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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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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

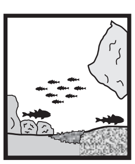
Relative abundance refers to the contribution a species makes to the total abundance of the fishery community. It is a measure that provides an index of the number of individuals present, but not the actual numbers. Relative abundance terms, such as “common,” “uncommon,” or “rare” often are used to express 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

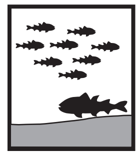
Benthic distribution refers to the spatial arrangement of a particular species at different depths over continental shelf and slope waters. The life cycle of fishes occurs in multiple dimensions in time and space and generally reflects genetically determined life history or behavior that has evolved 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.



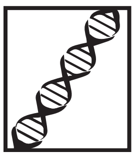
Behavior (see also Glossary [chapter 7]).—Behavior is the manner in which a fish operates or functions within its environment (that is, home range, territoriality, and many others) to procure food, orient to specific locations, or relate to other organisms. Knowing how individuals respond to the environment (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.

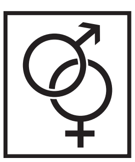
Schooling (that is, social structure of fish of the same species moving in more or less harmonious patterns in the sea) often is related to survival and reproduction. Schooling confers physical benefits to fish movement, safety against predators, search behaviors (for example, foods), population immunology,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

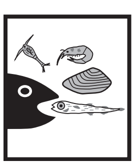
- Trophic level 1 (T1), plants and animals make their own food and are called primary producers;
- Trophic level 2 (T2), herbivores eat plants and are called primary consumers;
- Trophic level 3 (T3), carnivores eat herbivores and are called secondary consumers;
- Trophic level 4 (T4), carnivores eat 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.



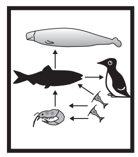
Populations or Stocks—A population often is defined as a group of organisms of the same species occupying a particular space at a particular time with the potential to breed with each other (Williams and others, 2002). Stocks are subpopulations of a particular species of fish that result from reproductive 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.



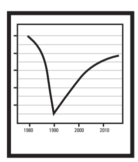
Reproduction Mode—Little information is available about the spawning times and locations, mating behaviors (breeders or nonbreeders), and genetic diversity of Arctic marine fishes. What is known is drawn largely from observations from populations studied outside the United States. For most Arctic marine 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.

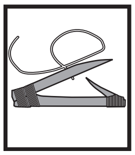


Resilience—In ecology, resilience traditionally refers to the ability of a population or biotic community to sustain or return to its former state after a disturbance. The rate of recovery is a measure of resilience determined by the population processes involved in restoring abundance to healthy, sustainable, 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.

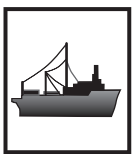
Traditional, Cultural, and Economic Values

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.



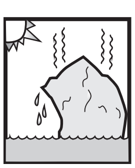
Traditional and Cultural Importance.—Several species of nearshore marine fishes are important in subsistence fisheries. The protection of traditional lifestyles and economies, including these subsistence fisheries, is a responsibility of the Federal government. Subsistence relates to resource use patterns (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

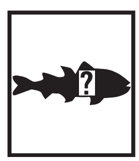
Alaska's climate is changing at more than twice the rate of the rest of the United States (Mellilo and others, 2014). Year-to-year and regional variability in air temperatures are evident and the warming trend currently is being moderated by large-scale cooling associated with the Pacific Decadal Oscillation. 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.

Northern Wolffish to Greenland Halibut

Northern Wolffish (*Anarhichas denticulatus*)

Krøyer, 1845

Family Anarhichadidae

Northern Wolffish (*Anarhichas denticulatus*), Barents Sea, 2010. Photograph by Arve Lynghammar, University of Tromsø, Norway.

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

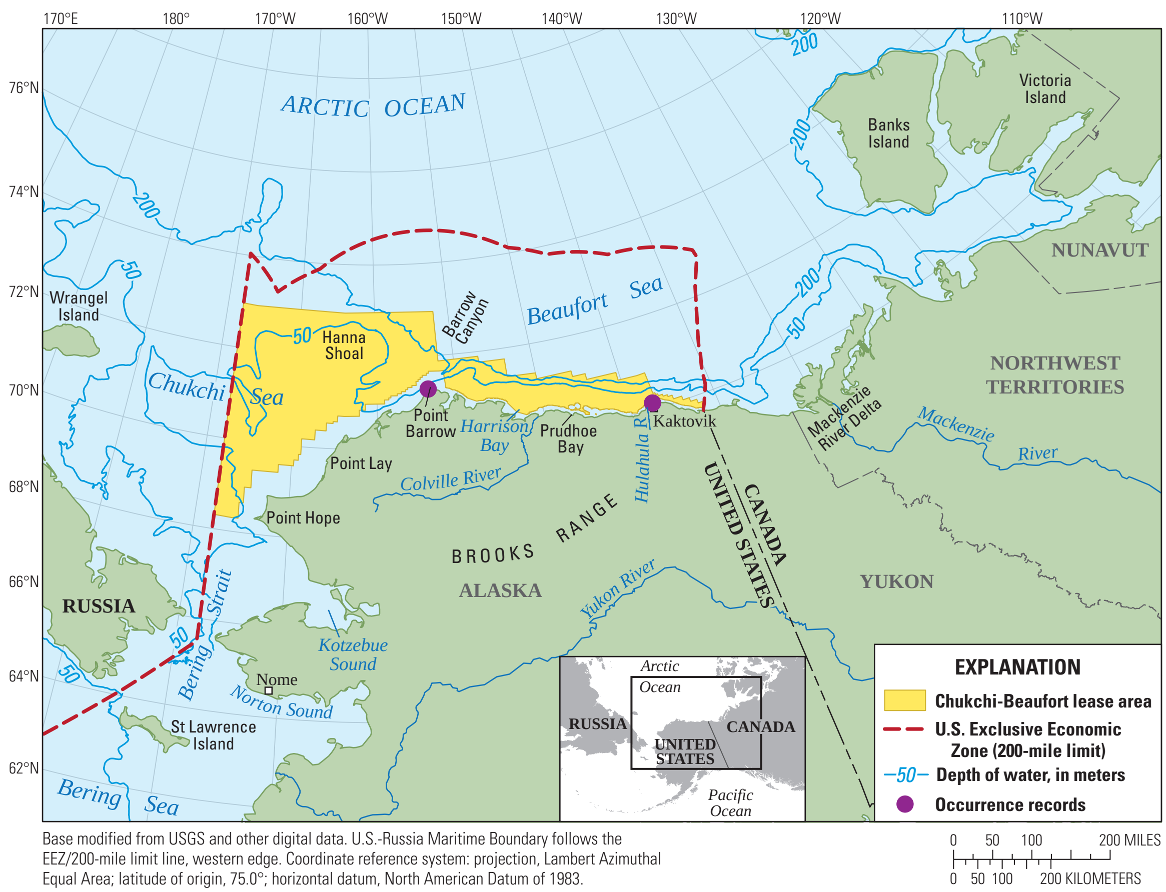
Colloquial Name: *None in U.S. Chukchi and Beaufort Seas.*

Ecological Role: Rare in both seas, which suggests a limited function role in marine ecosystem dynamics.

Physical Description/Attributes: Moderately thick, elongate gray to dark brown body, with bright violet shades or with brown tones. Body and dorsal fins covered with dark spots. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 784) [1]. Swim bladder: Absent [2]. Antifreeze glycoproteins in blood serum: Unknown.

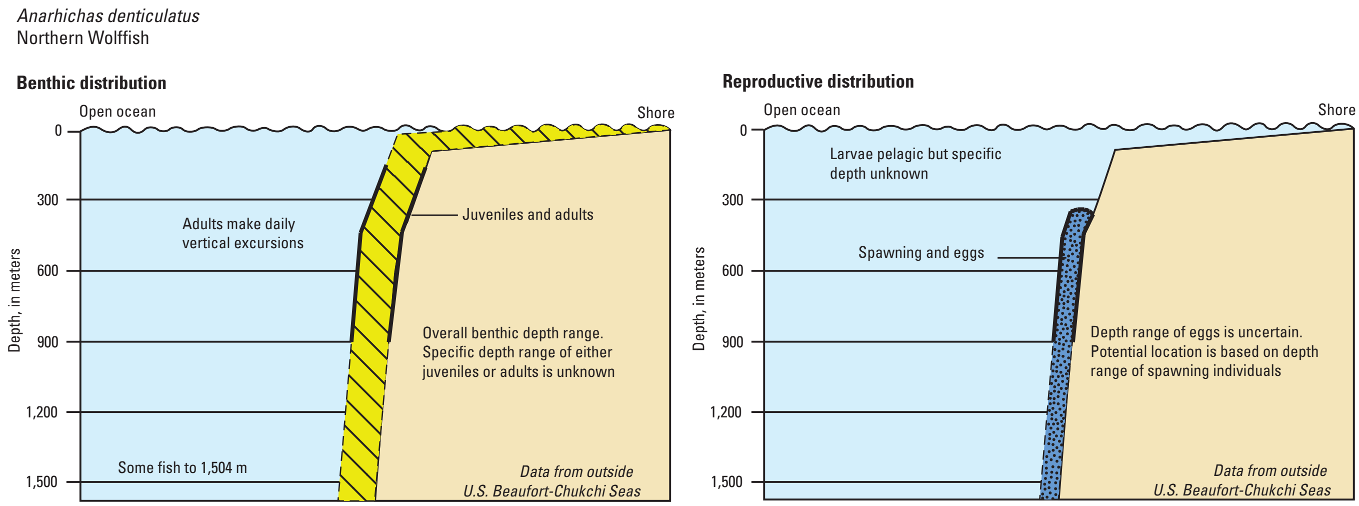
Range: *Known in the U.S. Chukchi Sea from one carcass found on the ice near Barrow and in the U.S. Beaufort Sea from a few carcasses on the beach at Kaktovik.* Worldwide, Barents and Norwegian Seas to Spitsbergen, Iceland, Faroe Islands, Greenland, south along east coast of North America to southern New England, and Canadian Arctic [3].

Relative Abundance: *Rare in U.S. Chukchi and Beaufort Seas* [3]. Elsewhere in world, uncommon in Gulf of St. Lawrence [6]. Previously common but declining in northwestern Atlantic Ocean [7].

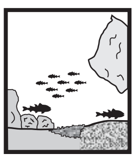


Geographic distribution of Northern Wolffish (*Anarhichas denticulatus*), within Arctic Outer Continental Shelf Planning Areas [4] based on review of published literature and specimens from historical and recent collections [3, 5].

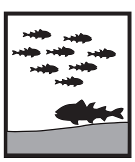
Depth Range: Surface to 1,504 m and possibly to 1,700 m [5]; mainly 150–900 m [7]. Spawns below 400 m [8].



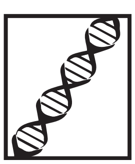
Benthic and reproductive distribution of Northern Wolffish (*Anarhichas denticulatus*).



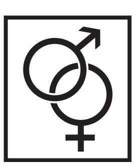
Habitats and Life History
Eggs—Size: 6–8 mm [6, 8]. Time to hatching: Unknown. Habitat: Benthic, on rocky bottoms [6, 7].
Larvae—Size at hatching: 25–26 mm [6]. Size at juvenile transformation: Unknown. Days to juvenile transformation: Unknown. Habitat: Pelagic [6].
Juveniles—Age and size: Unknown. Habitat: Benthopelagic to pelagic [2, 6, 8].
Adults—Age and size at first maturity: A few males mature starting at 5 years [7]. Females mature at 6–8 years (about 80 cm) [8].
Maximum age: 16 years [8]. Maximum size: To at least 138 cm TL [5] and 32 kg [8]. Habitat: Benthopelagic to pelagic [2, 6, 8] over soft bottoms near boulders [7].
Substrate—Mud, sand, pebbles, small rock, and hard bottoms [6, 8]. Rocky bottoms for spawning [6].
Physical/chemical—Temperature: -1.4–7.0 °C [8], most common from 1 to 5 °C [6]. Spawns at 1.6–4 °C [9]. Salinity: Prefers high salinity [8].



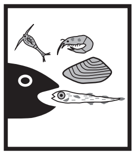
Behavior
Diel—Has extensive daily vertical migrations [8], but limited horizontal migrations [6]. Somewhat territorial [6, 10].
Seasonal—Migrates between spawning, feeding, and wintering grounds [8].
Reproductive—Builds nests [6].
Schooling—Solitary [6, 8]. Feeding: In Canadian Atlantic, feeds mid-water on both bathypelagic and mesopelagic prey [6]. Stops or reduces foraging in February–March when teeth are shed [6, 8].



Populations or Stocks
There have been no studies.

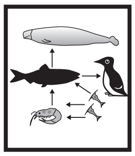


Reproduction
Mode—Separate sexes; oviparous [11].
Spawning season—Between April and October on continental slope of Barents and Norwegian Seas. Peak is during summer months [8].
Fecundity—23,380–42,500 eggs [6, 8].



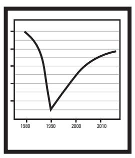
Food and Feeding

Food items—Pelagic larvae consume planktonic invertebrates, fish eggs and fish larvae [7]. Juveniles consume planktonic crustaceans (copepods, hyperiids, and euphausiids) [12]. Young adults consume fish, hyperiids, pteropods, sea urchins, ctenophores, and jellyfish [2, 8, 12, 13]. Older adults consume predominantly fish [13].
Trophic level—3.75 (standard error 0.46) [14].



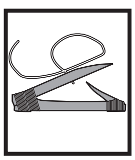
Biological Interactions

Predators—In Canada, ringed seals, Golden Redfish, cod, and Greenland Shark [7].
Competitors—For juveniles and young adults, likely various gadids, poachers, eelpouts, and flatfishes. For older adults, likely larger gadids and flatfishes.



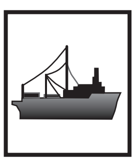
Resilience

Low, minimum population doubling time 4.5–14 years (*K*=0.08–0.10) [14].



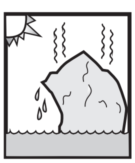
Traditional and Cultural Importance

None reported.



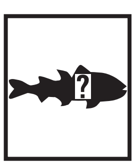
Commercial Fisheries

Currently, Northern Wolffish 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 study area. In particular, research needs in the study area 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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Kulka, D., Hood, C., and Huntington, J., 2007, Recovery strategy for northern wolffish (*Anarhichas denticulatus*) and spotted wolffish (*Anarhichas minor*), and management plan for Atlantic Wolffish (*Anarhichas lupus*) in Canada: St. John's, Fisheries and Oceans Canada, Newfoundland and Labrador Region, 103 p. [6]

Mecklenburg, C.W., Mecklenburg, T.A., and Thorsteinson, L.K., 2002, Fishes of Alaska: Bethesda, Maryland, American Fisheries Society, 1,116 p. [1]

Mecklenburg, C.W., Møller, P.R., and Steinke, D., 2011, Biodiversity of Arctic marine fishes—Taxonomy and zoogeography: Marine Biodiversity, v. 41, no. 1, p. 109–140, Online Resource 1. [3]

O'Dea, N.R., and Haedrich, R.L., 2001, COSEWIC status report on the northern wolffish *Anarhichas denticulatus* in Canada, *in* Committee on the Status of Endangered Wildlife in Canada, Status report on the northern wolffish *Anarhichas denticulatus* in Canada: Ottawa, Committee on the Status of Endangered Wildlife in Canada, p. 1–21. [7]

Wienerroither, R., Johannesen, E., Langøy, H., Børve Eriksen, K., de Lange Wenneck, T., Høines, Å., Bjelland, O., Aglen, A., Prokhorova, T., Murashko, P., Prozorkevich, D., Konstantin, Byrkjedal, I., Langhelle Drevetnyak, and G., Smirnov, O., 2011, Atlas of the Barents Sea fishes: IMR/PINRO Joint Report Series 1-2011, ISSN 1502-8828, 274 p. [8]

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8. Wienerroither, R., Johannesen, E., Langøy, H., Børve Eriksen, K., de Lange Wenneck, T., Høines, Å., Bjelland, O., Aglen, A., Prokhorova, T., Murashko, P., Prozorkevich, D., Konstantin, Byrkjedal, I., Langhelle Drevetnyak, and G., Smirnov, O., 2011, Atlas of the Barents Sea fishes: IMR/PINRO Joint Report Series 1-2011, ISSN 1502-8828, 274 p.
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11. Love, M.S., 2011, Certainly more than you wanted to know about the fishes of the Pacific Coast: Santa Barbara, California, Really Big Press, 649 p.
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Bering Wolffish (*Anarhichas orientalis*)

Pallas, 1814

Family Anarhichadidae

Bering Wolffish (*Anarhichas orientalis*), 193 mm, Chukchi Sea, 2007. Photograph by C.W. Mecklenburg, Point Stephens Research.

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

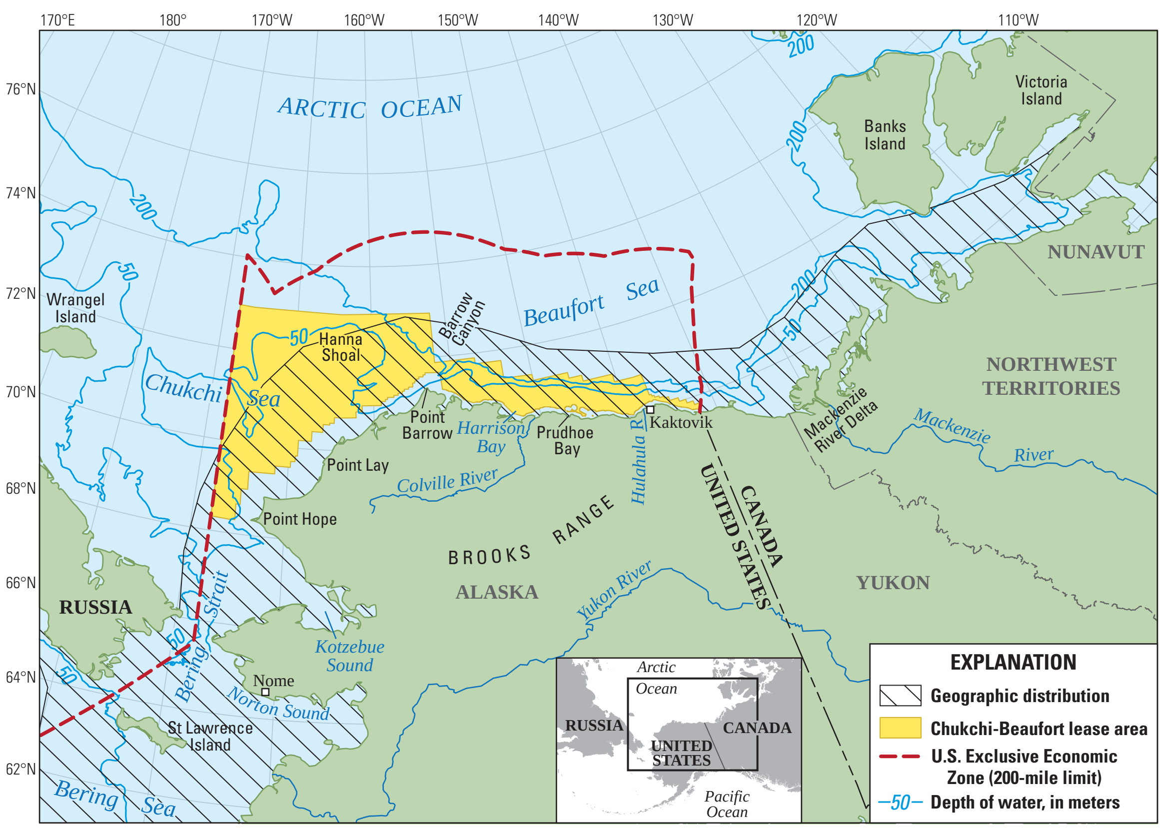
Ecological Role: This is an uncommon species in the U.S. Chukchi and Beaufort Seas. Its role in benthic ecosystem functioning probably is of modest significance regarding competition with marine invertebrate competitors.

Physical Description/Attributes: Elongate laterally compressed body, colored brown, reddish-brown, or black with mottling and blotches. Heads are blunt with large forward-projecting canine teeth. Juveniles have dark stripes. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 783) [1]. Swim bladder: Absent [2]. Antifreeze glycoproteins in blood serum: Unknown.

Range: *U.S. Chukchi and Beaufort Seas* [3]. Elsewhere in Alaska, this fish has been found southward to Prince William Sound, Gulf of Alaska. Worldwide, Bering Wolffish are found in the Sea of Okhotsk, Peter the Great Bay, Sea of Japan, and eastward in Canadian Beaufort Sea to Bathurst Inlet, Nunavut [3].

Relative Abundance: *Occasional in U.S. Chukchi and Beaufort Seas* [1, 6, 7]. Widespread and common in northern Sea of Okhotsk [8] and in eastern Bering Sea [9].

Bering Wolffish
Anarhichas orientalis

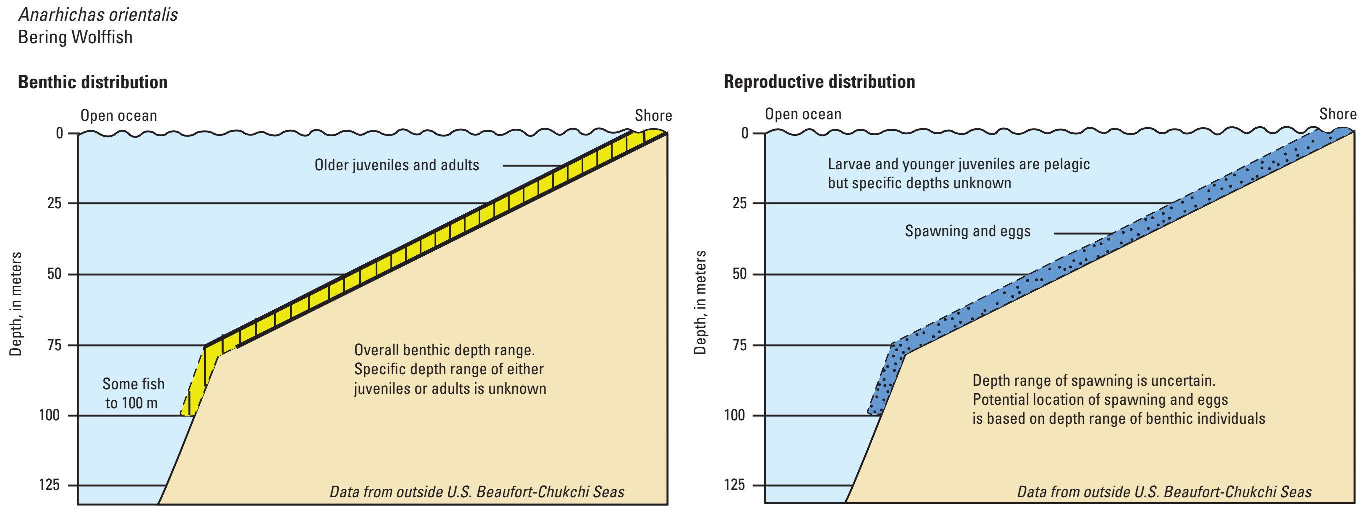


Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

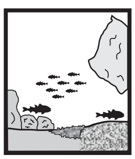
0 50 100 200 MILES
0 50 100 200 KILOMETERS

Geographic distribution of Bering Wolffish (*Anarhichas orientalis*), within Arctic Outer Continental Shelf Planning Areas [4] based on review of published literature and specimens from historical and recent collections [1, 3, 5].

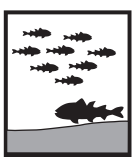
Depth Range: From shallow waters near shore to 100 m, typically in near-shore waters [3].



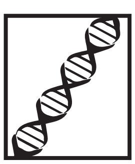
Benthic and reproductive distribution of Bering Wolffish (*Anarhichas orientalis*)



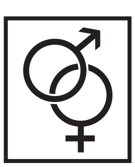
Habitats and Life History
Eggs—Size: 4–8 mm [10, 11]. Time to hatching: Unknown. Habitat: Benthic [10].
Larvae—Size at hatching: About 17–18 mm SL [10]. Size at juvenile transformation: About 40 mm SL [10]. Days to juvenile transformation: Unknown. Habitat: Pelagic [12].
Juveniles—Age and size: About 40–150 mm SL [10, 13]. Habitat: Benthopelagic [3]; juveniles to lengths of at least 50 mm TL, are sometimes found in surface waters [7, 14].
Adults—Age and size at first maturity: Age, unknown. Size, about 15–17 cm TL [11]. Maximum age: At least 17 years [11]. Maximum size: 124 cm TL and 19.5 kg and 15 kg [1]. Habitat: Benthopelagic [3]. Nearshore, intertidal area, among rocks and kelp [8, 12].
Substrate—Gravel and sand, around rocks [1, 13].
Physical/chemical—Temperature: -0.2–11.9 °C [5, 13]. Salinity: *Marine* [12, 13].



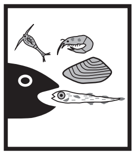
Behavior
Diel—Observed being nocturnally active near Saint Michael Island, northeastern Bering Sea [15].
Seasonal—Benthic; individuals are believed to migrate nearshore after ice melts [12].
Reproductive—One or both parents guard eggs [10].
Schooling—Unlikely. Generally, wolffish are solitary or occur in small groups [1].
Feeding—Unknown.



Populations or Stocks
There have been no studies.



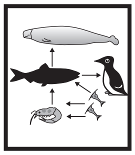
Reproduction
Mode—Oviparous [10]. Fertilization is external [16].
Spawning season—October and November in the Sea of Japan [17]. One female with well-developed eggs was taken in late May off Kamchatka [12].
Fecundity—Unknown.



Food and Feeding

Food items—Little is known. Hermit crabs, crabs, eggs, and snails based on a few fish from Russia [11, 12]. Juveniles (to 21 cm TL) in Russia fed on hyperiid amphipods, fishes (young Irish lords), pteropods, and euphausiids [18].

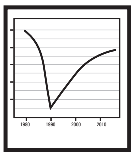
Trophic level—3.798 (standard error 0.60) [16].



Biological Interactions

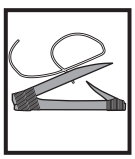
Predators—Pacific Cod and northern fur seals in the eastern Bering Sea [19, 20].

Competitors—Unknown, but likely to include pricklebacks, eelpouts, sculpins, and flatfishes.



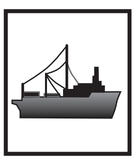
Resilience

Low, minimum population doubling time 4.5–14 years (assuming t_m>5) [16].



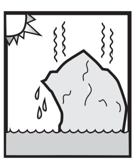
Traditional and Cultural Importance

None reported. Historically, on Saint Michael Island in Norton Sound, wolffish were a popular food with the Iñuits who caught them with hooks baited with grass. The tanned skin of this species was inserted between the seams of boots and other waterproof clothing as the skin was believed to swell when moistened [15].



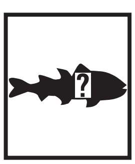
Commercial Fisheries

Currently, Bering Wolffish are not commercially harvested.



Potential Effects of Climate Change

Because Bering Wolffish are a predominantly boreal Pacific species that is typically found in nearshore, ice-free habitats, abundance would be expected to increase in both the U.S. Chukchi and Beaufort Seas wherever suitable habitat and diet occur.



Areas for Future Research [B]

Little is known about the ecology and life history of this species. Research needs in the study area 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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Prowfish (*Zaprora silenus*)

Jordan, 1896

Family Zaproridae

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

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

Ecological Role: Unknown. Only one specimen is known from the U.S. Chukchi Sea and the species is absent from the U.S. Beaufort Sea. The ecological role is probably insignificant.

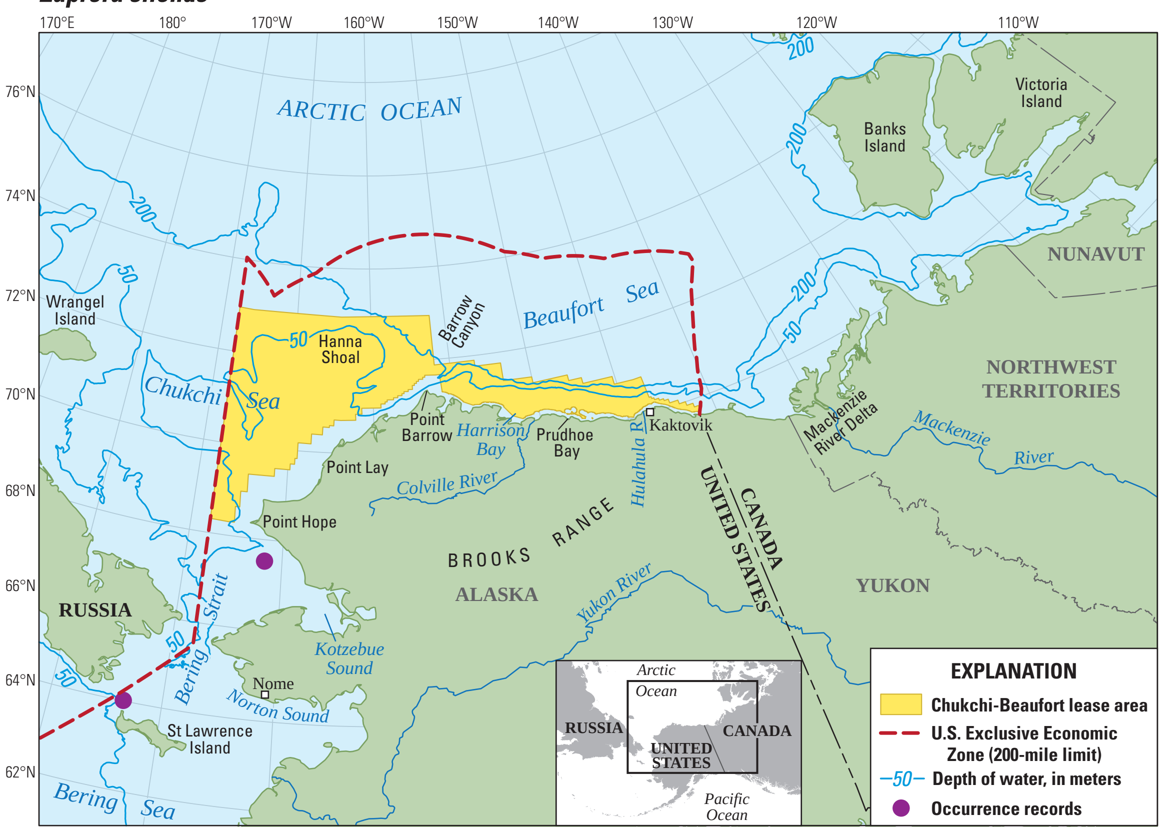
Prowfish (*Zaprora silenus*), juvenile, 139 mm, northeastern Bering Sea, 2007. Photograph by C.W. Mecklenburg, Point Stephens Research.

Physical Description/Attributes: Blunt snout and elongate, compressed, somewhat flaccid body. Head pores large, outlined in white, yellow, or pale blue. Adults are grayish blue to green and may have darker spots and yellow blotches. Juveniles are orange-brown and have spots and blotches. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 786) [1]. Swim bladder: Absent [2]. Antifreeze glycoproteins in blood serum: Unknown.

Range: *Southern U.S. Chukchi Sea* [3]. Elsewhere in Alaska, south from Bering Sea through Aleutian Islands to southern Gulf of Alaska. Worldwide, Pacific Ocean from Hokkaido, Japan, and Sea of Okhotsk south to San Miguel Island, southern California [1].

Relative Abundance: *Rare in U.S. Chukchi Sea, where presence is documented by one juvenile found west of Kivalina at 67°32'N, 165°54'W in 2007* [3]. Common at least from Kuril Islands and southeastern Kamchatka to eastern Bering Sea and southward to about Vancouver Island [6–8].

Prowfish
Zaprora silenus

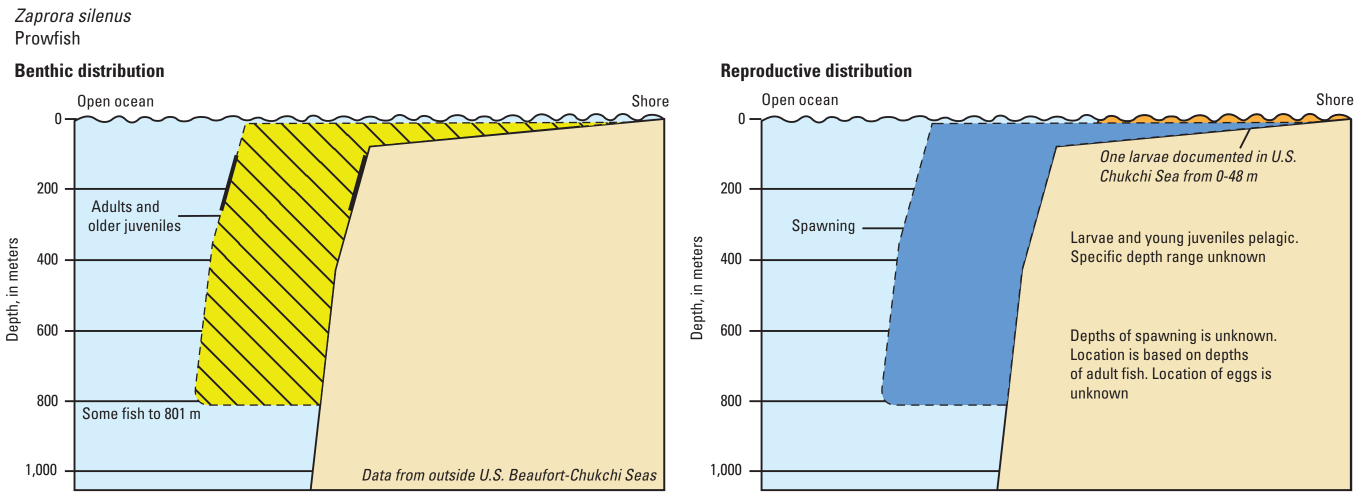


Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

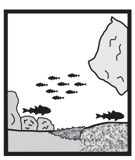
0 50 100 200 MILES
0 50 100 200 KILOMETERS

Geographic distribution of Prowfish (*Zaprora silenus*), 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: From 10 to 801 m, typically between 100 and 250 m, along deeper continental shelf and shallower continental slope [6, 7, 9]. Larvae and juveniles are pelagic in surface waters [6]. *One juvenile taken pelagically in U.S. Chukchi Sea over bottom depth of 43 m* [3].



Benthic and reproductive distribution of Prowfish (*Zaprora silenus*).



Habitats and Life History

Eggs—Size: Unknown. Time to hatching: Unknown. Habitat: Unknown.

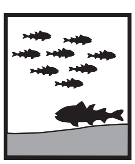
Larvae—Size at hatching: 4 mm SL [10]. Size at juvenile transformation: 3.0 cm TL [11, 12]. Days to juvenile transformation: Unknown. Habitat: Pelagic, common on outer shelf edges [6].

Juveniles—Age and size: Age unknown, 3.0–57 cm TL [6, 10]. Pelagic to at least 18 cm [6, 12]. Habitat: Young juveniles are pelagic. Older juveniles are benthopelagic [3, 6].

Adult—Age and size at first maturity: At about 5 years, 50 percent of females are mature at about 57 cm TL [6]. Females are slightly heavier at length than males. Males and females have similar growth rates and, in the northeast Pacific, females and males reach the same length [6]. Fish in northeast Pacific are larger at age than those in western Pacific and females are slightly heavier at length than males [6]. Off southeastern Kamchatka and northern Kuril Islands, females appear to grow larger than males [12]. Maximum age: At least 20 years old [6]. Maximum size: 1 m TL or more [1] and 9.3 kg [13]. Habitat: Benthopelagic [3, 6], in caves and other rocky habitats [14, 15].

Substrate—Cobble, mud, sand, and gravel [14–16].

Physical/chemical—Temperature: 0.2–8.5 °C off Russia [12, 13]. Salinity: Marine to slightly brackish water [17].



Behavior

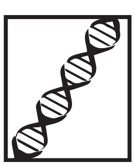
Diel—Pelagic larvae and juveniles may be obligate commensals of medusae, because they often are found in association with large jellyfish. Juveniles usually swim near tops and sides of bells, but will dive within or behind the tentacles when frightened. As many as nine juveniles have been seen associating with one medusa [18].

Seasonal—Off northern Kuril Islands and southeastern Kamchatka, prowfish may migrate from deep shelf to shallow slope waters in the late autumn and early winter [12].

Reproductive—Unknown.

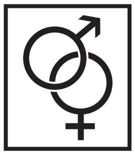
Schooling—Unknown.

Feeding—Mostly water column feeders [6, 19, 20].

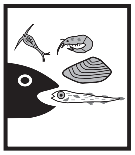


Populations or Stocks

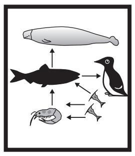
There have been no studies.



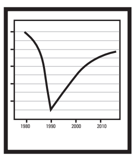
Reproduction
Mode— Unknown.
Spawning season—Spawning may occur primarily in the winter and spring, as most newly hatched larvae are captured during this period [10].
Fecundity—Unknown.



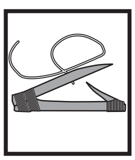
Food and Feeding
Food items—In eastern Bering Sea and northern Pacific, dominant prey are gelatinous organisms such as medusae, pelagic tunicates, and comb jellies [2, 12]. Other important prey includes copepods, amphipods, euphausiids, larvaceans, fish larvae, and polychaetes [6, 19, 20].
Trophic level—3.6 (standard error 0.5) [21].



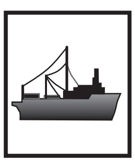
Biological Interactions
Predators—Black Rockfish, Chinook and Coho salmon, Pacific Cod, other prowfish, Whiteblotched Skates, and Tufted Puffins [22–27].
Competitors—In U.S. Chukchi Sea, likely competitors include midwater planktivores such as Arctic and Saffron Cods.



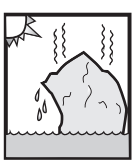
Resilience
Low, minimum population doubling time 4.5–14 years (*K*= 0.18, t_m= 5.1;) [21].



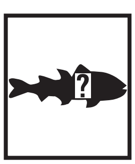
Traditional and Cultural Importance
None reported.



Commercial Fisheries
Currently, Prowfish are not commercially harvested.



Potential Effects of Climate Change
The Prowfish is a boreal Pacific species [3], which could be expected to increase in abundance in the Chukchi Sea and perhaps expand its range into the Beaufort Sea.



Areas for Future Research [B]
Little is known about the biology and ecology of this species from the 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.

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Arctic Sand Lance (*Ammodytes hexapterus*)

Pallas, 1814

Family Ammodytidae

Arctic Sand Lance (*Ammodytes hexapterus*), 149 mm TL, U.S. Chukchi Sea, 2007. Photograph by C.W. Mecklenburg, Point Stephens Research.

Note: *Until recently, it was assumed that the sand lance species found throughout the U.S. Arctic and southwards along both the eastern and western Pacific was* Ammodytes hexapterus*. Research has determined that beginning in the southeastern Bering Sea and particularly southward a second species,* Ammodytes personatus, *replaces* A. hexapturus. *Because of this historical confusion data presented below may refer to one or both species.*

Iñupiaq Name: Panmaksraq [1].

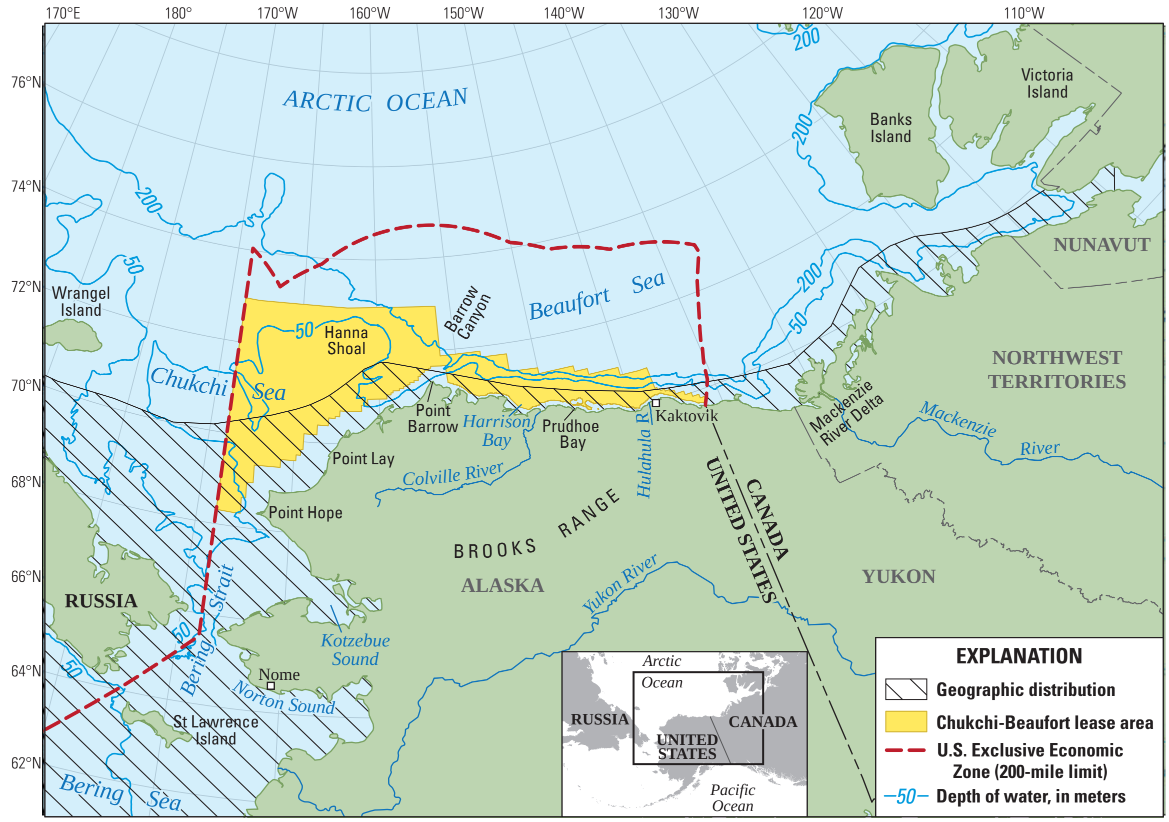
Ecological Role: Important high-lipid prey for many fishes, birds, and mammals throughout their range. Arctic Sand Lances are a critical summer food of nesting seabirds at Capes Lisburne and Thompson along the northwest coast of the Chukchi Sea. Their widespread geographic distribution and abundance and their mid-level trophic and food web importance makes them a significant component of marine ecosystems and a key species in the Alaskan high Arctic. The Arctic Sand Lance is a key forage species in the marine biological community due to its intermediate food web position and significant role in energy transfer between primary and higher-level consumers.

Physical Description and Attributes: Arctic Sand Lance have a metallic blue, elongate narrow body with a series of diagonal skin folds on sides, a fleshy ridge along body either side of the belly, a long dorsal fin that folds into a groove, and a projecting lower jaw (Fishes of Alaska [Mecklenburg and others, 2002, p. 795]) [2]. Swim bladder: Absent [2]. Antifreeze glycoproteins in blood serum: Unknown.

Range: *Throughout the U.S. Chukchi and Beaufort Seas.* Elsewhere in East Siberian, Chukchi, and Beaufort Seas eastward to Hudson and Ungava Bays; southward through eastern Bering Sea to Unimak Pass, and western Bering Sea to southeastern Kamchatka and Sea of Okhotsk [8].

Relative Abundance: *Common, although patchily distributed, throughout the U.S. Chukchi and Beaufort Seas* [6, 9–12]. Elsewhere regionally, common but not abundant in Canadian Beaufort Sea [11].

Arctic Sand Lance
Ammodytes hexapterus

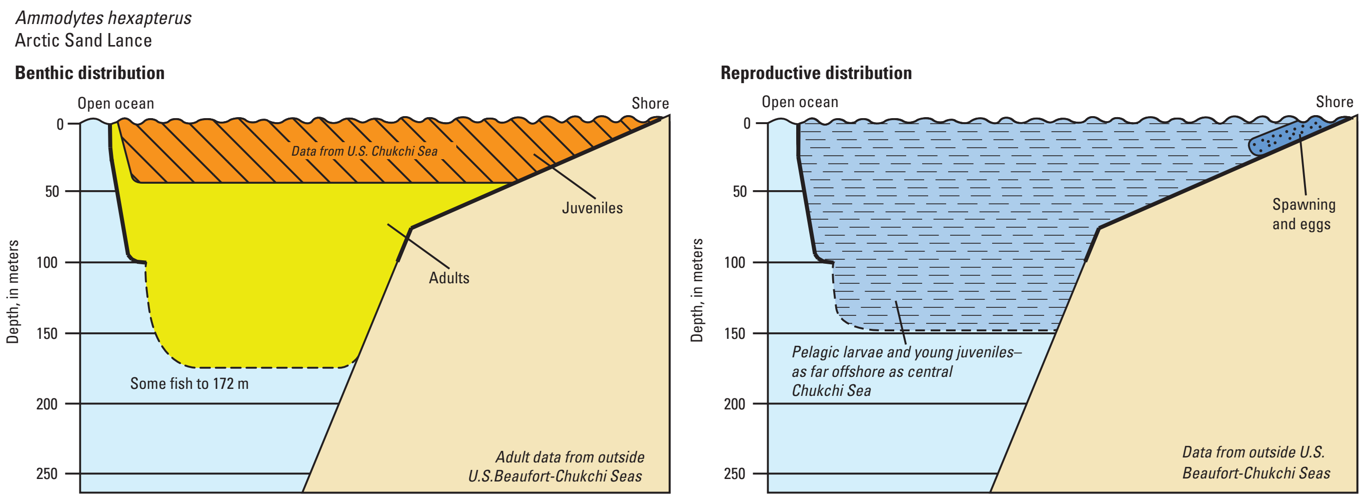


Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

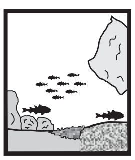
0 50 100 200 MILES
0 50 100 200 KILOMETERS

Geographic distribution of Arctic Sand Lance (*Ammodytes hexapterus*), within Arctic Outer Continental Shelf Planning Areas [7], based on review of published literature and specimens from historical and recent collections [6, 8].

Depth Range: *Unknown. Larvae, juveniles, and adults documented near surface to 49 m* [8, 13, 14] and at least in other areas to 100–120 m [8]. Spawning: Poorly known, although it is likely that *A. personatus* spawns in the intertidal and perhaps shallow subtidal waters [17–19].



Benthic and reproductive distribution of Arctic Sand Lance (*Ammodytes hexapterus*).



Habitats and Life History

Eggs—Size: perhaps 0.67–0.91 mm [20]. Time to hatching: 13–67 days (depending on water temperatures) [21–23]. Habitat: Eggs are demersal and slightly adhesive on coarse sand or fine gravel [17–19].

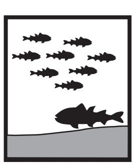
Larvae—Days to juvenile transformation: Unknown. Size: 4–7 mm at hatching to 40–80 mm FL at transformation [20]. Habitat: *Pelagic in the Chukchi Sea, in open water at depths of at least 45 m below surface* [13, 14]. In coastal, shelf, and slope waters, depth to at least 149 m in the Gulf of Alaska [likely *A. personatus*] [24, 25].

Juveniles—Age and size: Mature during second full year [26], 40–80 mm to 88–113 mm FL [17, 20, 27]. Habitat: *Has not been identified*. Elsewhere throughout range, mainly pelagic. Juveniles frequently recruit to shallow neritic waters and remain for some time [16, 28]. Frequently occupied habitats include eelgrass and algae beds, sand, and bedrock [29, 30].

Adults—Age and size at first maturity: *Unknown*. In the Gulf of Alaska [likely *A. personatus*], most fish mature at slightly less than 2 years old (age-1) (a few as old as 4 years). Smallest ripe males can be 88 mm FL and smallest ripe females 113 mm FL [17]. Maximum age: *Unknown*. In the Gulf of Alaska [likely *A. personatus*], at least 6 years [17] and to about 11 years in Asian waters [16]. Maximum size: 28 cm TL [2, 5]. Habitat: Pelagic. Habitats frequently occupied include eelgrass and algae beds, sand, and bedrock [29, 30] in very shallow neritic waters; also found along the shallower parts of the continental shelf [28].

Substrate—Arctic Sand Lance burrow under soft substrate at night and during colder-water months. Other, they dwell in water column [23, 31].

Physical/chemical— Temperature: *In the U.S. Beaufort Sea, -1.0 °C or less [10]*. Salinity: in marine, brackish, and nearly fresh waters in Bering Sea and Gulf of Alaska [33–35].

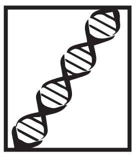


Behavior

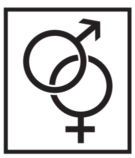
Diel—*Unknown.* In Gulf of Alaska [likely *A. personatus*], larvae migrate into deep waters at night [36]. In other regions, juveniles and adults school in water column by day (a few bury) and bury to depths of 10 cm in soft sediments of nearshore and shelf sea floors at night [18, 31, 34].

Seasonal—*Unknown.* In other areas, almost all fish spend coldest months under the sea floor in intertidal or subtidal waters, although occasionally individuals are taken in the water column pelagically [23]. Similarly, in warm-water seasons most or all fish remain buried at night and are most active in the water column during the day [31]. Burrowing fish apparently remain alert; even during the coldest months fish disturbed while in the sediment quickly move off [23].

Reproductive—*Unknown.* In other areas, spawn both day and night in intertidal waters (and perhaps in the shallow subtidal) on fine gravel or coarse sand beaches in marine and brackish waters [17–19]. May spawn on the same beaches year after year [17]. Prior to spawning, large mixed schools of males and females (sometimes males predominate) form in shallow water. Large schools may remain close to spawning beaches for days at a time; large numbers occasionally are stranded on shore as tides fall [18]. Spawning can occur over any part of the tidal cycle; may peak at high tide. Just prior to spawning, females excavate shallow pits in which the eggs are laid.
Schooling—Schooling primarily during daylight hours. Schools can be dense, monospecific, or composed of other species such as Pacific Herring [18, 31, 34].
Feeding—*Unknown*.

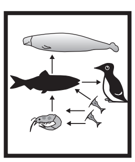


Populations or Stocks
DNA studies of fishes from the Hudson Bay-Beaufort Sea-Chukchi Sea-Bering Sea imply no distinct stocks [8].

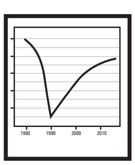


Reproduction
Mode—Separate sexes, oviparous. Fertilization is external [17, 21, 22].
Spawning season—Highly variable among geographic locations and may occur from August into late spring [17, 19, 37].
Fecundity—Off Kamchatka Peninsula, 6,150–59,900 [16].

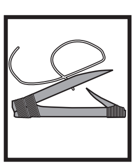
Food and Feeding
Food items—*Food habits and nutritional requirements have not been described.* Elsewhere, feed primarily on planktonic and epibenthic prey such as calanoid copepods, gammarid and hyperiid amphipods, crustacean larvae, and polychaete larvae [38–40].
Trophic level—3.5 [41].



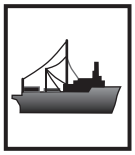
Biological Interactions
Predators—*In U.S. Chukchi Sea, Arctic Sand Lance are an important prey of both ringed (November to June) and bearded (February–March) seals, and seabirds (June–September)* [42]. *Other predators include Dolly Varden and Pacific Herring* [9, 43, 44]. Elsewhere, sand lance are heavily preyed upon by a wide range of fishes, birds, and marine mammals [45]. Some seabird populations including Pigeon Guillemot are partially or mainly dependent on them [17, 46, 47].
Competitors—Presumably, competitors are Capelin and Arctic Cod and other consumers of midwater zooplankton



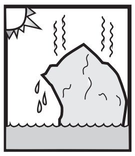
Resilience
Medium, minimum population doubling time is 1.4–4.4 years (t_m=2–3) [48].



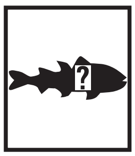
Traditional and Cultural Importance
Unknown in the Alaskan High Arctic. Elsewhere in Alaska were used as food and bait by indigenous peoples, but not of great importance [49]. Occasionally harvested for bait [21].



Commercial Fisheries
Currently, Arctic Sand Lance are not commercially harvested.



Potential Effects of Climate Change
As this species finds its southern boundary near the Aleutian Islands, it might be expected to retreat northwards as waters warm.



Areas for Future Research [A]
The ecology of Arctic Sand Lance is not well known for the U.S. Chukchi and Beaufort Seas. Of particular interest are standing stock, geographic and depth seasonal distribution, movements and migrations, spawning and overwintering grounds, and predator-prey relationships.

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