2022

Northern Bering Sea Groundfish and Crab Trawl Survey Highlights

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Introduction

In 2022, 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 is the 40th year of the EBS shelf survey and the fifth year of NBS survey using standardized sampling protocols. A rapid response survey for the NBS region was also conducted in 2018 using a modified spatial extent and sampling procedure and will not be covered here. 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). While the NBS region has been surveyed sporadically in the past, 2010 is considered the survey's inaugural year because it was the first year the region was sampled using the same standardized sampling methods as the EBS shelf survey.

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. In the NOAA LOSI research plan, the NBS was identified as a region of critical importance for increased scientific monitoring because this marine ecosystem may be rapidly altered by the 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 may 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.

Here, we provide some of the results of the 2022 NBS survey and compare these to observations from the 2010, 2017, 2019, and 2021 surveys. Continuation of the survey effort for a combined EBS and NBS bottom trawl survey will provide more comprehensive information to investigate how fishes, crabs, and other bottom dwellers respond to biological and environmental changes on a large spatial scale over a multi-year time period.

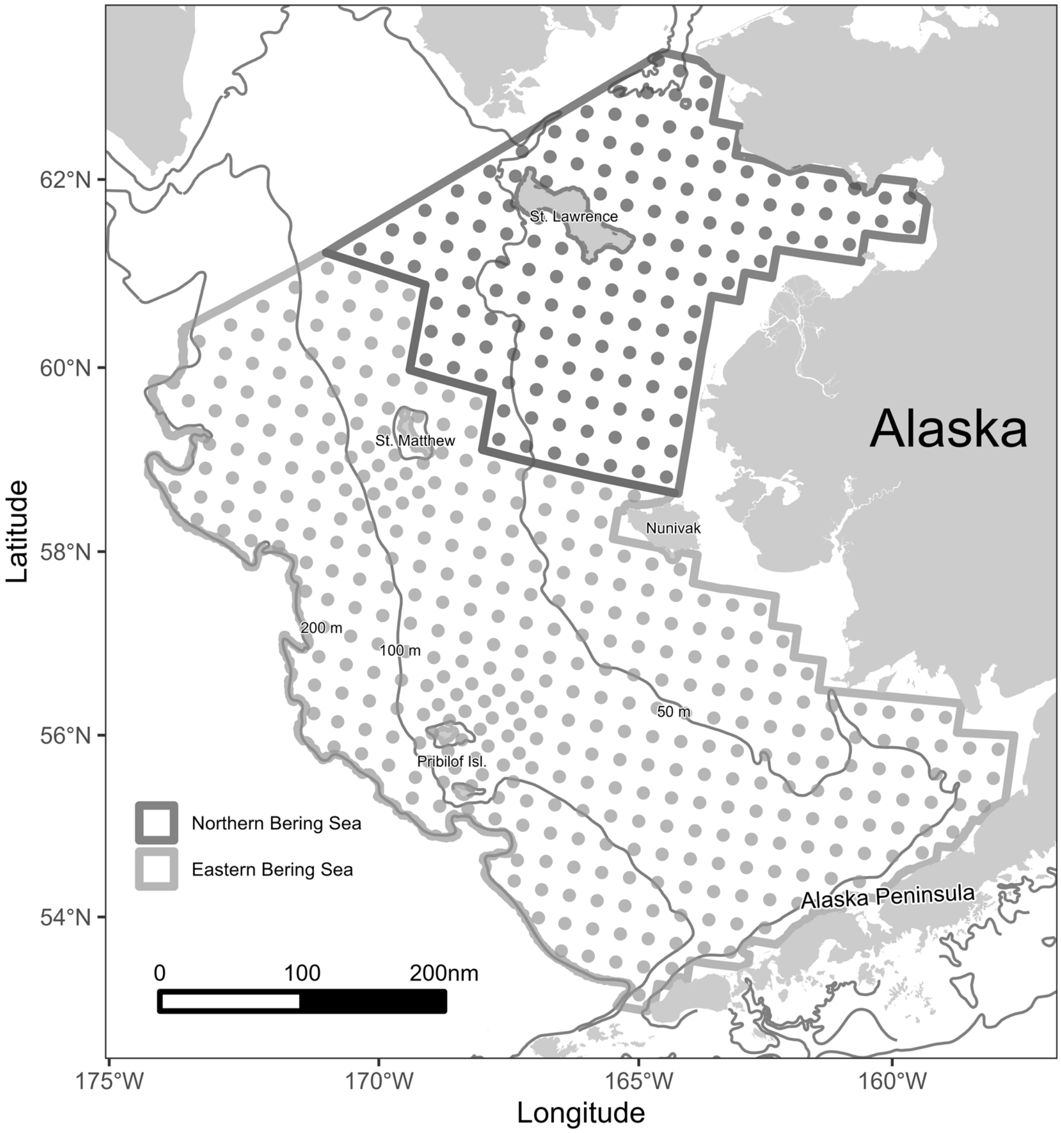


Figure 1. – Map of the Bering Sea survey stations sampled in 2022 during the EBS and NBS survey. The area enclosed within the light gray line contains the EBS shelf stations that have been sampled annually since 1982, whereas the area outlined by the dark gray line contains the NBS stations that were sampled in 2022. The dots within each area indicate station locations.

Survey Design, Execution, and Analysis

The 2022 EBS shelf and NBS bottom trawl surveys were conducted aboard the chartered commercial stern-trawlers F/V *Vesteraalen* and F/V *Alaska Knight* (Figure 2). For the EBS shelf survey, the F/V *Vesteraalen* started sampling on May 30, 2022 and ended on July 29, 2022 and the F/V *Alaska Knight* started sampling on May 31, 2022 and ended on July 28, 2022. 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 for both vessels on July 29, 2022 and ended on August 19, 2022 for the F/V *Vesteraalen* and on August 20, 2022 for the F/V *Alaska Knight*. After the NBS survey was completed, both vessels returned to Dutch Harbor to offload survey equipment and biological samples. 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.

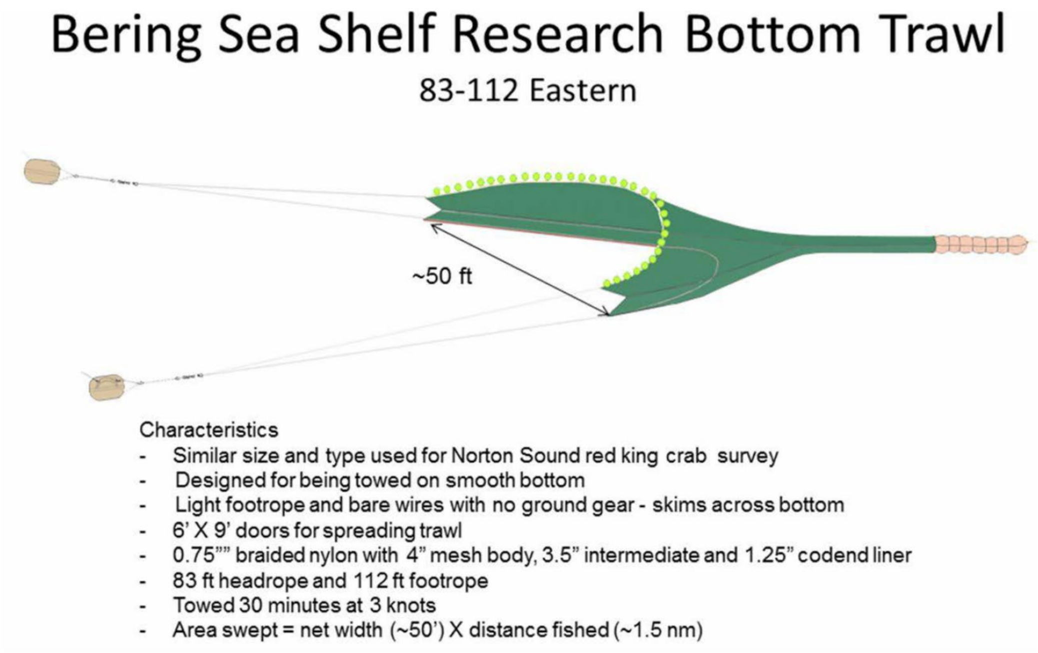
Figure 2. – Photographs of the fishing vessels F/V *Alaska Knight* (left) and F/V *Vesteraalen* (right) contracted to assist the 2022 EBS and NBS bottom trawl survey.

Scientists from the Alaska Fisheries Science Center, Alaska Department of Fish and Game, International Pacific Halibut Commission, Bigelow Laboratory for Ocean Sciences, A.I.S. Inc., University of Alaska Fairbanks, and volunteers from the University of Southern California and the University of Alaska Southeast participated in the survey. Lead scientist profiles can be found at the end of this document.

The same NBS stations were surveyed in 2022 as in 2021. 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 57,980 nmi^2 (198,867 km^2) that defines the NBS survey area. The EBS shelf survey area contains 376 stations distributed over 143,733 nmi^2 (492,990 km^2). The addition of the NBS survey expanded the overall survey coverage in the Bering Sea to 201,713 nmi^2 (691,857 km^2). In 2022, the NBS stations had bottom depths ranging from 36.1 ft (11 m) to 255.9 ft (78 m).

In the EBS shelf survey, sampling was typically conducted at a fixed sampling station located at the center of each grid cell (Figure 1). 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 (Figure 1). All stations were sampled during daylight hours.

Both vessels sampled using an 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 weighs less than trawls used for commercial fishing in Alaska. One 30-minute tow, at a target vessel speed of 3 knots, was conducted at 144 stations. The cumulative area sampled by trawls at the 144 stations was approximately 1.86 nmi^2 (6.39 km^2), covering 0.003% of the total area of the NBS.



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

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

Catches of less than approximately 1,200 kg (2,500 lbs) were sorted and weighed in their entirety and larger catches were subsampled. Fishes, crabs, and other invertebrates were identified and sorted by 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 caught species (except colonial species that cannot be individually counted) were counted and weighed. 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). Some of the species caught were grouped into higher taxa (common names for an assemblage of species) for analysis either because the catch size was very small for individual species or due to questionable identification. Samples of some species of fishes, crabs, and other invertebrates were also retained to gather additional information that included their size, weight, sex, age, reproductive state, genetics, health (condition factor), and stomach content/diet.

Trawl survey catch data were used to estimate catch-per-unit-effort (CPUE), population biomass, population abundance, and population abundance by size class for measured species. CPUE can be used as a measurement of the density of a species. CPUE is the estimated catch of organisms caught (in kilograms, kg, or number of individuals) per amount of effort (generally, effort is a combination of gear type, gear size, and length of time the gear is used). For these surveys, effort is estimated as the area sampled, or area swept (1 ha = 10,000 m^2 = 0.003 nmi^2). This area is computed by multiplying distance trawled by the mean width of the net during the tow. Net width during the tow was measured by acoustic sensors attached to the net. The same gear is used throughout the survey. Mean CPUE values were calculated for the overall survey areas. Biomass and population estimates were derived for each 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 carapace width or length interval (collected from subsamples at each station) was weighted based upon the mean CPUE (number of a taxon per hectare) and then expanded to the total population for the NBS survey area.

Environmental data, including water temperature in degrees Celsius (°C), depth in meters (m), salinity (parts per thousand), and underwater downwelling light 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).

2022 Survey Results with Snapshot Comparisons to 2021

Bering Sea Temperature Overview

Bottom temperature is a major environmental driver that influences the distribution of fishes, crabs, and other invertebrates on the Bering Sea shelf (Figures 4 and 5). The highly variable annual bottom temperatures are related to changes in the extent of the summer cold pool, defined as the areal extent of bottom temperatures below 2°C (35.6°F) on the EBS shelf. The size of the cold pool each summer depends on the extent of sea ice cover during the preceding winter and the timing of its retreat during the spring and early summer. During the coldest years, the cold pool has extended across the middle shelf from the northern edge of the EBS survey area and into Bristol Bay and near the Alaska Peninsula.

Subarctic fish and invertebrate species tend to avoid areas with cold bottom temperatures (below 0°C [32°C] or 1°C [33.8°C], depending on the species). Therefore, the size and location of the cold pool can affect the migration of species across the EBS shelf and between the EBS shelf and NBS. Cold temperatures may also provide a habitat refuge for cold-adapted Arctic species. During warm years, Arctic species may be forced to adapt to unfavorable conditions or redistribute due to the reduction in available cold pool habitat. Temperature data from the 2010, 2017, 2019, 2021, and 2022 NBS surveys provide information that improves understanding of how changes in bottom temperatures affect the distribution and migration of fishes, crabs, and other invertebrates.

The 2022 mean EBS shelf bottom temperature was 2.6°C (36.5°F), which is near the 2.5°C (36.5°F) time-series average from 1982 to 2022 (Figure 4). The average near-bottom temperature in 2022 represents a departure from recent years (2016–2021) that have included four of the five warmest years in the 40-year time series. The 2022 mean EBS shelf surface temperature was near the times-series average, but slightly warmer than the mean surface temperature in 2021 (Figure 4). Over the 40-year time series (1982–2022) of the EBS shelf bottom trawl survey, annual mean summer bottom temperatures were variable, ranging from 0.7°C (33.3°F) to 4.4°C (39.9°F; Figure 4). During the last 15 years, bottom temperatures from 2006-2013 were colder than average ("cold stanza"), while 2014-2019 and 2021 were warmer than average ("warm stanza"; Figure 4).

The areal extent of the cold pool in the EBS has varied greatly in size, from 1,793 nmi2 (6,150 km2) in 2018 to 112,532 nmi2 (385,975 km2) in 1999, respectively comprising 1.2% to 78.2% of EBS shelf area (Figure 5). In 2022, the cold pool covered 36.2% of the EBS shelf survey area (52,079 nmi2; 178,625 km2; Figure 5). The areal extent of bottom temperatures below 0°C and 1°C were near their time series averages.

The mean NBS bottom temperature in 2022 was 3.9°C (39.1°F), which was essentially equal to the mean bottom temperature in 2021 (Figure 4). The mean NBS surface temperature was 8.1°C (46.5°F), slightly cooler than the mean surface temperature in 2021 (Figure 4). Bottom temperatures measured during the 2022 NBS survey ranged from -1.7°C to 12°C (Figure 6a) and sea surface temperatures ranged from 0.7°C to 14.2°C (Figure 6b). In 2022, surface temperatures above 10°C were recorded in only 3% of the NBS survey area, which was less than in past years, when temperatures above 10°C were recorded in 5-39% of the NBS area (Figure 6b). Evidence of upwelling was observed in the Chirikov Basin south of Bering Strait, as indicated by surface temperatures below 0°C (32.0°F; Figure 6b).

The extent of the 2022 cold pool was similar to the most recent near-average year in 2017, but considerably larger than in 2019 and 2021. The cold pool covered nearly the entire middle shelf between 50 m and 100 m bottom depths, north of 57 °N (Figure 6a). Similar to 2017, the cold pool likely did not pose a major temperature barrier to the northward migration of mobile subarctic species from the EBS shelf to the NBS, such as walleye pollock and Pacific cod. The coldest bottom temperatures (below -1°C) were observed in the Chirikov Basin, along the US.-Russia Maritime Boundary. This area had extremely cold bottom temperatures even during recent extremely warm years (2018 and 2019), but the size of this cold patch increased in 2021 and again in 2022.

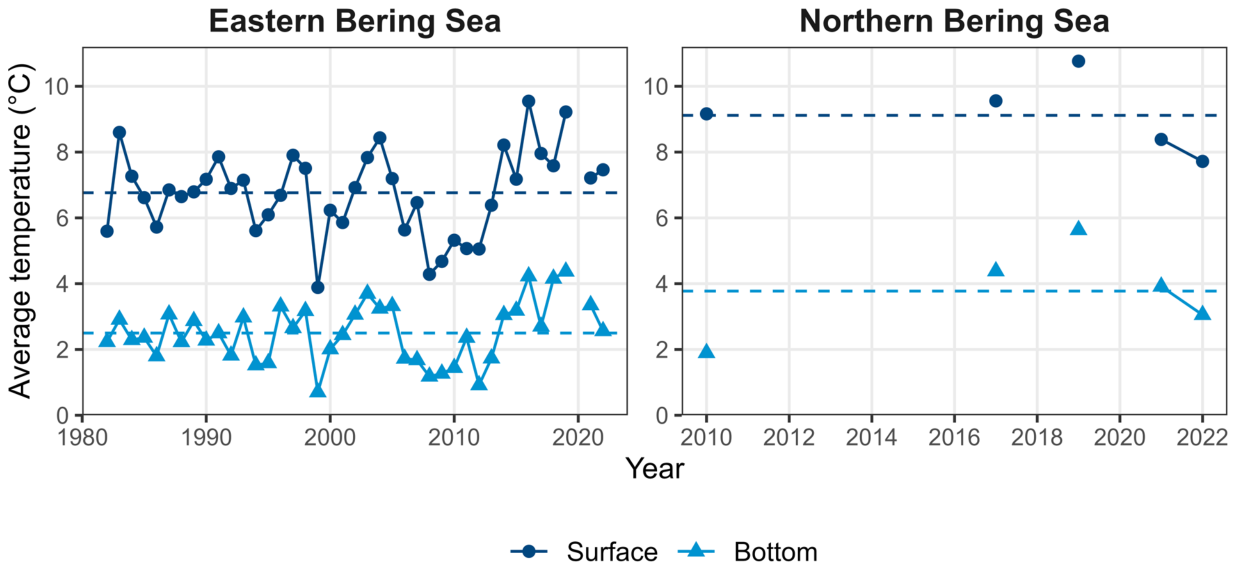


Figure 4. – Average summer surface (light blue triangles) and bottom (dark blue circles) temperatures (°C) and time-series average surface (dark blue dashed line) and bottom (light blue dashed line) temperatures (°C) on the EBS shelf, based on data collected during standardized summer bottom trawl surveys from 1982–2022 (left), and NBS shelf based on data collected during standardized summer bottom trawl surveys (right).

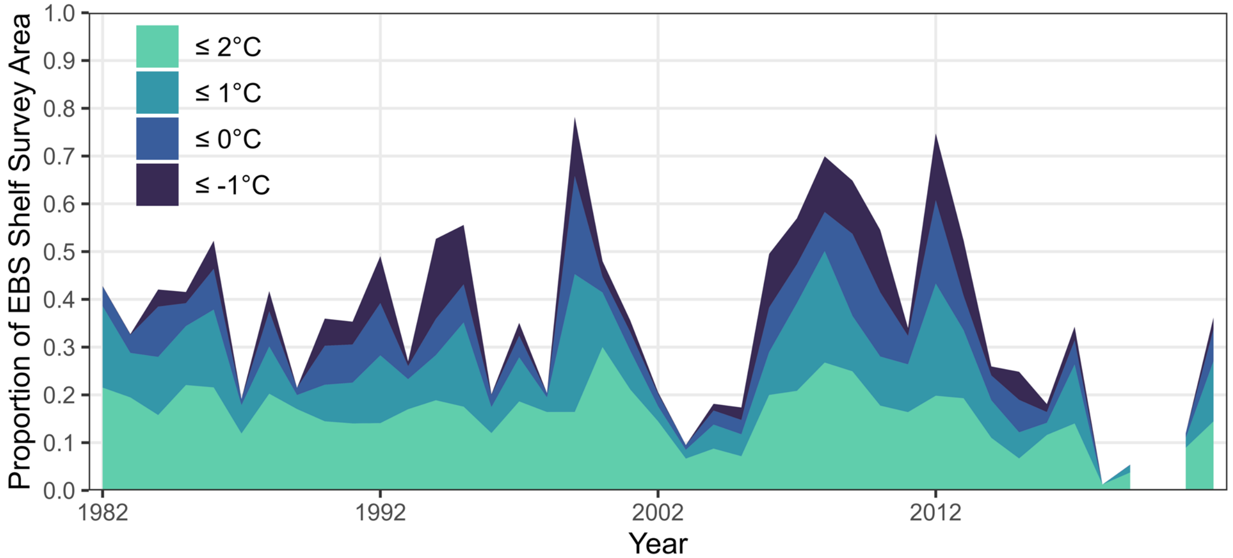


Figure 5. – Annual summer cold pool extent on the EBS shelf, based on observations from the EBS bottom trawl survey. The extent of the cold pool is shown in proportion to the total southern EBS shelf survey area. Shading denotes near-bottom temperatures ≤ 2°C (aqua blue), ≤ 1°C (cerulean blue), ≤ 0°C (cobalt blue), and ≤ -1°C (dark navy blue). Note that no surveys were conducted in 2020 due to the COVID-19 pandemic.

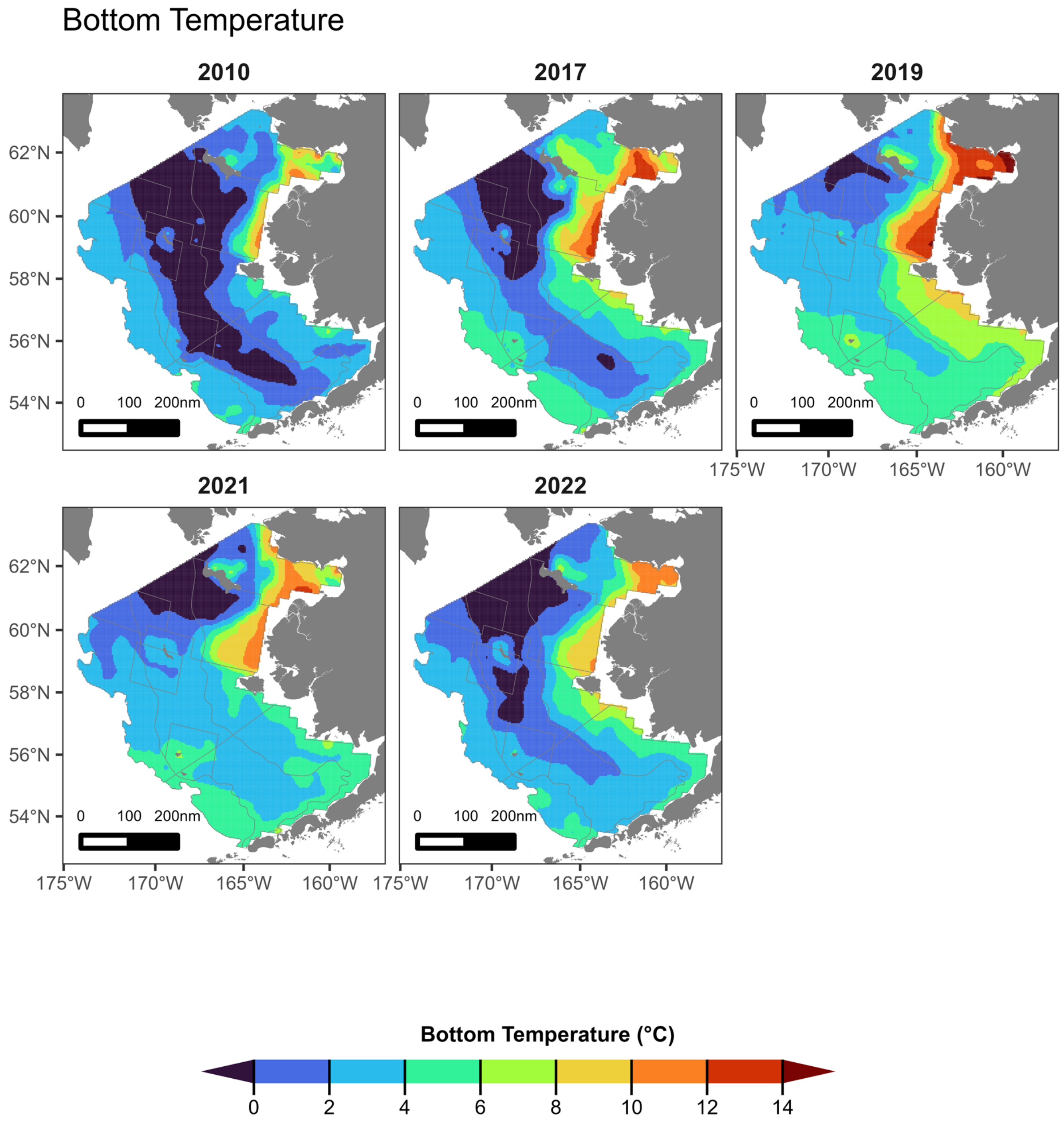


Figure 6a. – Bottom temperatures (°C) in the NBS and EBS during the 2010, 2017, 2019, 2021, and 2022 surveys, which included the full NBS shelf bottom trawl survey. Note that no surveys were conducted in 2020 due to the COVID-19 pandemic.

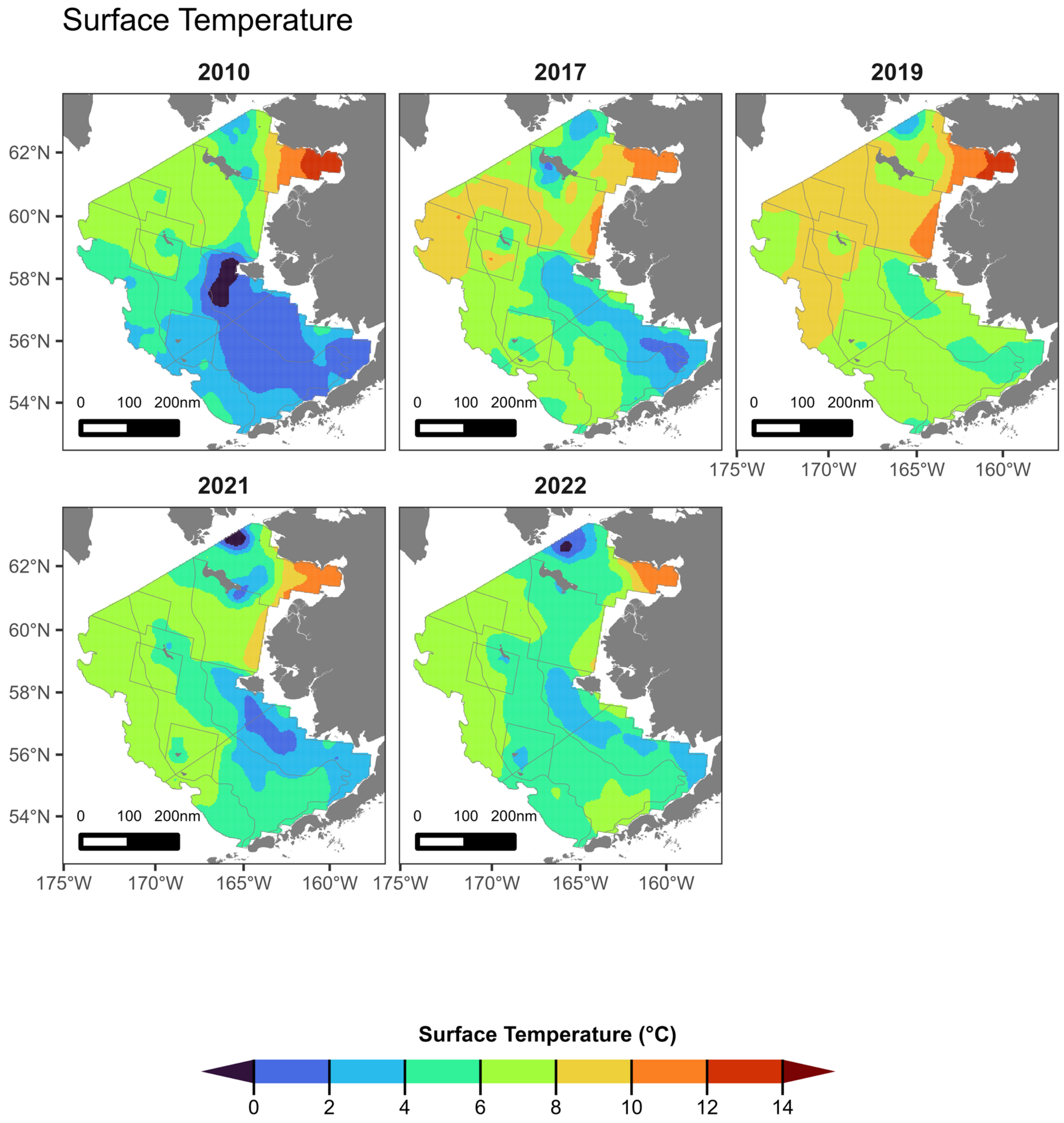


Figure 6b. – Surface temperatures (°C) in the NBS and EBS during the 2010, 2017, 2019, 2021, and 2022 surveys, which included the full NBS shelf bottom trawl survey. Note that no surveys were conducted in 2020 due to the COVID-19 pandemic.

Survey Data and Specimen Collections

From the EBS and NBS shelf trawl surveys, length measurements were collected from 186,968 individual fish representing 46 fish taxa. Additionally, 8,341 age structures (otoliths) were collected from 10 fish taxa; 4,233 stomach samples were collected from five fish taxa; 60 stress physiology samples were collected from Pacific halibut; 85 antifreeze blood samples were collected from Pacific cod; 348 fat-meter condition samples were collected from Pacific cod and walleye pollock; two genetic samples were collected from Pacific sleeper shark; and 104 genetic fin clip samples were collected from four fish taxa.

Estimates of Fishes and Invertebrates

From 2021 to 2022, eight fishes and two invertebrates experienced decreasing CPUE, three fishes and five invertebrates experienced increasing CPUE, and five fishes and two invertebrates experienced no notable change in CPUE. Prominent fish species that exhibited no change between 2021 and 2022, included yellowfin sole, Pacific capelin, Pacific halibut, Alaska plaice, and walleye pollock (within ± 25% change from the previous survey year) in CPUE. Between 2021 and 2022, the largest increases in CPUE were seen in Arctic cod (373%), blue king crab (190%), sea urchins (184%), saffron cod (179%), and snow crab (122%); the largest decreases in CPUE were seen in Pacific cod (-32%), Alaska skate (-39%), northern rock sole (-39%), shorthorn sculpin (-52%), sea peach (-63%), and Pacific herring (-80%).

In 2022, the total bottom-dwelling organismal biomass of the EBS shelf was estimated at 15.9 million metric tons (mmt) and the NBS shelf was estimated at 3.5 mmt. Previously, the total bottom-dwelling animal biomass of the 2021 EBS shelf was estimated at 13.2 mmt, 2021 NBS shelf was estimated at 3 mmt, 2019 EBS shelf was estimated at 16.3 mmt, 2019 NBS shelf was estimated at 4.4 mmt, 2017 EBS shelf was estimated at 17.5 mmt, 2017 NBS shelf was estimated at 4.5 mmt, 2010 EBS shelf was estimated at 16.9 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 23 taxa, did not change for one taxon, and increased for 23 taxa from 2021 (warm-stanza year) to 2022. Some of the largest increases in biomass from 2021 to 2022 were observed in the sea anemones (679%), other worms (476%), Arctic cod (367%), blue king crab (190%), and sea urchins (185%) groups. Decreases in biomass were observed in the other sculpins (-54%), sea peach (-63%), Pacific herring (-80%), eulachon (-100%), and sticklebacks (-100%) groups (Table 1).

Species groups that previously exhibited a decreasing trend in biomass from 2019 to 2021 but an increasing trend in biomass from 2021 to 2022 include sea anemones, other worms, blue king crab, sea urchins, saffron cod, clams, mussels, scallops, snow crab, bryozoans, snailfishes, basket sea stars, other brittle stars and sand dollars, northern Neptune whelk, hermit crabs, other sea stars, jellyfish, other snails, purple-orange sea star, and yellowfin sole (Table 1). Species groups that previously exhibited an increasing trend in biomass from 2019 to 2021 but a decreasing trend in biomass from 2021 to 2022 include other flatfishes, sea onion, Pacific capelin, Pacific halibut, corals, Alaska plaice, and red king crab (Table 1).

In 2022, yellowfin sole (16%), walleye pollock (11%), purple-orange sea star (9%), Alaska plaice (9%), northern Neptune whelk (5%), snow crab (5%), and sea urchins (5%) together comprised over 50% of the total estimated biomass in the NBS. Previously, in 2021, yellowfin sole (17%), walleye pollock (16%), Alaska plaice (12%), and purple-orange sea star (9%); 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%), other 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. Saffron cod and Arctic cod accounted for 0.8% of the total biomass in 2022, 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. Invertebrates (i.e., shrimps, sea squirts, sea stars, jellyfish, crabs, and urchins) made up 49% of the biomass in 2022, 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.

On average, NBS survey catches were smaller than those from the EBS. Distributions of some of the predominant species, such as Alaska plaice, Alaska skate, northern rock sole, Pacific cod, Pacific halibut, Pacific herring, plain sculpin, purple-orange sea star, snow crab, 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, rainbow smelt, saffron cod, and shorthorn sculpin.

Detailed summary profiles outlining several of the species showing ecologically significant trends are discussed in Table 1.

Table 1. -- Major taxa sampled in the NBS bottom trawl survey for 2010, 2017, 2019, 2021, and 2022, and the percentage change in biomass (metric tons) from 2021 to 2022 in descending order of percent (%) change. Differences in sums of estimates and totals are due to rounding.

Common name		**2010**	**2017**	**2019**	**2021**	**2022**	**Change (2022, 2021)**
all sea anemones	Actiniaria	9,439	20,922	10,378	8,711	67,867	679.1%
other worms		205	278	253	54	312	475.9%
Arctic cod	*Boreogadus saida*	37,862	3,906	47	83	387	366.7%
blue king crab	*Paralithodes platypus*	2,163	5,790	1,205	1,039	3,014	190.2%
sea urchins	*Strongylocentrotus* spp.	50,258	166,765	89,965	54,751	155,790	184.5%
saffron cod	*Eleginus gracilis*	90,301	76,244	81,278	9,974	27,738	178.1%
all shrimps		3,802	4,118	2,437	4,562	12,576	175.7%
clams, mussels, scallops	Bivalvia	2,475	4,993	6,662	2,417	6,348	162.7%
snow crab	*Chionoecetes opilio*	332,141	221,678	165,964	72,482	158,977	119.3%
bryozoans	Bryozoa	2,802	7,646	92,819	60,068	115,627	92.5%
snailfishes	Liparidae	3,305	4,864	777	329	630	91.6%
basket sea stars	*Gorgonocephalus eucnemis*	70,649	40,459	36,657	30,084	48,441	61.0%
other crabs	Crustacea	62,768	33,869	27,911	54,202	85,113	57.0%
other brittle stars and sand dollars		1,082	5,348	9,211	1,131	1,649	45.9%
northern Neptune whelk	*Neptunea heros*	110,920	178,939	146,350	114,183	166,181	45.5%
hermit crabs	Paguridae	133,111	162,378	139,249	107,059	153,983	43.8%
other tunicates	Urochordata	339,431	88,465	23,684	66,867	93,540	39.9%
other sea stars	Asteroidea	106,616	103,126	84,669	79,318	107,545	35.6%
jellyfish	Scyphozoa	12,862	66,295	88,795	21,959	28,510	29.8%
other snails	Gastropoda	42,473	73,193	47,515	44,473	52,265	17.5%
purple-orange sea star	*Asterias amurensis*	296,864	331,287	414,448	270,646	312,625	15.5%
yellowfin sole	*Limanda aspera*	427,374	434,088	520,031	496,045	548,027	10.5%
sea cucumbers	Holothuroidea	7,117	3,413	2,564	3,357	3,573	6.4%
Atka mackerel	*Pleurogrammus monopterygius*	0	0	19	0	0	0.0%
other flatfishes	Pleuronectidae	19,280	40,054	34,007	44,185	44,000	-0.4%
all poachers	Agonidae	416	2,027	1,346	779	770	-1.2%
eelpouts	Zoarcidae	10,666	9,760	1,707	425	417	-1.8%
sea onion	*Boltenia ovifera*	19,749	6,795	1,624	3,222	3,076	-4.5%
Pacific capelin	*Mallotus villosus*	14,632	179	50	76	72	-4.9%
Pacific halibut	*Hippoglossus stenolepis*	23,333	18,508	25,722	25,995	22,940	-11.8%
corals	Anthozoa	12,627	8,520	2,823	5,776	5,032	-12.9%

Table 1. -- Major taxa sampled in the NBS bottom trawl survey for 2010, 2017, 2019, 2021, and 2022, and the percentage change in biomass (metric tons) from 2021 to 2022 in descending order of percent (%) change. Differences in sums of estimates and totals are due to rounding.

Common name		**2010**	**2017**	**2019**	**2021**	**2022**	**Change (2022, 2021)**
Alaska plaice	*Pleuronectes quadrituberculatus*	302,979	330,733	321,575	344,581	299,028	-13.2%
walleye pollock	*Gadus chalcogrammus*	21,142	1,319,140	1,167,131	474,467	394,585	-16.8%
all pricklebacks	Stichaeidae	1,129	2,968	2,015	757	617	-18.5%
plain sculpin	*Myoxocephalus jaok*	28,275	36,208	41,639	20,652	15,392	-25.5%
rainbow smelt	*Osmerus mordax*	1,745	5,054	4,842	1,873	1,367	-27.0%
red king crab	*Paralithodes camtschaticus*	2,430	2,173	2,807	3,754	2,658	-29.2%
Bering flounder	*Hippoglossoides robustus*	12,355	19,804	18,526	8,384	5,910	-29.5%
Pacific cod	*Gadus macrocephalus*	29,126	287,551	365,005	227,582	153,735	-32.4%
Alaska skate	*Bathyraja parmifera*	76,942	83,255	95,104	80,207	48,920	-39.0%
northern rock sole	*Lepidopsetta polyxystra*	21,256	55,467	99,040	76,631	46,443	-39.4%
shorthorn sculpin	*Myoxocephalus scorpius*	39,828	111,363	14,161	7,627	3,664	-52.0%
other sculpins	Cottidae	10,416	10,394	4,862	3,725	1,724	-53.7%
sea peach	*Halocynthia* sp.	9,022	7,335	1,955	1,426	525	-63.2%
Pacific herring	*Clupea pallasii*	23,013	34,914	87,918	60,931	12,178	-80.0%
eulachon	*Thaleichthys pacificus*	0	27	0	0	0	-100.0%
all sticklebacks		0	0	1	1	0	-100.0%

Summary Results for Select Major Taxa[1]

Survey results for select taxa are presented with a photograph of the species or taxonomic group, maps of geographic distribution of CPUE (kg/ha), total abundance-at-size plots, and text summaries of results. Geographic maps of species distributions include both the EBS and NBS survey regions to better illustrate patterns and trends in fish distribution and movement. For comparison, distribution maps and abundance-at-size plots show survey data for the 2010, 2017, 2019, 2021, and 2022 surveys.

Alaska Plaice (*Pleuronectes quadrituberculatus*)

In the NBS, the estimated biomass of Alaska plaice decreased by 13% between 2021 (344,581 mt) and 2022 (299,028 mt; Table 1). This increase contrasts with the increase in biomass between 2019 (321,575 mt; Table 1) and 2021. Alaska plaice are able to inhabit shelf areas where bottom temperatures are below freezing because they have a type of protein in their blood that acts as antifreeze (Knight, Cheng, and DeVries 1991). Consequently, Alaska plaice were found in bottom temperatures between -1.7°C and 12°C. Alaska plaice also comprised approximately 9% of the total NBS survey estimated biomass in 2022. In the most recent five years of the NBS survey, length modes were observed 10 cm and 35 cm (Figure 7). Spatial distribution from 2017 to 2022 has been similar, with highest relative abundance located south of St. Lawrence Island (Figure 8).

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[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.

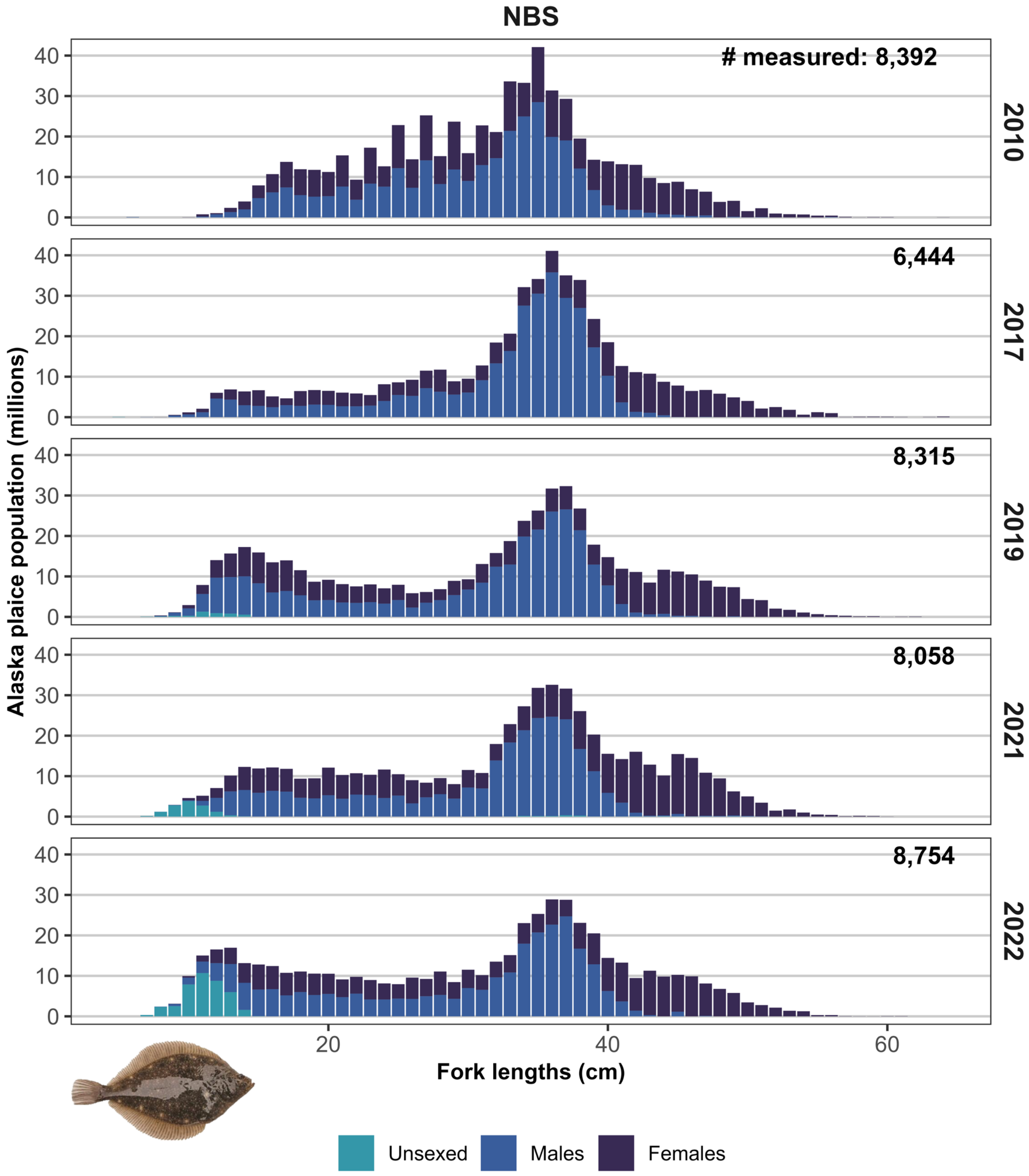

Figure 7. – Total abundance-at-size estimates of Alaska plaice (*Pleuronectes quadrituberculatus*) by sex (unsexed, males, and females) in centimeters (cm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

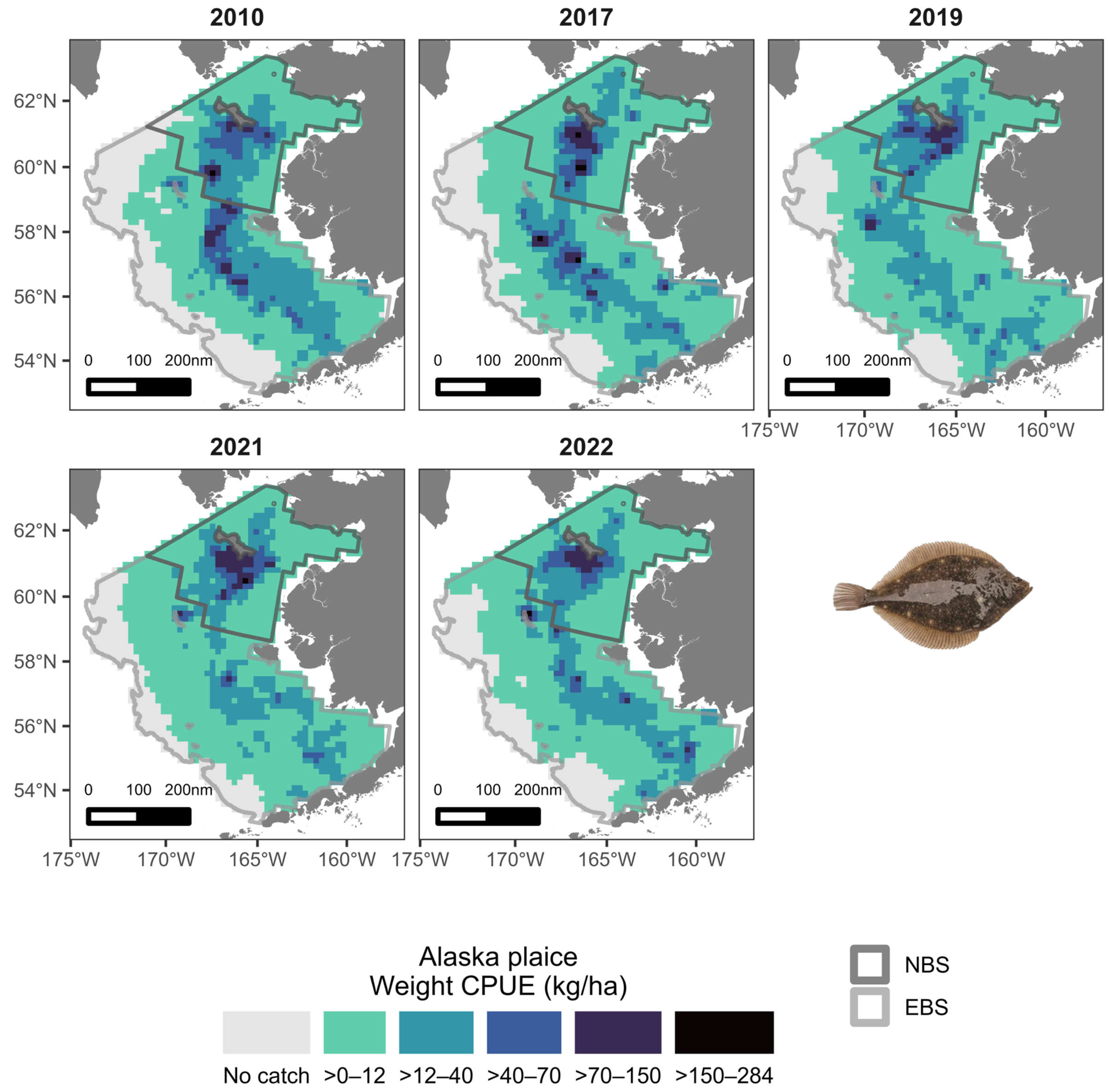

Figure 8. – Alaska plaice (*Pleuronectes quadrituberculatus*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Yellowfin Sole (*Limanda aspera*)

Yellowfin sole comprised 17% (548,027 mt; Table 1) of the total 2022 NBS estimated biomass. When compared with the estimated biomass in 2021 (496,045 mt; Table 1), this species experienced a 10% increase. Previously, yellowfin sole estimated biomass decreased by 5% from 2019 (520,029 mt; Table 1) to 2021. Sexually mature yellowfin sole adults complete an annual spawning migration to nearshore waters during the spring and summer (Nichol 1997). Younger and sexually immature individuals complete an ontogenetic (age-based) migration rather than a spawning migration, moving deeper as they get older (Nichol et al. 2019; Nichol 1997). Length or age at sexual maturity differs between males and females, causing further size segregation among spawning and non-spawning portions of the population (Nichol et al. 2019; Nichol 1997). In 2022, size modes are observed around 11 cm, 17 cm, and 32 cm (Figure 9). In 2022, the spatial distribution of yellowfin sole was similar to 2010 and 2017, with the densest aggregations along the Alaska mainland coast south of Nunivak and in Bristol Bay (Figure 10). High densities continue to be observed near Togiak Bay and the spawning grounds in Kuskokwim Bay and Bristol Bay (Spies et al. (2021); Figure 10).

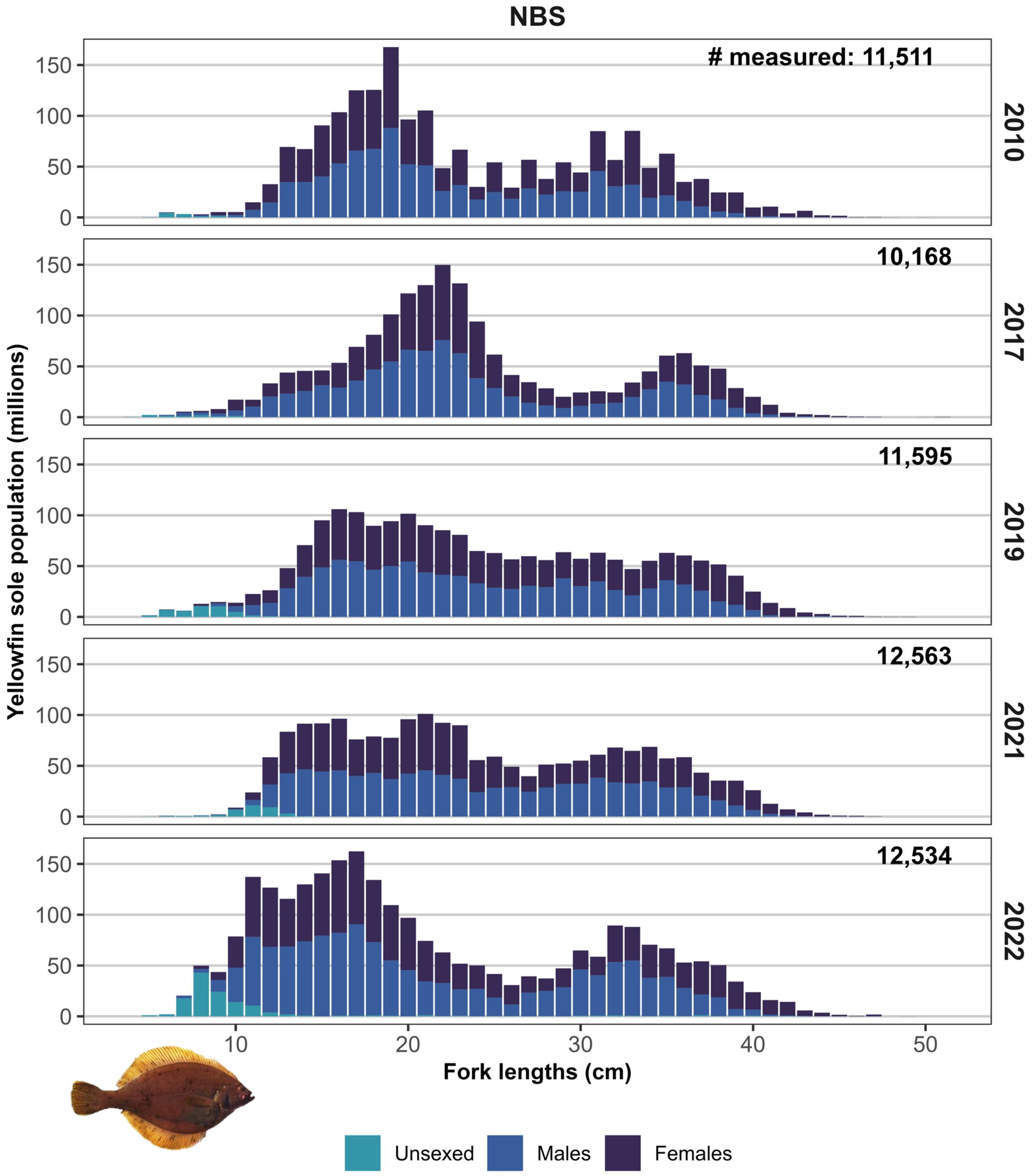

Figure 9. – Total abundance-at-size estimates of yellowfin sole (*Limanda aspera*) by sex (unsexed, males, and females) in centimeters (cm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

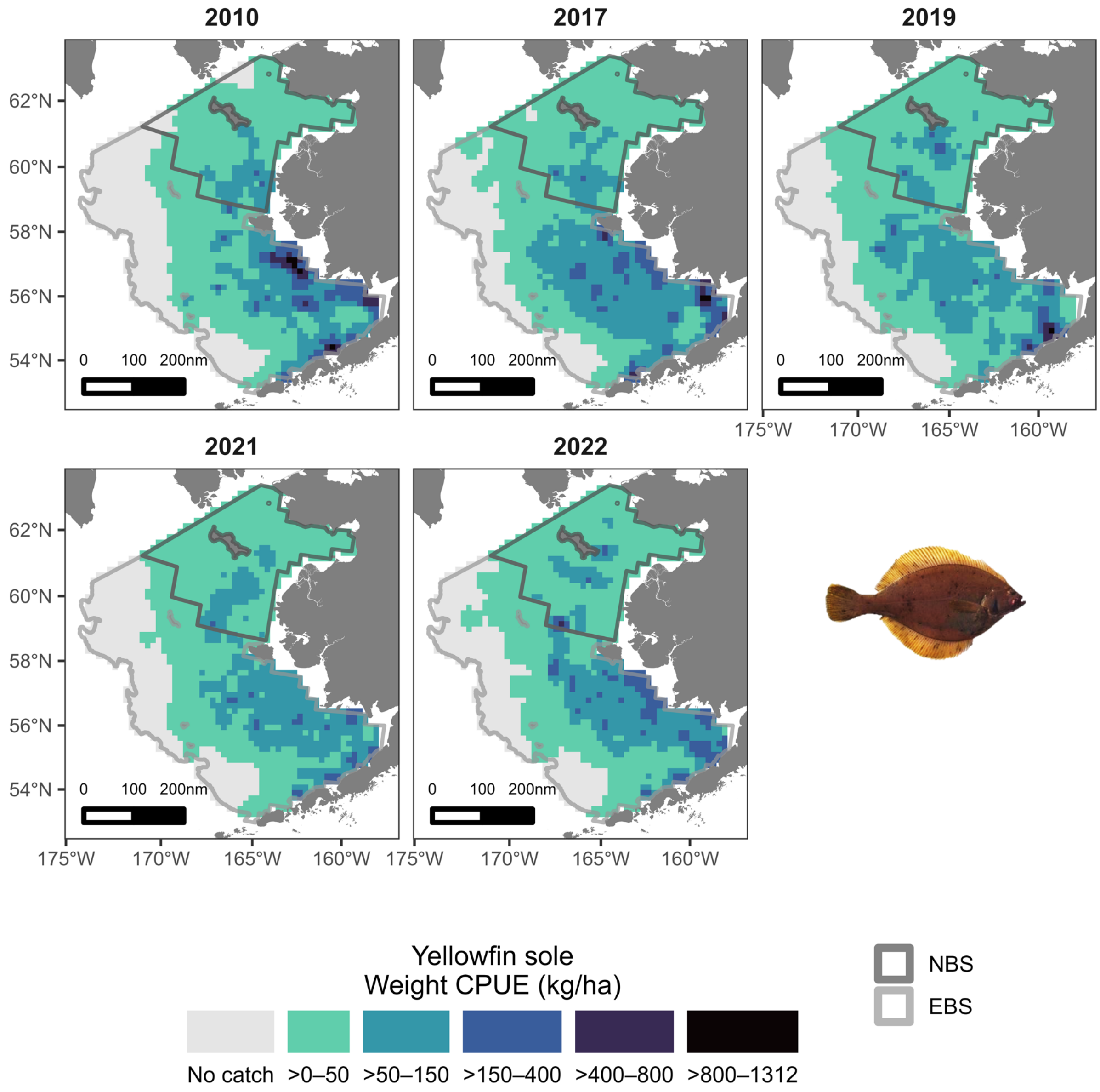

Figure 10. – Yellowfin sole (*Limanda aspera*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Pacific Halibut (*Hippoglossus stenolepis*)

The size composition of Pacific halibut observed in the NBS in 2022 was similar to 2021, with a large mode of 40-60 cm individuals and an overall range of fork lengths between 16 and 141 cm (Figure 11). In 2022, Pacific halibut were observed in 38.9% (56 of 144) of NBS stations, at bottom temperatures between -1.3 and 11.4°C and depths between 14 and 57 m. Compared with 2021, Pacific halibut biomass in 2022 in the NBS experienced a 12% decrease (Table 1). Pacific halibut NBS distribution in 2022 was similar to that observed in 2021, with the greatest densities of Pacific halibut southeast of St. Lawrence Island (Figure 12).

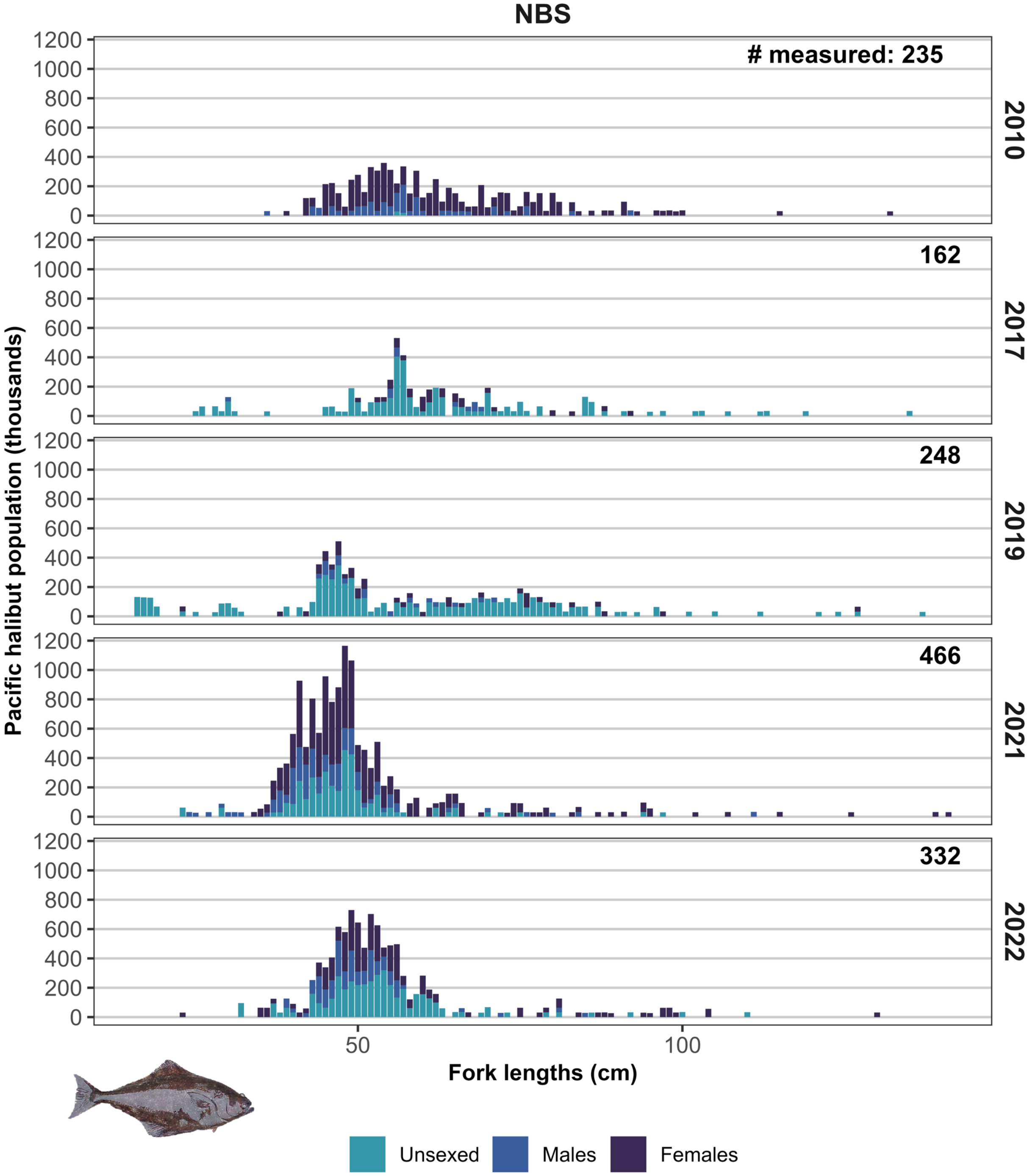

Figure 11. – Total abundance-at-size estimates of Pacific halibut (*Hippoglossus stenolepis*) by sex (unsexed, males, and females) in centimeters (cm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

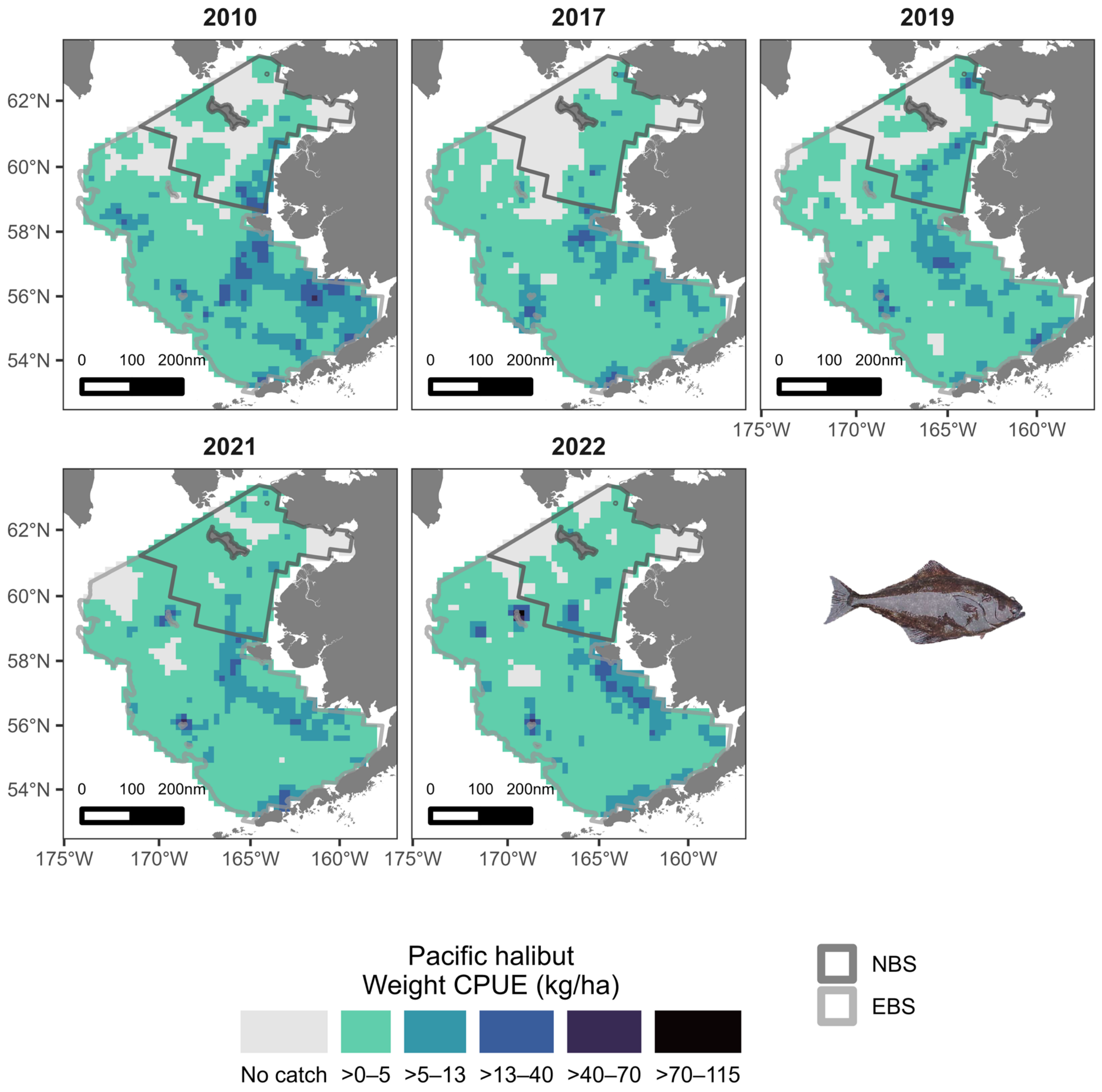

Figure 12. – Pacific halibut (*Hippoglossus stenolepis*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Bering Flounder (*Hippoglossoides robustus*)

During the 2022 survey, Bering flounder were present at 61.8% of stations in the NBS (89 of 144 stations) in depths ranging from 22 and 78 m. The estimated biomass in the NBS of Bering flounder decreased by 30% between 2021 (8,384 mt) and 2022 (5,910 mt; Table 1). Previously, Bering flounder estimated biomass in 2021 experienced a 55% decrease when compared to estimated biomass in 2019 (18,526 mt; Table 1). Bering flounder were found in areas where bottom temperatures were between -1.7°C and 10.2°C. In 2022, the greatest number of Bering flounder individuals were around 12 and 13 cm in length, with smaller modes existing around 19 and 35 cm (Figure 13). The highest densities of Bering flounder were found north of St. Matthew Island with smaller densities southwest of St Lawrence Island (Figure 14).

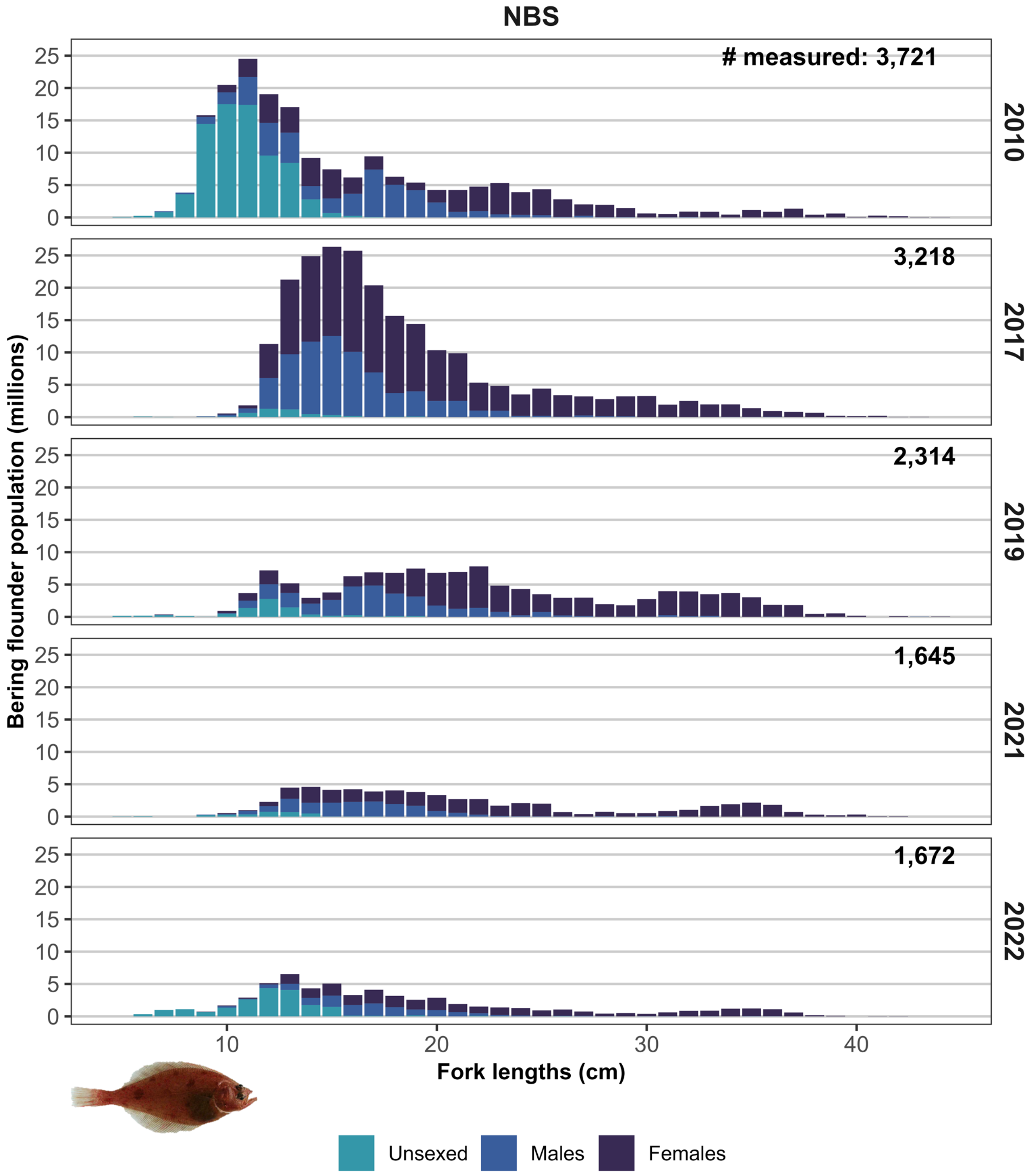

Figure 13. – Total abundance-at-size estimates of Bering flounder (*Hippoglossoides robustus*) by sex (unsexed, males, and females) in centimeters (cm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

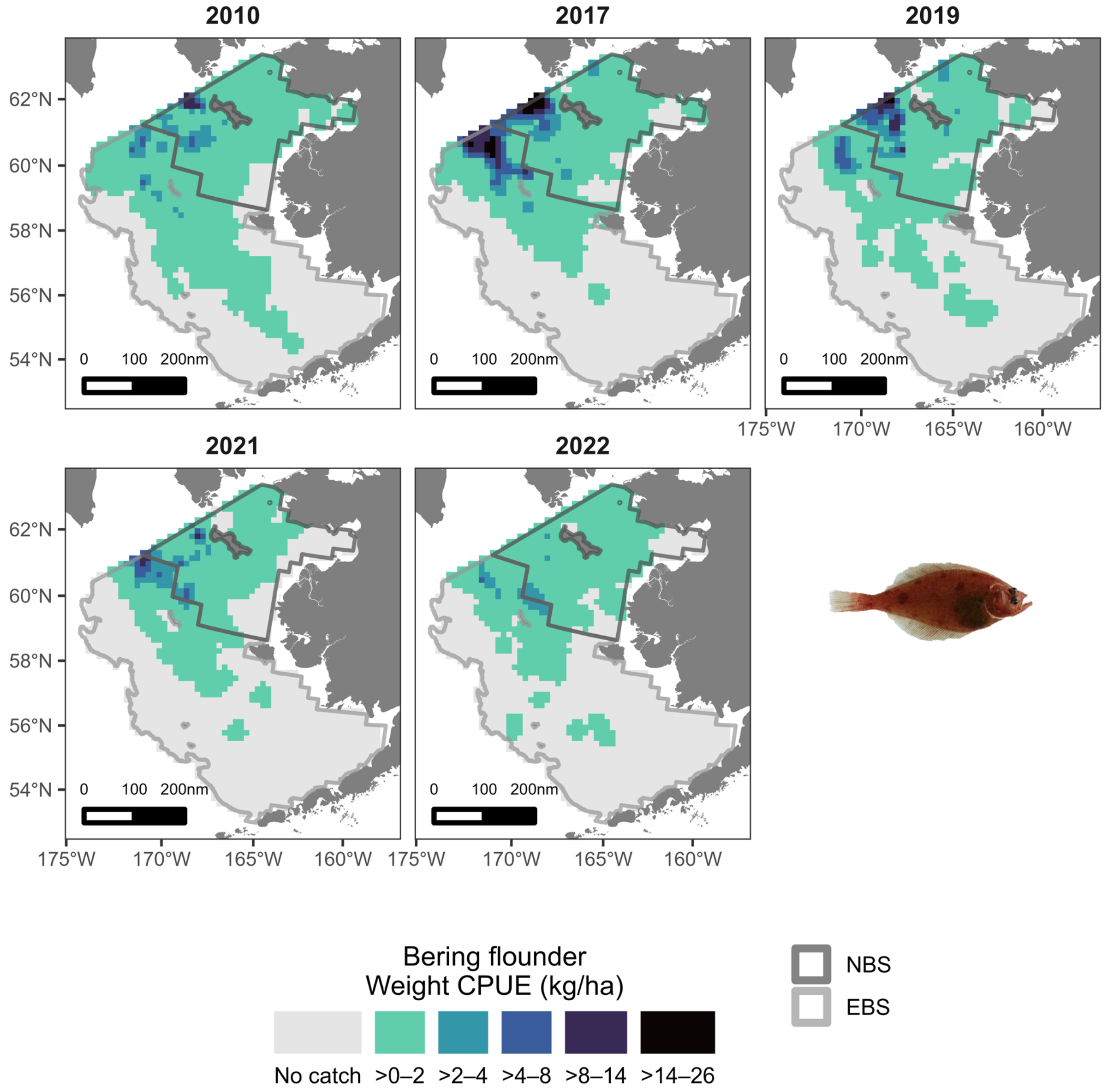

Figure 14. – Bering flounder (*Hippoglossoides robustus*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Northern Rock Sole (*Lepidopsetta polyxystra*)

During the 2022 survey, northern rock sole were present at 67.4% of stations in the NBS (97 of 144 stations) in depths ranging between 15 m and 73 m. The estimated biomass of northern rock sole decreased by 39% between 2021 (76,631 mt) and 2022 (46,443 mt; Table 1). Previously, northern rock sole estimated biomass decreased 23% between 2021 and 2019 (99,040 mt; Table 1). Northern rock sole were found in areas where bottom temperatures were between -1.6°C and 11°C. The fork lengths of northern rock sole measured during the 2022 NBS survey were between 4 and 52 cm, with modes at 16 cm and 30 cm (Figure 15). Northern rock sole are more abundant in the EBS shelf survey than the NBS survey (Figure 16). The highest densities of northern rock sole were observed north of the Pribilof Islands and in Bristol Bay (Figure 16).

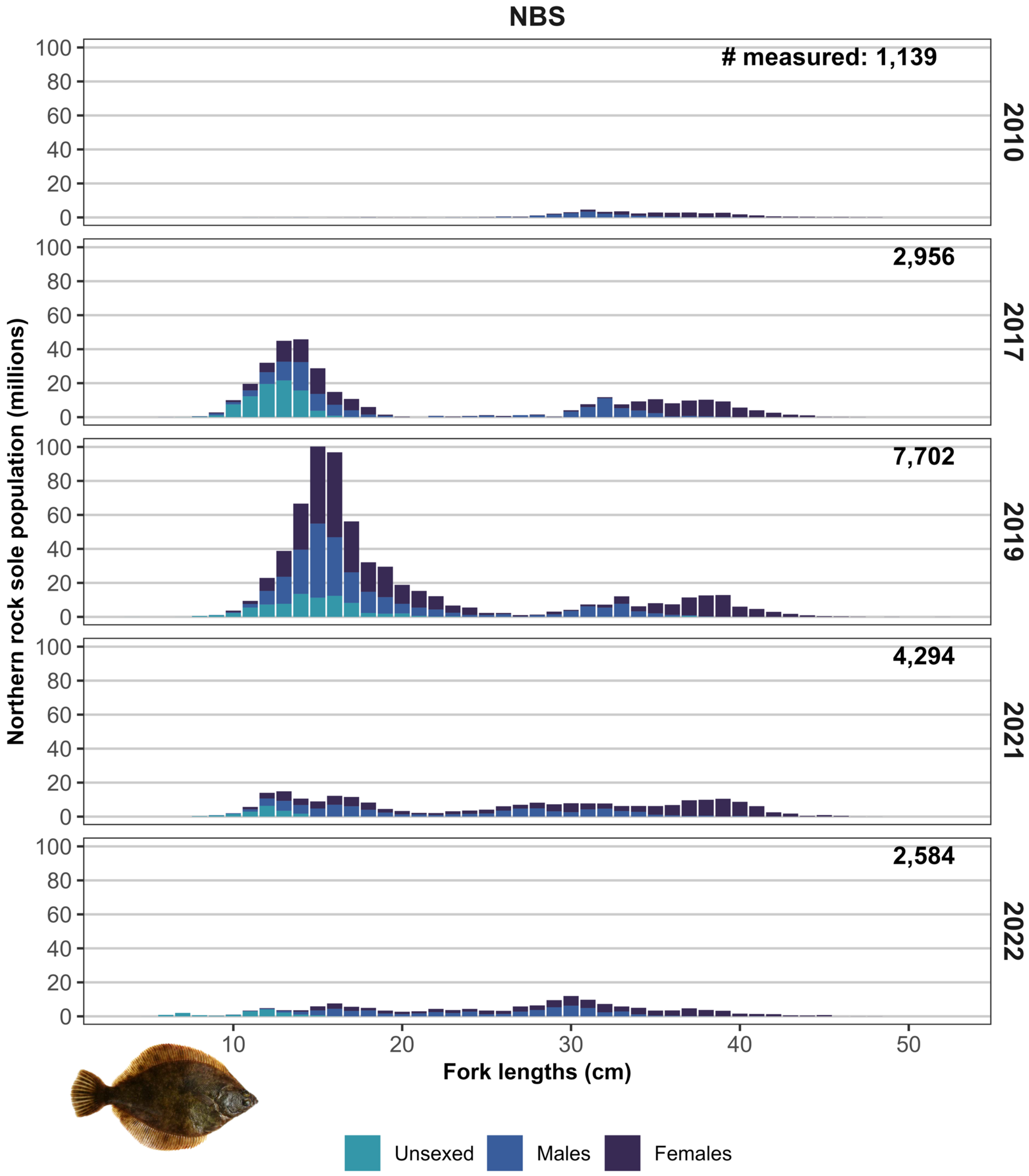

Figure 15. – Total abundance-at-size estimates of northern rock sole (*Lepidopsetta polyxystra*) by sex (unsexed, males, and females) in centimeters (cm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

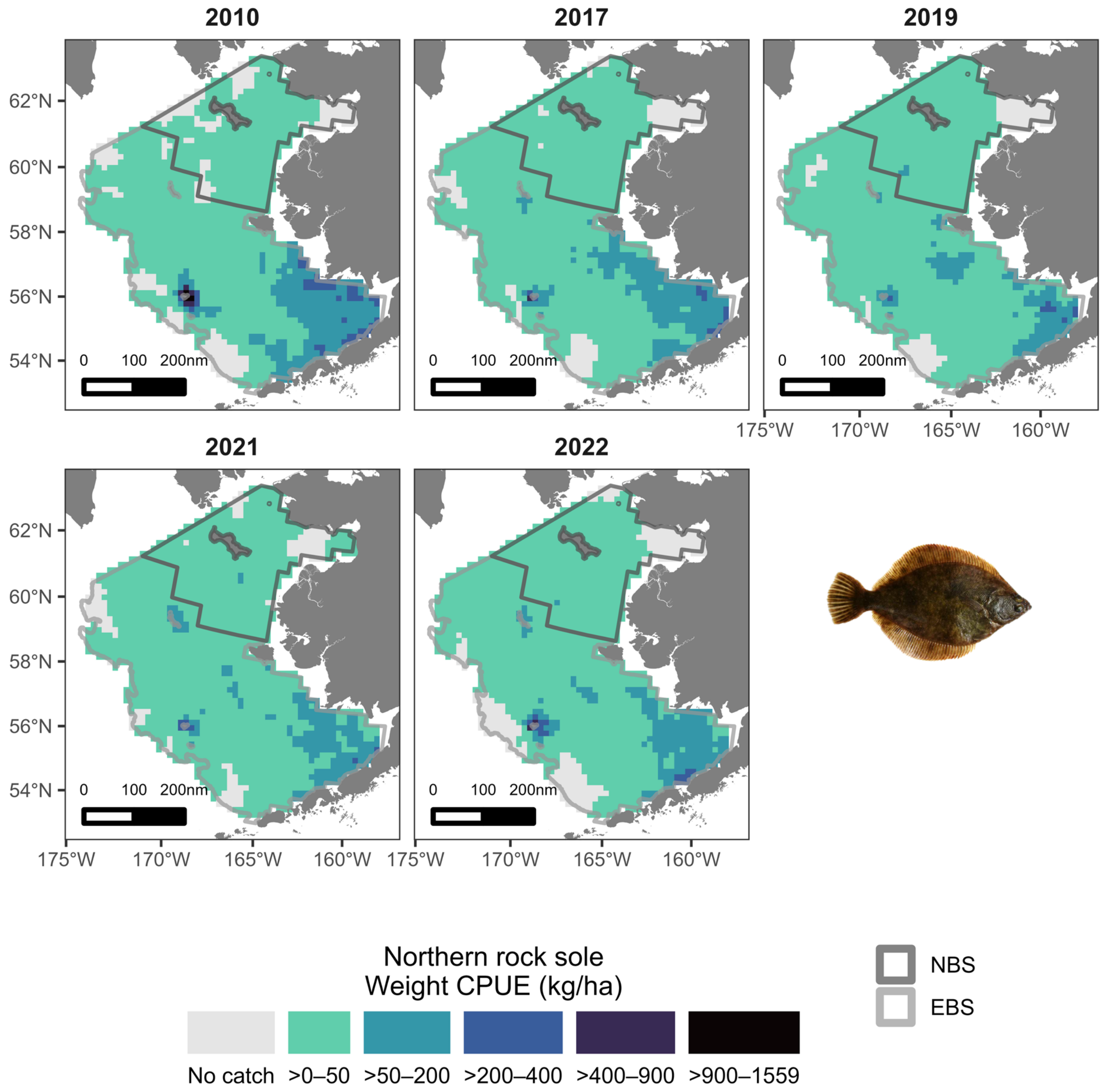

Figure 16. – Northern rock sole (*Lepidopsetta polyxystra*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Walleye Pollock (*Gadus chalcogrammus*)

In 2022, walleye pollock represented 12% (394,585 mt; Table 1) of the total NBS biomass. This species was present at 94.4% (136 of 144) NBS stations at depths between 11 m and 78 m and bottom temperatures between -1.7°C and 11.4°C. Compared with 2021 (474,467 mt), walleye pollock NBS biomass in 2022 (394,585 mt; Table 1) experienced a 17% decrease. Previously, walleye pollock biomass decreased by 59% between 2019 (1.2 million mt; Table 1) and 2021.

Size distributions of walleye pollock in 2022 are similar to 2021 and have two distinct modes (Figure 17). The total abundance of adult fish >40 cm is much smaller in 2022 than in 2021. However, the total abundance of juvenile fish <20 cm is much larger in 2022 than in 2021. Pollock in the 20-35 cm size range (representing 2-3 year-olds) are generally absent or are in low abundance from survey catch samples in the EBS (Figure 17) because they typically occupy a position much higher in the water column where they are unavailable to the survey trawl (Kotwicki et al. 2015). In contrast, only one length mode around 12 cm (representing 1 year-old) walleye pollock was observed in 2010 (Figure 17).

The spatial distribution of walleye pollock was relatively consistent throughout the NBS survey area, with a small area of relatively higher density in the Chirikov Basin just south of the Bering Strait (Figure 18). The vertical availability of pollock to the survey trawl depends on environmental factors and can be affected by bottom depth, light levels, fish size or age, and fish density (Kotwicki et al. 2015; Kotwicki, Ianelli, and Punt 2014).

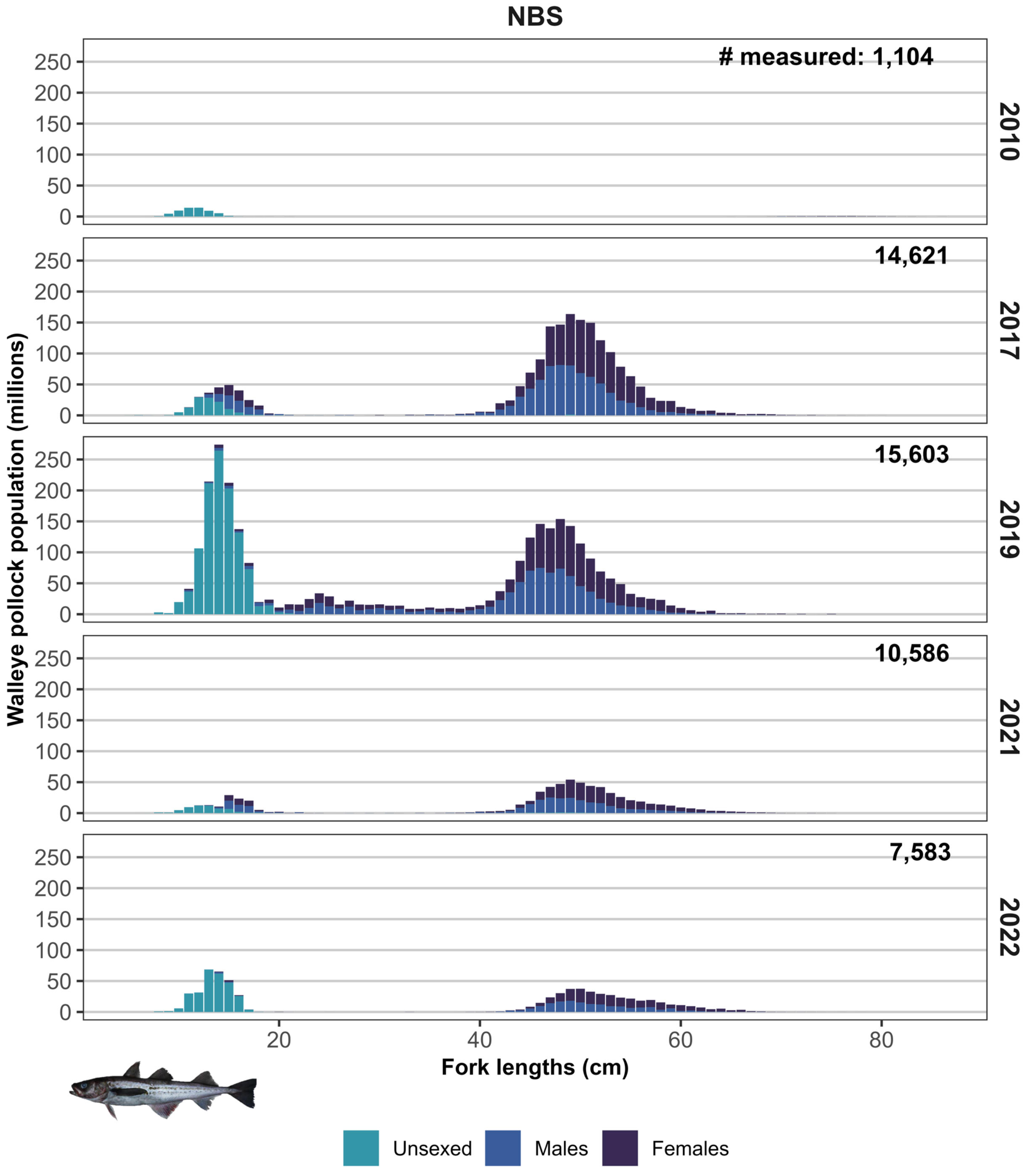

Figure 17. – Total abundance-at-size estimates of walleye pollock (*Gadus chalcogrammus*) by sex (unsexed, males, and females) in centimeters (cm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

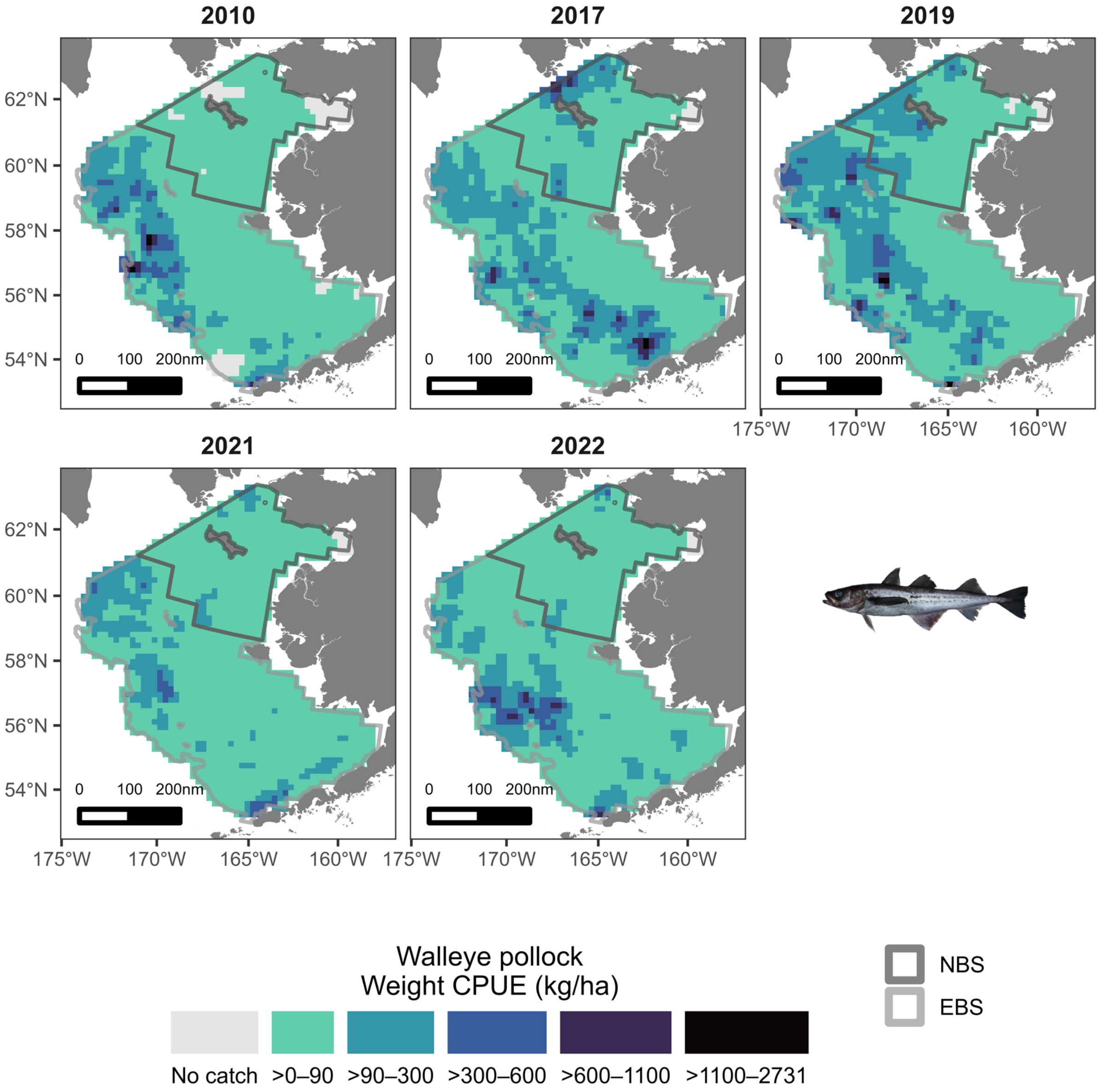

Figure 18. – Walleye pollock (*Gadus chalcogrammus*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Pacific Cod (*Gadus macrocephalus*)

Pacific cod represented approximately 5% (153,735 mt) of the 2022 NBS survey estimated biomass, which is a 32% decrease from 2021 estimated biomass (227,582 mt; Table 1). Pacific cod were present at 75% (108 of the 144) of NBS stations at depths between 22 and 78 m. Previously, Pacific cod estimated biomass experienced a 38% increase from 2019 (365,005 mt; Table 1) to 2021. Pacific cod were found in areas where bottom temperatures were between -1.6°C and 11°C. Pacific cod size composition in 2022 shows two distinct modes around 19 cm and 51 cm (Figure 19). The highest NBS densities of this species were present just south of St. Lawrence Island (Figure 20).

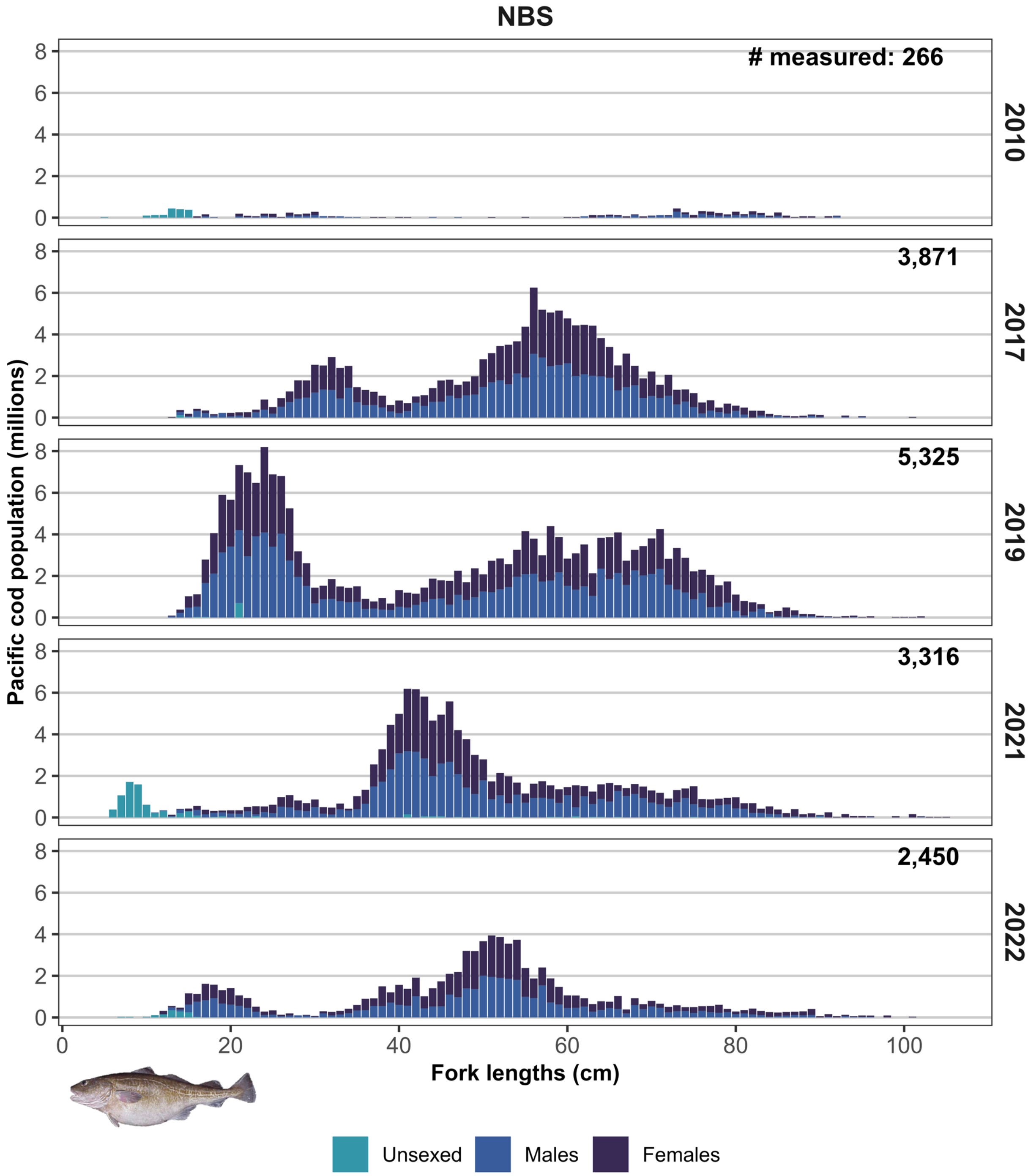

Figure 19. – Total abundance-at-size estimates of Pacific cod (*Gadus macrocephalus*) by sex (unsexed, males, and females) in centimeters (cm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

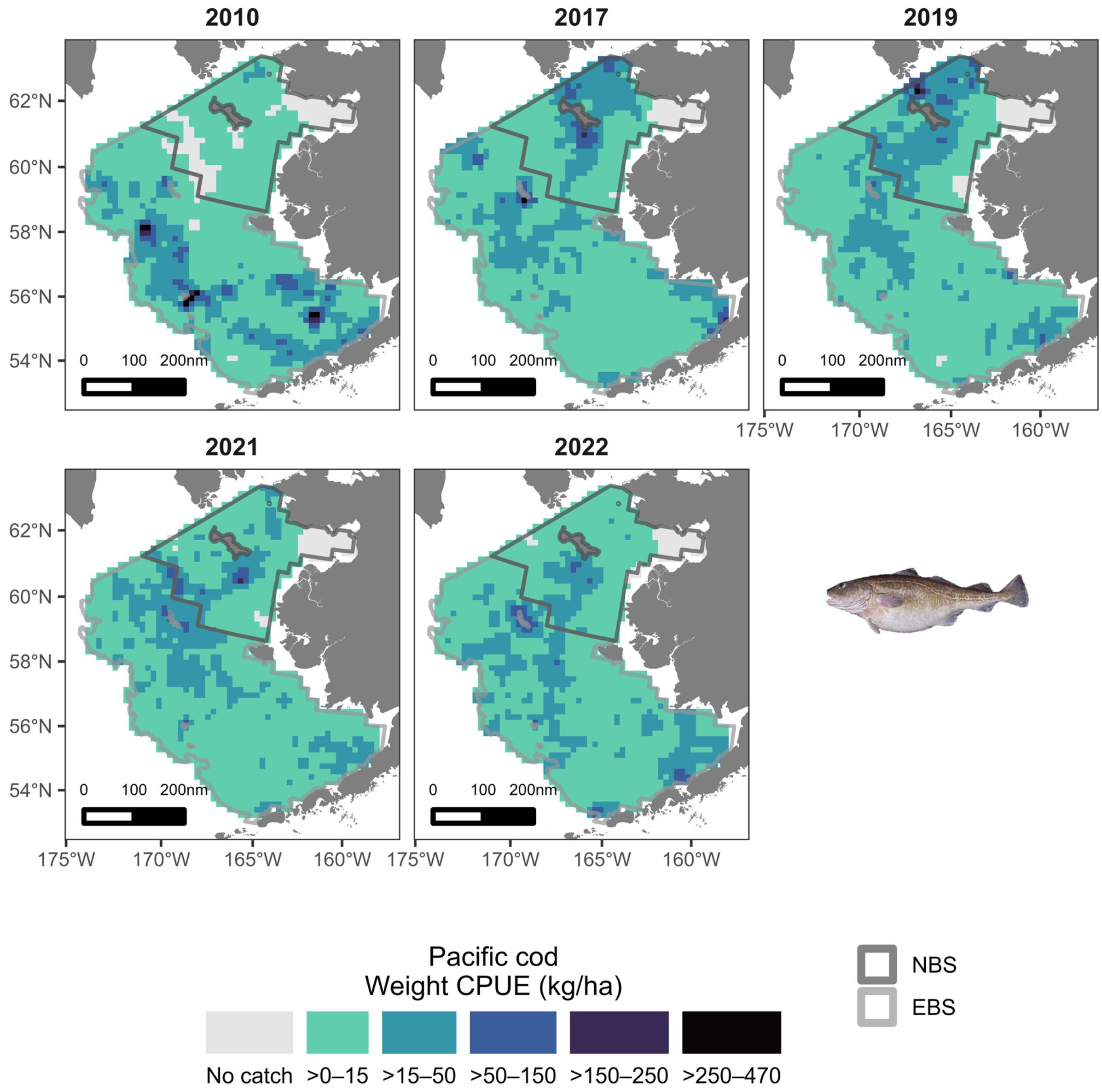

Figure 20. – Pacific cod (*Gadus macrocephalus*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Saffron Cod (*Eleginus gracilis*)

Saffron cod is considered to be a nearshore, bottom-dwelling species and represented 27,738 mt of the 2022 NBS biomass (Table 1). In 2022, saffron cod were present at 41% (59 of 144) of NBS stations at depths between 11 and 39 m. When compared with NBS biomass estimates in 2021 (9,974 mt; Table 1), this species experienced a 178% increase in 2022. Previously, saffron cod biomass decreased by 88% from 2019 (81,278 mt; Table 1) to 2021. The fork lengths of saffron cod measured during the 2022 NBS survey were between 4 and 41 cm (Figure 21). This species was most abundant just north of Nunivak, with lower densities in the waters off the coast of western Alaska, and into Norton Sound (Figure 22).

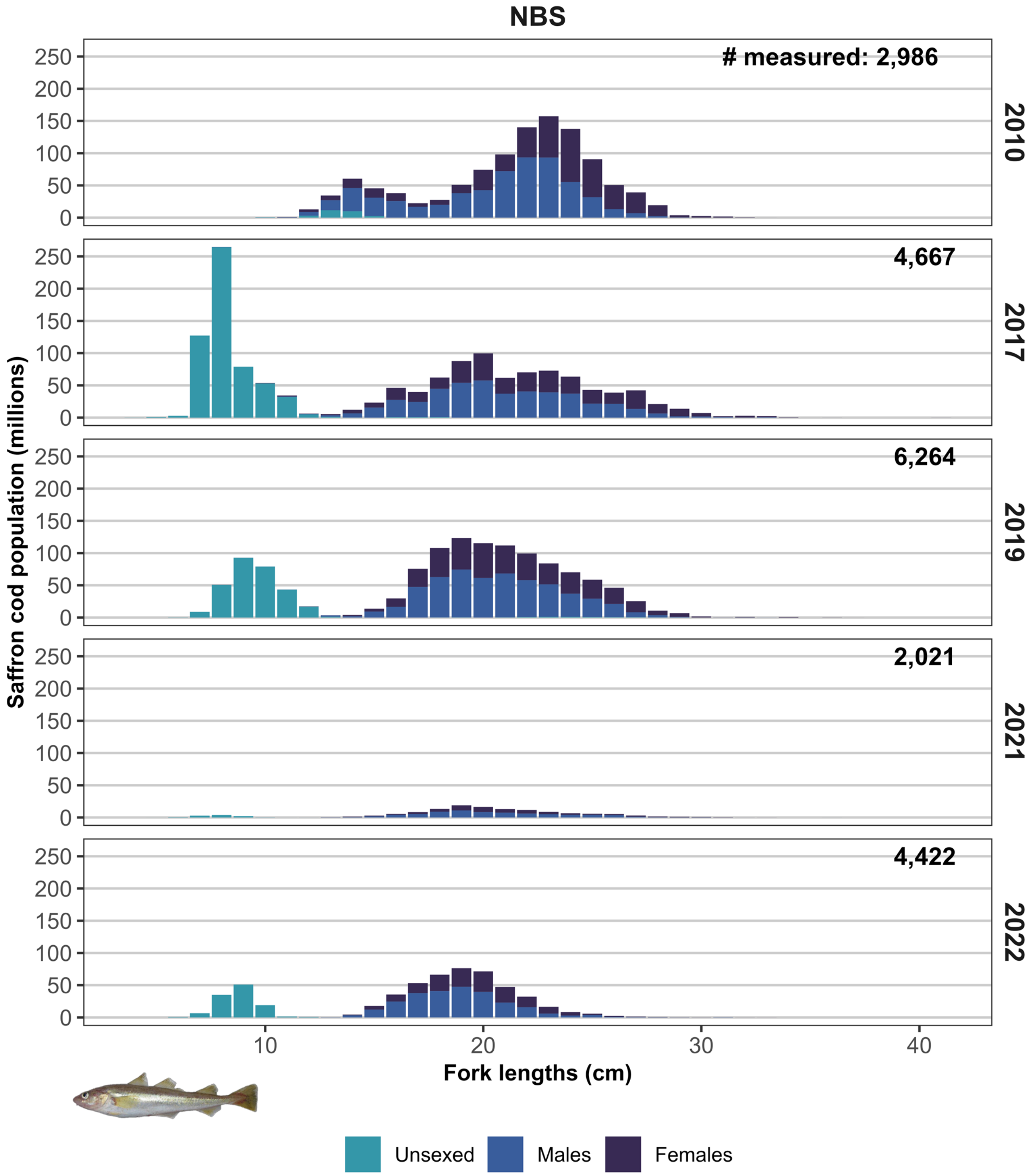

Figure 21. – Total abundance-at-size estimates of saffron cod (*Eleginus gracilis*) by sex (unsexed, males, and females) in centimeters (cm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

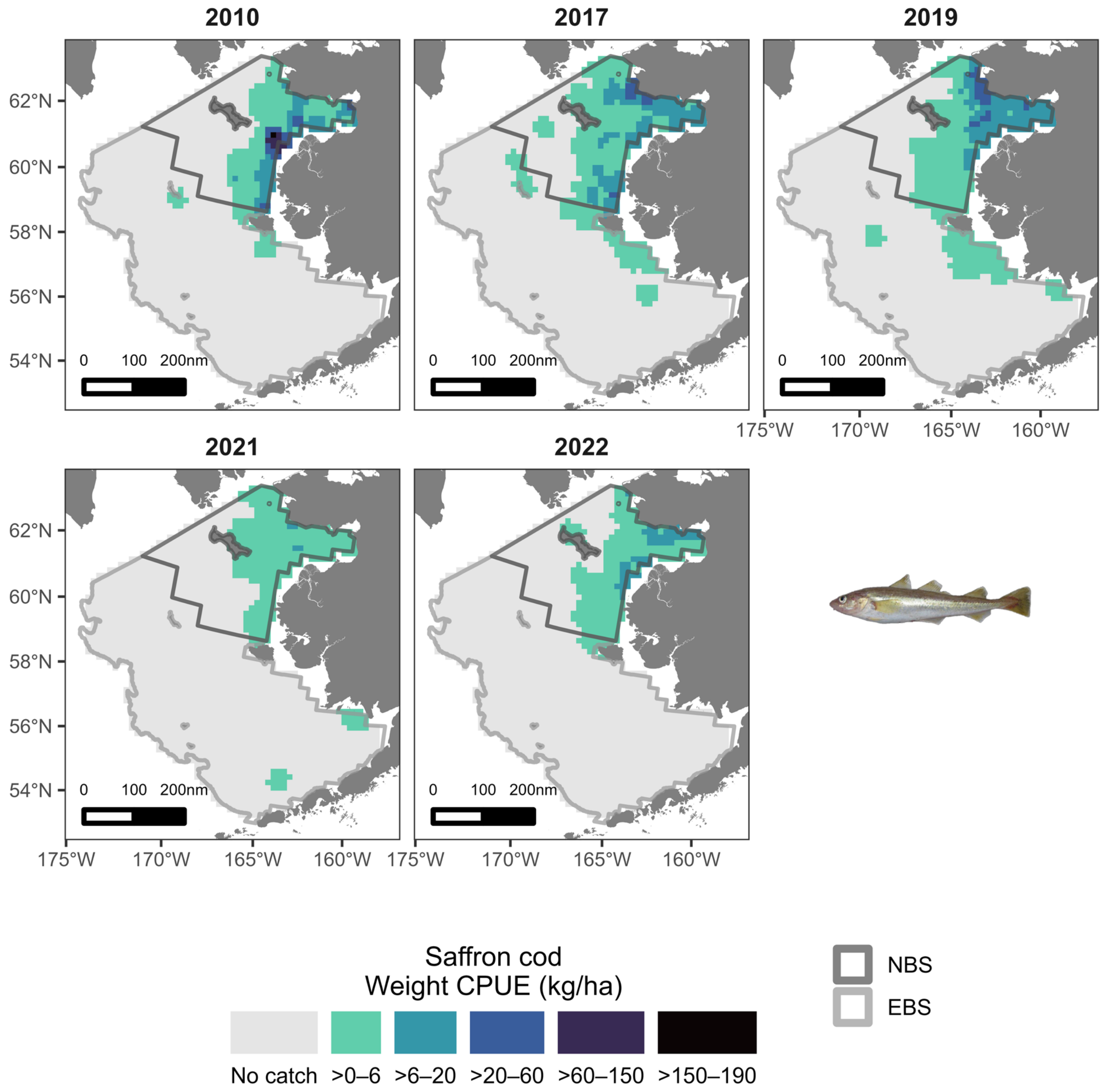

Figure 22. – Saffron cod (*Eleginus gracilis*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Arctic Cod (*Boreogadus saida*)

The estimated biomass of Arctic cod increased by 367% between 2021 (83 mt) and 2022 (387 mt; Table 1). The fork lengths of Arctic cod measured during the 2022 NBS survey were between 6 and 48 cm (Figure 23). The spatial distribution of this forage fish was observed in Norton Sound, as well as to the north, west, and southwest of St. Lawrence Island (Figure 24).

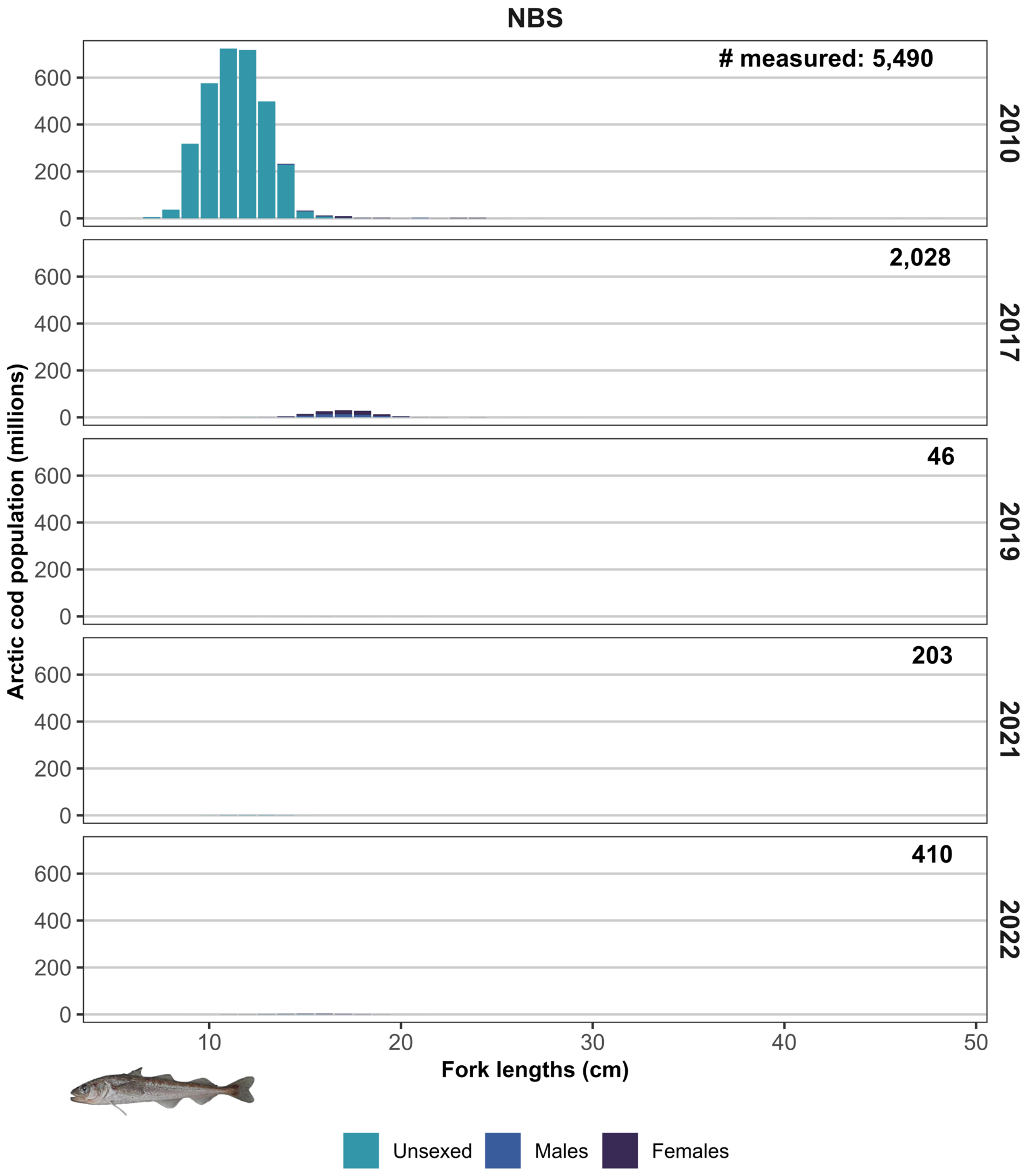

Figure 23. – Total abundance-at-size estimates of Arctic cod (*Boreogadus saida*) by sex (unsexed, males, and females) in centimeters (cm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

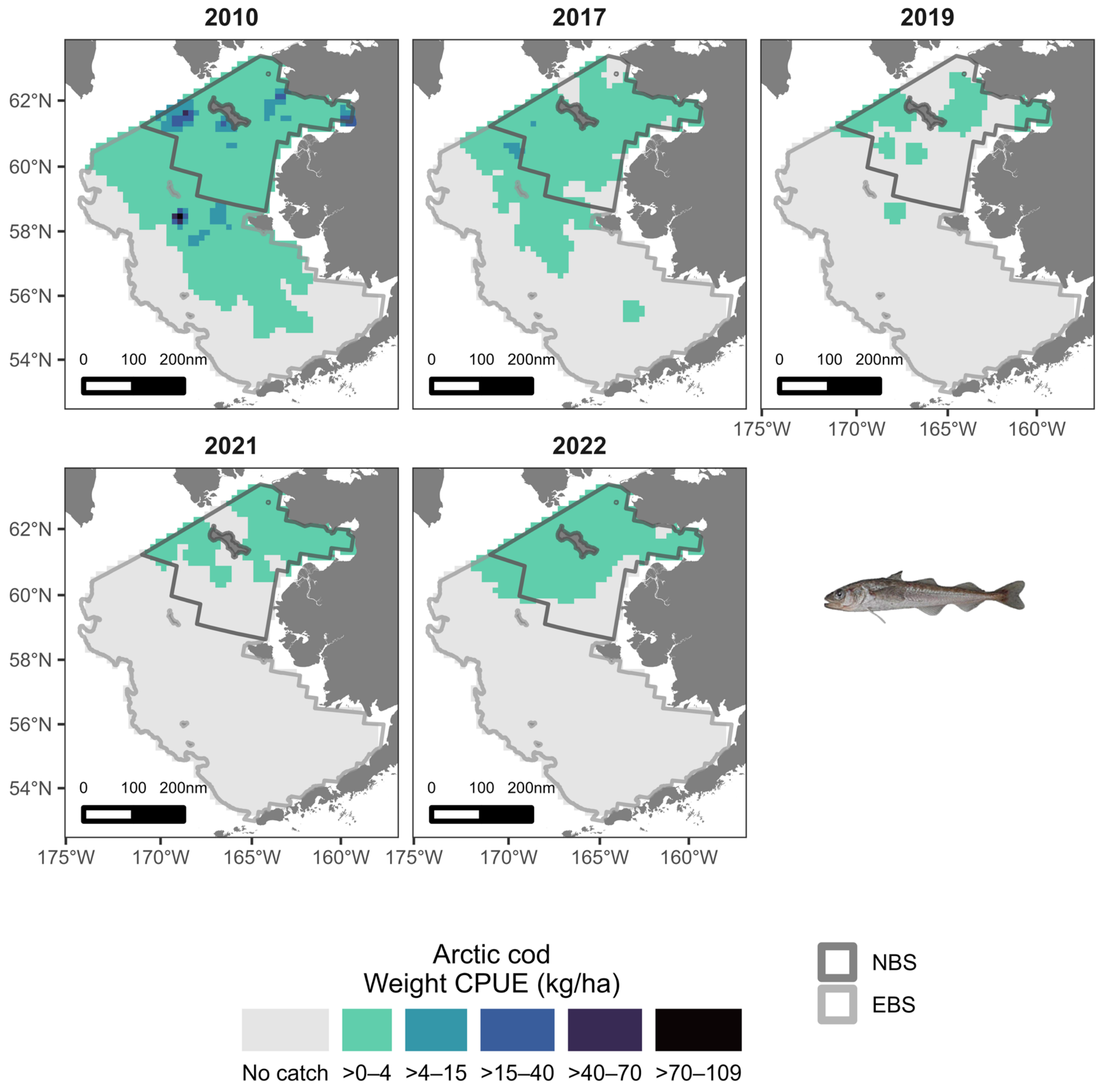

Figure 24. – Arctic cod (*Boreogadus saida*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Red King Crab (*Paralithodes camtschaticus*)

The estimated red king crab biomass in 2022 (2,658 mt) experienced a 29% decrease when compared to 2021 (3,754 mt; Table 1). Similar to the previous year, red king crab in the 2022 NBS survey were present at 17% (25 of 144) of NBS stations, up from 23 stations in 2019. Red king crab were found in waters with depths between 14 m and 65 m and with bottom temperatures between -1.0°C and 11.4°C. 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, and between 85 and 90 mm in 2022 (Figure 25). Within the NBS, red king crab occur predominantly in Norton Sound (Figure 26).

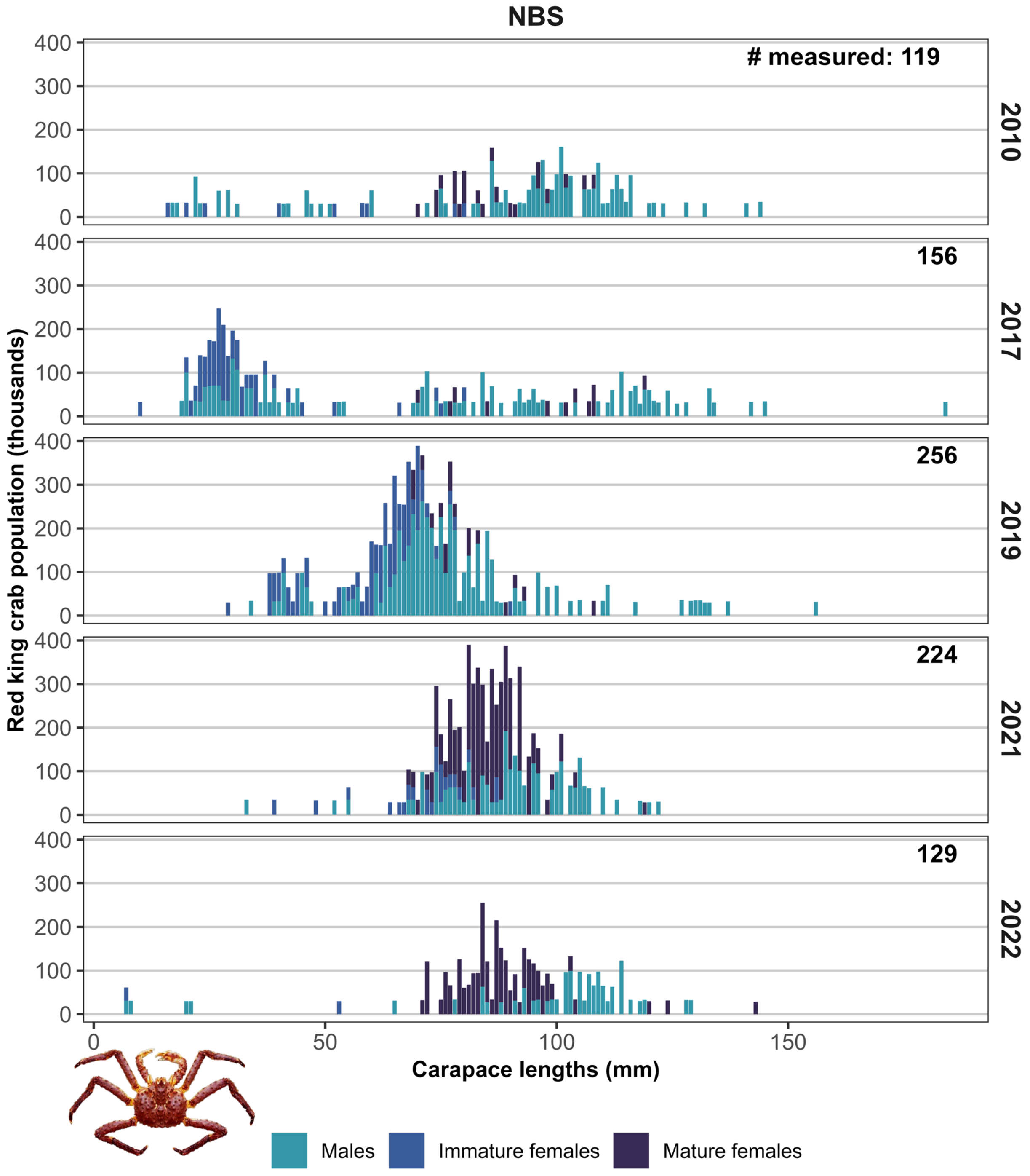

Figure 25. – Total abundance-at-size estimates of red king crab (*Paralithodes camtschaticus*) by sex (males, immature females, and mature females) in millimeters (mm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

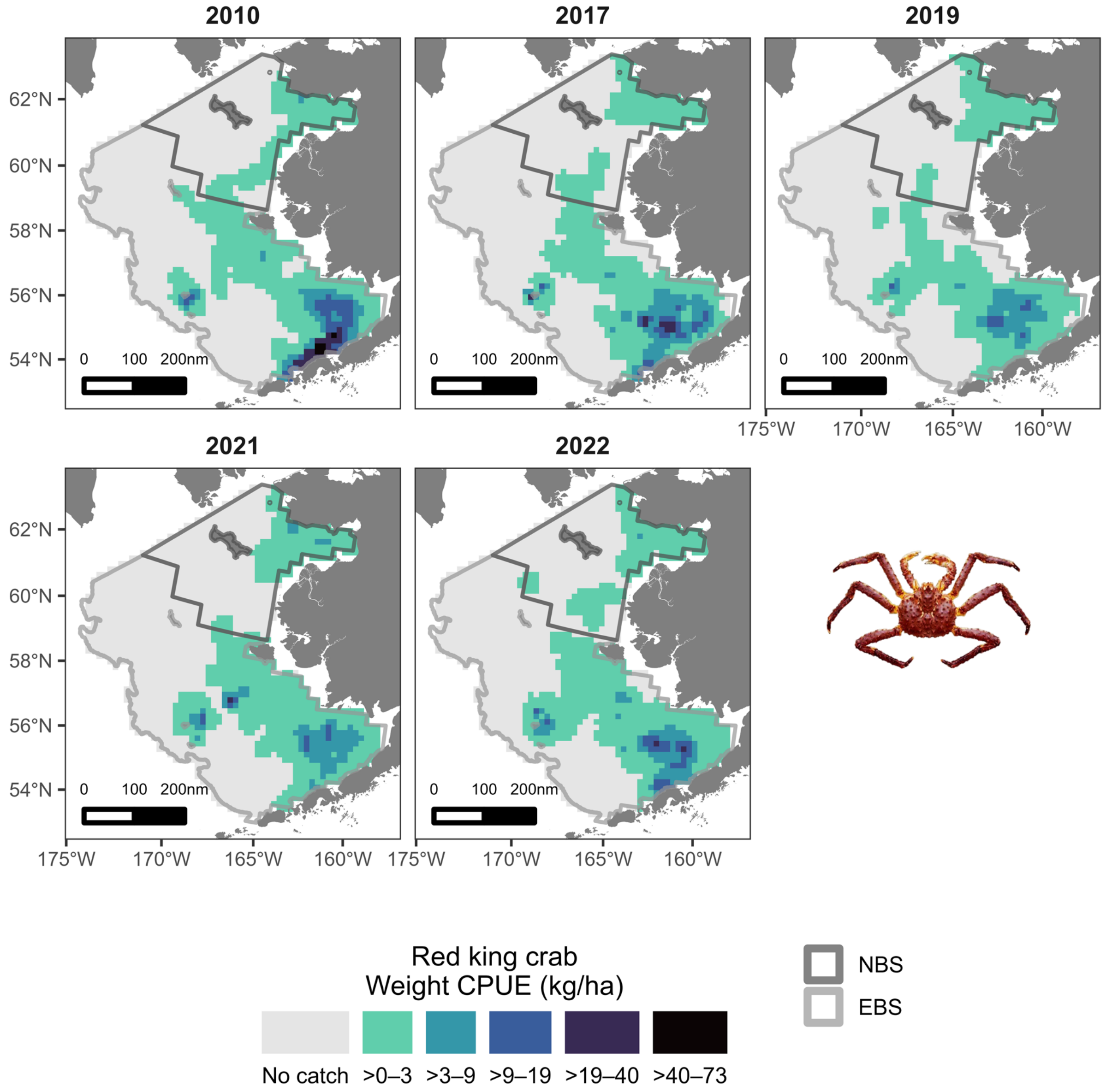

Figure 26. – Red king crab (*Paralithodes camtschaticus*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Blue King Crab (*Paralithodes platypus*)

Blue king crab biomass increased by 190% from 2021 (1,039 mt) to 2022 (3,014 mt; Table 1). Blue king crab were found in waters with depths between 28 m and 71 m and bottom temperatures between -1.7°C and 6.6°C. The carapace lengths of blue king crab measured during the 2022 NBS survey were between 17.2 and 148.5 mm (Figure 27). In 2022, the majority of blue king crab were distributed around St. Matthew Island, the Pribilof Islands, and north of St. Lawrence Island, with the highest densities of blue king crab encountered off the eastern edge of St. Matthew Island (Figure 28).

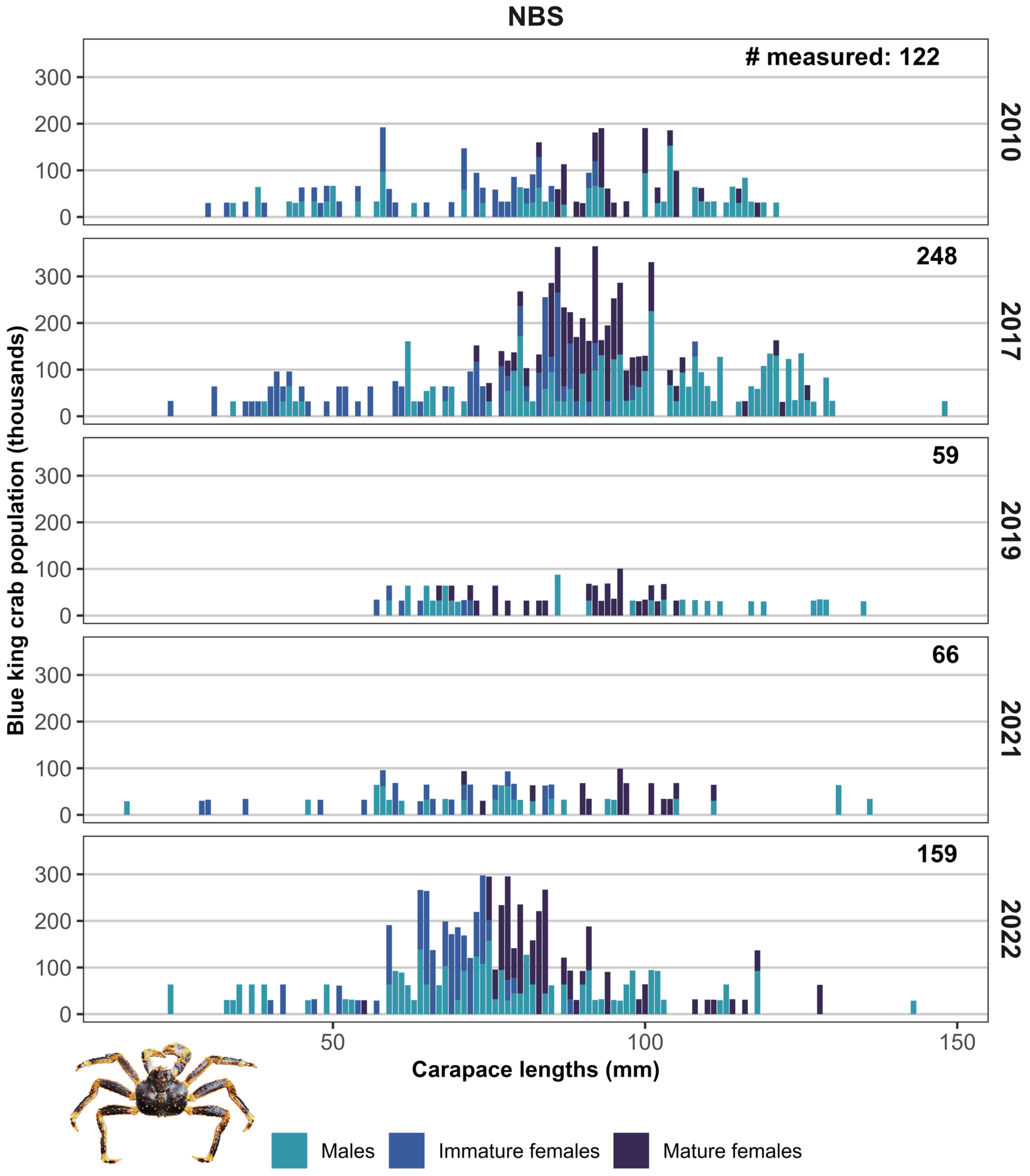

Figure 27. – Total abundance-at-size estimates of blue king crab (*Paralithodes platypus*) by sex (males, immature females, and mature females) in millimeters (mm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

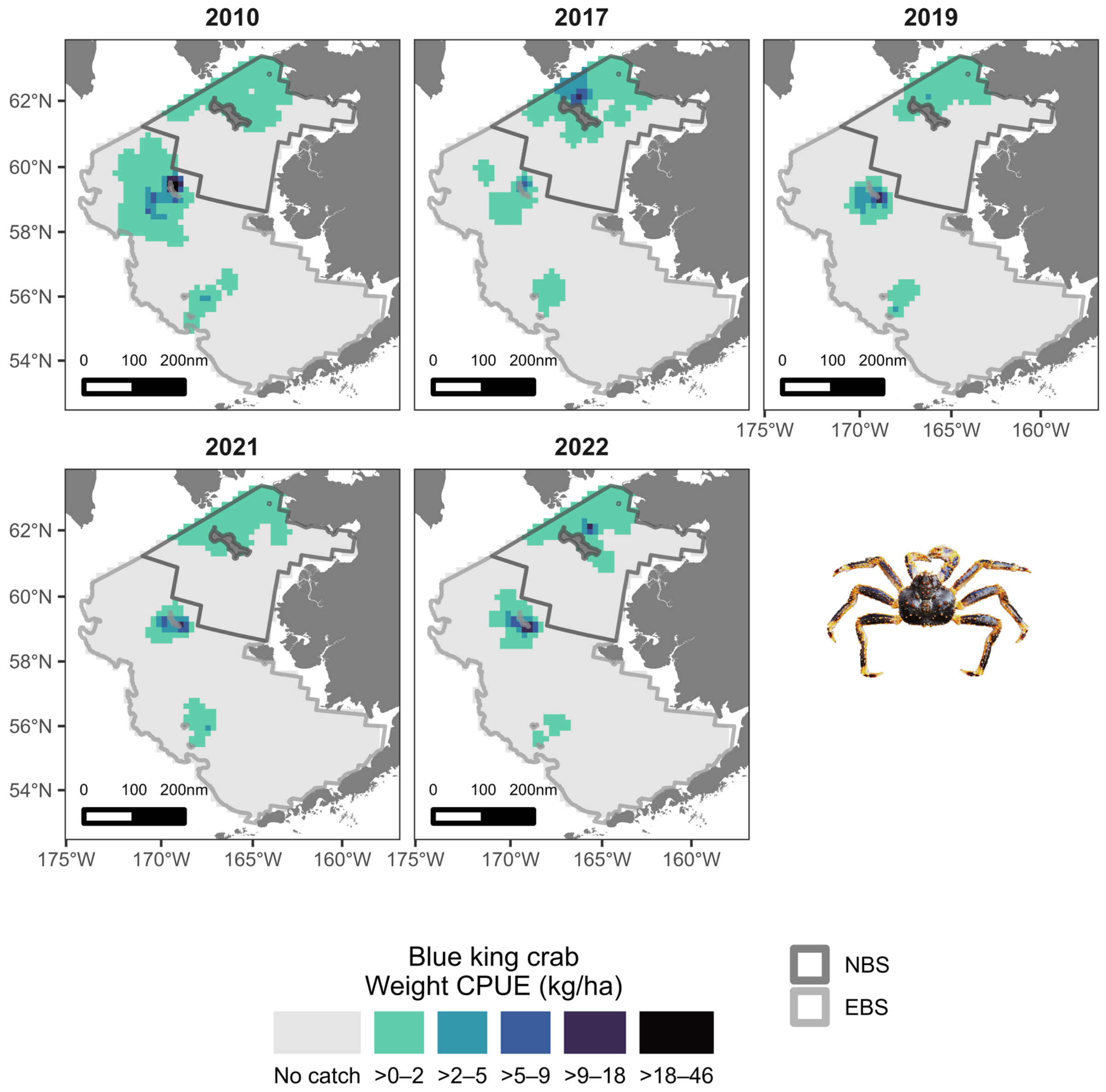

Figure 28. – Blue king crab (*Paralithodes platypus*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Snow Crab (*Chionoecetes opilio*)

Compared with 2021 (72,482 mt), snow crab biomass in the NBS experienced a 119% increase in 2022 (158,977 mt; Table 1). Previously, snow crab biomass experienced a 56% decrease from 2019 to 2021 (165,964 mt; Table 1). In 2022, snow crab were present at 75% (108 of 144) of NBS stations. A strong mode was present at 37-40 mm for both males and immature females in 2022 (Figure 29). While the overall estimated abundance of snow crab for that size range has increased since 2021, the number of legal males (greater than 78 mm carapace width) has notably decreased (Figure 29). The highest densities of snow crab in 2022 were observed to the north of St. Matthew Island (Figure 30). In 2021, the highest snow crab densities were observed immediately west of St. Matthew Island. From 2017 to 2019, the highest densities were located north and south of St. Matthew Island, in areas where bottom depths were between 50 m and 100 m (Figure 30).

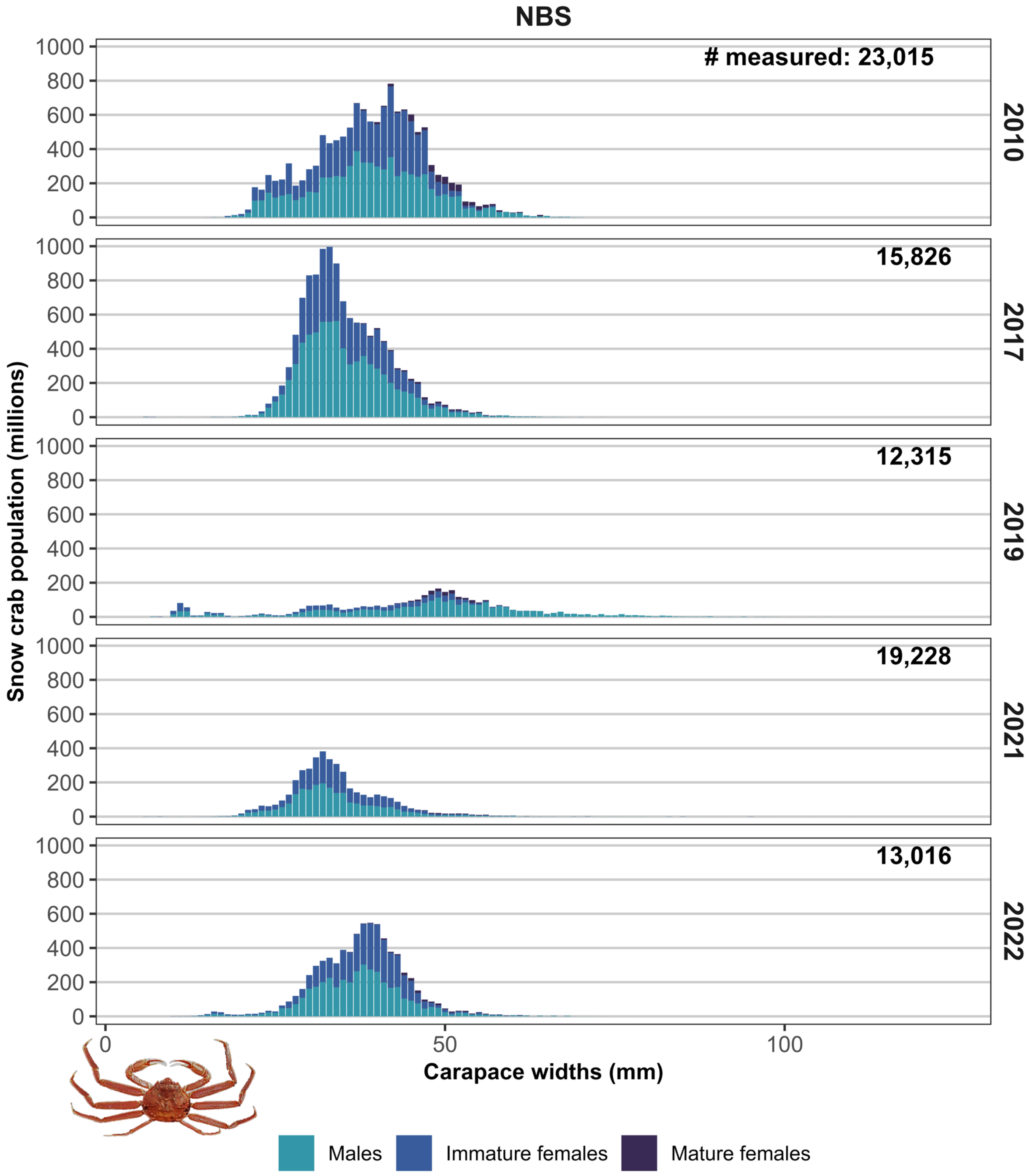

Figure 29. – Total abundance-at-size estimates of snow crab (*Chionoecetes opilio*) by sex (males, immature females, and mature females) in millimeters (mm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

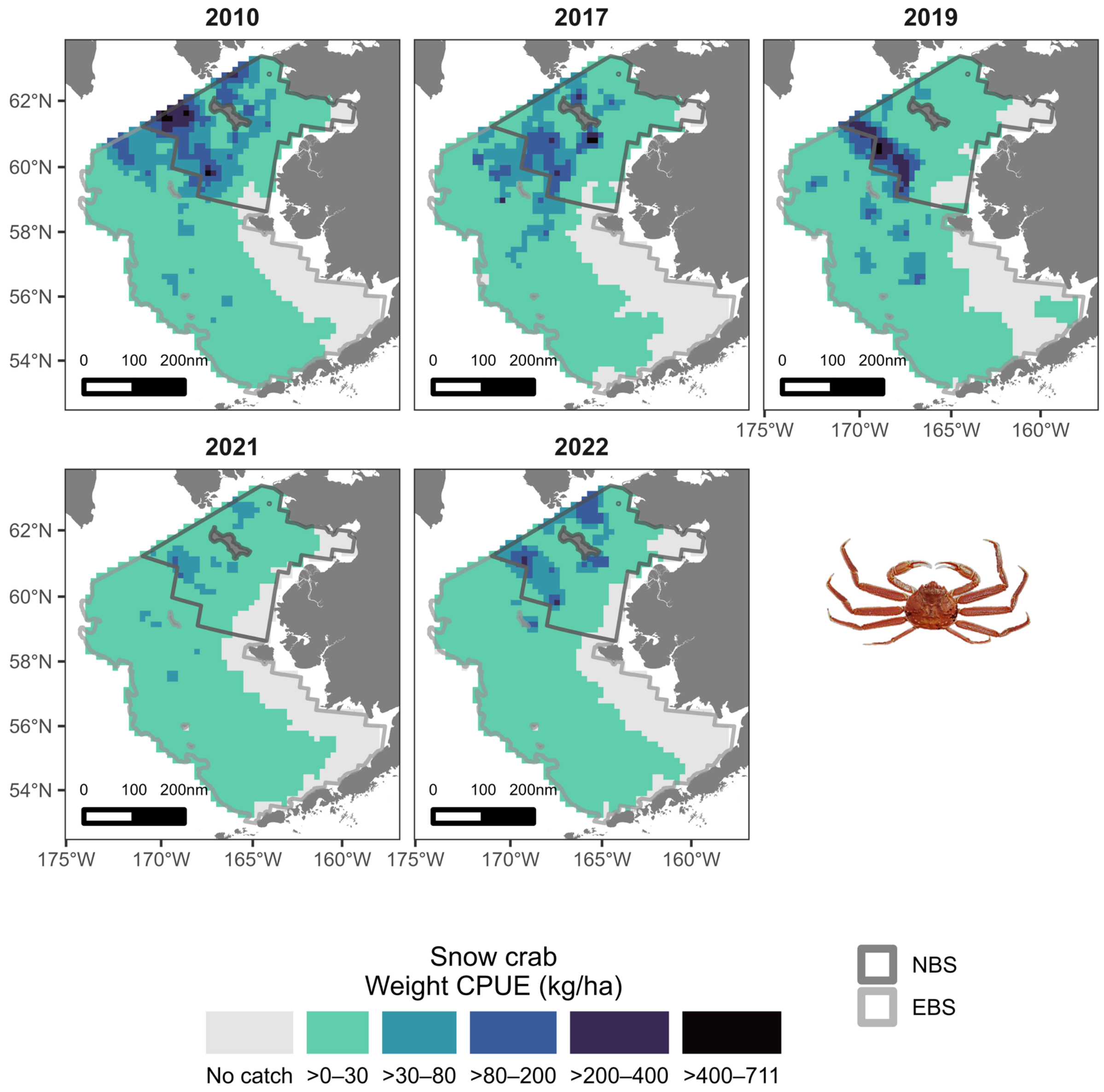

Figure 30. – Snow crab (*Chionoecetes opilio*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Alaska Skate (*Bathyraja parmifera*)

The Alaska skate is the most abundant skate on the continental shelf of the Bering Sea. A similar size composition of Alaska skate has been observed for all years of the NBS survey (Figure 31). In 2022, Alaska skates were present at 50% (72 of 144) NBS stations, at depths between 22 and 78 m, and where bottom temperatures were between -1.6°C and 9.4°C (Figure 32). Compared with 2021 (80,207 mt), Alaska skate biomass in 2022 (48,920 mt; Table 1) in the NBS declined by 39%. Their distribution was relatively consistent across the shelf in 2022, except in the area north of St. Lawrence Island to the Bering Strait, and in Norton Sound where no Alaska Skate was encountered (Figure 32).

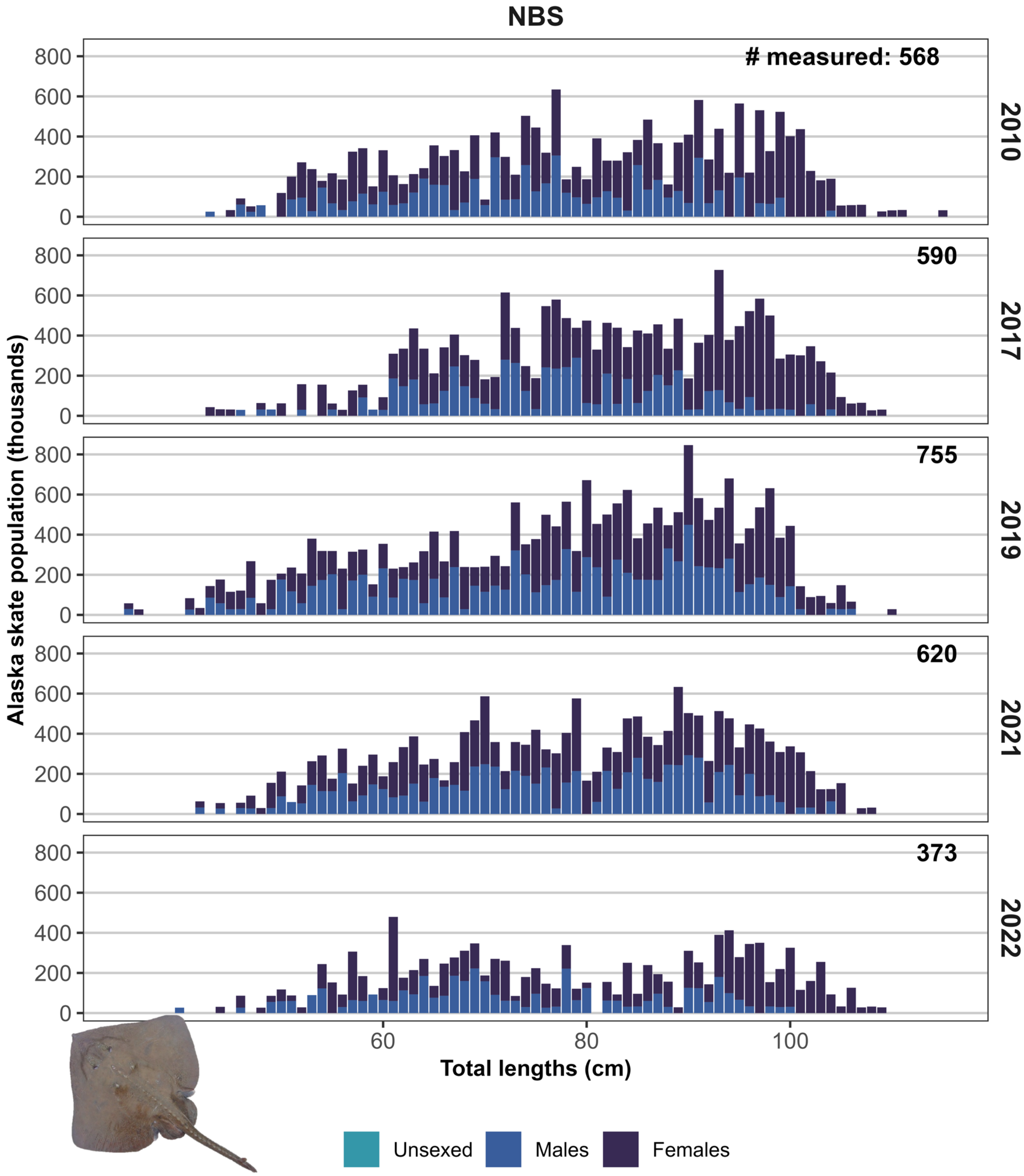

Figure 31. – Total abundance-at-size estimates of Alaska skate (*Bathyraja parmifera*) by sex (unsexed, males, and females) in centimeters (cm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

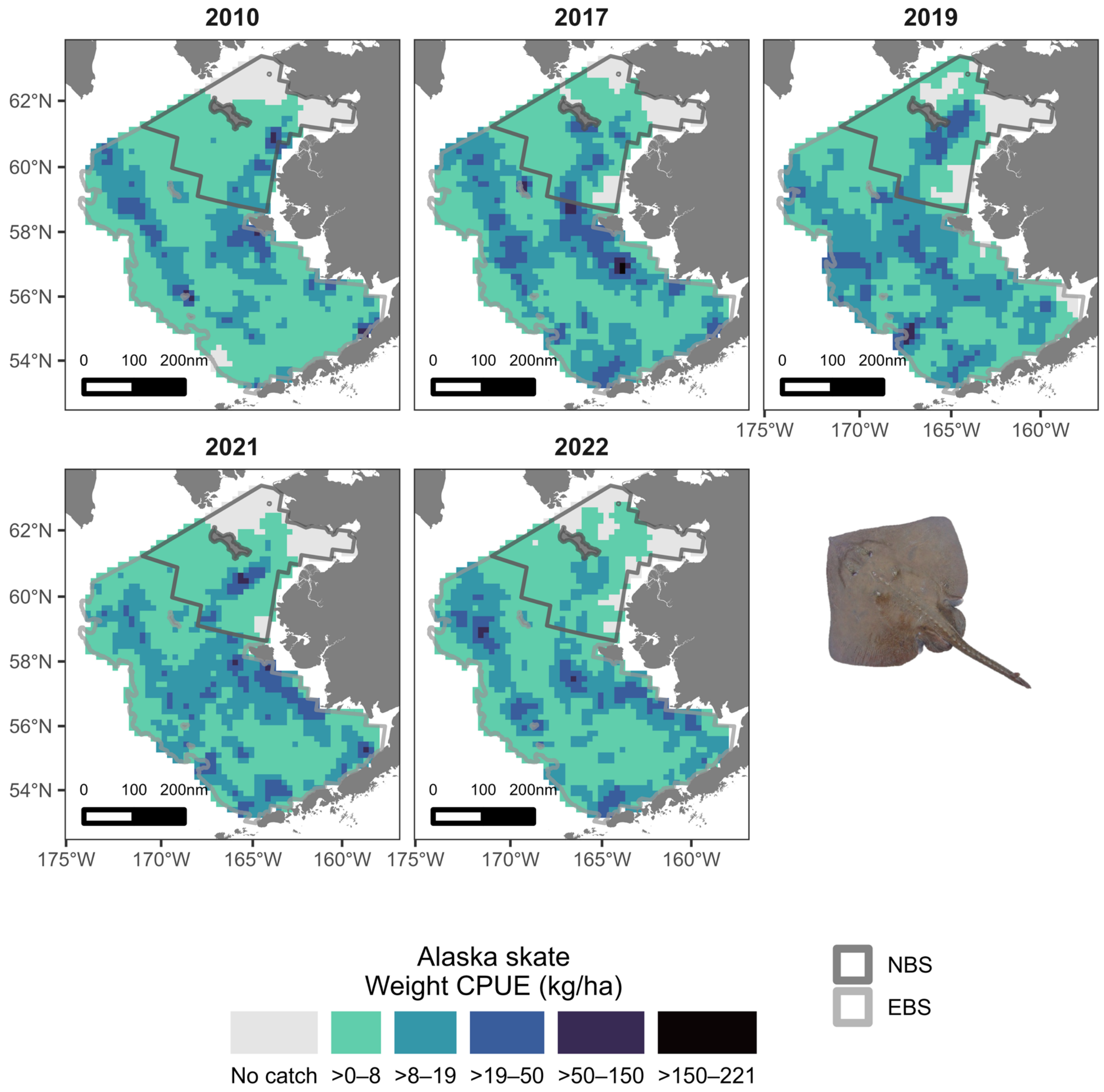

Figure 32. – Alaska skate (*Bathyraja parmifera*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Shorthorn Sculpin (*Myoxocephalus scorpius*)

The shorthorn sculpin was previously referred to as warty sculpin because of the presence of stellate scale patches, which appear similar to warts, on the body. During the 2022 survey, shorthorn sculpin were present at 16% (23 of 144 stations) of NBS stations. In the NBS, shorthorn sculpin were captured at depths between 22 m and 55 m and at bottom temperatures between 0.8°C and 7.2°C (Figure 34). The size distribution of shorthorn sculpin in the 2022 NBS survey ranged from individuals with fork lengths of 6 cm to 54 cm (Figure 33). Compared with 2021 (7,627 mt), shorthorn sculpin biomass in 2022 (3,664 mt; Table 1) in the NBS experienced a 52% decrease. The highest densities of shorthorn sculpin in 2022 occurred north of St. Lawrence Island and around St. Matthew Island (Figure 34).

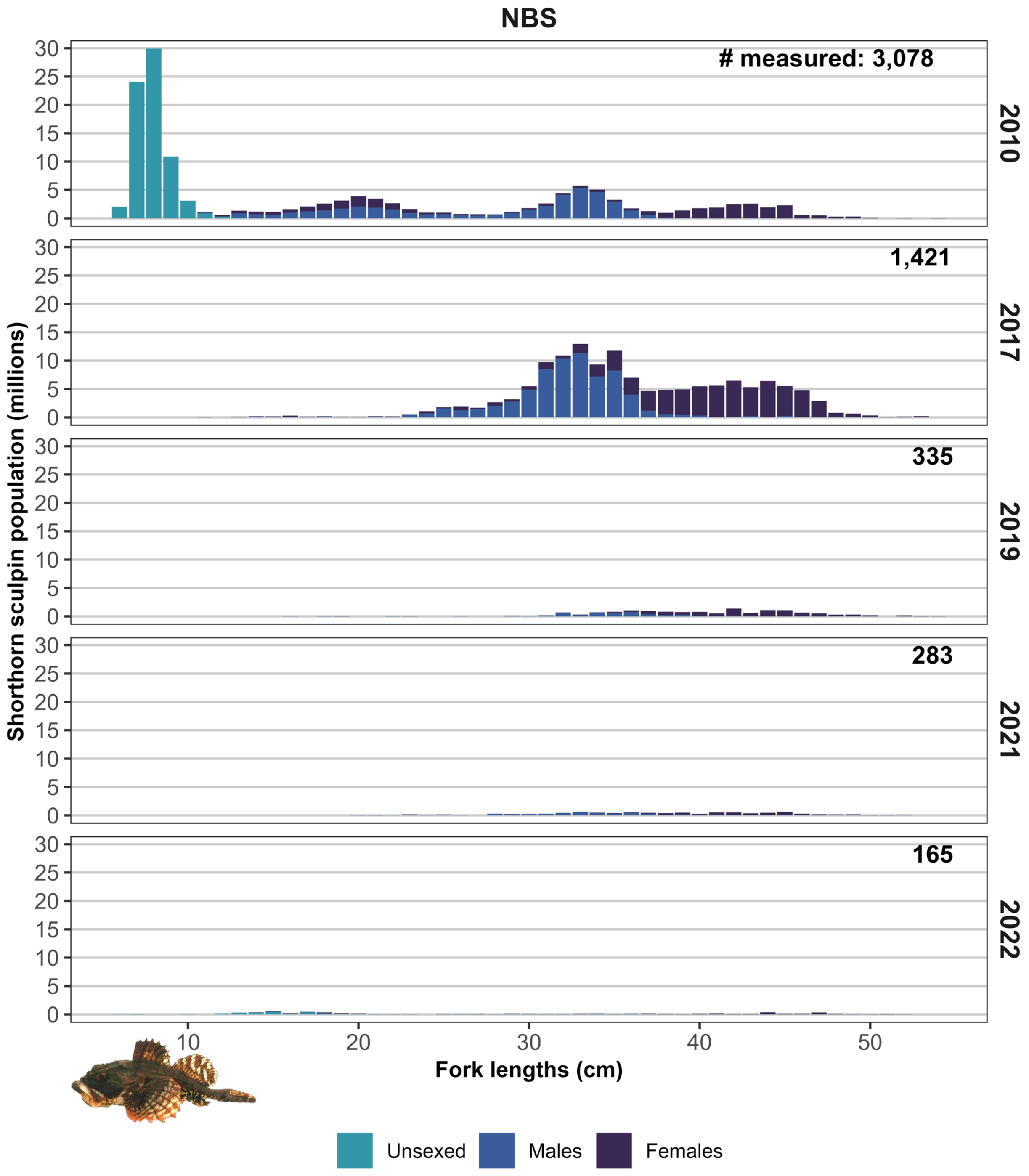

Figure 33. – Total abundance-at-size estimates of shorthorn sculpin (*Myoxocephalus scorpius*) by sex (unsexed, males, and females) in centimeters (cm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

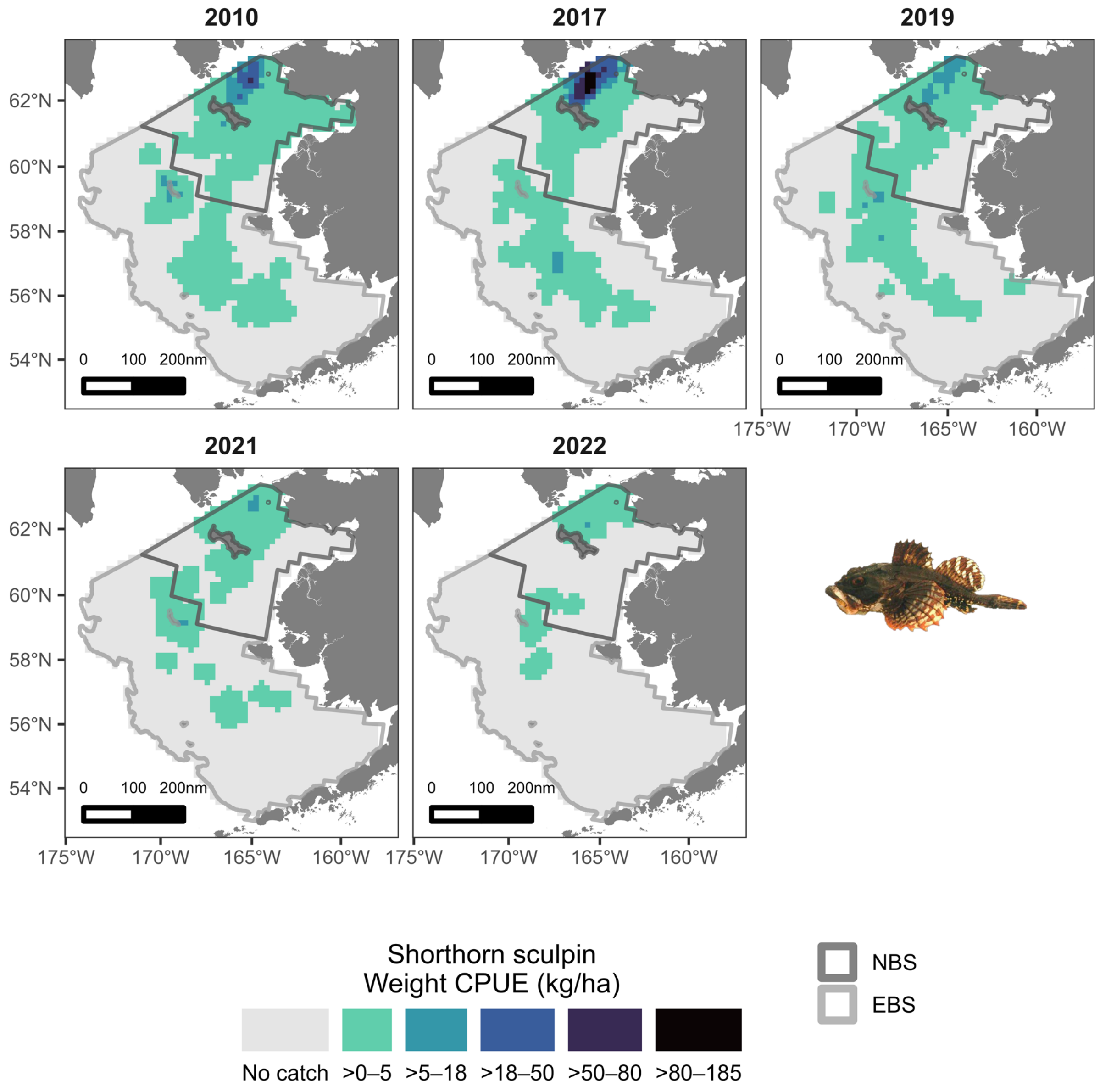

Figure 34. – Shorthorn sculpin (*Myoxocephalus scorpius*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Plain Sculpin (*Myoxocephalus jaok*)

In 2022, plain sculpin were present at 60.4% (87 of 144) of NBS stations, at depths between 11 and 56 m and temperatures between -1.4 and 12°C. There was a 25% decrease in plain sculpin biomass in the NBS between 2021 and 2022 (Table 1). The length composition of plain sculpin in 2022 was similar to that in previous years, with fork lengths of individuals ranging from 6 to 94 cm (Figure 35). The density of plain sculpin was highest east of St. Lawrence Island and both northwest and south of Nunivak (Figure 36).

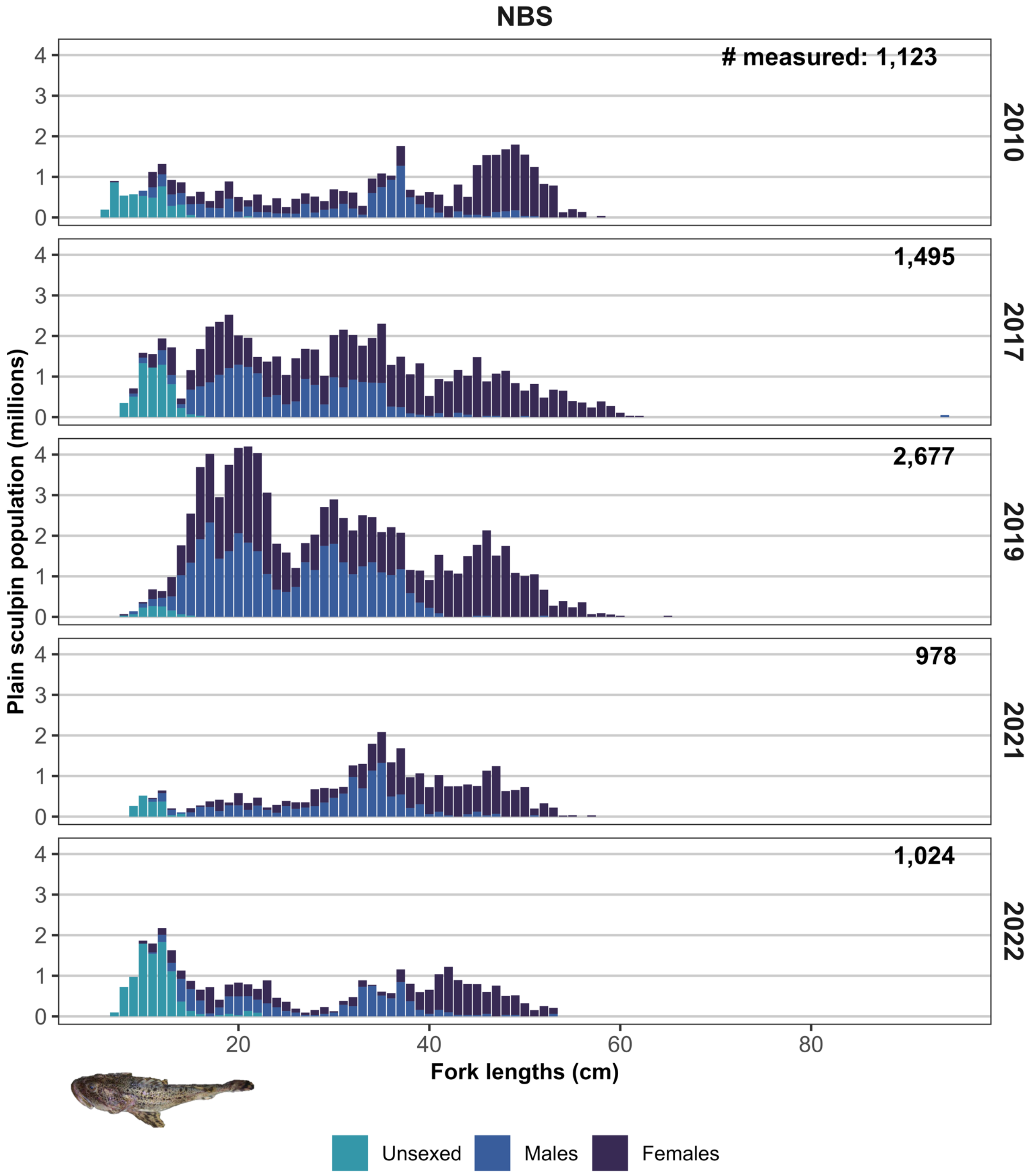

Figure 35. – Total abundance-at-size estimates of plain sculpin (*Myoxocephalus jaok*) by sex (unsexed, males, and females) in centimeters (cm) observed during the 2010, 2017, 2019, 2021, and 2022 NBS shelf bottom trawl surveys. Length distributions scaled up to total estimated population size. Total number of individuals measured during the survey is indicated in the upper right corner of each plot.

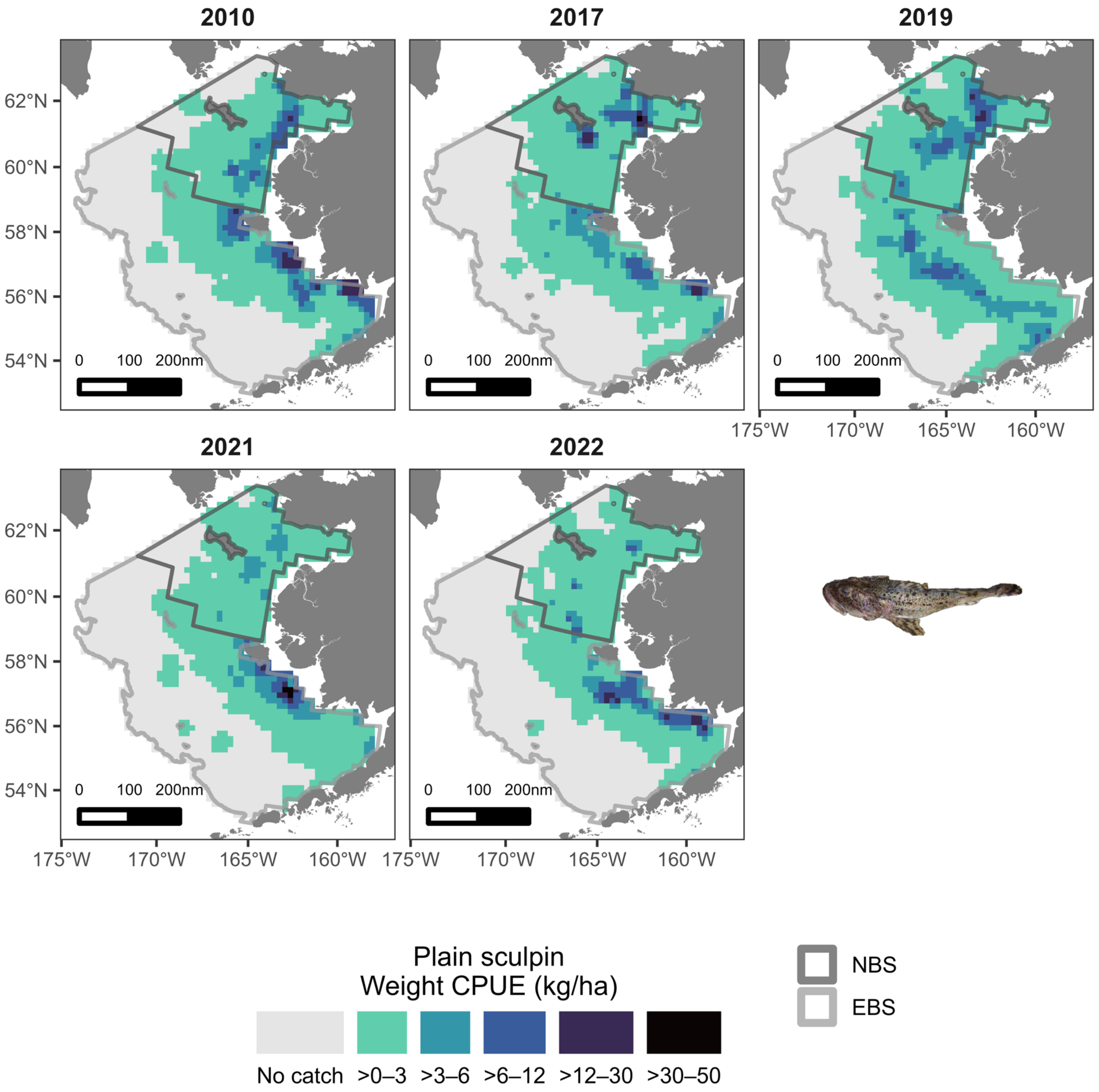

Figure 36. – Plain sculpin (*Myoxocephalus jaok*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Purple-Orange Sea Star (*Asterias amurensis*)

In 2022, purple-orange sea star, also known as the northern Pacific sea star, comprised 10% (312,625 mt; Table 1) of the NBS survey estimated biomass. Previously, in 2021, purple-orange sea star also comprised 10% (270,646 mt; Table 1) of the NBS survey estimated biomass. Compared with 2021 (270,646 mt), purple-orange sea star estimated NBS biomass in 2022 (312,625 mt; Table 1) experienced a 16% increase. Previously, purple-orange sea star estimated biomass in 2021 experienced a 35% decrease when compared to estimated biomass in 2019 (414,448 mt; Table 1). Densities of the purple-orange sea star within the NBS survey area were highest along the western coastline off Port Clarence and along the northeastern coastline of Norton Sound (Figure 37).

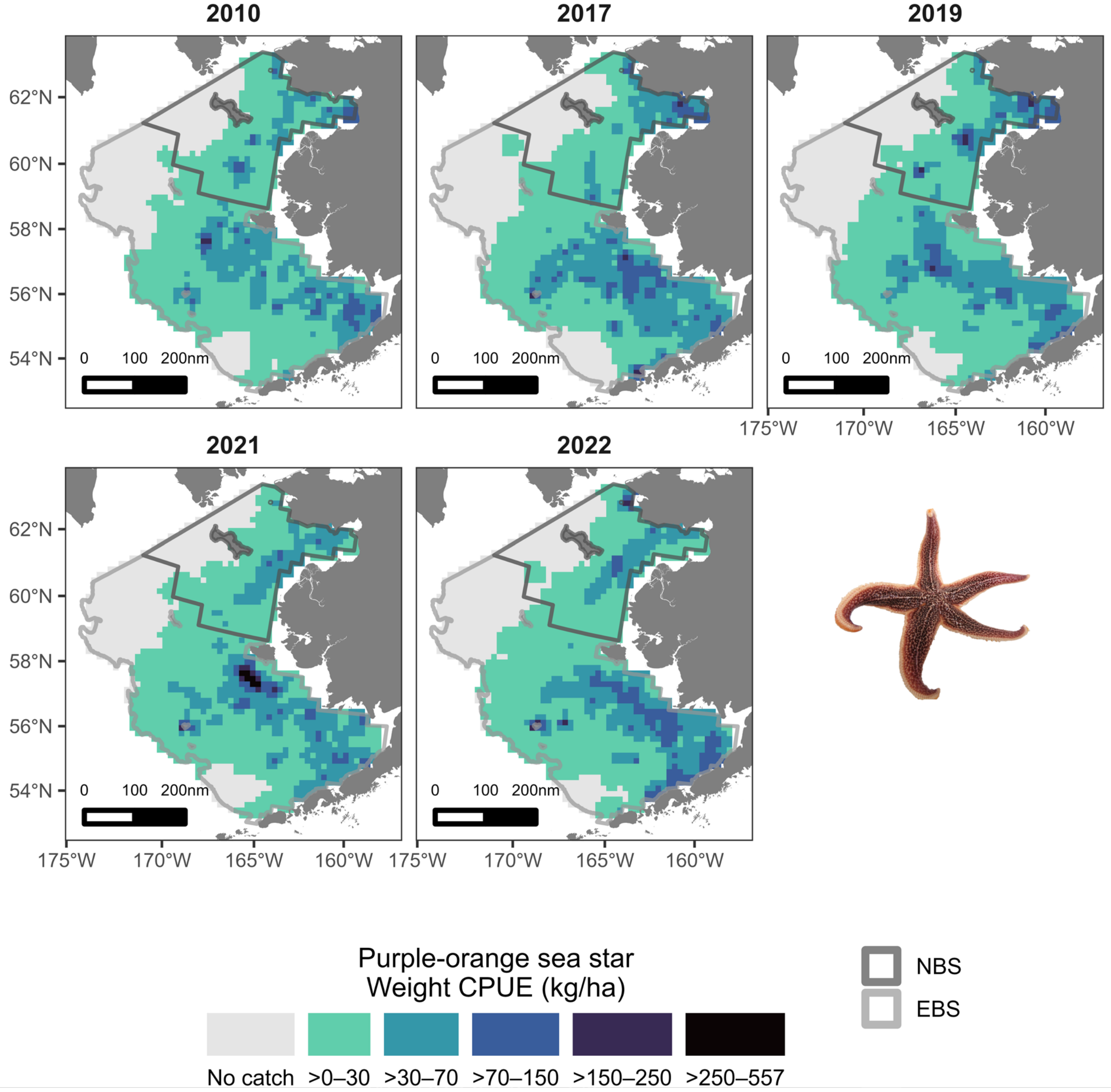

Figure 37. – Purple-orange sea star (*Asterias amurensis*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Sea Urchins (*Strongylocentrotus* spp.)

In 2022, sea urchins of the genus *Strongylocentrotus*, were present at 24.3% (35 of 144) NBS stations, at depths between 11 and 53 m, and at bottom temperatures between -0.9°C and 11.6°C. Compared with 2021, sea urchin estimated NBS biomass in 2022 experienced a 185% increase. In all five NBS surveys (2010, 2017, 2019, 2021 and 2022), the highest densities were observed just north of St. Lawrence Island (Figure 38).

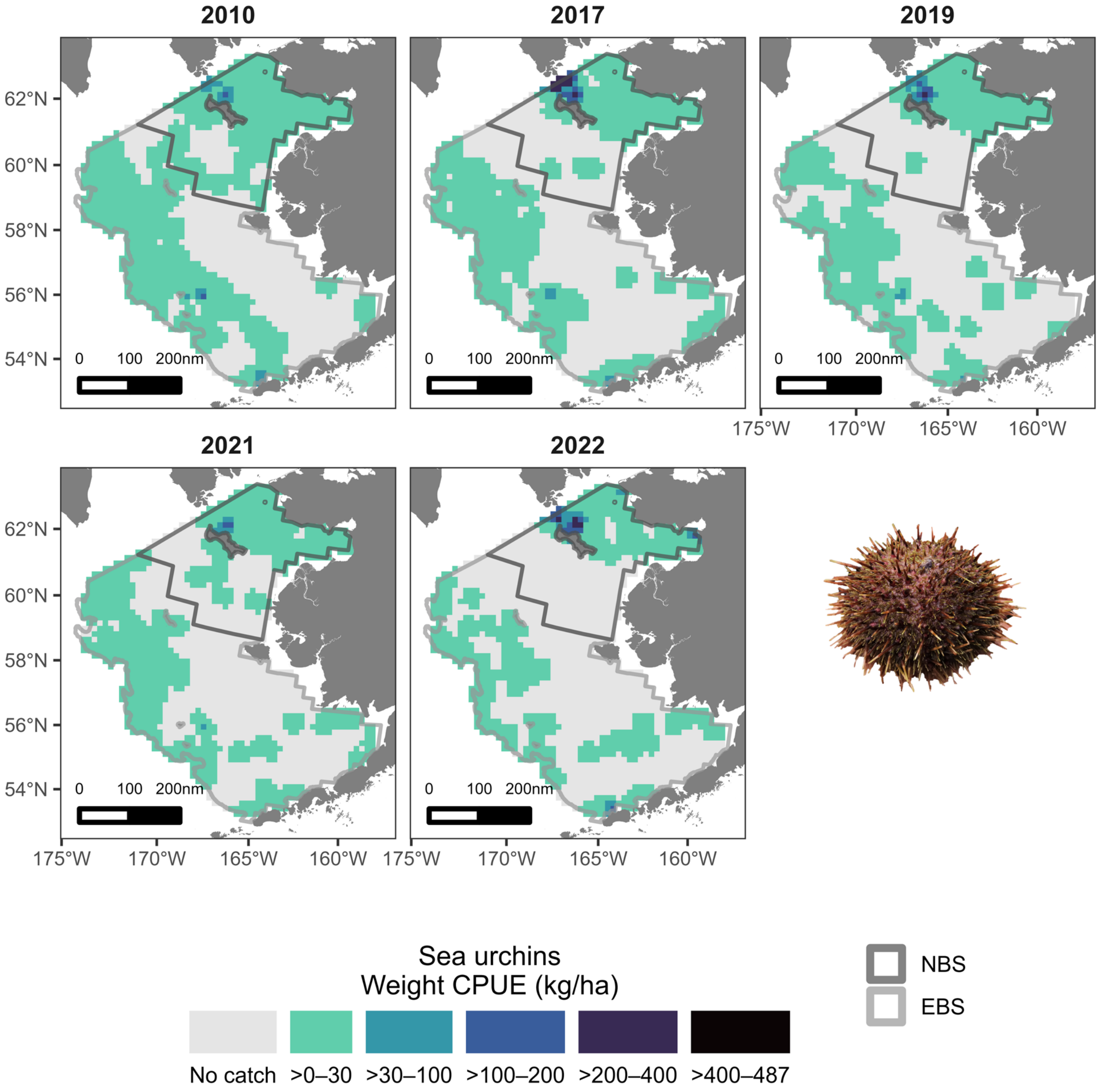

Figure 38. – Sea urchins (*Strongylocentrotus* spp.) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Jellyfish (Scyphozoa)

In the NBS, the jellyfish biomass increased 30% between 2021 and 2022 (Table 1), with jellyfish present at 78.7% (112 of 144) NBS stations. In 2022, jellyfishes had a relatively even distribution throughout the NBS, with a greater concentration found southwest of Norton Sound (Figure 39). In the 2022 NBS survey jellyfishes were found at bottom temperatures between -1.7 and 12°C, and at depths between 11 and 78 m. Jellyfishes play important roles as both predator and prey within the Bering Sea ecosystem. Large jellyfish blooms can have a significant effect 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).

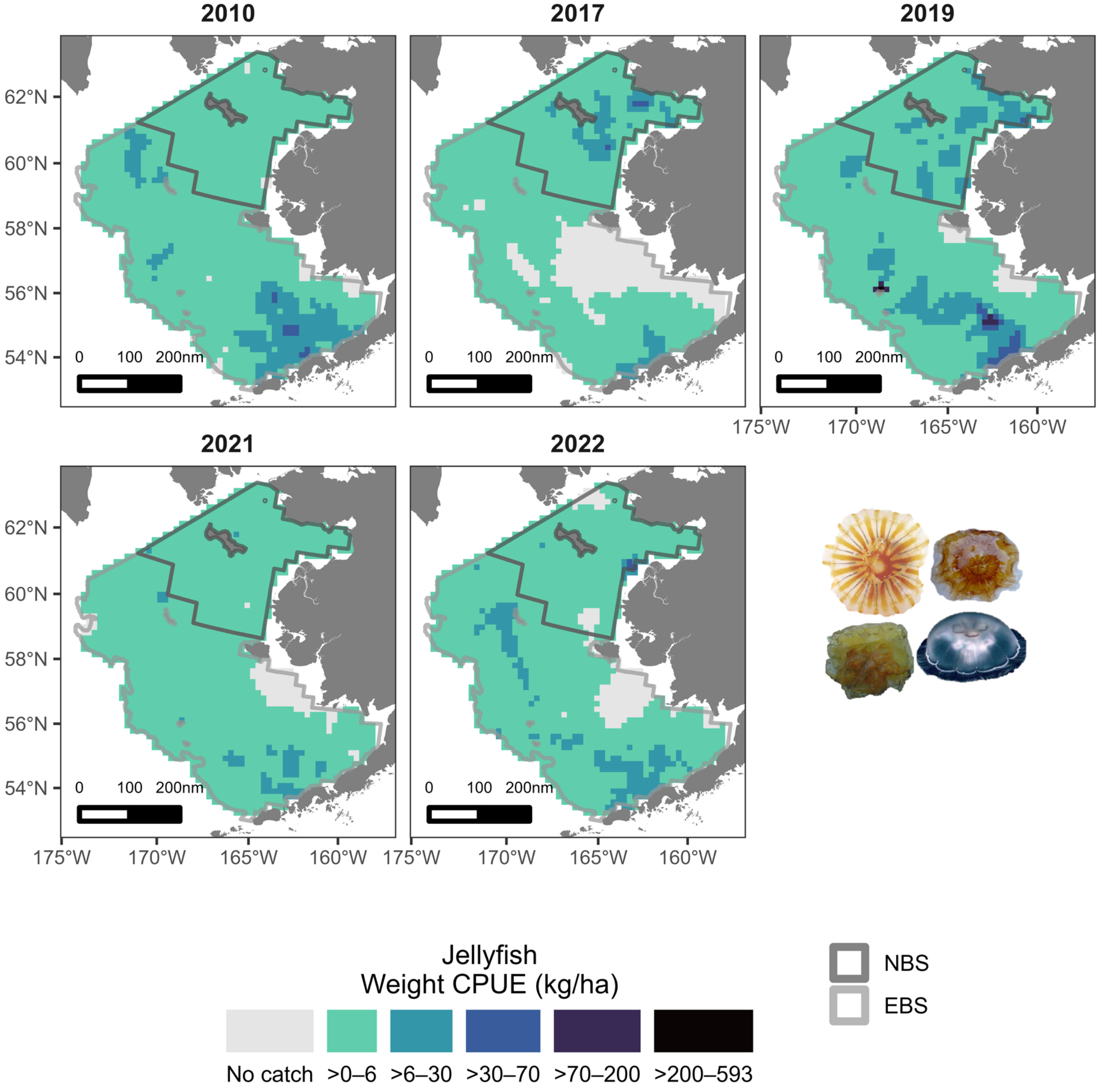

Figure 39. – Jellyfish (Scyphozoa) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Northern Neptune Whelk (*Neptunea heros*)

In 2022, the northern Neptune whelk accounted for 5% (166,181 mt; Table 1) of the total NBS survey biomass. Previously, the species comprised 4% (114,183 mt; Table 1) of the 2021 NBS survey biomass. When comparing the above biomass numbers, the northern Neptune whelk experienced a 46% increase from 2021 to 2022. Previously, northern Neptune whelk biomass in 2021 experienced a 22% decrease when compared to biomass in 2019 (146,350 mt; Table 1). Northern Neptune whelk were found in bottom temperatures between -1.7°C and 11.6°C. The density of this species was highest to the northeast and to the south of St. Lawrence Island and the northeast corner of Norton Sound in 2022 (Figure 40).

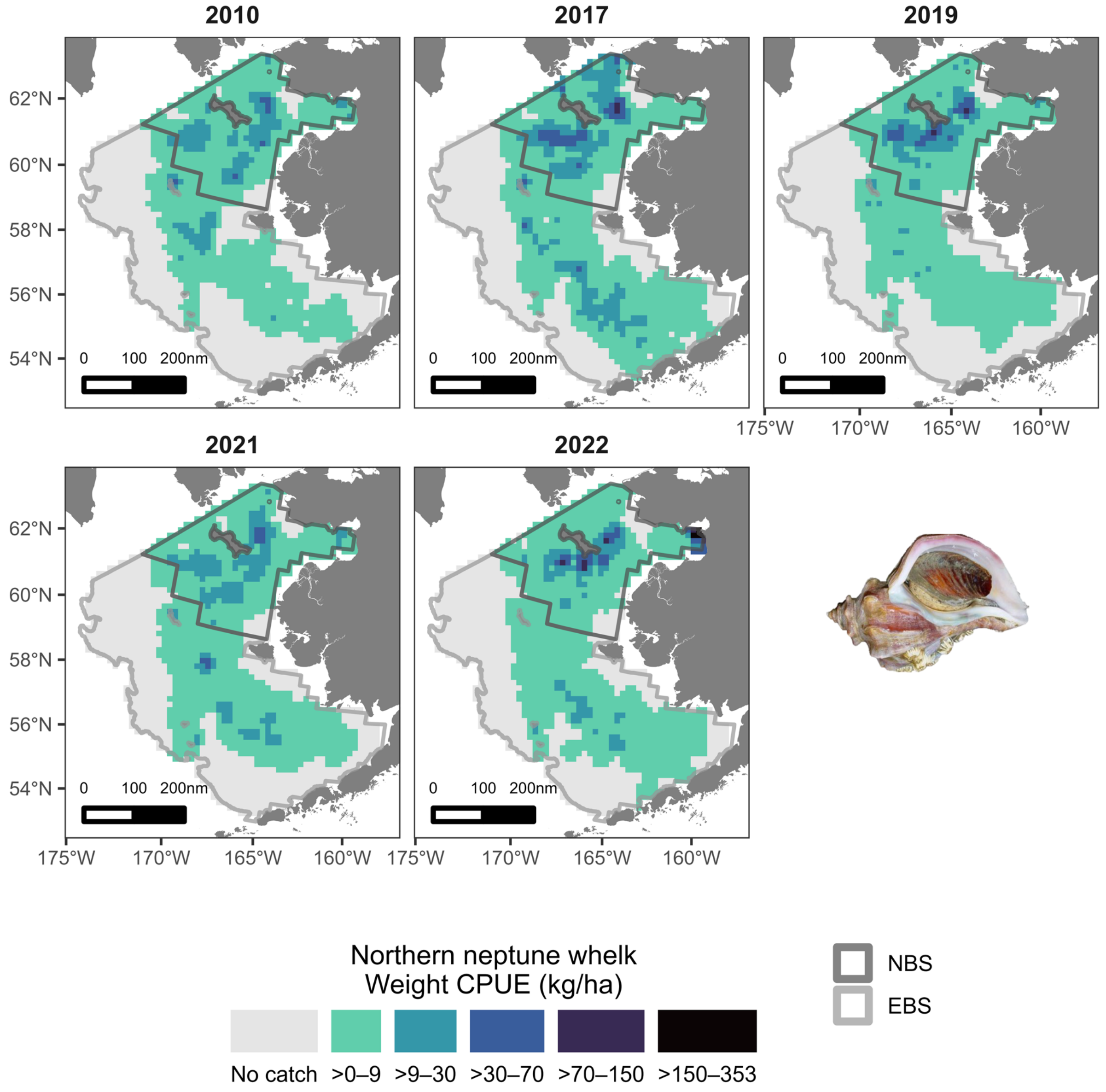

Figure 40. – Northern neptune whelk (*Neptunea heros*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

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 2022 NBS survey, sea onion density was highest on both the north and south of St. Lawrence Island (Figure 41). In 2022, sea onions were present at 13.2% of stations in the NBS (19 of 144 stations). These stations ranged in depth from 23 m to 55 m and recorded temperatures between -1.4°C and 10.2°C. Compared with 2021 (3,222 mt), sea onion biomass in 2022 (3,076 mt) in the NBS experienced a 5% decrease (Table 1). Previously, sea onion biomass in 2021 experienced a 98% increase when compared to biomass in 2019 (1,624 mt).

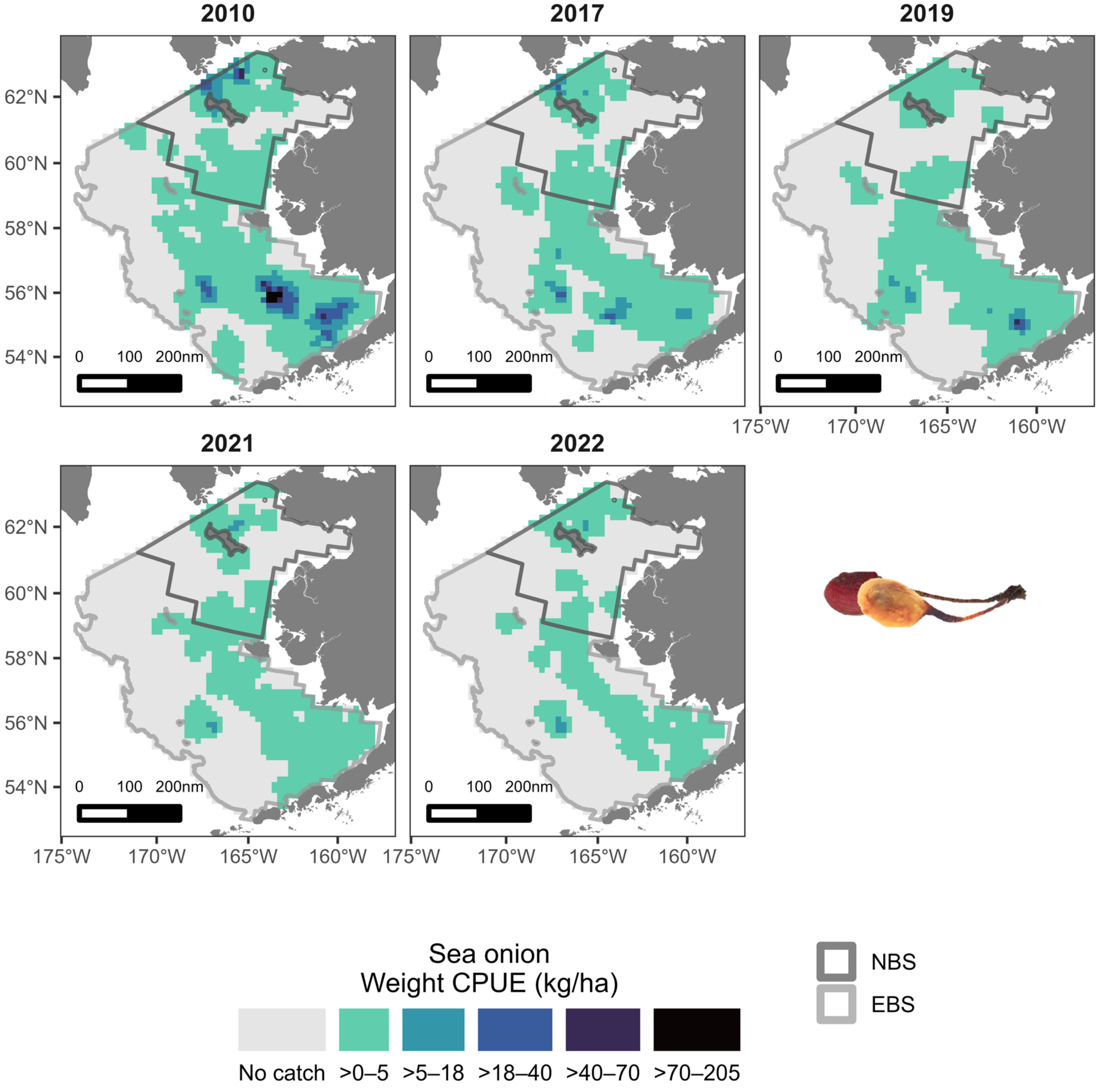

Figure 41. – Sea onion (*Boltenia ovifera*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Sea Peach (*Halocynthia* sp.)

Sea peaches are large, solitary ascidians, which are often found in clusters. Out of all successful NBS hauls (144), sea peaches were found during 3 hauls (2.1% of stations) covering bottom temperatures between 1.3°C and 3.8°C and depths between 36 m and 59 m. Compared with 2021 (1,426 mt), sea peach biomass in 2022 (525 mt; Table 1) in the NBS experienced a 63% decrease. Previously, sea peach biomass in 2021 experienced a 27% decrease when compared to biomass in 2019 (1,955 mt; Table 1).

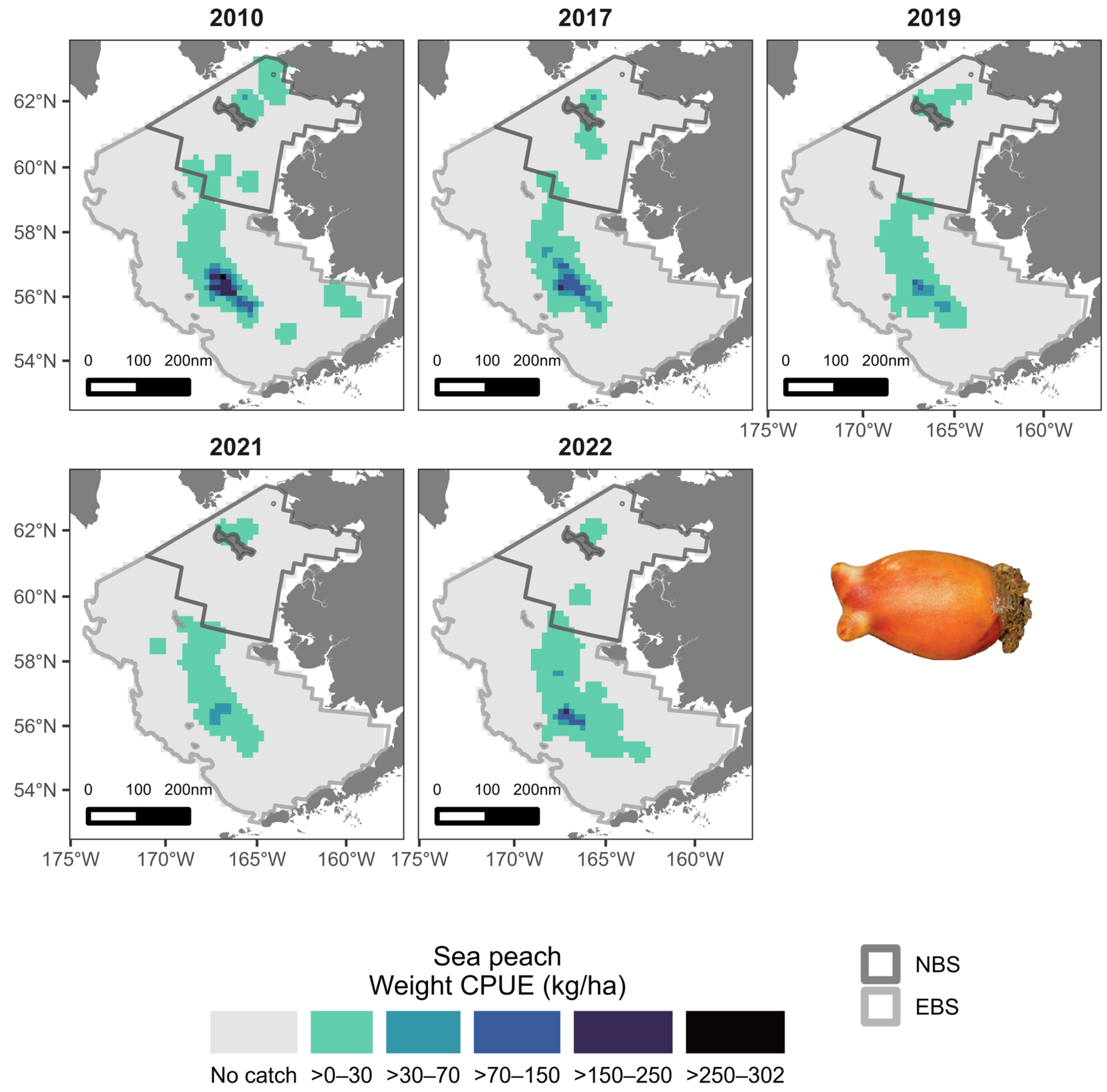

Figure 42. – Sea peach (*Halocynthia* sp.) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Pacific Herring (*Clupea pallasii*)

The relative biomass of Pacific herring decreased 80% from 2021 (60,931 mt) to 2022 (12,178 mt; Table 1). Pacific herring were present at 48.6% (70 of 144) of 2022 NBS stations in depths between 11 m and 78 m. Lengths of Pacific herring have not historically been recorded during the EBS and NBS surveys. Areas of highest density were located along the north of St. Lawrence Island (Figure 43).

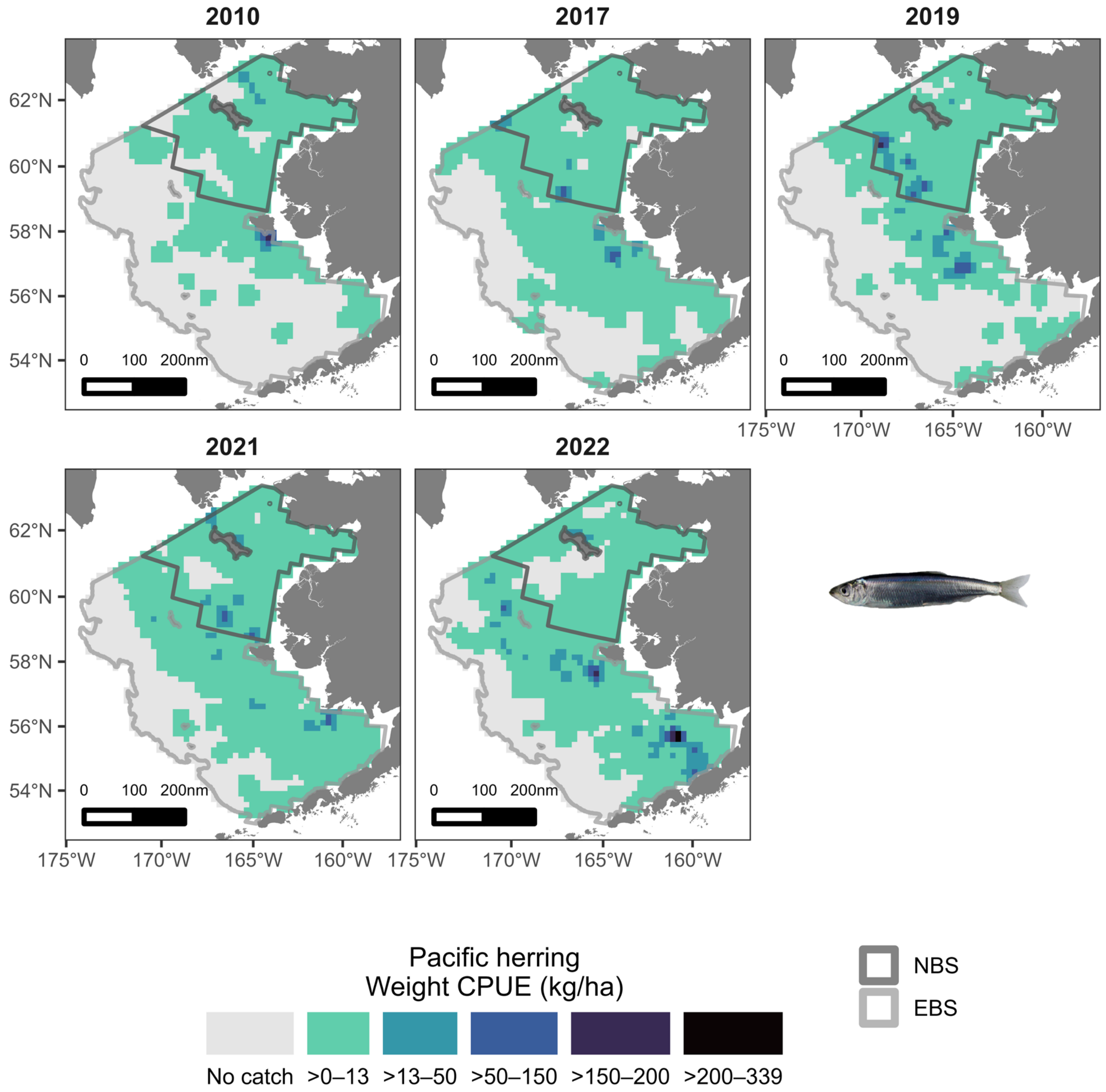

Figure 43. – Pacific herring (*Clupea pallasii*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Snailfishes (Liparidae)

In 2022, snailfishes were present at 13.3% (51 of 144) NBS stations, at depths between 17 and 78 m, and bottom temperatures between -1.7 and 11.2°C. In the 2022 NBS survey, snailfishes were captured in the waters surrounding St. Lawrence Island, as well as in Norton Sound (Figure 44). In comparison to 2021, snailfishes experienced a 92% increase in biomass in the 2022 NBS survey (Table 1). The species of snailfish most commonly encountered during the 2010, 2017, 2019, 2021 and 2022 NBS surveys was the variegated snailfish (*Liparis gibbus*), with 45 individuals captured in 2022. The other species of snailfish captured during the 2022 NBS survey were one monster snailfish, one nebulous snailfish, and six kelp snailfish. The 2010 NBS survey encountered the dusty, festive, kelp, monster, and variegated snailfish species, as well as some unidentified *Liparis* species. The 2017 NBS survey encountered festive, kelp, monster, peachskin, salmon and variegated snailfish species, as well as some unidentified *Liparis* species. In the 2019 NBS survey only monster and variegated snailfish were observed. During the 2021 NBS survey, unidentified snailfish were caught, as well as festive, kelp, monster, nebulous, peachskin and variegated snailfishes. Species information was added to this report by request of tribal councils.

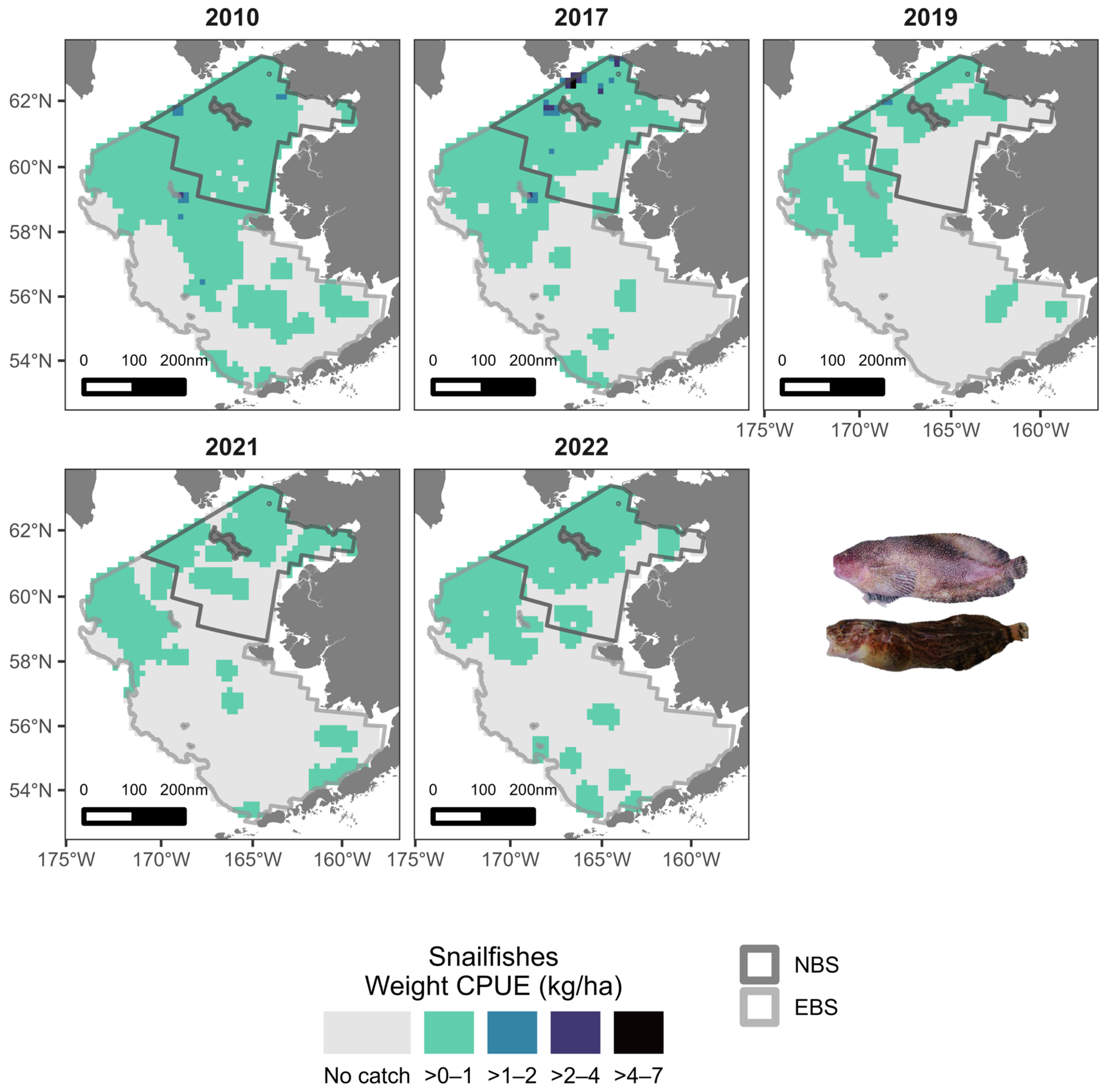

Figure 44. – Snailfishes (Liparidae) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Eulachon (*Thaleichthys pacificus*)

In 2022, no eulachon were encountered at any of the stations sampled in the NBS. The distribution of eulachon in the EBS in 2022 was northwest of Nunivak and northwest of the Alaska Peninsula and Aleutian Islands (Figure 45).

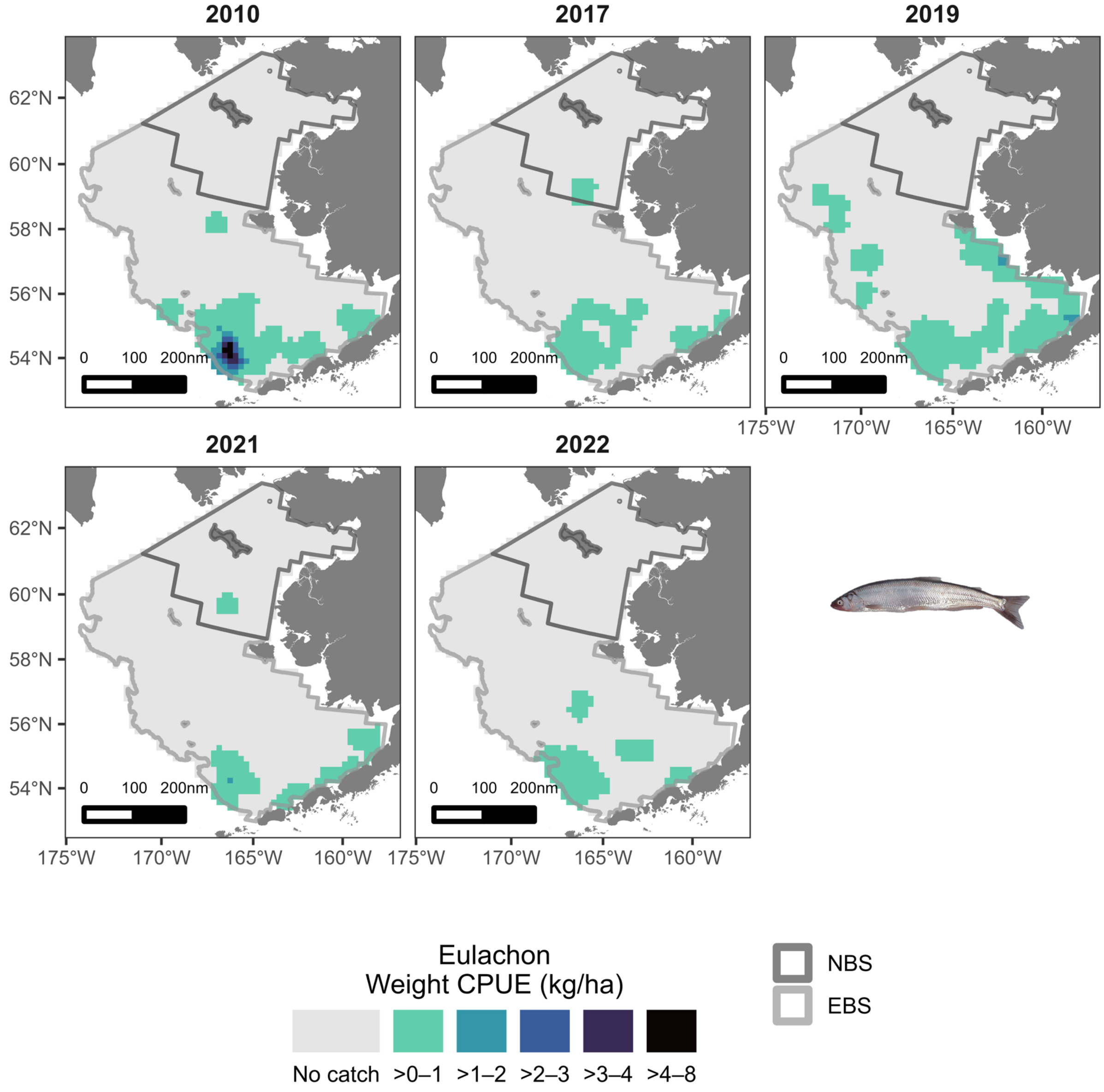

Figure 45. – Eulachon (*Thaleichthys pacificus*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Pacific Capelin (*Mallotus villosus*)

In 2022, Pacific capelin were present at 27.1% (39 of 144) of the NBS stations sampled, from depths between 22 m and 78 m. Compared with 2021 (76 mt), Pacific capelin estimated biomass in 2022 (72 mt; Table 1) in the NBS experienced a 5% decrease. Previously, Pacific capelin estimated biomass in 2021 experienced a 52% increase when compared to biomass in 2019 (50 mt; Table 1). This species was widely encountered to the southwest and east of St. Lawrence Island (Figure 46).

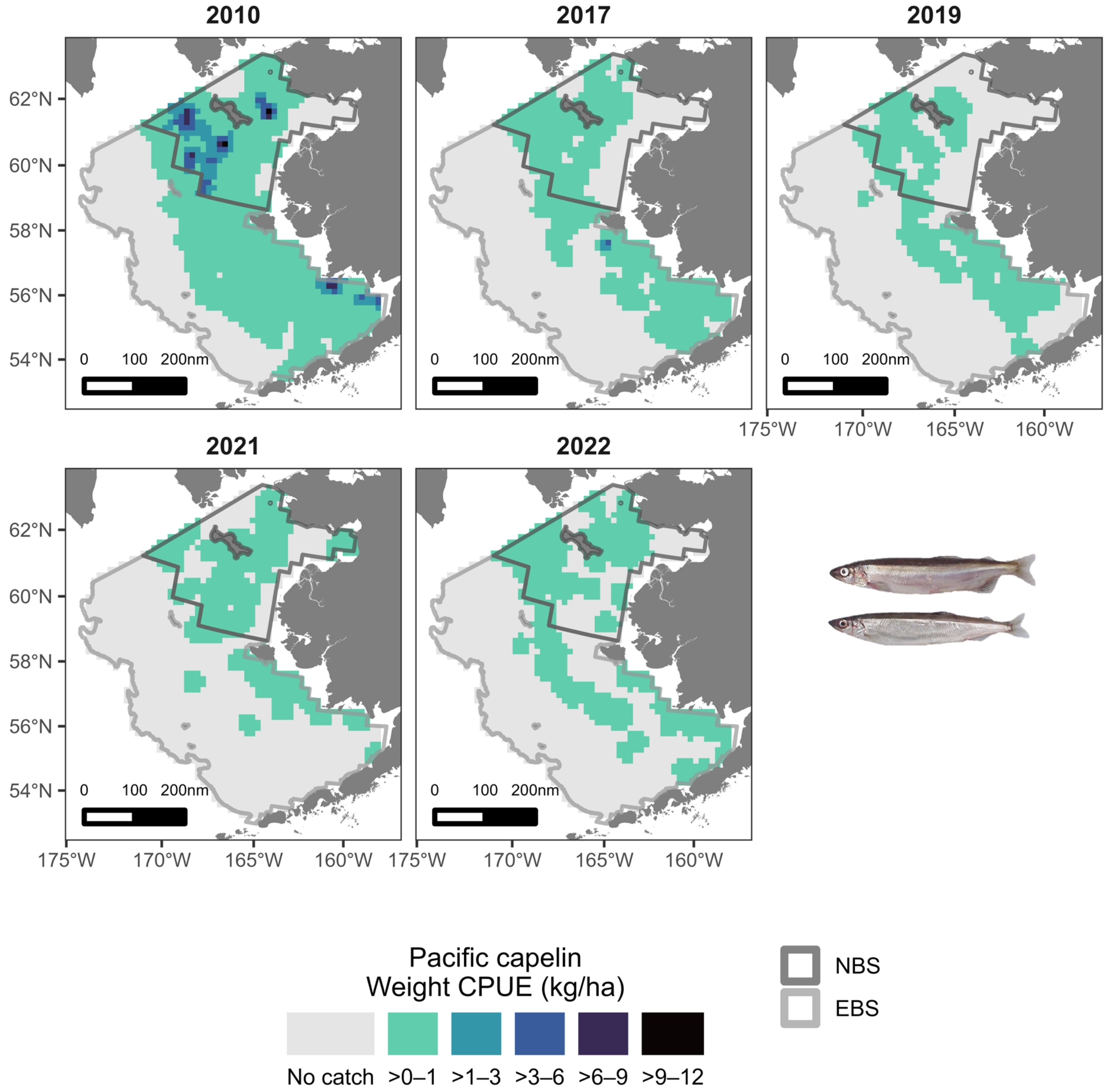

Figure 46. – Pacific capelin (*Mallotus villosus*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Rainbow Smelt (*Osmerus mordax*)

Rainbow smelt were present at 18.8% (27 of 144) of the 2022 NBS stations at depths between 11 m and 39 m. Compared with 2021 (1,873 mt), rainbow smelt estimated biomass in 2022 (1,367 mt; Table 1) in the NBS experienced a 27% decrease. Previously, rainbow smelt estimated biomass in 2021 experienced a 61% decrease when compared to estimated biomass in 2019 (4,842 mt; Table 1). Rainbow smelt distribution in the NBS in 2022 was primarily to the northeast and southeast of St. Lawrence Island, and throughout Norton Sound (Figure 47).

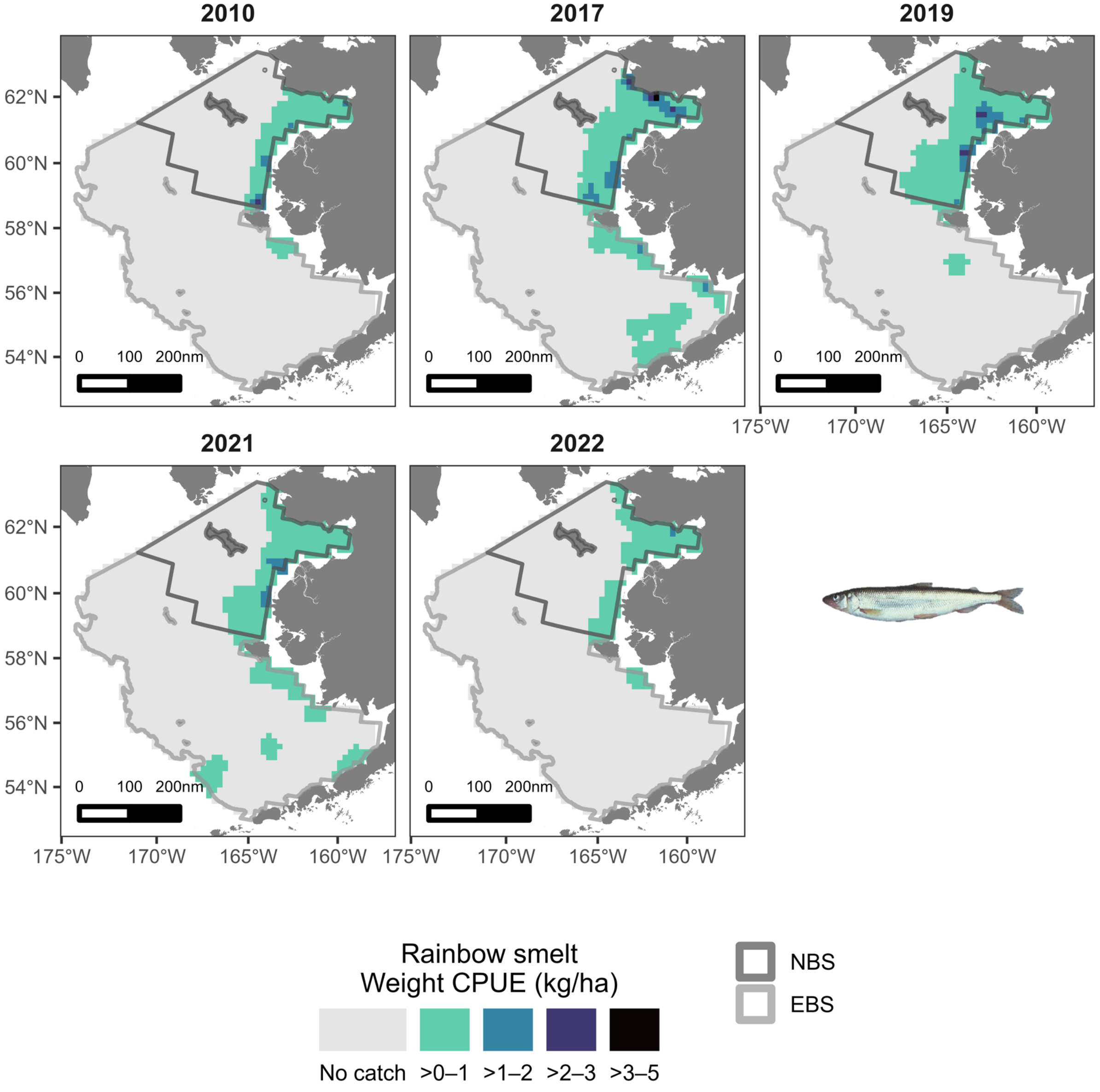

Figure 47. – Rainbow smelt (*Osmerus mordax*) distribution and weight CPUE (kg/ha) from the 2010, 2017, 2019, 2021, and 2022 EBS and NBS shelf bottom trawl surveys.

Scientist Profiles

Duane Stevenson

Groundfish Assessment Program
Bering Sea Survey Team Lead

Duane is a Supervisory 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. He recently became the team lead for the Bering Sea trawl survey group, overseeing AFSC bottom trawl surveys in the Bering Sea and Arctic. In his free time, Duane enjoys chasing birds with his dogs and riding anything with two wheels.

Liz Dawson

Groundfish Assessment Program
Bering Sea Survey Team

Liz has been a Fish Biologist with the group since January 2017. Prior to beginning her current position with NOAA, 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 publishing the survey results. Liz grew up snowmobiling and ice fishing in Minnesota. Liz is married to her college sweetheart, Jack, and they have two young children, Teddy (2) and Miggy (4 months), and a dog named Lily.

Emily Markowitz

Groundfish Assessment Program
Bering Sea Survey Team

Em is a Research Fisheries Biologist in Seattle, Washington. Prior to working at AFSC, she served as a 2018 Sea Grant Knauss Marine Policy Fellow and contractor for the protected species and fisheries socioeconomics teams at NOAA Fisheries' Office of Science and Technology in Silver Spring, Maryland. Em develops open science workflows with her team for everything from survey preparation to statistical fisheries model production. Em maintains strong opinions about New York pizza and bagels, and enjoys cooking, puzzles, and exploring above and below the surface, near and far!

Chris Anderson

Groundfish Assessment Program
Bering Sea Survey Team

Chris has been a Fisheries Biologist with NOAA at the Alaska Fisheries Science Center in Seattle, Washington since 2019. Prior to joining the Bering Sea group, he worked as an Alaskan Fisheries Observer and with the Fisheries Monitoring & Analysis Division assisting and guiding observers deployed in the field. He grew up in Minnesota hunting, fishing, snowmobiling, and skiing. Chris participates in the annual Bering Sea surveys, planning and preparing, and analyzing survey findings. When not at sea Chris enjoys cooking, diving, and playing games of all kinds, whether board games, video games, or tabletop roleplaying games.

Nicole Charriere

Groundfish Assessment Program
Bering Sea Survey Team

Nicole is a Fish Biologist in Seattle, Washington. Prior to joining the Bering Sea group in January 2021, Nicole spent over a decade at 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 enjoyed spending about a third of the year out at sea to help 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 hometown of Seattle, Nicole enjoys soccer, WW2 code breaking history, scuba diving, and playing the guitar.

Bianca Prohaska

Groundfish Assessment Program
Bering Sea Survey Team

Bianca is a Research Fish Biologist in Seattle, Washington. 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.

Sean Rohan

Groundfish Assessment Program
Bering Sea Survey Team

Sean is a Research Fisheries in Seattle, Washington. He 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, and spending time outdoors.

Jon Richar

Shellfish Assessment Program

Jon is a Research Fish Biologist in Kodiak, Alaska, and has been in this position since January 2017. Jon manages the SAP Bering Sea crab 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.

Data Sources

The data collection efforts that constitute the annual Bering Sea bottom trawl survey take place each summer by the Groundfish Assessment Program's Bering Sea Team and the Shellfish Assessment Program. These data are then extrapolated to catch-per-unit-effort (CPUE), population-level abundance, population-level abundance by size class, and population-level biomass estimates.

This document was generated using R and R Markdown. R is a coding language and environment for statistical computing and graphics. R Markdown provides a framework for reproducible, transparent, and documentable report writing.

Many of the data sources and tools used to develop the plots and content of this document have been developed by members across the AFSC's Groundfish Assessment Program. These tools and public-serving data products aim to increase transparency and accessibility to Bering Sea ecosystem data. The *akgfmaps* R package (https://github.com/afsc-gap-products/akgfmaps), developed by Sean Rohan, was used for producing the species distribution plots and other maps in this document. The *coldpool* R package (https://github.com/afsc-gap-products/coldpool), 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 (Rohan, Barnett, and Charriere in review).

The catch, environmental, and location data collected and calculated from the survey can be accessed directly and downloaded from the Fisheries One Stop Shop data webportal (https://www.fisheries.noaa.gov/foss/f?p=215:200:1099772399154:Mail:NO:::). Users can interactively select, view, and download data for this and other surveys conducted by AFSC's Resource Assessment and Conservation Engineering Division. Data from this and other fisheries-independent surveys are also used in the NOAA Fisheries Distribution Mapping and Analysis Portal (DisMAP), which provides easy access to information to track and understand distributions of marine species in U.S. Marine Ecosystems https://apps-st.fisheries.noaa.gov/dismap/.

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We would like to thank the many communities of the Bering Strait region and their members who have helped contribute to this document. 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 their insights, including the local names used for the species covered by this document, identifying species of interest or concern that should be included in this document, and participation in an open dialog about how we can improve our collective knowledge of the ecosystem and the region.

Recent Technical Memorandums

Copies of NOAA Technical Memorandums are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22167 (web site: www.ntis.gov). Paper and electronic (.pdf) copies vary in price. The recent Technical Memoranda produced by the Alaska Fisheries Science Center can be found at https://www.fisheries.noaa.gov/resource/publication-database/alaska-fisheries-science-center-technical-memorandums.

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