



*AFH Montpellier 'Les écosystèmes dans tous leurs états'*

# VULNERABILITY OF TELEOSTS CAUGHT BY TUNA LONGLINE FLEETS IN SOUTH ATLANTIC AND INDIAN OCEANS

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**Ecological Risk Assessment (ERA)** allows evaluating the vulnerability of a stock to becoming overfished based on its biological productivity and susceptibility to the fishery

**ERA** defines the risk of a population as a function of (1) **population PRODUCTIVITY**, as it determines the rate at which the population can recover from potential depletion or damage and (2) **population SUSCEPTIBILITY**, as it determines exposure and the extent of fishing activity effects (Cortes et al., 2009)

**ERA** provides  
an index of how vulnerable different species may  
be to direct interactions with fisheries, allowing  
**potential priorities for research and management**

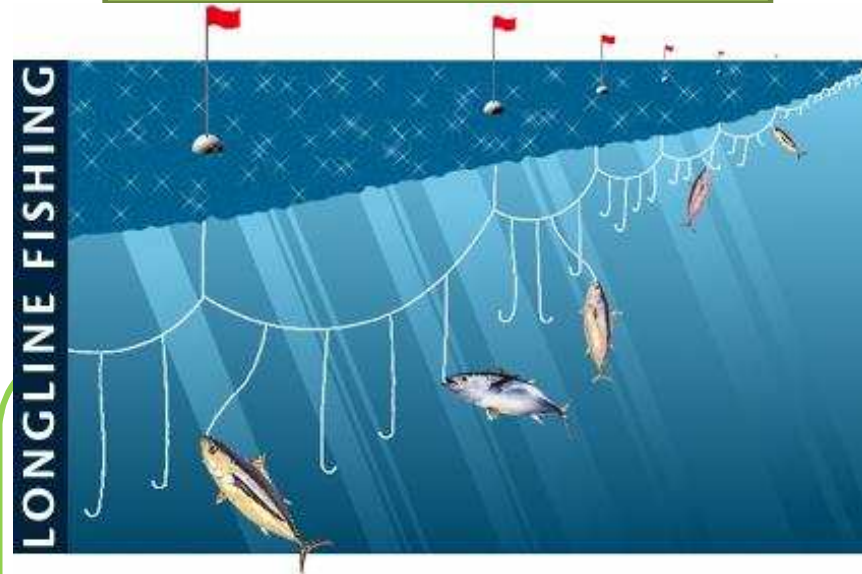
## Longline fisheries in South Atlantic and Indian Oceans

List of teleost species



60 species including  
17 common species  
in both oceans

Literature Review



Specialist  
advice

Sensitivity  
test on data

Weight the attributes

ERA – level 2 (semi-  
quantitative)

PRODUCTIVITY attributes	Definition
$L_{\max}$	Maximum Fork Length reported
$k$	von Bertalanffy growth coefficient
$L_{50}$ (size at first maturity)	Length at which 50% of the individuals attain gonadal maturity for the first time
$T_{\max}$	Maximum observed age reported
$L_{50}/L_{\max}$	Describes somatic and reproductive investments
Fecundity (in millions of oocytes)	Mid-point of the reported range of number of eggs per individual for a given spawning event or period
$R$	The intrinsic rate of population growth



**not available for all the stocks → estimation using empirical relations**

SUSCEPTIBILITY attributes	definition	
Availability	proportion of the spatial distribution of a given stock that overlaps with the fishery	greater overlap implies greater susceptibility
Vertical overlap	position of the stock within the water column in relation to the fishing gear	based on Patrick <i>et al.</i> (2010)
Mort	post-mortem capture mortality	based on Patrick <i>et al.</i> (2010)
% > L <sub>50</sub> (Adults)	sum of the percentage of the individuals larger than L <sub>50</sub>	greater attribute implies less susceptibility
Fate of the catch	<b>T</b> = target species, <b>BY/KC</b> = bycatch species kept for commercialization, <b>BY/KA</b> = bycatch species kept for autoconsumption, <b>BY/D</b> = bycatch and discarded species	target species are more vulnerable
Management strategy	management measures from RFMO	stocks where no regulation are considered more vulnerable
Z/k	ratio of total mortality Z to the growth rate k	expected to increase along the intensification of the exploitation rate

**PRODUCTIVITY attributes**

Attribute	Ranking		
	High (3)	Moderate (2)	Low (1)
L50/Lmax	< 0.49	0.49 - 0.59	> 0.59
Maximum Age	< 8 years	8 - 14 years	> 14 years
Maximum Size	< 110 cm	110 - 200	> 200 cm
k	> 0.35	0.26 - 0.35	< 0.26
R	> 0.95	0.74-0.95	< 0.74
Measured Fecundity	> 2.8millions	0.9 -2.8 millions	< 0.9 million
Lenght at First Maturity	< 60 cm	60-104 cm	> 104 cm

**Thresholds** defined using a **quantile method** from data of the 60 species

## SUSCEPTIBILITY attributes

(a) Specialist, (b) Literature, (c) Quantile method

Attribute	Ranking		
	Low (1)	Moderate (2)	High (3)
Availability (b)	< 25% of stock occurs in the area fished	Between 25% and 50% of the stock occurs in the area fished	> 50% of stock occurs in the area fished
Vertical overlap (b)	< 25% of stock occurs in the depths fished	Between 25% and 50% of the stock occurs in the depths fished	> 50% of stock occurs in the depths fished
Mort (b)	<33	33-67%	>67
% > L <sub>50</sub> (Adults) (c)	>95%	50-95%	<50%
Fate of the catch (a)	BY/KA & BY/D	BY/KC	T
Management strategy (a,b)	Currently subject to a number of conservation and management measures	No specific regulation are in effect, but some indirect measures are in course	No regulation are in effect
Z/k (a,b)	<0.5	0.5 - 1.0	>1

### Weight of the attributes – 1 to 3 (default 2)

- **Weight 3**
  - PCA analysis - mostly influenced by  $L_{\max}$  and  $k$
  - $R$  the intrinsic growth rate
- **Weight of 2 (default)**
  - other PRODUCTIVITY attributes
  - SUSCEPTIBILITY attributes

**Risk categories, high, moderate and low, was defined by dividing the vulnerability scores in three parts, using a quantile method**



Code	Lmax	k	Amax	L50	Fec	L50.Max	r
BUMind	355	0.249	28.0	141.7	4.15	0.40	0.64
SFAind	350	0.251	10.0	164.2	2.09	0.47	0.49
BLMind	461	0.090	20.0	282.6	-	0.61	0.36

BUMind

Productivity Attributes	High (3)	Moderate (2)	Low (1)	Weight (0 - 3); Default = 2	Attribute Score	Weighted Attribute Score
L50/Lmax	< 0.49	0.49 - 0.59	> 0.59	2	3.0	6.0
Maximum Age	< 8 years	8 - 14 years	> 14 years	2	1.0	2.0
Maximum Size	< 110 cm	110 - 200	> 200 cm	3	1.0	3.0
von Bertalanffy Growth Coefficient (k)	> 0.35	0.26 - 0.35	< 0.26	3	1.0	3.0
R	> 0.95	0.74-0.95	< 0.74	3	1.0	3.0
Measured Fecundity	> 2.8millions	0.9 -2.8 millions	< 0.9 million	2	3.0	6.0
Lenght at First Maturity	< 60 cm	60-104 cm	> 104 cm	2	1.0	2.0
<b>Overall Productivity Score</b>				<b>17</b>		<b>1.470</b>

## Introduction

## Data collection

## Data Analysis

## Results

Code	>L50	Z/k	Mort	Manag. Strategy	Avail	Encout	Fate of the catch
BUMind	99	2.96	50	REG	High	high	BY/KC
SFAind			60	REG	High	high	BY/KC
BLMind	11	3.32	0	REG	High	high	BY/KC
SSPind	100			NO	High	high	BY/KC
WAHind	76			NO	High	high	BY/KC
EUTind				GOOD	Low	high	

**BUMind**

Susceptibility Attributes	Low (1)	Moderate (2)	High (3)	Weight (0 - 4); Default = 2	Attribute Score	Weighted Attribute Score
<b>Management Strategy</b>	Currently subject to a number of Conservation and Management Measures	No specific regulation are in effect,	No Regulation are in effect	2	2.0	4.0
<b>Availability</b>	< 25% of stock occurs in the area fished	Between 25% and 50% of the stock occurs in the area fished	> 50% of stock occurs in the area fished	2	3.0	6.0
<b>&gt;&amp;L50</b>	>95%	50-95%	<50%	2	1.0	2.0
<b>Z/K</b>	<0.5	0.5 - 1.0	>1	2	3.0	6.0
<b>Encoutability</b>	< 25% of stock occurs in the depths fished	Between 25% and 50% of the stock occurs in the depths fished	> 50% of stock occurs in the depths fished	2	3.0	6.0
<b>Pdead</b>	<33	33-67%	>67	2	2.0	4.0
<b>Desirability/Value of the Fishery</b>	BY/KA & BY/D	BY/KC	Target	2	2.0	4.0
<b>Overall Susceptibility Scores</b>				14		2.3

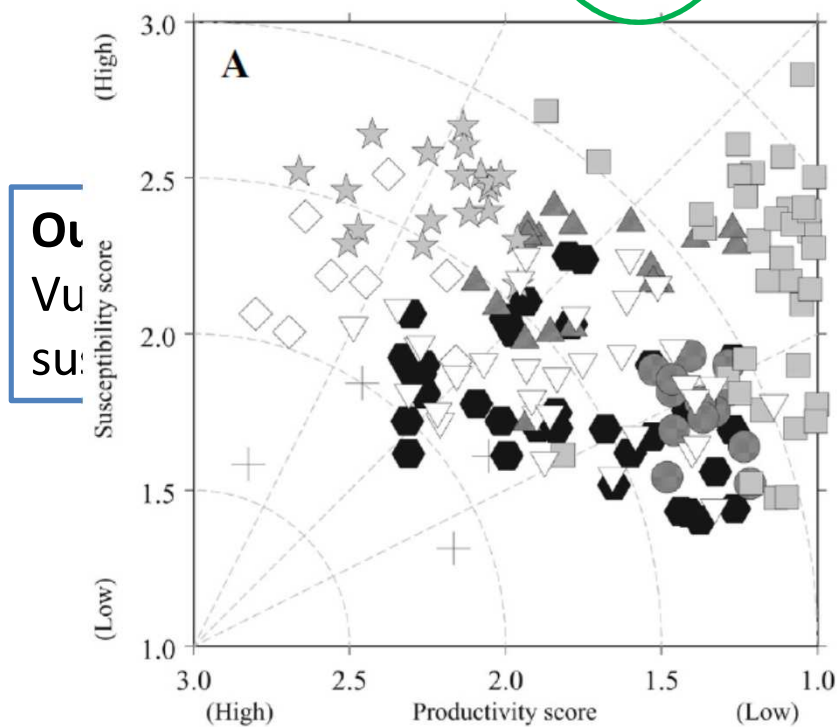
## DATA QUALITY

Data quality tier	Description
<b>Best Data (1)</b>	Data collected from the study stock and area, recent literature and appropriate stock assessment methods
<b>Good/adequate data (2)</b>	Data collected from the study stock and area. Relatively old information, reasonably appropriate stock assessment
<b>Acceptable data (3)</b>	Data obtained from empirical formulae or on studies of similar taxa of the same area or same species/adjacent area.
<b>Limited data (4)</b>	Expert opinion or data of no adjacent area
<b>No data (5)</b>	The person should give a score 5 and do not provide a score

Applied to control for inflated scores resulting from limited data  
(adapted from Patrick et al. 2010)

Hobday *et al.* (2007) - poor >3.5; moderate 2.0–3.5; and good <2.0.

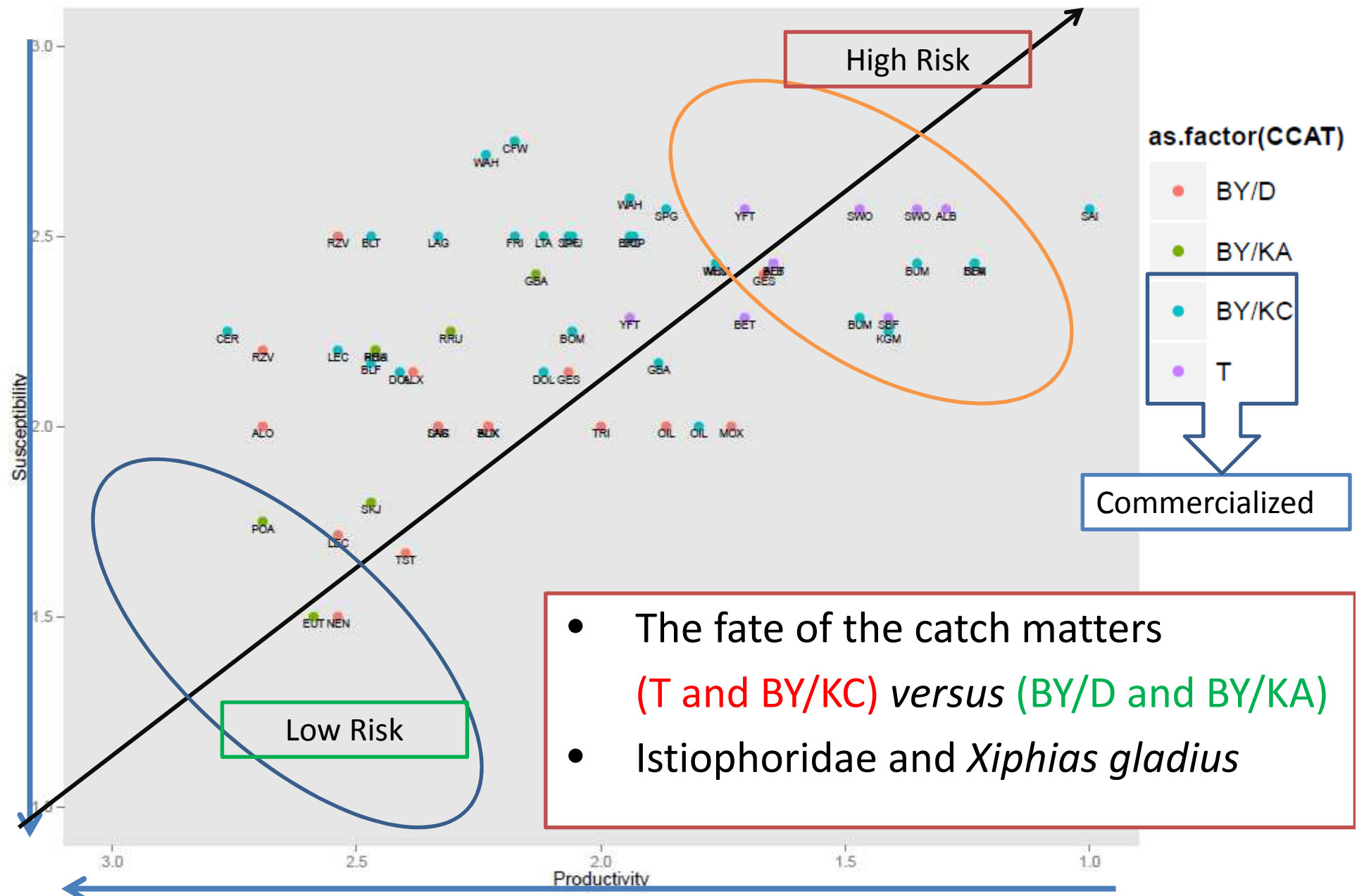
Stock Name	Productivity		Susceptibility		Vulnerability	
	Weighted Attribute Score	Weighted Data Quality Score	Weighted Attribute Score	Weighted Data Quality Score	Score	Rank
SAIatl	1.000	1.353	2.571	1.000	2.543	1
ALBatl	1.294	1.353	2.571	1.000	2.319	2
SWOind	1.353	1.588	2.571	1.000	2.276	3
SFAind	1.235	1.941	2.429	1.000	2.270	4
BLMind	1.235	1.706	2.429	1.000	2.270	4
SWOatl	1.471	1.353	2.571	1.000	2.193	6
BUMatl	1.353	1.706	2.429	1.000	2.180	7
SBFind	1.412	1.353	2.286	1.000	2.043	8
YFTatl	1.706	1.353	2.571	1.000	2.036	9
KGMatl	1.412	1.353	2.250	2.714	2.021	10
BUMind	1.471	1.706	2.286	1.000	1.998	11



$$v = \sqrt{[(P - X_0)^2 + (S - Y_0)^2]}$$

where  $X_0$  and  $Y_0$  are the  $(x, y)$  origin coordinates in the productivity susceptibility  $x$ - $y$  plot for the 60 stocks

## Vulnerability – Species X Fate of the catch



## Introduction

## Data collection

## Data Analysis

## Results

Ocean	Species	Rank	Risk
ATL	Istiophorus albicans	1	High
ATL	Thunnus alalunga	2	High
IND	Xiphias gladius	3	High
IND	Istiophorus platypterus	4	High
IND	Istiompax indica	4	High
ATL	Xiphias gladius	6	High
ATL	Makaira nigricans	7	High
IND	Thunnus maccoyii	8	High
ATL	Thunnus albacares	9	High
ATL	Scomberomorus cavalla	10	High
IND	Makaira nigricans	11	High
IND	Thunnus obesus	12	High
IND	Thunnus alalunga	12	High
ATL	Tetrapturus georgii	14	High
ATL	Coryphaena equiselis	15	High
ATL	Gempylus serpens	16	High
IND	Acanthocybium solandri	17	High
IND	Kajikia audax	18	High
ATL	Kajikia albidus	18	High
ATL	Acanthocybium solandri	20	High
IND	Tetrapturus angustirostris	21	High
ATL	Scomberomorus brasiliensis	22	Moderate
ATL	Thunnus obesus	23	Moderate
ATL	Katsuwonus pelamis	24	Moderate
ATL	Tetrapturus pfluegeri	25	Moderate
ATL	Euthynnus alleteratus	26	Moderate
ATL	Auxis thazard	27	Moderate
IND	Thunnus albacares	28	Moderate
ATL	Sphyraena barracuda	29	Moderate
IND	Lampris guttatus	30	Moderate
IND	Sphyraena barracuda	31	Moderate
ATL	Mola mola	32	Moderate
ATL	Auxis rochei	33	Moderate
ATL	Ranzania laevis	34	Moderate
ATL	Sarda sarda	35	Moderate
IND	Ruvettus pretiosus	36	Moderate
ATL	Ruvettus pretiosus	37	Moderate
IND	Gempylus serpens	38	Moderate
ATL	Coryphaena hippurus	39	Moderate

Most Istiophoridae & *Xiphias gladius*  
Most target sp (T) and bycatch kept  
for commercialization (BY/KC)

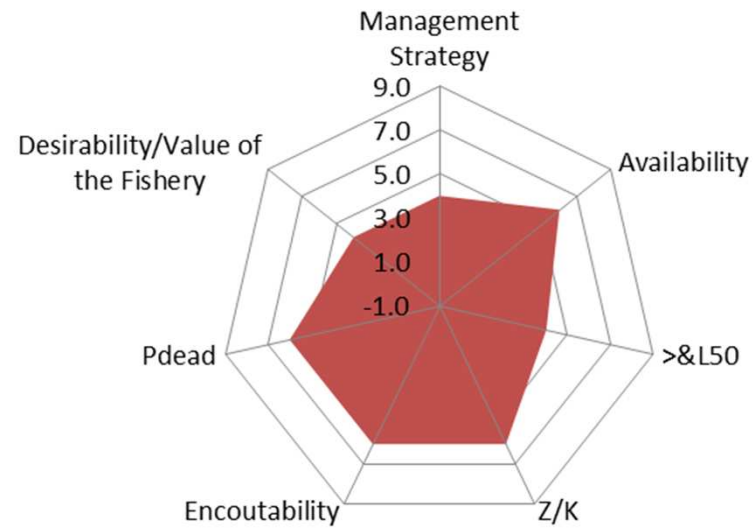
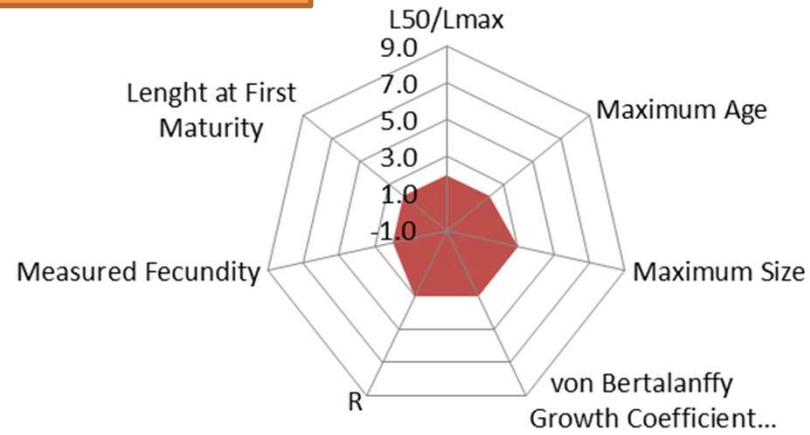
IND	Trachipterus ishikawae	41	Low
IND	Elagatis bipinnulata	42	Low
IND	Brama brama	42	Low
IND	Alepisaurus ferox	44	Low
ATL	Lepidocybium flavobrunneum	45	Low
IND	Coryphaena hippurus	46	Low
ATL	Thunnus atlanticus	47	Low
ATL	Scomberomorus regalis	48	Low
IND	Gasterochisma melampus	49	Low
ATL	Alepisaurus ferox	49	Low
IND	Ranzania laevis	51	Low
ATL	Lampris guttatus	52	Low
IND	Thysites atun	52	Low
ATL	Alepisaurus brevirostris	54	Low
IND	Katsuwonus pelamis	55	Low
IND	Taractichthys steindachneri	56	Low
IND	Lepidocybium flavobrunneum	57	Low
ATL	Brama brama	58	Low
ATL	Nesiarchus nasutus	59	Low
IND	Euthynnus affinis	60	Low

10 different families

Only 2 BY/KC  
Most discarded species (BY/D)  
No T

# Atlantic Sailfish

## PRODUCTIVITY



## SUSCEPTIBILITY

# ERA x IUCN x Stock Assessments

1- Do they give similar answer?

2- Do we manage our stock adequately?

Species	Ocean	Rank	Risk	IUCN	Stock Assessment
Istiophorus albicans	ATL	1	High	LC	?
Thunnus alalunga	ATL	2	High	LC	
Xiphias gladius	IND	3	High	LC	All Ocean (? SW (?))
Istiophorus platypterus	IND	4	High	LC	
Istiompax indica	IND	4	High	DD	
Xiphias gladius	ATL	6	High	NT	????
Makaira nigricans	ATL	7	High	Em	
Thunnus maccoyii	IND	8	High	CR	
Thunnus albacares	ATL	9	High	LC	
Scomberomorus cavalla	ATL	10	High	LC	
Makaira nigricans	IND	11	High	VU	
Thunnus obesus	IND	12	High	VU	
Thunnus alalunga	IND	12	High	NT	
Tetrapturus georgii	ATL	14	High	DD	
Coryphaena equiselis	ATL	15	High	LC	
Gempylus serpens	ATL	16	High	LC	
Acanthocybium solandri	IND	17	High	LC	
Kajikia audax	IND	18	High	NT	
Kajikia albidus	ATL	18	High	VU	
Acanthocybium solandri	ATL	20	High	LC	
Tetrapturus angustirostris	IND	21	High	DD	

IUCN

**Threatened 23 %**  
(VU, EN, CR)  
**Lower Risk 61%**  
(Least Concern 47% and  
Near Threatened 14%)  
**Data Deficient 14%**

Stock assessment

**57% are "alerting"  
and/or uncertain**

**33% were not  
assessed**

Colour key	Stock overfished ( $SB_{year}/SB_{MSY} < 1$ )	Stock not overfished ( $SB_{year}/SB_{MSY} \geq 1$ )
Stock subject to overfishing ( $F_{year}/F_{MSY} > 1$ )		
Stock not subject to overfishing ( $F_{year}/F_{MSY} \leq 1$ )		
Not assessed/Uncertain		



## ERA x IUCN x Stock Assessments

**1- Do they give similar answer?**  
**2- Do we manage our stock adequately?**

Species	Ocean	Rank	Risk	IUCN	Stock Assessment
<i>Scomberomorus brasiliensis</i>	ATL	22	Moderate	LC	
<i>Thunnus obesus</i>	ATL	23	Moderate	NT	??
<i>Katsuwonus pelamis</i>	ATL	24	Moderate	LC	
<i>Tetrapturus pfluegeri</i>	ATL	25	Moderate	LC	
<i>Euthynnus alleteratus</i>	ATL	26	Moderate	LC	
<i>Auxis thazard</i>	ATL	27	Moderate	LC	
<i>Thunnus albacares</i>	IND	28	Moderate	NT	
<i>Sphyraena barracuda</i>	ATL	29	Moderate	LC	
<i>Lampris guttatus</i>	IND	30	Moderate	-	
<i>Sphyraena barracuda</i>	IND	31	Moderate	-	
<i>Mola mola</i>	ATL	32	Moderate	LC	
<i>Auxis rochei</i>	ATL	33	Moderate	DD	
<i>Ranzania laevis</i>	ATL	34	Moderate	LC	
<i>Sarda sarda</i>	ATL	35	Moderate	LC	
<i>Ruvettus pretiosus</i>	IND	36	Moderate	-	
<i>Ruvettus pretiosus</i>	ATL	37	Moderate	LC	
<i>Gempylus serpens</i>	IND	38	Moderate	-	
<i>Coryphaena hippurus</i>	ATL	39	Moderate	LC	
<i>Elagatis bipinnulata</i>	ATL	40	Moderate	LC	

For the Atlantic species – Regional South Atlantic IUCN assessment (ICM BIO, in press)

### IUCN

**63% LC**  
**Only 2 NT and 1 DD**  
**No threatened category**

### Stock assessment

**Only 3 stocks assessed**  
**1 uncertain**

**85% not assessed**

## ERA x IUCN x Stock Assessments

1- Do they give similar answer?

2- Do we manage our stock adequately?

Species	Ocean	Rank	Risk	IUCN	Stock Assessment
Trachipterus ishikawae	IND	41	Low	-	
Elagatis bipinnulata	IND	42	Low	-	
Brama brama	IND	42	Low	-	
Alepisaurus ferox	IND	44	Low	LC	
Lepidocybium flavobrunneum	ATL	45	Low	LC	
Coryphaena hippurus	IND	46	Low	LC	
Thunnus atlanticus	ATL	47	Low	LC	
Scomberomorus regalis	ATL	48	Low	LC	
Gasterochisma melampus	IND	49	Low	LC	
Alepisaurus ferox	ATL	49	Low	LC	
Ranzania laevis	IND	51	Low	-	
Lampris guttatus	ATL	52	Low	LC	
Thyrsites atun	IND	52	Low	-	
Alepisaurus brevirostris	ATL	54	Low	LC	
Katsuwonus pelamis	IND	55	Low	LC	
Taractichthys steindachneri	IND	56	Low	-	
Lepidocybium flavobrunneum	IND	57	Low	-	
Brama brama	ATL	58	Low	LC	
Nesiarchus nasutus	ATL	59	Low	LC	
Euthynnus affinis	IND	60	Low	LC	

IUCN

All Least Concern

Stock assessment

Only 2 assessed –  
good state

# Most vulnerable species

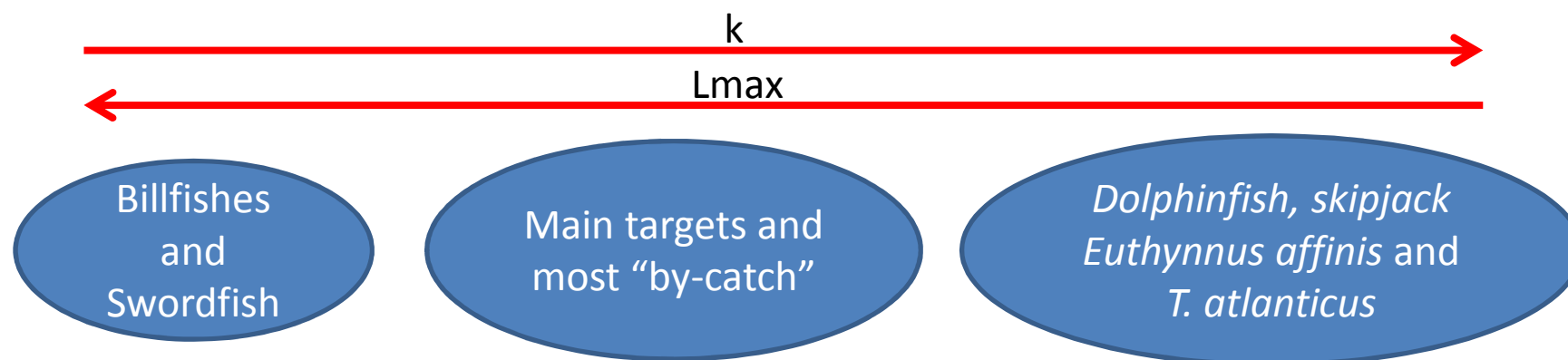
1. Long lived, late maturing, low growth rate and low fecundity (i.e., Low PRODUCTIVITY)
2. **not only the targets (most BY/KC)**, high horizontal and vertical gear overlap, not always assessed, high percent of juveniles, high post-mortality capture (High SUSCEPTIBILITY)

**Istiophoridae + Xiphiidae**

**lowest values of PRODUCTIVITY and highest scores of SUSCEPTIBILITY**

# Conclusions

## Three groups driven mainly by $L_{max}$ and $k$



- Many basic life history parameters are unknown
- Many species not assessed but not out of risk
- Methods for estimating missing parameters
- Sensitivity analyses
- Move to ERA level 3 for high risk species
- Improve data quality analysis



# Models?

Different data

Different assumptions

Different complexity

Convergent

Complementary

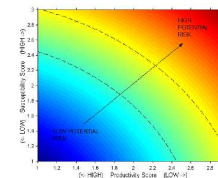
Multi-Model Approach

FAO – Precautionary approach

- Stock Assessment

- Red list (IUCN)

- ERA





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**Ministério  
da  
Pesca e Aquicultura**