The Ocean as a System

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The Ocean:
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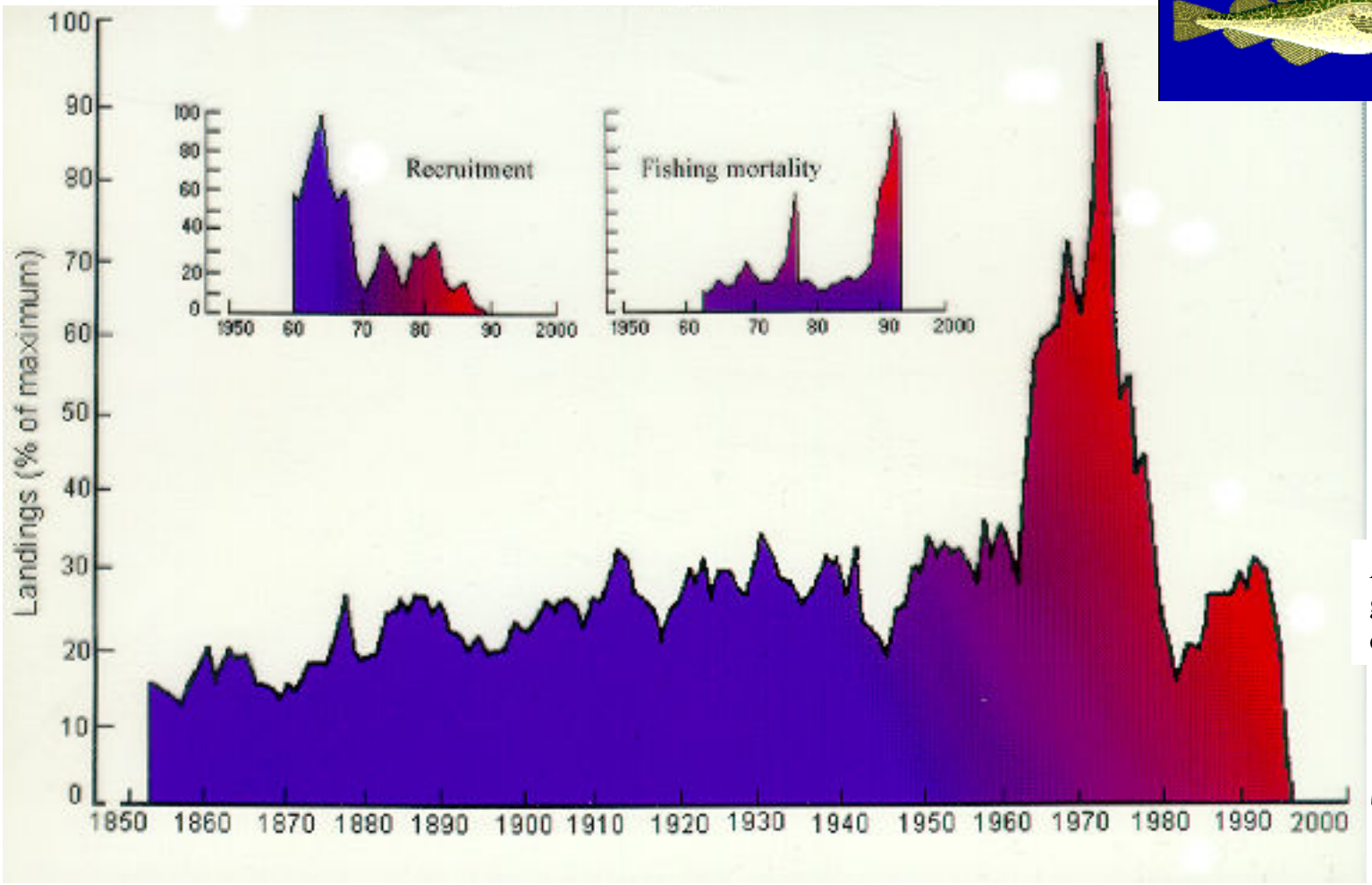
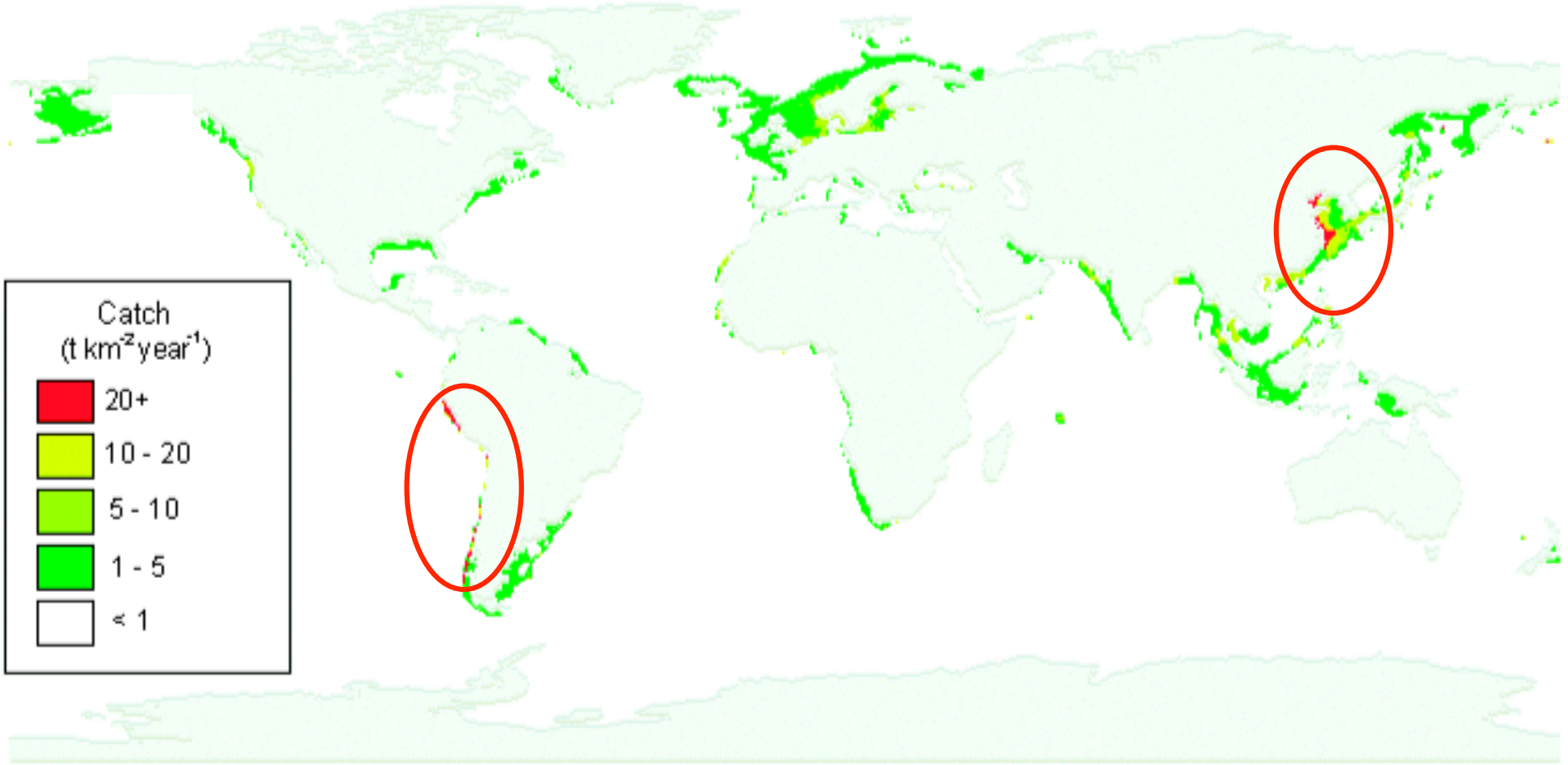
Institut océanographique de Paris,
April, 28-29, 2011

This graph, illustrating a Canadian tragedy, leads to several questions. One of them is: how typical is the story of the Northern cod fishery? Can we generalize?



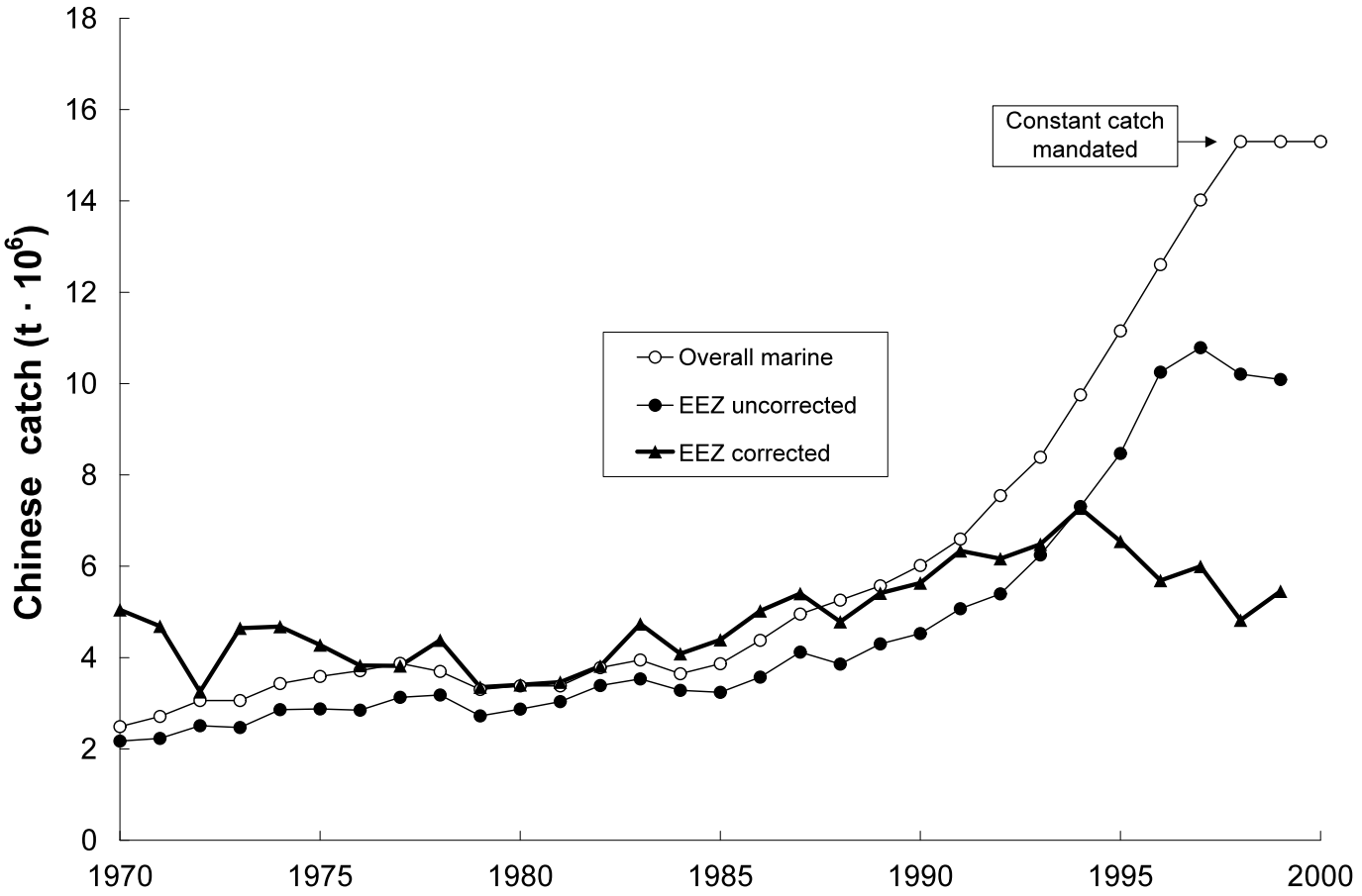
And it goes on!

This can be done by mapping fisheries. This is the first map we got. It was not very exciting, except for the anomalies (red)….



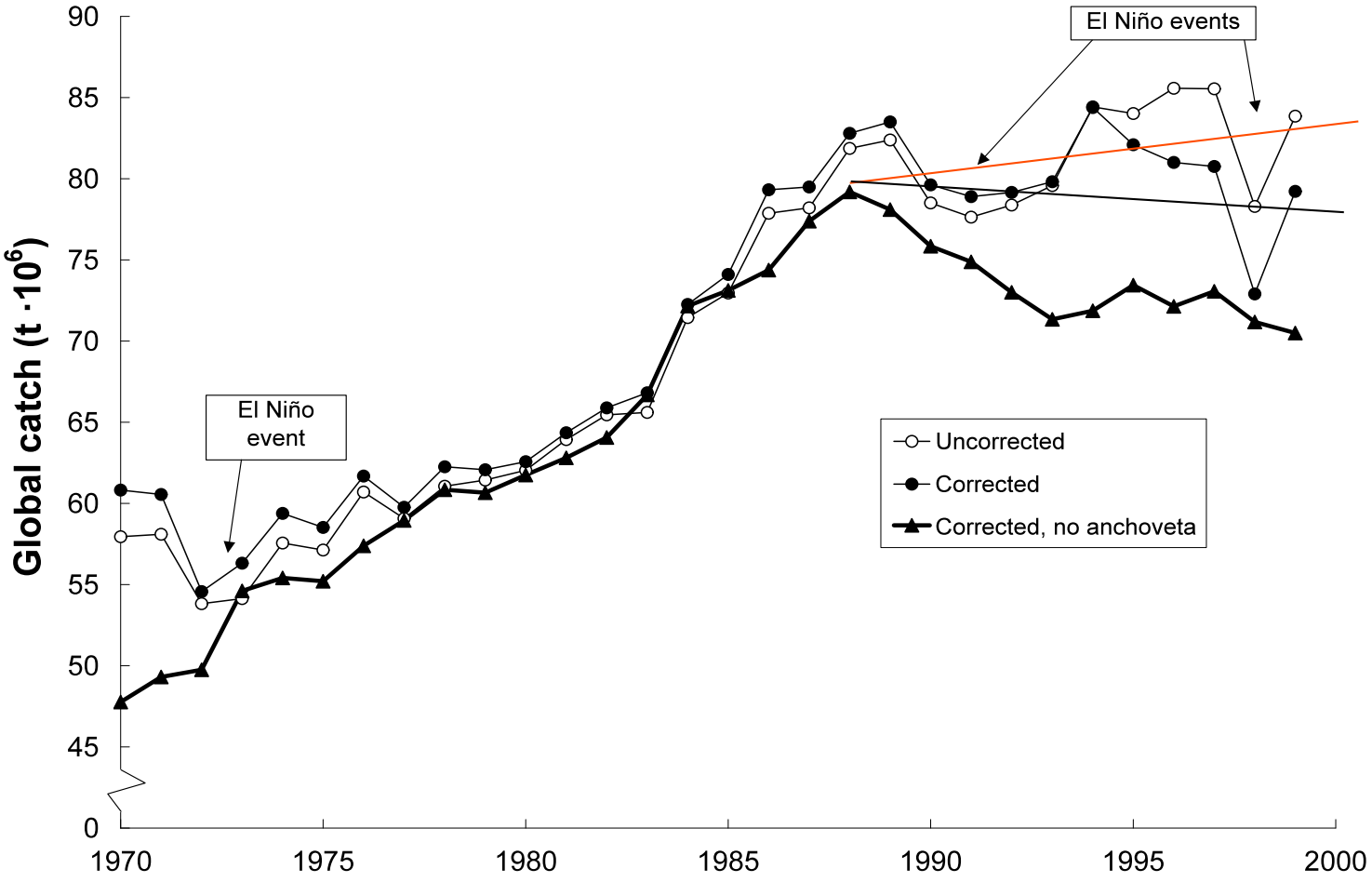
We had no problem with Peruvian and Chilean waters being extremely productive. But China?

The reason for the observed discrepancy was that China grossly over-reported its marine fisheries catches throughout the 1990s …



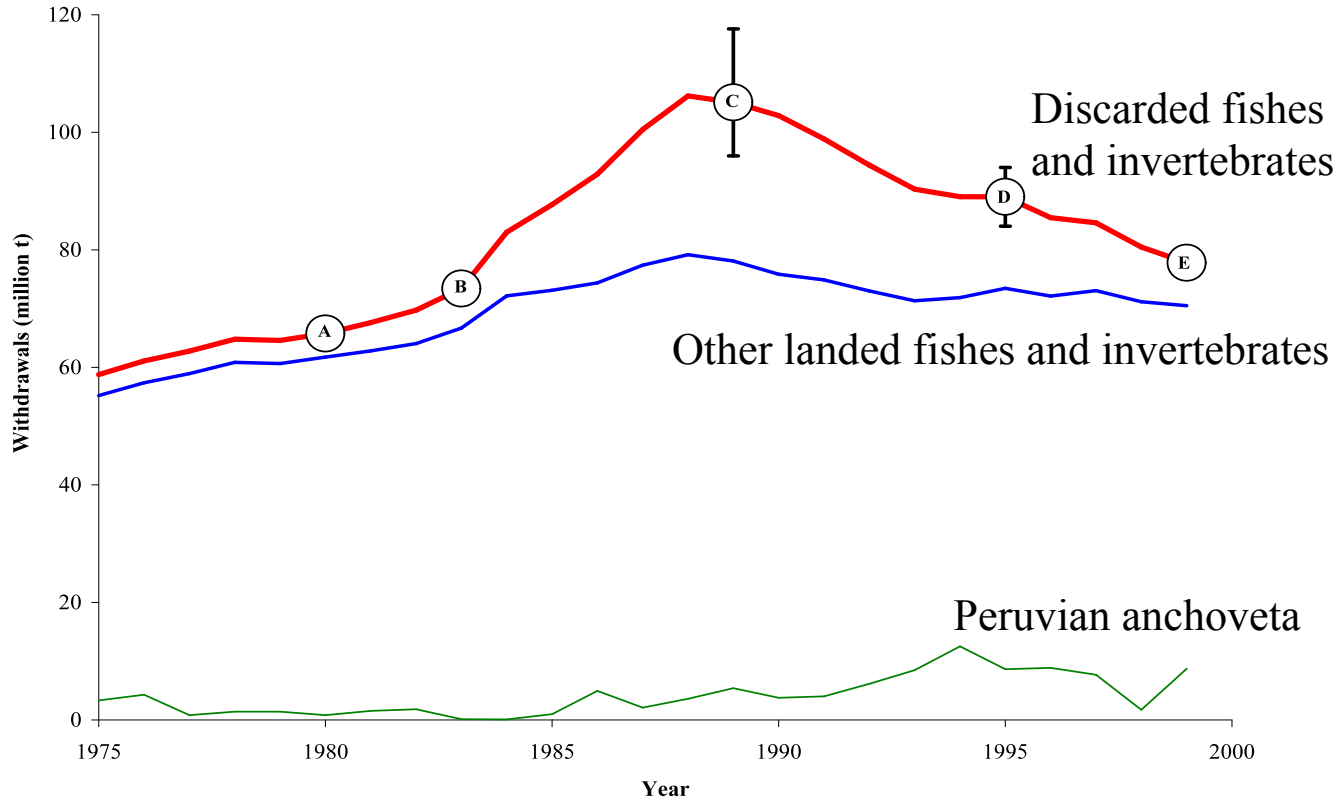
(Watson & Pauly, *Nature*, 2001).

Thus, global fisheries landings, despite (or because of) increasing effort, have been declining since the late 1980s, a fact long hidden by over-reporting from China:



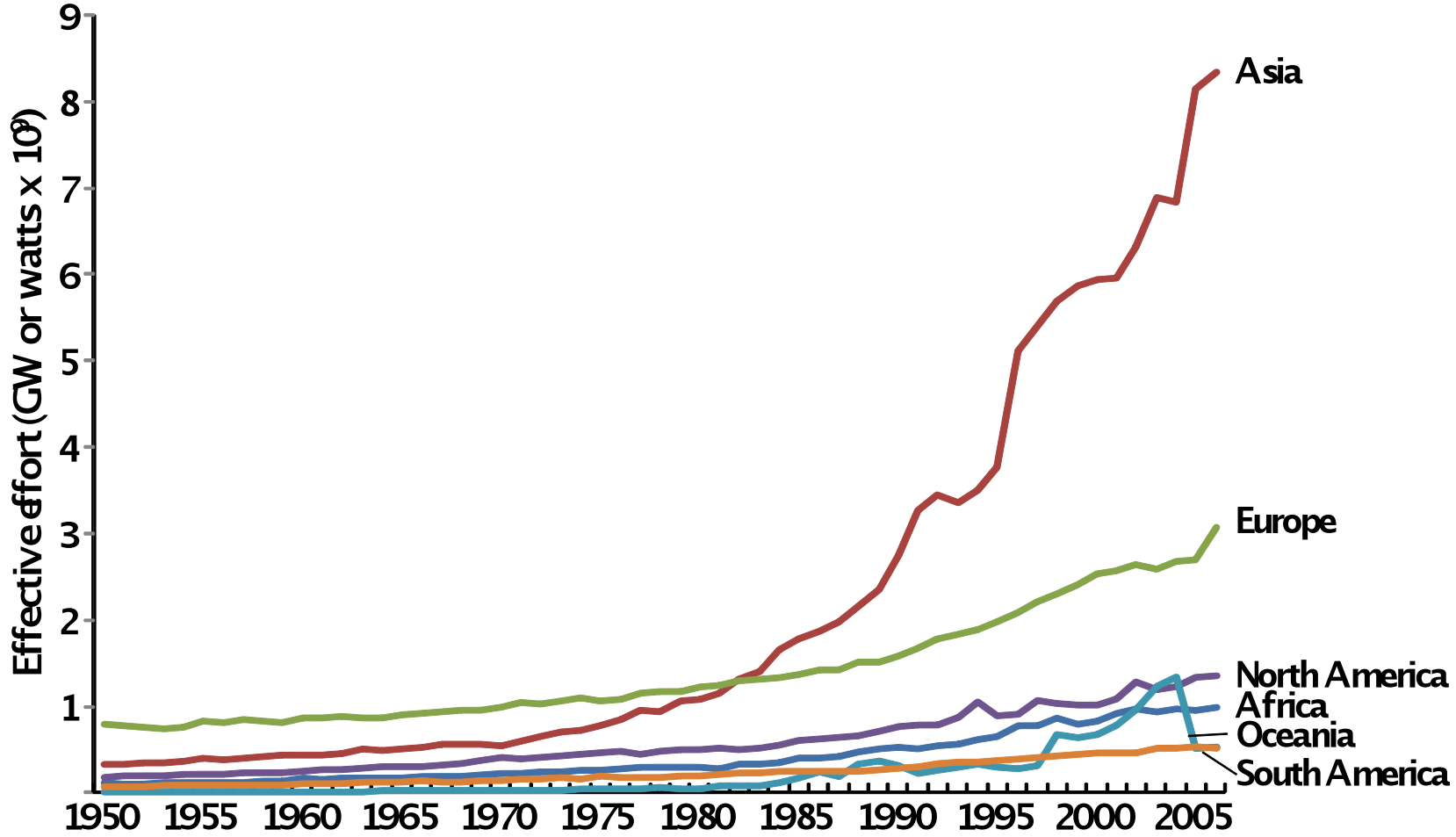
Watson and Pauly (*Nature)*, 2001.

In fact, the decline is even stronger if one considers discarded fish. This was generally overlooked when FAO's last estimate of discards (dot E; 7-8 million t) was released.

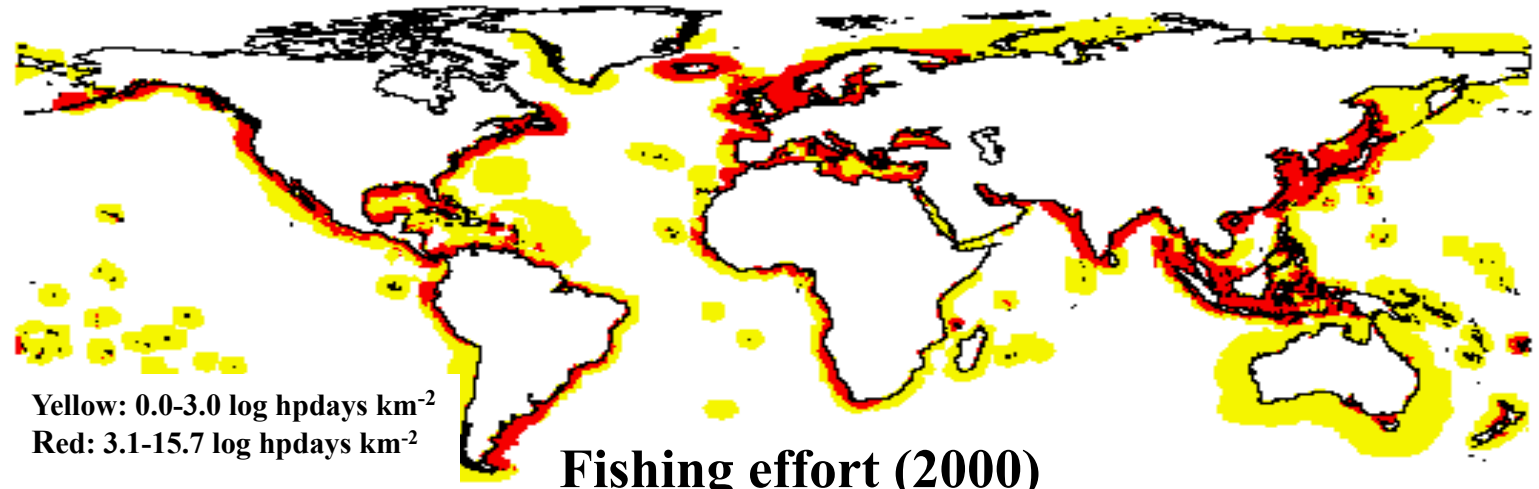


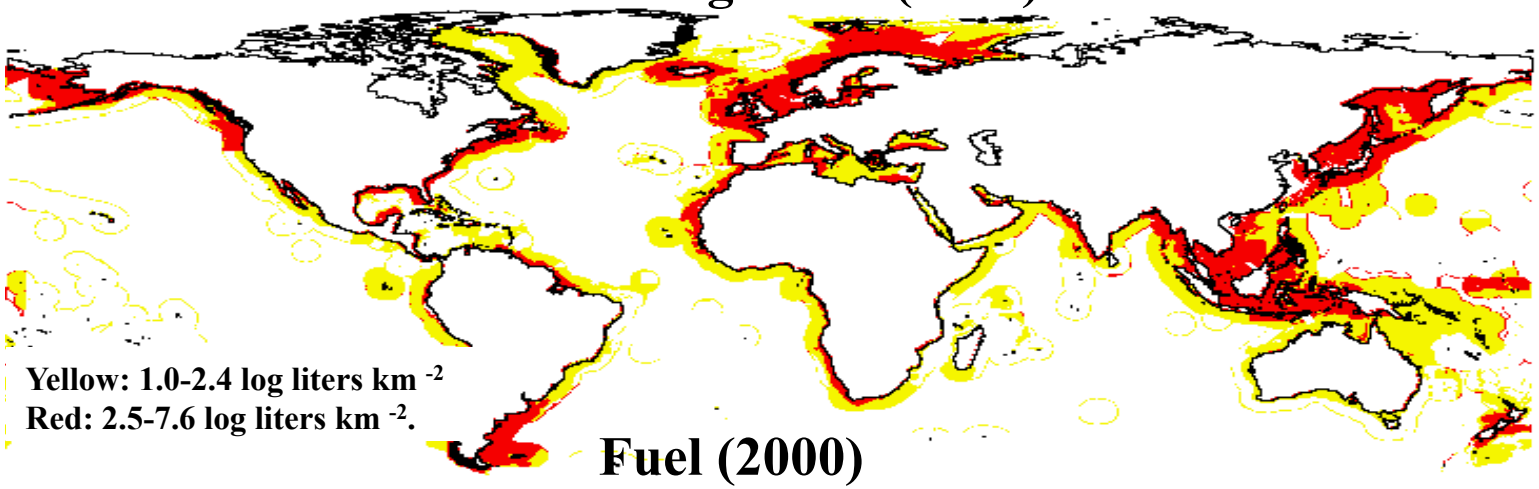
Zeller and Pauly (*Fish & Fisheries,* 2005)

Growth of ‘effective’ fishing effort, 1950-2006



It is our overfishing which is the cause for these catch declines...

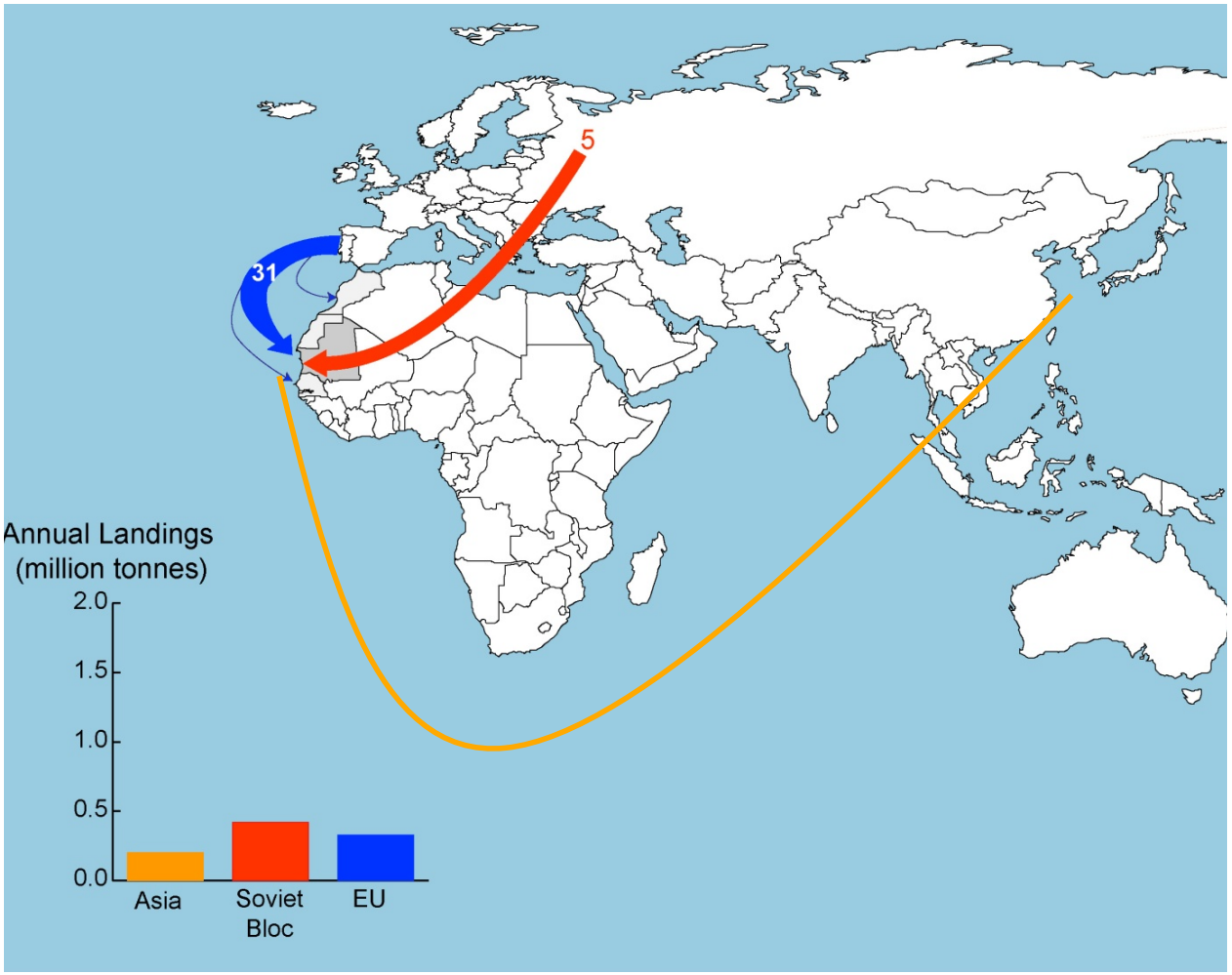




Effort data from Gelchu (2006); fuel data adapted from Tyedmers *et al.* (2005)

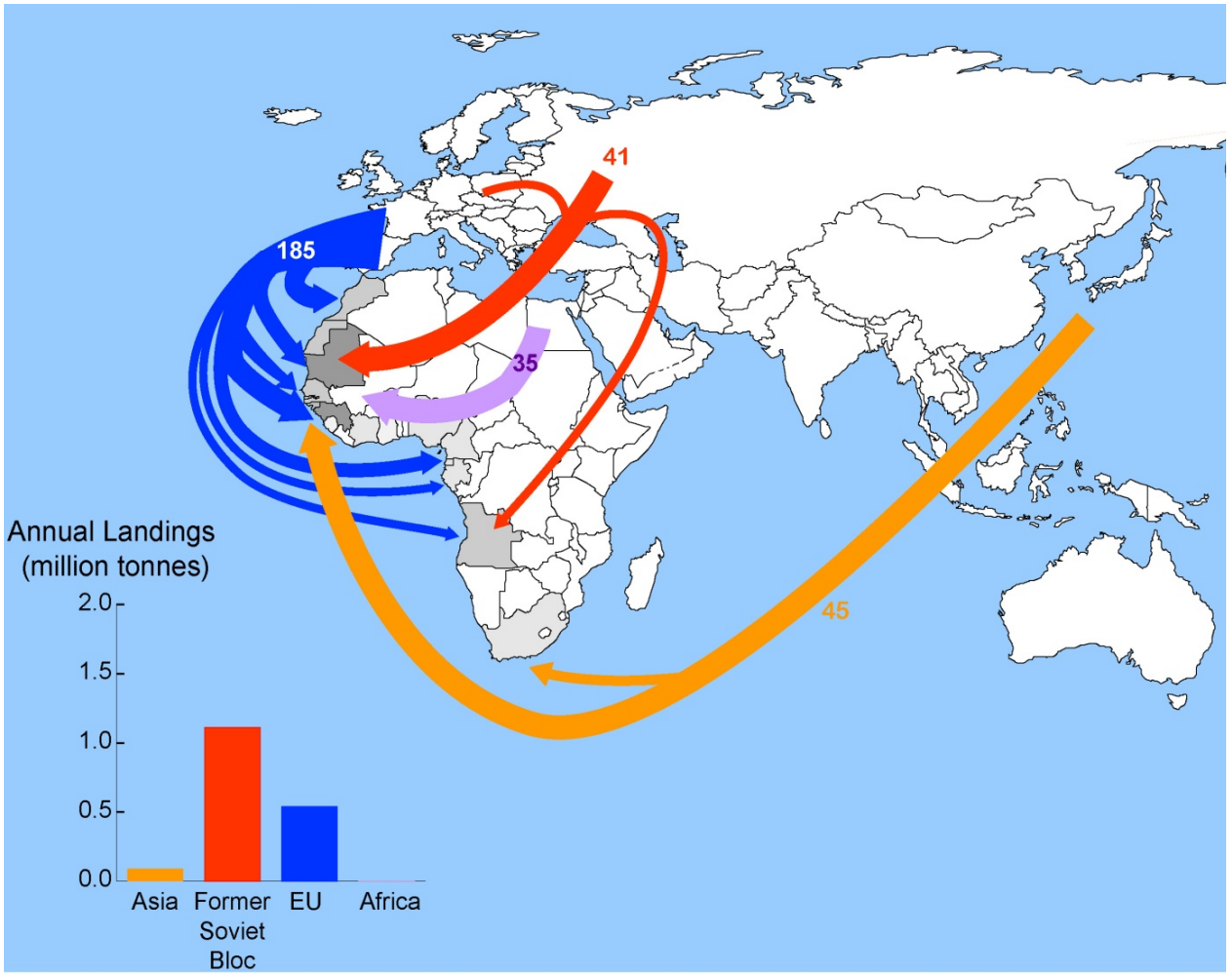
Historically, the answer to depletions was moving on, e.g., to West Africa, which has long attracted distant water fleets from other continents …

Number of ‘country access years’ by area, 1960-1969

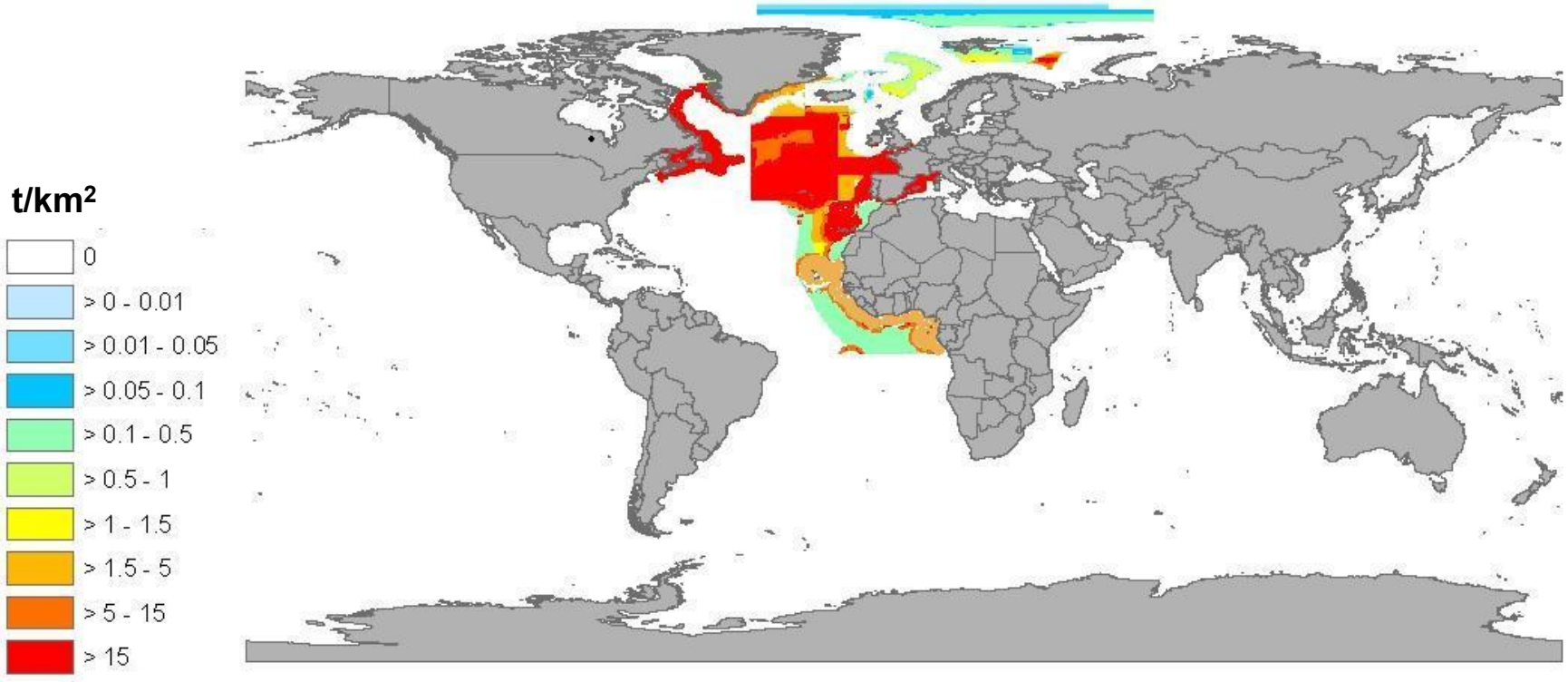


… which increased over the years, finally reaching the present, staggering levels.

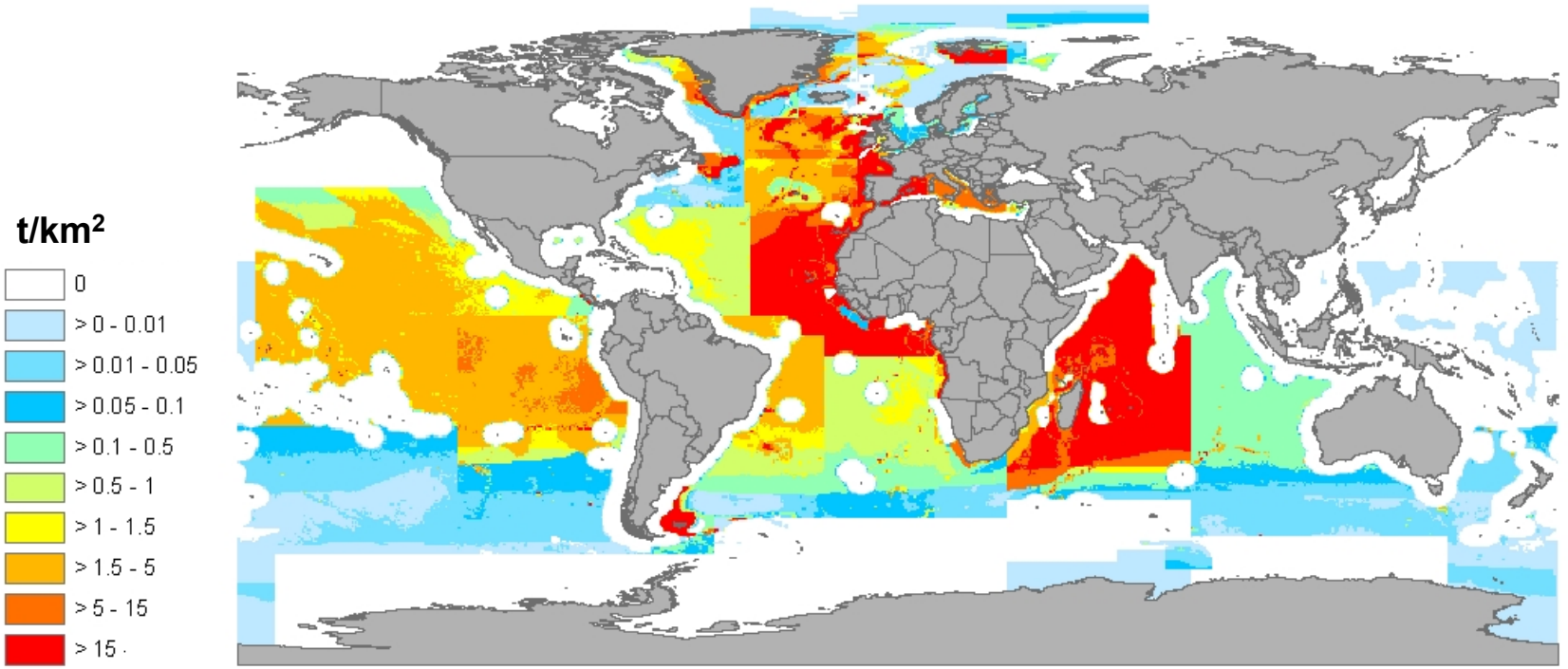
Number of ‘country access years’ by area, 1990-1999



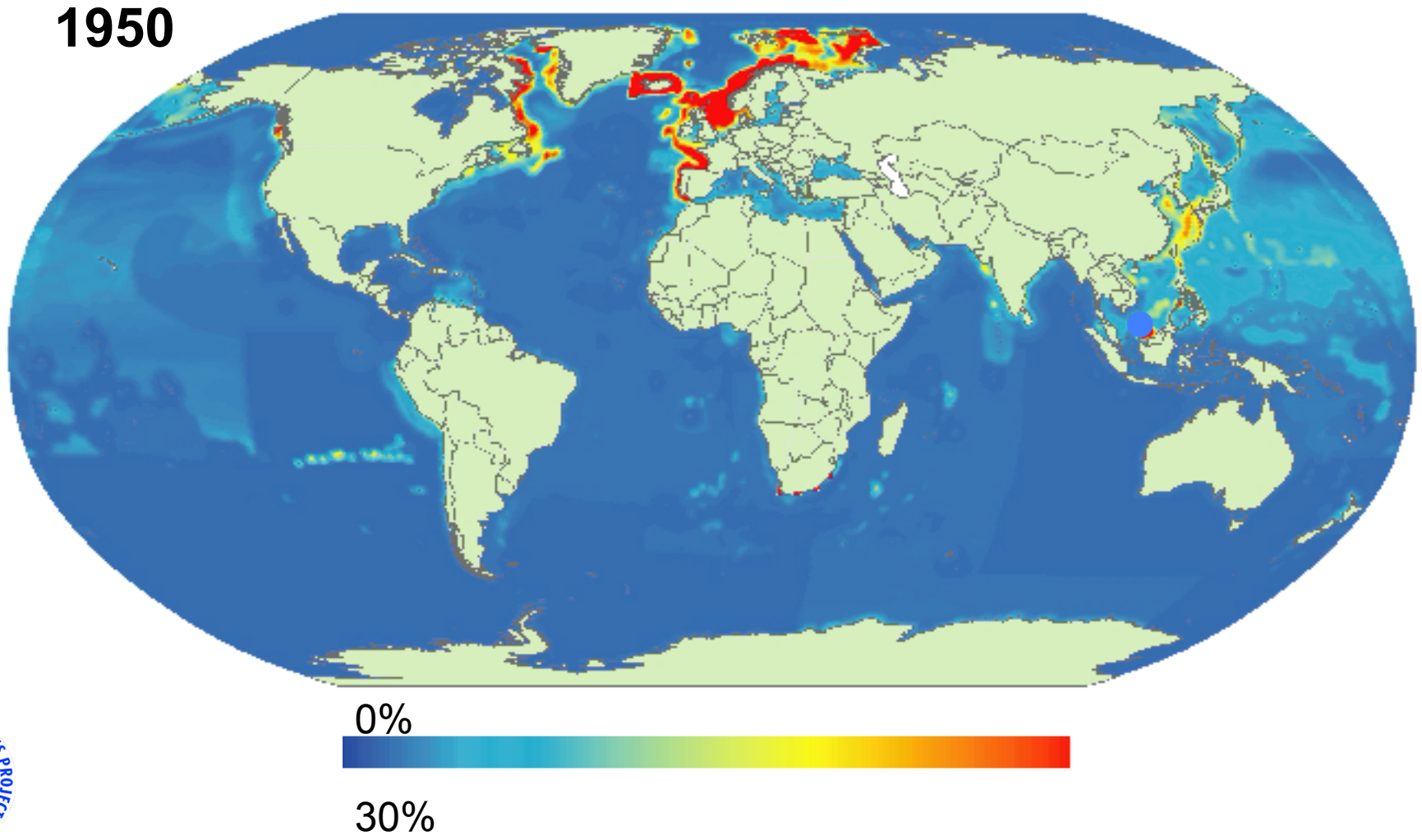
Catch intensity by Spain, 1950s



Catch intensity by Spain, 2000-2004

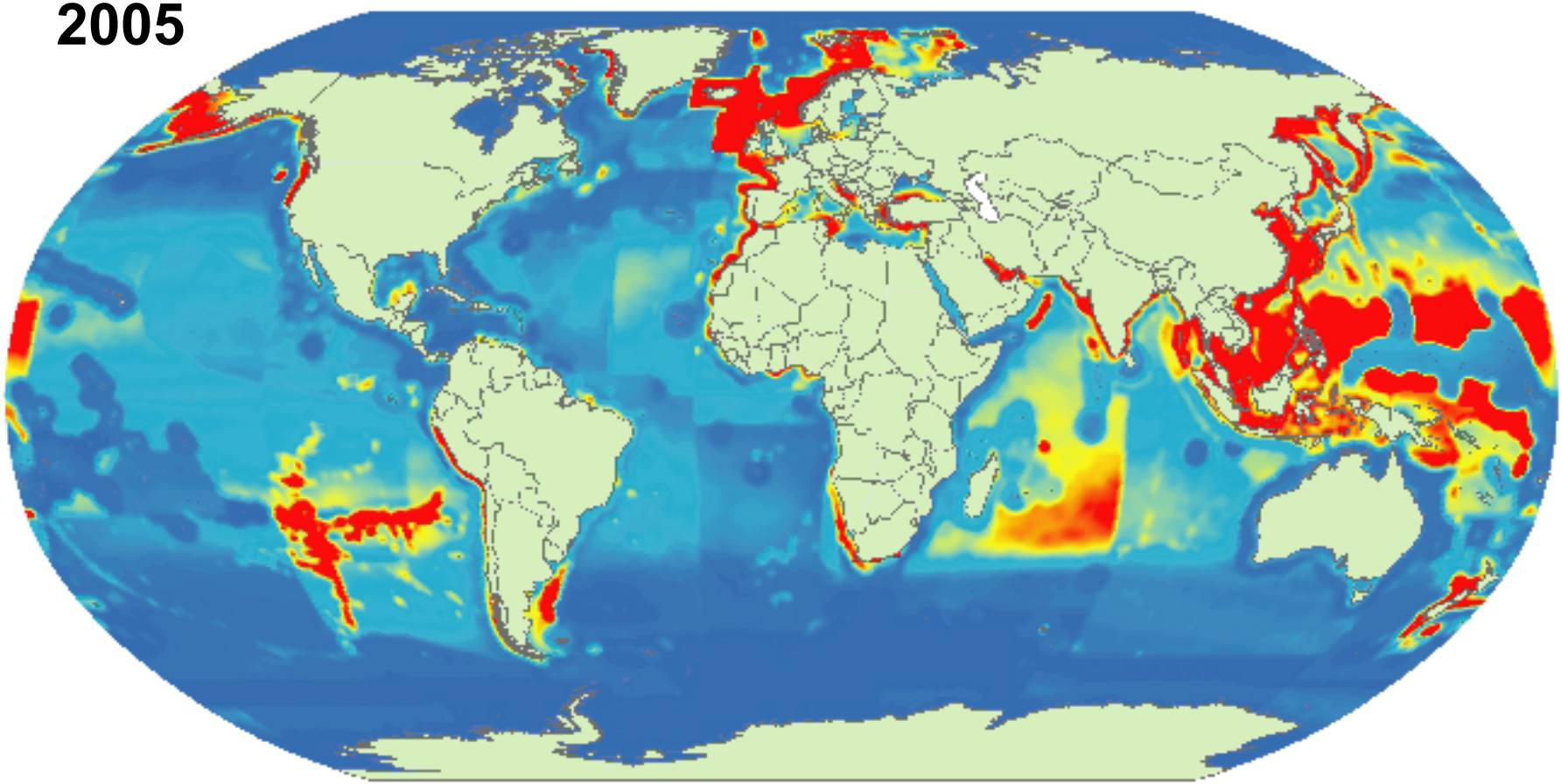


The expansion starts: marine ‘primary production’ required by fisheries in the 1950s…



The expansion continues: marine ‘primary production’ required by fisheries in the 2000s

2005

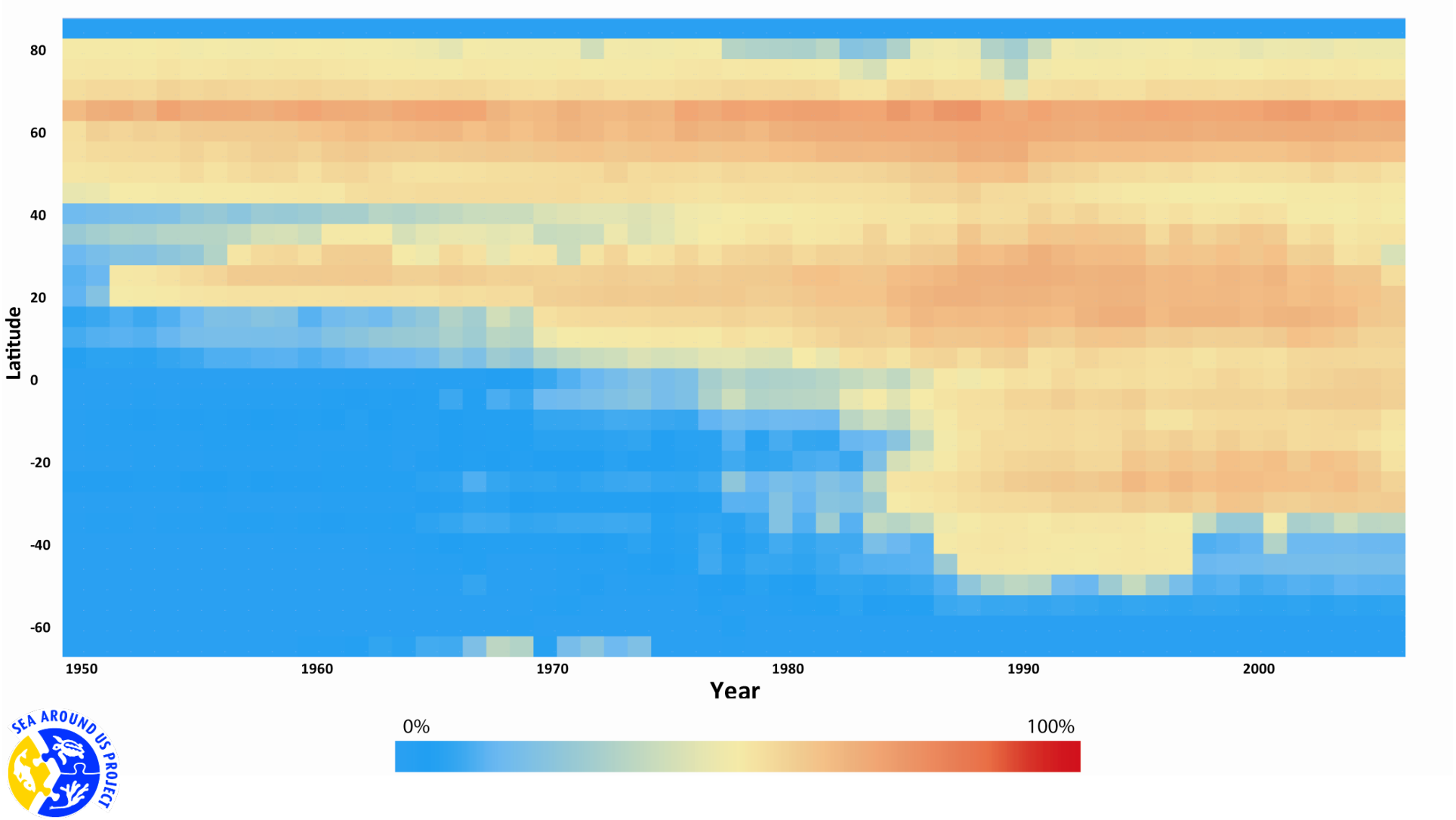


0%

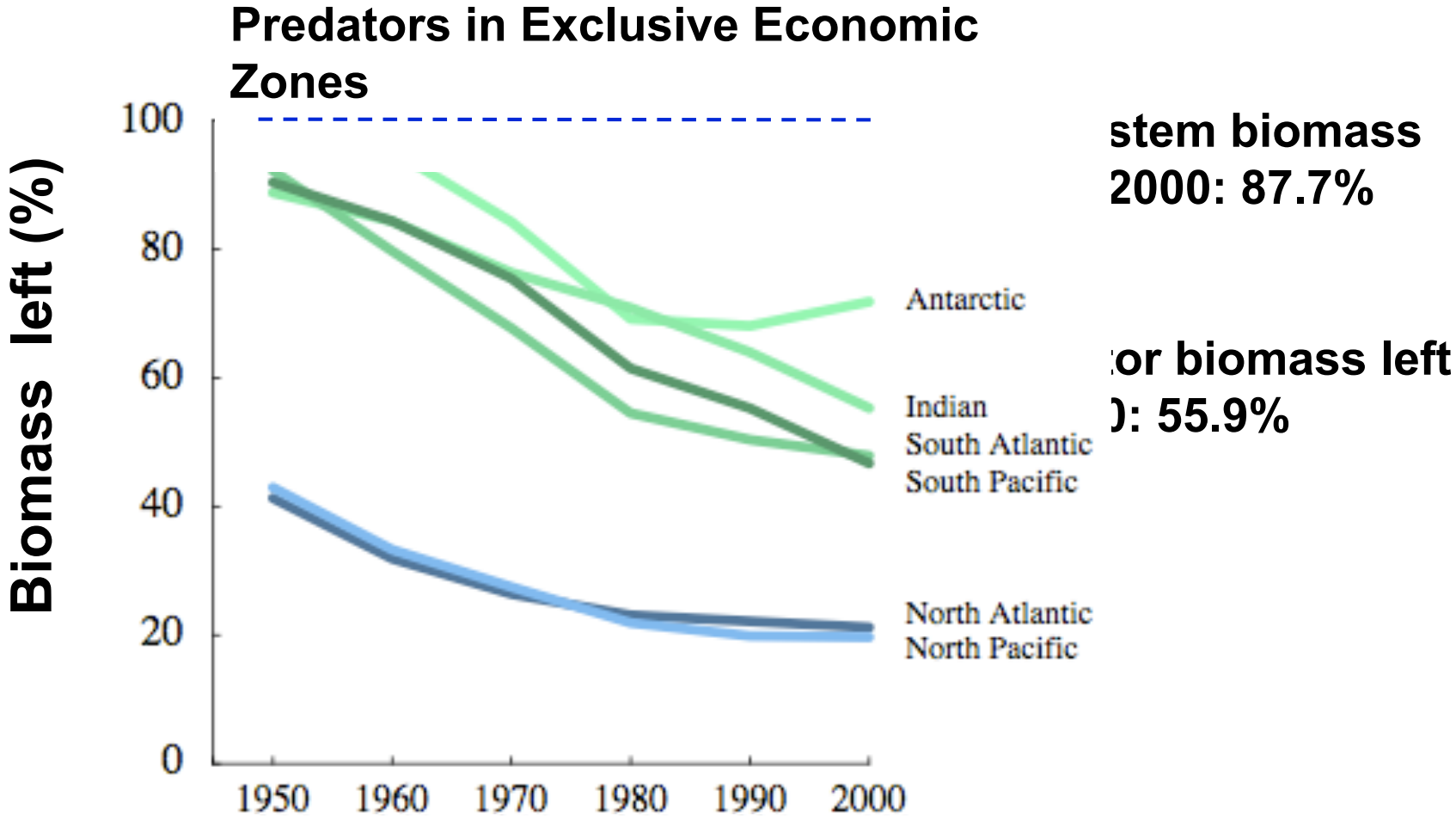
30%

Change in the fraction of the ocean under fisheries exploitation, 1950 to present

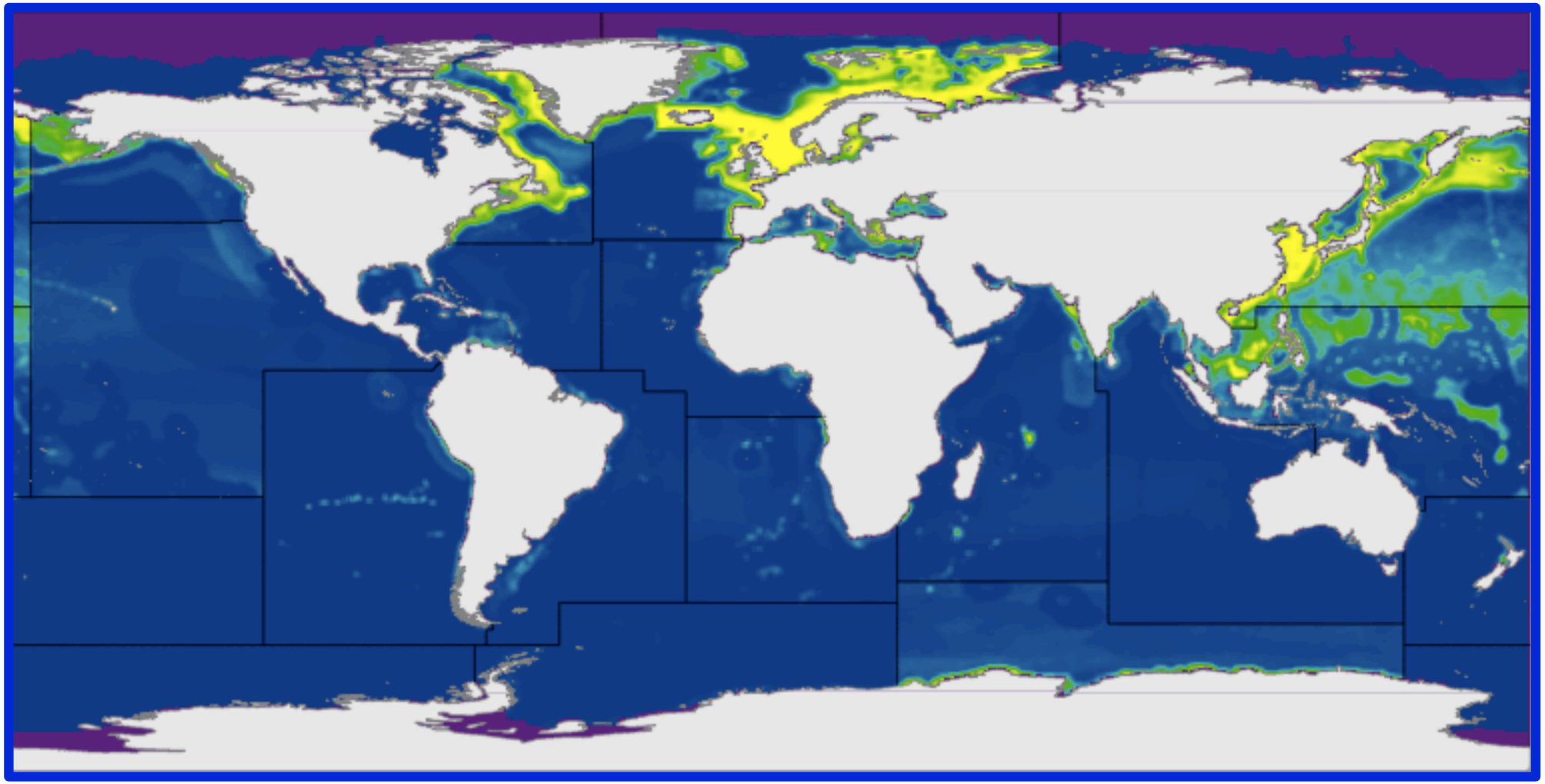
Fraction of the ocean exploited by fisheries, by latitude



The effect of all this fishing:



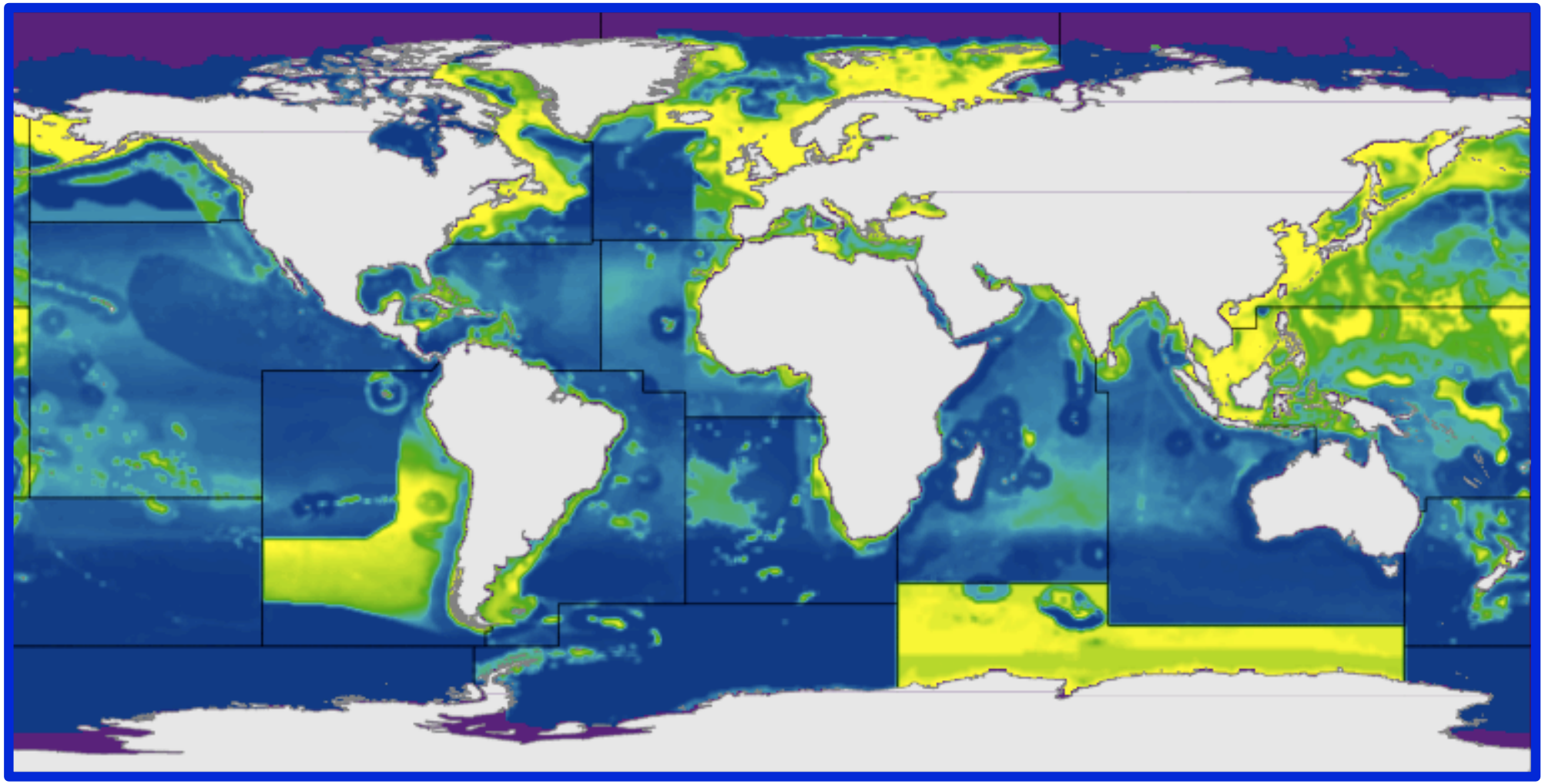
1950 1960 1970 1980 1990 2000



Predator biomass remaining (%):

100% 0%

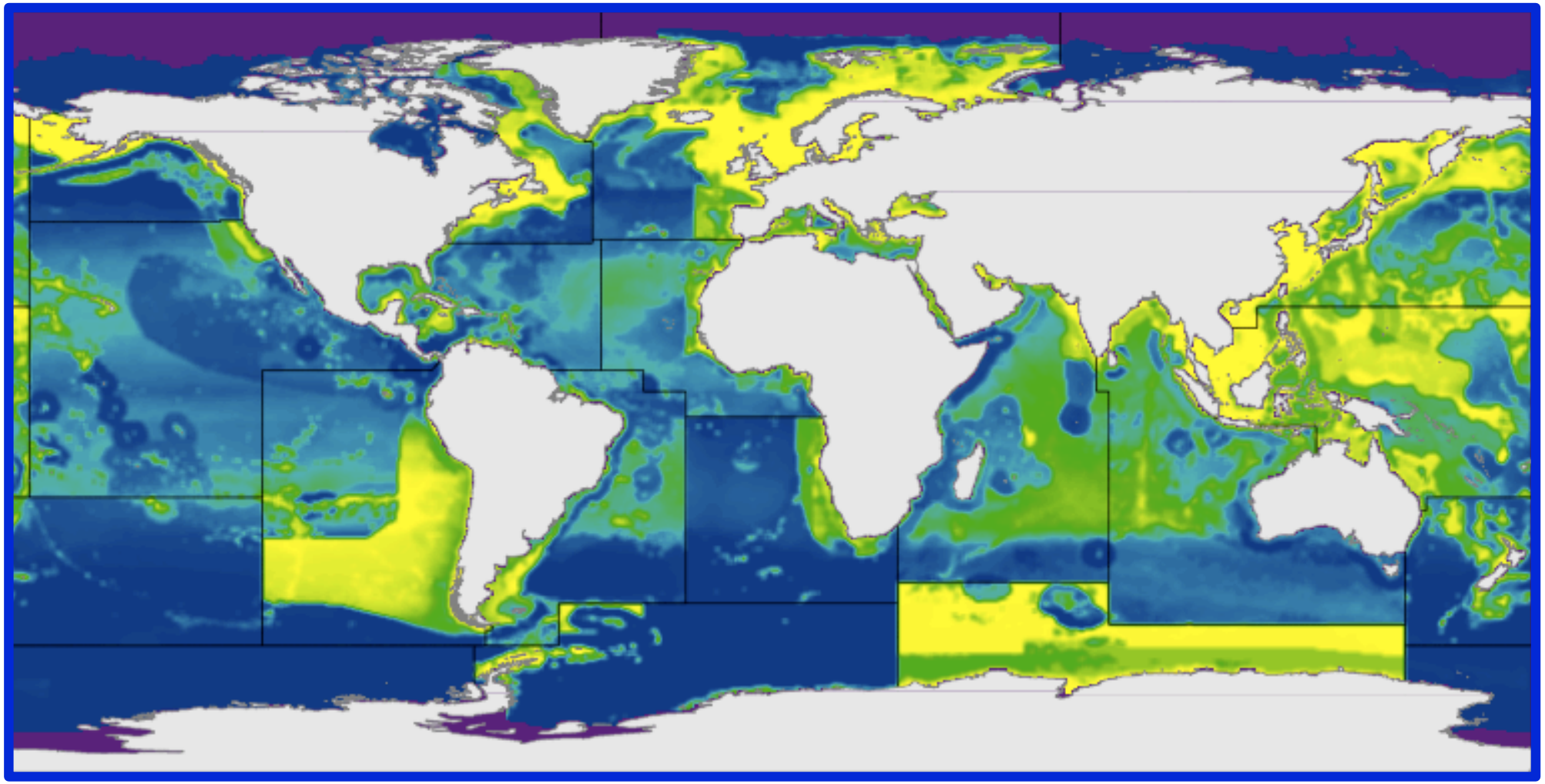
1950 1960 1970 1980 1990 2000



Predator biomass remaining (%):

100% 0%

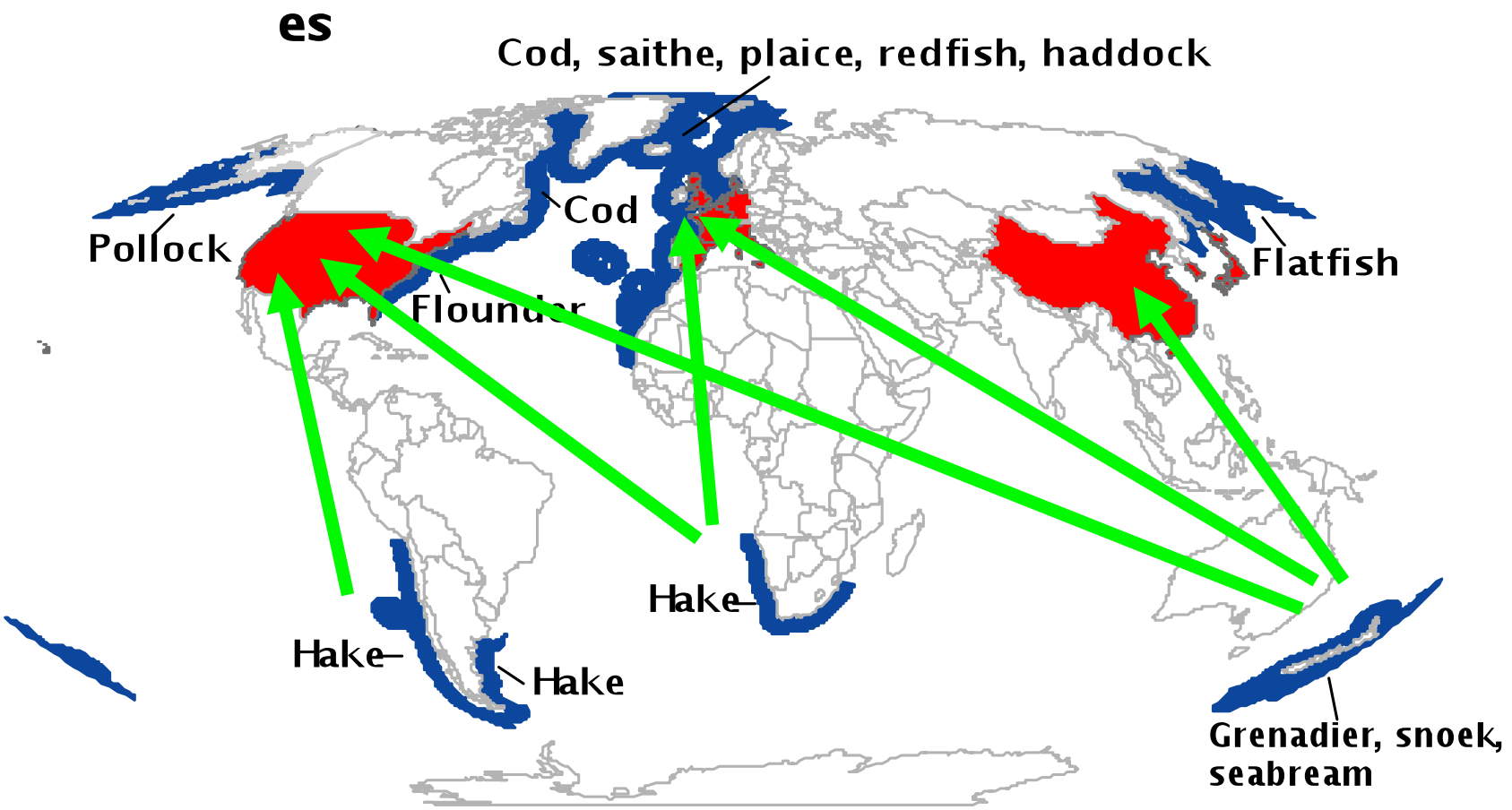
1950 1960 1970 1980 1990 2000



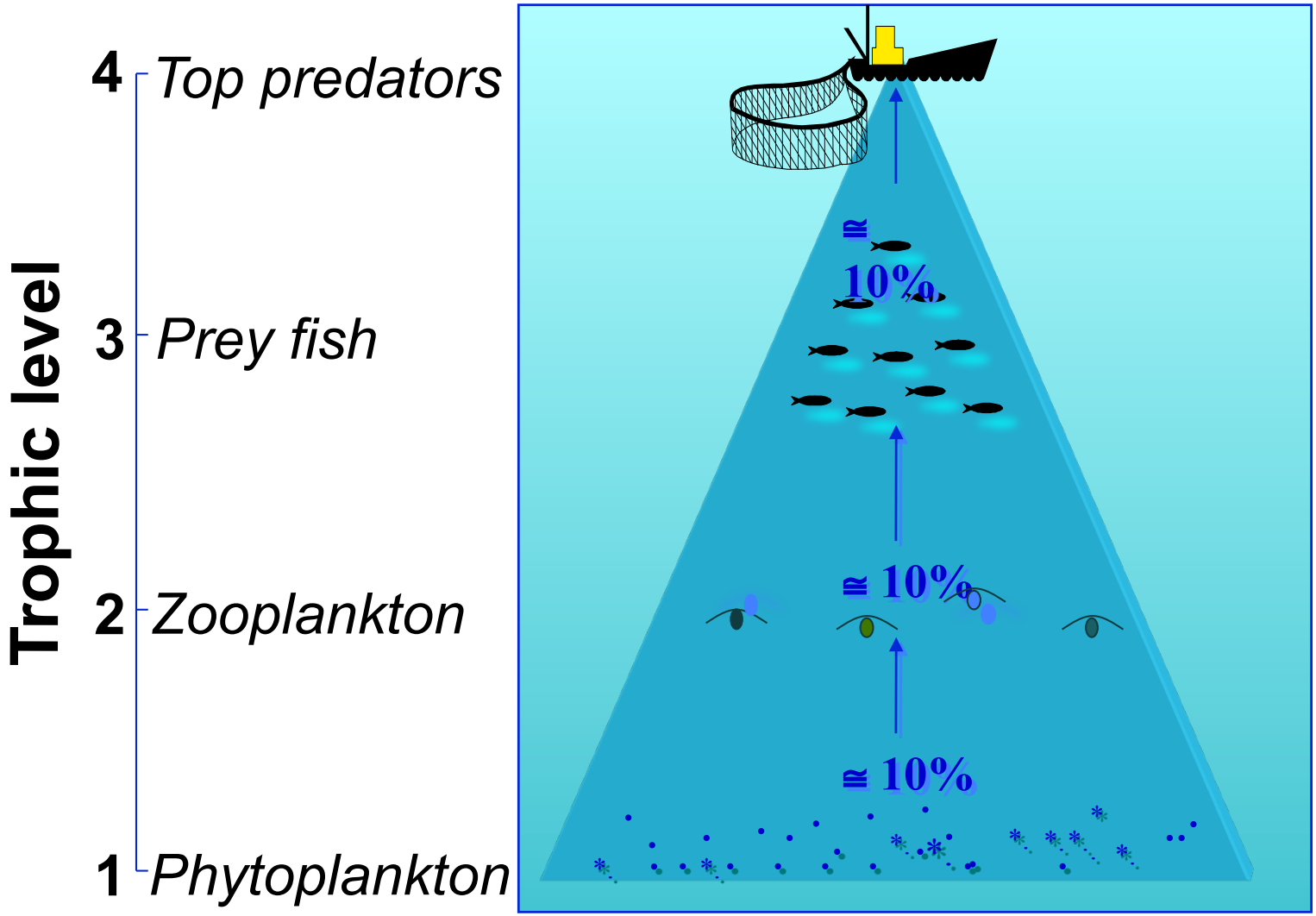
Predator biomass remaining (%):

100% 0%

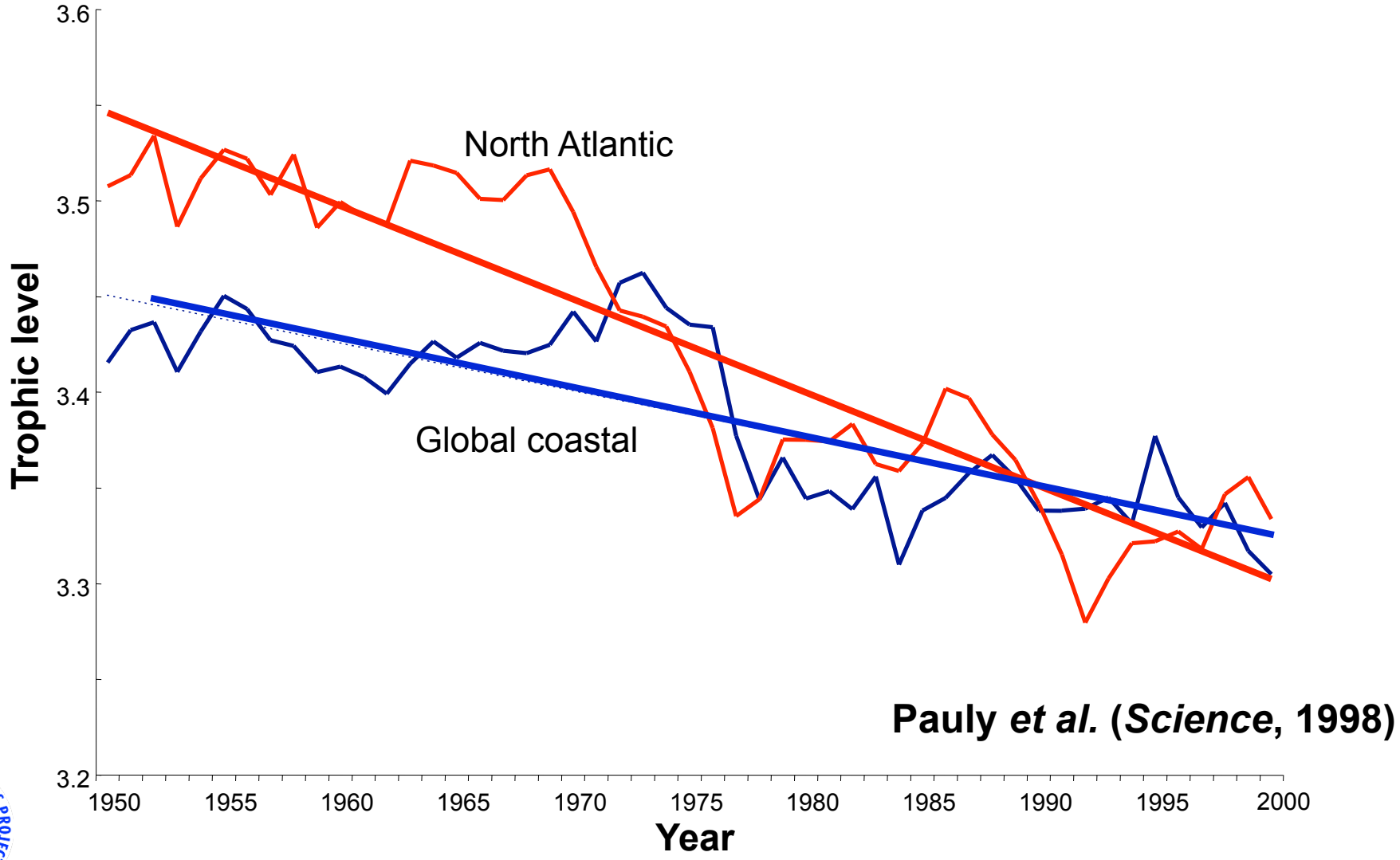
Consumers in the ‘North’ have not noticed these trends: while most seafood is traded between the EU, the USA and Northeast Asia, the ‘South’ has so far met the shortfall in the ‘North’….



But the ocean can't be fooled. Recall that ecosystems work as 'trophic pyramids'…

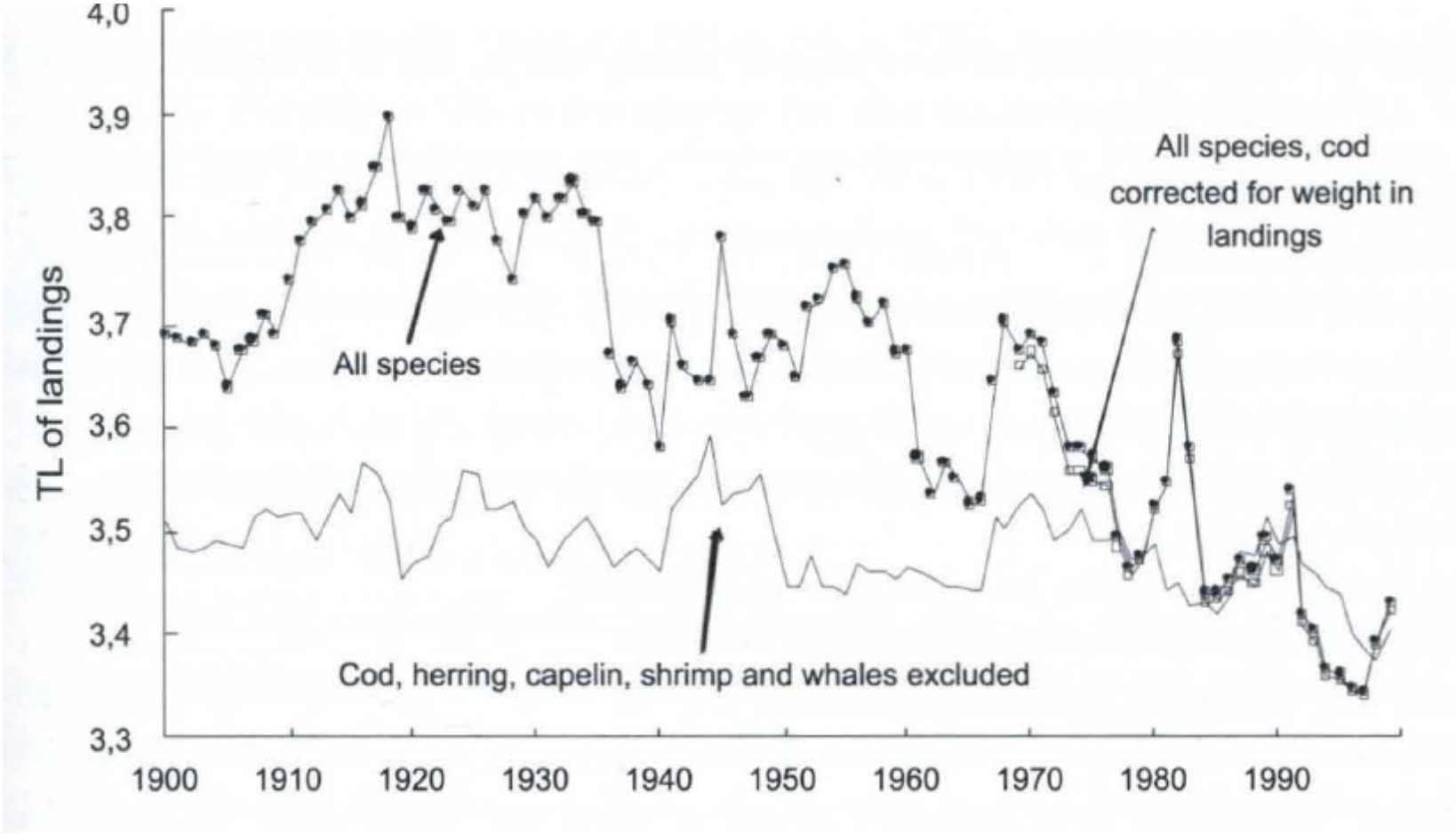


Thus, an ominous trend emerged when we computed the mean trophic level of world catches…



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

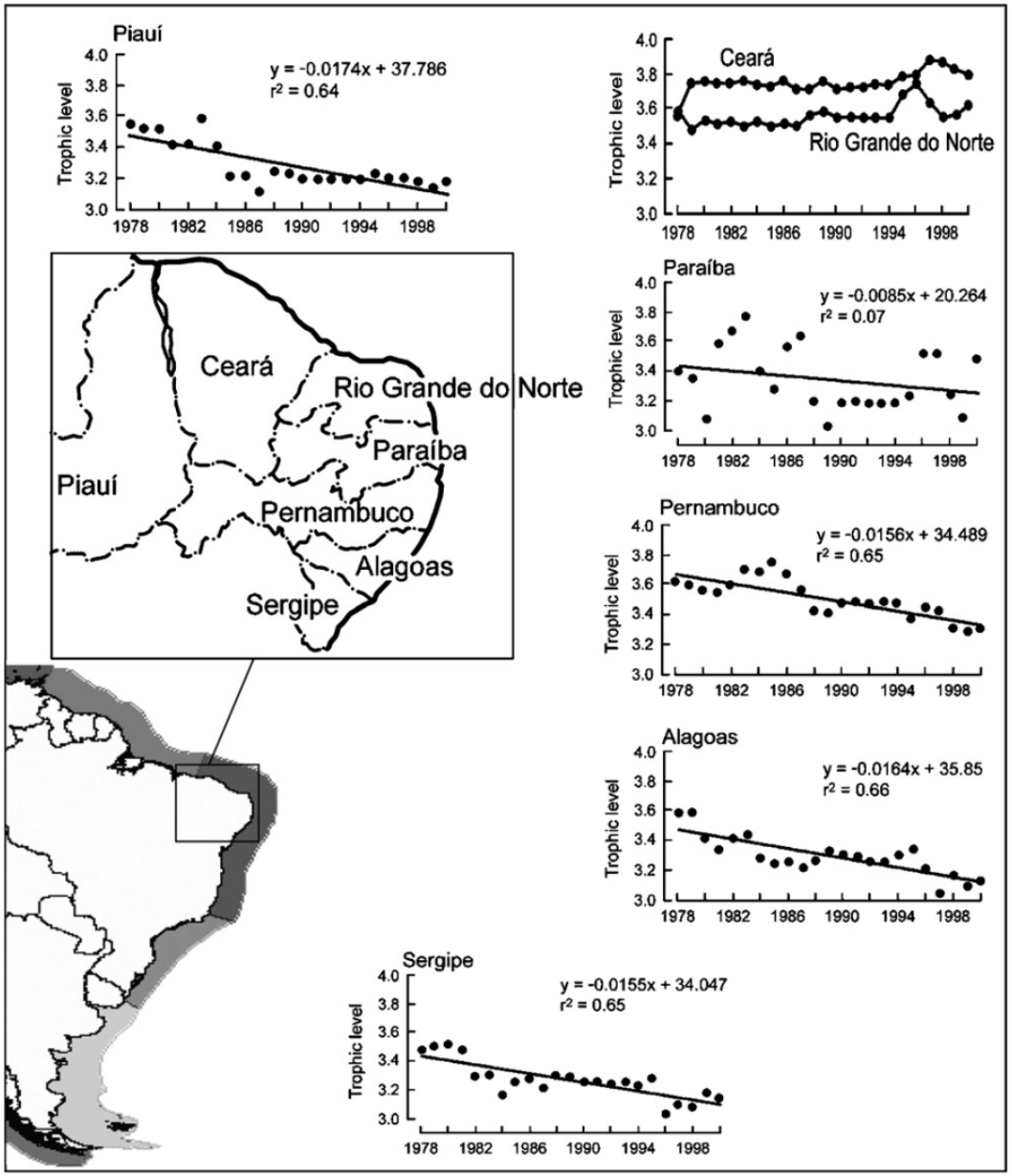
Iceland



Time series of mean TL of all fisheries in Icelandic waters, with and without correction for declining cod size.

Valtysson & Pauly (2003; Proc. Conf. Akureyri, Iceland, April 6-7, 2000

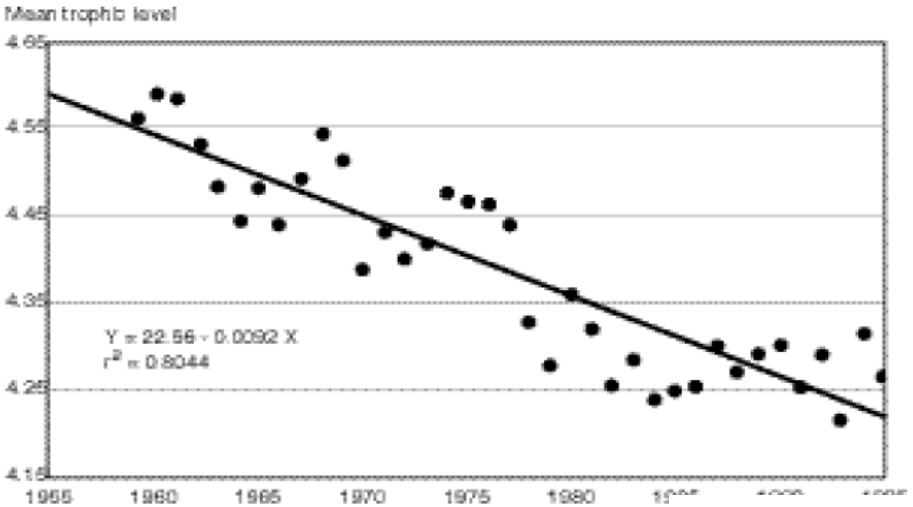
Brazil



Changes in mean trophic level for landings from Northeastern Brazil in 1978–2000. PI = Piauí, CE = Ceará, RN= Rio Grande do Norte, PB = Paraíba, PE = Pernambuco, AL = Alagoas, and SE = Sergipe. The States of Maranhão and Bahia are not shown due to the lack of a proper system of data collection. Large Marine Ecosystem 16 (East Brazil) is shown in dark gray.

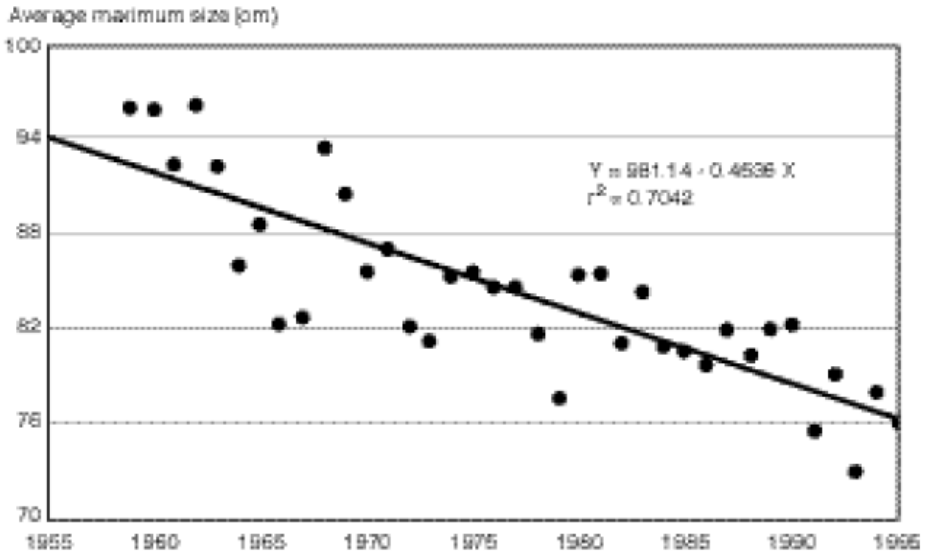
Freire, K.M.F. and Pauly, D. (2010, *Fisheries Research*)

Cuba, too

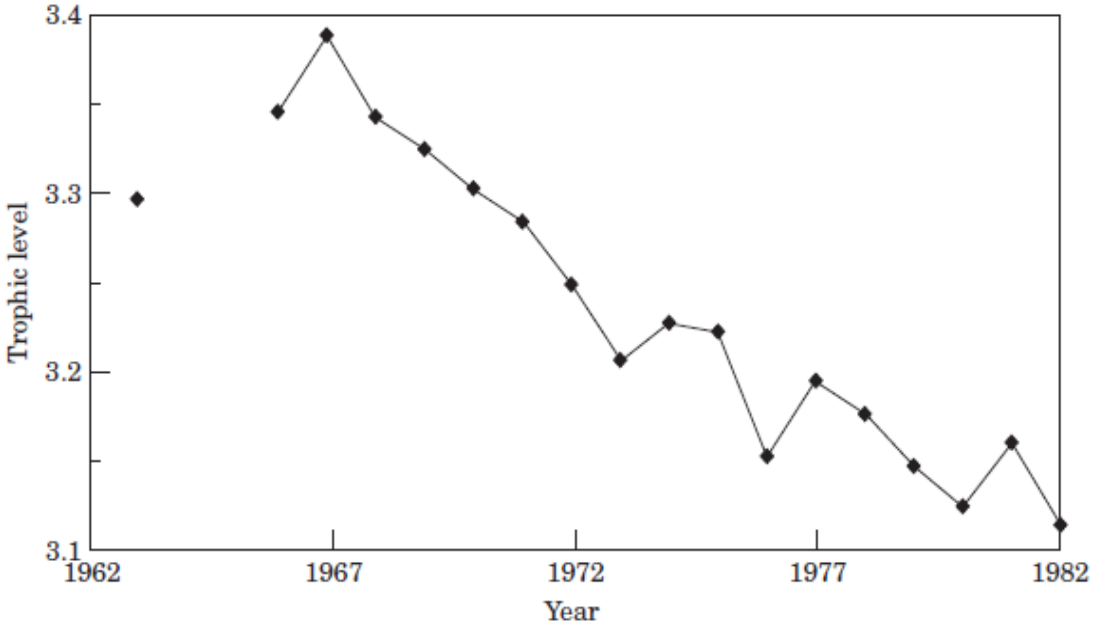


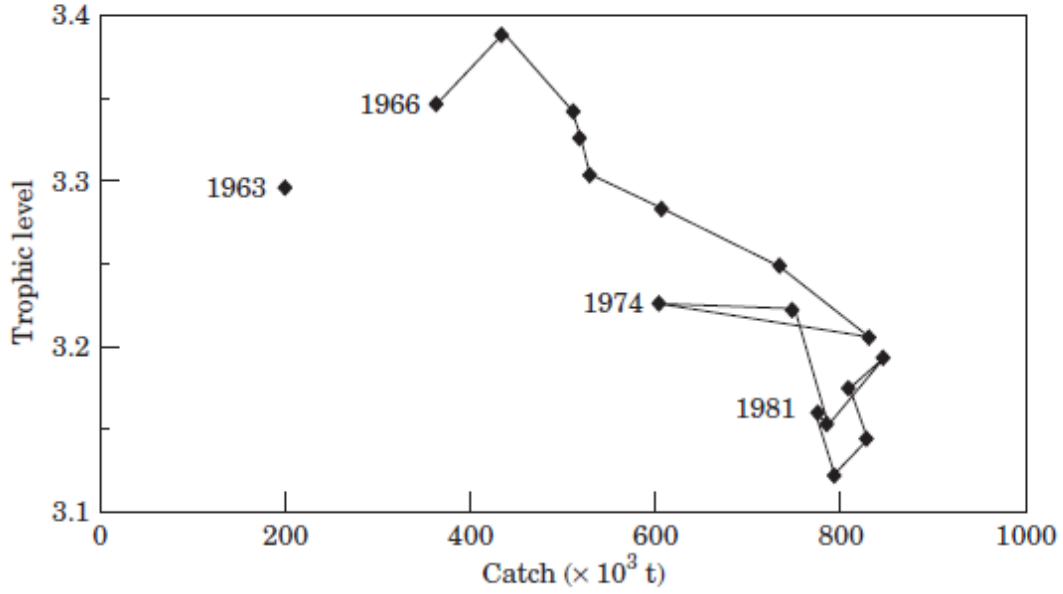
Trend of the mean trophic level of Cuban catches within the Cuban EEZ

Note similar trend in mean maximum length



Baisre, J.A.(2000) *FAO Fisheries Technical Paper* 394



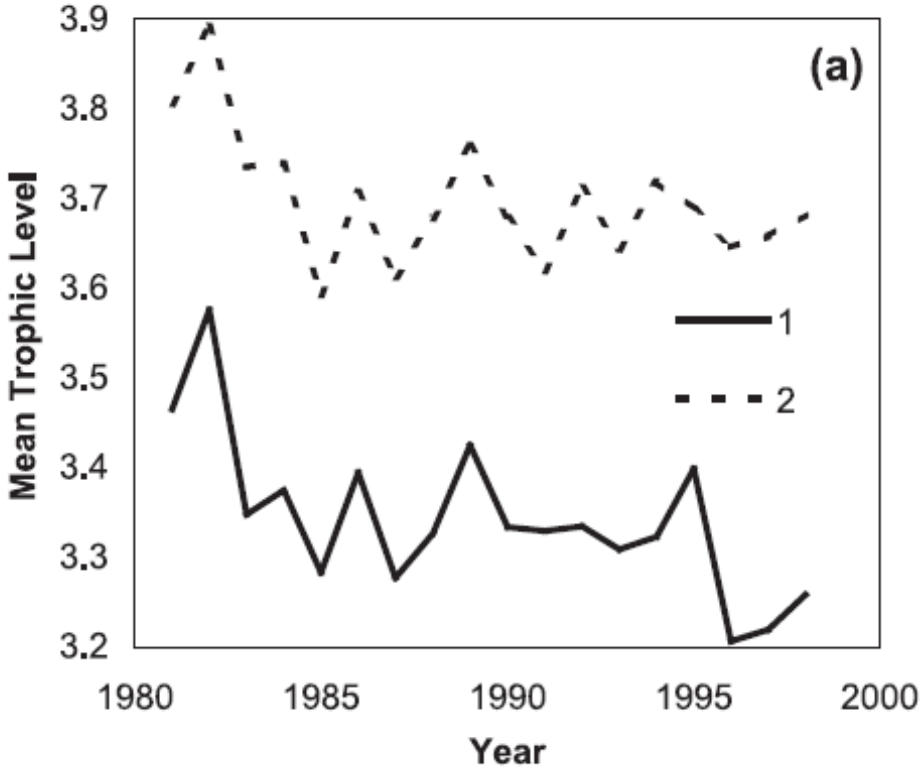


Gulf of Thailand

Average trophic level
Of the demersal fisheries
In the Gulf of Thailand
As a function of catch level
(1963, 1966-1981). Data are
based on fisheries-independent
trawl surveys and trophic
levels estimated from Ecopath
models of the Gulf.

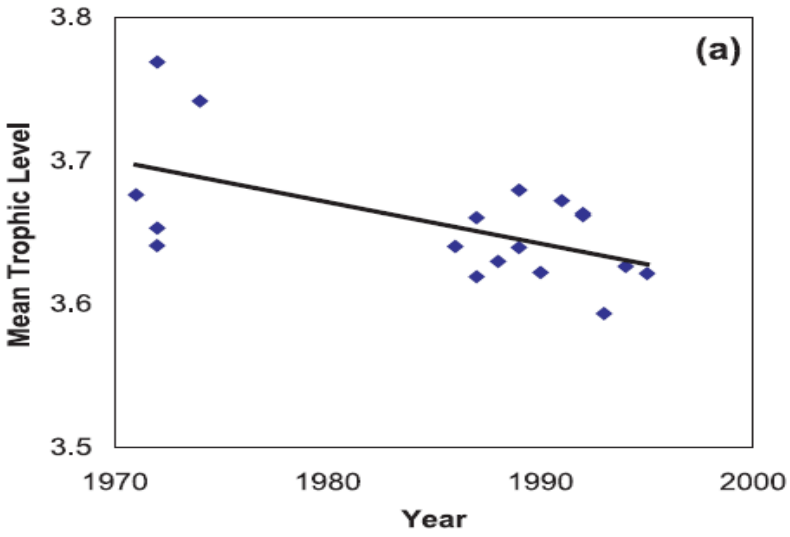
Christensen (1998; *Journal of Fish Biology* 53: 128-142)

Senegal



Trend in the Mean trophic level (MTL) estimated from landings in Senegal (1) w/out small pelagic fishes; (2) w/ all fishes included

Trend of the mean trophic level of the biomass of the demersal fish community in Senegal, as estimated from survey data



Laurans et al.(2004 *Aquatic Living Resources* 17: 163-173).

And to crown it all:

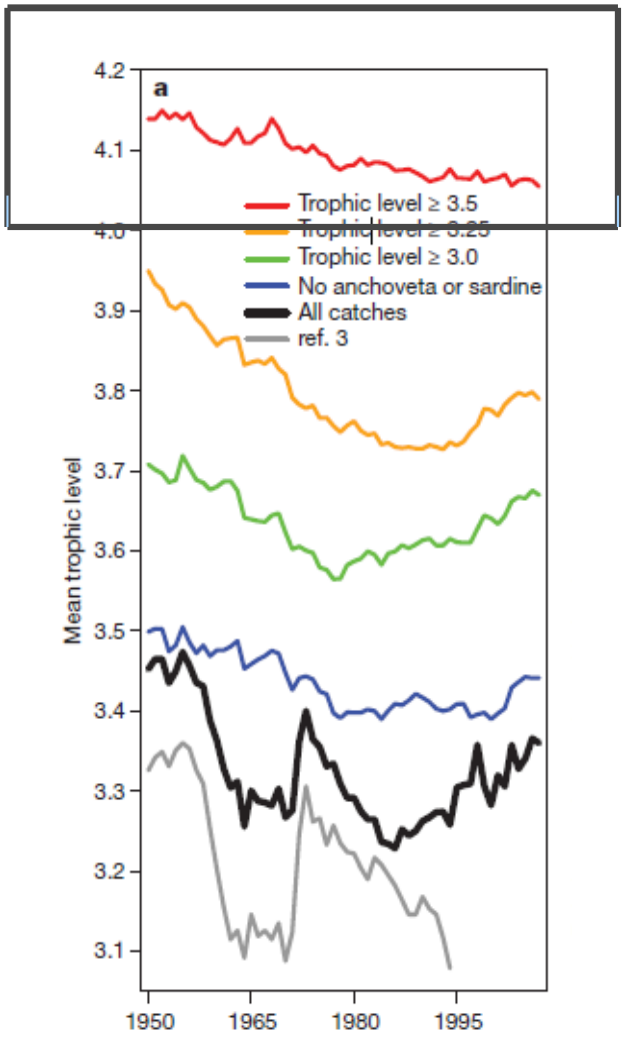
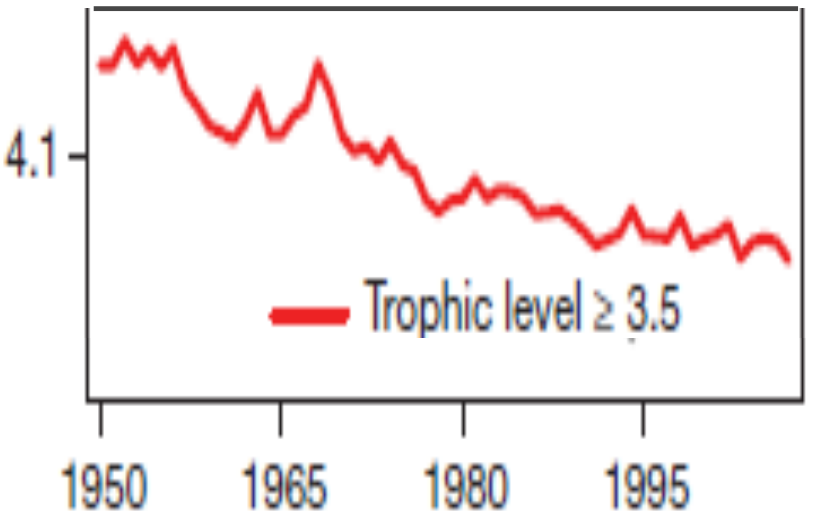
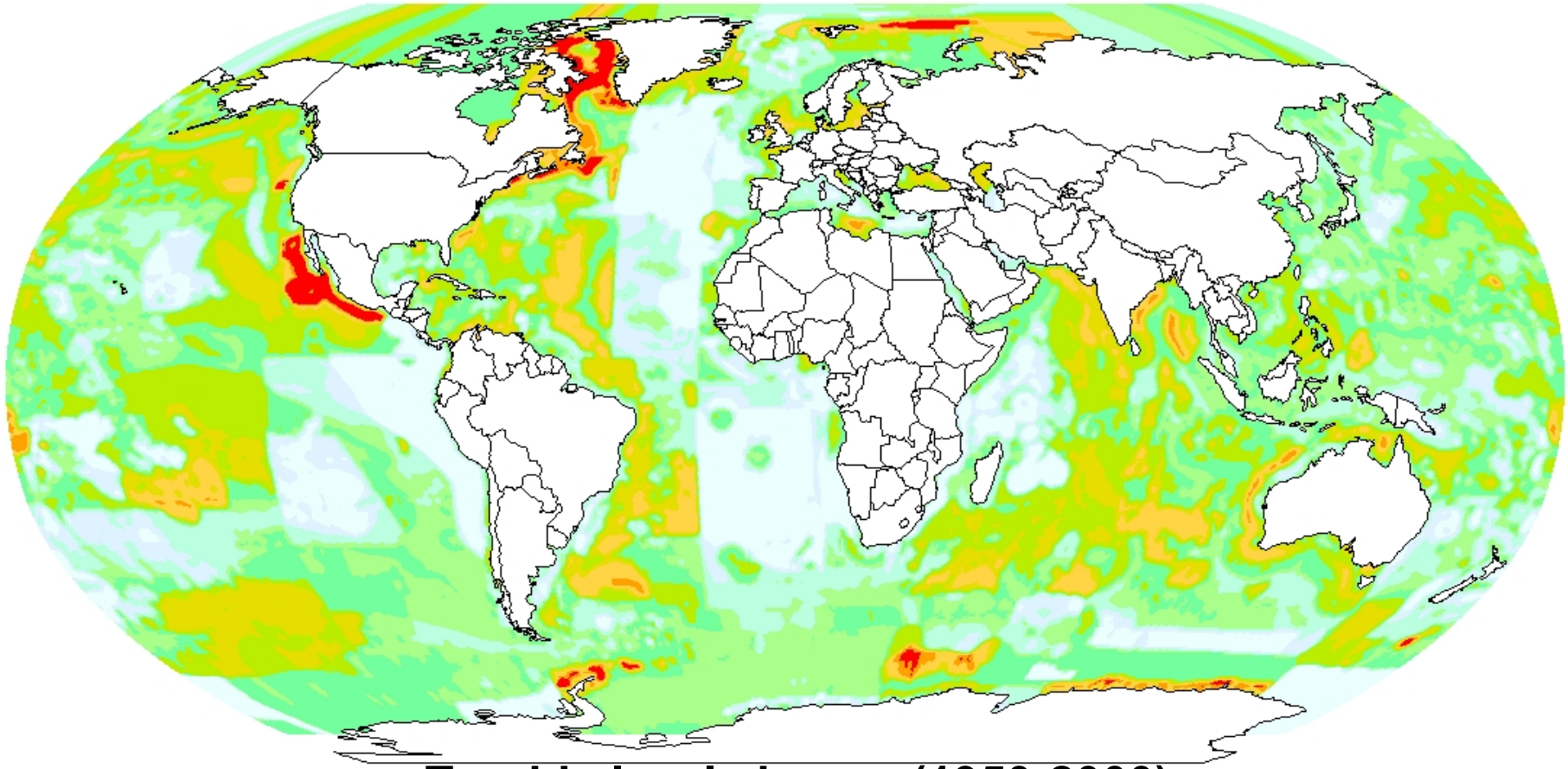


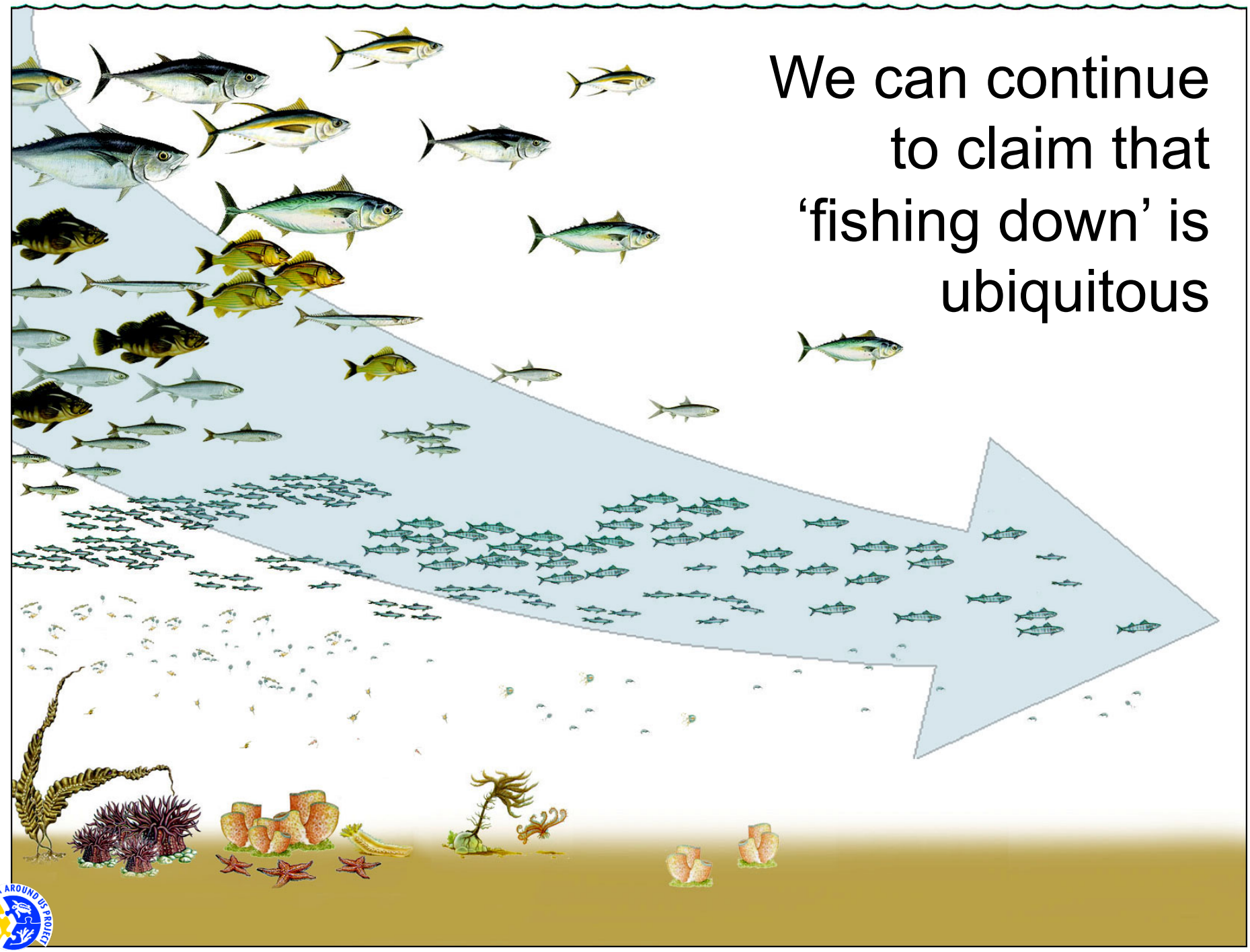
Figure 2 of Branch et al. (2010)



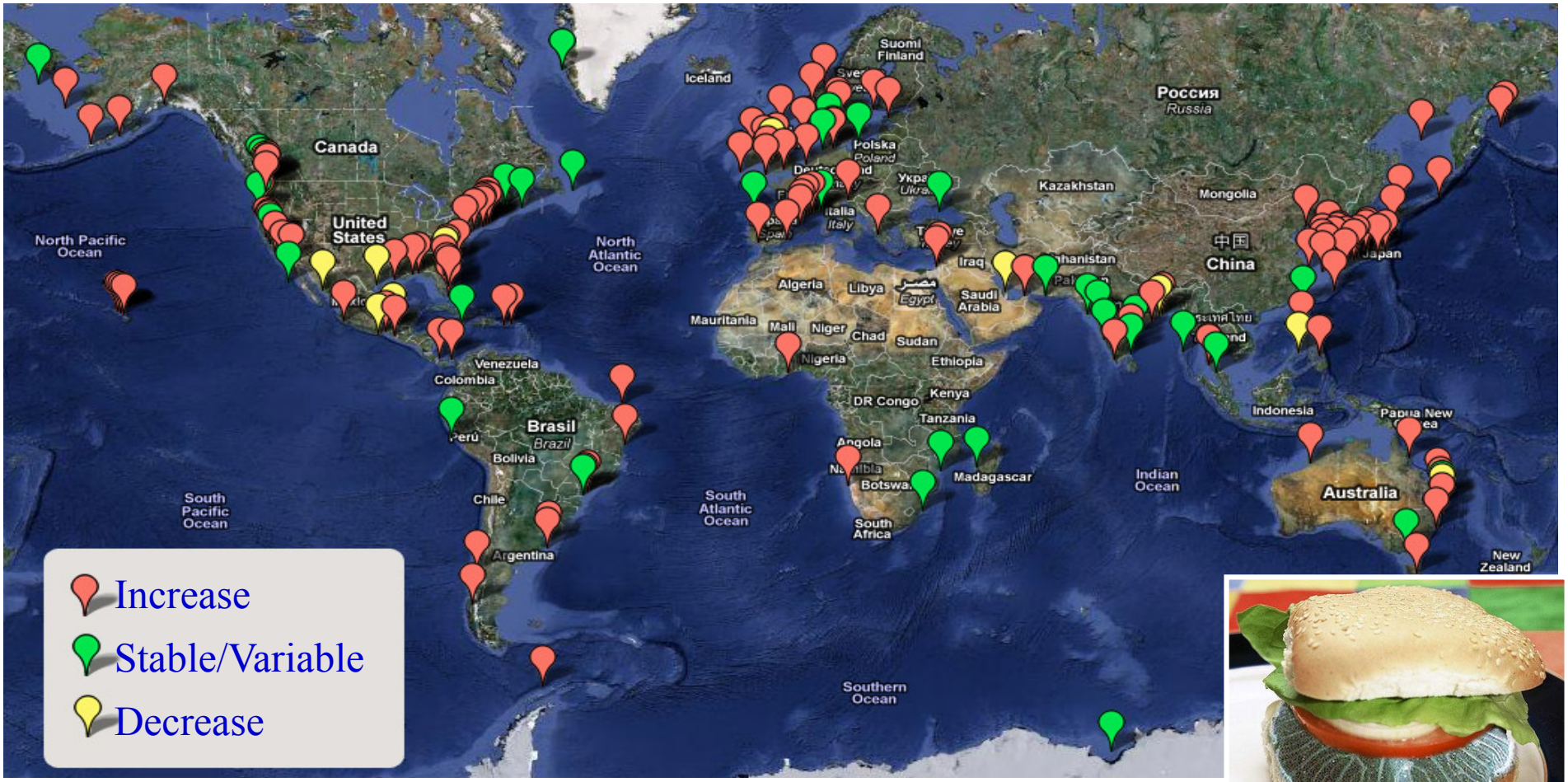
The mean trophic level of worldwide fish catches TL >3.5 declines steadily, just as fishing down predicts it should. The rest is due to geographic expansion of the fisheries ….

In fact, ‘Fishing down’ turned out to be so widespread that the Convention on Biological Diversity (CBD) adopted mean trophic levels as an index of biodiversity, the “Marine Trophic Index”.

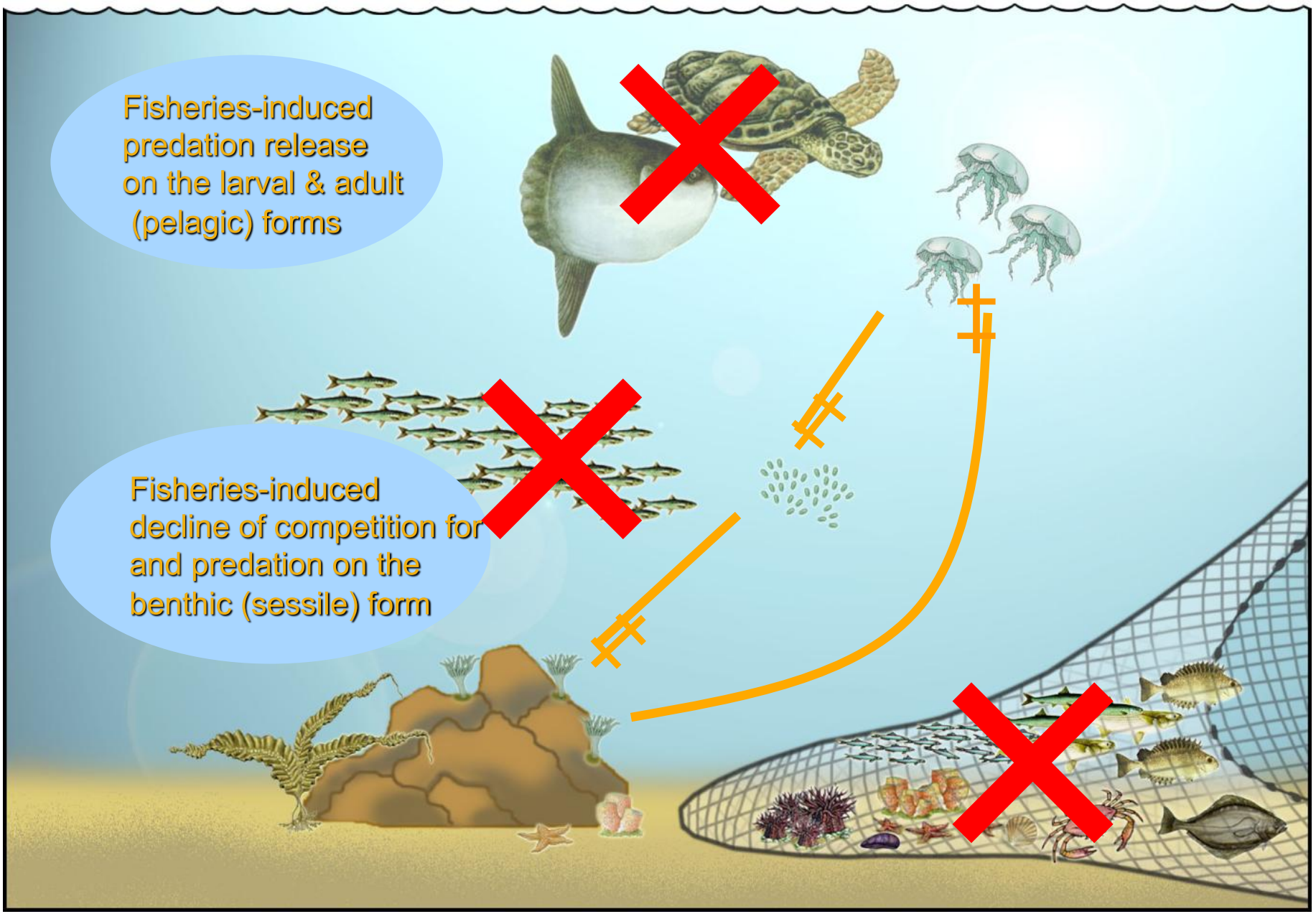



We can continue
to claim that
‘fishing down’ is
ubiquitous

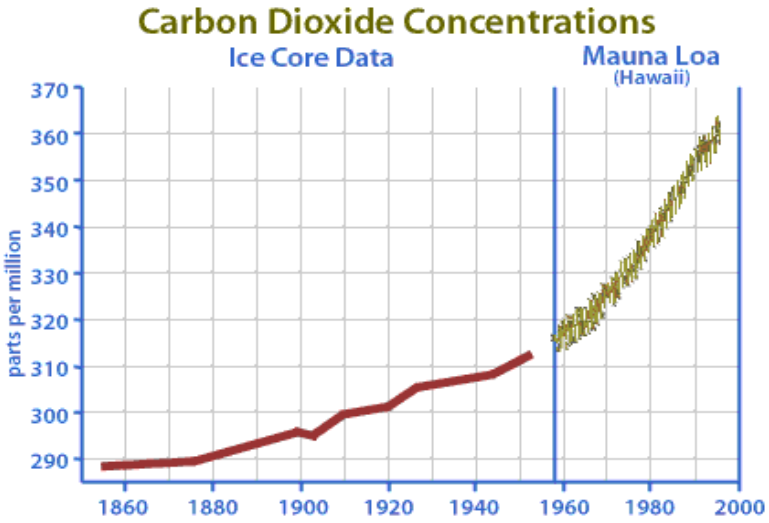
One of the many effects is that jellyfish increased globally, as documented in a paper now submitted….

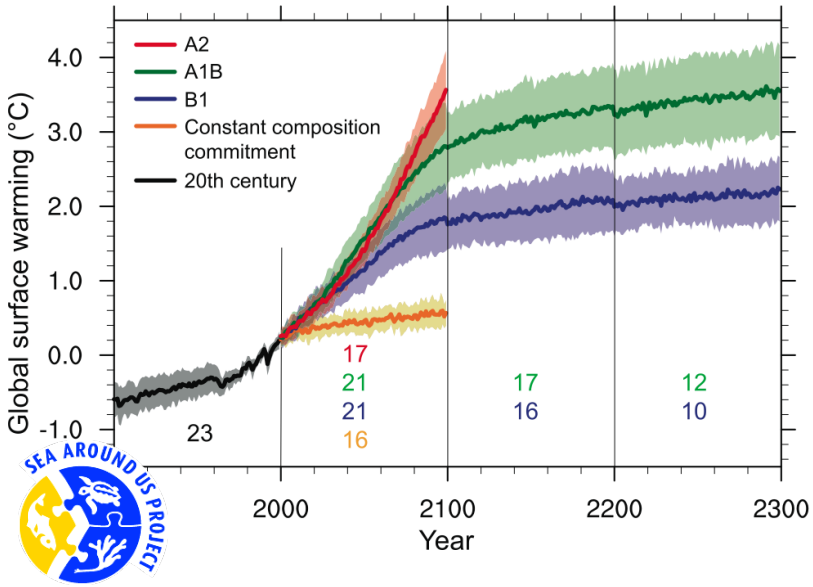


a JBLT anyone?


Fisheries-induced predation release on the larval & adult (pelagic) forms
Fisheries-induced decline of competition for and predation on the benthic (sessile) form

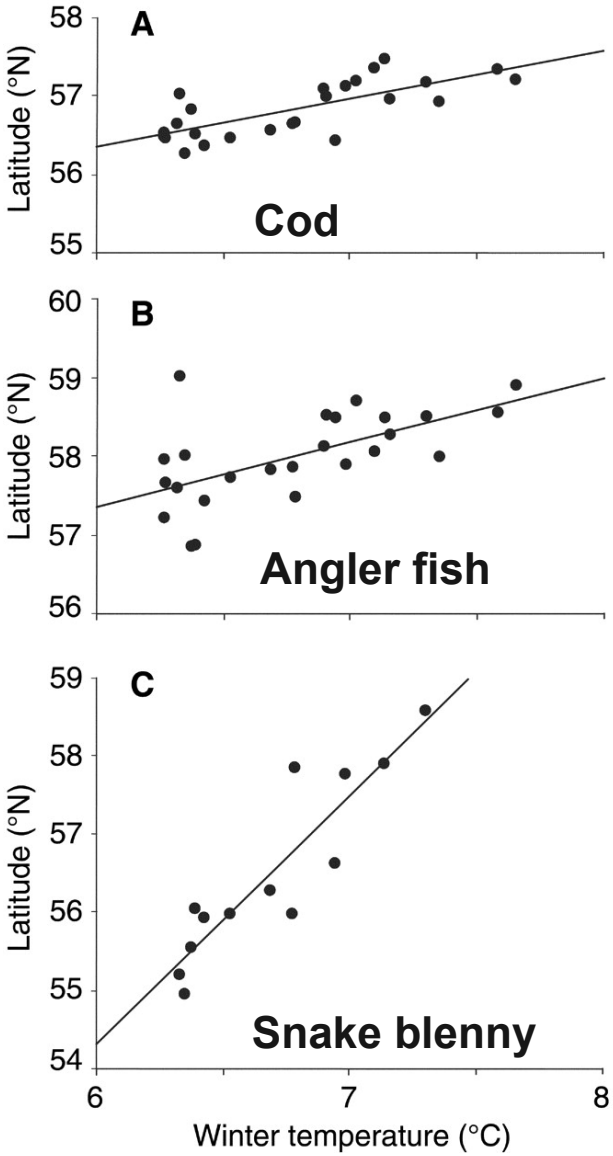
Meanwhile, things are heating up…

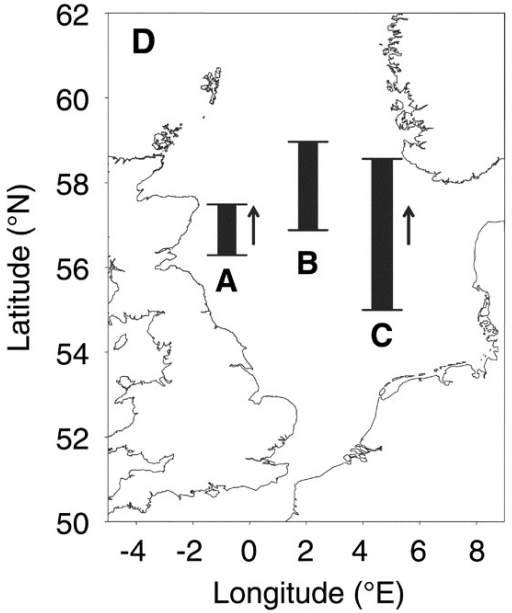




Observed climate-induced shifts in distribution ranges

Poleward shifts in distribution ranges of marine species, e.g., in the North Sea (Perry *et al. Science,* 2005).

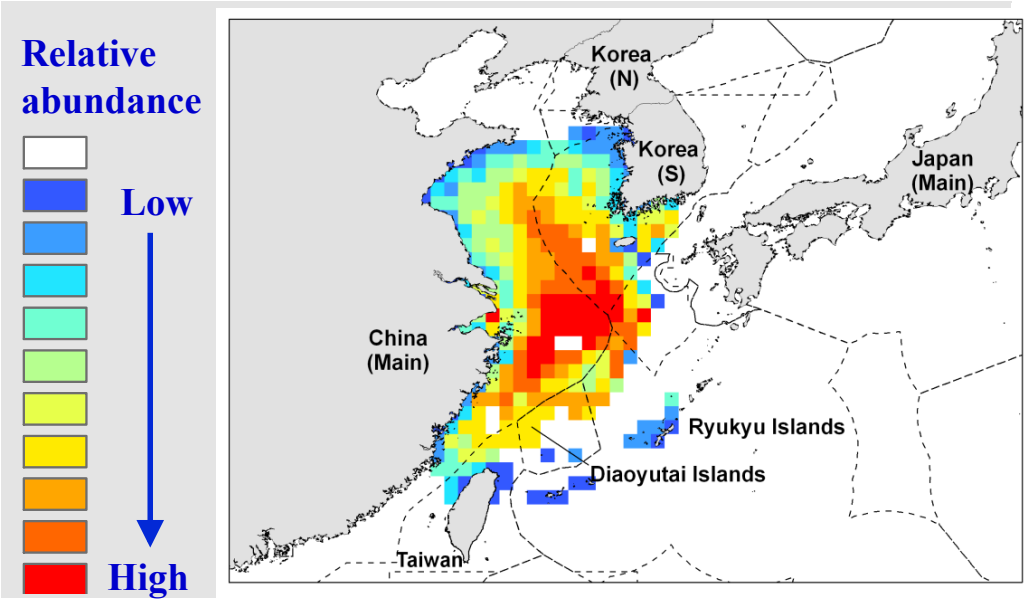


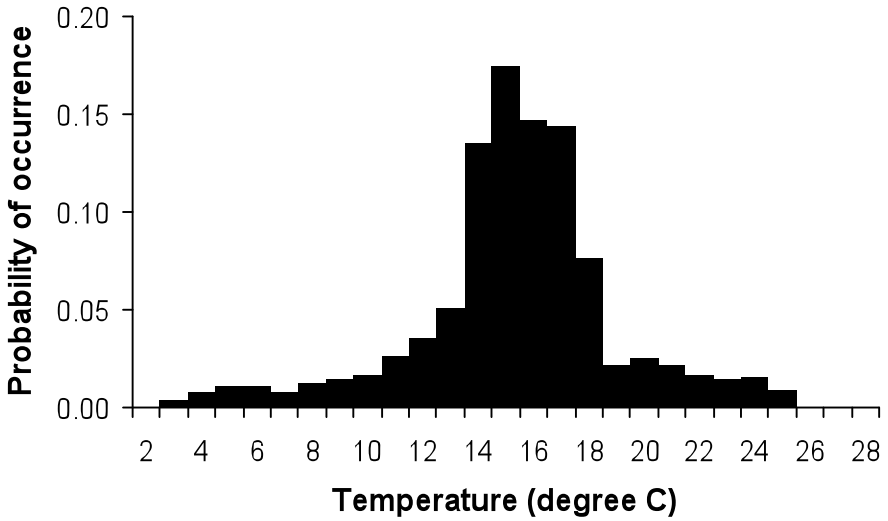


Simulating poleward shifts using temperature-abundance profiles…

Small yellow croaker
(*Larimichthys polyactis*)

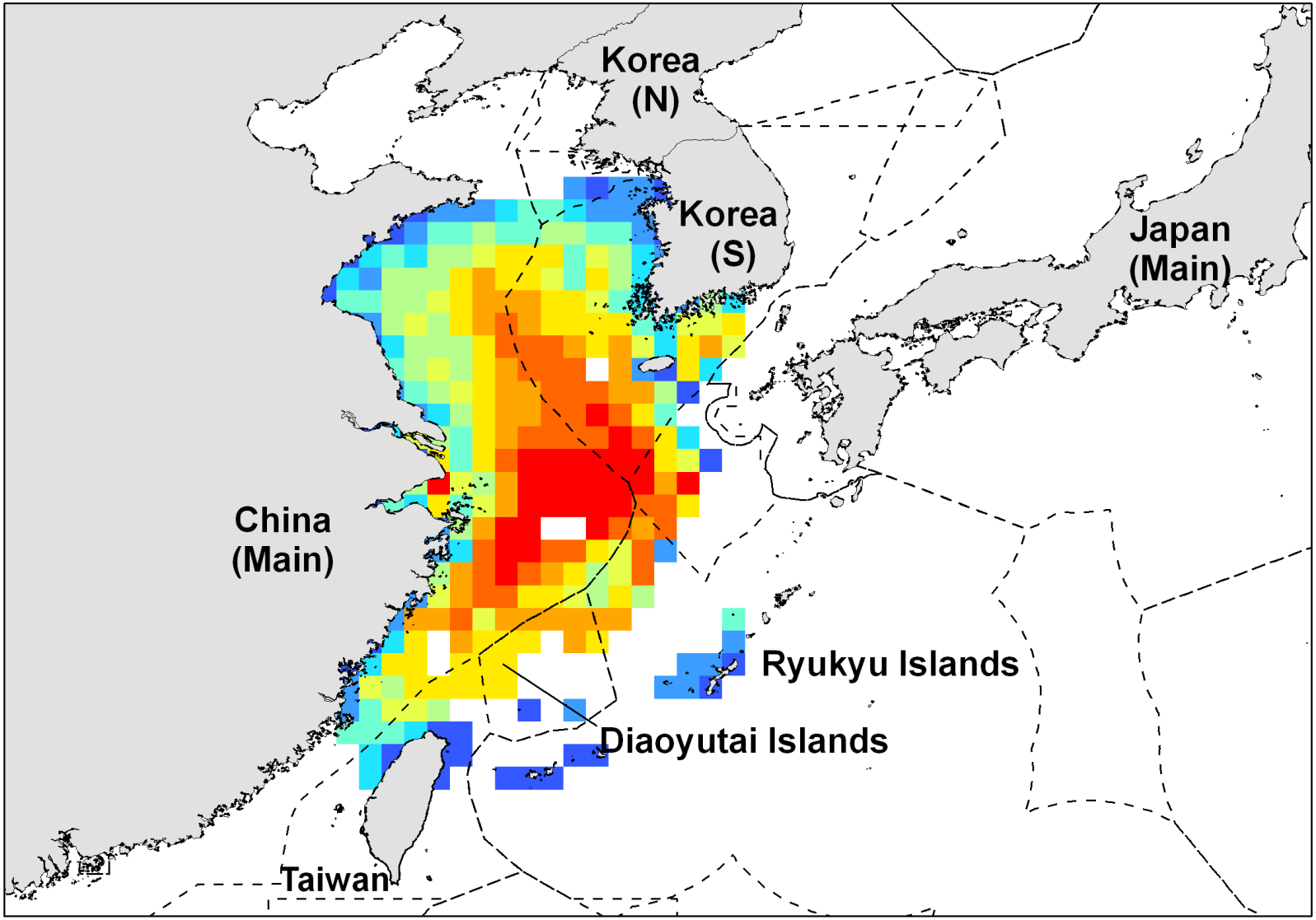
Probability of occurrence by water temperature





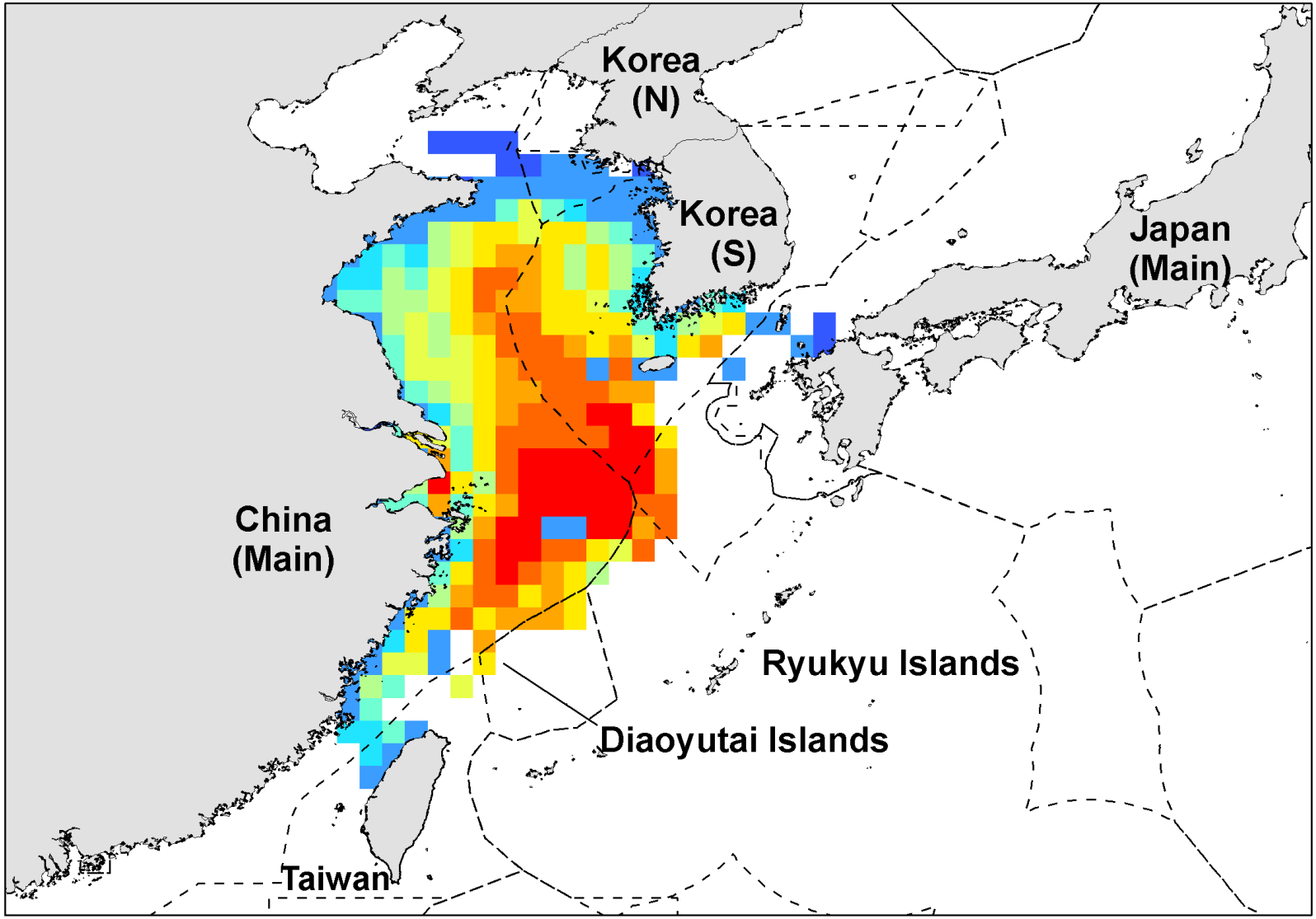
Small yellow croaker

Year 0



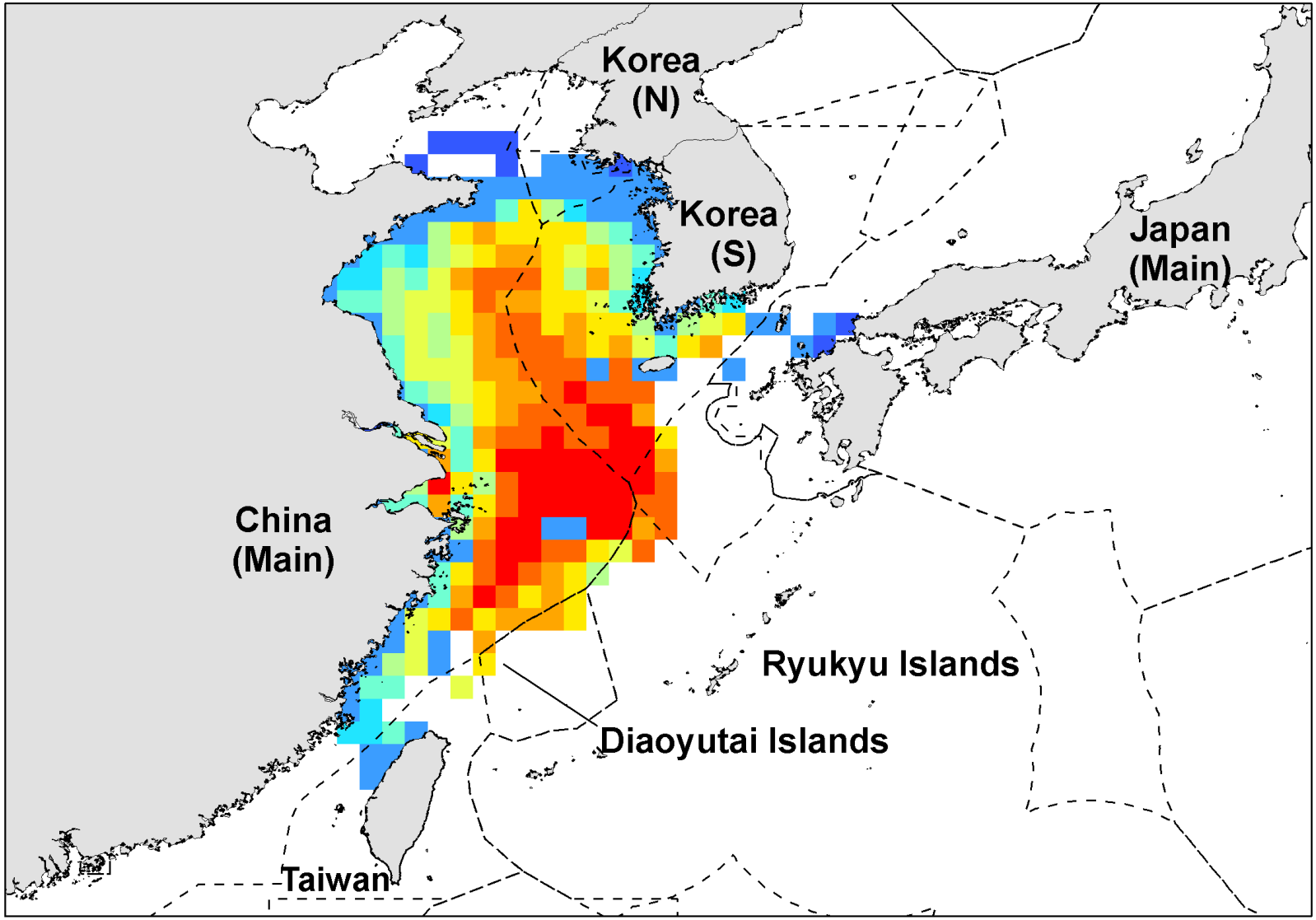
Small yellow croaker

Year 2



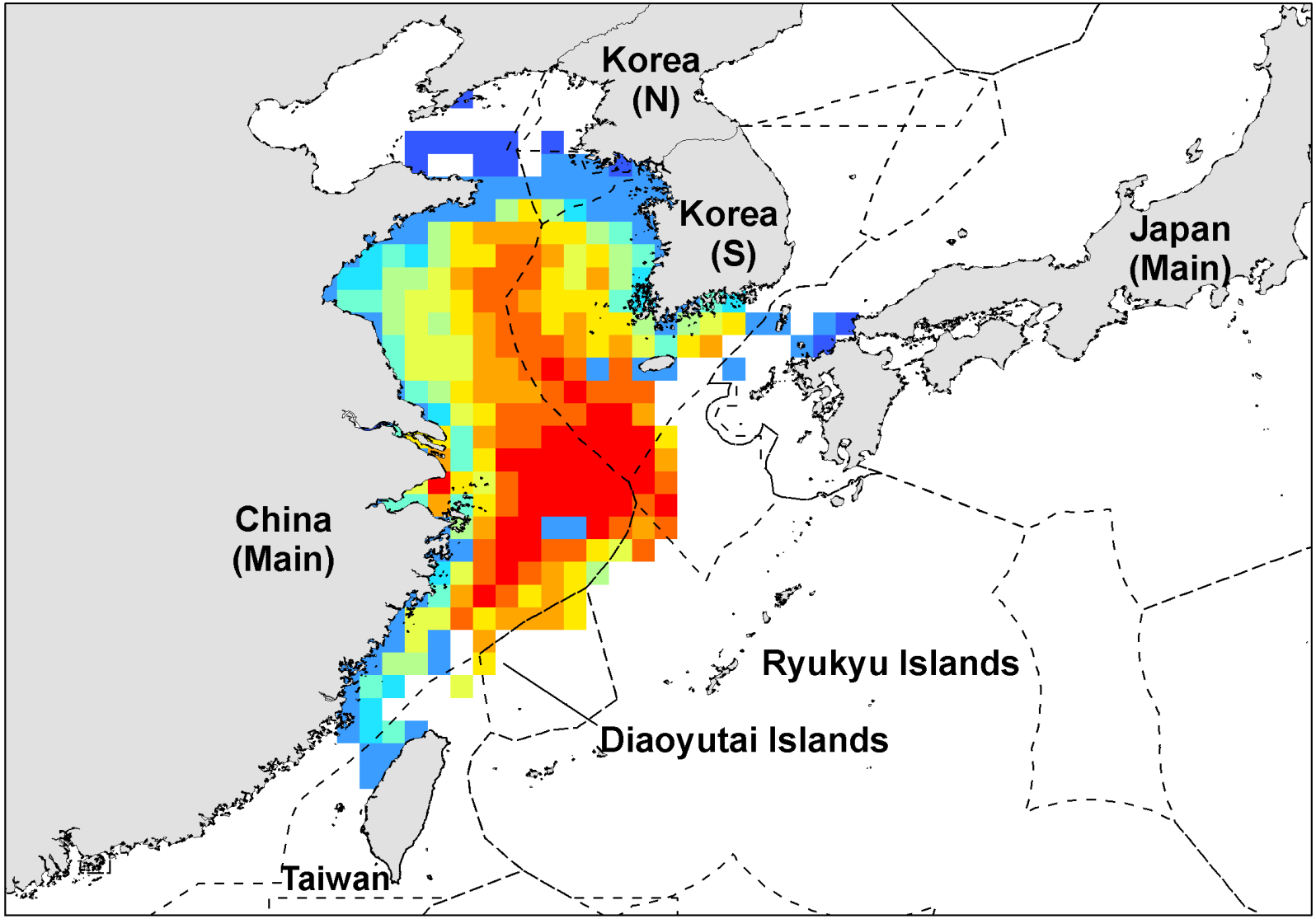
Small yellow croaker

Year 4



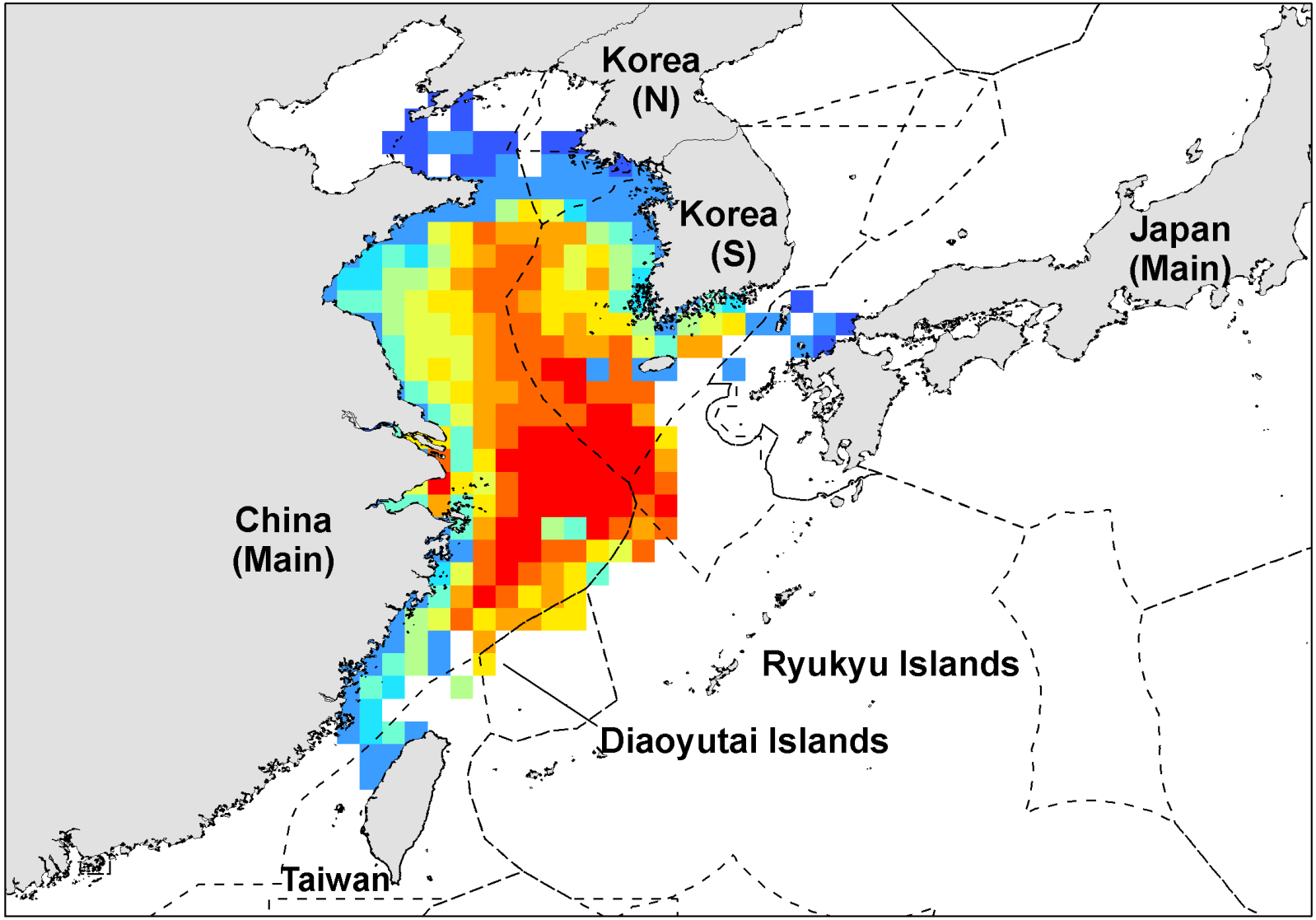
Small yellow croaker

Year 6



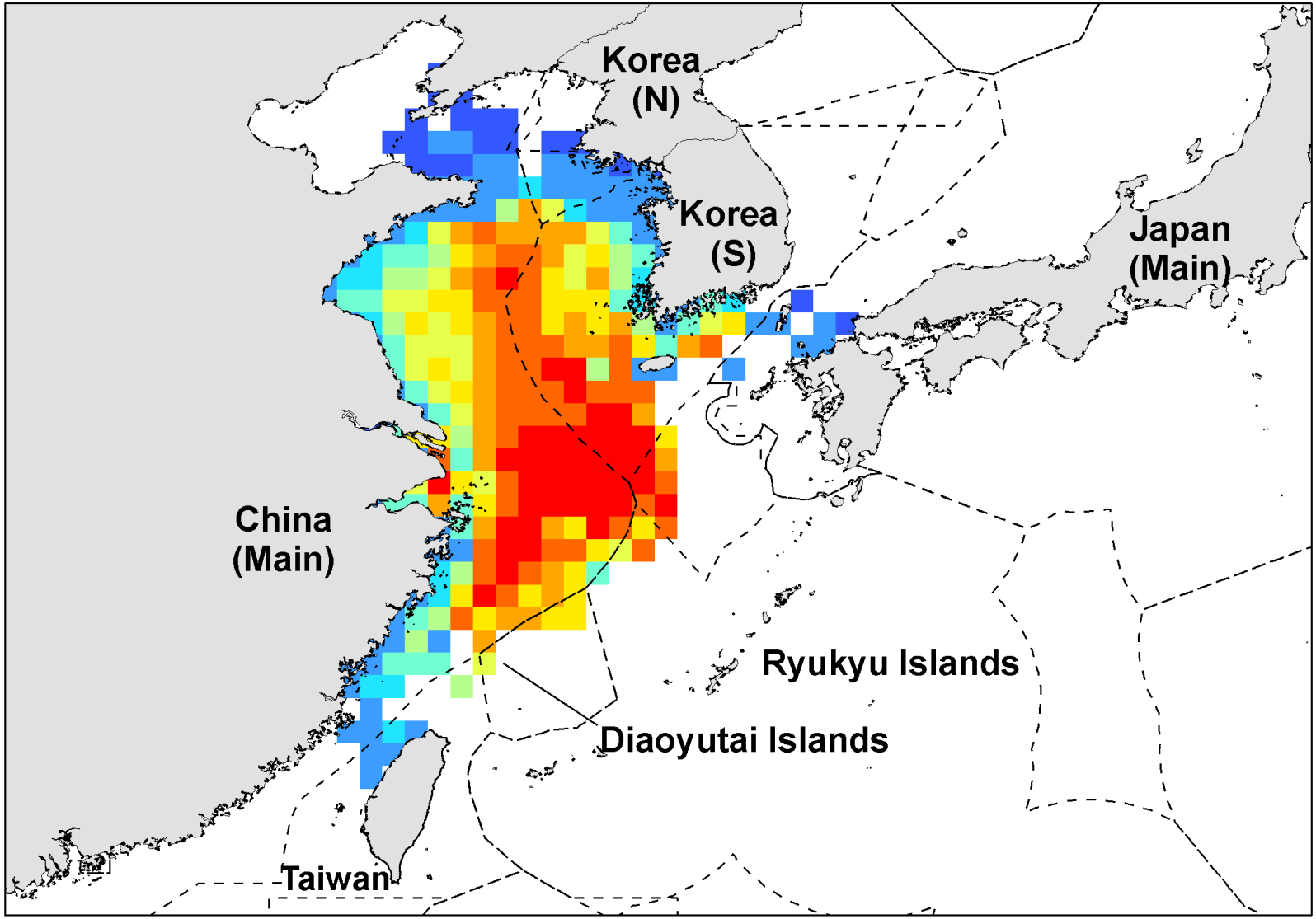
Small yellow croaker

Year 8



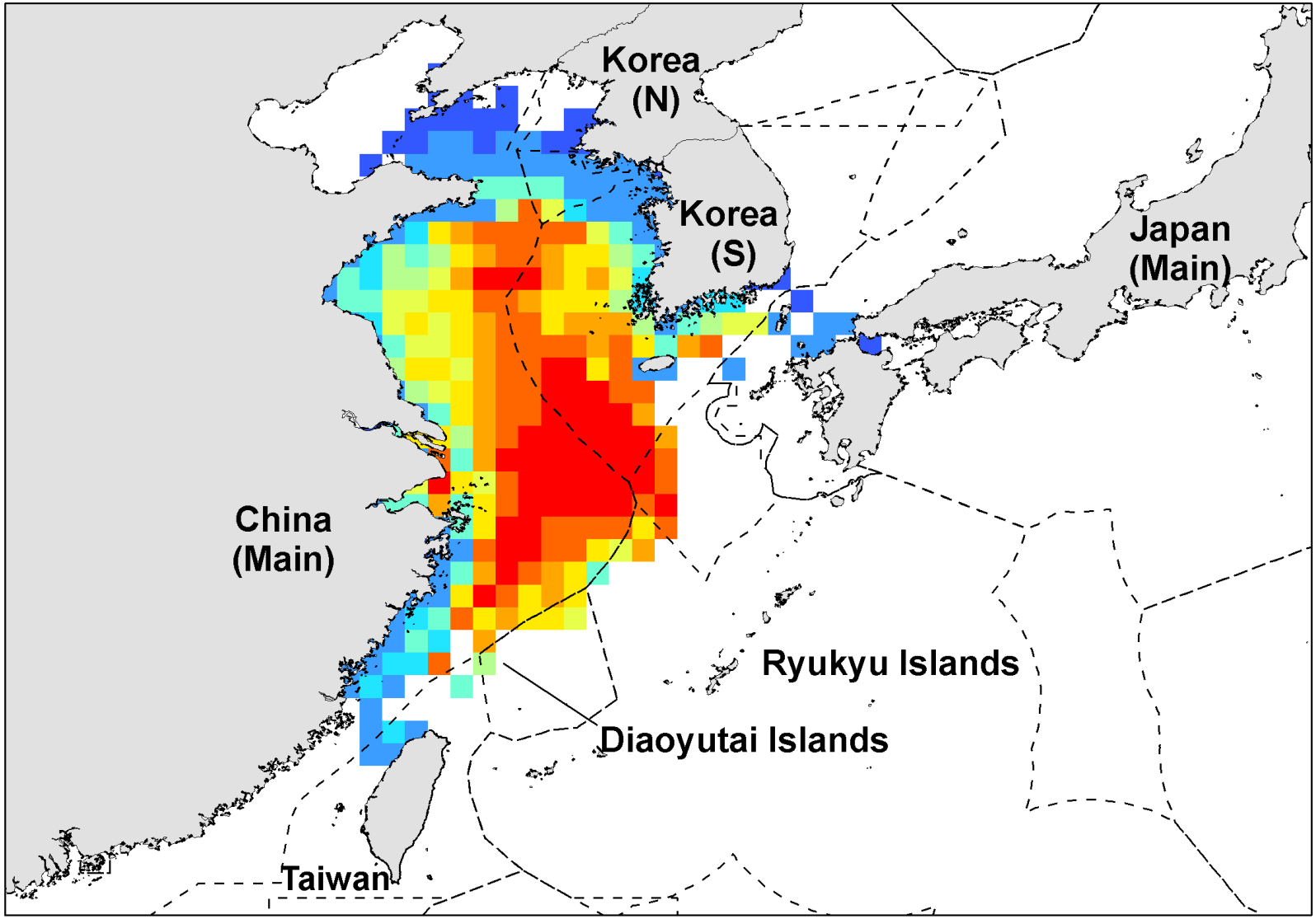
Small yellow croaker

Year 10



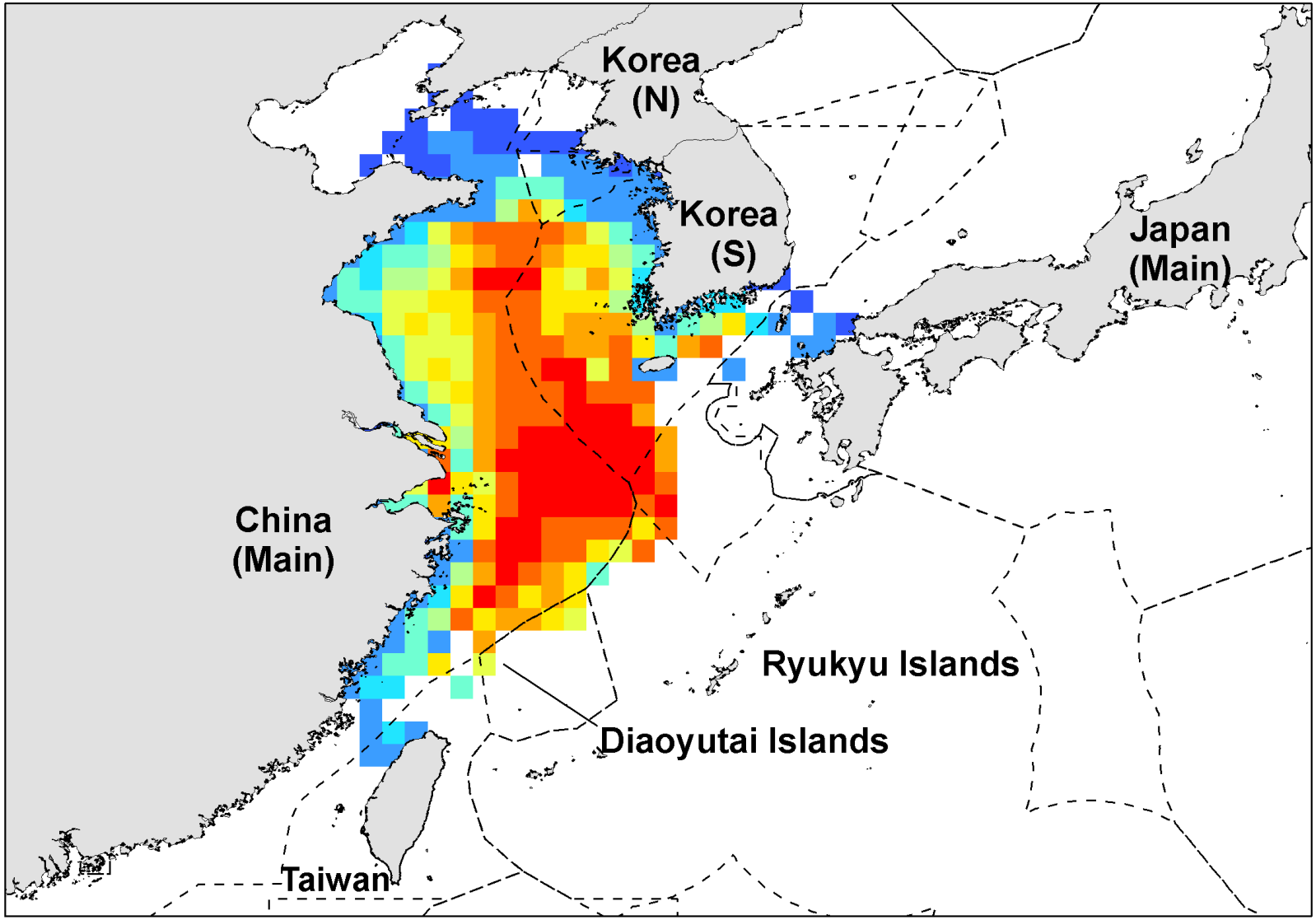
Small yellow croaker

Year 12



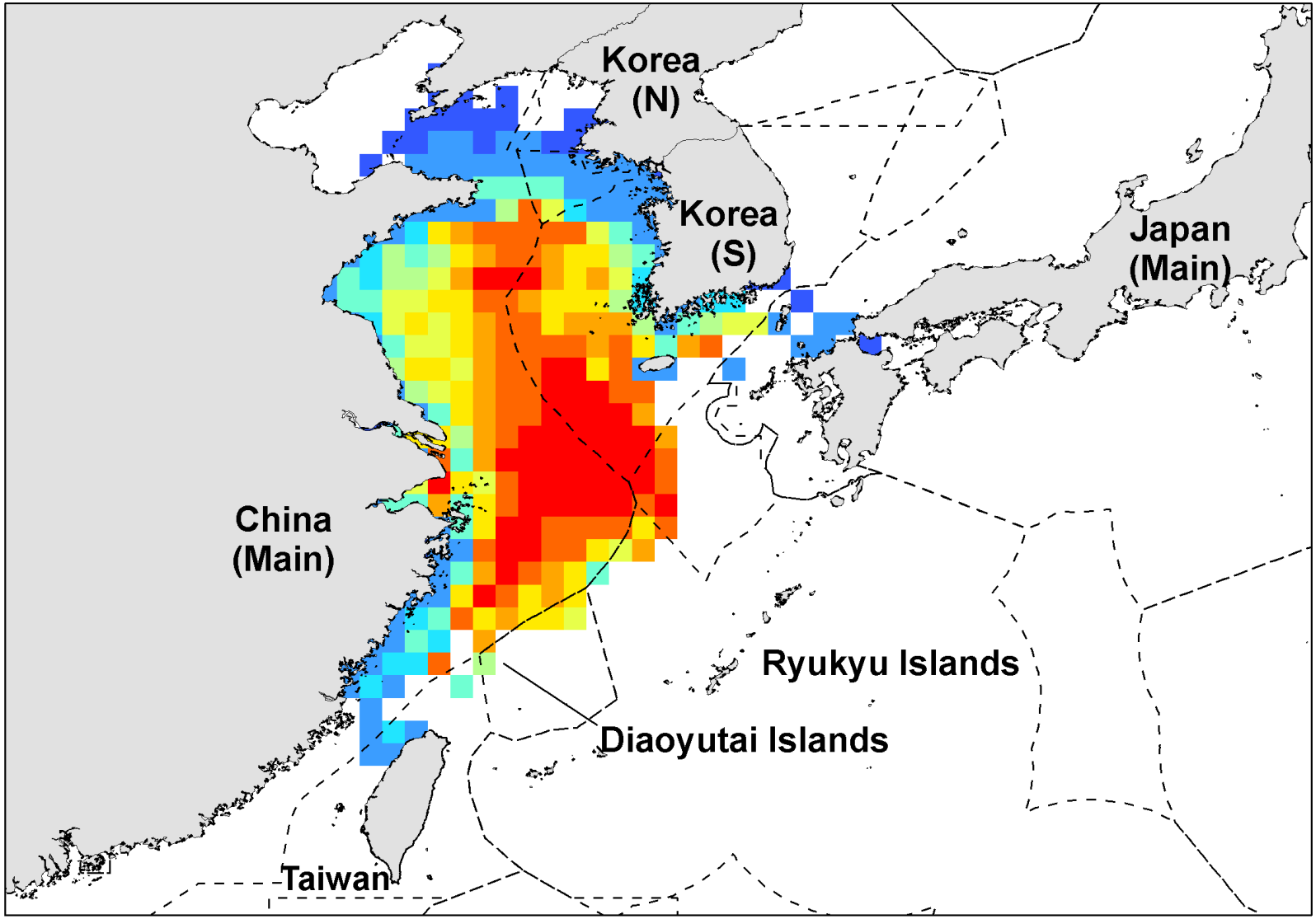
Small yellow croaker

Year 14



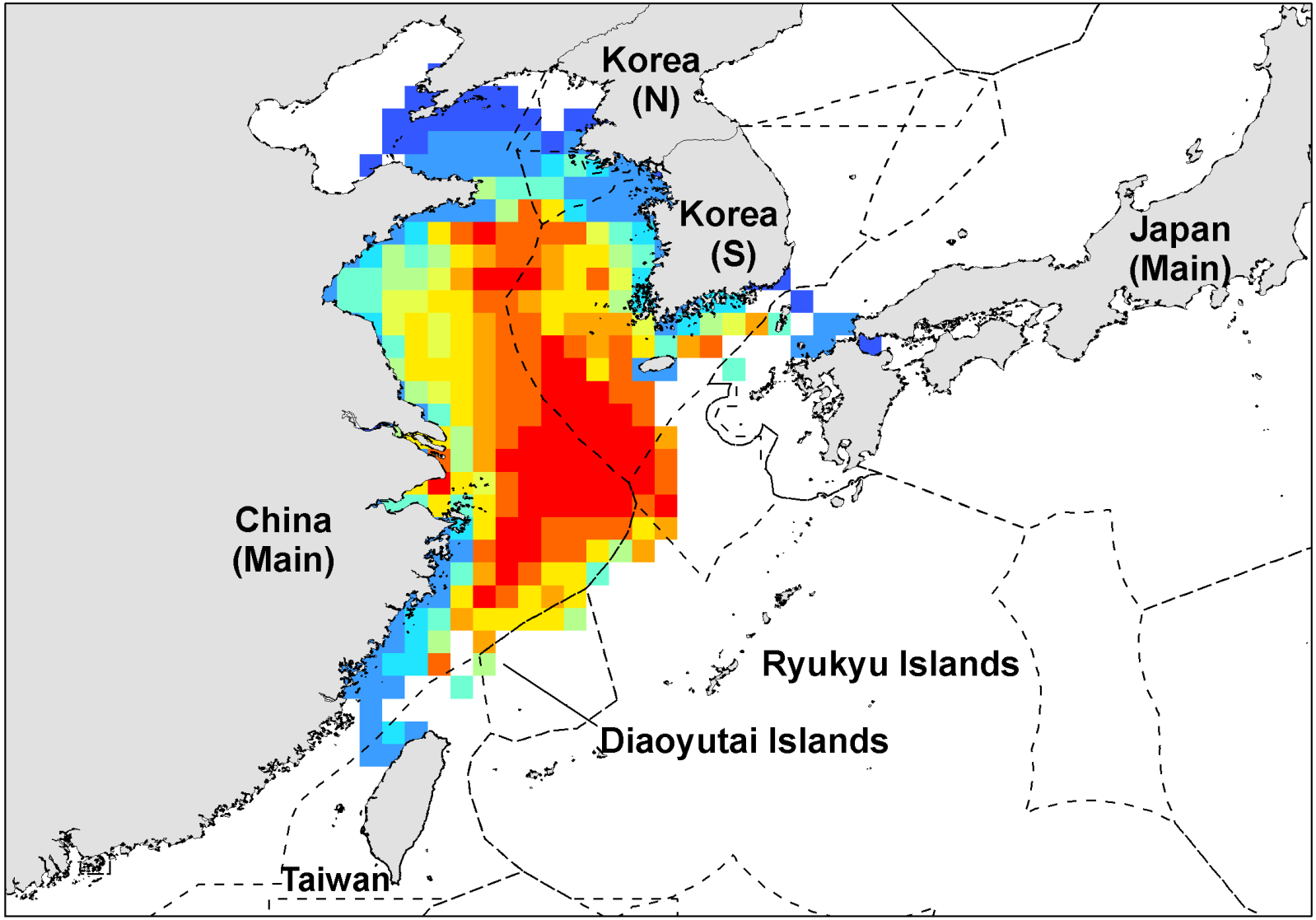
Small yellow croaker

Year 16



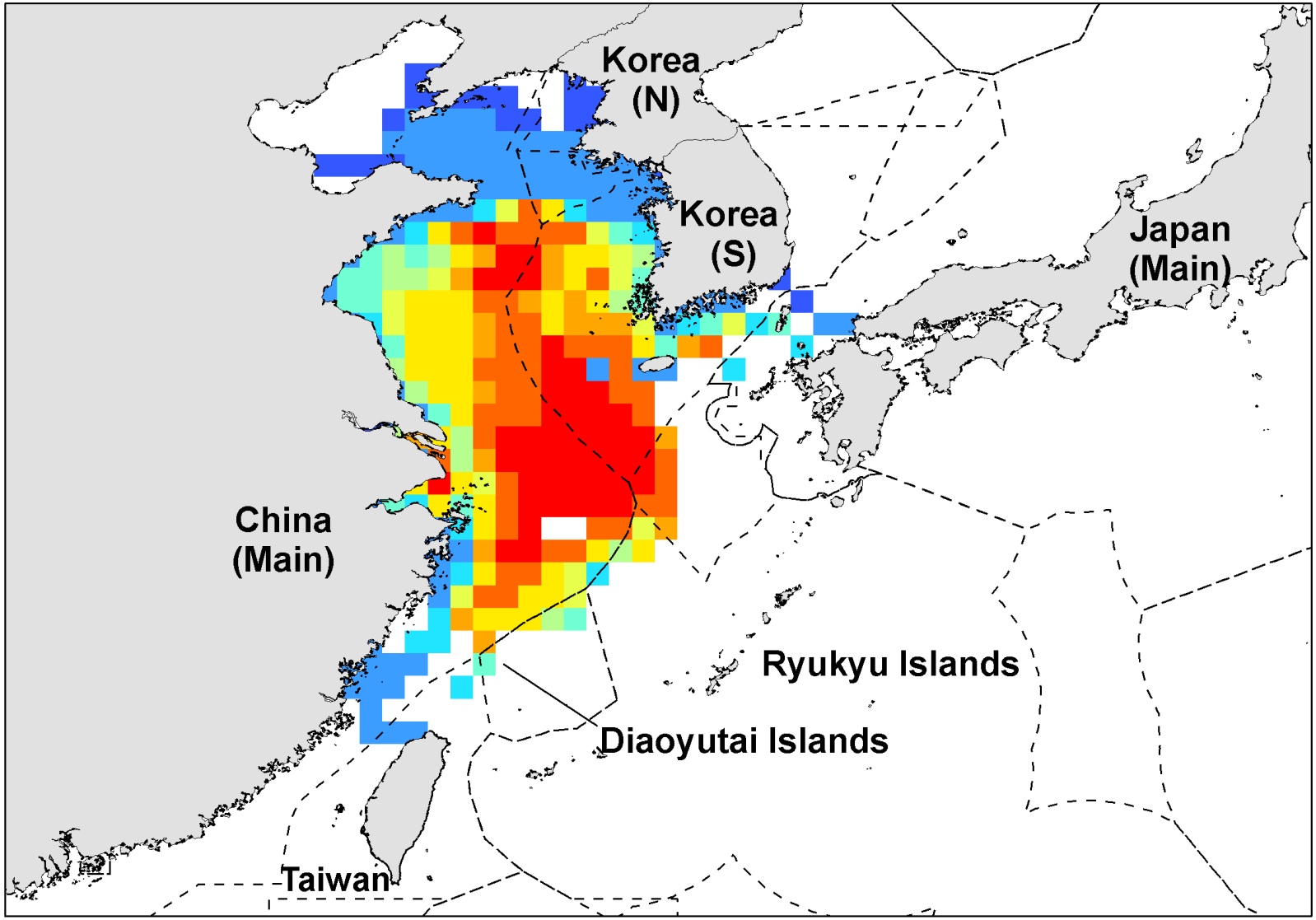
Small yellow croaker

Year 18



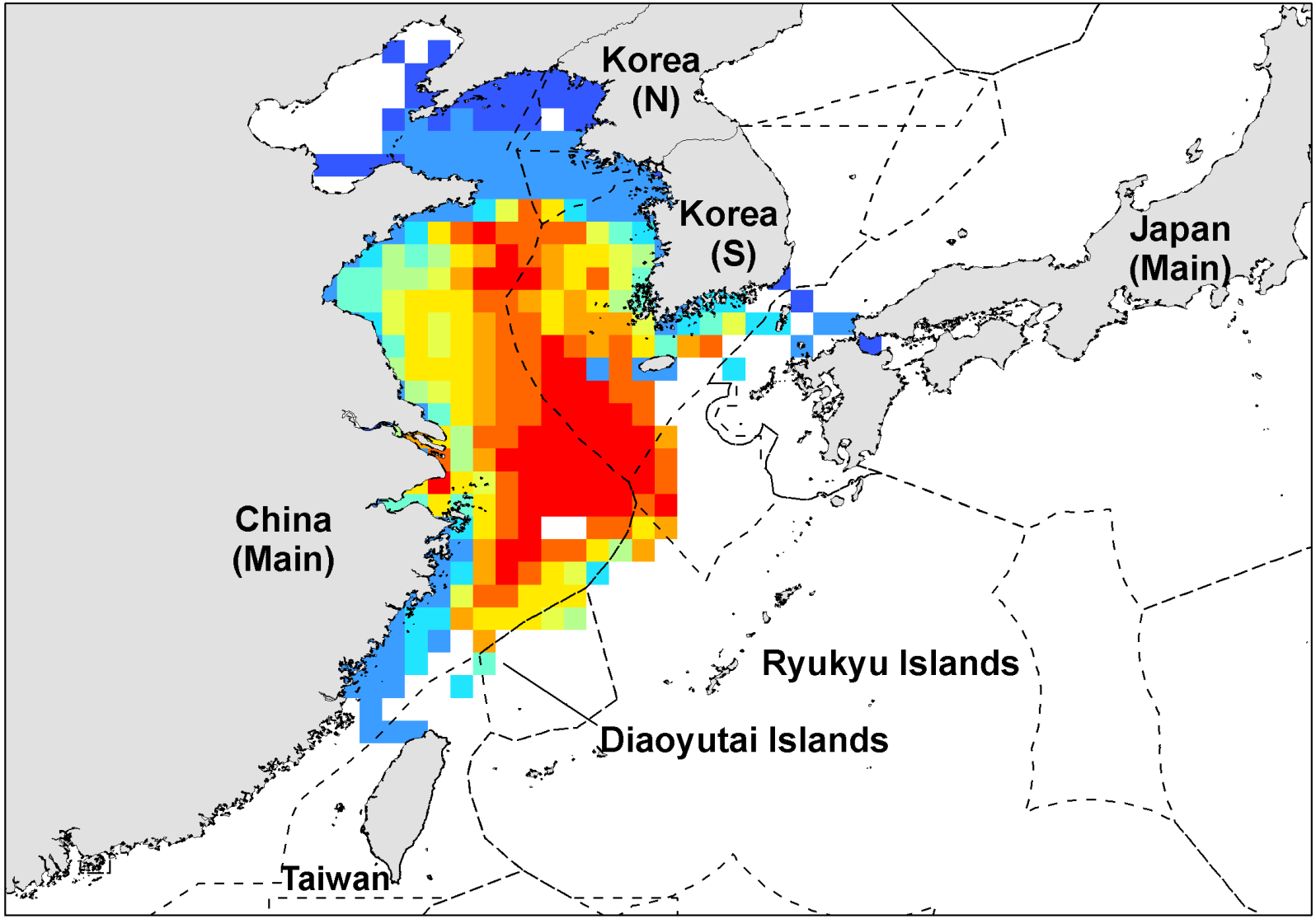
Small yellow croaker

Year 20



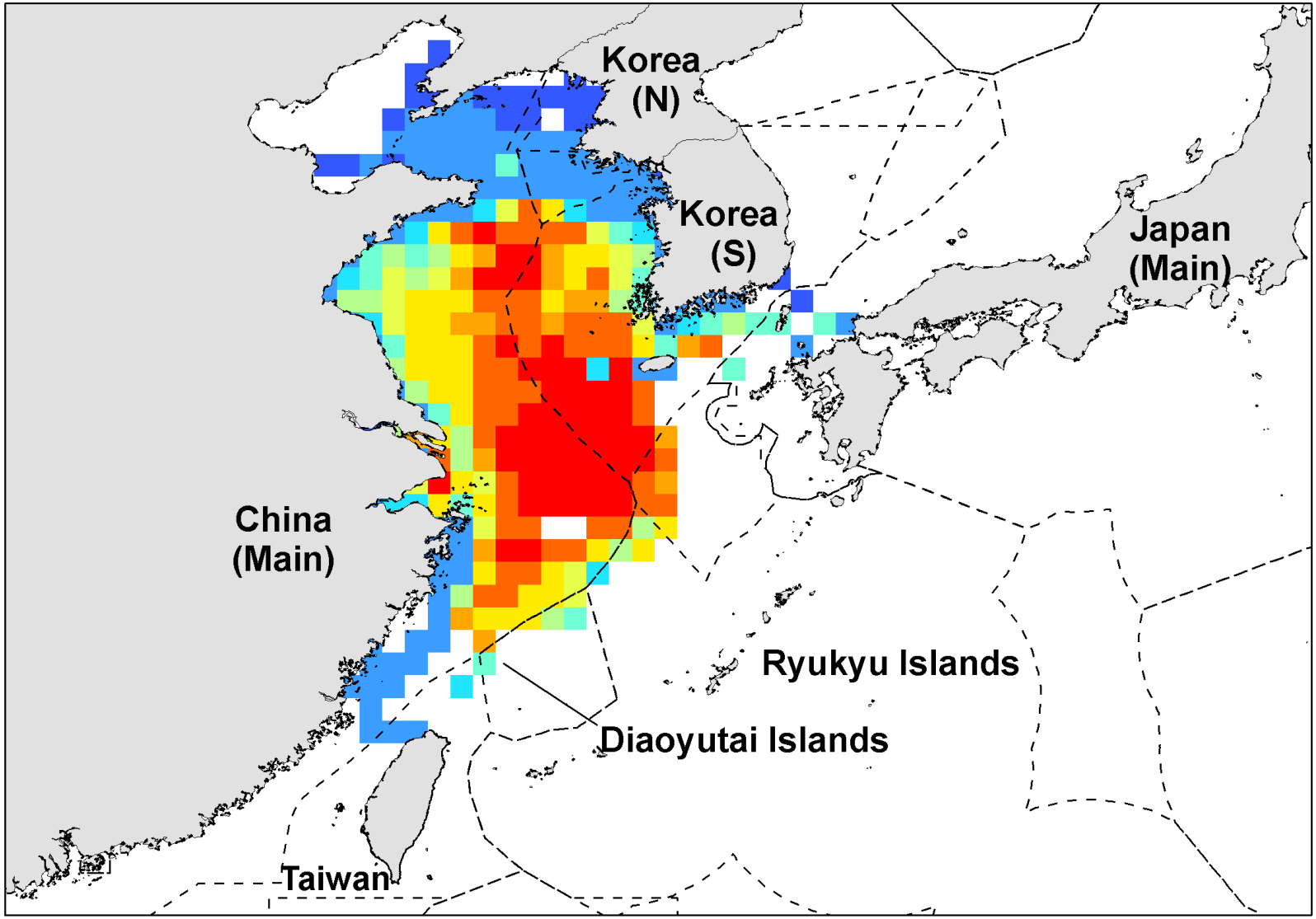
Small yellow croaker

Year 22



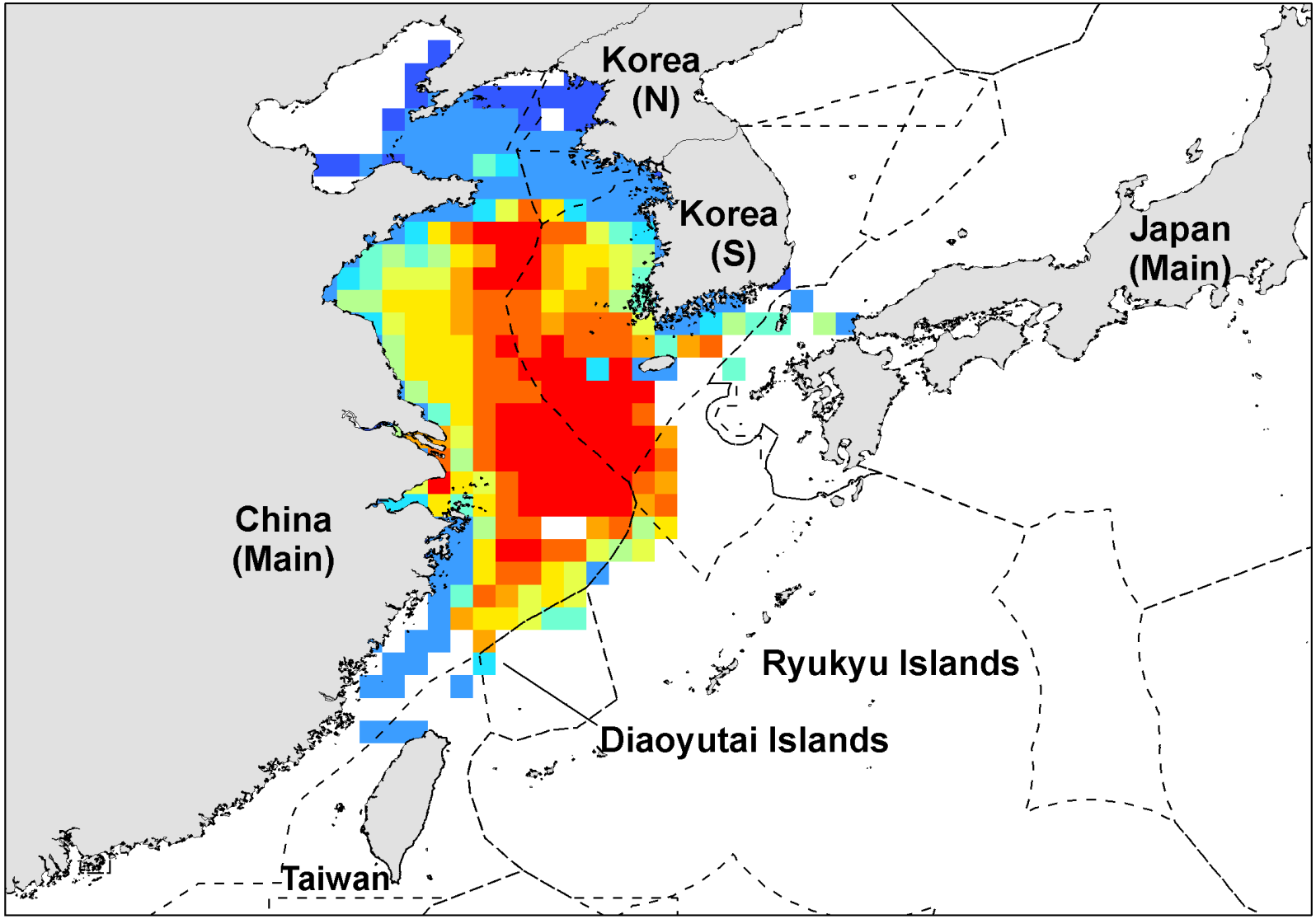
Small yellow croaker

Year 24



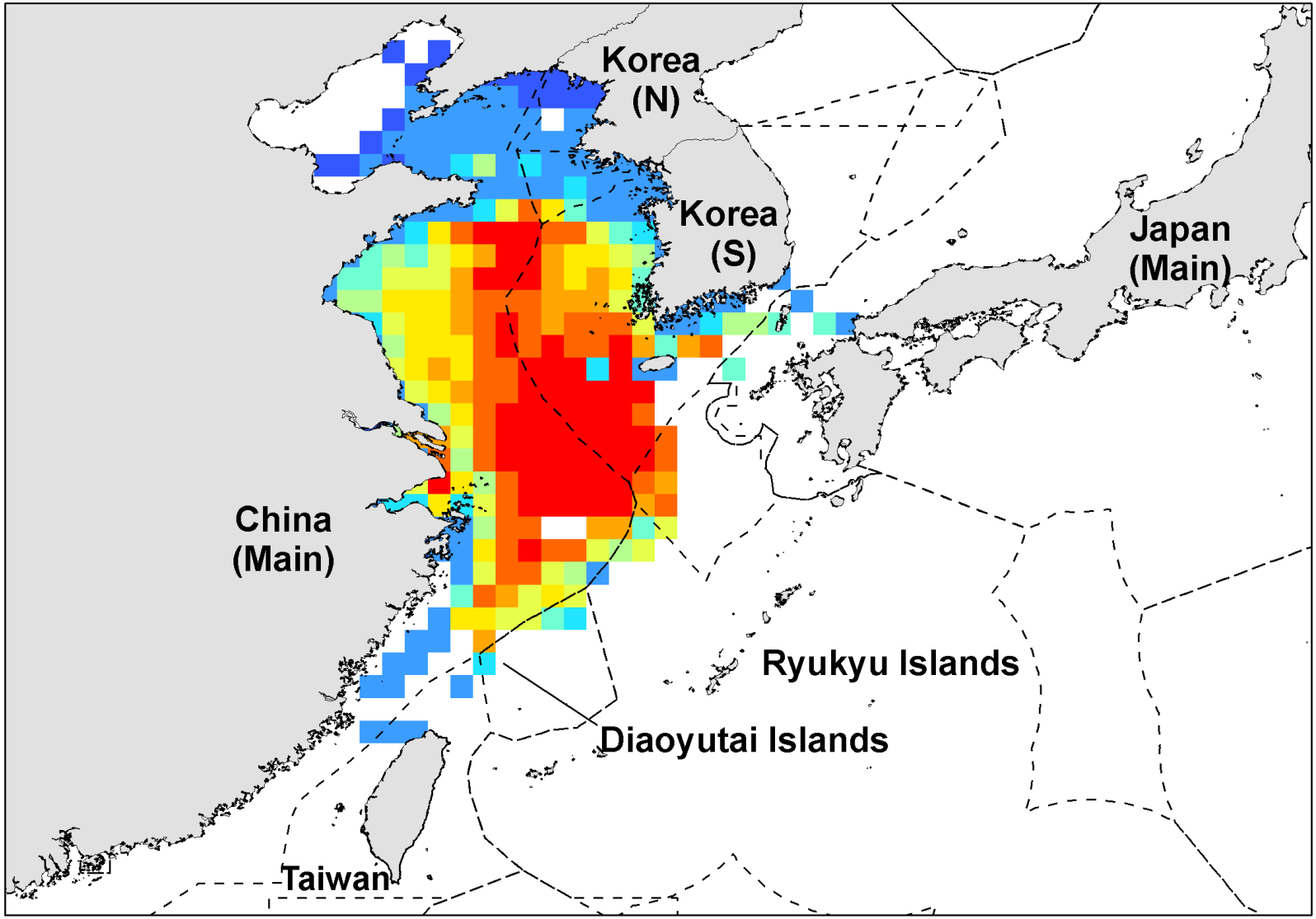
Small yellow croaker

Year 26



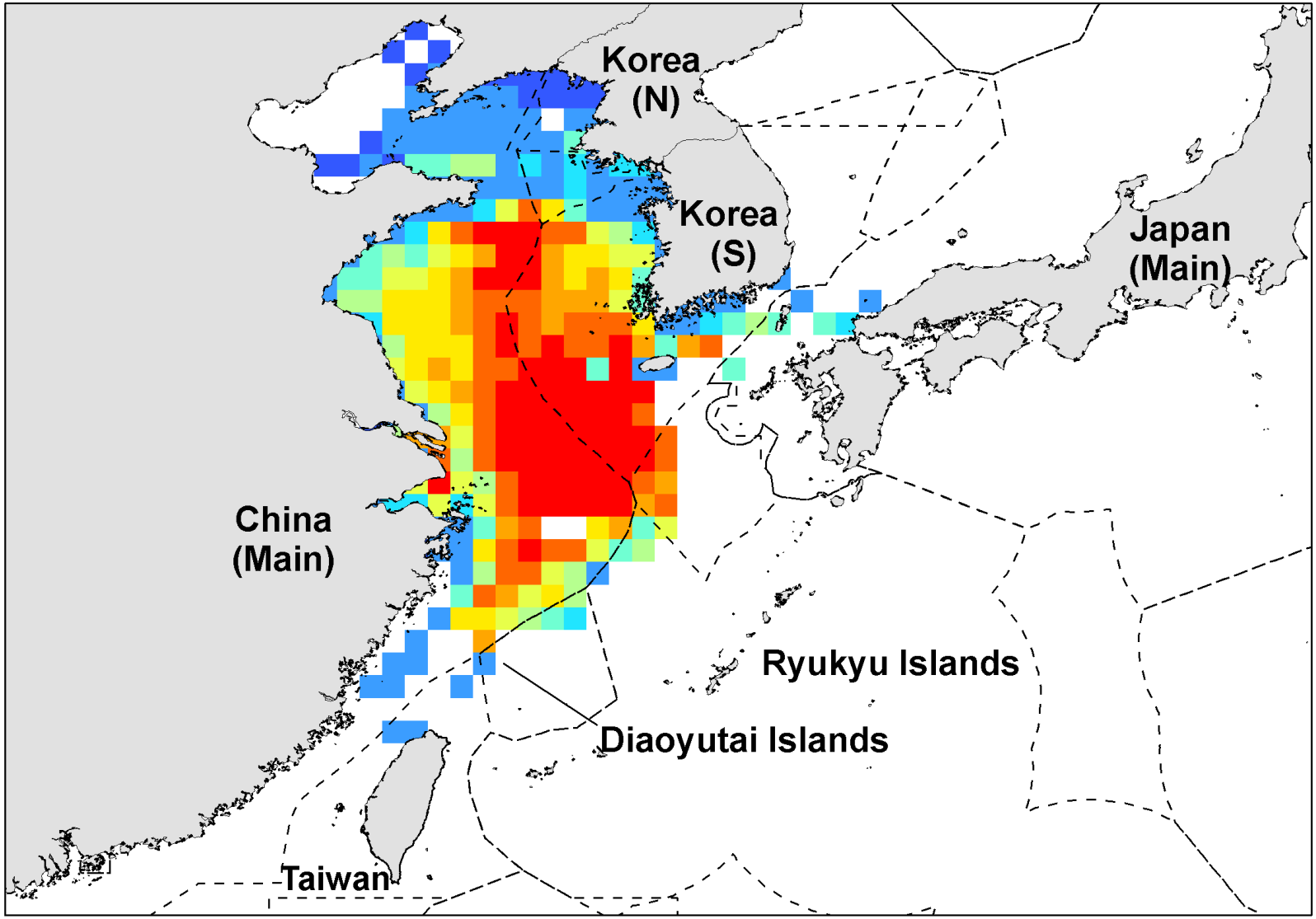
Small yellow croaker

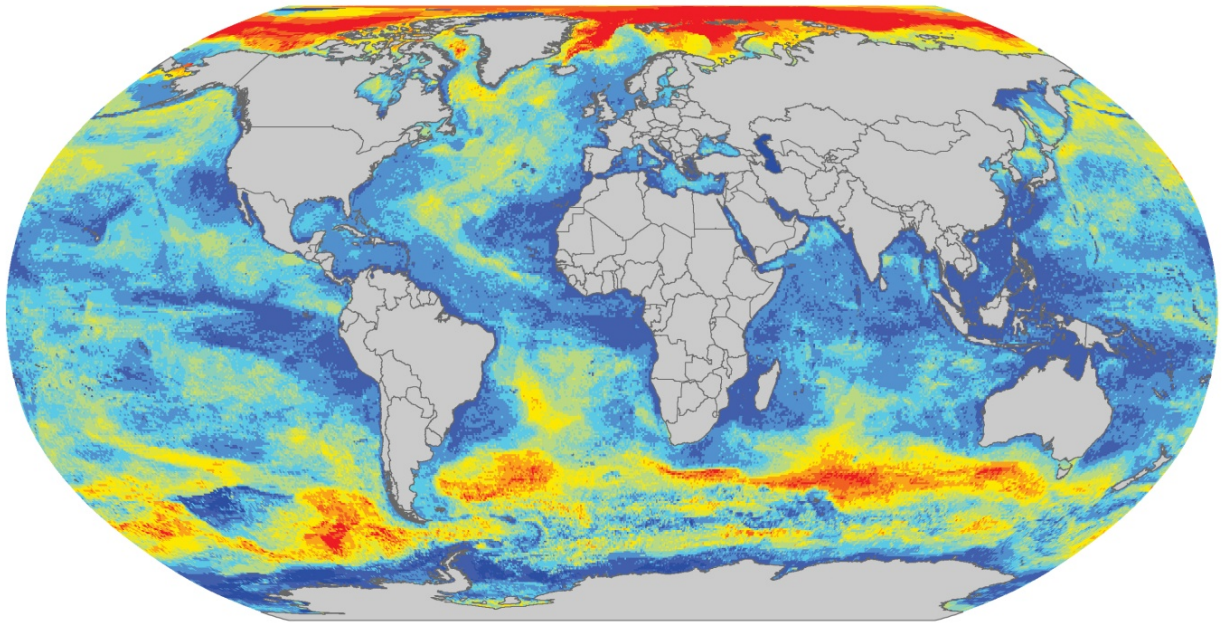
Year 28



Small yellow croaker

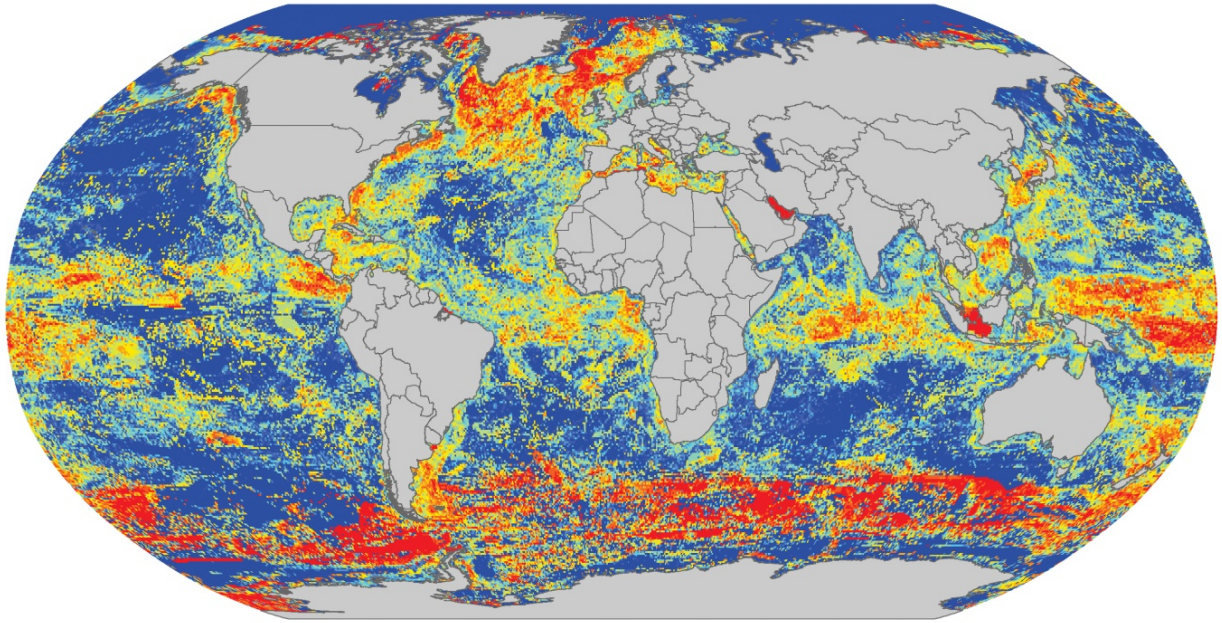
Year 30





Species invasion

- > 4.00
- > 2.80 - 4.00
- > 1.80 - 2.80
- > 1.20 - 1.80
- > 0.90 - 1.20
- > 0.60 - 0.90
- > 0.45 - 0.60
- > 0.30 - 0.45
- > 0.15 - 0.30
- > 0 - 0.15
- 0

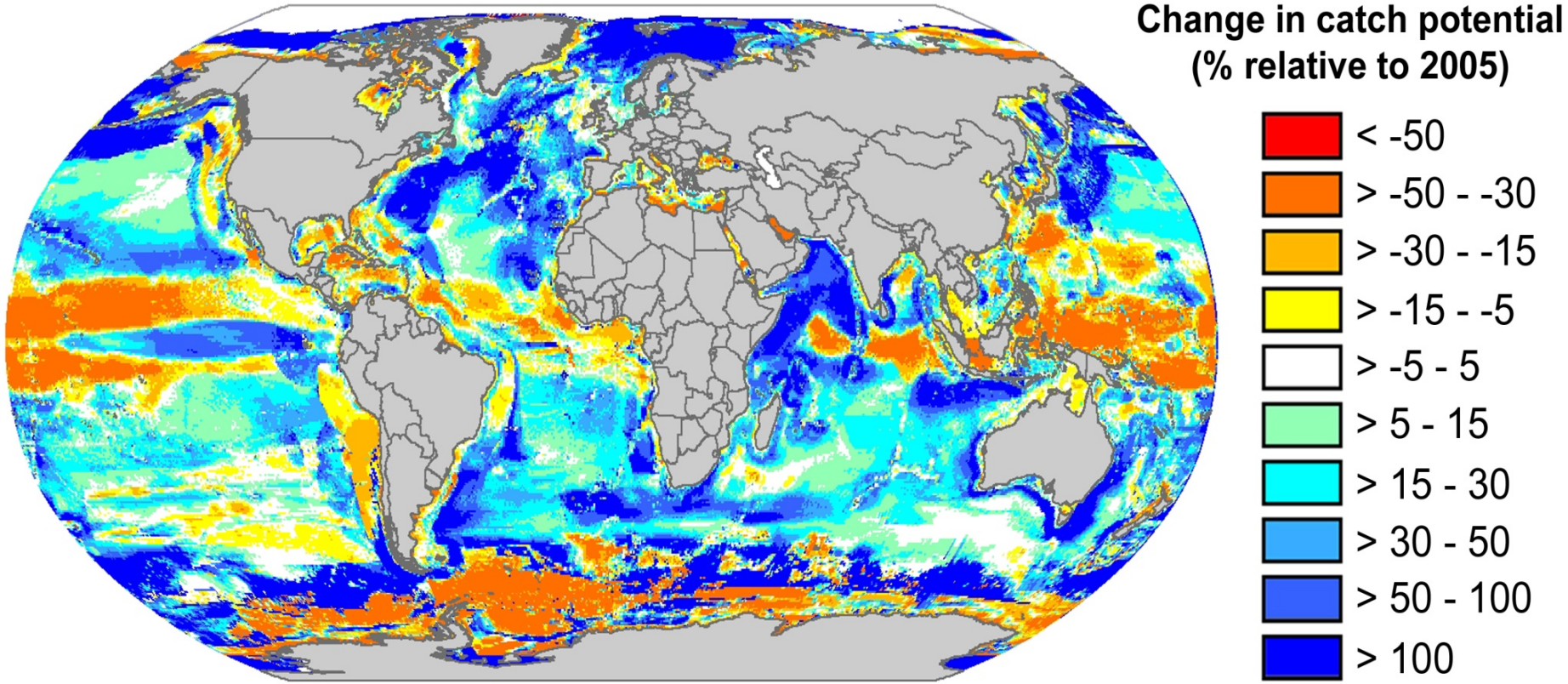


Local extinction

- > 0.120
- > 0.080 - 0.120
- > 0.060 - 0.080
- > 0.045 - 0.060
- > 0.035 - 0.045
- > 0.025 - 0.035
- > 0.015 - 0.025
- > 0.010 - 0.015
- > 0.005 - 0.010
- > 0 - 0.005
- 0

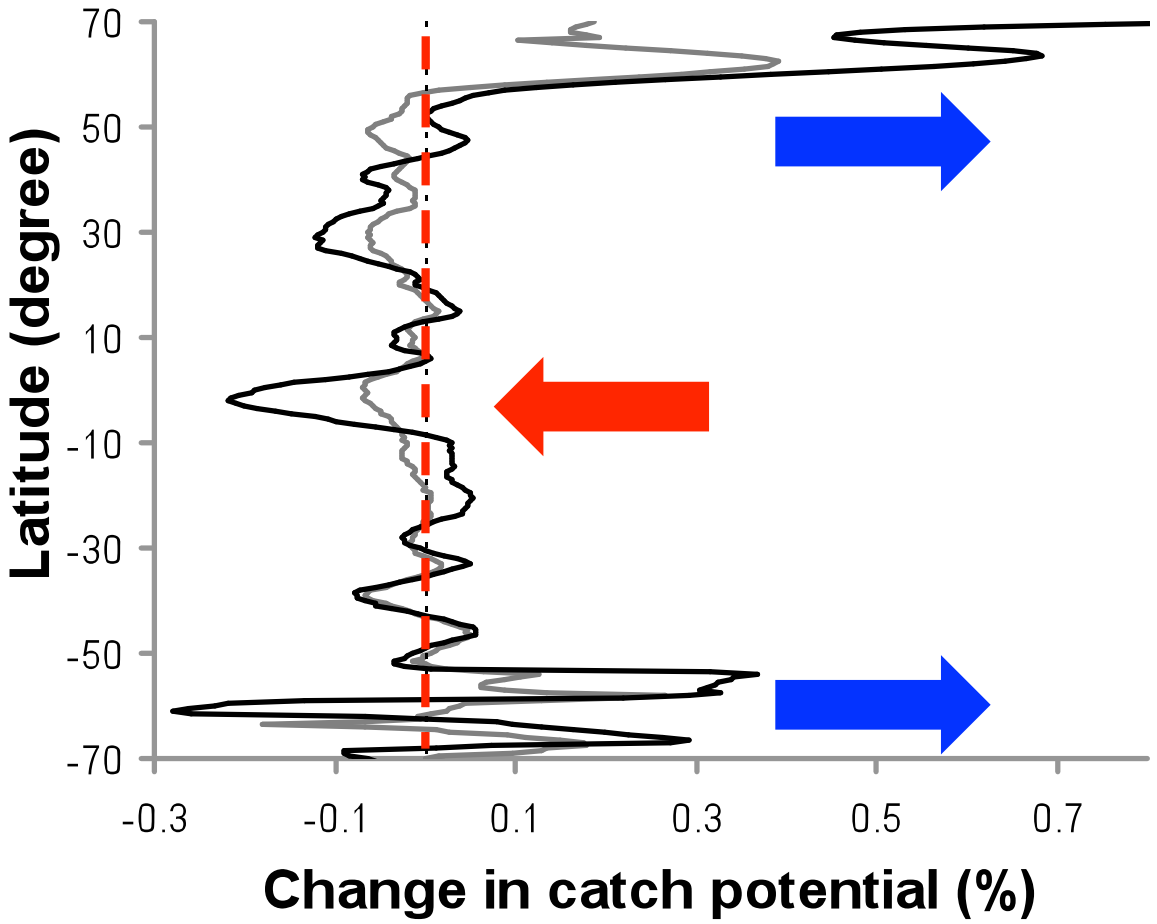
SEA AROUND US PROJECT

Projected change in catch potential in 50 years



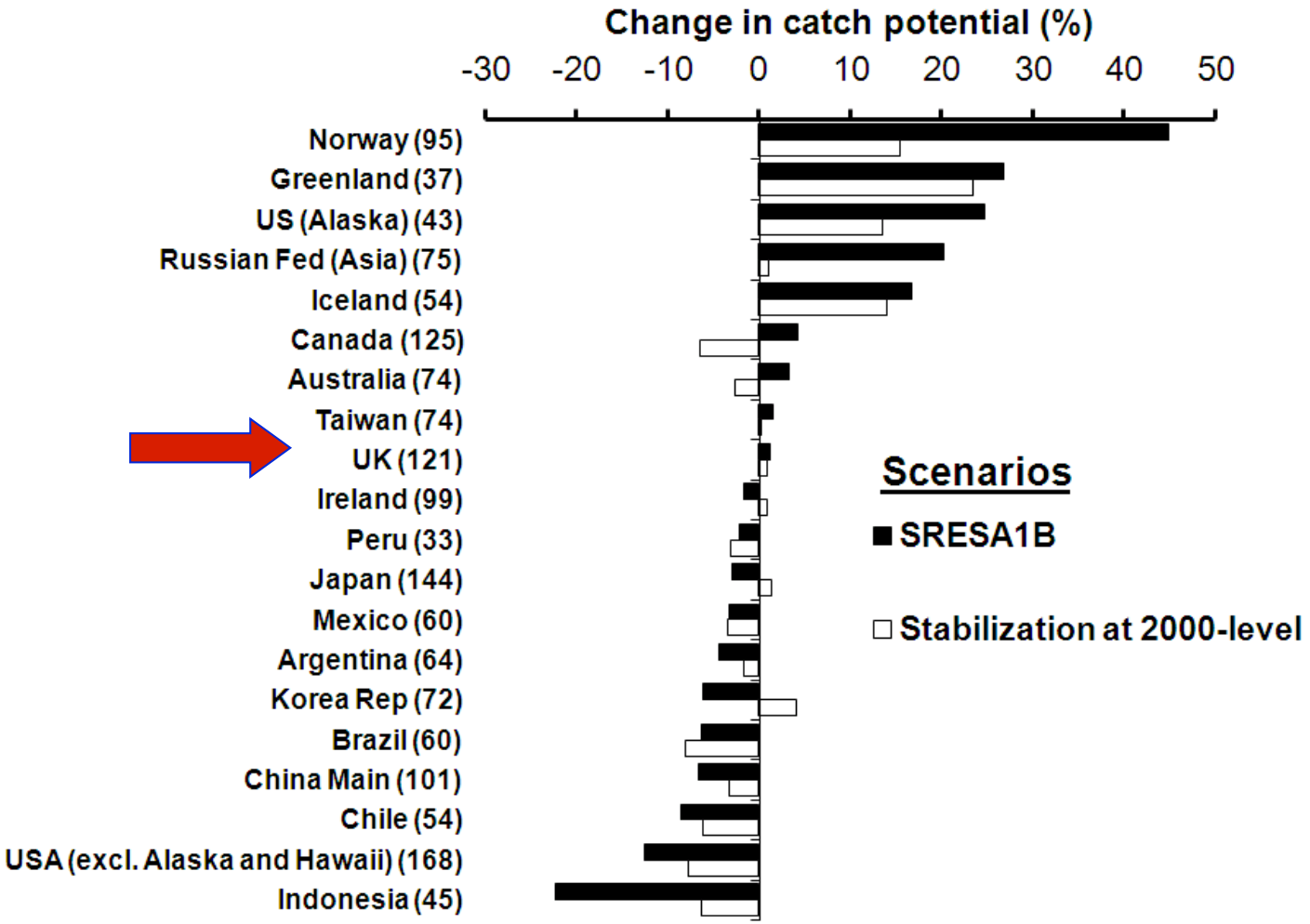
Cheung, Lam, Kearney, Sarmiento, Watson, Zeller and Pauly (*Global Change Biology*, 2009)

Global changes of fishery potential, by latitude



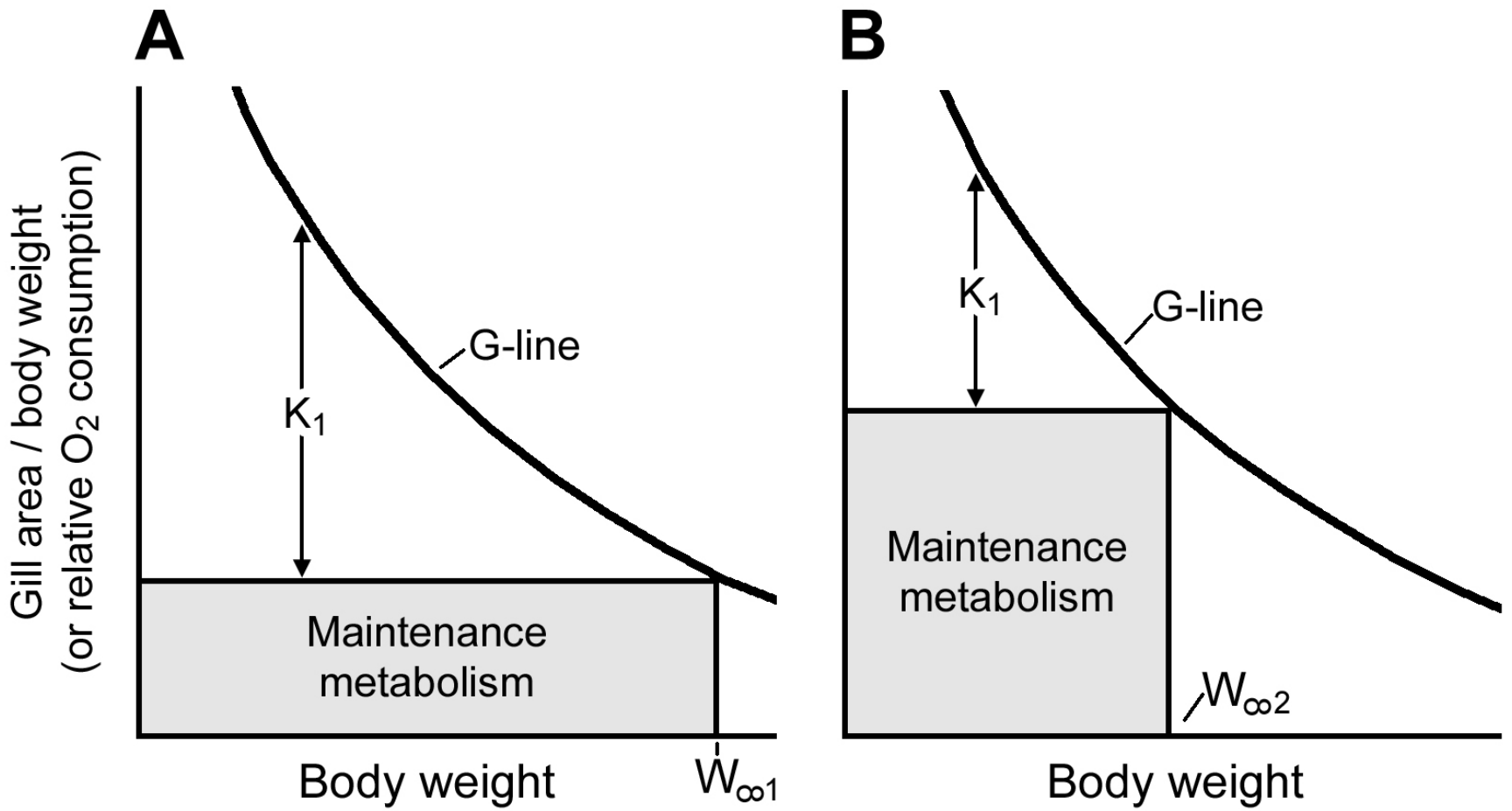
Cheung, Lam, Kearney, Sarmiento, Watson, Zeller, Pauly (*Global Change Biology*, 2009)

Changes in catch potential, by EEZ

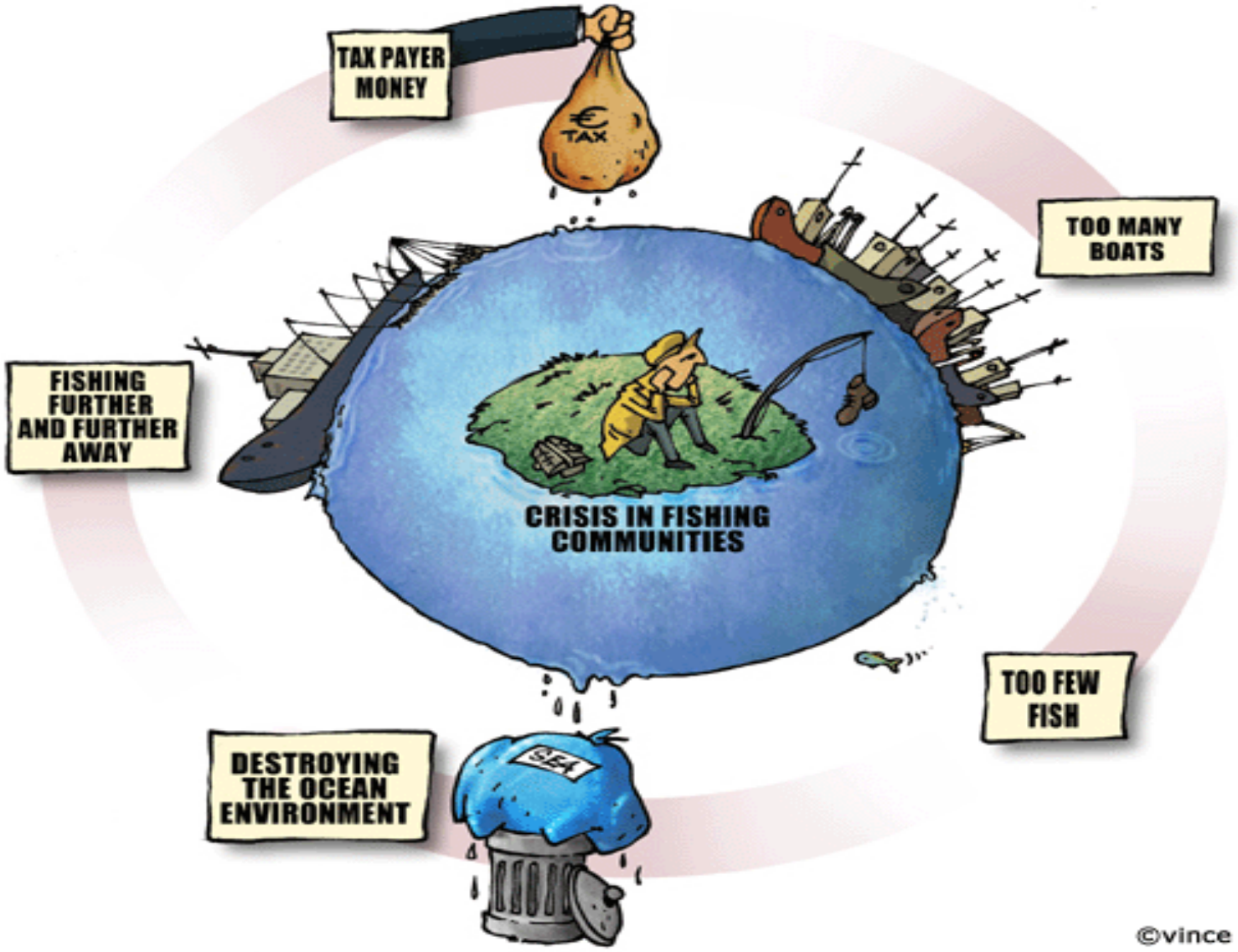


Cheung, Lam, Kearney, Sarmiento, Watson, Zeller and Pauly (*Global Change Biology.* 2009)

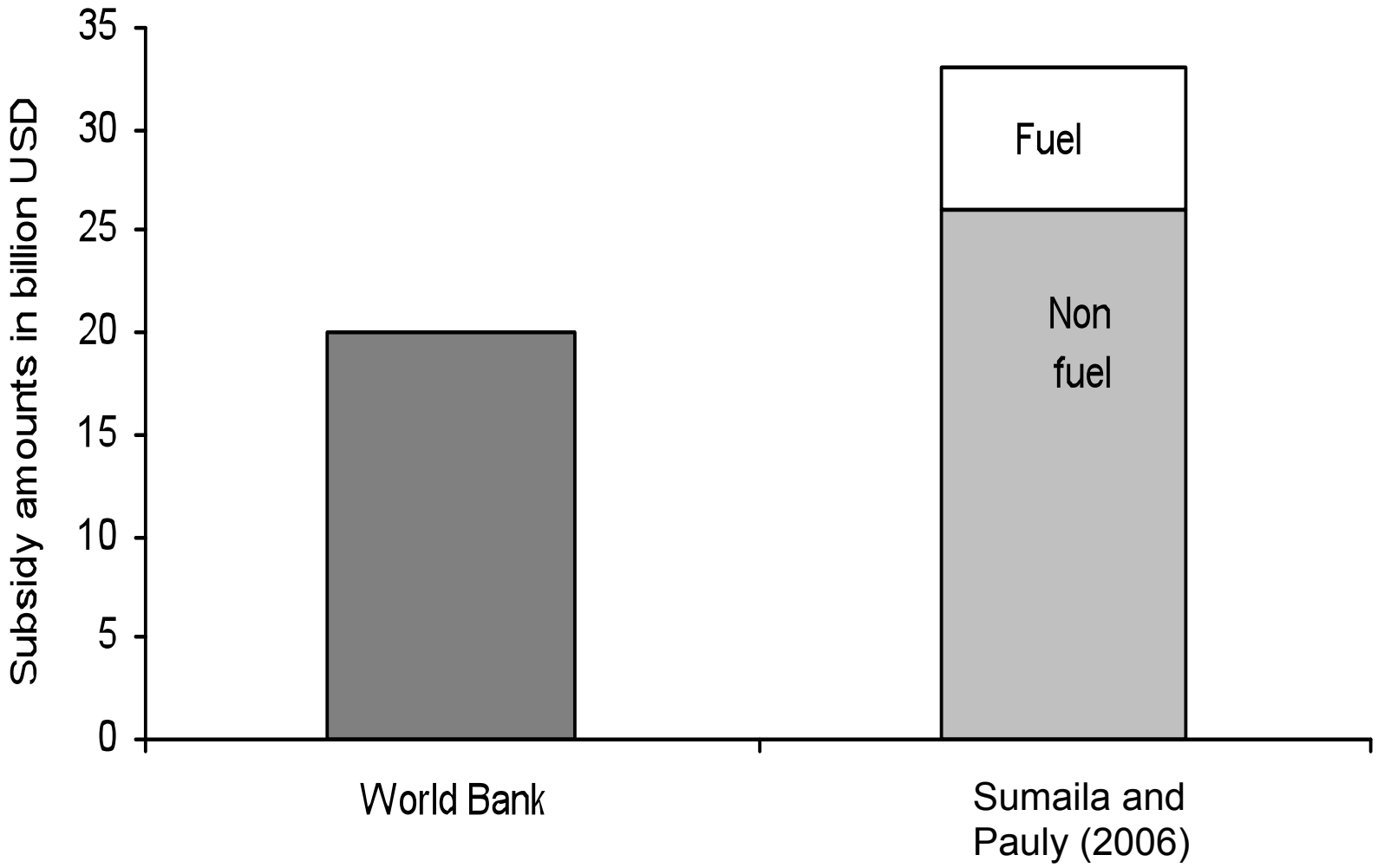
Why oxygen matters



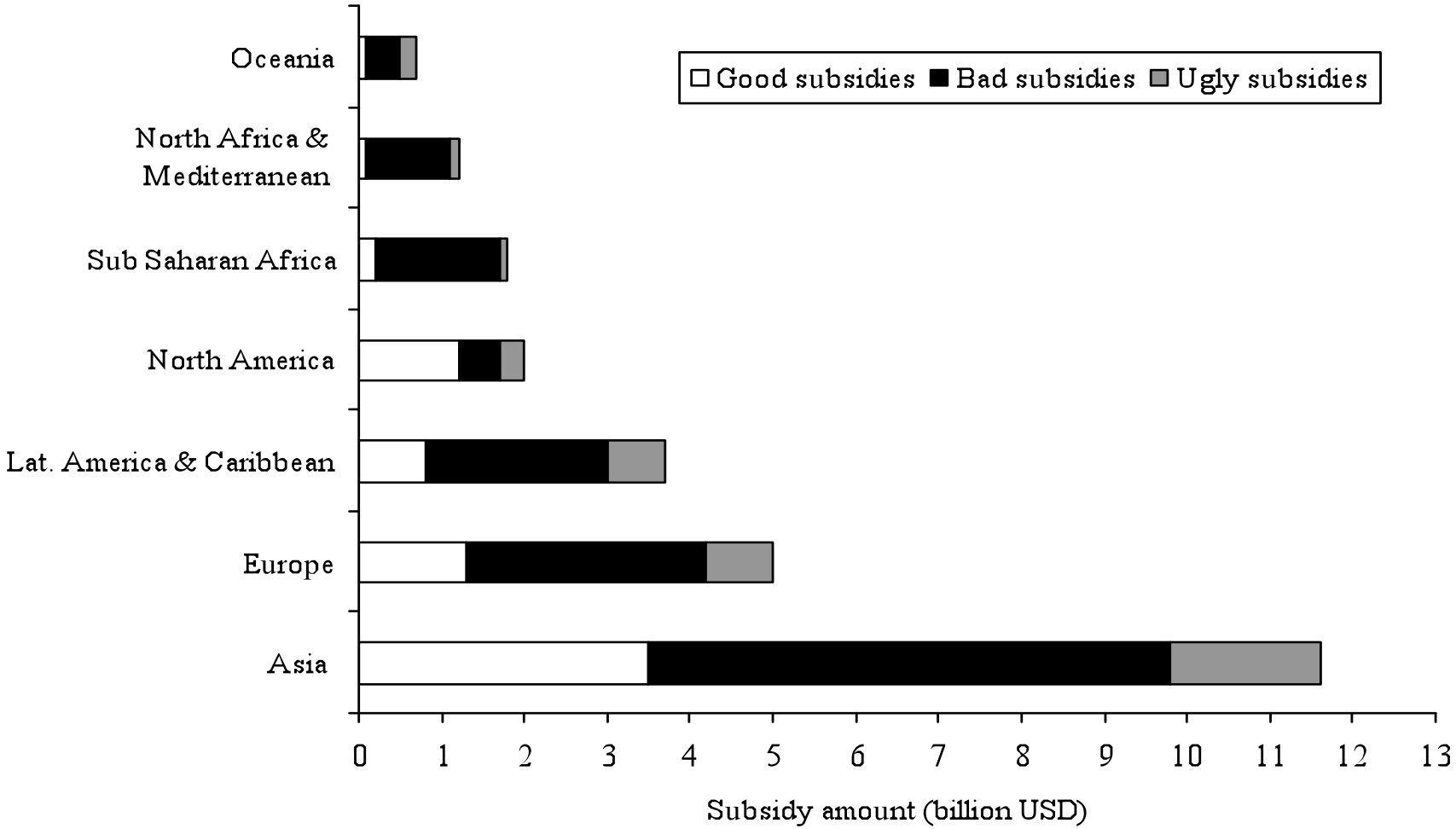
Subsidies drive further expansion of fishing



Global subsidy comparisons

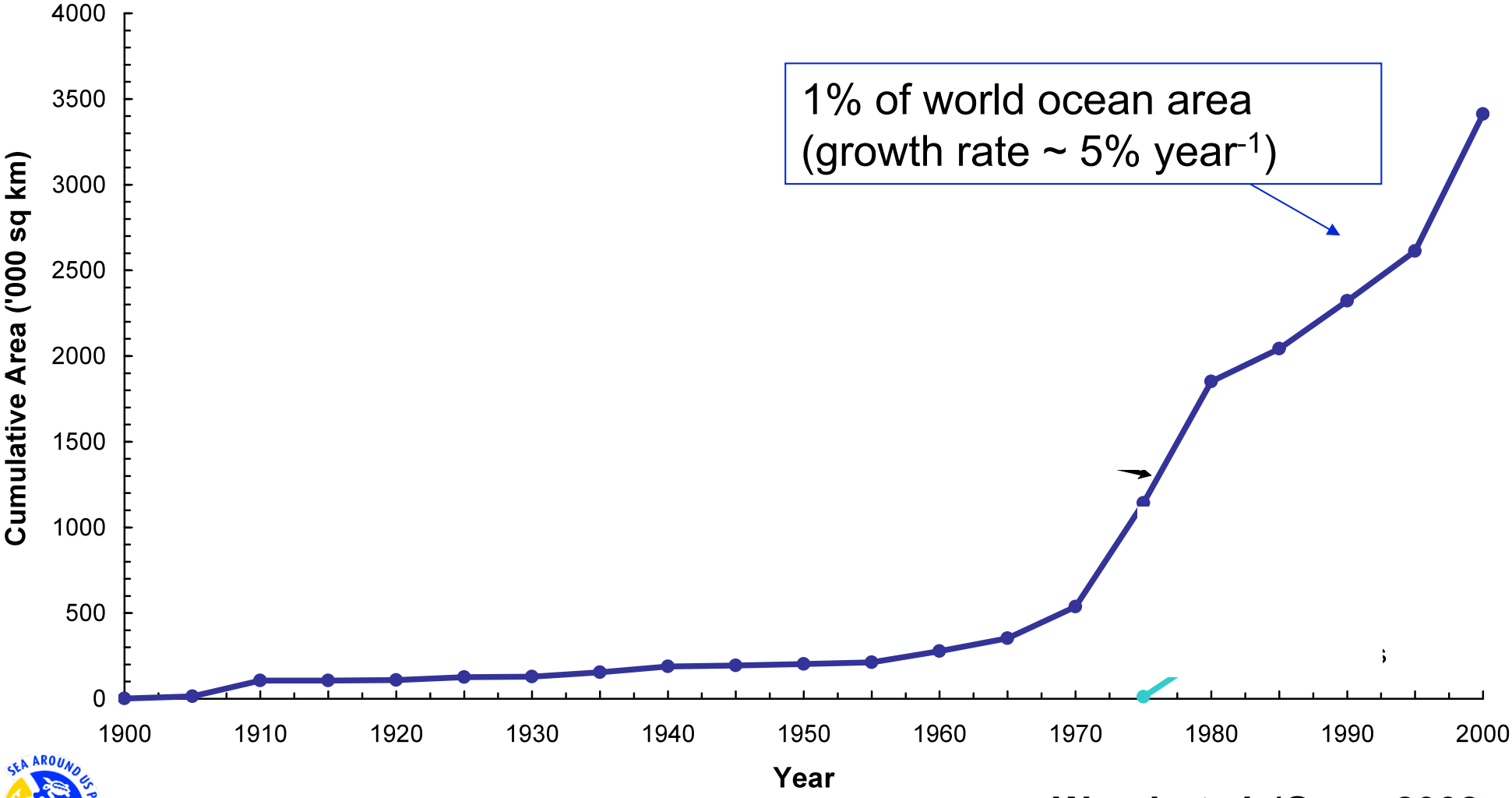


Subsidies come in different flavors…



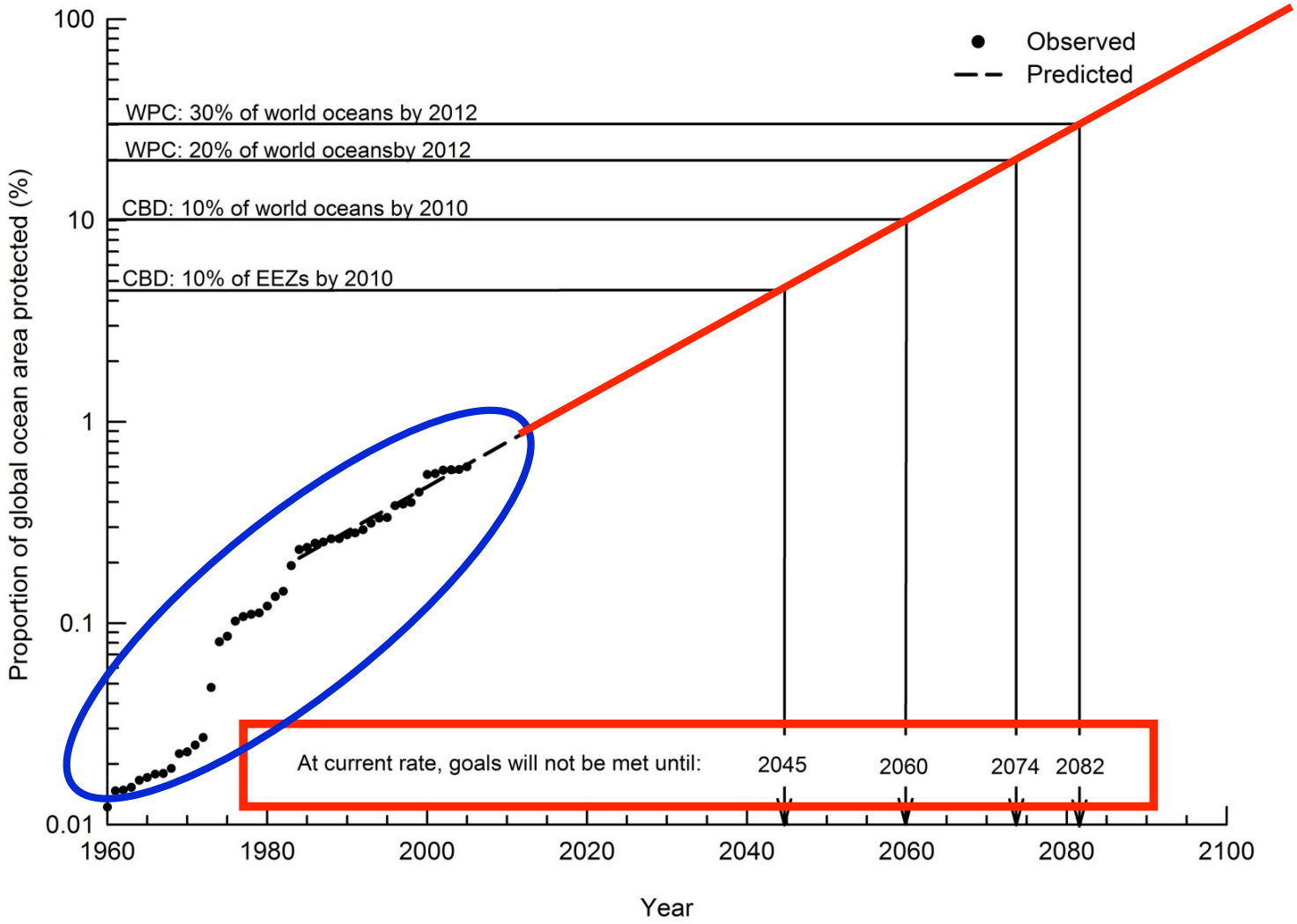
Sumaila and Pauly (2006)

Marine Protected Areas are part of the solution. There are many, but most of them are tiny…



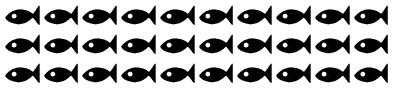
Wood *et al.* (Oryx; 2008)

As a result, the growth of the global MPA network is so slow that we will miss all the targets…



Wood *et al.* (2008)

Summary: This graph, which compares small-scale with large-scale fisheries, probably underestimates the role of small-scale fisheries. Also, we would achieve most stated aims of fisheries management (particularly its social aims) by dedicated access arrangement for small scale fisheries. But we must leave enough fish for the rest of the ecosystem, and to meet to challenges of global warming.

FISHERY *BENEFITS*	**LARGE SCALE** 	**SMALL SCALE** 
Number of fishers employed	 about ½ million	 over 12 millions
Annual catch of marine fish for human consumption	 about 29 million tonnes	 about 24 million tonnes
Capital cost of each job on fishing vessels	 $30,000 - $300,000	 $250 - $2,500
Annual catch of marine fish for industrial reduction to meal and oil, etc.	 about 22 million tonnes	 Almost none
Annual fuel oil consumption	 14 – 19 million tonnes	 1 – 3 million tonnes
Fish caught per tonne of fuel consumed	 2 – 5 tonnes	 10 – 20 tonnes
Fishers employed for each $1 million invested in fishing vessels	 5 - 30	 500 – 4,000
Fish and invertebrates discarded at sea	 10-20 million tonnes	Little

Acknowledgements…

- The Pew Environment Group, Washington, D.C.;

- The University of British Columbia's Fisheries Centre

- Members of the *Sea Around Us* project,

and many others...

visit us at **www.seaaroundus.org**