`ACCESS NUMBER: M10PC00093

STUDY TITLE: Evaluating Acoustic Technologies to Monitor Aquatic Organisms at Renewable Energy Sites

REPORT TITLE: Evaluating Acoustic Technologies to Monitor Aquatic Organisms at Renewable Energy Sites

CONTRACT NUMBER: M10PC00093

SPONSORING OCS REGION: Office of Environmental Programs, Herndon, Virginia

APPLICABLE PLANNING AREAS: All

FISCAL YEAR(S) of PROJECT FUNDING:

COMPLETION DATE OF REPORT: June 2013

COSTS: BOEM FY2010: $164,230.00; Department of Energy contribution $450,000.00; National Oceanic and Atmospheric Administration contribution, $100,000.00; TOTAL: $714,230.00

PROJECT MANAGER: Dr. John Horne

AFFILIATION (PROJECT MANAGER): University of Washington, School of Aquatic and Fishery Sciences

ADDRESS: University of Washington, School of Aquatic and Fishery Sciences, College of the Environment, Seattle, Washington 98105

PRINCIPAL INVESTIGATORS

John K. Horne
Dale A. Jacques
Sandra L. Parker-Stetter
Hannah L. Linder
Jennifer M. Nomura

KEY WORDS: Marine renewable energy; tidal energy; echosounder; multibeam sonar; acoustic camera; Acoustic Doppler Current Profiler

BACKGROUND: Marine renewable energy (MRE) devices potentially impact dynamics of aquatic organisms including macroinvertebrates, fish, seabirds, and marine mammals. Understanding potential impacts of MRE technologies on biological communities requires knowledge of species-specific spatial and temporal density distributions. Acoustic technologies capable of providing images and data for baseline characterizations and operational monitoring are commercially available but configurations and system integration for MRE applications have not been established nor evaluated. Deployment, operation, and retrieval of autonomous

acoustic instrument packages are also complicated by extreme water flows at MRE sites. At a proposed tidal energy site in Puget Sound, Washington, USA, an echosounder, multibeam sonar, acoustic camera, and an Acoustic Doppler Current Profiler (ADCP) were deployed on bottom during May and June, 2011. To provide a spatial characterization of the biological community at the site, a vessel-mounted echosounder and pelagic trawl were used to map fish and macrozooplankton densities during day, dusk, and night surveys. Marine mammals and seabirds were identified and counted during surveys. The primary objective of the project was to compare sampling capabilities of surface- and bottom-deployed acoustic instruments.

Our field work confirmed that autonomous instrument sampling is more constrained by power than by data storage; that direct sampling in high flow environments is a challenge; and that limited direct samples constrain acoustic target classification. A suite of metrics successfully characterized vertical distributions of aquatic organisms in the water column. Results showed that surface and bottom deployed echosounders detected horizontal and vertical density changes that were correlated with environmental covariates. Metric values from the acoustic camera and ADCP data were not as sensitive to changes in density.

Current acoustic technologies can be configured and used to characterize aquatic organism distributions at MRE sites. Integrated acoustic instrument systems that include target tracking and impact warning do not exist in autonomous or cabled configurations. Development of algorithms to translate temporal to spatial variance and to scale observed effects from pilot to commercial site domains is needed to complete the ability to monitor change and to detect impacts on biological communities for MRE site monitoring.

OBJECTIVES: This project was organized in four tasks: planning and mobilization, instrumentation deployment, data analysis, evaluation. Equipment manufacturers were invited to collaborate in the project. Their responsibility was to supply and program an acoustic system that would operate autonomously for a month period at a 10% duty cycle, and to recover and deliver the data. The collaborative partners were: echosounder – BioSonics Inc. (http://www.biosonicsinc.com); multibeam sonar – Teledyne Reson (http://www.teledyne-reson.com); acoustic camera – Sound Metrics (http://www.soundmetrics.com). Acoustic Doppler Current Profiler data from a Nortek (http://www.nortek-as.com/en?set_language=en) instrument was acquired in conjunction with concurrent measurements during the field sampling program.

The objectives for each task included:

Task 1: Planning and Mobilization

- Adapt and mount three acoustic instruments and power supplies on frames
- Design mobile survey (echosounder and midwater trawl) to characterize nekton density distribution variability
- Design sampling duty cycles and identify locations for acoustic packages

Task 2: Instrumentation Deployment

- Deploy acoustic packages
- Conduct mobile surveys

Task 3: Data Analysis

- Process all acoustic data using a common software
- Compute species-specific densities using all acoustic data in common spatial and temporal bins
- Compare stationary to mobile acoustic data

Task 4: Evaluation

- Evaluate the ability of representative instruments to detect, categorize, and enumerate aquatic species
- Compare density distributions measured by stationary instruments to those measured during mobile surveys
- Recommend use of acoustic packages, in conjunction with other monitoring to establish the environmental baseline and monitor for environmental effects of renewable energy project developments.

DESCRIPTION: The overall goal of this project was to evaluate the use of acoustic technologies to characterize nekton spatial and temporal distributions at a proposed MRE site in northern Admiralty Inlet, Puget Sound, Washington. This site was selected by Snohomish PUD for the deployment of two OpenHydro (http://openhydro.com/home.html) hydrokinetic turbines.

Four classes of acoustic technologies – echosounder, multibeam sonar, acoustic camera, and ADCP (Acoustic Doppler Current Profiler) were used to detect, and enumerate pelagic nekton at the site. Data from stationary instrument deployments were compared to data from a mobile acoustic and midwater trawling survey to determine how well each technology detected spatiotemporal variation in nekton distributions. Results of the design, deployment, retrieval, and analysis of data from these instrument classes were used to formulate recommendations for instrument choice, configuration, and methods to characterize and monitor pelagic nekton at any MRE site.

SIGNIFICANT CONCLUSIONS: Several technologies were evaluated to determine optimal and cost effective solutions for offshore renewable energy data collection. Challenges exist for all systems, including sufficient power supplies, ability to verify and monitor data acquisition, and data quality in a dynamic environment. Advancements were made on several areas to provide information for instrument design and use.

STUDY RESULTS: Existing acoustic technologies can be modified for autonomous deployments in high-flow environments. The biggest challenge was to provide sufficient power to meet demands of the sample design. Supplying power was a bigger constraint than electronic data storage. The physical space needed by marine batteries necessitated additional design and structural modifications to the Sea Spider tripods. A second constraint for autonomous deployments was the inability to verify and monitor data acquisition and data quality during deployments. As prudent examples, failure of the multibeam sonar and the presence of second or third surface echoes in the acoustic camera or echosounder data were not known until instruments were recovered. Given cost and time constraints of field deployments, acoustic modems were not integrated in the autonomous acoustic instrument packages, which would have required additional engineering to integrate communications. Constrained bandwidth of acoustic modems would also limit the amount of data that could be transmitted to the surface. But even

limited communications would have been useful. An initial check on operation and data files would have alerted operators to the failure of the multibeam sonar and the presence of second or third surface echoes in the echosounder and acoustic camera.

The temporary nature of biological and environmental sampling for MRE site evaluation ensures continued use of autonomous instrument packages. Increased experience with instrument and power integration for autonomous deployment will reduce failure rates of instruments such as the multibeam sonar used in this study. It was not the instrument itself that failed, but the power system that regulated start and stop sampling times that failed. Additional pre-deployment testing and standardized parameter settings will ensure high quality data acquisition by all instruments. For example, reductions in the pulse rate and power settings of the bottom-mounted echosounder would have reduced or eliminated multiple surface returns and data saturation in the upper water column. Similarly a very small shift in the angle of the acoustic camera transducer would have eliminated the second surface return. These examples illustrate the lack of vendor and research community experience in instrument setup and component integration of these acoustic technologies for MRE site sampling. Additional research and development are needed for MRE and other ocean observing applications that require extended autonomous instrument deployments. At pilot or commercial scale sites, the ultimate solution is to provide communication and power from shore or MRE devices to all monitoring packages. This may be convenient for near-field monitoring at device locations, but would require cabling and infrastructure equivalent to a dispersed ocean observing network for a commercial scale MRE site.

It is also important to state that autonomous deployment of any instrument includes risk. The deployment and retrieval of autonomous Sea Spider tripods was successful, in part, due to previous experience and modifications to the tripods and launch/recovery procedures. Partnering with equipment manufacturers was intended to minimize equipment failure risk and to maximize data acquisition quality. Any instrument package may collect no data, limited data, or poor data quality in non-traditional deployments. Partnering with equipment manufacturers and those with specific application experience remains the preferred operational strategy until integrated monitoring systems become commercially available.

Environmental monitoring of biological and physical variables will extend through the life cycle of any MRE site from site inspection to de-commissioning. An integrated characterization and monitoring plan is needed to ensure that biological effects and impacts can be detected, and to maximize the cost-effectiveness of all monitoring activities. The lack of definitions on what constitutes biological change, effect, and impact is a deficiency that impedes the development of standards and procedures for assessing and monitoring MRE sites and operations.

STUDY PRODUCTS:

Horne, J. K., D. A. Jacques, S. L. Parker-Stetter, H. L. Linder, and J. M. Nomura. 2013. Evaluating Acoustic Technologies to Monitor Aquatic Organisms at Renewable Energy Sites. U.S. Dept. of the Interior, Bureau of Ocean Energy Management.