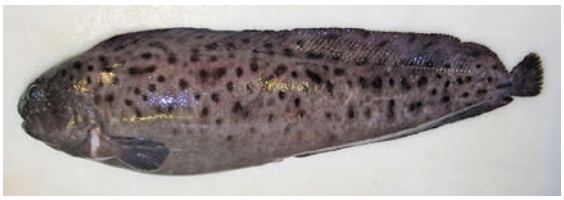
Northern Wolffish to Greenland Halibut

Northern Wolffish (*Anarhichas denticulatus*)

Krøyer, 1845



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

Family Anarhichadidae

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

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

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

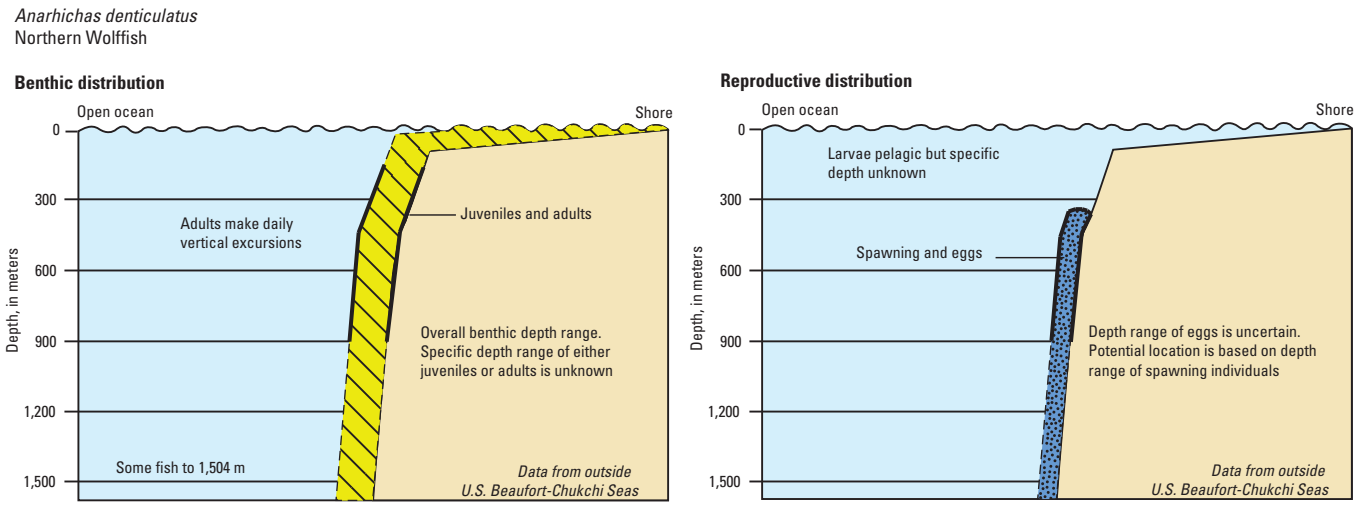
Physical Description/Attributes: Moderately thick, elongate gray to dark brown body, with bright violet shades or with brown tones. Body and dorsal fins covered with dark spots. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 784) [1]. Swim bladder: Absent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

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

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

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

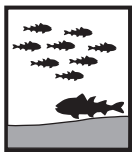
Depth Range: Surface to 1,504 m and possibly to 1,700 m [5]; mainly 150–900 m [7]. Spawns below 400 m [8].



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

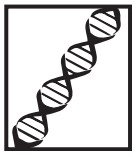
Habitats and Life History

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



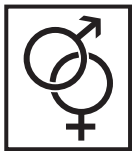
Behavior

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



Populations or Stocks

There have been no studies.

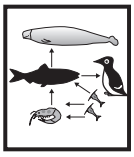


Reproduction

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

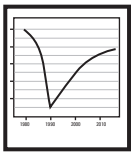
Food and Feeding

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



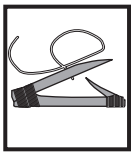
Biological Interactions

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



Resilience

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

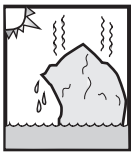


Traditional and Cultural Importance

None reported.

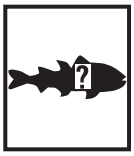
Commercial Fisheries

Currently, Northern Wolffish are not commercially harvested.



Potential Effects of Climate Change

Unknown.



Areas for Future Research [B]

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

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

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Bering Wolffish (*Anarhichas orientalis*)

Pallas, 1814

Family Anarhichadidae

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

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

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

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

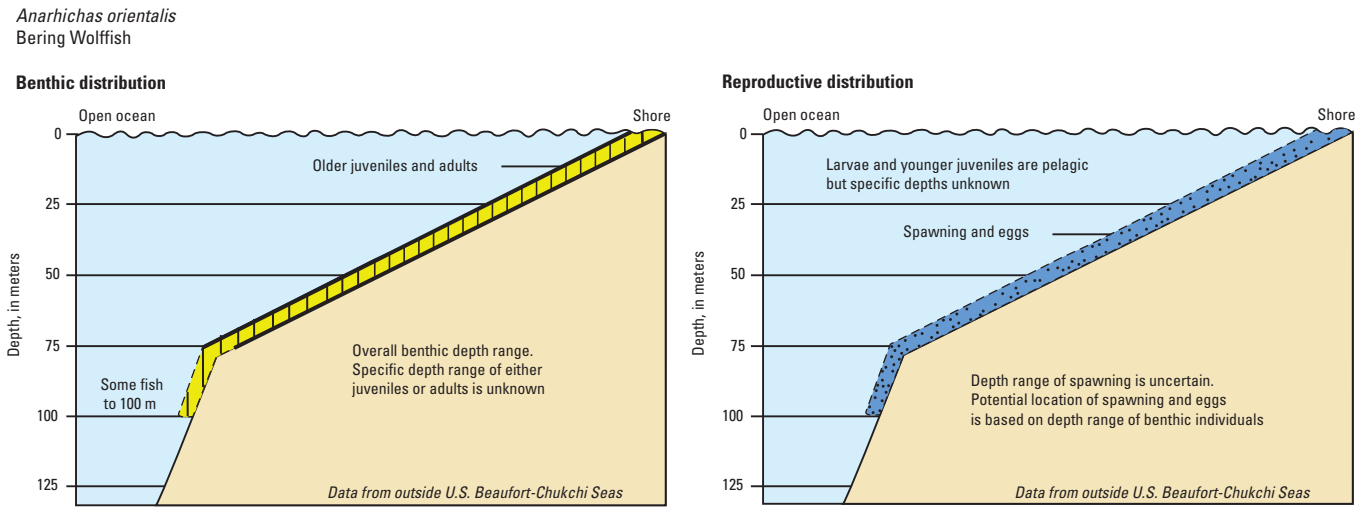
Range: *U.S. Chukchi and Beaufort Seas* [3]. Elsewhere in Alaska, this fish has been found southward to Prince William Sound, Gulf of Alaska. Worldwide, Bering Wolffish are found in the Sea of Okhotsk, Peter the Great Bay, Sea of Japan, and eastward in Canadian Beaufort Sea to Bathurst Inlet, Nunavut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

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

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

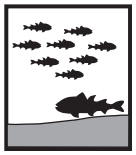
Depth Range: From shallow waters near shore to 100 m, typically in near-shore waters [3].



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

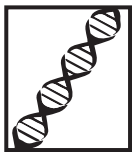
Habitats and Life History

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



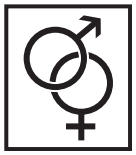
Behavior

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



Populations or Stocks

There have been no studies.



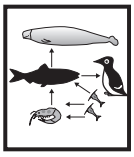
Reproduction

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

Food and Feeding

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

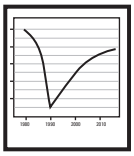
Trophic level—3.798 (standard error 0.60) [16].



Biological Interactions

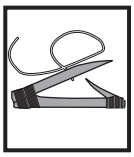
Predators—Pacific Cod and northern fur seals in the eastern Bering Sea [19, 20].

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



Resilience

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

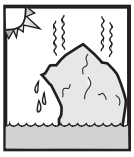


Traditional and Cultural Importance

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

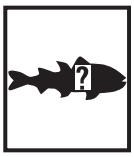
Commercial Fisheries

Currently, Bering Wolffish are not commercially harvested.



Potential Effects of Climate Change

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



Areas for Future Research [B]

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

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Prowfish (*Zaprora silenus*)

Jordan, 1896

Family Zaproridae

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

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

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

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

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

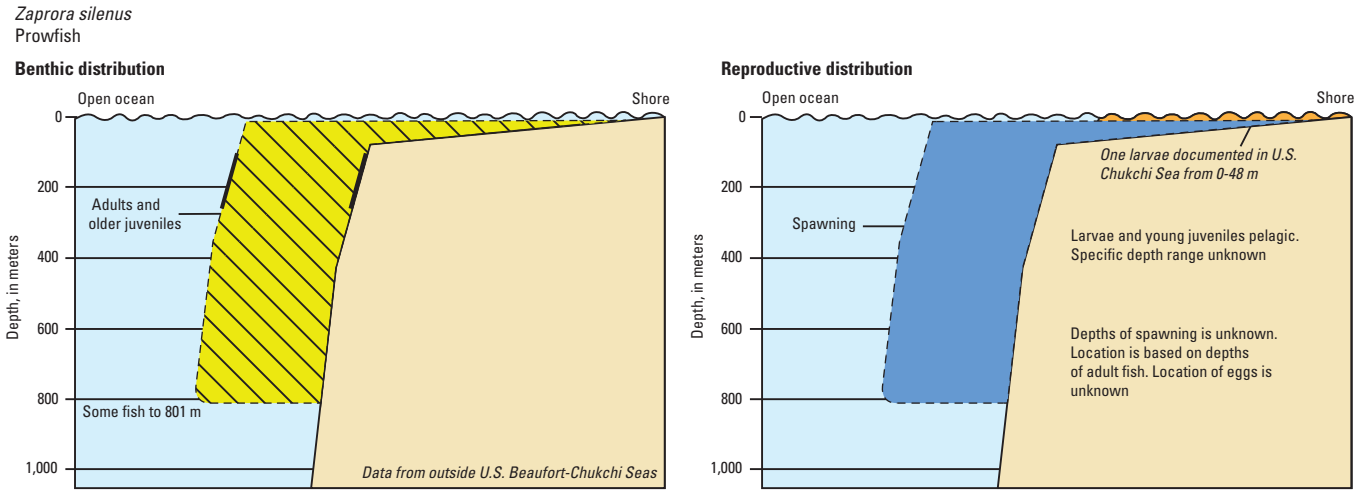
Range: *Southern U.S. Chukchi Sea* [3]. Elsewhere in Alaska, south from Bering Sea through Aleutian Islands to southern Gulf of Alaska. Worldwide, Pacific Ocean from Hokkaido, Japan, and Sea of Okhotsk south to San Miguel Island, southern California [1].

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

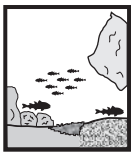
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

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

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

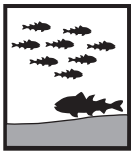


Benthic and reproductive distribution of Prowfish (*Zaprora silenus*).



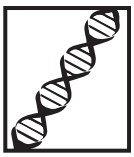
Habitats and Life History

Eggs—Size: Unknown. Time to hatching: Unknown. Habitat: Unknown.
Larvae—Size at hatching: 4 mm SL [10]. Size at juvenile transformation: 3.0 cm TL [11, 12]. Days to juvenile transformation: Unknown. Habitat: Pelagic, common on outer shelf edges [6].
Juveniles—Age and size: Age unknown, 3.0–57 cm TL [6, 10]. Pelagic to at least 18 cm [6, 12]. Habitat: Young juveniles are pelagic. Older juveniles are benthopelagic [3, 6].
Adult—Age and size at first maturity: At about 5 years, 50 percent of females are mature at about 57 cm TL [6]. Females are slightly heavier at length than males. Males and females have similar growth rates and, in the northeast Pacific, females and males reach the same length [6]. Fish in northeast Pacific are larger at age than those in western Pacific and females are slightly heavier at length than males [6]. Off southeastern Kamchatka and northern Kuril Islands, females appear to grow larger than males [12]. Maximum age: At least 20 years old [6]. Maximum size: 1 m TL or more [1] and 9.3 kg [13]. Habitat: Benthopelagic [3, 6], in caves and other rocky habitats [14, 15].
Substrate—Cobble, mud, sand, and gravel [14–16].
Physical/chemical—Temperature: 0.2–8.5 °C off Russia [12, 13]. Salinity: Marine to slightly brackish water [17].



Behavior

Diel—Pelagic larvae and juveniles may be obligate commensals of medusae, because they often are found in association with large jellyfish. Juveniles usually swim near tops and sides of bells, but will dive within or behind the tentacles when frightened. As many as nine juveniles have been seen associating with one medusa [18].
Seasonal—Off northern Kuril Islands and southeastern Kamchatka, prowfish may migrate from deep shelf to shallow slope waters in the late autumn and early winter [12].
Reproductive—Unknown.
Schooling—Unknown.
Feeding—Mostly water column feeders [6, 19, 20].

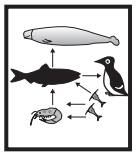


Populations or Stocks

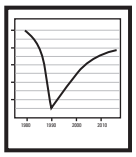
There have been no studies.

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

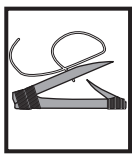
Food and Feeding
Food items—In eastern Bering Sea and northern Pacific, dominant prey are gelatinous organisms such as medusae, pelagic tunicates, and comb jellies [2, 12]. Other important prey includes copepods, amphipods, euphausiids, larvaceans, fish larvae, and polychaetes [6, 19, 20].
Trophic level—3.6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



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

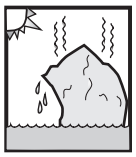


Resilience
Low, minimum population doubling time 4.5–14 years (K= 0.18, t_m= 5.1;) [21].

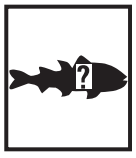


Traditional and Cultural Importance
None reported.

Commercial Fisheries
Currently, Prowfish are not commercially harvested.



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



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

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Arctic Sand Lance (*Ammodytes hexapterus*)

Pallas, 1814

Family Ammodytidae

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

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

Iñupiaq Name: Panmaksraq [1].

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

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

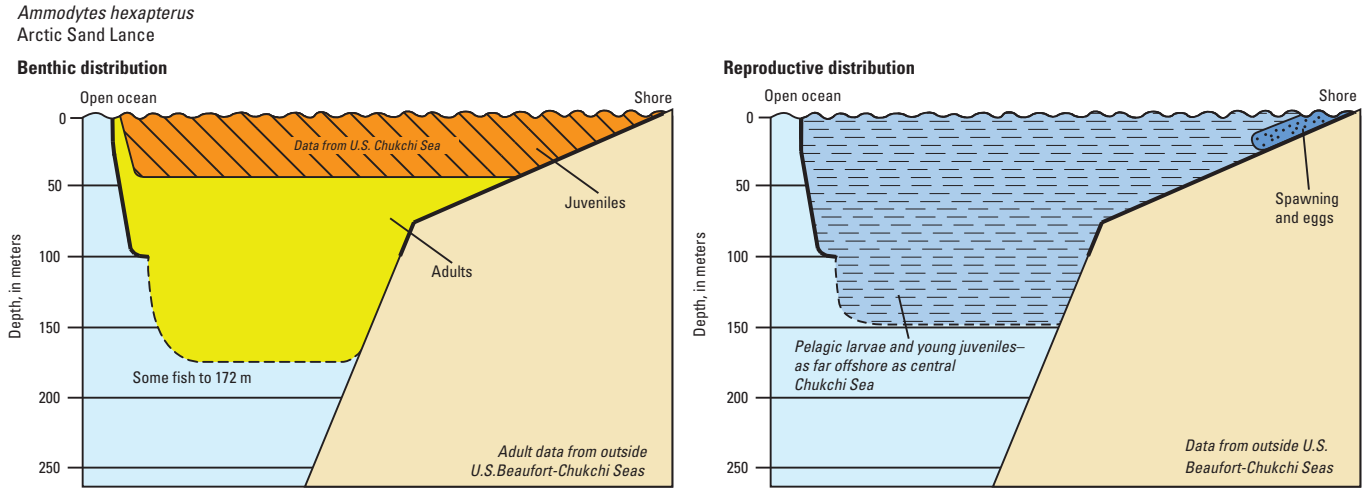
Range: *Throughout the U.S. Chukchi and Beaufort Seas.* Elsewhere in East Siberian, Chukchi, and Beaufort Seas eastward to Hudson and Ungava Bays; southward through eastern Bering Sea to Unimak Pass, and western Bering Sea to southeastern Kamchatka and Sea of Okhotsk [8].

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

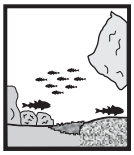
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

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

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



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



Habitats and Life History

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

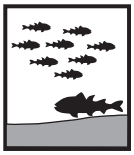
Larvae—Days to juvenile transformation: Unknown. Size: 4–7 mm at hatching to 40–80 mm FL at transformation [20]. Habitat: *Pelagic in the Chukchi Sea, in open water at depths of at least 45 m below surface* [13, 14]. In coastal, shelf, and slope waters, depth to at least 149 m in the Gulf of Alaska [likely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

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

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

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

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

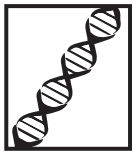


Behavior

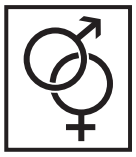
Diel—*Unknown.* In Gulf of Alaska [likely *A. personatus*], larvae migrate into deep waters at night [36]. In other regions, juveniles and adults school in water column by day (a few bury) and bury to depths of 10 cm in soft sediments of nearshore and shelf sea floors at night [18, 31, 34].

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

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

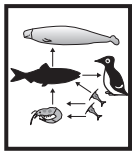


Populations or Stocks
DNA studies of fishes from the Hudson Bay-Beaufort Sea-Chukchi Sea-Bering Sea imply no distinct stocks [8].

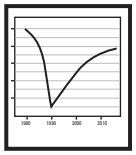


Reproduction
Mode—Separate sexes, oviparous. Fertilization is external [17, 21, 22].
Spawning season—Highly variable among geographic locations and may occur from August into late spring [17, 19, 37].
Fecundity—Off Kamchatka Peninsula, 6,150–59,900 [16].

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



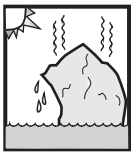
Biological Interactions
Predators—*In U.S. Chukchi Sea, Arctic Sand Lance are an important prey of both ringed (November to June) and bearded (February–March) seals, and seabirds (June–September)* [42]*. Other predators include Dolly Varden and Pacific Herring* [9, 43, 44]*.* Elsewhere, sand lance are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



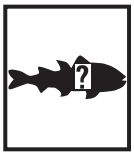
Resilience
Medium, minimum population doubling time is 1.4–4.4 years (t_m=2–3) [48].

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

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



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



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

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Bering Flounder (*Hippoglossoides robustus*)

Gill & Townsend, 1897

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.

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

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.

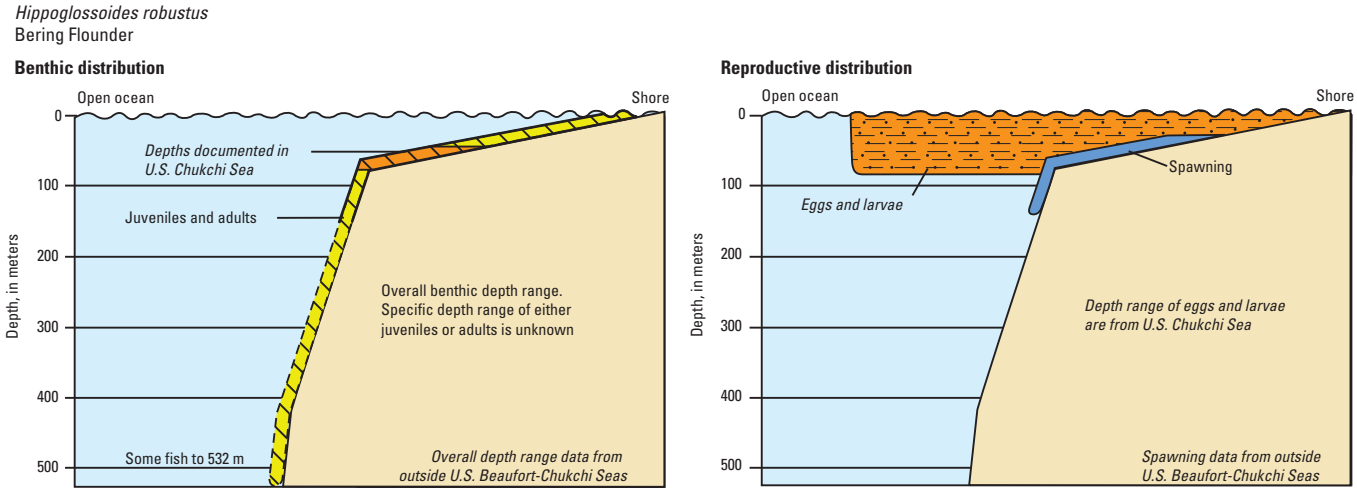
Range: *U.S. Chukchi Sea as far north as 72°19'N, 175°55'W* [2], *and U.S. Beaufort Sea* [5, 6]. Elsewhere in Alaska, Bering Flounder is found from Bering Sea off Alaska Peninsula, west to Akutan Island, Aleutian Islands [4]. Worldwide, from East Siberian Sea eastward to Bathurst Inlet, south of Dease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

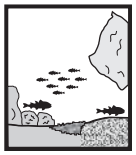
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

Geographic distribution of 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].

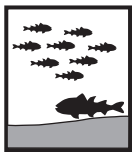


Benthic and reproductive distribution of Bering Flounder (*Hippoglossoides robustus*).



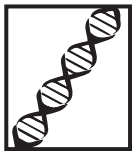
Habitats and Life History

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

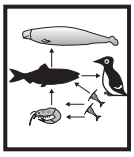
There have been no studies. Population information is available from the Bering Sea.

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.

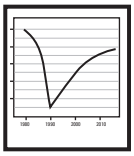
Food and Feeding

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].



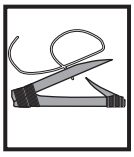
Biological Interactions

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].

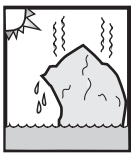


Traditional and Cultural Importance

None reported.

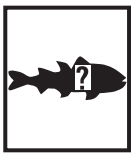
Commercial Fisheries

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

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.

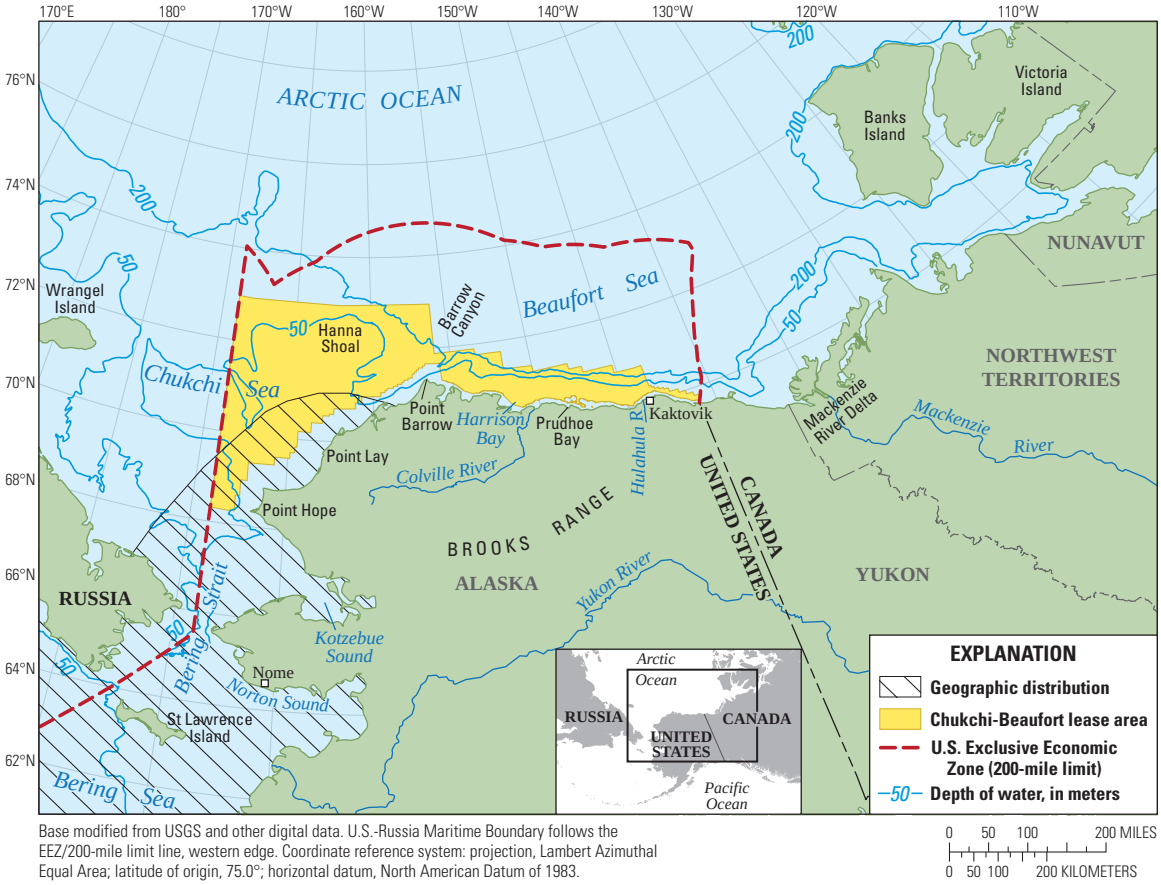
Pacific Halibut (*Hippoglossus stenolepis*), 633 mm, southeastern Bering Sea. Photograph by C.W. Mecklenburg, Point Stephens Research.

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].

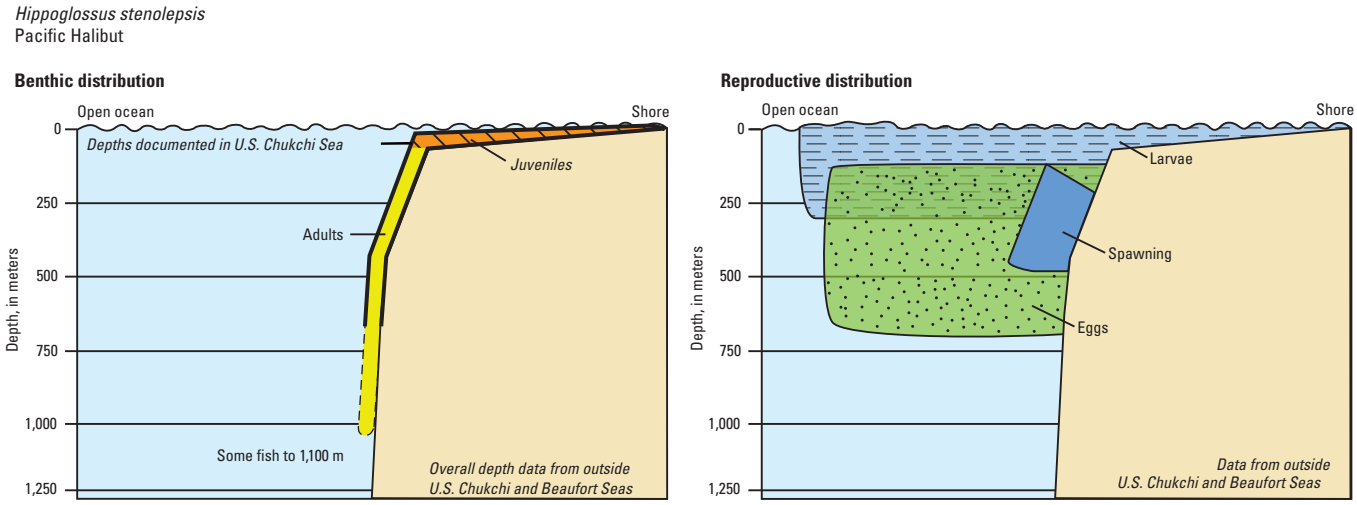
Pacific Halibut
Hippoglossus stenolepis



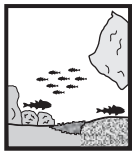
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

Geographic distribution of Pacific 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].

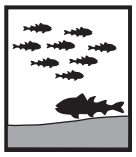


Benthic distribution and reproductive distribution of Pacific Halibut (*Hippoglossus stenolepis*).



Habitats and Life History

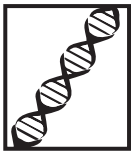
Eggs—Size: 2.9–3.8 mm [12, 13]. Time to hatching: 15–20 days at 5–6 °C and 12–14 days at 7–8 °C [12, 13]. Habitat: Epipelagic to mesopelagic [12–15].
Larvae—Size at hatching: 8.0 mm SL [13]. Size at juvenile transformation: 2.2 cm TL [17]. Days to juvenile transformation: About 180 days [12, 17, 19]. 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].

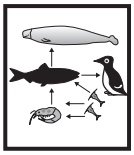
Reproductive—As waters cool, adults migrate offshore to spawning grounds on deeper parts of continental shelf and slope [15, 21]. Spawning grounds are relatively circumscribed and discrete and occur from at least British Columbia to the Pribilof Canyon area in the eastern Bering Sea and likely along 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].



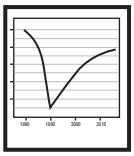
Populations or Stocks
There have been no studies.

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].

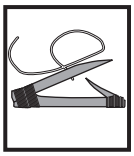
Food and Feeding
Food items—Young-of-the-year halibut feed on small crustaceans (for example, mysids, cumaceans, and gammarid amphipods), whereas older juveniles add crabs, shrimps, and small fishes to their diets [35, 36]. As halibut grow, crabs remain important, but fishes (for example, Walleye Pollock, 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.

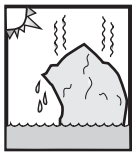


Resilience
Low, minimum population doubling time 4.5–14 years (r_m=0.2; K=0.05; t_m=5–20; t_{max}=30) [43].

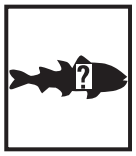


Traditional and Cultural Importance
Pacific Halibut were a major food fish for indigenous peoples living from the Bering Sea to Washington [44, 45], but their rarity in the Chukchi Sea precludes widespread use by coastal residents.

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.

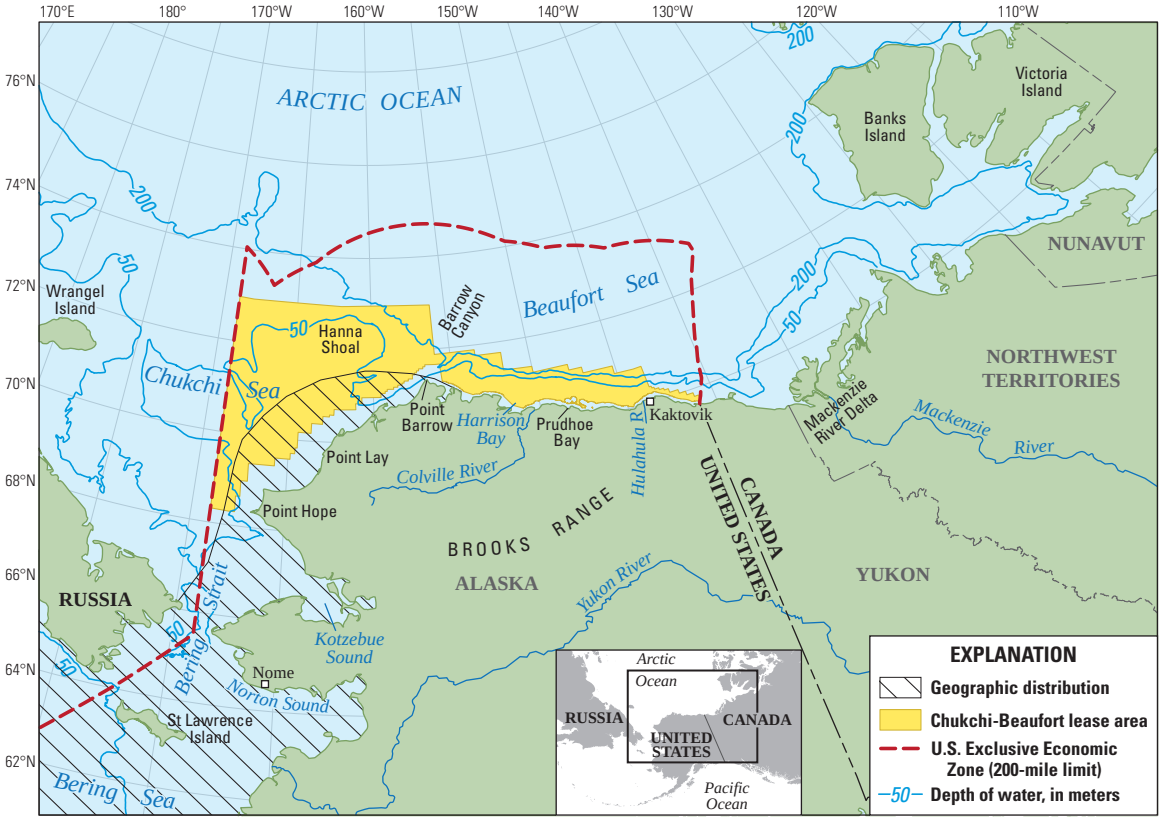
Physical Description/Attributes: Member of the right eyed flounders. Eyed side is brown and smaller individuals have dark spots on head and body. Median fins are yellowish, there is a narrow black line at base of dorsal and anal fins, and blind side is white. For specific diagnostic characteristic, see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

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

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].

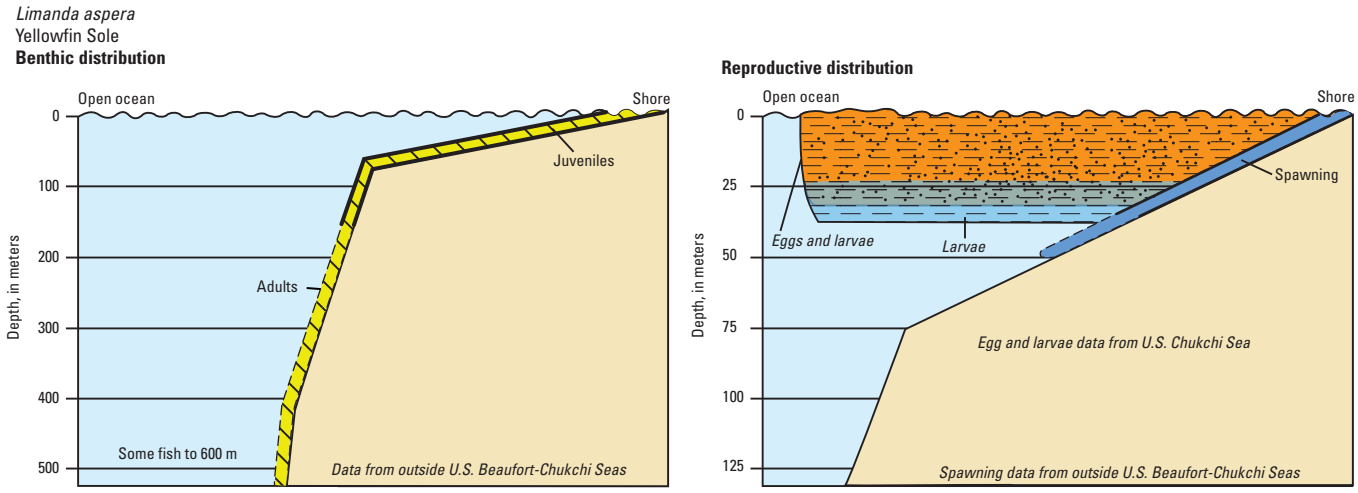
Yellowfin Sole
Limanda aspera



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 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].

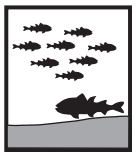
Larvae—Size at hatching: 2.2–3.1 mm SL [17, 20]. Size at juvenile transformation: As small as 1.2 cm SL [14, 15], but usually 1.5–1.7 cm SL [20]. Days to juvenile transformation: One month, but may continue as much as 4 months [18]. Habitat: Epipelagic [12, 17, 18, 20].

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].

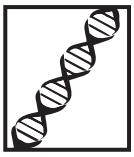


Behavior

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].

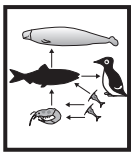
Reproductive—Spawn in nearshore waters [5]. May rise to surface waters to spawn [19]. Females are batch spawners and an individual female will spawn 8–11 batches per egg series with some females spawning more than 1 series per season [32].
Schooling—Occurs in very dense concentrations during winter [31].
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].



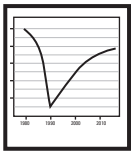
Populations or Stocks
There have been no studies.

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, echiurioids, 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].



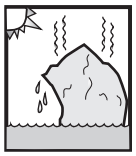
Biological Interactions
Predators—*In U.S Chukchi Sea, off Point Hope, ringed seals ate small numbers in April* [43]. In eastern Bering Sea and Gulf of Alaska, Bigmouth Sculpin, Great and Plain sculpins, Pacific Cod, Pacific Halibut, Skates, and Steller sea lions [41, 44–46].
Competitors—Likely a wide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



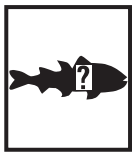
Resilience
Low, minimum population doubling time 4.5–14 years (K=0.1–0.15; t_m=4–10; t_{max}=26; Fecundity=1 million) [47].

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

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.

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

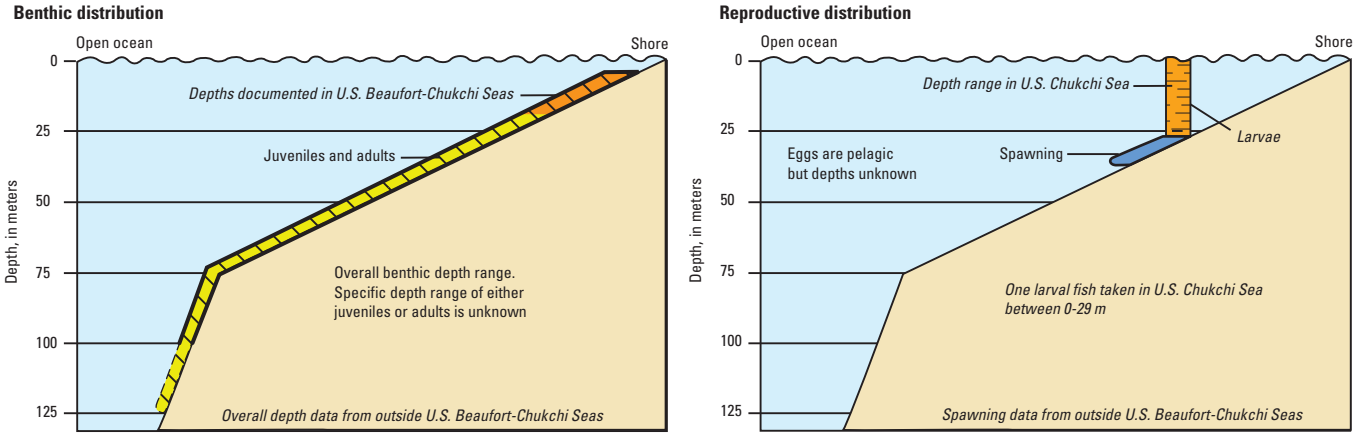
Range: *U.S. Chukchi and Beaufort Seas* [3]. Eastward in Canadian Arctic to Bathurst Inlet and westward to western Chukchi Sea [3, 4]. Elsewhere in Alaska, eastern Bering Sea north of Unimak Island. Worldwide, off Hokkaido, Japan, through Sea of Okhotsk [2, 4].

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].

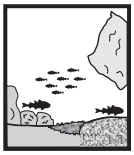
Geographic distribution of Longhead Dab (*Limanda proboscidea*), within Arctic Outer Continental Shelf Planning Areas [5] based on review of published literature and specimens from historical and recent collections [3, 6].

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].

Limanda proboscidea
Longhead Dab

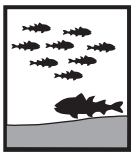


Benthic and reproductive distribution of Longhead Dab (*Limanda proboscidea*). Larval distribution reflects one record from the study area.



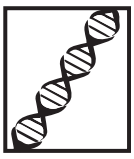
Habitats and Life History

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.



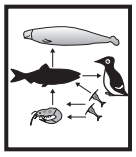
Populations or Stocks

There have been no studies.

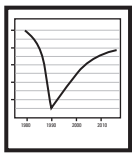
Reproduction

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].

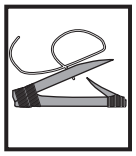
Food and Feeding
Food items—Polychaetes, crustaceans (for example, copepods, cumaceans, gammarid amphipods, and mysids) and clams [22, 23].
Trophic level—3.6 [12].



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

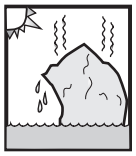


Resilience
Medium, minimum population doubling time 1.4–4.4 years (preliminary *K* or fecundity) [26].

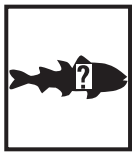


Traditional and Cultural Importance
Unknown, but of suspected limited use.

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*)

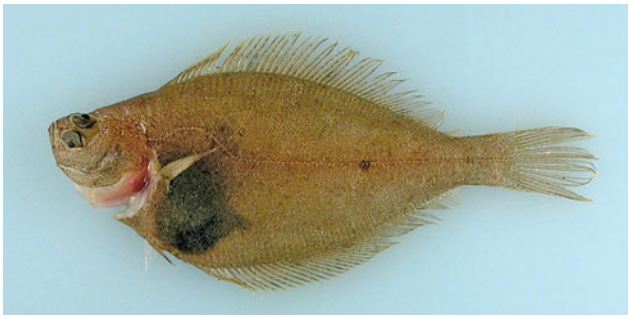
Hubbs, 1915

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.



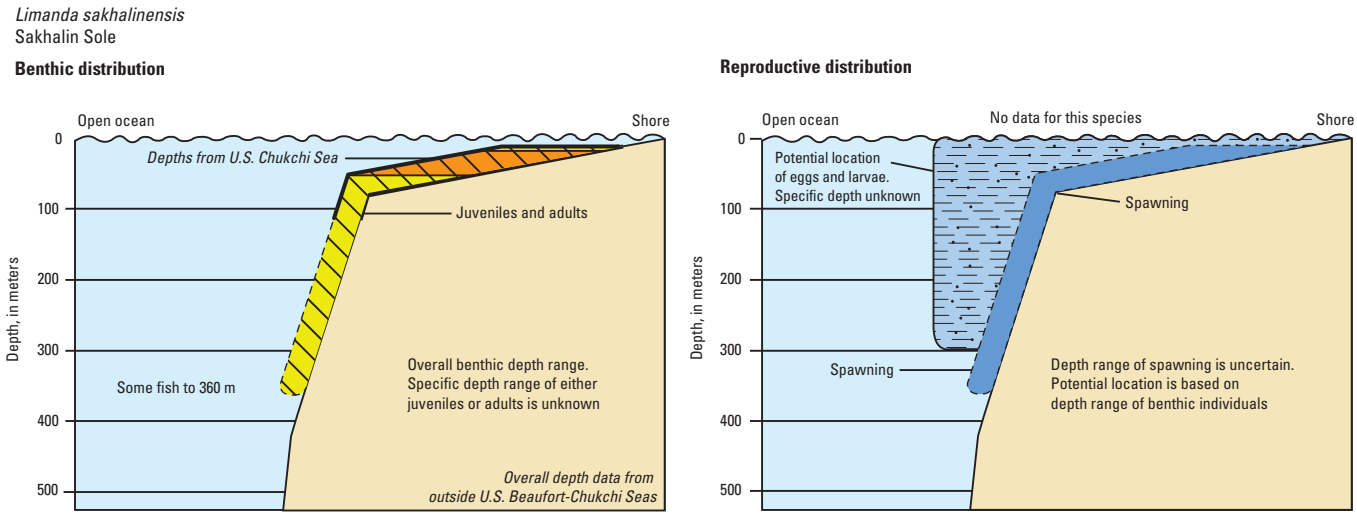
Sakhalin Sole (*Limanda sakhalinensis*), 123 mm, Chukchi Sea, 2009. Photograph by C.W. Mecklenburg, Point Stephens Research.

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].

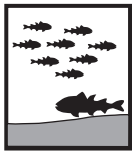
Depth Range: Overall 10–360 m [5], mainly less than 110 m [6]. At depths of 20–51 m in the U.S. Chukchi Sea and northern Bering Sea [2], to 95 m in southeastern Bering Sea [1].



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.

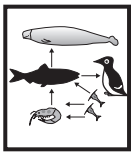
Populations or Stocks

There have been no studies.

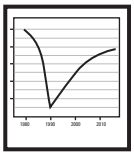
Reproduction

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

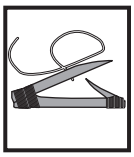
Food and Feeding
Food items—Amphipods, polychaetes, and euphausiids [8].
Trophic level—3.68 (standard error 0.55) [8].



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.

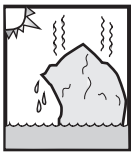


Resilience
Low, minimum population doubling time 4.5–14 years (preliminary *K* or fecundity) [8].

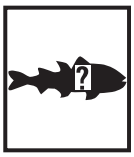


Traditional and Cultural Importance
None reported.

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.

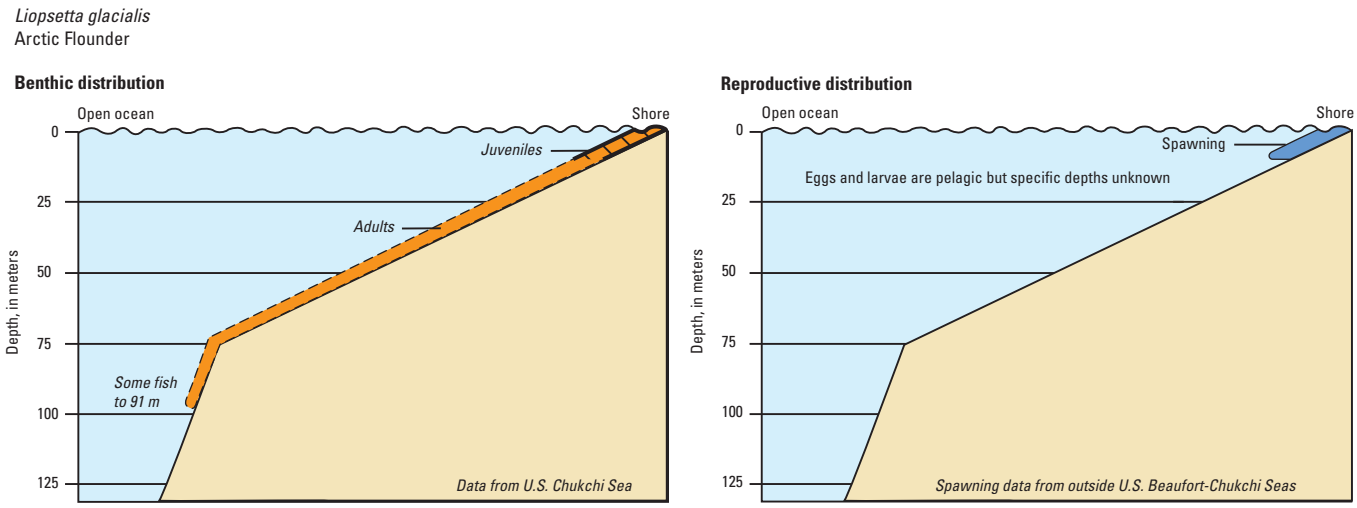
Range: *U.S. Chukchi and Beaufort Seas* [3]. Elsewhere in Alaska, to southeastern Bering Sea and Aleutian Islands. Worldwide, from Arctic Russia to Labrador, Canada, and in the Atlantic and Okhotsk Sea in western Pacific [2].

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].

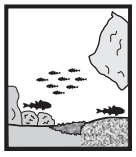
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

Geographic distribution of Arctic 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].

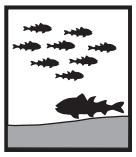
Larvae—Size at hatching: 5.6 mm [13]. Size at juvenile transformation: 14–*20 mm TL* [8, 10, 15]. Days to juvenile transformation: Unknown. Habitat: Pelagic [16].

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].

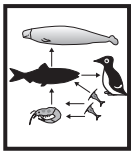
Feeding—Unknown.

Populations or Stocks

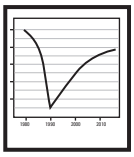
Life history parameters have been described from the northeastern Chukchi Sea and the coastal Beaufort Sea. No information about population size or stock structure is available.

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].

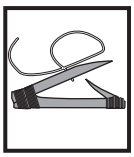
Food and Feeding
Food items—*Primarily epibenthic and benthic invertebrates, such as clams, isopods, amphipods, ascidians, and mysids* [11, 18, 29].
Trophic level—3.6 [27].



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

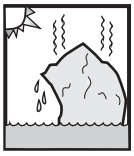


Resilience
Medium, minimum population doubling time 1.4–4.4 years (t_m=2; Fecundity =31,000–230,000).

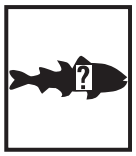


Traditional and Cultural Importance
Arctic Flounder form a minor part of the subsistence fisheries of the U.S. Beaufort and Chukchi Seas. It has been listed as a food fish from Kotzebue Sound and northward [30]. *Another reported "flounder" caught in the nearshore waters at Point Hope and Point Lay is 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.

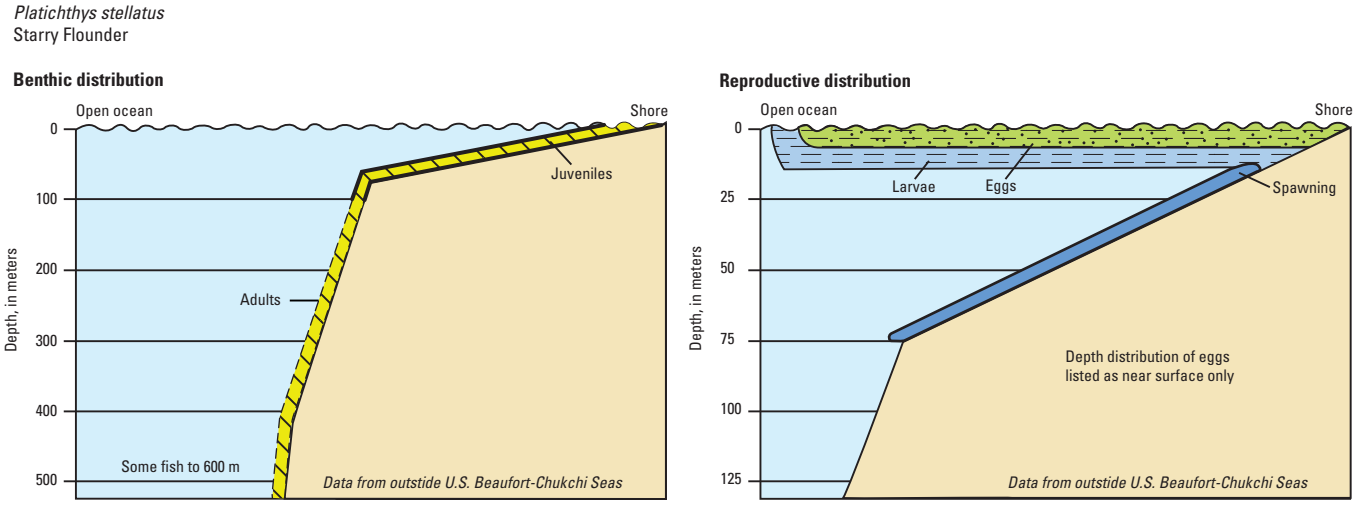
Range: *U.S. Chukchi and Beaufort Seas* [2]. Elsewhere in Alaska, throughout Bering Sea, Aleutian Islands, Gulf of Alaska and all southeastern waters. Worldwide, in Arctic Ocean from the East Siberian Sea eastward to Bathurst Inlet and Viscount Melville Sound in the Canadian high Arctic [2, 3]. In Pacific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

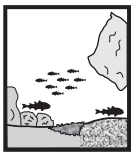
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

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

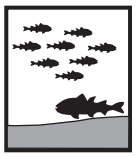
Eggs—Size: 0.9 to 1.3 mm [20]. Time to hatching: 68 hours at 12.5 °C and 110 hours at 10.5 °C [14]. Pale orange in color [21]. Habitat: Pelagic [14, 18]. —Size at hatching: 1.9–2.1 mm SL [20]. Size at juvenile transformation: 8.3–10.5 mm SL [22]. Days to juvenile transformation: About 39 days at 12–15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

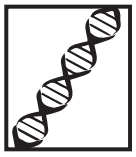
Diel—*Not well understood.* At night in summer, adults move into shallow, nearshore waters in Sea of Japan [12] and have been found midwaters or near the surface in Puget Sound [27, 36]. Adults exhibit tidally oriented, inshore movements [12]. An adult buries itself to avoid predators and can change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

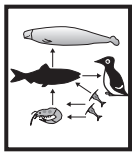
Spawning season—June and July in Canadian Beaufort Sea [25, 42]. Between November and February off central California and occurs progressively later to the north [14, 25, 42].

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].

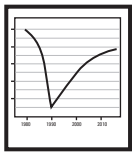
Trophic level—3.8 [45].



Biological Interactions

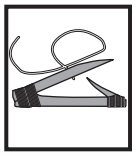
Predators—*Ringed seals in U.S. Chukchi Sea* [46] and beluga whales in Cook Inlet [47]. Elsewhere fishes such as Spotted Spiny Dogfish and White Sturgeon, as well as great blue herons, bald eagles, harbor seals and Stellar sea lions [48–52].

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



Resilience

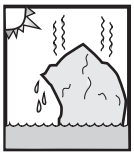
Medium, minimum population doubling time 1.4–4.4 years (t_m=2–3; t_{max}=24) [53].



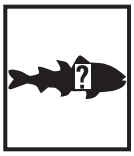
Traditional and Cultural Importance

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

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.

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

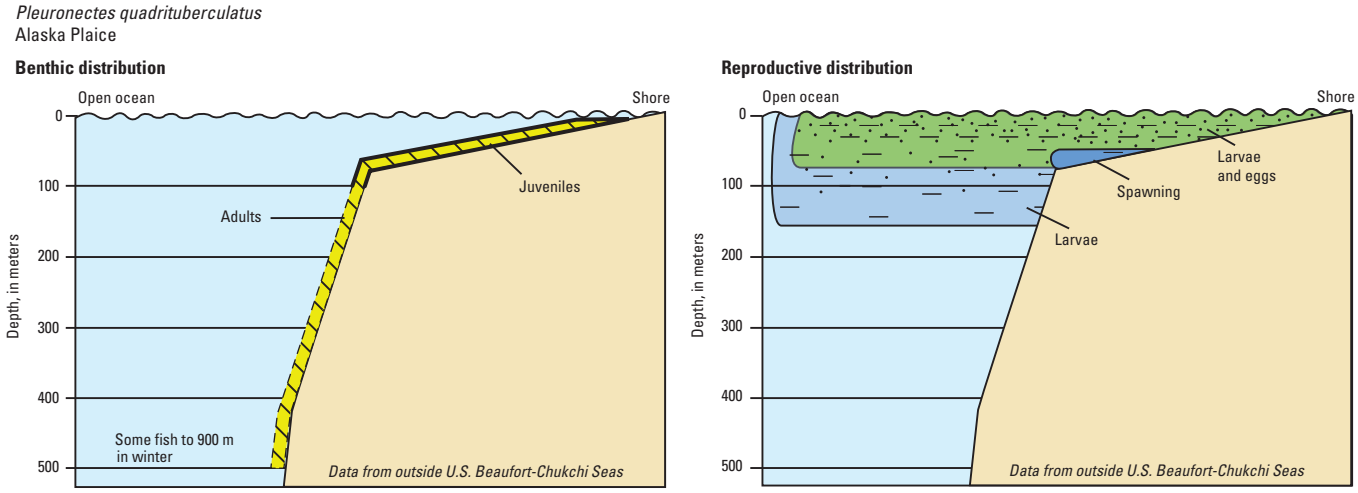
Physical Description/Attributes: Member of the right eyed flounders. Eyed side is greenish gray to almost black and blind side is yellow. Young adults are spotted and blotched. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 835) [1]. Swim bladder: Absent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

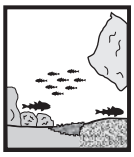
Relative Abundance: *Occasional in U.S. Chukchi Sea* [3, 6, 7]. Common from eastern Bering Sea to central Gulf of Alaska [8] and from Sea of Japan [9] to Kamchatka Peninsula [10].

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].

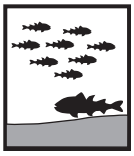


Benthic and reproductive distribution of Alaska Plaice (*Pleuronectes quadrituberculatus*).



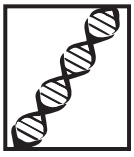
Habitats and Life History

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].



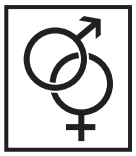
Behavior

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].



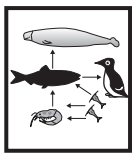
Populations or Stocks

There have been no studies.

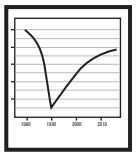


Reproduction
Mode—Separate sexes, oviparous. Fertilization is external [16].
Spawning season—In eastern Bering Sea spawning occurs from March to July and peak spawning season varies with year and area [16, 24].
Fecundity—Between 56,000 and 521,000 eggs per season and are probably batch spawners [25,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

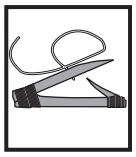
Food and Feeding
Food items—Benthic and epibenthic organisms are most important in eastern Bering Sea. In particular, polychaetes, clams, and such crustaceans as gammarid amphipods dominate the diets. Other preys include echiurioids, brittle stars, shrimps, snails, sea urchins, and sand dollars [27,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

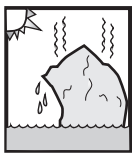


Resilience
Low, minimum population doubling time 4.5–14 years (K=0.1) [32].

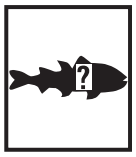


Traditional and Cultural Importance
Historically, Alaska Plaice were sought in various subsistence fisheries [12, 33]. Currently, they are taken primarily as bycatch in other fisheries [8].

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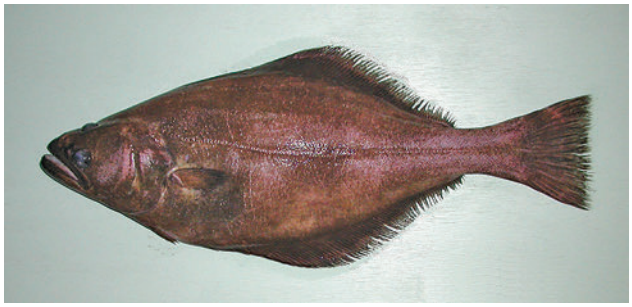
Greenland Halibut (*Reinhardtius hippoglossoides*)
(Walbaum, 1792)

Family Pleuronectidae

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.



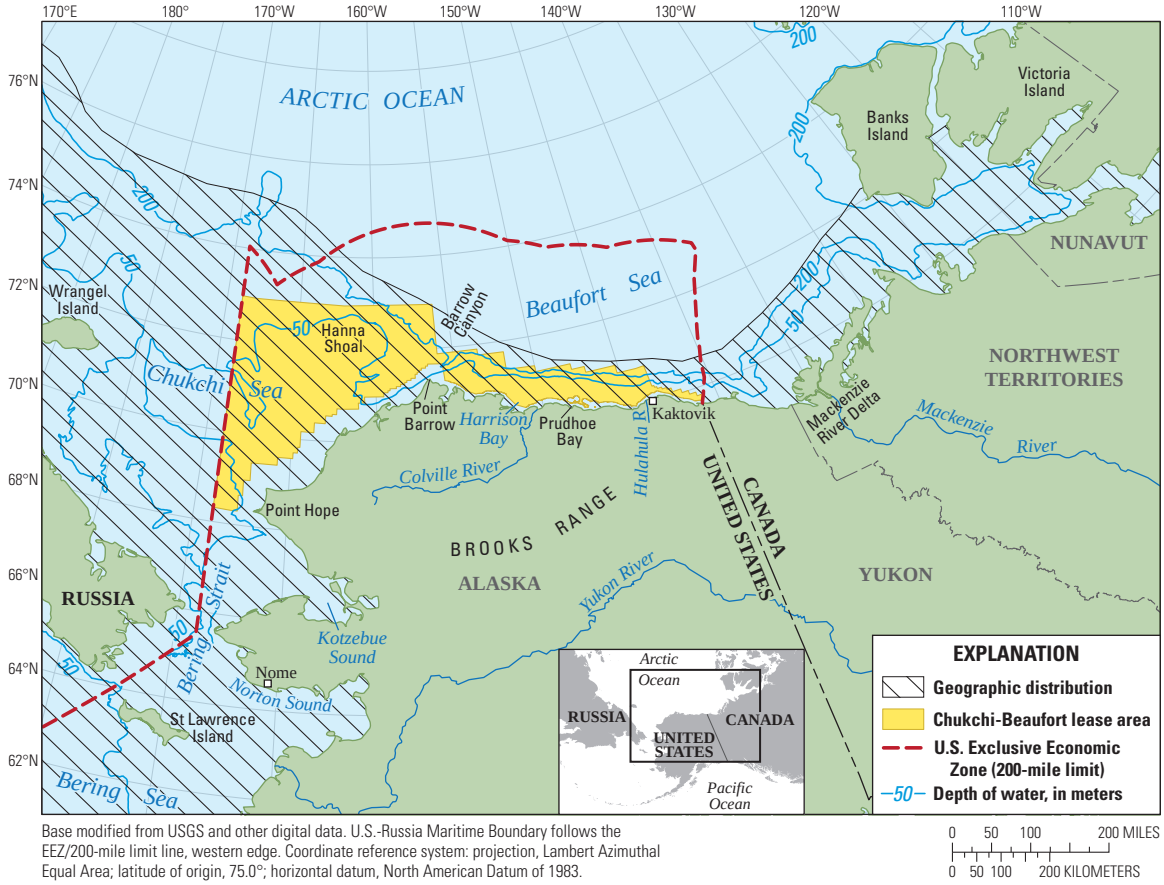
Greenland Halibut (*Reinhardtius hippoglossoides*), 437 mm, Chukchi Borderland, 2009. Photograph by C.W. Mecklenburg, Point Stephens Research.

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].

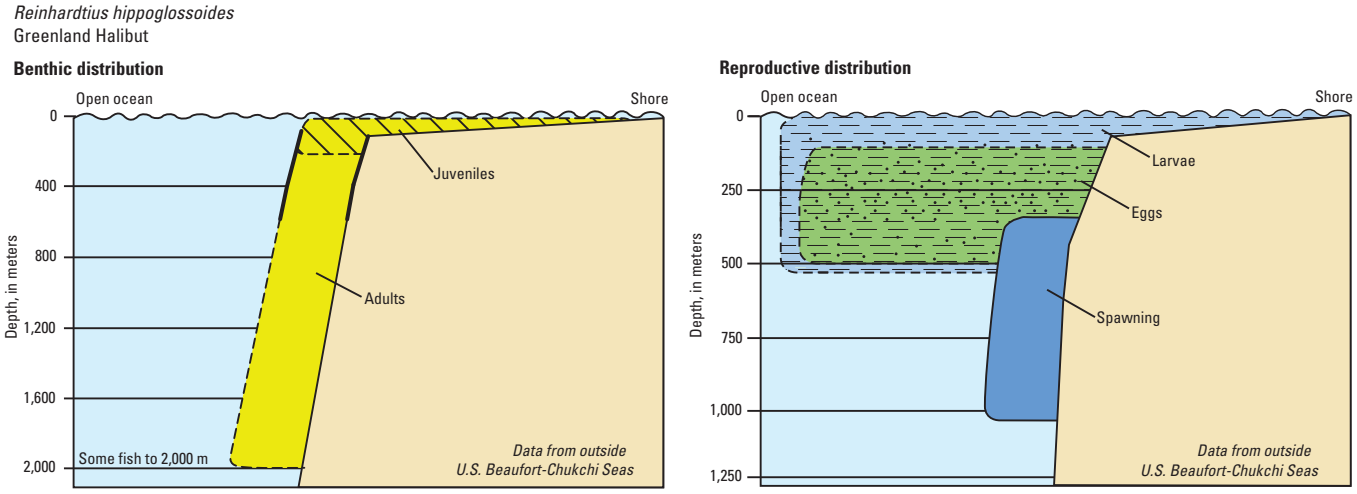
Greenland Halibut
Reinhardtius hippoglossoides



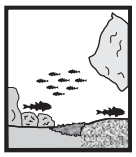
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

Geographic distribution of 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].

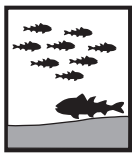


Benthic and reproductive distribution of Greenland Halibut (*Reinhardtius hippoglossoides*).



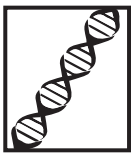
Habitats and Life History

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].

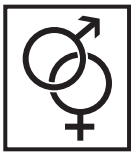


Behavior

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].

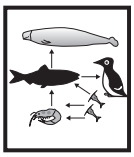


Populations or Stocks
There have been no studies.

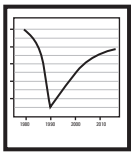


Reproduction
Mode—Separate sexes, oviparous. Fertilization is external [37]. Perhaps a batch spawner [40]. In Atlantic Ocean, egg maturation may take longer than 1 year or else some mature females may not reproduce in a given year [37].
Spawning season—At least August to March (peaking November through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

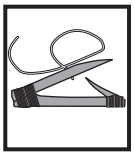
Food and Feeding
Food items—*No studies have been conducted in U.S. Chukchi and Beaufort Seas.* In Gulf of Alaska and along Aleutian Islands, a wide range of fishes (often Walleye Pollock) are dominant, although squids, octopi, euphausiids, and polychaetes also are consumed [42–44]. Smaller individuals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

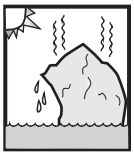


Resilience
Low, minimum population doubling time 4.5–14 years (K=0.07–0.10; t_{min}=7–12; t_{max}=30; Fecundity=6,800) [52].

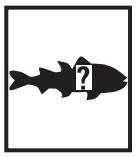


Traditional and Cultural Importance
None reported.

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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