Remote electronic monitoring technology solution for small and big and big scale fisheries

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Shellcatch has developed and applied its electronic monitoring system technology and functionality to 700+ small-scale fishing vessels in the Eastern and South Pacific and of Latin America, Eastern North Pacific, and the Arabian Sea. Recent hardware improvements combined with an optimized Artificial Intelligence algorithm and improved web platform have increased the detection rates and accuracy of various classes of bycatch (average score $=\sim 85-90\%$) while reducing dependency on human observers at a 5-25% of its cost. Shellcatch is looking to build collaborative partnerships with the scientific community in different parts of the world to test the accuracy of its system and further develop system functionality.

Index Terms—**Coastal monitoring, Large scale fishing, Fishing technology, Virtual observer**

I. Introduction

Monitoring bycatch in large industrial or small-scale coastal gillnet fisheries is notoriously challenging due to the inability to place observers on small vessels, and the difficulty of verifying information provided by fishers during interviews [1]. Remote Electronic Monitoring (REM) usually includes integrated onboard systems of cameras, gear sensors, video storage, and GPS units that capture video of fishing activities, with a current development trend towards the automated analysis of footage to flag vessel activity of interest, using wifi, satellite or cellular networks to transmit data in near real-time [2]. REM systems have been developed in the United States and Europe with moderate success in using recorded video to monitor the volumes of non-target fish bycatch as fish are sorted on board [3]. However, these systems were deemed less successful for monitoring cetacean bycatch due to their positioning, and less suited to artisanal fisheries in developing countries due to their high cost, the need to provide dry space on board for computers, battery packs, and computers, and highspeed 3G-4G networks requirements for transmission of real-time data [2].

Shellcatch has successfully implemented a technological vessel catch verification system for over 700 vessels and 15 coastal sites in the Eastern North and South Pacific, and Arabian Sea. Our work in these regions leveraged an official request from national governments and NGOs to monitor small-scale bycatch. The disruptive cloud system included the design and assembly of a small, waterproof video camera that can be mounted on an industrial vessel or even the smallest fishing vessel, and set to record sets and hauls of fishing gear [4]. In addition to the design and deployment of the unit, we created a simple smart-phone app that permits to configure of camera units remotely and also acts as an automatic data collection network at port (as soon as the cell phone is within $3G-4G$ network or WiFi range) as an alternative mean for data transmission, allowing the footage data together with GPS tracks of each fishing trip to be uploaded. Nevertheless, the Shellcatch uploader system is much quicker and more efficient in uploading data to the cloud platform so that machine learning and video analysts can provide near-real-time data on bycatch (or lack thereof). The system offers a unique opportunity to accurately monitor and collect statistics on fisheries practices, including the type of gear used, locations where nets are set, and any possible seabird, turtle, or marine mammal bycatch of high conservation value. The system can also be used to promote good release practices, enhance the implementation of sound-management measures, or certify a fishing operation as bycatch free. [5]

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II. Our Approach

Shellcatch mission is to bring technology to every dock with products that disrupt and accelerate the way governments, NGOs and fishing communities manage, monitor and market the ocean resources. With offices in four countries and eight years of work in fifteen countries with over 800 fishers, Shellcatch has created cutting-edge software and hardware as an approach to strengthening fisheries management. These technologies are highly flexible and have been customized to specific countries' needs and specific species fishery management plans.

Our methodology is composed of three stages: reporting, monitoring, and marketing. Shellcatch implements this methodology to build trust, credibility, and momentum. It is about adding value to fisheries management while helping fishers improve their livelihoods. From a fisheries management perspective, the methodology represents the increasing scale and saving time, while from a fishing perspective, it allows growing the business and ensure happy stakeholders.

III. Vessels of all sizes

Shellcatch has developed a unique technology whereby a small, rugged, waterproof monitoring system can be mounted on even the smallest fishing vessel.

Fig. 1. Shellcatch cloud based system

Fig. 2. Shellcatch Camera.

With its video and GPS (Global Positioning System) sensors, the system can be configured to track sets and hauls of fishing gear, measure vessel speed, record video, and track and manage its energy consumption autonomously. As part of this system there is an additional WiFi data link unit that captures the information from the boat, processes the video and GPS data and uploads it to the secure Shellcatch cloud platform, thus avoiding the need and time-consuming process to extract memory cards from monitoring units and transport them to have their contents downloaded, shared and analyzed.

Shellcatch has also created a customized smartphone app (Figure 3) that allows user to configure the monitoring unit and understands its basic functioning parameters.

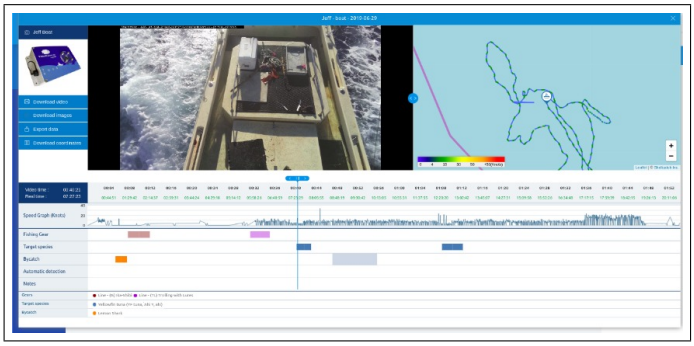


Fig. 3. Shellcatch cloud base dashboard.

The cloud component allows for accurately monitor and collection of statistics on fishing activities, bycatch of high conservation value wildlife, and/or certifying (verifying) a fishing operation as bycatch free in an efficient way that also prevents human errors in unnecessarily manipulating hardware and physical storage of video footage information.

Dimension	$58 \times 121 \times 203$ mm
Weight	714 g
Battery	13000mAh
Input Voltage	$7 - 24$ V
Picture resolution	$8\text{MP}(3280 \times 2464\text{px})$
Picture format	JPEG
Connectivity options	Wifi + GPS
Other options	2G/3G/ NBIoT (Narrow-Band IoT) / Iridium Satellite

TABLE I
SHELLCATCH CAMERA SPECIFICATIONS

IV. SHELLCATCH AI ALGORITHM

Creating accurate machine-learning models capable of localizing and identifying multiple objects in a single image remains a core challenge in computer vision [5]. The proprietary algorithm (Figure 4) is built on top of an open-source framework that makes it easy to construct, train and deploy object detection models.

Fig. 4. Sample of Shellcatch AI detection.

The art of machine learning lies in the fact that unlike traditional algorithms, where the computer is told exactly what to do in order to accomplish a certain task, in machine learning, the computer is not explicitly told what to do next. Instead, machine learning implies a set of training data that the algorithm uses to generate its own set of rules required to accomplish the task at hand.

The process is divided into two main stages: training and testing. While building the neural network, the algorithm first analyzes all the images on disk and calculates the bottleneck values for each of them. Once the bottlenecks are complete, the training of the network begins. By default, our algorithm runs 4,000 training steps. Each step outputs training accuracy, validation accuracy, and the cross entropy. The training accuracy shows what percent of the images used in the current training batch were labeled with the correct class. The validation accuracy is the precision on a randomly-selected group of images from a different set. The key difference is that the training accuracy is based on images that the network has been able to learn from, so the network can overfit to the noise in the training data. A true measure of the performance of the network is to measure its performance on a data set not contained in the training data; this is measured by the validation accuracy.

V. Coastal camera

As part of the surveillance of marine fauna, the coastal camera solution consists of placing fixed surveillance cameras for marine fishing protection zones, which capture consecutive images to be processed by means of a microprocessor using artificial intelligence algorithms for object detection. The objects to be detected are humans and boats. These detections must be relevant with a high fidelity rate of more than 80%. For this purpose, different heuristics are used to help eliminate false positives. [4]

Fig. 5. Coastal camera IA detection.

Upon detection of any intrusion by the neural network, the end user is notified instantly using two forms of communication. The first is using $3G-4G$ technology for communication via the Internet, using a cloud server as an intermediary and can close the communication chain to the end user. The second technology is satellite communication, which will send relevant metadata of the alert and notify the end user. In parallel, the camera has a backup of captured images that can be collected with a cell phone for future audits. The entire system is powered by solar energy and batteries that guarantee the autonomous operation of the camera.

VI. Reducing dependency on human observers

Small-scale coastal fisheries around the world are increasing their fishing effort to meet the evergrowing global demand for fisheries products [6]. A high proportion of these fisheries, particularly those in developing countries, use gill nets, a gear known to be associated with high levels of bycatch of nontarget high conservation value species like marine mammals and turtles [7]. While on-board observer programs have played an important role in adequately describing, monitoring, and eventually reducing by-catch in some large-scale offshore fisheries [2], small scale coastal fisheries present a greater challenge for observation and monitoring, particularly in remote areas where resources are scarce and new technologies are difficult to implement. For a typical daily fishing trip of 12 hours, Shellcatch REM system allows to reduce video footage analysis to less than 1 hour, using speed graphs and automatic fishing activity alerts. The cost of Shellcatch REM system on a one-year basis for one boat fishing an average 15 days per month is typically in the range of 5-25% of the cost of a human observer (variation depending on the country).

At a 1 image / 5 seconds framerate, our system allows to take continuous $24\ \mathrm{h/d}$ footage of a 19 days fishing trip.

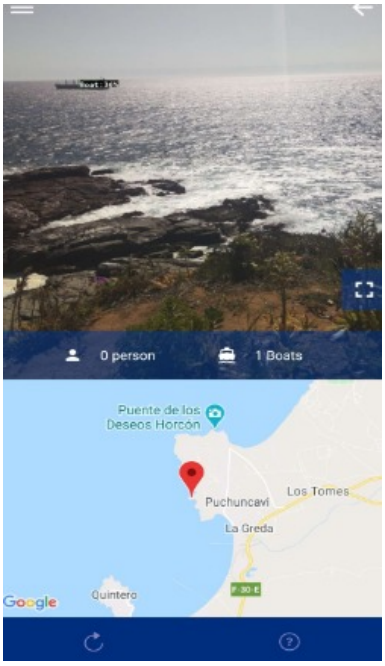


Fig. 6. Coastal camera app alert.

VII. Simple deployment

Shellcatch camera can easily be installed either with autonomous energy (solar panels) or directly to the boat's energy source. A data collector leverages the Internet connection to automatically upload information. All the information is uploaded to Shellcatch web platform which automatically processes the information. This significantly decreases the amount of video screening time needed and allow organizations to focus their efforts on important events only. The Shellcatch platform aims to streamline the management, storage and review of video footage and offers the following features amongst others:

- Review and registration area: The system allows to review and record events, fishing gear, target fishing and by-catch. This GPS and Video system lowers the review time.
- The graphics contain the results of the information generated from the videos to be able to make reports.
- Artificial Intelligence: The automatic detection of certain events relevant to the fishing in question can be implemented.
- Download: All videos and coordinates are downloadable and exportable.
- Search: The system is designed to upload a high number of videos. This includes a search mechanism to go directly to a specific vessel or fishing trip.

VIII. Discussion

Bartholomew et al. [4] assessed the ability of Shellcatch remote electronic monitoring (REM) system to identify and quantify captures in a dedicated Peruvian fishery by comparing its performance to on-board observer reports (five boats and 228 fishing sets). Their results showed that cameras were an

effective tool for identifying catch, with $> 90\%$ detection rates for 9 of 12 species of elasmobranchs, 50% for sea turtles, 80% for cetaceans, and 100% for pinnipeds.

REM can provide a time-and cost-effective method to monitor target catch in small-scale fisheries and can be used to overcome some deficiencies in human observer reports [4].

Since 2016, Shellcatch has modified the camera specifications and improved its accuracy in detecting target catch and bycatch species. The latest camera system (Table 1) features an improved camera chip (8 Megapixels), larger battery, and improved connectivity options. These new features enable the system to take better pictures (previous camera resolution $=\sim$ 5 Megapixels) while operating in the field continuously for ~ 36 hours without charge (previous camera system operation time $=\sim 16$ hours). The improved connectivity options allow the data to be transmitted over various networking interface (WiFi, 3G-4G GSM), thereby reducing the dependency on just one channel (old system uses WiFi). The improved network infrastructure enables the system to collect data from far away boats, thereby resulting in quicker turn-around time of the trip data.

All the above-mentioned hardware improvements combined with the optimized Al algorithm and the improved web platform have boosted the detection rates and accuracy of various classes (new average score $=\sim 85 - 90\%$).

IX. Conclusion and future work

Marine fisheries are facing increasing pressure on a global scale from widespread over fishing habitat destruction and climate change [6]. These cascading impacts are threatening the livelihoods of millions of people who depend on them for subsistence and income, while many developing countries fisheries are associated with high levels of bycatch of nontarget species [7]. As a result, over 300,000 sea mammals die each year from fishing activities [8], [9]. Governments are far from leveraging IT technologies to become more efficient, create relevant policies and capture data that would improve their management strategies.

Shellcatch develops cutting edge traceability technologies and deliver them through a marketbased approach that empowers fishers, strengthens government-monitoring programs and provides a more cost-effective solution for the industrial sector. The REM system that Shellcatch has developed and implemented in the Eastern North and South Pacific, and Arabian Sea has proven to be efficient in decreasing human analyst dedicated time, increasing monitoring coverage, improving data robustness and compliance to allow fisheries agencies to reduce uncertainty and react more rapidly, while machine learning and Al have become more reliable. Shellcatch REM system offers an increasingly robust technological solution in cetacean bycatch and the monitoring of other high-value conservation species such as sharks and rays. Furthermore, the powerful integration of eMonitoring, eReporting and eMarketing that Shellcatch has recently successfully implemented in the Eastern South Pacific is providing tangible market and unlocking operational benefits to seafood industry participants and amongst them, especially fishers.

The value of collaborative research between the industry, the academy and the nonprofit sector helps drive innovation and development. Shellcatch is a mission-driven company willing to establish partnerships and research collaborative processes with the international scientific community by lending prototype systems to conduct more trials on the effectiveness of the Shellcatch system to monitor cetacean bycatch and support the continuous development of its technology.

X. Fishing video annotations

The Shellcatch platform is designed so that users can make fishing annotations in a simple and friendly way, because the platform is fully automated and presents icons and legends that accurately describe the data entered by the user; therefore, the user is able to view the fishing videos, make annotations quickly and generate a statistical summary of the data entered. [8]

A. Viewing the fishing day

All the videos recorded during the fishing trip are uploaded to the Shellcatch platform according to the sequence in which they were generated, making it very easy to understand the dynamics of the fishing days, from the first to the last day of the fishing trip. Additionally, the fishing videos can be recorded 24 hours a day, which gives us much more details of the fishing trip at all times.

B. GPS Geolocation

The Shellcatch platform for the review of fishing videos, presents a section in which you can view the route followed by the boats, thanks to the geolocation of GPS coordinates and likewise, that route is observed within a satellite map on the same platform; which is very useful in terms of extracting additional data from the fishing trip, such as: The port of departure, the distance traveled by the vessel, the area of greatest fishing activity, among others. [10]

C. Fishing and vessel data characterization

In the Shellcatch platform, the user can make annotations in a simple and automated way, recording the precise time at which the events associated with the fishing trip are observed. In addition, the platform collects individually the fishing data for each generated video and once the annotations are made, the platform generates specific symbols for each data recorded in the fishing video. The data to be recorded are the following: Fishing data: 1) Knot speed of the vessel, 2) Fishing gear used by the vessel, 3) Target fishing species, 4) Bycatch species and 5) Fishing events (human activities, problems in camera vision, others). Vessel data: 1) Name of vessel, 2) Date of video generated. [11]

D. Statistical summary of fishing activity

In addition to the review of videos and annotations, the Shellcatch platform offers a statistical summary of the conglomerate of data recorded on the platform, such as the

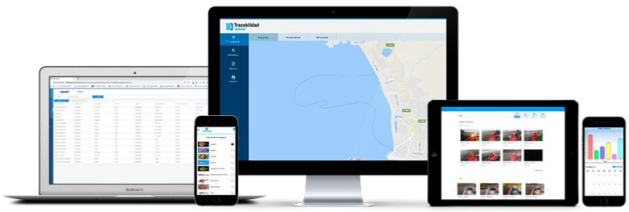
percentage of target or bycatch species, or the proportion of fishing species, which can be visualized through graphical representations. This is very useful for the user as he can continuously see the behavior of the data generated by the annotations of the fishing videos.

E. Virtual remote monitoring

The review of the fishing videos is completely virtual and can be observed from anywhere the user is.

F. Document updating

The Shellcatch platform allows documentation to be constantly updated, so the user can upload documents related to fishing video observations quickly and directly.



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