

Global decline of marine predators: causes, consequences, conservation



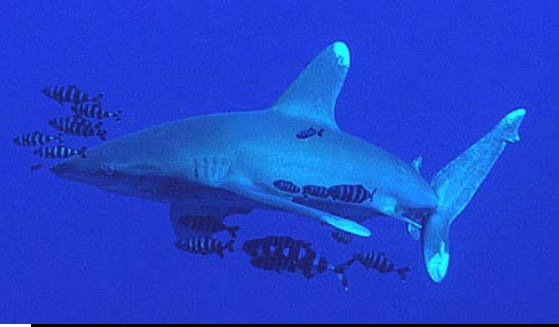
Ransom A. Myers (RAM) and Boris Worm
Dalhousie University, Halifax, Canada

OR: Shark-eating men:
the decline of our largest sea creatures



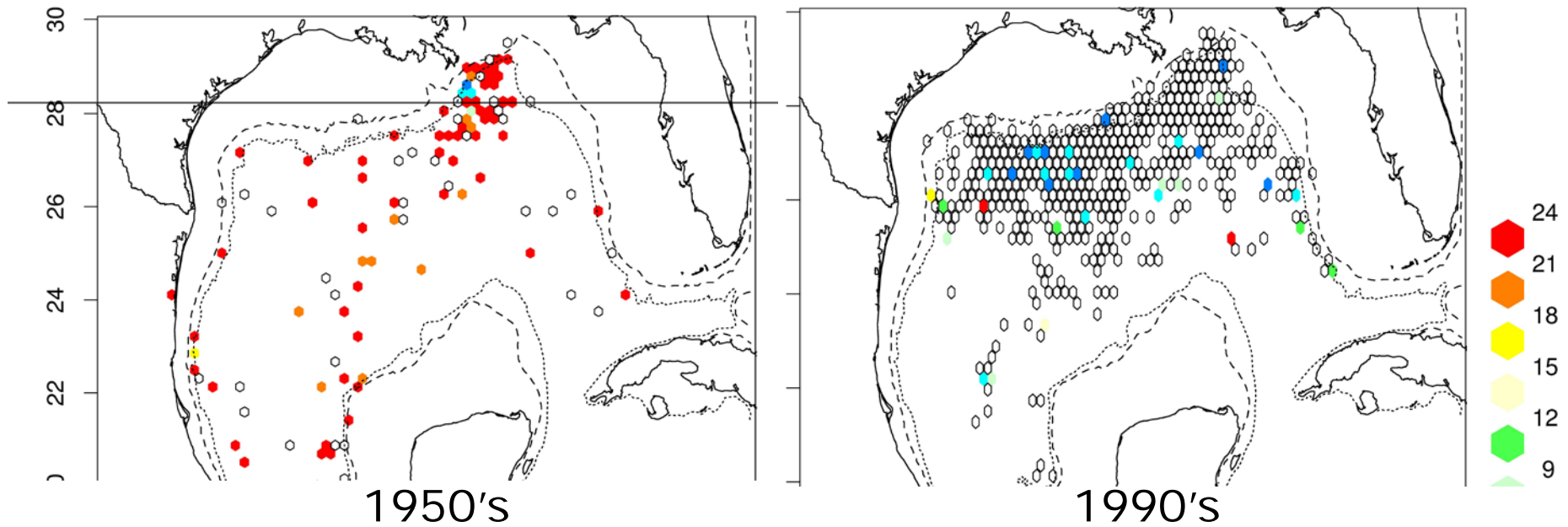
What was the most common large animal (>50 Kg) in the world? (perhaps this one was)





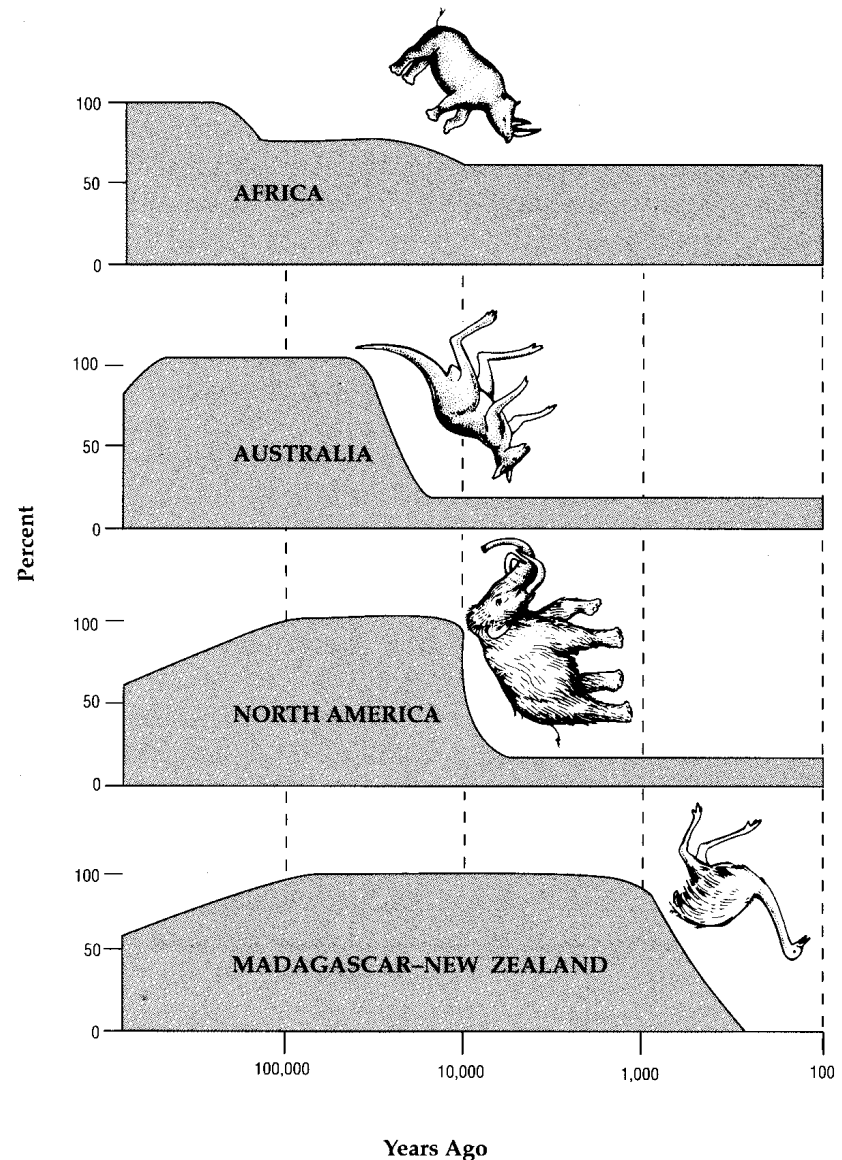
Loss of sharks in the Gulf of Mexico

300 fold decline – no one noticed



Oceanic Whitetip captures per 10,000 hooks

Are the pleistocene extinctions* going to be repeated in the ocean?



*Present North American biota has lost almost all large species – We have no mammoths, mastodons, giant ground sloths, giant beavers, and 65 other species that weighted more than 100 kilograms.

The extinction of large mammals and flightless birds coincided closely with the arrival of humans in North America, Madagascar, and New Zealand, and less decisively earlier in Australia. In Africa, where humans and animals evolved together for millions of years, the damage was less severe.

From land to sea

- Large land animals almost lost
- Coastal waters overfished
- The open ocean: our last frontier?

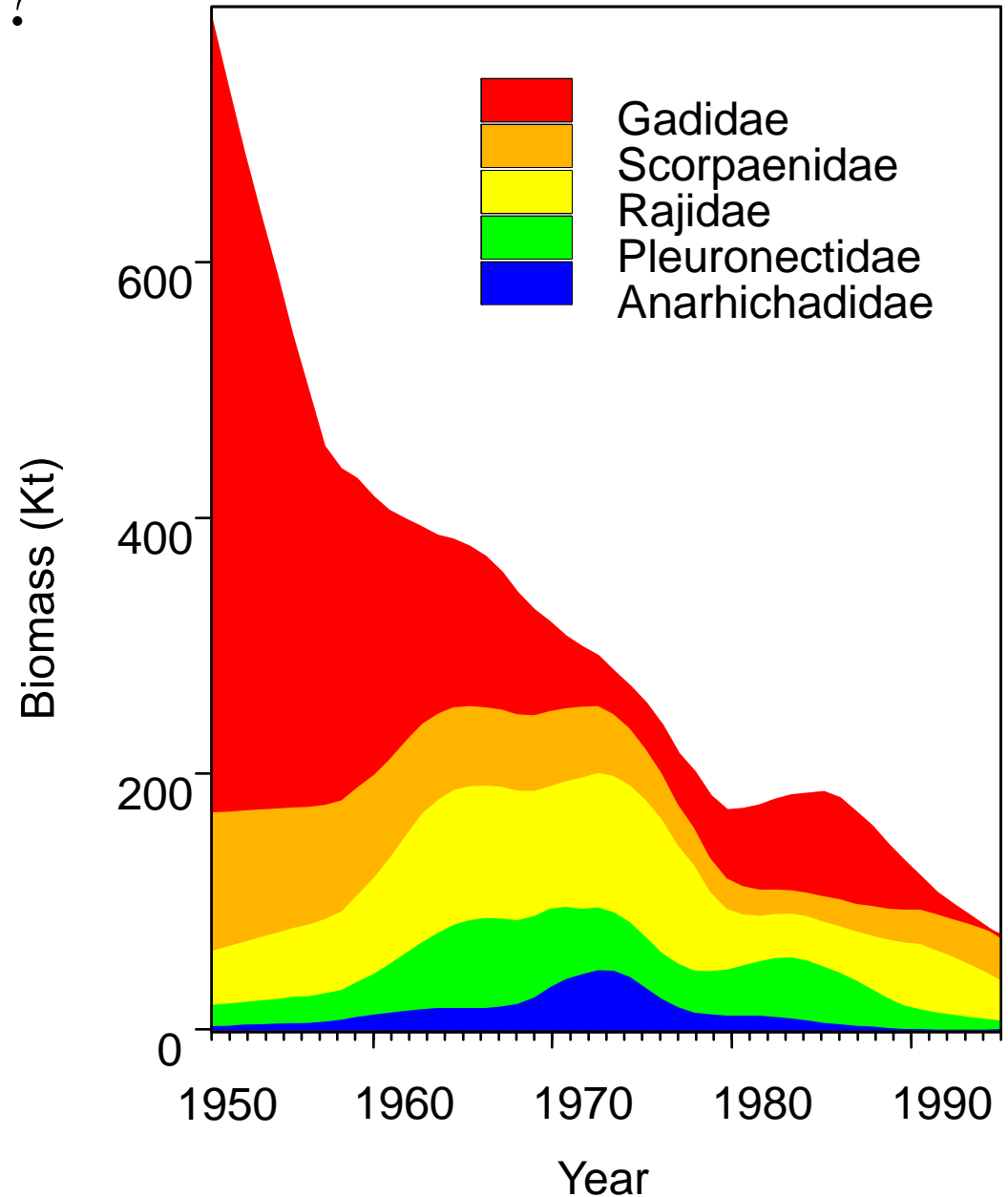


Continental shelves

- Few data from early period
- Demersal fish communities:
 - Southern Grand Banks
 - St. Pierre Bank
 - South Georgia
 - Gulf of Thailand

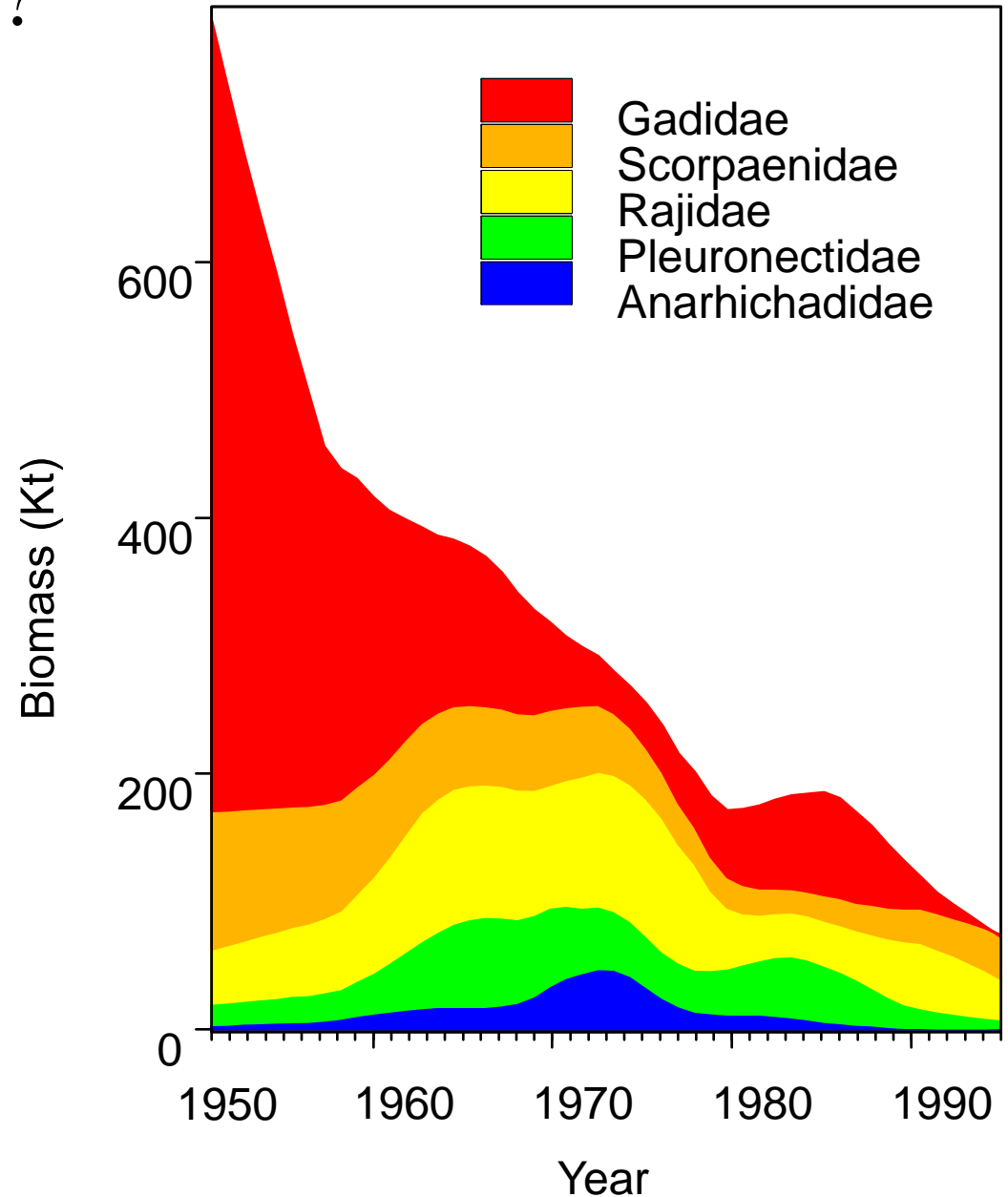
What has changed?

- 90% decline in numbers
- Approx. 50% decline in size
- Large changes in species composition

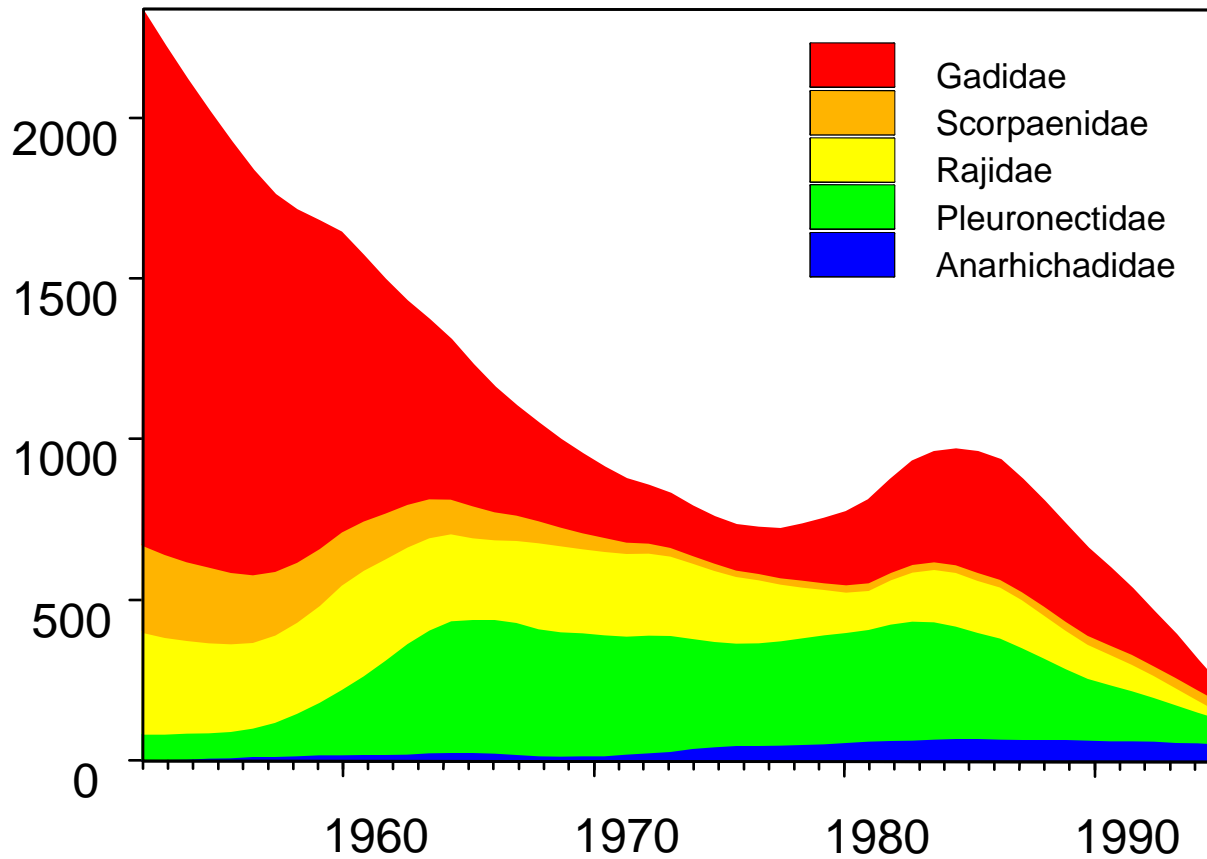


What has changed?

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Community Changes on Southern Grand Banks

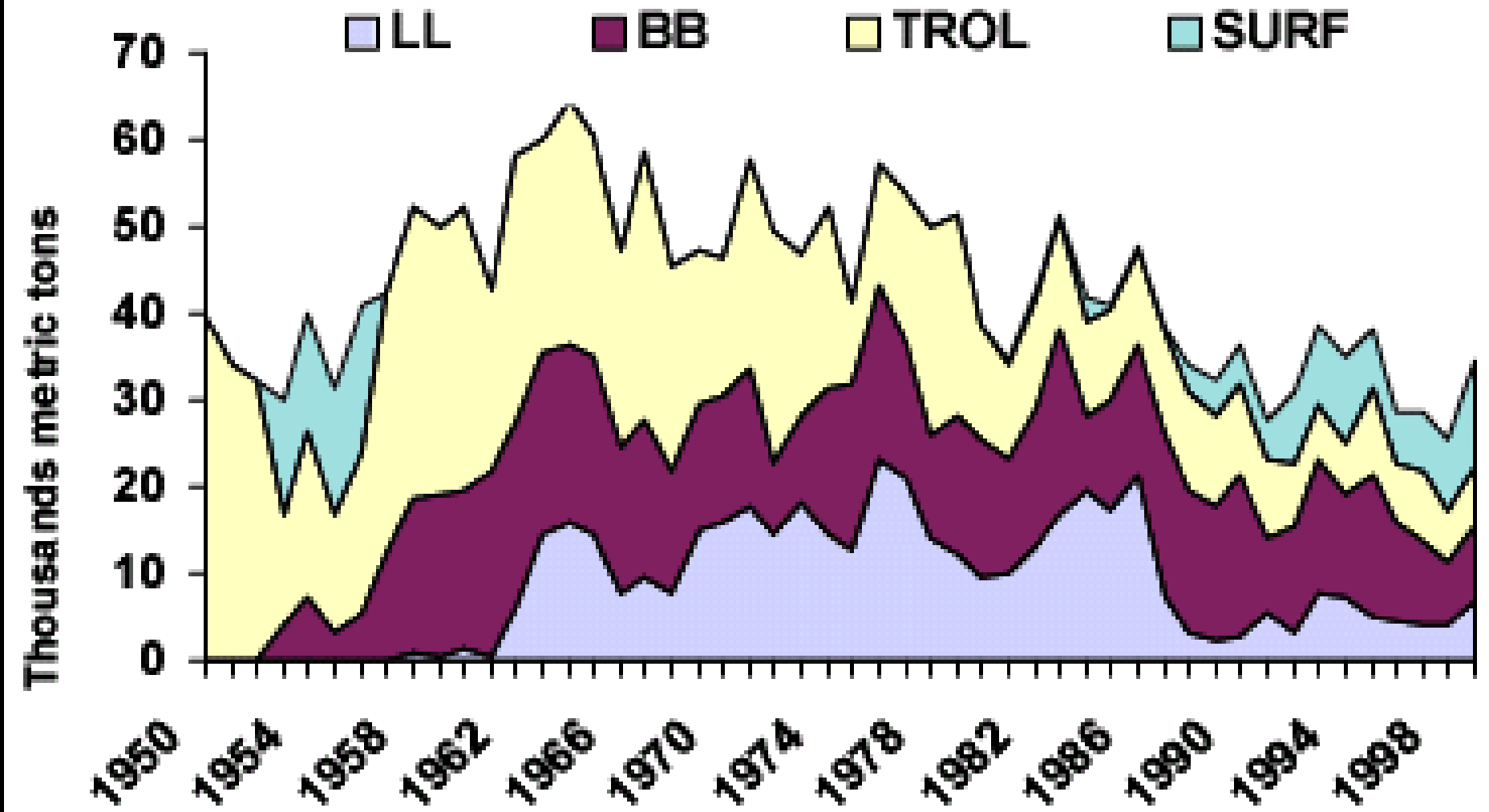


Open Ocean

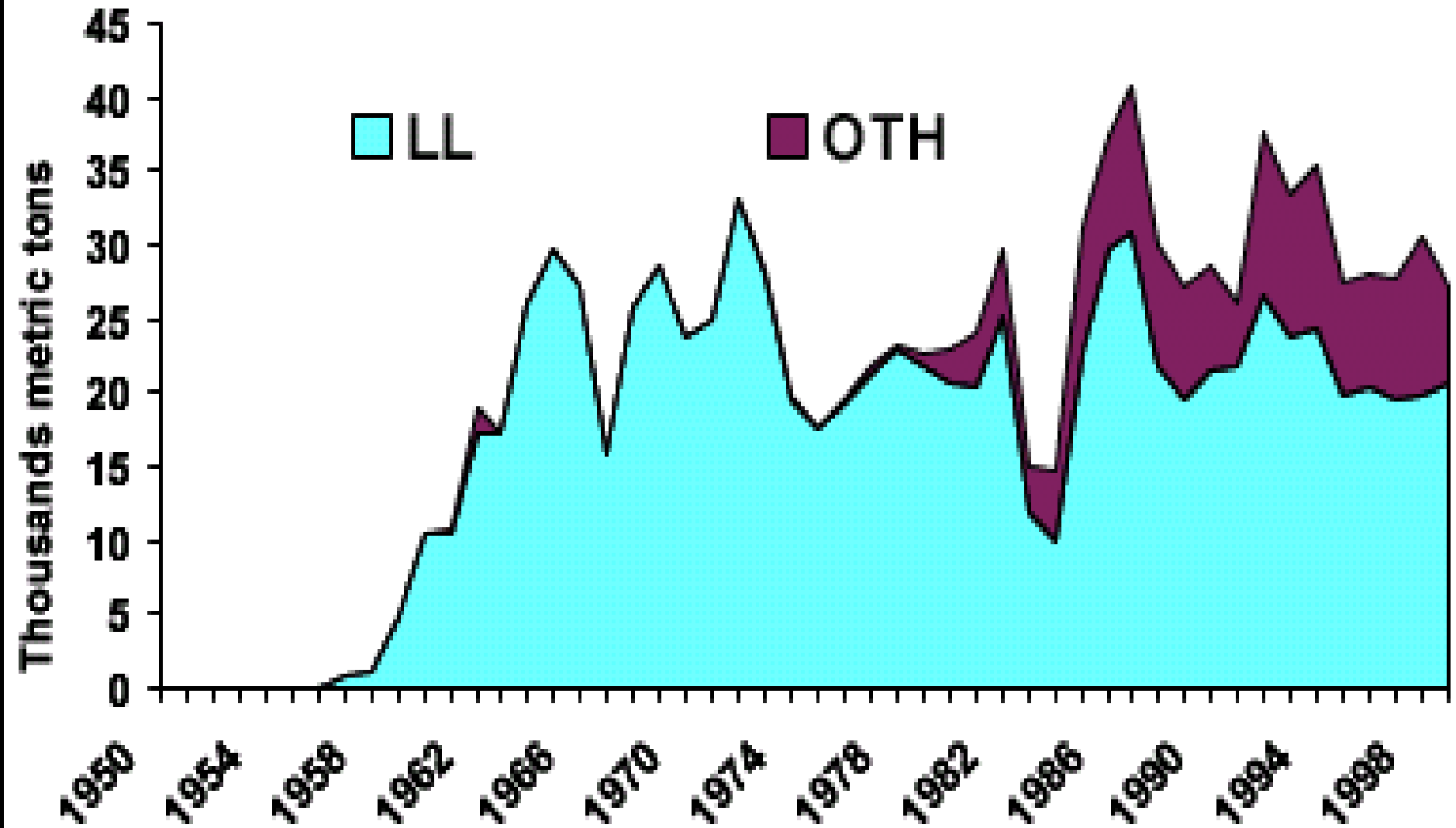
- Tuna, billfishes, sharks
- In the northern hemisphere intensive fisheries were being conducted before quantitative records were kept
- Japan harvested ~1,000,000 tons of tuna and marlin in the 5 years before WWII.
- In 1950 the US harvested ~170,000 tons.
- The 1950 harvest of albacore by Spain was greater than the total recent harvest in the North Atlantic.

Large Catches By 1950

North Atlantic Albacore Catch



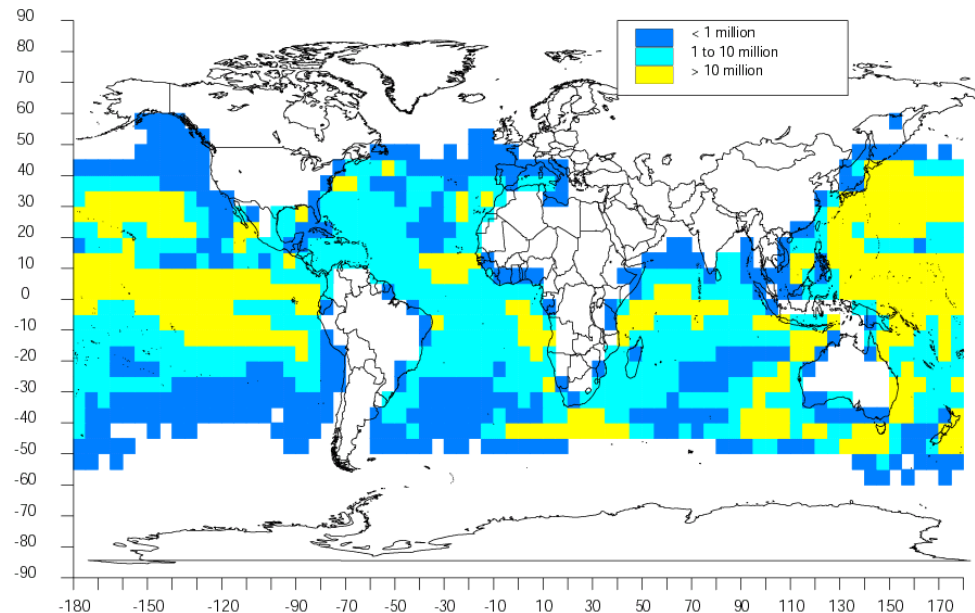
South Atlantic Albacore Catch



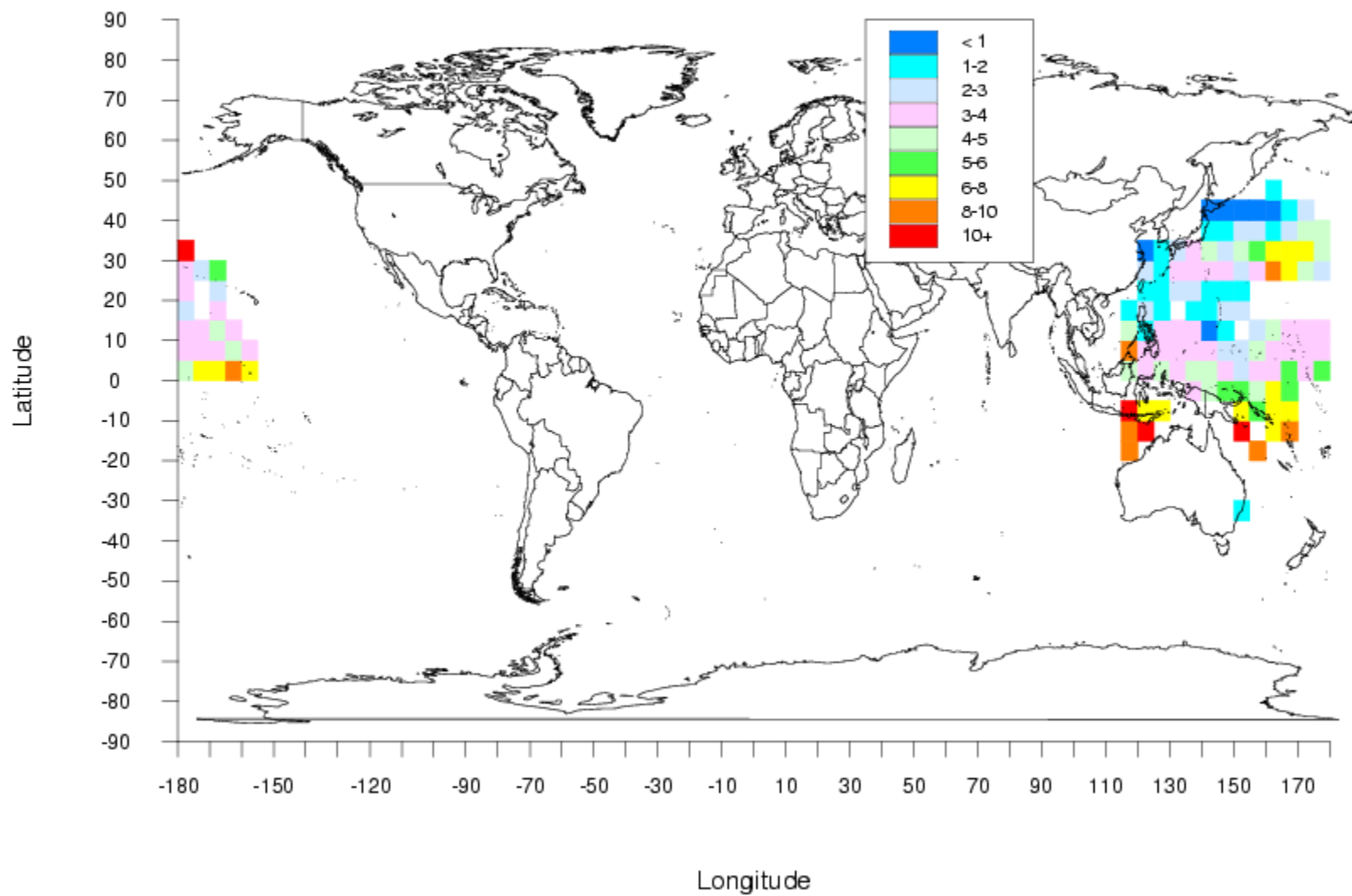
Japanese Longlining Data

- Detailed records from the beginning of the distant water fishery in the southern Indian and Atlantic
- Monthly data on a 5-degree square basis

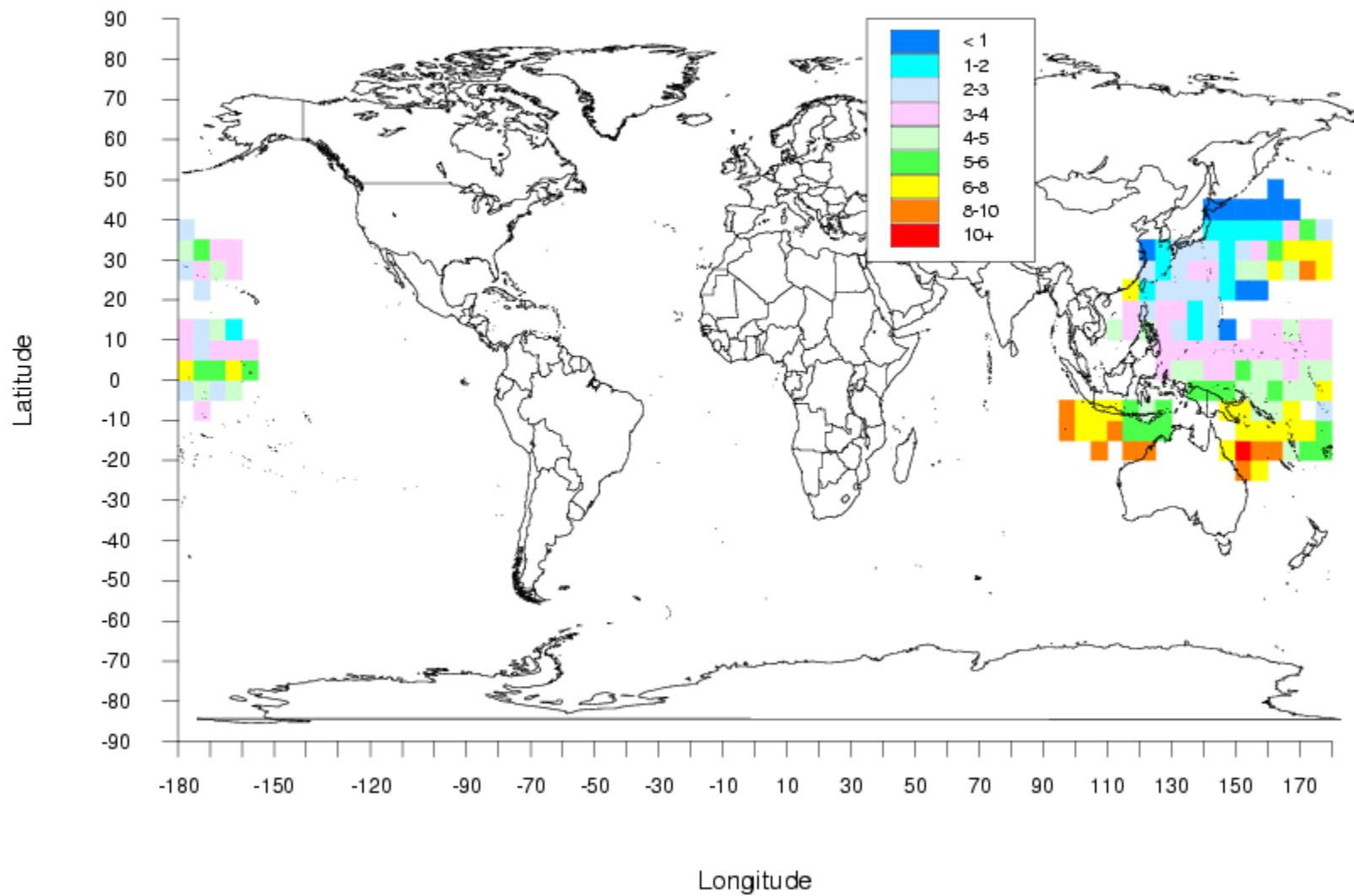
Total Number of Hooks Set by 5o Square (1956 - 1980)



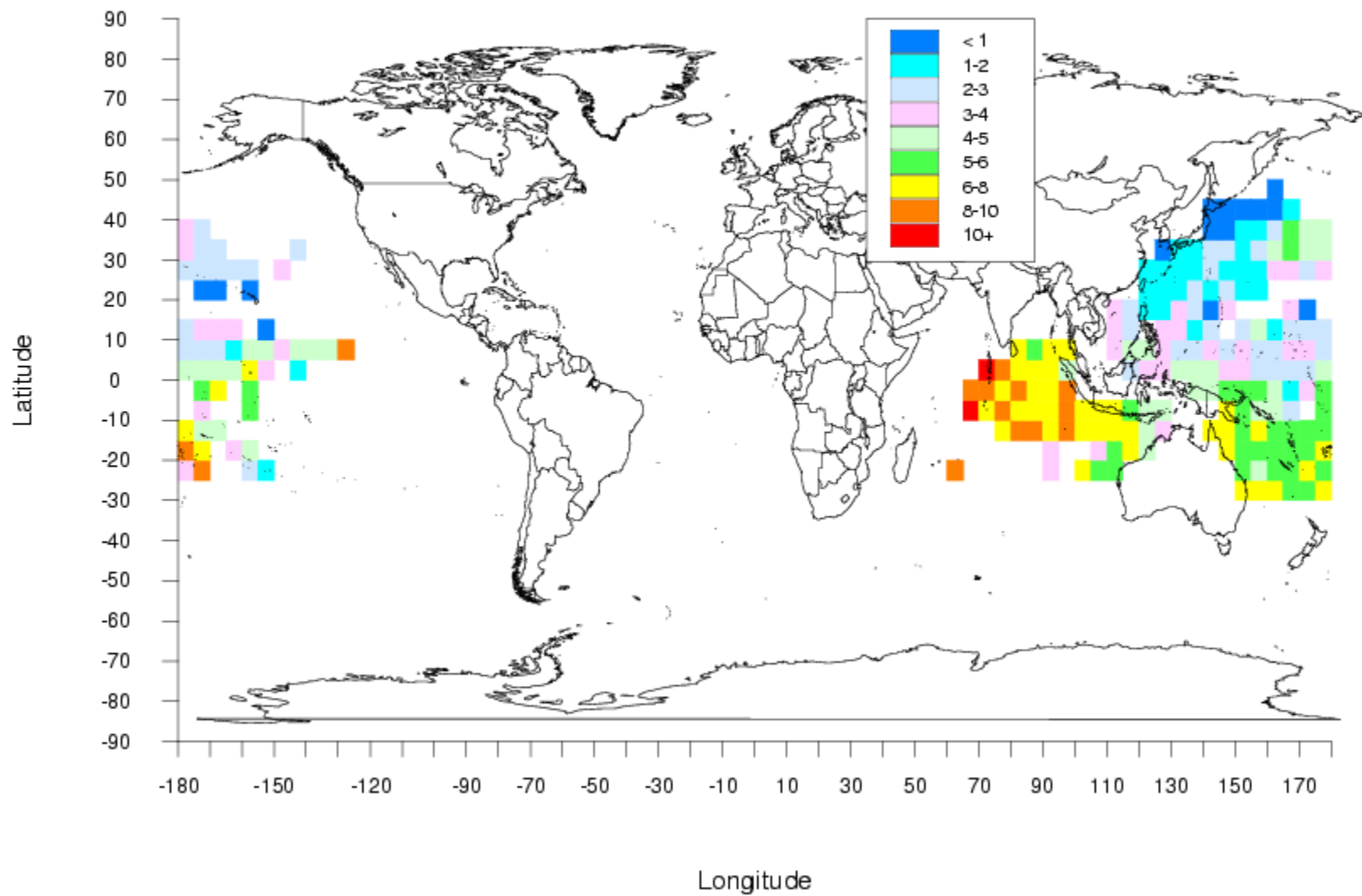
Catch Per Hundred Hooks, Year = 1952



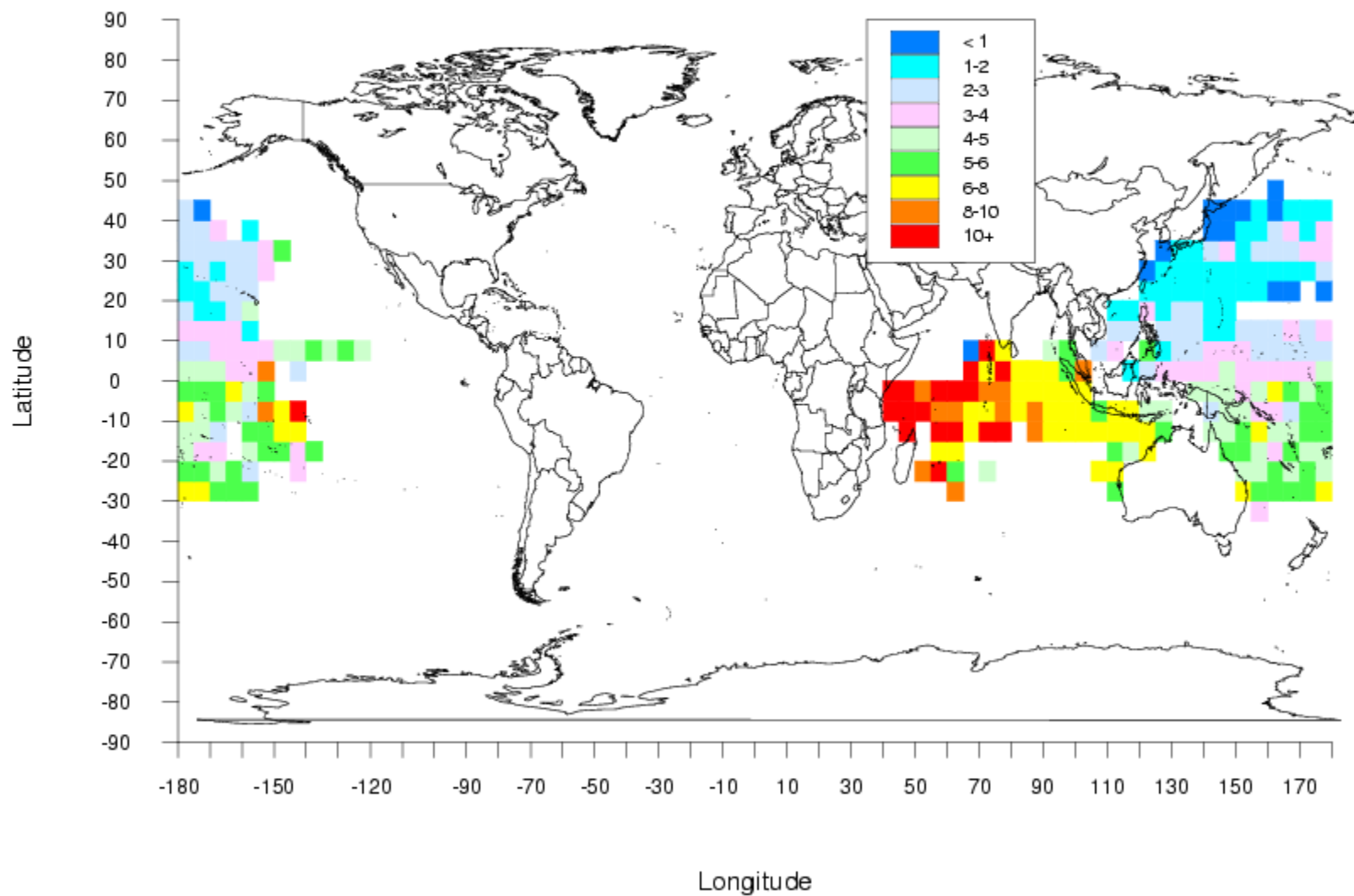
Catch Per Hundred Hooks, Year = 1953



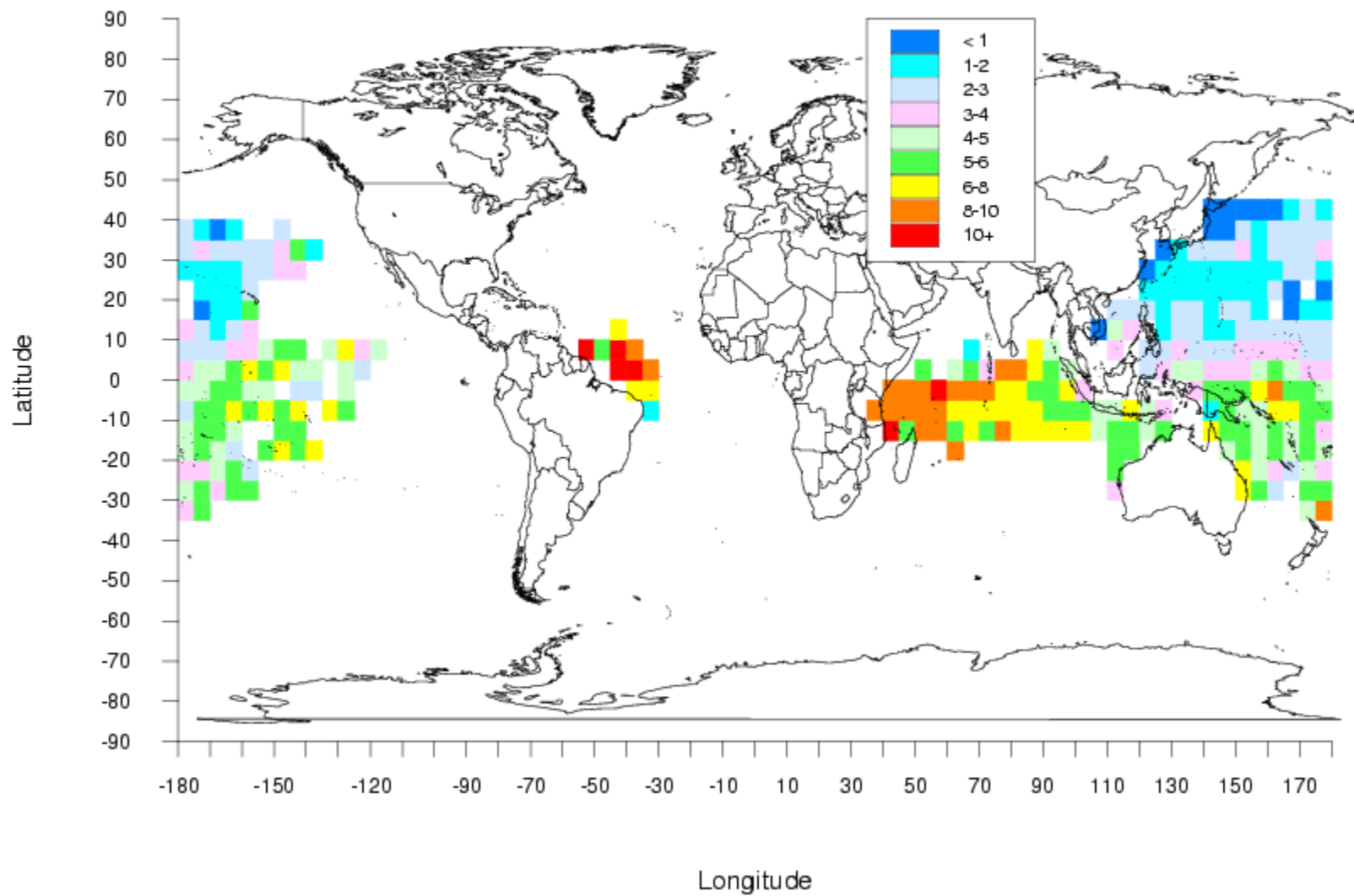
Catch Per Hundred Hooks, Year = 1954



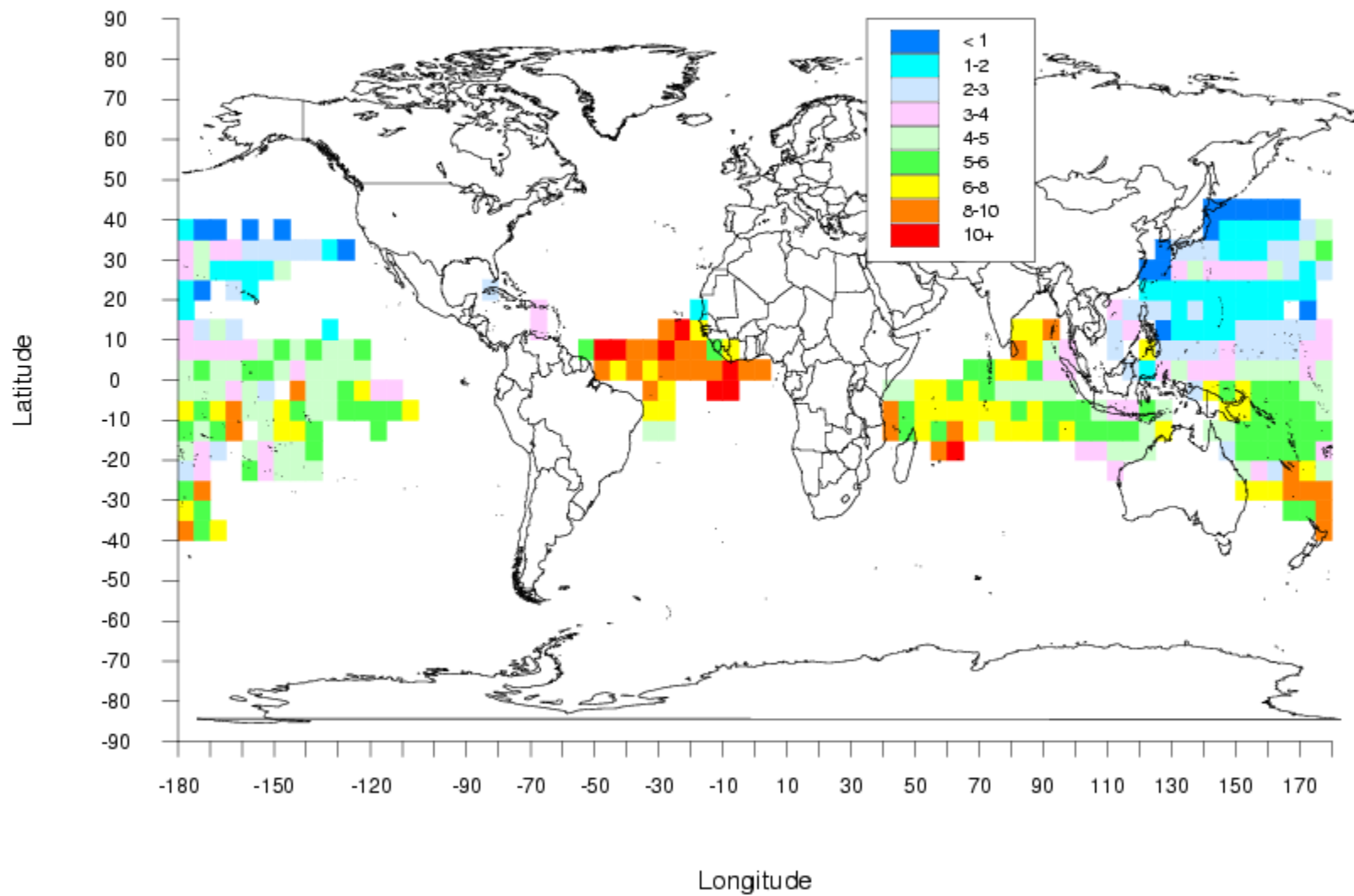
Catch Per Hundred Hooks, Year = 1955



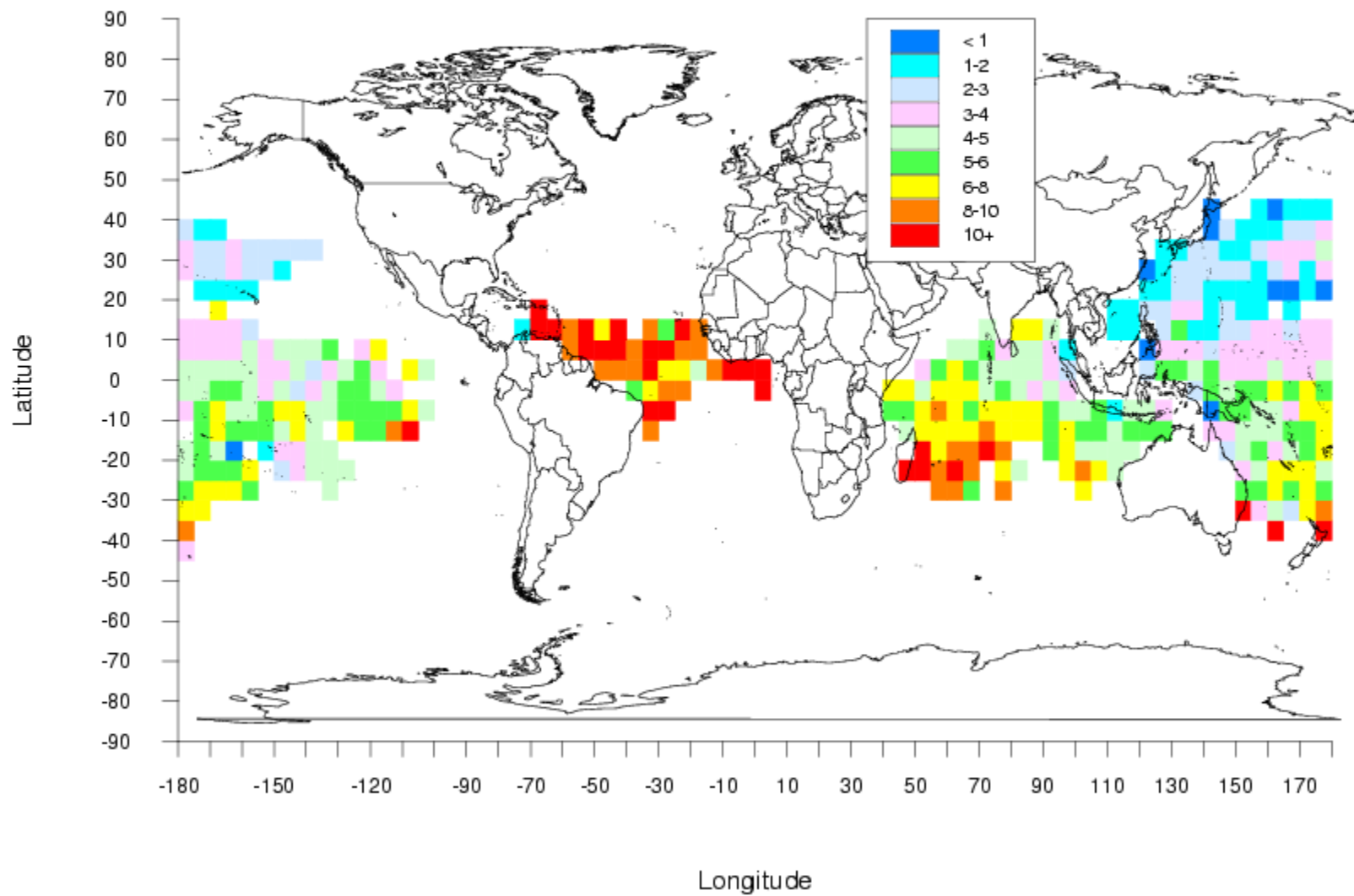
Catch Per Hundred Hooks, Year = 1956



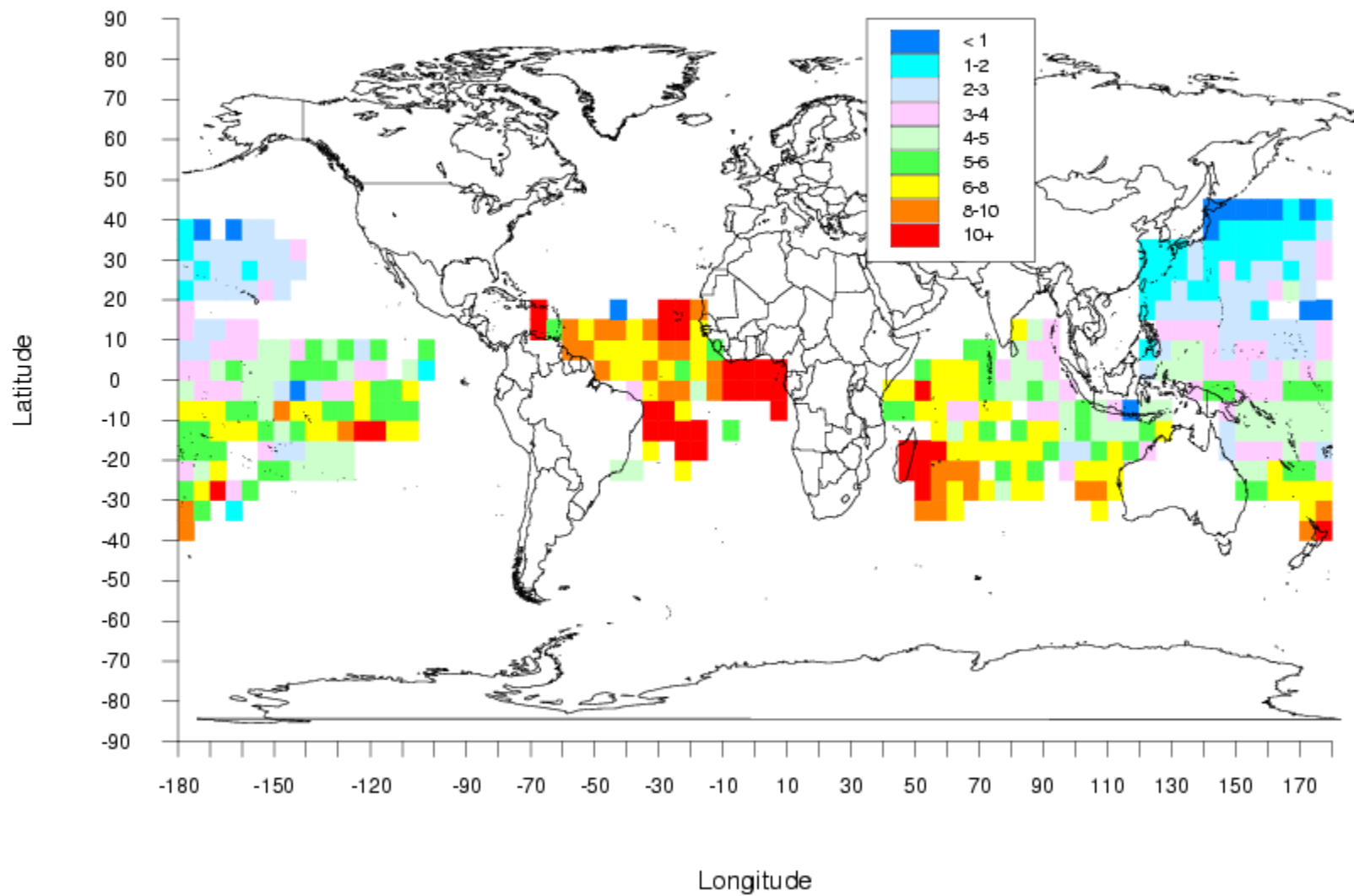
Catch Per Hundred Hooks, Year = 1957



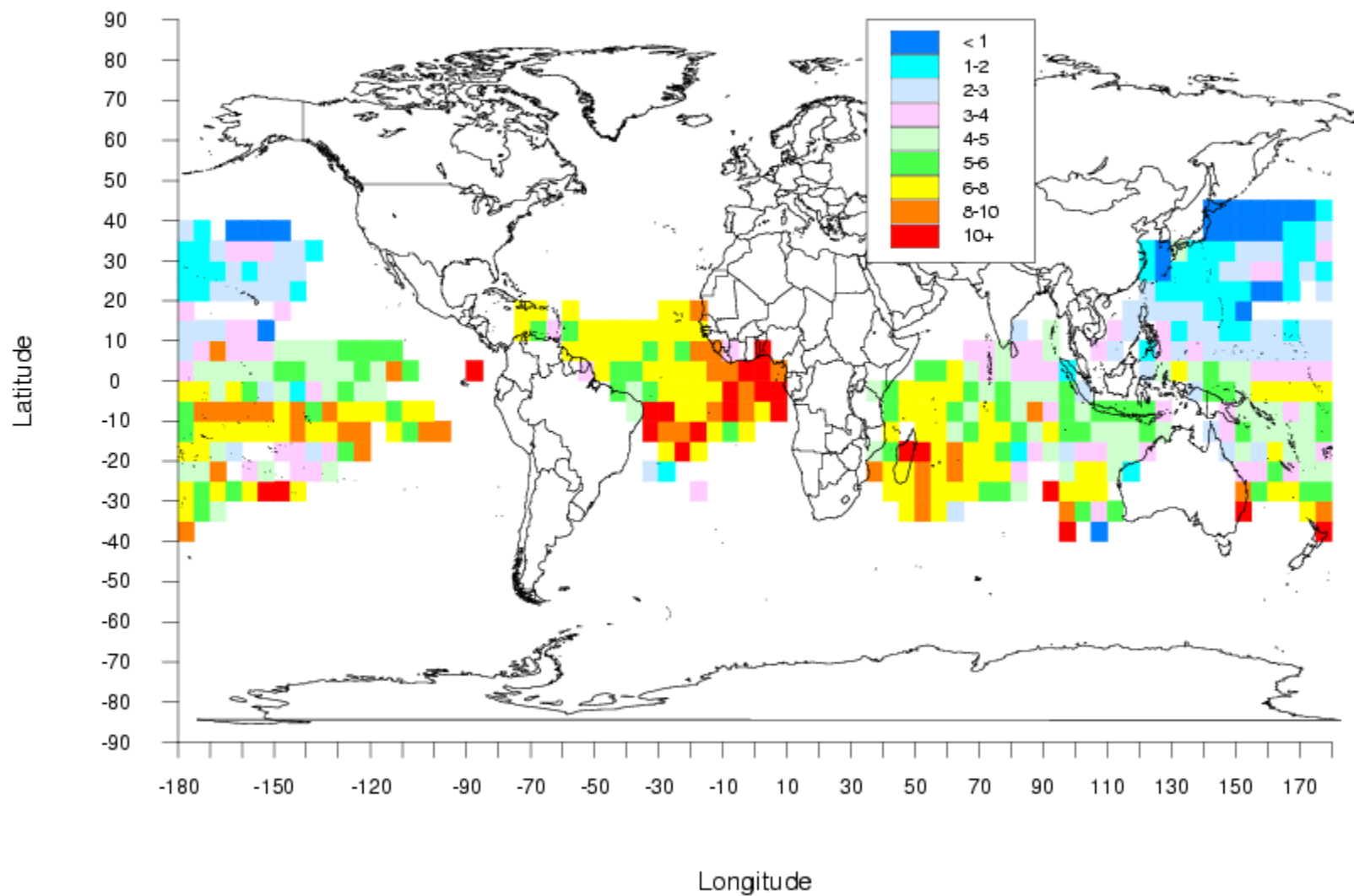
Catch Per Hundred Hooks, Year = 1958



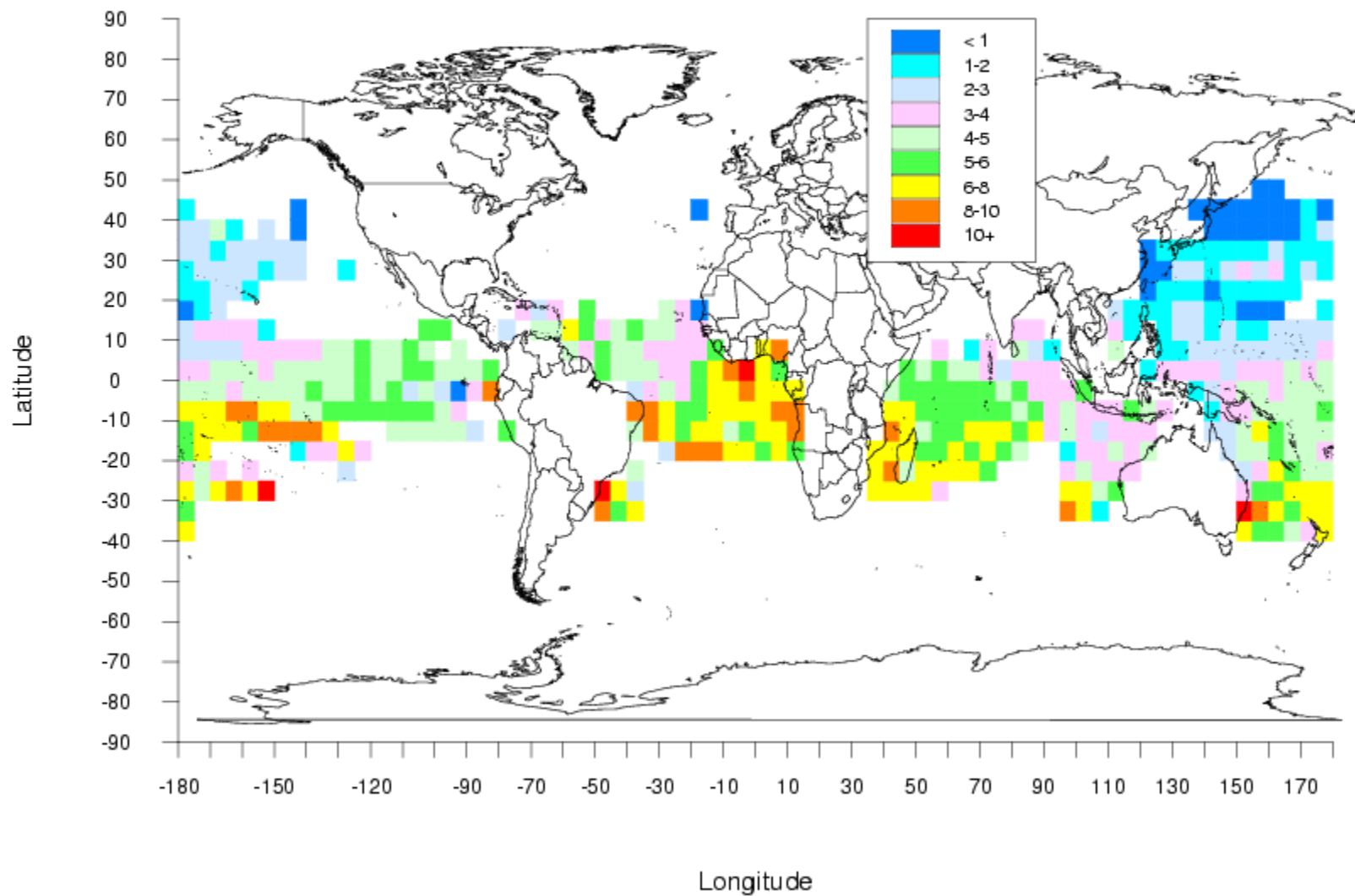
Catch Per Hundred Hooks, Year = 1959



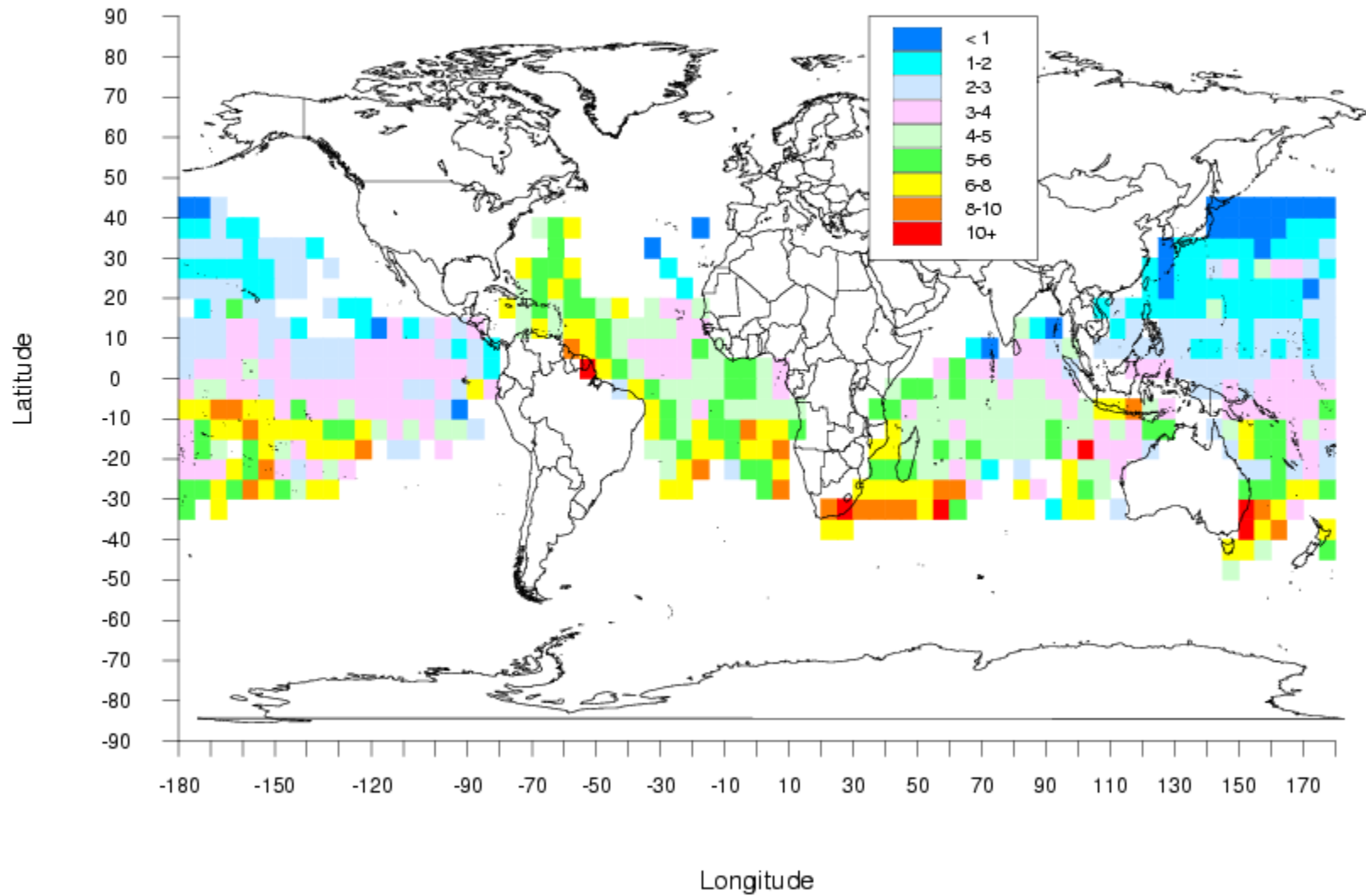
Catch Per Hundred Hooks, Year = 1960



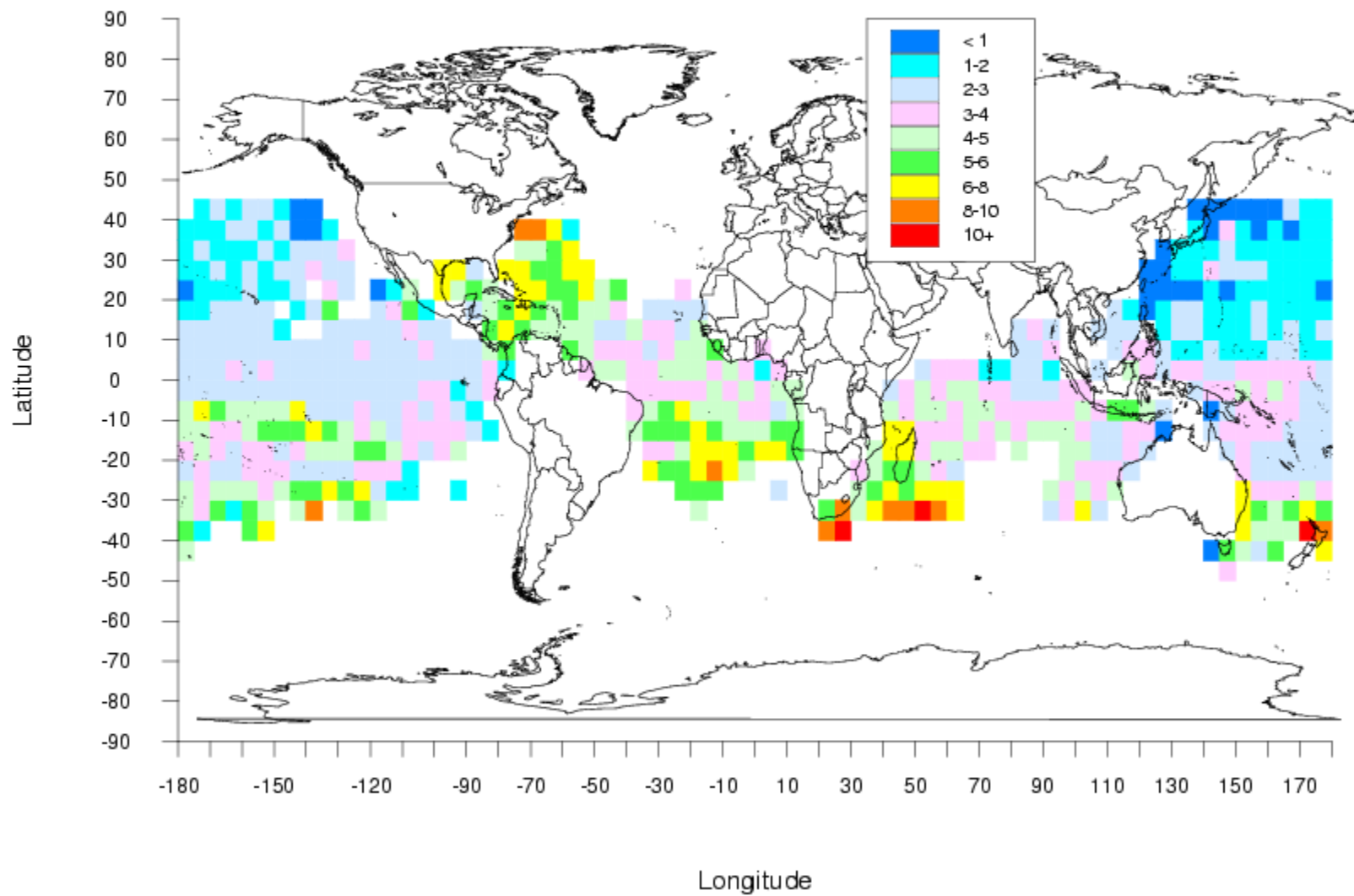
Catch Per Hundred Hooks, Year = 1961



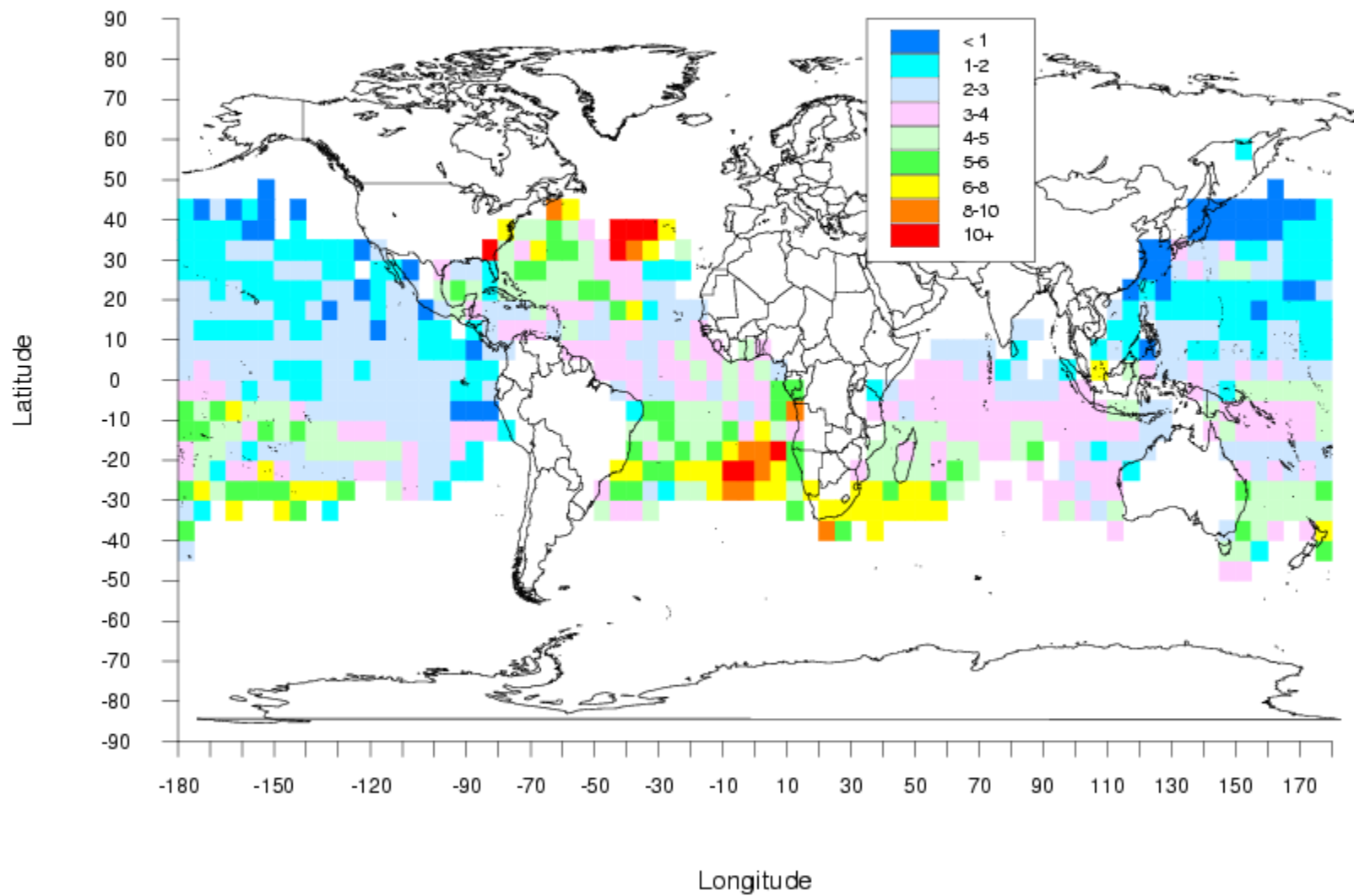
Catch Per Hundred Hooks, Year = 1962



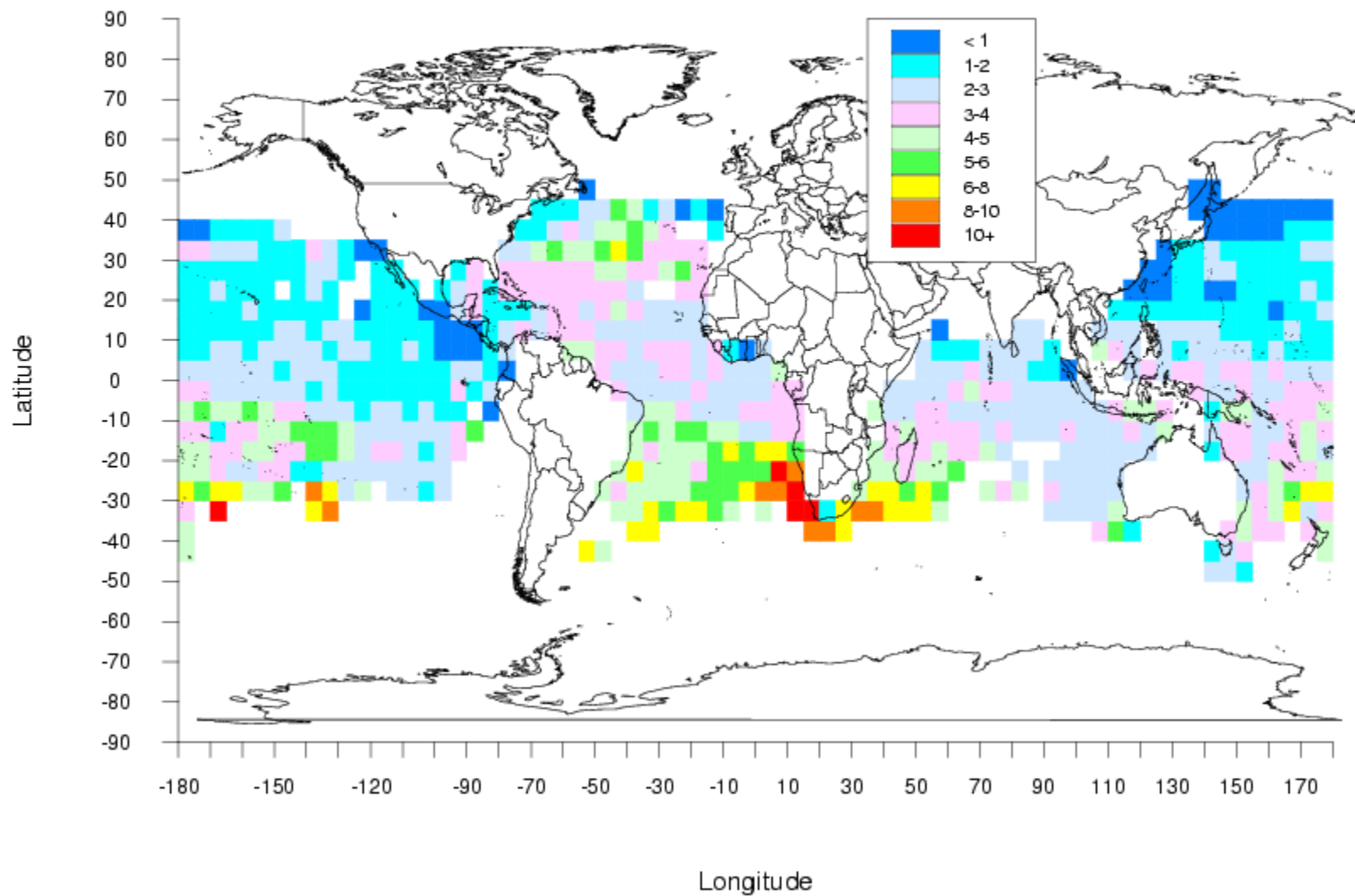
Catch Per Hundred Hooks, Year = 1963



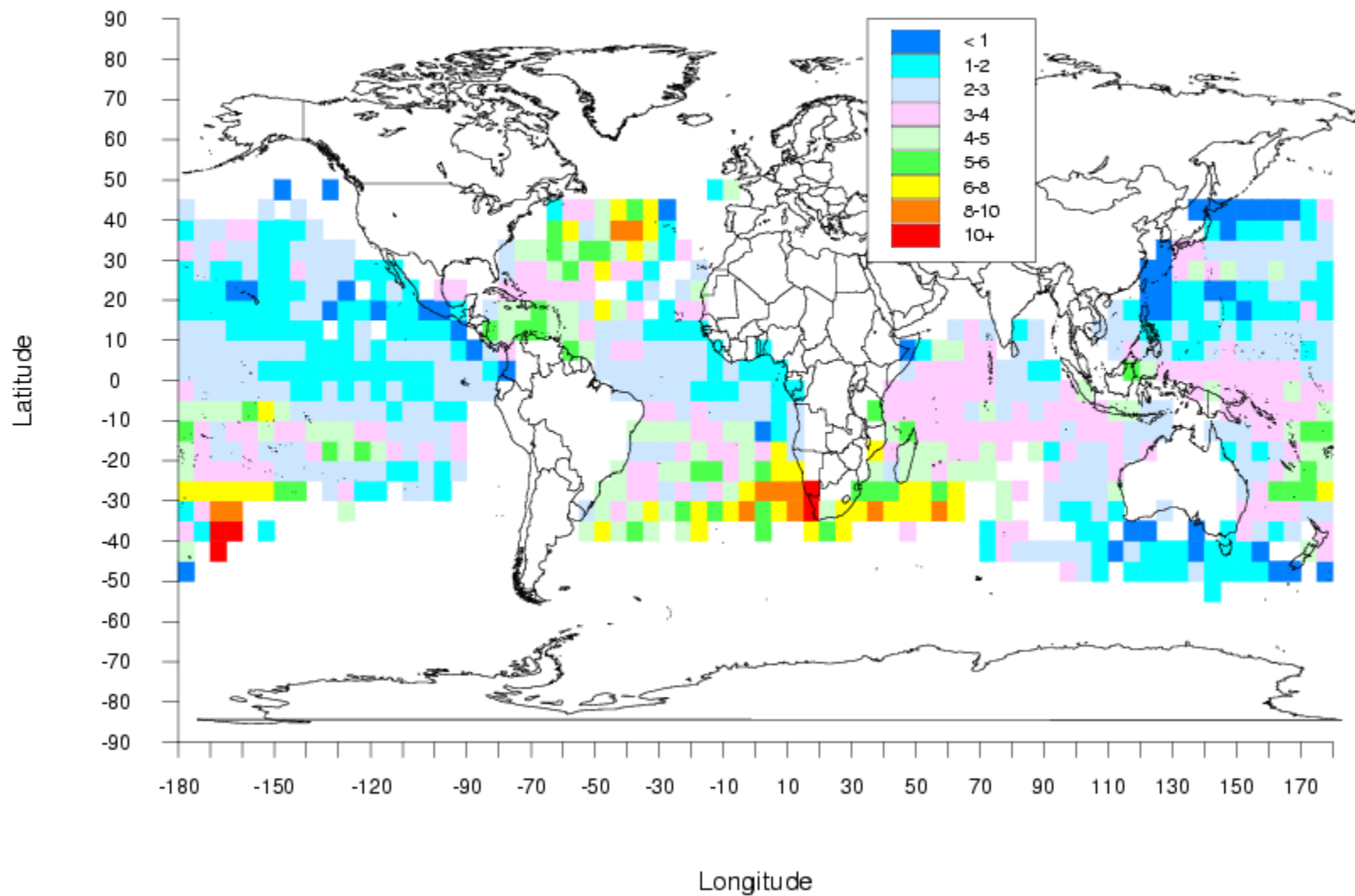
Catch Per Hundred Hooks, Year = 1964



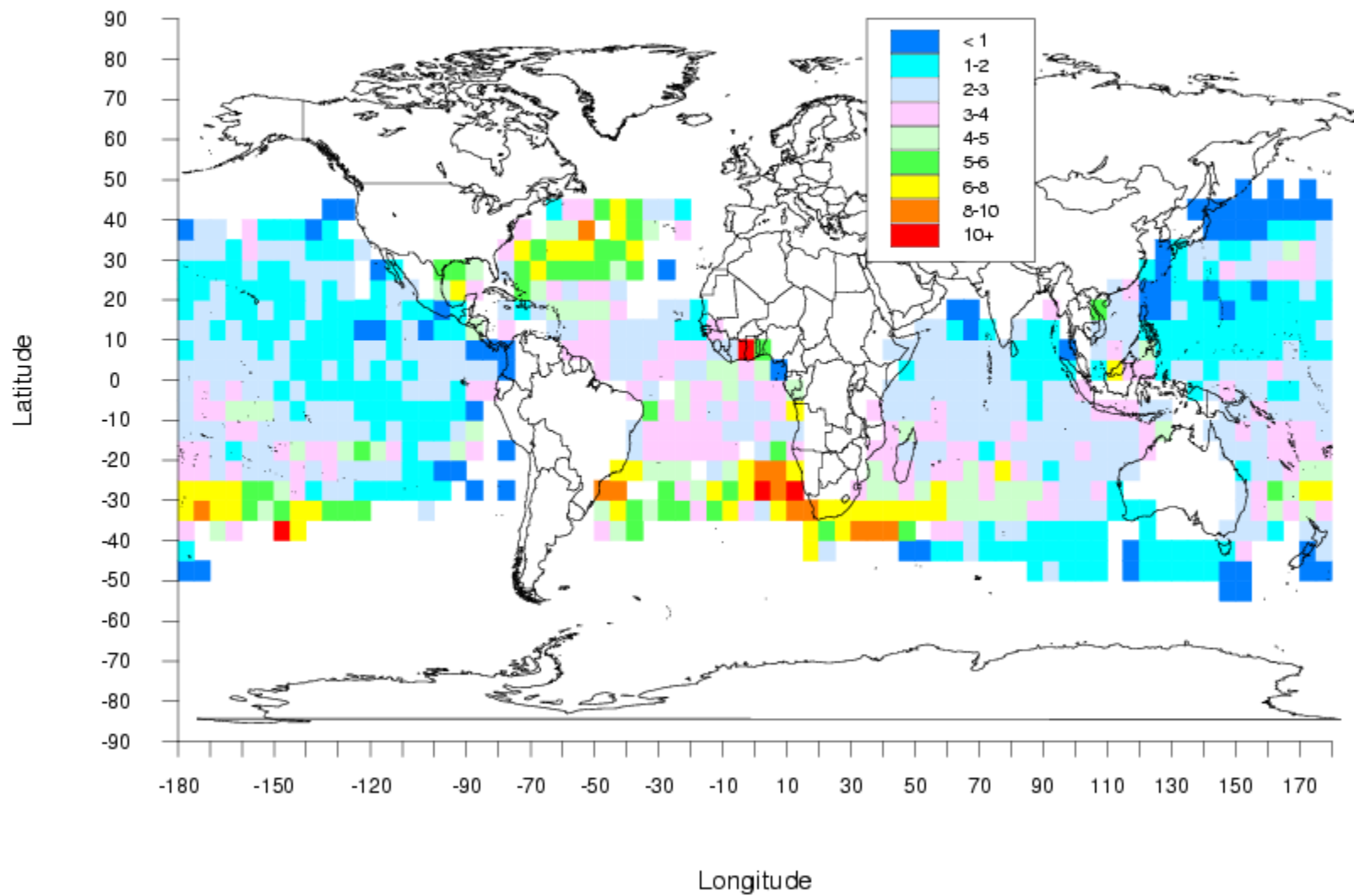
Catch Per Hundred Hooks, Year = 1965



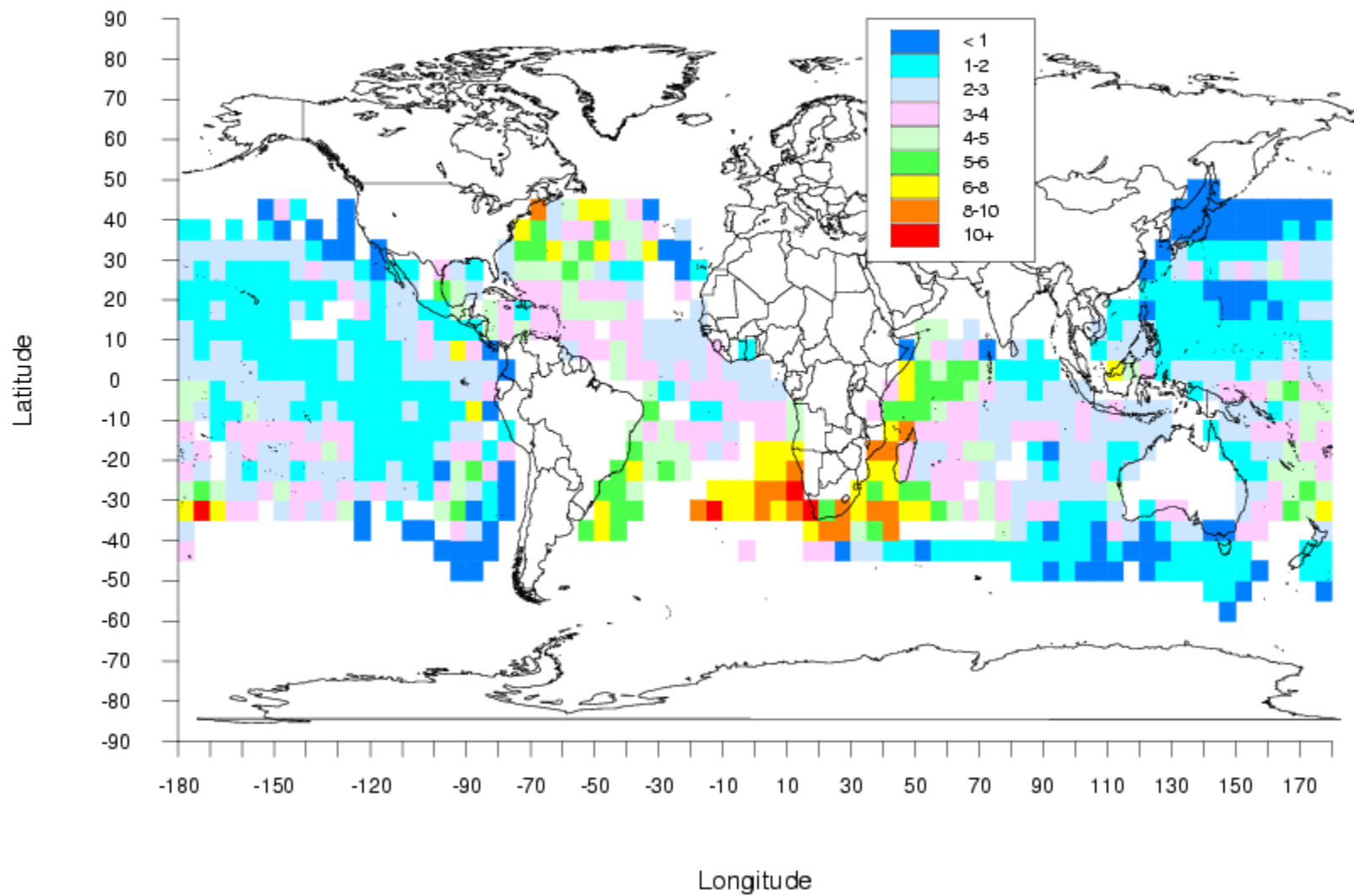
Catch Per Hundred Hooks, Year = 1966



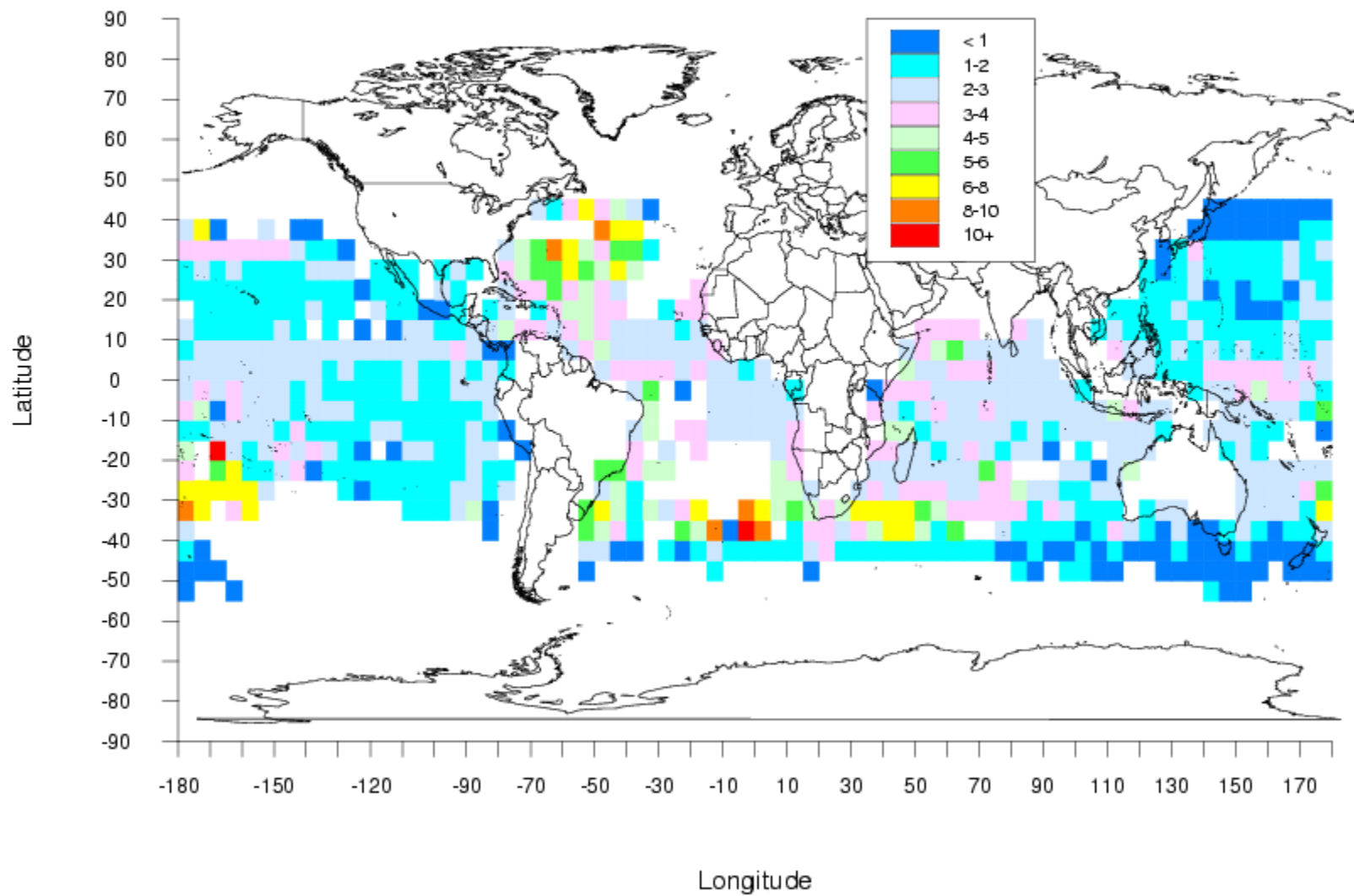
Catch Per Hundred Hooks, Year = 1967



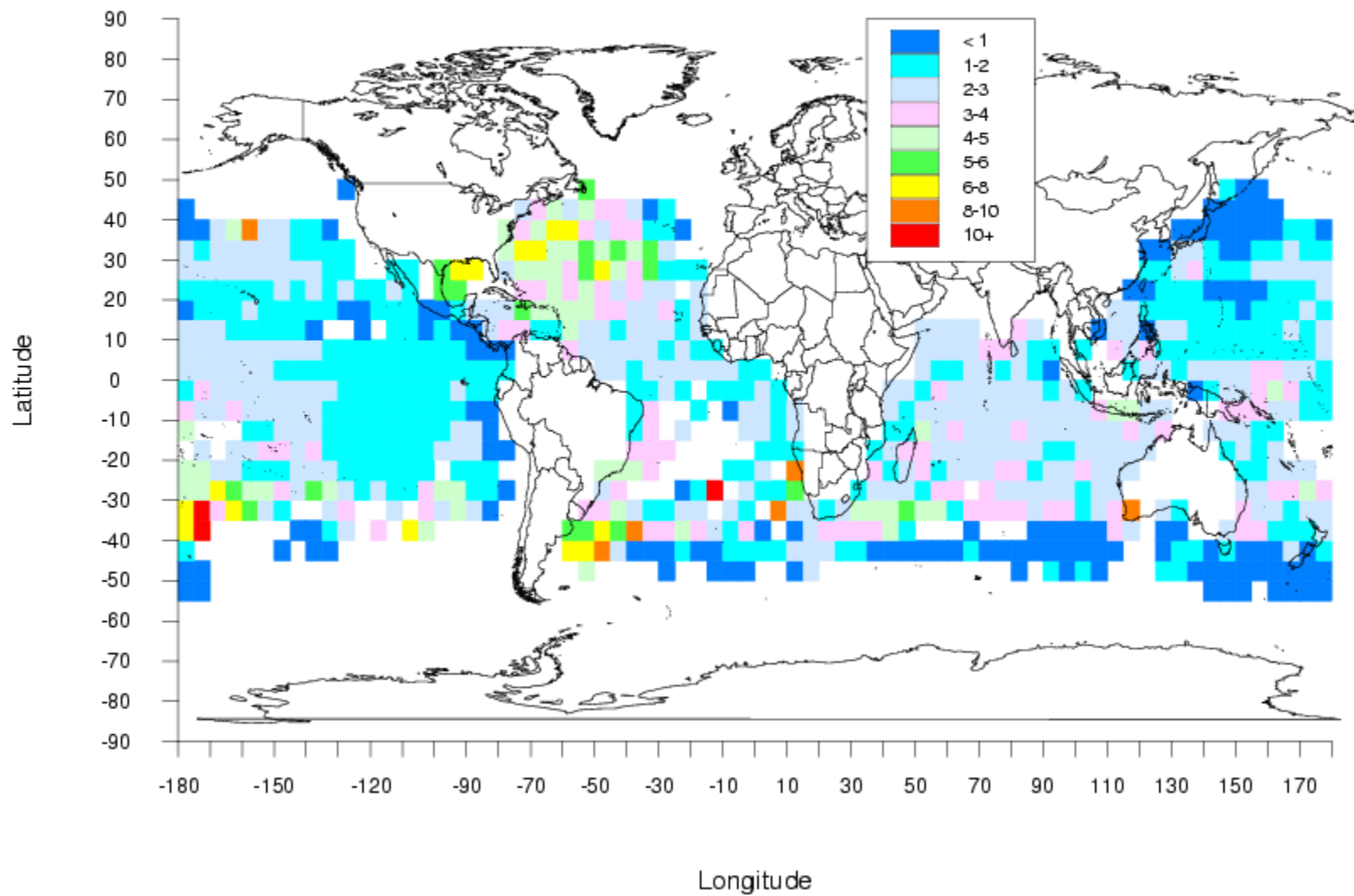
Catch Per Hundred Hooks, Year = 1968



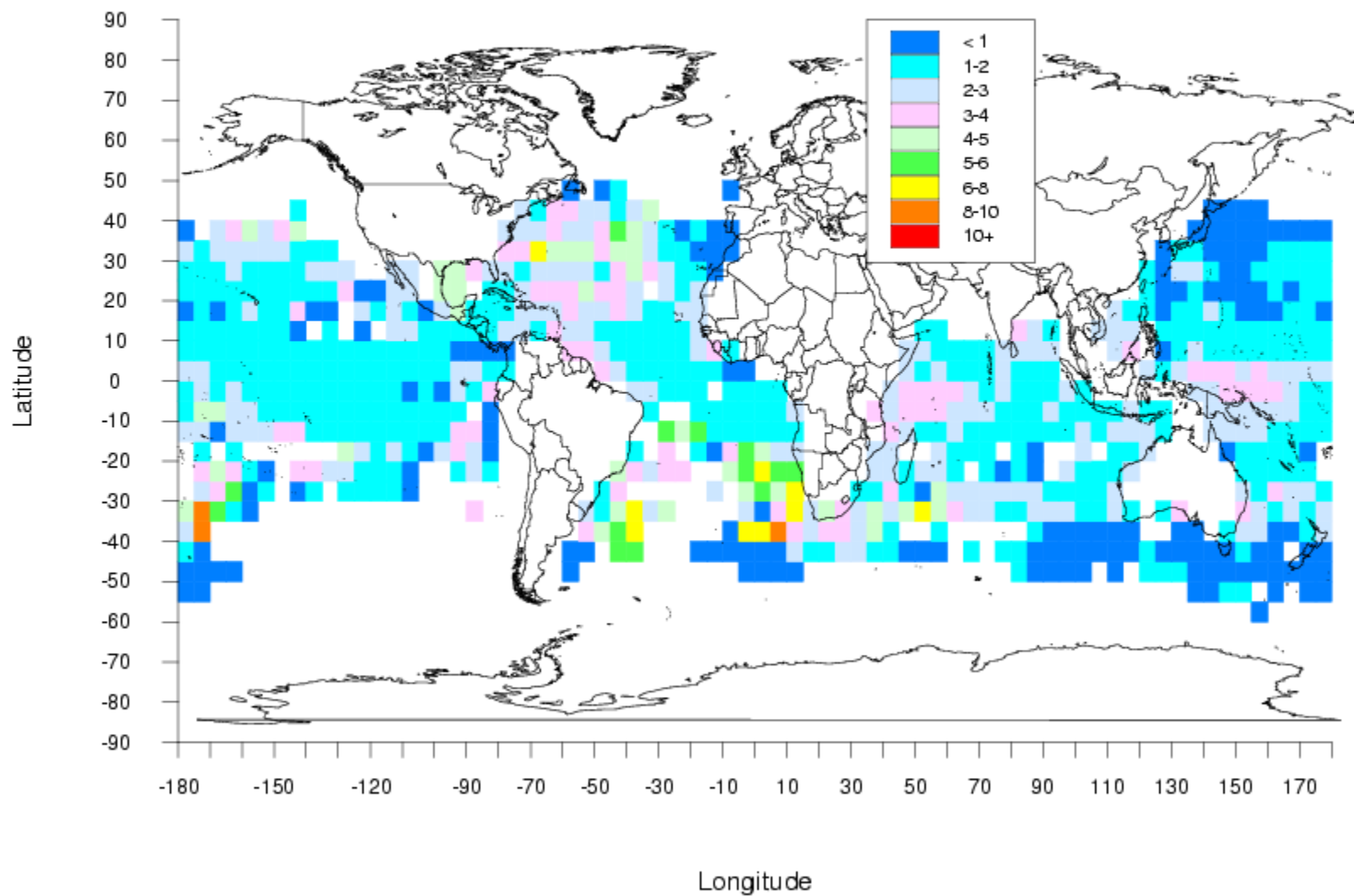
Catch Per Hundred Hooks, Year = 1969



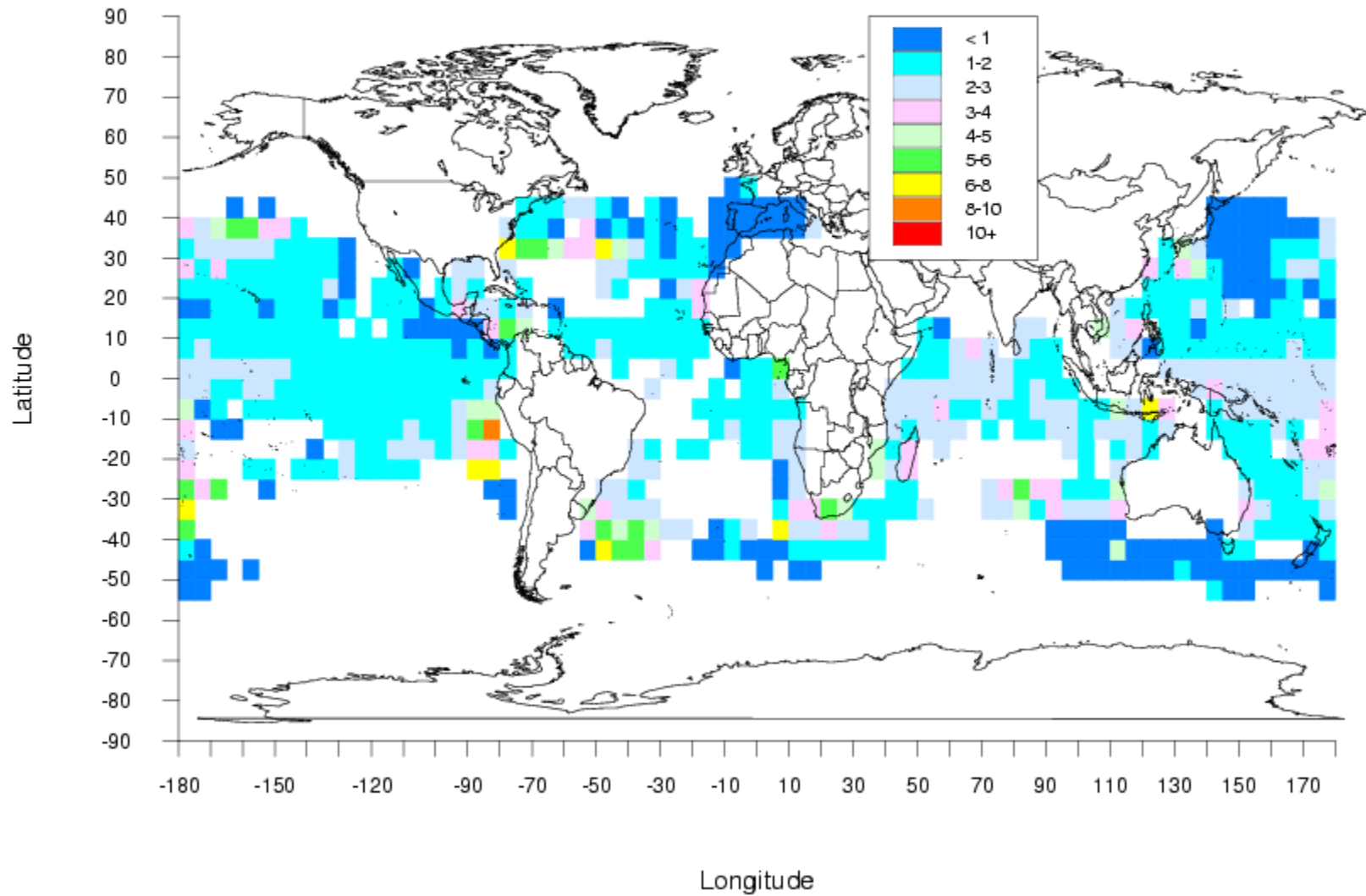
Catch Per Hundred Hooks, Year = 1970



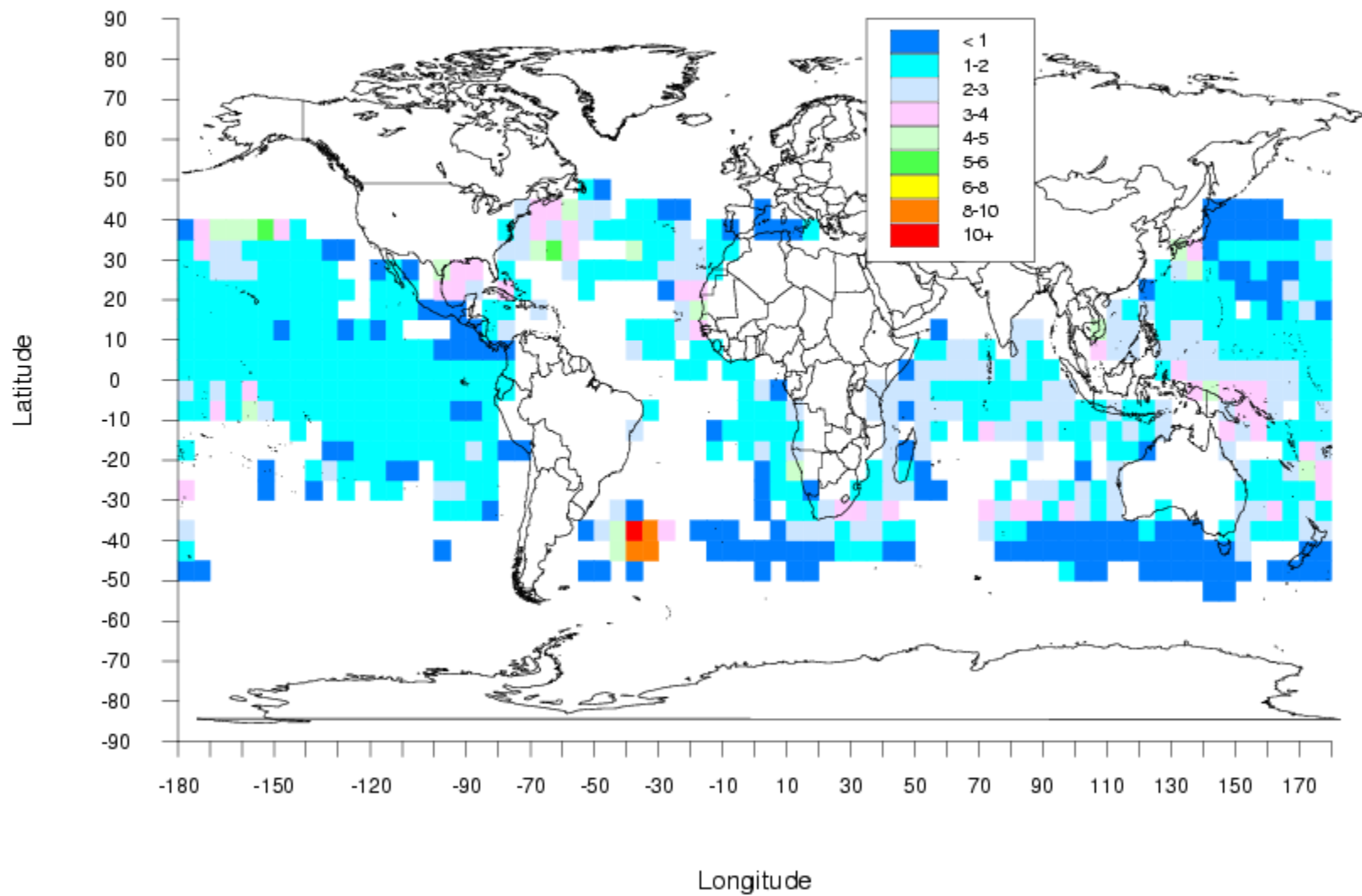
Catch Per Hundred Hooks, Year = 1971



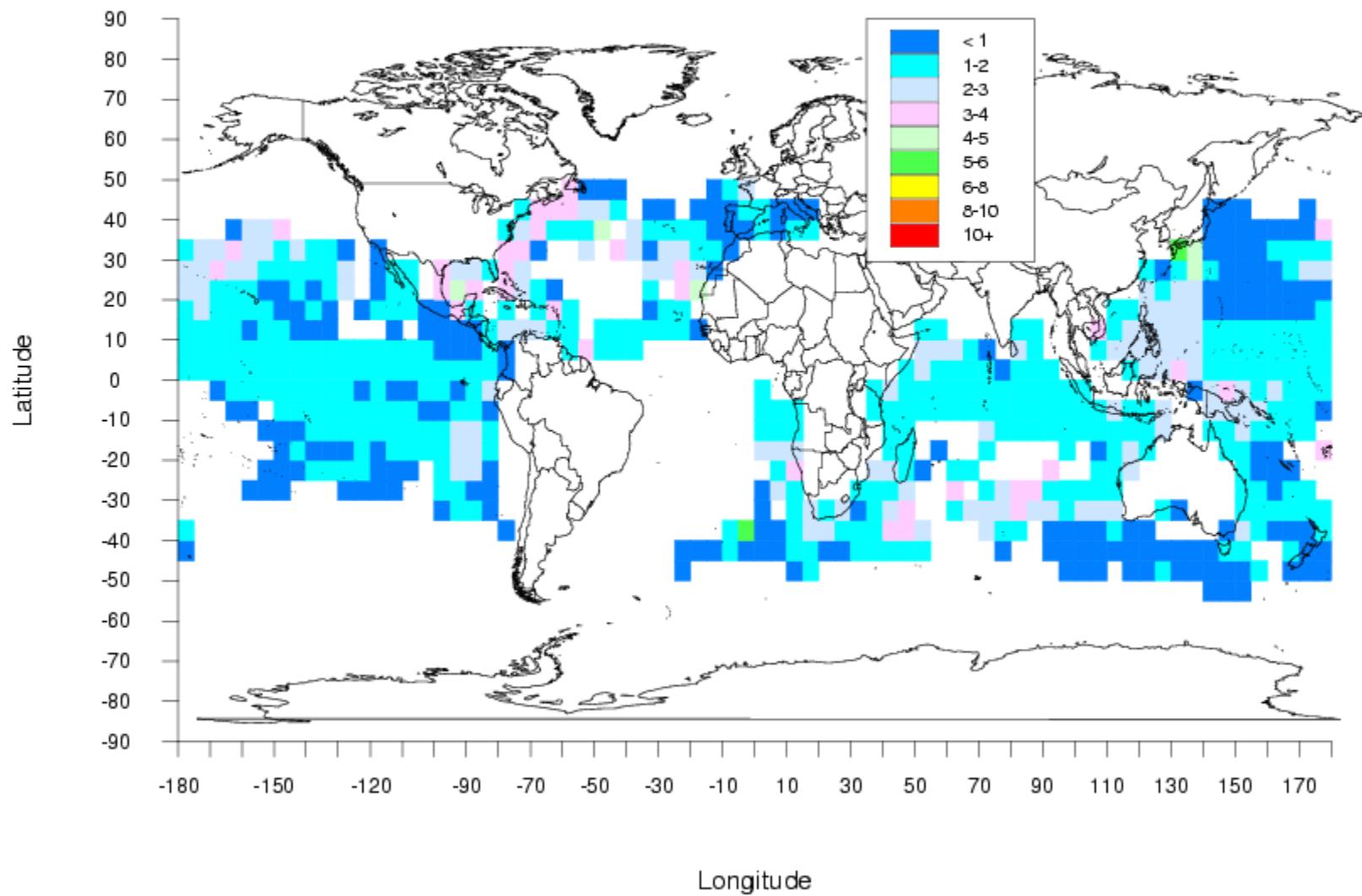
Catch Per Hundred Hooks, Year = 1972



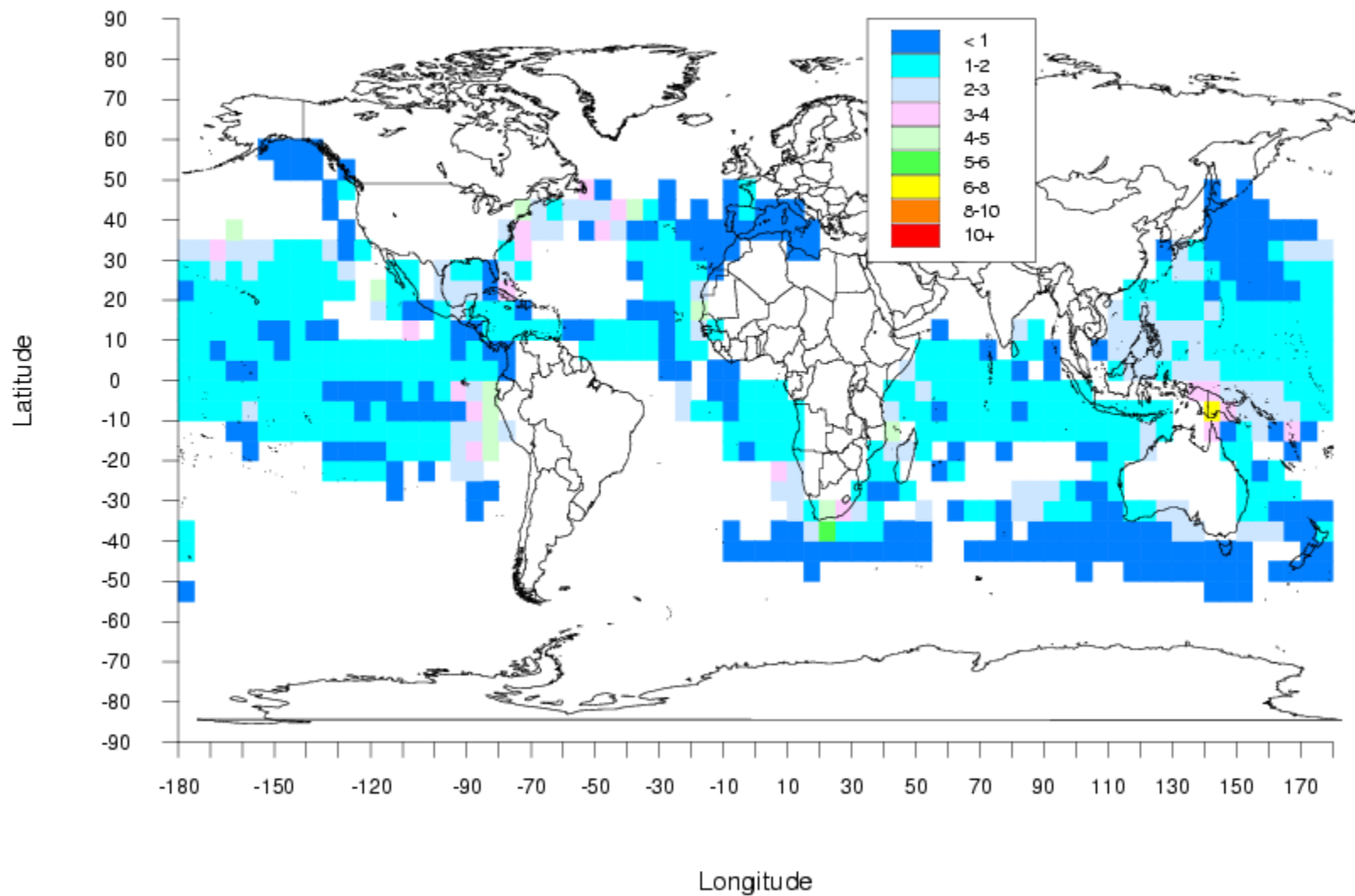
Catch Per Hundred Hooks, Year = 1973



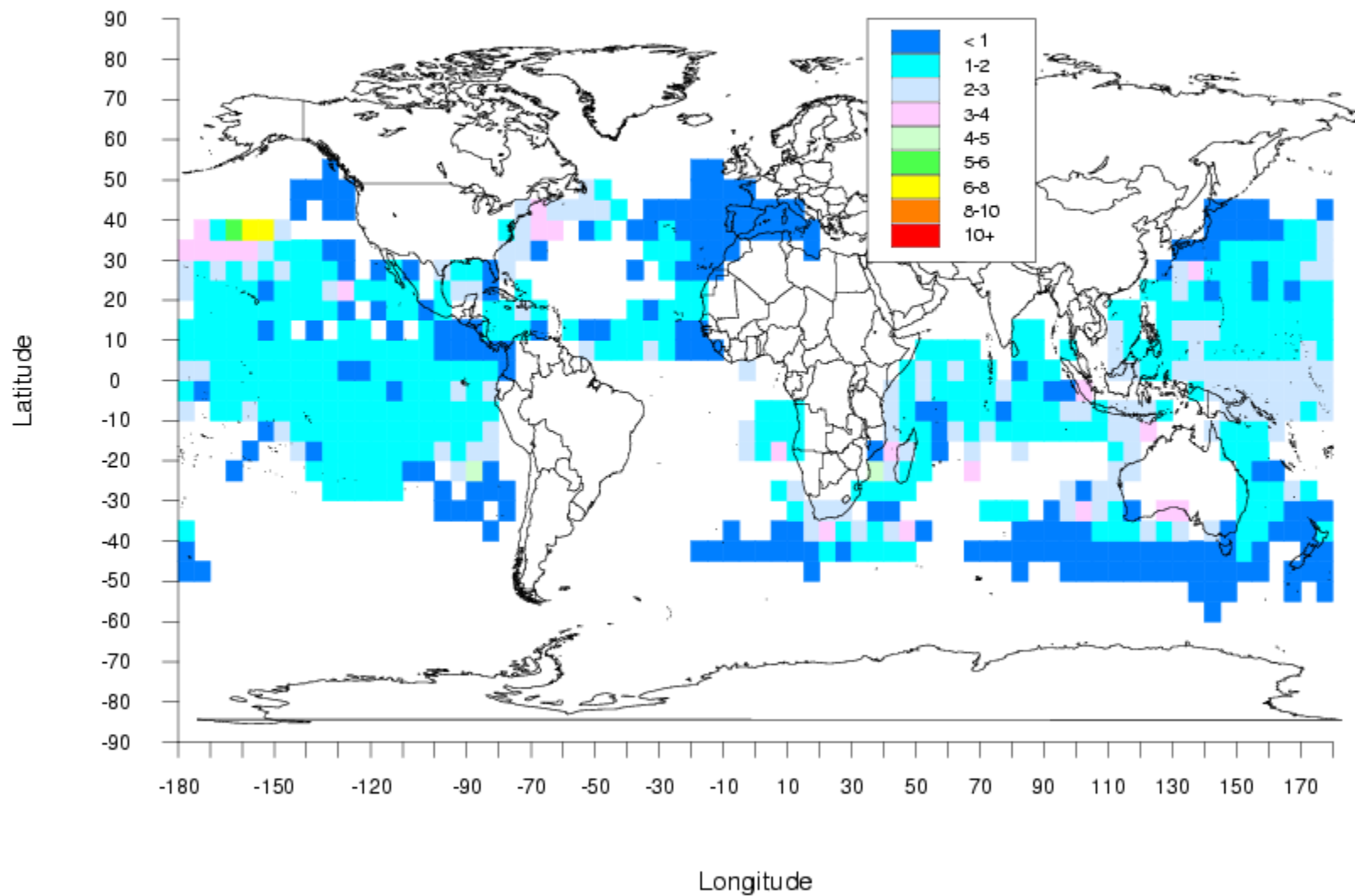
Catch Per Hundred Hooks, Year = 1974



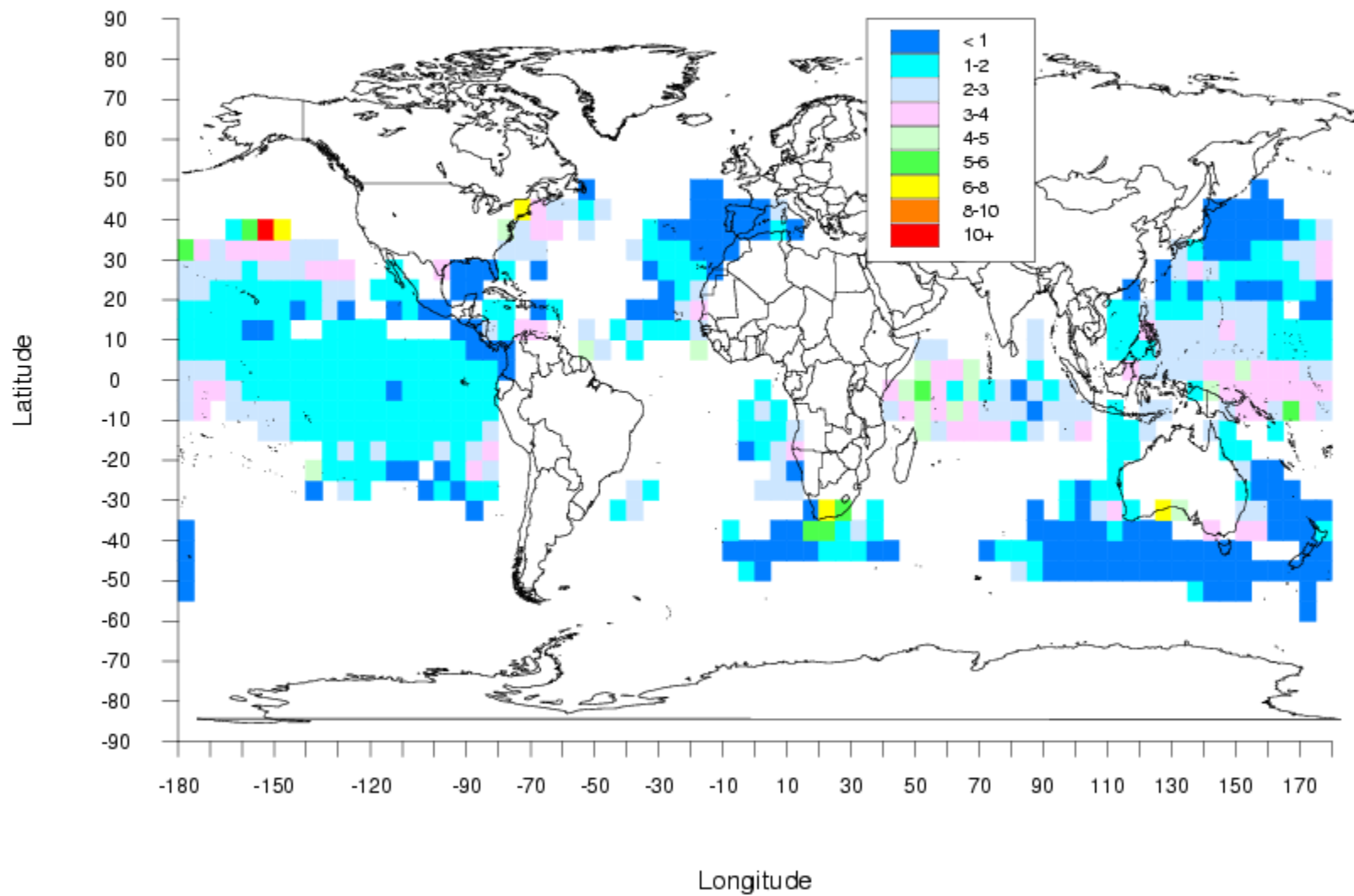
Catch Per Hundred Hooks, Year = 1975



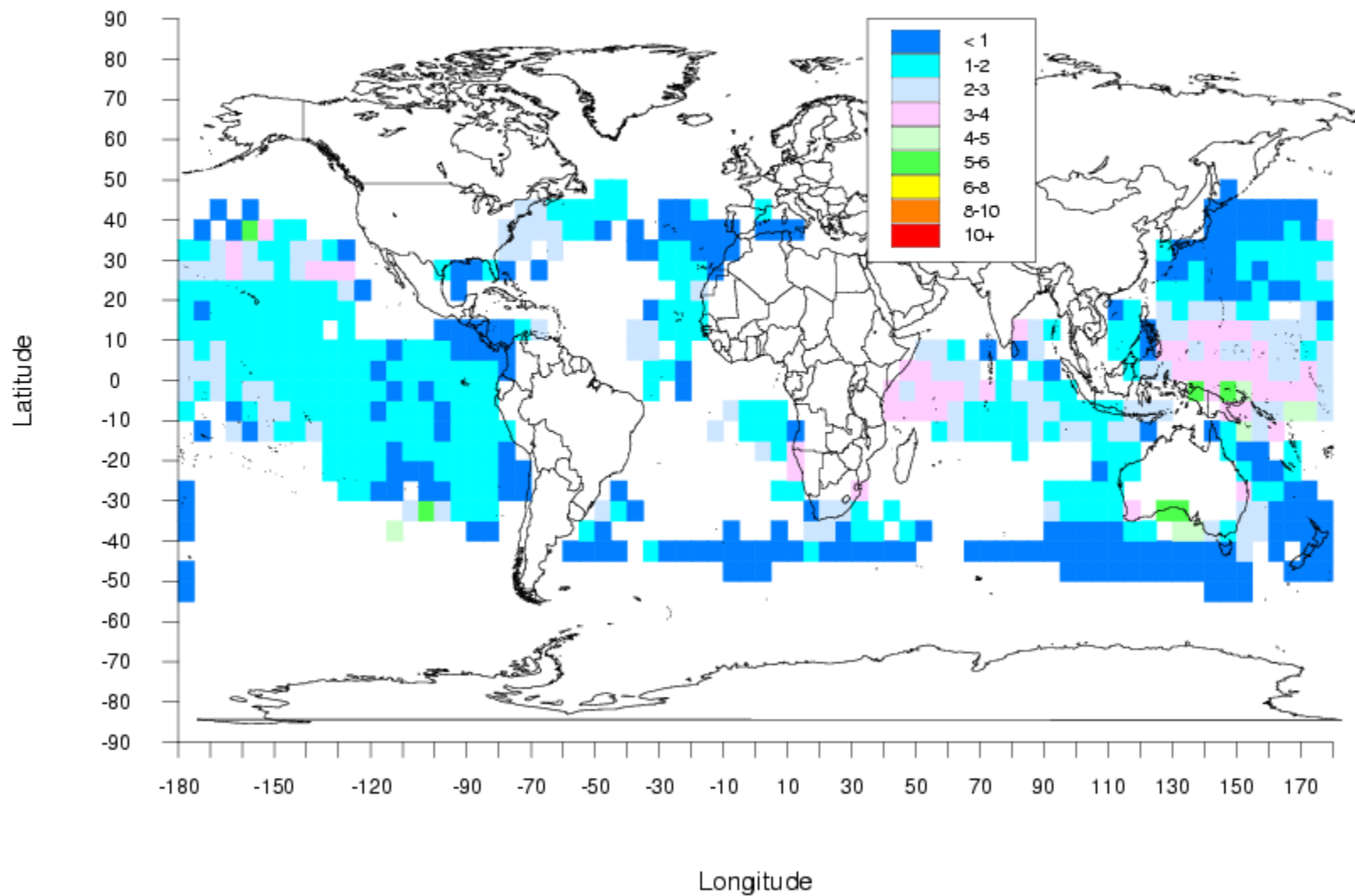
Catch Per Hundred Hooks, Year = 1976



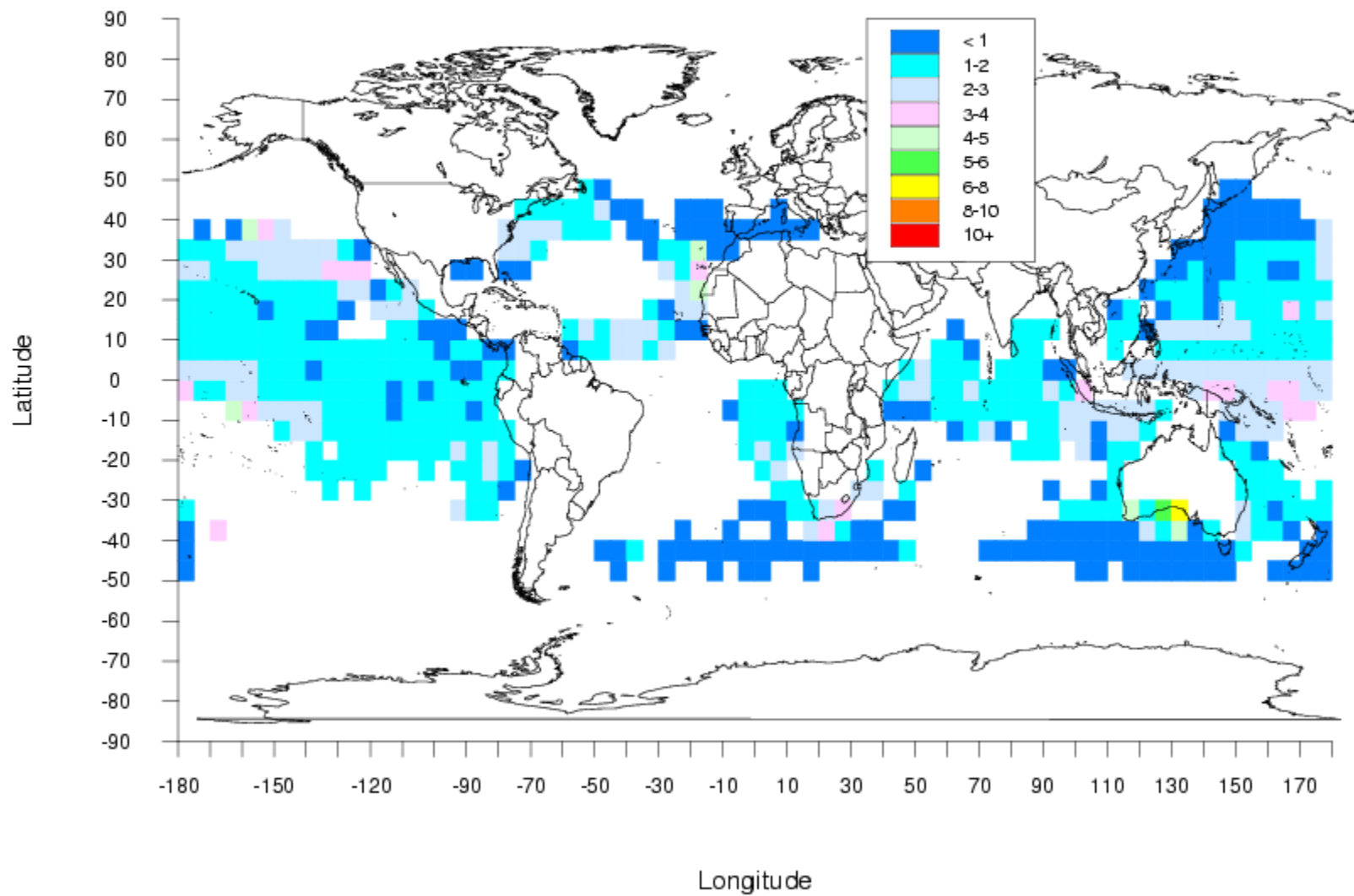
Catch Per Hundred Hooks, Year = 1977



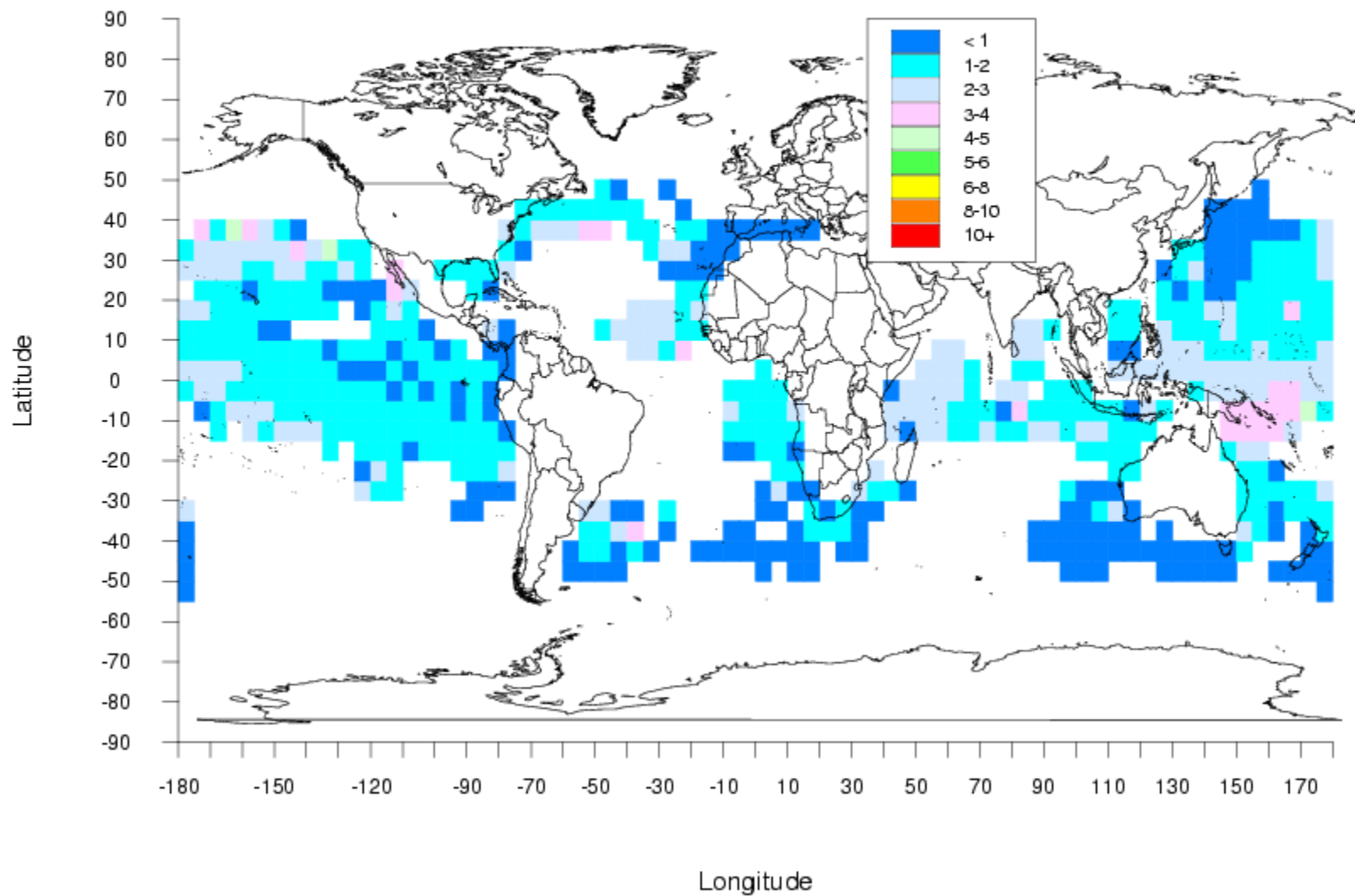
Catch Per Hundred Hooks, Year = 1978



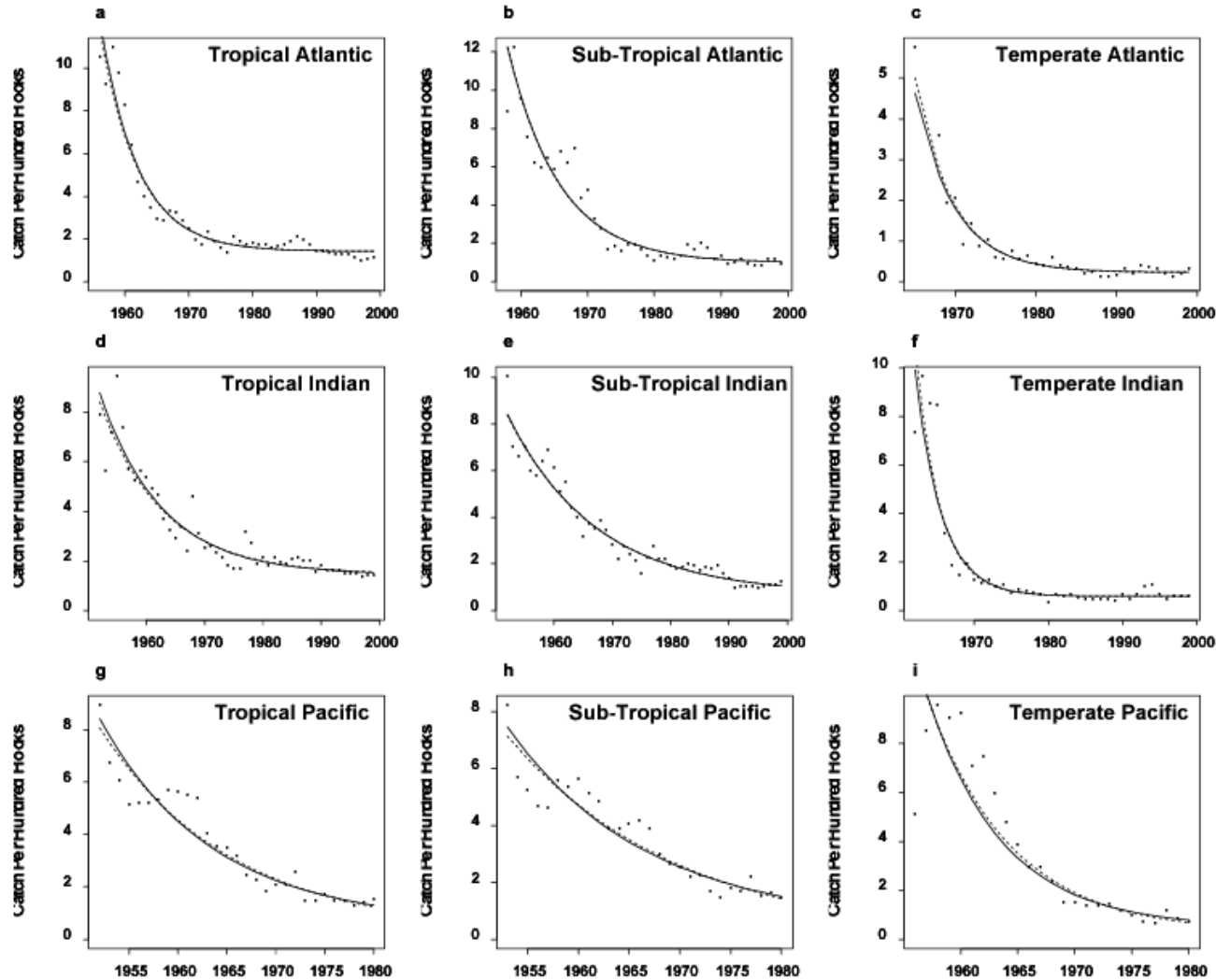
Catch Per Hundred Hooks, Year = 1979



Catch Per Hundred Hooks, Year = 1980

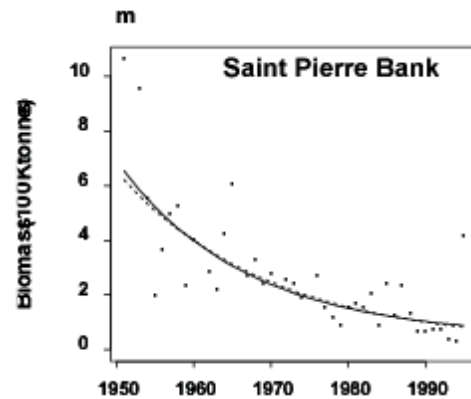
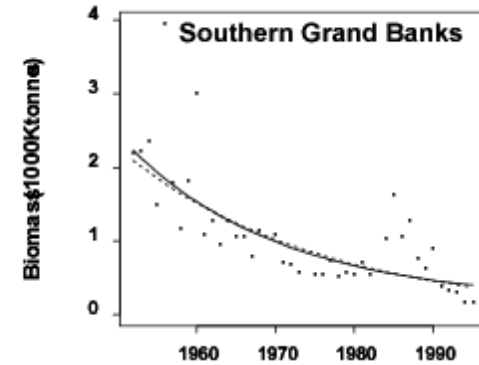
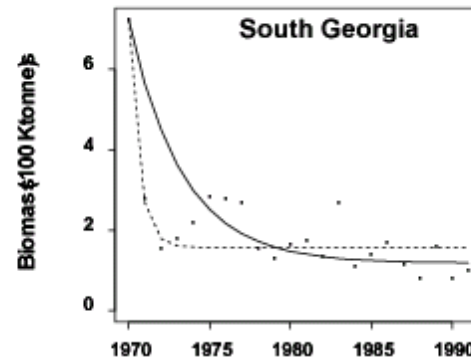
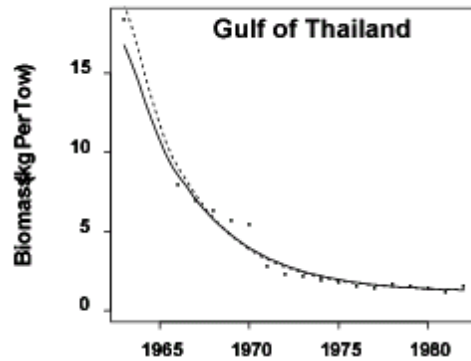


Common patterns of decline



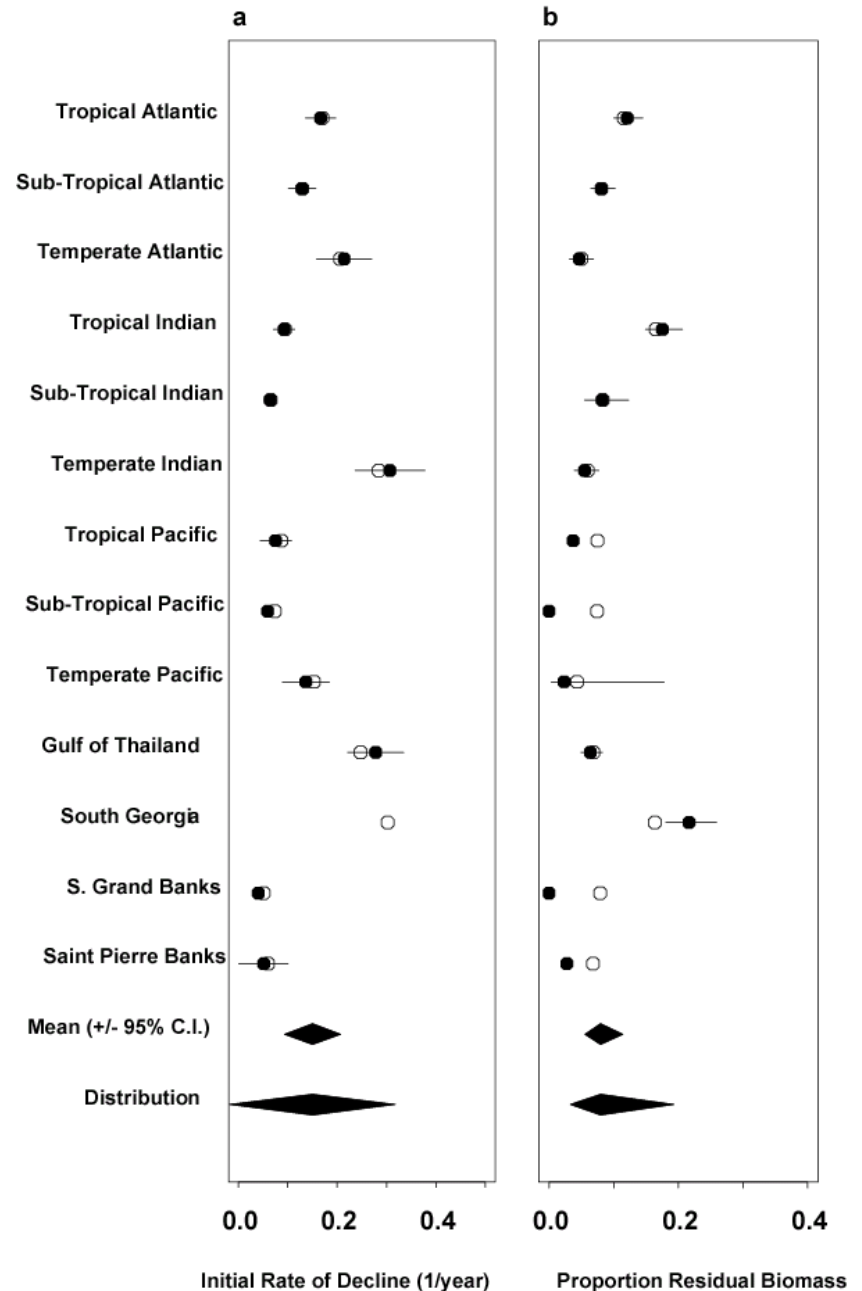
Source: Myers & Worm, 2003. Nature 423: 280-283

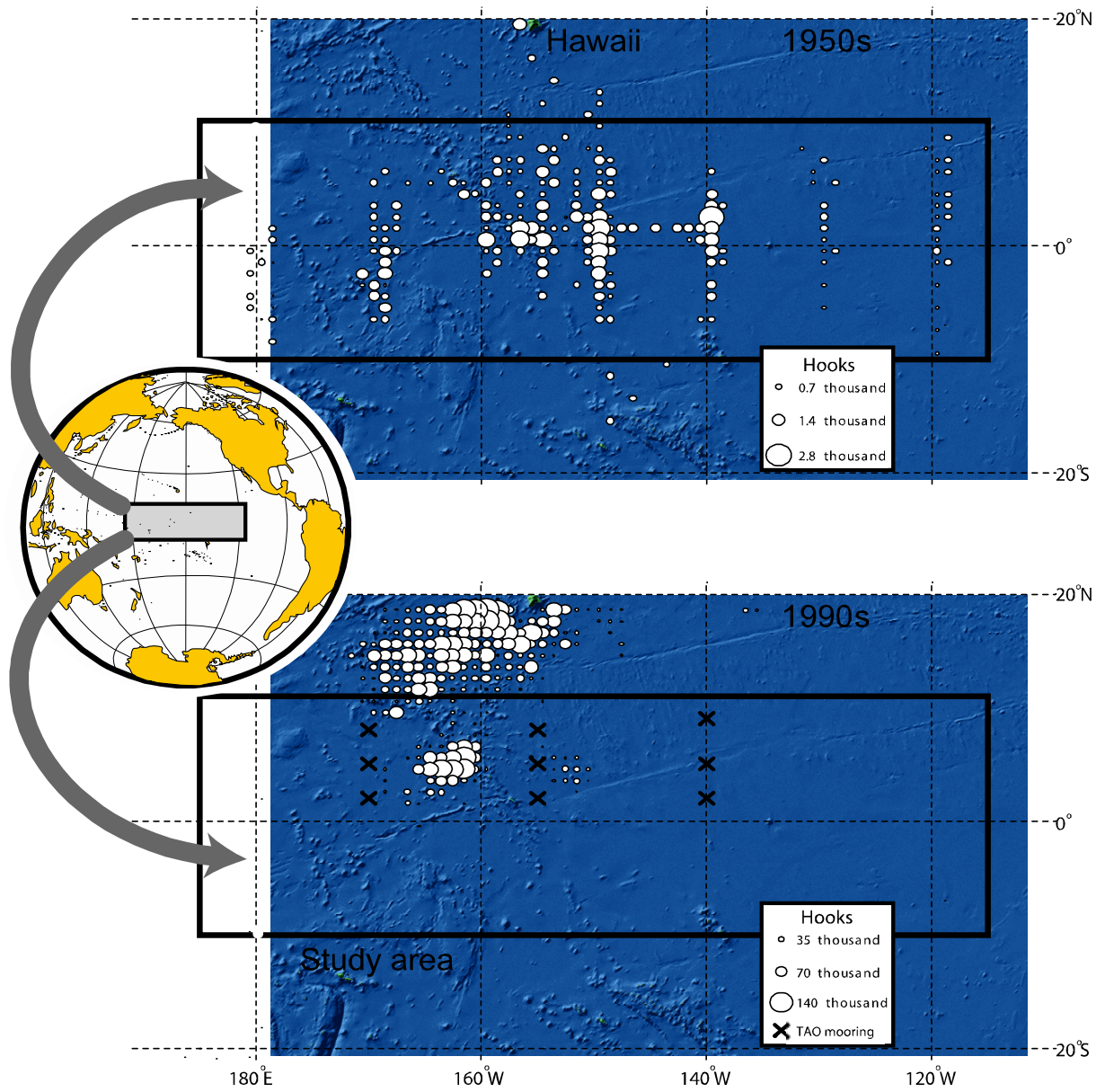
Shelf seas

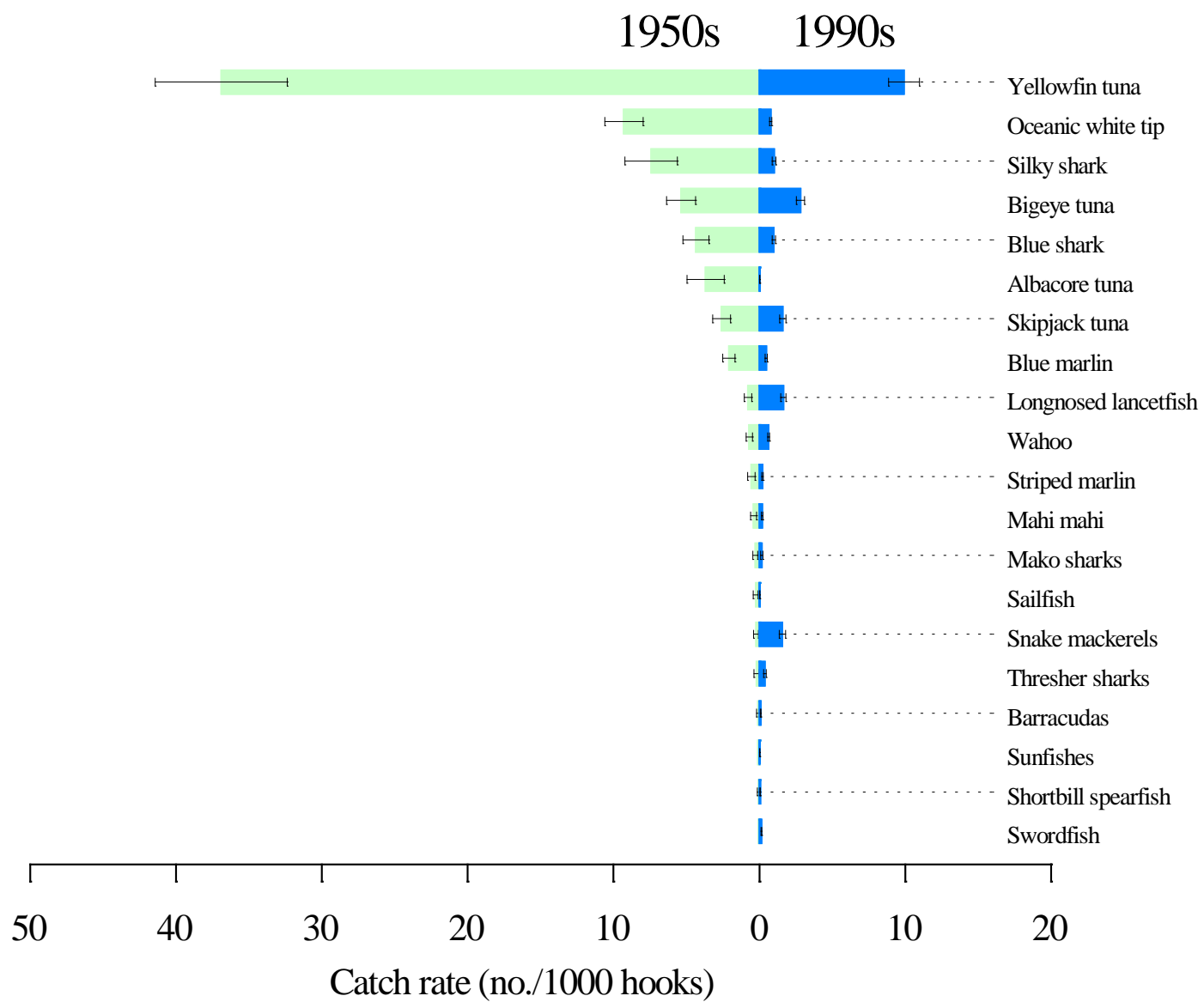


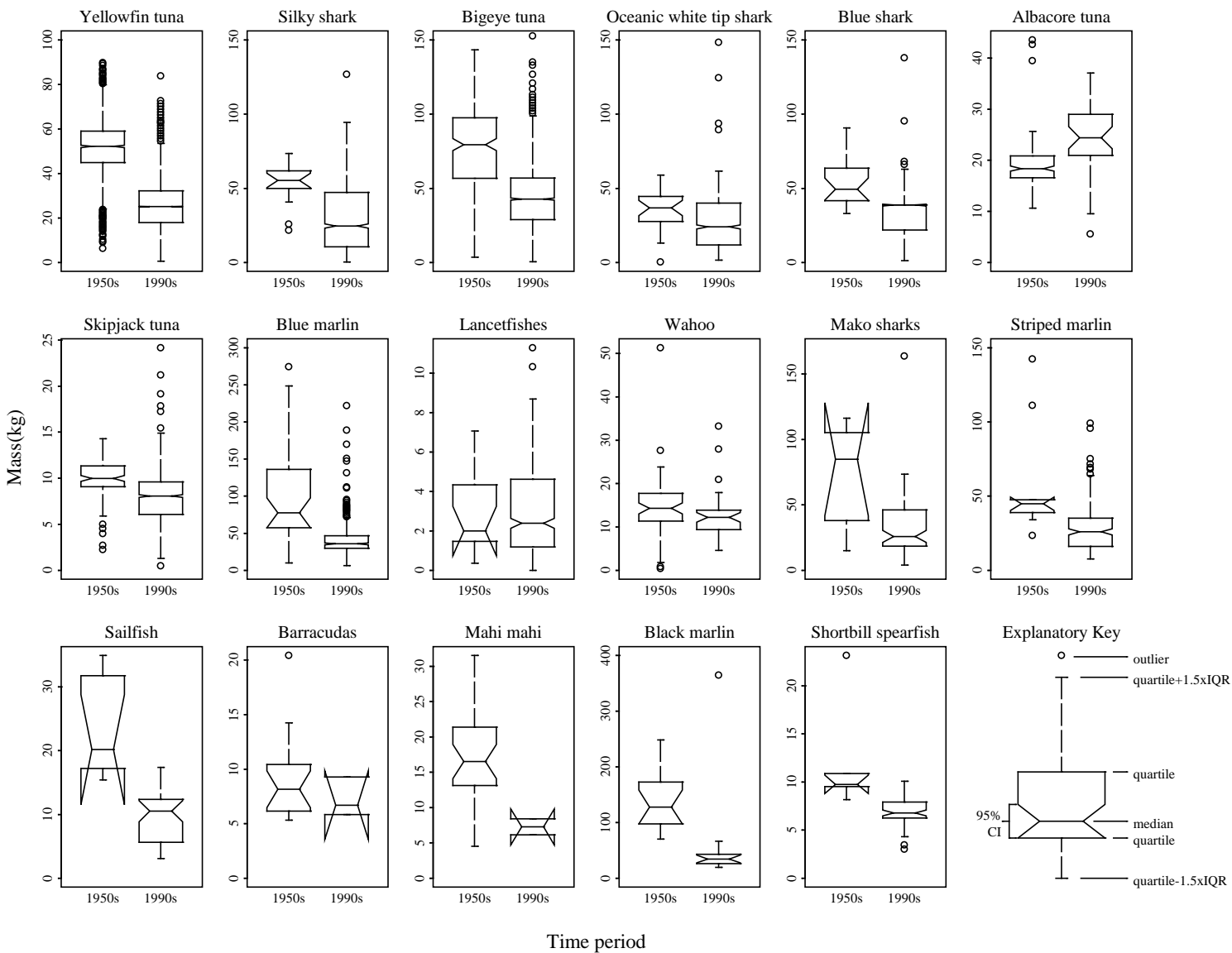
Meta-analysis

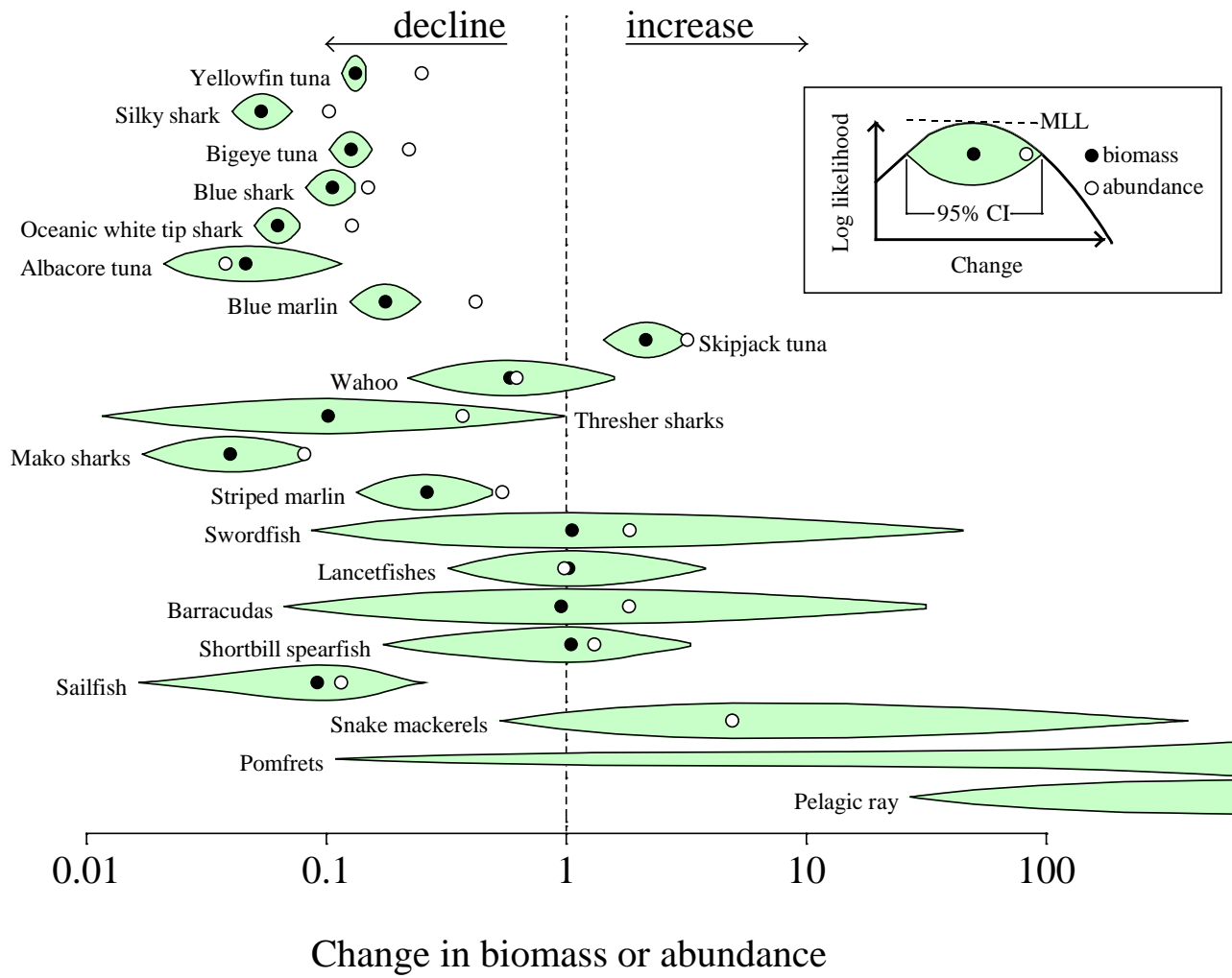
- Initial decline estimated as $14\% \text{ yr}^{-1}$ (95% CI: 9-19%)
- Residual biomass at 8% (95% CI: 6-11 CI) of virgin levels.











Yellowfin tuna

Silky shark

Bigeye tuna

Blue shark

Oceanic white tip shark

Albacore tuna

Blue marlin

Skipjack tuna

Wahoo

Thresher sharks

Mako sharks

Striped marlin

Swordfish

Lancetfishes

Barracudas

Shortbill spearfish

Sailfish

Snake mackerels

Pomfrets

Pelagic ray

0.01

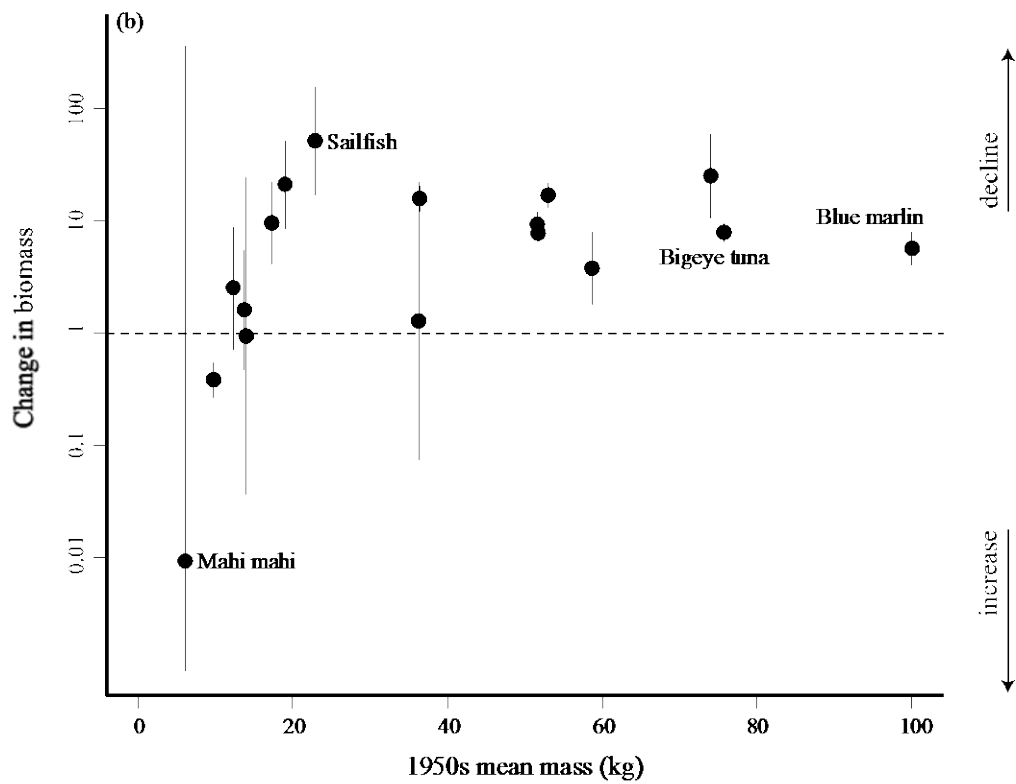
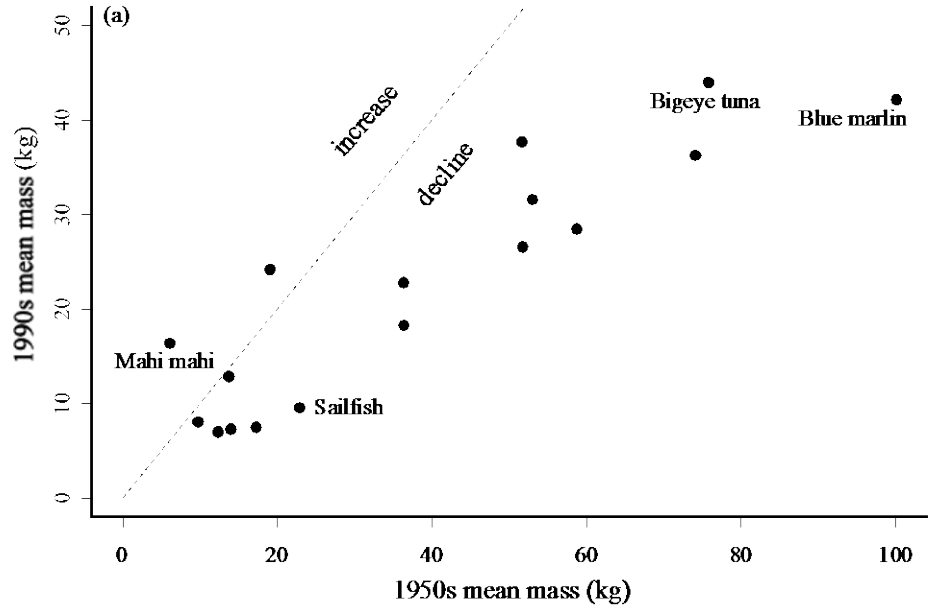
0.1

1

10

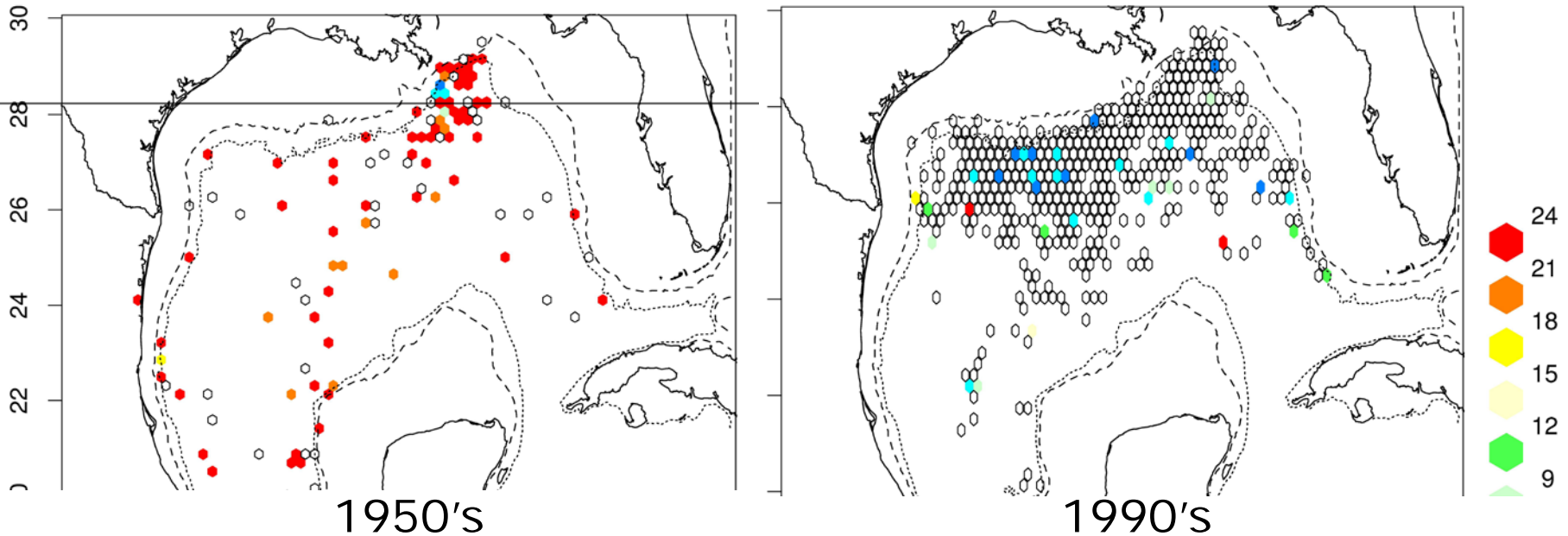
100

Change in biomass or abundance



Loss of sharks in the Gulf of Mexico

300 fold decline – no one noticed



Oceanic Whitetip captures per 10,000 hooks

Many thanks to NMFS for data and advice

Did everything decline?

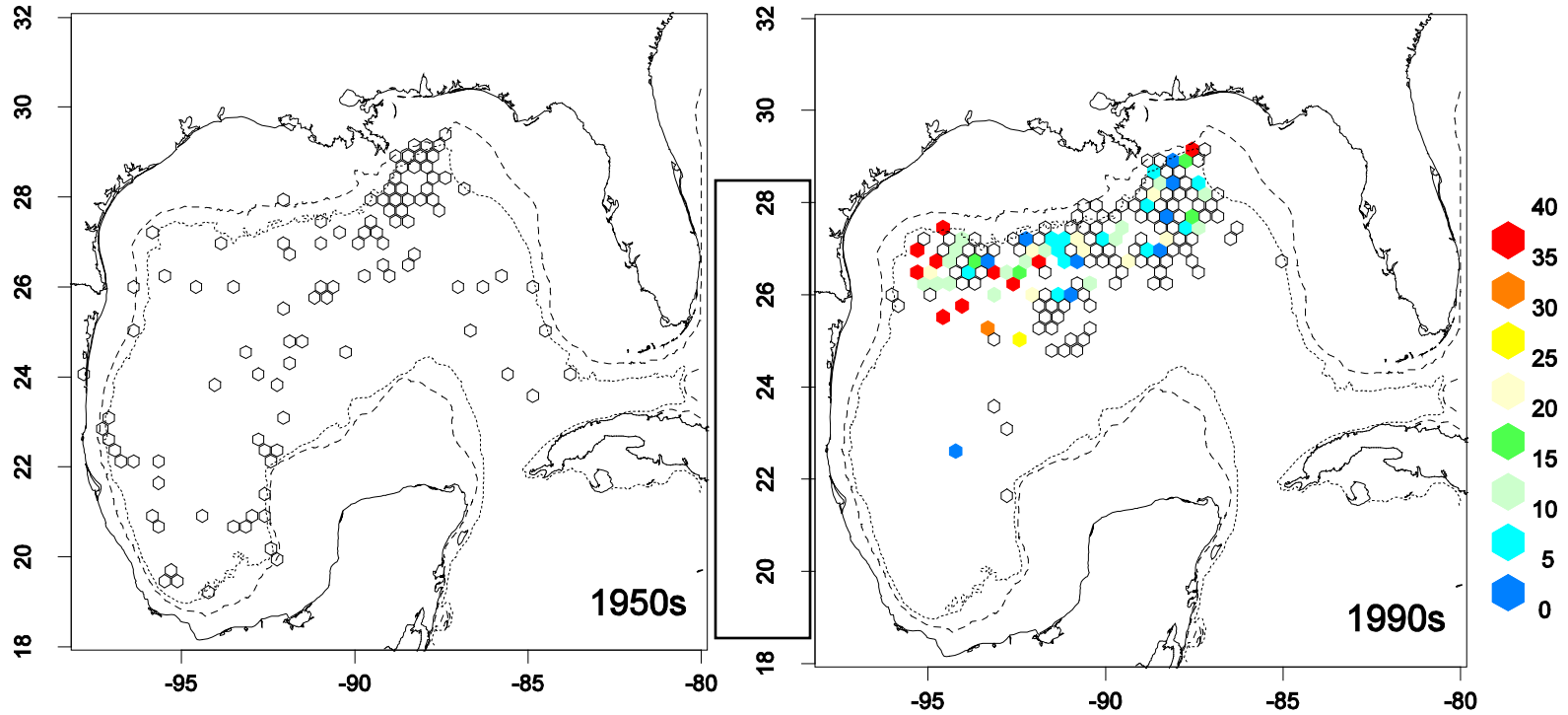


Pelagic Sting Ray
Pteroplatytrygon violacea



Photos from Phillip Colla, photography

Explosion of Pelagic Stingrays in the Gulf of Mexico ~ 1000 fold increase – no one noticed



1950's

1990's

Pelagic stingray captures per 10,000 hooks

What about prey fish?

Brama brama
Atlantic pomfret

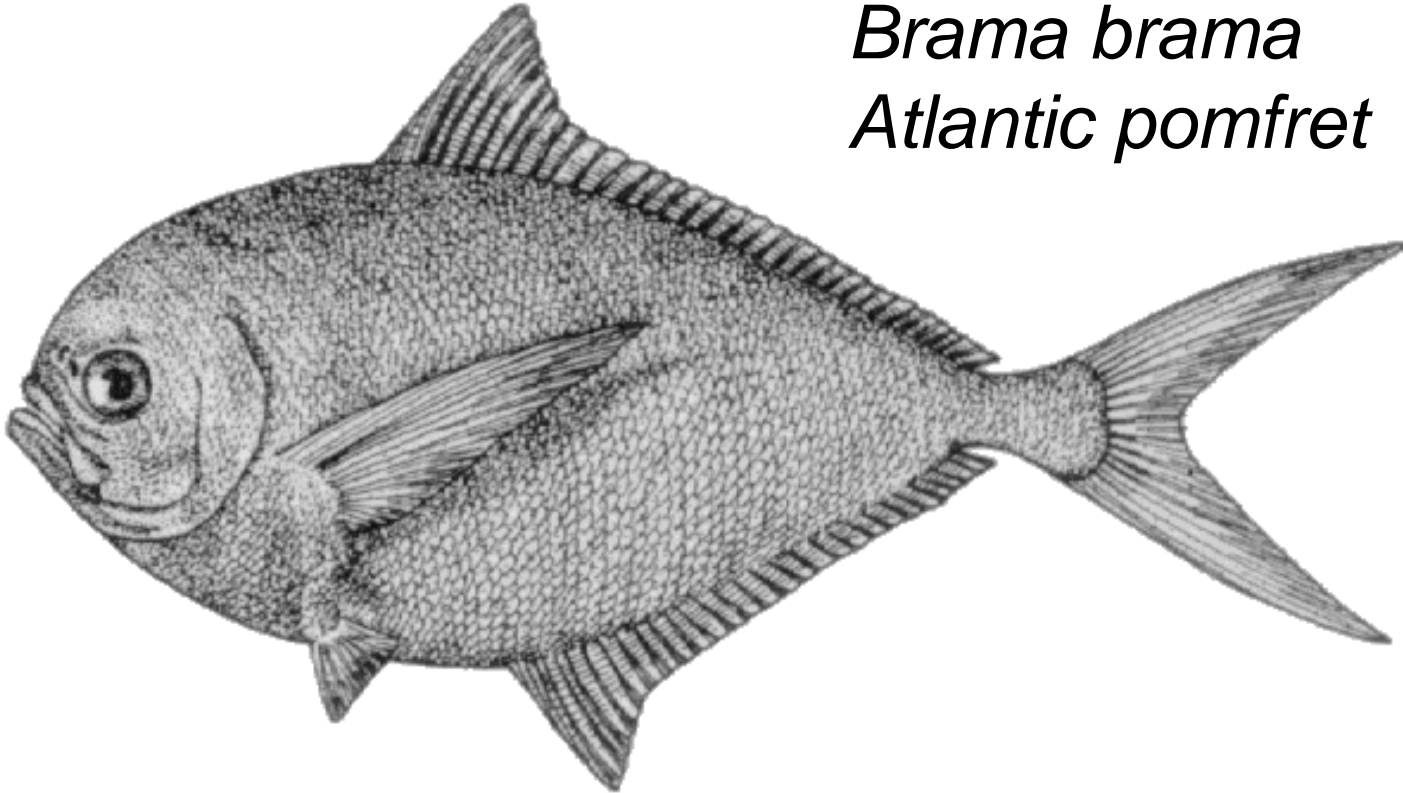
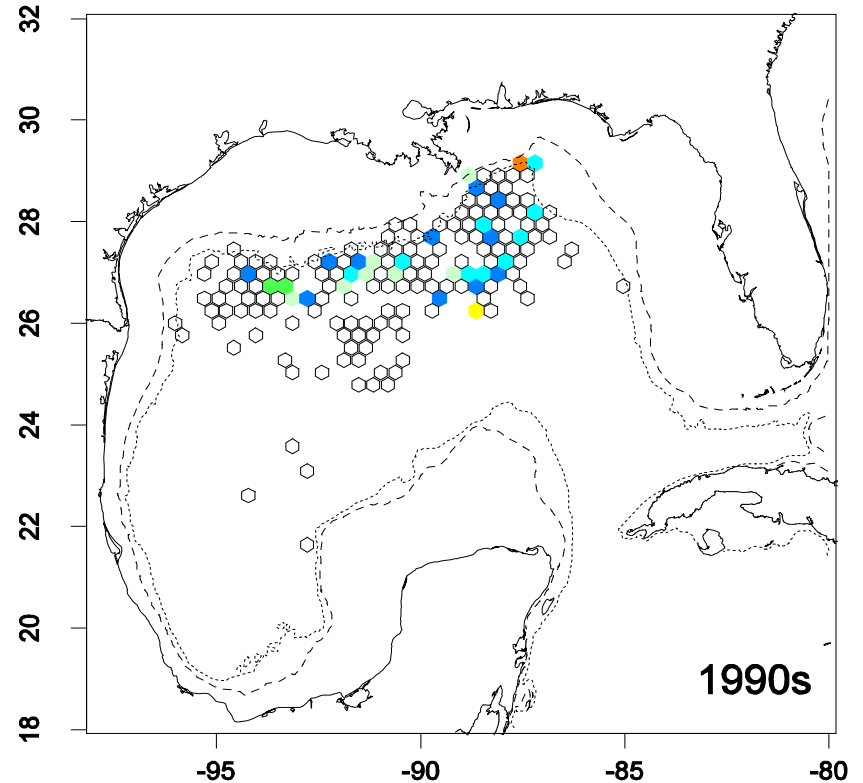
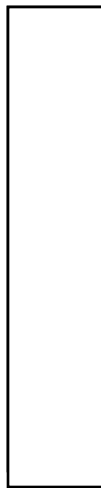
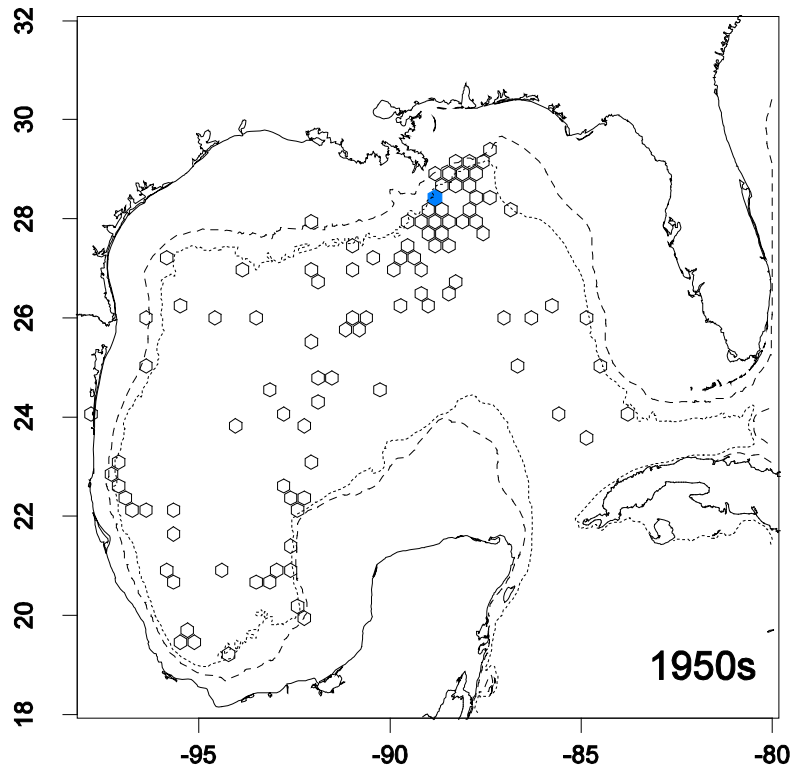


Illustration taken from the book "Encyclopedia of Canadian Fishes" by Brian W. Coad with Henry Waszczuk and Italo Labignan, 1995,

Explosion of Pomfrets in the Gulf of Mexico ~ 1000 fold increase – no one noticed



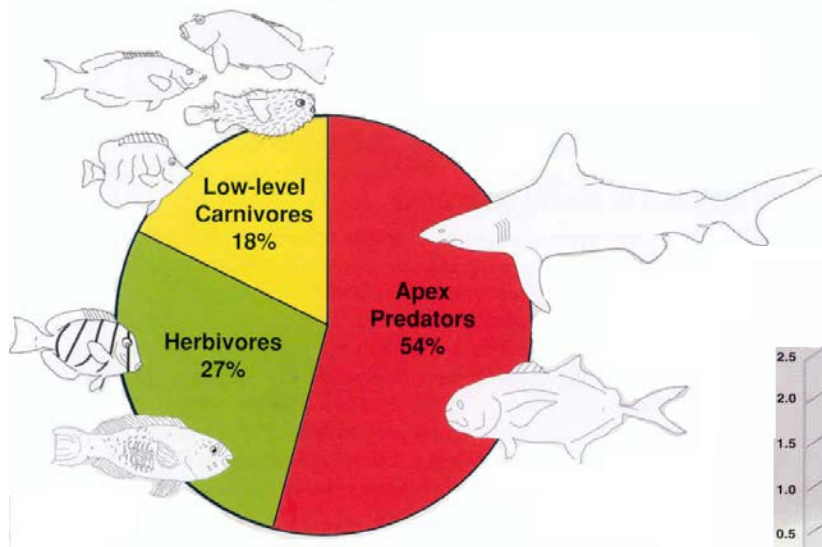
1950's

1990's

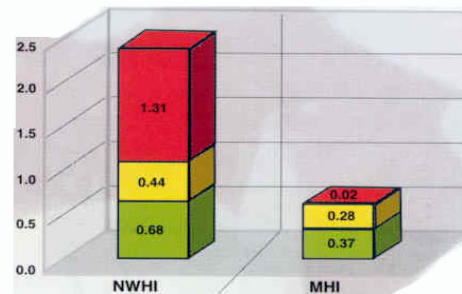
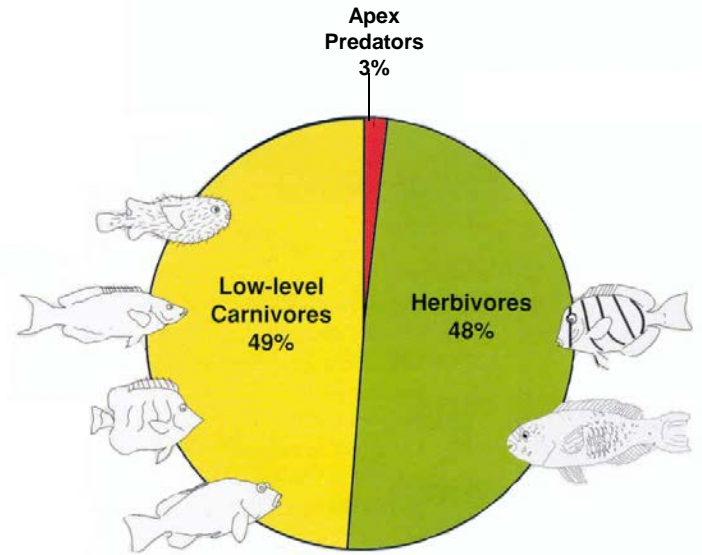
Pomfret captures per 10,000 hooks

Many thanks to NMFS for data and advice

NW Hawaiian Islands



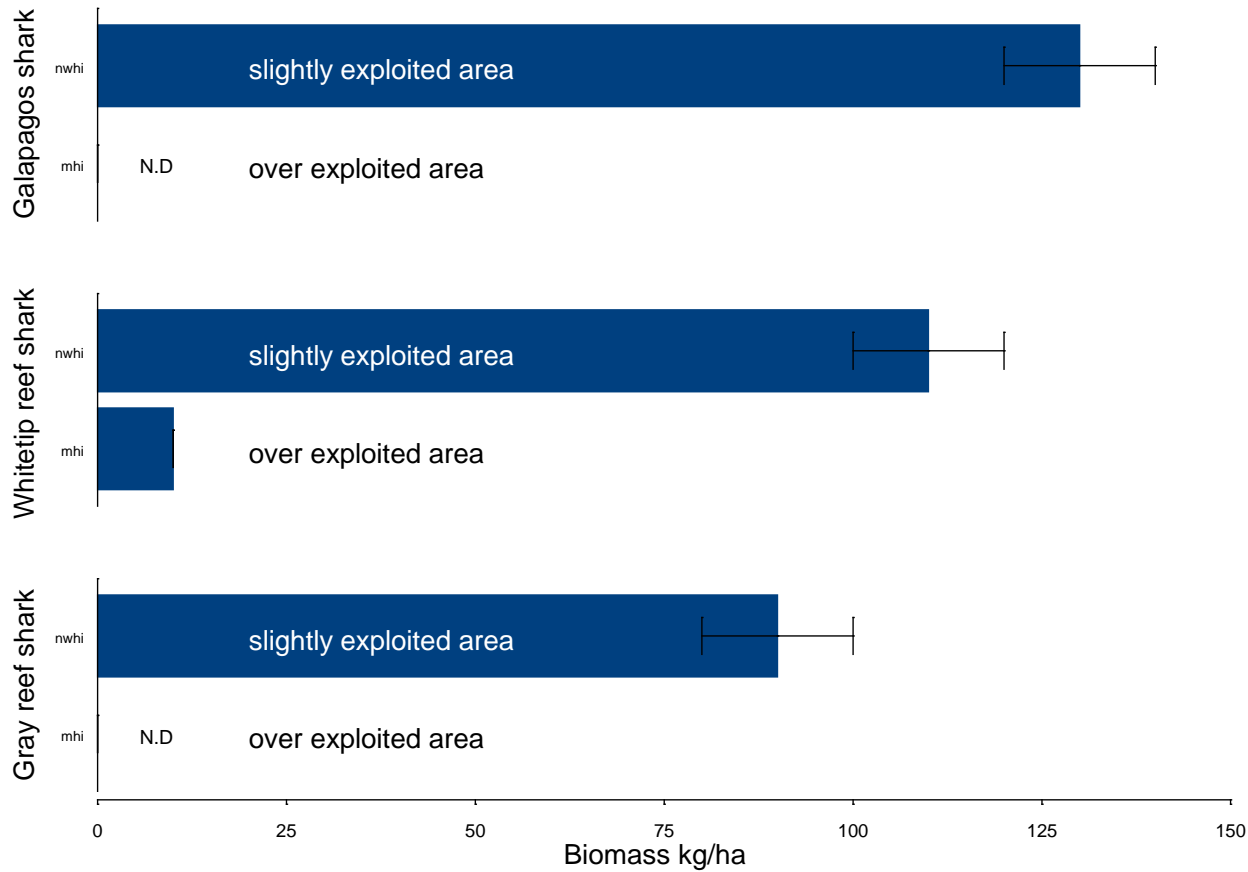
Main Hawaiian Islands



Comparative fish biomass (mT/ha)

Loss of Reef Sharks in the Hawaiian Islands

N.W.Hawaiian Islands vs Main Hawaiian Islands



Conclusion: The Factor of 10 Hypothesis

- Scientific investigations of marine fish stocks almost always begin after the fact.
- Here we compile data from which the size of the community of large predatory fishes can be estimated.
- New fisheries tend to deplete the biomass of large predators by at least a factor of 10 .
- These declines happen very rapidly, usually in a decade or less.

These estimates are conservative

- Weight of yellowfin and bigeye in catch is now half of the 1950's in the Pacific, for blue, black, and striped marlin the weight is now 1/4th.
- Shark damage caused underestimate by 30% of initial abundance.
- Fishermen are more efficient, e.g. satellite data increases catch rates by about 30%.
- Most areas were not “pristine”.
- Sharks probably declined more than tuna and billfish.
- So many fish were caught hooks were “full”.

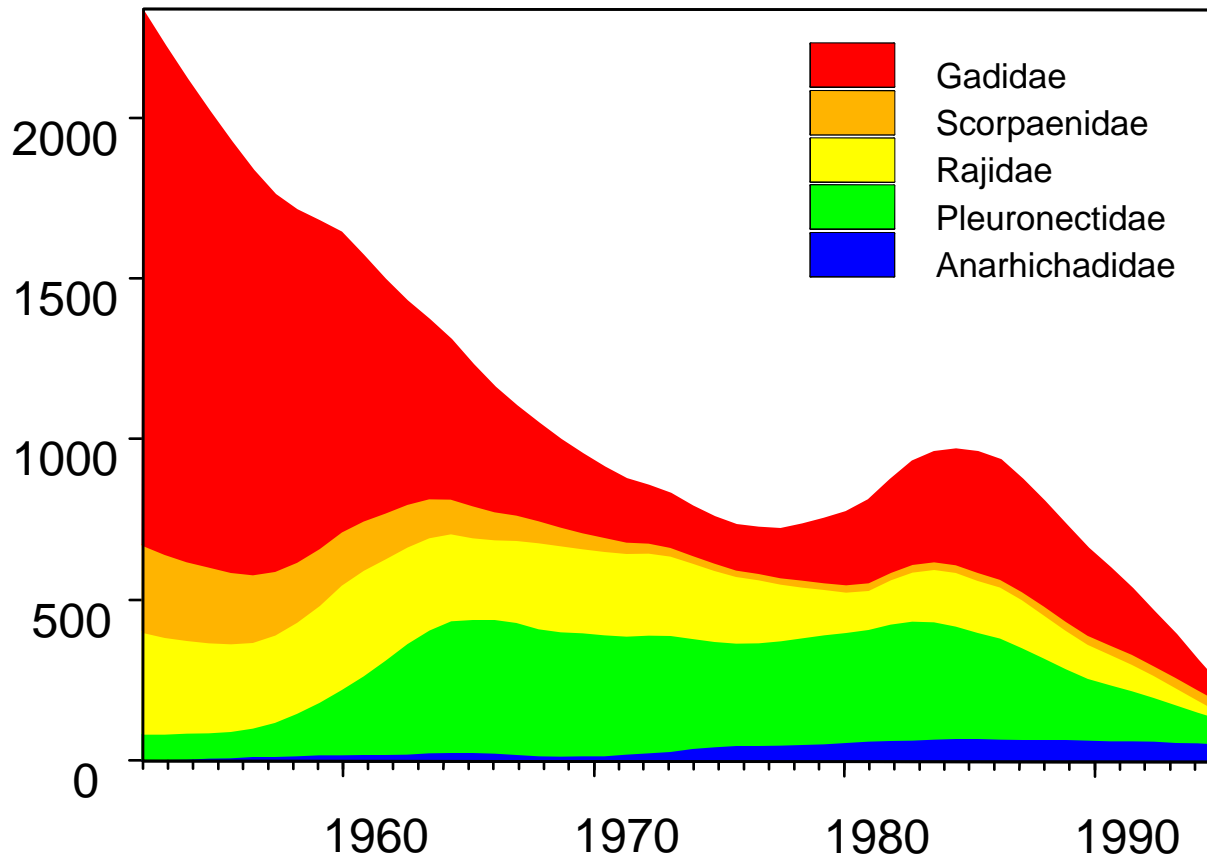
Other approaches

- Pelagic longline surveys (I will return to this).
- Simon Jenning's size based models – present biomass of fish over 2Kg is 1/60th of virgin in the North Sea.
- D. Pauly's ecopath models – factor of 10 change in North Atlantic.
- Spawner recruit models from assessments – factor of 10 changes in well studied, overexploited shelf.
- Comparative surveys on coral reef systems show that 1.5% are left in Hawaii.

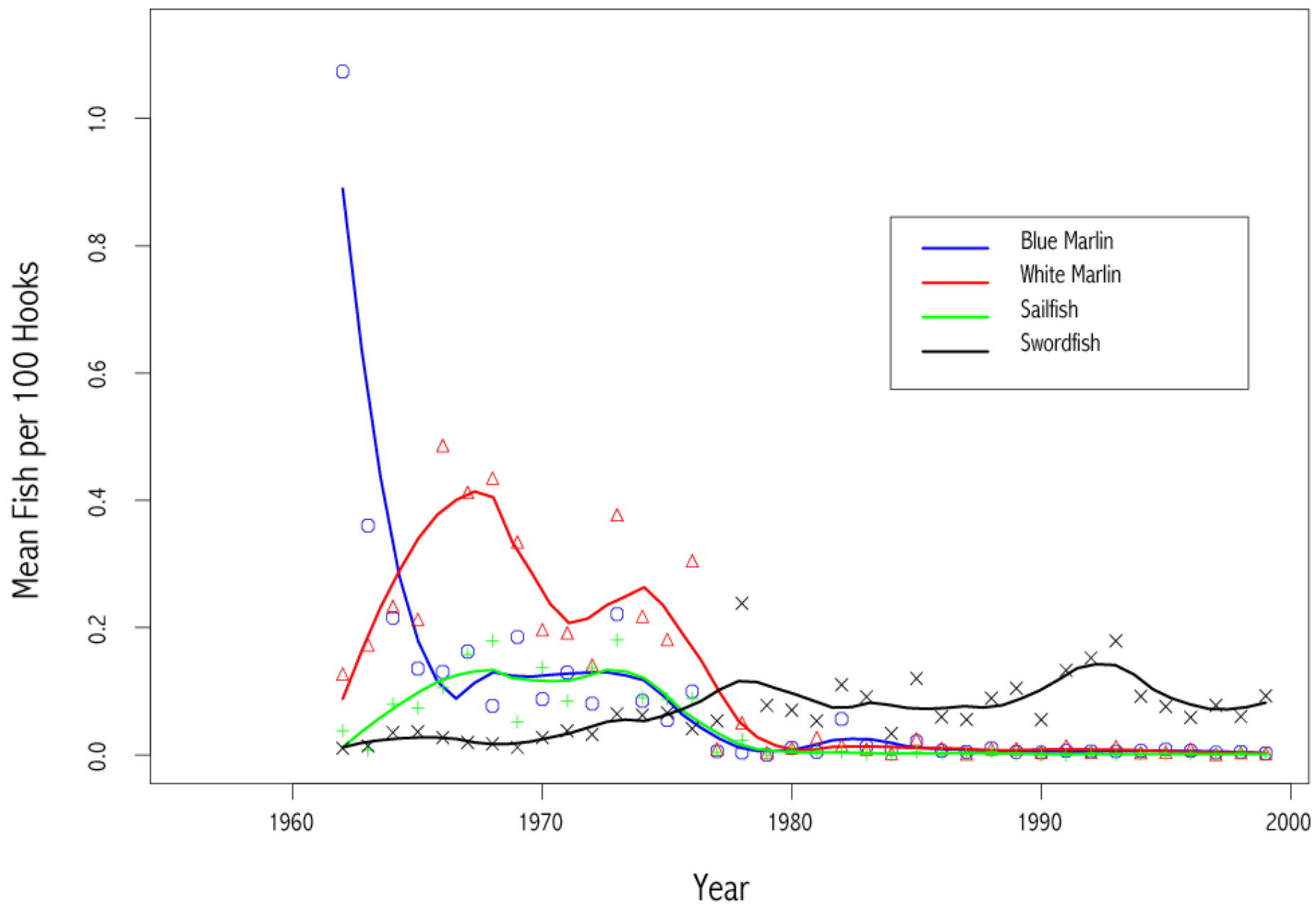
Question 1

- Compensation through changes in species composition?
 - Gadoids versus flatfishes on Grand Banks
 - Blue marlin versus sailfish, white marlin, swordfish in open ocean

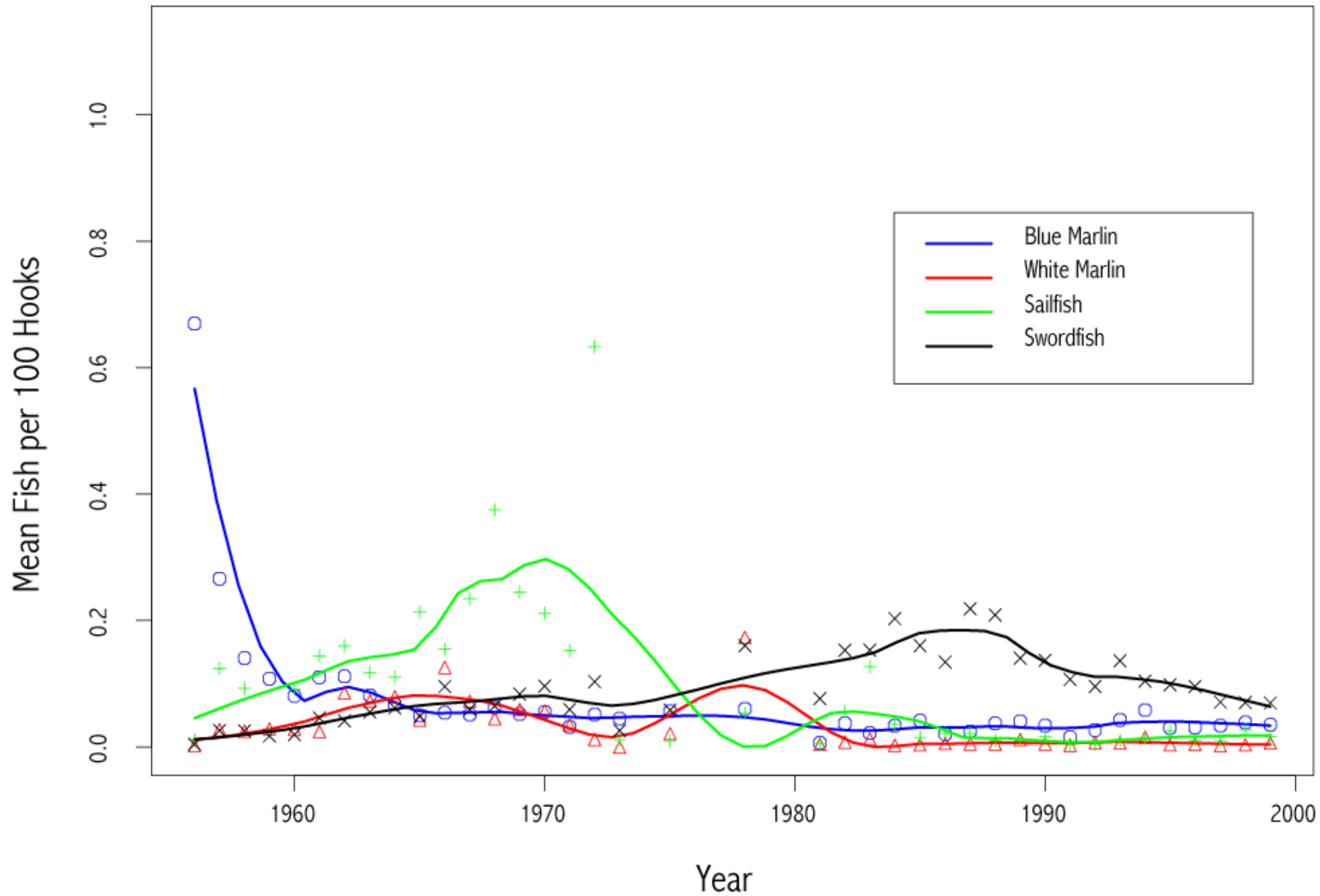
Community Changes on Southern Grand Banks



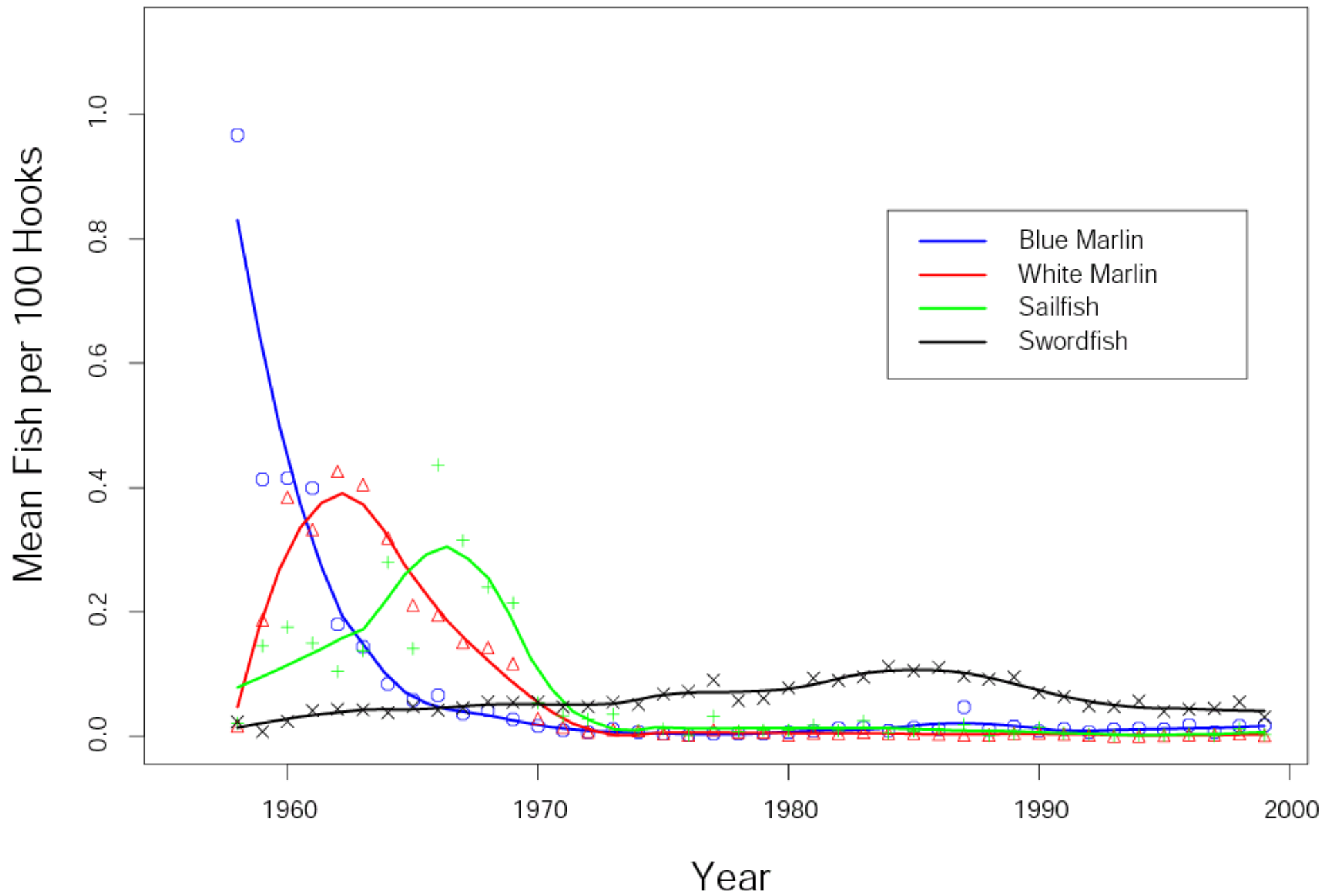
Atlantic, Latitude = 20 to 25



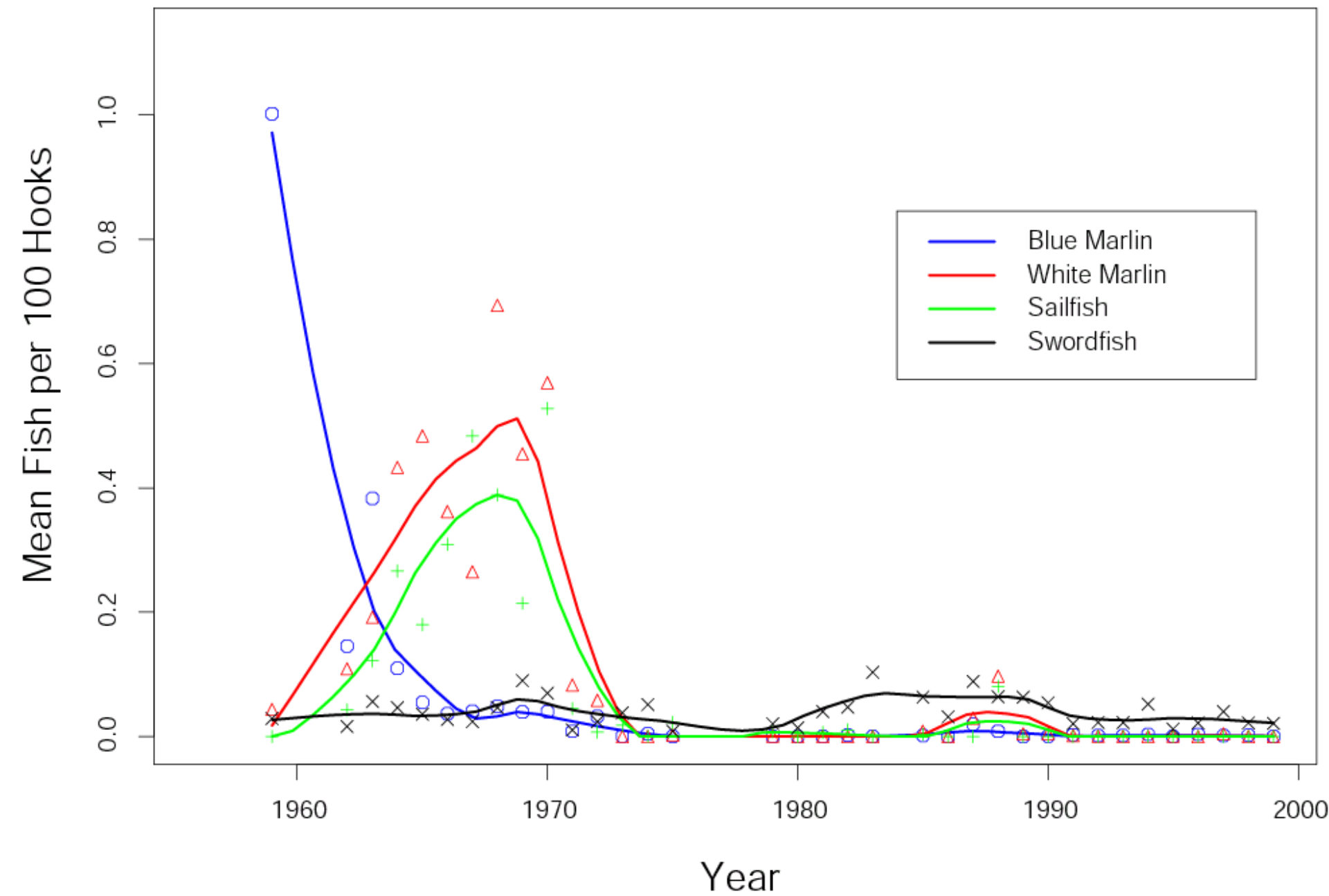
Atlantic, Latitude = 0 to 5



Atlantic, Latitude = -15 to -10



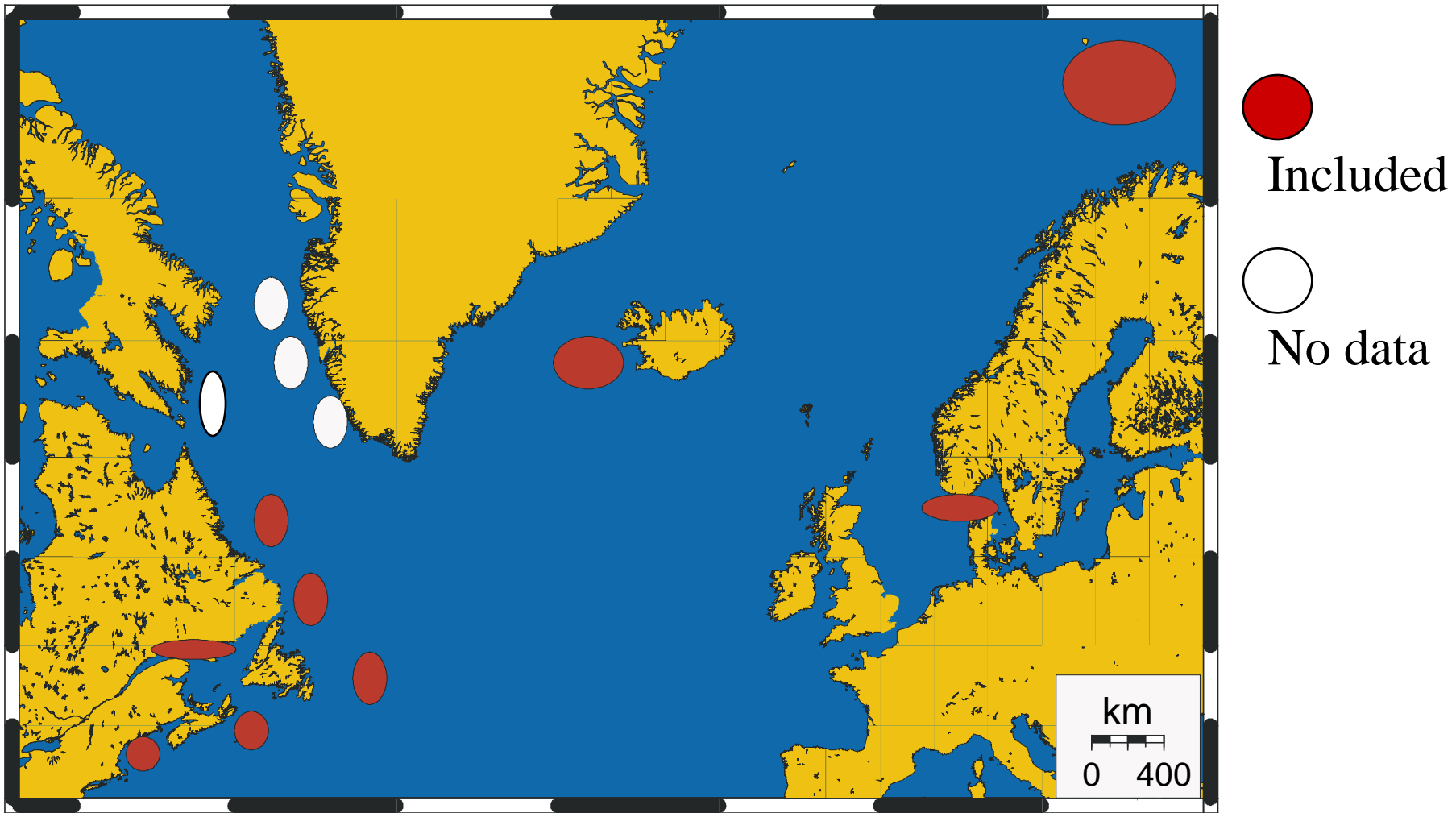
Atlantic, Latitude = -25 to -20



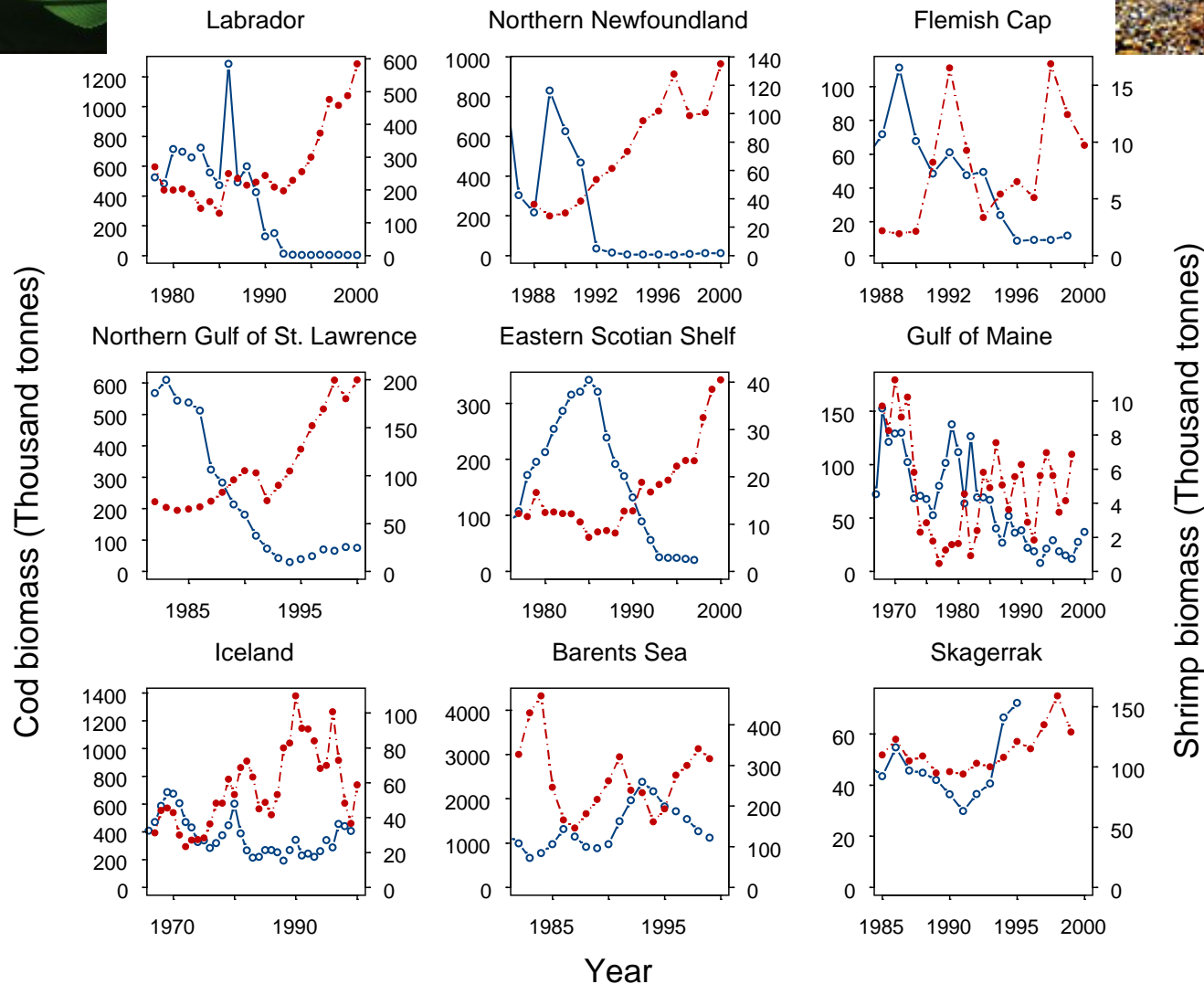
Question 2

- What are the fundamental changes in a community that occur after the apex predators are removed?
- Have lower trophic levels responded? Consistent with hypothesized top-down effects

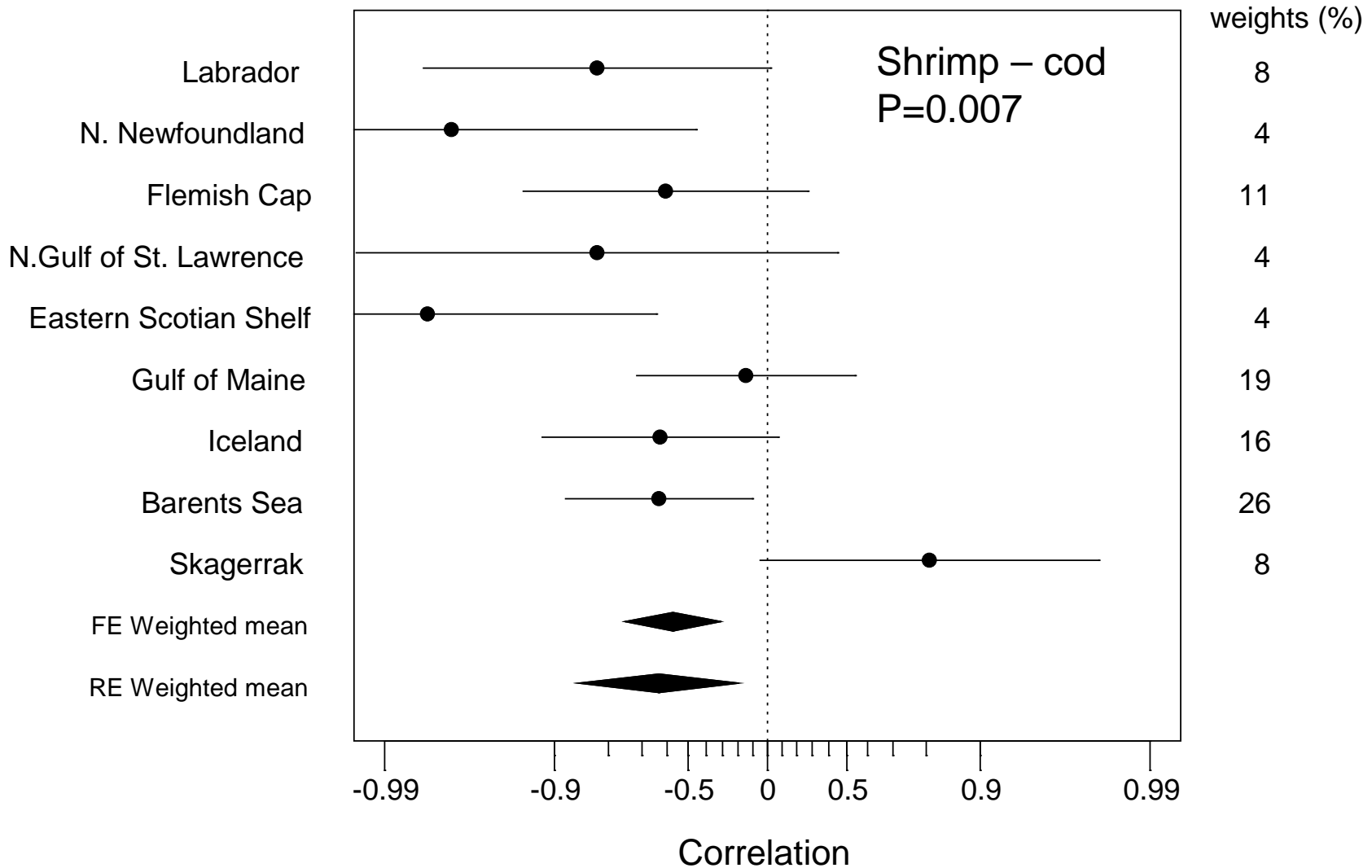
Major shrimp stocks in the North Atlantic



Cod and shrimp biomass in the North Atlantic: time series



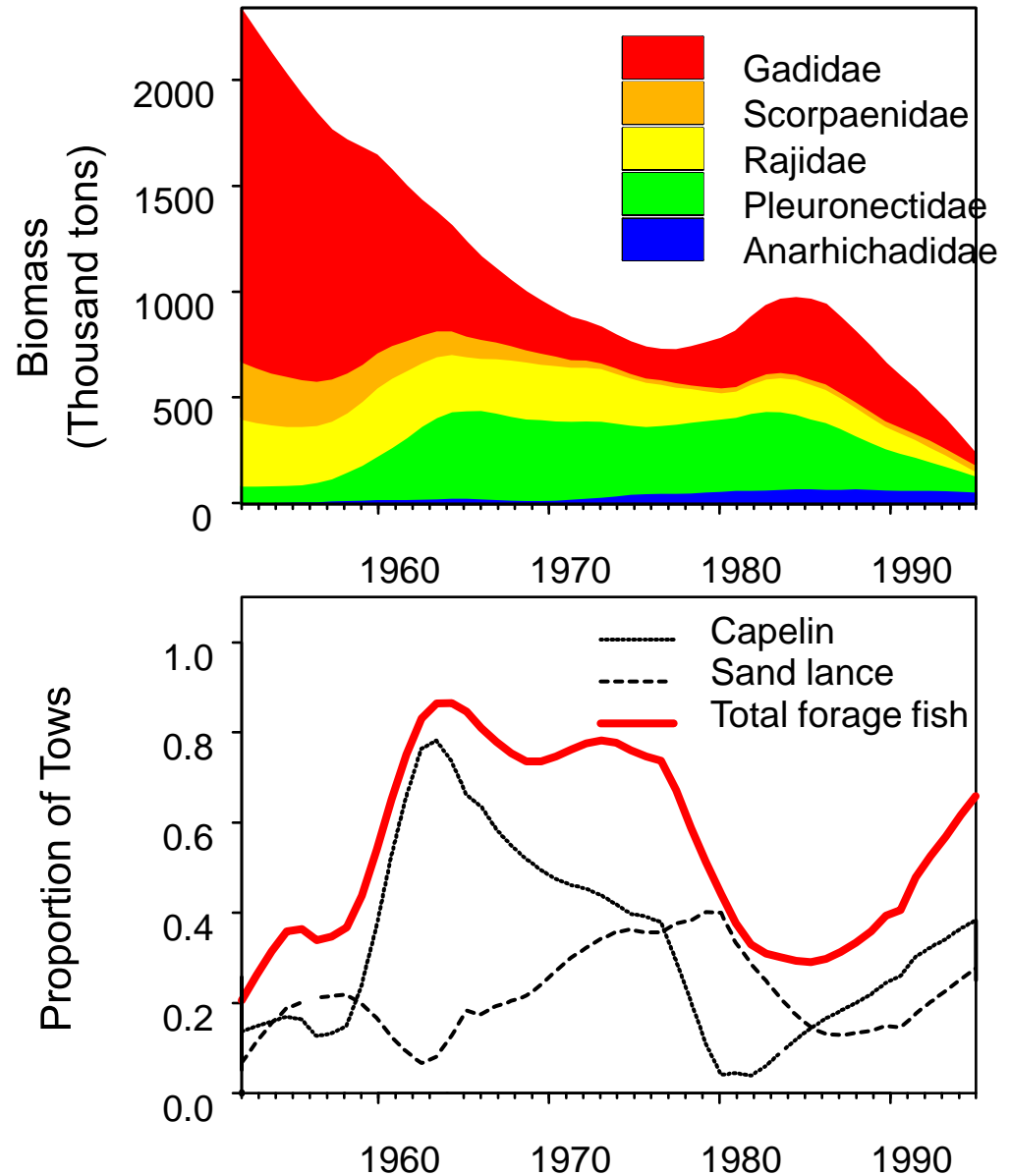
Step 2: Random-effects meta-analysis



Grand Banks forage fish

- Groundfish and small forage fish biomass are inversely correlated

Source: Casey 2000



Summary

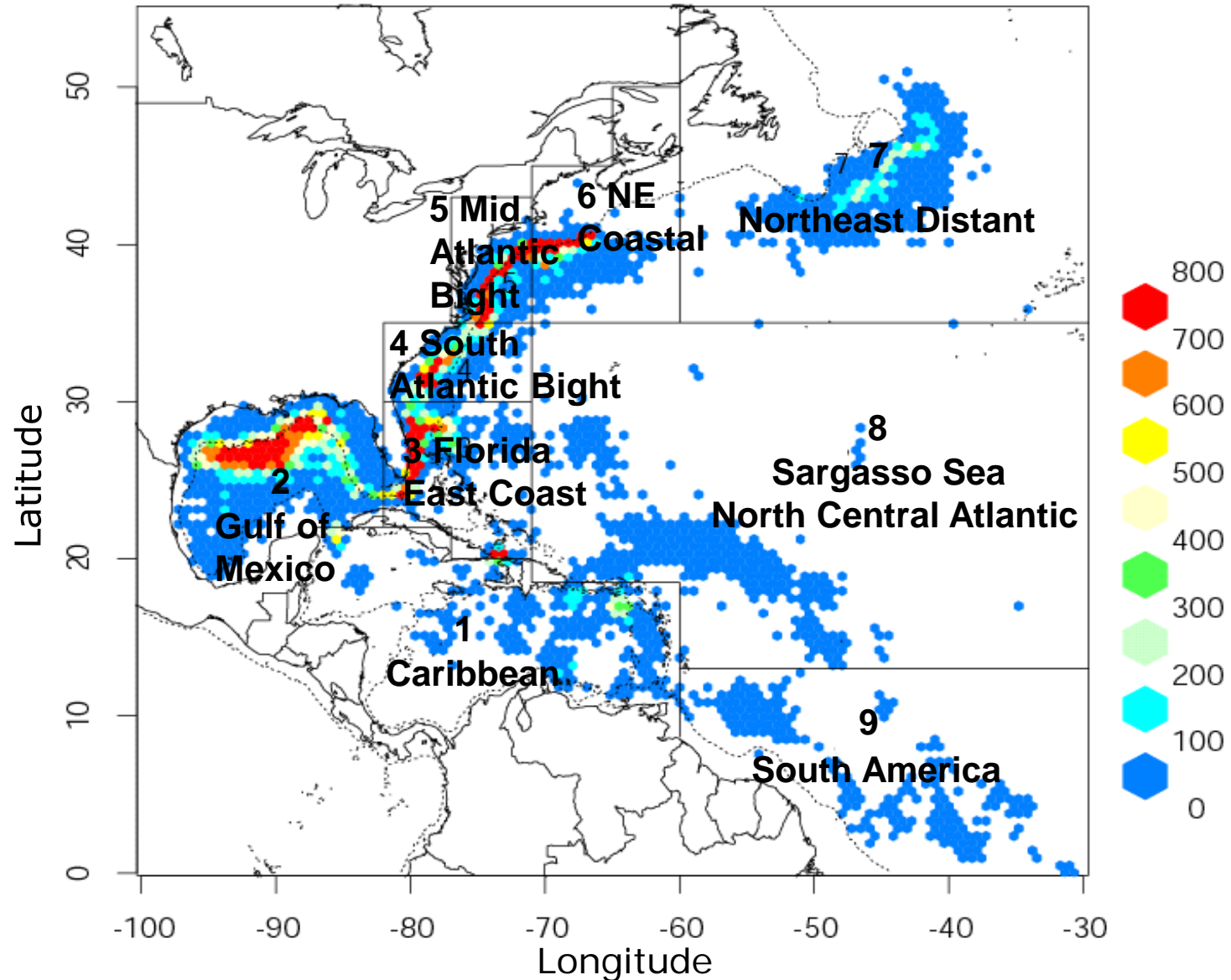
- The majority of large biomass declines on shelves and open oceans may have gone unnoticed.
- With the exception of the deep sea, large predatory fish biomass is at historic lows.
- Compensation occurs in some instances but is reversed by changes in targeting
- Lower trophic levels are on the rise but become targeted as well
- Communities must be understood and managed in a multispecies context

Collapse and Conservation of Shark Populations in the Northwest Atlantic



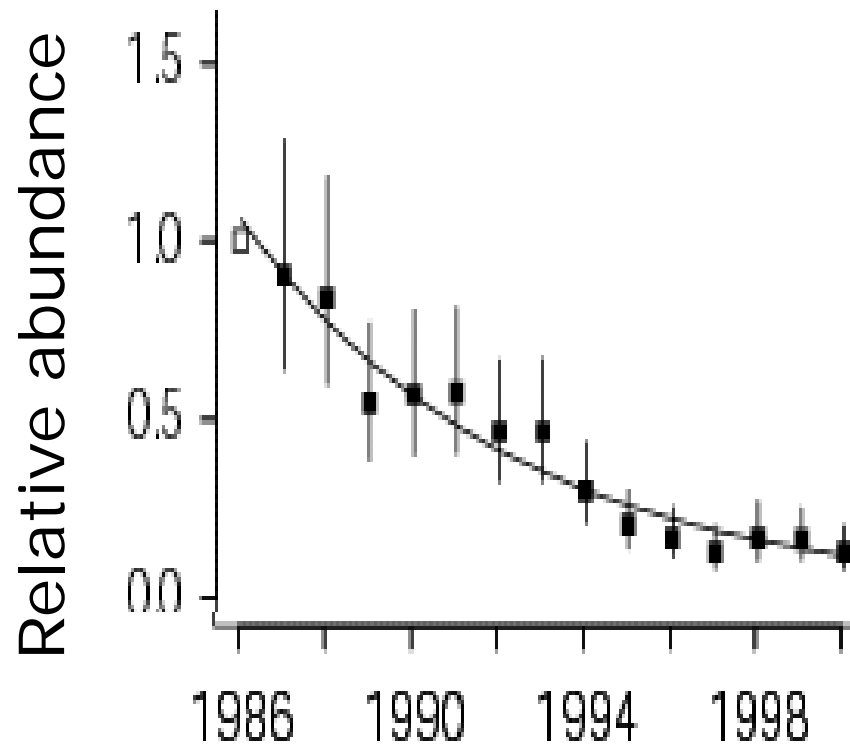
Science. Jan. 2003. J.K. Baum, R.A. Myers, D.G. Kehler, B. Worm, S.J. Harley, P.A. Doherty

U.S. Atlantic pelagic longline sets 1986-2000



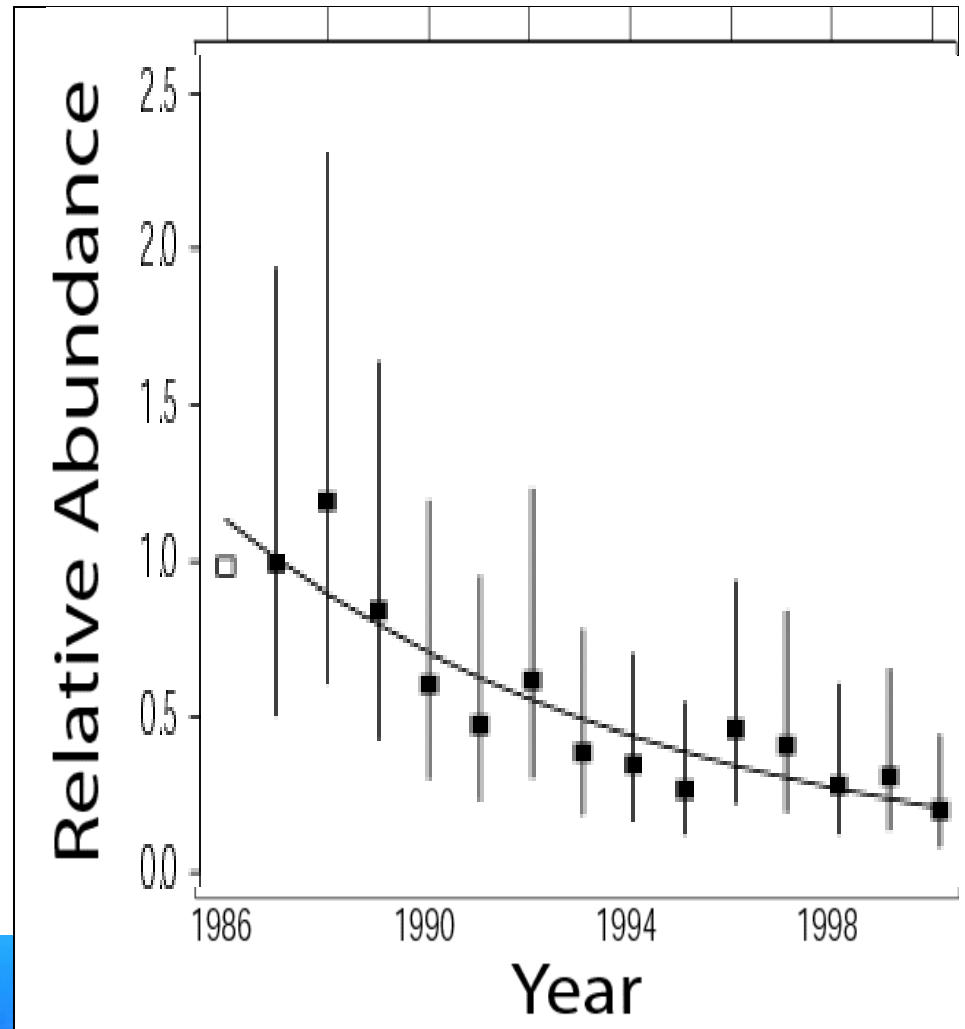
Hammerhead sharks

Sphyrna lewini



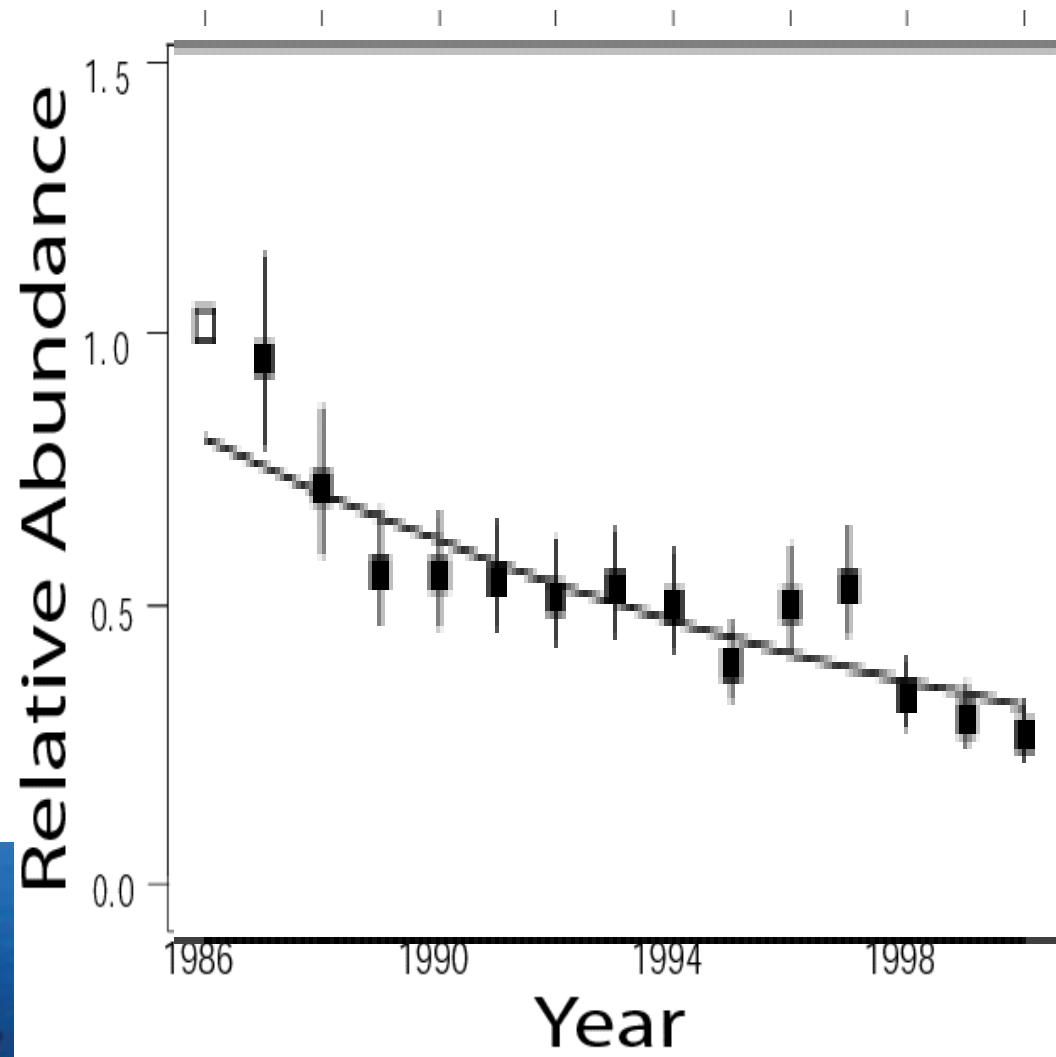
Thresher sharks

Alopias spp.

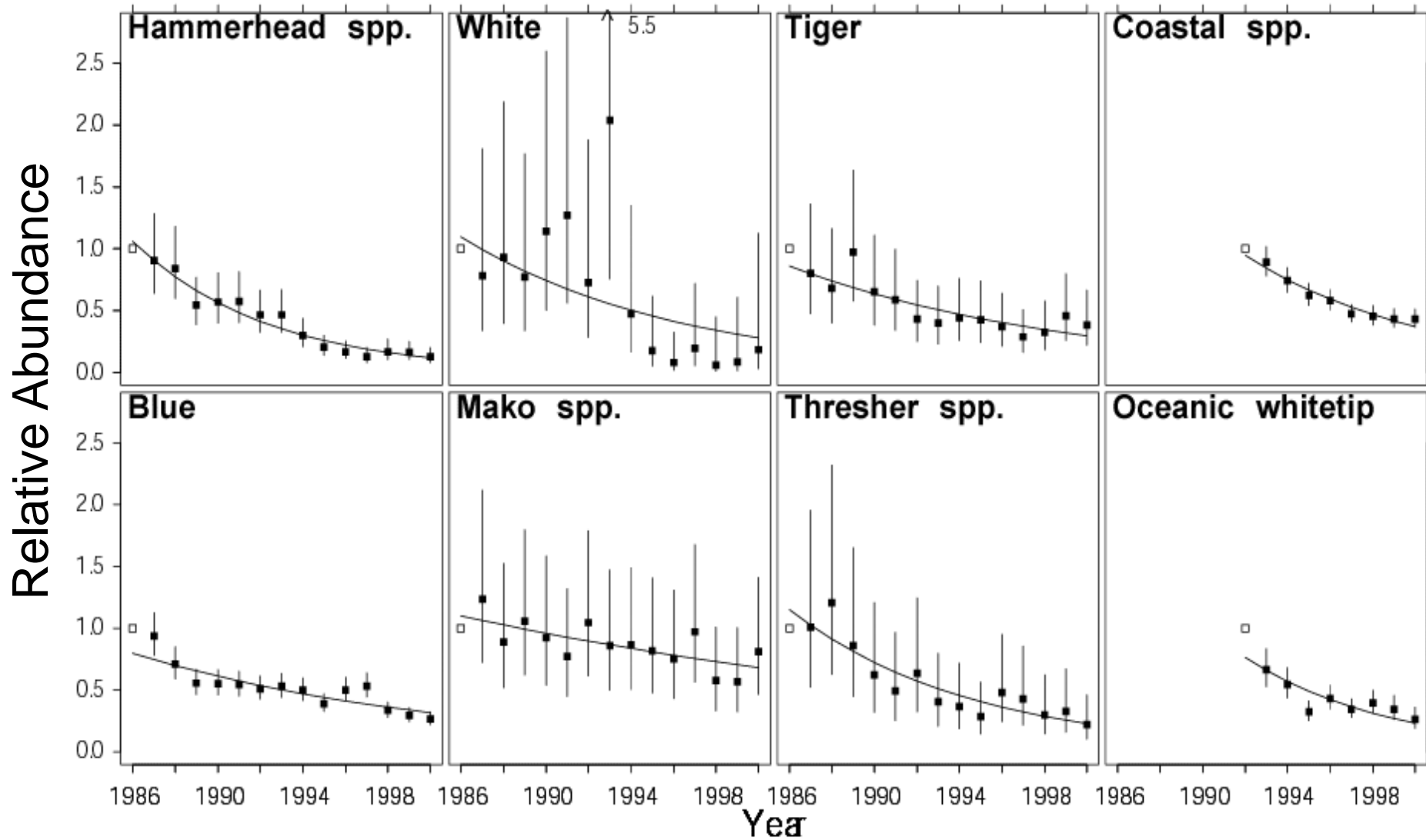


Blue sharks

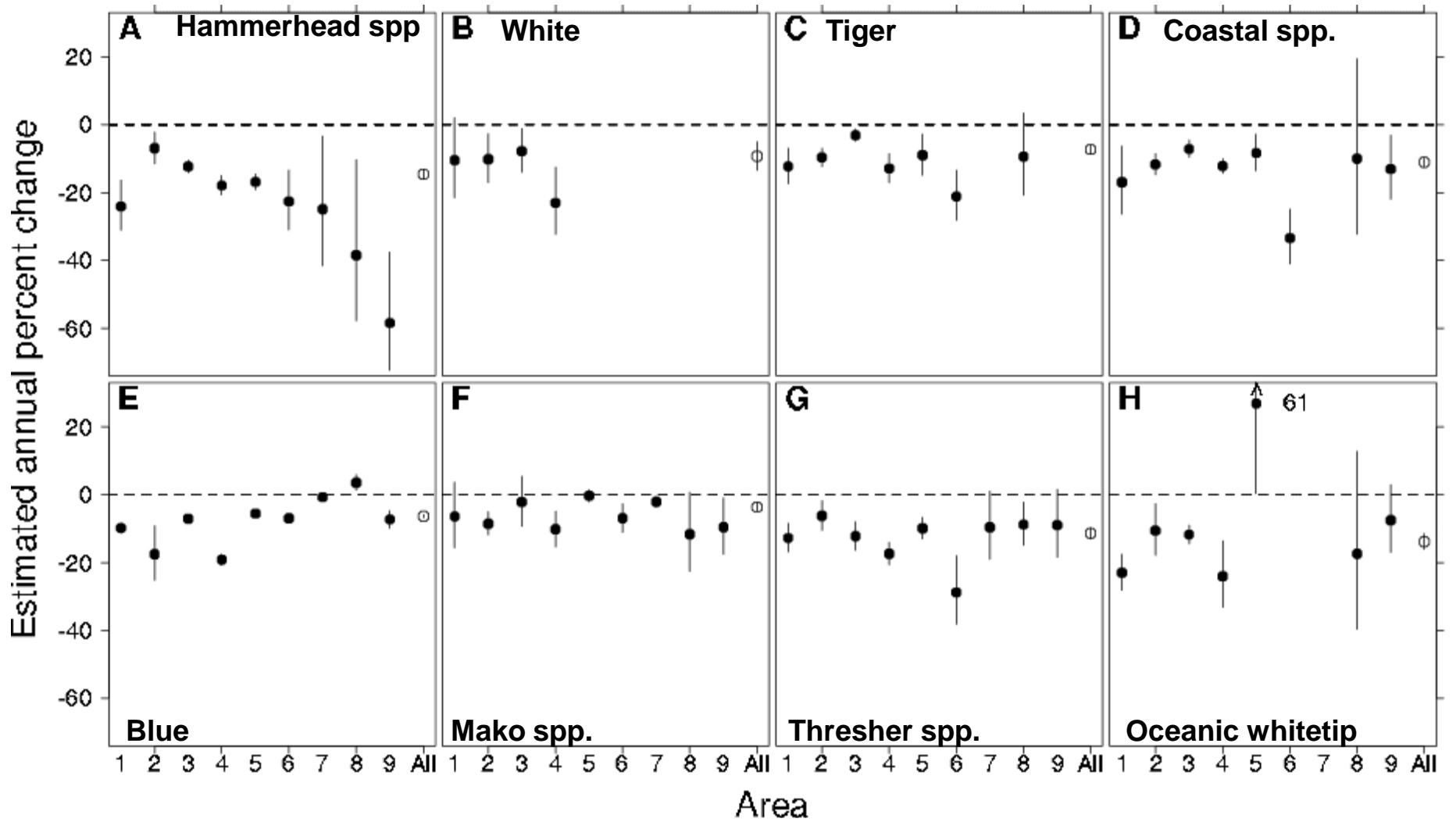
Prionace glauca



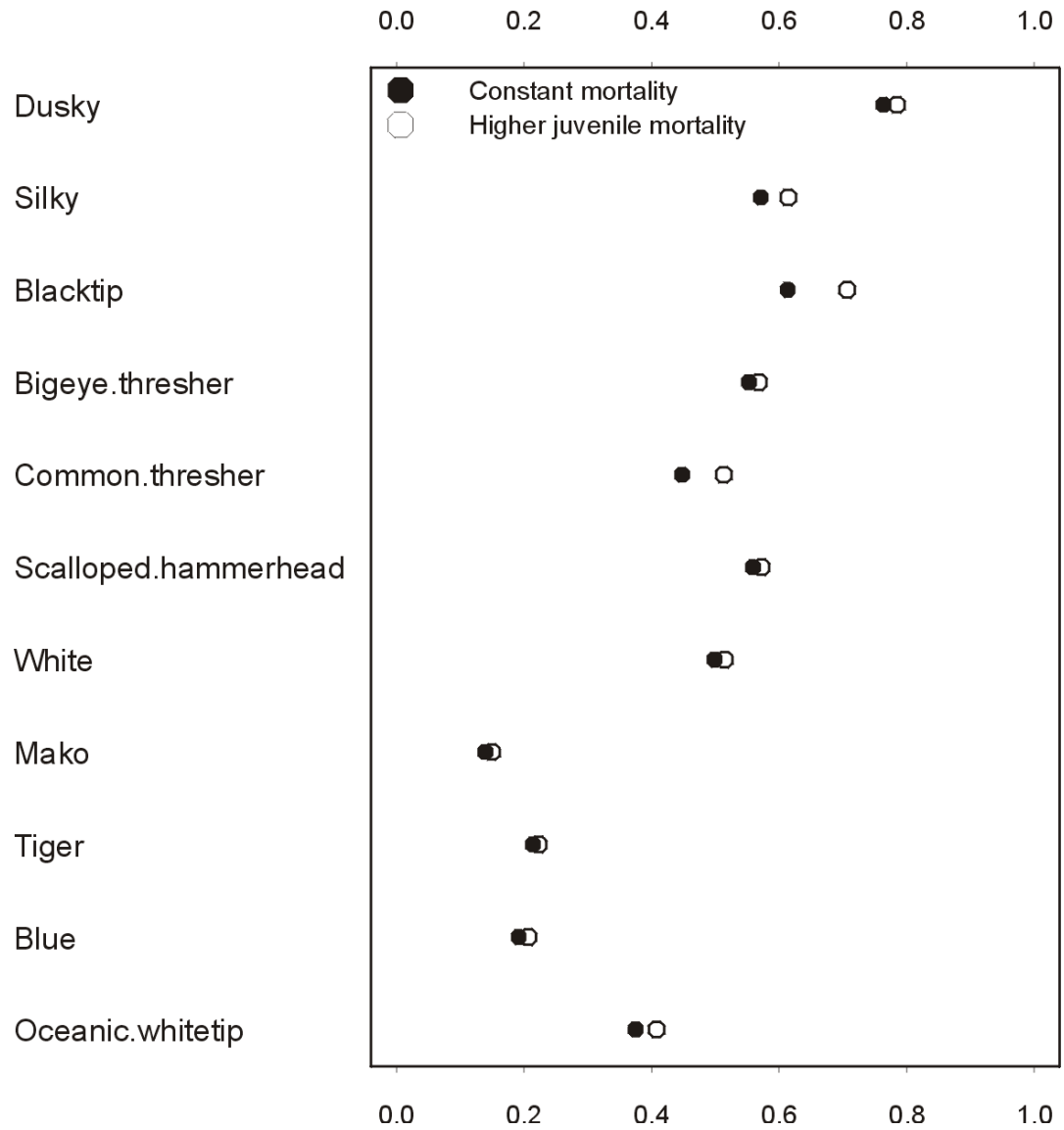
Results



- 1 Caribbean
- 2 Gulf of Mexico
- 3 Florida
- 4 S Atlantic Bight
- 5 Mid Atlantic Bight
- 6 NE Coastal
- 7 NE Distant
- 8 Sargasso
- 9 S America



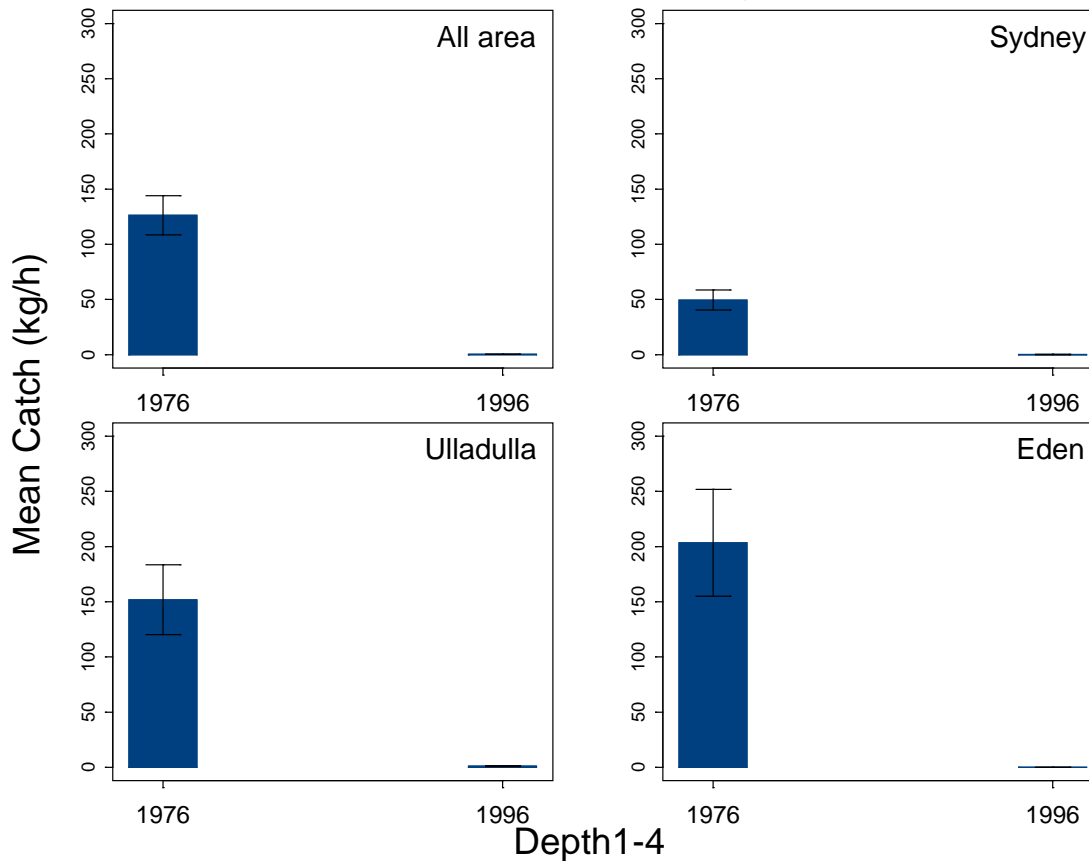
Proportional reduction in current fishing mortality needed to ensure survival of shark populations





Harrissons and Southern dogsharks in 1977 amounted at 18.5% of total biomass in surveys off New South Wales.

Harrissons & Southern dogsharks



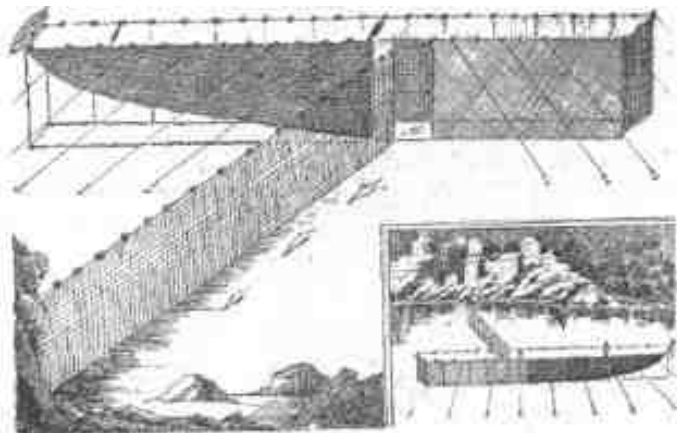
30 years later they declined by a factor of about 300.



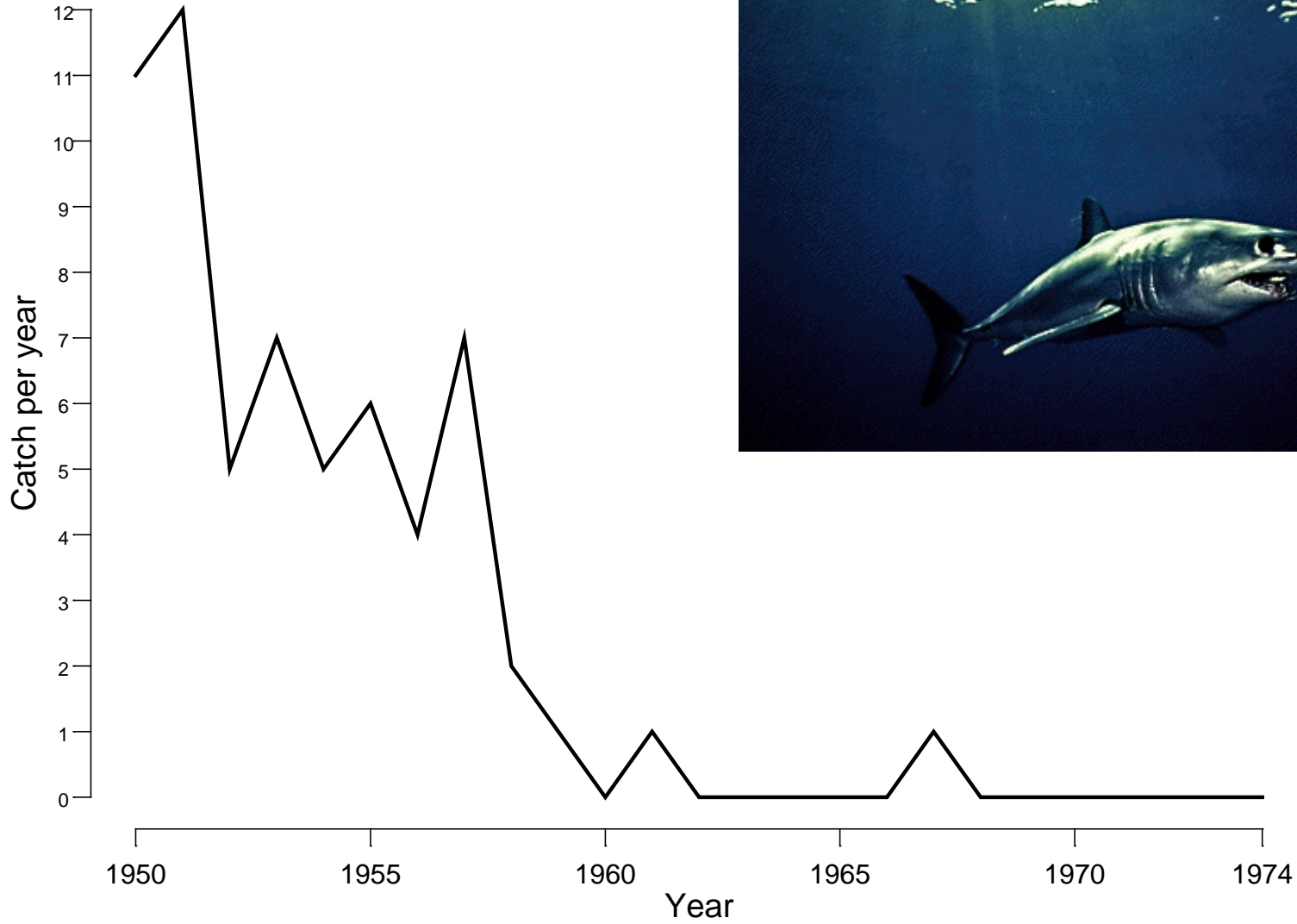
Decline of Mediterranean Sharks

By catch associated with a Tuna Trap
In Ligurian Sea

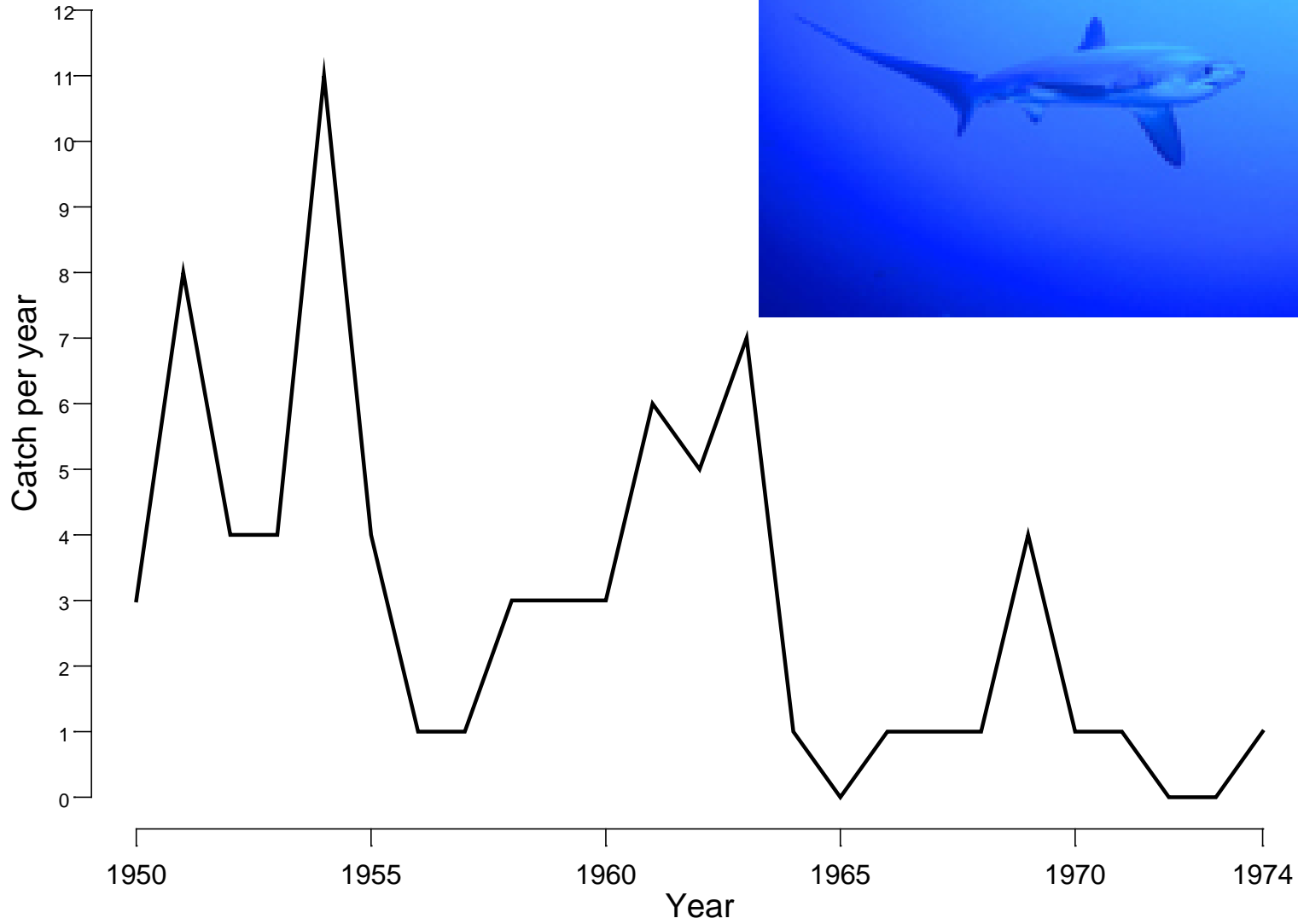
“Tonnara di Camogli”



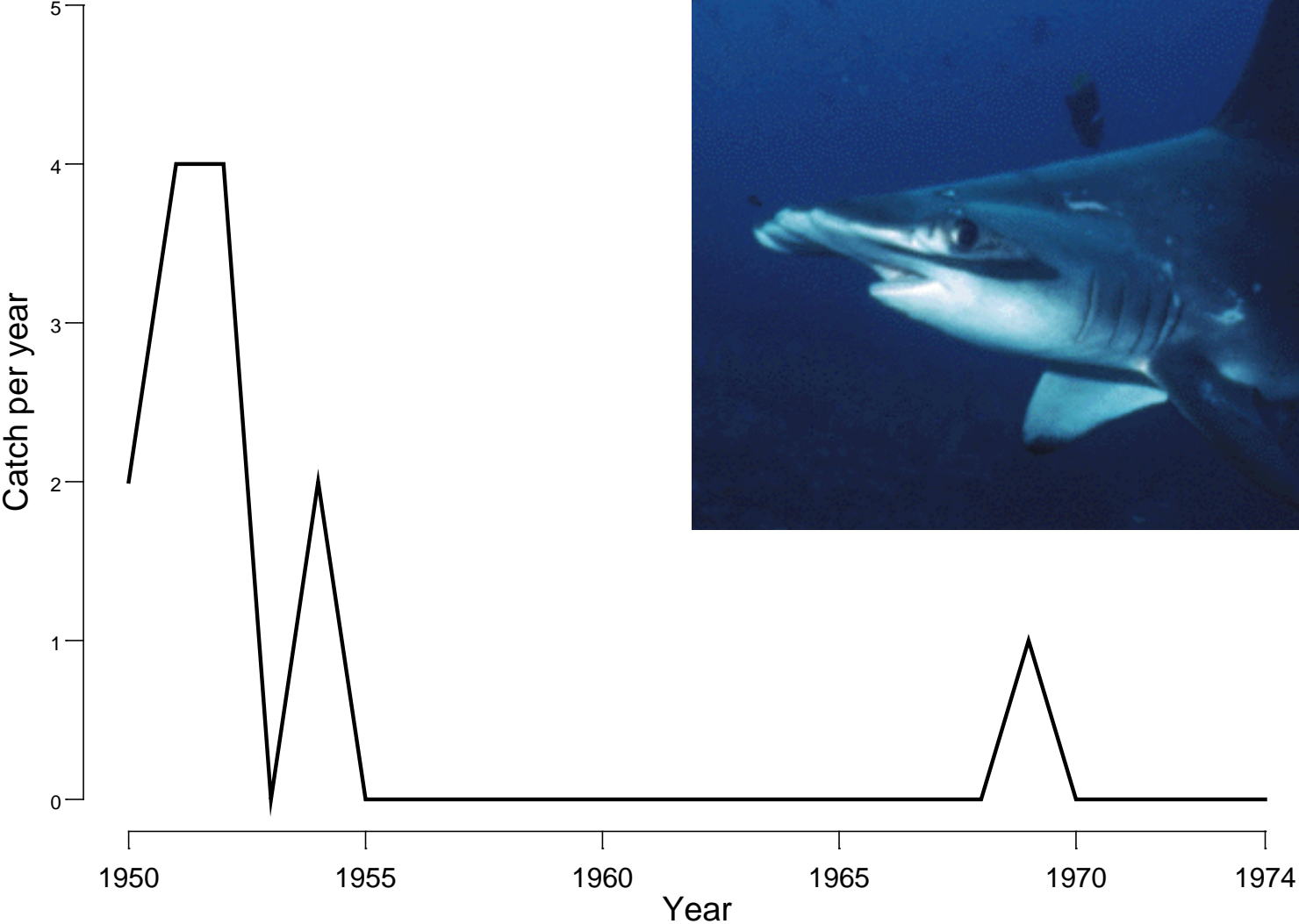
Decline of Mako sharks



Decline of Thresher sharks



Decline of Hammarhead sharks



Decline of Mediterranean Sharks

By catch associated with a Tuna Trap
In Tirrenian Sea

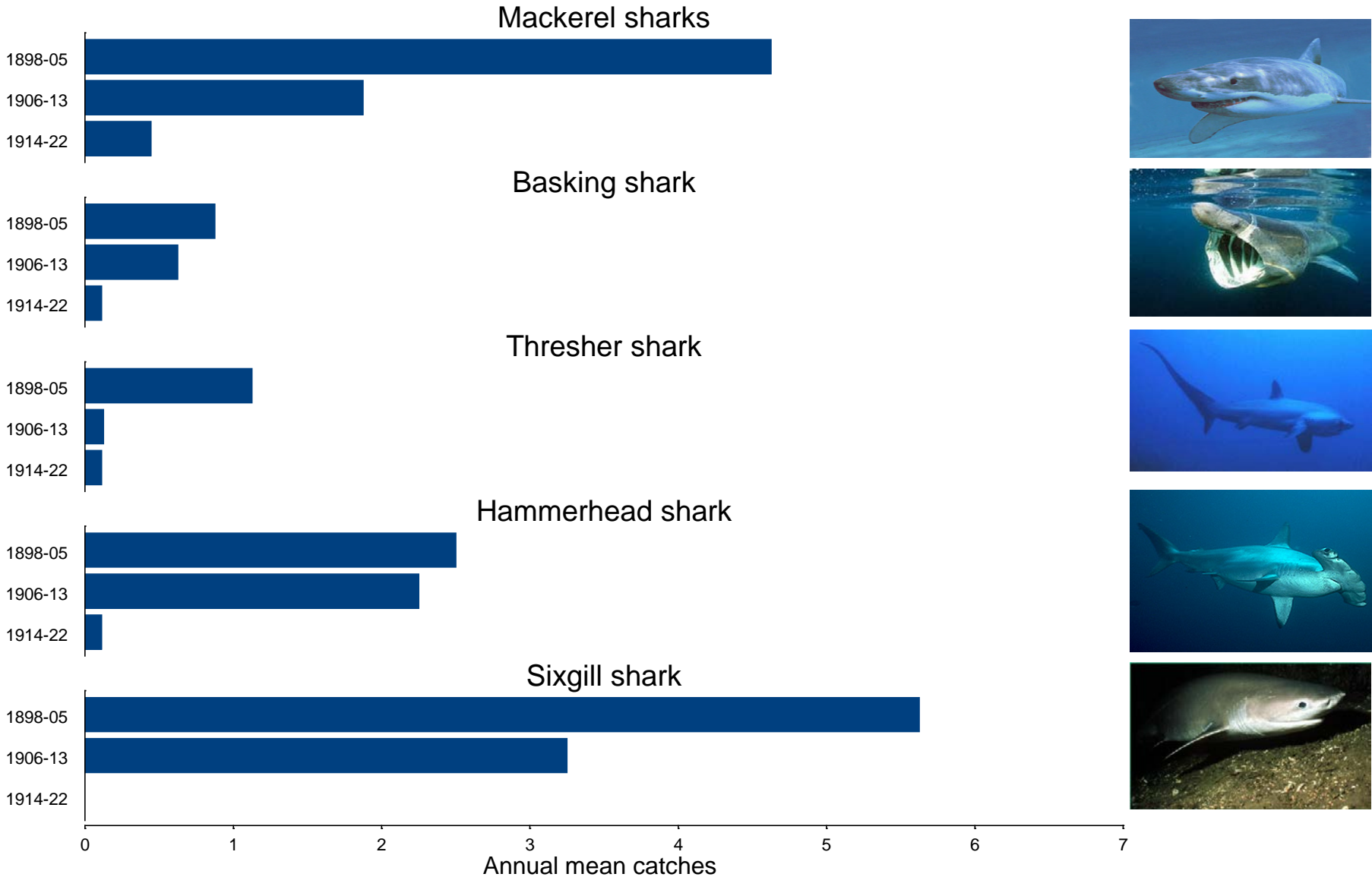


“Tonnarella di Baratti”

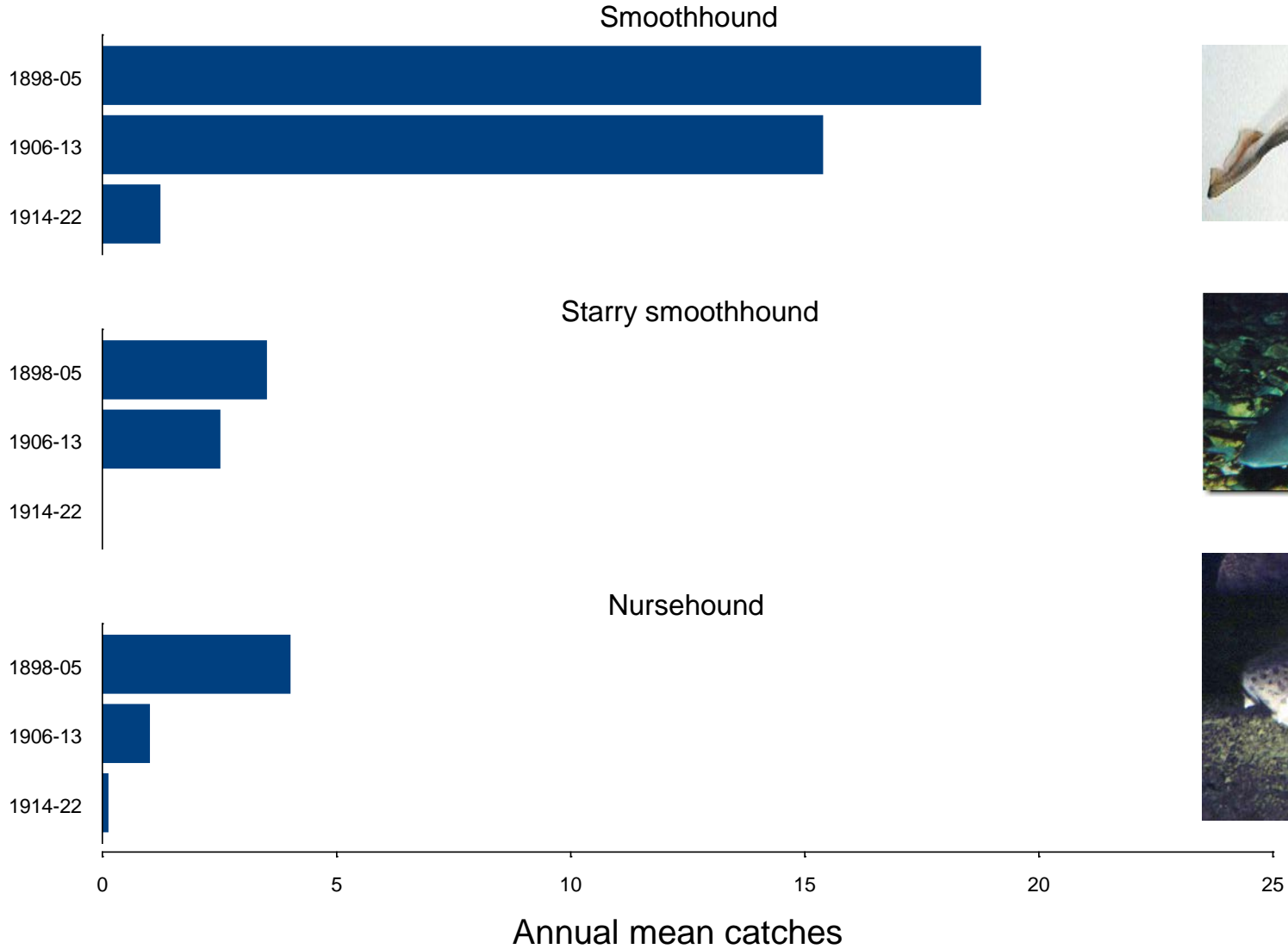


Decline in Large Sharks's Catches by an Italian Tuna Trap

Baratti's "Tonnarella"



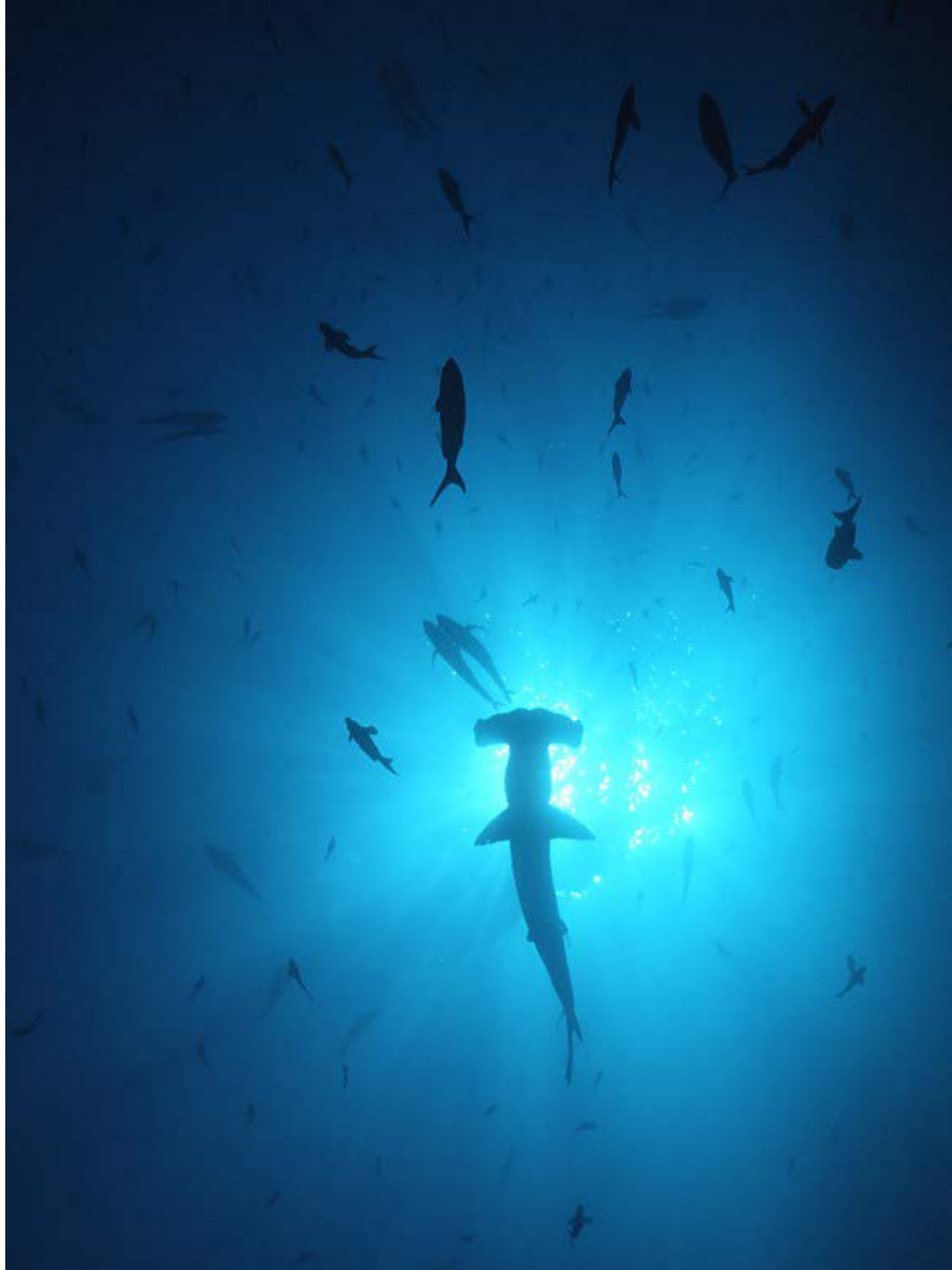
Decline of Demersal Sharks's Catches in the same Tuna Trap



***The First Collective Act of
Humanity was to save the
great whales –***

despite massive denial

***– we can do
the same for the remaining
virgin areas of the oceans
and for the great sharks.***



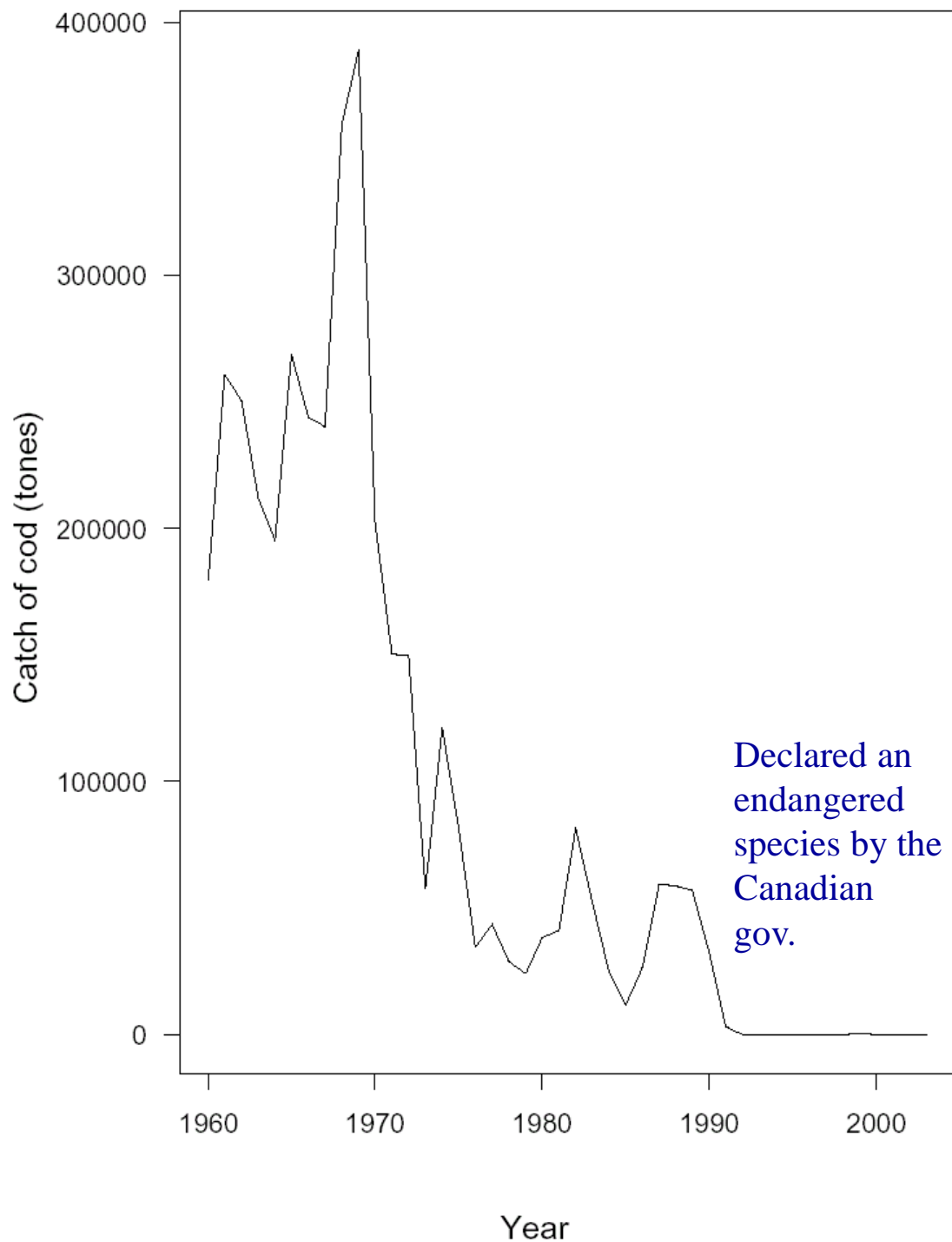
END

➤ Rest of slides are extra

Newfoundland cod

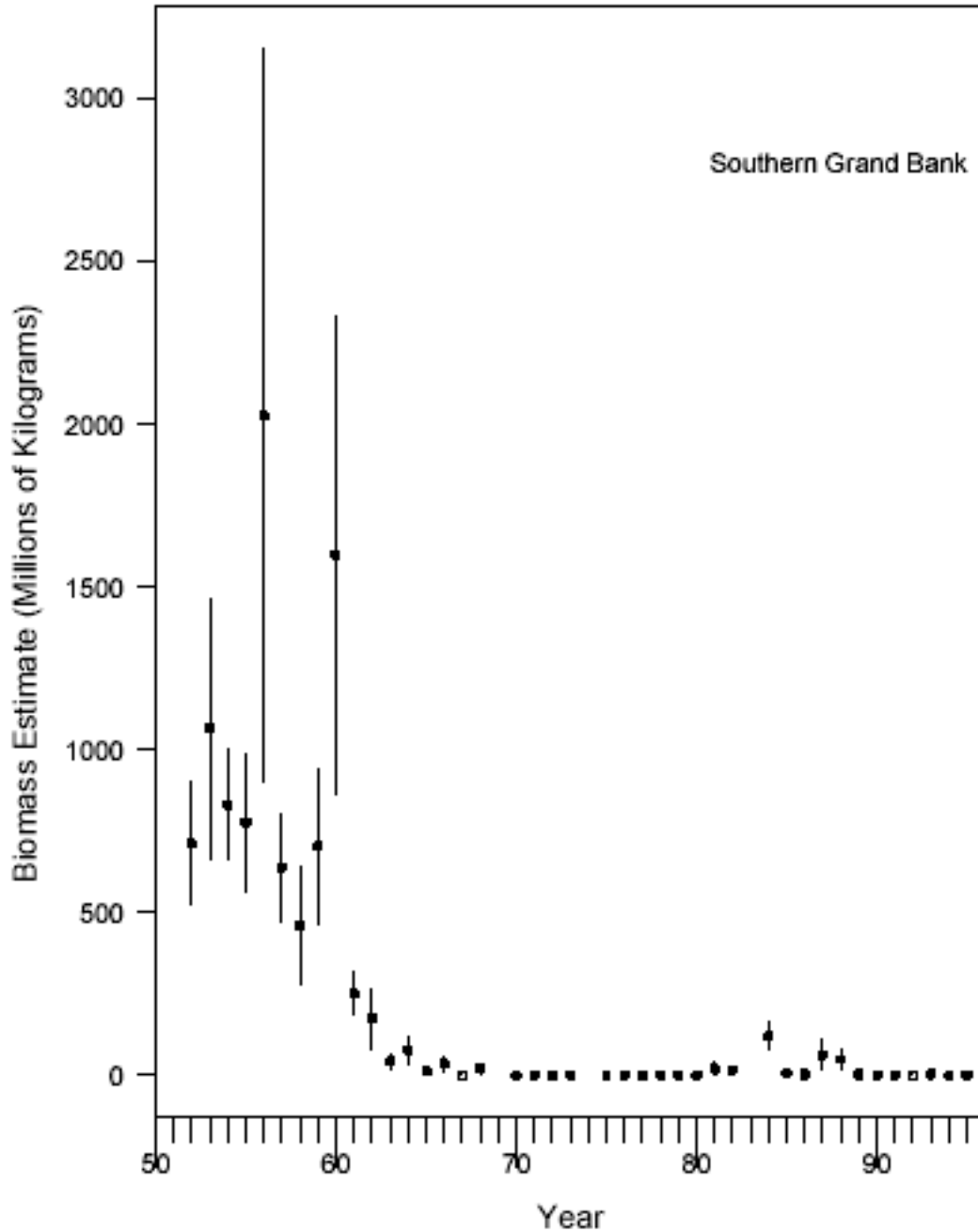
The loss of an industry that employed 40,000 people, and had sustained a culture for 400 years.

Cod in Newfoundland declared endangered in 2003.



Worldwide Loss of Sharks

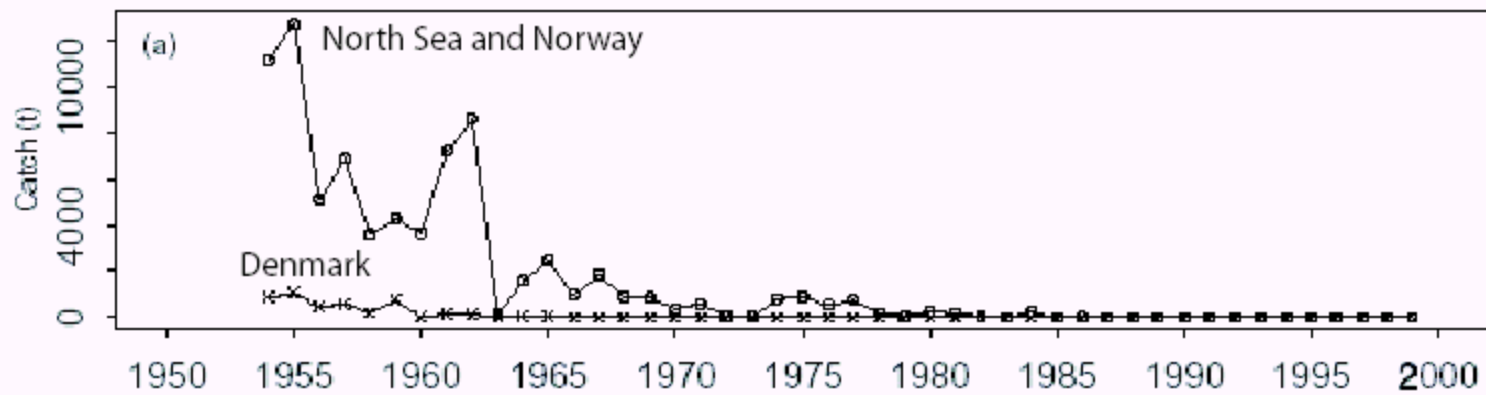
- Evidence is overwhelming where ever there are data.
- Central Pacific
- Coral Reefs
- Gulf of Mexico
- Australia
- Mediterranean



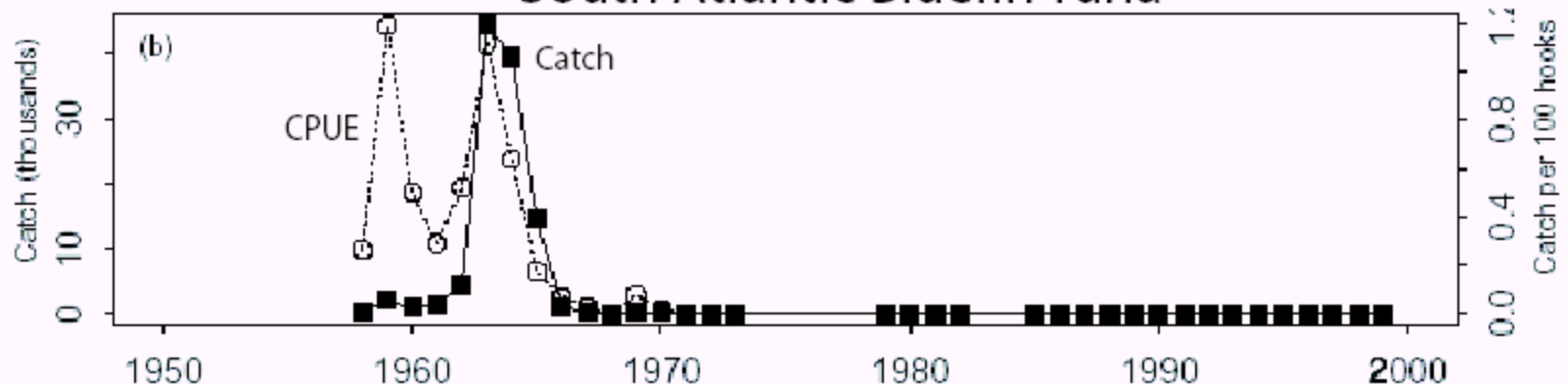
Loss of haddock on the Grand Banks – data from research suveys

Loss of Bluefin Tuna Populations in the Atlantic

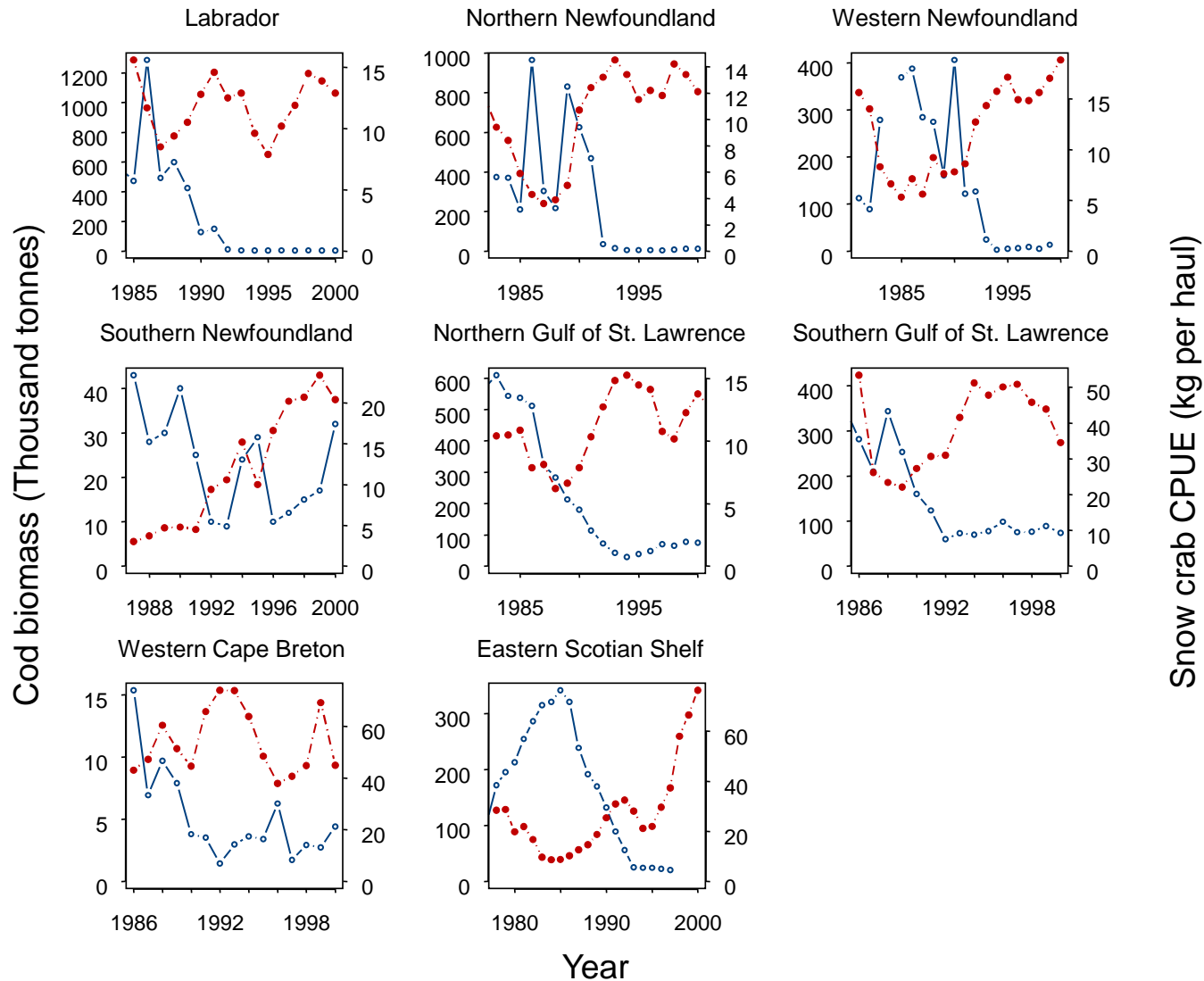
North Sea Bluefin Tuna



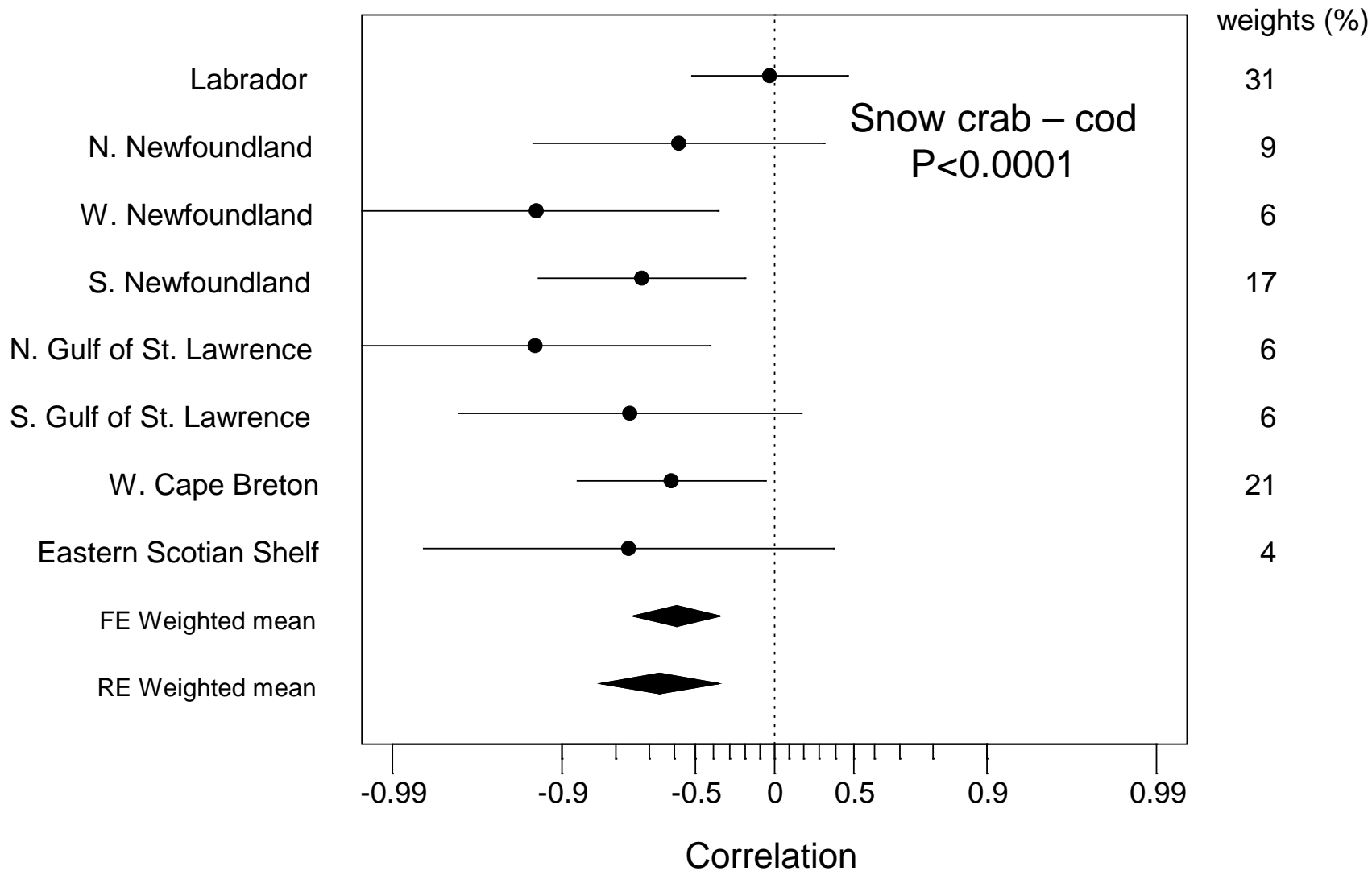
South Atlantic Bluefin Tuna



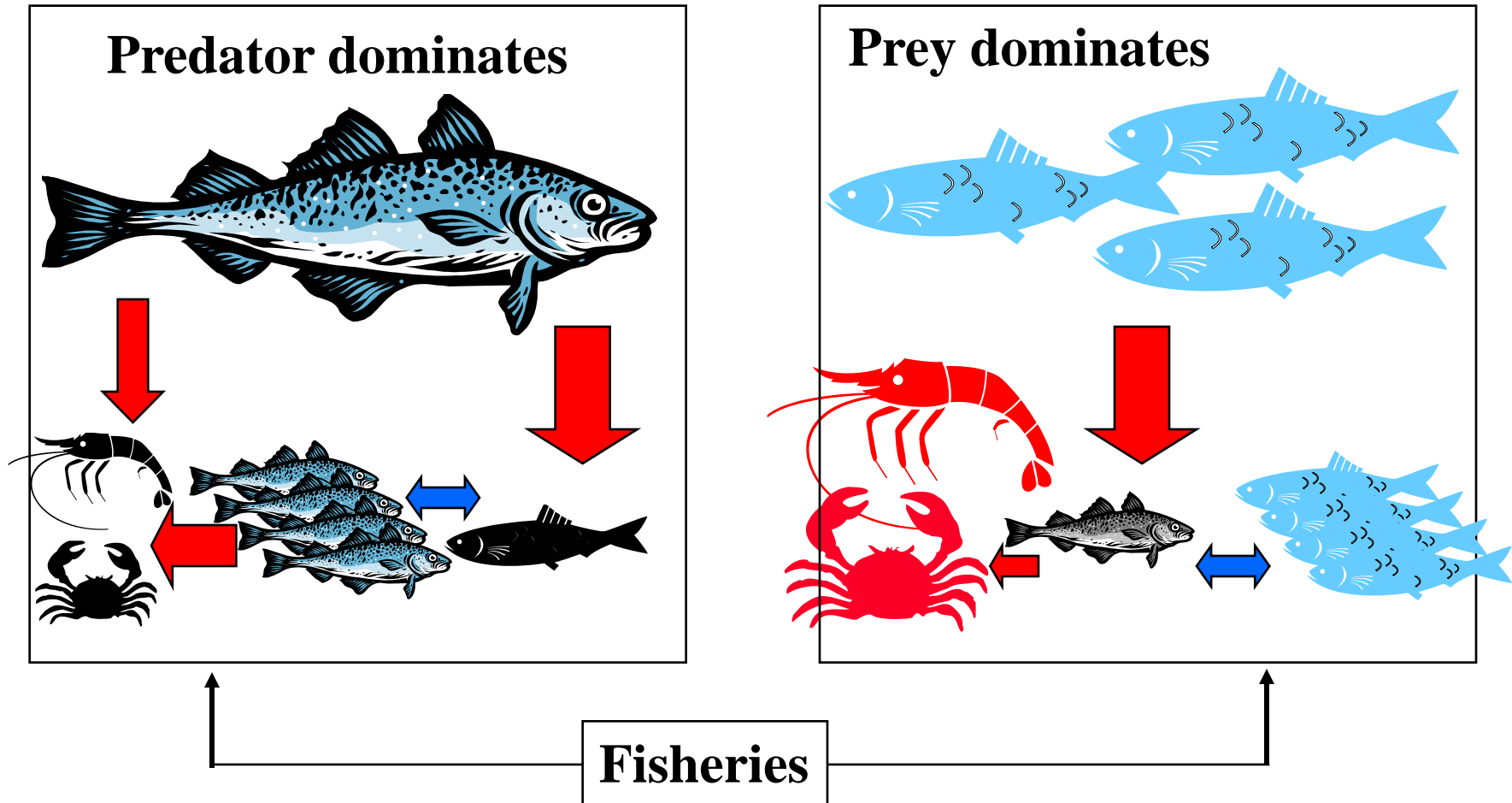
Other prey species: snow crab

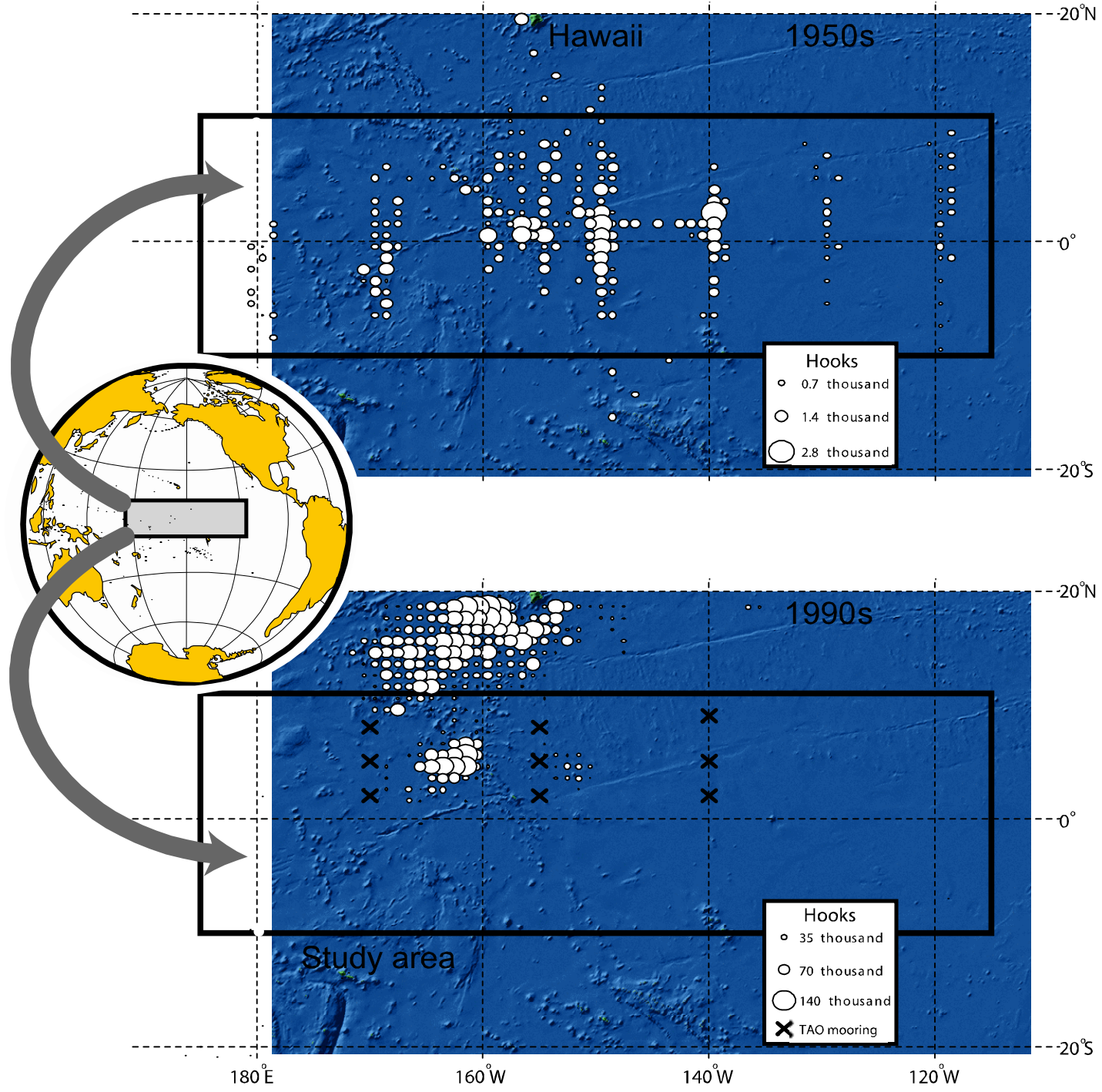


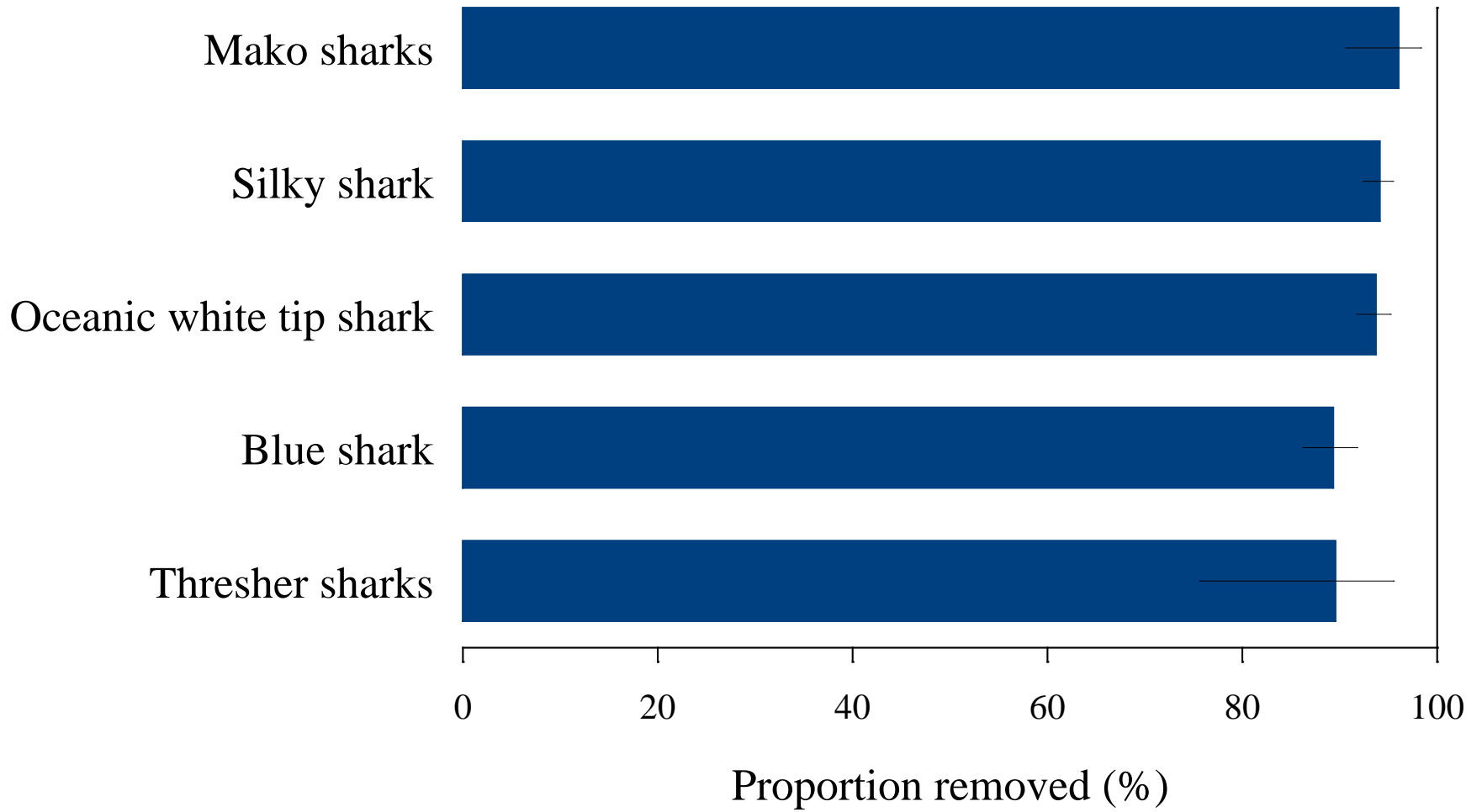
Snow crab analysis



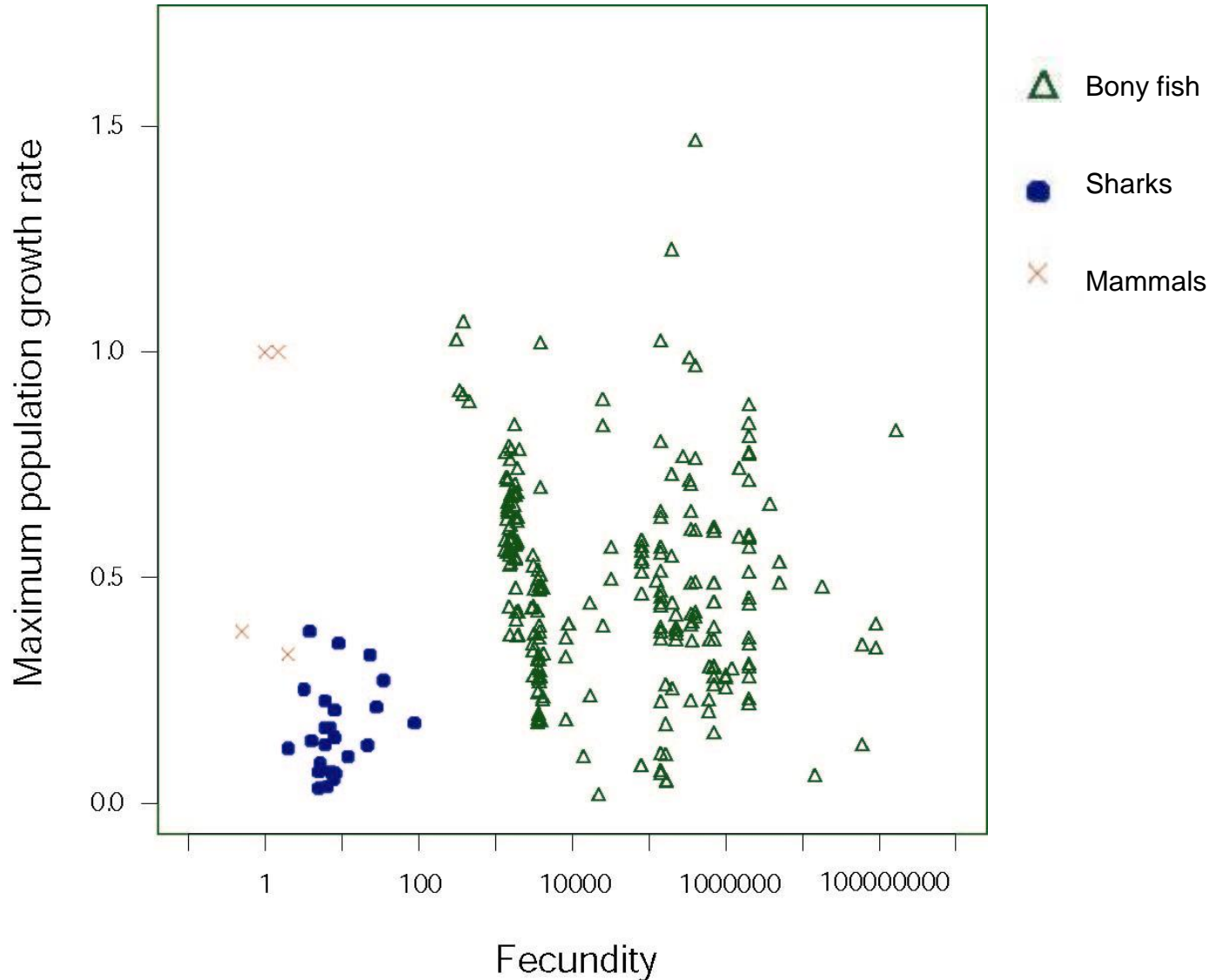
Multiple stable states in ocean food webs: a hypothesis







Meta-analysis of worldwide data



1950s
biomass = 6223 kg



- (1) Yellowfin tuna
- (2) Silky shark
- (3) Bigeye tuna
- (4) Oceanic white tip shark
- (5) Blue shark

1990s
biomass = 860 kg

