Acoustic Sledding on Lake Superior to Assess Native Cisco

By Dan Yule (USGS), Jared Myers (USFWS), and Ian Harding (Red Cliff Band of Lake Superior Chippewa)

Fishery scientists and managers have been using hydroacoustic surveys to estimate abundance of Lake Superior Cisco, a native coregonine species, for two decades. This method involves transmission of sound waves from the ship towards the lake bottom and recording the returning fish detections (echoes) in the water column. Traditional fishing gear (e.g., mid-water trawl or gillnet) is also deployed so the scientists can better appreciate the biological characteristics of the fish they see with hydroacoustics.

Fishery managers are increasingly relying on hydroacoustic surveys to help regulate the Lake Superior Cisco harvest by commercial fishers. Nearly 2.2 million pounds are harvested annually, and that product reaches a wide range of markets. The flesh is processed into smoked fish and fillets while the roe is primarily sold to Scandinavian countries where it is marketed as Löjrom, a type of caviar. This industry has a rich cultural history and provides sustenance and employment opportunities to local communities across the Lake Superior basin. For example, Anishinaabe people, such as the Red Cliff Band of Lake Superior Chippewa, have long relied on the fishes of Lake Superior for subsistence and commerce. The Red Cliff Band recently opened a fish processing facility and the Cisco fishery has been a vital component to both the business and community.

Cisco are difficult to sample because hydroacoustic surveys are best conducted during the fall when fish congregate in surface waters along the shoreline. Although this may be good for commercial fishers looking to capture Cisco with nets, the situation presents a challenge for scientists attempting to use acoustics to measure the abundance of fish at a given location. Traditional acoustic methods use sampling equipment attached to the research vessel and aimed downward toward the lakebed (see schematic below). This leads to low sample volumes near the surface and the potential for fish to swim away from the boat before they can be measured by the acoustic system.

The USGS, USFWS, and Red Cliff Band of Lake Superior Chippewa recently combined resources to assemble and test a new hydroacoustic system that relies on a sled towed behind and to the side of the vessel and deeper in the water column (see schematic below). The sled allowed the first ever mobile acoustic survey on Lake Superior that looked in multiple directions as opposed to just down. By using this new approach, a much larger volume of surface water was effectively sampled. In addition, the new approach could better detect fish that were displaced by the vessel that would be otherwise undetected by the traditional approach.

The USGS worked with the private sector on the design. The USFWS helped finance the submersible echosounder and funded a graduate student at the University of Minnesota-Duluth. The Red Cliff Band contributed funding for the fiber optic communication system that was critical for real time adjustments and data visualization during collections. All three agencies and the university participated in the field work.

Results from the new sled were compared to the traditional down-looking acoustic method along transects in western Lake Superior during the summer of 2018. While conditions during this summertime study were markedly different from the conditions that would be expected during a fall spawning Cisco survey, it did provide greater context to the limitations of traditional acoustic sampling. The two survey approaches provided significantly different estimates of fish density near the surface (approximately

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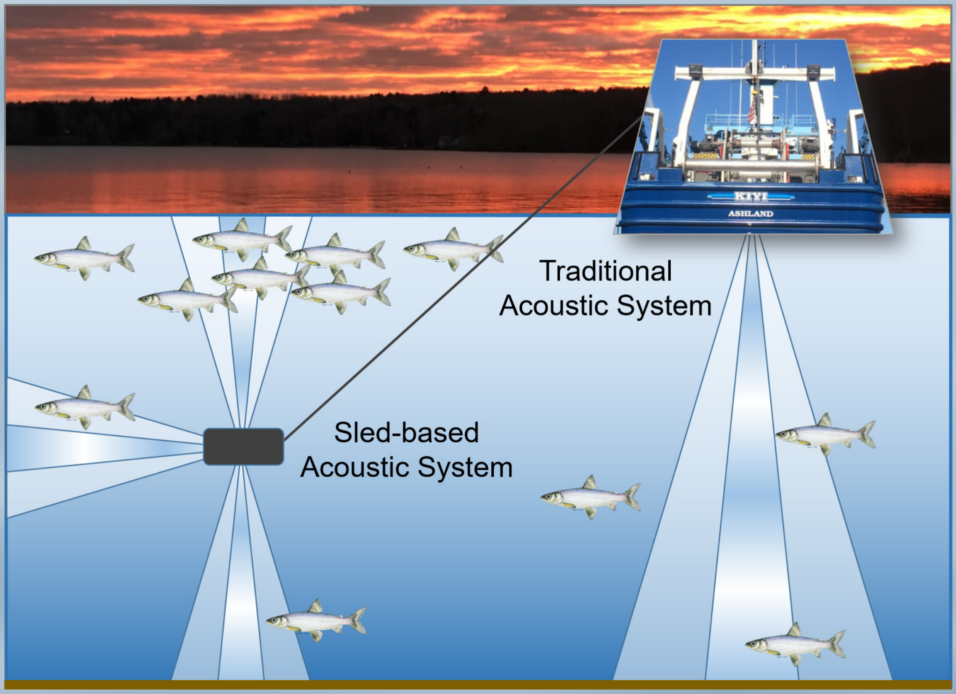

Schematic showing standard hydroacoustic survey (right) and the new towed hydroacoustic sled (left). Image credit: Jared Myers, USFWS

Lake Superior as a Reference Point

By Owen Gorman (USGS)

Lake Superior represents the exemplar Great Lake: it retains a nearly intact native fish community and its ecosystem has not been "re-engineered" by invasive mussels as have the lower Great Lakes. As such, Lake Superior serves as somewhat of a reference point for rehabilitating fish communities in the lower Great Lakes.

Lake Superior shoreline, Pictured Rocks National Lakeshore. Photo credit: Josh Miller, public domain

However, Lake Superior is not pristine and has undergone dramatic changes over the past century. Rapidly expanding European settlement of the basin in the late 19th and early 20th centuries drastically altered the watershed. Clear-cutting of forests resulted in catastrophic soil erosion and sedimentation of wetlands and bays. Fish stocks were depleted and rapidly growing cities discharged large volumes of untreated wastes. By the early 1960s, a combination of overfishing and rapid expansion of invasive sea lamprey resulted in the near collapse of the fish community.

Around this time, a concerted bi-national effort was launched to control sea lamprey and restore decimated native lake trout stocks across the Great Lakes. Early efforts were focused on Lake Superior where remnant lake trout stocks remained. The strategy was successful, and by the close of the 20th century, lake trout stocks were restored, native fishes, including coregonines, dominated the fish community, and sea lamprey were under control. Meanwhile the forests regenerated, land management practices were instituted, the Clean Water Act was passed, and human population levels dropped. Lake Superior recovered much of its former integrity, though it continues to face challenges due to changing climate. The lake currently retains all six original coregonine species, including Cisco, Kiyi, Bloater, Shortjaw Cisco, Blackfin Cisco, and Shortnose Ciscoe.

Due to its recovered state, Lake Superior has provided valuable information to guide coregonine restoration efforts across the other lakes, such as elucidating the ecology of Cisco during various life stages and the role lake trout and coregonines play in transferring energy throughout the ecosystem.

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4–9 m below the lake surface) with the sled up-looking transducer providing 56 times higher densities compared to the traditional down-looking method. Densities also varied significantly in the middle of the water column (9–14 m layer) where densities were 6.2 times higher in the sled survey. Midwater trawl sampling indicated that Rainbow Smelt were the most abundant species occupying the uppermost 14 m of the water column, but Cisco were also present. Overall, the sled-based estimates were, on average, 2.5 times higher for the whole water column.

The team's findings show that the new sled can reduce bias in fish surveys by better sampling the surface waters. The ability to provide more accurate estimates of fish densities will lead to more informed decisions and sustainable management of Lake Superior fishes. Moreover, the ability of the hydroacoustic sled to sample large volumes of surface water rapidly and more accurately has significant implications for monitoring native coregonine populations and assessing restoration efforts throughout the Great Lakes.

Read more: *https://doi.org/10.1016/j.jglr.2020.08.010*.

The new hydroacoustic sled being deployed off the back deck of the USGS R/V *Kiyi* in Lake Superior, summer 2018. Photo credit: USGS

A comparison between the echograms, or hydroacoustic readouts, of the ship-based down-looking echosounder (right) and sled-based up-looking echosounder (left) along a 15-minute transect in August 2018 on Lake Superior. Blue blips are individual fish measured within the uppermost 30 meters of the water column. Image credit: USGS