

ARCTIC COD

Boreogadus saida Lepechin 1774
(Gadidae)

Global rank GNR

State rank S4S5 (15Jul2004)

State rank reasons

Based on scant information, species appears relatively secure. However, due to importance as keystone species in arctic food webs is of particular conservation concern. Widely abundant, population trends variable. Along Beaufort Sea coast, near shore distribution in close proximity to oil exploration, vulnerable to oil spills and contamination. May be particularly sensitive to effects of climate change which could alter sea ice distribution and water temperature.

Taxonomy

Frequently called polar cod, which is confusing when not used with scientific name. The American Fisheries Society (AFS) uses polar cod for *Arctogadus glacialis*, which is in the same family. Conversely, the name Arctic cod is often used in European literature for *Gadus morhua*, the Atlantic cod (Mecklenburg et al. 2002).

General description

Brownish dorsally with fine black dots and violet or yellowish sheen; silvery white ventrally; caudal and three dorsal fins with white margins, two anal fins with black margins. Body is slender and tapered markedly toward tail, lower jaw slightly protruding or jaws are equal, caudal fin is deeply emarginate. Palatine teeth absent. Scales are non-overlapping, circular and embedded; skin has the texture of coarse sandpaper (Mecklenburg et al. 2002). Length to 40 cm, normally less than 25 cm (Cohen et al. 1990).

Length (cm) 40

Reproduction

Age at sexual maturity about 2-3 years for males and 3 years for females in the Beaufort Sea and most other parts of its range (Craig et al. 1982); 4-5 years for both sexes in the White Sea (Cohen et al. 1990). Usually spawn no more than once in a lifetime, commonly under sea ice, between November and February (Craig et al. 1982) but may extend to mid-July in the northeastern Chukchi Sea (Wyllie-Echeverria et al. 1997). Eggs produced are the largest and fewest (average of 11,900 per female) of all species in the cod family (ADFG 1986, Cohen et al. 1990). Eggs are fertilized externally and dispersed in the water



column. Incubation lasts 45-90 days, and varies with water temperature (Sameoto 1984).

Ecology

A keystone species in arctic ecosystems; a major trophic link between primary producers/zooplankters and upper trophic levels (Craig et al. 1982.). Human use includes harvest for fishmeal and a source of oil (Cohen et al. 1990). Associated with floating sea ice, under which it may spawn, forage, and seek protection in cracks; antifreeze glycoproteins synthesized in its liver aid survival in water below the equilibrium freezing point of body fluids (Gillispie 1997).

Migration

Observed in dense schools in open water in late summer and early winter prior to spawning. Migrates to nearshore waters in late summer as water salinity increases, and remains under nearshore ice in winter to spawn before moving offshore in spring (Craig 1984). Have been observed descending to greater depths and colder water when surface temperatures in the Barents Sea increased to 10 degrees C in late summer/early fall (Hognestad 1968, Ponomarenko 1968). Arctic cod from the northern Bering and southern Chukchi seas observed moving north with the receding ice edge (Lowry and Frost 1981).

Food

Young-of-year (YOY) consume phytoplankton and very small or early stages of zooplankton; adults prey on pelagic zooplankton, substrate and ice-associated crustaceans, and occasionally young fish (ADFG 1986). Zooplankton taken primarily include copepods (*Calanus* spp.), amphipods (*Themisto* spp.), and mysids (Fechhelm et al. 1984; Hop et al. 1997). Often found near ice edges and boundaries between warm and cold water bodies where phytoplankton and zooplankton concentrate. May exhibit two behavior strategies: schooling or individual foraging (Hop et al. 1997).

Phenology

Spawns between November and February under sea ice (Craig et al. 1982), but spawning may extend to mid-July in some areas (Wyllie-Echeverria et al. 1997). Annual schooling and migrations occur in fall/early winter to nearshore waters; in spring to offshore waters.

Habitat

Inhabits a wide variety of marine habitats. Prefers cold temperatures (-1.8-10 degrees C) but tolerates variable water temperatures and high or variable salinities (< 14 psu) and turbidities (Craig et al. 1982, ADFG 1986, Cannon et al. 1991). Found most commonly at the water's surface, close to shore among ice floes, but also occur offshore at depths greater than 900m. Species is associated with the undersurface and cracks in sea ice, but also found near the ocean bottom and throughout the water column in open water (ADFG 1986).

Global range

Circumpolar distribution. In Arctic Ocean to the White Sea, Iceland, and southern Greenland, in the western Atlantic into the Miramichi River, New Brunswick, and in the Chukchi, Beaufort, and Bering Sea to Cape Olyutorski, the Pribilof Islands, and Bristol Bay (Allen and Smith 1988). Observed farther north than any other fish species (Dept. of Fisheries and Oceans Canada 2004).

State range

Present in the Bering, Chukchi and Beaufort Seas. In the Bering Sea, rare in south and central parts but present generally north of 62° N from Bristol Bay northwards, and more commonly found offshore than in nearshore waters (Bradstreet et al. 1986). Present throughout the Chukchi Sea (Wyllie-Echeverria et al. 1997). In the Beaufort Sea, well documented in and near Prudhoe Bay and Simpson Lagoon.

Global abundance

Unknown, but apparently abundant based on total world catch of 23,709 metric tons in 1984 and 11,713 in 1987 (Cohen et al. 1990). Largest stocks probably occur in the Kara, Barents and White Seas (Ponomarenko 1968). In Alaska, more abundant in northeastern Chukchi and western Beaufort seas than in north Bering and central Beaufort seas (Frost and Lowry 1981).

State abundance

Localized abundance varies widely and naturally. The most abundant species, by far, in numerous fisheries studies in Arctic waters (Craig et al. 1982, Fruge et al. 1989, Palmer and Dugan 1990). Most abundant in the northeastern Chukchi and western Beaufort seas; least abundant in north Bering and central Beaufort seas (Frost and Lowry 1981). Abundance highly variable between years in Beaufort Sea studies (see State trend comments).

Global trend

Abundance varies widely and naturally. Studies of marine predator diets suggest a potential decline in Arctic cod abundance in the Canadian Arctic. Finley et al. (1990) attributed a decline of Arctic cod in harp seals' (*Phoca groenlandica*) diets from 1978 to 1979 to a decline in abundance or availability. Arctic cod decreased in murre (*Uria* spp.) diets (frequency of occurrence from 55% to 12%) in coastal Newfoundland between 1984-86 and 1996-98 (Rowe et al. 2000). The frequency of arctic cod delivered to Thick-billed murre (*Uria lomvia*) nestlings in Hudson Bay has declined (43% to 15%) since the 1980's; this decline has been linked to warming waters and a decrease in July ice cover (Gaston et al. 2003). The FAO reports steadily declining world catch numbers from 1984 to 1987, but notes stocks are fished less intensively than in the past (Cohen et al. 1990).

State trend

High variation in arctic cod abundance often reported in the Beaufort Sea. In the Sagavanirktok Delta, cod abundance varied between 1985 and 1993, but did not increase over time (Griffiths et al. 1998). Between 1977 and 1978, the number of cod collected at Simpson Lagoon, west of Prudhoe Bay, increased 200-fold (767 vs. 139,790) (Craig et al. 1982). This increase was also observed elsewhere along the Beaufort Sea coast. In the Barter Island region, 200 km east of Prudhoe Bay, significant differences were found in year-to-year abundance of cod between 1988 and 1992 (Underwood et al. 1995). In coastal waters of the Arctic National Wildlife Refuge, catch-per-unit-effort (CPUE) increased from 1988 to 1989, then decreased between 1988/1989 and 1991 (Palmer and Dugan 1990, Underwood et al. 1994).

Global protection

Unknown.

State protection

The Alaska Department of Fish and Game has managerial authority over arctic cod extending to three miles offshore. However, because harvest of cod is minimal, no management plan currently exists for this species (ADFG 1986).

Global threats

This species' preference for cold water and association with sea ice makes it vulnerable to climate change which could result in altering sea ice distribution and water temperatures in Arctic regions. A recent study in Hudson Bay has correlated decreasing July ice cover with a decline in arctic cod abundance (Gaston et al. 2003). Mortality has been associated with strong winds and storms: large numbers of arctic cod have been washed ashore during fall and winter storms in Russia; on the Kara Sea coast heaps of cod from 5 to 10m wide and 3 to 5m high, extending over tens of kilometers have accumulated after storms (Ponomarenko 1968).

State threat

Major threats include habitat degradation from coastal development, as well as pollution from offshore oil development, oil spills, and vessel traffic. Arctic cod eggs are buoyant and fish are pelagic, making both vulnerable to toxicants such as hydrocarbons, disinfectants, heavy metals, drilling muds and other chemicals which collect on the surface, in the water column, under ice, and in cracks in sea ice - consolidation areas for both cod and contaminants (Fechhelm et al. 1984, ADFG 1986). This species' preference for cold water and association with sea ice makes it vulnerable to climate change which could result in altering sea ice distribution and water temperatures in Arctic regions.

State research needs

Baseline information on life history and habitat requirements needed. Determine abundance and harvest levels in all parts of the arctic cod's distribution. Identify the effects of commercial/subsistence fisheries and possible climate change on populations and distribution. Study rates and effects of natural habitat change compared to human-caused habitat change in Arctic oceans.

State inventory needs

Baseline information on distribution needed. Monitoring needed to determine annual abundance, inter-annual variability, and population trends. Lack of information on harvest

data, and the impacts of harvest on population are unknown; harvest assessment needed.

State conservation and management needs

The importance of arctic cod as a primary food source for many marine species makes its conservation essential. A regular monitoring program to determine trends in abundance and distribution should be established. Methods for effective pollutant spill cleanup in ice-affected waters should be explored and spill response plans created for areas in arctic cod's range. Bycatch in commercial fisheries should be monitored and regulated.

LITERATURE CITED

- Alaska Department of Fish and Game (ADFG). 1986. Arctic cod life history and habitat requirements: Arctic region. Pp. 571-579 in: Alaska habitat management guide: life histories and habitat requirements of fish and wildlife. Juneau, Alaska.
- Allen, M.J. and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. National Marine Fisheries Service Technical Report 66.
- Barber, W.E., R.L. Smith, M. Vallarino, and R.M. Meyer. 1997. Demersal fish assemblages of the northeastern Chukchi Sea, Alaska. Fishery Bulletin 95:195-209.
- Bradstreet, M.S. W., K.J. Finley, A.D. Sekerak, W.B. Griffiths, C.R. Evans, M.F. Fabijan and H.E. Stallard. 1986. Aspects of the biology of arctic cod (*Boreogadus saida*) and its importance in arctic marine food chains. Central and Arctic region, Canadian Dept. of Fisheries and Oceans. Canadian technical report of fisheries and aquatic sciences no. 1491.
- Cannon, T.C., D.R. Glass, and C.M. Prewitt. 1991. Habitat use patterns of juvenile arctic cod in the coastal Beaufort Sea near Prudhoe Bay, Alaska. American Fisheries Society Symposium 11:157-162.
- Cohen, D.M., T. Inada, T. Iwamoto and N. Scialabba. 1990. Gadiform fishes of the world (Order Gadiformes). An annotated and illustrated catalogue of cods, hakes, grenadiers and other gadiform fishes known

- to date. FAO species catalogue: FAO Fisheries Synopsis No. 125, Vol. 10. 442 pp.
- Craig, P.C. 1984. Fish use of coastal waters of the Alaskan Beaufort Sea: a review. Transactions of the American Fisheries Society 113:265-282.
- Craig, P.C., W.B. Griffiths, L. Haldorson, and H. McElderry. 1982. Ecological studies of arctic cod (*Boreogadus saida*) in Beaufort Sea coastal water, Alaska. Canadian Journal of Fisheries and Aquatic Science 39:395-406.
- Dept. of Fisheries and Oceans (DFO) Canada. 2004. Underwater world/arctic cod. Available online at: http://www.dfo-mpo.gc.ca/zone/underwater_sous-marin/ArcticCod/artcod-saida_e.htm. Accessed 6/22/04.
- Fechhelm, R.G., P.C. Craig, J.S. Baker, and B.J. Gallaway. 1984. Fish distribution and use of nearshore waters in the northeastern Chukchi Sea. Final Report: NOAA/OCSEAP. Prepared by LGL Ecological Research Associates, Inc.
- Finley, K.J., M. S.W. Bradstreet, and G.W. Miller. 1990. Summer feeding ecology of harp seals (*Phoca groenlandica*) in relation to arctic cod (*Boreogadus saida*) in the Canadian high Arctic. Polar Biology 10:609-618.
- Frost, K. J., and L. F. Lowry. 1981. Ringed, Baikal, and Caspian seals. Pp. 29-53 in: Ridgeway, S. H. and R. J. Harrison, (eds.). Handbook of marine mammals. Vol. 2. Seals. Academic Press, N.Y.
- Fruge, D.J., D.W. Wiswar, L.J. Dugan, and D.E. Palmer. 1989. Fish population characteristics of Arctic National Wildlife Refuge coastal waters, summer 1988. US Fish and Wildlife Service, Progress Report, Fairbanks, Alaska.
- Gaston, A.J., K. Woo, and J.M. Hipfner. 2003. Trends in forage fish populations in the northern Hudson Bay since 1981, as determined from the diet of nestling thick-billed murre, *Uria lomvia*. Arctic 58:227-233.
- Gillispie, J.A.G. 1997. The Biology and ecology of arctic cod. M.S. Thesis, University of Alaska Fairbanks, Fairbanks, Alaska.
- Gillispie, J.G., R.L. Smith, E. Barbour, and W.E. Barber. 1997. Distribution, abundance, and growth of arctic cod in the northeastern Chukchi Sea. In: Fish ecology in Arctic North America, American Fisheries Society Symposium 19:81-89.
- Griffiths, W.B., R.G. Fechhelm, B.J. Gallaway, L.R. Martin and W.J. Wilson. 1998. Abundance of selected fish species in relation to temperature and salinity patterns in the Sagavanirktok Delta, Alaska, following construction of the Endicott Causeway. Arctic 51: 94-104.
- Hognestad, P.T. 1968. Observations on polar cod in the Barents Sea. Rapports et proces-verbaux des reunions, conseil permanent international pour l'exploration de la mer 158:126-130.
- Hop, H., H.E. Welch, and R.E. Crawford. 1997. Population structure and feeding ecology of arctic cod schools in the Canadian high Arctic. In: Fish ecology in Arctic North America, American Fisheries Society Symposium 19:68-80.
- Lowry, L.F. and K.J. Frost. 1981. Distribution, growth, and foods of arctic cod (*Boreogadus saida*) in the Bering, Chukchi, and Beaufort seas. Canadian Field-Naturalist 95:186-191.
- Mecklenburg, C.W., T.A. Mecklenburg and L.K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, p. 290.
- Palmer, D.E. and L.J. Dugan. 1990. Fish population characteristics of Arctic National Wildlife Refuge coastal water, summer 1989. US Fish and Wildlife Service, Progress Report, Fairbanks, Alaska.
- Ponomarenko, V.P. 1968. Some data on the distribution and migrations of polar cod in the seas of the Soviet Arctic. Rapports et proces-verbaux des reunions, conseil permanent international pour l'exploration de la mer 158:131-135.
- Rowe, S., I.L. Jones, J.W. Chardine, R.D. Elliot, and B.G. Veitch. 2000. Recent changes in the winter diet of murre (*Uria* spp.) in coastal Newfoundland waters. Canadian Journal of Zoology 78:495-500.

Sameoto, D. 1984. Review of current information on arctic cod (*Boreogadus saida*, Lepechin) and bibliography. Bedford Institute of Oceanography, Canadian Dept. of Fisheries and Oceans.

Underwood, T.J., J.A. Gordon, L.A. Thorpe, and B.M. Osborne. 1994. Fish population characteristics of Arctic National Wildlife Refuge coastal waters, summer 1991. US Fish and Wildlife Service, Alaska Fisheries Progress Report Number 94-1, Fairbanks, Alaska.

Underwood, T.J., J.A. Gordon, M.J. Millard, L.A. Thorpe, and B.M. Osborne. 1995. Characteristics of selected fish populations of Arctic Wildlife Range coastal waters. Final report, 1988-1991. Alaska Fisheries Technical Report, Number 28. U.S. Fish and Wildlife Service. Fairbanks Fishery Resource Office.

Wyllie-Echeverria, T. 1995. Seasonal sea ice, the cold pool and Gadid distribution on the Bering Sea shelf. M.S. Thesis, University of Alaska Fairbanks, Fairbanks, Alaska.

Wyllie-Echeverria, T., W.E. Barber, and W. Wyllie-Echeverria. 1997. Water masses and transport of age-0 arctic cod and age-0 Bering flounder into the northeastern Chukchi Sea. In: Fish ecology in Arctic North America, American Fisheries Society Symposium 19:60-67.

Acknowledgements

State Conservation Status, Element Ecology & Life History

Author(s): Gotthardt, T.A., J.G.
McClory

**State Conservation Status, Element Ecology &
Life History Edition Date:** 23Mar2005

Reviewer(s): Michael Kelly, Environment and
Natural Resources Institute, University of Alaska
Anchorage.

Life history and Global level information were obtained from the on-line database, NatureServe Explorer (www.natureserve.org/explorer). In many cases, life history and Global information were updated for this species account by Alaska Natural Heritage Program zoologist, Tracey Gotthardt. All Global level modifications will be sent to NatureServe to update the on-line version.

