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THE USE OF UNDERWATER VIDEO TO CHARACTERIZE THE SPECIES, SIZE COMPOSITION AND VERTICAL DISTRIBUTION OF TUNAS AND NON-TUNA BYCATCH AROUND FLOATING OBJECTS

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The use of underwater video to characterize the species, size composition and vertical distribution of tunas and non-tuna bycatch around floating objects[2]

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Abstract

Research surveys attempting to use acoustic devices (i.e. echo sounders and sonar) to avoid bycatch and STFO are significantly hindered by the lack of any way to accurately verify what is actually under their vessel and being recorded on their instruments. Purse seine fishermen have a distinct advantage as they can refine catch estimates with every successful set and no doubt become quite proficient at determining fish species by acoustic means. However, their ability to do so or to estimate fish size is difficult to test and has not been adequately documented. A self contained underwater video and recording system was tested on tuna schools aggregated to two anchored oceanographic buoys that act like FADs at 2°N and 5°N, 155°W. Skipjack and bigeye tuna were easily identified by body and fin morphology, swimming behaviour and the appearance of echo sounder images. Bigeye tuna were often observed to swim with a characteristic "waddling" movement with clearly visible tail beats. Yellowfin tuna were more difficult to positively identify but this was not fairly tested as few yellowfin were aggregated to the buoys visited during the cruise. Judging fish size from video images was found to be more difficult but could be greatly assisted by the development of identification guides based on external, visual characteristics of live tuna. The short duration of observations indicates that much more field work will be required in different areas and under a variety of conditions, including trials on commercial purse seine vessels. However, these preliminary tests were highly encouraging and will be continued in Hawaii and on the PTTP tagging vessel in the western Pacific during 2008/09.

Background

Fishing on FADs and floating objects can be an effective way to improve efficiency and viability of small scale fisheries. However, the negative impacts of intensive purse seine effort on natural and man-made floating objects; both anchored and free drifting, are well known. Floating objects aggregate undersize and juvenile tuna and tuna-like species, a wide variety of fish bycatch as well as bycatch of special ecological or fishery significance, i.e. oceanic sharks, billfish, marine mammals and marine turtles. These related issues of bycatch and small tuna fishing mortality on floating objects have become critical issues facing every RFMO that deals with the management of tropical tuna stocks.

The issue usually focuses on concern over the increased vulnerability and exploitation rate of "juvenile" bigeye tuna that has pushed stocks toward an overfished state. In the WCPO the issue has been expanded to include concern over the increased take of juvenile yellowfin tuna by purse seine effort on floating objects. Concern has also been expressed since the beginning of the WCPO surface fishery over catches of commercially undersize tuna or tuna-like species (e.g. *Euthynnus affinis, Auxis spp.)* that aggregate under drifting objects that are set upon and subsequently sorted out and discarded at sea or in port. Collectively, these categories of fishing mortality by surface fisheries were referred to as Small Tuna on Floating Objects (STFO) during WCPFC/SC3 and this acronym will be used in this paper. Mechanisms to reduce fishing mortality on STFO are critically needed in all surface fisheries A novel approach using underwater video is described in this report.

Management options to reduce STFO: summary

[2] Originally submitted to SC4 as WCPFC-SC4-2008/FT-WP-3

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Scientists and managers have approached the issue of avoiding or reducing STFO catch in a number of ways that include proposals or regulations for:

- time/area closures to avoid areas/seasons of high STFO vulnerability;
- reductions on individual vessel efficiency (i.e. limits on hauling gear, use of helicopters, electronics, net size, transhipment locations, etc.);
- FAD or floating object specific restrictions (i.e. prohibition of floating object effort, banning FAD tender vessels, limiting number of DFADs/vessel, restricting FAD fishing areas, mandating FAD design);
- minimum size restrictions and regulations for mandatory retention;
- mandating release mechanisms or techniques for undersize tuna (i.e. sorting grids, large mesh size, releasing undersize tuna alive);
- capacity limits, bigeye specific TACs or trigger catch limits.

These management options present significant difficulties related to enforcement, monitoring and compliance. For a more thorough discussion of the pros and cons of various output and input controls to reduce STFO, see WCPFC/PrepCon (2004) and Itano (2005).

Problem statement and justification for video project

Closing fisheries, intentionally reducing vessel efficiency or trying to devise ways to release (unharmed) undersize tuna or mandating their full retention are less than desirable management options for the fishers or the resource. The better choice would be to develop some means by which purse seine operators could continue fishing operations on the relatively robust skipjack stocks while avoiding the encirclement and capture of STFO, particularly bigeye tuna.

Scientists have generally taken three approaches to investigate ways to avoid STFO that include behavioral research (via electronic tagging); investigations of the influence of gear effects; and acoustic selectivity.

1) Tagging studies

Tagging studies using acoustic (depth reporting) or archival tags have been carried out which provide a means to verify tuna behavior and vertical behavior on floating objects in particular. Individually coded sonic tags provide data that is specific to the particular tuna (size and species) that was tagged. One application of these studies is to investigate whether certain categories of STFO and small bigeye tuna in particular can be avoided by regulating optimal times of day or depths at which purse seine nets can be set. Unfortunately, recent studies strongly suggest that the small size classes of bigeye tuna that associate with floating objects in the EPO and WCPO can be significantly mixed with yellowfin and skipjack on FADs; particularly during the early morning hours when purse seining on floating objects generally takes place (Schaefer and Fuller 2005; Matsumoto et al. 2006; Leroy et al. 2007). Requiring purse seine vessels to set drifting objects during daylight hours, which acoustic studies suggest would eliminate a great deal of bigeye catch does not appear feasible in the WCPO as this option would eliminate a great deal of the skipjack and yellowfin catch as well.

2) Gear effects

Lennert-Cody et al. (2008 and SC4-FT-IP-1) developed a classification algorithm to examine gear influence on bigeye catch by EPO purse seine vessels. Several gear and operational parameters were examined, i.e. vessel capacity, net depth, mesh size, depth of FAD aggregator, degree of FAD bio fouling (barnacles, etc), set time, location, SST, SST frontal zones, bathymetry, productivity, oceanographic parameters and the presence of non-tuna species.

Of the gear characteristics examined, the depth of the FAD and the hanging depth of the purse seine net had the greatest positive effect on bigeye catch, but geographic location within the EPO had the greatest overall influence on bigeye catch. However, previous studies provided some indication that skipjack catch per set also increases with increasing net depth (Lennert-Cody and Hall 2000), thus restricting net depth may reduce skipjack catches unfairly. This is not surprising and would be much more influential in the WCPO with a deeper thermocline and better underwater visibility. Under these conditions, very deep nets are necessary in order to successfully target unassociated schools during the day (Doulman 1987). Purse seine depth restrictions would greatly reduce a vessel's ability to exploit school fish which is generally considered a desirable harvest strategy. Other problems of analysis of net depth is that reported hanging depth of the net was used as a proxy for actual fishing depth which can vary widely depending on currents and pursing speed and net depth on vessel registers is not well documented and never validated.

Satoh et al. (2008, SC4-FT-WP-1) examined the depth of the netting aggregator on drifting FADs used by Japanese purse seiners operating in the WCPO. The analysis could not demonstrate a statistically significant influence of FAD depth on bigeye catch. However, bigeye made up only a minor component of total catch making analysis difficult. Other factors, such as area, month and total catch did indicate some significance to bigeye catch as was also noted by the study by Lennert-Cody (2008).

3) Acoustic discrimination and surveys

Acoustic surveys have attempted to identify and characterize fish communities on drifting FADs and natural floating objects using high definition echo sounder equipment capable of providing target strength (*TS*) measurements of individual fish. The intention has been to use *TS* measurements to remotely determine fish species and fish size using echo sounder or sonar equipment (Miguel et al. 2006).

Unfortunately, several problems and issues have reduced the viability and utility of acoustic gear to avoid small tuna. Scientific studies usually conduct surveys with the industry standard: SIMRAD EK or ES 60 echo sounders. These units are expensive, sensitive and require a highly experienced technician to operate. Research cruises utilizing this gear are also expensive to fund and logistically difficult to conduct in open oceanic environments.

Technical issues related to *TS* measurement and verification of acoustic targets can also become significant. Investigations to identify tuna species and size using echo sounder have reported numerous biases and problems associated with hull noise, vessel speed, fish orientation and the relative size or presence of a swim bladder. Skipjack for example do not possess a swim bladder at all and do not image well using echo sounder or sonar equipment while the opposite is true for many non-target teleosts.

The most significant problem faced by acoustic survey methods is direct verification of what the instruments display on screen versus what is actually under the vessel. This is due to the fact that scientific acoustic surveys are generally conducted on research vessels that do not have the ability to verify catch as can be accomplished by a commercial purse seine vessel. Scientific acoustic surveys have actually attempted to verify species and size of acoustic targets using rod and reel gear which obviously is inadequate.

It is believed that purse seine operators have become very efficient at determining the size of tuna schools, species composition and even fish size using a combination of echo sounders, sonar data, visual observations and accumulated experience (Schaefer and Fuller 2007 and SC4-FT-IP-2). Fishermen have the distinct advantage of being able to venture estimates from acoustic images and then verify their estimates by observing landed catch on a set by set basis, thereby continually refining their abilities. Scientists conducting infrequent acoustic surveys are at a distinct disadvantage and likely never attain the level of accuracy experienced by the industry.

Project proposal

The difficulty in verifying what is actually being detected on echo sounder and sonar equipment was discussed during the Third Regular Session of the Scientific Committee to the Commission (13-24 August 2007, Honolulu, Hawaii). In the paper by Schaefer and Fuller (2007) it was suggested that underwater video systems could be trialled to verify the size and species of fish aggregated to floating objects. The FT-SWG then proposed to conduct *in situ* tests of hard wired video gear to determine if this equipment could in fact be used to discriminate fish size and species under field conditions.

The FT-SWG convener proposed to conduct field tests during externally funded research and tagging cruises. The intention was to lower hard wired video equipment on FAD aggregated fish schools to observe fish identity, size and behavior. The proposal called for the recording of video images of fish schools while taking simultaneous digital still images of the echo sounder display. The contract outputs were agreed to be a presentation of preliminary results to SC4 (this paper) and submission of a final project report with recommendations on the use of this gear to reduce STFO to SC5.

Theoretically, recording video images and viewing images in real time can be used to improve selectivity and reduce bigeye and small (undersize) tuna and bycatch in three ways.

- Used as a way to visually check aggregations and avoid setting on STFO when observed.
- Used to verify sounder and sonar images to refine acoustic estimates of size and species.
- Used to test the ability of fishermen to interpret acoustic images (useful to assess efficacy of vessel or fleet specific quotas on STFO).

__Video and acoustic hardware__

The criteria for selecting underwater video gear to conduct this experiment were as follows:

- Deployable and water tight to at least 200m
- Robust, easily deployed and usable in difficult field conditions
- Self contained and operable for long periods on 12 or 24 v batteries
- Fully self contained for shipside viewing and recording
- Medium to high resolution
- Low light sensitive
- Inexpensive ($5000 maximum)

These criteria eliminated standard underwater video gear with water tight pressure housings used by SCUBA equipped divers. These units are generally rated to a maximum depth of around 70 meters and the housings alone cost $8000 or more. Remotely operated vehicles (ROVs) are also very expensive as were almost every other option, including automated digital still image systems. Hard-wired video equipment often used for inspection or surveillance was the only viable option located within the budget ($5000).

The project purchased a Deep Blue Professional Grade color video system from Splashcam Marine Video[4] which was the only vendor identified that marketed a fully equipped system meeting project criteria within budget. The system was rated to 600 m with cable rated at 318 kg breaking test with a camera head measuring only 7.6 x 8.9 cm. The system came complete with:

Camera Head
Umbilical Cable (244 m) with slip ring cable reel
UW Light Pod
Cigarette Lighter Power Adapter
AC/DC Power Adapter
6ft Male to Male Video Patch Cable
Drift Stabilizer Fin
High speed Tow Wing
Cable Clamp
7" Color LCD Monitor w/ Sunshade
12V 12AH Rechargeable Battery w/ Charger
Waterproof Pelican Brand Case
DVD Recorder
USB Video Adapter

Total cost with shipping: USD $4720

[4] http://www.splashcam.com/Deep_Blue/db.htm

Preliminary results

Hardware

The video system was received in April 2008 and tested on an SPC funded 30 day tuna tagging cruise south of Hawaii to the Line Islands of Kiribati and high seas areas east of Palmyra Atoll and Christmas Island. This cruise was the first Central Pacific tagging effort of the SPC lead Pacific Tuna Tagging Project (described in document **SC4 GN-IP-1)**. The cruise plan was based on searching for tuna schools found in association with floating objects and the NOAA maintained TAO oceanographic buoys set on the 155°W longitude line south of Hawaii.

The cruise took place on the Honolulu-based commercial fishing vessel *Double D* which used a combination of troll and handline gear to tag and release skipjack, yellowfin and bigeye. The cruise proved to be a very successful effort to boost bigeye tag releases in a difficult to access area of the WCPO, with 1909 tuna tagged on three TAO buoys of which 91% were bigeye. Dense tuna aggregations were found on the TAO buoys at 2°N and 5°N, 155°W line that provided ideal conditions to test the video gear.

The Splashcam video camera was deployed while monitoring the vessel's echo sounder; a Furuno 5FCB 585 with color LCD screen. This is a good quality echo sounder that provided a well defined color image from blue and green (weak return) to dark red (strong, dense return). Images of the Furuno echo sounder were captured during video tests using a Canon PowerShot A720 digital still camera. The video camera system ready to deploy is shown in **Figure 1**. Note the unit is fitted with a stabilizing fin below the camera head and lead weight (3 lbs). The actual depth of the camera head was recorded by attaching a Wildlife Computers MK9 archival tag to the camera which is shown taped to the cable above the camera.

Figure 1. Splashcam Deep Blue color video camera ready to deploy.

The video camera head is attached by cable to a cable reel and equipment for viewing and recording. All recording and electronic gear including 12v battery power is stored inside by a waterproof Pelican case supplied by the system manufacturer. The net reel, LCD viewing screen, DVD recorder and battery are shown in **Figure 2**.

Figure 2. Cable reel, viewing screen and recording components of video system.

Echo sounder and video images

The video camera was manually lowered into dense tuna aggregations on the TAO buoy at 2°N, 155°W from May 16 – 18, 2008 during which time 1132 tuna were tagged and released. Tag releases comprised 95% bigeye (~55-65 cm) with only 17 skipjack (42-48 cm) and 41 yellowfin (~50-60 cm) released. However, a large skipjack school was observed moving within 0.5 – 3 nautical miles of the buoy.

On the first day the buoy was fished (16/5/08), a dense, dark red acoustic signal was recorded on the Furuno echo sounder (50 kHz) and remained shallow (<50 m) until 10 AM (see **Figure 3**). The school responded very actively and 519 tuna were tagged. The Splashcam video system was lowered into the school and had no difficulty viewing clear images of bigeye tuna of the same size classes that were being tagged. The video image on the LCD viewing screen was clear and well focused. Unfortunately, the center of the image was very over-exposed, providing well exposed images only at the margins of the screen (see **Figure 4**). Unfortunately, what we saw on the viewing screen and DVD recorder screen was the same image that was recorded. The Splashcam company was contacted via IRIDIUM email during the cruise but was not able to resolve the issue. At the conclusion of the cruise, the unit was returned to the manufacturer and the camera was found to be defective. The company replaced the unit at no charge but a great opportunity to film tuna was missed. Despite the poor video image, the bigeye tuna are easily identifiable by their body depth, proportionally large head and long, curved pectoral fins.

On 17 May, the buoy was fished from 0630 – 1045 and 1600 – 1845. The school remained shallow until late morning and 530 tuna (mostly bigeye were tagged). The depth sounder image recorded a dense red image close to the TAO buoy (**Figure 5**). The Splashcam video camera was rigged and dropped into the tuna school in the early afternoon. Clear footage of bigeye and yellowfin tuna were easily recorded at depths of 35 – 50 m.

On 18 May, the 2N TAO buoy was approached at dawn but the biting response was very poor. A dense tuna school was still evident on the sounder but had already begun to descend to 110 m at 0600 (**Figure 6**). By 0707 AM the dark red sounder image had descended to 75 – 110 m (**Figure 7**). This was presumed to be the bigeye school as it was descending to greater depths. Tagging was very slow this morning.

Figure 8 was digitally captured one minute after the presumed bigeye school shown in **Figure 6** was taken of the bigeye school that was closely aggregated upcurrent of the TAO buoy. The sounder image in **Figure 6** was taken approximately 100 m from the TAO buoy when skipjack were visually observed jumping and breezing on the surface. The diffuse, light blue flecks and spots are believed to represent a sub-surface school of skipjack.

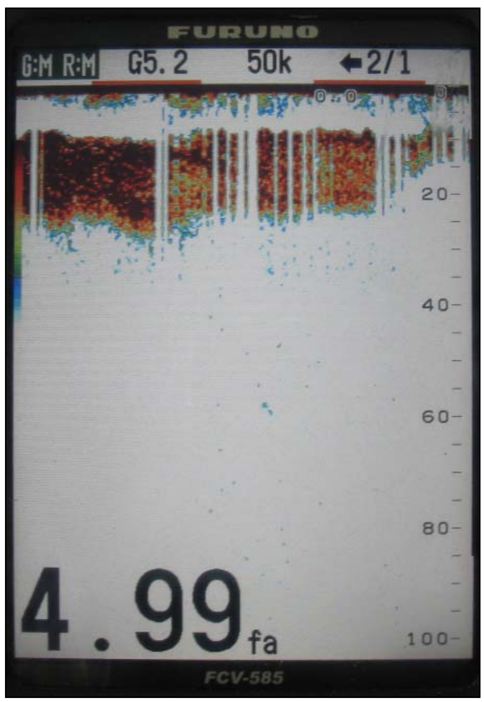

Figure 3. Echo sounder image at TAO 2N, 155W showing presumed bigeye school at 0930 AM, 16 May 2008 (depth at 100 fathom scale)

Figure 4. School of bigeye tuna filmed on TAO buoy 2N, 155W

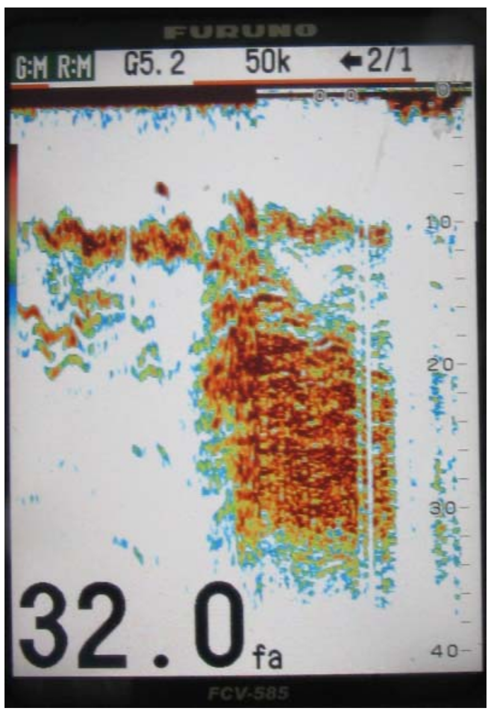

Figure 5. Echo sounder image of presumed bigeye school on TAO buoy 2N, 155W at 0744 AM, 17 May 2008 (depth at 40 fathom scale)

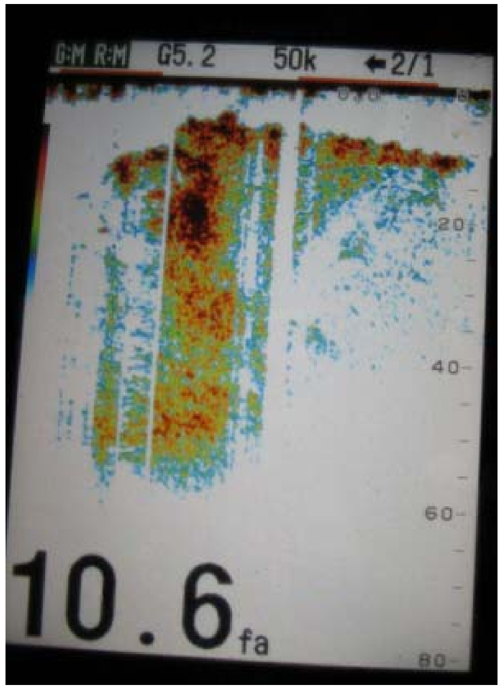

Figure 6. Echo sounder image of presumed bigeye school on TAO buoy 2N, 155W at 0601 AM, 18 May 2008 (depth at 80 fathom scale)

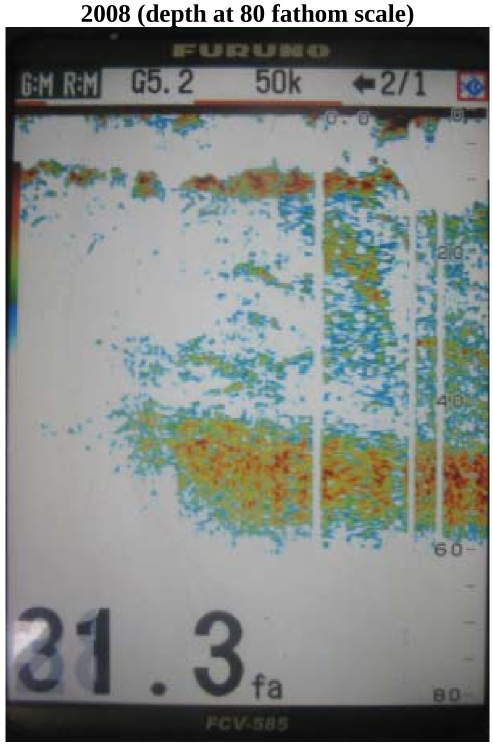

Figure 7. Echo sounder image of presumed bigeye school on TAO buoy 2N, 155W at 0707 AM, 18 May 2008 (depth at 80 fathom scale)

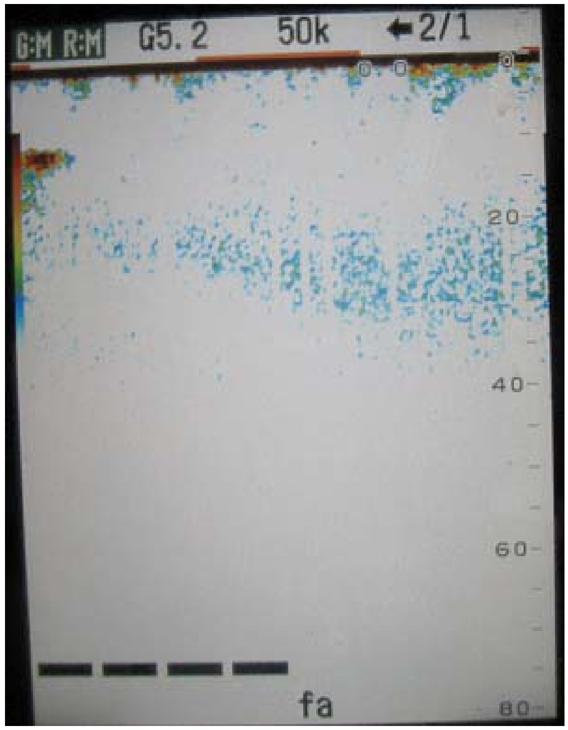

Figure 8. Echo sounder image of presumed skipjack school on TAO buoy 2N, 155W at 0707 AM, 18 May 2008 (depth at 80 fathom scale)

Size and species discrimination

The images in this report are very blurry as they are individual, low resolution JPEG files from the Splashcam video. Viewing the video provides a much better image and allows the observation of swimming and schooling behavior that is useful for identification. Skipjack were easily distinguished from yellowfin and bigeye by their streamlined, fusiform shape and tightly schooling behavior (**Figure 9**). When viewing the video, skipjack appeared to flow through the water without visible tail beats, grouped closely together and flowed in a continuous band.

Bigeye tended to move about in less organized schools. Individual bigeye were easily recognized by their deep body profile and long, swept back pectoral fins (**Figure 10**). When swimming, bigeye often moved with a characteristic “waddle” with slow, obvious tail strokes. The poor quality of these first video images made the identification of small yellowfin tuna very difficult. In some cases, their slim profile (compared to bigeye) and shorter, stiff pectoral fin was evident. Generally, it appeared that small yellowfin moved without an easily identifiable tail beat and never “waddled” like bigeye. However, more trials will be needed to better characterize yellowfin images. One problem during this cruise was that relatively few yellowfin were present on the buoys with no large, monospecific schools were filmed. **Figure 11** shows images of tuna that by appearance and behavior may be yellowfin but the identification is not positive.

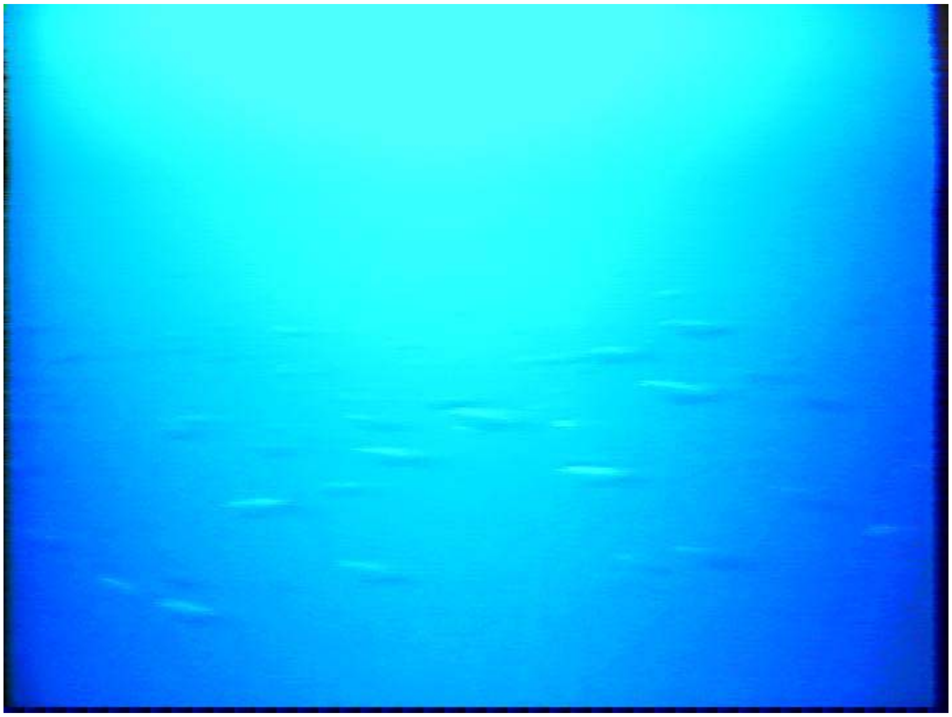

Figure 9. A school of skipjack filmed with the Splashcam video close to a TAO buoy

Figure 10. An individual bigeye tuna approximately 50 cm in fork length

Figure 11. Still image from Splashcam video showing possible yellowfin tuna near a TAO buoy.

School image on echo sounder

The Splashcam was lowered to depths indicated by echo sounder marks such as those shown in **Figure 12**. These schools were visually identified by video as monospecific schools of bigeye tuna. The echo sounder marks were dense, dark red and always close to (often upcurrent) of the TAO buoy. In contrast, **Figure 8** is believed to be representative of a skipjack school. Skipjack return a poor acoustic signature due to their lack of a swim bladder (see Schaefer and Fuller 2007). A general lack of yellowfin on these buoys during the cruise prevented imaging of yellowfin schools.

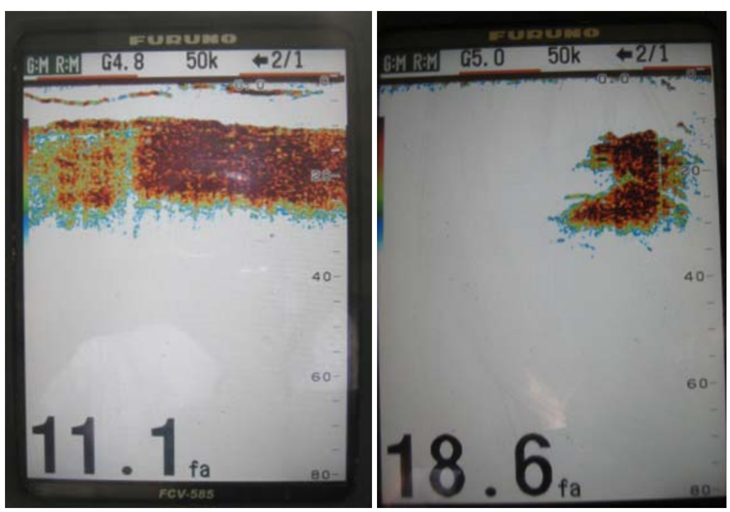

Figure 12. Echo sounder images (50 kHz) of dense tuna schools identified as bigeye by video

Summary and recommendations

Preliminary results of our first field trial were encouraging despite the poor video image caused by the defective camera head. The tuna did not seem concerned with the camera at all and did not appear to avoid or be concerned by its presence. The unit was easy to deploy and retrieve but it was strongly influenced by current or vessel drift. Another negative aspect of the system is the recorder, LCD screen and battery are not waterproof so a semi-protected area is needed for operation.

Skipjack could be easy to identified by shape, swimming and schooling behavior and echo sounder image. However, similar appearing species like kawakawa or *Auxis* spp. were not present which could complicate positive identifications of skipjack. It was encouraging to note that bigeye tuna were the easiest to identify using a combination of body morphology, pectoral fin length and appearance, head size, "waddling" swimming behavior and strong acoustic signatures. Their schooling behavior close to the buoy also seemed to be characteristic of the species. Yellowfin tuna proved to be more difficult to identify but part of the problem had to do with the fact that few yellowfin were aggregated to these buoys. However, it appeared that yellowfin could be differentiated from bigeye by their smaller head, more slender profile, smooth swimming behavior and shorter, stiffer appearing pectoral fin. However, all of these observations should be considered very preliminary. Much more time will be required under different conditions and areas to see if these identifying features are valid.

Determining fish size will require many more trials, preferably in conjunction with a purse seine vessel to verify video images. In the past, the FT-SWG has developed guides for identifying tuna useful for port samplers and observers. A useful project would be to develop guides of skipjack, yellowfin and bigeye tuna useful for determining their size based on external visual criteria.

Additional field trials and opportunities to test the new camera head will be conducted during 2008-2009 and summarized in the final project document at SC5. The camera gear will be deployed on FADs in Hawaii as well as during PTTP research cruises on their chartered tagging vessel ***Soltai 105***. Testing the gear on a commercial tuna purse seine vessel would be ideal and any opportunity to do so will be explored prior to SC5. Also, testing the gear in areas of high bycatch and STFO should be attempted.

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