Comparison of Hydroacoustic Surveys to Traditional Trawl Methods for Determining Nekton Biomass in a Louisiana Estuary

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ABSTRACT

Knowledge of the distribution and biomass of fishes within an estuarine system is needed to make effective management use of the concept of Essential Fish Habitat (EFH). Four basic habitat types are recognized in a typical estuary: marsh, marsh edge, open bay, and channel. Fish distributions and species diversities within these habitat types can vary with season, tide, lunar cycle, weather, and bottom type. Resolution of the influence of these and other variables on EFH is confounded by limitations of traditional sampling gears. Recently, hydroacoustics has been shown to be a useful sampling tool that avoids some of the selectivity issues encountered with traditional gear types. A survey was conducted in coastal Louisiana to evaluate the quantitative capabilities of hydroacoustics in a shallow water setting. Survey objectives were to 1) determine the nekton biomass associated with two different habitats (bay and channel), 2) compare hydroacoustic data to concurrently collected wing-net data, and 3) determine effect and magnitude of ambient acoustic

however, based on channel wing-net samples there was a three-fold greater biomass at night as compared to day. Based on wing-net data, bay anchovy, *Anchoa mitchilli,* dominated the catch (90-97%) in all sites. Diurnal differences between gear types was attributed to avoidance of the wing-net during the day. Length frequency data compared to acoustic data showed a 1 to 3 dB shift from Love's equation. Acoustically derived densities reflected densities from wing-net data. The high sediment load and plankton abundances common to coastal waters do not bias acoustic estimates. The data thus far suggest a positive outlook for the use of hydroacoustics as a tool for estimating biomass and abundance of nekton in ultra-shallow systems such as estuaries, coral reefs, and mangroves.

KEY WORDS: Estuary, hydroacoustics, nekton

Comparación de Encuestas Hidroacusticas con Métodos Tradicionales de Red de Arrastre para Determinacion de Biomasa Nectonica en un Estuario de Louisiana

El conocimiento de la distribución y biomasa de pesces dentro de un sistema estuarimo es necesario para hacer uso administrativo eficaz del concepto del "Habitat Escencial para Peces (siglas en ingles EFH). Se reconocen cuatro tipos básicos de habitat en un estuario típico: marisma, borde de marsima, bahía abierta, y canal. La distribucion de peces y diversidad de especies dentro de cada uno de estos tipos de habitat puede variar dependiendo de la estación, la marea, el ciclo lunar, clima, y tipo de sustrato. La resolución de la influencia de éstos y otras variables en la definicion de EFH es confundida por las limitaciones de los artes tradicionales del muestreo. Recientemente, el uso de tecnicas hidroacusticas ha demostrado ser una herramienta útil de muestreo, la cuál evita algunas de los problemas de selectividad encontrados en los tipos tradicionales del pesca. Se realizo una evaluacion, en las costas de Luisiana costera, de la capacidad cuantitativa de la tecnica hidroacustica en agues someras. Los objetivos de la evaluacion fueron 1) determinacion de la biomasa nectonica asociada a dos tipos de habitat (bahía y canal), 2) comparacion de datos hidroacusticos con los muestreos simultaneous usando una ala-red, y 3) determinacion del efecto y magnitud de ruido ambiental en las estimaciones de la biomasa del necton. De acuerdo con datos de la ala-red, la anchoveta (*Anchoa mitchilli*) dominó la captura (92-97%) en todos los sitios. Las diferencias entre muestreos diurnos se pueden atribuir a la evitación de la ala-red durante el día. De acuerdo con el muestreo acústico, no hubo diferencias diurna en biomasa en el canal. Sin embargo, basado en muestras de la ala-red, en el canal habria una biomasa triple durante la noche que con respecto al día. La comparacion de los datos de frecuencia de longitud con los datos acústicos indicaron un ajuste de 8db en la ecuación de Love, donde el tamaño fue sobrestimado basado en las estimaciones derivadas de la fuerza horizontal del blanco. Las densidades derivadas acusticamente corresponden con densidades de datos de la ala-red. Hasta el momento, los datos sugieren una prognosis positiva para el uso de tecnicas hidroacusticas como herramienta para estimar la biomasa y abundancia de necton en sistemas tales como estuarios, arrecifes coralinos y manglares

.PALABRAS CLAVES: Tecnicas hidroacusticas, distribucion de peces, Louisiana

INTRODUCTION

A quandary with the evaluation of Essential Fish Habitat (EFH) is the development of a reliable tool to quantify or index EFH as stated in the Sustainable Fisheries Act. Acoustics have been widely used in rivers (Burwen and Fleischman, 1998), lakes, and reservoirs (MacLennan and Simmonds 1992, Rudstam et al. 2001), and deep-water systems (Lima and Castello 1995, Stanley and Wilson 1998) for estimates of nekton populations. However, there is a paucity of literature on the use of hydroacoustics in ultra-shallow (~1 - 5 m) systems for estimating nekton communities (Kubecka 1996). Split-beam hydroacoustic systems have become popular in shallow waters (~10 m) because they allow for *in situ* measurements of individual acoustic target strength (TS) that enables the estimation of nekton densities and biomass. Side-looking sonar has an advantage over traditional sonar due to the beam configuration that provides an extended range of sampling in shallow environments. Advantages of using hydroacoustics over traditional biological sampling methods include: reduced sampling effort, reduced gear selectivity problems inherent in traditional sampling, and reduced biological and ecological impacts. Recent hydroacoustic surveys of a tidal creek near Port Fourchon, Louisiana showed promise for the use of acoustic systems in ultra-shallow water for surveying nekton (Harmon 2001, Karlson, 1999).

Hydroacoustic theory is based on the analysis of patterns of sound wave propagation through water. When a target is encountered by an acoustic wave, a portion of the incident energy is reflected, áσ_{bs}ñ, is the acoustic backscattering cross-section (m^2). Volume backscattering cross-section (s_V) is the sum of the reflecting intensity of all the discrete targets over a given volume (MacLennan et al., 2002). The primary output in hydroacoustic data collection is mean acoustic volume backscattering strength (S_V, in decibels); this is the summation of the amount of acoustic energy reflected from targets in a given volume of water divided by the sum of the samples:

$$S_V = (\rho_c \Sigma(C^2)) / \Sigma_{samples}, \qquad (1)$$

where ρ_c is the density scaling constant and C^2 is the squared digital counts (Biosonics 1999). S_V is commonly used as a proxy for fish biomass. Instead of using S_V as a direct measure of biomass, it must first be transformed into the linear form.

The swim bladder is responsible for approximately 90-97 % of acoustic energy reflected from a teleost target (Foote, 1980). Variations in target strength (TS) measurements are caused by the behavior of the target with respect to its aspect to the beam and swim bladder volume due to depth changes (Fleischer et al. 2000; Romare 2001, Love 1977). Love (1971) reported an empirical relationship between total length and acoustic cross-section of a fish. He sampled eight species in five orders. Bay anchovy was one of the species on which Love experimented. From his experiment he was able to derive an equation on the general relationship of fish length and acoustic backscatter. The lateral aspect TS of an individual fish is determined by:

$$TS_S = 22.8 \log L - 2.8 \log \lambda - 32.4, \qquad (2)$$

where L is the fish length and λ is the wavelength of the transducer, both in feet.

The following is a synthesis of two hydroacoustic experiments that were conducted near Port Fourchon, Louisiana over the past year. Our goal is to apply hydroacoustic techniques for measuring EFH in the ultra-shallow water habitat of Barataria Bay. The first experiment was a comparison study of nekton estimates derived from traditional net sampling and hydroacoustics. The second experiment was designed to quantify the effect and magnitude of ambient acoustic backscatter from suspended solids on acoustic based estimates of nekton biomass. Our objectives were to:

i) Develop an acoustic sampling technique to quantify nekton distribution and biomass in ultra-shallow water,
ii) Quantify and describe the nekton community associated with two common habitat types: semi-impounded bay and tidal channel, by using traditional net sampling and hydroacoustics, and
iii) Determine acoustic cross-sectional backscatter from non-nekton sources, mainly total suspended solids (TSS) and plankton to conclude if background acoustic noise affected our estimates of biomass.

METHODS AND MATERIALS

Study Site

The study was conducted in Bayou Tartellon (channel) and Bay Champagne (bay) near Port Fourchon, Louisiana. A pontoon boat was used as the sampling platform at each site off which acoustic and environmental monitoring equipment was deployed. The hydroacoustic array consisted of a Biosonics DE 6000 Scientific Echosounder, a personal computer to run acquisition software and store acoustic data, two 420 kHz analog 2° by 6° split-beam horizontally elliptical transducers. In order to maximize sampling range, transducers were deployed horizontally from the port and starboard sides of a pontoon boat. Acoustic data were collected at 5 pings per second with a pulse width of 0.3 ms and a collection threshold of –55 dB. Transducers were run for five minute alternating intervals allowing both to sample within a relatively similar period of time; a total of 30 minutes per site per sampling period were recorded. Data were analyzed with StatView 5.0 and SAS 8.2. Data were tested for normality and significance assuming an α-error level of 0.05.

Experiment One

Acoustic data were collected in Bayou Tartellon at night and during the day, and in the adjacent Bay Champagne during the day. Data were recorded in 1 m strata beginning 1 m from the face of the transducer, in order to eliminate any near-field interference; out to 12 m, the range of the transducer in the ultra-shallow conditions.

In order to make accurate acoustic estimates of nekton utilizing particular habitats, biological data on the composition and distribution of nekton must be collected in order to ground truth acoustic data. Wing-net trawls were conducted concurrently with acoustic sampling. Two 12.19 m^2 wing-nets with a net mesh size of 2.75 cm and a 0.635 cm nylon mesh insert from mid-trawl to the cod end were towed, from a second vessel with one net on each side of the vessel. Catches from both wing-nets combined as one sample with a total sampling volume of ~4,953 m^3 per sample. Samples were sorted by species; individual lengths (cm) and wet weight (g) were recorded. Catches with greater than 50 individuals of the same species were sub-sampled; total abundance, wet weight, and individual lengths of 50 individuals selected at random were recorded.

Acoustic output included S_V, TS distribution, and FPCM. Acoustic data collected beyond 9 m were excluded from analysis due to interference from surface and bottom as well as entrained air from passing boats. Measured length-frequency data were compared to TS distributions. Nekton density and biomass estimates from hydroacoustic and net sampling were compared.

Experiment Two

The objective was to determine the background acoustic "noise" attributable to plankton and suspended solids. For this study a 1.22 m wide X 1.22 m deep X 3.66 m long semi-enclosed (opening at top of net) box net was used. Net walls were made of 2 mm nylon mesh, to exclude nekton and allow planktonic organisms < 2mm in diameter and suspended solids to pass through.

The acoustic array and methods used for this study was the same as described for experiment one. Data from both transducers were collected from 1 to 3 m, from the transducer face. S_V values that were reported as 0 dB in the output were manually changed to -90 dB for calculation purposes as this was determined to be a reasonably low level of acoustic intensity that essentially signified a zero value for S_V. We subtracted S_V measurements from within the net from S_V measurements outside the net to calculate a "corrected" S_V (Rudstam, personal communication). Prior to subtraction, S_V was converted into FE the linear form using Equation 4.

Plankton samples were collected using a 10 L min^{-1} diaphragm pump. Ten L oblique samples were collected and filtered through a 75 µm mesh, concentrated in a cod end and fixed in a 12% formalin solution. In addition, 1 L water samples were taken to measure total suspended sediment (TSS) every 30 minutes. Analyses of TSS were performed as described by Greenberg et al. (1992).

RESULTS

Experiment One

Based on S_V, fish biomass was highest in the channel during the day (Figure 1); however, there was no difference in fish biomass between the channel and bay during the day. Density estimates varied significantly between sites and sampling period. Mean TS values were -45.5 dB, -44.4 dB, and -43.8 dB; for channel-night, channel-day, and bay-day. Based on the means these were all significantly different indicating that the average size target was smallest in the channel at night.

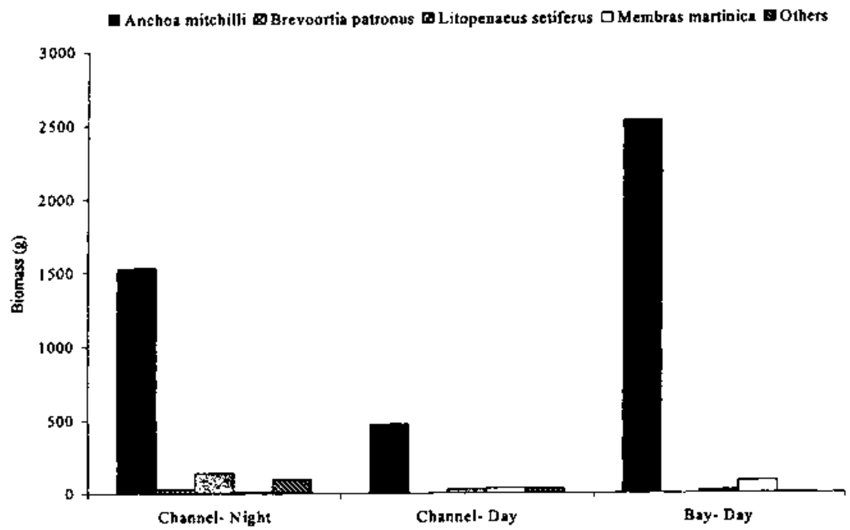

Figure 1. Biomass by species of catch from wing-net trawls by location and sampling period.

Bay anchovy, *Anchoa mitchilli* dominated the catch (90-97%) at all sites (Figure 1). Based on wing-net samples there was a three-fold greater biomass at night as compared to day (Figure 1). Anchovy is clearly the dominant species in terms of both abundance and biomass, as a result we inferred that approximately 90% of the biomass is *Anchoa mitchilli*; consequently, data presented from this point will be in terms of the contribution of anchovy to the system. Comparison of hydroacoustic density and wing-net density shows that acoustically derived densities are similar to densities obtained from net sampling.

Mean bay anchovy length was highest at night in the channel (44.8 mm) and smallest in the channel during the day (41.9 mm). When compared to anchovy length data, TS distributions show the opposite trend with smallest mean TS (-45.5 dB) occurring at night in the channel and largest mean TS (-43.8 dB) occurring in the bay during the day.

Experiment Two

The enclosure net proved to be effective in allowing us to measure the acoustic "background noise" in waters typical of coastal Louisiana. We found no significant interference from the suspended solids in the water column indicating that S_V was from nekton. "Acoustic noise," once converted into the linear form and then subtracted (corrected), is negligible. Corrected values either overlap or closely follow S_V values from outside the net during both sampling periods.

Neither plankton nor suspended sediment affected acoustic reflectivity. Acoustic values were not linearly related to total suspended solids or plankton abundance (r^2 = 0.265). Plankton were composed primarily of small copepods (>75 %). TSS values ranged from 47.4 mg/L to 128.5 mg/L with the highest TSS values at night.

DISCUSSION

Hydroacoustic sampling is a non-invasive technique that allows direct estimates to be made about nekton biomass, size frequency, and distribution. Acoustic surveys have proven to be effective tools for estimating and describing nekton communities in various aquatic habitats. Data from these studies suggest that hydroacoustic systems can be used in ultra-shallow water environments common to coastal Louisiana for estimating nekton biomass and distribution associated with different habitats. The use of hydroacoustics and limited net sampling will provide a description of nekton utilization of habitats within the Barataria Bay system and will aid in the identification of EFH of those species important to coastal Louisiana. The largest constraint we anticipate while sampling will be weather conditions, as entrained air from wave action will affect our ability to detect nekton, thereby limiting acoustic sampling to conditions without white-capping. These experiments have led to an understanding and identification of the proper collection and analysis parameters needed for use of acoustics in turbid ultra-shallow waters. Results from these experiments will aid in future endeavors as specific criteria for successful acoustic sampling are identified and refined.

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