Steps Using Hydroacoustic Techniques to Quantify Fish Populations in Shallow Riverine Environments: Rupert River 2007-2012 Spawning Cisco Abundance Studies

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DE LA RECHERCHE À LA GESTION DES PÊCHES: PENSER ET AGIR LOCALEMENT ET GLOBALEMENT
FROM FISHERIES RESEARCH TO MANAGEMENT: THINK AND ACT LOCALLY AND GLOBALLY
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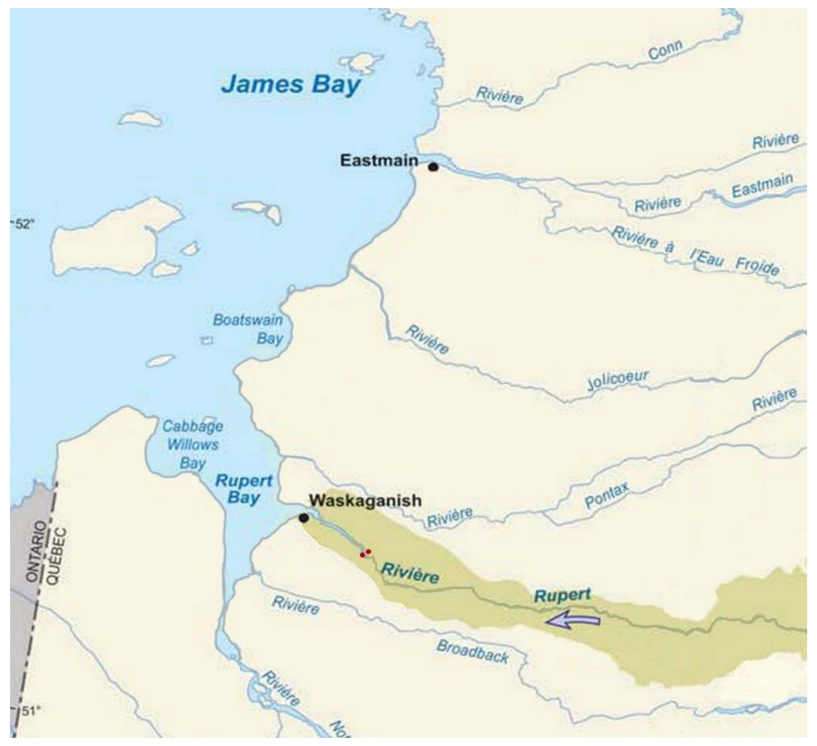
Introduction

The Rupert River in northern Quebec extends over a 560 km long reach from Mistassini Lake to Rupert Bay. An anadromous return of Cisco (*Coregonus artedii*) enters the lower Rupert River to spawn during the late summer and early fall months. These fish are of significant subsistence and cultural value to the local Waskaganish Cree First Nations community. Beginning in late 2009, water diversions for hydroelectric generation purposes commenced upstream in the Rupert River drainage, reducing the average flow at the mouth of the Rupert River to approximately 48% of mean flows prior to this diversion. Multiple Cisco habitat enhancement measures were implemented in the lower reaches of the Rupert River prior to the initiation of water diversion activities. Hydroacoustic sampling methods were employed as one tool in a larger study designed to assess the potential effects of lower Rupert River outflows on the population size of returning spawning Cisco in this region. Annual hydroacoustic Cisco population studies were conducted from 2007-2012, under both pre-diversion and post-diversion conditions.



Rupert River from Mistassi Lake to Rubert Bay, Canada.

The densely-schooled nature of pre-spawning Cisco schools and the relatively shallow environment present in the lower Rupert River area (typically < 8 m depth) necessitated development of specialized hydroacoustic sampling methods (Fig. 1). Side-aspect echo integration techniques were employed to quantify Cisco school aggregations located in shallow water, typically in close proximity to the river shorelines (Fig. 2). Successfully implementing this hydroacoustic enumeration method in a shallow-water boundary-limited environment required experimentation and iterative refinement of the initially applied sampling and data analysis methods. This effort occurred following the 2007 sampling period, when difficulties were encountered identifying and quantifying observed Cisco schools due to their close proximity to shoreline features, resulting in an underestimate of the pre-spawning biomass during that period.

This presentation discusses hydroacoustic sampling techniques that were developed and refined to enhance to resolution of schooled fish populations in the shallow water environment present in the Lower Rupert River.

Figure 1. Mobile hydroacoustic sampling in shallow water.

Methods

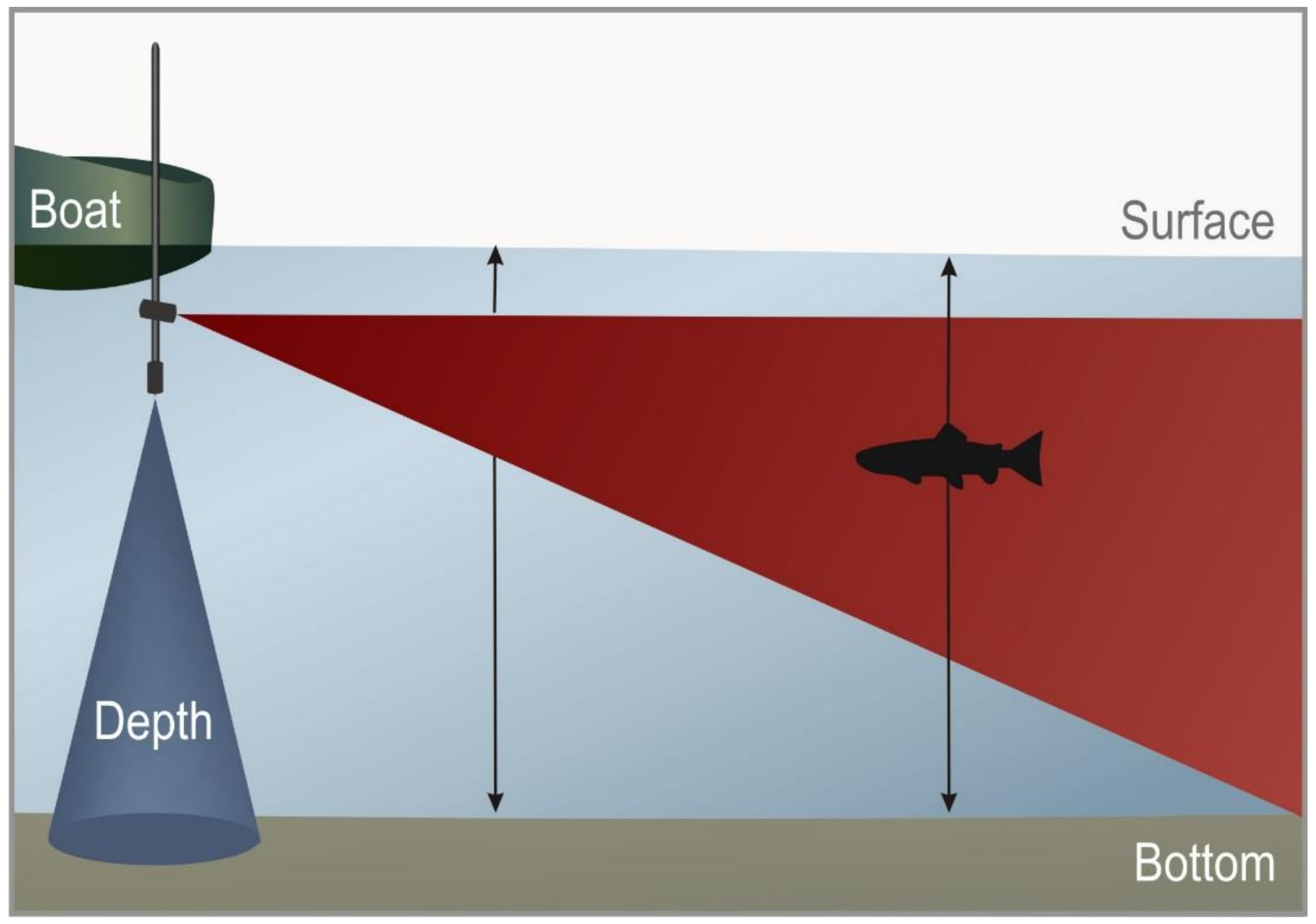


Figure 2. Two 120 kHz transducers simultaneously sampling on a singular mount for mobile application.

Annual mobile hydroacoustic surveys to quantify spawning lake herring, or Cisco populations were conducted in the lower Rupert River in Quebec from 2007 - 2012. The shallow water environment and the patchy, aggregated nature of the spawning Cisco schools in the Rupert River resulted in an underestimation of the population size in 2007. Refinements to the hydroacoustic sampling methodologies and analysis techniques were implemented in 2008, improving the ability to enumerate Cisco present in the lower Rupert River study areas. A combined target tracking and echo integration approach using simultaneously-sampled horizontally- and vertically-oriented transducers was employed to estimate Cisco biomass, acoustic size and distribution. The standardized sampling approach developed in 2008 was successfully employed during the subsequent 2009-2012 Rupert River spawning Cisco surveys to quantify the annual population size and distribution under varying hydraulic conditions (Fig. 3). Data collection and analysis methods will be presented, which may be suitable for other applications using scientific hydroacoustic sampling methods to sample fish populations in shallow water environments.

Two 120 kHz transducers were simultaneously sampled during repeat sampling of a intensive 50-m spaced survey transect grid encompassing three different potential Cisco spawning regions located near the town of Waskaganish in the Lower Rupert River. The annual Rupert River Cisco spawning population evaluations encompassed approximately 20 survey days, each sampling 20-25 km of transect data. The 6° beam width horizontal transducer axis was oriented down 5° to place the acoustic sampling volume just below the water surface. The vertical 15° beam width transducer data was used to establish water depth and volumes in the sampled areas, and to detect fish located close to the bottom that were not effectively sampled by the horizontal transducer. The measured individual tracked fish and school echo integration fish densities (Fig. 4) from the paired transducer data sets were combined during the data analysis efforts, to produce mean fish per unit surface area and per unit volume estimates within pre-defined 50x50 m spatial cells. This information was evaluated over each annual survey time series to determine peak fish population estimates during each annual Cisco spawning period. The results of these annual pre-spawning Cisco peak population estimates in the Lower Rupert River will be evaluated over time relative to pre- and post water diversion conditions to assess any potential changes in Cisco density and distribution.

Figure 3. Acoustic sampling in mobile application.

Methods (*cont.*)

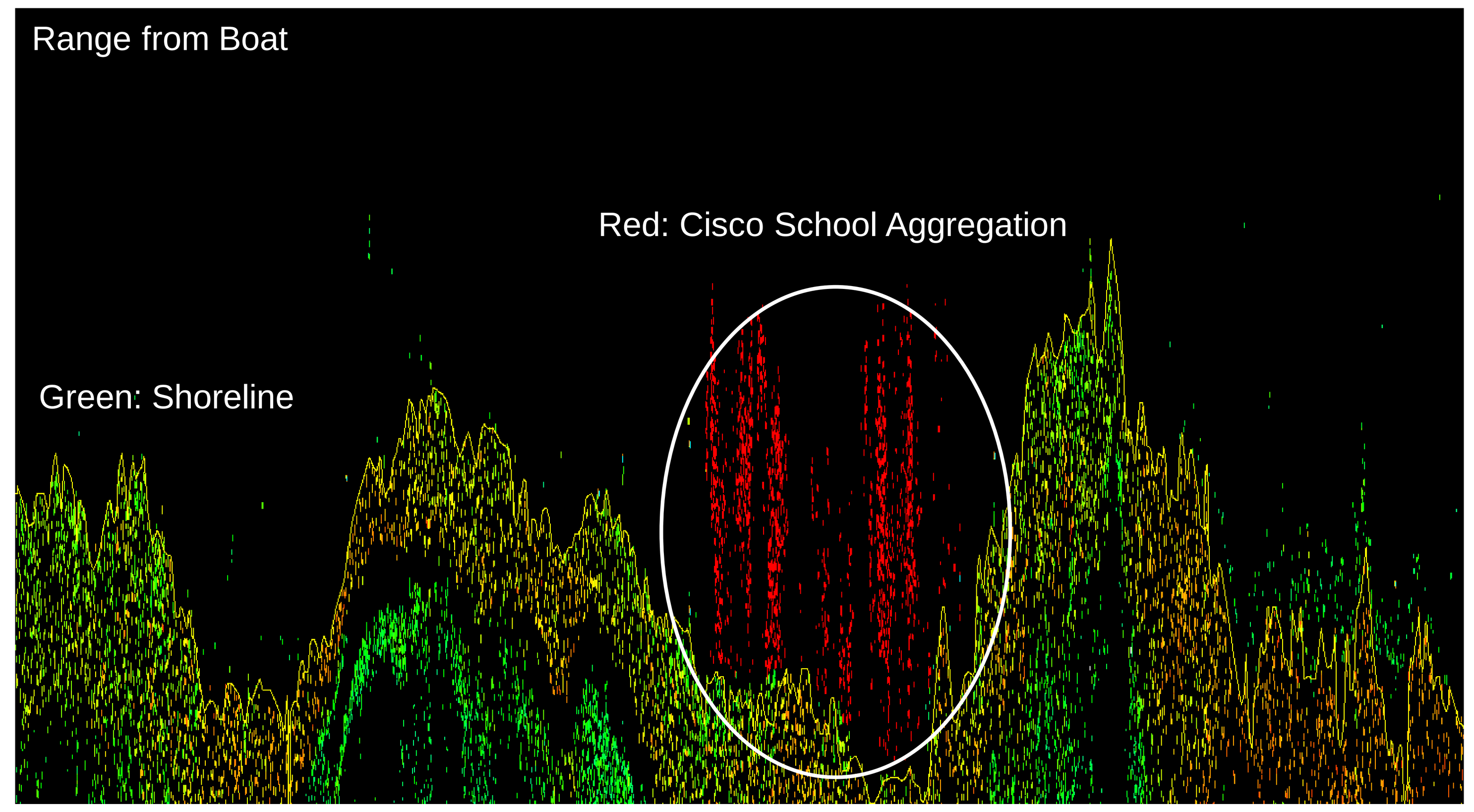


Figure 4. Typical Cisco school spawning aggregations near the shoreline.

Innovative Study Aspects

- Utilization of a 120 kHz frequency transducer array to reduce background noise levels from smaller scatters and boundary-effect noise. A higher-frequency 200 kHz system was employed during the initial 2007 surveys.
- The use of low side-lobe transducers to minimize acoustic returns from the water surface.
- Use of fish behavior (spawning aggregations) to identify and quantify a specific population in a mixed-species environment.
- School-based side-aspect echo integration using the unfiltered digital samples-level acoustic data. Acoustic background noise levels were measured and used to determine range-dependent integration thresholds, in order to exclude energy from non-biological sources from the biomass estimates.
- Sampling range and school resolution near shoreline and surface boundaries were optimized via the use of relatively high sampling frequency (120 kHz), narrow broadcast pulse widths (0.18 milliseconds) and chirp (signal frequency modulation) technology.
- Data was collected without the application of echo pulse length filters, which were observed to exclude valid echo returns from distributed single Cisco school aggregations during the initial 2007 study.

Acknowledgements

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