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Chapter 2. Alaska Arctic Marine Fish Inventory

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Abstract

Several other marine fishery investigations, including efforts for Arctic data recovery and regional analyses of range extensions, were ongoing concurrent to this study. These included Bureau of Ocean Energy Management-sponsored research in the Chukchi Sea and nearshore and transboundary surveys in the Beaufort Sea. New collections in the Chukchi Sea and Chukchi Borderland also were being obtained through National Oceanic and Atmospheric Administration's multidisciplinary Russian-American Long-term Census of the Arctic (RUSALCA) program. These were major exploratory efforts and represented potential sources of new marine species information. Building on the "*Fishes of Alaska,*" an updated checklist was constructed of known and probable marine fishes with catch data obtained in these studies. There are 109 known species from 24 families of marine fish from the United States High Arctic, with 97 species reported from the Chukchi Sea and 83 from the Beaufort Sea. As this synthesis was being done, changes in the confirmation process, based on morphological and genetic analysis, were captured as information became available in scientific publications. The known species are reviewed with respect to taxonomic, geographic, and large-scale abundance considerations. Each species' zoogeographic pattern with respect to our understanding of broadly defined evolutionary origins is noted. Changes in species nomenclature are described as they relate to newly described standards.

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Introduction

A large number of Arctic fisheries studies were started following the publication of the *Fishes of Alaska* (Mecklenburg and others, 2002). Although the results of many of these efforts are not yet available, those involving field sampling are important new sources of biodiversity information including voucher specimens and genetic confirmation of a species existence and phylogenetic relationships. The addition of new morphological data and genetic analyses is important because despite many efforts, systematic sampling in the Chukchi and Beaufort Seas has been logistically difficult due to ice, storms, and platform limitations. Further variations in research missions and sampling methods have hampered regional assessments of diversity, relative abundance, and habitat importance because the resulting database is sparse and fragmented in time and space. Quantitative evaluations of abundance based on catch data are difficult, although local variability and persistent hot spots are known to exist. This chapter builds on the species inventory established by the *Fishes of Alaska* by incorporating new species information obtained primarily in Bureau of Ocean Energy Management (BOEM)-sponsored (appendix A) and National Oceanic and Atmospheric Administration (NOAA) Russian-American Long-term Census of the Arctic (RUSALCA) surveys (Mecklenburg and Steinke, 2015). This information is complemented with a uniformly applied assessment of relative abundance and qualitative analysis of population viability based on present day understanding of endemism.

Checklist of Marine Fish

The updated checklist of confirmed occurrences is significant because it incorporates the new knowledge gained since the publication of the *Fishes of Alaska* (Mecklenburg and others, 2002). It includes the most recent information from the Pacific Arctic Region including the Chukchi and Beaufort Seas from Mecklenburg and Steinke (2015). Unlike Mecklenburg and Steinke (2015), this checklist includes diadromous species from the family Salmonidae as these species spend significant portions of their lives in the marine environment and have great importance in subsistence lifestyles. Even though this list represents a significant advance, many uncertainties remain about the true composition of the marine fish assemblage. For this reason, information about probable occurrences of marine fishes is included in this chapter. The uncertainties result in part because the taxonomy of Arctic fishes was still in its infancy at the turn of the 21st century, with many species misidentified in historical literature and others not recognized from the region due to sampling inadequacies (Mecklenburg and others, 2011). The scientific improvements in knowledge about the Arctic region's biodiversity reflect new data collection and, importantly, advances in taxonomic and zoogeographic understanding that have resulted from genetic resolution of issues that morphological studies failed to notice or resolve (for example, Mecklenburg and others, 2011; Lynghammar and others, 2012; Mecklenburg and Steinke, 2015). The Arctic marine fish inventory, presented in table 2.1, is a major biodiversity achievement, which documents known (verified) marine fish species from the Chukchi and Beaufort Seas.

Although advances have been significant in recent years, the taxonomy, including naming of Arctic marine fishes remains a source of inconsistency and confusion between leading authorities such as the American Fisheries Society (AFS), California Academy of Sciences *Catalog of Fishes*, Integrated Taxonomic Information Systems, and World Register of Marine Fishes, for members of several families. This is especially true for common names associated with different languages (Mecklenburg and others, 2013). Changes in nomenclature are not uncommon in the classification process, especially for lesser-studied species, and can affect the regional use of scientific and common names in literature (Eschmeyer and others, 2010). Thus, in creating checklists, it is important to cite the authority used and rationale for inclusion or naming of a particular species where disagreement occurs. In this report, the marine fish inventory presented in table 2.1 reflects the editors' understanding of the classification and nomenclature of marine Arctic fishes. In most instances, the scientific and common names are those listed by Page and others (2013) and Eschmeyer and others (2015). However, in several instances where differences exist, we relied on the work of contemporary Arctic specialists and note areas of transitional change with respect to common names for species.

The nomenclature of a small number of fish species from four families (Squalidae, Gadidae, Liparidae, and Zoarcidae) are in transition and reflect areas where we disagree with the AFS nomenclature (Page and others, 2013). For purposes of this report, we decided to agree with the AFS nomenclature for *Boreogadus saida* due to the species' significance to the region's marine ecology. Although, we acknowledge that Polar Cod is emerging as the widely accepted common name for *B. saida*, we decided to use Arctic Cod (as recommended by Page and others [2013]) to avoid any confusion with new and historical Alaska literature. In contrast, we decided to use Ice Cod, not Polar Cod, as the common name for *Arctogadus glacialis*. This decision was made to avoid any potential ambiguity and confusion with *B. saida*. The use of Ice Cod is emerging nomenclature in scientific literature (for example, Arctic Council's Conservation of Arctic Flora and Fauna) and clarification of the vernacular name is supported by genetic analysis (Nelson and Bouchard, 2013). Regarding other families and species, we recognize (1) Spotted Spiny Dogfish instead of Pacific Spiny Dogfish as the common name for *Squalus suckleyi* (Squalidae, see Lynghammar and others [2012]); (2) Estuarine Eelpout, not Polar Eelpout as the common name for *L. turneri* (Mecklenburg and others, 2002); and (3) Arctic Sand Lance for *Ammodytes hexapterus* following Orr and others (2015) and Mecklenburg and others (2016). Other more recent changes (for example, Mecklenburg and others, 2016) include changes in the scientific names for Capelin (now *Mallotus catervarius*) and Arctic Flounder (now *Liopsetta glacialis*). In every case, the scientific name of a fish is conclusive for the species being described.

One hundred nine (109) species from 24 families are confirmed with 97 verified occurrences from the Chukchi Sea and 83 from the Beaufort Sea (table 2.1). Mecklenburg and others (2002) suggested other species (<20) also might be present and it remains likely that the total number will change with additional field sampling, examination of existing voucher specimens, and with shifts in range due to climate warming. Mecklenburg and others (2007, 2011, 2014, 2016) and Mecklenburg and Steinke (2015) have recently confirmed the presence of at least 18 species in the Alaskan Chukchi and Beaufort Seas that were not previously verified to be present: *Somniosus pacificus*, *Amblyraja hyperborea*, *Bathyraja parmifera*, *Myoxocephalus polyacanthocephalus*, *Triglops nybelini*, *Hypsagonus quadricornis*, *Careproctus reinhardti*, *Liparis bathyarcticus*, *Paraliparis bathybius*, *Lycenchelys kolthoffi*, *Lycodes adolfi*, *L. frigidus*, *L. jugoricus*, *L. marisalbi*, *L. pallidus*, *L. reticulatus*, *Anarhichas denticulatus*, and *Zaprora silenus*. The status of three of these species was previously described as being of “probable” occurrence in the provisional checklist developed for this study:

- **Pacific Sleeper Shark** (*Somniosus pacificus*): Benz and others (2004) reported a new occurrence of the species from an animal found washed onshore at Point Hope, Alaska. The animal remains were highly decomposed; this occurrence was reviewed by Lynghammar and others (2012), who determined that the physical condition of the shark suggested its death from outside the Chukchi Sea. In 2014, a Pacific Sleeper Shark was taken alive by a seal hunter in a southeastern Chukchi Sea lagoon. Parts and photographs were archived in the University of Alaska Museum. This is a mesobenthopelagic shark species recorded as deep as 2,205 m. It is abundant in the southern Bering Sea and the Gulf of Alaska, and reaches 4.4 m TL or more (Mecklenburg and others (2016).

- **Alaska Skate** (*Bathyraja parmifera*): Mecklenburg and others (2011 Online Resource 1) reported that two specimens were found washed ashore in the Chukchi Sea. Examination of one of the specimens indicated advanced deterioration and possible death elsewhere in the northern Bering Sea. Later, Mecklenburg and others (2016) reported that in 2012 an adult specimen was taken alive in the southern Chukchi Sea. Mecklenburg and others (2016) also reported the collection locations of other beachcast specimens and spent egg cases from the Chukchi and Beaufort Sea. The authors noted the species can reach a size of 135 cm TL. They also reported that the occurrences of the Alaska Skate in the Chukchi Sea could indicate a northerly shift in its distribution.

- **Pale Eelpout** (*Lycodes pallidus*): Mecklenburg and others (2016) identified this species in a collection made in 1971 in the Beaufort Sea and confirmed presence in the Beaufort Sea again in voucher collections from 2012 and 2013. Common at least in the Greenland, Barents, and Kara Seas, otherwise found nearly circumpolar. It is epi-meso-bathybenthic and lives on muddy substrate at depths of 11–1,750 m and temperatures of -1.8–3.7 °C. Maximum size is 28.9 cm SL or more (Mecklenburg and others, 2016).

The updated checklist was examined with respect to new species occurrences and differences in the geographic distributions reported in the *Fishes of Alaska* (Mecklenburg and others, 2002) for the Chukchi and Beaufort Seas (table 2.2). Our decision to include two species, *Artediellus ochotensis* and *Lumpenus sagitta*, on the checklist was made recognizing that uncertainty exists about their occurrence in the Chukchi Sea (Mecklenburg and others, 2016). As an example, Mecklenburg and others (2016) state “Many of the specimens that had been previously identified as “*A. ochotensis*” on further investigation have been found to be *A. scaber*.” However, not all of the identifications were refuted. In the case of *L. sagitta*, Mecklenburg and others (2011) described a range extension for this species into the Chukchi Sea based on a single specimen. Presently, Mecklenburg and others (2016) raise doubts “The provenance of a specimen reported to be a possible record of *L. sagitta* from the Chukchi Sea...is uncertain.” The uncertainty stems from conflicting issues in the 1960s field collection data and location of sampling (possibly not Chukchi Sea), and not with species identification. Until these issues can be resolved with species confirmations with new specimens, we chose to retain them on the checklist. As a final note, we recognize *Icelus spiniger* as a valid species from the Chukchi Sea noting that genetic similarities with *I. spatul*a specimens from the region raise questions about relationships. Other technical and unresolved issues for the marine fishes in the Chukchi and Beaufort Seas are described in Mecklenburg and Steinke (2015) and Mecklenburg and others (2016).

Table 2.1. Inventory of confirmed species of Arctic marine fish in the United States Chukchi and Beaufort Seas, Alaska.

[Blank cells indicate that the species occurrence has not been confirmed in that sea. Marine waters out to the U.S. Exclusive Economic Zone (200-mile limit) are included]

Family	Scientific name	Common name	Confirmed occurrence	
			Chukchi Sea	Beaufort Sea
Petromyzontidae	*Entosphenus tridentatus*	Pacific Lamprey	X	
Petromyzontidae	*Lethenteron camtschaticum*	Arctic Lamprey	X	X
Squalidae	*Squalus suckleyi*	Spotted Spiny Dogfish	X	
Somniosidae	*Somniosus pacificus*	Pacific Sleeper Shark	X	
Rajidae	*Amblyraja hyperborea*	Arctic Skate		X
Rajidae	*Bathyraja parmifera*	Alaska Skate	X	
Clupeidae	*Clupea pallasii*	Pacific Herring	X	X
Osmeridae	*Hypomesus olidus*	Pond Smelt	X	
Osmeridae	*Mallotus catervarius*	Pacific Capelin	X	X
Osmeridae	*Osmerus dentex*	Arctic Smelt	X	X
Salmonidae	*Coregonus autumnalis*	Arctic Cisco	X	X
Salmonidae	*Coregonus laurettae*	Bering Cisco	X	X
Salmonidae	*Coregonus nasus*	Broad Whitefish	X	X
Salmonidae	*Coregonus pidschian*	Humpback Whitefish	X	X
Salmonidae	*Coregonus sardinella*	Least Cisco	X	X
Salmonidae	*Oncorhynchus gorbuscha*	Pink Salmon	X	X
Salmonidae	*Oncorhynchus keta*	Chum Salmon	X	X
Salmonidae	*Oncorhynchus kisutch*	Coho Salmon	X	X
Salmonidae	*Oncorhynchus nerka*	Sockeye Salmon	X	X
Salmonidae	*Oncorhynchus tshawytscha*	Chinook Salmon	X	X
Salmonidae	*Salvelinus malma*	Dolly Varden	X	X
Salmonidae	*Stenodus leucichthys*	Inconnu	X	
Myctophidae	*Benthosema glaciale*	Glacier Lanternfish	X	
Gadidae	*Arctogadus glacialis*	Ice Cod	X	X
Gadidae	*Boreogadus saida*	Arctic Cod	X	X
Gadidae	*Eleginus gracilis*	Saffron Cod	X	X
Gadidae	*Gadus chalcogrammus*	Walleye Pollock	X	X
Gadidae	*Gadus macrocephalus*	Pacific Cod	X	X
Gasterosteidae	*Gasterosteus aculeatus*	Threespine Stickleback	X	X
Gasterosteidae	*Pungitius pungitius*	Ninespine Stickleback	X	X
Hexagrammidae	*Hexagrammos stelleri*	Whitespotted Greenling	X	X
Cottidae	*Artediellus ochotensis*	Okhotsk Hookear Sculpin	X	
Cottidae	*Artediellus scaber*	Hamecon	X	X
Cottidae	*Enophrys diceraus*	Antlered Sculpin	X	X
Cottidae	*Gymnocanthus tricuspis*	Arctic Staghorn Sculpin	X	X
Cottidae	*Hemilepidotus papilio*	Butterfly Sculpin	X	
Cottidae	*Icelus bicornis*	Twohorn Sculpin	X	X
Cottidae	*Icelus spatula*	Spatulate Sculpin	X	X
Cottidae	*Icelus spiniger*	Thorny Sculpin	X	
Cottidae	*Megalocottus platycephalus*	Belligerent Sculpin	X	X
Cottidae	*Microcottus sellaris*	Brightbelly Sculpin	X	
Cottidae	*Myoxocephalus jaok*	Plain Sculpin	X	X
Cottidae	*Myoxocephalus polyacanthocephalus*	Great Sculpin	X	
Cottidae	*Myoxocephalus quadricornis*	Fourhorn Sculpin	X	X
Cottidae	*Myoxocephalus scorpioides*	Arctic Sculpin	X	X
Cottidae	*Myoxocephalus scorpius*	Shorthorn Sculpin	X	X
Cottidae	*Trichocottus brashnikovi*	Hairhead Sculpin	X	X
Cottidae	*Triglops nybelini*	Bigeye Sculpin	X	X
Cottidae	*Triglops pingelii*	Ribbed Sculpin	X	X
Hemitripteridae	*Blepsias bilobus*	Crested Sculpin	X	
Hemitripteridae	*Nautichthys pribilovius*	Eyeshade Sculpin	X	X
Psychrolutidae	*Cottunculus microps*	Polar Sculpin		X
Psychrolutidae	*Eurymen gyrinus*	Smoothcheek Sculpin	X	
Agonidae	*Aspidophoroides monopterygius*	Alligatorfish	X	X
Agonidae	*Aspidophoroides olrikii*	Arctic Alligatorfish	X	X

Table 2.1. Inventory of confirmed species of Arctic marine fish in the United States Chukchi and Beaufort Seas, Alaska.—Continued

Family	Scientific name	Common name	Confirmed occurrence	
			Chukchi Sea	Beaufort Sea
Agonidae	*Hypsagonus quadricornis*	Fourhorn Poacher	X	
Agonidae	*Leptagonus decagonus*	Atlantic Poacher	X	X
Agonidae	*Occella dodecaedron*	Bering Poacher	X	
Agonidae	*Pallasina barbata*	Tubenose Poacher	X	
Agonidae	*Podothecus veternus*	Veteran Poacher	X	X
Cyclopteridae	*Eumicrotremus andriashevi*	Pimpled Lumpsucker	X	
Cyclopteridae	*Eumicrotremus derjugini*	Leatherfin Lumpsucker	X	X
Liparidae	*Careproctus reinhardti*	Sea Tadpole	X	X
Liparidae	*Liparis bathyarcticus*	Nebulous Snailfish	X	X
Liparidae	*Liparis fabricii*	Gelatinous Seasnail	X	X
Liparidae	*Liparis gibbus*	Variegated Snailfish	X	X
Liparidae	*Liparis tunicatus*	Kelp Snailfish	X	X
Liparidae	*Paraliparis bathybius*	Black Seasnail	X	X
Zoarcidae	*Gymnelus hemifasciatus*	Halfbarred Pout	X	X
Zoarcidae	*Gymnelus viridis*	Fish Doctor	X	X
Zoarcidae	*Lycenchelys kolthoffi*	Checkered Wolf Eel		X
Zoarcidae	*Lycodes adolfi*	Adolf's Eelpout		X
Zoarcidae	*Lycodes eudipleurostictus*	Doubleline Eelpout		X
Zoarcidae	*Lycodes frigidus*	Glacial Eelpout	X	X
Zoarcidae	*Lycodes jugoricus*	Shulupaoluk		X
Zoarcidae	*Lycodes marisalbi*	White Sea Eelpout		X
Zoarcidae	*Lycodes mucosus*	Saddled Eelpout	X	X
Zoarcidae	*Lycodes palearis*	Wattled Eelpout	X	X
Zoarcidae	*Lycodes pallidus*	Pale Eelpout		X
Zoarcidae	*Lycodes polaris*	Polar Eelpout	X	X
Zoarcidae	*Lycodes raridens*	Marbled Eelpout	X	X
Zoarcidae	*Lycodes reticulatus*	Arctic Eelpout		X
Zoarcidae	*Lycodes rossi*	Threespot Eelpout		X
Zoarcidae	*Lycodes sagittarius*	Archer Eelpout		X
Zoarcidae	*Lycodes seminudus*	Longear Eelpout	X	X
Zoarcidae	*Lycodes squamiventer*	Scalebelly Eelpout		X
Zoarcidae	*Lycodes turneri*	Estuarine Eelpout	X	X
Stichaeidae	*Acantholumpenus mackayi*	Blackline Prickleback	X	
Stichaeidae	*Anisarchus medius*	Stout Eelblenny	X	X
Stichaeidae	*Chirolophis snyderi*	Bearded Warbonnet	X	
Stichaeidae	*Eumesogrammus praecisus*	Fourline Snakeblenny	X	X
Stichaeidae	*Leptoclinus maculatus*	Daubed Shanny	X	X
Stichaeidae	*Lumpenus fabricii*	Slender Eelblenny	X	X
Stichaeidae	*Lumpenus sagitta*	Snake Prickleback	X	
Stichaeidae	*Stichaeus punctatus*	Arctic Shanny	X	X
Pholidae	*Pholis fasciata*	Banded Gunnel	X	
Anarhichadidae	*Anarhichas denticulatus*	Northern Wolffish	X	X
Anarhichadidae	*Anarhichas orientalis*	Bering Wolffish	X	X
Zaproridae	*Zaprora silenus*	Prowfish	X	
Ammodytidae	*Ammodytes hexapterus*	Arctic Sand Lance	X	X
Pleuronectidae	*Hippoglossoides robustus*	Bering Flounder	X	X
Pleuronectidae	*Hippoglossus stenolepis*	Pacific Halibut	X	
Pleuronectidae	*Limanda aspera*	Yellowfin Sole	X	X
Pleuronectidae	*Limanda proboscidea*	Longhead Dab	X	X
Pleuronectidae	*Limanda sakhalinensis*	Sakhalin Sole	X	
Pleuronectidae	*Liopsetta glacialis*	Arctic Flounder	X	X
Pleuronectidae	*Platichthys stellatus*	Starry Flounder	X	X
Pleuronectidae	*Pleuronectes quadrituberculatus*	Alaska Plaice	X	
Pleuronectidae	*Reinhardtius hippoglossoides*	Greenland Halibut	X	X
	Totals:	109	97	83

Table 2.2. Changes in occurrence and geographic distribution of Arctic marine fishes in the Chukchi and Beaufort Seas since 2002.

[Changes were made since publication of Mecklenburg and others (2002)]

Scientific name	Common name	New occurrence	Geographic distribution	
			Range change	No change
Entosphenus tridentatus	Pacific Lamprey			X
Lethenteron camtschaticum	Arctic Lamprey			X
Squalus suckleyi	Spotted Spiny Dogfish		X	
Somniosus pacificus	Pacific Sleeper Shark	X	X	
Amblyraja hyperborea	Arctic Skate	X	X	
Bathyraja parmifera	Alaska Skate	X	X	
Clupea pallasii	Pacific Herring			X
Hypomesus olidus	Pond Smelt		X	
Mallotus catervarius	Pacific Capelin			X
Osmerus dentex	Arctic Smelt			X
Coregonus autumnalis	Arctic Cisco		X	
Coregonus laurettae	Bering Cisco			X
Coregonus nasus	Broad Whitefish			X
Coregonus pidschian	Humpback Whitefish			X
Coregonus sardinella	Least Cisco			X
Oncorhynchus gorbuscha	Pink Salmon			X
Oncorhynchus keta	Chum Salmon			X
Oncorhynchus kisutch	Coho Salmon		X	
Oncorhynchus nerka	Sockeye Salmon		X	
Oncorhynchus tshawytscha	Chinook Salmon			X
Salvelinus malma	Dolly Varden			X
Stenodus leucichthys	Inconnu		X	
Benthosema glaciale	Glacier Lanternfish			X
Arctogadus glacialis	Ice Cod		X	
Boreogadus saida	Arctic Cod			X
Eleginus gracilis	Saffron Cod			X
Gadus chalcogrammus	Walleye Pollock		X	
Gadus macrocephalus	Pacific Cod		X	
Gasterosteus aculeatus	Threespine Stickleback			X
Pungitius pungitius	Ninespine Stickleback			X
Hexagrammos stelleri	Whitespotted Greenling			X
Artediellus ochotensis	Okhotsk Hookear Sculpin			X
Artediellus scaber	Hamecon			X
Enophrys diceraus	Antlered Sculpin			X
Gymnocanthus tricuspis	Arctic Staghorn Sculpin			X
Hemilepidotus papilio	Butterfly Sculpin		X	
Icelus bicornis	Twohorn Sculpin		X	
Icelus spatula	Spatulate Sculpin			X
Icelus spiniger	Thorny Sculpin	X	X	
Megalocottus platycephalus	Belligerent Sculpin			X
Microcottus sellaris	Brightbelly Sculpin		X	
Myoxocephalus jaok	Plain Sculpin		X	
Myoxocephalus polyacanthocephalus	Great Sculpin	X	X	
Myoxocephalus quadricornis	Fourhorn Sculpin			X
Myoxocephalus scorpioides	Arctic Sculpin			X
Myoxocephalus scorpius	Shorthorn Sculpin			X
Trichocottus brashnikovi	Hairhead Sculpin		X	
Triglops nybelini	Bigeye Sculpin	X	X	
Triglops pingelii	Ribbed Sculpin		X	
Blepsias bilobus	Crested Sculpin			X
Nautichthys pribilovius	Eyeshade Sculpin		X	
Cottunculus microps	Polar Sculpin		X	
Eurymen gyrinus	Smoothcheek Sculpin			X
Aspidophoroides monopterygius	Alligatorfish		X	
Aspidophoroides olrikii	Arctic Alligatorfish			X

Table 2.2. Changes in occurrence and geographic distribution of Arctic marine fishes in the Chukchi and Beaufort Seas since 2002.—Continued

Scientific name	Common name	New occurrence	Geographic distribution	
			Range change	No change
Hypsagonus quadricornis	Fourhorn Poacher	X	X	
Leptagonus decagonus	Atlantic Poacher		X	
Occella dodecaedron	Bering Poacher		X	
Pallasina barbata	Tubenose Poacher		X	
Podothecus veternus	Veteran Poacher		X	
Eumicrotremus andriashevi	Pimpled Lumpsucker			X
Eumicrotremus derjugini	Leatherfin Lumpsucker		X	
Careproctus reinhardti	Sea Tadpole	X	X	
Liparis bathyarcticus	Nebulous Snailfish	X	X	
Liparis fabricii	Gelatinous Seasnail		X	
Liparis gibbus	Variegated Snailfish			X
Liparis tunicatus	Kelp Snailfish			X
Paraliparis bathybius	Black Seasnail	X	X	
Gymnelus hemifasciatus	Halfbarred Pout		X	
Gymnelus viridis	Fish Doctor		X	
Lycenchelys kolthoffi	Checkered Wolf Eel	X	X	
Lycodes adolfi	Adolf's Eelpout	X	X	
Lycodes eudipleurostictus	Doubleline Eelpout			X
Lycodes frigidus	Glacial Eelpout	X	X	
Lycodes jugoricus	Shulupaoluk	X	X	
Lycodes marisalbi	White Sea Eelpout	X	X	
Lycodes mucosus	Saddled Eelpout			X
Lycodes palearis	Wattled Eelpout			X
Lycodes pallidus	Pale Eelpout	X	X	
Lycodes polaris	Polar Eelpout			X
Lycodes raridens	Marbled Eelpout		X	
Lycodes reticulatus	Arctic Eelpout	X	X	
Lycodes rossi	Threespot Eelpout			X
Lycodes sagittarius	Archer Eelpout			X
Lycodes seminudus	Longear Eelpout		X	
Lycodes squamiventer	Scalebelly Eelpout		X	
Lycodes turneri	Estuarine Eelpout		X	
Acantholumpenus mackayi	Blackline Prickleback			X
Anisarchus medius	Stout Eelblenny			X
Chirolophis snyderi	Bearded Warbonnet			X
Eumesogrammus praecisus	Fourline Snakeblenny		X	
Leptoclinus maculatus	Daubed Shanny		X	
Lumpenus fabricii	Slender Eelblenny			X
Lumpenus sagitta	Snake Prickleback	X	X	
Stichaeus punctatus	Arctic Shanny		X	
Pholis fasciata	Banded Gunnel		X	
Anarhichas denticulatus	Northern Wolffish	X	X	
Anarhichas orientalis	Bering Wolffish			X
Zaprora silenus	Prowfish	X	X	
Ammodytes hexapterus	Arctic Sand Lance			X
Hippoglossoides robustus	Bering Flounder		X	
Hippoglossus stenolepis	Pacific Halibut		X	
Limanda aspera	Yellowfin Sole			X
Limanda proboscidea	Longhead Dab		X	
Limanda sakhalinensis	Sakhalin Sole		X	
Liopsetta glacialis	Arctic Flounder			X
Platichthys stellatus	Starry Flounder			X
Pleuronectes quadrituberculatus	Alaska Plaice		X	
Reinhardtius hippoglossoides	Greenland Halibut			X
	Totals: 109	20	59	50

Species Range Extensions

Comparing Arctic marine fish distributions as described by recent studies to similar historical information reveals some significant changes. Some of the changes in distributional patterns relate to increased sampling and new discovery and others to changes in species classifications and nomenclature. Since 2002, 20 new species were confirmed from the Chukchi and Beaufort Seas. By family, the new Alaska records were reported from Somniosidae (1), Rajidae (2), Cottidae (3), Agonidae (1), Liparidae (3), Zoarcidae (7), Stichaeidae (1), Anarhichadidae (1), and Zaproridae (1). The new Alaskan records are valid range extensions resulting from BOEM-sponsored surveys by NOAA (Logerwell and others, 2009; Rand and Logerwell, 2011) and University of Alaska-Fairbanks (UAF) and NOAA's RUSALCA (Mecklenburg and others, 2014; Mecklenburg and Steinke, 2015) or changes in taxonomy and distribution reported by Mecklenburg and others (2011, 2015, 2016).

Extensions to the known ranges for five marine species were reported from trawl collections in the Beaufort Sea by Rand and Logerwell (2011): Walleye Pollock (*Gadus chalcogrammus*), Pacific Cod (*G. macrocephalus*), Festive Snailfish (*Liparis marmoratus*), Bigeye Sculpin (*Triglops nybelini*), and Eyeshade Sculpin (*Nautichthys pribilovius)*. Apparently, Rand and Logerwell (2011) did not notice that the Antlered Sculpin (*Enophrys diceraus*) listed in their tables also was an extension of this species' known range in the Beaufort Sea. This extension was confirmed by Maslenikov and others (2013).

Additional information about the Rand and Logerwell (2011) collection includes:

- **Walleye Pollock** (*Gadus chalcogrammus*): This probably was the first published record from the Beaufort Sea for *G. chalcogrammus*, since the previous record from Elson Lagoon (near Barrow, Alaska) was shown to pertain to *Boreogadus saida* (Mecklenburg and others, 2011, Online Resource 1, p. 15). Rand and Logerwell (2011, p. 484) reported this occurrence from Elson Lagoon incorrectly.

- **Pacific Cod (***Gadus macrocephalus*): "*Major changes in the composition of gadine genera in recent years mean patterns of species distribution are different*" (Mecklenburg and others, 2011, Online Resource 1, p. 120). Historically, *G. macrocephalus* from the Beaufort Sea were identified as *G. ogac* (Mecklenburg and others, 2002). Owing to recent DNA studies and similarity in morphology, and the consequent synonymization of *G. ogac* in *G. macrocephalus*, this species is now recognized to have a broad distribution from the Chukchi Sea and continuing eastward in the Arctic across Canada to Greenland and the White Sea (Mecklenburg and others, 2011, Online Resource 1, p. 120). Given this information, the range extension reported by Rand and Logerwell (2011) was not truly an extension of known range.

- **Bigeye Sculpin** (*Triglops nybelini*); From Maslenikov and others, 2013, p. 12): "*An Arctic species reported from northwest of Alaska in the international waters of the Chukchi Borderland (Mecklenburg et al., 2011), the Beaufort Sea off Alaska (eastward to 71.21836N, 149.90316W by benthic trawl in 2011; C.W. Mecklenburg, personnel [sic.] communication), and from western Canada in Mackenzie Bay and Amundsen Gulf eastward around the Arctic to the Laptev Sea (Pietsch, 1993). Captured in a midwater tow, the specimens reported here from the Beaufort Sea east of Point Barrow are vouchers for the 1st Alaskan records cited by Rand and Logerwell (2011).*"

- **Eyeshade Sculpin** (*Nautichthys pribilovius*); From Maslenikov and others, 2013, p. 12) "*Known from the Chukchi Sea off Wainwright south through the western and eastern Bering Sea, Sea of Okhotsk, and Sea of Japan, and the Aleutian and Commander Islands to southeastern Alaska, the record cited here provides a voucher for the northern range extension of* Nautichthys pribilovius *into the Beaufort Sea cited by Rand and Logerwell (2011).*"

As an additional note, the single specimen reported by Rand and Logerwell (2011) from their 2008 cruise is the first record from the Beaufort Sea, as described by Mecklenburg and others (2011, Online Resource 1, p. 27). Others have been collected in the same area since then (Mecklenburg and others, 2016).

- **Festive Snailfish:** Reports of *L. marmoratus* in the Bering Sea and the Alaskan Arctic have been questioned because the voucher specimens are similar morphologically and genetically to *L. tunicatus* (Mecklenburg and others, 2011, 2016; Mecklenburg and Steinke, 2015). The DNA sequences from all specimens collected in the Bering and Chukchi Seas in recent years with the external appearance described for *L. marmoratus* (Mecklenburg and others, 2002), are identical to sequences from *L. tunicatus*. Mecklenburg and others (2011) did not count this species among those considered valid in their review and list of Arctic marine fishes. The specimens reported by Rand and Logerwell (2011), which would be the only records from the U.S. Arctic, look morphologically the same as the barcoded specimens[2].

[2]Mecklenburg and others (2011) questioned the validity of collection records for *L. marmoratus* from the Beaufort Sea. DNA barcoding indicate the species is not valid from the Chukchi or Beaufort Seas but may be found in the Sea of Okhotsk (Mecklenburg and Steinke, 2015).

- **Longear Eelpout** (*Lycodes seminudus*); from Maslenikov and others (2013)**:** *L. seminudus* is an Arctic species known from the Beaufort Sea and the Chukchi slope north of Alaska (Mecklenburg and others, 2011), as well as the Norwegian and Kara Seas. The record cited here extends the range 200 km west in the Beaufort Sea and represents only the second Alaskan record.

Mecklenburg and others (2016, p. 197) reported a significant extension in the northern distribution of the Bearded Warbonnet in sampling conducted off Pt. Barrow:

- **Bearded Warbonnet** (*Chirolophis snyderi*): "The northernmost documented locality is Point Barrow, Alaska, at 71°23′N, 156°29′W, where juvenile specimens were taken in a beach seine in 2012 (e.g., CAS 237946, 2 specimens, each 31 mm). The previously reported northernmost record was from northwest of Point Franklin in the eastern Chukchi Sea (Mecklenburg et al., 2002, 2011; UAM 4582)."

These descriptions highlight the dynamic nature and taxonomic issues associated with documenting or confirming range extensions from the Arctic. In many instances, Alaska records seem to be new because there has been so little previous sampling. Researchers often are not able to review historical collections in light of new taxonomic knowledge. In fairness, the historical data are often difficult to access and interpret because of documented changes in taxonomy and geographical distribution. To illustrate, Rand and Logerwell (2011) noted that Bering Flounder (*Hippoglossoides robustus*) was not reported in Arctic fish sampling by Frost and Lowry (1983) in 1977, nor was it reported north of Point Barrow by Mecklenburg and others (2002). However, additional research by Mecklenburg and others (2011) discovered that this species was distributed eastward through the Beaufort Sea to Bathurst Inlet (Canadian Arctic) as early as 1965.

The Walleye Pollock catches reported by Logerwell and others (2011) were to the north of all larval, age-1, and adult pollock catches depicted by Wyllie Echeverria (1996) for the northeastern Chukchi Sea and the geographic distributions described by Mecklenburg and others (2002). The new Alaskan records, and size of fish captured, raise the possibility that this species, particularly juvenile pollock, may have been misidentified in earlier Beaufort Sea surveys as Polar Cod[3]. It also raises questions about their potential origins and dispersal into this part of the Arctic Ocean. Walleye Pollock are captured off Norway and thus their dispersal into the Beaufort Sea with possible genetic interchange along the upper slope is plausible. Cold temperatures are constraints to northerly movements and abundance of pollock; therefore, large expansions and swarms, such as those reported for Arctic Cod (*Boreogadus saida*) by Crawford and others (2012), would not be expected under present environmental conditions.

Other range extensions are reported in Love and others (2005), Mecklenburg and others (2011), Maslenikov and others (2013), Mecklenburg and Steinke (2015), or evaluated more conventionally in the *Pacific Arctic Marine Fishes* guide (Mecklenburg and others, 2016). In addition to the species discussed from the Rand and Logerwell (2011) collection, an annotated list of range extensions provides new distributional information with supporting documentation as available, or appropriate, for citation at this time. The new information results from an increased Arctic research sampling emphasis in offshore marine habitats in the Chukchi and Beaufort Seas. The annotated list of extensions is represented by lesser-known marine fishes having no commercial value that researchers are aware of and are presented as they relate to the (1) Beaufort Sea, (2) Chukchi Sea, and (3) Chukchi and Beaufort Seas:

1. From the Beaufort Sea:
    - **Arctic Skate** (*Amblyraja hyperborea*)**:** Mecklenburg and others (2016) report this species to be circumpolar; found in polar basins southward to Beaufort Sea of Alaska and Western Canada at depths ranging from 92 to 2,925 m. Size information is reported in Wienerroither and others (2011).

    - **Plain Sculpin** (*Myoxocephalus jaok*)**:** New record identified from the Beaufort Sea in 2011 (Mecklenburg and others, 2016).

    - **Alligatorfish** (*Aspidophoroides monopterygius*)**:** Identified by Catherine W. Mecklenburg from a specimen voucher in the NOAA RACE groundfish surveys 2012 survey collections (Mecklenburg and others, 2016).

    - **Black Seasnail** (*Paraliparis bathybius*)**:** Previously reported from the western Arctic Canada Basin north of Alaska in 2005 (Mecklenburg and others, 2016). Alaskan collections were from slope and deep waters of the Beaufort Sea in 2011.

    - **Checkered Wolf Eel** (*Lycenchelys kolthoffi*): One specimen was taken in the Alaskan Beaufort Sea near the U.S.–Canada border at 70°28′N, 141°09′W at a depth of 500 m (Mecklenburg and others, 2016). Otherwise, the species lives eastward from that point to Greenland and on to the Kara Sea. It is common at least around Greenland. It is mesobenthic, lives on sandy or muddy or mixed soft-stony sea floors, at depths of 202–930 m and temperatures of -0.9–4.1 °C. Maximum size is 29 cm TL.

[3]This is a common misidentification in museum collections (Mecklenburg and others, 2011; Mecklenburg and Steinke, 2015).

At least five new occurrences of eelpout species (table 2.2) from the Beaufort Sea sampling were confirmed in the processing of voucher specimens from University of Alaska Fairbanks fishery collections between 2010 and 2011 (Mecklenburg and Steinke, 2015; Mecklenburg and others, 2016). Specimens collected from the WEBSEC-71 survey in the Beaufort Sea (U.S. Coast Guard Cutter [USCGC] Glacier; Hufford, 1974) were evaluated in 2007 and new information gleaned from the specimens was reported by Mecklenburg and others (2016). Additional records and information on the following species may also be found in Mecklenburg and others (2016):

- **Adolf's Eelpout** (*Lycodes adolfi*)**:** A voucher specimen collected in the Beaufort Sea in University of Alaska Fairbanks surveys conducted between 2010 and 2012 (Mecklenburg and others, 2016). This species was also sampled on Chukchi slope, outside the 200-mi limit, by 2009 RUSALCA (Russian-American Long-term Census of the Arctic, 2009); no other records near or in the Chukchi Sea); see Mecklenburg and others (2011, Online Reference 1).

- **Glacial Eelpout** (*Lycodes frigidus*); From Mecklenburg and others (2011, Online Resource 1, p. 39): "*Arctic; Makarov Basin northwest of Ellesmere Island, deep slopes and basins of Greenland and Norwegian Seas, Nansen to Canada basins off Laptev, East Siberian, Chukchi, and Beaufort Seas. Benthic, at depths of 475 m to 3,000 m, rare in depths less than 1,000 m. The first vouchered collection from north of Alaska (California Academy of Sciences, Department of Ichthyology, San Francisco, USA CAS 230372; 2 specimens, 53–76 mm) was made by remotely operated vehicle (ROV) and suction sampler in 2005 north-northwest of Point Barrow at a depth of about 2,500 m*."

- **Shulupaoluk** (*Lycodes jugoricus*)**:** The University of Alaska Fairbanks Beaufort Sea 2012 voucher specimen collection includes several *L. jugoricus*. (Mecklenburg and others, 2016).

- **White Sea Eelpout** (*Lycodes marisalbi*); From Mecklenburg and others (2011, Online Resource 1), p. 40: "*Arctic; White Sea and Beaufort Sea. Benthic, at depths of 6–335 m. Records from the Beaufort Sea off Alaska identified as* L. pallidus *(e.g., Mecklenburg et al. 2002) are* L. marisalbi *(Canadian Museum of Nature, Ottawa, Canada CMNFI 1974-279, 1974-285, 1974-287, 1978-302; CWM, 15 May 2008).*"

- **Arctic Eelpout** (*Lycodes reticulatus*)**:** Mecklenburg and Steinke (2015) investigated the validity of species in the family Lycodes from the Pacific Arctic Region using morphological observations and DNA barcoding sequences (http://dx.doi.org/10.5883/DS-LYCODES). Their genetic analysis revealed that specimens identified as *L. rossi* always fell into the Beaufort Sea clade for *L. reticulatus*.

- **Threespot Eelpout** (*Lycodes rossi*)**:** The inclusion of this species is based on information presented in Mecklenburg and others (2016).

- **Longear Eelpout** (*Lycodes seminudus*)**:** Based on UAF's fishery surveys in the Beaufort Sea (2011–12 records), an offshore pattern reflects a geographic distribution along the shelf deeper than 200–300 m to about 1,400 m. The species occurs only in the offshore-most tracts in the Beaufort Sea lease area.

- **Scalebelly Eelpout** (*Lycodes squamiventer*)**:** Catherine W. Mecklenburg tentatively identified this species from specimens collected from the Beaufort Sea in 2012 (Mecklenburg and others, 2016).

2. From the Chukchi Sea:

- **Ice Cod** (*Arctogadus glacialis*)**:** Identified from samples collected from the Chukchi Sea (Mecklenburg and others, 2016).

- **Sea Tadpole** (*Careproctus reinhardti*): Geographic distribution from Baffin Bay and Davis Strait, off eastern Greenland, off northern Russia (Kara, and Laptev Seas), and Chukchi Sea slope and northern Bering Sea (Mecklenburg and others, 2016). Benthic, at depth of 100–1,840 m. Preliminary genetic data suggest the sea tadpole could be a species complex (Mecklenburg and others, 2016).

- **Great Sculpin** (*Myoxocephalus polyacanthocephalus*)**:** Okhotsk Sea and eastern Japan Sea to Commander–Aleutian Island chain to Chukchi Sea, 70°20′N, 163°06′W (Mecklenburg and others, 2016) to southern Puget Sound, Washington. Benthic; intertidal and to 825 m.

- **Prowfish** (*Zaprora silenus*)**:** Hokkaido, Japan, and Sea of Okhotsk to Bering Sea (Mecklenburg and others, 2002) and to southeastern Chukchi Sea (west of Kivalina, 67°32′N, 165°54′W) (Mecklenburg and others, 2011) and Aleutian Islands (Mecklenburg and others, 2002) to San Miguel Island, southern California (Allen and Smith, 1988). At depths of 10–801 m. Adults found near bottom, young fish often collected near surface (Mecklenburg and others, 2002).

3. From the Chukchi and Beaufort Seas:

- **Bigeye Sculpin** (*Triglops nybelini*)**:** Arctic Ocean, practically circumpolar, Chukchi Sea north of Alaska, western Beaufort Sea slope between 152°W and 155°W (Mecklenburg and others, 2011). Benthic, at depths of 30–1,354 m, usually deeper than 200 m (Mecklenburg and others, 2016).

- **Nebulous Snailfish** (*Liparis bathyarcticus*)**:** Circumpolar, Beaufort and Chukchi Seas to southeastern Bering Sea (Mecklenburg and others, 2016). Benthic at depths of about 12–510 m (Mecklenburg and others, 2016).

Probable Occurrences in Alaska Arctic

More species are known to occur in the study area than are described in the species accounts in this catalog because the taxonomic examinations of these fish are in an early stage, and valid identifications are not possible without all results from the multi-faceted research (that is, meristic, morphological, and molecular genetic). The ongoing research approach will include formal descriptions of new species and documentation of significant distributional changes. For instance, Mecklenburg and others (2011) reported an unidentified sculpin, *Icelus sp.*, from the Chukchi Sea (*editor's note*: recently confirmed by Mecklenburg and Steinke, 2015), and Rand and Logerwell (2011) reported an unidentified snailfish, *Careproctus sp. cf. rastrinus*, from the Beaufort Sea. For this study, we determined that the biological information available for these two species to be too scant and preliminary to permit construction of dependable species accounts. Species accounts were not developed for *Sominiosus pacificus*, *Bathyraja parmifera*, or *Lycodes pallidus* due to their recent confirmation from the Chukchi Sea (December 2015); information about these species is available in the *Fishes of Alaska* and species accounts are presented in the *Pacific Arctic Marine Fishes* guide (Mecklenburg and others, 2016).

The additional species identified here are likely to be confirmed from Alaska waters. The information presented was primarily from an ongoing effort by several authors of this report to update Love and others (2005):

- **Atlantic Hookear Sculpin** (*Artediellus atlanticus*); From: Mecklenburg and others, (2011, Online Resource 1, p. 20): *Arctic–Boreal; to southern Baffin Island, northwest and northeast Greenland, Iceland, Jan Mayen, Faroe Islands, Norway, and Barents Sea, northern Kara Sea, and northwestern Laptev Sea; upper slope off the Chukchi Sea; south to Cape Cod, the Skagerrak, Irish Sea, and coasts of Ireland* (Fedorov, 1986, p. 1,245; Mecklenburg and others, 2011, fig. 2; this study). Benthic, at depths of 11–1,366 m. Found on the Chukchi slope (Chukchi Sea Borderlands, outside U.S. EEZ) in 2009: two at 74°29′N, 165°58′W, depth 365–370 m (California Academy of Sciences, Department of Ichthyology, San Francisco, USA CAS 228530, fig. 3; Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia ZIN 54840); and five at 74°07′N, 166°00′W, depth 227–236 m (CAS 228533, University of Alaska Museum, University of Alaska Fairbanks 5534). This is the first record from the East Siberian-Chukchi-Beaufort region. The specimens fit the description of *A. a. corniger* (Andriashev, 1954) from the Kara and Laptev Seas, Russia, with large parietal spines, but the most recent review of the species in the western Atlantic (Van Guelpen, 1986) determined this character not to discriminate between taxonomic groups and did not recognize any subspecies of *A. atlanticus.* Parietal spine size resembled a cline, with the most strongly developed found in northern parts of the range. The large size fish length (Total Length) of specimens from the Chukchi Sea (as long as 153 mm) agrees with Van Guelpen's determination that the largest specimens are found in the north. The four Co-1 (Cytochrome C Oxidase 1) gene sequences from the Chukchi Sea slope specimens match those of three specimens from southern Baffin Bay (Canadian Museum of Nature, Ottawa, Canada CMNFI 2002-0028.3, 2002-0031.1, 2002-0033.1; 68°26′–69°37′N). The species was confirmed from the Chukchi Borderland by Mecklenburg and others (2014).

- **Spinyhook Sculpin** (*Artediellus gomojunovi*): From Mecklenburg and others (2011, Online Resource 1)—Boreal Pacific north to Gulf of Anadyr, Russia, and Bering Strait. Benthic, at depths of 37–380 m (Mecklenburg and others, 2002). Bering Sea records are no deeper than 90 m. A specimen collected in 1950 near Point Barrow (Smithsonian National Museum of Natural History, Washington, D.C., USNM 152901) and tentatively identified as *A. gomojunovi* (Andriashev, 1961 as cited by Mecklenburg and others, 2011 Online Resource 1) was misplaced (Mecklenburg and others, 2002), but was found in 2005, and subsequently identified as *A. scaber*. The current northernmost record of *A. gomojunovi* is a specimen caught in 1933 at Bering Strait (ZIN 33093).

- **Hookhorn Sculpin** (*Artediellus pacificus*): From Mecklenburg and others, (2011, Online Resource 1)—Boreal Pacific north to southern Gulf of Anadyr and northeast of St. Lawrence Island, Bering Sea. Benthic, at depths of 15–250 m (Mecklenburg and others, 2002). The northern records are not recent: Zoological

Institute of the Russian Academy of Sciences, St. Petersburg, Russia ZIN 33657, Gulf of Anadyr at 63°53′N, 178°48′W, depth 87 m, collected in 1952; and University of Washington Fish Collection at the Burke Museum, Seattle, WA UW 11740, at 63°40′N, 167°28′W, depth 22–40 m, in 1949.

- **Leister Sculpin** (*Enophrys lucasi*): Mecklenburg and others (2016, p. 55) described the distribution as “Southeastern Kamchatka, Commander Islands, Aleutian Islands, Gulf British Columbia, Bering Sea north to Bering Strait. The distribution is difficult to assess due to misidentifications in the literature and museum collections, and the distribution depicted on our map may not be accurate north of the Aleutian Islands and Gulf of Alaska.”

- **Threaded Sculpin** (*Gymnocanthus pistilliger*): Mecklenburg and others (2016) suggested this species to be common from Bering Strait. The northernmost record is CAS 230370, taken in 2006 west of Port Clarence at 65°21′N, 167°41′W. Records from Port Clarence include CAS 230369, CAS 230370, CMNFI 1958-0093, UAM 1201, and UW 41676). The several records from Port Clarence and nearby suggest it also occurs in the southeastern Chukchi Sea and there are reliable identifications northward to Kotzebue Sound, but distribution in the Chukchi Sea has not been documented with voucher specimens. Historical records from the Chukchi Sea remain unverified or have been reidentified (Mecklenburg and others, 2016).

- **Yellow Irish Lord** (*Hemilepidotus jordani*): From Mecklenburg and others, (2011, Online Resource 1)—Boreal Pacific north to Bering Strait, perhaps to southeastern Chukchi Sea. Benthic, at depths of 15–400 m or more, typically shallower than 150 m. Reported from Chukchi Sea (Allen and Smith, 1988), but voucher specimens are lacking. A specimen from the Chukchi Sea southwest of Kivalina identified as *H. jordani* (University of British Columbia, Vancouver, B.C., UBC 61-0064) is *H. papilio* (Mecklenburg and others, 2016). The northernmost verified record is CAS 230368, two juveniles (77–82 mm) caught in 2006 near eastern Bering Strait at 64°59’N, 168°30’W, by bottom trawl in 25 m of water.

- **Frog Sculpin** (*Myoxocephalus stelleri*): This species, once believed to possibly be present rarely in Alaskan waters (Mecklenburg and others, 2002), has been determined from evaluation of all pertinent literature and voucher records identified as this species to be absent from the eastern Pacific and Alaskan waters (Mecklenburg and others, 2011, 2016). See also Mecklenburg and Steinke (2015, p. 176).

- **Polar Sculpin** (*Cottunculus microps*): One record is from the Arctic Ocean on the slope north of the Chukchi Sea, outside the 200-mi limit. Taxonomic revision is in progress; confirmed from the Chukchi Borderland (Mecklenburg and others, 2014).

- **Threaded Sculpin** (*Gymnocanthus pistilliger*): Mecklenburg and others (2016) extended the range for this species into the southeastern Chukchi Sea based on “reliable” identifications but not confirmed specimen vouchers. Although this species is likely to occur in the region, our list includes only species whose presence is known from voucher specimens.

- **Northern Sand Lance** (*Ammodytes dubius*): Predominantly in boreal western Atlantic; Canadian Arctic from Beaufort Sea to Baffin Bay, and Davis Strait. Benthic, shallows to 108 m (Coad and Reist, 2004). These authors also listed Alaska but provided no specific locality.

Other Changes in Species Distributions

In addition to the new occurrences and range extensions in table 2.2, mapping for this study (chapter 3) documents expansions in the known geographic distributions of another 45 species in this updating of information presented in the *Fishes of Alaska* (Mecklenburg and others, 2002). These shifts in range result from the new information and knowledge gained from recent field surveys and discoveries, improved identification techniques, evaluation of museum collections, and the wide-ranging search of data and literature for this study. In light of the recent field sampling, some changes in geographic, depth, or both, were realistic expectations. Marine ecosystems are dynamic and fish distributions may contract and expand due to various factors including, but not limited to, temperature changes, current patterns, changes in population size, and changes in predator and prey distribution.

Nomenclature and Previous Misidentifications

Genetic analysis, in concert with other species identification techniques, has greatly assisted ichthyological efforts to clarify and resolve existing taxonomic uncertainty surrounding many Arctic species. This work has resulted in several important changes in scientific and common names, which must be continually tracked for natural resource inventories to remain current. The changes in nomenclature in table 2.3 relate to the greater resolution in phylogenetic understanding that presently exists than was available at the time when the *Fishes of Alaska* (Mecklenburg and others, 2002) was published.

Many species relationships require further study and additional changes in synonymy are expected. As an example, the relationship between *Hippoglossiodes robutus* (Bering Flounder) and *H. elassodon* (Flathead Sole) are currently being investigated (Kartavtsev and others, 2008; Mecklenburg and Steinke, 2015; Mecklenburg and others, 2016); preliminary results suggest the two species are the same.

Table 2.3. Changes in scientific and common names of Arctic marine fishes in the Chukchi and Beaufort Seas since 2002.

[Changes were made since publication of Mecklenburg and others (2002). **Reference:** Information is critical for users. In some instances, specialists may disagree ("not clearly distinguishable" as supporting genetic information may not be available; for example, *Liparis herchelinus* not clearly distinguished from *L. tunicatus*), or species may be part of an evolving complex (for example, *Lycodes rossi* and *L. reticulatus*)]

Family	Common or scientific name	Change in common or scientific name		Reference
		From	To	
Squalidae	Spotted Spiny Dogfish	*Squalus acanthias*	*Squalus suckleyi*	Lynghammar and others, 2012
Osmeridae	Capelin	*Mallotus villosus*	*Mallotus catervarius*	Mecklenburg and Steinke, 2015
Osmeridae	*Mallotus catervarius*	Capelin	Pacific Capelin	Mecklenburg and Steinke, 2015
Osmeridae	Arctic Smelt	*Osmerus mordax*	*Osmerus dentex*	Mecklenburg and others, 2011
Gadidae	*Arctogadus glacialis*	Polar Cod	Ice Cod	Jørgen Schou Christiansen, oral commun, 2013[1]
Gadidae	Walleye Pollock	*Theragra chalcogramma*	*Gadus chalcogrammus*	Mecklenburg and others, 2011; Page and others, 2013
Gadidae	Pacific Cod	*Gadus ogac*	*Gadus macrocephalus*	Mecklenburg and others, 2011; Page and others, 2013
Psychrolutidae	Polar Sculpin	*Cottunculus sadko*	*Cottunculus microps*	Byrkjedal and others, 2014
Agonidae	Arctic Alligatorfish	*Ulcina olrikii*	*Aspidophoroides olrikii*	Mecklenburg and others, 2011; Page and others, 2013
Ammodytidae	*Ammodytes hexapterus*	Pacific Sand Lance	Arctic Sand Lance	Orr and others, 2015
Pleuronectidae	Arctic Flounder	*Pleuronectes glacialis*	*Liopsetta glacialis*	Eschmeyer and others, 2015; Mecklenburg and others, 2016

[1]From Jørgen Schou Christiansen, University of Tromsø, Norway, written commun., May 12, 2013, regarding common names for *A. glacialis* and *B. saida*: "*The scientific name is conclusive and should follow the vernacular name at first mention for these species. Whenever vernacular names are used, we suggest 'ice cod' for Arctogadus glacialis (Latin: glacialis = ice; Russian: ледовая треска) and 'polar cod' for Boreogadus saida. Fish names lists representing the official stand of national and international organizations such as the American Fisheries Society and American Society of Ichthyologists and Herpetologists (Nelson et al. 2004) and the Fisheries Society of the British Isles (Wheeler 1992) differ and, thus, preclude establishment of universal common names. Fortunately, use of scientific names at first mention allows preferential use of vernacular names.*" We acknowledge that our of use Ice Cod is different from other North American nomenclature (Page and others, 2013; Hoff and others, 2015; Mecklenburg and others, 2016). Mecklenburg and others (2013) list Ice Cod as one of the "English" names for *A. glacialis*.

Zoogeographic Patterns

Definitions of zoogeographic pattern are from Mecklenburg and others (2011, Online Resource 1) and relate to species endemism and ranges of their population viability:

- *Arctic*—Species that live and reproduce in Arctic waters and are not found, or only infrequently found, in adjacent boreal waters.
- *Predominantly Arctic*—Species that are usually found in Arctic waters.
- *Predominantly Boreal*—Species that are characteristic of boreal waters and common in the border regions of the Arctic (for example, eastern Barents Sea, Gulf of Anadyr [Russia], Norton Sound [Alaska]). Can be more specific, such as predominantly Boreal Pacific or predominantly Boreal eastern Atlantic.
- *Boreal*—Species that are characteristic of boreal waters and only rarely or temporarily found in the border regions of the Arctic. Can be more specific, such as Boreal Pacific or Boreal eastern Atlantic. Includes subtropical, southern boreal category of Andriashev and Chernova (1994).
- *Arctic-Boreal*—Species are distributed and spawn in both Arctic and Boreal waters.
- *Widely Distributed*—Species common in the temperate, boreal, and subtropical zones and in the warm waters of at least two oceans or known from the southern hemisphere, and occurring only rarely in the Arctic.

Abundance Terminology

Species distribution and abundance was determined from the reports of a large number of reconnaissance surveys and research expeditions. The wide variation in sampling times, areas, and collection methods reported raised issues of data comparability, which required reviewing existing abundance measures, defining appropriate relative abundance terms, and consistently applying operational definitions. Many methods and descriptors have been used to express fish abundance in Arctic studies. Relative abundance terms such as abundant, common, fairly common, present, occasional, uncommon, or rare are commonplace in the reported literature (for example, Coad and Reist, 2004). Existing baselines for Arctic marine fishes are not consistent for sampling in time, space, or methods to support a quantitative, multi-scaled classification that might be suggested by the definitions from Mecklenburg and others (2011) and Mecklenburg and Steinke, 2015). The challenge was to define a simple, but robust classification system that would have broad regional application.
Four ecological principles guided the definition process: (1) abundance is a continuum between rare and abundant, (2) abundance is scale dependent, (3) sampling bias affects estimates of abundance, and (4) environmental influences on species abundance are taxon-specific.

"Rare," "uncommon," and "common" terms are defined in this report to classify relative abundance in the species accounts. These terms also were used by Miller and Lea (1976) to describe the coastal marine fishes of California[4]. For the Arctic ichthyofauna, abundance was classified using the same terms but with different operational definitions determined by species compositions and capture rates of marine fishes. These descriptive statistics are commonly used to characterize catch and, with respect to a regional classification scheme, meet pragmatic criteria related to acceptability (are ecologically sound and reliable), practicality (are applicable to existing records), and effectiveness (are realistic with broad-scale[5] patterns). Species composition (percentage of occurrence of a species with respect to total number of individuals in the catch) provides a simple and scale dependent quantification of an assemblage on an acceptable[6] continuum. Capture rates are a lower resolution measure of abundance based on the presence or absence of a species detected per sampling session and frequency of capture (or rate) over sampling period and survey area.

[4]The decision to use three abundance categories used by Miller and Lea (1976) relates to the lack of consistent, long-term data sets needed for more precise estimates.

[5]Marine fishes are not uniformly distributed in time or space. This analysis was unable to capture seasonal and locality differences but rather portrays regional patterns in abundance.

[6]"Acceptable," as used here, refers to the precision of existing data with respect to the seasonal, geographic, and taxonomic qualities of data collection and how accurately they describe baseline conditions.

Detection rates allow a higher order, less precise comparison of abundance across gear-types and habitats and are a more subjective index. With respect to gear bias and comparability issues, the resultant abundance categories represent semi-quantitative composite metrics from descriptive analyses of catch and expert opinion about relative abundance across at the large-scales of distributional patterns (table 2.4).

Table 2.4. Relative abundance of Arctic marine fishes in the Chukchi and Beaufort Seas.

[**Symbols:** ≥, greater than or equal to; >, greater than; <, less than; ≤, less than or equal to]

Relative abundance term (ecological science)	Species composition (by geographic locale)	Frequency of capture (encounter rates in catch records)
Common	Regularly collected (comprise ≥10 to 50 percent of catch in terms of total numbers of individuals)	Constant rate of capture (>10 to 25 percent of records)
Uncommon	Infrequently observed or collected (<10 percent of catch in terms of total numbers of individuals)	Low rate of capture (≤10 percent of records)
Rare	Seldom reported	20 or fewer records in Arctic (or 1 to 2 captures per cruise)

Endemism and Relative Abundance

Mecklenburg and others, (2011) describe the zoogeographic pattern of 242 marine fish species from the Arctic zoogeographic province. This province includes the northern Bering Sea and North Atlantic Ocean at latitudes far south of this study area. These authors reported 41 percent of the zoogeographic patterns of the marine fauna were Arctic (that is, Arctic, Predominantly Arctic, and Arctic-Boreal zoogeographic patterns) and 59 percent were Boreal (that is, Predominantly Boreal, Boreal, and Widely Distributed zoogeographic patterns). Applying this approach to just the United States area of the Arctic Province, we determined that the Arctic pattern in 58 percent (n = 92) of the marine fishes was from the Chukchi Sea and 73 percent (n = 80) was from the Beaufort Sea. (Editors note: Analysis does not include newly confirmed species to the region—*Somniosus pacificus*, *Bathyraja parmifera*, *Icelus spiniger*, and *Lycodes pallidus*.) The Boreal pattern comprised 42 and 26 percent of the marine faunas, respectively. The ratio of Arctic to Boreal patterns for marine fish found in the U.S. Chukchi and Beaufort Seas is about 60:40 (table 2.5).

Table 2.5. Relative abundance and zoogeography of Arctic marine fishes in the Chukchi and Beaufort Seas.

[**Zoogeographic pattern:** Main references, Mecklenburg and others (2011) Online Resource 1, Mecklenburg and Steinke (2015), and Mecklenburg and others (2016). Blank cell indicates the species is unreported or unknown from the area]

Scientific name	Common name	Confirmed occurrence		Zoogeographic pattern
		Chukchi Sea	Beaufort Sea	
Entosphenus tridentatus	Pacific Lamprey	Rare		Boreal Pacific
Lethenteron camtschaticum	Arctic Lamprey	Common	Common	Arctic-Boreal
Squalus suckleyi	Spotted Spiny Dogfish	Rare		Boreal Pacific
Somniosus pacificus	Pacific Sleeper Shark	Rare		Boreal Pacific
Amblyraja hyperborea	Arctic Skate		Rare	Arctic
Bathyraja parmifera	Alaska Skate	Rare		Boreal Pacific
Clupea pallasii	Pacific Herring	Common	Uncommon	Arctic-Boreal Pacific
Hypomesus olidus	Pond Smelt	Rare		Predominantly Boreal Pacific
Mallotus catervarius	Pacific Capelin	Common	Common	Arctic-Boreal
Osmerus dentex	Arctic Smelt	Common	Common	Arctic Boreal Pacific
Coregonus autumnalis	Arctic Cisco	Rare	Common	Arctic
Coregonus laurettae	Bering Cisco	Common	Common	Predominantly Arctic
Coregonus nasus	Broad Whitefish	Common	Common	Predominantly Arctic
Coregonus pidschian	Humpback Whitefish	Common	Common	Predominantly Arctic
Coregonus sardinella	Least Cisco	Common	Common	Predominantly Arctic
Oncorhynchus gorbuscha	Pink Salmon	Common	Uncommon	Predominantly Boreal Pacific
Oncorhynchus keta	Chum Salmon	Common	Uncommon	Predominantly Boreal Pacific
Oncorhynchus kisutch	Coho Salmon	Uncommon	Uncommon	Predominantly Boreal Pacific
Oncorhynchus nerka	Sockeye Salmon	Uncommon	Uncommon	Predominantly Boreal Pacific
Oncorhynchus tshawytscha	Chinook Salmon	Uncommon	Uncommon	Predominantly Boreal Pacific
Salvelinus malma	Dolly Varden	Common	Common	Arctic-Boreal Pacific
Stenodus leucichthys	Inconnu	Common		Arctic-Boreal[1]
Benthosema glaciale	Glacier Lanternfish	Rare		Arctic-Boreal Atlantic
Arctogadus glacialis	Ice Cod		Rare	Arctic
Boreogadus saida	Arctic Cod	Common	Common	Arctic
Eleginus gracilis	Saffron Cod	Common	Common	Arctic-Boreal Pacific
Gadus chalcogrammus	Walleye Pollock	Uncommon	Uncommon	Predominantly Boreal Pacific and Atlantic
Gadus macrocephalus	Pacific Cod	Uncommon	Uncommon	Arctic-Boreal Pacific and western Atlantic
Gasterosteus aculeatus	Threespine Stickleback	Common	Rare	Predominantly Boreal
Pungitius pungitius	Ninespine Stickleback	Common	Common	Predominantly Boreal
Hexagrammos stelleri	Whitespotted Greenling	Uncommon	Rare	Predominantly Boreal Pacific
Artediellus ochotensis	Okhotsk Hookear Sculpin	Rare		Boreal Pacific
Artediellus scaber	Hamecon	Common	Common	Arctic
Enophrys diceraus	Antlered Sculpin	Common	Uncommon	Predominantly Boreal Pacific
Gymnocanthus tricuspis	Arctic Staghorn Sculpin	Common	Common	Arctic
Hemilepidotus papilio	Butterfly Sculpin	Common		Predominantly Boreal Pacific
Icelus bicornis	Twohorn Sculpin	Rare	Uncommon	Predominantly Arctic
Icelus spatula	Spatulate Sculpin	Common	Common	Arctic-Boreal
Icelus spiniger	Thorny Sculpin	Rare		Predominantly Boreal
Megalocottus platycephalus	Belligerent Sculpin	Common	Rare	Predominantly Boreal Pacific
Microcottus sellaris	Brightbelly Sculpin	Rare		Predominantly Boreal Pacific
Myoxocephalus jaok	Plain Sculpin	Rare	Rare	Predominantly Boreal Pacific
Myoxocephalus polyacanthocephalus	Great Sculpin	Rare		Boreal Pacific
Myoxocephalus quadricornis	Fourhorn Sculpin	Common	Common	Predominantly Arctic
Myoxocephalus scorpioides	Arctic Sculpin	Uncommon	Uncommon	Arctic
Myoxocephalus scorpius	Shorthorn Sculpin	Common	Common	Arctic-Boreal
Trichocottus brashnikovi	Hairhead Sculpin	Common	Uncommon	Predominantly Boreal Pacific
Triglops nybelini	Bigeye Sculpin	Uncommon	Uncommon	Arctic
Triglops pingelii	Ribbed Sculpin	Common	Uncommon	Arctic-Boreal
Blepsias bilobus	Crested Sculpin	Uncommon		Boreal Pacific
Nautichthys pribilovius	Eyeshade Sculpin	Common	Rare	Predominantly Boreal Pacific
Cottunculus microps	Polar Sculpin		Rare	Arctic-Boreal Atlantic
Eurymen gyrinus	Smoothcheek Sculpin	Rare		Predominantly Boreal Pacific

Table 2.5. Relative abundance and zoogeography of Arctic marine fishes in the Chukchi and Beaufort Seas.—Continued

Scientific name	Common name	Confirmed occurrence		Zoogeographic pattern
		Chukchi Sea	Beaufort Sea	
Aspidophoroides monopterygius	Alligatorfish	Common	Common	Predominantly Arctic
Aspidophoroides olrikii	Arctic Alligatorfish	Common	Common	Predominantly Arctic
Hypsagonus quadricornis	Fourhorn Poacher	Rare		Boreal Pacific
Leptagonus decagonus	Atlantic Poacher	Uncommon	Uncommon	Arctic-Boreal
Occella dodecaedron	Bering Poacher	Rare		Boreal Pacific
Pallasina barbata	Tubenose Poacher	Rare		Predominantly Boreal Pacific
Podothecus veternus	Veteran Poacher	Common	Common	Arctic-Boreal Pacific
Eumicrotremus andriashevi	Pimpled Lumpsucker	Rare		Arctic-Boreal Pacific
Eumicrotremus derjugini	Leatherfin Lumpsucker	Rare	Uncommon	Arctic
Careproctus reinhardti	Sea Tadpole	Rare	Rare	Arctic
Liparis bathyarcticus	Nebulous Snailfish	Common	Common	Predominantly Arctic
Liparis fabricii	Gelatinous Seasnail	Common	Common	Arctic
Liparis gibbus	Variegated Snailfish	Common	Uncommon	Arctic-Boreal
Liparis tunicatus	Kelp Snailfish	Common	Common	Arctic
Paraliparis bathybius	Black Seasnail	Rare	Rare	Arctic
Gymnelus hemifasciatus	Halfbarred Pout	Common	Common	Arctic-Boreal
Gymnelus viridis	Fish Doctor	Common	Common	Predominantly Arctic
Lycenchelys kolthoffi	Checkered Wolf Eel		Rare	Arctic
Lycodes adolfi	Adolf's Eelpout		Rare	Arctic
Lycodes eudipleurostictus	Doubleline Eelpout		Uncommon	Arctic
Lycodes frigidus	Glacial Eelpout	Rare	Rare	Arctic
Lycodes jugoricus	Shulupaoluk		Rare	Arctic
Lycodes marisalbi	White Sea Eelpout		Rare	Arctic
Lycodes mucosus	Saddled Eelpout	Common	Uncommon	Arctic
Lycodes palearis	Wattled Eelpout	Common	Uncommon	Predominantly Boreal Pacific
Lycodes pallidus	Pale Eelpout		Rare	Arctic
Lycodes polaris	Polar Eelpout	Common	Common	Arctic
Lycodes raridens	Marbled Eelpout	Common	Common	Arctic-Boreal Pacific
Lycodes reticulatus	Arctic Eelpout		Common	Arctic
Lycodes rossi	Threespot Eelpout		Rare	Arctic
Lycodes sagittarius	Archer Eelpout		Common	Arctic
Lycodes seminudus	Longear Eelpout	Rare	Rare	Arctic
Lycodes squamiventer	Scalebelly Eelpout		Rare	Arctic
Lycodes turneri	Estuarine Eelpout	Uncommon	Uncommon	Predominantly Arctic Pacific
Acantholumpenus mackayi	Blackline Prickleback	Uncommon		Predominantly Boreal Pacific
Anisarchus medius	Stout Eelblenny	Common	Uncommon	Arctic-Boreal
Chirolophis snyderi	Bearded Warbonnet	Uncommon		Predominantly Boreal Pacific
Eumesogrammus praecisus	Fourline Snakeblenny	Uncommon	Uncommon	Arctic-Boreal Pacific and western Atlantic
Leptoclinus maculatus	Daubed Shanny	Common	Common	Arctic-Boreal Pacific and Atlantic
Lumpenus fabricii	Slender Eelblenny	Common	Common	Arctic-Boreal
Lumpenus sagitta	Snake Prickleback	Rare		Boreal Pacific
Stichaeus punctatus	Arctic Shanny	Common	Common	Arctic-Boreal Pacific and western Atlantic
Pholis fasciata	Banded Gunnel	Uncommon	Rare	Arctic-Boreal
Anarhichas denticulatus	Northern Wolffish	Rare	Rare	Arctic-Boreal
Anarhichas orientalis	Bering Wolffish	Uncommon	Uncommon	Predominantly Boreal Pacific
Zaprora silenus	Prowfish	Rare		Boreal Pacific
Ammodytes hexapterus	Arctic Sand Lance	Common	Common	Arctic-Boreal Pacific
Hippoglossoides robustus	Bering Flounder	Common	Common	Arctic-Boreal Pacific
Hippoglossus stenolepis	Pacific Halibut	Rare		Boreal Pacific
Limanda aspera	Yellowfin Sole	Common	Rare	Predominantly Boreal Pacific
Limanda proboscidea	Longhead Dab	Uncommon	Rare	Predominantly Boreal Pacific
Limanda sakhalinensis	Sakhalin Sole	Uncommon		Predominantly Boreal Pacific
Liopsetta glacialis	Arctic Flounder	Common	Common	Predominantly Arctic
Platichthys stellatus	Starry Flounder	Uncommon	Uncommon	Arctic-Boreal Pacific
Pleuronectes quadrituberculatus	Alaska Plaice	Uncommon		Predominantly Boreal Pacific
Reinhardtius hippoglossoides	Greenland Halibut	Uncommon	Uncommon	Arctic-Boreal Pacific and Atlantic

[1]Author determination.

Acknowledgments

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Summary

One hundred nine (109) marine fishes from 24 families are described and compared regarding their occurrence in the United States Chukchi and Beaufort seas. Ninety-seven (97) species are confirmed from the Chukchi Sea and 83 from the Beaufort Sea. Twenty species are newly confirmed to the U.S. Arctic since the publication of *Fishes of Alaska* in 2002. The taxonomy of Arctic marine fishes has improved since 2002, but issues in the naming and acceptance and validity of several species in the Liparidae and Zoarcidae require additional resolution. Many of the common species are benthic or demersal in their habitat orientation. Small-sized marine species such as those representing Cottidae, Liparidae, Stichaeidae, and Zoarcidae families, were common to both seas. The diversity of Salmonidae species reflects the plasticity of this group of fishes and its adaptive linkage to freshwaters. Our analysis supports high rates of Arctic endemism in both seas, especially in the Beaufort Sea. Numerous range extensions and their sources are noted. The estimates of species diversity can be expected to increase with new sampling, with greater reliance on genetic and molecular identification aids, and in response to large-scale effects of changing environmental conditions on present patterns of regional fish distribution and abundance. *Fishes of Alaska* remains an important reference for species taxonomy and identification of more than 600 species from the Gulf of Alaska and Bering Sea to the Arctic but is not complete with respect to species in the Chukchi and Beaufort Seas.

Chapter 3. Alaska Arctic Marine Fish Species Accounts

By Milton S. Love[1], Nancy Elder[2], Catherine W. Mecklenburg[3], Lyman K. Thorsteinson[2], and T. Anthony Mecklenburg[4]

Abstract

Species accounts provide brief, but thorough descriptions about what is known, and not known, about the natural life histories and functional roles of marine fishes in the Arctic marine ecosystem. Information about human influences on traditional names and resource use and availability is limited, but what information is available provides important insights about marine ecosystem status and condition, seasonal patterns of fish habitat use, and community resilience. This linkage has received limited scientific attention and information is best for marine species occupying inshore and freshwater habitats. Some species, especially the salmonids and coregonids, are important in subsistence fisheries and have traditional values related to sustenance, kinship, and barter. Each account is an autonomous document providing concise information about a species zoogeography, western and Alaska Native taxonomy, life history, niches, and life requirements. Each account is fully referenced with the identification of the most critical literature for Alaska and a more comprehensive listing of referencing from which biological and ecological information was drawn. New-to-science narratives, distributional maps, and vertical profiles, provide quick, reliable sources of information about fish life history and habitat requirements for this segment of the Arctic fauna.

Purpose and Design of Species Accounts

Individual species accounts were prepared for 104 of the 109 confirmed marine fishes for which adequate biological information was available from the U.S. Chukchi and Beaufort Seas. These descriptions are an important source of documentation about Arctic Alaska's marine fish fauna. Although tailored to address the specific needs of BOEM Alaska OCS Region NEPA analysts, the information presented in each species account also is meant to be useful to other users including state and Federal fisheries managers and scientists, commercial and subsistence resource communities, and Arctic residents. Readers interested in obtaining additional information about the taxonomy and identification of marine Arctic fishes are encouraged to consult the *Fishes of Alaska* (Mecklenburg and others, 2002) and *Pacific Arctic Marine Fishes* (Mecklenburg and others, 2016). By design, the species accounts enhance and complement information presented in the *Fishes of Alaska* with more detailed attention to biological and ecological aspects of each species' natural history and, as necessary, updated information on taxonomy and geographic distribution.

Each species account includes a concise summary of the natural history, population dynamics, functional roles, and traditional and economic values of the marine fish found off Alaska. An initial organizational task was to create a standard format for effective information delivery. The species descriptions by Ehrlich and others (1988) were provided to the USGS by BOEM as an example of a creative template for information transfer. Four pilot species accounts, representing well known to poorly known species, were developed, reviewed, and repeatedly revised for improvements, interagency approval, and selection of the final layout and design. Final decisions about content represented the priority needs of BOEM.

More than 1,200 individual scientific publications relevant to Arctic marine fishes were reviewed in preparation of the species accounts. In each species account, the most relevant literature for each species is cited. A shorter list (about 5–10 articles) identifies key Alaskan information sources that, in our opinion, have had the greatest scientific effect on understanding the species of the Arctic area of the United States.

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[4]Point Stephens Research, Auke Bay, Alaska.

Limitations of Data

The species accounts reveal many gaps in the biological information needed to conduct vulnerability assessments of the marine fishes of the Beaufort and Chukchi Seas to human interventions. Part of this problem relates to the geographic coverage of existing research and surveys in Alaska as, in many instances, we were required to incorporate the results of investigations conducted outside the region. This raises an important caution because, even though the best available information was used in preparing the species accounts, our reliance on data and information from outside Alaska will introduce uncertainty to EIS expectations. Ideally, and with respect to oil and gas activities, baseline information for fishery resources should be collected from the potentially affected environment to appropriately evaluate the potential effects of oil spills or other possible industrial-related disturbances. However, as has been widely noted (for example, Bluhm and others, 2011), systematic and methodologically comparable data typically are not available from Arctic Alaska marine ecosystems. Evaluating change in populations and communities from natural and anthropogenic stressors is limited by the variable quality and lack of quantitative reports on abundance, distribution, community structure, and demographics for Arctic marine fishes.

In each species account, an attempt was made to incorporate the most reliable baseline information available and offer impressions of information needs. Important ongoing studies sponsored by BOEM, and others, may be addressing some of these needs. The needs assessments for this study considered these efforts to the extent that oral and (or) written communications and preliminary results allowed. The focus of this study was on impressions of the population parameters (Williams and others, 2002) and environmental measurements needed to detect changes in marine fish populations (Reist and others, 2006; Wassmann and others, 2011) and their resilience to a variable and rapidly changing environment (Holland-Bartels and Pierce, 2011). For key marine fish species, examples might include changes in range, community structure, abundance, phenology, behavior, and population growth and survival.

Each species account is designed as a self-contained article; therefore, no references to other accounts are included. Additionally, to reduce complexity in the presentations, only common names were used to identify the major predator and prey species for the marine fish described. Because this document was meant to be a companion document to the *Fishes of Alaska* (Mecklenburg and others, 2002), interested readers are encouraged to consult this book or Page and others (2013) and Mecklenburg and others (2016) for more complete information about the scientific authorities and literature citations associated with the original descriptions of each species. Readers are directed to the references cited in each species account for additional information on the species.

Operational Definitions

In chapter 1, several concepts about the temporal and spatial habitat requirements for Arctic marine fish were introduced. More information is presented in this chapter to explain the vertical distribution and the location of shelf break, as used in this report.

Vertical Distribution

The conceptual design of the species depth profiles (vertical structure by life history stage) was patterned after the “coastal marine life zones” of Allen and Smith (1988). The goal of the profiles is to visualize what is known about a species occurrence and reproductive ecology by depth and location. An idealized characterization of Arctic shelves was designed to visualize these relationships. Additional detail about origins of data was included in the depth profiles to reflect Alaskan records or collections from other Arctic regions. This is important because actual field collections and observations are limited from this region. In many instances, the actual presence of a life stage remains unverified by field sampling. Thus, for many of species, the depth of a fish’s life cycle should be considered untested hypotheses in need of additional testing.

Location of Shelf Break

Early versions of the depth profiles were modified at the request of BOEM with respect to the depiction of the continental shelf break. As a special effect for the Arctic, the species depth profiles were redrawn to depict the change in bathymetry that typically occurs at depths of about 75 m throughout the Chukchi and western Beaufort Seas. This depiction is not an attempt to redefine the oceanographic definition of shelf break. Instead, it highlights the relatively sharp gradient in depths that often occurs near 70- to 80-m contours over much of the region. Although species depth profiles in this report depict an apparent “break” at 75-m, three factors were considered: (1) this is a generalization and the actual shelf break may be geographically close but at a slightly greater depth; (2) shelf edge effects on fish distribution at depths occurring between 75-, 150-, or 200-m are likely negligible due to the gradient and area involved; and (3) the conceptual depictions of depth distributions by life history stage are consistent with accepted oceanographic conventions for continental shelf and slope (despite the magnified view at 75-m) and thus are compatible to the import of biological data obtained elsewhere.

Keystone Species

The concept of keystone species describes the critical role certain organisms are perceived to have in maintaining the structure of biological communities and resilience of ecosystem dynamics (Paine, 1966). Arctic Cod (*Boreogadus saida*) are widely distributed in the Arctic Ocean and by virtue of their abundance and intermediate trophic position between invertebrates and higher-level predators are integral to the movement of nutrients in marine food webs. For this reason, Arctic Cod are considered a keystone species in the Arctic marine (Bradstreet and others, 1986; Walkusz and others, 2011). Arctic Cod are common in United States waters of the Beaufort and Chukchi Seas being considered for energy exploration and development and are an ecological focus of BOEM fishery studies to understand potential effects on the species (Maule and Thorsteinson, 2012).

Outline of Species Accounts

The species accounts are scientifically accurate descriptions of the life histories, populations, habitats, and community values of individual species in the Arctic marine ecosystem. The mix of quantitative and qualitative information presented reflects state-of-the-art knowledge, a faunal assessment of information gaps, and prioritization of priority needs for population and process understanding. Limited information for many Alaskan species required that relevant observations from other geographic locales be included. Each species account attempts to be clear about the geographic origins of data and information, through scientific referencing or special notations in graphics. As an example, *italics* are used in the species accounts to highlight data collections from the Alaska study area. In several instances, species information was so lacking that inferences from a closely related species were required.

The generic species account includes a comprehensive accounting of scientific and cultural information in a standard format. The scientific information addresses multiple disciplinary areas including taxonomy, life history and habitats, ecological relationships including predator-prey interactions and environmental preferences, and population ecology. The population information is critical to evaluations of population status and health, resilience, and vulnerability to natural and anthropogenic changes in the marine environment. Each species account includes a photograph of an adult specimen (or line drawing if an image was not available); distribution maps (horizontal and vertical); and concise descriptions of abundance, life history, and ecology (11 life history categories); major stressors; research needs; and key references. To assist users, a suite of easily recognized icons was developed to provide quick access to specific life history information. In addition, some species attributes regarding life history, population dynamics, and biological interactions are defined in the Glossary (chapter 7).

Information presented in each species account is outlined and described as:

Taxonomic—Scientific and Common Names

The format of the species accounts was, by design, intended to link the biologic and ecologic information presented in this document directly to the species identification guides contained in the "*Fishes of Alaska*." This connection was established by adherence to naming conventions as described by Mecklenburg and others, 2002 (p. 25 and 26). The common names of each marine fish are presented first, followed by scientific and family names. Each scientific name includes a reference to the name of the person (author) who formally described and named the species in the ichthyological literature. The bibliographic data for the authors and dates of publication of scientific names can be found in Eschmeyer's Catalog of Fishes online (http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp) and are not reported here. In some instances, a *Note* (italicized) has been included to describe exceptional details about existing biological data, morphology, nomenclature, taxonomic status, life history strategy, or occurrence of a species in the United States Chukchi and Beaufort Seas.

Iñupiat Name

The existence of colloquial Iñupiat (Iñupiaq) names for the Arctic's marine fish fauna by indigenous peoples is an important component of traditional ecological knowledge. Relatively few marine fish species are abundant or susceptible enough to subsistence fisheries to have received special names. For those species having Iñupiat names, this information is reported to assure that a common vocabulary can facilitate future exchanges of ideas and knowledge across disciplinary boundaries. In this manner, colloquial names can provide a cultural link between local marine resources and science supporting sustainability of Arctic communities and ecosystems.

Ecological Role

Fishes play a pivotal role in marine ecosystems as secondary and higher-level consumers in many marine food webs. In many instances, information about predator-prey relationships is so limited that only preliminary, qualitative assessments of the relative role of each species are possible. The ecological niche describes how an organism or population responds to resources and competitors. Importance or significance descriptors do not diminish the fact that all organisms contribute in ways large or small to the provision of ecosystem goods and services. These descriptors however, may provide useful information about the relative importance of a particular species as an indicator of ecosystem condition and trajectories of change associated with climate change, habitat fragmentation, ecosystem stress, effect of pollutants, or other anthropogenic effects.

Physical Description/Attributes

A brief physical description of the species is summarized from information presented by Mecklenburg and others, (2002) in the *Fishes of Alaska*; the relevant page number is included for quick referral to more comprehensive morphological information. An image of the adult form of each fish is presented with appropriate attribution. High-quality images were selected to highlight the key identifying features of a particular species.

Information about the presence of a swim bladder and antifreeze glycoproteins is included because of its relevance to geo-seismic oil and gas exploration, climate change issues, and evolutionary life history.

Range

The geographic occupancy of the species in United States sectors of Chukchi and Beaufort Seas and adjacent waters is presented in brief narratives and depicted on maps. Known occurrence in the Arctic OCS Planning Areas is highlighted by symbols indicating locations of valid species identifications from properly archived voucher specimens on each map. Although the symbols on the maps may suggest that some of the species are rare in the region, the study of historical collections from the United States and Canadian sectors of the Beaufort Sea, as well as the collections from BOEM surveys in the Beaufort in 2011 and 2012, is still in progress and may reveal that these species are more abundant in deep sectors of the study area than the maps suggest. Definitions of zoogeographic pattern are from the Online Resource 1 (electronic supplemental to Mecklenburg and others, 2011), Mecklenburg and Steinke (2015), and Mecklenburg and others (2016) and relate to ranges of population viability (see chapter 2).

Depth profiles in each species account graphically summarize existing information about the benthic and reproductive distributions of each marine fish. In both depth profiles, the width of areas depicted confers species information about horizontal (onshore-offshore) patterns of distribution. The italicized captions in the depth profiles highlight species information germane to the study area. Areas in the graphs denoted by the orange coloration represent understanding from data collection within the United States Chukchi and Beaufort Seas; olive colors represent data collection outside the study area. For benthic distributions, solid lines in the depth profiles represent species for which no specific information is available about its preferred depth range. Solid lines represent a synthesis of understanding that includes information not necessarily specific to the study area. In some instances, only one record of a species occurrence by depth was available and coding in orange was not meaningful. In these cases, an explanatory comment, in italicized font, with a line pointing to the appropriate depth was included in the graph (for example, see the species account for *Megalocottus platycephalus*). Highlighted depths as indicated through “bolded” (dark black) and dashed segments, represent most common depths where the species has been detected, and depth distribution as has been reported throughout the species range, respectively. Areas denoted with diagonal cross-hatching represents depth distribution of juveniles (immature); adult distributions are not cross-hatched and age-related habitat overlaps, are informed by captioning in the figures.

For reproductive distribution, eggs and larvae (pre-juvenile life stages) of marine fishes are represented with respect to depth and distance from the coast. Orange areas in the reproductive distribution profiles represent data collection in the study area. In many instances, information about spawning habitats and egg and larval distributions is summarized from information reported from throughout a species range. In these cases, dark blue represents species distributions in spawning habitats; light blue represents the geographic distributions of eggs and larvae; and light green is used to highlight areas of substantial habitat overlap (for example, see the species account for *Hippoglossus stenolepsis*). Distribution patterns of eggs and larvae are symbolized by “dots” and “horizontal dashes,” respectively, in the graphs. As for benthic distribution, solid lines represent species-specific information from data collections from throughout the species entire range. Highlighted (dark black lines) segments of solid lines indicate the most common depths where egg and larvae samples have been collected. Dashed lines represent areas of hypothesized distributions for species for which no information is available about egg or larval occurrence. In these instances the hypothesized distributions are based on known patterns for closely related species; the lack of data is stated in captions above the graph.

Relative Abundance

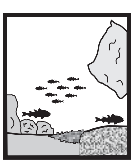
Relative abundance refers to the contribution a species makes to the total abundance of the fishery community. It is a measure that provides an index of the number of individuals present, but not the actual numbers. Relative abundance terms, such as “common,” “uncommon,” or “rare” often are used to express the general population status of a given species, but are most useful when they are defined by something that is measured or estimated in a manner that makes comparison meaningful.

Depth Range

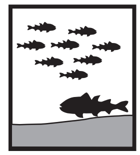
Benthic distribution refers to the spatial arrangement of a particular species at different depths over continental shelf and slope waters. The life cycle of fishes occurs in multiple dimensions in time and space and generally reflects genetically determined life history or behavior that has evolved to maximize fitness (life time reproductive success, see Gross [1987]). Benthic distribution profiles for each species represent the location of important habitats as they are presently known for juvenile and marine fishes. Reproductive distributions depict important habitats for spawning and early life history development.

Life History, Population Dynamics, and Biological Interactions

Life history theory holds that the schedule and duration of key events in a species' lifetime are shaped by natural selection to produce the largest possible number of surviving offspring. These events, notably juvenile development, age of sexual maturity, first reproduction, number of offspring and level of parental investment, senescence, and death, depend on the abiotic and biotic environment of the organism. Specific information about these traits informs understanding of a species' adaptive capacity including major influences on population abundance. A number of fisheries models use basic length-weight and age-at-size relationships to describe the growth and dynamics of fishery populations (for example, von Bertalanffy and Gompertz, growth models and derivatives [Ricker, 1975]). Ecological models estimate transfer of energy or matter along the trophic chain (Gamito, 1998). The parameters that are estimated in these models are individually important indicators of population condition and may be used with other indicators to derive quantitative information about compensatory responses and resilience. Much of this information, including population parameters, has been compiled in FishBase for the Arctic marine fish (Froese and Pauly, 2012).



Habitats and Life History—Basic information about the life history (for example, body size, reproductive ecology, growth) and ecology (for example, mobility, growth, habitat) of a species and the environmental area inhabited by that species is foundational to effective resource management. Habitat is the natural environment that influences and is used by a species population. Information about abiotic (that is, temperature, salinity, other physiochemical factors, depth, and substrate types) and biotic (that is, type and abundance of food, presence of other biota) often are used to describe fish habitats and provide insights about a species environmental preferences and habitat associations (for example, water masses). Maximum body size often is reported and can be an important surrogate of different life history traits (for example, age at maturity, growth, and reproductive output). In population dynamics studies, the relationships between length and weight and size and age form the basis for population growth and production models and quantitative analysis of environmental effects. Length measurements are reported as standard length (SL), total length (TL), and fork length (FL) in fisheries studies.



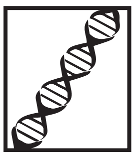
Behavior (see also Glossary [chapter 7]).— Behavior is the manner in which a fish operates or functions within its environment (that is, home range, territoriality, and many others) to procure food, orient to specific locations, or relate to other organisms. Knowing how individuals respond to the environment (physical, chemical, and biological cues) is critical to understanding population processes such as distribution, survival, and reproduction and recruitment and for managing fisheries. Many behaviors are evolutionary adaptations to the physiological and reproductive requirements for a species' survival. For example, migration involves the regular movement of animals between different geographic locations. Migrations can be extensive in terms of time and distance involved (anadromous model) or seasonal (amphidromous and marine models). Each of these models reflects a life strategy adapted for age and growth at sea. Diel relates to daily changes in water column position due to changes in light, temperature, and food supply.

Migratory behaviors are rooted in physiological requirements for food, growth, reproductive, and survival ("scope for growth"). Movement behaviors are more tactical responses to local environmental conditions (for example, variable hydrographic conditions in the nearshore Beaufort Sea). Fish movement can be active or passive and involve large distances in search of suitable habitats and foods. The seasonal nature of migration and movement behaviors are typically related to life history stage, predator-prey distributions, or energetic requirements for growth.

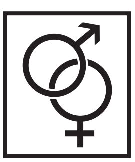
Schooling (that is, social structure of fish of the same species moving in more or less harmonious patterns in the sea) often is related to survival and reproduction. Schooling confers physical benefits to fish movement, safety against predators, search behaviors (for example, foods), population immunology, and reproduction.

The functional feeding morphology of a fish relates to its anatomical adaptations (for example, body size, gape sizes, shape, and body form) to environmental conditions especially food preferences. The adage "function determines morphology and morphology determines way of life" is an important evolutionary concept as it applies to fish feeding behavior, dietary preferences, habitat selection, and trophic stature. Trophic position (within categories of trophic levels) expresses the "tendency of larger (less abundant) fishes feeding on smaller (more abundant) fishes, which themselves feed on zooplankton and all these animals resting upon primary producers" (from Pauly and Watson, 2005). Categories of trophic levels are:

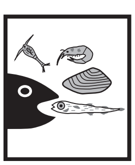
- Trophic level 1 (T1), plants and animals make their own food and are called primary producers;
- Trophic level 2 (T2), herbivores eat plants and are called primary consumers;
- Trophic level 3 (T3), carnivores eat herbivores and are called secondary consumers;
- Trophic level 4 (T4), carnivores eat other carnivores and are called tertiary consumers; and
- Trophic level 5 (T5), apex consumers, which have no predators, are at the top of the food chain.



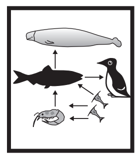
Populations or Stocks—A population often is defined as a group of organisms of the same species occupying a particular space at a particular time with the potential to breed with each other (Williams and others, 2002). Stocks are subpopulations of a particular species of fish that result from reproductive isolation and subdivisions within the biological range. The current state of knowledge about local stocks and their genetic population structure is reported. Grossberg and Cunningham (2001) described the combined effects of demographic, behavioral, genetic, oceanographic, climate, and tectonic processes as major determinants of population structure. These mechanisms act across a range of temporal and spatial scales to determine the rates and patterns of dispersal of different life stages of marine fishes. Dispersal, combined with the successful reproduction and survival of immigrants, control the scale and rate of processes that build or erode structure within and among groups of individuals.



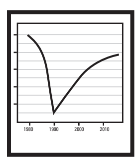
Reproduction Mode—Little information is available about the spawning times and locations, mating behaviors (breeders or nonbreeders), and genetic diversity of Arctic marine fishes. What is known is drawn largely from observations from populations studied outside the United States. For most Arctic marine fish species, there is no information about population or stock structure (for example, age structure, reproductive behavior, sex ratios, age-at-maturity, fecundity, and genetic). These are key population parameters needed for understanding reproductive ecology, population dynamics (for example, growth, survival, and mortality), and assessments of resiliency (response to disturbance).



Food and Feeding—Dietary information is summarized from literature and, unless in italics, is reported from other regions. Fish communities can affect the ecological characteristics of marine ecosystems in response to productivity and abundance patterns, the mobility and migratory behavior of species, and through food influences in different habitats (for example, Grebmeier and others, 2006b). Trophic Index (T) values are reported from FishBase (Froese and Pauly, 2012). The T values for Arctic marine fishes are largely derived from stomach contents analyses, which have correlated well with stable isotopes of nitrogen in tissues. The fractional values (between 1 and 5) realistically address complexities of consumer feeding behaviors (omnivory and feeding across multiple trophic levels) and predator-prey relationships. For example, the mean T value for Blackline Prickleback (*Acantholumpenus mackayi*) is 3.1 (±0.31). This mid food web value is indicative of a primary carnivore that feeds across trophic levels, in this case on lower level herbivores.



Biological Interactions.—The effects organisms in a community have on one another. Competition and consumption (predation, herbivory, or cannibalism) are the best known of the major ecological processes affecting resource abundance, community composition, and ecosystem function. Competition involves interactions between individuals of the same species (intraspecific) or different species (interspecific) in which the fitness of one is lowered by the presence of another. Competition often is related to food and habitat requirements and reproductive behavior. Interspecific competition for foods is greatest for species occupying similar trophic positions in relatively short food chains and for animals living in regions of low biological productivity.

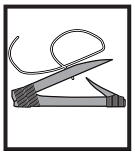


Resilience—In ecology, resilience traditionally refers to the ability of a population or biotic community to sustain or return to its former state after a disturbance. The rate of recovery is a measure of resilience determined by the population processes involved in restoring abundance to healthy, sustainable, or pre-disturbance levels. Four categories of productivity (high, medium, low, and very low) are used to classify reliance in marine fish populations (Musick, 1999). These categories are based on a combination of population parameters for intrinsic rate of growth, growth coefficient, fecundity, age at maturity, and maximum age. Because population parameters were unavailable, resiliency is defined here based on estimated population doubling time where high = <15 months, medium = 1.4–4.4 years, and low = 4.5–14 years.

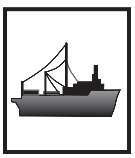
Traditional, Cultural, and Economic Values

In August 2009, the U.S. Secretary of Commerce approved a Fishery Management Plan for the Arctic Management Area. The plan covers U.S. Arctic waters in the

Chukchi and Beaufort Seas, and acknowledges that changing climate may potentially favor the development of commercial fisheries. However, until adequate fisheries resource assessments are completed, the region remains closed to commercial fishing in federal waters. A small salmon fishery exists in Kotzebue Sound; in 2010, a small commercial fishery for Arctic Ciscoes in the Colville River was terminated.



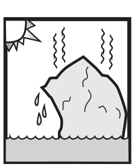
Traditional and Cultural Importance.—Several species of nearshore marine fishes are important in subsistence fisheries. The protection of traditional lifestyles and economies, including these subsistence fisheries, is a responsibility of the Federal government. Subsistence relates to resource use patterns (for example, seasonal round) and values (that is, sustenance, kinship, and barter) in coastal communities of northern Alaska.



Commercial Fisheries.—Currently (2016) there are no offshore marine fisheries in the U.S. Chukchi and Beaufort seas. Changing Arctic environmental conditions and shifting distributions of species in response to warming suggest that there may be fisheries in the future. A precautionary approach by fishery managers has been adopted that requires the collection of reliable baseline information for decision-making and ecosystem management (North Pacific Fishery Management Council [North Pacific Fishery Management Council, 2009; Wilson and Ormseth, 2009]).

Climate Change

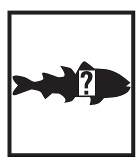
Alaska's climate is changing at more than twice the rate of the rest of the United States (Mellilo and others, 2014). Year-to-year and regional variability in air temperatures are evident and the warming trend currently is being moderated by large-scale cooling associated with the Pacific Decadal Oscillation. Even so, climate effects are pronounced and are being seen in changes in sea ice, timing of snowmelt, widespread glacier retreat, and changes in hydrology (runoff) and coastal processes, such as erosion (Markon and others, 2012). The effects of rising ocean temperatures and ocean acidification on marine food webs are of growing regional concern with respect to the condition and trends in marine ecosystems and human community resilience are of concern. Climate changes potentially can affect marine fish in numerous ways, leading to distributional changes, increased or decreased mortality rates, changes in growth rates, and by altering the timing in reproduction (Clow and others, 2011).



Potential Effects of Climate Change.—A pole-ward shift of many fish distributions is possible as is a reduction or extinction of species that are narrowly adapted to Arctic environments. Generally, the species are expected to increase in abundance if they are currently present in the Bering Sea and decrease if they have very low tolerance for temperatures greater than 1.5–2.0 °C. However, it is hypothesized in current climate projections that temperatures near the ocean floor in the northern Bering Sea will remain cold (<2 °C) due to persistence of winter sea ice (Sigler and others, 2011). Cold-water conditions and other marine ecosystem effects related to seasonal sea ice extent and timing of retreat may effectively block northward migrations and production of exploitable quantities of species, such as pollock and cod, for several decades. Shifts in range and other possible climate-related effects, such as increased predation or competition for food, are identified in the species accounts. Only "loose qualitative generalizations" are presently possible (Reist and others, 2006).

Research Needs

The compilation and review of species information for species in U.S. Arctic waters revealed many gaps in life history understanding and environmental relations. These are evaluated on the basis of a species current fishery and community values and ecological significance in marine ecosystem structure and function. The needs reflect the researcher's perceptions and their understanding that new fishery information is becoming available for the Arctic region and that, although Arctic research is currently a national priority, some aspects of population ecology will take many years of data collection to accurately assess.



Areas for Future Research.—The preparation of individual accounts led to the identification of many information gaps in knowledge about the biology and ecology of marine species including life history, population dynamics, and community associations. Generally, species life history and ecology gaps are most pronounced with respect to: (1) depth and location of pelagic larvae; (2) depth, location, and timing of young-of-the-year habitats; (3) preferred depth ranges for juveniles and adults; (4) spawning seasons; (5) seasonal and ontogenetic movements; (6) population genetics and dynamics; (7) prey–predator relationships and food web relationships; and (8) environmental health (multiple stressor effects on fitness). Behavioral studies for all life stages are virtually non-existent. New information is being developed and, for the lesser-known species, gaps may be slowly addressed over time. Priority needs, for species having special significance in subsistence fisheries and marine food webs or that may be indicator species are emphasized in the species accounts. One of two categories of identified research need is identified for each species. The meaning of the categories **[A]** and **[B]** is as follows:

- **[A]** Many gaps in our understanding of the species life history and ecology remain in Alaska (for example, research areas 1 through 8). These are high profile species in terms of ecological, subsistence, or potential fisheries values. Specific research priorities are briefly discussed.

- **[B]** Most aspects of the species life history and ecology are unknown for Alaska (for example, research areas 1 through 8). Species information will likely accumulate over time and focused studies are not warranted at this time.

References Cited and Bibliography

A thorough review of scientific literature was done in the preparation of the species account. A list of references (References Cited [chapter 8]) is provided for each species for readers seeking additional information. This list identifies key sources of information that make the greatest contributions to current knowledge (2014) and understanding. The Bibliography section provides a full accounting of all scientific literature cited in each species account. For a small number of species from the family Cottidae, only a Bibliography was possible to provide and this is indicative of the lack of information available. Citations are not always in numerical order in species accounts because new information became available during the production phase of this publication and were incorporated into the species accounts as appropriate.

Pacific and Arctic Lampreys

Pacific Lamprey (*Entosphenus tridentatus*)
(Gairdner, 1836)

Family Petromyzontidae

Pacific Lamprey (*Entosphenus tridentatus*). Photograph by René Reyes, Bureau of Reclamation.

Note: *Except for physical description and geographic range data, all information is from areas outside of the study area.*

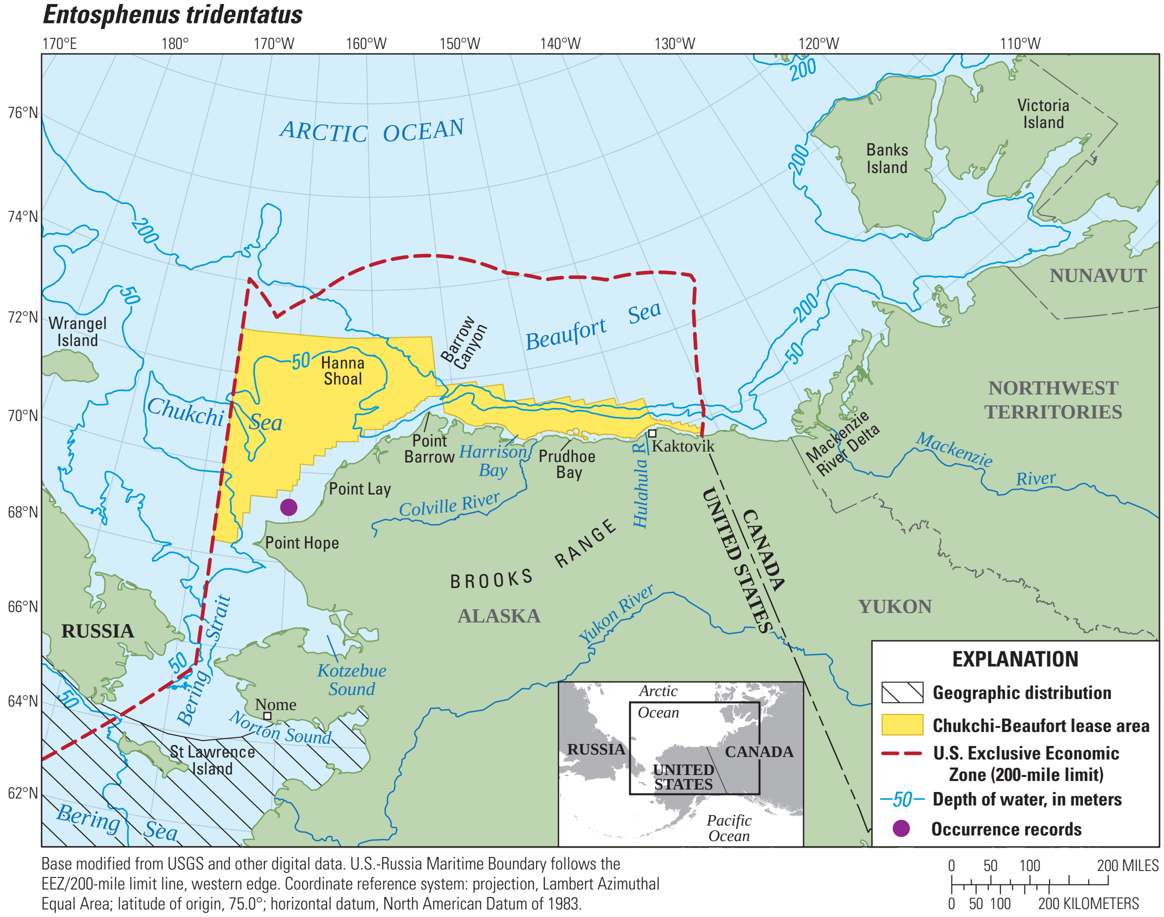
Colloquial Name: None within U.S. Chukchi and Beaufort Seas.

Ecological Role: Its rarity in the U.S. Chukchi Sea and absence from the U.S. Beaufort Sea implies an insignificant role in regional ecosystem dynamics.

Physical Description/Attributes: Elongate, eel-like body, blue-black to dark brown dorsally, pale or silver ventrally. For specific diagnostic characteristics, see *Fishes of Alaska*, (Mecklenburg and others, 2002, p. 61, as *Lampetra tridentata*) [1]. Swim bladder: Absent [2]. Antifreeze glycoproteins in blood serum: Unknown.

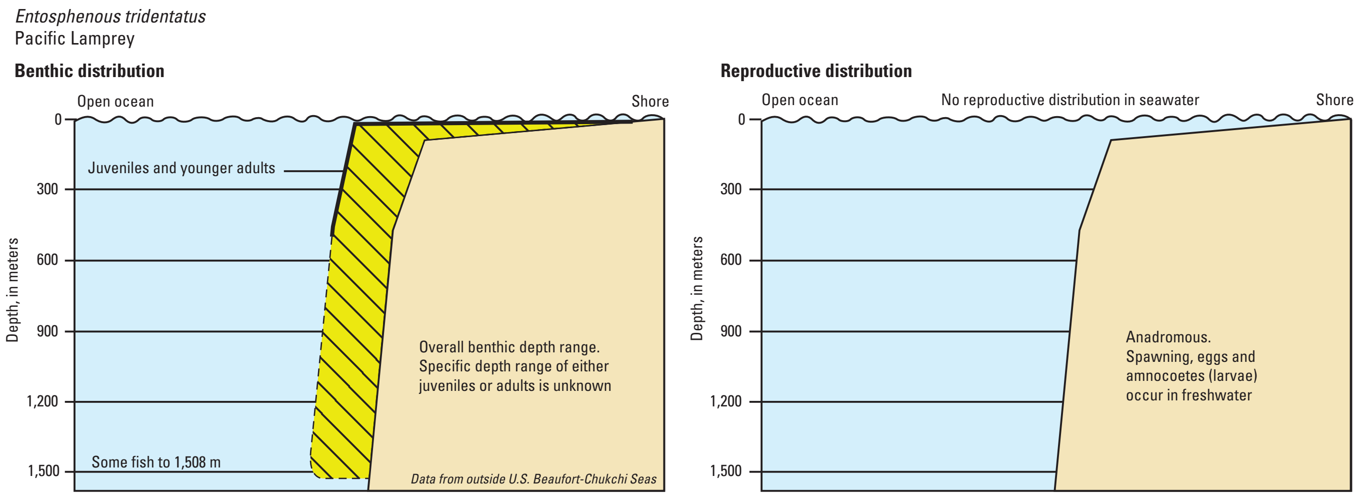
Range: *Eastern U.S. Chukchi Sea* [1, 3]. Elsewhere, from Bering Sea south to Punta Canoas, northern Baja California, Commander Islands, and Pacific coast of Kamchatka Peninsula, Russia, and Honshu, Japan [1].

Relative Abundance: *Rare in U.S. Chukchi Sea, with one record near Cape Lisburne, Alaska* [1, 3]. Common in southeastern Bering Sea [6]. Widespread at least as far southward as Honshu, Japan [7]. Rare to occasional in marine waters off Commander Islands and Pacific coasts of Kamchatka Peninsula, Russia, and Hokkaido, Japan [1].

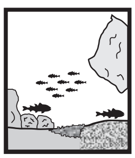


Geographic distribution of Pacific Lamprey (*Entosphenus tridentatus*), within Arctic Outer Continental Shelf Planning Areas [4] based on review of published literature and specimens from historical and recent collections [3, 5].

Depth Range: Over continental shelf and slope, near surface to 1,508 m. Most abundant at depths less than 500 m and pelagically most abundant above 100 m [7].



Benthic and reproductive distribution of Pacific Lamprey (*Entosphenus tridentatus*).



Habitats and Life History

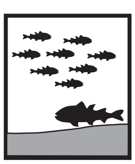
Eggs—Size: Small, 1.1–1.2 mm [8]. Time to hatching: 10–24 days, depending on temperature [9, 10]. Habitat: Freshwater, benthic [3]; attached to rocks among gravel nests near riffles in rivers [9, 11].

Larvae (ammocoetes)—Size at hatching: About 4–5 mm TL [12]. Size at juvenile transformation: From 4.7–17.0 cm [9, 13]. Days to juvenile transformation: 3–7 years [11]. Actual transformation process can take 85–126 days [14]. Habitat: Freshwater, benthic [3]; in gravel redds approximately 2–3 weeks after hatching, then drifts downstream and burrows into soft sediments of slow, shallow depositional areas along stream banks and in pools and eddies [15, 16].

Juveniles (macropthalmia)—Age and size: From 3 to 4.5–8 years [13, 15, 16]. Habitat: Pelagic and benthic in marine water [3]. Marine (parasitic) phase not well understood. Over continental shelf and slope sometimes far offshore [11]. Resides in ocean for 20 months up to 3.5 years, depending on area [7, 13, 17].

Adults—Age and size at first maturity: Unknown. Likely from 4.5–8 years [10–12]. Size at First Maturity: Size varies from 13–72 cm TL [13]. Maximum age: 9 years [18]. Maximum size: 85 cm TL and at least 0.5 kg [7, 11]. Habitat: Freshwater streams and rivers for a few months up to several years before spawning [3, 19]. Substrate: Unknown in ocean. Sandy gravel for spawning. Soft sediment for larval rearing [15, 16].

Physical/chemical—Temperature: Unknown at sea. Spawns between 13 and 18 °C [12]. Salinity: Fresh to marine waters [1].



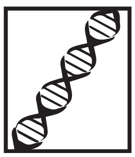
Behavior

Diel—In the ocean, makes daily vertical migrations into pelagic zone, higher at night perhaps to feed [7]. Ammocoete downstream migrations and adult upstream migrations are primarily at night [9, 19].

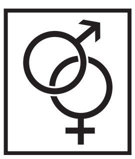
Seasonal—Ammocoete generally transform into juveniles during July through late November [15, 16]. Ammocoetes migrate downstream year-round but mainly from autumn through spring. Migration times differ among populations. In British Columbia, Canada, after leaving their mud-silt habitat they reside in gravel and boulder fields in moderate to strong current streams and then enter seawater from December–June (occasionally earlier than December or later than June) [13]. Adults generally return to freshwater rivers and streams in late spring and early summer (April–June in British Columbia) [13] and reside there from a few months to several years before spawning [19]. Generally, spawning begins the following spring and summer (about May–July) depending on river system [19].

Reproductive—Semelparous, most die within a month after spawning [16], though some seem to spawn at least twice [20]. Spawning occurs in low-gradient streams in sandy gravel usually at riffle heads and in pool tailouts [15, 19]. Males initiate nest building and then joined by females. Nests are constructed by fish attaching to rocks to lift them out of the nest and by digging down within the nest to line the bottom with loose sand for egg attachment [19]. Adults attach themselves side by side to a rock or to each other and release sperm and eggs.

Fertilized eggs drift into nests and attach to rocks. Some adults then cover eggs with rocks or debris [11].
Schooling—Unknown at sea. At times, tends to congregate in certain areas in freshwater rivers [9].
Feeding—Freshwater ammocoetes are burrowing filter feeders [9]. Macropthalmia begin parasitic feeding on fish during seaward migrations [19]. They are parasitic feeders, attaching themselves to fishes using their toothed tongues to penetrate scales and skin to suck out body fluid and blood. While feeding, anticoagulants are produced which prevents host's blood from coagulating [19, 21]. In general, host fish are not killed as various surveys show high incidences of fish with scars. For instance, off the Fraser River, British Columbia, Canada, 66 percent of Sockeye Salmon and 20 percent Coho Salmon had Pacific Lamprey wounds. Lampreys generally attack ventrally and anteriorly, leaving one to three holes, with younger fish creating more holes. They have been shown in the laboratory to hang on to a host for several days [13]. Feeding ceases during upstream migrations [22].

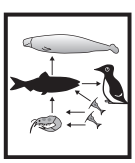


Populations or Stocks
There have been no studies within the study area. Elsewhere, recent studies show low levels of genetic differentiation between populations separated by large geographic distances [19].

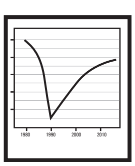


Reproduction
Mode—Oviparous, external fertilization [1].
Spawning season—Differs with regions, spawning earlier farther north. April–July in British Columbia [12]; in southern California occurs as early as January and may continue into at least May [23].
Fecundity—10,000–238,000 eggs [12, 16].

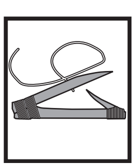
Food and Feeding
Food items–Ammocoetes: Detritus, diatoms and algae [19]. Parasitic macropthalmia and adults: Fishes and mammals including Greenland and Pacific Halibut, Arrowtooth and Kamchatka Flounders; Sablefish, Pacific Hake, Walleye Pollock, Pacific Cod, and Lingcod; Pink, Sockeye, Coho, and Chinook Salmon; Steelhead; Yellowmouth and Rougheye Rockfish; and cetaceans [13, 22]. Off Russia, Greenland Halibut were the most common prey [22].
Trophic level: 4.5 (standard error ±0.80) [18].



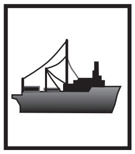
Biological Interactions
Predators—Fishes including Sablefish, rockfishes, various sharks, and White Sturgeon [11, 16, 24–26]. Ammocoetes are eaten by Coho Salmon [16]. Larger fish eaten by harbor seals, California sea lion, Steller sea lion, northern elephant seal, northern fur seal, sperm whales, Pacific White-sided Dolphin, minks, California Gulls, Ring-billed Gulls, Western Gulls, Foster's Terns, Great Blue Herons, and Common Murres [13, 16, 27–31, 32, 33].
Competitors: Pacific Lamprey in seawater [21].



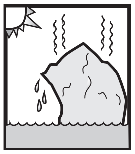
Resilience
Low, minimum population doubling time: 4.5–14 years (t_m 6–8; Fecundity=10,000–106,000) [18].



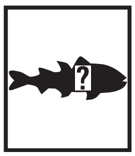
Traditional and Cultural Importance
None reported.



Commercial Fisheries
Currently, Pacific Lamprey are not commercially harvested.



Potential Effects of Climate Change
Unknown.



Areas for Future Research [B]
Little is known about the ecology and life history of this species in the U.S. Arctic. Research needs include: (1) locations of spawning areas, (2) spawning season, (3) size and age at maturity, (4) seasonal and ontogenetic movements, (5) population studies, (6) prey, and (7) predators.

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Arctic Lamprey (*Lethenteron camtschaticum*)

(Tilesius, 1811)

Family Petromyzontidae

Arctic Lamprey (*Lethenteron camtschaticum*), 176 mm TL, Norton Sound, northeastern Bering Sea, 2002. Photograph by C.W. Mecklenburg, Point Stephens Research.

Colloquial Name: Iñupiat: *Nimiqiaq* [24]

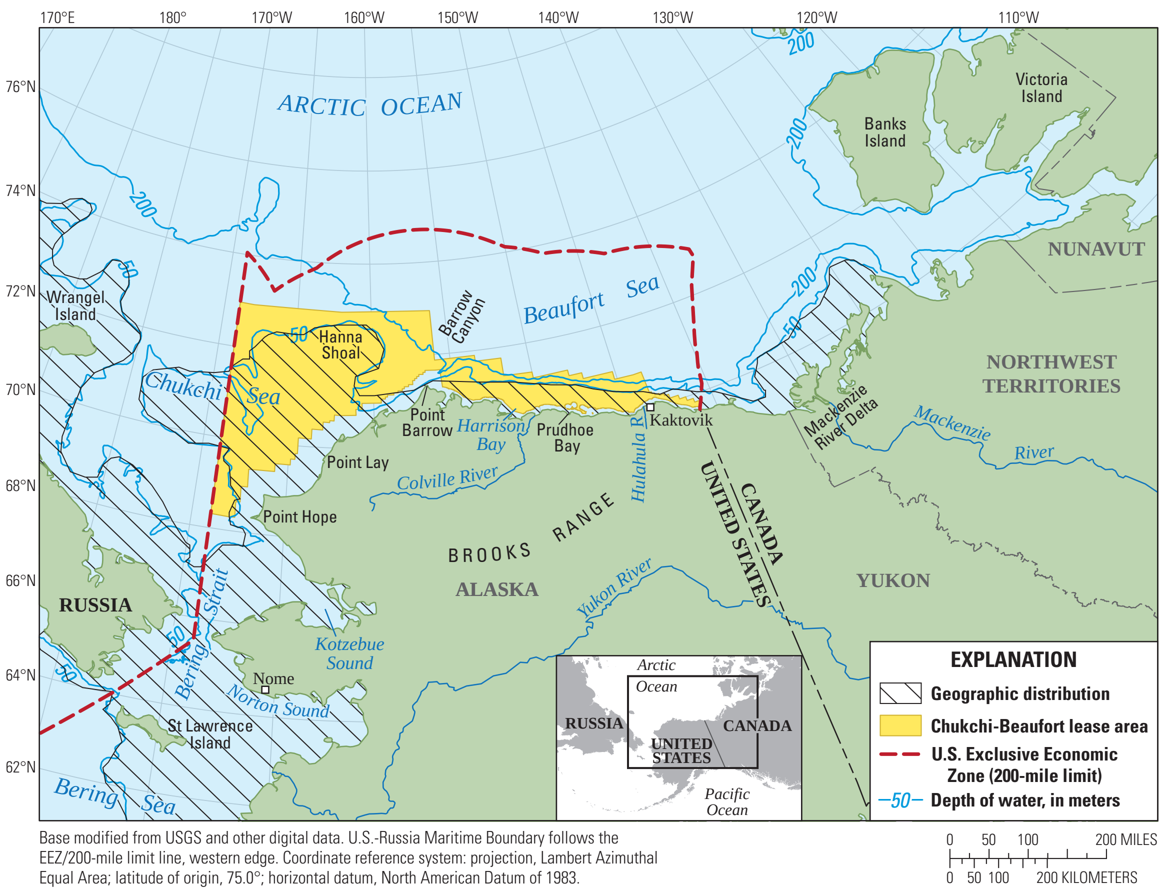
Ecological Role: The extent of this lamprey's parasitisms is *unknown in U.S. Chukchi and Beaufort Seas*.

Physical Description/Attributes: Elongate, eel-like body, blue-black to dark brown dorsally, silvery when fresh on sides and ventral surface, with blackish blotch on second dorsal fin and on tail. For specific diagnostic characteristics see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 62) [1]. Swim bladder: Absent [2]. Antifreeze glycoproteins in blood serum: Unknown.

Range: *U.S. Chukchi and Beaufort Seas* [3]. Elsewhere in Alaska, south through Bering Sea to Kenai Peninsula, Gulf of Alaska. Worldwide, White Sea and coasts of southern Barents Sea eastward off Siberia to Beaufort Sea off Anderson River, Canada; in western Pacific Ocean, south to Honshu, Japan, and Korean Peninsula, and East-Finnmark, Norway, in eastern Atlantic Ocean. Not in western Atlantic [3].

Relative Abundance: *Apparently common in some drainages of the U.S. Chukchi and Beaufort Seas. However, abundance in these drainages and in marine waters is poorly described. Presence at sea is typically indicated by wounds on pelagic fishes*. The most common lamprey in Alaska and, although abundance patterns are unknown, thought to occur in high numbers in localized areas [1, 6]. Common in Sea of Japan and around Sakhalin Island, Russia [7, 8].

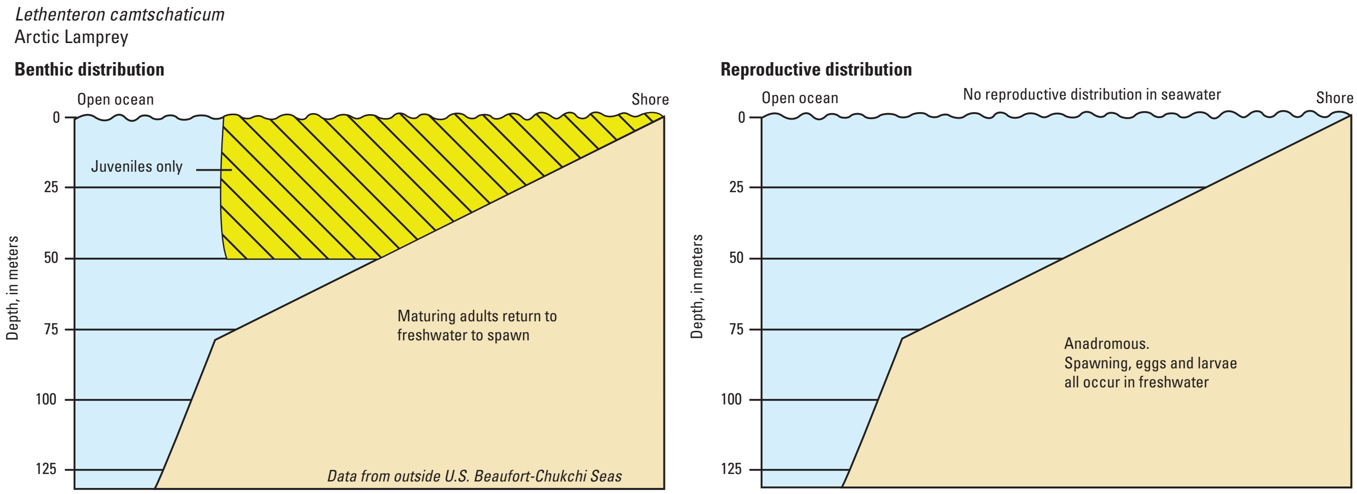
Arctic Lamprey
Lethenteron camtschaticum



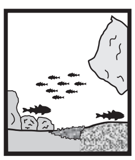
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

Geographic distribution of Arctic Lamprey (*Lethenteron camtschaticum*) within Arctic Outer Continental Shelf Planning Areas [4] based on review of published literature and specimens from historical and recent collections [3, 5].

Depth Range: Anadromous. Pelagic at sea over continental shelf to bottom depth of 50 m [1].



Benthic and reproductive distribution of Arctic Lamprey (*Lethenteron camtschaticum*).



Habitats and Life History

There are two life-history types, anadromous-parasitic and fluvial-nonparasitic. Eggs and ammocoete larvae of both types are demersal in freshwater lakes and streams. There are three juvenile/adult forms: typically anadromous, anadromous early maturing forma praecox (predominantly males), and resident freshwater. Both forms of anadromous fish are pelagic and migrate to sea. When mature they return to freshwater to spawn. The non-parasitic resident fish remain exclusively in fresh water until spawning [1, 9, 10].

Eggs—Size: As large as 1.25 mm, average of 0.8 mm [9]. Time to hatching: About 1 month after spawning [9]. Habitat: Pebble-sandy bottoms in rivers.

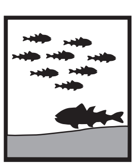
Ammocoetes (larvae)—Size at hatching: 6.8 mm long. Size at juvenile transformation: 13.1–16.8 cm [9]. Time to juvenile transformation: 4 years and longer [9]. Habitat: Sedentary burrowers in river and lake bottoms [11].

Juveniles/smolts (anadromous forms)—Age and size: 4–5 years. Transformation to smolt stage takes approximately 6 months and ends in downstream migration to the sea [10]. Size ranges from 13.0–16.8 to as long as 16.5–21.7 cm TL and from 2.8–4.4 to about 3.1–9.1 g. [10]. Habitat: Pelagic, in downstream migrations to the sea [10].

Adults—Age and size at first maturity: 7 years for anadromous form, 6 years for forma praecox and 5 years for freshwater residents. Typically, anadromous form is 25.0–35.0 cm TL and 30–88 g for males and 17.4–33.0 cm TL and 30–75 g for females [9, 10]. Anadromous forma praecox (predominantly males) is 14.5–22.0 cm TL and 3.2–15 g [9]. Freshwater residents are 11.3–13.9 cm and 1.6–5.0 g for males, and 110–141 cm TL and 2.1–4.5 g for females. Maximum age: Same as age at first maturity. Maximum size: 62.5 cm TL (anadromous form) [1]. Habitat: Anadromous form migrates downstream and becomes pelagic in shallow marine waters over continental shelf. Forma praecox remains in seawater from several months to 1 year, whereas typically anadromous lamprey remain as much as 1 year longer [9].

Substrate—In freshwater, gravel-sand for spawning and muddy sediments for ammocoete rearing [1].

Physical/chemical—Temperature: Spawning occurs between 12 and 15 °C in southwestern Alaska [12]. Salinity: Marine and fresh waters.



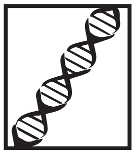
Behavior

Diel—Ammocoetes are primarily active at night and burrow into sediments during day [6].

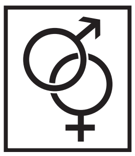
Seasonal—Metamorphosed ammocoetes migrate downstream to sea during August–November in Alaska [10] and May–July in Russia [9].

Reproductive—Adults migrate upstream to spawn in spring. Redds are constructed in riffles with pebbly-gravel bottom where sand prevails [10]. Redds are made by lampreys sucking on to rocks and swimming them away [13]. There is group spawning behavior in fast currents and paired behavior in slow, nearshore zones. In group

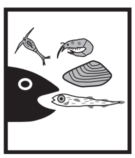
behavior, 6–44 individuals attach themselves by sucking on to each other and drifting downstream. Numerous males may attach to one female. Afterwards, individuals return to spawning redds. Females lay several batches of eggs in redd. One batch of eggs may be fertilized by several males. After spawning, fish stir up silt and small stones to cover the eggs [13]. Adults die after spawning [1].
Schooling—Migrating adults frequently congregate in large numbers, particularly around obstructions [14].
Feeding—Ammocoetes are filter feeders, whereas anadromous juveniles and adults are parasitic, feeding on other fish tissues and blood. Freshwater residents cease feeding upon sexual maturity [9, 10].



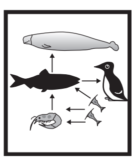
Populations or Stocks
There have been no studies.



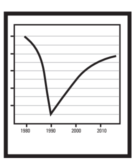
Reproduction
Mode—Separate sexes, oviparous [9, 13].
Spawning season—Spring in southwestern Alaska, generally late May to early July [12].
Fecundity: 12,272–34,586 eggs [9].



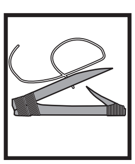
Food and Feeding
Food items—Ammocoetes filter-feed on small aquatic invertebrates, algae and fine organic debris [9]. Adults parasitize fish, including Pacific salmon, Starry Flounder, Saffron Cod, Least Cisco, Arctic Cisco, Broad Whitefish, Pacific Herring and smelt [11, 15–17].
Trophic level—4.5 (standard error ±0.81) [18].



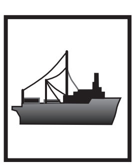
Biological Interactions
Predators—All life stages are preyed on by various fishes including Burbot, Northern Pike, Dolly Varden, and Inconnu; also taken by gulls, especially when lamprey are concentrated in shallow streams during migration [19].
Competitors—Pacific Lamprey in seawater [14]. In Alaska, often found co-occurring with Alaskan Brook Lamprey (*L. alaskensis*) [1].



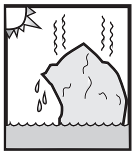
Resilience
Low, minimum population doubling time: 4.5–14 years (t_m 4–5) [18].



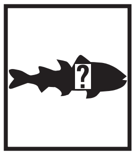
Traditional and Cultural Importance
None reported. Alaskan Natives on the Yukon and Kuskokwim Rivers have taken them in quantity for food using dip nets and sharped sticks [20, 21]. A small commercial fishery on the Yukon River was started in 2003 [6]. Commercially harvested in Sea of Okhotsk [22].



Commercial Fisheries
Currently, in Alaska, Arctic Lamprey are not commercially fished.



Potential Effects of Climate Change
Unknown.



Areas for Future Research [B]
Little is known about the ecology of this species from this region. Research needs include: (1) depth and location of pelagic larvae’ (2) depth, location, and timing of young-of-the-year benthic recruitment; (3) preferred depth ranges for juveniles and adults; (4) spawning season; (5) seasonal and ontogenetic movements; (6) population studies; (7) prey; and (8) predators.

Remarks

This is the most abundant and widely distributed lamprey in Alaska [23].

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Spotted Spiny Dogfish to Bering Cisco

Spotted Spiny Dogfish (*Squalus suckleyi*)
(Girard, 1855)

Family Squalidae

Spotted Spiny Dogfish (*Squalus suckleyi*). Photograph by NMFS-Alaska Fisheries Science Center, RACE Division.

Note on taxonomy: *Meristic, morphometric, and molecular data demonstrate that* Squalus suckleyi *is a distinct species from* S. acanthias (*Linnaeus, 1758*) *[1]. The latter species does not occur in the North Pacific, and previous reports of* S. acanthias *in the North Pacific are assumed to represent* S. suckleyi. *Information presented here is only from data or reports of Squalus in North Pacific waters.*

Note: *Except for geographic range data, all information is from areas outside of the Chukchi and Beaufort Seas.*

Colloquial Name: *None within U.S. Chukchi and Beaufort Seas*.

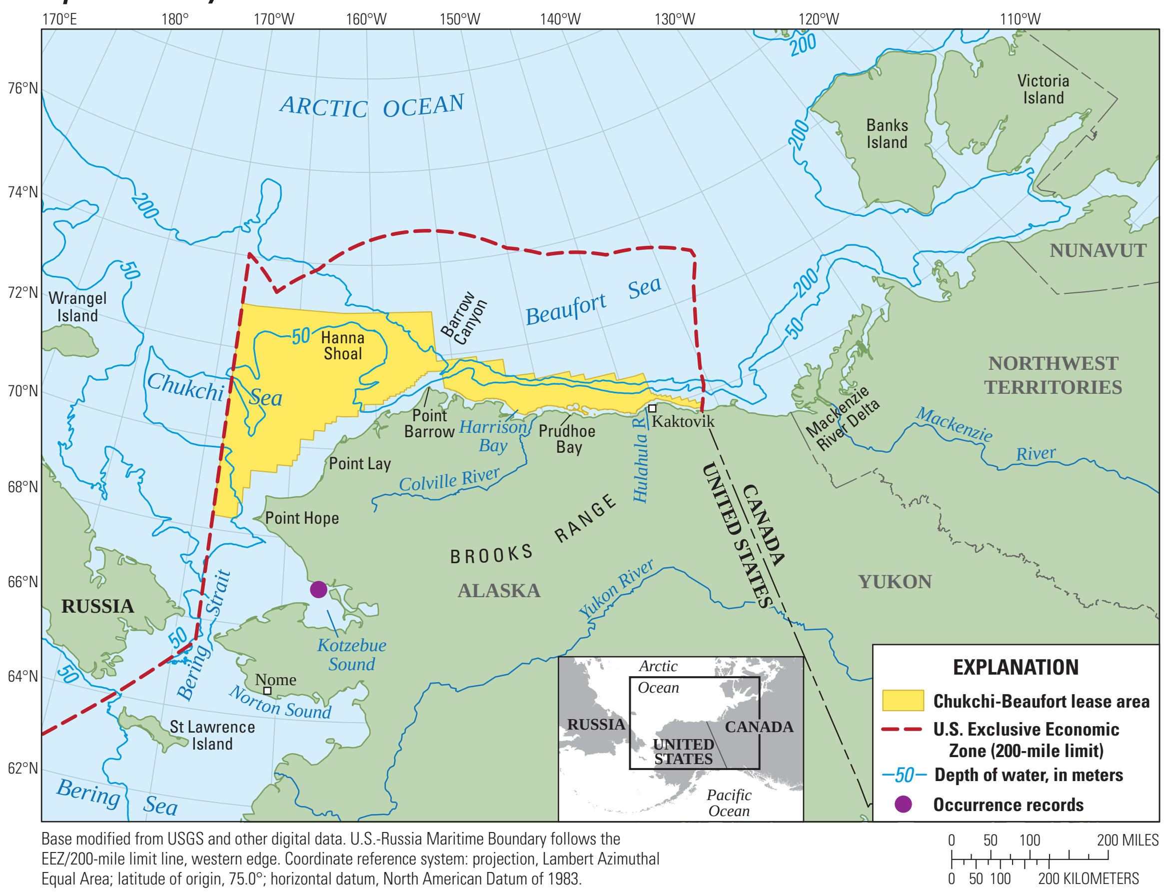
Ecological Role: A rare species in the U.S. Chukchi Sea and absent from the U.S. Beaufort Sea. The species has a very limited role and little significance in regional food webs.

Physical Description/Attributes: Gray or brown dorsally merging into lighter sides and belly with one or two rows of conspicuous white spots on sides. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 88) [1] and [2]. Swim bladder: Absent, as with other cartilaginous fishes [1]. Antifreeze glycoproteins in blood serum: Unknown. Dorsal spines are venomous [3].

Range: *U.S. Chukchi Sea at Kotzebue Sound* [1, 4]. Elsewhere in Alaska, from Bering Sea and Aleutian Islands, eastward in the Gulf of Alaska. Worldwide, from Koreas and Japan northwards to Bering Sea off Kamchatka Peninsula, Russia, Sea of Okhotsk and Sakhalin Island, and from British Columbia, Canada, and Washington south to southern Baja California [2, 5].

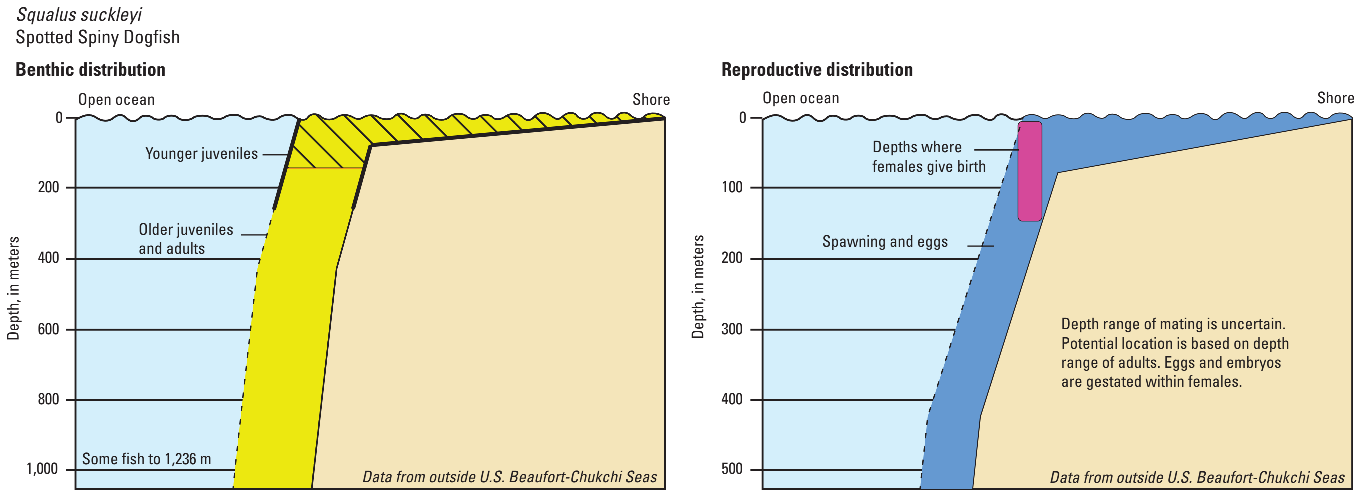
Relative Abundance: *Rare in U.S. Chukchi Sea, with one record of occurrence near Kotzebue* [1]. Common from Kodiak Island, Gulf of Alaska and southward into Baja California, and in Sea of Japan [7–9]. Very rare in northern Bering Sea [1, 10, 11]. Appears to be increasing in abundance in southern Bering Sea [10].

Spotted Spiny Dogfish
Squalus suckleyi

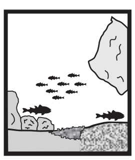


Geographic distribution of Spotted Spiny Dogfish (*Squalus suckleyi*) within Arctic Outer Continental Shelf Planning Areas based on review of published literature and specimens from historical and recent collections [4, 6].

Depth Range: Very shallow waters to at least 1,236 m [9], typically 250 m or less [5]. Juveniles are born in midwaters at depths of 10–140 m [12], and over bottom depths of 50–111 m [13].



Benthic and reproductive distribution of Spotted Spiny Dogfish (*Squalus suckleyi*).



Habitats and Life History

Eggs—Size: 3–4 cm [14]. Time to hatching: Fertilized eggs are contained within candles (a thin membrane containing multiple eggs) and incubated within the female's uterus. Candle membrane dissolves and embryos become free within the uterus within 4–6 months [5]. Habitat: In utero [5].

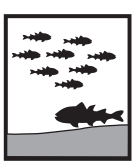
Embryos—Age and size: From about 4–6 months to 22 months (<10 to 22.5–30 cm TL) [5, 13]. Habitat: Embryos are completely dependent on their yolk-sacs and are gestated within the uterus [5, 13].

Juveniles—Size: 22.5–26.3 cm at birth to about 60 cm TL [5, 13]. Habitat: Pelagic, in water column, near surface and becoming benthic as they grow larger and near sexual maturity [5, 13].

Adults—Age and size at first maturity: Based on the most recent study (off British Columbia), a few females mature at about 80 cm TL (24 years), 50 percent matured at 93.9 cm (36 years), and almost all fish are mature at 110 cm (62 years) [15]. 100 percent of females matured at 119 cm [14]. A few males off British Columbia matured at 72 cm TL (15 years), 50 percent at 78 cm TL (19 years), and all at 94 cm [14]. In the North Pacific median size and age at maturity is 80–100 cm TL. (35.5 years) for females and 70–80 cm TL 18.5 for males [2]. Maximum age: 80 to possibly 100 years [5]. Maximum size: About 140 cm [10]. Habitat: Benthopelagic, in a wide depth range [5].

Substrate—Unknown. Have been taken over cobble [16].

Physical/chemical—Temperature: 0–15 °C [17]; prefers less than 7 °C, often migrating horizontally and vertically to follow temperature preference [9]. Salinity: Marine, but can tolerate freshwater for short periods [5].



Behavior

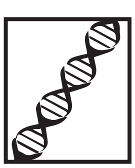
Diel—Migrates closer to surface at night [5, 10] and may be more active at night [16].

Seasonal—Makes seasonal feeding migrations, moving north and inshore as waters warm in spring [10]. Highly mobile in many areas, though movements are not completely predictable. In the North Pacific, many tagged fish were recaptured close to their release site, but some made extensive migrations (as far as 7,000 km) [16].

Reproductive—Males mate every year and females every other year. Smaller males mate earlier in the season [18]. Because of the female's long gestation period (22–24 months), she does not release young every year [9, 18, 19]. Females commonly give birth in shallow bays and estuaries or in mid-water at depths of 50–111 m [13].

Schooling—Forms large schools [5]. Sexes tend to segregate into separate schools around time of parturition [13].

Feeding—Opportunistic feeders [5], congregating in schools where prey is abundant and sensed by smell [20].



Populations or Stocks

There have been no studies.

Reproduction

Mode—Aplacental viviparous. Internal fertilization [2].
Parturition season—September–January, probably peaks in late autumn [14, 18].
Fecundity—Litters as high as 20, averaging between 2–12 [9, 12, 14]. Number of pups increases as size of female increases [13].

Food and Feeding

Food items—Fishes are a very important, particularly for larger individuals. However, squids, octopuses, medusae, ctenophores, crustaceans (for example, shrimps, euphausiids, and amphipods) and polychaetes also are often consumed [21–25].
Trophic level—4.3 (standard error 0.67) (based on trophic level of *S. acanthias)* [26].

Biological Interactions

Predators—Various larger sharks (for example, Salmon Sharks, White Sharks, Pacific Sleeper Sharks), bald eagles, and marine mammals such as Steller sea lion, northern elephant seal, and sperm whale [21, 27–31].
Competitors—Likely various larger cods, flatfishes, and other macrocarnivores.

Resilience

Low, minimum population doubling time is more than 14 years (r_m=0.034; K=0.03–0.07; t_m=10–30; t_{max}=75; Fecundity=1) (based on resilience of *S. acanthias*) [26].

Traditional and Cultural Importance

None reported

Commercial Fisheries

Currently, Spiny Spotted Dogfish are not commercially fished.

Potential Effects of Climate Change

A wider distribution of this species in the Bering Sea occurred after 2000, possibly associated with recent climate change [10]. This species would be expected to move northwards into the Chukchi Sea as waters warm.

Areas for Future Research [B]

Little is known about the biology and ecology of this species from the region. If the species becomes more common, research needs include: (1) preferred depth ranges for juveniles and adults, (2) growth rates and size at maturation, (3) birthing season, (4) seasonal and ontogenetic movements, (5) population studies, (6) prey, and (7) predators.

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Arctic Skate (*Amblyraja hyperborea*)

(Collett, 1879)

Family Rajidae

Arctic Skate (*Amblyraja hyperborea*), continental slope off Barents Sea, 2011. Photograph by Arve Lynghammar, University of Tromsø, Norway.

Note: *Except for geographic range data, all information is from areas outside of the study area.*

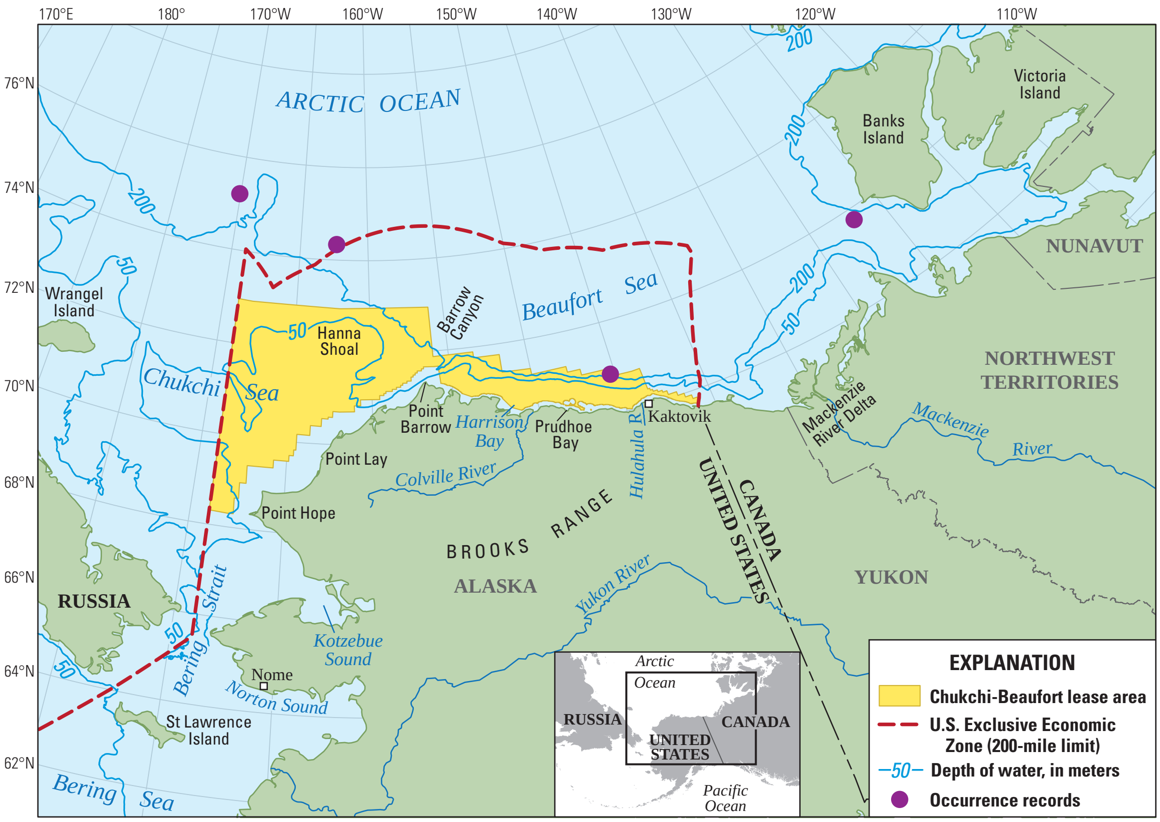
Colloquial Name: *None within U.S. Chukchi and Beaufort Seas.*

Ecological Role: Arctic Skate have only rarely been observed in deeper waters of the Alaska Beaufort Sea. Its role in benthic ecosystem dynamics, especially over shelf break and slope habitats is presently unknown.

Physical Description/Attributes: Brown or grayish brown, often with dark and light round spots. Body is flat, with wing-like pectoral fins, mouth on underside; has long rat-like tail with two small dorsal fins near the tip. For specific diagnostic characteristics, see Jensen (1948, p. 31–43) [1] and Stehmann and Bürkel (1984, p. 174) [2]. Swim bladder: Absent [3]. Antifreeze glycoproteins in blood serum: Unknown.

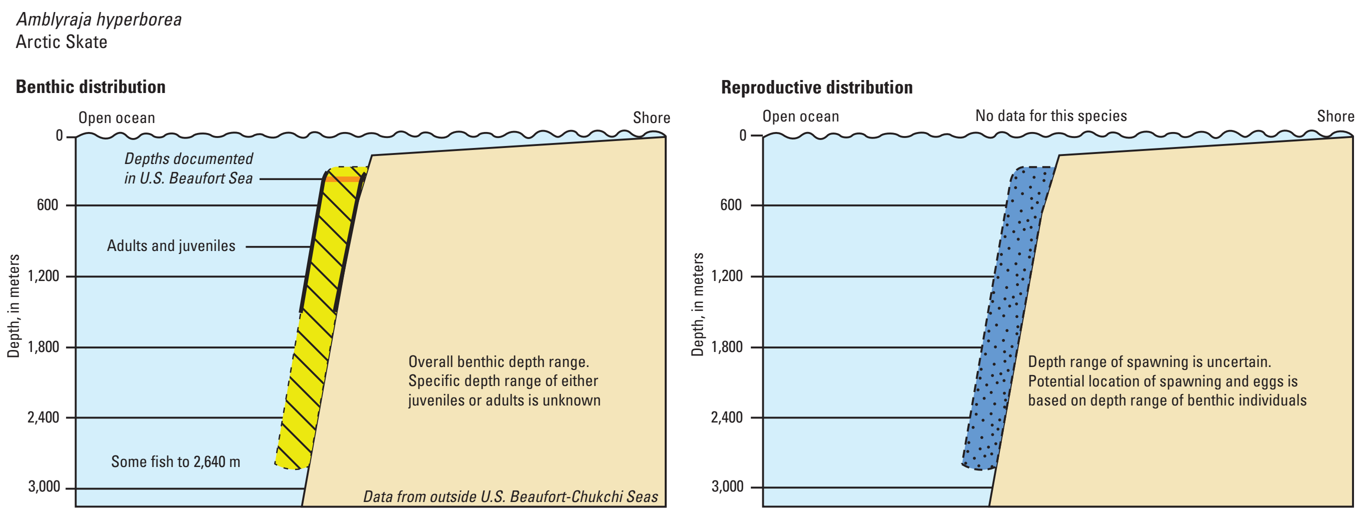
Range: *Continental slope off U.S. Beaufort Sea* [4]. Practically circumpolar; polar basins and south to western Canada, Davis Strait, Greenland, Iceland, Faroe-Shetland Ridge, Barents Sea and northern Norway [1, 4, 5].

Relative Abundance: *Absent from U.S. Beaufort Sea continental shelf, one record from the continental slope about 50 miles north-northeast of Brownlow Point at 70°51'N, 145°17'W; absent from Chukchi Sea* [4, 7]. Common off east and west Greenland, throughout the Norwegian Basin, and in Barents Sea [1, 5].

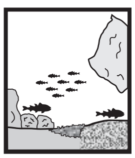


Geographic distribution of Arctic Skate (*Amblyraja hyperborea*) within Arctic Outer Continental Shelf Planning Areas [6] based on review of published literature and specimens from historical and recent collections [4, 7].

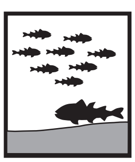
Depth Range: Typically between 300 and 1,500 m [2], with few records as shallow as 200 m [6] or as deep as 2,640 m [8]. *The one specimen from the slope off the U.S. Beaufort Sea was taken at a depth of 357 m* [7].



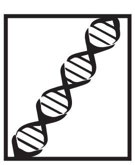
Benthic and reproductive distribution of Arctic Skate (*Amblyraja hyperborea*).



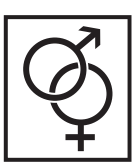
Habitats and Life History
Eggs—Female lays two egg cases, each with one egg [1]. Size: Egg cases measure 81–125 × 54–77 mm [2]. Time to hatching: Unknown. Habitat: Benthic [2].
Larvae—Eggs develop through larval stage to juvenile within the egg case [1]. Size at hatching: 15–16 cm [5]. Habitat: Benthic [2].
Juveniles—Age and size: Unknown. Habitat: Muddy bottoms [1].
Adults—Age and size at first maturity: Unknown. Maximum age: Unknown. Maximum size: 92 cm and 5.2 kg [5]. Habitat: Benthic, in deep water on the continental slopes and basins of the Arctic Ocean [1, 2, 4].
Substrate—Muddy bottoms [5].
Physical/chemical—Temperature: Mainly between -1.3 [1] and 1.5 °C [2], reported at 4 °C [7]. Salinity: Marine [3].



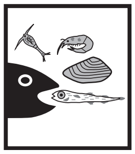
Behavior
Diel—Unknown.
Seasonal—Unknown.
Reproductive—Unknown.
Schooling: Unknown.
Feeding—Unknown.



Populations or Stocks
There have been no studies.



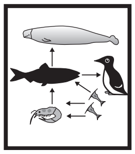
Reproduction
Mode—Oviparous [1, 2, 5, 9].
Spawning season—Unknown.
Fecundity—Less than 100 [10].



Food and Feeding

Food Items—Benthic and pelagic crustaceans such as shrimp, as well on fishes [1, 5].

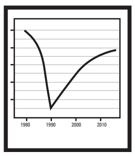
Trophic level—3.84 (standard error 0.58) [10]



Biological Interactions

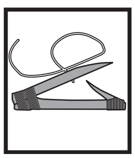
Predators—Unknown.

Competitors—Perhaps eelpouts and other benthic feeders.



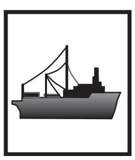
Resilience

Low, minimum population doubling time is 4.5–14 years (Fecundity assumed to be <100) [10].



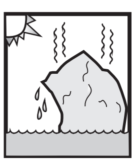
Traditional and Cultural Importance

None reported.



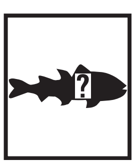
Commercial Fisheries

Currently, Arctic Skate are not commercially fished.



Potential Effects of Climate Change

Unknown.



Areas for Future Research [B]

Little is known about the ecology and life history of this species in the study area. In particular, research needs include: (1) preferred depth ranges for juveniles and adults, (2) growth rates and size at maturity, (3) spawning season, (4) seasonal and ontogenetic movements, (5) population studies, (6) prey, and (7) predators.

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Pacific Herring (*Clupea pallasii*)

Valenciennes, 1847

Family Clupeidae

Pacific Herring (*Clupea pallasii*) 217 mm TL, northeastern Chukchi Sea, 2007. Photograph by C.W. Mecklenburg, Point Stephens Research.

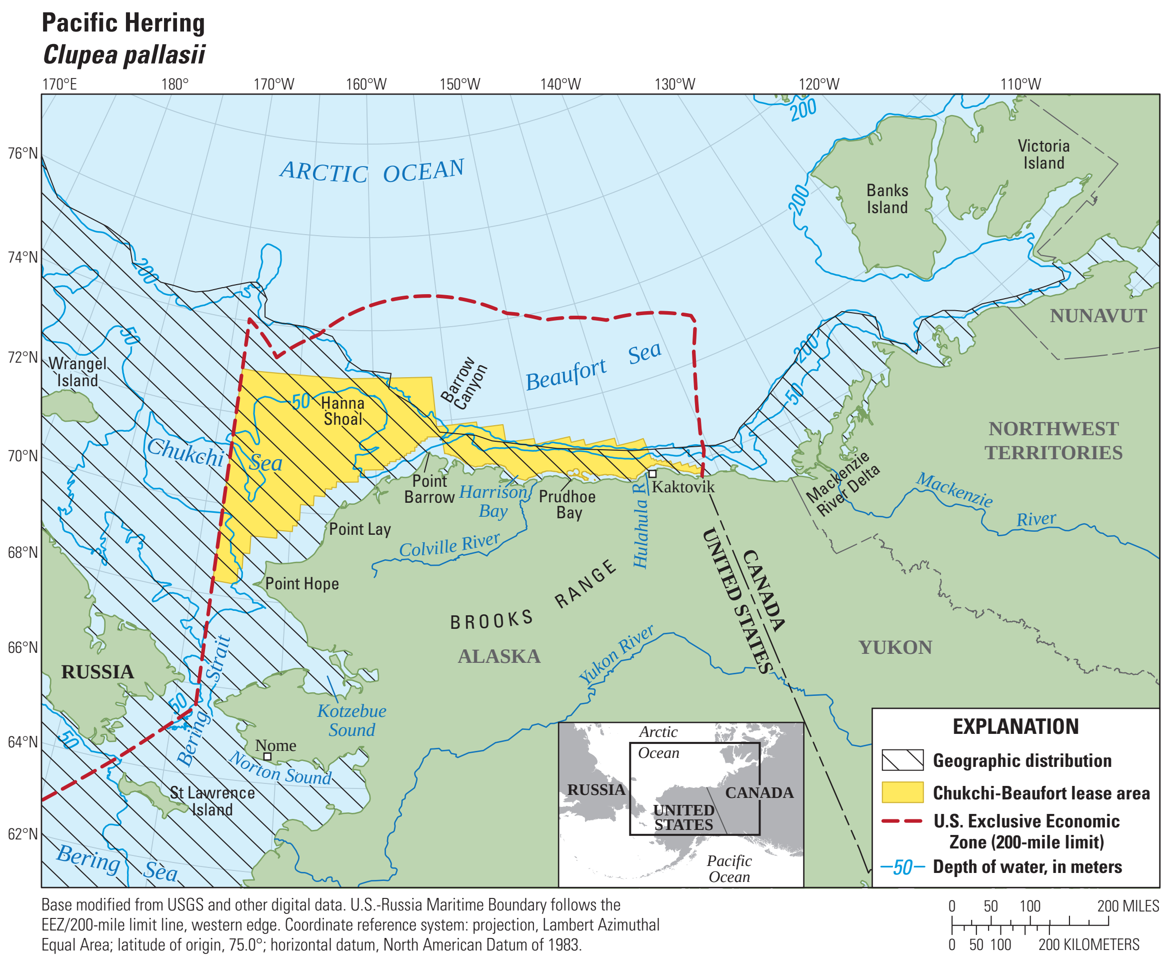
Colloquial Name: Iñupiat: *Uqsruqtuuq* [1].

Ecological Role: Based on patterns of abundance, Pacific Herring likely are of considerable importance in the U.S. Chukchi Sea and of less importance in the U.S. Beaufort Sea.

Physical Description/Attributes: Moderately compressed body with metallic blue-green to olive back with silvery sides and belly. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 134) [2]. Swim bladder: Present [2]. Antifreeze glycoproteins in blood serum: Unknown.

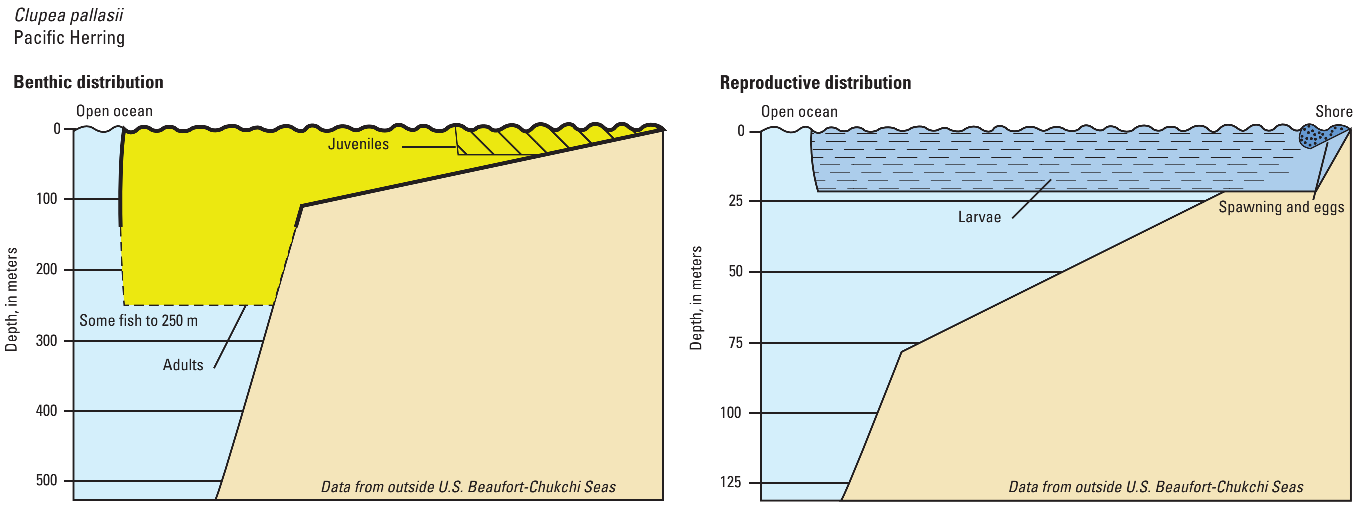
Range: *U.S. Chukchi and Beaufort Seas* [3]. Elsewhere in Alaska, occurs in all marine waters. Worldwide, from Korea and Japan and the White Sea to Arctic Canada (as far north and east as Viscount Melville Sound and south and east to Bathurst Inlet [4]) and along the Pacific Coast south to northern Baja California [2].

Relative Abundance: *Common in southeastern and northeastern Chukchi Sea* [7, 8], *occasionally found along much of U.S. Beaufort Sea* [9–13]. Occasionally found in Canadian Beaufort Sea to Mackenzie River, common from Tuktoyaktuk Peninsula, Northwest Territories [14] to as far east as Darnley Bay in Amundsen Gulf [4].

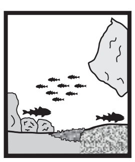


Geographic distribution within Arctic Outer Continental Shelf Planning Areas [5] of Pacific Herring (*Clupea pallasii*), based on review of published literature and specimens from historical and recent collections [3, 6].

Depth Range: Epipelagic, coastal and offshore, from surface to 250 m, typically 150 m or less. Juveniles usually remain in nearshore waters from barely subtidal to at least 30 m [15–17]. Spawning occurs intertidal to at least 10 m [18, 19]. Larvae in Canadian Beaufort Sea were most abundant at 20 m or less [20].

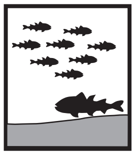


Benthic and reproductive distribution for Pacific Herring (*Clupea pallasii*).



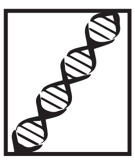
Habitats and Life History

Eggs—Size: 1.2–1.8 mm when mature [21]. Time to hatching: 6–21 days [18, 22]. Habitat: Nearshore, on kelp, eelgrass, other plant material, and on rocks and other solid surfaces [23].
Larvae—Size at hatching: 5.6–7.5 mm SL [21]. Size at juvenile transformation: Metamorphosis starts at 26 mm TL and completes by 35 mm TL [24]. Days to juvenile transformation: About 2–3 months [24]. Habitat: Epipelagic, in ocean currents [24]. Most abundant near surface in estuarine-influenced waters [20, 25].
Juveniles—Age and size: 35–150 mm TL, depending on region [24]. Habitat: Epipelagic; often found among kelp and eelgrass, and over soft sea floors [15, 17].
Adults—Age and size at first maturity: With a few exceptions, depends on water temperatures. Fish mature earlier in warmer waters (and lower latitudes) [24, 26]; 2 years in California, 3–5 years in eastern Bering Sea [24, 27], and 6 years or older in Canadian Beaufort Sea [28]. Fish in California have shorter life spans and smaller maximum lengths than do those in the north [18]. 13–26 cm TL, depending on region [29]. Growth patterns are highly variable throughout the species' geographic range as groups of fish living even tens of kilometers apart can grow at significantly different rates [7, 22, 24]. Maximum age: As old as 19 years [14], but rarely more than 15 years [4, 30]. Maximum size: 46 cm TL [2]. Habitat: Epipelagic.
Substrate—Kelp, eelgrass, other plant material, rocks and other solid surfaces for spawning [23].
Physical/chemical—Temperature: -1.7 °C to at least 20 °C [31–33]. Salinity: Marine and brackish waters [24]. Occasionally enter rivers [28, 34]. Eggs can survive between 6.1–34.2 parts per thousand [35] and 8-hour exposures to air twice daily [36].



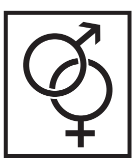
Behavior

Diel—At dawn and dusk, larvae, juveniles, and adults move toward the surface to feed [24].
Seasonal—Spawning, over-wintering, and migration patterns are highly variable. For example, within Tuktoyaktuk Harbor (Beaufort Sea) fish remain for most of the year, leaving the harbor only for a few months during the summer to feed. [28]. Of the 10 known wintering sites in the Tuktoyaktuk Peninsula region, 8 are in estuarine coastal habitats, 1 is in the lower Mackenzie River, and 1 in the marine waters of Tuktoyaktuk Harbour [37]. At the other extreme, in the eastern Bering Sea large schools of herring winter hundreds of kilometers offshore (at depths of 110–130 m) and move into nearshore waters in spring to prepare for summer spawning [27]. *Use of offshore waters as well as migrations within the U.S. Beaufort and Chukchi seas is unknown.* Elsewhere, there appears to be many migratory and non-migratory, as well as isolated and semi-isolated, populations throughout much of the species' range [24, 38, 39].
Reproductive—Spawning occurs nearshore in marine and brackish waters [18, 19]. During spawning, groups of males emit a pheromone-like substance that triggers egg laying [40]. Females lay adhesive eggs on kelp, eelgrass, and other plant material, as well as on rocks and other solid surfaces [23]. Eggs are usually deposited in layers of one or two eggs, but when spawning runs are heavy, egg deposits may reach 5 cm thick [18]. Off California, spawning occurs primarily at night, but has been observed during daylight hours and over all tidal stages [23]. Larger and older fish tend to spawn earliest and a female spawns all of her eggs in 1 or 2 days [24].
Schooling—Forms schools [24]. Depending on season and location, schools of adults may be found along the coast and out to 1,000 km or farther offshore [27]. Schools may remain quite cohesive for extended periods as individuals may associate with each other for more than 200 days while moving over 185 km (100 nautical miles) [41].
Feeding—Generally, feeding is less during winter [28, 42]. Larvae, juveniles, and adults are selective pelagic plankton feeders [24].



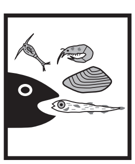
Populations or Stocks

Coastal sampling and aerial surveys have provided limited information about abundance. No detailed studies regarding populations or stocks have been conducted.



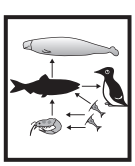
Reproduction

Mode—Gonochoristic, oviparous, and iteroparous with external fertilization [24].
Spawning season—June–September in the Canadian Beaufort Sea [14, 24, 25] where spawning begins in late spring and early summer around the time of ice break up when waters reach at least 2.5 °C [28, 31]. Spawning season is highly variable throughout its range, even among groups of fish in such relatively restricted areas such as Puget Sound [24]. Generally, spawning occurs earliest (often in the autumn) in the more southern part of the range.
Fecundity—Between 9,511 and 77,800 silver-gray eggs. Fecundity is highly variable and egg production at a particular body size is lower in high latitudes [26, 43].



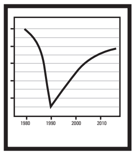
Food and Feeding

Food items—*Primarily zooplankton, such as mysids, euphausiids, copepods, amphipods, cumaceans, polychaetes, crustacean larvae, fish larvae, plant material, foraminifera, small fishes (for example, Arctic Cod, Fourhorn Sculpin, and Pacific Sand Lance), and fish larvae* [8, 14, 30, 44–46].
Trophic level—3.5 [47].



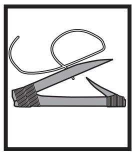
Biological Interactions

Predators—*Little is known. Beluga whales in spring near Barrow* [48, 49]. Elsewhere, all life stages, from eggs to adults, are heavily preyed upon by many species of fishes, seabirds, and marine mammals [16, 50].
Competitors—*Unknown, although likely to include various whitefishes, ciscoes, Capelin, Arctic Smelt, and Arctic Cod.*



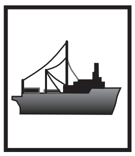
Resilience

Medium, minimum population doubling time: 1.4–4.4 years [51].



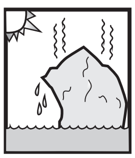
Traditional and Cultural Importance

Historically, Pacific Herring have been widely used as food as far north as the northeastern Bering Sea [52]. *Subsistence fisheries in most of the U.S. Chukchi and Beaufort Seas are modest, although some larger catches are made in the Chukchi Sea* [8, 45] and from the Mackenzie River eastward [4].



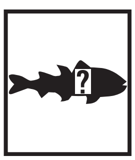
Commercial Fisheries

Currently, Pacific Herring are not commercially harvested. *The possibility of a fishery on the north side of the Seward Peninsula has been suggested*.



Potential Effects of Climate Change

Based on this species distributional pattern, increasing marine water temperatures will likely lead to increasing abundance in the U.S. Chukchi and Beaufort Seas. However, the introduction, transmission, and effects of novel pathogens and parasites associated with climate change elevates the risk of infection to Pacific Herring and its marine fish predators in the Chukchi Sea.



Areas for Future Research [A]

Pacific Herring are common in Port Clarence and Kotezebue Sound in the southeastern Chukchi Sea. Basic life history information and understanding of population dynamics are lacking. Improved knowledge about local patterns of abundance, timing and locations of reproduction, genetics, trophic linkages and energetic requirements, and movements and migrations are needed for stock assessments and information about their status and trends in time and space. Disease ecology research, including the periodic screening of Pacific Herring and its marine predators for the presence of infectious diseases, is recommended.

Remarks

Genetic analyses of Pacific and Atlantic Herrings imply that the ancestor of the Pacific Herring came across the Arctic from the Atlantic Ocean about 3 million years ago [53, 54].

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Pond Smelt (*Hypomesus olidus*)

(Pallas, 1814)

Family Osmeridae

Pond Smelt (*Hypomesus olidus*) 114 mm, northeastern Bering Sea, 2007. Photograph by C.W. Mecklenburg, Point Stephens Research.

Note: *Except for geographic range data, all information is from areas outside of the study area.*

Colloquial Name: *None within U.S. Chukchi and Beaufort Seas.* Called "Cigarfish" around Nome and other areas of Norton Sound [1].

Ecological Role: The rare occurrence of Pond Smelt in brackish and marine waters of the U.S. Chukchi Sea implies a minor ecological role in other than freshwater habitats.

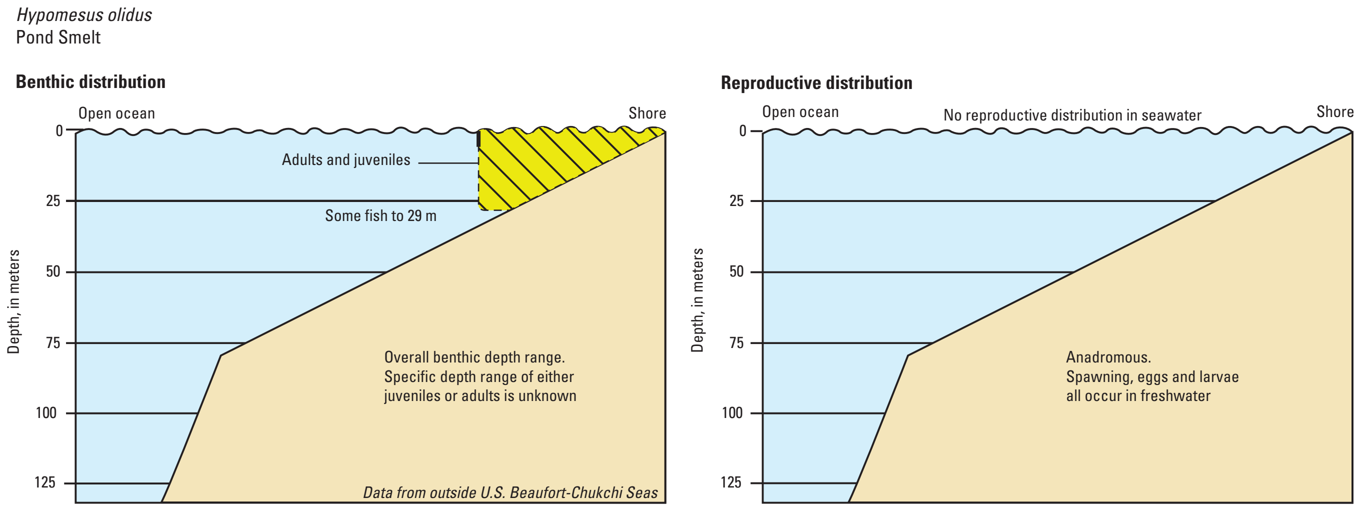
Physical Description/Attributes: Grey- or olive-green to yellow-brown dorsally becoming silvery white on belly. Snout and operculum are covered with black mottles or spots [2, 3]. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 172) [3]. Swim bladder: Present, physostomous [4]. Antifreeze glycoproteins in blood serum: Unknown.

Range: *U.S. Chukchi Sea.* In Alaska, in drainages northwards from the Copper River, northeastern Gulf of Alaska, to the Kobuk River (draining into the Chukchi Sea). Worldwide, from North Korea and Japan to northern Siberia and east through drainages of Arctic Canada to Coronation Gulf, Northwest Territories, Canada [3].

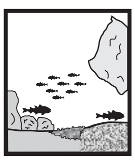
Relative Abundance: *Absent or rare in coastal waters of the U.S. Chukchi and Beaufort Seas.* Elsewhere, common at least as far north as Port Clarence, northeastern Bering Sea [1], wherePond Smelt is occasionally found well offshore [6]. Common in fresh water and occasional in coastal, brackish conditions in Mackenzie Delta region [8–10].

Geographic distribution of Pond Smelt (*Hypomesus olidus*) within Arctic Outer Continental Shelf Planning Areas [5] based on review of published literature and specimens from historical and recent collections [6, 7].

Depth Range: Nearshore, shallow waters, typically less than 5 m [1, 11]. Taken offshore of Cape Rodney and Sledge Island (northeastern Bering Sea) in 2007 by surface trawl fishing to depth of 29 m [6].



Benthic and reproductive distribution of Pond Smelt (*Hypomesus olidus*).



Habitats and Life History

Many populations are anadromous, although some stocks are landlocked [3].

Eggs—Size: 0.9 mm [12]. Time to hatching: 10–38 days at 5.0–15.0 °C [12, 13]. Habitat: Shallow depths of lakes and rivers, on submerged vegetation or rocks [12–14].

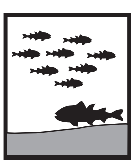
Larvae—Size at hatching: 4.6 mm long [12, 13]. Size at juvenile transformation: Unknown. Days to juvenile transformation: Unknown. Habitat: Pelagic, in freshwater rivers and lakes [12–15].

Juveniles—Age and size: As small as 24 mm FL [9, 12, 16]. Habitat: Pelagic in coastal marine and estuarine waters, and rivers and lakes [3]. Remain in their natal habitats 1 to 1 year before migrating to coastal waters [9, 12, 16].

Adults—Age and size at first maturity: 1–4 years for anadromous fish [2, 8, 12, 17–19]. In southwestern Bering Sea drainages, anadromous fish mature at age-3, whereas non-anadromous type matures at age-1 and age-2 [20]. Size is about 10.0 cm FL or more in Asia [2, 12–14]. In the Sea of Okhotsk, females are slightly larger at age than males [2]. Fish living in the Sea of Okhotsk grow faster than those in the Mackenzie Delta or a landlocked Yukon Lake population [2, 12–14]. Maximum age: About 6 years for anadromous fish in Asia, though few survive to that age [12, 20]. Maximum size: 20 cm TL [3]. Habitat: Pelagic, in coastal marine and estuarine waters, rivers and lakes [2, 3, 10, 12, 13, 17, 21].

Substrate—Taken over sand-gravel in Bristol Bay [22].

Physical/chemical—Temperature: As warm as 17 °C [20]. Salinity: Mainly freshwater, occasionally enters brackish river deltas and nearshore marine waters [3, 7].



Behavior

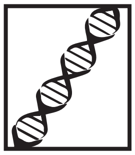
Diel—Unknown. Unidentified osmerid larvae in Auke Bay (southeastern Alaska) migrated to surface waters at midnight [23].

Seasonal—Large downstream migrations to Tuktoyaktuk Harbor occur August and September [9]. Migrations upstream may begin while the rivers are still under ice and be as long as 70 km (44 mi) [12].

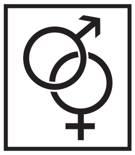
Reproductive—Spawning occurs in rivers and lakes. Some populations in Asia ascend rivers from coastal waters in spring, just before spawning, whereas others migrate into fresh waters in autumn and overwinter prior to spawning [17]. Spawning takes place at dusk. Eggs are laid on submerged vegetation or rocks in shallow, swift-flowing, waters [12–14]. In many, but not all populations, fish die after spawning [10, 12, 17, 19]. Surviving fish migrate downstream shortly after spawning [12].

Schooling—Forms schools [13].

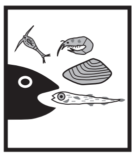
Feeding—Some populations do not feed during spawning season [20] although this is not a universal behavior [12].



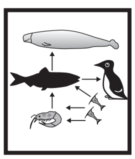
Populations or Stocks
There have been no studies.



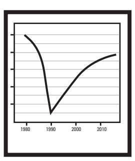
Reproduction
Mode—Oviparous [15].
Spawning season—Spawning in North America takes place at least during May–July [10, 19] and as early as April in Asia [13].
Fecundity—4,820–33,010 adhesive egg, spawned in a single batch (around Sakhalin Island, Russia) [12].



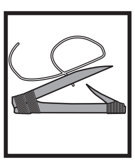
Food and Feeding
Food items—Primarily midwater crustaceans (for example, mysids, copepods, amphipods, and isopods), insects, snails, and small fishes [10, 18, 20, 24, 25].
Trophic level—3.21 (standard error 0.42) [11].



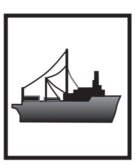
Biological Interactions
Predators—Beluga whales during May and June in Bristol Bay [26]. Inconnu and Northern Pike in North American Arctic fresh waters [10].
Competitors—Potentially midwater planktivores such as Arctic Cod, Pacific Herring, and Capelin, and other coastal fishes.



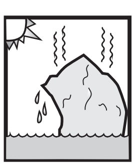
Resilience
Medium, minimum population doubling time: 1.4–4.4 years (t_m=2; t_{max}=5) [11].



Traditional and Cultural Importance
None reported.



Commercial Fisheries
Currently, Pond Smelt are not commercially harvested.



Potential Effects of Climate Change
Unclear. It is possible that warming Arctic waters will lead to increased abundance of this species as brackish habitats expand. However, it is unknown whether Arctic streams will become suitable spawning habitats for successful colonization.

Areas for Future Research [B]

Little is known about the ecology and life history of this species in the U.S. Chukchi and Beaufort Seas. Research needs include: (1) depth and location of pelagic larvae; (2) depth, location, and timing of young-of-the-year benthic recruitment; (3) preferred depth ranges for juveniles and adults; (4) spawning season; (5) seasonal and ontogenetic movements; (6) population studies; (7) prey; and (8) predators.

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Pacific Capelin (*Mallotus catervarius*)

(Pennant, 1784)

Family Osmeridae

Pacific Capelin (*Mallotus catervarius*) 84 mm TL, Semidi Islands, western Gulf of Alaska, 2001. Photograph by C.W. Mecklenburg, Point Stephens Research.

Note: *Until recently believed to be a junior synonym of* Mallotus villosus *(Müller, 1776). However, molecular genetic studies demonstrate a substantial genetic distance between this species and other Arctic mallotus spp. clades* [73].

Colloquial Name: Iñupiaq: *Panmagriq, Panmaksraq, Pagmaksraq* [1, 2].

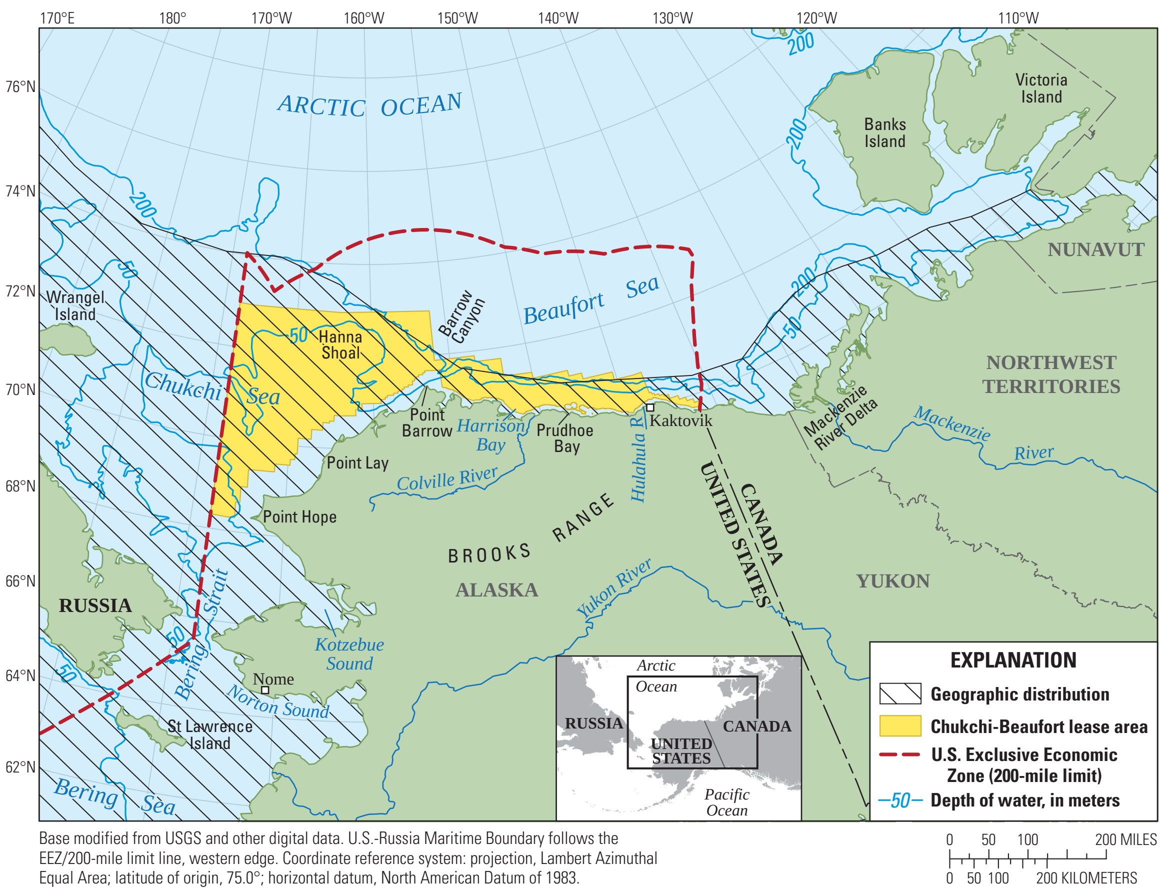
Ecological Role: The true abundance of Pacific Capelin is probably underestimated in existing survey data, but this species is hypothesized to be a major prey of many fish, birds, and marine mammals in the U.S. Chukchi and Beaufort Seas. Although its forage fish status is uncertain, its life history cycle suggests an important biological linkage between nearshore and offshore habitats especially in coastal waters influenced by large river deltas. It is a wide ranging, high lipid, cold-water fish that is an important part in Arctic and Subarctic food webs.

Physical Description: Elongate and narrow with a blueish, greenish, or yellowish back and silvery sides and belly. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 171) [3]. Swim bladder: Present [4]. Antifreeze glycoproteins in blood serum: Unknown, absent from *Mallotus villosus* in the Barents Sea [5].

Range: *U.S. Chukchi and Beaufort Seas* [3]. Elsewhere, Seas of Japan and Okhotsk, Commander and Aleutian Islands, Gulf of Alaska to Strait of Juan de Fuca eastwards to at least Davis Strait and southern end of Baffin Island, eastern Canada. Presence in Siberian Seas unclear [8].

Relative Abundance: *Common, patchily distributed, in U.S. Chukchi and Beaufort seas at least as far east as about Camden Bay* [9–14].

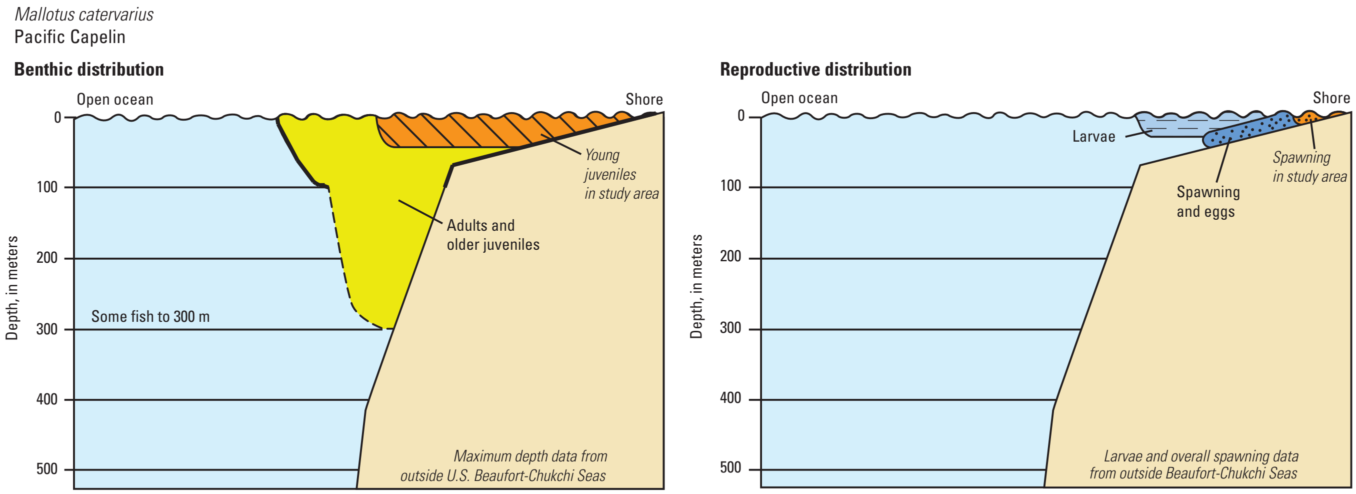
Pacific Capelin
Mallotus catervarius



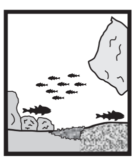
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

Geographic distribution of Pacific Capelin (*Mallotus catervarius*) within Arctic Outer Continental Shelf Planning Areas [7] based on review of published literature and specimens from historical and recent collections [3, 8].

Depth Distribution: Surface to 200 m [8]. *In western U.S. Beaufort Sea, common in intertidal and barely subtidal waters and to at least 8 m* [14]. In Prince William Sound and the Gulf of Alaska, most abundant in upper 100 m of water column [16]. Reports to 725 cm [17] are likely fish caught in trawls much nearer the surface. Larvae are found near the surface [18]. *Juveniles are reported in very shallow nearshore waters* [11, 14, 19]. Spawning occurs in very shallow waters barely subtidal waters [13, 20].



Benthic and reproductive distribution of Pacific Capelin (*Mallotus catervarius*).



Habitats and Life History

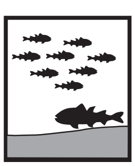
Eggs—Time to hatching: Unknown. Time to hatching: Unknown, but in *Mallotus villosus*, as much as 80 days at 2 °C, 30 days at 5 °C, and 15 days at 10 °C [22]. Size: Unknown. Once laid, eggs can survive as long as 6 hours at temperatures as low as -5 °C [25]. Habitat: *Spawning substrate has not been defined*. Demersal [26] or buried, usually in coarse sand and fine gravel [27, 28]. Occasionally in fine sand [26].

Larvae—Size at hatching: About 4 mm [31]. Size at juvenile transformation: 60 mm at start [31]. Larvae are found near the surface [18]. After hatching, some appear to remain in substrate for several days [33].

Juveniles—Age: Unknown. Size: 75.0–80.0 mm SL [31]. Habitat: *Poorly understood. Young-of-the-year live from very shallow nearshore waters out to at least 15 km from shore* [11, 14, 19].

Adults—Age and size at first maturity: *Little is known. At Point Lay, U.S. Chukchi Sea, almost all spawning fish were 2-year fish with a very small percentage of 3-year fish, and ranged in size from 110 to 155 mm FL* [9]. Bering Sea fish mature at 2 years [35]. Maximum age: In Canadian Beaufort Sea, at least 5 years [36]. Maximum size: *Fish in the U.S. Chukchi and Beaufort Seas do not appear to grow much larger than about 160 mm* [1, 9, 13, 36, 37]. Northern Pacific 21.8 cm [74]. Habitat: *Poorly understood. Older fish are taken in nearshore waters during the spawning season [11, 14, 19]. In a 3-year beach seine study conducted west of Barrow, Pacific Capelin were most abundant during the coldest-water year [14]. Their location in winter is unknown.* In Bering Sea, Pacific Capelin live as much as 560 km from shore, but only where the continental shelf is shallow and broad [35].

Physical/chemical—Temperature: Tolerate waters as cold as -2.0 to -1.8 °C and as warm as 14 °C for brief periods, but optimal temperatures are about -1.0–6.0 °C [16, 35, 38]. Salinity: Generally, marine and brackish waters, but may on occasion enter rivers [41].



Behavior

Capelin behavior is poorly understood in U.S. Chukchi and Beaufort Seas.

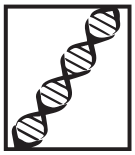
Diel—*Unknown.* Osmerid larvae in southeastern Alaska migrated to the surface at night [42].

Seasonal—*Unknown.* Some Capelin aggregations make extensive migrations to offshore feeding sites [35] where single sex schools are formed prior to migrating to spawning grounds [26].

Reproductive—*Poorly known.* Larger fish spawn earlier and males usually reach spawning grounds first [26]. Most spawning takes place in marine waters although some occurs in brackish conditions [26] and in very shallow, barely subtidal waters [13, 20]. However, there is some evidence that spawning in eastern Bering Sea and perhaps U.S. Chukchi and Beaufort Seas also may occur somewhat deeper [11, 46], although the maximum spawning depth is not known. In eastern Bering Sea and Gulf of Alaska, there is a tendency for spawning to occur or at least begin at night and around the highest tides. However, spawning can begin at any time of the day or night and has been known to continue over several days [26].

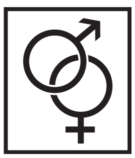
Schooling—*Capelin school in U.S. Chukchi and Beaufort Seas, but the extent of schools is unknown.* In the Gulf of Alaska, schools may be more than 1 km long and 20 m or more thick, and aggregations of schools may extend to 10 km [47].

Feeding—In the southeastern Bering Sea, Capelin feed most heavily in the afternoon and rarely at night [48]. Studies in the Chukchi and Barents Seas, North Atlantic Ocean, and off Kamchatka Peninsula, Russia, imply that fish feed heavily before and after the spawning season [9, 22, 49]. In the western Gulf of Alaska, fish to 126 mm were crepuscular feeders and fish in the Canadian Atlantic switch to diurnal feeding during winter [50].



Population or Stocks

Fish in U.S. Chukchi and Beaufort Seas may form a population that includes Bering Sea and western Pacific Ocean fish, but not fish from the Gulf of Alaska or Atlantic Ocean [51].

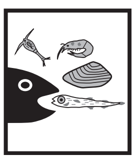


Reproduction

Mode—Separate sexes, oviparous. Fertilization is external.

Spawning season—*In the U.S. Chukchi and Beaufort Seas, spawning is primarily in July and August* [9, 19, 36, 52], *although some may take place in June* [53] *and early September* [54].

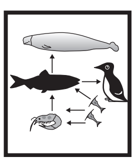
Fecundity—*Unknown.* Females release all of their eggs at one time and produce between 5,000 and 22,000 eggs [26]. Although not studied in the study area, in other locations most males die after the spawning season [26]. In some populations, substantial numbers of females may survive to spawn in the following year [56].



Food and Feeding

Food items—Food habits of larvae unknown. Capelin feed on midwater crustaceans, fish larvae, and other planktonic organisms. *Limited surveys in the Chukchi and Beaufort Seas have indicated that mysids are the most important prey, although calanoid and harpacticoid copepods, euphausiids, amphipods, crustacean larvae, and fish eggs and larvae also are consumed* [1, 9, 36].

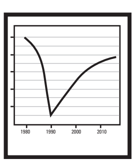
Trophic level—3.5 [60].



Biological Interactions

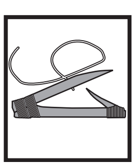
Predators—Besides the seabirds found at Capes Lisburne and Thompson, *Capelin are rarely reported in food habit studies in the U.S. Chukchi and Beaufort Seas. Ringed seals have eaten Capelin during the winter in the U.S. Chukchi Sea* [61]. In the Bering Sea, Gulf of Alaska, and eastern Canadian Arctic and northern Atlantic, this species is extremely important as food for a very wide range of marine mammals, seabirds, and fishes [63–67].

Competitors—Presumably a wide range of water-column, zooplankton feeders, including Arctic Cod and Walleye Pollock.



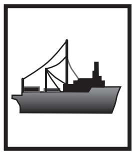
Resilience

Unknown for this species, but estimated for *Mallotus villosus* as medium, minimum population doubling time is 1.4–4.4 years (K=0.3–0.5; t_m=3; t_{max}=10; Fecundity=6,000) [68].



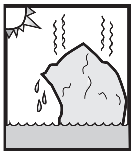
Traditional and Cultural Importance

Moderate importance in subsistence fisheries. Most fish are taken during spawning runs [2, 69–71].



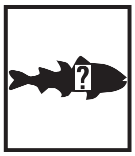
Commercial Fisheries

Currently, Pacific Capelin are not commercially harvested.



Potential Effects of Climate Change

Unclear for this species. However, *Mallotus villosus* have the capacity to respond quickly to climate change [for example, water temperature and food availability [72].



Areas for Future Research [A]

Although commonly sampled in coastal habitats, very little information exists on the life history of Pacific Capelin, particularly in U.S. Chukchi and Beaufort Seas. Because of this, many aspects of the biology of this species were inferred from other regions. It is a major forage species elsewhere in the Arctic and in other parts of Alaska. The phenology of the species in nearshore waters is brief and linked to reproduction and nursery. Early life history stages are likely swept offshore in wind-driven currents and thus the forage significance of the species in more poorly studied offshore habitats is not well documented. In particular, although it is clear that Pacific Capelin live and spawn (that is, beach versus ocean spawners) in this region, often in large numbers, there is a paucity of data on their basic biology, seasonality of their movements and behaviors, and locations of overwintering grounds. The basal metabolic and growth rates of Pacific Capelin living in the U.S. Chukchi and Beaufort Seas indicate adaptations to cold-water marine environments. The effects of warming temperatures on these physiological processes should be determined in laboratory experiments.

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Arctic Smelt (*Osmerus dentex*)

Steindachner & Kner, 1870

Family Osmeridae

Note on taxonomy: *Previously called* Osmerus mordax *in references by authors, as well as* O. eperlanus *and* O. mordax *dentex populations from the Pacific Arctic are now recognized from molecular genetics and morphological studies to be a distinct species*, O. dentex [1].

Colloquial Name: Iñupiat: *Ithuagniq* [2]; *Ilhuagnig* [3, 4]. *Frequently called Rainbow Smelt and Boreal Smelt.*

Arctic Smelt (*Osmerus dentex*), 273 mm, eastern Chukchi Sea, 2007. Photograph by C.W. Mecklenburg, Point Stephens Research.

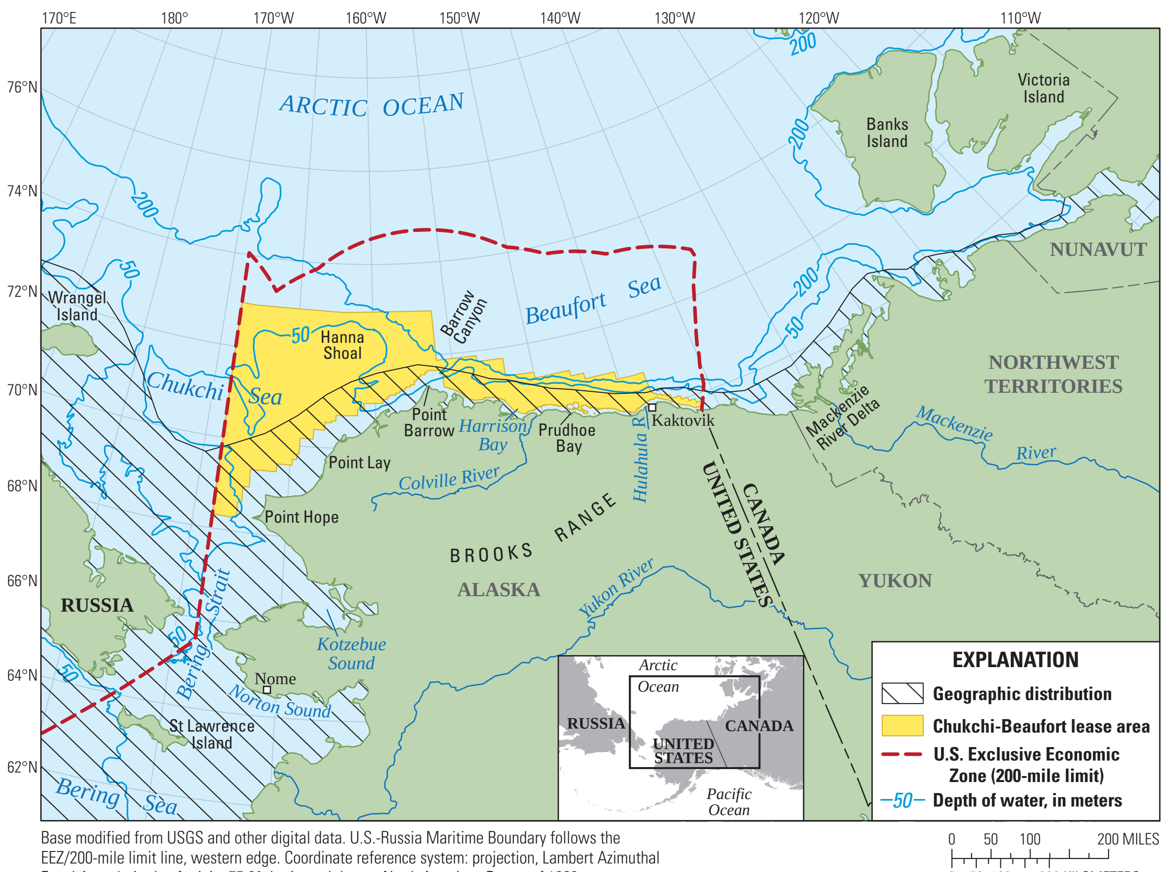
Ecological Role: Likely of considerable importance as a prey species, at least in the Chukchi Sea.

Physical Description/Attributes: Elongate, slender body with olive or pale green back, sometimes speckled with black, and a silvery belly. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 174, as *O. mordax*) [5]. Swim bladder: Present, physostomous [6]. Antifreeze glycoproteins in blood serum: Present [7].

Range: *U.S. Chukchi and Beaufort Seas.* Elsewhere, White and Barents Seas eastward to Bathurst Inlet, Nunavut, and southward to North Korea, Japan, Sea of Okhotsk, and Heceta Head, Oregon [1, 8].

Relative Abundance: *Common along all coasts of U.S. Chukchi and Beaufort Seas* [11–14]. Common in Canadian Beaufort Sea as far east as Liverpool Bay [15–17].

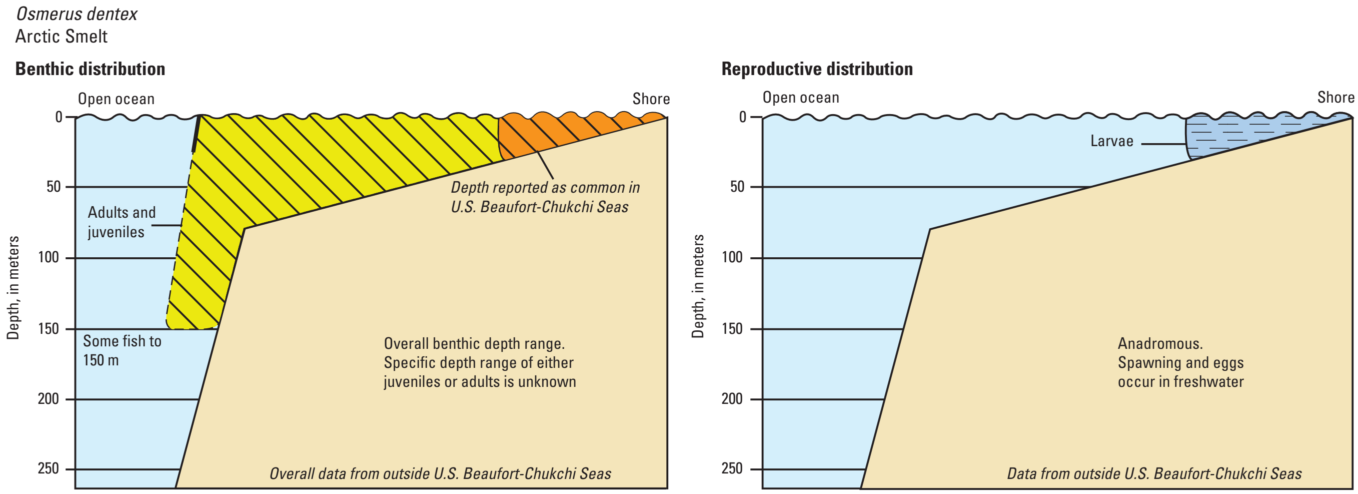
Arctic Smelt
Osmerus dentex



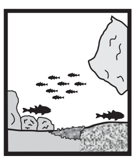
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

Geographic distribution of Arctic Smelt (*Osmerus dentex*) within Arctic Outer Continental Shelf Planning Areas [9] based on review of published literature and specimens from historical and recent collections [1, 5, 10].

Depth Range: *Primarily in shallow, coastal waters of U.S. Chukchi and Beaufort Seas, common to a depth of about 25 m* [18]. In Bering Sea and northeastern Pacific Ocean, nearshore, surface to 150 m, occasionally deeper but deep records probably due to fish entering nets nearer the surface than at maximum depth of tow [19]. In late autumn, migrate to bottom depths of 90 m or more in southwestern Bering Sea [20].



Benthic and reproductive distribution of Arctic Smelt (*Osmerus dentex*).



Habitats and Life History

Anadromous [8].

Eggs—Size: *0.8–1.0 mm* [21, 22]. Time to hatching: *10–30 days depending on temperature* [23–26]. *Probably over 30 days on Alaskan North Slope in near-freezing waters* [2]. Habitat: Freshwater, on gravel, sand, or plants in shallow, swift flowing waters (to depths of a few meters). Adheres to substrate until hatching [20, 23, 25, 26].

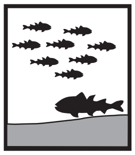
Larvae (fry)—Size at hatching: 5–8 mm SL [20, 27]. Size at juvenile transformation: Reported as post-larval at 14.7 mm TL [27]. Days to juvenile transformation: Unknown. Habitat: Pelagic in brackish to marine waters [5, 8]. Soon after hatching in freshwater, larvae are carried downriver and recruit to sheltered, shallow brackish and marine waters as small as 10–20 mm FL [15, 16, 28–30].

Juveniles—Age and size: A few months to 10 years [23–25, 31, 32]. Habitat: Pelagic in brackish to marine waters [5, 8]. *Nearshore estuaries, embayments and, at least in southeastern Chukchi Sea, coastal waters* [18].

Adults—Age and size at first maturity: Highly variable and ranges from 1 to 10 years or more [23–25, 31, 32]. *Averages between 5–7 years and perhaps 20.0–22.5 cm FL* [12, 26, 28, 33, 34]. *Growth rates vary between areas. Length-weight relationships also vary with location and perhaps with year. Larger males may be heavier at length than females* [16, 18]. Maximum age: At least 18 years in Arctic and subarctic waters [33], *however, rarely longer than 15 years* [22, 26, 30]. Fish in more temperate waters (specifically, southwestern Bering Sea and off Sakhalin Island, Russia) have much shorter life spans, rarely exceeding 6–9 years [20, 24, 25, 34]. Maximum size: 31.0 cm FL [8]. Habitat: Pelagic in brackish to marine waters [5, 8]. *Nearshore estuaries, embayments and, at least in southeastern Chukchi Sea, coastal waters* [18].

Substrate—Taken over sand-gravel in Bristol Bay [35].

Physical/chemical—Temperature: *2.0–13.5 °C. Tolerant of a very wide range* [22]. Salinity: *Tolerates brackish conditions, but typically 22 parts per thousand or greater and will avoid nearshore waters of lower salinities* [26]. Although most fish enter fresh water only to spawn, landlocked populations are known [36].



Behavior

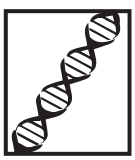
Diel—Enters rivers and spawns at night at least in Asia and eastern North America, [24, 25].

Seasonal—*Schools of juveniles and adults inhabit nearshore waters during summer* [20, 22, 29], *although significant numbers feed as far as 10 km (6 mi) offshore* [37]. Other than for spawning, fish in northeastern North America do not make extensive migrations [24], although those in southwestern Bering Sea do move offshore in early winter [20]. *In U.S. Beaufort and Chukchi Seas, juveniles and adults overwinter under ice in brackish river deltas and coastal waters*, whereas fish in southwestern Bering Sea retreat offshore to 90–100 m depths during early winter, returning to coastal waters in January and February [20]. *Many river mouths along U.S. Chukchi and Beaufort Seas harbor overwintering populations* [30, 32, 38–41]. Larvae and perhaps fertilized eggs are carried into marine waters during spring and early summer [23, 28, 30]

Reproductive—*Fish gather near spawning grounds as winter progresses* [34]. Spawning takes place in spring, just prior to ice break-up [28, 30, 32]. *Spawning takes place in many rivers entering U.S. Chukchi and Beaufort Seas* [33, 34, 42] and in at least one lake (Lake Tasiqpaatchiaq, Alaska) [37]. *Most spawning seems to occur in lowermost but still freshwater parts of rivers, often very near the mouth* [23, 26]. However, fish in some Russian waters (for example, Yenisei River, Siberia) may travel upstream more than 1,000 km (621 mi) to spawning grounds [43] and some have been taken well upstream on the Mackenzie River in the Arctic Red River area, though it is not clear that spawning had occurred there [44]. Occasionally spawns in estuaries and possibly coastal marine waters [17, 27, 43]. Sticky and stalked eggs are shed over gravel, sand, or plants in shallow, swift flowing waters (to depths of a few meters) and adhere to the substrate until hatching [20, 23, 25, 26]. In Asia, adults often leave fresh waters within a few hours of spawning, although some remain in spawning area for several weeks [20]. *At least some spawn more than once in their lifetimes* [26].

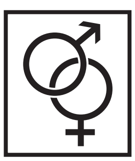
Schooling—*Schooling, water column fish* [18].

Feeding—*Midwater and, to a certain extent, benthic feeders. Feeding is most intense in summer, declines as winter progresses, and almost ceases during spring spawning* [20, 22, 26, 33, 34].



Populations or Stocks

There have been no studies. Some life history parameters for Arctic Smelt in Simpson Lagoon, Alaska, were estimated [34].



Reproduction

Mode—Oviparous [8].

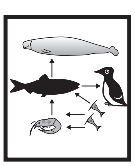
Spawning season—*March–July, peaking in May–June in the U.S. Chukchi and Beaufort Sea drainages* [12, 22, 29, 34, 45]. May–July in Bering Sea and Asia [20, 25, 46].

Fecundity—1,700–207,900 eggs. Females lay eggs in small batches [24, 25].

Food and Feeding

Food items—*Small fishes (for example, Arctic Cod, Fourhorn Sculpin, Arctic Cisco, Arctic Smelt, and eelpouts) and small crustaceans (for example, mysids, amphipods, isopods, and copepods) but occasionally snails, plant material, oligochaetes, penaeid shrimps, fish larvae, and insects* [12, 16, 29, 34, 42]. Very young fish eat zooplankton and insects [33].

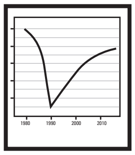
Trophic level—4.2 (standard error 0.73) [47].



Biological Interactions

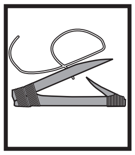
Predators—Dolly Varden and other Arctic Smelt in Canadian Beaufort Sea [16, 30]. *May be a major food for Beluga Whales between May and July in U.S. Chukchi Sea, at least in Wainwright area*, and in eastern Bering Sea [48]. *Extensively preyed upon by spotted seals in summer near Point Lay* [26] *and in April in eastern Chukchi Sea by ringed seals* [49]. In eastern Bering Sea, other predators include harbor seals, Fin and Sei Whales [50, 51].

Competitors—Other water column piscivores and zooplanktivores such as Arctic Cod and Dolly Varden.



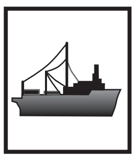
Resilience

Medium, minimum population doubling time: 1.4–4.4 years (t_m=2–3; t_{max}=7; Fecundity=1,700) [47].



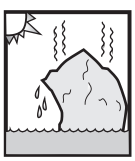
Traditional and Cultural Importance

For many years, Arctic Smelt have been of great importance to the subsistence fisheries in the Wainwright, Alaska, area [52], *where during winter and spring fishermen catch large numbers by jigging through the ice as these highly valued fish aggregate in the lower Kak River* [2, 53]. *Arctic Smelt are believed to be one of the few resources in the Wainwright area that were regularly sold* [53]. *During the autumn and winter of 1937, hunting was particularly poor around Wainwright and Arctic Smelt saved the local peoples from starvation* [26]. *Fish caught in November are perceived to taste saltier and are less valued than those taken later in the winter* [26]. *Elsewhere in U.S. Chukchi and Beaufort Seas, occasionally taken as bycatch in other subsistence fisheries* [53–55]. Also taken in some numbers in eastern Bering Sea [11] and off Russia [23].



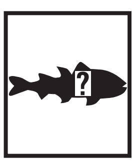
Commercial Fisheries

Currently, Arctic Smelt are not commercially harvested.



Potential Effects of Climate Change

Arctic Smelt reproduce in both Arctic and Boreal waters [1], which makes it difficult to predict how their distribution might be affected by climate warming. Like other Arctic marine fish species, they are adapted to life in cold waters and changes in temperature could affect physiological functions such as growth and metabolism.



Areas for Future Research [A]

Little offshore research has been conducted in the Arctic and their abundance in offshore waters is unknown [26, 32], although likely to be negligible since Arctic Smelt are primarily a shallow-water coastal species. Basic life history information is limited and little is known about the larval and juvenile ecology of this species. Overwintering areas have not been described and no population studies have been conducted. Bioenergetic relationships, including consumption rates by high trophic level organisms need to be described as this species is believed to be of major forage importance in certain locales, such as coastally in the southeastern Chukchi Sea and near the Colville River Delta.

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