ISSF Technical Report 2019-08

REPORT OF THE INTERNATIONAL WORKSHOP on Mitigating Environmental Impacts of Tropical Tuna Purse Seine Fisheries | Rome, Italy, 12-13 March 2019

Victor Restrepo, Laurent Dagorn, Gala Moreno, Jefferson Murua, Fabien Forget and Ana Justel-Rubio / **April 2019**

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Topic Categories: Tropical tuna purse seine fisheries, bycatch mitigation, environmental and ecosystem impacts, sharks, rays, bigeye and yellowfin tuna, FADs, FAD management

Abstract

This is the report of a workshop held to review ISSF research and advocacy activities on mitigating environmental impacts of tropical tuna purse seine fisheries, with emphasis on bycatch and FADs. Workshop participants included scientists, NGOs, tuna RFMOs, manufacturers and purse seine fishing companies. The workshop was co-sponsored by the Common Oceans ABNJ Tuna Project and focused on six sessions: (1) Bycatch of the tuna purse seine fishery, (2) sharks and rays, (3) small bigeye and yellowfin tuna, (4) FAD structure impacts, (5) FAD management, and, (6) looking ahead: the next 10 years. Presentations for each of these topics were made, followed by discussions. This report summarizes the main points made during presentations and discussions.

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The workshop reported in the present Technical Report was co-funded by the Common Oceans ABNJ Tuna Project and by the International Seafood Sustainability Foundation (ISSF). The research results presented and discussed at the workshop were also funded by these and other funding organizations and conducted independently by various researchers, as noted in the third presentation. This report was prepared by six scientists who did most of the planning and put together the scientific presentations for the workshop.

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. Helping global tuna fisheries meet sustainability criteria to achieve the Marine Stewardship Council certification standard — without conditions — is ISSF's ultimate objective. ISSF receives financial support from charitable foundations and industry sources.

To learn more, visit **iss-foundation.org**.

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Introduction

For the last ten years, the International Seafood Sustainability Foundation (ISSF) has been conducting research and advocacy activities on mitigating environmental impacts of purse seine fisheries, with emphasis on bycatch and FADs. These include, broadly, at-sea research, interactive workshops with vessel skippers, and advocacy for RFMOs to adopt mitigation measures.

A Workshop was held at FAO Headquarters, 12-13 March, 2019, to review progress made and to identify main focus areas for future mitigation activities. The Workshop was co-funded by the Common Oceans ABNJ Tuna Project, which has also funded some of the research activities over the past five years.

A list of participants is included in Appendix 1. Participants included scientists, NGOs, tuna RFMOs, manufacturers and purse seine fishing companies. Victor Restrepo served as Chair and Ian Cartwright served as Facilitator for the six Sessions that addressed the main topics of discussion. Download the Workshop presentations from the ISSF Website.

The inaugural session included presentations by Susan Jackson and Alejandro Anganuzzi on the ISSF approach and on the ABNJ Tuna Project, respectively. Victor Restrepo then presented on key terms and the ISSF approach to bycatch research and mitigation efforts that would be a common denominator to all of the subsequent sessions; this presentation also acknowledged all of the organizations involved in the research efforts, including scientists, vessel-owning companies and funders.

The remainder of the Workshop was spent in six sessions devoted to different topics (see below). Each session consisted of a participant poll with 4-5 questions, a detailed technical presentation, and a general discussion in which participants made their own observations and asked questions to a panel of experts.

It should be noted that the polls did not follow a rigorous statistical design. They served primarily to gauge the audience's perceptions before each presentation; Poll results are shown in Appendix 2.

Each presentation aimed to summarize the changes that have occurred in the last 10 years. The presentations and key discussion points are summarized below, by session.

For all sessions, bycatch was defined as the catch of everything other than yellowfin, skipjack and bigeye tunas, relative to the catch of these three species, regardless of fate (kept or discarded). Also, the term "FAD" was used loosely to represent all sets on floating objects and was not strictly limited to drifting FADs.

List of acronyms

AO - Atlantic Ocean
BET - Bigeye Tuna
CPUE - Catch Per Unit of Effort
EMS - Electronic Monitoring System
EPO - Eastern Pacific Ocean
FAD - Fish Aggregating Device
FAO - Food and Agriculture Organization of the United Nations
IO - Indian Ocean
ISSF - International Seafood Sustainability Foundation
MSY - Maximum Sustainable Yield
NEFAD - Non-entangling FAD
NGO - Non-governmental Organization
PS - Purse Seiner
RFMO - Regional Fisheries Management Organization
YFT - Yellowfin Tuna
WCPO - Western and Central Pacific Ocean

1. Bycatch of the tuna purse seine fishery

PRESENTATION

Victor Restrepo gave a general presentation on bycatch in the purse seine fishery. The presentation reviewed bycatch by set type and ocean region and how this bycatch was conformed by five different species groups (minor tuna species, rays, sharks, billfishes, and other bony fishes). The presentation showed that purse seine bycatch of species of concern such as sharks and marine mammals was very minor compared to that of other tuna fishing gears. The presentation reached the following conclusions:

- Overall rates of bycatch in tropical tuna purse seine fisheries are very small.
- In the Atlantic Ocean, bycatch rates are higher due to minor tuna species which are targeted and marketed.
- Purse seine fisheries in all oceans are required to carry some level of human observer coverage, the main source of bycatch data.
- EMS can augment the data collected on bycatch.
- Retention and utilization are one way of reducing discards. Utilization is already high in the Atlantic.
- Skippers are interested in reducing the bycatch generated in their fisheries. Keeping them involved in the process is key.

DISCUSSION PANEL

Participants in the Panel were N. Beetle, N. Faricic, T. Peatman, V. Restrepo and J. Ruiz. The following points were made during discussion:

- The definitions of “bycatch” should be clear whenever bycatch estimates are presented. If not, it is possible that different concepts are compared, leading to confusion.
- In general, the estimates done by observers at sea are considered accurate. But these, as estimates, could always have some error/bias. It is important to include the uncertainty associated with the different bycatch estimates. In general terms, this uncertainty is reduced with higher observation coverage.
- The bycatch ratio by purse-seiners is relatively low but its contribution to the overall bycatch of marine species is not so negligible because total purse seine catches are high. Compared to other gears, PS seems to have less bycatch for most of the species groups.
- Shark bycatch is the main conservation issue for purse seine fisheries.
- The overall bycatch (biomass) in purse seine fisheries has decreased in all ocean regions in the last ten years for reasons such as using purse seine nets with bigger mesh size and searching for FADs with large aggregations (fewer sets likely result in less bycatch).
- EMS, implemented recently in some fleets, could be a good complement/alternative to increase human observer coverage. RFMOs should continue working for the correct implementation of this tool (minimum standards, etc.).
- Optimum observer coverage should be based on the program objectives (science, compliance …) and on the species (rare-species interactions require higher coverage). A combination of 100% human observer coverage

plus EMS would be ideal for better monitoring and control of fishing operations as well as reducing errors on tuna and bycatch quantity estimation.

- Installation of onshore facilities in designated ports for transshipment would facilitate full retention of bycatch.

2. Sharks and rays

PRESENTATION

Laurent Dagorn gave a presentation on sharks and rays, the species groups that are most vulnerable to the purse seine fishery. The presentation showed that the main shark species caught at FADs is the silky shark, followed by oceanic white tip. Other shark species and rays are also caught in free-swimming school sets, and whale sharks are rarely caught around man-made drifting FADs.

The presentation showed how research found that the issue of shark entanglement in traditional (open netting) FADs was probably of a very high magnitude 10 years ago, and how ISSF and other organizations advocated for non-entangling FADs, which are now required by the four tropical tuna RFMOs. The presentation reached the following conclusions:

- Shark bycatch is very low, less than 0.5% by weight. Still, some shark species are vulnerable or at-risk, and the purse seine fishery should strive to mitigate this bycatch.
- Shark bycatch is higher in other tuna fishing gears. Shark bycatch tends to be higher in FAD sets but also occurs in free school sets. Ray bycatch tends to be higher in free school sets.
- Shark entanglement in traditional FADs that use open netting can be very high. But the solution of non-entangling FADs that still aggregate tunas is easy (NEFAD guide).
- ISSF research has been conducted to investigate ways to avoid catching sharks or releasing them from the net or from the deck, with varying degrees of success.
- Besides non-entangling FADs, reducing shark mortality in the purse seine fishery will likely entail the use of several actions used in combination (setting on large tuna aggregations, fishing and releasing sharks from the net, safe handling and release from the deck, avoiding hot spots, etc.).

DISCUSSION PANEL

Participants in the Panel were J. Amande, S. Clarke, L. Dagorn and A. Rodrigues. The following points were made during discussion:

- The tropical tuna purse seine fishery is certainly not the gear that catches most of the silky and oceanic white tip sharks, but a part of the sustainability of the fishery depends on mitigating impacts of the fishery on sharks. The species caught most commonly by purse seines (silky, oceanic whitetips, whale sharks, mobulids) are of international conservation concern, and continuing efforts to mitigate PS shark and ray bycatch are required.
- FAD entanglement was previously identified as the main threat to silky sharks. All RFMOs have now adopted measures to promote the use of non-entangling FADs. Unfortunately, entanglement before and after these measures were adopted has not been quantified. However, observers and fishers report a reduction in accidentally-meshed shark and turtle encounters.
- A series of partial solutions have been found to reduce catches of sharks by tropical tuna purse seiners. Animals arriving on the deck are usually in bad condition, and solutions should be prioritized for when sharks are still in the water. For now, it appears that a combination of different technical mitigation techniques needs to be employed, tailored to the specific circumstances (perhaps to the level of region, season, fleet).

- Some skippers voluntarily avoid small sets (< 10 tons) to reduce bycatch, but it is difficult for many other skippers especially at times when only small sets are available.
- Skippers (and other anecdotal evidence) suggest that some shark populations are showing signs of recovery.
- Handlining to remove sharks from the purse seine net can work in some circumstances but in many cases will not be practical.

3. Small bigeye and yellowfin tunas

PRESENTATION

Jefferson Murua gave a presentation on small individuals of bigeye and yellowfin caught in purse seine fisheries, primarily on FAD sets. While these are not bycatch strictly speaking, there is a desire to find solutions to catch less of them, especially for overfished stocks.

The presentation discussed the two separate issues of growth overfishing (catching them at sizes that are sub-optimal from the point of view of higher yields) and recruitment overfishing (catching so many of them that it impacts the reproductive output of the stock). The presentation highlighted ISSF research conducted on acoustic species discrimination and on FAD designs that could result in lower catches of small individuals. The presentation reached the following conclusions:

- The relative importance of catches of BET and YFT by gear differs by ocean region: The majority of catches of YFT and BET come from PS in the EPO, from a mixture of gears in the AO, or a combination of both in the WCPO and AO.
- Catching juvenile bigeye and yellowfin does not necessarily cause overfishing. Overfishing can occur by catching too many small fish, too many large fish, or too many of both.
- Catching juveniles does result in loss of potential yield (lower MSY). In general, RFMOs do not have objectives for how to distribute catch allocations between gears that catch juveniles and those that catch adults.
- RFMOs can manage these impacts through quotas and/or seasonal or time/area closures.
- Better stock assessments can be achieved integrating tuna behavior and data from the echosounder buoys used to track FADs.
- In the near future, research on acoustics can result in technology for fishers to be more selective in targeting FADs with higher proportion of skipjack relative to yellowfin and bigeye.

DISCUSSION PANEL

Participants in the Panel were C. Groba, K. Holland, J. Murua and B. Vanden Heuvel. The following points were made during discussion:

- There is agreement that catching too many small and large tunas can cause overfishing, and that a holistic approach including all gears is necessary. There are some concerns about small tuna catch data from artisanal and semi-industrial vessels not being collected or being inaccurate.
- To date, many behavioral studies to mitigate small tuna catches have been conducted in research cruises (e.g. differences in residency times, depth distribution, movements in the net, moving away from FADs, catches modifying FAD depths, etc.), but none have yielded yet a clear solution which would aid to reduce their catches. Selectivity research in large PS vessels is complex due to the expensive nature of research in the high seas and the mixing of many species of different sizes under FADs.

- PS companies in the last decade have changed many aspects of their fishing strategy such as sharing of FADs between company vessels, instrumentation of all FADs with echosounders, etc. This has possibly led to a higher efficiency of these fleets but is not understood in detail how it can be incorporated to CPUE standardization and stock assessment evaluations.
- Some limited size closures, such as the "Corralito" in the EPO, are too small in size and time to yield a significant reduction in catches of small BET at oceanic region level. Other approaches, like total allowable catches per vessels, might have had unintended effects such as an even greater dependence on FAD sets, because vessels do not want to quickly consume their annual BET or YFT allocation fishing on free schools.
- Dynamic closures are preferred by some scientists and industry members to fixed time/area closures. Similarly, buoy data provision for independent indices of abundance are seen as a positive initiative. However, some fishing companies are concerned about the confidentiality of the data and prefer a time delay, which might be fine for abundance indices but not so effective for dynamic closures. Other types of real-time data sharing approaches may be welcomed by industry, such as on hotspots for undesirable bycatch like sharks.
- Fishers are not able yet to discriminate well between species with current echosounder buoys, but the technology is gradually improving, and it is a process that takes time. There is strong industry support (and hope) for improved acoustic technology that can discriminate sizes and species to be incorporated both in the acoustic equipment used onboard vessels and in the echosounder buoys used to track FADs.
- There is heterogeneity across oceans and within oceans both in terms of FAD performance and the biology and ecology of tuna. While much has been learned in recent years regarding tuna behavior, there is much still to be learned before we fully understand how the resource behaves and the impact of FADs on those behaviors and these phenomena may be region-specific.

4. FAD structure impacts

PRESENTATION

Gala Moreno gave a presentation on the impacts of FAD structure on vulnerable marine ecosystems, and in terms of marine pollution, ghost fishing and interference with other economic activities.

One of the primary ISSF focus areas to mitigate these impacts is research to develop biodegradable FADs, which has been ongoing since 2016 and now includes several large-scale pilot tests. But additional activities to better manage FADs and lower the risk of negative impacts are also necessary. The presentation reached the following conclusions on how FADs should be used to minimize impacts:

- Currently, except for the satellite buoy, biodegradable FADs should be made of only natural fibers/materials that are sustainably harvested, until other materials such as synthetic bio-materials become available and are proven to be non-toxic for the marine environment.
- Fleets should strive to reduce the size and weight of the FADs they build.
- Fleets should avoid FAD deployment areas that imply high risk of stranding.
- Fleets should implement policies to reduce and control FAD loss and abandonment, to the extent possible.

DISCUSSION PANEL

Participants in the Panel were J. Bilbao, M. Hall, A. Maufroy, G. Moreno and H. Murua. The following points were made during discussion:

- FAD structure has evolved towards deeper ones mainly to slow down the drift, which fishers believe is better to aggregate tuna and also to make the FAD stay within the fishing grounds. In the IO, fishers have recently started to use very shallow FADs (~2 m deep), mostly outside of the equatorial zone.
- Some fleets are testing biodegradable FADs themselves by deploying a limited number of FADs. It is difficult to learn from those small-scale trials because most of them end up lost or appropriated by other fleets. It would be good if these initiatives joined forces in some coordinated way that would allow tracking the lifetime of FADs and catches around those FADs.
- There is no quantitative information on the effect of FAD structure and materials on the amount of bycatch gathered, although some skippers believe that natural logs attract more bycatch than man-made FADs do. Ongoing projects that will deploy large numbers of biodegradable and traditional FADs at sea (in the AO, IO and EPO) will allow comparing the amount of bycatch at biodegradable FADs and at conventional FADs made of plastics.
- The definition of biodegradable FADs could also consider synthetic polymers that degrade, and not just vegetal fibers. The important issue is that the product of their degradation should be non-toxic for the environment. It is possible that natural materials degrade too fast and that other materials (such as biodegradable synthetic materials) could be a better solution.
- FAD structure impacts are mostly produced by the tail (submerged part of the FAD structure). For the rafts, using metal could be considered, together with a mechanism (similar to the one used in pop up tags) to make the metal structure detach and sink before the FAD drifts towards a vulnerable ecosystem.
- The priority to mitigate impacts should probably be to reduce the overall use of FADs and to enforce existing limits. However, even if FAD numbers are reduced, they will continue to be lost, so that other solutions (e.g. biodegradable FADs, FAD Watch, FAD recovery in the high seas) would be necessary. More research is needed to find satisfying technical solution for biodegradable FADs, and protocols to reduce the abandonment and loss of FADs.
- Discussions indicated that there is no unique solution to reduce the impacts of FAD structure on ecosystems. A combination of solutions adapted to each ocean and region may be necessary (e.g. reducing the length of the submerged part of FAD may be suitable in the EPO but not in the AO).
- Data on the position of FADs that are abandoned or lost is needed in order to develop better models of risk areas.

5. FAD management

PRESENTATION

Victor Restrepo made a presentation on management of purse seine fisheries, with emphasis on FADs. The presentation reviewed the many factors that make FAD management a complex undertaking. It also reviewed the evolution of RFMO management in the last decade, which has improved considerably. A series of management best practices was presented. The presentation reached the following conclusions:

- A lack of clear objectives by RFMOs makes it difficult to define science-based targets. For example, the optimum number of FADs or FAD sets would depend on the managers' targets such as (i) the relative catches to be achieved by longline and purse seine fisheries, (ii) the relative catch of juveniles vs adult fish, (iii) the allowable bycatch levels, etc.
- The PS fishery needs to be managed holistically. Too much focus on FAD sets detracts from other important issues.

- Fisheries other than PS need to be managed too, but there are no overall objectives between gears.
- Over the past decade, many NGOs have converged on what they consider are best practice elements for FAD management. Comparing these elements to RFMO management shows that RFMOs follow some or all of these to some extent. But there are loopholes, exemptions and weak compliance systems.
- RFMOs have made much progress in managing FADs over the past 10 years, but FAD data reporting is still sparse, with some exceptions.
- The RFMO limits on active FAD buoys warrant a careful look because they could actually allow for increases in the number of FADs deployed over current levels, perhaps up to 2.4 times higher. In addition, these limits do not account for derelict FADs that usually have their buoys turned off.
- Many factors make FAD management complicated. Holistic management of the fishery will require a comprehensive package of measures, tailored to each RFMO.
- Fleets have much to contribute in terms of finding practical and effective solutions.

DISCUSSION PANEL

Participants in the Panel were A. Anganuzzi, J.-N. Danielou, G. Holmes, A. Lazazzara and V. Restrepo. The following points were made during discussion:

- There is still some misunderstanding of why data on FADs should be shared with RFMOs/scientists and how this can help manage the fishery when “all that really matters is how much fish are taken out of the sea.”
- Clear management objectives must be developed. Once these are in place, it will quickly become clear why data should be shared (see previous point) and will clarify what types of FAD data are needed by scientists to help identify management pathways to achieve those objectives.
- There are multiple pathways to achieving management objectives including using economic levers, but all will come at some level of cost. The challenge is to determine which pathway will achieve the objective with the best cost to benefit ratio.
- FADs remain a sensitive issue even though the overall bycatch compared to other gears is much lower. Compliance with existing management measures such as limits on active buoys needs to be demonstrated.
- Testing of biodegradable FADs, and "better FADs" in general, should be accelerated as much as possible.

6. Looking ahead: The next 10 years

PRESENTATION

Laurent Dagorn made a presentation that, based on the progress made during the past 10 years, identified five objectives that still need attention during the decade ahead: (i) Improve data for ecosystem-based fisheries management; (ii) further reduce fishery-induced mortality of sharks and rays; (iii) further reduce fishery-induced mortality of small bigeye and yellowfin tuna; (iv) further reduce environmental impacts of FADs; (v) improve the knowledge on the effects of FADs on the ecology of tunas and other associated species (ecological trap hypothesis).

The presentation provided ideas on how progress could be made on each of these topics. The presentation noted that there are still a lot of challenges to be addressed in order to make the use of FADs more sustainable. For instance:

- There is a need for more fundamental and applied research.

- There is great potential for using FADs and fishing vessels as scientific platforms and practical pilot projects need to be implemented to demonstrate the benefits.
- There is still a need for better knowledge on the behavior of tunas, sharks and other species.
- Managers and fleets should consider using fewer, but better, FADs.
- New ways of selective fishing and sorting should be explored.

DISCUSSION PANEL

Participants in the Panel were L. Dagorn, S. Fagnani, M. Herrera, S. Jackson and F. Forget. The following points were made during discussion:

- There is a need to continue research on procedures to mitigate impacts on target species (reduce catch of juveniles, e.g. through further work on acoustic discrimination and sorting grids), bycatch (avoid bycatch or procedures for safe release, e.g. hopper) and habitat impacts (through FAD design, technological improvements, property rights, rewarding mechanisms on recovered FADs, data sharing, etc.).
- Technological developments could further improve the selectivity of the fishery. Real-time management, using daily data inputs from EMS and observer data, could feed dynamic closure models (e.g. for hotspots of sharks or undesirably-small tuna).
- The future of the fishery cannot rely entirely on technological improvements to enable more selective fishing. Fishing effort (number of vessels, number of FADs, days at sea, etc.) needs to be better managed. Clearer management objectives need to be set by RFMOs across all fisheries impacting on the concerned species. Further collaboration among scientists, the fishing sector, NGOs and administrators would be beneficial to this end.
- It is essential to look ahead and identify how the fishery should be in 10 years. A sophisticated instrumented controllable FAD (high-tech FAD) is something that can be tried as it could represent an option for the fishery to avoid FAD loss, beaching, optimization of the number of FADs, etc.
- The ecological trap hypothesis is still a debate in the scientific community.
- There is a need to clearly define FAD data needs for scientific purposes and data exchange and utilization mechanisms (e.g. collaborative work along the lines of what Asian longline fleets are doing for CPUE standardization). Voluntary provision can be made through scientific institutes.
- A lot of data are already being collected by fleets (from FADs or fishing vessels), but they are not all accessible to scientists. Scientists need to get ready for Big Data tools and the use of Artificial Intelligence to better understand the tropical pelagic ecosystems once the availability of these data starts becoming routine.
- Industry recognizes the reality that there is a need for increased transparency into their activities and that enhanced data provision close to real-time will increase, and scientific advice and fisheries management will be improved as a result.
- The mistrust that exists between different fleets is very extended (between fleets that use different gears; between fleets of the same gear but different flags; between fleets with strong flag state enforcement and those with weak one; etc.) and should be addressed through stronger and more transparent compliance in the RFMOs.
- Pressure by environmental NGOs is expected to continue to stimulate progress on more selective FAD fishing in order to reduce the bycatch of vulnerable species and catch of juvenile target tunas.

Overarching Conclusions

These are the authors' conclusions based on the discussions during the workshop.

During the last ten years, ISSF has made great progress on documenting with facts what are the main bycatch issues with purse seine fisheries that use FADs, and on researching technical solutions to these issues. But these fisheries are complex and there is a lot of variability by ocean, season, and even in vessel-specific strategies. There is no solution that fits all circumstances. A good example is mitigating the impacts of FAD structure on the ecosystem, in which so many factors play a role, and these factors can vary a lot depending on circumstances. Therefore, more of the same type of work that ISSF has been conducting needs to continue into the future, but perhaps with increased regional emphasis.

The provision of "FAD data" to scientists was discussed in every session. But the term "FAD data" is used by different people to mean different things, much like the term "bycatch." For example, the FAD data fields needed to improve CPUE standardization differ from the fields needed to develop indices of abundance from echosounder readings, and these differ from the data needed to develop beaching risk profiles. The view more regularly expressed by industry is that the exact objectives and data needed have to be clearly specified, and mechanisms for data used have to be established, before the data are made available. On the other hand, a view regularly expressed by scientists is that if they had all of the data, they could look into all these things, and perhaps other useful things that they have not thought about. Perhaps the distance separating these two points of view will diminish when the currently-ongoing voluntary data provision programs mature and establish trust between the fleets and the scientific institutes. Unfortunately, there are only a handful of such programs, and more efforts need to be made to make progress.

The sustainability of the purse seine fishery cannot rely on the availability of technical measures alone. Even if a great technical solution to a problem is found, like was the case for shark entanglement on FADs, it needs to be implemented by the fleets. This "uptake" tends to be slow and imperfect and it depends on the attitude of fleets, governments and other stakeholders (markets, NGOs, etc.). And even if the RFMOs end up adopting a requirement for such solutions in a binding fashion, there still needs to be a rigorous and transparent mechanism to ensure implementation. At the same time, non-technical aspects such as the fishing capacity and efficiency of the fleets need to be better managed.

On a closing note, four skippers participated in the workshop, and many of the other participants made numerous remarks about how great their participation was. Gathering skippers from different oceans and different fleets provided fruitful interactions that even went beyond the regular outcomes of the skippers workshops (where skippers usually come from the same nation). All of this shows that skippers, with all the at-sea knowledge that they accumulate, should be a very important stakeholder to be consulted when considering different solutions to sustainability issues.

Acknowledgments

We are grateful to all the workshop participants for positive engagement. Special thanks to Kathrin Hett for organizing all of the logistics at FAO and to Ian Cartwright for his facilitation of the sessions. This workshop was financed by the Common Oceans ABNJ Tuna Project.

Appendix 1. List of Participants

Francisco Abascal
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Nathan Taylor
Mariana Travassos
Beth Vanden Heuvel
Pedro Vigil

Appendix 2. Poll Results

Informal polls were conducted amongst participants during the six sessions, before each technical presentation. All questions were multiple-choice. The results are presented here, sorted from the choice with the largest number of respondents, to the lowest.

1. Bycatch of the tuna purse seine fishery

Do you consider that fishing effort on FADs in the last ten years has:	**Increased 80.4%** Decreased: 9.8% No change: 9.8%
Do you think that the technology developed to find and catch more tuna has also led to increased bycatch rates:	**No: 54.7%** Yes: 45.3%
Do you consider that bycatch rates (% of catch) in the PS fishery between 2009 and 2019, have:	**Decreased: 49.0%** Not changed: 38.8% Increased: 12.2%

Has there been progress in overall bycatch biomass (tons) reduction in the last 10 years in the PS fishery?	**Little improvement: 68.6%** Total bycatch increased: 13.7% No improvement: 11.8% High improvement: 5.9%
Do you think full retention of bycatch species (bony fishes) is a good method to incentivize the reduction of catches of non-target species?	**Yes: 57.1%** No: 42.9%

2. Sharks and rays

Do you consider that PS catch of sharks is a sustainability issue?	**Yes: 65.3%** No: 34.7%
Do you think there has been progress in collection of PS catch data on sharks in the last 10 years?	**Yes: 96.2%** No: 3.8%
Excluding ghost fishing, do you consider that shark mortality in the PS fishery between 2009 and 2019 has:	**Decreased: 36.5%** Not changed: 32.7% Increased: 30.8%
Do you think that good handling and release practices for sharks and rays are implemented by most PS fleets?	**No: 59.6%** Yes: 40.4%
Do you think there are less sharks killed through FAD entanglement in 2019 than in 2009?	**Significantly less: 49.1%** Less: 37.7% No change: 13.2% More: 0% Significantly more: 0%

3. Small bigeye and yellowfin tunas

The total catch of small BET and YFT by PS now compared to 10 years ago is:	**Higher: 89.4%** Lower: 10.6%
Is it unsustainable to fish small BET and YFT tunas?	**No: 57.1%** Yes: 42.9%
Do you think that deploying large numbers of FADs in the ocean can negatively impact tuna populations, even without fishing?	**Yes: 59.2%** No: 40.8% Increased: 30.8%
Do you think there has been progress in technical methods in the last 10 years to reduce catch of small BET and YFT tunas?	**Yes: 52.0%** No: 48.0%

Do you think small BET and YFT tunas are better managed now than 10 years ago?	**Yes: 70.6%** No: 29.4%

4. FAD structure impacts

Do you think FAD debris between 2009 and 2019 has:	**Increased: 75.5%** Not changed: 12.2% Decreased: 12.2%
Do you consider that FAD beaching is a significant issue?	**Yes: 78.4%** No: 21.6%
Do you think FADs should be retrieved before they sink or become derelict?	**Yes: 90.2%** No: 9.8%
Do you think any floating object attracts tuna equally, regardless of its complexity (size, depth, materials, etc.)?	**No: 57.7%** Yes: 42.3%
Do you think FADs (excluding the buoys) can be made only from natural materials?	**Yes: 84.6%** No: 15.4%

5. FAD management

Do you think the total number of FADs at sea has increased in the last 10 years?	**Yes: 88.4%** No: 11.6%
Do you think that FADs are better managed now than 10 years ago?	**Yes: 87.0%** No: 13.0%
Do you think that FAD management (limits, closures, etc.) is a key element of sustainably managing tropical tuna purse seine fisheries?	**Yes: 95.7%** No: 4.3%
Are the current limits on the numbers of active buoys effective in limiting the number of FADs at sea?	**No: 66.0%** Yes: 34.0%
Do you think that the impact of FADs can be mitigated without limiting the number of purse seine fishing vessels?	**Yes: 64.0%** No: 36.0%

6. Looking ahead: The next 10 years

What would be the main concerns of consumers in the next 10 years?	**Product price: 45.7%** Ecological sustainability: 28.3% Healthy food: 13.0% Labor rights: 6.5% Food security in developing countries: 6.5%
What are the main issues to be addressed by research and management in the next 10 years?	**Reduce catches of vulnerable species: 55.3%** Reduce catches of small tunas: 19.2% Reduce pollution (incl. FADs): 12.8% Reduce FAD impacts on tuna ecology: 12.8% Reduce catches of other bony fish: 0.0%
Do you think that RFMOs' management objectives are well defined?	**No: 95.8%** Yes: 4.2%
Do you think in 10 years the impact of the fishery will be:	**Lower: 49.0%** Higher: 28.6% The same: 22.4%

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