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ISSF SKIPPERS' WORKSHOPS ROUND 7

Photo: J. Murua

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Abstract

In 2017 the ISSF Skippers Workshops round 7 reached a record number of 794 participants, where 88 percent participation was comprised by tuna purse seiner skippers (457) and crew (238). New workshop locations included Zhoushan in China, or Ambon, Makassar and Manado in Indonesia. In its second year now, the train the trainer program in Indonesia, established to reach small-vessel tuna purse seiner captains widely distributed across the archipelago, delivered 7 workshops. In total 18 Skippers Workshops were conducted in 10 countries covering fleets working in the Western and Central Pacific Ocean (e.g. China, Federated States of Micronesia, United States of America, Marshall Islands, Indonesia), Atlantic Ocean (e.g. Spain, Ghana, France), Indian Ocean (e.g. Spain, France), and the Eastern Pacific Ocean (e.g. Ecuador, Peru).

The workshops continued to show advances in the use of lower entanglement risk FADs (LERFADs) and non-entangling FADs (NEFADs) by fleets in three out of the four oceanic regions. This move is also supported by measures adopted by RFMOs like IATTC, ICCAT and IOTC, or conservation measures by ISSF (e.g. Conservation Measure 3.5.). The first reported voluntary tests with NEFADs in the WCPO by some private companies have started in 2017. The acceptance of biodegradable FADs to reduce marine pollution has risen in 2017 too, with important initiatives in the Indian Ocean with the project BIOFAD with the Spanish and French fleets and TUNACONs in the Eastern Pacific with the Ecuadorian fleet on the way. Best release practices from deck have also shown a rise in acceptance and a gradual but steady increase in their adoption. Other activities to release sharks in the net (e.g. fishing sharks in the net) received poorer acceptance due to associated difficulties such as lack of extra-crew for this activity and safety concerns. Regarding small bigeye and yellowfin tuna, fishers welcome technology for discrimination with multi-frequency echo-sounder buoys which could help identify species composition at FADs. Meanwhile, shorter tail FADs were not considered an effective option to reduce bigeye presence in sets, especially as FAD depth continues to increase in most oceans, because skippers considered that zone and time of the year are the most important factor for bigeye tuna presence in sets. Fishers also discussed alternative management options which could reduce FAD impacts such as FAD number limits, FAD closures or prohibiting the use of supply vessels.

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ISSF is a global coalition of scientists, the tuna industry and World Wildlife Fund (WWF) — the world's leading conservation organization — promoting science-based initiatives for the long-term conservation and sustainable use of tuna stocks, reducing bycatch and promoting ecosystem health. ISSF receives financial support from foundations and industry sources.

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Executive Summary

Key Findings:

1. **Workshops reached a record of 794 participants in a year, conducted at 18 locations in 10 countries.**
2. **Adoption of best practices for non-entangling FADs and release of bycatch from deck continues to advance in most oceanic regions.**
3. **Important biodegradable FAD initiatives have commenced in 2017 in the Indian Ocean and Eastern Pacific.**

During 2017, the seventh round of ISSF Skippers' Workshops visited 18 locations in 10 countries covering 15 purse seine fleets with the participation of 794 fishers and stakeholders (**Table 1**). This document summarizes the results and acceptance levels of participants for various bycatch mitigation activities and advance in the adoption of best fishing practices by various fleets distributed across 4 tropical tuna RFMOs.

The application of several bycatch mitigation activities, including entanglement-minimizing FAD designs, continued to grow in most oceanic regions (**Table 7**). Only in the WCPO the majority of drifting FADs continue to be high entanglement risk (HERFADs) because most use wide mesh (4-5 inch) open net panels reaching 50-80 m in depth. Note that anchored FADs, like those used in Indonesia or Philippines, are all non-entangling. Some WCPO fleets showed some doubts that their FADs entangled many sharks and asked for research surveys to address this knowledge gap. Other WCPO skippers said they would start trying NEFADs to see if they work well at attracting tuna in their fishery.

Meanwhile, biodegradable FADs, which reduce environmental pollution caused by stranding FADs were generally well accepted across fleets and some companies are starting to test prototypes in the Atlantic, Indian Ocean and Eastern Pacific. A specific biodegradable workshop by ISSF with scientists and skippers examined best materials and designs options currently available for each oceanic region in late 2016. Since, other projects like BIOFAD in the IO or the FIP TUNACONS in the EPO were approved in 2017 and large-scale trials at sea with hundreds of biodegradable FADs will take place in 2018.

Best bycatch release methods from deck are widely accepted and some fleets are now routinely applying them in daily fishing (**Table 6**). Use of stretcher beds, cargo nets or other equipment to release large bycatch like manta rays or sharks is spreading. In contrast, low acceptance levels for activities related to shark release from the net like fishing in the net, shark escape windows or the shark backdown are documented. Fishers thought that these methods would be difficult to implement in their oceanic region or with their current nets, or could entail risk to crew. However, if control measures were to be adopted by RFMOs to protect shark declining shark populations (e.g. fishing closures in shark nursery zones) perhaps fishers would be more willing to adopt active mitigation measures.

Use of FADs with echo-sounder buoys continues to increase in all regions, with many companies now using 100% instrumented buoys. Fishing strategies and vessel trips are strongly dictated by the information provided by the echo-sounder buoys. Development of echo-sounder selective technology to avoid FADs with higher bigeye tuna (*Thunnus obesus*) proportions, accompanied by control measures (e.g. vessel TACs), are viewed by many captains as a promising option.

Some small-vessel fleets like Indonesia only fish on anchored FADs and do not have equipment like echo-sounder buoys. These require a different approach to bycatch mitigation. In 2017 local scientists from the Indonesian Centre of Fisheries Research and Development (CFRD) have visited 7 key ports to discuss in person with fishers which are the best options to mitigate bycatch with the kind of smaller artisanal boats they use.

Research Questions

- **What is the added value of participatory approach between tuna scientists and fishers from diverse fleets and oceanic regions to find bycatch mitigation solutions?**
- **Can all bycatch reduction activities function equally between and within oceanic regions?**
- **Are there any promising activities to mitigate shark bycatch in FADs?**
- **What is the current state of adoption of NE FADs and biodegradable FADs by fleets across oceanic regions?**
- **Which are the latest advances in the application of best release methods from deck for bycatch species like turtles, manta rays or sharks?**
- **What solutions do fishers see as more feasible for avoiding undesirable sizes of bigeye tuna?**
- **Do small-vessel tuna purse seiner fleets, with different fishing practices and technological capabilities, require custom-made bycatch mitigation approaches?**

Introduction

Participatory approach workshops between tuna fishers and scientists have led in the past to the development of novel fishing techniques and equipment to prevent dolphin bycatch (Hall et al., 2003). Based on this successful experience, since 2009 ISSF has been organizing workshops between fishery scientist and **captains from tropical tuna purse seine fleets** to discuss ways in which to **reduce bycatch**, principally in fish aggregating device (FAD) sets. Skippers Workshops are framed within the broader **ISSF Bycatch Project** and provide useful feedback to ISSF scientists to help design bycatch solutions adjusted to different oceanic regions and fleets. More than 75 workshops have been facilitated in 17 countries and covered over 25 flags. Tuna fleets from Asia, Africa, Europe, North and South America regularly attend these meetings. The workshops help scientists inform fishers and other key stakeholders (e.g. ship-owners, fleet managers, fisheries managers) about the latest advances in bycatch reduction discovered by scientific studies or learnt from other fleets around the world. Scientists also present possible mitigation activities that **ISSF Bycatch Mitigation Steering Committee (BMSC)** would like to test at sea during the **ISSF research cruises**. Scientists pursue opinions from skilled fishers on bycatch mitigation activities which could result in improvements in experimental design and innovative ideas worth testing. Key recent advances in bycatch mitigation like NE FAD designs or techniques for bycatch release from deck are a direct outcome from the collaboration between scientists and fishers (Poisson et al., 2012; Murua et al., 2014). Best fishing practices developed with the direct input from fishers leads to faster advance in the development of efficient bycatch solutions and higher voluntary adoption by many fleets. Due to the worldwide workshop coverage details on the different operational and gear characteristics between fleets have been documented (e.g. net types, use of lights or bait in FADs, auxiliary vessels, etc.). Many fishers have also worked in multiple oceanic areas and describe oceanographic or fish behaviour differences between regions. Many workshops are facilitated at key tuna ports giving scientists the opportunity to conduct vessel visits. Although workshops focus on industrial sized purse seiner fleets (e.g. > 500 gross tonnage) other fleets with smaller-scaled vessels are also addressed.

The following sections provide updated information on the ISSF Skippers Workshops in the latest completed round of workshops during 2017.

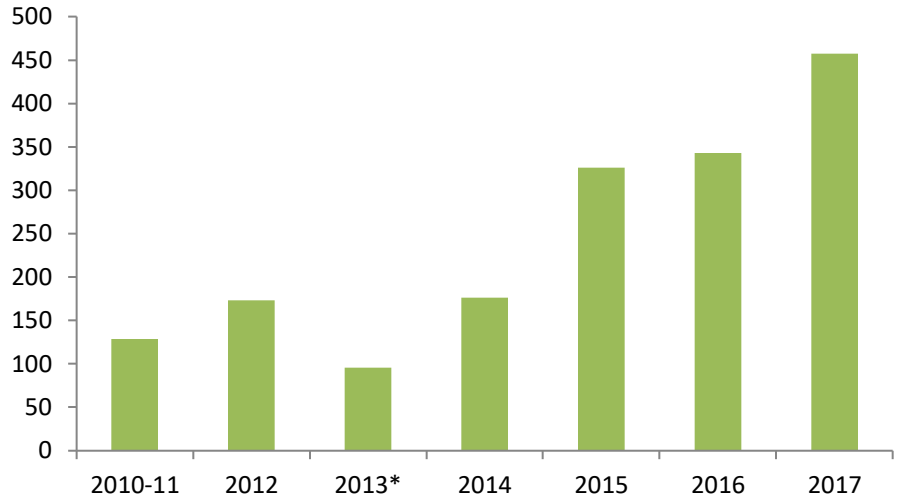
2017 SKIPPERS' WORKSHOPS FLEET COVERAGE

In 2017, a total of 10 countries were visited and workshops conducted at 18 locations (**Table 1**). By continent, there were 3 workshops in South America, 1 in North America, 8 in Asia, 3 in Europe, 2 in Oceania, and 1 in Africa. The skew towards the larger number of workshops in Asia was due to the workshops conducted in Indonesia in 2017 with 7 workshops delivered by local scientists with the train-the-trainer program.

The total number of participants in 2017 was 794, superseding last year's record by 42 percent. Most participants were skippers (i.e. fishing masters or captains) totaling 58 percent and other crew (i.e. officers, chief engineers, deck bosses, deck crew) amounting to 30 percent. With 457skippers in 2017 a new record in number of attending skippers in a year was reached (**Figure 1**). An important part of certified skippers (38 percent) belonged to small-sized purse seiners (i.e. < 100 GT vessels). All fishers participating receive a certificate in skipper education valid for the ProActive Vessel Register (PVR). These statistics do not account for other fishers obtaining their PVR certification through other online methods such as the Skippers Guidebooks or Skippers Workshops Video.

Table 1 – Skippers' Workshop locations and participation by work group category in 2017.

WS	LOCATION	DATE	SKIPPERS	CREW	SHIP-OWNERS	FLEET MANAGERS	FLEET REP.	OFFICIALS	SCIENTISTS	TOTAL
7.1	MANTA (ECUADOR)	10-11/01/2017	95	16	0	1	3	0	2	117
7.2	TEMA (GHANA)	21/02/2017	22	20	1	5	6	1	1	56
7.3	SAN DIEGO (USA)	27/03/2017	7	1	2	4	3	1	1	19
7.4	MAJURO (MARSHALL ISLANDS)	03/04/2017	5	4	0	0	2	0	0	11
7.5	POHNPEI (MICRONESIA)	06/04/2017	8	6	1	0	2	0	2	19
7.6	KENDARI (INDONESIA)	03/04/2017	23	9	0	0	0	4	0	36
7.7	PAOTERE-MAKASSAR (INDONESIA)	05/04/2017	20	8	0	0	0	3	0	31
7.8	TUMUMPA-MANADO (INDONESIA)	07/04/2017	35	6	0	0	0	1	0	42
7.9	AMBON (INDONESIA)	11/04/2017	22	1	0	0	0	4	0	27
7.10	ZHOUSHAN (CHINA)	01/08/2017	8	1	0	4	8	0	3	24
7.11	VIGO (SPAIN)	10/08/2017	24	68	0	0	0	0	0	92
7.12	SIBOLGA (INDONESIA)	04/09/2017	16	19	0	3	0	0	0	38
7.13	LAMPULO (INDONESIA)	07/09/2017	23	4	1	1	0	2	0	31
7.14	JAKARTA (INDONESIA)	19/09/2017	33	3	0	0	0	0	0	36
7.15	LIMA (PERU)	29/'9/2017	14	8	0	1	8	3	4	38
7.16	MANTA (ECUADOR)	04/10/2017	29	41	0	0	0	1	1	72
7.17	CONCARNEAU (FRANCE)	09/10/2017	27	7	0	1	1	0	2	38
7.18	SUKARRIETA (SPAIN)	16-20/10/2017	46	16	0	3	1	0	1	67
TOTAL			457	238	5	23	34	20	17	794



**2013 – only 5 workshops were conducted.*

Figure 1. Historical number of skippers participating in the ISSF Skippers' Workshops.

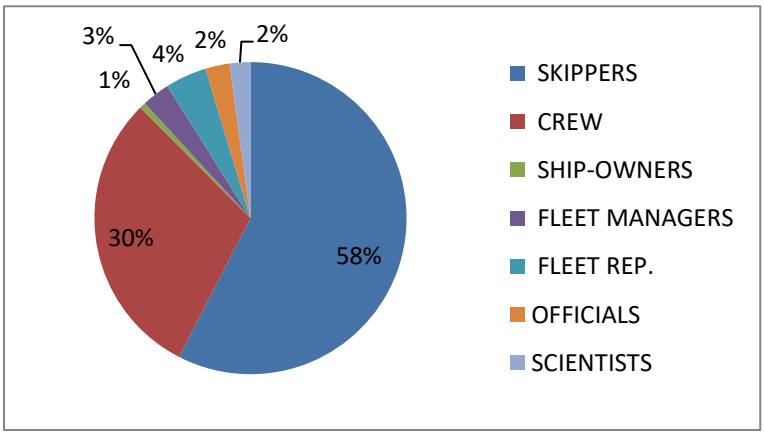


Figure 2. Participation by work group category in 2017 Skippers Workshops.

The overall attendant numbers since the start of the Skippers' Workshops amount to 3056 participations, of which 1703 were skippers and 550 crew (**Table 2**). Note that some fishers may have participated in more than one workshop over the years. Highest fisher attendance has historically been at locations like Sukarrieta (Spain) or Manta (Ecuador), due to the size of these fleets and because workshops have been conducted on an annual basis since 2010.

Table 2 – Skippers' Workshop locations and participation by work group category since 2009.

WS	LOCATION	DATE	SKIPPERS	CREW	SHIP-OWNERS	FLEET MANAGERS	FLEET REP.	OFFICIALS	SCIENTISTS	TOTAL
1.0	SUKARRIETA (SPAIN)	27/11/2009	15	1	1	1	6	1	0	25
1.1	MANTA (ECUADOR)	18/09/2010	56	18	1	0	1	0	0	76
1.2	PANAMA CITY (PANAMA)	22/09/2010	6	6	1	0	0	3	6	22
1.3	ACCRA (GHANA)	10/11/2010	2	0	0	2	21	6	1	32
1.4	SUKARRIETA (SPAIN)	13-17/12/2010	32	0	0	0	6	0	5	43
1.5/1.6	MAHE (SEYCHELLES) / PORT LOUIS (MAURITIUS)	1-19/02/2011	11	5	0	0	1	0	0	17
1.7	PAGO PAGO (AMERICAN SAMOA)	05/03/2011	2	0	2	1	4	3	2	14
1.8	MAJURO (MARSHALL ISLANDS)	22/06/2011	2	1	0	0	1	1	0	5
1.9	POHNPEI (MICRONESIA)	24/06/2011	3	1	0	0	4	0	0	8
2.1	ACCRA (GHANA)	14/03/2012	2	0	0	2	18	6	0	28
2.2	MAHE (SEYCHELLES)	21-18/05/12	5	2	0	0	1	0	0	8
2.3	PAGO PAGO (AMERICAN SAMOA)	11/06/2012	3	2	0	0	3	0	2	10
2.4	GENERAL SANTOS (PHILIPPINES)	08/09/2012	26	4	0	1	3	0	21	55
2.5	BINTUNG (INDONESIA)	11/09/2012	20	0	0	0	0	25	3	48
2.6	JAKARTA (INDONESIA)	13/09/2012	13	1	0	0	0	10	3	27
2.7	MANTA (ECUADOR)	26-27/09/2012	17	4	4	0	1	0	1	27
2.8	SUKARRIETA (SPAIN)	09/10;27/11-5/12/2012	87	3	2	2	9	0	6	109
3.1	ACCRA (GHANA)	08/05/2013	13	0	2	1	18	7	0	41
3.2	LIMA (PERU)	05/08/2013	0	0	2	2	16	2	15	37
3.3	MANTA (ECUADOR)	08/08/2013	37	5	0	3	4	1	0	50
3.4	PANAMA CITY (PANAMA)	12/08/2013	2	0	2	1	7	0	7	19
3.5	SUKARRIETA (SPAIN)	07/11-10/12/2013	44	6	2	2	5	0	0	59
4.1	BUSAN (KOREA)	14/02/2014	8	9	0	1	10	3	12	43
4.2	KAOHSIUNG (TAIWAN)	18/02/2014	1	0	0	6	12	0	0	19
4.3	CANGAS (SPAIN)	28-29/05/2014	20	10	0	0	0	0	0	30
4.4	ACCRA (GHANA)	15/07/2014	7	6	10	9	11	4	1	48
4.5	MANTA (ECUADOR)	12/08/2014	35	1	0	0	1	0	3	40
4.6	JAKARTA (INDONESIA)	19/08/2014	21	2	0	0	1	1	3	28
4.7	GENERAL SANTOS (PHILIPPINES)	05/09/2014	24	6	0	0	2	0	2	34
4.8.	SUKARRIETA (SPAIN)	18/09-14/10/2014	52	5	0	1	3	1	1	63
4.9.	PAGO PAGO (AMERICAN SAMOA)	15-20/10/2014	8	1	0	0	4	0	1	14
5.1.	MANZANILLO (MEXICO)	12/01/2015	34	20	1	1	2	4	0	62
5.2	MAZATLAN (MEXICO)	14/01/2015	65	46	0	1	1	4	1	118
5.3	SAN DIEGO (USA)	12/02/2015	5	0	0	1	3	0	0	9
5.4	TEMA (GHANA)	08/05/2015	10	5	2	9	18	0	1	45
5.5.	JAKARTA (INDONESIA)	19/06/2015	8	14	1	0	5	0	4	32
5.6	BINTUNG (INDONESIA)	22/06/2015	21	13	0	0	1	1	2	38
5.7	SIBOLGA (INDONESIA)	25/06/2015	22	15	0	0	0	1	1	39
5.8	LIMA (PERU)	11/08/2015	10	5	1	1	16	3	6	42
5.9	MANTA (ECUADOR)	14/08/2015	83	8	3	8	6	0	0	108
5.10	BUSAN (KOREA)	15/09/2015	8	0	0	1	8	2	25	44
5.11	CONCARNEAU (FRANCE)	13/10/2015	14	6	0	2	2	0	2	26
5.12	SUKARRIETA (SPAIN)	8,26-30/10/2015	49	5	4	1	2	0	0	61
6.1	SHANGHAI (CHINA)	06/04/2016	10	0	0	6	5	0	6	27
6.2	TEMA (GHANA)	04/05/2016	8	6	2	5	20	4	2	47
6.3	VIGO (SPAIN)	20/07/2016	51	23	0	1	0	0	0	75
6.4	MANTA (ECUADOR)	03/08/2016	33	17	0	2	3	0	1	56
6.5	POSORJA (ECUADOR)	05/08/2016	8	5	0	1	0	0	0	14
6.6	JAKARTA (INDONESIA)	05/09/2016	27	0	0	1	3	0	0	31
6.7	BINTUNG (INDONESIA)	07/09/2016	27	1	1	0	0	1	10	40
6.8	KENDARI (INDONESIA)	09/09/2016	32	0	1	3	1	3	10	50
6.9	BENOA (INDONESIA)	10/09/2016	21	0	0	0	6	0	0	27
6.10	SIBOLGA (INDONESIA)	14/09/2016	15	0	0	7	1	2	0	25
6.11	BANDA ACEH (INDONESIA)	16/09/2016	23	0	0	0	8	0	0	31
6.12	QUY NHON (VIETNAM)	17/09/2016	42	0	0	0	13	0	3	58
6.13	SUKARRIETA (SPAIN)	24-28/10/2016	42	5	1	0	3	0	1	52
6.14	MADEIRA (PORTUGAL)	01/11/2016	4	19	0	0	2	0	1	26
7.1	MANTA (ECUADOR)	10-11/01/2017	95	16	0	1	3	0	2	117
7.2	TEMA (GHANA)	21/02/2017	22	20	1	5	6	1	1	56
7.3	SAN DIEGO (USA)	27/03/2017	7	1	2	4	3	1	1	19
7.4	MAJURO (MARSHALL ISLANDS)	03/04/2017	5	4	0	0	2	0	0	11
7.5	POHNPEI (MICRONESIA)	06/04/2017	8	6	1	0	2	0	2	19
7.6	KENDARI (INDONESIA)	03/04/2017	23	9	0	0	0	4	0	36
7.7	PAOTERE-MAKASSAR (INDONESIA)	05/04/2017	20	8	0	0	0	3	0	31
7.8	TUMUMPA-MANADO (INDONESIA)	07/04/2017	35	6	0	0	0	1	0	42
7.9	AMBON (INDONESIA)	11/04/2017	22	1	0	0	0	4	0	27
7.10	ZHOUSHAN (CHINA)	01/08/2017	8	1	0	4	8	0	3	24
7.11	VIGO (SPAIN)	10/08/2017	24	68	0	0	0	0	0	92
7.12	SIBOLGA (INDONESIA)	04/09/2017	16	19	0	3	0	0	0	38
7.13	LAMPULO (INDONESIA)	07/09/2017	23	4	1	1	0	2	0	31
7.14	JAKARTA (INDONESIA)	19/09/2017	33	3	0	0	0	0	0	36
7.15	LIMA (PERU)	29/'9/2017	14	8	0	1	8	3	4	38
7.16	MANTA (ECUADOR)	04/10/2017	29	41	0	0	0	1	1	72
7.17	CONCARNEAU (FRANCE)	09/10/2017	27	7	0	1	1	0	2	38
7.18	SUKARRIETA (SPAIN)	16-20/10/2017	46	16	0	3	1	0	1	67
TOTAL			1703	550	51	109	336	119	188	3056

INDONESIAN TRAIN-THE-TRAINER PROGRAM

Since 2012 the Indonesian Centre for Fisheries Research and Development (CFRD) has been collaborating in Skippers Workshops, assisting ISSF scientists with workshop presentation and translation tasks. In 2016, a program referred to as "Train-the-Trainer" was set up in Indonesia, training a group of Indonesian tuna fisheries scientists in relevant bycatch mitigation information and how to conduct ISSF Skipper Workshops. Due to the generalized used of anchored FADs (aFADs), small-size of vessels, limited technological gear on board and fleet-specific operational strategies, these workshops require a completely different approach to bycatch mitigation solutions proposed for high-tech tuna super-seiners.

The aim of the program was to have an "in house" team that could deliver multiple opportunistic or planned workshops in Indonesia, necessary to cover the vast number of ports and small-scale purse seine vessels in this country. Limited access by many fishers to online training tools (e.g. Skipper Guidebooks or videos) means that in-person training is required to obtain certification. In 2017, the second round of workshops covered 7 ports including Jakarta in the island of Java, Bitung, Manado, Makassar and Manado in Sulawesi, Sibolga and Lampulo in Sumatra, and Ambon in Moluccas Islands. A total of 241 participants attended these workshops, mostly being skippers (71 percent) and crew (21 percent). All workshops were conducted by the program lead scientists, Mr. Anung Widodo, and an assistant scientist in Bahasa Indonesian. The program is widely supported by Indonesian port directors and industry.

Figure 3. Participants at ISSF Skippers Workshops conducted by CFRD scientists in (a) Ambon and (b) Manado (Indonesia) in 2017.

As in previous rounds, the highest level of acceptance was for use of non-entangling (NE) FADs (but see some Western and Central Pacific fleets) and bycatch release practices from deck (**Table 3**). Another activity for which acceptance has been general is the option of biodegradable FADs to reduce marine debris. Note that these acceptance levels are based on the comments from skippers present at the time of the workshops and do not necessarily represent the views of a whole fleet.

As mentioned in the previous section some of the mitigation activities proposed for the large-scale vessels (e.g. > 500 GT) are often not applicable to the smaller-sized tuna vessels like those of Indonesia or Vietnam. These small wooden boats lack many of the technological advances (e.g. echo-sounder buoys, high-tech sounders and radars) and require specific bycatch mitigation practices adapted to their fishery and vessel characteristics.

Table 3 – Acceptance level of activities proposed in 2017 workshops by fleets. H-High, M-Medium, L-Low, NA-No Answer.

GROUP	MEASURES	CHINA	GHANA	ECUADOR	INDONESIA	SPAIN	FRANCE	USA	PERU
SHARKS	FISHING IN THE NET	M-L	M	M-L	NA	M	M-L	M-L	M-L
	RELEASE PRACTICES	M	H	H	H-M	H	H	H-M	H
	NON-ENTANGLING FADS	M-L	H-M	H	H	H	H	M-L	H
	BIODEGRADABLE FADS	M-L	H-M	H	H-M	H	H	M	H
	DOUBLE FADS	L	L	L	NA	L	L	L	L
TURTLES	RELEASE PRACTICES	M	H	H	H	H	H	H	H
	NON-ENTANGLING FADS	M-L	H-M	H	H	H	H	M-L	H
SMALL TUNA	ECHO-SOUNDER BUOYS	H-M	H-M	H	NA	H	H	H-M	H
	PRE-ESTIMATE ACOUSTICS	M-L	L	L	L	M-L	H	M-L	M
	SMALL SETS	L	L	L	L	L	NA	L	M-L
	CLOSURES/REDUCE FADS	H-M	H-M	M	NA	L	H	H-M	H-M
	SHORT APPENDAGE FADS	M-L	L	L	NA	L	NA	L	L
BONY FISH	UTILIZATION	L	H	H	H	H-M	M	H-M	M

Shark release from the net

Because shark release options such as escape windows in the net and back down for sharks had received poor acceptance ratings in previous years (see previous reports), and no new trials to test these ideas have been conducted since, these options have not been discussed during 2017 workshops. Instead, the latest shark mitigation activity tested during the Mar de Sergio cruise in the Atlantic Ocean, which was the concept of fishing sharks in the net from the speedboat with hooks, has received mixed reviews. In general acceptance has been medium to low. Skippers concerns with this approach included that in addition to the speedboat driver an extra member of crew is needed to assist with the fishing activity, but all crew are needed on deck during the net hauling operation. If this mitigation was to be utilized regularly, ship owners should hire an extra member of crew dedicated to this task. Some fishers pointed out that many times sharks are not small sized and would take a longer time to catch them and take them out of the net. Some raised concern about safety, despite explaining that in this activity no shark manipulation is required as the line can be cut, leaving the hook in the shark's mouth if necessary. Other skippers thought that often due to harsh weather conditions this activity would have limited success.

Table 4 – Evolution in the acceptance level of fishers for the use of shark fishing in the net by different tuna fleets in ISSF Skippers' Workshops between 2015 and 2017.

	FLEET	ACCEPTANCE LEVEL	
		2015-16	2016-17
FISHING SHARK IN NET	ECUADOR	MID	LOW-MID
	MEXICO	-	-
	PERU	-	LOW-MID
	PANAMA	-	-
	USA	-	LOW-MID
	INDONESIA	NA	NA
	KOREA	-	-
	PHILIPPINES	-	-
	TAIWAN	-	-
	FRANCE	-	LOW-MID
	SPAIN	MID	MID
	GHANA	MID	MID
	PORTUGAL	MID-HIGH	-
	VIETNAM	NA	NA
	CHINA	LOW-MID	LOW-MID

Best release practices from deck

High levels of acceptance were recorded for release of bycatch species like turtles, sharks, or manta rays from deck, and whale sharks from the net (**Table 5**). There has been a gradual increase in the number of fishers using tools such as cargo nets, stretcher beds, or ramps to release large sharks or manta rays. Still not all fleets use on a regular basis this simple equipment and it would be advisable to do so, as these mitigation techniques are designed not only to facilitate fast and efficient release, but also ensure crew safety. Fishers said that factors which can delay bycatch release include rough weather conditions, having large aggressive individuals, or a large set where the catch needs to be loaded quickly to prevent tuna spoilage.

For small-vessel fleets like Indonesia, many boats lack enough deck space or even cranes to lift the animals, thus release practices are mostly manual. Several hundred posters of best release practices were distributed at key ports for fishers to display on the boat notice boards so that all crew members are aware of the release protocols.

Table 5 – Evolution in the acceptance level of fishers for the use of best release practices from deck by different tuna fleets in ISSF Skippers' Workshops between 2010 and 2017.

BEST RELEASE PRACTICES	FLEET	ACCEPTANCE LEVEL						
		2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
	ECUADOR	MID	MID	MID-HIGH	HIGH	MID-HIGH	HIGH	HIGH
	MEXICO	-	-	-	-	HIGH	-	-
	PERU	-	-	MID-HIGH	-	MID-HIGH	-	HIGH
	PANAMA	MID-HIGH	-	MID-HIGH	-	-	-	-
	USA	MID	MID-HIGH	-	MID-HIGH	HIGH	-	MID-HIGH
	INDONESIA	-	-	-	LOW	LOW-MID	MID	MID-HIGH
	KOREA	-	-	-	MID-HIGH	MID-HIGH	-	-
	PHILIPPINES	-	MID	-	MID	-	-	-
	TAIWAN	-		-	MID-HIGH	-	-	-
	FRANCE	HIGH	MID	-	-	MID	-	HIGH
	SPAIN	MID	MID-HIGH	MID-HIGH	HIGH	HIGH	HIGH	HIGH
	GHANA	LOW-MID	MID	MID	HIGH	HIGH	HIGH	HIGH
	PORTUGAL	-	-	-	-	-	HIGH	-
	VIETNAM	-	-	-	-	-	MID	-
	CHINA	-	-	-	-	-	LOW-MID	MID

Non-entangling FADs

The use of non-entangling FADs (NE FADs) and lower entanglement risk FADs (LER FADs) has continued to increase in three out of the four oceanic regions. Practically all high-risk entanglement FADs (HER FADs; see ISSF non-entangling FAD guide for FAD type classification) have been discontinued in the Indian and Atlantic Oceans. The RFMOs in these regions have adopted measures requiring the use of NE FADs (e.g. IOTC Resolution 15/08; ICCAT Rec. 16-01). Meanwhile, according to skippers' anonymous questionnaires, for Eastern Pacific fleets like Ecuador the proportion of HER FADs is decreasing, accounting for less than 10% of all FADs (Round 7.16. Manta (Ecuador) report). Most vessels use LER FADs constructed still with netting but either tied up in bundles or made with small mesh netting from anchoveta net or Medina panels. This year the IATTC has passed a measure (C-17-02) which establishes January 2019 as the deadline for full NE FAD implementation.

"Currently in the Indian, Atlantic and Eastern Pacific Oceans, entanglement preventing FADs are the norm. This is supported by regulations from their respective RFMOs."

Meanwhile, in the Western and Central Pacific Ocean most dFADs continue to be of the HER FAD type, only anchored FADs like those in Indonesia, Philippines or Papua New Guinea are non-entangling. No binding NE FAD conservation measure has been adopted yet by the WCPFC, which could favor the adoption of FAD designs minimizing shark and turtle ghost fishing. In 2017, during workshops like those of San Diego (USA), Zhoushan (China), Majuro (Marshall Islands) or Pohnpei (Federated States of Micronesia), skippers described using a similar FAD design, consisting of a floating part made out of a line of cork-line floats wrapped in 4-5-inch mesh netting and an underwater hanging open panel net tail made as well with old 4-5 inch mesh purse seine netting and reaching 40-60 m depth. Multiple elements like colored streamers and rope, green trawling net sections, or palm leaves are added in some cases. In some workshops like China or USA (see **Table 6**) fishers put in doubt that their dFADs entangled many sharks and asked for an oceanic area-specific study in the Western and Central Pacific to evaluate the ghost fishing impact of their dFADs. Since these workshops some companies have communicated ISSF scientists that they have commenced tests with LER FADs and NEFADs to examine their performance in this oceanic region.

Table 6 – Evolution in the acceptance level of fishers for the use of FADs that minimize entanglement by different tuna fleets in ISSF Skippers' Workshops between 2010 and 2017. Estimated number of large purse seiners (> 335 m^3 fish holding volume) by fleet and level of use of FADs.

	FLEET	FAD USE	ACCEPTANCE LEVEL						
			2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
NON-ENTANGLING FADS	ECUADOR	HIGH	LOW	MID	MID-HIGH	MID-HIGH	MID-HIGH	HIGH	HIGH
	MEXICO	LOW	-	-	-	-	HIGH	-	-
	PERU	LOW	-	-	MID	-	MID-HIGH	-	HIGH
	PANAMA	MID	MID	-	MID-HIGH	-	-	-	-
	USA	MID	MID-HIGH	HIGH	-	MID-HIGH	MID-HIGH	-	LOW-MID
	INDONESIA	HIGH	-	-	-	HIGH	HIGH	HIGH	HIGH
	KOREA	HIGH	-	-	-	HIGH	MID	-	-
	PHILIPPINES	HIGH	-	MID-HIGH	-	MID-HIGH	MID-HIGH	-	-
	TAIWAN	MID	-	-	-	MID-HIGH	-	-	-
	FRANCE	MID	HIGH	HIGH	-	-	HIGH	-	HIGH
	SPAIN	HIGH	MID-HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
	GHANA	HIGH	LOW	LOW-MID	MID	MID	MID-HIGH	MID-HIGH	MID-HIGH
	PORTUGAL	MID	-	-	-	-	-	HIGH	-
	VIETNAM	NONE	-	-	-	-	-	NA	-
	CHINA	MID	-	-	-	-	-	MID	LOW-MID

Biodegradable FADs

The end of Round 6 of the Skippers Workshops in 2016 reported on the progress in moving towards biodegradable FADs, and the special Biodegradable FAD workshop organized by ISSF in San Sebastian (Moreno et al., 2016) between scientists and skippers was a precursor of further advances observed in 2017. Fishers understand that marine debris and ghost fishing produced by lost FADs is counterproductive for the FAD fishery's public image and would like to solve this problem. Although alternative options to prevent FAD beaching, such as having a dedicated boat to collect lost FADs, have been discussed, the most widely accepted option is the construction of FADs with biodegradable materials. Acceptance has been broad across fleets (**Table 7**), but fleets from the Western and Central Pacific Ocean raised some concerns regarding increased costs of shipping biodegradable materials as the small islands in the region would not be able to source the required quantities, and also stated that some FADs can last over year and a half and are moved frequently between areas, so they need to be quite resistant.

Table 7 – Evolution in the acceptance level of fishers for biodegradable FADs by different tuna fleets in ISSF Skippers' Workshops between 2015 and 2017.

	FLEET	ACCEPTANCE LEVEL	
		2015-16	2016-17
BIODEGRADABLE FADS	ECUADOR	MID-HIGH	HIGH
	MEXICO	-	-
	PERU	-	HIGH
	PANAMA	-	-
	USA	-	MID
	INDONESIA	HIGH	HIGH
	KOREA	-	-
	PHILIPPINES	-	-
	TAIWAN	-	-
	FRANCE	-	HIGH
	SPAIN	MID-HIGH	HIGH
	GHANA	MID	MID-HIGH
	PORTUGAL	MID-HIGH	-
	VIETNAM	NA	-
	CHINA	LOW-MID	LOW-MID

Several companies from the Spanish and French fleet in different oceans have been testing biodegradable FAD materials such as ropes for the FAD's tail appendage made with recycled cotton. These ropes currently being built by the company Itxaskorda in the Basque Country (Spain) are yielding satisfactory results according to personal comments by fishers testing the materials. A previous study by ISSF scientists testing cotton and regenerated cotton ropes under controlled conditions in the Maldives showed that the ropes could last up to a year. Most skippers think that a FAD which can last between 6 and 9 months in working order is acceptable.

Important biodegradable FAD projects have emerged in 2017. One of them is BIOFAD in which the European tuna purse seine fleet (e.g. Spanish and French) will test 1000 biodegradable FADs in the Indian Ocean in 2018. The project is funded by the EU and co-sponsored by ISSF providing funding for biodegradable materials. Bamboo and cotton canvas rafts and cotton rope tails will form the principal structure of these FADs. Non-biodegradable flotation (e.g. net corks) have been allowed as suitable biodegradable floating materials are still examined. Balsa wood holds promise as a good water-resistant natural float material.

In October 2017 a two-day workshop on biodegradable FADs was organized by TUNACONS. The idea of this initiative was to find suitable FAD designs and materials to test at sea by the Ecuadorian fleet in the Eastern Pacific. Small scale trials with biodegradable materials such as agave fiber (cabuya in Spanish) showed this material degrades too quickly in the water (e.g. 1-3 months). Tests with hemp (Muxa textilis; abacá in Spanish) were being conducted at the time of the workshop and showed some promise. This material is widely available and cheap in Ecuador, but construction into a canvas configuration is still artisanal (i.e. by hand) and mechanizing production could further lower costs. The TUNACONS project was aiming to try around 800 biodegradable FADs. The project has not started yet, but several hundred FADs made out of bamboo, hemp and balsa wood were being tested by companies on their own initiative (**Figure 4**).

Figure 4. Biodegradable FADs. a) FADs with biodegradable cotton rope appendages tested by Inpesca boats in the Indian Ocean, b) underside of 100% biodegradable FAD with bamboo frame, balsa wood flotation and canvas and ropes made of hemp (Manta, Ecuador).

Selective echo-sounder buoys

By now most large-scale purse seiners use almost exclusively buoys with echo-sounders, with Satlink, Zunibal and Nautical dominating the international market. According to fishers the information on tuna biomass provided by the echo-sounder buoys is the most crucial factor to driving the fishing strategy of skippers (e.g. where will the boat be going next to fish). Biomass estimates are fairly reliable, fishers scoring echo-sounder buoys on average 6-7 points out of 10 on accuracy. However, most skippers say that distinguishing species (e.g. skipjack, bigeye or yellowfin) and size (e.g. juvenile or adult) composition under the FAD is almost impossible with the current echo-sounders in the buoys. Fishers from all oceanic zones reported that there are occasions when the echo-sounder buoy signals a large fish biomass under a FAD, but when they arrive at the FAD they find the school is formed by poor quality small pelagic species. Fishers would welcome a tool that could provide better species composition estimates to avoid trips to low fish quality FADs or to prevent captures of small bigeye or yellowfin if a quota system is in place. ISSF has been funding research in the last several years to improve echo-sounder buoy technology that would be able to provide tuna species estimates remotely. Fishers show a high acceptance level for this activity as it can improve their fishing selectivity and could have benefits in case of species quota regulations (**Table 8**).

Table 8 – Evolution in the acceptance level of fishers for the use of selective echo-sounder buoys by different tuna fleets in ISSF Skippers' Workshops between 2010 and 2017.

	FLEET	ACCEPTANCE LEVEL						
		2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
ECHO-SOUNDER SELECTIVITY	ECUADOR	MID	MID	MID	HIGH	MID-HIGH	MID-HIGH	HIGH
	MEXICO	-	-	-	-	MID	-	-
	PERU	-	-	MID	-	MID	-	HIGH
	PANAMA	MID	-	MID	-	-	-	-
	USA	MID-HIGH	MID	-	MID	MID	-	MID-HIGH
	INDONESIA	-	-	-	NA	NA	NA	NA
	KOREA	-	-	-	MID	HIGH	-	-
	PHILIPPINES	-	LOW	-	MID	-	-	-
	TAIWAN	-	-	-	MID	-	-	-
	FRANCE	MID-HIGH	MID	-	-	-	-	HIGH
	SPAIN	MID	MID	MID	MID	HIGH	HIGH	HIGH
	GHANA	LOW	LOW	MID	MID	MID	MID	HIGH
	PORTUGAL	-	-	-	-	-	HIGH	-
	VIETNAM	-	-	-	-	-	NA	-
	CHINA	-	-	-	-	-	MID	MID-HIGH

FAD Control Measures

Due to overfishing of bigeye or yellowfin tuna stocks, most tuna RFMOs have introduced controls to limit fishing efforts on FADs. These come in different forms from FAD closures (e.g. 4 months in the Western and Central Pacific, 2 months in the Atlantic), total fishing area closures (e.g. approx. 2 months in the Eastern Pacific), or active buoy limits per vessel (e.g. in the Atlantic, Indian and Eastern Pacific ranging from 500 to 350 buoys). In general, many fishers see the introduction of limits on numbers of FADs as a positive thing, as they thought that FAD numbers were getting out of hand and could have a negative impact on target stocks.

Another conservation measure that has commenced in 2017 in the Indian Ocean has been the introduction of yellowfin quotas by flag by the IOTC. The catch of yellowfin in the Indian Ocean this year has been unusually high, resulting in an early closure of the fishery (by October) for some flags that surpassed their quota. Fishers asked how could the stock of yellowfin tuna be overfished if so much yellowfin has emerged in the fishery during the season and questioned the accuracy of fish stock assessments. Fishers in this ocean thought that FAD number reductions were good but thought that the yellowfin quota system should be either total or by boat, but not by flag; and pointed out that supply vessels should be kept out of the water during the closure as otherwise they will be cherry picking the best FADs which will be immediately fished on once the fishery is reopened at the start of the year.

Short tail FADs

This mitigation activity has seen a drop in acceptance level in the last year (**Table 9**). Although many fishers think there is some truth in thinking that deeper tail FADs may attract deeper dwelling tuna species like bigeye, most think that other factors are more important to determine bigeye presence. In particular fishing zone and season have a stronger influence on catches of bigeye according to skippers. Cooler waters and shallow thermoclines can increase the presence of bigeye in the sets.

Table 9 – Evolution in the acceptance level of fishers for the use of FADs with short tail appendages by different tuna fleets in ISSF Skippers' Workshops between 2010 and 2017.

	FLEET	ACCEPTANCE LEVEL		
		2014-15	2015-16	2016-17
SHORT TAIL FADS	ECUADOR	LOW	MID	LOW
	MEXICO	-	-	-
	PERU	-	-	-
	PANAMA	-	-	-
	USA	-	-	LOW
	INDONESIA	-	NA	NA
	KOREA	MID-HIGH	-	-
	PHILIPPINES	-	-	-
	TAIWAN	-	-	-
	FRANCE	-	-	-
	SPAIN	MID	MID-HIGH	LOW
	GHANA	-	MID-HIGH	LOW
	PORTUGAL	-	LOW-MID	-
	VIETNAM	-	NA	NA
	CHINA	-	MID-HIGH	LOW-MID

Another reason why the shallow tail option has been widely rejected is because many fishers think they need deep tails for the FAD to drift slowly and aggregate tuna. Skippers also think that due to high FAD densities, the larger FADs have a better chance of attracting tuna and out compete smaller FADs in the area. The depth of FAD appendages in recent years has been increasing. FADs in the Western and Central Pacific and the Atlantic Ocean reach on average 50-60 m depth according to workshop questionnaires. Other oceanic regions in which traditionally shallower FADs (e.g. 5-25 m) have been used, have seen a significant increase in the proportion of deeper tail FADs such as in the Indian Ocean with over 50 percent and the Eastern Pacific with over 25 percent of FADs now are between 40-80 m deep. Skippers think that short tail FADs would move too fast in regions of strong currents (e.g. Somalian waters in the Indian Ocean, near the equator in the Eastern Pacific, most of the eastern Atlantic, etc.) leading to overall poor catch rates.

Utilization

Use of bony fish species for human consumption like mahi mahi, barracuda, small tuna species, etc. rather than discarding them dead to sea is widely accepted by fishers (**Table 10**). In aFAD small-vessel fisheries like Indonesia, Philippines and Vietnam discard is almost null and all species (except sharks or turtles) are utilized. In fact, species like mahi mahi or rainbow runner can reach higher prices than skipjack tuna in these markets. In the Atlantic also these species are sold in Abidjan (Ivory Coast) or Tema (Ghana) as "faux poisson" in local markets. Some smaller tunas, mackerel or species like blue runner (*Caranx Crysos*) are often discarded when encountered. In the Eastern Pacific some bycatch bony fishes like mahi mahi or marlin are processed in factories and commercialized. In the Indian Ocean non-tuna finfish species may be discarded due to lack of a large enough local market (e.g. in Seychelles) but some boats have now started to store these species for shipping to other regions. In the Western and Central Pacific, fleets like China and others may encounter the problem of not having a large continental mass (like Africa for the Atlantic or South America for the Eastern Pacific) to sell their product in local markets. Often bycatch fish is consumed onboard or given away to people at local islands. Note that bycatch of bony fish at FADs in this oceanic region is much lower than in other regions.

Table 10 – Evolution in the acceptance level of fishers for bony fish bycatch utilization by different tuna fleets in ISSF Skippers' Workshops between 2010 and 2016.

	FLEET	ACCEPTANCE LEVEL						
		2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
BYCATCH UTILIZATION	ECUADOR	MID-HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
	MEXICO	-	-	-	-	MID	-	-
	PERU	-	-	HIGH	-	HIGH	-	MID
	PANAMA	MID-HIGH	-	MID-HIGH	-	-	-	-
	USA	MID-HIGH	MID-HIGH	-	HIGH	LOW-MID	-	MID-HIGH
	INDONESIA	-	-	-	HIGH	HIGH	HIGH	HIGH
	KOREA	-	-	-	LOW-MID	LOW	-	-
	PHILIPPINES	-	HIGH	-	HIGH	-	-	-
	TAIWAN	-	-	-	HIGH	-	-	-
	FRANCE	HIGH	HIGH	-	-	MID	-	MID
	SPAIN	MID	MID	HIGH	MID-HIGH	HIGH	MID-HIGH	MID-HIGH
	GHANA	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
	CHINA	-	-	-	-	-	LOW	LOW
	PORTUGAL	-	-	-	-	-	MID-HIGH	-
	VIETMAN	-	-	-	-	-	HIGH	-

NOVEL IDEAS AND IMPROVEMENTS FOR MITIGATION ACTIVITIES

Grids for deck bycatch release

Some of the medium and small tuna purse seine vessels in Ecuador brail directly into the well openings on the top deck (i.e. there is no lower deck with a conveyor belt). Many do not have a crane either to lift manta rays or larger sharks with a cargo net. A skipper suggested constructing a metallic grid with four handles that could manually be rested over the well opening. When the catch is unloaded with the brail the manta ray or larger shark would stay over the grid while other smaller fish fall through it. Then four crew could lift the frame and go to one side of the boat to release it. The grid could even be foldable, maybe constructed with hinges, to me more compact when not used, as space can be an issue in these smaller vessels.

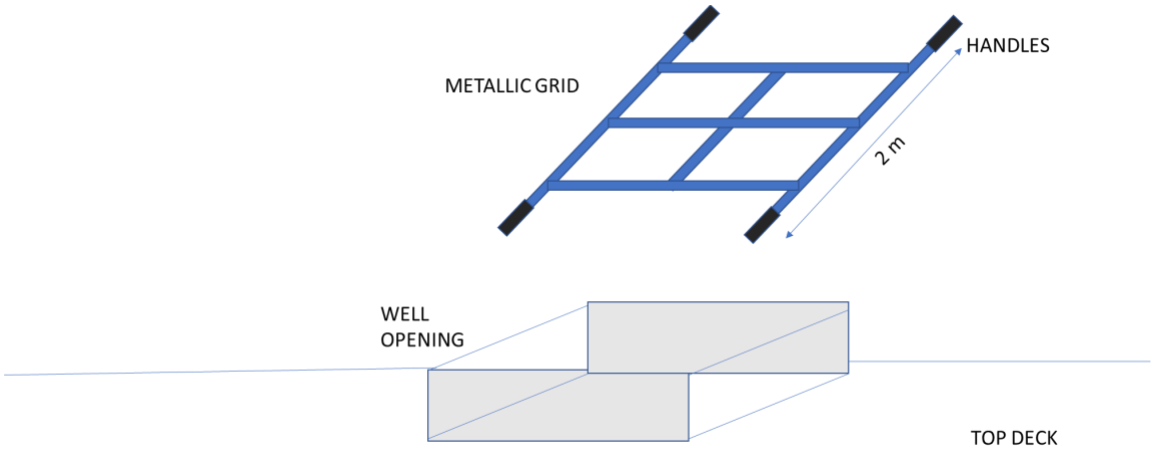


Figure 5. Metallic shorting grid to release mantas and other bycatch in smaller purse seiners.

Biodegradable FAD materials and designs

Highly resistant natural materials like bamboo can also be confectioned into twines or canvas. In Manta (Ecuador) a research scientist in textile materials presented bamboo cloth which was not specifically designed for FADs, but rather for clothing. However, the configuration of the canvas in terms of strength, fiber density, etc. can be molded to better meet the strenuous demands in a harsh environment like the marine is. Agave fiber has been less resistant than expected and quickly decayed after a few weeks to months. On the other hand, local hemp in Ecuador (abacá) could provide a stronger water-resistant natural material that can be utilized in biodegradable FADs. Tested canvases with hemp at present have been quite rudimentary as the material is sewn by hand. As flotation, balsa wood seems like a feasible option, especially in South America where this wood is widely available and cheap. Balsa wood, like bamboo, grows very fast and after 3-4 months logs with sufficient diameter for FAD raft construction can be utilized. Tests by Guayatuna S.A. with bamboo and balsa wood rafts have shown good flotation maintenance after 10 months in a controlled seawater pool environment.

Figure 6. Biodegradable FAD materials: a) Bamboo twine (white), bamboo canvas (pink), and agave fiber rope (natural color and died black and dark blue); b) bamboo and balsa wood raft after 10 months in a seawater pool.

FAD Control Measures

Fishers from several oceanic regions provided insight into how to better implement FAD control measures such as closures or FAD limits. To control FAD number limits (or rather buoy numbers) are really being respected, it is essential that all buoys pass through an inspector or control system at port, to examine each buoy ID before being activated at sea. Otherwise, buoy identity could be swapped with other additional "unregistered" FAD buoys floating at sea, seriously undermining the efficiency of FAD limitations. Also, RFMO measures should not only limit number of buoys but also FADs themselves as fishers could be seeding FADs without buoys, but these would not enter in the FAD limit regulation.

Skippers also asked that total FAD closures, when purse seiners return to port, should also be applied to the supply vessels. If supply vessels can operate during the closure, it will reduce the efficiency of the closure as these vessels will be seeding new FADs and cherry picking the most productive ones for the owner purse seiner to fish on its return.

Skippers complained about a general state of observer corruption in many regions, where observers charge a set amount per animal bycaught (e.g. dolphins, turtles, etc.) or to misreport certain events. If this is truth, it could seriously undermine the confidence in the control of conservation measures and also the veracity of bycatch data as a whole. In this sense, electronic monitoring systems (EMS) could be more resistant to manipulation. However, EMS still have some limitations such as missing sets on whales or inability to report seeding of FADs in the dark for example.

Recommendations

Continued dialogue between skippers from different fleets and scientist favours the construction of bridges to find better solutions to bycatch issues and implement best fishing practices. Without a real grasp of how the principal actors in the fishery think and act, it is difficult for scientists and fishery managers to reach meaningful and efficient conservation measures.

The discussion resulted in three recommendations:

Recommendation 1:

- Encourage the use of NEFADs, especially in the WCPO, and the adoption of biodegradable FADs.

Recommendation 2:

- Promote research in shark bycatch mitigation to find viable solutions to prevent shark capture in the net or release before brailing.

Recommendation 3:

- Continue work in the development of selective technologies, such as echo-sounder buoy species discrimination, to provide fishers with tools to minimize unwanted catches.

Recommendation 4:

- Maintain continued communication with skippers and stakeholders of the different fleets through various channels (e.g. workshops, online tools, small-group meetings, guidebooks, etc.) to solidify collaboration in the search for best bycatch mitigation options.

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