Spotted Spiny Dogfish to Bering Cisco

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

Family Squalidae

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

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

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

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

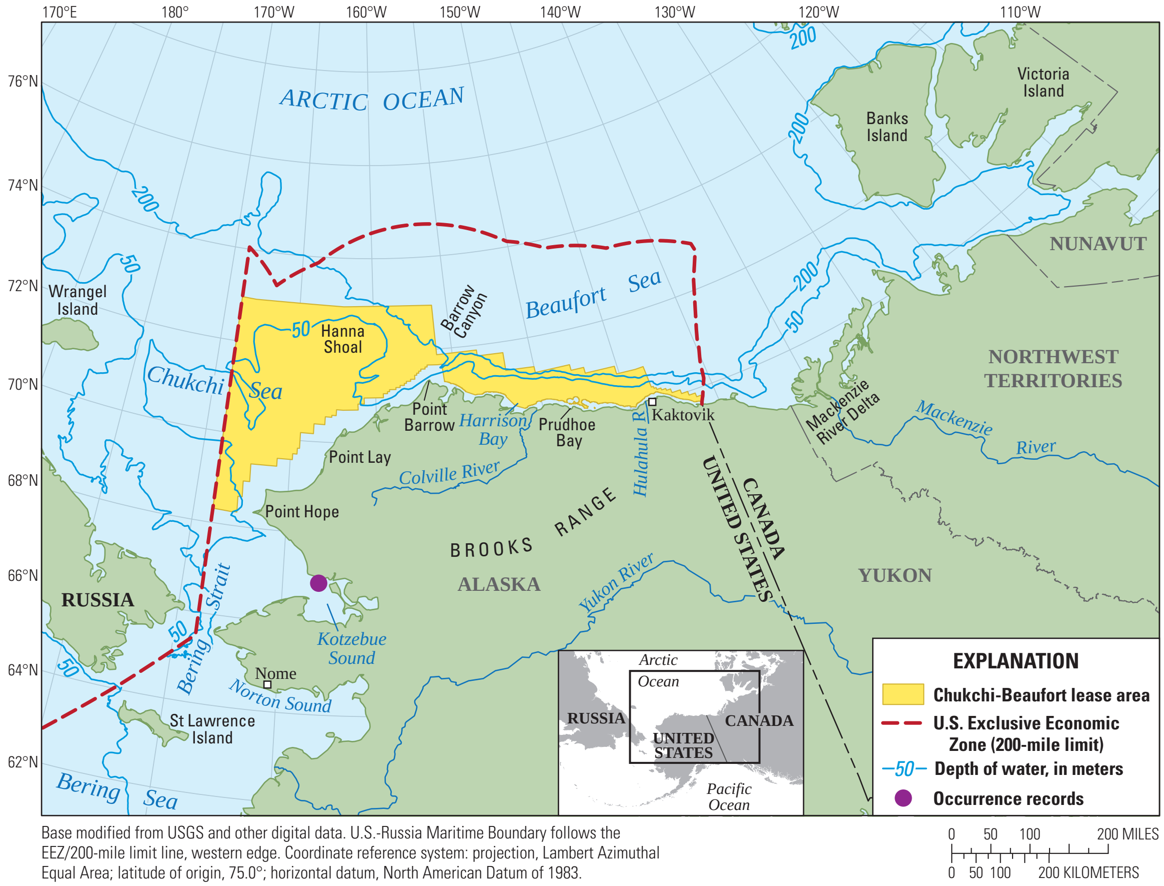
Ecological Role: A rare species in the U.S. Chukchi Sea and absent from the U.S. Beaufort Sea. The species has a very limited role and little significance in regional food webs.

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

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

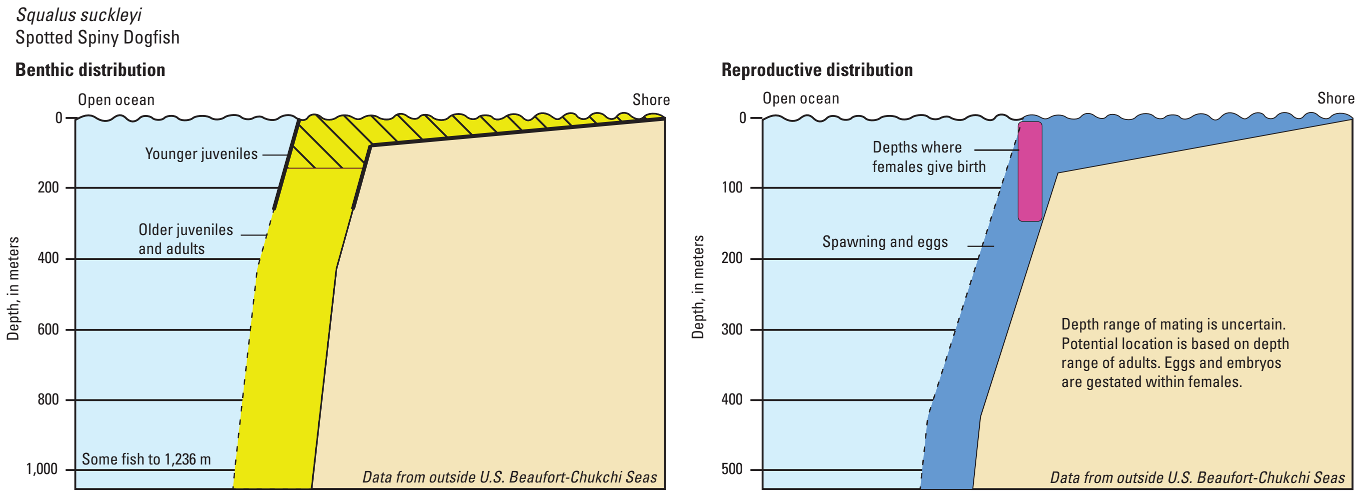
Relative Abundance: *Rare in U.S. Chukchi Sea, with one record of occurrence near Kotzebue* [1]. Common from Kodiak Island, Gulf of Alaska and southward into Baja California, and in Sea of Japan [7–9]. Very rare in northern Bering Sea [1, 10, 11]. Appears to be increasing in abundance in southern Bering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

Spotted Spiny Dogfish
Squalus suckleyi

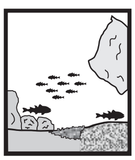


Geographic distribution of Spotted Spiny Dogfish (*Squalus suckleyi*) within Arctic Outer Continental Shelf Planning Areas based on review of published literature and specimens from historical and recent collections [4, 6].

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



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



Habitats and Life History

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

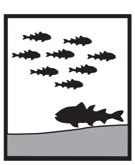
Embryos—Age and size: From about 4–6 months to 22 months (<10 to 22.5–30 cm TL) [5, 13]. Habitat: Embryos are completely dependent on their yolk-sacs and are gestated within the uterus [5, 13].

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

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

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

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



Behavior

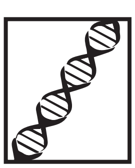
Diel—Migrates closer to surface at night [5, 10] and may be more active at night [16].

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

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

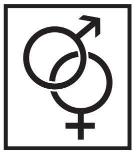
Schooling—Forms large schools [5]. Sexes tend to segregate into separate schools around time of parturition [13].

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



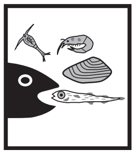
Populations or Stocks

There have been no studies.



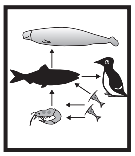
Reproduction

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



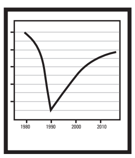
Food and Feeding

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



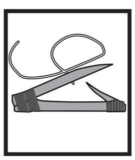
Biological Interactions

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



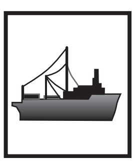
Resilience

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



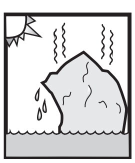
Traditional and Cultural Importance

None reported



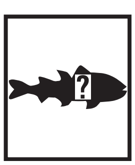
Commercial Fisheries

Currently, Spiny Spotted Dogfish are not commercially fished.



Potential Effects of Climate Change

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



Areas for Future Research [B]

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

References Cited

Ebert, D.A., 2003, Sharks, rays, and chimaeras of California: Berkeley, University of California Press, California Natural History Guide, v. 71, 297 p. [9]

Ebert, D.A., White, W.T., Goldman, K.J., Compagno, L.J.V., Daly-Engel, T.S., and Ward, R.D., 2010, Resurrection and redescription of *Squalus suckleyi* (Girard, 1854) from the North Pacific, with comments on the *Squalus acanthias* subgroup (Squaliformes: Squalidae): Zootaxa, v. 2612, p. 22–40. [2]

Ketchen, K.S., 1972, Size at maturity, fecundity, and embryonic growth of the spiny dogfish (*Squalus acanthias*) in British Columbia waters: Journal of the Fisheries Research Board of Canada, v. 29, no. 12, p. 1,717–1,723. [14]

Love, M.S., 2011, Certainly more than you wanted to know about the fishes of the Pacific Coast: Santa Barbara, California, Really Big Press, 649 p. [5]

Tribuzio, C.A., 2004, An investigation of the reproductive physiology of two North Pacific shark species—Spiny Dogfish (*Squalus acanthias*) and salmon shark (*Lamna ditropis*): Seattle, University of Washington, Master's thesis, 147 p. [13]

Bibliography

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

2. Ebert, D.A., White, W.T., Goldman, K.J., Compagno, L.J.V., Daly-Engel, T.S., and Ward, R.D., 2010, Resurrection and redescription of *Squalus suckleyi* (Girard, 1854) from the North Pacific, with comments on the *Squalus acanthias* subgroup (Squaliformes: Squalidae): Zootaxa, v. 2612, p. 22–40.

3. Halstead, B.W., 1995, Dangerous marine animals that bite, sting, or are non-edible: Centreville, Maryland, Cornell Maritime Press, 275 p.

4. 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.

5. Love, M.S., 2011, Certainly more than you wanted to know about the fishes of the Pacific Coast: Santa Barbara, California, Really Big Press, 649 p.

6. Mecklenburg, C.W., Mecklenburg, T.A., Sheiko, B.A., and Steinke, D., 2016, Pacific Arctic marine fishes: Akureyri, Iceland, Conservation of Arctic Flora and Fauna, Monitoring Series Report No. 23, 406 p., accessed May 10, 2016, at http://caff.is/monitoring-series/370-pacific-arcticmarine-fishes.

7. Allen, M.J., and Smith, G.B., 1988, Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, NOAA Technical Report NMFS 66, 151 p.

8. Sokolovskaya, T.G., Sokolovskii, A.S., and Sobolevskii, E.I., 1998, A list of fishes of Peter the Great Bay (the Sea of Japan): Journal of Ichthyology, v. 38, no. 1, p. 1–11.

9. Ebert, D.A., 2003, Sharks, rays, and chimaeras of California: Berkeley, University of California Press, California Natural History Guide, v. 71, 297 p.

10. Orlov, A.M., Savinykh, V.F., Kulish, E.F., and Pelenev, D.V., 2012, New data on the distribution and size composition of the North Pacific spiny dogfish *Squalus suckleyi* (Girard, 1854): Scientia Marina, v. 76, no. 1, p. 111–122.

11. Stevenson, D.E., Orr, J.W., Hoff, G.R., and McEachran, J.D., 2007, Field guide to sharks, skates, and ratfish of Alaska: Fairbanks, University of Alaska, Alaska Sea Grant Program, 77 p.

12. Ketchen, K.S., 1986, The spiny dogfish (*Squalus acanthias*) in the northeast Pacific and a history of its utilization: Canadian Special Publication of Fisheries and Aquatic Sciences, v. 88, 78 p.

13. Tribuzio, C.A., 2004, An investigation of the reproductive physiology of two North Pacific shark species—Spiny Dogfish (*Squalus acanthias*) and salmon shark (*Lamna ditropis*): Seattle, University of Washington, Master's thesis, 147 p.

14. Ketchen, K.S., 1972, Size at maturity, fecundity, and embryonic growth of the spiny dogfish (*Squalus acanthias*) in British Columbia waters: Journal of the Fisheries Research Board of Canada, v. 29, no. 12, p. 1,717–1,723.

15. Saunders, M.W. and McFarlane, G.A., 1993, Age and length of maturity of the female spiny dogfish, *Squalus acanthias*, in the Strait of Georgia, British Columbia, Canada: Environmental Biology of Fishes, v. 38, p. 49–57.

16. Miller, B.S., Simenstad, C.A., Moulton, L.L., Fresh, K.L., Funk, F.C., Karp, W.A., and others, 1977, Puget Sound baseline program—Nearshore fish survey: University of Washington, Fishery Research Institute, FRI-UW-7710, 219 p.

17. Orlov, A.M., 2004, Migrations of various fish species between Asian and American waters in the North Pacific Ocean: Aqua, Journal of Ichthyology and Aquatic Biology of Fishes, v. 8, no. 3, p. 109–124.

18. Jones, B.C., and Geen, G.H., 1977, Reproduction and embryonic development of spiny dogfish (*Squalus acanthias*) in the Strait of Georgia, British Columbia: Journal of the Fisheries Research Board of Canada, v. 34, no. 9, p. 1,286–1,292.

19. Pratt, H.L., and Carrier, J.C., 2005, Elasmobranch courtship and mating behavior, *in* Hamlett, W., ed., Reproductive behavior and phylogeny of elasmobranchs: Queensland, Australia, Science Publishers, Inc., p. 129–169.

20. Hart, J.L., 1973, Pacific fishes of Canada: Ottawa, Fisheries Research Board of Canada, 740 p.

21. Fraser, C.M., 1923, Ichthyological notes: Contributions to Canadian Biology, New Series, v. 1, no. 14, p. 287–295.

22. Fraser, C.M., 1946, Food of fishes: Transactions of the Royal Society of Canada, v. 45, sec. 5, p. 33–39.

23. Beamish, R.J., and Smith, M.S., 1976, A preliminary report on the distribution, abundance, and biology of juvenile spiny dogfish (*Squalus acanthias*) in the Strait of Georgia and their relationship with other fishes: Environment Canada, Fisheries and Marine Service, Technical Report 629, 44 p.

24. Simenstad, C.A., Miller, B.S., Nyblade, C.F., Thornburgh, K., and Bledsoe, L.J., 1979, Food web relationships of northern Puget Sound and the Strait of Juan de Fuca—A synthesis of the available knowledge: National Oceanic and Atmospheric Administration/Marine Ecosystems Analysis Puget Sound Project, Prepared for Office of Environmental Engineering and Technology, United States Environmental Protection Agency, 334 p.

25. Tanasichuk, R.W., Ware, D.M., Shaw, W., and McFarlane, G.A., 1991, Variations in diet, daily ration, and feeding periodicity of Pacific hake (*Merluccius productus*) and spiny dogfish (*Squalus acanthias*) off the lower west coast of Vancouver Island: Canadian Journal of Fisheries and Aquatic Sciences, v. 48, no. 11, p. 2,118–2,128.

26. Froese, R., and Pauly, D., eds., 2012, FishBase—Global information system on fishes: FishBase database, accessed July 8, 2012, at http://www.fishbase.org.

27. Antonelis, G.A., and Fiscus, C.H., 1980, The pinnipeds of the California current: California Cooperative Oceanic Fisheries Investigations Reports, v. 21, p. 68–78.

28. Tricas, T.C., and McCosker, J.E., 1984, Predatory behavior of the white shark (*Carcharodon carcharias*), with notes on biology: Proceedings of the California Academy of Sciences, v. 43, no. 14, p. 221–238.

29. Flinn, R.D., Trites, A.W., Gregr, E.J., and Perry, R.I., 2002, Diets of fin, sei, and sperm whales in British Columbia—An analysis of commercial whaling records, 1963–1967: Marine Mammal Science, v. 18, no. 3, p. 663–679.

30. Hulbert, L.B., Sigler, M.F., and Lunsford, C.R., 2006, Depth and movement behaviour of the Pacific sleeper shark in the north-east Pacific Ocean: Journal of Fish Biology, v. 69, no. 2, p. 406–425.

31. Sigler, M.F., Hulbert, L.B., Lunsford, C.R., Thompson, N.H., Burek, K., O'Corry-Crowe, G., and others, 2006, Diet of Pacific sleeper shark, a potential Steller sea lion predator, in the north-east Pacific Ocean: Journal of Fish Biology, v. 69, no. 2, p. 392–405.

Arctic Skate (*Amblyraja hyperborea*)
(Collett, 1879)

Family Rajidae

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

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

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

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

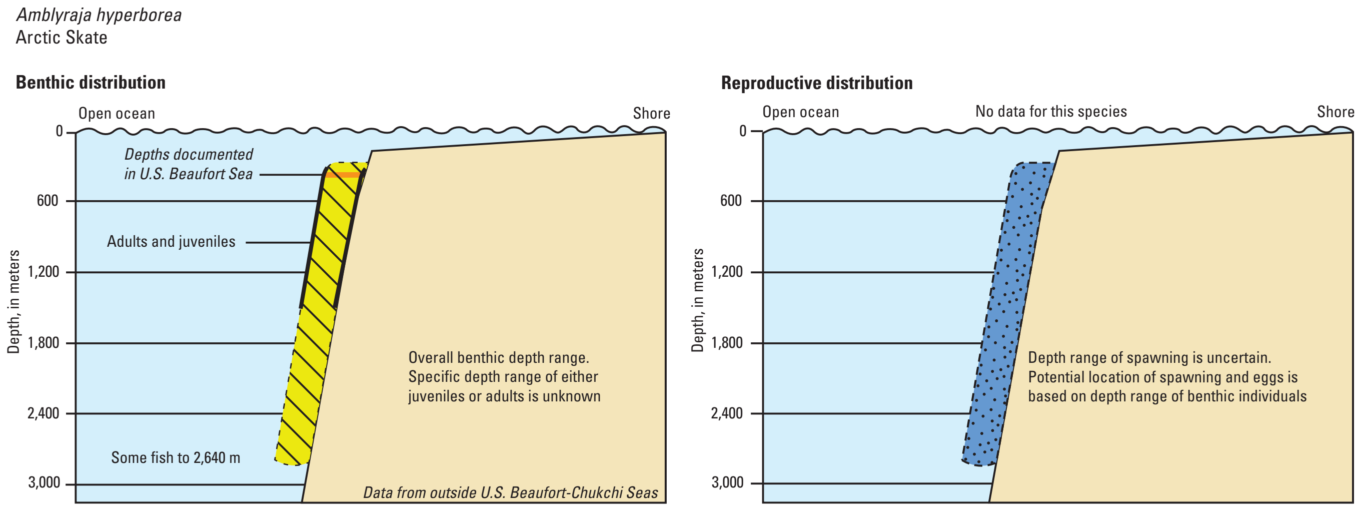
Arctic Skate (*Amblyraja hyperborea*), continental slope off Barents Sea, 2011. Photograph by Arve Lynghammar, University of Tromsø, Norway.

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

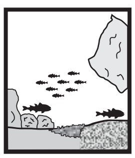
Relative Abundance: *Absent from U.S. Beaufort Sea continental shelf, one record from the continental slope about 50 miles north-northeast of Brownlow Point at 70°51'N, 145°17'W; absent from Chukchi Sea* [4, 7]. Common off east and west Greenland, throughout the Norwegian Basin, and in Barents Sea [1,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

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

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

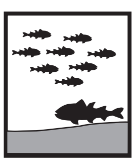


Benthic and reproductive distribution of Arctic Skate (*Amblyraja hyperborea*).



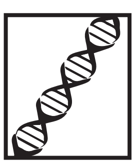
Habitats and Life History

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



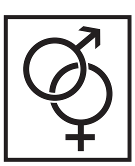
Behavior

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



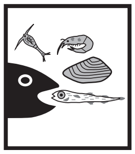
Populations or Stocks

There have been no studies.



Reproduction

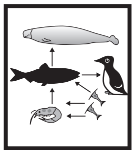
Mode—Oviparous [1, 2, 5, 9].
Spawning season—Unknown.
Fecundity—Less than 100 [10].



Food and Feeding

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

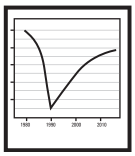
Trophic level—3.84 (standard error 0.58) [10]



Biological Interactions

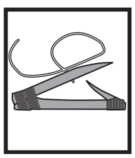
Predators—Unknown.

Competitors—Perhaps eelpouts and other benthic feeders.



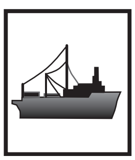
Resilience

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



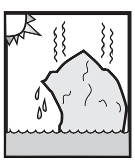
Traditional and Cultural Importance

None reported.



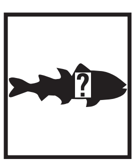
Commercial Fisheries

Currently, Arctic Skate are not commercially fished.



Potential Effects of Climate Change

Unknown.



Areas for Future Research [B]

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

References Cited

Jensen, A.S., 1948, A contribution to the ichthyofauna of Greenland: Spoila Zoologica Musei Hauniensis, v. 9, p. 27–57. [1]

Mecklenburg, C.W., Møller, P.R., and Steinke, D., 2011, Biodiversity of Arctic marine fishes—Taxonomy and zoogeography: Marine Biodiversity, v. 41, no. 1, p. 109–140, Online Resource 1. [4]

Stehmann, M., and Bürkel, D.L., 1984, Rajidae, *in* Whitehead, P.J.P., and others, eds., Fishes of the North-eastern Atlantic and the Mediterranean: Paris, Unesco, p. 163–196. [2]

Wienerroither, R., Johannesen, E., Langøy, H., Børve Eriksen, K., de Lange Wenneck, T., Høines, Å., Bjelland, O., Aglen, A., Prokhorova, T., Murashko, P., Prozorkevich, D., Konstantin, Byrkjedal, I., Langhelle Drevetnyak, and G., Smirnov, O., 2011, Atlas of the Barents Sea fishes: IMR/PINRO Joint Report Series 1-2011, ISSN 1502-8828, 274 p. [5]

Bibliography

1. Jensen, A.S., 1948, A contribution to the ichthyofauna of Greenland: Spoila Zoologica Musei Hauniensis, v. 9, p. 27–57.
2. Stehmann, M., and Bürkel, D.L., 1984, Rajidae, *in* Whitehead, P.J.P., and others, eds., Fishes of the North-eastern Atlantic and the Mediterranean: Paris, Unesco, p. 163–196.
3. Mecklenburg, C.W., Mecklenburg, T.A., and Thorsteinson, L.K., 2002, Fishes of Alaska: Bethesda, Maryland, American Fisheries Society, 1,116 p.
4. 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.
5. Wienerroither, R., Johannesen, E., Langøy, H., Børve Eriksen, K., de Lange Wenneck, T., Høines, Å., Bjelland, O., Aglen, A., Prokhorova, T., Murashko, P., Prozorkevich, D., Konstantin, Byrkjedal, I., Langhelle Drevetnyak, and G., Smirnov, O., 2011, Atlas of the Barents Sea fishes: IMR/PINRO Joint Report Series 1-2011, ISSN 1502-8828, 274 p.
6. Minerals Management Service, 2008, Beaufort Sea and Chukchi Sea planning areas—Oil and Gas Lease Sales 209, 212, 217, and 221: U.S. Department of the Interior, Minerals Management Service Alaska OCS Region, OCS EIS/EA, MMS 2008-0055, 538 p.
7. Mecklenburg, C.W., Mecklenburg, T.A., Sheiko, B.A., and Steinke, D., 2016, Pacific Arctic marine fishes: Akureyri, Iceland, Conservation of Arctic Flora and Fauna, Monitoring Series Report No. 23, 406 p., accessed May 10, 2016, at http://caff.is/monitoring-series/370-pacific-arctic-marine-fishes.
8. Essipov, V.K., 1937, On the fishes of the Polar Basin and adjacent deep waters: Problemy Arktiki, v. 4, p. 85–97. [In Russian.]
9. Love, M.S., 2011, Certainly more than you wanted to know about the fishes of the Pacific Coast: Santa Barbara, California, Really Big Press, 649 p.
10. Froese, R., and Pauly, D., eds., 2012, FishBase—Global information system on fishes: FishBase database, accessed July 8, 2012, at http://www.fishbase.org.

Pacific Herring (*Clupea pallasii*)
Valenciennes, 1847

Family Clupeidae

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

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

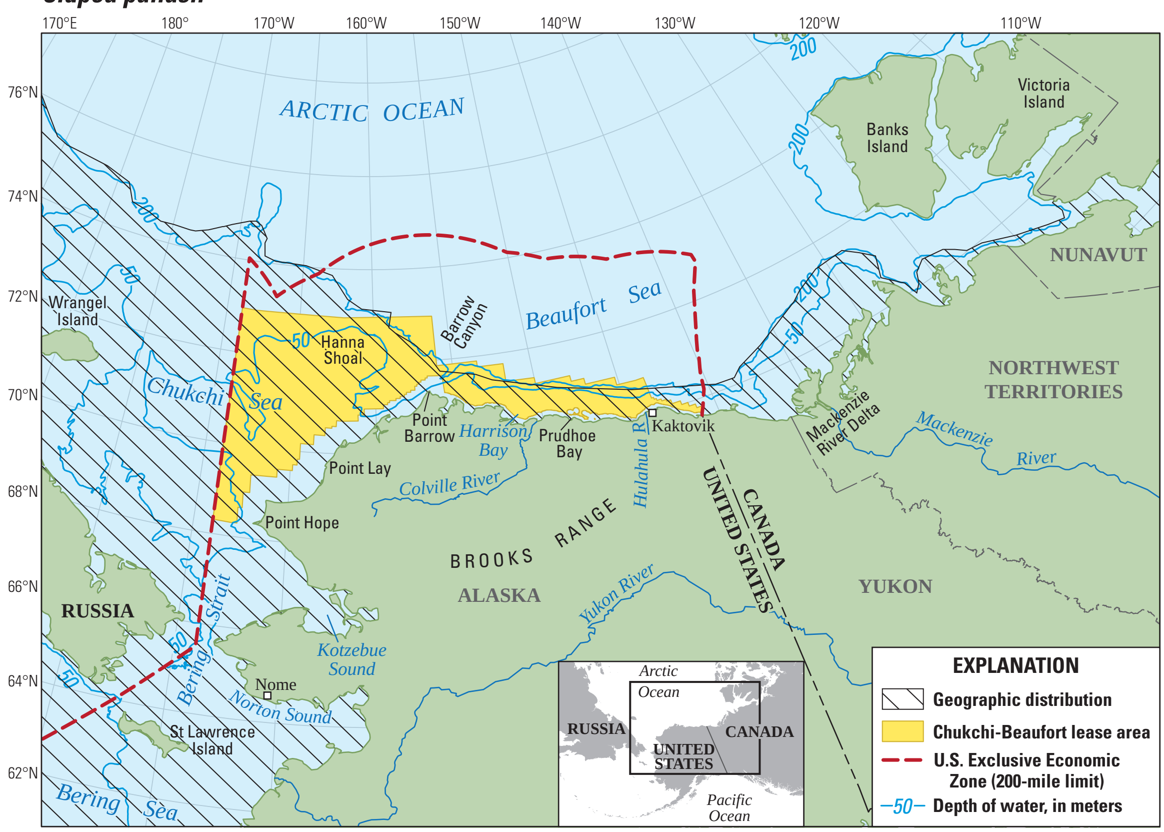
Ecological Role: Based on patterns of abundance, Pacific Herring likely are of considerable importance in the U.S. Chukchi Sea and of less importance in the U.S. Beaufort Sea.

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

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

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

Pacific Herring
Clupea pallasii

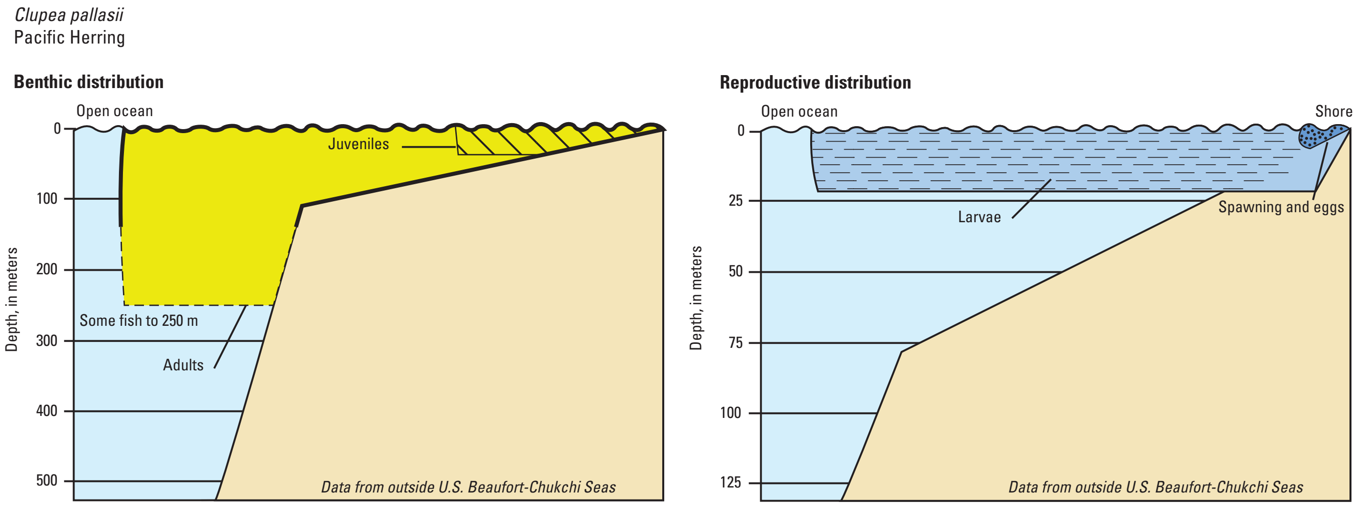


Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

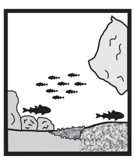
0 50 100 200 MILES
0 50 100 200 KILOMETERS

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

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



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



Habitats and Life History

Eggs—Size: 1.2–1.8 mm when mature [21]. Time to hatching: 6–21 days [18, 22]. Habitat: Nearshore, on kelp, eelgrass, other plant material, and on rocks and other solid surfaces [23].

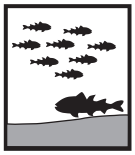
Larvae—Size at hatching: 5.6–7.5 mm SL [21]. Size at juvenile transformation: Metamorphosis starts at 26 mm TL and completes by 35 mm TL [24]. Days to juvenile transformation: About 2–3 months [24]. Habitat: Epipelagic, in ocean currents [24]. Most abundant near surface in estuarine-influenced waters [20, 25].

Juveniles—Age and size: 35–150 mm TL, depending on region [24]. Habitat: Epipelagic; often found among kelp and eelgrass, and over soft sea floors [15, 17].

Adults—Age and size at first maturity: With a few exceptions, depends on water temperatures. Fish mature earlier in warmer waters (and lower latitudes) [24, 26]; 2 years in California, 3–5 years in eastern Bering Sea [24, 27], and 6 years or older in Canadian Beaufort Sea [28]. Fish in California have shorter life spans and smaller maximum lengths than do those in the north [18]. 13–26 cm TL, depending on region [29]. Growth patterns are highly variable throughout the species' geographic range as groups of fish living even tens of kilometers apart can grow at significantly different rates [7, 22, 24]. Maximum age: As old as 19 years [14], but rarely more than 15 years [4, 30]. Maximum size: 46 cm TL [2]. Habitat: Epipelagic.

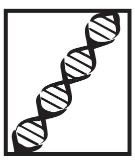
Substrate—Kelp, eelgrass, other plant material, rocks and other solid surfaces for spawning [23].

Physical/chemical—Temperature: -1.7 °C to at least 20 °C [31–33]. Salinity: Marine and brackish waters [24]. Occasionally enter rivers [28, 34]. Eggs can survive between 6.1–34.2 parts per thousand [35] and 8-hour exposures to air twice daily [36].

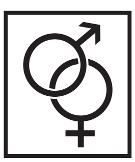


Behavior

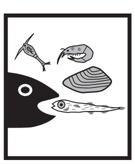
Diel—At dawn and dusk, larvae, juveniles, and adults move toward the surface to feed [24].
Seasonal—Spawning, over-wintering, and migration patterns are highly variable. For example, within Tuktoyaktuk Harbor (Beaufort Sea) fish remain for most of the year, leaving the harbor only for a few months during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



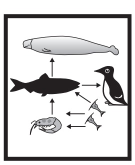
Populations or Stocks
Coastal sampling and aerial surveys have provided limited information about abundance. No detailed studies regarding populations or stocks have been conducted.



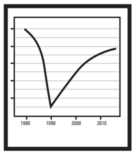
Reproduction
Mode—Gonochoristic, oviparous, and iteroparous with external fertilization [24].
Spawning season—June–September in the Canadian Beaufort Sea [14, 24, 25] where spawning begins in late spring and early summer around the time of ice break up when waters reach at least 2.5 °C [28, 31]. Spawning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



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

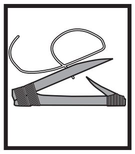


Biological Interactions
Predators—*Little is known. Beluga whales in spring near Barrow* [48, 49]. Elsewhere, all life stages, from eggs to adults, are heavily preyed upon by many species of fishes, seabirds, and marine mammals [16, 50].
Competitors—*Unknown, although likely to include various whitefishes,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



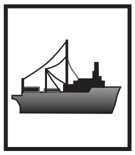
Resilience

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



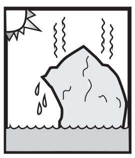
Traditional and Cultural Importance

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



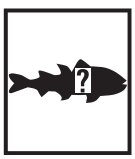
Commercial Fisheries

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



Potential Effects of Climate Change

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



Areas for Future Research [A]

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

Remarks

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

References Cited

Bond, W.A., 1982, A study of the fishery resources of Tuktoyaktuk Harbour, southern Beaufort Sea coast, with special reference to life histories of anadromous coregonids: Canadian Technical Report of Fisheries and Aquatic Sciences, no. 1119, 90 p. [28]

Lawrence, M.J., Lacho, G., and Davies, S., 1984, A survey of the coastal fishes of the southeastern Beaufort Sea: Canadian Technical Report of Fisheries and Aquatic Sciences, no. 1220, 178 p. [14]

Mecklenburg, C.W., Mecklenburg, T.A., and Thorsteinson, L.K., 2002, Fishes of Alaska: Bethesda, Maryland, American Fisheries Society, 1,116 p. [2]

Miller, D.J., and Schmidtke, J., 1956, Report on the distribution and abundance of Pacific herring (*Clupea pallasi*) along the coast of central and southern California: California Fish and Game, v. 42, no. 3, p. 163–187. [18]

Stout, H.A., Gastafson, R.G., Lenarz, W.H., McCain, B.B., VanDoornik, D.M., Builder, T.L., and Methot, R.D., 2001, Status review of Pacific herring (*Clupea pallasi*) in Puget Sound, Washington: National Oceanic and Atmospheric Administration Technical Memorandum NMFS-NWFSC-45, 175 p. [24]

Bibliography

1. Craig, P.C., 1987, Subsistence fisheries at coastal villages in the Alaskan Arctic, 1970–1986: U.S. Department of the Interior, Minerals Management Service, OCS Study MMS 87-6044, Technical Report No. 129, 63 p.

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

3. 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.

4. Stewart, D.B., Ratynski, R.A., Bernier, L.M.J., and Ramsey, D.J., 1993, A fishery development strategy for the Canadian Beaufort Sea-Amundsen Gulf area: Canadian Technical Report Fisheries and Aquatic Sciences 1910, 135 p.

5. Minerals Management Service, 2008, Beaufort Sea and Chukchi Sea planning areas—Oil and Gas Lease Sales 209, 212, 217, and 221: U.S. Department of the Interior, Minerals Management Service Alaska OCS Region, OCS EIS/EA, MMS 2008-0055, 538 p.

6. Mecklenburg, C.W., Mecklenburg, T.A., Sheiko, B.A., and Steinke, D., 2016, Pacific Arctic marine fishes: Akureyri, Iceland, Conservation of Arctic Flora and Fauna, Monitoring Series Report No. 23, 406 p., accessed May 10, 2016, at http://caff.is/monitoring-series/370-pacific-arcticmarine-fishes.

7. Wolotira, R.J., Jr., Sample, T.M., and Morin, M., Jr., 1977, Demersal fish and shellfish resources of Norton Sound, the southeastern Chukchi Sea, and adjacent waters in the baseline year 1976: Seattle, Washington, Northwest and Alaska Fisheries Center, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Processed Report, 69 p.

8. Fechhelm, R.G., Craig, P.C., Baker, J.S., and Gallaway, B.J., 1984, Fish distribution and use of nearshore waters in the northeastern Chukchi Sea: LGL Ecological Research Associates Inc., Outer Continental Shelf Environmental Assessment Program, National Oceanic and Atmospheric Administration, OMPA/OCSEAP, Final Report, 190 p.

9. Craig, P.C., and Haldorson, L.J., 1981, Beaufort Sea Barrier Island Lagoon ecological process studies—Final report, Simpson Lagoon—Fish: U.S. Department of Commerce, Biological Studies, p. 384–649.

10. Fruge, D.J., Wiswar, D.W., Dugan, L.J., and Palmer, D.E., 1989, Fish population characteristics of Arctic National Wildlife Refuge coastal waters, summer 1988: Fairbanks, Alaska, U.S. Fish and Wildlife Service, Fishery Assistance office, Progress Report, 73 p.

11. Palmer, D.E., and Dugan, L.J., 1990, Fish population characteristics of Arctic National Wildlife Refuge coastal waters, summer 1989: Fairbanks, Alaska, U.S. Fish and Wildlife Service, Progress Report, 83 p.

12. Wiswar, D.W., and Frugé, D.J., 2006, Fisheries investigations in western Camden Bay, Arctic National Wildlife Refuge, Alaska, 1987: Alaska Fisheries Data Series, U.S. Fish and Wildlife Service, 2006-10, 49 p.

13. Kendel, R.E., Johnston, R.A.C., Lobsiger, U., and Kozak, M.D., 1975, Fishes of the Yukon coast: Victoria, British Columbia, Department of the Environment (Canada), Beaufort Sea Project, Technical Report 6, 114 p.

14. Lawrence, M.J., Lacho, G., and Davies, S., 1984, A survey of the coastal fishes of the southeastern Beaufort Sea: Canadian Technical Report of Fisheries and Aquatic Sciences, no. 1220, 178 p.

15. Rosenthal, R.J., 1980, Shallow water fish assemblages in the northeastern Gulf of Alaska—Habitat evaluation, species composition, abundance, spatial distribution and trophic interaction, *in* Bureau of Land Management, Environmental assessment of the Alaskan Continental Shelf, final reports of principal investigators: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, p. 451–540.

16. Hay, D.E., Healey, M.C., Ware, D.M., and Wilimovsky, N.J., 1992, Distribution, abundance, and habitat of prey fish on the west coast of Vancouver Island, *in* Vermeer, K., Butler, R.W., and Morgan, K.H., eds., The ecology, status, and conservation of marine and shoreline birds on the west coast of Vancouver Island: Canadian Wildlife Service, Occasional Paper, no. 75, p. 22–50.

17. Johnson, S.W., Neff, A.D., and Thedinga, J.F., 2005, An atlas on the distribution and habitat of common fishes in shallow nearshore waters of southeastern Alaska: Alaska Fisheries Science Center, Technical Memorandum NMFS-AFSC-157, 98 p.

18. Miller, D.J., and Schmidtke, J., 1956, Report on the distribution and abundance of Pacific herring (*Clupea pallasi*) along the coast of central and southern California: California Fish and Game, v. 42, no. 3, p. 163–187.

19. Chereshnev, I., Nazarkin, M.V., Skopets, M.B., Pitruk, D., Shestakov, A.V., Yabe, M., and others, 2001, Annotated list of fish-like vertebrates and fish in Tauisk Bay (northern part of the Sea of Okhotsk), *in* Andreev, A.V., and Bergmann, H.H., eds., Biodiversity and ecological status along the northern coast of the Sea of Okhotsk—A collection of study reports: Dalnauka Vladivostok, Russia, Institute of Biological Problems of the North, p. 64–86.

20. Sareault, J., 2009, Marine larval fish assemblages in the nearshore Canadian Beaufort Sea during July and August: Winnipeg, University of Manitoba, Master's thesis, 146 p.

21. Moser, H.G., 1996, The early stages of fishes in the California current region: Atlas, California Cooperative Oceanic Fisheries Investigations, no. 33, 1,505 p.

22. Wespestad, V.G., and Barton, L.H., 1981, Distribution, migrations, and status of Pacific herring, *in* Hood, D.W., and Calder, J.A., eds., The Eastern Bering Sea Shelf—Oceanography and Resources: National Oceanic and Atmospheric Administration, p. 509–524.

23. Eldridge, M.B., and Kaill, W.M., 1973, San Francisco Bay area's herring resource—A colorful past and a controversial future: Marine Fisheries Review, v. 35, no. 11, p. 25–31.

24. Stout, H.A., Gastafson, R.G., Lenarz, W.H., McCain, B.B., VanDoornik, D.M., Builder, T.L., and Methot, R.D., 2001, Status review of Pacific herring (*Clupea pallasi*) in Puget Sound, Washington: National Oceanic and Atmospheric Administration Technical Memorandum NMFS-NWFSC-45, 175 p.

25. Ratynski, R.A., 1983, Mid-summer ichthyoplankton populations of Tuktoyaktuk Harbour, N.W.T.: Canadian Technical Report of Fisheries and Aquatic Sciences, no. 1218, 21 p.

26. Hay, D.E., 1985, Reproductive biology of Pacific herring (*Clupea harengus pallasi*): Canadian Journal of Fisheries and Aquatic Sciences, v. 42, suppl. 1, p. 111–126.

27. Dudnik, Y.I., and Usol'tsev, E.A., 1964, The herrings of the eastern part of the Bering Sea, Moiseev, P.A., ed., *in* Soviet fisheries investigations in the Northeastern Pacific, part 1: Jerusalem, Israel Program for Scientific Translations [1968], p. 236–240.

28. Bond, W.A., 1982, A study of the fishery resources of Tuktoyaktuk Harbour, southern Beaufort Sea coast, with special reference to life histories of anadromous coregonids: Canadian Technical Report of Fisheries and Aquatic Sciences, no. 1119, 90 p.

29. Emmett, R.L., Stone, S.L., Hinton, S.A., and Monaco, M.E., 1991, Distribution and abundance of fishes and invertebrates in west coast estuaries, Volume II—Species life history summaries: NOAA/NOS Strategic Environmental Assessments Division, ELMR Report no. 8, 327 p.

30. Barton, L.H., 1978, Finfish resource surveys in Norton Sound and Kotzebue Sound: Alaska Department of Fish and Game, Commercial Fisheries Division, p. 75–313.

31. Gillman, D.V., and Kristofferson, A.H., 1984, Biological data on Pacific herring (*Clupea harengus pallasi*) from Tuktoyaktuk Harbour and the Liverpoor Bay area, Northwest Territories, 1981 to 1983: Winnipeg, Manitoba, Canada, Canadian Data Report of Fisheries and Aquatic Sciences, Department of Fisheries and Oceans, Western Region, no. 485, 22 p.

32. Grosse, D.J., and Hay, D.E., 1988, Pacific herring, *Clupea harengus pallasi*, in the northeast Pacific and Bering Sea, *in* Wilimovsky, N.J., Incze, L.S., and Westrheim, S.J., eds., Species synopses—Life histories of selected fish and shellfish of the northeast Pacific and Bering Sea: Seattle, University of Washington, Washington Sea Grant Program and Fisheries Research Institute, p. 34–54.

33. Mueter, F.J., University of Alaska-Fairbanks, written commun., 2010.

34. McAllister, D.E., 1959, Records of marine fishes from fresh water in British Columbia: The Canadian Field-Naturalist, v. 73, no. 1, p. 13–14.

35. McMynn, R.G., and Hoar, W.S., 1953, Effects of salinity on the development of the Pacific herring: Canadian Journal of Zoology, v. 31, no. 4, p. 417–432.

36. Jones, B.C., 1972, Effect of intertidal exposure on survival and embryonic development of Pacific herring spawn: Journal of the Fisheries Research Board of Canada, v. 29, no. 8, p. 1,119–1,124.

37. Sekerak, A.D., Stallard, N., and Griffiths, W.B., 1992, Distribution of fish and fish harvests in the nearshore Beaufort Sea and Mackenzie Delta during ice-covered periods, October–June: Environmental Studies Research Funds Report, LGS Ltd. No. 117, 524 p.

38. Moser, M., and Hsieh, J., 1992, Biological tags for stock separation in Pacific herring *Clupea harengus pallasi* in California: Journal of Parasitology, v. 78, no. 1, p. 54–60.

39. O’Connell, M., Dillon, M.C., Wright, J.M., Bentzen, P., Merkouris, S.E., and Seeb, J.E., 1998, Genetic structuring among Alaskan Pacific herring populations identified using microsatellite variation: Journal of Fish Biology, v. 53, no. 1, p. 150–163.

40. Sherwood, N.M., Kyle, A.L., Kreiberg, H., Warby, C.M., Magnus, T.H., Carolsfeld, J., and others, 1991, Partial characterization of a spawning pheromone in the herring *Clupea harengus pallasi*: Canadian Journal of Zoology, v. 69, no. 1, p. 91–103.

41. Hay, D.E., and McKinnell, S.M., 2002, Tagging along—Association among individual Pacific herring (*Clupea pallasi*) revealed by tagging: Canadian Journal of Fisheries and Aquatic Sciences, v. 59, no. 12, p. 1,960–1,968.

42. Percy, R., 1975, Fishes of the outer Mackenzie Delta: Victoria, British, Beaufort Sea Project, Beaufort Sea Technical Report, no. 8, 114 p.

43. Paulson, A.C., and Smith, R.L., 1977, Latitudinal variation of Pacific herring fecundity: Transactions of the American Fisheries Society, v. 106, no. 3, p. 244–247.

44. Jones, M.L., and Den Beste, J., 1977, Tuft Point and adjacent coastal areas fisheries projects: Calgary, Alberta, Canada, Aquatic Environments, Ltd., 152 p.

45. Craig, P.C., and Schmidt, D.R., 1985, Fish resources at Point Lay, Alaska: Barrow, Alaska, LGL Alaska Research Associates, Inc., North Slope Borough, Materials Source Division, 105 p.

46. Lacho, G., 1991, Stomach content analyses of fishes from Tuktoyaktuk Harbour, N.W.T., 1981: Winnipeg, Manitoba, Canadian Data Report of Fisheries and Aquatic Sciences, Central and Arctic Region, Department of Fisheries and Oceans, no. 853, 15 p.

47. Mueter, F.J., and Litzow, M.A., 2008, Sea ice retreat alters the biogeography of the Bering Sea continental shelf: Ecological Applications, v. 18, no. 2, p. 309–320.

48. Seaman, G.A., Lowry, L.F., and Frost, K.J., 1982, Food of beluga whales (*Delphinapterus leucas*) in western Alaska: Cetology, v. 44, p. 1–19.

49. Lowry, L.F., Frost, K.J., and Seaman, G.A., 1986, Investigations of belukha whales in coastal waters of western and northern Alaska: Outer Continental Shelf Environmental Program Unit 612, Final Report, p. 359–392.

50. Gerke, B.L., 2002, Spawning habitat characteristics of Pacific herring (*Clupea pallasii*) in Prince William Sound, Alaska: Fairbanks, University of Alaska, Master’s thesis, 112 p.

51. Froese, R., and Pauly, D., eds., 2012, FishBase—Global information system on fishes: FishBase database, accessed July 8, 2012, at http://www.fishbase.org.

52. Bean, T.H., 1887, The fishery resources and fishing-grounds of Alaska, *in* Goode, G.B., ed., The fisheries and fishery industries of the United States, Section III: United States Commission of Fish and Fisheries, p. 81–115.

53. Grant, W.S., 1986, Biochemical genetic divergence between Atlantic, *Clupea harengus*, and Pacific, C. pallasi, herring: Lawrence, Kansas, Copeia, no. 3, p. 714–719.

54. Domanico, M.J., Phillips, R.B., and Schweigert, J.F., 1996, Sequence variation in ribosomal DNA of Pacific (*Clupea pallasi*) and Atlantic herring (*Clupea harengus*): Canadian Journal of Fisheries and Aquatic Sciences, v. 53, no. 11, p. 2,418–2,423.

Pond Smelt (*Hypomesus olidus*)

(Pallas, 1814)

Family Osmeridae

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

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

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

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

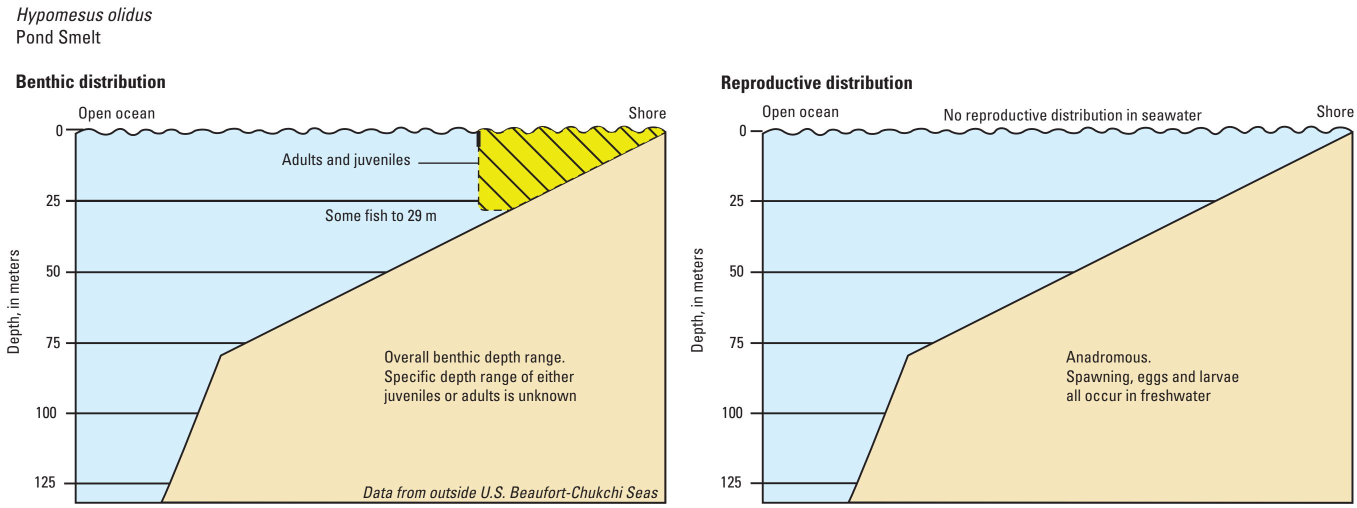
Physical Description/Attributes: Grey- or olive-green to yellow-brown dorsally becoming silvery white on belly. Snout and operculum are covered with black mottles or spots [2, 3]. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 172) [3]. Swim bladder: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

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

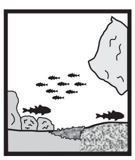
Relative Abundance: *Absent or rare in coastal waters of the U.S. Chukchi and Beaufort Seas.* Elsewhere, common at least as far north as Port Clarence, northeastern Bering Sea [1], wherePond Smelt is occasionally found well offshore [6]. Common in fresh water and occasional in coastal, brackish conditions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

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

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



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



Habitats and Life History

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

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

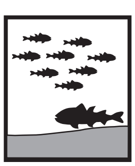
Larvae—Size at hatching: 4.6 mm long [12, 13]. Size at juvenile transformation: Unknown. Days to juvenile transformation: Unknown. Habitat: Pelagic, in freshwater rivers and lakes [12–15].

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

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

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

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



Behavior

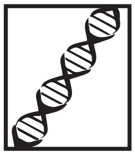
Diel—Unknown. Unidentified osmerid larvae in Auke Bay (southeastern Alaska) migrated to surface waters at midnight [23].

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

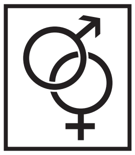
Reproductive—Spawning occurs in rivers and lakes. Some populations in Asia ascend rivers from coastal waters in spring, just before spawning, whereas others migrate into fresh waters in autumn and overwinter prior to spawning [17]. Spawning takes place at dusk. Eggs are laid on submerged vegetation or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

Schooling—Forms schools [13].

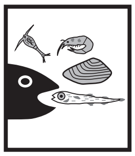
Feeding—Some populations do not feed during spawning season [20] although this is not a universal behavior [12].



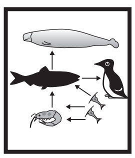
Populations or Stocks
There have been no studies.



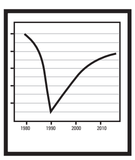
Reproduction
Mode—Oviparous [15].
Spawning season—Spawning in North America takes place at least during May–July [10, 19] and as early as April in Asia [13].
Fecundity—4,820–33,010 adhesive egg, spawned in a single batch (around Sakhalin Island, Russia) [12].



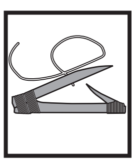
Food and Feeding
Food items—Primarily midwater crustaceans (for example, mysids, copepods, amphipods, and isopods), insects, snails, and small fishes [10, 18, 20, 24, 25].
Trophic level—3.21 (standard error 0.42) [11].



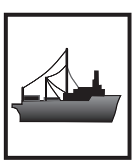
Biological Interactions
Predators—Beluga whales during May and June in Bristol Bay [26]. Inconnu and Northern Pike in North American Arctic fresh waters [10].
Competitors—Potentially midwater planktivores such as Arctic Cod, Pacific Herring, and Capelin, and other coastal fishes.



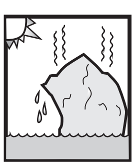
Resilience
Medium, minimum population doubling time: 1.4–4.4 years (t_m=2; t_{max}=5) [11].



Traditional and Cultural Importance
None reported.



Commercial Fisheries
Currently, Pond Smelt are not commercially harvested.



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

Areas for Future Research [B]

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

References Cited

Chereshnev, I., Shestakov, A.V., and Skopets, M.B., 1999, On the distribution of silver smelts of the genus *Hypomesus* (Osmeridae) in the northern part of the Sea of Okhotsk: Journal of Ichthyology, v. 39, no. 7, p. 498–503. [2]

DeGraaf, D.A., 1986, Aspects of the life history of the pond smelt (*Hypomesus olidus*) in the Yukon and Northwest Territories: Arctic, v. 39, no. 3, p. 260–263. [10]

Gritsenko, O.F., Churikov, A.A., and Rodionova, S.S., 1984a, The ecology of the pond smelt, *Hypomesus olidus* (Osmeridae), on Sakhalin: Journal of Ichthyology, v. 24, no. 4, p. 91–100. [12]

Mecklenburg, C.W., Mecklenburg, T.A., and Thorsteinson, L.K., 2002, Fishes of Alaska: Bethesda, Maryland, American Fisheries Society, 1,116 p. [3]

Musienko, L.N., 1970, Reproduction and development of Bering Sea fishes, *in* Moiseev, P.A., ed., Soviet fisheries investigations in the northeastern Pacific—part V: Jerusalem, Israel Program for Scientific Translations, p. 161–224. [13]

Bibliography

1. Barton, L.H., 1978, Finfish resource surveys in Norton Sound and Kotzebue Sound: Alaska Department of Fish and Game, Commercial Fisheries Division, p. 75–313.
2. Chereshnev, I., Shestakov, A.V., and Skopets, M.B., 1999, On the distribution of silver smelts of the genus *Hypomesus* (Osmeridae) in the northern part of the Sea of Okhotsk: Journal of Ichthyology, v. 39, no. 7, p. 498–503.
3. Mecklenburg, C.W., Mecklenburg, T.A., and Thorsteinson, L.K., 2002, Fishes of Alaska: Bethesda, Maryland, American Fisheries Society, 1,116 p.
4. Jørgensen, R., 2003, The effects of swimbladder size, condition and gonads on the acoustic target strength of mature capelin: ICES Journal of Marine Science, v. 60, no. 5, p. 1,056–1,062.
5. Minerals Management Service, 2008, Beaufort Sea and Chukchi Sea planning areas—Oil and Gas Lease Sales 209, 212, 217, and 221: U.S. Department of the Interior, Minerals Management Service Alaska OCS Region, OCS EIS/EA, MMS 2008-0055, 538 p.
6. Mecklenburg, C.W., Mecklenburg, T.A., Sheiko, B.A., and Steinke, D., 2016, Pacific Arctic marine fishes: Akureyri, Iceland, Conservation of Arctic Flora and Fauna, Monitoring Series Report No. 23, 406 p., accessed May 10, 2016, at http://caff.is/monitoring-series/370-pacific-arcticmarine-fishes.
7. 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.
8. DeGraaf, D.A., and Machniak, K., 1977, Fisheries investigations along the cross delta pipeline route in the MacKenzie Delta, *in* McCart, P.J., ed., Studies to determine the impact of gas pipeline development on aquatic ecosystems: Arctic Gas, Biological Report Series 39, p. 1–169.
9. Bond, W.A., 1982, A study of the fishery resources of Tuktoyaktuk Harbour, southern Beaufort Sea coast, with special reference to life histories of anadromous coregonids: Canadian Technical Report of Fisheries and Aquatic Sciences, no. 1119, 90 p.
10. DeGraaf, D.A., 1986, Aspects of the life history of the pond smelt (*Hypomesus olidus*) in the Yukon and Northwest Territories: Arctic, v. 39, no. 3, p. 260–263.

11. Froese, R., and Pauly, D., eds., 2012, FishBase—Global information system on fishes: FishBase database, accessed July 8, 2012, at http://www.fishbase.org.

12. Gritsenko, O.F., Churikov, A.A., and Rodionova, S.S., 1984a, The ecology of the pond smelt, *Hypomesus olidus* (Osmeridae), on Sakhalin: Journal of Ichthyology, v. 24, no. 4, p. 91–100.

13. Musienko, L.N., 1970, Reproduction and development of Bering Sea fishes, *in* Moiseev, P.A., ed., Soviet fisheries investigations in the northeastern Pacific—part V: Jerusalem, Israel Program for Scientific Translations, p. 161–224.

14. Berg, L.S., 1948, Freshwater fishes of the USSR and adjacent countries, volume 1 (4th ed.): Moscow, Academy of Sciences of the USSR Zoological Institute, 466 p. [Translated from Russian by Israel Program for Science Translation, Jerusalem, 505 p.]

15. Love, M.S., 2011, Certainly more than you wanted to know about the fishes of the Pacific Coast: Santa Barbara, California, Really Big Press, 649 p.

16. Lawrence, M.J., Lacho, G., and Davies, S., 1984, A survey of the coastal fishes of the southeastern Beaufort Sea: Canadian Technical Report of Fisheries and Aquatic Sciences, no. 1220, 178 p.

17. Hamada, K., 1961, Taxonomic and ecological studies of the genus *Hypomesus* of Japan: Hokkaido University, Memoirs of the Faculty of Fisheries, v. 9, no. 1, p. 1–55.

18. Percy, R., 1975, Fishes of the outer Mackenzie Delta: Victoria, British Columbia, Beaufort Sea Project, Beaufort Sea Technical Report, no. 8, 114 p.

19. Harvey, C.J., Ruggerone, G.T., and Rogers, D.E., 1997, Migrations of three-spined stickleback, nine-spined stickleback, and pond smelt in the Chignik catchment, Alaska: Journal of Fish Biology, v. 50, no. 5, p. 1,133–1,137.

20. Karpenko, V.I., and Vasilets, P.M., 1996, Biology of smelt (Osmeridae) in the Korf-Karagin coastal area of the southwestern Bering Sea, *in* Mathisen, O.A., and Coyle, K.O., eds., Ecology of the Bering Sea—A review of Russian literature: Fairbanks, Alaska, University of Alaska, Alaska Sea Grant Program, AK-SG-96-01, p. 217–235.

21. Reshetnikov, Y.S., Bogutskaya, N.G., Vasil'eva, E.D., Dorofeeva, E.A., Naseka, A.M., Popova, O.A., and others, 1997, An annotated check-list of the freshwater fishes of Russia: Journal of Ichthyology, v. 37, no. 9, p. 687–736.

22. Johnson, S.W., Thedinga, J.F., and Lindeberg, M.R., 2012, Nearshore fish atlas of Alaska: National Oceanic and Atmospheric Administration Fisheries, accessed February 2012 at http://www.fakr.noaa.gov/habitat/fishatlas/.

23. Haldorson, L.J., Prichett, M., Paul, A.J., and Ziemann, D., 1993, Vertical distribution and migration of fish larvae in a northeast Pacific bay: Marine Ecology Progress Series, v. 101, p. 67–80.

24. Martin, D.J., Glass, D.R., Whitmus, C.J., Simenstad, C.A., Milward, D.A., Volk, E.C., Stevenson, M.L., Nunes, P., Savoie, M., and Grotefendt, R.A., 1986, Distribution, seasonal abundance, and feeding dependencies of juvenile salmon and non-salmonid fishes in the Yukon River Delta: Outer Continental Shelf Environmental Assessment Program, Reports of Principal Investigators, U.S. Department of Commerce and U.S. Department of the Interior, 388 p.

25. Maksimenkov, V.V., and Tokranov, A.M., 1993, The diet of the pond smelt, *Hypomesus olidus*, in the Bol'shaya River Estuary (Western Kamchatka): Journal of Ichthyology, v. 33, no. 9, p. 11–21.

26. Lowry, L.F., Frost, K.J., and Seaman, G.A., 1986, Investigations of belukha whales in coastal waters of western and northern Alaska: Outer Continental Shelf Environmental Program Unit 612, Final Report, p. 359–392.

Pacific Capelin (*Mallotus catervarius*)

(Pennant, 1784)

Family Osmeridae

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

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

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

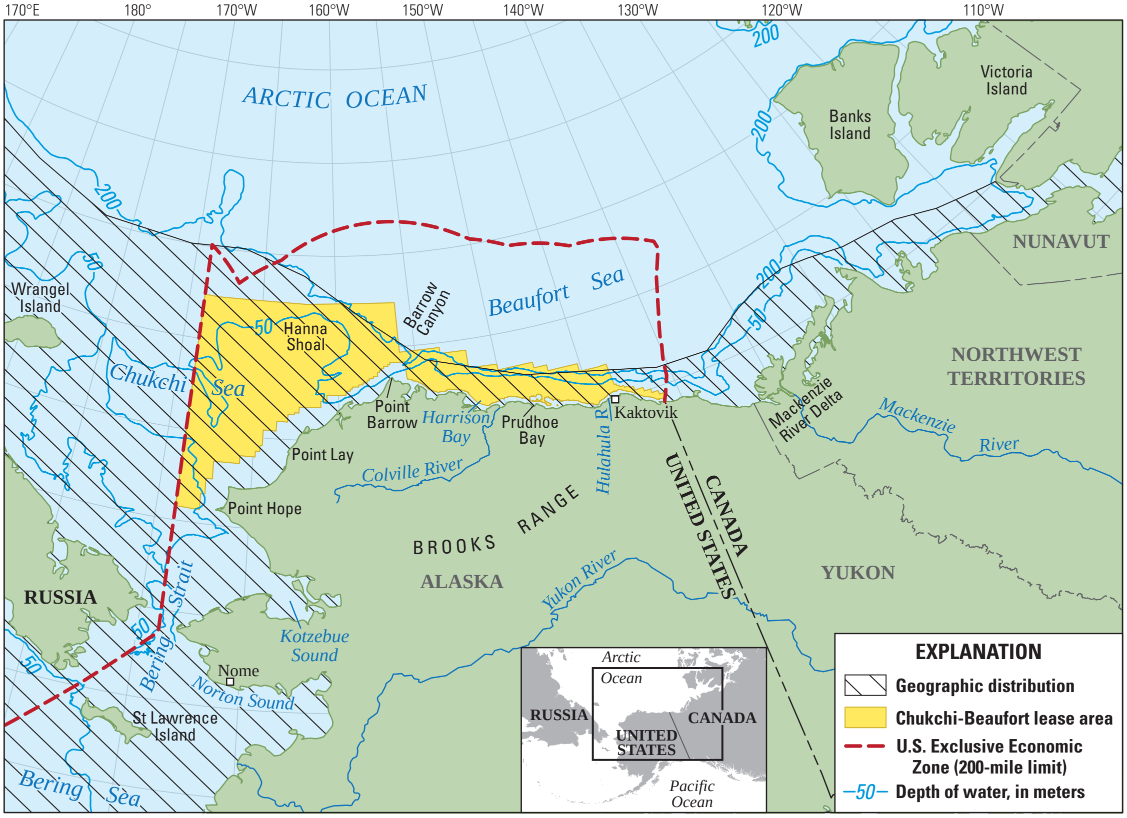
Ecological Role: The true abundance of Pacific Capelin is probably underestimated in existing survey data, but this species is hypothesized to be a major prey of many fish, birds, and marine mammals in the U.S. Chukchi and Beaufort Seas. Although its forage fish status is uncertain, its life history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

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

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

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

Pacific Capelin
Mallotus catervarius

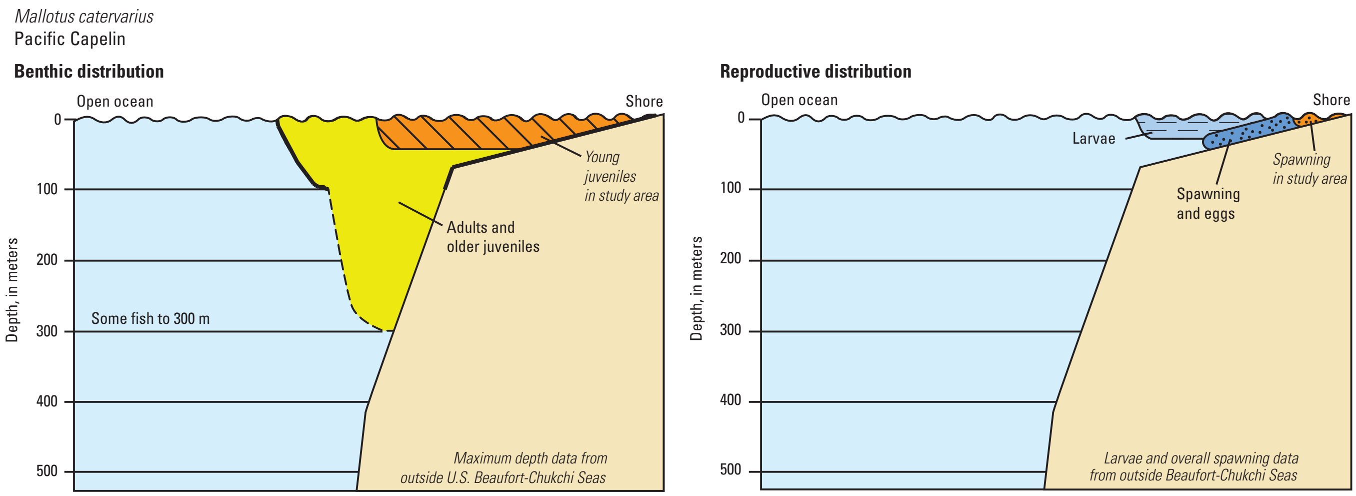


Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

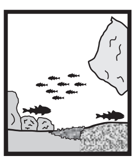
0 50 100 200 MILES
0 50 100 200 KILOMETERS

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

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



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



Habitats and Life History

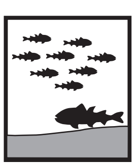
Eggs—Time to hatching: Unknown. Time to hatching: Unknown, but in *Mallotus villosus*, as much as 80 days at 2 °C, 30 days at 5 °C, and 15 days at 10 °C [22]. Size: Unknown. Once laid, eggs can survive as long as 6 hours at temperatures as low as -5 °C [25]. Habitat: *Spawning substrate has not been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

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

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

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

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



Behavior

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

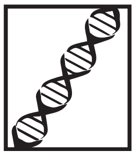
Diel—*Unknown.* Osmerid larvae in southeastern Alaska migrated to the surface at night [42].

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

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

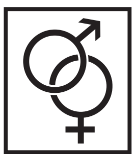
Schooling—*Capelin school in U.S. Chukchi and Beaufort Seas, but the extent of schools is unknown.* In the Gulf of Alaska, schools may be more than 1 km long and 20 m or more thick, and aggregations of schools may extend to 10 km [47].

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



Population or Stocks

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

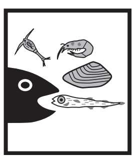


Reproduction

Mode—Separate sexes, oviparous. Fertilization is external.

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

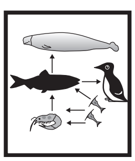
Fecundity—*Unknown.* Females release all of their eggs at one time and produce between 5,000 and 22,000 eggs [26]. Although not studied in the study area, in other locations most males die after the spawning season [26]. In some populations, substantial numbers of females may survive to spawn in the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



Food and Feeding

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

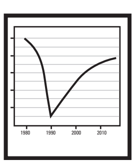
Trophic level—3.5 [60].



Biological Interactions

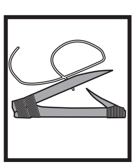
Predators—Besides the seabirds found at Capes Lisburne and Thompson, *Capelin are rarely reported in food habit studies in the U.S. Chukchi and Beaufort Seas. Ringed seals have eaten Capelin during the winter in the U.S. Chukchi Sea* [61]. In the Bering Sea, Gulf of Alaska, and eastern Canadian Arctic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

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



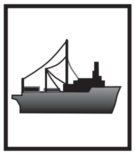
Resilience

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



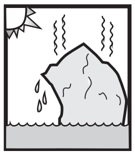
Traditional and Cultural Importance

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



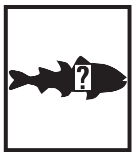
Commercial Fisheries

Currently, Pacific Capelin are not commercially harvested.



Potential Effects of Climate Change

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



Areas for Future Research [A]

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

References Cited

Craig, P.C., 1989a, An introduction to anadromous fishes in the Alaskan Arctic: Biological Papers of the University of Alaska, v. 24, p. 27–54. [2]

Craig, P.C., and Schmidt, D.R., 1985, Fish resources at Point Lay, Alaska: Barrow, Alaska, LGL Alaska Research Associates, Inc., North Slope Borough, Materials Source Division, 105 p. [1]

Fechhelm, R.G., Craig, P.C., Baker, J.S., and Gallaway, B.J., 1984, Fish distribution and use of nearshore waters in the northeastern Chukchi Sea: LGL Ecological Research Associates Inc., Outer Continental Shelf Environmental Assessment Program, National Oceanic and Atmospheric Administration, OMPA/OCSEAP, Final Report, 190 p. [9]

Hart, J.J., 1973, Pacific fishes of Canada: Ottawa, Fisheries Research Board of Canada, Bulletin 180 [74].

Mecklenburg, C.W., Mecklenburg, T.A., and Thorsteinson, L.K., 2002, Fishes of Alaska: Bethesda, Maryland, American Fisheries Society, 1.116 p. [3]

Pahlke, K.A., 1985, Preliminary studies of capelin (*Mallotus villosus*) in Alaskan waters: Alaska Department of Fish and Game, Informational Leaflet No. 250, 64 p. [26]

Thorsteinson, L.K., Jarvela, L.E., and Hale, D.A., 1990, Arctic fish habitat use investigations—Nearshore studies in the Alaskan Beaufort Sea, summer 1988: Final Report, Alaska Office, Ocean Assessments Division, National Oceanic and Atmospheric Administration, Research Unit 682, 125 p. [11]

Bibliography

1. Craig, P.C., and Schmidt, D.R., 1985, Fish resources at Point Lay, Alaska: Barrow, Alaska, LGL Alaska Research Associates, Inc., North Slope Borough, Materials Source Division, 105 p.

2. Craig, P.C., 1989a, An introduction to anadromous fishes in the Alaskan Arctic: Biological Papers of the University of Alaska, v. 24, p. 27–54.

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

4. Jørgensen, R., 2003, The effects of swimbladder size, condition and gonads on the acoustic target strength of mature capelin: ICES Journal of Marine Science, v. 60, no. 5, p. 1,056–1,062.

5. Raymond, J.A., and Hassel, A., 2000, Some characteristics of freezing avoidance in two osmerids, rainbow smelt and capelin: Journal of Fish Biology, v. 57, suppl. A, p. 1–7.

6. Hay, D.E., 1998, Historic changes in capelin and eulachon populations in the Strait of Georgia, *in* Pauly, D., Pitcher, T.J., Preikshot, David, Hearne, J., eds., Back to the future—Reconstructing the Strait of Georgia ecosystem: Vancouver, University of British Columbia, The Fisheries Center Research Reports, p. 42–44.

7. Minerals Management Service, 2008, Beaufort Sea and Chukchi Sea planning areas—Oil and Gas Lease Sales 209, 212, 217, and 221: U.S. Department of the Interior, Minerals Management Service Alaska OCS Region, OCS EIS/EA, MMS 2008-0055, 538 p.

8. Mecklenburg, C.W., Mecklenburg, T.A., Sheiko, B.A., and Steinke, D., 2016, Pacific Arctic marine fishes: Akureyri, Iceland, Conservation of Arctic Flora and Fauna, Monitoring Series Report No. 23, 406 p., accessed May 10, 2016, at http://caff.is/monitoring-series/370-pacific-arcticmarine-fishes.

9. Fechhelm, R.G., Craig, P.C., Baker, J.S., and Gallaway, B.J., 1984, Fish distribution and use of nearshore waters in the northeastern Chukchi Sea: LGL Ecological Research Associates Inc., Outer Continental Shelf Environmental Assessment Program, National Oceanic and Atmospheric Administration, OMPA/OCSEAP, Final Report, 190 p.

10. Fruge, D.J., Wiswar, D.W., Dugan, L.J., and Palmer, D.E., 1989, Fish population characteristics of Arctic National Wildlife Refuge coastal waters, summer 1988: Fairbanks, Alaska, U.S. Fish and Wildlife Service, Fishery Assistance office, Progress Report, 73 p.

11. Thorsteinson, L.K., Jarvela, L.E., and Hale, D.A., 1990, Arctic fish habitat use investigations—Nearshore studies in the Alaskan Beaufort Sea, summer 1988: Final Report, Alaska Office, Ocean Assessments Division, National Oceanic and Atmospheric Administration, Research Unit 682, 125 p.

12. Barber, W.E., Smith, R.L., Vallarino, M., and Meyer, R.M., 1997, Demersal fish assemblages of the northeastern Chukchi Sea, Alaska: Fishery Bulletin, v. 95, no. 2, p. 195–209.

13. Wiswar, D.W., and Frugé, D.J., 2006, Fisheries investigations in western Camden Bay, Arctic National Wildlife Refuge, Alaska, 1987: Alaska Fisheries Data Series, U.S. Fish and Wildlife Service, 2006-10, 49 p.

14. Johnson, S.W., Thedinga, J.F., Neff, A.D., and Hoffman, C.A., 2010, Fish fauna in nearshore waters of a Barrier Island in the western Beaufort Sea, Alaska: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Technical Memorandum, NMFSAFSC-210, 28 p.

15. 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.

16. Brown, E.D., 2002, Life history, distribution, and size structure of Pacific capelin in Prince William Sound and the northern Gulf of Alaska: ICES Journal of Marine Science, v. 59, p. 983–996.

17. Coad, B.W., and Reist, J.D., 2004, Annotated list of the Arctic marine fishes of Canada: Canadian Manuscript Report of Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, no. 2674, 112 p.

18. Jump, C.M., Duffy-Anderson, J.T., and Mier, K.L., 2008, Comparison of the Sameoto, Manta and MARMAP neustonic ichthyoplankton samplers in the Gulf of Alaska: Fisheries Research, v. 89, no. 3, p. 222–229.

19. Houghton, J.P., and Whitmus, C.J., 1988, Shallow neritic fish of the central Beaufort Sea: Seattle, Washington, Report prepared for Standard Alaska Production Company by Dames and Moore, 17298-002-20.

20. Bendock, T.N., 1977, Beaufort Sea estuarine fishery study: Alaska Department of Fish and Game Annual Report, Contract #03-5-022-69, p. 670–729.

21. Huse, G., 1998, Sex-specific life history strategies in capelin (*Mallotus villosus*): Canadian Journal of Fisheries and Aquatic Sciences, v. 55, no. 3, p. 631–638.

22. Gjøsaeter, H., 1998, The population biology and exploitation of capelin (*Mallotus villosus*) in the Barents Sea: Sarsia, v. 83, no. 6, p. 453–496.

23. Nakashima, B.S., and Taggart, C.T., 2002, Is beach-spawning success for capelin, *Mallotus villosus* (Müller), a function of the beach?: ICES Journal of Marine Science, v. 59, no. 5, p. 897–908.

24. Grégoire, F., Morneau, R., Caron, G., Beaudoin, M., Lévesque, C., Rose, C., and others, 2004, Fécondité du capelan (*Mallotus villosus*) dans l-estuaire de le golfe du Saint-Laurent en 2003: Rapport Technique Canadien Dessciences Halieutiques et Aquatiques, Ministère des Pêches et des Océans, Mont-Joli, Québec, no. 2560, 30 p.

25. Power, G., 1997, A review of fish ecology in Arctic North America: American Fisheries Society Symposium, no. 19, p. 13–39.

26. Pahlke, K.A., 1985, Preliminary studies of capelin (*Mallotus villosus*) in Alaskan waters: Alaska Department of Fish and Game, Informational Leaflet No. 250, 64 p.

27. Hart, J.L., and McHugh, J.L., 1944, The smelts (Osmeridae) of British Columbia: Fisheries Research Board of Canada, v. 64, 27 p.

28. Velikanov, A.Y., 1984, Ecology of reproduction of the fareastern capelin, *Mallotus villosus socialis* (Osmeridae), along the coasts of Sakhalin Island: Journal of Ichthyology, v. 24, no. 3, p. 43–48.

29. Davoren, G.K., Anderson, J.T., and Montevecchi, W.A., 2006, Shoal behaviour and maturity relations of spawning capelin (*Mallotus villosus*) off Newfoundland—Demersal spawning and diel vertical movement patterns: Canadian Journal of Fisheries and Aquatic Sciences, v. 63, no. 2, p. 268–284.

30. Jangaard, P.M., 1974, The capelin (*Mallotus villosus*): Fisheries Research Board of Canada, Bulletin no. 186, p. 1–70.

31. Doyle, M.J., Busby, M.S., Duffy-Anderson, J.T., Picquelle, S.J., and Matarese, A.C., 2002, Aspects of the early life history of the capelin (*Mallotus villosus*) in the northeast Gulf of Alaska—A historical perspective based on larval collections October 1977-March 1979: National Oceanic and Atmospheric Administration Technical Memorandum, NMFS-AFSC-132, 41 p.

32. Collette, B.B., and Klein-MacPhee, G., 2002, Bigelow and Schroeder’s fishes of the Gulf of Maine (3rd ed.): Washington, D.C., Smithsonian Institution Press, 882 p.

33. Velikanov, A.Y., 1988, Data on the eggs and larvae of the Pacific capelin (*Mallotus villosus socialis*) along the shores of southern Sakhalin: Journal of Ichthyology, v. 28, p. 86–91.

34. Ochman, S., and Dodson, J.J., 1982, Composition and structure of the larval and juvenile fish community of the Eastman River and estuary, James Bay: Naturaliste Canada, v. 109, p. 803–813.

35. Naumenko, E.A., 1996, Distribution, biological condition, and abundance of capelin (*Mallotus villosus socialis*) in the Bering Sea, *in* Mathisen, O.A., and Coyle, K.O., eds., Ecology of the Bering Sea: Fairbanks, Alaska, University of Alaska, Alaska Sea Grant College Program, p. 237–256.

36. Kendel, R.E., Johnston, R.A.C., Lobsiger, U., and Kozak, M.D., 1975, Fishes of the Yukon coast: Victoria, British Columbia, Department of the Environment (Canada), Beaufort Sea Project, Technical Report 6, 114 p.

37. Wiswar, D.W., West, R.L., and Winkleman, W.N., 1995, Fisheries investigation in Oruktalik Lagoon, Arctic National Wildlife Refuge, Alaska, 1986: U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report, no. 30, 38 p.

38. Moulton, L.L., and Tarbox, K.E., 1987, Analysis of Arctic cod movements in the Beaufort Sea nearshore region, 1978–79: Arctic, v. 40, no. 1, p. 43–49.

39. Rose, G.A., 2005, Capelin (*Mallotus villosus*) distribution and climate—A sea “canary” for marine ecosystem change: ICES Journal of Marine Science, v. 62, no. 7, p. 1,524–1,530.

40. Stergiou, K.I., 1989, Capelin *Mallotus villosus* (Pisces: Osmeridae), glaciations, and speciation—A nomothetic approach to fisheries ecology and reproductive biology: Marine Ecology Progress Series, v. 56, p. 211–224.

41. Safronov, S.N., and Nikiforov, S.N., 2003, The list of pisciformes and fishes of the fresh and brackish waters of Sakhalin: Journal of Ichthyology, v. 43, no. 1, p. 38–49.

42. Haldorson, L.J., Prichett, M., Paul, A.J., and Ziemann, D., 1993, Vertical distribution and migration of fish larvae in a northeast Pacific bay: Marine Ecology Progress Series, v. 101, p. 67–80.

43. Vilhjalmsson, H., 2002, Capelin (*Mallotus villosus*) in the Iceland-East Greenland-Jan Mayen ecosystem: ICES Journal of Marine Science, v. 59, no. 5, p. 870–883.

44. Friis-Rødel, E., and Kanneworff, P., 2002, A review of capelin (*Mallotus villosus*) in Greenland waters: ICES Journal of Marine Science, v. 59, no. 5, p. 890–896.

45. Morin, R., and Dodson, J.J., 1986, The ecology of fishes in James Bay, Hudson Bay and Hudson Strait, *in* Martini, I.P., ed., Canadian Inland Seas: Amsterdam, Elsevier Science Publishers B.V., p. 293–323.

46. Barton, L.H., 1978, Finfish resource surveys in Norton Sound and Kotzebue Sound: Alaska Department of Fish and Game, Commercial Fisheries Division, p. 75–313.

47. Brown, E.D., Churnside, J.H., Collins, R.L., Veenstra, T., Wilson, J.J., and Abnett, K., 2002, Remote sensing of capelin and other biological features in the North Pacific using lidar and video technology: ICES Journal of Marine Science, v. 59, no. 5, p. 1,120–1,130.

48. Naumenko, E.A., 1987, Daily feeding rhythm and ration of the capelin, *Mallotus villosus socialis* (Osmeridae), in the southeastern part of the Bering Sea during winter: Journal of Ichthyology, v. 27, no. 1, p. 158–161.

49. Savin, A.B., 2001, Dynamics of main biological indices of capelin *Mallotus villosus catervarius* (Osmeridae) in its wintering prespawning and postspawning aggregations off western Kamchatka: Journal of Ichthyology, v. 41, no. 8, p. 589–599.

50. Wilson, M.T., Jump, C.M., and Duffy-Anderson, J.T., 2006, Comparative analysis of the feeding ecology of two pelagic forage fishes—Capelin *Mallotus villosus* and walleye pollock *Theragra chalcogramma*: Marine Ecology Progress Series, v. 317, p. 245–258.

51. Dodson, J.J., Tremblay, S., Colombani, F., Carscadden, J.E., and Lecomte, F., 2007, Trans-Arctic dispersals and the evolution of a circumpolar marine fish species complex, the capelin (*Mallotus villosus*): Molecular Ecology, v. 16, p. 5,030–5,043.

52. Stewart, D.B., Ratynski, R.A., Bernier, L.M.J., and Ramsey, D.J., 1993, A fishery development strategy for the Canadian Beaufort Sea-Amundsen Gulf area: Canadian Technical Report Fisheries and Aquatic Sciences 1910, 135 p.

53. Jarvela, L.E., and Thorsteinson, L.K., 1999, The epipelagic fish community of Beaufort Sea coastal waters, Alaska: Arctic, v. 52, no. 1, p. 80–94.

54. Craig, P.C., and Haldorson, L.J., 1981, Beaufort Sea Barrier Island Lagoon ecological process studies—Final report, Simpson Lagoon—Fish: U.S. Department of Commerce, Biological Studies, p. 384–649.

55. Tereshchenko, E.S., 2002, The dynamics of population fecundity in Barents Sea capelin: ICES Journal of Marine Science, v. 59, no. 5, p. 976–982.

56. Blackburn, J.E., Jackson, P.B., Warner, I.M., and Dick, M.H., 1981, A survey for spawning forage fish on the east side of the Kodiak Archipelago by air and boat during spring and summer 1979: Outer Continental Shelf Environmental Assessment Program, Alaska Department of Fish and Game, Final Report, Research Unit 552, p. 309–376.

57. Huse, G., and Gjosaeter, H., 1997, Fecundity of the Barents Sea capelin (*Mallotus villosus*): Marine Biology, v. 130, no. 2, p. 309–313.

58. Flynn, S.R., Nakashima, B.S., and Burton, M.P.M., 2001, Direct assessment of post-spawning survival of female capelin, *Mallotus villosus*: Journal of the Marine Biological Association of the United Kingdom, v. 81, p. 307–312.

59. Christiansen, J.S., Preaebel, K., Siikavuopio, S.I., and Carscadden, J.E., 2008, Facultative semelparity in capelin *Mallotus villosus* (Osmeridae)—An experimental test of a life history phenomenon in a sub-arctic fish: Journal of Experimental Marine Biology and Ecology, v. 360, no. 1, p. 47–55.

60. Mueter, F.J., and Litzow, M.A., 2008, Sea ice retreat alters the biogeography of the Bering Sea continental shelf: Ecological Applications, v. 18, no. 2, p. 309–320.

61. Johnson, M.L., Fiscus, C.H., Ostenson, B.T., and Barbour, M.L., 1966, Marine mammals, *in* Wilimovsky, N.J., and Wolfe, J.N., eds., Environment of the Cape Thompson Region, Alaska: Oak Ridge, Tennessee, United States Atomic Energy Commission, Division of Technical Information, p. 877–924.

62. Slotte, A., Mikkelsen, N., and Gjøsæter, H., 2006, Egg cannibalism in Barents Sea capelin in relation to a narrow spawning distribution: Journal of Fish Biology, v. 69, no. 1, p. 187–202.

63. Frost, K.J., and Lowry, L.F., 1981, Foods and trophic relationships of cetaceans in the Bering Sea, *in* Hood, D.W., and Calder, J.A., eds., The Eastern Bering Sea Shelf—Oceanography and Resources: National Oceanic and Atmospheric Administration, p. 825–836.

64. Hunt, G.L., Burgeson, B., and Sanger, G.A., 1981, Feeding ecology of seabirds of the Eastern Bering Sea, *in* Hood, D.W., and Calder, J.A., eds., The Eastern Bering Sea Shelf—Oceanography and Resources: National Oceanic and Atmospheric Administration, p. 629–641.

65. Gaston, A.J., Woo, K., and Hipfner, J.M., 2003, Trends in forage fish populations in northern Hudson Bay since 1981, as determined from the diet of nestling thick-billed murres *Uria lomvia*: Arctic, v. 56, no. 3, p. 227–233.

66. Yang, M.-S., Aydin, K., Greig, A., Lang, G.M., and Livingston, P.A., 2005, Historical review of capelin (*Mallotus villosus*) consumption in the Gulf of Alaska and eastern Bering Sea: U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum NMFS-AFSC-155, 89 p.

67. Davoren, G.K., May, C., Penton, P., Reinfort, B., Buren, A., Burke, C., and others, 2007, An ecosystem-based research program for capelin (*Mallotus villosus*) in the northwest Atlantic—Overview and results: Journal of the Northwest Atlantic Fishery Science, v. 39, p. 35–48.

68. Froese, R., and Pauly, D., eds., 2012, FishBase—Global information system on fishes: FishBase database, accessed July 8, 2012, at http://www.fishbase.org.

69. Murdoch, J., 1884, Fish and fishing at Point Barrow, Arctic Alaska: Transactions of the American Fisheries Society, v. 13, no. 1, p. 111–115.

70. Bean, T.H., 1887, The fishery resources and fishing-grounds of Alaska, *in* Goode, G.B., ed., The fisheries and fishery industries of the United States, Section III: United States Commission of Fish and Fisheries, p. 81–115.

71. George, C., Moulton, L.L., and Johnson, M., 2007, A field guide to the common fishes of the North Slope of Alaska: Alaska Department of Wildlife Management, North Slope Borough, 93 p.

72. Rose, G.A., 2005, On distributional responses of North Atlantic fish to climate change: ICES Journal of Marine Science, v. 62, no. 7, p. 1,360–1,374.

73. Mecklenburg, C.W., and Steinke, D., 2015, Ichthyofaunal baselines in the Pacific Arctic region and RUSALCA study area: Oceanography, v. 28, no. 3, p. 158–189.

74. Hart, J.L., 1973, Pacific fishes of Canada: Ottawa, Fisheries Research Board of Canada, Bulletin 180.

Arctic Smelt (*Osmerus dentex*)

Steindachner & Kner, 1870

Family Osmeridae

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

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

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

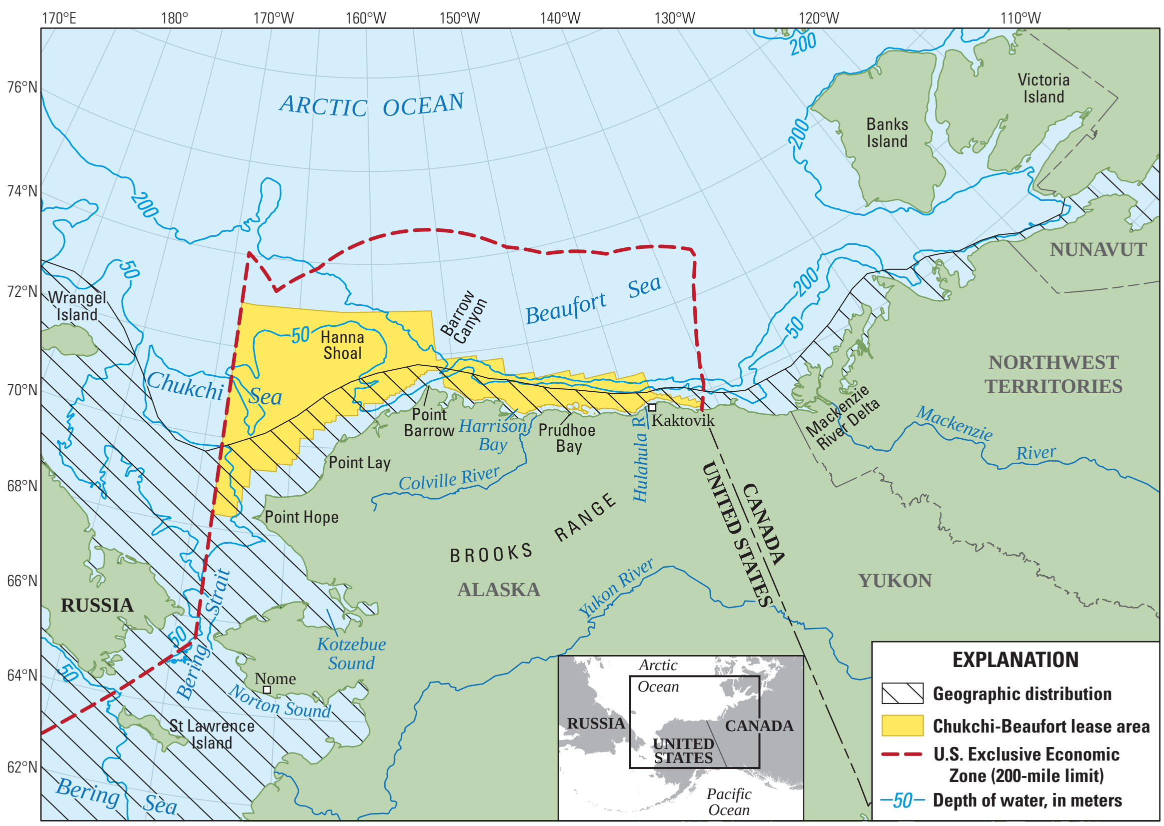
Ecological Role: Likely of considerable importance as a prey species, at least in the Chukchi Sea.

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

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

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

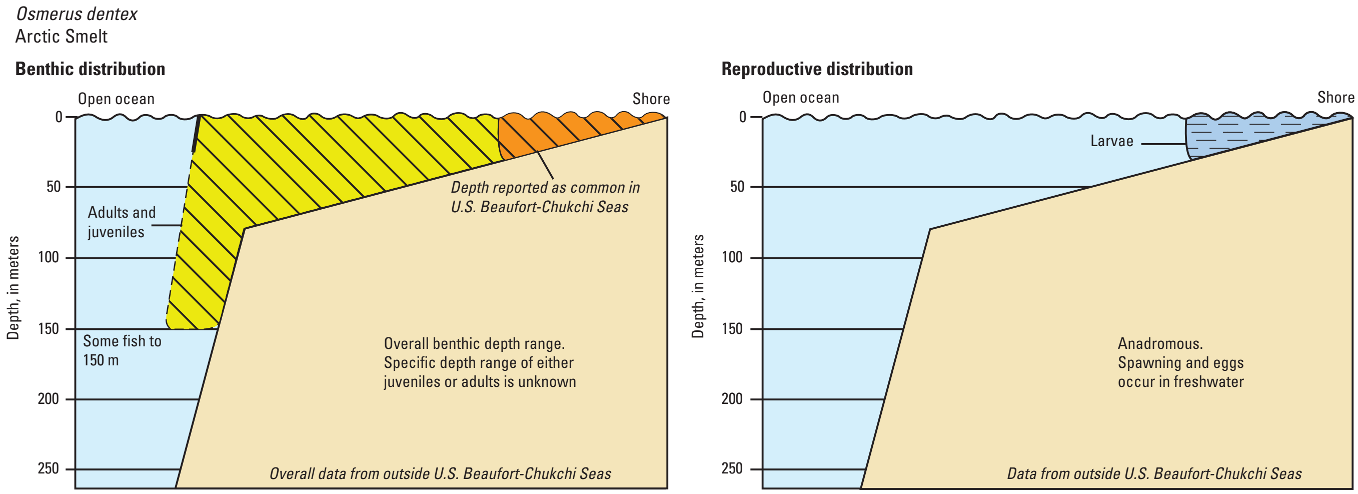
Arctic Smelt
Osmerus dentex



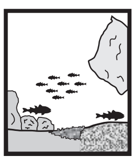
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

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

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



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



Habitats and Life History

Anadromous [8].

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

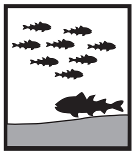
Larvae (fry)—Size at hatching: 5–8 mm SL [20, 27]. Size at juvenile transformation: Reported as post-larval at 14.7 mm TL [27]. Days to juvenile transformation: Unknown. Habitat: Pelagic in brackish to marine waters [5, 8]. Soon after hatching in freshwater, larvae are carried downriver and recruit to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

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

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

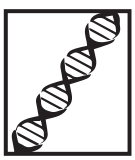
Substrate—Taken over sand-gravel in Bristol Bay [35].

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



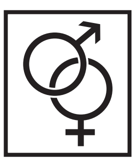
Behavior

Diel—Enters rivers and spawns at night at least in Asia and eastern North America, [24, 25].
Seasonal—*Schools of juveniles and adults inhabit nearshore waters during summer* [20, 22, 29], *although significant numbers feed as far as 10 km (6 mi) offshore* [37]. Other than for spawning, fish in northeastern North America do not make extensive migrations [24], although those in southwestern Bering Sea do move offshore in early winter [20]. *In U.S. Beaufort and Chukchi Seas, juveniles and adults overwinter under ice in brackish river deltas and coastal waters*, whereas fish in southwestern Bering Sea retreat offshore to 90–100 m depths during early winter, returning to coastal waters in January and February [20]. *Many river mouths along U.S. Chukchi and Beaufort Seas harbor overwintering populations* [30, 32, 38–41]. Larvae and perhaps fertilized eggs are carried into marine waters during spring and early summer [23, 28, 30]
Reproductive—*Fish gather near spawning grounds as winter progresses* [34]. Spawning takes place in spring, just prior to ice break-up [28, 30, 32]. *Spawning takes place in many rivers entering U.S. Chukchi and Beaufort Seas* [33, 34, 42] and in at least one lake (Lake Tasiqpaatchiaq, Alaska) [37]. *Most spawning seems to occur in lowermost but still freshwater parts of rivers, often very near the mouth* [23, 26]. However, fish in some Russian waters (for example, Yenisei River, Siberia) may travel upstream more than 1,000 km (621 mi) to spawning grounds [43] and some have been taken well upstream on the Mackenzie River in the Arctic Red River area, though it is not clear that spawning had occurred there [44]. Occasionally spawns in estuaries and possibly coastal marine waters [17, 27, 43]. Sticky and stalked eggs are shed over gravel, sand, or plants in shallow, swift flowing waters (to depths of a few meters) and adhere to the substrate until hatching [20, 23, 25, 26]. In Asia, adults often leave fresh waters within a few hours of spawning, although some remain in spawning area for several weeks [20]. *At least some spawn more than once in their lifetimes* [26].
Schooling—*Schooling, water column fish* [18].
Feeding—*Midwater and, to a certain extent, benthic feeders. Feeding is most intense in summer, declines as winter progresses, and almost ceases during spring spawning* [20, 22, 26, 33, 34].



Populations or Stocks

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

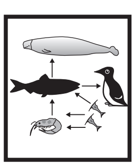


Reproduction

Mode—Oviparous [8].
Spawning season—*March–July, peaking in May–June in the U.S. Chukchi and Beaufort Sea drainages* [12, 22, 29, 34, 45]. May–July in Bering Sea and Asia [20, 25, 46].
Fecundity—1,700–207,900 eggs. Females lay eggs in small batches [24, 25].

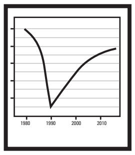
Food and Feeding

Food items—*Small fishes (for example, Arctic Cod, Fourhorn Sculpin, Arctic Cisco, Arctic Smelt, and eelpouts) and small crustaceans (for example, mysids, amphipods, isopods, and copepods) but occasionally snails, plant material, oligochaetes, penaeid shrimps, fish larvae, and insects* [12, 16, 29, 34, 42]. Very young fish eat zooplankton and insects [33].
Trophic level—4.2 (standard error 0.73) [47].



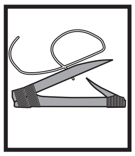
Biological Interactions

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



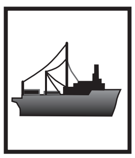
Resilience

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



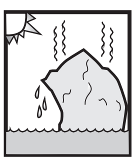
Traditional and Cultural Importance

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



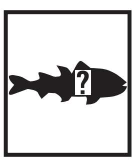
Commercial Fisheries

Currently, Arctic Smelt are not commercially harvested.



Potential Effects of Climate Change

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



Areas for Future Research [A]

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

References Cited

Belyanina, T.N., 1968, Dynamics of smelt populations in sub-arctic waters: Rapports et procès-verbaux des réunions / Conseil permanent international pour l’exploration de la mer, v. 158, p. 74–79. [23]

Burns, J.J., 1990, Proceedings of a technical workshop on fishes utilized in subsistence fisheries in National Petroleum Reserve-Alaska—Barrow, Alaska, October 26–28, 1988: Report to North Shore Bureau, Department of Wildlife Management, Barrow, Alaska, 94 p. [26]

Gritsenko, O.F., Churikov, A.A., and Rodionova, S.S., 1984b, The reproductive ecology of the Arctic smelt, *Osmerus mordax dentex* (Osmeridae), in the rivers of Sakhalin Island: Journal of Ichthyology, v. 24, no. 3, p. 23–33. [25]

Haldorson, L.J., and Craig, P., 1984, Life history and ecology of a Pacific-Arctic population of rainbow smelt in coastal waters of the Beaufort Sea: Transactions of the American Fisheries Society, v. 113, no. 1, p. 33–38. [34]

Karpenko, V.I., and Vasilets, P.M., 1996, Biology of smelt (Osmeridae) in the Korf-Karagin coastal area of the southwestern Bering Sea, *in* Mathisen, O.A., and Coyle, K.O., eds., Ecology of the Bering Sea—A review of Russian literature: Fairbanks, Alaska, University of Alaska, Alaska Sea Grant Program, AK-SG-96-01, p. 217–235. [20]

Mecklenburg, C.W., Mecklenburg, T.A., and Thorsteinson, L.K., 2002, Fishes of Alaska: Bethesda, Maryland, American Fisheries Society, 1,116 p. [5]

Bibliography

1. Mecklenburg, C.W., Møller, P.R., and Steinke, D., 2011, Biodiversity of Arctic marine fishes—Taxonomy and zoogeography: Marine Biodiversity, v. 41, no. 1, p. 109–140, Online Resource 1.
2. George, C., Moulton, L.L., and Johnson, M., 2007, A field guide to the common fishes of the North Slope of Alaska: Alaska Department of Wildlife Management, North Slope Borough, 93 p.
3. Nelson, R.K., 1981, Harvest of the sea—Coastal subsistence in modern Wainwright: North Slope Borough, 112 p.
4. Pedersen, S., and Linn, A., Jr., 2005, Kaktovik 2000–2002 subsistence fishery harvest assessment: U.S. Fish and Wildlife Service, Fisheries Resource Monitoring Program, Final Report for FIS Study, Study No. 01-101.
5. Mecklenburg, C.W., Mecklenburg, T.A., and Thorsteinson, L.K., 2002, Fishes of Alaska: Bethesda, Maryland, American Fisheries Society, 1,116 p.
6. Jørgensen, R., 2003, The effects of swimbladder size, condition and gonads on the acoustic target strength of mature capelin: ICES Journal of Marine Science, v. 60, no. 5, p. 1,056–1,062.
7. Power, G., 1997, A review of fish ecology in Arctic North America: American Fisheries Society Symposium, no. 19, p. 13–39.
8. Love, M.S., 2011, Certainly more than you wanted to know about the fishes of the Pacific Coast: Santa Barbara, California, Really Big Press, 649 p.
9. Minerals Management Service, 2008, Beaufort Sea and Chukchi Sea planning areas—Oil and Gas Lease Sales 209, 212, 217, and 221: U.S. Department of the Interior, Minerals Management Service Alaska OCS Region, OCS EIS/EA, MMS 2008-0055, 538 p.
10. Mecklenburg, C.W., Mecklenburg, T.A., Sheiko, B.A., and Steinke, D., 2016, Pacific Arctic marine fishes: Akureyri, Iceland, Conservation of Arctic Flora and Fauna, Monitoring Series Report No. 23, 406 p., accessed May 10, 2016, at http://caff.is/monitoring-series/370-pacific-arcticmarine-fishes.
11. Barton, L.H., 1978, Finfish resource surveys in Norton Sound and Kotzebue Sound: Alaska Department of Fish and Game, Commercial Fisheries Division, p. 75–313.
12. Craig, P.C., and Schmidt, D.R., 1985, Fish resources at Point Lay, Alaska: Barrow, Alaska, LGL Alaska Research Associates, Inc., North Slope Borough, Materials Source Division, 105 p.
13. Palmer, D.E., and Dugan, L.J., 1990, Fish population characteristics of Arctic National Wildlife Refuge coastal waters, summer 1989: Fairbanks, Alaska, U.S. Fish and Wildlife Service, Progress Report, 83 p.
14. Barber, W.E., Smith, R.L., Vallarino, M., and Meyer, R.M., 1997, Demersal fish assemblages of the northeastern Chukchi Sea, Alaska: Fishery Bulletin, v. 95, no. 2, p. 195–209.
15. Jones, M.L., and Den Beste, J., 1977, Tuft Point and adjacent coastal areas fisheries projects: Calgary, Alberta, Canada, Aquatic Environments, Ltd., 152 p.
16. Bond, W.A., and Erickson, R.N., 1987, Fishery data from Phillips Bay, Yukon, 1985: Winnipeg, Manitoba, Canadian Data Report of Fisheries and Aquatic Sciences, Central and Artic Region, Department of Fisheries and Oceans, no. 635, 47 p.
17. Stewart, D.B., Ratynski, R.A., Bernier, L.M.J., and Ramsey, D.J., 1993, A fishery development strategy for the Canadian Beaufort Sea-Amundsen Gulf area: Canadian Technical Report Fisheries and Aquatic Sciences 1910, 135 p.
18. Wolotira, R.J., Jr., Sample, T.M., and Morin, M., Jr., 1977, Demersal fish and shellfish resources of Norton Sound, the southeastern Chukchi Sea, and adjacent waters in the baseline year 1976: Seattle, Washington, Northwest and Alaska Fisheries Center, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Processed Report, 69 p.
19. Allen, M.J., and Smith, G.B., 1988, Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific: National Oceanic and Atmospheric Administration Technical Report NMFS 66, 151 p.

20. Karpenko, V.I., and Vasilets, P.M., 1996, Biology of smelt (Osmeridae) in the Korf-Karagin coastal area of the southwestern Bering Sea, *in* Mathisen, O.A., and Coyle, K.O., eds., Ecology of the Bering Sea—A review of Russian literature: Fairbanks, Alaska, University of Alaska, Alaska Sea Grant Program, AK-SG-96-01, p. 217–235.

21. Andriashev, A.P., 1954, Fishes of the northern seas of the U.S.S.R.—Keys to the fauna of the U.S.S.R.: Academy of Sciences of the U.S.S.R., Zoological Institute, no. 53, 566 p. [In Russian, translation by Israel Program for Scientific Translation, Jerusalem, 1964, 617 p., available from U.S. Department of Commerce, Springfield, Virginia.]

22. Craig, P.C., and Haldorson, L.J., 1981, Beaufort Sea Barrier Island Lagoon ecological process studies—Final report, Simpson Lagoon—Fish: U.S. Department of Commerce, Biological Studies, p. 384–649.

23. Belyanina, T.N., 1968, Dynamics of smelt populations in sub-arctic waters: Rapports et procès-verbaux des réunions / Conseil permanent international pour l'exploration de la mer, v. 158, p. 74–79.

24. Morrow, J.E., 1980, The freshwater fishes of Alaska: Anchorage, Alaska Northwest Publishing Company, 248 p.

25. Gritsenko, O.F., Churikov, A.A., and Rodionova, S.S., 1984b, The reproductive ecology of the Arctic smelt, *Osmerus mordax dentex* (Osmeridae), in the rivers of Sakhalin Island: Journal of Ichthyology, v. 24, no. 3, p. 23–33.

26. Burns, J.J., 1990, Proceedings of a technical workshop on fishes utilized in subsistence fisheries in National Petroleum Reserve-Alaska—Barrow, Alaska, October 26–28, 1988: Report to North Shore Bureau, Department of Wildlife Management, Barrow, Alaska, 94 p.

27. Ratynski, R.A., 1983, Mid-summer ichthyoplankton populations of Tuktoyaktuk Harbour, N.W.T.: Canadian Technical Report of Fisheries and Aquatic Sciences, no. 1218, 21 p.

28. Kendel, R.E., Johnston, R.A.C., Lobsiger, U., and Kozak, M.D., 1975, Fishes of the Yukon coast: Victoria, British Columbia, Department of the Environment (Canada), Beaufort Sea Project, Technical Report 6, 114 p.

29. Lawrence, M.J., Lacho, G., and Davies, S., 1984, A survey of the coastal fishes of the southeastern Beaufort Sea: Canadian Technical Report of Fisheries and Aquatic Sciences, no. 1220, 178 p.

30. Bond, W.A., and Erickson, R.N., 1989, Summer studies of the nearshore fish community at Phillips Bay, Beaufort Sea coast, Yukon: Winnepeg, Manitoba, Canadian Technical Report of Fisheries and Aquatic Sciences, Central and Arctic Region, Department of Fisheries and Oceans, no. 1676, 102 p.

31. Bendock, T.N., 1977, Beaufort Sea estuarine fishery study: Alaska Department of Fish and Game Annual Report, Contract #03-5-022-69, p. 670–729.

32. Bond, W.A., 1982, A study of the fishery resources of Tuktoyaktuk Harbour, southern Beaufort Sea coast, with special reference to life histories of anadromous coregonids: Canadian Technical Report of Fisheries and Aquatic Sciences, no. 1119, 90 p.

33. Percy, R., 1975, Fishes of the outer Mackenzie Delta: Victoria, British Columbia, Beaufort Sea Project, Beaufort Sea Technical Report, no. 8, 114 p.

34. Haldorson, L.J., and Craig, P., 1984, Life history and ecology of a Pacific-Arctic population of rainbow smelt in coastal waters of the Beaufort Sea: Transactions of the American Fisheries Society, v. 113, no. 1, p. 33–38.

35. Johnson, S.W., Thedinga, J.F., and Lindeberg, M.R., 2012, Nearshore fish atlas of Alaska: National Oceanic and Atmospheric Administration Fisheries, accessed February 2012 at http://www.fakr.noaa.gov/habitat/fishatlas/.

36. McPhail, J.D., and Lindsey, C.C., 1970, Freshwater fishes of northwestern Canada and Alaska: Bulletin of the Fisheries Research Board of Canada Bulletin 173, 381 p.

37. Moulton, L.L., Owl Ridge Natural Resource Consultants, written commun., 2011.

38. Schmidt, D.R., Griffiths, W.B., and Martin, L.R., 1987, Importance of anadromous fish overwintering habitat in the Sagavanirktok River Delta, Alaska: Anchorage, Alaska, Report by Ecological Research Associates for Standard Alaska Production Company and North Slope Borough, 71 p.

39. Bond, W.A., and Erickson, R.N., 1993, Fisheries investigations in coastal waters of Liverpool Bay, Northwest Territories: Winnipeg, Manitoba, Canada Department of Fisheries and Oceans, Central and Arctic Region, Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2204, 59 p.

40. Craig, P.C., 1989a, An introduction to anadromous fishes in the Alaskan Arctic: Biological Papers of the University of Alaska, v. 24, p. 27–54.

41. Sekerak, A.D., Stallard, N., and Griffiths, W.B., 1992, Distribution of fish and fish harvests in the nearshore Beaufort Sea and Mackenzie Delta during ice-covered periods, October–June: Environmental Studies Research Funds Report, LGS Ltd. No. 117, 524 p.

42. Fechhelm, R.G., Craig, P.C., Baker, J.S., and Gallaway, B.J., 1984, Fish distribution and use of nearshore waters in the northeastern Chukchi Sea: LGL Ecological Research Associates Inc., Outer Continental Shelf Environmental Assessment Program, National Oceanic and Atmospheric Administration, OMPA/OCSEAP, Final Report, 190 p.

43. Berg, L.S., 1948, Freshwater fishes of the USSR and adjacent countries, volume 1 (4th ed.): Moscow, Academy of Sciences of the USSR Zoological Institute, 466 p. [Translated from Russian by Israel Program for Science Translation, Jerusalem, 505 p.]

44. Hatfield, C.T., Stein, J.N., Falk, M.R., and Jessop, C.S., 1972, Fish resources of the Mackenzie River Valley: Winnepeg, Environment Canada Fisheries Service, Interim report 1, v. 1.

45. Mann, G.J., 1975, Winter fisheries survey across the Mackenzie Delta, *in* Craig, P.C., ed., Fisheries investigations in a coastal region of the Beaufort Sea: Arctic Gas Biological Report Series, v. 34.

46. Chereshnev, I., Nazarkin, M.V., Skopets, M.B., Pitruk, D., Shestakov, A.V., Yabe, M., and others, 2001, Annotated list of fish-like vertebrates and fish in Tauisk Bay (northern part of the Sea of Okhotsk), *in* Andreev, A.V., and Bergmann, H.H., eds., Biodiversity and ecological status along the northern coast of the Sea of Okhotsk—A collection of study reports: Dalnauka Vladivostok, Russia, Institute of Biological Problems of the North, p. 64–86.

47. Froese, R., and Pauly, D., eds., 2012, FishBase—Global information system on fishes: FishBase database, accessed July 8, 2012, at http://www.fishbase.org.

48. Lowry, L.F., Frost, K.J., and Seaman, G.A., 1986, Investigations of belukha whales in coastal waters of western and northern Alaska: Outer Continental Shelf Environmental Program Unit 612, Final Report, p. 359–392.

49. Johnson, M.L., Fiscus, C.H., Ostenson, B.T., and Barbour, M.L., 1966, Marine mammals, *in* Wilimovsky, N.J., and Wolfe, J.N., eds., Environment of the Cape Thompson Region, Alaska: Oak Ridge, Tennesee, United States Atomic Energy Commission, Division of Technical Information, p. 877–924.

50. Lowry, L.F., and Frost, K.J., 1981, Feeding and trophic relationships of phocid seals and walruses in the eastern Bering Sea, *in* Hood, D.W., and Calder, J.A., eds., The Eastern Bering Sea Shelf—Oceanography and resources: National Oceanic and Atmospheric Administration, p. 813–824.

51. Frost, K.J., and Lowry, L.F., 1981, Foods and trophic relationships of cetaceans in the Bering Sea, *in* Hood, D.W., and Calder, J.A., eds., The Eastern Bering Sea Shelf—Oceanography and Resources: National Oceanic and Atmospheric Administration, p. 825–836.

52. Murdoch, J., 1884, Fish and fishing at Point Barrow, Arctic Alaska: Transactions of the American Fisheries Society, v. 13, no. 1, p. 111–115.

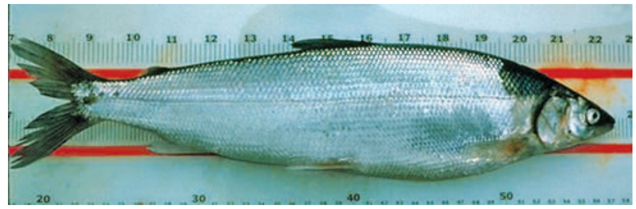
53. Craig, P.C., 1989b, Subsistence fisheries at coastal villages in the Alaskan Arctic, 1970–1986: Biological Papers of the University of Alaska, v. 24, p. 131–152.

54. George, J.C., and Kovalsky, R., 1986, Observations on the Kupigruak Channel (Colville River) subsistence fishery, October 1985: Alaska Department of Wildlife Management, 66 p.

55. Moulton, L.L., Field, L.J., and Kovalsky, R., 1991, Predictability in the catch of Arctic cisco in the Colville River, Alaska: American Fisheries Society Symposium no. 11, p. 145–156.

Arctic Cisco (*Coregonus autumnalis*)
(Pallas, 1776)

Family Salmonidae



Arctic Cisco (*Coregonus autumnalis*). Photograph by Kirk Waggoner, MJM Research LCC.

Colloquial Name: Iñupiat: *Qaatag*, *Qaaktaq* [1]; *Qaaqtaq* [2].

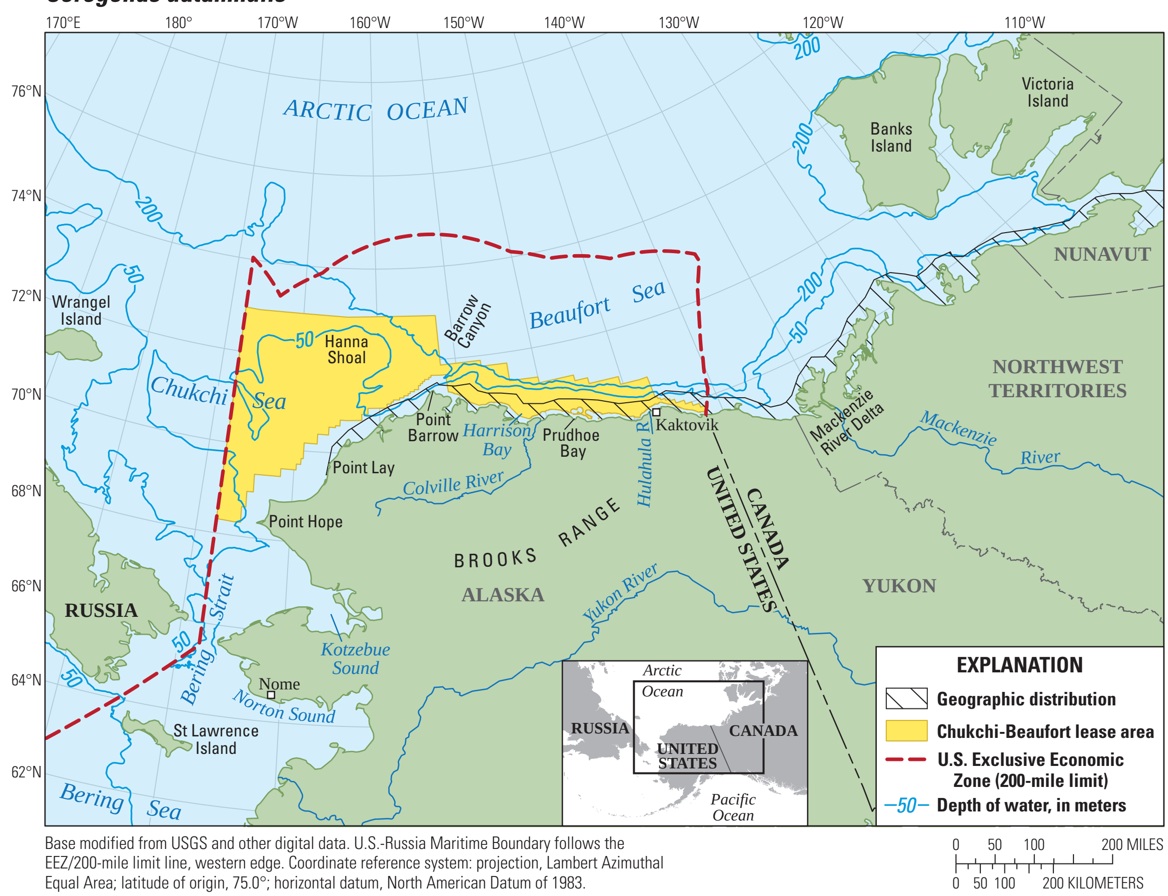
Ecological Role: As one of the most common and widely distributed coregonids found in Alaskan Beaufort Sea coastal waters during summer [3], this species is a prominent member of the nearshore fish assemblage. Arctic Cisco is an important subsistence resource.

Physical Description/Attributes: Slender body with a dark brown to green back, silver belly, and pale (almost colorless) anal, pectoral, and pelvic fins. Unlike other ciscoes, does not have black spots on back or white spots on fins. Lower jaw does not protrude beyond upper jaw. Very closely resembles Bering Cisco. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 183) [4]. Swim bladder: Present [5]. Swim bladder ruptures have been documented when exposed to explosive-based instantaneous pressure change [6]. Antifreeze glycoproteins in blood serum: Unknown.

Range: *U.S. Beaufort Sea westward to northeastern Chukchi Sea at Point Lay* [7]. Worldwide, along coasts from the White Sea east through Siberia and to Mackenzie River, Canada [8].

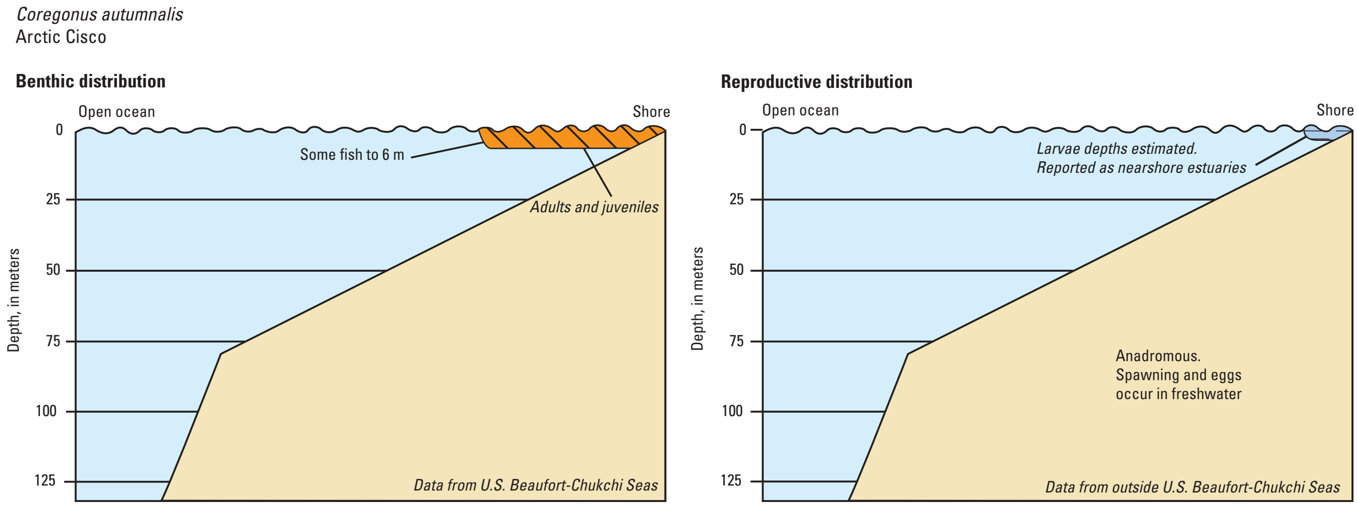
Relative Abundance: *Rare from Barrow to Point Lay in U.S. Chukchi Sea* [7, 11]. Common *along coast of U.S. Beaufort Sea eastward from at least Colville River* [12]. Common at least as far east as Coppermine River mouth in Coronation Gulf, Canada [13].

Arctic Cisco
Coregonus autumnalis

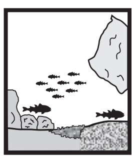


Geographic distribution of Arctic Cisco (*Coregonus autumnalis*) at sea within Arctic Outer Continental Shelf Planning Areas [9] based on review of published literature and specimens from historical and recent collections [4, 8, 10].

Depth Range: *Nearshore, rarely deeper than about 6 m. Common within a few hundred meters from shore*. [12, 14–19]. However, in Canadian Beaufort Sea, juveniles have been taken near the surface as far as 50 km offshore [20].



Benthic and reproductive distribution of Arctic Cisco (*Coregonus autumnalis*).



Habitats and Life History

Anadromous. *There appear to be some landlocked populations* [15].

Eggs—Size: 0.5–1.3 mm [21]. Time to hatching: Unknown. Habitat: Gravel beds in fast flowing freshwater rivers [15, 22].

Larvae—Size at hatching: As small as 19 mm FL [15, 22]. Size at juvenile transformation: *About 45–54 mm FL* [12, 15, 23]. Days to juvenile transformation: Unknown. Habitat: Freshwater rivers to nearshore estuaries [22, 24, 25].

Juveniles—Age and size: 0–5 years and 4.5–32.8 cm FL [21, 23]. Habitat: Nearshore brackish or marine waters [22, 24, 25]. *Occasionally, juveniles have been found well upstream in some river systems (for example, Colville and Babbage Rivers)* [15, 26].

Adults—Age and size at first maturity: As young as 5 years in Russia, where males mature about 1 year earlier than females [27]. *North American fish mature at a wide range of ages. A few mature as early as 5 years, many at 6–8 years, and some at perhaps 11 years or older. A few are mature by 32.8 cm FL and virtually all by about 40.0 cm FL* [15, 21, 26, 28–30]. Length-weight relationships appear to be similar along much of the species' range. Male and female growth rates are similar [31], but females are larger at older ages than males and may also be heavier at length [30]. *Fish weigh less at length during years of cold water and heavy ice packs* [32]. Maximum age: At least 21 years [33]. Males and females may have similar life spans [26, 27]. Maximum size: 64 cm TL [4]. Habitat: Pelagic, nearshore brackish or marine waters and freshwater rivers [22, 24, 25]. *Adults generally re-enter fresh water only to spawn and then return to estuarine coastal waters* [22, 24, 25].

Substrate—Gravel for spawning [15, 22]. *Taken over sand-gravel in Chukchi Sea* [34].

Physical/chemical—Temperature:*–1.–13.5 °C* [12]. Salinity: *0–30.0 parts per thousand* [15, 35], *mainly in 10–25 parts per thousand except when spawning in fresh water* [15, 21]. Prefers relatively warm and brackish conditions [16, 35–38] but tolerant of cold and saline waters [17, 32, 39–41]. *May grow faster in warm and low-salinity water* [37].

Behavior

Diel—Unknown.

Seasonal—Spawning occurs in autumn and eggs hatch during spring in MacKenzie River, Canada [15, 22]. Yolk-sac larvae are flushed downstream into the river delta in late May or early June [15, 22]. *Migrations to either east or west are passive, depending on strength and direction of winds and currents.* The predominant westerly winds tend to propel fish along Tuktoyaktuk Peninsula, Canada (at least as far as Liverpool Bay, near the Anderson River) [15]. *Strong easterlies assist their wind-aided migration westward, often to Colville River area*, although many are carried only as far as the Yukon Territory coast [39, 42]. *Successful year classes that reach the Colville River Delta are associated with summers when easterly winds are strong and more-or-less continuous, often of 5 km/h or more* [17, 29, 43, 44]. Eastward-moving juveniles often stay within 100 m of shore although more offshore migrations may occur [15, 17, 45]. Young-of-the-year first occurs off Yukon coast (Phillips Bay) between early July and September, and *recruit to the Prudhoe Bay-Colville River-Simpson Lagoon area between mid-August and late September* [12, 15, 23].

Juveniles migrate to overwintering grounds as autumn approaches. In Alaska, most fish winter under ice in brackish, deep channels of the Colville River, and some in lower parts of the Sagavanirktok River [15, 24, 46]. *However, the Sagavanirktok River may not provide sufficient annual winter refuge to sustain long-term populations* [40]. *An estimated 1.2–1.8 million individuals larger than 250 mm FL overwinter in the Colville River Delta* [46]. To the east, wintering grounds are in the Mackenzie River Delta (perhaps as far west as Herschel Island), as well as in bays and lagoons along the Tuktoyaktuk Peninsula, in Tuktoyaktuk Harbour, and as far east as at least the Anderson River [22, 25, 31, 47, 48].

Juveniles leave overwintering grounds in summer when waters warm and disperse to feed in the nearshore, some moving at an average rate of 2.9 km/d [12]. Younger fish tend to remain in brackish waters and do not venture far [39]. *Older juveniles migrate farther during summer and are able to tolerate more saline conditions. Regardless of size, juveniles always begin to return to overwintering grounds after a few months and are usually in place by September* [12, 15, 49]. *At least in Arctic National Wildlife Refuge region, larger fish tend to move back to overwintering grounds earlier than do smaller ones* [16].

Populations or Stocks

Fish utilizing different Mackenzie River tributaries may form different genetic stocks [50].

Reproduction

Mode—Iteroparous [26].

Spawning season—September to early October in Mackenzie River tributaries [15, 51], and September–December in Russia.

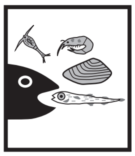
Fecundity—11,316–30,267 eggs in North America [30] and 7,700–52,000 eggs in Russia [15, 28].

Reproductive—Upon maturity, their life cycle is dominated by migrations to and from spawning sites. Adults migrate back to the Mackenzie River, spending less time than usual in coastal waters. Autumn spawners enter the river from May to early August [22]. Little is known about spawning behaviors or specific conditions. Spawning occurs in fast waters over gravel [27, 52]. Most females spawn every other year [21, 26, 27, 51]. Post-spawning fish move downstream and overwinter in the Mackenzie River Delta [22, 52]. *During the next spring and summer they will disperse, with some exceptions, as far westward as Barter Island and at least as far eastward as the Anderson River* [15, 22, 26]. *The presence of a few older individuals (10–15 years) along the North Slope as far west as Simpson Lagoon implies that older fish will occasionally make more extensive migrations* [12, 16, 18, 32].

Although common along much of the Beaufort Sea coast, most, or perhaps all Arctic Cisco are believed to spawn in Mackenzie River tributaries such as Great Bear, Arctic Red, Peel, and Liard Rivers, the latter being more than 1,700 km from the Beaufort Sea [15, 42, 53]. Evidence for limited spawning in other waterways is discussed in the section, “Remarks.” Intertidal or subtidal spawning in estuaries and perhaps the sea has been reported in Russian waters [27] but has not been observed in North America.

Schooling—*Forms schools, often in groups of tens to several hundreds. Sometimes schools with Dolly Varden* [12, 18, 26]. *Individuals may stay together in same school for months at a time (specifically, several fish tagged on same date at Simpson Lagoon were recaptured together several months later)* [12].

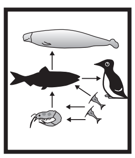
Feeding—*Opportunistic feeders. Feed under ice during winter (at a reduced rate)* [46], *although food habits may change, reflecting differences in food availability* [12]. Rarely feeds during spawning migrations [48, 51, 52, 54].



Food and Feeding

Food items—*A wide variety of benthic and water column prey. Important prey include various crustaceans (for example, amphipods, copepods, mysids, and cladocerans), insects (particularly chironomids), snails, clams, polychaetes, fishes* (for example, Fourhorn Sculpin and Arctic Cisco), fish eggs, and occasionally plant material [12, 31, 35, 54].

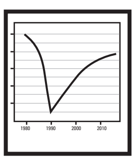
Trophic level—3.57 (standard error 0.56) [55].



Biological Interactions

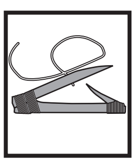
Predators—Dolly Varden, Arctic Smelt, and Arctic Cisco [21, 26].

Competitors—Shallow, nearshore species such as Dolly Varden, Arctic Cod, other whitefishes, and sculpins.



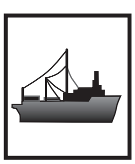
Resilience

Low, minimum population doubling time is 4.5–14 years (t_m=6; Fecundity=2,000) [55].



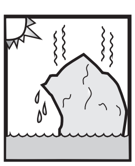
Traditional and Cultural Importance

Arctic Cisco are widely taken in subsistence fisheries along much of the U.S. Beaufort Sea coast. Juvenile Arctic Cisco in particular form the basis for major subsistence in the Colville River Delta. Most of the fish are captured under the ice by gill nets during the autumn. Currently, the principal fishing areas on the Colville River are in the lower delta and near the village of Nuiqsut [29, 56, 57]. *Part of this catch is distributed to other parts of Alaska* [12]. *The summer fishery at Kaktovik may catch newly matured fish as they migrate back to the Mackenzie River* [1, 58]. Annual catch records have been collected since 1968.



Commercial Fisheries

A small commercial fishery for Arctic Cisco in the Colville River Delta was terminated in 2010. Currently, there is no commercial fishing for Arctic Cisco.



Potential Effects of Climate Change

Unknown, as the effect of climate change on the Mackenzie River system and on the wind patterns that control juvenile movements, are unclear. However, von Biela and others (2011) [59] determined that young-of-the-year growth increased during years of stronger east winds, as well as reduced sea-ice concentration and Mackenzie River discharge, and that there was a time lag of one or 2 years. Generally, Durand and others (2011) [60] predict that, at least for anadromous fishes in subarctic rivers, shifts in biology will be effected by spring ice break-up and resultant peak flows and surrounding permafrost processes: both of which affect the supply of nutrients and (or) sediment to the watershed of climate change on spring break-up intensity.

Areas for Future Research [A]

Although it is clear that Arctic Cisco frequently use nearshore, shallow waters for feeding and migration, the role, if any, of offshore waters has not been completely investigated. The physiological tolerance of young-of-the-year fish to cold, high salinity water has been suggested but not confirmed in laboratory studies and may be an important constraint to recruitment in Alaskan waters. Environmental tolerance experiments including effects of different temperature and salinity regimes on the growth and survival of Arctic Cisco are needed to assess the species vulnerability to climatic changes. In addition, the location and significance of important habitats in the Mackenzie River and the potential for isolated spawning stocks should also be explored. Studies to describe the genetic relationships between Arctic and Bering Cisco are needed. Coastal monitoring at key reference locations should be designed to track changes in population health (growth, survival, recruitment, and condition).

Remarks

Although it is clear that most, if not all, Beaufort Sea Arctic Cisco spawn in the Mackenzie River, there is evidence that spawning may occur on other grounds. Colonell and Gallaway (1997) [53] provide indirect evidence for some spawning west of the Colville River. They noted that some subsistence fishermen near Barrow stated that they captured mature Arctic Cisco in their autumn fishery. The Colonell and Gallaway (1997) indicated that on several occasions strong westerly winds, anticipated to lead to poor recruitment of young Arctic Cisco in the Colville River area (through poor transport from the Mackenzie River to the east), led instead to large recruitment. This would imply that westerly currents from some spawning waters west of the Colville River carried young fish to the study site. Colonell and Gallaway (1997) [53] also cited three genetic studies that posit a genetically differentiated group of Arctic Cisco in western Alaska. Bond and Erickson (1997) [22] reported on the capture of young-of-the-year Arctic Cisco at the mouth of the Anderson River in early July. They suggested that these captures were too early in the season to be fish that had hatched in the Mackenzie River and then carried eastward for hundreds of kilometers. They also noted that capture in Wood Bay (into which the Anderson River empties) of hybrid Arctic Cisco-other coregonids; captures that imply that Arctic Cisco were mating with fishes in that region. *Lastly, Bickham and others (1997)* [61] *determined that some Arctic Cisco from the western Beaufort Sea carried mitochondrial DNA of Bering Cisco* (C. laurettae). *As Bering Cisco are unknown from the Mackenzie River (the putative site of all Arctic Cisco spawning) it appears that some Arctic Cisco spawn to the west of the MacKenzie River.*

Arctic Cisco are closely related to Lake Cisco (*Coregonus artedi*) and Bering Cisco (*C. laurettae*) [62]. In the Northwest Territories, they occasionally hybridize with Least Cisco and Humpback Whitefish [63].

References Cited

Bond, W.A., and Erickson, R.N., 1997, Coastal migrations of Arctic ciscoes in the eastern Beaufort Sea, *in* Reynolds, J., ed., Fish ecology in Arctic North America, symposium 19: Bethesda, Maryland, American Fisheries Society, p. 155–164. [22]

Burns, J.J., 1990, Proceedings of a technical workshop on fishes utilized in subsistence fisheries in National Petroleum Reserve-Alaska—Barrow, Alaska, October 26–28, 1988: Report to North Shore Bureau, Department of Wildlife Management, Barrow, Alaska, 94 p. [15]

Craig, P.C., and Haldorson, L.J., 1981, Beaufort Sea Barrier Island Lagoon ecological process studies—Final report, Simpson Lagoon—Fish: U.S. Department of Commerce, Biological Studies, p. 384–649. [12]

Griffiths, W.B., Craig, P., Walder, G., and Mann, G., 1975, Fisheries investigations in a coastal region of the Beaufort Sea (Nunaluk Lagoon, Yukon), *in* Craig, P.C., ed., Fisheries investigations in a coastal region of the Beaufort Sea: Arctic Gas, Biological Report Series, v. 34, p. 1–129. [26]

Mecklenburg, C.W., Mecklenburg, T.A., and Thorsteinson, L.K., 2002, Fishes of Alaska: Bethesda, Maryland, American Fisheries Society, 1,116 p. [4]

Bibliography

1. Craig, P.C., 1989b, Subsistence fisheries at coastal villages in the Alaskan Arctic, 1970–1986: Biological Papers University of Alaska, no. 24, p. 131–152.

2. Pedersen, S., and Linn, A., Jr., 2005, Kaktovik 2000–2002 subsistence fishery harvest assessment: U.S. Fish and Wildlife Service, Fisheries Resource Monitoring Program, Final Report for FIS Study, Study No. 01-101.

3. Craig, P.C., 1984, Fish use of coastal waters of the Alaskan Beaufort Sea—A review: Transactions of the American Fisheries Society, v. 113, no. 3, p. 265–282.

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

5. Moyle, P.B., and Cech, J.J., Jr., 1996, Fishes—An introduction to ichthyology: Upper Saddle River, New Jersey, Prentice-Hall, 590 p.

6. Godard, D.R., 2010, Pathological examination of fish exposed to explosive based instantaneous pressure change: Winnipeg, Univerity of Monitoba, Master's thesis, 253 p.

7. Craig, P.C., and Schmidt, D.R., 1985, Fish resources at Point Lay, Alaska: Barrow, Alaska, LGL Alaska Research Associates, Inc., North Slope Borough, Materials Source Division, 105 p.

8. 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.

9. Minerals Management Service, 2008, Beaufort Sea and Chukchi Sea planning areas—Oil and Gas Lease Sales 209, 212, 217, and 221: U.S. Department of the Interior, Minerals Management Service Alaska OCS Region, OCS EIS/EA, MMS 2008-0055, 538 p.

10. Mecklenburg, C.W., and Mecklenburg, T.A., 2009, Arctic marine fish museum specimens, 2nd ed., Metadata report and database submitted to ArcOD, Institute of Marine Science: University of Alaska, Fairbanks, by Point Stephens Research, metadata report accessed August 8, 2012, at http://www.arcodiv.org/Database/Fish_datasets.html.

11. Philo, L.M., George, J.C., and Moulton, L.L., 1993, The occurrence and description of anadromous fish in the Dease Inlet/Admiralty Bay, Alaska area, 1988–1990: Barrow, Alaska, Department of Wildlife Management, North Slope Borough and MJM Research, 150 p.

12. Craig, P.C., and Haldorson, L.J., 1981, Beaufort Sea Barrier Island Lagoon ecological process studies—Final report, Simpson Lagoon—Fish: U.S. Department of Commerce, Biological Studies, p. 384–649.

13. Gillman, D.V., and Kristofferson, A.H., 1984, Biological data on Pacific herring (*Clupea harengus pallasi*) from Tuktoyaktuk Harbour and the Liverpoor Bay area, Northwest Territories, 1981 to 1983: Winnipeg, Manitoba, Canada, Canadian Data Report of Fisheries and Aquatic Sciences, Department of Fisheries and Oceans, Western Region, no. 485, 22 p.

14. Fruge, D.J., Wiswar, D.W., Dugan, L.J., and Palmer, D.E., 1989, Fish population characteristics of Arctic National Wildlife Refuge coastal waters, summer 1988: Fairbanks, Alaska, U.S. Fish and Wildlife Service, Fishery Assistance office, Progress Report, 73 p.

15. Burns, J.J., 1990, Proceedings of a technical workshop on fishes utilized in subsistence fisheries in National Petroleum Reserve-Alaska—Barrow, Alaska, October 26–28, 1988: Report to North Shore Bureau, Department of Wildlife Management, Barrow, Alaska, 94 p.

16. Palmer, D.E., and Dugan, L.J., 1990, Fish population characteristics of Arctic National Wildlife Refuge coastal waters, summer 1989: Fairbanks, Alaska, U.S. Fish and Wildlife Service, Progress Report, 83 p.

17. Schmidt, D.R., Griffiths, W.B., Beaubien, D.K., and Herlugson, C.J., 1991, Movement of young-of-the-year Arctic ciscoes across the Beaufort Sea coast, 1985–1988: American Fisheries Society Symposium, no. 11, p. 132–144.

18. Wiswar, D.W., West, R.L., and Winkleman, W.N., 1995, Fisheries investigation in Oruktalik Lagoon, Arctic National Wildlife Refuge, Alaska, 1986: U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report, no. 30, 38 p.

19. Jarvela, L.E., and Thorsteinson, L.K., 1997, Movements and temperature occupancy of sonically tracked Dolly Varden and Arctic ciscoes in Camden Bay, Alaska: American Fisheries Society Symposium, no. 19, p. 165–174.

20. Majewski, A.R., Sareault, J.E., and Reist, J., 2006, Fish catch data from offshore sites in the Mackenzie River estuary and Beaufort Sea during the open water season, August 2004 aboard the CCGS Nahidik: Winnipeg, Manitoba, Fisheries and Oceans Canada, no. 2771, 42 p.

21. Bond, W.A., and Erickson, R.N., 1987, Fishery data from Phillips Bay, Yukon, 1985: Winnipeg, Manitoba, Canadian Data Report of Fisheries and Aquatic Sciences, Central and Artic Region, Department of Fisheries and Oceans, no. 635, 47 p.

22. Bond, W.A., and Erickson, R.N., 1997, Coastal migrations of Arctic ciscoes in the eastern Beaufort Sea, *in* Reynolds, J., ed., Fish ecology in Arctic North America, symposium 19: Bethesda, Maryland, American Fisheries Society, p. 155–164.

23. Moulton, L.L., 1989, Recruitment of Arctic cisco (*Coregonus autumnalis*) into the Colville Delta, Alaska, in 1985: Biological Papers of the University of Alaska, no. 24, p. 107–111.

24. Craig, P.C., 1989a, An introduction to anadromous fishes in the Alaskan Arctic: Biological Papers of the University of Alaska, v. 24, p. 27–54.

25. Sekerak, A.D., Stallard, N., and Griffiths, W.B., 1992, Distribution of fish and fish harvests in the nearshore Beaufort Sea and Mackenzie Delta during ice-covered periods, October–June: Environmental Studies Research Funds Report, LGS Ltd. No. 117, 524 p.

26. Griffiths, W.B., Craig, P., Walder, G., and Mann, G., 1975, Fisheries investigations in a coastal region of the Beaufort Sea (Nunaluk Lagoon, Yukon), *in* Craig, P.C., ed., Fisheries investigations in a coastal region of the Beaufort Sea: Arctic Gas, Biological Report Series, v. 34, p. 1–129.

27. Berg, L.S., 1948, Freshwater fishes of the USSR and adjacent countries, volume 1 (4th ed.): Moscow, Academy of Sciences of the USSR Zoological Institute, 466 p. [Translated from Russian by Israel Program for Science Translation, Jerusalem, 505 p.]

28. Craig, P.C., and Mann, G.J., 1974, Life history and distribution of Arctic Cisco (*Coregonus autumnalis*) along the Beaufort Sea Coastline in Alaska and the Yukon Territory, *in* McCart, P.J., ed., Life histories of anadromous and freshwater fish in the western Arctic: Aquatic Environments, Ltd., Arctic Gas Biological Report Series, v. 20, Prepared for Canadian Arctic Gas Study Limited and Alaskan Arctic Gas Study Company, 225 p.

29. Fechhelm, R.G., Streever, B., and Gallaway, B.J., 2007, The Arctic cisco (*Coregonus autumnalis*) subsistence and commercial fisheries, Colville River, Alaska—A conceptual model: Arctic, v. 60, no. 4, p. 421–429.

30. Van Gerwen-Toyne, M., Walker-Larsen, J., and Tallman, R.F., 2008, Monitoring spawning populations of migratory coregonids in the Peel River, NT—The Peel River fish study 1998-2002: Canadian Manuscript Report of Fisheries and Aquatic Sciences no. 2851, 56 p.

31. Bond, W.A., 1982, A study of the fishery resources of Tuktoyaktuk Harbour, southern Beaufort Sea coast, with special reference to life histories of anadromous coregonids: Canadian Technical Report of Fisheries and Aquatic Sciences, no. 1119, 90 p.

32. Underwood, T.J., Gordon, J.A., Millard, M.J., Thorpe, L.A., and Osborne, B.M., 1995, Characteristics of selected fish populations of Arctic National Wildlife Refuge coastal waters, final report, 1988–91: Fairbanks, Alaska, U.S. Fish and Wildlife Service, Fairbanks Fishery Resource Office, Alaska Fisheries Technical Report, no. 28.

33. Craig, P.C., and McCart, P.J., 1975, Fish utilization of nearshore coastal waters between the Colville and Mackenzie rivers with an emphasis on anadromous species, *in* Craig, P.C., ed., Fisheries Investigations in a coastal region of the Beaufort Sea: Calgary, Alberta, Canadian Arctic Gas Study Ltd. and Alaskan Arctic Gas Study Co., Biological Report Series 34, p. 172–219.

34. Johnson, S.W., Neff, A.D., and Thedinga, J.F., 2005, An atlas on the distribution and habitat of common fishes in shallow nearshore waters of southeastern Alaska: Alaska Fisheries Science Center, Technical Memorandum NMFS-AFSC-157, 98 p.

35. Fechhelm, R.G., Bryan, J.D., Griffiths, W.B., and Martin, L.R., 1997, Summer growth patterns of northern Dolly Varden (*Salvelinus malma*) smolts from the Prudhoe Bay region of Alaska: Canadian Journal of Fisheries and Aquatic Sciences, v. 54, no. 5, p. 1,103–1,110.

36. Fechhelm, R.G., Craig, P.C., Baker, J.S., and Gallaway, B.J., 1984, Fish distribution and use of nearshore waters in the northeastern Chukchi Sea: LGL Ecological Research Associates Inc., Outer Continental Shelf Environmental Assessment Program, National Oceanic and Atmospheric Administration, OMPA/OCSEAP, Final Report, 190 p.

37. Hachmeister, L.E., Glass, D.R., and Cannon, T.C., 1991, Effects of solid-fill gravel causeways on the coastal central Beaufort Sea environment: American Fisheries Society Symposium, no. 11, p. 81–96.

38. Robertson, S.B., 1991, Habitats versus populations—Approaches for assessing impacts on fish: American Fisheries Society Symposium, no. 11, p. 97–108.

39. Griffiths, W.B., Fechhelm, R.G., Gallaway, B.J., and Fissel, D.B., 1988, Yukon fish and effects of causeway: For Indian and Northern Affairs Canada, LGL Ltd. and Arctic Science Ltd., 124 p.

40. Fechhelm, R.G., Griffiths, W.B., Wilson, W.J., Trimm, B.A., and Colonell, J.M., 1996, The 1995 fish and oceanography study in Mikkelsen Bay, Alaska: Anchorage, Alaska, Prepared by LGL Alaska Research Associates and Woodward-Clyde Consultant for BP Exploration (Alaska) Inc.

41. Jarvela, L.E., and Thorsteinson, L.K., 1999, The epipelagic fish community of Beaufort Sea coastal waters, Alaska: Arctic, v. 52, no. 1, p. 80–94.

42. Gallaway, B.J., Griffiths, W.B., Craig, P.C., Gazey, W.J., and Helmericks, J.W., 1983, An assessment of the Colville River Delta stock of Arctic cisco—Migrants from Canada?: Biological Papers of the University of Alaska, no. 21, p. 4–23.

43. Fechhelm, R.G., and Fissel, D.B., 1988, Wind-aided recruitment of Canadian Arctic cisco (*Coregonus autumnalis*) into Alaskan waters: Canadian Journal of Fisheries and Aquatic Sciences, v. 45, no. 5, p. 906–910.

44. Fechhelm, R.G., and Griffiths, W.B., 1990, Effect of wind on the recruitment of Canadian Arctic cisco (*Coregonus autumnalis*) into the central Alaskan Beaufort Sea: Canadian Journal of Fisheries and Aquatic Sciences, v. 47, no. 11, p. 2,164–2,171.

45. Gallaway, B.J., Gazey, W.J., Colonell, J.M., Niedoroda, A.W., and Herlugson, C.J., 1991, The Endicott development project-preliminary assessment of impacts from the first major offshore oil development in the Alaskan Arctic: American Fisheries Society Symposium, no.11, p. 42–80.

46. Schmidt, D.R., Griffiths, W.B., and Martin, L.R., 1987, Importance of anadromous fish overwintering habitat in the Sagavanirktok River Delta, Alaska: Anchorage, Alaska, Report by Ecological Research Associates for Standard Alaska Production Company and North Slope Borough, 71 p.

47. Kendel, R.E., Johnston, R.A.C., Kozak, M.D., and Lobsiger, U., 1974, Movements, distribution, populations and food habits of fish in the western coastal Beaufort Sea: Department of the Environment, Canada, Interim Report of Beaufort Sea Project, Study B1, 64 p.

48. Lawrence, M.J., Lacho, G., and Davies, S., 1984, A survey of the coastal fishes of the southeastern Beaufort Sea: Canadian Technical Report of Fisheries and Aquatic Sciences, no. 1220, 178 p.

49. Bond, W.A., and Erickson, R.N., 1989, Summer studies of the nearshore fish community at Phillips Bay, Beaufort Sea coast, Yukon: Winnepeg, Manitoba, Canadian Technical Report of Fisheries and Aquatic Sciences, Central and Arctic Region, Department of Fisheries and Oceans, no. 1676, 102 p.

50. Bickham, J.W., Carr, S.M., Hanks, B.G., Burton, D.W., and Gallaway, B.J., 1989, Genetic analysis of population variation in the Arctic cisco (*Coregonus autumnalis*) using electrophoretic, flow cytometric, and mitochondrial DNA restriction analyses: Biological Papers of the University of Alaska, no. 24, p. 112–122.

51. Percy, R., 1975, Fishes of the outer Mackenzie Delta: Victoria, British Columbia, Beaufort Sea Project, Beaufort Sea Technical Report, no. 8, 114 p.

52. Hatfield, C.T., Stein, J.N., Falk, M.R., and Jessop, C.S., 1972, Fish resources of the Mackenzie River Valley: Winnepeg, Environment Canada Fisheries Service, Interim report 1, v. 1.53.

53. Colonell, J.M., and Gallaway, B.J., 1997, Wind-driven transport and dispersion of age-0 Arctic ciscoes along the Alaska Beaufort coast: American Fisheries Society Symposium, no. 19, p. 90–103.

54. Jones, M.L., and Den Beste, J., 1977, Tuft Point and adjacent coastal areas fisheries projects: Calgary, Alberta, Canada, Aquatic Environments, Ltd., 152 p.

55. Froese, R., and Pauly, D., eds., 2012, FishBase—Global information system on fishes: FishBase database, accessed July 8, 2012, at http://www.fishbase.org.

56. George, J.C., and Kovalsky, R., 1986, Observations on the Kupigruak Channel (Colville River) subsistence fishery, October 1985: Alaska Department of Wildlife Management, 66 p.

57. Moulton, L.L., Field, L.J., and Kovalsky, R., 1991, Predictability in the catch of Arctic cisco in the Colville River, Alaska: American Fisheries Society Symposium no. 11, p. 145–156.

58. George, C., Moulton, L.L., and Johnson, M., 2007, A field guide to the common fishes of the North Slope of Alaska: Alaska Department of Wildlife Management, North Slope Borough, 93 p.

59. von Biela, V.R., Zimmerman, C.E., and Moulton, L.L., 2011, Long-term increases in young-of-the-year growth of Arctic cisco *Coregonus autumnalis* and environmental influences: Journal of Fish Biology, v. 78, no. 1, p. 39–56.

60. Durand, J.R., Lusardi, R.A., Nover, D.M., Suddeth, R.J., Carmona-Catot, G., Connell-Buck, C.R., and others, 2011, Environmental heterogeneity and community structure of the Kobuk River, Alaska, in response to climate change: Ecosphere, v. 2, no. 4.

61. Bickham, J.W., Patton, J.C., Minzenmayer, S., Moulton, L.L., and Gallaway, B.J., 1997, Identification of Arctic and Bering ciscoes in the Colville River Delta, Beaufort Sea coast, Alaska, *in* Reynolds, J., ed., Fish ecology in Arctic North America: Bethesda, Maryland, American Fisheries Society, Symposium no. 19, p. 224–228.

62. Reist, J.D., Maiers, L.D., Bodaly, R.A., Vuorinen, J.A., and Carmichael, T.J., 1998, The phylogeny of new- and old-world coregonine fishes as revealed by sequence variation in a portion of the d-loop of mitochondrial DNA: Archiv für Hydrobiologie, Special Issues Advances in Limnology, v. 50, p. 323–339.

63. Reist, J.D., Vuorinen, J.A., and Bodily, R.A., 1992, Genetic and morphological identification of coregonid hybrid fishes from Arctic Canada: Polskie Archiwum Hydrobiologii, v. 39, no. 3/4, p. 551–562.

Bering Cisco (*Coregonus laurettae*)

Bean, 1881

Family Salmonidae

Bering Cisco (*Coregonus laurettae*). Photograph by R.J. Brown, U.S. Fish and Wildlife Service.

Colloquial Name: Iñupiat: *Qaaktaq*, *tipuk* [1].

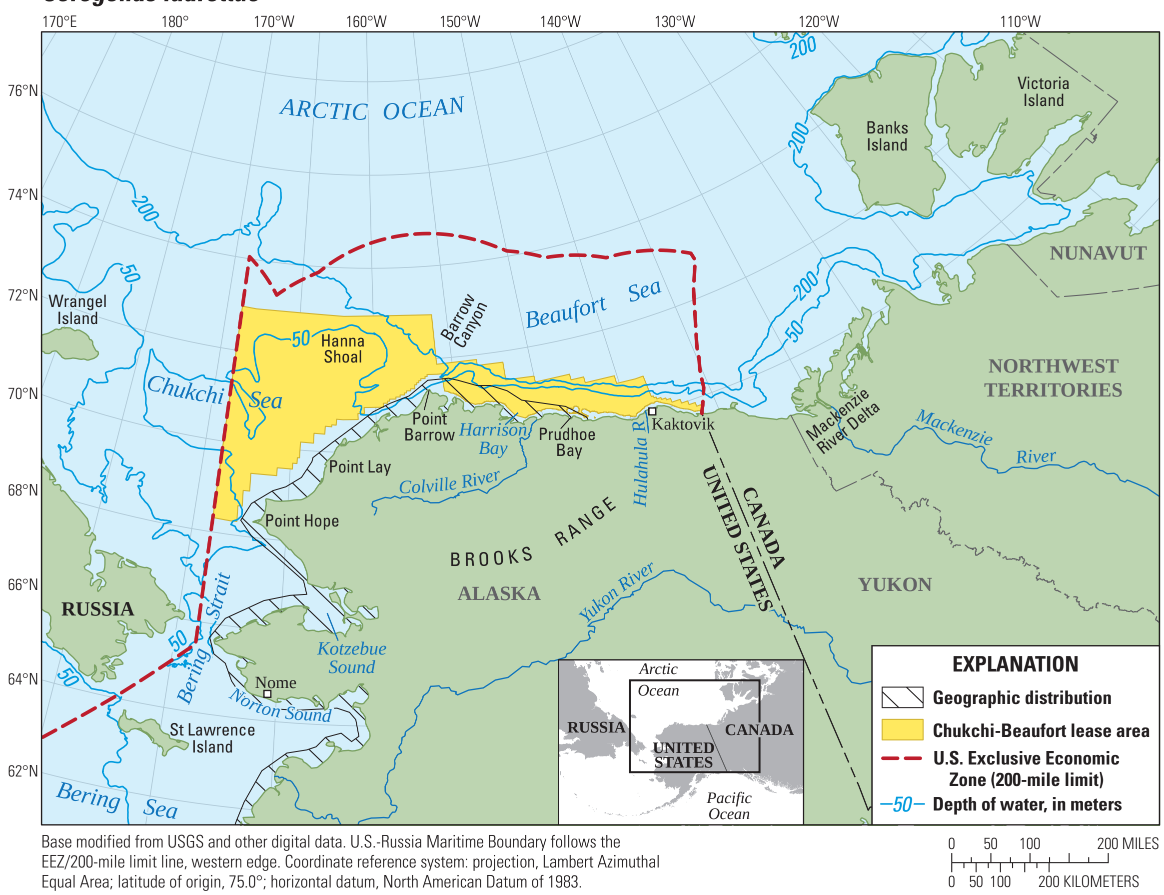
Ecological Role: Although data are lacking, this is a schooling species, and may be of some ecological importance in the nearshore of the U.S. Chukchi Sea and perhaps western part of U.S. Beaufort Sea.

Physical Description/Attributes: Elongate, slightly compressed body with brownish to dark green back and silvery belly. There may be black dots with faint halos on the body, or white spots on the fins, or both. The anal, pectoral, and pelvic fins are pale. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 184) [2]. Swim bladder: Present [3]. Antifreeze glycoproteins in blood serum: Unknown.

Range: *U.S. Chukchi Sea east to U.S. Beaufort Sea at Oliktok Point (just east of the Colville River).* Elsewhere in Alaska, southward to the Kenai Peninsula, northern Gulf of Alaska. Worldwide, Chukotka Peninsula, eastern Siberia, Russia [2].

Relative Abundance: *Patchily abundant (common on rare occasions) as far eastward as the Colville River, as well as such locations as the Barrow, Wainwright, and Kotzebue regions* [7–9].

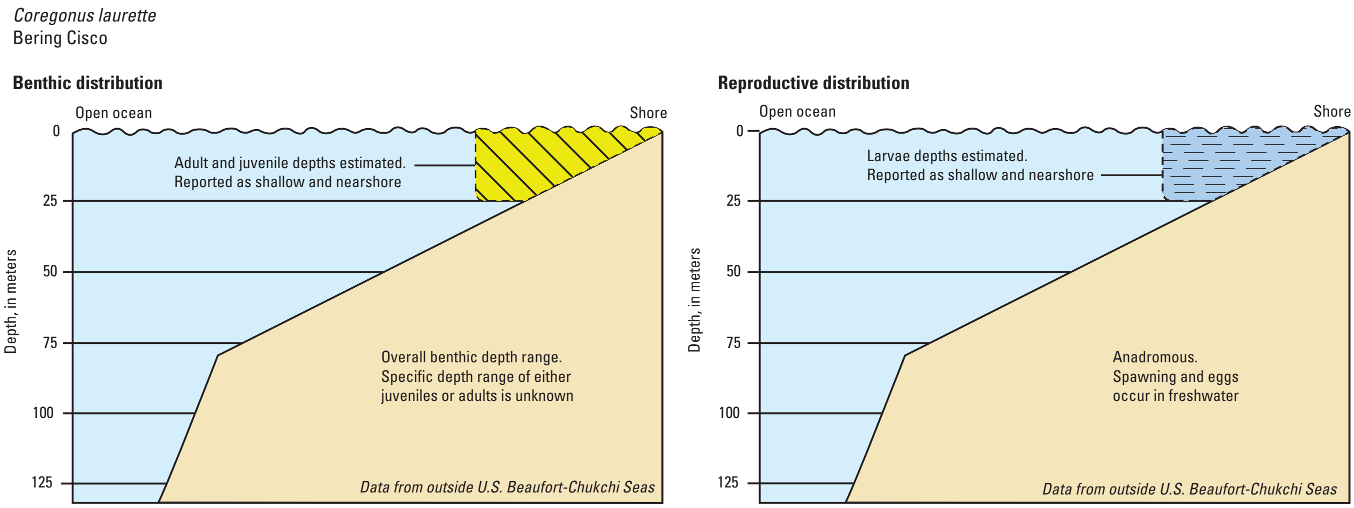
Bering Cisco
Coregonus laurettae



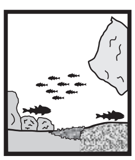
Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

Geographic distribution of Bering Cisco (*Coregonus laurettae*) at sea within 2008–09 lease areas [4] based on review of published literature and specimens from historical and recent collections [5, 6].

Depth Range: Mainly shallow nearshore waters, although taken as much as 20–30 km offshore in Yukon River plume [10, 11].

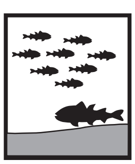


Benthic and reproductive distribution of Bering Cisco (*Coregonus laurette*).



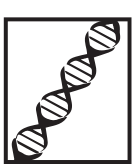
Habitats and Life History

Anadromous [12].
Eggs—Size: Specific size unknown. 2.3–3.0 mm for whitefish in general [12]. Time to hatching: Specific time unknown. 150–200 days for northern whitefish in general [12]. Habitat: Benthic, in gravel beds of fast-flowing rivers [11, 12].
Alevins (larvae)—Size at hatching: Unknown. Size at juvenile transformation: Unknown. Days to juvenile transformation: Unknown. Habitat: Pelagic, in freshwater rivers to nearshore estuaries [11].
Juveniles—Age and size: Minimum size unknown. Matures at about 4 years and 310 mm [11, 13]. Habitat: Nearshore marine and brackish waters [11].
Adults—Age and size at first maturity: 4 years and as small as 310 mm (Yukon River) [11, 13]. Maximum age: At least 13 years [12], *and at least 8 years in Colville River area* [9]. Maximum size: 48 cm [2]. Habitat: Pelagic, mainly in marine and estuarine nearshore waters. Fast-flowing rivers for spawning [11].
Substrate—Sand and gravel for spawning [11, 12].
Physical/chemical—Temperature: Unknown. Salinity: Fresh to full seawater. The most marine-tolerant of all coregonids within the study area range [13].



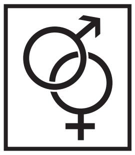
Behavior

Diel—Unknown.
Seasonal—Eggs hatch in spring. Alevins (larvae) likely move downstream soon after and enter coastal waters where they spend their first years [11]. Upon maturity, adults migrate up river. Anadromous fish, probably on spawning runs, have been found at least 2,000 km [14] or perhaps as much as 2,150 km [15] upstream in the Yukon River. Spawning occurs in Yukon, Kuskokwim, and Susitna Rivers [11, 12, 16]. Yukon River spawning migrations are continuous throughout the summer with major pulses varying from year to year [12]. Spawning occurs in autumn [11]. *Juveniles and adults overwinter beneath ice of river deltas and other coastal waters* [7, 11, 17].
Reproductive—Spawns annually [12]. Broadcast spawners over gravel beds in fast-flowing rivers [11]. Returns to sea after spawning [11].
Schooling—Forms schools [11].
Feeding—Feeding likely occurs in nearshore waters, especially near river mouths and brackish estuaries [11]. Does not feed during spawning migrations [11].

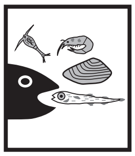


Populations or Stocks

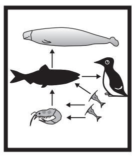
There have been no studies within the study area.



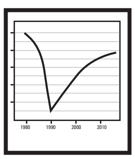
Reproduction
Mode—Gonochoristic, oviparous, iteroparous with external fertilization [11].
Spawning season—Autumn; early to mid-October in Yukon and Kuskokwim River drainages [11, 12].
Fecundity—In Yukon River, 20,210–34,166 orange, non-adhesive eggs [12].



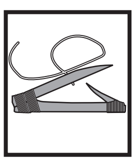
Food and Feeding
Food items—Mysids as well as harpacticoid copepods, isopods, gammarid amphipods, crangonid shrimps, insects, and small fishes [18].
Trophic level—3.79 (standard error 0.59) [19].



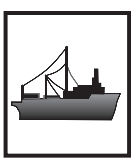
Biological Interactions
Predators—Unknown.
Competitors—Unknown.



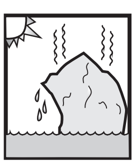
Resilience
Medium, minimum population doubling time: 1.4–4.4 years (Preliminary *K* or Fecundity) [19].



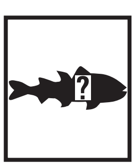
Traditional and Cultural Importance
There are subsistence fisheries for Bering Cisco wherever the species is found. *The species is most important near Wainwright* [20] *and Kotzebue Sound* [7], *although occasional anomalously large runs are known from the Colville River region* [8]. *Bering Cisco are taken during open water seasons and under the ice by gillnets and hook and line* [20, 21]. *This very oily species is most often roasted, salted, or frozen* [7].



Commercial Fisheries
Currently, Bering Cisco are not commercially harvested. Historically, there has been no commercial fishery for this species [22] until 2008, when a fishery was initiated at the mouth of the Yukon River to supply a New York kosher market with smoked fish [12].



Potential Effects of Climate Change
Unknown. However, Durand and others (2011) estimate that, at least for anadromous fishes in sub-arctic rivers various biological shifts will be caused by the timing of spring ice break-up (and thus peak flow timing) and various permafrost processes that influence nutrient and sediment supply [23]



Areas for Future Research [B]
Little is known about the ecology and life history of this species in the study area. Research needs include: (1) depth, location, and timing of spawning; (2) size and age of fish at hatching and transformation; (3) preferred depth ranges and locations for juveniles and adults; (4) spawning season; (5) seasonal and ontogenetic movements; (6) population studies; (7) prey; and (8) predators.

References Cited

Alt, K.T., 1973a, Contributions to the biology of the Bering cisco (*Coregonus laurettae*) in Alaska: Journal of the Fisheries Research Board of Canada, v. 30, no. 12, p. 1,885–1,888. [13]

Brown, R.J., Brown, C., Braem, N.M., Carter, W.K., III, Legere, N., and Slayton, L., 2012, Whitefish biology, distribution, and fisheries in the Yukon and Kuskokwim river drainages in Alaska—A synthesis of available information: U.S. Fish and Wildlife Service, Alaska Fisheries Data Series Number 2012-4, 316 p. [12]

Committee on the Status of Endangered Wildlife in Canada, 2004, COSEWIC assessment and update status report on the Bering cisco *Coregonus laurettae* in Canada: Ottawa, Canada, Committee on the Status of Endangered Wildlife in Canada, 19 p. [11]

Georgette, S., and Shiedt, A., 2005, Whitefish—Traditional ecological knowledge and subsistence fishing in the Kotzebue Sound, Alaska: Alaska Department of Fish and Game, Technical Report No. 290, 148 p. [7]

Mecklenburg, C.W., Mecklenburg, T.A., and Thorsteinson, L.K., 2002, Fishes of Alaska: Bethesda, Maryland, American Fisheries Society, 1,116 p. [2]

Bibliography

1. Craig, P.C., 1989, Subsistence fisheries at coastal villages in the Alaskan Arctic, 1970–1986: Biological Papers University of Alaska, no. 24, p. 131–152.
2. Mecklenburg, C.W., Mecklenburg, T.A., and Thorsteinson, L.K., 2002, Fishes of Alaska: Bethesda, Maryland, American Fisheries Society, 1,116 p.
3. Jordan, D.S., and Evermann, B.W., 1896, The fishes of North and Middle America—A descriptive catalogue of the species of fish-like vertebrates found in the waters of North America, North of the Isthmus of Panama, part 1: Bulletin of the United States National Museum, no. 47, 1,240 p.
4. Minerals Management Service, 2008, Beaufort Sea and Chukchi Sea planning areas—Oil and Gas Lease Sales 209, 212, 217, and 221: U.S. Department of the Interior, Minerals Management Service Alaska OCS Region, OCS EIS/EA, MMS 2008-0055, 538 p.
5. Mecklenburg, C.W., and Mecklenburg, T.A., 2009, Arctic marine fish museum specimens, 2nd ed., Metadata report and database submitted to ArcOD, Institute of Marine Science: University of Alaska, Fairbanks, by Point Stephens Research, metadata report accessed August 8, 2012, at http://www.arcodiv.org/Database/Fish_datasets.html.
6. 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.
7. Georgette, S., and Shiedt, A., 2005, Whitefish—Traditional ecological knowledge and subsistence fishing in the Kotzebue Sound, Alaska: Alaska Department of Fish and Game, Technical Report No. 290, 148 p.
8. George, C., Moulton, L.L., and Johnson, M., 2007, A field guide to the common fishes of the North Slope of Alaska: Alaska Department of Wildlife Management, North Slope Borough, 93 p.
9. Moulton, L.L., Owl Ridge Natural Resource Consultants, written commun., 2011.
10. Schmidt, D.R., Griffiths, W.B., Beaubien, D.K., and Herlugson, C.J., 1991, Movement of young-of-the-year Arctic ciscoes across the Beaufort Sea coast, 1985–1988: American Fisheries Society Symposium, no. 11, p. 132–144.
11. Committee on the Status of Endangered Wildlife in Canada, 2004, COSEWIC assessment and update status report on the Bering cisco *Coregonus laurettae* in Canada: Ottawa, Canada, Committee on the Status of Endangered Wildlife in Canada, 19 p.
12. Brown, R.J., Brown, C., Braem, N.M., Carter, W.K., III, Legere, N., and Slayton, L., 2012, Whitefish biology, distribution, and fisheries in the Yukon and Kuskokwim river drainages in Alaska—A synthesis of available information: U.S. Fish and Wildlife Service, Alaska Fisheries Data Series Number 2012-4, 316 p.

13. Alt, K.T., 1973a, Contributions to the biology of the Bering cisco (*Coregonus laurettae*) in Alaska: Journal of the Fisheries Research Board of Canada, v. 30, no. 12, p. 1,885–1,888.

14. Brown, R.J., Bickford, N., and Severin, K., 2007, Otolith trace element chemistry as an indicator of anadromy in Yukon River drainage coregonine fishes: Transactions of the American Fisheries Society, v. 136, no. 3, p. 678–690.

15. DeGraaf, D.A., 1981, First Canadian record of Bering cisco (*Coregonus laurettae*) from the Yukon River at Dawson, Yukon Territory: The Canadian Field-Naturalist, v. 95, no. 1, p. 365.

16. Bickham, J.W., Patton, J.C., Minzenmayer, S., Moulton, L.L., and Gallaway, B.J., 1997, Identification of Arctic and Bering ciscoes in the Colville River Delta, Beaufort Sea coast, Alaska, *in* Reynolds, J., ed., Fish ecology in Arctic North America: Bethesda, Maryland, American Fisheries Society, Symposium no. 19, p. 224–228.

17. Craig, P.C., 1989, An introduction to anadromous fishes in the Alaskan Arctic: Biological Papers of the University of Alaska, v. 24, p. 27–54.

18. Martin, D.J., Glass, D.R., Whitmus, C.J., Simenstad, C.A., Milward, D.A., Volk, E.C., Stevenson, M.L., Nunes, P., Savoie, M., and Grotefendt, R.A., 1986, Distribution, seasonal abundance, and feeding dependencies of juvenile salmon and non-salmonid fishes in the Yukon River Delta: Outer Continental Shelf Environmental Assessment Program, Reports of Principal Investigators, U.S. Department of Commerce and U.S. Department of the Interior, 388 p.

19. Froese, R., and Pauly, D., eds., 2012, FishBase—Global information system on fishes: FishBase database, accessed July 8, 2012, at http://www.fishbase.org.

20. Nelson, R.K., 1981, Harvest of the sea—Coastal subsistence in modern Wainwright: North Slope Borough, 112 p.

21. Moulton, L.L., Field, L.J., and Kovalsky, R., 1991, Predictability in the catch of Arctic cisco in the Colville River, Alaska: American Fisheries Society Symposium no. 11, p. 145–156.

22. Alaska Department of Fish and Game, 2008, 2008 Lower Yukon whitefish fishery outlook, regulations, and management strategies: Alaska Department of Fish and Game, Division of Commercial Fisheries, news release, no. 51.

23. Durand, J.R., Lusardi, R.A., Nover, D.M., Suddeth, R.J., Carmona-Catot, G., Connell-Buck, C.R., and others, 2011, Environmental heterogeneity and community structure of the Kobuk River, Alaska, in response to climate change: Ecosphere, v. 2, no. 4.