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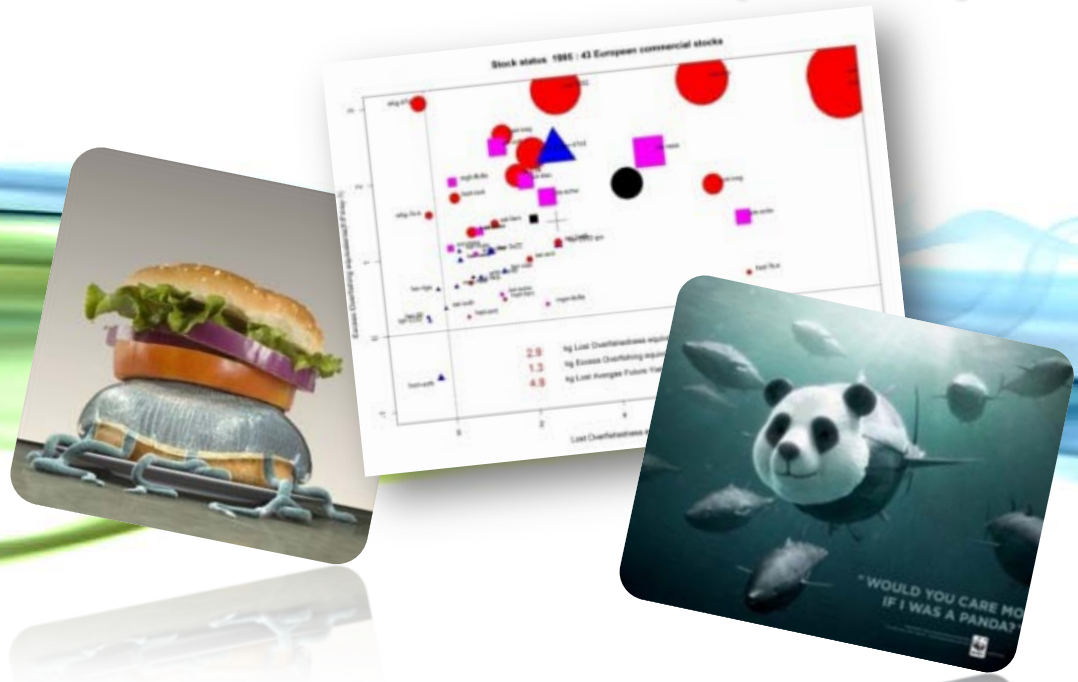
Marine Resource Use

- in Life Cycle Assessments (LCA)



Andreas Emanuelsson, Sara Hornborg, Friederike Ziegler, Ulf Sonesson

LC-IMPACT

[1]**SIK – Swedish Institute for Food and Biotechnology.**
Sustainable food productions. Gothenburg. Sweden
[2] **University of Gothenburg**.
Department Biological and Environmental science. Gothenburg. Sweden

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“Overfishing” is the largest driver of species loss in marine ecosystem

(Millennium Ecosystem Assessment 2005)

AoP: Natural Ecosystem

87% of the world’s commercial marine fish stocks are either “fully exploited” or “overexploited” (30%). (FAO 2012)

Clearly a “relevant issue” for seafood products (ISO, ILCD)

AoP: Natural Resources

Trophic Cascade effects…

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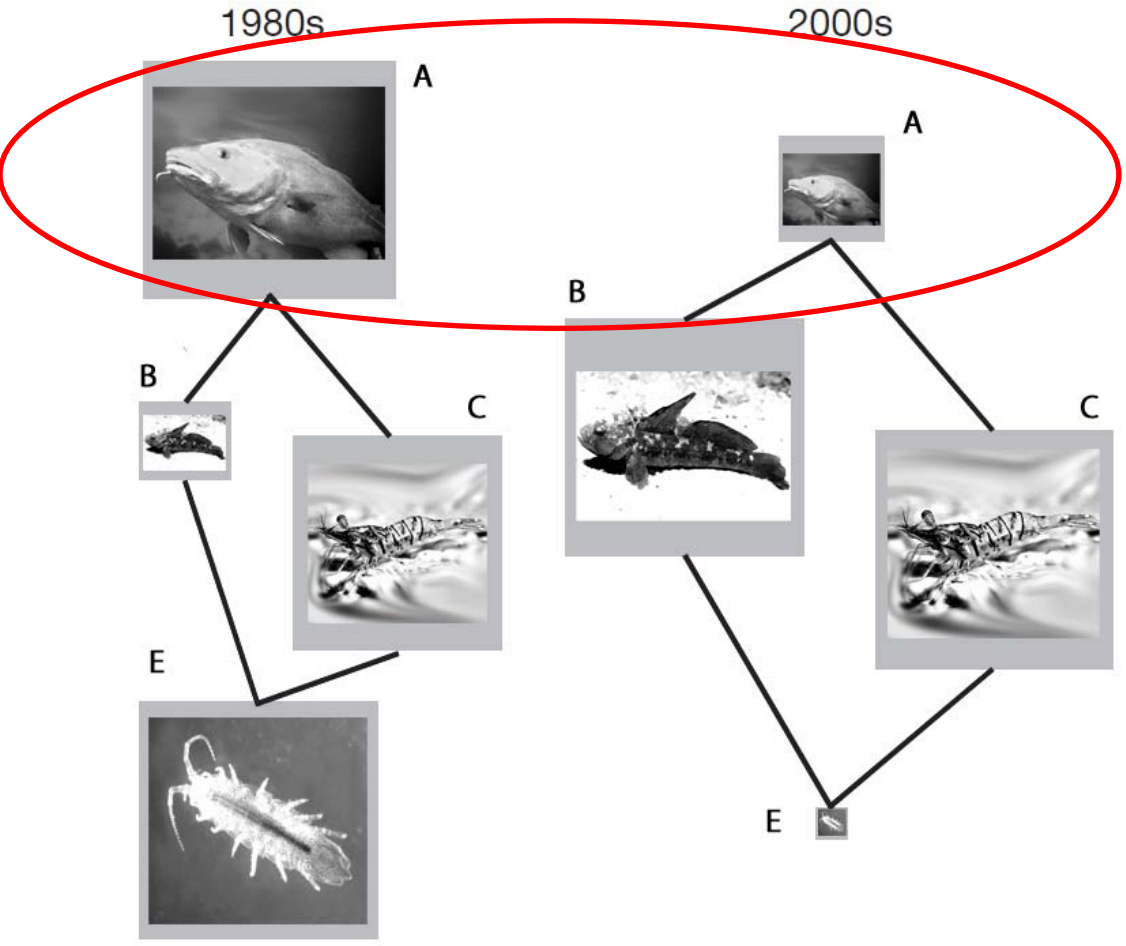

Loss of 60% of the eelgrass meadows. since the 1980s… important nursing grounds for fish

Baden. S.. Emanuelsson. A.. Pihl. L.. Svensson.C.J.. Åberg. P. 2012 **"Shift in food web structure over decades linked to overfishing"**. Marine Ecology Progress Series. 451: 61-73.

Sik Your Science Partner

Carbon footprint of some marine products (per edible filet)

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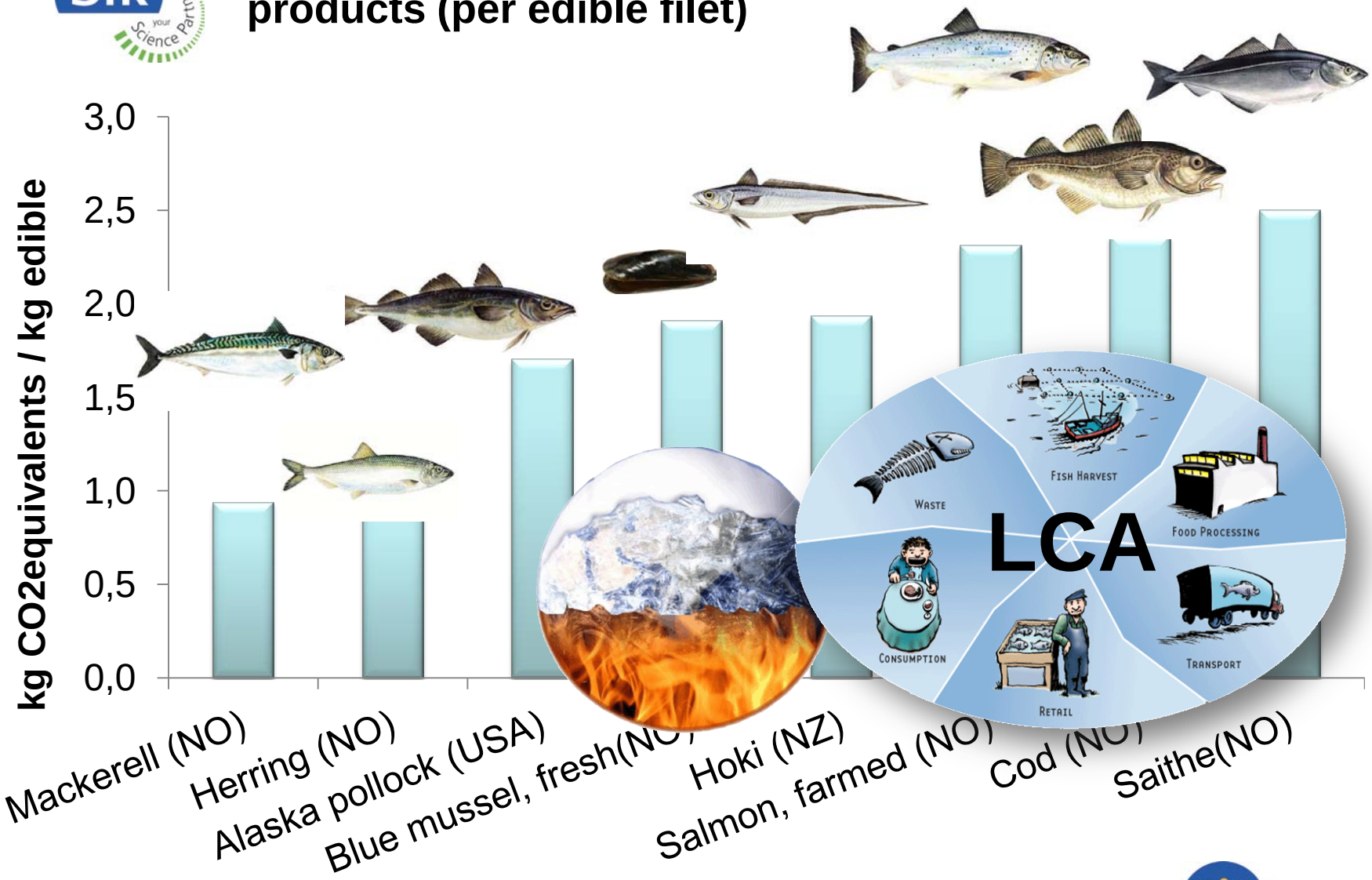

Ziegler F, Winther U, Hognes ES, Emanuelsson A, Sund V, Ellingsen H (2012) **The carbon footprint of Norwegian seafood products on the global seafood market.** Journal of Industrial Ecology

The big picture….

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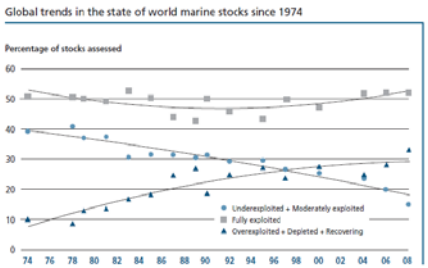
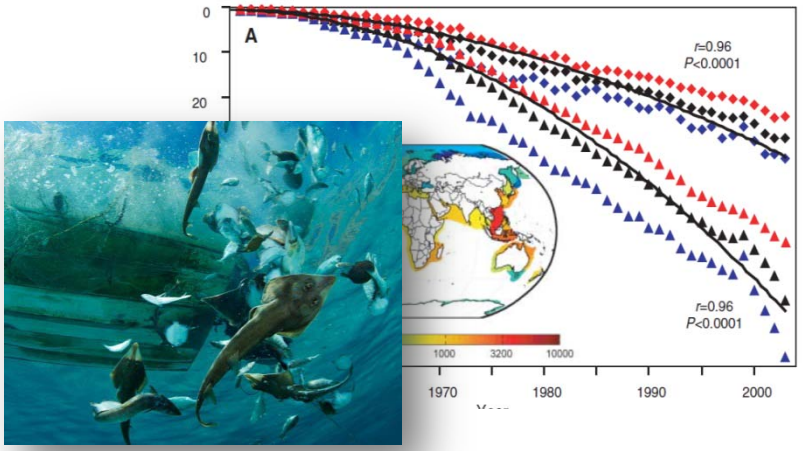
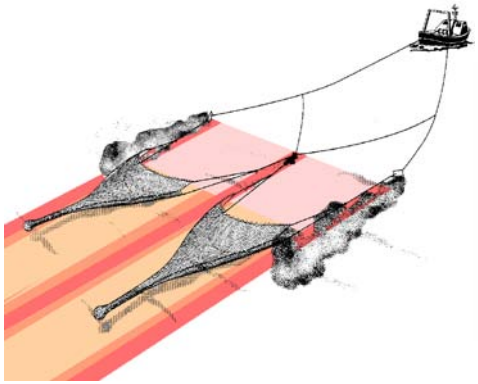
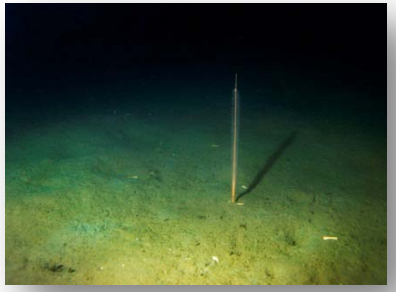


>70% all commercial marine fish stocks are either fully exploited or overfished!!! (FAO 2010)



Globally **8%** discard (FAO 2005)





40% of continental shelf swept every year (Kura et al 2000)

1% of ALL oil (Tyedmers et al 2005)

Today's Agenda

I. Background

II. Target Catch

III. Ecosystem
(Discard & Seafloor)

IV. Future outlook

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Sara Hornborg, Andreas Emanuelsson, Friederike Ziegler, Ulf Sonesson

Gothenburg Univ:
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Daniel Valentinsson, Mattias Sköld, Andrea Belgrano, Valerio Bartolino, Mikael Svensson

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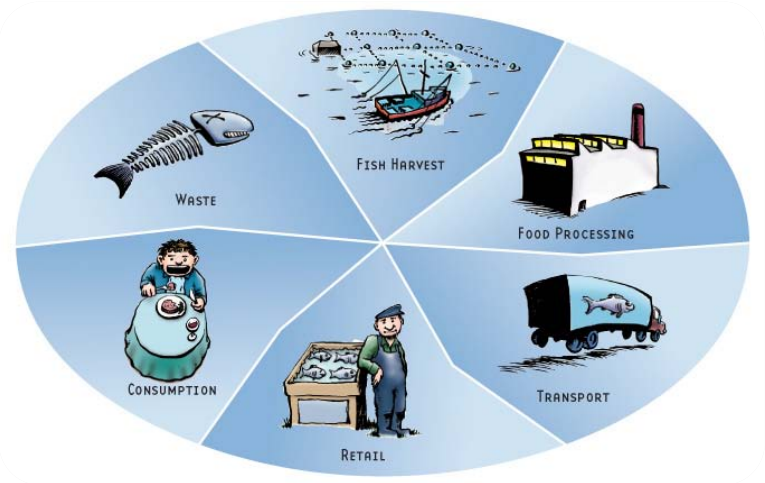
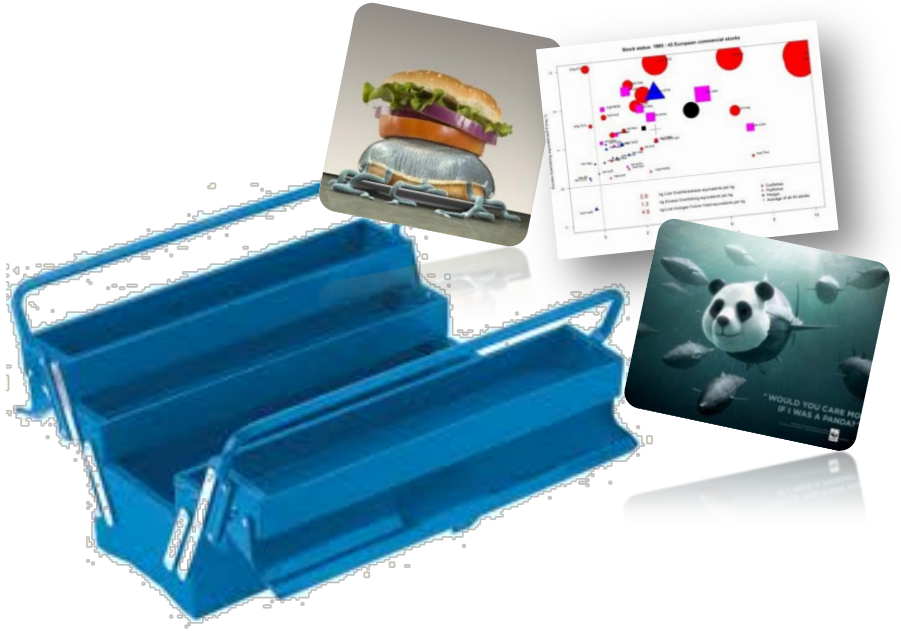
SVERIGES LANTBRUKSUNIVERSITET SLU

UNIVERSITY OF GOTHENBURG

D1.4 Marine Resource Use





New methods in the seafood LCA toolbox

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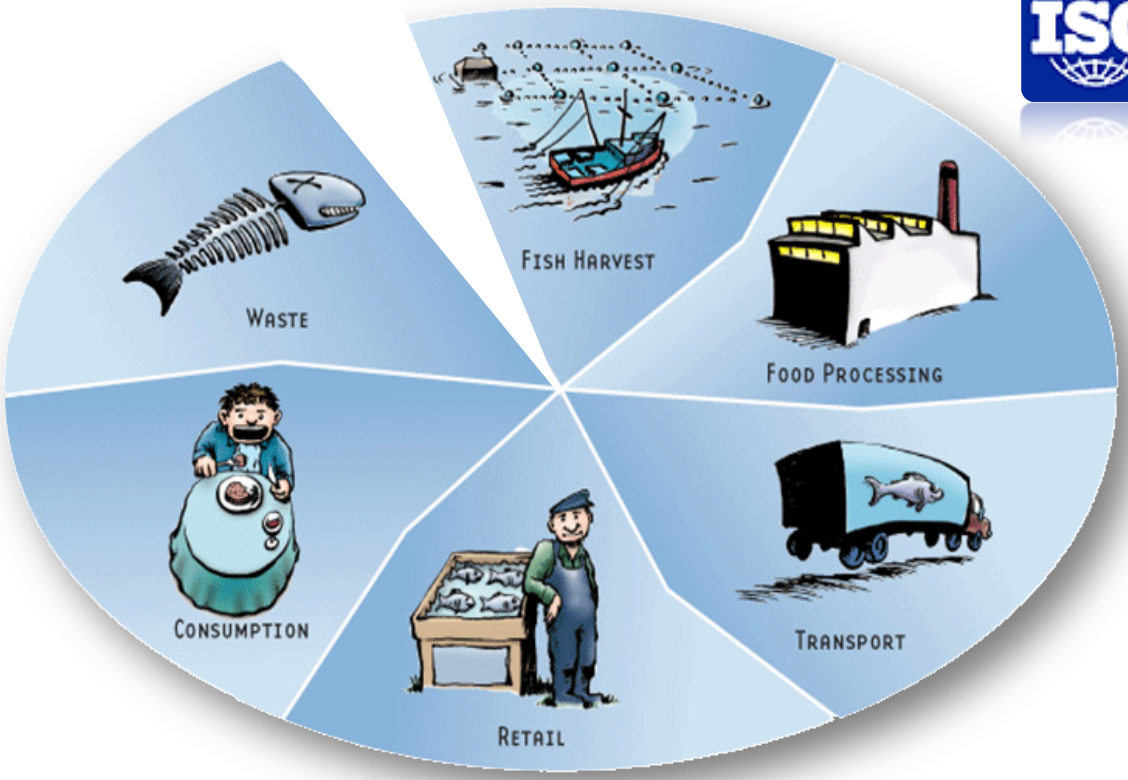
Life Cycle Assessment (LCA)

ISO International Organization for Standardization



The International Journal of Life Cycle Assessment

Editor-in-Chief: Walter Klöpffer

ISSN: 0948-3349 (print version)
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Journal no. 11367

2010 Impact Factor 3.148

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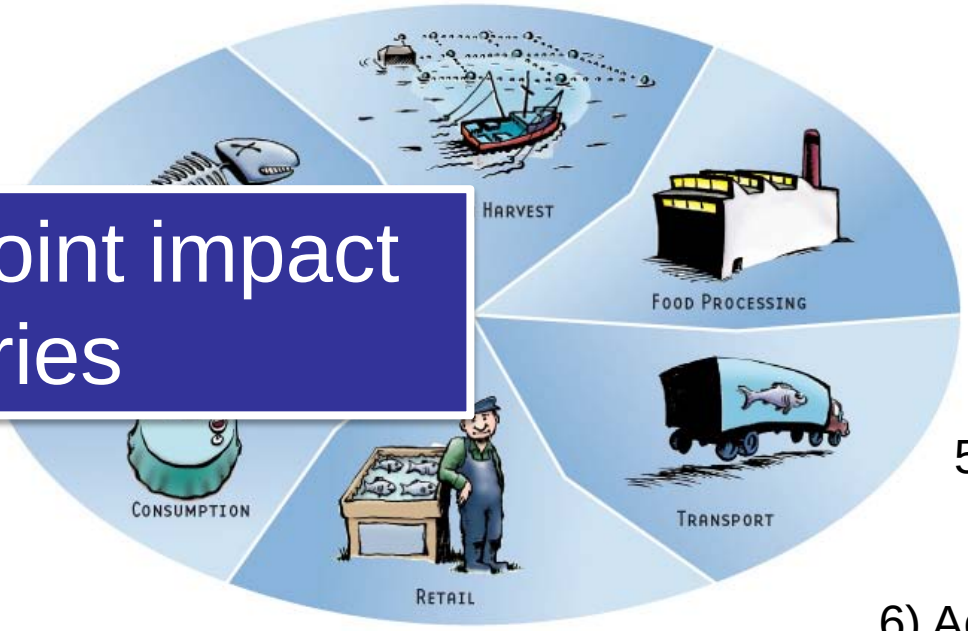
Account for Potential impacts!

1) Target stock

2) By-catches (ecosystem)

3) Swept area (ecosystem)



= Midpoint impact categories

4) Greenhousegases

5) Ozone depletion

6) Acidiphication

7) Eutrophication

8) Toxical emissons

9) X

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..or Potential damage to Safeguard objects!

1) Target stock

2) By-catches (ecosystem)

3) Swept area (ecosystem)

= Endpoint impact categories

4) Greenhousegases

Damage of "*Natural environment*"

Damage of "Natural Resources"

5) Ozone depletion

Damage on "Human Health"

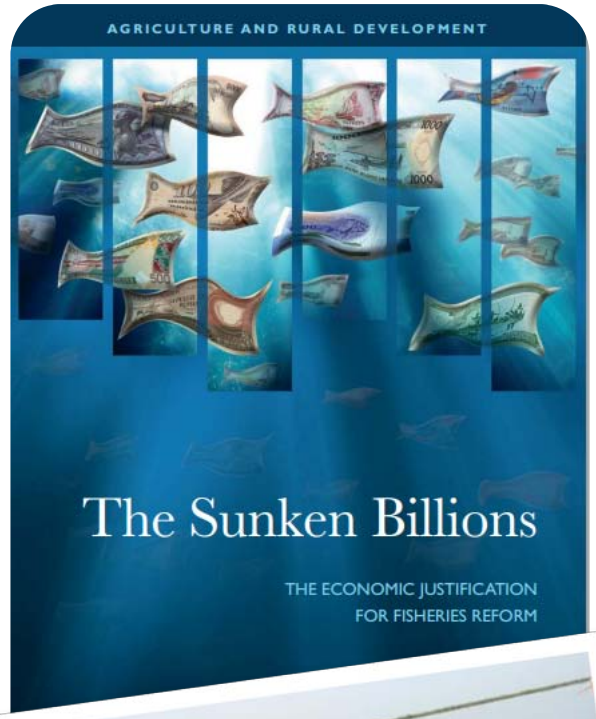
6) Acidiphication

9) X

8) Toxical emissons

7) Eutrophication

I. Target stock (Lost resources…)



- Sunken billions (FAO 2009)
  50 billion $ annually. 64% of landed value…jobs lost…
- Health benefits:
  1 billion starving/ malnourished.
  >1 billion “over nourished”
- 17% an animal protein (7% all protein) 0.1% global GDP

ICES CIEM

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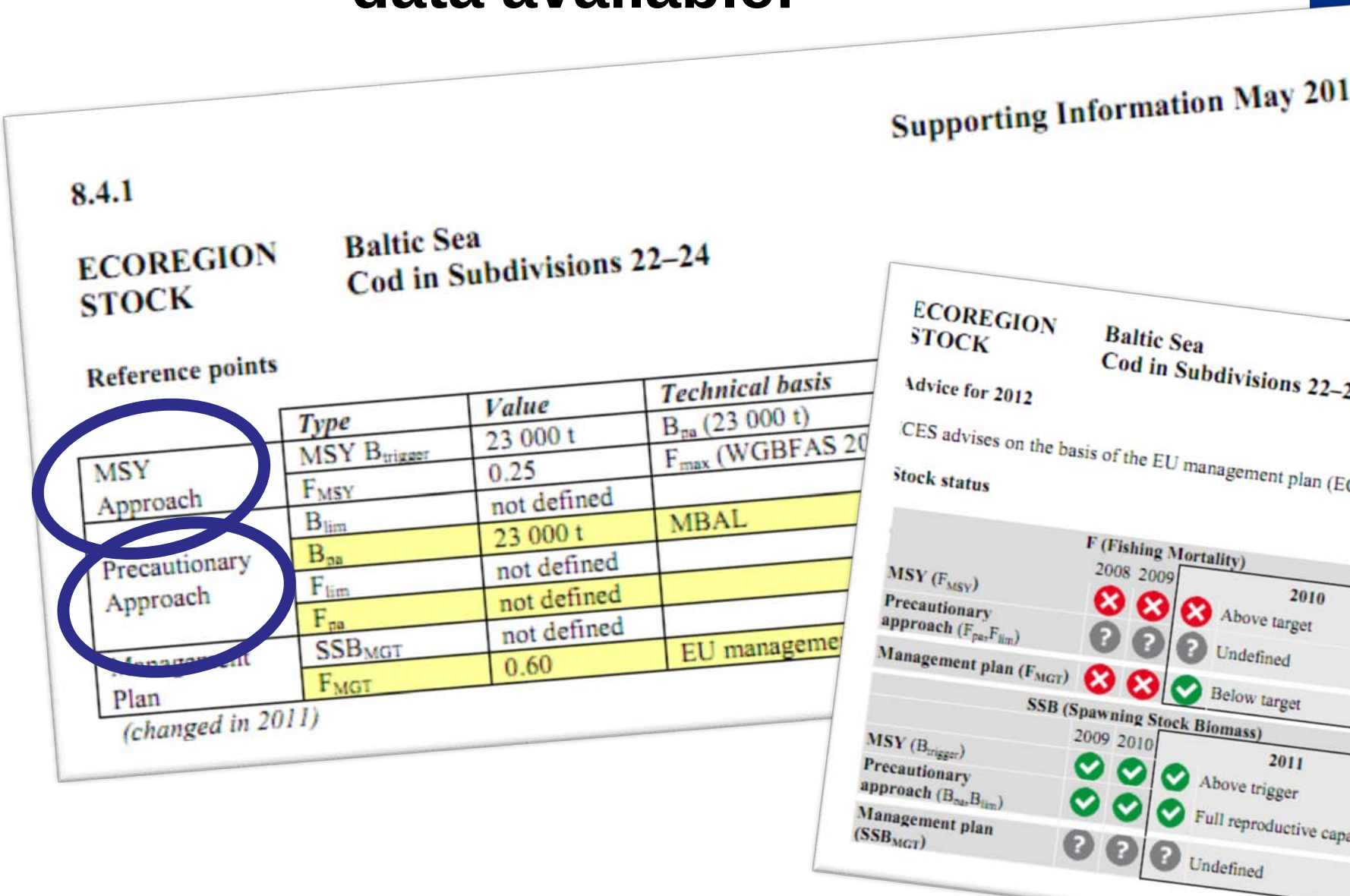
Stock Assessment data available!



Supporting Information May 201

8.4.1

ECOREGION Baltic Sea
STOCK Cod in Subdivisions 22–24

Reference points

	Type	Value	Technical basis
MSY Approach	MSY $B_{trigger}$	23 000 t	B_{pa} (23 000 t)
	F_{MSY}	0.25	F_{max} (WGBFAS 20
Precautionary Approach	B_{lim}	not defined	
	B_{pa}	23 000 t	MBAL
	F_{lim}	not defined	
	F_{pa}	not defined	
Management Plan	SSB_{MGT}	not defined	
	F_{MGT}	0.60	EU manageme

(changed in 2011)

ECOREGION Baltic Sea
STOCK Cod in Subdivisions 22–2

Advice for 2012

CES advises on the basis of the EU management plan (E

Stock status

	F (Fishing Mortality)		
	2008	2009	2010
MSY (F_{MSY})	✗	✗	✗ Above target
Precautionary approach (F_{pa},F_{lim})	?	?	? Undefined
Management plan (F_{MGT})	✗	✗	✓ Below target

	SSB (Spawning Stock Biomass)		
	2009	2010	2011
MSY ($B_{trigger}$)	✓	✓	✓ Above trigger
Precautionary approach (B_{pa},B_{lim})	✓	✓	✓ Full reproductive capa
Management plan (SSB_{MGT})	?	?	? Undefined

Maximum Sustainable Yield (MSY)

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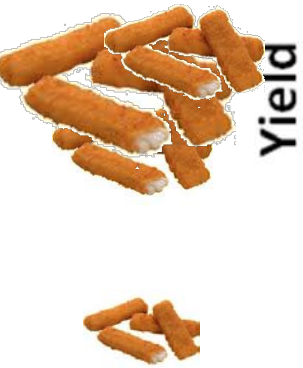
Birth-Crucifiction-Resurrection (1930ies – present)



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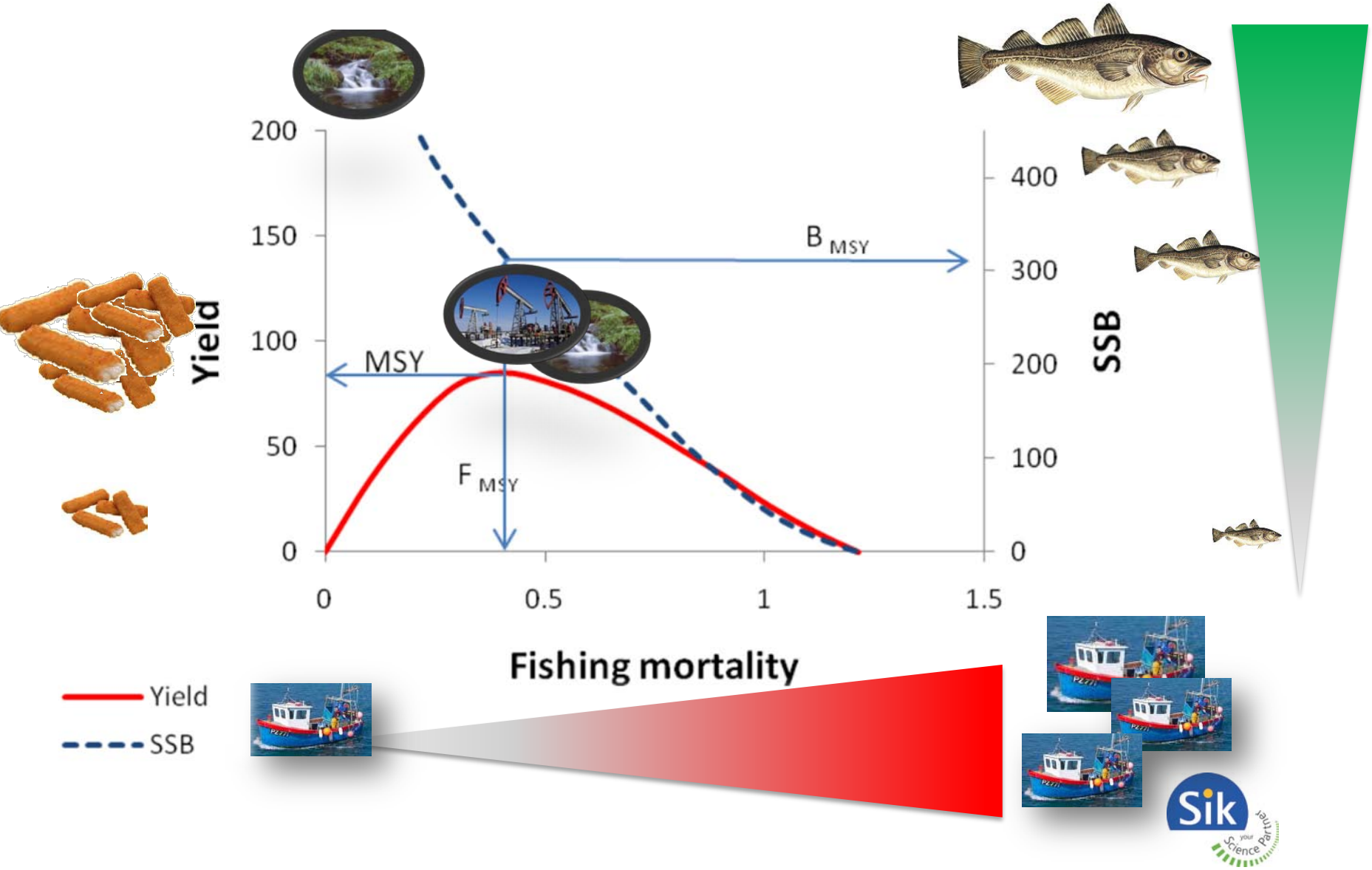
Maximum Sustainable Yield (MSY)

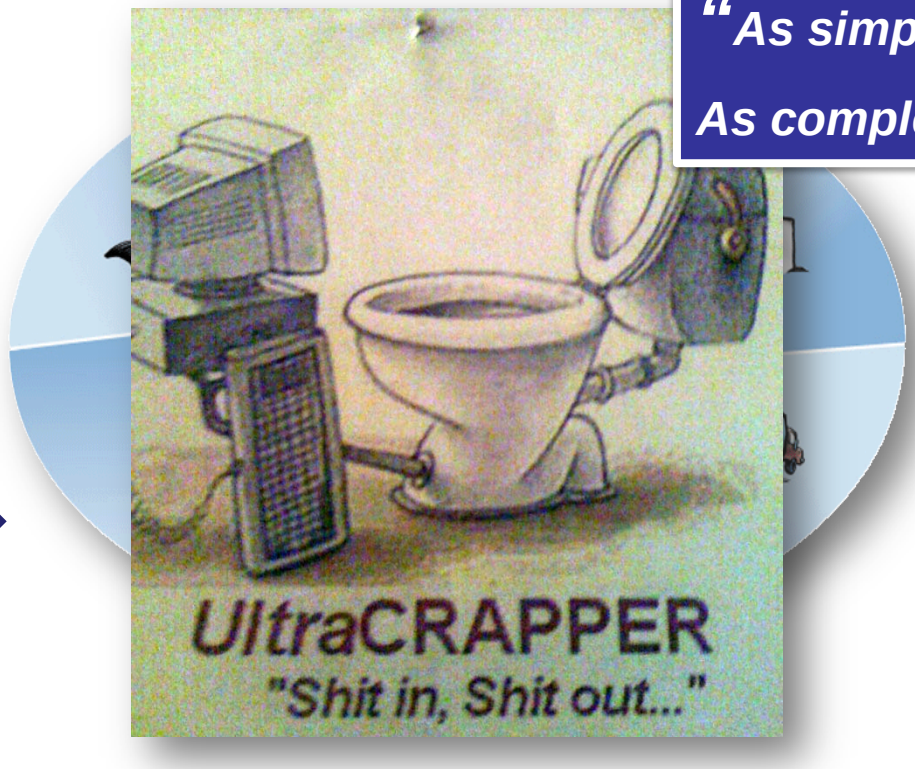


Impact assessment models

"As simple as possible,

As complex as necessary"

Observation, field work, statistics



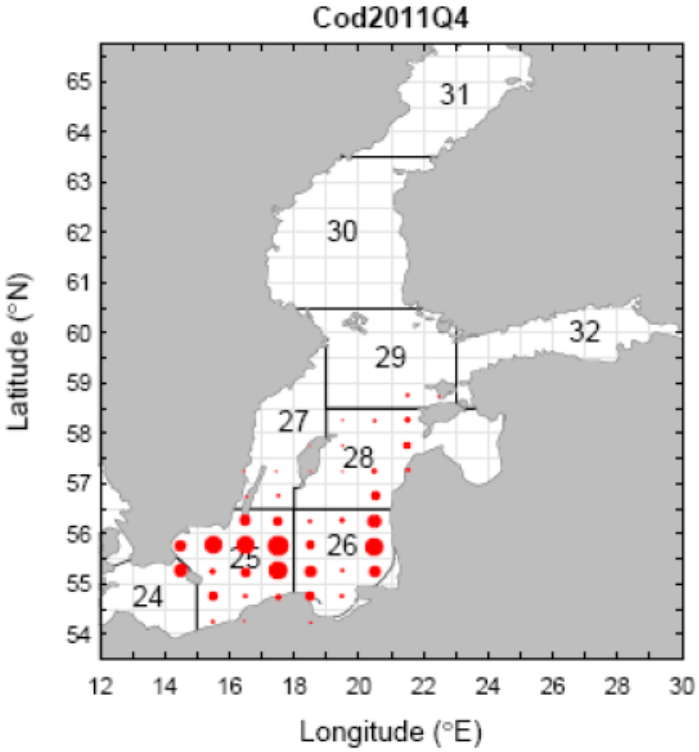
Prediction, conclusions, Action

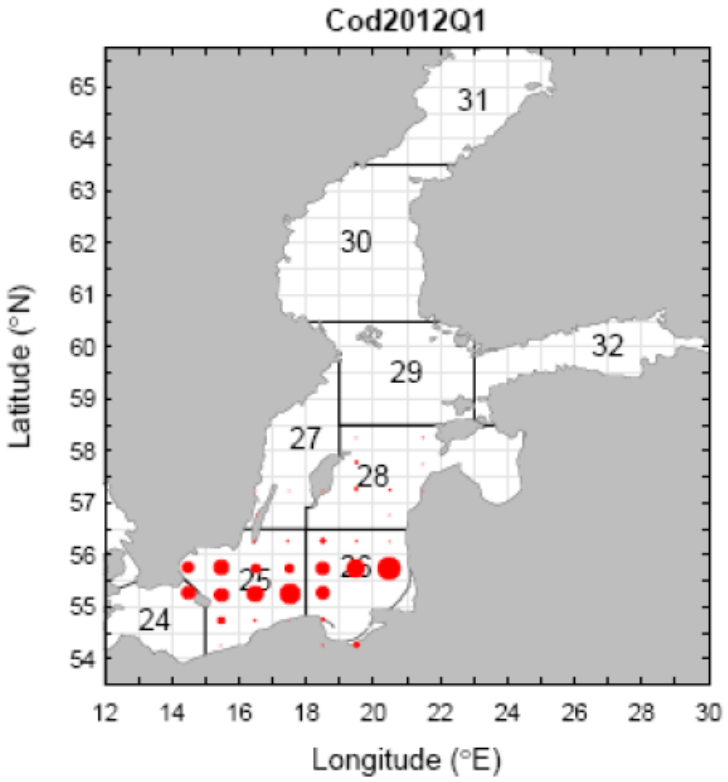
"Essentially. all models are wrong. but some are useful"

George E. P. Box. Empirical Model-Building and Response Surfaces (1987)

Spatial/temporal resolution!

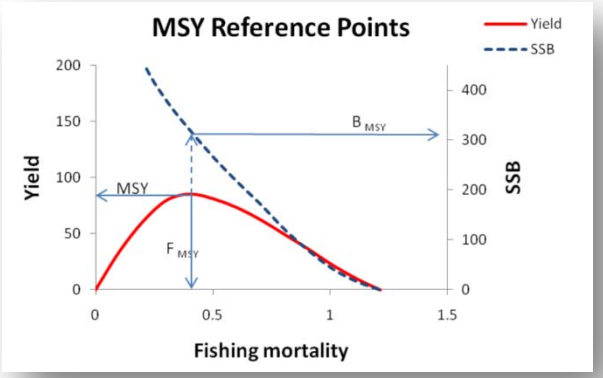
Eastern Baltic Cod *(Gadus morhua)*





Iterative characterization function

$$CF_{x,y,T} = \frac{\sum_T Y_{opt} - \sum_T Y}{\sum_T Y}$$



$$Y_t \approx \hat{F}_{annual,t} B_t = (1 - \exp(-\hat{F}_{inst,t})) * B_t$$

$$B_{t+1} = B_t + 2\hat{F}_{MSY} B_t \left(1 - \frac{B_t}{2B_{MSY}}\right) - \hat{F}_t B_t$$

Lost Potential Yield 2010

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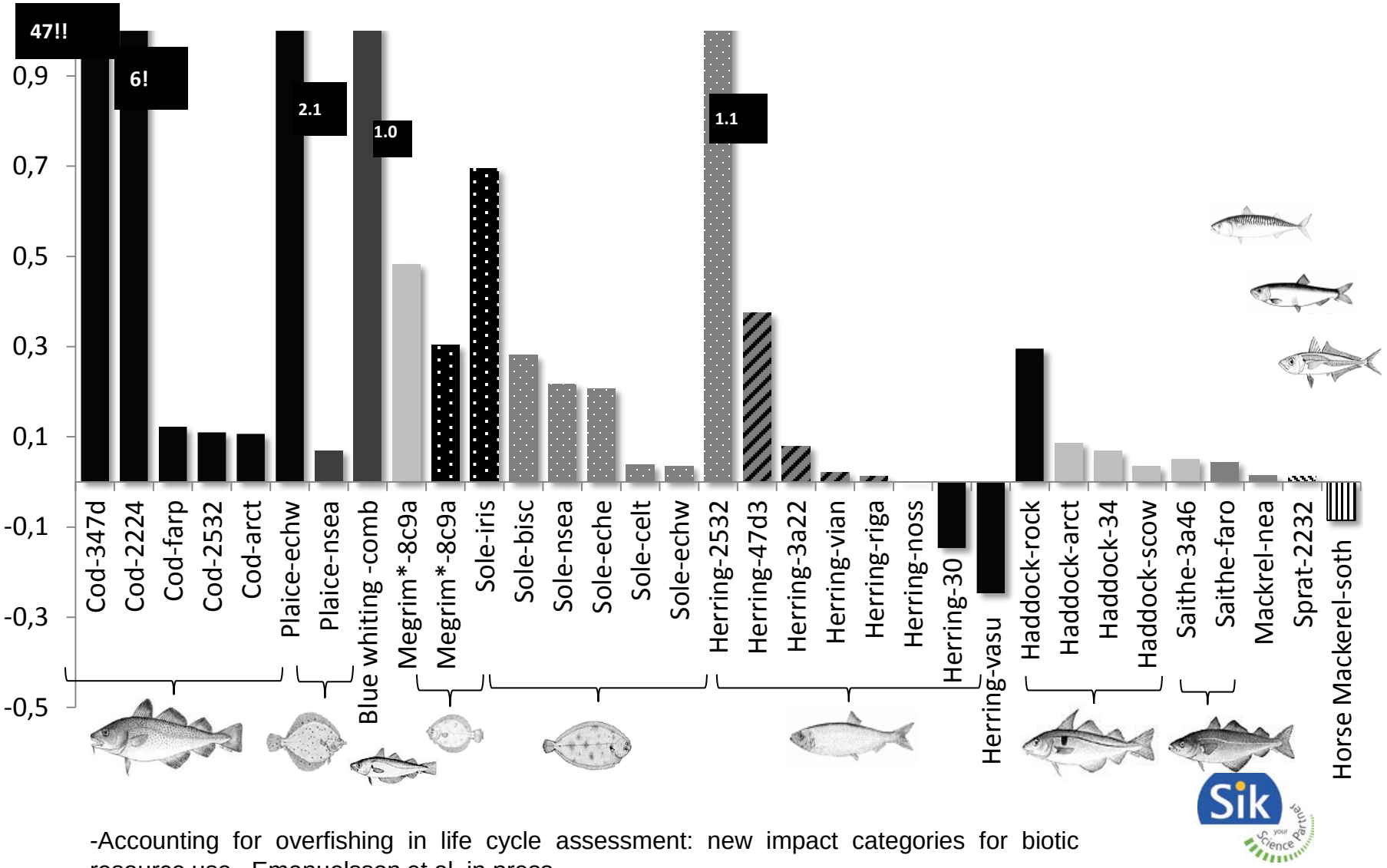

-Accounting for overfishing in life cycle assessment: new impact categories for biotic resource use, Emanuelsson et al, in press

Overfishedness (Bmsy/B-1) vs Overfishing (F/Fmsy-1)

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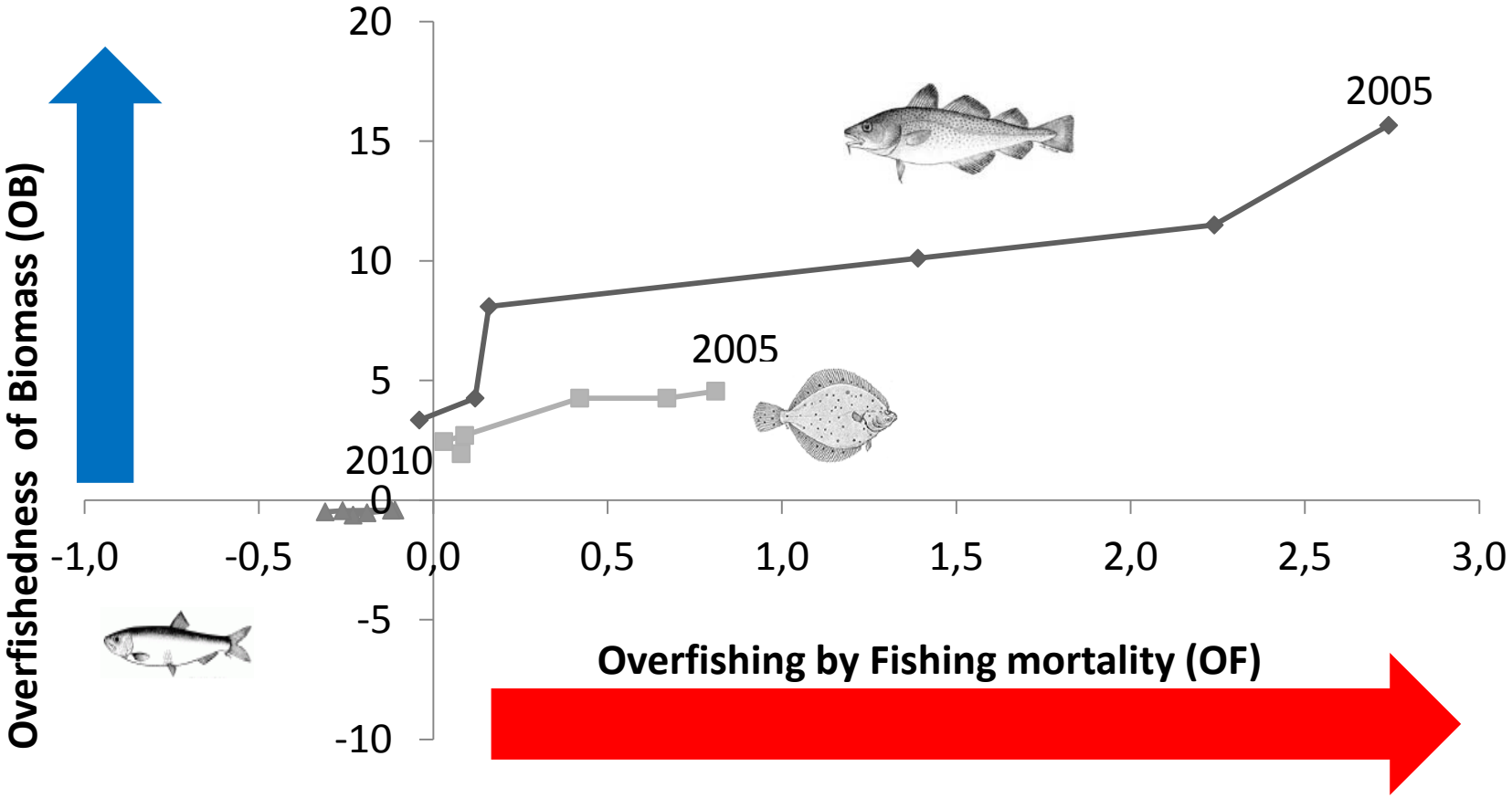
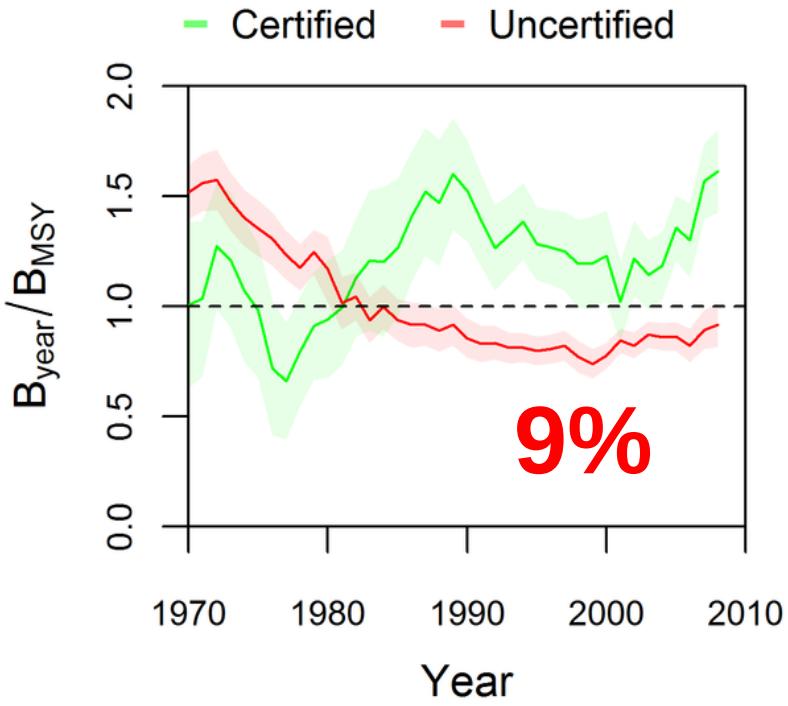
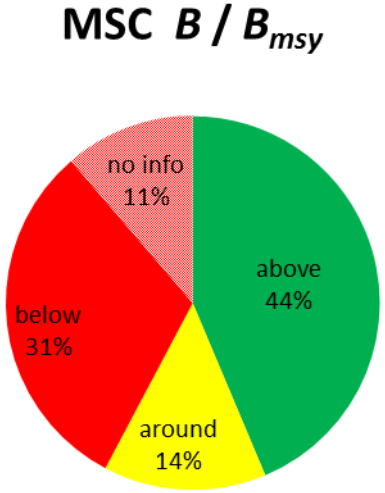


…..Bmsy Input data



***Gutiérrez et al 2012**. Eco-Label Conveys Reliable Information on Fish Stock Health to Seafood Consumers. PLoS One.*



31%

***Froese R. Proelss A.** Evaluation and legal assessment of certified seafood. Mar. Policy (2012)*

Future endpoint characterization

Biomass (B)

$B_{PRISTINE}$ $B_{ECOSYSTEM}$? B_{MSY} B_{PA} or $B_{TRIGGER}$ $B_{NON\ RECOVERY}$

Fishing mortality (F)

No fishing $F_{ECOSYSTEM}$? F_{MSY} F_{PA} F_{LIM} $F_{COLLAPSE}$

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Stock resolution!

Spatial variability!

Cod	Haddock	Herring	Sole
6.6	0.07	1.04	0.28
0.09	0.09	0.15	0.04
42.6	0.29	0.11	0.20
0.14	0.04	0.37	0.04
0.10		-0.01	0.78
0.11		0.01	0.18
		0.24	
		0.02	

kg WPY lost per kg landed

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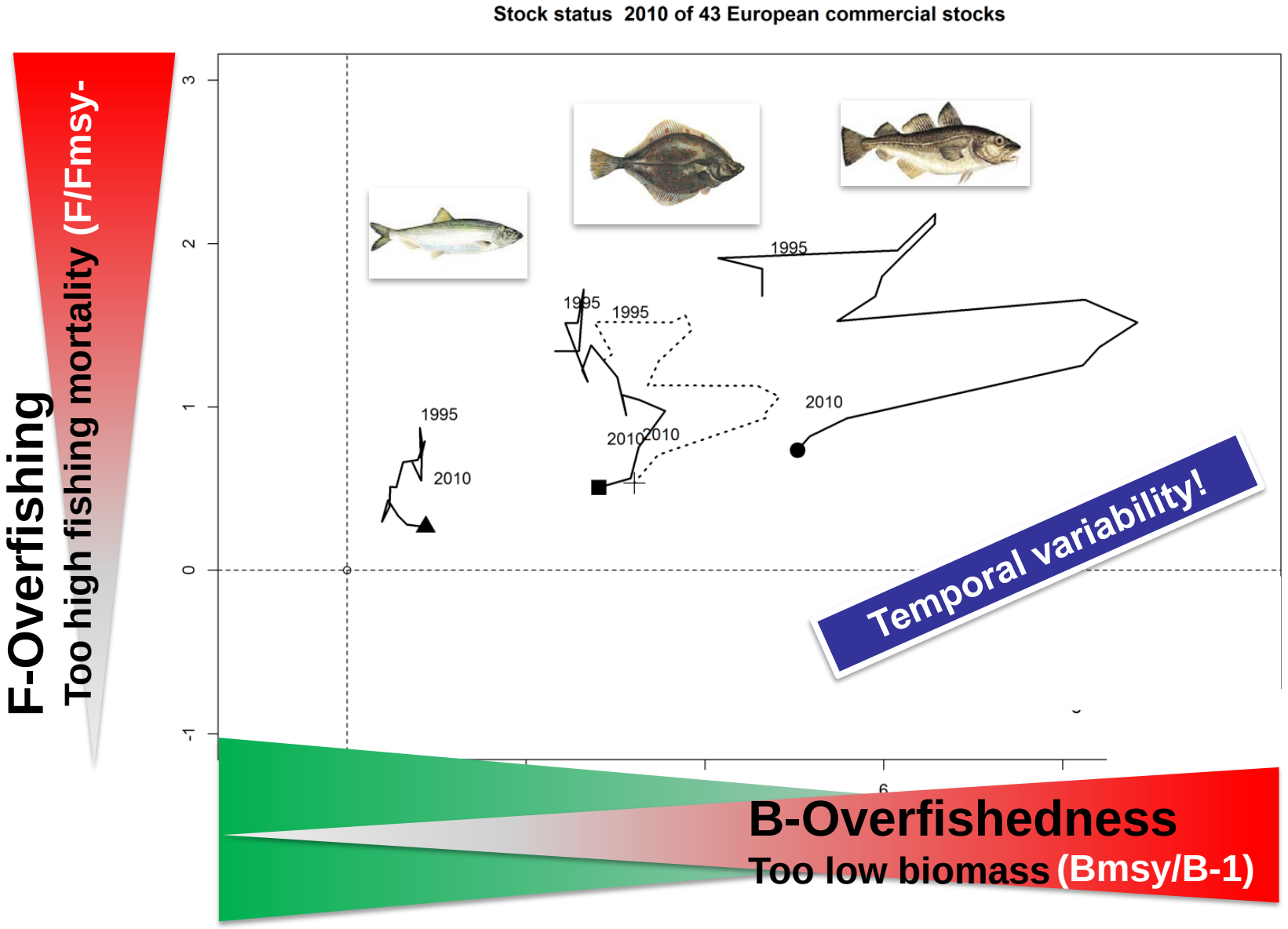
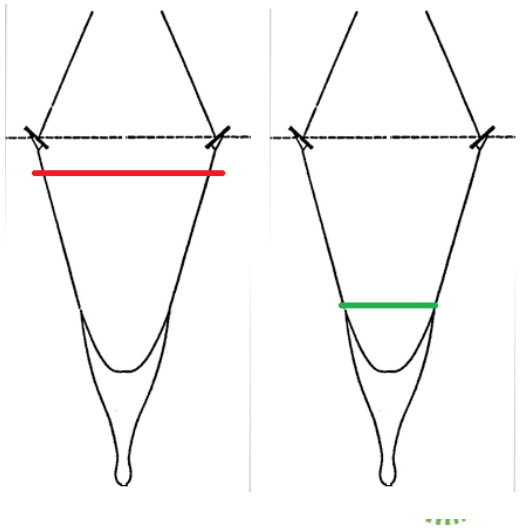
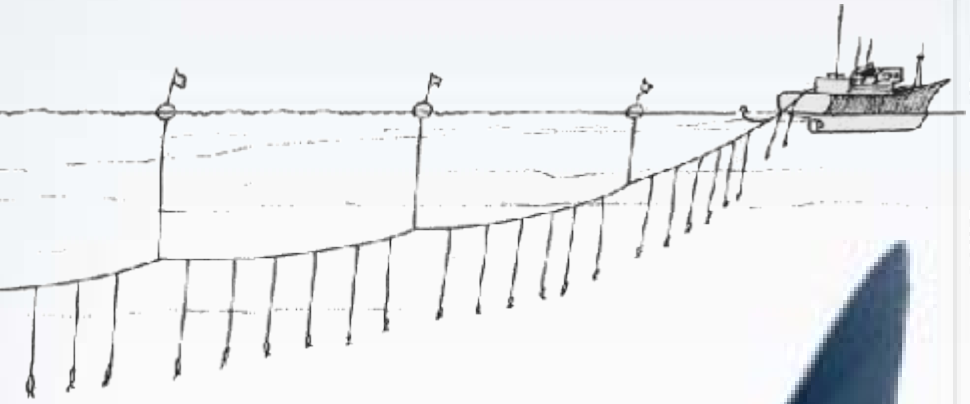
European fisheries…



II. ECOSYSTEM (VEC, PPR, Swept area)



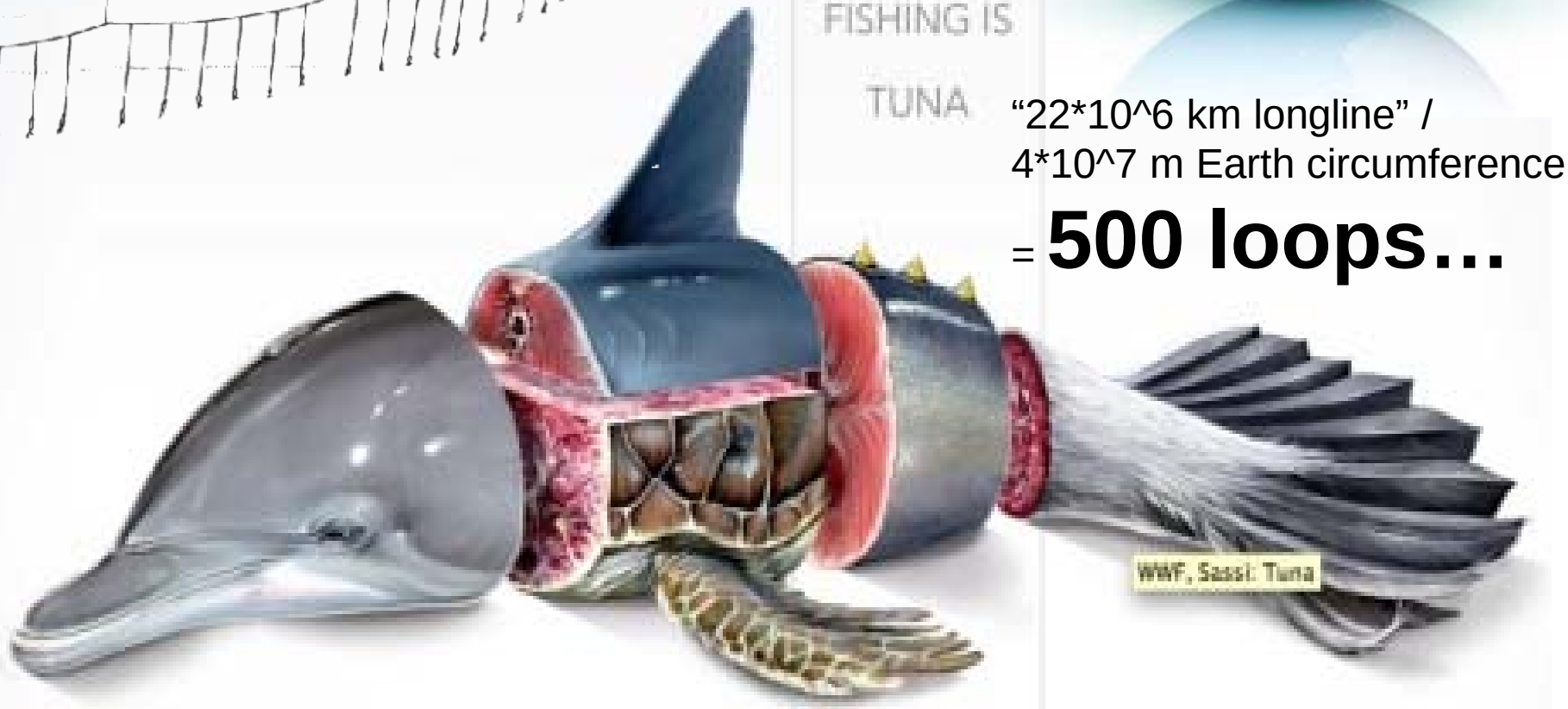
By-catches



ONLY A PORTION OF THE CATCH IN LONG LINE TUNA FISHING IS TUNA

“22*10^6 km longline” /
4*10^7 m Earth circumference

= **500 loops…**



By-catch: catch of non-targeted species

- Non optimized resource use
- Impedes rebuilding of stocks
- Pressure on data deficient species
- Impact on threatened species

By-catches, some estimates

- **40 % of global catches** are by-catches (Davis et al., 2009)
- 0-96% of catches could be discarded at sea (**8% weighted global average**) (Kelleher, 2005)
- **80 % of global catches lack stock assessment** (Costello et al., 2012)

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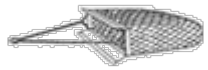
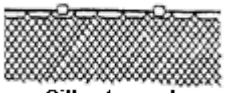
% Discard by Fishery

	Weighted average discard rate (%)	Landings	Discards
Shrimp trawl	62.3	1 126 267	1 865 064
Tuna and HMS longline	28.5	1 403 591	560 481
Dredge	28.3	165 660	65 373
Mobile trap/pot	23.2	240 551	72 472
Demersal finfish trawl	9.6	16 050 978	1 704 107
Demersal longline	7.5	581 560	47 257
Tuna purse seine	5.1	2 673 378	144 152
Midwater (pelagic) trawl	3.4	4 133 203	147 126
Handline	2.0	155 211	3 149
Multigear and multispecies	1.4	6 023 146	85 436
Small pelagics purse seine	1.2	3 882 885	48 852
Gillnet (surface/bottom/trammel)	0.5	3 350 299	29 004
Tuna pole and line	0.4	818 505	3 121
Hand collection	0.1	1 134 432	1 671


Trawls


Dredges


Gillnets and Entangling Nets

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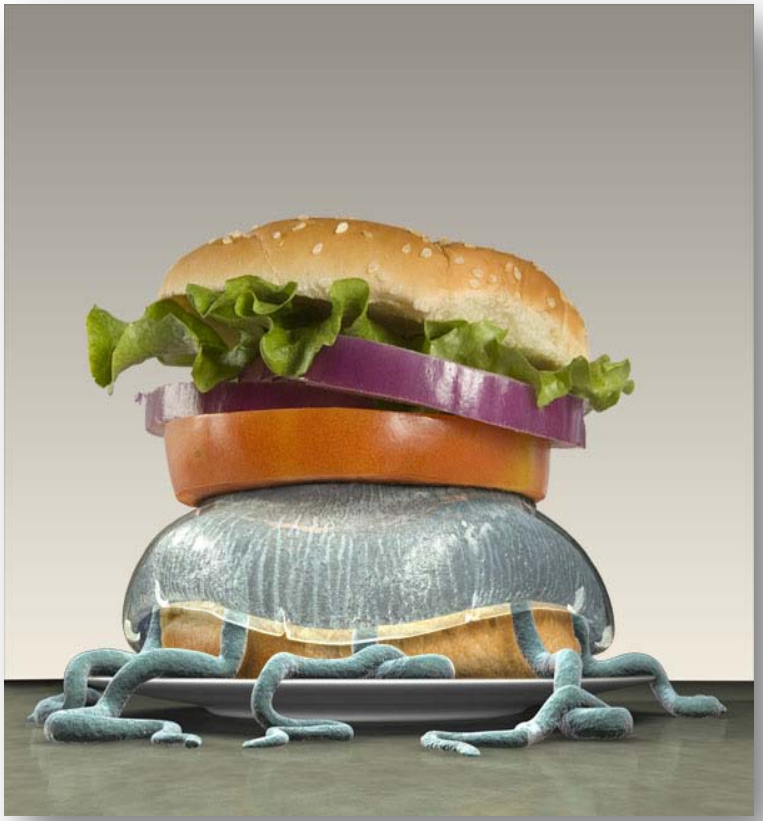
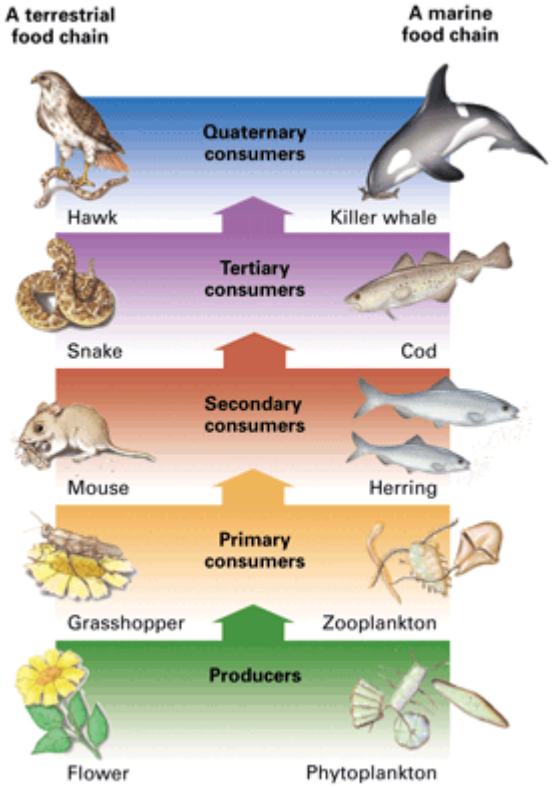
Primary Production Required



$$PPR = (Catch / 9) * 10\text{^} (TL - 1)$$



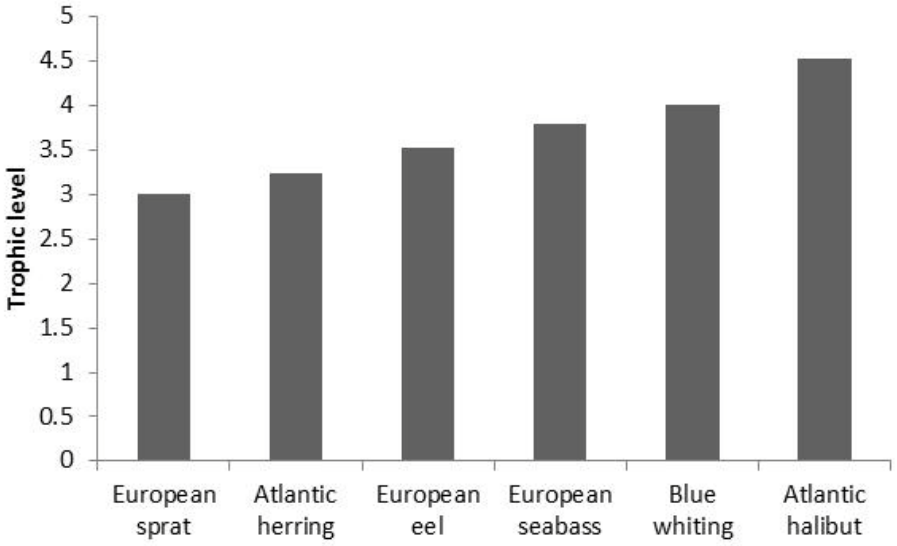
Papatryphon 2004, Pelletiers 2007, Aubin et al 2008

Factor 1/9 aproximates an carbon content of 111.1 g carbon / kg wet weight

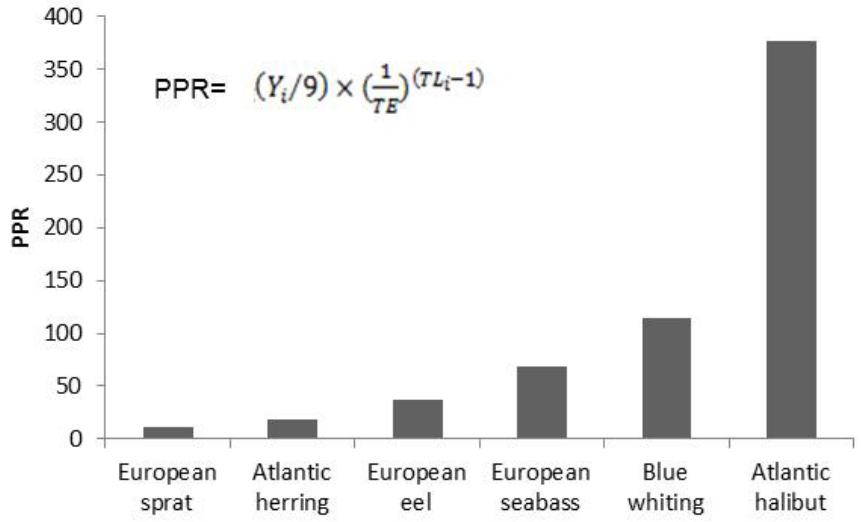
Primary Production Required (PPR)

in kilo carbon from discards per kilo landed product.

Related to trophic level, but energy transfer is acknowledged



Trophic levels



PPR

Primary Production Required (PPR)

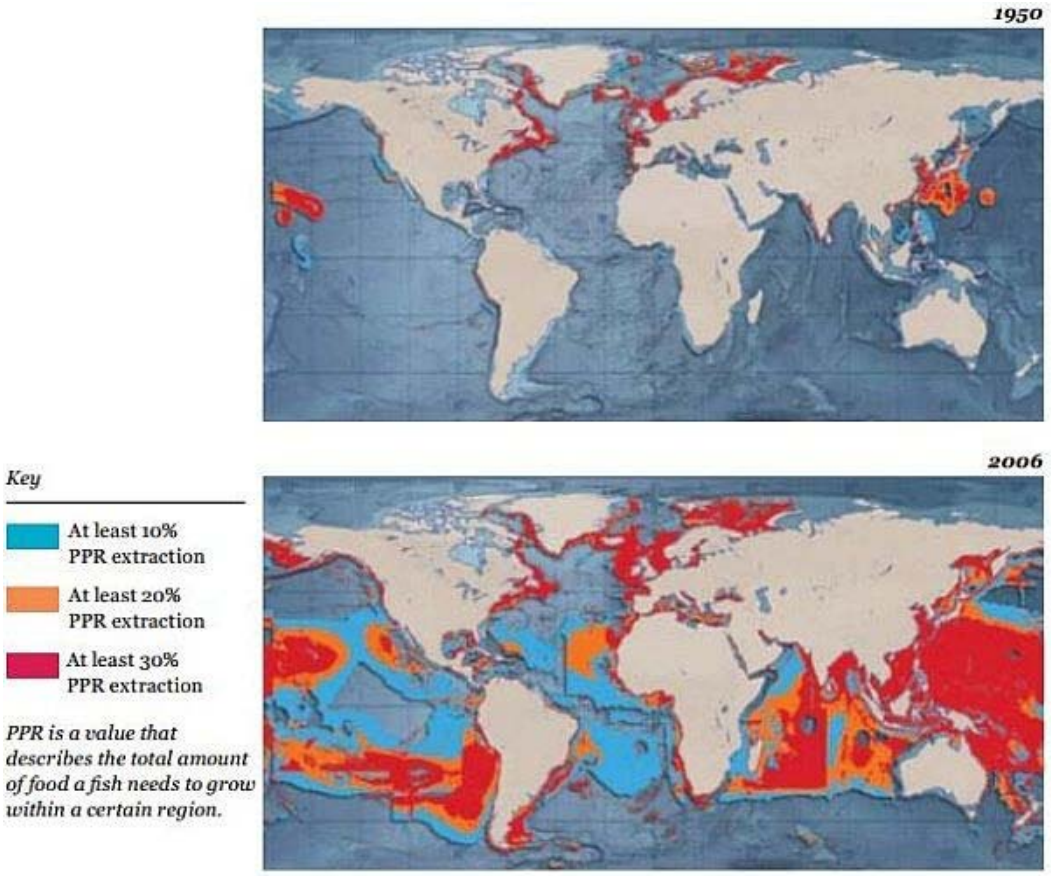
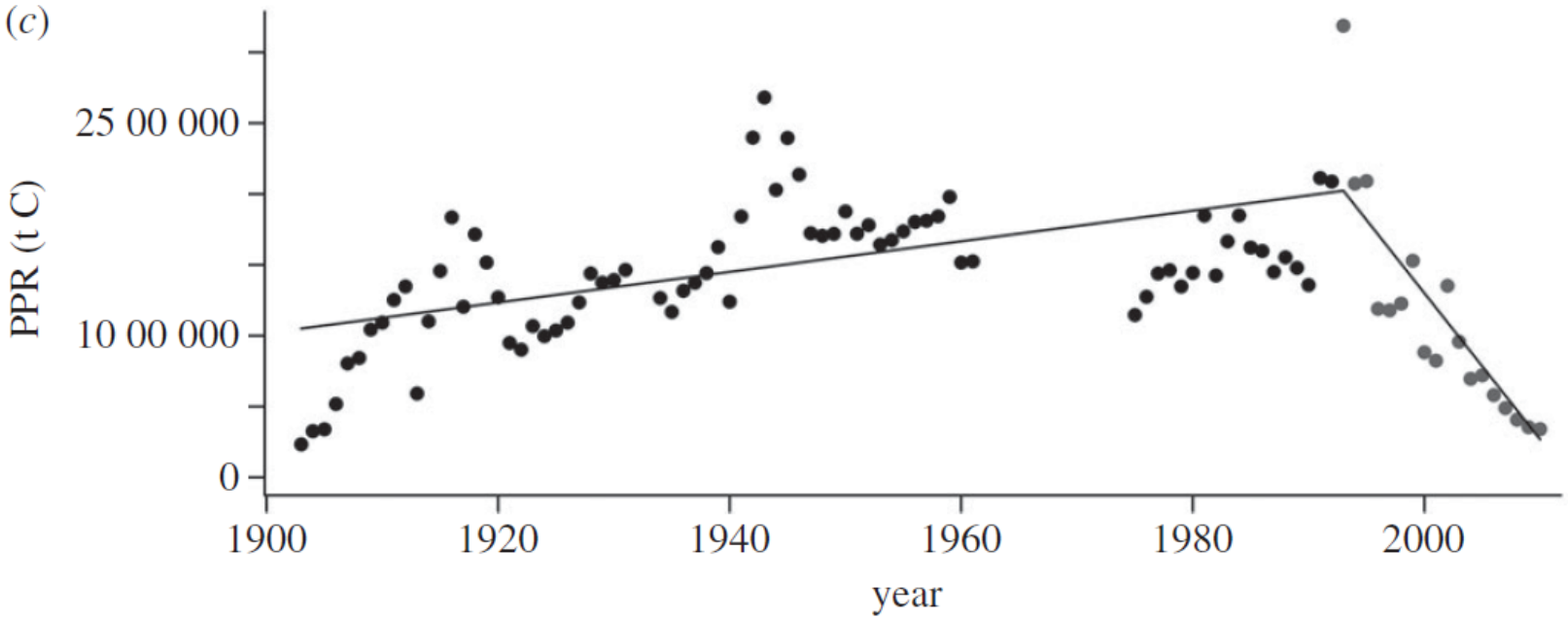


Figure 51: The expansion and impact of world fishing fleets in a) 1950 and b) 2006

Swartz et al 2010

Primary Production Required (PPR)

What is the impact?



Hornborg et al. 2013 Biology Letters

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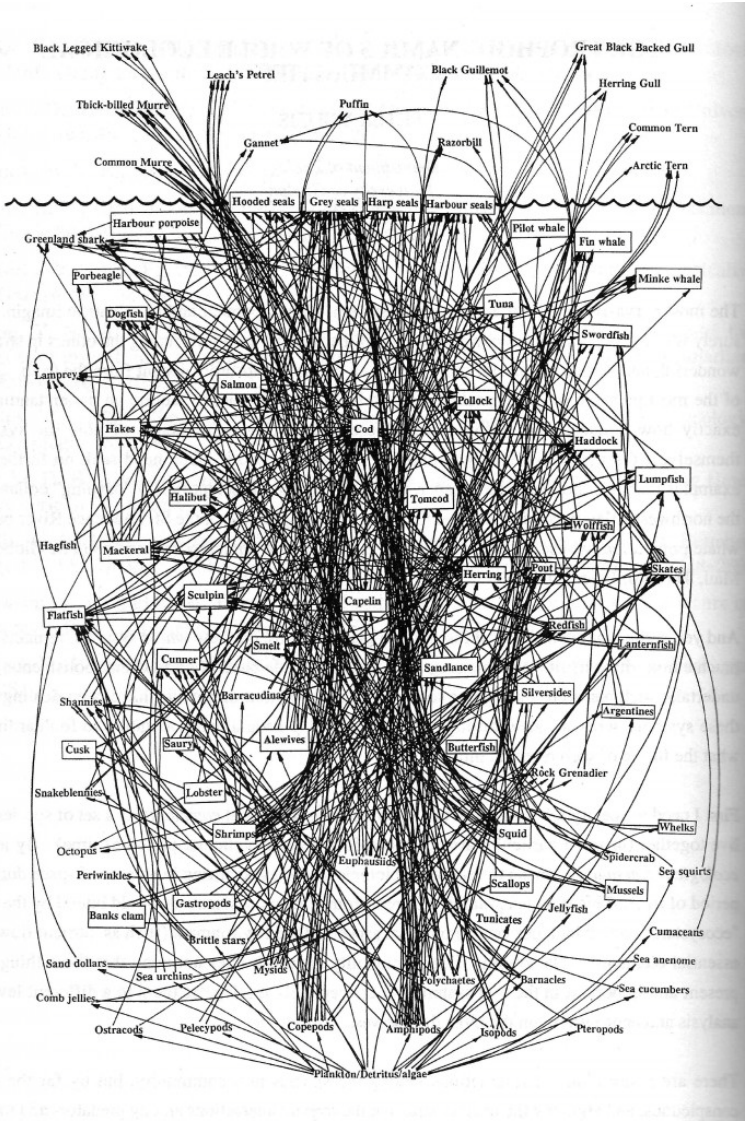
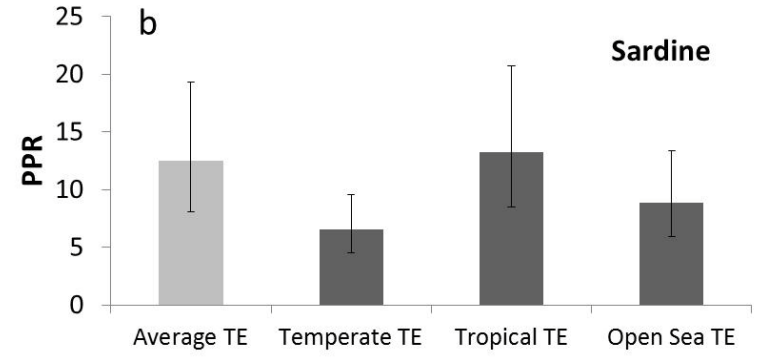
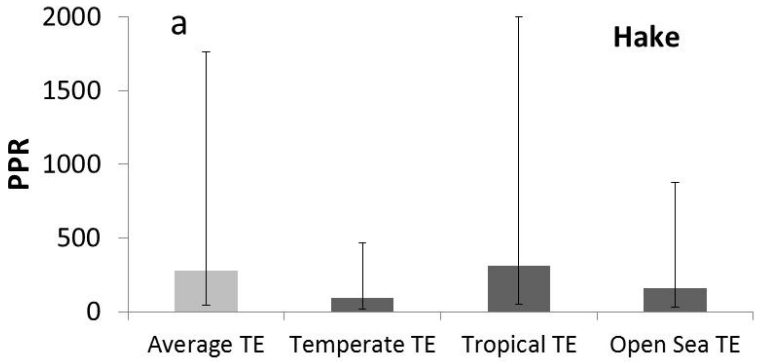
Constraints

- **Great uncertainties and variability in TL and TE estimates**







Lack the dimension of sensitivity to pressure!

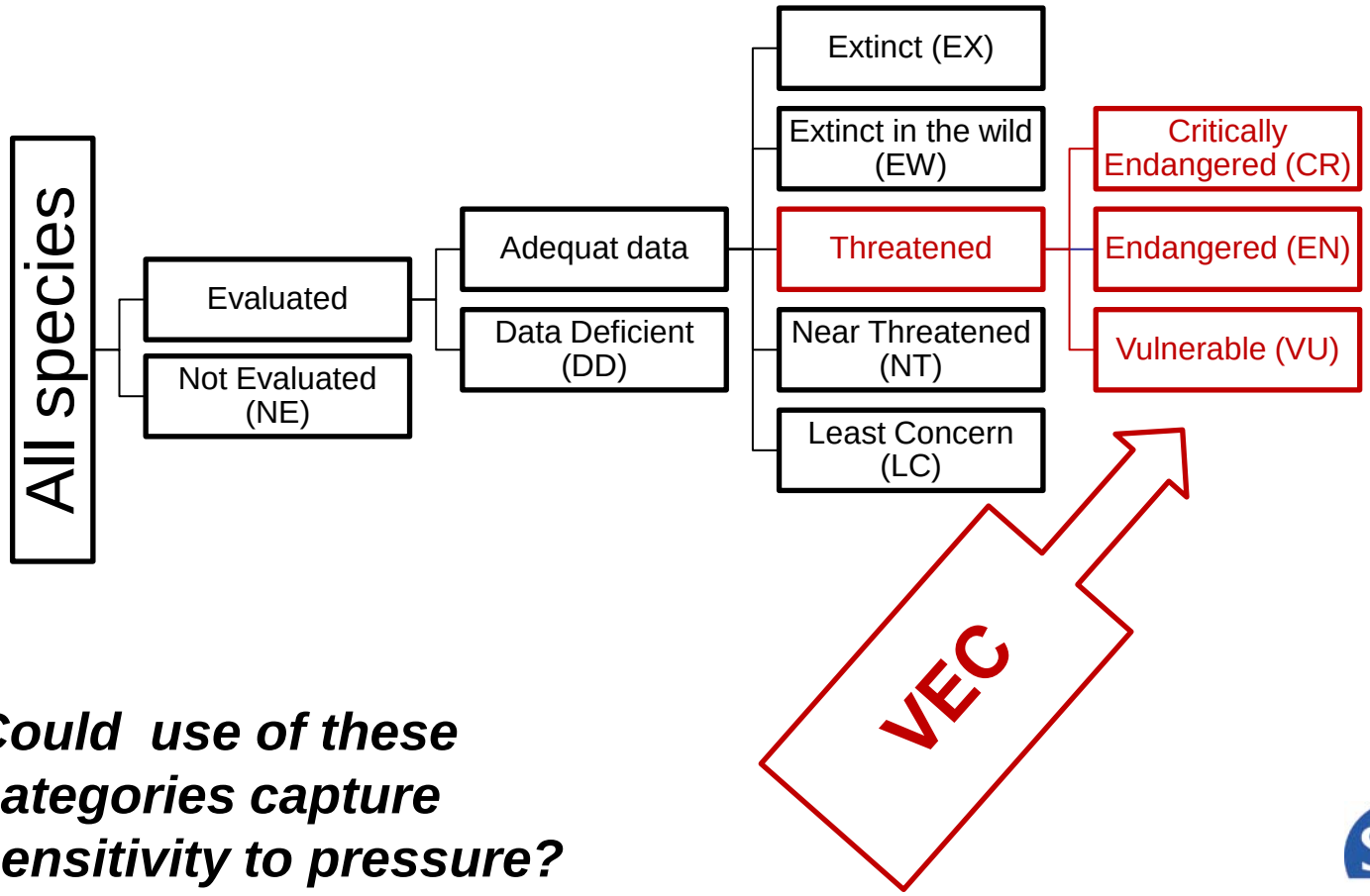
Futher development marine resource use

- **Different TE values for PPR estimates?**

	Average	Temperate	Tropical	Open Sea	Upwelling	
TL	**10**	**7.3**	**10.3**	**8.5**	**25.0**	**1/TE**
3.11	14.3	7.4	15.3	14.3	98.9	
4	111.1	43.2	121.7	67.6	1736.1	
4.4	279.1	95.7	309.6	159.0	6291.5	

$$PPR = (Y_i/9) \times \left(\frac{1}{TE}\right)^{(TL_i - 1)}$$

The IUCN Red List Categories and Criteria



Could use of these categories capture sensitivity to pressure?

IUCN Red List: Sweden 2010

REGIONAL EXTINCT (RE)

Dipturus batis

Acipenser oxyrinchus

CRITICALY THREATNED (CT)

Lamna nasus

Cetorhinus maximus

Squalus acanthias

Anguilla anguilla

Pollachius pollachius

ENDANGERED (EN)

Chimaera monstrosa

Raja clavata

Coryphaenoides rupestris

Molva molva

Gadus morhua

Melanogrammus aeglefinus

Anarhichas lupus

Hippoglossus hippoglossus

VULNERABLE (VU)

Galeorhinus galeus

Somniosus microcephalus

Etmopterus spinax

Merlangius merlangus

NEAR THREATNED (NT)

Petromyzon marinus

Dipturus linteus

Sebastes viviparus

Cyclopterus lumpus

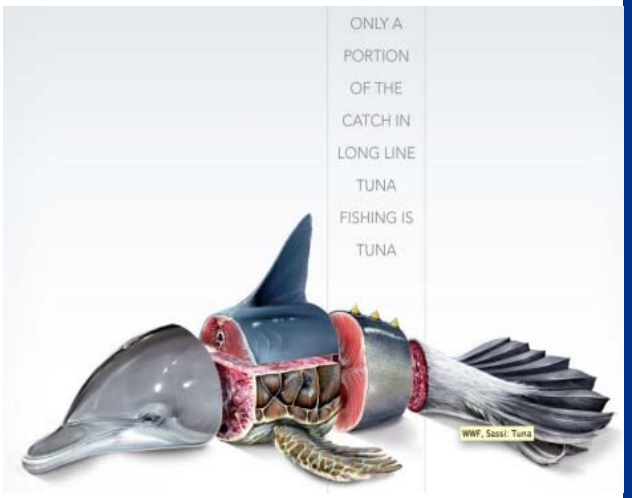
Zoarces viviparus

DATA DEFICIENCY (DD)

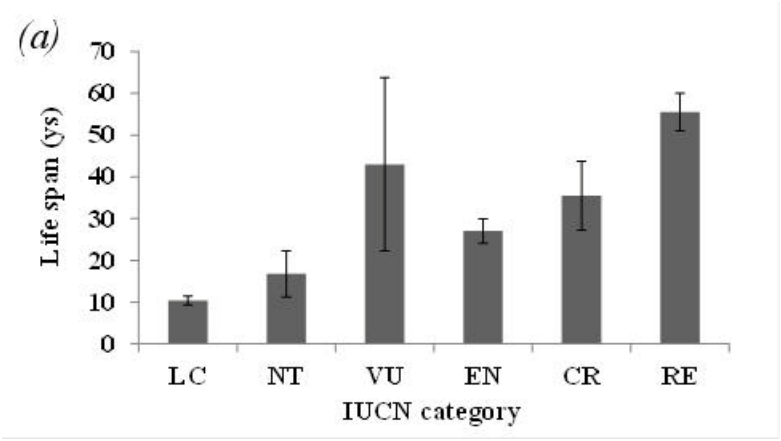
Enchelyopus cimbrius

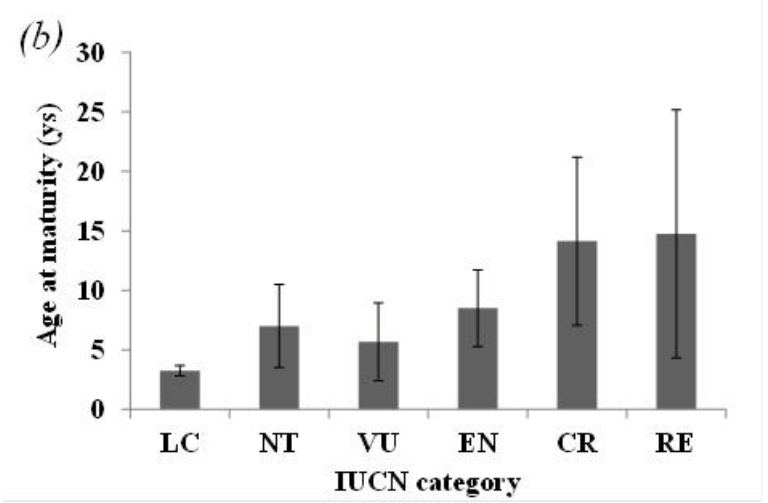
Micrenophrys lilljeborgii

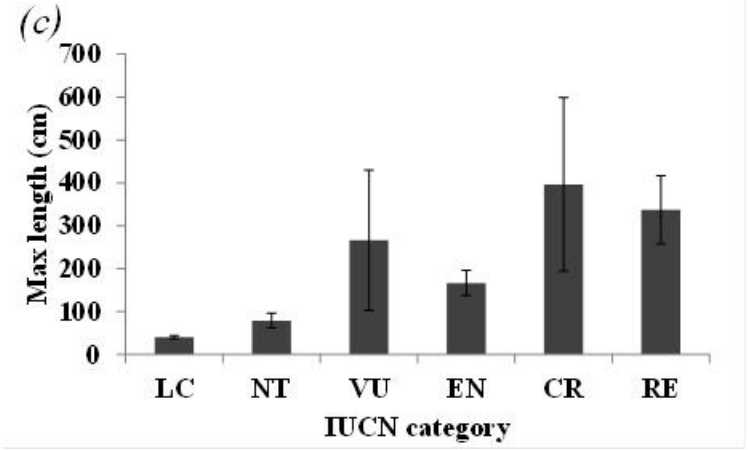
Lebetus scorpioides



Consistent sensitive life history traits





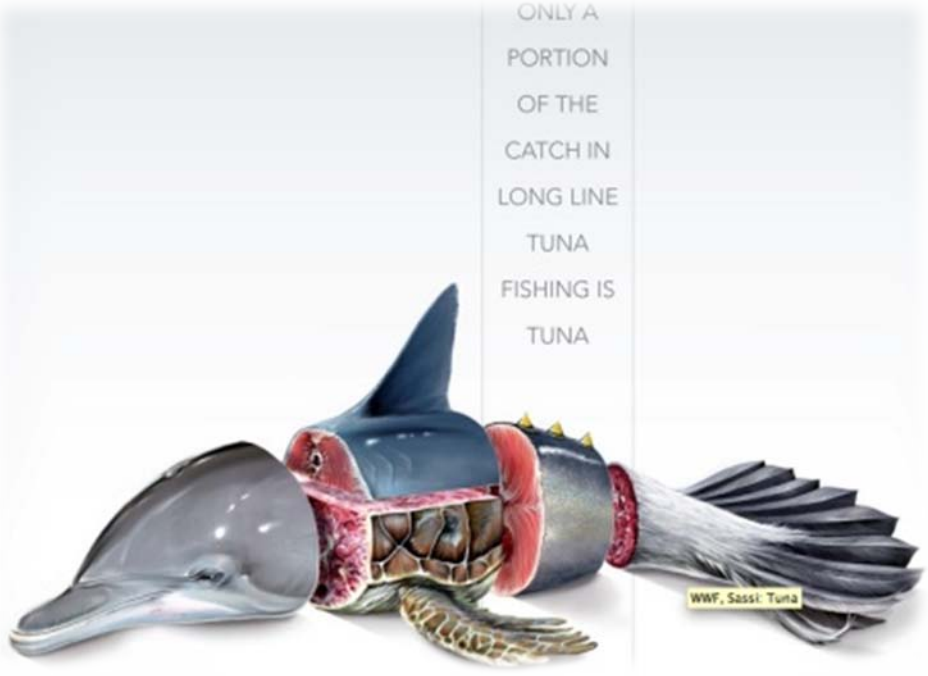


Hornborg et al. under revision

Consistent with advice in fisheries

IUCN	IUCN/ICES compatibility	Species/stocks with ICES advice (2009)	Comment
CR	4 hits	4 species	
EN	5 hits, 2 false alarms	4 species, 7 stocks	False alarms: Haddock[a] and cod[b] (Eastern Baltic, stock 25-32).
VU	1 uncertain	1 species	
NT	-	-	
LC	3 hits, 2 misses and 14 uncertain	13 species, 19 stocks	Misses: Herring[c] (stock IIIa, autumn spawners) and salmon[d].
NA	-	8 species	

Robust to sensitive life history traits and scientific advice =carrier of aggregated information



Constraints

- **Differences between stocks**
- **Coverage of assessments**
- **Other threatened species: birds, mammals, invertebrates**
- **Lacks dimension of resource use**

Future endpoint characterization

Resource/Economic endpoint

Ecosystem costing,
Pricing index WPY

Natural Environment endpoint

Disturbed natural flow (PPR) / Pristine biomass (K)
Allocate Extinction?

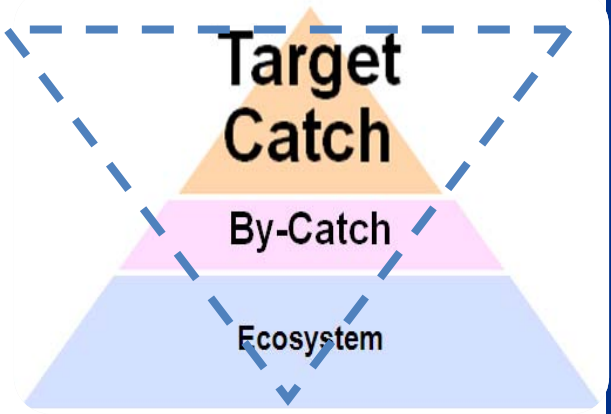
LCA – NOT A SUBSTITUTE FOR ECOLOGICAL RISK ASSESSMENTS

Complexity of marine LCIA

A. Monitoring / General data availability

B. High variability (Natural production)

C. Biodiversity - Risk assessment, probabilistic approach



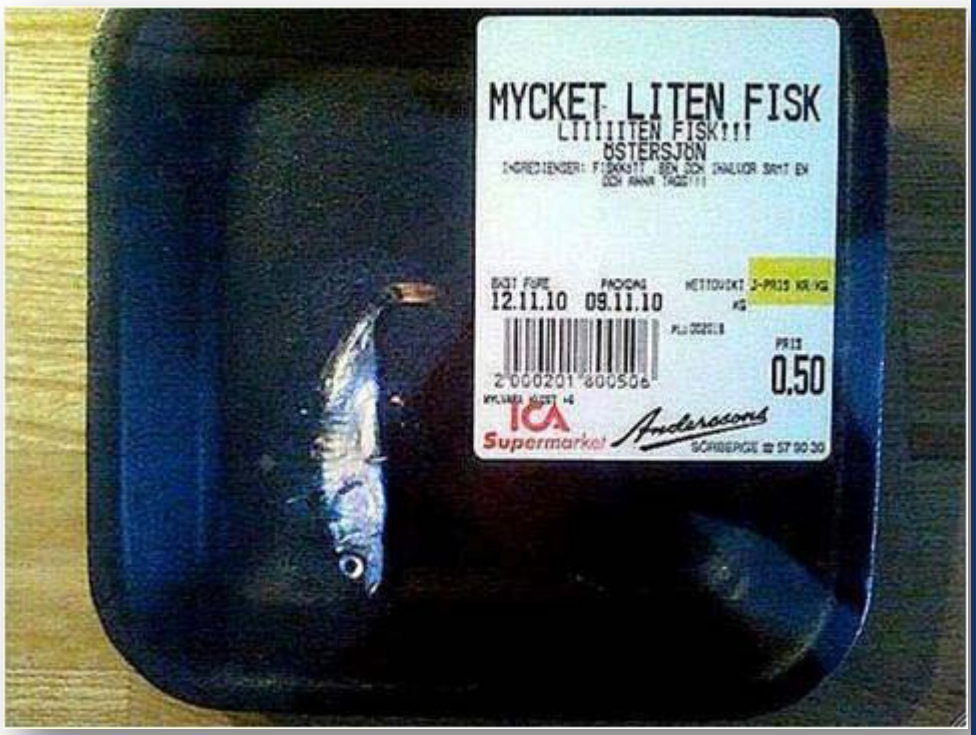
- approaching the boundaries of LCA applicability?

Future concepts to include

Size overfishing (*L-opt)*

Probabilistic approach
(risk assessments. role of LCA)

Data deficient stocks
= Bycatch (Vulnerability/CPUE approach)



Seize selectivity?

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Atlantic cod

Conservation status

Extinct | Threatened | Lower Risk

EX EW CR EN VU cd nt lc

Vulnerable (IUCN 2.3)[1]

Scientific classification

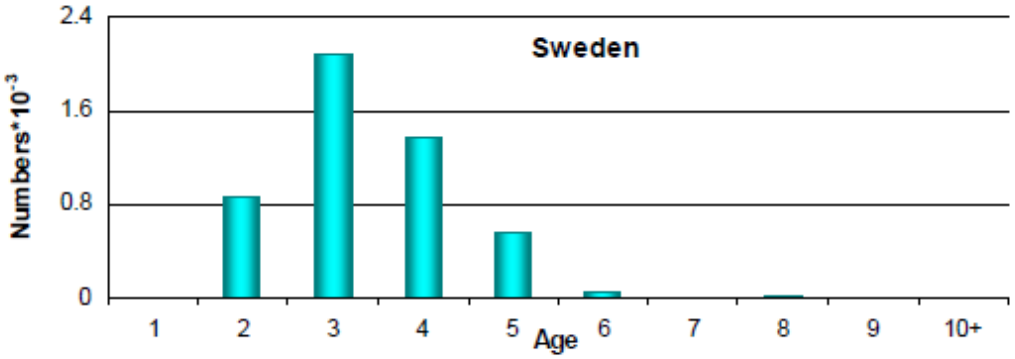
Kingdom:	Animalia
Phylum:	Chordata
Class:	Actinopterygii
Order:	Gadiformes
Family:	Gadidae
Genus:	*Gadus*
Species:	***G. morhua***

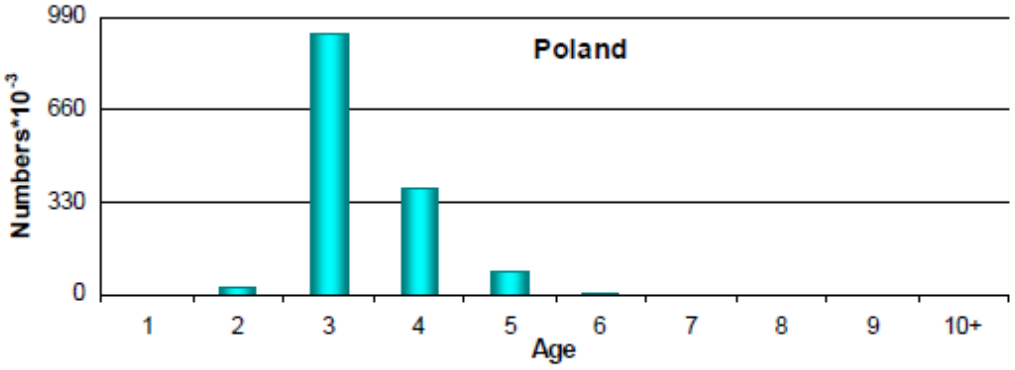
Binomial name

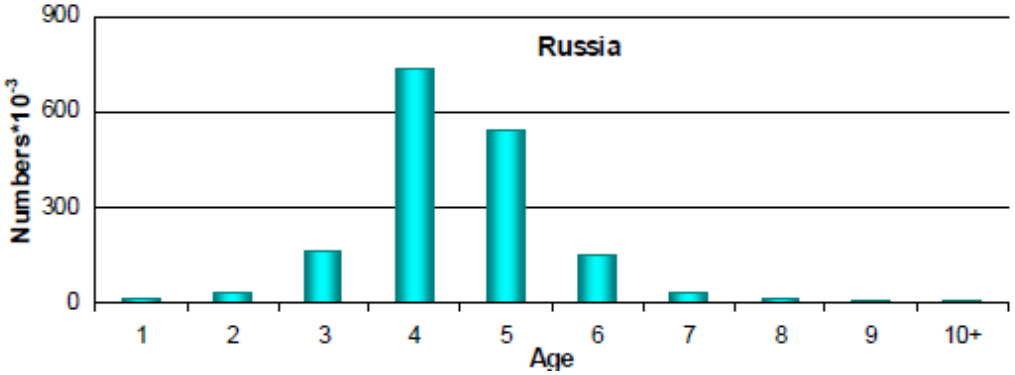
Gadus morhua

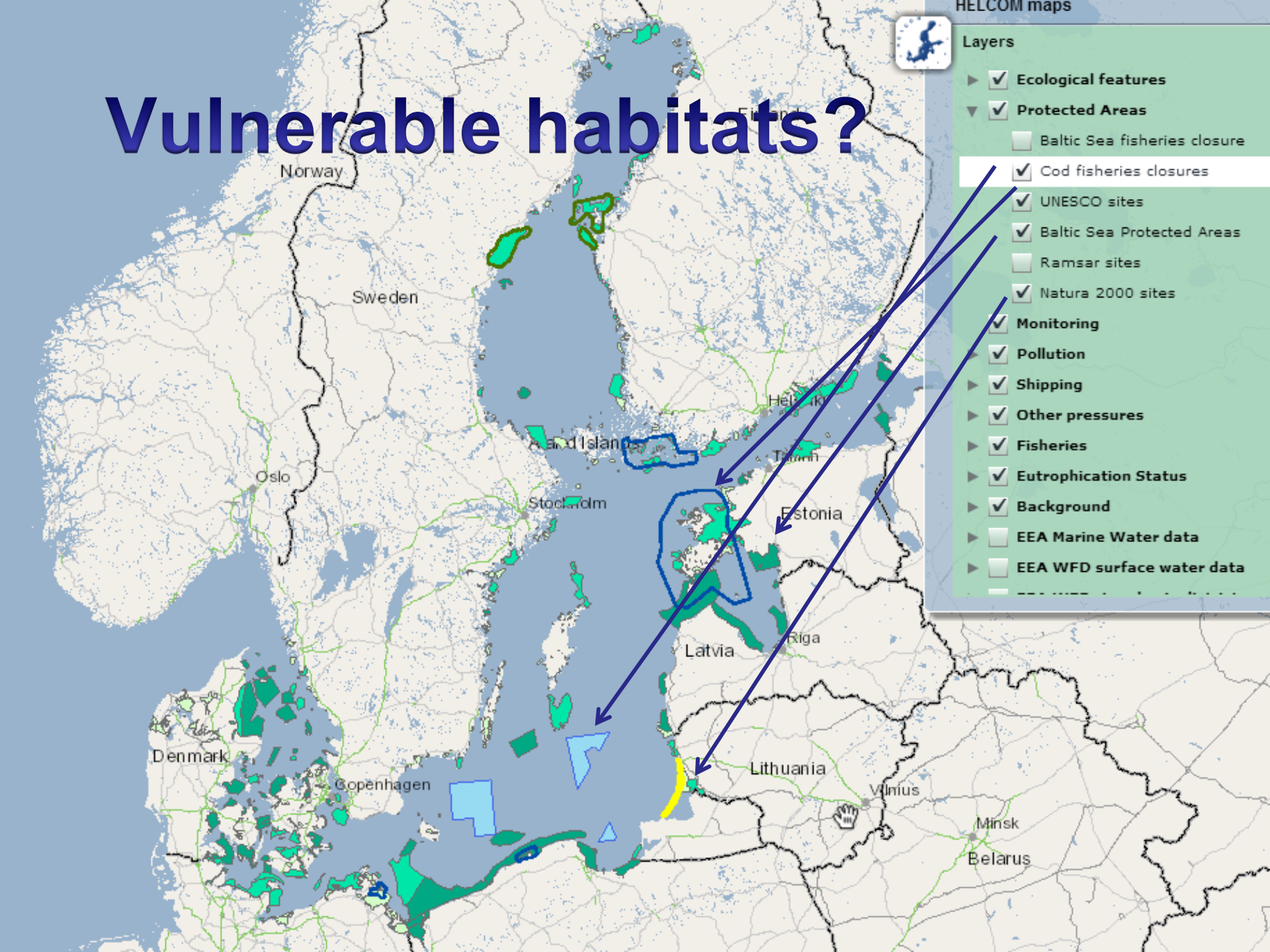
Linnaeus, 1758

Distribution of Atlantic cod








Vulnerable habitats?
HELCOM maps
Layers
Ecological features
Protected Areas
Baltic Sea fisheries closure
Cod fisheries closures
UNESCO sites
Baltic Sea Protected Areas
Ramsar sites
Natura 2000 sites
Monitoring
Pollution
Shipping
Other pressures
Fisheries
Eutrophication Status
Background
EEA Marine Water data
EEA WFD surface water data
Norway
Sweden
Oslo
Stockholm
Estonia
Latvia
Riga
Lithuania
Vilnius
Minsk
Belarus
Denmark
Copenhagen

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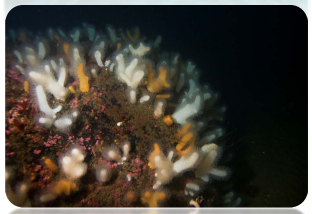
Focus on applicability

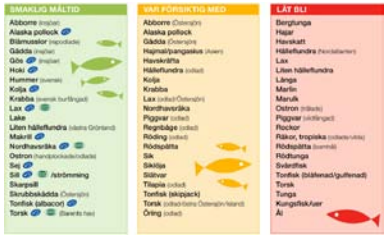
"Common" principals of sustainable fisheries (MSC/WWF)

1.The condition of the fish stock(s) of the fishery

2.The impact of the fishery on the marine ecosystem



3.The fishery management system



MARINE STEWARDSHIP COUNCIL ©

WWF

Application Seafood LCA

Production

Havs och Vatten myndigheten

STPO

Torskfiskarnas Producentorganisation
STPO Ek.för.

Communication

Findus

WWF

Unilever

Sik

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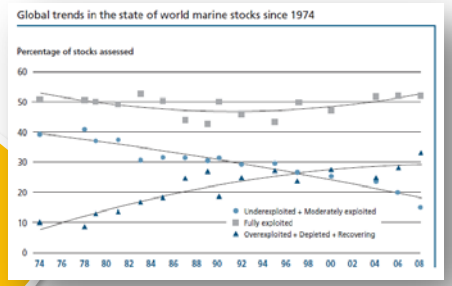
European Seafood LCA database?

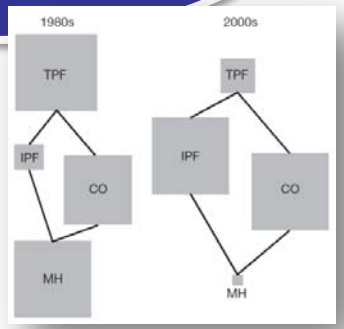


Fuel (EU national gear/size specific

Stock Assessment (stock specific)

Bycatch (FAO gear specifc)

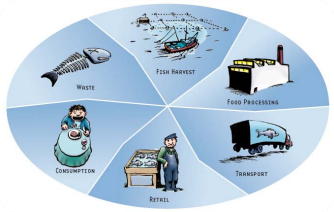
Species specific life traits (Fishbase)



WPY:
a) Database
b) Script R
c) Reference points only

Sik your Science Partner

A. Bias of completeness



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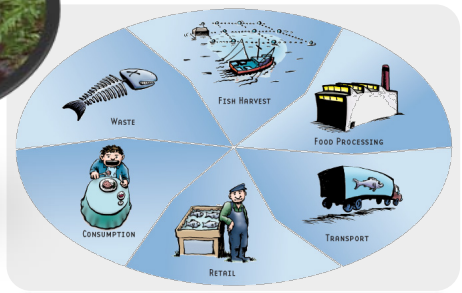
B. Bias of model design

C. LCA as <u>a holistic framework</u>
(Standard LCA + Biological Toolbox + Non LCA Risk assessment)



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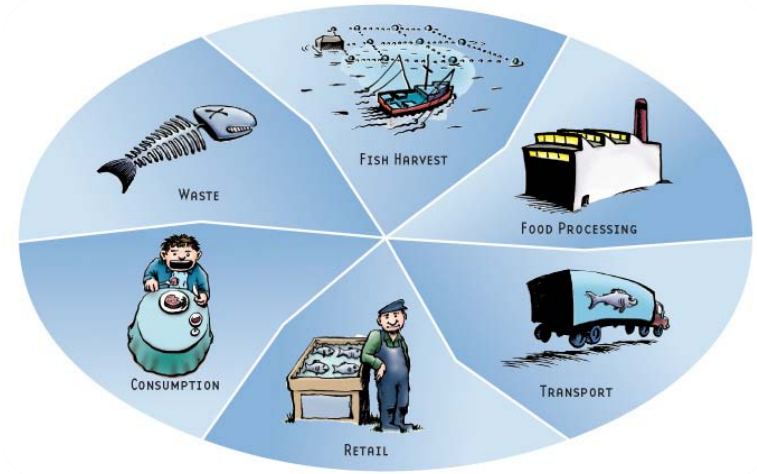
Sik your Science Partner

Thank you for your attention



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