

# How much fish are we really catching?

## The reconstructed catches of global marine fisheries



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Canada

The audio is over the phone; please call toll free (US and CAN) 1-877-708-1667, passcode is 7028688#



NOAA Seminar Series  
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We can start considering catch reconstructions here, when *Nature* asked a misleading question:

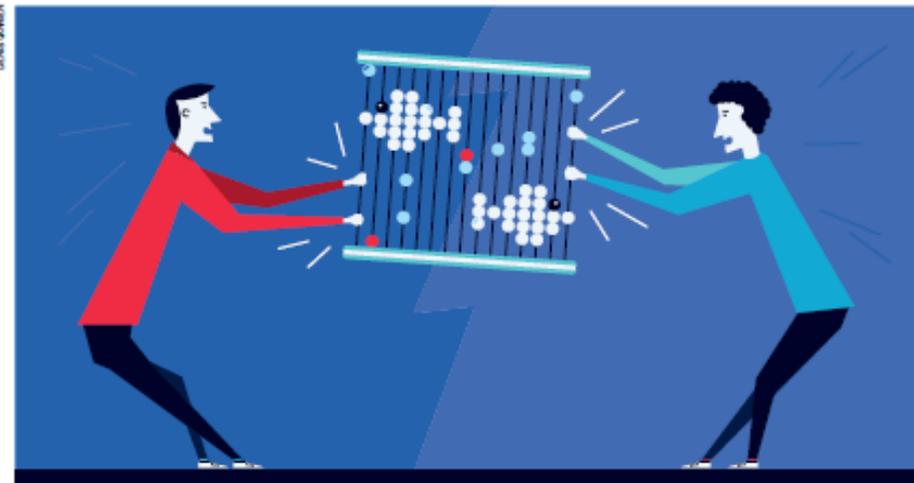
# COMMENT

**ENERGY** Shale gas and oil will run out faster than champions predict **p.307**

**ANTHROPOLOGY** Napoleon Chagnon sets the record straight **p.310**

**BIOGRAPHY** A flattering life of impish physicist Freeman Dyson **p.311**

**HEALTH** Iran needs international help to fight HIV epidemic **p.314**

## Does catch reflect abundance?

Researchers are divided over the wisdom of using estimates of the amount of fish hauled in each year to assess the health of fisheries.

**POINT**  
**Yes, it is a crucial signal**  
 The only data available for most fisheries are the weight of fish caught each year, insists Daniel Pauly.

In developed countries such as the United States, Australia and members of the European Union, many fisheries are monitored by fisheries scientists using expensive stock assessments. To infer the size of the fish populations being exploited, scientists use the age and size distributions of the fish caught; the results of scientific surveys carried out from research vessels; and information about growth and migration from tag and recapture studies. Yet the only data ▶

**COUNTERPOINT**  
**No, it is misleading**  
 Many factors as well as abundance determine the hauls of fishermen, warn Ray Hilborn and Trevor A. Branch.

The major database on all the fisheries of the world is the *FAO Yearbook of Fishery and Aquaculture Statistics*. This collates the amount (in weight) of haddock, bream, cod and more than 1,000 other species hauled in each year by fishermen, whether from commercial trawlers or canoes, using estimates sent in by officials from individual countries. For the past few years, researchers have been conducting analyses ▶



As posed by *Nature*, this question is misleading because even if the answer were negative, we still require catch data when working on fisheries, because:

1. The size of a fishery, relevant to assessing whether, e.g., it warrants devoting resources to its study and management;
2. The gross value of a fishery (when landings are multiplied with ex-vessel prices), as required, e.g., for negotiations about bilateral fisheries access agreement;
3. The magnitude of the environmental impacts of fisheries (especially when combined with the catch rate of various habitat impacting gear); and
4. The extent of criminal and/or fraudulent activities in the case of illegal catches, etc.



Indeed, one could argue that we don't know a fishery when we don't know its catch – since it is conducted, after all, to produce a catch.

Which is where accurate statistics come in...

When working on the fisheries of their country, fisheries scientists, staff of environmental NGO's and other parties, usually work with their own, and/or national data, and there are few problems of accuracy. The excellent USA – NOAA data is a case in point.

When working on foreign countries, most actors use FAO statistics, which are based on annual submissions by their member countries.



The FAO statistics are misleading. After working with them for decades, and initially thinking that they were roughly correct, i.e., that their errors are more or less randomly distributed (except for the famous case of China).

We were wrong: the FAO data (with a few exceptions) are strongly biased downward because the countries do not see it fit to report on all of their fisheries, especially on their small-scale fisheries, which turn out to be one of the major sources of IUU catches (i.e., unreported catches).



But how can we know what FAO and/or its member countries don't seem to know? (Or more accurately: don't bother with.)

This is where catch reconstruction comes in, which are based on two pillars:

1) Fishing is a *social* activity, which therefore throws a 'shadow' on the economy and the society that it is embedded in. Thus, in literate societies, it is not possible to operate a fishery which will leave no written trace on other sectors of the economy and/or on society at large; and

2) Almost any reasonable estimate, even a guess based on this societal 'shadow' in (1) will be a better than the precise estimate of *zero* that is implied when, absent detailed statistics, a bureaucrat simply ignores a fishery.



These two points were first made in a 1998 newsletter article of which a PDF can be sent to anyone who wants one.



Pauly D (1998) Rationale for reconstructing catch time series. EC Fisheries Cooperation Bulletin 11(2): 4-10.

Pauly, D. 1998. Rationale for reconstructing catch time series. *EC Fisheries Cooperation Bulletin*, 11(2): 4-7 [Also in French: "Approche raisonnée de la reconstruction des séries temporelles de prises", p. 8-10]

**KNOWLEDGE FOR THE FUTURE**



## Rationale for reconstructing catch time series

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**Keywords:** fishbase; fishery management; catch time series; overfishing; acp-eu fisheries research initiative; caribbean; acp; philippines; asia



**Introduction**

The 'FishBase' Project organised the second regional training course in Trinidad in May/June 1998. Colleagues from most Caribbean ACP countries participated (see also this Bulletin Vol. 10(1) March 1997 and Vol. 11(1) March 1998). Their course work on their own data and additional information accessed additional data sources in the library gave rise to discussions among participants and the following reasoning on the importance of historical data and their analysis.

Estimating catches from the catch/effort of selected gear and fishing effort is a standard method for fisheries management. Reconstruction of historic catches and catch compositions series may require interpolations and other bold assumptions, justified by the unacceptability of the alternative (i.e. accepting catches to be zero, or otherwise known to be incompatible with empirical data and historic records). Simple equations are presented from which the status of fisheries and their resources can then be inferred. Early catch and effort figures from the Philippines, and catch data from Trinidad & Tobago are presented which illustrate some of these points.

**The catch in using catch statistics**

It is widely recognised that catch statistics are crucial to fisheries management. However, the catch statistics routinely collected and published in most countries are deficient in numerous ways. This is particularly true of the national data summary sent by the statistical offices of various Caribbean and Pacific countries to the Food and Agriculture Organization of the United Nations (FAO) for inclusion in the global statistics compiled by that organisation, and included in FishBase (see Froese & Pauly, 1996).

A frequent response in this situation has been to set up intensive, but relatively short-term projects devoted to improving national data reporting systems. Their key products are detailed statistics covering the (few) years of the project. However, these data are usually hard to interpret, given the frequent absence of data from previous periods, from which changes could be evaluated. This is a major drawback, as it is the changes occurring within a contrast-rich dataset which provide the basis from which trends in the status of the resources supporting various fisheries can be determined (Uhlirsen & Walters, 1992; Pauly, 1995).

It is thus evident that reconstructing past catches and catch compositions is a crucial activity for fisheries scientists and officers in the Caribbean or the Pacific, and that such activity is required to fully interpret the data emanating from current data collection projects. This may be illustrated by the following example: suppose that the Fisheries Department of Country A establishes, after a large and costly sampling project, that its reef fishery generated catches of say 5 and 4 t km<sup>-2</sup> year<sup>-1</sup> for the years 1993 and 1996, respectively. The question now is: are these catch figures high values, allowing an extension of the fishery, or low values, indicative of an excessive level of effort?

Clearly, one approach would be to compare these figures with those of adjacent Countries B and C. However, these countries may lack precise statistics, or have fisheries using a different gear. Furthermore, A's Minister in



Participants of the Caribbean regional training Fishbase course for trainers, Port of Spain, 2 June '98.  
Participants de la cours régional de formation Fishbase pour formateurs des Caraïbes, Port of Spain, 2 juin '98

Bulletin vol 11 n°2

- 4 -

Juin 1998

# Thus, what are 'catch reconstructions?

Catch reconstructions are estimates of all withdrawals from the ecosystem, based on:

- Baseline catches back to 1950 (to be able to compare present with earlier system state);
- All sectors: industrial, artisanal, subsistence, and recreational;
- Include landed catch as well as discards (because the fish don't care who killed them);
- National or other information complementing the data submitted to FAO or other international bodies.



The *Sea Around Us* and our network of colleagues throughout the world have completed about 200 reconstruction studies for the EEZs (or ‘chunks’ thereof) for about 150 maritime countries and their territories, i.e., a total of 273 reconstructions, by sector and species, for 1950 to 2010 (updates to 2013/2014 are in progress), covering all marine fisheries of the world (see [www.seaaroundus.org](http://www.seaaroundus.org)).

This allows for a re-assessment of fishery trends in the world. Some examples will be presented, but first some definitions:



# Our definitions

- **Industrial sector:** consisting of relatively large motorized vessels, requiring large sums for their construction, maintenance and operation, either domestically, in the waters of other countries and/or the high seas, and landing a catch that is overwhelmingly sold commercially;
- **Artisanal sector:** consisting of small-scale (hand lines, gillnets etc.) and fixed gears (weirs, traps, etc.) whose catch is predominantly sold commercially (notwithstanding a small fraction of this catch being consumed or given away by the crew);
- **Subsistence sector:** consisting of fisheries whose primary driver is for consumption by ones family, rather than engage in commerce. Often these are conducted by women and children. Also the fraction of the catch of mainly artisanal boats that is given away to the crews' families or the local community;
- **Recreational sector:** consisting of fisheries conducted mainly for pleasure, although a fraction of the catch may end up being sold or consumed by the recreational fishers and their families and friends.

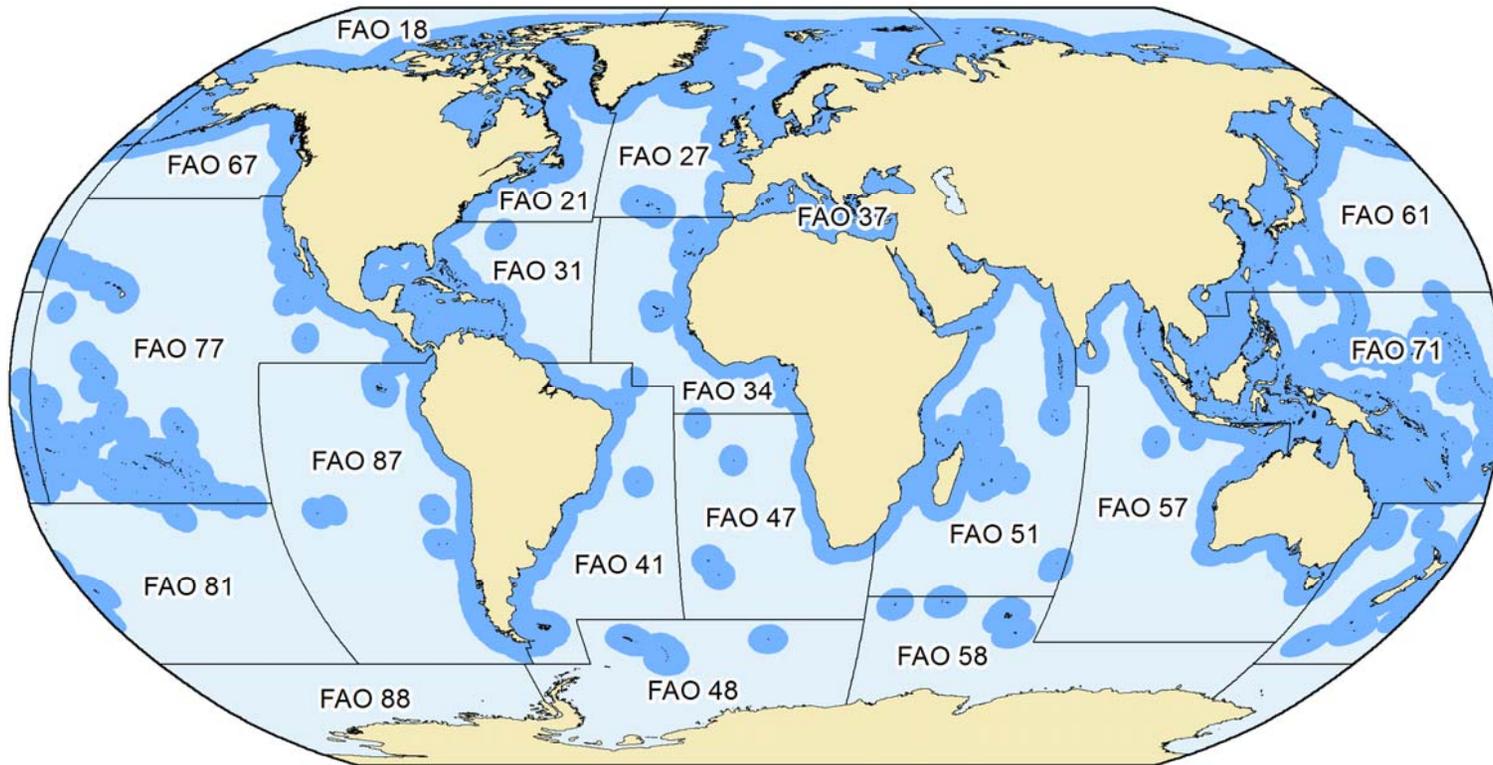
Also: **Catch = Landings + Discards**



Zeller *et al.* (2007) Fishery Bulletin 105(2): 266-277

Zeller *et al.* (2015) Coral Reefs 34(1): 25-39

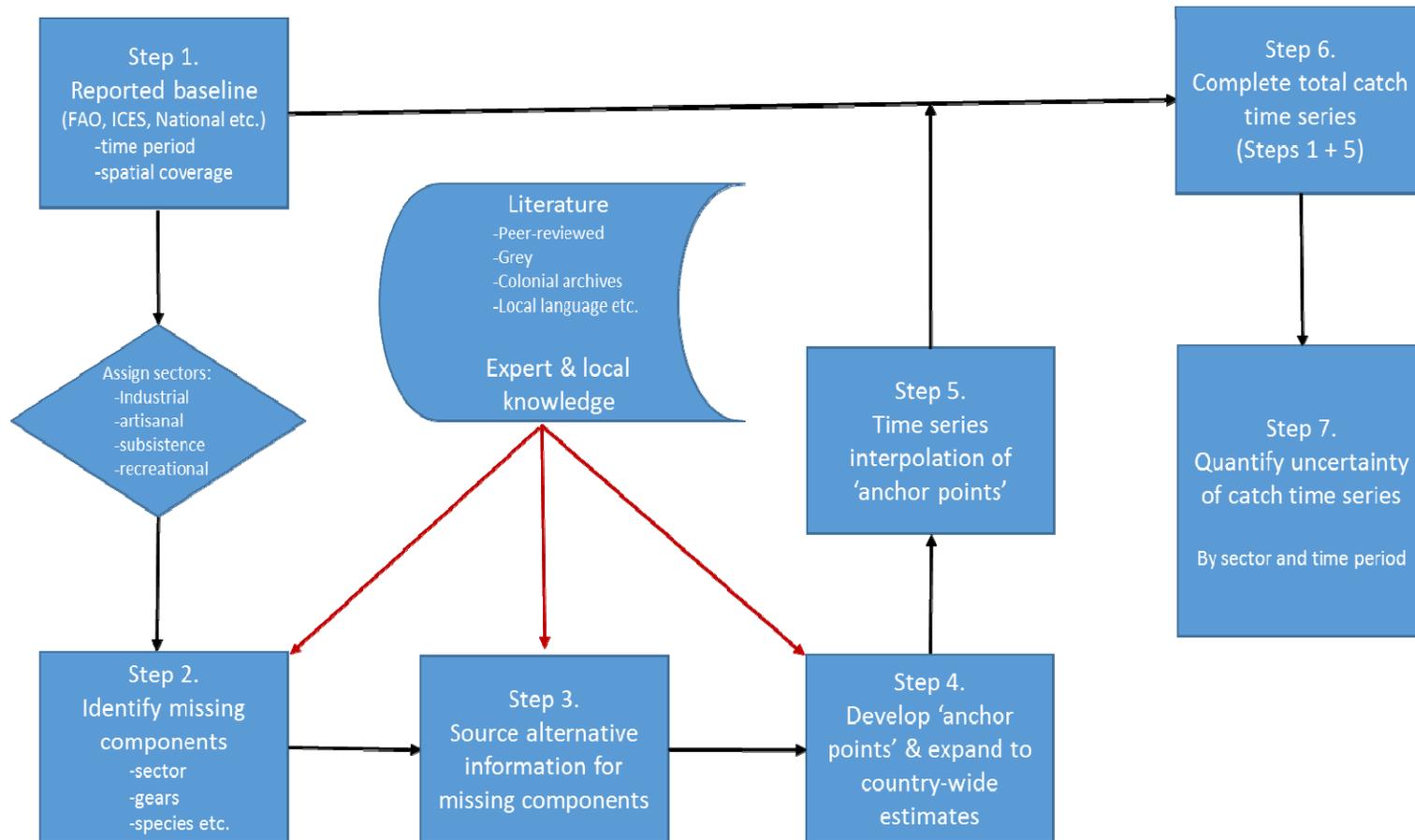
Pauly and Zeller (2016) Nature Communications 7: 10244. Suppl. Mat.



The reconstructions are done by Exclusive Economic Zones (EEZs; except for industrially-caught tuna). Extent and delimitation of countries' EEZs, as declared by individual countries, or as defined by the *Sea Around Us* are based on the fundamental principles outlined in UNCLOS (i.e., 200 nautical miles or mid-line rules), and the FAO statistical areas by which global catch statistics are reported. Note that for several FAO areas, some data exist by sub-areas as provided through regional organizations.



# Reconstruction approach



Conceptual representation of the stepwise catch reconstruction approach as developed by members of the *Sea Around Us*.



Zeller *et al.* (2007) *Fishery Bulletin* 105(2): 266-277

Zeller *et al.* (2015) *Coral Reefs* 34(1): 25-39

Pauly and Zeller (2016) *Nature Communications* 7: 10244. Suppl. Mat.

# Quantify uncertainty: 'Score' quality of time series data

'Scores' for evaluating the quality of time series of reconstructed catches, with their approximate confidence intervals (IPCC criteria from Figure 1 of Mastrandrea *et al.* 2010); the percent intervals are adapted from various sources (available on request)

Score		+/- (%)	Corresponding IPCC criteria*
4	Very high	10	High agreement & robust evidence
3	High	20	High agreement & medium evidence or medium agreement & robust evidence
2	Low	30	High agreement & limited evidence or medium agreement & medium evidence or low agreement & robust evidence.
1	Very low	50	Low agreement & low evidence

Mastrandrea *et al.* (2010) note that "confidence increase" (and hence confidence intervals are reduced) "when there are multiple, consistent independent lines of high-quality evidence".

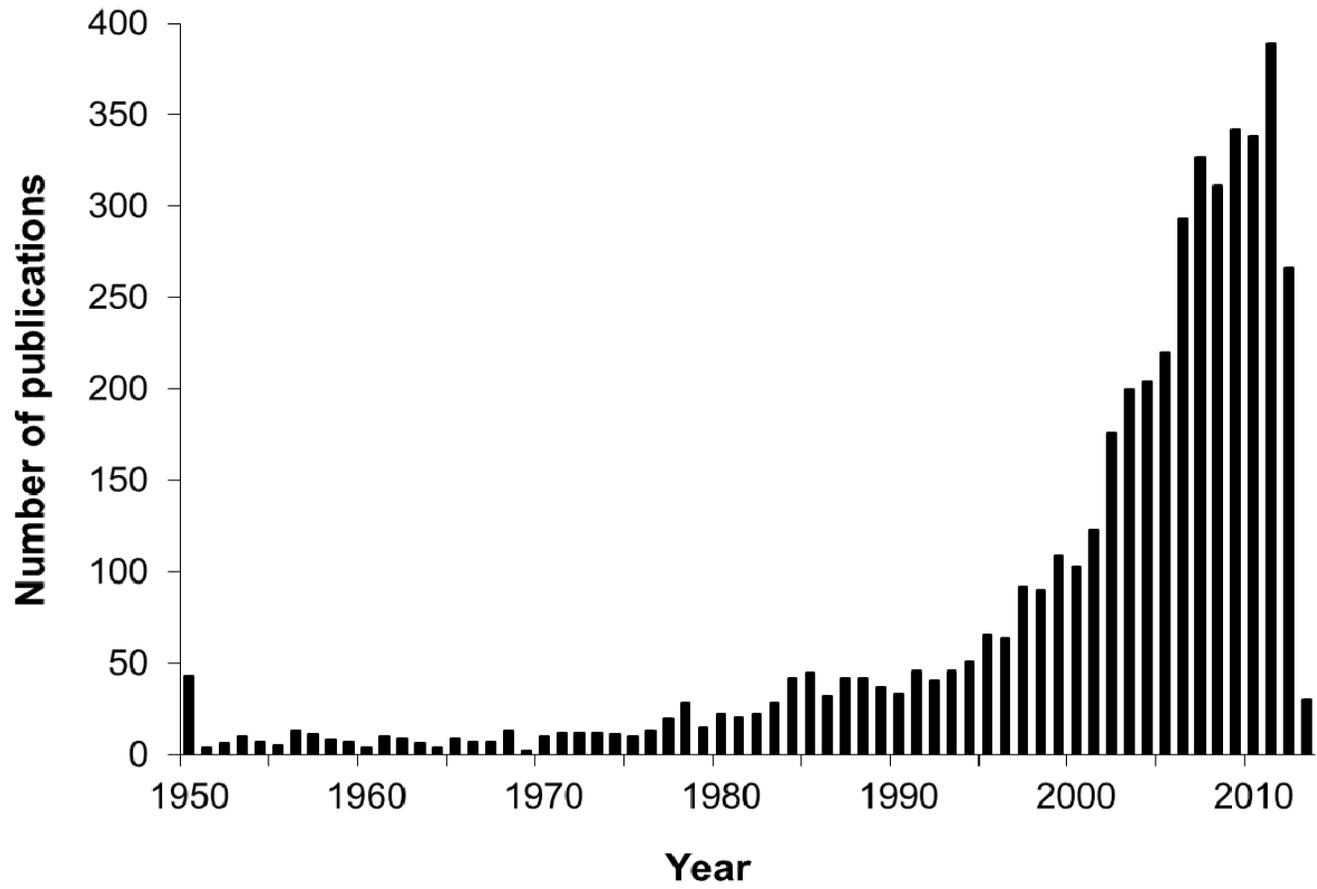


Mastrandrea *et al.* (2010) Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties. Intergovernmental Panel on Climate Change (IPCC).

# “No data....”

- “But.... there are no data...!” fallacy
  - Historical studies (literature archives)
  - Grey literature (Gov. & NGO reports)
  - Household, health & nutrition surveys
  - Stock assessment reports (ICES)
  - Media stories...
  - Local language (-> local collaborators)
- → ‘shadow’ that no one looks at: > 4000 publications used, i.e., approx. 35 source per country (excl. online). Also: >300 collaborators over the whole world..





## Data status:

- Over 200 catch reconstructions for 273 EEZ items
- Spatially assigned global large pelagic data (RFMO)
- 1950-2010 (2013/14 update in progress)
- By year, taxon, sector, catch type & reporting status

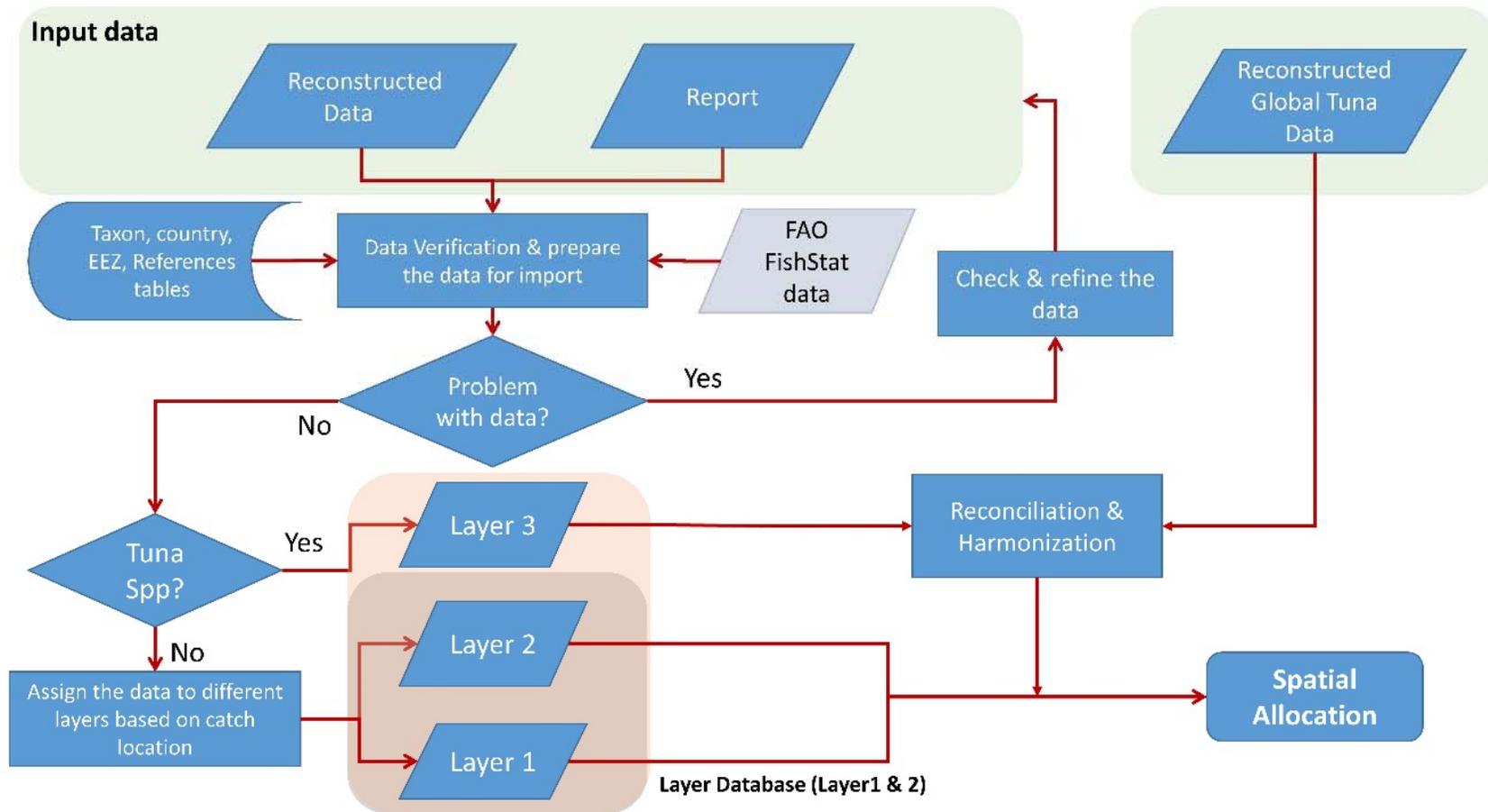
## Catch data integration:

- Three data layers
  1. Domestic catch within home EEZ  
(e.g., US catch in US EEZ)
  2. Inferred foreign catch in EEZs/High Seas  
(e.g., Russian catch in US EEZ)
  3. Global, industrial large pelagic catches  
(e.g., US tuna catch in Western Pacific Ocean)
- Data verification/integration

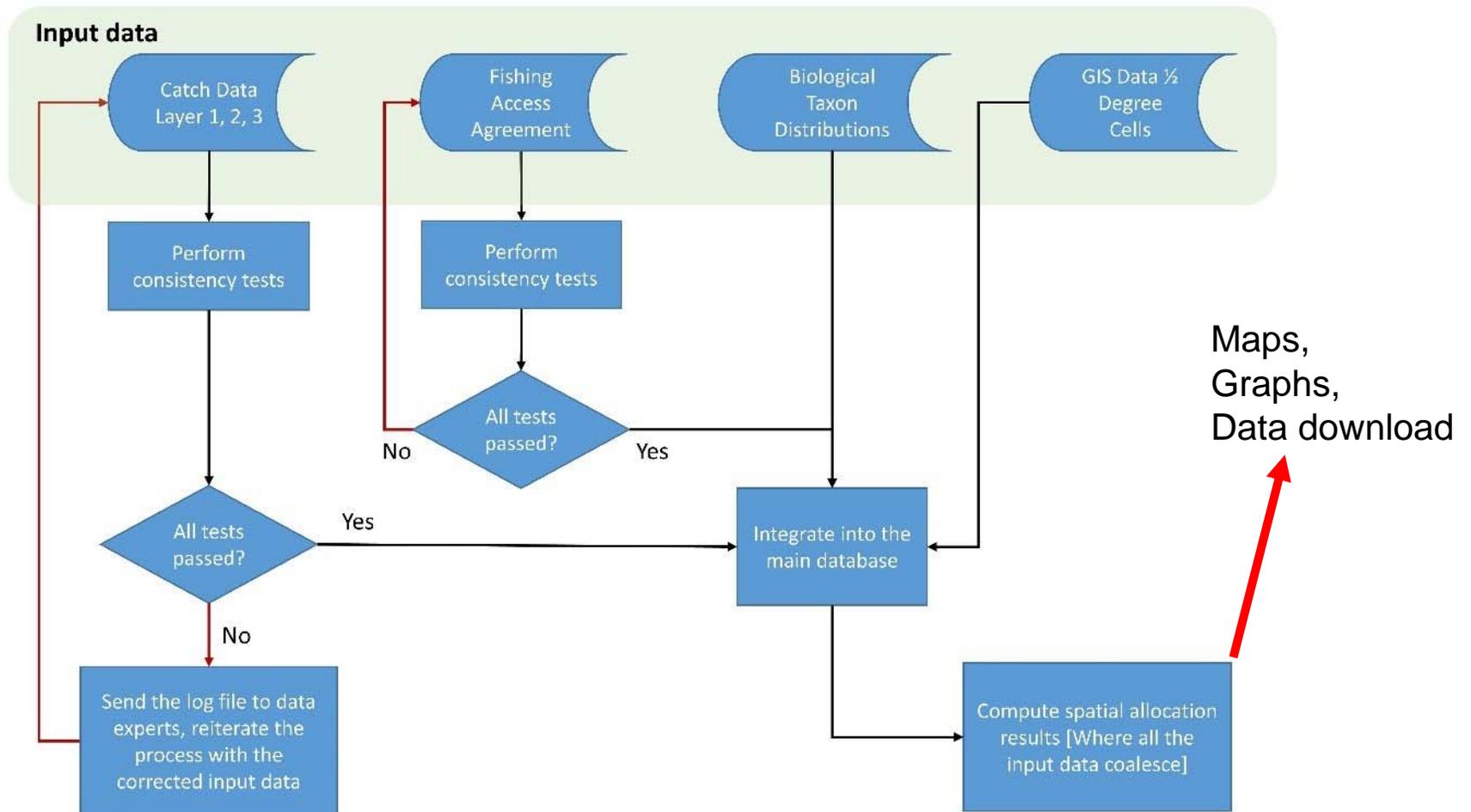
## Spatial allocation:



# Data verification process for country/territory-specific 'reconstructed' data



# Spatial allocation to 180,000 half degree cells



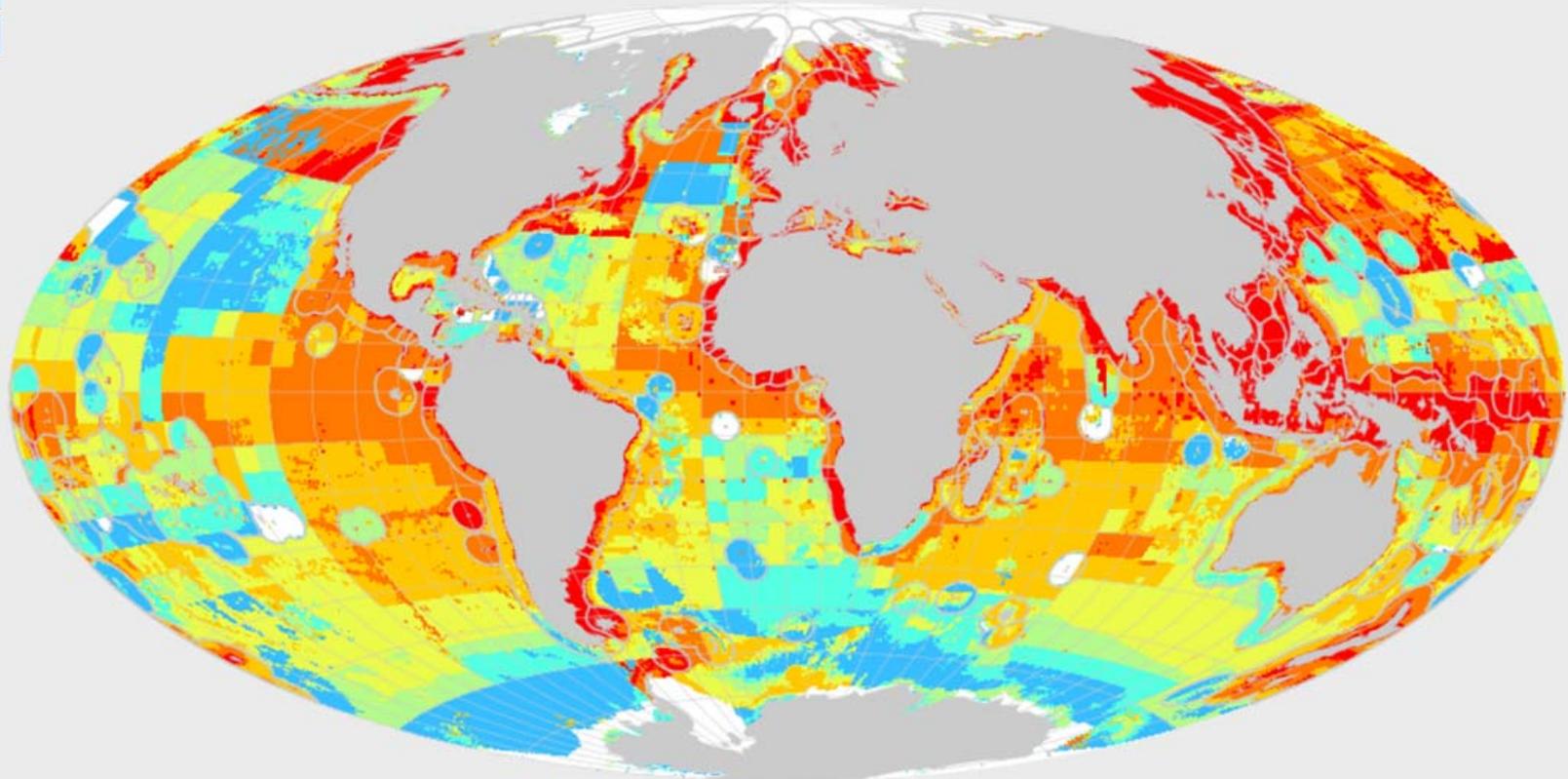
Global fishing in 2010 (Total:  $108,433 \times 10^3$  t)



$1.3e-15$  t/km<sup>2</sup>

$5.6e+2$  t/km<sup>2</sup>

No catch



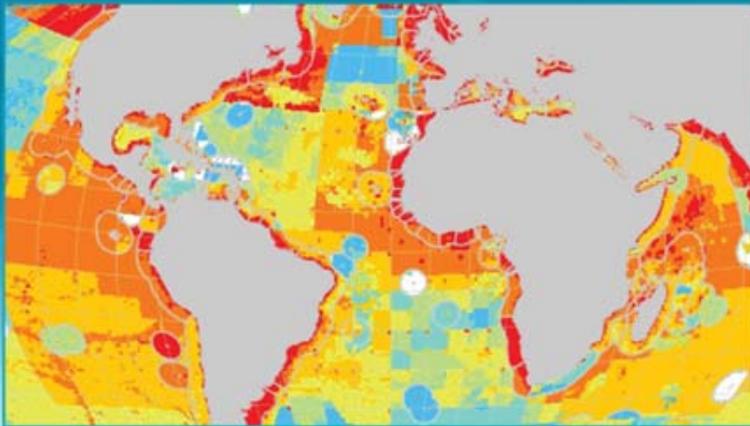
www.seaaroundus.org



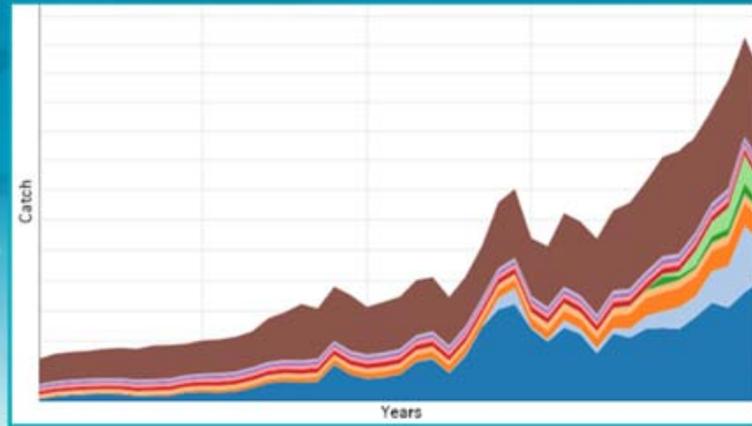
**SEA AROUND US**  
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We present fisheries and fisheries-related data at spatial scales that have ecological and policy relevance, such as by Exclusive Economic Zones, High Seas, or Large Marine Ecosystems.



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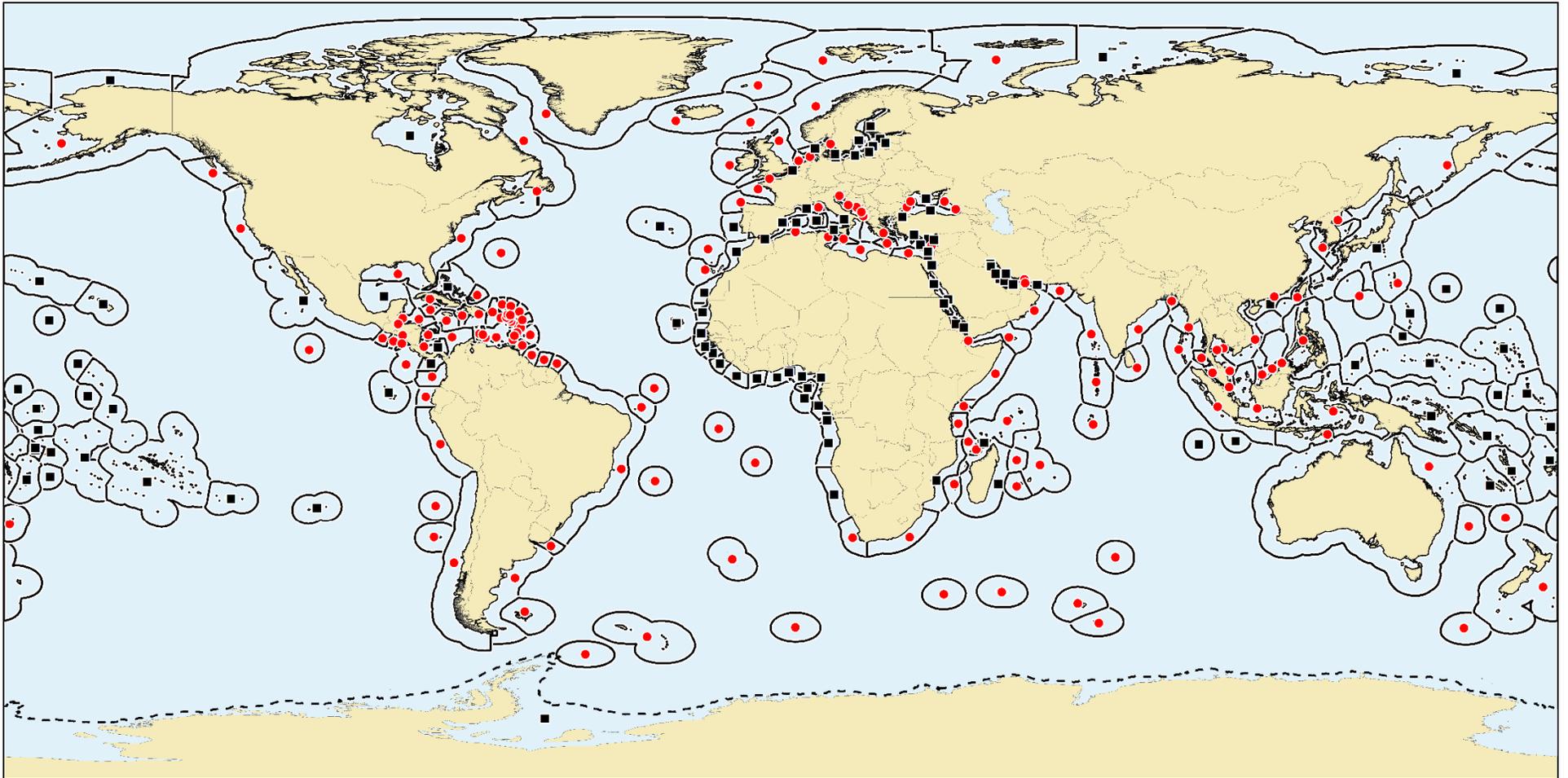
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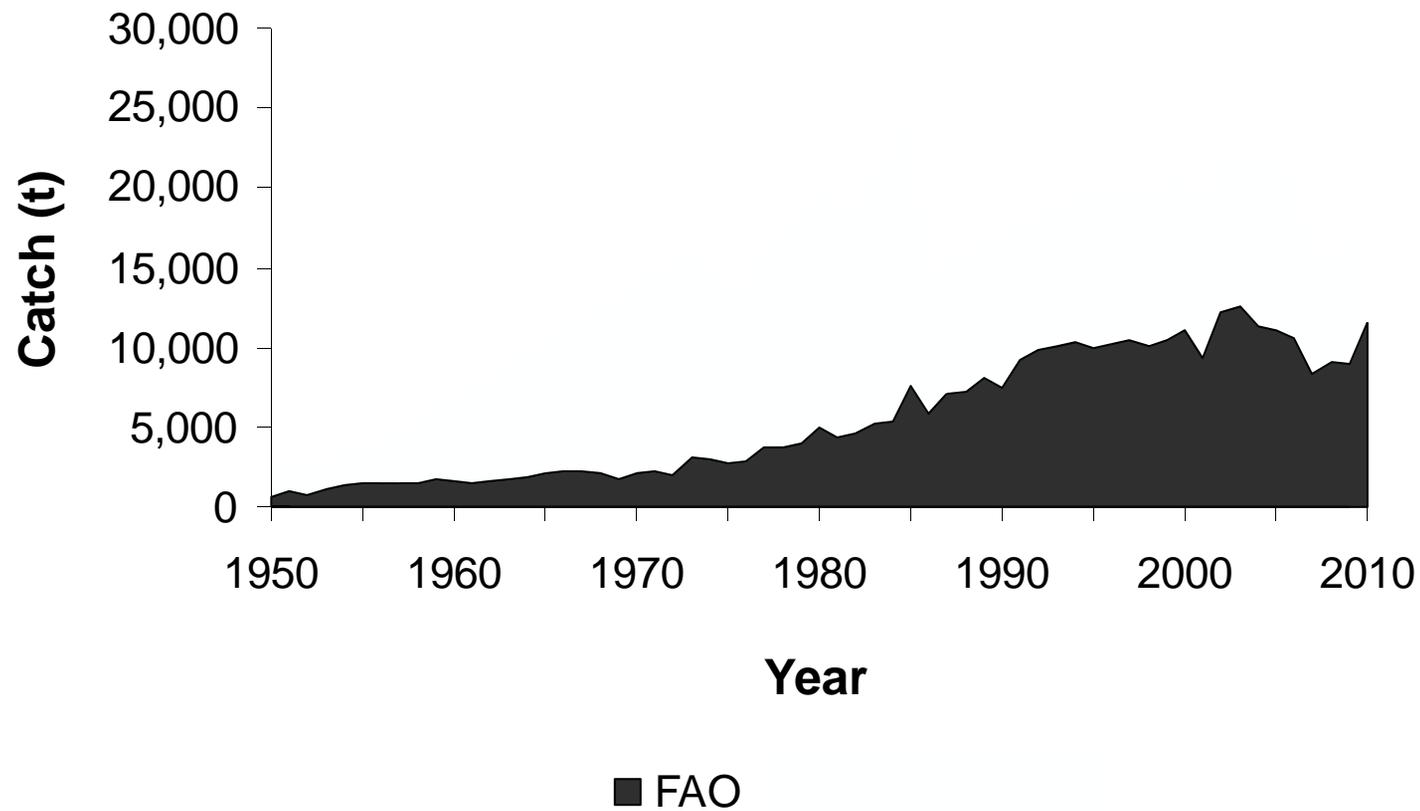
[Fishing country](#)

[www.seaaroundus.org](http://www.seaaroundus.org)

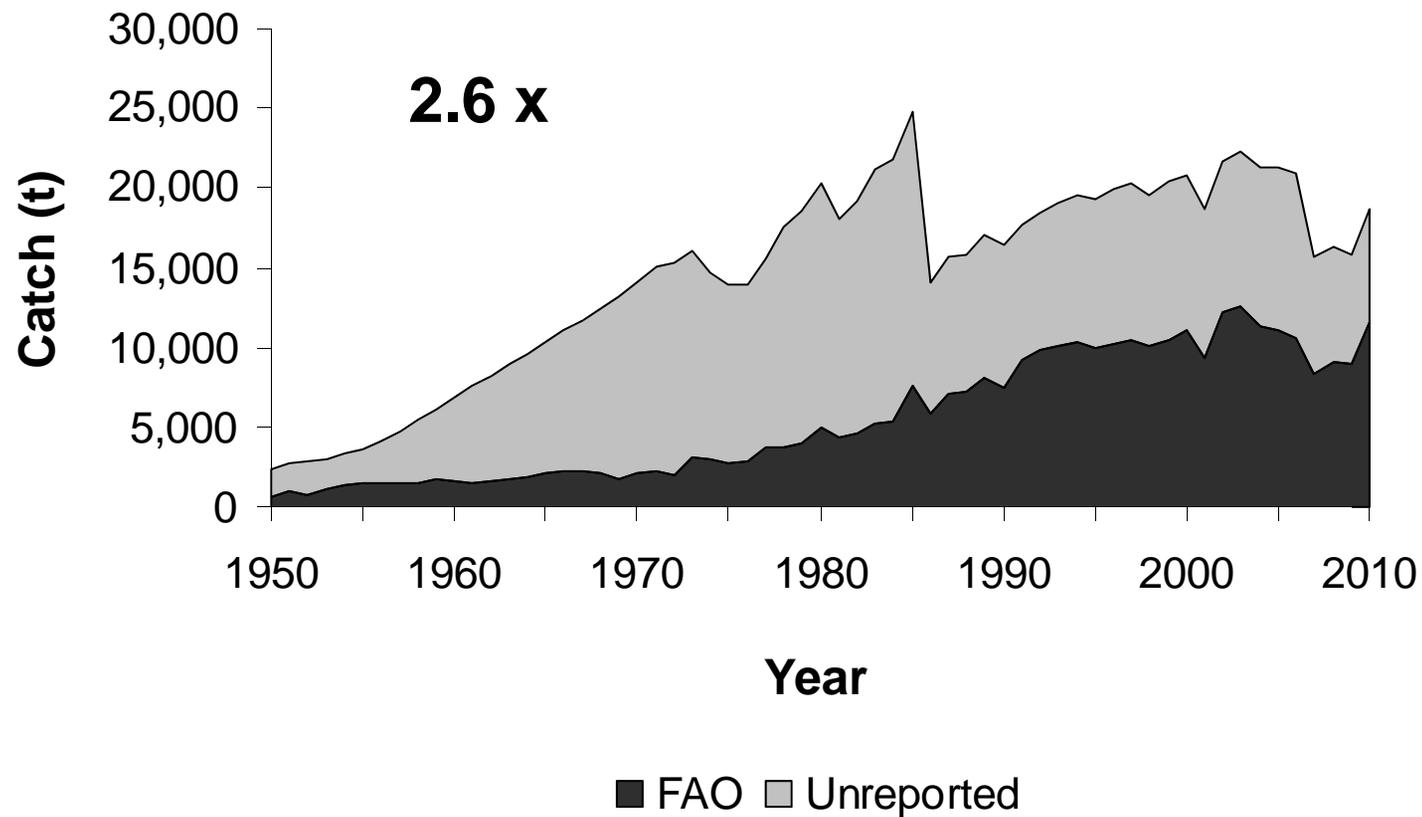


Catch reconstruction examples

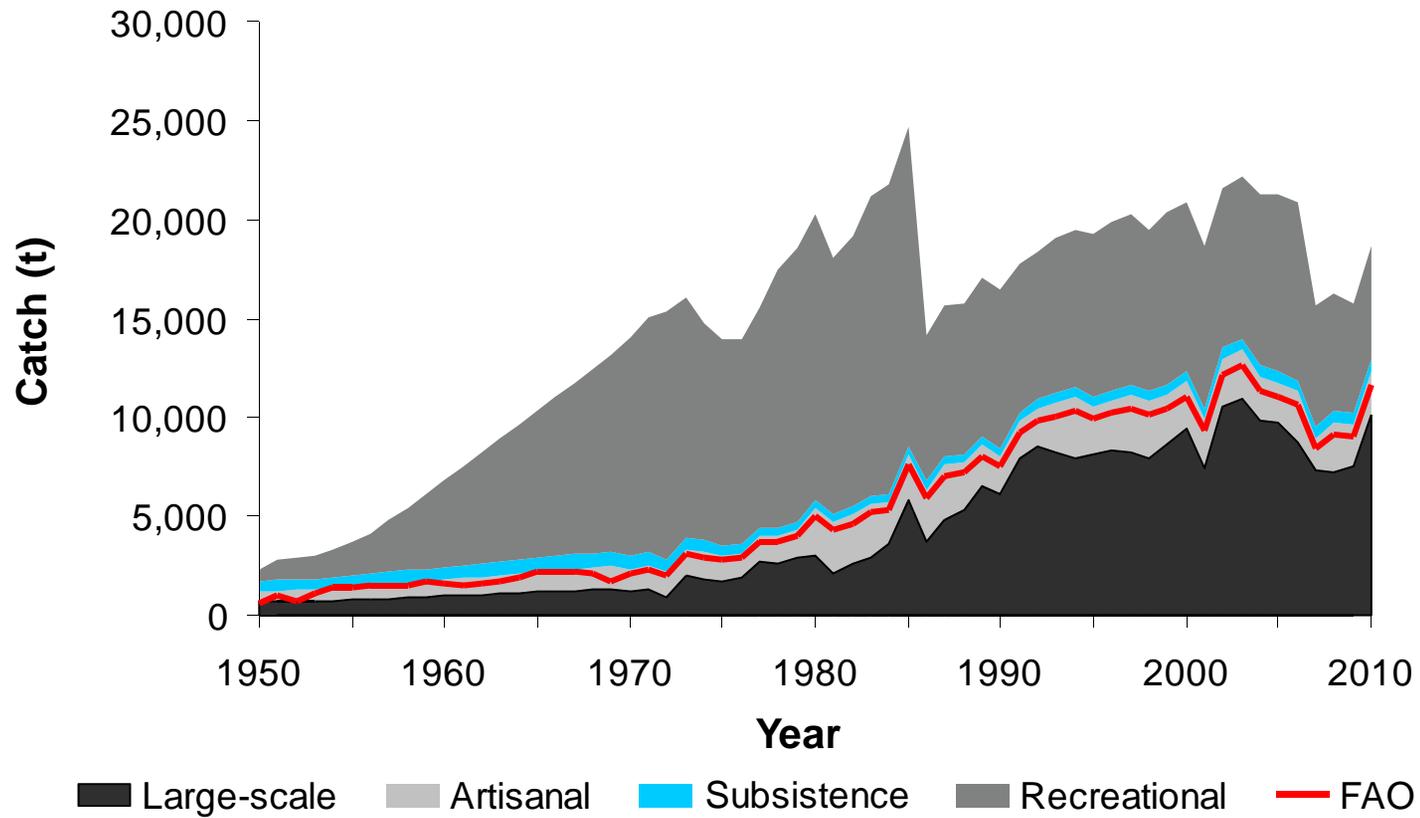
# The Bahamas



# The Bahamas



# The Bahamas



# United States

5 separate reconstructions:

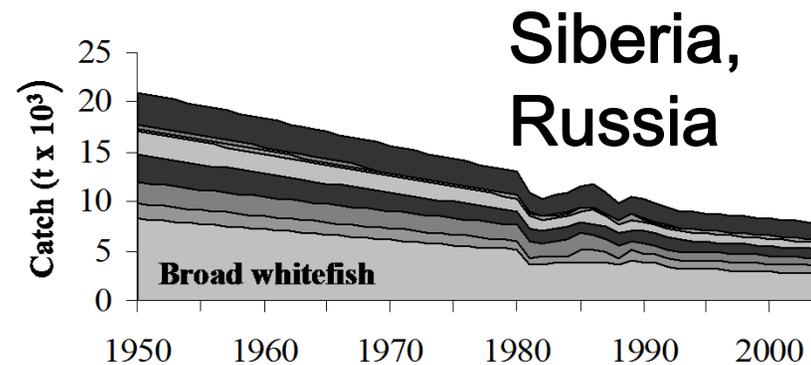
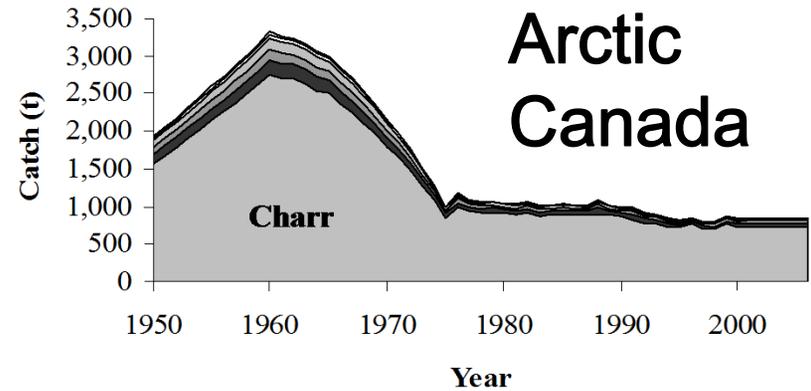
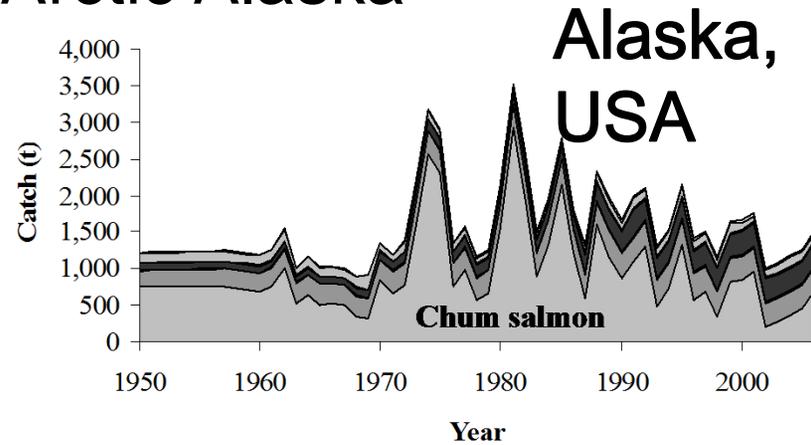
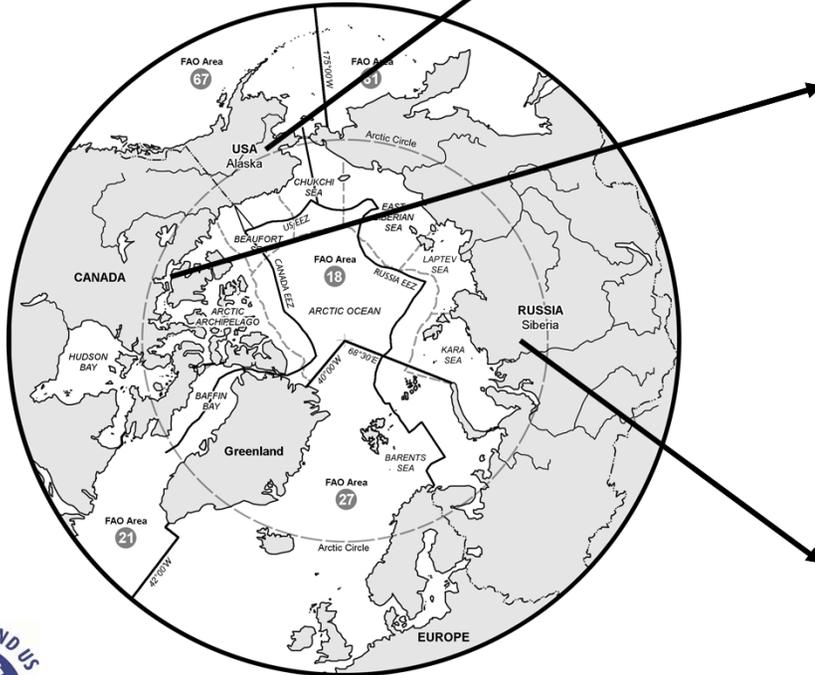
- 1) Arctic Alaska
- 2) Sub-arctic Alaska
- 3) East Coast & GoM
- 4) West Coast
- 5) Hawaii



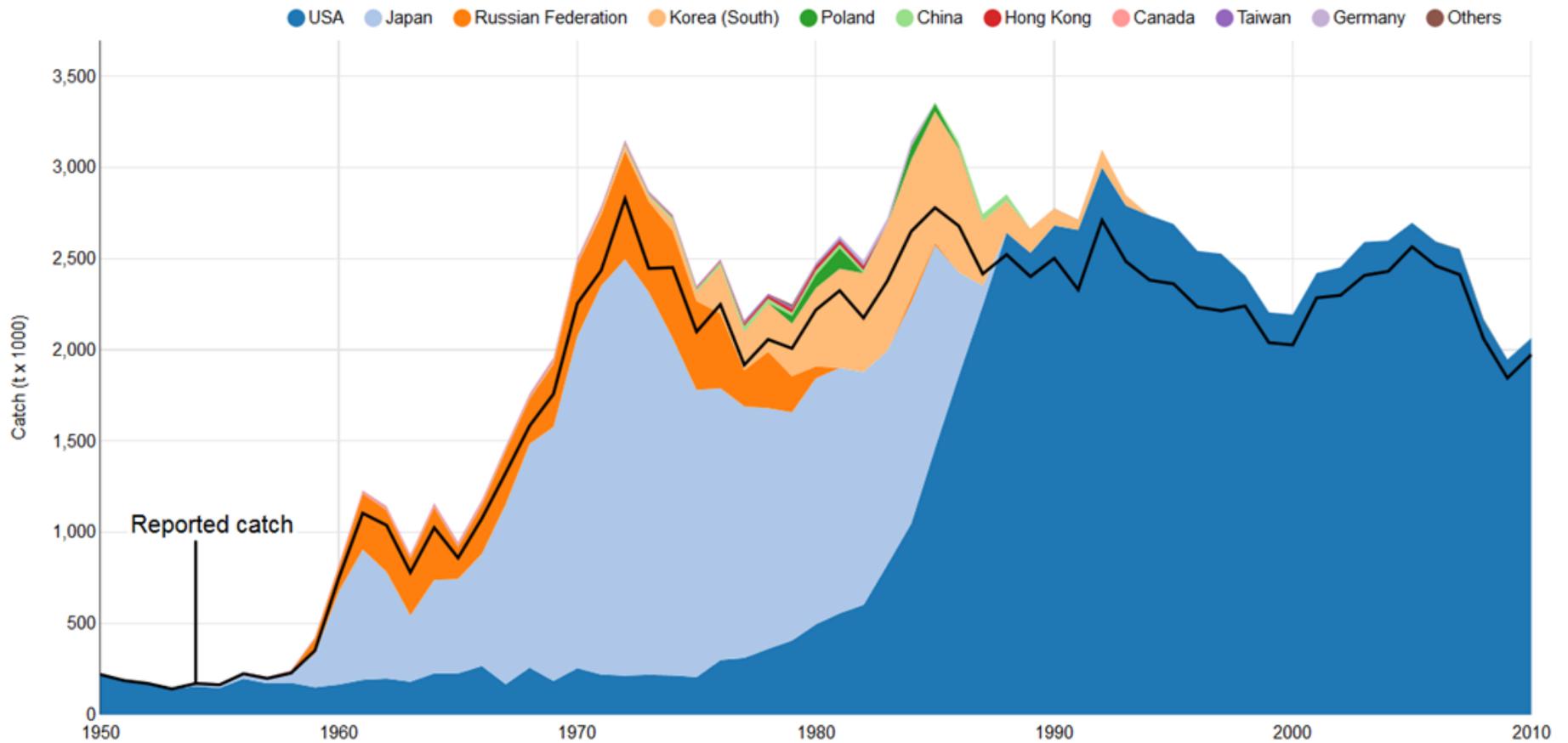
# United States: Arctic Alaska

## FAO Area 18

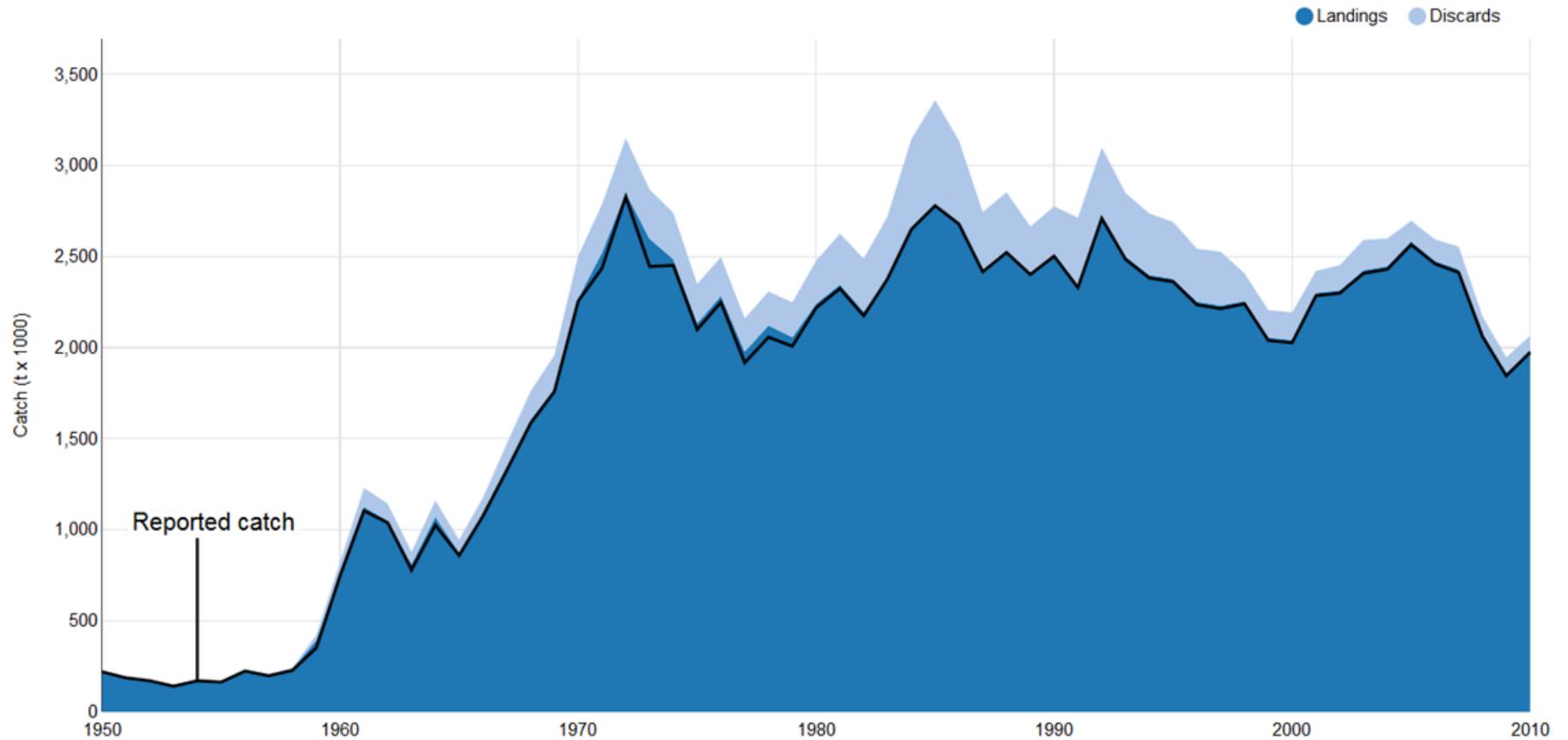
Example of catch reconstructions for an area from which Russia, the USA and Canada report zero or near zero catch



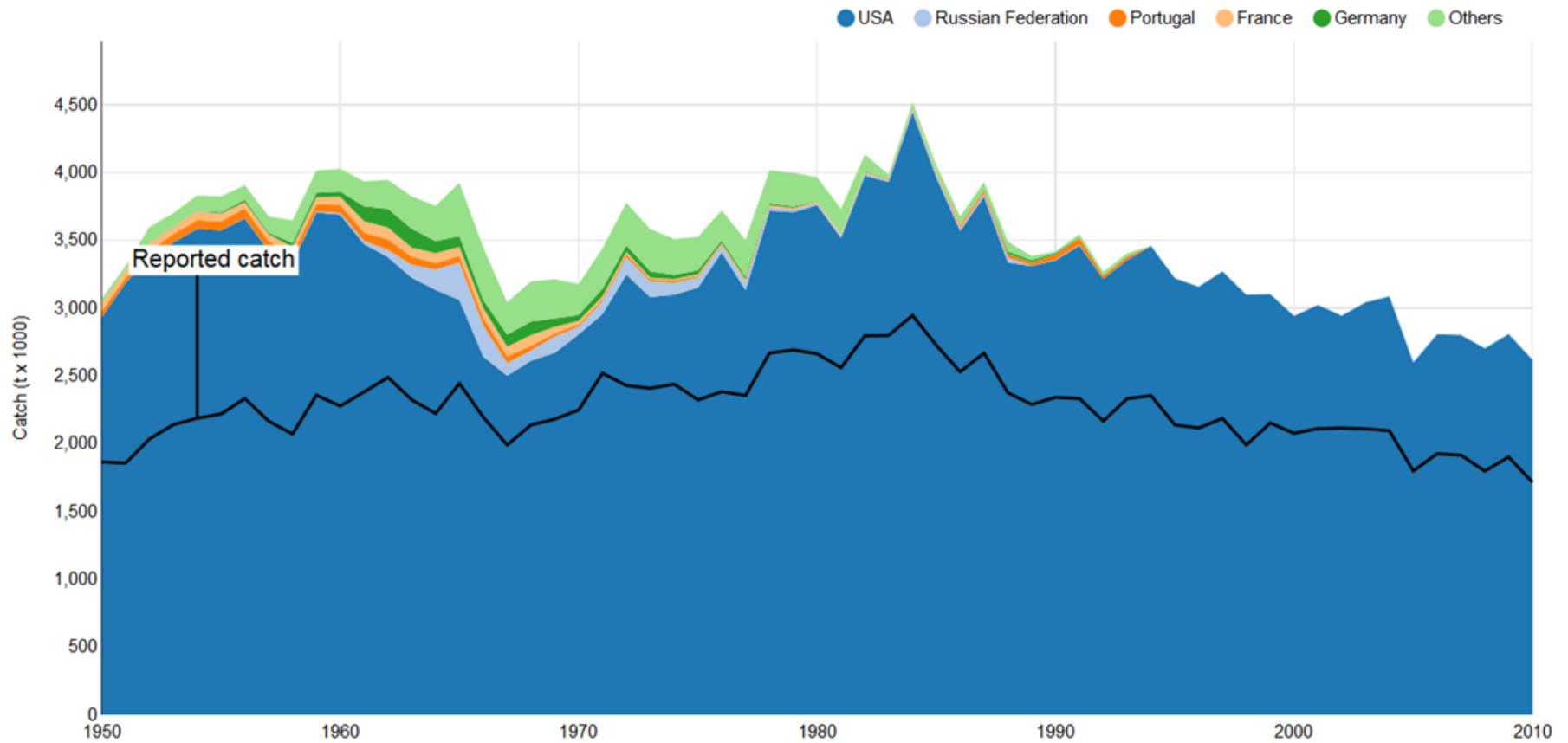
# United States: Sub-arctic Alaska



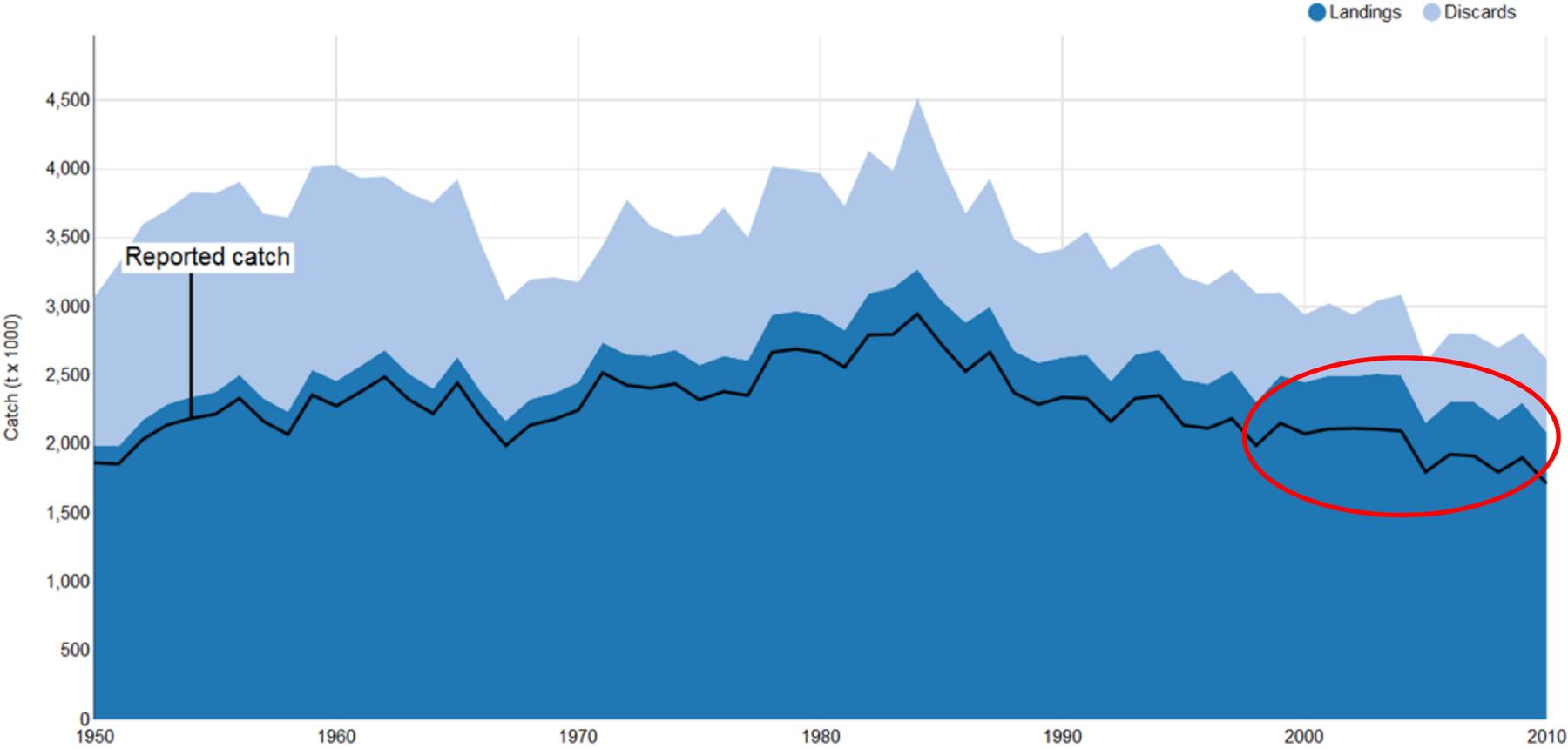
# United States: Sub-arctic Alaska



# United States: East Coast & GoM



# United States: East Coast & GoM



# United States: West Coast



U.S. » Fishing business owner to face scales of justice in alleged scheme

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## Fishing business owner to face scales of justice in alleged scheme



By **Scott Glover**, CNN

Updated 7:12 PM ET, Fri February 26, 2016



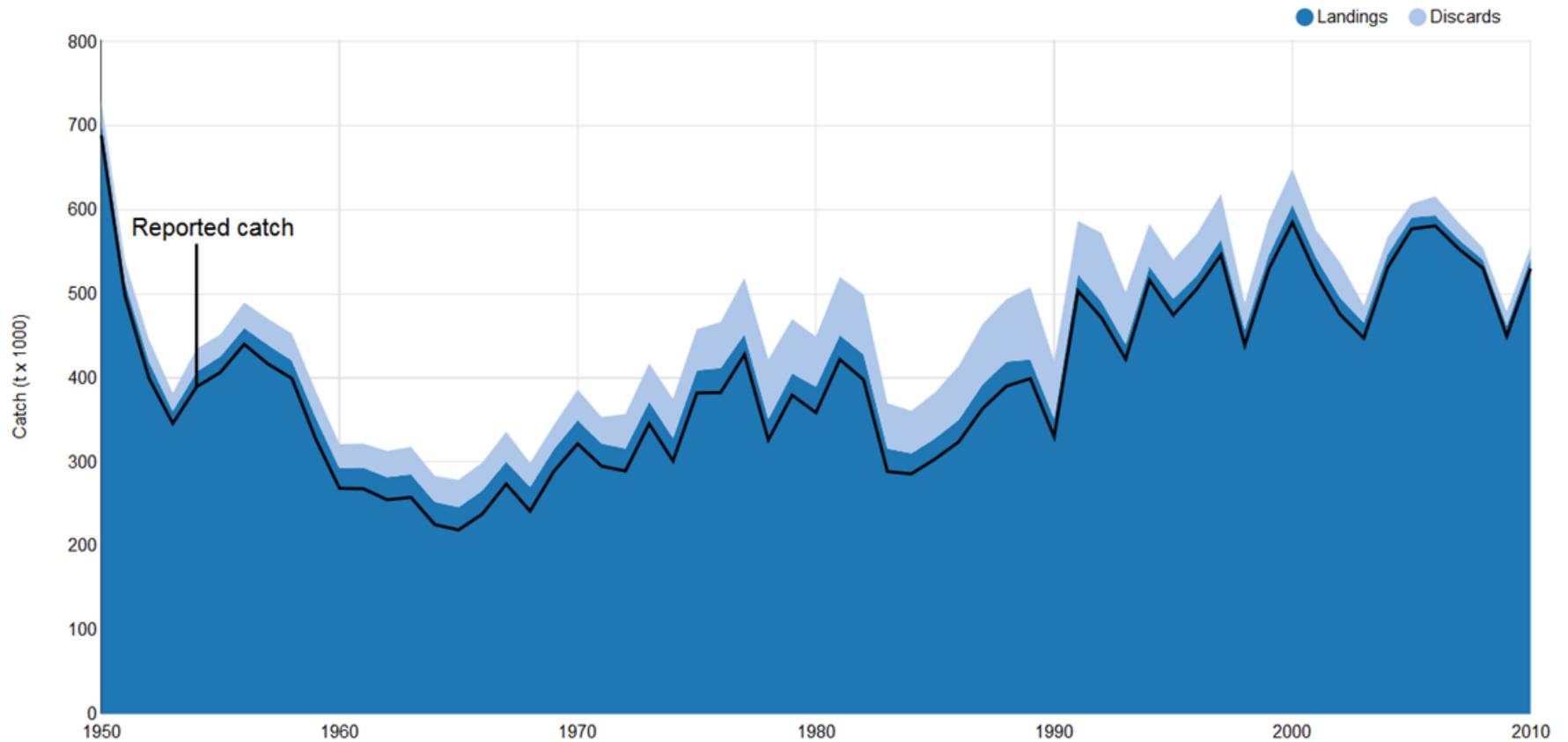
Federal agents raid the Carlos Seafood offices in New Bedford, Massachusetts. Owner Carlos Rafael is accused of lying to federal authorities about the quantities and species of fish his fleet of boats caught in order to evade quotas aimed at guaranteeing sustainable fisheries.



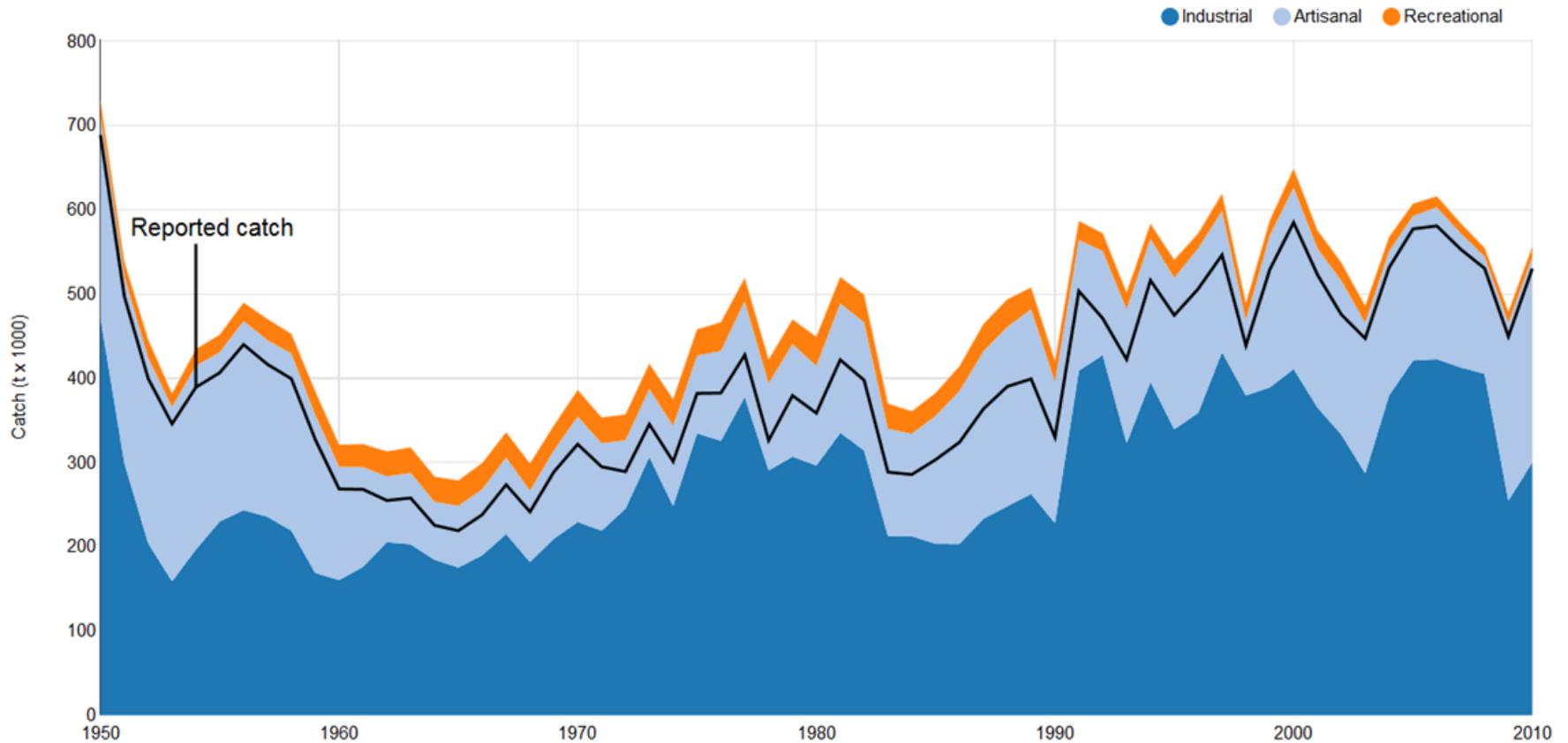
Carlos Rafael in October 2014. Rafael is sometimes referred to as "The Godfather" for his prominence in commercial fishing.



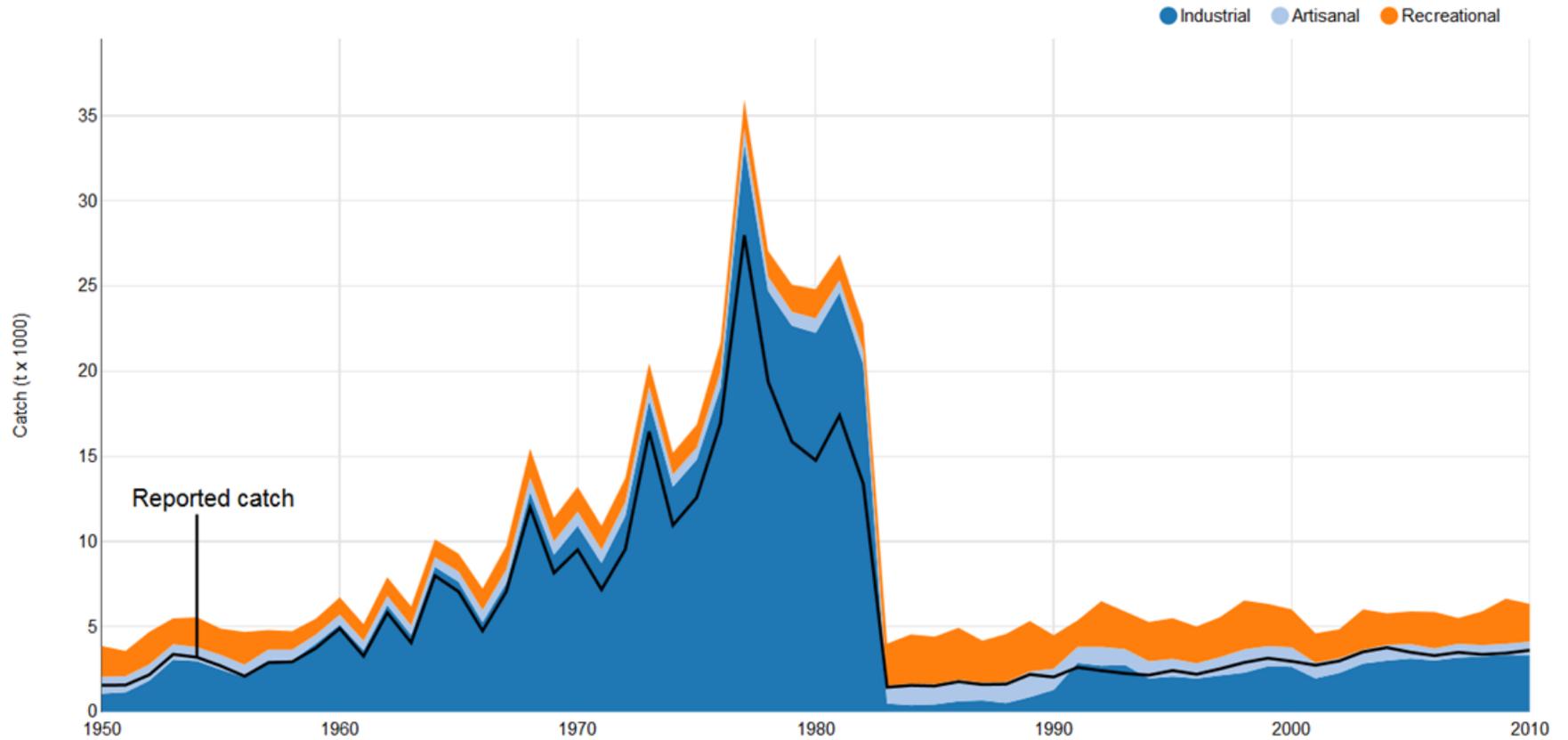
# United States: West Coast



# United States: West Coast



# United States: Hawaii



Zeller *et al.* 2015 (Coral Reefs 34[1]:25-39)

# United States

Take home:

- 1) Global leader in transparency and openness
- 2) Majority of commercial landings accounted for
- 3) Discards not reported to FAO (explicit)
- 4) Recreational catches domestically known but missing from FAO data (but explicitly requested)



# Global catches



## ARTICLE

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DOI: [10.1038/ncomms10244](https://doi.org/10.1038/ncomms10244)

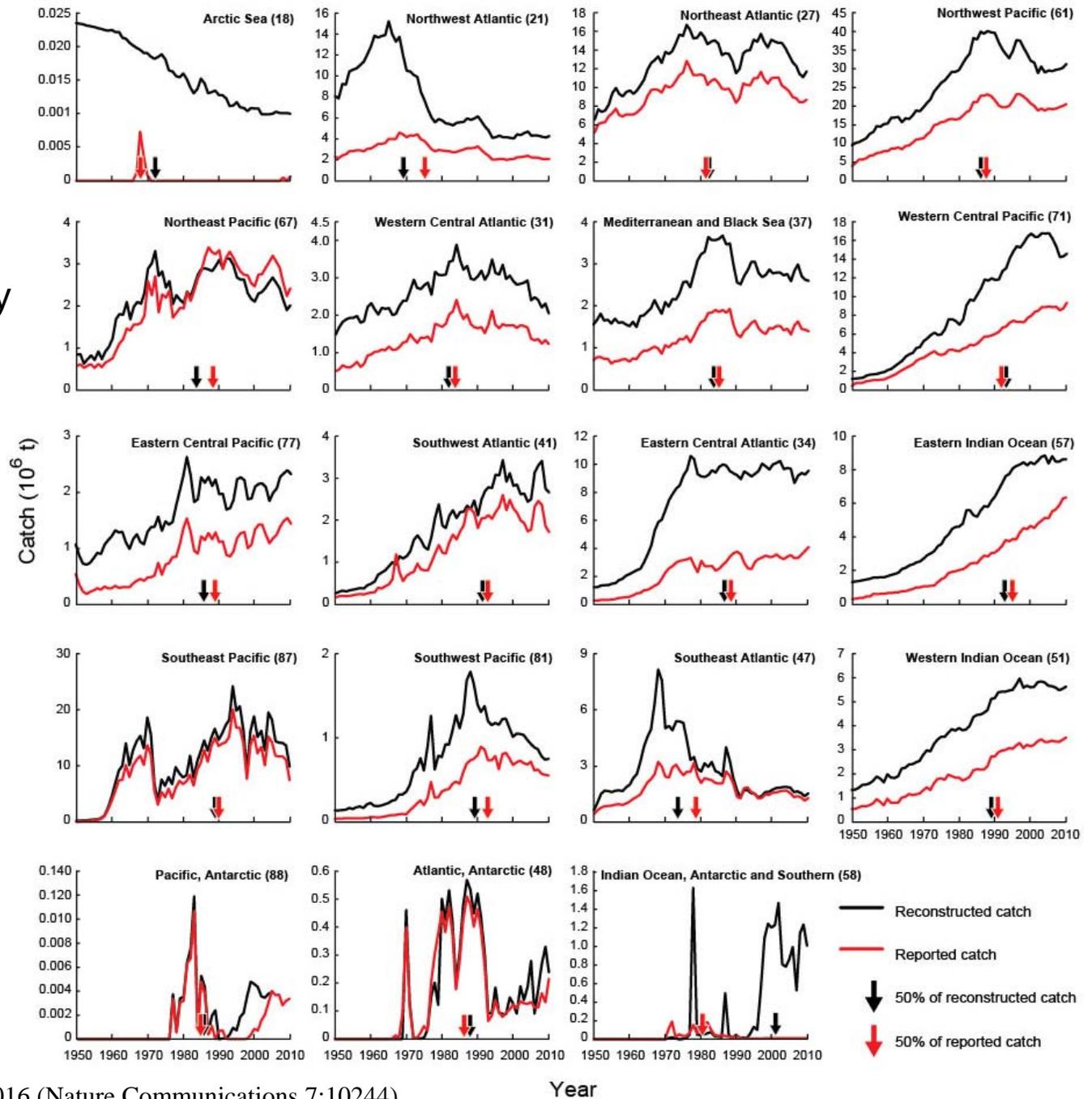
[OPEN](#)

## Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining

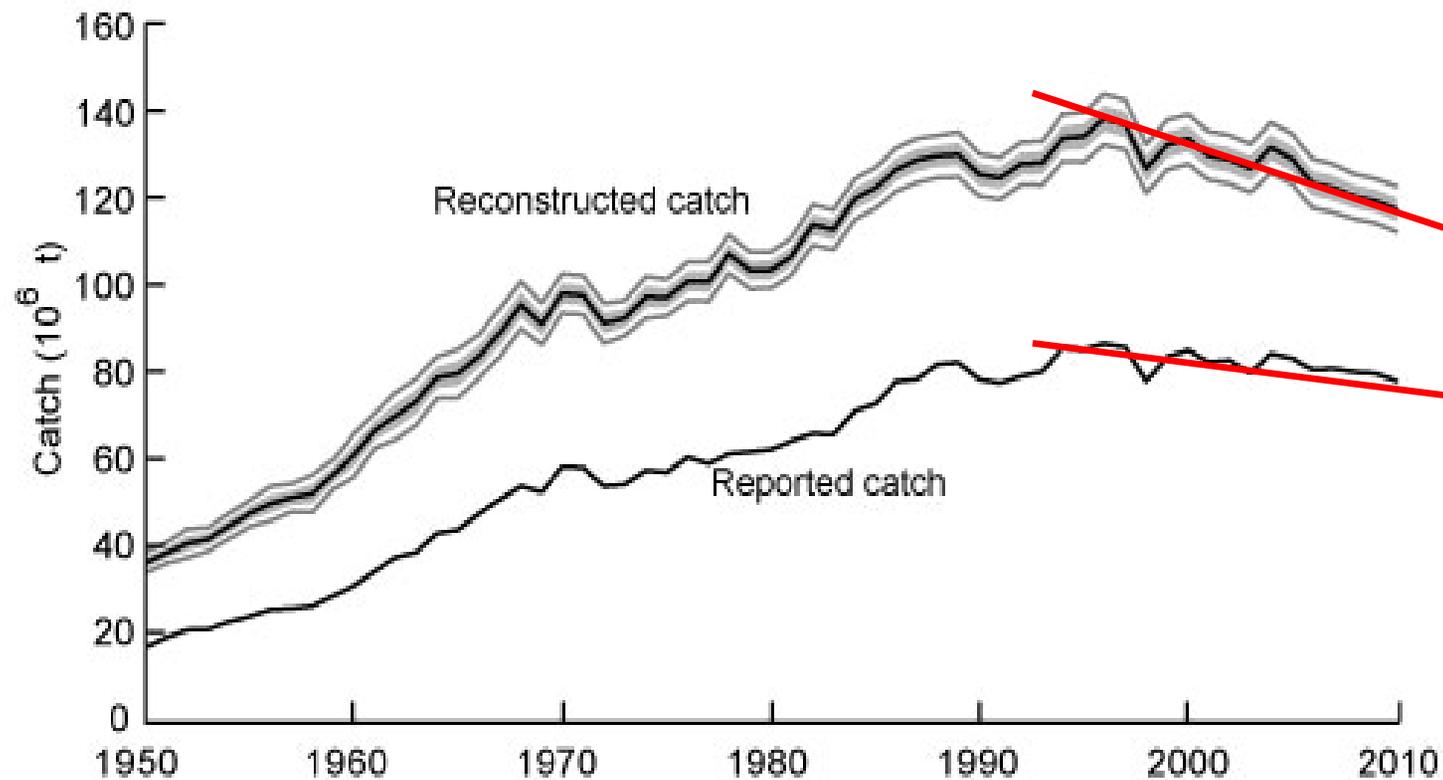
Daniel Pauly<sup>1</sup> & Dirk Zeller<sup>1</sup>

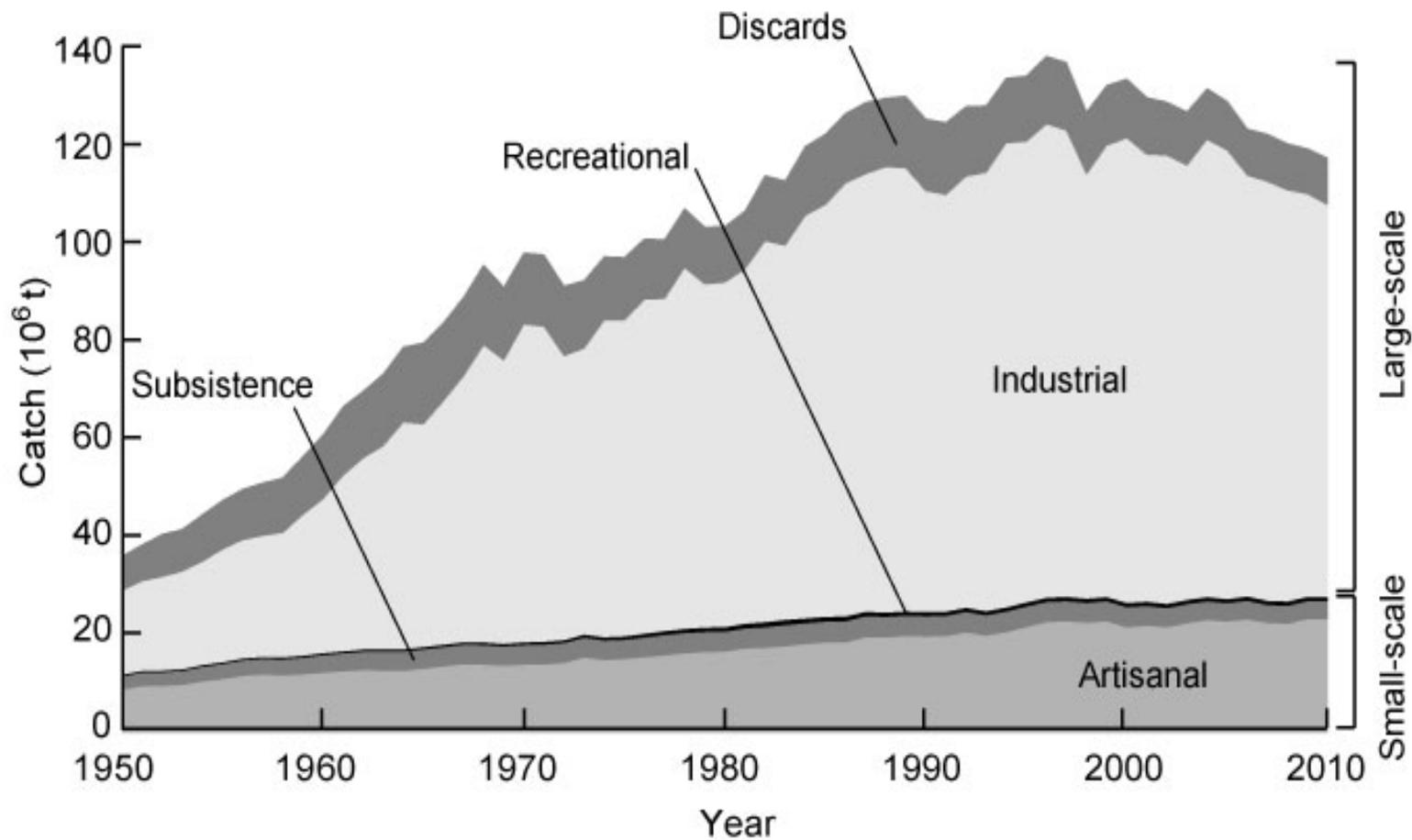


# Comparing reported and reconstructed catches by FAO areas....



When added up, the country catch reconstructions confirm that the world catch has been declining for the last 2 decades. Important is also that the trend is more marked than in the officially reported catch.





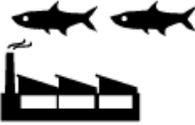
Reconstructed catches for all countries in the world, plus High Seas, by large-scale (industrial) and small-scale sectors (artisanal, subsistence, recreational); industrial discards are presented separately.



# An important comparison...

This graph highlights the crucial role of small-scale fisheries, so far often neglected.

Indeed, we would achieve most stated aims of fisheries management plans (particularly their social aims) by dedicated access arrangements for small-scale fisheries.

Fisheries benefits	 Large-scale	 Small-scale
Annual landings for human consumption	 about 60 million tonnes	 about 27 million tonnes
Annual catch discarded at sea	 10 million tonnes	 Almost none
Annual catch for industrial reduction to fishmeal and oil, etc.	 26 million tonnes	 Almost none
Fuel used per tonne of fish for human consumption	 5-20 tonnes	 2-5 tonnes
Number of fishers employed	 about 1/2 million	 about 12 million
Government subsidies (billions of USD)	 25-30 billion USD	 5-7 billion USD



## What the future will bring (hopefully):

- We will continue to improve the contents and usefulness of our newly revamped website ([www.seaaroundus.org](http://www.seaaroundus.org)), which presents all the reconstructed data (and from which they can be downloaded);
- We will soon publish (in August 2016) a 500-page 'Atlas' of the world's fisheries based on the catch reconstruction;
- We will work with our network of colleagues throughout the world to update and correct the reconstructed catch time series time;
- We will add new global data sets to the website (e.g., on fishing effort), for joint analyses with the catch time series.



# Acknowledgements...

- Thanks to The Pew Charitable Trusts and the Paul G. Allen Family Foundation for support



THE PAUL G. ALLEN  
FAMILY FOUNDATION

- Thanks to other funding sources: FAO, US Western Pacific Fisheries Management Council, EU-Parliament, UNEP, BOBLME, MAVA Foundation, Rockefeller Foundation, WWF
- Thanks to all members of the *Sea Around Us*, past and present...



... sorry, we ran out of pictures....



*and thanks to many other colleagues*

visit us at [www.searoundus.org](http://www.searoundus.org)

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