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Behavior of target and non-target species on drifting FADs and when encircled by purse seine gear

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Abstract

Empirical and observational data were collected from 31 sets made from a tuna purse seine vessel during the International Seafood Sustainability Foundation's (ISSF) WCPO bycatch reduction research cruise. Simultaneously, skipjack (*Katsuwonis pelamis*), yellowfin (*Thunnus albacares*), and bigeye (*T. obesus*) tuna and silky sharks (*Carcharhinus falciformis*) were implanted with pressure sensing acoustic transmitters and monitored on drifting FADs in the same areas. Untested assumptions relating to natural behavior of encircled fish in purse seine gear were clarified; divers observed separation of target species by species as well as size. Additionally, non-target species consistently separated themselves from target species and remained shallow. This species segregation was consistently observed during all sets and lasted throughout the duration of the haul until the beginning of sacking was reached, at which point individuals and schools were forced to intermingle. Acoustic tagging data confirms these behavioral characteristics displayed naturally while associated with a floating object, which is well documented by other tagging studies on FADs. These observations provide much needed insight to behavioral patterns of non-target and unwanted species, which may inform further research and development of options to selectively release or sort these from the net before these animals sustain mortal injuries.

Background/Relevance

The International Seafood Sustainability Foundation's (ISSF) bycatch reduction project is an ongoing process to investigate and test methods for reducing non-target and unwanted catch in the tuna purse seine fishery, with a specific focus on reducing the take of these animals around fish aggregating devices (FADs). The Western Central Pacific Ocean (WCPO) research cruise was conducted during May-July 2012 aboard the F/V Cape Finisterre, based in Pago Pago, American Samoa. The research objectives of this cruise were to improved data collection and selectivity of the region's drifting FAD (raft) fishery. Research permits were obtained for the Tokelau, Tuvalu, Solomon Islands, Kiribati, and Cook Islands Exclusive Economic Zones (EEZs) to accommodate a large research area, but fishing only occurred in the Tokelau, Tuvalu and Kiribati EEZs as well as the high seas pocket in this region. The objectives of the study addressed in this module include:

1. To observe the behavior of tuna and bycatch species in the purse seine net to explore possibility of isolating and releasing in good condition bigeye tuna, sharks and other non-target species.
2. Determine if economically viable landings of skipjack and yellowfin tuna can be maintained while avoiding bigeye, small tuna and miscellaneous bycatch species.
3. To determine if bigeye, yellowfin and skipjack tuna separate horizontally after dawn allowing the targeting of pure skipjack or skipjack and yellowfin mixed schools both at the FAD and away from the FAD that they were associated with during the previous evening.

Methods

The objectives were addressed using 2 methods: 1) SCUBA divers deployed inside of the net after approximately 75% of net rolling was completed, made observations during visual surveys and collected photographic and video data on behavior of target and non-target catch; and 2) acoustic tagging of bigeye, yellowfin, skipjack, and silky sharks on drifting FADs in the study area.

Dive Surveys

Divers were deployed inside of the net during 15 of the 31 total sets for the cruise. Free divers were sent in on all but a few sets. After an initial assessment of the conditions inside of the net from the surface, the dive was commenced and divers descended to depths between 80' and 120'. The divers then slowly ascended, visually surveying as much of the area inside of the pursed net as possible without disturbing the aggregation of fish. Total dive time inside of the net was approximately 18-25 minutes. The end of the dive usually coincided with the final few minutes of net rolling, in which the corks become enclosed enough that divers must exit the net to ensure safety. Once outside the corkline, the divers observed the beginning of the sacking up process, and then exited the water. Canon G-12 cameras with underwater housings were used to obtain digital still images, and GoPro Hero HD2 video cameras were utilized for video.

Acoustic Tagging

Tagging was conducted on three occasions at floating objects in the study area on drifting FADs equipped with Zuniball GPS-Sonar capable buoys. Fish were captured using sport rod and reel fishing gear, with barbless hooks to minimize hook damage.

Each fish was netted and brought aboard with a knotless webbing nylon mesh net, and hydrated for the duration of the tagging procedure with salt water via a hose through the mouth. Vemco V9P and V13P pressure sensing acoustic coded pinger tags were surgically implanted into the peritoneal cavity each fish, and the incision was closed with 2 sutures. An 11cm Hallprint conventional dart tag was placed by the second dorsal fin to aid in locating recaptured fish. Each fish was immediately released in excellent condition. Vemco VR2W acoustic receivers were fastened to each FAD which tagged fish were released and then retrieved when the FAD was set on.

Results

During the 40 day research cruise, a total of 31 sets were made. Thirty of these sets were on floating objects, and one on a free school. Of the 30 floating object sets, 27 occurred around right before dawn, the typical time for a floating object set in the WCPO fishery. Set size ranged between 7-174 mt, averaging 42.67 mt.

1. **Observations made by divers while inside the net**

Several consistent behavioral observations emerged from this experiment:

a. **Grouping of similar size fish by species**

Skipjack, yellowfin and bigeye tuna observed during these surveys appeared to remain separated by size class, and also by species. For example, small (35-40cm) to medium (40-55cm) sized skipjack displayed cohesive schooling behavior with each other, and avoided separate schools of larger skipjack or yellowfin and bigeye. Large (>100cm) yellowfin also schooled together and rarely split up. These large yellowfin occasionally had large (>90cm) bigeye on the periphery of the school as well. Some mixing of similar sized small (<60cm) yellowfin and bigeye did occur, which formed mixed aggregations with each other. However, on multiple occasions these small yellowfin and bigeye were observed to separate themselves from each other and form loose schools of mono specific groups.

b. **Vertical stratification of fish by size and species**

Similar sized fish schools also displayed vertical stratification during most of the dive surveys. Large yellowfin and bigeye occupied the lowest portions of the pursed net, bigeye were found between 30-60m. Size separated schools of skipjack, as described

in (a) occupied the middle of the water column, bigeye between 15-30m, and small yellowfin and bigeye occupied the upper portion of the water column from 10-20m. Some mixing occurred but this vertical stratification of species seemed to remain constant until it was physically impossible towards the end of the net rolling when space became confined.

c. Non-target species separation from target tuna species

Non target species including mahi mahi (*Coryphaenus hippurus*), wahoo (*Acanthocybium solanderi*), rainbow runner(*Elagatis bipinnulata*), and silky sharks were observed spending the majority of their time in the upper 20m of the water column, usually in mono specific schools, containing varying sizes of fish. Silky sharks seemed to consistently end up at the far side of the net away from the fishing vessel, inspiring the design, construction, and testing of a release panel in the net to attempt to release them and other non-target species as described in EB-WP-14.

d. Net predation

Net predation and foraging behavior was observed on several occasions, with large yellowfin and bigeye foraging on small skipjack. As the area in the net became more confined, net predation rates increased and continued into the beginning of the sacking up process. The observation of foraging inside of the net by larger tuna provides some evidence of these animals may visit or occupy floating objects as a feeding station as well as for other reasons.

These so called “natural behaviors” of all species inside of the net rapidly deteriorated as the end of net rolling began. As the space inside the net became more confined, these groups of fish that had previously been segregated by species, size and depth were forced to mix. At this point the situation typically became a chaotic spectacle of larger fish displaying aggressive foraging behavior on smaller fish frantically avoiding them, and sharks and other non-target species becoming intermixed with these mixed schools of tuna. This confinement also occurred earlier in the net rolling process with larger sets, as the fish ran out of space.

2. Vertical and horizontal behavior of tuna and bycatch species on FAD aggregations

a. Sonic Tagging on Floating Object no. 2

Five bigeye (65-91cm fork length) were captured with sport fishing gear and surgically implanted with V9-P coded acoustic pressure sensing transmitters at floating object no. 2 in the Tokelau EEZ on 26 May 2012. A receiver was attached to the FAD and left for 8 days to passively monitor the transmitters. Two of five fish were detected for most or all of the monitoring period, indicating that they had high fidelity to the FAD. One of the bigeye was detected for the first half of the detection period and then disappeared, and the fourth was only detected for the first day and then disappeared. Typical vertical (shallow during the nighttime hours, deeper during the daytime hours) and horizontal (detected more at the FAD after 01:00hrs until midday, then less detections in the afternoon and evening) behavior was displayed for the 8 days that the fish were monitored at the FAD. Vertical detection plots show that the four fish on the FAD at the same time showed consistent vertical behavior implying that the school of fish was a cohesive unit occupying the same depths together. On-off behavior showed some consistency; three of the five bigeye appeared to depart and return to the FAD together on multiple occasions, again suggesting school cohesion and FAD fidelity.

A set was made on this FAD on 03 June 2012 at 05:25hrs with a maximum recorded net depth during the set of 171m. Seven metric tons of small fish was landed, and no tagged fish were spotted in the brail or hopper during the brailing process. The receiver detected two tagged fish were present up to the point of the set. No fish were recorder after 05:18hrs. The receiver was pulled off of the FAD at 07:30hrs and downloaded. It is unclear whether the fish were captured in the set or not, but highly unlikely since the small amount of fish was visually inspected by several crewman and scientists as it was transferred into the well via the hopper and deck hatch, and no tags were discovered when the vessel was unloaded.

b. Sonic Tagging on Floating Object-33

On June 15, 2012, five skipjack (47-59cm fork length), 10 yellowfin (44-68cm FL), one bigeye (59cm FL), and one silky shark (89cm FL) were tagged and released on floating object no. 33 in the Tokelau zone. A receiver was attached to the FAD and left for 11 days to passively monitor the transmitters. A receiver was hung at a neighboring (about 4nm away) floating object on June 25, 2012 to assess if any of these tagged animals had abandoned the tagging release site; none were detected for the brief time the receiver was deployed.

Two yellowfin and one bigeye remained at the FAD for the entire detection period with only a few brief departures. Two skipjack and two yellowfin departed the FAD within 24 hours of release. The remaining 10 fish were not detected at the FAD during the monitoring period. The silky shark was double tagged with a satellite archival tag and was detected at the FAD intermittently for about 36 hours after release. No clear school patterning or fidelity was apparent for tagged animals during the detection period, with different departure and arrival times for each animal's on-off behavior. Initial analysis of vertical behavior shows normal FAD influenced behavior, similar to the results from FO-2, discussed above.

FO-33 was investigated and set on June 26, 2012. A receiver was hung off of the main vessel during the entire fishing process from pursing to the end of brailing. No fish were detected after the end of brailing, indicating that no fish escaped the fishing process, or that they were not present on the FAD during the set. No tagged fish were seen or recovered during the brailing or unloading process. The total catch for this set was 22 mt.

c. Sonic Tagging on Zuniball 118

On June 23rd, 2012, one skipjack (55cm FL), four yellowfin (43-46cm FL), one bigeye (43cm FL), and two silky sharks (75 and 83cm FL) were tagged and released on a drifting FAD. A receiver was attached to the FAD and left for 5 days to passively monitor the transmitters.

All four of the yellowfin tagged remained at the FAD for the duration of the detection period with no departures. The single bigeye tagged remained at the FAD and departed 1.5 days before the receiver was retrieved. One silky shark came and went from the FAD with no consistent patterning for the first 3 days after release, and then was not detected again. The single skipjack tagged remained around the FAD for most of the detection period, with consistent departures for 2-6 hours from the FAD at sunset. Initial analysis of vertical behavior shows normal FAD influenced behavior, similar to FO-2's tagging results.

The four small yellowfin appeared to remain in close vertical proximity to one another for most of the detection period, occupying relatively shallow depths (average 67m) and rarely exceeding 120m.

Zuniball 118 was investigated and set on June 29, 2012. A receiver was hung off of the main vessel during the entire fishing process from pursing to the end of brailing.

Two of the tagged yellowfin were detected until the beginning of brailing, and displayed very shallow vertical behavior, suggesting that they were encircled in the net. The remaining two tagged yellowfin were not detected past end of pursing, indicating that they may have escaped the fishing process, No tagged fish were seen or recovered during the brailing or unloading process. The total catch for this set was 25 mt.

Discussion

The species segregation observed during the dive surveys in this experiment provide evidence that it may be possible to selectively release unwanted small tuna and non-target species from the net before they sustain mortal injuries. Although we conducted surveys over a wide range of set sizes (7-174 mt), it seems that these behaviors are most consistent in sets under 100 mt, and any release panel research or implementation should take this into consideration to reduce risk of unintentional release of larger fish.

Although results from the acoustic tagging efforts during this cruise are still being analyzed, preliminary analysis provides conclusive evidence of vertical behavior of encircled animals. Future research efforts should focus on the use of continuous acoustic pressure sensing tags and active tracking of fish and sharks captured, tagged, and monitored after they have been encircled in the net to better understand these behaviors. The results from this type of experiment would be very useful to identify the specific depths these unwanted catch occupy during the fishing process, which in turn could be used to guide future release panel design, testing and implementation.

Recommendations:

1. Continue research and testing of release panels or other ways to selectively release unwanted small tuna and non-target species before they sustain injury as discussed in EB-WP-14.
2. Conduct an active tracking experiment of encircled fish and sharks after they have been encircled in the net to validate visual observations made in this experiment.