Systematization of Information Management in Sea Turtle Recovery

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Abstract. Sea turtles have faced the impacts of human activities for many decades, and their current threats are so severe that they are critically endangered. One of the most significant threats to their populations is entanglement in fishing gear. To protect and recover these animals, an advanced information collection system has been developed. This system allows fishermen to record the GPS location, date, and time when a turtle becomes trapped in their fishing nets. This crucial information is collected by the "Quelona" Sea Turtle Rescue Center, providing valuable data for research and conservation efforts. The project was designed with simplicity in mind, ensuring that it is easy to use. It also addresses challenges such as poor telephone service coverage and data redundancy, ensuring that the system remains functional in difficult conditions. By addressing these issues, the project aims to significantly contribute to the preservation and recovery of sea turtle populations.

Keywords: sea turtle recovery, usability, software engineering

1 Introduction

Sea turtles have been significantly impacted by human activities for many decades [1], placing them in a critical state of conservation. Among the most significant threats to their populations is entanglement in fishing gear. Four species of sea turtles are common in the exclusive economic zones of Argentina, Uruguay, and Brazil: the green turtle, the loggerhead turtle, the leatherback turtle, and the

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hawksbill turtle. The coast of Buenos Aires province, particularly the estuaries of the Río de La Plata and Bahía Blanca [6], are crucial feeding areas in the life cycle of these turtles. Unfortunately, these sites also represent high-risk areas for entanglement in fishing nets. It is estimated that hundreds of turtles become entangled in these environments.

Turtles are injured when they come into contact with fishermen's nets during their usual activities. Fishermen often take the entangled turtles to port, where rescuers assess the animals' injuries and provide necessary treatment, sometimes taking them to shelters until they recover. Upon arrival at port, rescuers collect data from the fishermen, including the location where the sea turtle was found. However, the descriptions provided by fishermen are often vague and imprecise. Precise information about the location, date, and time of the entanglement would help establish behavioral patterns of the turtles, thereby improving protection and conservation policies.

While there are platforms available for recording animal sightings, they do not meet the specific needs of this project, as detailed in section 2. Therefore, we propose developing a new solution, in cooperation with the "Quelona" Sea Turtle Rescue Center [8]. Our proposal is to establish an information collection system that allows fishermen in the region to record the GPS location, date, and time when a turtle becomes trapped in their fishing nets. This information will be displayed on a webpage, providing an additional resource for investigations and rescuers. The project focuses on simplicity of use and addresses challenges such as poor telephone service coverage and data redundancy.

2 Digital Solutions in the Field of Conservation

Before our development, there was no application designed to meet the conditions necessary for the recovery and protection of sea turtles, considering the challenging work context of fishermen. These fishermen often face situations that make it difficult to use an information system. However, there are applications for other animal species. In this section, we will highlight the work done in three specific cases.

2.1 Ladybug Data Collection

The Vaquitas Project [2,3] (in Argentina, the ladybug is called "Vaquita de San Antonio") is an initiative created to enhance knowledge about the biodiversity of these ladybugs in Argentina. The project aims to map the distribution of conspicuous ladybugs (those visible to the naked eye) across the country, providing a foundation for future conservation programs for this important group of insects.

The Vaquitas Project is driven by a group of professionals and students dedicated to biodiversity conservation and science dissemination. It includes researchers, scholarship holders, support staff, and students from various universities and institutions in Argentina and Chile.

(a) Four species of sea turtle are common in the exclusive economic zones of Argentina, Uruguay and Brazil. These are the green turtle, the loggerhead turtle, the leatherback turtle, and the hawksbill turtle.

(b) "Quelona" deals with the rehabilitation and reintroduction of sea turtles in the local estuary, studying issues related to the behavior, conservation and ecology of the environments where these species live.

Fig. 1: The "Quelona" Sea Turtle Rescue Center operates within the framework of the Department of Biochemical Biology and Pharmacy of the National University of the South. Recently, it was authorized by the Directorate of Flora and Fauna of the Ministry of Agrarian Affairs of the province of Buenos Aires (Argentina), and is the first in the country to achieve official recognition of this type. The photos are from the official "Quelona" account on Facebook.

To report a ladybug sighting, the project requires individuals to send one or more photos along with the date and geographical location of the sighting. The project offers three methods for submitting this information:

- Through the site `www.argentinat.org`, where participants must join the Vaquitas project. Once part of the project, they can upload the collected information on an "observation card." This includes entering the date and place of the observation. This functionality is available via browser on a PC or on a mobile device with Android or iPhone.
- Through a WhatsApp message to the number +5492944239168, which includes the photos, location, and any relevant information the observer considers important.
- Through an email to `vaquita@comahue-conicet.gob.ar`, which includes the photos, location, and any relevant information the observer considers important.

2.2 iNaturalist

The iNaturalist platform [4,5] is defined as an online social network where people share biodiversity information to help each other learn about nature. It serves as

(a) Making an observation from the mobile application of iNaturalist.

(b) Making an observation from the web site of iNaturalist

Fig. 2: An observation records an encounter with an individual organism at a particular time and location. These observations can be record through the web site or a mobile application.

a crowdsourcing species identification system and a tool for recording organism occurrences. Users can record their own observations, get help with identifications, collaborate with others, collect information for common purposes, and access observational data collected by other users. This project helps identify the plants and animals around us while generating data for science and conservation.

To make an observation, users can do so through the web or from a mobile application available for Android or iPhone. The process is similar to that in the previous case; an observation is made by capturing one or more photos and including pertinent information along with the location. Users can link to projects and contribute to them.

2.3 EcoRegistros

EcoRegistros [7, 9] is a platform designed as a meeting point for bird watchers, nature photographers, filmmakers, and sound engineers. It provides a space where each person can contribute fauna information, which is automatically organized into species-specific cards. The EcoRegistros team embraces two fundamental ideas. First, they emphasize the importance of community in achieving significant works. They create a space where generalists, specialists, and amateurs can provide valuable information. They believe that extensive works, like books or electronic formats, should be built by the community, recognizing diverse knowledge and experiences. Second, they highlight the role of technology in this collaborative process, stressing the need for order, ease of development, and communication between collaborators. Technology is seen as a tool for documentation, using a highly typified system that eliminates ambiguity and allows easy access to necessary information.

A distinctive feature of the site is the automatic generation of geographic distribution maps based on entered records, providing an instant and up-to-date view of species locations. The platform is a valuable tool for learning, research, and nature dissemination. Its objective is to facilitate community participation in building knowledge about fauna, hoping this tool will be useful for anyone interested in exploring and understanding biodiversity.

To contribute information, users must register on the site and complete a form depending on whether they wish to incorporate graphic, auditory, or other types of information. There is an upload form where users enter all relevant information.

2.4 Discussion

In the cases presented in this section, a common factor is the user's role in entering sighting information into a system. In all instances, the user completes a form detailing relevant information about the sighting, especially the geographic location and images. This process requires the user to devote time and attention to recording the sighting.

This is crucial because it relates to the user's context. When recording the location where a fisherman found a turtle trapped in his nets, we must consider the fisherman's environment. On a fishing boat at sea, a fisherman's attention is focused on fishing and handling the nets. It is unrealistic to expect a fisherman to take out his cell phone and complete a form with the required information in such a situation.

This particular context makes it impractical to use solutions similar to those detailed in this section. Instead, we moved forward with our own development, focusing on facilitating the interaction between the user and the system while maintaining the required functionality for the project.

This article is organized as follows: In the next section, we describe works similar in functionality to what we intend to carry out and discuss why these developments do not meet the needs of this project. Then, in Section 3, we detail our proposal, including its scope and limitations, along with information about the design, development, and testing of the system. Finally, Section 4 summarizes the conclusions of our work and outlines the areas that remain open for further research.

3 Our Proposal

Our proposal to address the issues raised is the creation of a mobile application that allows fishermen to send the precise location where they encountered a turtle. The mobile application should be simple and enable the user to send the position, along with the date and time, in as few steps as possible.

Additionally, a web portal is necessary to display the information received from fishermen. This portal should be intuitive for researchers and rescuers to use, collecting basic information such as date, time, and geographic coordinates. This setup aims to resolve the aforementioned problem effectively.

3.1 Design & Development

The main objective when designing the application was to make it as simple as possible, following the premise set by the "Quelona" team from day one: "*using the application is a favor that the fishermen do for us.*" Therefore, from the first version, we opted for a "Big Red Button" application where the only action required from the user is to press the button, which sends their GPS location to the database along with the date and time.

Technologies were chosen based on familiarity and ease of access to necessary libraries. The Ionic framework was used with Angular for the code, avoiding native Android development due to lack of experience in that field. The use of Capacitor, provided by Ionic, allowed access to the cell phone's GPS API, obtaining the location easily and quickly. Although the tools allow for iPhone development, it was decided not to pursue this due to the cost of obtaining an Apple developer license, which was not feasible.

Once the GPS functionality was completed, a database service was needed. Firebase from Google was chosen for being free, easy to integrate, and manageable with a new Gmail account, which was also used to create the repository on GitHub. This completed the development of the mobile application.

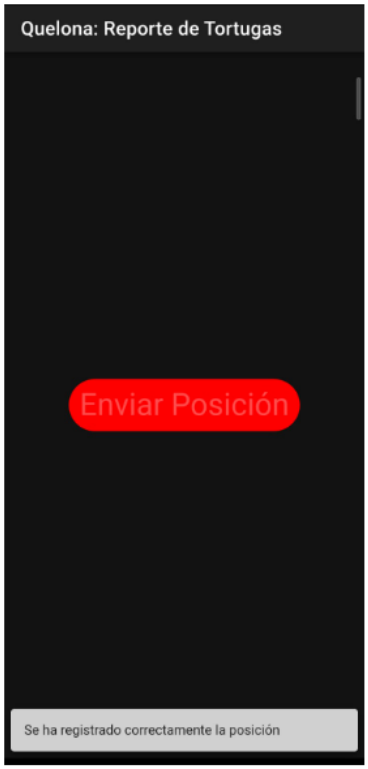
Along with the development of this functional requirement, two non-functional requirements emerged. The first, critical for the proposed use case, was the need for data persistence in scenarios of low or no connectivity. To address this, a queue was implemented to store the data and a service was created to check connectivity. Once connectivity was restored, all stored data would be sent. The second non-functional requirement was to prevent fishermen from accidentally sending the same position multiple times. To achieve this, the button was disabled once the position was registered in the queue, and a toast message indicated that the position had been recorded. The button would be re-enabled 20 seconds later to allow for additional turtle encounters to be recorded.

After this, we began developing the web application to observe the information and host the other functionalities required by the work team. The key functionalities required were:

- Viewing GPS positions recorded by fishermen, including longitude, latitude, date, and time.
- Associating each GPS position with a unique code entered by the work team.
- Downloading all information in .csv format.

To keep the development concise, we chose Angular for the web application and GitHub Pages for hosting, as it provided a simple, free, and effective solution. Seeking an attractive and maintainable visual solution, we incorporated the Angular Material library to use prefabricated components, enhancing the code's maintainability for future iterations. From this library, we used NavBar for the application header, Footer, and Tables. The Tables, in particular, were instrumental in fulfilling some requirements to refine the information visualization.

(a) Single screen fishermen application. In order to maintain the simplicity of the system, only one button was tested to record the position in which the angler encountered a turtle.



(b) Single screen of fishermen application, after sending the position. The button is disabled for 20 seconds after successfully registering the location.

Fig. 3: When designing the graphical interface of the application, the main objective was to make it as simple as possible. The "Quelona" team emphasized that using this application was a favor the fishermen were doing for us, so it was crucial to minimize any interruption to their work routine.

Additionally, we added the ability to sort the information in ascending or descending order based on different table headers (Code, Date, Time, Longitude, Latitude) and to filter the data based on a desired date range. Once the development was completed, the page was hosted on GitHub Pages.

3.2 Test Cases

We began the testing stage with the mobile application in operation along with its respective database to verify the registered positions. Initial tests were conducted on our personal cell phones at home, and the results were satisfactory

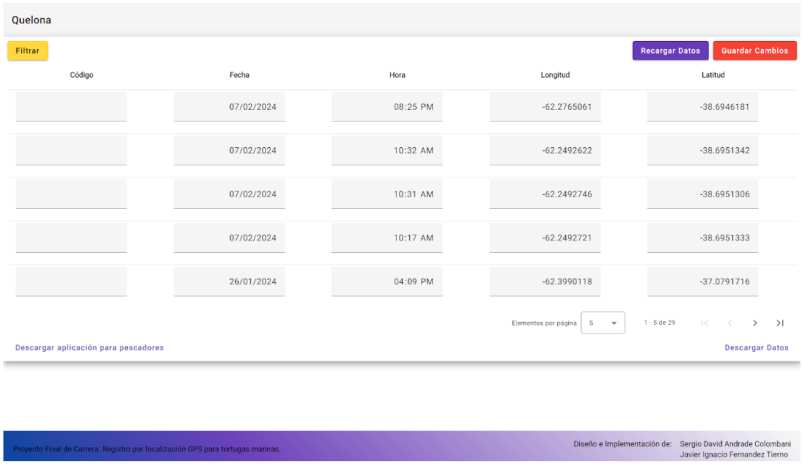


Fig. 4: Full view of the data management web application.

as the coordinates were recorded correctly, though not precisely accurate to the actual locations.

Locations were also recorded from other common places within the city of Bahía Blanca. The results were approximately correct, within a few meters of the actual location from which the position was sent. Additional tests were conducted by disconnecting the devices from Wi-Fi and mobile data, then reconnecting to verify the positions sent in these cases. Tests included sending the location from one point, moving to a different point, and then reactivating the device's internet services. The results showed the positions recorded were from where the signal was sent, not where the device was when reconnected. The initial tests were satisfactory, but there was still a discrepancy between the real location and the recorded location, with errors ranging from approximately 100 meters to 500 meters.

Further tests were conducted on third-party mobile devices to verify compatibility, yielding good results and new positions from different cities, including Bahía Blanca, Sierra de la Ventana, Bariloche, and even Barcelona (Spain). In one test, two devices more than ten blocks apart recorded the same position, prompting further investigation.

After a few weeks, we discovered an additional function that allowed mobile devices to send geographical coordinates with greater precision. This new function significantly improved location accuracy, solving the initial problem. Tests continued in different cities with various devices to ensure compatibility and portability. All data, from the beginning to the end of the tests, were verified using Google Maps, which allows geographical coordinates to be entered and recorded positions to be displayed.

By early December 2023, the project was ready for field testing. We had arranged a departure with the "Quelona" researchers and a fishing team. Un-

fortunately, on December 17, a severe storm hit Bahía Blanca and the region, causing fatalities and injuries. With winds exceeding 100 kilometers per hour and heavy rainfall, the storm resulted in the fall of trees and poles, as well as widespread power outages. The fishing boats were damaged, preventing the program field tests from being conducted. The peak period for turtle occurrences in the area is between December and March, so we must wait for the 2024-2025 season to put the developed system to real use. So far, all tests have shown that the system works correctly.

4 Conclusions & Future Work

This work aimed to develop an information system to aid in the conservation of sea turtles by providing accurate data on their GPS location, time, and date when they are trapped in fishermen's nets. This objective was achieved through the development of an Android mobile application for fishermen and a web platform for researchers and rescuers to collect and use the information.

On the mobile development side, a robust and easy-to-use application with an intuitive interface was implemented. This allows fishermen and rescue personnel to quickly and accurately record bycatch incidents, ensuring effective adoption of the tool in various fishing contexts. This development generated a database to understand patterns and identify critical areas for turtle conservation. On the web platform side, a site was developed where the collected information can be viewed, new data can be incorporated, and data can be downloaded for further use and processing, as preferred by researchers and rescuers.

This project follows an open-source policy and is available to anyone who wishes to extend its functionality or apply it in other areas. We hope this work serves as a foundation for new applications aimed at fauna conservation and protection.

The project faced several challenges, such as the inability to conduct user tests in the estuary due to adverse weather conditions and the inability to develop a distributable version for iOS devices. Additionally, an iPhone version was not developed due to the need for an Apple developer license to distribute the application.

The idea of including a heat map on the website for better visualization of recorded geographical coordinates was considered but discarded to reduce the website's complexity and make it simpler and easier to read.

Furthermore, the Angular Material library was incorporated to use prefabricated components, increasing code maintainability for future project iterations. This decision also favors extensibility for future iterations requiring new functionalities. Finally, all accounts created for the project's development are not linked and are free for those interested in continuing the development.

As final closing words, we would like to highlight that interdisciplinary work is crucial for achieving conservation objectives and is essential for student development by exposing them to real-world conservation issues. Engaging with actual conservation challenges allows students to understand the complexities

involved and learn to address them effectively. Moreover, interacting with real clients helps students to listen to and understand the specific needs of stakeholders, enabling them to provide practical and impactful solutions for biodiversity conservation. This hands-on experience is invaluable for preparing future conservationists to make meaningful contributions in their field.

Acknowledgments. This work was partially supported by the following research projects: PGI 24/N059 and PGI 24/N050 from the Secretaría General de Ciencia y Tecnología, Universidad Nacional del Sur, Argentina.

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