

Broad Whitefish to Dolly Varden

Broad Whitefish (*Coregonus nasus*)

(Pallas, 1776)

Family Salmonidae

Colloquial Name: *Iñupiat*—*Aanaakliq*, *Aanaaliq* [1, 2]; *Qalupiaq*, *Qausriluk*, *Qausiluk*, *Sigguilaq*, *Siyyuilaq* [3, 57].

Ecological Role: This species rarely ventures into marine waters, preferring fresh and nearshore brackish conditions. It is one of the most prominent members of the coastal fish community and is important in seasonal food webs during ice-free periods.

Physical Description/Attributes: Laterally compressed with a rounded to flat head, a broad maxilla, short and blunt gill rakers, and very thick scales. These scales develop prominent tubercles during the spawning season. Colors are olive-brown to nearly black on back, silvery, and white to yellowish belly. Fins of small fish are pale and in older individuals are dark [3, 4]. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 185) [4]. Swim bladder: Present [5]. Antifreeze glycoproteins in blood serum: Unknown.

Range: *U.S.* *Chukchi and Beaufort Seas* [4]. Elsewhere in Alaska, found in Bering Sea drainages south to Kuskokwim Bay, southwestern Alaska. Worldwide, Arctic coasts from Siberia eastward to the Perry River, Nunavut, eastern Canada [4].



Broad Whitefish (*Coregonus nasus*). Photograph by R.J. Brown, U.S. Fish and Wildlife Service.

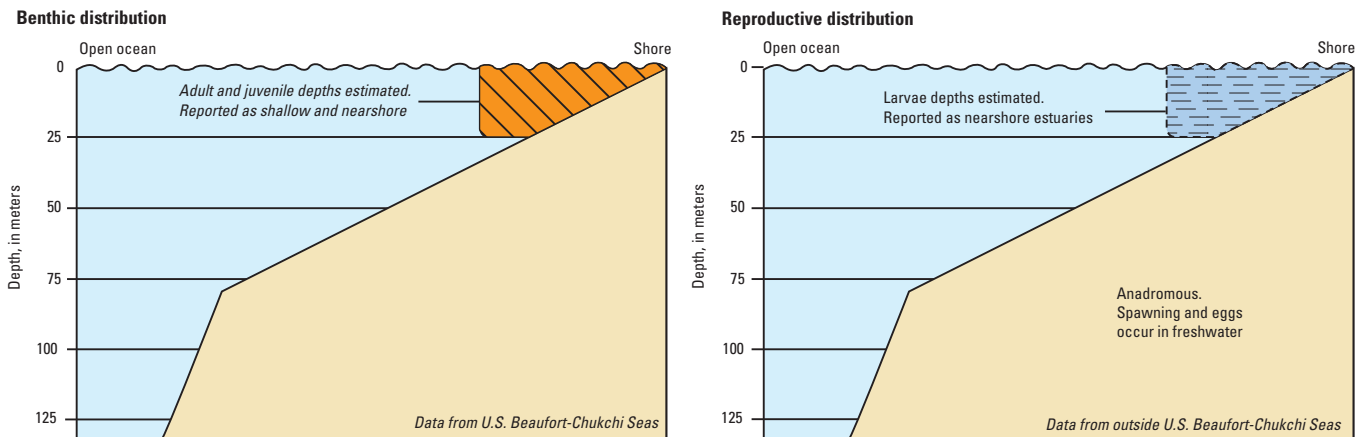
Relative Abundance: Common in parts of U.S. Beaufort Sea and southward in U.S. Chukchi Sea to at least the Kotzebue Sound [3, 9]. Relatively rare nearshore between Smith Bay and Cape Halkett in Beaufort Sea [10], along ANWR and Yukon coasts [11–16], and along northeast Chukchi Sea coast [17], reflecting this species' intolerance of cold and saline waters. Elsewhere, common eastward in Canadian Beaufort Sea to at least the Coppermine River [18].



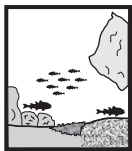
Geographic distribution of Broad Whitefish (*Coregonus nasus*), at sea within Alaska Outer Continental Shelf Planning Areas [6] based on review of published literature and specimens from historical and recent collections [4, 7, 8].

Depth Range: *Shallow, nearshore waters* [4, 19, 20].

Coregonus nasus
Broad Whitefish



Benthic and reproductive distribution of Broad Whitefish (*Coregonus nasus*).



Habitats and Life History

Exhibits a wide range of life history strategies. Anadromous, migrating from fresh to brackish waters for a few months in summer, to lacustrine, never leaving fresh water [21–24]. Migratory fish have been variously termed “facultative anadromous” [14], “semi-anadromous” [23], and “diadromous” [25]. *Those entering U.S. Chukchi and Beaufort seas are primarily freshwater residents, only using the coastal zone as a migration corridor and an alternate feeding habitat under suitable (low-salinity) conditions* [26]. *This account focuses on those fish that migrate into the shallow waters of the Chukchi and Beaufort Seas.* Lacustrine and riverine types are discussed elsewhere [23, 27–29]. The early life history of this species is best known for fish produced in the Mackenzie River watershed, however even here there are some uncertainties.

Eggs—Size: 1.7–2.3 mm [30]. Time to hatching: Specific time unknown; 150–200 days for northern whitefish in general [31]. *Spawning is in autumn and eggs hatch during spring* [3, 27, 32, 33]. Habitat: *Gravel beds in fast-flowing freshwater rivers* [27].

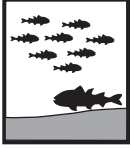
Fry—Size at hatching: Unknown. Days to juvenile transformation: Unknown. Habitat: *Freshwater rivers to nearshore estuaries* [14, 16, 27, 34].

Juveniles—Age and size: 0–5 years and 4.5–32.8 cm [35, 36]. Habitat: Primarily freshwater rivers and lakes to nearshore estuaries [14, 16, 34]. In the Mackenzie River, when young-of-the-year fish are flushed out of the river, they mainly are carried eastward along the Tuktoyaktuk Peninsula; some move into the outer or inner delta regions or eastward along the Yukon coast. Those reaching the Tuktoyaktuk Peninsula ascend rivers and spend up to 4 years in lakes. Larger, but still immature, fish may over winter in lakes or coastal waters, and use the coast, creeks, and lakes of the Tuktoyaktuk Peninsula as summer feeding grounds [12, 13, 16, 23, 27, 37]. Outcome of fish not transported along the Tuktoyaktuk Peninsula is unknown; although those carried westward along the Yukon coast may not survive due to its cold and highly saline waters [12, 13, 16, 23, 27, 37].

Adults—Age and size at first maturity: Highly variable throughout its range; *from 3 to at least 21 years, mostly at 6–9 years (30–40 cm long)* [13, 20, 22, 23, 27, 29, 37, 38]. Maximum age: Between 30 and 38 or more years [2, 27]. Maximum size: 83.5 cm [2]. Habitat: Pelagic, in fresh and nearshore brackish (rarely marine) waters [21, 23, 24, 26, 28].

Substrate—Sand and gravel beds for spawning [27, 31].

Physical/chemical—Temperature: At least 0–16 °C [24]. Spawning occurs at about 0 °C [13]. Salinity: *0–30 parts per thousand, but rare in higher salinity waters. Juveniles cope with salinities greater than 15–20 parts per thousand for only short periods, whereas larger fish are more tolerant of brackish conditions* [20, 22, 26, 39].



Behavior

Diel—Unknown. Seasonal—*In spring eggs hatch under ice (perhaps in April and May) [23, 27] and young-of-the-year are flushed out of the river into the river’s estuary during break-up [12, 13, 16, 23, 27, 37]. In June fish migrate into the smaller estuarine river deltas of the U.S. Beaufort Sea [19] [20], and generally do not migrate far [12, 40, 41]. For instance, Sagavanirktok River fish remain in the river delta until they are at least 3 years old [41]. In that population, the somewhat older fish are more tolerant of saline conditions and may migrate farther along coasts, typically moving between the Sagavanirktok and Colville Rivers [25]. At the extreme, a fish tagged in Prudhoe Bay was recaptured in Kaktovik Lagoon, 175 km to the east [42]. However, once mature, many adult fish also exhibit restricted movements [26]. At least in the Mackenzie River, once a fish has spawned it remains within the river’s influence for the rest of its life and never returns to its Tuktoyaktuk Peninsula nursery grounds [23]. Fish destined to spawn begin to enter rivers mostly in July and August [19, 27, 38]. Mature fish preparing to spawn tend to move to staging areas in river mouths earlier than do mature, non-spawning individuals. Regardless of maturation state, by September all broad whitefish have returned to rivers, with spawning fish migrating earliest [27, 37]. Fish overwinter in a wide range of habitats. Depending on location, overwintering grounds include nearshore brackish waters, river deltas, deep pools in rivers, and a variety of lakes [16, 19, 23, 27, 43]. In Alaska, overwintering in nearshore waters is not known to occur.*

Reproductive—Spawning occurs in fresh water, likely in their natal streams [23]. In some river systems, fish may travel great distances to spawning sites. For instance, Yukon River fish may migrate at least 1,700 km [44]. In the Mackenzie River, fish first congregate in the river delta for a few months before moving upstream to the spawning grounds, perhaps waiting for water temperatures to be to near 0 °C before migrating [13, 23, 27]. *In U.S. Chukchi and Beaufort Seas, spawning occurs in many rivers, from the Sagavanirktok River to at least the Meade River [12, 19], and in the Kobuk and Selawik Rivers in the Kotzebue region [3]. In most northern Alaskan rivers, spawning occurs in the lower parts of the waterways in deeper pools [19, 27], except the Colville River where fish may spawn a significant distance from the mouth [27]. With the possible exception of the Canning River, none of the “mountain” rivers or streams of the eastern Alaskan and Yukon coasts harbor spawning populations [12, 25, 45]. However, scattered non-spawning fish have been captured in a number of Canadian rivers west of the Mackenzie River [12]. Upon reaching maturity, spawning may occur annually or every other year [31]. Broad Whitefish are broadcast spawners that release gametes into the water column over gravel beds; eggs sink to the bottom after fertilization [27, 46].*

Schooling—Unknown.

Feeding—*Opportunistic predators [27]. Adults undertaking spawning migrations only occasionally feed [47]. Mature individuals or current-year spawners spend the summer prior to spawning feeding in delta habitats, peninsula lakes, or brackish water environments [23]. In the Alaska Beaufort Sea, nearshore brackish habitats are annually colonized by a rich benthic invertebrate community that forms the base of the coastal food web.*



Populations or Stocks

Information about population sizes of Broad Whitefish occurring in U.S. Chukchi and Beaufort Sea drainages does not exist. However, life history parameters have been developed for fish found in the Sagavanirktok and Colville Rivers. Genetic distinctions among fish from the Mackenzie River and its tributaries appear likely. Groups of fish may have both distinct spawning and overwintering grounds [16]. Fish of the Mackenzie River Basin also likely are genetically distinct from those living in other watersheds [32, 48–50]. Investigators have reported genetic differences in fish found in the Sagavanirktok and Colville Rivers.



Reproduction

Mode—Gonochoristic, oviparous, and iteroparous with external fertilization [27].

Spawning season—*Mainly in October and November, at freeze-up under the ice [3, 21, 23, 27].*

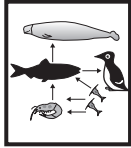
Fecundity—10,070–117,687 pale-colored eggs [3, 33].



Food and Feeding

Food items—*Zooplankton, for young-of-the-year; a wide range of invertebrates including chironomids and other insects, clams, amphipods, snails, polychaetes, oligochaetes, mysids, isopods, and plants for larger individuals [27, 28, 47, 51, 52].*

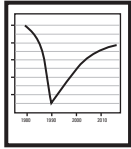
Trophic level—3.28 (standard error 0.44) [53].



Biological Interactions

Predators—*Not well understood.* Ringed seals are probably a major predator; brown bears in the Mackenzie River occasionally feed on them [54].

Competitors—Likely other opportunistic feeders, such as other whitefish species, Dolly Varden, Arctic Cisco, Least Cisco, Bering Cisco, Humpback Whitefish, Arctic Flounder, Fourhorn Sculpin, and Arctic Cod.



Resilience

Low, minimum population doubling time 4.5–14 years ($K=0.10-0.30$; $t_m=7$; $t_{max}=15$; Fecundity=10,000) [53].



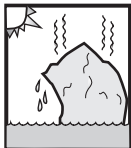
Traditional and Cultural Importance

Among the most important food fishes in the Arctic, taken in large numbers in the Kotzebue region on the Chukchi Sea, and from about Barrow, Alaska, to the Coppermine River, Northwest Territories, Canada, in the Beaufort Sea [1–3, 18, 37, 55]. Depending on location, and apparently on local preferences, most Broad Whitefish are frozen and either aged or dried [2, 3, 55].



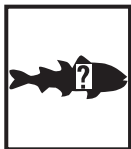
Commercial Fisheries

Currently, Broad Whitefish are not commercially harvested. *Repeated efforts to create viable, large-scale commercial fisheries for this species have failed, although they were caught and sold as by-catch in the Arctic Cisco fishery on the Colville River [20, 39].* The Iñupiat currently harvest and sale in Barrow under the subsistence barter and trade category rather than as an actual commercial fishing operation.



Potential Effects of Climate Change

Unknown. 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]

The Broad Whitefish is a dominant species in brackish waters of the Alaska Beaufort Sea and has been well studied in the central Beaufort Sea near Prudhoe Bay. Population parameters including condition factors, genetic information, and habitat use are reasonably well known for this area. Coastal monitoring of populations should be continued to track population growth, survival, and recruitment patterns and changes in the coastal fish assemblage as indicators of environmental change.

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Humpback Whitefish (*Coregonus pidschian*)

(Gmelin, 1789)

Family Salmonidae

Colloquial Name: Iñupiat—*Piqutuuq*, *Pikuktuuq* [1]; *Ikkuiyiq*, *Iqalupiaq*, *Iqalutchiaq*, *Qaalgiq* [2].

Note: American biologists have generally referred to anadromous and Alaska-dwelling individuals of this species as “humpback” whitefish (*Coregonus pidschian*). Anadromous fish in northern Canada usually have been called “lake” whitefish (*C. clupeaformis*), by Canadian researchers. Based on both morphological and genetic studies, McDermid and others (2005) [3] determined that, in North America, individuals of this group could be assigned to one of three subspecies (1) Humpback Whitefish (*Coregonus clupeaformis pidschian*), (2) Mississippian Lake Whitefish (*Coregonus clupeaformis clupeaformis*), and (3) Alaska Whitefish (*Coregonus clupeaformis nelsonii*). In particular, fish referable to the Humpback Whitefish subspecies were found in waters from the Alaska Peninsula through the U.S. Chukchi and Beaufort Sea drainages, and eastward to at least the lower Mackenzie River. For geographic ranges of all three subspecies, see McDermid and others (2005) [3]. In this account, data are included only from populations living within those ranges.

Taxonomy: The correct species name for this complex is *pidschian*, because it is the oldest name, used by Gmelin in 1789 when naming and describing the species. The name *clupeaformis* is more recent, used by Mitchill in 1818. In zoological nomenclature the oldest name has priority.

Ecological Role: This species rarely ventures into marine waters, and prefers freshwaters and nearshore brackish waters. It likely is of considerable ecological importance only within this relatively proscribed area.

Physical Description/Attributes: Dark brown to dark blue back, silver sides, and white belly prominent nuchal hump [4]. Both sexes (more prominently in males) develop “nuptial tubercles” on head and scales [2]. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 188) [4]. Swim bladder: Present [5]. Antifreeze glycoproteins in blood serum: Unknown.

Range: Coastal waters of U.S. Chukchi and Beaufort Seas. Elsewhere in Alaska, found in Bering Sea south to Bristol Bay [6]. Worldwide, along Arctic coasts from Siberia, Russia, west to Kara Sea, and eastward along Alaskan and Canadian coasts to Hudson Bay and New England (as *C. clupeaformis* of Canadian authors) [4, 7].



Humpback Whitefish (*Coregonus pidschian*). Photograph by R.J. Brown, U.S. Fish and Wildlife Service.

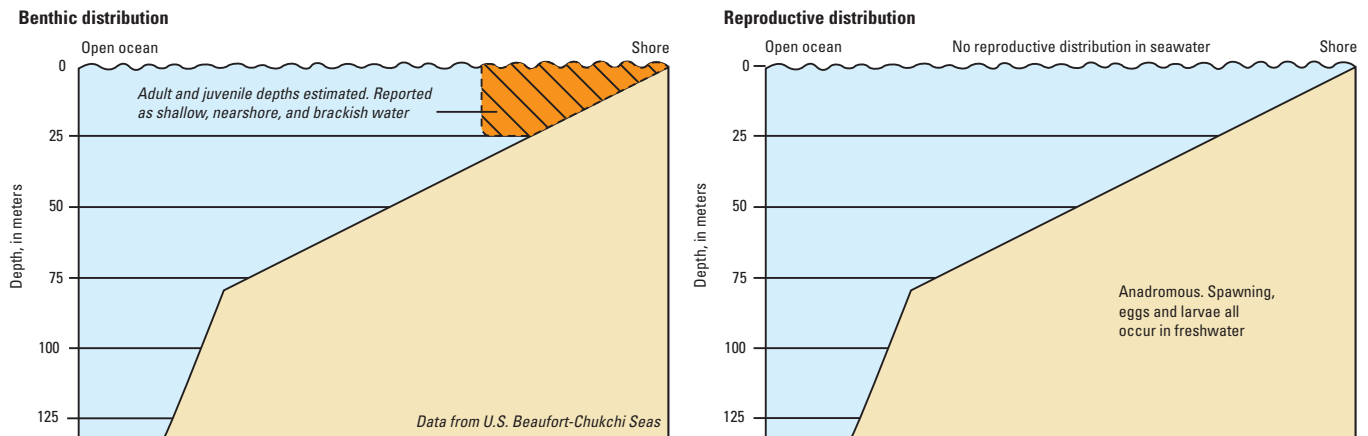
Relative Abundance: Common in coastal waters of southeastern U.S. Chukchi Sea, but is uncommon in northeastern Chukchi Sea [8]. Common in coastal waters of U.S. Beaufort Sea, except is uncommon between about Smith Bay and Cape Halkett [9] and off the Arctic National Wildlife Refuge [10, 11]. Elsewhere, fairly common in Canadian Beaufort Sea along the outer Mackenzie River Delta [12].



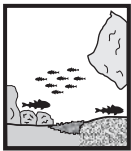
Geographic distribution of Humpback Whitefish (*Coregonus pidschian*), at sea within Arctic Outer Continental Shelf Planning Areas [13] based on review of published literature and specimens from historical and recent collections [4, 14, 15].

Depth Range: *Shallow, nearshore waters* [16, 17].

Coregonus pidschian
Humpback Whitefish



Benthic and reproductive distribution of Humpback Whitefish (*Coregonus pidschian*).



Habitats and Life History

Populations are amphidromous and freshwater [18, 19]. Amphidromous fish tend to remain in estuaries, within the influence of freshwater drainages [12, 16, 17].

Eggs—Size: 1.2–1.6 mm [20] and 144–257 eggs per gram ovary weight [21]. Time to hatching: About 6 months, based on autumn spawning and late winter to spring hatching [22, 23]. Size of eggs: Unhatched. Habitat: Freshwater; gravel beds in shallow and moderately swift waters [24].

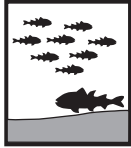
Larvae—Size at hatching: Unknown. Size at juvenile transformation: Unknown. Days to juvenile transformation: Unknown. Habitat: Freshwater [18].

Juveniles—Age and size: *On average, to about 6 years and about 30.0 cm* [16, 18, 23, 25, 26]. *Habitat: Fresh and brackish waters* [23, 26]; *tend to remain in estuaries, within the influence of freshwater drainages* [12, 16, 17].

Adults—Age and size at first maturity: *Primarily at 7–10 years* [16, 18, 23, 25]. *However, in some populations, maturation occurs at a later age. For example, in Dease Inlet/Admiralty Bay region, 50 percent of fish are mature at about 11 years and not all fish mature until perhaps 14 years* [26, 27]. *Most fish are mature between 300 and 350 mm* [23, 26, 28]. Maximum age: 37 years [23]. Maximum size: 54 cm [39]. *Habitat: Pelagic, in fresh and nearshore brackish waters; tend to remain in estuaries, within the influence of freshwater drainages* [12, 16, 17].

Substrate—Gravel to sand and silt for spawning [24, 29].

Physical/chemical—Temperature: 0–16 °C [19]. Salinity: *At least 0–28 parts per thousand* [17].

**Behavior****Diel**—Unknown.

Seasonal—*Young fish are carried downstream to lower parts of rivers and into brackish coastal waters [22, 23]. Smaller fish tend to stay in or near river mouths, whereas larger individuals are able to tolerate somewhat colder and more saline waters and venture somewhat farther along the coast [23, 26]. However, most fish tend to remain within the brackish water lens [17, 24]. In Mackenzie River area (including the Tuktoyaktuk Peninsula), juvenile fish may remain in coastal channels, lakes, and other quiet waters for several years before returning to the river [24]. Mature fish return to rivers beginning in June and this migration perhaps peaks in August [25, 30, 31].*

Reproductive—Although spawning may occur within a few kilometers of river mouths [23], spawning migrations may be quite extensive (as far as 1,700 km from the mouth in the Yukon River) [32]. Spawning tends to occur in relatively slow- or moderate-moving rivers (that is, Colville River, Alaska, and Mackenzie River, Canada). *In Beaufort Sea drainages, most spawning takes place between Barrow and the Sagavanirktok River and in the Mackenzie River [18, 23, 33]. Although Humpback Whitefish have been captured in most of the rivers flowing into the Beaufort Sea, it is not known whether fish spawn in such fast-flowing rivers as the Canning River, Alaska, or if these are only seasonal visits. Similarly, in the Chukchi Sea, Humpback Whitefish have not been found in numerous rivers, including the Kokolik, Utukok, Kukpowruk, and Kuk, Alaska [23], although they do spawn in the Kobuk River [2]. Spawning occurs over gravel or sand, in shallow waters. Eggs are broadcast over the river floor and lodge in crevices [24]. After spawning, mature fish migrate down river and overwinter in brackish waters of river mouths and perhaps in fresh water [18, 24, 34].*

Schooling—Unknown.**Feeding**—Unknown.**Populations or Stocks**

At least some distinct populations may exist among drainages running into the Beaufort and Chukchi Seas [3].

**Reproduction****Mode**—Gonochoristic, oviparous, and iteroparous with external fertilization [23].

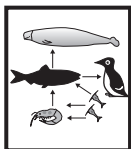
Spawning season—*Primarily September–October, but may extend into November and December [2, 22, 29]. At least some mature individuals spawn only every other year [19, 26].*

Fecundity—5,000–122,000 eggs, with higher numbers in larger fish [21, 26, 27, 29].

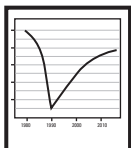
**Food and Feeding**

Food items—*Benthic and epibenthic prey including clams, crustaceans (for example, isopods, amphipods, copepods, and mysids), insects, snails, fishes, and plants [26, 28].*

Trophic level— 3.2 (standard error 0.40) [35].

**Biological Interactions****Predators**—Unknown.

Competitors—Likely other benthic and epibenthic predators including other whitefish species, sculpins, Arctic Flounder, and Dolly Varden.

**Resilience**

Low, minimum population doubling time 4.5–14 years ($t_m=3-14$; $t_{max}=14$; Fecundity=8,000) [35].



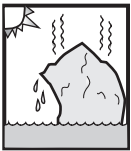
Traditional and Cultural Importance

A very important part of several subsistence fisheries, particularly those in the Kotzebue Sound [2]. Humpback Whitefish also are taken in some numbers in the Barrow area and in the lower Colville River [36, 37]. In Kotzebue Sound, their ease of scaling and lower oil content makes them a preferred species for paniqtuq (dried fish) and also for the aged and frozen product (quaq). Most fish are taken in seines or gillnets, but many are captured in ditches (qargisat) that are dug to divert migrating fish [2].



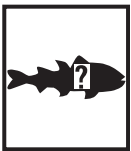
Commercial Fisheries

Currently, Humpback Whitefish are not commercially harvested.



Potential Effects of Climate Change

Unknown. 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]

Research needs for this species in the study area include: spawning behavior, spawning locations and early life histories, as well as studies on populations and predators. The vulnerability of the species to climate change effects on hydrology, timing of key life history events, and habitat use requires investigation. The projected expansion of brackish water habitats could greatly change this species occurrence in nearshore areas.

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Least Cisco (*Coregonus sardinella*)

Valenciennes, 1848

Family Salmonidae

Colloquial Name: Iñupiat—*Iqalusaaq* [1]; Anuutituuq, *Qalusraaq*, *Qalutchiaq* [2].

Ecological Role: This species rarely ventures into marine waters, preferring fresh and nearshore brackish conditions. Least Cisco are seasonally common in nearshore waters and are important in coastal food webs.

Physical Description/Attributes: Brownish to dark green back and silvery belly; back and dorsal fin have dark spots and fish more than 15 cm long and have dusky or black pelvic fins. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 182) [3]. Swim bladder: Present [4]. Antifreeze glycoproteins in blood serum: Unknown.

Range: *U.S. Chukchi and Beaufort Seas. Along U.S. Chukchi Sea, found at least in Utukok, Kokolik, Kuk, Kukpowruk, and Utukok Rivers* [5] *and rivers running into Kotzebue Sound* [2]. *In U.S. Beaufort Sea, found in most rivers of North Slope region, from Inaru to Canning River, but are not presumed to live in or enter the rivers between Canning River and Babbage River in Yukon Territory* [6–10]. Elsewhere in Alaska, south to Bristol Bay in eastern Bering Sea [3, 11]. Worldwide, Siberia, Russia, west to the White Sea and east to Southampton Island, Hudson Bay, Canada, northeast to Viscount Melville Sound, Beaufort Sea [12].



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

Relative Abundance: Common in U.S. Chukchi and Beaufort Sea coastal waters north from at least Kotzebue Sound [2] but relatively uncommon along some of the northeastern Chukchi Sea coast and in U.S. Beaufort Sea between Smith Bay and Cape Halkett, and between Canning River–Camden Bay region and near Phillips Bay, reflecting this species' tendency to avoid high salinity and cold marine waters [5, 6, 16–20]. Common in Canadian Beaufort Sea east to as close as the Tuktoyaktuk Peninsula, Canada [21].

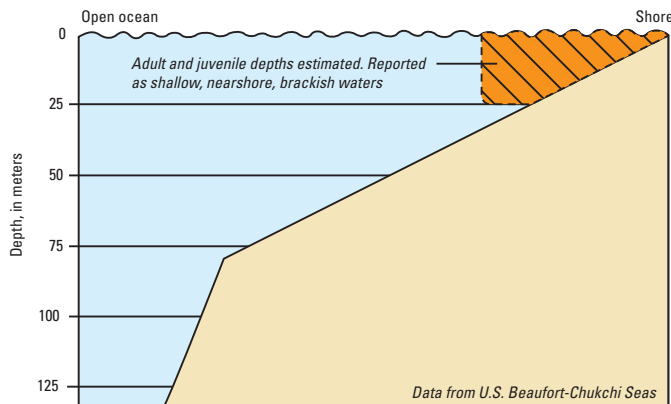


Geographic distribution of Least Cisco (*Coregonus sardinella*), at sea within Arctic Outer Continental Shelf Planning Areas [13] based on review of published literature and specimens from historical and recent collections [3, 14, 15].

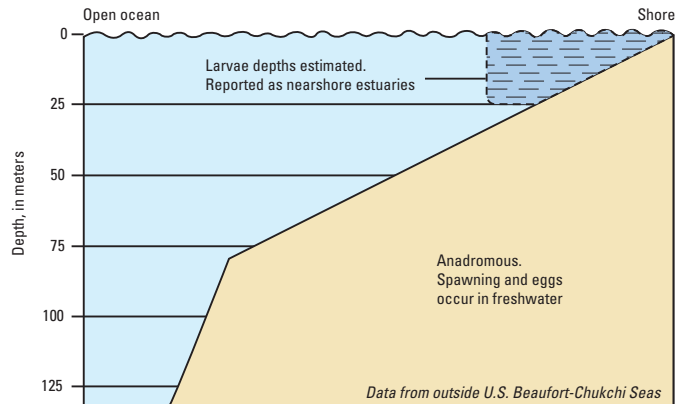
Depth Range: *Shallow, nearshore waters* [5, 22–24].

Coregonus sardinella
Least Cisco

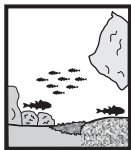
Benthic distribution



Reproductive distribution



Benthic and reproductive distribution of Least Cisco (*Coregonus sardinella*).



Habitats and Life History

In Alaska, Least Cisco has three life history patterns: (1) amphidromous (feeding in brackish or marine systems during the summer), (2) exclusively freshwater, found in lakes, and (3) a resident dwarf form of freshwater variety. Amphidromous and freshwater forms can occur together [25]. Information in this account is about the amphidromous form. For information on freshwater residents, see [1, 5, 24, 26–28].

Eggs—Size: 0.9–2.0 mm for mature eggs [29, 30]. Time to hatching: *Based on autumn spawning and late winter and spring hatching, about 6 months* [5, 31]. Habitat: *Shallow waters of rivers, in gravel and sand* [5, 31–33].

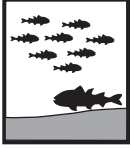
Larvae—Size at hatching: Unknown. Size at juvenile transformation: Unknown. Some fish as small as 25 mm migrate to sea [34]. Days to juvenile transformation: Unknown. Habitat: *Hatches in freshwater rivers* [5]. In Siberia, amphidromous fish move downstream to sea soon after hatching [35].

Juveniles—Age and size: 0 to at least 3 years and to at least 220 mm [24, 31, 36]. Habitat: *Fresh and nearshore brackish (rarely marine waters)* [5].

Adults—Age and size at first maturity: Highly variable, age ranges from 4 to 18 years [24, 31]. *Most are mature by perhaps 6–10 years* [5, 16, 21, 25, 29, 30]; *size at least a few by about 220 mm and all by about 350 mm* [24, 36]. Maximum age: 28 years [24]. Maximum size: 47 cm [3]. Habitat: *Fresh and nearshore brackish (rarely marine waters)* [5].

Substrate—Gravel to sand in freshwater for spawning [5, 37].

Physical/chemical—Temperature: -1.7 – 16 °C [25, 29]. Salinity: 0–32 parts per thousand [25, 29], *primarily 20 parts per thousand or less* [5]. *Juveniles tend to remain in warmer and less saline waters, whereas older fishes are more tolerant of colder temperatures and increased salinity* [5, 8, 16, 22–24].



Behavior

Diel—Unknown.

Seasonal—Fish enter U.S. Beaufort Sea following ice breakup in June and July, and begin to disperse and feed along the coast [21, 29, 30, 34, 38]. Young fish may remain in rivers for several years before entering the sea [16]. Due to higher temperature and lower salinity preferences, juveniles do not migrate as far as adults, who disperse farther along the coast [5, 8, 16, 22–24]. Most Least Cisco found along the North Slope originate from spawning and overwintering grounds in the Colville River [8]. Colville River fish migrate farther east in years of strong westerly winds. Similarly, Mackenzie River fish move westward to a greater extent in years with strong easterly winds [8, 39, 40]. Along the North Slope, larger fish can swim faster and reach distant feeding grounds before smaller individuals [41]. Given the short summer season, Least Cisco can travel substantial distances when conditions are favorable. For instance a fish tagged in Simpson Lagoon was recaptured off Barrow, 300 km to the west [29]. However, fish leaving the Colville River generally migrate eastward along the Arctic National Wildlife Refuge coast, because nearshore marine waters between Smith Bay and Cape Halkett may block westward movements [20, 40]. Return migrations to spawning and overwintering grounds begin between July and September [8, 29, 41]. Both juveniles and adults overwinter in brackish waters of river deltas (for example, Colville River, Alaska, and Mackenzie River, Canada, are the largest overwintering areas along the Beaufort Sea), open coast (for example, Tuktoyaktuk Harbor), and freshwater lakes of the Tuktoyaktuk Peninsula, Canada [21, 41, 42]. Except for the Sagavanirktok River (where some overwintering occurs in delta waters), Least Cisco do not seem to either spawn or overwinter in any waterway between the Colville and Mackenzie Rivers [41].

Reproductive—Spawning occurs under ice in the shallow waters of rivers over gravel and sand [5, 31–33]. During spawning, males and females move toward the surface, perpendicular to the current, while the eggs are released and fertilized [43]. Sea-run fish spawn in lower reaches of rivers or, as in the Yukon-Koyukuk River system, may migrate at least as much as 1,600 km upstream [44]. In U.S. Chukchi and Beaufort Sea drainages, spawning by the Least Cisco is known to occur in various rivers including the Kobuk River [2], Colville River [45], and Mackenzie River and its tributaries [42]. Individuals have been variously reported to spawn annually [25], in alternate years, or perhaps for some fish, less often [5, 16, 24, 28]. After spawning, fish quickly migrate downstream to freshwater overwintering grounds [22].

Schooling—In coastal waters, forms schools that can maintain their integrity for months [29].

Feeding—Generalists, feeding throughout the water column with planktonic organisms dominating [28]. Feeds both during winter and during spawning migrations, although feeding intensity in both instances may be low [7, 29, 33, 42, 46].



Populations or Stocks

Catch statistics from the Colville River and coastal monitoring in Prudhoe Bay provide useful life history information and indices of population abundance. Genetic research (phylogeography and population structure) is ongoing (University of Alaska, Fairbanks).



Reproduction

Mode—Gonochoristic, oviparous, and iteroparous with external fertilization [5].

Spawning season—September–November [2, 5].

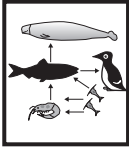
Fecundity—10,505–100,939 eggs in North America [24, 47].



Food and Feeding

Food items—Primarily crustaceans (for example, copepods, mysids, isopods, and amphipods) and insects, along with some polychaetes, clams, snails, fishes, fish eggs, fish larvae, and plant material [5, 24, 28, 29, 48, 49].

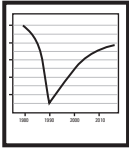
Trophic level—3.24 (standard error 0.50) [50].



Biological Interactions

Predators—Dolly Varden and Arctic Smelt [34, 42], ice seals, and various seabirds such as the red throated loon.

Competitors—Other generalist feeders including various whitefish species and Dolly Varden, Arctic Flounder, and Fourhorn Sculpin. Lease Cisco is an important prey for loons and other predators in the coastal Chukchi Sea.



Resilience

Medium, minimum population doubling time 1.4–4.4 years ($K=0.40$; $t_m=2-4$; $t_{max}=11$; Fecundity=2,500) [50].



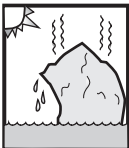
Traditional and Cultural Importance

Historically, Least Cisco have been of some importance in subsistence fisheries, particularly before the advent of snowmobiles, when local populations depended on dogs for transportation. At that time, this small species was widely caught and used for dog food. Currently, along many rivers, Least Cisco are only occasionally harvested for human and dog food [1, 25, 29, 51]. Subsistence fishermen in the Kotzebue Sound area often consume the eggs of freshly caught fish [2].



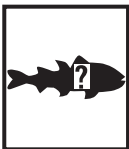
Commercial Fisheries

Currently, Least Cisco are not commercially harvested.



Potential Effects of Climate Change

Unknown. A general prediction is 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 [52].



Areas for Future Research [A]

Least Cisco populations are best studied in the western (for example, Dease Inlet) and central (Prudhoe Bay) regions of the southeastern Beaufort Sea. They are an important member of the coastal fish assemblage during ice-free months. Monitoring of key parameters relative to population growth, survival, and recruitment, relative abundance, and condition, should be continued at key reference locations.

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Pink Salmon (*Oncorhynchus gorbuscha*)

(Walbaum, 1792)

Family Salmonidae

Colloquial Name: Iñupiat—*Amaqtuuq* [1].

Ecological Role: The seeming relatively recent increase in abundance of this species north and eastward to at least the Barrow area implies that this species is becoming of some ecological importance in coastal waters of the U.S. Chukchi Sea.



Pink Salmon (*Oncorhynchus gorbuscha*), 211 mm, southeastern Chukchi Sea, 2007. Photograph by C.W. Mecklenburg, Point Stephens Research.

Physical Description/Attributes: At sea, metallic-blue to blue-green on back, silvery on sides, and white on belly with black, oval spots on the backs and upper sides and on both lobes of the caudal fins. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 205) [2]. Swim bladder: Present [3]. Antifreeze glycoproteins in blood serum: Unknown.

Range: U.S. Chukchi and Beaufort Seas [4, 5]. North Korea and Japan and northern Siberia to the Beaufort Sea coast of Alaska and western Canada, eastward to Sachs Harbor, Banks Island, [5] and south to La Jolla, California [6].

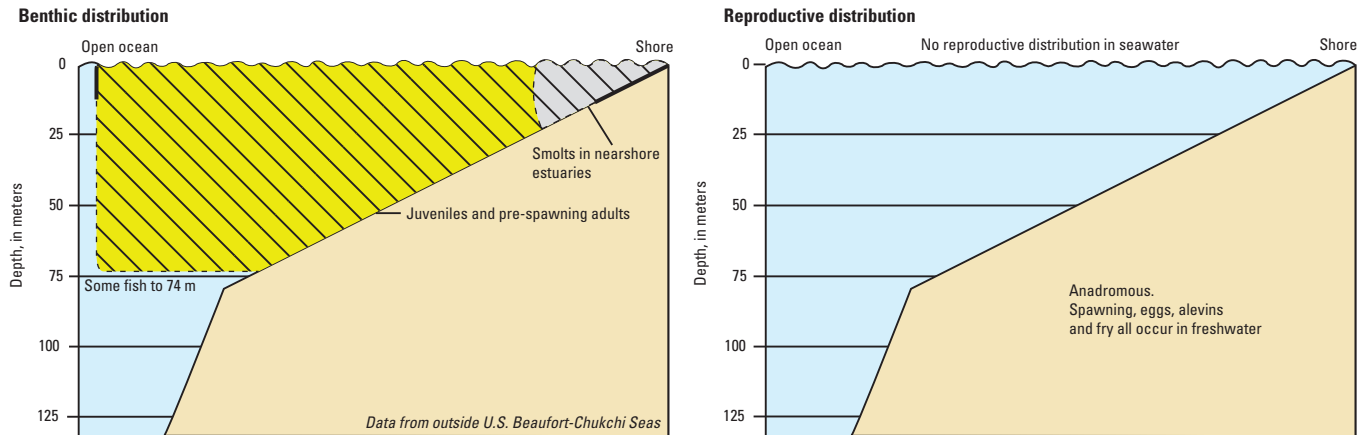
Relative Abundance: Small runs occur in numerous rivers and streams running into the Chukchi Sea to about Barrow and perhaps in the Colville River [4, 10]; common in the Chukchi Sea (the most abundant of the salmon species) and, in the Beaufort Sea, at least as far east as Simpson Lagoon and in smaller numbers along the Alaska National Wildlife Refuge [4, 11–14].



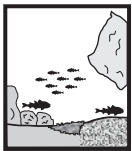
Geographic distribution of Pink Salmon (*Oncorhynchus gorbuscha*), at sea within Arctic Outer Continental Shelf Planning Areas [7] based on review of published literature and specimens from historical and recent collections [2, 8, 9].

Depth Range: Epipelagic, coastal and offshore, from surface to at least 74 m [15], usually from 0 to 10 m [16]. Young juveniles are neritic, occurring from nearshore waters as shallow as a few centimeters deep to the edge of the continental shelf as they mature [17].

Oncorhynchus gorbuscha
Pink Salmon



Benthic and reproductive distribution of Pink Salmon (*Oncorhynchus gorbuscha*).



Habitats and Life History

Anadromous.

Eggs—Size: 4.0–7.9 mm [17]. Time to hatching: 5–8 months [17]. Length at hatching: About 19–24 mm [18]. Habitat: Benthic, buried under gravel in shallow, relatively fast-flowing waters of streams and rivers, often near the ocean [16, 17, 19, 20].

Alevins (larvae)—Size: 19–28 mm [16, 18]. Habitat: Under gravel for a few weeks to several months in shallow, relatively fast-flowing waters of streams and rivers, often near the ocean [16, 17, 19, 20].

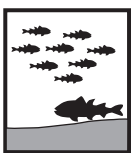
Fry—Size at emergence: About 28–34 mm [18]. Time as fry: Relatively short, as little as a few days [17]. Habitat: Benthopelagic in shallow waters of streams and rivers [16, 17].

Smolt and ocean phase—Age and size at smoltification: as young as a few days and 3.0–45.0 cm [16, 17]. Habitat: Epipelagic in ocean, over various habitats and often far from shore [16, 17, 20].

Adults—Age and size at first maturity: On average, 1.5 years and 45–55 cm [17]. Maximum age: 2 years [16]. Maximum size: 76 cm [2]. Habitat: Mature adults return to freshwater rivers and streams to spawn [17].

Substrate—Over various substrates while in ocean [16]. Gravel for spawning [17].

Physical/chemical—Temperature: In ocean, at least 3–15 °C, perhaps primarily at 4–11 °C [21]. Salinity: Tolerates fresh to marine waters, depending on life stage [17].



Behavior

Diel—Migrations of fry to sea take place at night [17].

Seasonal—Unknown in U.S. Chukchi and Beaufort Seas, although it is speculated that juveniles enter the northeastern Chukchi Sea during the late spring thaw (June to early July) [11]. Vertical distribution at sea may change with season, with fish remaining in deep water during the night early in the year and then moving to shallow water later in the year [17].

Reproductive—Spawning occurs in freshwater streams and rivers, often very close to the ocean. Females prepare a gravel nest and lay their eggs, which are fertilized by the males. All adults die after spawning [16].

Schooling—Newly emerged fry may or may not school; fry do school when they reach the lower reaches of rivers [17]. Juveniles school in nearshore waters during early phases of their seaward migration [17]. Schooling behavior during ocean phases of migration may be less structured and include intermingling with other stocks [17].

Feeding—At sea, may vertically migrate (ascending during the night) when following prey [17]. Juveniles feed primarily during the day with peak feeding at dusk [17].



Populations or Stocks

There have been no studies in the U.S. Chukchi and Beaufort Seas.



Reproduction

Mode—Gonochoristic, oviparous, and semelparous with external fertilization [22].

Spawning season—July–October and usually earlier in more northern waters [17, 23].

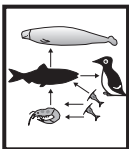
Fecundity—854–1,549, *Simpson Lagoon* [4].



Food and Feeding

Food items—*In the U.S. Chukchi Sea, fishes, planktonic crustaceans (for example, mysids, calanoid copepods, and gammarid amphipods), fish eggs, and fish larvae* [11, 12].

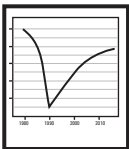
Trophic level— 4.19 (standard error 0.71) [24].



Biological Interactions

Predators—Dolly Varden, Arctic Smelt, Starry Flounder, Walleye Pollock, spotted seal, beluga whale, and orca [25–29].

Competitors—Likely other salmon species, as well as such gadids as Arctic Cod.



Resilience

Medium, minimum population doubling time 1.4–4.4 years ($t_m=2$; $t_{max}=3$; Fecundity=800) [24].



Traditional and Cultural Importance

Taken in subsistence fisheries in the U.S. Chukchi Sea [10, 30, 31] *and are caught in relatively small numbers in subsistence fisheries along the U.S. Beaufort Sea at least as far east as the Colville River* [32].



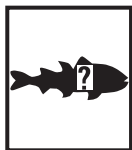
Commercial Fisheries

Pink Salmon are captured in small numbers in salmon fisheries for Chum Salmon in Kotzebue Sound.



Potential Effects of Climate Change

Warming temperatures likely will allow this species to become more abundant in the U.S. Chukchi and Beaufort Seas. Whether this species will be able to colonize additional freshwater habitats successfully on Alaska’s North Slope is hypothesized, but is not known.



Areas for Future Research [A]

Little is known about the ecology and life history of this species in the study area. Human use of this species in coastal villages seems to be increasing. Research needs include: preferred habitats (including depth ranges for juveniles and adults), spawning season, seasonal and ontogenetic movements, population studies, and predators. The success of colonization east of Point Hope will depend on the presence of suitable spawning habitats and thermal regimes for developing embryos. The timing of seaward migrations and quality of nearshore marine environments will be critical to population viability. The potential for colonization of perennial springs in the eastern Beaufort Sea and other prospective spawning areas in the Colville and Sagavanirktok Rivers should be examined in habitat-based monitoring. Salmon catches at Point Barrow and other villages should be monitored and biological investigations of salmon interactions with traditional fish foods, such as Arctic and Least cisco and Dolly Varden, should be undertaken.

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Chum Salmon (*Oncorhynchus keta*)

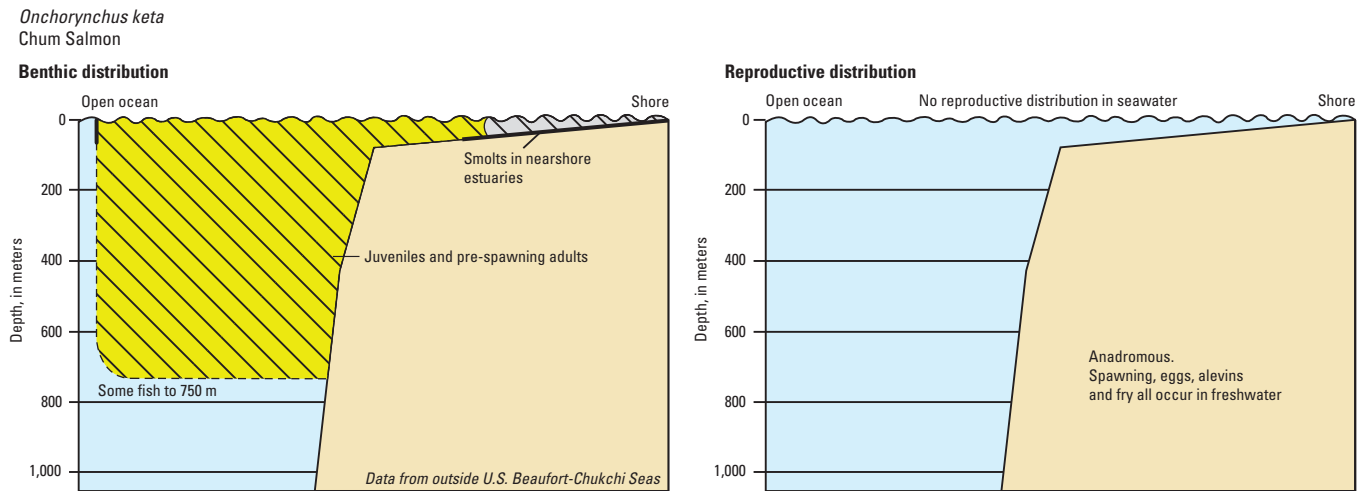
(Walbaum, 1792)

Family Salmonidae

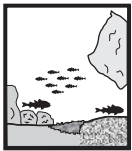
Colloquial Name: Iñupiat—*Iqalugruaq* [1].**Ecological Role:** The abundance of this species north and eastward to at least the Barrow area implies that this species is likely of some ecological importance. Especially important member of the nearshore marine in Kotzebue Sound.**Physical Description/Attributes:** At sea, Chum Salmon have dark blue backs with silvery sides and bellies and no distinct black spots, fewer than 30 gill rakers, and gill rakers that are smooth, fairly short, stout, and widely spaced. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 208) [2]. Swim bladder: Present [3]. Antifreeze glycoproteins in blood serum: Unknown.**Range:** U.S. Chukchi and Beaufort Seas. Arctic coasts of Siberia west to the Laptev Sea and east across Alaskan and Canadian Arctic to Kugluktuk, Nunavut; southward through Bering Sea to Korea and southern Japan, and to Del Mar, southern California near the United States–Mexico border [4, 5].**Relative Abundance:** The most common salmon species in the U.S. Chukchi and Beaufort Seas [5]. Spawning runs occur in a number of Chukchi Sea drainages and at least in a few Beaufort Sea drainages, such as the Mackenzie River, perhaps the Colville River, and others [8, 9].Chum Salmon (*Oncorhynchus keta*), 209 mm, northeastern Chukchi Sea, 2007. Photograph by C.W. Mecklenburg, Point Stephens Research.

Geographic distribution of Chum Salmon (*Oncorhynchus keta*), at sea within Arctic Outer Continental Shelf Planning Areas [6] based on review of published literature and specimens from historical and recent collections [2, 7].

Depth Range: Epipelagic, coast and offshore, from surface to at least 750 m [10], primarily less than 40 m [10–12].



Benthic and reproductive distribution of Chum Salmon (*Onchorhynchus keta*).



Habitats and Life History

Anadromous.

Eggs—Size: At least 6.0–10.0 mm [13, 14]. Time to hatching: Highly variable, 52–182 days [14]. Size at hatching: 20–25.0 mm [13, 15]. Habitat: Benthic, buried under gravel of streams and rivers [13, 14].

Alevins (larvae)—Size range: 20–35.0 mm [13] Habitat: Under gravel of streams and rivers until yolk sac absorbed (30–50 days) [14, 16].

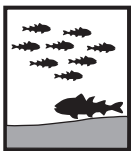
Fry—Size at emergence: About 30–39 mm [15]. Length of time as fry: 1 month or more. May remain in fresh water for several weeks or may immediately migrate downstream and enter marine or estuarine waters [14, 17]. Habitat: Demersal, in streams and rivers [13, 14].

Smolt (juveniles) and ocean phase—Size when entering ocean: Between 30–70.0 mm, depending on distance from spawning grounds [13]. Habitat: Juveniles spend their first few months to a year in nearshore, marine waters, often inhabiting eelgrass or algal beds [18], and then two to five winters offshore [19].

Adults: Age and size at first maturity: Highly variable, 2–6 years, primarily 3–5 years, and 60–80 cm [14]. Maximum age: 7 years [16]. Maximum size: 109 cm [14]. Habitat: Adults return to freshwater streams and rivers to spawn [13, 14].

Substrate—Gravel for spawning [14].

Physical/chemical—Temperature: At sea, -0.8–22.5 °C [20], most common between 2 and 11 °C [21]. Salinity: Fresh water to marine, depending on life stage [14]. Fry are euryhaline and can withstand daily fluctuations of 0–27 parts per thousand [14].



Behavior

Diel—Fry typically emerge from gravel and migrate downstream at night [14]. At sea, many individuals may ascend into surface waters at night and return to depth during the day [20].

Seasonal—Fry emerge from gravel beds in spring [17]. *At-sea behavior in U.S. Chukchi and Beaufort Seas is unknown.* It is speculated that fish entering the Beaufort Sea from various drainages may overwinter either in deeper waters of the Beaufort Sea or in the North Pacific [9].

Reproductive—Spawning occurs in freshwater in streams and rivers. Females prepare a gravel nest and lay their eggs, which are fertilized by a male [14]. All adults die after spawning [13].

Schooling—Fry do not strongly school [14]. Juveniles in estuaries and nearshore waters may form loose aggregations [14].

Feeding—Juveniles in estuaries feed most intensely at high tides when marsh is submerged [14].



Populations or Stocks

The State of Alaska monitors catch and escapement of Chum Salmon in the major river drainages in Kotzebue Sound. Genetic analysis of samples of summer run Chum Salmon from six watersheds indicates a Kotzebue Sound complex that is related to but distinct from Norton Sound, Yukon, and Kuskokwim regions [22].



Reproduction

Mode—Gonochoristic, oviparous, and semelparous with external fertilization [23].

Spawning season—*Unknown in U.S. Chukchi and Beaufort Seas watersheds except for stocks from Kotzebue Sound.* In the Mackenzie River, Canada, spawning migrations are during July and August with spawning in autumn [24]. In other regions, spawning is in June–January [17].

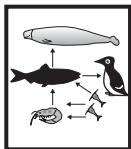
Fecundity—At least 900–8,000 eggs [17].



Food and Feeding

Food items—Zooplankton (for example, copepods, euphausiids, mysids, pteropods, and fish larvae) as well as insects and small amounts of fishes [25–27].

Trophic level—3.47 (standard error 0.48) [28].



Biological Interactions

Predators—A wide variety of fishes, sea birds, and mammals. Examples include Pacific Halibut, Pacific Sleeper Shark, Walleye Pollock, rhinoceros auklet, pigeon guillemot, marbled murrelet, pelagic cormorant, northern fur seal, beluga whale, and orca [16, 29–31] [32–35].

Competitors—Likely other planktivores (for example, salmonids, Pacific Herring, and Polar and Saffron cods).



Resilience

Medium, minimum population doubling time 1.4–4.4 years ($K=0.27-0.45$; $t_m=2-5$; $t_{max}=6$) [28].



Traditional and Cultural Importance

Taken with some frequency in subsistence fisheries along the Chukchi Sea (that is, Kotzebue Sound) and near Barrow [36–40]. Chum Salmon also are taken in the Mackenzie River and its tributaries and in the Colville River [37, 41].



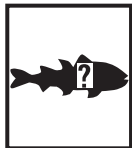
Commercial Fisheries

The Alaska Department of Fish and Game manages small Chum Salmon fisheries in Kotzebue Sound. Market conditions and availability of fish buyers have affected harvest levels in recent years. Estimated low salmon abundance in 2014 resulted in the termination of the fishery.



Potential Effects of Climate Change

An increase in the Arctic population with climate change has been hypothesized [42]. Availability of freshwater habitats and sufficient thermal conditions for incubation are potential limiting factors.



Areas for Future Research [A]

The potential colonization rivers and streams of Arctic Alaska is of research interest. Like other salmonids, limitations associated with potential source populations, incubation in freshwater habitats (temperature and oxygen), timing of seaward migration and related quality of nearshore marine habitats for juveniles, dispersal routes and migration corridors, and distance from natal habitats to oceanic rearing grounds will affect colonization success. Potential interactions and outcomes of Chum Salmon and other nearshore fishes is an expressed concern to residents. Regular surveys of prospective habitats for colonizing fish and evidence of successful reproduction should be established.

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Coho Salmon (*Oncorhynchus kisutch*)

(Walbaum, 1792)

Family Salmonidae

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

Colloquial Name: Inupiat—*Iqalugruaq* [1].

Ecological Role: Likely of minor subsistence importance in southeastern U.S. Chukchi Sea and occasional occurrence in coastal captures farther north.

Physical Description/Attributes: At sea, metallic-blue on back, silvery flanks, and white belly, small black spots on back and sides and on the upper lobe of the caudal fin, and white gums at the base of the teeth on the lower jaw. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 206) [2]. Swim bladder: Present [3]. Antifreeze glycoproteins in blood serum: Unknown.

Range: U.S. Chukchi and Beaufort Seas [2, 4, 5]. Worldwide, North Korea and Japan to the Mackenzie River, Canada, and to Bahia Camalu, northern Baja California, Mexico [2, 6].

Relative Abundance: Uncommon in southeastern Chukchi Sea (where it returns to rivers to spawn) and rare in northeastern Chukchi and Beaufort Seas east to Mackenzie River, Canada [4, 5, 10].

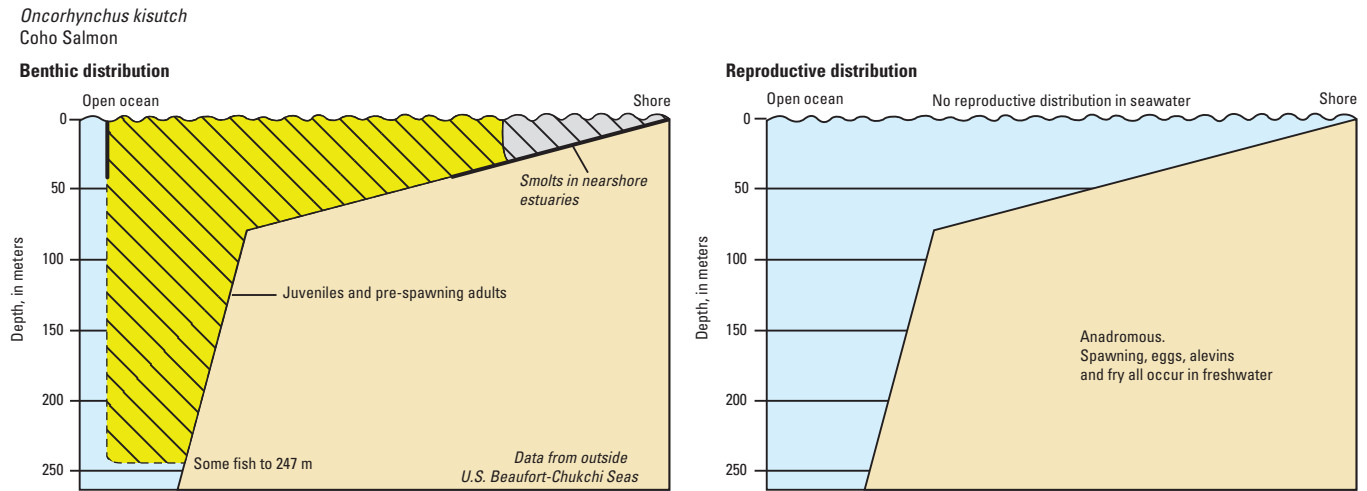


Coho salmon (*Oncorhynchus kisutch*), freshwater spawning stage. Photograph by Thomas Kline, <http://www.salmonography.com>.



Geographic distribution of Coho Salmon (*Oncorhynchus kisutch*), at sea within Arctic Outer Continental Shelf Planning Areas [7] based on review of published literature and specimens from historical and recent collections [2, 8, 9].

Depth Range: Epipelagic, coastal and offshore, from surface to 247 m [11], primarily 40 m or less [12].



Benthic and reproductive distribution of Coho Salmon (*Oncorhynchus kisutch*).



Habitats and Life History

Anadromous.

Eggs—Size: 4.5–7.9 mm [13]. Time to hatching: 5–12 weeks. Length at hatching: About 19–24 mm [14].

Habitat: Benthic, buried under gravel of streams and rivers [15].

Alevins (larvae)—Size range: 19–30 mm [14, 15]. Habitat: Benthic, remain under gravel for 3–26 weeks until yolk sac is absorbed [11, 15].

Fry—Size at emergence: About 27–30 mm [14, 15]. Length of time as fry: 1–4 years, typically 1 year [15].

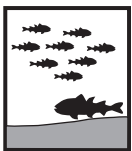
Habitat: Benthic, in streams and rivers [15].

Smolt and ocean phase—Age and size at smoltification: 1–4 years and 8–17 cm [15]. Habitat: Epipelagic [13, 15]. Young fish newly entered into ocean waters often reside near shore, frequently in eelgrass beds, but also in kelp or over bare sea floor [16]. Generally, do not migrate far offshore. Some spend their entire marine lives in inshore waters [17].

Adults—Age and size at first maturity: A few males mature at 1 year, but most fish at 3–4 years and at about 60–70 cm [15]. Maximum age: About 4 years [15]. Maximum size: 108 cm [2]. Habitat: Mature adults return to rivers and streams to spawn [13, 15].

Substrate—Gravel for spawning [15].

Physical/chemical—Temperature: At sea, 5–16.2 °C, primarily 7 °C and greater [15, 18, 19]. Salinity: Fresh to marine waters depending on life stage [15].



Behavior

Diel—Fry and smolts migrate primarily at night [15]. At sea, many or most individuals may ascend into surface waters at night and return to depth during day [19].

Seasonal—Fry emerge from under gravel as much as 6 months after eggs were laid [15]. Young fish may spend as much as 4 years in fresh water before migrating to the sea, although a 1-year residency (including a winter) is more typical [15]. Most fish enter seawater in spring and many remain nearshore for at least a few months before moving somewhat offshore. At sea, fish entering from California to British Columbia tend to move northwards. Generally, Coho Salmon do not migrate far offshore and some spend their entire marine lives in inshore waters [17]. *Utilization of offshore waters as well as migrations in U.S. Chukchi and Beaufort Seas is unknown.* Coho Salmon spend 18 months or more at sea before entering freshwater to spawn [15].

Reproductive—Spawning occurs in freshwater streams and rivers. Females prepare a gravel nest and lay their eggs, which are fertilized by a male [15]. All adults die after spawning [13].

Schooling—Smolts and marine individuals form schools [15].

Feeding—Juveniles and adults are carnivorous, opportunistic feeders [13].



Populations or Stocks

There have been no studies in the U.S. Chukchi and Beaufort Seas.



Reproduction

Mode—Gonochoristic, oviparous, and semelparous with external fertilization [20].

Spawning season—October–March, primarily November–January [15].

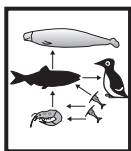
Fecundity—At least 1,724–7,600 eggs [15], varies between years, increasing to the north [21, 22].



Food and Feeding

Food items—Various fishes and squids, and such small water column zooplankters as euphausiids, hyperiid amphipods, and crustacean larvae. Diets change seasonally and between years [23].

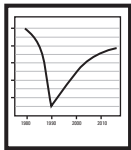
Trophic level—4.2 [24].



Biological Interactions

Predators—Fishes, sea birds, and marine mammals [11].

Competitors—Possibly gadids such as Arctic Cod and other salmonids.



Resilience

Medium, minimum population doubling time 1.4–4.4 years ($K=0.98$; $t_m=2-4$; Fecundity=1,400) [24].



Traditional and Cultural Importance

Only rarely, but apparently increasing numbers harvested in subsistence fisheries in U.S. Chukchi and Beaufort Seas [10].



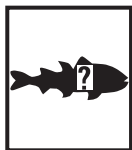
Commercial Fisheries

Currently, Coho Salmon are not commercially harvested.



Potential Effects of Climate Change

Warming temperatures likely will allow this species to colonize Arctic marine and freshwater ecosystems. It can be expected that Coho Salmon will eventually become more abundant, especially in the southeastern Chukchi Sea. Because of thermal requirements for incubation, it is unclear whether the viable populations will be able to establish in watersheds of the Chukchi and Beaufort Seas.



Areas for Future Research [B]

Coho Salmon are well studied in the State of Alaska. Specific information from the region is lacking with respect to (1) preferred habitat, including depth ranges for juveniles and adults; (2) spawning season; (3) seasonal and ontogenetic movements; (4) population studies; (5) prey; and (6) predators. Surveys of Chukchi and Beaufort Sea watersheds for suitable spawning and rearing habitats, evidence of spawning, or successful reproduction, should be considered.

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Sockeye Salmon (*Oncorhynchus nerka*)

(Walbaum, 1792)

Family Salmonidae

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

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

Ecological Role: Of limited ecological importance in the U.S. Chukchi and Beaufort Seas. Harvested in small numbers in Kotzebue Sound; therefore, this fish may play a seasonal role in pelagic ecosystems in the southeastern Chukchi Sea.

Physical Description/Attributes: At sea, head blue to green-blue, rest of body silvery. Usually no black spots on back and fins, occasionally small spots on caudal or dorsal fin. For specific diagnostic characteristics and spawning coloration, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 209) [1]. Swim bladder: Present [2]. Antifreeze glycoproteins in blood serum: Unknown.

Range: U.S. Chukchi and Beaufort Seas [3]. Worldwide, northern Japan and the Sea of Okhotsk to the Klamath River, northern California, and Arctic Canada coasts to Bathurst Inlet, Nunavut and northward to the Sachs River estuary, Banks Island [3].

Relative Abundance: Common in U.S. Chukchi Sea northward to about Kotzebue Sound area (where it spawns), occasionally farther north in U.S. Chukchi and Beaufort Seas and to Sachs River, Canada [3, 7]. Generally, Sockeye Salmon are uncommon in the U.S. Chukchi and Beaufort Seas north of about Kotzebue Sound.



Sockeye Salmon (*Oncorhynchus nerka*), 237 mm, southwestern Gulf of Alaska, 2007. Photograph by C.W. Mecklenburg, Point Stephens Research.

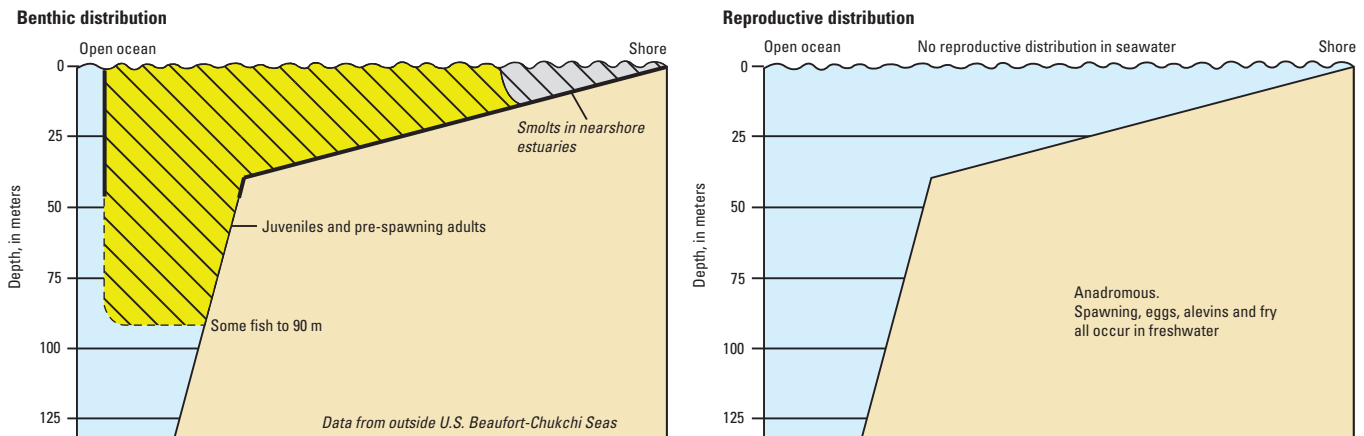


Base modified from USGS and other digital data. U.S.-Russia Maritime Boundary follows the EEZ/200-mile limit line, western edge. Coordinate reference system: projection, Lambert Azimuthal Equal Area; latitude of origin, 75.0°; horizontal datum, North American Datum of 1983.

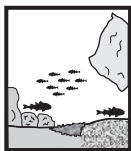
Geographic distribution of Sockeye Salmon (*Oncorhynchus nerka*), at sea within Arctic Outer Continental Shelf Planning Areas [4] based on review of published literature and specimens from historical and recent collections [1, 5, 6].

Depth Range: Epipelagic, coastal and offshore, from surface to 90 m, but mostly 40 m and less [8, 9].

Oncorhynchus nerka
Sockeye Salmon



Benthic and reproductive distribution of Sockeye Salmon (*Oncorhynchus nerka*).



Habitats and Life History

Anadromous.

Eggs—Size: 5.0–6.6 mm [10]. Size at hatching: Unknown, probably 20–25 mm TL [11]. Time to hatching: 57–171 days [10]. Habitat: Benthic, buried in gravel in waterways entering lakes or in shallow waters of lakes [10].

Alevins (larvae)—Size range: Become fry at about 25–30 mm [10, 11]. Habitat: Benthic, buried in the substrate of lakes and rivers [10].

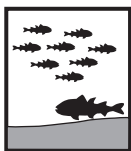
Fry—Size at emergence: 25–31 mm [10]. Length of time as fry: Several weeks to 3 years (although stream-reared juveniles and juveniles that migrate to sea within a few weeks are known) [10]. Habitat: Lakes and streams [10].

Smolt and ocean phase—Age and size at smoltification: Less than 1 year to 3 years and at a minimum of 60 mm [10]. Habitat: Following smoltification, epipelagic in ocean for 1–4 years (mostly 2–3 years), often far from shore [10]. In North American waters, may migrate almost as far west as Kamchatka Peninsula, Russia, and fish from Asia intermingle with those from North America [10, 12].

Adults—Age and size at spawning: On average 3–5 years and 50–60 cm [10]. Maximum age: At least 6 years [10], a non-native individual lived to 8 years in Connecticut [13]. Maximum size: 84 cm [1]. Habitat: At maturity, ascends natal rivers and lake systems to spawn [11].

Substrate—Coarse sand to large rubble for spawning [10].

Physical/chemical—Temperature: At least 2–8 °C in freshwater during spawning [10]. Less than 1–15 °C, mainly 2.5–9 °C at sea [14]. Salinity: Fresh to marine waters, depending on life stage [10].



Behavior

Diel—Fry emerge from substrate and make initial downstream migration at night. Smolt migrations to sea tend to be at night [10].

Seasonal—Smolts tend to migrate out of lakes when waters warm in spring and summer [11]. *Utilization of offshore waters as well as migrations in U.S. Chukchi and Beaufort Seas are unknown.*

Reproductive—Spawning occurs in freshwater, most often in shallow water of lakes [10]. All adults die after spawning [11].

Schooling—Fry and freshwater smolts form schools, as do at least younger individuals at sea. The degree of schooling at sea, particularly of older individuals, is not well understood [10].

Feeding—Juveniles and adults are carnivorous planktivores. Spawning adults cease feeding [11].



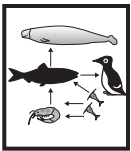
Populations or Stocks
There have been no studies.



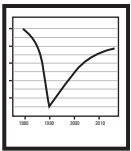
Reproduction
Mode—Gonochoristic, oviparous, and semelparous with external fertilization [15].
Spawning season—Late July through January, typically from midsummer through late autumn [10].
Fecundity—Highly variable, 2,000–5,000 eggs on average [10].



Food and Feeding
Food items—Primarily zooplankton (for example, euphausiids, hyperiid amphipods, copepods, pteropods, and crustacean larvae), as well as small fishes and squids. Diets vary with area and year [16, 17].
Trophic level—3.4 [18].



Biological Interactions
Predators—Fishes, sea birds, and marine mammals [10].
Competitors—Unknown, but likely to include Pacific Herring, Arctic Cod, Saffron Cod, and Dolly Varden.



Resilience
Medium, minimum population doubling time 1.4–4.4 years ($K=0.37-0.58$; $t_m=2-4$; $t_{max}=7$; Fecundity=300) [18].



Traditional and Cultural Importance
Only rarely taken in subsistence fisheries in U.S. Chukchi Sea [19].



Commercial Fisheries
Currently, Sockeye Salmon are not commercially harvested in the U.S. Chukchi or Beaufort Seas.



Potential Effects of Climate Change
Warming temperatures will likely allow this species to become more abundant in the U.S. Chukchi and Beaufort Seas. Whether this species will be able to reproduce in the waters draining into these seas is unknown.



Areas for Future Research [B]

Sockeye Salmon are well studied in Alaska, but are not of great abundance in the American high Arctic. Specific information needs include: (1) preferred habitat, including depth ranges for juveniles and adults; (2) spawning season; (3) seasonal and ontogenetic movements; (4) population studies; (5) prey; and (6) predators. If range expansions occur, surveys for suitable spawning and rearing habitats and evidence of successful spawning should be undertaken.

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Chinook Salmon (*Oncorhynchus tshawytscha*)

(Walbaum, 1792)

Family Salmonidae

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

Colloquial Name: Inupiat—*Iqalugruaq* [1].

Ecological Role: With its apparent increase in abundance in the U.S. Chukchi and Beaufort Seas [1], this species is likely to be of increasing ecological importance. Chinook Salmon are occasionally captured in recreational fisheries at Point Barrow.

Physical Description/Attributes: At sea, metallic green to blue-black back, silver flanks, and white belly, small black spots on both lobes of the caudal fin and on back and the gums at the base of the teeth of the lower jaw are black. For specific diagnostic characteristics, see *Fishes of Alaska* (Mecklenburg and others, 2002, p. 207) [2]. Swim bladder: Present [3]. Antifreeze glycoproteins in blood serum: Unknown.

Range: U.S. Beaufort and Chukchi Seas [4, 5]. Worldwide, from Northern Japan to Canadian Beaufort Sea at Coppermine River [2, 4] and to Bahia de Sebastian Vizcaino, central Baja California, Mexico [6].

Relative Abundance: Common to at least the Barrow region [1]. Rare eastward to the Coppermine River, Canada [2, 4]. Currently, the northernmost spawning stock known is in Kotzebue Sound, Alaska [10].



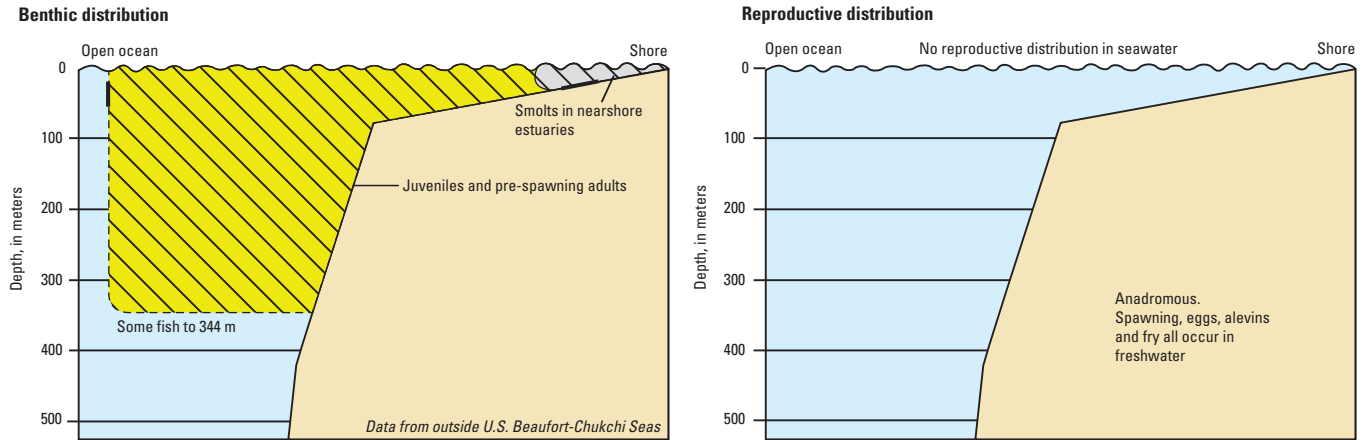
Chinook Salmon (*Oncorhynchus tshawytscha*), southeastern Gulf of Alaska, 2003. Photograph by C.W. Mecklenburg, Point Stephens Research.



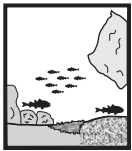
Geographic distribution of Chinook Salmon (*Oncorhynchus tshawytscha*), at sea within Arctic Outer Continental Shelf Planning Areas [7] based on review of published literature and specimens from historical and recent collections [8, 9].

Depth Range: Epipelagic, coastal and offshore, from surface to 344 m [11]. Bering Sea fish tend to remain 30–50 m below the surface, making occasional forays into somewhat shallower waters during the day [12], although those farther south tend to remain in deeper waters [13].

Oncorhynchus tshawytscha
Chinook Salmon



Benthic and reproductive distribution of Chinook Salmon (*Oncorhynchus tshawytscha*).



Habitats and Life History

Anadromous.

Eggs—Size: 6.0–8.5 mm [14]. Size at hatching: About 20–24 mm [14, 15]. Time to hatching: 30–160 days, warmer temperatures speed hatching time [16]. Habitat: Benthic, buried in gravel in streams and rivers [10].

Alevins (larvae)—Size range: 20–35 mm [14]. Habitat: Benthic, buried in gravel in streams and rivers [10]. Stay under gravel until yolk sac absorbed (4–6 weeks) [17].

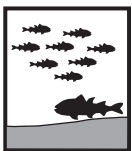
Fry—Size at emergence: About 33–37 mm [15]. Length of time as fry: Several weeks to more than 1 year [10]. Habitat: Epipelagic in streams, rivers, and estuaries [10].

Smolt (juveniles) and ocean phase—Age and size at smoltification: Several weeks to at least 18 months and at least 35 mm to perhaps 160 mm [17]. Habitat: Epipelagic [10, 14, 18]. Smolts that quickly leave fresh water reside in estuaries for at least a few months, although length of residence varies annually and with location [10]. Two life history types: Ocean-type enters the ocean in their first year and migrates less. Stream-type spends first year in fresh water, enters the ocean in their second year, and tends to migrate farther [18]. Generally, ocean-type does not migrate out of nearshore waters when at sea, whereas stream-type disperses much broader and farther from shore [10].

Adults—Age at first maturity: Highly variable, depending on stock and ranges from 1 year for males to 7–8 years for females [10]. Mean ages per stock range from 3–6 years [10]. Maximum age: 8 years [10]. Maximum size: 160 cm [2]. Habitat: At maturity, ascends rivers and streams to spawn [10].

Substrate—Gravel for spawning [10]. Mud, sand, gravel, and over eelgrass for juveniles in estuaries [14].

Physical/chemical—Temperature: At sea, 2–16.9 °C [19, 20], may prefer 7–12 °C [13, 20]. Salinity: Fresh to marine waters, depending on life stage [10].



Behavior

Diel—Fry emerge from gravel and travel downstream primarily at night [10]. In at least some areas, fry settle to the bottom at dusk and move into shallow waters at night. Juveniles entering estuaries do so at night [17]. At sea, appears to move toward surface waters in evening and returns to depth in morning [21].

Seasonal—Depending on geographical location, Chinook Salmon may return to natal rivers during almost any month of the year [10]. *In the U.S. Chukchi and Beaufort Seas, utilization of ocean waters as well as migrations are unknown.*

Reproductive—Spawning occurs in freshwater streams and rivers. Females prepare a gravel nest and lay their eggs, which are fertilized by a male [10]. All adults die after spawning except for a few “jack” males [14].

Schooling—Fry form schools [22].

Feeding—Juveniles and adults are carnivorous, opportunistic feeders [10, 14].



Populations or Stocks

There have been no studies in the U.S. Chukchi and Beaufort Seas.



Reproduction

Mode—Gonochoristic, oviparous, and semelparous with external fertilization [23].

Spawning season—May–January, depending on run, fish in the more northerly parts of the range tend to spawn earlier in the season [10].

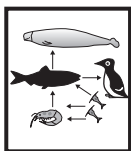
Fecundity—Highly variable, less than 2,000 to more than 17,000 eggs [10].



Food and Feeding

Food items—At sea, primarily fishes, although zooplankton (for example, euphausiids, amphipods, copepods, and pteropods) also is consumed [24].

Trophic level—4.4 (standard error 0.76) [25].



Biological Interactions

Predators—Fishes, sea birds, and marine mammals [26].

Competitors—Likely other Pacific Salmon, as well as gadid species.



Resilience

Medium, minimum population doubling time 1.4–4.4 years ($t_m=4$; $t_{max}=9$; Fecundity=4,000) [25].



Traditional and Cultural Importance

Historically, Chinook Salmon were only rarely taken in the subsistence fisheries of the Chukchi and Beaufort Seas [27, 28]. However, recent catches in the Point Barrow area suggest an increased abundance in recent years [1].



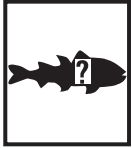
Commercial Fisheries

Currently, Chinook Salmon are not commercially harvested in the U.S. Chukchi and Beaufort Seas.



Potential Effects of Climate Change

Warming temperatures likely will allow this species to become more abundant in the U.S. Chukchi and Beaufort Seas. Whether this species will be able to successfully reproduce due to thermal requirements for incubation, phenology of seaward migration, and quality of nearshore habitats, is unknown.



Areas for Future Research [B]

Chinook Salmon are well studied in areas where their populations are abundant in the State of Alaska. Little information is available about this species from the U.S. Chukchi and Beaufort Seas. Specific information needs include: (1) preferred habitat, including depth ranges for juveniles and adults; (2) spawning season; (3) seasonal and ontogenetic movements; (4) population studies; (5) prey; and (6) predators. Surveys to identify suitable habitats for spawning and rearing of young are needed. Coastal monitoring of freshwater drainages should include searches for evidence of Chinook Salmon spawning and successful reproduction.

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Dolly Varden (*Salvelinus malma*)

(Walbaum, 1792)

Family Salmonidae

Note: Two subspecies are recognized by some taxonomists: *Salvelinus malma malma*, distributed from the Mackenzie River to the Alaska Peninsula, and *S. malma lordi*, living along and southward of the Alaska Peninsula [1, 2].

Colloquial Name: Iñupiat—*Iqalukpik* [3].

Ecological Role: Likely of considerable ecological importance as fish predator in nearshore areas of the U.S. Chukchi and Beaufort Seas. Dolly Varden are widely distributed and common throughout the region.

Physical Description/Attributes: Olive green to dark blue or brown on back and sides, with profuse yellow, orange, or red spots on side; largest spots usually smaller than pupil of eye; pectoral, pelvic, and anal fins with white leading edge and black or red line behind; spawning males orange to red, ventrally [4]. Coloration is highly variable and depends on race, age, and reproductive state. Extensive descriptions are given in *Fishes of Alaska* (Mecklenburg and others, 2002, p. 200) [4], McCart and others (1972) [5], and Armstrong and Morrow (1980) [1]. Swim bladder: Present [6]. Antifreeze glycoproteins in blood serum: Unknown.

Range: U.S. Chukchi and Beaufort Seas. Elsewhere in Alaska, found in all coastal waters in Bering Sea, south to Aleutian Islands and southern Gulf of Alaska. Worldwide, south to northern Washington and Korean Peninsula and Japan, northward to the Chukchi Peninsula, Russia, and east in Arctic to Mackenzie River, Canada, [4, 7].



Dolly Varden (*Salvelinus malma*). Photograph by Alfred L. DeCicco, Alaska Department of Fish and Game.

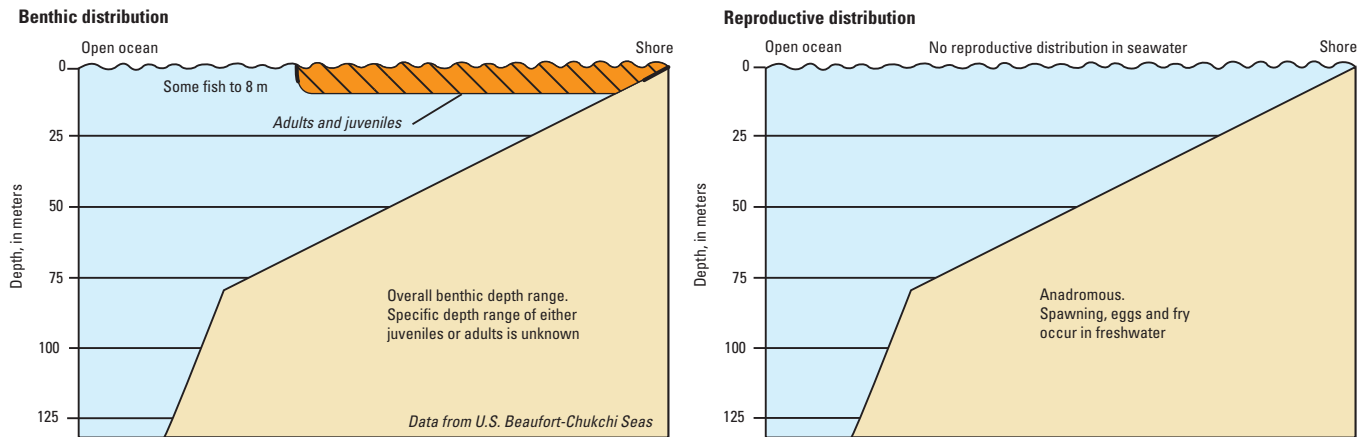
Relative Abundance: Common near shore in U.S. Chukchi and Beaufort Seas during summer, except along northeastern Chukchi Sea coast (for example Point Lay) [11, 12]. Elsewhere, common in Alaska throughout its range [13].



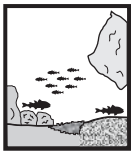
Geographic distribution of Dolly Varden (*Salvelinus malma*), at sea within Arctic Outer Continental Shelf Planning Areas [8] based on review of published literature and specimens from historical and recent collections [9, 10].

Depth Range: *Epipelagic, mostly nearshore but occasionally well offshore* [1]. *Primarily stays in top 3–4 m of water column, with occasional excursions down to 8 m* [14, 15].

Salvelinus malma
Dolly Varden



Benthic and reproductive distribution of Dolly Varden (*Salvelinus malma*).



Habitats and Life History

Note: The systematics of Dolly Varden are complex and the species exhibits a wide range of behaviors including amphidromous stocks, stocks with freshwater resident males, but ocean-going females (termed “facultative anadromous” in literature, but referred to here as “amphidromous”) [16], and various stocks where both sexes permanently reside in streams, springs, or lakes [1, 17]. Information in this account is on amphidromous *S. malma malma* living in U.S. Chukchi and Beaufort Sea drainages. Biological aspects of landlocked stocks and of more southerly subspecies are available in [1, 13, 18]. In U.S. Chukchi and Beaufort Sea drainages, most individuals are amphidromous, although some males and dwarf residents never leave freshwater [1]. In Beaufort Sea drainages, winter and spring are spent in those few areas of rivers kept ice-free by freshwater springs [1].

Eggs—Size: 3.2–6.0 mm [1, 19, 20]. Time to hatching: 7–9 months [1, 5]. Length at hatching: 8–12 mm [5, 19, 21]. Habitat: Benthic, buried under gravel in freshwater streams and rivers [1].

Alevins (larvae)—Size: From 8–27 mm [5, 19]. Time to emergence: 60–70 days post-hatching [22]. Habitat: Benthic, in freshwater rivers and streams, under gravel until emergence (yolk-sac absorbed) [22].

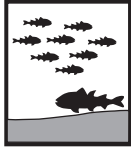
Fry and parr—Size at emergence: 20–27 mm [5, 19]. Length of time as fry and parr: 1 to 5 years, mostly at 3–5 years [1, 19, 20, 23]. Habitat: Freshwater, in streams and rivers.

Smolt and Adult—Age and size at smoltification: 1 to 5 years, mostly at 3–5 years [1, 19, 20, 23], and 16–39 cm [1]. Habitat: Nearshore waters during summer and early autumn and freshwater during winter and spring [1].

Adults—Age and size at first maturity: 4–10 years, mostly at 6–8 years [5, 19, 23, 24] and 32–47 cm [20, 24–26]. Nonmigratory or “residual” males mature at 2 years [5]. Maximum age: At least 18 years [16], although fish over 10 years are relatively uncommon [1, 20, 27–29]. Anadromous fish may live slightly longer than resident individuals and grow larger [5, 30]. Maximum size: 100 cm TL [4]. Habitat: Nearshore, shallow waters in ocean. In freshwater on spawning grounds, main channels of rivers, usually in strong currents or in the presence of springs [1].

Substrate—In marine conditions, mostly in mid-depths and surface waters. Spawning occurs in freshwater over gravel [1].

Physical/chemical—Temperature: -1–14 °C [16, 31]. Salinity: Freshwater to 32 parts per thousand [16, 31].



Behavior

Diel—Unknown.

Seasonal—On North Slope watersheds, before their first seaward migration, parr often overwinter in areas kept free of ice by perennial springs [5]. Some offspring of amphidromous Dolly Varden do not migrate to sea, but remain and mature in freshwaters. These diminutive “resident,” “residual,” or “accessory” fish are mostly males [5, 16]. Seaward migrations occur with ice break-up between May and July, with larger individuals leaving over-wintering grounds first. Fish enter marine waters in June and July [19, 31, 32]. Most juveniles have a variable freshwater rearing period of 1–3 years before first migrating to sea. Smaller fish entering marine waters form small schools [23, 31] and remain near mouths of natal rivers, whereas larger fish disperse widely along the coast, sometimes traveling as much as 300 km (Beaufort Sea) [1, 16, 30, 33, 34]. Some fish from Chukchi Sea drainages make even longer marine excursions. At the extreme, two fish tagged on overwintering grounds in the Wulik River (southeastern Chukchi Sea) were recovered well upstream in the Anadyr River of Siberia with one of the recoveries as much 1,690 km from the tagging site. It is likely that these recoveries were of Anadyr stock that had overwintered in the Wulik River [32]. Once in coastal waters many Dolly Varden inhabit shallow nearshore depths [14, 31, 33], although some move away from the coast, perhaps to feed under pack ice or when brackish waters extend off shore [31, 33, 35]. All Beaufort and Chukchi Sea Dolly Varden overwinter in freshwater and must return to rivers and streams during summer or early autumn [23]. In Beaufort Sea watersheds, both spawning and overwintering always take place in tributaries where perennial springs prevent freezing throughout the water column [21, 36], although in rivers flowing to the Chukchi Sea the lower parts of the waterways also may be partially ice free [32]. In Beaufort Sea, most fish overwinter in their natal drainages located in the mountain streams and rivers flowing from the Brooks Range [37]. In the southeastern Chukchi Sea, fish do not show overwintering fidelity to natal waterways and stocks from various rivers share ice-free zones [1, 32, 37]. During return migrations into fresh waters, the timing and behavior of Dolly Varden are quite complex and vary with location and with the state of maturity of individual fish [32, 37].

Reproductive—Spawning occurs in freshwater streams and rivers. Females prepare a gravel nest and lay their eggs, which are fertilized by a male [1]. Spawning periodicity is variable. Some individuals spawn annually, whereas many spawn every other year, and apparently there are a few that may reproduce only every third year [16, 19, 20, 23, 32]. In Beaufort Sea drainages, fish spawn in many of the “mountain” waterways located between the Colville and Mackenzie Rivers. In the southeastern Chukchi Sea, fish spawn in a number of rivers including the Kivalina, Noatak, and Wulik Rivers [32]. It is likely that spawning does not occur in Beaufort Sea coastal plain rivers that lie west of the Colville River because these waterways lack the perennial springs needed to keep waters from freezing solid [36, 38]. The vast majority of Dolly Varden seem to return to natal rivers and streams to spawn [32, 36].

Schooling—Juveniles form small schools upon entering marine waters [23, 31].

Feeding—Opportunistic feeders on various epibenthic and water column organisms including fishes [28]. Majority of annual growth is obtained while feeding at sea [22]. Fish migrating upstream in rivers during spawning runs feed only occasionally [20, 39].



Populations or Stocks

Genetic studies have shown that there are multiple populations in drainages throughout their range, that these populations are centered around the various spawning and overwintering areas, and that there may be more than one population occupying tributaries of a single river system [2, 32, 40, 41]. Aerial surveys are used to monitor abundance in North Slope drainages. A combination of mark-recapture and genetic studies examined the feasibility of estimating population size and stock composition at overwintering grounds on the Ivishak River. DIDSON sonar has been used to study abundance patterns in the Hulahula River. The largest overwintering populations of Dolly Varden occur in Ivishak, Kongakut and Anaktuvuk Rivers. Other large overwintering populations occur in the Hulahula, Canning, and Sagavanirktok Rivers.



Reproduction

Mode—Gonochoristic, oviparous, and iteroparous with external fertilization [1].

Spawning season—August–December, peaking in September and October [5, 19, 20, 23, 27, 32].

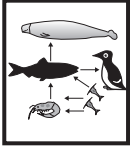
Fecundity—1,500–7,000 eggs [1].



Food and Feeding

Food items—*Epibenthic and water column organisms. Crustaceans (for example, amphipods, mysids, and isopods), fishes (for example, Dolly Varden, Fourhorn Sculpin, Arctic Cod, Least Cisco, Arctic Cisco, Arctic Lamprey, and snailfish), and insects tend to dominate the diet; fish eggs and polychaetes also are consumed. Smaller fish target insects and crustaceans, whereas larger individuals are more apt to feed on fishes* [19, 24, 31, 42].

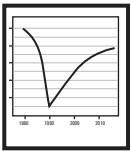
Trophic level—4.5 [43].



Biological Interactions

Predators—*Beluga whales, ringed seals, polar bears, and other Dolly Varden* [39, 44–46].

Competitors—*Likely other nearshore fishes, including salmonids, whitefishes, sculpins, and Arctic Cod.*



Resilience

Low, minimum population doubling time 4.5–14 years ($t_m=3-5$) [43].



Traditional and Cultural Importance

A very important subsistence species along much of the Alaskan Beaufort and Chukchi Seas, although catches in the northeastern Chukchi Sea are small. Depending on location, large numbers are taken during the summer in coastal waters and at inland sites in autumn and winter [12, 24, 47–49]. *Also an important recreational species* [50].



Commercial Fisheries

Currently, Dolly Varden are not commercially harvested.



Potential Effects of Climate Change

Unknown. Of particular relevance is the effect of climate change on the freshwater springs of rivers on the North Slope. If these springs dry up in the winter, the winter river refuges afforded Dolly Varden will not exist.



Areas for Future Research [A]

Future research should address the need for reliable estimates of population abundance from major overwintering habitats and genetic samples collected. Critical spawning and overwintering habitat should be identified and mapped. Subsistence harvests should be monitored, and the stock contribution in those harvests determined. Population parameters at key freshwater and coastal monitoring sites should be routinely monitored.

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