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Section News

Pushing the sampling boundaries: Advanced technology is allowing us to survey deeper, longer, and in harder to reach areas of our oceans, lakes, and rivers.

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Considering the myriad of ways in which advanced technology is being used in fisheries research, keeping atop of the newest developments is a challenge. The transfer of such specialized knowledge can be difficult, thereby hindering more widespread use of advanced technology in fisheries research. This predicament is often further compounded when information exchange between the freshwater and marine fisheries communities is limited. In a constantly shifting technological landscape, effecting stronger information transfer about technology within the fisheries community will lead to greater innovation, broader application, and more efficient and accurate science. This is the goal of the AFS Fisheries Information and Technology Section (FITS).

This is the second article in FITS quarterly series to highlight some of the ways in which the latest advanced technologies are being used in marine and freshwater fisheries research. To learn more, check out https://units.fisheries.org/fits/, find us on Facebook (@AFSFITS), and attend the Section’s symposium at the 2019 meeting in Reno, Nevada.

Ever since the first submarine was used for deep-sea research in the 1930s, researchers and engineers have continued to develop new ways of reaching the outermost reaches of our oceans. In the last couple of decades, the rapid progression of underwater vehicles have afforded scientists not only the ability to go deeper and into more remote areas, but also collect larger suites of data over longer time scales[a] (Robison 1999). One type of vehicle, in particular, has facilitated new ways of sampling and viewing areas of interest in both marine and freshwater environments: remotely operated vehicles (ROVs; Figure 1; Textbox 1)**.** These systems have been used for several decades by fisheries and marine scientists for exploration studies as well as fish population and habitat assessments (Jones 2009). Now, several resources are available for DIY ROVs through modular kits, which allow for greater customization of tools, maneuverability, and sensor payloads. John Janssen's lab at the University of Wisconsin-Milwaukee has done a significant amount of DIY to develop their own custom ROV, which integrates optical, electroshocking (Textbox 1), and suction sampling equipment for studying Lake Trout *Salvelinus namaycush* fry and Slimy Sculpins *Cottus cognatus*. These two species reside in deep, rocky areas of Lake Superior and Lake Michigan (as deep as 40 m for Lake Trout fry; as deep as 100 m for Silmy Sculpin), which make them difficult to collect for tissue samples required for genetic analysis (DeKoning et al. 2006). The electroshocking technology is an integral part of this sampling approach's success. Without the ability to stun and immobilize the individuals, it would be almost impossible to collect the fry and sculpins in sufficient sample sizes. Study of the Lake Trout in Lake Michigan, specifically, is of great interest as the lake's population was extirpated by the 1960s after the Sea Lamprey *Petromyzon marinus* invasion which began in the 1930s (Eschmeyer 1957).

[Textbox 1]

[Labeled ROV Picture]

It is believed that the first use of electroshocking via an underwater vehicle was achieved by a manned submersible to collect Sea Lamprey larvae in the late 1980s (Lee and Weise 1989). Building on that concept, Janssen's lab has opted to use a highly modified ROV. The original configuration inside the plastic shell proved capable of stunning and suction collection of Slimy Sculpins at a Lake Michigan deep reef down to 60 m (Janssen et al. 2006; Houghton et al. 2010). However, custom modifications were needed to improve performance and these included: (1) a flushable collection chamber built from off-the-shelf pipes and passive valves, with a viewing window so that contents from a collection event can be evaluated and recorded, (2) a position tracking system, and (3) a conductivity, temperature, and depth (CTD) Rosette to record temperature and depth. The ROV track is determined using acoustic beacons integrated with shipboard GPS and displayed in real-time on a computer as an overlay on a multibeam bathymetry map (Textbox 1). This is significant as it allows Janssen and his team to target specific habitats in new locations and track where the ROV has been (Figure 2). Other modifications the lab made include an upgraded digital camera capable of recording both video and still images, and upgrading to an aluminum and plastic frame for the ROV shell that results in easy exchange of ROV system components.

[*ROV Underwater Image*]

Significant challenges exist when trying to conduct efficient fish assessments in deeper waters where there are rocky or coral reef systems (i.e. untrawlable habitats [Textbox 1]) and in areas of high complexity and species diversity. Self-propelled autonomous underwater vehicles (AUVs; Textbox 1), buoyancy driven ocean gliders (Textbox 1), and sail drones allow fisheries researchers to survey and explore remote areas of the ocean. Over the past decade, these technologies have seen increased use and development to study ocean chemistry and physics to improve meteorological and oceanographic circulation models. Scientists and engineers are now identifying new sensors, which could be added to the vehicle payload to connect the physical and chemical phenomena with the biological.

The growth in use of gliders (Figure 3) for fisheries research has been aided mainly by the rapid decrease in the size and power requirements needed to control and operate integrated acoustic and optical sensors over long duration missions (e.g., weeks to months). Passive acoustic hydrophones and recorders, now smaller than a candy bar, can be mounted on ocean gliders and record biological sounds or acoustic transmissions from tags implanted in marine animals. More recently, scientific gliders are now being outfitted with echosounders to remotely detect and measure relative biomass of phytoplankton and fish in ecosystems. The gliders are being used as reconnaissance tools to extend the survey coverage of our research fleet and thereby making optimal use of valuable sea time.

A team leading the effort of coupling scientific echosounders with an ocean glider is headed by Chris Taylor with NOAA's National Center for Coastal Ocean Science and comprised of personnel from NOAA, the state of Florida, and the University of South Florida's College of Marine Science. Thus far, they have integrated a passive acoustic recorder, high-frequency acoustic tag receiver, and a scientific echosounder on an ocean glider (Lembke et al. 2018) The impetus for this was to fill data gaps and to complement marine ecosystem assessments conducted on ocean research vessels with measures of biological components of the ecosystem to understand the drivers of productivity throughout the food web: from phytoplankton and zooplankton (i.e., primary producers) to higher trophic level groups such as fishes.

[*Glider Infographic*]

During a series of glider missions, Taylor and his team were searching for potential biological hotspots tied to rocky and coral reefs on the West Florida Shelf in the eastern Gulf of Mexico. They began their study by targeting a well-known natural gas pipeline that provided a known location of artificial hardbottom with a concentration of reef fishes, including Red Grouper *Epinephelus morio* and Red Snapper *Lutjanus campechanus* that carried implanted acoustic tags. This would allow them to efficiently evaluate the performance of the acoustic sensors and develop a set of expectations used in glider mission planning. The test also allowed their team to develop data management and analysis processes as they integrated data streams from the various sensors. The glider mission was, at times, at the whim of the ocean currents, which proved fortuitous as the echosounder and acoustic recorder discovered a previously unknown patch of hard bottom reef along its path. A subsequent survey used ship-based hydrographic multibeam, fishery echosounders, as well as a towed camera system called the Camera-Based Assessment Survey System (C-BASS; Lembke et al. 2017) to confirm the reef location, thereby adding to the growing knowledge of the distribution of essential fish habitat in the eastern Gulf of Mexico. The team will next use an acoustically instrumented glider to explore the deep and dark regions of the Gulf of Mexico in order to better understand how plankton and fish use some of the largest ocean habitats on the planet. Gliders outfitted with echosounders have also recently become the primary tool for surveying plankton like krill in the Southern Ocean around Antarctica, replacing the more expensive missions on board research ships.

These projects highlight how the evolution of underwater technology has facilitated the expansion of fisheries and ecosystem research capabilities. While the ability to develop and customize scientific instruments and vehicles is becoming more accessible to scientists who may not have formal engineering experience, these cases highlight how impactful it can be when scientists and engineers collaborate and develop strong working relationships. Both Janssen and Taylor’s work hinged on knowledge and experience from engineers outside of the fisheries field, and the benefits of working together were exceptional advances for fisheries data collection and research.

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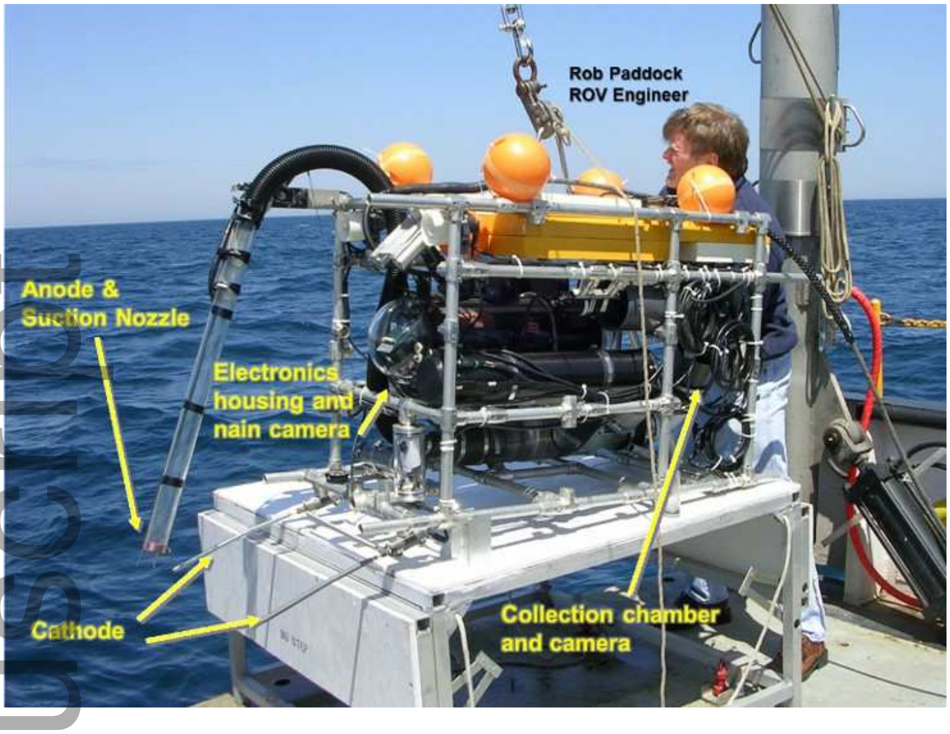

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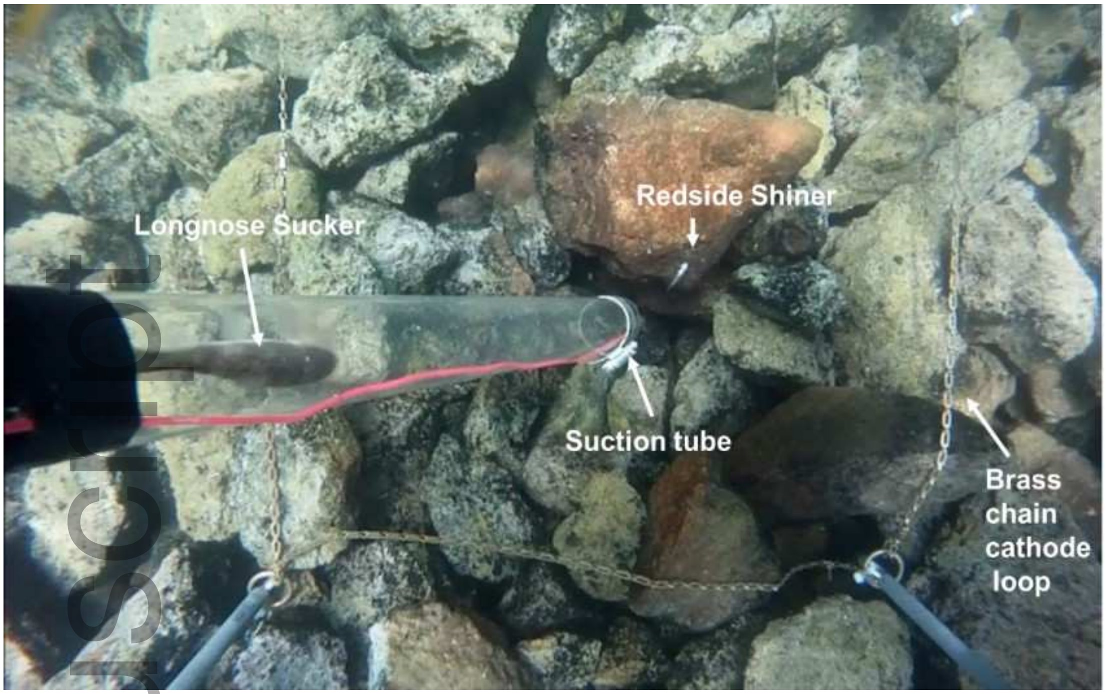

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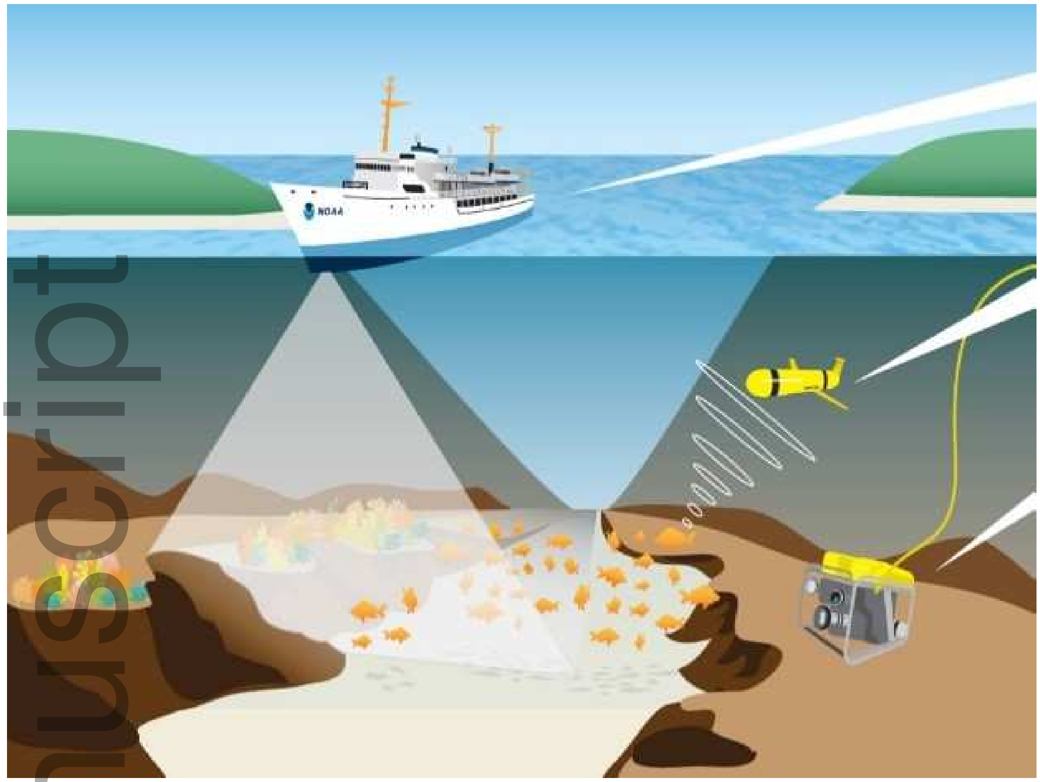

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