Vulnerability Assessment of Sharks Caught in Eastern Pacific Ocean Pelagic Fisheries Using the EASI-Fish Approach

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Ecological sustainability

- IATTC mandated to ensure ecologically sustainability of its fisheries
  - Antigua Convention, specific IATTC Resolutions (e.g., sharks, rays, turtles, dolphins)

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)*"

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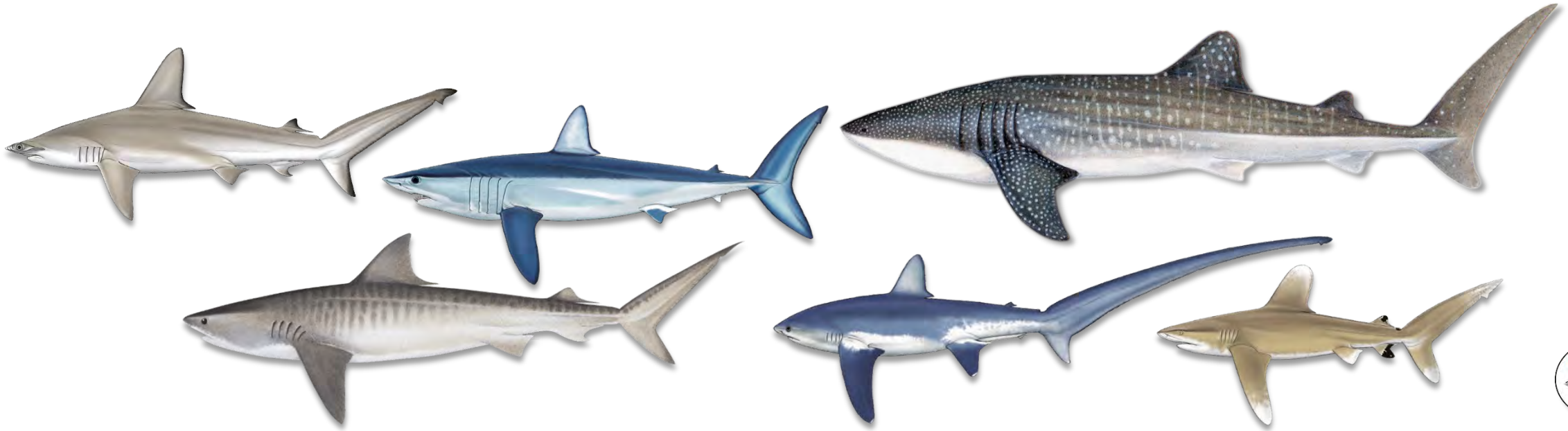
Article VII. "…*adopt, as necessary, conservation and management measures and recommendations for species belonging to the same ecosystem and that are affected by fishing for, or dependent on or associated with, the fish stocks covered by this Convention, with a view to maintaining or restoring populations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

Ecological sustainability

- But demonstrating we meet these mandates is challenging
- EPO fisheries interact with at least 49 shark species
- Some caught infrequently, little value, poor reporting (e.g. “sharks”)
- Lack basic biological and ecological data for traditional assessment
- What has the IATTC been doing to meet mandates for sharks?



Ecological sustainability

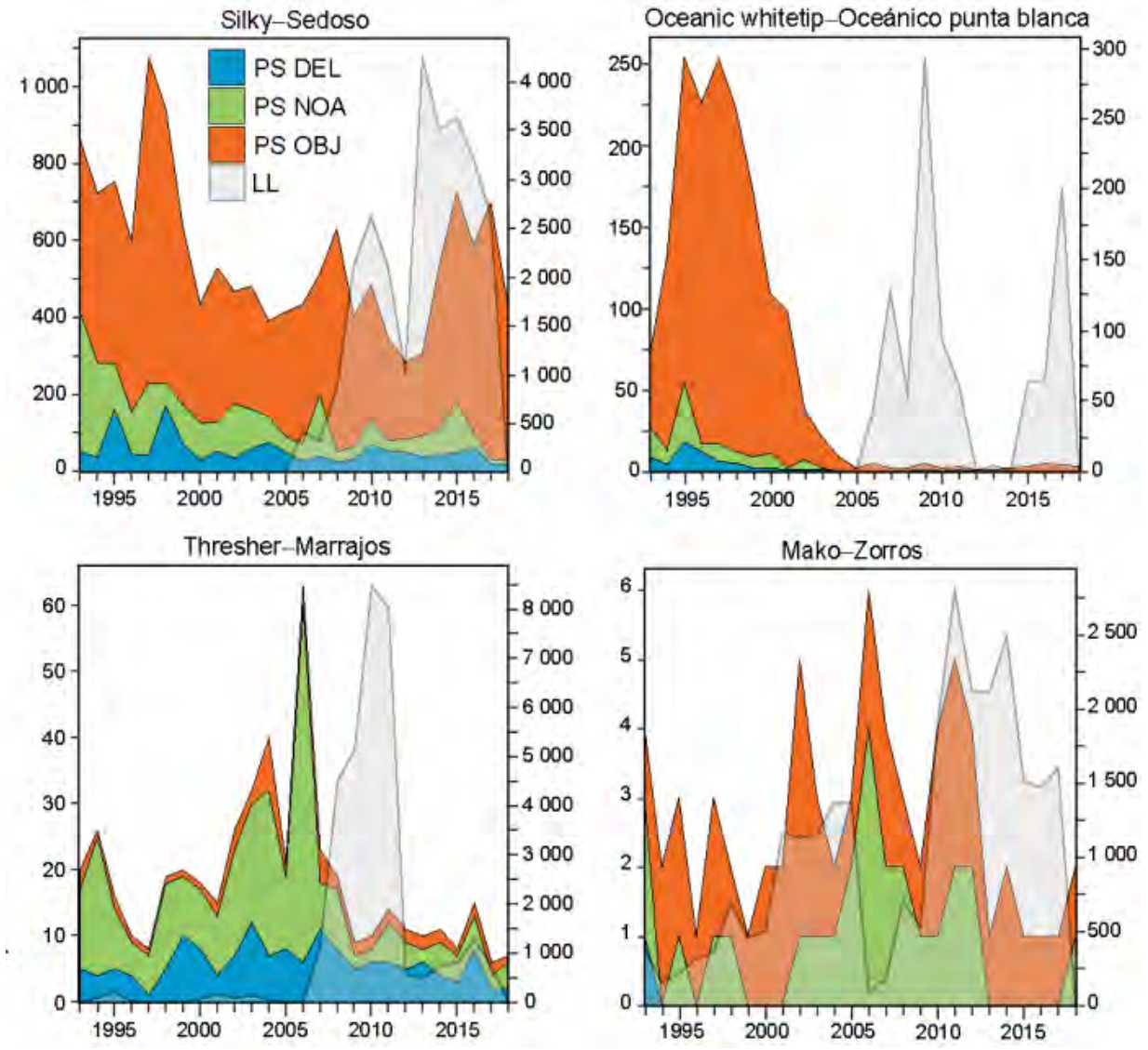
- Improved catch/interaction reports

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-
Species	OBJ	NOA	DEL	Total	line*
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	-

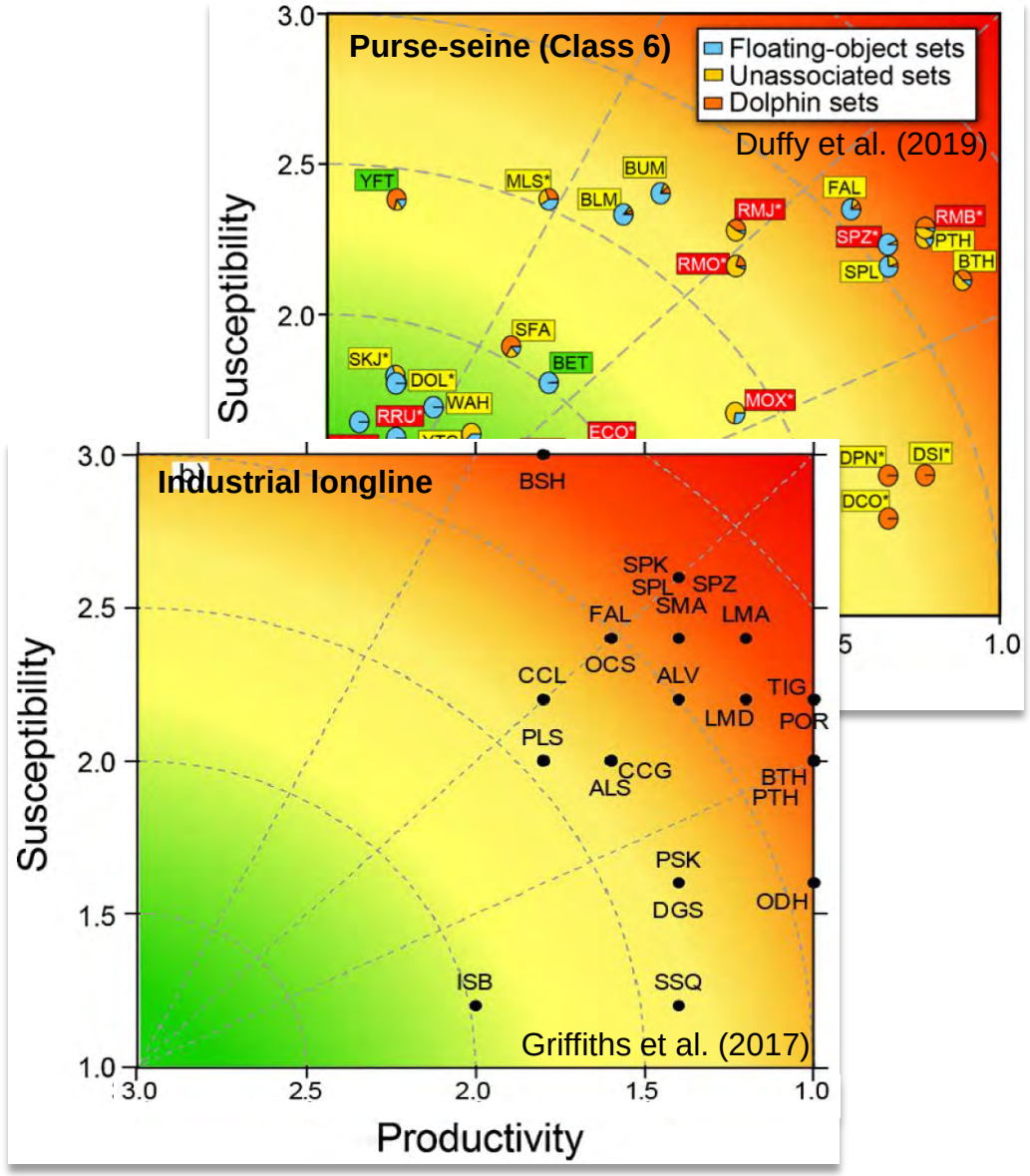
Ecological sustainability

- Improved catch/interaction reports
- Catch time series



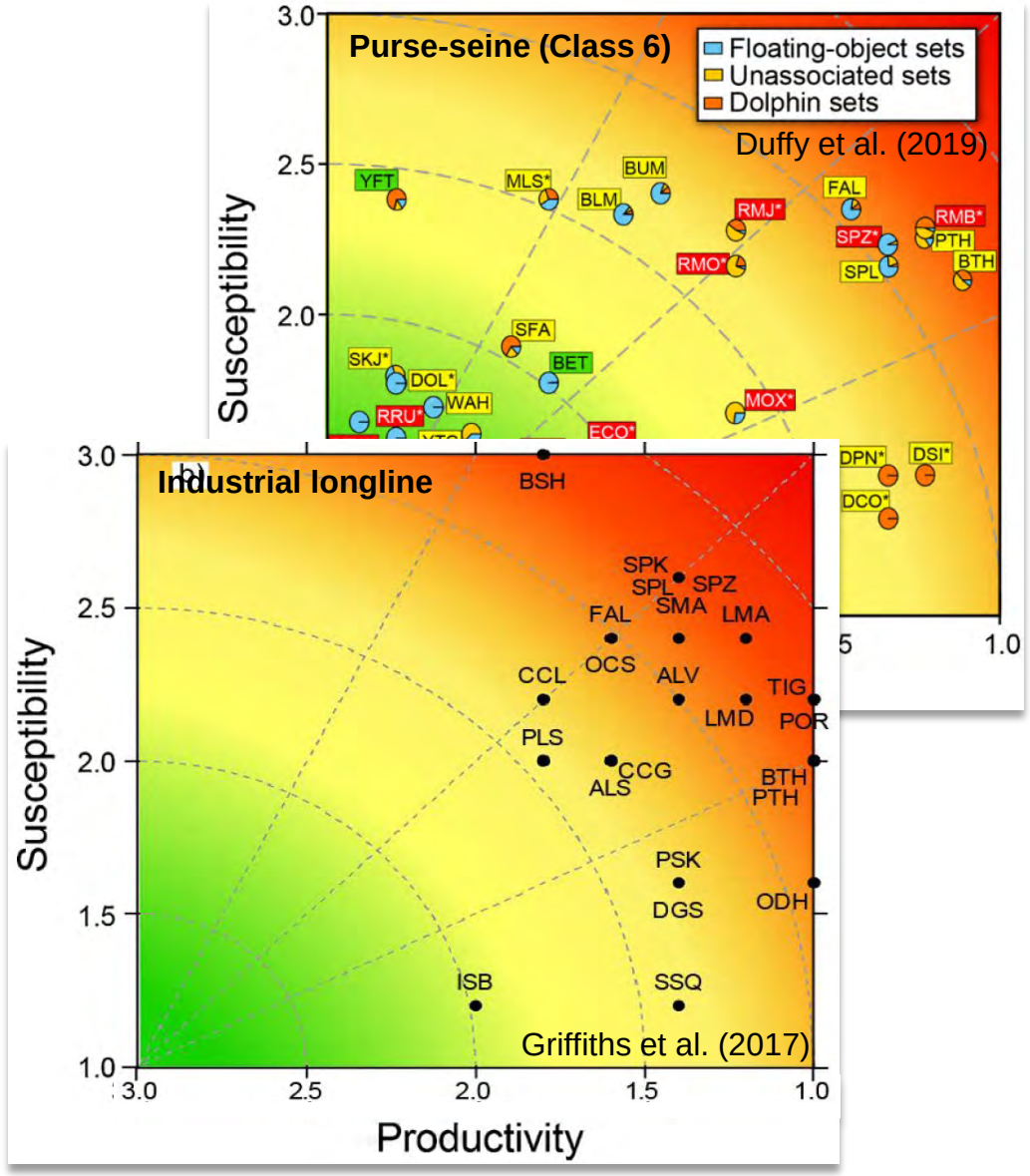
Ecological sustainability

- Improved catch/interaction reports
- Catch time series
- Ecological Risk Assessments



Ecological sustainability

- Improved catch/interaction reports
- Catch time series
- Ecological Risk Assessments
- Insufficient data for stock assessment
- Data collection takes years
  - 5% longline coverage insufficient (BYC-10-INF-D)
  - Central American shark program discontinued



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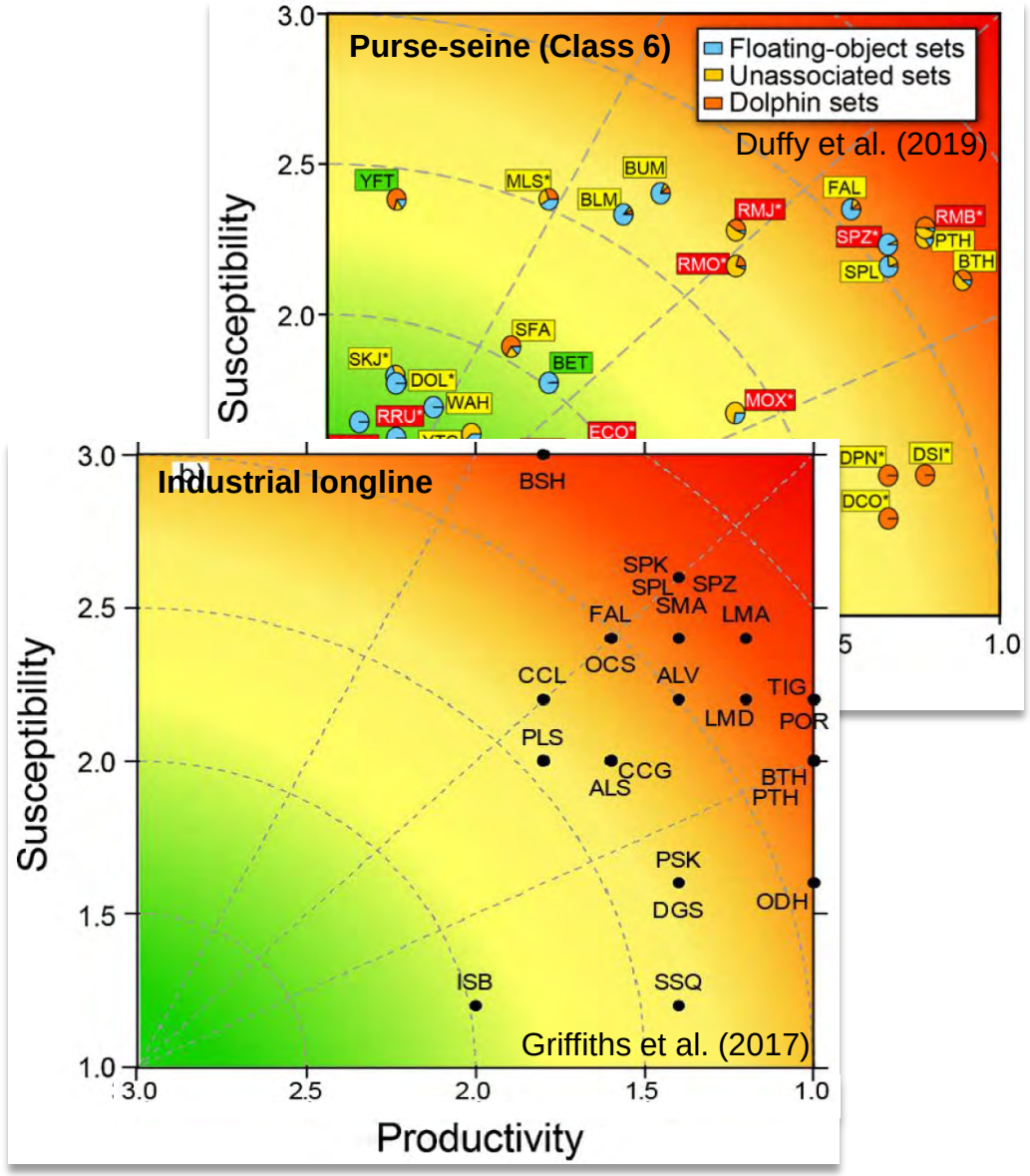
- **Article IV. Application of the Precautionary Approach**
  - 2. "…The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures."



Ecological Assessment of the Sustainable Impacts of Fisheries

EASI-Fish

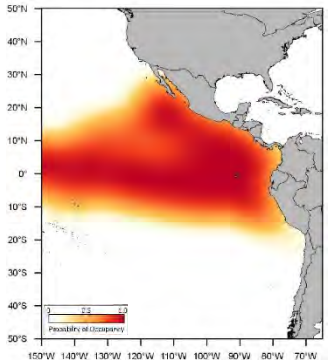
CIAT
IATTC

EASI-Fish

- Similar PSA “Productivity” and “Susceptibility” components
- **Susceptibility** component estimates the proportion of the population potentially impacted by fishery *x* to estimate fishing mortality ($\tilde{F}$ yr^{-1})
- **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 species/fisheries
  - See paper SAC-13-11 complete methodology, data inputs, and assumptions

EASI-Fish – an overview

Susceptibility - “Volumetric overlap”



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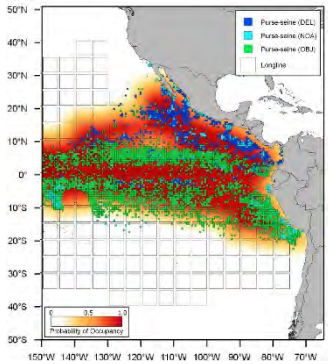

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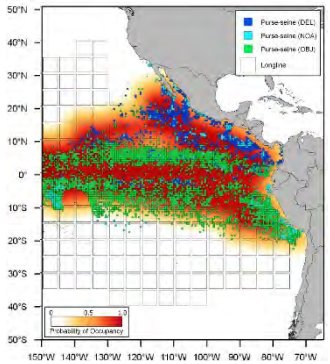

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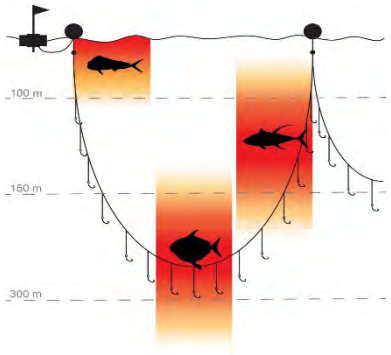

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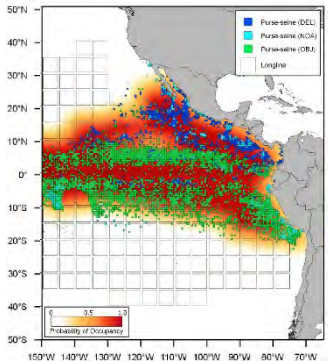

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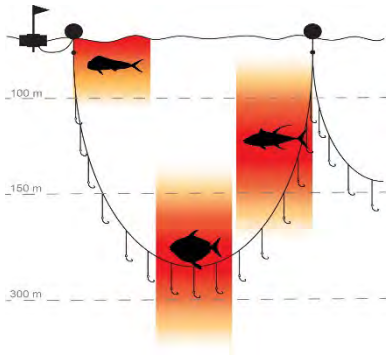

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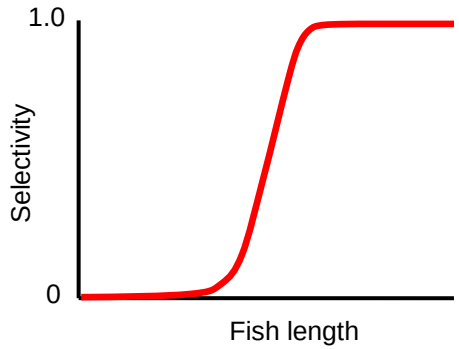

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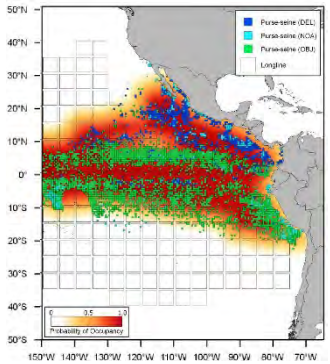

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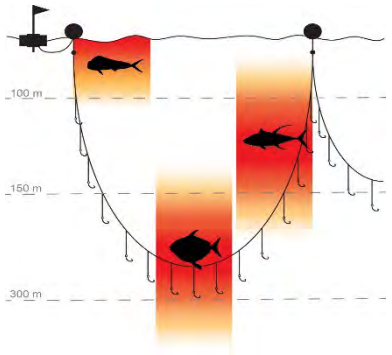

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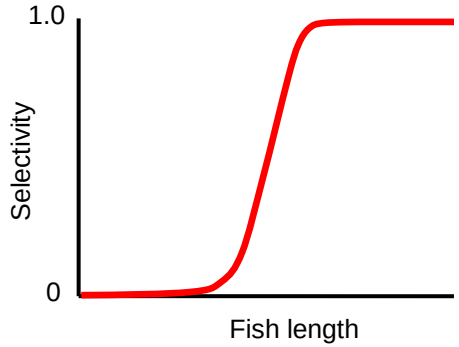

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Post-
Release
Mortality

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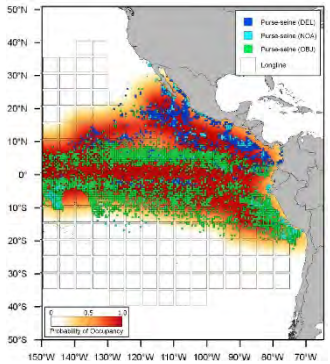

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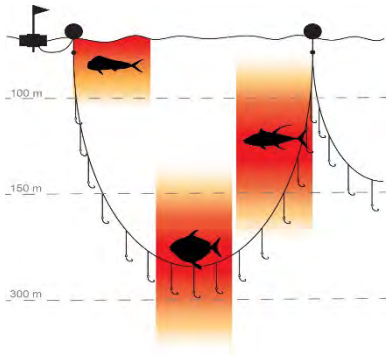

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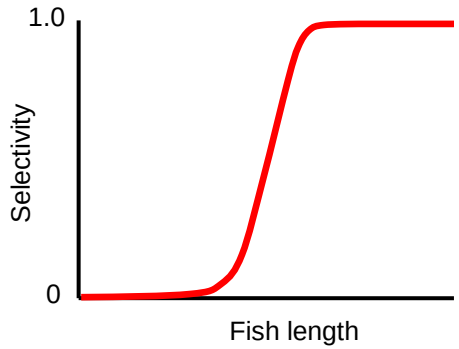

+ Post-Release Mortality = Fishing Mortality ($\widetilde{F}$ yr^{-1})

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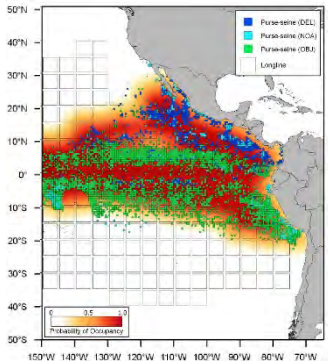

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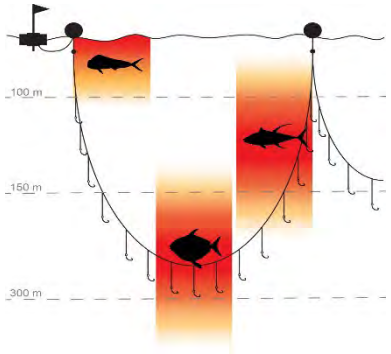

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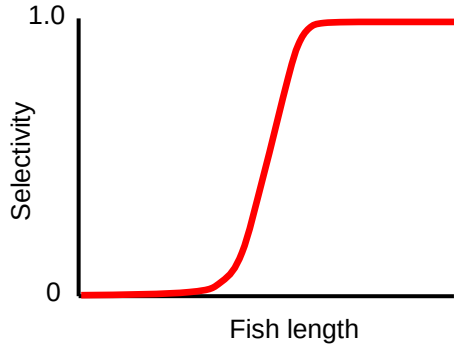

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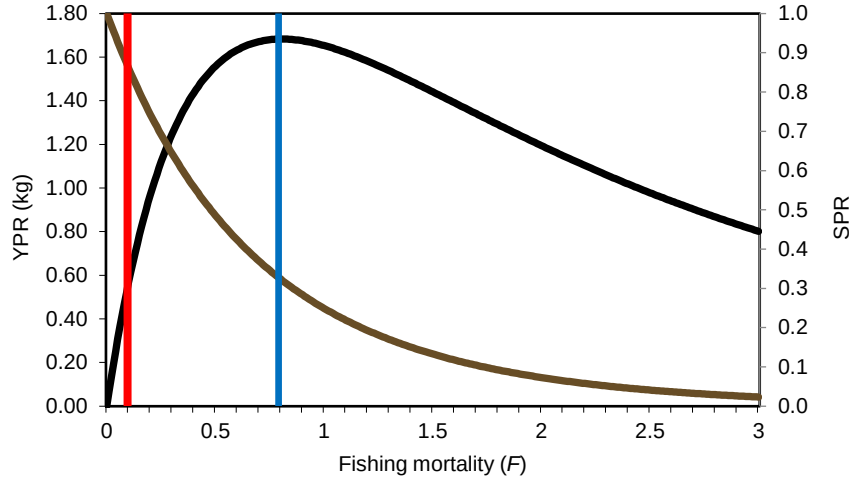
Productivity – YPR & SBR



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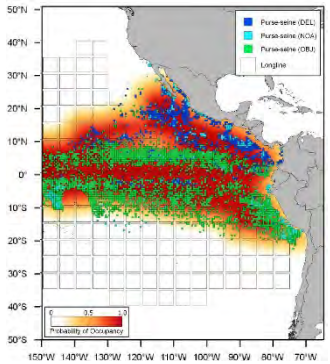

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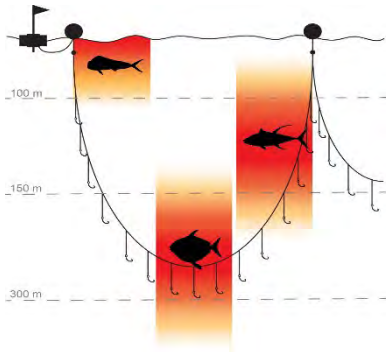

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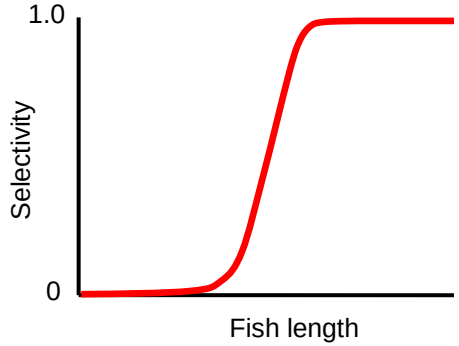

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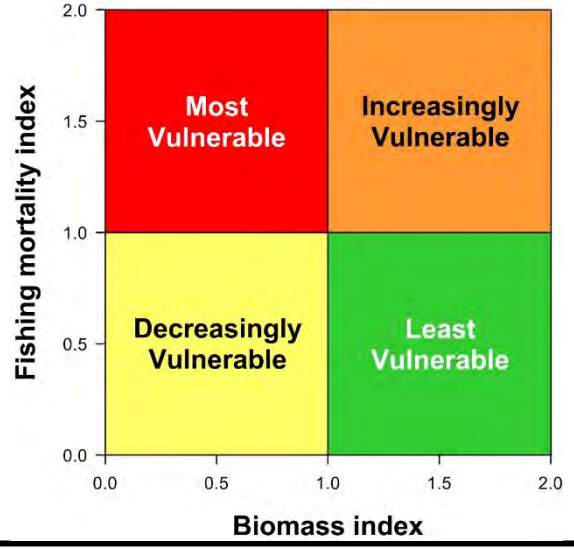
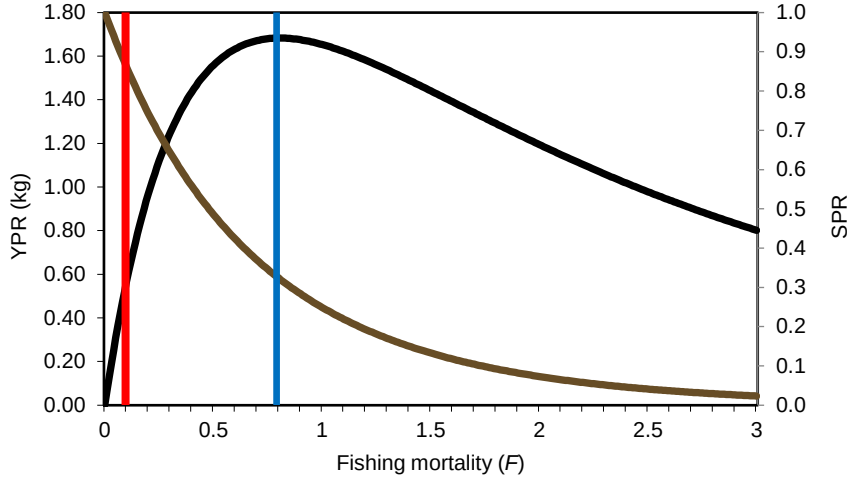
Vulnerability status



BRP values ($F_{40\%}$ and $SBR_{40\%}$)

Productivity – YPR & SBR

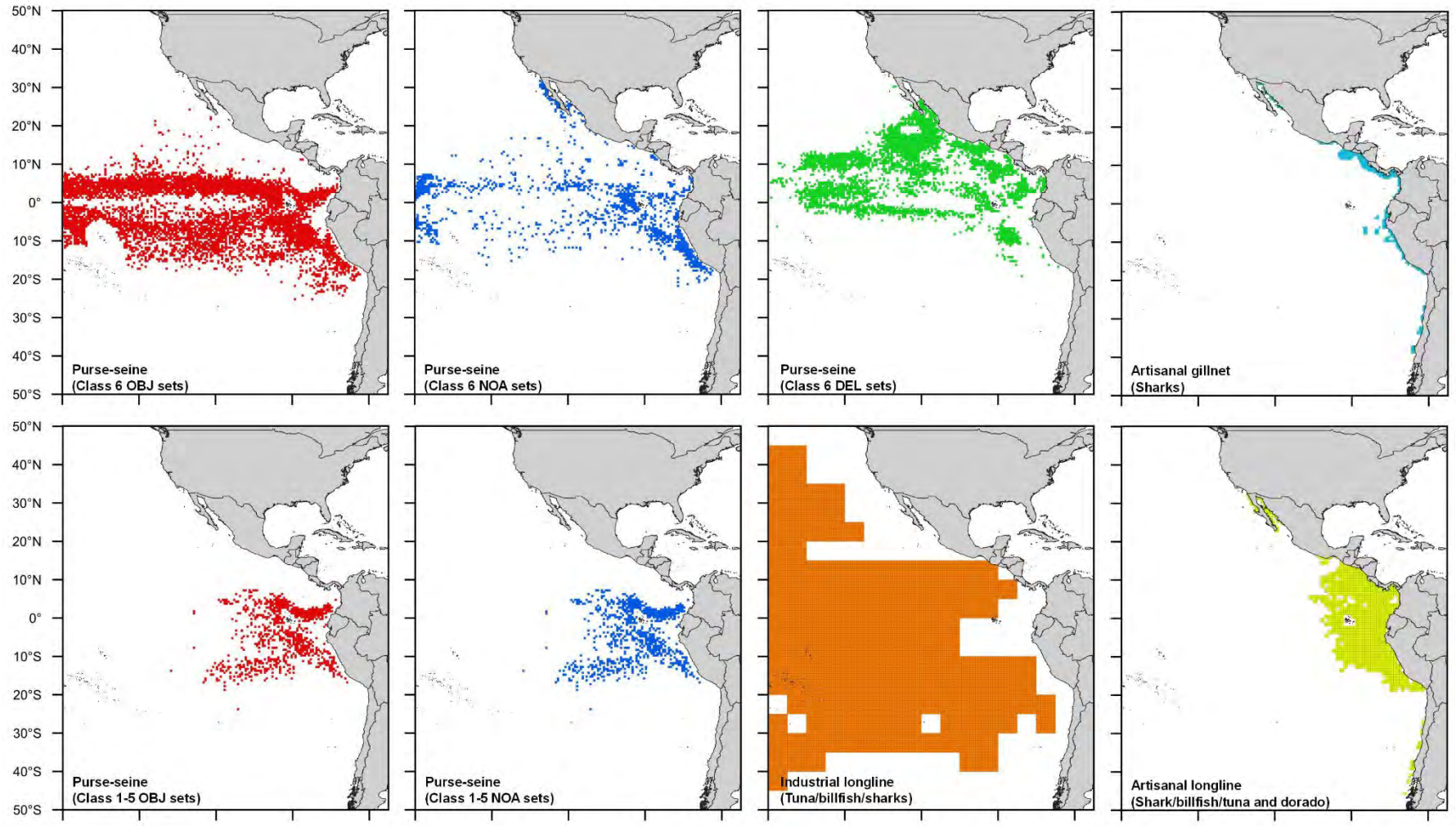


Definition of EPO Pelagic Fisheries

- 8 “pelagic” EPO fisheries included in the assessment
  - Industrial longline
  - Purse-seine (Class 6) with sub-fisheries NOA, OBJ, DEL
  - Purse-seine (Class 1-5) with sub-fisheries NOA, OBJ
  - Artisanal longline
  - Artisanal driftnet/gillnet

Distribution of fishing effort

- Spatially-explicit fishing effort for 2019 (most recent pre-COVID year) obtained from reported/observed/published data



Species assessed

- Interactions recorded with 49 shark species (excl. taxonomic groupings)
  - Reported/observed/published data
- Species recorded on >20 occasions assessed by EASI-Fish (**32 species**)
- Biological parameters collated and added to IATTC database (Project A.3.b)
  - Data quality scores applied (no data = 0; species-specific and regionally-specific data = 10)

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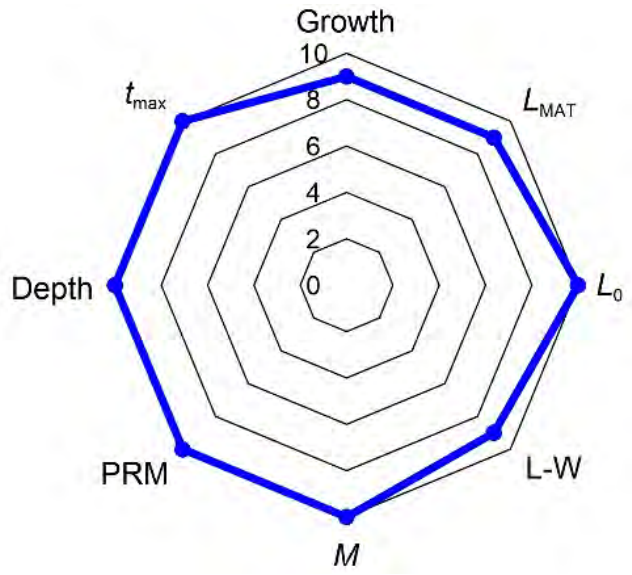
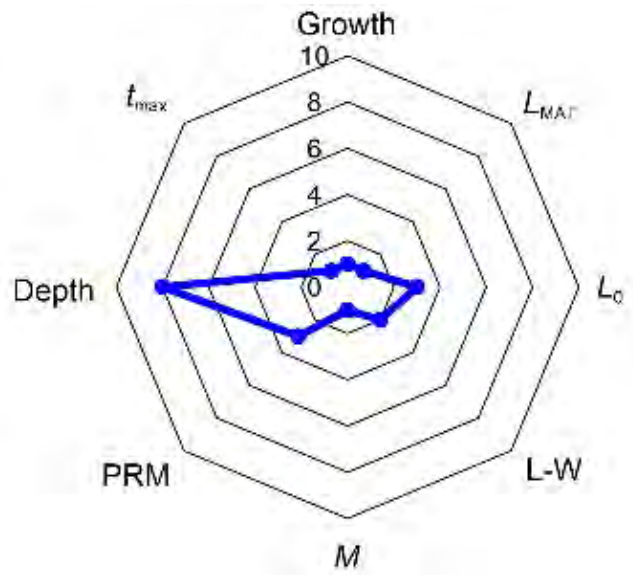
High quality data

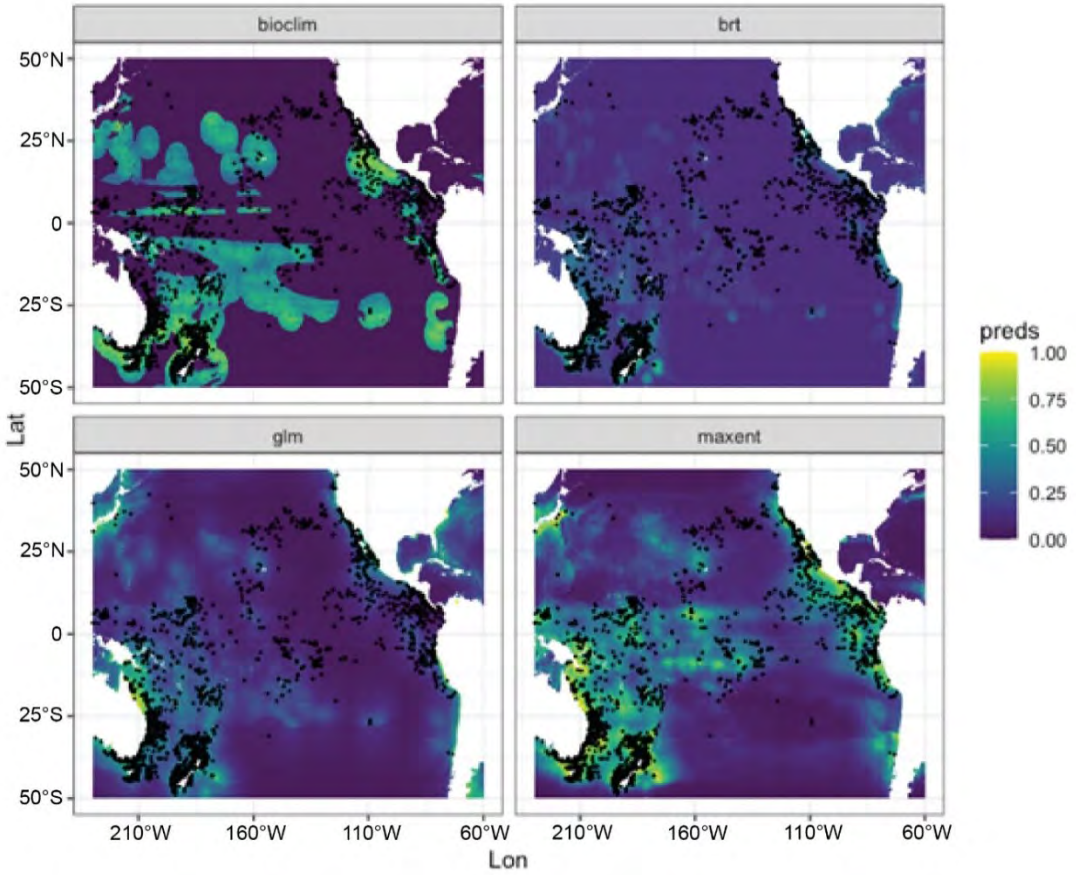


Low quality data



Species Distribution Models (SDMs)

- Presence data derived from SPC, IATTC and Aquamaps databases
- SDMs developed by SPC for each species – Bioclim, BRT, GLM, and MaxEnt



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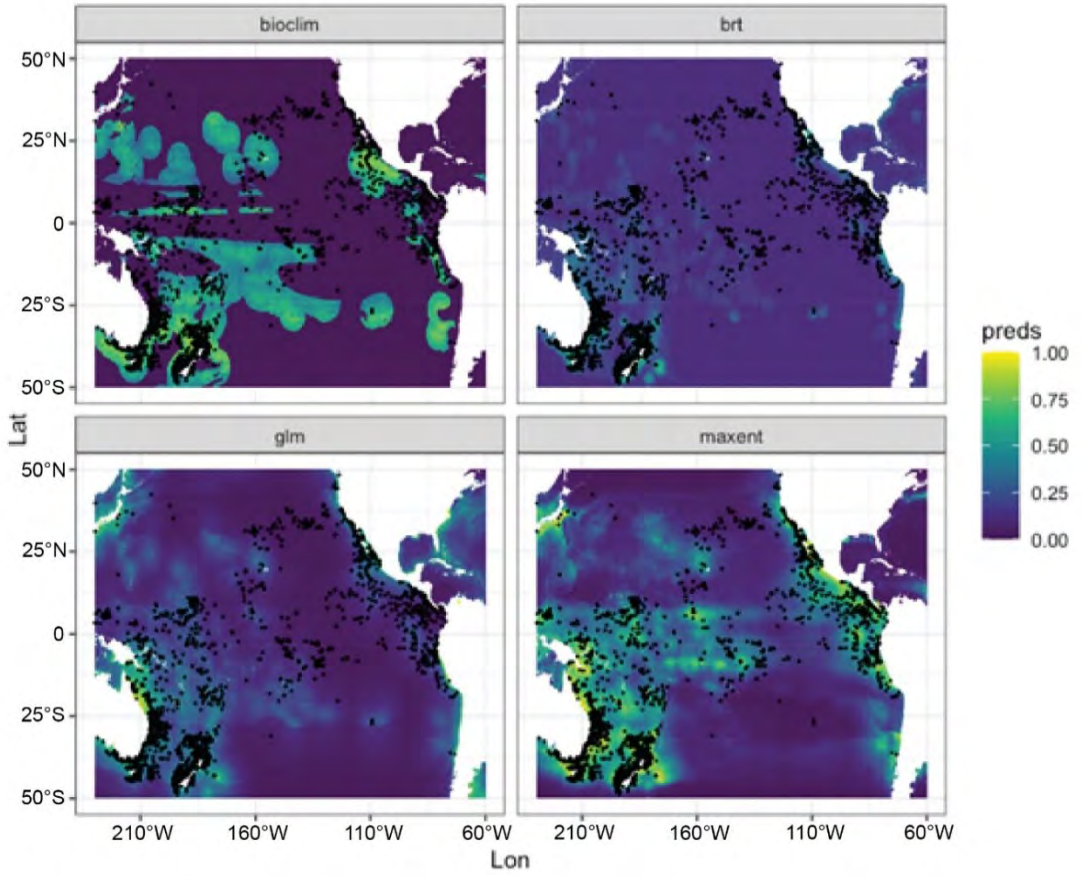
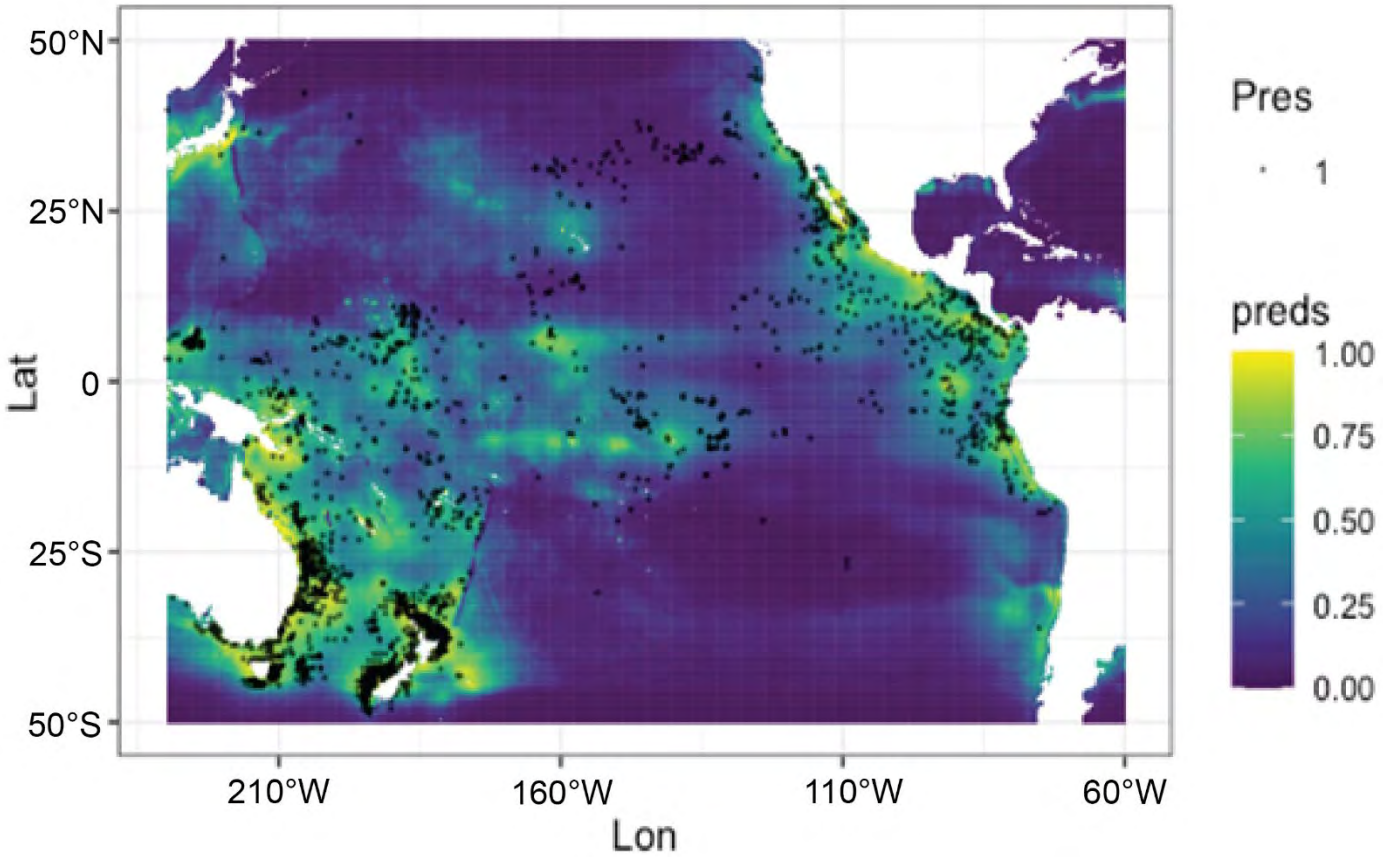
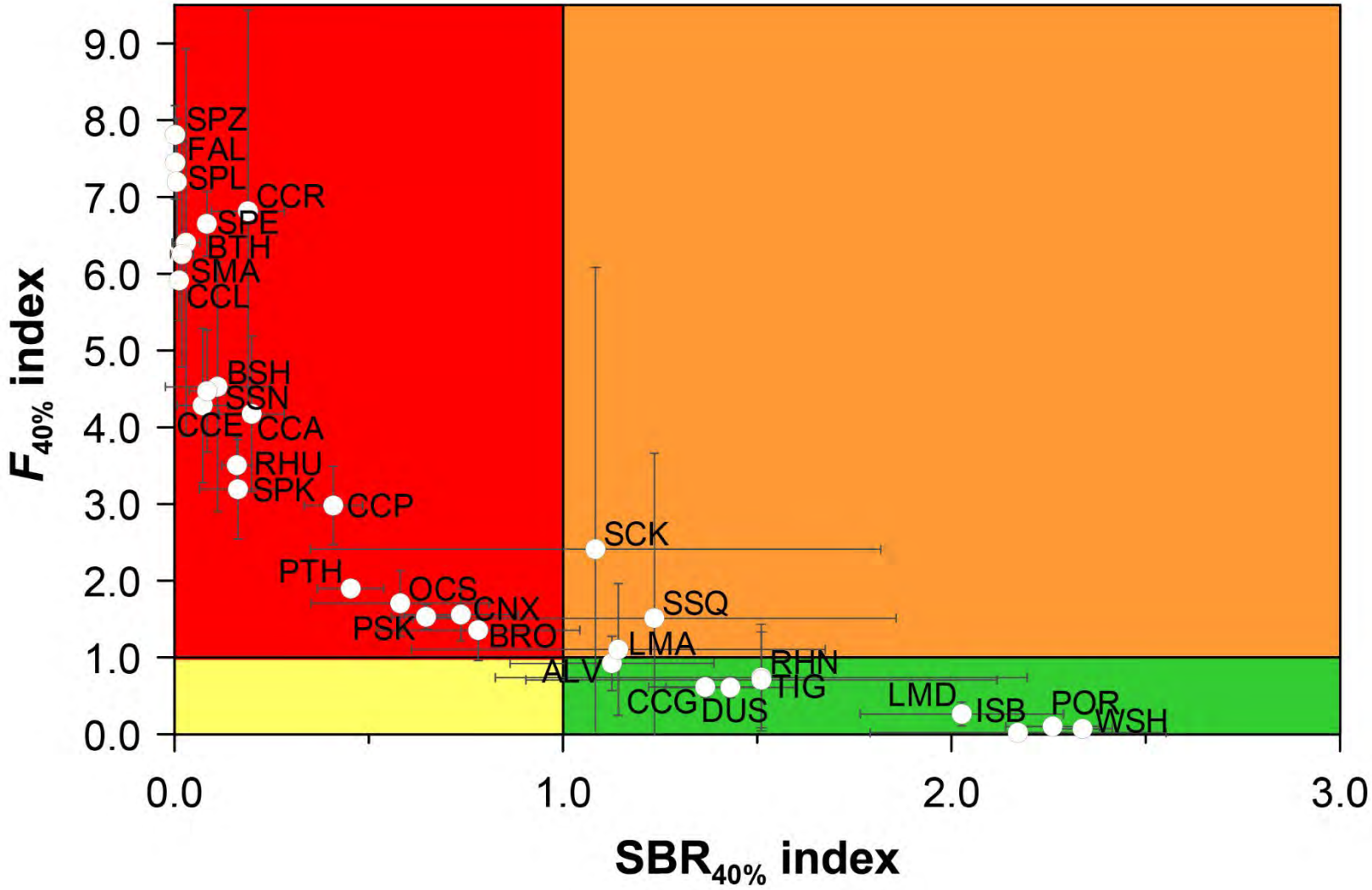
- Model ensemble used as final SDM





Results - 2019 Shark Vulnerability Status

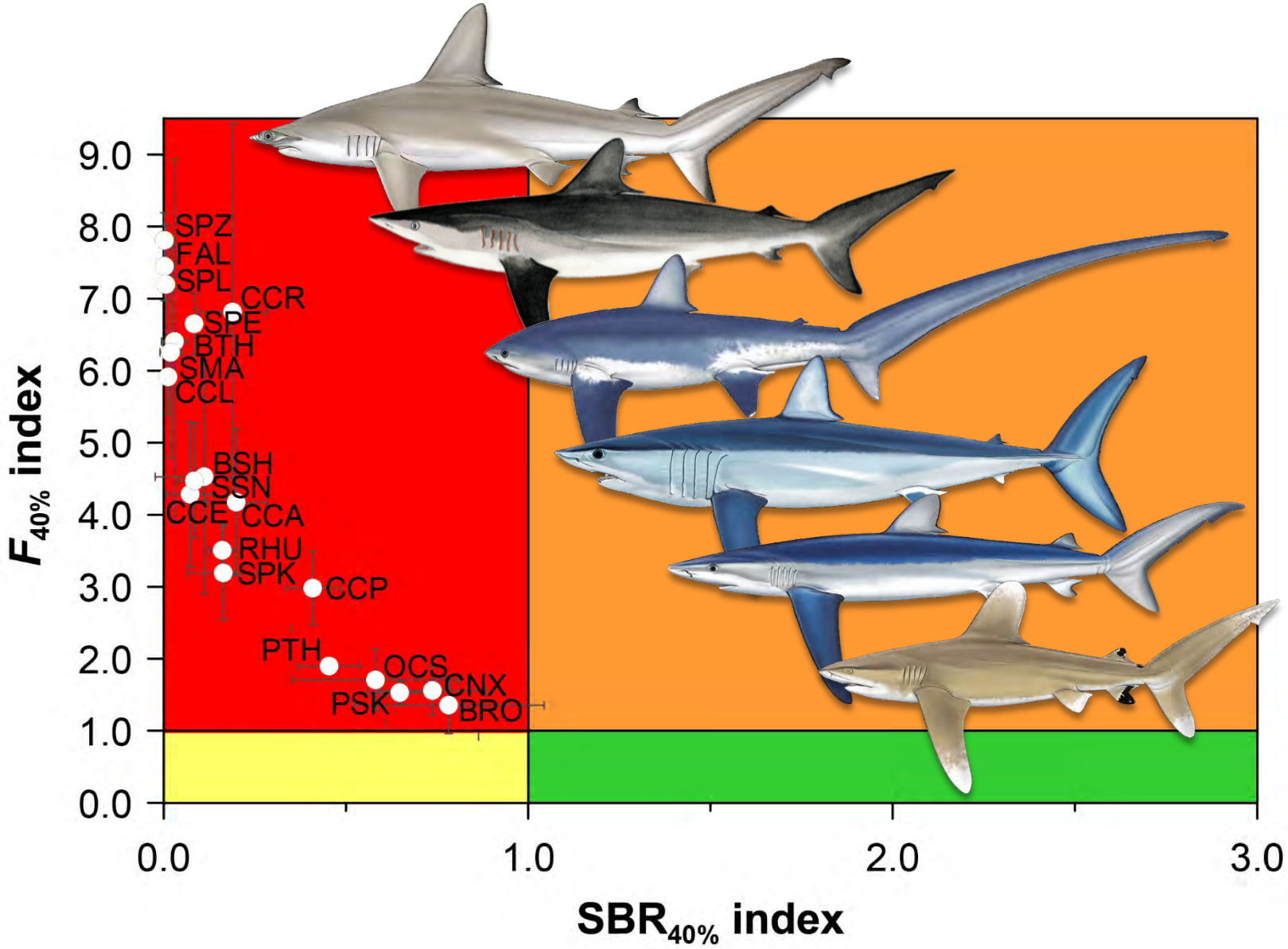
- 20 species "**most vulnerable**"
- 9 species "**Least vulnerable**"
- 3 species "**Increasingly vulnerable**"



“Most Vulnerable” Species

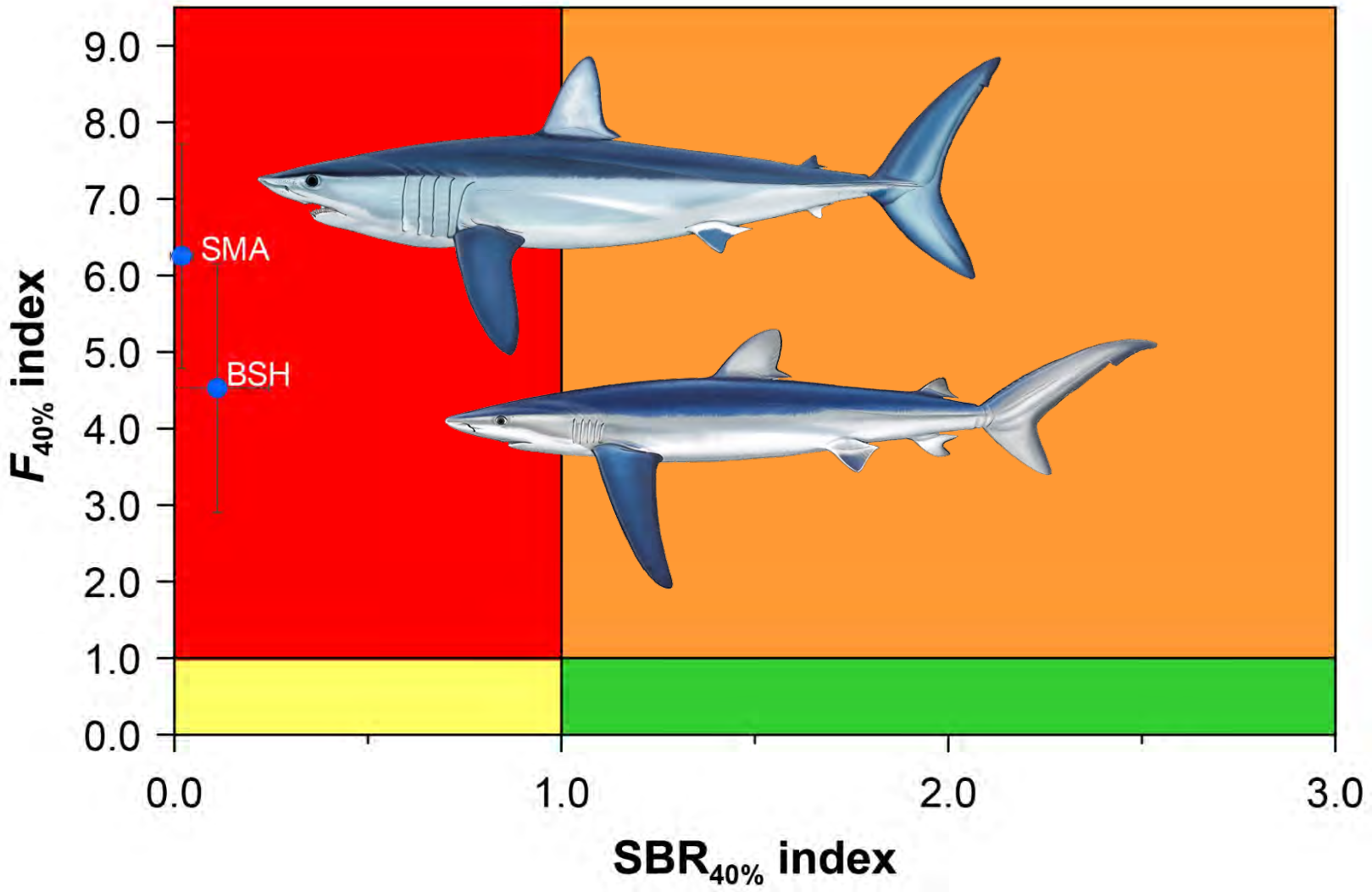
- 20 species “**most vulnerable**”

- Varied life histories
  - Pelagic lamnids
  - Mesopelagic crocodile shark
  - Hammerheads
  - Requiem sharks



Shortfin Mako and Blue sharks

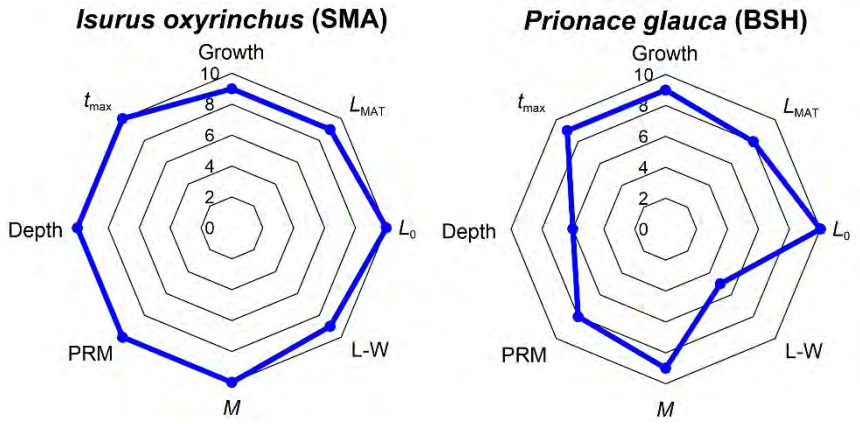
- Commercial target species
- ISC & WCPFC stock assessments guide managers

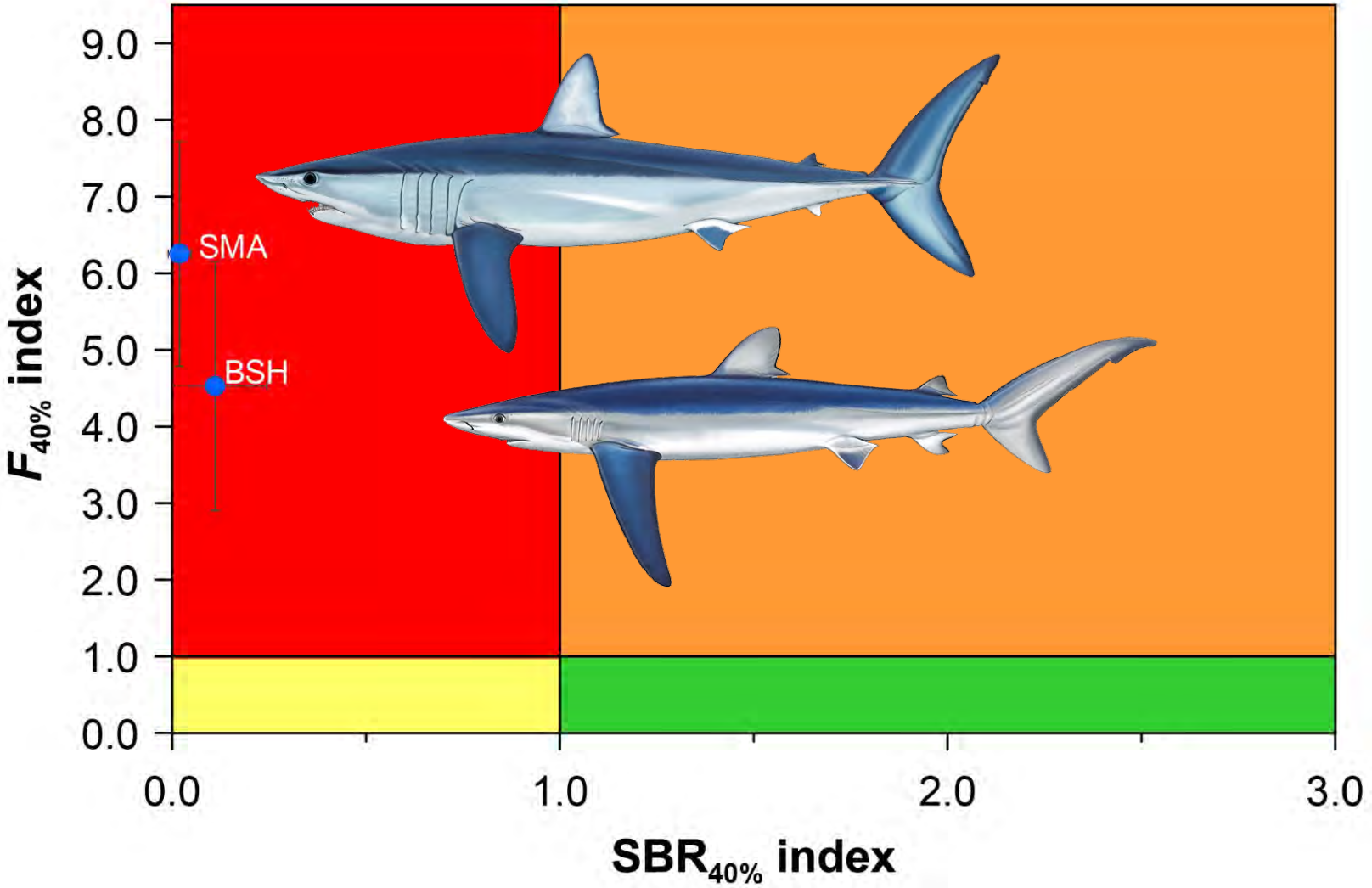


Shortfin Mako and Blue sharks

- Commercial target species
- ISC & WCPFC stock assessments guide managers
- Limited data for some fisheries (e.g. artisanal)

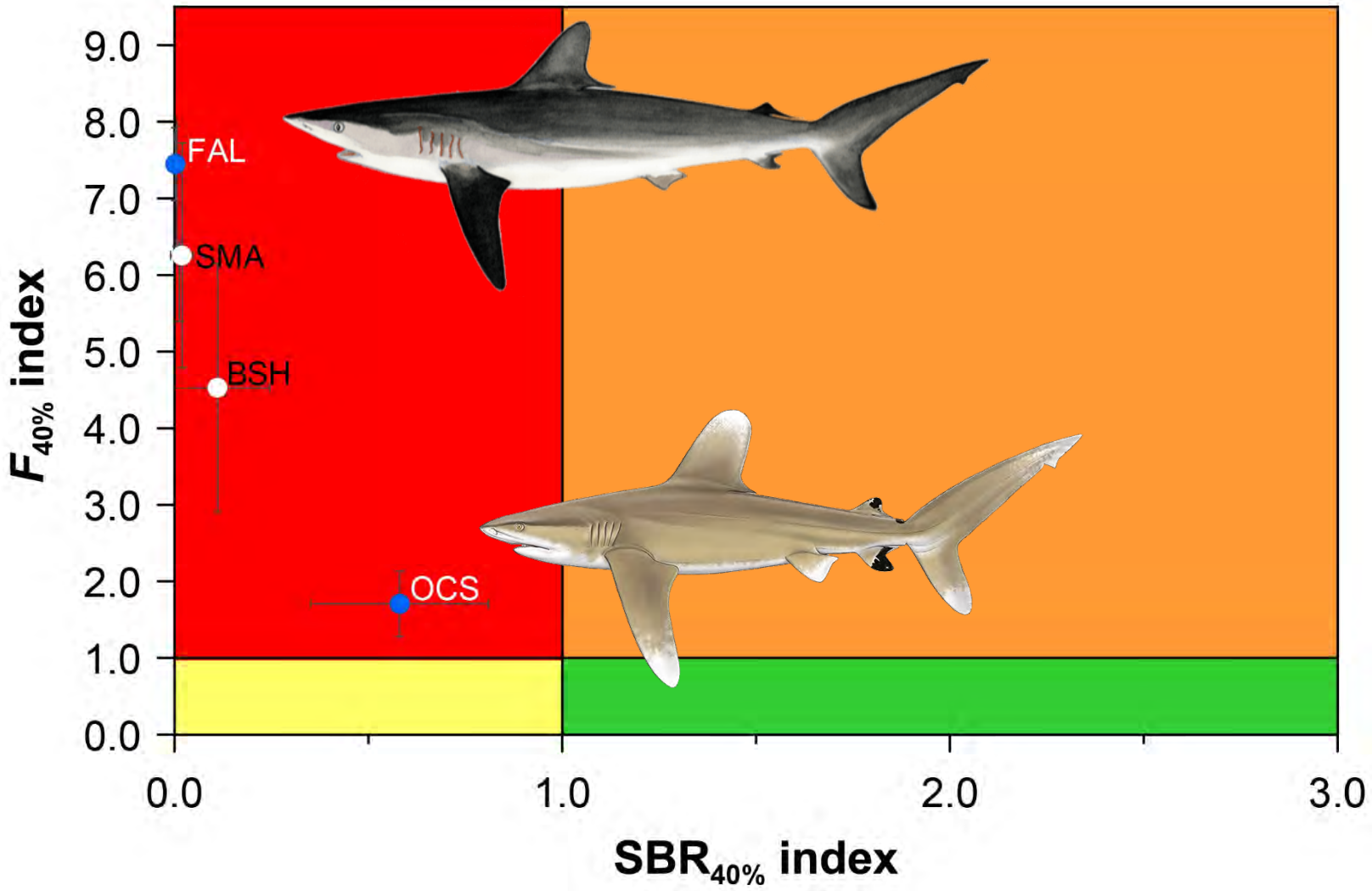
Data reliability scores





Silky and Oceanic Whitetip sharks

- Silky 2nd highest rank
- Pacific stock assessment
- OCS no retention and PRS high



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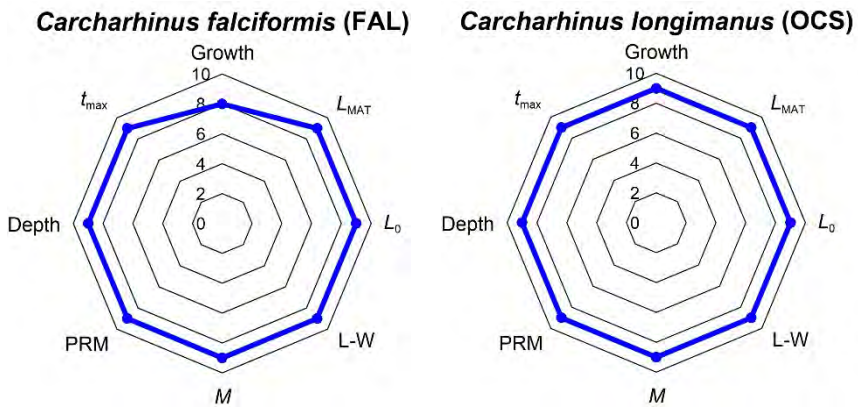
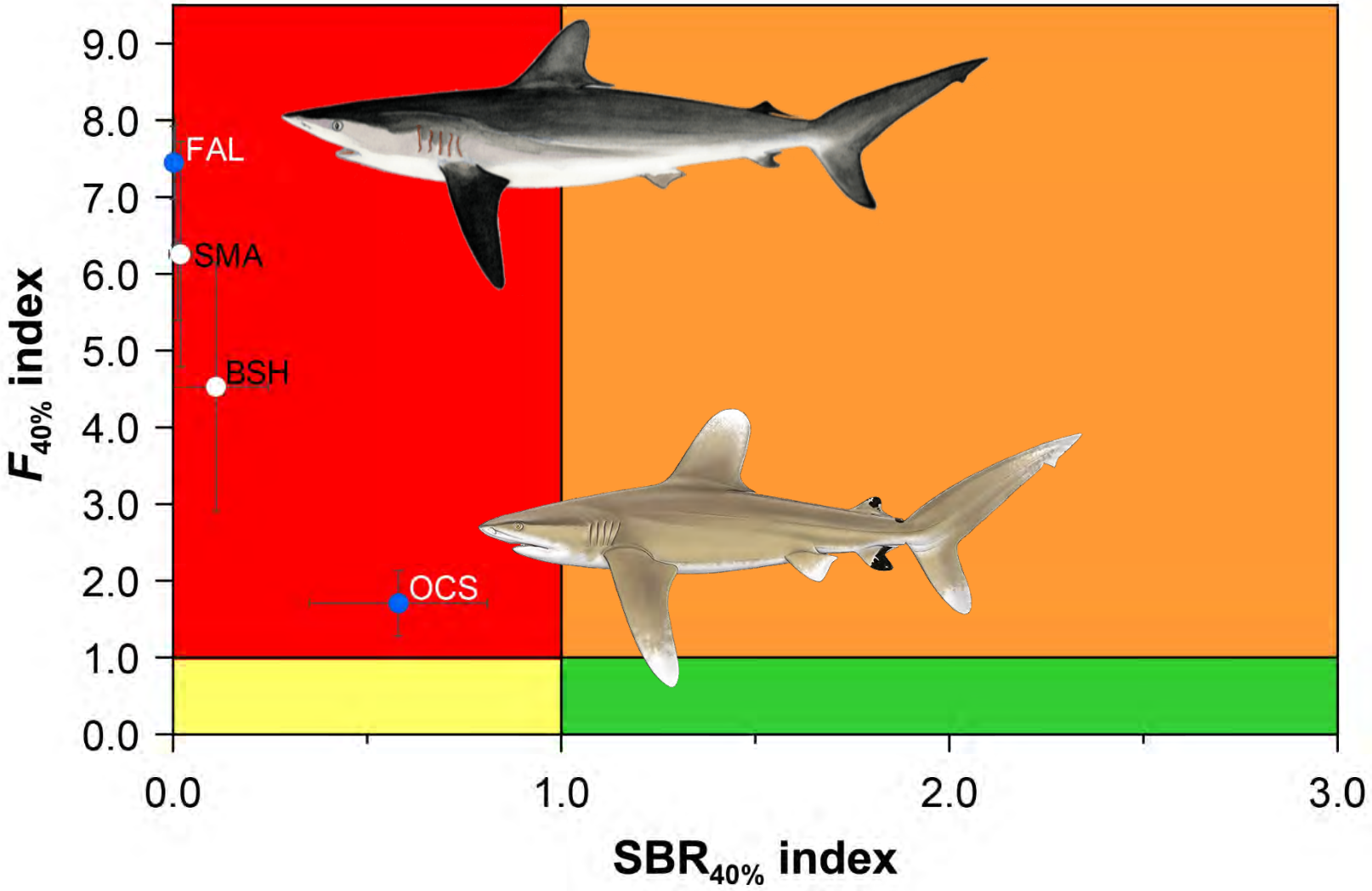
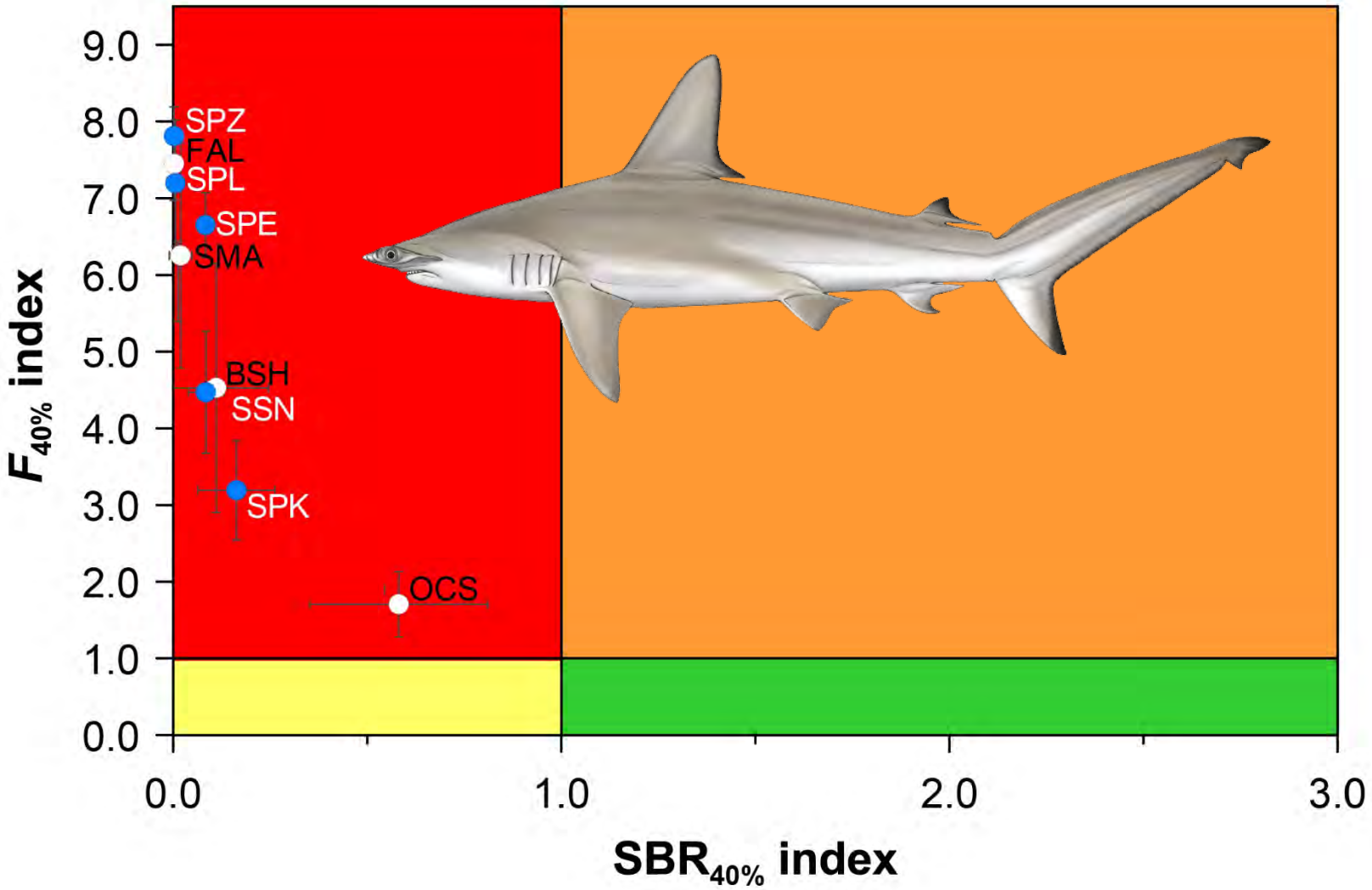




Hammerheads (*Sphyrna* spp.)

- *S. zygaena* highest ranked
- No stock assessments
- Local extinction concerns
  - *S. corona* (1994)
  - *S. media* & *S. tiburo:* 3 in 40 yrs
- Limited artisanal fishery data



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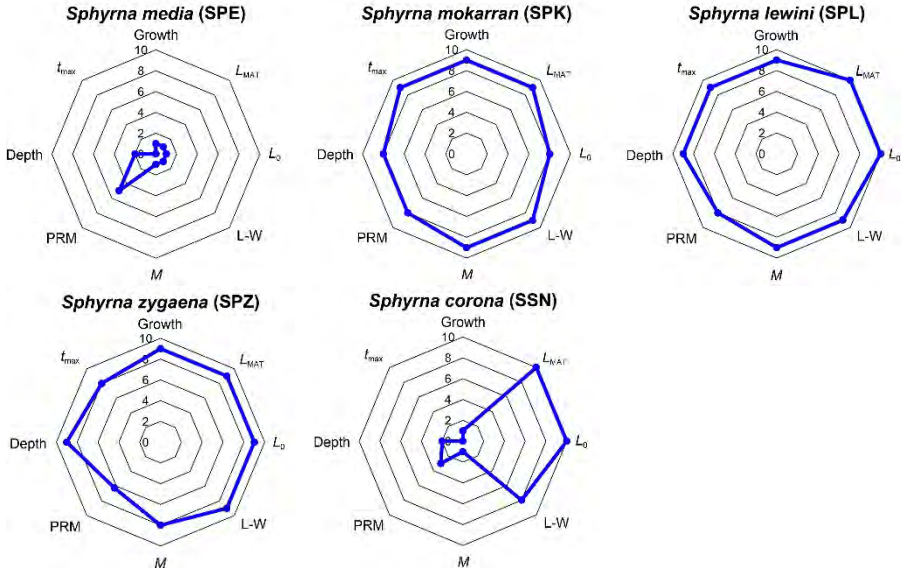
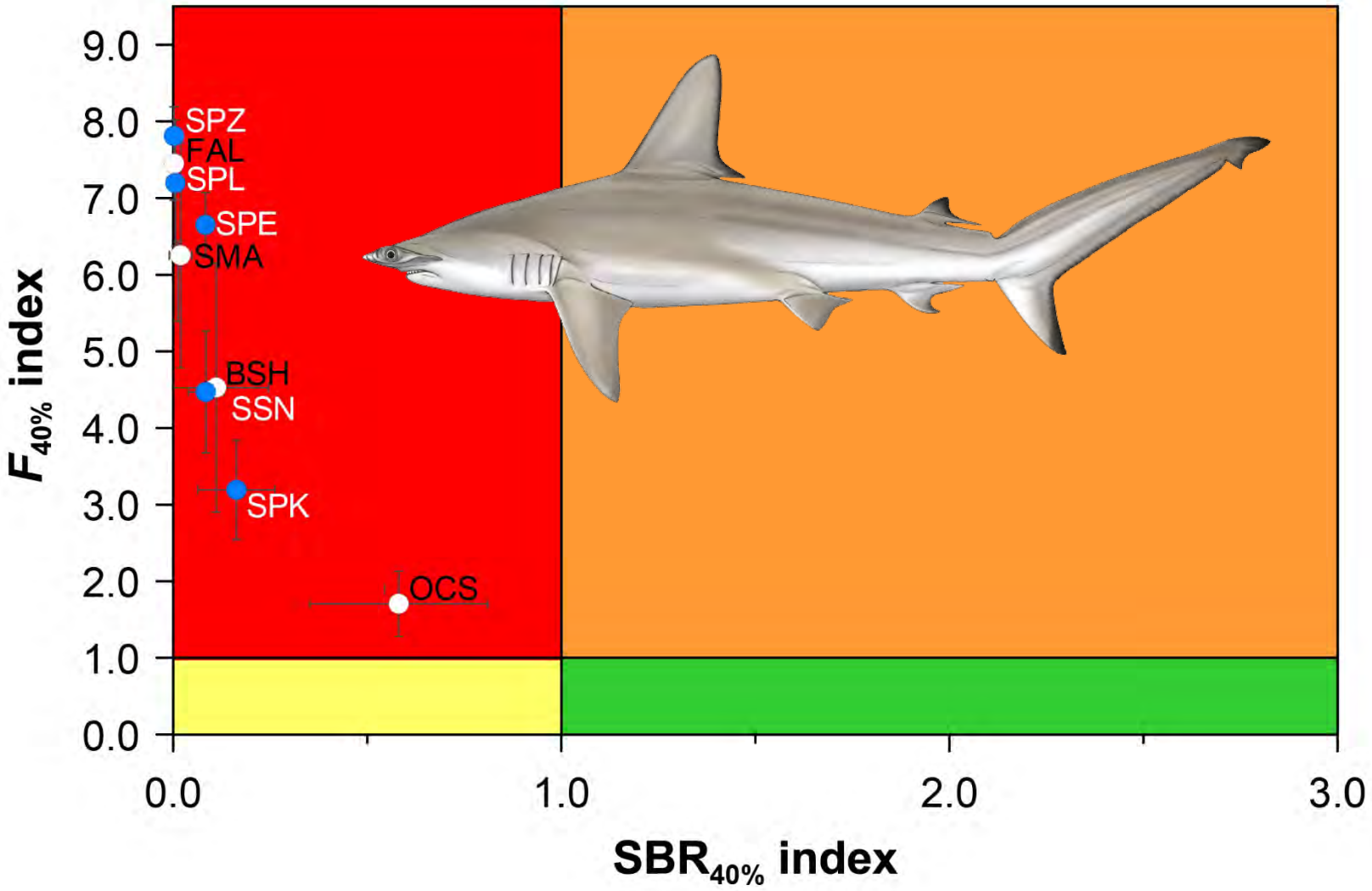
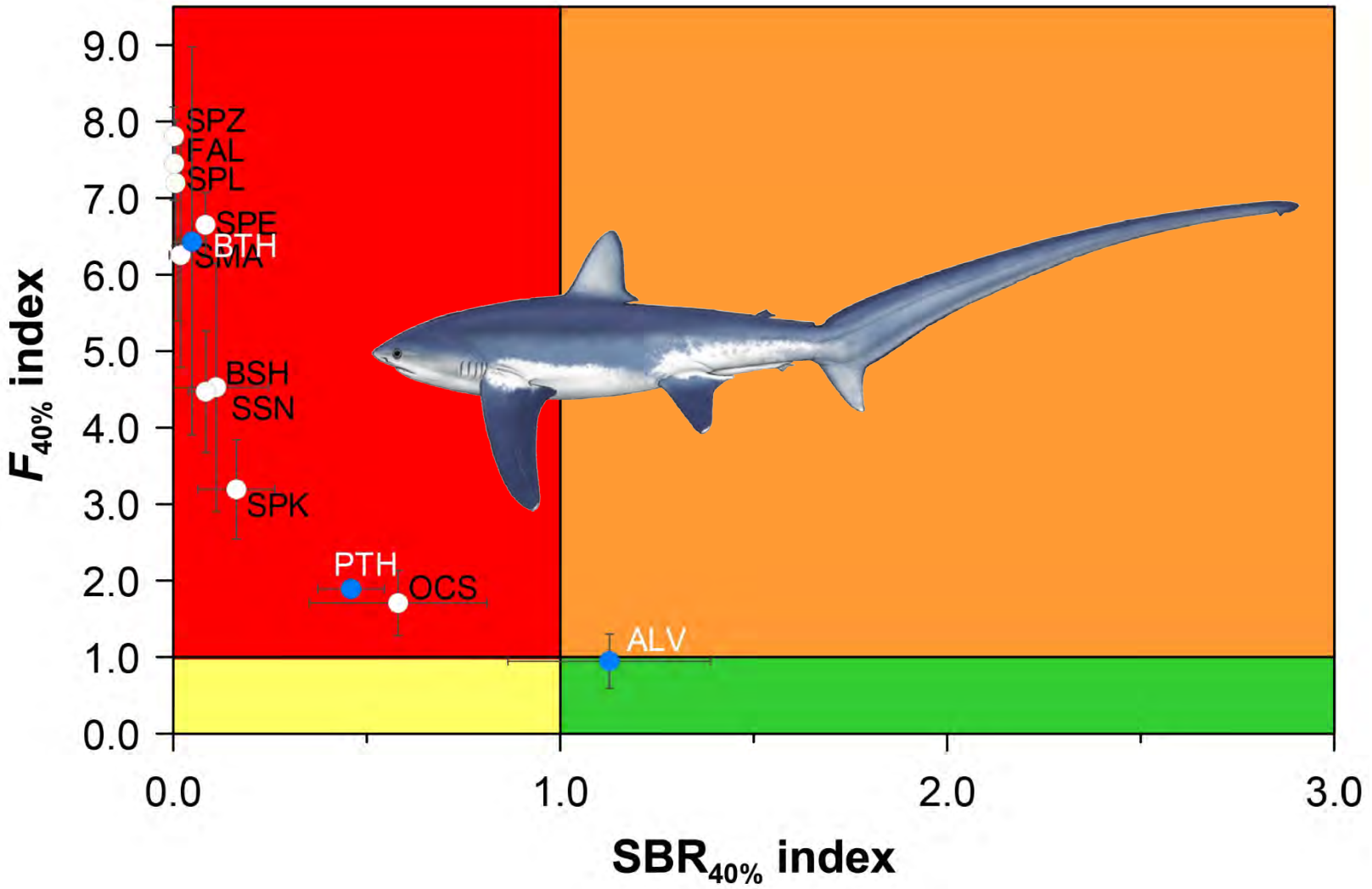




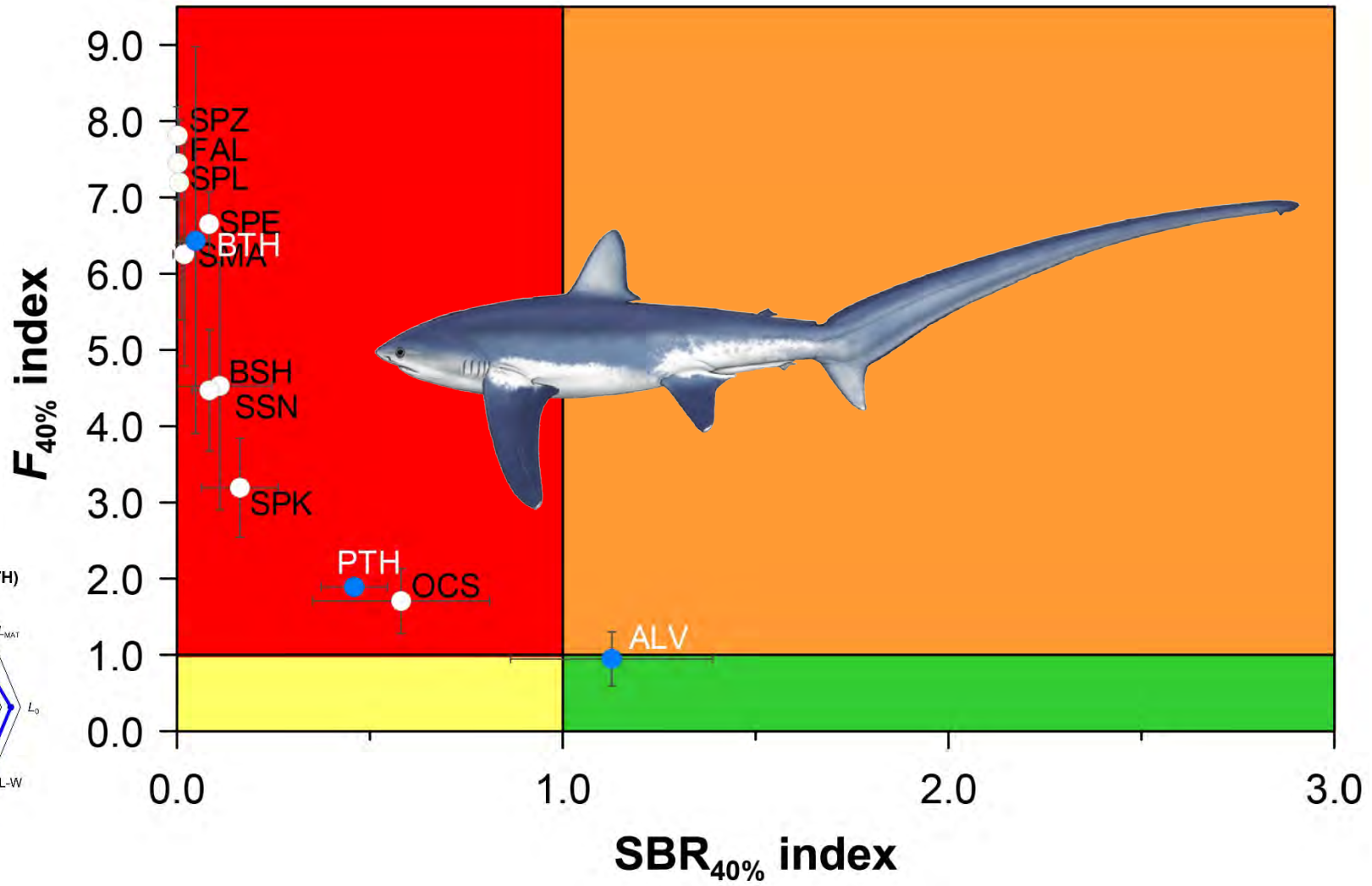
Threshers (*Alopias* spp.)

- ALV US stock assessment
- Little PRM data

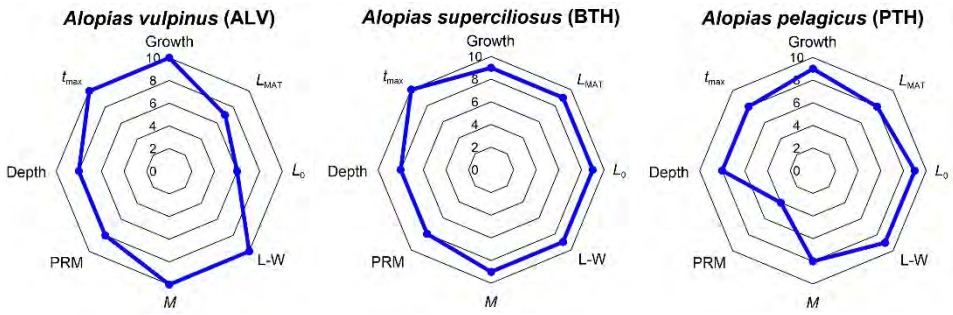


Threshers (*Alopias* spp.)

- ALV US stock assessment
- Little PRM data
- PTH highest catch in artisanal offshore fleet (Martínez-Ortiz et al. 2015), but limited data for most artisanal fisheries

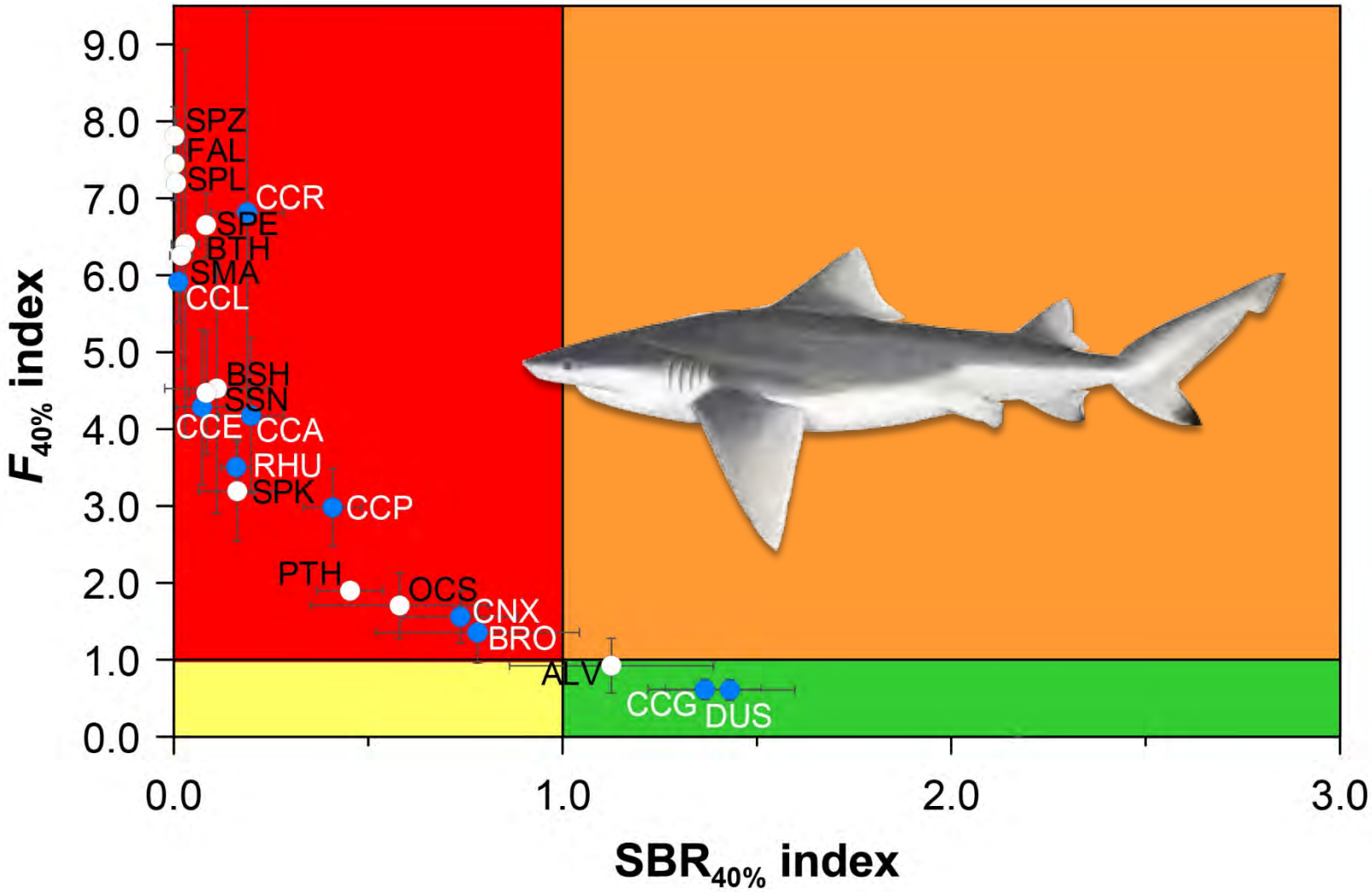


Data reliability scores



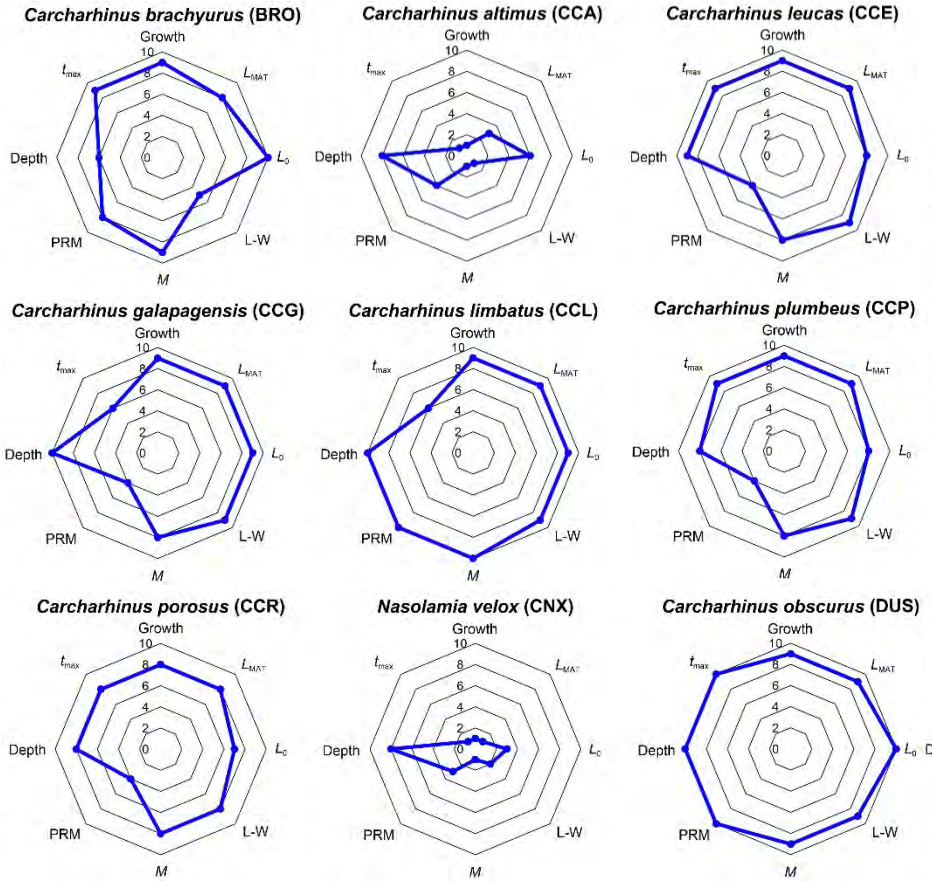
Requiem sharks (Carcharhinidae)

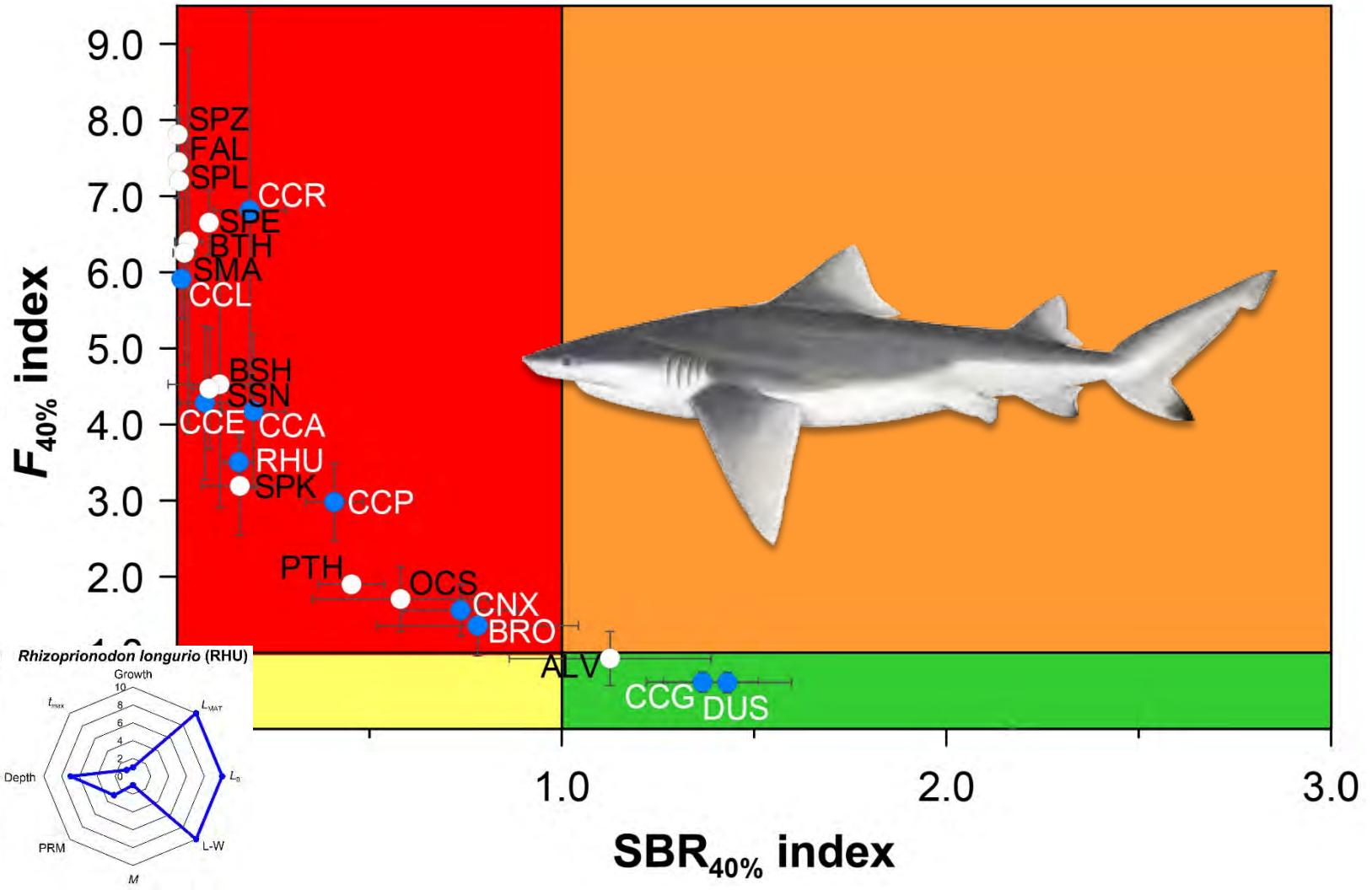
- Most small-growing species
- No stock assessments
- Local extinctions (*C. porosus)*



Requiem sharks (Carcharhinidae)

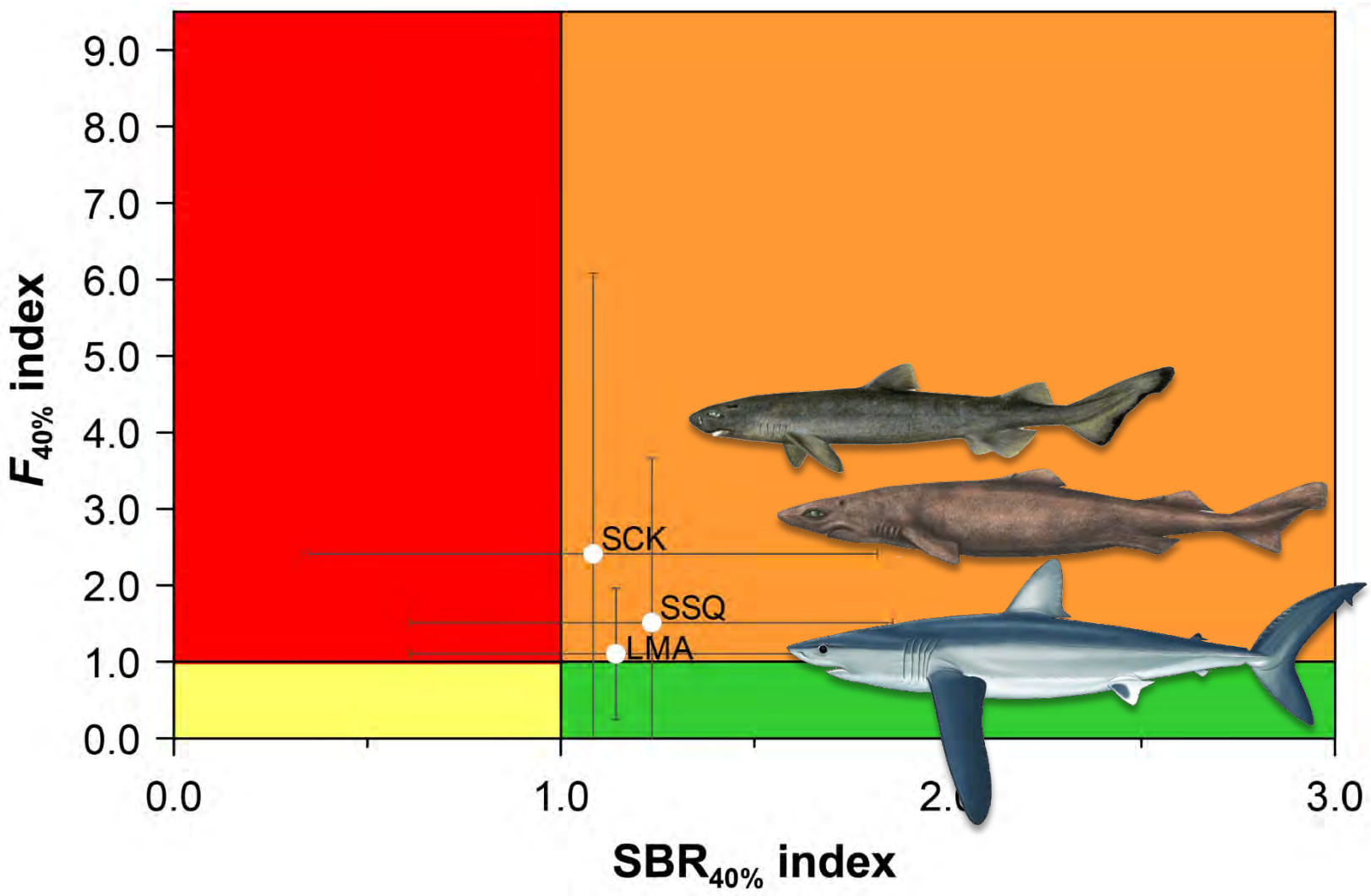
- Identification issues
  C. porosus/C. cerdale
- Limited artisanal fishery data





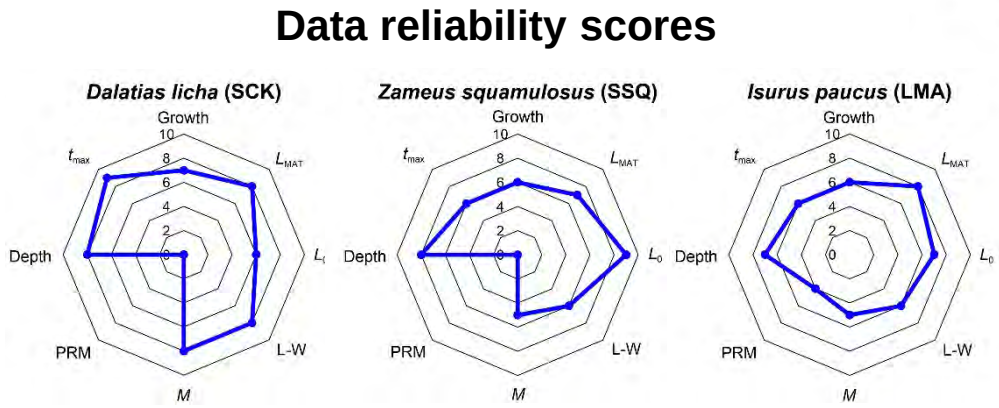
“Increasingly Vulnerable” Species

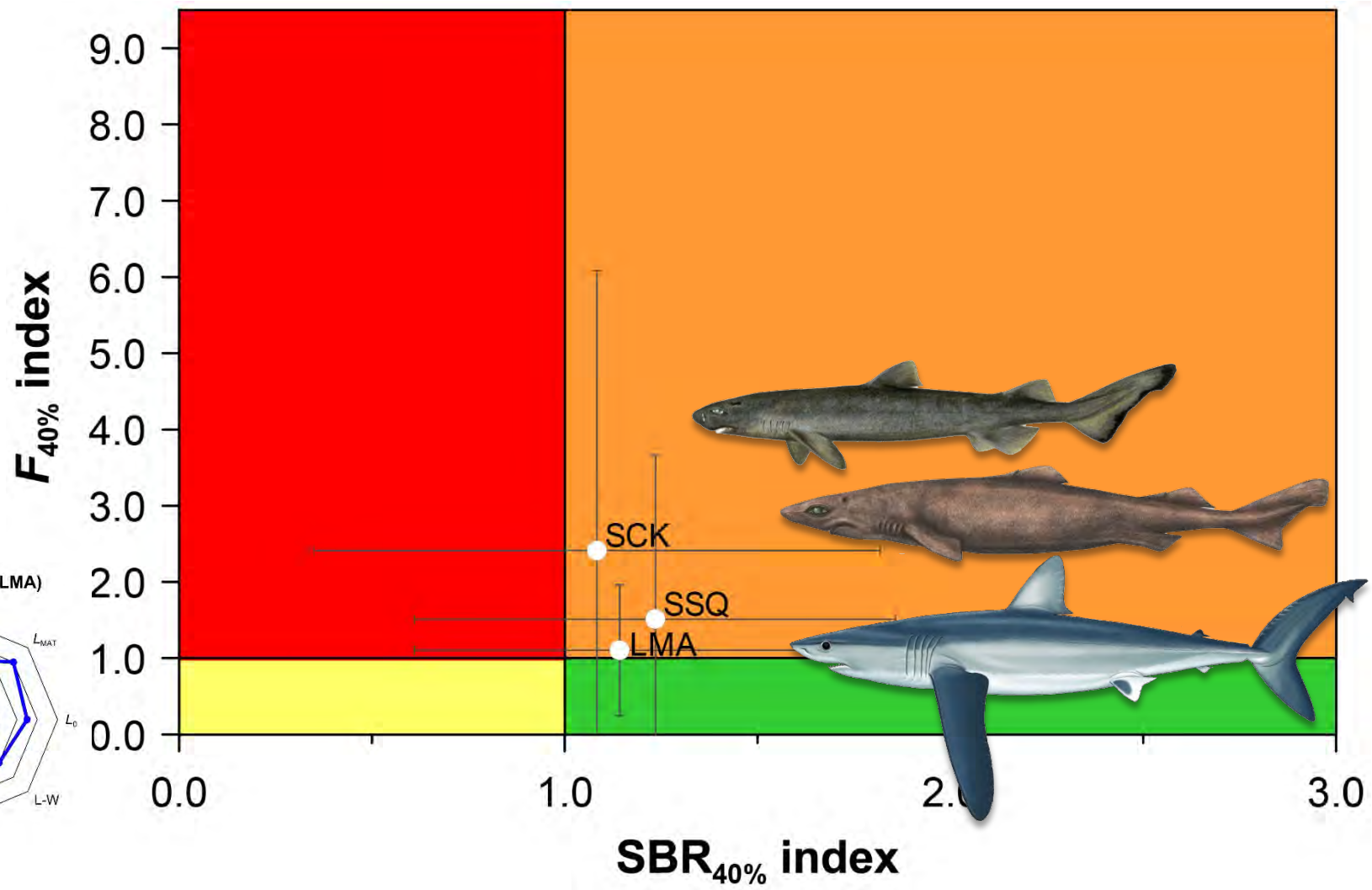
- 3 species “**increasingly vulnerable**”
- Mesopelagic sleeper sharks
- Longfin mako



“Increasingly Vulnerable” Species

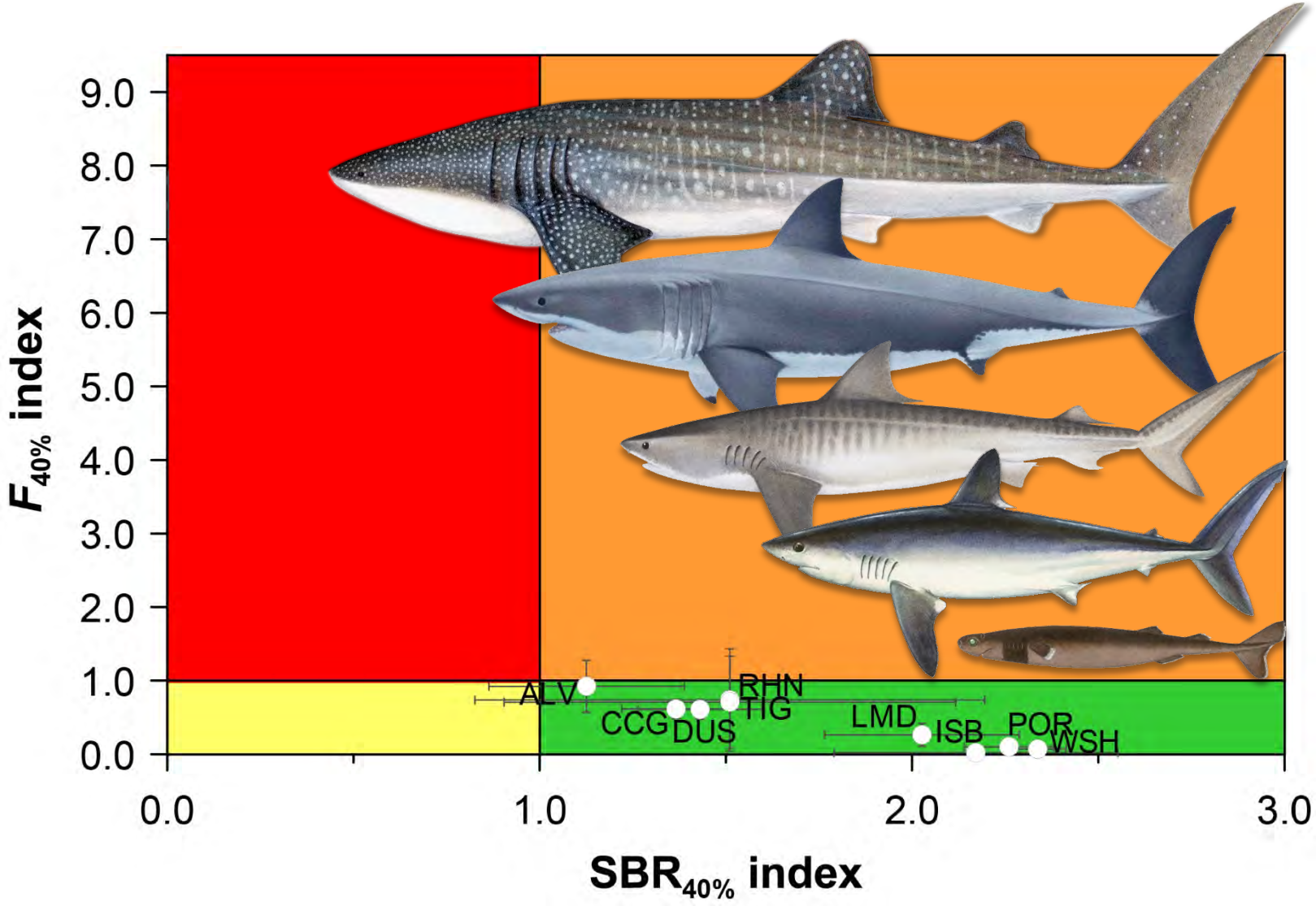
- 3 species “**increasingly vulnerable**”
- Mesopelagic sleeper sharks
- Longfin mako
- Low data reliability
- High status uncertainty





“Least Vulnerable” Species

- 9 “**Least vulnerable**” species
- Several listed species
- Coastal distributions
- Encounterability low
- PRM low



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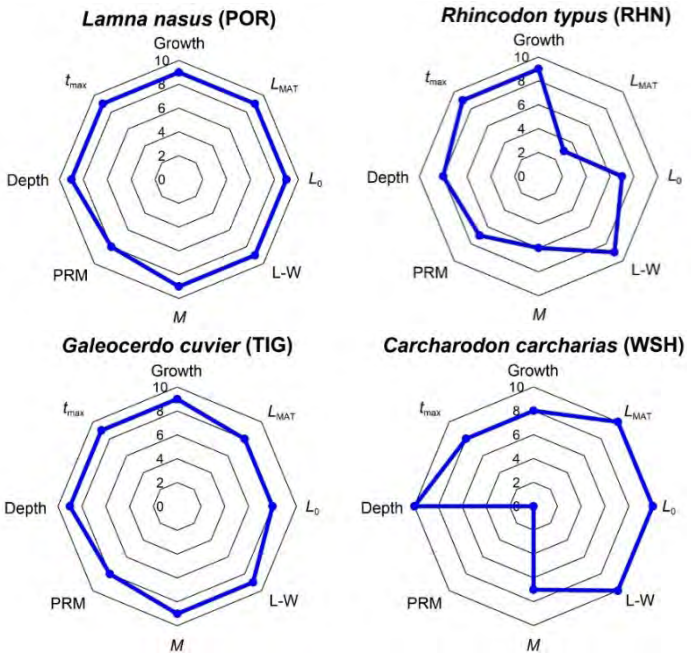

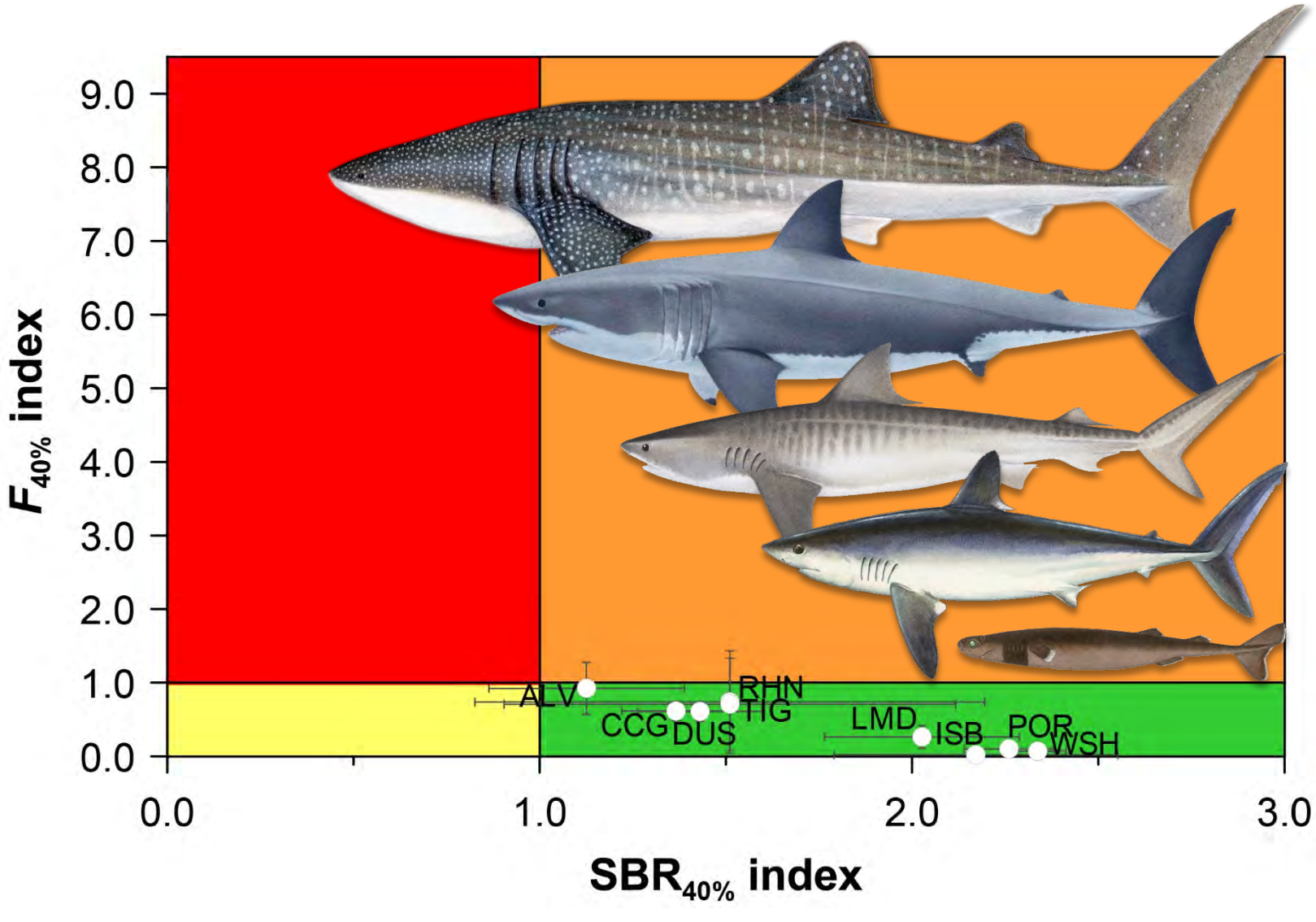

Conclusions

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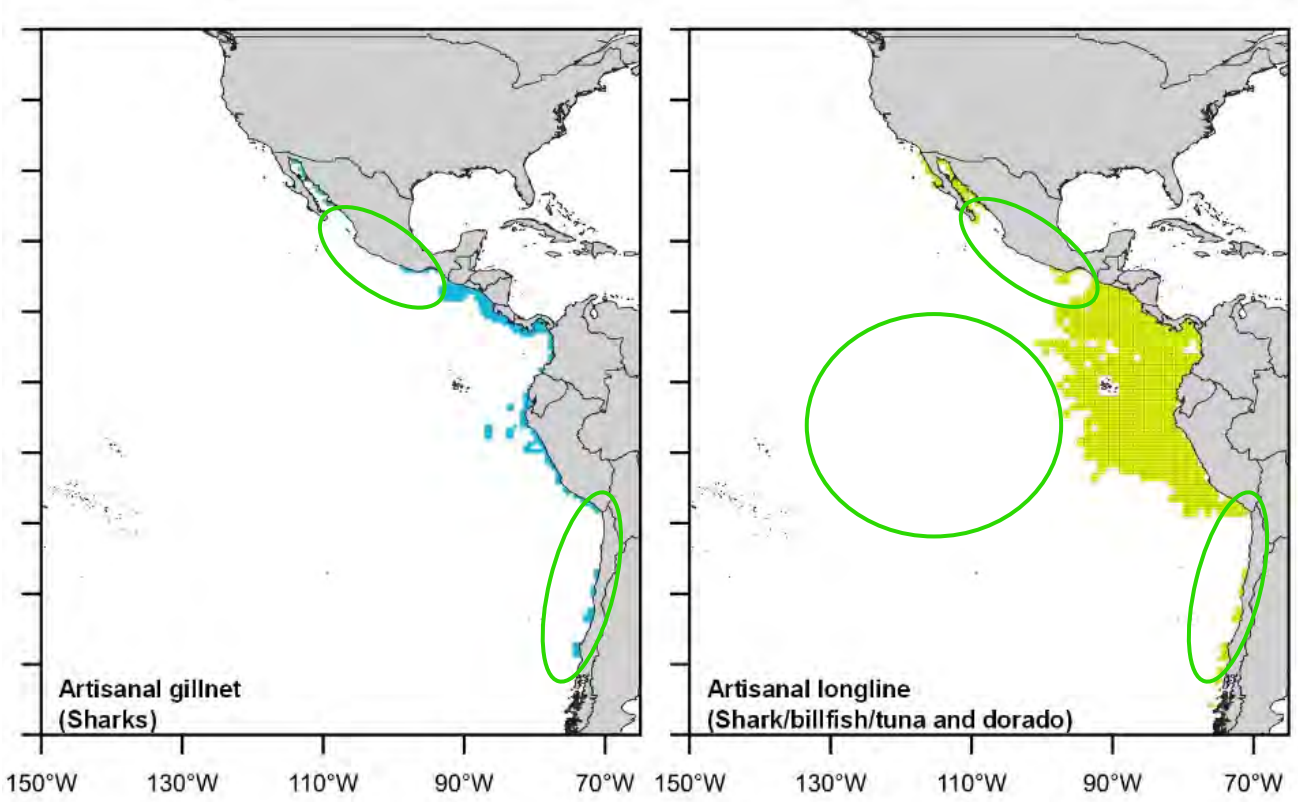
- Artisanal effort is underrepresented, so vulnerability likely higher.



Conclusions

- EASI-Fish allows prioritization of species for research & management
- Some species not only “most vulnerable” but possible risk of extirpation
  - *Sphyrna corona, S. media* & *S. tiburo* recorded a few times in the past 40 years
  - *Carcharhinus porosus/C. cerdale*
- Clearly, bycatch and biological data are insufficient for many species
- Article IV. Application of the Precautionary Approach
  - 2. “The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures.”
  - 3. “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…”

Considerations for future work

- Improve bycatch and effort reporting in all EPO fleets
  - Spatial effort data required for EASI-Fish overlap estimates
  - Species identification training - “Shark unidentified”, “Thresher, nei” are lost data opportunities
- Artisanal fisheries - use established methods (e.g. GEF ABNJ pilot) to implement a long-term monitoring program
- Increase observer coverage (human and/or EM) of key fisheries
  - Industrial longline (currently 5%, staff recommended at least 20%)
  - Purse-seine Class 1-5 (TUNACONS 12% in 2019)
- Revision of *Resolution on Data Provision* C-03-05 (workshops 2022/23)

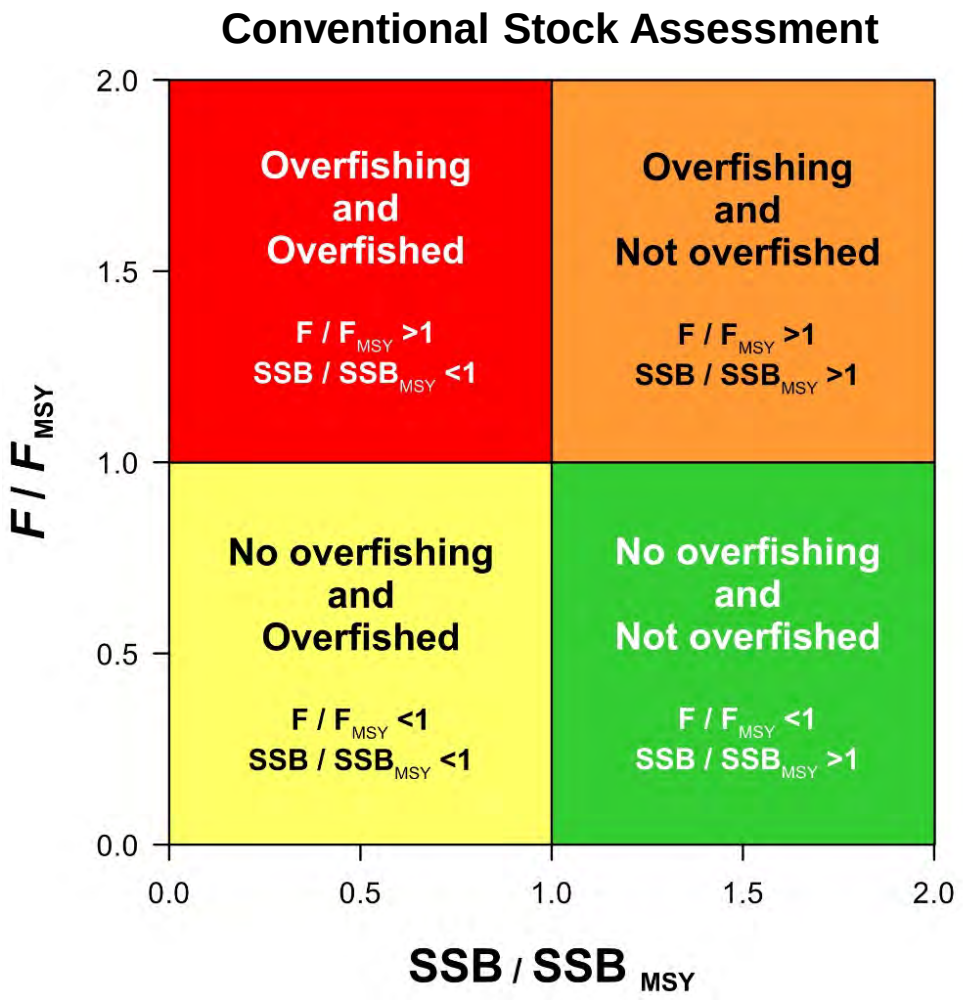
Considerations for future work

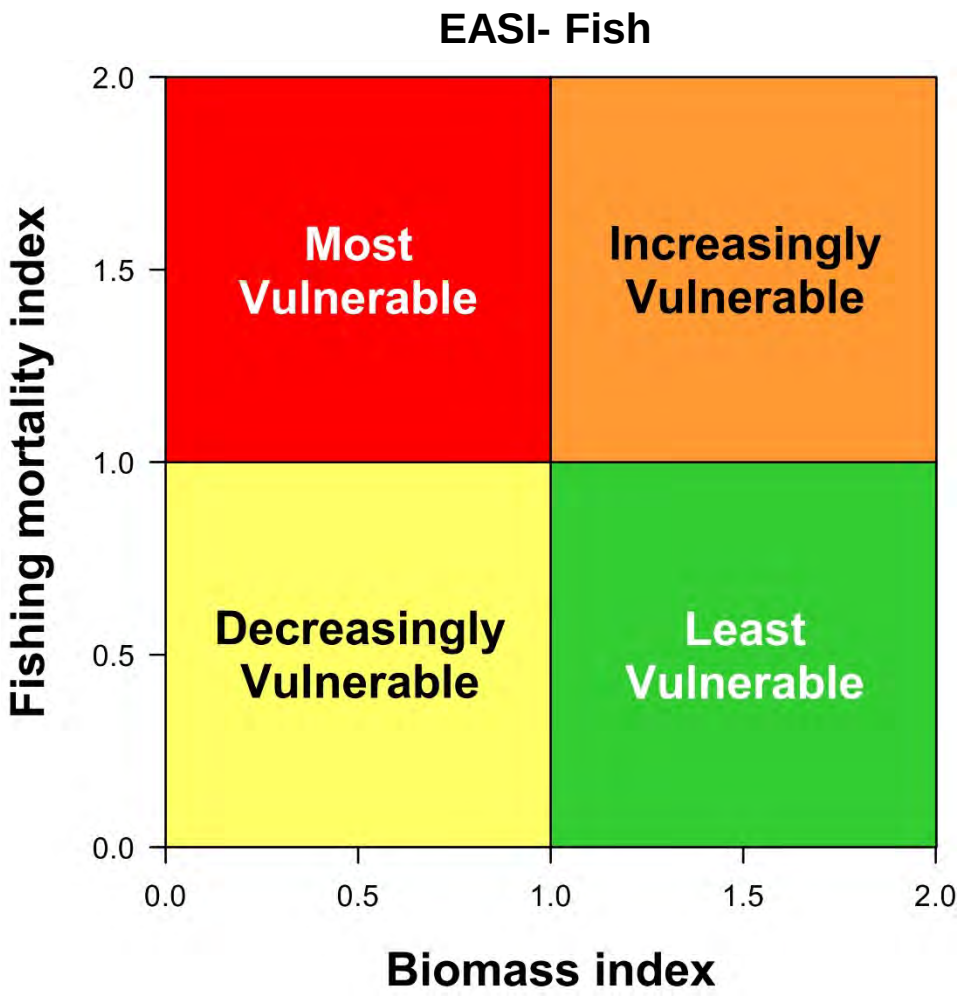
- Improve basic biological information on shark bycatch species in EPO
  - Length-weight and length-length relationships
  - Maturity ogives
  - Growth curves
- Consider partnering of IATTC, CPC ministries, and research institutions
  - IATTC SSP Goal Q: Provide training opportunities for scientists and technicians of CPCs
  - IATTC “Capacity building fund” - Technical Assistance for Developing Countries (CAF-08-03)
- Post-release survival tagging studies required (assumed 100% mortality)
- In absence of data for hammerhead and silky shark stock assessments (C-16-05), EASI-Fish can assess relative efficacy of potential CMMs

Questions?

Defining vulnerability status

- Similar reference points can define vulnerability





Vulnerability Status

- Improve species identification and catch/effort reporting in all fleet

Code	Species	$F_{2019}/F_{40\%}$	$F_{2019}/F_{40\%}$ Std Dev	$SBR_{2019}/SBR_{40\%}$	$SBR_{2019}/SBR_{40\%}$ Std Dev
ALV	*Alopias vulpinus*	0.924	0.355	1.126	0.262
BRO	*Carcharhinus brachyurus*	1.356	0.396	0.782	0.262
BSH	*Prionace glauca*	4.526	1.623	0.111	0.134
BTH	*Alopias superciliosus*	6.404	2.526	0.030	0.036
CCA	*Carcharhinus altimus*	4.173	1.014	0.199	0.084
CCE	*Carcharhinus leucas*	4.284	1.006	0.073	0.066
CCG	*Carcharhinus galapagensis*	0.615	0.131	1.366	0.146
CCL	*Carcharhinus limbatus*	5.911	0.520	0.012	0.007
CCP	*Carcharhinus plumbeus*	2.980	0.508	0.409	0.075
CCR	*Carcharhinus porosus*	6.814	2.616	0.189	0.094
CNX	*Nasolamia velox*	1.559	0.339	0.737	0.147
DUS	*Carcharhinus obscurus*	0.610	0.133	1.431	0.167
FAL	*Carcharhinus falciformis*	7.447	0.477	0.002	0.001
ISB	*Isistius brasiliensis*	0.021	0.020	2.171	0.381
LMA	*Isurus paucus*	1.104	0.858	1.142	0.533
LMD	*Lamna ditropis*	0.264	0.154	2.026	0.262

Code	Species	$F_{2019}/F_{40\%}$	$F_{2019}/F_{40\%}$ Std Dev	$SBR_{2019}/SBR_{40\%}$	$SBR_{2019}/SBR_{40\%}$ Std Dev
OCS	*Carcharhinus longimanus*	1.706	0.427	0.581	0.229
POR	*Lamna nasus*	0.102	0.051	2.260	0.121
PSK	*Pseudocarcharias kamoharai*	1.529	0.159	0.648	0.089
PTH	*Alopias pelagicus*	1.903	0.084	0.446	0.037
RHN	*Rhincodon typus*	0.738	0.694	1.510	0.684
RHU	*Rhizoprionodon longurio*	3.504	0.380	0.161	0.039
SCK	*Dalatias licha*	2.411	3.670	1.083	0.734
SMA	*Isurus oxyrinchus*	6.254	1.468	0.019	0.029
SPE	*Sphyrna media*	6.648	0.422	0.083	0.011
SPK	*Sphyrna mokarran*	3.192	0.649	0.163	0.099
SPL	*Sphyrna lewini*	7.196	0.821	0.006	0.003
SPZ	*Sphyrna zygaena*	7.808	0.382	0.002	0.001
SSN	*Sphyrna corona*	4.470	0.794	0.084	0.046
SSQ	*Zameus squamulosus*	1.512	2.147	1.235	0.622
TIG	*Galeocerdo cuvier*	0.708	0.624	1.511	0.606
WSH	*Carcharodon carcharias*	0.070	0.032	2.337	0.076

Species distribution models (SDMs)

- SDMs developed for 32 species