



資源枯渇の最先端をいく漁業。狂い始めた生態系。われわれの食卓はどうなるのか、そして輸入大國日本の責任とは？
歴史的考察をふまえ、人類学・経済学・生態学的視点から、海の持続可能な利用を考える

Philippe Cury | Yves Miserey
UNE MER SANS POISSONS

水面下で進行する
恐ろしい事態

NTT出版
定価(本体2400円+税)

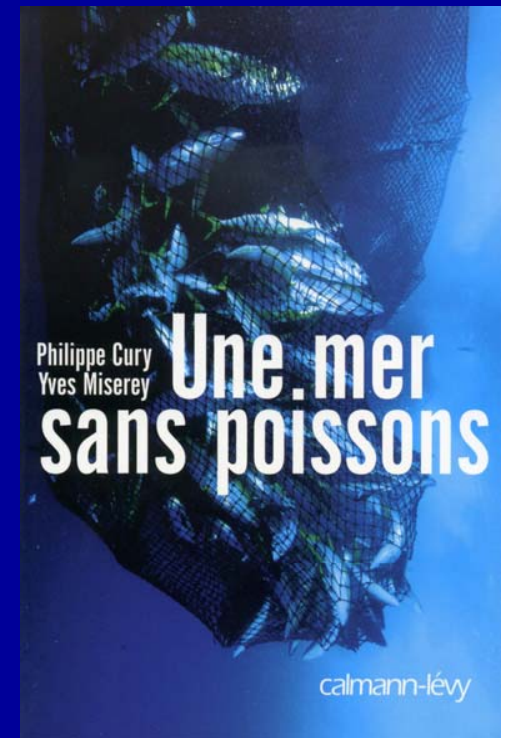
Managing world fisheries

Towards the ecosystem approach to fisheries

Philippe Cury

ENVIM

12th January 2016



Sustainable development of marine resources

1. State of world fisheries and marine resources
2. Managing fisheries: towards the EAF (Ecosystem Approach to Fisheries)
3. Building scenarios for marine resource in a global change context

1. State of world fisheries and marine resources



Fishery is equivalent to hunting in the aquatic environment

For the past 10.000 years, our societies have domesticated plants and animals

Since 2000 years our societies have mainly been living from agriculture and husbandry ("food revolution" of the Neolithic)

First a survival activity, hunting has now become a recreational activity in most countries

It is difficult to imagine a hunting activity (buffalos, rabbits, pheasants, and so on...) on a large industrial scale

Is fishery going to suffer the same fate as hunting?

FISHERIES IN THE MEDITERRANEAN SEA

Marine resources appear inexhaustible



Roman mosaic from Early empire (27 BC - 395 AD), Sousse museum, Tunisia

“Fishing in the Sea is open access -, because it is impossible to exhaust all its resources”

Hugo Grotius, Mare Liberum - 1609

“Whatever is the number of cods eaten by human each year, or eaten by other fishes, what is left is always more than sufficient to give us back the same number one or two years later”

Arnault de Nobleville et Salerne (18th Century)

“We have calculated that if no accident stops the hatching of the eggs and if each cod comes to adulthood, only three years would be necessary for the Sea to be filled in and for us to walk across the Atlantic ocean on cods backs”

Alexandre Dumas
Grand Dictionnaire de Cuisine, 1871

Great international exhibition on fisheries London 1883

“Nothing of what we do can affect the
number of fish”

Thomas Huxley

”A mistake to believe that the Ocean
was a huge attic where resources are
infinite ”

Ray Lancaster

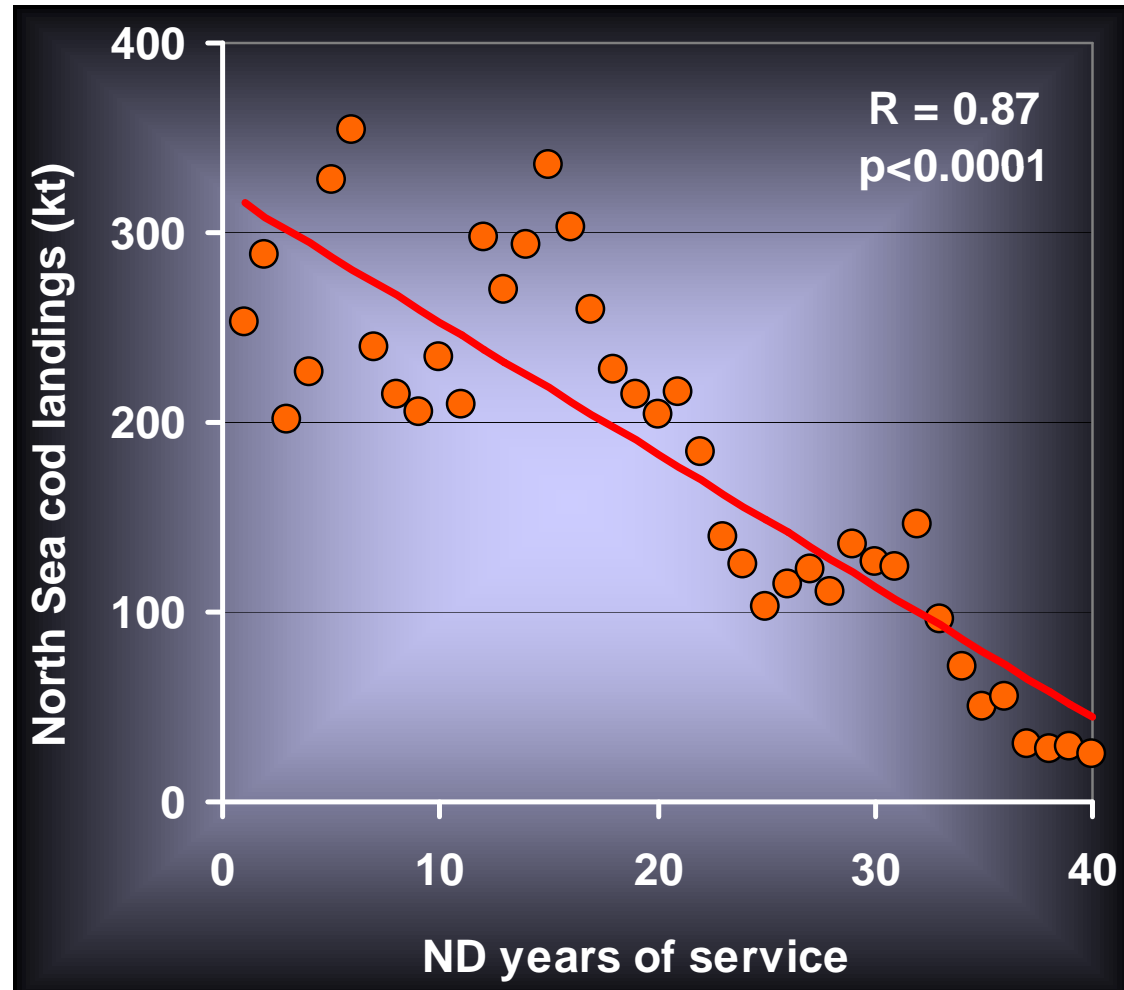
The Rome Conference in 1955 : a decisive turn for fisheries management

- MSY (Maximum Sustainable Yield - Graham & Schaefer) was defined as the key indicator for managing fisheries (no need to limit effort or access until the limit is not reached)
- The vote was tight (18 - USA driving the process against 17 - most developing countries!)
- MSY as a tool to reach global fisheries
- Instrumentalisation of ICES (no environmental studies or economists in fisheries management!)

Nils Daan: a life dedicated to North Sea cod

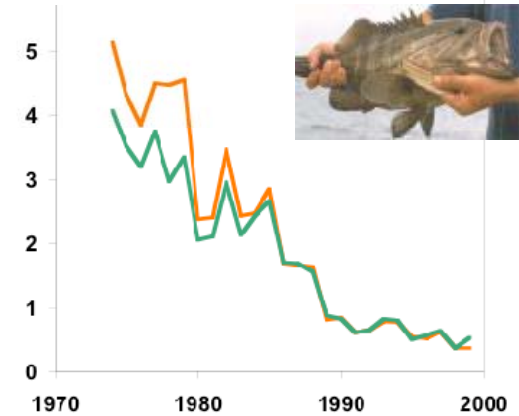
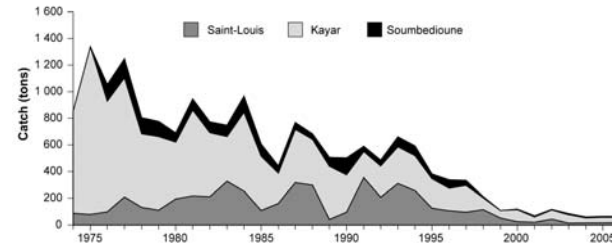
(Brest conference December 2008)

TACs \longrightarrow



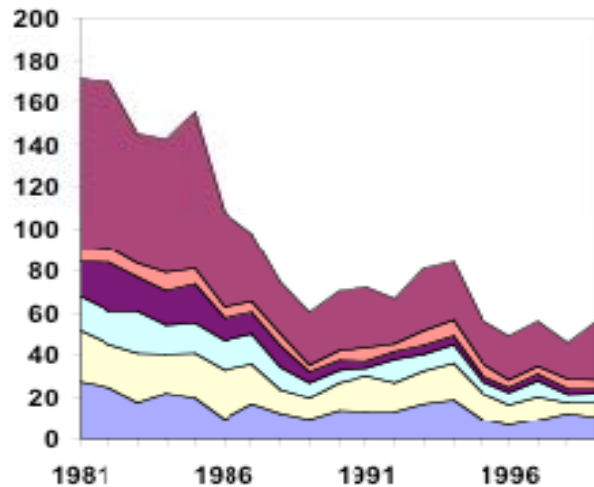


Senegalese fisheries



Groupers' abundance

Photos: P. Chavance & C. Chaboud, IRD

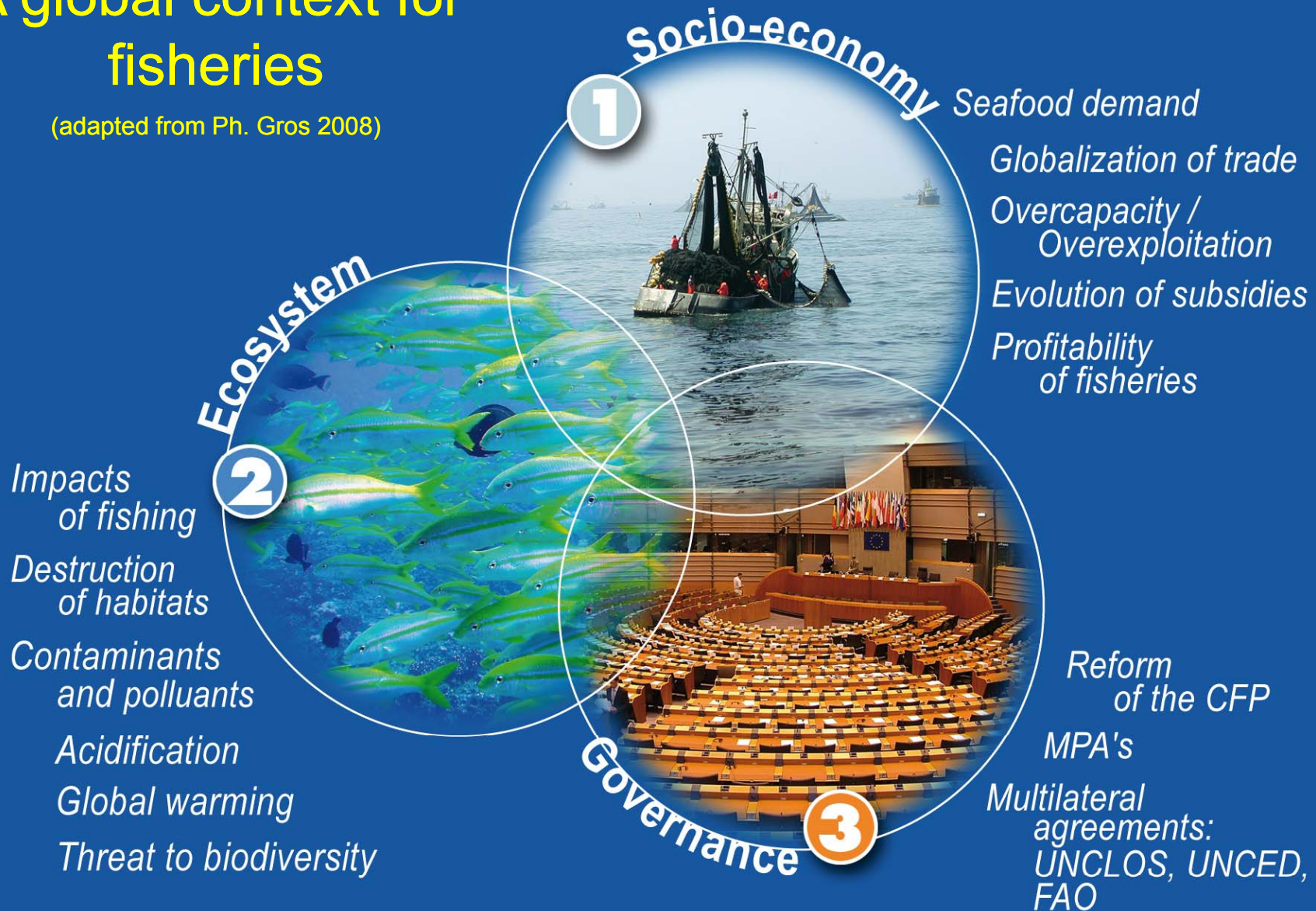


Abundance trends

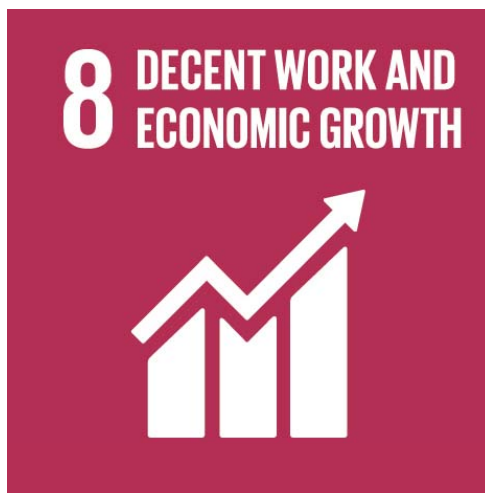
M. Laurans thèse 2004

A global context for fisheries

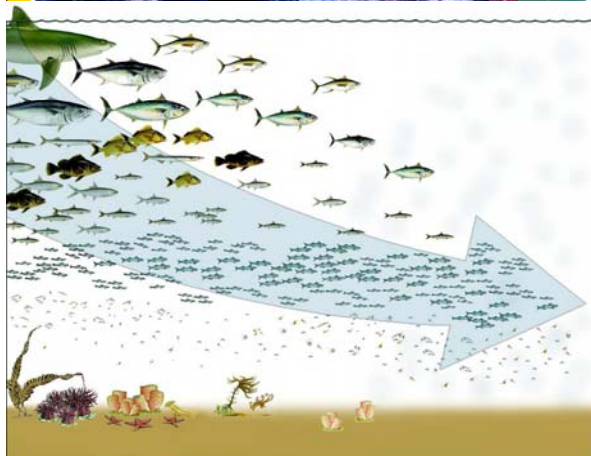
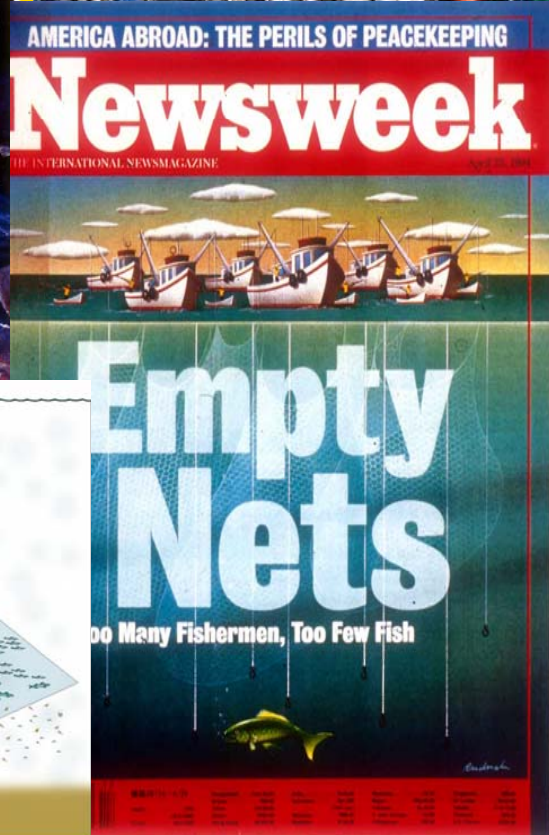
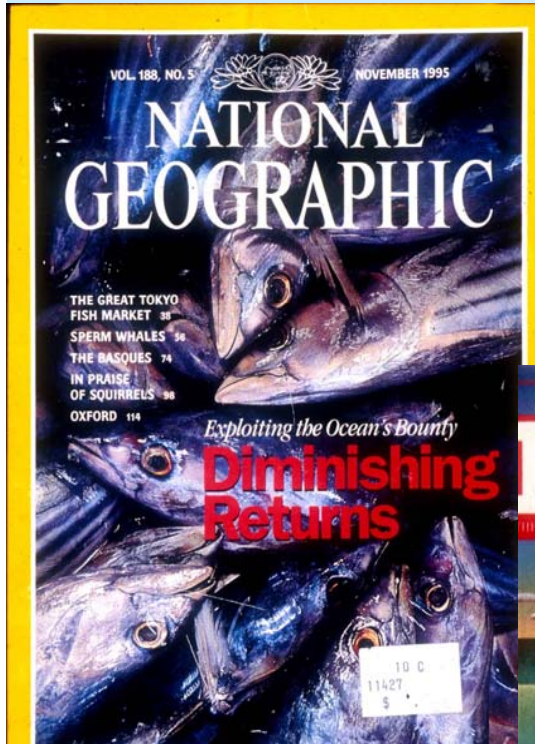
(adapted from Ph. Gros 2008)



A new international framework : the U.N. Agenda 2030



Human impacts on marine ecosystems



July
2011



1€
la Gazette de Sète

N° 280 - janvier 2013

et du bassin de Thau

★ **FRONTIGNAN**

Volontaires
pour créer
leur entreprise

★ **SÈTE**

Jean-Claude Reilles
revient sur la tuerie

★ **FRONTIGNAN**

Pour les minots,
le "baby-rugby"

TOUTES
LES
SORTIES
DE JANVIER



Sète
**La plaisance
va-t-elle remplacer
la pêche?**

Frequently asked questions from fishers

“If you do not have good fishers on board of research boats, you will not find the fish and scientific estimates will be wrong ”

“ The trawl was there a long time ago. If it really destroyed the seabed,
there would be any fish left ”

“There is still room left for fishing. But in order to judge you must know fishers. In any case, if fishing disappears, it will not be because there is no fish left ”

Multiple misunderstandings

Is the sea getting empty of fish?

Why do scientists sample where there is no fish?

Is a stable catch an indicator of sustainable exploitation?

Why is there still so many fish in our fish markets?



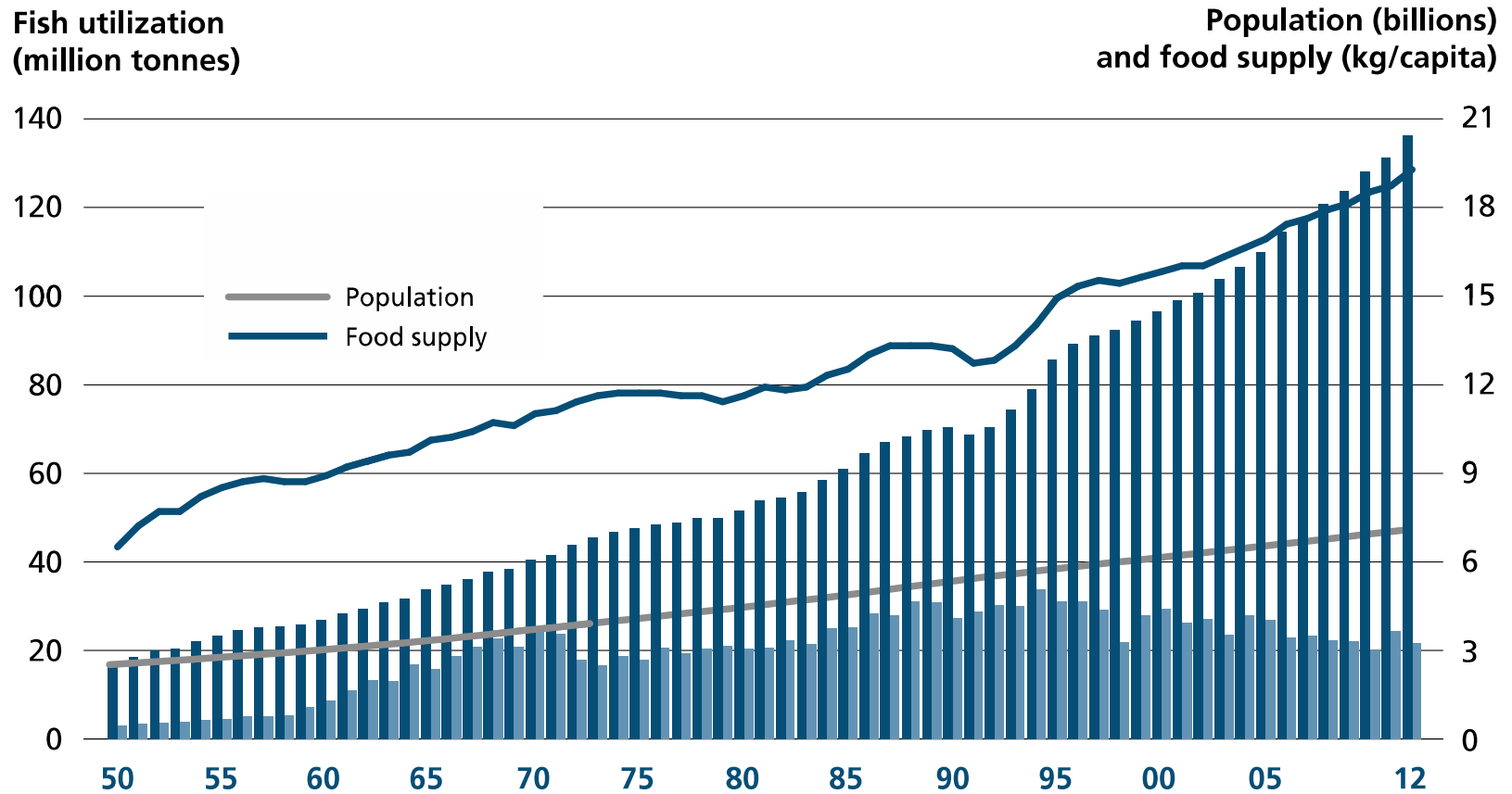
© IRD, C. Peignon

Marine resources : some facts



A growing appetite for marine resources

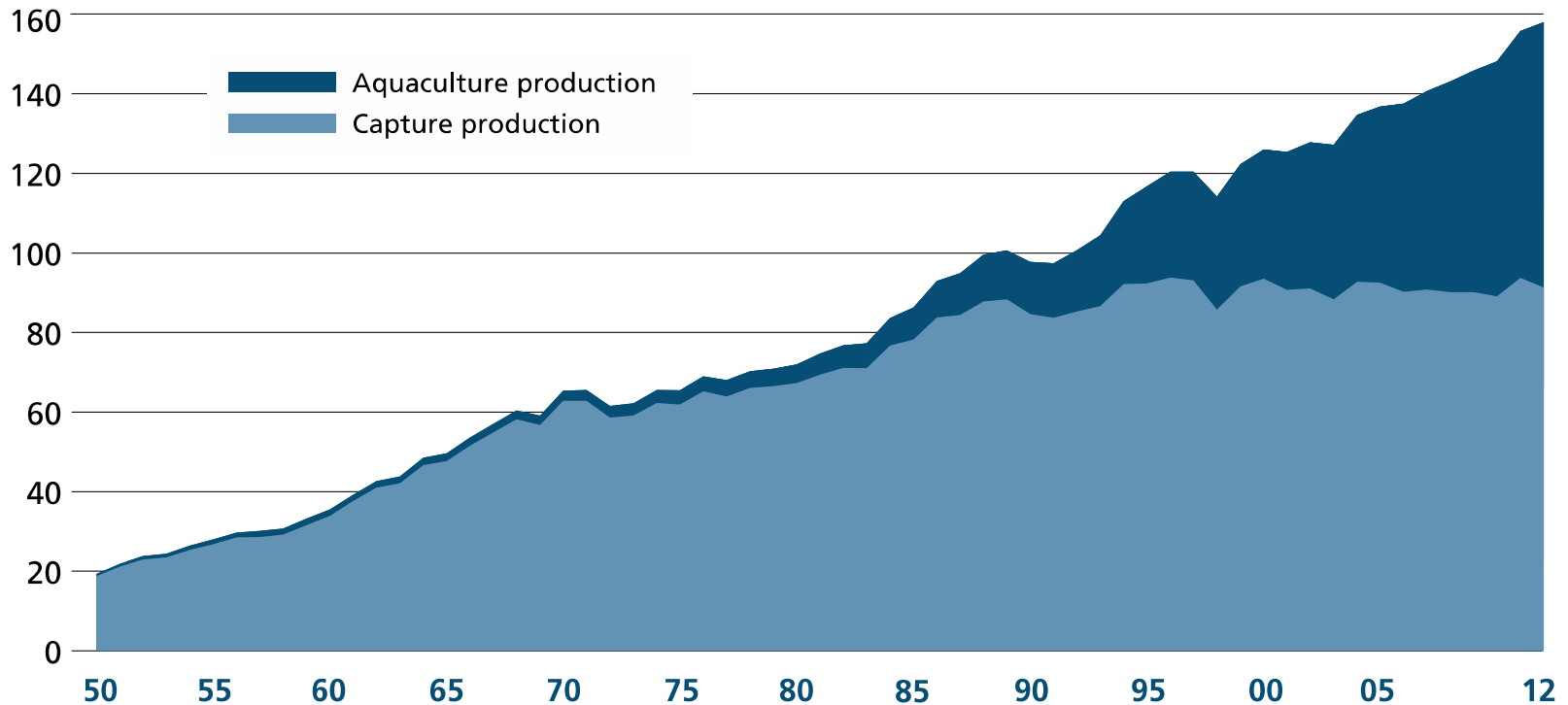
(Fao Sofia 2014)



Mise en œuvre de l'Objectif de développement durable Océans : de la science à l'action
Paris, 2 octobre 2015

...increasing demand for marine products (Fao Sofia 2014)

Million tonnes



IDDRI



Organisation
des Nations Unies
pour la science et la culture

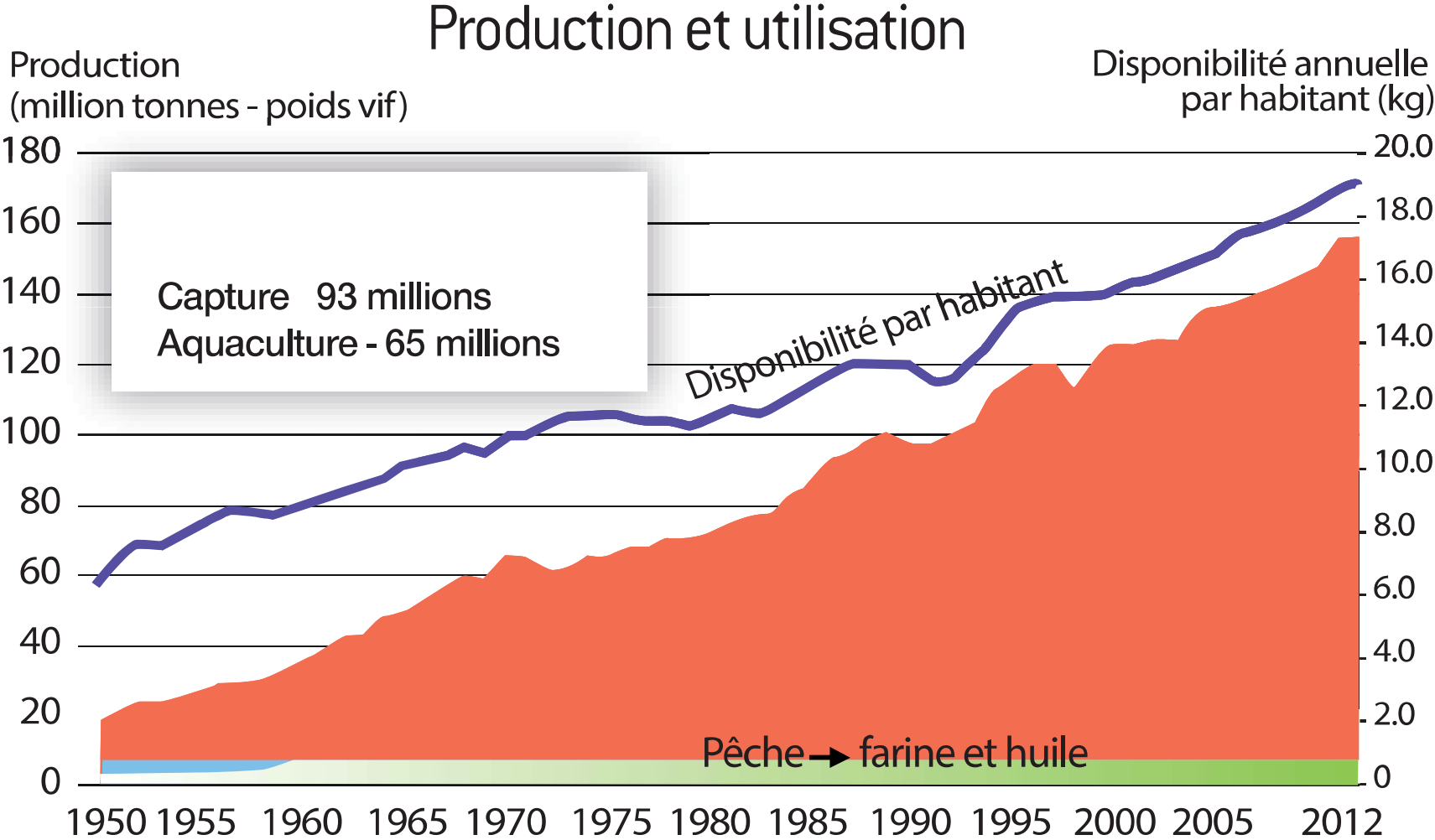


Commission
océanographique
intergouvernementale



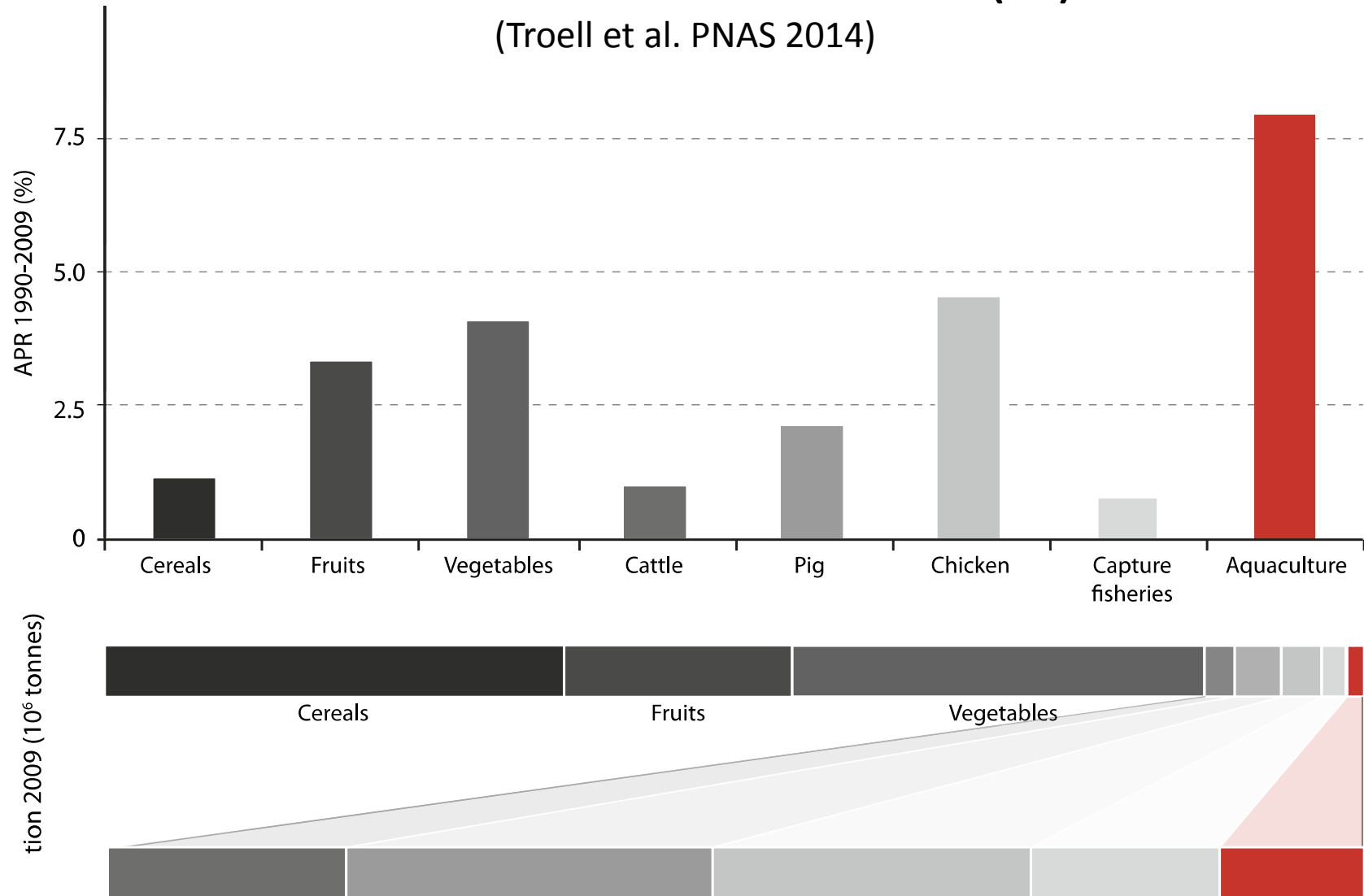
Production and use of marine products

(FAO 2011)

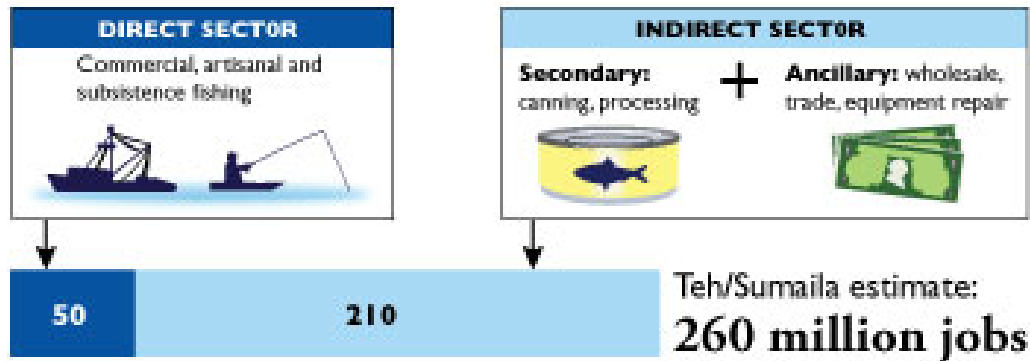


Growth of aquaculture and main food commodities 1990-2009 (%)

(Troell et al. PNAS 2014)

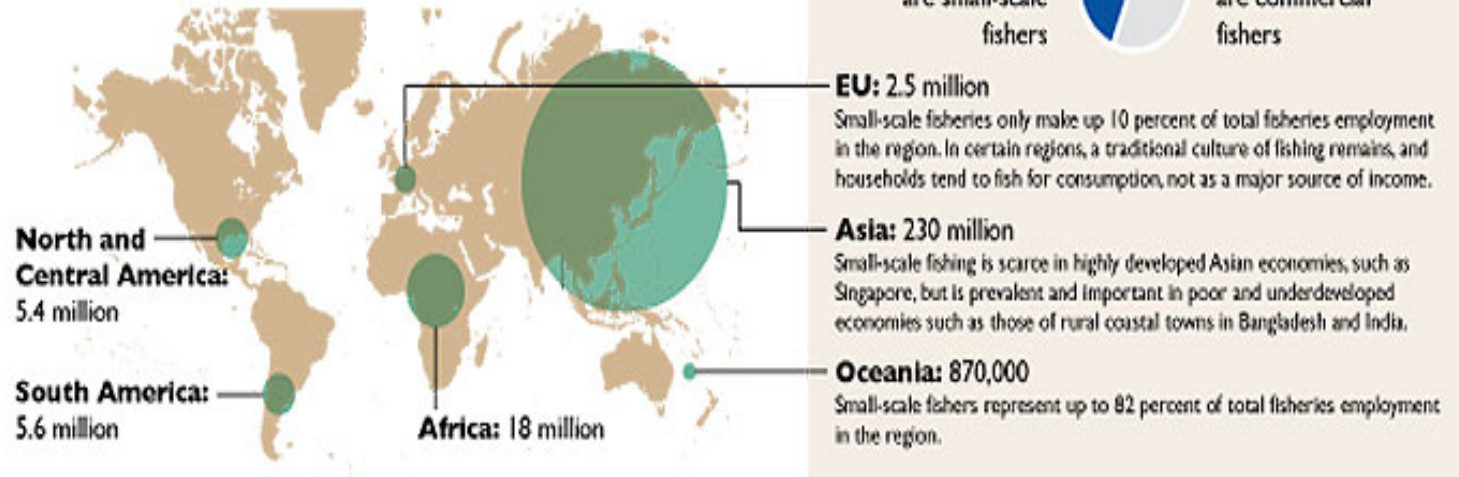


Employment increasing in the South (i.e, Asia, Africa) and decreasing in the North (Europe)



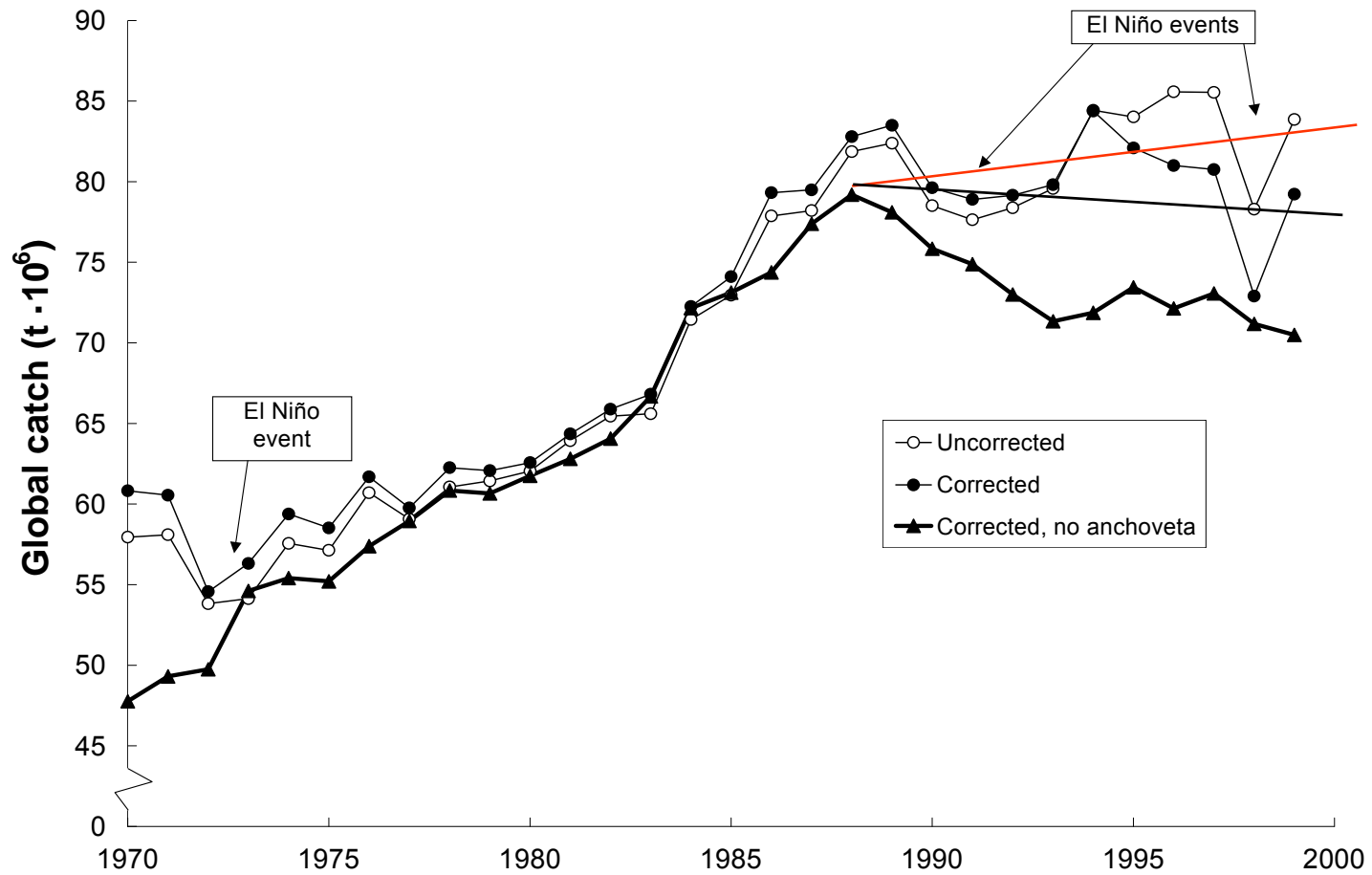
FISHERIES EMPLOYMENT, BY REGION

● Size of circle represents number of jobs



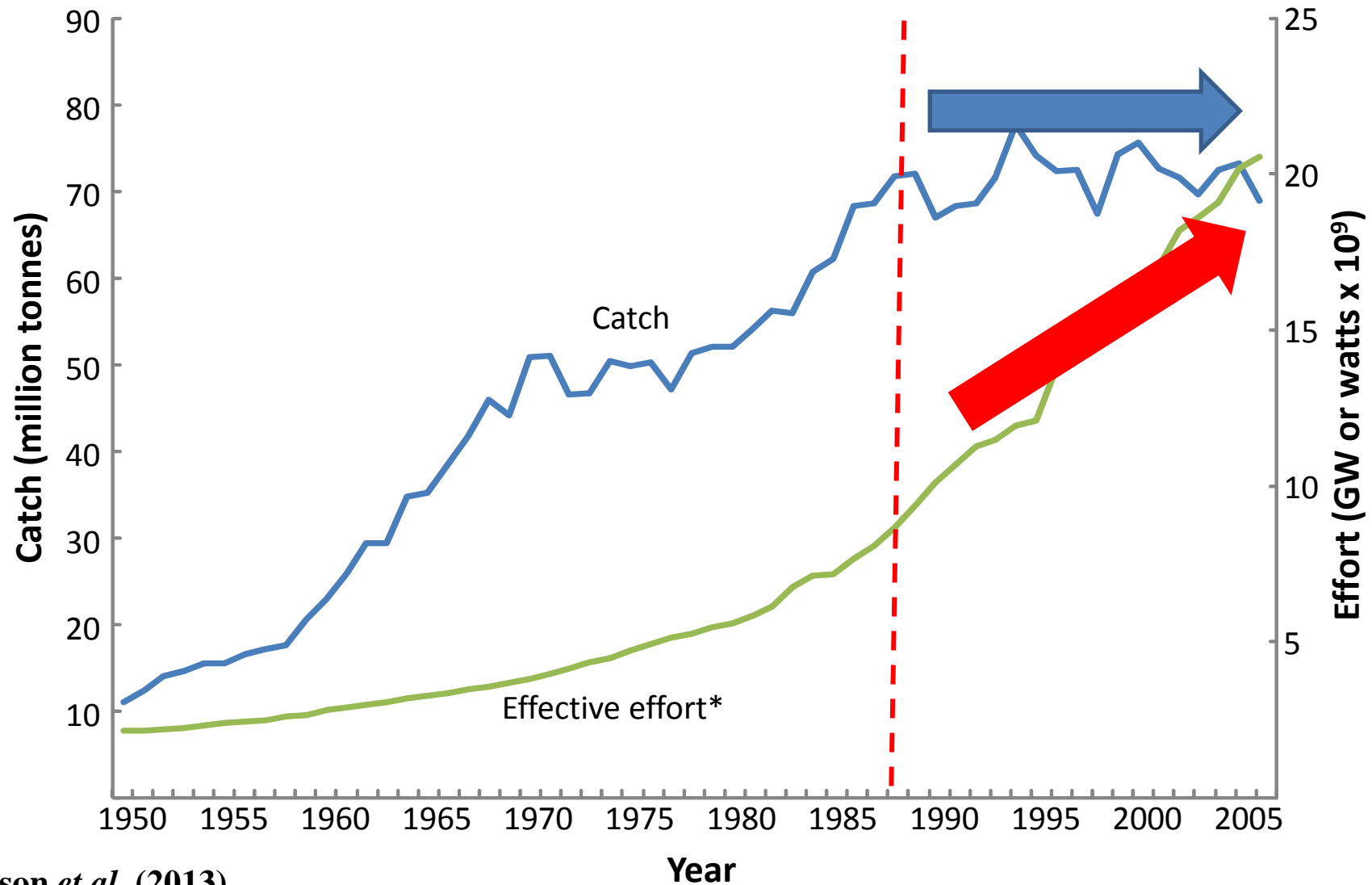
World Fish Catch has been more or less stable for the past three decades

(Pauly, Grainger Nature 2003)



Watson and Pauly (*Nature*),
2004

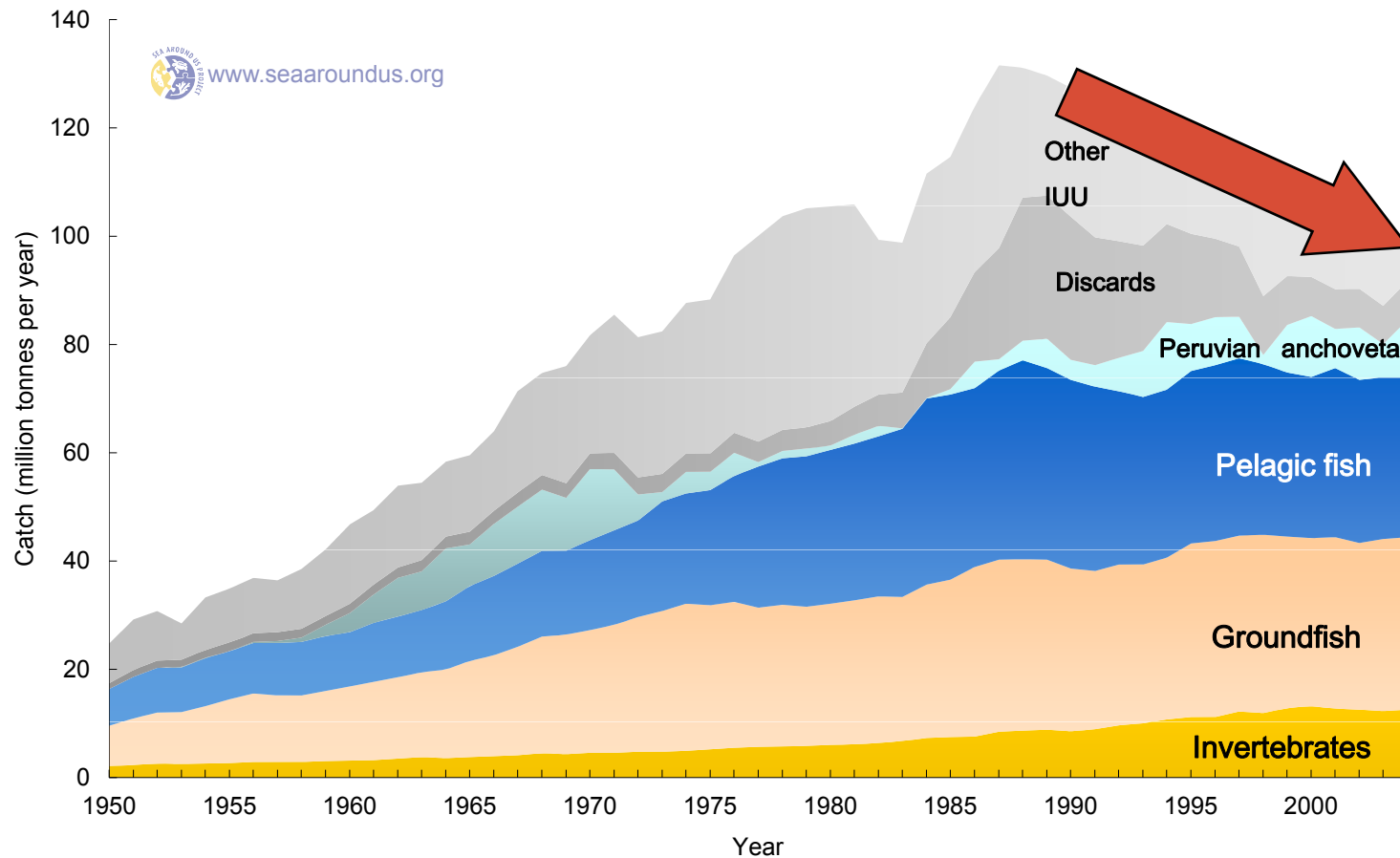
Stable catch but increasing fishing effort



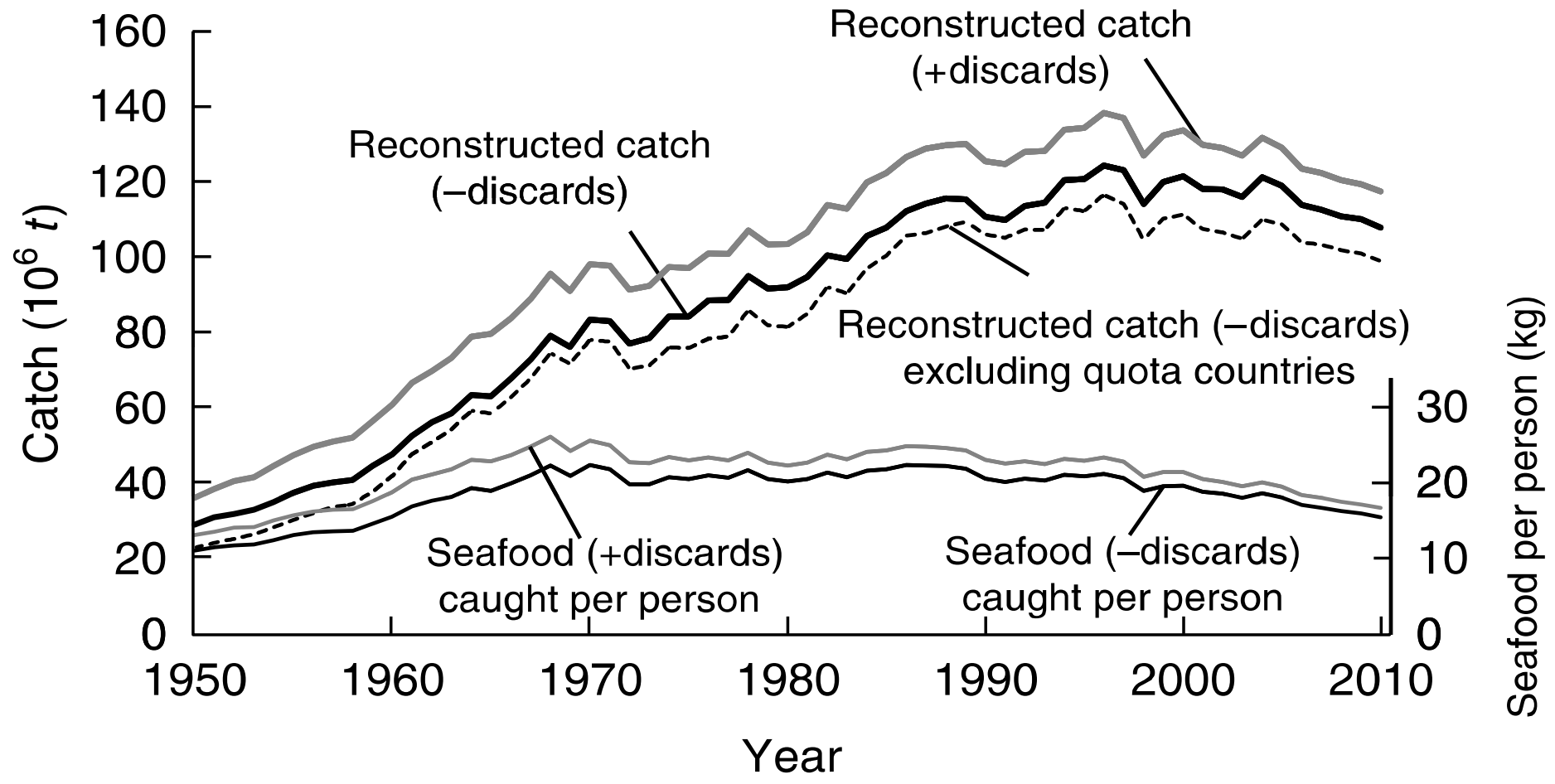
Watson *et al.* (2013)

*Effective effort indexed on 2000 based on average 2.42% increase annually

Recent catch reconstruction reveals that the world catch is (or was) much higher than we think, while declining much faster than FAO thinks ...(Pauly & Zeller Nature 2016)



Recent catch reconstruction reveals that the world catch is (or was) much higher than we think, while declining much faster than FAO thinks ...(Pauly & Zeller Nature 2016)



Extinction of marine and terrestrial species (6 times more species on land)

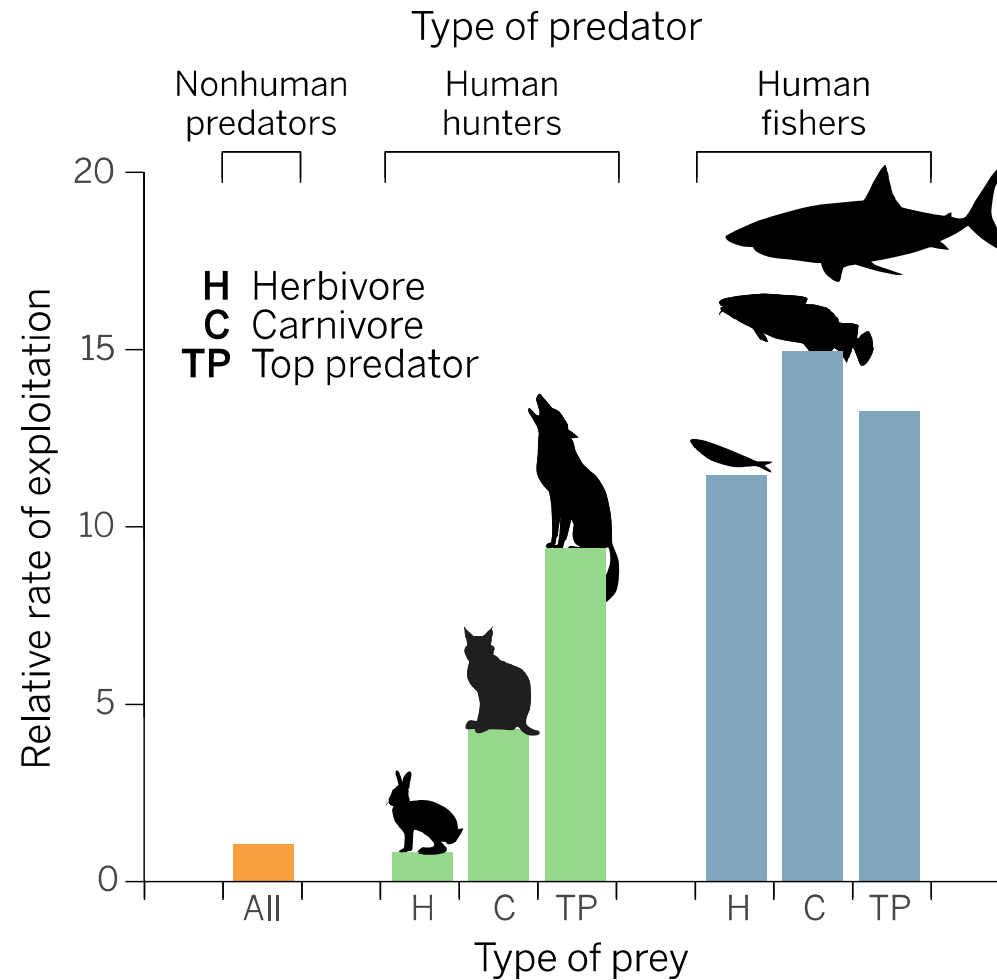
514 global extinctions on land and 15 in the sea (IUCN)

(McCauley et al Science et al 2015)



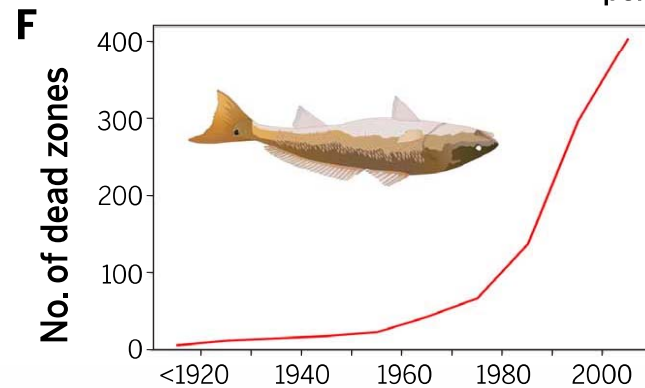
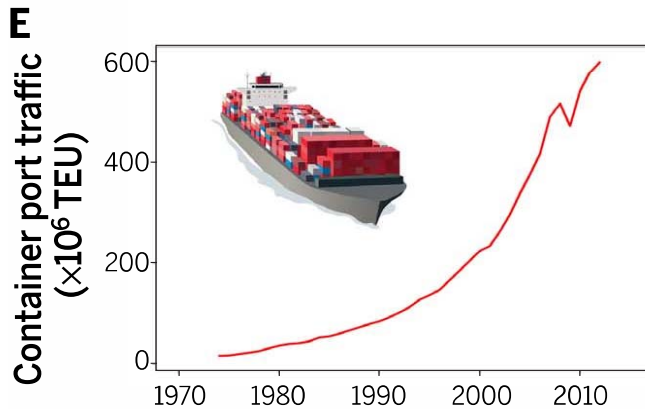
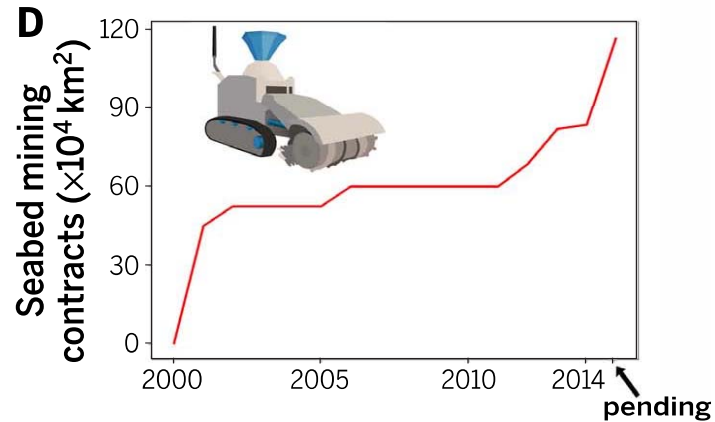
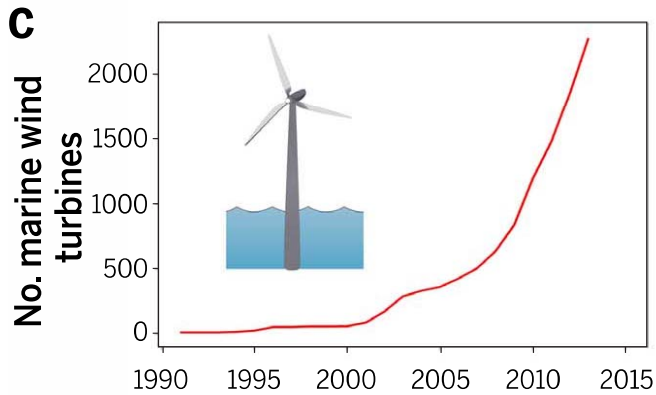
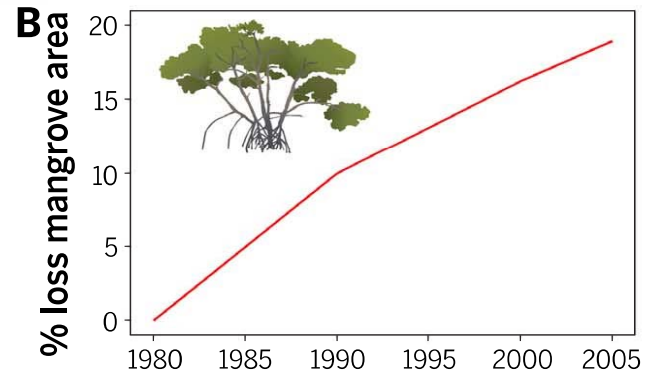
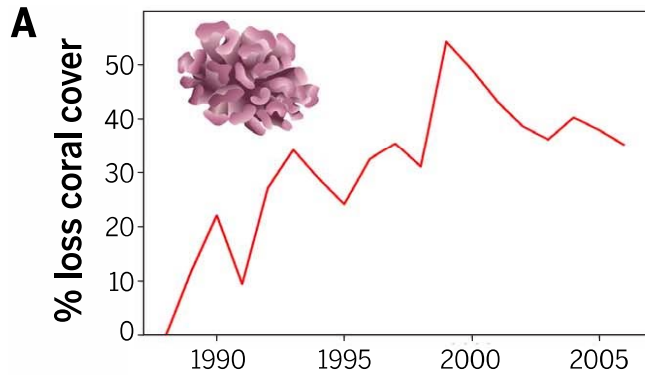
Exploitation Pressure on global oceans is greater than on terrestrial

(McCauley et al Science et al 2015)



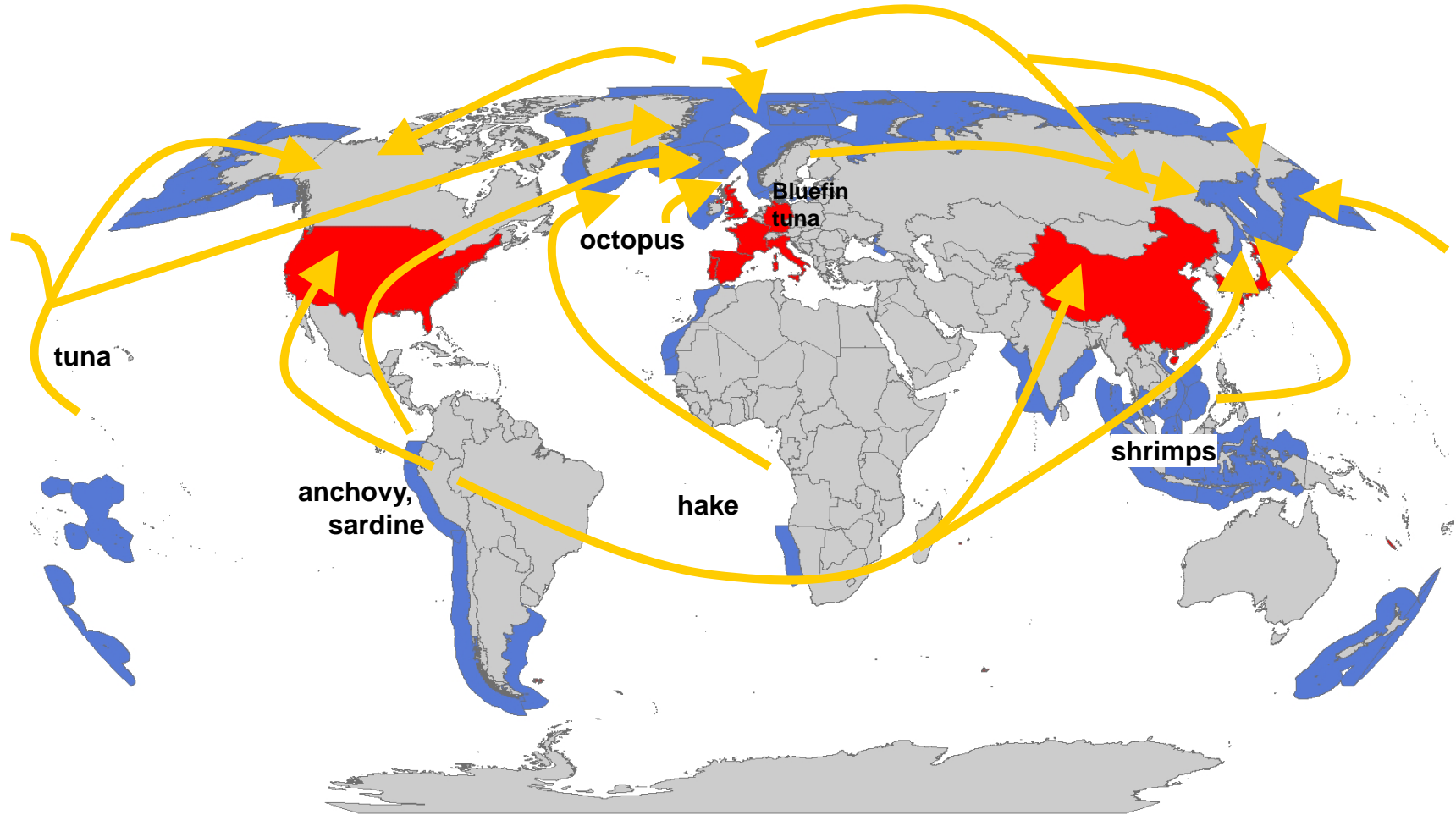
Habitat change in the global oceans

(McCauley et al Science et al 2015)



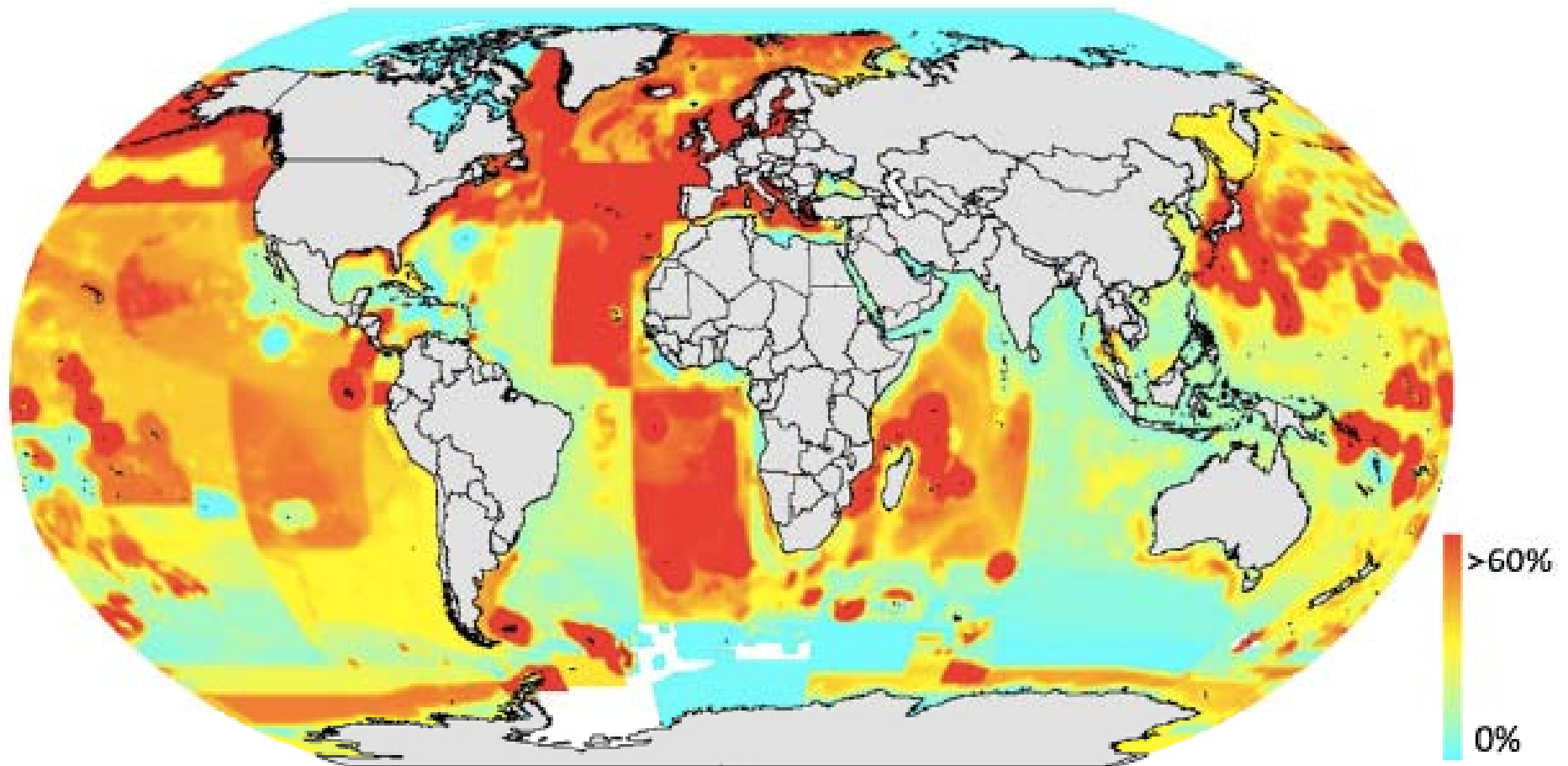
Fish is the most widely traded commodities in the world with nearly 40% of world fish production entering the international market (Wheat 20%, rice 5%)

(Pauly et al. 2005)



EU + Japan +USA :

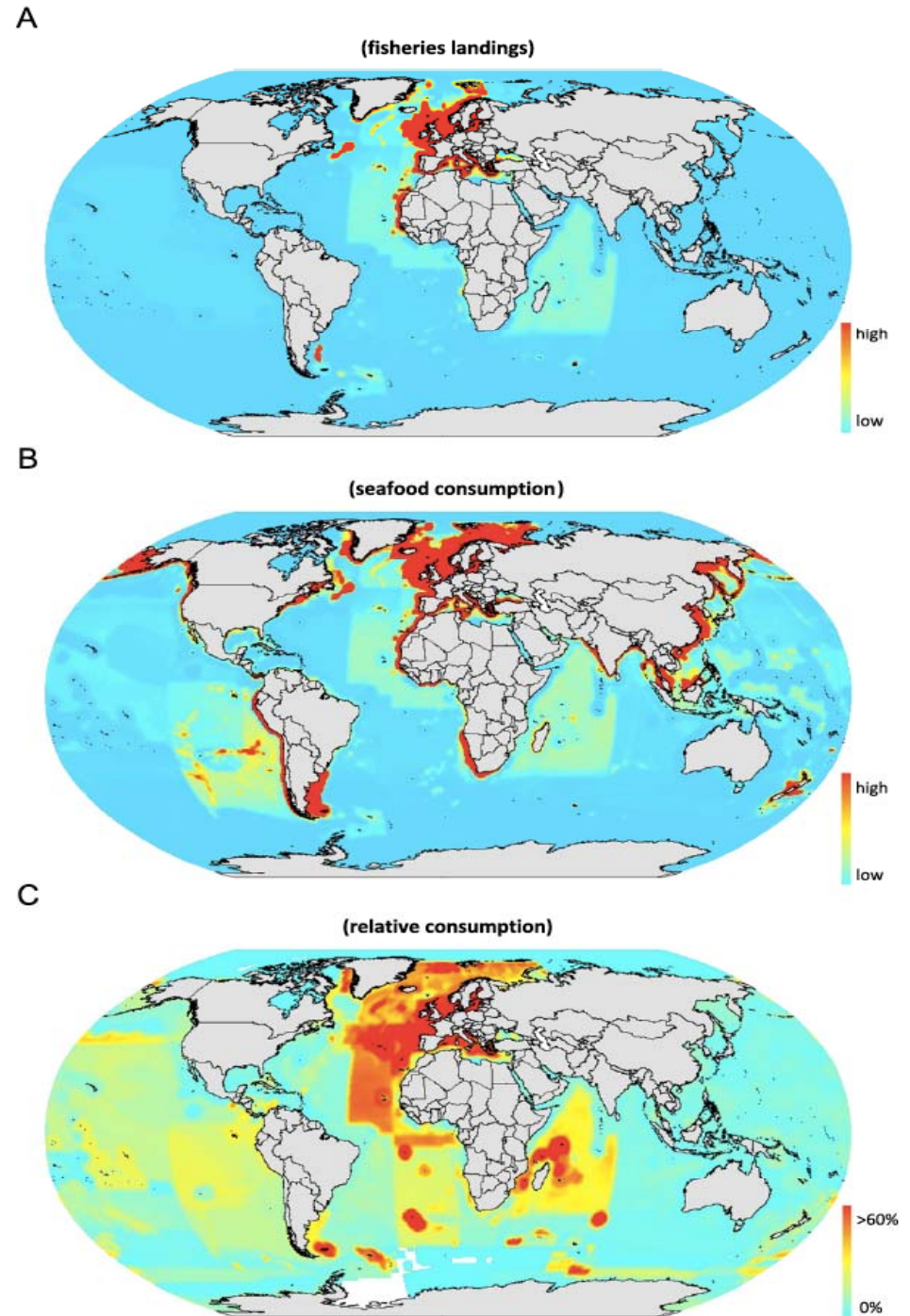
28mt marine fish, 35% of marine fish catch, above 2/3 of fish catch in fishing areas



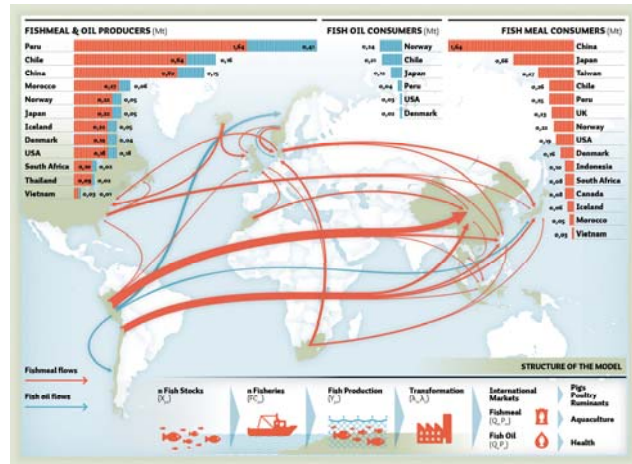
Spheres of influence:
Origin of fish landed,
consumed and relative
sea food consumption
by the EU
2001-2005

40% originated from outside
their EEZ

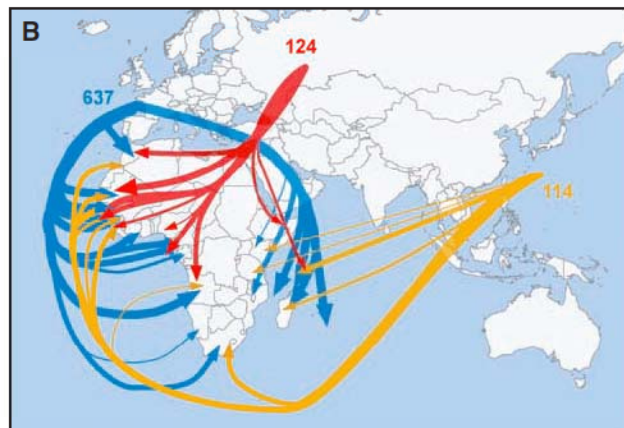
(Swartz et al 2010)



Developing countries under pressure....



- Fish as one of the most traded commodities (40%) compared to wheat (20%) or rice (5%)
- 37% of the catch are transformed into fishmeal and fish oil for aquaculture and husbandry
- 3 millions tonnes of fish are captured in Africa without any statistical records
- Although European public fishing agreements are transparent, EU has subsidized these agreements at an average of 75% of their cost while private European business interests paid the equivalent of 1.5% of the value of the landed fish (Le Manach et al. 2013)



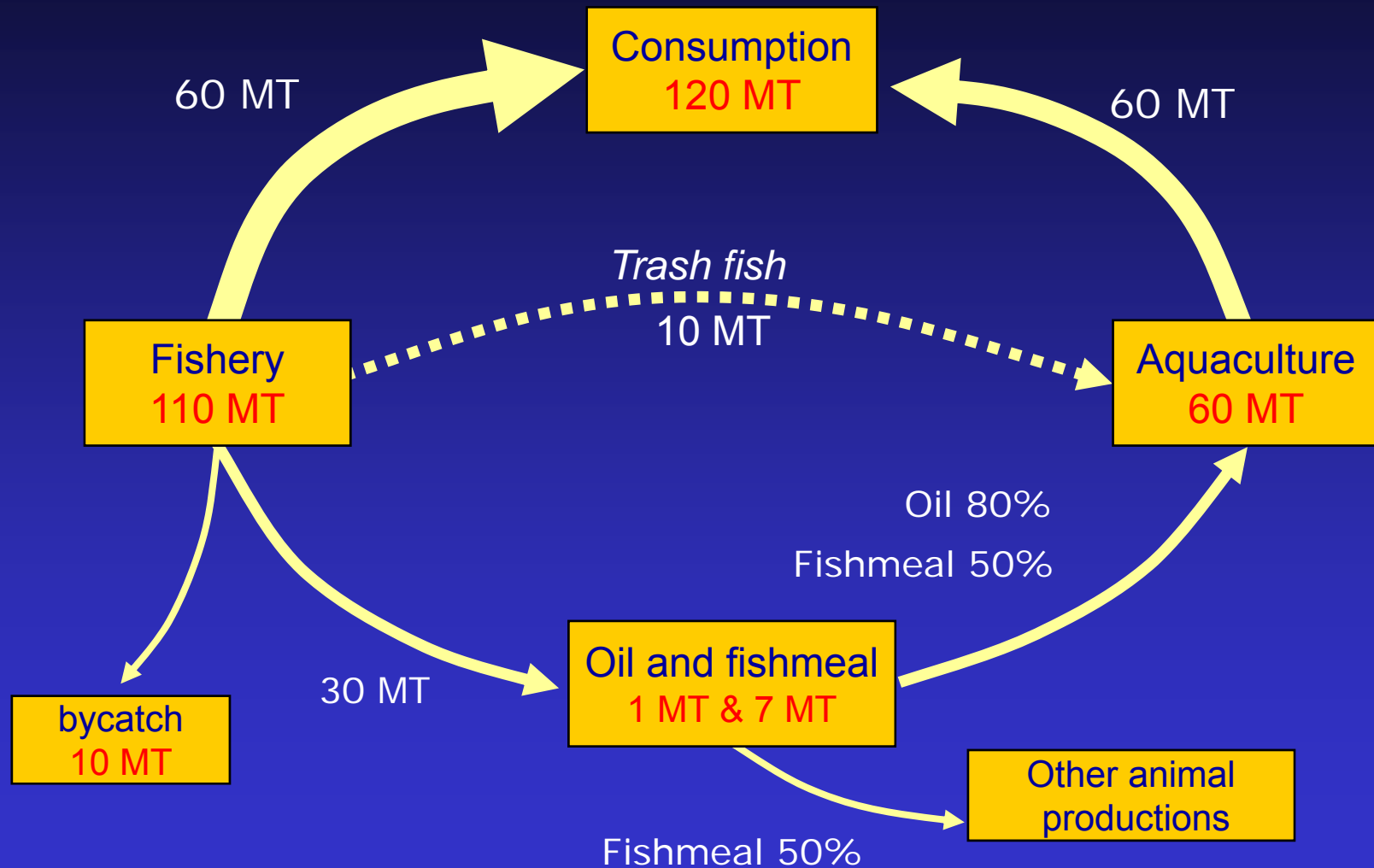


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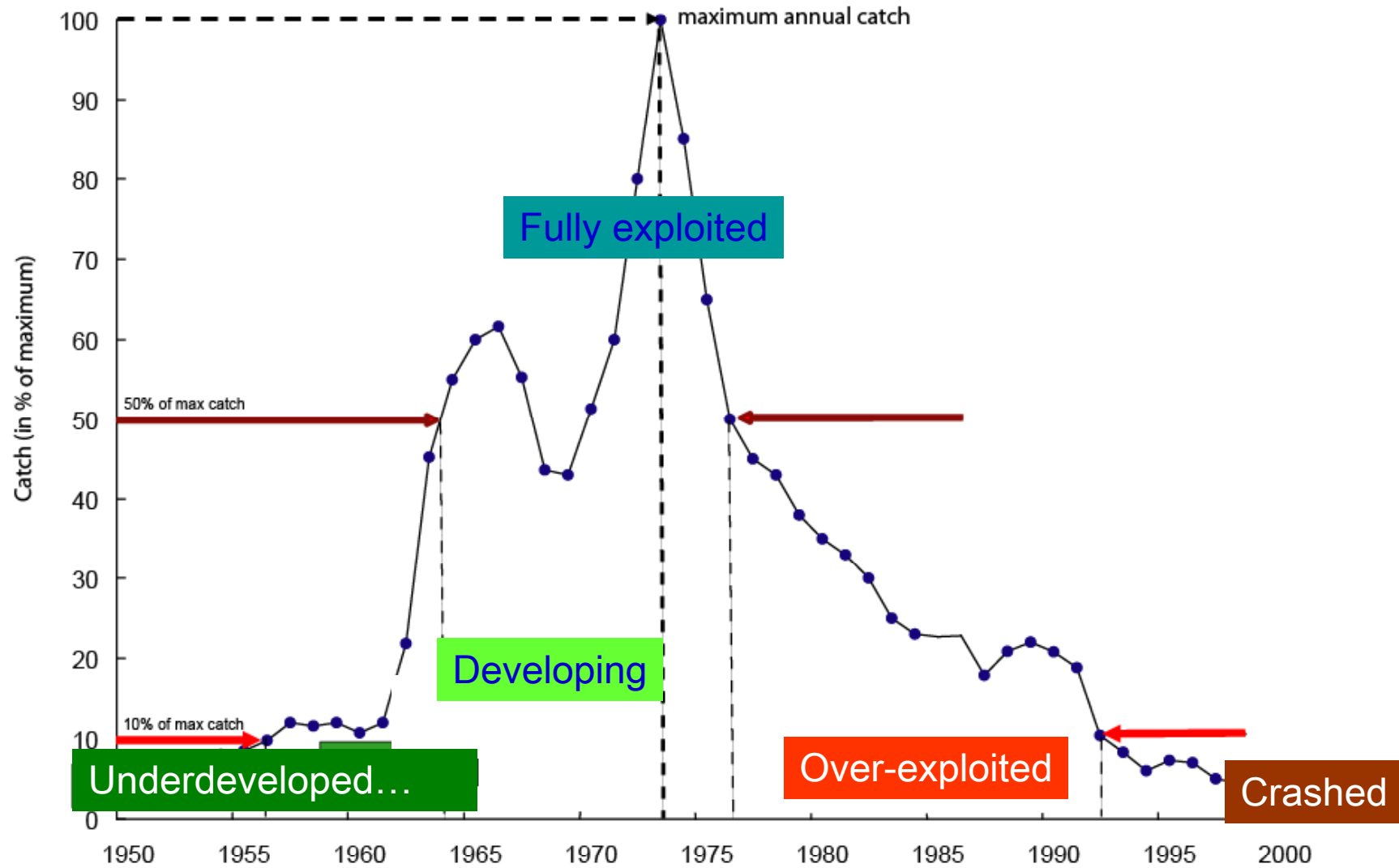
World exploitation of marine
resources :
an example of sustainable
development ?

World production and consumption of aquatic products in 2011 (millions tonnes)

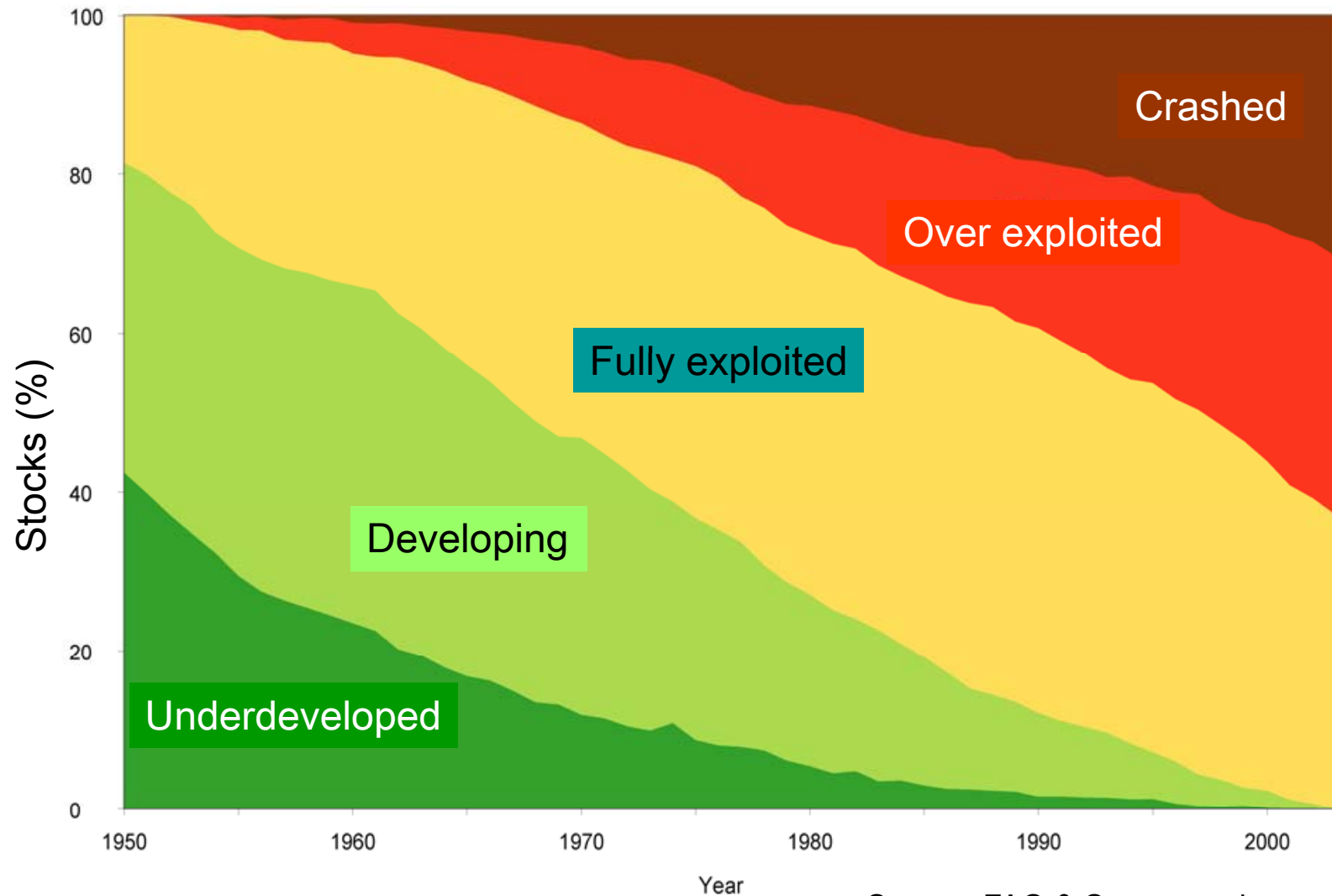
ifremer



Stocks characterization...

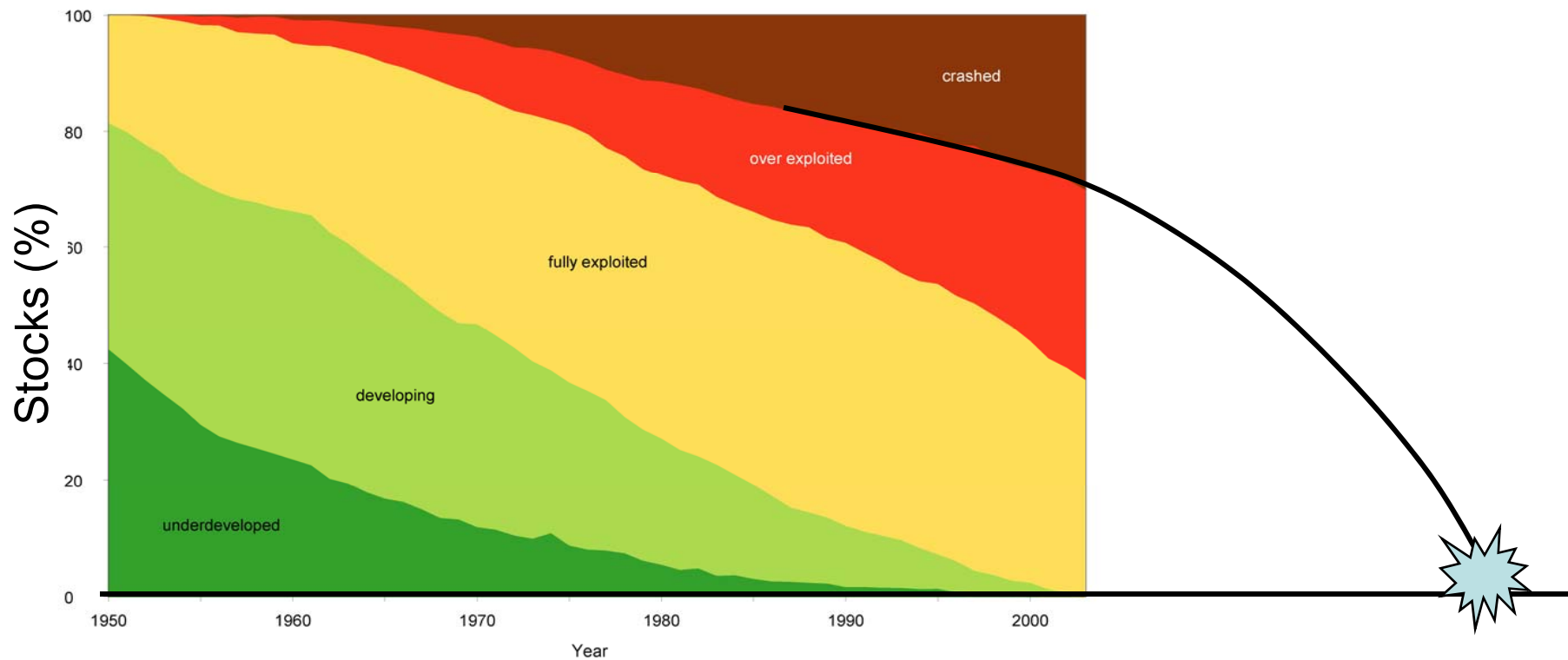


A sustained degradation of marine fish stocks ...



Source: FAO & Sea around us project

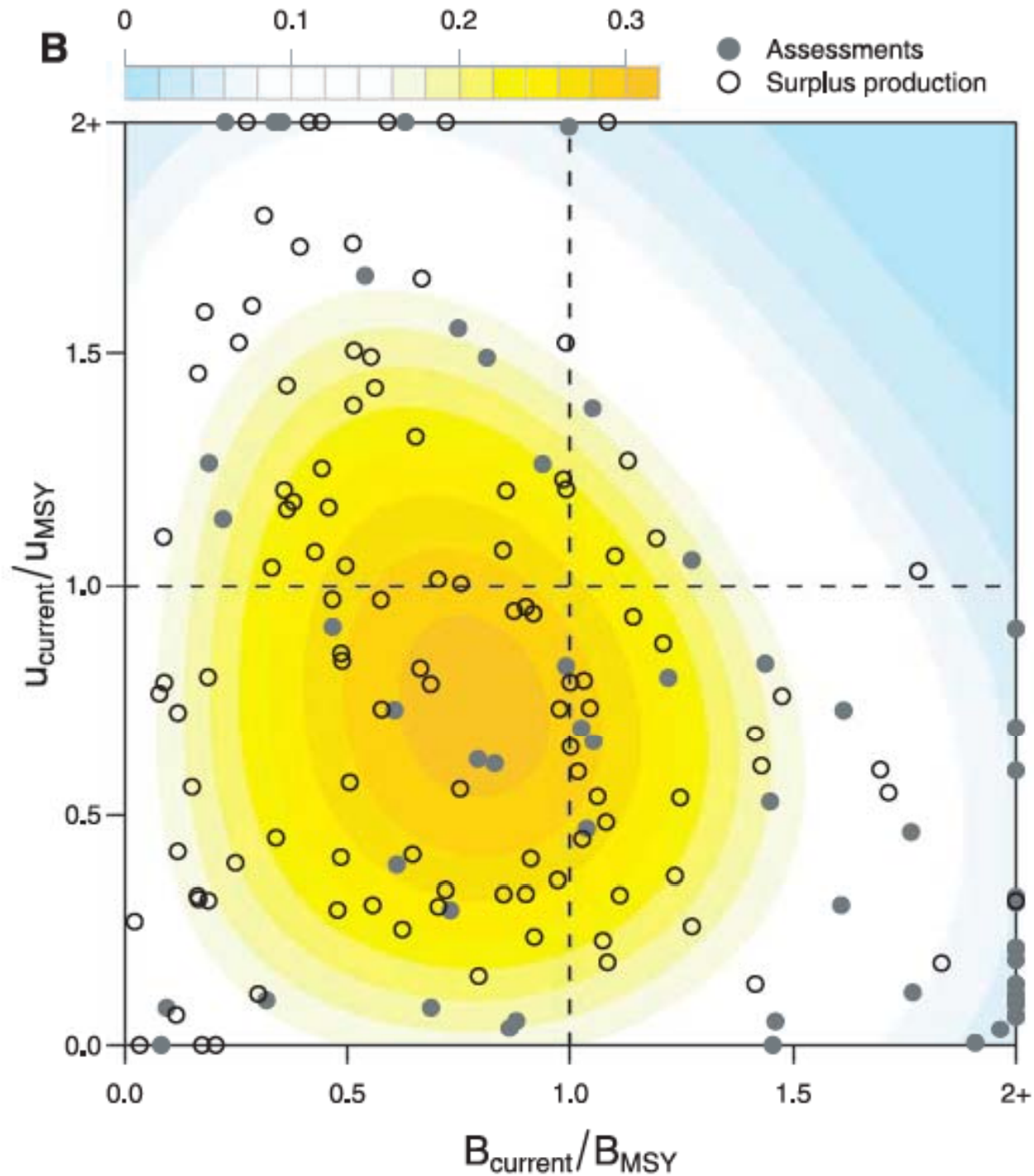
Worrying projections....



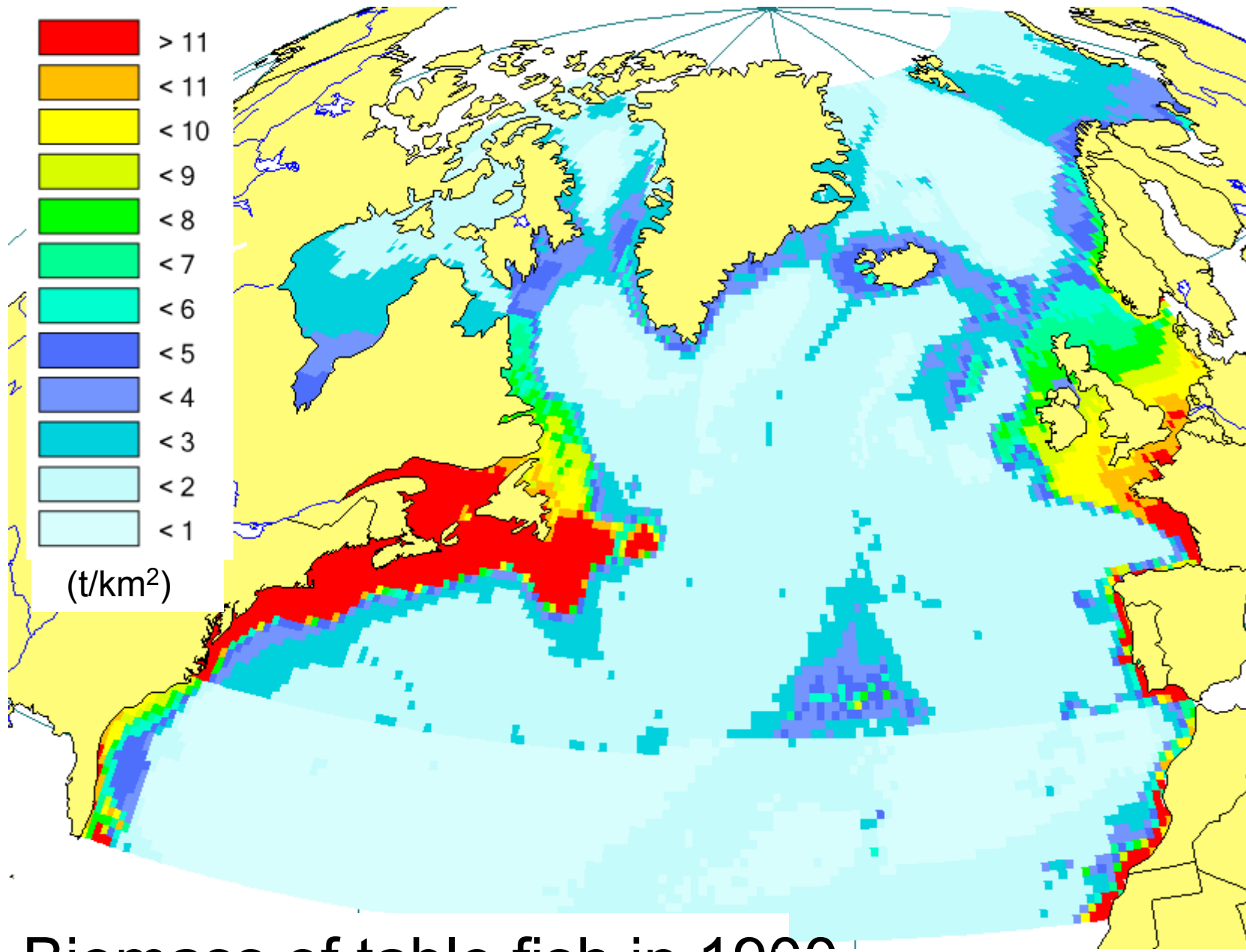
2048 ?



Worm et al. (*Science*) 2006

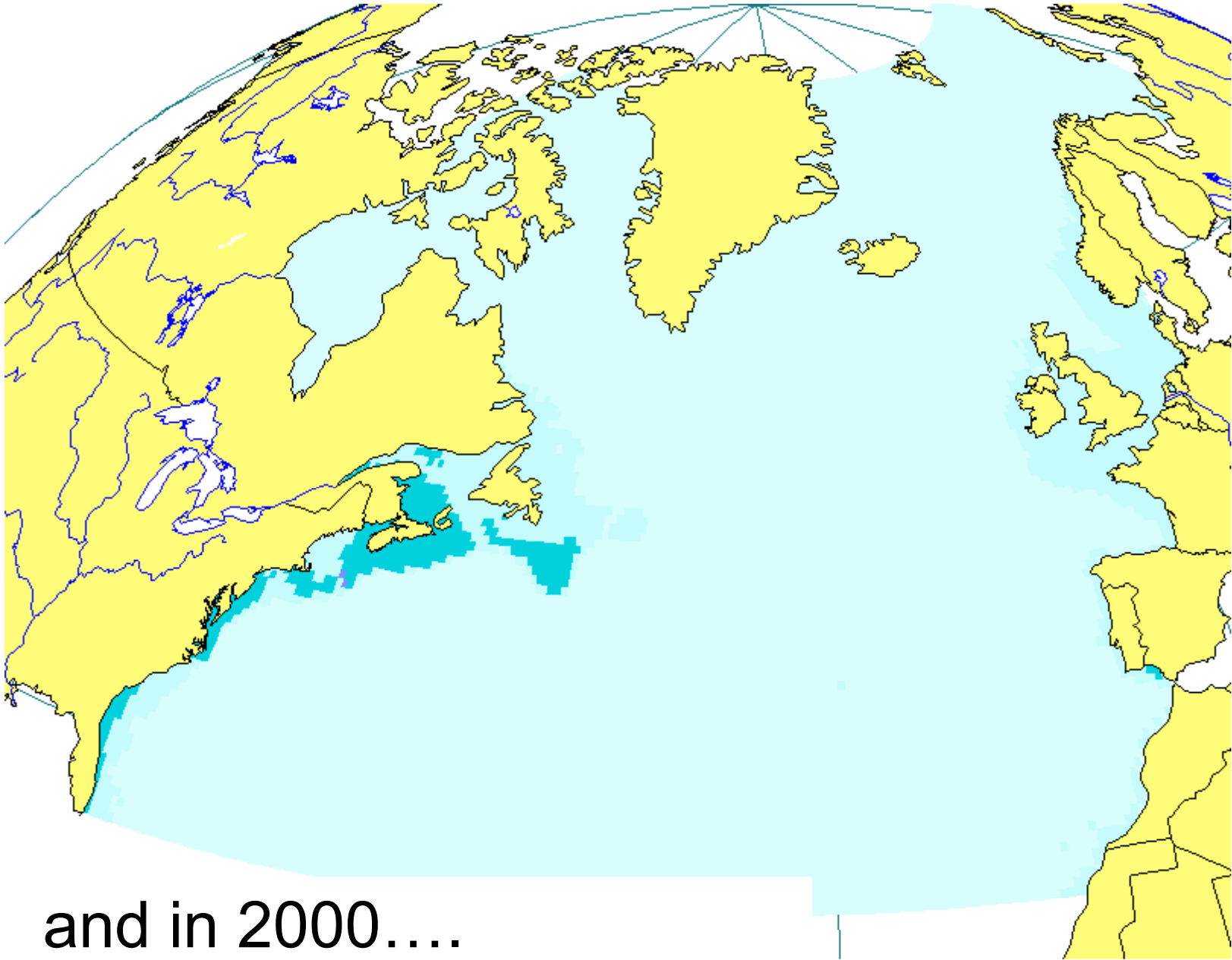


63 % of assessed fish stocks worldwide still require rebuilding (Worm et al science 2009)



Biomass of table fish in 1900 (Christensen *et al.* 2003, *Fish & Fisheries*)



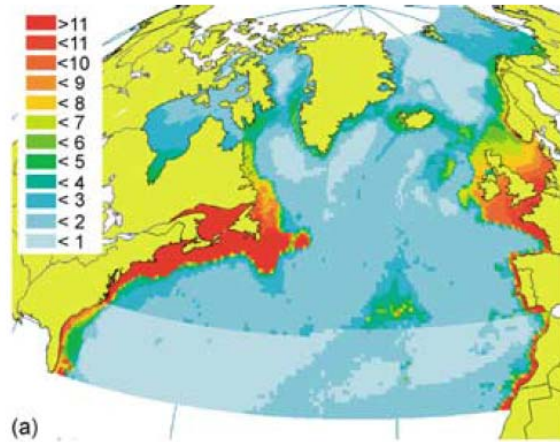


and in 2000....

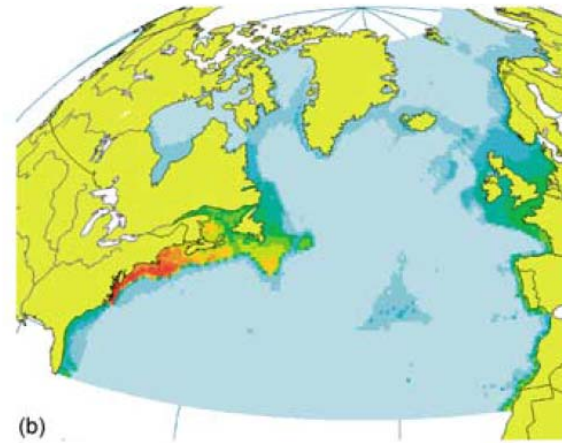


Abundance of high trophic level fishes in the North Atlantic

1900



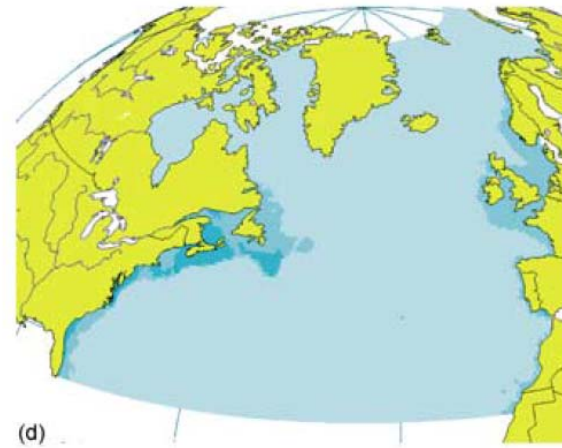
1950

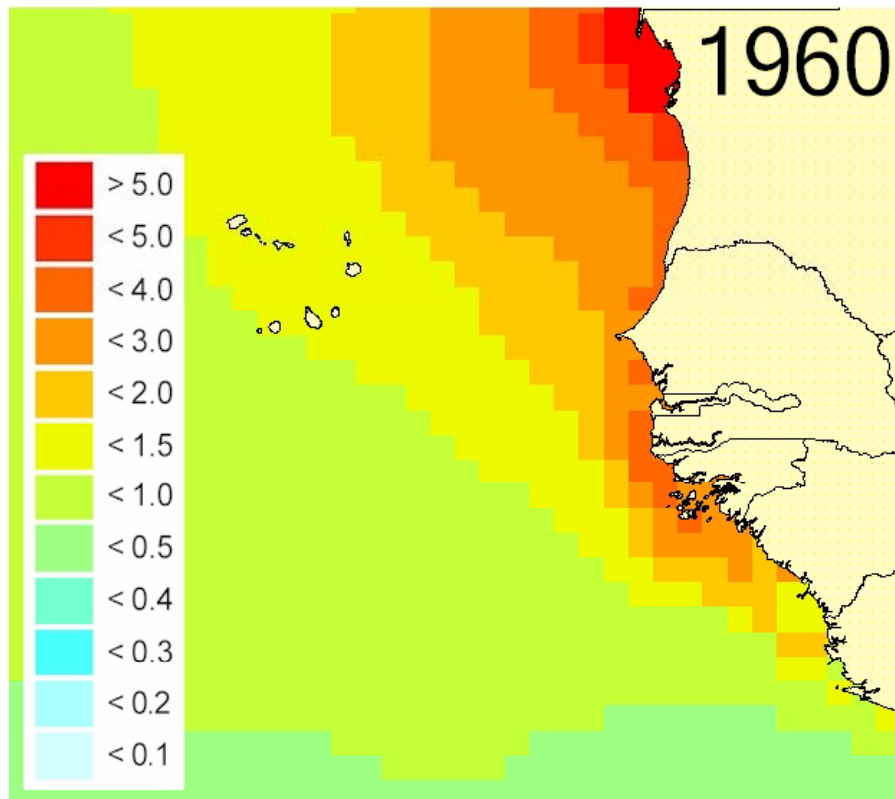


1975

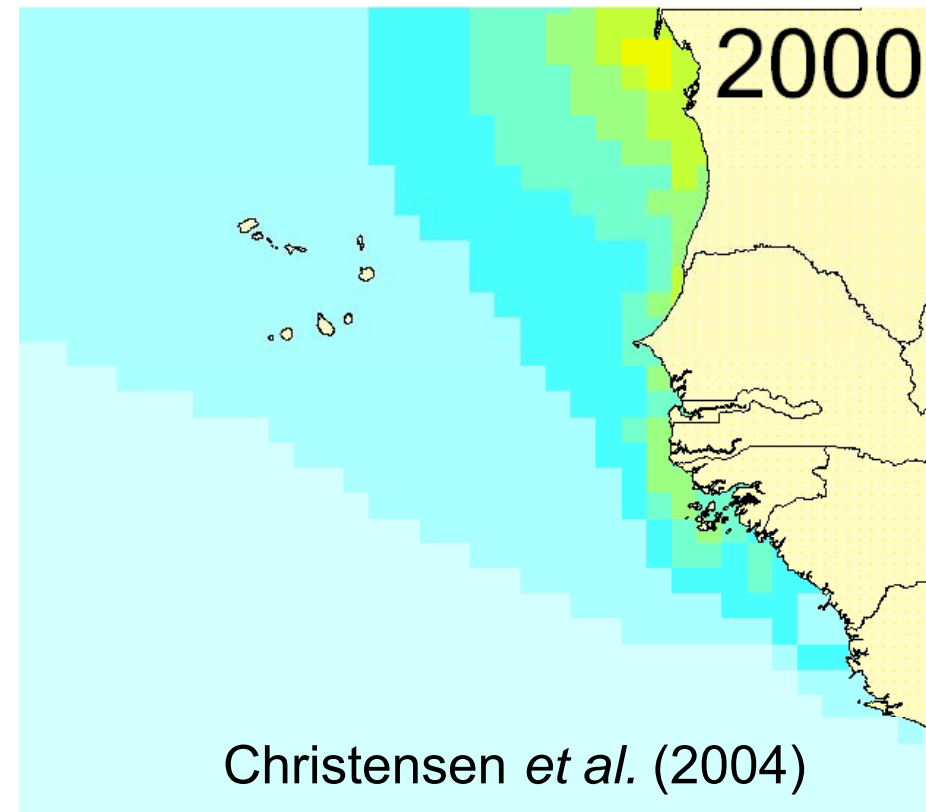


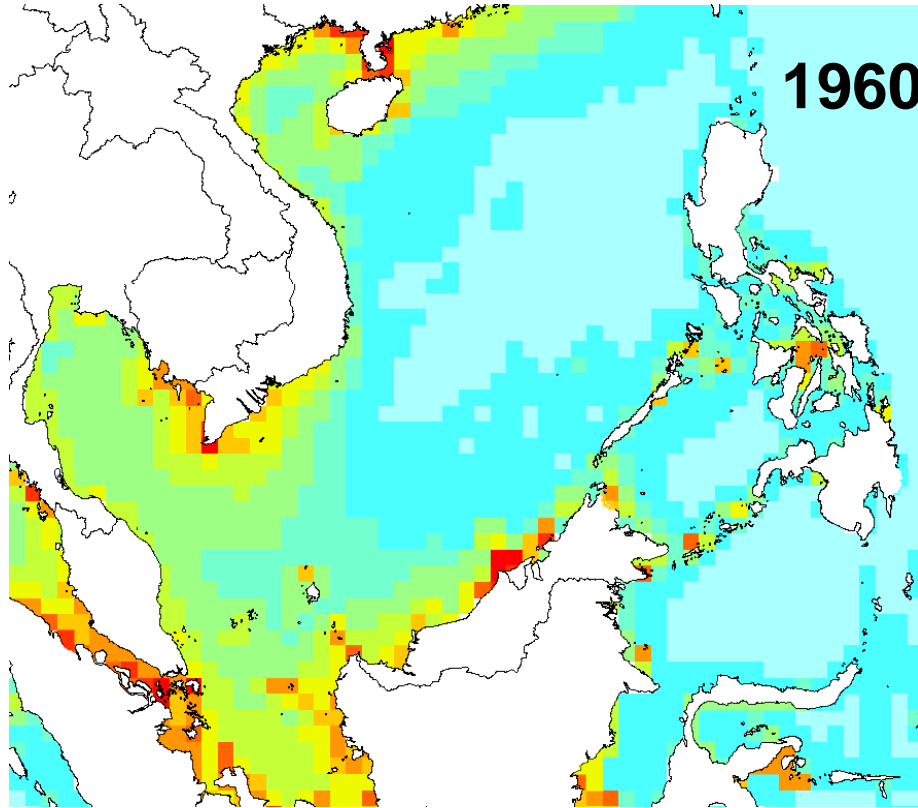
2000





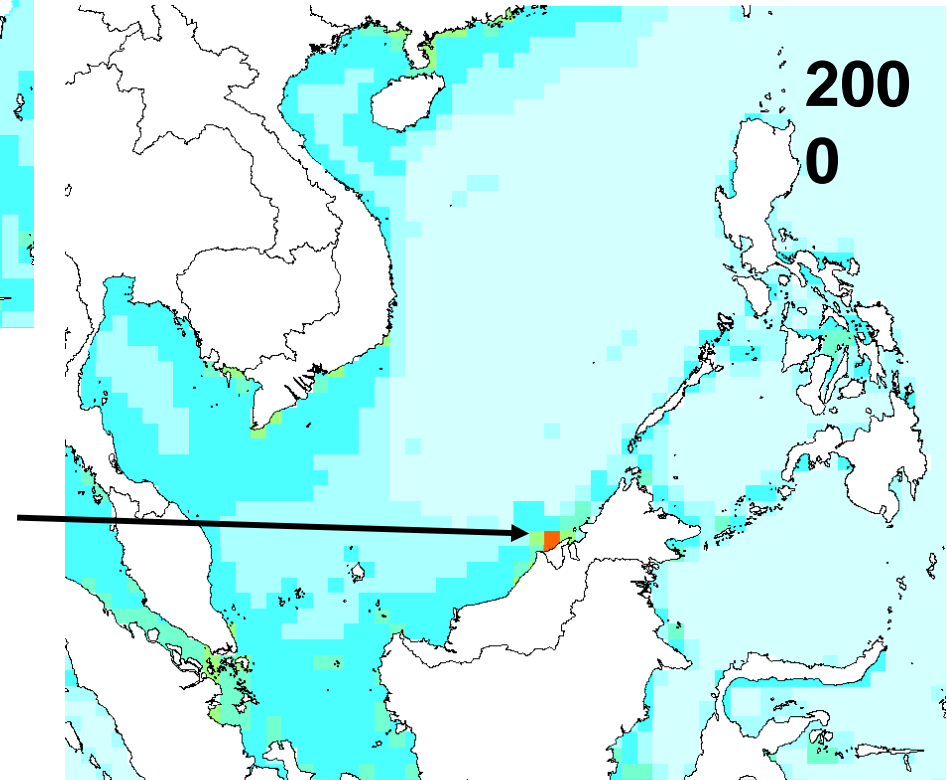
This is not different in Northwest Africa, where there is much fishing by Distant Water Fleets...





The situation is similar in Southeast Asia...

Note Brunei as exception



Christensen *et al.* (2004)





1950



1970

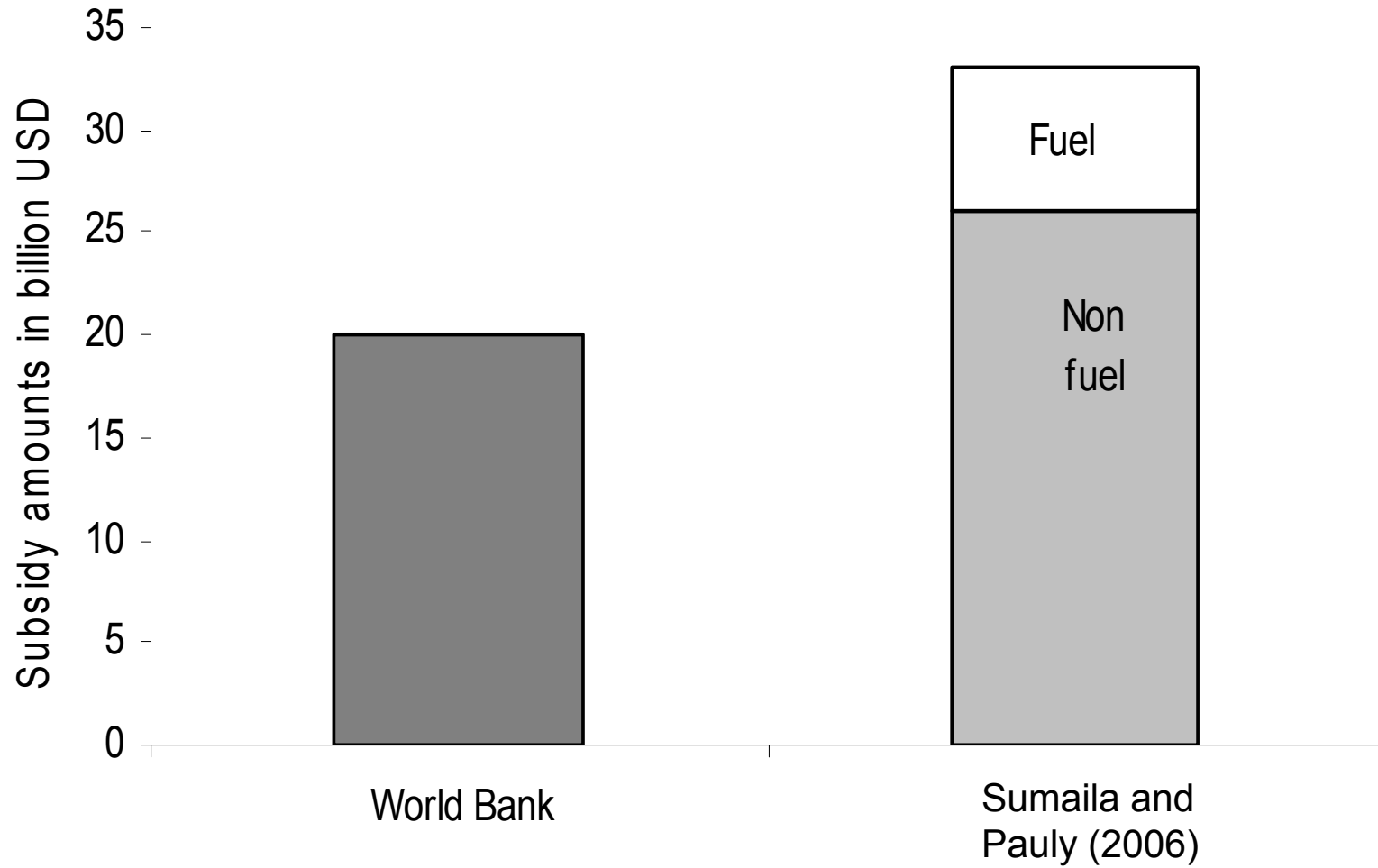
The fishing power of boats is increasing tremendously... boats' size, fishing techniques, detection means of boats, Fish aggregating devices FADs...)

In Europe, the nominal effort decreased by 25% since 1992 while the effective effort increased by 18%

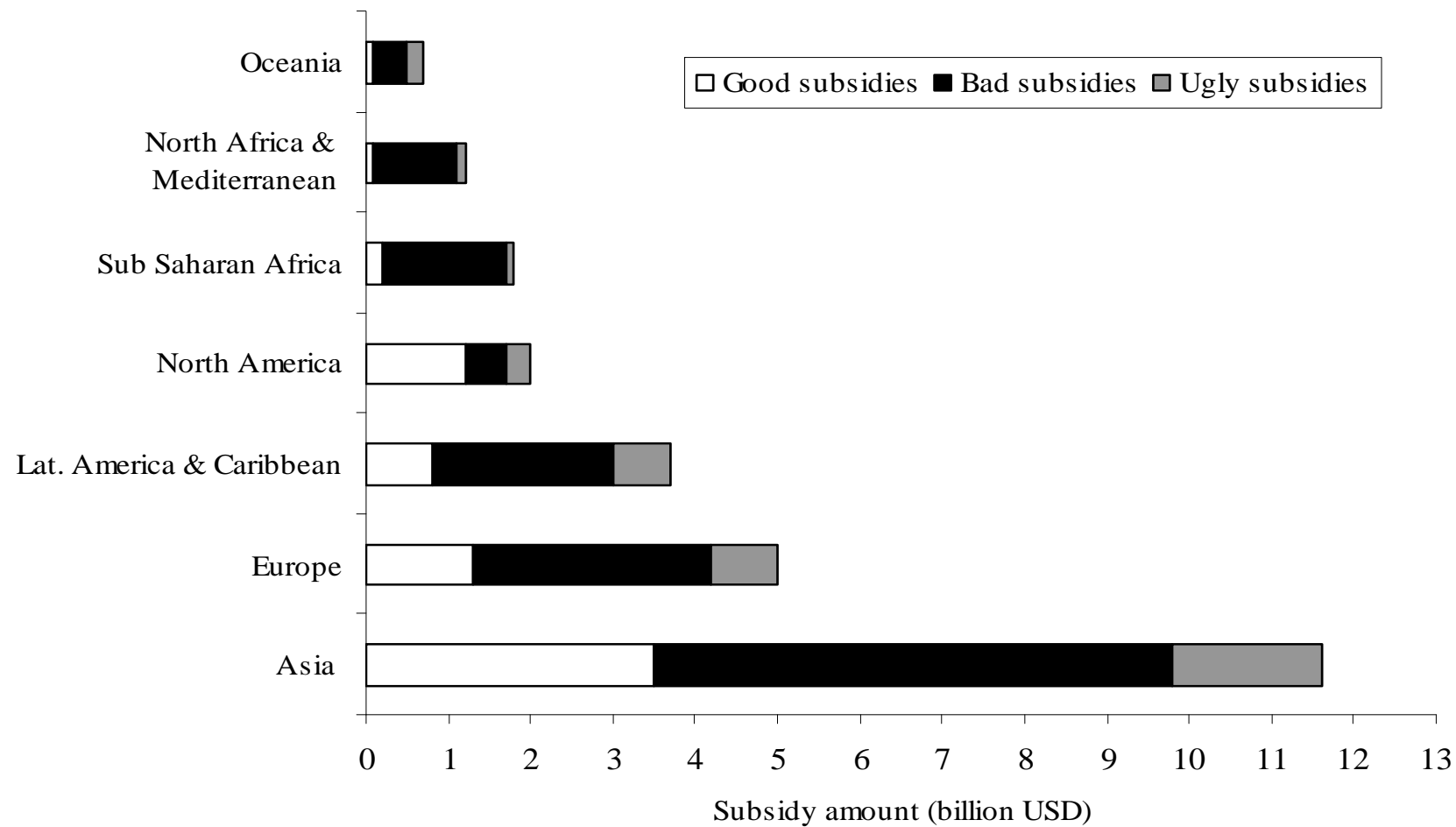


2000

Global subsidy comparisons



Subsidies come in different flavors...

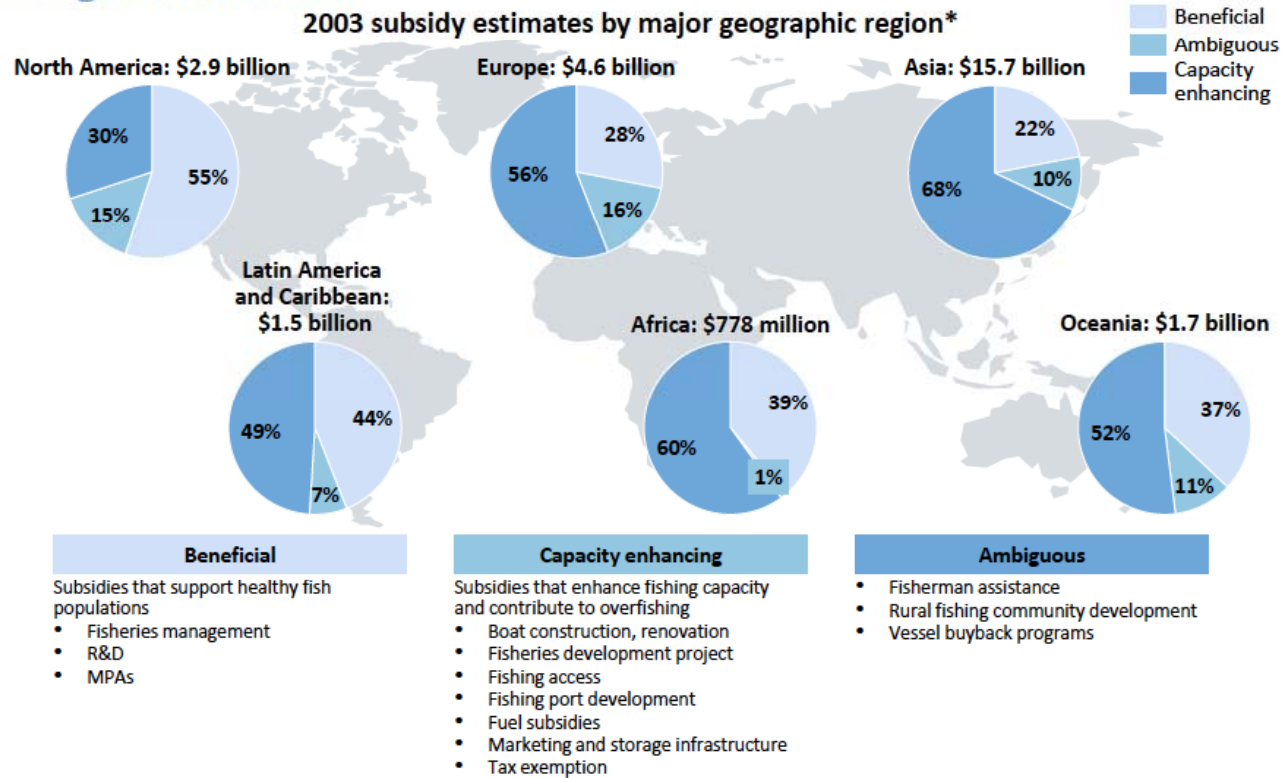


Sumaila and Pauly
(2006)

Huge ambiguous subsidies at the world level

(CEA fisheries report 2012)

Asia spends about \$11 billion per year on capacity enhancing or more ambiguous subsidies



Coral reefs after trawling

(Australia - A. Charles)



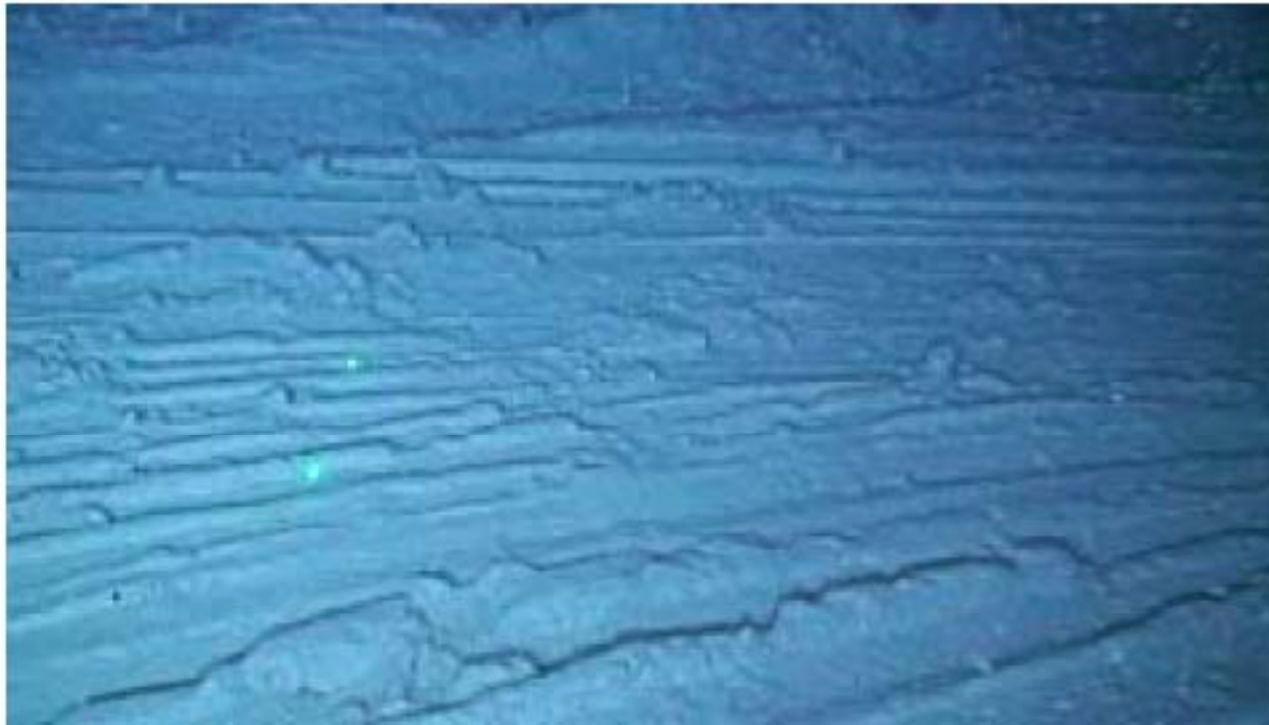
Coral reefs after trawling

(Australia - A. Charles)



Bottom trawling has become an important driver of deep seascape evolution

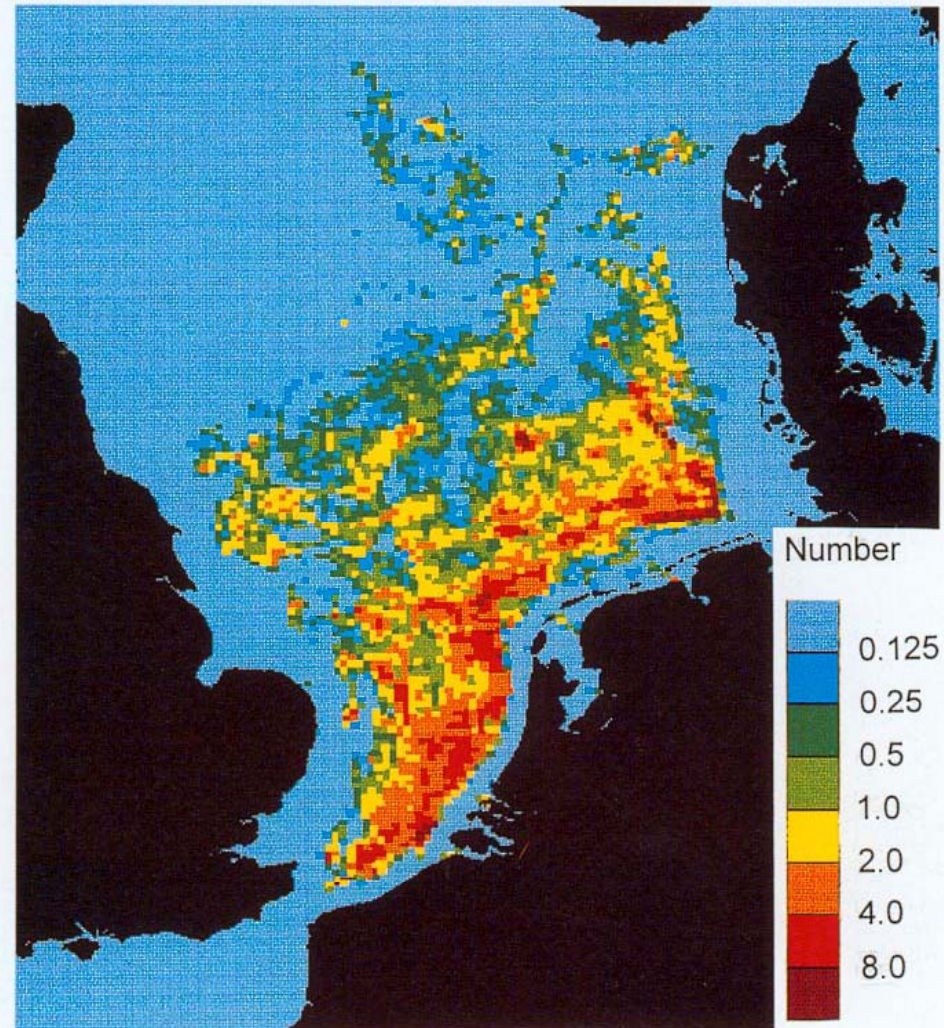
(Puig et al Nature 2012)



Habitat Change: Mean Beam trawling intensity by Dutch beam trawlers from 1993 to 1996

(Rijnsdorp 1997)

- Trawling activity covers half of the continental shelves, which represents 150 times forestation every year
- Certain areas can be fished 8 times per year in the north sea (Rijnsdorp 1997) to even 25-141 times in several estuaries



Bycatch in world fisheries : between 10 and 27 millions tonnes of marine products are wasted annually (FAO)



For 1 kg of shrimp 5 to 10 kg of marine organisms are trashed
Hundred of thousands of birds and mammals are killed every year...
meanwhile 2.5 millions birds are sustained by discards in the North :



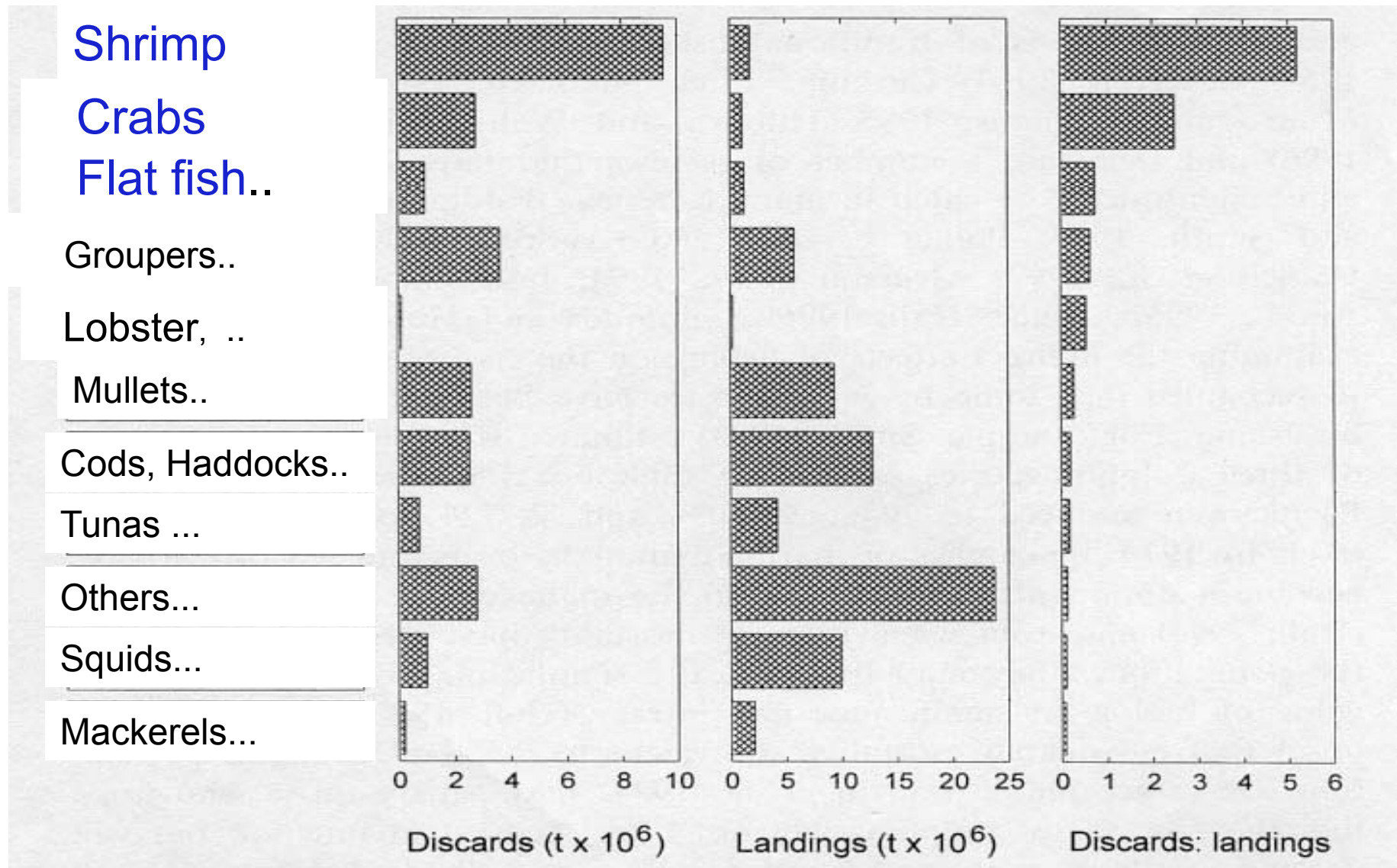
Bycatch in tuna fisheries

(source IRD)



Bycatch in world fisheries

(source FAO 1998, 2006)



Bycatch of Nephrops –langostina fisheries in France

(Perronet et al. Ifremer 2008)

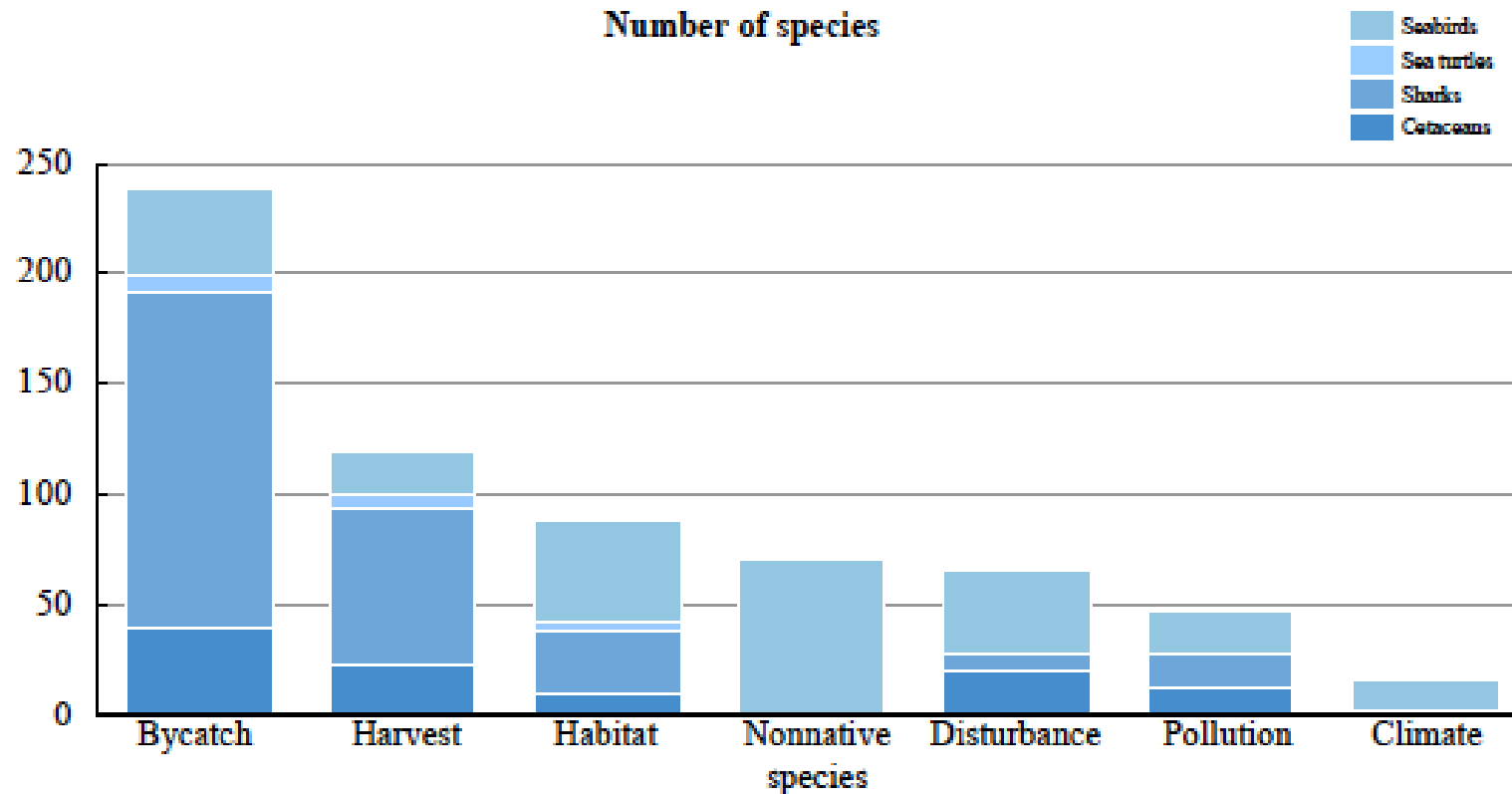
• Nombres	1987	1991	1998	2003
Rejets/Captures en %	51	41	49	60

	Langoustines femelles	Langoustines mâles	Total
rejets/débqts (nombre)	0.679	0.620	-
Rejets estimés (millions)	104	94	198
rejets/débqts (poids)	0.311	0.283	-
Rejets estimés (tonnes)	990	885	1875
<i>Estimateur simple</i> <i>(rappel)</i>	<i>1 049</i>	<i>953</i>	<i>2002</i>

Bycatch

(CEA fisheries report 2012)

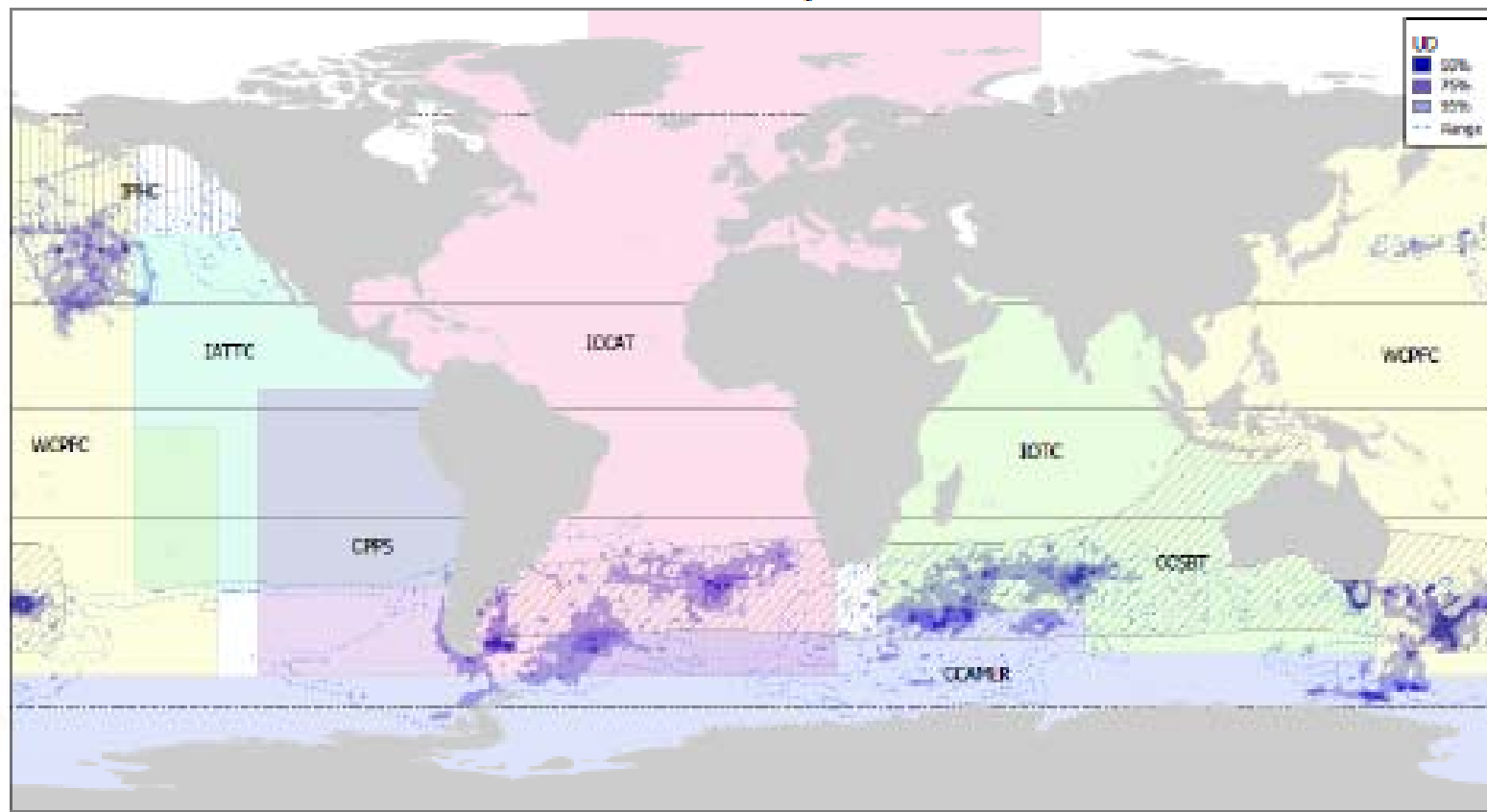
Bycatch and harvesting are primary threats for the most IUCN red listed marine species



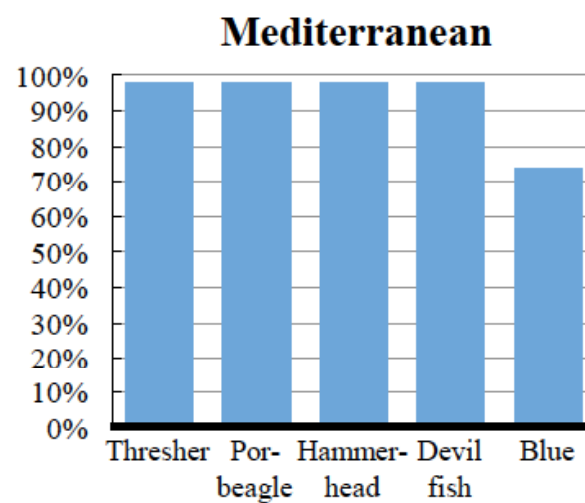
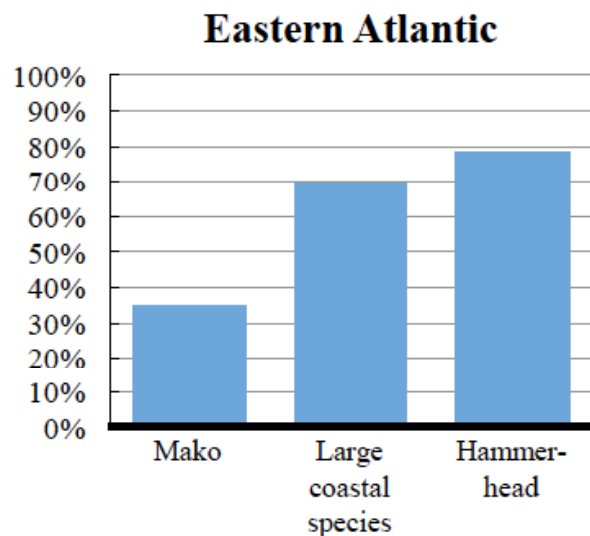
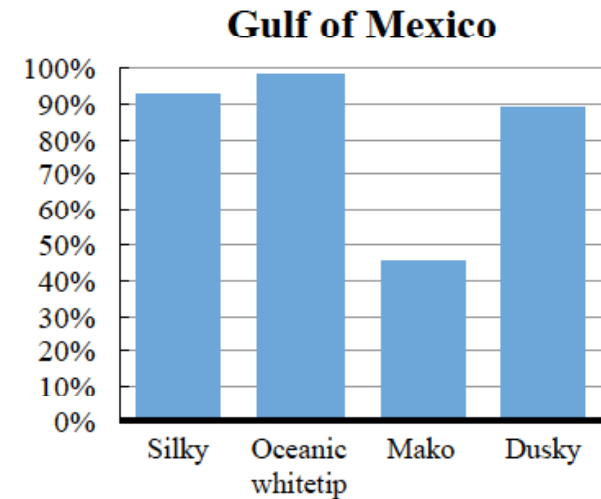
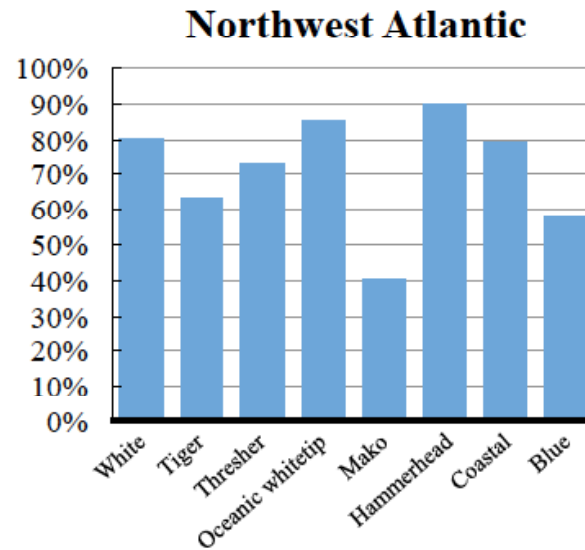
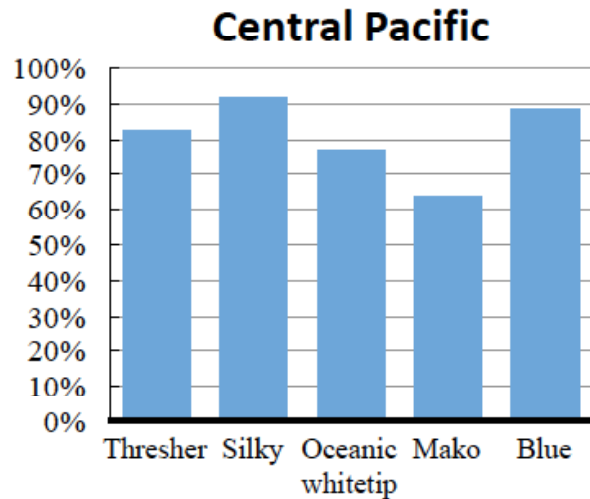
Albatros bycatch (CEA fisheries report 2012)

The most dangerous fisheries for threatened seabirds are the open ocean longline fisheries in the Southern hemisphere

Distribution of threatened albatross species in relation to RFMO areas



Shark decline bycatch (CEA fisheries report 2012)



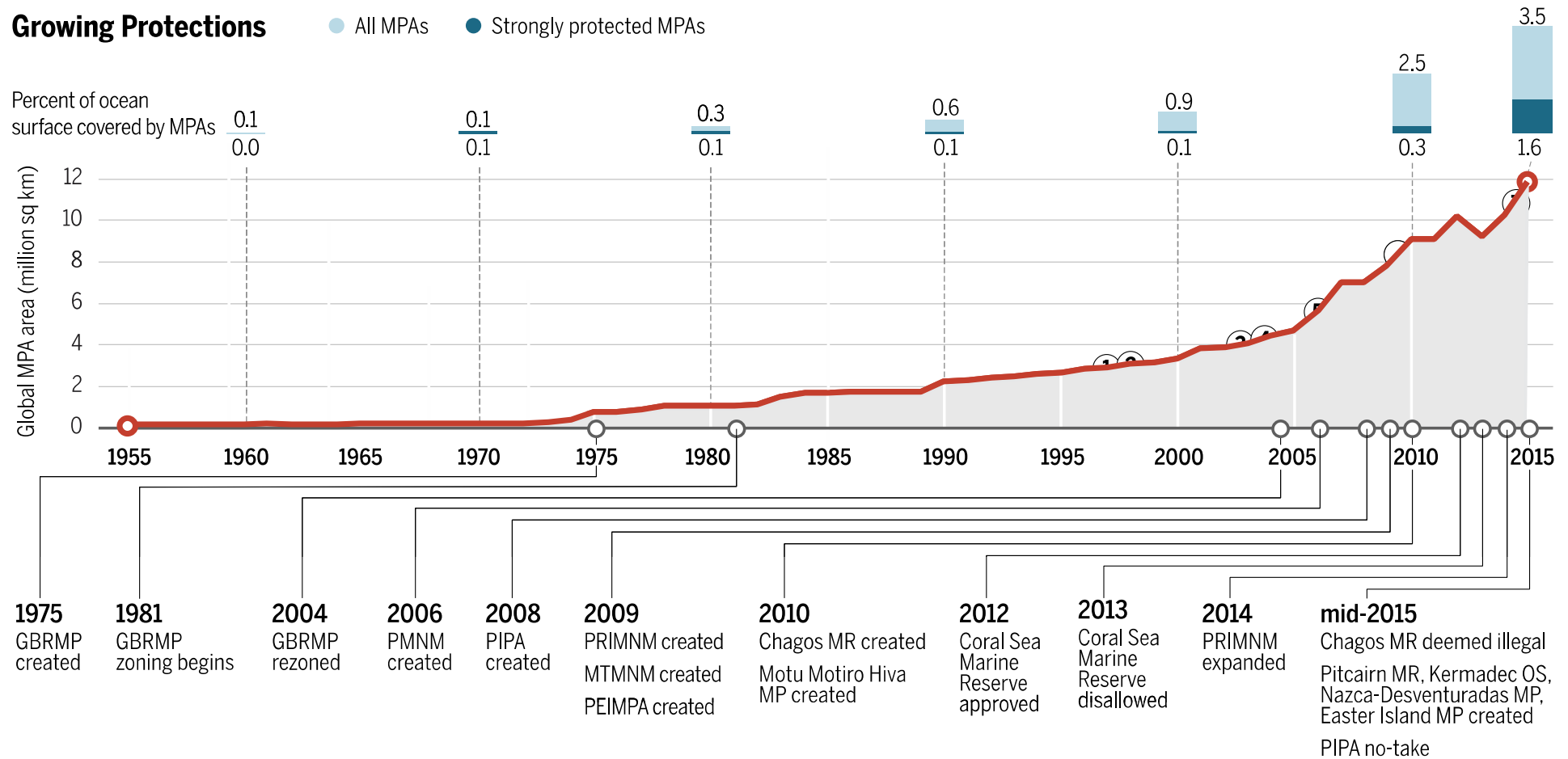
**Nearly all
shark species in the
Mediterranean have
declined by over 97%
in a span of
20 years**

MPAs as a tool to protect biodiversity

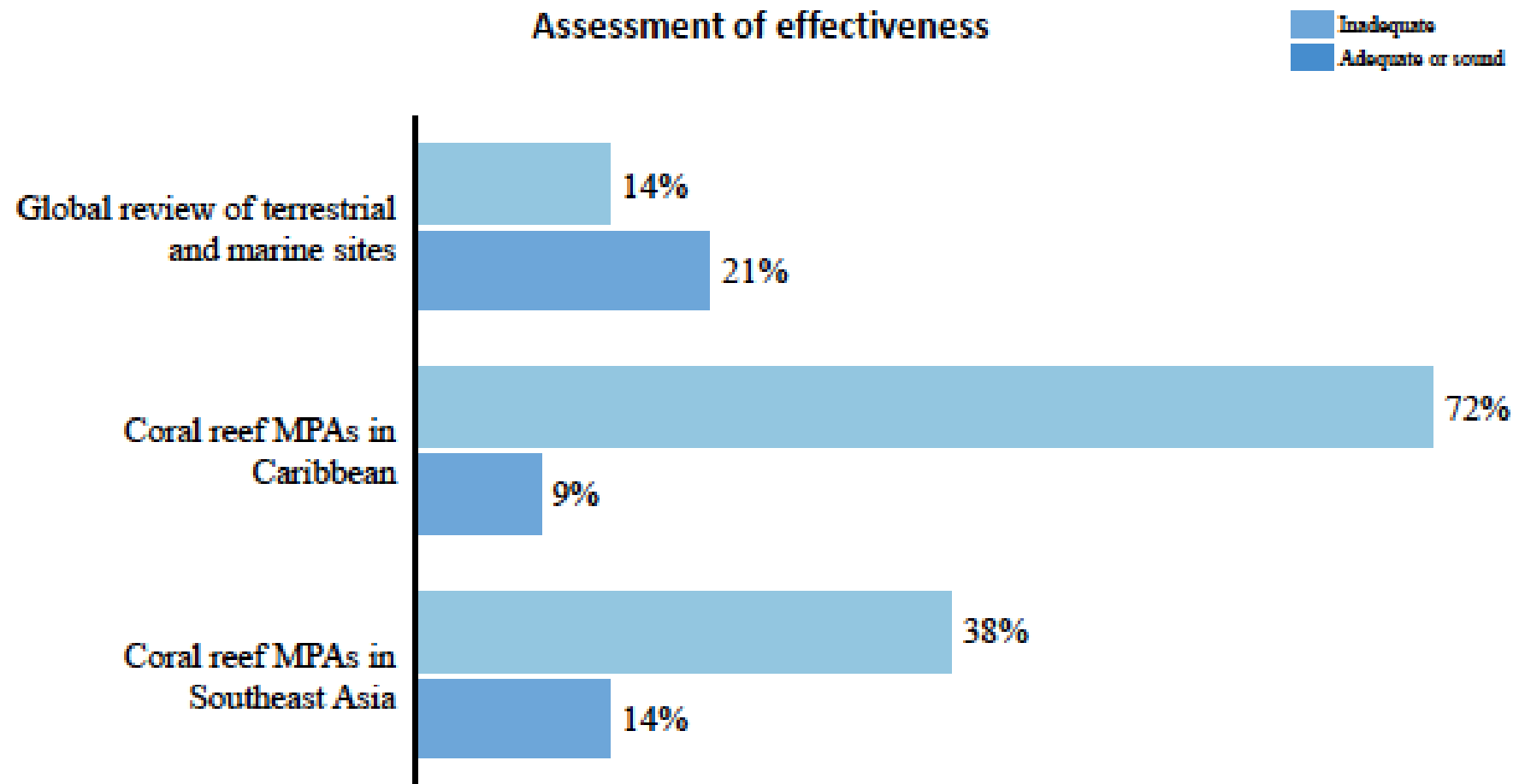
(Lubchenco Science 2015)

Growing Protections

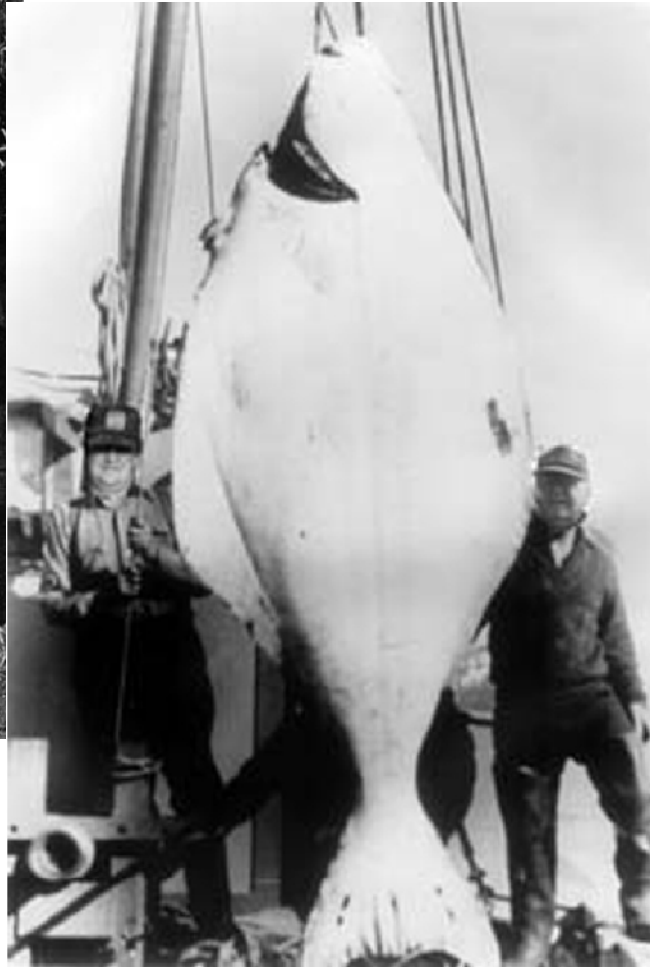
● All MPAs ● Strongly protected MPAs



Many MPAs lack sufficient management and enforcement capacity



Archive documents



Fishers like big fish ... that become rare :

Trophy fish caught in Florida

(McClenachan 2009)

1957



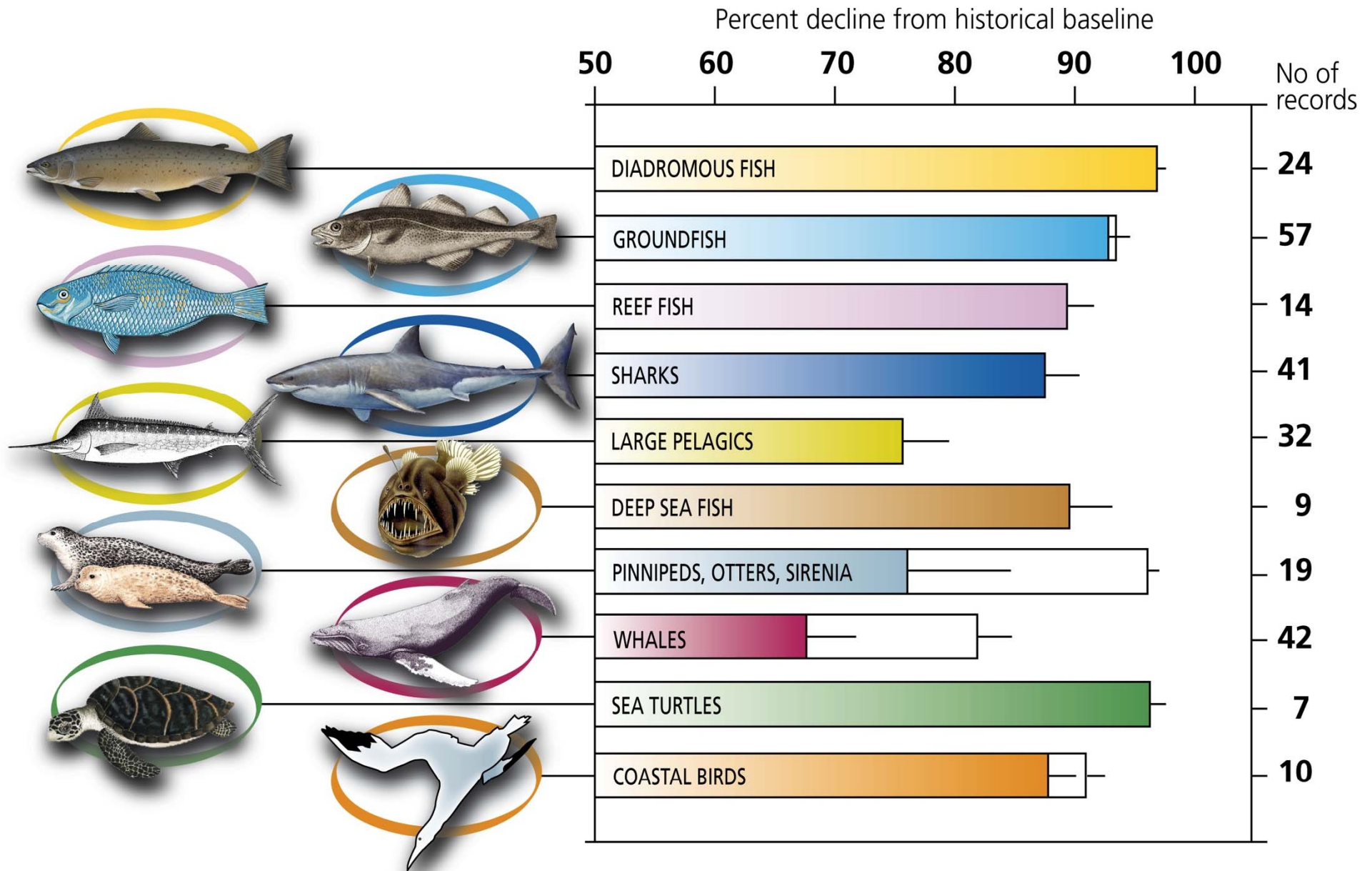
1980



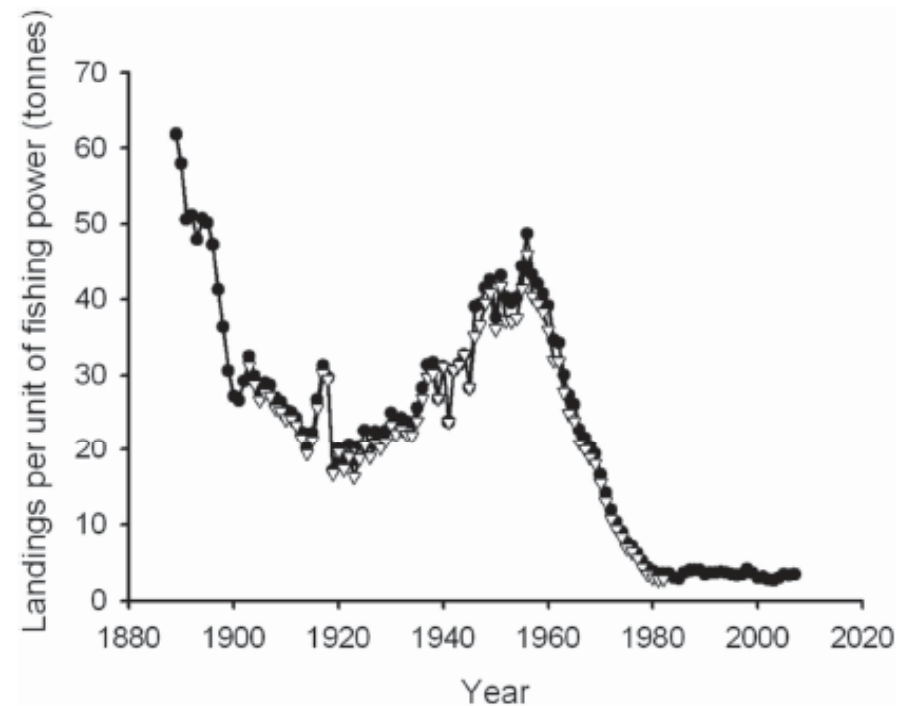
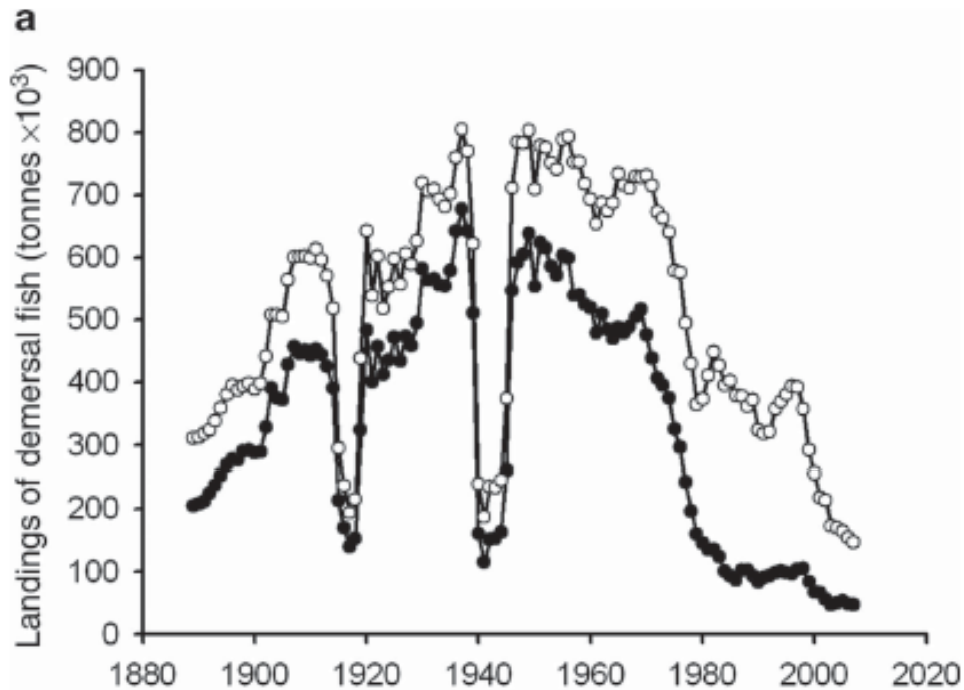
2007



Decline of large marine animals (Lotze et al. 2008)



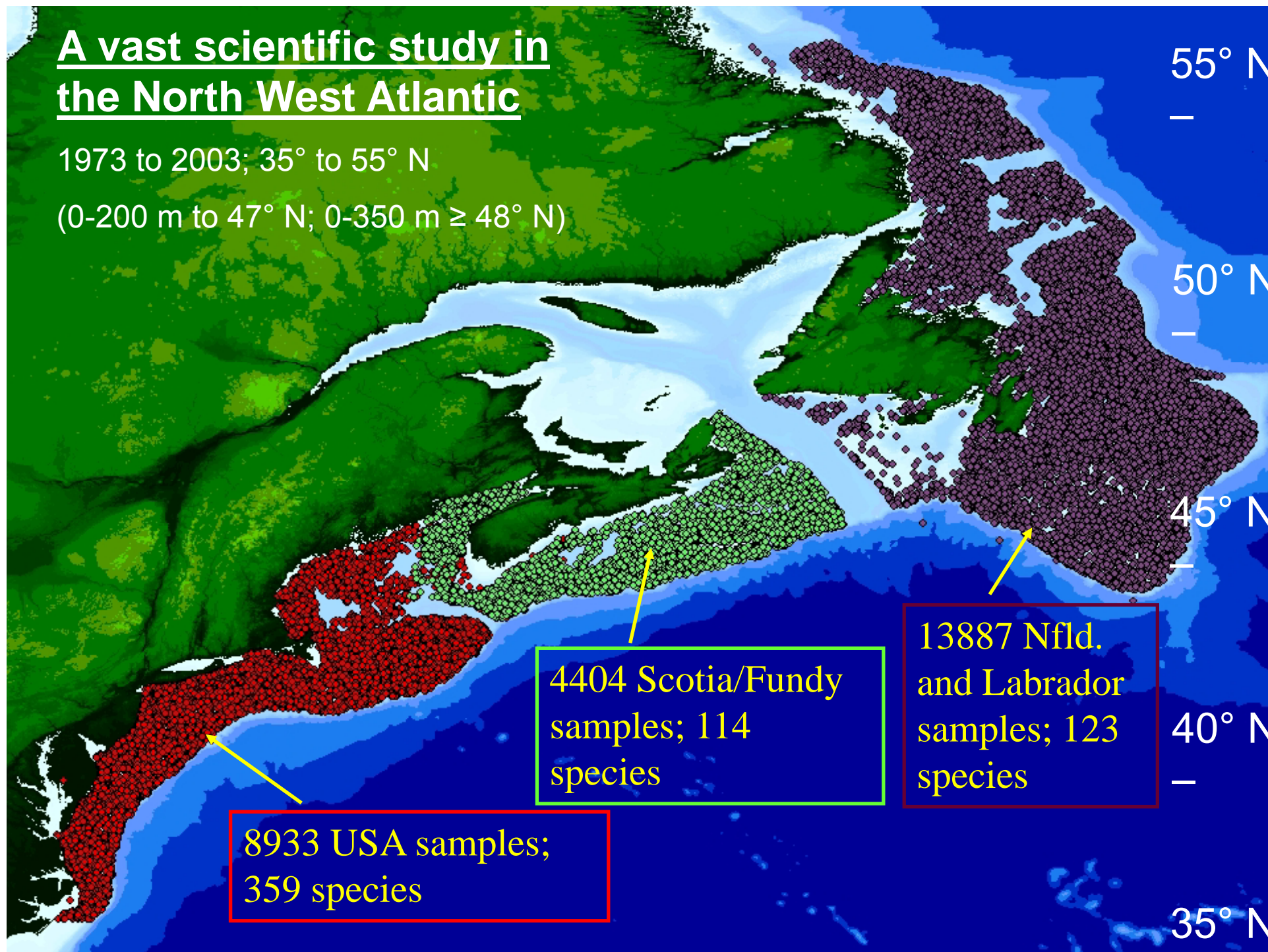
UK bottom trawl fisheries during the last 118 years:
94% decline in fish abundance (cod and groupers) and
4 times more catch than today
(Thrustan et al. Nature Comm. 2010)



A vast scientific study in the North West Atlantic

1973 to 2003; 35° to 55° N

(0-200 m to 47° N; 0-350 m \geq 48° N)



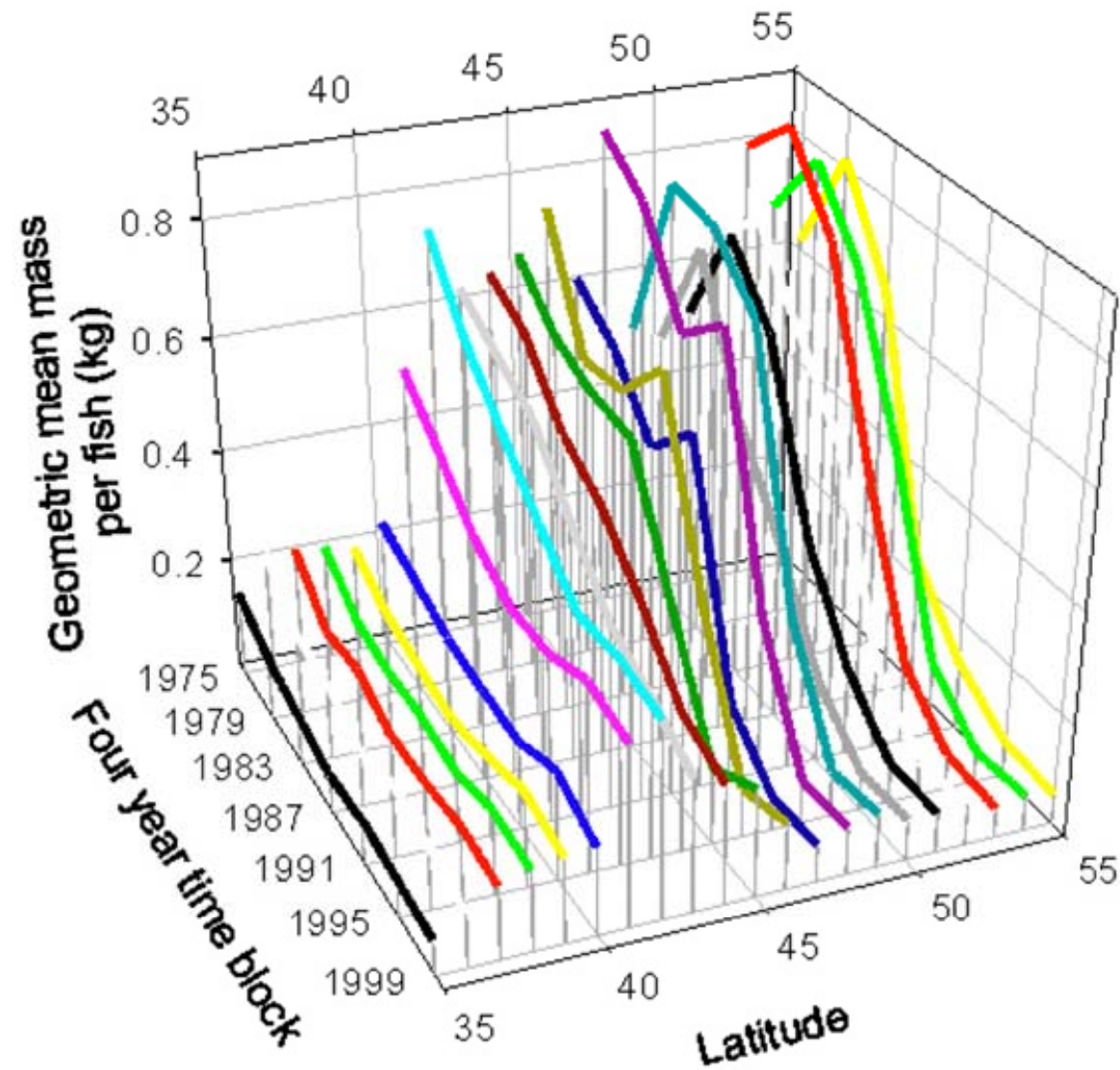
8933 USA samples;
359 species

4404 Scotia/Fundy
samples; 114
species

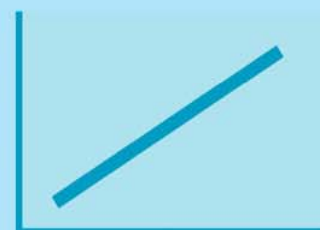
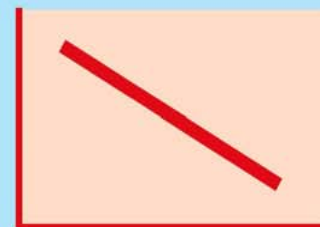
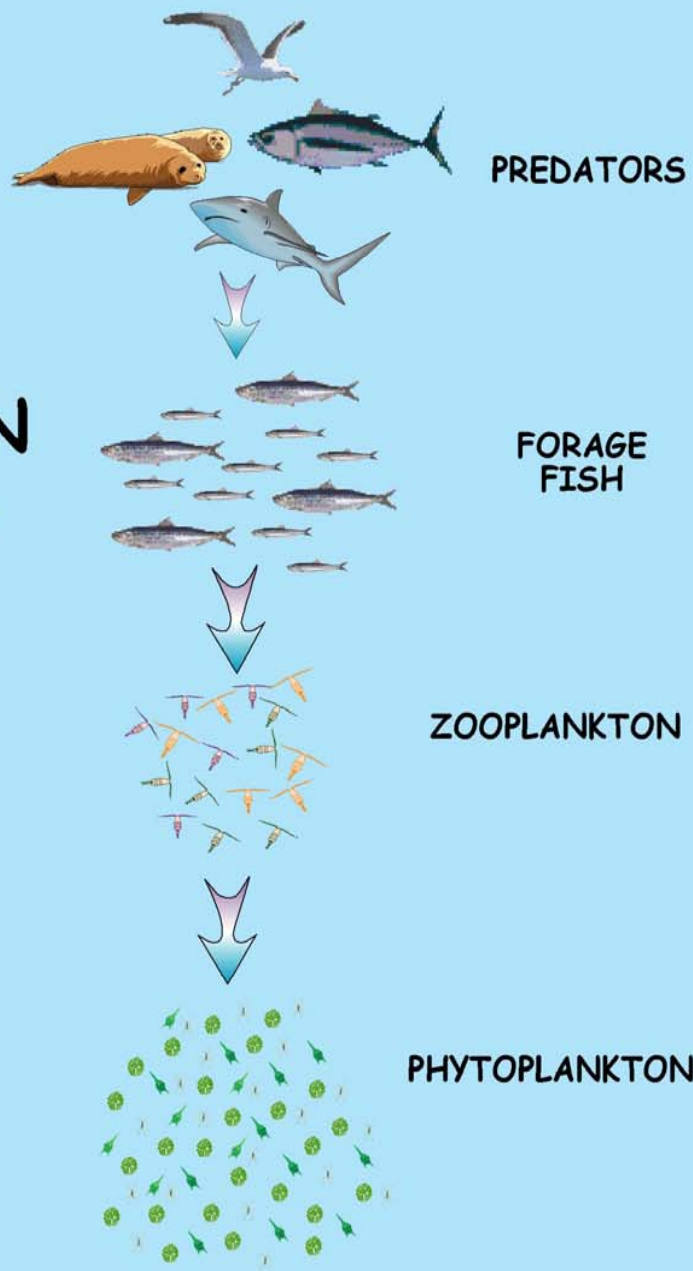
13887 Nfld.
and Labrador
samples; 123
species

The mean weight of fish decreased from 800g to less than 200g in 25 years in the North West Atlantic

(Fisher, Frank, Leggett in press)

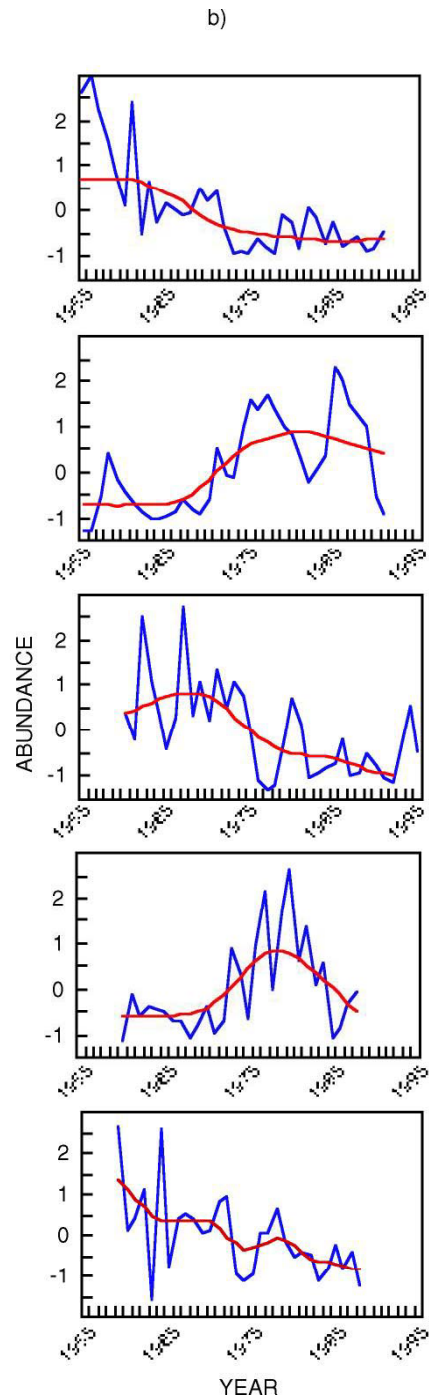
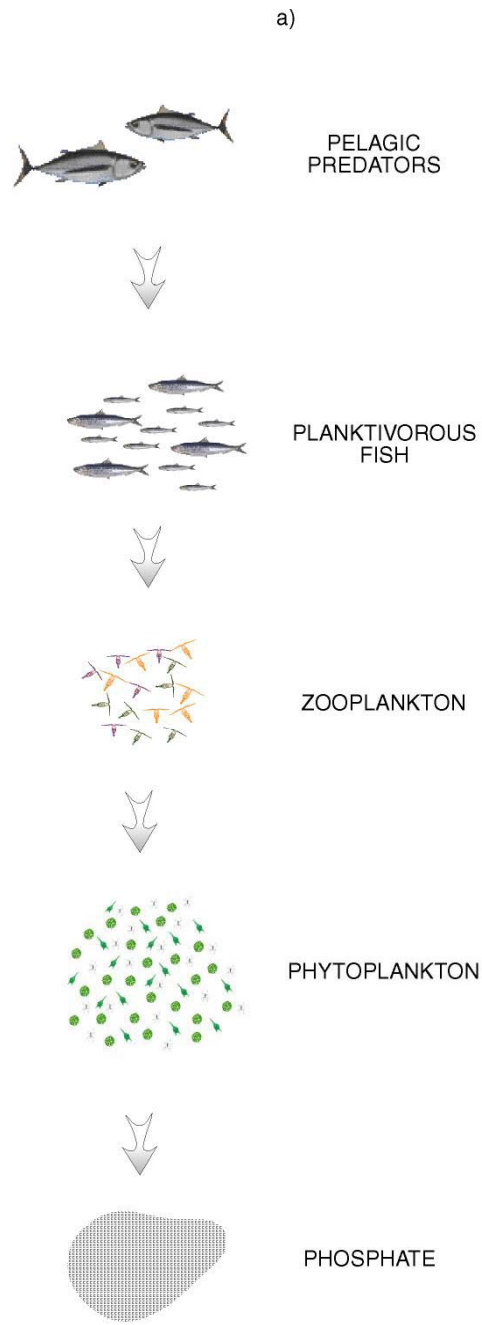


TOP-DOWN CONTROL



ABUNDANCE

TIME

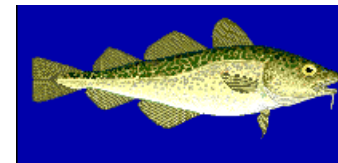
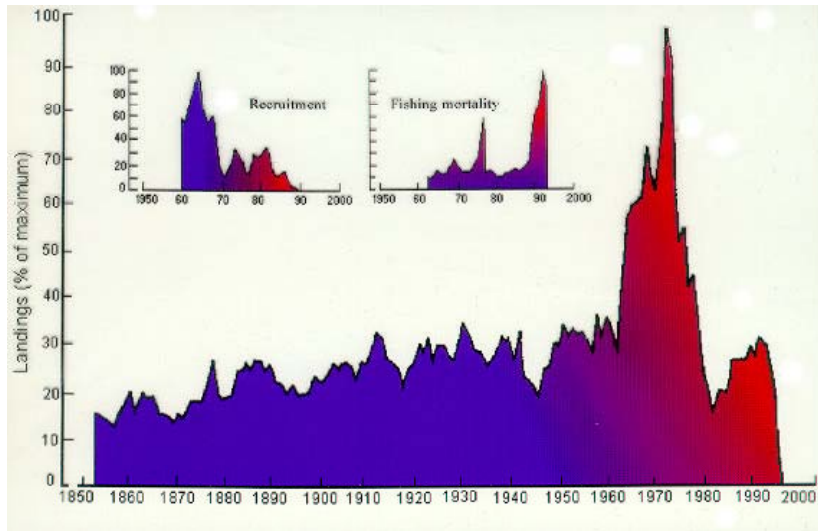
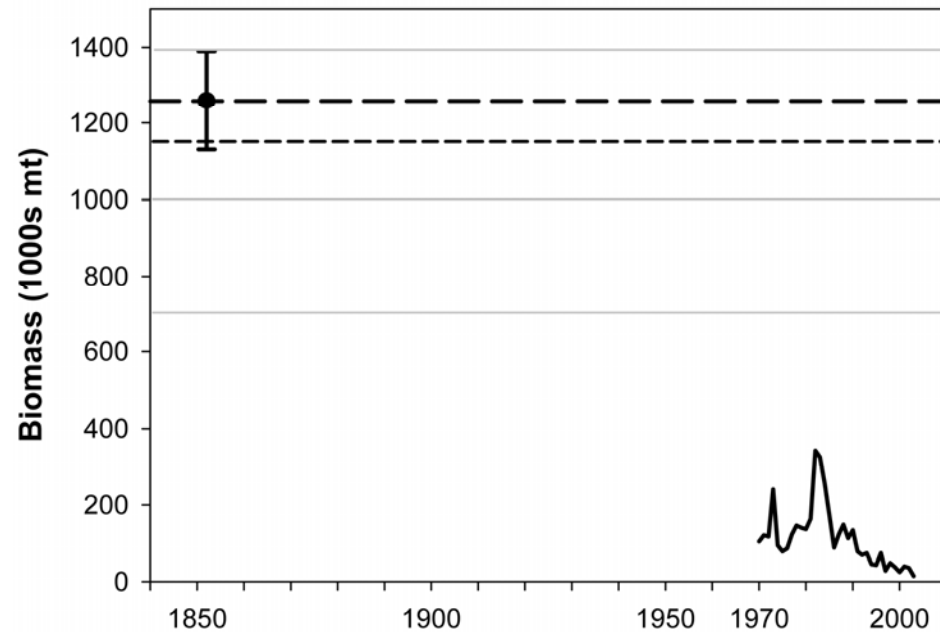


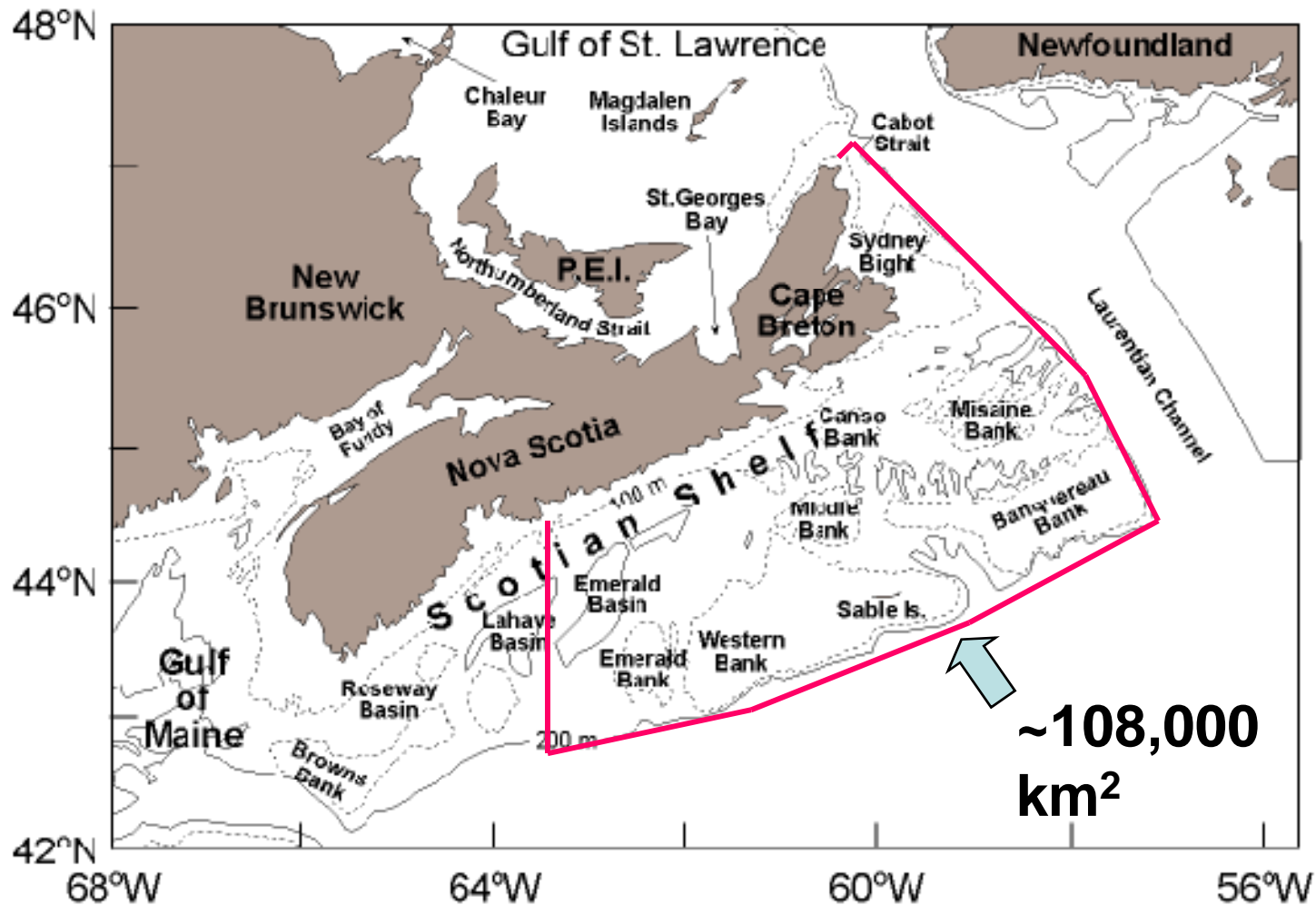
Trophic cascade in the Black Sea

(Daskalov, 2002, 2007)

Cod fishery in the North West Atlantic

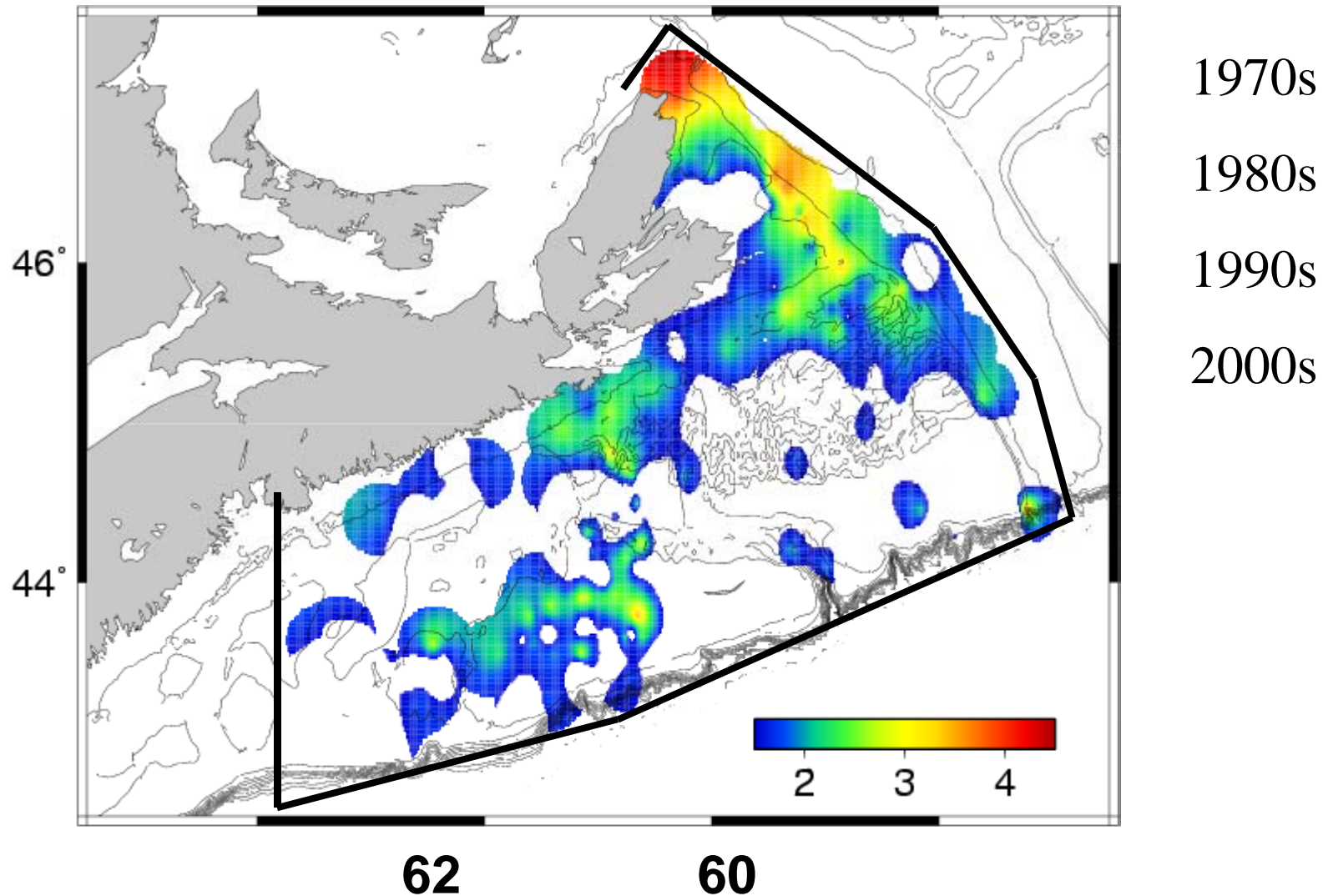
(source Lotze & Worm TREE in press)



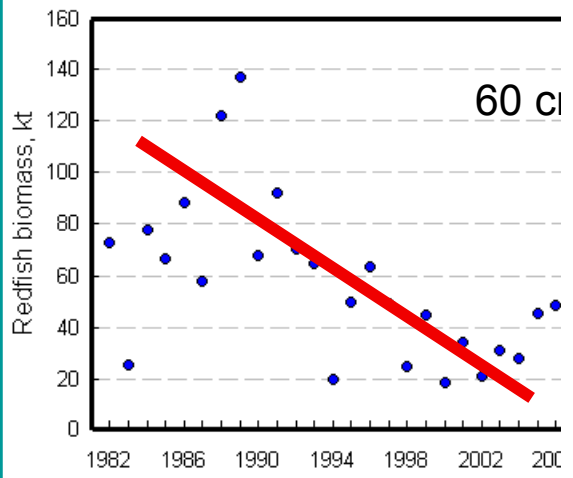
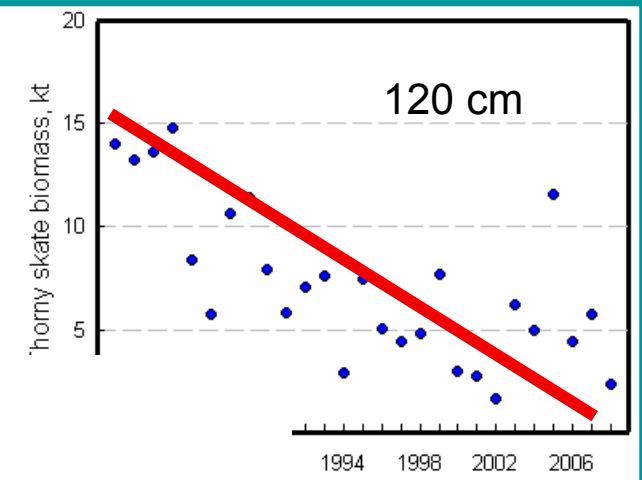
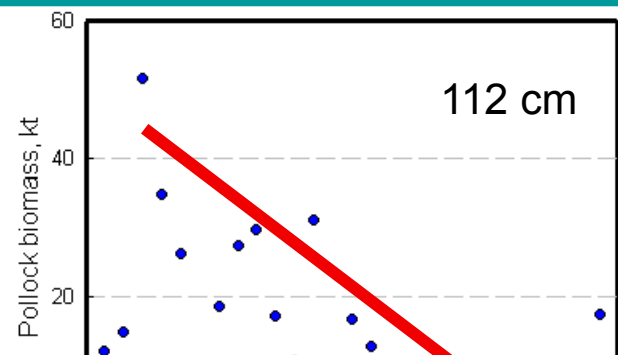
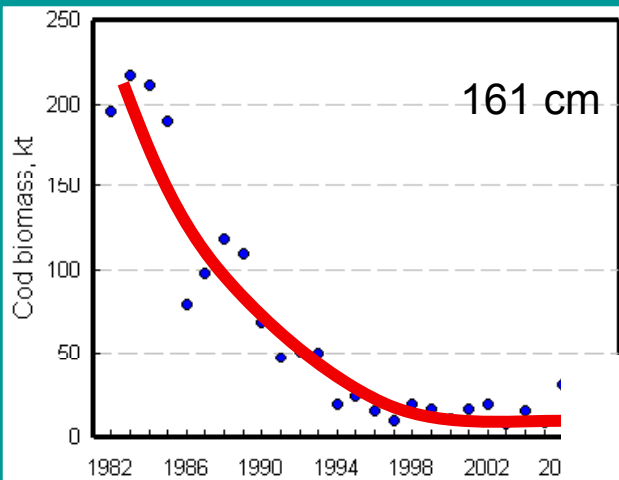


Data rich area: long-term (30+ yr), standardized, annual monitoring programs representative of major trophic levels (Frank et al. 2009)

Over-exploitation of cod and other top predators
on the eastern half of Scotian Shelf (Frank et al. 2009)

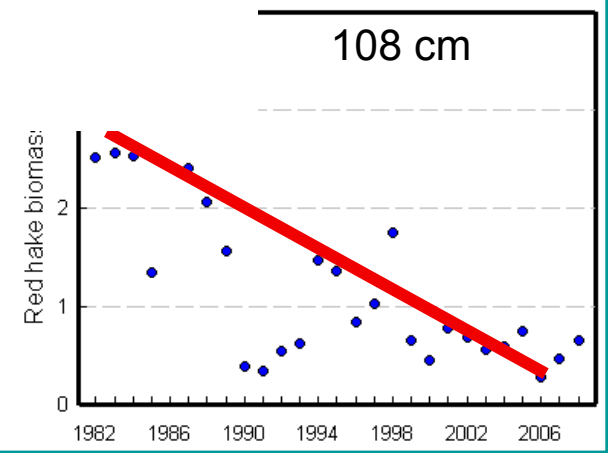
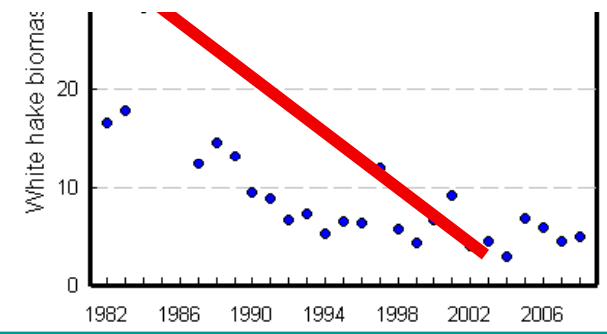
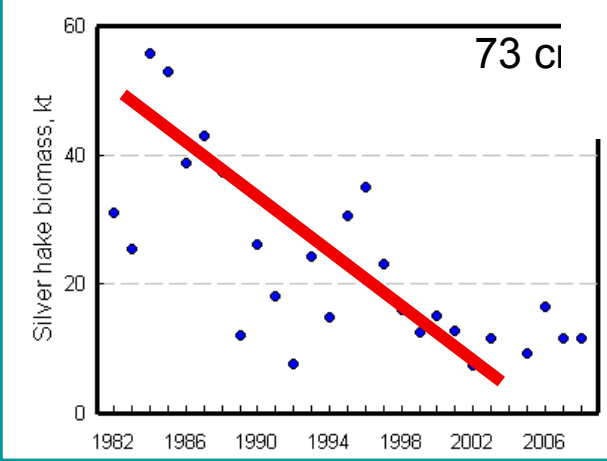
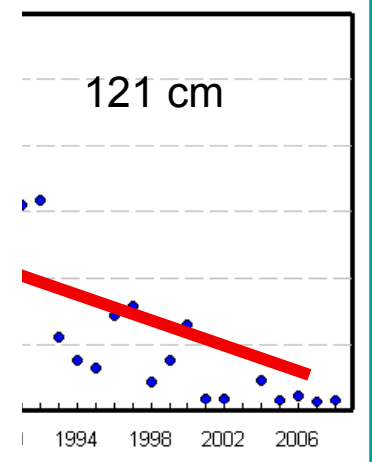


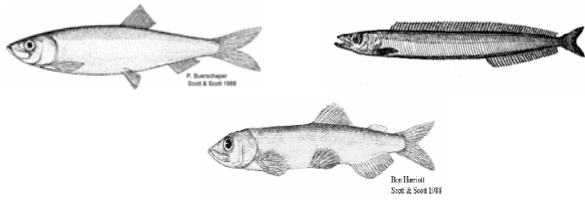
58 W Cod biomass: \log_{10} (kg per km²)



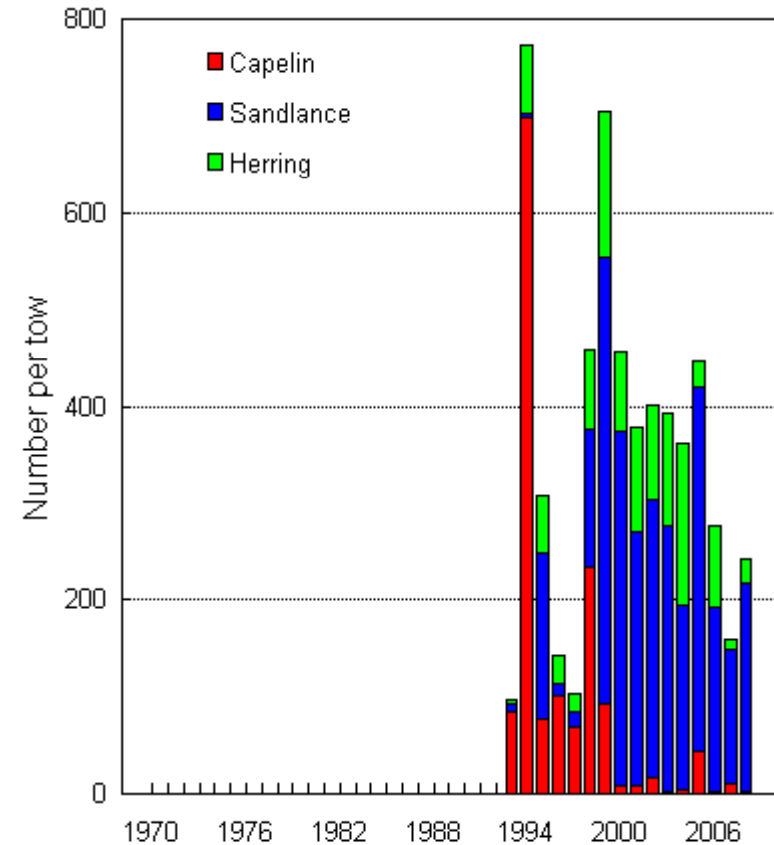
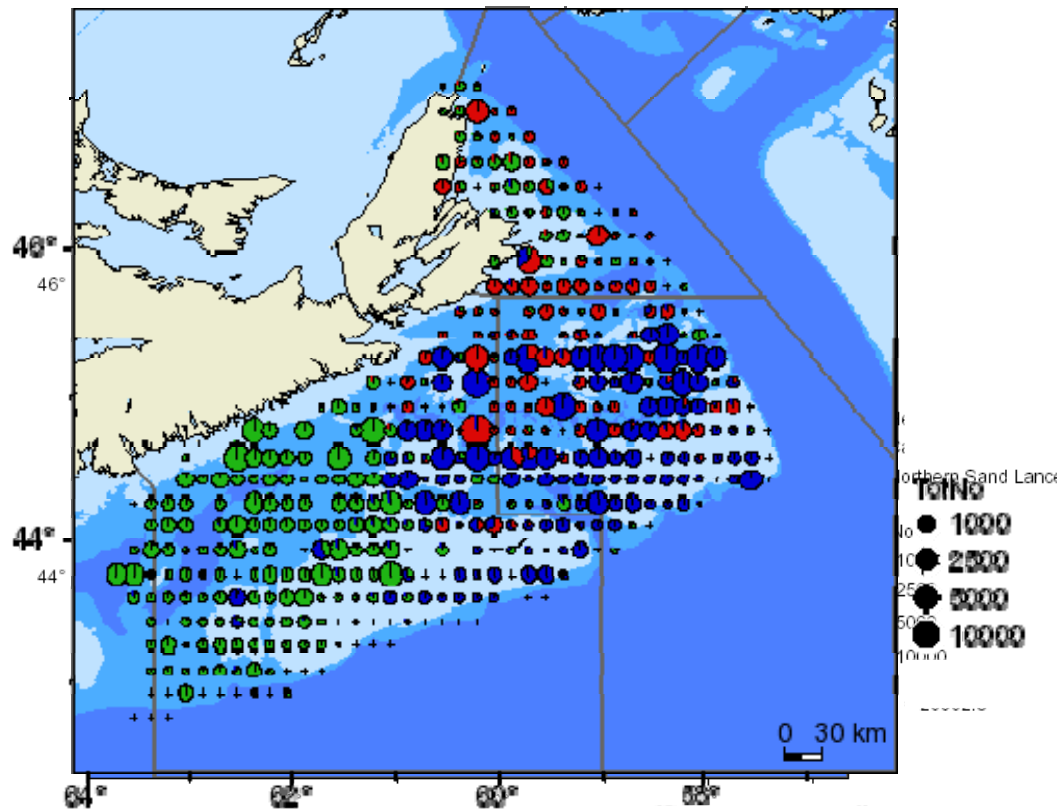
Drastic decrease of all the predators

(Ken Frank 2008)

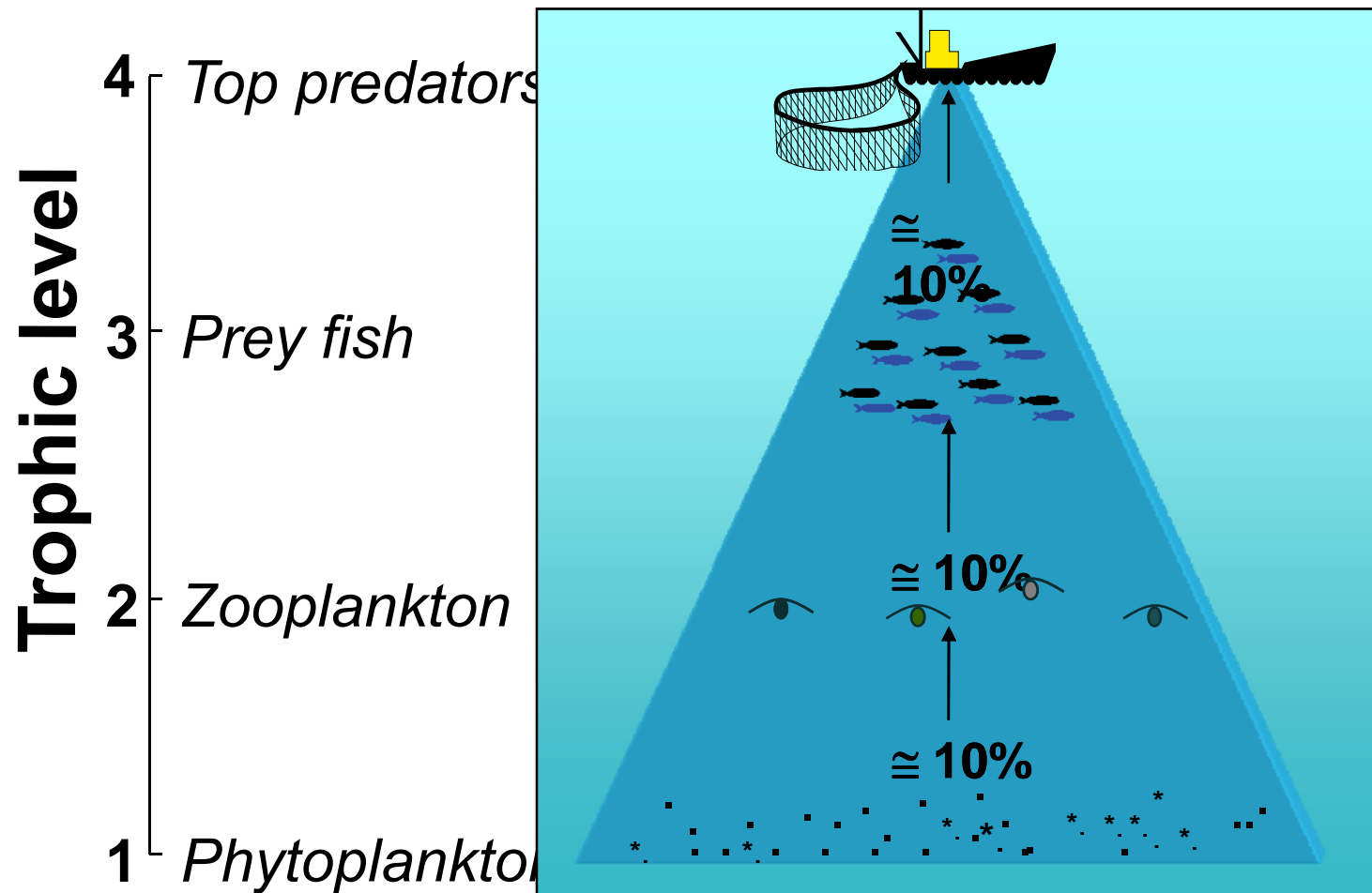




Response of major forage fish species (planktivores)



Back to basics: trophic levels...



Trophic level:

DC_{ij} is the fraction of prey j in diet of predator i

G number of prey species

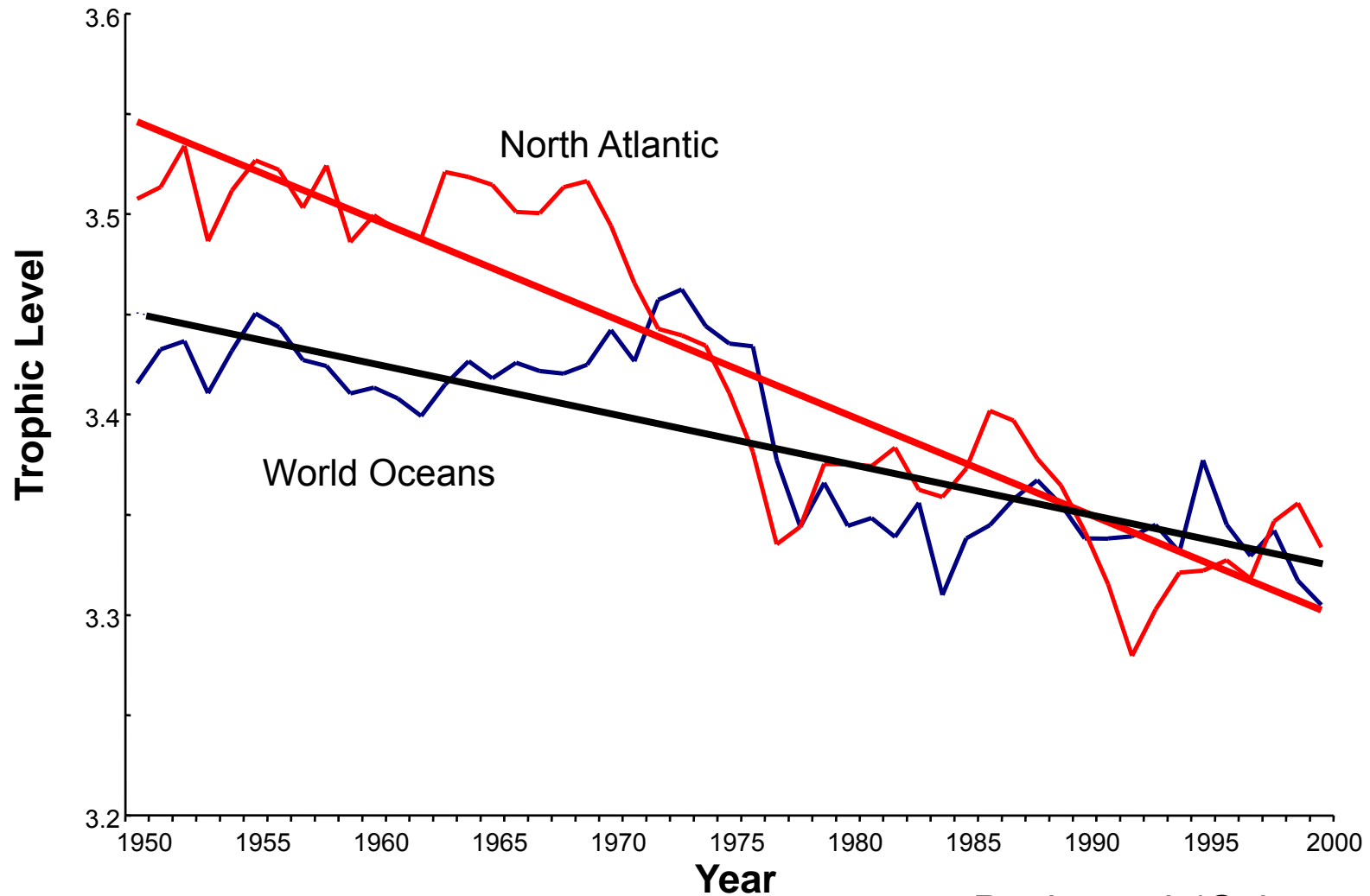
TROPH $_j$ is the fractional TL of prey j

$$\text{TROPH}_i = 1 + \sum_{j=1}^G DC_{ij} * \text{TROPH}_j,$$

Question, Method and Data

- What is the main effect of fisheries on exploited fish communities?
- Key equation (for year k):
$$TL_{\text{mean}k} = \frac{\sum_i \text{catch}_{ik} * TL_i}{\sum_i \text{catch}_{ik}}$$
- Catch must be taxonomically disaggregated (as many i 's as possible);
- Results (i.e., time series of TL_{mean}) are plotted by FAO area, for 1950-1996.

Fishing down marine food webs...

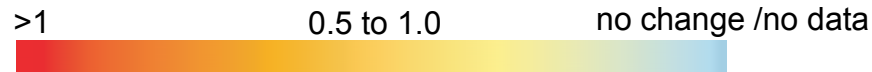
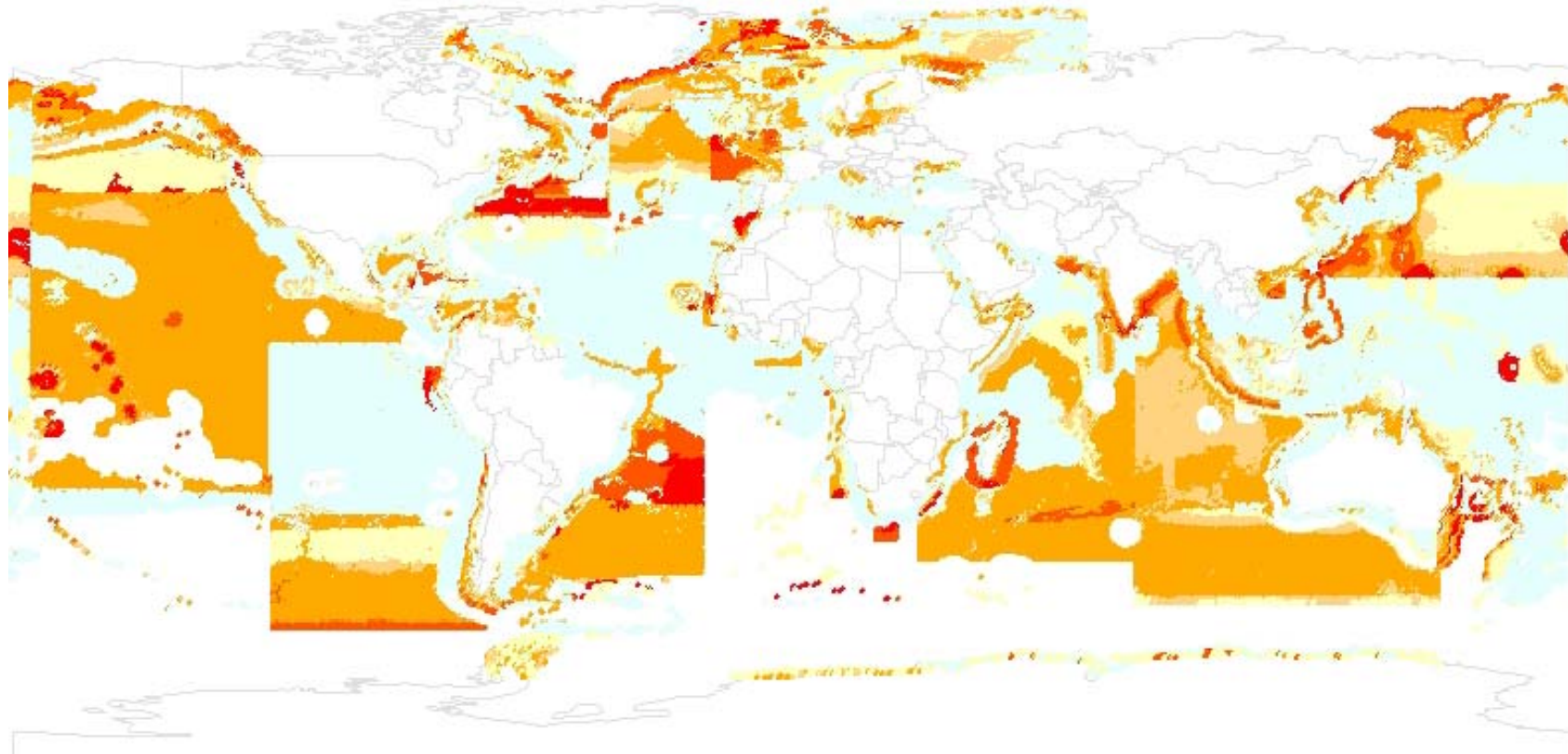


Pauly *et al.* (*Science*, 1998)

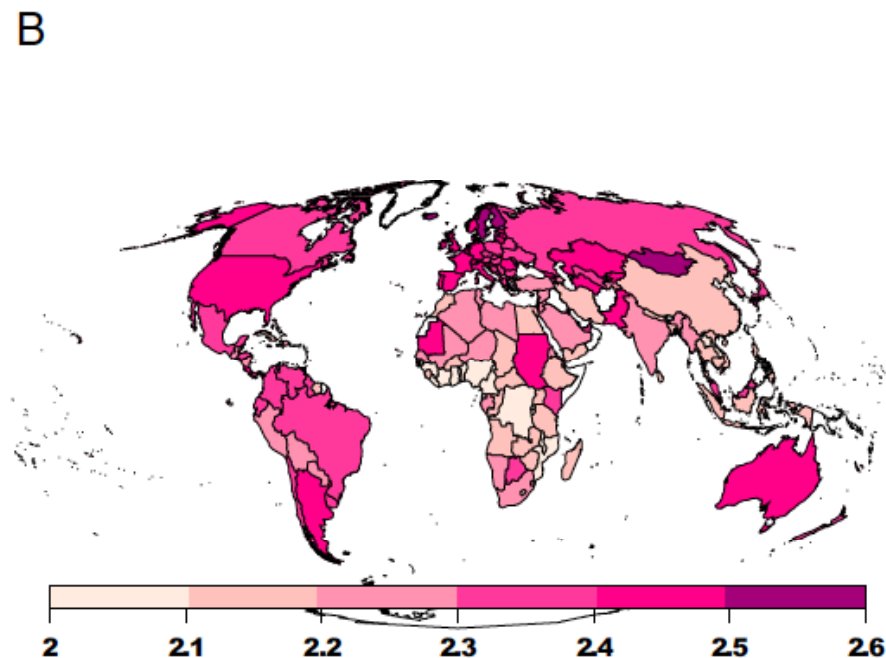
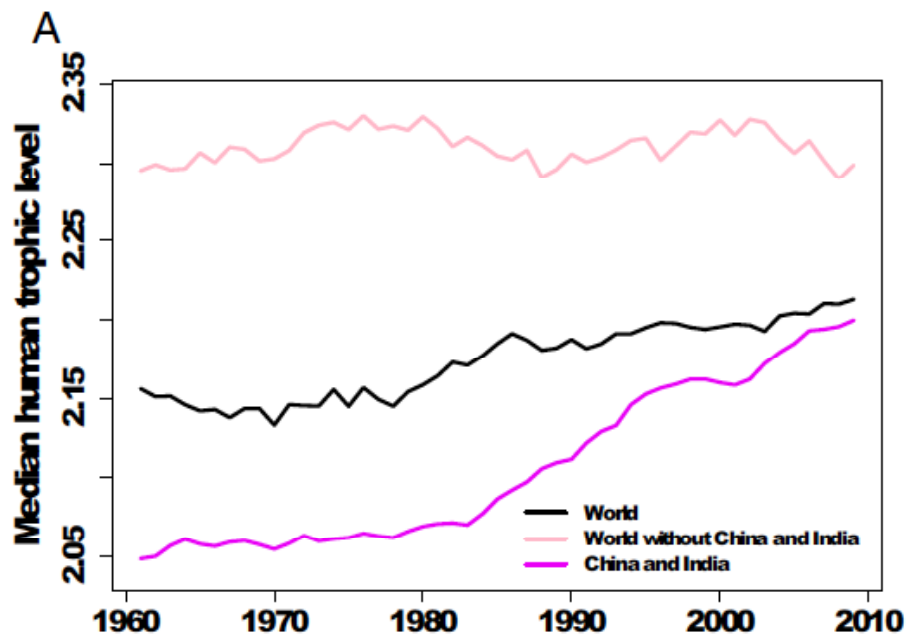


In fact, this process is so widespread that the Convention on Biological Diversity (CBD) now uses mean trophic levels as an index of biodiversity, the “Marine Trophic Index”.

Trophic level change (1950-2000)



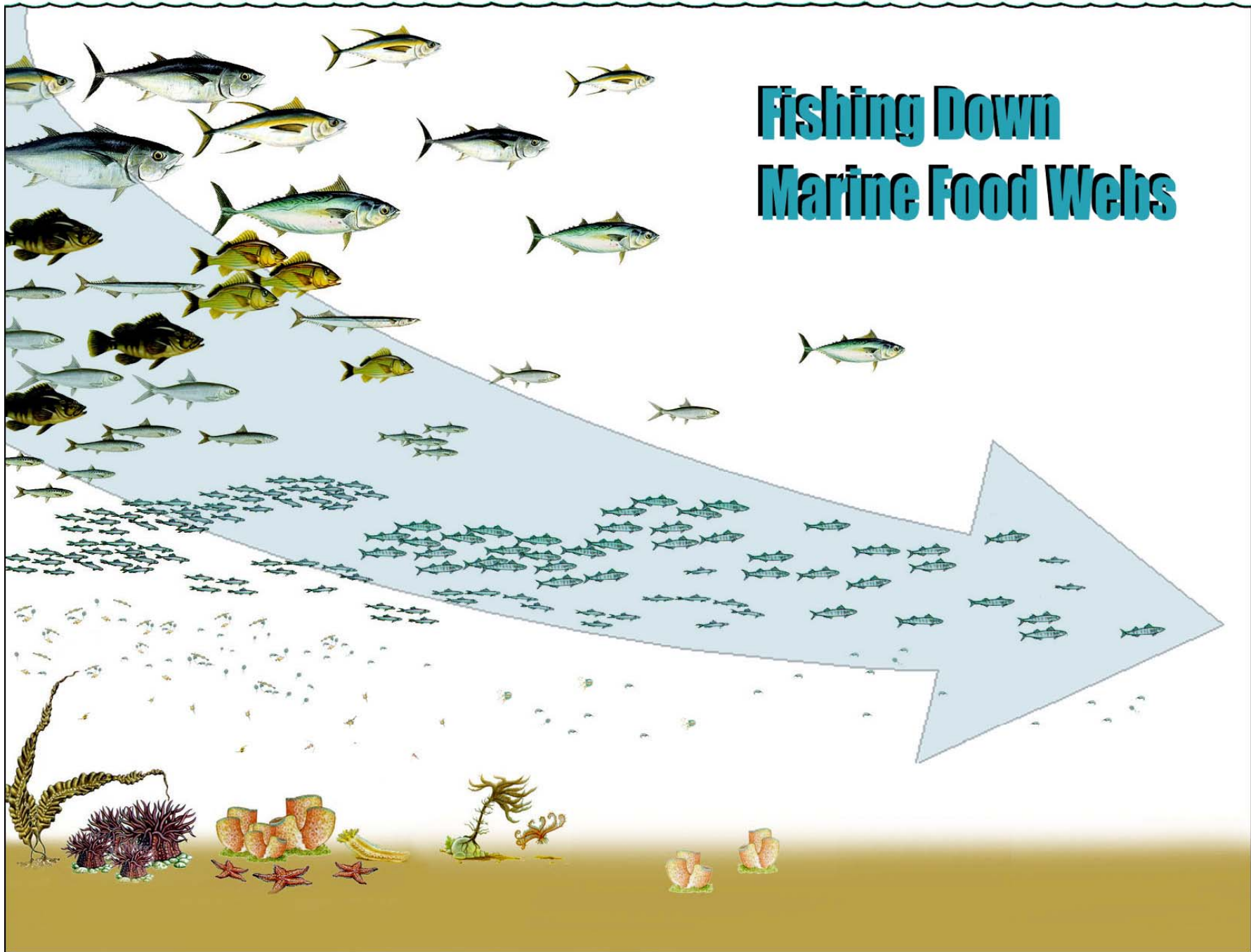
Eating up the food chain: trends in the human trophic level 1961-2009 and median TL over 2005-2009



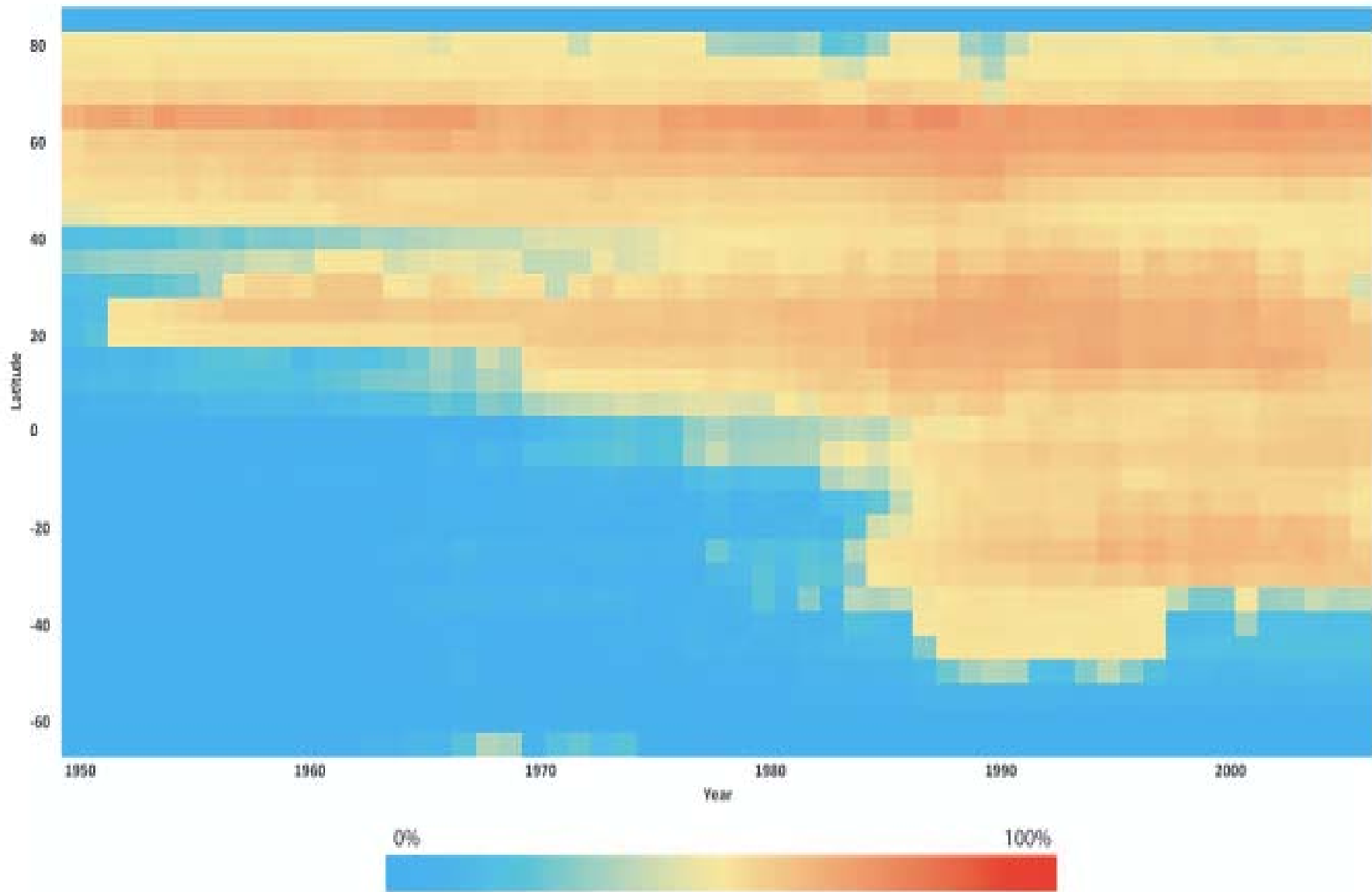
Key findings

- There are widespread declines of TL_{mean} , suggesting a 'fishing down' effect;
- The decline is in the order of 0.05-0.10 TL per decade. Given that the fish we consume are mostly confined between $TL=3.0$ and $TL=4.5$, this is alarming;
- This is even more alarming if we consider that these TL declines occur in an age of stagnating or declining world catches.

Fishing Down Marine Food Webs

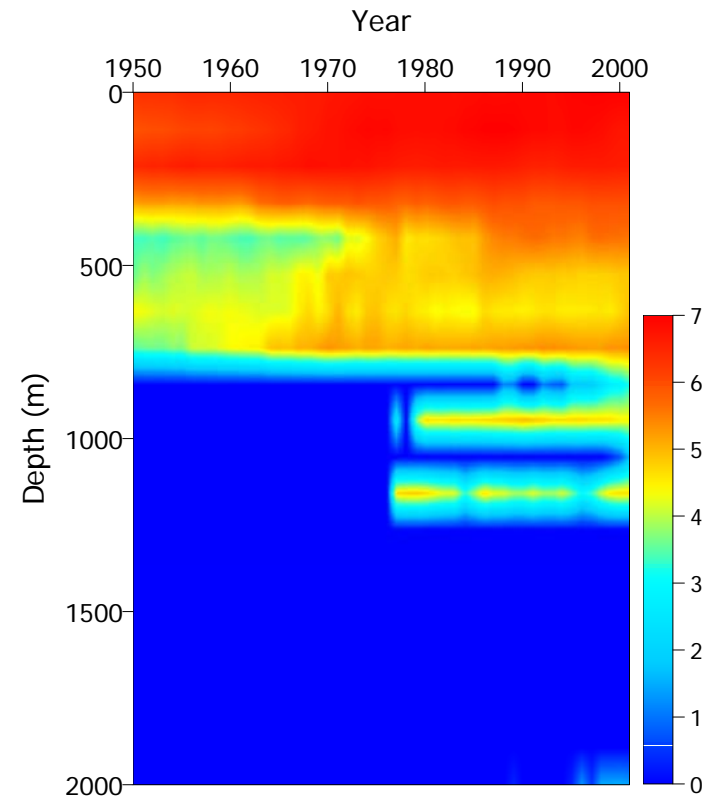
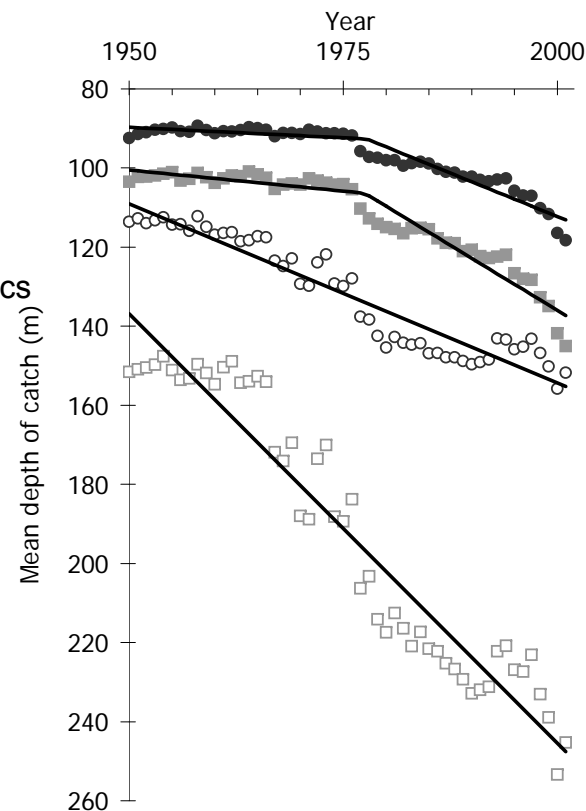


Newly exploited areas: Latitudinal extension of fisheries (threshold is PPR 10%)



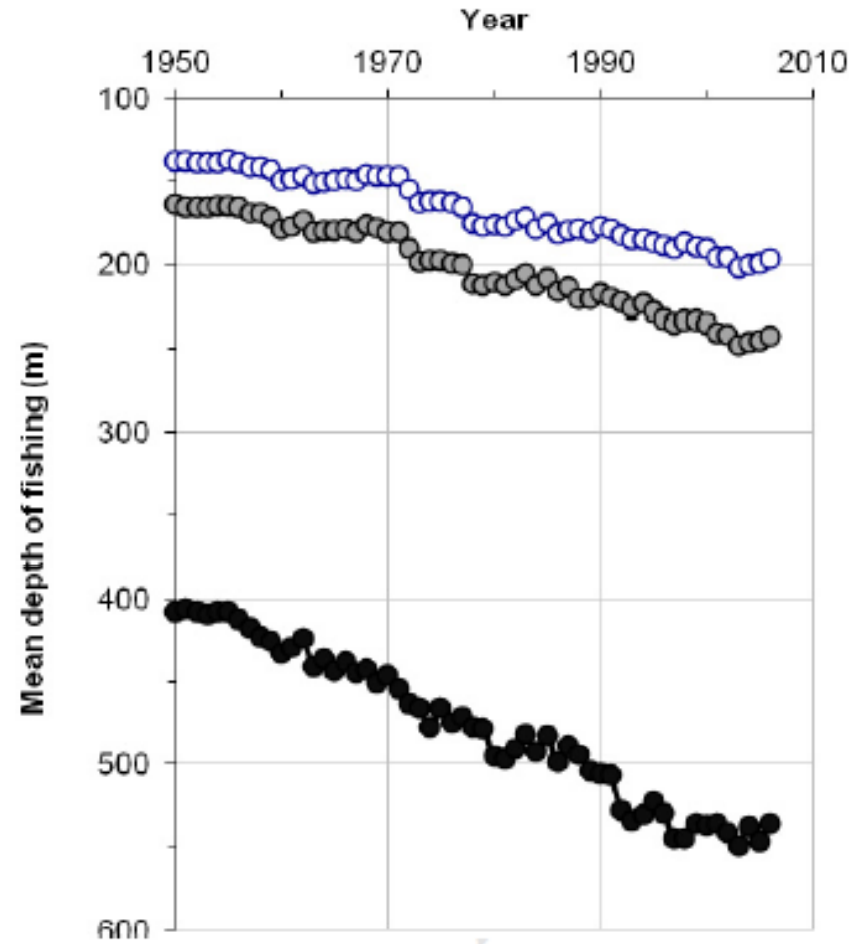
The expansion toward deeper waters was also very strong

- Marine fishes including pelagics
- Bottom fishes only
- High seas areas; inc. large pelagics
- High seas areas, only demersals

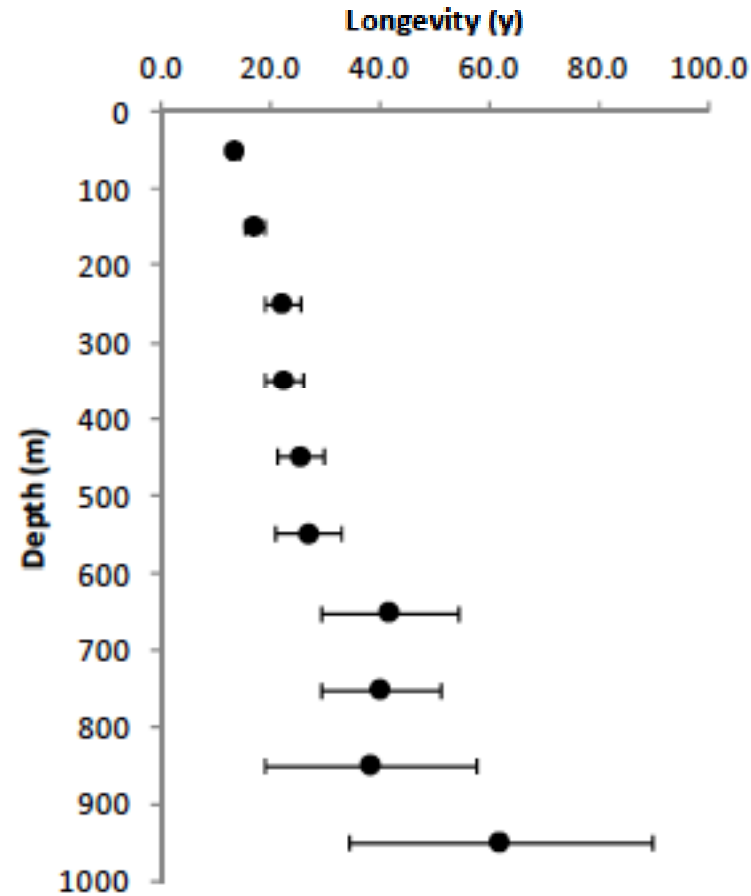


Morato *et al.* (*Fish & Fisheries*, 2006)

Mean Depth of Fishing in European waters (Vilasante Oceans and coastal management et al 2012)



Trend of mean longevity of the European Union marine fisheries (Vilasante et al 2012)



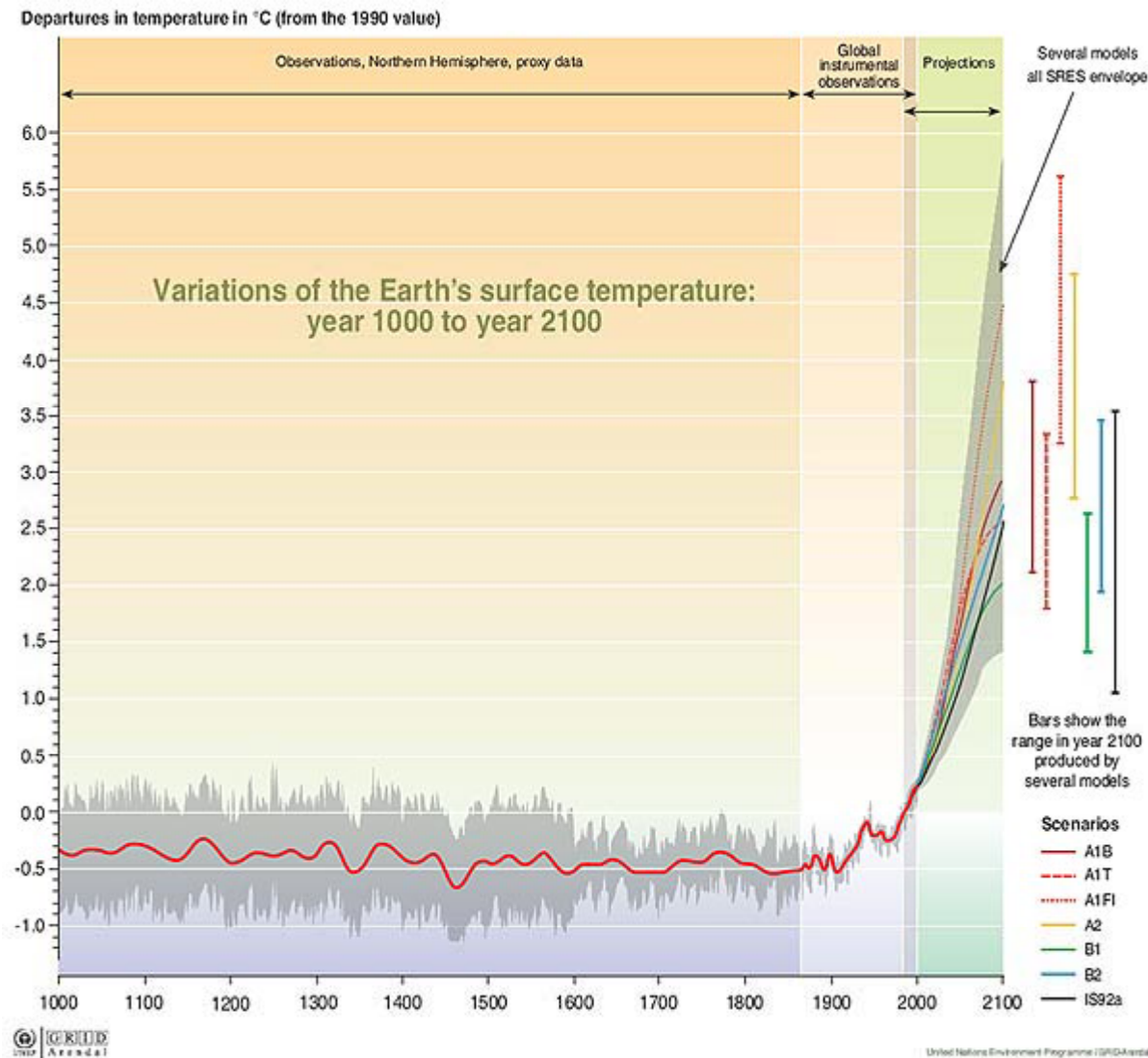
The geographic and depth expansions led to markets being supplied by fish that nobody knew before, offering opportunities for mischief (see Jacquet, J. and D. Pauly, 2008. Trade secrets: renaming and mislabeling of seafood. *Marine Policy* 32: 309-318).



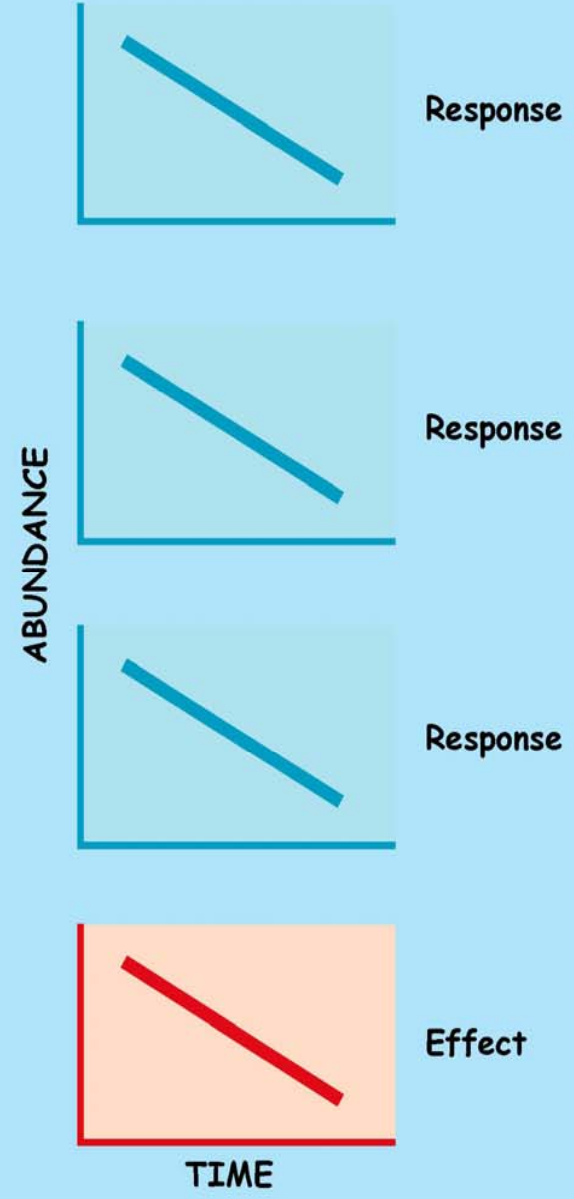
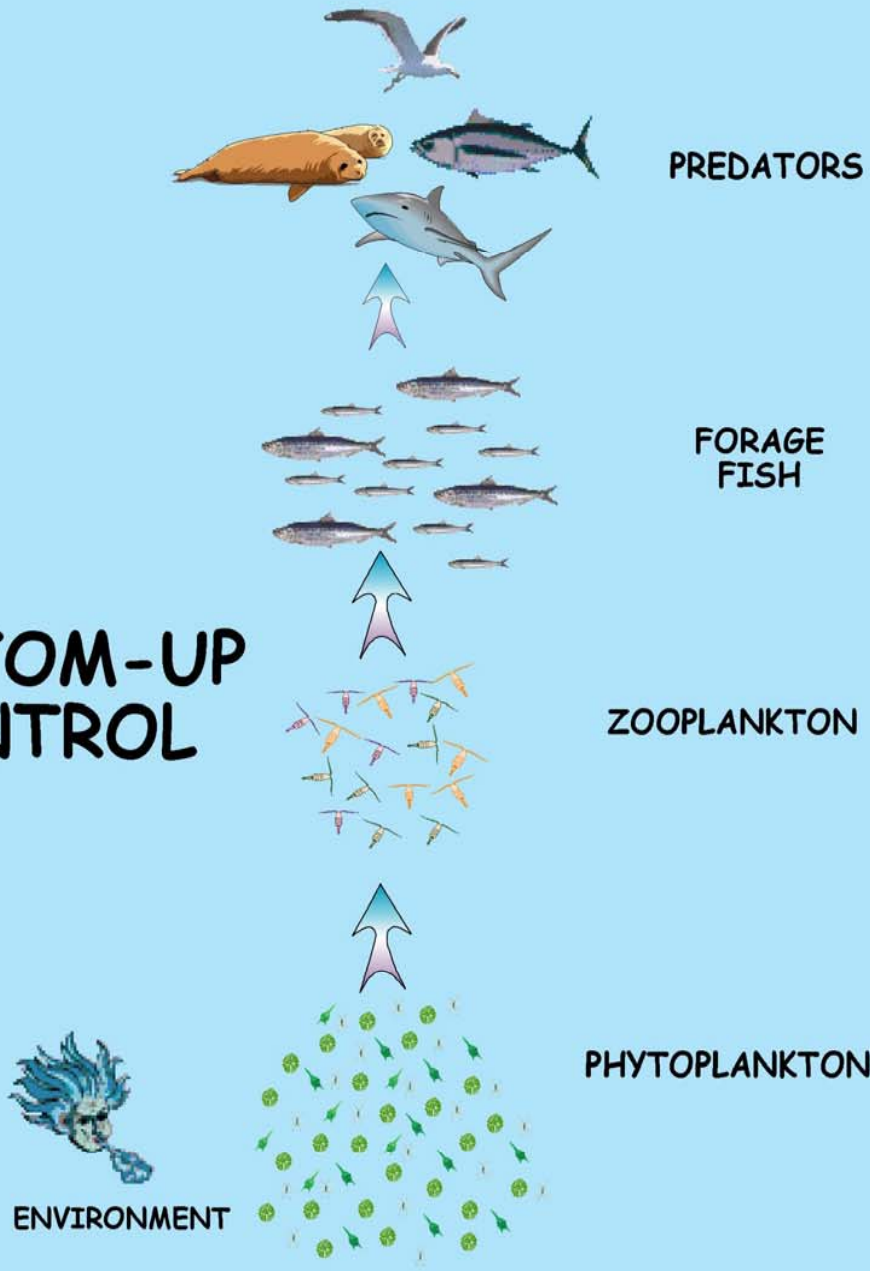
(see also www.seafoodguide.org)

What are the
consequences of an
increase in sea
temperature for
fisheries ?

Fundamental departure from history

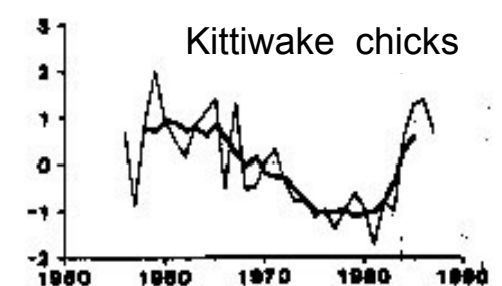
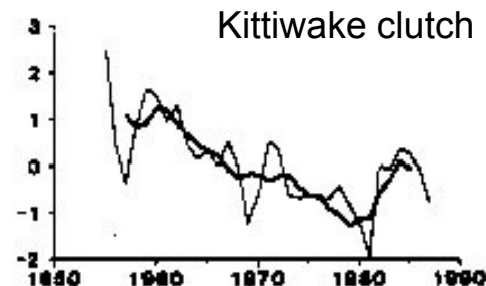
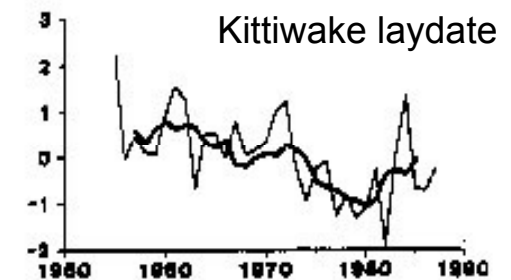
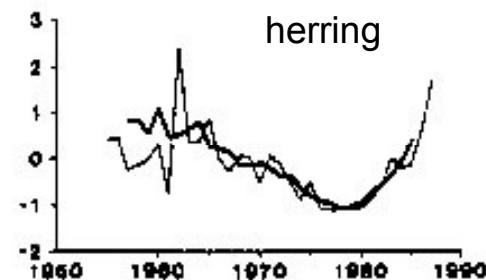
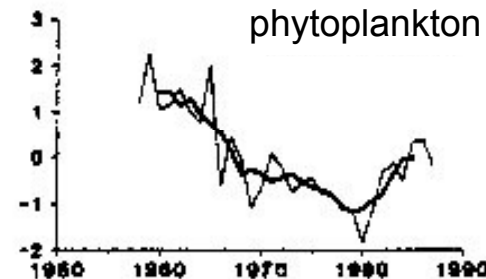
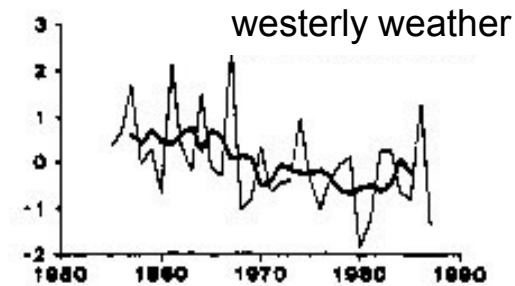


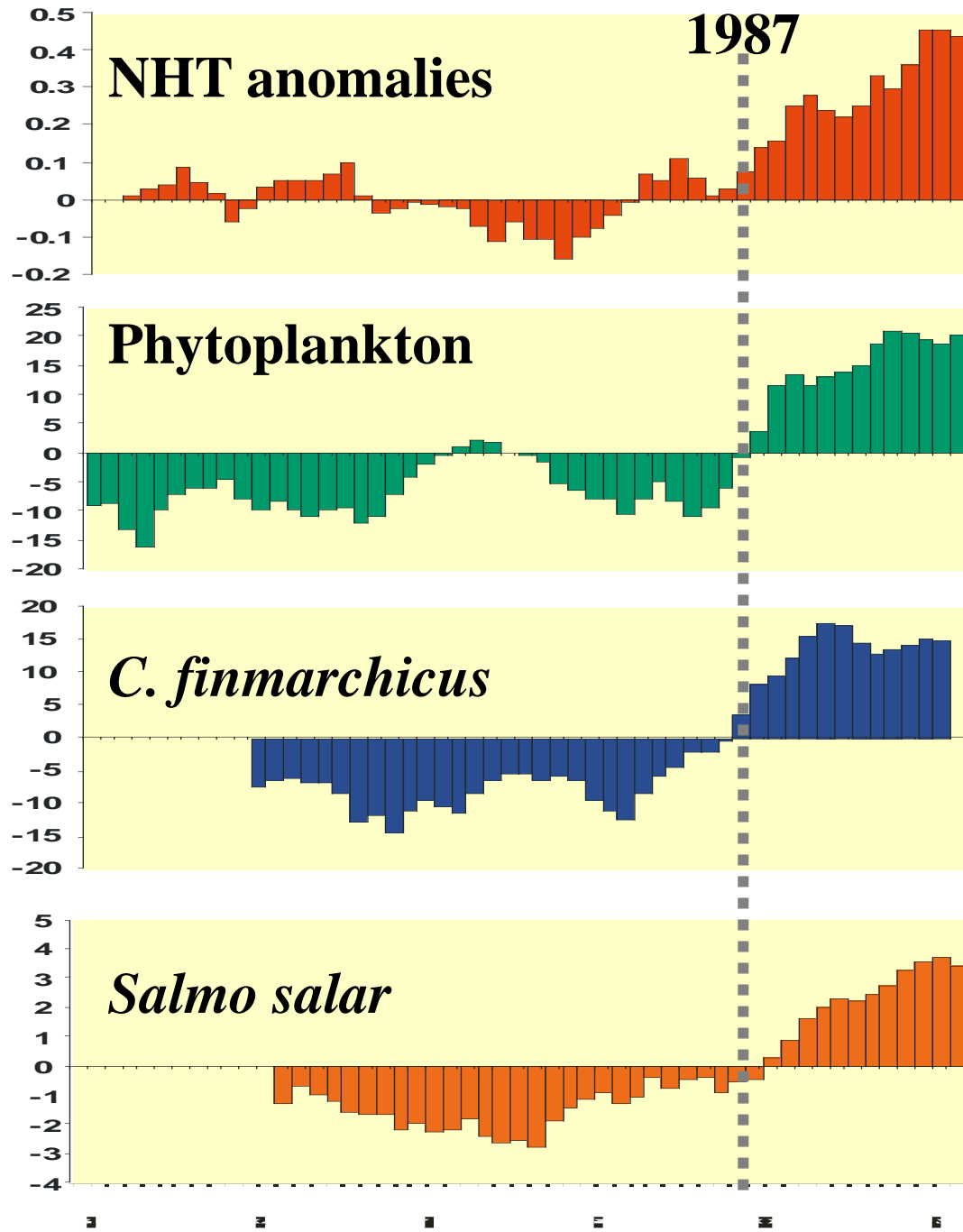
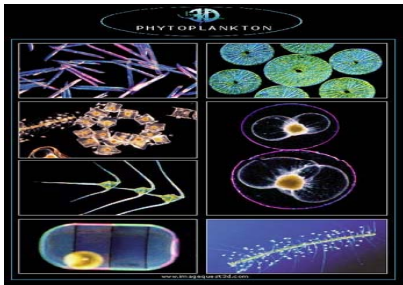
BOTTOM-UP CONTROL

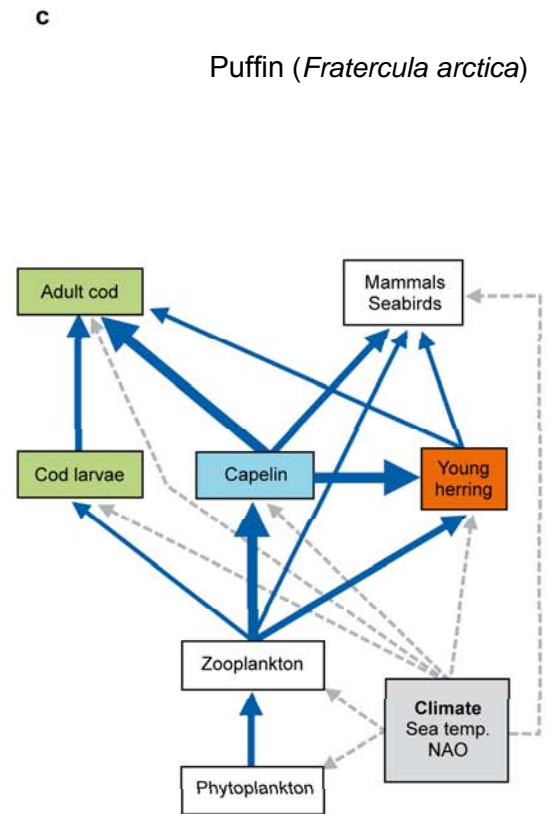
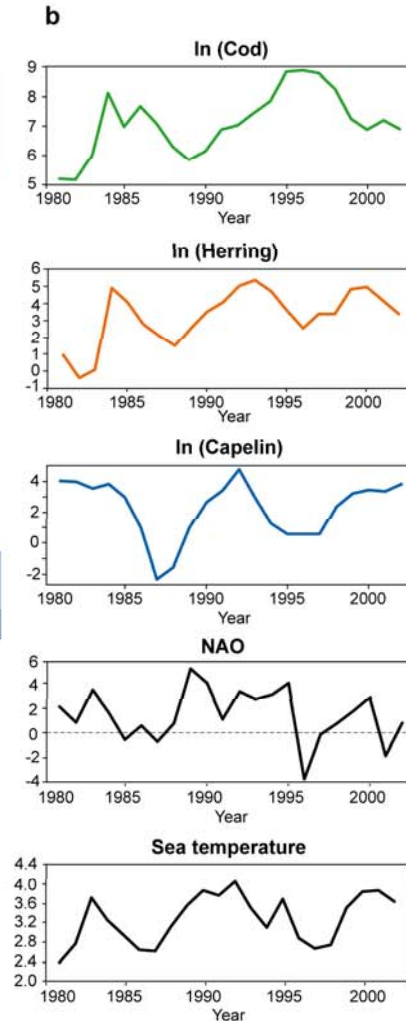
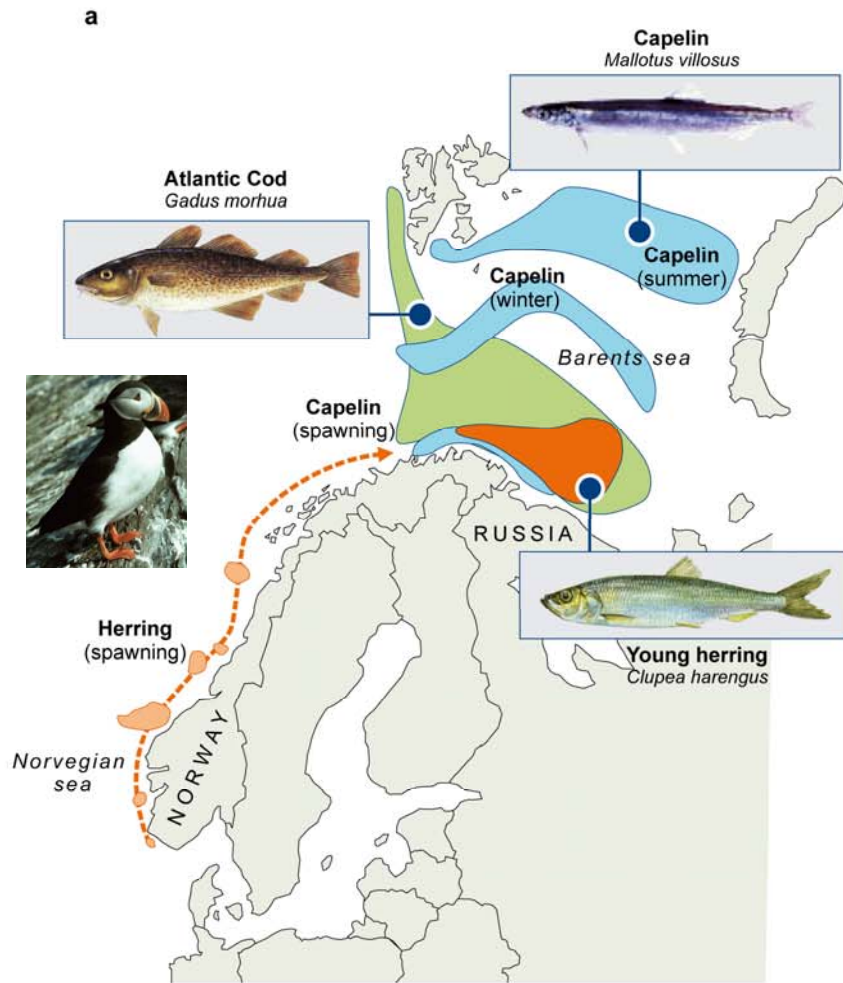


Parallel long term changes for four trophic levels and climate in the North Sea

(from Aebischer et al, Nature 1990)







$$\log(N_t^1) = a_1 + (1 - b_1) \log(N_{t-2}^{\text{mat}}) - c_1 (\text{har}_{\text{aut}-2} + \text{har}_{\text{wint}-1}) / \text{BM}_{t-2} - d_1 \log(\text{cod}_{t-1}^? \text{BM}_{t-1}^?) - e_1 \text{herr}_{t-1}$$

$$\log(N_t^2) = a_2 + (1 - b_2) \log(N_{t-1}^1) - c_2 \text{har}_{\text{aut}-1} / \text{BM}_{t-1} - d_2 \log(\text{cod}_t^? \text{BM}_{t-1}^{\text{immat}}) - e_2 \text{herr}_t$$

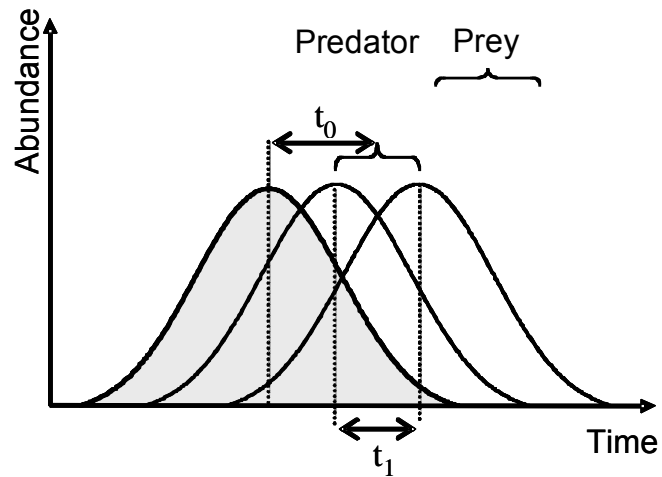
$$\log(N_t^3) = a_3 + (1 - b_3) \log(N_{t-1}^2 - N_{t-1}^{\text{mat}}) - c_3 \text{har}_{\text{aut}-1} / \text{BM}_{t-1} - d_3 \log(\text{cod}_t^? \text{BM}_{t-1}^{\text{immat}}) - e_3 \text{herr}_t$$

$$\log(N_t^4) = a_4 + (1 - b_4) \log(N_{t-1}^3 - N_{t-1}^{\text{mat}}) - c_4 \text{har}_{\text{aut}-1} / \text{BM}_{t-1} - d_4 \log(\text{cod}_t^? \text{BM}_{t-1}^{\text{immat}}) - e_4 \text{herr}_t$$

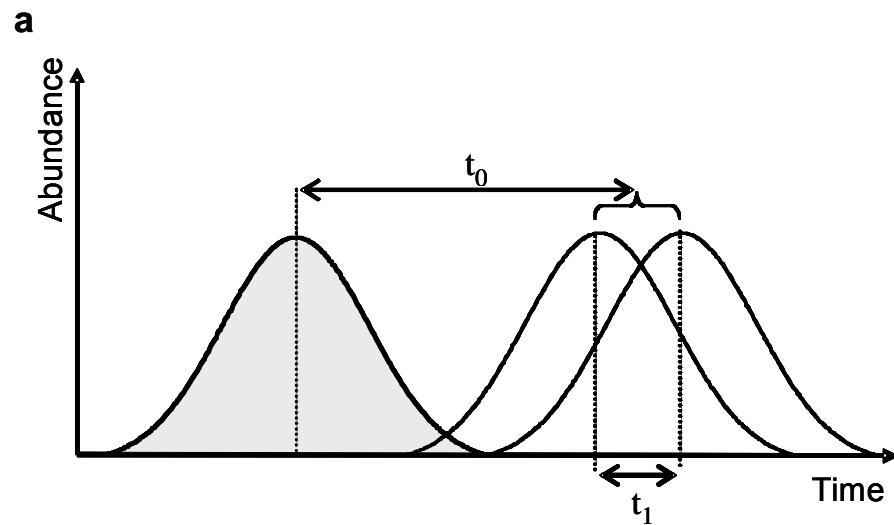
Revisit old concept in the climate change context: example of the match-mismatch

(Cury et al. TREE 2008)

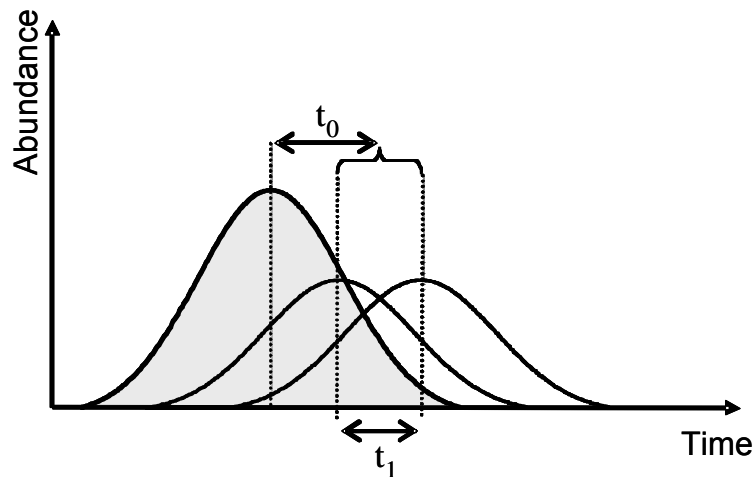
Before



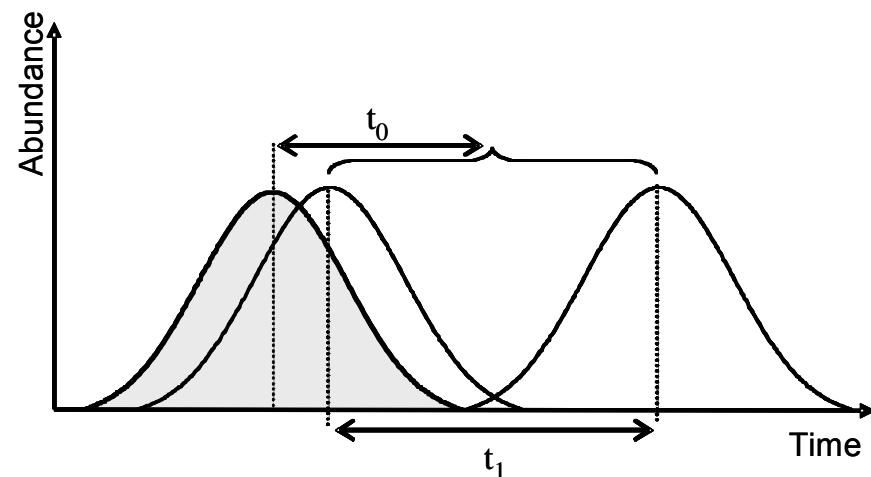
After climate change



b

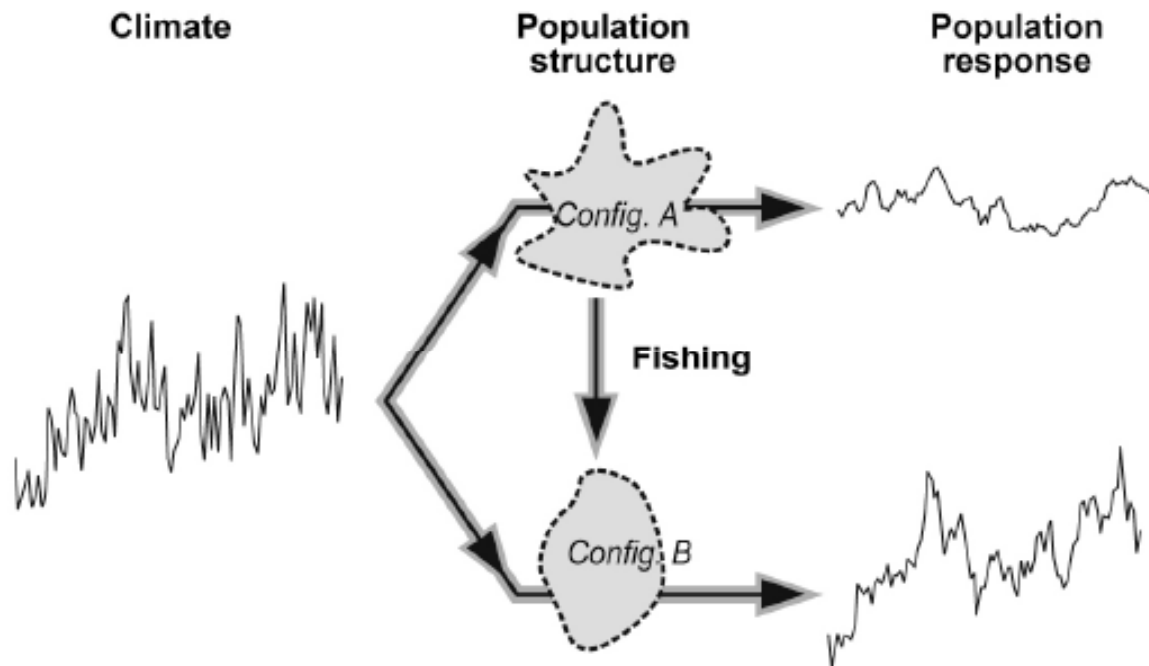
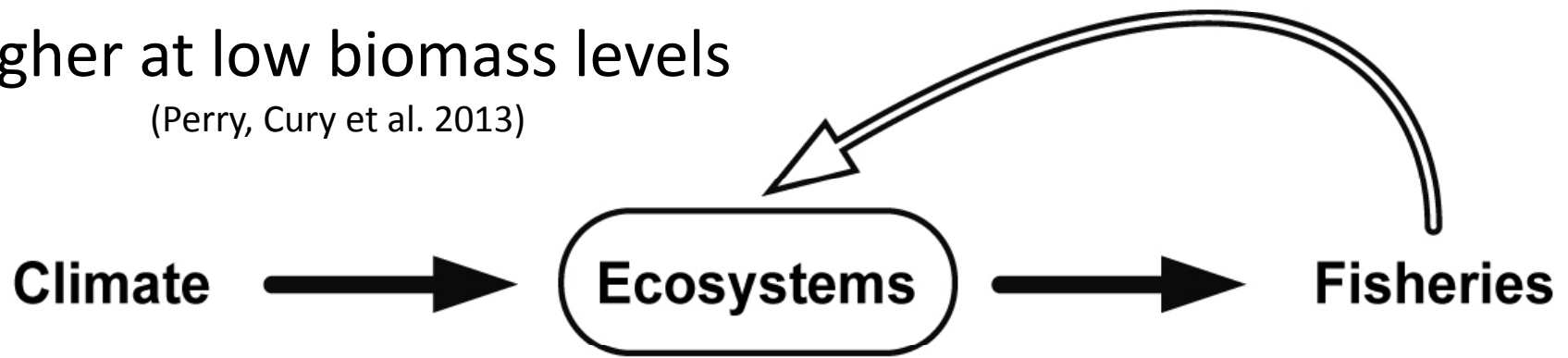


c

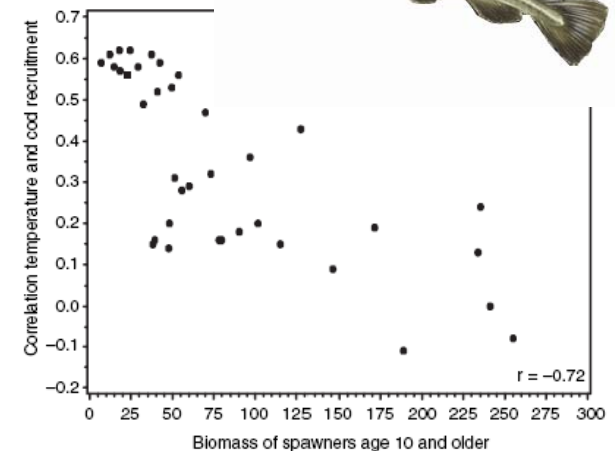


Environmental effects are higher at low biomass levels

(Perry, Cury et al. 2013)

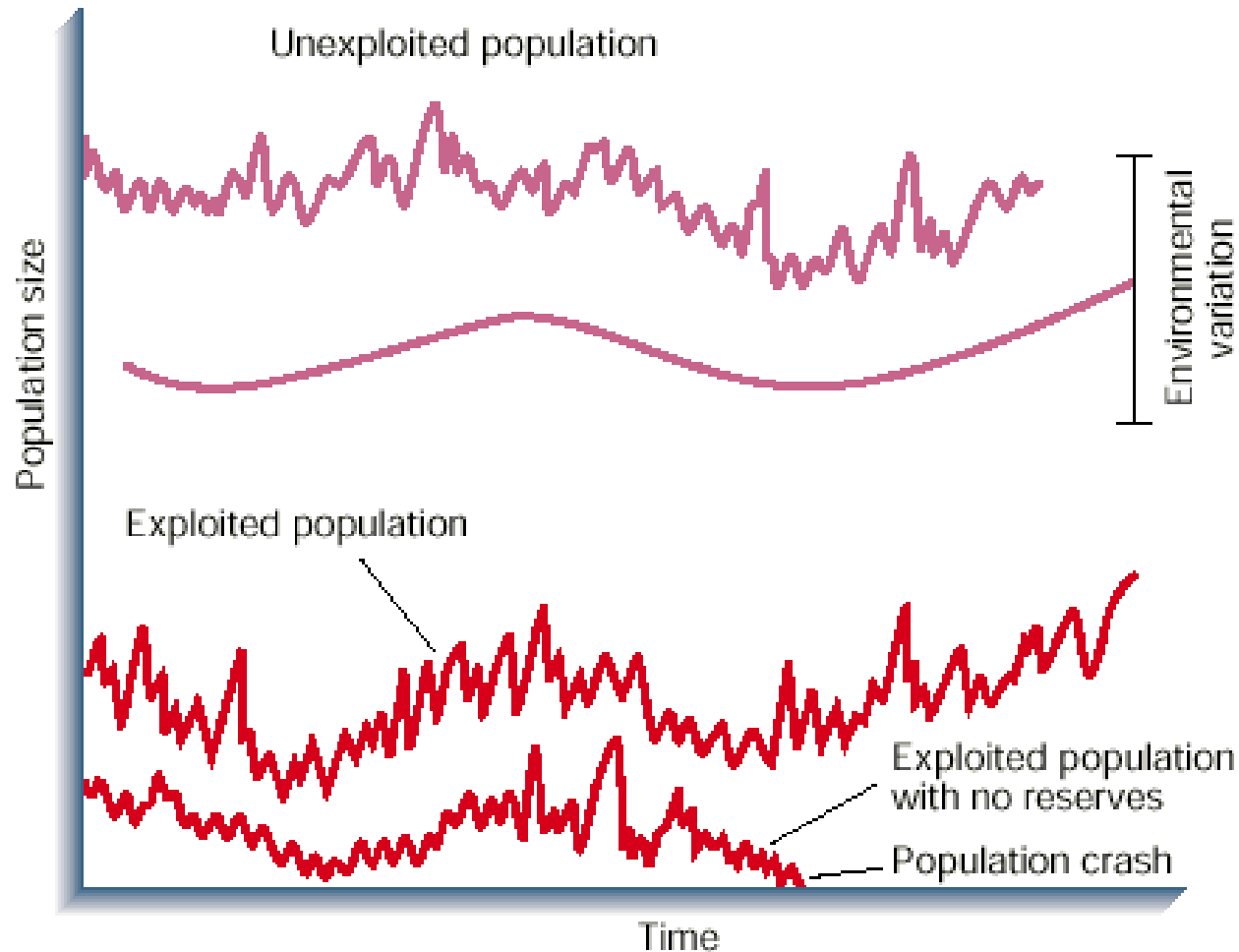


Ottersen et al. 2006



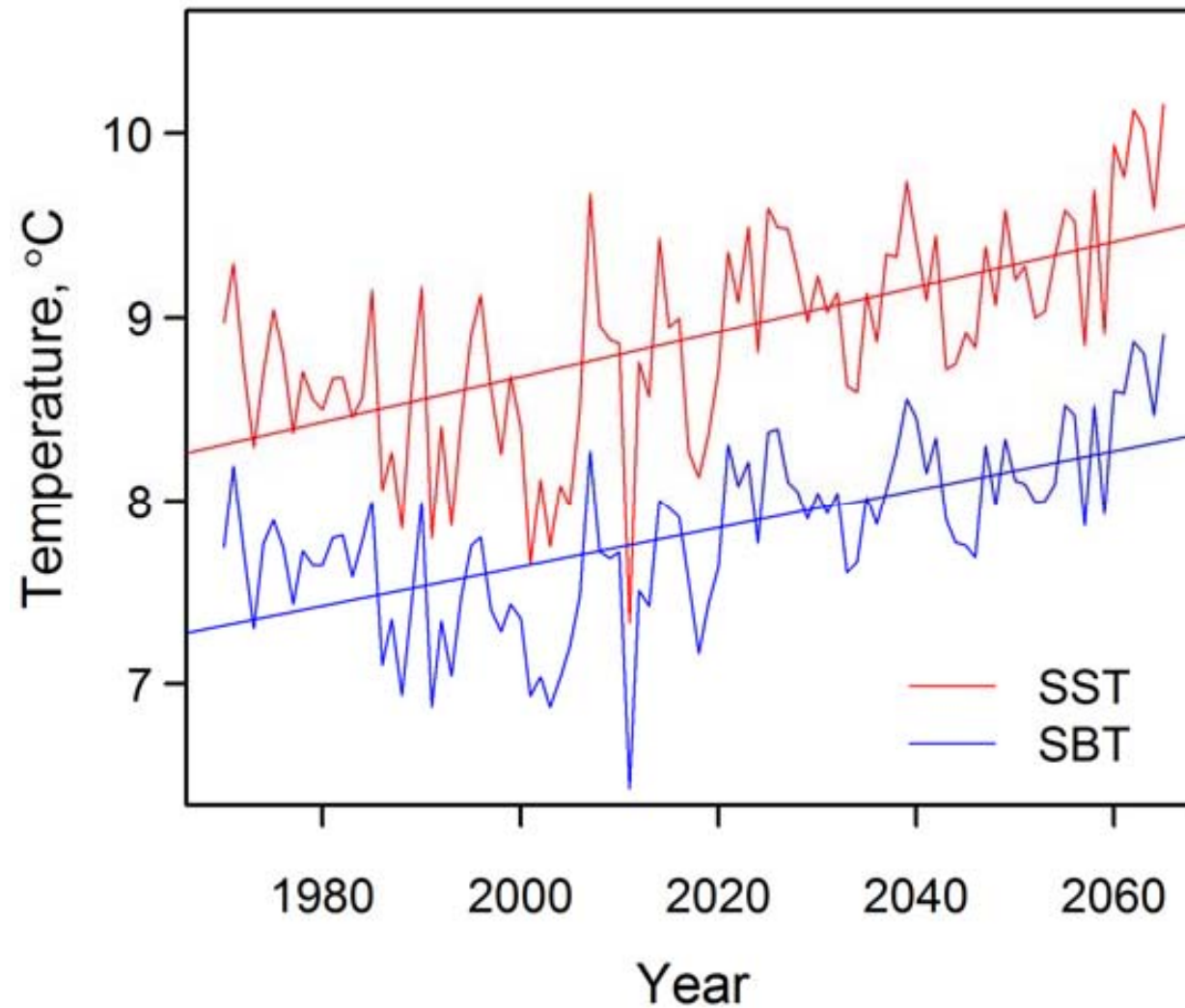
Environmental effects at low biomass level

(adapted from Pauly et al. 2003)

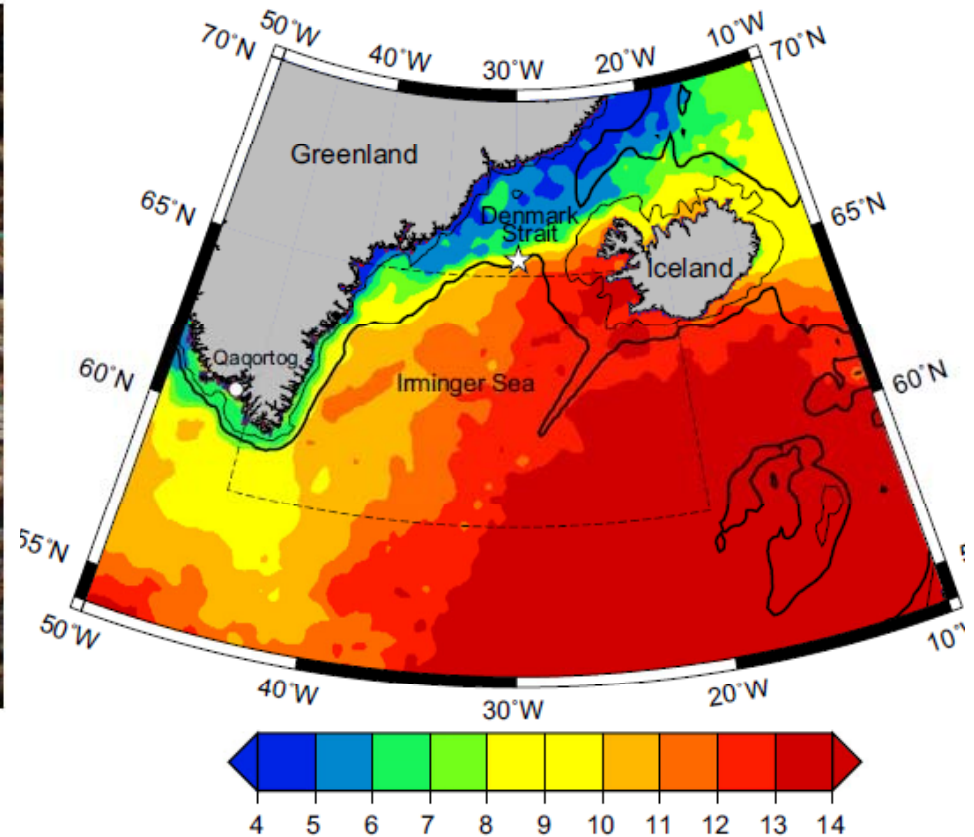


Temperature trends from 1970–2065 in the North Sea

(Jones et al Plos one 2013)

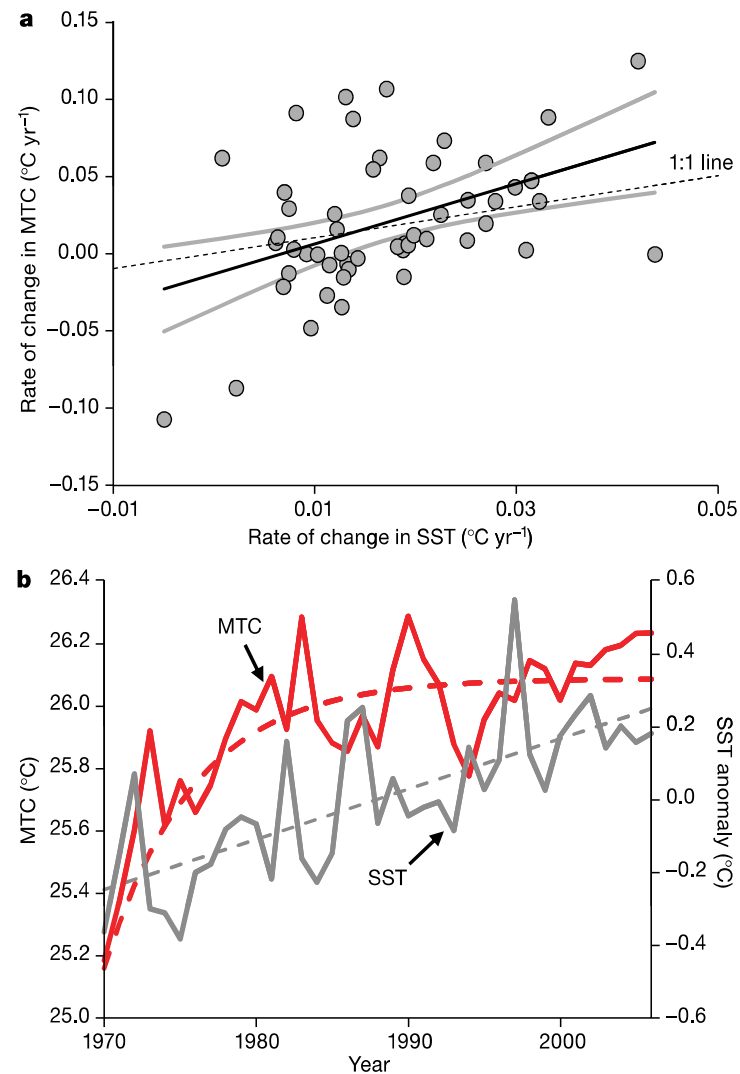


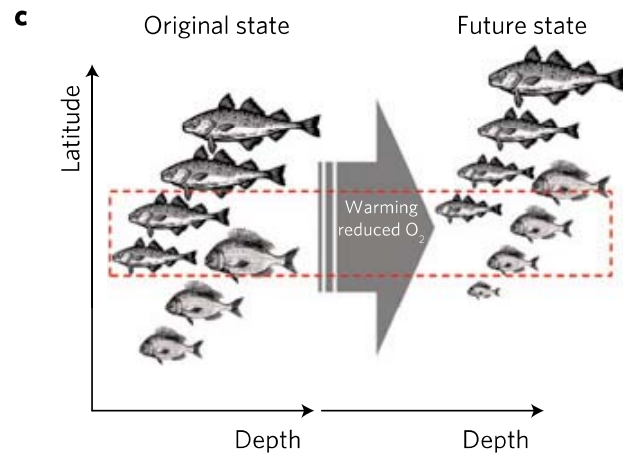
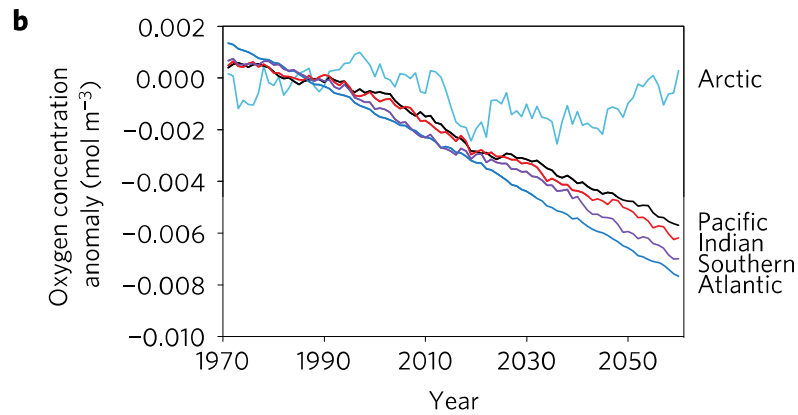
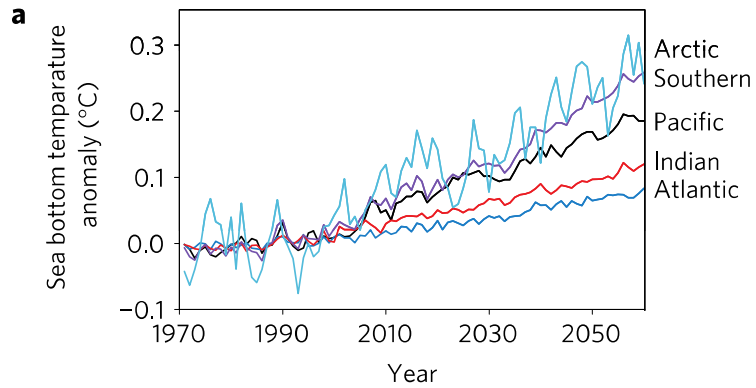
A new world: Tuna in Greenland



Source: MacKenzie et al. (2014)
Global Change Biology 20:2484-2491

The 'fish thermometer': mean Temperature of the World fish Catch (MTC) (Cheung et al 2013)

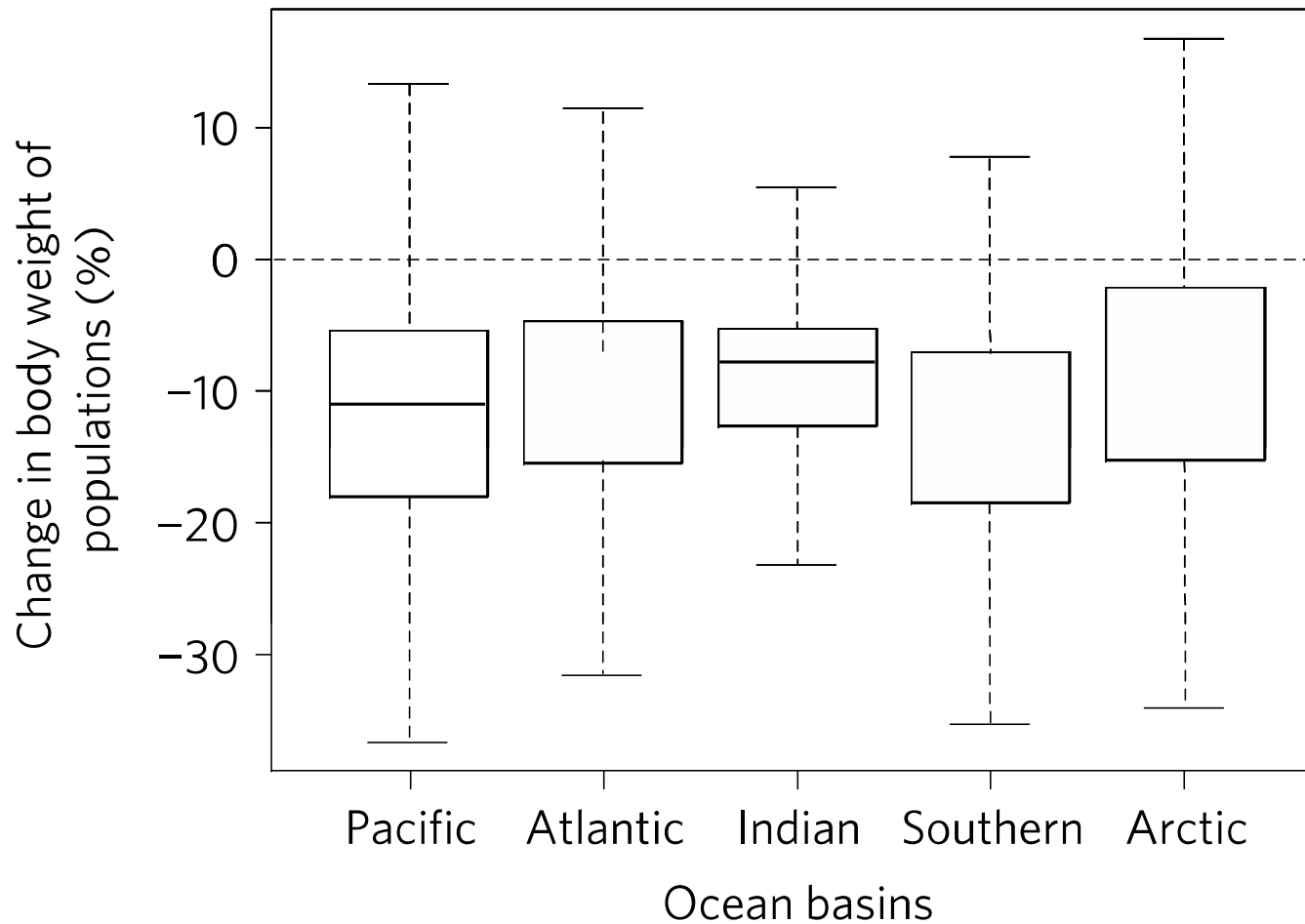




Projected changes in
ocean conditions and the
expected biological
responses of fish
communities in terms of
distribution and body size
(Cheung et al Nature CC 2013)

Change in individual-level maximum body size of fishes in different ocean basins from 2000 (averages of 1991–2010) to 2050 (averages of 2041–2060).

(Cheung et al Nature CC 2013)

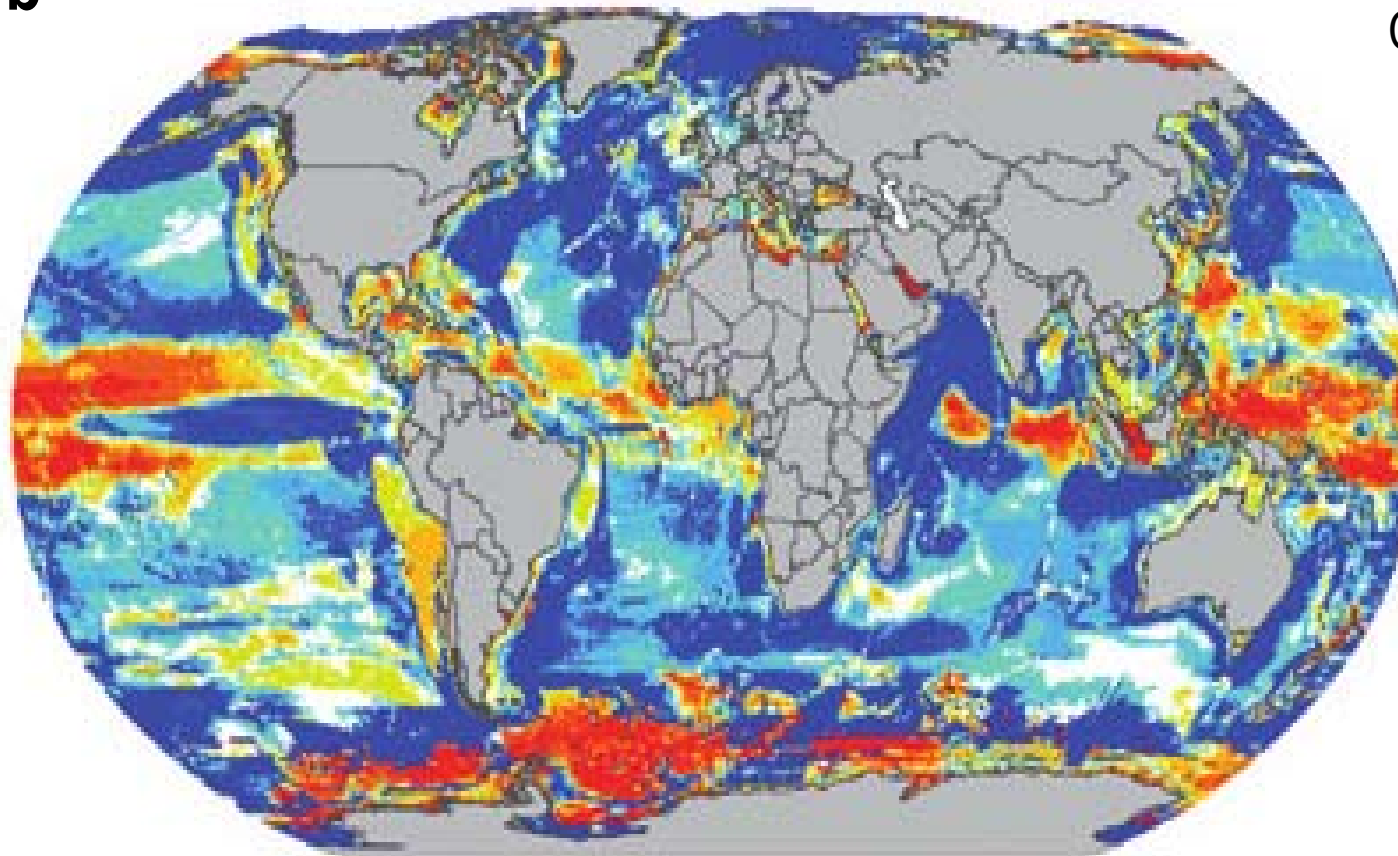


Impact of climate change on potential catches from global fisheries

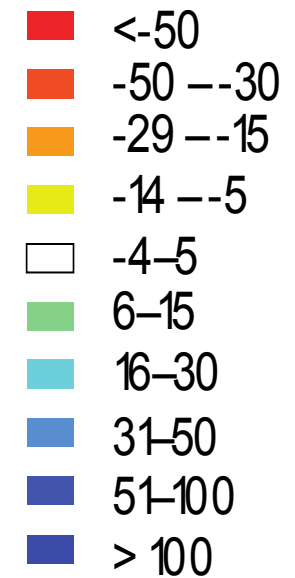
Fish species moving at a speed of $72,0 \pm 13,5$ km per decade

(Sumaila et al Nature CC 2014)

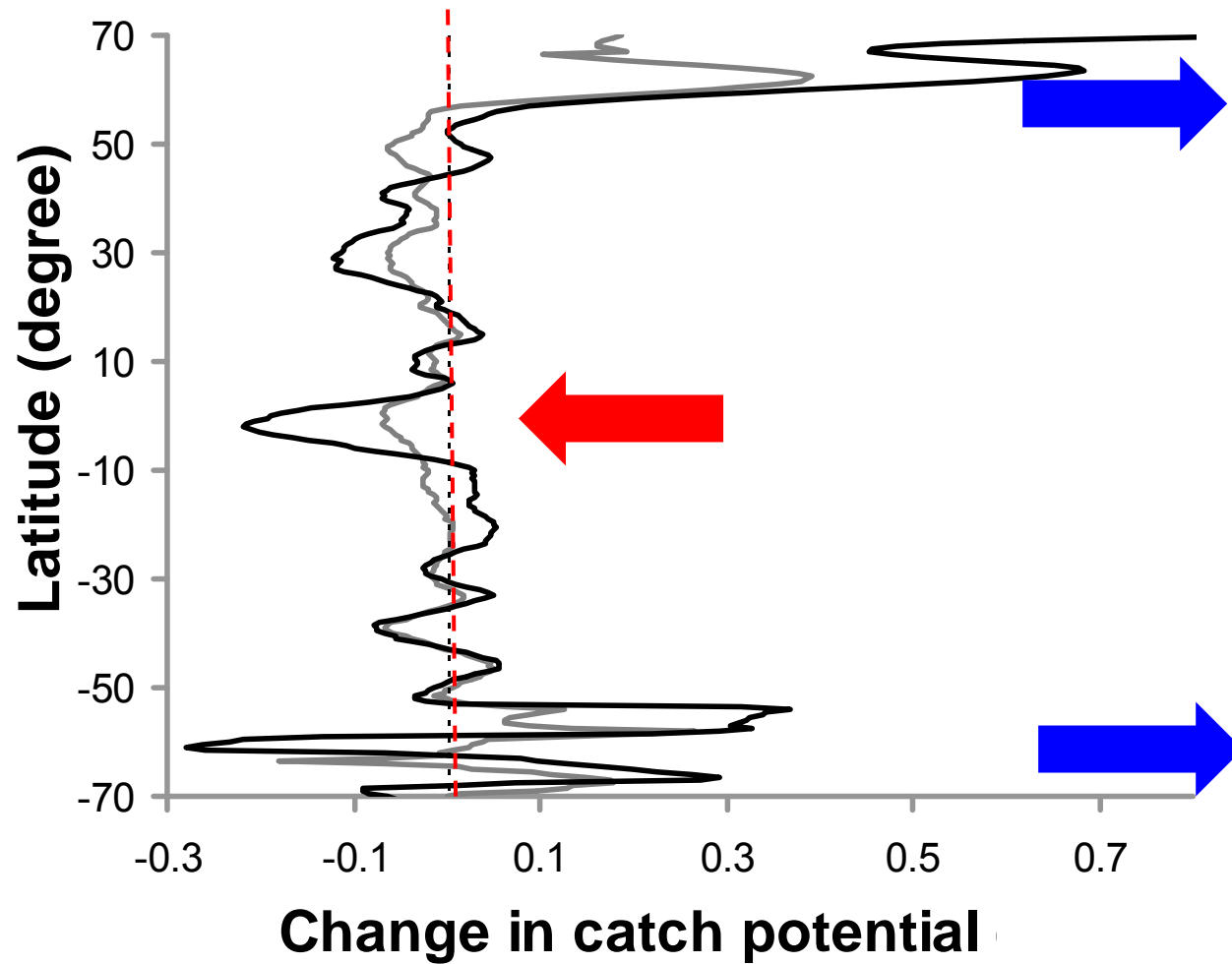
b



Change in catch potential
(% relative to 2005)



Latitudinal changes in potential world catch in a climate change context (in 2050)
(Cheung et al 2013)

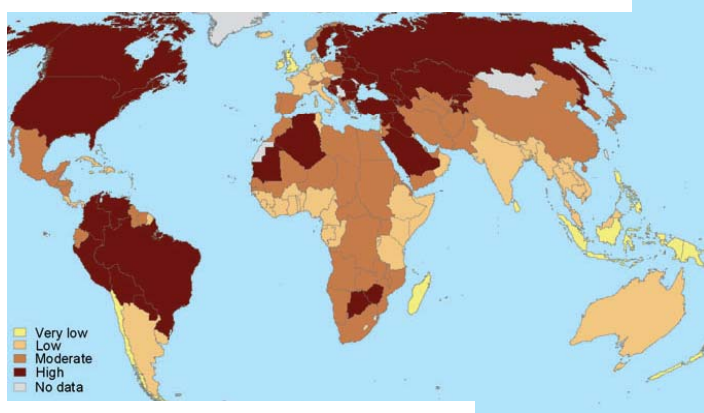


The distributions of benthic, pelagic, and demersal species and communities have shifted by up to a thousand kilometers

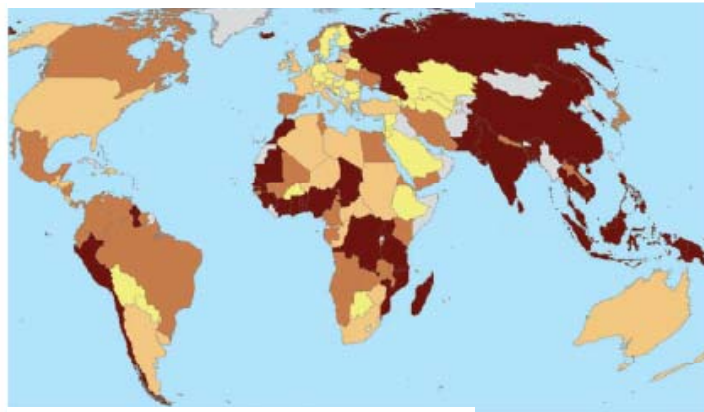
(Poloczanska et al AR5 2014)

- Range shifts have not been uniform across taxonomic groups or ocean regions
- Range edges expanded in a poleward direction at 72.0 ± 13.5 km per decade
- Observed changes in species composition of catches from 1970–2006 that are partly attributed to long-term ocean warming suggest increasing dominance of warmer water species in subtropical and higher latitude regions, and reduction in abundance of subtropical species in equatorial waters (Cheung et al. 2013)

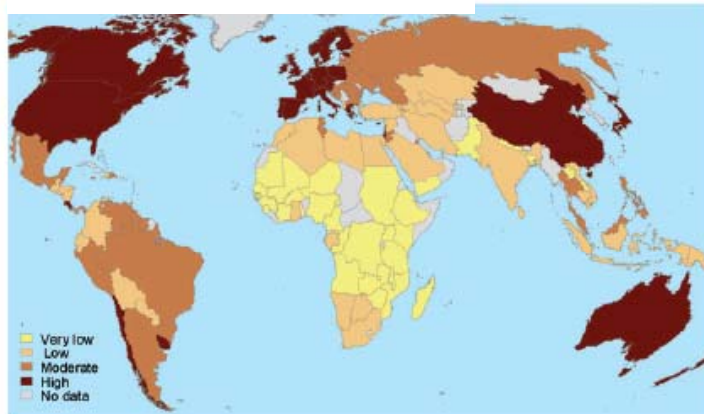
Exposure (SST in 2050)



Fisheries Sensitivity



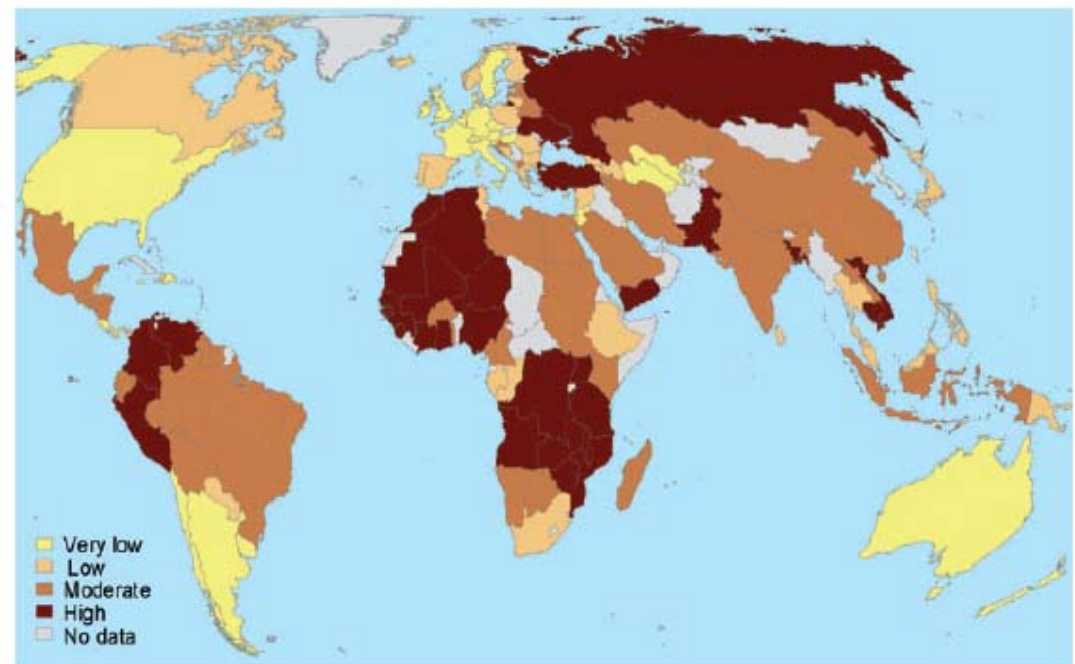
Adaptive Capacity



Vulnerability of 132 national economies of climate change impacts on fisheries under IPCC scenario B2

(Allison et al. Fish & Fisheries 2009)

Vulnerability scenario



Conclusion :

maintaining ecosystem integrity will help
mitigating climate change effects

- CC amplifies populations fluctuations when depleted
- Global fish catches are changing (catching more warmer species)
- Marine habitats are changing and fish are migrating to the poles
- The Ecosystem Approach to Fisheries (EAF) and scenario building can help in mitigating CC effects

Crisis in world fisheries

- 30% of the stocks are overexploited and 57% fully exploited
- Discard and illegal fishing constitute a huge amount of fish and catches are underestimated and declining
- Fishery overcapacity: fishing less with an increasing fishing effort
- The fishery activity is destroying habitats and other species : the waste is important
- Climate Change affects world catch
- The annual cost of overexploitation on a worldwide level is immense : the annual estimate loss is estimated to be 51b\$ while the world fishery value is around 85b\$ (World Bank 2008)
- The subsidies (20-35b\$ on a worldwide level, in France comparable to the annual landing value reinforce the problem linked to over exploitation)

EXPLOITATION OF FINANCIAL resources: a Ponzi scheme?



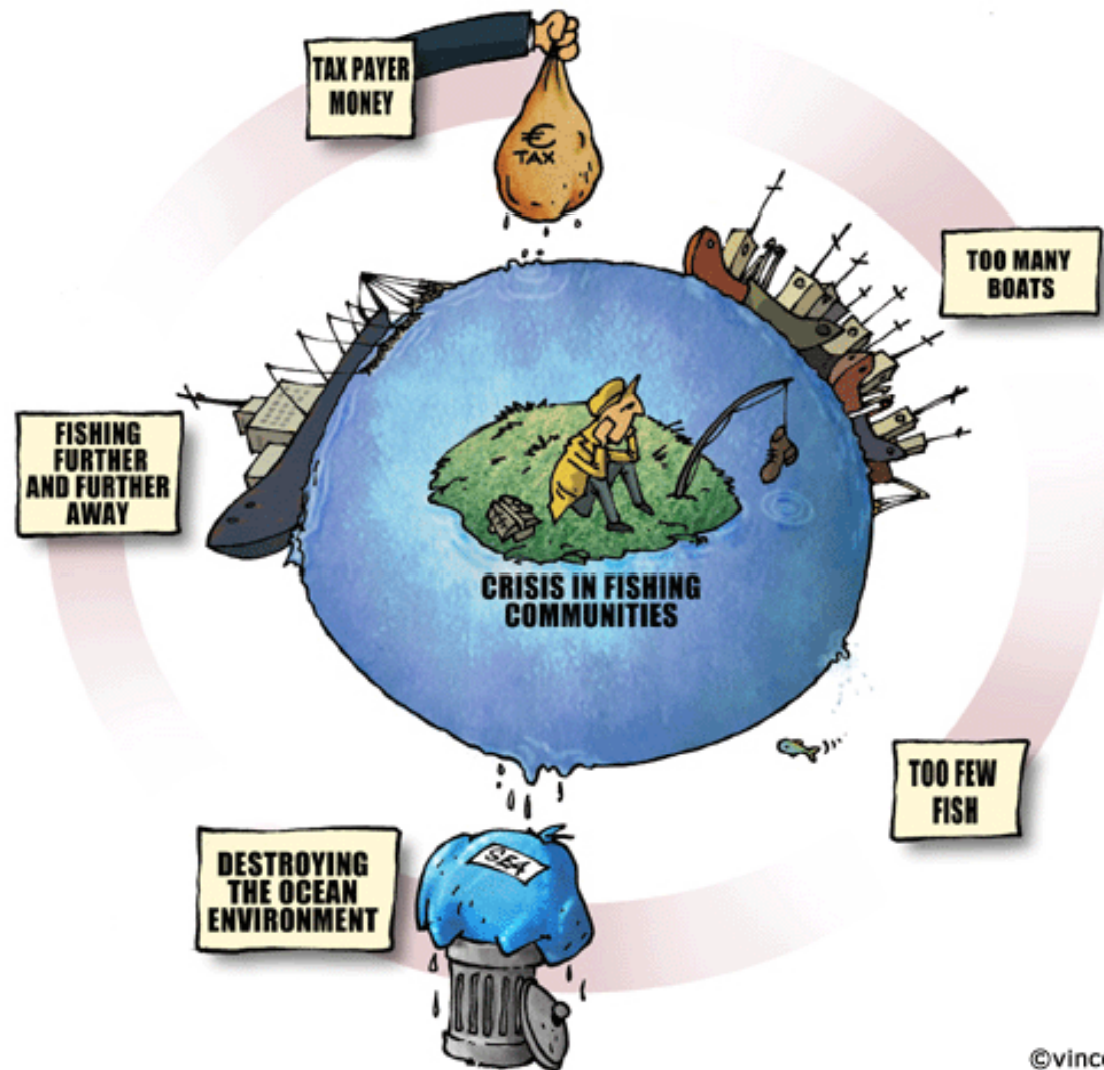
A Ponzi-Madoff scheme is a fraudulent investment operation that pays returns to separate investors, not from any actual profit earned by the organization, but from their own money or money paid by subsequent investors.

EXPLOITATION OF MARINE resources: a Ponzi scheme?

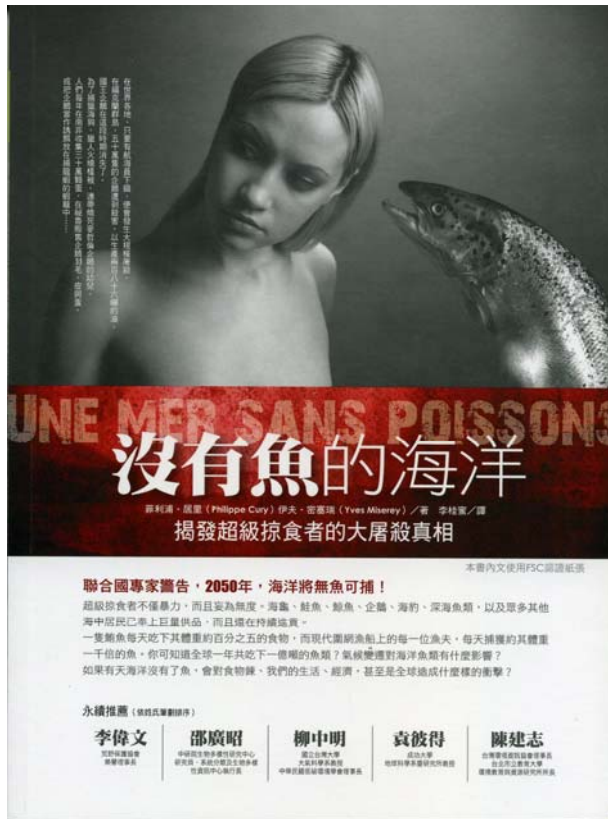
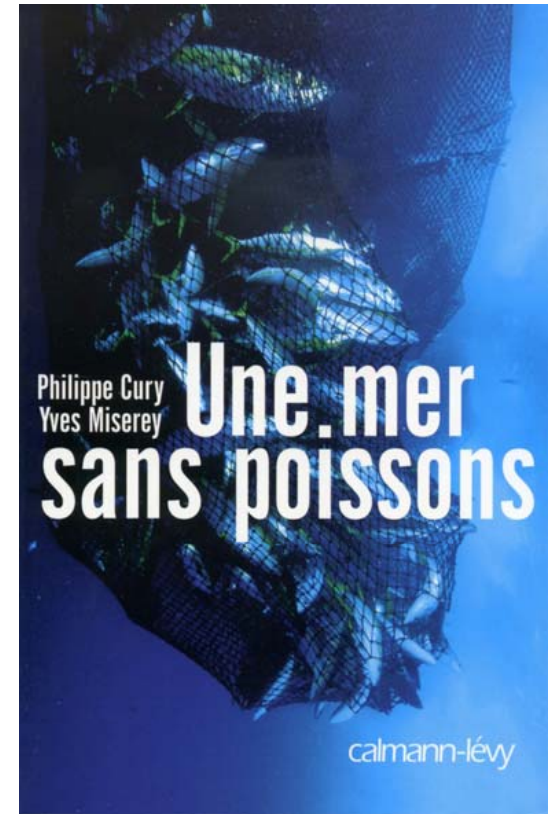
By overexploiting and fishing down marine food webs, expanding fisheries, in space and toward deeper waters, targeting new species, fisheries tend to mask the constant decrease in catch and are not sustainable worldwide

(Pauly Aquacalypse Now 2009, Cury and Pauly 2013)

We'll need to get out of the vicious circle of contemporary fisheries management



Thank you for your attention



水面下で進行する
恐ろしい事態

Philippe Cury | Yves Miserey,
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