

A moored system for understanding the temporal variability of prey fields of deep diving predators off Cape Hatteras and response to Gulf Stream fronts

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LONG-TERM GOALS

Fisheries acoustics are routinely used for biomass and abundance surveys and used for behavioral and ecological studies of marine organisms. Marine mammal prey surveys are typically conducted from the ocean surface during shipboard surveys using active acoustic echosounders mounted over the side or in the hull of a research ship. The range for acoustic echosounders is limited by the absorption of sound through the water, and is dependent on the frequency produced by the instrument. Typical prey surveys are therefore limited to providing data from only the upper couple hundred meters of the water column, and often cannot resolve prey targets at the depths of deep-diving predators like pilot whales, especially with the higher frequency instruments, which are needed to resolve small prey targets and useful in the frequency differencing techniques.

The mooring system will address the temporal variability of the prey field off Cape Hatteras throughout the entire depth range observed for foraging odontocetes, e.g., pilot whales, using split-beam echosounders. Furthermore, we hope be able to resolve deep sea squids in the lower half of the

water column using frequency differencing in combination with single target detection of large prey targets.

OBJECTIVES

- Identify seasonal changes in prey and hydrographic fields
- Identify prey field response to front crossings
- Test specific hypothesis that fronts can create a barrier to prey that predators could use as an advantage in prey capture

APPROACH

The mooring (Figure 1) addresses the temporal variability of the prey field off Cape Hatteras throughout the entire water column. Relative prey density will be quantified using split-beam echosounders. The use of multiple frequencies (likely 38 and 70 kHz) will allow for relative frequency difference calculations that will be used to distinguish between 2 broad size classes of prey types; 1) large prey including fish and squid and 2) krill and other large zooplankton comprising the mesopelagic community. While deep diving pilot whales are likely targeting animals in the large prey category, having a second frequency to quantify the smaller size classes will help us to more accurately quantify the large prey and provide a broader ecological context to relative temporal variability of the biology for the region.

The mooring system (Figure 1) is designed for extended durations (servicing will be required every 10-12 months), allowing us to address the seasonality and the inter-annual variability in prey biomass and density in relation to ocean physical dynamics with low maintenance. In order to relate changes in the prey field observations to key environmental features (i.e., Gulf Stream front crossings), the mooring system will include an array of physical oceanography sensors. First, conductivity, temperature, and depth (CTD) sensors, or just conductivity, temperature sensors (CT) will be placed along the mooring periodically. We will use a combination of alternating CTD and CT sensors to get accurate depth recordings at 3 places along the mooring line to get accurate depth of each instrument. While fronts will be identified using the density measurements, specific water masses will also be identified using hydrographic characteristics (i.e., low salinity Mid Atlantic Bight water, and warm, saline Gulf stream water). Secondly, two acoustic Doppler current profilers each operating at 75 kHz (ADCP manufactured by Teledyne's RD Instruments) will measure current velocity throughout the water column. Current profiles are necessary to interpret hydrographic data by identifying time periods where upwelling may be occurring and to help understand water column dynamics by identifying the source of density intrusions. The ADCPs will be programmed to sample in long range and low power modes in order to provide data coverage throughout the entire depth range and to extend through the year-long deployments.

The development of this tool comes at an opportune time as Simrad, the industry leader in scientific echosounders has completed development and delivered the first Wideband Autonomous Transceiver (WBAT, Figure 2), and the second unit will be delivered to this project in February for incorporation into the mooring. Development and testing of this unit (Figure 3) has delayed the project somewhat, but delivery is promised for February, which should allow for a spring/early summer deployment of the mooring.

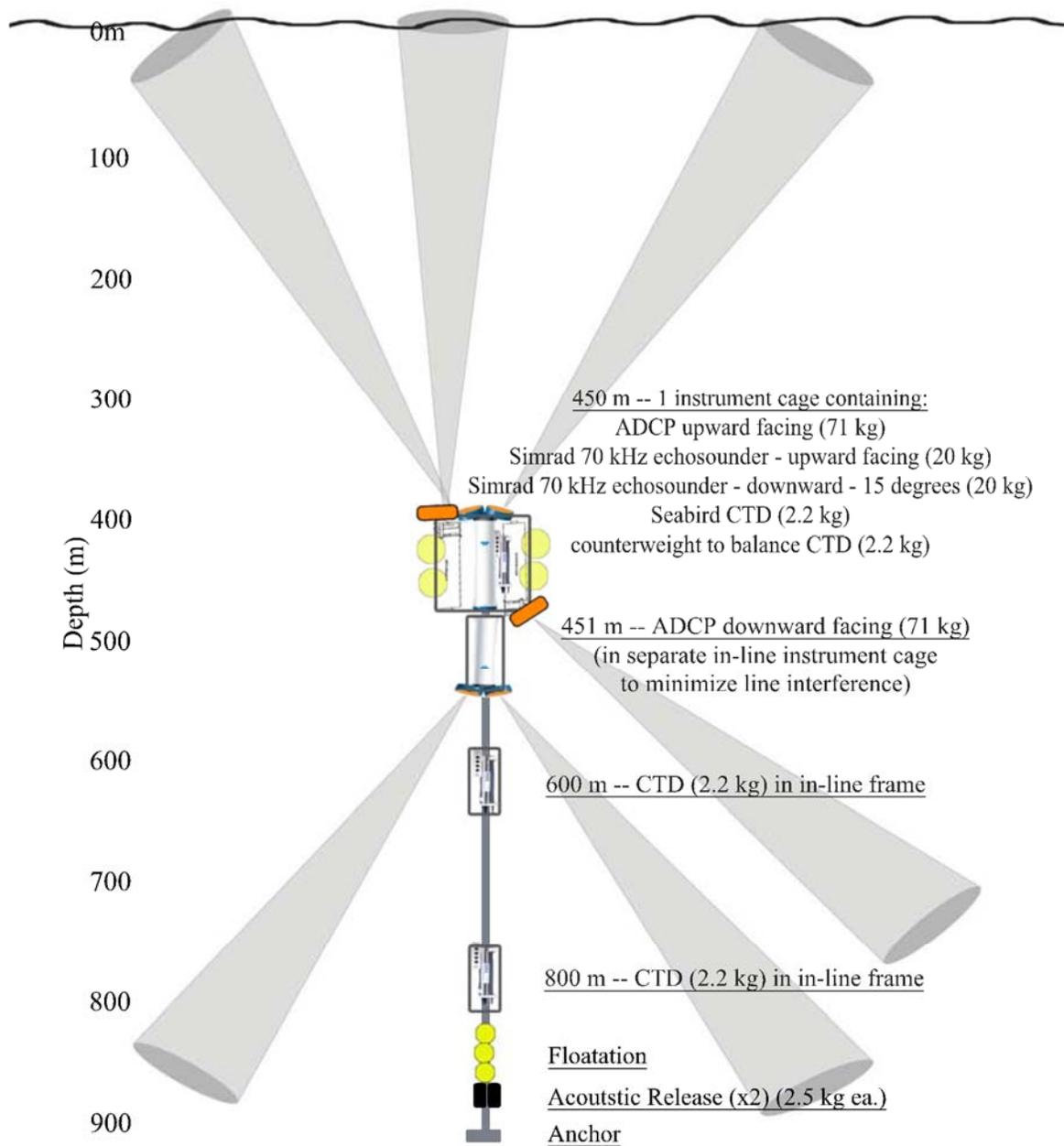


Figure 1. The mooring design, nearly finalized, showing the primary components of echosounders, CTDs and ADCPs. By locating the first components at ca. 400 m fouling will be much less of an issue while still allowing sampling of the entire water column.

Figure 2. The wideband autonomous transceiver (WBAT) as it will be incorporated into the mooring (A), and recent pool testing of the WBAT (B) with transducer in the water.

WORK COMPLETED

We have completed research into the particulars of the mooring location, e.g., bathymetry, water currents. All components of the mooring (e.g., specific echosounders, ADCPs) and the mooring design are finalized, and the contract for construction and deployment of the mooring system are in place. Additionally, the purchase order for the echosounder systems is ready and waiting for Simrad.

RESULTS

While the construction and completion of the mooring has been delayed somewhat, the testing (Figures 2 & 3) from the WBAT show that the system truly is the next benchmark in quality of remotely collected echosounder data. The WBAT is a new product from Kongsberg-Simrad, and provides the industry-standard quantitative Simrad components in an autonomous package. With this project, we have had a hand in molding this new technology as one of its original customers, and we are at the leading edge in the field.

IMPACT/APPLICATIONS

At the Duke University Marine Lab we have a very active program of work supported by and of intense interest to the DoD (see letter from Joel T. Bell, NAVFAC Atlantic). This work, lead by Dr. Read, includes visual surveys and passive acoustic monitoring in three areas along the east coast of the U.S. One of these areas is precisely the location we are proposing for this instrument, so our instrument would be co-located with the HARP and sampling in an area that is routinely covered by visual survey, both vessel and airplane based. The areas monitored by Duke's program include the Point area we have described in the current proposal as well Onslow Bay and then directly east of Jacksonville, FL and the Mayport Naval Station. Our instrument would significantly enhance the research already being conducted at the Point under the awards to Duke and Dr. Read. This research is focused on understanding the distribution and basic ecology of the marine mammals that utilize this area so that potential effects of DoD activity (e.g., Naval movements or sonar) can be monitored and better understood. The data our instrument will collect would significantly contribute to the ecological understanding of the animals and the location.

Likewise, the proposed instrument will significantly augment the research-related education currently occurring at the Duke Marine Lab. The education programs that will benefit include undergraduate, masters and PhD. At the Duke Marine Lab we have ca. 25 undergraduates in residence each semester, and these students are enriched by the research being conducted at the lab and they also have the opportunity, through independent study projects, to work directly with faculty and PhD students in analyzing data collected on various projects. At the master's level, the Nicholas School at Duke offers a professional degree in Environmental Management, and these students often focus their final projects on data collected by faculty at the Lab. Additionally, as management students they often relate the science data to some policy issue, and so the data our instrument will collect, as it helps to elucidate the ecology of the area, will be important in policy discussions. Finally, several of our PhD students have already utilized the data collected under these DoD programs, and we have current students who are already scheduled to work with the survey and acoustic data.

RELATED PROJECTS

None

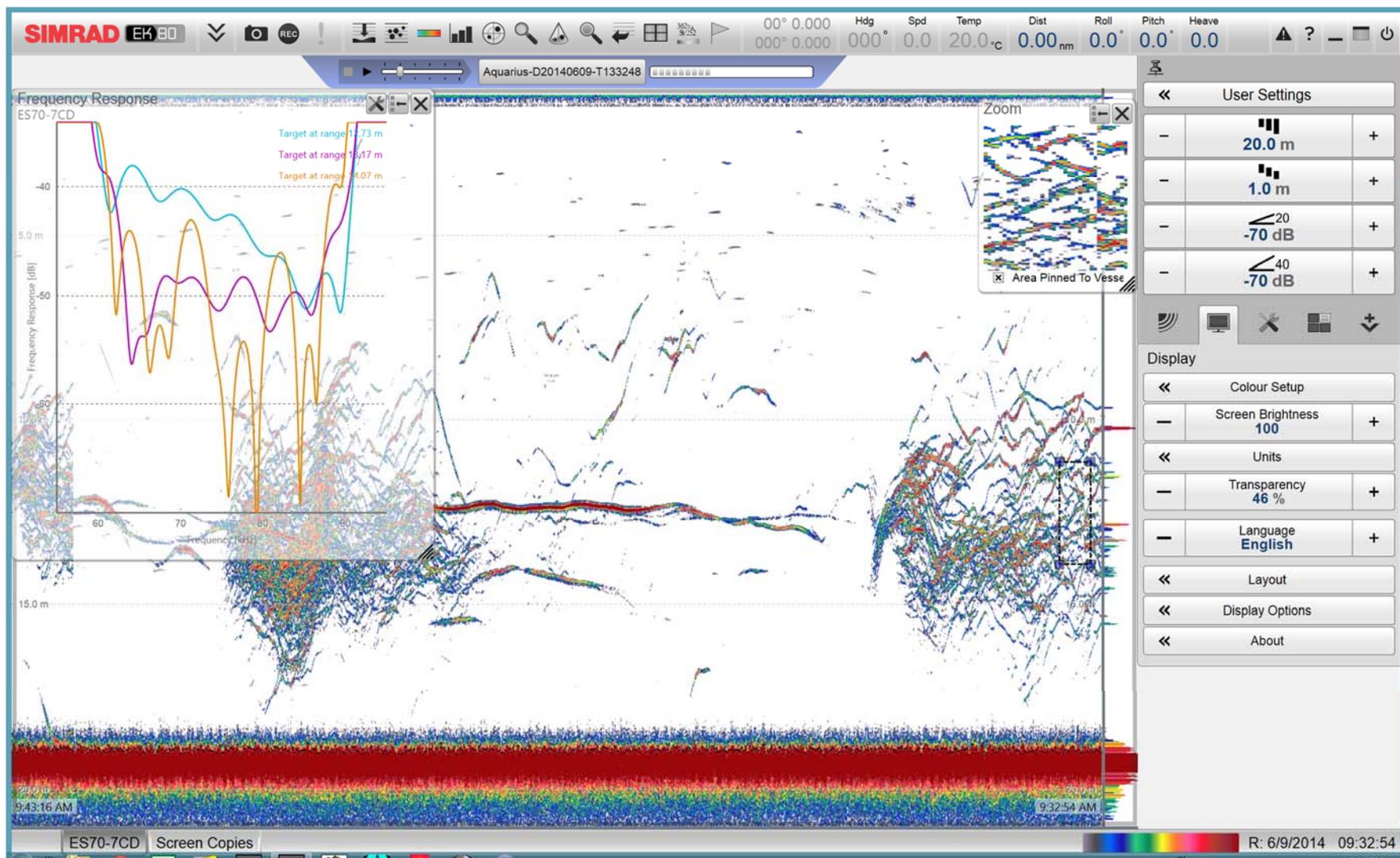


Figure 3. Data recorded by the test/prototype Simrad WBAT unit. These data, taken from the Aquarius deployment, show a school of grunts with individual targets (upper left) tracked and their reflected frequency response shown. Also, the transducer was upward looking, which is relevant as one of the mooring transducers will be similarly oriented.