# Improved Fish Tagging Technology

## Field Test Results and Analysis


Hyunju Blemel
*Point Road Solutions*
Burlington, USA
info@prsolutions.com

Andrew Bennett
*Point Road Solutions*
Burlington, USA

Silas Hughes
*Point Road Solutions*
Burlington, USA

Kathleen Wienhold
*Point Road Solutions*
Burlington, USA

Thomas Flanigan
*Point Road Solutions*
Burlington, USA

Molly Lutcavage
*Large Pelagics Research Center*
Gloucester, MA
me.lutcavage@gmail.com

Chi Hin Lam
*Large Pelagics Research Center*
Gloucester, MA
tagtuna@gmail.com

Clayward Tam
*Pacific Islands Fisheries Group*
Honolulu, HI
pacificfisheries@gmail.com



***Abstract*—Conventional tagging methods using plastic streamer ID tags have been the most widely used tool for elucidating fish movements in the last half century. However, this universal method for fish tagging is not optimal for tracking global fish populations because it requires fishermen to log details of each catch while they are also attempting to perform all of their usual at-sea activities. Under the current method, fishermen are asked to remember the time and location of the catch, in addition to its size, weight, and condition of the fish and then record it on a data card or similar. The potentially long delay between the recapture event when a previously tagged fish is caught and the associated data entry creates a barrier to accurate data collection and may result in poor data logging. Building on the work of the Olin College of Engineering Intelligent Vehicles Laboratory, Point Road Solutions, LLC (PRS), in partnership with The Large Pelagics Research Center (LPRC) and the Pacific Islands Fisheries Group (PIFC), the research team has been developing a more streamlined, automated method for fisherman to submit data from fish tags while at sea.**

**In the new process, a fish is tagged with a modified streamer tag carrying a rice grain radio-frequency identification (RFID), chip. A fisherman would scan the tag at or near the time of capture with a compatible RFID reader, which will transmit the fish's tag information to a personal smartphone pre-installed with our reporting application (Hawaii, or "HI", Tag App). The application then appends the tag ID with information such as location, date and time from the phone. Initial tests conducted off the island of Hawaii (Summer 2016) demonstrated that the HI Tag application greatly improved the process of fish tagging and reporting when compared to the current manual data logging method. However, during the 2017 sea trials the HI Tag required extensive interaction with a phone or tablet to properly function. This was deemed inappropriate by the fishermen who asked for a simpler, more streamlined process which was compatible with the kind of environment and work flow found on a fishing vessel at sea. PRS therefore constructed a custom-designed RFID reader with an integrated camera and Bluetooth, designed for use in the kind of challenging environments found on a small working fishing vessels. With this addition, fishermen could scan a tag and image a fish without ever touching their phone or tablet. The RFID information and photo would be automatically transmitted to the phone or tablet via Bluetooth and then associated with time, date and location data on the phone. We tested the improved device off Kona-Kailua, Hawaii, in the summer of 2018 during what turned out to be one of the most prolific Yellowfin fishing periods in living memory. The team then conducted a post-mission interview and debriefing with the local fishermen to determine what aspects of the new generation tagging system were improved and which did not have the desired utility. The feedback has resulted in a finished design that the authors deem "complete", fully functional, and ready for wider distribution and application.**


## I. Introduction

Fish tagging is increasingly utilized by fishermen and researchers to track the growth of various fish. This is done to better understand the lifespan and migratory patterns of marine life. A barrier to the existing method of fish tagging is the fishermen's difficulties when trying to rapidly measure, photograph, and tag a fish while minimizing the harmful effects of keeping the fish on deck. The aim of this project was to create a sustainable, simplified technology that will allow fishermen to efficiently gather data without the struggle associated with current data collection methods. The user-driven interface, combined with repeated testing, has allowed for successful field usage. This paper goes in depth into the creation, processes, and improvements made to the existing fish tagging system, the methodology of it, and the collection of data.

## 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 [3] 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. Despite their importance, the highly migratory nature of these species makes gaining the data necessary to develop favorable fisheries management systems difficult. Using current tagging practices, scientists and fishermen insert plastic and vinyl dart tags into the dorsal fin area of the fish. Before releasing the fish, they record data about the time, location, weight, and fork length (the length of a fish from tip of the snout to the end of the middle caudal fin) and write the tag ID of the catch on a piece of paper. Fishermen who do not directly work with a scientist are asked to mail the information or call the research center to submit the collected data as soon as they return to shore.

Fisheries rely on this data to observe species' growth and travel patterns, which directly influences decisions about sustainability and ecosystem management. Past efforts that incorporated this tagging method include the LPRC "Tag a Tiny Program" [4], which 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. Most importantly, the data on the migratory patterns of many of these species has allowed for more effective conservation and management strategies to protect them, from both an economic and an ecological standpoint [5]. The disadvantage of the current tagging method is that the process is cumbersome, and the data collected is often inaccurate [6]. For instance, the current initial reporting system often relies on a group of two or three volunteer fishermen who may record only a single location at the beginning of their tagging session. However, the vessel and the fish move throughout the day, often covering several miles at sea. This results in an inaccurate grouping of fish that may have been caught at varying locations in the ocean [7]. 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 system is growing increasingly outdated and requires a significant commitment of time by fishermen to tag and report the data. We have developed an intuitive system in which fishermen can focus more on the fishing experience while researchers gather more accurate, more detailed data in an efficient manner.

## III. SYSTEM DESCRIPTION

The HI Tag platform consists of three separate components: a mobile phone/tablet application, a specialized multipurpose RFID reader, and a central database. A successful tagging session starts with catching a tagged (or taggable) large pelagic species. The existing tag, or new tag if no tag is present, is then scanned with the RFID reader, which automatically sends the tag information to the HI Tag mobile application via Bluetooth. This same reader can also be used to take a photo of the fish. Using the mobile application, a fisherman or researcher can then additionally verify the tag and record the fork length before submitting the data to form a tag report. If the fisherman does not choose to access their phone or tablet, the HI Tag app will still have recorded the image, tag number, date, time and location of the catch. Finally, once the device with the app is in range of WiFi or a cellular network, each tag report created by the fishermen or researchers will upload automatically to the database and be parsed to display relevant information in an easy-to-understand format.

### *A. Mobile Application*

Given the prevalence of smartphones, a mobile application is the logical means to easily record and upload fish tag data using already on-hand technology to provide an interface for users. For the test described in this paper, the HI Tag mobile application was ported from iOS to Android and deployed on a typical smart phone (Samsung Galaxy S5). The app was designed to provide the core features of a tagging activity, including the ability to view/edit a tag ID, record the capture/release location, take a photograph, and record fork length. Additional features were designed to improve the data sets made available to scientists and researchers. Based on feedback from the 2017 field tests, the workflow of the HI Tag mobile app was not changed, and is represented by figures 1 through 4.

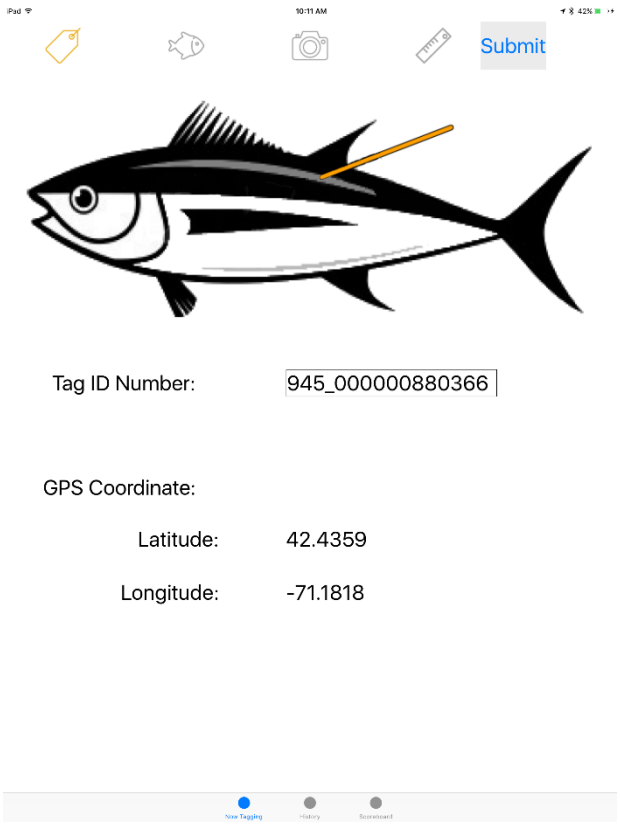


**Figure 1**

Figure 1 illustrates the tag entry screen. The tag's ID number is automatically read and transmitted to the app via Bluetooth when used with the RFID reader/tag applicator (see Figures 6 and 7). The user can also manually enter the tag ID number. The HI Tag mobile application takes advantage of the smartphone's ability to record accurate GPS location and time data to autofill the location and the time of the tagged fish in the report, saving valuable time.

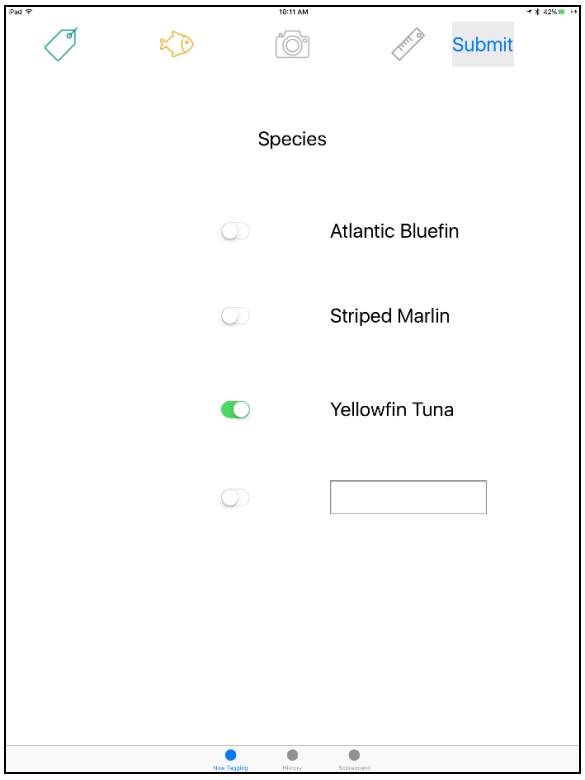


**Figure 2**

The user is then asked to select the species of the fish they are reporting (Figure 2). The user may enter a species name if the species of the fish being tagged is not listed.

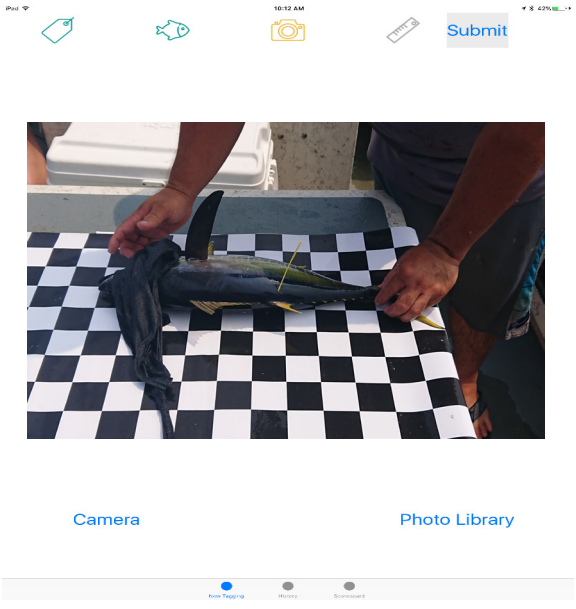


**Figure 3**

Next, the phone's camera capabilities are used to obtain a photo of the fish (Figure 3), enabling scientists and researchers to visually confirm the species and gain valuable insight based on visual observation of the actual fish in question, rather than relying solely on the description.

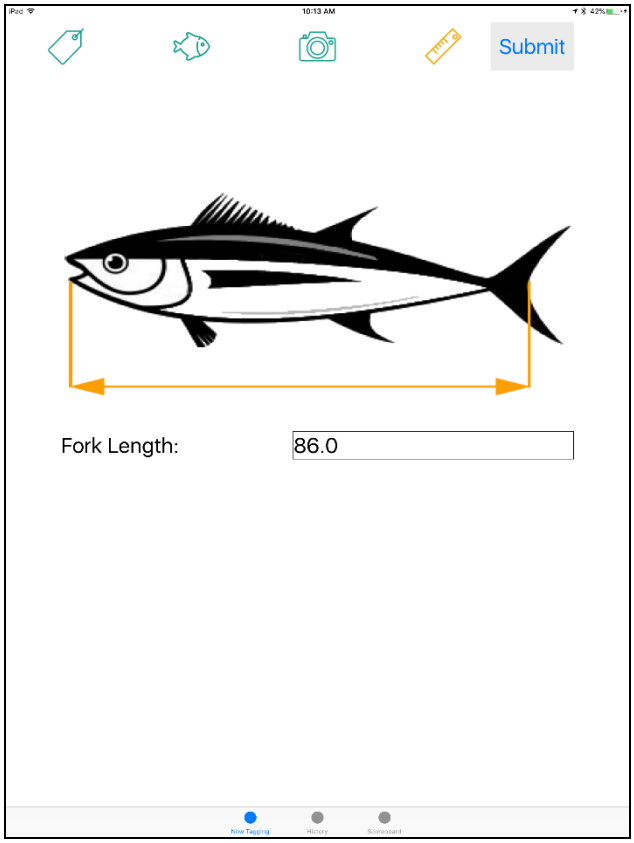


**Figure 4**

Finally, the user is asked to measure the fish (Figure 4). If the measurement is not made, the photo can be used to calculate the length of the fish using the checkerboard background as a reference.

*B. RFID Tags*

The HI Tag system uses a tiny, rice-grain sized RFID chip to automate the process of tag identification (Figure 5). Given that any future tagging technology must be compatible with current systems already in place and onboard, rice-grain sized chips were chosen as they are easy to implement in existing "spaghetti" tags.

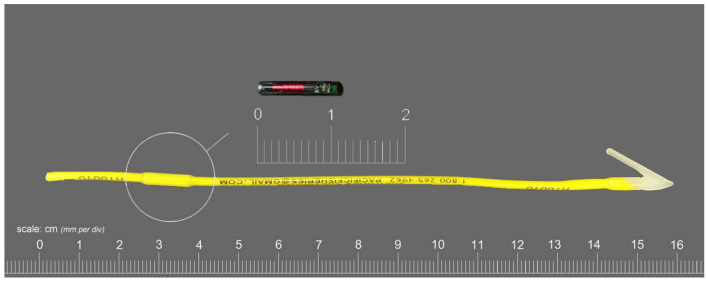


**Figure 5**

The chip is embedded in a conventional dart tag made from nylon and vinyl. Rice-grain RFID chips are durable, capable of staying in a tag for the lifetime of a large pelagic, are easy to read, and scan with commercially available RFID readers. Most importantly, the nature of radio-frequency (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 chips implanted in fish caught in a commercial fishing operation. The ability to use the same RFID technology for a commercial operation and an entry level fishing expedition simplifies adoption of the technology and gives the tagging community a much broader impact.

*C. RFID Reader*

To accommodate the fishermen's desire not to handle their phones while fishing, the team constructed a separate RFID reader that connects to the mobile app via Bluetooth. Designed for shipboard use, the reader incorporates an RFID antenna and, new this year, a built-in tag applicator, wireless charging, and a built-in camera to capture an image of the fish. The device was built for a saltwater environment and was fully sealed. By integrating multiple functions into the reader, the fishermen can now perform a full tagging operation using just one tool. By integrating everything into one piece of hardware, the fisherman can implant the tag and read the chip all in one action (Figs 9-10). If a chip/tag is already present, then the number can be recorded with a wave of the device.

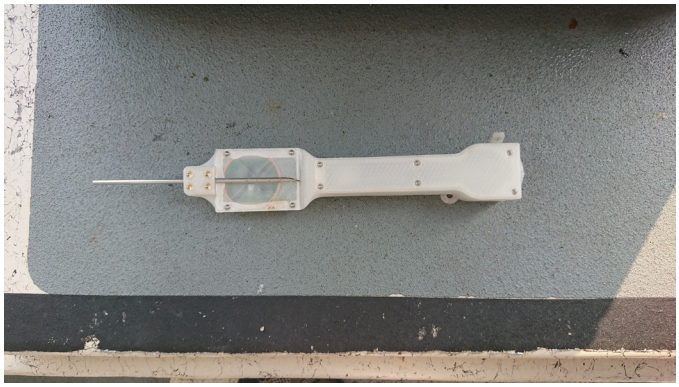

**Figure 6**

Figure 6 shows the integrated tag reader rear view. The application needle and RFID chip reader (large circular antenna) are on the left. The magnet/camera button is to the upper right.

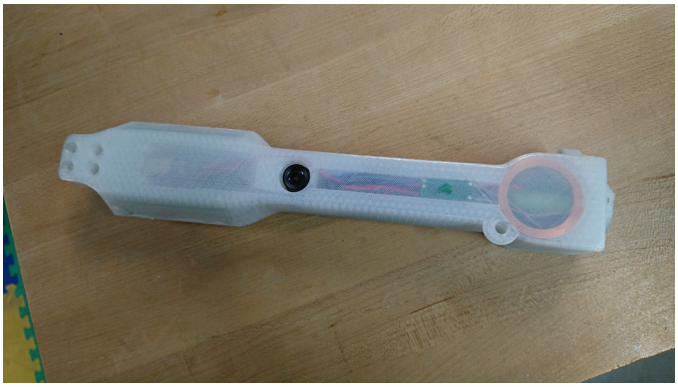

**Figure 7**

Figure 7 shows the integrated tag reader, front view. The integrated camera is to the center/left and the inductive charging coil is to the right. A lanyard attachment is on the lower right and the on-off switch is just visible on the far right.

*D. Database*

While the HI Tag application and open access to advanced RFID technology should make it easier for fishermen to contribute data to scientists and researchers, this data is only helpful if it can be easily accessed and analyzed. We developed a database where all tag data can be automatically uploaded and parsed when a cellular or WiFi connection is available from the user's mobile application.

Figure 8 shows tagging reports from the HI Tag application, showing the date/time of the tagging event, the tag number, the latitude/longitude at which the tag was read, the species, the fork length, and a photo of the fish.

| | | | | | |
|---|---|---|---|---|---|
| 2017-07-02 17:20:59 +0000 | 945_000001122... | 19.7674 -156.094 | Yellowfin Tuna | 85.0 |  |
| 2017-07-02 18:44:49 +0000 | 945_000001109... | 19.7709 -156.096 | Yellowfin Tuna | 85.0 |  |
| 2017-07-02 19:13:24 +0000 | 945_000001105... | 19.7681 -156.095 | Yellowfin Tuna | 79.0 |  |

**Figure 8**

The database is easily viewable, allowing researchers, such as the Pacific Islands Fisheries Group (PIFG), and marine biologists who are part of the PIFG program, to view the data from a fishing session just minutes after the boat has arrived back at the docks. Moreover, we intend to implement data visualization tools in later versions 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 show researchers an at-a-glance view of tagged large pelagic species while maintaining the privacy of the fishermen.

## IV. Field Tests

### *A. Experimental Methods*

Based on experimental trials in 2016 [8], and 2017 [9], hardware and interface testing were again conducted off the island of Hawaii using new equipment in the summer of 2018. While the 2017 reader was an improvement, the need to photograph the fish using the phone meant that the fishermen's underlying desire to avoid working with their phones during a tagging operation was still not met. In addition, the need to swap the tag applicator for the reader complicated the operation in the most time-critical moments. In 2018, changes were made to incorporate the applicator, the RFID reader and camera into one device. One single device was used to implant the tag, read the tag, and take a photo of the fish, simultaneously recording location, time, and date.

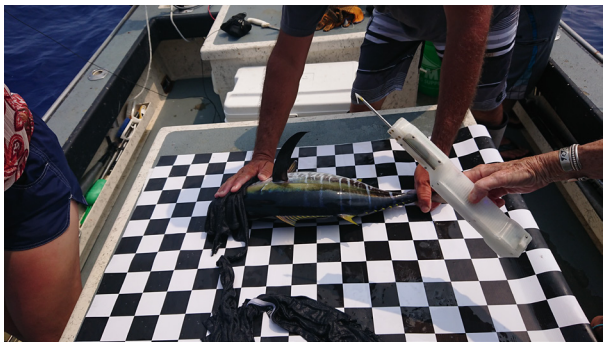

**Figure 9**
Wand with a tag loaded just prior to tagging.

**Figure 10**
Tagging a Yellowfin using the tagging device.

### *B. Process*

For testing, two boats were used. Both boats were tasked with tagging juvenile Yellowfin tuna using the HI Tag platform in an effort to maximize the number of tagged fish in the time available for our research (approximately two days). Over the course of testing, our entire inventory of 20 tags were successfully deployed.

Research materials included the RFID tags, the redesigned tagging device, a calibration sheet to enable future automatic size calculation), and a cloth to protect the eyes of the fish. The fish used for data collection in this research were primarily Yellowfin and Bigeye. Once a fish was caught, the live fish was brought on the calibration mat (Figure 10, checkerboard pattern) and had its eye covered with a dark cloth (Figure 3). Once the tag was implanted, a photo was taken with the built-in camera in the tagging device. The transfer of the image triggered the app to simultaneously record the GPS location. While the goal is to automatically calculate the length of the fish from the image, the fish were still measured to provide ground truth for future comparison. Once tagged, measured, and imaged, the fish was released.

### C. Results

The new 2018 tagging process was successful in streamlining the process, as compared to feedback from the 2017 field tests. The fishermen observed that even small details, such as having a squared-off device with cubed edges that would stay in place with the rolling of the ship, were very beneficial. Tagging the fish, photographing the species, and recording the size and physical attributes with the built-in camera combined with automatically recording the date, time, and location all in one snapshot achieved the fishermen's desire to remove the need for touching the smartphone HI Tag app in open water. The process typically took 10 seconds per fish, with the longest delay attributed to the fish flopping around on the deck.

In a post-mission debriefing, the fishermen praised the new tagging device and asked for a hardened version. An unexpected use of the system identified by the fishermen is to inventory their gear as supporting documentation in the event of theft or loss. The fishermen observed that the photographing method did not facilitate estimating the size of the fish visually unless an object was placed in the frame to provide a reference when reviewing the image after the fact. While the checkerboard was intended for this purpose, the fishermen did not want to have such a sheet on their boats. A possible solution could be a calibration sticker placed on the boat in the field of view of the camera or having the fishermen pick an object already on the boat and providing the exact dimensions as part of registering for the app. Given such a fixed frame of reference, all fish caught on a given boat could be measured against the known object.

## V. Conclusion

The study of large pelagic species can inform us about an entire ecosystem's health because they are both highly mobile animals and the apex predators of their environment. Based on our latest findings and field testing, we concluded that the HI Tag system is now ready to provide tremendous benefits to the community of fishermen, scientists, and ocean-related researchers interested in this data. The data collection went smoothly and according to plan. Use of this all-in-one tagger in the field is realistic and ready for wider distribution and application. The HI Tag platform allowed 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. We believe the HI Tag platform has the potential to be a cost-efficient, easy to implement at scale 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 can further open 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 2018 development and testing effort was devoted to taking the feedback from fishermen and refining the HI Tag platform from the perspective of the end-user community. Based on our successful field tests, we believe the platform is ready for hardening and large-scale rollout. Additional improvements will be to expand the reach of the platform to include the development of an iOS version of the HI Tag app, an improved auto-measurement of fish length, 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.

## Acknowledgment

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