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ISSF BYCATCH REDUCTION RESEARCH CRUISE ON THE F/V MAR DE SERGIO IN 2016

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SUMMARY

A research cruise in support of the International Seafood Sustainability Foundation (ISSF) bycatch reduction project was conducted on the tuna purse seine vessel MAR DE SERGIO, during March-April 2016 in the eastern tropical Atlantic Ocean. During a 4-week period a group of three scientists joined the fishing trip with the following objectives: (1) Improving pre-set estimation of species composition, sizes, and quantities of tunas associated with FADs using acoustics: Attaching fishers´ echo-sounder buoys from four different brands to the FADs to compare signals; (2) Use of three scientific echo-sounders with frequencies of 38, 120 and 200 kHz and an EK80 wideband echo-sounder for the frequency band from 85 kHz to 170 kHz onboard a work boat, followed by intensive spill sampling to compare acoustic data and species composition; (3) Study of fish behavior inside the net; (4) shark fish and release from the net; (5) Making other observations that could lead to further tests of mitigation techniques. Preliminary results of these studies are presented.

RÉSUMÉ

Une campagne de recherche, en appui au projet de réduction des prises accessoires de International Seafood Sustainability Foundation (ISSF) a été réalisée à bord du thonier senneur Mar de Sergio en mars et avril 2016 dans l'océan Atlantique tropical oriental. Pendant quatre semaines, trois scientifiques ont participé à la sortie de pêche dans le but de remplir les objectifs suivants : (1) amélioration de l'estimation préalable à l'opération de la composition par espèce, des tailles et des quantités de thons associés aux DCP au moyen de dispositifs acoustiques : apposition sur des DCP de balises pourvues d'échosondeur de quatre différentes marques afin de comparer les signaux ; (2) utilisation de trois échosondeurs scientifiques opérant à trois fréquences différentes (38 kHz, 120 kHz et 200 kHz) et d'un échosondeur à large bande EK80 pour la bande de fréquence oscillant entre 85 kHz et 170 kHz à bord d'un navire de travail, suivie par un échantillonnage en blocs (« spill sampling ») intensif visant à comparer les données acoustiques et la composition par espèce ; (3) étude du comportement du poisson à l'intérieur du filet ; (4) capture et remise à l'eau des requins depuis le filet ; (5) réalisation d'autres observations qui pourraient donner lieu à d'autres tests de techniques d'atténuation. Les résultats préliminaires de ces études sont présentés.

RESUMEN

Se llevó a cabo un crucero de investigación en apoyo del proyecto de reducción de la captura fortuita de International Seafood Sustainability Foundation (ISSF) durante marzo-abril de 2016 en el cerquero MAR DE SERGIO en el Atlántico tropical oriental. Durante cuatro semanas, un grupo de tres científicos se unió al crucero con los siguientes objetivos: (1) mejorar la estimación previa al lance de la composición por especies, las tallas y la cantidad de atunes asociada a los DCP por medio de la acústica: colocando boyas con ecosondas de cuatro marcas diferentes en los DCP para comparar las señales, (2) utilizar tres ecosondas científicas con frecuencias de 38, 120 y 200 kHz y una ecosonda de banda ancha EK80 para la banda de frecuencia de 85 kHz a 170 kHz a bordo de un barco de trabajo, seguido de un muestreo detallado intensivo para comparar los datos acústicos y la composición por especies, (3) estudiar el comportamiento de los peces dentro de la red, (4) capturar los tiburones y liberarlos de la red, (5) realizar otras observaciones que puedan generar más pruebas de técnicas de mitigación. Se presentan los resultados preliminares de estos estudios.

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KEYWORDS

Purse Seine, Echo-sounders, Acoustic Selectivity, Bycatch, FAD, Silky Shark, Tuna

1. Introduction

The International Seafood Sustainability Foundation (ISSF) supports science-based initiatives for the long-term conservation and sustainable use of global tuna stocks. Bycatch reduction and improved targeting in large-scale tuna fisheries is a primary focus area implemented by the ISSF Bycatch Steering Committee. In order to define and test technical solutions to bycatch reduction, ISSF conducts at-sea research cruises to investigate potential mitigation measures centered on tropical tuna purse seine fisheries operating on floating objects. Fifteen research cruises have been conducted in the western Indian Ocean, Eastern Pacific, Western and Central Pacific and Atlantic Oceans since 2011 (Restrepo *et al.*, 2016), mainly looking at ways to reduce catches of bigeye tuna and oceanic sharks.

This report summarizes the activities of the third ISSF bycatch reduction research cruise in the Atlantic Ocean onboard the Spanish purse seine vessel F/V MAR DE SERGIO.

2. Cruise description and objectives

2.1 Vessel and personnel

The F/V MAR DE SERGIO (MDS) is an 83m tuna purse seiner built in 1984 with 1,300T of carrying capacity. The cruise started in Abidjan (Ivory Coast) on March 14th and ended in Dakar (Senegal) on April 11th, 2016. Research was conducted by ISSF-supported scientists Igor Sancristobal, Udane Martinez and Jeff Muir with technical support provided by the vessel captain and crew. The vessel made 33 sets during the cruise (**Figure 1**).

2.2 Cruise objectives

The research cruise had the following objectives:

(1) Improving pre-set estimation of species composition, sizes, and quantities of tunas associated with FADs using fishers´ echo-sounder buoys: Attaching echo-sounder buoys from four different brands to the FADs to compare signals.

(2) Improving pre-set estimation of species, sizes, and quantities of tunas associated with FADs using scientific echo-sounders: Use of three scientific echo-sounders with frequencies of 38, 120 and 200 kHz and a EK80 wideband echo-sounder onboard a work boat, followed by intensive spill sampling to compare acoustic data and species composition.

(3) Behavior of tunas and other fishes within purse-seine nets: Study of fish behavior inside the net

(4) Releasing sharks from the net: Fish and release sharks from inside the net.

3 Materials and methods

3.1 Improving pre-set estimation of species, sizes, and quantities of tunas associated with FADs using fishers´echo-sounder buoys

The objective was to attach one buoy per type (M3i, M4i, Thalos MB and Zunibal; **Figure 2**) to a FAD which was already equipped with a Satlink buoy belonging to the vessel. This was to be done upon arrival, the evening before the set. This way, the buoys' echo-sounders would record data throughout the night until the set was made in the morning. The readings from the different buoys would then be compared against each other and to the actual catch in each set.

3.2 Improving pre-set estimation of species, sizes, and quantities of tunas associated with FADs using scientific echo-sounders

Three narrowband scientific echo-sounders Simrad EK60 operating at frequencies of 38, 120 and 200 kHz was installed on board a work boat (**Figure 3**). In addition, a Simrad EK80 wideband system with a split-beam transceiver with operating software for the frequency band from 85 kHz to 170 kHz was also installed on board the work-boat. Both acoustic systems were calibrated.

In each of the sets where the acoustic equipment was used, the work-boat was attached to the FAD starting about 10 minutes before the set and remained attached between 30-45min during the purse seiner's set. During the first 20-25 minutes, the work boat would drift together with the FAD. Then, it moved slowly to keep the FAD 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 20 to 30 minutes of acoustic data were recorded, with approximately 50% 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. In the case of FAD sets, approximately 1 ton of fish was measured in each of these sets using a plastic bin of dimensions 100cm x 70cm x 100cm (approximately 0.7 t capacity; **Figure 4**). In general, samples were taken from the first or second brail and the last brail for sets less than 10-15 t, for which normally there would be a maximum of 4 brails. For sets over 15t one additional mid-way sample would be taken as soon as first bin's sampling was completed. 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 (Cayré & Laloë 1986). These proportions by weight were then extrapolated to the total tonnage of each set.

3.3 Behavior of tunas and other fishes within purse-seine nets

Underwater visual surveys were to be conducted by snorkeling when feasible, considering sea conditions and other workload, with a focus on shark behavior. One of the main ideas was to see if a channel was formed in the net and if sharks congregated next to this bend, in order to see if an escape panel for sharks would work.

3.4 Releasing sharks from the net

Several skippers as well as the ISSF Bycatch Mitigation Steering Committee suggested the use of baited hooks to catch and release sharks after they are encircled by the purse seine net as a simple option to mitigate shark bycatch. To test the efficacy of the method, survival of the animals once fished and released out of the net was necessary. This was accomplished with the use of survival and mini PAT (SPAT and miniPAT) electronic tags manufactured by Wildlife Computers.

Handlines and chunk fish bait (skipjack, yellowfin, bigeye, bullet tuna, rainbow runner and jacks) in the purse seine net were used during the early stages of net rolling. Handlines consisted of 10m of synthetic tuna cord, which was used as a mainline for a leader and hook. Various leader materials were used, including monofilament (1.6-2.2mm), Sevenstrand coated wire (1.2mm) and stainless steel cable (49 strand 1.6mm). Various circle and J-hook types (no. 26 BKN light and heavy wire, 28 BKN heavy wire, 12/0 VMC, 10/0 VMC) were also trialed during the experiment (**Figure 5**).

Fishing commenced shortly after rings up for each set during the experiment. A speed-boat containing all fishing equipment, tagging equipment, 2 scientists, and 1 volunteer fisherman was used to accomplish this (**Figure 6**).

Implantation of SPAT and miniPAT tags followed protocols used in previous ISSF experiments in the IO (Poisson *et al.* 2014) and the WCPO (Hutchinson *et al.* 2015), with the main difference in this experiment being that sharks were not supplied with a source of salt water to irrigate gills during tag implantation. The reason for this was to closely duplicate "real" fishing conditions, where fishermen would simply catch the shark, negotiate it over the corks, unhook or cut the line, and release the shark as quickly as possible. Upon release, the animal's condition was scored on a 0-4 scale, with 0 being dead, and 4 being excellent condition.

4. Results and conclusions

4.1 Improving pre-set estimation using echo-sounder buoys

Due to the fishing strategy during the trip, this activity was only carried out once. The four echo-sounder buoy brands were attached to a FAD but, afterwards, instead of setting on it, the vessel had to sail to port to repair fishing gear. Thus, this objective could not be achieved.

4.2 Improving pre-set estimation using scientific echo-sounders

Due to a malfunction, no valid data was recorded for the wideband EK80 system. However, the EK60 system was used successfully in 15 of the 33 sets.

From the 15 sets with acoustic data, two had over 80% of non-swim bladder tunas (Skipjack and *Auxis* Sp.), thus served to increase the database for the target strength (TS) and frequency response analysis of this species (TS and frequency response data were first obtained in the ALBATUN TRES cruise; see Sancristobal *et al.* 2014; this cruise served the purpose of augmenting that dataset). Unfortunately, no valid acoustic data was recorded for sets that provided more than 80 % of YFT or BET.

Preliminary analysis confirms the patterns of different frequency response for Skipjack tuna found in the 2014 Western Pacific Ocean ISSF survey data on-board the ALBATUN TRES (Sancristobal *et al.* 2014). The non-swim bladder tuna (i.e., SKJ) was more reflective on the high frequency echograms (120 and 200 kHz, **Figure 7**), whereas the SB tuna (Bigeye and Yellowfin) were more intense on the low frequency echograms. Preliminary Target Strength analyses for skipjack tuna showed the same frequency response patterns observed by Sancristobal *et al.* (2014) but values were somewhat smaller (about -42 dB instead of -37/-40 dB with/without light; **Figure 8**).

Spill sampling of the catch was conducted 22 out of 33 sets. Each time acoustic EK60 data was recorded, spill sampling helped to adjust the species composition derived from the signals recorded by the echo-sounders. Additionally, spill sampling was also carried out in some free school sets in order to improve the catch composition calculated through the electronic monitoring system that the vessel had installed onboard.

One set had 80% of blue runner (**Figure 9**) in number and another set had 56% blue runner. In both cases, echo sounder buoys estimated biomasses over 40t of tunas but the subsequent sets yielded 10t of tunas. Underwater visual observations confirmed that blue runners seemed to extend their habitat deeper than first 10-20 m layer, where some buoy manufacturers have established a threshold to classify the acoustic backscatter of fish as tunas versus non-tuna species. Blue runners’ habitat extension, together with their relatively large swim bladder, could be one of the causes of incorrect tuna biomass estimations done by commercial echo-sounder buoys sometimes. Non-tuna species such as blue runners can be quite abundant in some sets. This should be taken into consideration in future acoustic discrimination studies.

Ongoing analyses comprise the following activities:

- Obtaining Target Strength (TS)-length relationships for the mono-specific (or almost so) tuna sets during this cruise.
- Obtaining frequency response for the three main tuna species (SKJ, BET, YFT).
- Adjusting a frequency response mask to discriminate between species; and validate the mask.

The objective was successfully achieved for SKJ and BET; insufficient data were collected for yellowfin. These data will be combined with data collected in other ISSF research cruises to discriminate these species using acoustic echo-sounders operating at different frequencies. The acoustic selectivity analyses will need to continue, with emphasis on yellowfin.

4.3 Behavior of tunas and other fishes within purse-seine nets

Net hauling by the skipper of the MAR DE SERGIO was very consistent and the shape of the net was similar during every set. A bend between half and quarter net in a “shark fin” type shape was observed on almost all sets. Note that this shape differs from the “bend” observed in the WCPO aboard the CAPE FINISTERRE in 2012 and 2013 and quite similar to the shape on the net in ALBATUN TRES. This may be due to the skipper of the MAR DE SERGIO uses the skiff to pull the purse seine vessel in circles while hauling (facilitating faster hauling and consistent, safe net shape while hauling).

Visual surveys were conducted 15 times (7 FAD sets and 8 Free School sets). There was a relatively low number of sharks present in the net in each set (range: 0 to 6 sharks per set). There was no consistent behavior or location of the sharks at any stage during the survey (which occurred between 1/2 net and the sack). Sharks were often seen swimming the perimeter of the net, both with and against the current, and in and outside the net, but not remaining in any location long enough for the use of a release panel as previously observed by Itano *et al.* (2012).

Due to the shape of the net during hauling, the use of an escape panel for sharks did not appear to be practical. The behavior of the sharks within the net suggested there is no specific point to install an escape panel.

4.4 Releasing sharks from the net

Monofilament line was ruled out quickly, due to its susceptibility to being bitten through by sharks. Sevenstrand coated wire and stainless cable both worked well as leader material, with no distinguishable difference in fishing success when used solely and side by side. A notable difference, though, is the coated wire was easier and safer to work with, as it did not kink and bend and expose bare wire ends after use, which could pose a potential hazard to fishermen's hands when handling used leader portions.

It was found that heavier, larger hooks were preferable because they held up to larger animals both target and non-target (a 160cm YFT straightened a 26 BKN with virtually no effort), resulting in less fishing time lost re-tying and re-rigging handlines. This experiment, though, featured the availability of animals often less than 5m from the boat, feeding actively. This allowed scientists (and a volunteer fisherman from the vessel) to "sight fish", the practice of being able to see when an animal takes your bait, and then setting the hook before it swallows, making the use of "J" style hooks possible. It is preferable to use J hooks in some situations because they often hook animals more readily than circle hooks, and they are also easier to unhook in order to release an animal.

A total of 72 sharks where encircled in the 33 sets of the cruise. The shark catch and release activity was tried in 7 of these sets (**Table 2**). A total of 11 silky sharks were fished and released out of the purse seine net among the 53 sharks caught on those 7 sets (i.e., 21%). All animals for this experiment were released in either good (3) or excellent (4) condition. According to the tagging data, 100% of the sharks survived past 21 days post-release, indicating that the animals suffered no insurmountable amount of stress or injury as a result of being fished and hooked, removed from the water, tagged, and released over the corks.

The objective was achieved successfully. Fishing sharks from the net was found to be a relatively simple and low-risk (to the catch and PS vessel's net) way of removing sharks from the net once they are encircled. Further testing and refinement of this method will continue on future ISSF research cruises.

5 Discussion

This was the second ISSF bycatch research cruise conducted in the Atlantic Ocean onboard a tropical tuna purse seine vessel. Some of the objectives could not be achieved due to uncontrollable circumstances. Such is the nature of at-sea research, where activities do not always take place the way they are planned.

However, other objectives were successfully achieved. One of the ongoing research activities by ISSF is to use acoustic methods to estimate biomass of tunas under FADs, by species. Commercial echo-sounder buoys attached by fishers to FADs typically use a single frequency and they give an estimate of biomass that is simply a composite value. If the biomass estimates were species-specific instead, this would allow fishers to remotely determine the relative species composition under different FADs, to enable them decide on their fishing strategy (e.g. to visit FADs that contain more skipjack and less bigeye). ISSF at-sea research on this issue began in the western and central Pacific in 2014 (Sancristobal *et al.* 2014). The cruise described here in the Atlantic Ocean generated additional data that will help obtain better estimates of target strength, particularly for bigeye and skipjack. Ongoing research in the eastern Pacific is focused on yellowfin tuna.

The other important objective that was achieved was releasing sharks from the net. It is well known that shark survival in purse seine fisheries is very low once they are brailed on board. With good practices for handling and releasing sharks (ISSF, 2014), survival can be increased, up to about 20% (Filmalter *et al.*, 2015). ISSF has been researching ways in which sharks could be released before they are brailed onboard, which could have an even greater impact on survival. One possible approach that has been tested is to install an escape panel in the net (e.g.

Itano *et al.*, 2012). Several ISSF research cruises, including this one, have shown mixed potential for success that depend on factors like the size of the net, the way the skipper sets, and oceanographic variables. And, vessel owners usually react quite negatively to what they see as "making a hole in the net". In this MAR DE SERGIO cruise, scientists tested a much simpler method: Fishing the sharks from inside the net and releasing them outside the net. Results show that this is relatively easy to do and 100% of those sharks released survived. The proportion of sharks encircled that were fished and released was 21%. But, this percentage can probably be increased very easily. Firstly, because in a practical application more time could be spent fishing, without needing to spend time tagging. Secondly, because this cruise was only the first trial of this method. Future research will focus on how to make the catch and release more efficient, and making sure it will be safe for fishers to employ this technique.

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Table 1. Sets made by the MAR DE SERGIO during the research cruise. The last column shows sets where acoustic tests were done.

Set no.	*Date*	*Time of Event(local)*	*Position Lat*	*Position Long*	*Acoustics*
1	3/15/2016	6:20	3.32	-4.16	-
2	3/15/2016	12:54	3.37	-3.31	-
3	3/16/2016	10:28	3.03	-1.2	-
4	3/17/2016	6:21	2.28	0.02	1
5	3/17/2016	9:18	2.36	0	2
6	3/19/2016	6:30	0.59	-4.52	3
7	3/19/2016	9:30	0.59	-4.59	-
8	3/20/2016	11:30	1.09	-9.25	-
9	3/20/2016	13:40	1.11	-9.26	-
10	3/21/2016	9:55	1.18	-9.24	-
11	3/22/2016	7:05	-0.24	-8.39	4
12	3/25/2016	13:45	4.21	-3.43	5
13	3/26/2016	7:25	1.3	-5.15	6
14	3/28/2016	6:45	6.42	-12.48	7
15	3/28/2016	8:50	6.41	-12.48	-
16	3/28/2016	13:15	6.1	-13.03	-
17	3/29/2016	8:15	7.21	-15.34	-
18	3/29/2016	11:00	7.19	-15.34	-
19	3/29/2016	16:40	7.23	-15.34	-
20	3/30/2016	10:05	7.32	-15.25	-
21	3/30/2016	12:35	7.32	-15.26	8
22	3/31/2016	10:55	7.44	-15.23	-
23	3/31/2016	14:00	7.55	-15.18	-
24	4/1/2016	7:00	5.46	-14.05	9
25	4/1/2016	10:20	5.5	-14.22	10
26	4/1/2016	15:10	6.13	-14.34	11
27	4/2/2016	7:10	7.29	-14.49	12
28	4/2/2016	11:25	7.18	-14.37	13
29	4/2/2016	17:00	7.55	-14.42	-
30	4/4/2016	9:45	8.17	-18.14	-
31	4/5/2016	7:30	10.24	-18.44	14
32	4/5/2016	10:40	10.23	-18.44	-
33	4/7/2016	7:35	11.49	-22.15	15
Total					**15**

Table 2. Information on sharks observed, caught and released in the fishing experiment to release sharks from the net.

Set no.	*Tonnage (m)*	*Shark Fishing Activity*	*no. sharks observed*	*no. sharks caught*	*no. sharks released*
1	20	no	0	0	-
2	5	no	0	0	-
3	25	no	0	0	-
4	25	no	3	2	-
5	5	no	0	0	-
6	15	no	-	1	-
7	5	no	0	0	-
8	0	no	-	0	-
9	0	no	-	0	-
10	0	no	-	0	-
11	0	no	-	0	-
12	10	no	2	1	-
13	3	no	0	0	-
14	0	no	6	5	-
15	0	no	0	3	-
16	25	no	2	3	-
17	20	no	0	0	-
18	0	no	0	0	-
19	5	no	0	0	-
20	16	no	0	0	-
21	25	no	0	0	-
22	7	no	0	0	-
23	20	no	0	0	-
24	10	no	-	0	-
25	10	yes	3	5	0
26	15	yes	3	9	1
27	45	yes	0	4	3
28	55	yes	1	6	0
29	10	no	0	1	0
30	25	yes	-	1	1
31	20	yes	-	20	3
32	10	no	-	3	-
33	10	yes	-	8	2
	TOTAL	**7**	**20**	**72**	**10**

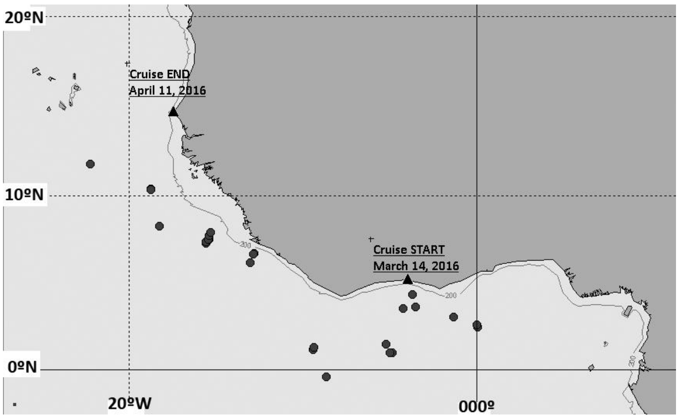

Figure 1. Map of cruise starting and ending ports (black triangles) and set locations (dots) aboard the F/V MAR DE SERGIO.

Figure 2. Different brands of echo-sounder buoys ready to be deployed.

Figure 3. Scientific echo-sounders installed on the work boat.

Figure 4. Spill sampling on the lower deck.

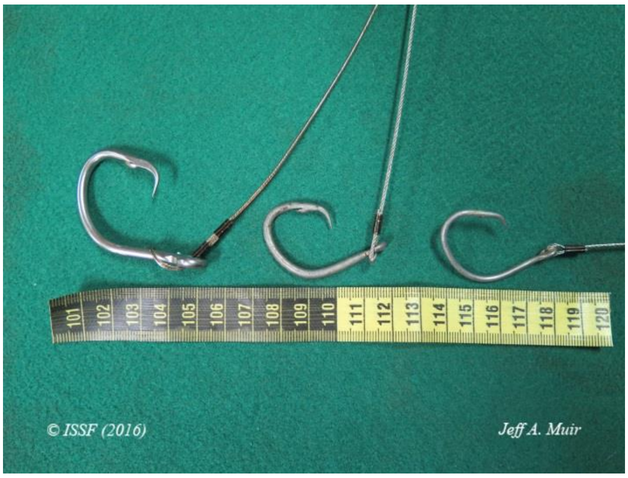

Figure 5. Hook types used in the experiments to fish sharks out of the net.

Figure 6. Handline fishing for sharks within the purse-seine net, to be tagged and released.

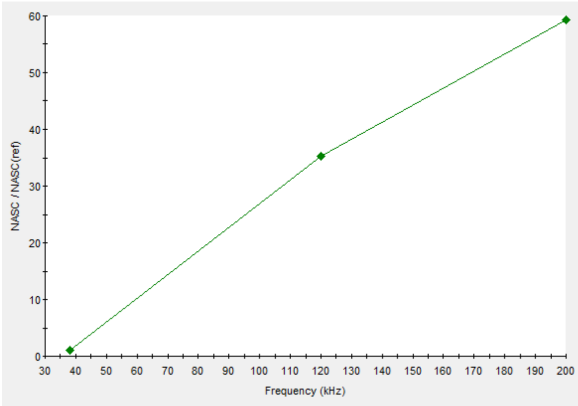

Figure 7. Preliminary frequency response for skipjack tuna (non-swim bladder fish) in the Atlantic Ocean.

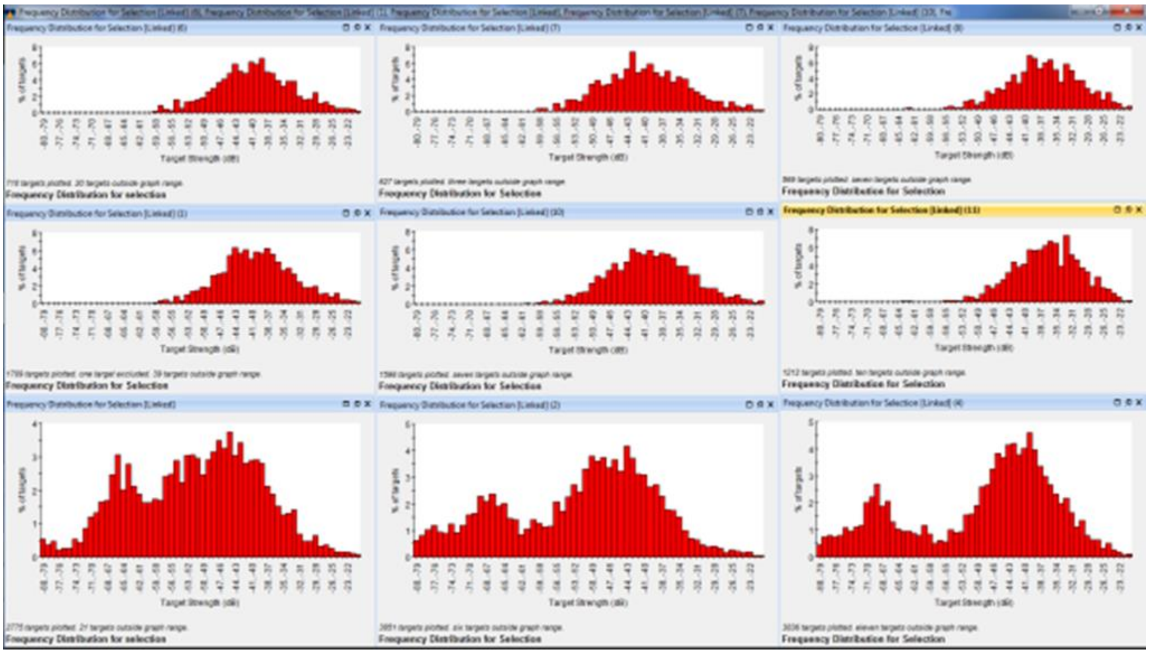

Figure 8. Skipjack Target Strength values for 38 (left) and 120 (middle) and 200 kHz (right) using different filters. Bottom: simultaneous frequency single target location filter based on the “ST intersection” variable in Echoview; Middle: simultaneous frequency threshold filter.

Figure 9. Blue Runner (*Caranx Crysox*) swim bladder.