Moving towards quantitative ecological risk assessment for data-limited tuna fishery bycatch: application of "EASI-Fish" to the spinetail devil ray (*Mobula mobular*) in the eastern Pacific Ocean

Shane Griffiths, Nerea Lezama-Ochoa, and Marlon Román

9th Meeting of the Bycatch Working Group La Jolla, California USA, 11 May 2019
Document: BYC-09-01

Personal introduction

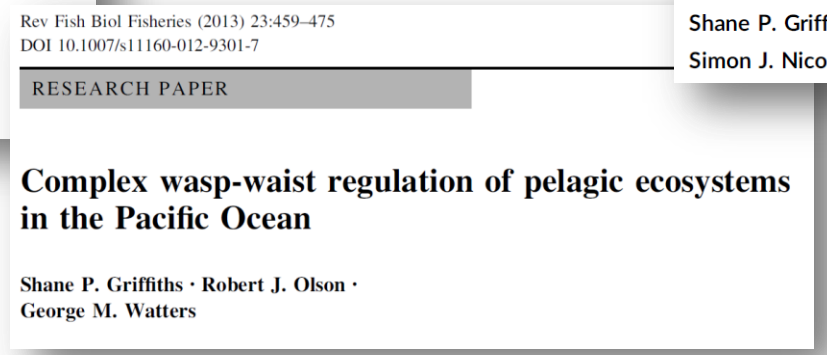
- Ecosystem Group Leader - IATTC, La Jolla (2016-current)
- Principal Scientist - CSIRO Marine Research, Australia (2002-2016)
- Fisheries biology and ecology of neritic tunas (e.g. *Thunnus tonggol*)
- Development of Ecological Risk Assessment methods (PSA, SAFE, EASI-Fish)
- Ecosystem modelling (Ecopath with Ecosim)


Rev Fish Biol Fisheries (2010) 20:239–272
DOI 10.1007/s11160-009-9157-7

RESEARCH PAPER

Ecological effects of longline fishing and climate change on the pelagic ecosystem off eastern Australia

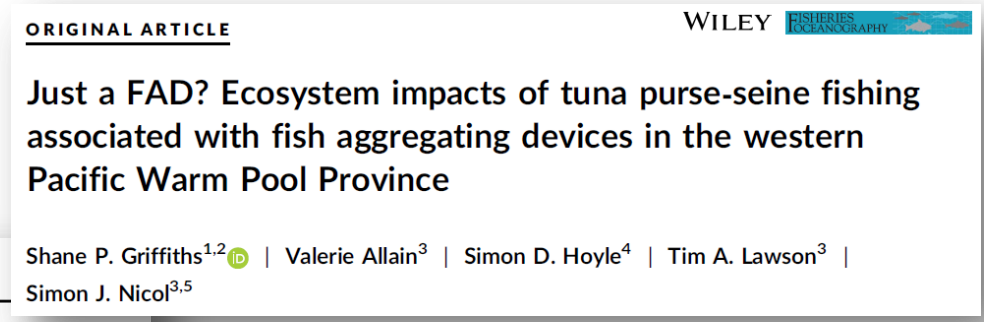
Shane P. Griffiths · Jock W. Young · Matt J. Lansdell · Robert A. Campbell · John Hampton · Simon D. Hoyle · Adam Langley · Donald Bromhead · Michael G. Hinton


Rev Fish Biol Fisheries (2013) 23:459–475
DOI 10.1007/s11160-012-9301-7

RESEARCH PAPER

Complex wasp-waist regulation of pelagic ecosystems in the Pacific Ocean

Shane P. Griffiths · Robert J. Olson · George M. Watters


ORIGINAL ARTICLE

WILEY FISHERIES OCEANOGRAPHY

Just a FAD? Ecosystem impacts of tuna purse-seine fishing associated with fish aggregating devices in the western Pacific Warm Pool Province

Shane P. Griffiths[1,2] | Valerie Allain[3] | Simon D. Hoyle[4] | Tim A. Lawson[3] | Simon J. Nicol[3,5]

Outline

- Inter-American Tropical Tuna Commission (IATTC) responsibilities
- Ecological reporting by the IATTC – indicators, ERA, ecosystem models
- A brief overview of “EASI-Fish” - identifying vulnerable species in EPO
- Using EASI-Fish to explore conservation measures to reduce vulnerability of *Mobula mobular*

Ecological sustainability

- IATTC committed to ensuring ecologically sustainability of its fisheries
  - Antigua Convention, specific IATTC Resolutions (e.g. sharks, rays, turtles, dolphins) (SAC-10 INF-B)

To ensure the "*long-term conservation and sustainable use of the stocks of tunas and tuna-like species and other associated species of fish taken by vessels fishing for tunas and tuna-like species in the eastern Pacific Ocean (EPO)*"

Article IV. "*Where the status of target stocks or non-target or associated or dependent species is of concern, the members of the Commission shall subject such stocks and species to enhanced monitoring in order to review their status and the efficacy of conservation and management measures.*"

Article VII. "…*adopt, as necessary, conservation and management measures and recommendations for species belonging to the same ecosystem and that are affected by fishing for, or dependent on or associated with, the fish stocks covered by this Convention, with a view to maintaining or restoring populations of such species above levels at which their reproduction may become seriously threatened*"

Ecosystem reporting by the IATTC

- Annual "*Ecosystems Considerations*" report (SAC and FSR report)
  - Mortalities and interactions of TEPs by species (e.g. turtles, marine mammals)
  - Estimated total catches of key bycatch species (e.g. sharks, wahoo)

TABLE 1. Incidental mortality of dolphins and other marine mammals caused by the purse-seine fishery in the EPO, 2018.

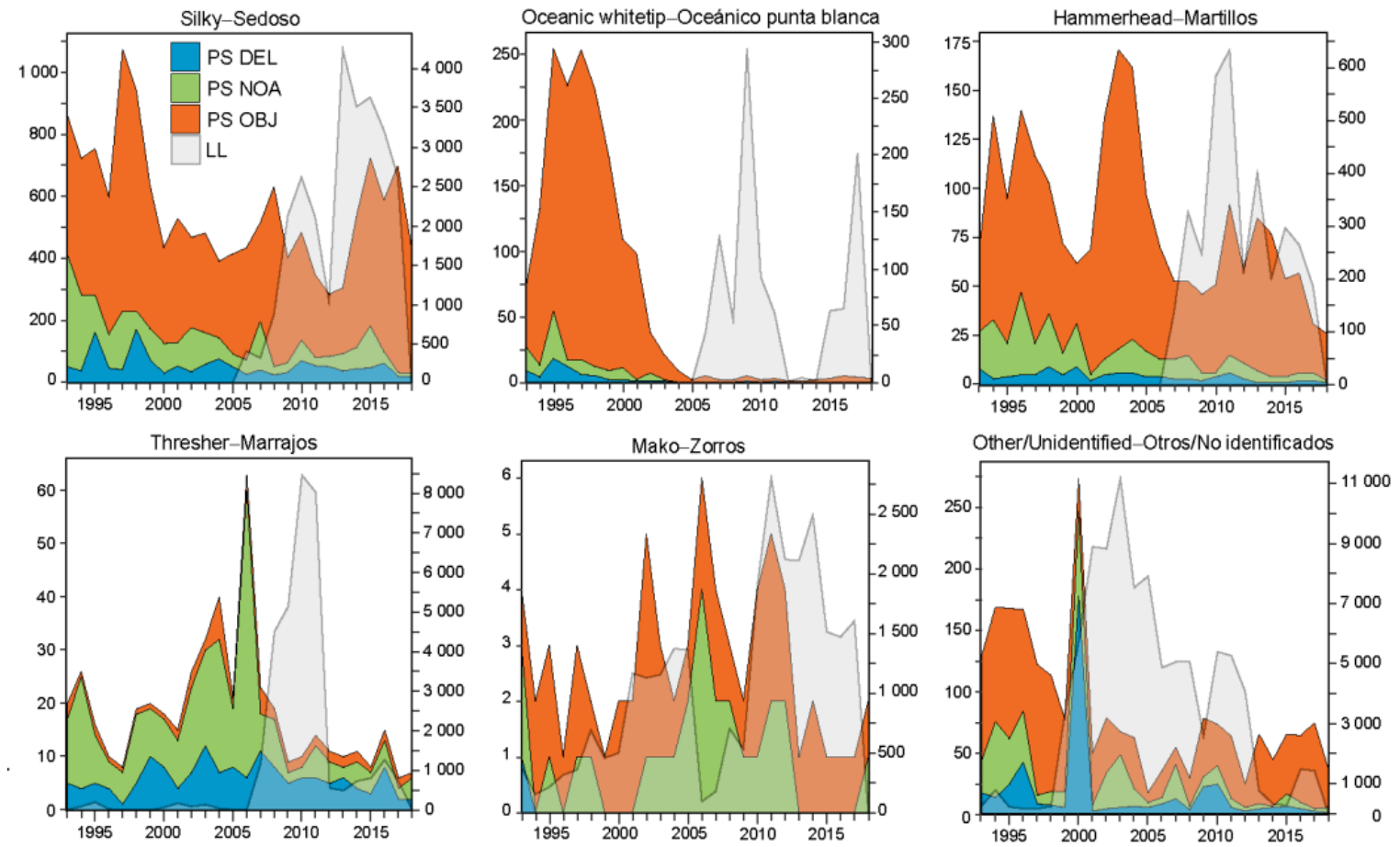
	Incidental mortality	
Species and stock	Numbers	t
Offshore spotted dolphin		
Northeastern	99	6.5
Western-southern	197	12.9
Spinner dolphin		
Eastern	252	11.2
Whitebelly	205	12.4
Common dolphin		
Northern	41	2.9
Central	1	0.1
Southern	18	1.3
Other mammals*	6	0.4
Total	**819**	**47.5**

TABLE 3. Preliminary catches, in tons, of sharks and rays in the EPO by large purse-seine vessels, by set type, 2018, and by longline vessels, 2017. *Longline sample data should be considered minimum catch estimates due to incomplete data reporting (see section 2.1)

	Purse seine				Long-line*
Species	OBJ	NOA	DEL	Total	
Silky shark (*Carcharhinus falciformis)*	400	11	20	431	2,626
Oceanic whitetip shark (*C. longimanus)*	3	-	<1	3	202
Hammerhead sharks (*Sphyrna* spp.)	24	<1	<1	26	186
Thresher sharks (*Alopias* spp.)	<1	4	2	7	724
Mako sharks (*Isurus* spp.)	1	<1	<1	2	1,606
Other sharks	31	4	1	36	1,430
Blue sharks (*Prionace glauca*)	-	-	-	-	6,908
Manta rays (Mobulidae)	16	20	13	49	-
Pelagic sting rays (Dasyatidae)	<1	<1	<1	1	-

Improved *Ecosystem Considerations* report

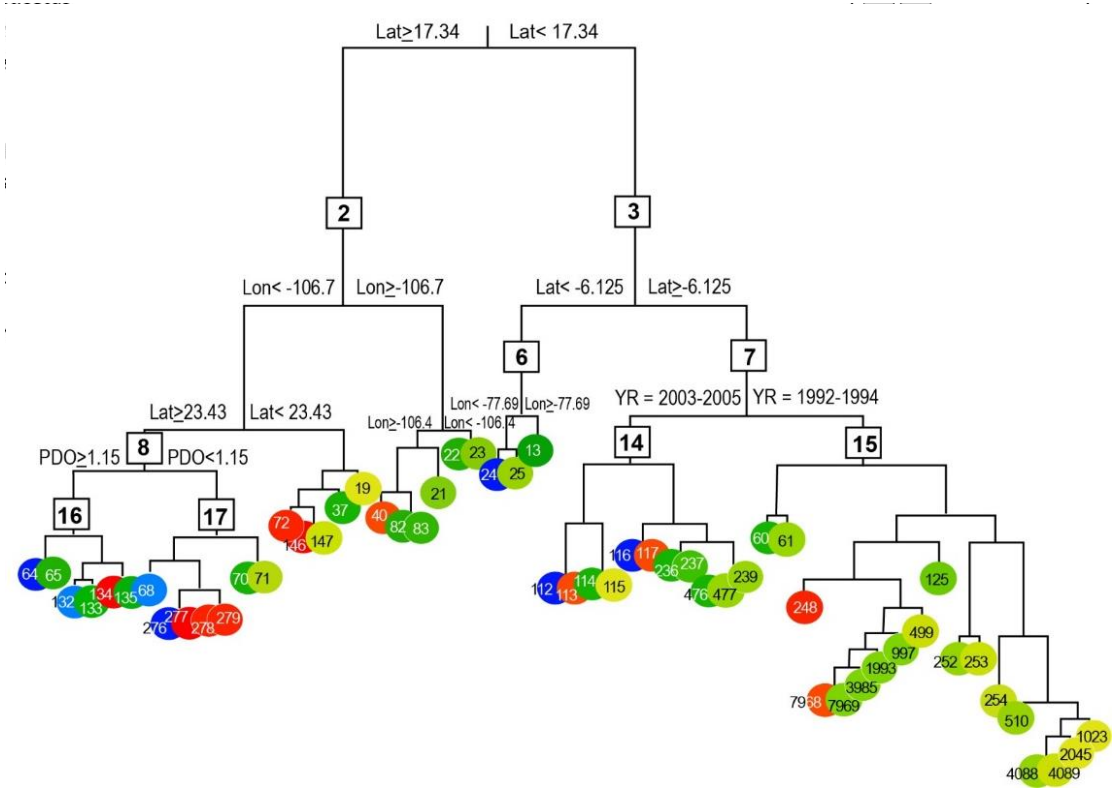
- Since 2017, *Ecosystem Considerations* report improved (SAC-10-14)
  - Catch trends by gear type from 1993 to provide context, including longline



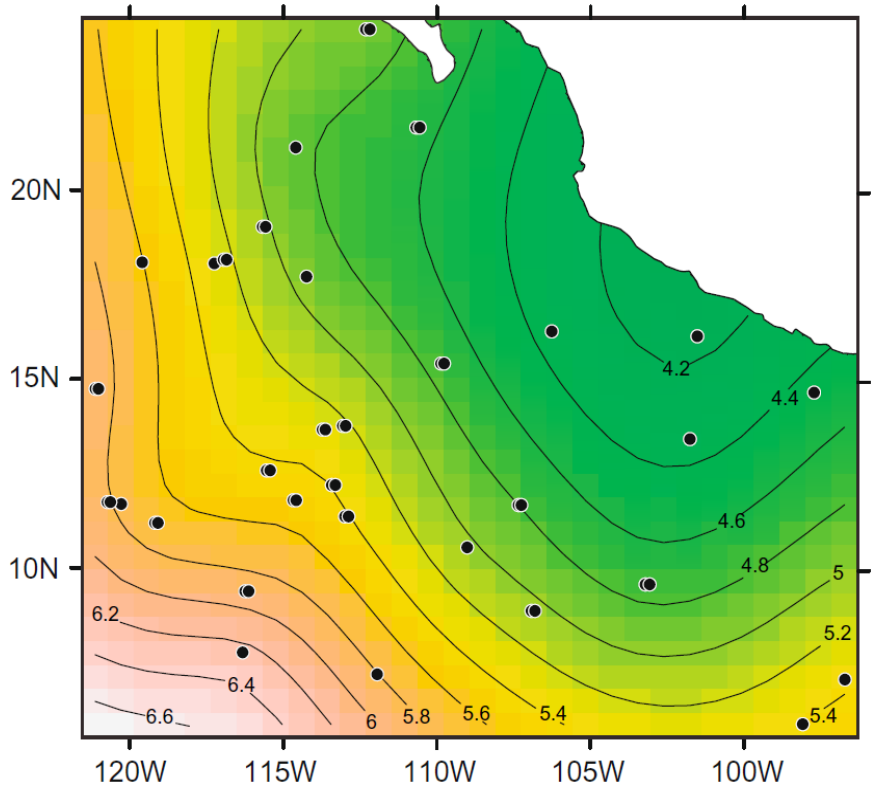
Improved *Ecosystem Considerations* report

- Trophic ecology research & proposed experimental work (SAC 10 INF-E)

Stomach content analysis

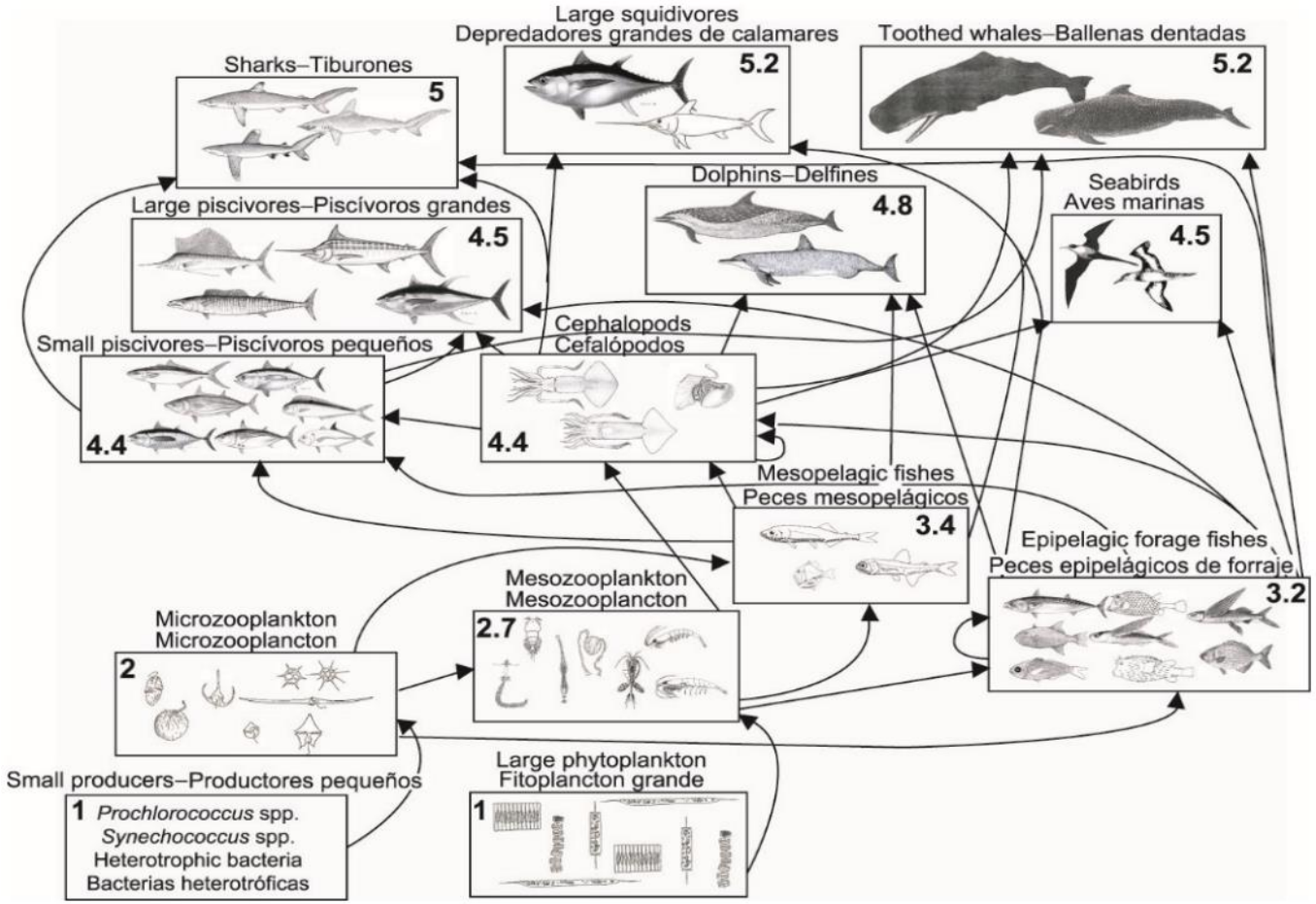


Stable isotope analysis



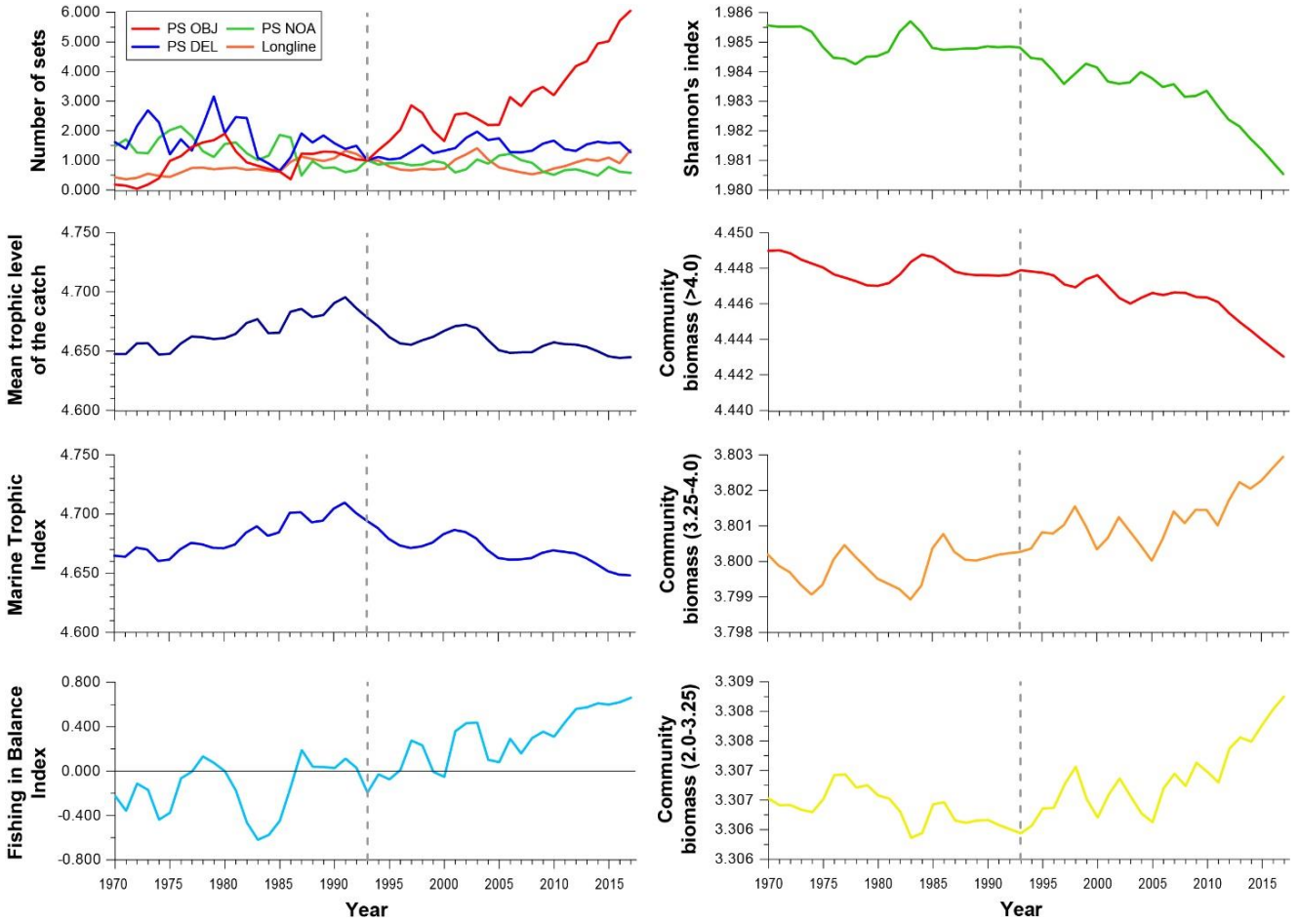
Improved *Ecosystem Considerations* report

- Trophic ecology research & proposed experimental work (SAC 10 INF-E)
- Allowed the development of an ETP ecosystem model



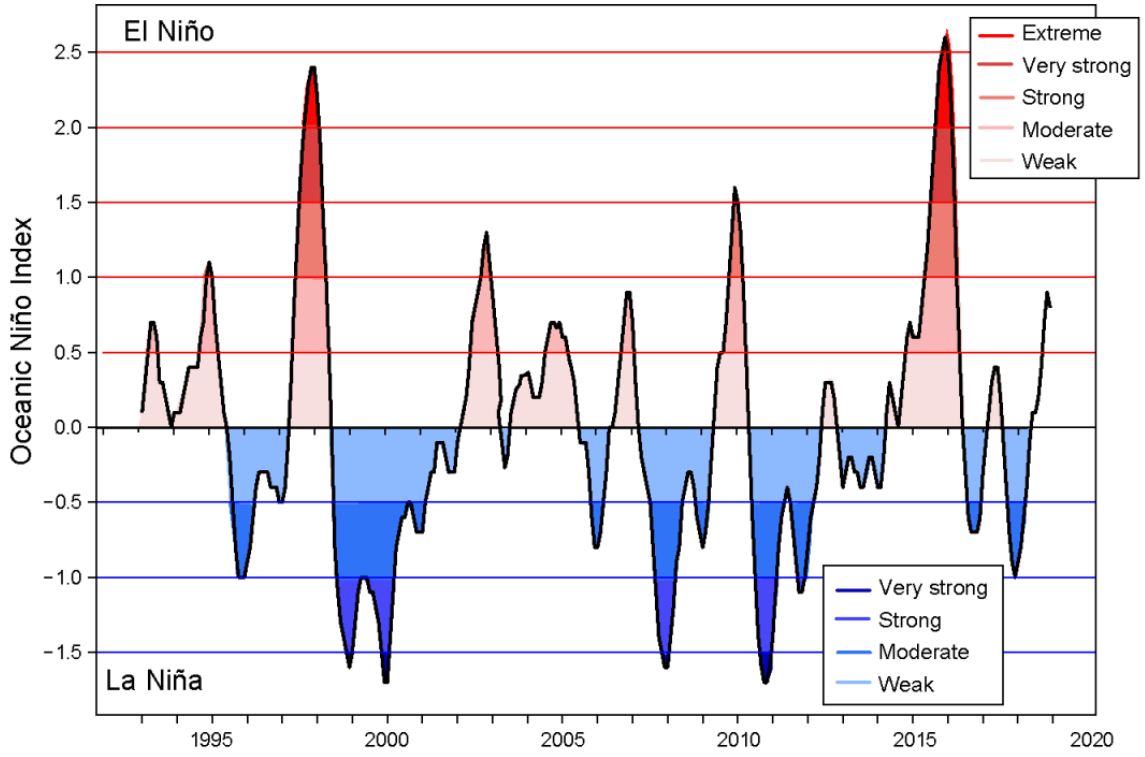
Improved *Ecosystem Considerations* report

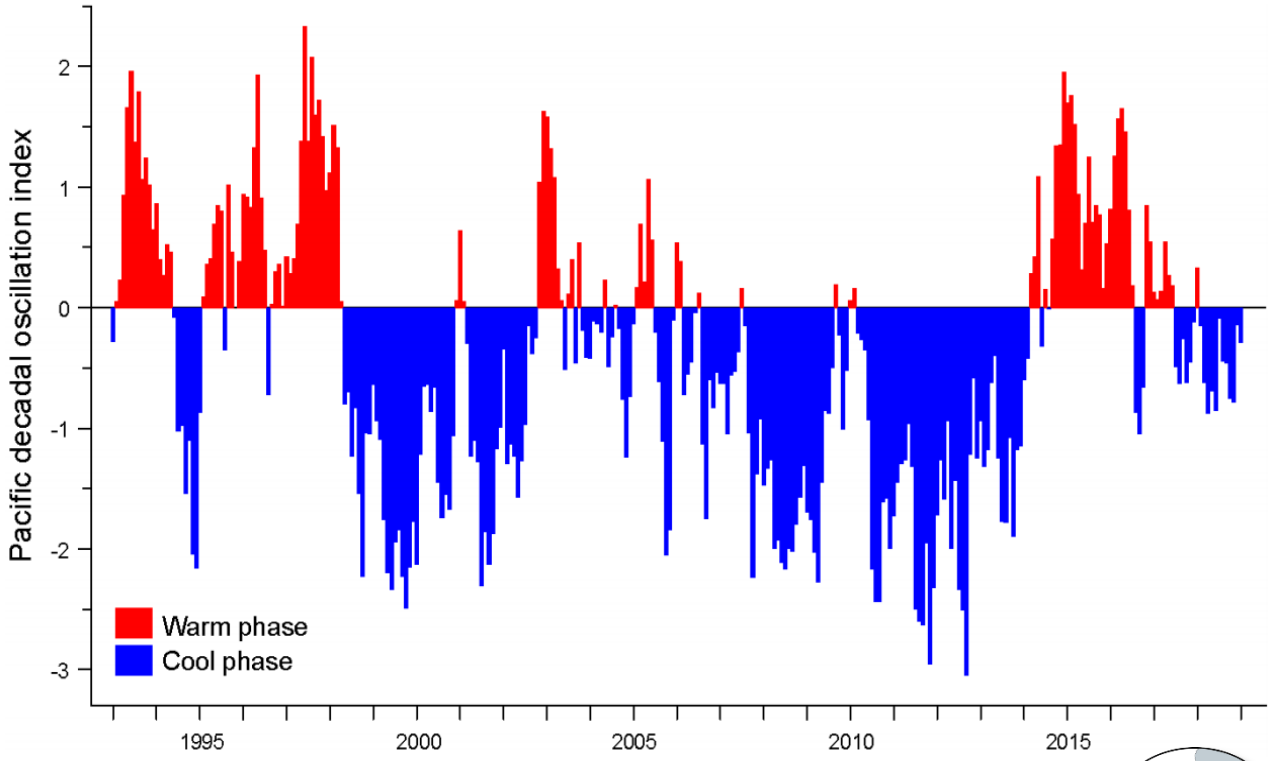
- Ecosystem model updated annually to produce ecological indicators
- Model ‘what if’ scenarios of fishery impacts (e.g. FADs) (SAC-10-15)



Improved *Ecosystem Considerations* report

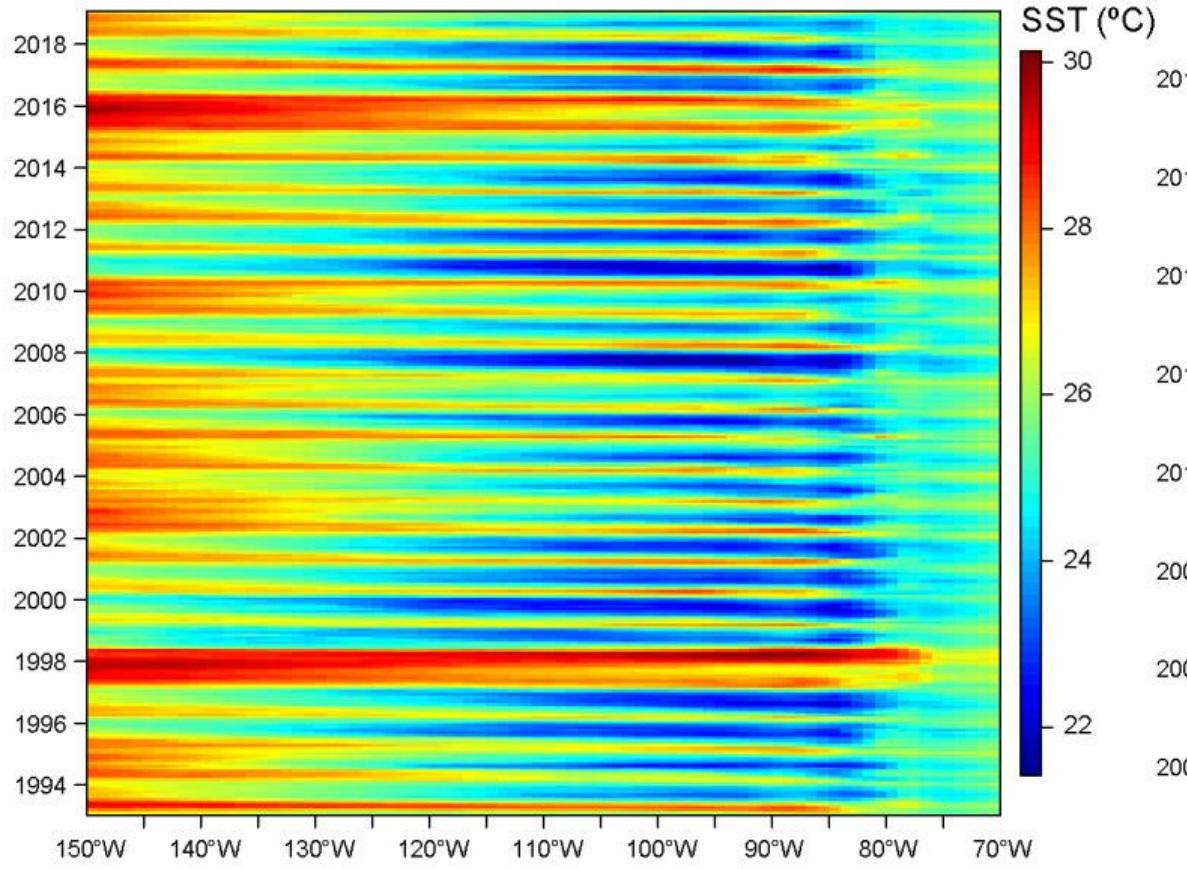
- Physical environment indicators now reported - Oceanic Niño Index (ONI) & Pacific Decadal Oscillation index (PDO)

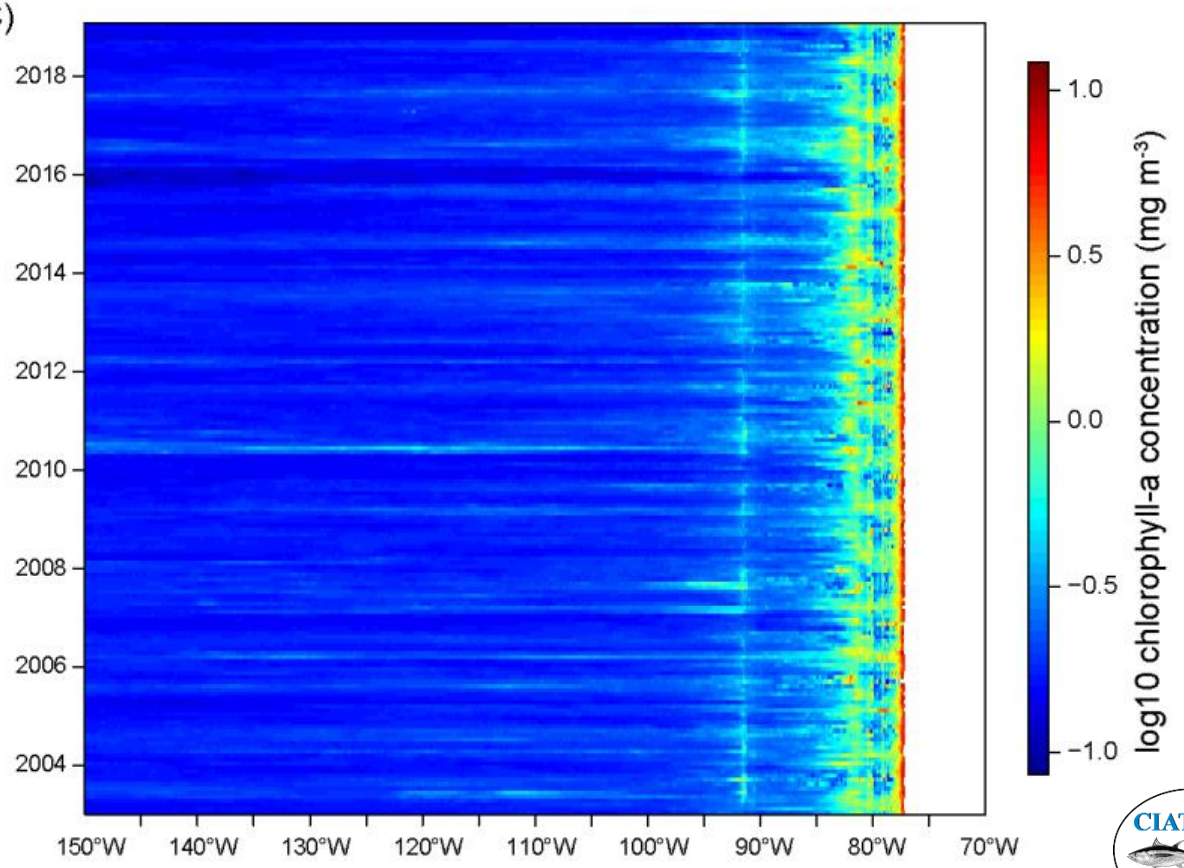




Improved *Ecosystem Considerations* report

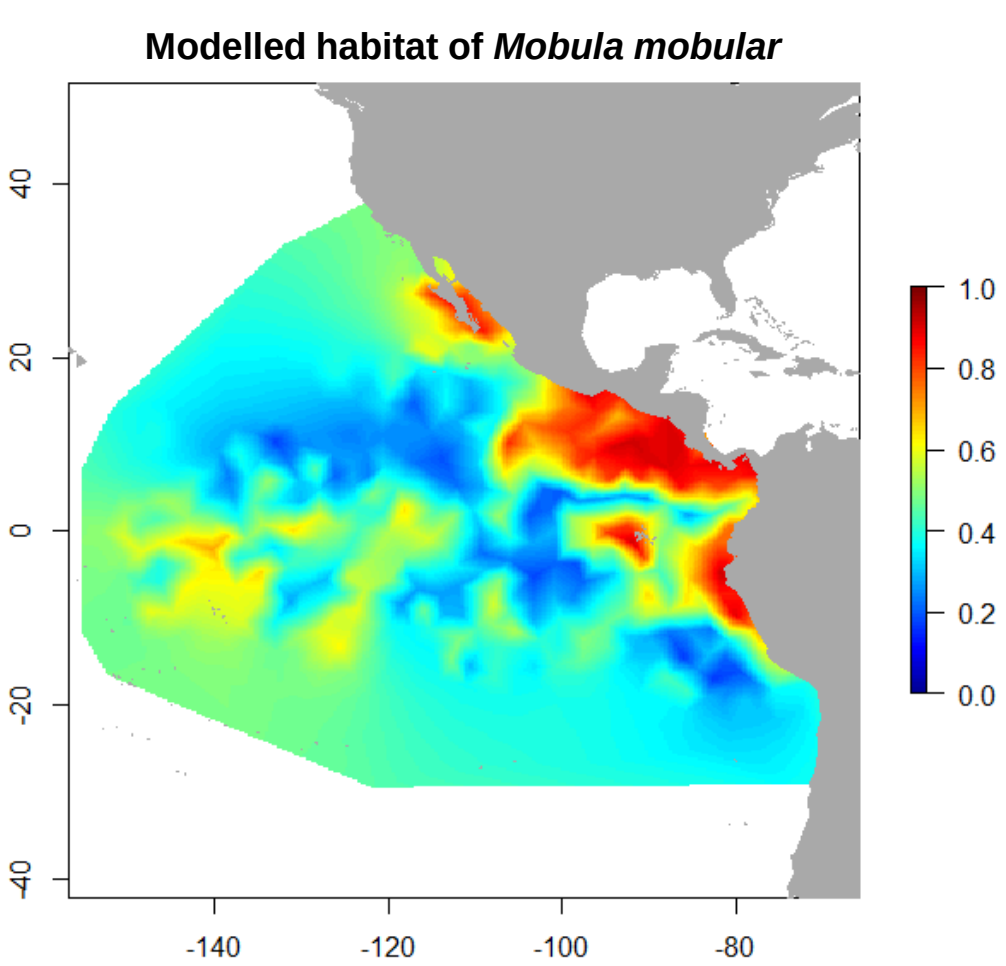
- Spatio-temporal analysis of monthly SST and Chl-a using Hovmöller diagrams

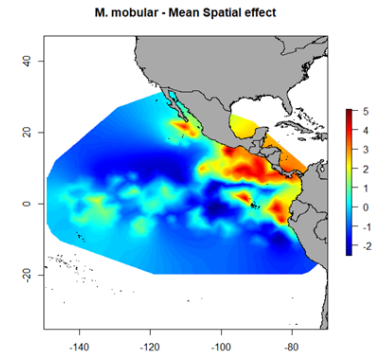


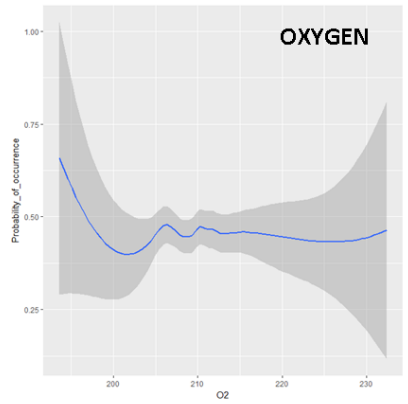


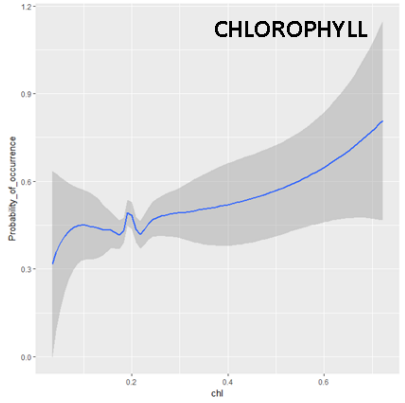
Improved *Ecosystem Considerations* report

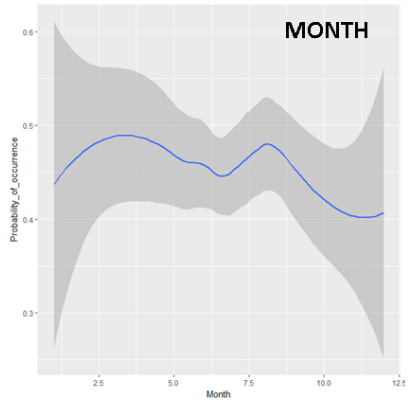
- Spatio-temporal analysis of monthly SST and Chl-a using Hovmöller diagrams
- Better understand environmental impacts on species habitats and catches

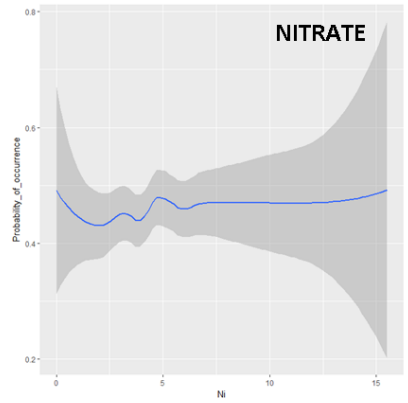


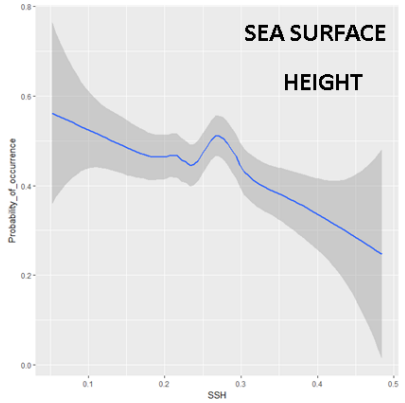








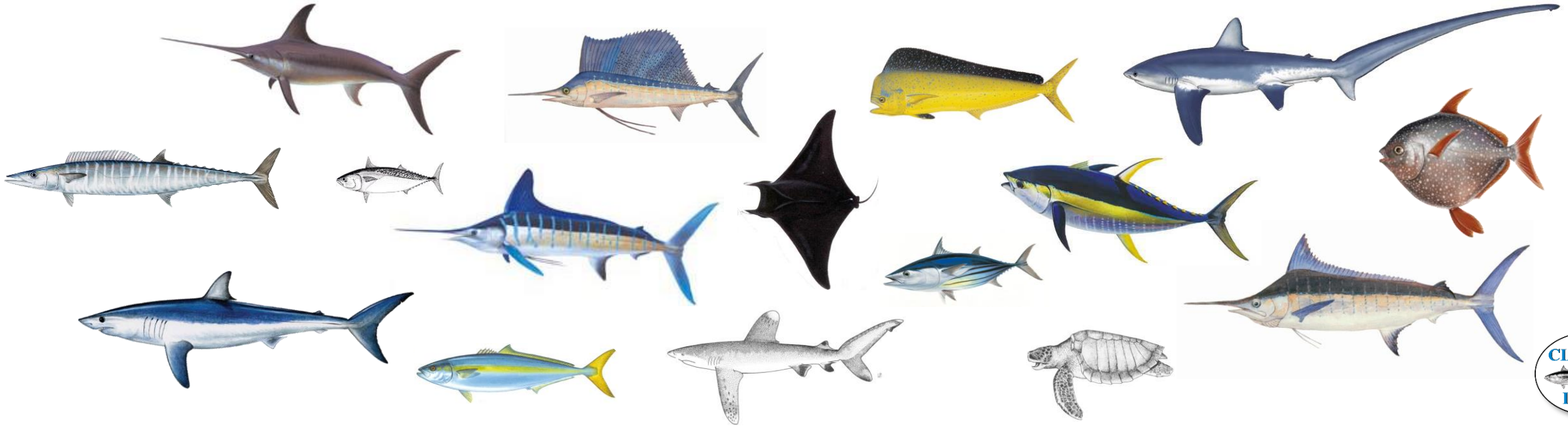




Lezama-Ochoa et al. (*in review*)

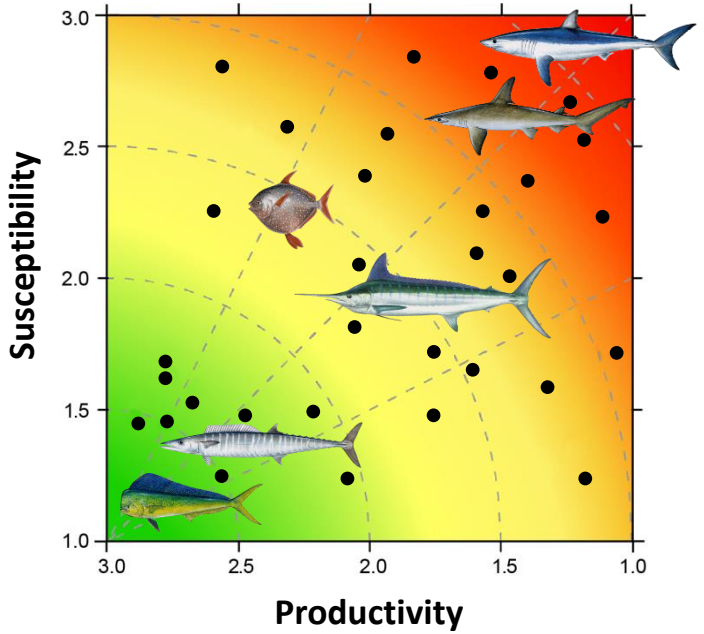
Ecological sustainability

- Monitoring common species, environmental indices, and modelling indicators allow us to see trends, but are populations sustainable?
- Many species interactions in EPO fisheries - “bycatch” & “byproduct”
- Some caught infrequently, little value, poor reporting (e.g. “Mobulids”)
- Lack basic biological and ecological data for traditional assessment



Ecological Risk Assessment (ERA)

- ERA is used in data-limited settings to prioritize species most vulnerable to fishing impacts
  - Implement immediate mitigation measures to reduce risk
  - Further data collection and research for future conventional assessment
- Qualitative (‘expert opinion’) to quantitative methods (stock assessment)
- Productivity-Susceptibility Analysis (PSA) most widely used
  - Widely used (e.g. WCPFC, IOTC, ICCAT, IATTC)
  - Preferred method by MSC for fishery certification



Need for improved ERA methods

- PSA produces only a relative measure of vulnerability
- Arbitrary threshold value defining “at risk” has no biological meaning
- Cannot assess the cumulative impacts of multiple fisheries
- Managers need a quantitative method to reliably identify vulnerable species and populations
- Rapid, inexpensive, and repeatable, especially in data-limited settings
- Spatially explicit for moving fishing effort, specify existing closures, but also to explore ‘what if’ scenarios as mitigation measures.

EASI-Fish

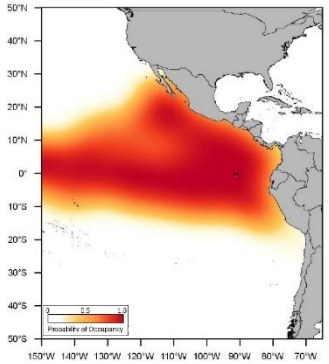
Ecological **A**ssessment of the **S**ustainable **I**mpacts by **F**isheries

EASI-Fish

- Similar PSA “Productivity” and “Susceptibility” components
- **Susceptibility** component estimates the proportion of the population that is potentially impacted by fishery *x* to estimate fishing mortality (*F*)
- **Productivity** component is a length-based per-recruit model
- **Vulnerability status** determined by traditional biological reference points
- Designed to be user-friendly and flexible for data-poor fisheries

EASI-Fish – an overview

Susceptibility - “Volumetric overlap”



EASI-Fish – an overview

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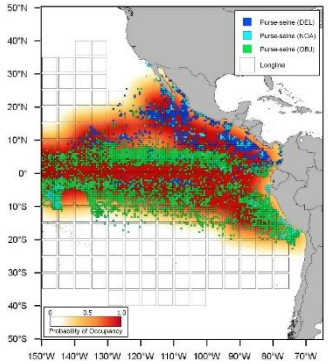

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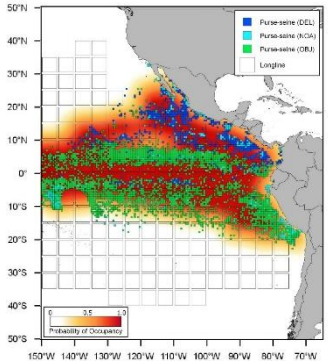

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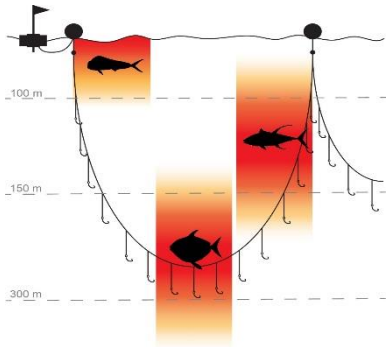

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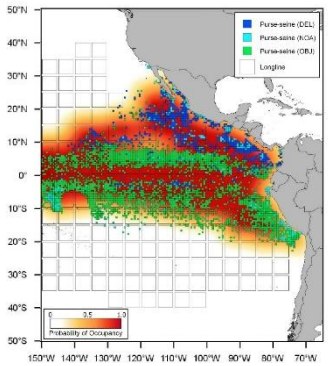

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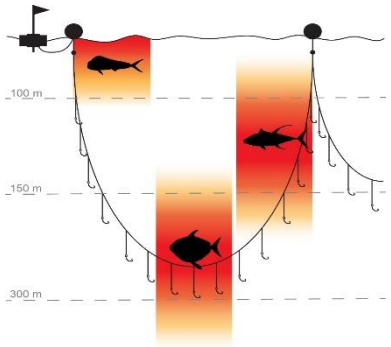

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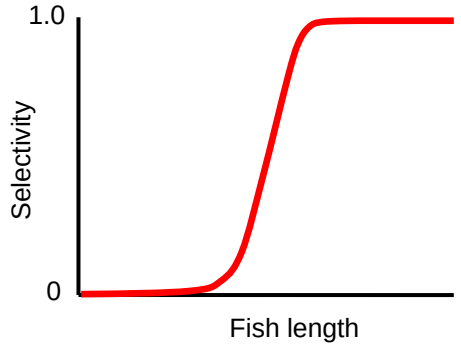

EASI-Fish – an overview

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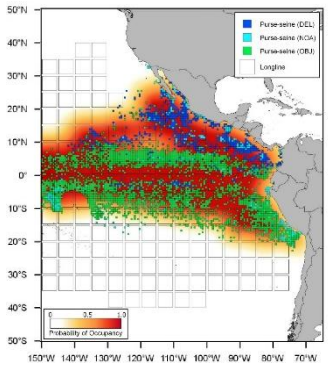

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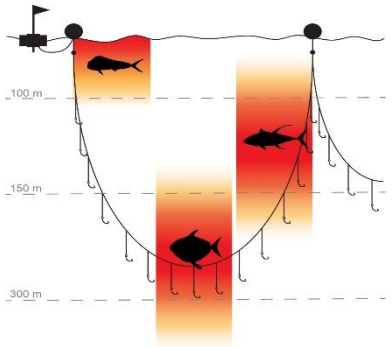

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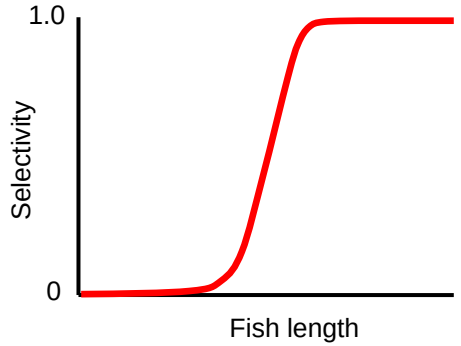

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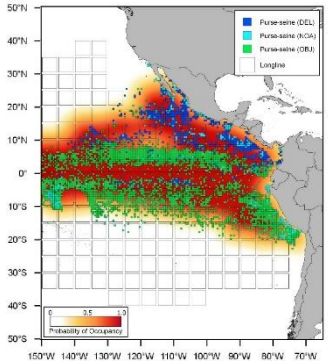
Post-Release Mortality

EASI-Fish – an overview

Susceptibility - “Volumetric overlap”



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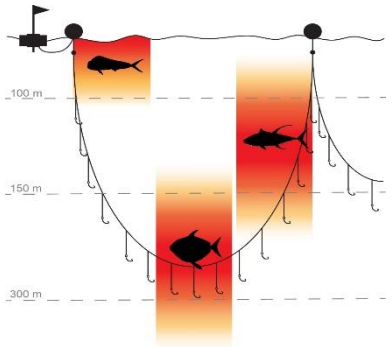

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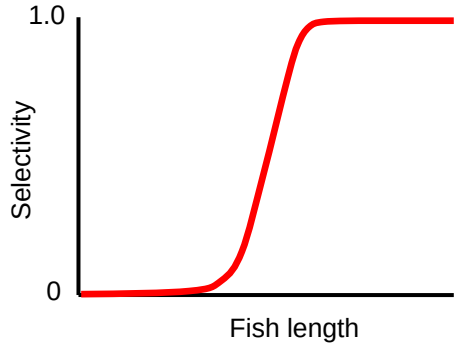
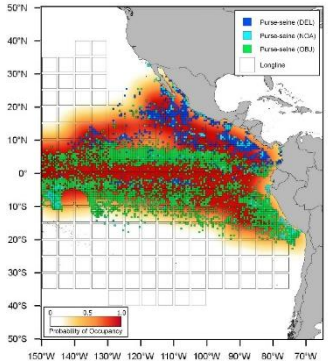


+ Post-Release Mortality = Fishing Mortality (***F***)

EASI-Fish – an overview

Susceptibility - “Volumetric overlap”



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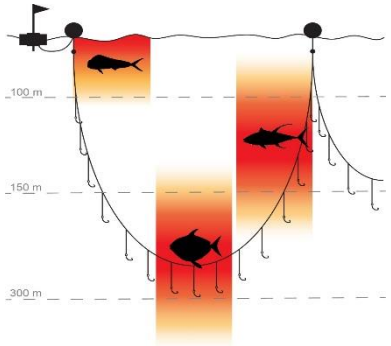

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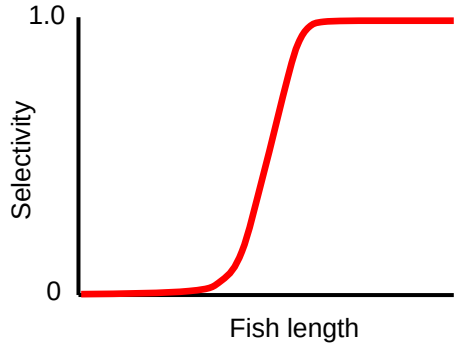

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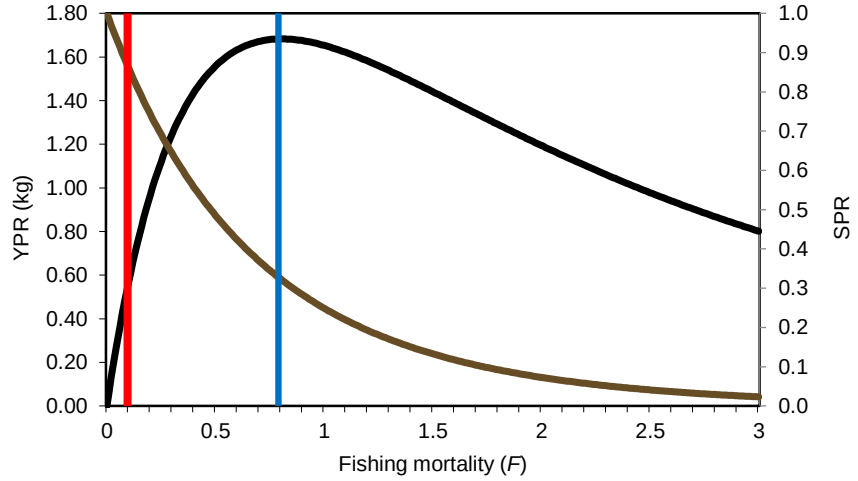
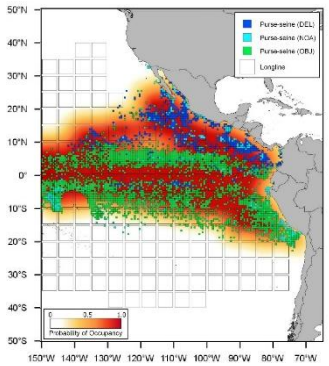
Productivity - YPR



EASI-Fish – an overview

Susceptibility - “Volumetric overlap”



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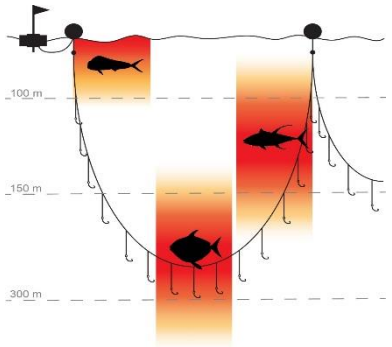

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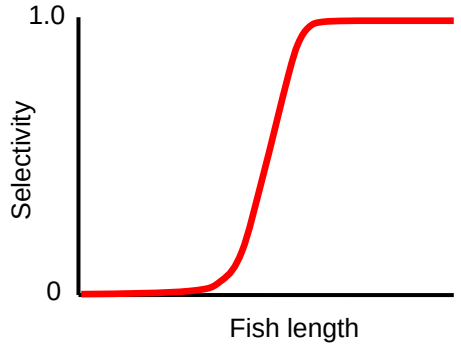

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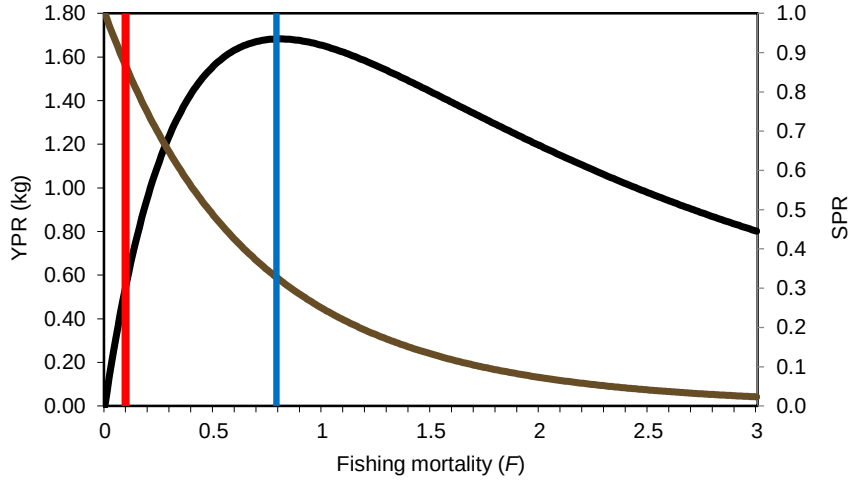
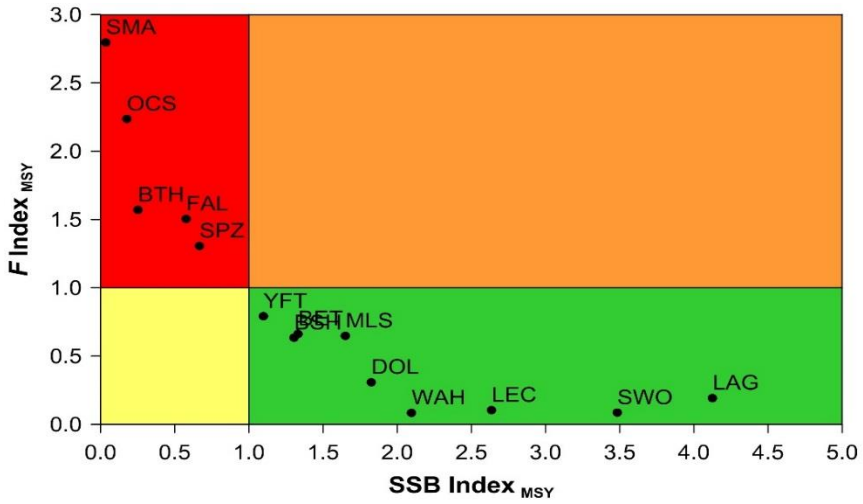


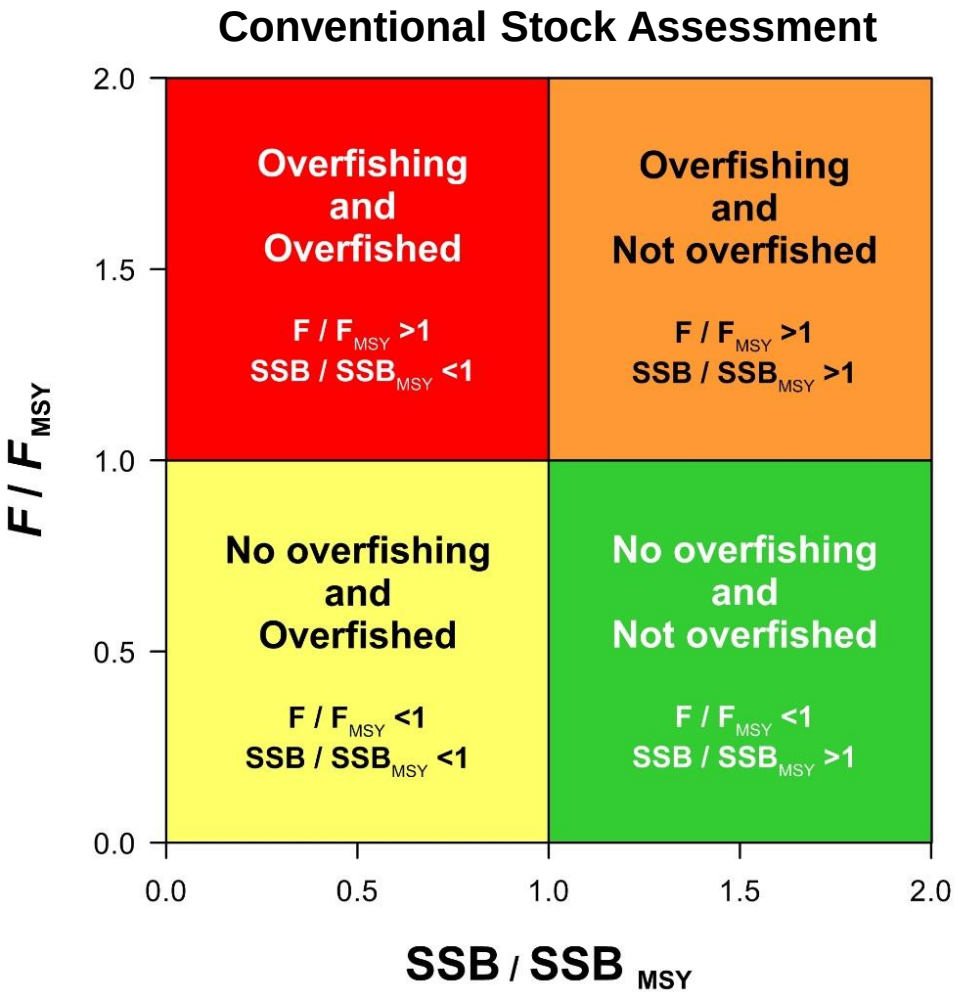
BRP values

Vulnerability status



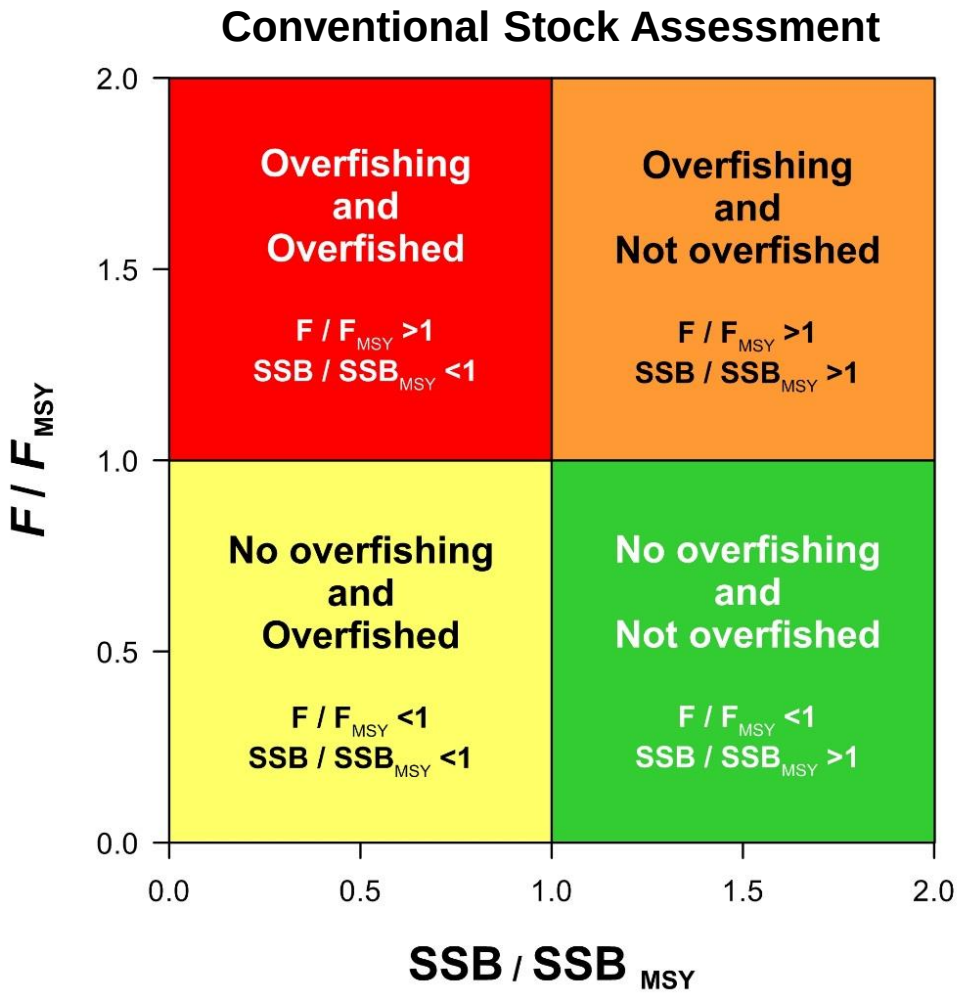
Defining vulnerability status

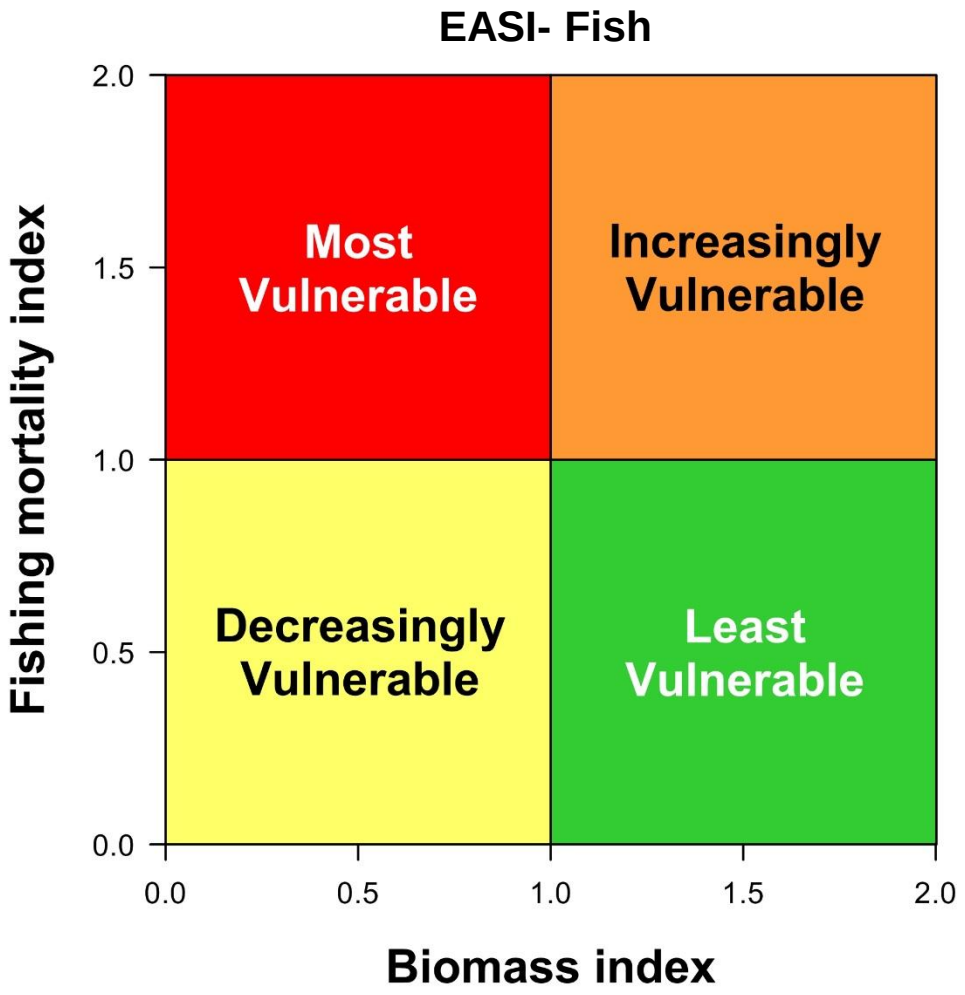
- In stock assessment BRPs define stock status (e.g. F/F_{MSY})



Defining vulnerability status

- Similar reference points can define <u>vulnerability</u>

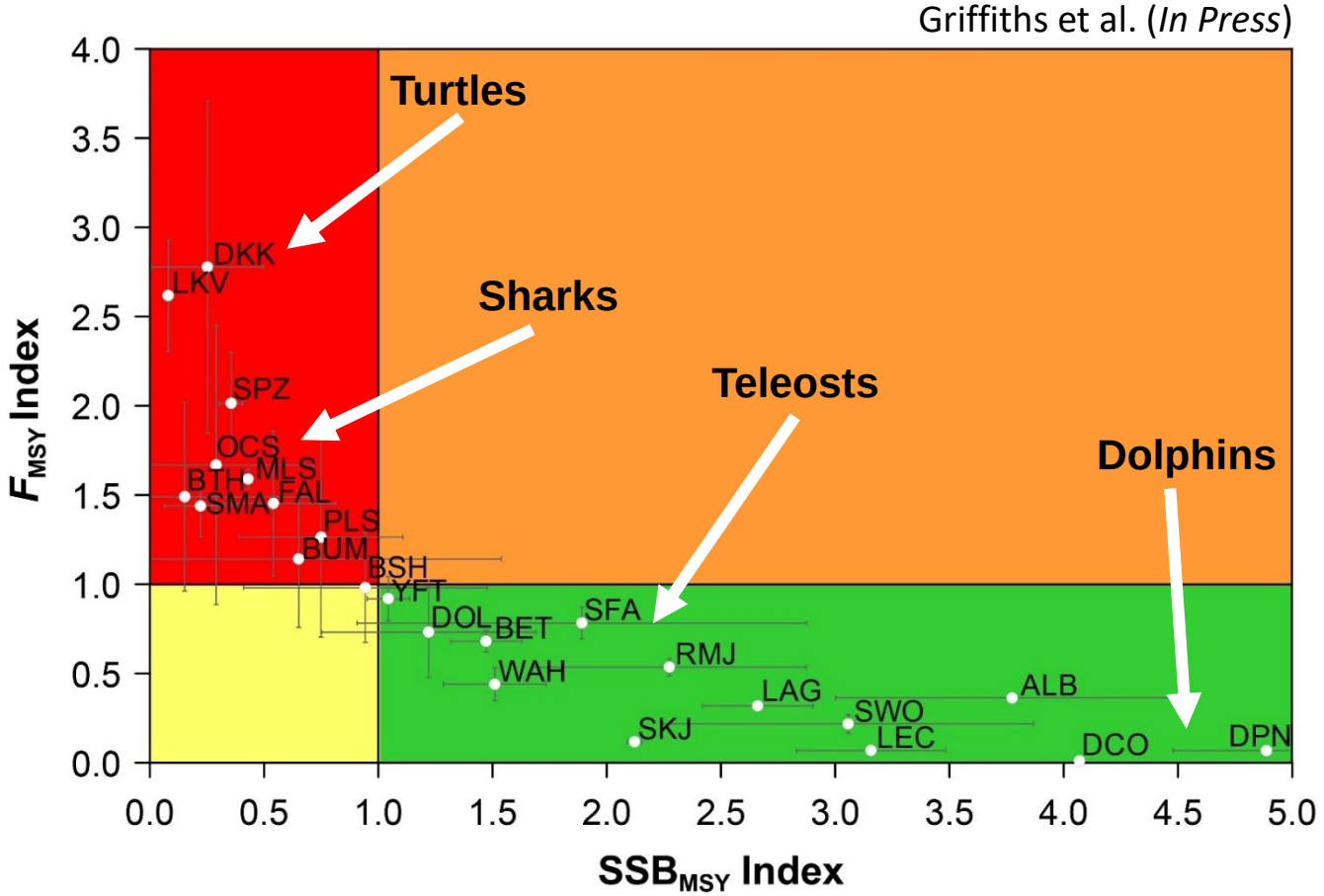




EPO ‘proof of concept’ assessment

- Four fisheries included in a ‘proof of concept’ assessment for 2016
  - Large scale tuna ‘industrial’ longline and purse-seine (NOA, DEL, OBJ) fisheries
- 24 representative species
  - 6 target teleosts
  - 6 non-target teleosts
  - 6 sharks
  - 2 rays
  - 2 dolphins
  - 2 sea turtles

Griffiths et al. (*In Press*)

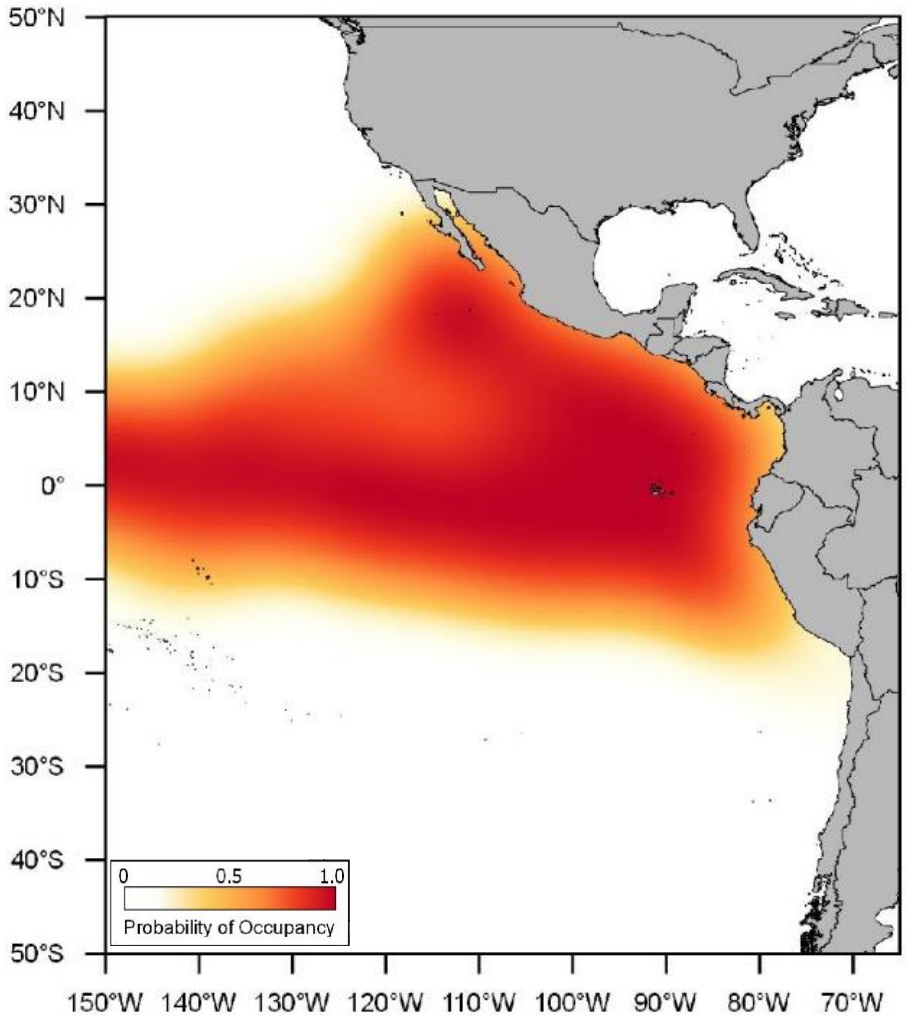


Case study

Application of “EASI-Fish” to explore measures to reduce the vulnerability status of the Spinetail devil ray (*Mobula mobular*) in the EPO

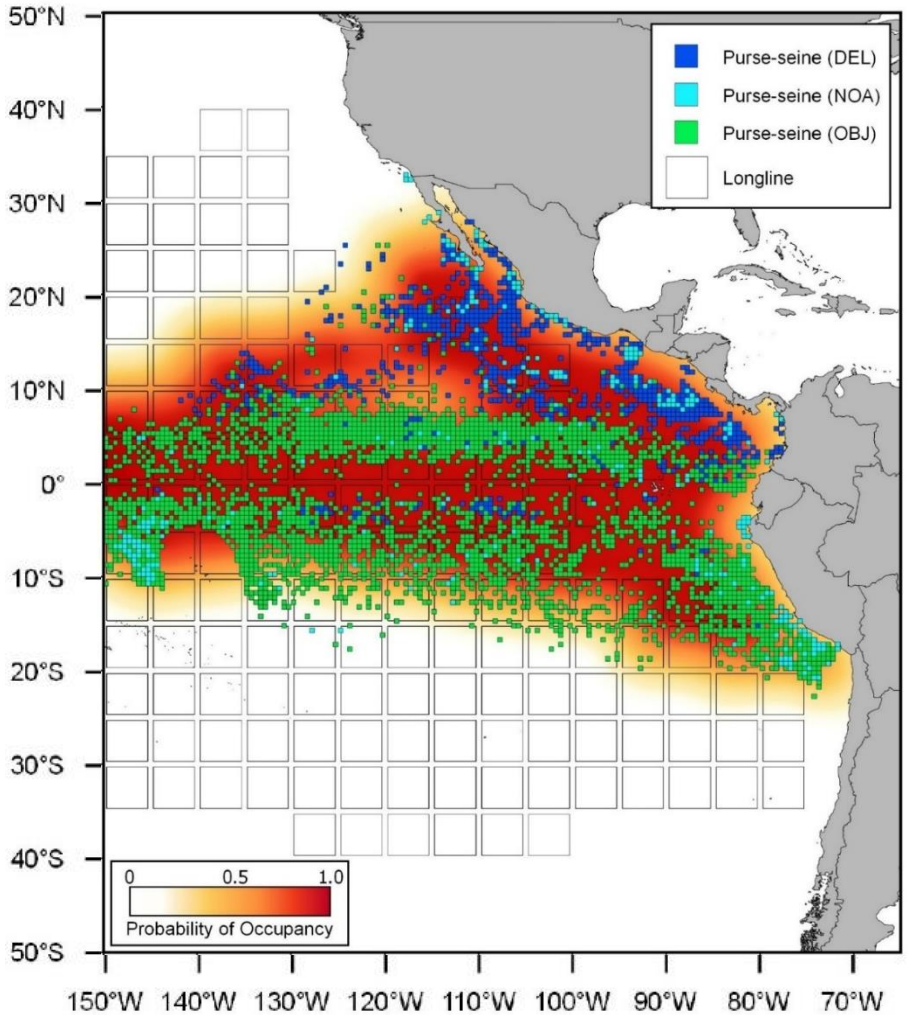
Species distribution ‘base map’

- Habitat modeled using Relative Environmental Suitability (RES) model



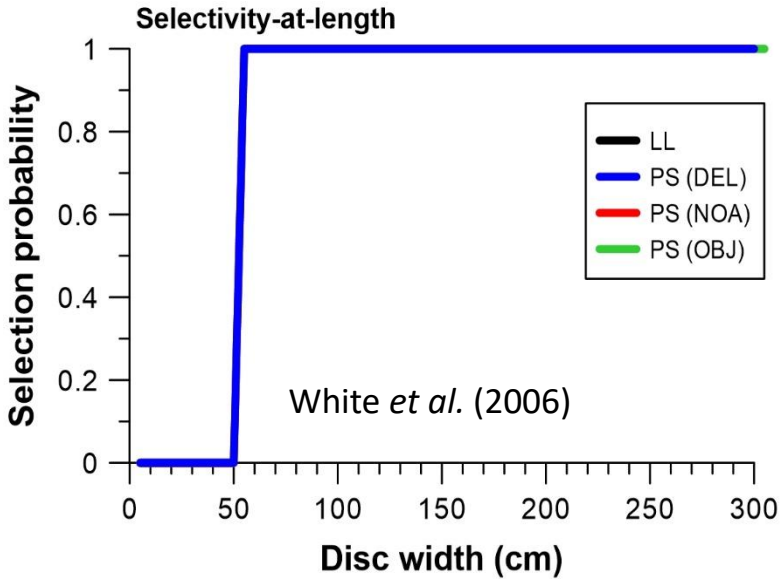
Areal overlap of fisheries for 2016

- Habitat map overlaid with fishing effort at 0.5°x 0.5° (PS) and 5°x 5° (LL)



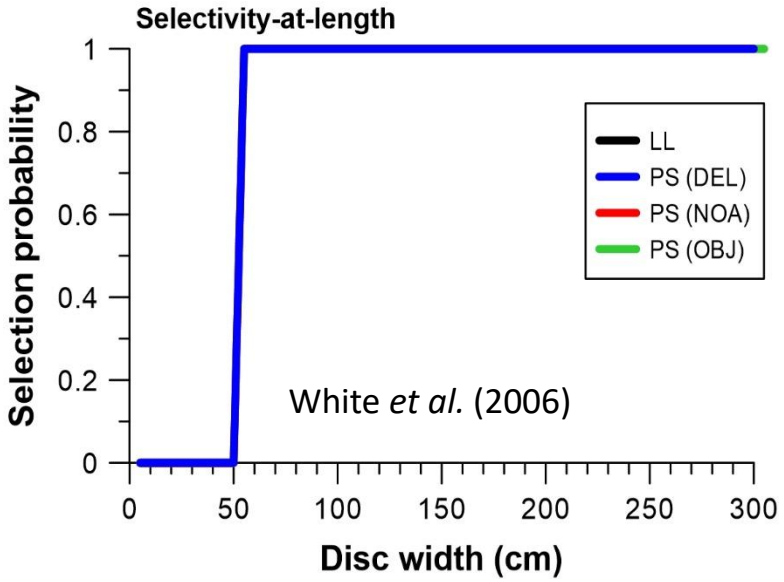
Susceptibility and productivity inputs

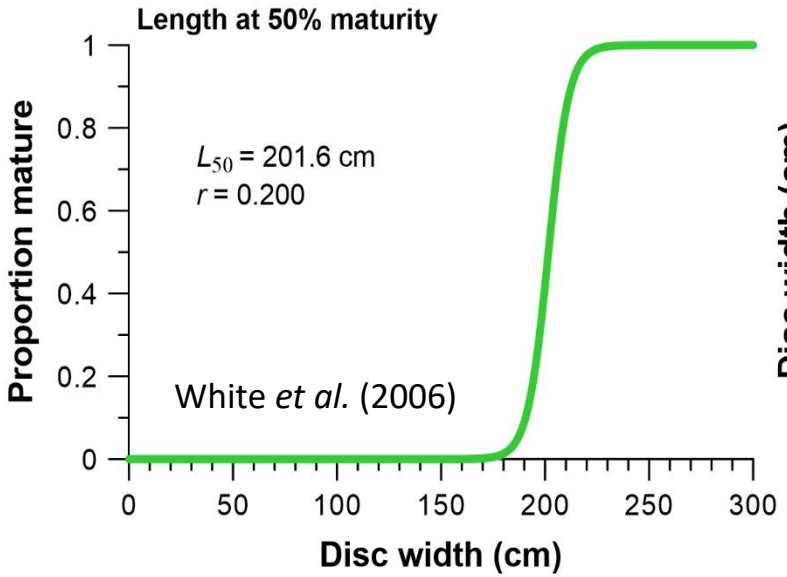
- Encounterability and seasonal availability. No data = 1.0

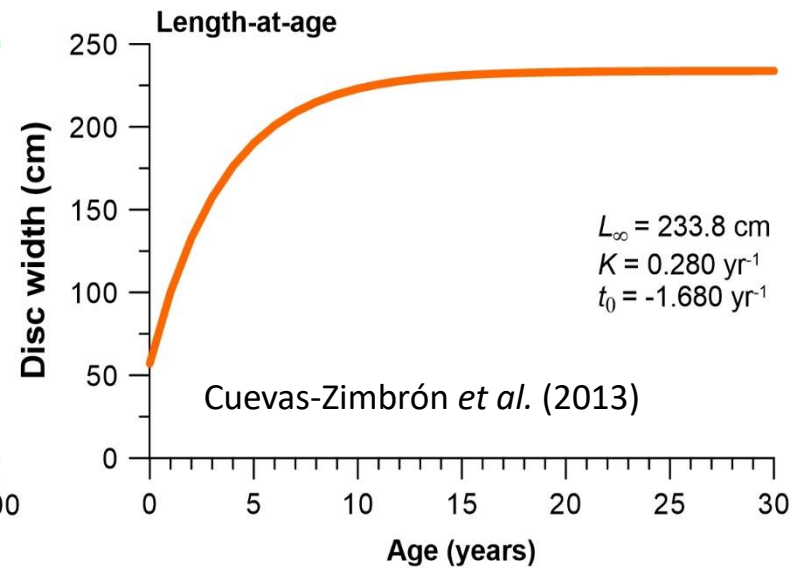


Susceptibility and productivity inputs

- Encounterability and seasonal availability. No data = 1.0

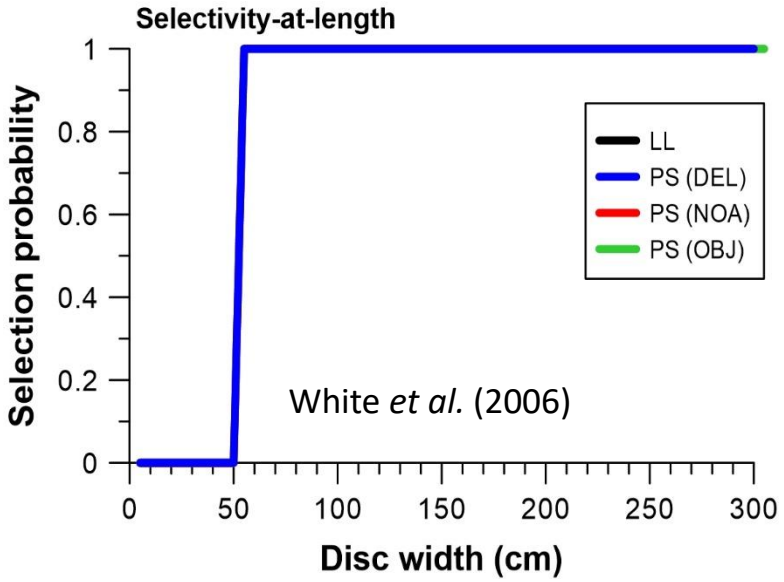


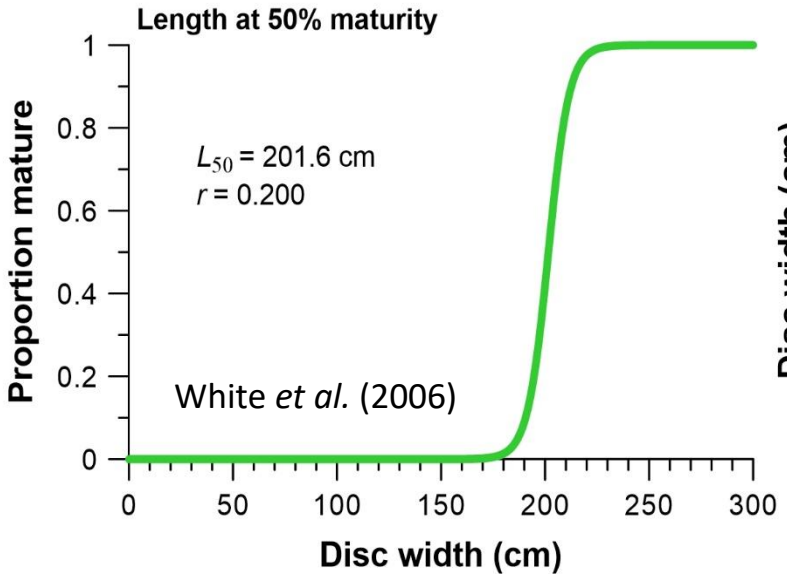


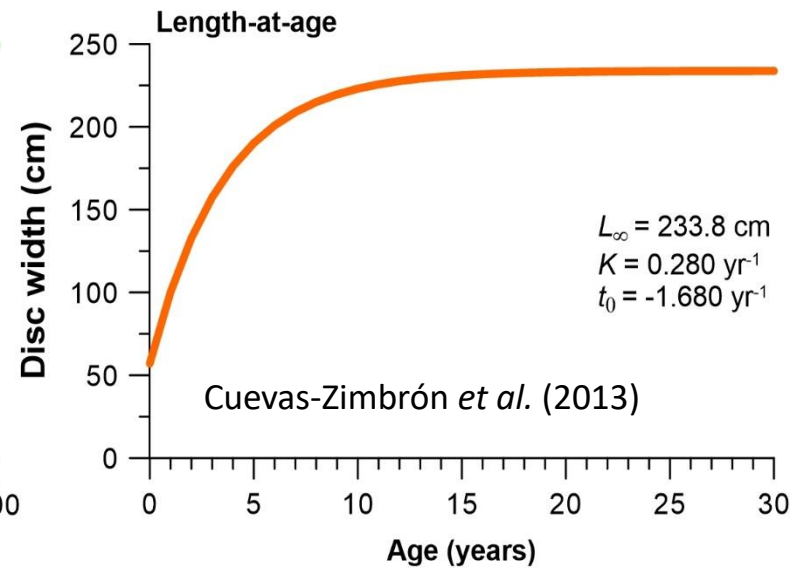


Susceptibility and productivity inputs

- Encounterability and seasonal availability. No data = 1.0
- Natural mortality = 0.370 (± 0.260-0.437) yr^{-1}



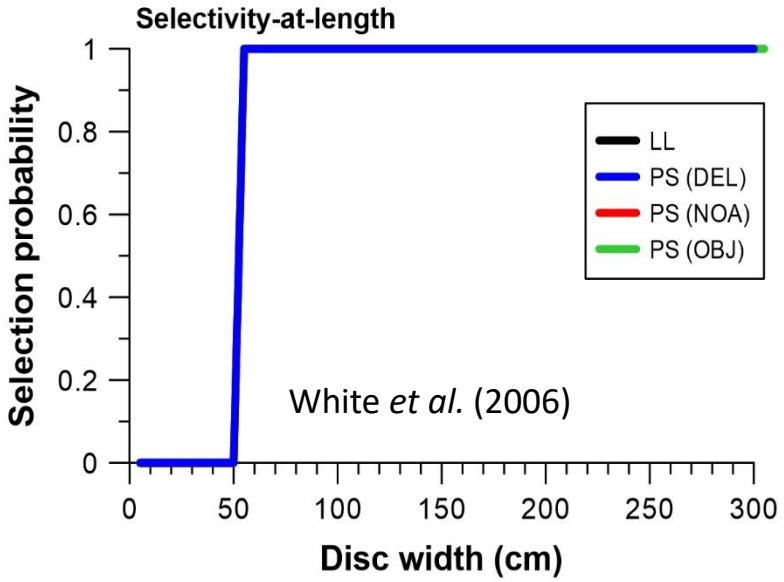


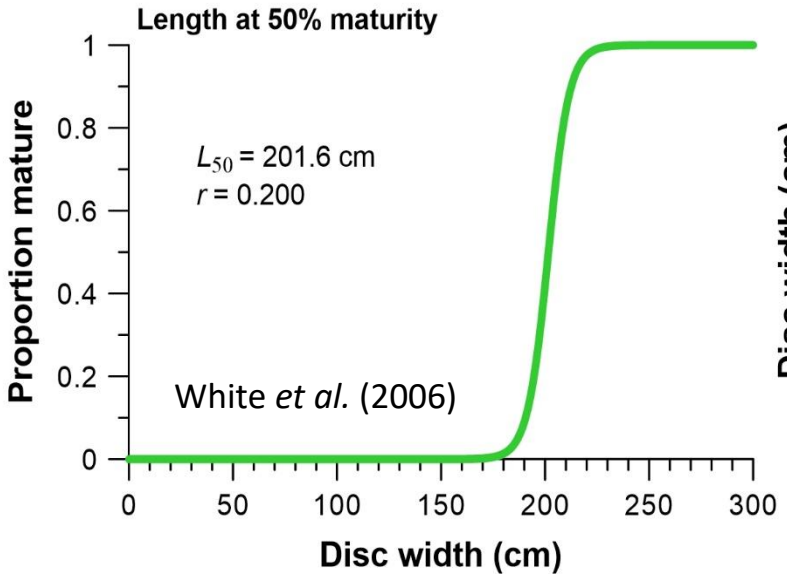


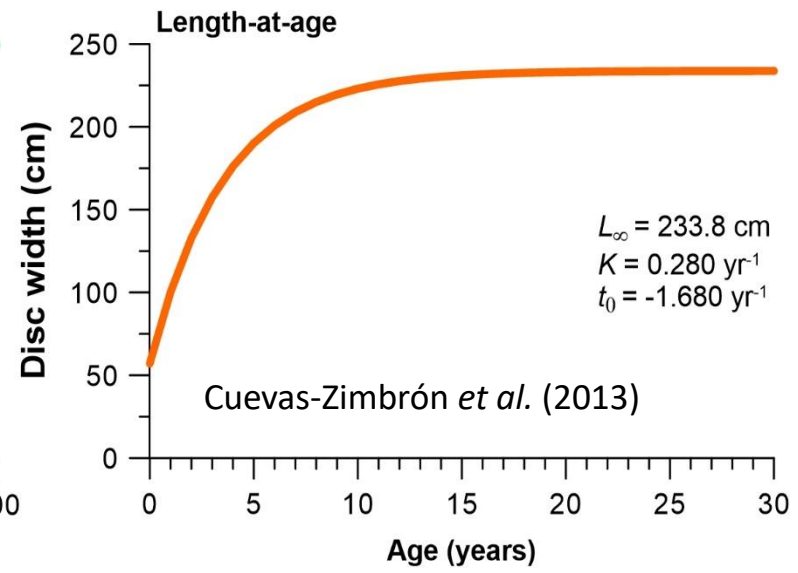
CIAT
IATTC

Susceptibility and productivity inputs

- Encounterability and seasonal availability. No data = 1.0
- Natural mortality = 0.370 (± 0.260-0.437) yr^{-1}
- Post-release mortality – no reliable EPO data, assumed to be 100%







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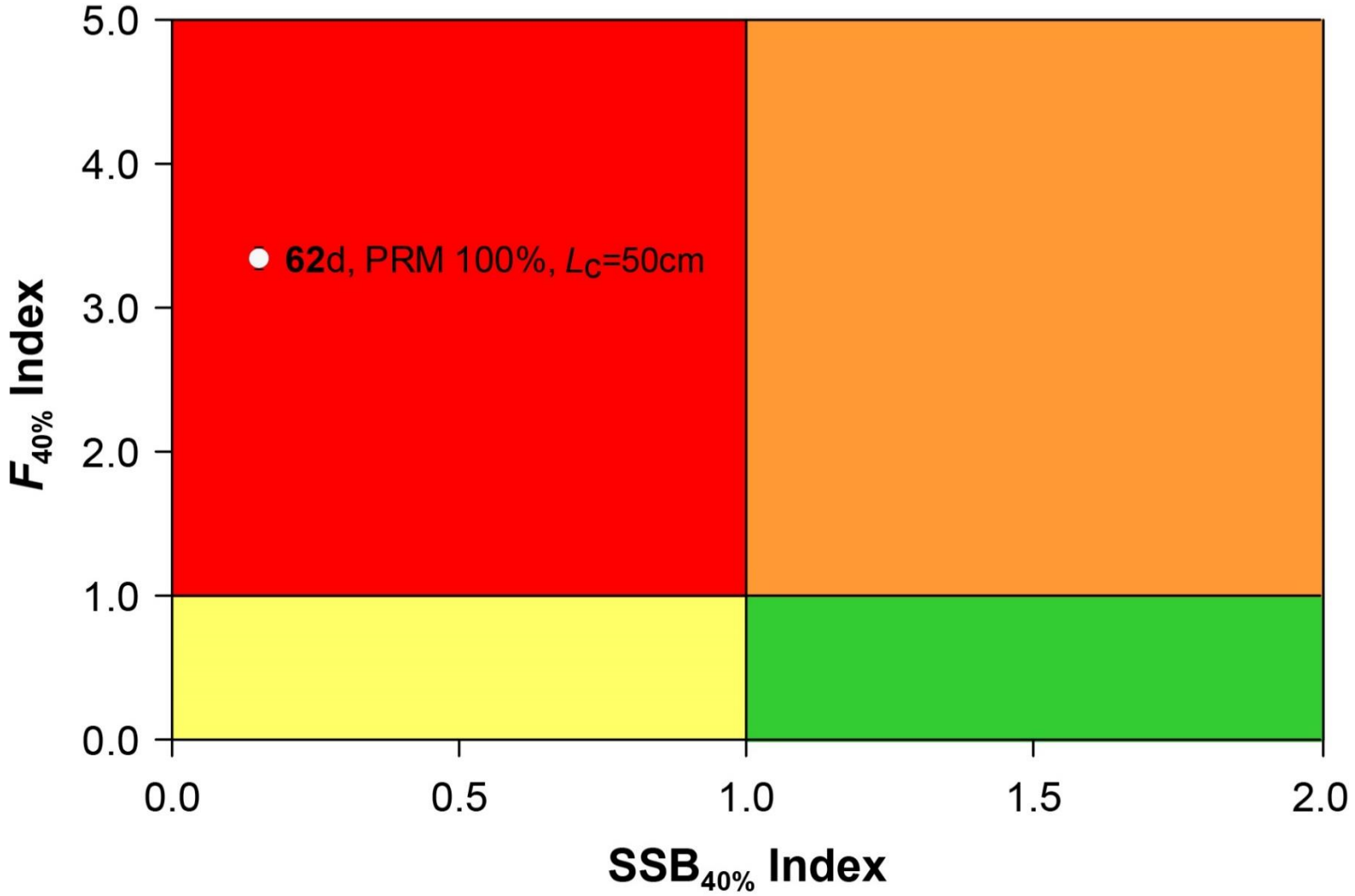
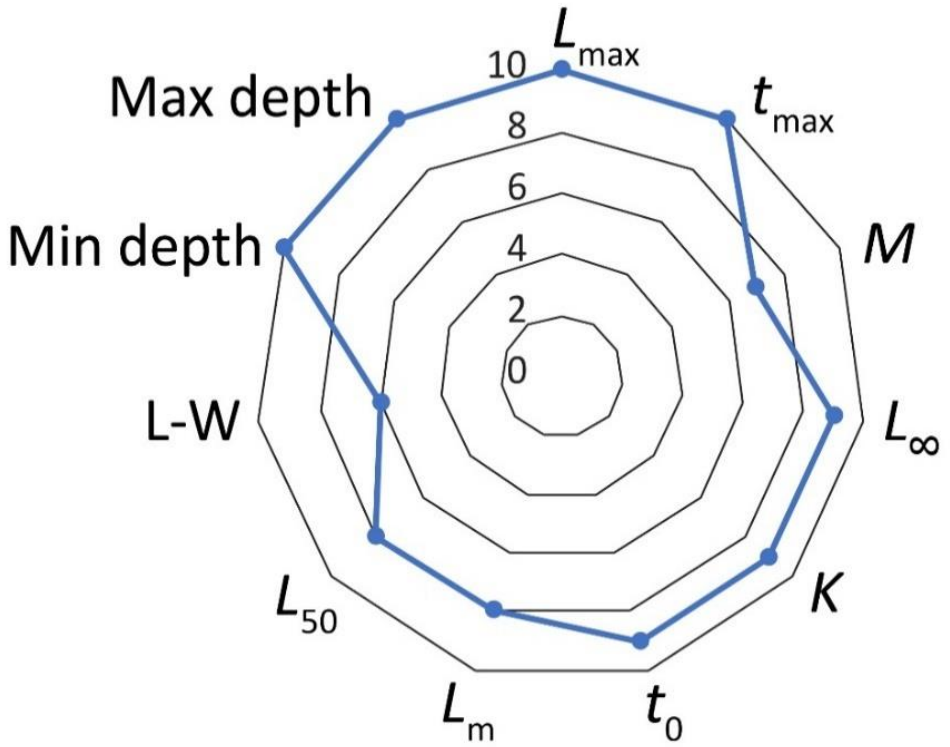
2016 vulnerability status in the EPO

- Vulnerability status defined as “most vulnerable” for 2016



Input data reliability

- A species may “most vulnerable” due to poor quality input data
- EASI-Fish uses a qualitative data reliability index (0-10 scale)
- Radar plot quickly identifies data gaps
- Reliable data inputs, so status unlikely to be a ‘false positive’



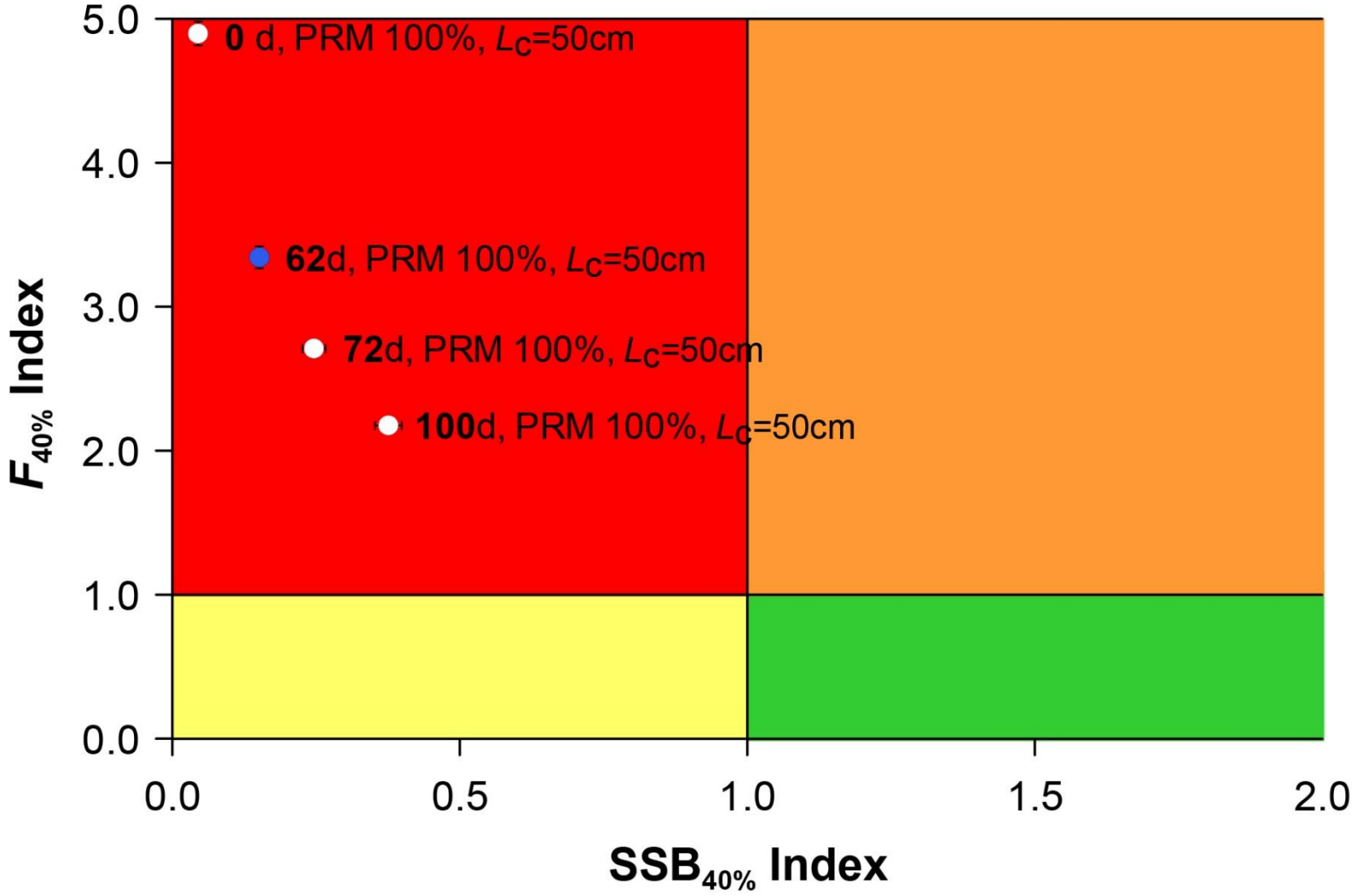
Exploring hypothetical conservation measures

- EASI-Fish designed to identify vulnerable species for *status quo* settings
- 'What if' scenarios can be explored to reduce a species' vulnerability

- 18 hypothetical conservation measures for *M. mobular* in 2016
  - EPO-wide temporal closures
  - Temporary closures of 'hot spots' for Mobulid catches
  - Reducing post-release mortality through improved handling practices
  - Increasing length at first capture through gear selectivity changes
  - Various combinations of the above measures

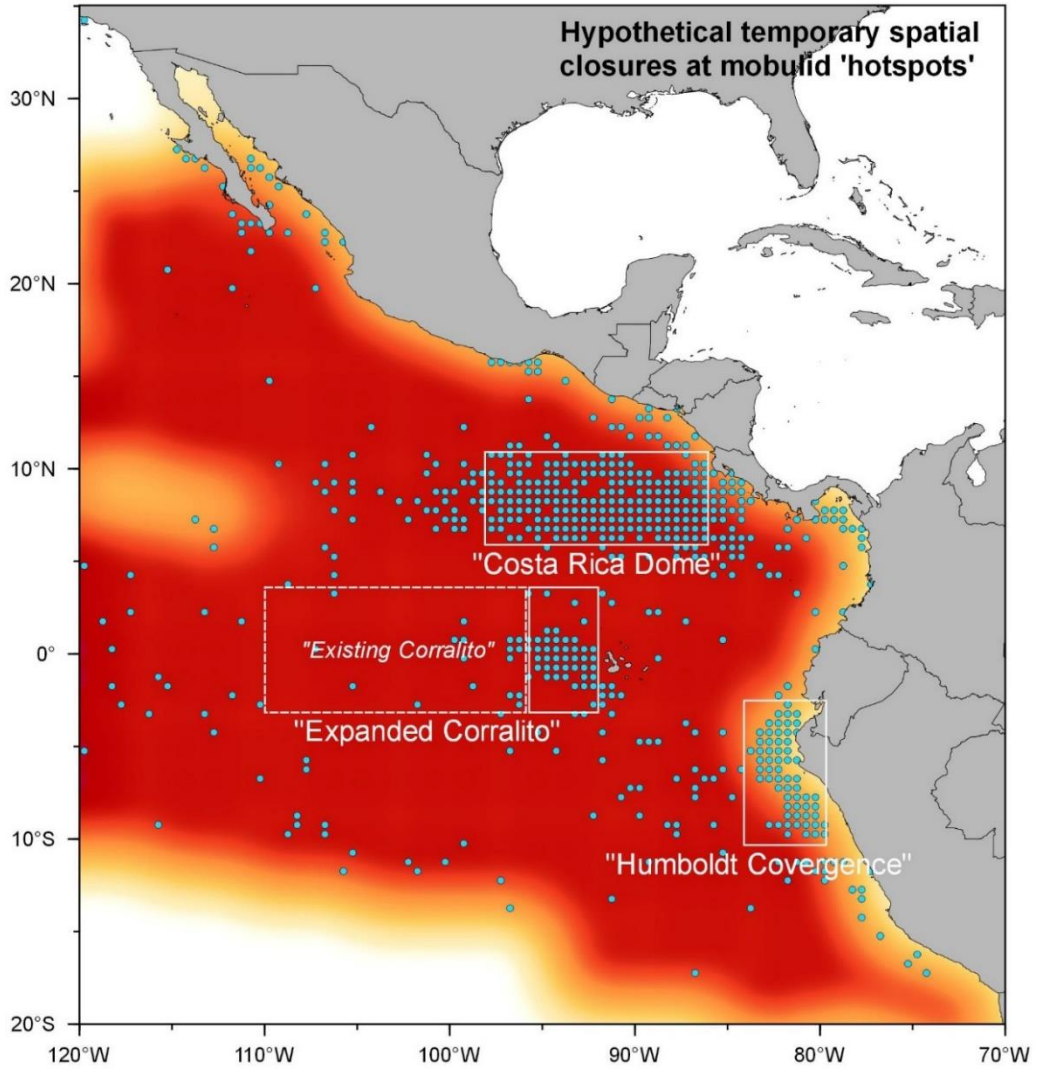
1) EPO-wide temporal closure

- **No closure**, **62d** (2016), **72d** (present CMM), **100d**



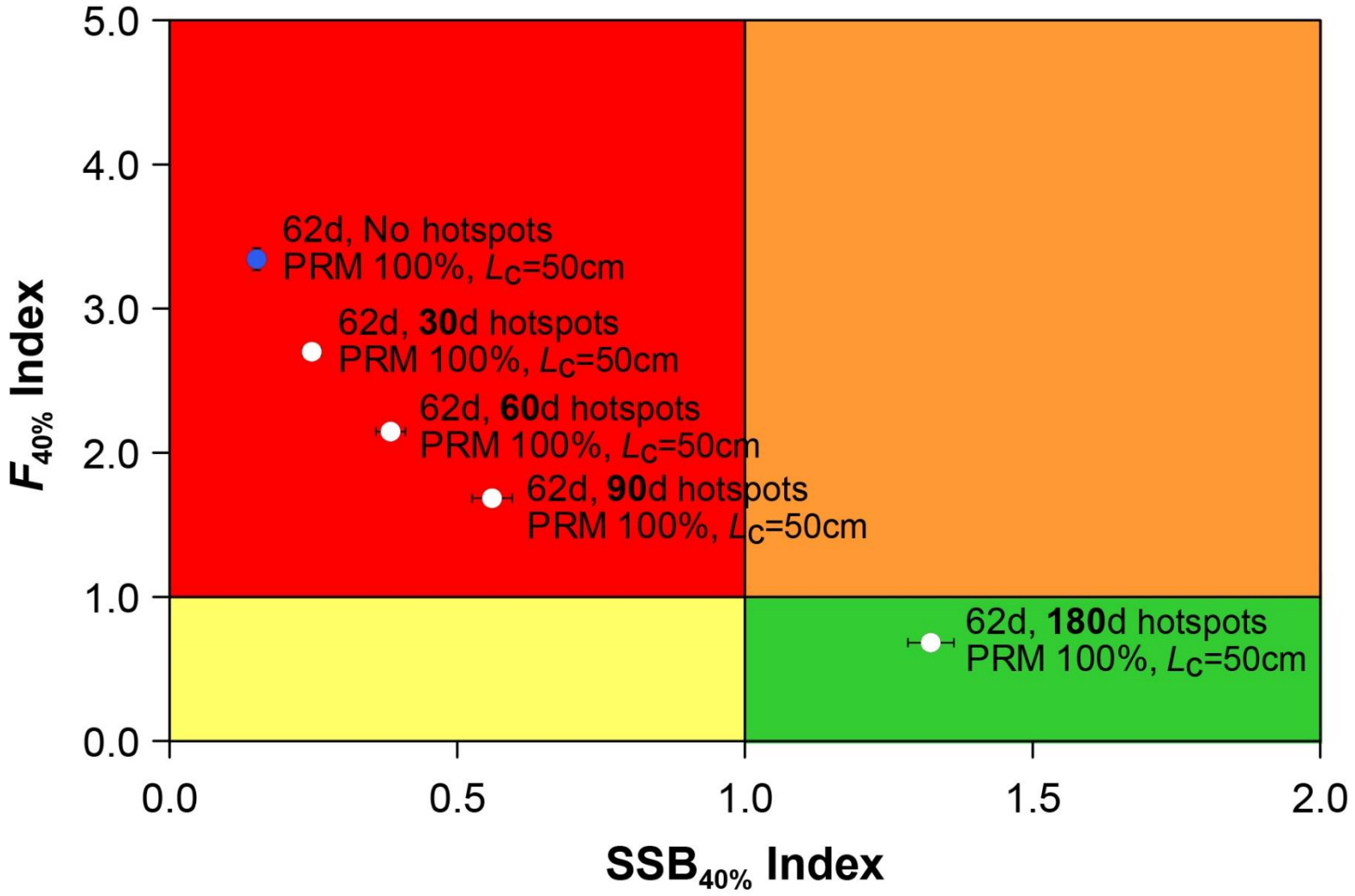
2) Temporary closure of ‘hot spots’

- Catches from 1993-2017 also show 3 catch ‘hot spots’ for mobulids



2) Temporary closure of ‘hot spots’

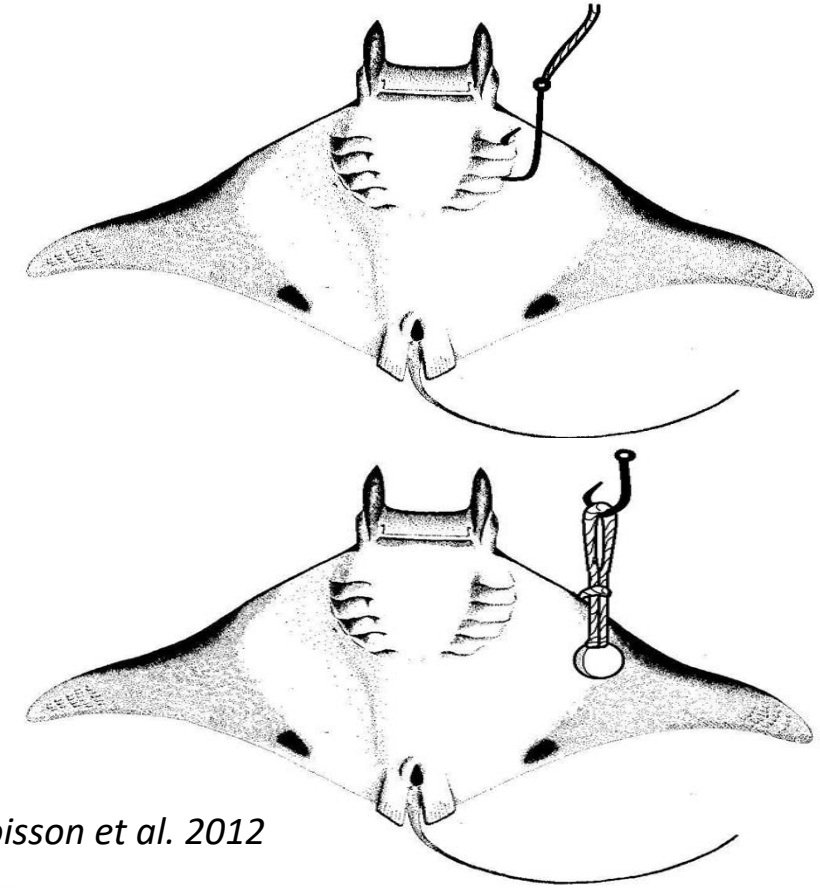
- Hot spot closure of **0d** (status quo), **30d**, **60d**, **90d**, **180d**



3) Reduce post-release mortality

- Various methods currently used to handle large and dangerous rays

Traditional bad practices banned

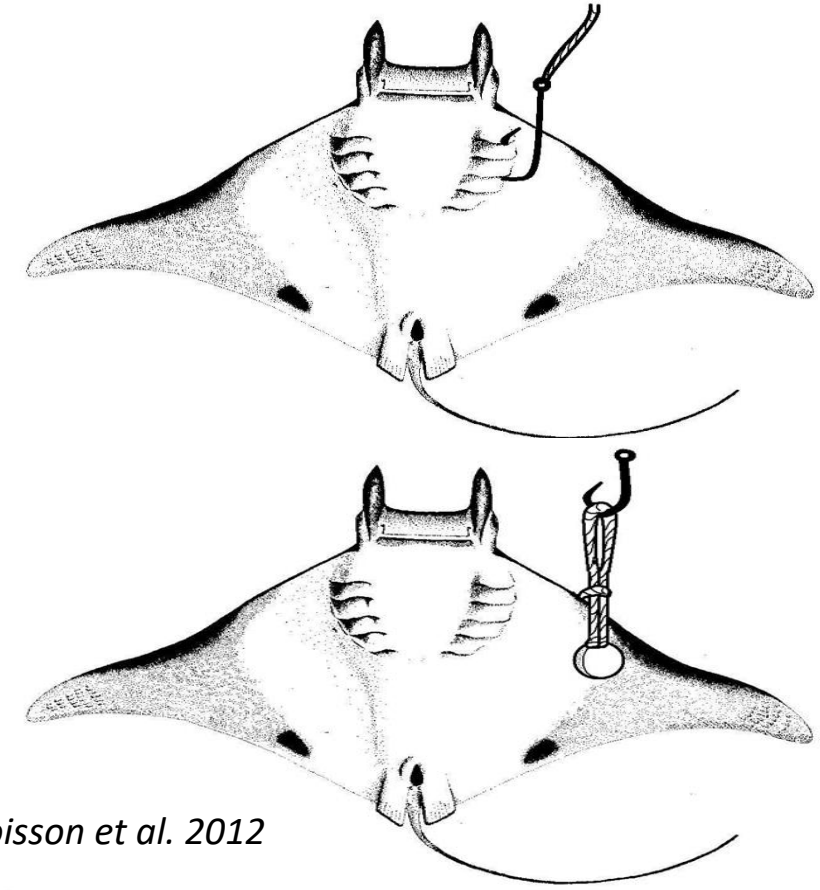


Poisson et al. 2012

3) Reduce post-release mortality

- Various methods currently used to handle large and dangerous rays
- Best practices have the potential to reduce post-release mortality

Traditional bad practices banned



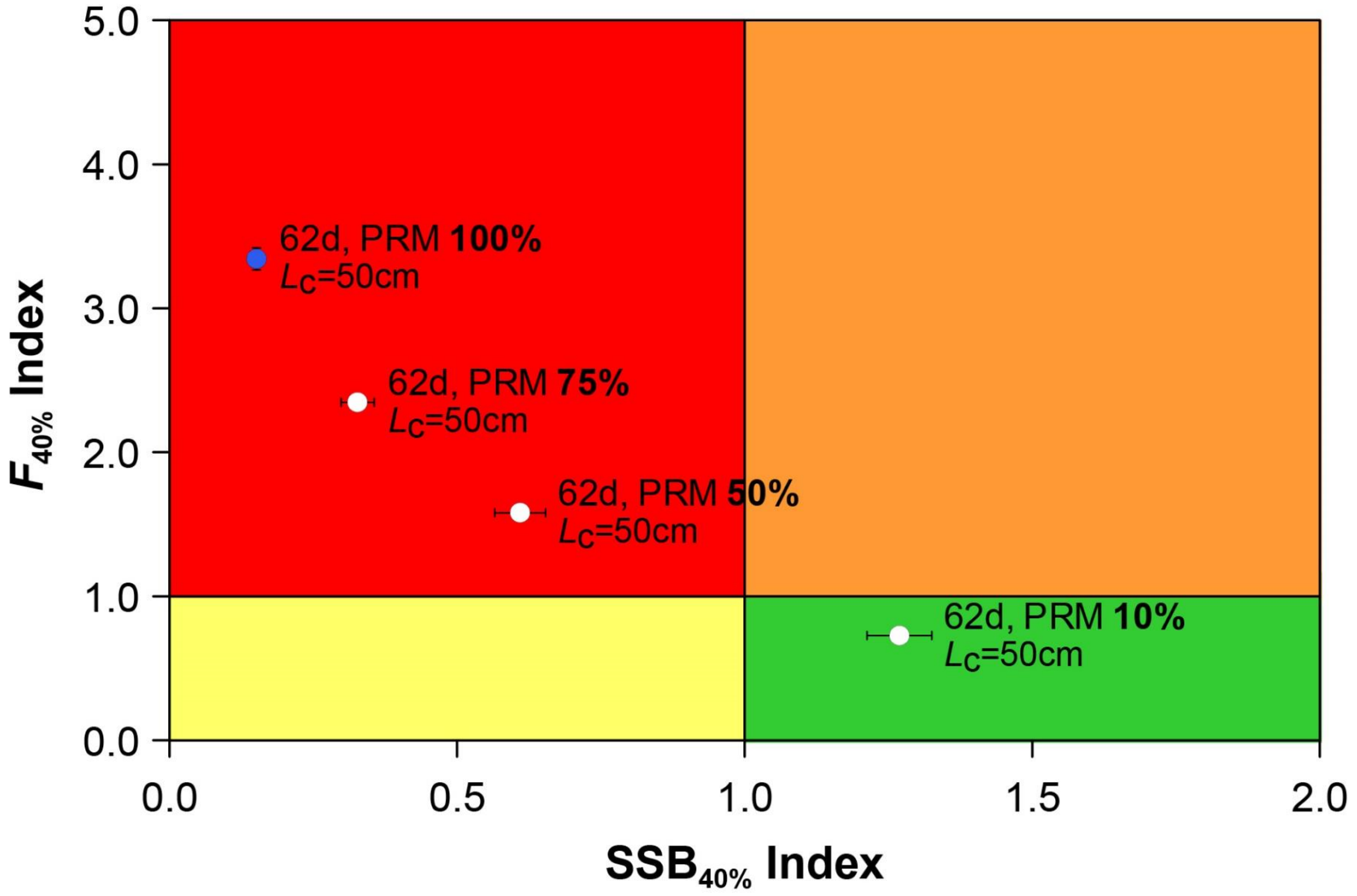
Poisson et al. 2012

Cargo net

Stretcher

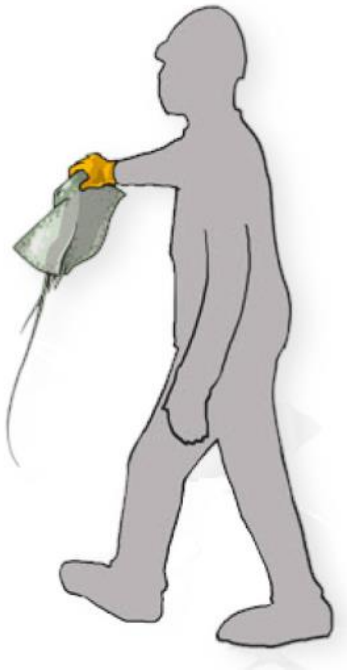
3) Reduce post-release mortality

- Post-release mortality of **100%** (status quo), **75%**, **50%**, **10%**



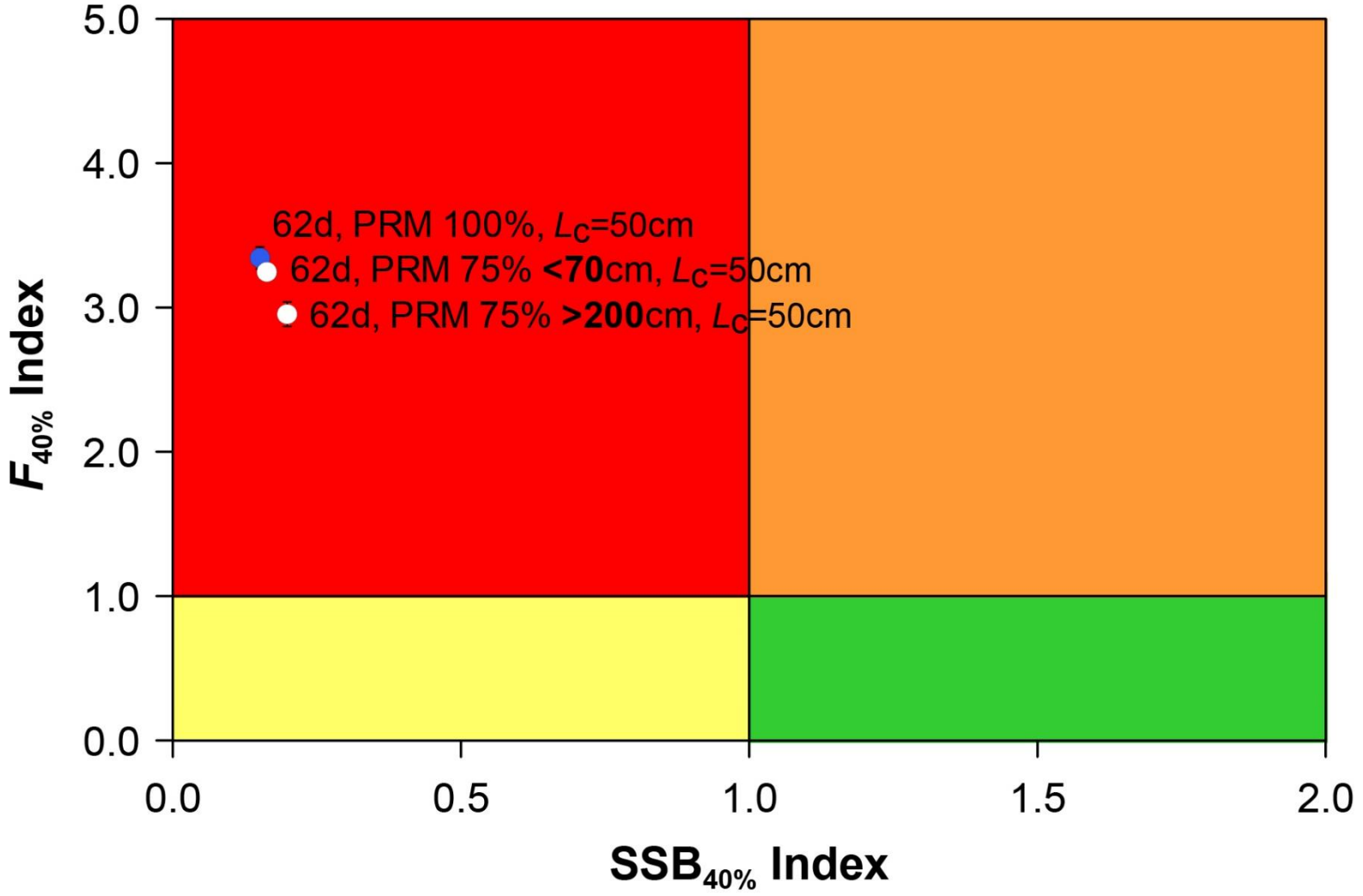
4) Reduction of Post Release Mortality by Size

- Post-release mortality likely to depend on size of ray
  - Small rays <70 cm DW may be released quickly by a single person
  - Large rays >200 cm DW require more time and effort



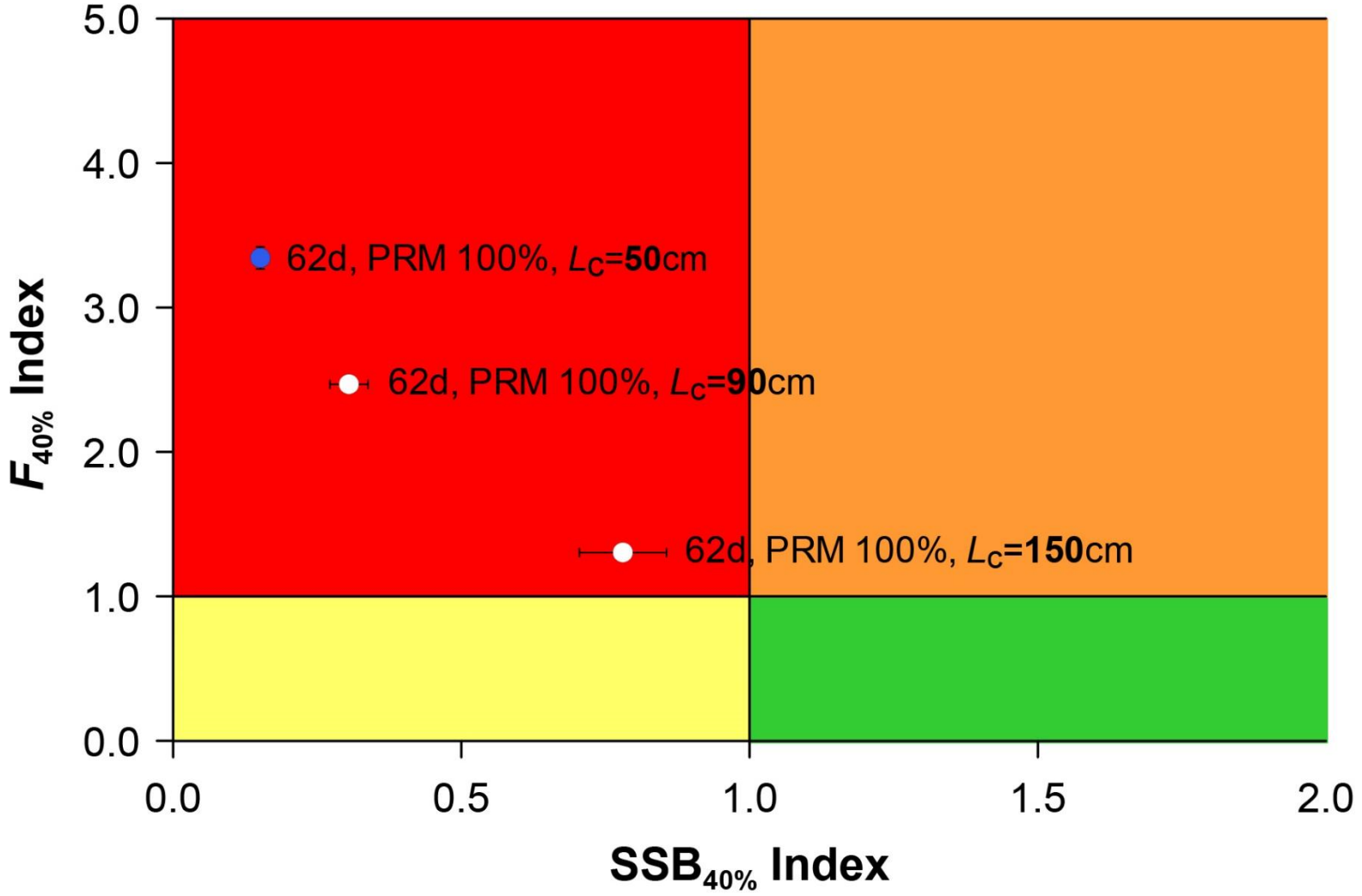
4) Reduction of Post Release Mortality by Size

- Post-release mortality of **75%** for rays **<70 cm** DW or **>200 cm** DW



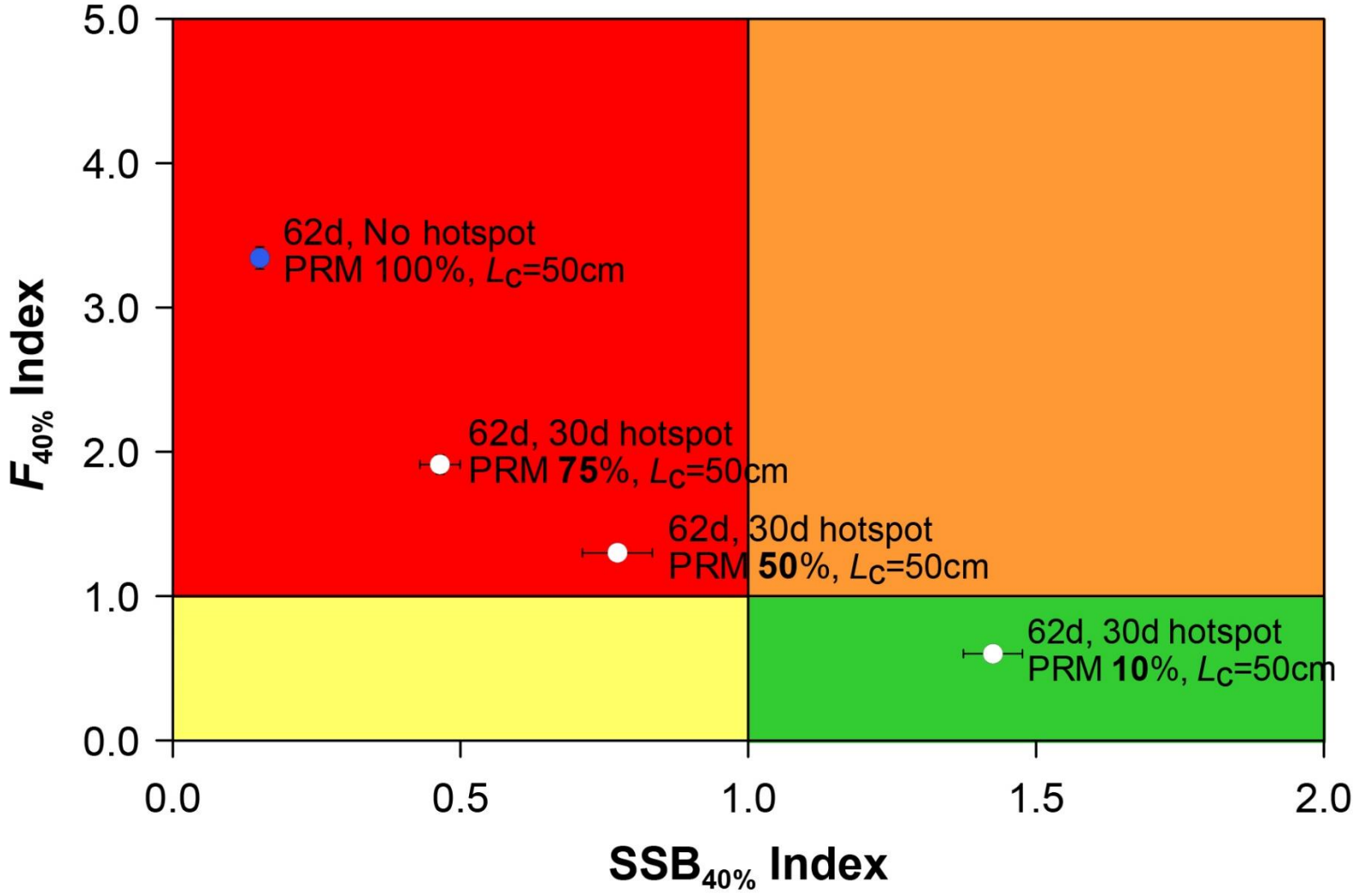
5) Increase length at first capture (L_c)

- L_c of **50 cm** DW (length at birth; status quo), **90 cm**, **150 cm**



6) 30d ‘hot spots’ closure + reducing PRM

- **30d** ‘hot spot’ closure **+** reduction in PRM to **75%**, **50%**, **10%**



Summary of results

- Only 3 of 18 scenarios changed status from '**most**' to '**least**' vulnerable.
- A large increase in post-release survival or 'hot spot' closure required.

Scenario description	Scenario no.	EPO closure (days)	'Hotspot' Closure (days)	Post-release mortality (%)			Length at first capture (L_c) (cm)
				All sizes	<70 cm	>200 cm	
2016 Status quo	1	62		100			50
EPO-wide closure of the purse-seine fishery	2	0		100			50
	3	72		100			50
	4	100		100			50
Reduction in post-release mortality (PRM)	5	62		75			50
	6	62		50			50
	7	62		10			50
Increased length at first capture (L_c)	8	62		100			90
	9	62		100			150
Temporary closure of 'hotspots'	10	62	30	100			50
	11	62	60	100			50
	12	62	90	100			50
	13	62	180	100			50
Reduction of PRM by size (<75 cm or > 200 cm)	14	62		75	75		50
	15	62		75		75	50
30 d 'hotspot' closure and a reduction in PRM	16	62	30	75			50
	17	62	30	50			50
	18	62	30	10			50

Conclusions

- Demonstrating ecological sustainability of data-poor bycatch species is a significant challenge, but necessary for fisheries moving to EBFM

- EASI-Fish improves on previous ERA methods:
  - Quantitative assessment of the cumulative fishing impacts
  - Uses biological reference points and Kobe plot familiar to managers
  - Species are not ranked relative to each other - BRPs allow all species to be assessed together
  - Requires significantly less data than PSA
  - Spatially-explicit, so assessments can be made under various spatial and temporal scenarios

- EASI-Fish is not a stock assessment, it's a quantitative prioritization tool
  - Identifies species requiring immediate mitigation measures, or
  - Further data collection and research for future conventional stock assessment

Future work

- Reducing post-release mortality clearly a key conservation strategy
- Post-release mortality requires a large-scale tagging project to quantify:
  - Mortality rate using existing and best handling practices, stratified by gear type,
  - Vertical and horizontal habitat use to refine “encounterability” and “seasonality” parameters,
- Species distribution modelling:
  - Reassess with habitat maps from other models (GAMs, INLA) – see Lezama-Ochoa et al. (in prep)
- Complete EPO-wide assessment
  - 100+ species to be assessed in EPO tuna fisheries ‘Industrial’ longline and purse-seine fisheries
  - Class 1-5 purse-seine, other small scale and artisanal fisheries important
  - Encourage collaboration of CPCs to supply data for smaller fisheries
- Invite suggestions for species and CMM scenarios to be assessed

Questions?