Appendix2. Preliminary assessment of forage species in the Bering Sea and Aleutian Islands

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Introduction to the new forage species reports and their relation to the ecosystem considerations chapter

Beginning in 2012, a new approach was initiated for reporting on Alaska marine forage species that occurs as part of the North Pacific Fishery Management Council's (NPFMC) annual stock assessment process. These changes were accepted for the 2012 Gulf of Alaska (GOA) forage fish report, and this 2013 document represents the first forage fish report for the Bering Sea and Aleutian Islands (BSAI). The primary changes are:

1) Historically, a forage fish report has been prepared for only the GOA. As of 2013 there will be reports for both the GOA and the BSAI areas. A regular schedule of reporting will be established, most likely on a biennial basis that corresponds with the "off-survey" year in each area.
2) The forage report has historically focused only on those species included in the "forage fish" group included in the fishery management plan (FMP) for each area. However, the group excludes key forage species that are managed elsewhere in or independently of the NPFMC process. To provide a fuller assessment of the marine forage base in Alaska, the forage species reports will now consider a wider range of species.
3) Another historical characteristic of the forage fish reports is that they have been a catch-all repository for information on forage fishes. The reports will still include some descriptive information on forage species. However to make the document more useful and relevant, the focus will be narrowed to these main issues:
    a) Monitoring of the distribution, abundance, and availability to predators of forage species in Alaska. This is the most important content in the report, and the most challenging to address. Dedicated forage surveys do not exist in Alaska, and the existing surveys are inadequate for monitoring most forage species. As a result, this section will contain a variety of different types of data.
    b) Bycatch data and reporting on other conservation issues. This section will deal mainly with bycatch in federal fisheries, but other impacts to forage species may be included.
4) The forage reports will be tightly coordinated with the ecosystem considerations chapter. Some types of data (e.g. survey biomass timeseries) have been removed from the ecosystems chapter and will now reside exclusively in the forage fish reports. Other data types (e.g. predator diets) may exist in both reports but the forage fish report will include a broader description of these data. The rationale for this new coordination is that the ecosystem chapter should be limited to those data that are thought to be reliable ecosystem indicators, rather than just all of the survey time series. In contrast, the forage species report will be a repository for all relevant indices of abundance/population status/prey availability that are available, with greater exploration of each index than is possible in the ecosystem chapter.

NOTE: This report has been titled "preliminary assessment" because it is the first instance of a BSAI forage fish report. This report will change substantially as a result of discussions among the author, the Plan Team, and the SSC.

Recent developments

- Forage fishes received considerable attention in 2012. In April, the Lenfest Ocean Program released a report analyzing forage fish management on a global scale (http://www.lenfestocean.org/foragefish). The analysis focuses on the role of forage fishes in ecosystems and the impacts of directed fishing for forage species. A symposium on the conservation of forage fishes on the US West Coast and in British Columbia and Alaska was held in Washington state in September. In November, the International Council for the Exploration of the Sea will hold a forage fish symposium in France. These events are likely to raise the public profile of forage fishes.
- The Midwater Assessment and Conservation Engineering group at the Alaska Fisheries Science Center has developed a method for distinguishing euphausiid biomass from acoustic backscatter in acoustic surveys for pollock. The results are discussed here and will provide a valuable forage index in the future.

Responses to Plan Team and SSC comments

SSC comment December 2009: "The [forage fish] chapter reports that forage fish species in the GOA (with over 60 species) are similar to those in the Bering Sea, and thus this summary for GOA suffices for both regions. However, the SSC notes that species composition is not the same between regions, and requests that future reports and executive summaries provide results for both BS and GOA. Graphs of relative CPUE of forage fish by regions are in the EC for both GOA and BS; in addition to these, SSC requests that forage fish sections include distribution maps from trawl surveys and acoustical survey indices of abundance."

Response: The author agrees that the forage base in the BSAI is substantially different, and this report will begin to address forage issues in the BSAI. Key components of the new BSAI report (as well as the revised GOA report) are distribution maps based on aggregated trawl survey data.

Overview of forage species and their management

Defining "forage species" can be a difficult task, as most fish species experience predation at some point in their life cycle. A forage fish designation is sometimes applied only to small, energy-rich, schooling fishes like sardines and herring (e.g. Lenfest 2012), but in most ecosystems this is too limiting a description. Generally, forage species are those whose primary ecosystem role is as prey and that serve a critical link between lower and upper trophic levels. For this report, the following species or groups of species are considered to be critical components of the forage base in the Bering Sea and Aleutian Islands (BSAI) area:

- Members of the "forage fish group" listed in the BSAI Fishery Management Plan (FMP)
- Pacific herring *Clupea pallasii*
- juvenile groundfishes and salmon
- shrimps
- squids
- Arctic cod *Boreogadus saida*

Forage fish group in the FMP

Prior to 1998, forage fishes in the BSAI were either managed as part of the Other Species group (nontarget species caught incidentally in commercial fisheries) or were classified as "nonspecified" in the FMP, with no conservation measures. In 1998 Amendment 36 to the BSAI FMP created a separate forage fish category, with conservation measures that included a ban on directed fishing. Beginning in 2011, members of this forage fish group (the "FMP forage group" in this report) are considered "ecosystem components". The group is large and diverse, containing over fifty species from these taxonomic groups (see the appendix at the end of this report for a full list of species):

- Osmeridae (smelts; eulachon *Thaleichthys pacificus* and capelin *Mallotus villosus* are the principal species, with rainbow smelt *Osmerus mordax* locally abundant in some areas)
- Ammodytidae (sand lances; Pacific sand lance *Ammodytes hexapterus* is the only representative)
- Trichodontidae (sandfishes; Pacific sandfish *Trichodon trichodon* is the main species)
- Stichaeidae (pricklebacks)
- Pholidae (gunnels)
- Myctophidae (lanternfishes)
- Bathylagidae (blacksmelts)
- Gonostomatidae (bristlemouths)
- Euphausiacea (krill; these are crustaceans, not fish, but are considered essential forage)

The primary motivation for the creation of the FMP forage group was to prevent fishing-related impacts to the forage base in the BSAI; it was an early example of ecosystem-based fisheries management. The management measures for the group are specified in section 50 CFR 679b20.doc of the federal code:

50 CFR 679b20.doc § 679.20 General limitations

(i) Forage fish

(1) Definition. See Table 2c to this part.

(2) Applicability.

The provisions of § 679.20 (i) apply to all vessels fishing for groundfish in the BSAI or GOA, and to all vessels processing groundfish harvested in the BSAI or GOA.
(3) Closure to directed fishing.
Directed fishing for forage fish is prohibited at all times in the BSAI and GOA.
(4) Limits on sale, barter, trade, and processing.
The sale, barter, trade, or processing of forage fish is prohibited, except as provided in paragraph (i)(5) of this section.
(5) Allowable fishmeal production.
Retained catch of forage fish not exceeding the maximum retainable bycatch amount may be processed into fishmeal for sale, barter, or trade.

In sum, directed fishing for species in the FMP forage fish group is prohibited, catches are limited by a maximum retention allowance (MRA) of 2% by weight of the retained target species (Table 10 to 50 CFR part 679), and processing of forage fishes is limited to fishmeal production. While the basis for a 2% MRA is not entirely clear, it appears this percentage was chosen to accommodate existing levels of catch that were believed to be sustainable (Federal Register, 1998, vol. 63(51), pages 13009-13012). The intent of amendment 36 was thus to prevent an increase in forage fish removals, not to reduce existing levels of catch. In 1999, the state of Alaska adopted a statute with the same taxonomic groups and limitations (5 AAC 39.212 of the Alaska administrative code), except that no regulations were passed regarding the processing of forage fishes. This exception has caused some confusion regarding the onshore processing of forage fishes for human consumption (J. Bonney, pers. comm.).

Pacific herring

Herring are highly abundant and ubiquitous in Alaska marine waters. Commercial fisheries, mainly for herring roe, exist along the western coast of Alaska from Port Moller north to Norton Sound. The largest of these fisheries occurs in Togiak Bay in northern Bristol Bay: the Togiak catch in 2011 was 22,699 short tons out of a 23,428 short ton total catch for the BSAI. The herring fisheries are managed by the Alaska Department of Fish & Game (ADFG), which uses a combination of various types of surveys and population modeling to set catch limits. In federal fisheries herring are managed as Prohibited Species: directed fishing is banned and any bycatch must be returned to the sea immediately. The amount of herring bycatch allowed is also capped, and if the cap is exceeded the responsible target fishery is closed to limit further impacts to the species. In the BSAI, the Prohibited Species Catch Quota for herring is calculated as 1% of the estimated annual biomass of herring in the eastern Bering Sea.

Juvenile groundfishes and salmon

Members of this group, particularly age-0 and age-1 walleye pollock *Theragra chalcogramma*, are key forage species in the BSAI. As they are early life stages of important commercially fished species, however, their status depends almost entirely on the assessment and management of the recruited portion of the population. Highly detailed information regarding these species is available in NPFMC stock assessments and ADFG reports. In this report, they will be included mainly in the "monitoring" section.

Shrimps

A variety of shrimps occur in the BSAI. Members of the family Pandalidae are generally found in offshore waters while shrimps of the family Crangonidae are distributed mainly in nearshore waters.

Commercial fisheries for shrimps are managed by ADFG and are currently closed in the BSAI. Information on shrimps in Alaska waters is available from ADFG and they are included here mainly in the "monitoring" section.

Squids

Squids are abundant along the EBS slope and in the Aleutian Islands. Up to 15 species exist in the BSAI. Although no directed fisheries currently exist for squids, they are managed as "in the fishery" due to high levels of incidental catch, mainly in the fisheries for walleye pollock. Detailed information regarding BSAI squids can be found in the relevant stock assessment report.

Arctic cod

Arctic cod is not currently included in the FMP for the BSAI. It is primarily a cold-water species with a northern distribution in the EBS. In the Alaska arctic it is likely the dominant prey species, and the Arctic FMP prohibits directed fishing for Arctic cod due to ecosystem concerns. As fish distributions and fishing locations shift, conservation measures for Arctic cod in the BSAI may become necessary.

Distribution of forage species in the BSAI

Cross-shelf distribution

Methods: The cross-shelf distribution of forage fishes in the BSAI (i.e. nearshore vs. offshore) was investigated using data from the three bottom trawl surveys conducted in the region. Data were binned by the bottom depth at the location of survey hauls. Because the species examined normally have pelagic distributions, the bottom depth is not indicative of the depths inhabited by these species. Rather the bottom depth at the haul location reveals the cross-shelf location of the haul, from the most nearshore hauls (in about 20 m depth) to the outermost hauls on the continental slope (> 1000 m depth). Because the survey gears and fishing methods are not optimized for catching these species, data from any one year likely provide inaccurate depictions of distribution and relative abundance. Therefore, all survey data from 2000-2012 were aggregated and a mean catch-per-unit-effort (CPUE; numbers/hectare) was calculated for each 1 m bottom depth bin.

Results and discussion: In the eastern Bering Sea, there appears to be strong cross-shelf among the six species/ species groups studied (Fig. 1). The mean CPUE of sandfish and sand lance was highest at bottom depths below 50 m, suggesting a nearshore distribution in the inner domain of the EBS shelf. Capelin CPUE was also highest at bottom depths of approximately 50 m, but their distribution extended out to beyond 100 m. The distribution of herring was more variable, existing at a range of depths from 0 to more than 100 m. Eulachon were concentrated in hauls with 100-200 m bottom depth, with some catch over the EBS slope, while myctophids were found only on the slope. This type of segregation is similar to segregation observed among capelin and juvenile pollock (Hollowed et al. 2012). Habitat preferences and competitive interactions are both likely to influence these distributions. For example, sandfish and sand lance both depend on sandy substrates for burrowing. Myctophids have a mesopelagic distribution, so are unlikely to be found on the shelf. Spatial partitioning among capelin and juvenile pollock in the Gulf of Alaska (GOA) was thought to be due to competition between the species (Logerwell et al. 2007).

Similar results were observed in the Aleutian Islands (Fig. 2), although the trawl survey has found fewer forage species there. Herring and sandfish occurred in only a very small number of hauls over the 12-year period and were not included in the analysis. Capelin and eulachon were scarce. Sand lance and particularly myctophids were found in abundance. Of the four species studied, the cross-shelf pattern was identical to the EBS.

Geographic distribution – bottom trawl survey data

Methods: To further analyze the distribution of forage species in the BSAI, maps of mean CPUE were generated for the six forage groups using the same data used in the cross-shelf analysis. Point data for each survey haul (latitude, longitude, CPUE by number) during the 2000-2012 timeperiod was mapped in ArcGIS. Using the point-to-raster function within ArcGIS, individual haul data were aggregated into 20 km X 20 km cells and a mean CPUE was calculated for each cell using data from all years. The values were symbolized using a logarithmic distribution to visualize areas with high mean CPUEs.

Results and discussion: The results matched the analysis of cross-shelf distribution, but also provided further evidence of segregation among forage groups. Sand lance (Fig. 3) and sandfish (Fig. 4) were both distributed almost exclusively in the inner domain of the EBS, but their spatial distribution differed. Sand lance appeared more evenly distributed along the coast, whereas sandfish were concentrated in the extreme eastern portion of the survey area in Bristol Bay. Capelin was encountered throughout the inner and middle domains (Fig. 5), but the highest mean CPUEs were located in the nearshore. The transition from high to low capelin density appeared to occur along a smooth gradient. In contrast, herring were also distributed throughout the same area but appeared to occur in disjointed patches (Fig. 6). The distribution of eulachon was limited to the southeastern Bering Sea and the highest CPUEs were recorded in the vicinity of Bering Canyon (Fig. 7). Myctophids were observed only in the areas of the slope sampled by the slope trawl survey (Fig. 8).

In the Aleutian Islands, capelin (Fig. 9) and eulachon (Fig. 10) were found only in a few locations, mainly in the eastern Aleutians. Sand lance (Fig. 11) was observed throughout the region but the highest CPUEs were all recorded in the western Aleutians beyond Amchitka Pass. Myctophids (Fig. 12) were ubiquitous throughout the Aleutians and had similarly high CPUEs west of Amchitka.

Geographic distribution – BASIS

Methods: Because the bottom trawl survey data are suboptimal for studying forage fishes, an additional dataset was used to analyze distributions. Since 2002, the Bering-Aleutians Salmon International Survey (BASIS) has conducted surveys in the eastern Bering and Chukchi seas oriented towards the study of salmon distribution. The main survey gear consists of a surface trawl that samples from the surface down to a maximum depth of 20 m. Therefore the survey suffers some of the same limitations as the trawl survey, i.e. that it is only sampling a portion of the habitats occupied by forage fishes. However, combining BASIS results with bottom trawl data provides much greater insight into distributions of forage fishes. BASIS data were obtained from the Ecosystem Monitoring and Assessment program at the AFSC's Auke Bay Laboratory. Similar to the analysis of the bottom trawl survey data, point data for all years (2002-2011) was mapped in ArcGIS. Gridded datasets (20 km X 20 km cells) were produced displaying mean catch/haul in numbers (from all years) for each cell. The survey extent has varied from

2002-2011, so data availability differed among cells. Mean values were symbolized logarithmically and a different color scheme was used to differentiate the data from the bottom trawl survey.

Results and discussion: The distribution of sandfish in the BASIS surveys (Fig. 13) was very similar to that observed in the bottom trawl survey, with catches limited to the southeastern Bering Sea and the highest catch rates where bottom depths were less than 50 m. As in the bottom trawl survey, sand lance catches were highest in the inner domain of the EBS (Fig. 14). However the BASIS survey suggested a wider distribution in the EBS as well as a substantial presence of sand lance in the northeastern Bering and Chukchi Seas. Capelin (Fig. 15) was distributed throughout the inner and middle domains, as well as in the northern parts of the survey area. The nearshore concentration of capelin observed in the bottom trawl survey was not apparent. The distribution of herring catches in the BASIS surveys (Fig. 16) was substantially different than in the bottom trawl surveys. Catches appeared to be less patchy and the highest catches were concentrated in the northeastern Bering Sea, particularly Norton Sound. Few eulachon were observed during BASIS, but rainbow smelt were regularly encountered in some areas (Fig. 17). Rainbow smelt catches were concentrated in nearshore areas and Norton Sound.

Geographic distribution – euphausiids

The AFSC's Midwater Assessment and Conservation Engineering (MACE) program has recently developed the ability to discriminate between acoustic backscatter associated with fish versus backscatter from euphausiids. They have applied this methodology to acoustic data from acoustic trawl surveys conducted on the outer EBS shelf and have produced information regarding distribution and abundance since 2004 (Ressler et al. 2012). These results suggest that euphausiid distributions are variable but that the largest biomass is consistently found in the southeastern Bering Sea (Fig. 18).

Bycatch and other conservation issues

FMP forage group

Data regarding incidental catches of this group exist from 2003 and are maintained by the Alaska Regional Office (Table 1). Prior to 2005, species identification by observes was unreliable and many smelt catches were recorded as "other osmerid". While identification has improved since then, smelts in catches are often too damaged for accurate identification and much of the catch is still reported as "other osmerid". Eulachon are the most abundant forage fish in catches, and it is likely that they make up the majority of the "other osmerid" catch. Myctophids also occur in catches, but most of the remaining FMP forage group species are rarely caught.

The osmerid bycatch occurs primarily in two trawl fisheries: walleye pollock and yellowfin sole (Table 2). Catches are generally greater in the pollock fishery, but in some years (e.g. 2008, 2012) catches are greater in the yellowfin fishery. During 2008-2013, total osmerid catch varied between 2.1 t and 14.9 t. In 2006 and 2007, however, catches were an order of magnitude higher (100.9 and 179.5 t, respectively) with most of the additional catch occurring in the pollock fishery. A similar pattern is observed in the Gulf of Alaska, where a background level of eulachon bycatch is periodically interrupted by very high bycatch levels in midwater fisheries. The spatial concentration of eulachon bycatch corresponds to the two fisheries, taking place mainly in the southeastern Bering Sea where the pollock fishery occurs (NMFS

areas 517 and 519; Table 3 & Fig. 19) but also in the northern part of the inner shelf (area 514) which is the focus of the yellowfin sole fishery.

Pacific herring

Data regarding the Prohibited Species Catch of herring exists from 1991 and are maintained by the Alaska Regional Office (Table 4 & Fig. 20). Until 2012, catches of the last few years had been substantially smaller than during the 1990s. The 2012 catch was 2,376 t, which was an order of magnitude larger than the 2011 catch and for the first time exceeded the PSC quota for herring. Most of this 2012 catch occurred in NMFS area 524 in the northern Bering Sea. The 2013 catch as of October 29 was 986 t, still high relative to earlier years but much less than the PSC quota of 2,648 t.

Monitoring

The monitoring section of this report is the most important section, but also the most difficult to address. Due to the complete lack of surveys dedicated to sampling forage fishes, monitoring of forage species relies on gleaning what data are available from existing surveys and the use of proxies (e.g. predator diets). As this report develops, this section aims to contain a full suite of indices relevant to forage abundance and availability. For this year, the data are limited to timeseries of CPUE from the bottom trawl surveys and the BASIS surveys. Prior to 2012, the bottom trawl surveys have been reported in the Ecosystem Considerations chapter. They have been removed from there and will now reside in this report. Data from these surveys should be treated with extreme caution, particularly for species such as sand lance. The timeseries include estimated confidence intervals (CIs), but the presence of a small CI does not necessarily mean that the data are valid indicators of population status.

In general, analyses of these data should be limited to the existence of broad trends or to common patterns among timeseries from different surveys. For example the mean CPUE of sand lance in the EBS shelf survey during the 2000s was much lower than during the 1990s (Fig. 21). While the survey is a very poor sampler of sand lance, it is likely that sand lance were more abundant in the survey area during the 1990s. Comparing CPUE between 1994 & 1995 would, on the other hand, not be appropriate. For most of the species there is little agreement among the timeseries (Figs. 21-23). For capelin however an apparent small increase in the EBS shelf survey from 2010-2012 is matched by higher capelin abundance in the BASIS surveys during 2010 and 2011.

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Table 1. Bycatch (t) of FMP forage fish groups in BSAI federal fisheries, 2003-2013. 2013 data are incomplete; retrieved September 18, 2013.

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013***
eulachon	2.5	20.2	9.4	94.1	106.0	2.5	5.4	0.8	3.9	1.9	1.0
other osmerids	16.2	7.0	4.7	6.8	73.5	12.4	1.1	2.9	2.5	4.9	1.1
Myctophidae	0.3	0.1	0.6	9.6	5.8	1.5	0.5	0.3	0.2	0.1	0.5
capelin	0.0	5.4	0.4	2.6	1.2	0.2	0.6	0.8	4.2	2.5	0.3
Stichaeidae	0.2	0.1	0.1	0.2	0.8	0.3	0.1	0.2	0.4	0.4	0.2
surf smelt	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
sand lance	0.1	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.4	0.2	0.0
Bathylagidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pholidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
total FMP forage fishes	**19.4**	**33.1**	**15.6**	**113.4**	**188.0**	**17.0**	**7.7**	**5.1**	**11.6**	**9.9**	**3.1**

*2013 data are incomplete; retrieved September 18, 2013.

Table 2. Bycatch (t) of eulachon & "other osmerids" in the BSAI by target fishery, 2003-2013. 2013 data are incomplete; retrieved September 18, 2013.

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
YFS	4.3	4.6	0.5	0.7	40.8	9.9	0.9	3.0	2.5	4.8	1.0
pollock	10.0	21.3	12.6	99.6	138.5	4.4	5.4	0.8	3.6	1.9	1.0
FHS	0.3	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1
rock sole	3.7	0.1	0.7	0.3	0.2	0.6	0.1	0.1	0.2	0.0	0.0
ATF	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pacific cod	0.2	0.5	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BSAI total	**18.8**	**27.2**	**14.1**	**100.9**	**179.5**	**14.9**	**6.4**	**3.8**	**6.4**	**6.7**	**2.1**

* 2013 data are incomplete; retrieved September 18, 2013.

Table 3. Bycatch (t) of eulachon & "other osmerids" in the BSAI by NMFS statistical area, 2003-2013. 2013 data are incomplete; retrieved September 18, 2013.

		2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	***2013****
EBS	508	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*
	509	0.1	0.1	0.3	0.3	0.8	0.4	0.1	0.1	0.5	0.1	*0.1*
	512	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*
	513	3.7	0.5	0.3	0.4	1.4	0.0	0.0	0.1	1.3	0.1	*0.0*
	514	7.4	4.6	1.2	1.0	40.9	10.5	0.9	2.9	2.0	4.8	*1.0*
	516	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*
	517	7.4	21.7	12.1	63.8	95.1	2.0	1.4	0.7	2.6	1.8	*1.0*
	518	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*
	519	0.2	0.2	0.1	35.2	41.0	1.3	4.0	0.0	0.0	0.1	*0.0*
	521	0.1	0.1	0.1	0.1	0.1	0.6	0.0	0.0	0.0	0.0	*0.0*
	523	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	*0.0*
	524	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*
	EBS total	**18.8**	**27.2**	**14.1**	**100.8**	**179.4**	**14.9**	**6.4**	**3.8**	**6.4**	**6.7**	***2.1***
AI	541	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	*0.0*
	542	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*
	543	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*
	AI total	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	***0.0***
BSAI total		**18.8**	**27.2**	**14.1**	**100.9**	**179.5**	**14.9**	**6.4**	**3.8**	**6.4**	**6.7**	***2.1***

* 2013 data are incomplete; retrieved September 18, 2013.

Table 4. Bycatch (t) of Pacific herring in BSAI federal fisheries. Data are from the Prohibited Species Catch (PSC) database maintained by the NMFS Alaska Regional Office. 2013 data are incomplete; retrieved October 28, 2013.

	herring PSC	**herring PSC limit**
1991	3,761	
1992	1,059	
1993	784	
1994	1,728	
1995	970	
1996	1,513	
1997	1,298	
1998	963	
1999	895	
2000	512	
2001	270	
2002	134	
2003	962	1,525
2004	1,208	1,876
2005	692	2,013
2006	485	1,770
2007	409	1,787
2008	216	1,726
2009	63	1,697
2010	356	1,973
2011	397	2,273
2012	2,376	2,094
2013	*986*	2,648

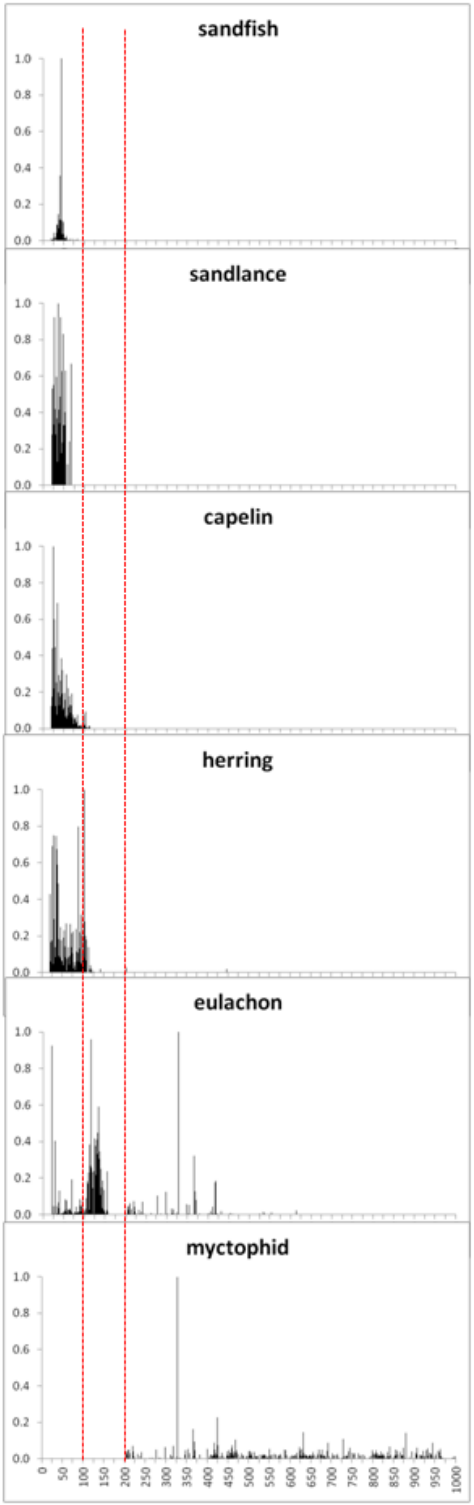

Figure 1. Mean bottom trawl survey CPUE versus bottom depth (m) of haul for six forage groups in the eastern Bering Sea.

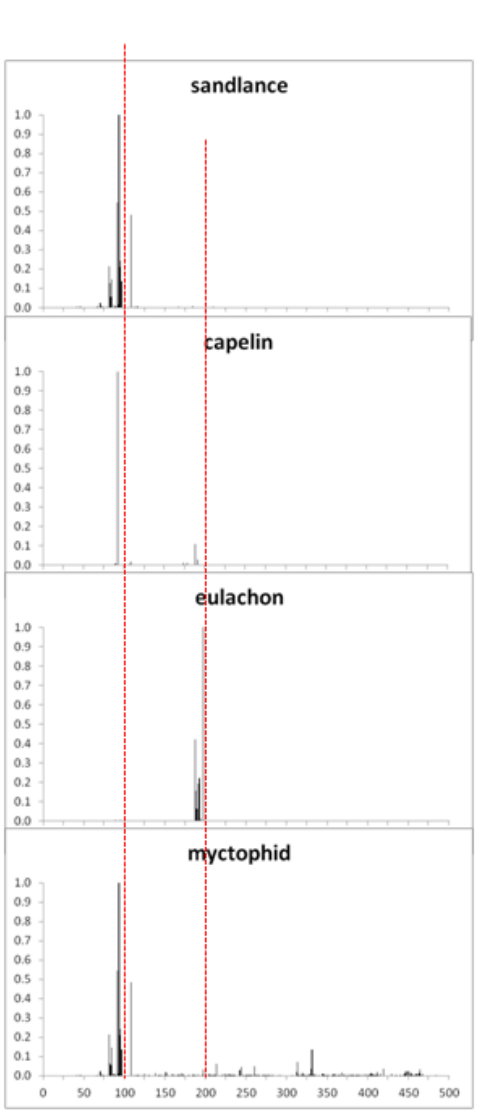

Figure 2. Mean bottom trawl survey CPUE versus bottom depth (m) of haul for four forage groups in the Aleutian Islands.

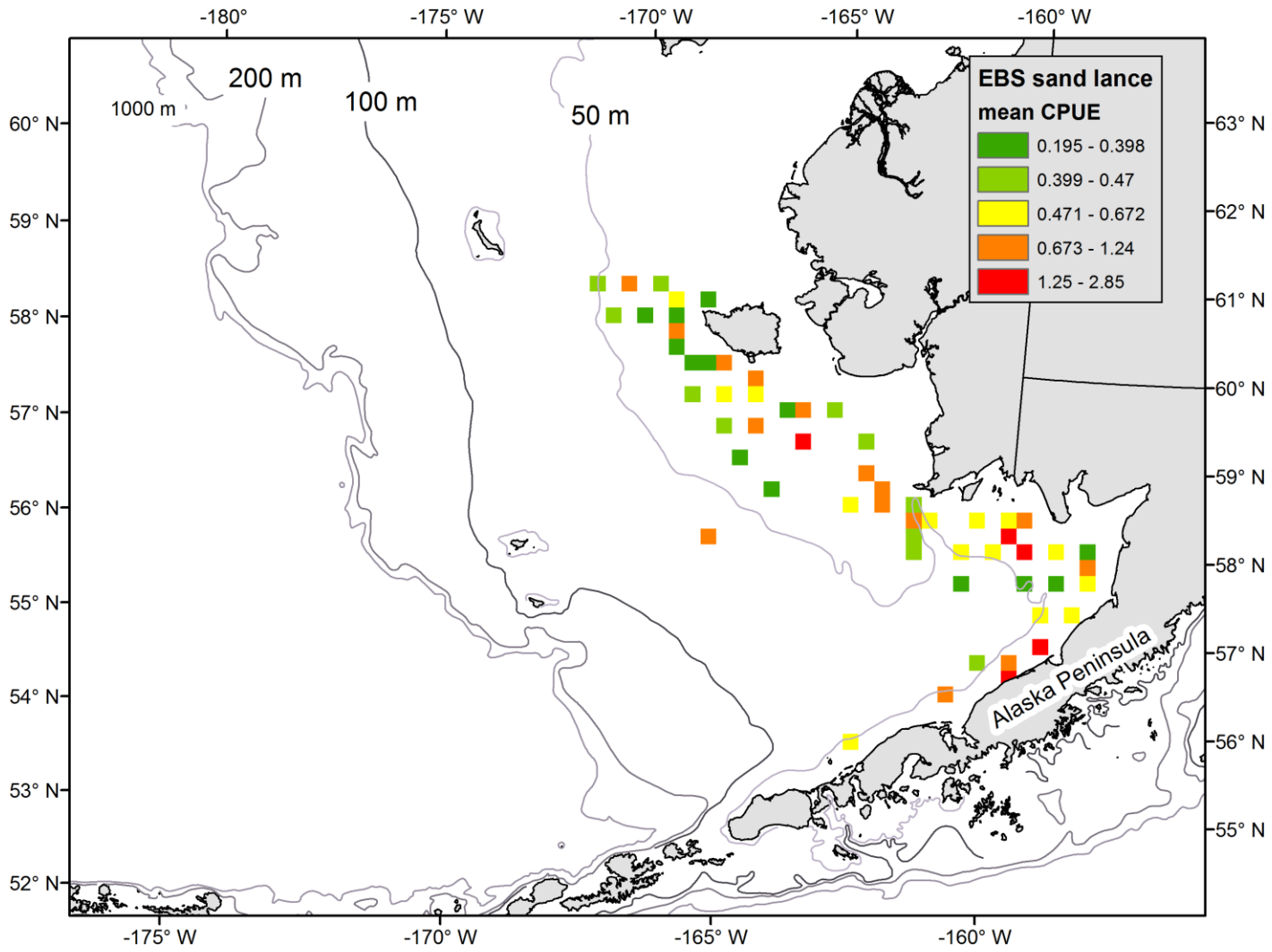

Figure 3. Mean bottom trawl survey CPUE of Pacific sand lance in the eastern Bering Sea, 2000-2011. Grid cells are 20 km X 20 km.

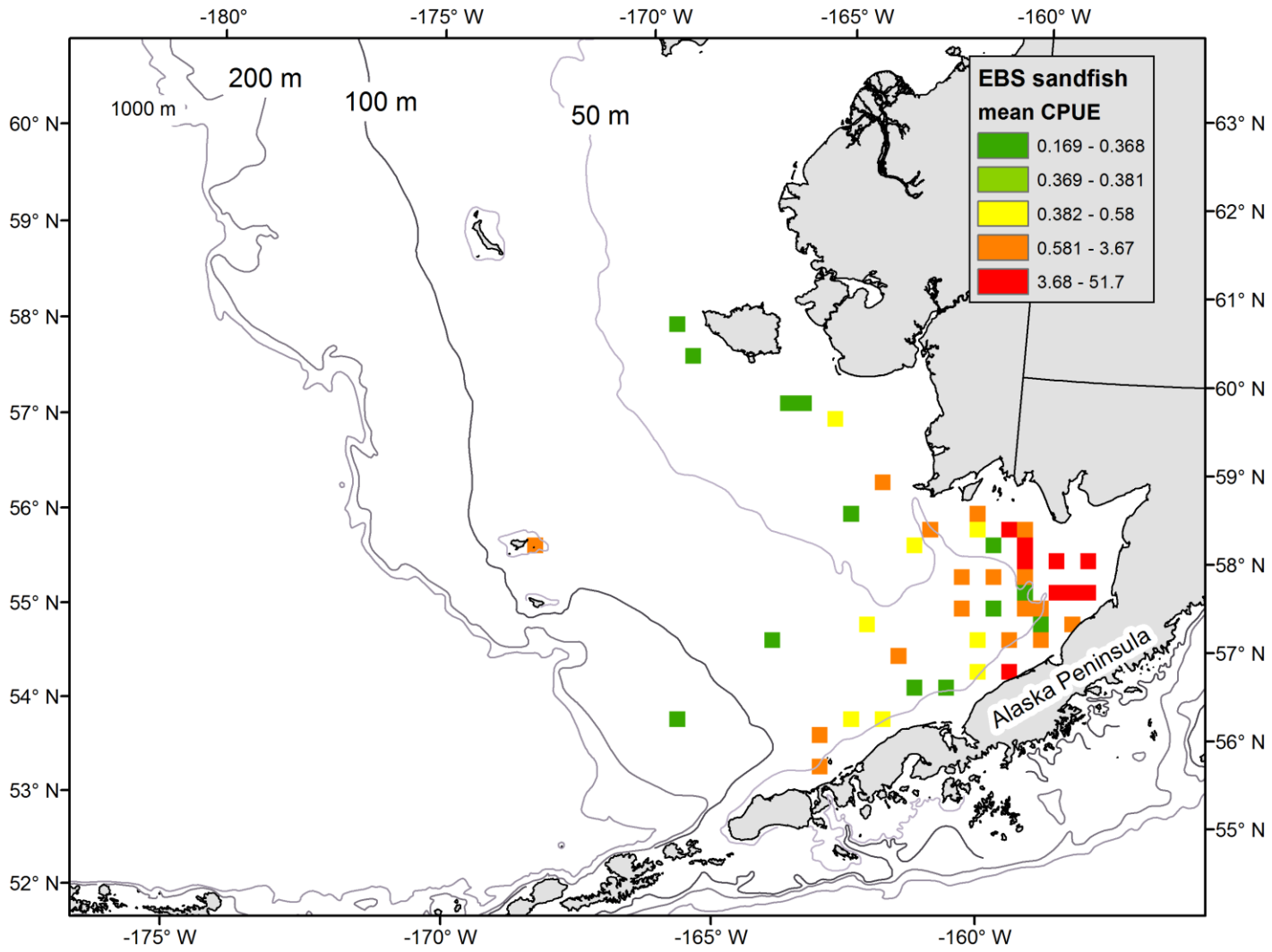

Figure 4. Mean bottom trawl survey CPUE of Pacific sandfish in the eastern Bering Sea, 2000-2011. Grid cells are 20 km X 20 km.

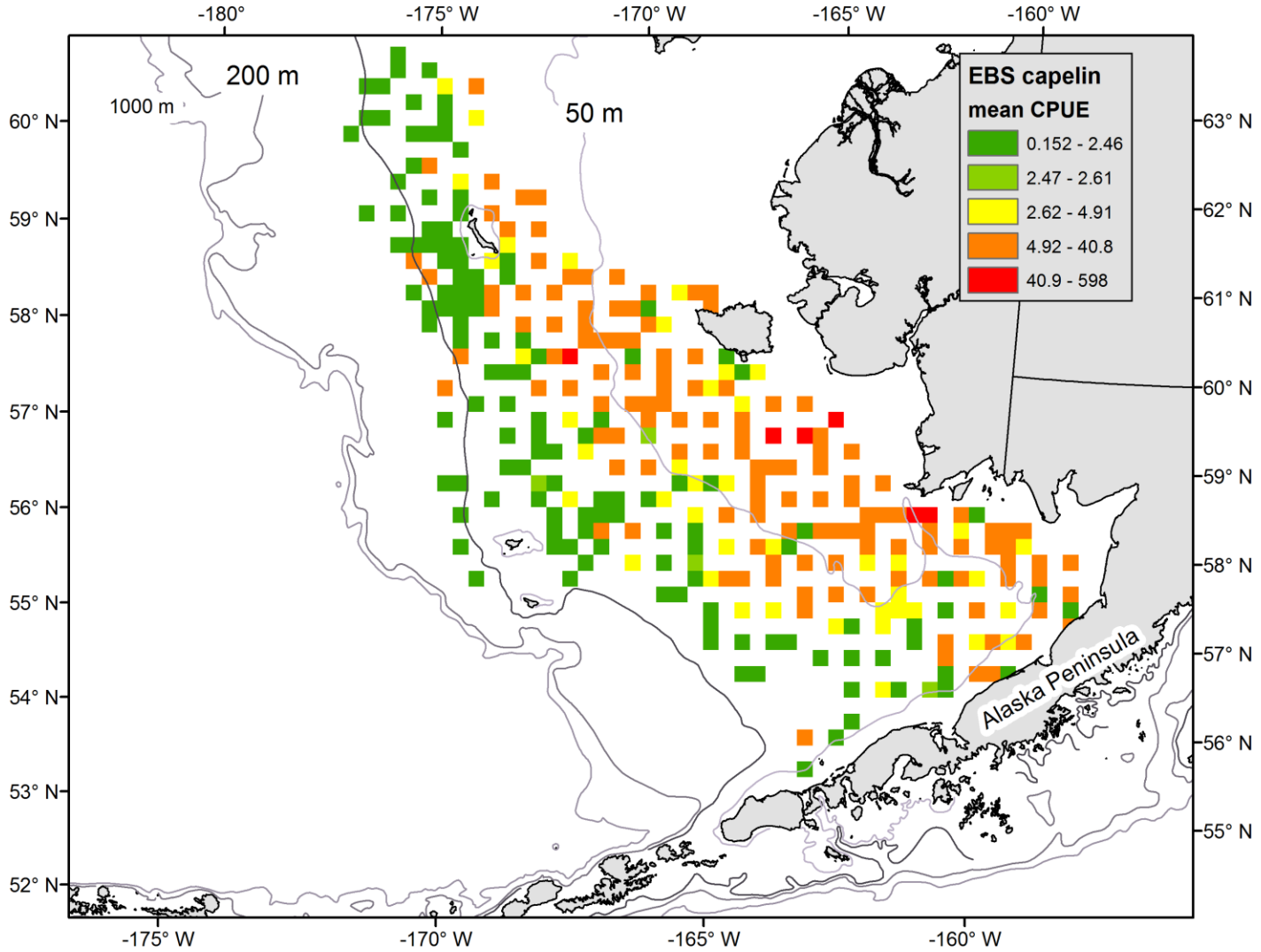

Figure 5. Mean bottom trawl survey CPUE of capelin in the eastern Bering Sea, 2000-2011. Grid cells are 20 km X 20 km.

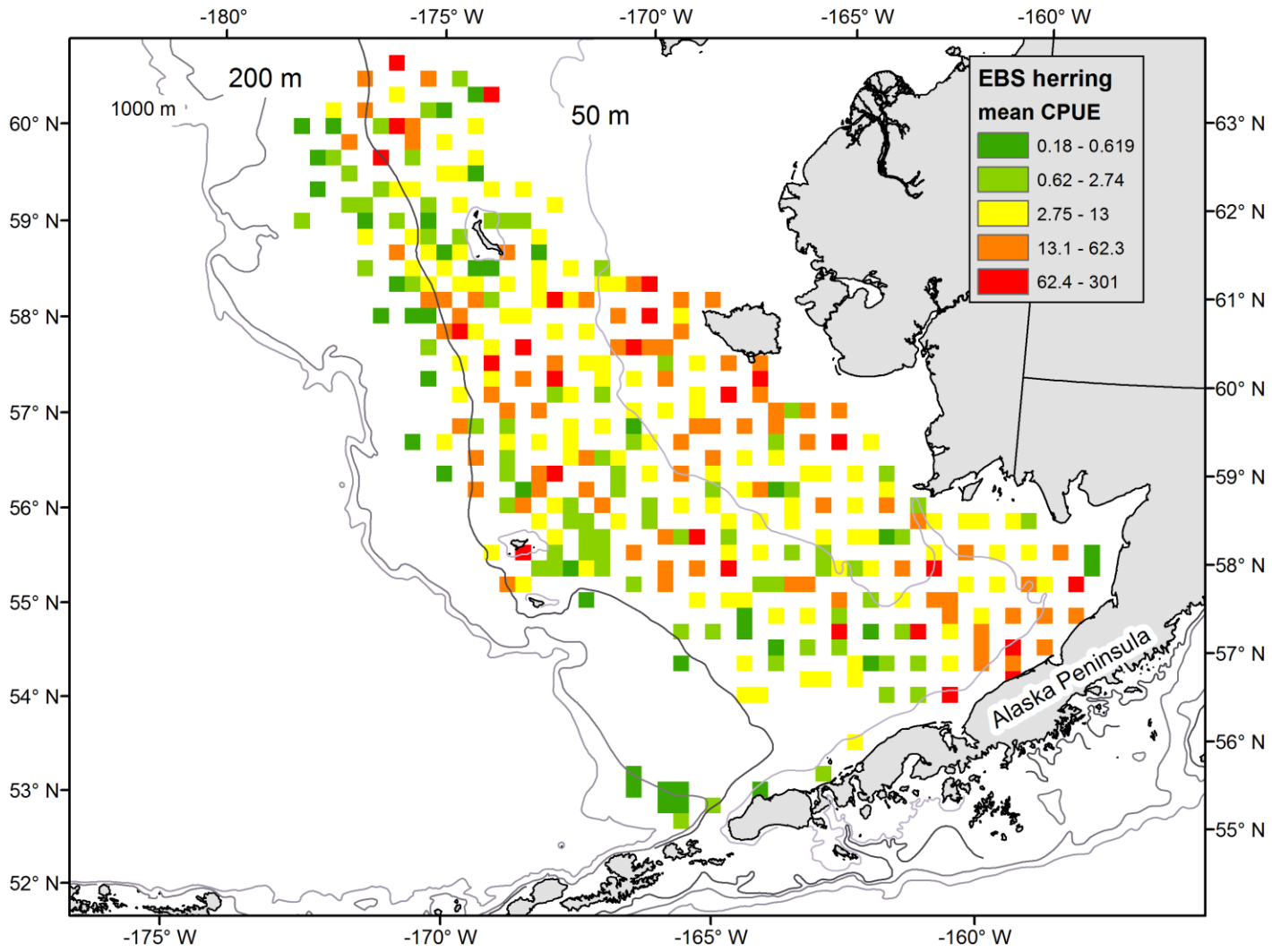

Figure 6. Mean bottom trawl survey CPUE of Pacific herring in the eastern Bering Sea, 2000-2011. Grid cells are 20 km X 20 km.

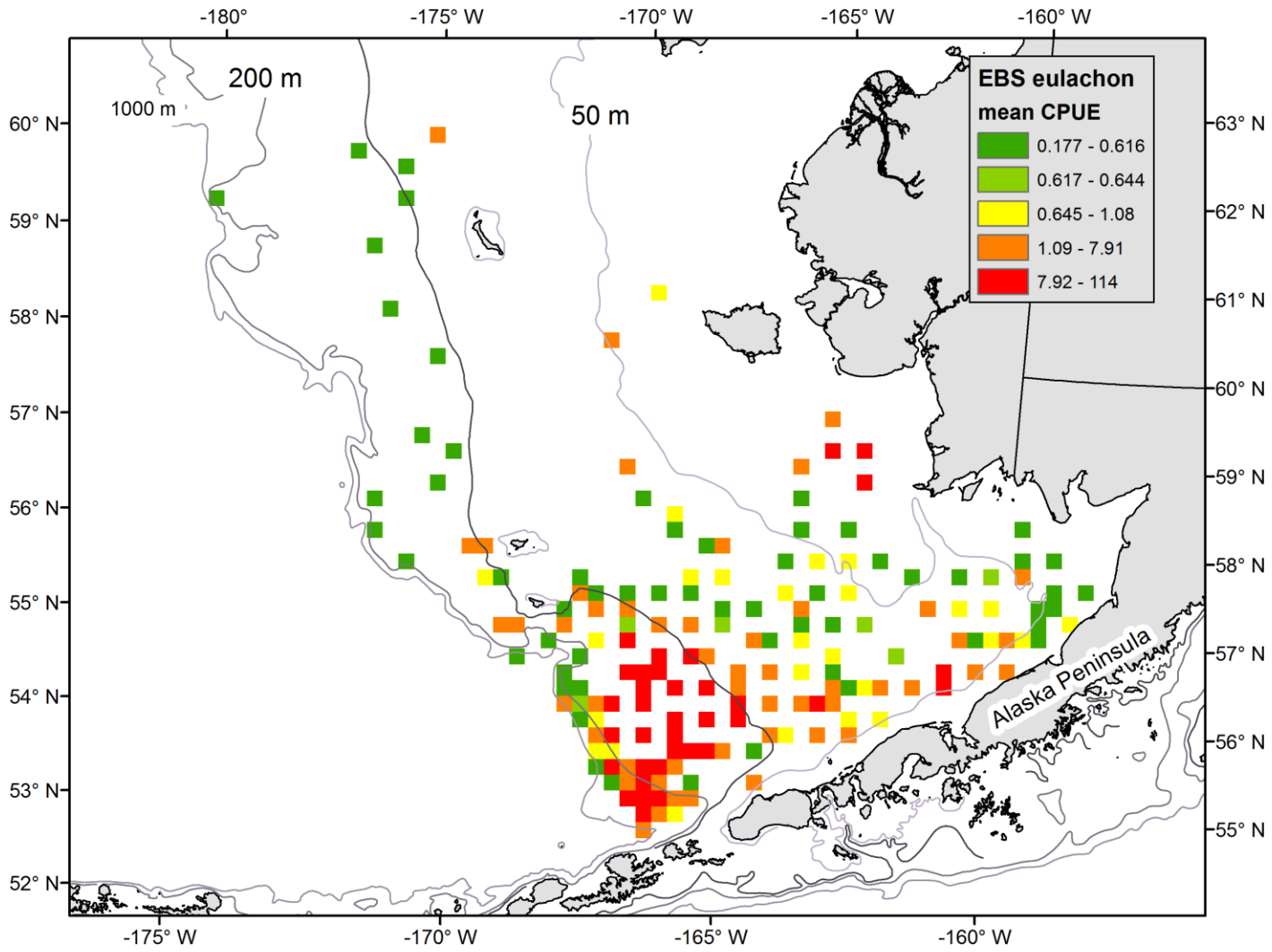

Figure 7. Mean bottom trawl survey CPUE of eulachon in the eastern Bering Sea, 2000-2011. Grid cells are 20 km X 20 km.

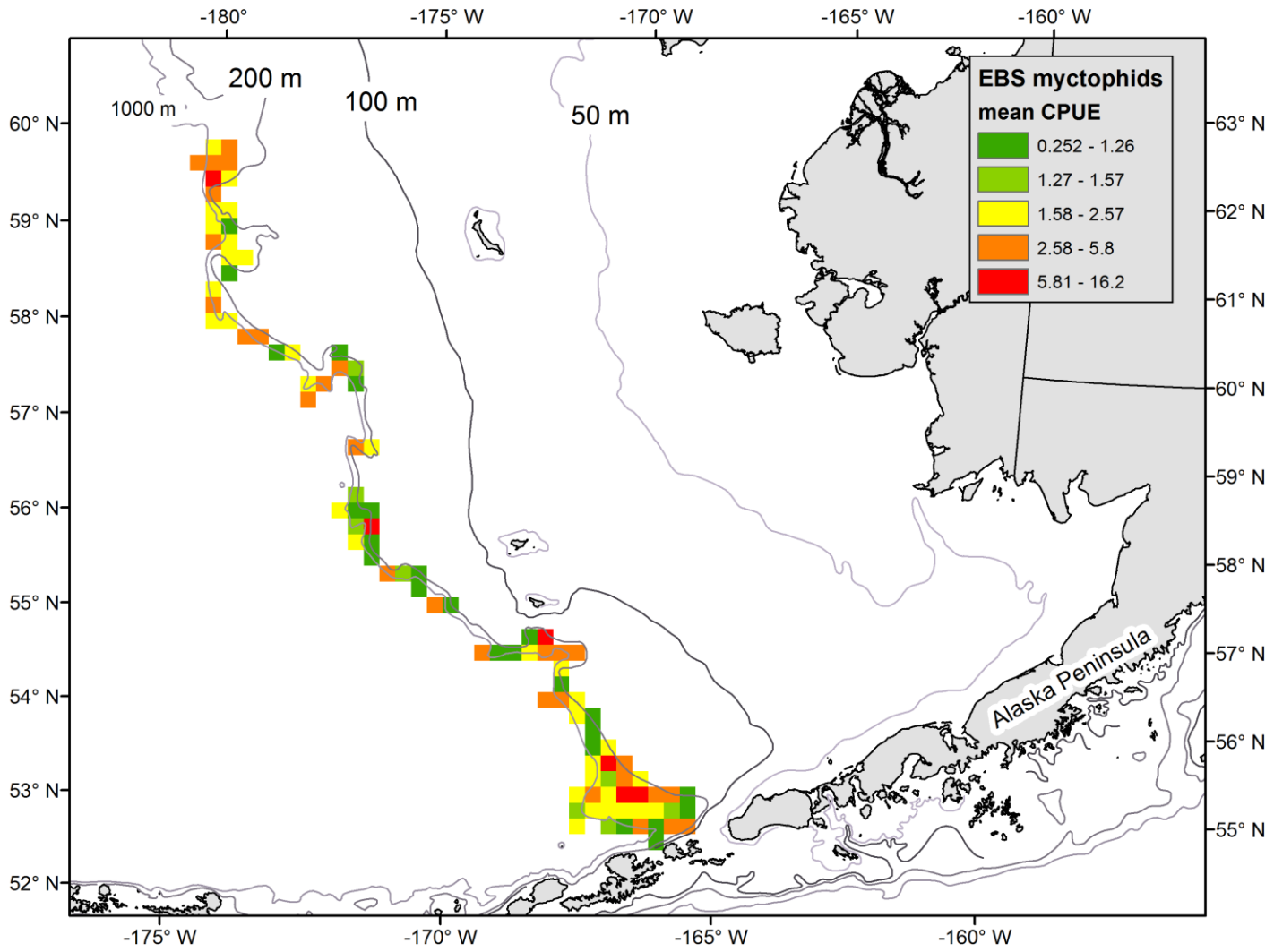

Figure 8. Mean bottom trawl survey CPUE of myctophids in the eastern Bering Sea, 2000-2011. Grid cells are 20 km X 20 km.

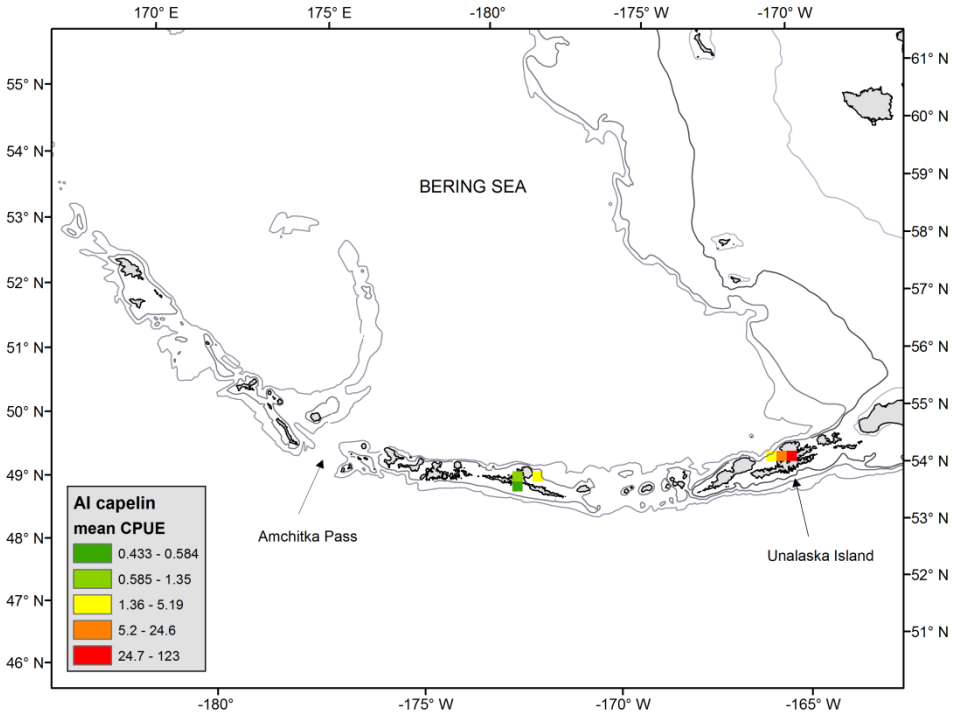

Figure 9. Mean bottom trawl survey CPUE of capelin in the Aleutian Islands, 2000-2011. Grid cells are 20 km X 20 km.

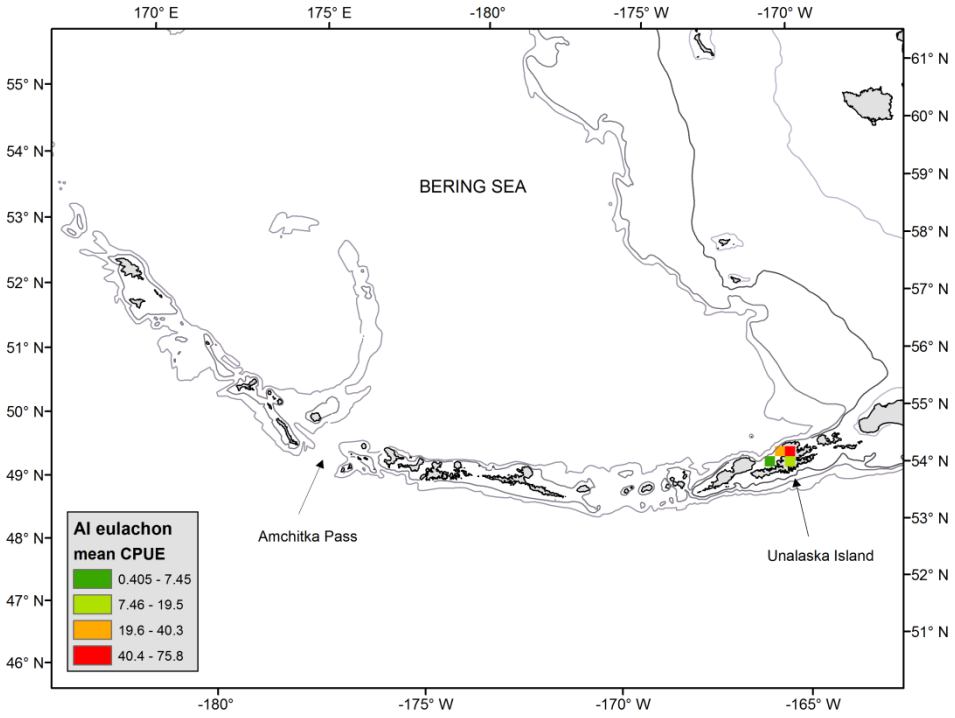

Figure 10. Mean bottom trawl survey CPUE of eulachon in the Aleutian Islands, 2000-2011. Grid cells are 20 km X 20 km.

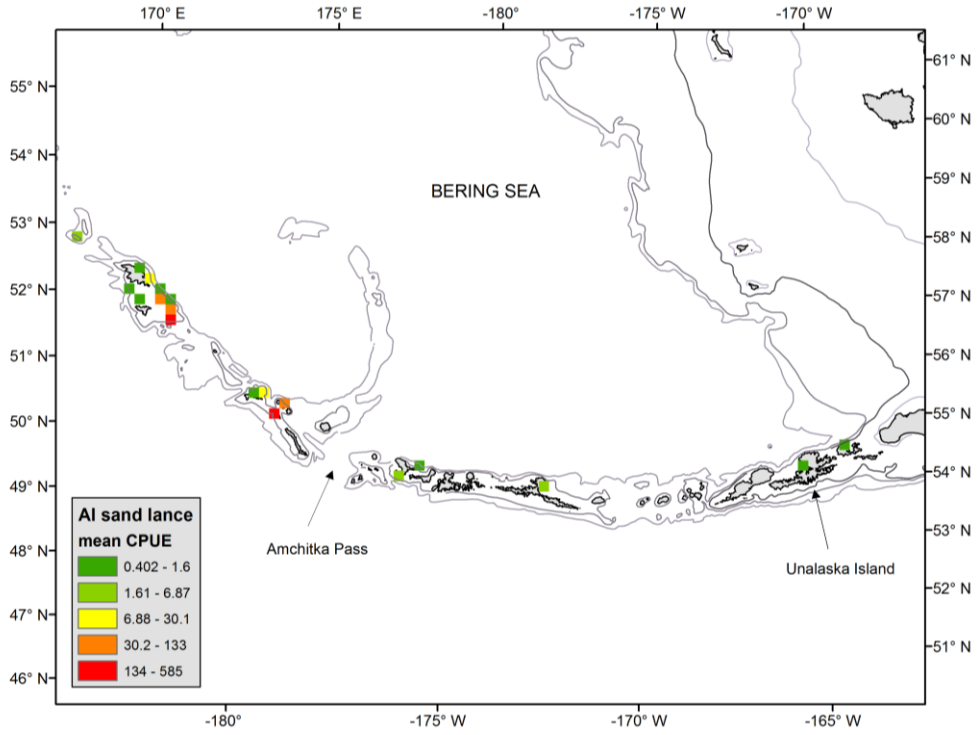

Figure 11. Mean bottom trawl survey CPUE of Pacific sand lance in the Aleutian Islands, 2000-2011. Grid cells are 20 km X 20 km.

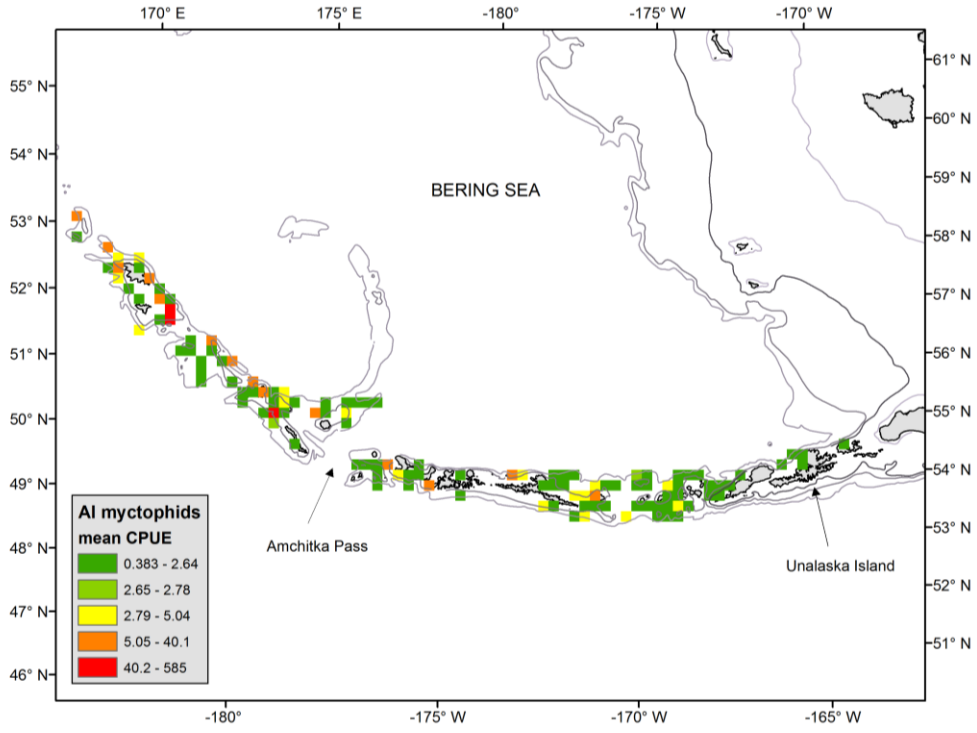

Figure 12. Mean bottom trawl survey CPUE of myctophids in the Aleutian Islands, 2000-2011. Grid cells are 20 km X 20 km.

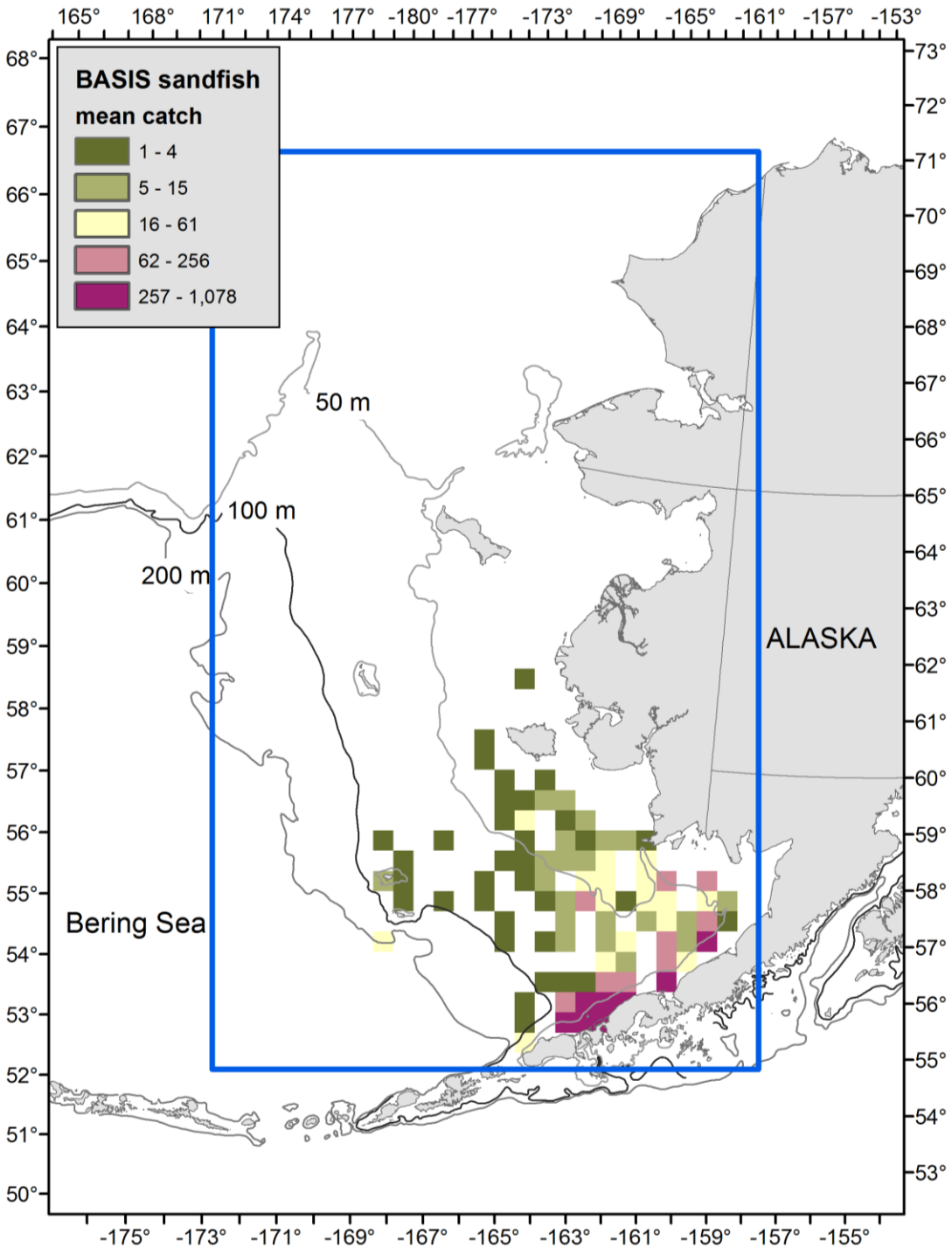

Figure 13. Mean catch (in numbers) of Pacific sandfish in BASIS surveys in the eastern Bering Sea, 2002-2011. Grid cells are 20 km X 20 km. Blue box indicates approximate extent of survey hauls over the entire time period.

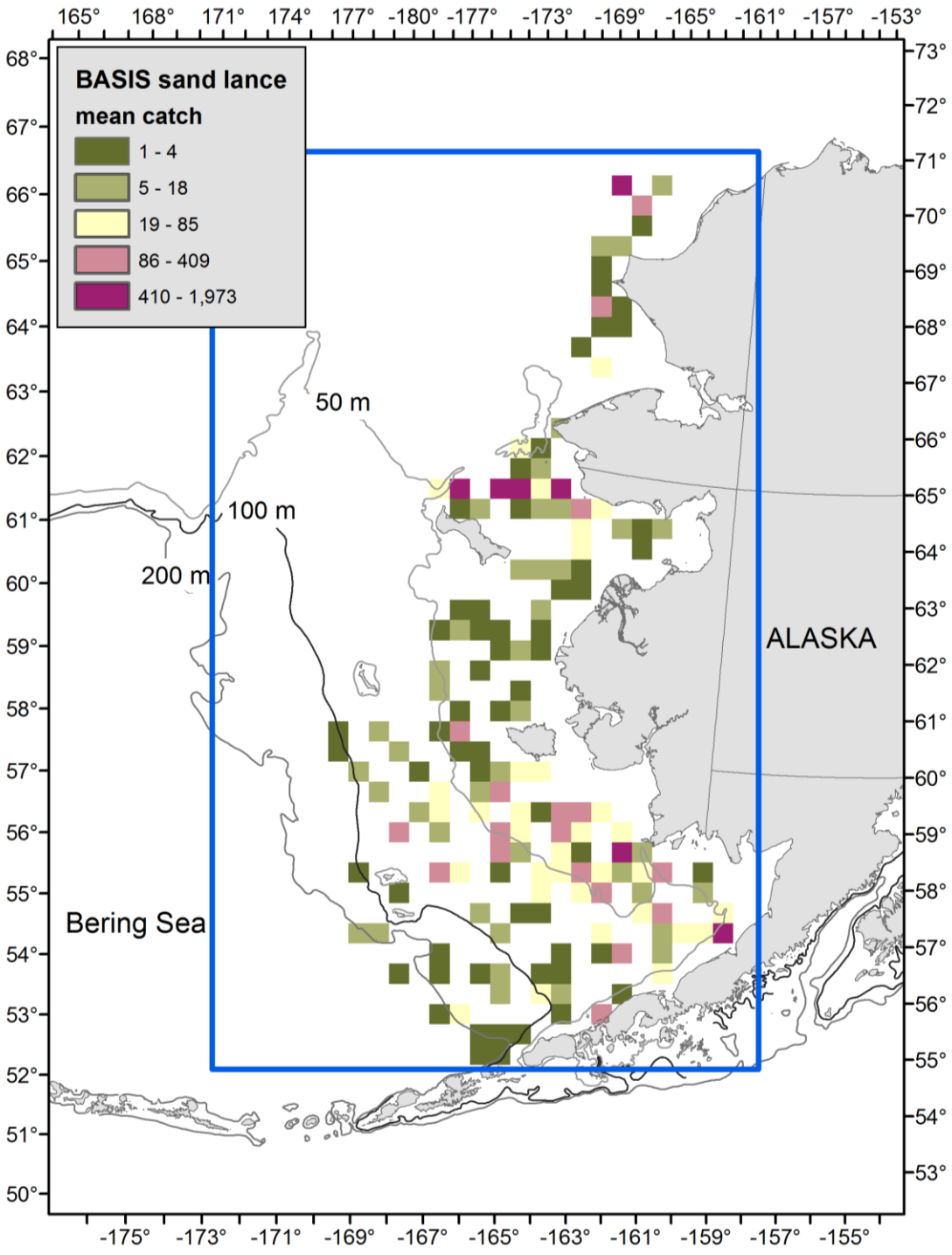

Figure 14. Mean catch (in numbers) of Pacific sand lance in BASIS surveys in the eastern Bering Sea, 2002-2011. Grid cells are 20 km X 20 km. Blue box indicates approximate extent of survey hauls over the entire time period.

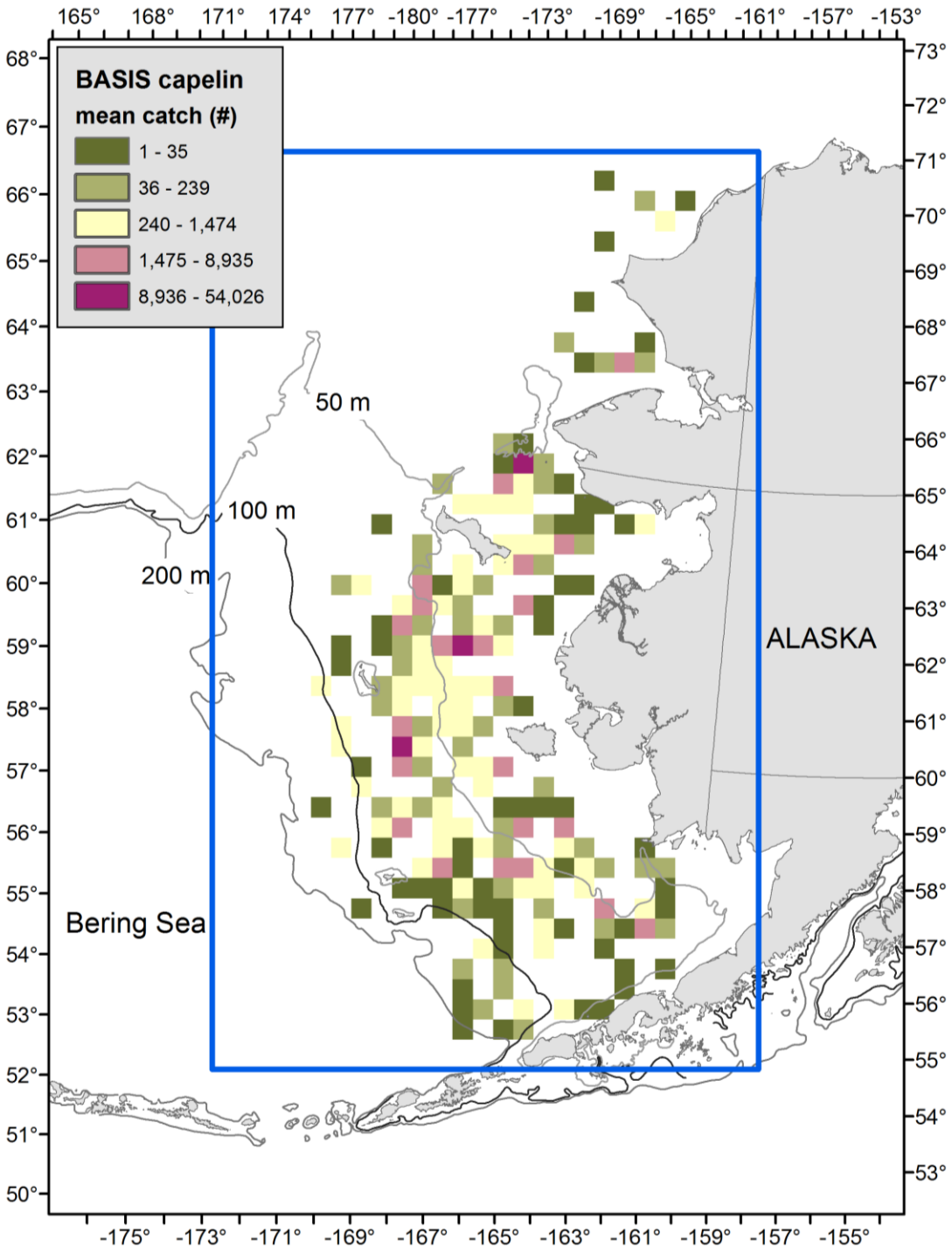

Figure 15. Mean catch (in numbers) of capelin in BASIS surveys in the eastern Bering Sea, 2002-2011. Grid cells are 20 km X 20 km. Blue box indicates approximate extent of survey hauls over the entire time period.

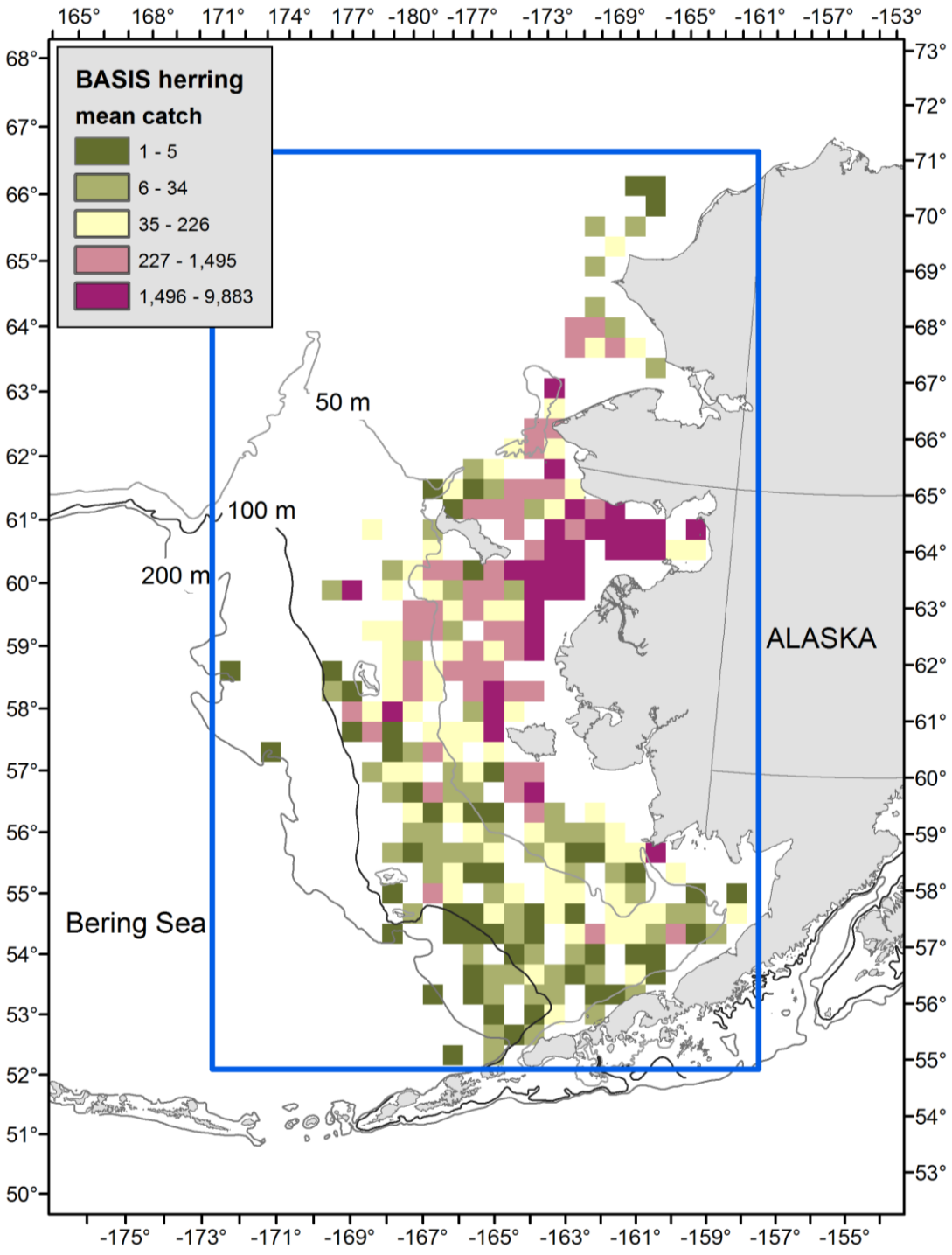

Figure 16. Mean catch (in numbers) of Pacific herring in BASIS surveys in the eastern Bering Sea, 2002-2011. Grid cells are 20 km X 20 km. Blue box indicates approximate extent of survey hauls over the entire time period.

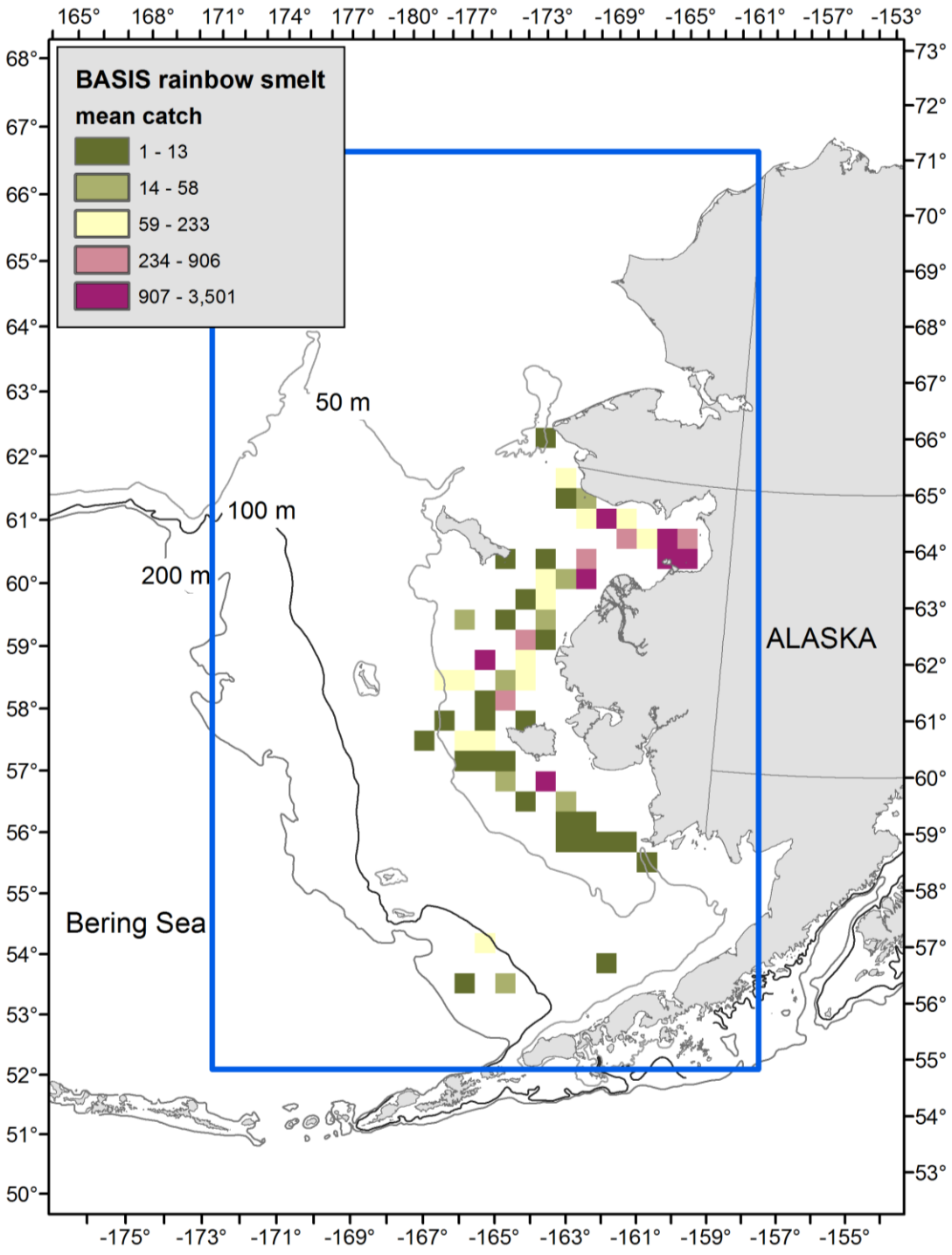

Figure 17. Mean catch (in numbers) of rainbow smelt in BASIS surveys in the eastern Bering Sea, 2002-2011. Grid cells are 20 km X 20 km. Blue box indicates approximate extent of survey hauls over the entire time period.

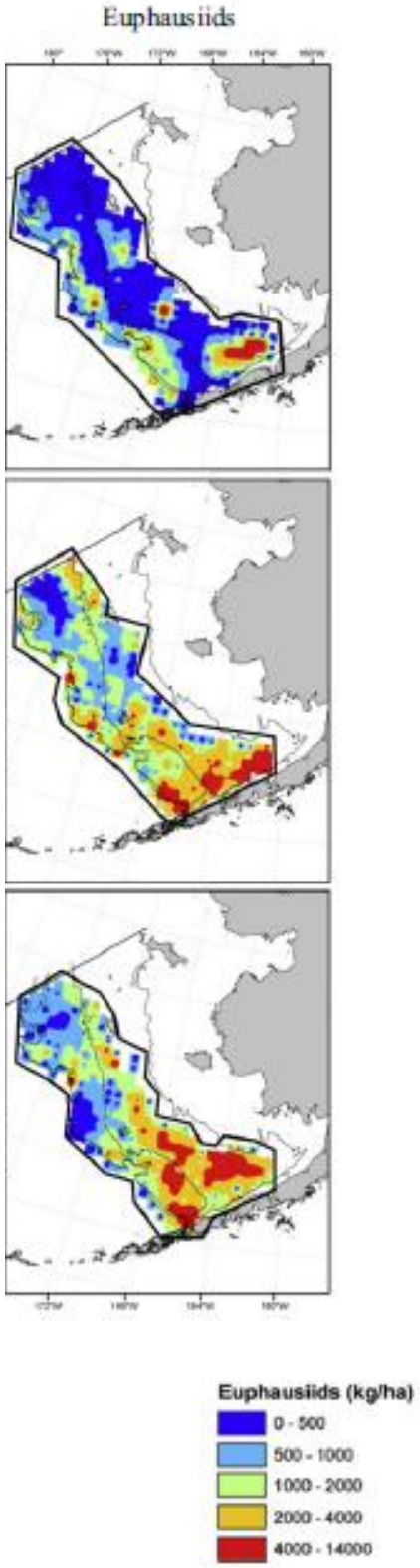

Figure 18. Spatial distribution of euphausiids as estimated using acoustic backscatter. Figure is taken from Ressler et al. 2012. Beginning with the top panel, data are from 2004, 2007, and 2010.

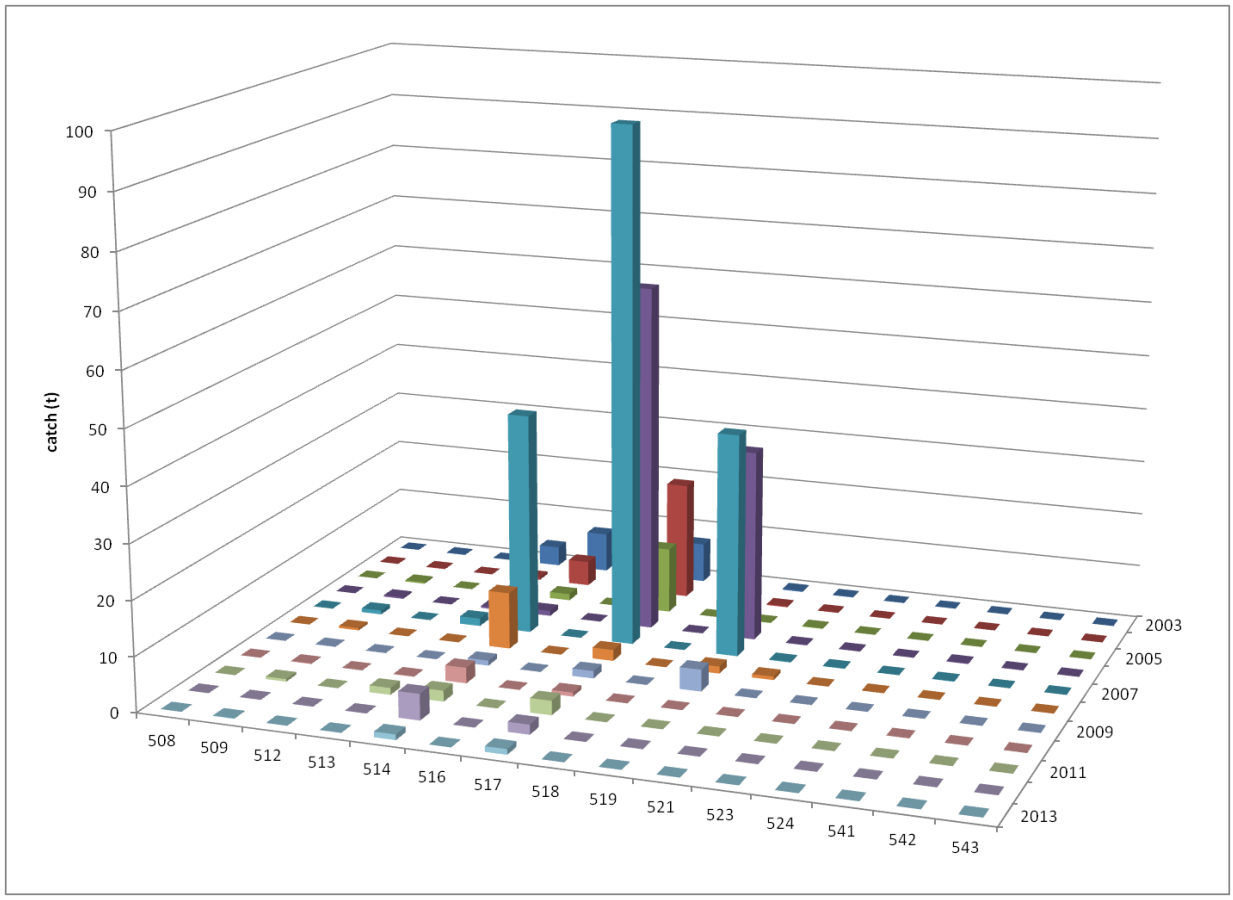

Figure 19. Incidental catches (t) of eulachon & "other osmerids" in the BSAI by NMFS statistical area, 2003-2013. 2013 data are incomplete; retrieved September 18, 2013.

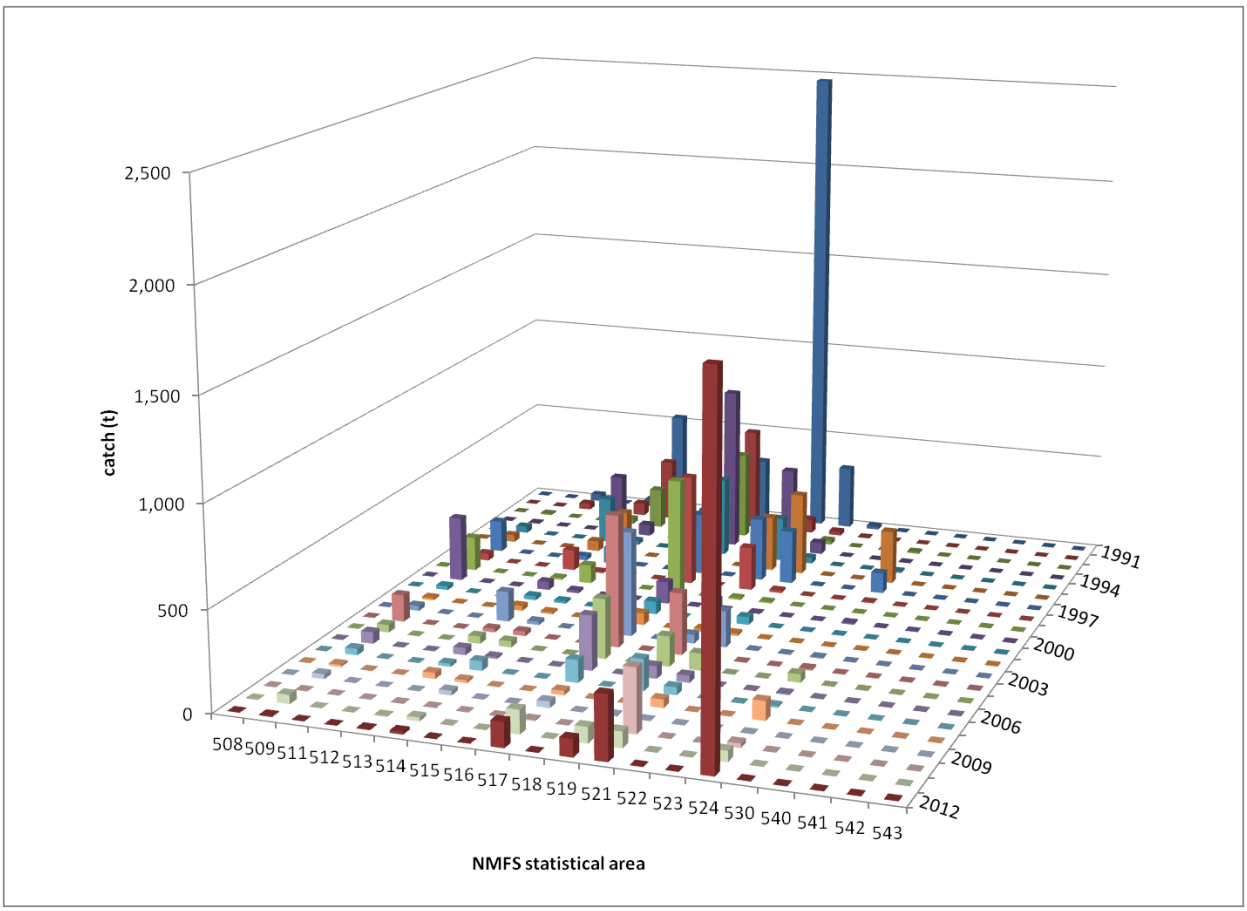

Figure 20. Bycatch of Pacific herring in BSAI federal fisheries by NMFS statistical area, 1991-2012. Data are from the Prohibited Species Catch (PSC) database maintained by the NMFS Alaska Regional Office.

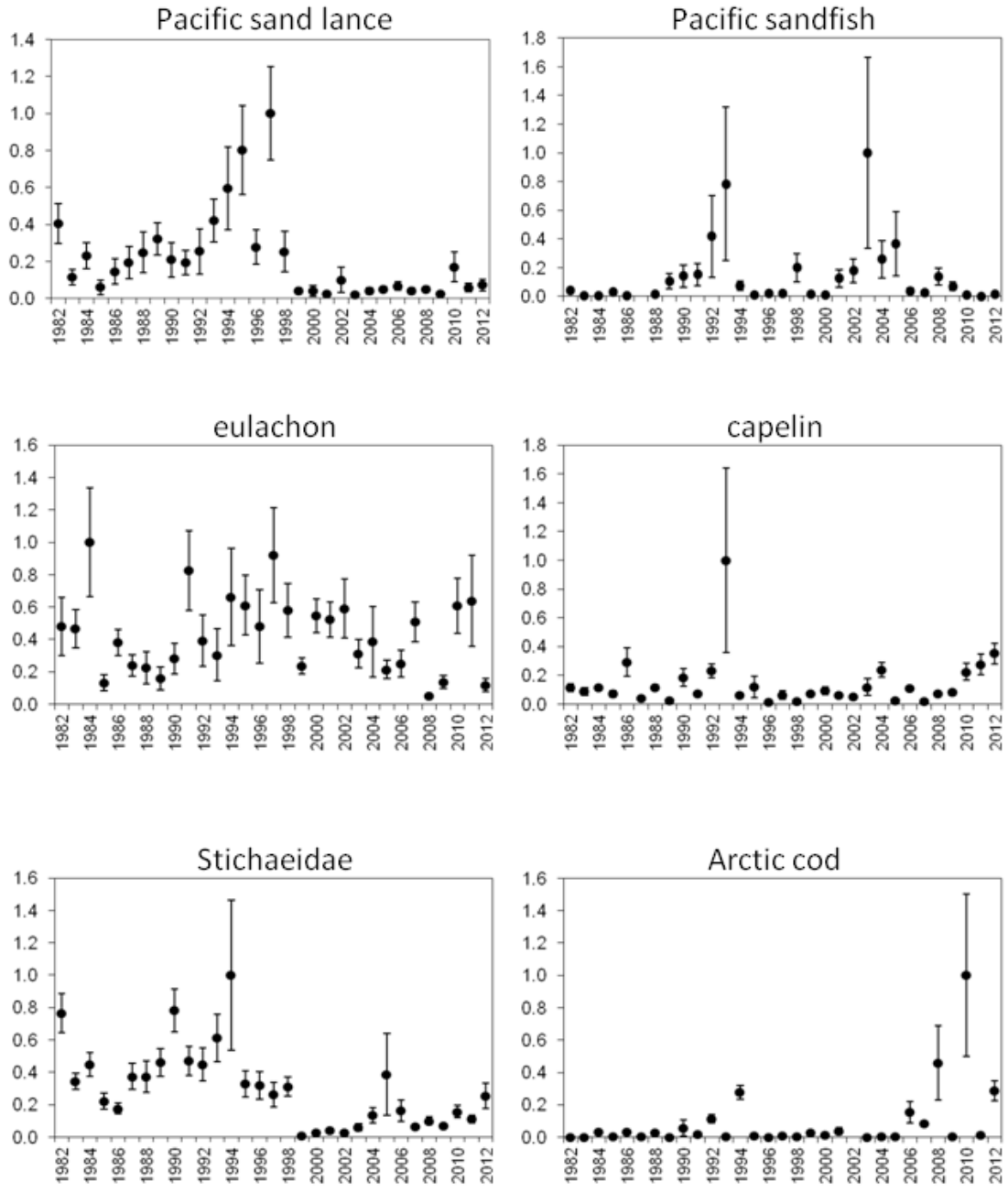

Figure 21. Timeseries of mean forage fish CPUE by weight (kg/hectare) from the EBS shelf trawl survey, 1982-2012. Error bars indicate 95% confidence interval.

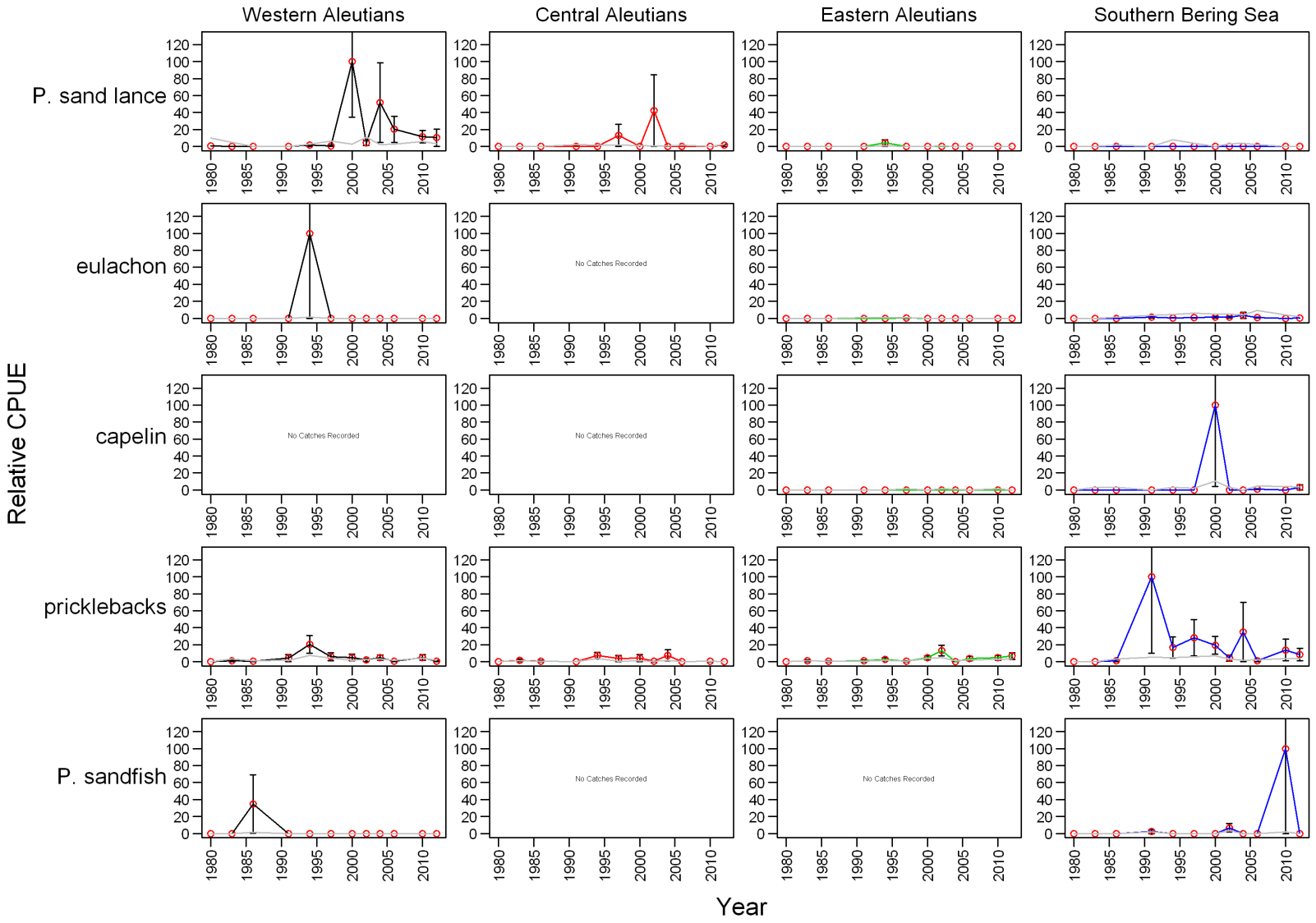

Figure 22. Timeseries of relative forage fish survey CPUE in four subareas of the Aleutian Islands, 1980-2012. Data are from the AI bottom trawl survey. Error bars indicate 95% confidence interval.

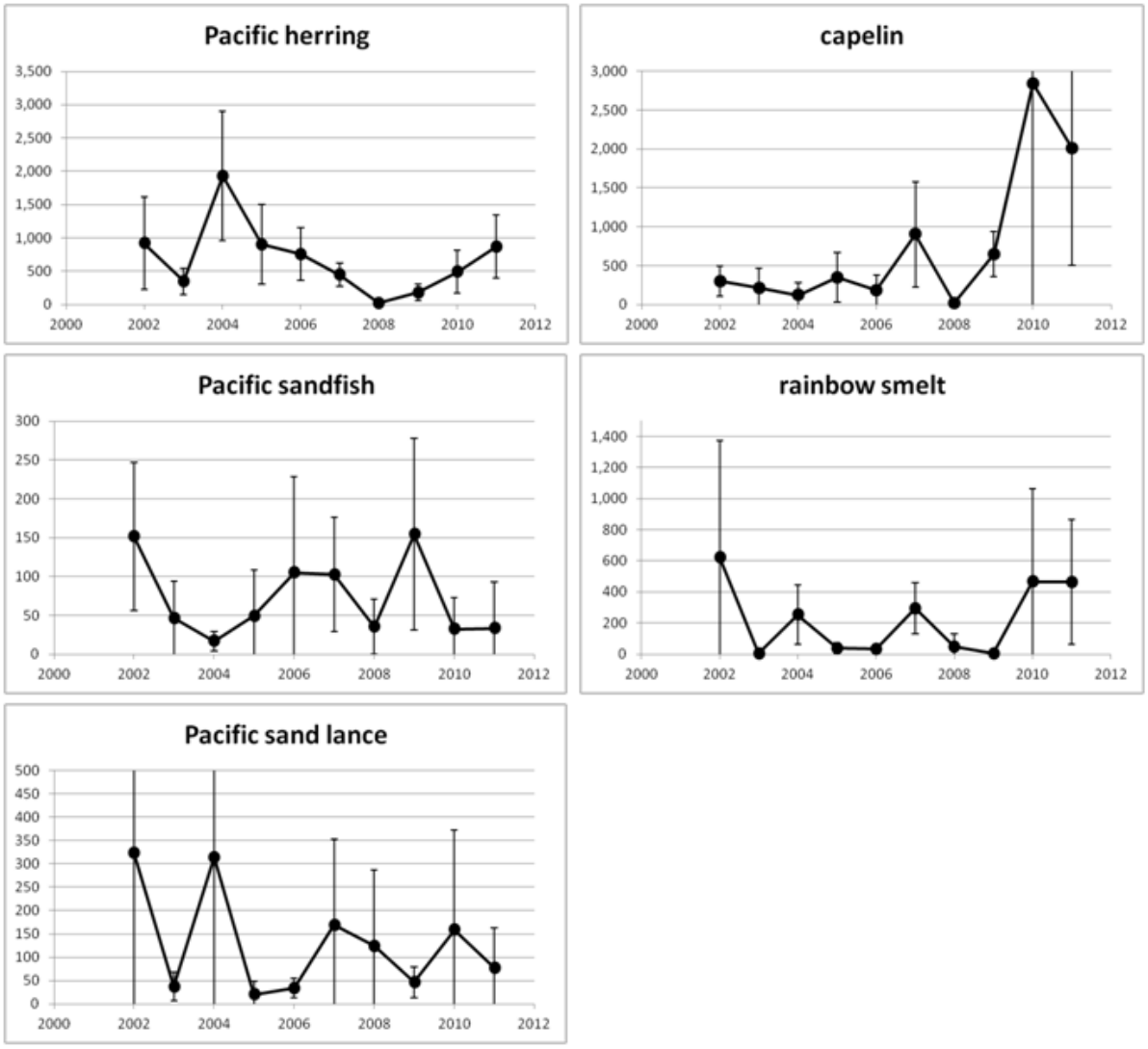

Figure 23. Timeseries of mean forage fish catches (numbers of individuals) in BASIS surface tows in the eastern Bering Sea, 2002-2011. Error bars indicate 95% confidence interval.

Appendix: List of scientific and common names of species contained within the "FMP forage fish" category. Data sources: BSAI FMP, "Fishes of Alaska" (Mecklenburg et al. 2002).

Scientific Name	**Common Name**
Family Osmeridae	smelts
Mallotus villosus	capelin
Hypomesus pretiosus	surf smelt
Osmerus mordax	rainbow smelt
Thaleichthys pacificus	eulachon
Spirinchus thaleichthys	longfin smelt
Spirinchus starksi	night smelt
Family Myctophidae	lanternfish
Protomyctophum thompsoni	bigeye lanternfish
Benthosema glaciale	glacier lanternfish
Tarletonbeania taylori	taillight lanternfish
Tarletonbeania crenularis	blue lanternfish
Diaphus theta	California headlightfish
Stenobrachius leucopsarus	northern lampfish
Stenobrachius nannochir	garnet lampfish
Lampanyctus jordani	brokenline lanternfish
Nannobrachium regale	pinpoint lampfish
Nannobrachium ritteri	broadfin lanternfish
Family Bathylagidae	blacksmelts
Leuroglossus schmidti	northern smoothtongue
Lipolagus ochotensis	popeye blacksmelt
Pseudobathylagus milleri	stout blacksmelt
Bathylagus pacificus	slender blacksmelt
Family Ammodytidae	sand lances
Ammodytes hexapterus	Pacific sand lance
Family Trichodontidae	sandfish
Trichodon trichodon	Pacific sandfish
Arctoscopus japonicus	sailfin sandfish
Family Pholidae	gunnels
Apodichthys flavidus	penpoint gunnel
Rhodymenichthys dolichogaster	stippled gunnel
Pholis fasciata	banded gunnel
Pholis clemensi	longfin gunnel
Pholis laeta	crescent gunnel
Pholis schultzi	red gunnel

Scientific Name	**Common Name**
Family Stichaeidae	pricklebacks
Eumesogrammus praecisus	fourline snakeblenny
Stichaeus punctatus	arctic shanny
Gymnoclinus cristulatus	trident prickleback
Chirolophis tarsodes	matcheek warbonnet
Chirolophis nugatory	mosshead warbonnet
Chirolophis decoratus	decorated warbonnet
Chirolophis snyderi	bearded warbonnet
Bryozoichthys lysimus	nutcracker prickleback
Bryozoichthys majorius	pearly prickleback
Lumpenella longirostris	longsnout prickleback
Leptoclinus maculates	daubed shanny
Poroclinus rothrocki	whitebarred prickleback
Anisarchus medius	stout eelblenny
Lumpenus fabricii	slender eelblenny
Lumpenus sagitta	snake prickleback
Acantholumpenus mackayi	blackline prickleback
Opisthocentrus ocellatus	ocellated blenny
Alectridium aurantiacum	lesser prickleback
Alectrias alectrolophus	stone cockscomb
Anoplarchus purpurescens	high cockscomb
Anoplarchus insignis	slender cockscomb
Phytichthys chirus	ribbon prickleback
Xiphister mucosus	rock prickleback
Xiphister atropurpureus	black prickleback
Family Gonostomatidae	bristlemouths
Sigmops gracilis	slender fangjaw
Cyclothone alba	white bristlemouth
Cyclothone signata	showy bristlemouth
Cyclothone atraria	black bristlemouth
Cyclothone pseudopallida	phantom bristlemouth
Cyclothone pallida	tan bristlemouth
Order Euphausiacea	krill

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