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Relationships between hydroacoustic derived density and gill net catch: Implications for fish assessments

Donald E. Dennerline[a,*], Cecil A. Jennings[a], Donald J. Degan[b]

[a] U.S. Geological Survey, Georgia Cooperative Fish and Wildlife Research Unit, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA 30602, USA
[b] Aquacoustics, Inc., P.O. Box 1473, 29824 Birdie Haven Court, Sterling, AK 99672-1473, USA

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ABSTRACT

In this paper, we describe our assessment of whether gill nets and hydroacoustics provided similar inferences on the local abundance of fishes and whether gill net catch could be used to predict acoustic-derived abundances. We collected hydroacoustic and gill netting samples from a restricted area of large hydropower reservoir in the southeastern United States. We used mixed linear models in an information theoretic framework to model acoustic-derived abundances as a function of gill net catch and a variety of biological and environmental covariates. Overall, gill net catch was a poor predictor of acoustic-derived abundance and the best model only accounted for 39.6% of the within year variation. In fact, a gill net catch (e.g., 100 fish/net) was approximately equally likely across several orders of magnitude in fish abundance. This result suggests that gill net catch was unable to reliably discern substantive changes in fish abundance. Consequently, the most appropriate role for gill nets in fisheries research assessments may be to: (1) supplement hydroacoustic data by providing information on species composition and fish sizes and (2) provide information on metrics other than fish abundance, such as fish growth and condition.

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1. Introduction

Active and passive gears have been used widely in reservoir fisheries assessments to make inferences regarding the abundance of fishes. Though a seemingly common goal, the approaches often differ in that active gears such as hydroacoustics attempt to directly estimate fish density or abundance whereas passive gears typically provide an indirect estimate of relative abundance (Ney, 1999; Hubert and Fabrizio, 2007). Both approaches suffer from biases related to the gears used and the gears have their own positive and negative attributes in terms of costs and ease of use. Given these differences and trade-offs, a fundamental question for fisheries managers is whether these gears provide similar inferences on the abundance of fishes over time and space.

Indices of abundance based on any gear will only reflect abundance when the probability of capturing fishes is constant over space and time, and this assumption is rarely the case when sampling fishes (Guy and Willis, 1991; Neumann and Willis, 1995; Pope and Willis, 1996). Changes in capture probability can result from changes in fish activity, gear selectivity (Hamley, 1975; Spangler and Collins, 1992; Van Den Avyle et al., 1995a; Finstad and Berg, 2004), or changes in the environment. For example, because fish activity is temperature-dependent, encounter rates with and the resulting catch of gill nets would be expected to be very low at cold temperatures regardless of absolute fish abundance. For these reasons, Hamley (1975) cautioned that the selectivity of the same net fished in the same way may vary between different seasons or locations because of differences in distribution, behavior or condition of the fish. A large and growing body of aquatic and terrestrial literature support's Hamley's (1975) concern and suggests that indices based on counts, from most sampling gears, likely are poor indicators of abundance (Anderson, 2001; Yoccoz et al., 2001; Rosenstock et al., 2002; Thompson, 2002; Peterson et al., 2004).

Because of the problems associated with passive gears and associated indices, hydroacoustics has become a widely used and accepted method for estimating total fish abundance in lake and reservoir fisheries assessments (Simmonds and MacLennan, 2005; Kubecka et al., 2009; Yule et al., 2009). In fact, recent sampling protocols developed to meet European initiatives mandating lake and fisheries assessments rely on hydroacoustics for deriving abundance of pelagic fishes (Winfield et al., 2009). Similarly, as part of an on-going research project, we concurrently collected hydroacoustic and gill net samples from a small area immediately adjacent to a hydropower dam to estimate the number of fishes that might be vulnerable to entrainment during pumped storage operation of the dam. A fundamental question of interest was to assess how similar inferences regarding total abundance were between hydroacoustics and gill nets.

* Corresponding author. Tel.: +1 706 542 4988; fax: +1 706 542 8356.
E-mail address: don_dennerline@usgs.gov (D.E. Dennerline).

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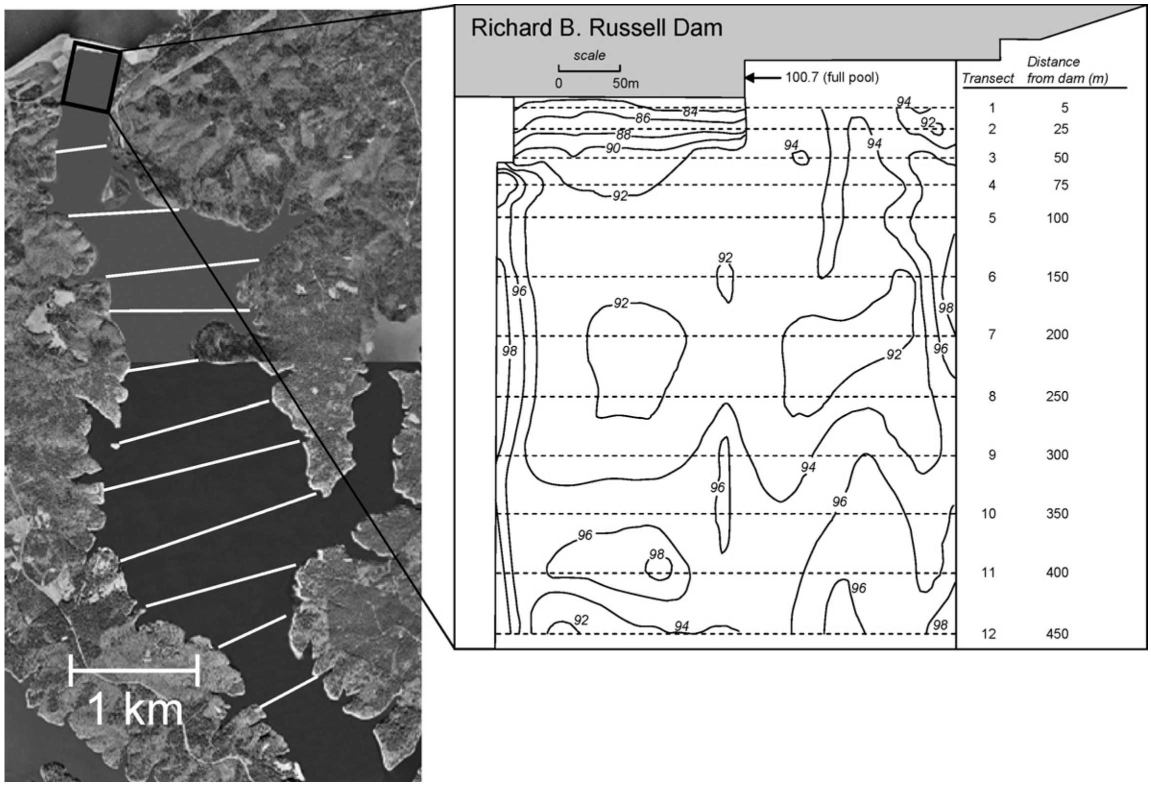

Fig. 1. Picture showing the Richard B. Russell (RBR) Dam tailrace and tailwater, hydroacoustic transects 1–12 (in inset) and transects 13–23 (white lines). The inset shows the area immediately below RBR Dam including the first 12 transects, the distances (in meters) of each transect from the dam, and the bottom contour of the area. The tailrace extends from the dam to transect number 8 and the tailwater extends from the dam to the last transect (number 23).

The specific objective of this study was to develop predictive models relating acoustic-derived abundance with gill-net catch, environmental variables, and time. The underlying hypothesis is that the encounter rate of fishes with gill nets varies over time, but that it can be modeled by incorporating the biology and life-history of the fishes sampled. If successful, the models developed would provide managers with the flexibility to choose which gear to use at specific times based on costs, ease of use, or desire to minimize fish mortality and handling. A secondary objective was to determine if month-to-month variability in hydroacoustic-derived abundances and gill net catch were repeatable and predictable among years. If predictable temporal patterns are identified, the information could be used to allocate future sampling efforts or modify operational guidelines to minimize abundance-based entrainment risk.

2. Materials and methods

2.1. Site description

Gill-netting and hydroacoustic sampling were conducted immediately below Richard B. Russell Dam (RBR, Fig. 1) on the Savannah River (GA-SC). Because RBR Dam is pumped-storage project, the sampling area is unique in many ways. The habitat is generally lacustrine because water impounded by the J. Strom Thurmond (JST) Dam backs all the way to the RBR Dam to facilitate pumped storage. However, appreciable flow exists during conventional hydropower generation and pumped-storage operation. A relatively deep pool (8–10 m when JST is at full pool) that was created during construction of the dam is another unique feature of this site. This pool starts at the dam and extends 300 m downstream, but quickly rises to just several meters in depth. The morphology creates an artificial 10-ha “pool” that captures and retains cold water from conventional hydropower releases. Unlike hypolimnetic releases from most southeastern reservoirs, the water coming through RBR Dam is well oxygenated because of an oxygen injection system in the RBR forebay. As a result, several cool-water species such as striped bass *Morone saxatilis* and blueback herring *Alosa aestivalis* inhabit this general area throughout the summer.

2.2. Sampling

Gill-netting and hydroacoustic sampling were both conducted during (48 h) generation moratoria. A BioSonics®[1] 200-kHz DTX system with a 6° circular split-beam transducer mounted on a pole 0.5 m below the water surface was used to conduct acoustic sampling during night-time hours. Data were collected from 1.5 m below the water surface to bottom and stored in digital format on a laptop PC. A total of 23 fixed, cross-channel transects were sampled in the two areas of interest: the immediate “tailrace” area consisted of 8 transects starting from the base of Russell Dam and extending approximately 250 m downstream (~10 ha); and the entire “tailwater” area that included the tailrace and 15 additional transects that extended ~5 km downstream (534 ha, Fig. 1). During each survey, a calibration sphere with known target strength (TS) of −42.0 dB was used for an in situ calibration. For all surveys, the echo amplitude threshold, pulse rate and pulse duration were set as −60 dB, 10 pulses s^{-1}, and 0.4 ms, respectively. The hydroacoustic data were processed using Echoview® software (up to V3.5) with the target threshold set at −60 db to provide mean acoustic size of the fish targets, total acoustic energy reflected for geo-referenced cells 1 m deep by 200 m distance, and geo-referenced total lake depths along

[1] The use of trade names or products does not constitute endorsement by the U.S. Government.