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International Seafood Sustainability Foundation's Third Bycatch Mitigation Research Cruise in the WCPO

WCPFC-SC10-2014/EB-WP-08

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Abstract

The scientific cruise took place during May 2014 in the central Pacific Ocean onboard the purse seiner ALBATUN TRES, a Spanish-flagged vessel. The ALBATUN TRES is a 115m purse seiner built in 2004 with 4,406 GT. The cruise started in Christmas (Kiribati Is.) on May 3rd and ended in Tarawa (Kiribati Is.) on May 31st. During a 4-week period a group of four scientists joined fishers headed out into the Pacific in search of better fishing practices that would avoid or mitigate the capture of non-target species or undesirable sized tunas. Specific objectives included: (1) Attaching echosounder buoys from four different brands to the FADs to compare signals; (2) Use of a scientific acoustic echo-sounder with frequencies of 38, 120 and 200 kHz onboard the work boat, followed by intensive spill sampling to compare acoustic data and species composition; (3) Study of fish behavior inside the net; (4) Use of an escape panel to release sharks; (5) Making other observations that could lead to further tests of mitigation techniques. Preliminary results of these studies are presented.

Cruise Synopsis

The cruise took place during May 2014 in the central Pacific Ocean onboard the purse seiner F/V ALBATUN TRES, a 115m Spanish purse seiner built in 2004 with 4,406 GT (2,260 tons carrying capacity). The vessel was commanded by a fishing master with more than 30 years of expertise in the Pacific Ocean. The cruise started in Christmas (Kiribati Is.) on May 3rd and ended in Tarawa (Kiribati Is.) on May 31st (**Figure 1**). Specific objectives included: (1) Attaching echosounder buoys from four different brands to the FADs to compare signals; (2) Use of a scientific acoustic echo-sounder with frequencies of 38, 120 and 200 kHz onboard the work boat, followed by intensive spill sampling to compare acoustic data and species composition; (3) Study of fish behavior inside the net; (4) Use of an escape panel to release sharks; (5) Making other observations that could lead to further tests of mitigation techniques. In total, 27 sets were made, 26 of which were on drifting FADs (dFADs), and one on a free school of skipjack tuna.

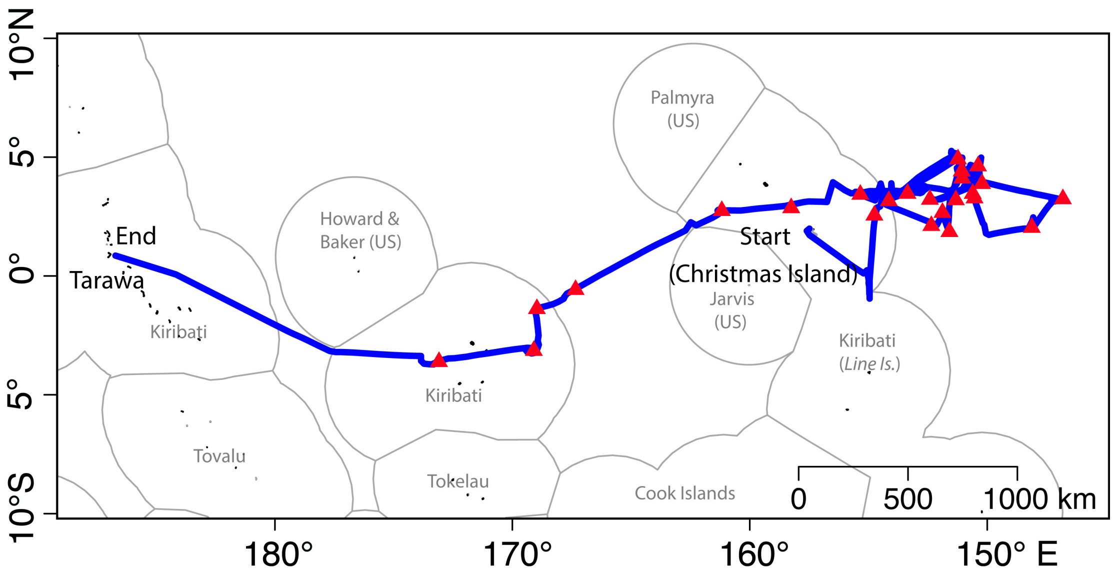

Figure 1. Map of cruise track (blue line) and set locations (red triangles) aboard the F/V ALBATUN TRES.

1. Echo-sounder buoy selectivity

The objective of this scientific activity was to improve the remote estimates of species and size composition of the aggregation, using the information of fishers' echo-sounder buoys attached to FADs (**Figure 2**). For this purpose, echo-sounder buoys from four manufacturing brands were used in the experiment (Marine Instruments M4i, Zunibal, Thalos Iris SB and MB, and Satlink DSL+).

Figure 2. Echo-sounder buoys on the ALBATUN TRES.

With the aim to acquire acoustic estimations of the same aggregation from different brands of buoys (**Figure 3**), the cruise plan was to add 1 buoy per brand (M4i, Iris and Zunibal) to the dFAD which was already equipped with a Satlink buoy belonging to the vessel. This was to be done upon arrival, the night before to the set. In this way, the echo-sounder would record data throughout the night until the set was made in the morning. However, this was not possible for all the FADs encountered, often because the vessel arrived too late in the evening. **Table 1** shows the number of sets made with different combinations of buoys; it was possible to have more than one echo-sounder buoy in only 30% of the dFADs.

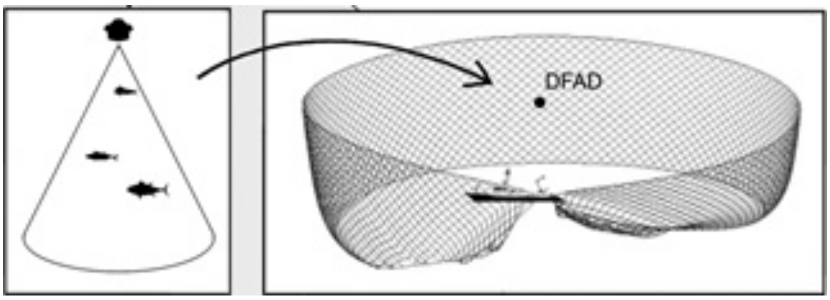

Figure 3. Conceptual drawing of data collection. Four different echo-sounder buoys brands where attached to the same FAD, then the set was conducted to obtain by spill sampling the proportion of each species in the set.

Table 1. Number of replicates with each type of echo-sounder buoy.

	DFAD	Free School
Satlink	18	1
Satlink + M4i	3	
Satlink + M4i. + Thalos	1	
Satlink + M4i. + Zunibal	1	
Satlink + M4i + Thalos + Zunibal	3	
nº Sets	26	1

Acoustic raw data collected with the different buoys will be compared to the species composition and biomass obtained by spill sampling of the catch (see **Section 3**), to help better understand differences between different buoys' selectivity of by-catch and tuna. The results from these analyses will be presented at a later date.

2. Scientific acoustic echo-sounders

The objective of this activity was to develop methods that could allow fishers to improve their estimates of species and size composition of fish aggregations using the acoustic equipment on board the purse seiner prior to setting.

A scientific acoustic echo-sounder Simrad EK60 of frequencies 38, 120 and 200 kHz was installed onboard the "panguita" (i.e. work boat, **Figure 4**). The acoustic equipment was calibrated using a tungsten carbide sphere of 38.1 mm. During the cruise, the panguita was used in 20 of the 27 sets (**Table 2**). In each of these sets, the panguita was attached to the dFAD starting about 10 minutes before the set and remained attached during the purse seiner's set. During the first part of the set, the panguita drifted with the dFAD and, afterwards, it moved slowly to keep the dFAD separated from both the net boundaries and the purse seiner. The transducers were focused vertically downwards, to acoustically sample the fish aggregation down to 200 m below the surface. In each set, around 60 to 70 minutes of acoustic data were recorded, with approximately 75% of the pings successfully detecting the tuna aggregation.

Spill sampling of the catch was done each time acoustic EK60 data was recorded, in order to help acoustic analysis to convert acoustic backscatter into skipjack, bigeye and yellowfin proportion at each set (see **Section 3**).

Figure 4. Scientific echo-sounders installed on the work boat ("panguita").

2.1 Data analysis

The Simrad EK60 acoustic data were backed up and then pre-processed. The pre-processing included the following steps (**Figure 5**):

Draw upper and lower (200 m or net) exclusion lines
Plankton removal
Spikes (interferences) filtering
Wave-induced gap filtering

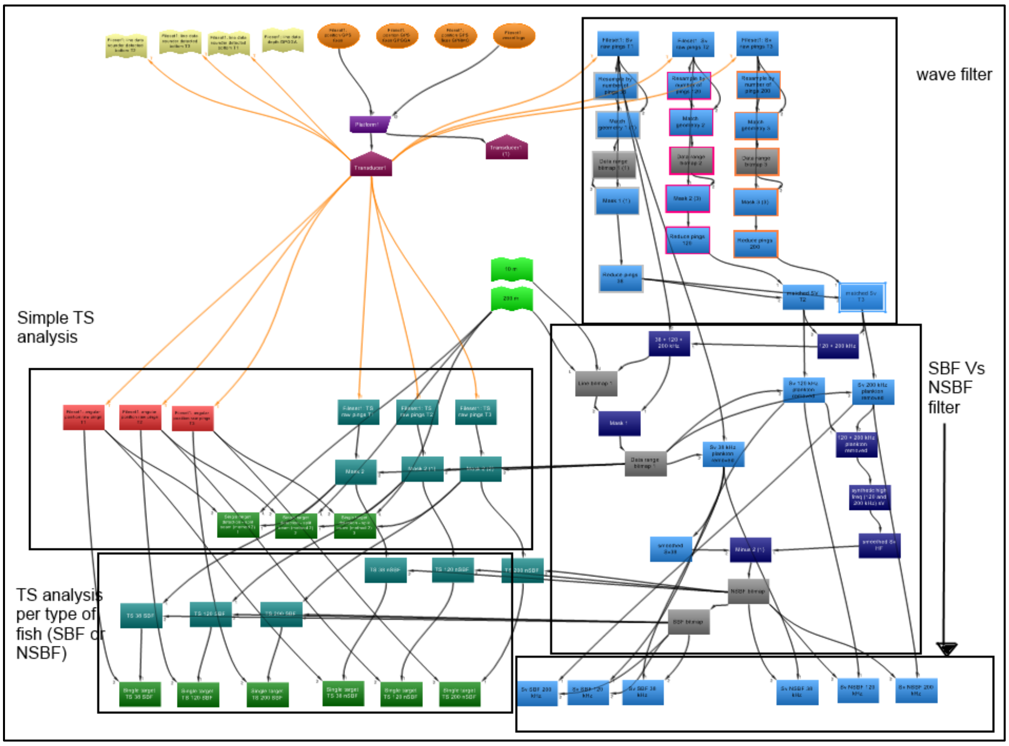

Figure 5. Echoview algorithms to pre-process acoustic data, from the 3 original frequencies (38, 70, 120 kHz), removing wave induced gaps, plankton and interferences.

A frequency response based mask was also developed to split the acoustic backscattering between swim-bladdered and non-swim-bladdered fish (SBF and NSBF). The mask was adapted from Ballón et al (2011) and Korneliusen (2010), following two steps:

A. *Collective thresholding*. A collective threshold was applied to the echograms. First, a virtual echogram was obtained by summing Sv echograms for the three frequencies (38, 120 and 200 kHz). Then the resulting samples of the echogram were thresholded at a value of -180 dB. As a result, we obtained a bitmap with the same number of samples as the summed echogram, in which each pixel had a value of 1 if higher than the threshold and a 0 value if lower than the threshold. Each of the individual frequency Sv echograms were masked by this bitmap.

Summarizing, Sv38 +Sv120 + Sv200 <> -180 dB fish vs. plankton

B. *Delta MVBS*. For the second step, first the high frequency (HF) (120 and 200 kHz) Sv echograms were combined into one single virtual echogram in which each sample was the average of the samples of the individual frequencies. Then, this HF Sv echogram was subtracted from the low frequency one (38 kHz). And, similarly to the first step, a bitmap was built based on thresholding the resulting virtual echogram. The aim was to look for a threshold value that will distinguish fish with a swimm-bladder (SB) and without swim-bladder (nSB).

In order to obtain a proper threshold value to split the type of fish (SB vs nSB), it will be necessary to adjust values in order to predict the species distribution obtained during the spill sampling of each set. In order to do so, the mean target strength (TS) values for each species is needed. Therefore, this optimization step can only be finished after a proper TS-length relationship is obtained for the main tuna species (BET, YFT and SKJ).

Analyses have not been completed at the time of preparing this report for WCPFC-SC10. Ongoing analyses will comprise the following activities:

- Obtaining TS-length relationships for the mono-specific (or almost so) tuna sets, i.e., skipjack sets 24, 26 and 27.
- Obtaining TS-length relationships for the three main tuna species (SKJ, BET, YFT).
- Adjusting and measuring the efficiency of the frequency response mask to discriminate between species.
- Estimating the percentage of species and sizes of tuna present at DFADs.

Ultimately, the aim of this research would be transferring to fishers the knowledge acquired in order to help discriminate tuna species (and if possible, sizes) at dFADs before setting.

2.2 Preliminary results

Preliminary analysis showed early patterns for different frequency response for the swimbladder (SB) and non-swimbladder (nSB) tuna species. The nSB tuna (i.e., skipjack) was more reflective on the high frequency echograms (120 and 200 kHz) (**Figure 6**), whereas the SB tuna (BET and YFT) were more intense on the low frequency echograms (**Figure 7**) which shows a great potential to discriminate these species using acoustic echo-sounders operating at different frequencies.

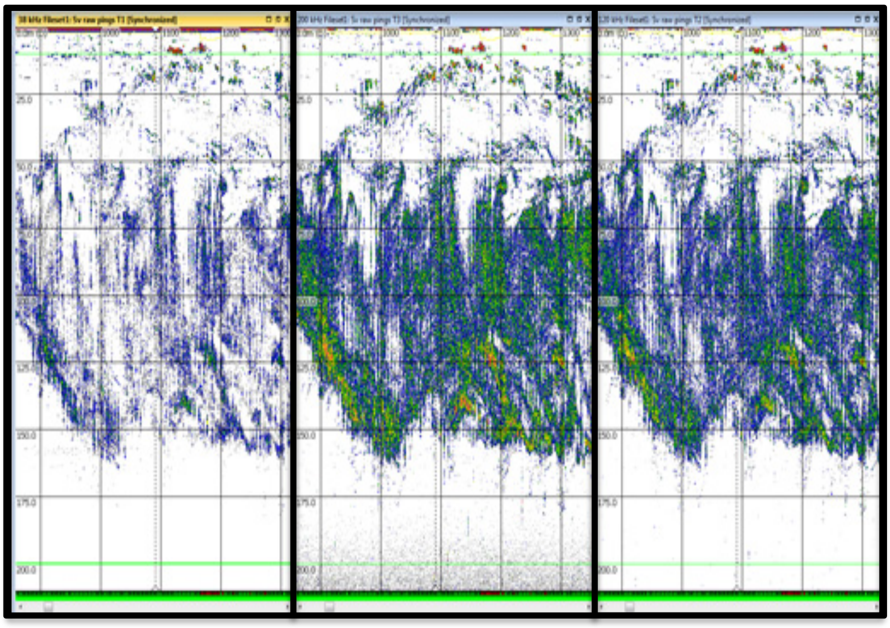

Figure 6. Skipjack tuna (non-swim-bladder fish) response to the different frequencies (38, 120 and 200 kHz from left to right respectively).

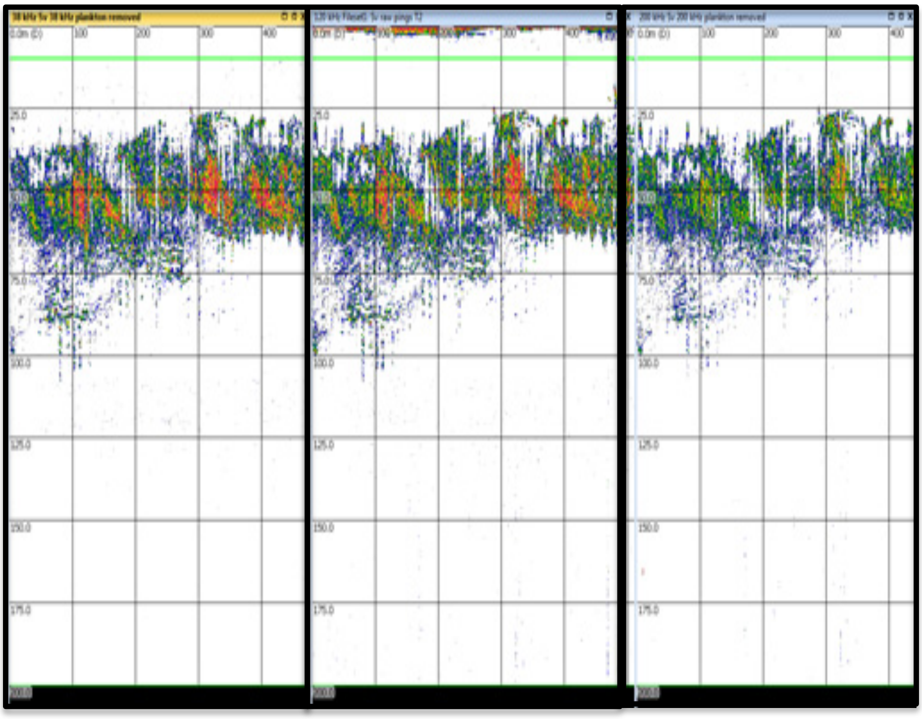

Figure 7. Bigeye tuna (swim-bladder fish) response to the different frequencies (38, 120 and 200 kHz from left to right respectively).

Preliminary Target Strength analyses for skipjack tuna showed, as well, large differences in response to the high and low frequencies used (**Figure 8**). A difference of around 6 dB for b20 values (theoretical TS for 1 cm individual) where observed for the same insonified skipjack tuna.

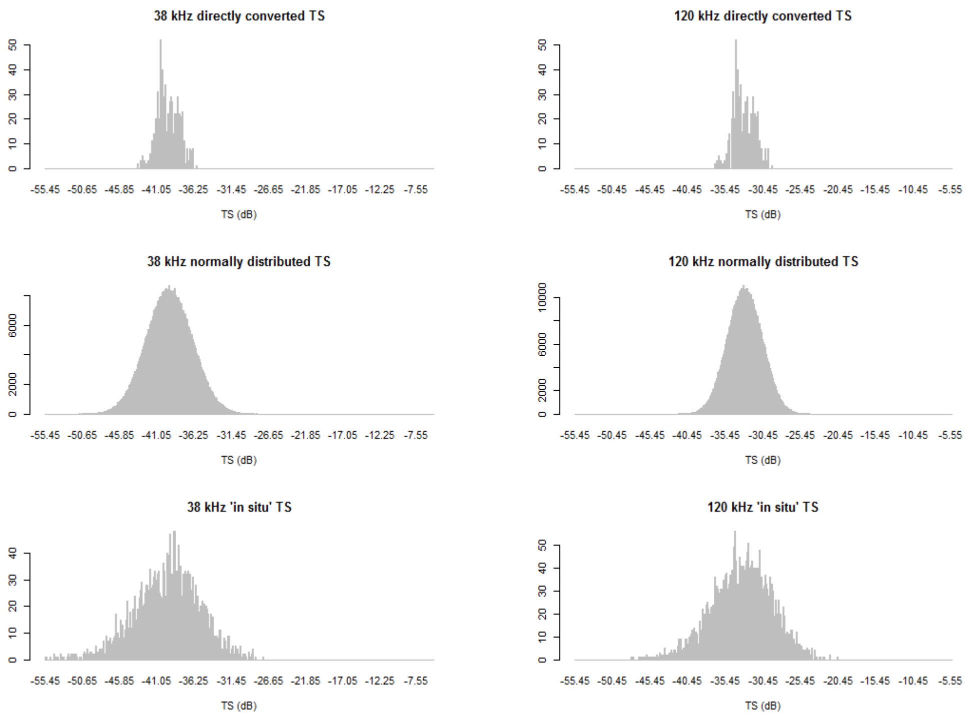

Figure 8. Skipjack Target Strength values for 38 kHz low frequency (left) and 120 kHz high frequency (right).

Values shown in **Figure 8** were obtained for a skipjack tuna aggregation at night (the set made the following morning was comprised of 99% of skipjack). Further analyses are being conducted due to the different TS values obtained during the day for the same aggregation.

In addition to the observations obtained with the scientific EK60, acoustic information was also gathered from the equipment onboard the ALBATUN TRES (echo-sounder ES70 and sonar FSV35, **Figure 9**). The different instruments used in different sets is presented in **Table 2**.

Figure 9. Echo-sounders onboard ALBATUN TRES.

Table 2. Purse seine sets and EK60, ES70 and FSV35 observation replicates.

Set	Latitude	Longitude	EK60	ES70	FSV35
1	2.53	-154.37	-	-	-
2	3.37	-151.28	-	-	-
3	3.36	-151.28	-	yes	-
4	4.34	-150.34	1	yes	-
5	3.1	-152.12	2	yes	-
6	3.44	-150.49	3	yes	-
7	2.01	-148.06	4	yes	-
8	3.13	-146.56	5	yes	-
9	4.03	-150.2	6	-	-
10	4.05	-150.17	-	-	-
11	3.54	-150.2	7	-	-
12	4.28	-151.01	8	yes	-
13	5.09	-151.19	9	yes	-
14	3.36	-153.33	10	yes	-
15	4.58	-151.03	11	yes	-
16	1.56	-151.37	12	yes	-
17	3.32	-155.33	13	yes	-
18	3.38	-152.38	14	yes	photo
19	-0.46	-152.41	-	-	-
20	3.05	-154.03	15	yes	photo
21	2.57	-158.26	-	-	-
22	2.36	-161.11	16	yes	photo
23	-0.53	-167.4	-	-	-
24	-1.25	-169.04	17	yes	photo
25	-3.03	-169.11	18	yes	photo
26	-3.02	-169.17	19	yes	photo
27	-3.4	-173.19	20	yes	photo
Total replicates			**20**	**19**	**7**

3. Species Composition Estimation by Set

Spill sampling of the catch was conducted 24 out of 27 sets, each time acoustic EK60 data was recorded (**Table 2**). This was done in order to be able to compare the actual catch species composition with the signals recorded by the echo-sounders (see **Sections 1 and 2**). Between 1 and 2 tons of fish were measured in each of these sets using a fiberglass box of dimensions 110cm x 70cm x 100cm (approximately 0.8 ton capacity, **Figure 10**). Spill samples were selected randomly during each set to avoid bias. In general, samples were taken every 6th or 7th brail, which provided enough time for the entire sample to be processed before the next sample was chosen. Scientists identified species and measured each fish in the sample to the nearest centimeter on flat measuring boards. The weights of sampled individuals were estimated using length-weight relationships available for each species. These proportions by weight were then extrapolated to the total tonnage of each set, as estimated by the fishing master.

Figure 10. Spill sampling by scientists on the lower deck.

A second estimate of catch composition for each set was also obtained with assistance from the vessel's fishing master and crew. This was achieved by spill sampling on a smaller scale (only a few individual fish per brail were sampled). This procedure is basically what sometimes observers do when intensive sampling is not carried out. The estimation of species composition in tropical tuna purse seiners is a difficult and complex topic and the focus of intensive study in the WCPFC (Project 60: "Collection and evaluation of purse seine species composition data"). **Table 3** provides these data as well as the difference in the percentage of bigeye estimated by scientists with intensive spill sampling ("scientists") and with the second, less intensive sampling approach ("vessel"). In all sets except for two, the scientist’s intensive spill sampling estimation of bigeye percentage was higher and the estimation of skipjack percentage was lower. In most sets, the disparity was relatively large (**Figure 11**).

Other comparisons between the different catch estimation methods will be made in the future, once the authors receive the data from the regional observer onboard (the data that are actually used for reporting species composition), as well as data from the cannery that processed the trip's catch.

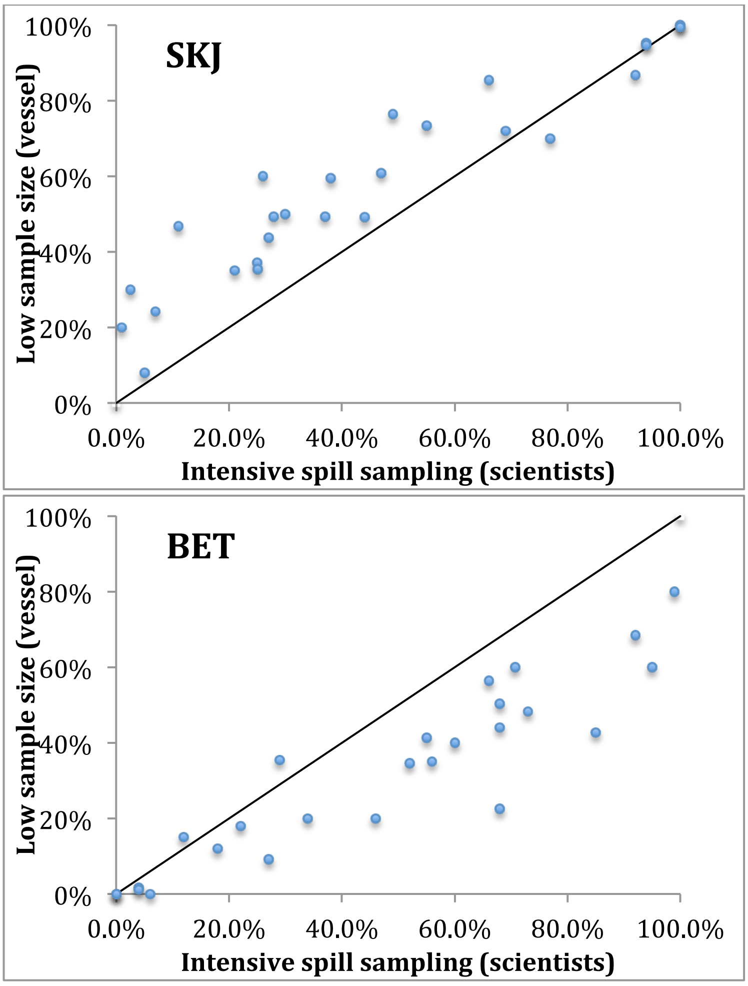

Figure 11. Comparison of estimates of percent skipjack (top) or percent bigeye (bottom) in each set. The X-axis are the results obtained by the scientists with spill sampling, and the Y-axis are the estimates obtained with the assistance from the crew using smaller sample sizes.

Catch composition of each set as estimated by scientists through spill sampling is provided in **Table 3** and **Figure 12**. Sets #s 1, 5, 6 and 7 were close to mono-specific for bigeye. An additional nine sets consisted of over 50% bigeye by weight. These sets were concentrated east of the Line Islands, an area which has been identified as a bigeye spawning area and fishing hotspot for both purse seine and longline vessels (Nishikawa et al 1985; Schaefer et al 2005). There was some correlation of higher proportion of bigeye in total catch by set with more easterly longitudes (**Figure 13**), although note that only four sets were made west of 160°W. Catches with larger proportions of skipjack were observed in sets made further to the west, near the Phoenix and Gilbert islands, with mono-specific sets of skipjack observed in sets # 2, 23, 24, 26 and 27. Set 23 was made on a free school of skipjack. No mono-specific sets of yellowfin tuna were observed.

Table 3. Species composition by weight as obtained from intensive spill sampling by scientists and less intensive sampling by the vessel crew onboard the ALBATUN TRES fishing in the central Pacific Ocean.

		Intensive spill sampling (scientists)			Alternative sampling (vessel)		
Set #	Tons	% SKJ (weight)	% BET (weight)	% YFT (weight)	% SKJ (weight)	% BET (weight)	% YFT (weight)
1	160	2.5%	95.0%	2.5%	30%	60%	10%
2	15	92.0%	6.0%	2.0%	87%	0%	13%
3	25	5.0%	18.0%	77.0%	8%	12%	80%
4	45	55.0%	34.0%	11.0%	73%	20%	7%
5	75	11.0%	85.0%	4.0%	47%	43%	11%
6	25	1.0%	99.0%	0.0%	20%	80%	0%
7	95	7.0%	92.0%	2.0%	24%	68%	7%
8	140	25.0%	66.0%	8.0%	37%	56%	6%
9	40	26.0%	68.0%	6.0%	60%	23%	18%
10	50	69.0%	22.0%	8.0%	72%	18%	10%
11	20	30.0%	60.0%	10.0%	50%	40%	10%
12	20	77.0%	12.0%	11.0%	70%	15%	15%
13	55	66.0%	27.0%	8.0%	85%	9%	5%
14	75	28.0%	68.0%	5.0%	49%	44%	7%
15	55	49.0%	46.0%	4.0%	76%	20%	4%
16	60	21.0%	73.0%	6.0%	35%	48%	17%
17	180	38.0%	56.0%	6.0%	59%	35%	6%
18	65	25.1%	70.7%	4.2%	35%	60%	5%
19	75	37.0%	55.0%	7.0%	49%	41%	9%
20	215	27.0%	68.0%	5.0%	44%	50%	6%
21	130	47.0%	52.0%	2.0%	61%	35%	5%
22	110	44.0%	29.0%	26.0%	49%	35%	15%
23	30	100.0%	0.0%	0.0%	100%	0%	0%
24	170	100.0%	0.0%	0.0%	99%	0%	1%
25	65				94%	0%	6%
26	125	94.0%	4.0%	2.0%	95%	2%	3%
27	170	94.0%	4.0%	2.0%	95%	1%	4%

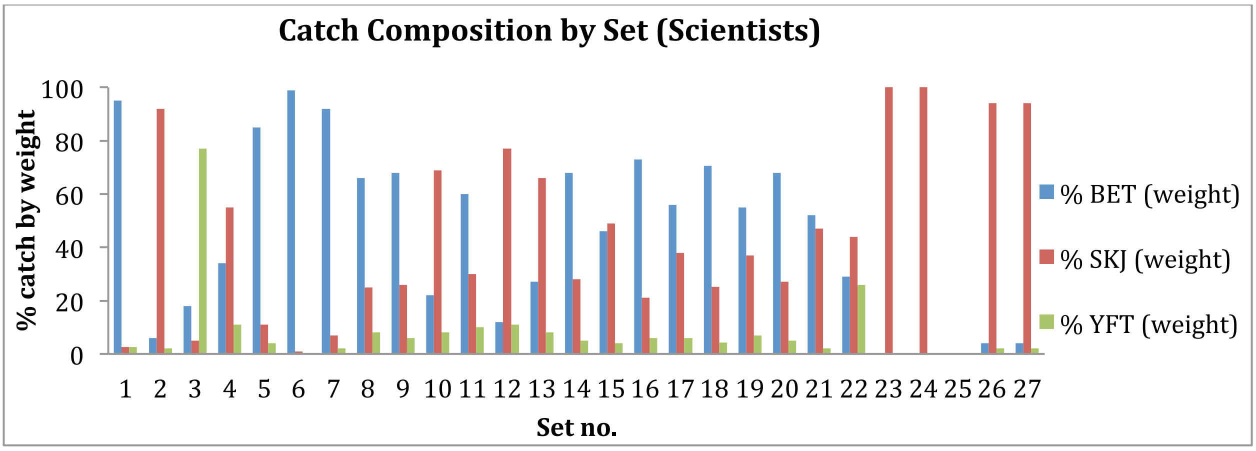

Figure 12. Catch composition by weight for each set for the three target tuna species, estimated through spill sampling.

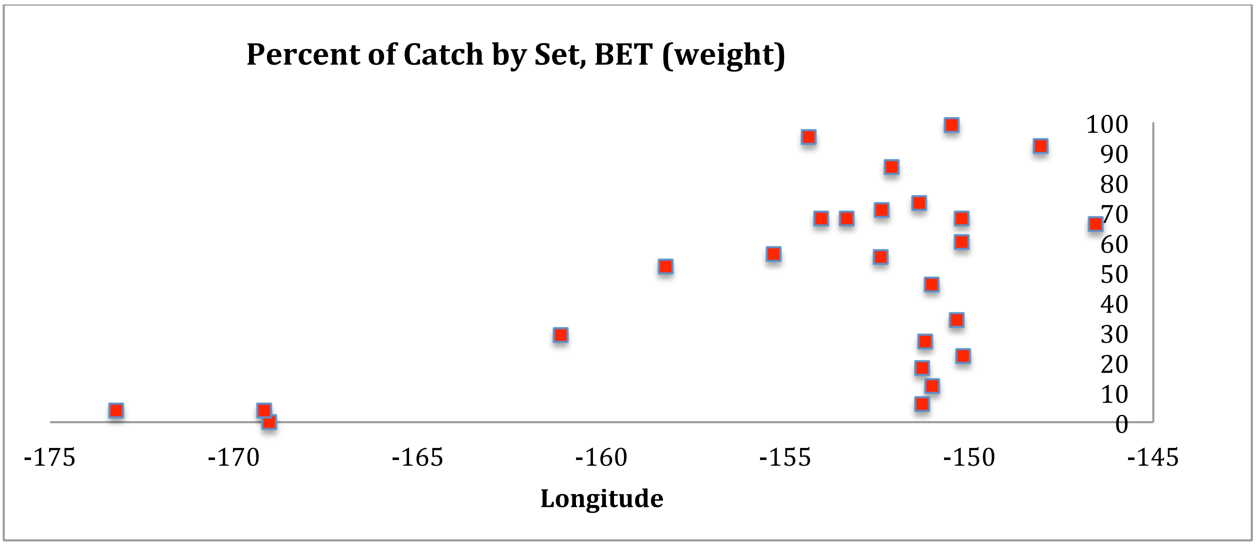

Figure 13. Proportion of catch consisting of bigeye tuna as a function of longitude from sets as obtained by spill sampling.

4. Fish behavior inside the net

As nearly all sets during the cruise were initiated well before sunrise, observations of tuna behavior by divers in the net were not feasible. Furthermore, the visibility (8-15m) was insufficient, making it impossible to collect any accurate behavioral observations.

5. Progress on the use of an Escape Panel for Sharks and other Bycatch

The objective of this activity was to test if sharks can be effectively released alive from a set through an escape panel, before being brought onboard. This experiment had been carried out in a previous ISSF cruise onboard the U.S. vessel CAPE FINISTERRE (WCPFC-SC8-2012/EB-WP-11) with promising results but a small number of observations.

In order to test the escape panel, it is essential to create a 'bend' in the net's shape, where sharks have been observed to accumulate while the net is being hauled. In observing the fishing process onboard the ISSF research cruises to-date onboard different vessels in the Indian and Pacific oceans, it became evident that the 'bend' is not always present. The way the fishing master of the ALBATUN TRES hauled the net did not result in this 'bend' shape under normal conditions (**Figure 14**). The resulting shape was more similar to a mushroom, and such a round shape would not provide any particular area where sharks could concentrate for an extended period of time.

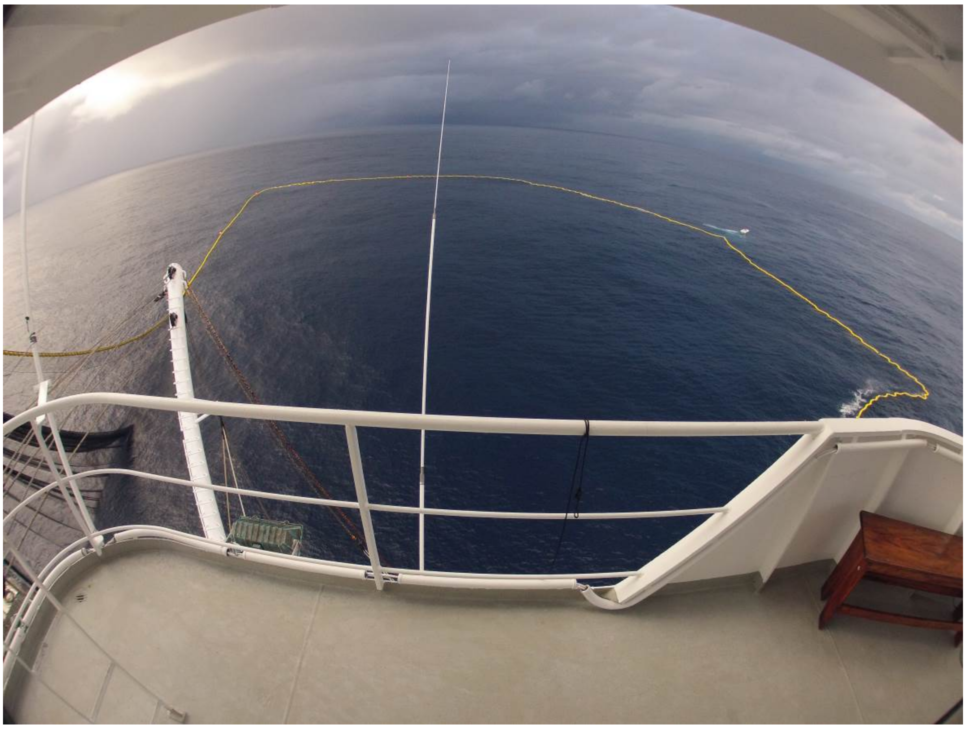

Figure 14. Vessel retrieving the net with the typical “mushroom” shape.

Considering that this was not a chartered research cruise, the idea was to initially locate the ideal place in the net to situate the escape panel, according to the vessel’s standard net setting and hauling procedure. Once this location was determined, the objective was to open the panel as many times as possible. To minimize the risks to the net and vessel, it was agreed before the cruise that the panel would only be tested when various safety conditions were (size of aggregation, metereological conditions, etc.)

From a total of 27 sets during the trip, the creation of a bend occurred 9 times. However, in 6 of those 9 sets the bend was created only briefly and just before sacking-up, too late for testing an escape panel due to the high tension on the net at that stage of the net recovery (in addition to a high probability of tunas escaping). Therefore, only in 3 of the 27 sets (set #s 18, 21, 22, with 8, 8 and 30 sharks, respectively) was the bend created in time to theoretically be able to test an escape panel. In two out of these three sets, sharks were observed in the area of the bend. However, all of these sets contained more than 50 tons of tuna so the pre-agreed conditions for the tests were not met, and the escape panel was therefore not installed.

During the majority of sets when sharks were seen while snorkeling, they were in close proximity to the tunas, and often mixed right in between them. They also moved around the net freely, and were seldom located at any one point for more than a few seconds. It is not known whether their behavior would change, and whether a greater spatial division would develop between sharks and tunas, if the maneuvers to create the net bend were carried out. It is possible that pulling persistently on the net towards the starboard side of the vessel, i.e. creating an outwards current towards the panel, might cause the sharks to separate more regularly from the tunas and accumulate in the bend area as observed during the first CAPE FINISTERRE cruise (WCPFC-SC8-2012/EB-WP-11). However, it would certainly require several replicates to ascertain this possibility.

Early in the trip, it was thought that the bend was not being created due solely to the way of setting the net by the fishing master. Different procedures of setting the net might facilitate the creation of a bend. Setting with or towards the wind (more commonly used in vessels focusing on dolphin-tuna aggregations, or free school sets) might end up in a position where the wind is on the stern or port side of the vessel after the set. This would facilitate the use of thrusters sooner, without the risk of the net becoming entangled in them. On the contrary, the setting mode more commonly used among the vessels primarily fishing on dFADs is to follow the current (parallel and in favor of the current). This setting mode prioritizes the direction of the current and therefore the wind is not always at the stern or from the port side after the set, causing the vessel to drift into the net itself and therefore creating a situation with high risk of net entanglement in thrusters if the fishing master uses them persistently.

After a couple of weeks and several sets of observation and discussion with the fishing master and captain onboard, the scientists concluded that the way of setting and the creation of a bend were not mutually exclusive. The bend creation is not subject to a particular way of setting, as the fishing master always holds the capacity and tools to create the bend if there are good oceanographic and meteorological conditions. The fishing master suggested the following protocol for creating a bend:

- Wait until the wind is on port side. If it is not (depends on the setting direction), pull strongly with the skiff to turn the vessel.
- Recover the net until 2/3 is onboard or the escape panel area is close to being perpendicular to the vessel.
- Block the corkline with a winch so that it does not come out during the vessel pulling process (which would cause a disequilibrium between the amount of corkline and the amount of chain line recovered, which would make the sack creation impossible). This might not be necessary with the aluminum power blocks because they tend to have a stronger hold on the corkline.
- Pull strongly with the 2 thrusters (stern and bow) until the bend is created (his estimation is that this could take around 15-20 min of pulling, depending on the net size, mesh size of the net and the current direction/strength). It would take shorter with lighter nets with big mesh size.
- Open the escape panel and continue pulling the vessel out with the thrusters to maintain the outwards current that could increase the separation between the tunas and sharks, and eventually the shark accumulation in the bend area. There must be a good communication with the divers so that the net does not collapse or there would be massive entanglement of tunas.
- "Close" the escape panel and pull the skiff towards the rear to decrease the corkline tension in the power block to help with recovering the net.

6. Other observations

6.1 Shark bycatch

A total of 301 sharks caught were caught during the trip, 299 of which were individuals were silky sharks (*Carcharhinus falciformis*). The other two sharks were an oceanic whitetip (*C. longimanus*) and a hammerhead (*Sphyrnia sp.*). All sharks were diligently released by the crew as they were detected (after brailing or from the lower deck). Measurements were only obtained for a few individuals, but estimates of total length of sharks from each set were made from a combination of underwater and on-deck observations. In this way the mean total length of silky sharks across all sets was estimated to be 1.4 m. An average of 11.1 sharks set^{-1} were caught during the trip.

After observing the way sharks (primarily silky sharks) were manipulated onboard during the sets, scientists tried to improve both the survival rate of sharks and the safety of the crew while they were manipulating sharks. To this end, a stretcher was constructed for carrying sharks from the lower deck to the upper deck, where they could be released (**Figure 15**). In this way, large sharks could be handled more safely when they were very lively, and thus have an improved chance of survival once released with lesser risk of injury to the crew.

Figure 15. Bycatch release bed.

6.2 Survival of mega-fauna

During the cruise, only one mobulid ray was captured in set #5. The scientific team was unaware of its presence until it was being released and there was no opportunity to tag it. No whale sharks were captured incidentally during the cruise. As such, no results were obtained regarding the survival of rays or whale sharks during this cruise.

6.3 Condition of tuna

As priority was given to the collection of spill sample data for the improved analysis of the acoustic data, there were few opportunities to collect data on the condition of tunas. Additionally, the BIA unit used for collecting this data was providing inconsistent measurements and as such only 44 yellowfin tuna from two sets were successfully sampled.

Acknowledgements

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