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Chapter 3m   Alaska Arctic Marine Fish Species

Chapter 3. Alaska Arctic Marine Fish Species Accounts

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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

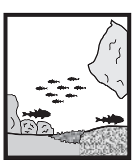
Relative abundance refers to the contribution a species makes to the total abundance of the fishery community. It is a measure that provides an index of the number of individuals present, but not the actual numbers. Relative abundance terms, such as “common,” “uncommon,” or “rare” often are used to express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

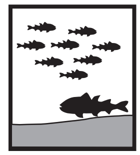
Benthic distribution refers to the spatial arrangement of a particular species at different depths over continental shelf and slope waters. The life cycle of fishes occurs in multiple dimensions in time and space and generally reflects genetically determined life history or behavior that has evolved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



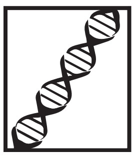
Behavior (see also Glossary [chapter 7]).— Behavior is the manner in which a fish operates or functions within its environment (that is, home range, territoriality, and many others) to procure food, orient to specific locations, or relate to other organisms. Knowing how individuals respond to the environment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

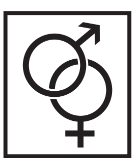
Schooling (that is, social structure of fish of the same species moving in more or less harmonious patterns in the sea) often is related to survival and reproduction. Schooling confers physical benefits to fish movement, safety against predators, search behaviors (for example, foods), population immunology,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

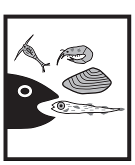
- Trophic level 1 (T1), plants and animals make their own food and are called primary producers;
- Trophic level 2 (T2), herbivores eat plants and are called primary consumers;
- Trophic level 3 (T3), carnivores eat herbivores and are called secondary consumers;
- Trophic level 4 (T4), carnivores eat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



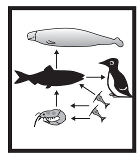
Populations or Stocks—A population often is defined as a group of organisms of the same species occupying a particular space at a particular time with the potential to breed with each other (Williams and others, 2002). Stocks are subpopulations of a particular species of fish that result from reproductive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



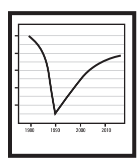
Reproduction Mode—Little information is available about the spawning times and locations, mating behaviors (breeders or nonbreeders), and genetic diversity of Arctic marine fishes. What is known is drawn largely from observations from populations studied outside the United States. For most Arctic marine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

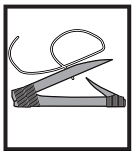


Resilience—In ecology, resilience traditionally refers to the ability of a population or biotic community to sustain or return to its former state after a disturbance. The rate of recovery is a measure of resilience determined by the population processes involved in restoring abundance to healthy, sustainable,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

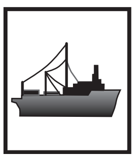
Traditional, Cultural, and Economic Values

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.



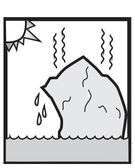
Traditional and Cultural Importance.—Several species of nearshore marine fishes are important in subsistence fisheries. The protection of traditional lifestyles and economies, including these subsistence fisheries, is a responsibility of the Federal government. Subsistence relates to resource use patterns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

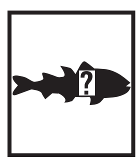
Alaska's climate is changing at more than twice the rate of the rest of the United States (Mellilo and others, 2014). Year-to-year and regional variability in air temperatures are evident and the warming trend currently is being moderated by large-scale cooling associated with the Pacific Decadal Oscillation.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

Bering Flounder (*Hippoglossoides robustus*)

Gill & Townsend, 1897

Bering Flounder (*Hippoglossoides robustus*), 185 mm, western Chukchi Sea, 2004. Photograph by C.W. Mecklenburg, Point Stephens Research.

Family Pleuronectidae

Note: *This species may be a synonym of* Hippoglossoides elassodon *Jordan & Gilbert, 1880* [3].

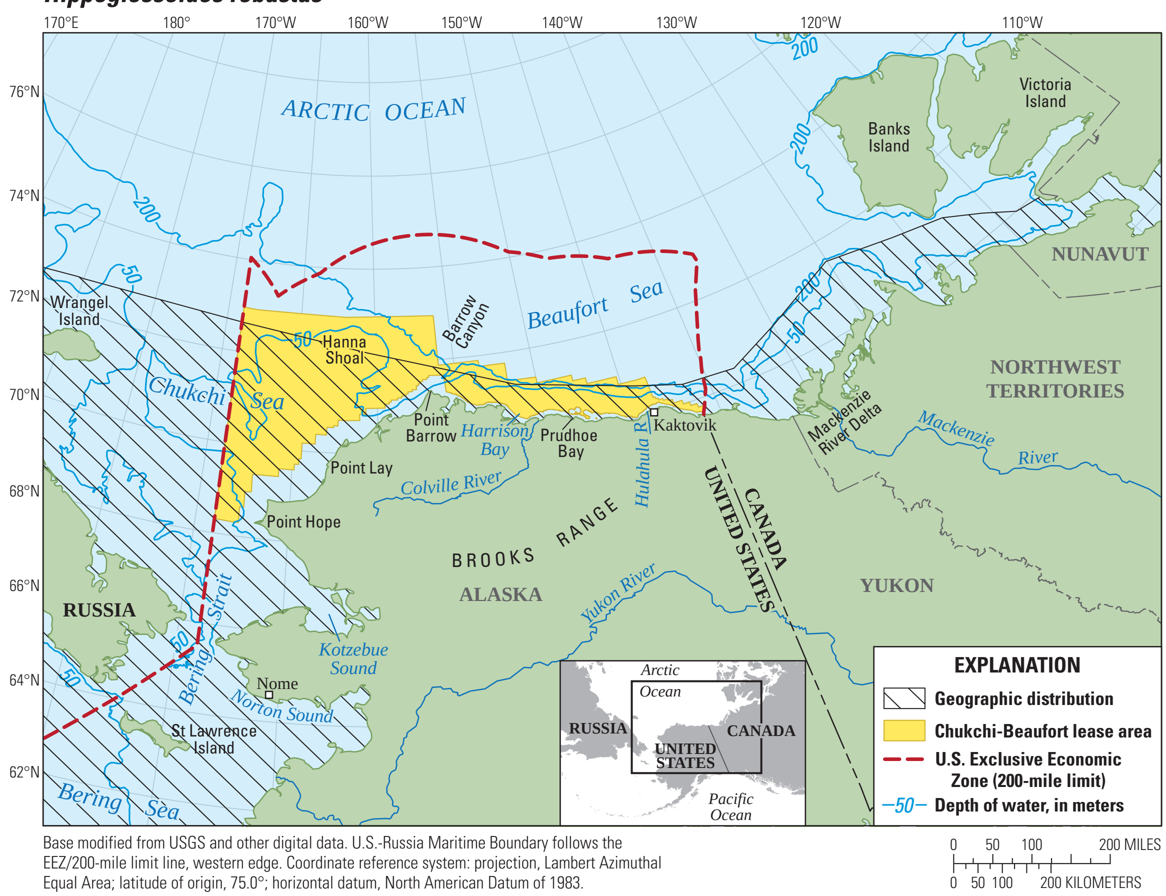
Colloquial Name: *None in U.S. Chukchi and Beaufort Seas*.

Ecological Role: Bering Flounder are the most common flatfish in the U.S. Chukchi Sea [1, 2] and are one of the most abundant fishes found there [2, 3]. Shifts in this species range in the northern Bering Sea make it an important population to monitor with respect to climate change.

Physical Description/Attributes: Member of the right eyed flounders. Eyed side is reddish brown to grayish brown and blind side is white. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 829) [4]. Swim bladder: Absent [4]. Antifreeze glycoproteins in blood serum: Unknown.

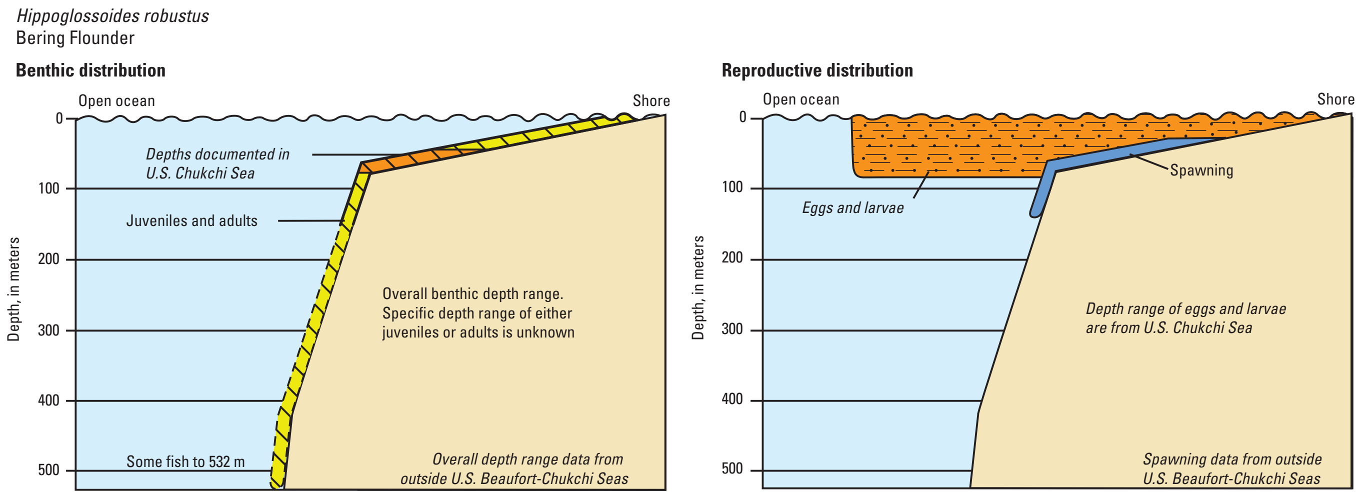
Range: *U.S. Chukchi Sea as far north as 72°19'N, 175°55'W* [2], *and U.S. Beaufort Sea* [5, 6]. Elsewhere in Alaska, Bering Flounder is found from Bering Sea off Alaska Peninsula, west to Akutan Island, Aleutian Islands [4]. Worldwide, from East Siberian Sea eastward to Bathurst Inlet, south of Dease Strait, Nunavut in Canadian Arctic, and in northern Sea of Japan off Hokkaido, Okhotsk Sea, Pacific Ocean off Kamchatka Peninsula, and Commander Islands [4, 6, 7].

Relative Abundance: *Common in U.S. Chukchi and western Beaufort Seas* [2, 5, 6]. Elsewhere, common in Bering Sea and to Kuril and Sakhalin Islands, Russia [9–11].

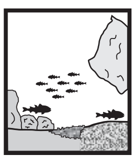


Geographic distribution of Bering Flounder (*Hippoglossoides robustus*), within Arctic Outer Continental Shelf Planning Areas [8] based on review of published literature and specimens from historical and recent collections [3, 6].

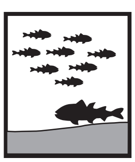
Depth Range: *Documented at 40–72 m in southern U.S. Chukchi Sea* [12]. Elsewhere, intertidal to 425 m, typically 150 m or less [3, 6, 13–15]. Spawning occurs primarily at 25–130 m [13]. *In northern Chukchi Sea, pelagic eggs documented from near surface to 81 m. Larvae in midwaters from near surface to 81 m* [12].



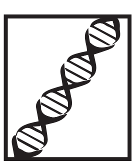
Benthic and reproductive distribution of Bering Flounder (*Hippoglossoides robustus*).



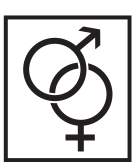
Habitats and Life History
Eggs—Size: 2.4–2.7 mm [16]. Time to hatching: Unknown. Habitat: Pelagic [17].
Larvae—Size at hatching: 4 mm SL [17]. Size at juvenile transformation: Greater than 28.6 mm SL [18]. Days to juvenile transformation: Unknown. Habitat: Pelagic [17].
Juveniles—Age and size: Unknown, greater than 28.6 mm SL to 25 cm TL [18, 19]. Habitat: Demersal [6].
Adults—Age and size at first maturity: Females mature as small as 25 cm TL. Females grow larger and faster than males [19]. Maximum age: 30 years [20]. Maximum size: 52 cm TL [4]. Habitat: Demersal [6].
Substrate—Mud sea floors [2].
Physical/chemical—Temperature: *-1.8–7.9 °C in U.S. Chukchi Sea* [6]. Elsewhere, between -1.7 and 9.2 °C [5, 13]. Salinity: Marine. *Documented between 29.4 and 33.5 parts per thousand in northeastern Chukchi Sea* [1].



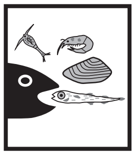
Behavior
Diel—Unknown.
Seasonal—Unknown.
Reproductive—Spawns in shallow bays and gulfs [21].
Schooling—Unknown.
Feeding—Unknown.



Populations or Stocks
There have been no studies. Population information is available from the Bering Sea.

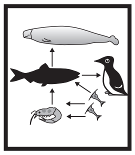


Reproduction
Mode—Unknown.
Mating/Spawning Season—Between April and June in western Bering Sea and off Kamchatka Island and may extend into August in Sea of Okhotsk [13]. *In U.S. Chukchi Sea, pelagic eggs were taken in August* [12].
Fecundity—Unknown.



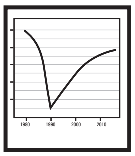
Food and Feeding

Food items—*In U.S. Chukchi Sea, fishes (for example, eel blennies, poachers, sculpins, and cods) are a major part of the diet, along with such benthic and epibenthic crustaceans as amphipods, shrimps, and hermit crabs* [22].
Trophic level—3.7 [23].



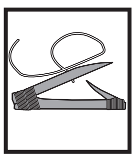
Biological Interactions

Predators—*Arctic Cod, in U.S. Chukchi Sea* [22]. Pacific Halibut, bearded seals, and beluga whales in Bering Sea, [1, 24].
Competitors—Presumably a wide range of other zoobenthos feeders such as Arctic Cod, Walleye Pollock, other flounders, eelpouts, and sculpins.



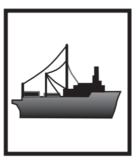
Resilience

Low, minimum population doubling time 4.5–14 years (t_{max}=11; *K*=0.21) [25].



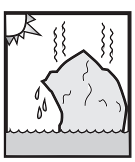
Traditional and Cultural Importance

None reported.



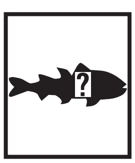
Commercial Fisheries

Currently, Bering Flounder are not commercially harvested.



Potential Effects of Climate Change

As a predominantly northern species with a low water temperature preference [26], it would be expected that climate warming would result in a northward shift in range.



Areas for Future Research [A]

Little is known about the ecology of this species in the study area. Research needs for this species 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. The Bering Flounder is an important shelf species and monitoring programs should be designed such that shifts in abundance and changes in vital statistics can be detected.

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Pacific Halibut (*Hippoglossus stenolepis*)

Schmidt, 1904

Family Pleuronectidae

Pacific Halibut (*Hippoglossus stenolepis*), 633 mm, southeastern Bering Sea. Photograph by C.W. Mecklenburg, Point Stephens Research.

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

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

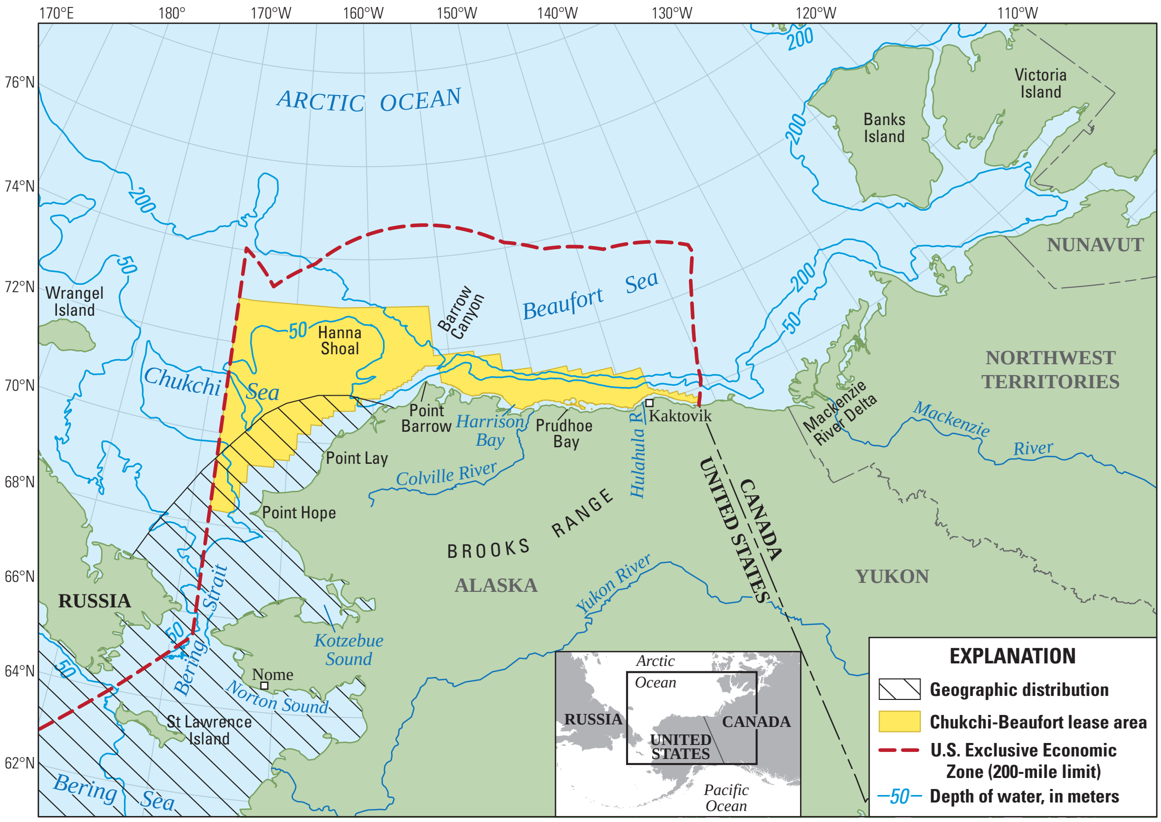
Ecological Role: Pacific Halibut are absent from the U.S. Beaufort Sea and only rarely observed in the southeastern Chukchi Sea. At present, the species ecological role in marine ecosystem function is minor.

Physical Description/Attributes: Member of the right eyed flounders. Eyed side of body is grayish to greenish brown or black with various light and dark mottling. The blind side is white. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, p. 823) [1]. Swim bladder: Absent [1]. Antifreeze glycoproteins in blood serum: Unknown.

Range: *Northeastern U.S. Chukchi Sea* to 71°12'N, 163°05'W [2]. Elsewhere in Alaska, throughout Bering Sea, Aleutian Islands, Gulf of Alaska and all southeastern Alaska waters [1]. Worldwide, to Pacific off Hokkaido, Japan and Sea of Okhotsk, and to Punta Camalu, Baja California [1, 3–5].

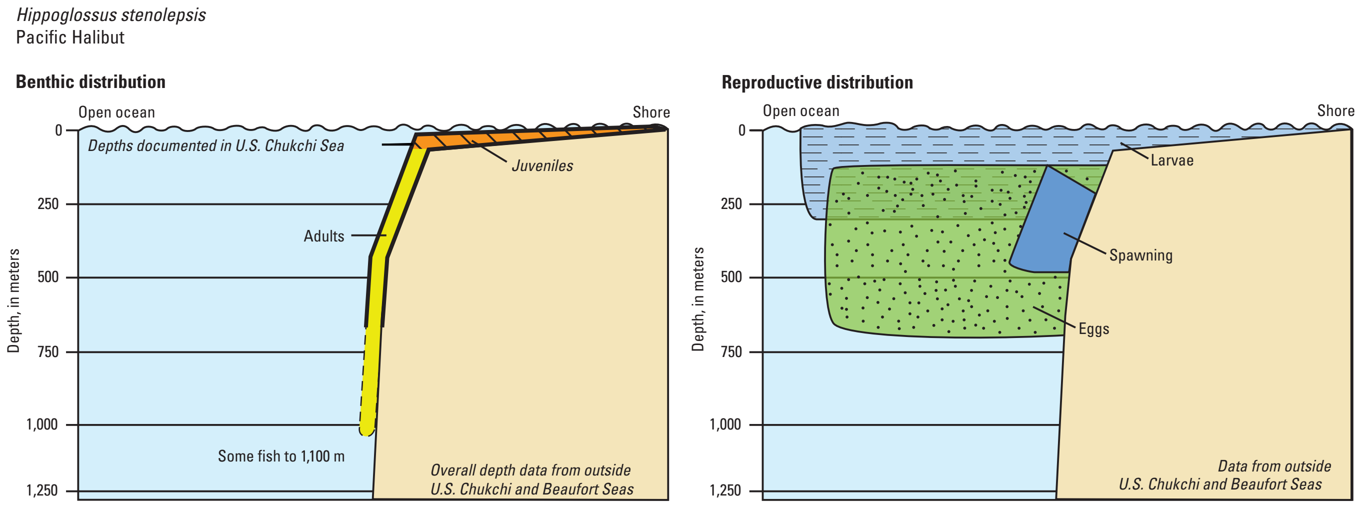
Relative Abundance: *Absent from U.S. Beaufort Sea and rare in U.S. Chukchi Sea* [2]. Uncommon in northern Bering Sea, but common in eastern Bering Sea as far north as Norton Sound [2]. Resource assessment data suggest a northward shift in this species' distribution in the Bering Sea [8]. Common west to Sea of Okhotsk and northern Kuril Islands, Russia, and southward to the Pacific Ocean off Oregon [1, 3–5].

Pacific Halibut
Hippoglossus stenolepis

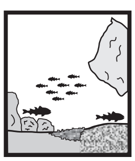


Geographic distribution of Pacific Halibut (*Hippoglossus stenolepis*), within Arctic Outer Continental Shelf Planning Areas [6] based on review of published literature and specimens from historical and recent collections [2, 7].

Depth Range: *Adults and juveniles documented in U.S. Chukchi Sea from 2–51 m* [1, 2, 9]. Overall, 6–1,200 m [7], typically less than 600 m [10, 11]. Eggs are found at 92–700 m [12–14] and larvae from surface waters to 300 m [15]. Larvae are found over the continental shelf and slope [16]. Juveniles are mostly in depths of 40 m or less [12, 17–19]. Spawning is often at 183–457 m [20–22].

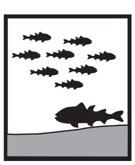


Benthic distribution and reproductive distribution of Pacific Halibut (*Hippoglossus stenolepis*).



Habitats and Life History

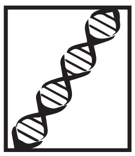
Eggs—Size: 2.9–3.8 mm [12, 13]. Time to hatching: 15–20 days at 5–6 °C and 12–14 days at 7–8 °C [12, 13]. Habitat: Epipelagic to mesopelagic [12–15].
Larvae—Size at hatching: 8.0 mm SL [13]. Size at juvenile transformation: 2.2 cm TL [17]. Days to juvenile transformation: About 180 days [12, 17, 19]. Habitat: Pelagic, over continental shelf and slope [13–16].
Juveniles—Age and size: Age unknown. 2.2 cm TL to 72–120 cm FL [12, 17, 23, 24]. Habitat: Benthic [25]. Younger juveniles settle on fine sand sea floors in or near bays [12, 17–19]. Older juveniles are on coarser-grained sediments and migrate into deeper waters [12, 19].
Adults—Age and size at first maturity: 8 years (72 cm FL) for males and 12 years (120 cm FL) for females [12, 23, 24]. Females grow faster than males and males mature when younger. Growth rates vary by area [12]. Maximum age: To at least 55 years old [12]. Maximum size: 267 cm TL [1]. The heaviest documented fish weighed 227 kg, but fish to 318 kg have been reported. Males rarely reach 36 kg [12]. Habitat: Benthic [25].
Substrate—Mostly associated with soft sea floors, but also rest on rocky bottoms [26].
Physical/chemical—Temperature: Between -1.7 and 12.2 °C [27–29], mainly at 3–8 °C [12]. Salinity: Marine, occasionally found in somewhat estuarine waters [25].



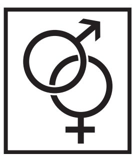
Behavior

Diel—Juveniles and adults bury themselves in bottom sediments to escape predators, reduce their metabolic rate to resting phase, and to avoid fast currents [19, 30].
Seasonal—Overall movements vary considerably between individuals and between areas. Adults tend to remain on the same grounds from year to year, making only seasonal migrations from shallow feeding grounds in summer to deeper spawning grounds in winter [12]. Individuals appear to home to these grounds year after year [22]. Some individuals exhibit only limited movements [22, 31, 32]. However, fish tagged in both the Bering Sea and in the north and northeast Pacific Ocean traveled many hundreds of kilometers [12, 31]. Generally, relatively few fish appear to move between the Gulf of Alaska and Bering Sea [12, 32]. Egg and larvae spawned off southeastern Alaska and British Columbia tend to drift northwest into the Gulf of Alaska, and some juveniles that have settled there move back to the southeast as they mature [12, 33].

Reproductive—As waters cool, adults migrate offshore to spawning grounds on deeper parts of continental shelf and slope [15, 21]. Spawning grounds are relatively circumscribed and discrete and occur from at least British Columbia to the Pribilof Canyon area in the eastern Bering Sea and likely along the Aleutian Islands [12, 20–22]. Males ripen earlier than females and extrude milt after females have finished spawning. Females shed ripe eggs gradually and spawn over an extended period, as all eggs are not ripe at any given time [34]. Some adults may not spawn every year [21, 22]. Potential courtship behavior may include a spawning pair rapidly ascending 100–175 m off the seafloor, releasing gametes, and immediately returning to the bottom [21, 28].
Schooling—Adults have been found schooling at the edge of the continental shelf in October and November prior to spawning [34].
Feeding—They are strong swimmers who are found feeding off-bottom [22].

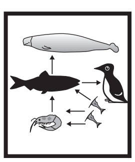


Populations or Stocks
There have been no studies.

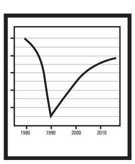


Reproduction
Mode—Separate sexes, oviparous. Fertilization is external.
Spawning season—Spawning occurs from November to March in eastern Bering Sea [12, 24].
Fecundity—Between 102,000 and more than 4 million eggs [12, 24].

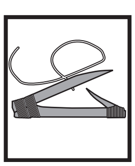
Food and Feeding
Food items—Young-of-the-year halibut feed on small crustaceans (for example, mysids, cumaceans, and gammarid amphipods), whereas older juveniles add crabs, shrimps, and small fishes to their diets [35, 36]. As halibut grow, crabs remain important, but fishes (for example, Walleye Pollock, Capelin, and Pacific Sand Lance) may make up more than half of the diet. Other important preys include hermit crabs, squids, octopi, and snails [36–38].
Trophic level—4.6 [8].



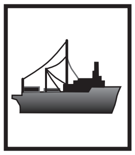
Biological Interactions
Predators—Alaska Skate, Pacific Cod, Pacific Halibut, Walleye Pollock, bald eagles, Steller sea lions, and orcas [36, 38–42].
Competitors—Larger fishes, such as Pacific Cod and Walleye Pollock, and marine mammals such as orcas and seals.



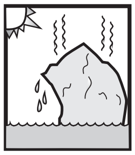
Resilience
Low, minimum population doubling time 4.5–14 years (r_m=0.2; K=0.05; t_m=5–20; t_{max}=30) [43].



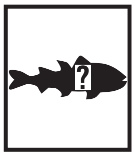
Traditional and Cultural Importance
Pacific Halibut were a major food fish for indigenous peoples living from the Bering Sea to Washington [44, 45], but their rarity in the Chukchi Sea precludes widespread use by coastal residents.



Commercial Fisheries
Currently, Pacific Halibut are not commercially harvested.



Potential Effects of Climate Change
A northward shift in distribution is expected into the Chukchi Sea. Pacific Halibut are likely to increase in abundance, especially in the southeastern Chukchi Sea and perhaps gradually expand their range into the Beaufort Sea.



Areas for Future Research [B]
This is a well-studied marine fish due to its commercial importance elsewhere. As the species range expands, additional research will be needed on the location of important habitats, species reproductive ecology (depth and location of eggs and larvae), life history (age and size at maturity), and population dynamics.

Remarks

A condition called "Chalky" halibut occurs in a substantial number of landed fish. This condition, which renders the fish unsalable due to dry and powdery musculature, is caused by high lactic acid buildup in the muscles, and is apparently linked to stress at capture, along with precapture physiology and water conditions [46].

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Yellowfin Sole (*Limanda aspera*)
(Pallas, 1814)

Family Pleuronectidae

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

Ecological Role: Yellowfin Sole are likely of only modest ecological importance in the U.S. Chukchi Sea and are unimportant in the U.S. Beaufort Sea. Increases in abundance associated with warming may attract commercial interests.

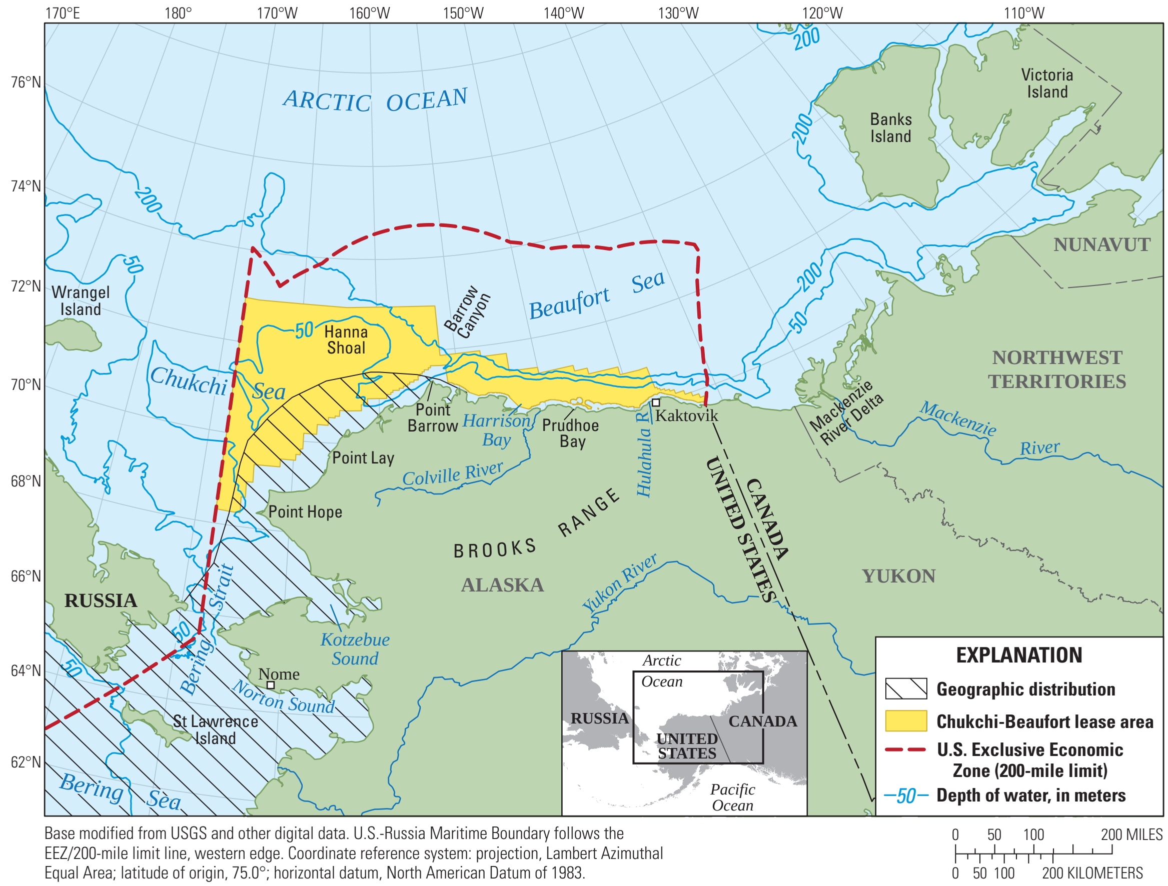
Yellowfin Sole (*Limanda aspera*), 185 mm, U.S. Chukchi Sea, 2007. Photograph by C.W. Mecklenburg, Point Stephens Research.

Physical Description/Attributes: Member of the right eyed flounders. Eyed side is brown and smaller individuals have dark spots on head and body. Median fins are yellowish, there is a narrow black line at base of dorsal and anal fins, and blind side is white. For specific diagnostic characteristic, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 844) [1]. Swim bladder: Absent [1]. Antifreeze glycoproteins in blood serum: Unknown.

Range: *U.S. Chukchi Sea to U.S. Beaufort Sea at about 71°14'N, 155°35'W, east of Point Barrow* [2]. Elsewhere in Alaska, throughout Bering Sea, eastern Aleutian Islands, Gulf of Alaska and all southeastern waters. Worldwide, in western Pacific Ocean southward to Sea of Japan off Korea and Okhotsk Sea and southward in eastern Pacific Ocean to Barkley Sound, British Columbia [1].

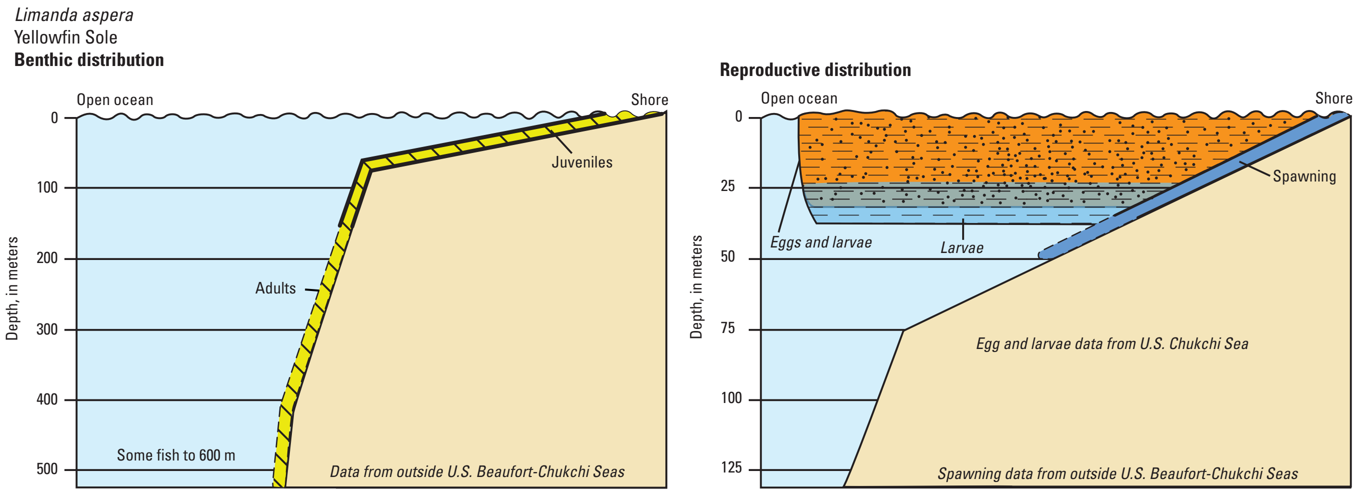
Relative Abundance: *Common, although not abundant, in southern U.S. Chukchi Sea, rare farther north and east and in U.S. Beaufort Sea* [2]. Common throughout much of Bering Sea (particularly to as far north as 61°N) and eastward to Kenai Peninsula and Cook Inlet [5–8]. Common from Sea of Japan [9] and Sea of Okhotsk [10].

Yellowfin Sole
Limanda aspera

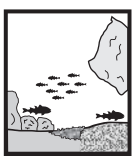


Geographic distribution of Yellowfin Sole (*Limanda aspera*), within Alaska Outer Continental Shelf Planning Areas [3] based on review of published literature and specimens from historical and recent collections [2, 4].

Depth Range: At 10–600 m, typically 150 or less [1]. Winters at 100–270 m in eastern Bering Sea [5]. Spawning occurs nearshore to a depth of 50 m [5], but mainly at 30 m or less [11]. *In U.S. Chukchi Sea, eggs of Limanda sp. taken as deep as 29 m, or to surface* [12]. Eggs at surface in Sea of Japan [13]. *In U.S. Chukchi Sea, larvae and young juveniles taken in midwater as deep as 37 m, as shallow as 25, m and perhaps to surface* [12]. Older juveniles are nearshore, from intertidal to 50 m [14, 15].



Benthic and reproductive distribution of Yellowfin Sole (*Limanda aspera*).



Habitats and Life History

Eggs—Size: 0.8–0.9 mm [18]. Time to hatching: 100 hours at 13 °C [16]. Lower threshold temperature for successful egg development is about 4.0 °C [17]. Eggs are colorless or pale gray with a very slight greenish tinge [19]. Habitat: Epipelagic [12, 13, 20].

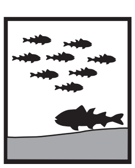
Larvae—Size at hatching: 2.2–3.1 mm SL [17, 20]. Size at juvenile transformation: As small as 1.2 cm SL [14, 15], but usually 1.5–1.7 cm SL [20]. Days to juvenile transformation: One month, but may continue as much as 4 months [18]. Habitat: Epipelagic [12, 17, 18, 20].

Juveniles—Age and size: From one month to at least 7 years [18], 2.2 mm to 1.7 cm SL [17, 20]. Habitat: Benthic [1], shallow, sometimes intertidal, waters over soft seafloors (often among eelgrass) [14, 15, 21]. Remain on mixed sand-mud bottoms for several years [5, 22]. At 3–5 years, fish begin to migrate into deeper waters and within a few years occupy same depth and habitat as adults [17].

Adults—Age and size at first maturity: Age varies with location, bottom depth, and year [23]; size varies with bottom depth [23]. Studies in the eastern Bering Sea showed female length at 50 percent maturity varied between 27 and 34 cm TL and about 10–13 years [23]. Other studies have yielded a similar range of length (as small as 25 cm) and ages of 7–11 years [5, 11]. Males mature when smaller and younger, between 10.5 and 20.3 cm and perhaps 4 years younger than females [5, 17]. From about 10 years and older, females are larger at age than males. Growth rates vary with area. For instance, fish living in northwestern (and colder) parts of eastern Bering Sea are larger at age than those living more to the southeast [23]. Length-weight relations are similar between sexes. Maximum age: 39 years [24]. Males and females may have similar life spans [25]. Maximum size: 49 cm TL [1]. Habitat: Benthic [1, 2].

Substrate—Mud, sand, and mixed soft sediments [8, 14, 19, 26].

Physical/chemical—Temperature: -1.5–13 °C, mostly 0–11 °C [7, 16, 17, 27]. In southeastern Bering Sea, from -1.7 to 11.7 °C (mainly 1.8–4.9 °C) [28]. Salinity: Marine and estuarine, to at least 16 parts per thousand [8, 14, 29].

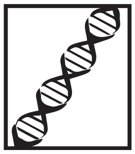


Behavior

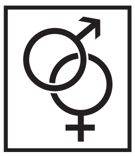
Diel—Unknown. Flatfish generally tend to bury themselves in bottom sediments to escape predators, reduce their metabolic rate to resting phase, and to avoid fast currents [30].

Seasonal—Extensive seasonal migrations of 402–482 km or more in eastern Bering Sea. In winter, they occupy three major grounds on the lower continental shelf-upper slope region. In spring (as early as March through May), they migrate nearshore to spawn, then into slightly deeper waters to feed. The spring migration is thought to follow the ice edge as it recedes [17]. In autumn, adults move offshore to wintering grounds [5, 25, 29, 31].

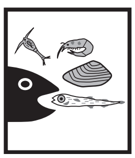
Reproductive—Spawn in nearshore waters [5]. May rise to surface waters to spawn [19]. Females are batch spawners and an individual female will spawn 8–11 batches per egg series with some females spawning more than 1 series per season [32].
Schooling—Occurs in very dense concentrations during winter [31].
Feeding—An opportunistic, benthopelagic feeder [5]. Generally feeds on or in bottom, but may ascend to surface waters to feed on midwater animals [19, 33]. Few fish feed during winter. Feeding intensity increases before and during spring migration and particularly before spawning [5, 19, 34, 35].



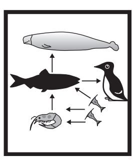
Populations or Stocks
There have been no studies.



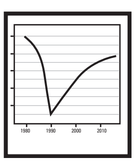
Reproduction
Mode—Separate sexes, oviparous. Fertilization is external [5].
Spawning season—May through September in eastern Bering Sea and May through November in Gulf of Alaska. During warmer-water years, spawning may occur earlier in the season [25, 36–38].
Fecundity—Batch fecundity ranges from 2,400 to 408,000 eggs and total fecundity for a series ranges from 295,615 to 3,635,108 [32].



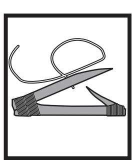
Food and Feeding
Food items—Young fish prey on small crustaceans (gammarid amphipods, harpacticoid copepods, and ostracods) and polychaetes [14, 39]. Older fish consume mostly benthic invertebrates (for example, polychaetes, clams, brittle stars, echiuroids, shrimps, crabs, sand dollars, sea cucumbers) and some fishes; diets vary depending on habitat type and geographic location [19, 34, 40, 41].
Trophic level—3.6 [42].



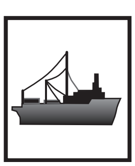
Biological Interactions
Predators—*In U.S Chukchi Sea, off Point Hope, ringed seals ate small numbers in April* [43]. In eastern Bering Sea and Gulf of Alaska, Bigmouth Sculpin, Great and Plain sculpins, Pacific Cod, Pacific Halibut, Skates, and Steller sea lions [41, 44–46].
Competitors—Likely a wide range of benthic feeding fishes, including eelpouts, Walleye Pollock, sculpins, and other flatfishes.



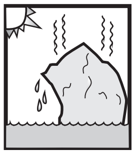
Resilience
Low, minimum population doubling time 4.5–14 years (*K*=0.1–0.15; t_m=4–10; t_{max}=26; Fecundity=1 million) [47].



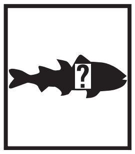
Traditional and Cultural Importance
Yellowfin Sole are of little importance in subsistence fisheries in Arctic waters.



Commercial Fisheries
Currently, Yellowfin Sole are not commercially harvested.



Potential Effects of Climate Change
As a boreal Pacific fish common throughout much of the Bering Sea and only fairly common to rare in the U.S. Chukchi and Beaufort Seas, Yellowfin Sole would be expected to increase in abundance in the study area as climate warms.



Areas for Future Research [A]
Yellowfin Sole are of commercial interest in the southeastern Bering Sea. As a potential indicator species, long-term monitoring programs should be designed to understand trends in population growth, survival, and recruitment. The location of spawning grounds and overwintering areas should be described along with seasonal information about habitat usage including trophic interactions.

Remarks

Allozyme analyses have shown some population differences between fish living in the Bering Sea and the Gulf of Alaska [48].

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Longhead Dab (*Limanda proboscidea*)

Gilbert, 1896

Family Pleuronectidae

Longhead Dab (*Limanda proboscidea*), 170 mm, U.S. Chukchi Sea, 2007. Photograph by C.W. Mecklenburg, Point Stephens Research.

Colloquial Name: Iñupiaq—Nataagnaq [1].

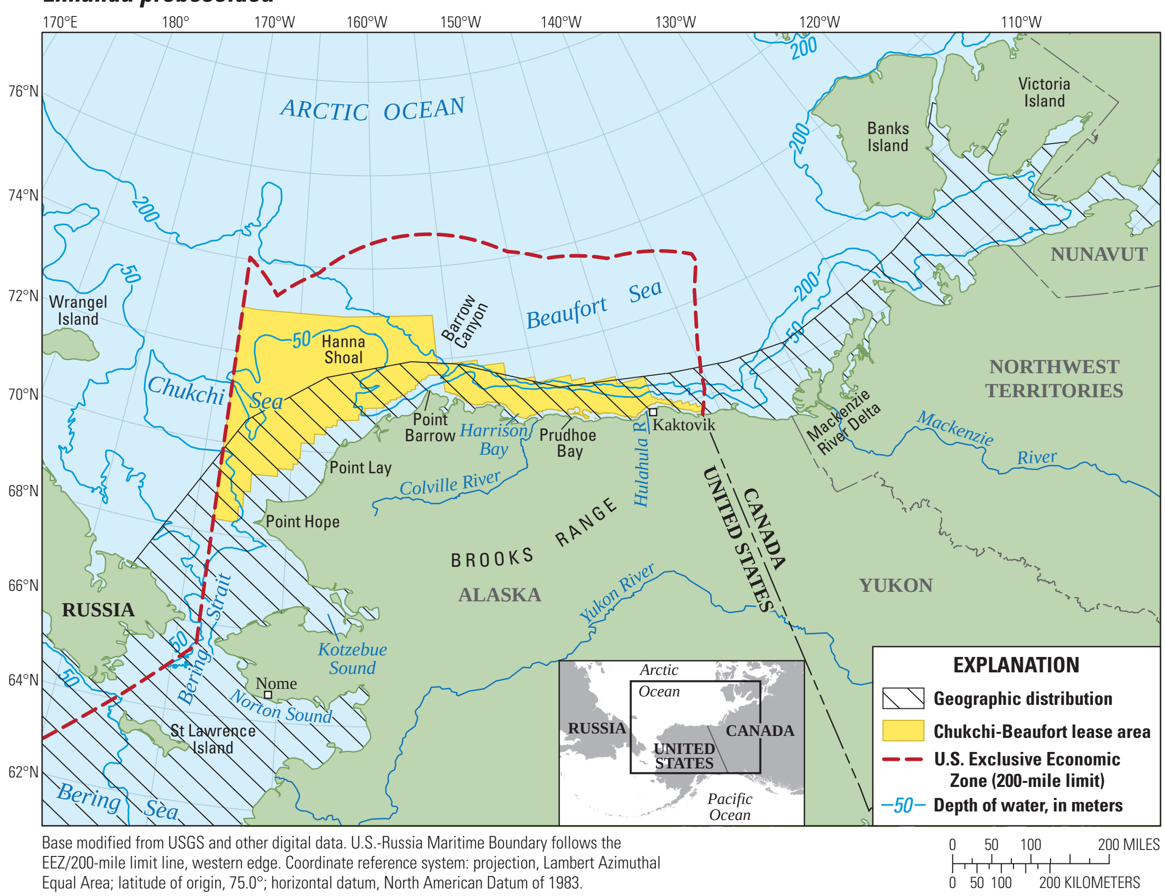
Ecological Role: Due to its relative scarcity in Arctic waters, the Longhead Dab is likely to be of little ecological importance in the U.S. Chukchi and Beaufort Seas.

Physical Description/Attributes: Member of the right eyed flounders. Grayish brown with small whitish spots on the eyed side and lemon yellow on blind side. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 843) [2]. Swim bladder: Absent [2]. Antifreeze glycoproteins in blood serum: Unknown.

Range: *U.S. Chukchi and Beaufort Seas* [3]. Eastward in Canadian Arctic to Bathurst Inlet and westward to western Chukchi Sea [3, 4]. Elsewhere in Alaska, eastern Bering Sea north of Unimak Island. Worldwide, off Hokkaido, Japan, through Sea of Okhotsk [2, 4].

Relative Abundance: *Uncommon in U.S. Chukchi Sea and rare in U.S. Beaufort Sea* [3, 7, 8]. Rare in Canadian Arctic [3]. Common from Sea of Japan and along eastern Kamchatka Peninsula, Russia, to eastern Bering Sea at least as far north as Bristol Bay [9–11]. Populations in southeastern Bering Sea appear to be expanding their distribution northward [12].

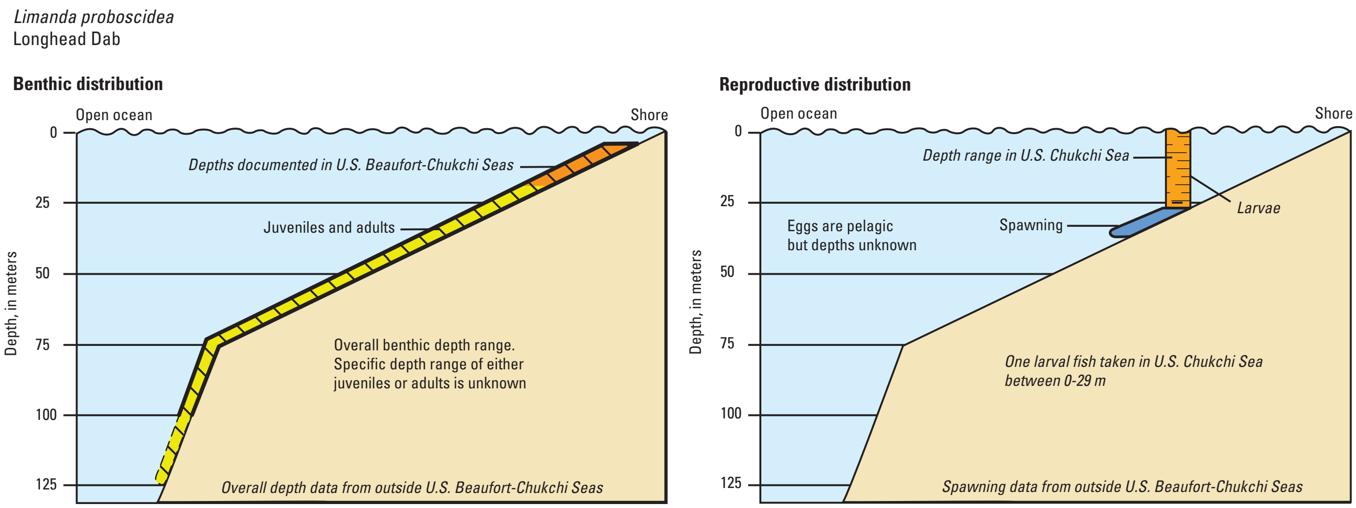
Longhead Dab
Limanda proboscidea



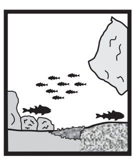
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

Geographic distribution of Longhead Dab (*Limanda proboscidea*), within Arctic Outer Continental Shelf Planning Areas [5] based on review of published literature and specimens from historical and recent collections [3, 6].

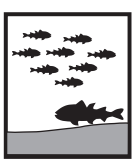
Depth Range: *Benthic individuals taken in U.S. Beaufort Sea at 5–8 m* [13] *and U.S. Chukchi Sea at 17 m* [7]. *Pelagic larvae taken in U.S. Chukchi Sea at 29 m or less* [14]. Generally, 5–125 m or perhaps to 160 m [6], almost always less than 100 m [2, 13, 15]. Spawn nearshore [16].



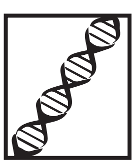
Benthic and reproductive distribution of Longhead Dab (*Limanda proboscidea*). Larval distribution reflects one record from the study area.



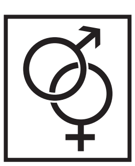
Habitats and Life History
Eggs—Size: 0.72–0.87 mm [17]. Time to hatching: Unknown. Habitat: Pelagic [18].
Larvae—Size at hatching: Less than 4.8 mm [17]. Size at juvenile transformation: Unknown. Days to juvenile transformation: Unknown. Habitat: Pelagic [18].
Juveniles—Age and size: Unknown. Habitat: Benthic, on soft sea floors [9].
Adults—Age and size at first maturity: Unknown. Maximum age: Unknown. Maximum size: 41 cm TL [2]. Habitat: Nearshore, benthic [9].
Substrate—Sand and mud [18].
Physical/chemical—Temperature: -1.8–11.7 °C [6, 19]. Salinity: Marine [9].



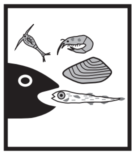
Behavior
Diel—Unknown.
Seasonal—In summer relatively common in nearshore waters of Bristol Bay and absent from those waters in winter [9].
Reproductive—Spawn nearshore [16].
Schooling—Often with starry flounder [9].
Feeding—Unknown.



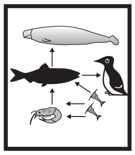
Populations or Stocks
There have been no studies.



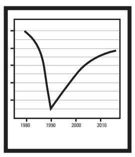
Reproduction
Mode—Separate sexes, oviparous. Fertilization is external [20].
Spawning season—Between May and September [9, 16, 21].
Fecundity—78,700–841,200 eggs per season [9].



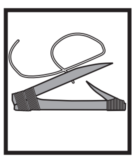
Food and Feeding
Food items—Polychaetes, crustaceans (for example, copepods, cumaceans, gammarid amphipods, and mysids) and clams [22, 23].
Trophic level—3.6 [12].



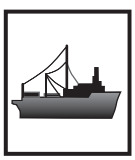
Biological Interactions
Predators—Pacific Cod, Pacific Halibut, Plain Sculpin, and skates [23–25].
Competitors—Other relatively small benthic feeders, such as eelpouts and sculpins.



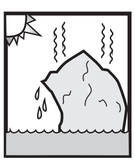
Resilience
Medium, minimum population doubling time 1.4–4.4 years (preliminary *K* or fecundity) [26].



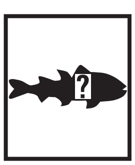
Traditional and Cultural Importance
Unknown, but of suspected limited use.



Commercial Fisheries
Currently, Longhead Dab are not commercially harvested [27].



Potential Effects of Climate Change
As Longhead Dab are common in part of the Bering Sea and those populations appear to be expanding their distribution northward [12], an increase in abundance in both the U.S. Chukchi and Beaufort Seas would be expected as the climate warms.



Areas for Future Research [B]
Changes in abundance patterns are an expected outcome of global warming. Reliable baseline information and regular monitoring are needed to evaluate northerly shifts in this population. The monitoring should include estimation of key vital statistics in the population (growth, survival, and recruitment), especially in the Chukchi Sea.

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Sakhalin Sole (*Limanda sakhalinensis*)

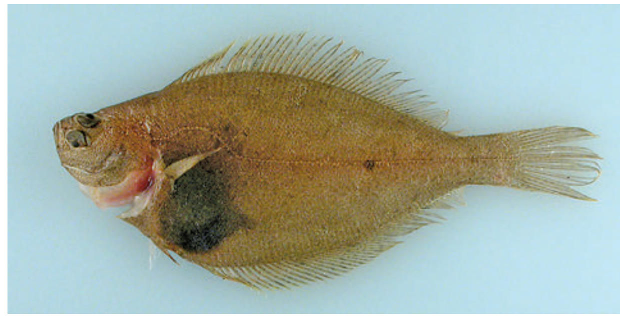
Hubbs, 1915

Family Pleuronectidae

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

Ecological Role: Likely of little ecological significance in Chukchi Sea marine food webs.

Physical Description/Attributes: Member of the right eyed flounders. Slightly elongate oval body. Eyed side uniformly brown or with vague dark blotches, blind side off-white. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 845) [1]. Swim bladder: Absent [1]. Antifreeze glycoproteins in blood serum: Unknown.



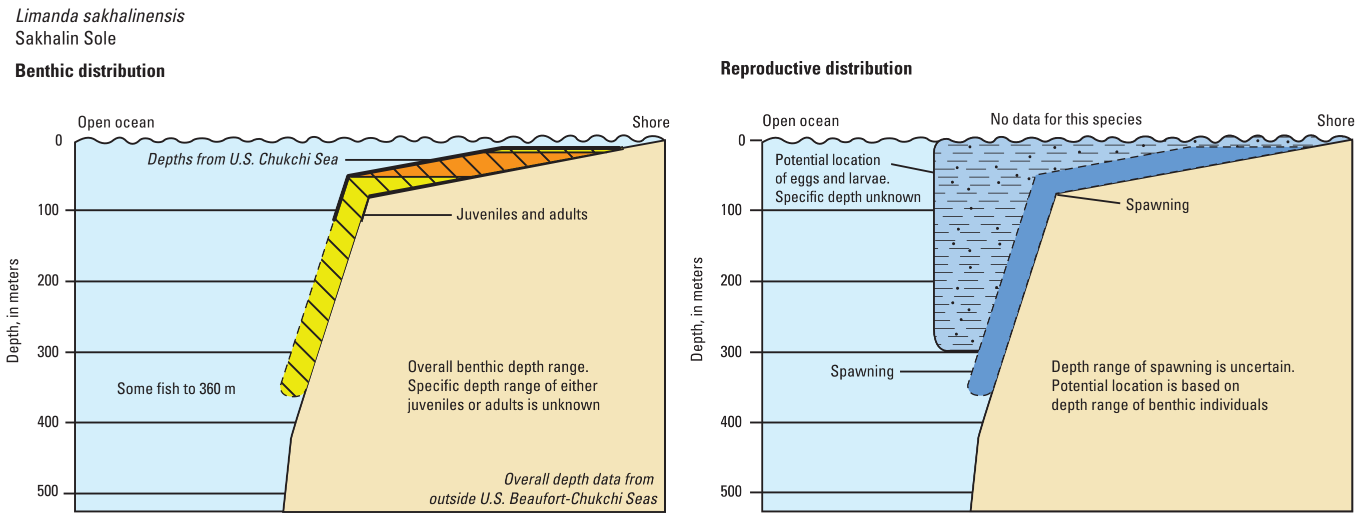
Sakhalin Sole (*Limanda sakhalinensis*), 123 mm, Chukchi Sea, 2009. Photograph by C.W. Mecklenburg, Point Stephens Research.

Range: *U.S. Chukchi Sea as far northward as 71°04'N, 158°26'W* [2]. Elsewhere in Alaska, to southeastern Bering Sea. Worldwide, from Sea of Okhotsk and northern Sea of Japan (Tatar Strait) to Gulf of Anadyr, Russia, and St. Lawrence Island, Alaska [1].

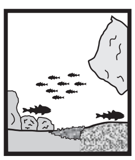
Relative Abundance: *Uncommon in U.S. Chukchi Sea* and northern Bering Sea [4].

Geographic distribution of Sakhalin Sole (*Limanda sakhalinensis*), within Alaskan Outer Continental Shelf Planning Areas [3], based on review of published literature and specimens from historical and recent collections [1, 2, 4].

Depth Range: Overall 10–360 m [5], mainly less than 110 m [6]. At depths of 20–51 m in the U.S. Chukchi Sea and northern Bering Sea [2], to 95 m in southeastern Bering Sea [1].

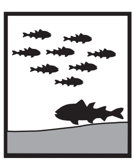


Benthic and reproductive distribution of Sakhalin Sole (*Limanda sakhalinensis*).



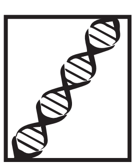
Habitats and Life History

Eggs—Size: Unknown. Time to hatching: Unknown. Habitat: Likely pelagic, as are most other righteye flounders [7].
Larvae—Size at hatching: Unknown. Size at juvenile transformation: Unknown. Days to juvenile transformation: Unknown. Habitat: Likely pelagic, as are most other righteye flounders [7].
Juveniles—Age and size: Unknown. Habitat: Benthic [1, 4].
Adults—Age and size at first maturity: Unknown. Maximum age: 8 years [8]. Maximum size: 35 cm TL [1]. Habitat: Benthic [1, 4].
Substrate—Soft bottoms [1].
Physical/chemical—Temperature: -1.7–9.3 °C [2]. Salinity: Marine.



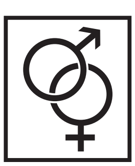
Behavior

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



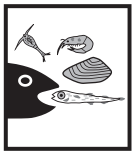
Populations or Stocks

There have been no studies.



Reproduction

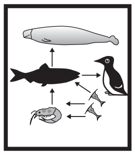
Mode—Oviparous [7].
Spawning season—Unknown.
Fecundity—Unknown.



Food and Feeding

Food items—Amphipods, polychaetes, and euphausiids [8].

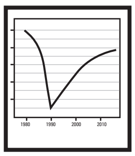
Trophic level—3.68 (standard error 0.55) [8].



Biological Interactions

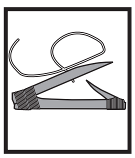
Predators—Pacific Cod and Great Sculpin [9, 10].

Competitors—Presumably a wide range of other zoobenthos feeders such as Arctic Cod, Walleye Pollock, other flounders, eelpouts, and sculpins.



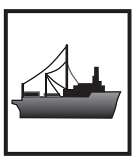
Resilience

Low, minimum population doubling time 4.5–14 years (preliminary *K* or fecundity) [8].



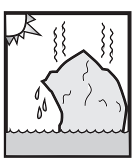
Traditional and Cultural Importance

None reported.



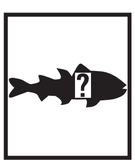
Commercial Fisheries

Sakhalin Sole are not commercially harvested currently.



Potential Effects of Climate Change

Warming conditions would likely lead to an increased expansion of this species' distribution in the U.S. Chukchi Sea and possibly into the Beaufort Sea.



Areas for Future Research [B]

Little is known about the ecology and life history 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 Flounder (*Liopsetta glacialis*)

(Pallas, 1776)

Family Pleuronectidae

Arctic Flounder (*Liopsetta glacialis*), from Love (2011, p. 588). Photograph attributed to National Oceanic and Atmospheric Administration Fisheries.

Colloquial Name: Iñupiaq—*Nataagnaq, Puyyaqiaq* [1].

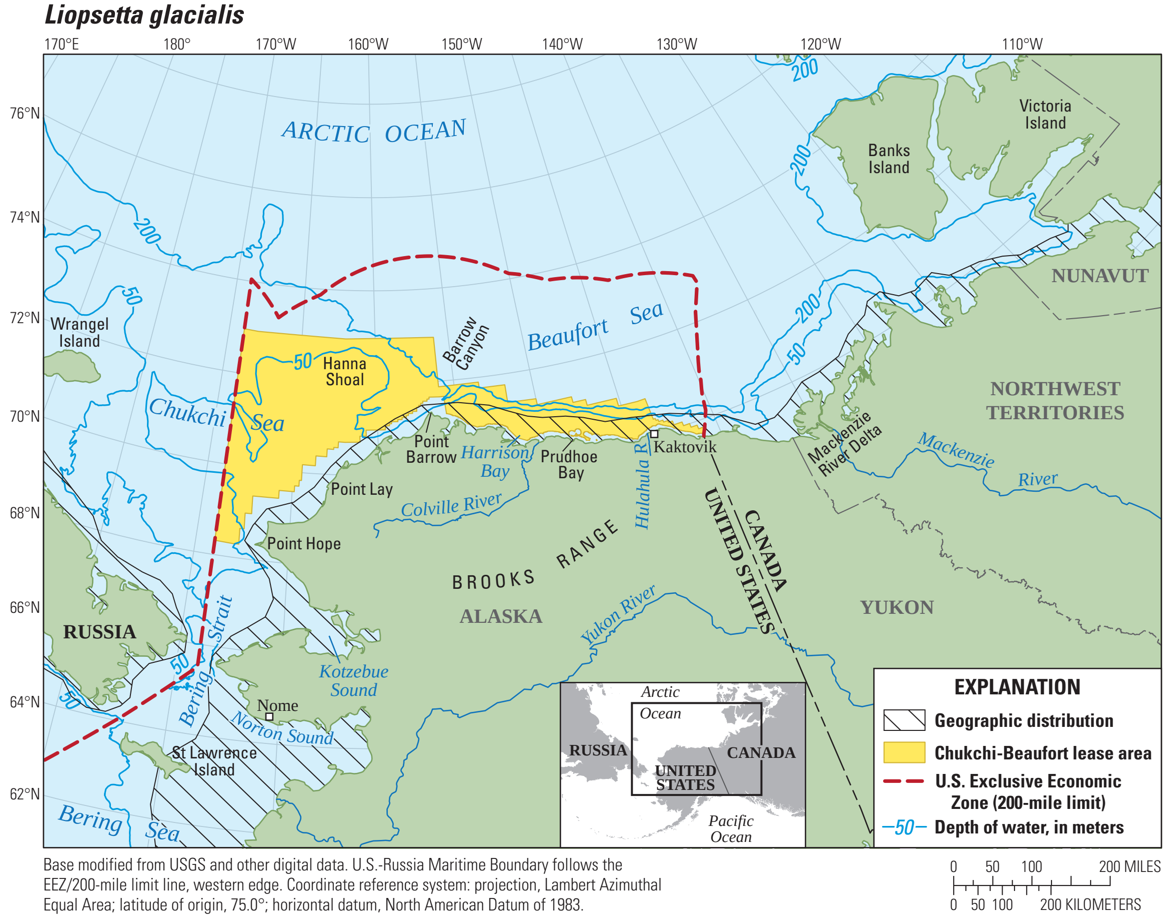
Ecological Role: Unknown. Despite being common in nearshore Arctic waters, little data are available on its role in the food chain.

Physical Description/Attributes: Member of the right eyed flounders. Eyed side is darkish brown or black. Blind side is chalky white to lime green. Fins are paler. Dorsal and anal fins usually spotted. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 836) [2]. Swim bladder: Absent [2] Antifreeze glycoproteins in blood serum: Unknown.

Range: *U.S. Chukchi and Beaufort Seas* [3]. Elsewhere in Alaska, to southeastern Bering Sea and Aleutian Islands. Worldwide, from Arctic Russia to Labrador, Canada, and in the Atlantic and Okhotsk Sea in western Pacific [2].

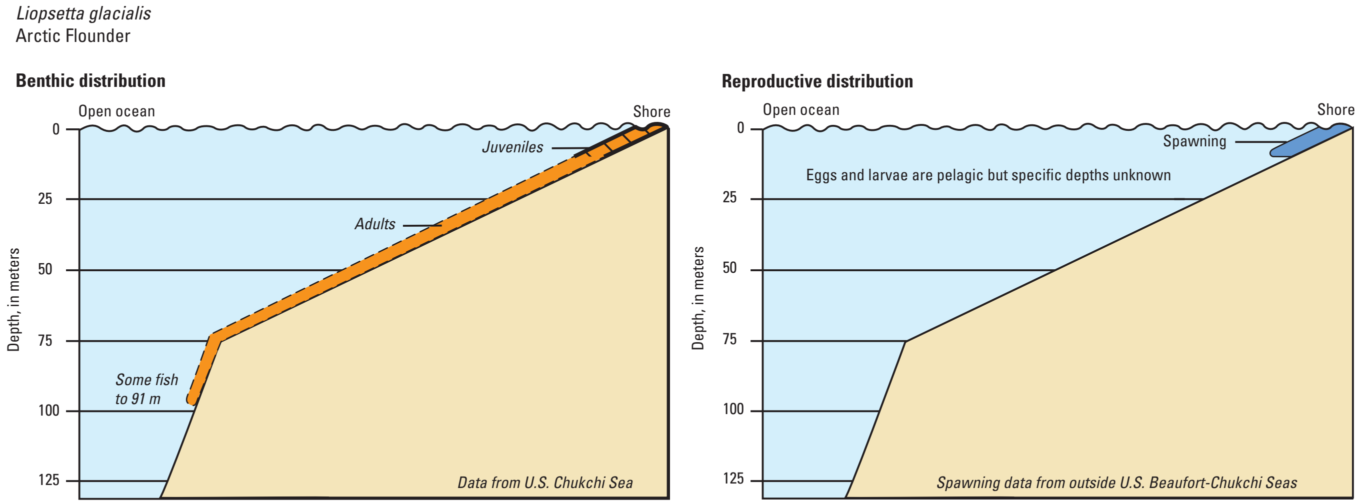
Relative Abundance: *Common near shore in U.S. Chukchi and Beaufort Seas* [6]. Common from at least Bristol Bay [7] to Canadian Arctic at least to Tuktoyaktuk Harbor [8, 9], but appears to be uncommon east of Cape Bathurst [10].

Arctic Flounder
Liopsetta glacialis

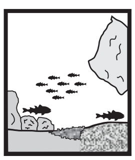


Geographic distribution of Arctic Flounder (*Liopsetta glacialis*), within Arctic Outer Continental Shelf Planning Areas [4] based on review of published literature and specimens from historical and recent collections [3, 5].

Depth Range: *Nearshore, barely subtidal to 91 m, rarely deeper than about 10 m in U.S. Chukchi Sea* [11]. Spawns between 5 and 10 m [12].



Benthic and reproductive distribution of Arctic Flounder (*Liopsetta glacialis*).



Habitats and Life History

Eggs—Size: 1.5–1.7 mm [13, 14]. Time to hatching: 22–42 days at a mean temperature of 1.0 °C (range–0.5 to 3.1 °C) [13]. Habitat: Pelagic [13, 14].

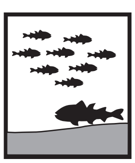
Larvae—Size at hatching: 5.6 mm [13]. Size at juvenile transformation: 14–*20 mm TL* [8, 10, 15]. Days to juvenile transformation: Unknown. Habitat: Pelagic [16].

Juveniles—Age and size: 1.4–*20.0 cm TL* [10, 11]. Habitat: *Benthic, soft sea floors in nearshore protected waters* [8, 10, 15]. The smallest fish tend to live in quiet sloughs and other backwaters [17].

Adults—Age and size at first maturity: *Generally, most fish mature at between 4 and 8 years and 13.0 and 20.0 cm TL* [9, 11, 18]. *Males tend to mature at a slightly younger age and smaller size than females* [18–20]. Females grow larger, live longer, and may grow faster than males, although growth rates vary widely with region. Maximum age: *At least 28 years* [21]). Maximum size: 44 cm (17.6 in) TL [20]. Habitat: *Benthic, nearshore* [7, 22, 23].

Substrate—Mud and fine sand [7].

Physical/chemical—Temperature: *Less than –1.0–13.5 °C* [7, 23]. Salinity: 0–*31 parts per thousand. Tolerant of estuarine conditions* [7, 16, 23]. Occasionally ascends into fresh water [22].



Behavior

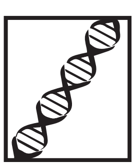
Diel—*Relatively sedentary, few move more than a few kilometers in a year* [21], *although one tagged fish in the ANWR moved 62 km before being recaptured* [24]. Moves closer to shore in evening and mainly on incoming tides (Morrow 1980).

Seasonal—Slight offshore movements in autumn; however, *extent of this migration is unknown in U.S. Beaufort and Chukchi Seas* [14, 23]. Over winters in the deeper parts of Tuktoyatuk Harbor, at depths of 12 m or more [25]. In spring, as temperatures warm, large numbers move into shallow, nearshore waters where they remain until fall [25].

Reproductive—Spawning occurs under ice in winter and spring in nearshore waters, although location of spawning aggregations is poorly understood [25, 26]. Mature fish may spawn only once every 2 years [11].

Schooling—At certain times, single-sex aggregations are formed [9].

Feeding—Unknown.



Populations or Stocks

Life history parameters have been described from the northeastern Chukchi Sea and the coastal Beaufort Sea. No information about population size or stock structure is available.

Reproduction
Mode—Separate sexes, oviparous. Fertilization is external [27].
Spawning season—At least March through June in Tuktoyaktuk, Canada, region [9, 28]. From December through March in White and Kara Seas [13, 14].
Fecundity—50,000–200,000 pelagic eggs [13, 14].

Food and Feeding
Food items—*Primarily epibenthic and benthic invertebrates, such as clams, isopods, amphipods, ascidians, and mysids* [11, 18, 29].
Trophic level—3.6 [27].

Biological Interactions
Predators—Unknown.
Competitors—Unknown, but presumably other benthic feeding predators, such as other flatfishes, as well as eelpouts and sculpins.

Resilience
Medium, minimum population doubling time 1.4–4.4 years (t_m=2; Fecundity =31,000–230,000).

Traditional and Cultural Importance
Arctic Flounder form a minor part of the subsistence fisheries of the U.S. Beaufort and Chukchi Seas. It has been listed as a food fish from Kotzebue Sound and northward [30]. *Another reported "flounder" caught in the nearshore waters at Point Hope and Point Lay is likely this species* [31]. In the Canadian Beaufort Sea, small numbers were reported in subsistence catches along the Yukon coast [32] and some were reportedly fed to dogs in the Canadian Arctic [10].

Commercial Fisheries
Currently, Arctic Flounder are not commercially harvested.

Potential Effects of Climate Change
Because Arctic Flounder are predominantly an Arctic species, it would be expected that climate warming would push this species northward.

Areas for Future Research [A]

Even though the species is relatively common, especially in coastal waters of the Alaska Beaufort Sea, compared to the amphidromous species, little is known about its biology and ecology in the U.S. Chukchi and Beaufort Seas. Its distribution and abundance, and the amount of existing information, make it a potential indicator of change associated with climate warming. The vulnerability of this species to climate changes in light of possible increases in abundance of other flatfish and associated interactions should be assessed. The Arctic Flounder is considered a potential indicator for monitoring effects of climate change.

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Starry Flounder (*Platichthys stellatus*)
(Pallas, 1787)

Family Pleuronectidae

Colloquial Name: Iñupiaq—*Nataagnaq* [1].

Ecological Role: Starry flounder are uncommon in U.S. Arctic waters. Their abundance is greatest in the southeastern Chukchi Sea where they are important predators of the coastal marine community.

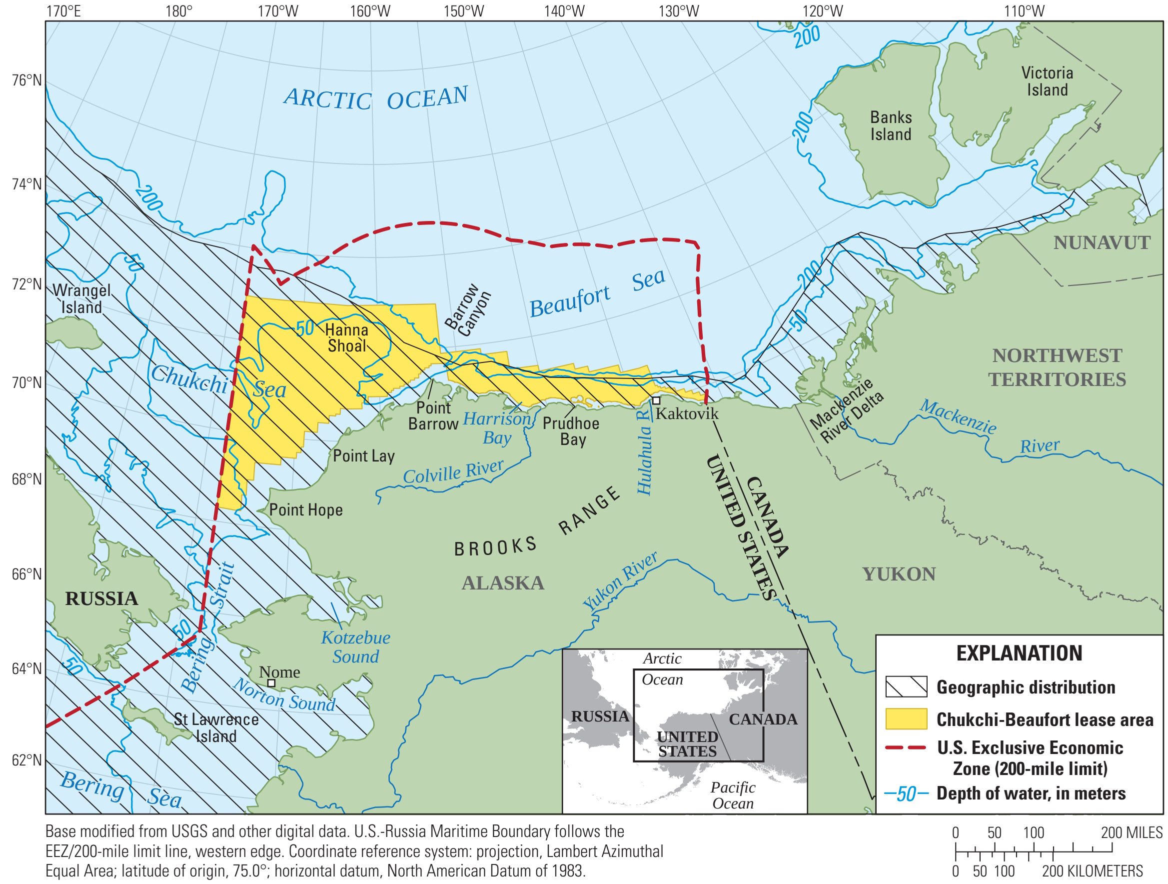
Physical Description/Attributes: Member of the right eyed flounders. Dark brown on eyed side and white on blind side. Median fins are white to orange with broad black bands. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 833) [2]. Swim bladder: Absent [2]. Antifreeze glycoproteins in blood serum: Unknown.

Starry Flounder (*Platichthys stellatus*), 290 mm TL, off northeastern Sakhalin, Sea of Okhotsk, 2003. Photograph by B.A. Sheiko, Russian Academy of Sciences.

Range: *U.S. Chukchi and Beaufort Seas* [2]. Elsewhere in Alaska, throughout Bering Sea, Aleutian Islands, Gulf of Alaska and all southeastern waters. Worldwide, in Arctic Ocean from the East Siberian Sea eastward to Bathurst Inlet and Viscount Melville Sound in the Canadian high Arctic [2, 3]. In Pacific Ocean, southward to Sea of Japan off Korean Peninsula and Sea of Okhotsk, and to Los Angeles Harbor, southern California [2].

Relative Abundance: *Uncommon in U.S. Chukchi and Beaufort Seas* [7, 8], becoming more abundant in Canadian Beaufort Sea at about the Tuktoyaktuk Peninsula and eastward to at least Coppermine, Amundsen Gulf [9, 10]. Common in Bering Sea [11] to Sea of Japan [12], Sea of Okhotsk [13], and southward to central California [14].

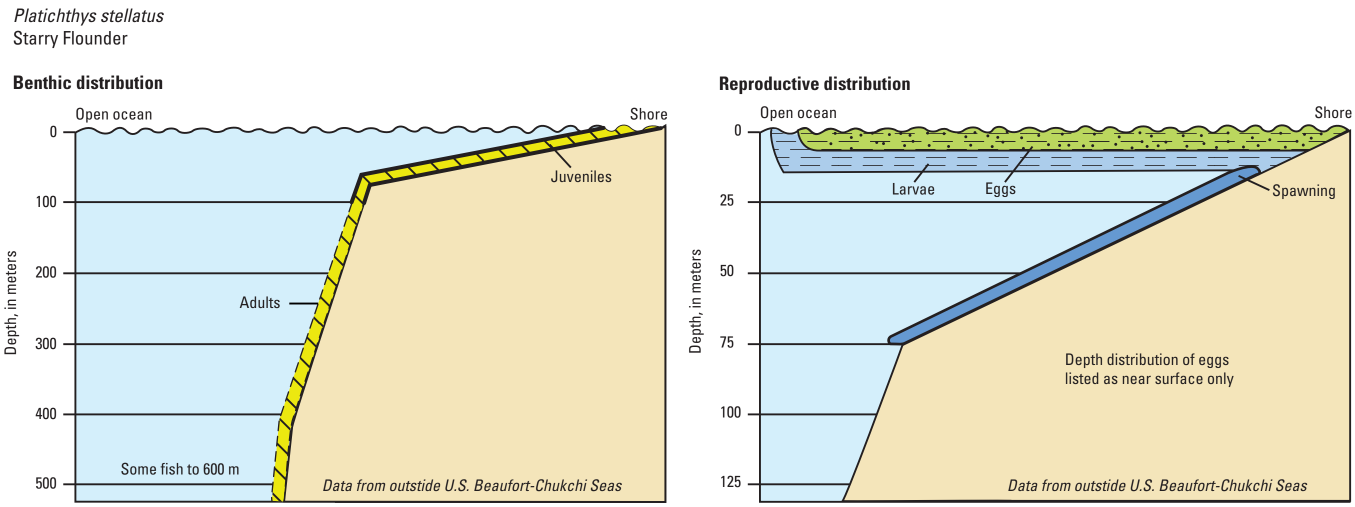
Starry Flounder
Platichthys stellatus



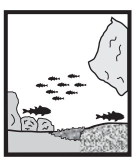
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

Geographic distribution of Starry Flounder (*Platichthys stellatus*), within Arctic Outer Continental Shelf Planning Areas [4] based on review of published literature and specimens from historical and recent collections [5, 6].

Depth Range: Intertidal to 600 m, mainly 100 m or less [15–17]. Larvae are found at least in upper 15 m of water column in Gulf of Alaska [18]. In Sea of Japan, juveniles are found less than 55 m [12]. Spawning has been reported at 11–75 m in Bering Sea [19].



Benthic and reproductive distribution of Starry Flounder (*Platichthys stellatus*).



Habitats and Life History

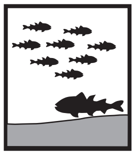
Eggs—Size: 0.9 to 1.3 mm [20]. Time to hatching: 68 hours at 12.5 °C and 110 hours at 10.5 °C [14]. Pale orange in color [21]. Habitat: Pelagic [14, 18]. —Size at hatching: 1.9–2.1 mm SL [20]. Size at juvenile transformation: 8.3–10.5 mm SL [22]. Days to juvenile transformation: About 39 days at 12–15 °C in one laboratory study [23]. Habitat: Epipelagic, along the coast to the outer shelf [14, 18, 24].

Juveniles—Age and size: Age unknown. 8.3–10.5 mm SL to 220 mm TL [22, 25]. Habitat: Benthic [26], in backwaters and estuaries, around drift algae, and eelgrass beds [12, 27]. Remain in shallow (often intertidal) fresh or brackish waters for several years [12, 28].

Adults—Age and size at first maturity: About 8 years and 220 mm TL in Canadian Beaufort Sea based on limited data [25]. Elsewhere, varies between 2–4 years and 220–300 mm off central California [14], 2–3 years off Washington [29], and about 5 years and 240 mm FL in Sea of Japan [12]. Males mature slightly younger than females [14, 29]. Generally, females grow larger than males, live longer, and weigh more at length. Both sexes grow faster in warmer temperatures [12, 30]. Maximum age: At least 42 years old in Canadian Beaufort Sea [25]. Life spans of fish in warmer waters appear to be much shorter than fish in the Arctic [12, 14]. Maximum size: 91 cm TL [2]. Habitat: Benthic [26], on soft bottoms and eelgrass beds [12, 27].

Substrate—Soft bottoms [12, 27].

Physical/chemical—Temperature: -1.8–11.7 °C. Fairly resistant to cold [31]. Spawning occurs at 1.5–6.8 °C just after ice break-up in Canadian Beaufort Sea, [30]. Salinity: Mostly marine and estuarine. However, juveniles enter fresh water and have been found as much as 121 km upstream in the Columbia River and 32 km upstream in the Fraser River [28, 32, 33]. Juveniles (often intertidal) remain in fresh or brackish waters for several years [12, 28] and migrate into more saline waters as they mature. Generally, larger adult fish enter estuaries only on occasion, for instance at high tide to feed [12, 34, 35]. However, during summer along the Tuktoyaktuk Peninsula (Canadian Beaufort Sea), many large fish remained in salinities of 3.7–8.0 parts per thousand [30].



Behavior

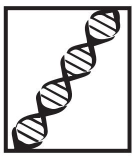
Diel—*Not well understood.* At night in summer, adults move into shallow, nearshore waters in Sea of Japan [12] and have been found midwaters or near the surface in Puget Sound [27, 36]. Adults exhibit tidally oriented, inshore movements [12]. An adult buries itself to avoid predators and can change color to match bottom substrate [14].

Seasonal—*Little is known.* In Canadian Beaufort Sea, moves inshore in early summer prior to spawning. Some move offshore in autumn [25, 30] and others over winter in nearshore waters [25, 37]. *Location of offshore wintering is unknown.* In Sea of Japan, juveniles winter in coastal estuaries less than 55 m and larger fish winter at 45–200 m [12].

Reproductive—In Canadian Beaufort Sea, spawning occurs in inshore waters just after ice break-up [30]. In California, spawning fish seek shallow water near river mouths and sloughs [14].

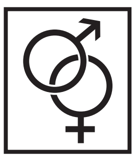
Schooling—Unknown.

Feeding—Adults enter estuaries at high tides only to feed [34]. Seems to feed mainly during daylight hours [38].



Populations or Stocks

There have been no studies.



Reproduction

Mode—Separate sexes, oviparous [39]. Fertilization is external [14]. Females are batch spawners [40, 41].

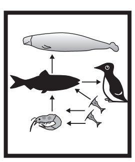
Spawning season—June and July in Canadian Beaufort Sea [25, 42]. Between November and February off central California and occurs progressively later to the north [14, 25, 42].

Fecundity—Between 914,000 and 2,287,000 eggs [40, 41].

Food and Feeding

Food items—In Canadian Beaufort Sea, benthic and epibenthic prey. Clams, crustaceans (for example, mysids and isopods), and polychaetes are often most important, and fishes, plants, insects, and priapulids also are consumed [25, 30, 43]. *Diets are similar in southeastern Chukchi Sea and northeastern Bering Sea, but also include brittle stars, cockles, mussels, snails, shrimps, and hermit crabs* [44].

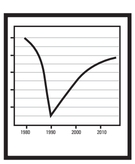
Trophic level—3.8 [45].



Biological Interactions

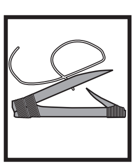
Predators—*Ringed seals in U.S. Chukchi Sea* [46] and beluga whales in Cook Inlet [47]. Elsewhere fishes such as Spotted Spiny Dogfish and White Sturgeon, as well as great blue herons, bald eagles, harbor seals and Stellar sea lions [48–52].

Competitors—Likely such bottom feeding taxa as sculpins and other flatfishes.



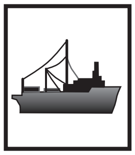
Resilience

Medium, minimum population doubling time 1.4–4.4 years (t_m=2–3; t_{max}=24) [53].

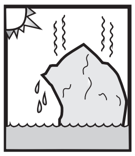


Traditional and Cultural Importance

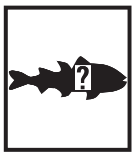
Starry Flounder were of minor significance to Iñuits living near the U.S. Chukchi Sea, perhaps due to their relative scarcity [54]. Some fish are taken in artisanal fisheries in the Canadian Beaufort Sea and Amundsen Gulf, where they are eaten by humans and fed to dogs [3, 37, 55]. Small numbers are commercially harvested throughout much of their range and they are frequently taken in the recreational catch.



Commercial Fisheries
Currently, Starry Flounder are not commercially harvested.



Potential Effects of Climate Change
Changes in coastal hydrography resulting in increased freshening of coastal waters may expand the habitat and range of Starry Flounder in the U.S. Chukchi and Beaufort Seas. Increased abundance will result in increased interactions and competition with other marine fishes with unknown ecological effect. Community effects would probably be greatest in the nearshore.



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.

Remarks

Along the Pacific Coast, Starry Flounder hybridize with English Sole (*Parophrys vetulus*) *and in the western Pacific Ocean, with the Stone Flounder* (*Kareius bicoloratus*) [56].

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Alaska Plaice (*Pleuronectes quadrituberculatus*)
Pallas, 1814

Family Pleuronectidae

Alaska Plaice (*Pleuronectes quadrituberculatus*), 60 cm TL, off northeastern Sakhalin, Okhotsk Sea, 2003. Photograph by B.A. Sheiko, Russian Academy of Sciences.

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

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

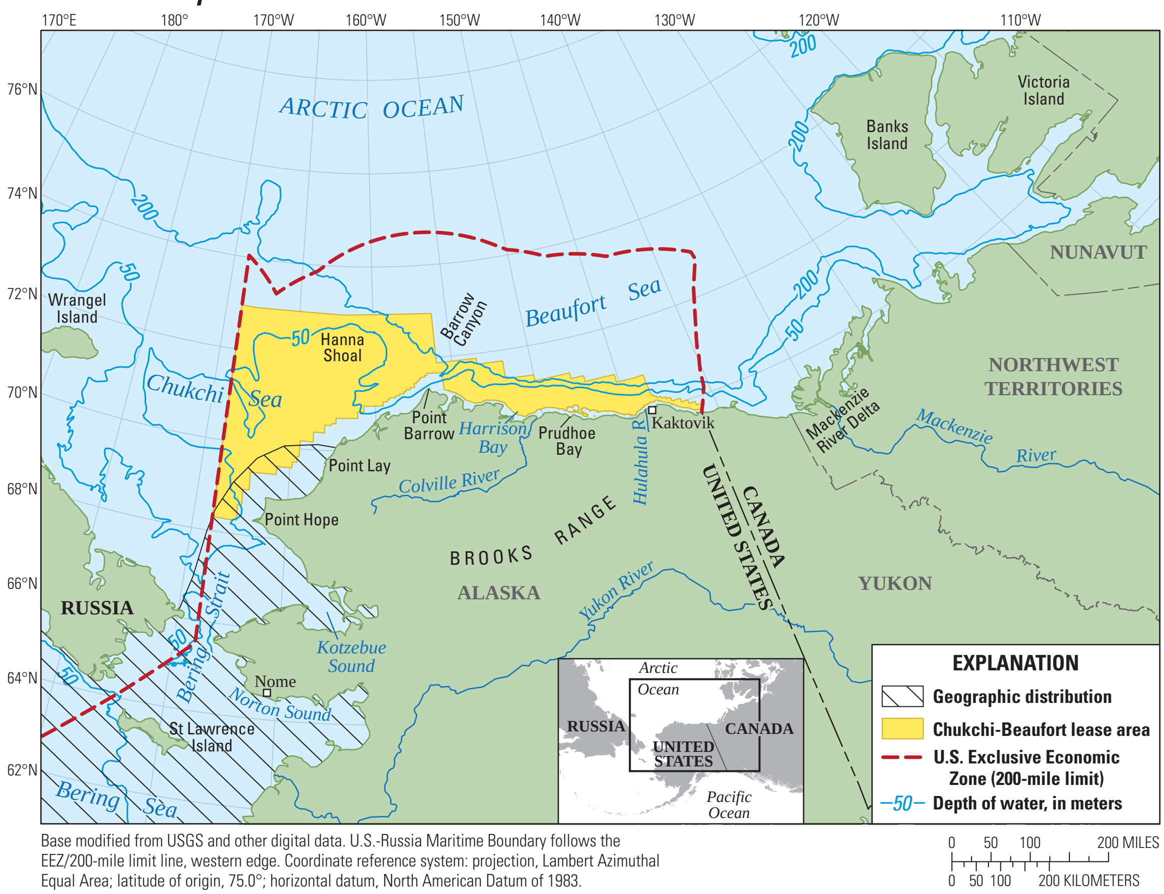
Ecological Role: Largely unknown. This species is absent from the U.S. Beaufort Sea and is present only occasionally in the U.S. Chukchi Sea. It is unlikely to represent a significant prey resource to higher level organisms.

Physical Description/Attributes: Member of the right eyed flounders. Eyed side is greenish gray to almost black and blind side is yellow. Young adults are spotted and blotched. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 835) [1]. Swim bladder: Absent [1]. Antifreeze glycoproteins in blood serum: Present [2].

Range: *U.S. Chukchi Sea, as far northward as 70°16'N, 163°58'W* [3]. Elsewhere in Alaska, from Bering Sea to eastern Aleutian Islands and Gulf of Alaska to southeastern Alaska near Ketchikan [1]. Worldwide, to Sea of Japan; one record from Bellingham Bay, Washington [1].

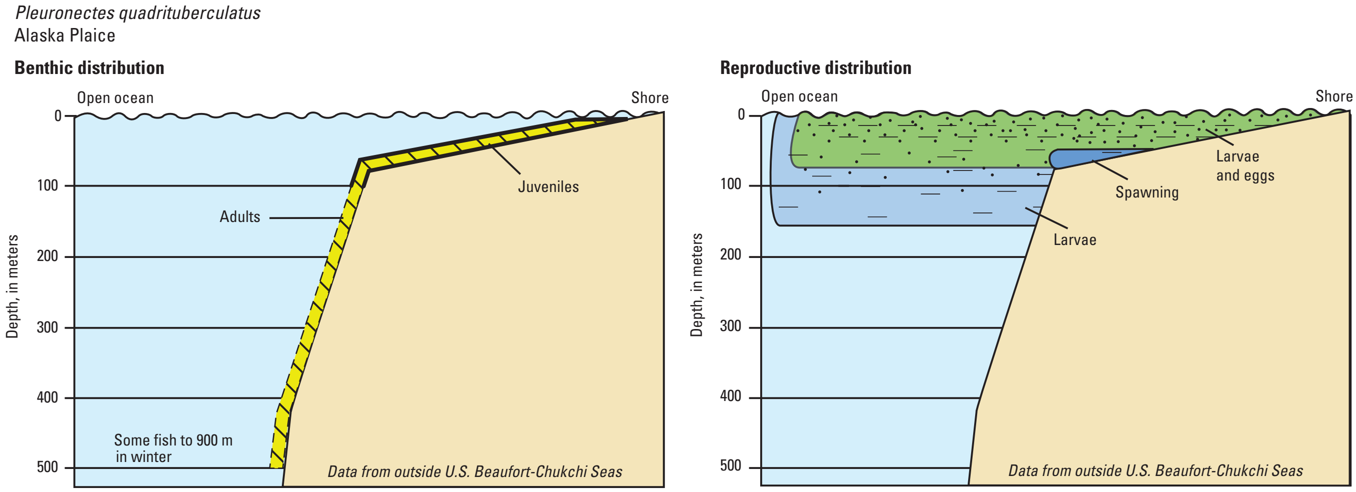
Relative Abundance: *Occasional in U.S. Chukchi Sea* [3, 6, 7]. Common from eastern Bering Sea to central Gulf of Alaska [8] and from Sea of Japan [9] to Kamchatka Peninsula [10].

Alaska Plaice
Pleuronectes quadrituberculatus

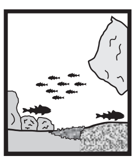


Geographic distribution of Alaska Plaice (*Pleuronectes quadrituberculatus*) within Alaska Outer Continental Shelf Planning Areas [4] based on review of published literature and specimens from historical and recent collections [1, 3, 5].

Depth Range: Between 5 and 500 m, mainly 100 m or less in northeast Pacific Ocean and Bering Sea [8, 11]. In winter, occurs much deeper (400–900 m) around Sakhalin Island, Sea of Okhotsk [12, 13]. Eggs occur from 0–60 m, mainly 30 m or less [14]. Larvae are found between 0–149 m [15], mainly 20 m or less [14]. Juveniles are found inshore, mostly 50 m or less [8]. Most spawning occurs at 50–100 m [16].

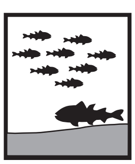


Benthic and reproductive distribution of Alaska Plaice (*Pleuronectes quadrituberculatus*).



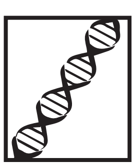
Habitats and Life History

Eggs—Size: 1.6–2.2 mm [17–19]. Time to hatching: 16 days to two months [20]. Habitat: Epipelagic [16].
Larvae—Size at hatching: 5.6–5.8 mm SL [17–19]. Size at juvenile transformation: 13–17 mm SL [16]. Days to juvenile transformation: Unknown. Habitat: Pelagic [16].
Juveniles—Age and size: 1.6–17 mm SL. Habitat: Benthic, inshore waters [8, 16].
Adults—Age and size at first maturity: In eastern Bering Sea, few females mature at 27 cm TL (about 7 years), 50 percent at 31 cm (8 years), and 100 percent at 39 cm (11 years) [16]. Off western Kamchatka Peninsula, Russia, most males mature at 26–30 cm (6–7 years) and females at 32–36 cm (8–9 years old) [21]. Females grow larger and faster than males [16]. Larger females are heavier at length than males [16]. Maximum age: At least 37 years [22]. Maximum size: 62 cm TL [1]. Habitat: Benthic, mostly on continental shelf [8, 16].
Substrate—Sand and mud [8].
Physical/chemical—Temperature: Between -1.7 and 12 °C [5, 23]. Salinity: Marine [8].



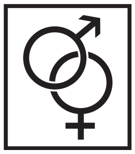
Behavior

Diel—Unknown.
Seasonal—During summer in eastern Bering Sea, females tend to be in deeper (60 m) water than males (45–55 m) [16].
Reproductive—Prior to spawning in spring, mature plaice migrate into somewhat shallower waters. Do not aggregate for spawning, but spawn over a wide area of the middle shelf [16].
Schooling—Unknown.
Feeding—Probably do not feed at night or in winter [16, 24].

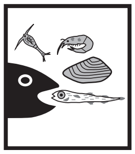


Populations or Stocks

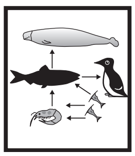
There have been no studies.



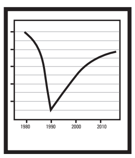
Reproduction
Mode—Separate sexes, oviparous. Fertilization is external [16].
Spawning season—In eastern Bering Sea spawning occurs from March to July and peak spawning season varies with year and area [16, 24].
Fecundity—Between 56,000 and 521,000 eggs per season and are probably batch spawners [25, 26].



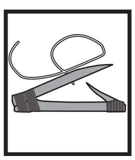
Food and Feeding
Food items—Benthic and epibenthic organisms are most important in eastern Bering Sea. In particular, polychaetes, clams, and such crustaceans as gammarid amphipods dominate the diets. Other preys include echiurioids, brittle stars, shrimps, snails, sea urchins, and sand dollars [27, 28].
Trophic level—3.5 [29].



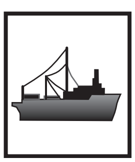
Biological Interactions
Predators—Alaska Plaice, Flathead Sole, Great and Plain sculpins, and Walleye Pollock [27, 28, 30, 31].
Competitors—Flatfishes such as Yellowfin and Rock soles, as well as various sculpins, poachers, and other bottom feeders have been reported south of the Bering Strait [16].



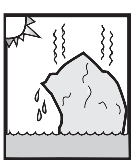
Resilience
Low, minimum population doubling time 4.5–14 years (*K*=0.1) [32].



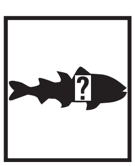
Traditional and Cultural Importance
Historically, Alaska Plaice were sought in various subsistence fisheries [12, 33]. Currently, they are taken primarily as bycatch in other fisheries [8].



Commercial Fisheries
Currently, Alaska Plaice are not commercially harvested.



Potential Effects of Climate Change
Because Alaska Plaice are common in the Bering Sea and only occasionally in the U.S. Chukchi Sea, populations would be expected to increase as the climate warms.



Areas for Future Research [B]
Alaska Plaice are common in the Bering Sea. Distributional shifts in the population into the Chukchi Sea are possible. Reliable baseline information about distribution and abundance and their use of habitats is needed to evaluate possible climate effects on demersal fish assemblages.

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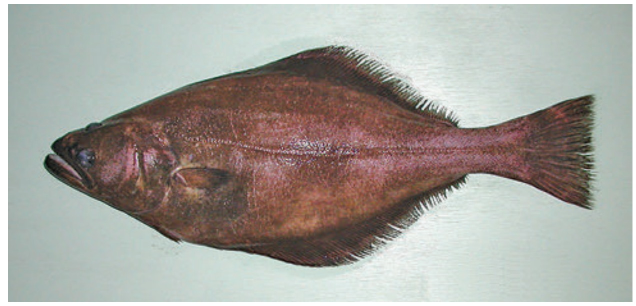
Greenland Halibut (*Reinhardtius hippoglossoides*)
(Walbaum, 1792)

Family Pleuronectidae



Greenland Halibut (*Reinhardtius hippoglossoides*), 437 mm, Chukchi Borderland, 2009. Photograph by C.W. Mecklenburg, Point Stephens Research.

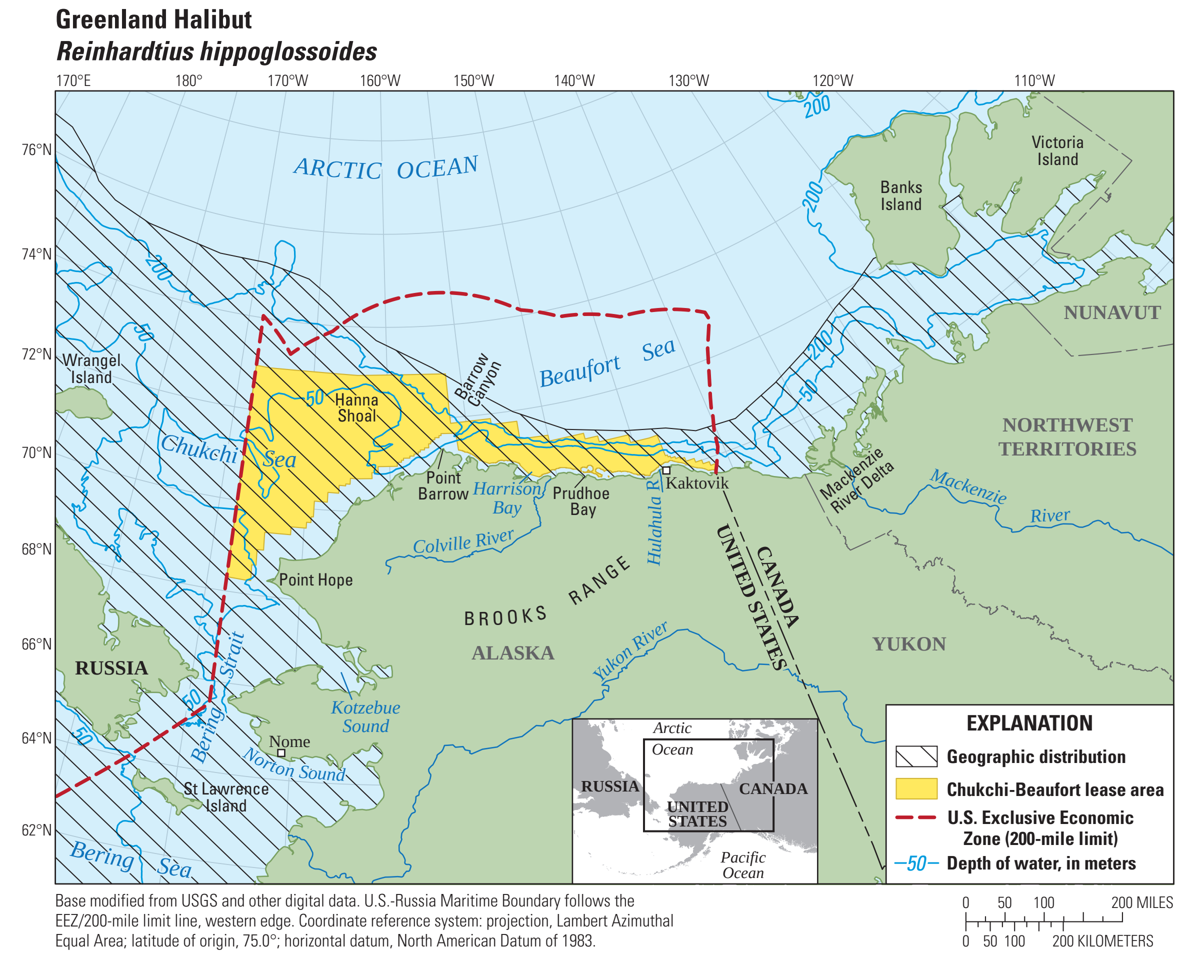
Colloquial Name: *None in U.S. Chukchi and Beaufort Seas.*

Ecological Role: Poorly understood, but likely of limited importance. Potentially, a relatively dominant species in offshore Beaufort Sea.

Physical Description/Attributes: Member of the right eyed flounders. Both eyed and blind sides are pigmented. Eyed side varies among black, brown, purplish brown, grey, or blue, and blind side is similarly colored, although lighter [1–3]. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 830) [3]. Swim bladder: Absent [3]. Antifreeze glycoproteins in blood serum: Unknown.

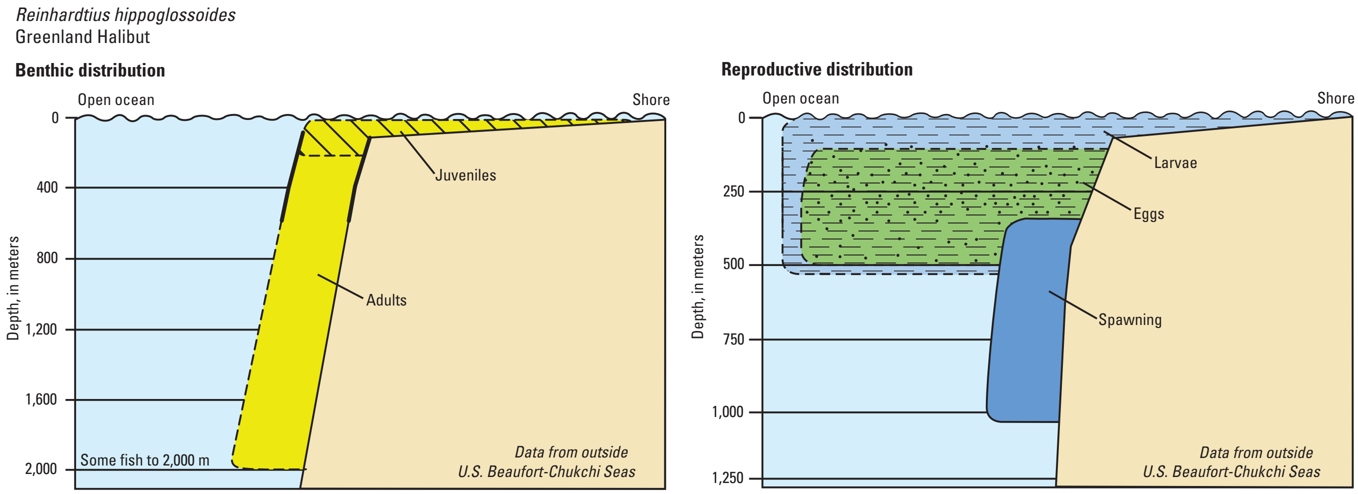
Range: *U.S. Chukchi and Beaufort Seas*. Elsewhere in Alaska, throughout Bering Sea, Aleutian Islands, Gulf of Alaska, and all southeastern waters [3]. Worldwide, on continental slope north of Alaska, in North Pacific from Seas of Japan and Okhotsk to just south of U.S.–Mexico border; in North Atlantic, from Ungava Bay, Canada, to northwest Greenland and south to Gulf of Maine; northeast Greenland, Iceland, northern Norway, White Sea, and Kara Sea [4].

Relative Abundance: *Uncommon in U.S. Chukchi and Beaufort Seas* [4, 7]. Elsewhere in Alaska, common along Aleutian Islands to Bering Sea [8, 9]. Worldwide, common in Seas of Japan and Okhotsk [10], and along northern Kuril Islands and southeastern Kamchatka Peninsula, Russia [11, 12] but rare south of Alaska [13]. There has been a general northward movement of populations in southeastern Bering Sea [14].

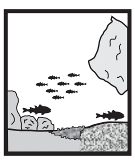


Geographic distribution of Greenland Halibut (*Reinhardtius hippoglossoides*), within Arctic Outer Continental Shelf Planning Areas [5] based on review of published literature and specimens from historical and recent collections [4, 6].

Depth Range: Overall, 14–2,000 m, usually at 50–650 m [3, 4]. Young juveniles live mainly on continental shelf (less than 200 m) [15, 16]. Spawning typically occurs along continental slope between 400 and 1,100 m [17]. In Atlantic Ocean, eggs are mesopelagic (600–1,000 m) [17]. In Bering Sea, eggs are at 50–400 m, mostly at 200–300 m [18]. Early larvae are found throughout water column to 530 m, mostly down to 450 m [17]. Older larvae in 0–530 m depths, mostly at less than 45 m [18].



Benthic and reproductive distribution of Greenland Halibut (*Reinhardtius hippoglossoides*).



Habitats and Life History

Eggs—Size: 3.7–4.1 mm [15, 19]. Time to hatching: 53 days at 4 °C in Atlantic Ocean [17]. Habitat: Bathypelagic, in eastern Bering Sea [15, 19].

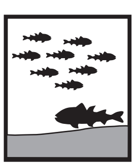
Larvae—Size at hatching: 10–16 mm SL [15, 20]. Size at juvenile transformation: As small as 34 mm FL in western Bering [16] and about 8.0 cm TL in Hudson Bay [21]. Days to juvenile transformation: 8–9 months in eastern Bering Sea and Gulf of Alaska [22]. Habitat: Bathypelagic to pelagic [15, 20], from oceanic to coastal waters [23]. Larvae 2.7 cm and larger vertically migrate [19].

Juveniles—Age and size: As small as 60 mm FL in eastern Bering Sea and Gulf of Alaska [17]. Habitat: Benthopelagic, mainly on continental shelf and migrate onto slope at around 4–5 years of age [15, 16].

Adults—Age and size at first maturity: Poorly known in eastern Bering Sea, but 50 percent maturity of females is likely at 65–70 cm FL [24] and about 10–11 years old [25]. Worldwide, estimates of size of females at 50 percent maturity range from 48–80 cm FL. Females grow larger than males, are larger at age, and weigh more at length [25–28]. Maximum age: Ageing techniques for Greenland Halibut are inadequate and growth rates are likely to be much slower than previously estimated [29]. Live to at least 36 years, given limitations of current ageing techniques, [28]. Maximum size: 130 cm TL [3] and 44 kg [30]. Habitat: Benthopelagic [4].

Substrate—Sand and mud.

Physical/chemical—Temperature: -1.7 to about 10 °C, primarily 0–5 °C [15, 31–33]. Juveniles seem to tolerate colder waters than adults [31]. Salinity: Marine [15, 31–33].



Behavior

Diel—Often found midwaters, unusual behavior for flatfishes. Off Greenland and Norway, nocturnal excursions are made hundreds of meters off bottom and fish remain in water column during night [2, 34]. Similar behavior may occur in Bering Sea [25].

Seasonal—Adults appear to make limited, seasonal bathymetric movements, entering somewhat shallower waters in spring and summer [31, 35]. During at least some parts of year, females may tend to be in deeper waters than males [11, 36]. In eastern Bering Sea, larvae drift from spawning grounds in southern slope area northward to northern shelf area, followed by a gradual shifting of immature and maturing fish to deeper and more southern waters [15]. Some individuals make extensive horizontal movements of as much as 687 km [25].

Reproductive—Thought to spawn synchronously [37].

Schooling—Appears to have no tendency to schooling [38].

Feeding—At least some feed well up in water column [39].

Populations or Stocks
There have been no studies.

Reproduction
Mode—Separate sexes, oviparous. Fertilization is external [37]. Perhaps a batch spawner [40]. In Atlantic Ocean, egg maturation may take longer than 1 year or else some mature females may not reproduce in a given year [37].
Spawning season—At least August to March (peaking November through February) in Bering Sea, [16, 31].
Fecundity—At least 23,900–149,000 eggs [41].

Food and Feeding
Food items—*No studies have been conducted in U.S. Chukchi and Beaufort Seas.* In Gulf of Alaska and along Aleutian Islands, a wide range of fishes (often Walleye Pollock) are dominant, although squids, octopi, euphausiids, and polychaetes also are consumed [42–44]. Smaller individuals feed on both fishes and invertebrates, whereas larger individuals primarily target fishes
Trophic level—4.6 [14].

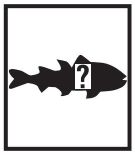
Biological Interactions
Predators—*No studies have been conducted*. Elsewhere, thick-billed murre, ringed seal, and narwhal in Canadian Arctic [45–47]. Flathead Sole, Greenland Halibut, Walleye Pollock, Yellowfin Sole, northern fur seal, and ribbon seal in eastern Bering Sea [48–51].
Competitors—*Unknown in U.S. Chukchi and Beaufort Seas.* As it is both a benthic and midwater predator, this species likely competes with cods, including Walleye Pollock, and flatfishes.

Resilience
Low, minimum population doubling time 4.5–14 years (K=0.07–0.10; t_{min}=7–12; t_{max}=30; Fecundity=6,800) [52].

Traditional and Cultural Importance
None reported.

Commercial Fisheries
Currently, Greenland Halibut are not commercially harvested. In U.S. waters outside of the Chukchi and Beaufort Seas, Greenland Halibut are taken with bottom trawls and longlines in a directed fishery and as bycatch in fisheries for sablefish and Pacific cod [22].

Potential Effects of Climate Change
Because Greenland Halibut are common in the Bering Sea but uncommon farther north and their population appears to be shifting northward in the southeastern Bering Sea, abundance and limits of distribution would be expected to increase in the U.S. Chukchi and Beaufort Seas as climate warms.



Areas for Future Research [A]

The species may be more common in the Beaufort Sea than previously thought. From a zoogeographic standpoint, improved information about the geographic distribution and origins of the species is of interest. It is hypothesized that the species may be of North Atlantic origins and this could be resolved with genetic research to determine biogeographic and phylogenetic relationships. All aspects of the species biology and ecology require further attention, but information about important habitats and seasonal movements and migrations is most important.

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Summary

The species accounts are a major biodiversity milestone confirming the presence of 109 marine fishes in 24 families in the U.S. Chukchi and Beaufort Seas. One hundred four (104) species accounts are presented. Full species accounts for the Alaska Skate, Pacific Sleeper Shark, Thorny Sculpin, Checkered Wolf Eel, and Pale Eelpout were not prepared due to their very recent confirmation and general lack of information from the region. Each account describes what is presently known about the biology and ecology of each species from observations from Alaska, adjacent seas, and other locations. A species account summarizes current information about geographic distribution, abundance, life history and habitats, community relationships and population ecology, and ecological roles. The listing of Iñupiaq names for some species, but not others, provides an important measure of traditional values of these fish. Each species account represents an autonomous review of relevant data and information; each is scientifically documented with key literature sources so that users will have easy access to additional detail from the studies reviewed. Collectively, this treatment is the most comprehensive inventory of species information undertaken for this segment of Alaska's marine fish fauna to date. The species accounts present thorough information, some of which reflects quantitative depictions of complex ecological concepts and population understanding. Information about life cycle requirements, trophic position, and population resilience are essential to National Environmental Policy Act assessments of potential effects from offshore energy development at population and ecosystem levels of biological organization.

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