Laurea Magistrale in Scienze per l'Ambiente
MArino e Costiero (SAMAC)

Anno accademico 2023-2024

Gestione delle risorse alieutiche

Parte - Simone Libralato
(slibralato@ogs.it)

Lezione 1

UNIVERSITY OF TRIESTE

OGS

i) Introduzione alla gestione dello sfruttamento delle risorse alieutiche, problematiche generali, stato delle risorse, targets internazionali.

ii) Massimo rendimento sostenibile, sforzo di pesca, mortalità da pesca, costi, rendimento economico. *esercizi*

iii) (continua) Massimo rendimento sostenibile, sforzo di pesca, mortalità da pesca, costi, rendimento economico. *esercizi*

iv) Le specie ittiche: crescita, riproduzione, mortalità: esercizio modelli e dati.

v) Stock assessment basi: dalla cohort analysis e virtual population analysis ad oggi (*esercizi*).
Le attività di pesca: selettività, catturabilità, impatto sugli habitat. Dati fishery dependent e fishery independent per la gestione: uso, limitazioni, problematiche.

vi) Pesca e interazioni con altri fattori: approccio multispecifico integrato. Modelli di ecosistema per la gestione della pesca: Ecopath with Ecosim (*esercizio EwE*). Sintesi problematiche, approcci, limitazioni, gaps e aree di sviluppo

vii) Prodotti ittici da acquacoltura: sistemi di produzione, problematiche generali, sostanibilitá, soluzioni. Gestione integrata pesca e acquacoltura. Target di pesca sostenibile, approcci alla gestione, problematiche: il caso del mediterraneo. Gestione spaziale della pesca, essential fish habitats, regolamenti comunitari ed internazionali. Sforzo di pesca, gestione dello sforzo di pesca, misure tecniche, misure economiche.

www.ecopath.org

i) Introduzione alla gestione dello sfruttamento delle risorse alieutiche, problematiche generali, stato delle risorse, targets internazionali.

Importanza dello sfruttamento delle risorse alieutiche

Perché è necessario gestire lo sfruttamento (problematiche)

Problematica generale: open access, rinnovabilitá, sostenibilitá

OPEN ACCESS

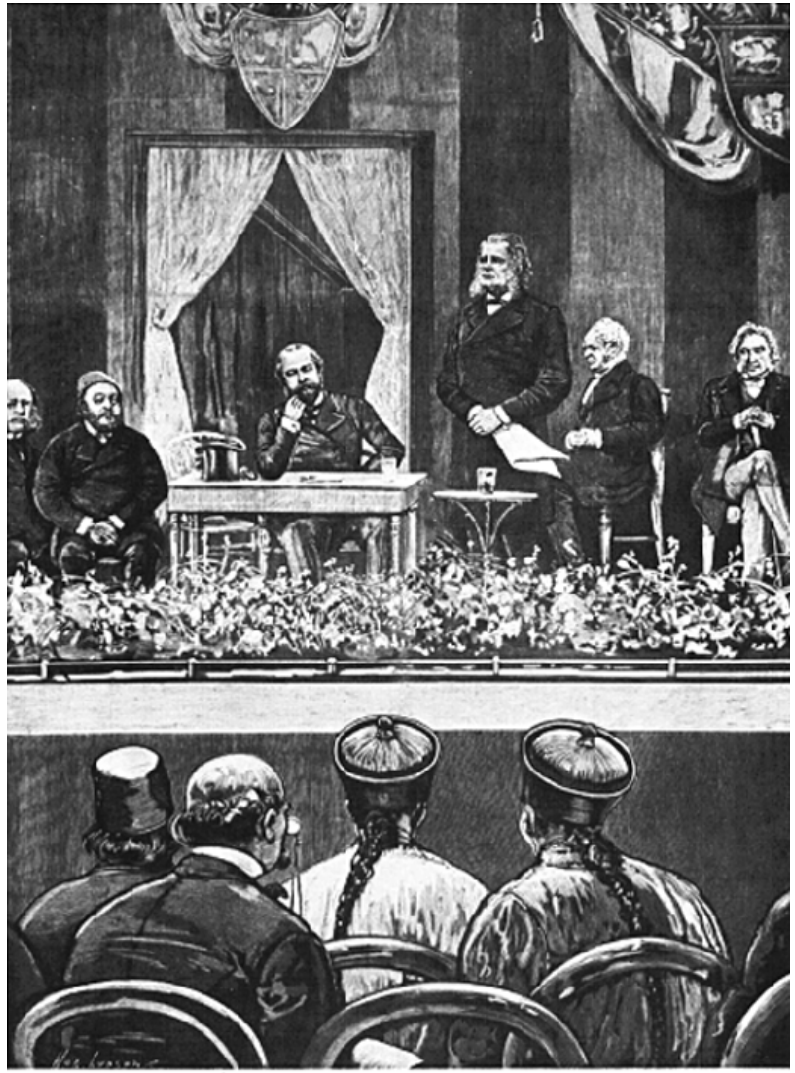
Exercise 1) A box of 12 candies in a classroom at school of 24 children that can be accessed freely

Will it last?
How much?
Each child will have a candy?

Exercise 2) The box of candies in a classroom at school that can be accessed freely but …

… if at least 6 candies will remain after 5 minutes other 6 candies will be given. This can be repeated.

Will it last?
How much?
Each child will have a candy?
What childern need to do to have candies forever?



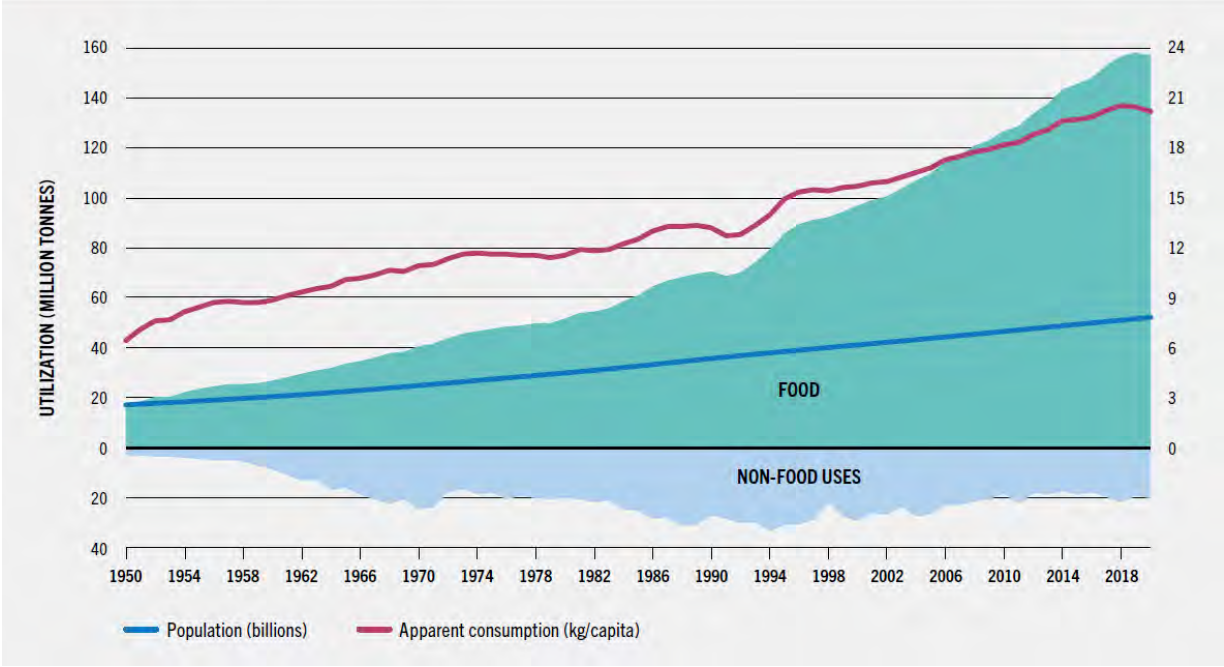
Thomas Huxley, president of the Royal Society, 1883 at the Opening of the International Fisheries Exibition

[…] It is doubtful whether any branch of industry can lay claim to greater antiquity than that of Fishing. […] The supply of food is, in the long run, the chief of these interests. […] it is satisfactory to reflect that the sea which shuts us in, at the same time opens up its supplies of food of almost unlimited extent.[…] The produce of the sea around our coasts bears a far higher proportion to that of the land than is generally imagined. […] I have no doubt whatever that some fisheries may be exhausted. Take the case of a salmon river, for example….. […]. Does the same reasoning apply to the sea fisheries? […] I believe that it may be affirmed with confidence that, in relation to our present modes of fishing, a number of the most important sea fisheries, such as the cod fishery, the herring fishery, and the mackerel fishery, are inexhaustible.[…]

Importance of the ocean is increasingly feeding humanity

Per capita consumption of aquatic products grew from 9 kg in 1961 to more than 20 kg in 2020.
Linear growth of per capita seafood consumption, linear world population growth: non linear growth of yearly seafood consumption.

FIGURE 2 WORLD FISHERIES AND AQUACULTURE PRODUCTION: UTILIZATION AND APPARENT CONSUMPTION

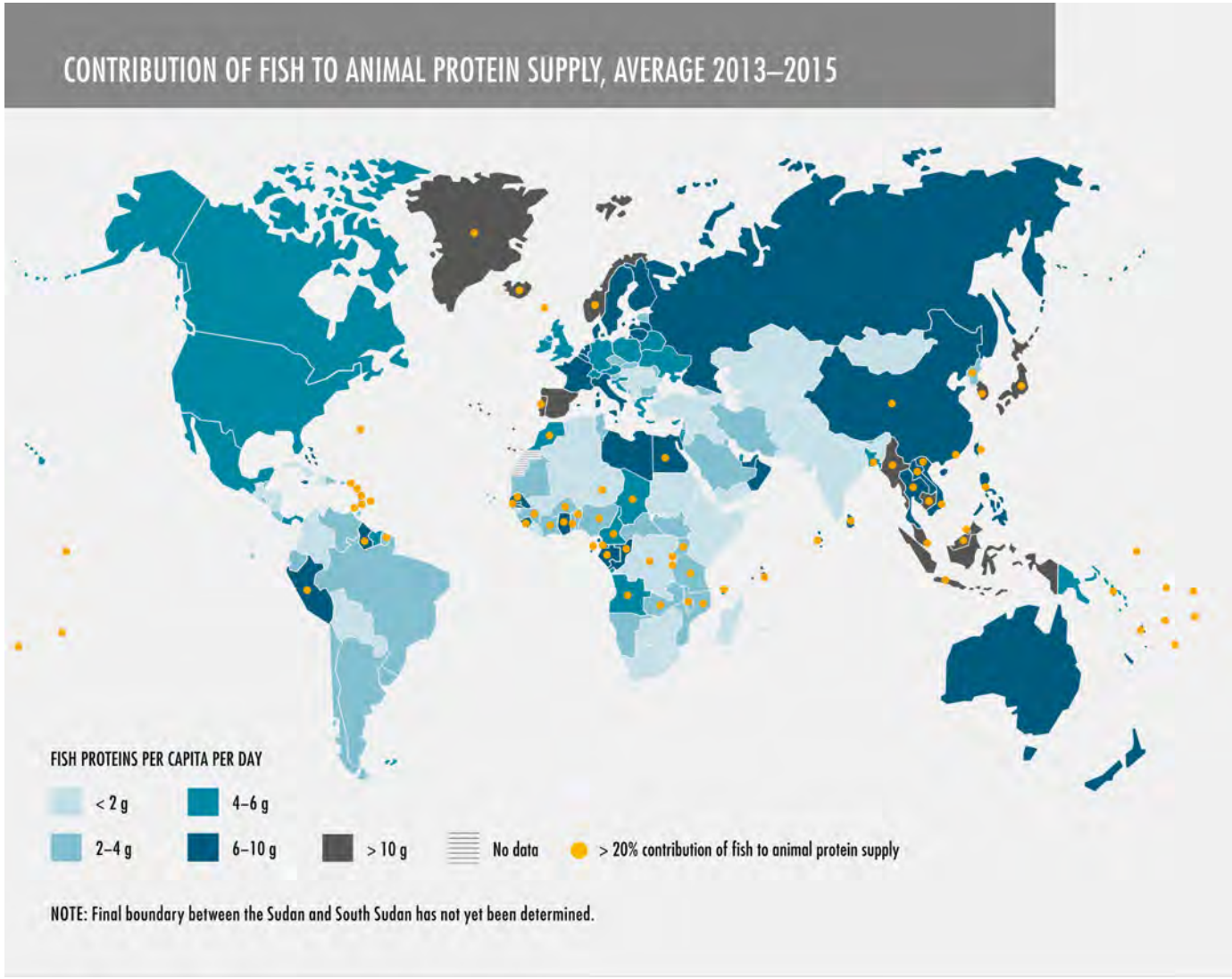


Source: FAO - State of World Fisheries and Aquaculture, SOFIA (2022)

Will the ocean feed humanity?

Looking at the contribution of fish and seafood to animal protein in the human diet, reveals the importance of seafood for several developing countries.

Therefore, not only seafood contributes to feed humanity but it is of fundamental importance to feed populations of some low income countries.

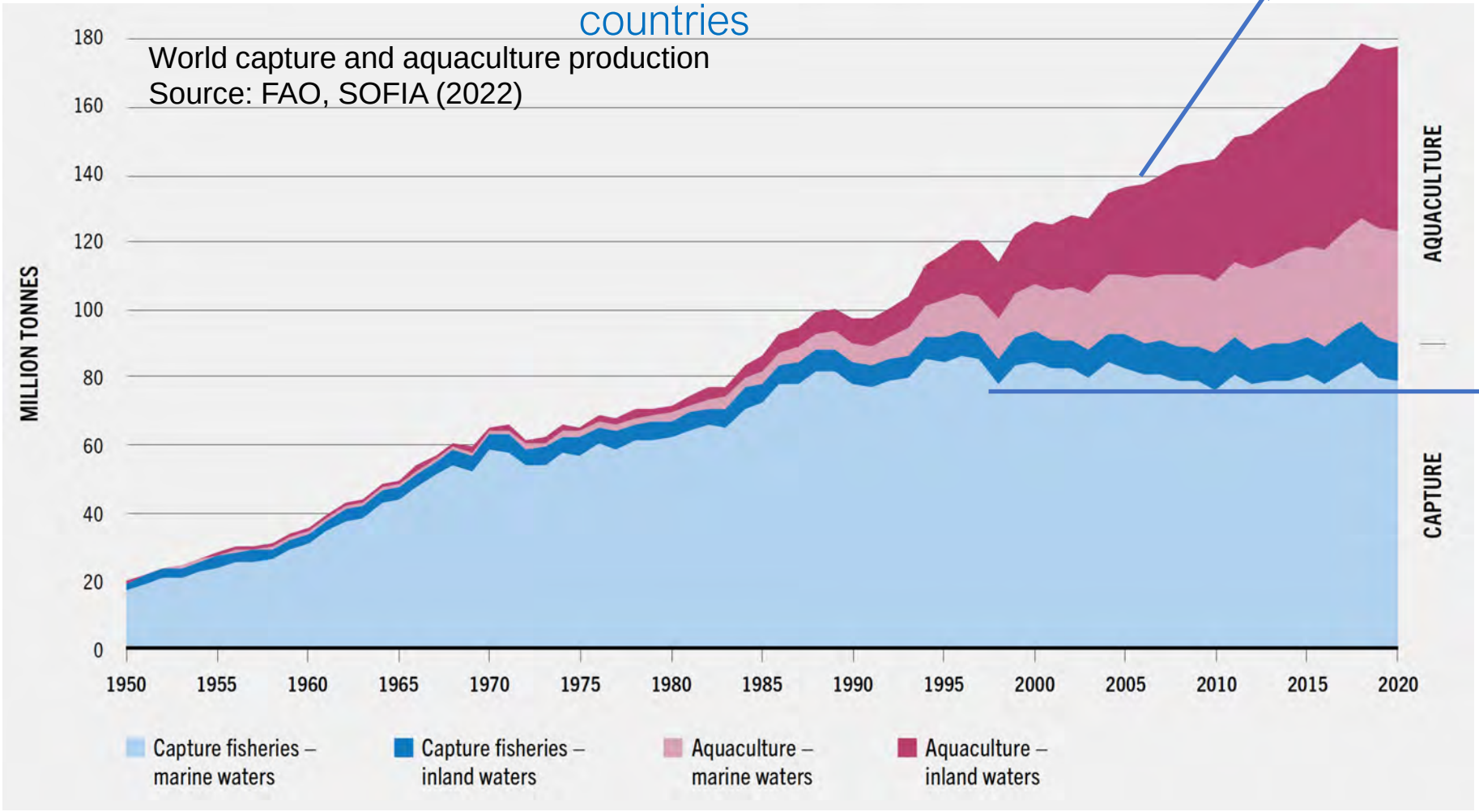


Source: FAO - State of World Fisheries and Aquaculture, SOFIA (2022)

What origin for seafood?

Looking at the world capture and aquaculture production, however, one note an increasing contribution of aquaculture through time, that therefore explain the increased role of the seafood as commodity in developed countries

World capture and aquaculture production
Source: FAO, SOFIA (2022)



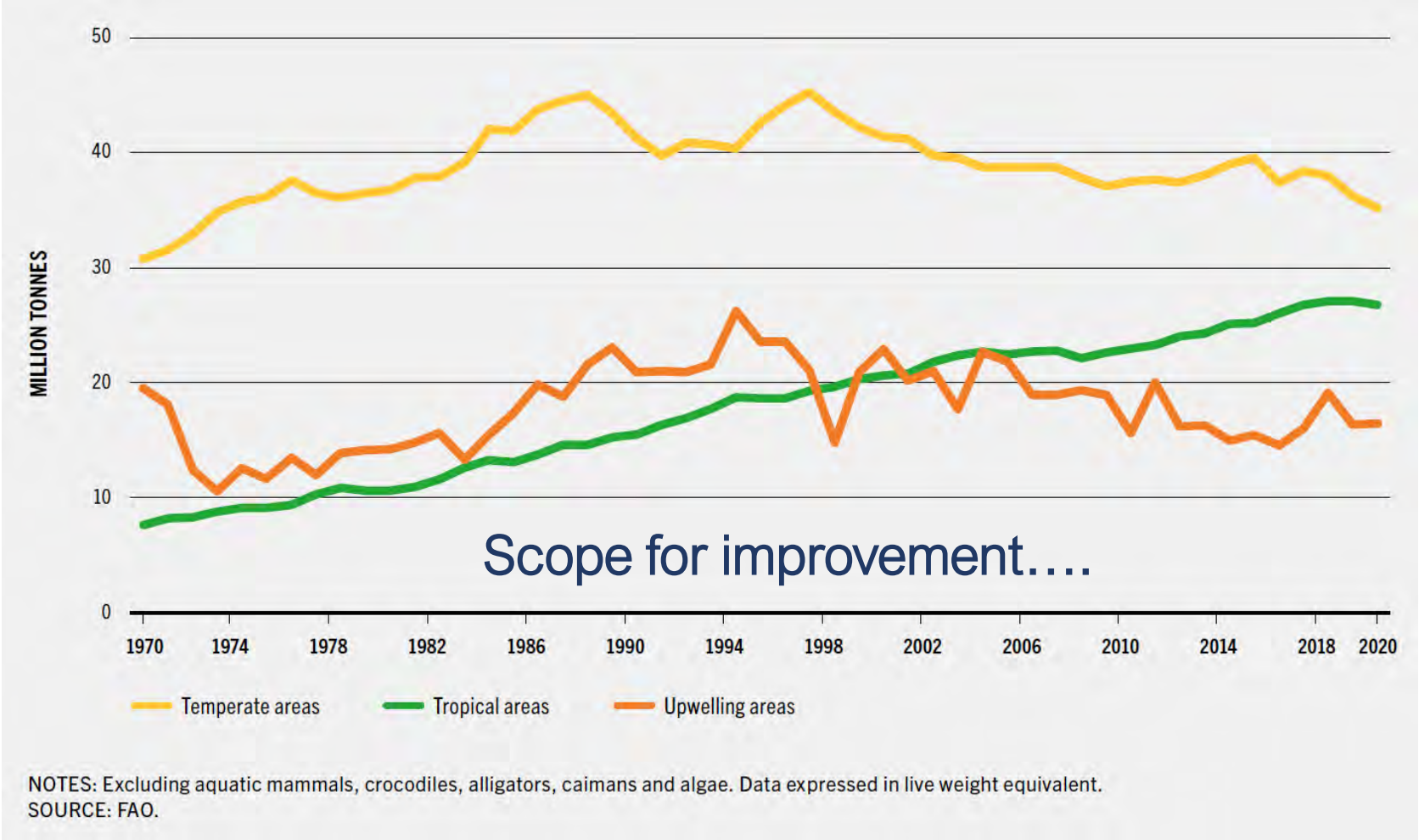
It is also evident that fisheries production is not growing at all since the 90s, this despite improvements in technology and fleets capabilities to reach any place in the ocean.

Regulation-based limits?
Natural productive limits?

Or something else?

Fisheries in countries well developed and under development: differences

Trends of marine capture reveals that nowadays we catch less than in the 90s in temperate areas, upwelling and EU Mediterranean countries. Tropical areas and non developed countries landings are increasing…



Trends of Marine capture production in three main categories of fishing areas. Source: FAO, SOFIA (2022)

Dynamics of catches in Mediterranean Sea

Catches from fully developed fisheries and under development fisheries demonstrate large differences also within the same basin

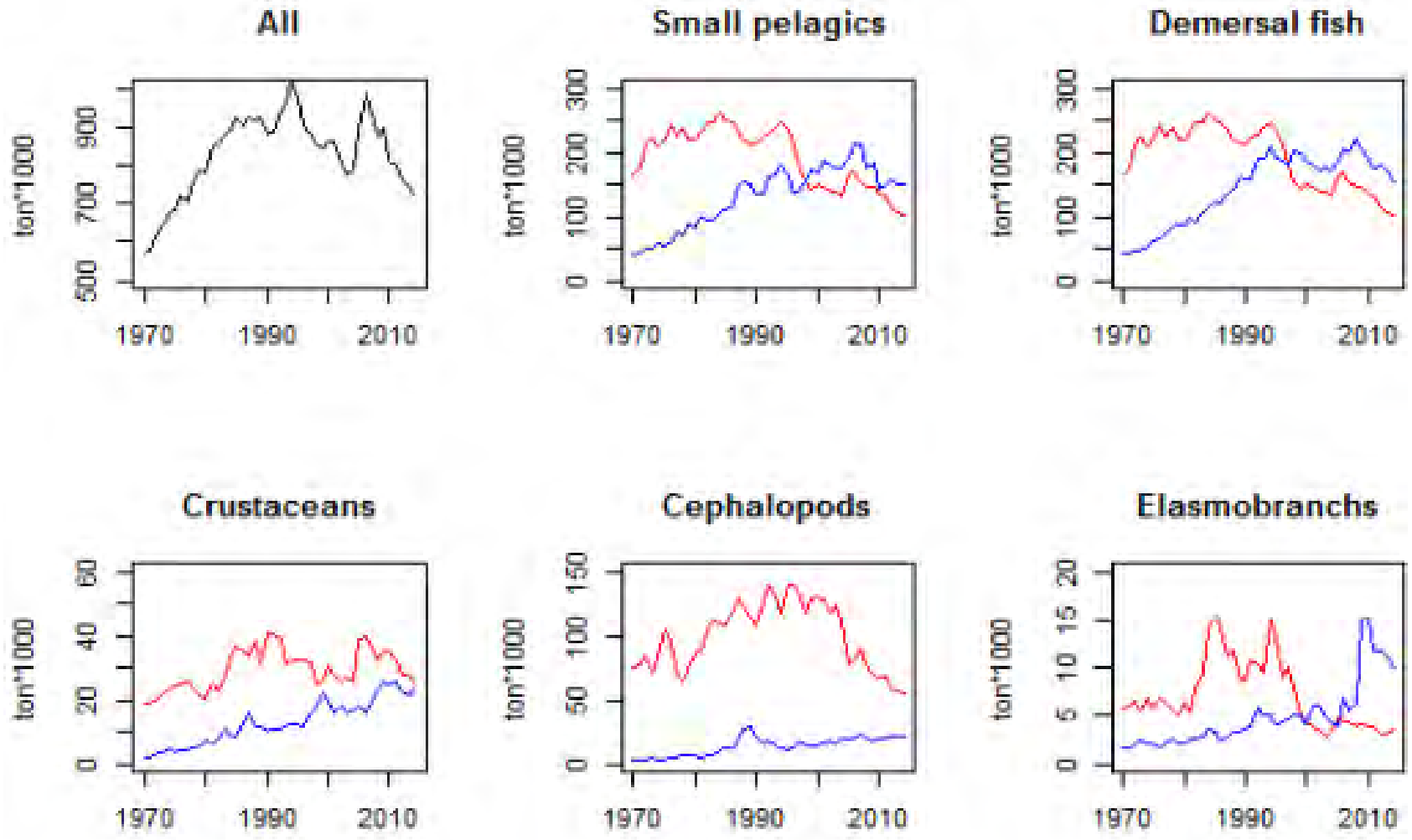
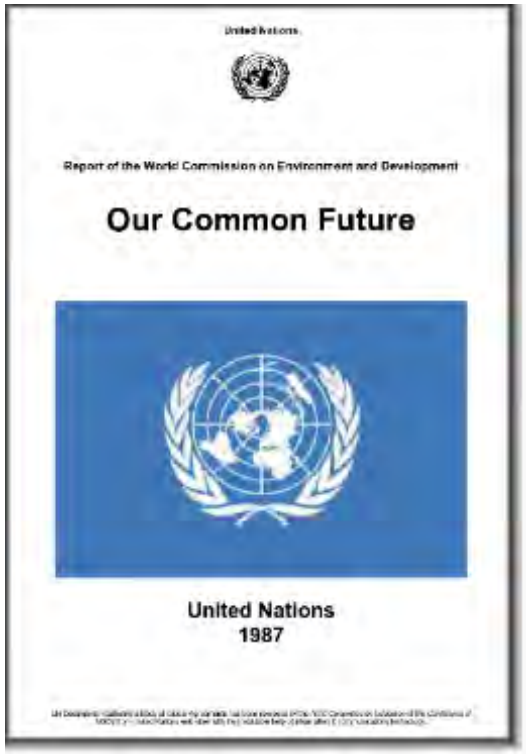


FIGURE 4 | Trend in annual landings of small pelagics, demersal fish, crustaceans, cephalopods, and elasmobranchs in EU (red line) and non-EU (blue line) Mediterranean GSAs. Data were retrieved from the GFCM capture fisheries database (http://www.fao.org/gfcm/data/capture-production-statistics/en/?platform=hootsuite).

Colloca, Scarcella, Libralato (2017) Recent trends and impacts of fisheries exploitation on Mediterranean stocks and ecosystems. Front. Mar. Sci.

Sustainability

- **Sustainability** derive from «sustain»
- Environmental sustainability indicates the **limits** within which the anthropic activities are sustained by nature.

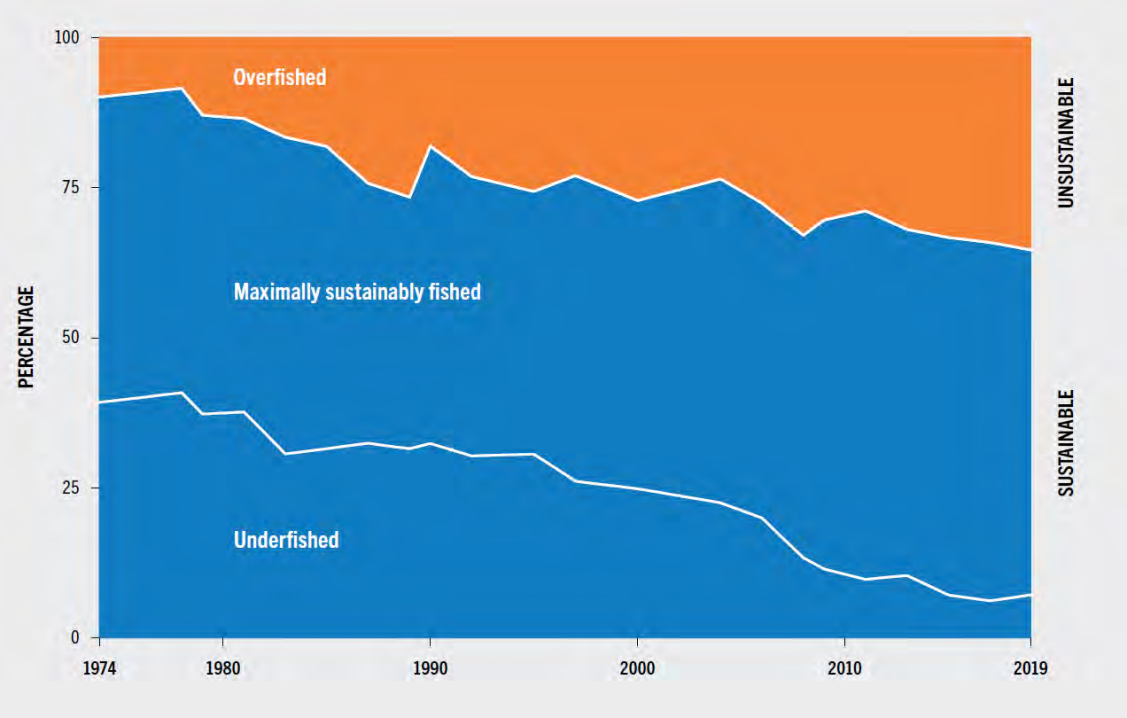


Sustainable exploitation: *satisfy the needs of today without compromising the capability of next generations to satisfy their needs* (Bruntland 1987).

It is not only a question of **quantity** but also of **quality** and **velocity** of human activities

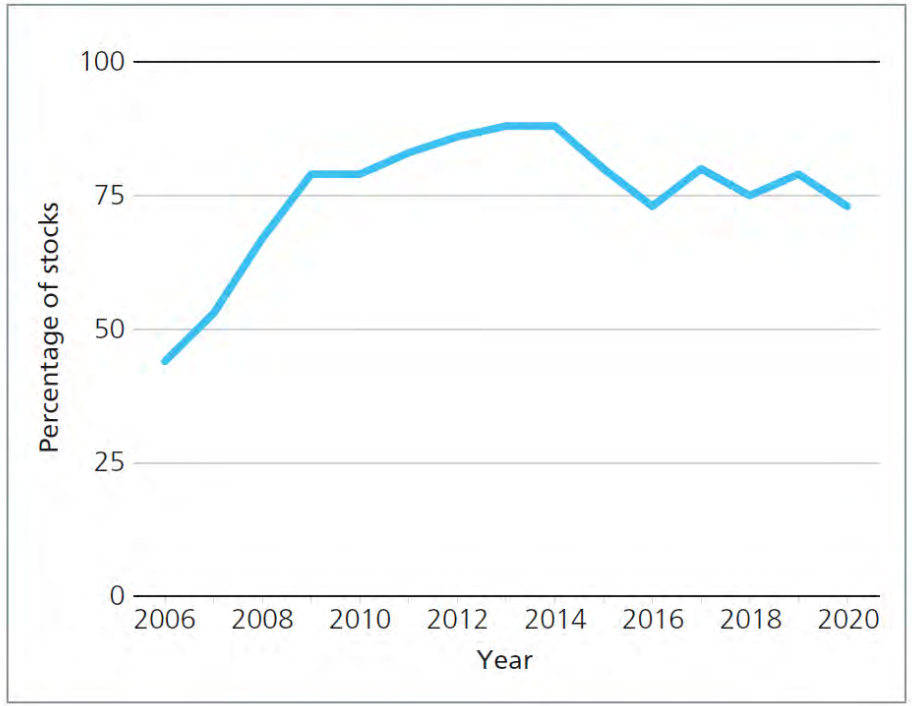
Sustainable exploitation? Level of exploitation that can sustain the socio-ecological system now and in the future.

Worldwide and Mediterranean status of stocks



Global trends in the status of the world's marine fishery stocks. Source: FAO, SOFIA (2022)

FIGURE 73. Percentage of stocks in overexploitation in the GFCM area of application, 2008–2020



GFCM-FAO (2022) The State of Mediterranean and Black Sea Fisheries.

Overfished stocks are increasing worldwide; in the Mediterranean the number of overexploited stocks is stabilized at an impressively high proportion (nearly 75% overexploited)

Overfishing

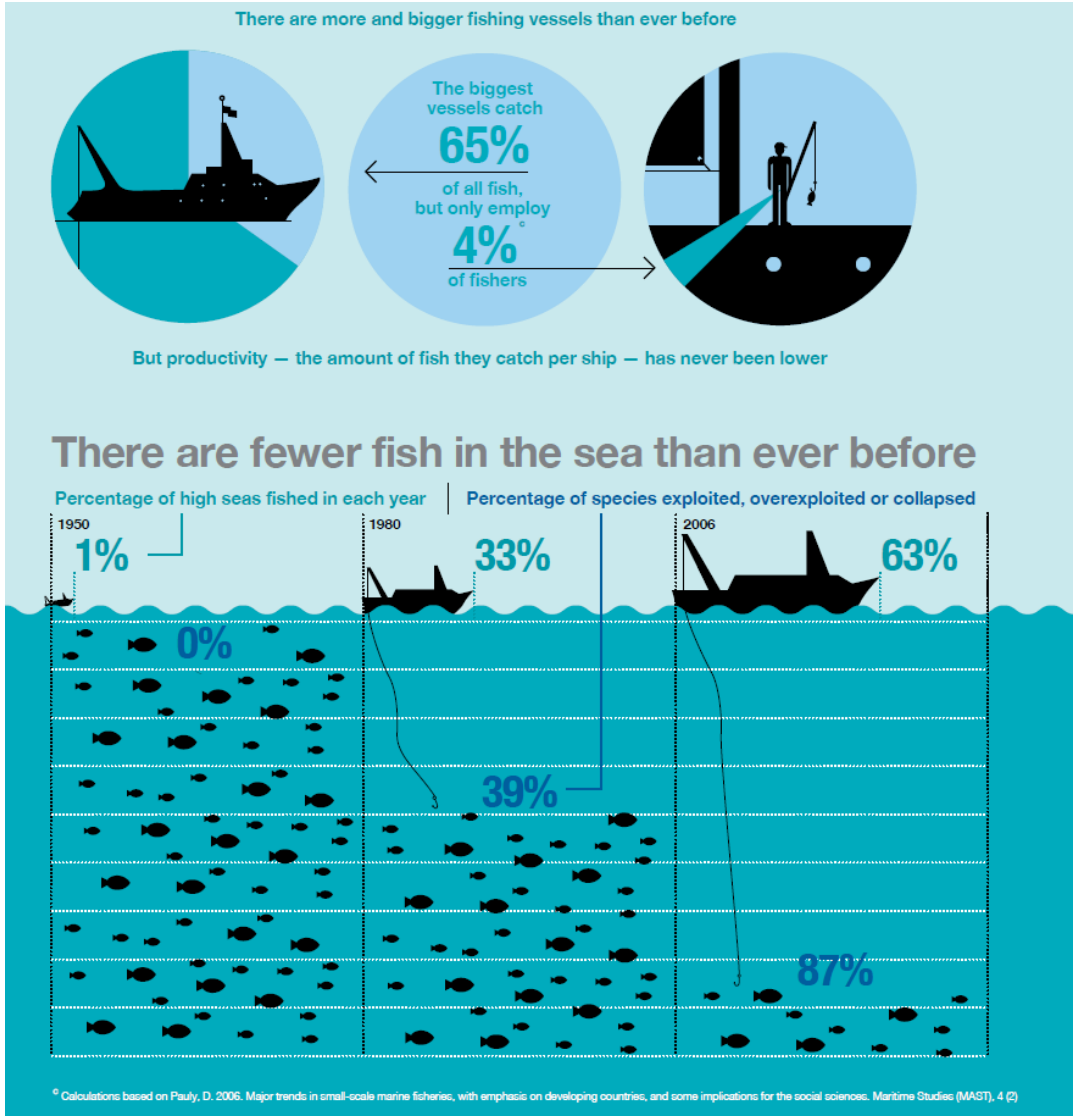
Catching too much fish for the system to support leads to an overall degradation to the system.

According to organisations and governments:

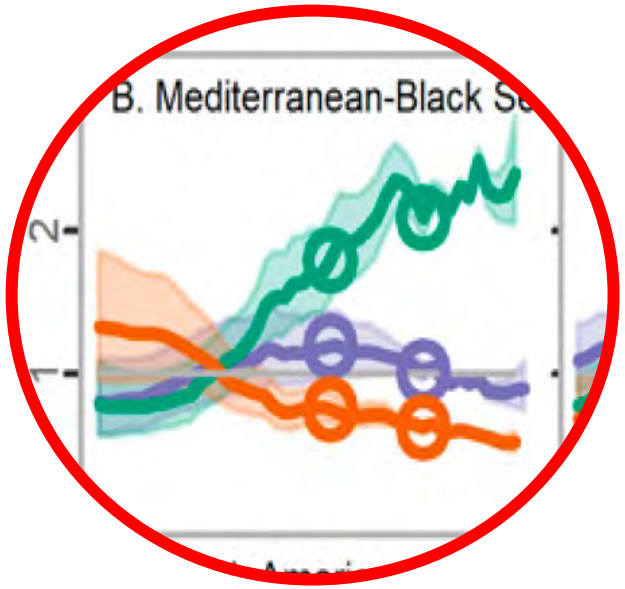
•The practice of commercial and non-commercial fishing which depletes a fishery by catching so many adult fish that not enough remain to breed and replenish the population.

• when fishing exploitation exceeds the carrying capacity of the system.

•Fishing with a sufficiently high intensity to reduce the breeding stock levels to such an extent that they will no longer support a sufficient quantity of fish for sport or commercial harvest.



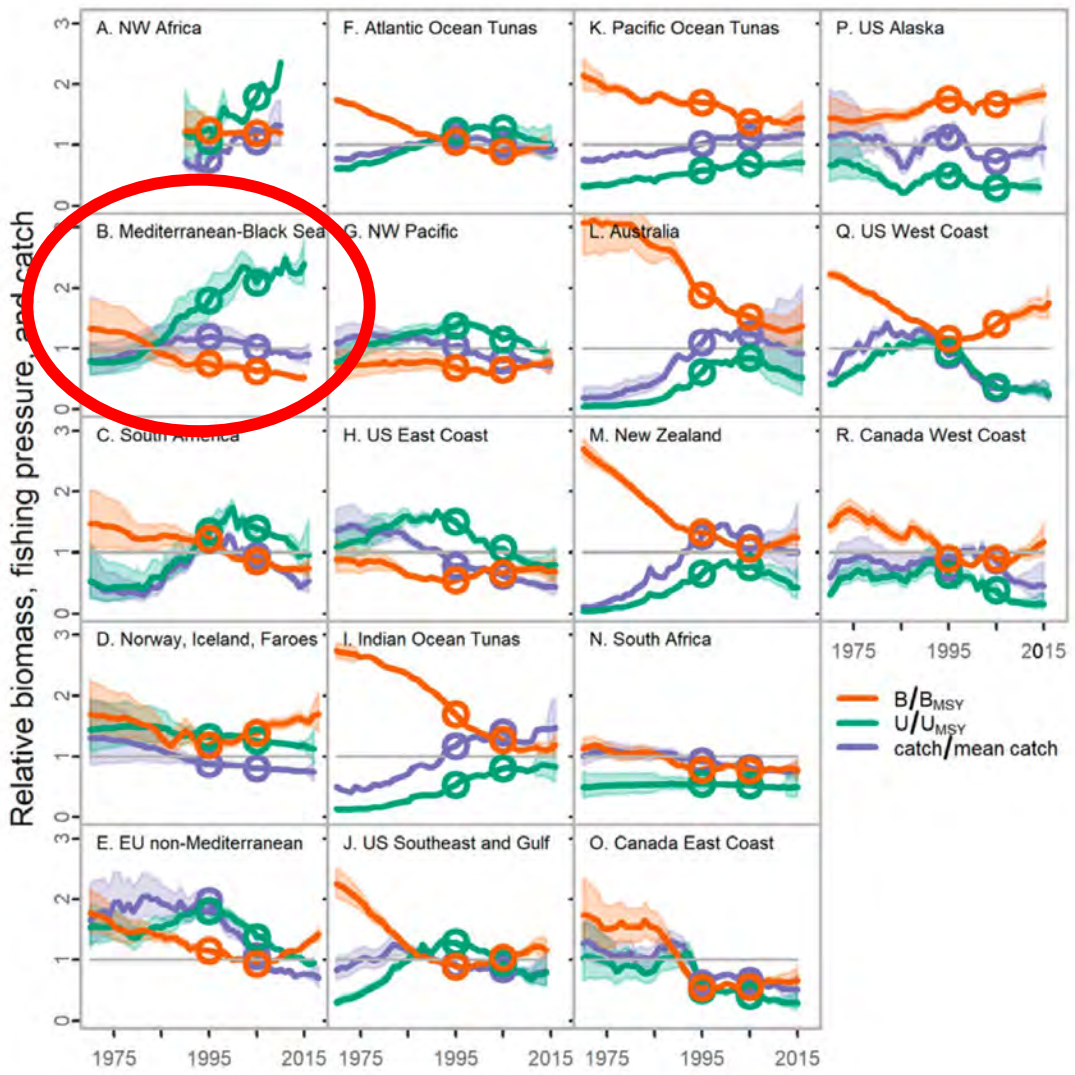
Status of stocks around the world: improving in several areas where intense fishing management is carried out since long time



Hilborn et al., PNAS, 2020

Effective fisheries management instrumental in improving fish stock status

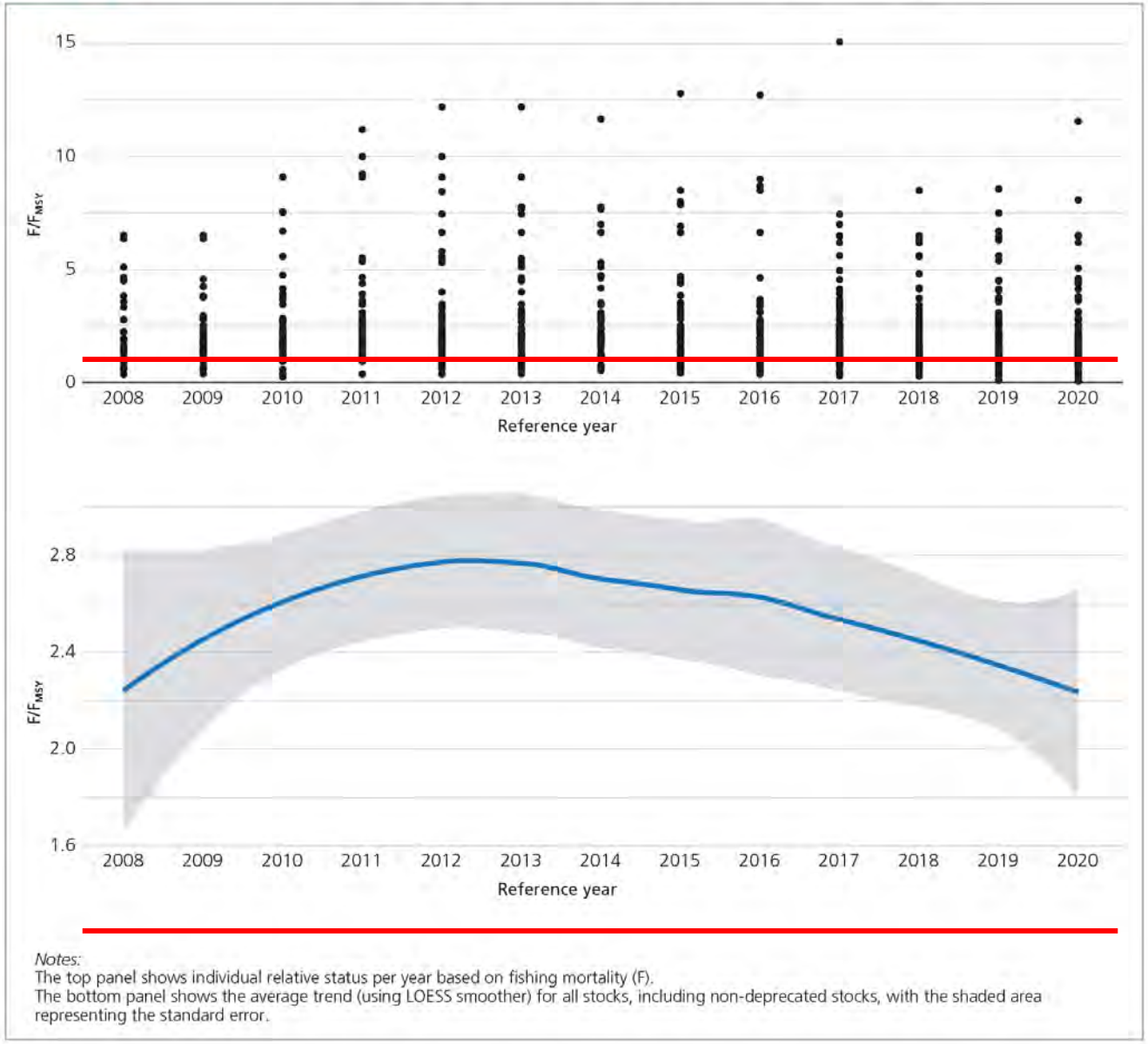
Ray Hilborn[a,1], Ricardo Oscar Amoroso[a], Christopher M. Anderson[a], Julia K. Baum[b], Trevor A. Branch[a], Christopher Costello[c], Carryn L. de Moor[d], Abdelmalek Faraj[e], Daniel Hively[a], Olaf P. Jensen[f], Hiroyuki Kurota[g], L. Richard Little[h], Pamela Mace[i], Tim McClanahan[j], Michael C. Melnychuk[a], Cóilín Minto[k], Giacomo Chato Osio[l,m], Ana M. Parma[n], Maite Pons[a], Susana Segurado[o], Cody S. Szuwalski[c], Jono R. Wilson[c,p], and Yimin Ye[q]



The Mediterranean Sea

Routinely done stock assessment started relatively late in Mediterranean Sea (around 2007) and the situation is improving but still overexploitation level is very high and domininating

FIGURE 74. Exploitation ratios (F/F_{MSY}) of all species and management units, 2008–2020



Notes:
The top panel shows individual relative status per year based on fishing mortality (F).
The bottom panel shows the average trend (using LOESS smoother) for all stocks, including non-deprecated stocks, with the shaded area representing the standard error.

GFCM-FAO (2022) The State of Mediterranean and Black Sea Fisheries.

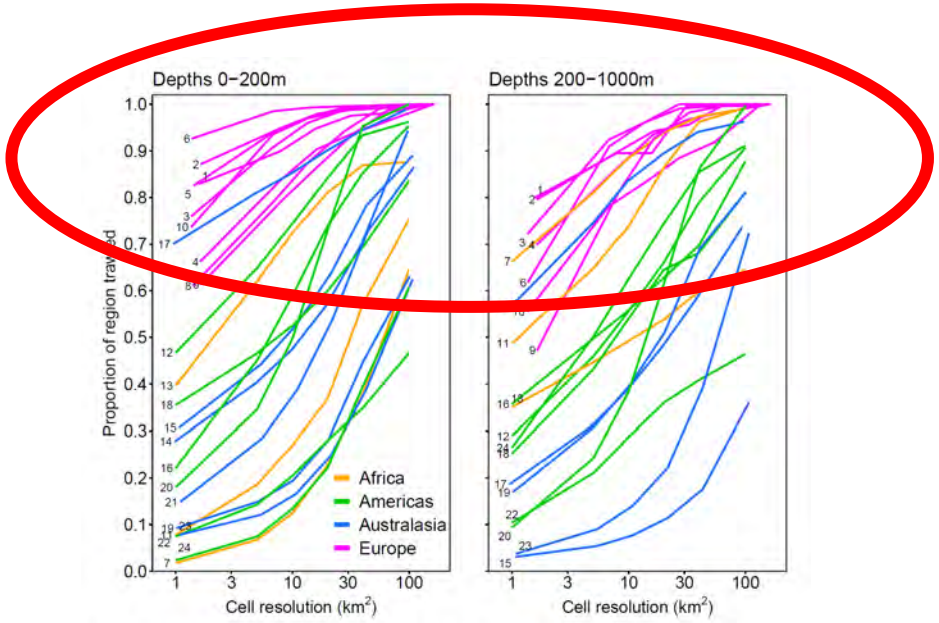
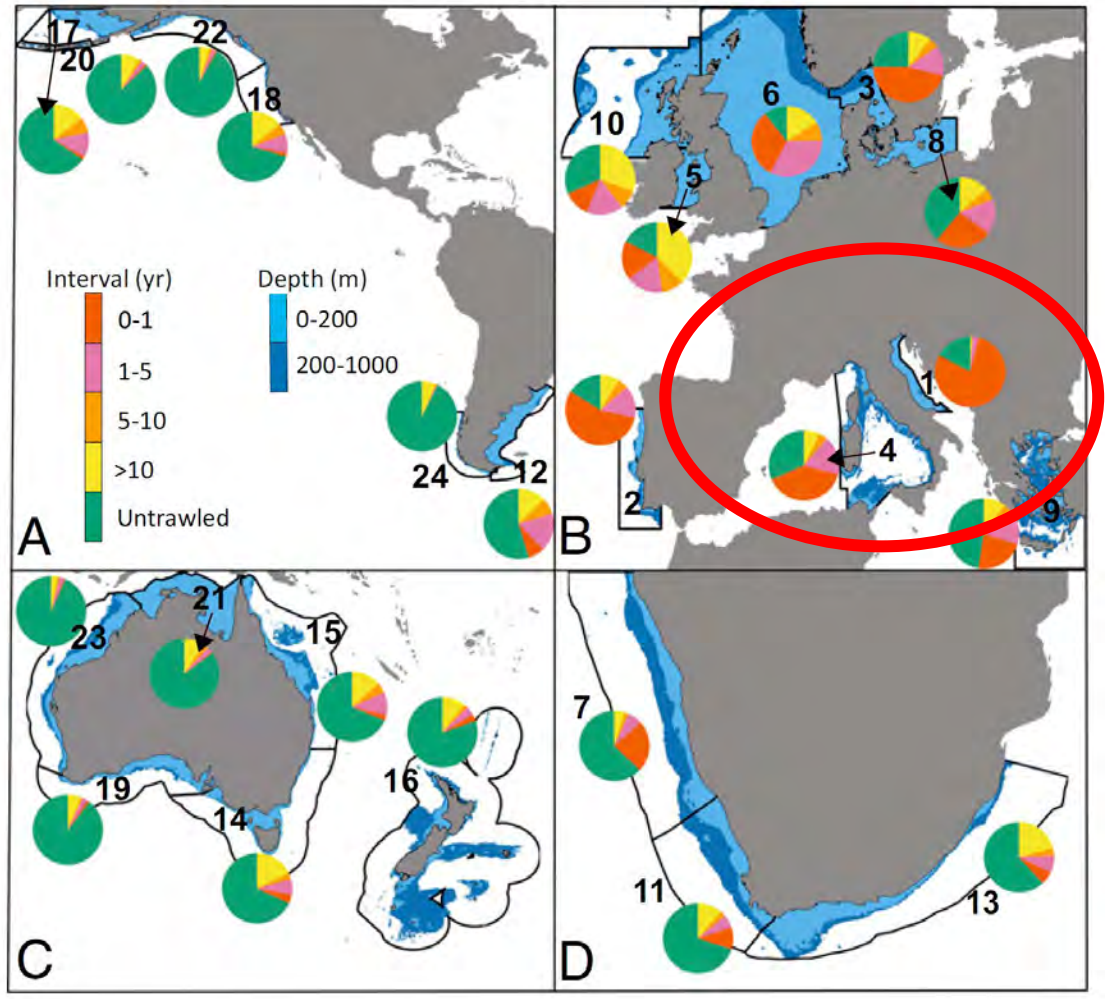


Fig. 1. Relationships between the spatial resolution of effort data and the trawling footprint (approach A, grid cell based; in the text) for depth ranges of 0–200 and >200–1,000 m. Region codes follow Fig. 3 and Table 1. Three regions are not represented in *Right* (depths of 200–1,000 m), because these regions are predominantly <200-m deep.

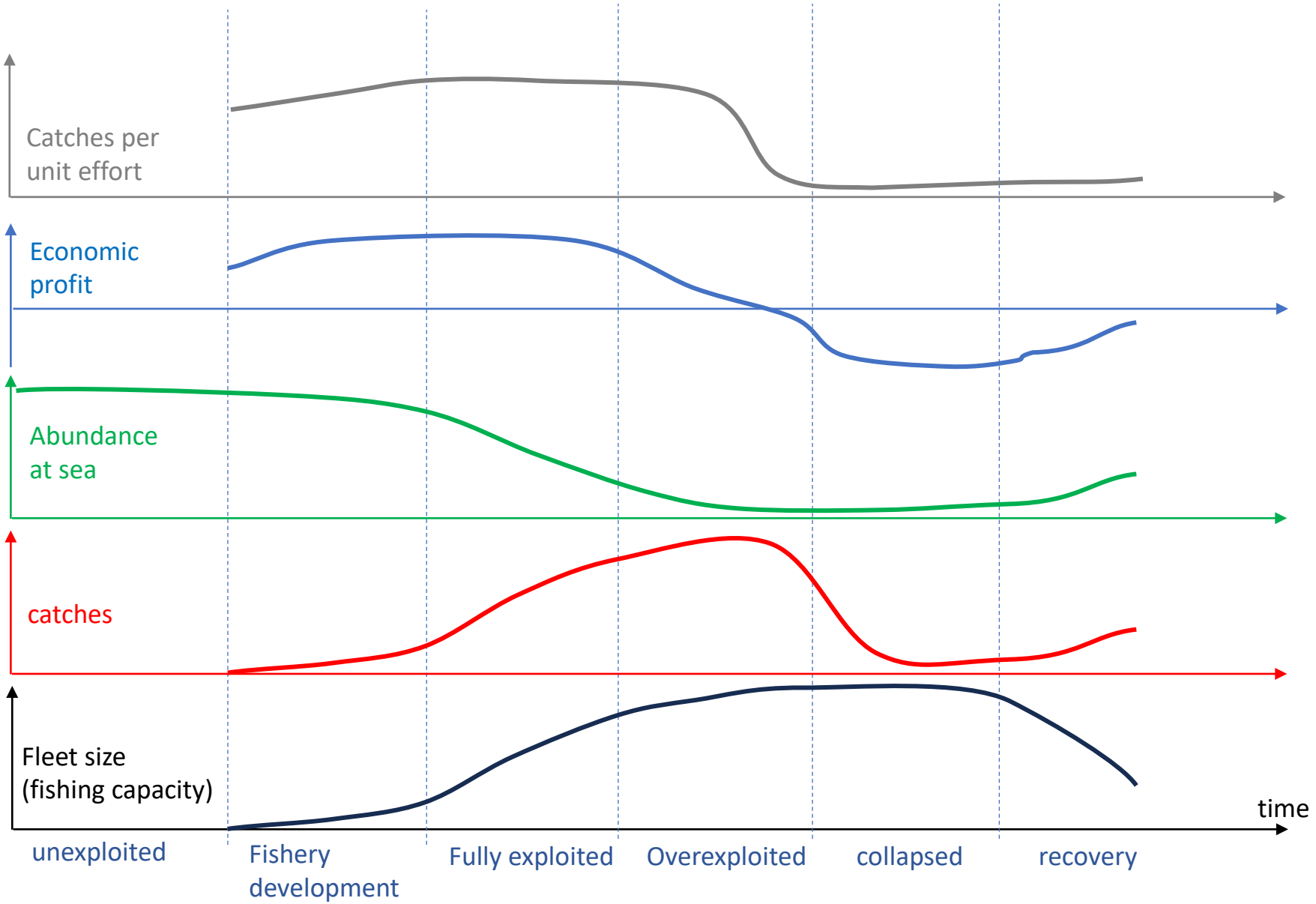


PNAS

Bottom trawl fishing footprints on the world's continental shelves

Ricardo O. Amoroso[a,1], C. Roland Pitcher[b], Adriaan D. Rijnsdorp[c], Robert A. McConnaughey[d], Ana M. Parma[e], Petri Suuronen[f,g], Ole R. Eigaard[h], Francois Bastardie[h], Niels T. Hintzen[c], Franziska Althaus[i], Susan Jane Baird[j], Jenny Black[k], Lene Buhl-Mortensen[l], Alexander B. Campbell[m], Rui Catarino[n,o], Jeremy Collie[p], James H. Cowan Jr.[q], Deon Durholtz[r], Nadia Engstrom[s], Tracey P. Fairweather[r], Heino O. Fock[t], Richard Ford[u], Patricio A. Gálvez[v], Hans Gerritsen[w], María Eva Góngora[x], Jessica A. González[v], Jan G. Hiddink[y], Kathryn M. Hughes[y], Steven S. Intelmann[d], Chris Jenkins[z], Patrik Jonsson[aa], Paulus Kainge[bb], Mervi Kangas[cc], Johannes N. Kathena[bb], Stefanos Kavadas[dd], Rob W. Leslie[r], Steve G. Lewis[ee], Mathieu Lundy[ff], David Makin[gg], Julie Martin[hh], Tessa Mazor[b], Genoveva Gonzalez-Mirelis[l], Stephen J. Newman[cc], Nadia Papadopoulou[ii], Paulette E. Posen[jj], Wayne Rochester[b], Tommaso Russo[kk], Antonello Sala[ll], Jayson M. Semmens[mm], Cristina Silva[nn], Angelo Tsolos[oo], Bart Vanelslander[pp], Corey B. Wakefield[cc], Brent A. Wood[j], Ray Hilborn[a], Michel J. Kaiser[y,qq], and Simon Jennings[o,jj,rr]

Schematic general dynamic of exploitation

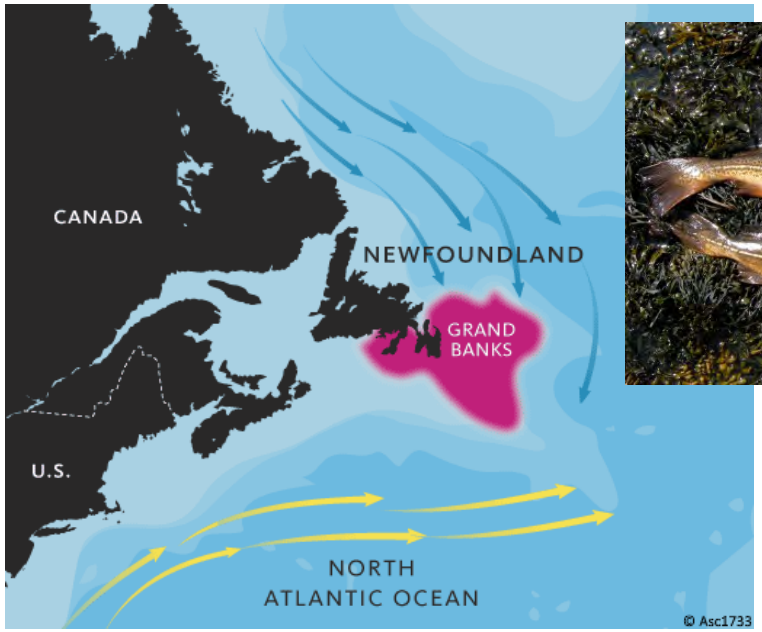


The history of exploitation by fisheries of several stocks worldwide show similar kind of dynamics of the socio-ecological-economic system which represents fisheries and the stock.

Note that allowing uncontrolled development result in several drawbacks: in the period of collapse ecological and economic issues

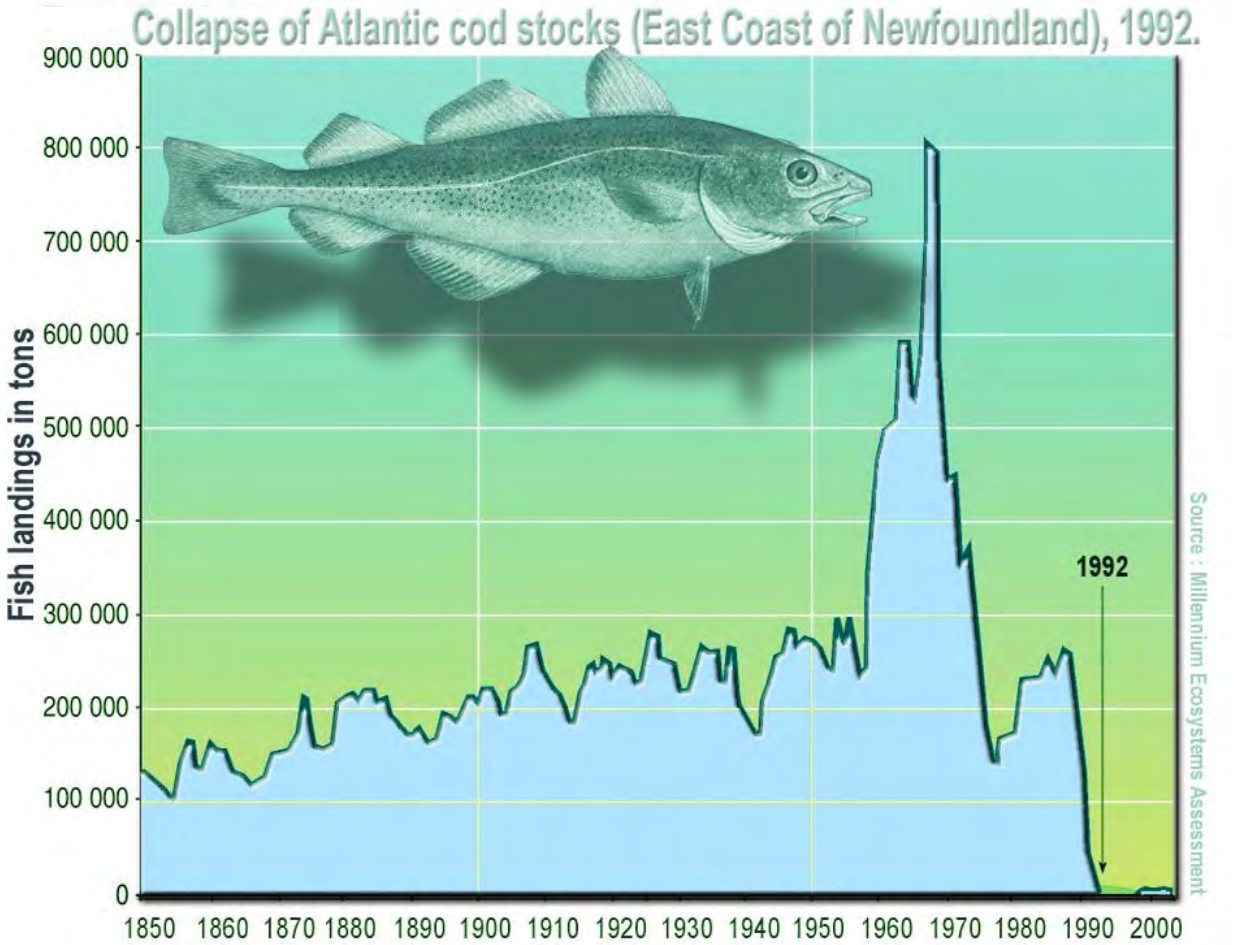
From Hilborn & Walters (1992)

Example: Cod collapse and moratorium



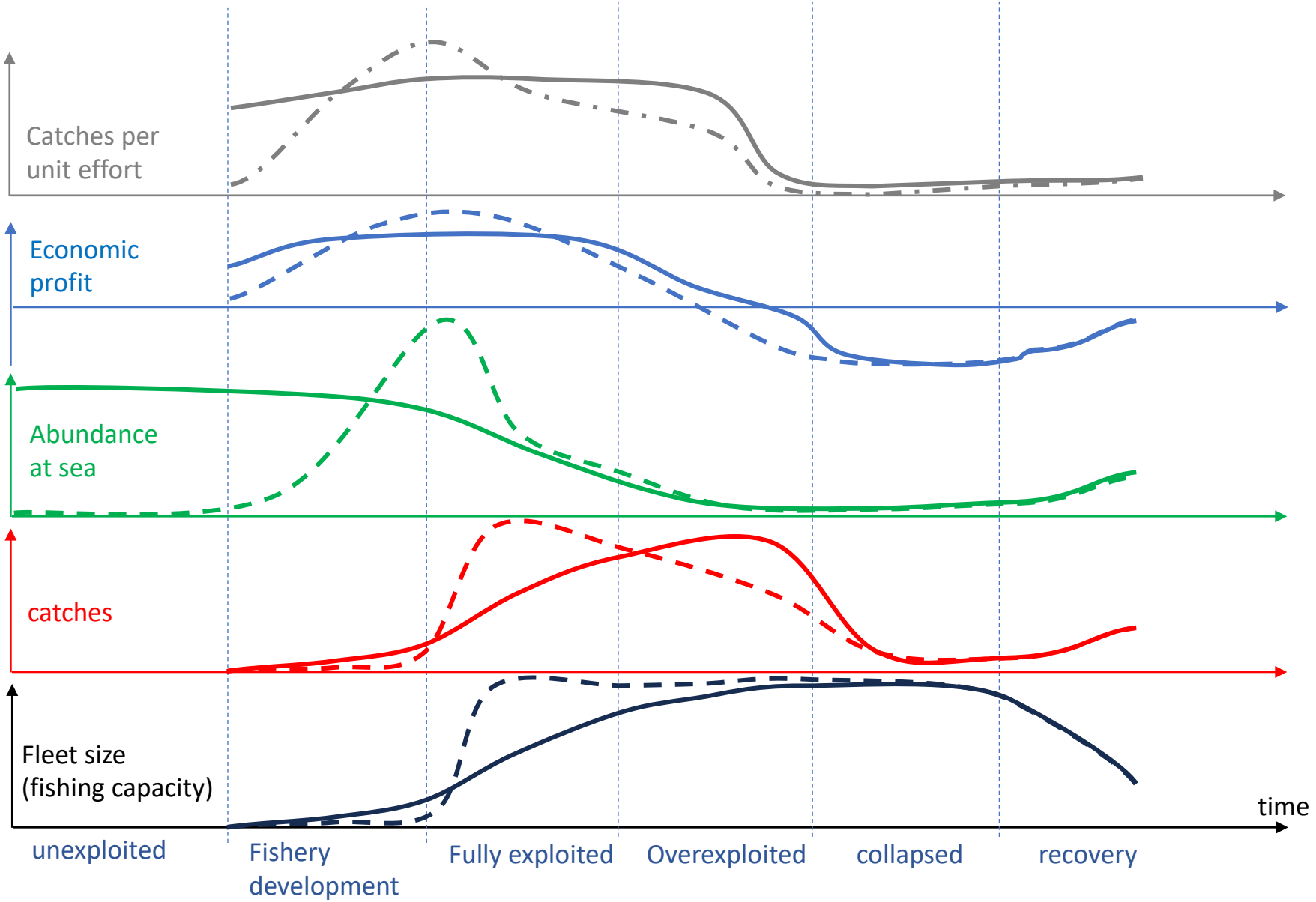
Atlantic cod
Gadus morhua

Fishing for cod (*Gadus morhua*) at Grand Banks was an historical profitable activities. After the development of steam vessels, several countries other than Canada and US started to fish there. Factory trawlers from Britain and the Soviet Union began to appear on the Grand Banks in the mid-1960s, followed by others from Spain, Romania, France and West Germany…



In 1992 was introduced a moratorium; several cascading effects in the ecosystem due to the lack of top predator; Atlantic cod is recovered in eastern Atlantic but it is still recovering on western coasts….

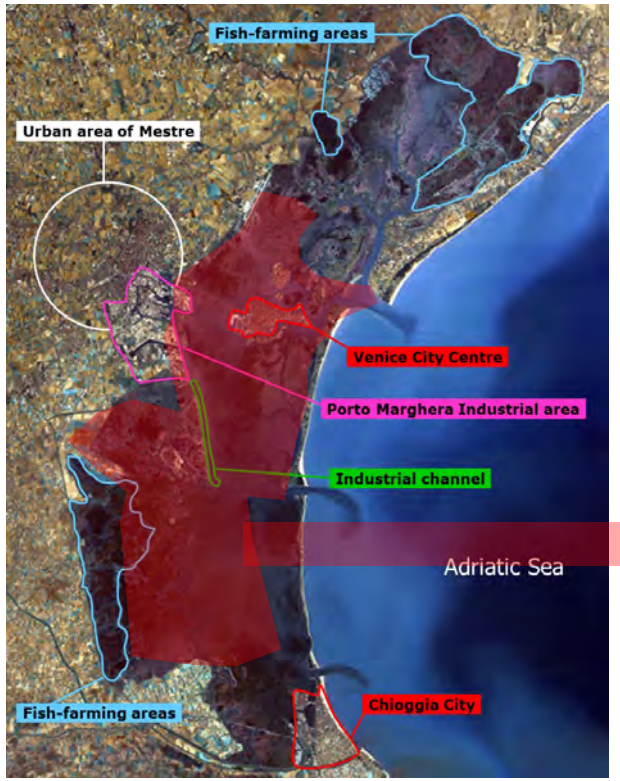
Schematic general dynamic of exploitation of an invasive species



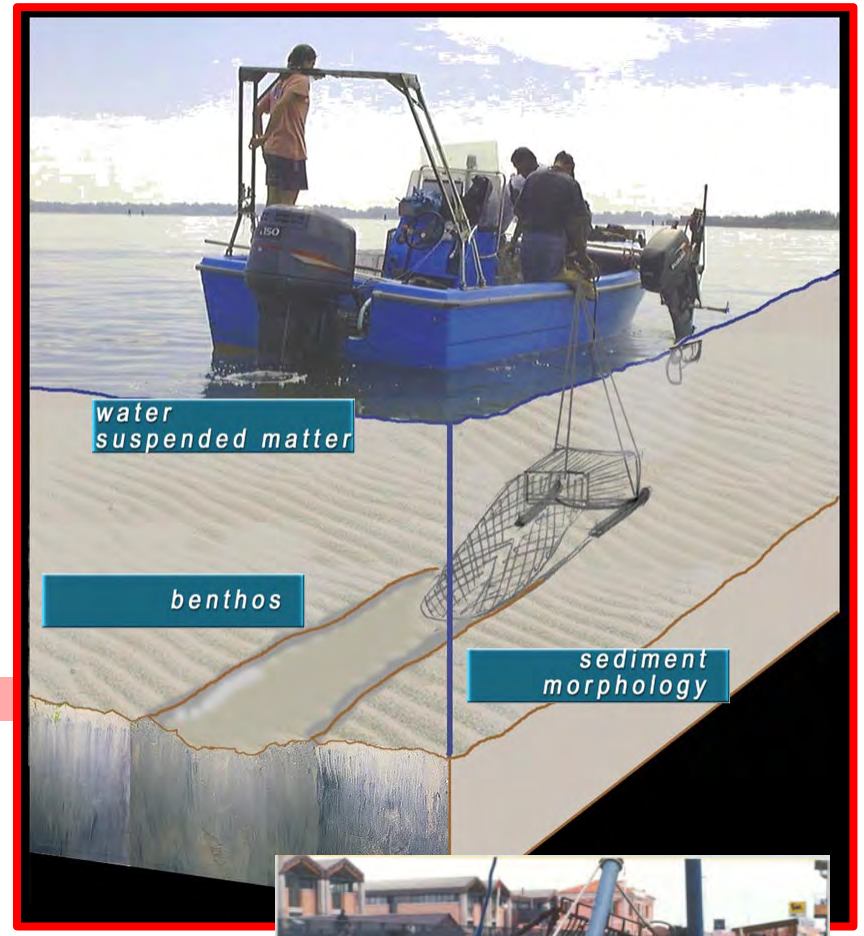
In the case of the invasive species, there is also a combination with the colonization process. The invasion usually generates a peack in abundance that represent a great attraction and can result in extremely large exploitations but leaves even faster declines

Modified From
Hilborn & Walters (1992)

Example: Ruditapes philippinarum in Venice Lagoon

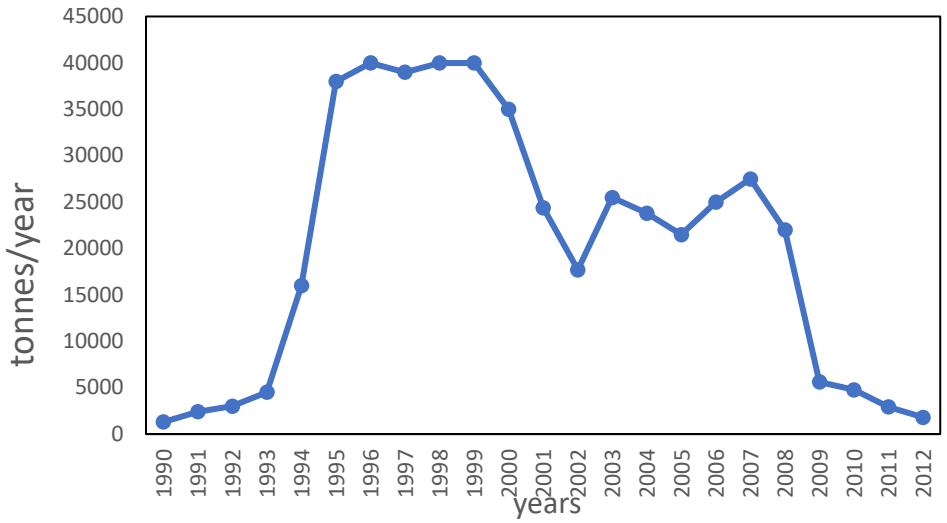


The alloctonhous bivalve *Ruditapes philippinarum* was introduced in 1983 in the Venice lagoon to increase fisheries opportunities. It spreads well and during the 90s started an intensive uncontrolled exploitation. By the end of the 90s (1998-99) the Venice lagoon alone was extimated to produce 40 000 t/y per year of clams (more than 50% of the whole italian production). Then by 2012 the catches went down to less than 2000 t/y and never recovered.



Ruditapes philippinarum

Manila clam



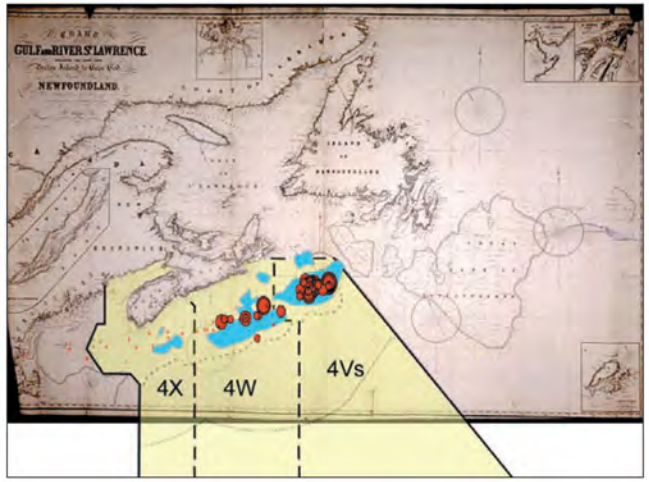
Mechanical harvesting for clam

Libralato et al., 2002; 2004; Solidoro et al., 2010

Effects of fishing (1): depletion of species to extremely low biomasses

Figure 1. *(a) Beverly, Massachusetts, circa 1840, as seen from the south-west. (b) Schooners on the Scotian Shelf in the mid 19th century fished for cod with handlines (Goode 1884–87). This illustration from the 1880s shows fishermen lining the rails, each deploying two baited hooks in essentially the same manner as European fishermen had done off Newfoundland in the 1500s. Although some Beverly captains employed dories for handlining and a few experimented with tub trawls as catch per unit effort (CPUE) declined, handlining from the vessel remained prevalent in this fishery until the early 1860s.*

Rosenberg et al., 2005



Historical fishing for
Atlantic cod
Gadus morhua

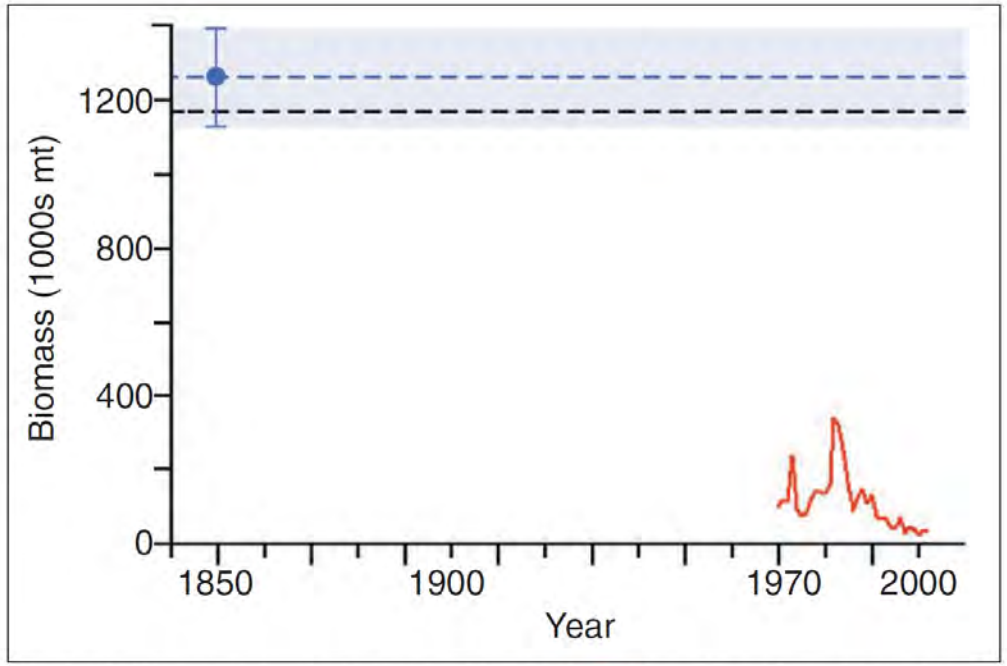


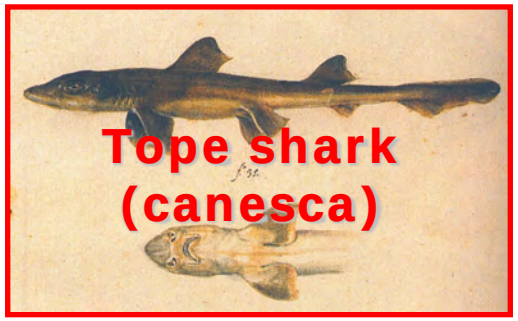
Figure 4. *Biomass estimates for Scotian Shelf Cod: ● this study, with confidence interval (1852); – – – estimated carrying capacity of this marine ecosystem from late 20th century data (Myers et al. 2001); ——— total biomass estimates from 1970 to 2000 for cod, 4X,4VsW (Mohn 1998; Canada DFO 2000; Fanning 2003).*

Combined with ancillary fishery documents, these logs provide a solid, reliable basis for stock assessment. Based on these data we estimate a biomass for cod of 1.26 x 106 mt in 1852 – compared with less than 5 x 104 mt of total biomass today. In the current policy debate about rebuilding depleted fisheries and restoring marine ecosystems, it is important to recognize that fisheries for key commercial species like cod were far more productive in the past.

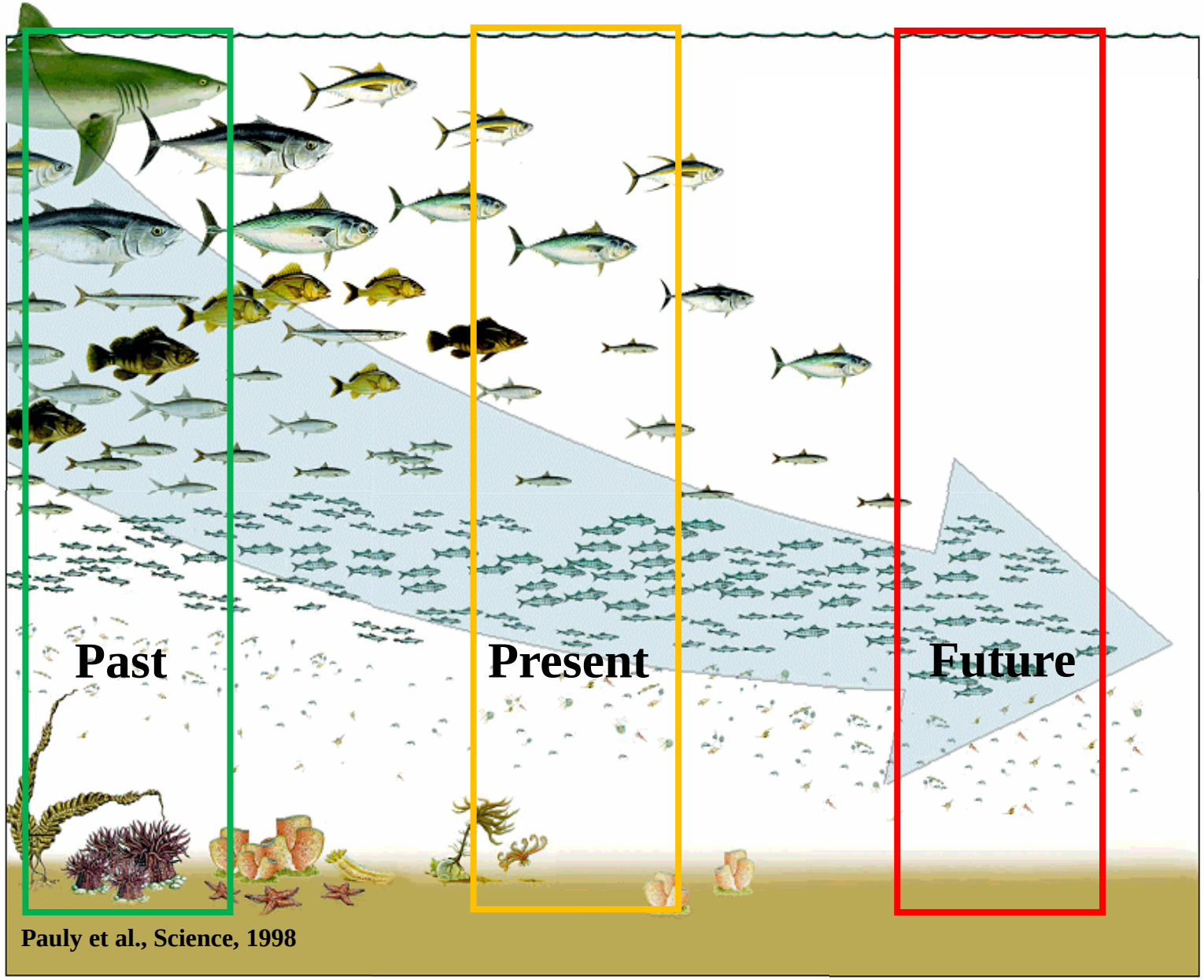
Effects of fishing (2): local extirpation

Species	1800-1825	1826-1850	1851-1875	1876-1900	1901-1925	1926-1950	Expedition HVAR (1948)	MEDIterranean Trawl Survey (1998)	IUCN Red List (2008)
Angelshark (*Squatina squatina*)	common		common	common	common		YES	NO	Critically Endangered
Angular roughshark (*Oxynotus centrina*)	rare		rare	rare	rare	rare	YES	NO	Vulnerable
Sharpnose sevengill shark (*Heptranchias perlo*)			rare	rare	rare	very rare	YES	NO	Near Threatened
Bottlenosed skate (*Rostroraja alba*)			common	common	common	common	YES	NO	Edangered
Blue skate (*Dipturus batis*)			common	common	common		NO	NO	Critically Endangered
Tope shark (*Galeorhinus galeus*)	common		common	common	common	common	YES	NO	Vulnerable
Sturgeon (*Acipenser sturio*)			common	common	common	common	YES	NO	Critically Endangered
Dusky grouper (*Epinephelus marginatus*)		very rare	rare	rare		rare	YES	NO	Endangered

Some species (especially elasmobranchs) were common in Adriatic sea up to the 50s: these species are now considered locally extinct



Fortibuoni et al., 2010



Pauly et al., Science, 1998

Effects of fishing (3): «fishing down the food web»

Fishing down the food web is the process induced by fisheries on the communities of a given ecosystem: “having depleted the large predatory fish on top of the food web, turn to increasingly smaller species, finally ending up with previously spurned small fish and invertebrates”

Prof. Daniel Pauly

(UBC, Canada)

Effects of fishing (3): «fishing down the food web»; global and local

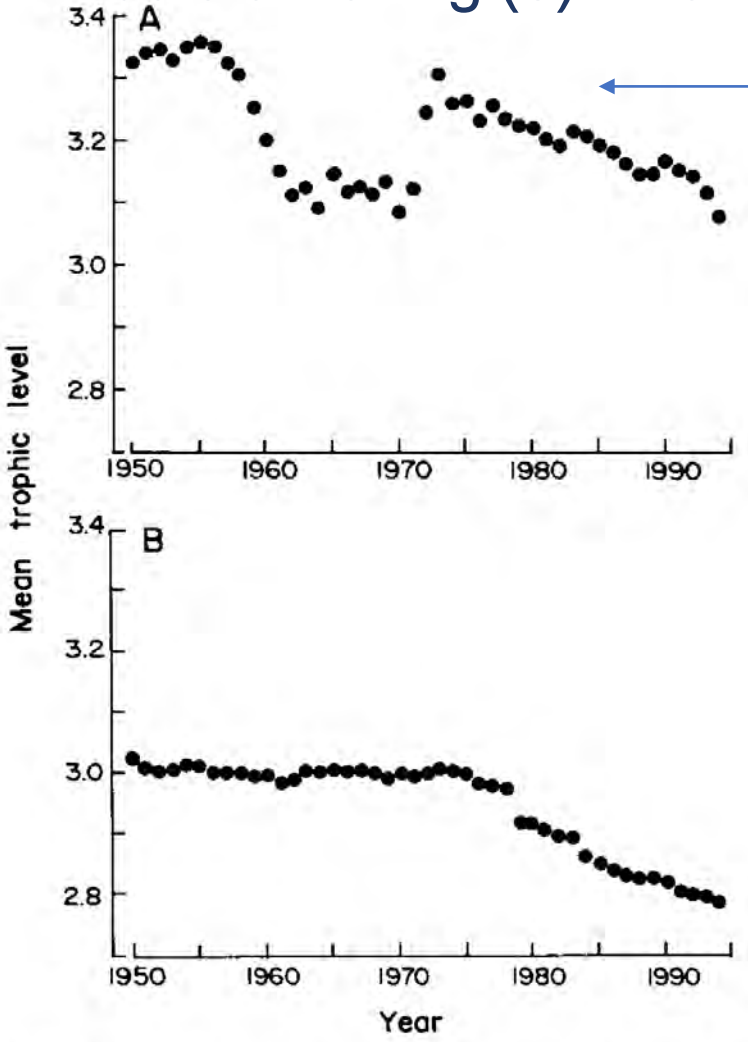


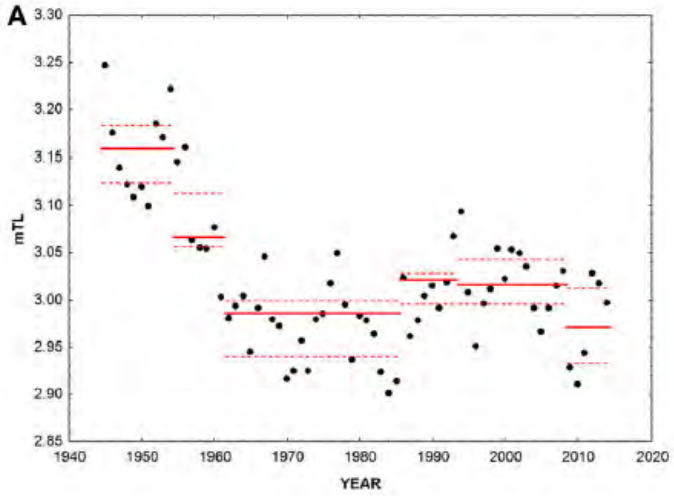
Fig. 1. Global trends of mean trophic level of fisheries landings, 1950 to 1994. (**A**) Marine areas; (**B**) inland areas.

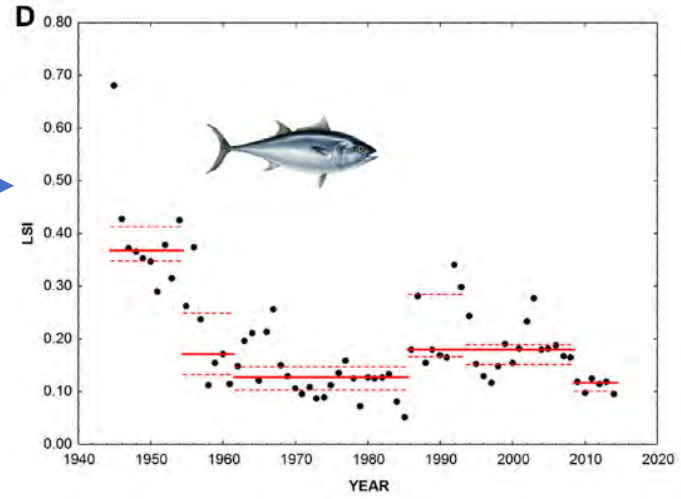
At global level

The mean trophic level of the species groups reported in Food and Agricultural Organization global fisheries statistics declined from 1950 to 1994. This reflects a gradual transition in landings from long-lived, high trophic level, piscivorous bottom fish toward short-lived, low trophic level invertebrates and planktivorous pelagic fish. (Pauly et al., 1998).

At local level

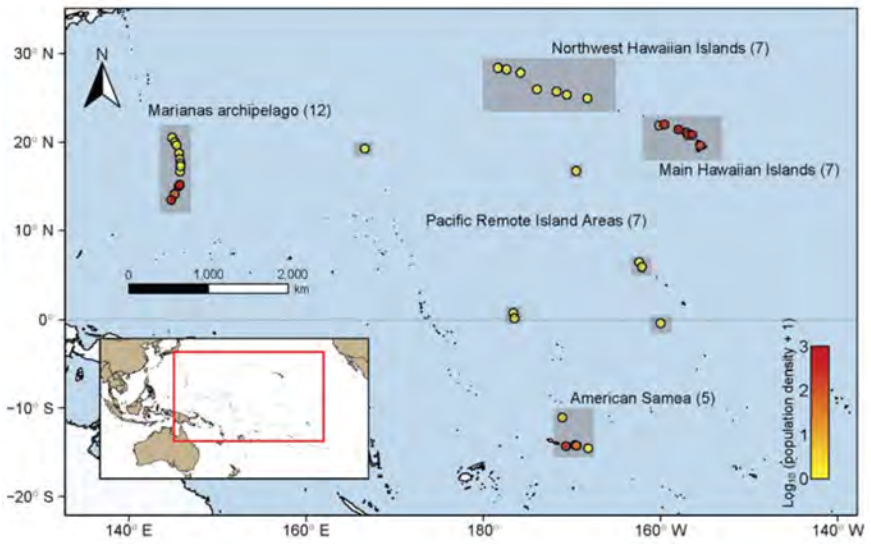
The mean trophic level of the catches in Chioggia's fleet (in the Northern Adriatic Sea; one of the biggest in Italy) declined considerably from 1945 to 2018 together with large fish and elasmobranches (Fortibuoni et al., 2017)

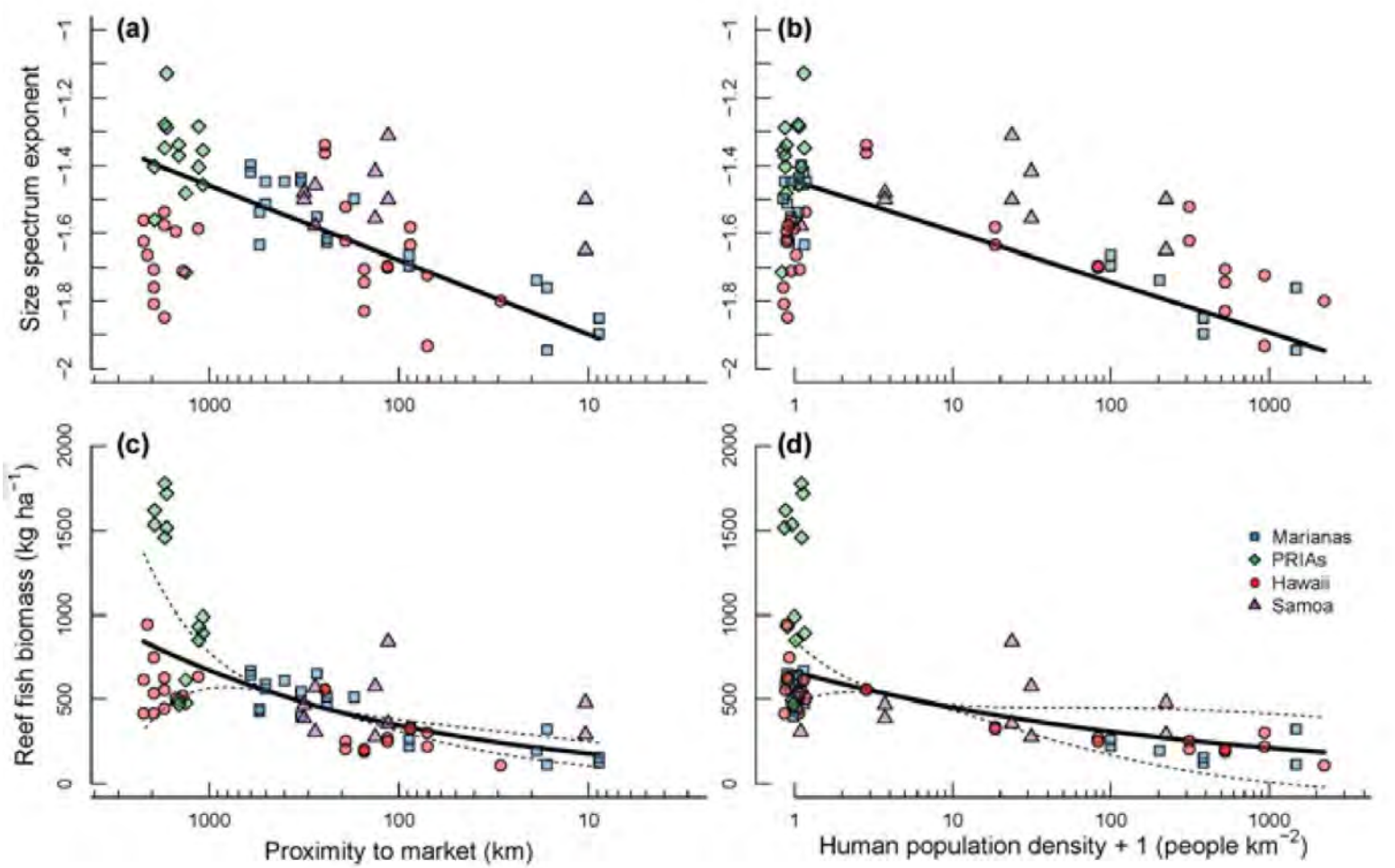




Effects of fishing (4): decline of species fish size

By selectively target larger individuals, fisheries tend to impact the average size of the marine populations, by selecting smaller and smaller individuals.

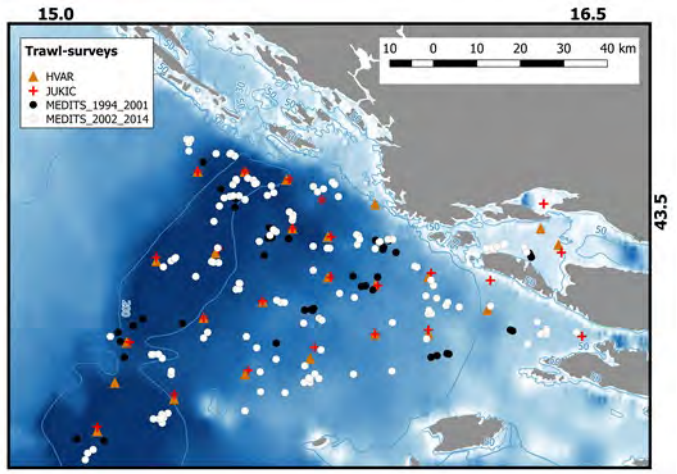


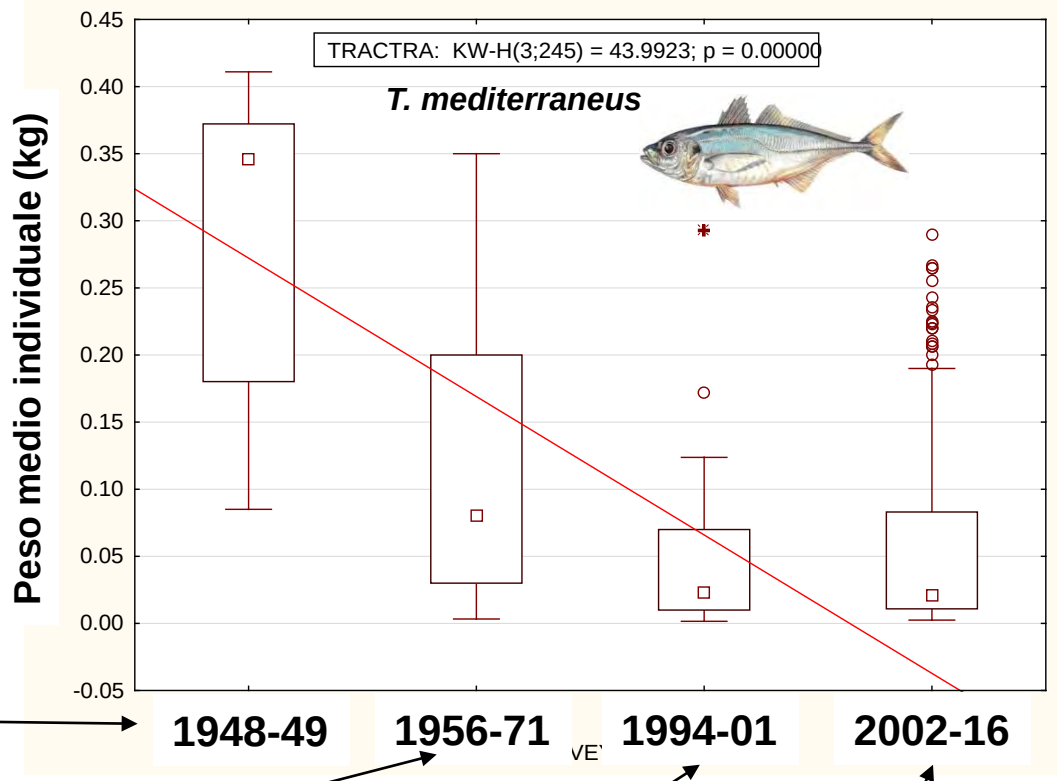


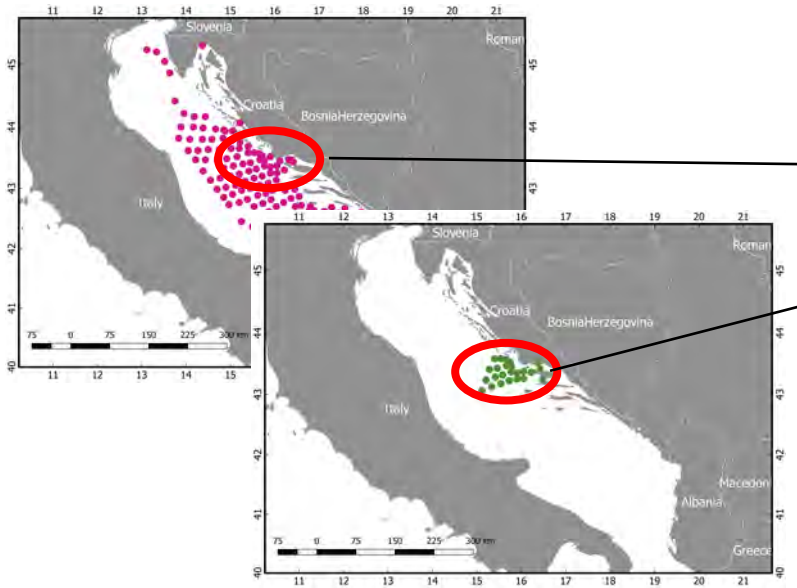
Robinson et al., Global Change Biology, 2016

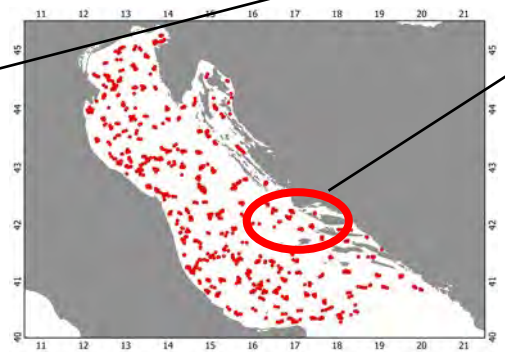
Effects of fishing (4): decline of species fish size

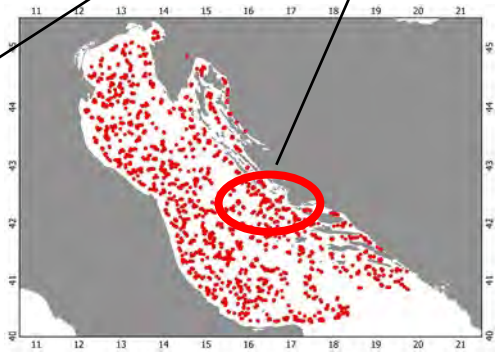
Decline of body size has been detected for many species. Historical declines might be more likely connected with fishing activities but recent decrease of size cannot be disentangled easily from effects of climate change





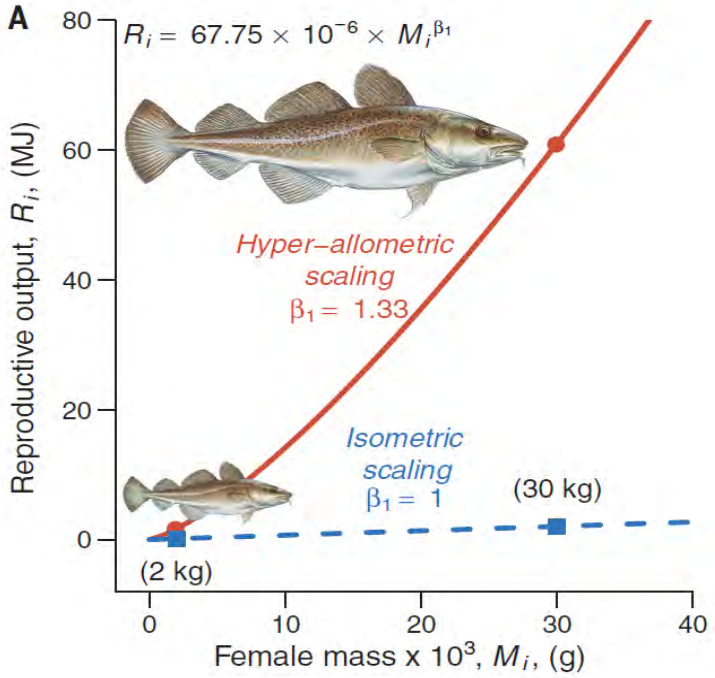


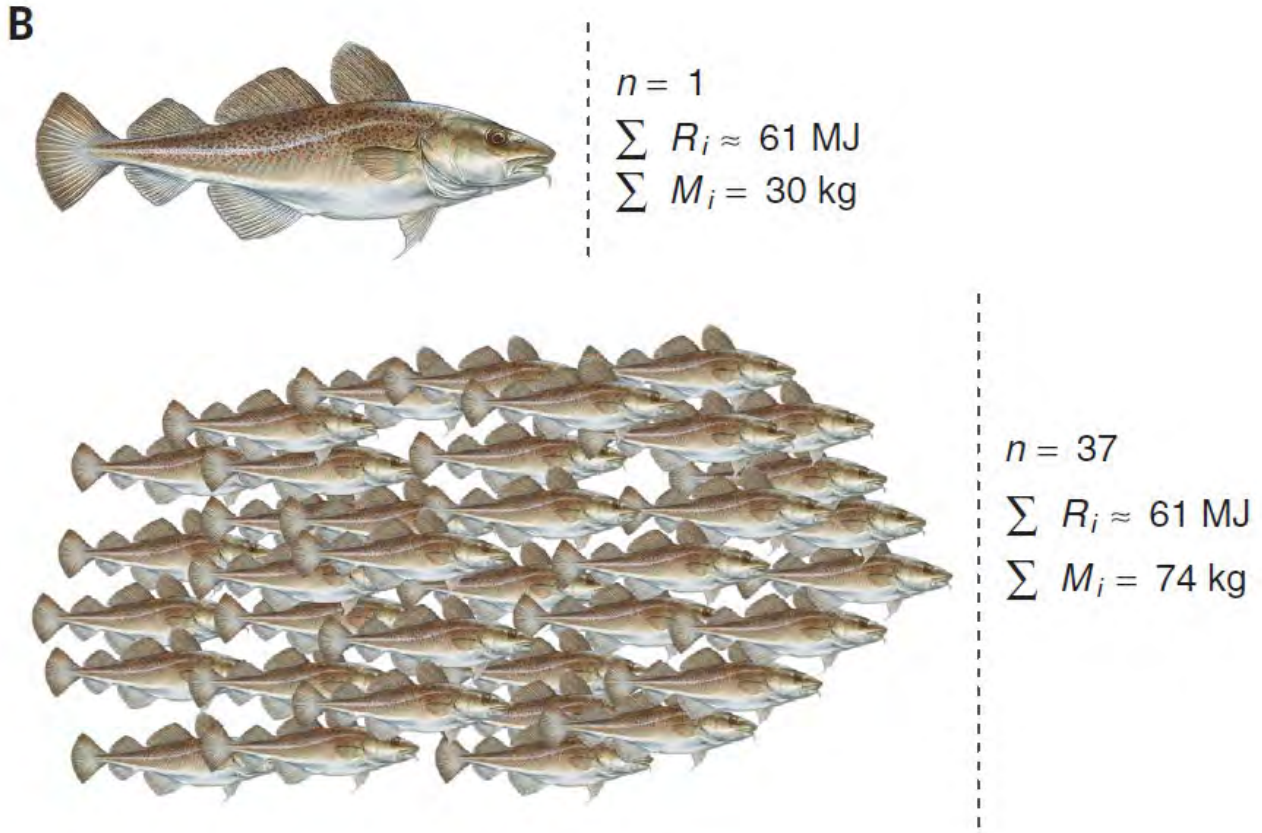




Effects of fishing (5): removing large individuals imply reduction of the reproductive capacities of the species

Reproductive output (eggs) is non-linear increasing function of weight (hyper-allometric). Therefore a large individual (large spawners) have much more reproductive potential than several small ones.

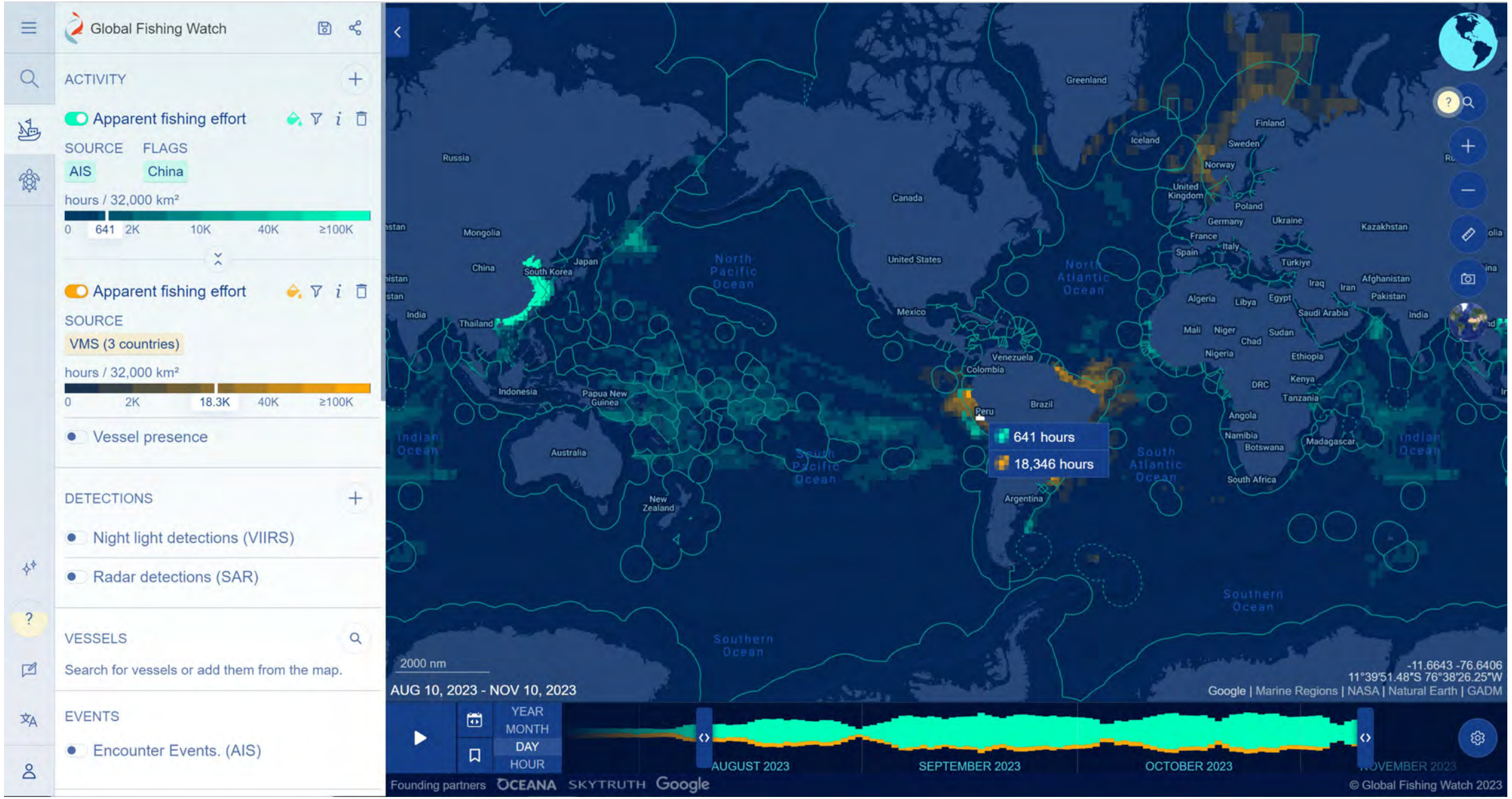




Barneche et al (2018). Fish reproductive-energy output increases disproportionately with body size. *Science*, *360*(6389), 642-645.

Uncontrolled fisheries goes everywhere today

Expansion of fisheries (see www.globalfishwatch.org)



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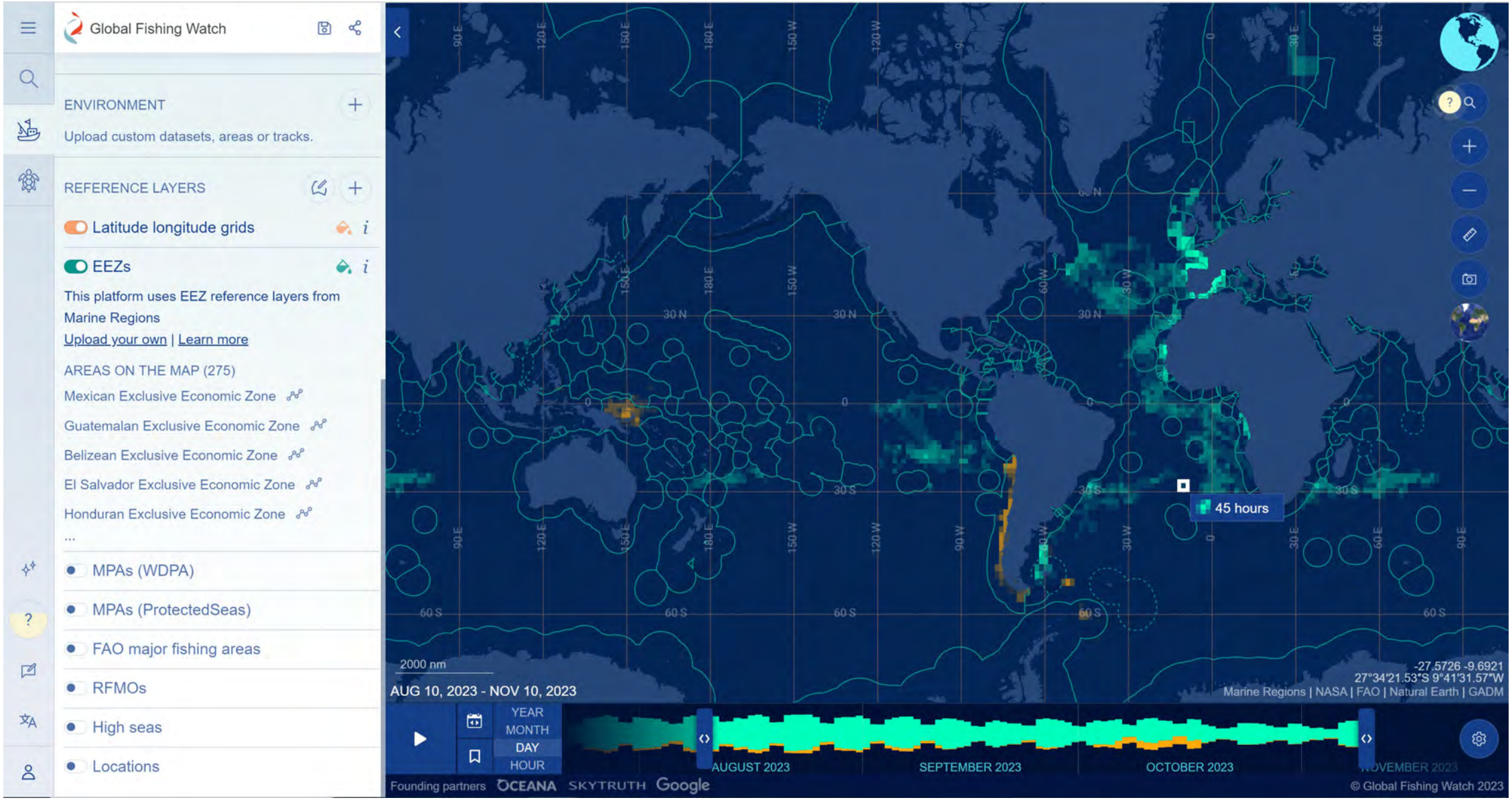

Worldwide depletion of large predatory fish

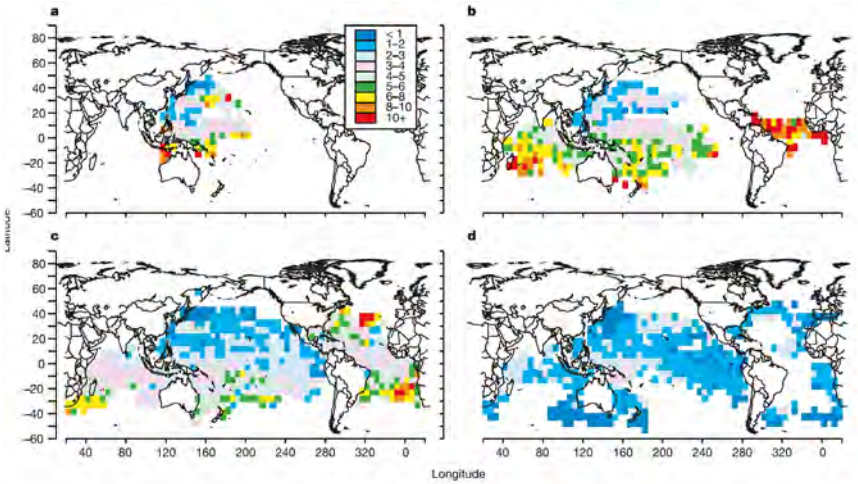

Figure 2 Spatial patterns of relative predator biomass in 1952 (**a**), 1958 (**b**), 1964 (**c**) and 1980 (**d**). Colour codes depict the number of fish caught per 100 hooks on pelagic longlines set by the Japanese fleet. Data are binned in a global 5° × 5° grid. For complete year-by-year maps, refer to the Supplementary Information.

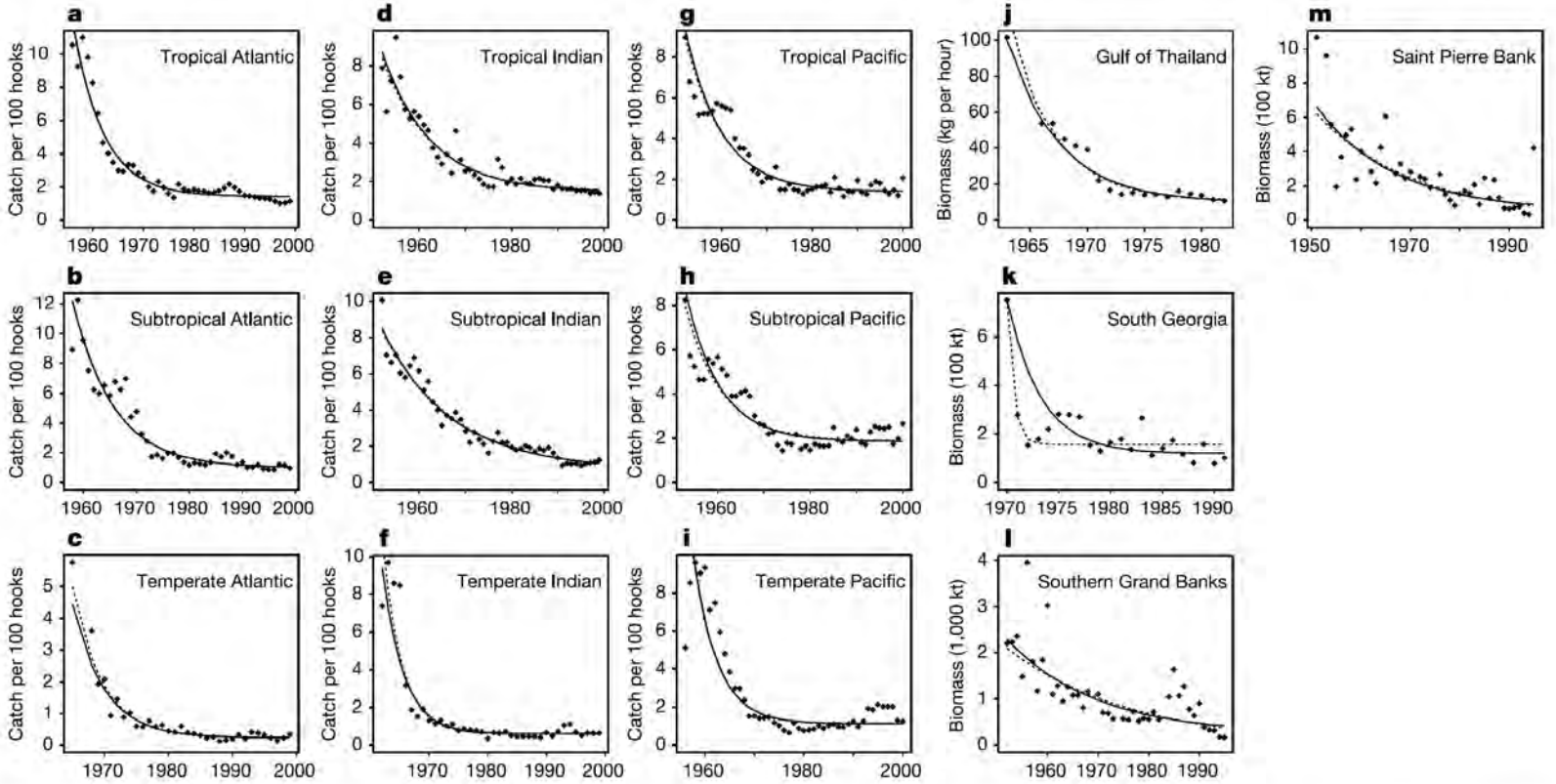

Figure 1 Time trends of community biomass in oceanic (**a**–**i**) and shelf (**j**–**m**) ecosystems. Relative biomass estimates from the beginning of industrialized fishing (solid points) are shown with superimposed fitted curves from individual maximum-likelihood fits (solid lines) and empirical Bayes predictions from a mixed-model fit (dashed lines).

Myers and Worm (2003). Rapid worldwide depletion of predatory fish communities. *Nature*.

i) Introduzione alla gestione dello sfruttamento delle risorse alieutiche, problematiche generali, stato delle risorse, targets internazionali.

Importanza dello sfruttamento delle risorse alieutiche

Perché è necessario gestire lo sfruttamento (problematiche)

Problematica generale: open access, rinnovabilitá, sostenibilitá

ii) Massimo rendimento sostenibile, sforzo di pesca, mortalità da pesca, costi, rendimento economico. *esercizi*