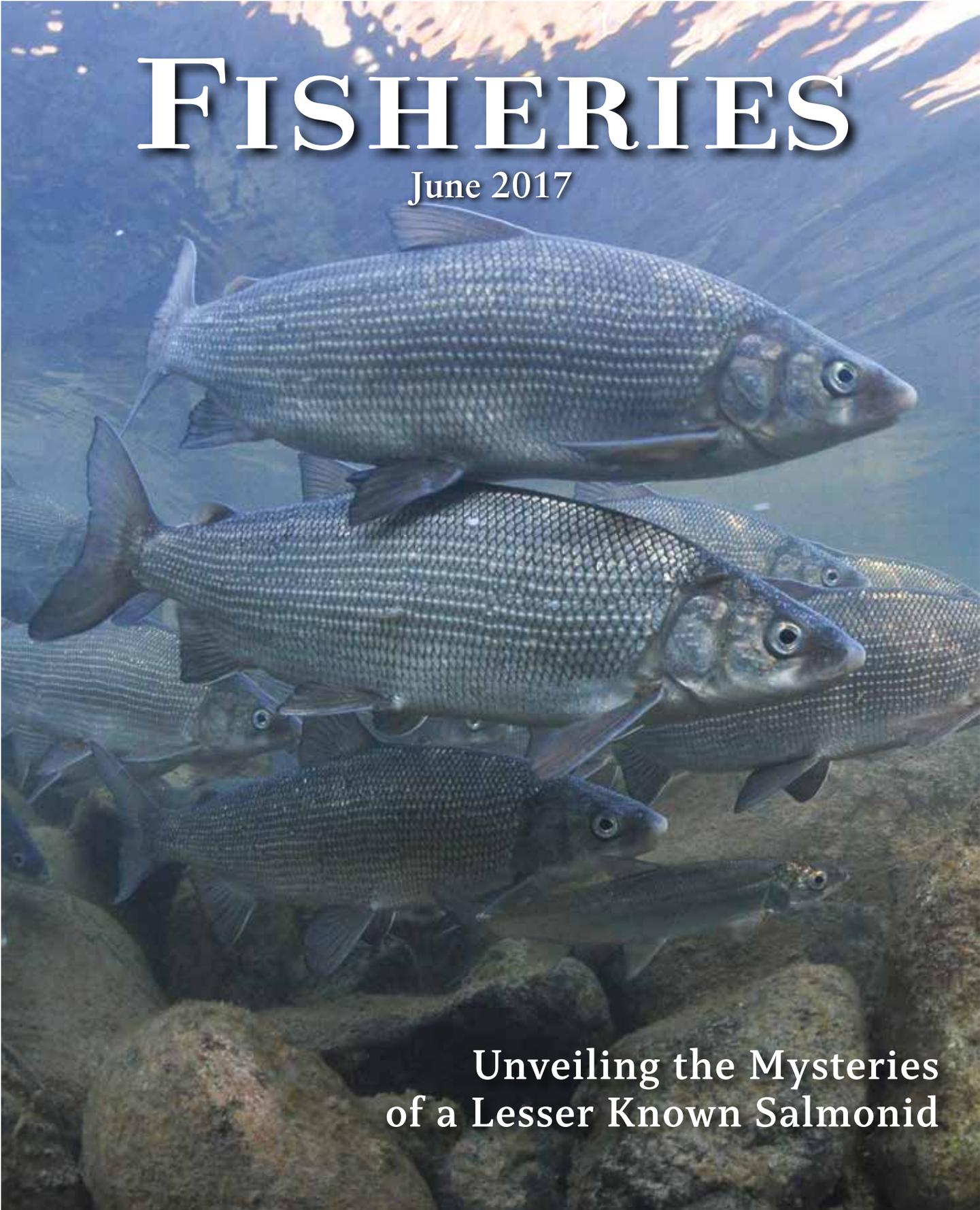


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In Search of Arctic Bonefish

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Fisheries technician Mike Lunde prepares to check a floating gill net on the middle Colville River. Photo credit: Jason C. Leppi.

In the cold waters of Alaska's Arctic swims a mysterious fish with large, silvery scales and a strong tapered body.

With its mouth turned down slightly, the fish is adapted to feeding on its prey from above. Moving between marine and freshwater habitats, it covers great distances while using shallow lakes and flooded marshes to gorge on a diverse array of prey. Sometimes all that can be seen at the surface is a series of fins like those of a school of tropical bonefishes *Albula* spp. working saltwater flats in search of food.

A close-up inspection reveals that this is not a type of bonefish commonly found feeding on tropical and subtropical coastal flats. It is not the famous sport fish that inspires fishers to make pilgrimages from around the globe. There is no one here working the network of shallow lakes with expensive fly-fishing gear in hopes of landing the silvery fish under Alaska's midnight sun. Unknown to most people, this fish belongs to the Salmonidae subfamily Coregoninae (which contains whitefishes and ciscoes) and has quietly inhabited Arctic and sub-Arctic ecosystems for thousands of years.

Broad Whitefish *Coregonus nasus*, the whitefish species under study here, is widely distributed in Arctic and boreal basins of North America and Eurasia. These fish are known to travel great distances between habitat types (e.g., summer foraging, spawning, and overwintering areas) within a single year, sometimes traveling hundreds of kilometers.

Aquatic ecosystems in the Arctic change dramatically from summer—when most water bodies are open and connected—to the winter, when ice reduces habitat connections and limits movement for nearly 9 months each year. To cope with extreme seasonal changes in habitat and resources, many fish species have

evolved migration strategies and life history patterns to maximize individual fitness.

Large summer dispersal patterns are common for Broad Whitefish and allow fish to exploit abundant food resources during the brief but productive warm period. During summer, fish are thought to migrate to a variety of productive habitat types such as streams, shallow lakes, and coastal marine areas, to feed on abundant clams, snails, crustaceans, and shrimp.

Anadromy is a common strategy for high-latitude fish species, and Broad Whitefish engage in it to varying degrees. Migrations between freshwater and marine ecosystems are thought to be a successful strategy to capitalize on dispersed food resources and important habitat. In late summer, Broad Whitefish generally leave productive foraging areas and migrate to freshwater spawning locations conducive for egg development. While populations have been studied extensively in some areas, the proportion of time spent in freshwater, brackish, and marine habitats remains largely unknown for many populations across Alaska's Arctic.

Broad Whitefish spawn in early winter after fish migrate to freshwater habitats. To increase offspring survival, spawning typically occurs in gravel-rich habitat that does not freeze during the long, cold Arctic winter. Timing of spawning likely varies by region, habitat, and individual, and typically involves individuals greater than 5 years of age and occurs over several days as rivers begin to freeze. The fish congregate as water temperatures begin to drop, signaling the start of the spawning ritual. Females are thought to initiate the spawning process, and as they broadcast their eggs, one or more males simultaneously broadcast their milt into the water column.

A female can release between 10,000 to 70,000 eggs about 2



A Colville River Broad Whitefish *Coregonus nasus* is held briefly before a radio transmitter is surgically implanted. Photo credit: Jason C. Leppi.



Aerial photo of the middle Colville River, looking downstream and toward the Colville River Special Area within the National Petroleum Reserve-Alaska. The middle section of the Colville River is composed mainly of a single deep channel bounded by high bluffs on the west with only small creeks entering as tributaries. Photo credit: Jason C. Leppi.

mm in diameter, which sink rapidly due to their negatively buoyant properties. Once the eggs reach the streambed, they become lodged within gravel crevices, preventing the eggs from being swept downstream.

FIELDWORK

It is September, and we are on the third trip of our second field season working on the mighty Colville River. The Colville is the largest Arctic river in Alaska, about 560 km long, with its headwaters in the partially glaciated Brooks Range and a large delta on the edge of the Arctic Ocean near the village of Nuiqsut. As we stretch out another 45-m gill net, a cool breeze blows across the Arctic Coastal Plain. Leaves of the alpine shrubs have faded to yellow, snow covers the high peaks of the Brooks Range. This will be our last chance this season to catch Broad Whitefish.

As fisheries researchers for the Alaska Cooperative Fish and Wildlife Research Unit, we began a collaborative project a year ago with The Wilderness Society, U.S. Bureau of Land Management, U.S. Fish Wildlife Service, and U.S. Geological Survey to investigate the ecology of Broad Whitefish. One goal for this field season is to understand how the species uses the watershed's habitat by season. This can be a challenging task, but working on an under-studied species in a remote Arctic location greatly complicates the collection of fish and the ability to track them. From our previous field season, we collected baseline information that showed that pre-spawning fish were migrating through the middle Colville during August, but our attempt to intercept fish during

that month was abruptly halted by a large storm that dumped 8 cm of rain across the 52,000-km² watershed (an area five times as large as Yellowstone National Park). The Arctic receives precipitation amounts similar to those of a desert, but large, late-summer rainstorms commonly cause the Colville to flood. The river is crystal clear now, but less than a month ago it was raging at 10 times its normal flow and remained high and filled with suspended sediment debris for several weeks.

Our nets have been set again at several strategic locations throughout the river to intercept Broad Whitefish migrating upstream. For 4 days, we have failed to catch a fish. Our objectives are to catch pre-spawning fish and surgically implant radio transmitters into them so we can track their movements to spawning and overwintering habitat. We watch the nets intently, but hours slowly pass with nothing happening. This requires extreme patience but is crucial for our project if we hope to release each fish back into the river unharmed. Broad Whitefish are known to respond poorly to minor injuries so we want to minimize the time that each fish is entangled.

Suddenly the white foam floats at the top of a gill net begin to bobble up and down on the water's surface. We race to our Zodiac boat, fire up the 40-hp jet motor, and head toward the net. Reaching into the frigid water with elbow-length neoprene gloves, we slowly pull in the net while scanning the depths for entangled fish. The breeze blows harder now, creating whitecaps on the river as snow begins to fall. At last, a white underbelly emerges as the mesh ascends toward the surface. It is a large Broad

Whitefish. The sounds of shouts and high fives carry across the floodplain. We scoop up the fish and place it in a small tote filled with oxygenated water. We fire up the jet motor and transport the fish to a holding pen near the shore, where it will wait to undergo anesthesia and surgery. Catching the fish has proved difficult, but it is only the first step. We have to be extremely careful handling each fish as we surgically implant the radio transmitter.

Half an hour after we removed the fish from our net, the surgery was successful and we have implanted our first transmitter. The wind is cranking outside the ice-fishing tent that we use as our portable surgical room. We carefully hold the fish upright in the holding pen for 5 minutes until it can maintain its position. After another 10 minutes, we watch our first tagged fish swim upstream toward a river eddy, seemingly unaffected by the transmitter.

It took nearly 5 days of watching our nets to catch and tag our first fish. Our catch rate picked up a little after that and we managed to bring our total up to 14 for the season. While this was much lower than our goal of 50, every fish we caught was well earned. Wildlife is abundant in the Arctic, but not everywhere and not all the time. Resources are dispersed across the landscape, and animals must make large seasonal migrations to find food resources. Just like caribou, Arctic fishes move hundreds of kilometers seasonally across a variety of aquatic habitats, and there can be countless fish in an area one week and none the next. To understand more about these seasonal movements, our tagged fish will transmit radio signals every 3 seconds for more than 2 years. During this period, we will track fish using aerial and ground-based methods during the fall and winter to understand their story.

Subsistence fisheries are a vital resource to most Arctic communities. About one-third of all adults participate in some type of fishery, and the mass of fish harvest by coastal communities is roughly equal to the annual harvest of bowhead whales *Balaena mysticetus* (ca. 90,000 kg). Of the numerous fish species caught, Broad Whitefish is among the most important subsistence species because of its size and abundance during migrations. Fish reach maturity around 40 cm long, but individuals have been caught that are 65 cm long, which is similar in size to Sockeye Salmon *Oncorhynchus nerka*.

Nuiqsut, a native Inupiat village, is located near the Colville River delta, and village residents target Broad Whitefish using gill nets from June through September during the upstream migration. Nuiqsut fishers have been annually harvesting fish from the Colville River for more than 50 years, and their harvest of Broad Whitefish ranges from 6,300 to 15,800 kg. Despite the historical importance of this fishery, the basic ecology of the Broad Whitefish remains poorly understood.

The lack of basic information on habitat use, especially during the spawning period, puts this important subsistence fish species potentially at risk. Expanding hydrocarbon development in the Colville Delta and lower watershed has the potential to overlap with critical habitat, so identifying spawning and overwintering habitat is more important than ever.

AN EARLY END TO THE SEASON

Twelve days later, as we board our charter flight heading back to Fairbanks, the temperature is well below freezing and heavy snow is forecast to hit soon. The first winter storm of the season is bringing our field season to an abrupt end. The landing strip at Umiat, a former Air Force base, is unmaintained, so if we do not take advantage of this window of “good” weather, we could easily be stuck here for days or even weeks. With no permanent residents and a record low temperature of -66°C , Umiat



Broad Whitefishes with surgically implanted radio transmitters recover in a holding pen before being released into the Colville River. Photo credit: Jason C. Leppi.

serves as a center for summer research, a fuel stop for aircraft, and a camp for oil and gas exploration.

Our small Piper Navajo accelerates down the landing strip and rises above the Colville River. Looking down from the air, the perspective has changed. Braided and side channels seem separate on the ground, but now from above, it is obvious that they are annually connected by seasonal floods. Oxbow lakes, remnant channels, and floodplain features are suddenly revealed without the interference of riparian vegetation. We continue to fly upriver toward the Brooks Range. The Colville is wide, with numerous channels and gravel bars as far as the eye can see. Most of the river appears to be good spawning habitat, and we begin to wonder if our tagged fish will be nearby or 100 km



Aerial view of the middle Colville River, looking upstream toward the Brooks Range. In this section, the river channel has a lower gradient than the upper section, and is wider (ca. 100–300 m) and contains numerous side channels and large sand and gravel bars. Photo credit: Jason C. Leppi.

upstream when we return.

Soon, the plane leaves the river and heads southeast over the foothills of the Brooks Range, toward Anaktuvuk Pass and then Fairbanks. Besides the small native community of Anaktuvuk Pass, there are no year-round residents living within the upper watershed, and even today, most of the area remains wild and free from human disturbance. The view from inside the small plane is unreal. We fly over creeks and tributaries, and the high mountains of the magnificent Brooks Range begin to rise in the distance. To the west, you can see the upper section of the Colville that flows almost directly east for 200 km from the De Long Mountains before making a sharp turn north at Killik Bend. To the east, we can begin to see the meandering Anaktuvuk River that flows down from the pass and between a network of small lakes. Snow has already blanketed the mountains, and it will not be long until the entire North Slope is frozen and covered in snow.

As our plane starts to gain altitude, rising above the foothills, we begin to imagine our tagged fish along with hundreds of other Arctic bonefish swimming below in the middle Colville river. Slowly climbing into the clouds above the Brooks Range, we imagine our tagged fish, packed tightly, swirling in the mighty



A Broad Whitefish with a surgically implanted radio transmitter is released into the Colville River. Photo credit: Jason C. Leppi.

Colville, waiting for river temperatures to drop to begin their mating ritual.

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