# Evaluating Fine-scale Nekton Distribution and Behavior in Intertidal-subtidal Salt Marsh Creek Complexes

# Evaluación a Escala Fina de la Distribucion y Comportamiento de Necton en Ecosistema Intermareal y Submareal

# Évaluer la Distribution de Petite Échelle Necton et Comportement dans les Complexes de Ruisseau Intertidales et Subtidales des Marais Salants

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## ABSTRACT

Fine-scale habitat use and partitioning by fishes is difficult to observe in dynamic estuarine systems and, to date, habitat utilization information is primarily inferred from direct capture of organisms. In addition, the temporal domain of nekton movement and behavior remains largely undescribed as traditional observational techniques (i.e., optical methods) are impeded by physical characteristics of estuarine ecosystems (e.g., suspended load). We report on a recent effort to integrate high-resolution multibeam imaging sonars (ARIS and DIDSON) in intertidal and subtidal creek habitats to evaluate the behavioral patterns, abundance, and size of nekton moving between these two adjacent, interconnected habitats as a function of tidal forcing over 8 complete ebb-flood cycles. Fish abundance and movement were highly coordinated with water level patterns, suggesting that nekton were cued into moving between interconnected habitats at specific depths, and that movement was not always in the direction of water flow. This was observed during both day and night tidal cycles. Further, nekton utilized specific parcels of the water column rather than being ubiquitously distributed throughout the entire water column, suggesting that fish orient to discrete depth intervals despite the overall shallow depths (~2 m). By integrating advanced survey technologies, fine-scale temporal and spatial nekton habitat use and behavior patterns can be explored, potentially providing novel insights into the value of tidally-available salt marsh habitats at scales not previously described.

KEY WORDS: Estuary, sonar, habitat utilization, survey, behavior

## INTRODUCTION

While it is understood that estuarine systems comprise a mosaic of habitat types, gradients in physical and environmental conditions (i.e., abiotic variables) vary widely within and across estuarine systems. Characterizing the importance of abiotic factors such as water depth and flow direction in structuring nekton distributions in shallow tidal salt marsh habitats is a primary need. This is of particular importance when these gradients vary within a system on short temporal scales (i.e., hours), such as in temperate semi-diurnal tidal salt marsh systems. Thus, a principal challenge in understanding the mechanisms that underlie the observed distributional changes of nekton is the ability to acquire measurements at appropriate scales, both temporal and spatial.

Often field sampling in salt marshes is restricted to discrete efforts which represent a single point in time (e.g., seine haul) or a block of time compressed into a single measurement (e.g., gill net). The resulting information is a series of independent measurements associated with some number of categorical factors, offering a relatively coarse, and possibly biased, representation of target metric (e.g., abundance, distribution). Further, traditional sampling approaches (e.g., active net gears) targeting larger nekton often result in a less than representative description of the community which can be attributed to the synergistic effects of gear performance and animal behavior. An alternative approach, which also requires a reduced direct sampling effort, is to integrate high-resolution imaging sonar technologies that allow continuous observation of organisms (in this case, nekton) with virtually no habitat disturbance. Acoustic imaging permits the gathering of information on nekton size and abundance, but also behavior (e.g., habitat preference, swimming speed and direction, predator-prey interactions), which is difficult or impossible to infer/observe with traditional sampling gears. In addition, when considering the three-dimensional habitat in which these fishes are distributed (i.e, water column), acoustic imaging methods offer a mechanism to evaluate both the lateral and vertical distribution of fishes (Figure 1).

The primary objective of this study was to evaluate the potential to integrate high-resolution imaging sonars with traditional sampling methods to quantify fine-scale (both temporal and spatial) salt marsh nekton habitat use and movement throughout the tidal cycle, with a specific focus on shifts in the size distribution and abundance as a function of water level.

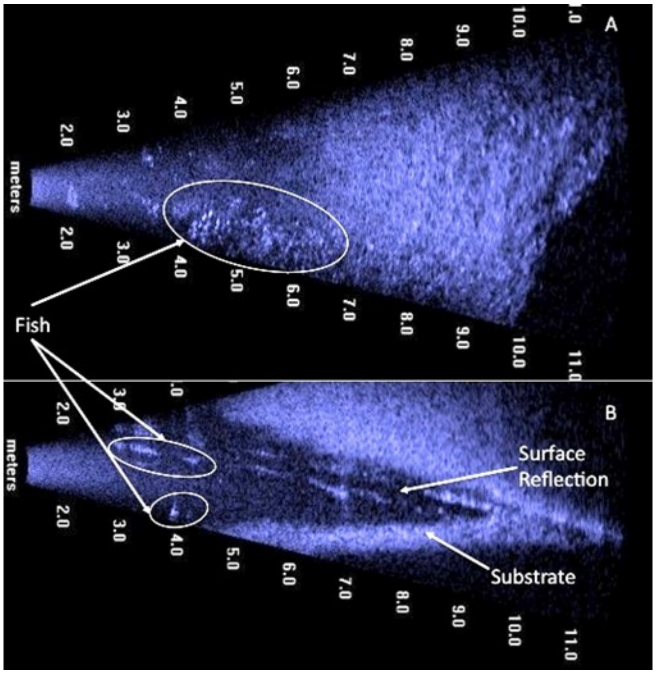


**Figure 1.** Example of horizontal (A; lateral) and vertical (B) rotation of the DIDSON sonar deployed at the confluence of the subtidal-intertidal system. The lateral view shows the extent of the tidal channel at approximately 10 m in range from the sonar. The orthogonal view (B) illustrates the vertical perspective with the reflective water surface and substrate interfacing at approximately 10 m range to the sonar.

## MATERIALS AND METHODS

Two high-resolution imaging sonars (DIDSON and ARIS; www.soundmetrics.com) were deployed in an interconnected subtidal-intertidal creek complex within the North Inlet estuary in Georgetown, South Carolina during early August 2012. The DIDSON (dual-frequency identification sonar) was deployed looking across the confluence of the intertidal creek mouth with the subtidal creek and was oriented to allow detection of fishes moving between the two creeks. The ARIS (adaptive resolution imaging sonar) was deployed directly upstream of the DIDSON within the intertidal creek (approx. 30 m from mouth) and inside a pool that retained water even during slack low tide. This deployment strategy allowed for a direct and simultaneous comparison of the abundance, size, and behavior of nekton in these interconnected subtidal and intertidal habitats. Both sonars were deployed and left in place to operate for 70 hours continuously. Fishes were manually enumerated using the DIDSON topside software package and information was also collected on fish length, fish range from the sonar, and the vertical position of fishes in the water column

In addition to acoustic sampling, physical and environmental conditions were continuously examined during sonar deployment. Water level loggers and light-temperature loggers (both Onset) were deployed at each sonar to measure the precise water depth available to nekton as well as ambient temperature and light levels throughout the tidal cycle. This region is characterized by strong semi-diurnal tides, with water levels varying by approximately 1.5 – 2 m during tidal phases, offering extensive opportunity to observe tidally-induced shifts in nekton habitat occupation and behavior.

To groundtruth acoustic imaging observations and characterize species composition and size ranges, seining occurred during the 70 hour sonar deployment and information from previous research focused on nekton at the study site was examined.

## RESULTS AND DISCUSSION

Measured physical parameters (i.e., water level, temperature, light level) varied across the period of observation with distinct departures occurring on shifts in tidal amplitude and time of day (Figure 2). As expected, fish abundance, expressed as the mean number of fish observed per frame over an hour, was highly variable and showed a high degree of correspondence with tide stage. Interestingly, the majority of fish were observed moving through the upper half of the water column except for the crepuscular period at dusk, corresponding to the slack high tide during the study period (Figure 3). Further examination of the data should reveal the effect of fish size on the distribution of biomass throughout the water column. Based on the variability in the length distributions between the two gear types compared (Figure 4), it is anticipated that the biomass partitioned throughout the water column is likely distributed in a size-structured fashion. That is, upon initial inspection, smaller schooling fishes were associated with the upper water column and larger targets appeared to move between these systems nearer the substrate, perhaps cuing into the bathymetric features as they move throughout the intertidal-subtidal complex. Additionally, when partitioning by size, we will be able to estimate the amount of biomass and direction of movement through the system

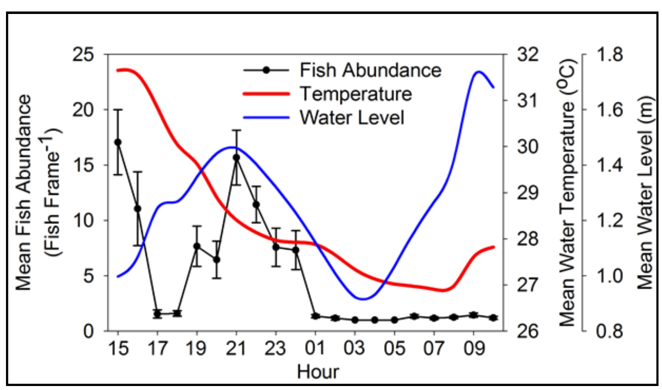


**Figure 2.** Hourly mean fish abundance expressed as the number of fish counted per acoustic pulse (frame) compared to water level (blue line) and water temperature (red line). Water level and temperature are shown from the second day of deployment to represent average changes in physical conditions. Error bars represent ± 1 standard error.

to gain a better understanding of the influential cues that act to structure nekton movement patterns and habitat associations, particularly in strongly tidally-influenced systems.

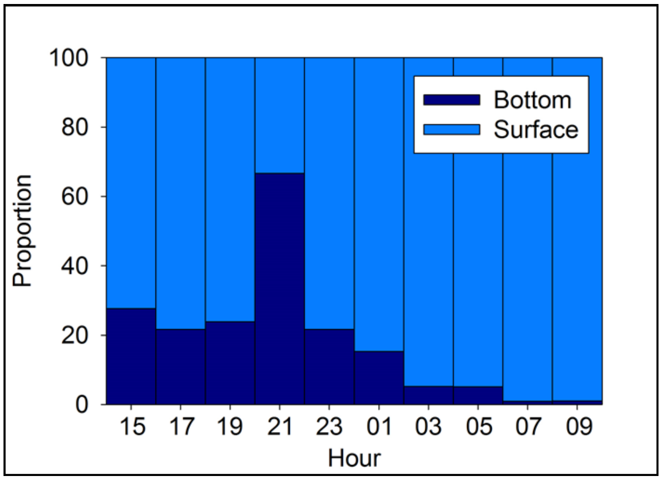


**Figure 3.** Proportion of fish abundance distributed in upper (surface) or lower half (bottom) of the water column, observed from orthogonally rotated (vertical) sonar averaged over a period of interest throughout the 70 hour deployment.

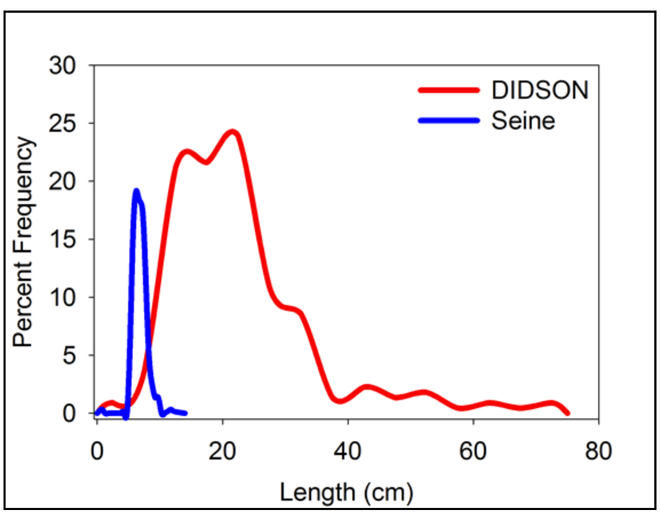


**Figure 4.** Comparison of length distributions derived from both the DIDSON imaging sonar and direct catches from seine collections.