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Use of still and video cameras to record deepwater shark and VME indicator catches by scientific observers - 31 August 2021

Summary from virtual meeting

Relates to agenda items:
Session 2 - Agenda Item 6

Delegation of FAO

Abstract

The purpose of this paper is to inform the SIOFA SC of a webinar on the use of on-board cameras to assist scientific observers in the collection of information required for the scientific assessments of fished stocks and potential impacts from fishing. The information is also relevant to compliance monitoring and supports industry meet their data collection requirements. The use of cameras would increase the efficiency of the observer's work and promote personal safety. Cameras would provide increased spatial and temporal coverage, as they could be used when observers were either off-duty or not carried. The hardware and software technologies are largely developed, but their use in commercial situations is in its infancy and requires support. Cameras could be used to efficiently monitor both catch and bycatch. It is important to have a clearly defined sampling programme, with target numbers by species, area and time, that is linked to the types of assessments to be undertaken. With this, tasks better undertaken by camera systems could be used to free-up observer's time for other tasks such as otolith sampling. The use of "mobile applications" could help direct the sampling requirements to be undertaken by observers.

INTRODUCTION

This information paper reports on a webinar on "The use of on-board cameras by scientific observers" held by FAO and supported by Japan and the ABNJ Deep-sea Fisheries Project. It also lists RFMO management measures related to data collection by commercial vessels.

Identifying, recording and monitoring fish caught at sea is a time consuming task. Observers on commercial fishing vessels are often requested to record retained and discarded catch, and take length-frequencies and otoliths of selected commercial species. Additional requests may include identifying and measuring catches of deepwater sharks and VME indicator species above threshold. The tasks assigned to observers quickly become untenable.

On-board observers formally fall into two categories – compliance and scientific. For example, during normal commercial fishing operations, NAFO has only compliance observers, CCAMLR has only scientific observers, and NEAFC does not carry observers. In the other regions, the assignment is often less clear with observers being given tasks that are both compliance and scientific related. Observers that have both compliance and scientific duties will usually prioritise data collection required by the control measures (Annex 1). This mainly involves recording the catch retained on board, as this is checked by inspectors when boarding or at port. It is also something that the vessel master monitors for their own commercial requirements. Additional compliance duties involve monitoring effort, fishing positions, fishing gear, etc. Scientific information relevant to assessing stock status, discards, and impacts is invariably given a lower priority and not collected due to time constraints. Further, observers' tasks are increasing as they are required to report on more and more things by their contracting parties. In addition, observers often work in dangerous situations for extended periods. The compliance and scientific "labels" are important and, generally, it is agreed that observers should be assigned as being either compliance or scientific, with their duties matched accordingly. However, this may be difficult for practical reasons, though in some cases two observers are carried on vessels (e.g an RFMO compliance observer and a CP scientific observer). Given the above, it was felt that on-board camera systems could be used to support observer in some of their data collection duties, and in so doing free up their time for other tasks that could not be undertaken with cameras.

The use of on-board cameras to support data collection falls into a continuum that range from cheap and simple to expensive and complicated. At one end, is the taking and cataloguing of photographs usually of difficult to identify taxa such as VME species or deepwater sharks. This is useful, but often requires trained observers with the knowledge of how to take the photographs. In the middle of the spectrum, for example, is the use of a chute to transport fish under a camera for identification and length measurements and is often associated with the use of artificial intelligence and pattern recognition software. At the top end is a multi-camera deck monitoring taking video of trawl or longline catches often connected to electronic monitoring winch activated systems and requiring extensive video storage and analysis capabilities. The more complicated system may operate independently of observers, and ideally would be designed to supplement information collected by observers rather than replace the need for observers. As presented at the webinar, the technology exists for all these systems and its use is somewhere between experimental and fully operational. The webinar explains the current status of these technologies and its uptake.

THE WEBINAR

This webinar was aimed at supporting scientific observers by using camera systems, though much of the content was also applicable to supporting compliance observers and industry. There were eight presentations on a variety of topics (Annex 2). It became apparent that it was not always easy to separate the use of on-board cameras and electronic monitoring (e.g. of winches) or vessel monitoring system (VMS).

The process of developing an electronic monitoring system using cameras to support on-board observers follows a reasonably well defined path, which was outlined in many of the talks:

- Clearly defined problem
- Solutions camera monitoring can provide
- Address "privacy" issues in advance
- Establish "user" chain (the various people/groups that will be involved)
- Source funding
- Identify hardware requirements (cameras, computers, winch recorders, satellite communications, etc)
- Identify/develop software requirements (image capture, image processing, AI, results format, etc)
- Perform trials, machine learning, validation of results, accuracy checking, etc.
- Operationalise system
- Review and further development

Video recordings from the webinar are available on the FAO YouTube site and are available through the following links:

http://www.fao.org/in-action/commonoceans/documents/videos-and-audio/en/
https://www.youtube.com/playlist?list=PLzp5NgJ2-dK5Ke9H5L5-BMYjvZN_opyvj

CONCLUSIONS

The webinar was entitled "Use of still and video cameras to record deepwater shark and VME indicator catches by scientific observers". In fact, five talks related more to data collection of the entire catch, two on deepwater sharks and one was a summary of a recent 3-day forum on the use of Artificial Intelligence in the marine environment more generally (FAO, 2021a). There were no presentations regarding VMEs, as there has been no systematic use of on-board cameras to record VME indicator catches beyond simple photographs (but see presentation by DJ Laycock that would assist this).

It is clear that there is potential for the use of on-board cameras to assist scientific observers in recording catch and bycatch data. And that this would lead to better temporal (i.e., 24/7) and spatial coverage and improvements in data quality. It would also help overcome constraints related to observer experience. The technology exists and its use has progressed beyond the experimental stage. It is still restricted largely to scientific trials, though it has gone beyond this in Alaska and Indonesia (see presentations by Cindy Tribuzio, Suzanne Romain, and Peter Mous). The use of cameras, in the process of collecting more and better data, can also support issues related to observer safety and working conditions (presentations by Stewart Norman & Chris Heinecken) and the requirements of industry (presentation by Andy Smith).
The use of on-board cameras needs to be supported with a clearly defined and targeted data collection programme. The programme must include precise types and quantities of data to be collected, and were and when they must be collected. This must be linked with the reasons for collecting the information and the subsequent analysis. Electronic applications, like the FAO SmartForms or the one reported by DJ Laycock, can ensure that observers are informed of what is required for the trips they are on.

The final consideration is how to reconcile the management/compliance information with the scientific information, and indeed the types of observers carried and their duties. The former is a requirement linked to the RFMO annual compliance reviews and the possibility of RFMO members being assessed non-compliant. The latter is not normally related to non-compliance, but results in scientific advice of a lower quality (or often being unable to provide advice).

REFERENCES

FAO. 2021a. Artificial Intelligence for a Digital Blue Planet - Forum Agenda - 28th, 29th & 30th of June 2021. [online]. Rome. [Cited 6 October 2021]. www.fao.org/3/cb5356en/cb5356en.pdf

FAO. 2021b. Use of still and video cameras to record deepwater shark and VME indicator catches by scientific observers Virtual meeting Tuesday 31 August 202108:00–10:30 and 14:00–16:30 UTC. In press.

ANNEX 1. MANAGEMENT MEASURES RELATED TO OBSERVER DUTIES

This summary mainly relates to the requirements to collect data, but lists some other measure where appropriate. Blanks reflect no measure adopted for that issue. These measures are binding on member States, though the precise "wording" is important and reference to the original measures should be made for further details. All recorded data is the property of the flag state CP and is submitted by the flag state to the RFMO secretariat, who make it available to other CPs and the committees under various rules governing transparency and confidentiality. Flag states also have their own rules for transparency and confidentiality and often the submitted data is in a summary form. It is often difficult to assess what data is actually collected on-board the vessels, passed to the flag state, then to the secretariat, and then to the committees.

Retained catch which is due to be trans-shipped or landed must be recorded and submitted to the Secretariat. This is done by the electronic catch reporting systems, in logbooks, and by observers. Associated information, such as gear used, effort and locations, is now usually reported to the Secretariats in more of less real time for compliance purposes. Catch (actually landings) are also reported to FAO by major statistical area, and finer in some regions, but is for ABNJ and EEZs combined.

There is often confusion and rather loose wording in the measures about the meaning of "catch". This is not helped when placed in a historical context where the objective was to estimate "production" from fisheries in terms of what is provided for human consumption or industrial use. Discarded catch was considered unimportant and not recorded. In general, "catch" now refers to "retained catch" and the principal purpose of recording this is for compliance with regulations. It is also relatively easy to verify by on-board inspections and port sampling.

The recording of discards is required in almost all regions, but again unclear if this relates only to discards of commercial species (i.e. the same species as those retained) or includes other non-commercial species. Strictly speaking, the measures do not distinguish and so require full discard reporting and is included in the electronic reporting systems. The principal use of recording the discards of commercial species is to assess fishing mortality necessary for the stock assessments undertaken by scientific councils, and is generally not an issue dealt with by the compliance committees. The recording and reporting of catches of VME indicators, usually when a threshold value is exceeded that elicits a management response, is required and is regarded as a compliance issue. The full reporting of VME indicators is less commonly required, but is of importance to scientific committees when assessing significant adverse impacts and is undertaken during some observer programmes especially when exploratory fishing is being undertaken.

In recent years, the full reporting of catches of sharks has been required, subject to the need for immediate live release, in most regions. Though this is clearly stipulated in the measures it seems that little reporting generally happens. There are no management responses attached to the catching of sharks, except for no directed fishing, and to report catches and release live if possible. There are no move-on rules associated with shark catches and this is not seen as a compliance issue.

The catches of vulnerable species, usually seabirds, marine mammals and marine turtles, are required and it seems are usually reported by observers. Whereas the actual catching of these species is quite easy to record, mortality due to strikes with gear by seabirds is very difficult to observe. The catching of these species may result in management responses and it is seen as a compliance issue.

Catches of other species, once referred to as "trash" fish, is required but it seems very seldom undertaken on commercial fishing vessels. This is likely a result of the difficulty and time taken to do this, and it is an activity that may be best undertaken by dedicated research surveys and on specific targeted vessels cooperating with scientific programmes.

	Retained (landed) catch	Discarded catch				
RFMO	**commercial spp**	**commercial spp**	**VMEs**	**Sharks**	**Seabirds, marine mammals and turtles.**	**Other associated species**
NAFO	Record in logbook and CAT report Also by observers to flag State (to nearest 100 kg)	Record in logbook and CAT report Also by observers to flag State (to nearest 100 kg)	Above threshold to flag State Also by observers to flag State	Report catches to flag State, live release (emphasis on Greenland shark). No directed fishing on Greenland shark.		Probably not required for logbook
NEAFC	"VMS" catch reports to FMC and Secretariat. Landing (monthly) reported to Secretariat by flag state	Ban on discarding certain commercial species (= herring, redfish, blue whiting, mackerel, haddock)	Above threshold to flag State and Secretariat	No directed fishing and report incidental catches for sharks, rays and chimaeras. Ndf for spurdog and live release.		
SEAFO	Yes, Patagonian Toothfish, Deep-Sea Red Crab, Alfonsino, Orange Roughy and Pelagic Armourhead. CA in CAT reports.	RJ in CAT reports and reported in annual catch tables.	Above threshold to flag State and Secretariat and summarised in SC reports.			Probably not,
NPFC	Yes, for retained catches by observers. I don't think they are required to be recorded in logbooks.	Unclear if observers record discards.	Above threshold to flag State		Observers in bottom fisheries to report these groups.	No, except in bottom fisheries where an observer is present.
SPRFMO	Reported by flag states annually. Data collected by observers?	Reported by flag states annually. Data collected by observers?	Above threshold	Reported by flag states annually. Data collected by observers?	Reported by flag states annually. Data collected by observers?	Reported by flag states annually. Data collected by observers?
SIOFA	Recorded in logbooks (includes target and non-target species). Observers to record.	Observers to record.	Above threshold	Ndf and full reporting with live release.	Observers to record.	?? Unclear if this is covered by recording on non-target species.
GFCM	Yes, key stocks to be entered in log-books (key stocks are European hake, Norway lobster, Common sole, Deep-water rose shrimp, Red mullet)	Probably not, though included in the DCRF.	Voluntary reporting by Cps for VME database.	Yes, if under vulnerable species	Yes, under vulnerable species	Not in shrimp fisheries. Not unless it is an ETP species.

ANNEX 2. SUMMARIES OF PRESENTATIONS

A summary of the webinar presentations are given below. A full description of the webinar is provided in the report (FAO, 2021b).

Title and **presenter**	Summary
Artificial intelligence for a digital blue planet – Summary from FAO workshop, 28–30 June 2021 **Kim Friedman, FAO**	Artificial Intelligence for a Digital Blue Planet Forum was held virtually on 28–30 June 2021, bringing practitioners and stakeholders together to share what innovations in artificial intelligence (AI) and deep learning are bringing to fisheries and aquaculture management, markets and consumers. The meeting hosted over 40 presentations on the current state-of-the-art in AI and how it is applied in a diverse range of fisheries situations. These products are evolving, and with the help of innovative technologies, we are finding ways to make these tasks simpler and more accessible to a broad range of users. Over the three day Forum, FAO explained why, what and how technologies and AI can be used to support information gathering in a wide variety of fisheries from all over the world in order to improve management and trade practices for aquatic resources. Recordings from the Forum presentations are available on the FAO YouTube channel.
Using electronic monitoring to improve data-limited catch estimates for sharks **Cindy Tribuzio,** NOAA-NMFS Alaska Fisheries Science Center	The stock assessment for sharks in federal waters of Alaska are considered severely data-limited, with harvest recommendations based solely on historical catch. Catch for large sharks is believed to be inaccurate due to gaps in the data available for total catch estimation in both longline and trawl fisheries. Electronic monitoring (EM) may provide new tools to close those gaps and provide previously unavailable data to improve the estimates of total catch of sharks. The project presented here has four objectives: 1) verify that can accurately detect sharks; 2) develop automated species identification to aid in video review; 3) use machine learning tools to size grade sharks based on visual cues; and 4) integrate categorical size data into total catch estimates. This project began in March 2021 and has already had success with industry participation and initial versions of species identification software.
A Picture is Worth a Thousand Words: Identifying Shark Bycatch using Artificial Intelligence **Paul Clerkin,** Virginia Institute of Marine Science	Sharks are known to be important predators in every environment they inhabit, yet most remain poorly studied. This is especially true of deep-sea sharks where most are data deficient, and 20 percent have yet to be described. Data from commercial fishing vessels is critical for researchers and policy makers, but constraints make it difficult for observers to collect the necessary information. Issues with proper identification of deep-sea sharks is the first and foremost hinderance blocking the flow of data from at-sea observers to researchers and policy makers. We believe that the solution is through technological innovation. By pairing traditional taxonomy, genetics, and information management systems with artificial intelligence, we hope to create a direct line of data from deepwater fishing vessels to researchers and policy makers.
Machine vision applications for observer data collection in Alaskan fisheries **Suzanne Romain** Pacific States Marine Fisheries Commission,	The North Pacific Observer Program trains and manages the data collections of over 450 observers per year with multiple target fisheries and gear types covering over 1 800 vessels and 20 000 fishing trips. Several image collection systems and machine vision algorithms have been developed for different gear types and target fisheries, one of which is an electronic monitoring camera system that records fish coming down a chute. Depending on the model loaded, the system is capable of identifying and enumerating fish and estimating length. Multiple years of data in two different regions have redirected the refinement of the classifiers to directly address the uneven, or long tailed distribution of species observations as well as the differences between collections, known as the domain differences. Currently, identification accuracy is 90-–100 percent for 27 species, and even three species of rockfish with low rates of accurate field identifications by humans had an overall accuracy of 93 percent.

Advantages of EM and cameras to enhance the value of observer's outputs and personal safety **Stewart Norman &** **Chris Heinecken** CapMarine and CapFish	Observers onboard fishing vessels have a complex and demanding task with an overloaded demand for accurate data and near real time reporting. Most *at-sea observer programs* focus on compliance related issues. Automating electronic monitoring (EM) has the potential to save observers time and remove them from situations that are operationally unsafe. Modern cameras and rapid advances in imagery and AI technology makes it possible to monitor on-deck tasks from remote positions in safety and comfort. The observer can then focus on tasks where cameras are inefficient. EM and remote sensing can independently provide images and information in settings that have a compliance factor and safety issue, for example, monitoring bird scaring/tori-lines. EM can increase monitoring from 5–20 percent up to 100–200 percent in cases where human and EM work together on the same vessel. It also has significant advantage on small vessels which are generally less safe and suitable for accommodating an observer.
Observer App with Species Identification by Expert Reviewer **DJ Laycock, NAFO Secretariat**	Onboard observers for NAFO record all retained and discarded catches. The observer application allows the observers to record catches with a user-friendly questionnaire. When the observer is unsure of the discarded species, a photograph of the unknown specimen is uploaded from the device to a NAFO website. On the secure website, experts from NAFO's member flag states can then review the list of unknown species and attempt to identify the species based on the photographs captured by the observer. The website also provides a feature that provides an estimated length of large species (sharks) in a picture.
Use of camera systems on commercial fishing vessels – an industry perspective **Andy Smith,** Talley's Ltd, (now at A.P. Smith Fishing Consultancy Ltd)	Cameras in our at sea application can provide verifiable information to science and compliance in real time. We have had a three camera system in operation in the Southern Ocean region of the Ross Sea for four seasons and it has been highly valuable to showing fine detail such as a fish tagged by a New Zealand vessel in an area, then caught by another UK vessel 400 kilometres away. This was not an anomaly, as it showed this particular fish had travelled contrary to normal patterns. Antarctica is one of the harshest climates on earth and the system has proven itself beyond expectation. The system has helped review information from the fishery and assist international and national observers who are onboard when there sighting has been questions. The camera footage is usually absolute and will not exaggerate a situation either way. Smith cautioned that footage needed to be secure, subject to privilege, owned and controlled by the company that operates the vessel.
Image-based data collection by crews of tracked Indonesian snapper and tuna fishing vessels **Peter Mous** Yayasan Konservasi Alam Nusantara (YKAN), an affiliate of The Nature Conservancy	Indonesia's fisheries are mostly small-scale, species-diverse, multi-gear, and landed at many sites. The monitoring of catch composition and fishing practices is challenging. We developed an image-based catch and effort data recording system, which we tried out on Indonesia's snapper and tuna fisheries to generate data for length-based stock assessments. We worked with crews of tracked snapper and tuna vessels over 2015–2021, and we asked crew to take images of their catch with pocket cameras. We developed an AI system for automatic species identification and length measurement. Performance of AI was good, and a training dataset of 2 500 images of 44 species resulted in 95 percent accuracy for species identification. The collaborative, image-based catch monitoring program resulted in credible data for fish stock assessment, based on detailed data from 22 393 trips of 709 snapper vessels and 4536 trips for 159 tuna vessels for 2015–2020. The program was not interrupted by the covid-19 pandemic.