Using a SeaPerch ROV to Track Indicator Species for Waterway Health

Team Blue Water

Ann Arbor MI, USA

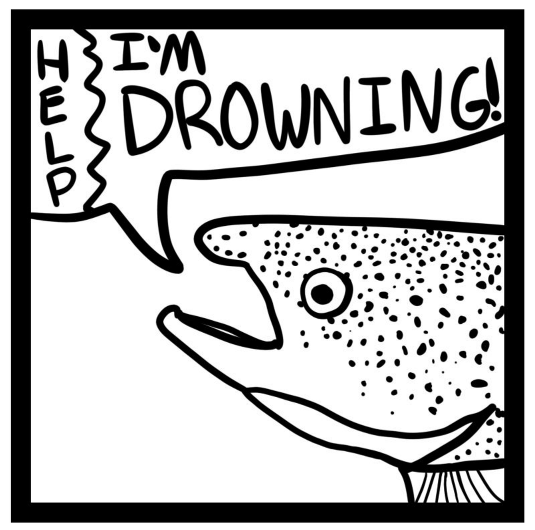
Our Project: Tracking Indicator Species

In Michigan, we are blessed to have many beautiful freshwater lakes, rivers, ponds, and streams. Because of this, Michigan has earned itself many nicknames, such as "The Great Lakes State" and "Water Wonderland".

Our project uses a modified SeaPerch ROV to find "indicator species", which researchers can use to track waterway health.

The health of our local waterways depends on many factors, such as:

- The amount of dissolved oxygen in the water
- The water's pH level
- The level of bacterial contamination
- The level of chemical pollutants, such as PFAS or 1,4 Dioxane



Low Dissolved Oxygen

These items can be measured directly, through collecting water samples at various times and locations and processing those water samples at a lab. They can also be measured indirectly - which can sometimes be more effective and efficient than direct sampling - by looking at "indicator species" in the waterway. An ***indicator species*** is a species of plant or animal that is sensitive to its environment, and can tell you something about that environment.

Aquatic indicator species in Michigan can include "benthic macroinvertebrates," which are insects and animals that spend most or all of their lives underwater. Benthic (bottom-dwelling) macro (visible to the naked eye) invertebrates (no backbone) tend to have low mobility, and can't easily escape their local environment, so they are very good indicators of water quality in a given area. Researchers will find and sample these animals by going out to the waterways and trying to locate and capture them; however, they often have to try to find them without any specific information on where they are. This can be a time-consuming and inefficient process.

A modified SeaPerch can be used to locate the specific sites containing the indicator species that researchers want to find, including areas that are not easily accessible by researchers on foot. This will speed up the process of finding and sampling indicator species. It will also allow researchers to find more areas with indicator species, in addition to the areas they would find while wading near the shoreline.

Indicator Species & Water Quality

An indicator species is an animal that is very sensitive to changes in its environment. Indicator species in Midwestern freshwater environments include animals such as:

- Gilled Snails
- Crayfish
- Nymphs or Larvae of certain insect species (Caddisfly, Stonefly, Mayfly, etc.)
- Certain species of mussels and clams
- Certain fish species, such as trout and bass

Researchers find, count, catch and sample these animals to see if there is an environmental issue, such as an inappropriate level of dissolved oxygen, unhealthy pH levels, or chemical pollutants in the water. Sometimes, indicator species can tell researchers things about water quality that water sampling alone will not reveal. Many indicator species tend to bioaccumulate pollution. This means that pollution will build up inside their bodies over time, and while just taking water samples may not reveal that the pollution is there (because the pollutant's level in the water is low), it will show up in the animal's tissue due to bioaccumulation, letting scientists know that there is a pollution issue in that waterway.

In addition to sampling and testing indicator species, sometimes researchers will look for a diversity of indicator species in the water. A large diversity of species generally means that the water is relatively healthy. If there only seem to be more pollution-tolerant species in the water, that could indicate an issue with waterway health.

Using a modified SeaPerch ROV to find and record the locations of these indicator species would make the process a lot more efficient, allowing researchers to find exactly where the target species are in the waterway, as well as make it easier to find indicator species in deep or murky water (i.e., areas they can't easily access or investigate on foot).

There is an additional benefit once this modified SeaPerch ROV is developed: researchers can use it not just for finding indicator species, but also to find and record *invasive species* and *endangered species* as well.

Methodology: Prepping the Perch

In order to make this modified ROV, one would start with the standard SeaPerch design, and make the following modifications:

- Attach an underwater camera to the ROV. Ziptie the camera to the ROV, and ziptie the camera's cable to the ROV's power control cord.
- The camera should include the following:
  - Infrared and white LED lights
  - A depth sensor
  - Video/photo recording capability
  - A paired small color screen carried by the operator, displaying what the camera sees in real time
- The SeaPerch battery should be waterproofed by putting it in a sealed case, so water won't damage anything.

When using the modified SeaPerch ROV, one person would pilot the ROV, while another would record exactly where they find members of the targeted indicator species. (For specific location information, the ROV operator can carry a GPS unit, with exact coordinates noted.) The ROV operator can also record photos or video of the species they find. Armed with this information, the researchers can then return to the precise areas to sample or study the species they're looking for - saving time and money, and producing more effective research results.

This modified SeaPerch ROV can be used in lakes, ponds, and slow-moving rivers and streams.

Discussion: Design Advantages & Challenges

This modified SeaPerch will work well for many reasons:

- Underwater cameras with the features listed above are already commercially available at a reasonable cost.
- A camera with real-time feed will allow researchers to see if the target species is currently in the area, without having to remove the data chip and process the video at a separate location.
- Attaching the camera and ROV cords to each other via ziptie will reduce the chances of the cords getting tangled or entwined.
- A depth sensor will give researchers much more precise data about where precisely to find the target animal.
- Video and photo recording capabilities allow the researchers to re-watch and analyze what they're seeing, as well as get input from third parties.
- White LED lights will give the camera clear visibility and a sharp color display.
- Infrared lights will enable the camera to display well in low-light areas, and are less frightening to some species (such as certain fish) than white lights.
- A waterproof battery encasement will protect both the battery and the operators from injury due to moisture.

There are also some challenges:

- Using this SeaPerch setup requires two people: one to operate the ROV, and one to record data.
- The operators have to be physically attached to the ROV via the power cords.
- There are many different types of vegetation and terrain that the ROV could get stuck on.
- In rivers, there is a current that can be stronger than the ROV's motors, especially in the center of the stream.

See "Next Steps" for further discussion of these items.

Summary of Benefits

This SeaPerch system can greatly reduce the time it takes for researchers to find and sample indicator species, and it can help them to find indicator species in harder-to-access places. When that happens:

- Indicator species can be located, sampled and tested quickly and effectively across a wide range of aquatic habitats.
- Researchers can precisely pinpoint and test areas of concern.
- Environmental issues can efficiently be found, tracked and addressed, benefiting our ecosystem's health.

This modified SeaPerch system has many other practical uses as well. It can be used to:

- Locate and control *invasive species*, such as zebra mussels and New Zealand mudsnails
- Find and track *endangered and threatened species*, such as Snuffbox, Clubshell, and White Catspaw mussels, so they can be better protected
- *Encourage students to get involved* and help protect their local waterways, through volunteering to build and operate these ROVs for local waterway projects
- Assess the health of *fish stocks and spawning areas*
- Assist in aquatic *search, rescue and recovery missions*

Invasive Species Found Easily

Next Steps: Charting the Course Forward

The modified SeaPerch ROV as described would be highly useful, bringing benefits to researchers and the environment. Moving forward, if we want to increase the ROV's strength and capabilities, we can give future, more advanced models a high-tech makeover, including:

- Onboard battery
- Two-way wireless communication capability for remote control of ROV and real-time data feed to the operator
- Autonomous operation capability
- Stronger motors and propellers
- More durable frame, possibly fully enclosed
- Multiple –cameras showing multiple views around the ROV
- Abovewater GPS linked to an acoustic signaling device on the ROV (because GPS doesn't work well underwater)
- A small, onboard computer or data card that can store information
- Enclosed, waterproof casing for electronic components
- Associated software: see discussion below

Hardware. The *stronger motors and propellers* would allow the ROV to work in areas with stronger currents, providing access to information from more locations (such as faster-flowing streams and rivers, the Great Lakes, etc.). *Multiple cameras* would allow the ROV to display more views around itself, reducing the chance of missing a target species. An *acoustic signaling device linked to above-water GPS* would allow the ROV to record its location data, linked to its camera data, providing precise locations of target species. The ROV could record this data on a *small computer or data chip*. This will save all data from the ROV's run for future upload and processing. The *GPS link*, *two-way wireless communication capability*, and *autonomous operation capability* would allow the ROV to be either manually piloted (using real-time camera feed and GPS tracking), or autonomously directed - i.e., the ROV would complete a pre-programmed course, using the GPS for guidance. An *onboard battery* would give the ROV much more freedom, as it would no longer need to be connected to an external battery to function. A *more durable frame, possibly fully enclosing the ROV*, would reduce the risk of the ROV becoming damaged or entangled during its travels. Enclosing all electronic components in *waterproof casing* would help ensure that all parts of the ROV work correctly, and do not suffer water damage.

Some other possible ROV upgrades could include: *wheels or treads*, so that the ROV would be able to cross above-water or shallow-water terrain, where the water is not deep enough for the ROV to operate fully submerged. The ROV developers could also add *capability for the ROV to collect samples* and return the samples to researchers on land. This would speed up the job of sampling even more.

Software and Usage. No complex software is necessary for this upgraded ROV to work, as researchers could simply watch the video footage (either in real-time, or after the fact) and note where the indicator species are. However, a machine learning algorithm could be developed to process the ROV's video data, freeing people from having to watch the entire video feed. The ROV's camera and GPS data would be uploaded to another computer, which would then run an algorithm to decide which frames have an aquatic animal in them. This specific animal-recognition algorithm may not yet exist. However, it would be possible to create a machine-learning algorithm and then feed it the data it needs to learn to identify aquatic animals in a video.

Once the algorithm has identified frames with aquatic animals, humans can view those segments and decide which frames show indicator species. They would then provide the corresponding species and location data to the people who will be sampling indicator species in the field. From there, the people sampling the species will have extremely accurate and detailed information about where to conduct their samples.

Moving Forward With Development. The Ann Arbor, Michigan area is lucky to have many people and organizations that are knowledgeable on marine engineering, STEM, environmental issues, and waterway health. For example, the University of Michigan's Naval Architecture and Marine Engineering program (NAME) has expertise in developing advanced ROVs. And the Huron River Watershed Council (HRWC) has in-depth knowledge of the environmental issues affecting our local waterways. As a first step, the HRWC could work with NAME to identify the specific features they need in the ROV: for example, where it would be used, what indicator species they are looking for, and how they would be taking samples. Then, NAME could help develop the technology and make a prototype ROV. There would also be many opportunities for students of all ages to get involved, contributing their ideas and knowledge to help develop and test the ROV. This cooperation will let us set sail for a brighter, more environmentally healthy future.

Fully Autonomous ROV

Special Thanks

We would like to thank the Huron River Watershed Council for helping us, especially Mr. Jason Frenzel, Stewardship Coordinator. Mr. Frenzel gave us thoughtful guidance regarding the environmental issues affecting the Huron River watershed, what is needed to help solve these issues, what actions are being taken, and possible ways to help.

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