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OPTIONS FOR MANAGING FAD IMPACTS ON TARGET TUNA STOCKS

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SUMMARY

It is currently very common to encounter statements that "FADs need to be managed." But, in the context of managing fisheries, all sources of fishing mortality need to be monitored and managed. FADs contribute to fishing mortality, but are not the only source. In this document, we discuss FAD management in the context of overall management of tropical tuna purse seine fisheries. We also present recommendations for arriving at science-based management solutions and for enabling more complete monitoring of purse seine fisheries.

RÉSUMÉ

Actuellement, il n'est pas rare que des déclarations stipulent que « les DCP doivent être gérés ». Cependant, dans le contexte de la gestion des pêcheries, toutes les sources de mortalité par pêche doivent être contrôlées et gérées. Les DCP contribuent à la mortalité par pêche, mais ne sont pas la seule source. Le présent document aborde la gestion des DCP dans le contexte de la gestion globale des pêcheries de senneurs tropicaux. Ce document présente également des recommandations visant à aboutir à des solutions de gestion fondées sur la science et permettant un contrôle plus complet des pêcheries de senneurs.

RESUMEN

Actualmente es muy común encontrarse con afirmaciones del tipo "los DCP tienen que ser objeto de ordenación". Pero, en el contexto de la ordenación pesquera, debe hacerse un seguimiento de todas las fuentes de mortalidad por pesca, y éstas deben ser objeto de ordenación. Los DCP contribuyen a la mortalidad por pesca, pero no son su única fuente. En este documento, se discute la ordenación de los DCP en el contexto de la ordenación global de las pesquerías de cerco de túnidos tropicales. Se presentan también recomendaciones para llegar a soluciones de ordenación basadas en la ciencia y para permitir un seguimiento más completo de las pesquerías de cerco.

KEYWORDS

Catchability, fishing power, fishing buoys, purse seining, fishery management

1. Introduction

In 2014, ICCAT established an Ad Hoc Working Group on FADs [Rec. 14-03]. One of the main objectives of the Working Group on FADs is to:

> "*e) Identify management options, including the regulation of deployment limits and characteristics of FADs, and evaluate their effect on ICCAT managed species and on the pelagic eco-systems, based on scientific advice and the precautionary approach. This should take into consideration all the fishing mortality components, the methods by which FAD fishing has increased a vessel's ability to catch fish, as well as socio-economic elements with the view to provide effective recommendations to the Commission for FAD management in tropical tuna fisheries.*"

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The primary objective of this paper is to provide thoughts and insight on issues relevant to the first Working Group meeting, particularly in relation to target tuna species. However, information relevant to bycatch issues is also presented (**Appendices 1 and 2**).

The use of FADs in tropical tuna purse seine fisheries has been receiving a lot of attention in recent years because of various considerations. These include increases in the fishing efficiency of vessels, and higher catches of undesirably small tuna (especially bigeye) and several non-tuna species compared to free-school sets. In some cases, the magnitude of these impacts has not been well quantified, which has added uncertainty to the debate on how to manage FADs to such a degree that some organizations are calling for a complete ban on FADs or for arbitrary FAD limits.

ISSF strongly believes that FAD management should be science-based, and that the need to manage FADs is essentially no different from the need to manage all types of fishing activities. For this reason, ISSF has been devoting considerable efforts to (a) informing the debate through analyses of existing data, (b) advocating for more comprehensive data collection and use of non-entangling FAD designs, (c) carrying out research to identify potential changes in fishing practices and/or technology that can help mitigate adverse impacts, and (d) working directly with fishers to identify best practices for bycatch mitigation and to collect information on fleet preferences.

While we focus on purse seine fisheries, it is necessary to keep in mind that there are other fishing mortality components when managing tuna stocks. For example, in the Atlantic Ocean, the catch of bigeye in recent years has been taken by the following gears (ISSF, 2015):

Longline: 49%
Purse seine sets on floating objects (incl. FADs): 28%
Rod-and-reel (pole and line): 15%
Purse seine sets on free schools: 7%

All sources of fishing mortality need to be monitored and managed.

2. Understanding the contribution of FADs to fishing mortality of target tunas

The mechanism by which fisheries are managed is through changes in fishing mortality with so-called input (number of vessels, number of fishing days, time-area closures, etc.) and output controls (TACs etc.). There are many elements or actions that affect the fishing mortality of the tropical tuna purse seine fleets, including the use of FADs, and it is not easy to disentangle the effect of FADs from the effects of other elements.

One way to approach the task is by quantifying the fishing power of individual vessels. Fishing power provides a measure of vessel efficiency. It can be defined as the product of the area of influence of the gear during a unit operation and the efficiency of the gear during that operation (Gulland, 1956). Because absolute fishing power is difficult to measure, most studies are based on measuring the relative efficiency of one type of vessel against the relative efficiency of a "standard" vessel (this is what is basically done in CPUE standardization; see Smith, 1994). For example, one could try to estimate the relative fishing power of a purse seiner that uses 400 FADs against that of an identical purse seiner that does not use FADs.

But the real situation is not so simple in practice. Even the vessels that have the same engine and size have differences between them that also affect fishing power, such as the experience of the skipper and crew, the use of bird radars, sonars, auxiliary vessels, helicopters, size and materials of the net, etc. The FADs themselves are unlikely to be uniform (e.g. different depth of the submerged structure) and may also be equipped with different types of buoys. This large number of possible combinations of influential variables complicates the standardization of purse seine CPUE for the purpose of estimating fishing power.

In 2012, ISSF convened a workshop to consider this problem and come up with recommendations (Anonymous, 2012). The list below shows the factors that workshop participants noted have changed historically (or that are changing now) in purse seine fisheries and are likely to have affected fishing power in a major or significant way:

- Use of FADs
- Use of supply vessels
- Faster unloading of the catch
- Use of computers
- Technological improvement of FADs
- Increased freezing capacity
- Increasing vessel size and capacity
- Use of satellite imagery
- Bird radars
- Helicopters
- Improved Sonar/long range
- Improved navigation radars
- Real-time private radio communication
- Improved lateral echo sounders
- Deeper and faster nets

Unfortunately, details (when and where) on the use of many of these factors are not available to scientists for analyses. Basically, the adoption of these changes by individual skippers or fleets is not well documented. Furthermore, the use of many of these factors is largely unobservable by scientists or observers in most fleets, as they are not easily visible and are often kept confidential by fishers/vessel owners because of competitive business reasons.

Therefore, if we really want to understand fishing power in the purse seine fishery for improved management, the first two things that need to happen are:

1) A data-mining exercise to determine the time when changes in technology/practices by individual vessels or fleets took place, and
2) The reporting of more detailed operational-level and strategic data to scientists.

Neither of these two actions is too difficult, but they would be impossible to achieve without the collaboration from the industry.

Access to detailed information (set-by-set) about the use of floating objects (including FADs) is of course a critical part of this task. Floating objects affect both the availability and the vulnerability of tunas to fishing (availability is the proportion of the stock which is susceptible to fishing, given consistent fishing methods; vulnerability measures how easily the species is caught, given constant availability.) But, without detailed data, these effects cannot be quantified.

Therefore, at present, attempts to manage tuna fishing mortality through FAD limits and related measures will be policy decisions without a solid quantitative basis. Rec. [14-01] stipulates the collection and reporting (to CPCs) of much of the needed data but, as of yet, the data are not available to scientists for analyses on a regional basis.

3. Growth in fishing effort and FAD usage in the Atlantic and Indian Oceans

In Section 2, we noted that there is a general lack of detailed data that would be needed to standardize purse seine CPUE. In this Section, we summarize what is known about FAD usage in the Indian and Atlantic oceans, based on aggregated data (and sometimes educated guesses or extrapolations).

While tuna fishermen have been setting on floating objects (FAD, logs, marine mammals, etc) for decades, since the early 1990s, the use of manufactured FADs for tuna fishing has widely and rapidly expanded, especially for the purse seine fleet targeting tropical tunas. As mentioned in Section 2, a number of factors contribute to a vessel's increased ability to catch fish, including those related to FAD fishing. Purse seine fishing in general, and especially in FAD fishing, has experienced a large number of innovations that have made fishing more effective over time. The application of tracking buoys are likely the most significant technological development that has occurred within the last 20-30 years for increasing the efficiency of FAD fishing for tuna (Scott and Lopez 2014).

Across the world's oceans, floating object purse seine fishing is now about 50% more productive (in tons per set) than free-school fishing for the three tropical tunas in combination and about twice as effective for skipjack. For yellowfin, however, the relative efficiency of floating object fishing is about the same as for free schools, although the size of yellowfin caught on objects is much smaller than for free schools. On the other hand, the relative efficiency of bigeye caught on floating objects is about 10 times that for free-school fishing and the fish taken are also typically much smaller (around 50 cm fork length (FL) for FAD fishing and >100 cm FL for free school fishing). Ocean-specific patterns show variation from all of the global patterns noted, as the global patterns are dominated by the western Pacific statistics (Scott and Lopez 2014).

In the Atlantic and Indian Oceans, growth in drifting FAD usage is evidenced by the rate of tuna production by this fishing mode (**Figure 1** and **Table 1**) and the evolution of recorded and reported effort (sets) made on drifting objects versus free schools by purse seiners (**Figure 2** and **Table 1**). The pattern in the Atlantic reflects a general decline in purse seine fishing effort (sets), from the early 1990s until 2006-2007, followed by a rapid re-introduction of effort into the tropical Atlantic since then, with an average annual rate of 14% increase in purse seine sets and 17% in FAD sets since that time (**Figure 2**). In the Atlantic in 2012, the number of FAD sets were 50% greater than the number of free school sets and produced on average 140% of the tonnage per set in free school fishing. In the Indian Ocean, the pattern of purse seine effort is somewhat of a mirror image of the Atlantic with a generally increasing pattern in purse seine sets from the early 1990s until 2006-2007 at which time the number of purse seine sets fell by about 20% due to piracy on the fishing grounds (IOTC 2013) and this reduction was mainly in free school sets. FAD sets have shown a relatively constant increasing trend at about 2.6% per year over the period since the early 1990s through 2012 (**Figure 2**). In the Indian Ocean in 2013, the number of reported FAD sets were almost 4 times the number of free school sets and produced, on average, about 130% of the tonnage per set in free school fishing. On average, per set production (t) of the three species was about 18% greater in the Indian Ocean between the early 1990s and 2013, mostly attributed to higher average production per FAD set, since the average free school production per set was only slightly higher in the Indian Ocean compared to the Atlantic.

Recent estimates of FAD usage in the Atlantic and Indian Oceans are quite uncertain owing to a lack of information about both fleet activity levels and usage patterns across fleets (Baske *et.al.* 2012, Scott and Lopez 2014). While fisheries in both Oceans make use of anchored FADs, drifting or DFADs are much more predominant in terms of numbers deployed (Fonteneau 2011, Fonteneau *et.al*. 2013, Hall and Roman 2013, Davies *et.al.* 2014, Maufroy *et.al.* 2014). Estimates of DFADs now deployed annually in the Indian and Atlantic Oceans range from around 8,000 to close to 15,000 per ocean, depending on assumptions. For example, Fonteneau and Chassot (2014) indicate that in the Indian Ocean, growth in DFAD use has increased by 70% since the early 2000s and thus the number of annual FAD deployments may now reach 10,500-14,500. The IOTC Scientific Committee indicated the annual level was likely in excess of 10,000 per year (IOTC 2014). Given similar fleet composition, similar numbers could now be occurring in the Atlantic as well.

The size of the fleet authorized to fish for tropical tuna species in the Atlantic is more constrained than in the Indian Ocean. **Table 2** provides a summary of the number of vessels by gear and flag authorized to fish for yellowfin and bigeye based upon ICCAT Recommendation 11-01. Overall, the authorized Atlantic fleet is more than 900 vessels >20m LOA. Of these, 59 are purse seiners, over 600 are longliners and more than 300 are hook and line vessels. The authorized purse seine vessels are nearly all categorized as large scale (>335m^3) using the criterion of Justel and Restrepo (2015), with an overall fish hold volume of ~80,000 m^3, with Spanish, Ghanaian, and French fleets ranking first through third (**Figure 3**). The overall average age of this fleet is 26.5 years with a range of from 1 to 44 years.

For the Indian Ocean, **Table 3** provides a summary of the number of active vessels by gear and flag registered on the IOTC authorized list and which target tropical species. Of the more than 6,000 authorized vessels (see Moreno and Herrera, 2013 for a complete description), 183 are purse seiners (CLAV data set available at: http://clav.iotc.org/browser/search/#.VUHJ087BvF-; **Figure 4**). Additionally, at least 320 longliners and 1200 gillnetters are involved in the Indian Ocean tropical tuna fishery.

In summary, the available data shows that there have been important technological changes in tropical tuna fisheries in the Indian and Atlantic Oceans over the past decades, with an increasing reliance on FADs. Also, there are many vessels using many fishing gears fishing for tropical tunas in these oceans besides purse seiners, and their impacts should also be borne in mind.

4. Monitoring needs and available tools

If RFMOs such as ICCAT and IOTC want to make progress on managing fishing mortality caused by the purse seine fleet, it is imperative that more detailed operational FAD data be made available to scientists. We believe that this is feasible and confidentiality rules could be used to ensure that individual vessel or individual company data are protected. Also, data submissions could be delayed by some period of time to ensure the confidentiality of real-time fishing operations.

We identify the following as actions that would be useful for ICCAT and IOTC to consider in order to improve monitoring and enable the scientific analyses that are required:

- ***Increase observer coverage***. Some of the key information required can be collected by observers onboard the purse seine vessels. However, with the existing diversity of fishing vessels, equipment, fishing strategies, etc., it is unlikely that observer coverage rates of 5% to 10% will result in sufficient data to allow for a proper standardization. ISSF advocates for 100% observer coverage (most practically achieved with a combination of human and electronic systems.) New Electronic Monitoring Systems (EMS) are being developed by several manufacturers and they are proving to be a cost-effective means to collect required information.

- ***Allow for the provision of set-by-set data at a regional level***. Virtually all of the data reported to ICCAT and IOTC are in aggregated form. Operational level data are only available to national authorities and research institutes. Ideally, all of the detailed data sets should be analyzed together so that differences between fleets (flags) can be understood. To do this, it would useful to have a regional repository of data that national scientists could access and collaborate on.

- ***Require a marking and identification scheme for FADs and buoys***. A better understanding of each FAD's "life-history" would be very useful. If scientists were able to know the FADs that each vessel deploys, and then to match individual sets (by that or any other vessel) on those FADs, then it would be possible to estimate the impact of FAD densities on catch rates. This is what the "FAD logbooks" required by ICCAT (Rec. 14-01) and IOTC aim to achieve, but as those requirements became effective only recently, these data are not yet available.

- ***Require the reporting of satellite buoy position data***. Data from VMS (Vessel Monitoring System) or EMS as well as scientific access to instrumented buoy tracking and echosounder data, with a suitable delay to ensure confidentiality, should be provided to help in efforts to examine the impacts of effort creep and assist in managing growing fleet capacity. This would allow for the linking of individual FADs to catch. Also importantly, it would enable scientists to understand FAD density impacts on purse seine catch rates (both FAD and free school), which is critical for the sustainable management of the purse seine fishery.

5. Conclusions

In this paper, we have provided primarily information and thoughts relevant to the Working Group on FADs' objective of managing fishing mortality for target tuna stocks (information relevant to other objectives is given in **Appendices 1 and 2**).

We conclude the following:

- It is necessary to consider all fishing mortality components when managing tuna stocks. For Atlantic bigeye, 28% of the catch made on floating objects (including FADs) and the purse seine fishery as a whole takes 35% of the catch. Clearly focusing on FADs alone is insufficient. All sources of fishing mortality need to be monitored and managed.
- There are many factors that affect the efficiency of tuna purse seiners (number of vessels, capacity, equipment, crew, FADs, etc.). The use of FADs is an important one, but not the only one. In order to carry out a proper fishing power analysis to quantify the effect that the different factors have on fishing mortality, more detailed information is necessary. In particular, a data-mining exercise to determine the time when changes in technology/practices by individual vessels or fleets took place, and the reporting of more detailed operational-level and strategic data to scientists.

- In order for more complete historical and current data to become available, collaboration from industry is essential. This should not pose a problem if done under reasonable confidentiality rules and time delays.
- We identify a number of actions that would improve data availability and facilitate quantitative analyses of purse seine effort and FAD data. These include 100% observer coverage, FAD markings, allowance for set-by-set data to be reported to ICCAT, and satellite buoy position and track information.

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Table 1. Reported tropical tuna catch (tons) and effort (sets) in the Atlantic and Indian Oceans for the European and associated purse seine fleets (kindly provided by E. Chassot and A. Delgado de Moreno (pers comm).

	ICCAT						IOTC						Sets Recorded			
	FSC			OBJ			FSC			OBJ			ICCAT		IOTC	
Year	BET	YFT	SKJ	BET	YFT	SKJ	BET	YFT	SKJ	BET	YFT	SKJ	FSC	OBJ	FSC	OBJ
1991	1730	75987	39065	11957	15577	80819	3744	72023	11553	7785	20330	79392	6833	3272	4387	3419
1992	3176	77835	17616	14378	17904	64160	1142	61182	18821	5852	27970	82686	5434	3058	5349	3444
1993	7197	69066	38454	21853	19404	75561	5258	70669	27357	5469	29831	88113	6243	3159	5357	3701
1994	3755	62661	28987	25911	23044	65750	3031	66199	38102	9043	30043	104900	5676	3314	5503	4313
1995	2467	62390	19501	19167	19260	68641	3337	56817	27024	17298	64433	111808	5180	4068	4635	5164
1996	3118	62083	12510	17476	17282	58964	2515	58688	30193	16732	50022	92611	4714	3742	5045	5006
1997	2304	55834	21275	11895	11079	35269	1614	42757	17480	25107	68772	102395	4099	2593	3492	6842
1998	2238	62405	26605	10382	10844	29805	4983	38008	20627	15739	45336	106692	5134	2395	4020	6676
1999	2899	45888	36874	12380	12132	38779	4125	42258	30209	26654	70853	132641	4273	1947	4338	5943
2000	2536	51305	19439	11162	12879	45038	4137	52126	25991	16766	63826	145198	4138	2246	4274	5710
2001	2836	65154	15250	11784	11660	45397	4936	72706	26552	15575	41229	130812	4313	2305	5286	5230
2002	3148	64046	10722	11230	11776	36634	4741	68330	18448	22200	54444	189264	3496	1913	3749	5979
2003	3349	53779	28845	11063	12860	43877	9389	126304	29053	13185	72833	154242	4403	2111	5210	4792
2004	1792	41303	24594	9101	11952	52293	5299	157642	17541	16902	47120	120195	2871	2182	6507	4616
2005	1862	38504	10181	7824	10820	48329	8025	113898	42234	13984	59498	145979	2512	2001	7358	5923
2006	4451	39869	6666	6499	10352	41039	5852	80411	32908	14350	68380	188082	1888	1725	6802	6630
2007	3197	33261	3814	7598	9922	50363	5566	52365	23647	15581	40774	108675	1744	2012	5662	6538
2008	2268	48320	6598	10336	14256	51671	9610	73360	14779	16972	39377	119219	2484	2574	5284	5954
2009	4124	56529	4775	12773	12237	58360	5349	35980	9379	21116	48720	137402	3280	3162	2467	6690
2010	4144	46182	7830	14974	15906	68180	3722	31641	8601	17805	70259	139456	3252	4129	2100	7029
2011	3609	36628	6995	17550	13099	76151	6351	35932	9030	15088	75582	120319	2710	4413	2676	6935
2012	4209	43298	6287	13352	13239	88635	7351	65501	3798	9552	64570	76718	2803	4225	3342	5653
2013	2626	39061	13609	13980	11100	107755	4197	34417	5693	19937	98280	108421	2800	4000	1919	7424

Table 2. Vessels (>20m LOA) by flag and gear type authorized to fish YFT-BET with at least 60 days authorization remaining as of March 26, 2015 (from ICCAT vessel List).

Flag	*PS*	*BB*	*LL*	*Oth*	*Grand Total*
BLZ	2		3		3
BRA			40		40
CHN		9	30		39
CIV	1				
CPV	5	1			1
CUW	3			3	3
EU.ESP	14	6	1		7
EU.FRA	11[2]				
EU.PRT		223	87	1	311
FR.SPM		1			1
GHA	16	20			20
GTM	2				
JPN		2	231		233
KOR			2		2
MEX			16		16
PAN	3		31		31
PHL			6		6
SLV	2				
TAI			75		75
TTO			16		16
USA		55	37	1	93
VCT		1	27	3	31
VUT		1			1
Grand Total	59	319	602	8	929

[2] These vessels, while on the current ICCAT positive list of authorized vessels, showed no available days of authorization for BET-YFT fishing in the ICCAT vessel list downloaded on March 26, 2015.

Table 3. List of Active vessels in the IOTC region by Flag and type that targeted tropical species in 2013-2014.

Flag	Gill Netters	Longliners	Multipurpose	Purse seiners	Research-Training	Supply vessel (purse seiners)	Unknown
Australia				4			
Belize							
China		67					
France (EU)				13			
Italy (EU)							
Portugal (EU)							
Spain (EU)				29		10	
United Kingdom (EU)							
France (Territories)							
Guinea							
India							
Indonesia							
Iran	1223			5			
Japan		125			1		
Kenya							
Korea_Republic of		19		8			
Madagascar		7					
Malaysia							
Mauritius				9			
Oman		3					
Philippines		13					
Senegal							
Seychelles		31		14		4	
South Africa		3					
Sri Lanka		20	3816	15			
Tanzania		8					
Thailand					2		2
Uruguay							
Mozambique							
Pakistan							
Vanuatu							
Maldives		32					628
Grand Total	1223	328	3816	97	3	14	630

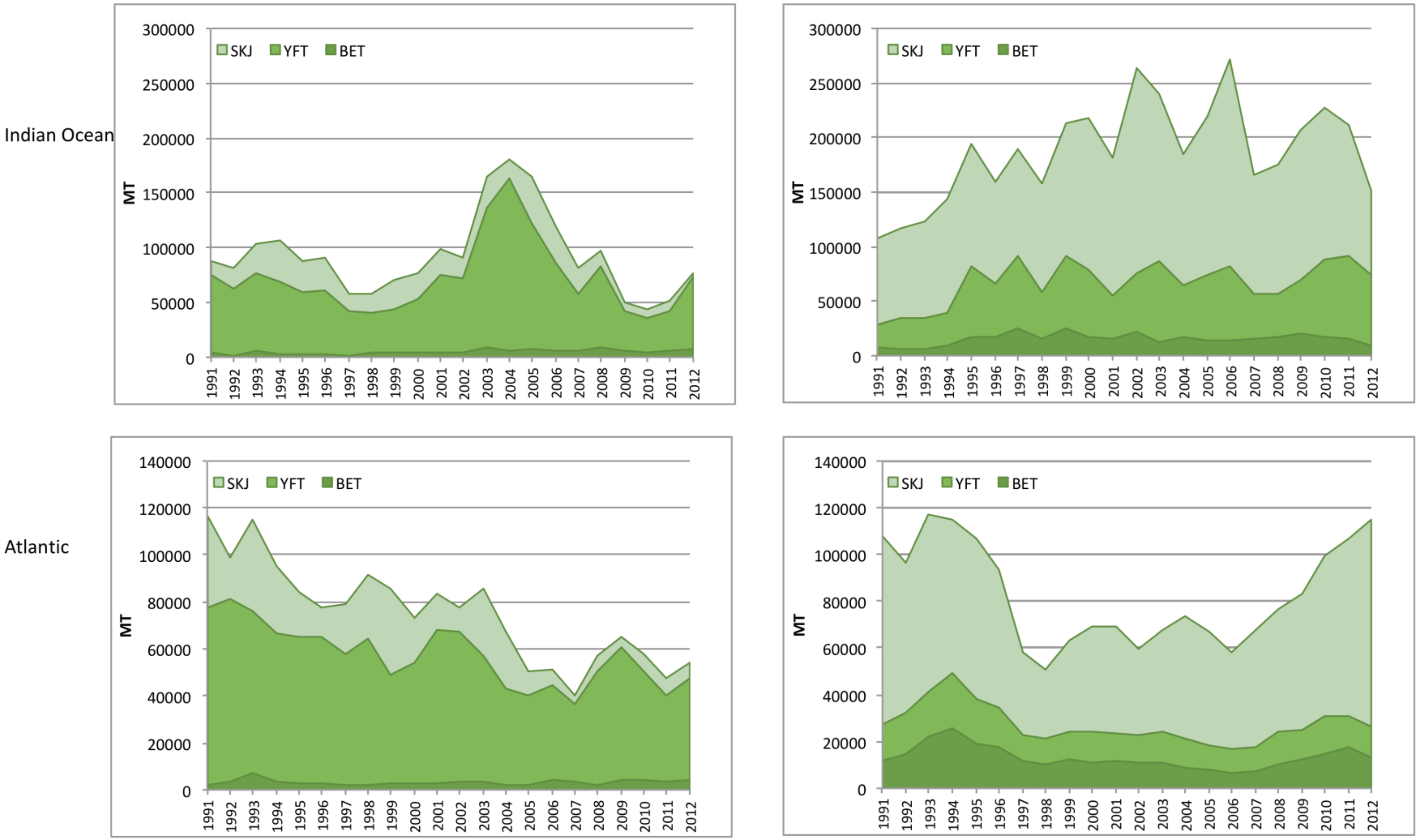

Figure 1. Evolution of Purse Seine Free School (left plates) and FAD (Object) catches (right plates) by species in the Atlantic and Indian Oceans since 1991.

Figure 2. Evolution of purse seine fishing effort (sets) by fishing mode in the Indian and Atlantic Oceans from 1991-2012.

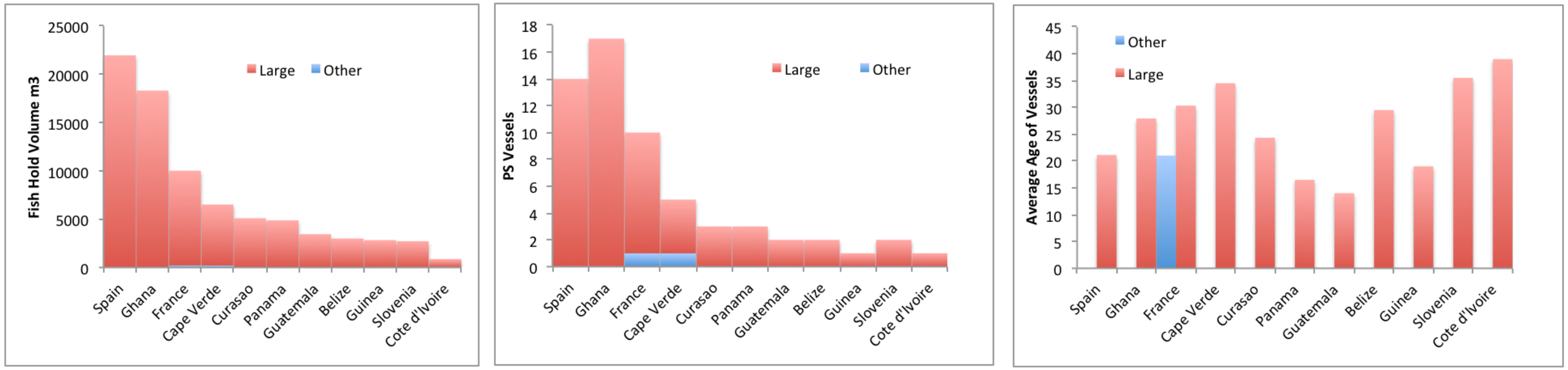

Figure 3. Estimated fish hold volume (m3), number, and average age of the Atlantic purse seine fleet authorized to fish YFT-BET in the Atlantic Ocean.

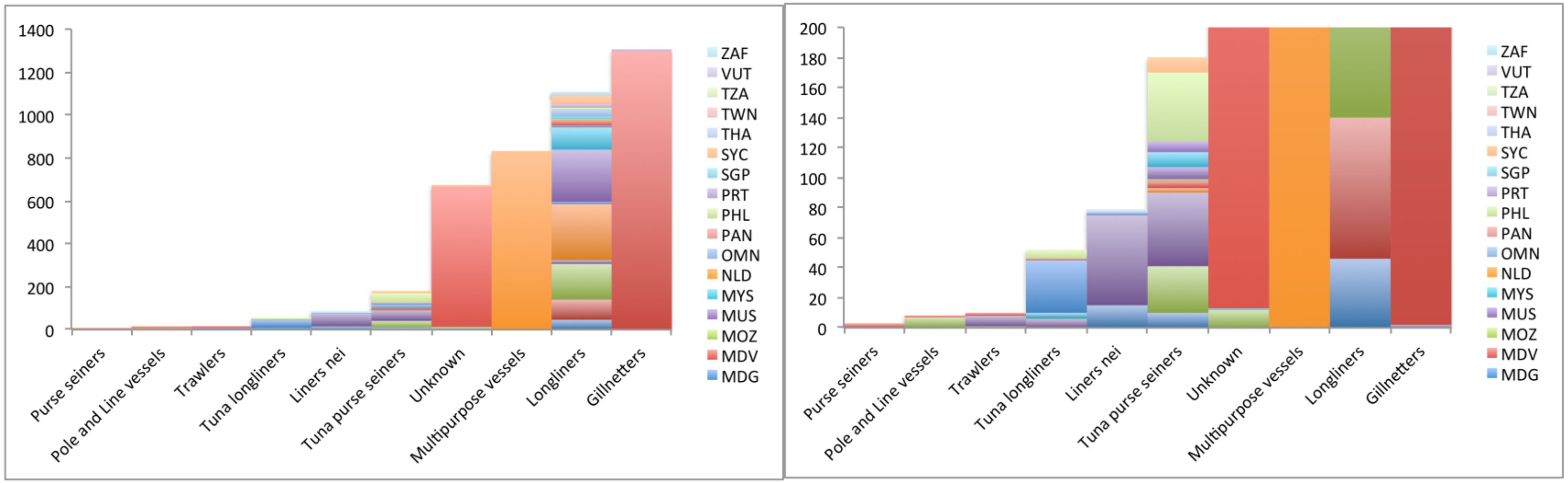

Figure 4. Fishing vessels authorized in the IOTC area by flag and vessel. Right hand plate shows the distribution of vessels by flag for vessel categories with totals less than 200. Data available from CLAV (http://clav.iotc.org/browser/search/#.VUHJ087BvF-).

Appendix 1

ISSF Advocacy and Outreach Efforts to date

ISSF engages in strategic outreach and advocacy on FAD data collection and management and non-entangling FAD designs to tuna RFMOs, vessel owners and skippers, other non-governmental organizations and governments using a variety of tools.

Starting in 2012, ISSF began to advocate annually that tuna RFMOs adopt measures requiring the collection of specific data on FADs, by both observers and vessel operators, to support the development of management measures, and a FAD marking scheme, and measures for the use of non-entangling FAD designs. Also in 2012, following the advice of the ISSF Bycatch Committee, ISSF published a guide for non-entangling FADs with best practice recommendations. This guide was disseminated to all RFMOs the same year. In 2013, a peer-reviewed scientific paper showing the extent of the shark mortality in FADs in the Indian Ocean was published (Filmalter *et al*., 2013), and this information was also widely disseminated to all RFMOs and other stakeholders, including the vessel and non-governmental communities.

In 2013, ISSF began to provide financial support to RFMOs to assist in the processing and analyses of existing observer reports so these FAD data, collected on some level by observers in some RFMOs since 2010, can be used to recommend future FAD management measures. In the case of the WCPFC, this support resulted in more than 13,000 FAD records collected by observers being entered into SPC databases.

In 2013 and 2014, ISSF hosted or supported four side events during the WCPFC, ICCAT and IATTC annual commission meetings that provided the current science on issues like mitigating ecosystem impacts of FADs, how additional data on FADs could help improve stock assessments and scientific management advice, comprehensive monitoring of FAD usage in PNA EEZs, opportunities for improved data collection through electronic monitoring and reporting, and the movement and behavior of bigeye.

Also, in February 2015, ISSF held a joint vessel industry – ISSF Bycatch Steering Committee workshop to receive input from the vessel community about best practices in non-entangling FAD designs. The Workshop Report informed the development by the ISSF Scientific Advisory Committee of an updated guide for non-entangling FAD design best practices.

Before each RFMO annual commission meeting, ISSF hosts a coordination call with those non-governmental organizations that are on the ISSF Environmental Stakeholder Committee (ESC) and other NGO partners. The purpose of these calls is to discuss ISSF RFMO advocacy priorities, and opportunities for coordinated outreach on issues of shared interest. Since 2013, twelve such calls have been held.

ISSF Participating Companies also engage in advocacy and outreach to RFMO member nations in support of ISSF priorities and the ISSF Position Statement. Since 2012, ISSF Participating Companies have sent nearly 600 letters to national delegations in all four tuna RFMOs.

Results

In 2013, IOTC, IATTC and ICCAT all adopted measures requiring the collection of specific FAD data (i.e., an inventory and activity record of FADs ("FAD logbook": FAD markings, construction specifications, deployment, retrievals, etc.), and a record of encounters of fishing and supply vessels with the FADs ("fishing logbook": catch, by species, that results from sets made on FADs).

Also in 2013, IOTC, IATTC and ICCAT adopted provisions for the progressive use of non-entangling FADs designs, based on the ISSF guidelines for the construction of such FADs developed by the ISSF Bycatch Steering Committee. In November 2014, ICCAT became the first tuna RFMO to set a date certain (2016) by which nations are to be using only non-entangling FADs designs.

In 2014, an information paper was presented to the WCPFC Science Committee analyzing the available data on FADs collected via the regional observer program (http://www.wcpfc.int/node/19075). Noting the many data gaps, the Science Committee recommended that the WCPFC Commission set up a working group on FAD monitoring and management that will further evaluate these issues and options for management. The WCPFC adopted this recommendation in December 2014 and the working group will commence in 2015. In November 2014, ICCAT created a similar FAD working group, which will also begin its work in 2015. In December 2014, the IOTC Scientific Committee recommended that the IOTC Commission establish a FAD working Group. In 2015, the European Union tabled a proposal to implement the Scientific Committee's recommendation, which will be considered in April at the IOTC annual Commission meeting.

Appendix 2

Reports and publications relevant to purse seine fisheries and mitigation of FAD impacts that have been partially or totally funded by ISSF

Research cruises on bycatch mitigation

Anonymous 2014. Bycatch cruise planning workshop report for 2014. International Seafood Sustainability Foundation, Washington, D.C., USA.

Anonymous. 2011. Report of the ISSF Meeting on mitigation of by-catches in the Tuna Purse seine Floating Object fisheries. AZTI. Sukarrieta, Spain, 24-27 November 2009.

Anonymous. 2011. Report of the Second meeting of the scientific committee of the ISSF Bycatch Mitigation project. San Diego, California, August 21 - 23, 2011. International Seafood Sustainability Foundation, Washington, D.C., USA.

Anonymous. 2012. Report of the Third meeting of the scientific committee of the ISSF Bycatch Mitigation project. Montpellier, France. 14, 20, 21 October 2012. International Seafood Sustainability Foundation, Washington, D.C., USA.

Dagorn L. *et al*. 2012. IOTC-2012-WPEB08-21. Summary of results on the development of methods to reduce the mortality of silky sharks by purse seiners.

Fuller D.W. and Schaefer K. M. Evaluation of a fishing captain's ability to predict species composition, sizes, and quantities of tunas associated with drifting fish-aggregating devices in the eastern Pacific Ocean. – ICES Journal of Marine Science, doi:10.1093/icesjms/fsu012.

Itano D. *et al*. Scientific Committee eighth Regular Session. WCPFC-SC8-2012/ EB-WP-14. Development and testing of a release panel for sharks and non-target finfish in purse seine gear. Republic of Korea, 2012.

Itano D. *et al*. Scientific Committee seventh Regular Session. WCPFC-SC7-2011/ EB-WP-11. Status of the Purse Seine Bycatch Mitigation Project and research cruises funded by the International Seafood Sustainability Foundation with notes on the development of best practices for the live release of encircled animals. FSM, 2011.

Muir J. *et al*. Scientific Committee Eighth Regular Session. WCPFC－SC8－2012/EB－WP－13. Behavior of target and non-target species on drifting FADs and when encircled by purse seine gear. Republic of Korea, 2012.

Muir J. *et al*. Scientific Committee Ninth Regular Session. WCPFC－SC9－2013/EB－WP－07. Summary of Research Activities and Results of the International Seafood Sustainability Foundation's (ISSF) Second Bycatch Project Cruise WCPO-2 in the Western Central Pacific Ocean (WCPO). FSM, 2013.

Restrepo V. *et al*. 2010. IOTC-2010-WPEB-13, WCPFC-SC6-2010/FT-WP-04, SCRS/2010/152. International Seafood Sustainability Foundation initiatives to develop and test bycatch mitigation options for tropical purse seine fisheries.

Sancristobal I. *et al*. Scientific Committee Tenth Regular Session. WCPFC-SC10-2014/EB-WP-08. International Seafood Sustainability Foundation's Third Bycatch Mitigation Research Cruise in the WCPO. RMI, 2014.

Schaefer K.M. *et al*. 2011. Scientific Committee seventh Regular Session. WCPFC-SC7-2011/ EB-WP-13. An Overview of The 2011 ISSF/IATTC Research Cruise for Investigating Potential Solutions for Reducing Fishing Mortality on Undesirable Sizes of Bigeye And Yellowfin Tunas, and Sharks, in Purse-Seine Sets on Drifting FADs. FSM, 2011.

Fishing capacity

Engler-Palma M.C. 2011. Managing Fishing Capacity in International Fisheries: Approaches and Practices in Tuna Regional Fisheries Management Organizations (RFMOs). ISSF Technical Report 2011-06. International Seafood Sustainability Foundation, McLean, Virginia, USA.

Justel-Rubio A. and Restrepo V.R. 2014. A Snapshot of the Large-Scale Tropical Tuna Purse Seine Fishing Fleets at the Beginning of 2014. ISSF Technical Report 2014-07. International Seafood Sustainability Foundation, McLean, Virginia, USA.

Justel-Rubio A. and Restrepo V.R. 2015. A Snapshot of the Large-Scale Tropical Tuna Purse Seine Fishing Fleets at the Beginning of 2015. ISSF Technical Report 2015-05. International Seafood Sustainability Foundation, McLean, Virginia, USA.

Restrepo V.R. and Forrestal F. 2012. A Snapshot of the Tropical Tuna Purse Seine Large-Scale Fishing Fleets at the End of 2011. ISSF Technical Report 2012-01. International Seafood Sustainability Foundation, McLean, Virginia, USA.

Shrader J. and Squires D. 2013. Fishing Capacity and Efficient Fleet Configuration for the Tuna Purse Seine Fishery in the Eastern Pacific Ocean. ISSF Technical Report 2013-06. International Seafood Sustainability Foundation, Washington, D.C., USA.

Purse seine fisheries (incl. FADs) and bycatch

Abascal F. *et al*. OFP-SPC. 2014. Scientific Committee Tenth Regular Session. WCPFC-SC10-2014/ST-IP-09. Preliminary analysis of the Regional Observer Programme data on FAD design. Republic of the Marshall Islands, 2014.

Anonymous 2014. Report of the ISSF workshop on FADs as ecological traps. ISSF Technical Report 2014-03. International Seafood Sustainability Foundation, Washington, D.C., USA.

Anonymous. 2012. Report of the 2012 ISSF Stock Assessment Workshop: Understanding Purse Seine CPUE. ISSF Technical Report 2012-10. International Seafood Sustainability Foundation, Washington, D.C., USA.

Dagorn L., and Restrepo V.R. 2011. Questions and answers about FADs and bycatch. ISSF Technical Report 2011 - 03. International Seafood Sustainability Foundation, McLean, Virginia, USA.

Dagorn L., Holland K. N., Restrepo V. and Moreno G. (2013), Is it good or bad to fish with FADs? What are the real impacts of the use of drifting FADs on pelagic marine ecosystems? Fish and Fisheries, 14: 391–415. doi: 10.1111/j.1467-2979.2012.00478.x.

Hutchinson M. *et al*. Scientific Committee eighth Regular Session. WCPFC-SC8-2012/ EB-WP-12 Rev 1. The Post-release Condition of FAD Associated Silky Sharks (Carcharhinus falciformis) Caught in Tuna Purse Seine Gear. Republic of Korea, 2012.

Hutchinson M., Itano D., Muir J., LeRoy B. and Holland K. 2015. Post-release survival of juvenile silky sharks captured in a tropical tuna purse seine fishery. Marine Ecology Progress Series. In press. doi: 10.3354/meps11073.

John David Filmalter, Manuela Capello, Jean-Louis Deneubourg, Paul Denfer Cowley, and Laurent Dagorn 2013. Looking behind the curtain: quantifying massive shark mortality in fish aggregating devices. Frontiers in Ecology and the Environment 11: 291–296. http://dx.doi.org/10.1890/130045.

Justel-Rubio A. and Restrepo V. 2015. Preliminary study of the relative fishery impacts on non-tuna species caught in tuna fisheries. ISSF Technical Report 2015-02. International Seafood Sustainability Foundation, Washington, D.C., USA.

Lopez J. *et al*. 2014. Evolution and current state of the technology of echo-sounder buoys used by Spanish tropical tuna purse seiners in the Atlantic, Indian and Pacific Oceans. Fisheries Research 155 (2014) 127–137.

Poisson F. *et al*. 2014. Mortality rate of silky sharks (Carcharhinus falciformis) caught in the tropical tuna purse seine fishery in the Indian Ocean. Can. J. Fish. Aquat. Sci. 71(6): 795-798 (2014) dx.doi.org/10.1139/cjfas-2013-0561.

Restrepo V., Dagorn L., Itano D., Justel-Rubio A., Forget F., and Filmalter J.D. 2014. A Summary of Bycatch Issues and ISSF Mitigation Initiatives To-Date in Purse Seine Fisheries, with emphasis on FADs. ISSF Technical Report 2014-11. International Seafood Sustainability Foundation, Washington, D.C., USA.

Restrepo V.R. 2011. Computing a global bycatch Rate of non-target species in tropical tuna purse seine fisheries. ISSF Technical Report 2011-07. International Seafood Sustainability Foundation, McLean, Virginia, USA.

Bycatch mitigation

Lewis A. 2014. Exploration of market viability for the full retention of non-tuna species in purse seine fisheries: Interim report. ISSF Technical Report 2014-12. International Seafood Sustainability Foundation, Washington, D.C., USA.

Murua J., Moreno G., Hall M., Itano D., Dagorn L. and Restrepo V. 2014. ISSF Skipper Workshops: Collaboration between scientists and fishing industry to mitigate bycatch in tuna FAD fisheries. ISSF Technical Report 2014-06. International Seafood Sustainability Foundation, Washington, D.C., USA.

Poisson F. *et al.* 2014. Collaborative research: Development of a manual on elasmobranch handling and release best practices in tropical tuna purse-seine fisheries. Marine Policy 44 (2014) 312-320.

Observer data and programs

Anonymous. 2012. KOBE III Bycatch Joint Technical Working Group: Harmonisation of Purse-seine Data Collected by Tuna RFMO Observer Programmes. ISSF Technical Report 2012-12. International Seafood Sustainability Foundation, Washington, D.C., USA.

Chavance P. *et al*. 2013. Comparing observer data with video monitoring on a French purse seiner in the Indian Ocean. IOTC-2013-WPEB09-43.

Monteagudo, J. P., G. Legorburu, A. Justel-Rubio and V. Restrepo. 2015. Preliminary study about the suitability of an electronic monitoring system to record scientific and other information from the tropical tuna purse seine fishery. Col. Vol. Sci. Pap. ICCAT, 71(1): 440-459.

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Restrepo V.R. 2012. Guidance on electronic monitoring for observer programs to comply with ISSF Commitments. ISSF Technical Report 2012-13. International Seafood Sustainability Foundation, Washington, D.C., USA.

Ruiz J. *et al*. 2013. Pilot study of an electronic monitoring system on a tropical tuna purse seine vessel in the Atlantic Ocean. Col. Vol. Sci. Pap. ICCAT, 69(5): 1995-2032.

Ruiz J., Batty A., Chavance P., McElderry H., Restrepo V., Sharples P., Santos J. and Urtizberea A. Electronic monitoring trials on in the tropical tuna purse-seine fishery. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsu224.