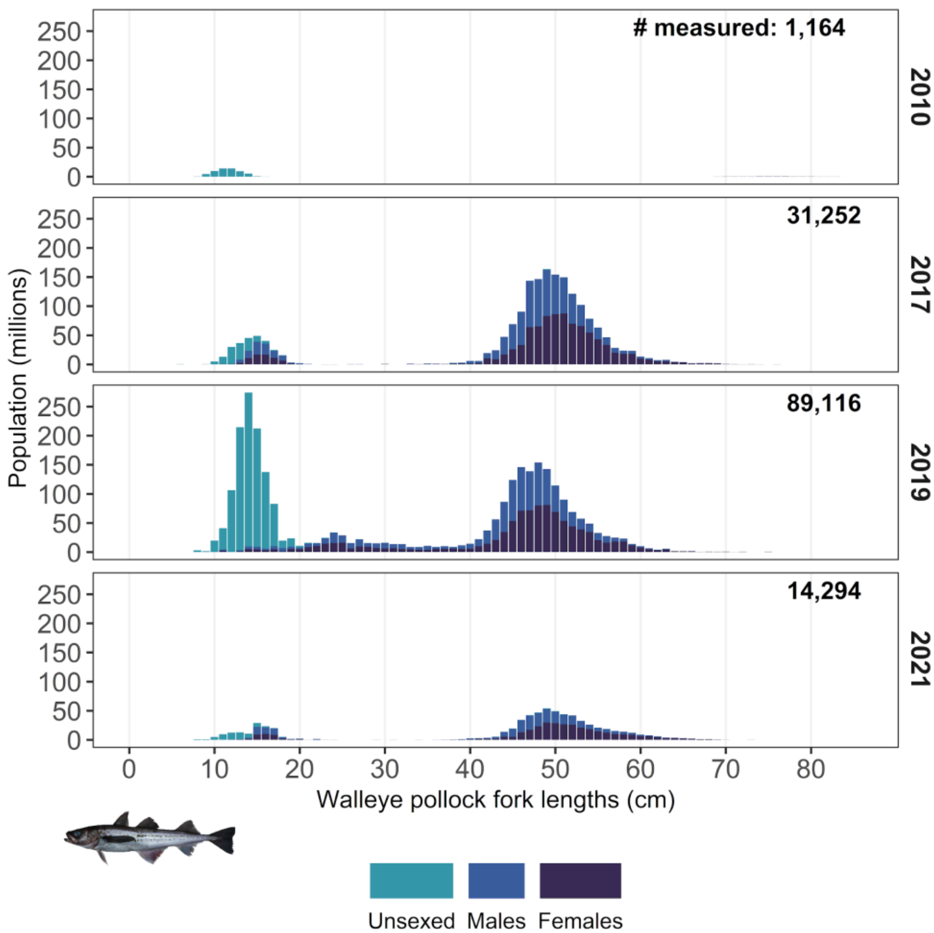

*Figure 22. Total abundance-at-size of walleye pollock (*Gadus chalcogrammus*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

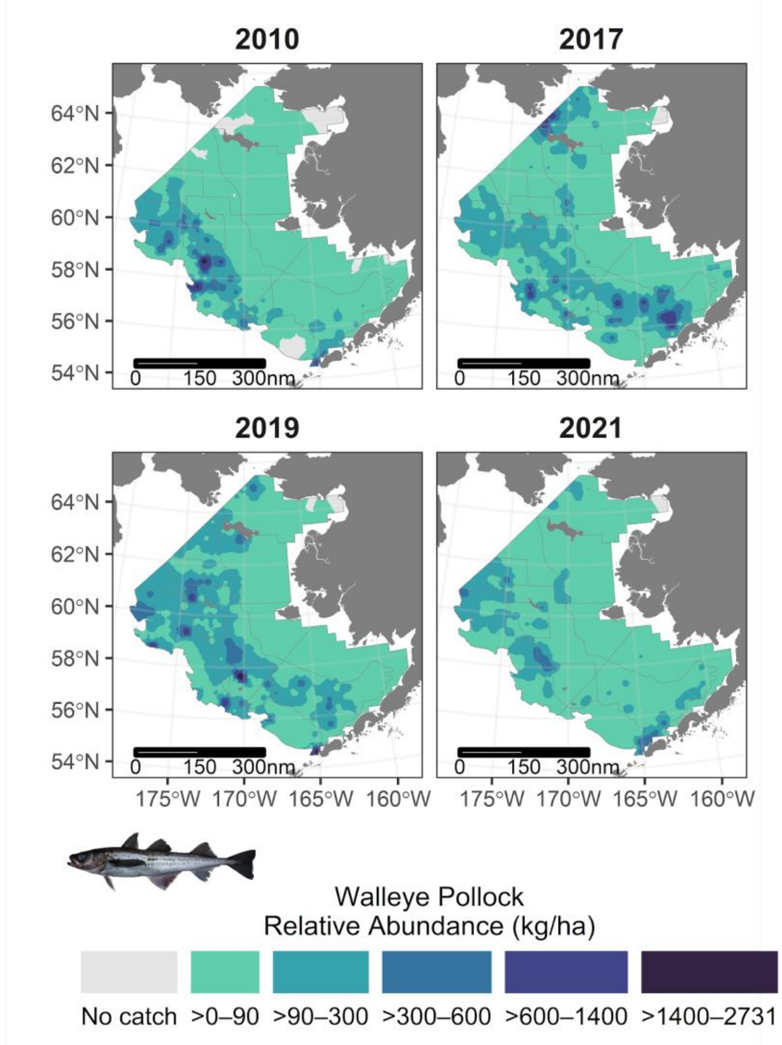

*Figure 23. Distribution and relative abundance (in kg/ha) of walleye pollock (*Gadus chalcogrammus*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Alaska Skate (*Bathyraja parmifera*)

The Alaska skate is the most abundant skate on the continental shelf of the Bering Sea. A similar size composition to 2021 was observed in 2010, 2017 and 2019 (Figure 24). Alaska skate were present at 69 of the 144 stations in the NBS survey area in 2021, at depths ranging from 22 to 79 m (Figure 25). Compared with 2019, Alaska skate biomass in 2021 in the NBS experienced a 16% decrease. The distribution is relatively consistent across the shelf in 2021, with the exception of the area north of St. Lawrence Island north to the Bering Strait (Figure 25), where the species was not encountered.

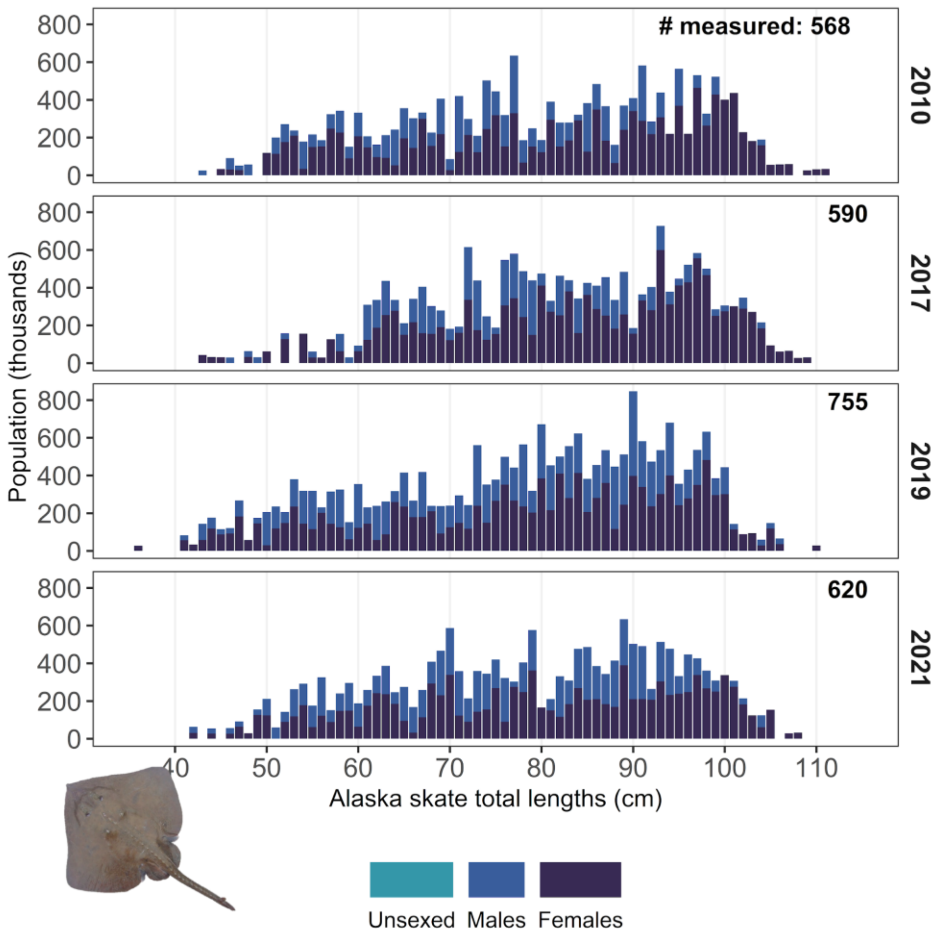

*Figure 24. Total abundance-at-size of Alaska skate (*Bathyraja parmifera*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

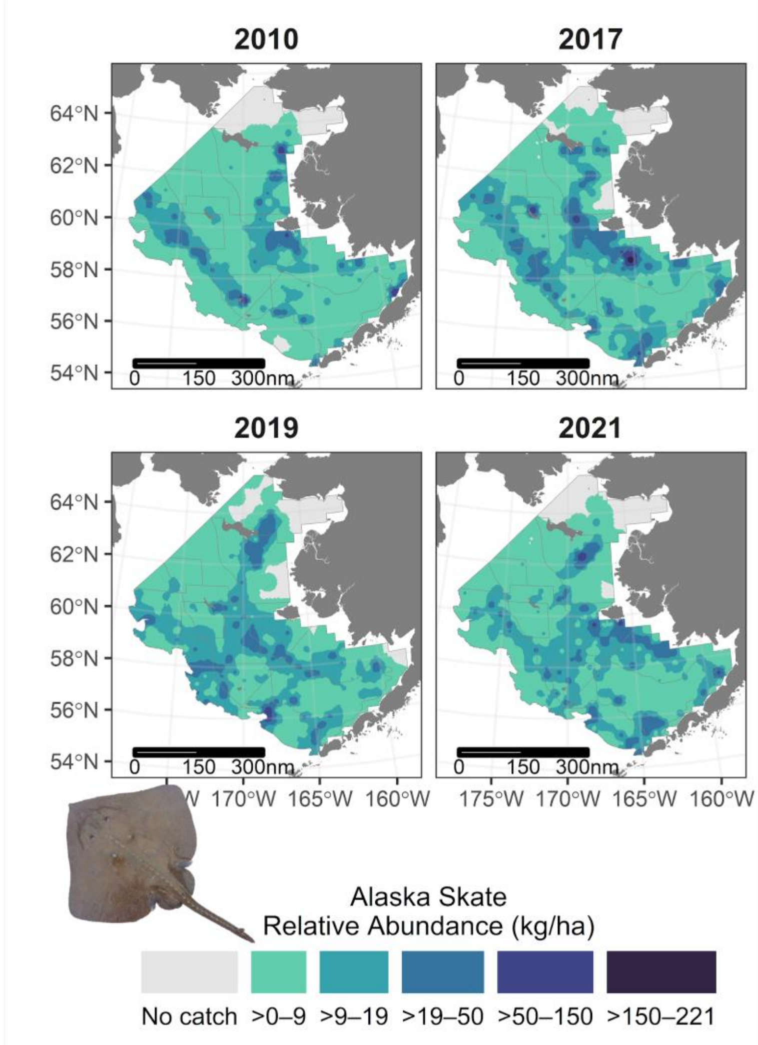

*Figure 25. Distribution and relative abundance (in kg/ha) of Alaska skate (*Bathyraja parmifera*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Shorthorn Sculpin (*Myoxocephalus scorpius*)

Previous Scientific Name: *Myoxocephalus verrucosus*

St. Lawrence Island Yup'ik: nertuli

Inupiaq: kanayuq

The shorthorn sculpin was previously referred to as warty sculpin due to the presence of stellate scale patches, which appear similar to warts, on the body. The size distribution of shorthorn sculpin in the NBS in 2021 was very similar to that of 2019, with primarily larger individuals (Figure 26). Since 2019 there has been an estimated decrease in biomass of 46% in the NBS. The highest densities of shorthorn sculpin occurred north of St. Lawrence Island. Shorthorn sculpin occurred at 38 of 144 stations sampled in the NBS area at bottom depths between 26 and 68 m (Figure 27).

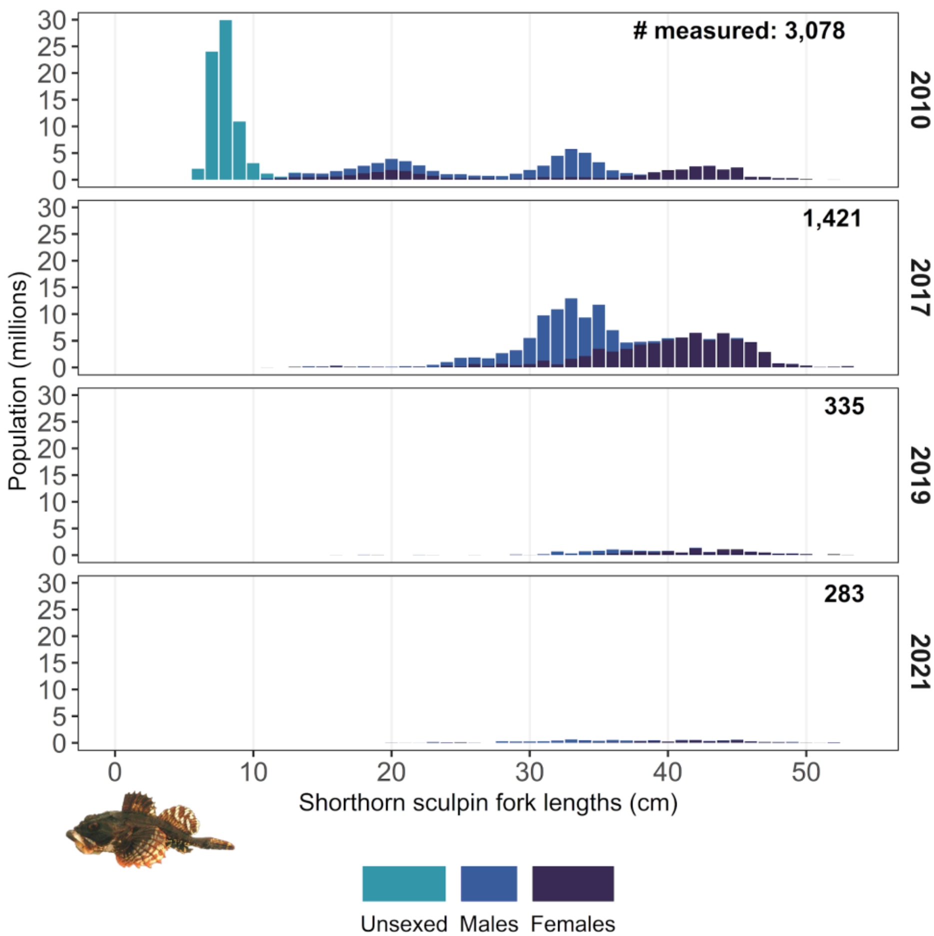

*Figure 26. Total abundance-at-size of shorthorn sculpin (*Myoxocephalus scorpius*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

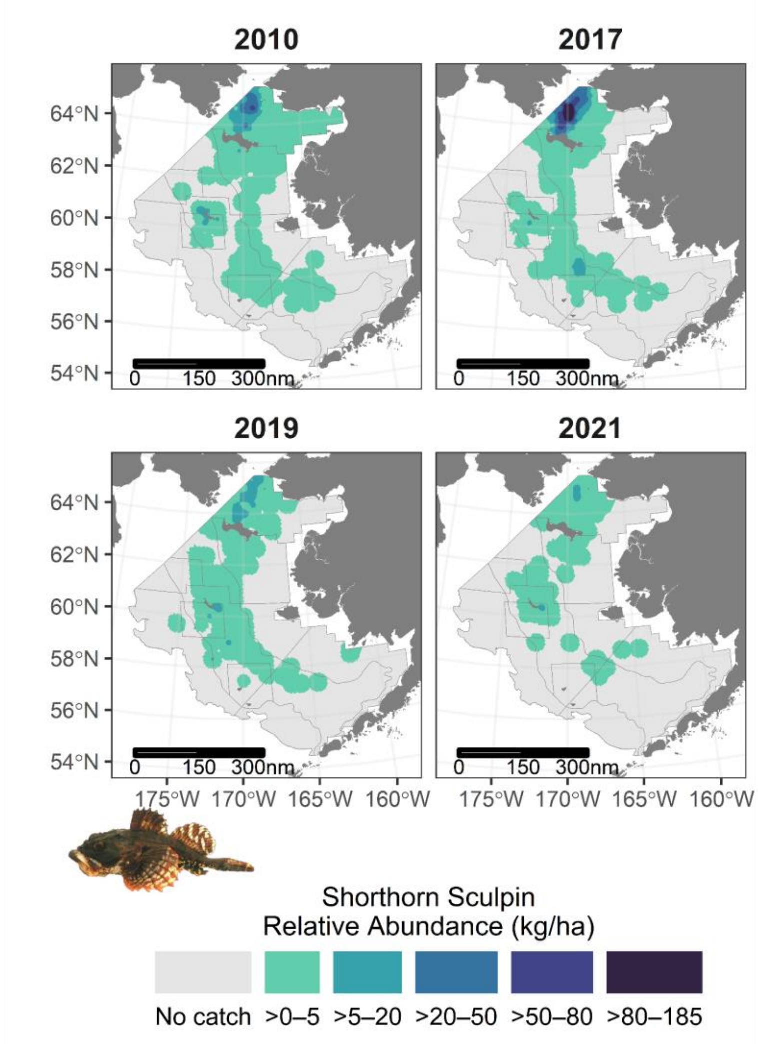

*Figure 27. Distribution and relative abundance (in kg/ha) of shorthorn sculpin (*Myoxocephalus scorpius*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Plain Sculpin (*Myoxocephalus jaok*)

St. Lawrence Island Yup'ik: nertuli

Plain sculpin were caught at 95 of 144 stations sampled in the NBS at depths between 11 and 63 m. The size distribution of plain sculpin was similar to that in 2010, 2017 and 2019; however, compared with 2019, plain sculpin biomass in 2021 in the NBS experienced a 50% decrease. (Figure 28; Figure 29). The density of plain sculpin was highest north and east of St. Lawrence Island and southwest of Nunivak (Figure 29).

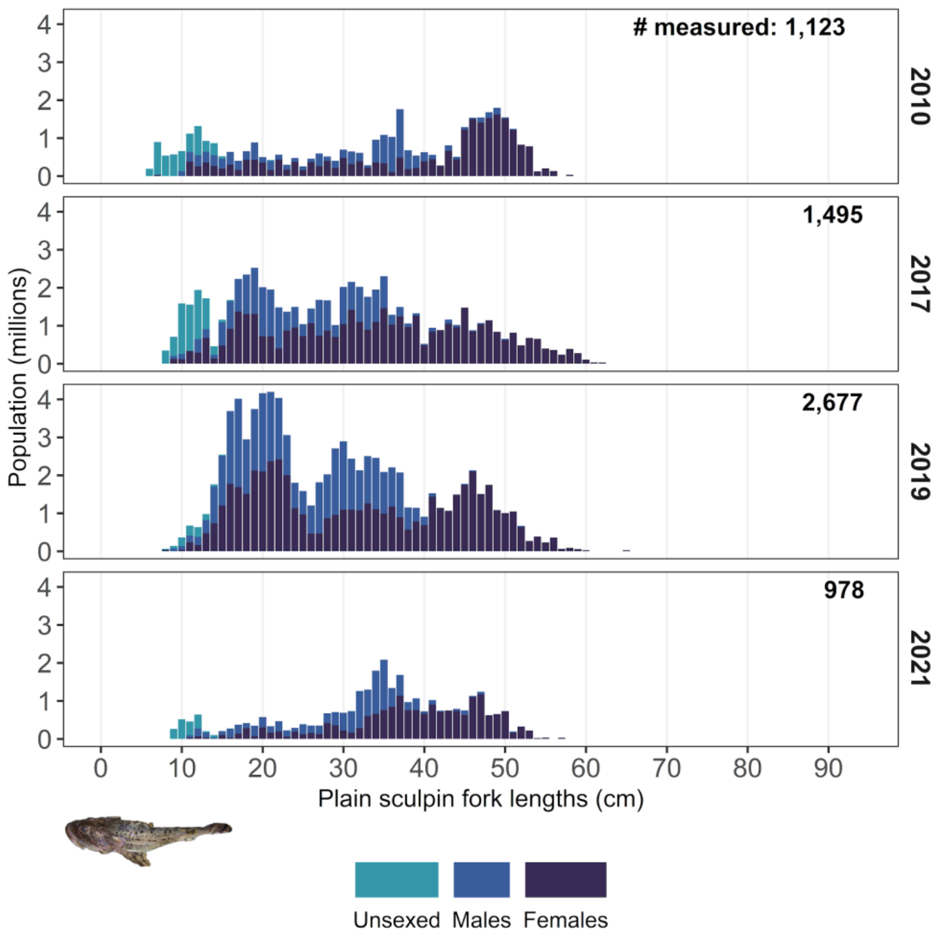

*Figure 28. Total abundance-at-size of plain sculpin (*Myoxocephalus jaok*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

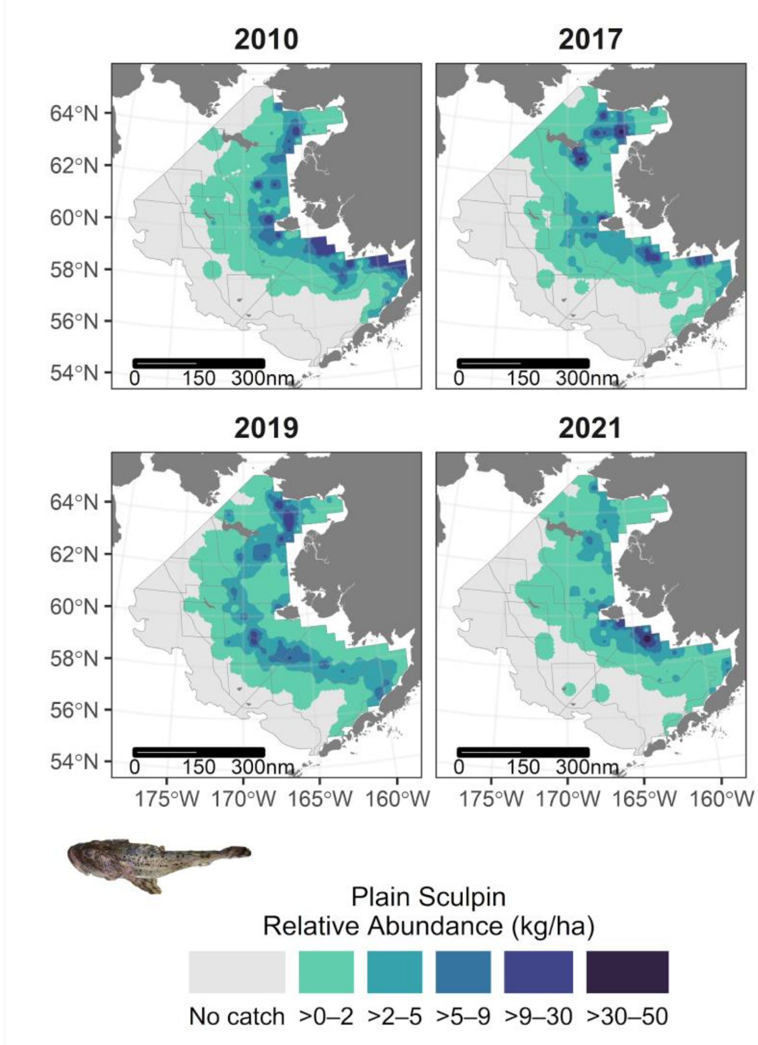

*Figure 29. Distribution and relative abundance (in kg/ha) of plain sculpin (*Myoxocephalus jaok*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Red King Crab (*Paralithodes camtschaticus*)

A strong mode was present for red king crab around 30 mm carapace length in 2017, 70 mm in 2019 and 80 mm in 2021 (Figure 30). Within the NBS, red king crab occur predominantly in Norton Sound (Figure 31). Red king crab were caught at 25 of the 144 total stations within the NBS survey area in 2021, up from 23 stations in 2019 (Figure 31), and there was a 26% increase (3,600 mt; Table 1) in the estimated biomass of red king crab compared to 2019 (2,865 mt; Table 1). Red king crab were found in waters with depths between 15 m and 43 m with bottom temperatures as warm as 11.7°C and as cold as 2.1°C.

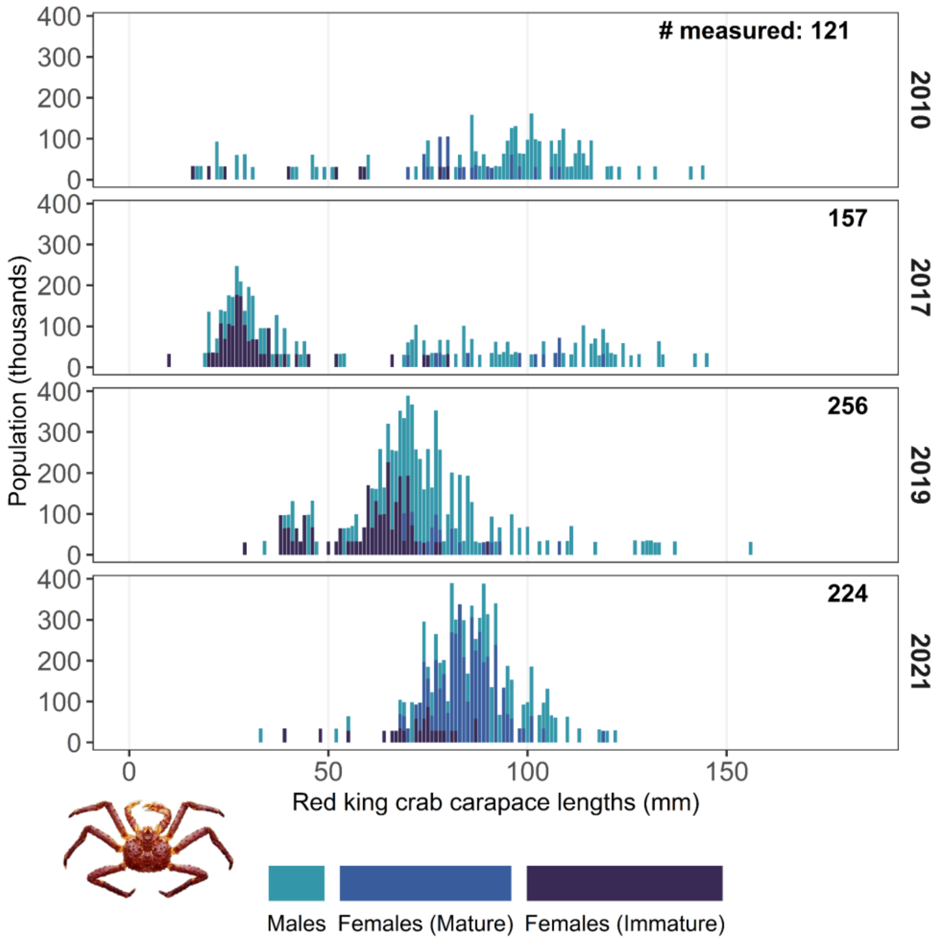

*Figure 30. Total abundance-at-size of red king crab (*Paralithodes camtschaticus*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

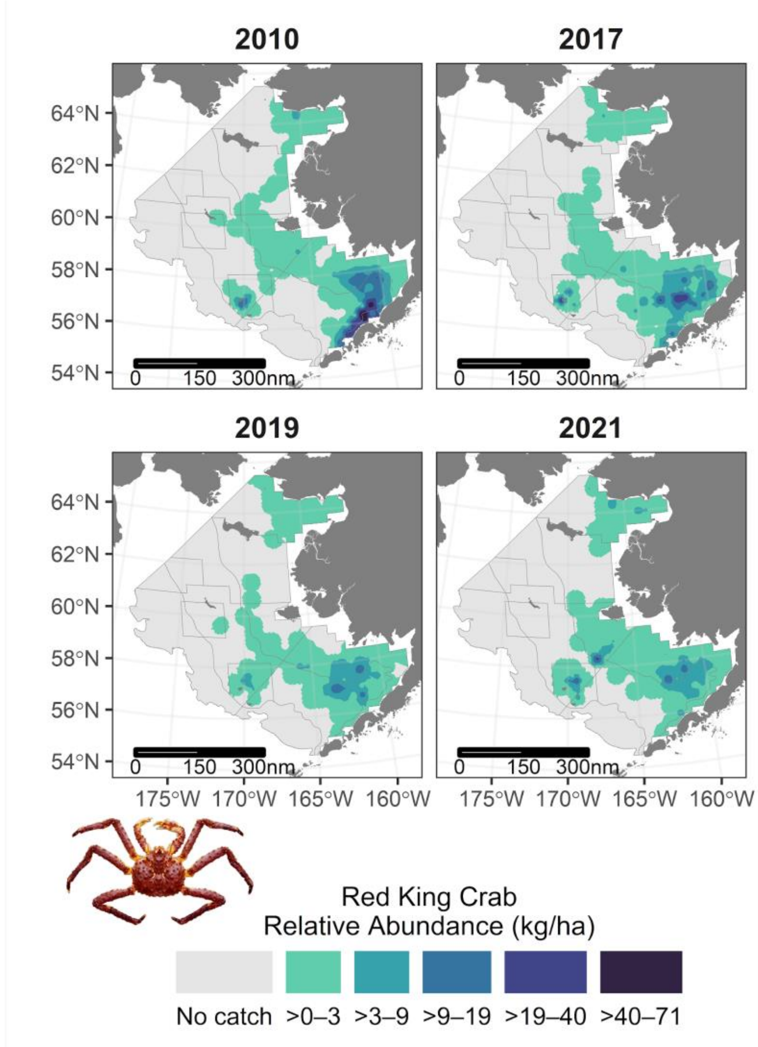

*Figure 31. Distribution and relative abundance (in kg/ha) of red king crab (*Paralithodes camtschaticus*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Blue King Crab (*Paralithodes platypus*)

In 2021, the majority of blue king crab were distributed around St. Matthew Island, the Pribilof Islands, and north of St. Lawrence Island (Figure 33). In 2021, highest densities of blue king crab were encountered off the eastern edge of St. Matthew Island (Figure 33). Blue king crab biomass decreased by 12% from 2019 to 2021. Biomass in 2021 was 1,083 mt, while in 2019 the biomass was 1,228 mt (Table 1). Blue king crab were found in waters with depths between 21 m and 71 m and bottom temperatures as warm as 9.3°C and as cold as -1.6°C. Blue king crab size distributions are shown in Figure 32.

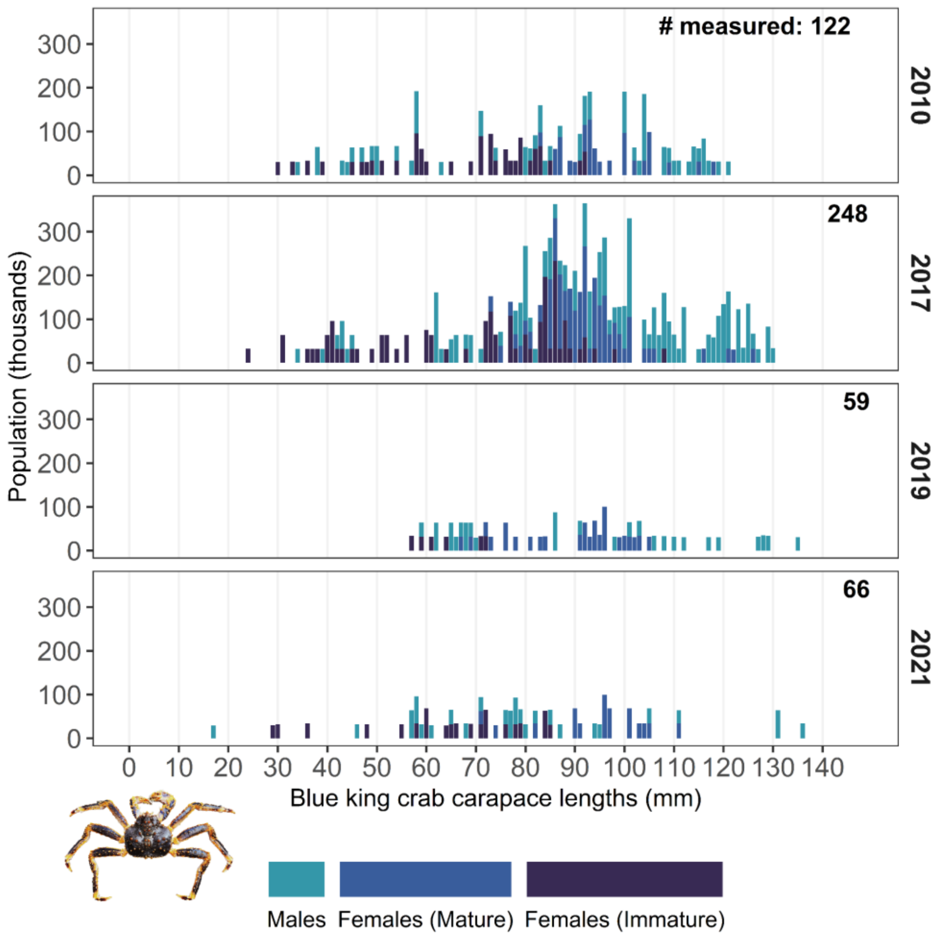

*Figure 32. Total abundance-at-size of blue king crab (*Paralithodes platypus*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

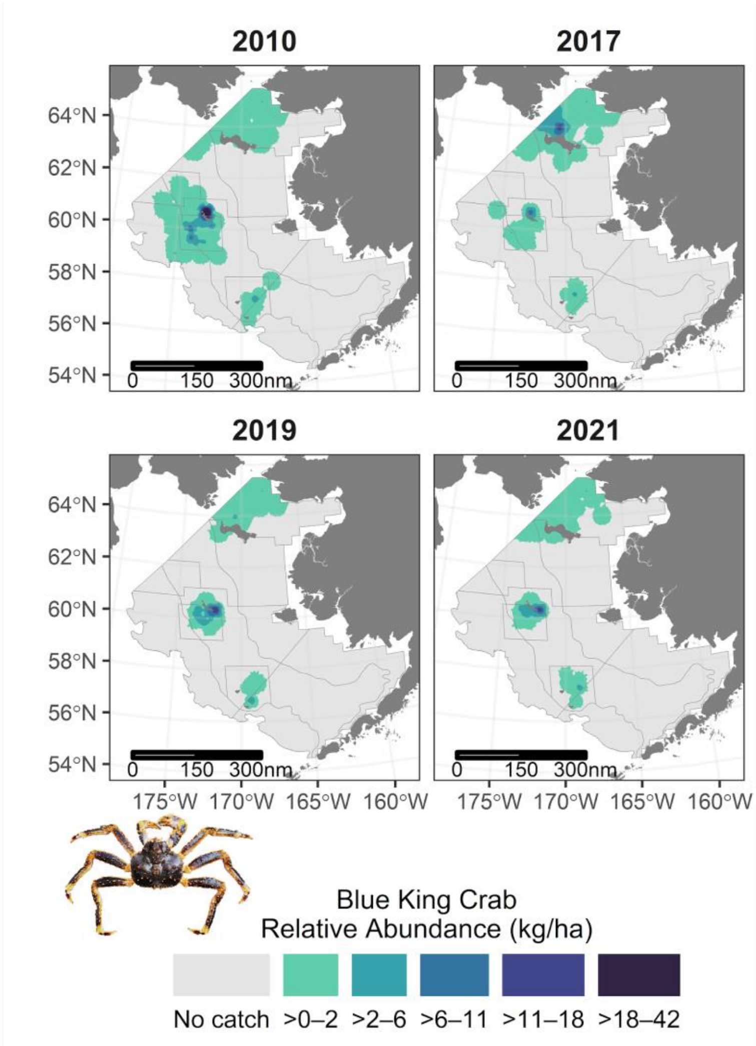

*Figure 33. Distribution and relative abundance (in kg/ha) of blue king crab (*Paralithodes platypus*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Pacific Halibut (*Hippoglossus stenolepis*)

St. Lawrence Island Yup'ik: cagiq, naternarpak

Pacific halibut size composition indicates a large mode of 40-50 cm individuals compared to 2019, 2017, or 2010 (Figure 34). As a result, the average size of halibut in the NBS was smaller in 2021 (49.8 cm) than in 2019 (57.9 cm), 2017 (62.0 cm) and 2010 (61.6 cm). In 2019, Pacific halibut were recorded at depths ranging from 18 m to 79 m in the NBS area (Figure 35). Pacific halibut showed an estimated 1% increase in total biomass from 2019 (25,722 mt; Table 1) to 2021 (25,995 mt; Table 1). However, the 2019 biomass increased by 39% from 2017. In 2021, highest spatial densities were distributed shallower than 50 m, from the southeastern side of St. Lawrence Island east across the mouth of Norton Sound, and to the north near the Bering Strait (Figure 35).

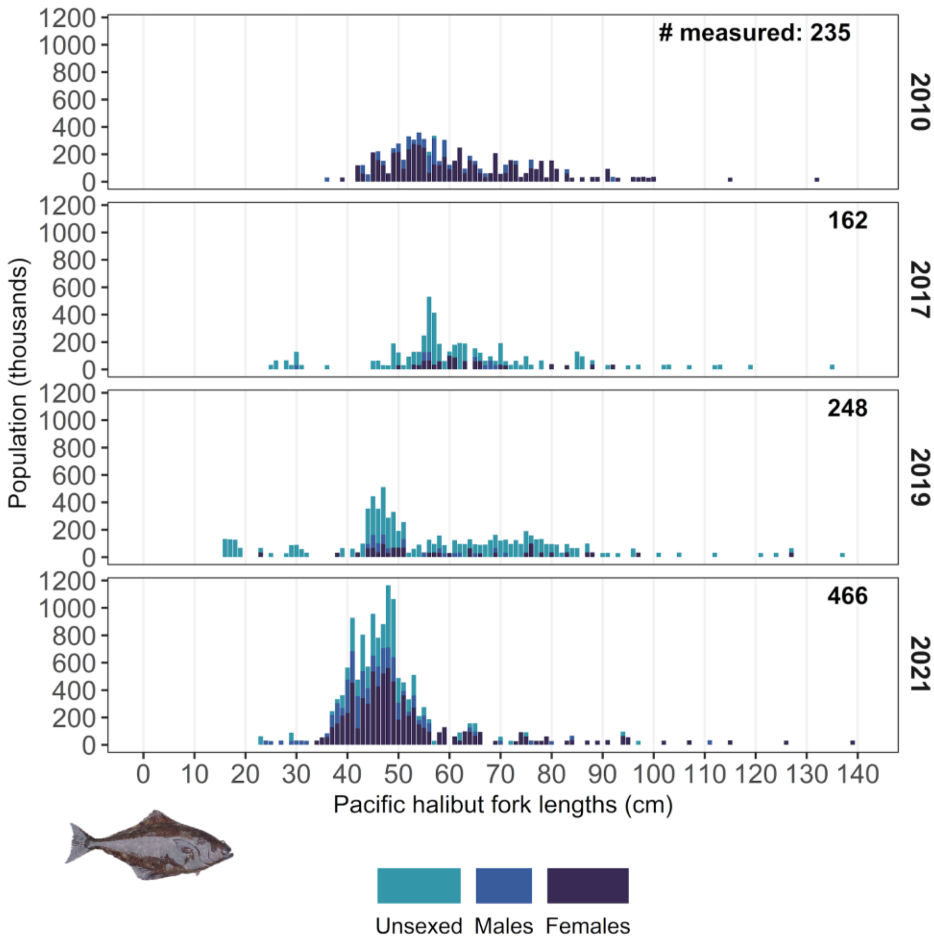

*Figure 34. Total abundance-at-size of Pacific halibut (*Hippoglossus stenolepis*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

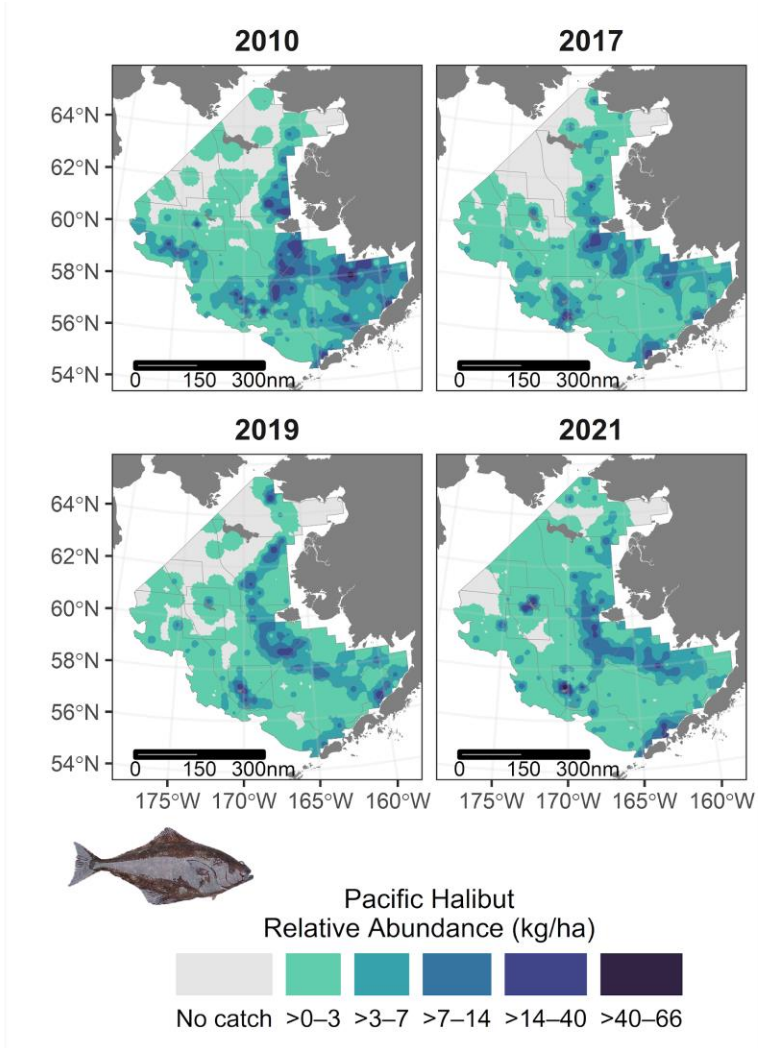

*Figure 35. Distribution and relative abundance (in kg/ha) of Pacific halibut (*Hippoglossus stenolepis*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Bering Flounder (*Hippoglossoides robustus*)

St. Lawrence Island Yup'ik: cagiq, sagiq

In 2021, the greatest number of Bering flounder individuals were around 13 and 14 cm in length (Figure 36), with smaller modes existing around 17 and 35 cm. Bering flounder were recorded at depths between 23 and 79 m. The highest densities were concentrated from St. Matthew Island north to the U.S.- Russia maritime border (Figure 37). Biomass of Bering flounder decreased by 55% between 2019 and 2021 (18,526 mt to 8,384 mt; Table 1).

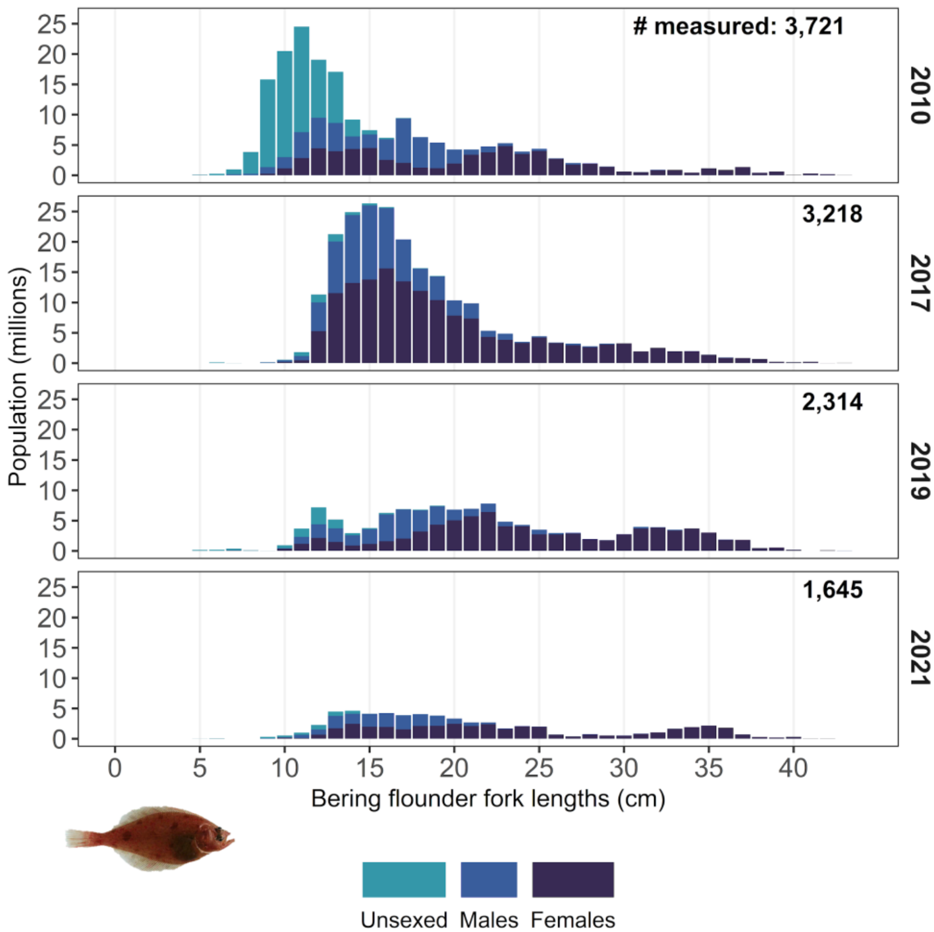

*Figure 36. Total abundance-at-size of Bering flounder (*Hippoglossoides robustus*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

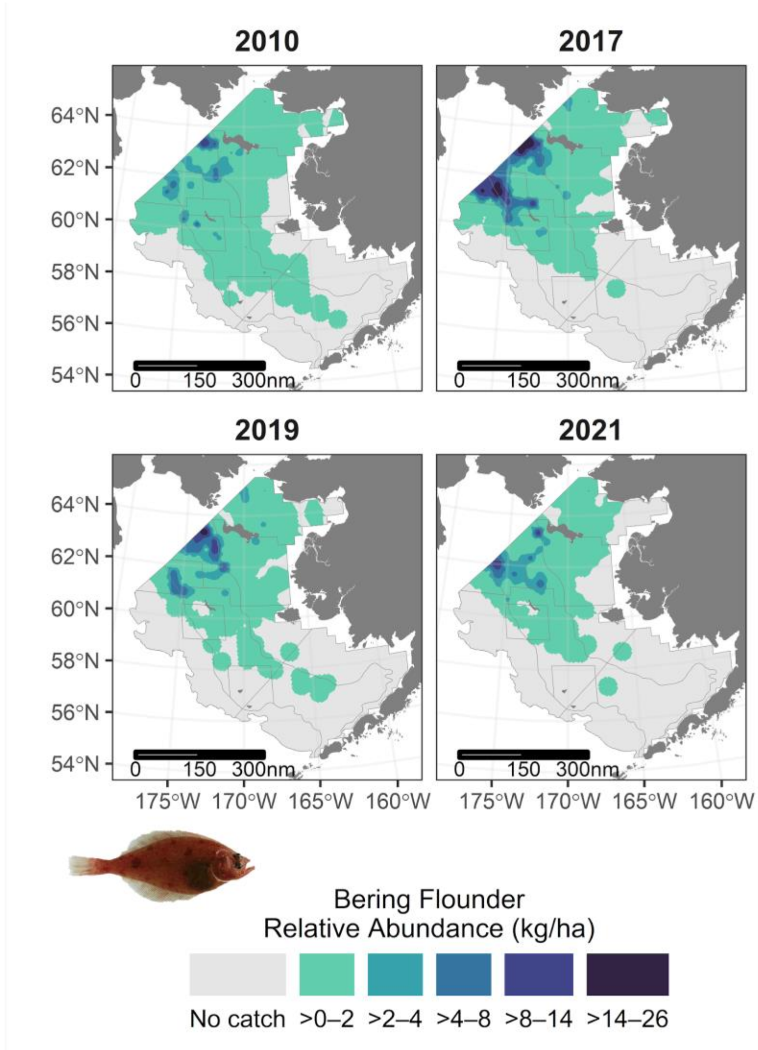

*Figure 37. Distribution and relative abundance (in kg/ha) of Bering flounder (*Hippoglossoides robustus*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Northern Rock Sole (*Lepidopsetta polyxystra*)

St. Lawrence Island Yup'ik: cagiq, sagiq

In 2019, the largest number of northern rock sole individuals caught were around 12 and 13 cm in length while another smaller magnitude mode existed at 39 cm (Figure 38). Since 2010, relatively few northern rock sole have been caught during the NBS survey compared to the EBS survey (Figure 38). The highest densities of northern rock sole in the EBS survey area were recorded north of the Pribilof Islands and in Bristol Bay (Figure 39).

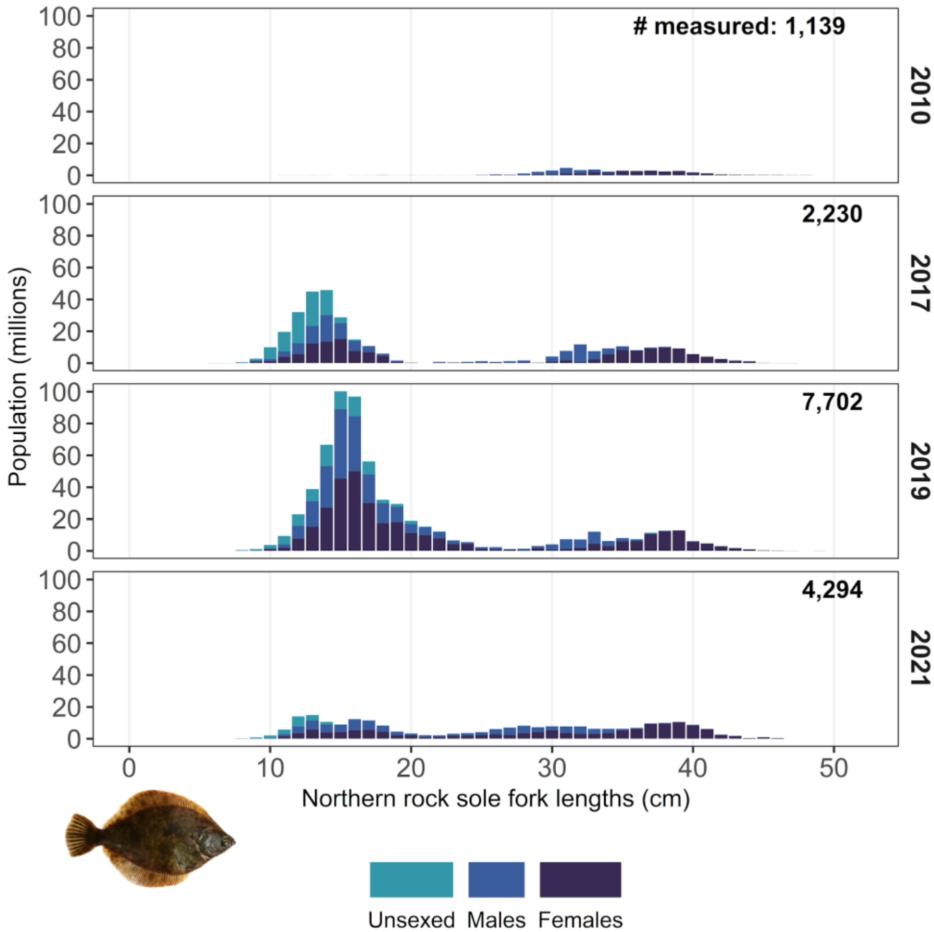

*Figure 38. Total abundance-at-size of northern rock sole (*Lepidopsetta polyxystra*) in the NBS for the survey years 2010, 2017, 2019, and 2021. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey indicated in the upper right of each plot.*

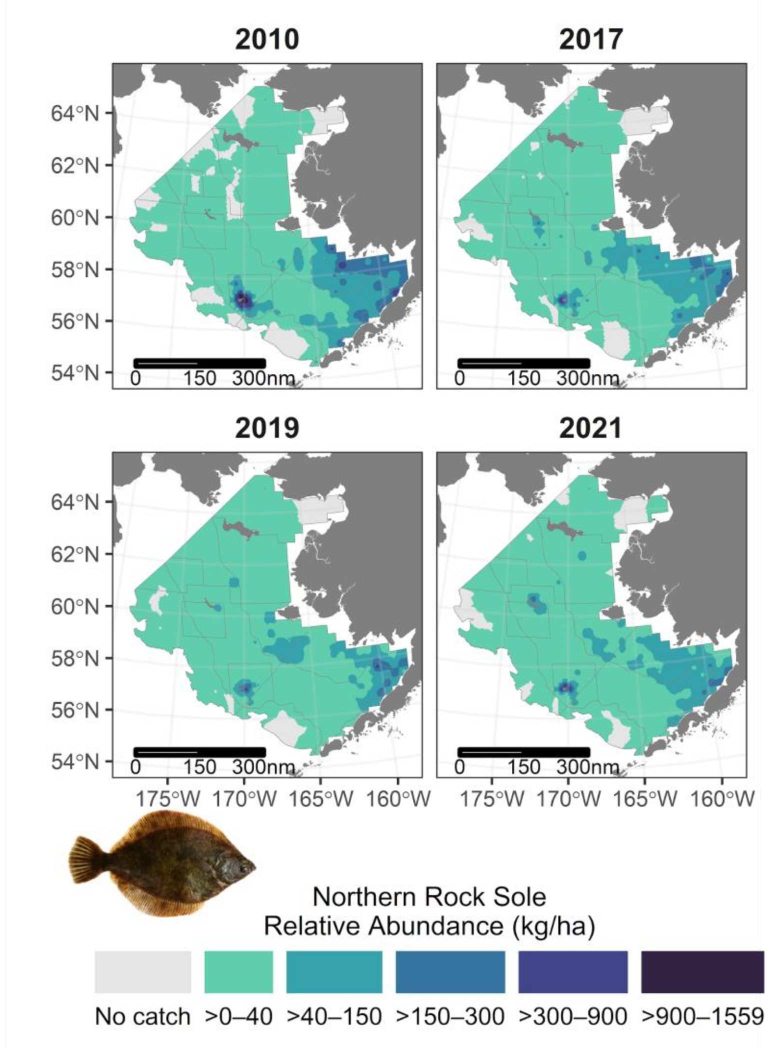

*Figure 39. Distribution and relative abundance (in kg/ha) of northern rock sole (*Lepidopsetta polyxystra*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Pacific Herring (*Clupea pallasii*)

St. Lawrence Island Yup'ik: iqalluarpak, iqallugpak

Inupiaq: Uqsruqtuuq

Central Yup'ik: neqalluarpak

In 2021, Pacific herring were recorded at 83 of 144 NBS stations in depths ranging from 15 m to 73 m. Areas of highest density were located on the inner shelf southeast of St. Lawrence Island, east of St. Matthew Island, and west and southwest of Nunivak Island in 2021 (Figure 40). The relative Pacific herring biomass decreased 31% from 87,918 mt in 2019 to 60,929 mt in 2021 (Table 1). Lengths of Pacific herring have not historically been recorded during the EBS and NBS surveys.

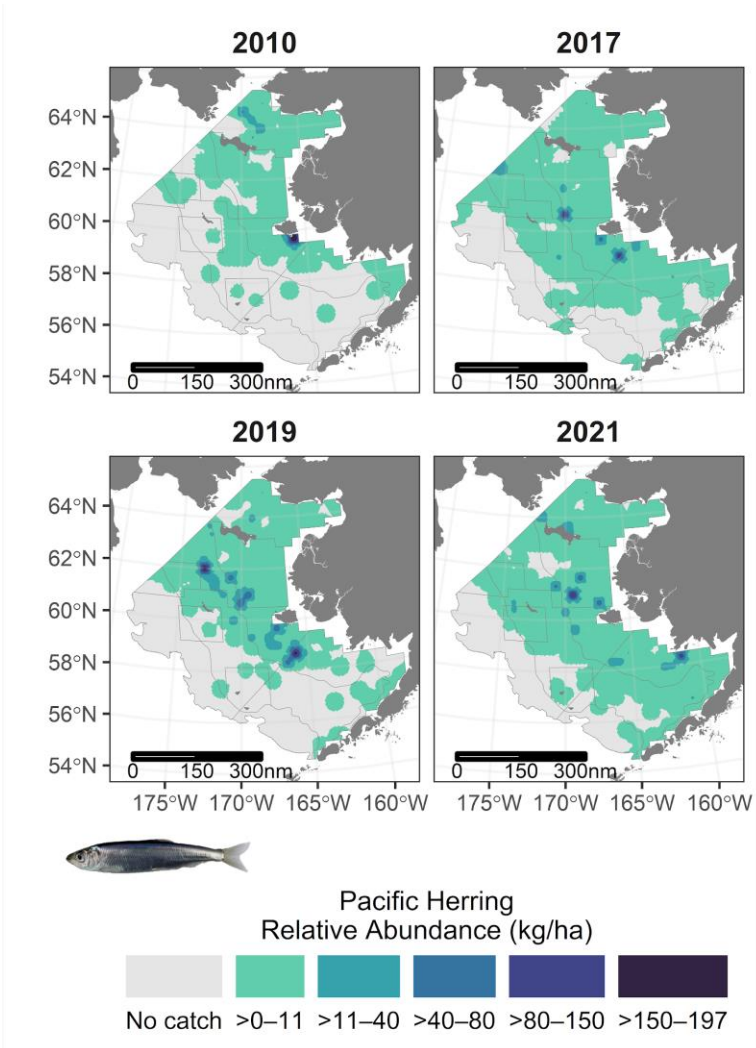

*Figure 40. Distribution and relative abundance (in kg/ha) of Pacific herring (*Clupea pallasii*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Urchins (*Strongylocentrotus* spp.)

St. Lawrence Island Yup'ik: kemagnaq, uutuk

Central Yup'ik: kemagnaq, uutuk

Sea urchins within the genus *Strongylocentrotus* were recorded at 48 of the 144 NBS stations in 2021. In all four NBS surveys (2010, 2017, 2019, and 2021), the highest densities were observed just north of St. Lawrence Island (Figure 41).

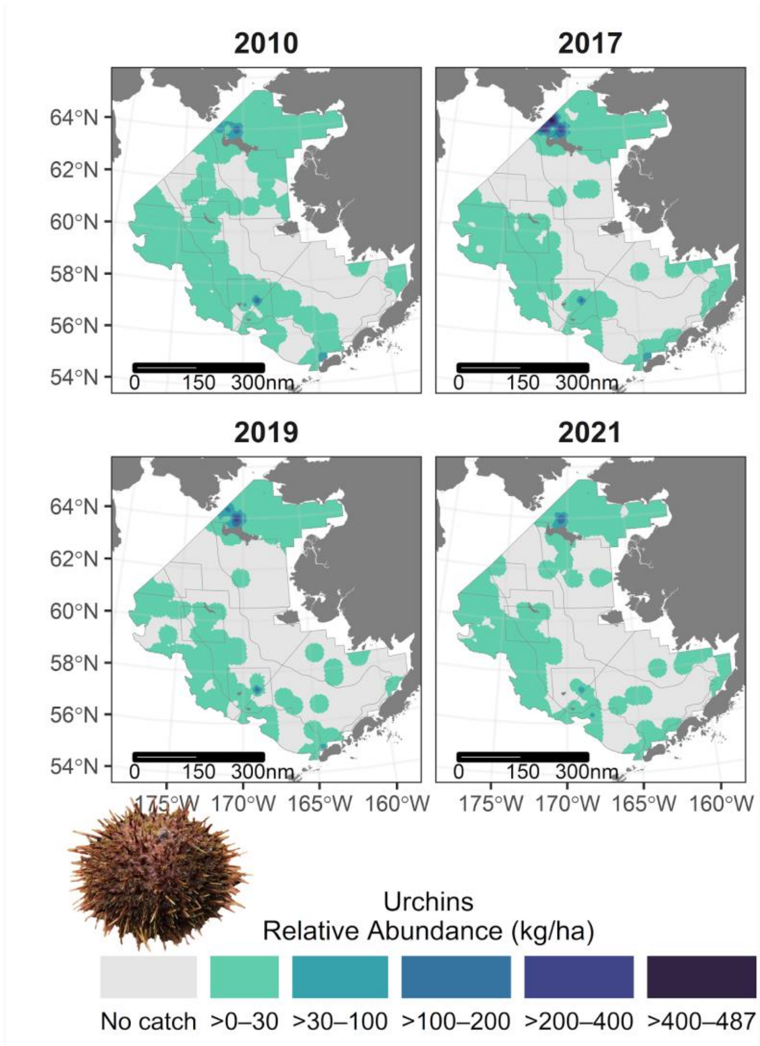

*Figure 41. Distribution and relative abundance (in kg/ha) of urchins (*Strongylocentrotus *spp.) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Jellyfishes (Scyphozoa)

In the NBS, the jellyfish biomass decreased 75% between 2019 and 2021. In 2021, jellyfishes were evenly distributed throughout the NBS, similar to the distribution observed in 2010 (Figure 42). Jellyfishes play important roles as both predator and prey with the Bering Sea ecosystem. Large jellyfish blooms can have a significant impact on the survival of larval and juvenile forage fishes, juvenile pollock, salmon, and the larval stages of many invertebrates, including crabs (Ruzicka et al. 2020).

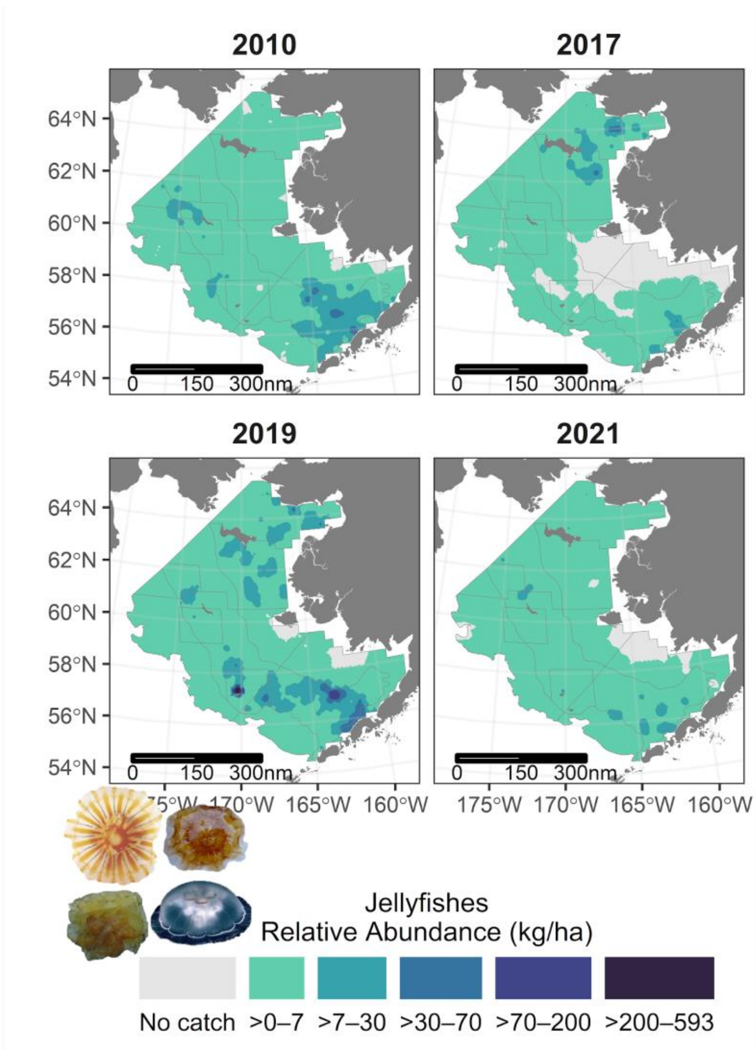

Figure 42. Distribution and relative abundance (in kg/ha) of jellyfishes (Scyphozoa) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.

References

Ruzicka, James, Richard D. Brodeur, Kristin Cieciel, and Mary Beth Decker. 2020. “Examining the Ecological Role of Jellyfish in the Eastern Bering Sea.” Journal Article. *ICES Journal of Marine Science* 77 (2): 791–802. https://doi.org/10.1093/icesjms/fsz244.

Snailfishes (Liparidae)

The species of snailfish most commonly encountered in the 2021 NBS survey area is the variegated snailfish (*Liparis gibbus*). This species was caught at 30 stations at depths ranging from 16 m to 73 m, in locations to the north, northwest, and south of St. Lawrence Island (Figure 43). During the 2021 NBS survey, two unidentified snailfish were caught, as well as one monster snailfish, one peachskin snailfish, three kelp snailfish, and one festive snailfish. The 2010 NBS survey encountered both the kelp and variegated snailfish species as well as the festive snailfish (*Liparis marmoratus*) and an unidentified *Liparis* species. In 2019, a total of 18 variegated snailfish were caught while 711 were caught in 2010. Species information was added to this report by request of tribal councils.

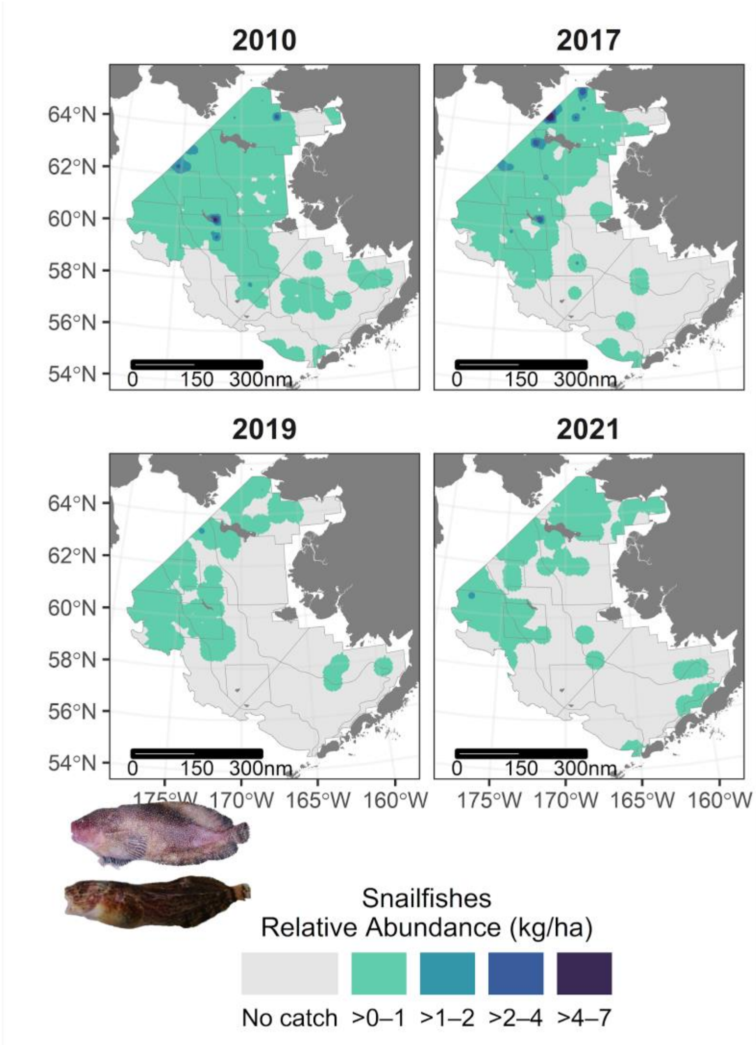

Figure 43. Distribution and relative abundance (in kg/ha) of snailfishes (Liparidae) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.

Sea Onion (*Boltenia ovifera*)

Sea onions are stalked, solitary ascidians, which are widely distributed in the North Atlantic, North Pacific, and Bering Sea. During the 2021 NBS survey, sea onion density was highest just north of St. Lawrence Island and east of St Paul Island. (Figure 44). In 2021, sea onions were present at 16.7% of stations in the NBS (24 of 144 stations). These stations ranged in depth from 21 m to 53 m and recorded temperatures between -1.4°C and 10.8°C. Compared with 2019 (1,623 mt; Table 1), sea onion biomass in 2021 (3,221 mt; Table 1) in the NBS experienced a 98% increase. Previously, sea onion biomass in 2019 experienced a 76% decrease compared to biomass in 2017 (6,794 mt; Table 1). In 2021, sea onions comprised 0.1% (3,221 mt, Table 1) of the NBS survey biomass. Previously in 2019, sea onions comprised 0% (1,623 mt, Table 1) of the NBS survey biomass.

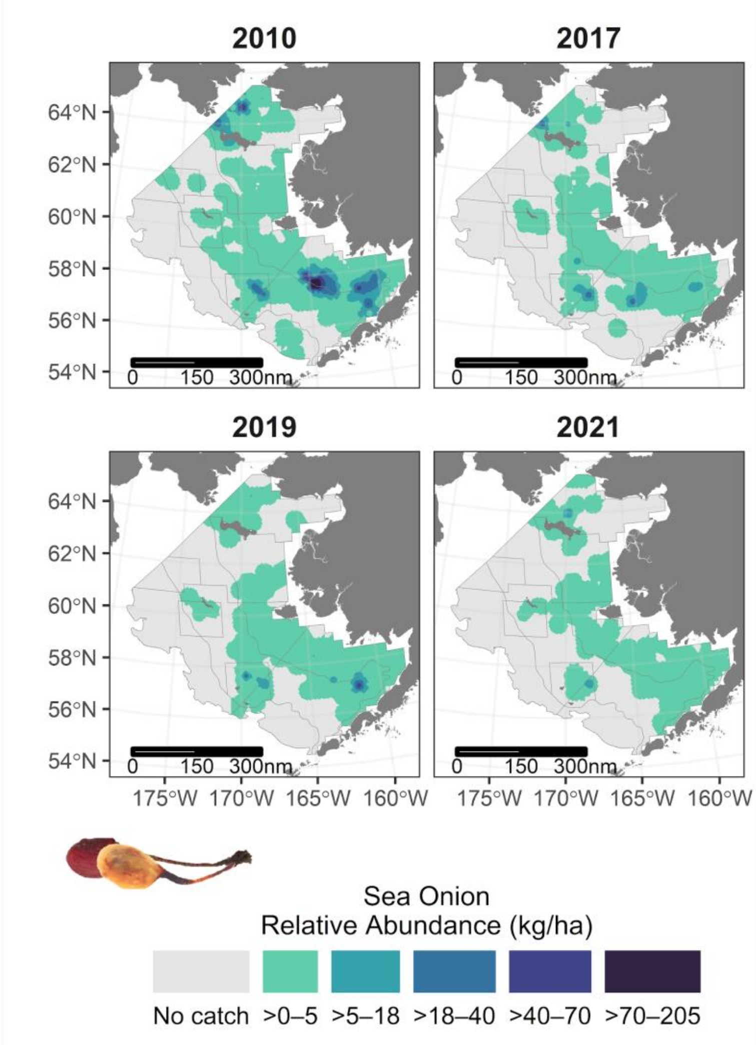

*Figure 44. Distribution and relative abundance (in kg/ha) of sea onion (*Boltenia ovifera*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Sea Peach (*Halocynthia* sp.)

Sea peaches are large, solitary ascidians, which are often found in clusters. The 2019 and 2021 NBS survey located low densities (0-15 kg/ha) of sea peaches north-northeast and southeast of St. Lawrence Island (Figure 45). These invertebrates are found at stations between 21 m and 35 m depth and in bottom temperatures ranging from 6.7°C to 7.5°C in the NBS survey area. The 2021 NBS sea peach biomass (1,425 mt; Table 1) declined 27% from 2019 (1,955 mt; Table 1).

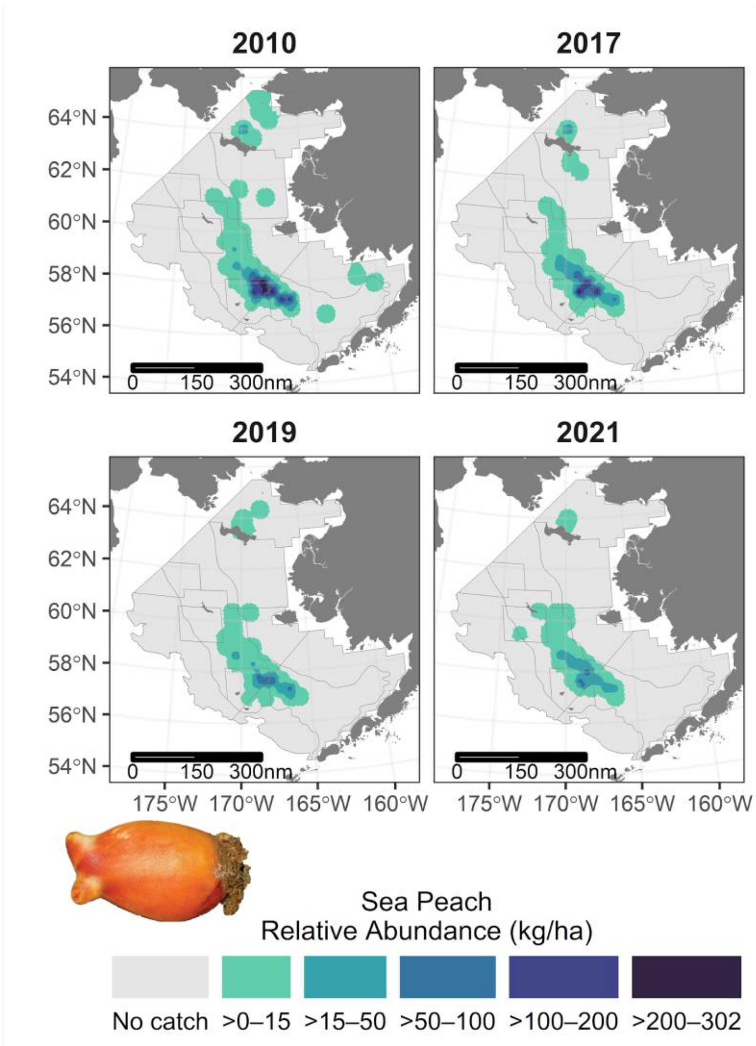

*Figure 45. Distribution and relative abundance (in kg/ha) of sea peach (*Halocynthia *sp.) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Eulachon (*Thaleichthys pacificus*)

In 2021, eulachon were only caught at one station sampled in the NBS at a depth of 41 m. The distribution of eulachon in the EBS in 2021 was northwest of Nunivak and northwest of the Alaska Peninsula and Aleutian Islands (Figure 46).

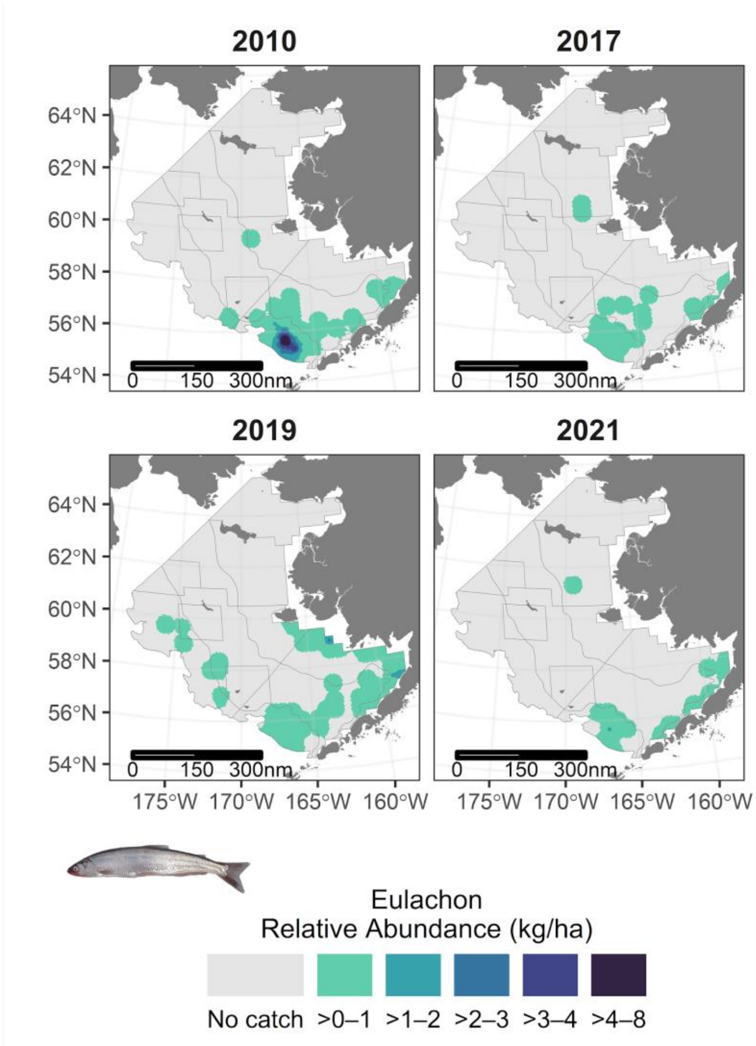

*Figure 46. Distribution and relative abundance (in kg/ha) of eulachon (*Thaleichthys pacificus*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Pacific Capelin (*Mallotus villosus*)

In 2021, capelin were present at 43 of the 144 stations sampled from depths of 18 to 73 m. From 2019 to 2021 there was a 52% increase in the estimated biomass of capelin in the NBS. This species had a relatively even distribution through the central area of the NBS (Figure 47).

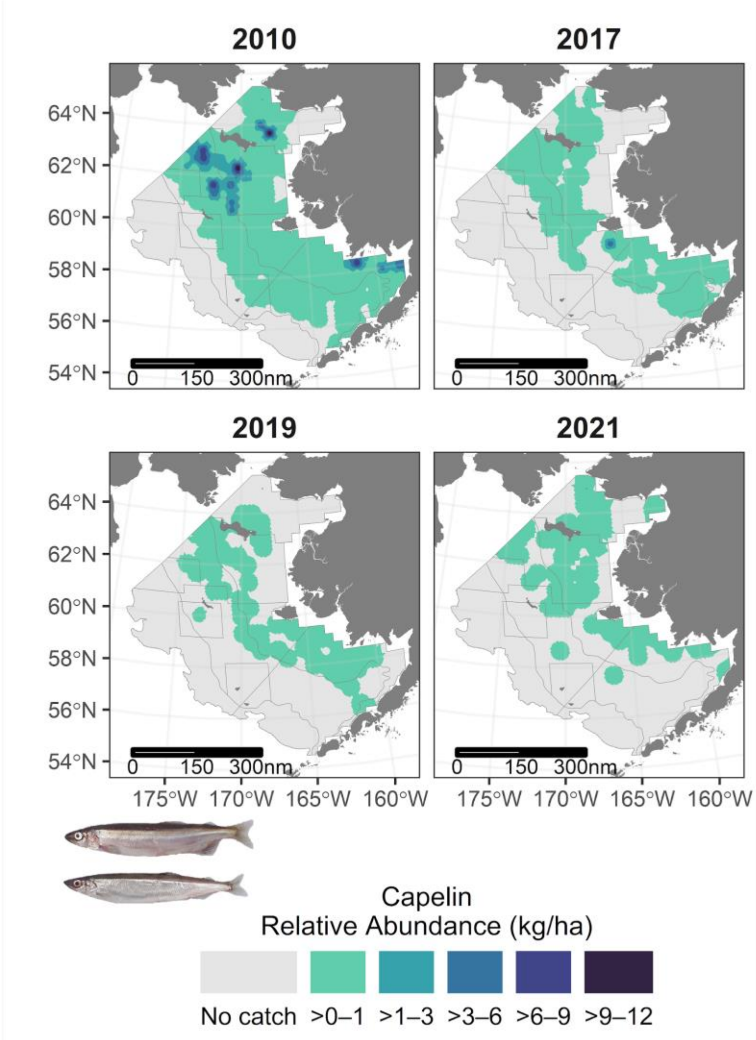

*Figure 47. Distribution and relative abundance (in kg/ha) of Pacific capelin (*Mallotus villosus*) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.*

Rainbow Smelt (*Osmerus mordax*)

Rainbow smelt were present during the 2021 NBS survey at 41 of 144 stations at depths of 11 to 34 m. Rainbow smelt distribution in the NBS in 2021 was primarily to the north and east of St. Lawrence Island (Figure 48). Compared with 2019, rainbow smelt biomass in 2021 in the NBS experienced a 61% decrease.

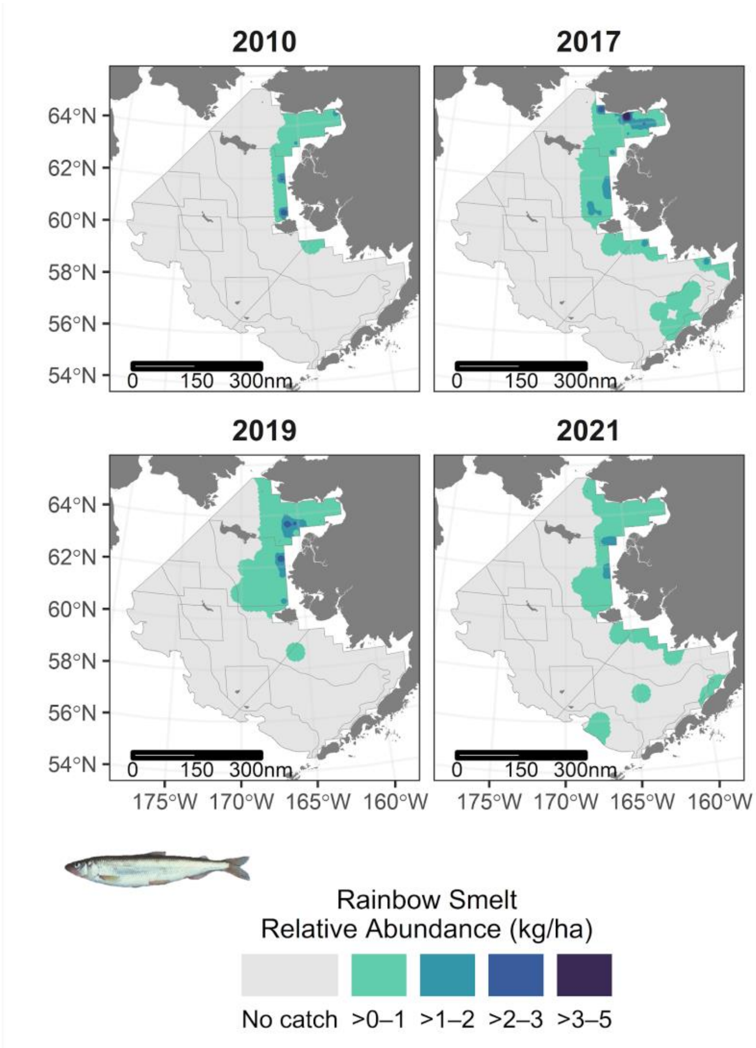

Figure 48. Distribution and relative abundance (in kg/ha) of rainbow smelt (Osmerus mordax) estimated from the 2010, 2017, 2019, and 2021 NBS and EBS surveys.

Data Sources

This report was generated in the R environment using R Markdown. The R Markdown framework allows for reproducible and documentable reporting. Many of the data sources and tools used to develop the plots and content of this report have been developed by members of the Alaska Fisheries Science Center's Groundfish Assessment Program. In addition to the data collection efforts that constitute the annual Bering Sea trawl survey and the work to extrapolate these data to population-level abundance, biomass, and catch per unit effort (CPUE) estimates, the Bering Sea group members are working to develop several public-serving data products to increase transparency and access to Bering Sea ecosystem data. The *akgfmaps* R package, developed by Sean Rohan, was used for producing the species distribution plots and maps for this report. This code is available on GitHub for public use. The *coldpool* R package, developed by Sean Rohan and Lewis Barnett, uses newly developed and reproducible interpolation techniques to better understand changes in surface temperature, bottom temperature, and the cold pool in the Bering Sea. This code is under review and will be shared publicly on GitHub in the near future.

Acknowledgments

We would like to thank the many communities of the Bering Strait region and their members who have helped contribute to this report. The knowledge, experiences, and insights of the people of the Bering Strait region have been instrumental in expanding the scope of our science and knowledge to encompass the many issues that face this important ecosystem. We appreciate feedback from those residing in the region that are willing to share insights into the region, including the local names used for the species covered by this report, identifying species of interest or concern that should be included in this report, and your participation in an open dialog about how we can improve our collective knowledge of the ecosystem and the region.

Appendix A: Scientist Profiles

Lyle Britt, Research Survey Chief Scientist

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

Emily Markowitz, Bering Sea Group

Emily is a Research Fisheries Biologist in the Bering Sea Team in Seattle, WA. Prior to starting her position at AFSC, she worked in Silver Spring, MD as a contractor for the Office of Science and Technology (OST) in the Economics and Social Analysis Division providing programming and data visualization expertise. Before that, Em was a John A. Knauss Marine Policy Fellow working in OST's Assessment and Monitoring Division's Protected Species Science Branch, where she facilitated sea turtle and marine mammal science. In her off time, Em enjoys puzzles and exploring above and below the surface, near and far!

Liz Dawson, Bering Sea Group

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

Nicole Charriere, Bering Sea Group

Nicole is a new Fish Biologist with the NOAA Fisheries Alaska Fisheries Science Center in Seattle, Washington. Prior to joining the Bering Sea group in January 2021, Nicole worked for over 10 years with the Ecosystems Surveys Branch at the Northeast Fisheries Science Center in Woods Hole, Massachusetts. She provided essential leadership and mission support to bottom trawl, scallop/HabCam, clam, and cooperative gear study surveys, and was fortunate enough to repeatedly spend about a third of the year out at sea helping to conduct those same fisheries research expeditions. Nicole was born and raised in Massachusetts, but is a proud citizen of Belize, as well. When she's not working out at sea, preparing for surveys, or exploring her new hometown of Seattle, Nicole enjoys soccer, WW2 code breaking history, scuba diving, and playing the guitar.

Jon Richar, Shellfish Assessment Program

Jon is a Research Fish Biologist with the NOAA AFSC Shellfish Assessment Program in Kodiak Alaska, and has been in this position since January 2017. Jon manages the SAP Bering Sea database, participates in the Bering Sea survey every summer, conducts research focusing on Bering Sea crab stocks, and undertakes SCUBA-based research in the waters near Kodiak. Previously he was a National Academy of Sciences post-doctoral researcher, and a shellfish observer and technician for the Alaska Department of Fish and Game. In his free time, Jon enjoys reading, hiking, photography and cooking Indian dishes.

Sean Rohan, Bering Sea Group

Sean is a Research Fisheries Biologist with the NOAA Fisheries Alaska Fisheries Science Center in Seattle, Washington, and has been working with the AFSC in the Bering Sea since 2011, initially as a contractor with the University of Washington. In addition to his work on surveys, Sean conducts research on behavioral interactions between fish and fishing gear and the ecology of the Bering Sea ecosystem. Outside of work, Sean enjoys cooking, watching football (Go Hawks!), and spending time outdoors.

 ***Bianca Prohaska, Bering Sea Group*** Bianca is a Research Fish Biologist with the NOAA Fisheries Alaska Fisheries Science Center in Seattle, Washington, where she works on the EBS Survey Team. Prior to beginning her position at the AFSC, Bianca was a contractor for the US Fish and Wildlife Service's Coastal and Marine Resources Division, and in 2019 Bianca served as a Sea Grant Knauss Marine Policy Fellow in NOAA's Oceanic and Atmospheric Research International Activities office. In her free time, Bianca enjoys beach volleyball, tennis and hiking	 ***Rebecca Haehn, Bering Sea Group*** Rebecca is a Fish Biologist with the NOAA Fisheries Alaska Fisheries Science Center in Seattle, Washington. Rebecca joined the Bering Sea group in 2017 and has previously participated in coastal fisheries research in New York, Alaska, southern California, Florida and Mississippi. With the AFSC, Rebecca is responsible for assisting senior scientists with survey logistics and staffing, and acts as field party chief and deck scientist on the NBS survey. During her off time in Seattle, she enjoys hiking with her dog, her friends and their dogs, and looks forward to attempting to snowshoe this winter.
 ***Duane Stevenson, Research Survey Chief Scientist*** Duane is a Research Fishery Biologist with the NOAA Fisheries Alaska Fisheries Science Center in Seattle, Washington, and has been working with the AFSC in the Bering Sea for 20 years. He is an expert in the taxonomy and evolutionary relationships of marine fishes, and his research focuses on the identification and distribution of fishes in Alaska's marine ecosystems. Duane also works closely with the North Pacific Observer Program, where he has been training observers to identify fishes and invertebrates for over 20 years. More recently, he is responsible for developing training materials for fishery observers working throughout Alaska, designing and implementing quality control measures, and analyzing patterns in observer-collected fishery data.	***If you have any questions or would like more information, please contact:*** Lyle Britt Phone: (206) 526-4501 Email: lyle.britt@noaa.gov

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