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Developing techniques for mapping and characterisation of artisanal fisheries in Oman.

Introduction

Organisations including the Ministry of Agriculture and Fisheries Wealth, Environment Authority and Environment Society of Oman have been working on monitoring and management of sea turtle and marine mammal populations in the Sultanate since the late 70's. During that time artisanal fisheries have expanded in fleet size and spatial extent due to modernisation and infrastructure improvements. In 2010 a committee of the above organisations consulted with the public (including artisanal fishermen) to understand if there were potential threats to turtles and marine mammals from artisanal fishing activities and initiated a programme of work to investigate co-occurrence and bycatch landed on skiffs and dhows. Additional financial support has been provided by the US Department of Interior, US Fish and Wildlife and National Oceanographic and Atmospheric Administration, and technical support from Ocean Ecology Network, Five Oceans Environmental Services and Future Seas.

Description of Activities

The 'Masirah Community-based Fisheries Project' was initiated in 2009. Masirah Island sits 13km off the mainland in a known biodiversity hotspot (including Important Marine Mammal Area and Ecologically and Biologically Significant Area). The island has a population of approximately 12,000 with artisanal fishing one of the leading activities for domestic income. Table 1 below summarises the work conducted to date resulting in the development of Remote Electronic Monitoring (REM) systems for the purpose of mapping of fishing activities and evaluating bycatch.

Table 1. Summary of objectives and achievements of fisheries mapping and characterisation work from the 'Masirah Community-based Fisheries Project' between 2010 and 2023.

Year	Objectives	Achievements
2009-2010	○ Preliminary consultation with the fishing community on Masirah island to profile artisanal fisheries and understand potential for interaction between fishing and non-targeted taxa. ○ Develop leads for engaging fishmen in effort and bycatch mapping trials. ○ Investigate future funding options.	○ One family-owned company with a factory and owning numerous skiff and dhow vessels agreed to work with the investigation team. ○ A consultant team visited dhows and skiffs and made initial report on discussions for setting up data collection and experiments. ○ Funding proposals submitted for future work.
2012-2013	○ Characterise and map artisanal fishery through questionnaire surveys. ○ Review trends and evaluate potential for bycatch. ○ Provide recommendations to committee for next steps. ○ Investigate further sources of funding if required.	○ Over 100 fishermen were interviewed representing skiff and dhow fleets. Participants provided information detailing the seasonality of target catch, gear used and bycatch. A mapping exercise compiling hand drawn annotation of sea areas visited (compiled within a GIS system) provided the first overview of fishing gear space-use in the area. ○ The project committee agreed there was sufficient requirement to support on-board data collection efforts to evaluate bycatch and investigate suitable techniques for collecting data from artisanal vessels.
2015-2016	○ Development of crew-based observer method for documenting fishing effort, gear use and bycatch.	○ Approximately 8 vessels were trained with a combined log-book, camera and GPS (waypoint) data collection technique.

	○ Implement new method with a 6-month programme of data collection. ○ Provide committee recommendations for future monitoring	○ The technique failed to be used appropriately by fisher crews to provide useful information. Literacy, cultural barriers, perception of importance (to the crew) and ease of implementation were considered reasons for failure of this approach. ○ Standard GPS trackers (logging units) applied later in the season (set at 1 min logging intervals) provided useful tracking data of vessel movements. ○ A GIS team developed manual processing algorithm and processing method to convert tracking data into effort maps for drifting gillnet fishing operations. This worked well for vessels engaged in drifting gillnet operations. Effort could not be defined for anchored gillnet operations due to track complexities. ○ The success of tracking data application resulted in recommendations to continue the remote electronic monitoring with the addition of cameras to monitoring the deck in future seasons. The cameras to be used for ground truthing of vessel modes, events on deck including capturing landed bycatch.
2017-2018	○ Installation of Remote Electronic Monitoring (REM) systems on a larger fleet, targeting only dhows. ○ Review success of logging. ○ Produce maps of fishing effort and co-occurrence with bycatch. ○ Recommendations for next steps with local stakeholders and committee.	○ 14 dhow vessels were fitted with REM systems for a period of up to 9 months. ○ Equipment used included simple GPS track loggers (IgotU) and Brinno TLC200 time lapse camera. Equipment was ordered off the shelf, fitted with extended battery life and mounted in a electronic box on a scaffold pole over the deck of the vessel. ○ Cameras had an operating time of approx. 6 weeks and GPS loggers of 3 months set on 1 minute intervals. Total system cost of approximately per vessel per year of 500 USD. ○ 8 vessels produced data from the system. Data was patchy due to difficulty in intercepting vessels when they returned to port to recover the data and refit refurbished REM system. ○ A GIS team worked on manual process of track and camera data. The systems provided excellent performance for defining fishing effort (of drifting and anchored gillnets) over a 4–6-week period before the need for system intervention and maintenance. ○ Resolution of images and dirt on camera optics prevented the camera system for providing species level identification of catch and bycatch. ○ Sufficient information of co-occurrence of summer fishing with turtle distribution and density resulted in recommendations for bycatch reduction experiments.
2022 - 2023	○ Installation of upgraded REM systems for bycatch mitigation experiments. ○ Fisheries engagement exercise to develop method for collating	○ Review of affordable REM solutions for fisheries mitigation trials. ○ Purchase of Telematics vehicle tracking systems (used for cars) with 1 year service contract to log vessel tracks (at 10 second intervals) and

	information on target catch and bycatch. ○ Develop method for parallel trials of surface vs subsurface gillnet setting during routine fishing operations. ○ Review vessel effort and catch statistics. ○ Provide recommendations for additional trials and mitigation options. ○ Test satellite remote sensing techniques to detect and map artisanal fishing fleets ○ Integrate results and applications with Vessel Tracking Systems (CLS Nemo units) recently installed on artisanal dhow vessels	relay data via GSM network. Geofencing of fish landing sites to allow fast response of field team to recover REM system data and fit reconditioned systems. ○ Purchase Brinno BCC2000 timelapse camera system with 1040i resolution, 1 min interval and 40-day endurance. Total system cost for tracking and video data anticipated to be approximately 750-1000 USD per vessel per year (to be confirmed by end of year) ○ Fisheries trials planned to start in March 2023. ○ Research and development of remote sensing options with application of free Sentinel data together with ground truthing vessel counts for detection and mapping of dhow vessel distribution. ○ Higher resolution data in consideration for detecting smaller skiff vessels. ○
2023-Onwards	○ Scaling of fisheries experiments and REM techniques for vessel-based monitoring. ○ Fisheries consultation to adopt techniques with reduced bycatch	

Summary

Independent fisheries observer strategies for data collection on vessels remains a challenge to dhow operations due to difficult living conditions on vessels, and for skiffs due to the number of vessels operating.

Crew based observer strategies have been successful in artisanal fisheries in some localities in the IOTC area (i.e Pakistan), but not initially successful in Oman. Literacy and other cultural values of crew (and lack of incentives) are considered as reasons for the difficulty in implementing this strategy.

REM approaches tested so far have been suitable for developing fishing effort spatial data that can be used in conjunction with species distribution models for co-occurrence analysis.

Constraints with the REM systems tested so far have been recovery of data from the vessels, maintenance and refurbishing of REM systems to provide continuous coverage and for the image resolution to be sufficient for accurate identification of catch.

For mapping and characterisation of artisanal fishing effort, mapping requires track logging interval of at least one location point every minute to determine the vessel mode. Use of cameras further enhances the value of track data for effort mapping at an interval of one minute. Higher sampling rate of pictures and high-resolution video (1040i) is required to be able to detect bycatch events and identify catch. Multiple cameras may be required to capture effort and bycatch events.

REM systems require a field intervention team with multilanguage capabilities to engage with vessel captains of different nationalities. Whilst tracking data is easily acquired with (with minimal system intervention and remote access to data), high quality imagery is difficult to attain over a long period of time due to high data storage requirements (which restricts access via remote transfer) and servicing required to keep camera optics clean. However, when systems are functional, they can be more reliable (for specific purposes) than data collected by vessel crews.

REM systems develop high volumes of tracking and event data for processing. Currently this is done manually and requires a lab/ team-based approach to process data from many vessels across a season. Resources need

to be applied to streamlining and automating the data processing workflow to make REM system use a reality if it is to be applied at any scale.

The team in Oman will look at combining the crew-based observer manual data collection techniques together with REM systems to improve data collection performance over the next year (2023-2024). Collaborations have been sought with other projects (including WWF Pakistan crew-based observer programme) to gain insights on successful crew-based data collection. This will also be combined with trials to map the distribution of vessels from remote sensing imagery.