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Unmanned Underwater Vehicles for Fish and Marine Mammal Shadowing and Data Acquisition: A Concept

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Extensive resource monitoring and near real-time data acquisition are required to accomplish the NMFS mission. Resource monitoring and information gathering will only be achieved through the development and deployment of new technology and approaches. Customized underwater vehicles (UVs) such as semiautonomous and autonomous underwater vehicles (SAUVs and AUVs) in concert with new tags and sensors can play an important role in achieving the goals outlined. The information gleaned from use of this new technology will be required to conserve and manage our marine resources on an ecosystem level.

Monitoring and information-gathering challenges can be partially addressed using present technology by reconfiguring existing data-gathering systems and tools, and by developing new tools and products using existing technology (Figure 1). One of the new tools required is a miniature transponding pressure sensitive tag. Miniature pinger-type acoustic tags (without pressure-sensing capability) exist but miniature sub-22-mm tags having pressure sensors that can be automatically calibrated do not. This class of acoustic tag is considered essential to obtain accurate target position information.

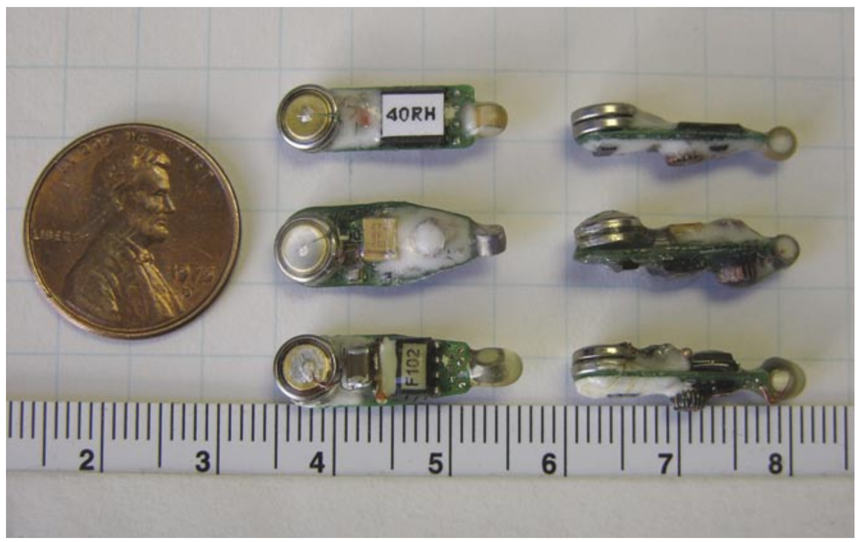

Figure 1. Sample microacoustic tags used to tag juvenile salmonids shown to scale against a penny and a millimeter rule.

Using existing techniques and equipment, mobile tracking of aquatic targets is not reliable from an active tracking, three-dimensional positioning, or at times from a safety standpoint. For instance, using fixed interrogation points ("picket fence" target intercept approach) to track animals only provides information for one point in time. In addition, the receiver may not be in the correct location for target detection and thus no information is collected. Furthermore, limited spatial, temporal, hydrographical, or environmental data, if any, are obtained using this approach.

Causal relationships between the physical environment and animal behavior remain a mystery for many fish and marine mammal species and for various life stages of these animals. Using UVs in concert with a new class of acoustic tag would provide new and critical information needed to address many questions and concerns of fisheries managers. The proposed concept is not limited to any one area of fisheries or marine mammal and has national and international application. What is being proposed is a suite of tools and approaches that can be used to gather data on free-roaming targets of interest (e.g., fish and marine mammals) in situ (Figure 2).

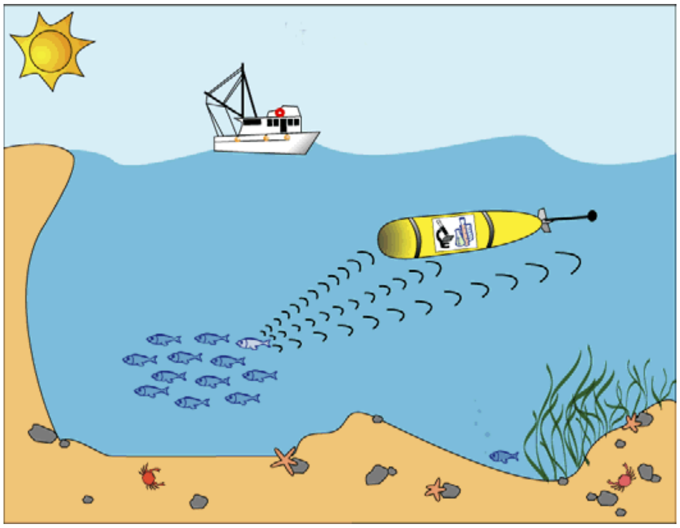

Figure 2. In future technology, an unmanned underwater vehicle tracks an acoustically tagged fish and relays that information back to a ship. The vehicle would also collect environmental and hydrological data.

Technology objectives include 1) identifying or developing technology to shadow (track) acoustically tagged and nontagged fish and marine mammals using unmanned, underwater-type vehicles (e.g., SAUVs and AUVs), while gathering environmental and hydrological data; and 2) developing a suite of transponding acoustic tags suitable for use with juvenile and adult fish and marine mammals that are capable of being accurately and precisely tracked by AUVs and similar vehicles. An abbreviated list of technology challenges includes 1) target acquisition, tracking, and positioning; 2) UV positioning and object avoidance; 3) mission duration; 4) power for propulsion and its management for the instrument suite; 5) tag miniaturization (weight and size), read range, and duration; and 6) tag battery size, shape, and power density.

Fisheries science is experiencing rapidly expanding capabilities through developments in computational, robotic, communications, and sensor industries. This expansion is further driven by the biological sciences' need to understand the interactive dynamics between organisms and the environments in which they live, in order to manage, restore, and maintain our natural resources. To satisfy this informational need, an extensive, remote, continual, and interactive sensor presence within particular areas of interest is required. The following concepts are presented as a means of obtaining some of the required information about the interaction between aquatic animals and their environment.

The basic concept is to shadow targets of interest (e.g., fish and marine mammals) using underwater vehicles (e.g., SAUVs and AUVs) while continuously collecting environmental, hydrographical, and other information of interest in the immediate vicinity of the tracking vehicle. Besides obtaining information on the movement of individual fish, in the future it may also be possible to passively identify stocks of fish using DNA sensors aboard the UV. NASA scientists have developed an ultrasensitive electronic DNA detector that uses a forest of carbon nanotubes and probe DNA molecules to sense meager amounts of specific DNA. The basic detector could be used in practical land-based applications within 2 years and in the aquatic environment a short time later.

Once the above objectives are achieved, the resulting tools could be used to collect information on the seasonal movements of fish and mammals, their responses to environmental and hydrographic factors, their responses to trophic interactions (i.e., predator-prey relationships), and their responses to and use of micro- and monohabitats. In addition, the system could be used to document habitat use during various life history stages to augment existing life history information and demographics, and to help define the functional relationships governing animal spatial and temporal distribution and movement. Finally, the system could be used to collect information on fish and marine mammals so that ecosystem-based considerations can be incorporated into management decisions and to provide near real-time information on the environment they inhabit so that adaptive management strategies can be applied. In other words, in contrast to traditional Eularian sampling strategies, Lagrangian methods could be used to monitor specific species. The concepts and ideas presented do not cover all scenarios for the use of such vehicles but do provide a vision for the development of a program to address goals and needs outlined in NOAA Fisheries Strategic Plan for FY 2003–FY 2008 and Beyond (online at http://www.ppi.noaa.gov/pdfs/Strategic_Plans/2003_NOAA_Strategic_Plan.pdf) and, in part, to serve the fishery communities' information needs on a global scale.