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Report Series: *Life in the Heart of the Arctic*

Fish in the Heart of the Arctic

A Journey through the Arctic National Wildlife Refuge

Audubon | ALASKA

Chum salmon.
Photo: Katrina Mueller/USFWS

Contents

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Chum salmon. Photo: John Schoen

Fish in the Arctic National Wildlife Refuge

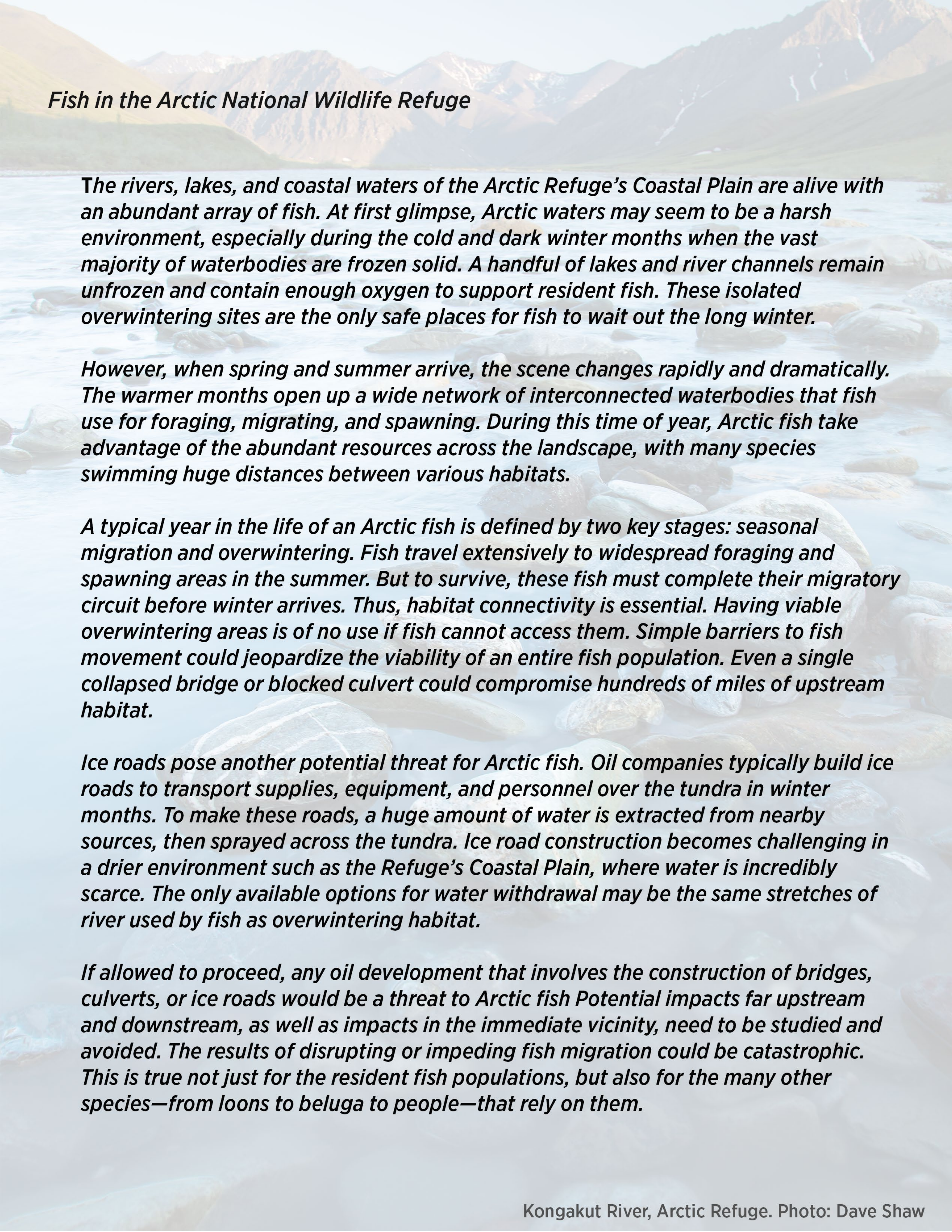
The rivers, lakes, and coastal waters of the Arctic Refuge's Coastal Plain are alive with an abundant array of fish. At first glimpse, Arctic waters may seem to be a harsh environment, especially during the cold and dark winter months when the vast majority of waterbodies are frozen solid. A handful of lakes and river channels remain unfrozen and contain enough oxygen to support resident fish. These isolated overwintering sites are the only safe places for fish to wait out the long winter.

However, when spring and summer arrive, the scene changes rapidly and dramatically. The warmer months open up a wide network of interconnected waterbodies that fish use for foraging, migrating, and spawning. During this time of year, Arctic fish take advantage of the abundant resources across the landscape, with many species swimming huge distances between various habitats.

A typical year in the life of an Arctic fish is defined by two key stages: seasonal migration and overwintering. Fish travel extensively to widespread foraging and spawning areas in the summer. But to survive, these fish must complete their migratory circuit before winter arrives. Thus, habitat connectivity is essential. Having viable overwintering areas is of no use if fish cannot access them. Simple barriers to fish movement could jeopardize the viability of an entire fish population. Even a single collapsed bridge or blocked culvert could compromise hundreds of miles of upstream habitat.

Ice roads pose another potential threat for Arctic fish. Oil companies typically build ice roads to transport supplies, equipment, and personnel over the tundra in winter months. To make these roads, a huge amount of water is extracted from nearby sources, then sprayed across the tundra. Ice road construction becomes challenging in a drier environment such as the Refuge's Coastal Plain, where water is incredibly scarce. The only available options for water withdrawal may be the same stretches of river used by fish as overwintering habitat.

If allowed to proceed, any oil development that involves the construction of bridges, culverts, or ice roads would be a threat to Arctic fish Potential impacts far upstream and downstream, as well as impacts in the immediate vicinity, need to be studied and avoided. The results of disrupting or impeding fish migration could be catastrophic. This is true not just for the resident fish populations, but also for the many other species—from loons to beluga to people—that rely on them.



Kongakut River, Arctic Refuge. Photo: Dave Shaw

Seasonality, Migration, and Overwintering Habitat

On the Arctic National Wildlife's Coastal Plain, wintertime brings over 50 consecutive days of darkness. During February, the coldest month, temperatures generally range between -18° F and -6° F (-28°C to -21°C). With sun-driven productivity halted and almost every body of water frozen solid, suitable fish habitat is constrained to a small number of overwintering sites, typically deep lakes or river channels fed by perennial springs. As spring arrives, ice breaks up and snow melts, connecting the scarce overwintering areas with a much broader array of productive habitats.

The Sheenjek and Teedriinjik Rivers, both of which flow from the Arctic National Wildlife Refuge, together support about 5% of the entire Yukon River basin's annual run of king salmon.

Arctic fish rely on long-distance migrations to capitalize on such variable conditions. Anadromous fish such as salmon reach maturity at sea, then undertake long journeys back to their natal streams to spawn. South of the Brooks Range, mature king salmon (*Oncorhynchus tshawytscha*) swim more than 1,800 miles (3,000 km) up the Yukon River to major tributaries in the Arctic National Wildlife Refuge. The East Fork Chandalar, Christian, Sheenjek, Coleen, and Porcupine Rivers all run in whole or in part within the Arctic Refuge, and all support notable populations of king salmon. The Sheenjek River alone provides about 2% of the entire Yukon system's annual king salmon run (Brown et al. 2017). In addition to king salmon, spawning populations of chum salmon (*Oncorhynchus keta*) and silver salmon (*Oncorhynchus kisutch*) also return to rivers within the Arctic National Wildlife Refuge (Alaska Department of Fish and Game 2018). Fewer salmon species can survive conditions on the North Slope, although chum salmon can be found in the Canning and Kongakut Rivers (Alaska Department of Fish and Game 2018). Pink salmon also have been regularly observed on some Arctic Coastal Plain rivers (Alaska Department of Fish and Game 2018; Craig and Haldorson 1986).

Most species of adult Pacific salmon can generally thrive in Arctic marine waters. King salmon have been occasionally caught as far north as Kaktovik (Harcharek et al. 2018) and the mouths of the Firth, Babbage, and Blow Rivers in Canada (Aurora Research Institute 2012). However, marine habitat use is more common than spawning, as successful spawning requires navigating complex and highly variable freshwater dynamics (Nielsen et al. 2013). As climate change warms Arctic marine waters and shifts other aquatic species' ranges northward, salmon are likely tracking preferred conditions and expanding their range deeper into the Arctic (Dunmall et al. 2013).

Young Arctic cisco. Photo: Vanessa von Biela/USGA

Despite spawning hundreds of miles away, Arctic cisco comprise a major part of North Slope fish harvest: in Nuiqsut, two out of every three fish caught were Arctic cisco.

Migration is a critical adaptation for many other Arctic fish species. Dolly Varden (*Salvelinus malma*)—a type of salmonid similar to trout—spend most of their lives in freshwater, but can undertake extended foraging excursions in marine waters. Studies of Dolly Varden in the Hulahula River reveal that in the summer, these fish travel as far as 43 miles (69 km) into the Arctic Ocean (Courtney et al. 2018). Similar tracking studies show that Arctic grayling (*Thymallus arcticus*), a popular sport fish, can travel over 60 miles (100 km) between summer and winter habitats on the Arctic Refuge's Coastal Plain (West et al. 1992).

Even more extensive migrations allow the Arctic cisco (*Coregonus autumnalis*) to comprise a large portion of North Slope community fish harvest despite not even spawning in Alaska. In Kaktovik, Arctic cisco generally comprise about a quarter of the fish harvested by weight, second only to Dolly Varden (Harcharek et al. 2018). In 2000–2001 in Nuiqsut, two out of every three fish caught were Arctic cisco (Bacon et al. 2011). Despite their abundance across the Alaska Beaufort coast, recent studies show that all of these Arctic cisco come from a single river system hundreds of miles away: Canada's Mackenzie River (Brown 2008; Fechhelm et al. 2007). Juveniles are pushed out into the ocean by the Mackenzie's sizable discharge, and predominant easterly winds fuel a coastal current that carries them over 400 miles (650 km) west (Brown 2008). These fish spend seven or eight years in Alaskan coastal waters, foraging in shallow lagoons and retreating to winter habitats in either the Colville River or the Sagavanirktok River. Finally, after reaching maturity, Arctic cisco migrate along the Arctic Refuge coastline back to the Mackenzie River to spawn (Fechhelm et al. 2007). Although the lifetime range of an Arctic cisco covers an enormous area, the entire population relies on only one spawning river-system, just two known overwintering habitats, and open passage between those three locations (Fechhelm et al. 2007).

As evidenced by the Arctic cisco, good overwintering habitat is both incredibly important and incredibly scarce. Although in May through September, fish travel extensively to widespread foraging and spawning areas, these fish's movements are very constrained for the rest of the year. Systematic surveys across Alaska's eastern Arctic Coastal Plain have revealed only a handful of suitable overwintering sites. When combined, these sites are assumed to contain every freshwater fish on the Arctic Refuge's entire Coastal Plain (Brown et al. 2019). The entire Hulahula River contains only four overwintering sites, one of which sits in the middle of the Coastal Plain; the whole drainage's population of Dolly Varden relies solely on those sites to survive the winter (Brown et al. 2014).

Dolly Varden
Photo: Morgan Bond/University of Washington

Jago River, Arctic Refuge.
Photo: Dave Shaw

Conservation Issues

Connectivity and Transportation Infrastructure

There is much still to learn about fish in the Arctic, especially in the Arctic Refuge. What we do know points to the importance of free movement among different habitat types. Because migration is a key part of Arctic fish life history, habitat connectivity is essential (Haynes et al. 2014). Industrial infrastructure that blocks fish passage, particularly from an oil and gas industrial complex, is therefore a serious conservation issue for Arctic fish. Although a single barrier may seem to block only a small portion of a given river, it can compromise hundreds of miles of upstream habitat (Cott et al. 2015).

For example, in order for Arctic grayling to access wintering habitat upstream in the Canning River, channels throughout the lower river must have enough open water to allow fish passage from summer foraging habitat close to the delta (West et al. 1992). For Dolly Varden, blockage anywhere along a stream could prevent summer access to marine foraging areas or fall access upstream to overwintering sites. Arctic fish rely on consuming enough resources during the summer to survive the winter, during which fish have little to no food (Brown et al. 2014). Preventing, inhibiting, or delaying movement to either summer or winter habitats could be fatal for an individual fish (Heim et al. 2015).

Similarly, marine travel is essential for many fish. The Mackenzie-to-Colville migration of Arctic cisco relies on transiting the network of lagoons and nearshore waters across the Alaskan coastline. Docks, gravel islands, causeways, or other similar features act as physical obstacles to migrating fish. Since they interrupt natural water flow, such features cause hydrographic changes—meaning swirling eddies, disrupted currents, increased or decreased temperature, and altered chemistry. Salinity and seawater changes due to the construction of West Dock in Prudhoe Bay have periodically stalled or entirely halted migration of juvenile least cisco (*Coregonus sardinella*; Fechhelm et al. 1989). Since fishes' metabolisms rely on a certain balance of salinity and temperature, these changes can be significant. Causeway-related temperature changes reduced growth rates of Arctic cisco and broad whitefish (*Coregonus nasus*) by 4-6% on average (Griffiths et al. 1992).

On the North Slope, a typical 14-acre oil production pad was projected to consume 395,000,000 gallons of water.

However, the overall impact of these documented effects remains somewhat uncertain. Adult fish are able to navigate the barriers more successfully than the juveniles (Fechhelm et al. 1999), and even the demonstrated changes likely do not translate to notable effects on the population scale (Wilson and Gallaway 1997). Furthermore, naturally occurring variability makes it difficult to parse out any major construction-related shifts in fish distribution or abundance (Griffiths et al. 1998). Still, the cumulative effects of a series of smaller impacts may be substantial, even if they seem benign when analyzed piecemeal.


Arctic Grayling. Photo: WikiCommons

Map 1: Salmon distribution in the Arctic National Wildlife Refuge and nearby waters.

Sources: [1] Alaska Department of Fish and Game 2018; [2] Brown et al. 2017; [3] Craig and Haldorson 1986; Aurora Research Institute 2012.

Ice Roads and Water Withdrawal

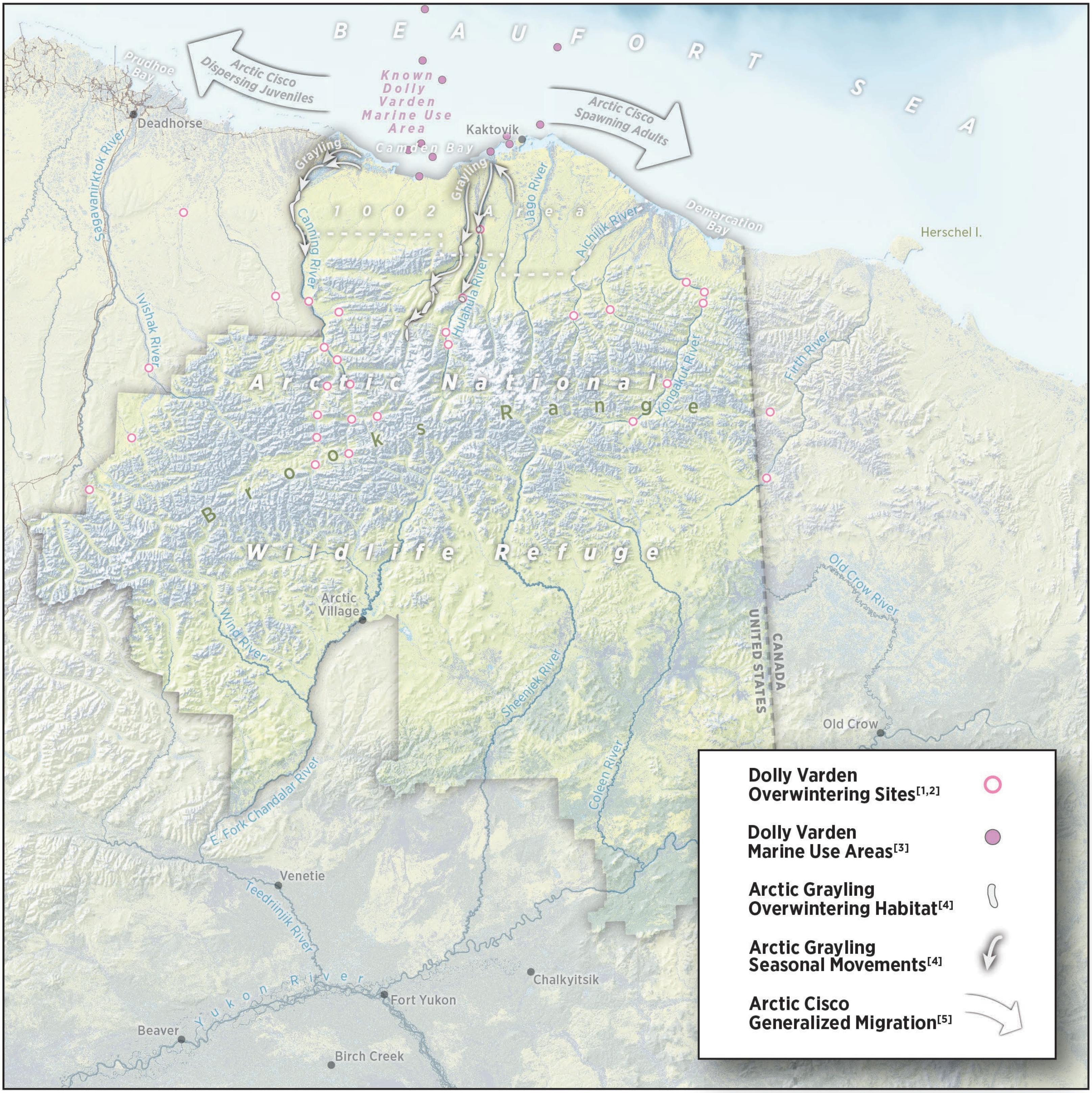
North Slope oil field development has historically relied on ice roads to transport supplies, equipment, and personnel during winter months, taking advantage of Prudhoe Bay's wetlands, numerous small lakes, and water resources. To make an ice road, liquid water is first extracted from a nearby source, then sprayed on the tundra to create a protective ice surface that prevents vehicles and equipment from directly coming into contact with fragile plants. It takes an enormous amount of water to construct ice roads: on average, about one and a half million gallons per mile (3,600,000 L/km; Nolan 2005). Because the Arctic Coastal Plain has very little precipitation, the only option is to use existing sources of water. Although the use of ice roads has generally mitigated many environmental impacts in the wetter Prudhoe Bay area, the Refuge's portion of the Coastal Plain is much drier. Water scarcity may preclude the construction and use of ice roads in this area. If oil and gas leasing were to occur, ice road construction could mean draining the same stretches of river used by fish as critical overwintering habitat.

If oil and gas development proceeds, industrial water withdrawal would not be limited to open water. It could also include the harvest of aufeis from perennial springs. Aufeis is ice that forms on the surface of rivers, streams, or permafrost as a result of year-round water discharge from perennial sources. It is found directly downstream from known overwintering fish sites across the eastern Brooks Range (Brown et al. 2014) and provides year-round habitat for fish and invertebrates. Aufeis can contribute one-third of a river's summer flow (Yoshikawa et al. 2007), providing a critical water resource across the Coastal Plain. Aufeis harvest for industrial requirements may impact both volumetric water and available overwintering habitat for fish and aquatic invertebrates.

On average, 1,500,000 gallons of water are required to construct a single mile of ice road.

Additionally, in the Arctic, correct timing of seasonal movements is critical. Although summer foraging areas provide abundant resources, Arctic grayling that remain for too long have an increased risk of failing to reach wintering habitat and subsequently have higher mortality rates (Heim et al. 2015). Even if industrial water withdrawal doesn't entirely dry up a riverbed, it can disrupt fish migration cues by changing the flow rate or interrupting seasonal pulses. Given the high densities of fish sheltering in these areas, a miscalculated water withdrawal or a stubborn ice road blocking spring water flows could be devastating, both for resident fish and for the food webs they support.

Map 2: Fish habitat use and movement patterns in the Arctic National Wildlife Refuge.



Sources: [1] Brown et al. 2014; [2] Brown et al. 2019; [3] Courtney et al. 2018; [4] West et al. 1992; [5] Fechhelm et al. 2007.

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