IOTC-2021-WPM12-19

Rethinking a science-based management of FADs

12th WORKING PARTY ON METHODS
18-20 October 2021

Manuela Capello
IRD & Marine Biodiversity, Exploitation and Conservation

Re-thinking a science-based FAD management:

Management objectives

See IOTC-2021-WGFAD02-12 WGFAD

Management options
& Mitigation measures

Several papers @WGFAD
(IOTC-2021-WGFAD02-11, IOTC-2021-WGFAD02-08, IOTC-2021-WGFAD02-09
IOTC-2021-WGFAD02-10 , IOTC-2021-WGFAD02-05, IOTC-2021-WGFAD02-13 ..)

Re-thinking a science-based FAD management:

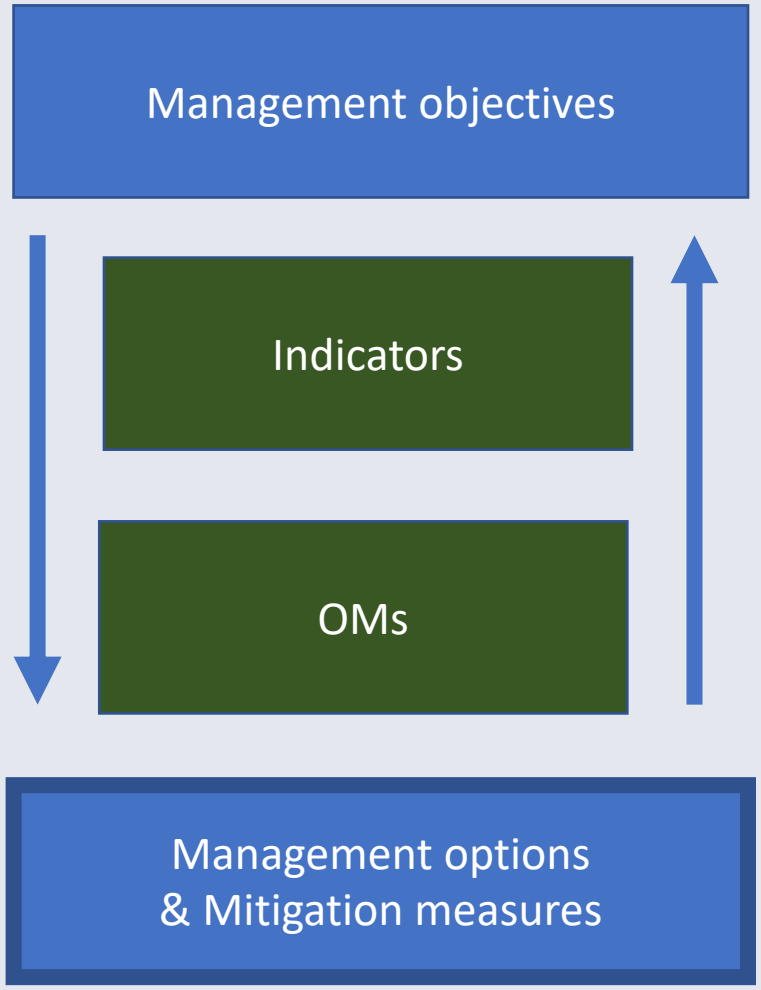
Management objectives

Indicators

OMs

Management options
& Mitigation measures

Re-thinking a science-based FAD management:



Challenges :

Find the best indicators/OMs :

- To translate management objectives in quantitative terms
- To evaluate the effectiveness of past management decisions
- To evaluate the effectiveness of past mitigation measures
- To predict the consequences of novel management decisions

Indicators

Tuna

- **FOB* Catches of tuna**
- **FOB Catches of *juvenile* YFT/BET**

Bycatch & ETP species

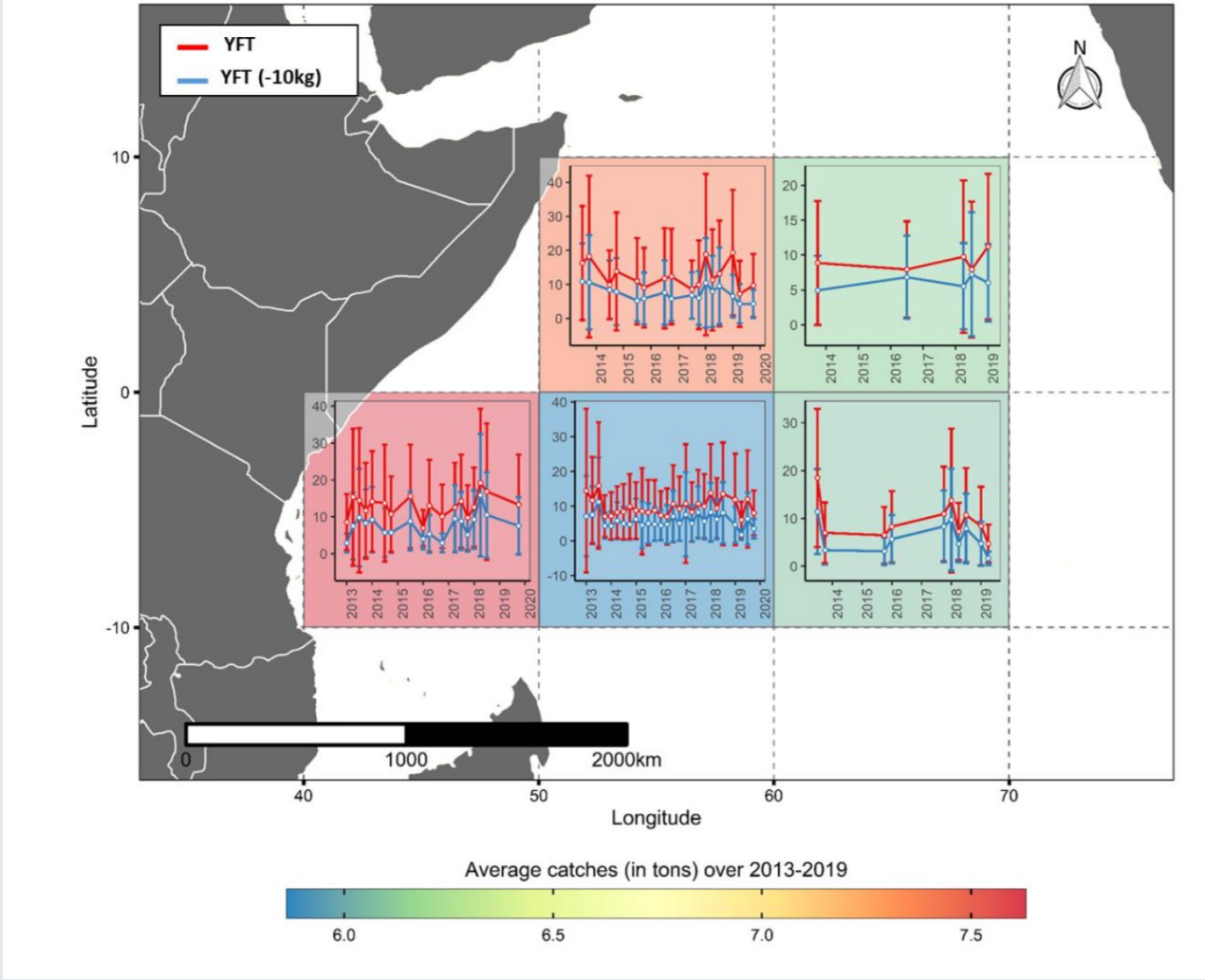
- **Total bycatch**
- **Catches of ETP species (silky sharks)**
- **Entanglement of sharks**
- **Post-release survival of sharks**

Habitat

- **Number of FAD beachings**
- **Number of FADs losses (abandoned/sank) / Amount of plastics in the water**
- **Changes in surface habitat (number of FADs/NLOGs**)**

*FOB=Floating object (includes FADs and natural logs)
**NLOG = Natural floating object

Indicators: FOB catch per set of YFT and YFT < 10 kg



Baidai et al IOTC-2021-WPTT23(DP)-15

Indicators: FAD beaching

Biological Conservation 254 (2021) 108939

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Spatial management can significantly reduce dFAD beachings in Indian and Atlantic Ocean tropical tuna purse seine fisheries

Taha Imzilen [a,b,c,*], Christophe Lett [a,b], Emmanuel Chassot [d,e], David M. Kaplan [a,b]

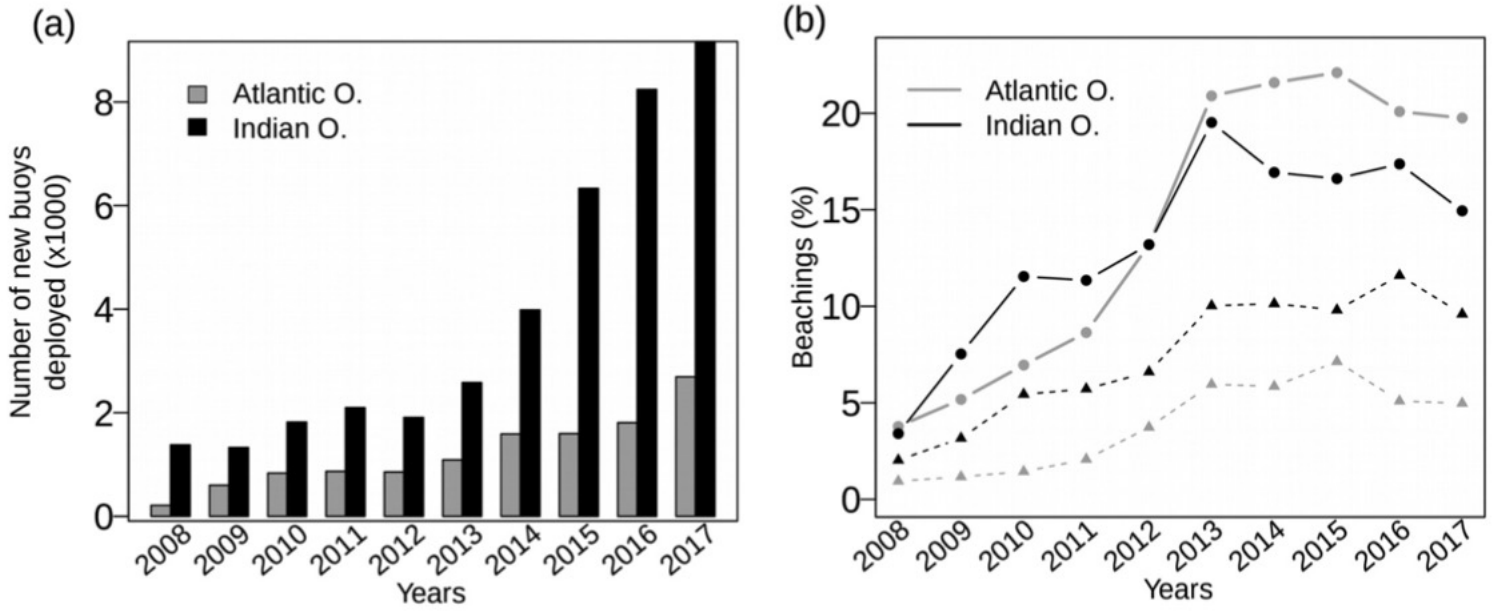
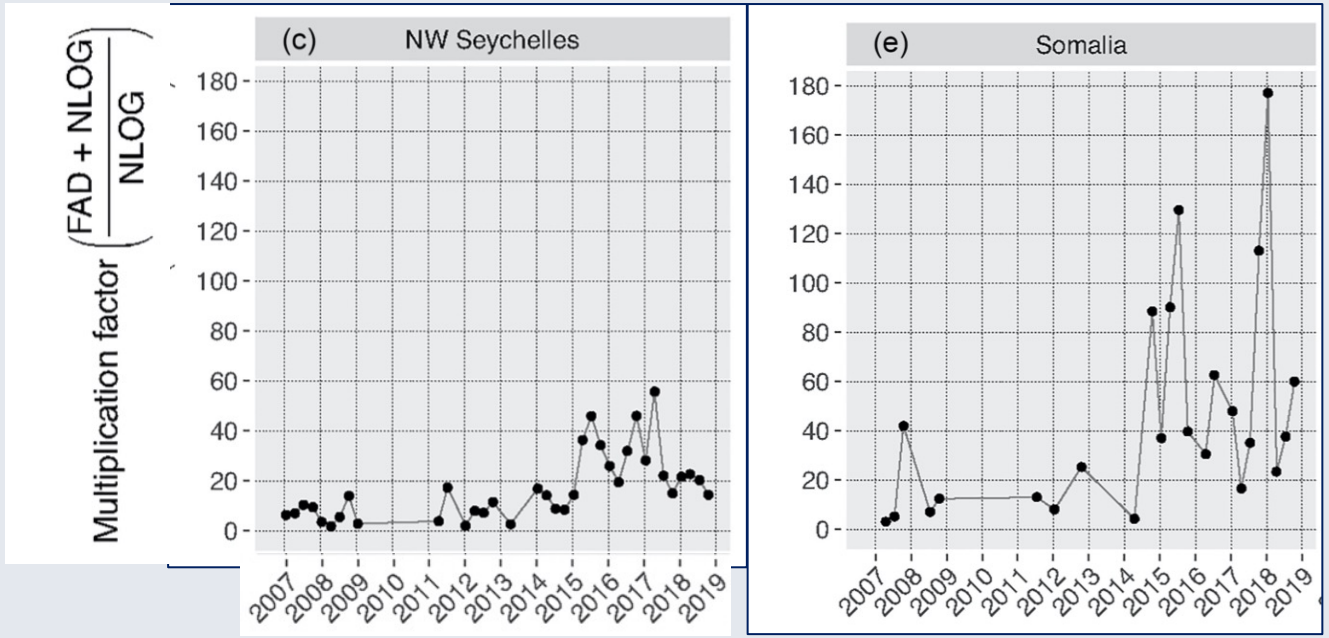


Fig. 1. (a) Annual number of new buoys deployed by the French and associated flags purse seine fleet in the Atlantic (grey) and Indian (black) oceans over the period 2008–2017 and (b) percentage of these buoys that beached. The lines in (b) with solid circles include all beachings, whereas the lines with solid triangles include only beachings identified along shore. Beachings along shore and recoveries displaced to shore were separated via intersection with OpenStreetMap land polygons.

IOTC-2021-WGFAD02-07

Indicators: habitat changes

- **Habitat changes**



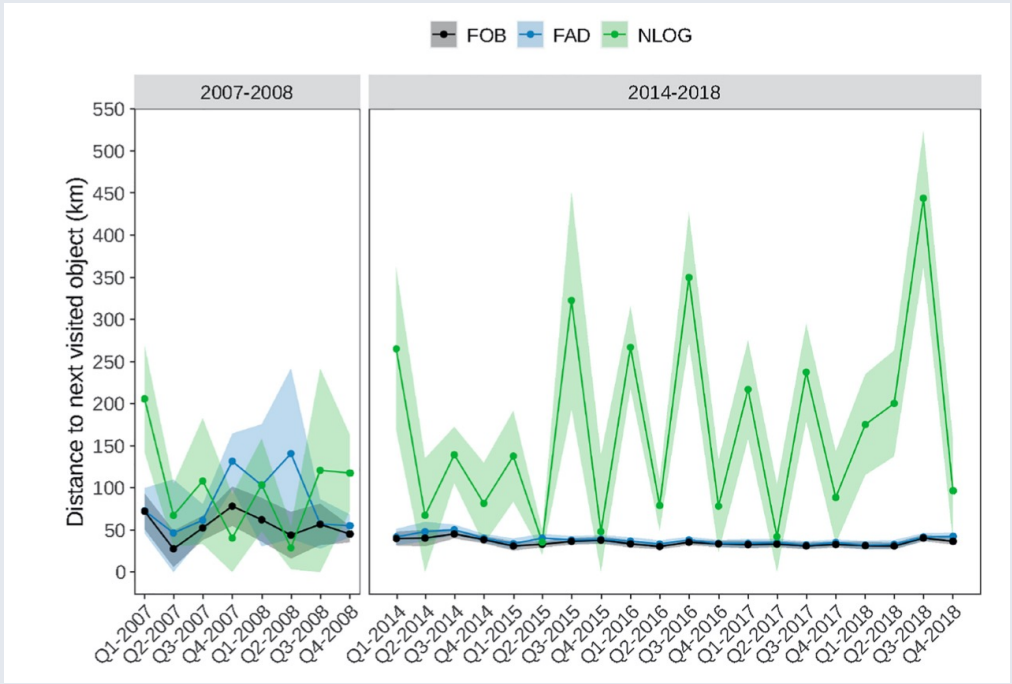
ICES Journal of Marine Science

ICES Journal of Marine Science (2021), https://doi.org/10.1093/icesjms/fsab175

Original Article

Surface habitat modification through industrial tuna fishery practices

Amaël Dupaix[1,*], Manuela Capello[1], Christophe Lett[1], Marco Andrello[2], Nicolas Barrier[1], Gaëlle Viennois[3], and Laurent Dagorn[1]



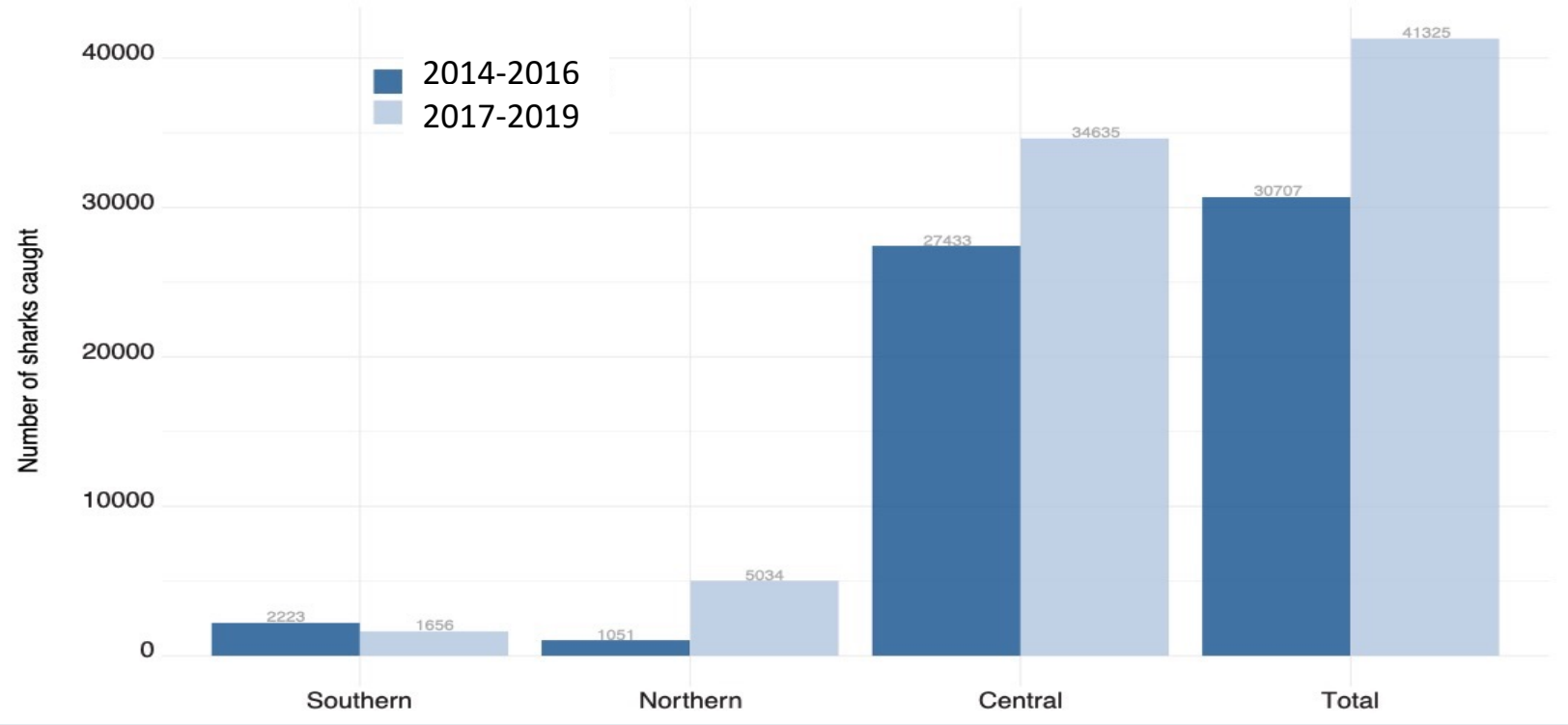
IOTC-2021-WGFAD02-INF11

*FOB=Floating object (includes FADs and natural logs)
**NLOG = Natural floating object

Indicators: ETP species

(Tolotti et al. under review)

- **Catches of silky sharks at FOBs (French fleet, observers' data)**



(can be shark population and FOB density dependent but still provides trends of shark mortality due to FADs)

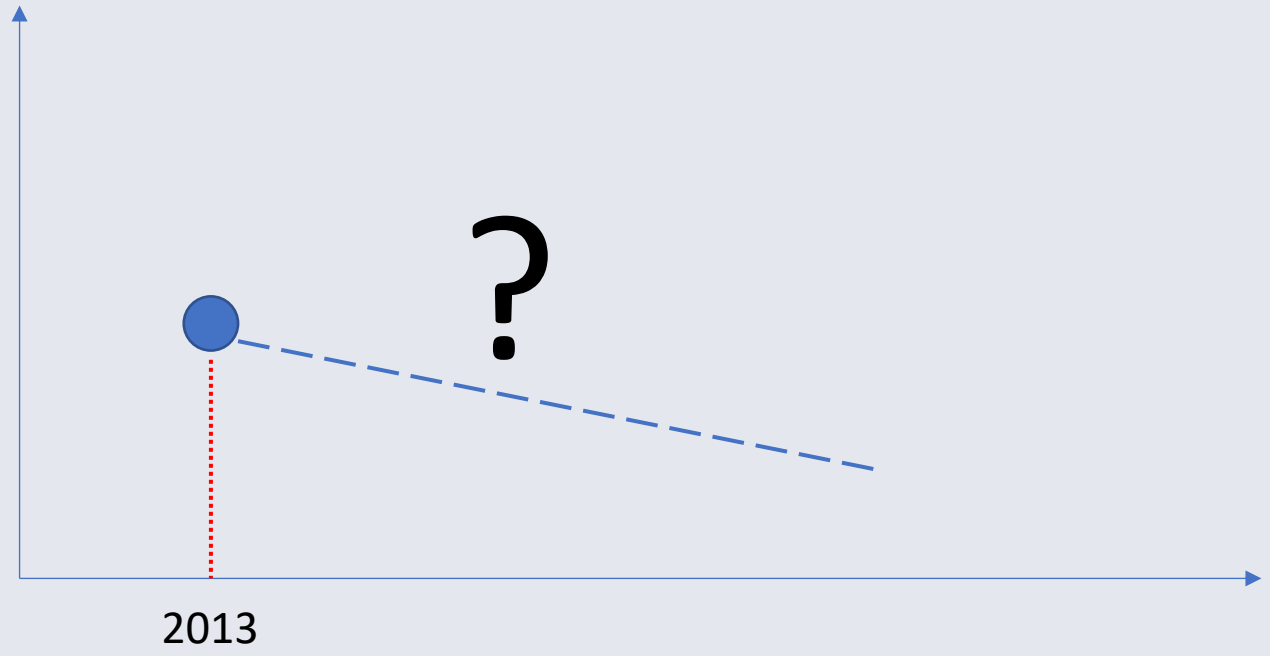
Indicators: ETP species

Front Ecol Environ 2013; doi:10.1890/130045

Looking behind the curtain: quantifying massive shark mortality in fish aggregating devices

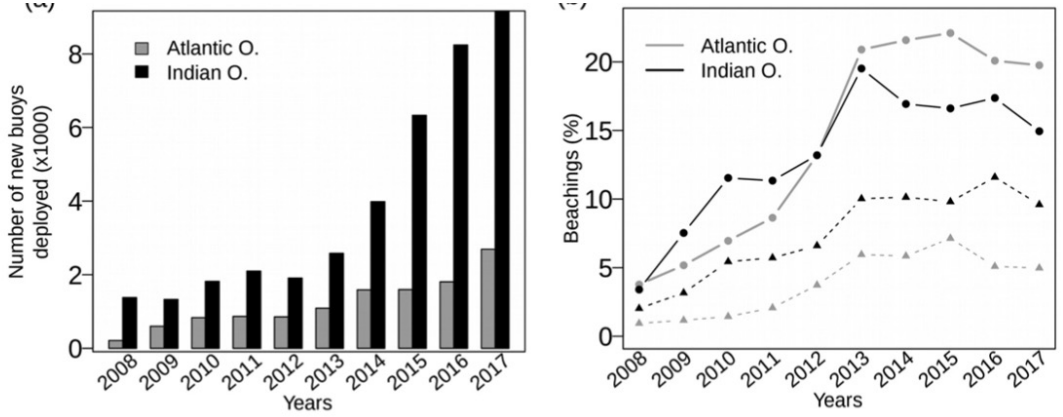
John David Filmalter[1,2,3*], Manuela Capello[4], Jean-Louis Deneubourg[4], Paul Denfer Cowley[2], and Laurent Dagorn[1]

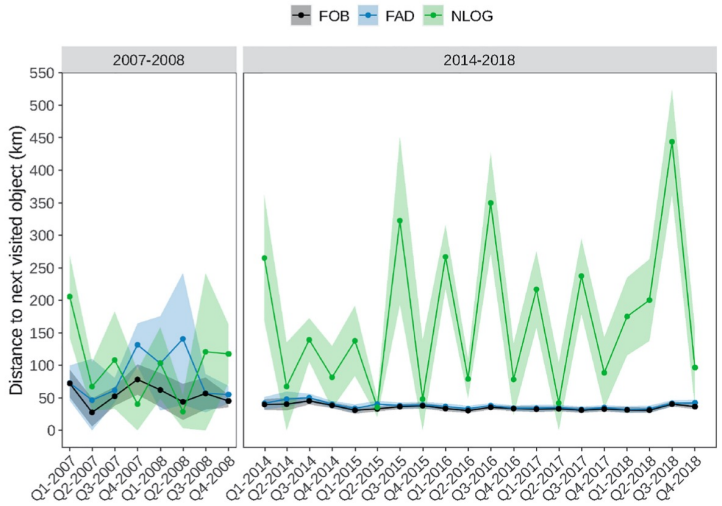
- **Shark entanglement:**
  - **Average time before entanglement (from tagging data)**
  - **Average number of entangled sharks per FAD**

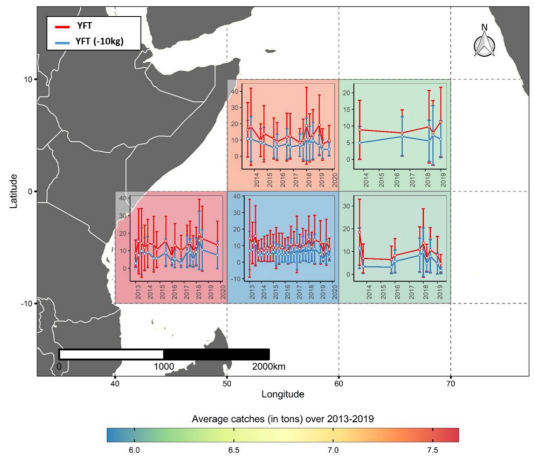


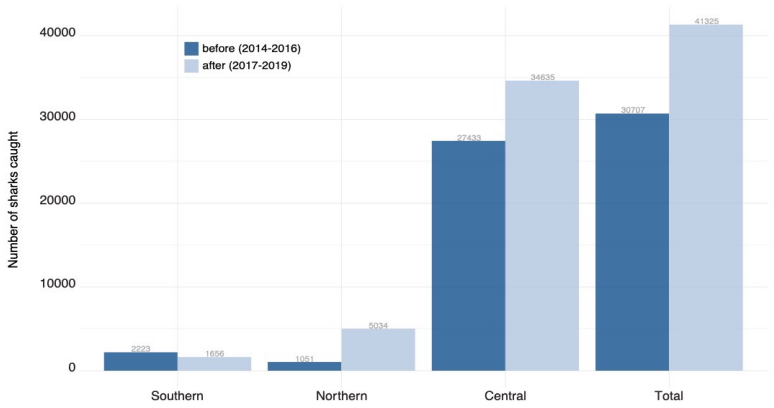
Need to account for FAD-density dependent effects
+ shark-population density dependent effects

Indicators









Can we support management decisions based on such indicators ?

Operating models (OM)

OMs **simulate the dynamics of the resources and the fisheries**.

Within the Management Strategy Evaluation scheme (MSE), OMs are generally used to identify **harvest control rules** with respect to a given set of management objectives (Punt et al., 2016).

From a more general perspective, the main scope (and challenge) of an OM is to **catch the main population and fishery processes that are relevant to fisheries-management decisions.**

Objective: OMs catching the effects of FAD-management actions on tropical tuna.

Operating models

FOB trajectories

=> Reducing FAD beaching/loss (Imzilen et al. 2021)

=> Evaluate habitat changes (FADs compared to density of NLOGs) (Dupaix et al. 2021)

SS3 (or other stock-assessment models):

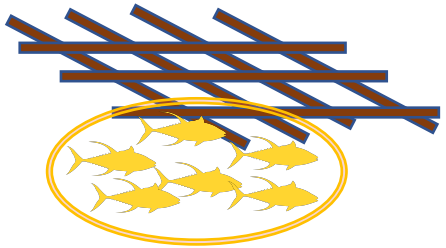
=> Impacts of increased catches of juvenile YFT on the stock

FAD association dynamics models :

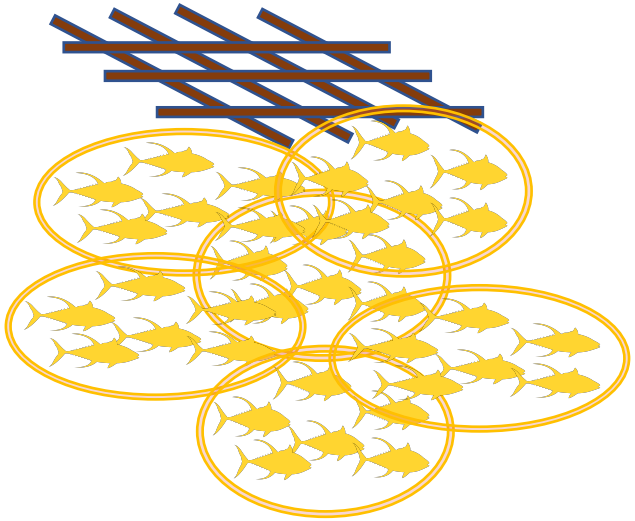
=> Effects of FADs on tuna catchability

Total catches at FADs (PS) depend on:

1. **The size of FAD aggregations (Catch per set)**



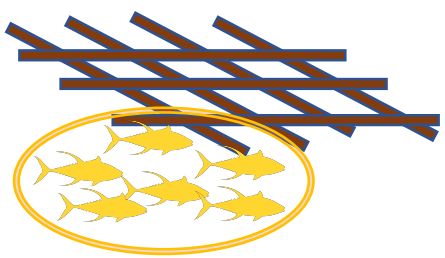
5 tonnes



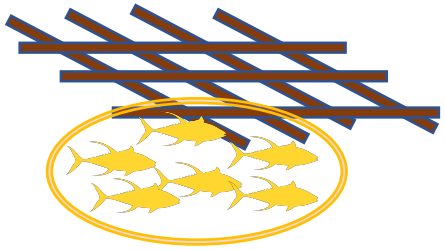
30 tonnes

Total catches at FADs (PS) depend on:

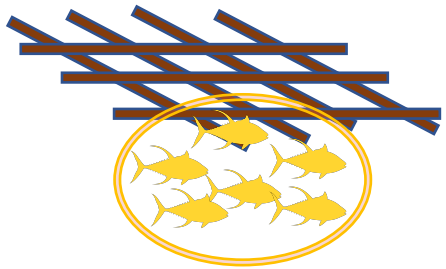
1. **The size of FAD aggregations (Catch per set)**
2. **The number of FAD sets (Number of FADs + fraction of FADs occupied by tuna)**



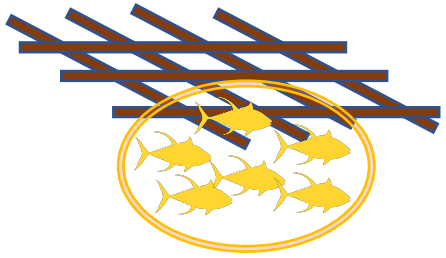
5 tonnes



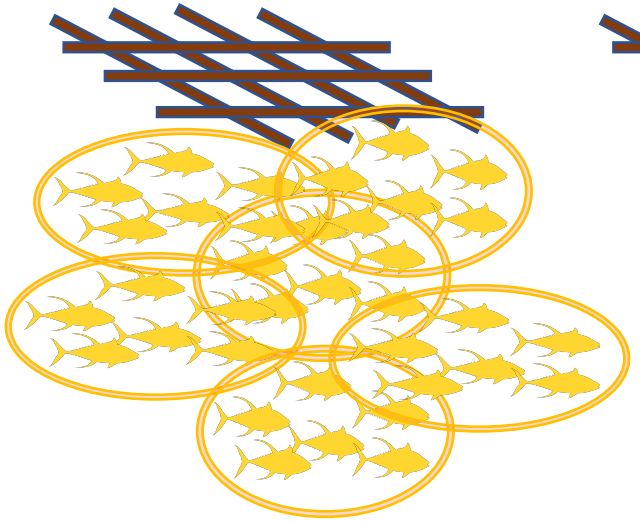
5 tonnes

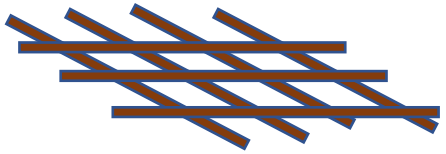


5 tonnes



5 tonnes



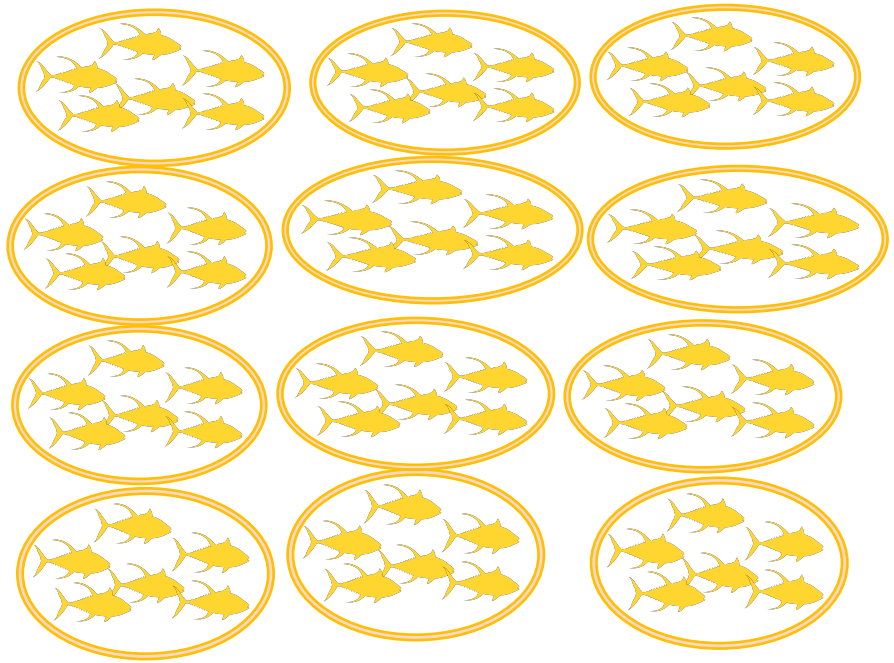


30 tonnes

How does tuna distribute in a FAD array?

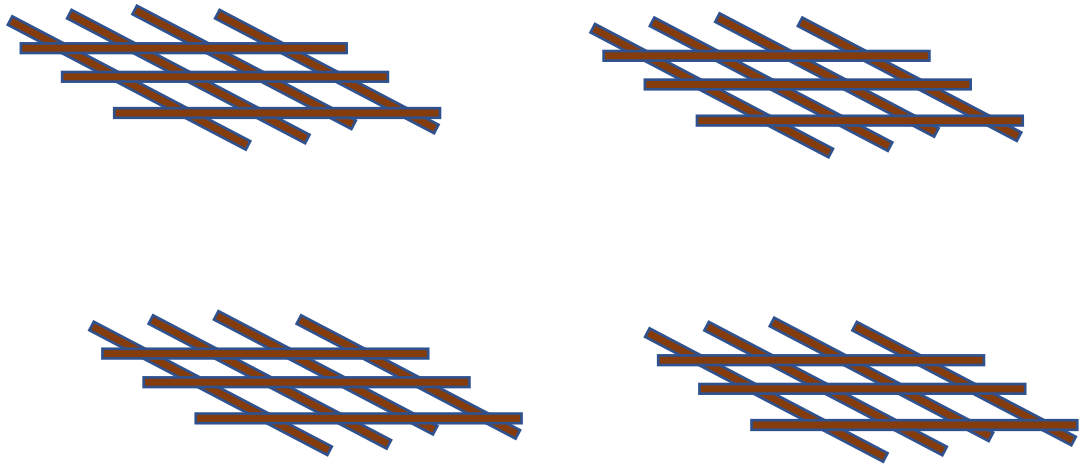
Need to consider 3 main components :

1. Tuna population



3. Behavior/ Associative dynamics

2. Number of FADs



Associative dynamics

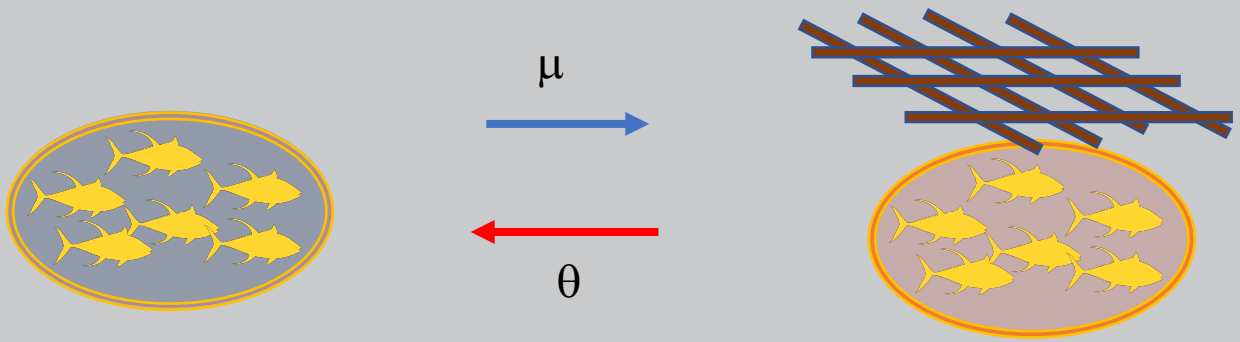
$$\frac{dx_i(t)}{dt} = \mu_i(t)x_e(t) - \theta_i(t)x_i(t)$$

$x_i(t)$ *number of schools associated with FAD i*

$x_e(t)$ *number of free schools*

Unassociated
(Free school)

Associated with a FAD



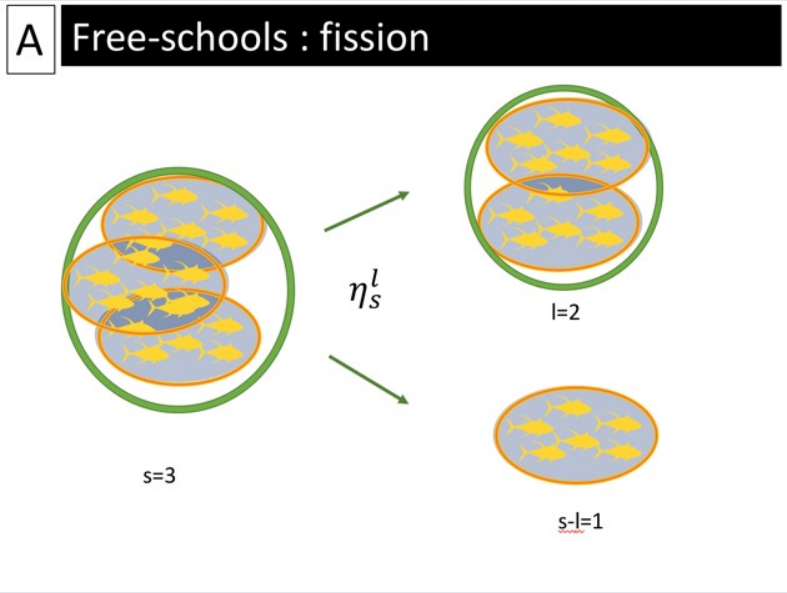
2 main model parameters :

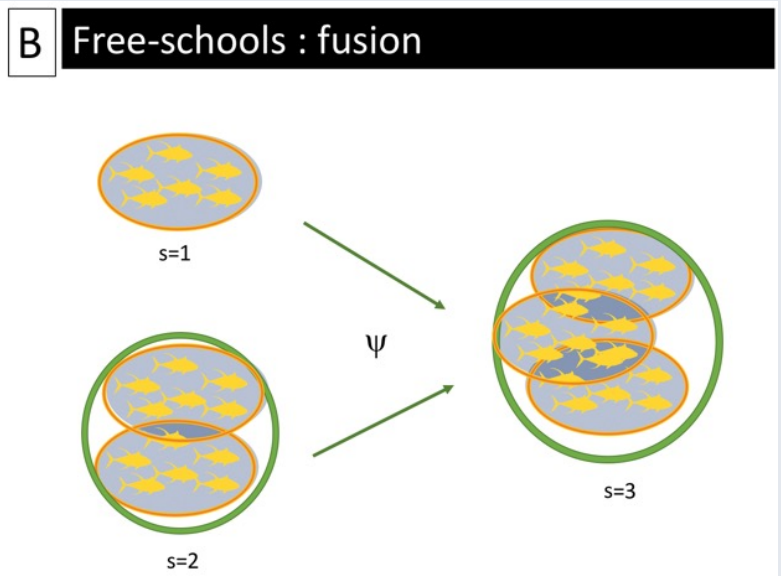
μ — Probability to associate with a FAD

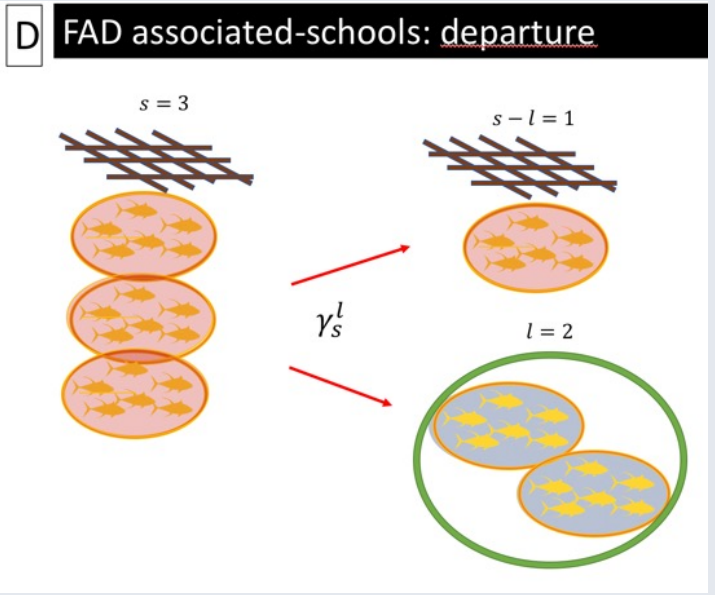
θ — Probability to depart from the FAD (become free)

(Sempo et al. 2013; Capello et al. 2015; 2016)

Accounting for schooling dynamics







Outputs:

Size of FAD aggregations
Fraction of occupied FADs
Total associated population

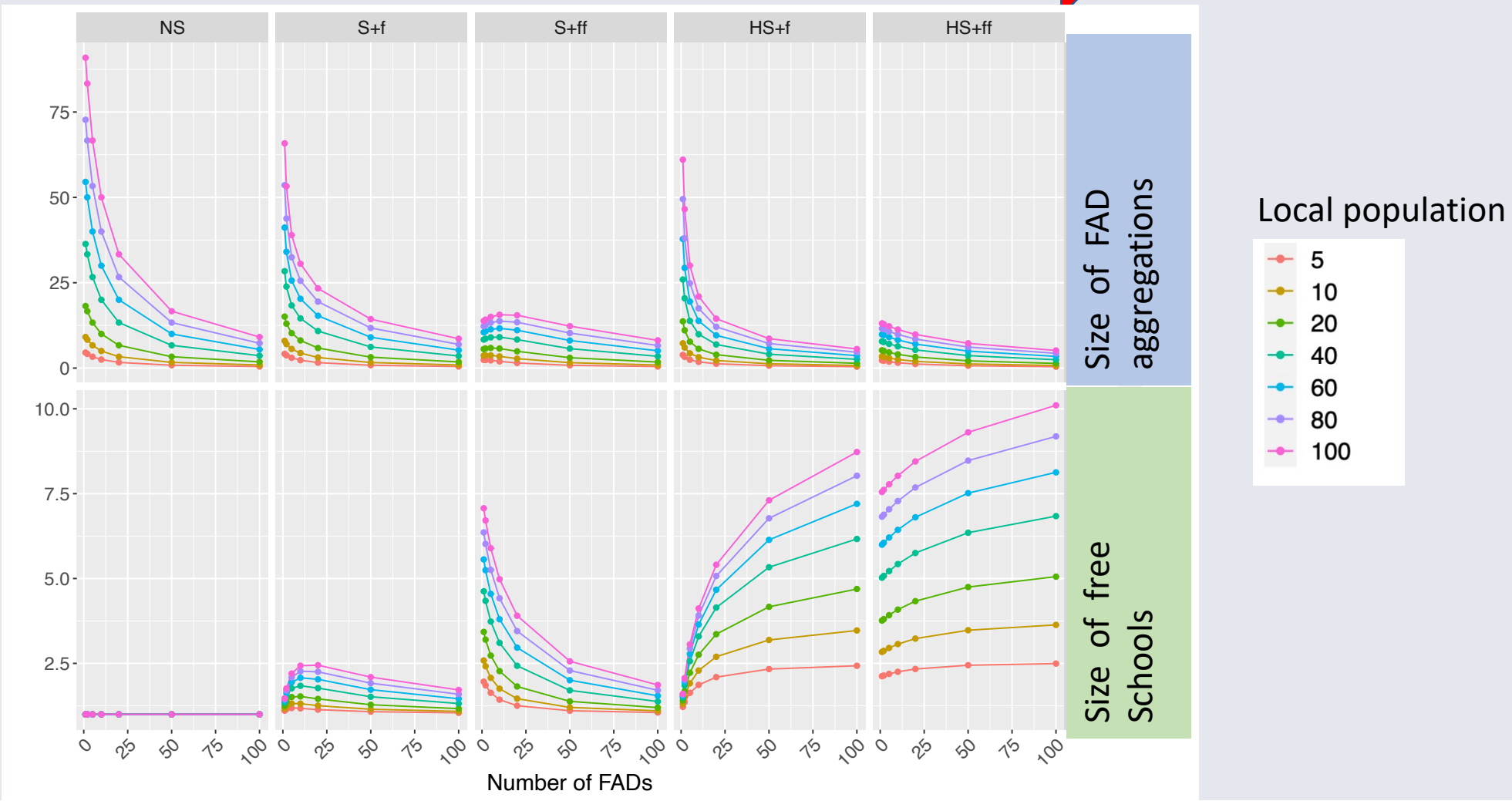
Affect tuna catchability at FOBs

Size of free schools
Number of free schools

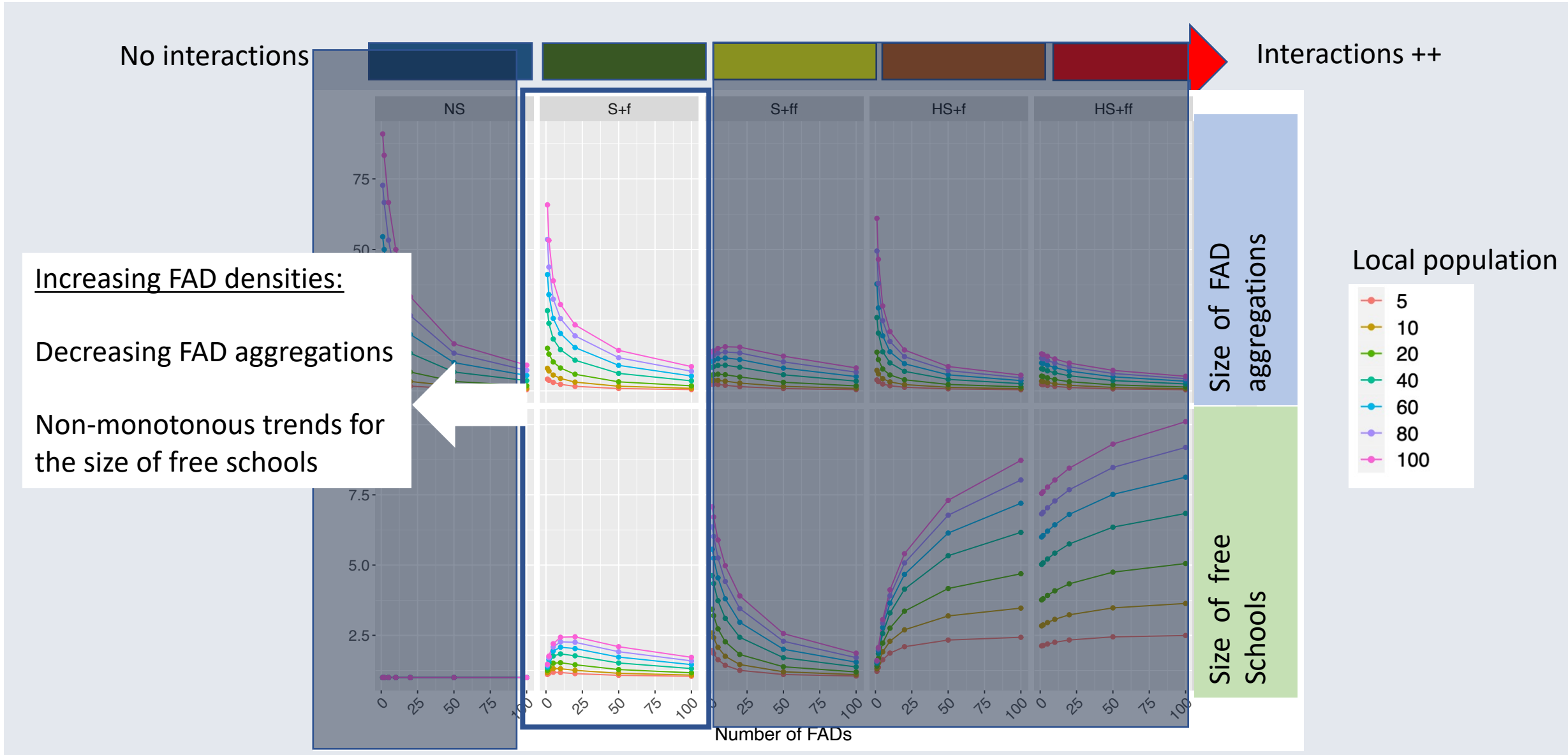
Trends for increasing FAD densities

No interactions

Interactions ++



Size of FAD aggregations and FS



Increasing FAD densities:

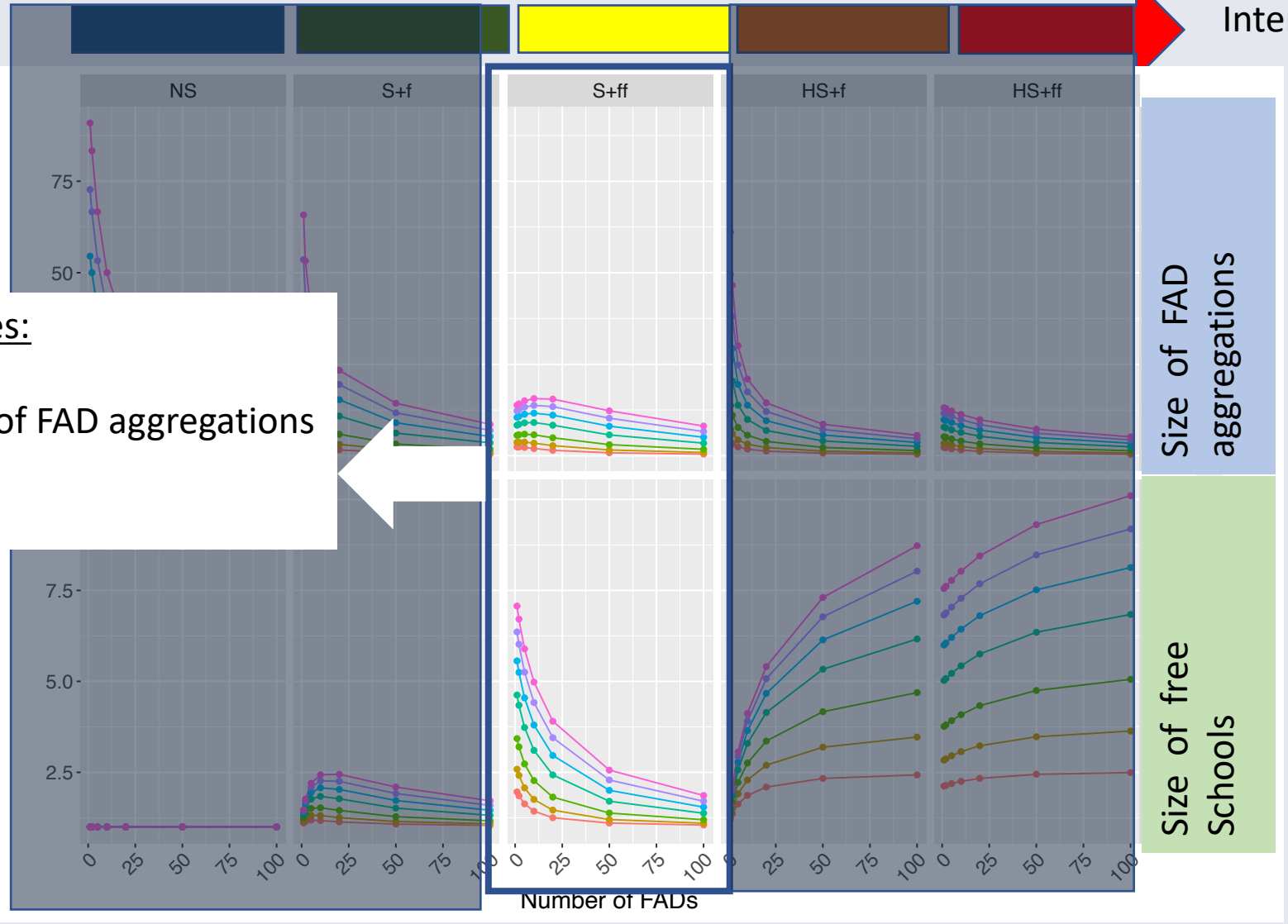
Decreasing FAD aggregations

Non-monotonous trends for the size of free schools

Size of FAD aggregations and FS

No interactions

Interactions ++



Local population

5
10
20
40
60
80
100

<u>Increasing FAD densities:</u>

Non-monotonous size of FAD aggregations

Smaller free schools

Conditioning the model

Next step: Fitting the model with the available field data

Catch-dependent data:
- Catch per set for FS and FADs

Catch-independent data:
- Tagging (Time spent by tuna associated/free)
- Echosounder buoys data (fraction of occupied FADs, lifetime of FAD aggregations, time spent by a FAD empty)

Environment:
- **Number of FOBs**

Model (**behavior**) → *Conditioning with available data*

SCENARIOS & DIAGNOSTICS

Tuna catchability trends vs number of FADs:
- Size of FAD aggregations & free school
- Fraction of occupied FADs & number of FS

Evaluate robustness of direct abundance indices (BAI/ABBI)

Adding a fishery component

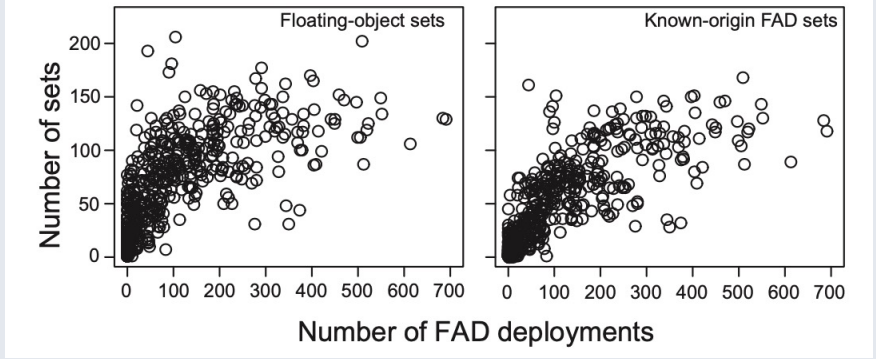
IOTC-2021-WGFAD02-06

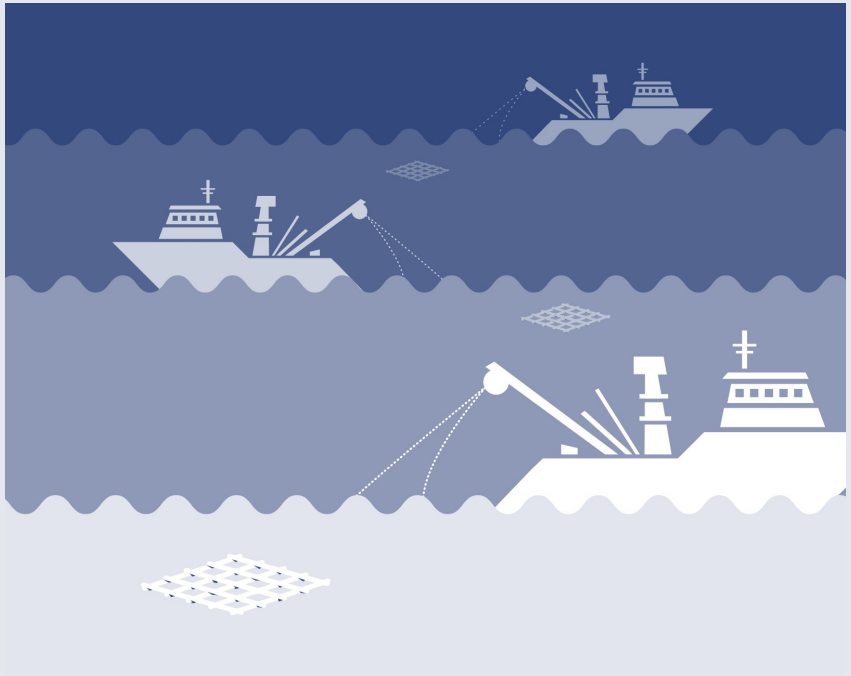
ICES Journal of Marine Science

ICES Journal of Marine Science (2018), doi:10.1093/icesjms/fsy046

Recent purse-seine FAD fishing strategies in the eastern Pacific Ocean: what is the appropriate number of FADs at sea?

Cleridy E. Lennert-Cody[1]*, Gala Moreno[2], Victor Restrepo[2], Marlon H. Román[1], and Mark N. Maunder[1]





Future studies: number of FOB sets vs number of FOBs (owned, not owned) located in proximity of the vessel to estimate catches vs **local** number of FOBs

Model (**behavior+fishery**)

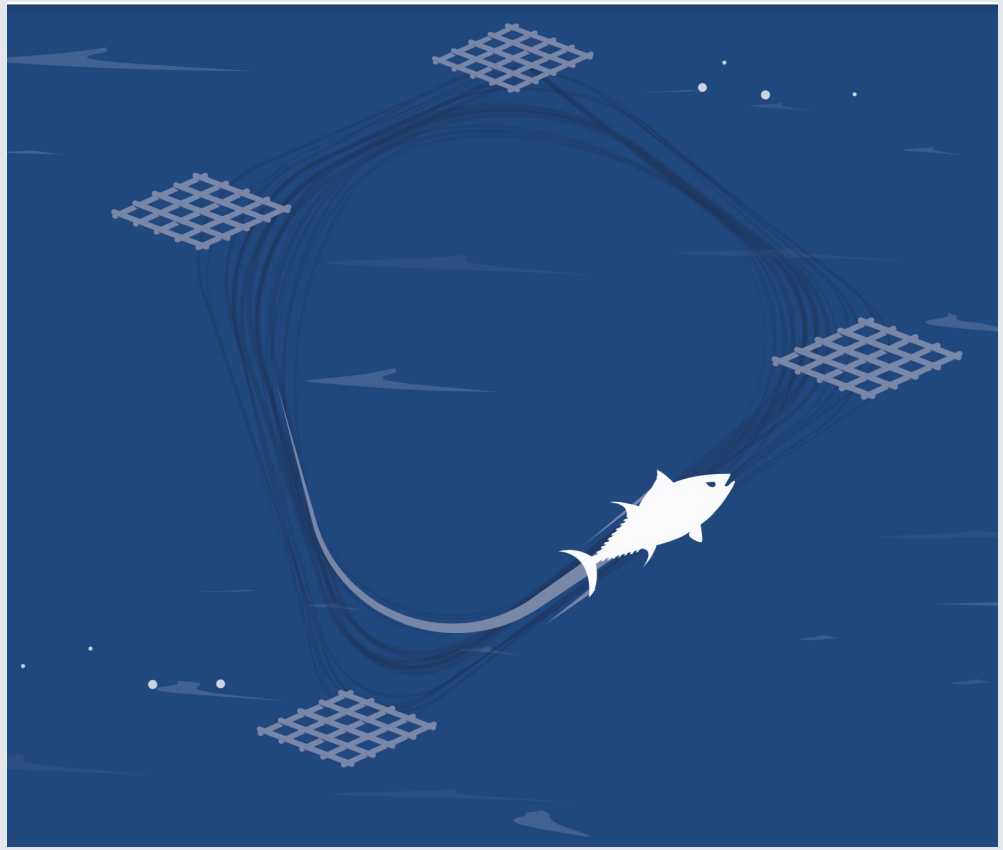
Conditioning with available data

SCENARIOS & DIAGNOSTICS

Tuna catches at FOBs vs number of FADs

Evaluate robustness of FAD CPUE abundance indices

Adding a physiological component



Model (**behavior + physiology**) → Data collection (in captivity + field data) →

SCENARIOS & DIAGNOSTICS

Tuna physiological condition vs changes in surface habitats induced by FADs (ecological trap)

Importance of buoys data for scientists

For building indicators:

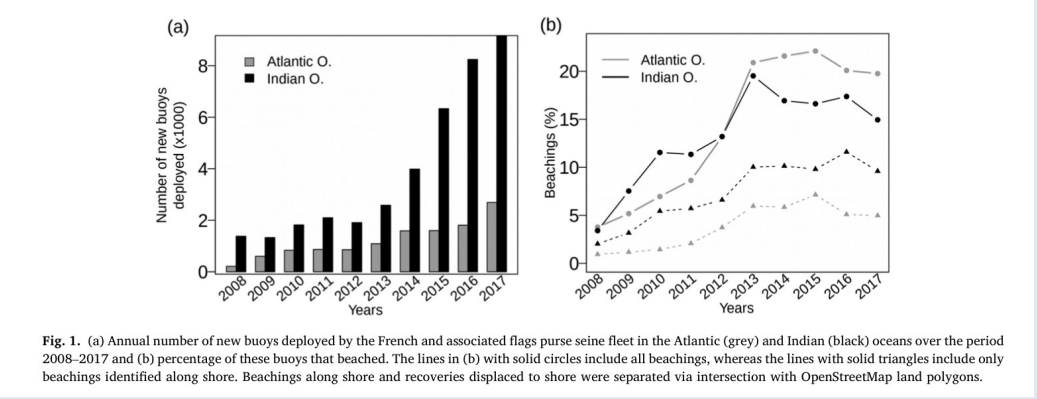
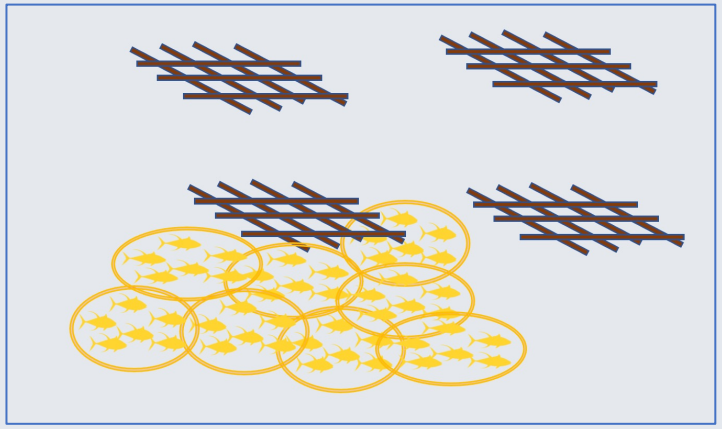
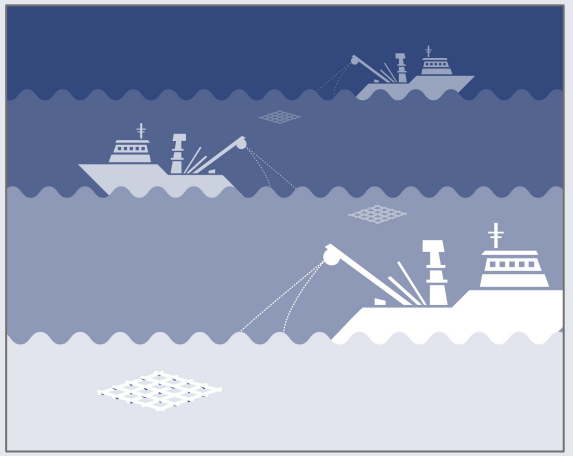


Fig. 1. (a) Annual number of new buoys deployed by the French and associated flags purse seine fleet in the Atlantic (grey) and Indian (black) oceans over the period 2008–2017 and (b) percentage of these buoys that beached. The lines in (b) with solid circles include all beachings, whereas the lines with solid triangles include only beachings identified along shore. Beachings along shore and recoveries displaced to shore were separated via intersection with OpenStreetMap land polygons.

For conditioning FAD operating models:





Local number of FADs is a key variable

Tuna and PS vessels interact <u>locally</u> with FADs,
need fine-scale data (in time and space) on all FOBs

Conclusions

Management objectives

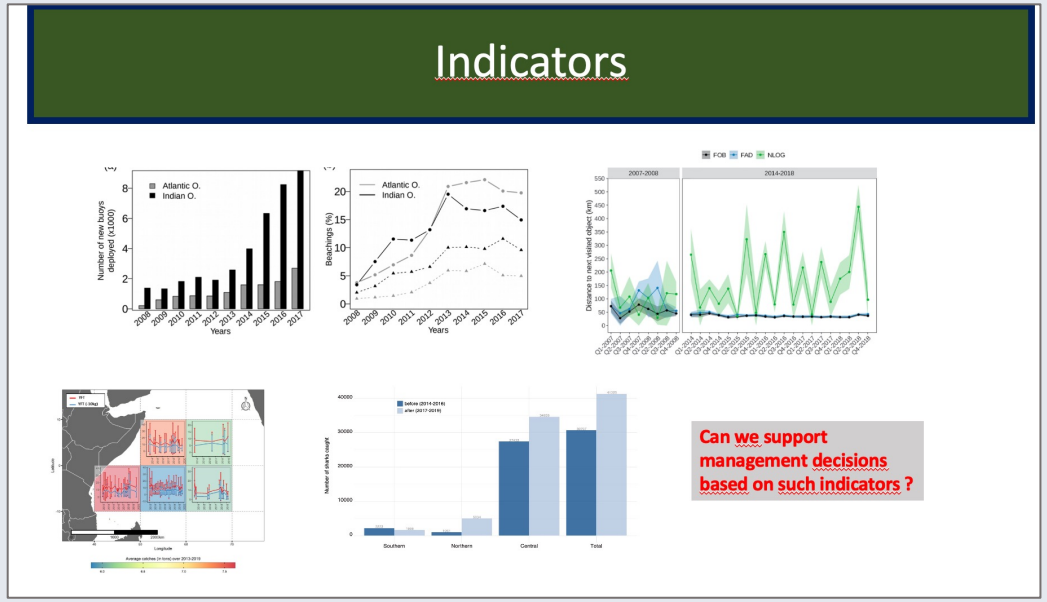
Indicators

OMs

Management options
+ Mitigation measures

Buoys data is key for building indicators and OMs

Indicators



Operating models

FOB trajectories
=> Reducing FAD beaching/loss (Imzilen et al. 2021)
=> Evaluate habitat changes (FADs compared to density of NLOGs) (Dupaix et al. 2021)

SS3 (or other stock-assessment models):
=> Impacts of increased catches of juvenile YFT on the stock

FAD association dynamics models :
=> Effects of FADs on tuna catchability // Catches of tuna