Use of productivity and susceptibility indices to evaluate vulnerability in the purse-seine fishery of the eastern Pacific Ocean

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Scientific Advisory Committee, 1st Meeting

1ª Reunión del Comité Científico Asesor

Resolutions to reduce incidence of bycatch of non-target species

INTER-AMERICAN TROPICAL TUNA COMMISSION

74TH MEETING

PUSAN (KOREA)
26-30 JUNE 2006

RESOLUTION C-04-05 (REV 2)

CONSOLIDATED RESOLUTION ON BYCATCH

The Inter-American Tropical Tuna Commission (IATTC):

Recalling and reaffirming the Resolutions on Bycatch adopted at the 66th, 68th, and 69th Meetings of the Commission in June 2000, 2001, and 2002, respectively;

Recognizing the value of consolidating the operative parts of these resolutions into one comprehensive resolution on bycatch;

Believing that any additional measures on bycatch should also be incorporated into this single resolution;

Has agreed as follows:

Vulnerability of non-target species

Goal – Provide a tool for determining vulnerability of a species/stock to a fishery

- **Vulnerability**: potential for the productivity of a stock to be diminished by direct and indirect fishing pressure. PSA: vulnerability is combination of a stock's productivity and its susceptibility to the fishery.
- **Productivity** – capacity to recover if stock is depleted (function of life history characteristics)
- **Susceptibility** – degree to which a fishery can negatively impact a stock (propensity of species to be captured by and incur mortality from a fishery). Can differ by fishery.

Vulnerability of non-target species

The tool should be:

1. adaptable to factors in epipelagic ecosystem of EPO
2. flexible to different fisheries in the EPO
3. Applicable for data-poor species/stocks, different levels of data availability and reliability
4. History of use in other fisheries

History of PSA use in other fisheries

- Braccini, J.M., B.M. Gillanders, and T.I. Walker. 2006. Hierarchical approach to the assessment of fishing effects on non-target chondrichthyans: a case study of *Squalus megalops* in southeastern Australia. Canadian Journal of Fisheries and Aquatic Sciences, 63: 2456-2466.
- Gribble, N., O. Whybird, L. Williams, and R. Garrett. 2004. Fishery assessment update 1988-2003: Queensland East Coast shark. Report QI04070. Department of Primary Industries and Fisheries, Queensland: 26 p.
- Griffiths, S.P., D.T. Brewer, D.S. Heales, A. Milton, and I.C. Stobutzki. 2006. Validating ecological risk assessments for fisheries: assessing the impacts of turtle excluder devices on elasmobranch bycatch populations in an Australian trawl fishery. Marine and Freshwater Research, 57: 395-401.
- Hobday, A.J., A. Smith, R. Webb, R. Daley, S. Wayte, C. Bulman, J. Dowdney, A. Williams, M. Sporcic, J. Dambacher, M. Fuller, and T. Walker. 2007. Ecological risk assessment for the effects of fishing: methodology. R04/1072. 174 p.
- Milton, D.A. 2001. Assessing the susceptibility to fishing of populations of rare trawl bycatch: sea snakes caught by Australia's northern prawn fishery. Biological Conservation, 101 (3): 281-290.
- Stobutzki, I.C., M. Miller, and D. Brewer. 2001. Sustainability of fishery bycatch: a process for assessing highly diverse and numerous bycatch. Environmental Conservation, 28: 167-181.
- Zhou, S., and S.P. Griffiths. 2008. Sustainability assessments for fishing effects (SAFE): a new quantitative ecological risk assessment method and its application to elasmobranch bycatch in an Australian trawl fishery. Fisheries Research, 91: 56-68.

Sample PSA procedure

Using productivity and susceptibility indices to assess the vulnerability of United States fish stocks to overfishing

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Jason Link[3]
Jason Cope[4]
John Field[5]
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Keith Bigelow[6]
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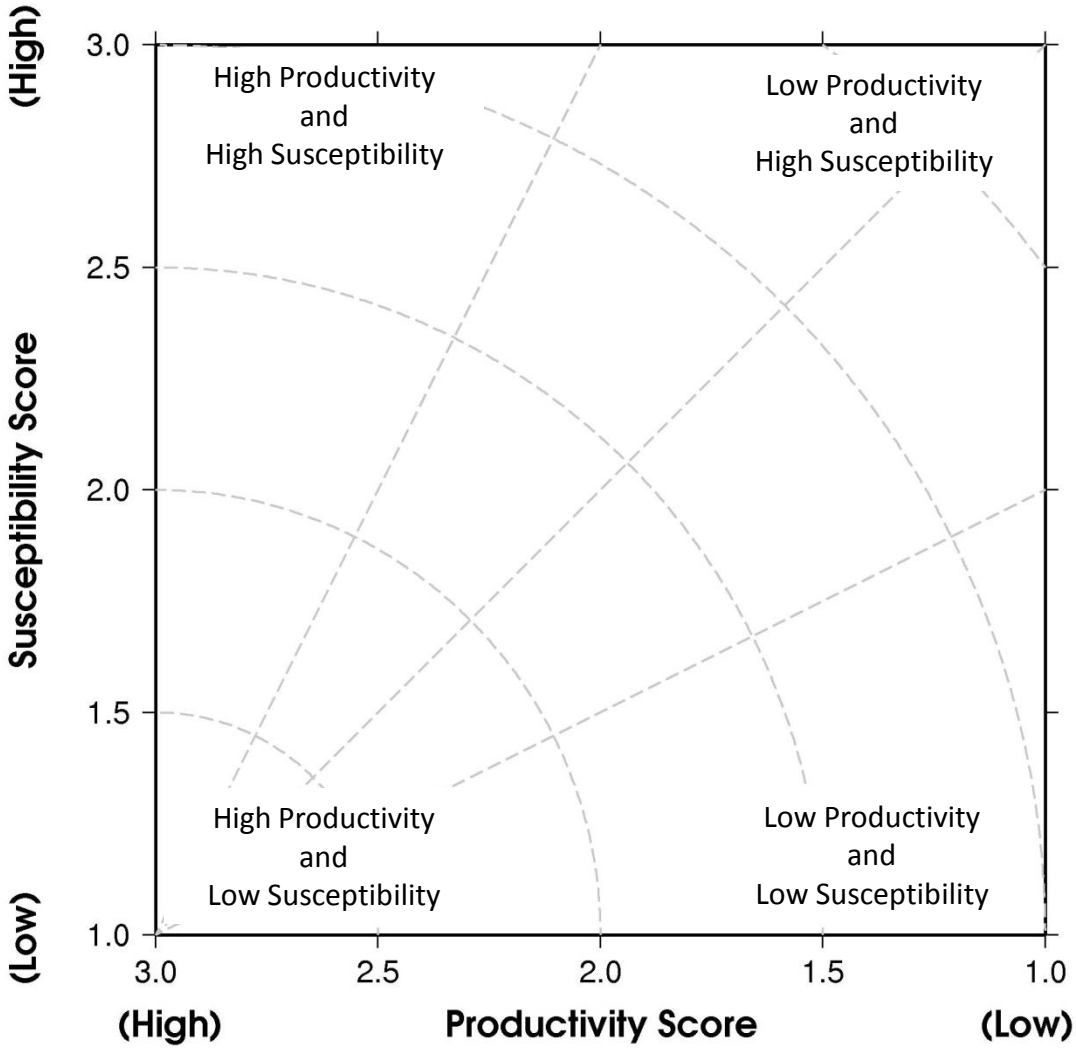
Elements of IATTC's preliminary PSA

1) Portion of fishery to evaluate: purse-seine floating-object sets, dolphin sets, unassociated sets, vessels > 363 t.
2) Species complexes to evaluate: target species, species comprising greatest percentages of bycatch, sensitive species (sharks, turtle, dolphins).
3) Attributes pertinent to P and S: from Patrick et al. 2010 (modified, added).
4) Gathered attribute data for each species: published and unpublished sources, EPO fisheries data.
5) Determine scoring bins for P and S attribute data (low, moderate, high)
6) Compute weighted average P and S scores
7) Plot P and S scores on XY scatter plot
8) Vulnerability = distance from origin of plot to P-S point

PSA scatter plot



Vulnerability is measured as Euclidian distance from plot origin

$$v = \sqrt{(p-3)^2 + (s-1)^2}$$

Productivity indicators

1. Population growth rate (*r*)
2. Maximum age
3. Maximum size
4. von Bertalanffy growth coefficient (k)
5. Natural mortality
6. Fecundity
7. Breeding strategy (Winemiller's (1989) index of parental investment)
8. Recruitment pattern
9. Age at maturity
10. Mean trophic level

Patrick, W.S., P. Spencer, O. Ormseth, J. Cope, J. Field, D. Kobayashi, T. Gedamke, E. Cortés, K. Bigelow, W. Overholtz, J. Link, and P. Lawson. 2009. Use of productivity and susceptibility indices to determine stock vulnerability, with example applications to six U.S. fisheries. NOAA Technical Memorandum NMFS-F/SPO-101: 1-90.

Susceptibility indicators

Catchability:

1. Areal overlap with fishery
2. Geographic concentration (*i.e.*, patchiness)
3. Vertical overlap with fishery

Combined spatial measures (See SAC-01-INF-A)

4. Seasonal migrations
5. Schooling/Aggregation or other behavioral responses
6. Morphology affecting capture
7. Desirability/value of fishery (% retention)

Management:

8. Management Strategy (redefined, see Table 3)
9. F/M
10. Biomass of spawners
11. Survival after capture and release
12. Fishery impact on habitat

New:

13. Temporal catch trends (increasing, no change, decreasing)

Patrick, W.S., P. Spencer, O. Ormseth, J. Cope, J. Field, D. Kobayashi, T. Gedamke, E. Cortés, K. Bigelow, W. Overholtz, J. Link, and P. Lawson. 2009. Use of productivity and susceptibility indices to determine stock vulnerability, with example applications to six U.S. fisheries. NOAA Technical Memorandum NMFS-F/SPO-101: 1-90.

PSA data quality index

Recent data for stock and area of interest

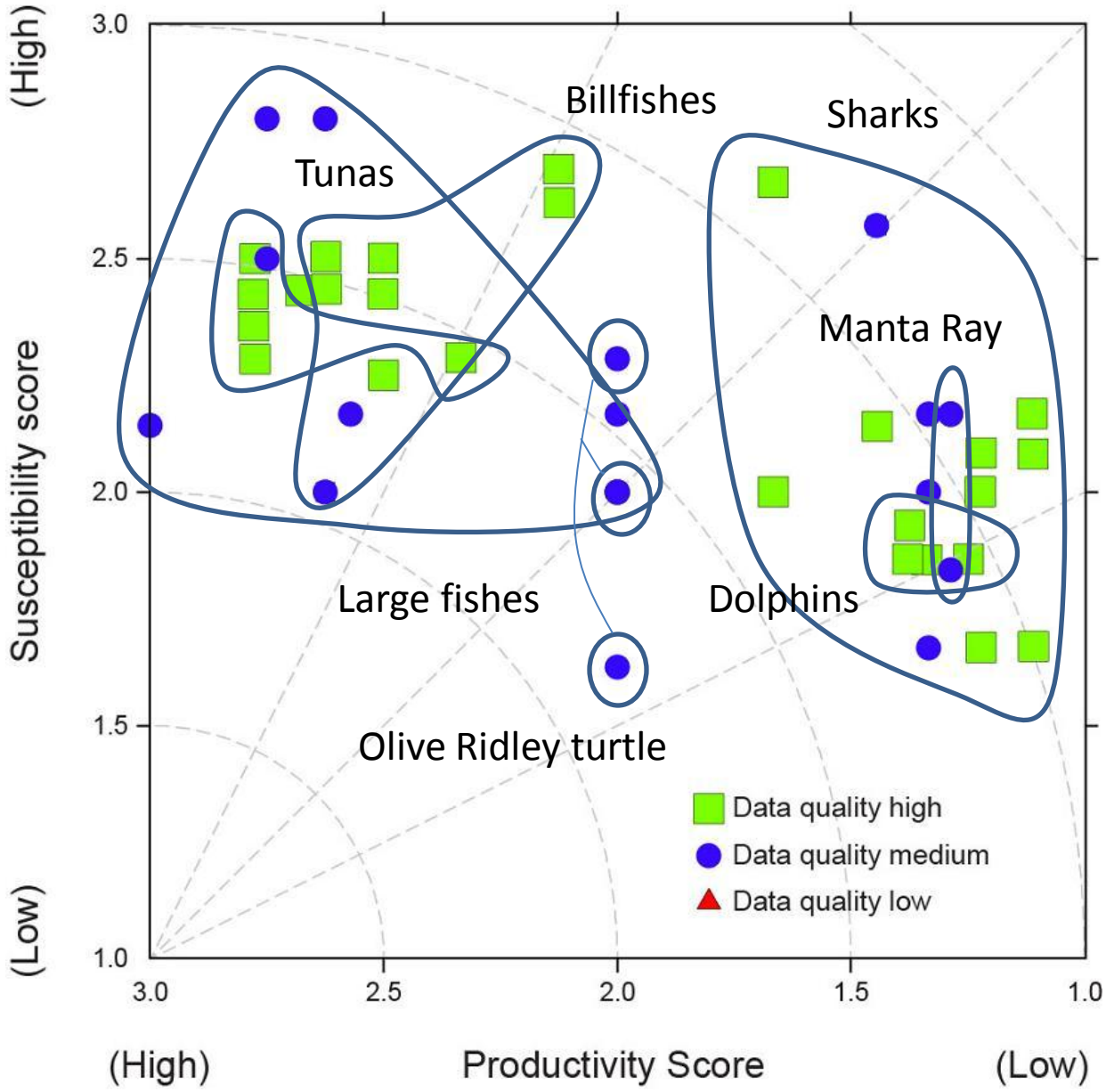
No data. Not included in PSA, but included in data quality index score

"Previous applications have generally ignored overall uncertainty, and assumed the lowest level of productivity (or highest susceptibility) for attributes with missing data. This could lead to inaccurate characterizations of risk."

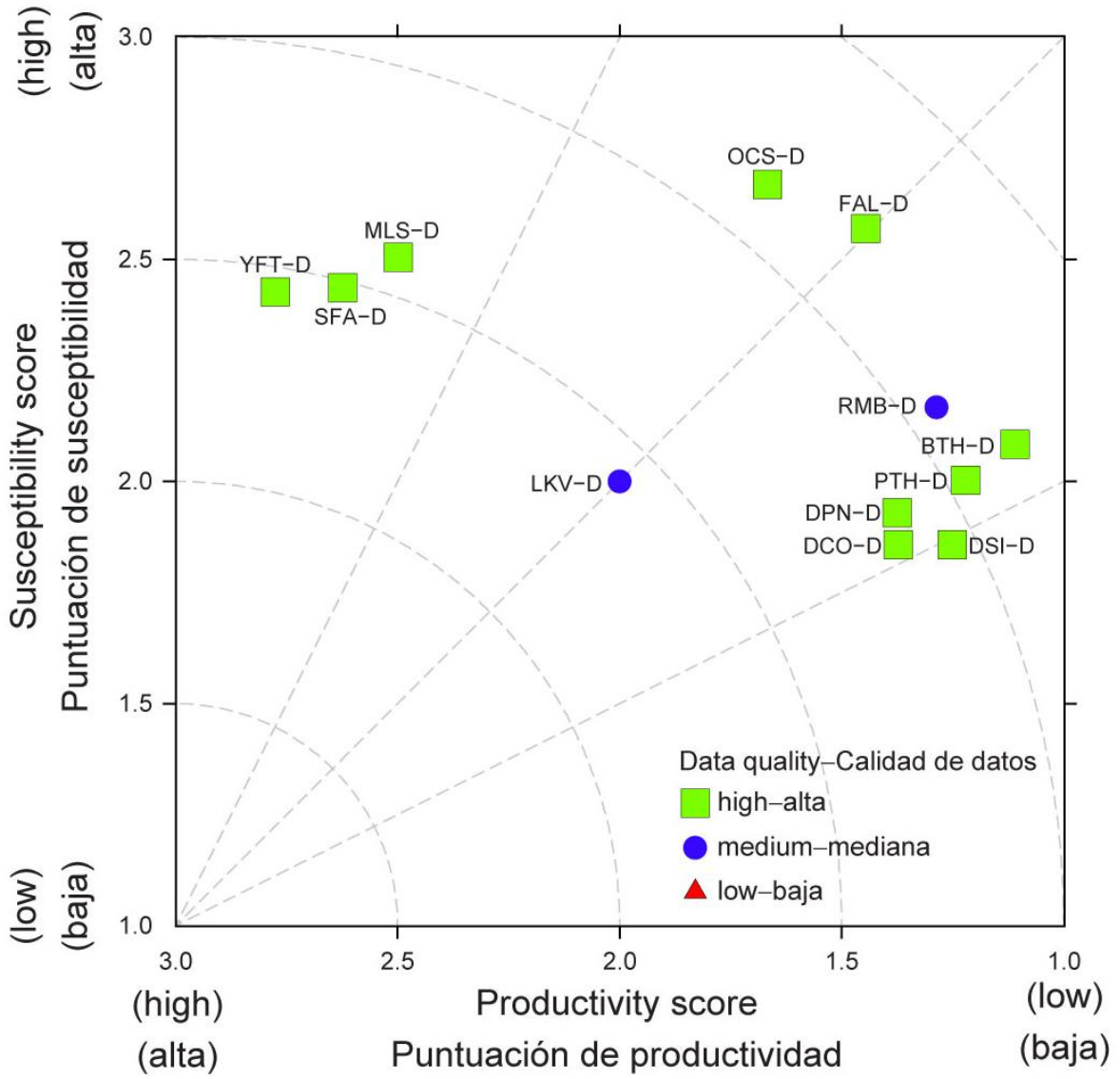
PSA species complexes

Species			Bycatch (percent by set type)		
Group Name	**Common Name**	**Scientific Name**	**Dolphin sets**	**Unassociated sets**	**Floating-object sets**
Tunas	Yellowfin tuna	*Thunnus albacares*	n/a	n/a	n/a
	Bigeye tuna	*Thunnus obesus*	--	n/a	n/a
	Skipjack	*Katsuwonus pelamis*	--	n/a	n/a
Billfishes	Black marlin	*Makaira indica*	--	--	85%
	Blue marlin	*Makaira nigricans*	--	--	89%
	Striped marlin	*Tetrapturus audax*	28%	24%	48%
	Indo-Pacific sailfish	*Istiophorus platypterus*	68%	17%	15%
Dolphins	Spotted dolphin	*Stenella attenuata*	100%	--	--
	Spinner dolphin	*Stenella longirostris*	100%	--	--
	Common dolphin	*Delphinus delphis*	100%	--	--
Large Fishes	Common dolphinfish	*Coryphaena hippurus*	--	--	98%
	Wahoo	*Acanthocybium solandri*	--	--	100%
	Rainbow runner	*Elagatis bipinnulata*	--	--	100%
	Bigeye trevally	*Caranx sexfasciatus*	--	52%	48%
	Yellowtail amberjack	*Seriola lalandi*	--	15%	85%
	Ocean sunfish	*Mola mola*	--	14%	79%
Rays	Giant manta	*Manta birostris*	61%	25%	13%
Sharks	Silky shark	*Carcharhinus falciformis*	3%	4%	93%
	Oceanic whitetip shark	*Carcharhinus longimanus*	8%	--	91%
	Bigeye thresher shark	*Alopias superciliosus*	35%	51%	14%
	Pelagic thresher shark	*Alopias pelagicus*	34%	43%	23%
	Scalloped hammerhead shark	*Sphyrna lewini*	--	18%	77%
	Great hammerhead	*Sphyrna mokarran*	--	--	93%
	Smooth hammerhead shark	*Sphyrna zygaena*	--	--	88%
Small Fishes	Ocean triggerfish	*Canthidermis maculatus*	--	--	100%
Turtles	Olive Ridley turtle	*Lepidochelys olivacea*	18%	13%	69%

Preliminary PSA (all species and fisheries)

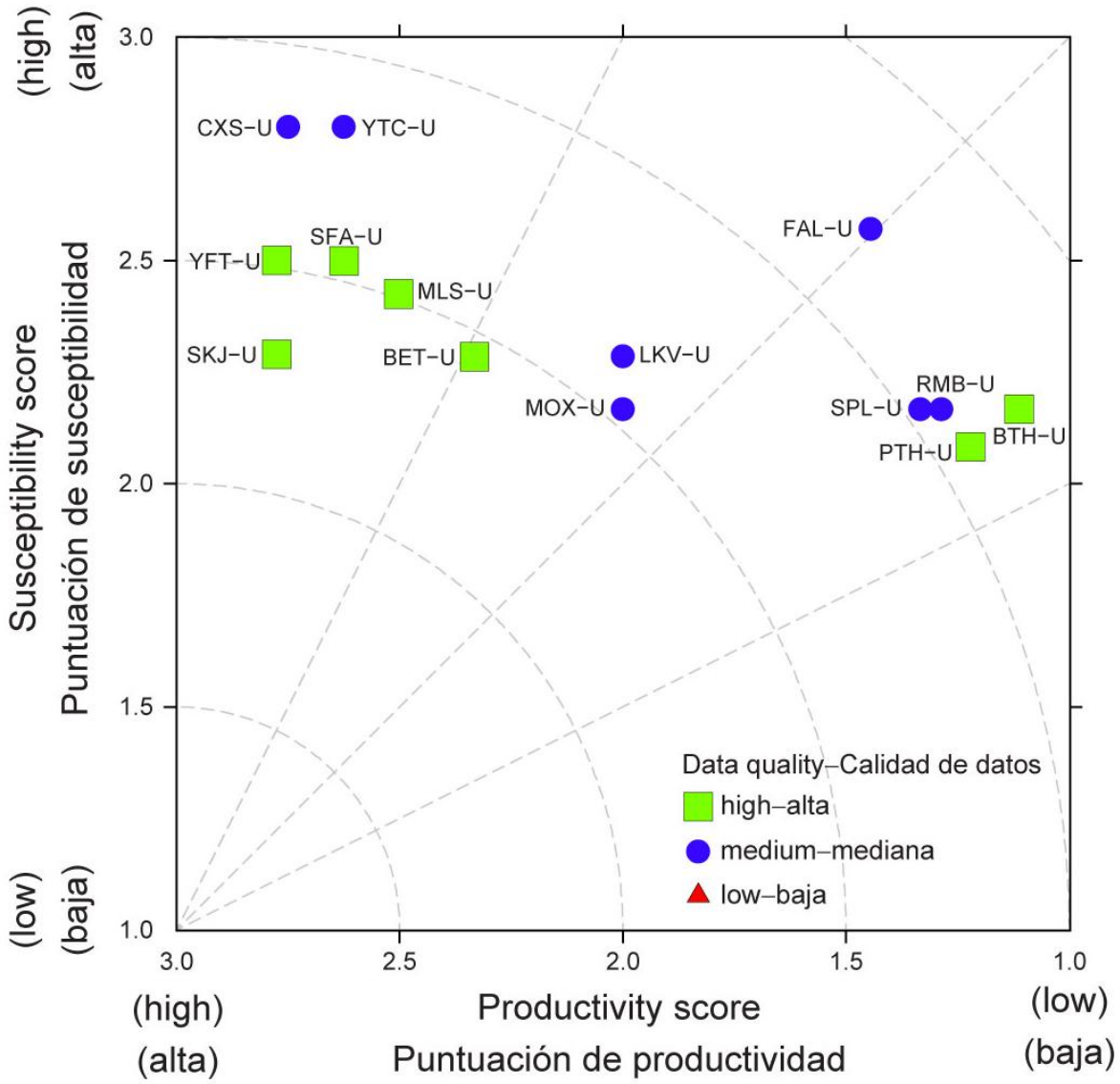


P and S scores for dolphin sets



3-Alpha code	Species
BET	Bigeye tuna
BLM	Black marlin
BTH	Bigeye thresher shark
BUM	Blue marlin
CNT	Ocean triggerfish
CXS	Bigeye trevally
DCO	Common dolphin
DOL	Dolphinfish
DPN	Spotted dolphin
DSI	Spinner dolphin
FAL	Silky shark
LKV	Olive Ridley turtle
MLS	Striped marlin
MOX	Ocean sunfish
OCS	Oceanic whitetip shark
PTH	Pelagic thresher shark
RMB	Giant manta
RRU	Rainbow runner
SFA	Indo-Pacific sailfish
SKJ	Skipjack tuna
SPK	Great hammerhead
SPL	Scalloped hammerhead shark
SPZ	Smooth hammerhead shark
WAH	Wahoo
YFT	Yellowfin tuna
YTC	Yellowtail amberjack

P and S scores for unassociated sets



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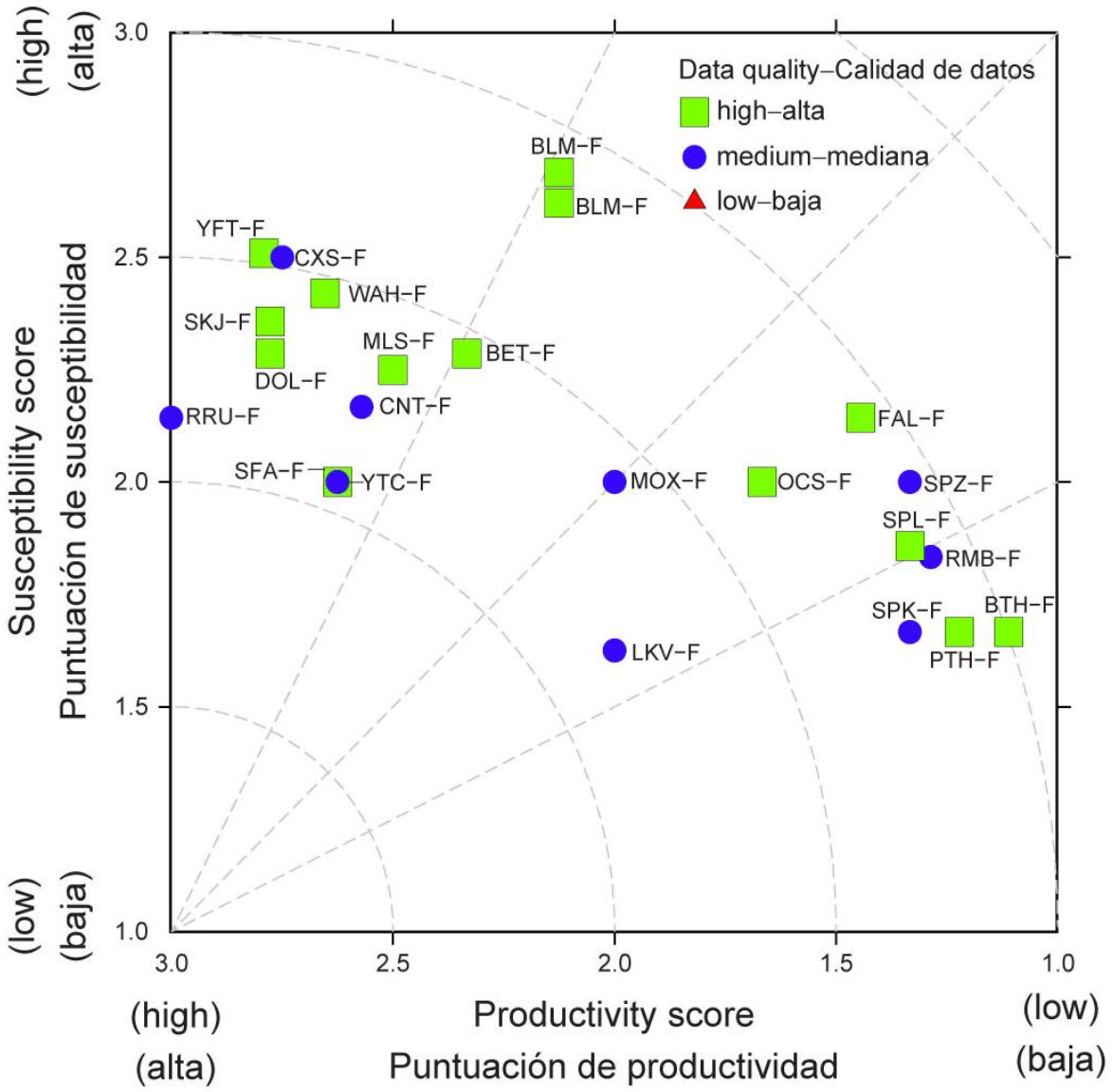
P and S scores for floating-object sets



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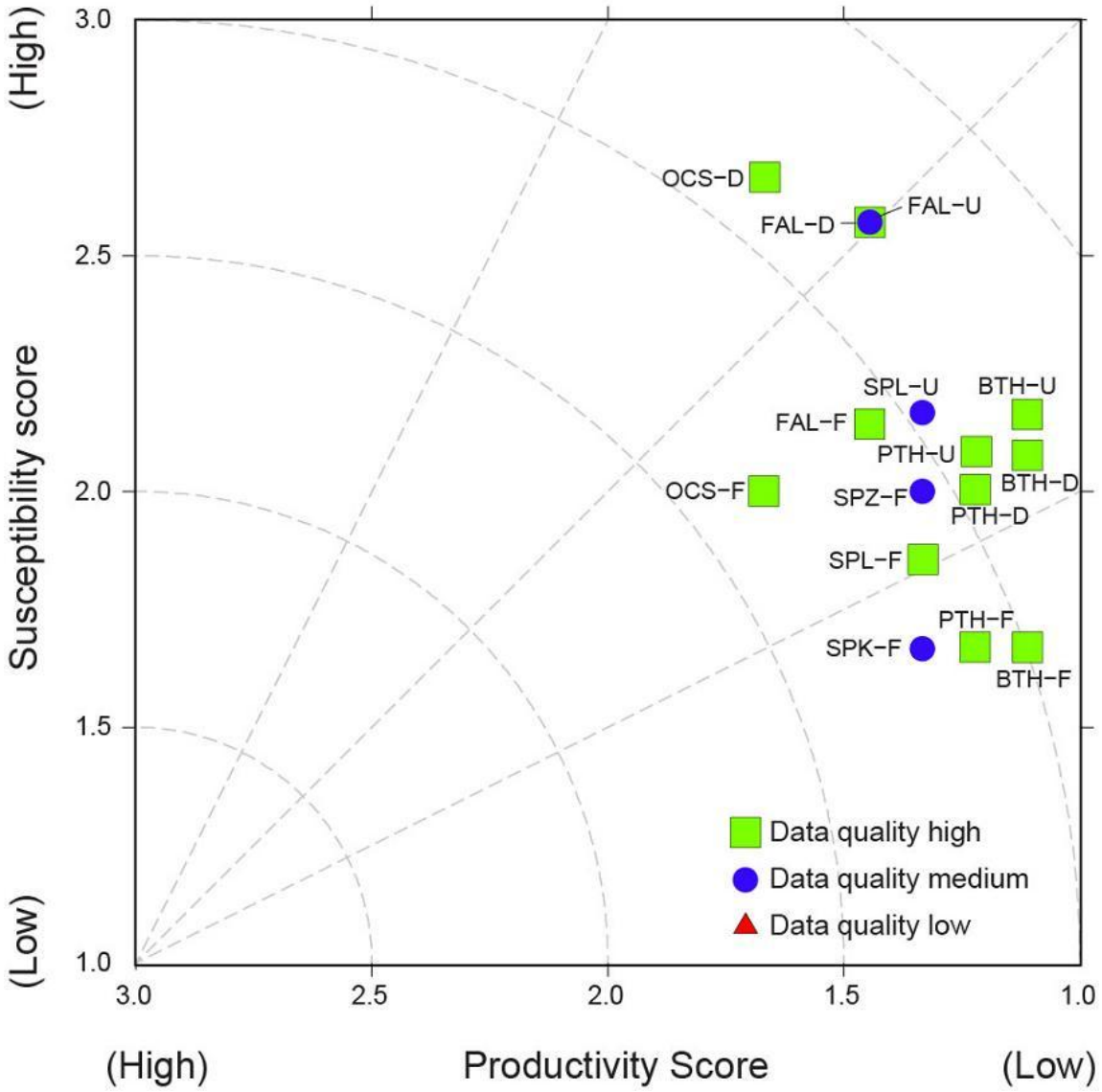
PSA results for sharks



3-Alpha code	Species
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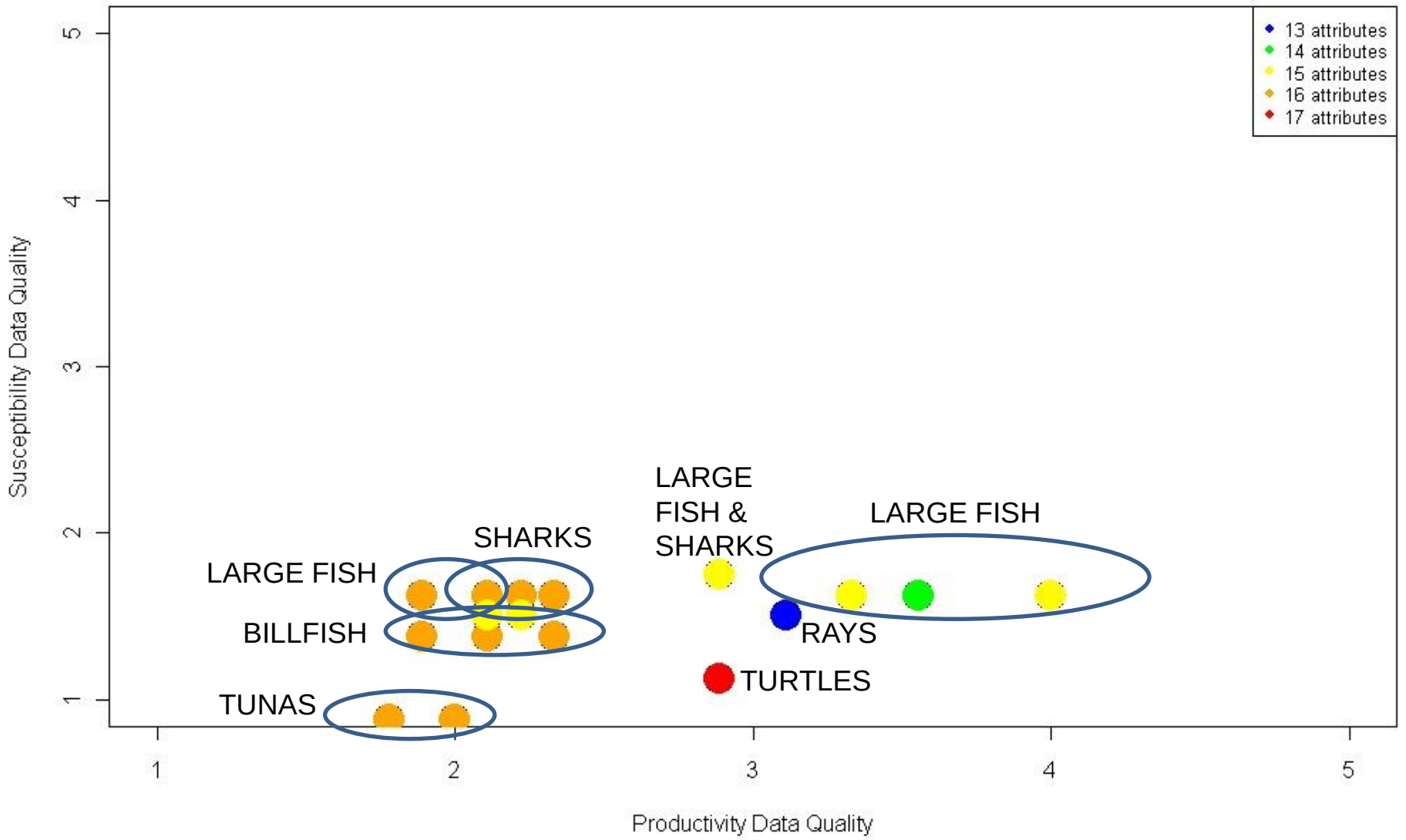
Data quality: floating-object sets



Future work

- Continue PSA: complete this preliminary analysis and prepare a complete report.
  - Include more species of bycatch by purse-seine
  - Explore adding more fisheries (longline, smaller purse-seine vessels, etc.)
  - Explore effect of retaining data-poor attributes
  - Explore other productivity attributes: e.g. strong, moderate, or no trophic connections among species
- Examine alternative methods of ecological risk assessment.

PSA used by other organizations

Marine Stewardship Council
Fisheries Assessment Methodology
and
Guidance to Certification Bodies

Including Default Assessment Tree
and Risk-Based Framework

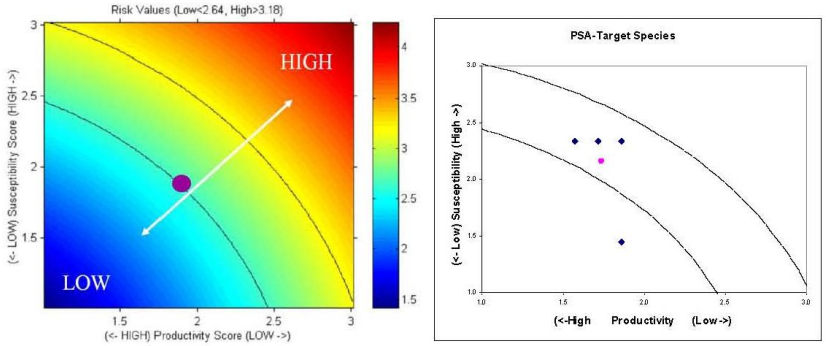


Figure A2. Examples of diagnostic charts for displaying PSA values for each species. **Left:** Low risk species have high productivity and low susceptibility, while high risk species have low productivity and high susceptibility. The curved lines divide the potential risk scores into thirds on the basis of the Euclidean distance from the origin (0,0). **Right**. Example PSA plot for a set of target species. Note the curved lines that divide the risk space into equal thirds, as described in the text

PSA Step 4: Convert PSA scores into MSC scores and feed back into default assessment tree

A3.3.31 Using the Excel worksheet PSA for MSC.xls, or the formula provided in Paragraph 4.4.2, convert the PSA scores resulting from this analysis into MSC scores. Follow guidance in Section 4.4 as well for scoring a PI using PSA results for multiple species.