In 2009, acclaimed scientists, leaders in industry, and environmental champions launched the International Seafood Sustainability Foundation (ISSF) based on shared concerns about the future of tuna fisheries and a desire to do something about it — together.

**SCIENCE IS OUR GUIDE.**
- Science, not politics or profit, drives the ISSF.
- More than 70 percent of our budget goes toward original, collaborative research by leading marine scientists across a wide range of fields.
- Our research leads to policies and practices that promote better fishery management.

**THROUGH ISSF, MANY VOICES SPEAK.**
- Our success depends on the diversity of our stakeholders: scientists, NGOs, governments, and foundations, as well as fishing, processing, retail, and food-service companies.
- Working together, our stakeholders develop science-based policies and practices that get proven results.
- ISSF is unique in uniting a long-term vision of conservation with a businesslike concern for accountability and results.

**WE SIDE WITH THE FACTS, NOT THE FUNDERS.**
- Support from conservation-oriented foundations balances the support we receive from industry.
- Scientific institutions, NGOs, and fishing companies provide in-kind support as well as financial backing.
- All of our sponsors respect our independence. No supporting organization controls our policies, our practices, or the findings of our research.

**WE CLEAR THE WAY FOR COLLABORATION.**
- ISSF values the interests and expertise of all of our stakeholders: scientists, NGOs, governments, and foundations, as well as fishing, processing, retail, and food-service companies.
- When our stakeholders disagree, we help them find common ground.
Our Work

Bycatch Mitigation
Finding ways to reduce or eliminate tuna fishing’s negative impacts on “non-target” species and the marine ecosystem – that’s been an ISSF objective from the beginning. ISSF has researched bycatch-mitigation approaches across different fisheries and gear types, and shared our findings and recommendations with industry and tuna RFMOs. We’ve disseminated many best practices already, and new projects to discover even better ways to protect marine species and environments are underway.

FADs & FAD Management
Since ISSF’s founding, fish aggregating devices (FADs) have been a major research topic. FAD fishing catches about 40% of tuna worldwide, and certain FAD structures can trap sharks and other marine animals, impacting bycatch rates in tuna fisheries, and pollute the ocean when they are lost or discarded. To help make FAD fishing more sustainable, ISSF examines and addresses the issue from scientific, RFMO policymaking, and industry perspectives.

Nearly 2,000 SKIPPERS reached to date

In addition to Skippers Workshops & videos, ISSF offers bycatch-mitigation guidelines for purse-seine and longline fisheries in 10 languages.
Embracing a Better FAD
As sustainable fishing approaches, like using non-entangling FADs, become more familiar, fishers in ISSF skippers workshops express a growing acceptance of them over time.

What we have learned in 10 years?
Where do we go from here?

Thank You!
The Common Oceans ABNJ Tuna Project

Sustainable Management of Tuna Fisheries and Biodiversity Conservation in the ABNJ:

- To promote efficient and sustainable management of fisheries resources and biodiversity conservation in the ABNJ, in accordance with the global targets agreed in international fora.
- Supported by the Global Environmental Facility, with a grant of USD 27 million over five years and over USD 150 million of co-financing from the partners.
- More than 20 partners including all RFMOs, IGO, NGOs and private sector organizations.
- Since January 2014 until December 2019
## Main Project areas of work

<table>
<thead>
<tr>
<th>C.1 Sustainable management</th>
<th>C.2 Strengthening MCS and compliance</th>
<th>C.3 Reducing ecosystem impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Support to RFMO’s adoption of harvest strategies.</td>
<td>• Capacity building and global networking for MCS officers.</td>
<td>• Improved shark management across the Pacific.</td>
</tr>
<tr>
<td>• Support science-management dialogues.</td>
<td>• Compliance improvement in 1-RFMO members.</td>
<td>• Bycatch reduction in purse seiners.</td>
</tr>
<tr>
<td>• Support preparation of EAF plans at RFMO level</td>
<td>• Port State measures template legislation</td>
<td>• Global FAD issues.</td>
</tr>
<tr>
<td></td>
<td>• Electronic monitoring on board vessels</td>
<td>• Mortality reduction of seabirds in longliners.</td>
</tr>
<tr>
<td></td>
<td>• Best practices in MCS and market controls</td>
<td>• Global Information Portal on bycatch.</td>
</tr>
</tbody>
</table>

## What has been unique about the ABNJ Tuna Project

A rare opportunity to facilitate global collaboration between RFMOs, exchanging technical experiences on similar subjects:
- Management Strategy Evaluation
- Bycatch Mitigation
- Ecosystem Approach
- Compliance

Unique opportunity to work directly with:
- CSO and private sector partners: WWF, ISSF, Birdlife International, ACAP, MSC
- Other intergovernmental organizations: SPC, FFA, OSPESCA
- Governments of Fiji, Ghana, US, EU

Bycatch issues in center stage

## Coming to a future second phase (2020-2024)

Success brought an invitation to a second phase

**Inclusive partnerships** to continue

Work to continue on reducing impacts on the environment, including:
- Bycatch reduction
- Better FADs: non-entangling, biodegradable
- Support to FAD management

## Thank you for your attention...
Welcome!

Workshop Introduction
International Workshop on Mitigating Environmental Impacts of Tropical Tuna Purse Seine Fisheries
12-13 March, 2019 | FAO HQ, Rome, Italy

Objectives

• Go over Basic Concepts so that they do not need to be repeated in every talk
• Summarize the Approach used in bycatch mitigation
• Acknowledge sponsors, scientists and fleets
• Introduce the sessions and other Workshop details

1. Basic Concepts

Terms

FAD (Fish Aggregating Device)
• There are several types of floating objects that can aggregate tunas: Man-made FADs, natural logs, algae, dead whales, vessels, washing machines...
• In this workshop we call all of these either FADs or Floating Objects (FOB)

Bycatch
• This term means different things to different people.
• In this workshop, Bycatch means the catch of everything other than skipjack, bigeye or yellowfin tuna, regardless of whether it is kept or discarded (alive or dead).

Bycatch Rate
• We use this term to mean total tons of Bycatch, divided by total tons of (SKJ+BET+YFT).
Bycatch Ratios

Bycatch-to-catch ratios (non-target / SKJ+YFT+BET)

- Generally small
- Decreased slightly over the past 10 years
- Highest in the Atlantic mostly because minor tuna species are caught and utilized

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<tbody>
<tr>
<td>WCPO</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.2%</td>
<td>0.1%</td>
</tr>
<tr>
<td>AO</td>
<td>13.8%</td>
<td>10.5%</td>
<td>4.0%</td>
<td>1.7%</td>
<td>0.4%</td>
<td>0.0%</td>
</tr>
<tr>
<td>AO</td>
<td>13.8%</td>
<td>10.5%</td>
<td>4.0%</td>
<td>1.7%</td>
<td>0.4%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

2. Our Approach

General Principle

Skippers Workshops
Hierarchical steps

Ideas for tests are designed by the time at which the measure takes place within the fishing operation:

1. Passive mitigation – before the vessels are at the FAD
   e.g., non-entangling FADs, acoustic species discrimination

2. Avoid catching bycatch – before setting when the vessel is at the FAD. e.g., attraction of sharks away from FADs before setting, acoustic discrimination of species before setting

3. Release bycatch from the net
   e.g., release sharks and small bigeye and/or yellowfin tuna out of the net

4. Release bycatch from the deck
   e.g., release animals alive from the deck

3. Acknowledgments
Bycatch Research Steering Committee

- Javier Ariz*
- Diego Bernal
- Richard Brill
- Laurent Dagorn
- Martin Hall
- Kim Holland
- David Itano
- Bruno Lenny
- Gala Moreno
- Simon Nizet*
- Miki Ogura*
- Hisashi Okamoto*
- Tatsuki Oshima
- Jacques Sacchi
- Kurt Schwaiger
- Peter Sharples*

* Past members

Diverse expertise

Skippers' Workshop Team

- Laurent Dagorn
- Fabien Forget
- Martin Hall
- David Itano
- Eric Largacha
- Gala Moreno
- Jefferson Mora
- Igor Sanchez
- Anung Widodo

At-Sea Researchers

- Shiham Adam
- Rhett Bennett
- Alfredo Boris
- Guillermo Boyra
- Patrice Dewals
- Cory Eddy
- John Filmalter
- Fabien Forget
- Dan Fuller
- Kim Holland
- Melanie Hutchinson
- David Itano
- Rysz Jejk
- Bruno Lenny
- Udane Martinez
- Gala Moreno
- Jeff Muir
- Blanca Onue
- Alex Salgado
- Igor Sanchez
- Kurt Schwaiger
- Beth Vanden Heuvel

Teams

- Jeff Muir: 8 cruises
- Fabien Forget: 8 cruises
- JD Filmalter: 6 cruises
Our Funders

Our Research Partners

The Vessels and Their Crew

Service Providers
## Sessions

**Day 1 — PM**
- Session 1: Bycatch of the Tuna Purse Seine Fishery — V. Restrepo
- Session 2: Sharks and Rays — L. Dagorn

**Day 2 — AM**
- Session 3: Small BET and Yellowfin Tunas — J. Murua
- Session 4: FAD Structure Impact — G. Moreno

**Day 2 — PM**
- Session 5: FAD Management — V. Restrepo
- Session 6: Looking Ahead: The Next 10 Years — L. Dagorn

**EACH SESSION:** Introduction, Poll / 10 min.
Presentation / 35 min.
Discussion Panel / 45 min.

---

### Logistics

**Facilitator:** Ian Cartwright

**Simultaneous Interpretation:** Speak slowly; use microphone

**Food:** On your own (FAO cafeterias). Be prompt!

**Next:** Poll training!

---

**Thank You!**
Bycatch of the Tuna Purse Seine Fishery

1. Perception of bycatch issues 10 years ago and now
2. Bycatch = BPUE x Fishing effort
3. Total bycatch and bycatch by species group
4. Bycatch composition
5. Other tropical tuna fishing gears
6. Observers programs globally
7. Electronic monitoring
8. Retention and utilization
9. Skippers’ Workshop results

1. Perception of bycatch issues 10 years ago and now

Some issues were not apparent (e.g. shark entangling)

Other issues have been better characterized (e.g. bycatch-to-catch ratio)

2. Bycatch = BPUE x Fishing effort

Given that total bycatch is directly correlated to bycatch per unit of effort (BPUE) and total effort.

2 possible approaches to reduce bycatch:

- BPUE
- Overall effort

Bycatch of the tuna purse seine fishery
3. Bycatch vs. Target Catch

Total catch composition: Bycatch vs. target tuna catch

- Target catch/total catch
- Bycatch/total catch

4. Bycatch by Species Group

Western and Central Pacific Ocean (WCPO)

4. Bycatch by Species Group

Eastern Pacific Ocean (EPO)

4. Bycatch by Species Group

Atlantic Ocean (AO)
4. Bycatch by Species Group

Indian Ocean (IO)

ALL OCEANS — Current bycatch by species group and set type

5. Other Gears

Indian Ocean (2014–2016)

Figure B: Contribution of fishercruising, longline (blue), pole-and-line (yellow), and gillnet (pink) to the total bycatch estimated for marine turtles (in numbers), marine mammals (in number, molars, and teeth), and sharks (by weight, length) for the period 2014–16.

5. Other Gears

Western and Central Pacific Ocean (2014–2017)
Contribution to total mortality of purse seine and longline fisheries

6. Observer Programs Globally

- WCPFC ROP — 2007
- Forum Fisheries Agency (FFA) — 1986
- IATTC/AIDCP Program — 1993
- ICCAT Scientific Observer program — 2010
- ICCAT Eastern Atlantic and Mediterranean Bluefin Tuna Observer Programs — 2010
- ICCAT Observer Program for Bigeye and Yellowfin — 2011
- IOTC Regional Observer Scheme — 2010
- CCSBT Observer Program — 2001

6. Observer Programs Globally

- Most programs were created as a solution to low data reporting by crew
- All RFMO programs have detailed training standards and entrance qualifications (no conflict of interest)
- Observers functions differ among RFMOs — scientific role vs dual scientific and compliance role.
- Observer coverage requirements are also different depending on ocean/region

Human observer coverage requirements vary among tuna RFMOs

- WCPFC and IATTC — 100% coverage is required for large-scale purse seine vessels.
- ICCAT and IOTC — a minimum of 5% coverage is required for various gear types, including purse seine.
- ICCAT also requires 100% observer coverage for all vessels 125m LDA or greater during a FAD time-area closure, including support vessels, and 100% coverage in the bluefin fishery.
- Large-scale longline vessels in all RFMOs have a requirement of a minimum of 5% coverage.
7. Electronic Monitoring

Development of Electronic Monitoring Systems (EMS) was triggered by:

- The need for an alternative source of data that could complement data collected by human observers (e.g., EMS can provide 24-hour coverage, monitor both decks at the same time)
- Space problems in small vessels
- Need to reduce corruption and enhance safety

EMS: Useful tool to monitor many aspects of fishing operations, for scientific and/or compliance purposes. Also for vessel owner.

ISSF PS pilots in all Oceans showed promising results. ABNJ Tuna Project implemented EMS for Ghana fleet.

EMS could complement human observers, depending on the goals.
- One of the strengths in PS fisheries is reporting of large specimens
- There are still some weaknesses, e.g., accurate species composition (but this is also a problem for humans)

EMS could significantly increase the coverage of current programs.

A certain level of human observer coverage is still needed (e.g., biological samples, fishing activity at a fine scale).

Some RFMOs have already adopted EMS minimum standards for PS to harmonize the implementation of EM systems across different vendors.
8. Retention and Utilization

Full retention and subsequent utilization of non-target species is one way in which the wasteful practice of discarding fish at sea can be reduced.

Several pilot projects have been conducted to better understand the potential for bycatch utilization in tropical tuna purse seine fisheries.

**IMPLEMENTATION OF PILOT PROJECTS TO EXPLORE THE MARKET VIABILITY OF FULL RETENTION OF NON-TUNA SPECIES IN PURSE SEINE FISHERIES / ISSF Technical reports 2014-12 and 2016-16**

- Retaining bycatch to avoid wastage of fishery resources: How important is bycatch landed by purse-seiners in Abidjan? / SCRIS/2016/017
- Utilization and trade of faux-poilisson landed in Abidjan / SCRIS/2016/116

**MAIN OUTCOMES/ RECOMMENDATIONS**

- Pilot bycatch marketing projects should continue in additional areas, along with efforts to monitor and encourage enhanced bycatch utilization.
- Priority: WCPO and IO. In the AO bycatch utilization is already at high levels. In the EPO total retention for all catch has long been common practice.
- Need to increase availability and timeliness of observer data on all aspects of bycatch and utilization, including information on the post-harvest disposal of both bycatch and small/undersized tunas.

9. Skippers Workshops Results

- **Include fishers in the process.** They are experts and in charge of daily fishing operations. They provide feedback on activities most likely to succeed in their ocean and type of vessel.
- **Perception of bycatch issues for fishers and fleets is not fixed,** but rather evolves overtime. Provision of “sound” scientific information helps.
- **Reward for good practices that benefit fishers and companies.** Incentive of better fish prices and market options, avoid closures or prohibitions, etc. are ways to encourage skippers to adopt best bycatch mitigation practices.
- **Fishers want to catch tuna and do not like to generate bycatch.** For them it is a problem, hence they are interested in solutions, especially when they do not interfere greatly with the fishing operation.

Concluding remarks

- **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 is 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.

Concluding remarks

Thank You!

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Sharks and Rays

International Workshop on Mitigating Environmental Impacts of Tropical Tuna Purse Seine Fisheries
12-13 March, 2019 | FAO HQ, Rome, Italy

Key Shark Species Caught by Purse Seiners

Over 90% of shark bycatch by purse seiners is composed of Silky Sharks (mostly small individuals)

Key Shark Species Caught by Purse Seiners

• Second main shark species caught at FADs is Oceanic White Tip Sharks
• Commonly perceived as rare
• There is a wide consensus that populations are decreasing

Whale Sharks & Mobulid Rays

Whale sharks and Mobulid rays are not caught on logs or FADs, but some sets are done on tunas associated with them.
Incidental Catches

- Sharks are not targeted by Purse Seiners
- Shark bycatch-to-tuna catch ratio is quite small: < 0.5% in weight

Caught by Several Gears

Most Floating Objects Have Sharks

- Average Floating Object: 5 to 15 Sharks

Source: French Observers Data, IRD MARBEC Ob7, 2011-2018
Sharks Stay a Long Time at FADs

Juvenile Silky Sharks Can Avoid Fishing Grounds but Not FAD Grounds

The Chronological Hierarchy of Bycatch Mitigation
Sharks Like Playing... but it can be risky

Entanglement Issues

Scientists, managers, fishers:
Problem of entanglement of sharks in nets of FADs was considered negligible compared to fishery mortality

How Did We Find It?

Two independent methods have shown the extent of the issue in the Indian Ocean.

Electronic Tagging

Underwater Observations

Modeling
What Would Happen with FAD Entanglements?

Conclusions

- Extrapolation to other oceans was not possible (FAD density, shark density, FAD design)
- Large uncertainty, but problem is clear and solutions evident: Ban the use of netting to build FADs (See ISSF guide for Non Entangling FADs)

The Chronological Hierarchy of Bycatch Mitigation

Can We Adjust the Fishing Time?

Tunas and sharks reveal the same short-scale association patterns.

Forget et al. 2015
Target Large Schools

Avoiding sets on schools of tuna less than 10 tons would reduce the amount of bycatch of silky sharks by 21-41% depending on the ocean.

Dagorn et al. 2012

The Chronological Hierarchy of Bycatch Mitigation

Passive Mitigation  Avoid Before Setting  Release From the Net  Release From the Deck

Sharks Aggregate in a Particular Area of the Net

Create a Window in the Net
Let the Sharks Swim Out…

Fishing for Sharks

Shark Trap

Fish and Release

15-35% of sharks present in the net can be caught and released.
**Fish-and-Release Success**

15–35% of sharks present in the net can be caught and released (depending on shark fishing experience) with 97% survival rate

**Whale Sharks**

12 whale sharks encircled in tuna purse seine nets and released using “best practice,” when possible (ISSF + IRD/AZTI projects) — NO MORTALITY

Escalle et al. 2016

**The Chronological Hierarchy of Bycatch Mitigation**

70% of Sharks Arrive Dead on the Deck... but 30% Arrive Alive
Post-Release Survival of Silky Sharks

Studies in three oceans, onboard different purse seiners, have shown that about 50% of sharks released can survive.

<table>
<thead>
<tr>
<th>Ocean</th>
<th>Total Survival Rate</th>
<th>Total Mortality Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indian Ocean</td>
<td>19%</td>
<td>81%</td>
</tr>
<tr>
<td>Western Pacific Ocean</td>
<td>16%</td>
<td>84%</td>
</tr>
<tr>
<td>Eastern Pacific Ocean</td>
<td>8%</td>
<td>92%</td>
</tr>
</tbody>
</table>

Protecting Sharks

4. Release from deck after incidental catch

Implement best practices to maximize shark survival after release.

Mobulid Rays

Chilean Devil Ray
- 6 tagged rays
- 5 mortalities
- 17% survival

Spintail Devil Ray
- 7 tagged rays
- 4 mortalities
- 43% survival

Improvements Achieved So Far

Used in combination, Four actions can increase silky shark survival in purse seine fisheries by 62%.

- Shift 30% effort to free school sets
- Set only on FAIs with >10 t tuna
- Fish longer duration to target sharks and release them outside

+62% survival rate
What are “Small Tunas”?

- Commercially speaking, undesirably small tuna sizes are individuals below 3 pounds/1.4 kg. Biologically, most YFT and BET below 1 m length are juveniles/maturing.
- Most gears catch to some degree juvenile YFT and BET.
- PS catches on FADs for target species are: SKJ (70%), YFT (20%) and BET (10%).
- Discarding of undesirable sizes of SKJ, YFT and BET tuna is not permitted by most RFMOs and other organizations (e.g. ISSF Measure 3.3).
- Different from “minor tunas” which are species such as the Auxis group (bullet and frigate tunas) and the Euthynnus group (Pacific black skipjack and little tunny). In some fisheries these species are targeted and commercialized.

Quality Stock Evaluations Require Good Data

- Key to reliable stock evaluations need quality scientific data (e.g. observer data, buoy data, fishing technology, etc.).
- MSY is notoriously difficult to estimate as models are highly sensitive to assumptions.
- Precise knowledge on biological characteristics of each stock are essential → Improving last 10 years.
- Reliable CPUEs accounting for “technological creep” and fishing strategies → Rapid evolution, complex.
A stock can be overfished by catching too many juveniles, too many adults or a combination of both. Estimates of reduction in spawning potential due to fishing WCP/eggs by various gears / Source: McKechnie et al., 2017

Potential yield results from differences in catch sizes. Having the right equilibrium of gears to catch small vs. large fish is often a political management decision rather than scientific.

Small YFT/BET Mitigation Activities

- Acoustic selectivity to address undesired tuna mortality in FADs
- Tuna behaviour around the FAD and in the net (spatial and temporal separation)
- Effect of FAD depth on BET aggregation
- Fishery-independent indexes of abundance

Predicting Tuna Composition at FADs

With current PS acoustics (sonars, echo-sounders) it is difficult to distinguish tuna species at FADs.

Source: Fuller and Schaefer, 2014
Selective fishing to address undesired tuna catches

Acoustic Discrimination

Technology to Address Undesired Tuna Mortality

ROUGH BIOMASS ESTIMATES

BIOLGICALLY RELEVANT MEASURES

Research Towards Tuna Species Discrimination

Research cruises on-board purse seiners

2014_Central Pacific Ocean

2016_Atlantic Ocean

Target Strength measurements based on theoretical models

74 cm Yellowfin 20 min post mortem

Source: Boyra et al. 2018
Acoustics: State of Knowledge & Technology

- Frequency response is promising for discrimination between tunas.
- Obtained TS for BET and SKJ, which is fundamental knowledge needed to scale acoustic measurements into biomass, and can be integrated in acoustic tools used by fishers.
- Buoy manufacturers have started introducing 2 contrasting frequencies in their buoys.
- Future work: improve TS-size frequencies for YFT, develop refined discrimination algorithms, make knowledge available to fishers and technology manufacturers.

Tuna Residency at Dfads

<table>
<thead>
<tr>
<th>Island</th>
<th>SKJ (Short)</th>
<th>YFT (Long)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IO (Seychelles)</td>
<td>0-1 days</td>
<td>9 days (0-17)</td>
</tr>
<tr>
<td>IO (Mozambique)</td>
<td>5 days (4-8)</td>
<td>7 days (0-20)</td>
</tr>
<tr>
<td>WCPO (PNA)</td>
<td>2 days (Max 10)</td>
<td>2.5 days (Max 50)</td>
</tr>
<tr>
<td>AD (Sengal)</td>
<td>7 days</td>
<td>14 day</td>
</tr>
</tbody>
</table>

Source: Dagorn et al., 2007; Forget et al., 2015

Tuna Diel Behavior at FADs

- When associated with FADs, swimming depths of SKJ, BET and YFT (e.g. 0-100 m) day-night movements are shallower than the effective fishing depths of most PS nets (e.g. 120-160 m)

Catching SKJ Away From the FAD

- There is variability in movements of SKJ and YFT, with temporary formations of species-specific subgroups.
- Targeting mono-specific SKJ schools when they move away from the FAD does not seem feasible to reduce fishing of small YFT/BET.

Source: Schaefer and Fuller, 2013

EPO 2011 Research Cruise
Effect of FAD Depth on Catch Composition

Source: Schaefer et al. 2016, 2018 IATTC, NIRSA, ISSF

“SAUSAGE” NET TAIL
37-45 m

1st Experiment: 50 FADs each
2nd Experiment: 100 FADs each

Effect of FAD Depth on Catch Composition

Source: Itano et al., 2012, 2017

Tuna Behavior: Distribution in the PS Net

Atlantic Ocean TTV Research Cruise

VIDEO: WCPO ISSF Trimarine Research Cruise

Tuna Fishery-Independent Indices of Abundance

- Currently no method exists for obtaining direct, fishery-independent estimates of tuna populations.
- Electronic tags provide information on associative patterns over the course of several months.
- Fishers use FADs with echo-sounder buoys with information on presence and abundance of tunas (+100,000 per year).
- If we know FAD densities and associative behaviors of each species, we can translate real-time information of associated populations into total population estimates.

Source: Moreno et al., 2016; Capello et al., 2016
Small BET and YFT Tunas Skippers Workshop Results

- Fishing areas, rather than FAD depth, determining BET presence and the possibility of real-time closures.
- Regulations like closures or TACs have an effect on the fishing strategies of fleets.
- Difficulty discerning species composition at FADs with current acoustic technology used by fishers. Progress required to improve the species identification using multiple frequencies.
- Small-scale vessels in developing countries due to low technology and proximity to the coastline catch mostly BET and YFT of smaller sizes.

Conclusions

- Catching juvenile BET and YFT does not necessarily cause overfishing
- But catching juveniles results in loss of potential yield (lower MSY)
- RFMOs can manage these impacts through quotas and/or seasonal or time/area closures
- Better stock assessments can be achieved integrating tuna behavior and buoy data
- In the near future, acoustics work can result in tools for fishers to be more selective in targeting FADs with higher proportion of SKU

Thank You!

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Floating Objects

Naturally occurring components of the pelagic ecosystem

Fish Aggregating Devices:
A fishing gear well known to fishers

Percentage of FAD Sets vs. Natural Logs

WCPO — Percentage of total sets by school type for the major PS fleets

Source: Allain et al. 2016. DOI: 10.4000/books.pacific.423

200 BC
Rimae Sea
Only natural floating objects
Tracking natural floating objects
Man-made floating objects


200 BC
1900
High Diversity of FADs Worldwide

Global Trend Toward Deeper FADs

FAD Structure Depth

Research Focused on Modification of FAD Structure
Research Focused on Modification of FAD Structure

**SCIENTIFIC KNOWLEDGE:**

Experiment in the EPO to compare shallow vs. normal FADs

After 60 days monitoring the 2 types:

- No significant difference in drift speed
- No significant difference in total tuna catch
- No significant difference in species composition

<table>
<thead>
<tr>
<th>300 FADs Each Type</th>
<th>5 m. depth</th>
<th>37 m. depth</th>
</tr>
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</table>

Impacts Caused by FAD Structure

**Ghost Fishing:**

Entanglement Issues

**FAD Beaching & Marine Pollution**

Indian & Atlantic Ocean

10% of the FADs deployed end up beaching

Maufroy et al. 2015

Western and Central Pacific

- 5% beaching
- 26% buoy ‘lost’, likely leading to marine pollution or unnoticed beaching

Escalle et al. 2018

Impact of FAD Structures

- Damage of vulnerable ecosystems, such as coral reefs
- Marine pollution
- Interference with other economic activities
- Ghost fishing
Marine Pollution: Oceans Can Not “Digest” Plastics

FADs accumulate year after year

Reducing Marine Pollution by FADs

- Reduce numbers of FADs
- Modification of FAD structure
- Reduce lost or abandoned FADs

The impact is proportional to the number of FADs and their size.

Other Actions to Reduce Marine Pollution by FADs

- Reduce numbers of FADs
- Modification of FAD structure
- Reduce lost or abandoned FADs
Reducing FAD Structure Impact: Modification of FAD Structure

OBJECTIVE
To find a biodegradable FAD that degrades after its useful lifetime for fishing.

What is the best definition for a biodegradable FAD?

ISSF definition of a Biodegradable FAD:
a non-entangling FAD made of 100% vegetal fibers or materials.*
*This definition does not apply to buoys attached to track them.

FIRST STEP: Material Selection

- 100% natural fibers / materials
- Sustainably harvested
- Accessible & available in great quantities
- Available as close as possible to fishing grounds
- They can be processed to make ropes
- Rope diameter and material easy to handle onboard
- Cost

2007 to Present: Small-Scale At-Sea Experiments
Across 3 Oceans

2016 Tests In Controlled Conditions: Maldives

3 TYPES OF ROPE selected:
- Raw Cotton Twisted
- Raw Cotton + Sisal
- Raw Cotton + Linen + Sisal

DEPLOYED IN MALDIVES
Results: Maldives

- Breaking strength measurements showed that mixed cotton and sisal rope was the strongest rope after one year at sea.
- 100% cotton rope was the easiest to handle.
- Lower cost of 100% cotton rope.
- 100% cotton rope degradation faster after one year.

Other Problems to Solve

1. Determine the working lifetime required for a FAD in the different oceans.
2. Design biodegradable FAD structures best suited for each ocean.
3. Define the strategy to test biodegradable FADs in real fishing conditions.

Workshops Designed to Answer These Questions

- Raft synthetic materials
- Tail structure with cotton ropes

Pilot in Indian Ocean — 2017

- Testing 100 BIO-FADs in fishing conditions

  - Tuna aggregated to Biodegradable FADs
  - Tuna aggregated to Non-Biodegradable FADs
2019–2020
EPO fleet
46 PS
800 bio-FADs
2019
Ghanaian fleet
16 PS +10 PL vessels
800 bio-FADs
2018–2019
BIOFAD project Indian Ocean: EU & Korean fleets
1000 bio-FADs

Large-Scale Deployment of Bio-FADs

Other Actions to Reduce Marine Pollution by FADs

- Reduce numbers of FADs
- Modification of FAD structure
- Reduce lost or abandoned FADs

Workshop Recommendations

- Quantify strandings: Identify main beaching zones by establishing priority areas based on the vulnerability of the ecosystem and the degree of stranding.
- Develop a guide of good practices for tuna purse seiners and auxiliary vessels with the aim to reduce the loss and abandonment of FADs.
- Study the trajectories of FADs based on the position and time of deployment to determine the deployment areas with the highest risk of FAD loss of FADs.
- Conduct pilot studies at sea of FADs with navigation capacity to better understand the behavior of these FAD “drones” and the possible strategy for their use.
- In projects on FAD retrieval from the coast, determine the minimum requirements for the vessels that would recover FADs, as well as ensure the management of the waste on land.

Source: Moreno et al 2018
Next Steps

- Quantify FAD loss: Identify FAD beaching and FAD retrieval priority areas
- Research to find a biodegradable material for the floatation
- Tests in the western Pacific Ocean
- Evaluate the possibility of applying a hierarchy scheme in the definition of biodegradable FADs according to the results of the ongoing experiments at sea and the size and weight of the FAD structure

In Summary

What does a FAD fishery that avoids impacts on the ecosystem look like?

- Uses FADs 100% made of natural fibers/materials that are sustainably harvested
- Reduces the size and weight of the FAD
- Avoids FAD deployment areas that imply high risk of stranding
- Reduces and control FAD lost and abandonment, to the extent possible

Thank You!
FAD Management

International Workshop on Mitigating Environmental Impacts of Tropical Tuna Purse Seine Fisheries

12-13 March, 2019 | FAO HQ, Rome, Italy

FAD Management

Not just about managing FADs

- Delivering sustainability requires managing all PS set types & all other fishing gears
- Free School sets also have impacts
- As do dolphin sets, whale shark sets, natural log sets, dead whale sets, etc.

PS fisheries need to be managed holistically

What affects fishing efficiency?

FAD-related
- Use of FADs, supply vessels, FAD technology

Other technology
- Helicopters, bird radars, computers, satellite imagery, long-range sonar, lateral echo-sounders, navigation radars, private radio communications

Vessel-related
- Vessel size, capacity and speed, freezing capacity, net depth and speed, speed of unloadings

Many of these started in the 1990s and continue to evolve. Many are not well monitored historically.

Key Elements of FAD Management

Development
- 2010 onwards: RFMO measures
- 2017 Global FAD Science Symposium
- ISSF 2018-05 “Best practices for PS Fisheries in transition to MSC”
- NGO “Collective Best Practices for Well-Managed FAD Fisheries”
### Key Elements of FAD Management

**Element 1: Data Reporting**
- Data on FADs (e.g., tracks, echosounder data) to science bodies and authorities with appropriate time lags
- Reporting catch/effort by set type and comply with RFMO and flag state requirements
- Data from supply and tender vessels

**Element 2: Bycatch Mitigation**
- Require:
  - Non-entangling FADs
  - Participation in pilots with biodegradable FADs (eventually required)
  - Safe handling and best release practices for sharks and rays (and additional measures for silky sharks)
  - Prohibit intentional setting on whale sharks and cetaceans

**Element 3: Monitoring**
- Require 100% observer coverage (human or electronic) on PS and supply/tender vessels

**Element 4: Management - General**
- Require FADs to be marked (FAO Guidelines)
- Develop science-based FAD and FAD set limits
- Retain by-catch that can be utilized except vulnerable species that need to be released following best practices
- Require a FAD recovery policy
- Ensure management measures also apply to supply/tender vessels and list them on RFMO Records

### Evolution in RFMO FAD Management

#### FAD Measures that were in place 10 years ago:
- **IATTC**: Prohibit the use of supply vessels (C-99-07, still in force)
- **ICCAT**: 2-month total closure (C-06-01)
- **IOTC**: No FAD-specific measures
- **WCPFC**: FAD closures (2 months in EEZs and 3 months in high seas; Required Management Plans (CMM 2008-01)

All RFMOs had initiated some type of scientific or management effort to better understand the impact of FADs, especially on juvenile tunas.

### Where are RFMOs today?
- FAD data reporting by set type required and flag State compliance assessed?
  - **IATTC**: Data required, but compliance assessment weak
  - **ICCAT**: Data required, but flag state compliance weak
  - **IOTC**: Data required, but compliance assessment weak
  - **WCPFC**: Data required, but compliance assessment is not transparent
### Current RFMO Measures

#### Provide data on FAD use to RFMO science bodies (e.g., buoy tracks, echosounder estimates of biomass, etc.) even if not required?
- **IATTC**: Provided voluntarily
- **ICCAT**: ✗
- **IOTC**: ✗
- **WCPFC**: PNA members voluntarily provide to the SPC available buoy track data for vessels operating under the PNA VDS

#### Science-based limits on active FADs and/or FAD sets
<table>
<thead>
<tr>
<th>RFMO</th>
<th>Limit</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>IATTC</td>
<td>450-70 active FAD limit per vessel</td>
<td>Basis unknown</td>
</tr>
<tr>
<td>ICCAT</td>
<td>500 active FAD limit per vessel</td>
<td>Basis unknown</td>
</tr>
<tr>
<td>IOTC</td>
<td>350 active FAD limit per vessel</td>
<td>Basis unknown</td>
</tr>
<tr>
<td>WCPFC</td>
<td>350 active FAD limit per vessel</td>
<td>Basis unknown</td>
</tr>
</tbody>
</table>

#### Time/Area FAD closure?
- **IATTC**: ✗
- **ICCAT**: ✗
- **IOTC**: ✗
- **WCPFC**: ✗

#### Require the use of non-entangling FAD designs?
- **IATTC**: ✗
- **ICCAT**: ✗
- **IOTC**: ✗
- **WCPFC**: ✗

#### Promote the use of biodegradable FADs?
- **IATTC**: ✗
- **ICCAT**: ✗
- **IOTC**: ✗
- **WCPFC**: ✗

#### Establishes FAD recovery policy?
- **IATTC**: ✗
- **ICCAT**: ✗
- **IOTC**: ✗
- **WCPFC**: ✗

#### Safe handling and release practices for sharks, rays & turtles?
- **IATTC**: ✗
- **ICCAT**: ✗
- **IOTC**: ✗
- **WCPFC**: ✗

#### Other silky shark measures?
- **IATTC**: Retention prohibition
- **ICCAT**: Retention prohibition
- **IOTC**: ✗
- **WCPFC**: Retention prohibition
Prohibit intentional setting on whale sharks & cetaceans?

<table>
<thead>
<tr>
<th>RFMO</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>IATTC</td>
<td>✗</td>
</tr>
<tr>
<td>ICCAT</td>
<td>✗</td>
</tr>
<tr>
<td>IOTC</td>
<td>✓</td>
</tr>
<tr>
<td>WCPFC</td>
<td>✓</td>
</tr>
</tbody>
</table>

In Summary

- Each RFMO requires several best practice elements of FAD management. (WCPFC addresses all.)
- Many measures have loopholes. Example: IOTC requires FADs to be non-entangling “applied gradually from 2014”; it does not set a date for a complete transition.
- Some measures are set to enter into force in the future.
- Compliance mechanisms are weak. It is not possible to know if measures are being implemented.

Factors that make FAD management complicated

- Management objectives are not well defined for FADs within PS, or for PS relative to other gears (especially LL). Setting science-based limits without clear objectives is hard.
- Many anti-FAD positions are not fact-based.
- Industry and governments resist change. RFMOs are consensus-based.
- Effort creep is difficult to detect. Monitoring usually lags behind innovation.
- With few exceptions, FAD data reporting is still very incomplete.
- Overcapacity is a driver for increased fishing and ineffective regulations. Reducing it is expensive and politically difficult.
- Lack of FAD ownership and marking rules result in complex fishing strategies that are difficult to monitor.

Vessel Capacity

There are about 670 large-scale purse seine vessels targeting tropical tunas worldwide. Hold capacity ~860,000 m³.

NOTE: Active FAD limits are per vessel so they are not really hard limits unless vessel numbers are limited as well.
How many active FADs could be allowed by RFMOs?

- Using ISSF 2018-17 "snapshot of the number of PS vessels"
- Assuming each vessel uses its maximum
- Using the ISSF PVR and the RFMO CLAV to assign RFMO area

<table>
<thead>
<tr>
<th>RFMO</th>
<th>Limit/vessel</th>
<th># PS Vessels</th>
<th>Max # active FADs</th>
</tr>
</thead>
<tbody>
<tr>
<td>IATTC</td>
<td>70-450</td>
<td>227</td>
<td>70,220</td>
</tr>
<tr>
<td>ICCAT</td>
<td>500</td>
<td>79</td>
<td>39,500</td>
</tr>
<tr>
<td>IOTC</td>
<td>350</td>
<td>80</td>
<td>28,000</td>
</tr>
<tr>
<td>WCPFC</td>
<td>350</td>
<td>305</td>
<td>108,750</td>
</tr>
<tr>
<td>Total</td>
<td>&gt;350</td>
<td>691</td>
<td>244,470</td>
</tr>
</tbody>
</table>

The number of FADs in the water globally is thought to be around 100,000. But, if each LSPS vessel used the maximum allowed, the number of FADs in the water could increase by nearly 2.5 times!

Other alternatives for tuna management

Managing by catch quotas (TACs)
- Ineffective if not fully allocated between flags
- Real-time monitoring of PS catch by species is very difficult
- May lead to mis-reporting

Managing by seasonal closure
- A blunt instrument but it seems to work

Managing by time/area closure
- Ineffective unless they are very large

Managing fishing capacity
- I remain hopeful!

RFMO challenges to adopt resolutions

All RFMOs work by consensus. It takes just 1 member to block or weaken proposed actions.

- Resolutions are adopted for periods of 3-4 years and are unlikely to be revisited in the interim.
- Fleets want certainty that a problem is real and that a solution can be implemented cost-effectively while still catching tuna. Example: Adoption of non-entangling FADs. Lessons from other oceans or other fleets are often ignored.
- Sometimes fleets act faster than RFMOs do, especially if they perceive some market reward such as access or price differential.
- PS fleets perceive that they are being monitored and managed much more strictly than LL fleets are (e.g. observer coverage; bycatch mitigation). PS countries are less likely to agree to measures that seem unbalanced.

Skippers Workshop Lessons

In general, PS skippers share these opinions about management:

- The number of FADs is not the only thing to be managed. Many elements assist FAD fishing such as supply vessels, helicopters and other technologies like echo-sounder buoys.
- Fishers have thoughts on the efficacy and feasibility of different types of measures and possible loopholes; they can contribute to management.
- Regulations are more closely followed when accompanied by incentives.
- Fishers perceive that there usually is not a level-playing field and that enforcement varies greatly by flag and by RFMO.
Concluding remarks

• A lack of clear objectives makes it difficult to define science-based targets.
• 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. Objectives?
• Over the past decade, many NGOs have converged on what they consider are best practice elements for FAD management.

Concluding remarks

• 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 (e.g. PNA) and the limits on active FADs warrant a careful look.
• 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.

Thank You!
Looking Ahead: The Next 10 Years
International Workshop on Mitigating Environmental Impacts of Tropical Tuna Purse Seine Fisheries
12-13 March, 2019 | FAO HQ, Rome, Italy

Objectives

However, management objectives are not always well defined by RFMOs

- All fishing gears are concerned by the sustainable exploitation of tunas
- An holistic approach is necessary to address all fisheries impacts on the stocks and the ecosystem in general
- The current presentation will focus on research needed to improve the sustainability of tropical tuna purse seine fisheries

Objectives for the Next 10 Years?

In Line with RFMO Objectives

- Improve data for ecosystem-based fisheries management
- Further reduce fishery-induced mortality of sharks and rays
- Further reduce fishery-induced mortality of small bigeye and yellowfin tuna
- Further reduce environmental impacts of FADs
- Improve the knowledge on the effects of FADs on the ecology of tunas and other associated species (ecological trap hypothesis)

Need for Science Fiction

- Improve for research
Objectives for the Next 10 Years?

In Line with RFMO Objectives

• Improve data for ecosystem-based fisheries management
• Further reduce fishery-induced mortality of sharks and rays
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Data Collection

One challenge in moving to ecosystem-based fisheries management is the difficulty of integrating and understanding all components

• Big data and AI: All data accessible to scientists, analyzed with AI techniques
• Fishing vessels as scientific platforms (Melvin et al. 2016): Bird radars, sonars, echo-sounders, EMS, e-logs, etc.
• FADs as scientific platforms (Moreno et al. 2016)

The international PS fleet maintains about 100,000 FADs worldwide

Are sharks swimming in a safe environment?

Are there very few “entangling” FADs in the 4 oceans?

• Need independent verification
• Tag silky sharks in every ocean every year and check if entanglement events are observed
**Counting the Number of Sharks**

Having a few sharks or >50 sharks in the net completely changes the release issue.

**Innovation:** Develop an electronic buoy which counts the number of sharks at FADs and sends data to PS (similar to the echo-sounder buoys)

- No shark
- Few sharks
- Many sharks

**Average FAD: Few sharks but frequent**

Can we attract sharks away from FADs (using bait), then set on tunas?

→ 50% success

**Separate Sharks and Bycatch**

- Trap net or ring net

**Behavior of Fish in the Net**

- Sharks, but also bigeye and yellowfin
- Species are not mixed in the net
- Potential for segregation
- Need to investigate sensory abilities for behavioral manipulation (e.g., attracting one species with lights and not the others)
• Identify hotspots (using observers data and tagging data)
• Real-time management (immediate communication within the fleet to inform about sets with large numbers of sharks)

**Exceptional Sets (FADs or FSC): Large number of sharks**

*Main areas describing status geographical distribution*

---

**Objectives for the Next 10 Years?**

*In Line with RFMO Objectives*

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**Can bigeye tuna dive to escape nets during setting?**

**Small Bigeye and Yellowfin**

**Sorting hopper operation**

- Door is opened and marketable tunas are shuttled to the wells
- Smaller fishes swim down through the grid
- Fishes are placed in the hopper
A New Way of Fishing?
Sorting fish in the water (ex. of bluefin tuna)

PS encircles the fish

Another vessel sorts the fish: captures SKJ, releases non wanted species

Transfer all fish to a cage

Objectives for the Next 10 Years?
In Line with RFMO Objectives
• Improve data for ecosystem-based fisheries management
• Further reduce fishery-induced mortality of sharks and rays
• Further reduce fishery-induced mortality of small bigeye and yellowfin tuna
• Further reduce environmental impacts of FADs
• Improve the knowledge on the effects of FADs on the ecology of tunas and other associated species (ecological trap hypothesis)

Real Ecosystem-Based Fisheries?
• Harvest an ecosystem in an ecological sustainable way?
• Design a fishery composed of different fishing gears characterized by their size and species selectivities to achieve a balanced harvest of the ecosystem

FAD drone
A FAD trajectory can be controlled / modified in order to avoid coasts
Other Options to Investigate

- “FAD watch” programs with a database with all FAD trajectories, automatic quantification of beaching, setting alerts to sensitive areas
- Change fishing strategy with FADs. Use FADs shared by all fishers (similar to some anchored FAD arrays)
- Use anchored FADs in areas where drifts of FADs are likely to end beaching

Objectives for the Next 10 Years?

In Line with RFMO Objectives

- Improve data for ecosystem-based fisheries management
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Ecological Trap Hypothesis

Logs have always been natural components of the surface habitat of tuna

Poor Habitat

Rich Habitat

Interplay between number of floating objects and environment on the ecology of tuna

Dedicated research:
- Electronic tagging in array of instrumented drifting FADs
- Condition factors of tunas on- vs. off-FAD and fed vs. starved
Conclusions

Looking back 10 years shows that there has been great progress.

But there is still a lot of challenges to address to make the use of FADs more sustainable.

Need for fundamental & applied research

- FADs and fishing vessels as scientific platforms
- Better knowledge on tunas, sharks and other species
- Fewer FADs, but better FADs
- New ways of fishing.

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Thank You!