Fish Tagging via RFID and Bluetooth: Crowdsourced Fish Tracking Through Better Reporting Tools

Andrew Bennett, David Barrett
Intelligent Vehicle Lab Advisors
Olin College of Engineering
Needham, MA 02492
Email: andrew.bennett@olin.edu

Isaac Vandor, Katerina Soltan, Yoonyoung Cho
Intelligent Vehicle Lab Researchers
Olin College of Engineering
Needham, MA 02492

Molly Lutcavage, Chi Hin Lam
Large Pelagics Research Center
Gloucester, MA 01930
Email: tagtuna@gmail.com

***Abstract*—Conventional tagging methods using plastic streamer tags have been the most widely used tool for elucidating fish movements in the last half century. With a very high failure rate1, these methods for fish tagging and tracking are unreliable and prohibitively expensive for tracking global fish populations. Under the current method, fishermen are required to remember the time and location of the catch, the size of the fish, and the weight of the fish. In order to report a tagged fish, a fisherman cuts off and keeps the tag from the fish. Later, the fisherman must go back and submit the form using the information they can remember from earlier in the day or even several days ago. The long delay and relative difficulty between catch and data entry creates a barrier to data collection. The Olin College of Engineering Intelligent Vehicles Laboratory, in partnership with The Large Pelagics Research Center, has been developing a new, automated method for data reporting from fish tags.**

In the proposed process, a fish will be tagged with a modified streamer tag carrying a rice grain RFID chip. A fisherman can scan the tag at or near the moment of capture with a compatible RFID reader, which will transmit the fish's data file to a personal smartphone pre-installed with our reporting application (HI Tag App). From the application, the fisherman has the option to save the form directly as generated, input any missing data, or add richer data (i.e. a photo of the fish) before saving the form and storing the data on internal memory. When the application has detected a cellular or wireless connection, the data will be immediately uploaded to the Pacific Islands Fisheries Group database. Tests conducted off the island of Hawaii (Summer 2016) demonstrated that the HI Tag application greatly improved the process of fish tagging and reporting with respect to automating the process of collecting, parsing, and transmitting data without requiring supervision from the user. In this way, the reporting can be integrated into the fishing experience itself. Minimizing the barrier between catching and reporting the fish should create a direct relationship between identifying and reporting the tag, thereby providing a direct improvement to "catch and release" fishing activities while enabling scientists and researchers access to richer data, collected from the same tag over the entire lifetime of a fish.

I. Introduction

Large pelagic species such as tuna and billfish are considered vital in socioeconomic and cultural perspectives for communities throughout the globe. Consequently, information about marine species' behavior – migration patterns and mating habits, to list a few – are critical to the fisheries' missions of conservation and sustainability. In spite of increasing attention to environmental preservation and technological advancements that enable obtaining richer data with faster means, the tagging programs have seen little advancement since the 1900s[1]. In order to combat this stasis, the Olin College Intelligent Vehicles Lab, in partnership with the Large Pelagics Research Center, has been developing an alternative system to fish tagging: a platform called HI (Hawaii) Tag that incorporates the RFID technology with the widespread popularity of mobile applications. Promoting a smart and sustainable management approach will ensure the continued growth and availability of fish stock for the future.

II. Large Pelagics and the Fisheries Management Problem

Large Pelagics are highly migratory species of fish that live in near-surface waters of the ocean [2] and include some of the most important fish species from an economic, social, and cultural perspective. These fish primarily include tuna (Yellowfin, Bigeye, Albacore, etc.) and Billfish (Blue Marlin, Striped Marlin, etc.) species. In spite of their importance, the highly migratory nature of these species rendered them difficult to gain valuable insight and data for developing a good fisheries management system. In the current tagging practices, scientists and fishermen insert plastic and vinyl dart tags into the dorsal fin area of the fish. Before releasing it, they record data about the time, location, weight, fork length, and tag ID of the catch on a piece of paper.

Fishermen who are not directly working with a scientist are asked to mail the information or call the research center to submit the data they collected as soon as they return to shore. Fisheries rely on these programs to observe species' growth and general travel patterns which directly influence decisions about sustainability and ecosystem management. Past efforts that incorporate such a tagging scheme includes the LPRC Tag a Tiny Program[3], which has led to the successful tagging of over 2,000 Bluefin with conventional "spaghetti" tags. Even this relatively small sample size has contributed tremendously towards the scientific understanding of large pelagic species. Of crucial importance, data on the migratory patterns of these large pelagic species has allowed for more effective conservation and management strategies in order to protect the importance of many large pelagic species from both an economic and an ecological standpoint[4]. The disadvantage of the current tagging scheme is that the process is cumbersome, and the data collected is often inaccurate[5]; for instance, the current initial reporting system often relies on a group of two to three volunteer fishermen who may record a single location at the beginning of their tagging session. However, the fisherman and the fish move around throughout the day, covering several miles. This results in an inaccurate grouping of the fish at various locations in the ocean. Many inaccuracies are also made in estimating the fish's length and weight as these require extra steps to measure accurately. As a result, the current systems are growing increasingly outdated and require non-trivial commitment of fishermen to tag and report the data. The HI-tag platform aims for an intuitive system in which fishermen are able to focus more on the fishing experience while researchers gather more accurate, more detailed data in a much more efficient manner.

III. System Description

The HI Tag platform consists of three separate components: the HI Tag mobile application, the RFID reader, and the database. A successful tagging session involves catching a tagged or taggable large pelagic species, scanning the tag with the RFID reader and sending the tag information to the HI Tag mobile application. From the mobile application, a fisherman or researcher can verify the tag ID generated automatically from the file sent by the RFID reader, take a photo of the fish, record the fork length and make any additional notes before submitting a report. Once in range of a wifi or cellular network, each tag report created by the fishermen or researcher will upload automatically to the database and parsed to display relevant information in an easy-to-understand format.

A. Mobile Application

Given the prevalence of smartphones, a mobile application was the logical starting point for the development of a new interaction between the tagging technology and the users. The HI Tag mobile application was designed to provide the core feature set of a tagging experience (e.g. the ability to view/edit a tag ID and capture/release location as well as fork length) in addition to new features designed to improve on the data-set available to scientists and researchers.

Fig. 1. The tag ID number is automatically filled in when used with an RFID reader. The user can also manually enter the tag ID number.

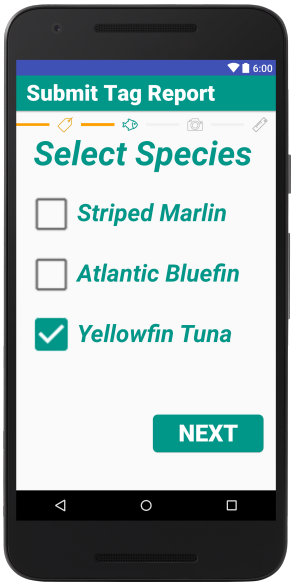

Fig. 2. The user is asked to select the species of the fish they are reporting.

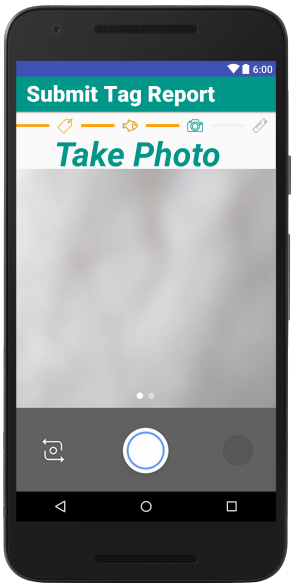

Fig. 3. The phone's camera capabilities are used to obtain a photo of the fish which can provide valuable insight to scientists.

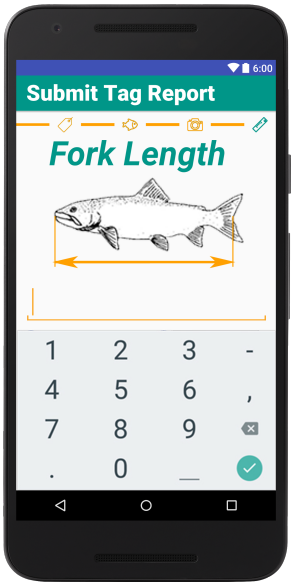

Fig. 4. The user is asked to measure the fish to track its growth.

Chief among these new features is the ability to take a photo of a captured fish, enabling scientists and researchers to place a face to the ID as it were and perhaps gain valuable insight based on viewing a photo of the actual fish in question as well as to verify any data included in the tag report for said fish. Additionally, the HI Tag mobile application allows fishermen to easily input notes, enabling them to make quick notes in the field that may later influence researchers and scientists. For instance, it may be helpful to note that captured fish in a particular area appear to have many more bite scars

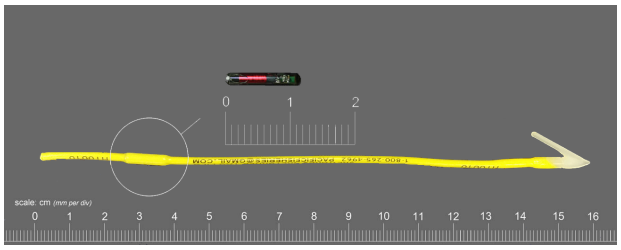

Fig. 5. The HI tag uses a tiny RFID chip to automate the process of tag identification. The chip is embedded in a conventional dart tag made from nylon and vinyl.

from Cookiecutter Sharks (*Isistius brasiliensis*)[6] than pelagic fish caught in another area. This type of insight is one that can only be gathered utilizing the advanced feature set capable in the HI Tag mobile application. The HI Tag mobile application also takes advantage of the smartphone's ability to record accurate GPS location and time data to autofill the location of the tagged fish and the time of catch in the report, saving valuable time and allowing for the collection of photos and notes.

B. RFID Tags

Given that any future tagging technology must be compatible with current systems already in place and onboard, rice-grain RFID chips were chosen as they are easy to implement in existing "spaghetti" tags.

Rice-grain RFID chips are durable, capable of staying in a tag for the lifetime of a large pelagic and are easy to read and scan with commercially available RFID readers. Most importantly, the nature of the RF tags means that they can be implemented at scale for each of the different groups involved in tagging projects. For instance, handheld RFID readers can be used to read rice-grain RFID chips implanted in conventional "spaghetti" tags while RF sensors can be embedded in a gate placed on a longline fishing vessel and used to read rice-grain RFID chips implanted in fish caught in a commercial fishing operation. The ability to use the same technology at every level of the tagging community allows for a much broader impact and opens up the ability to tag a fish and to report a tagged fish much more easily. Through this, we believe that many individuals and groups of fishermen will be empowered to start tagging large pelagics and submitting tag reports thereby increasing the pool of data available to scientists and researchers.

C. Database

While the HI Tag application and open access to advanced RFID technology should make it easier for fishermen to contribute to the amount of data available to scientists and researchers, this data is only helpful if it

can be easily accessed and analyzed. With this in mind, we have developed a database where all tag data will be automatically uploaded and parsed upon a cellular or wifi connection. Living in the cloud, the database is easily viewable, allowing fisheries personnel and marine biologists who are part of the program to view the data from a particular fishing session just minutes after the boat has arrived back at the docks. Moreover, we intend to implement data visualization tools in order to broaden the community of users who can easily view tag data and get a better grasp of ocean ecosystem health from the perspective of a large pelagic. For instance, the tag data from the database could be integrated with a map, providing a broad view of the locations of recently recorded tags. Such a tool would allow researchers an at-a-glance view of tagged large pelagic species while maintaining the privacy of the fishermen.

IV. Field Tests

A. Experimental Methods

Before the HI Tag platform can be fully deployed within the fishing and scientific communities, testing is necessary in order to determine that the platform is fully functional and can work successfully in the hands of users. As such, the first iteration of the HI Tag platform was tested in July 2016 with fishermen from the Pacific Islands Fisheries Group off of the coast of Kona, Hawaii.

B. Process

For the testing, two boats were used: one boat was tagging fish using the HI Tag platform while the other was using the paper and pencil method for recording catches. In about six hours of fishing time, 8 HI tags and 15 conventional tags were deployed. The time taken to tag and report each fish was not significantly different between boats. However, when we returned to the docks, data from the HI tags was already available for analysis in a database for the researchers in an organized way, as can be observed from figure 6.

The information from the conventional tags needed to be manually entered into the database, was difficult to read, and did not provide extra data like a photograph or precise location of the catch. Figure 7 displays the reporting card completed by fishermen using the current reporting method.

C. Results

Using the HI Tag platform in the field obtained a richer dataset with photographs and precise locations in the same amount of time it took to collect basic and approximate information using the current reporting method because it used the smartphone's capability to easily calculate GPS coordinates and take a photo. The results from the tagging session were also available much

Fig. 6. The HI Tag platform uploads the report as soon as it is in range of a cellular or wifi network, making the data collected from the trip available very fast and in an organized manner.

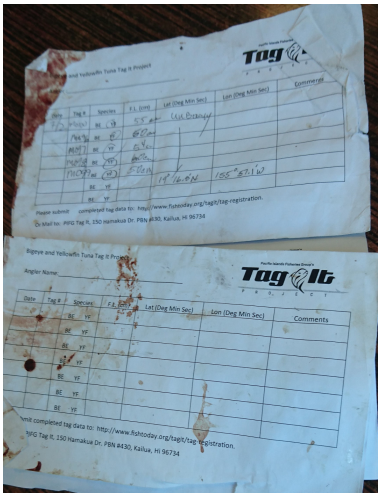

Fig. 7. The data sheet produced by the current conventional tagging method is a paper and pencil process that must be delivered to the research center and manually entered into the database. The paper is often covered in blood and illegible.

faster and in a much more organized and useable way than the paper notes produced by the current reporting process. The first iteration of HI Tag platform has demonstrated its capacity to produce quality, detailed, and useful data, preparing it almost instantaneously for analysis. We are working to optimize the platform even more using the feedback of users from the boats. We did not anticipate the difficulty of inputting data onboard a moving fishing vessel and the short amount of time there is to collect all of the data before having to release the

fish back into the water. Based on our experience and in order to improve the speed and ease of the tagging process, we refined the workflow of the application to guide the user through discrete steps instead of asking them to fill out a form (Figures 1 through 4 display the redesigned application). Typefaces and buttons were enlarged to make it significantly easier to view and use the application on board the vessel. More field tests will be conducted in the fall of 2016 on tuna off of the coast of Gloucester, Massachusetts to receive feedback on the changes prompted by the first test. The RFID reader used for the first iteration slowed the process of scanning and sending tag information to the phone due to its unintuitive interface and short reading distance. We hope to design a smaller, more portable, and faster reader that does not require switching multiple screens to scan and send tag data. By controlling the user interface in all parts of the HI Tag platform, the tagging process will be more efficient and user friendly, encouraging widespread participation and consequent higher impact of the program.

V. Conclusion

The study of large pelagic species informs us about an entire ecosystem's health. Based on preliminary findings and field testing, we believe that the HI Tag platform can provide tremendous benefits to the community of fishermen, scientists, and ocean-related researchers interested in this data. The HI Tag app will allow fishermen to more efficiently tag large pelagic species and gather more data when recording tagged fish with little-to-no detriment to their fishing experience. With the new embedded RFID chips in the conventional "spaghetti" tags, combined with the easy to access database and data visualization tools, we believe the HI Tag platform has the potential to be a cost-efficient, easy to implement at scale method for conducting ecosystem research and understanding more about the day-to-day state of the oceans. By making this data easy to collect and access, the HI Tag platform should be able to open up ocean research and data collection to a much broader community, thereby increasing the interest of the scientific community and pushing further innovation in the space.

A. Considerations for future work

The 2015-2016 academic year has been devoted to the design and development of the HI Tag platform with all core functionality. While the platform will continue to be iterated on and improved through testing in the field and feedback from users, we will be focusing on improving the RF technology such that the platform can be opened up to include the broader fishing community, from recreational fishermen on a kayak to commercial longline fishing vessels. Part of this focus on expanding the reach of the platform will include the development of an iOS version of the HI Tag app and tools for better understanding and analyzing the data found in the database. Additional research may focus on improving the tags themselves, particularly in developing more advanced satellite tag technology, further expanding the amount of data we can gather on large pelagic species and the ocean ecosystem.

Acknowledgement

Our efforts would not have been realized without the assistance of the Olin College Robotics Lab, The Large Pelagics Research Center, and the Pacific Islands Fisheries Group.

References

[1] Scott, Edwin L., Eric D. Prince, and Carole D. Goodyear. "History of the cooperative game fish tagging program in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea, 1954–1987." American Fisheries Society Symposium. Vol. 7. 1990.

[2] Lau, Dodie. "PFRP Program Overview." Pelagic Fisheries Research Program. University of Hawaii at Manoa, 31 Jan. 2013. Web. 18 July 2016.

[3] Lutcavage, Molly, and Chi Hin (Tim) Lam. "Tag A Tiny." Large Pelagics Research Center. UMass Boston School for the Environment, n.d. Web. 15 July 2016.

[4] Greene, Jennifer, Caroly Shumway, Mark Anderson, Jay Odell, and Kevin Ruddock. Large Pelagic Fish. N.p.: Northwest Atlantic Marine Ecoregional Assesment, n.d. PDF.

[5] Scott, Edwin L., Eric D. Prince, and Carole D. Goodyear. "History of the cooperative game fish tagging program in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea, 1954–1987." American Fisheries Society Symposium. Vol. 7. 1990.

[6] Papastamatiou, Y.P., Wetherbee, B.M., O'Sullivan, J. et al. Environ Biol Fish (2010) 88: 361. doi:10.1007/s10641-010-9649-2