he Six Golden Rules for Modeling Life in the cean

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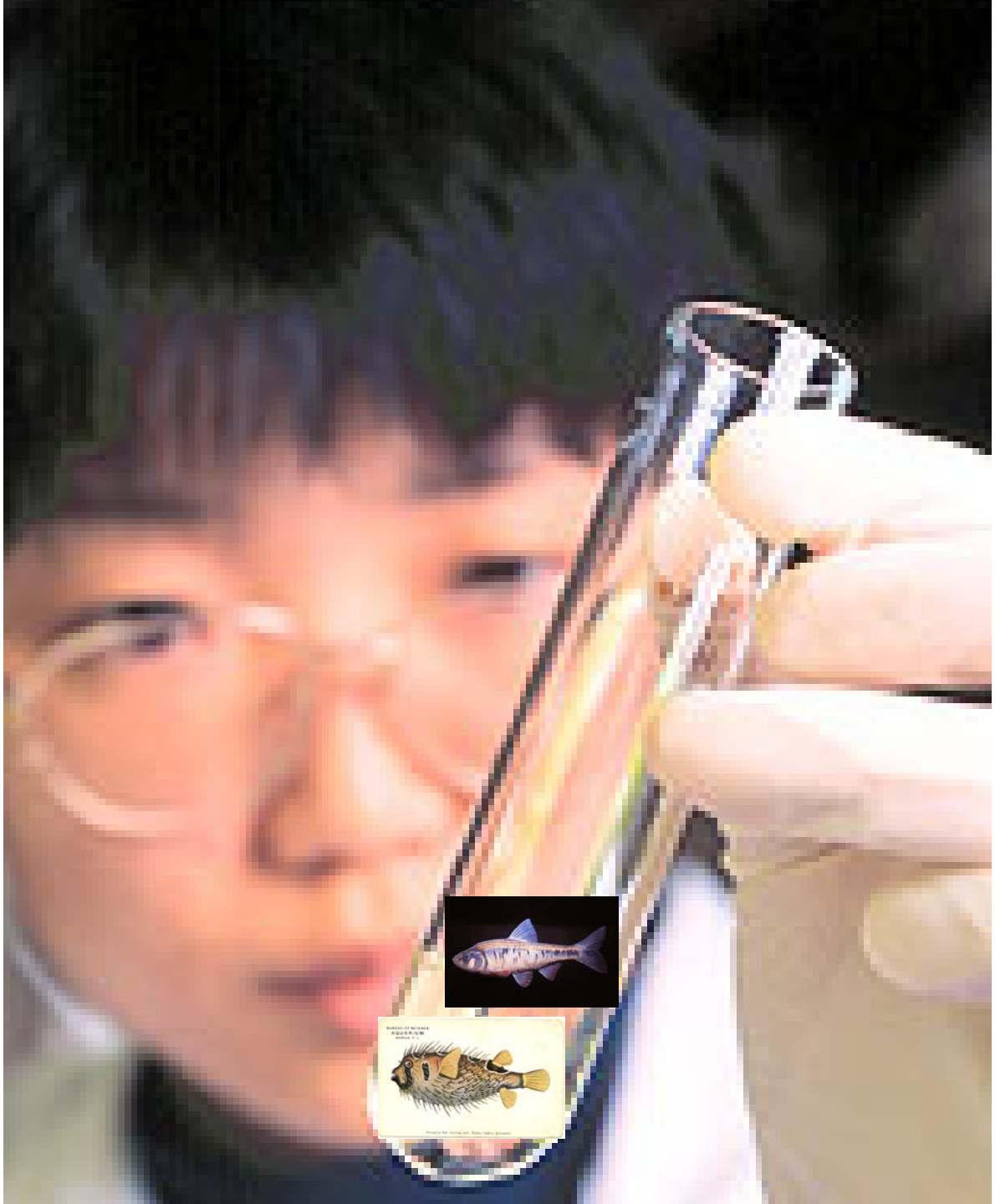
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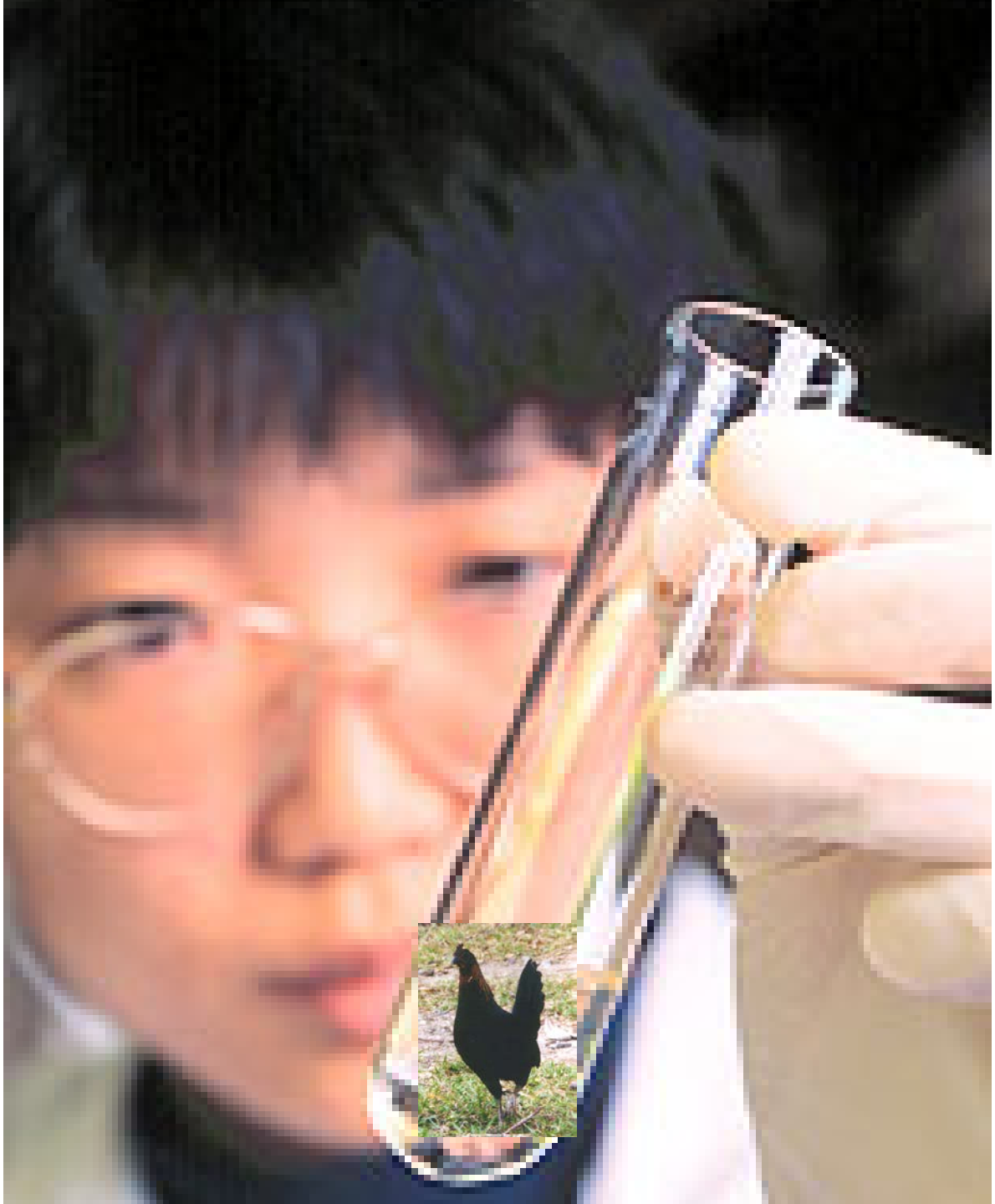
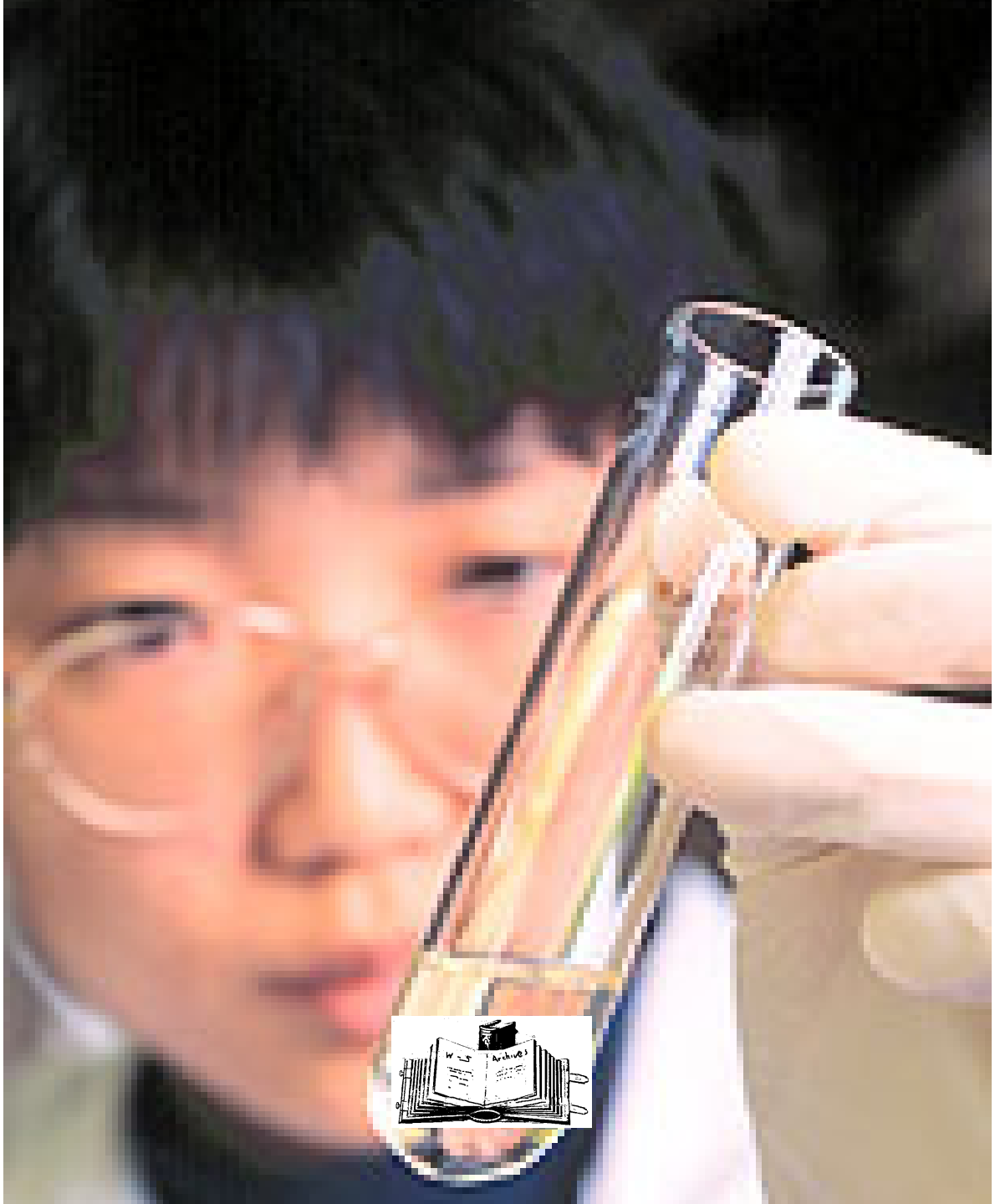



Archives

Strategy:

- Formulate the most important problem in terms of a critical model where in terms of a few parameters that can be well estimated.
- Compile all data in the world on the issue
- Analyze it the right way

How do you get the right results from models?

- Right question
- As simple models as possible, (and no simpler)
- Parameters are random variables in which everything is heirachically structured.
- Multiple tests for robustness
- Repeat analysis using all other independent data in the world and combine using meta-analysis.
- Plot data and model results to reveal truth.

Asking the right question requires intellectual honesty and independence.

- “Tame” scientist: “Think what they are told to think even before they told to think it”.
- We are a tribal species, and anyone who believes that thinking independently is easy, has simply never tried it.

Keep Models As Simple as Possible.

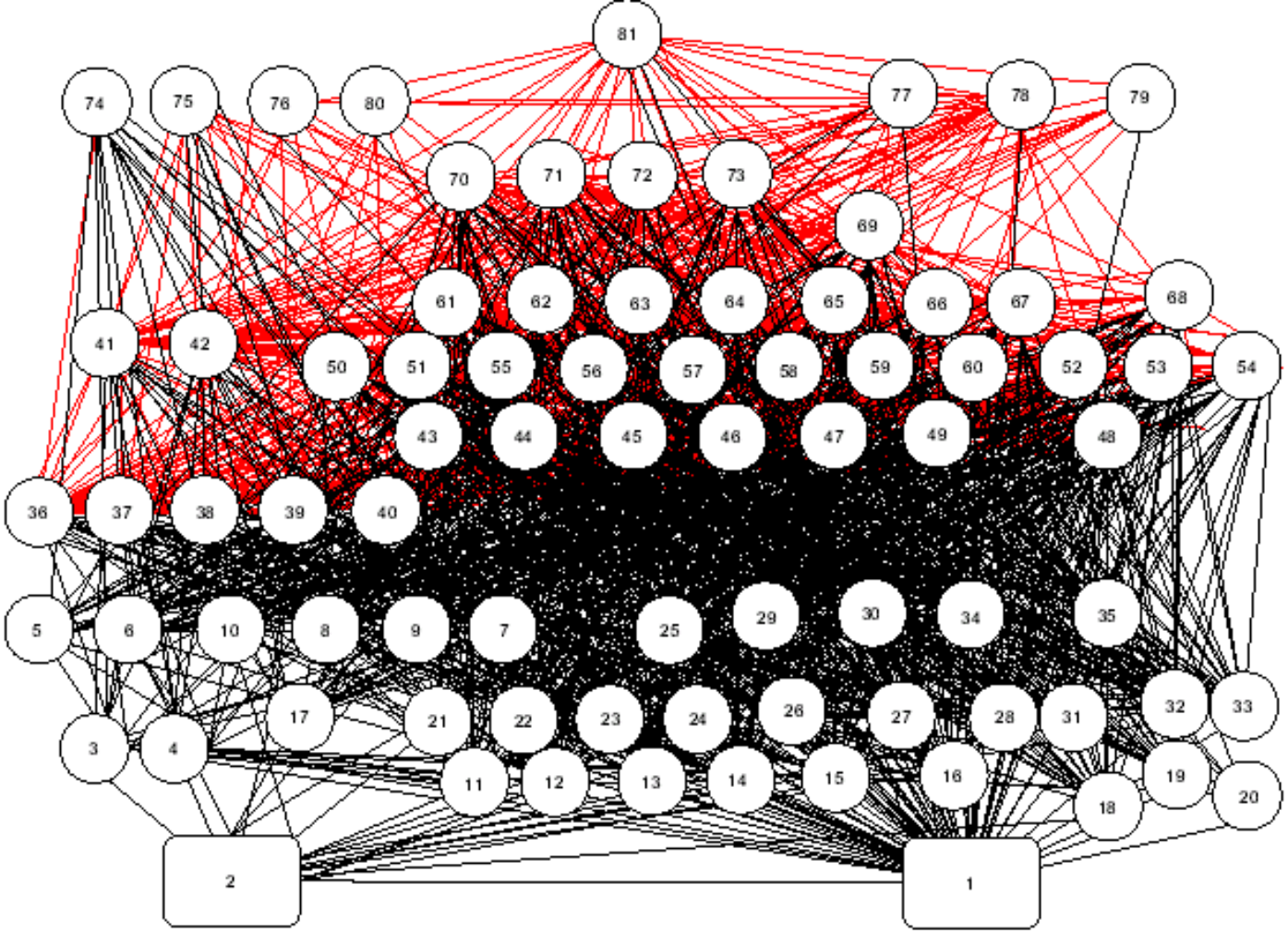
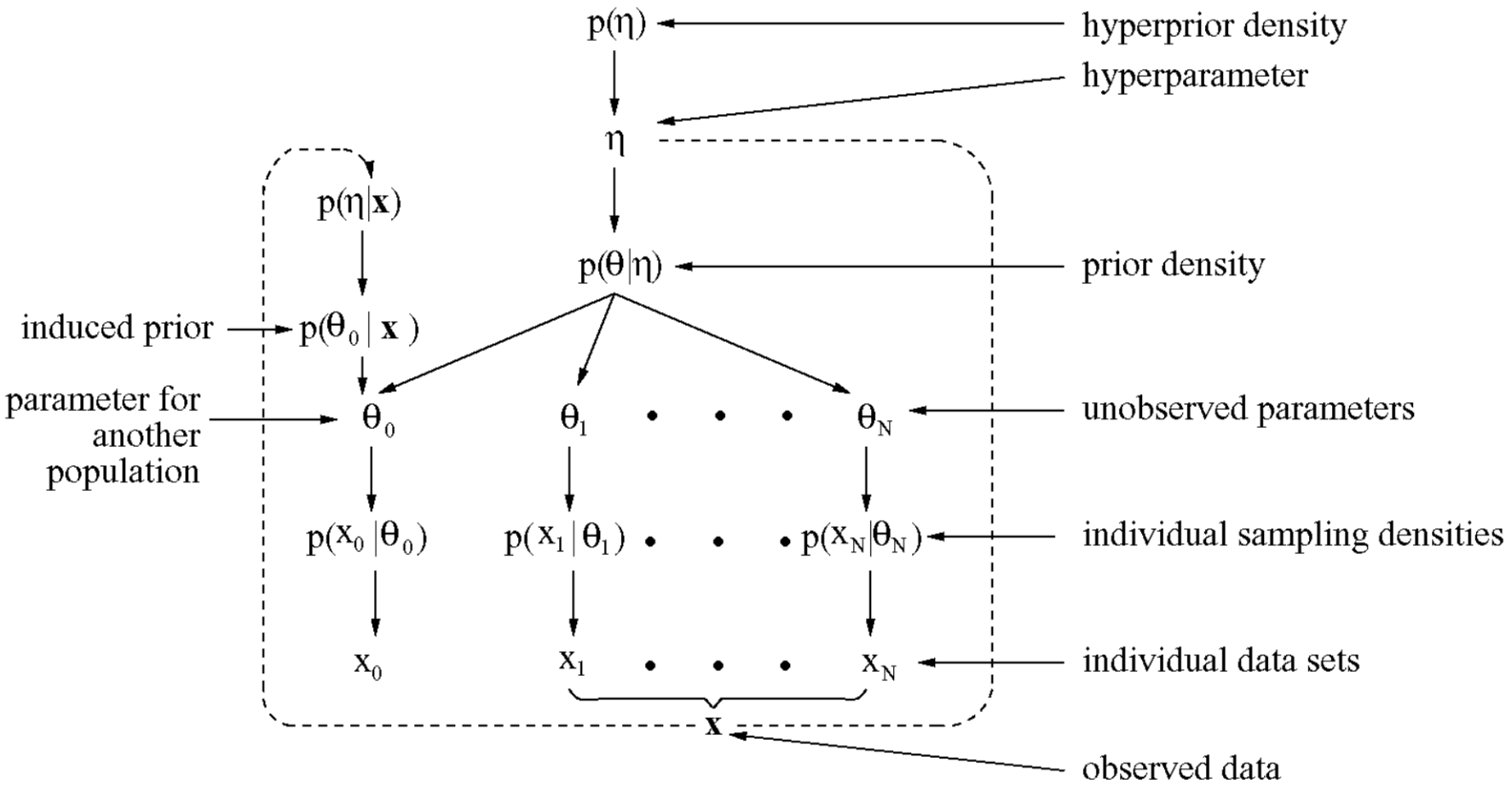


Fig. 1. Species and links of the northwest Atlantic food web. This tangled 'bird's nest' represents interactions at the approximate trophic level of each species, with increasing trophic level towards the top of the web. The left side of the web generally typifies pelagic organisms, and the right to middle represents more benthic/demersally oriented organisms. Red lines indicate predation on fish. 1 = detritus, 2 = phytoplankton, 3 = *Calanus* sp., 4 = other copepods, 5 = ctenophores, 6 = chaetognatha (i.e. arrow worms), 7 = jellyfish, 8 = euphasiids, 9 = *Crangon* sp., 10 = mysids, 11 = pandalids, 12 = other decapods, 13 = gammarids, 14 = hyperiids, 15 = caprellids, 16 = isopods, 17 = pteropods, 18 = cumaceans, 19 = mantis shrimps, 20 = tunicates, 21 = porifera, 22 = cancer crabs, 23 = other crabs, 24 = lobster, 25 = hydroids, 26 = corals and anemones, 27 = polychaetes, 28 = other worms, 29 = starfish, 30 = brittle stars, 31 = sea cucumbers, 32 = scallops, 33 = clams and mussels, 34 = snails, 35 = urchins, 36 = sand lance, 37 = Atlantic herring, 38 = alewife, 39 = Atlantic mackerel, 40 = butterfish, 41 = loligo, 42 = illex, 43 = pollock, 44 = silver hake, 45 = spotted hake, 46 = white hake, 47 = red hake, 48 = Atlantic cod, 49 = haddock, 50 = sea raven, 51 = longhorn sculpin, 52 = little skate, 53 = winter skate, 54 = thorny skate, 55 = ocean pout, 56 = cusk, 57 = wolfish, 58 = cunner, 59 = sea robins, 60 = redfish, 61 = yellowtail flounder, 62 = windowpane flounder, 63 = summer flounder, 64 = witch flounder, 65 = four-spot flounder, 66 = winter flounder, 67 = American plaice, 68 = American halibut, 69 = smooth dogfish, 70 = spiny dogfish, 71 = goosefish, 72 = weakfish, 73 = bluefish, 74 = baleen whales, 75 = toothed whales and porpoises, 76 = seals, 77 = migratory scombrids, 78 = migratory sharks, 79 = migratory billfish, 80 = birds, 81 = humans

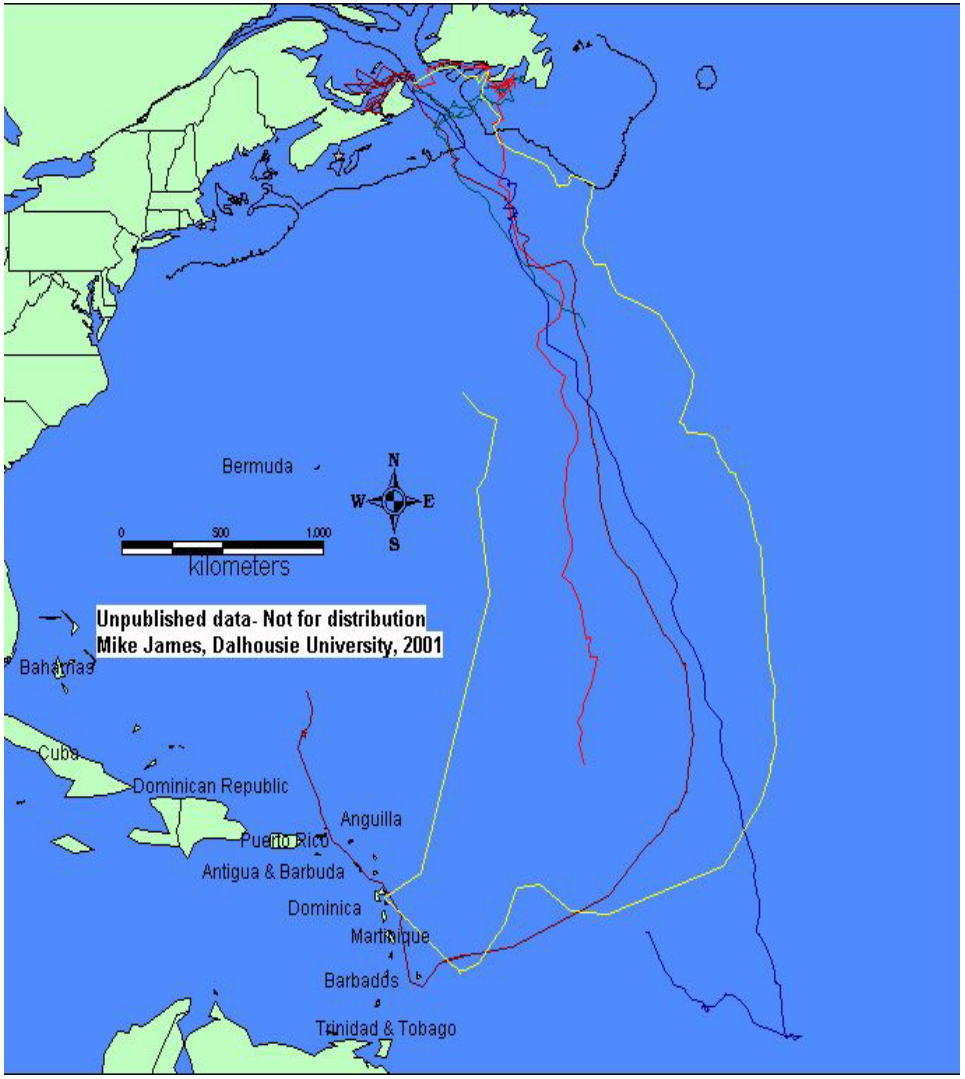
Link, MEPS. 2002.

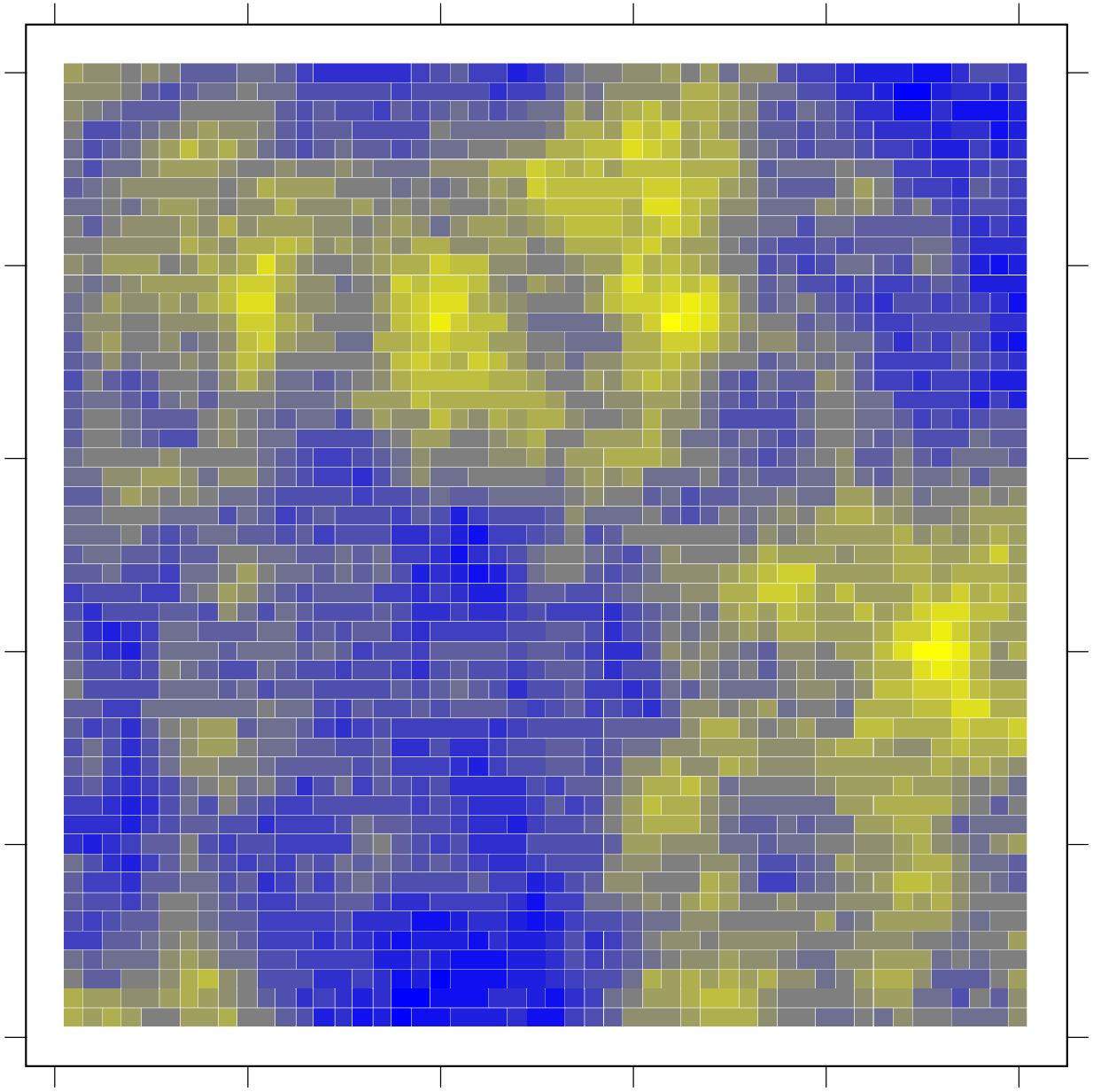
All parameters are random variables.
All problems are related hierachically.
Problems are formulated so that the parameters can be combined.

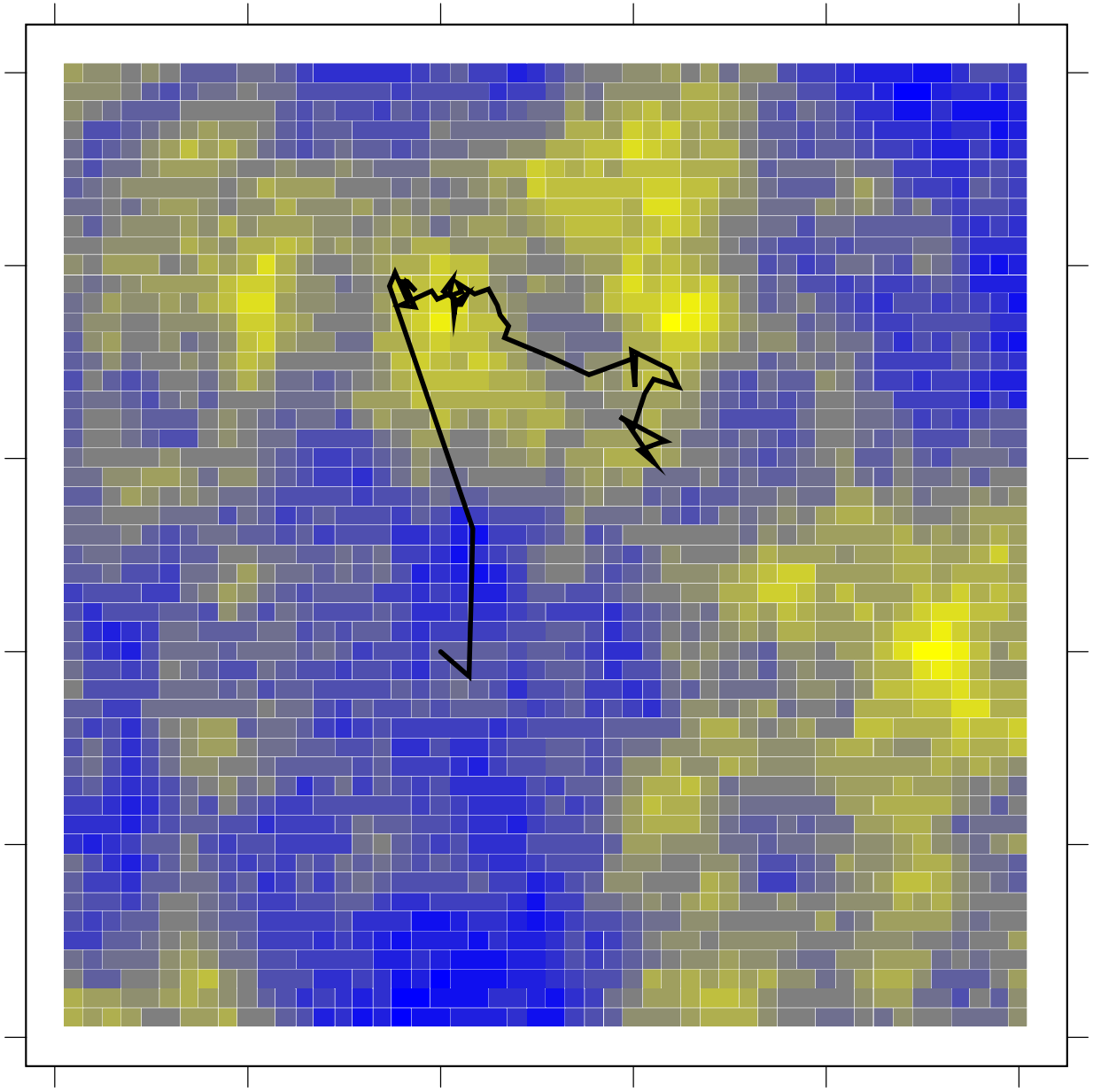


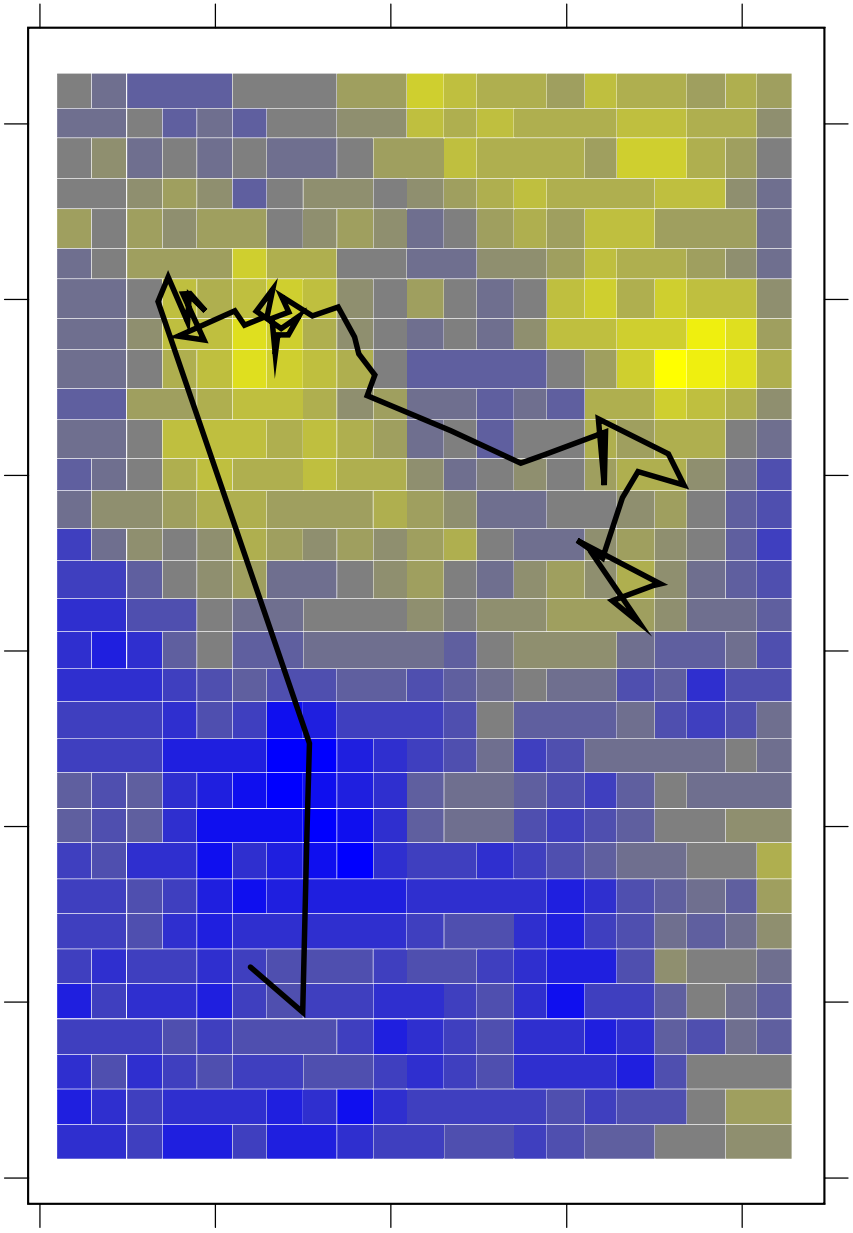
A meta-analytic approach is required

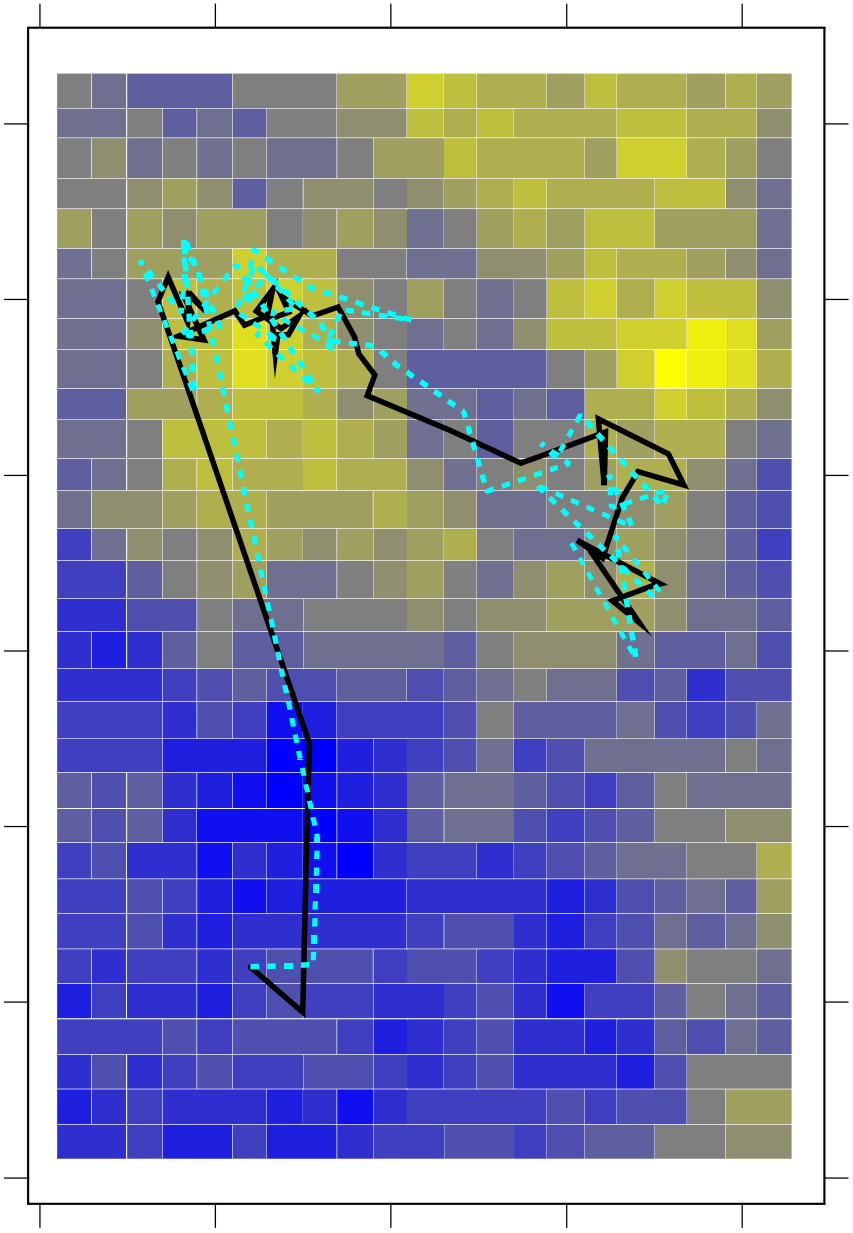
- Information combined over multiple pathways
- Optimal parameter estimation for data-poor pathways
- Population-level behavior inferred

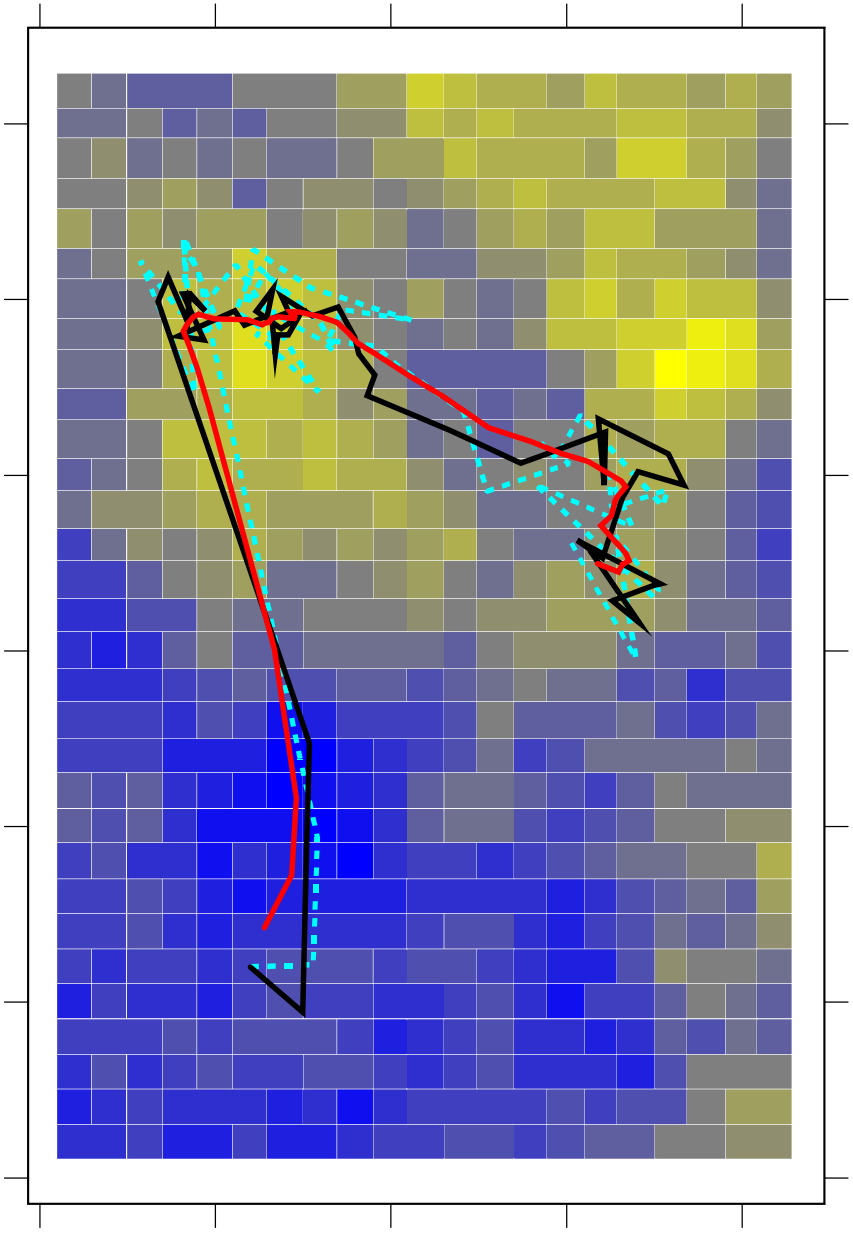




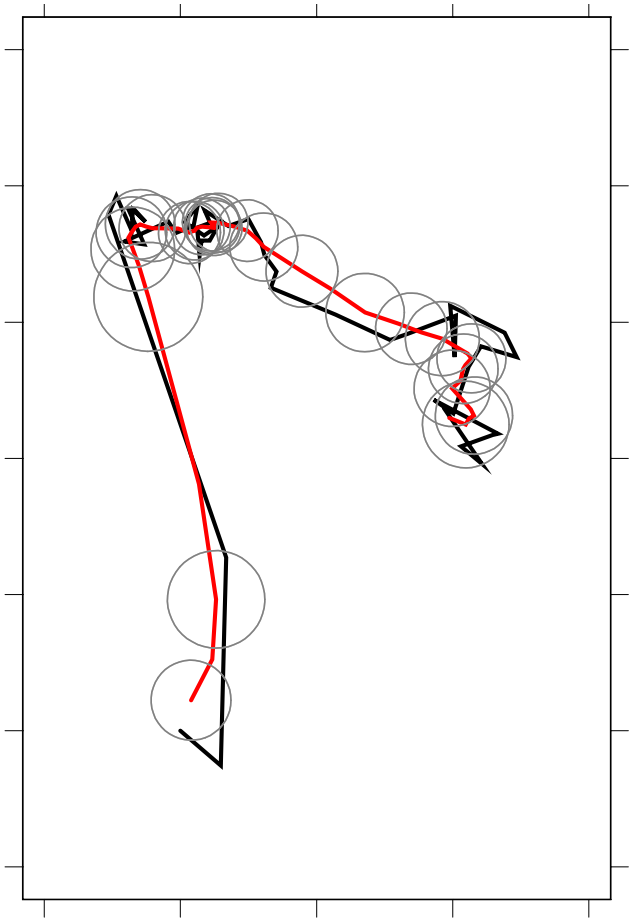








Credible limits on predictions

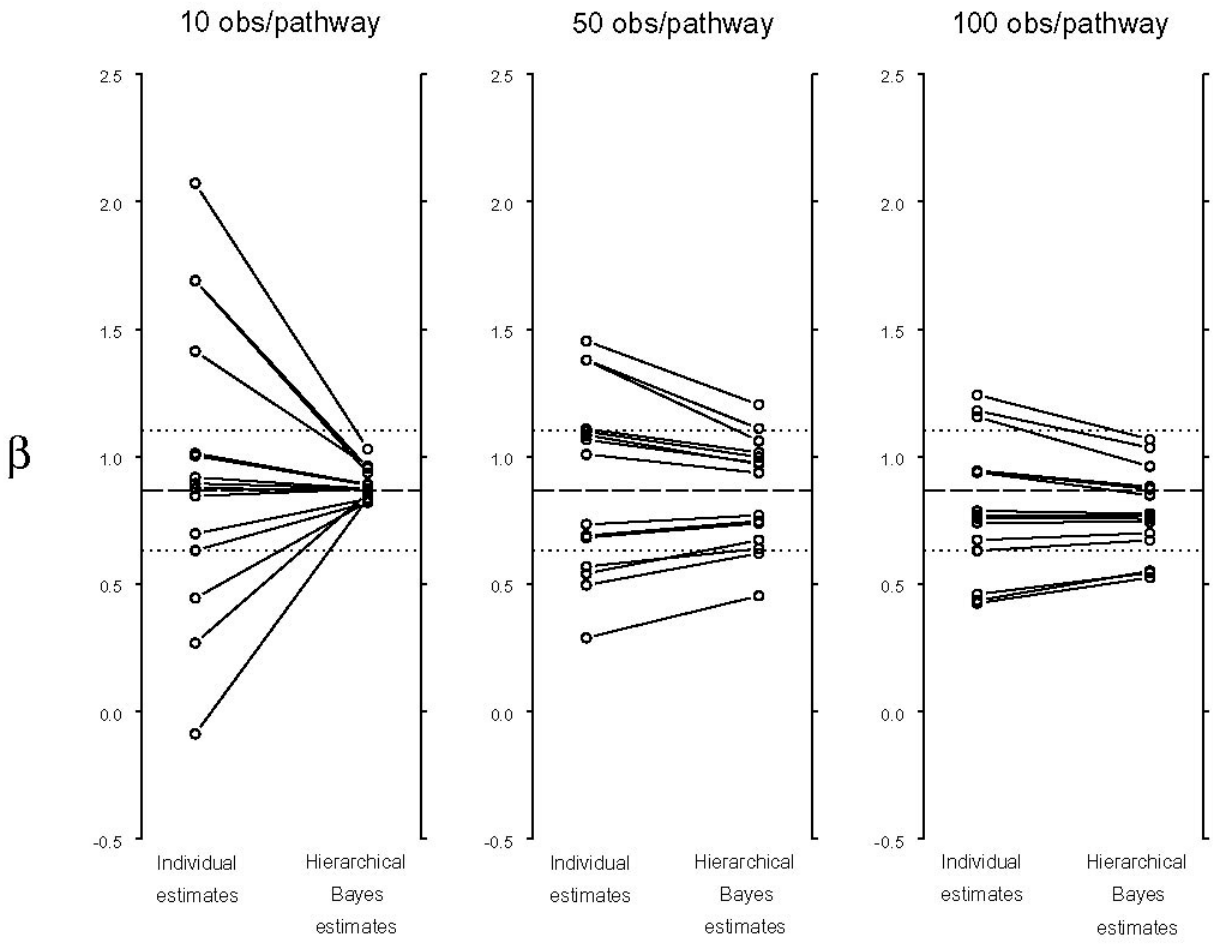


Meta-analysis of pathways

- Need to combine information over many individual tracks
- We allow parameters of the vector (γ) describing behavior to be random variables:

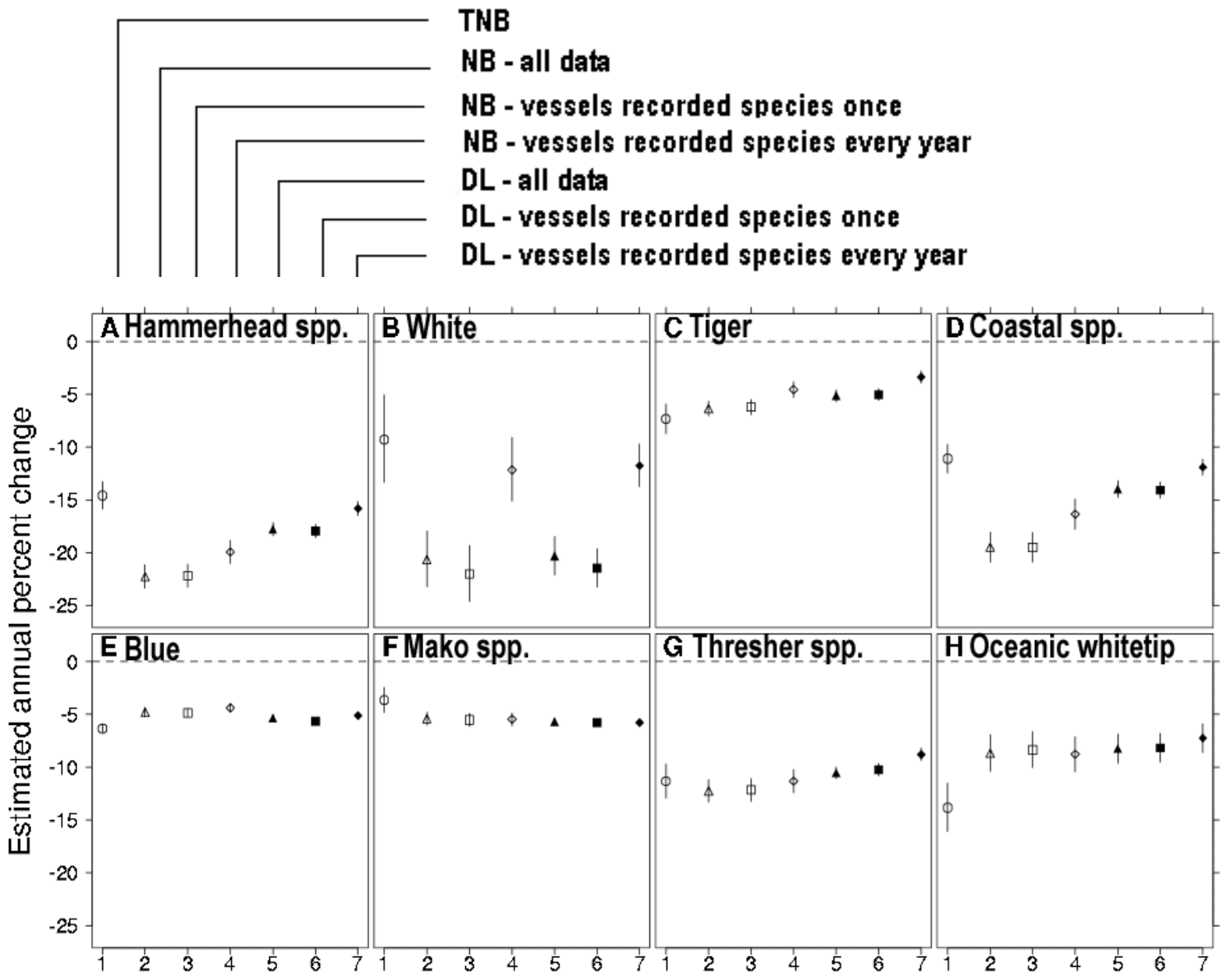
$$\gamma_i \sim N(\mu, \sigma^2)$$

Improved parameter estimation

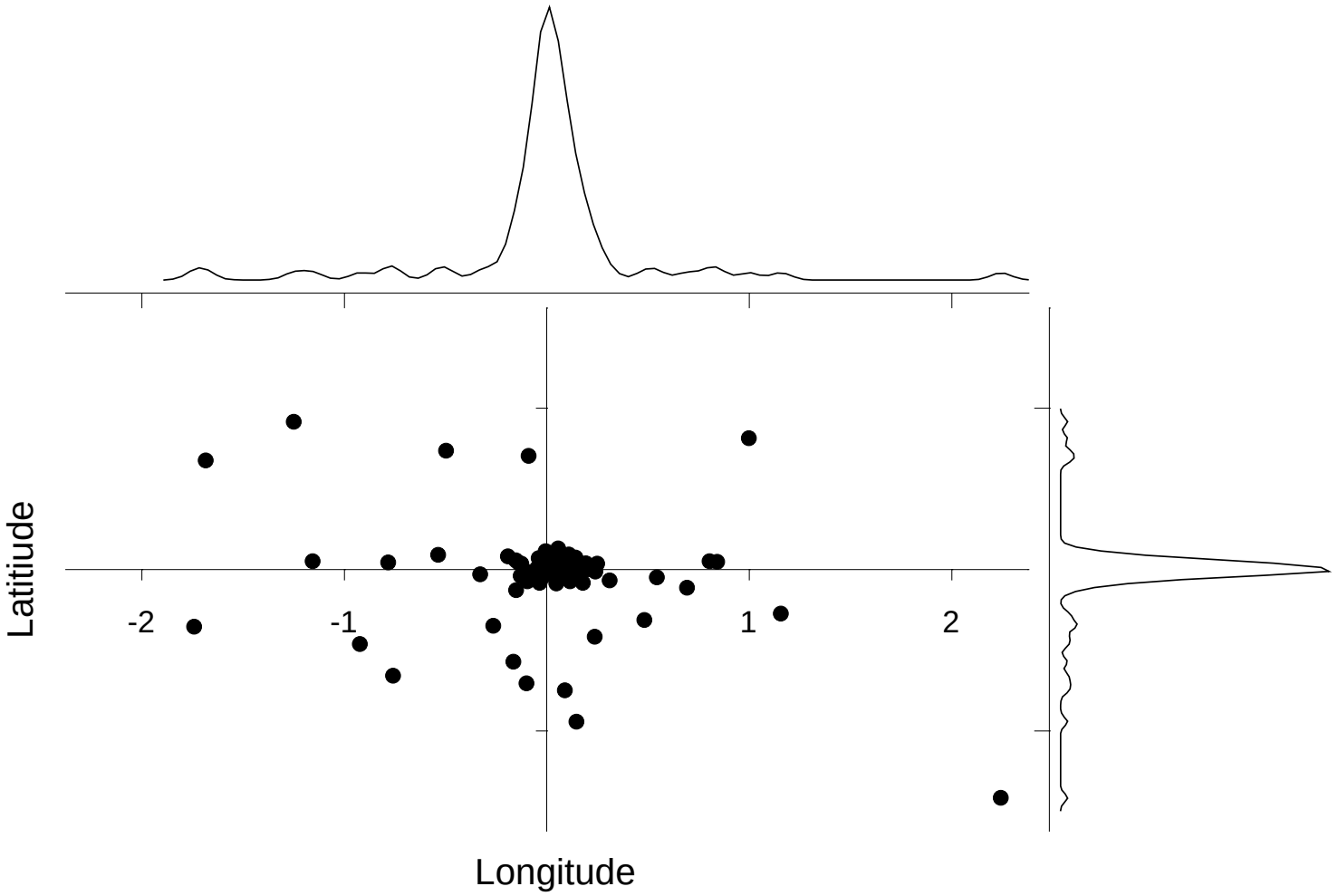


Multiple tests for robustness

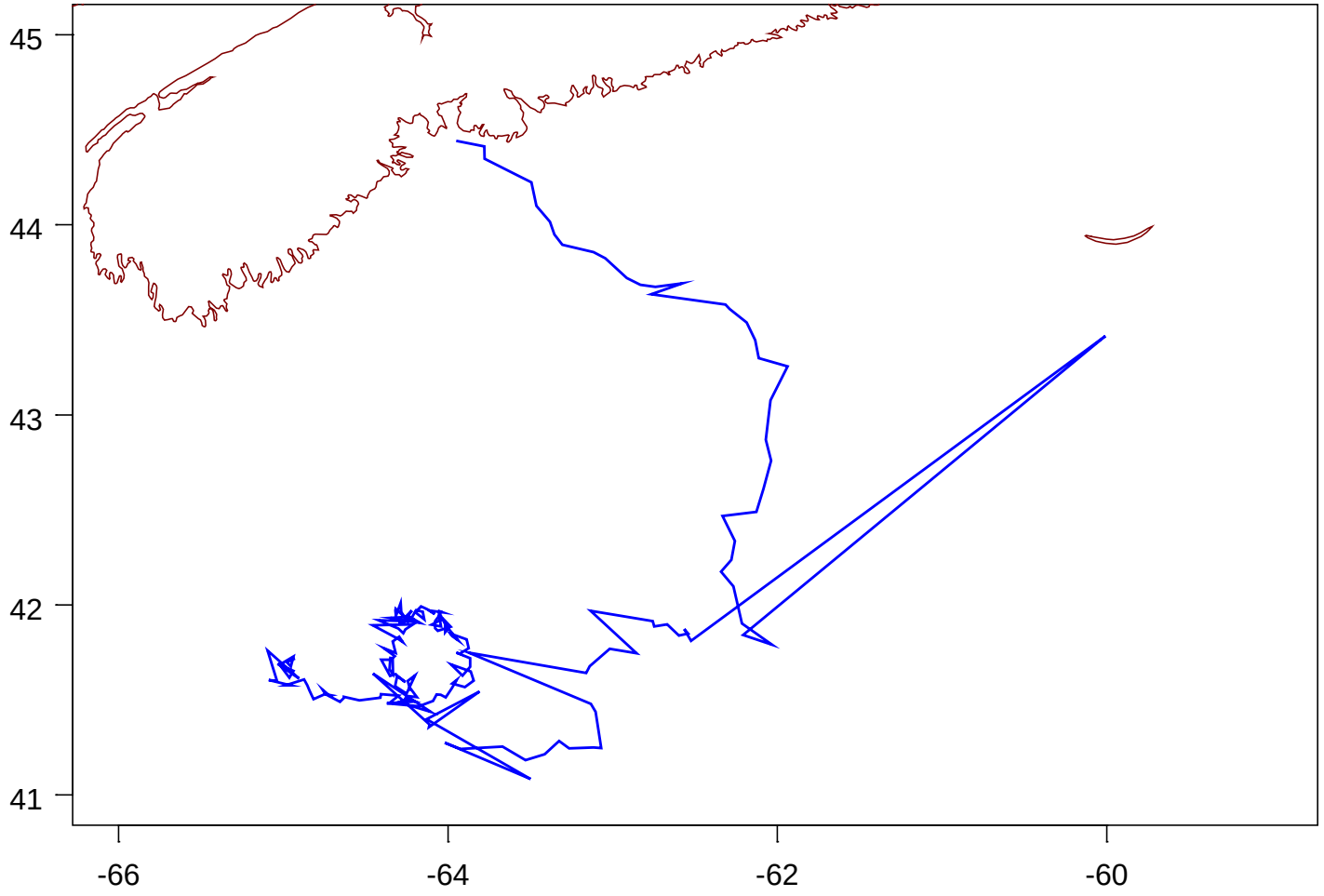
E



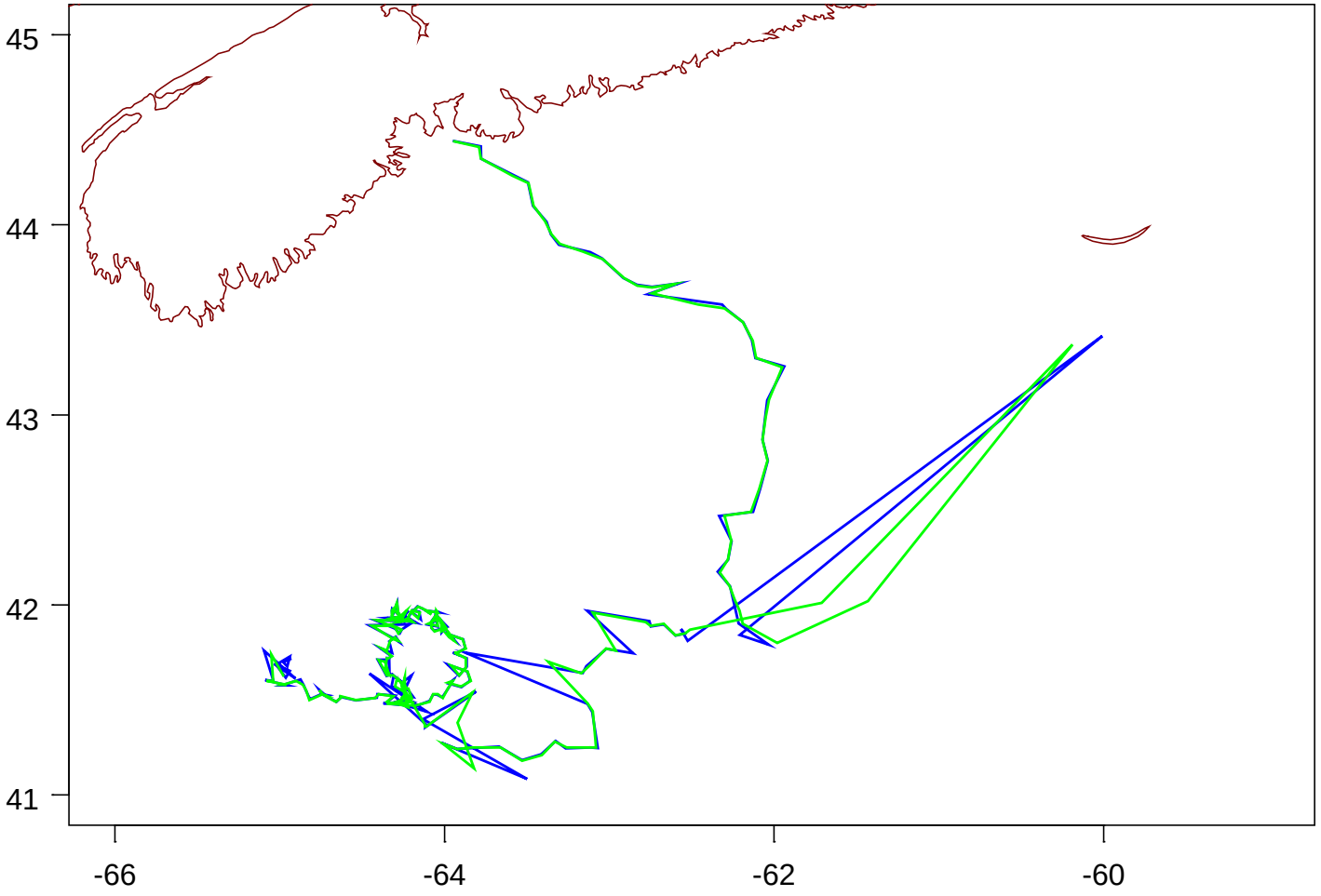
Argos: Location errors non-Normal



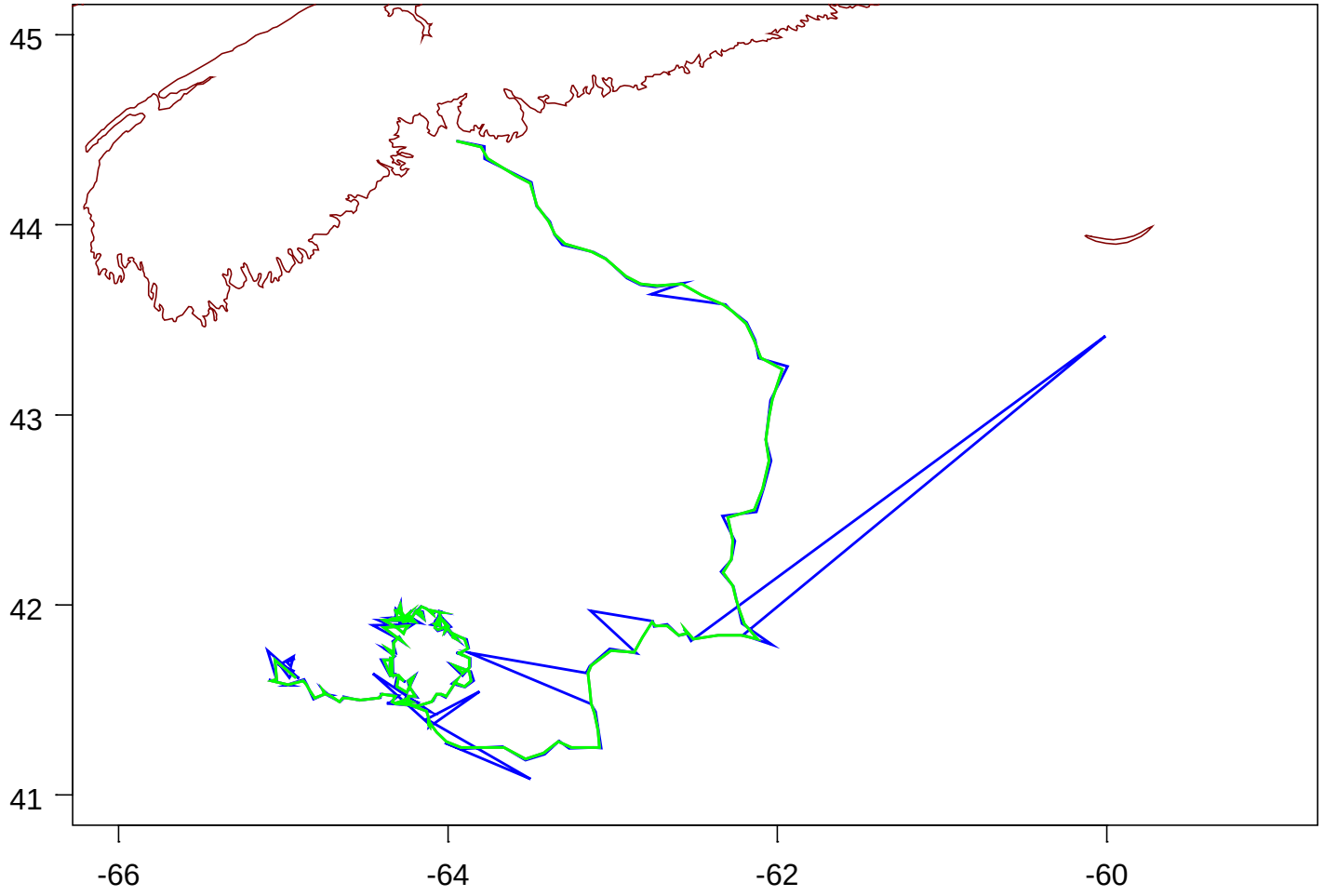
Robust methods are required



Normal model



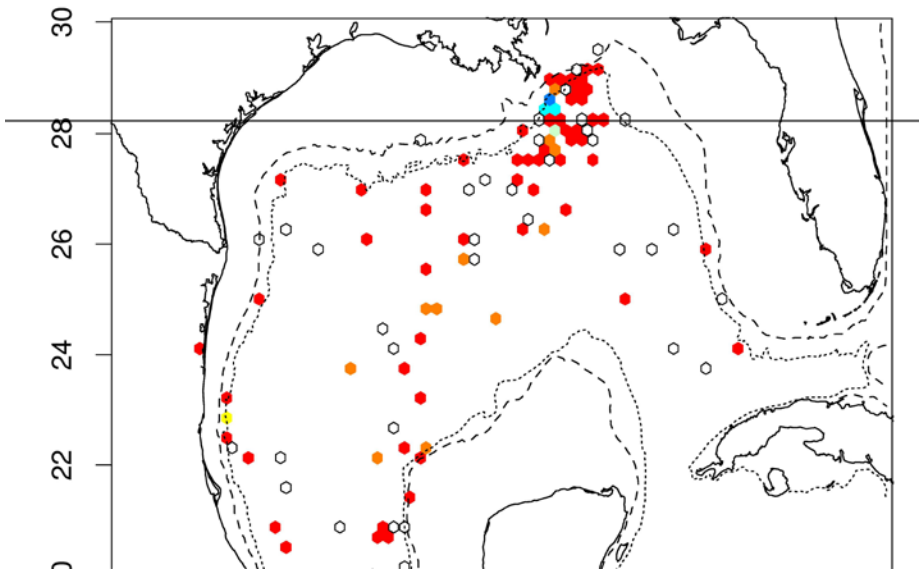
Robust Model (Mixture model)



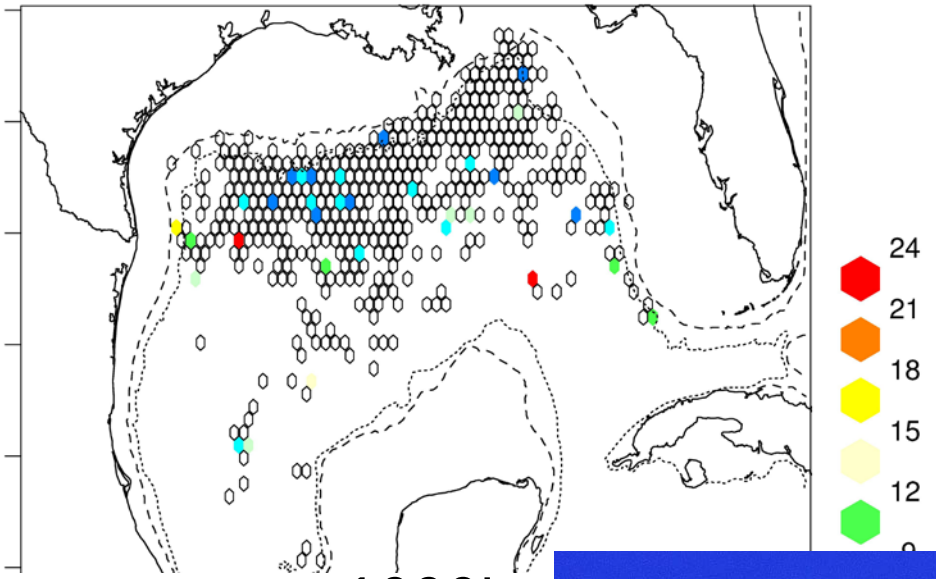
Repeat analysis using
all other independent data

Loss of sharks in
the Gulf of Mexico

300 fold decline – no one noticed

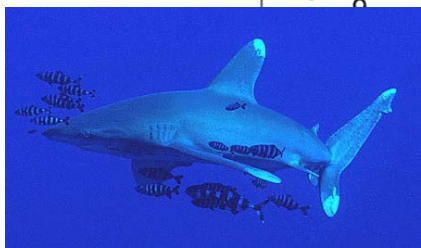


1950's



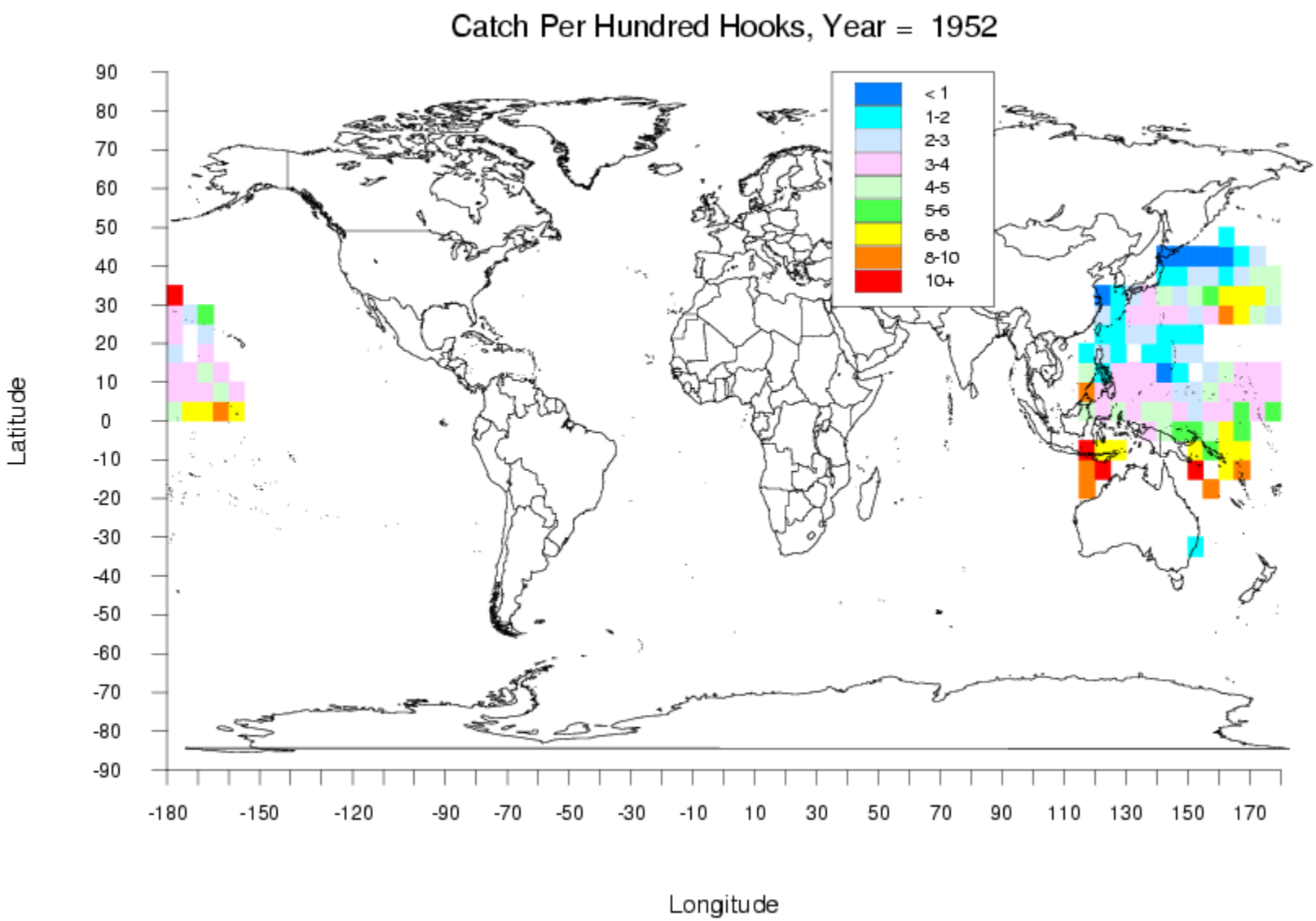
1990's

Oceanic Whitetip captures per 10,000 hooks



Baum and Myers, 2004 Ecology Letters

Plot to reveal truth.


Catch Per Hundred Hooks, Year = 1952
< 1
1-2
2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
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80
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-10
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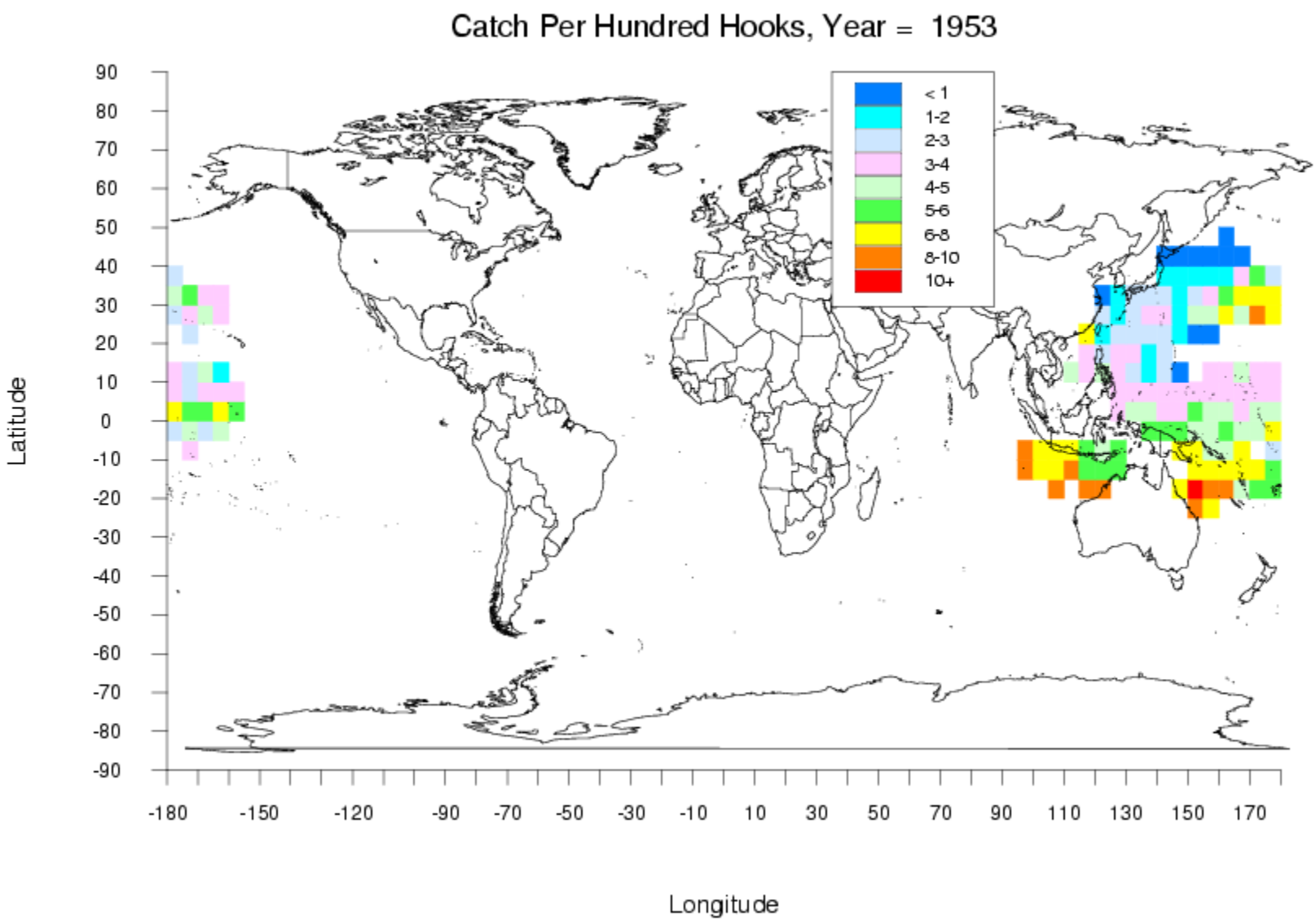
Longitude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2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
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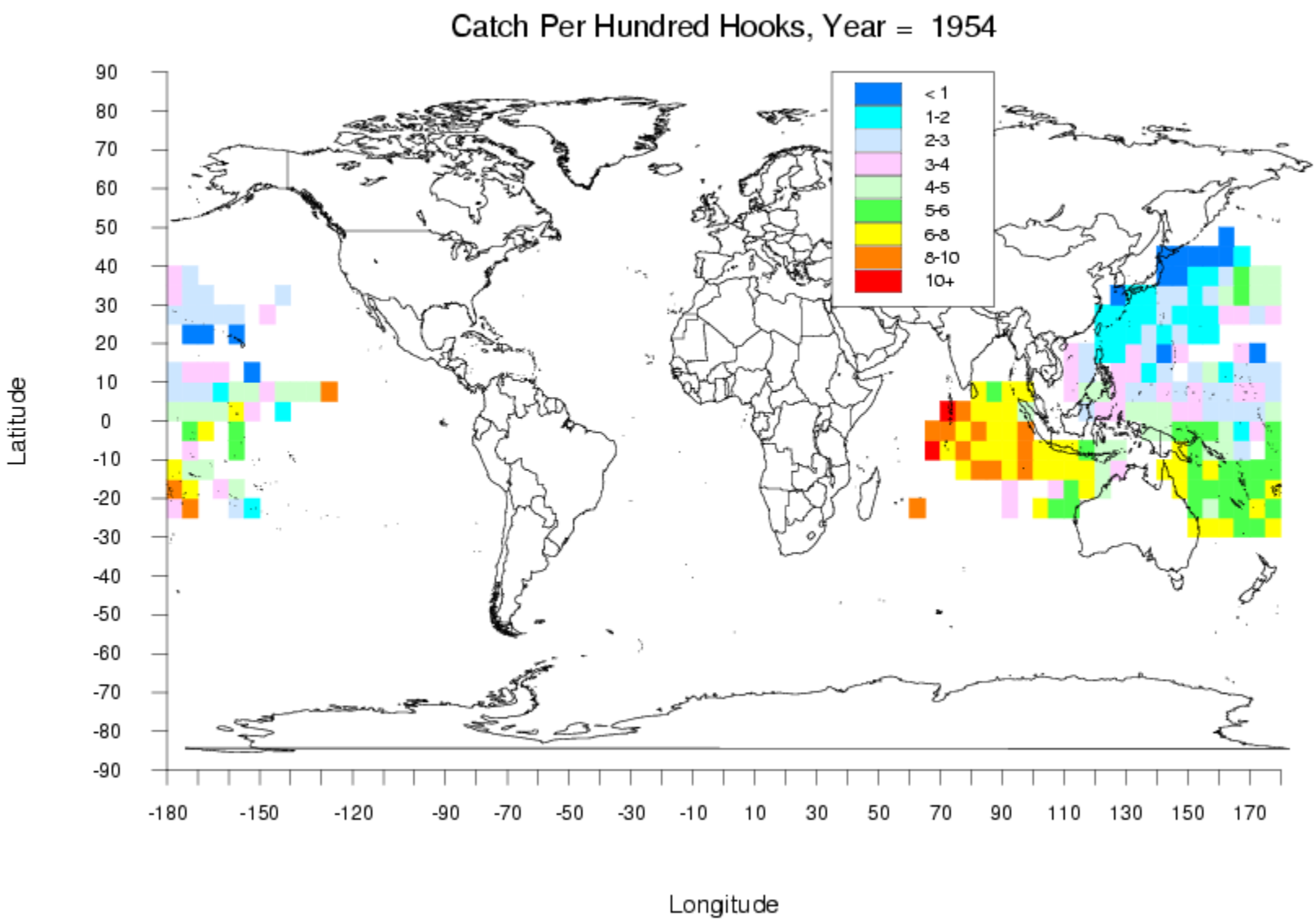
Longitude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3-4
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5-6
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8-10
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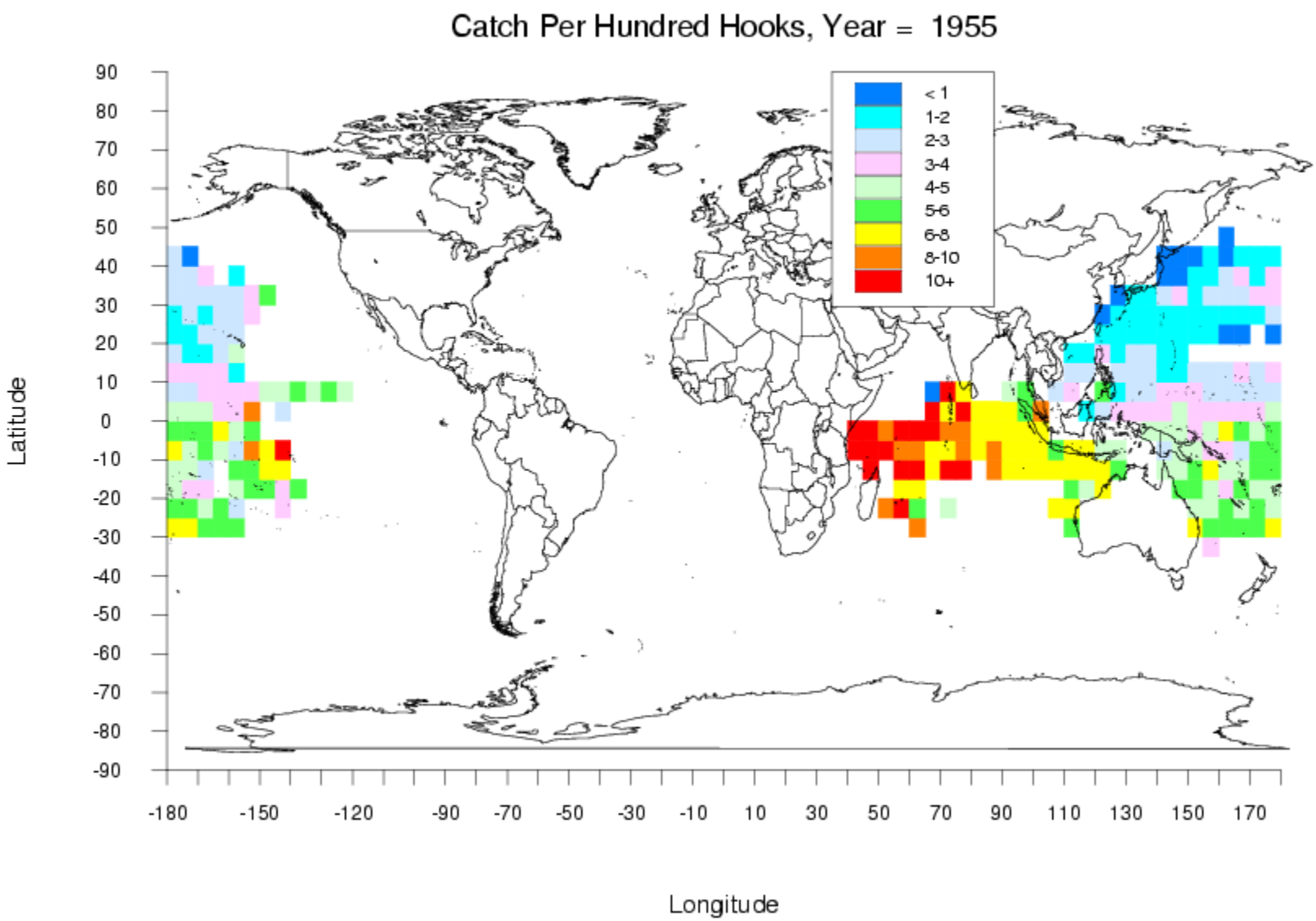
Longitude


Catch Per Hundred Hooks, Year = 1955
< 1
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8-10
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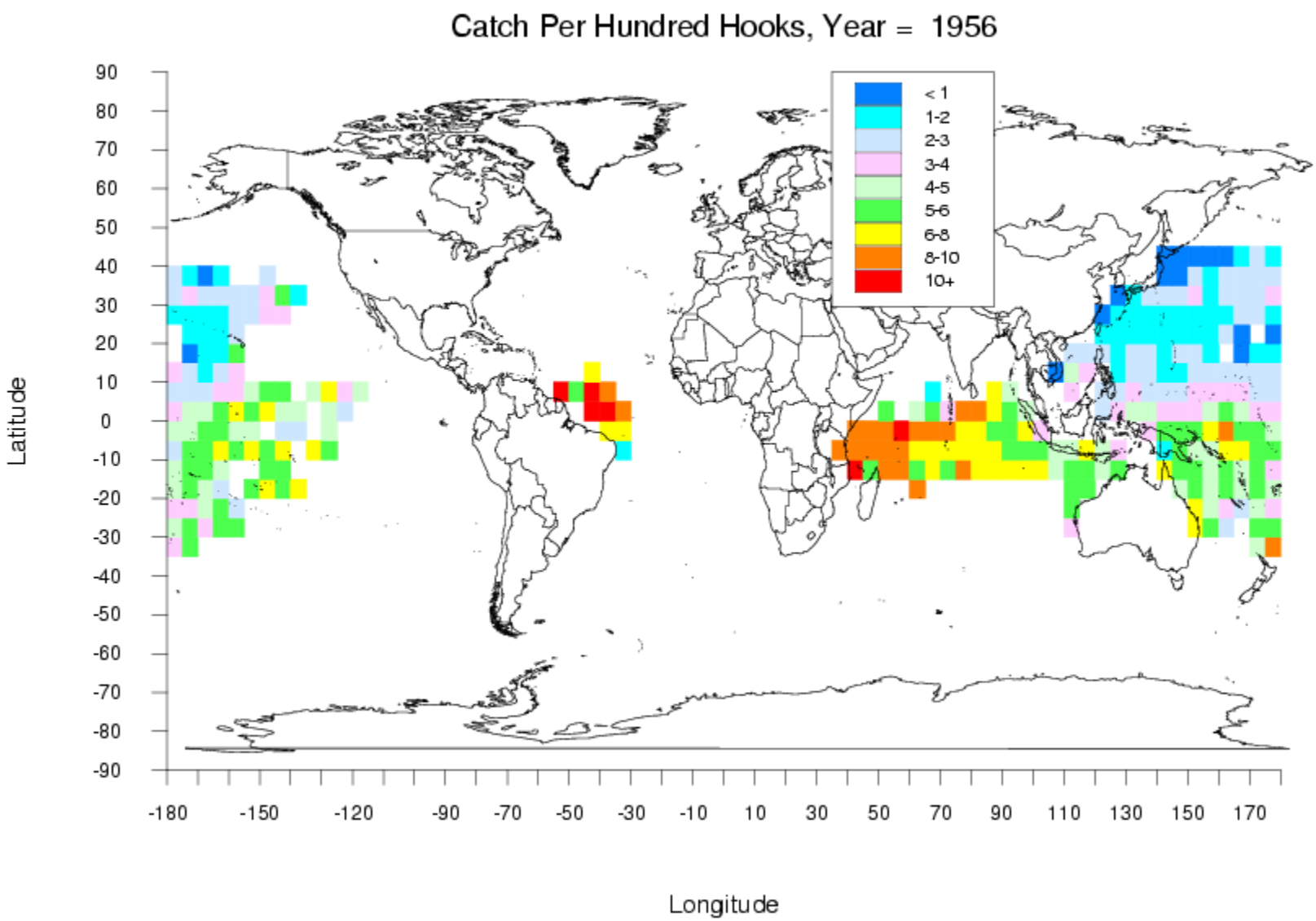
Longitude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Latitude
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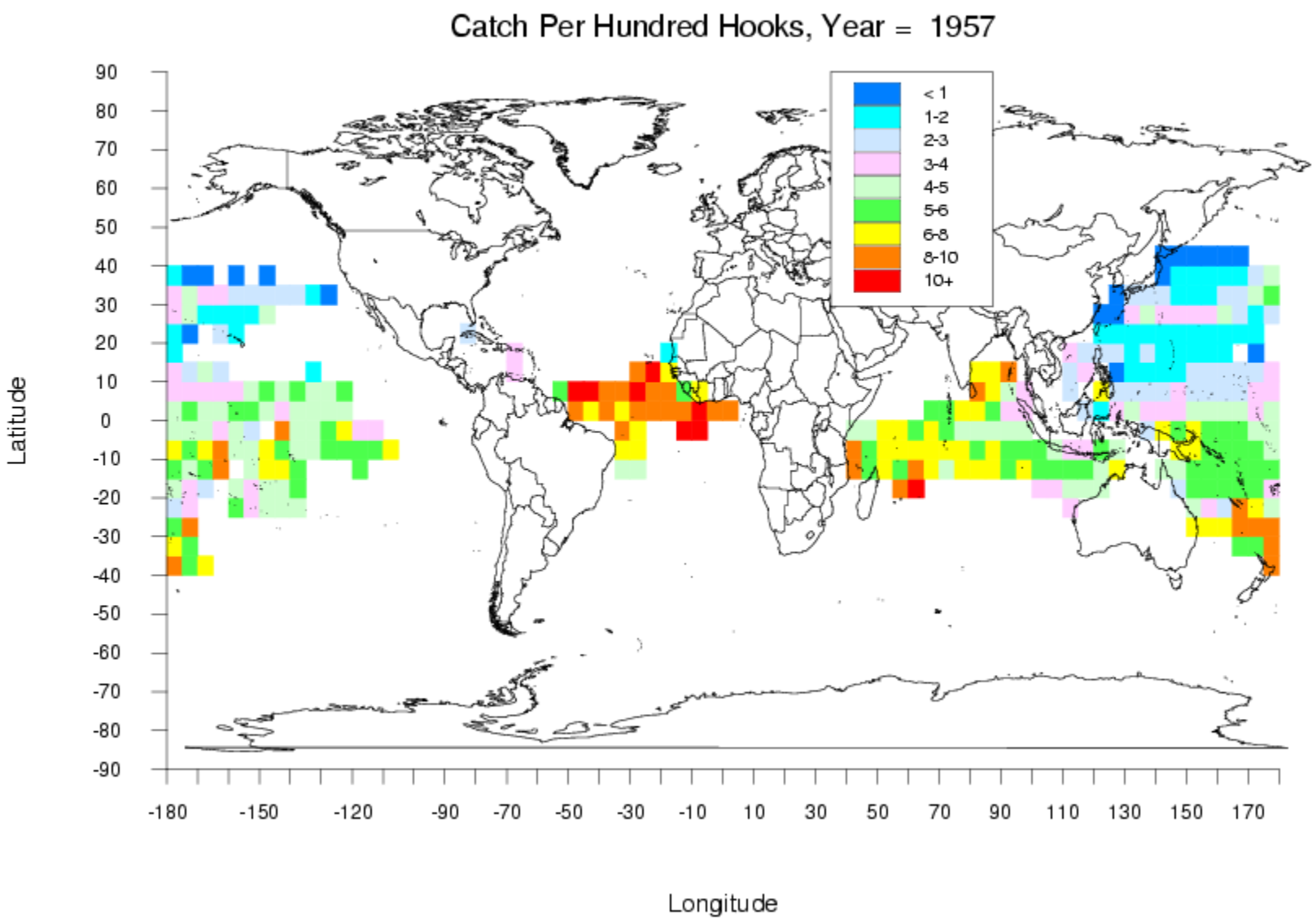
Longitude


Catch Per Hundred Hooks, Year = 1957
< 1
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6-8
8-10
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Latitude
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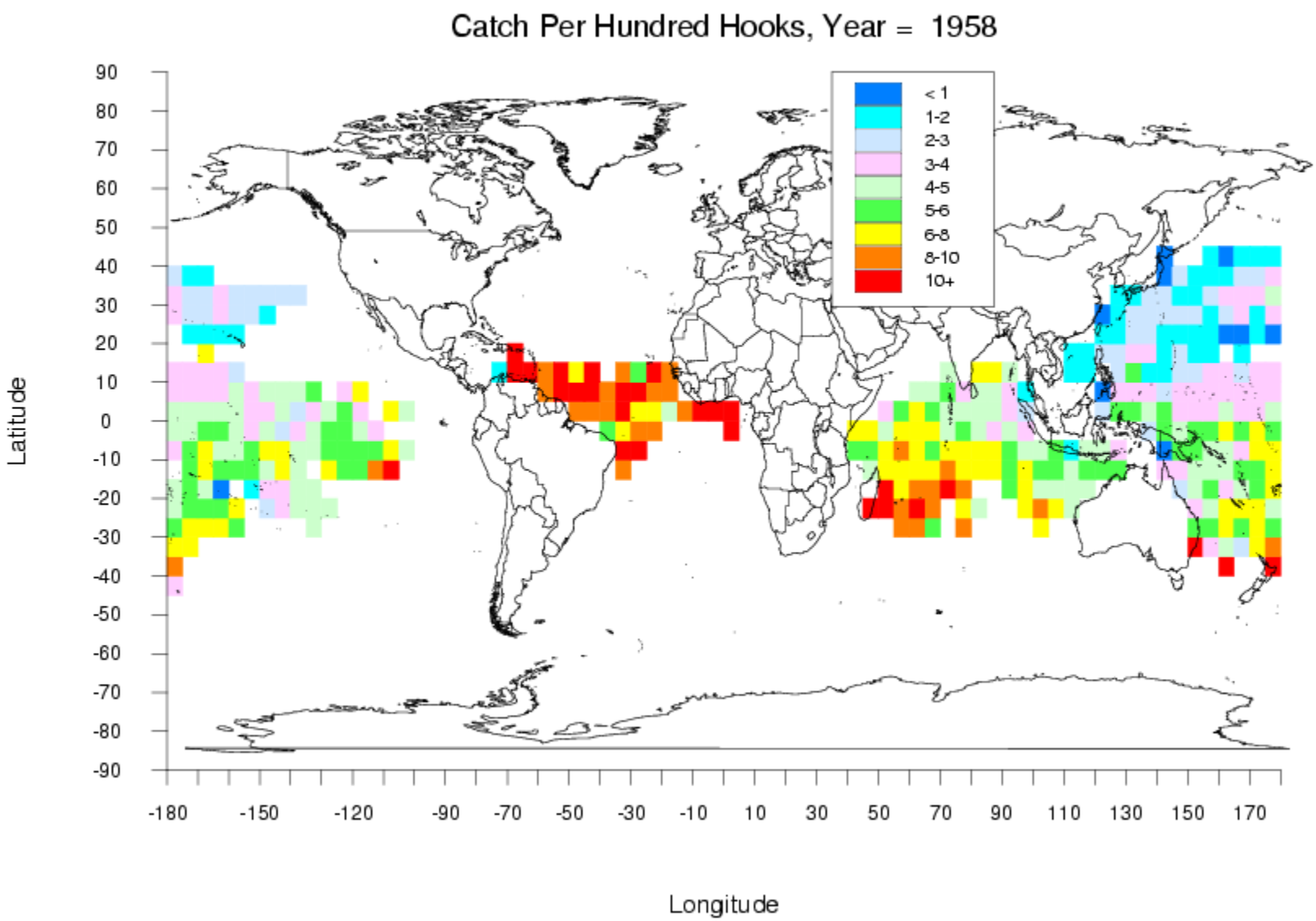
Longitude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< 1
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2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
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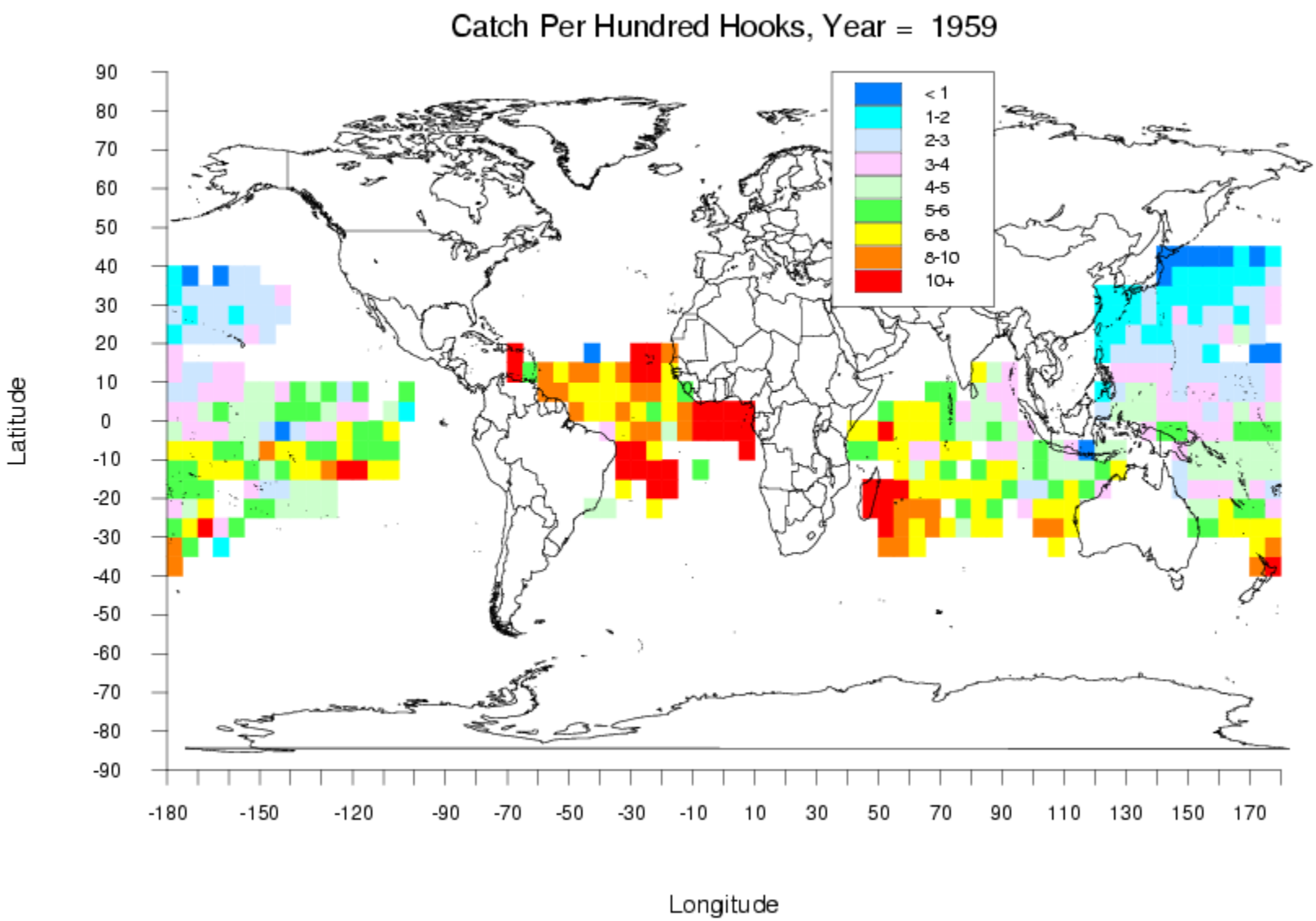
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2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
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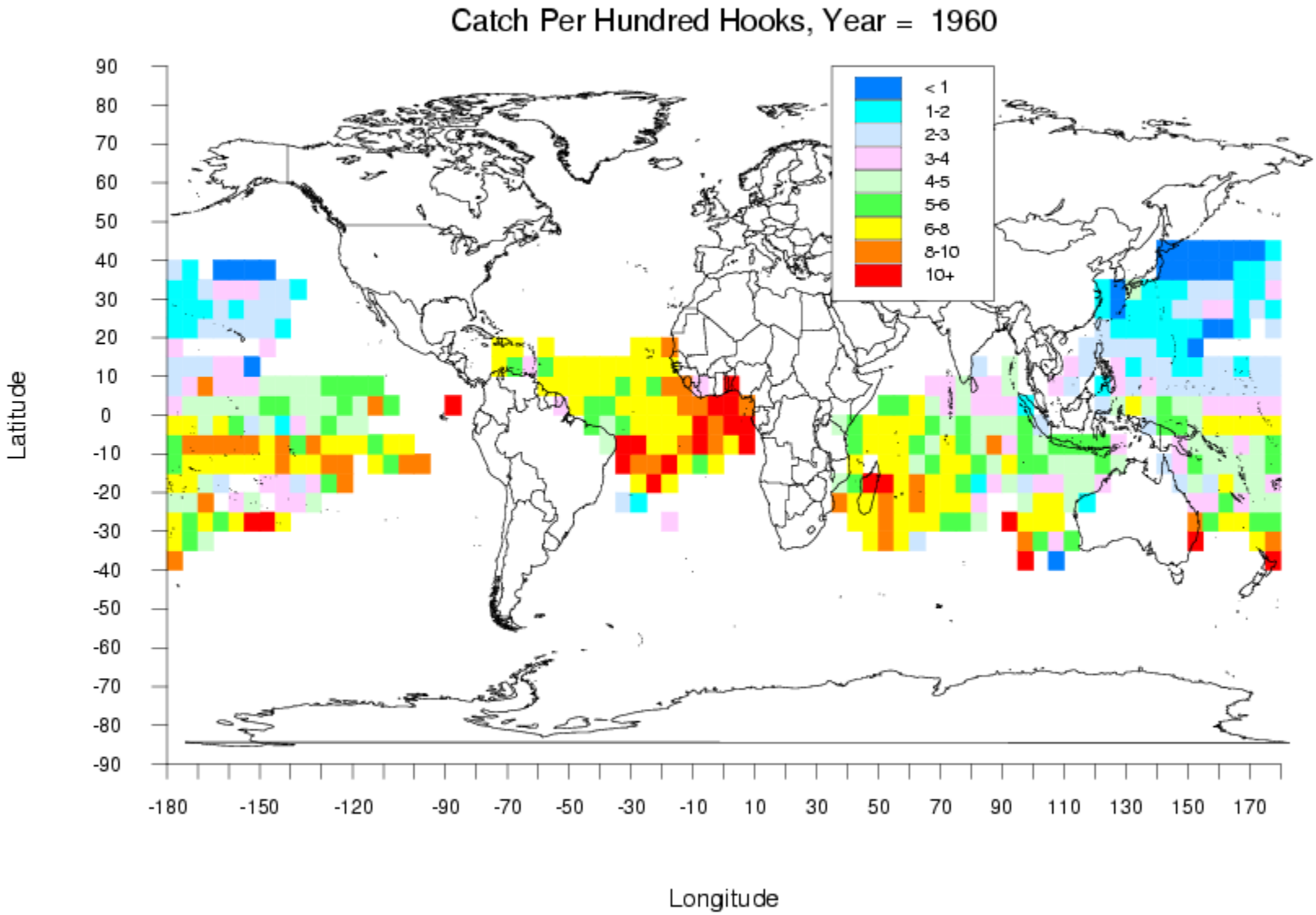
Longitude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5-6
6-8
8-10
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Latitude
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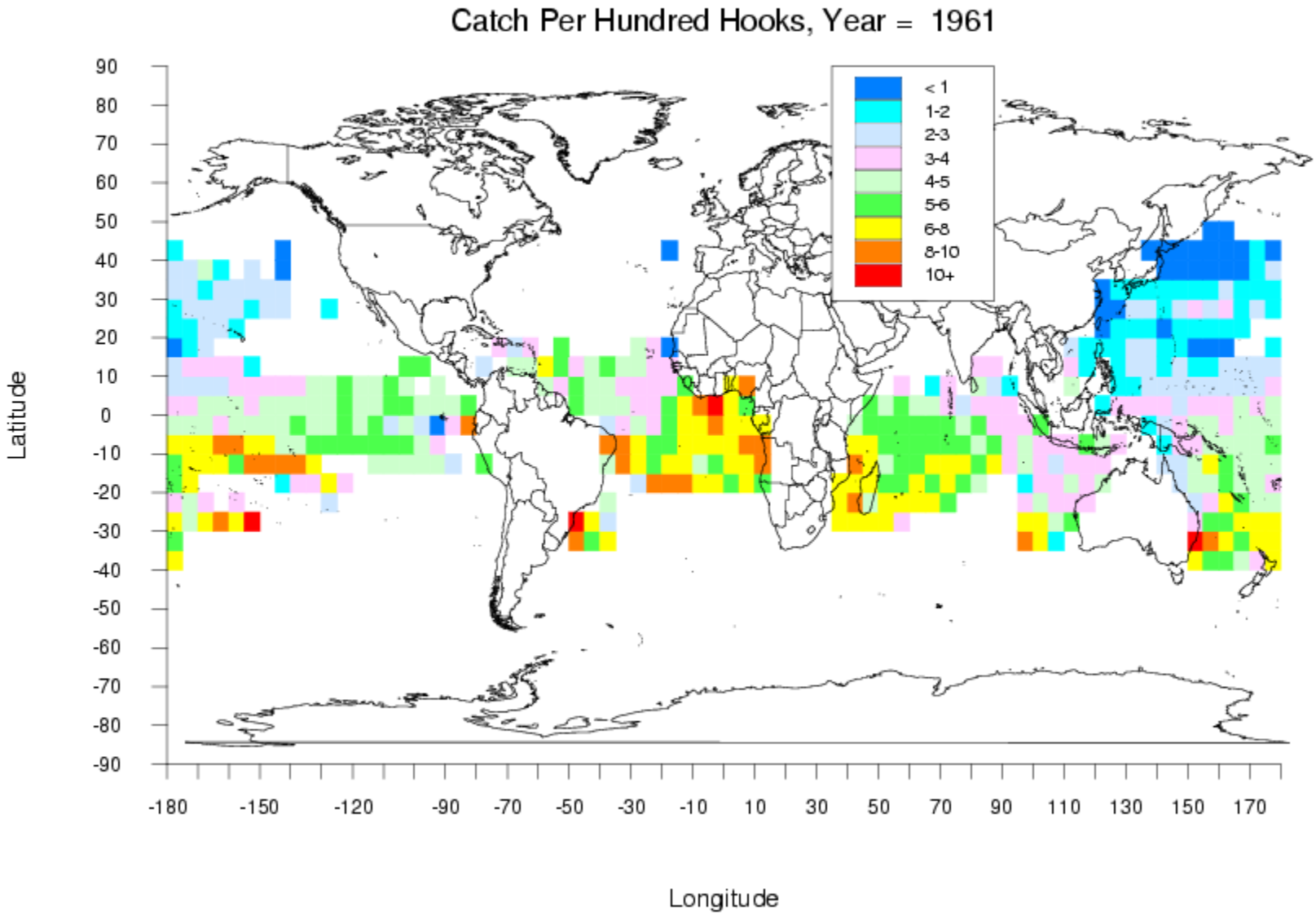
Longitude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3-4
4-5
5-6
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8-10
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Latitude
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80
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60
50
40
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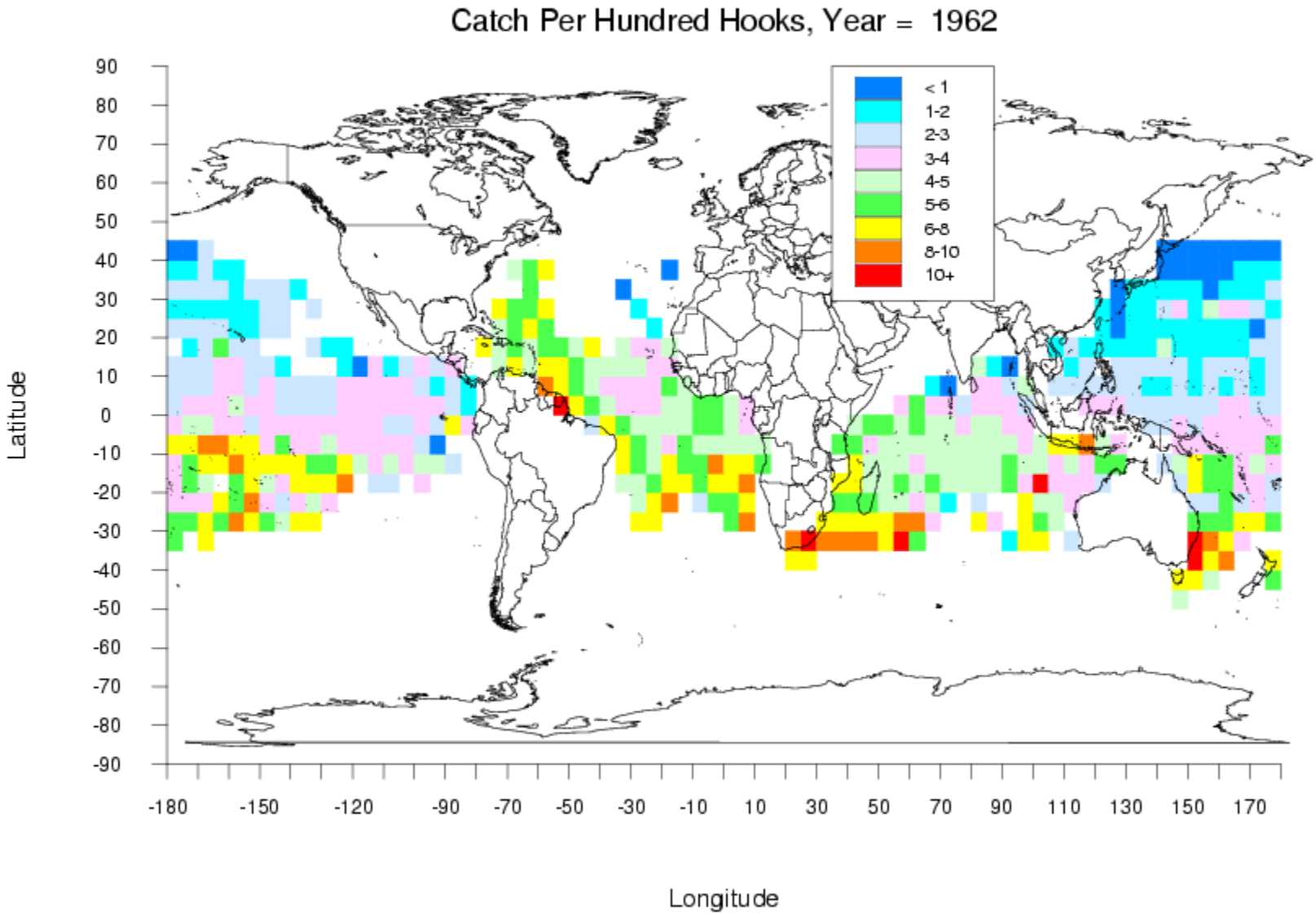
Longitude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< 1
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2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
90
80
70
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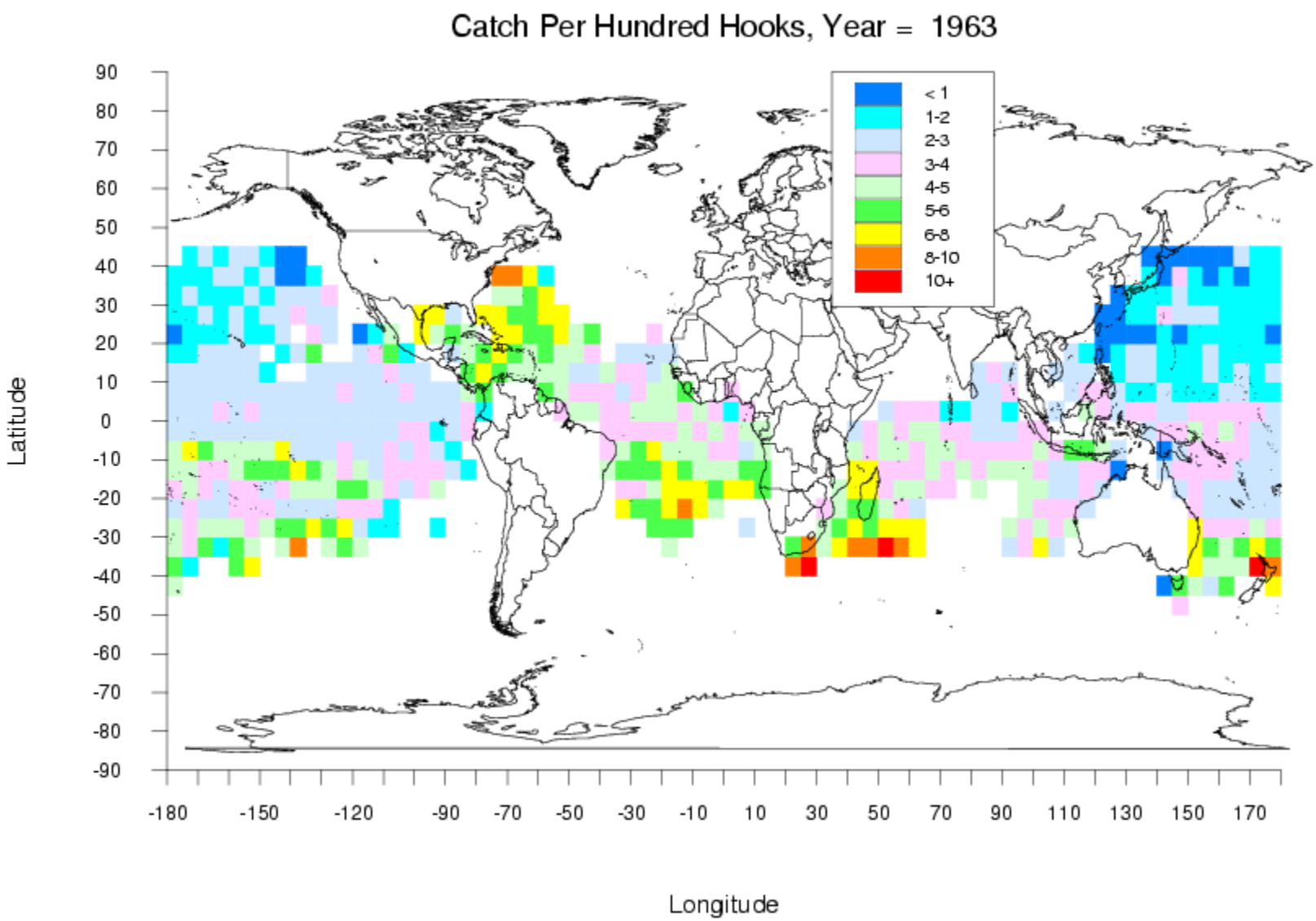
Longitude


Catch Per Hundred Hooks, Year = 1963
< 1
1-2
2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
90
80
70
60
50
40
30
20
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0
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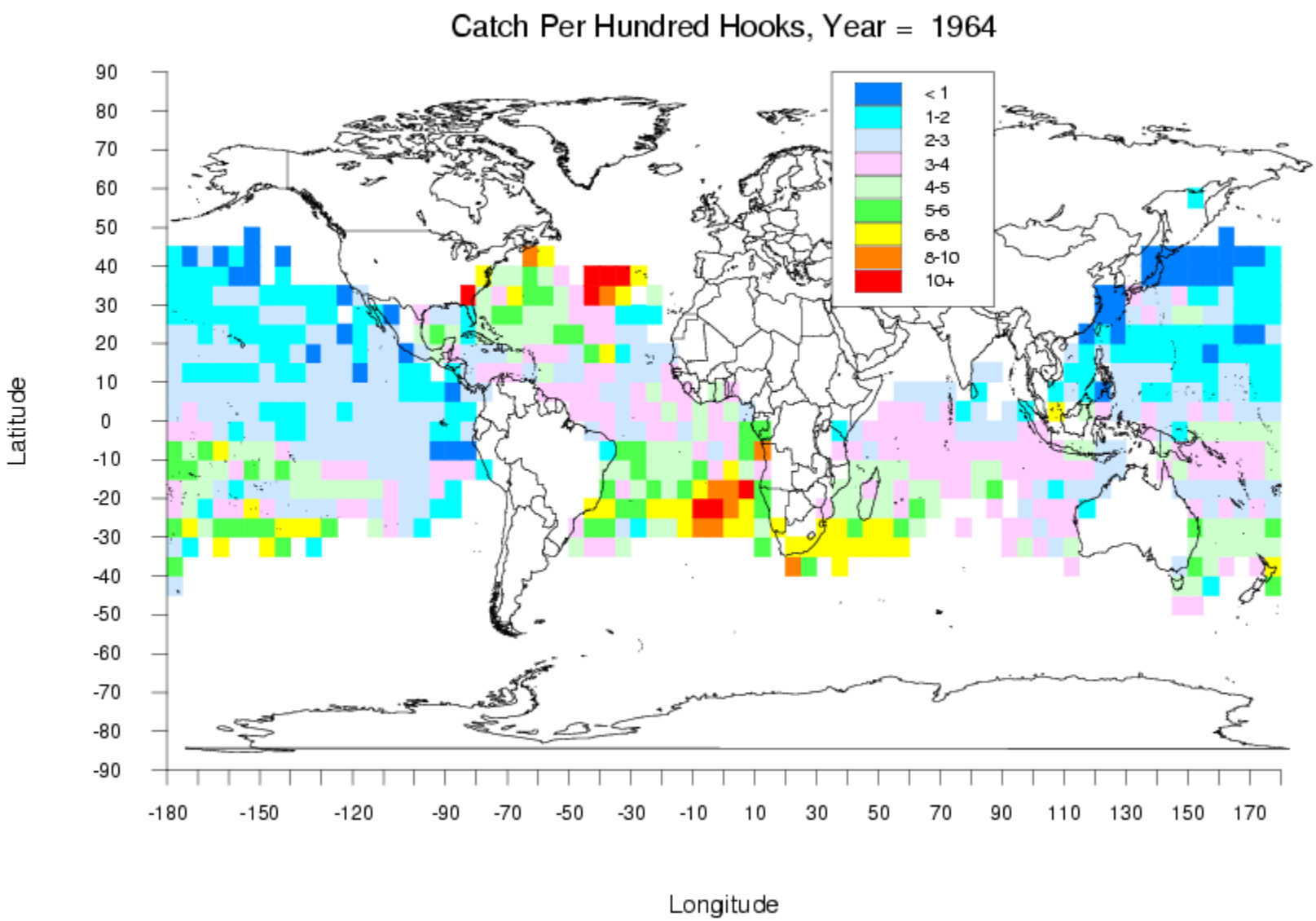
Catch Per Hundred Hooks, Year = 1964
< 1
1-2
2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
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80
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60
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30
20
10
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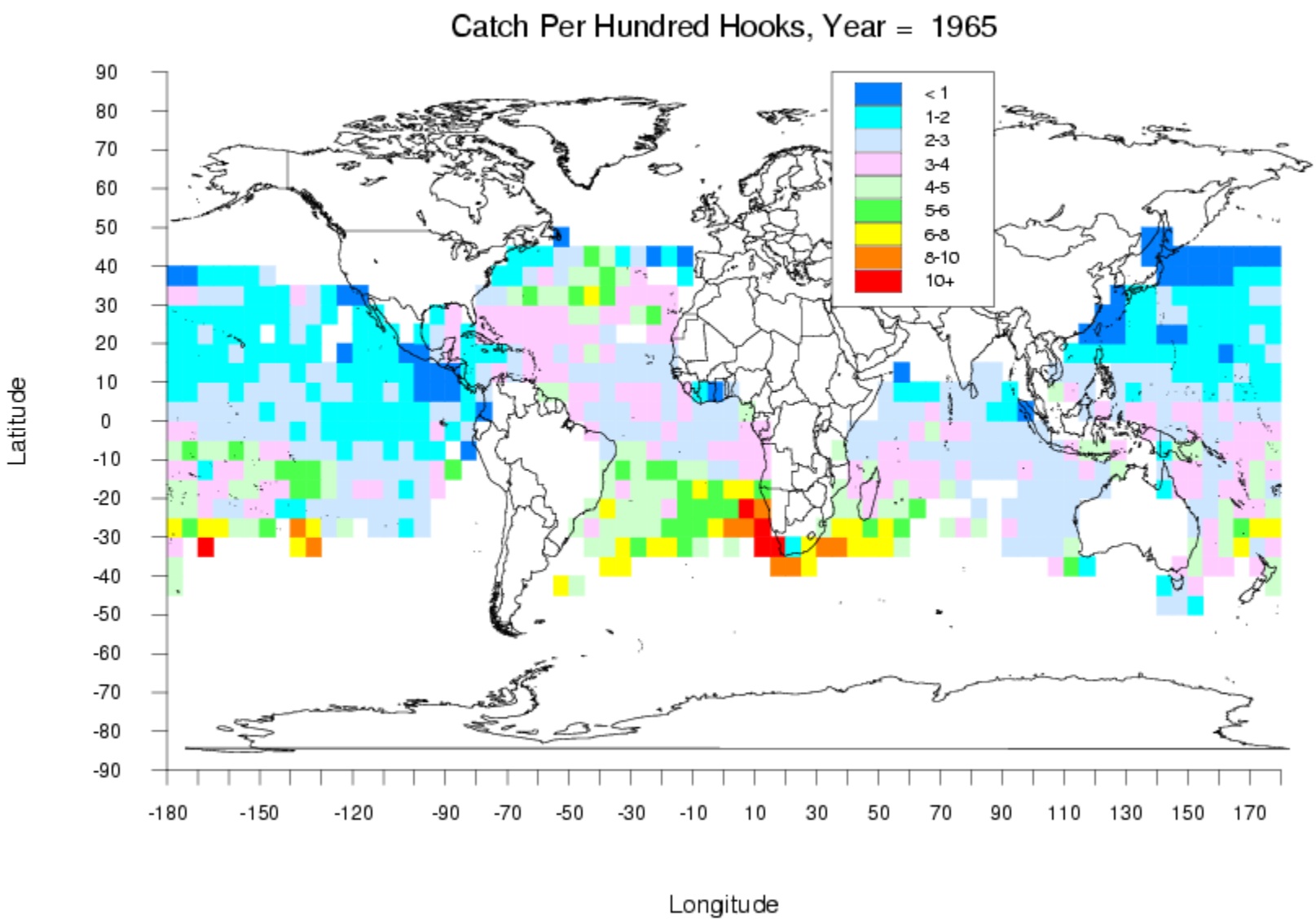
Longitude


Catch Per Hundred Hooks, Year = 1965
< 1
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2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
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40
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20
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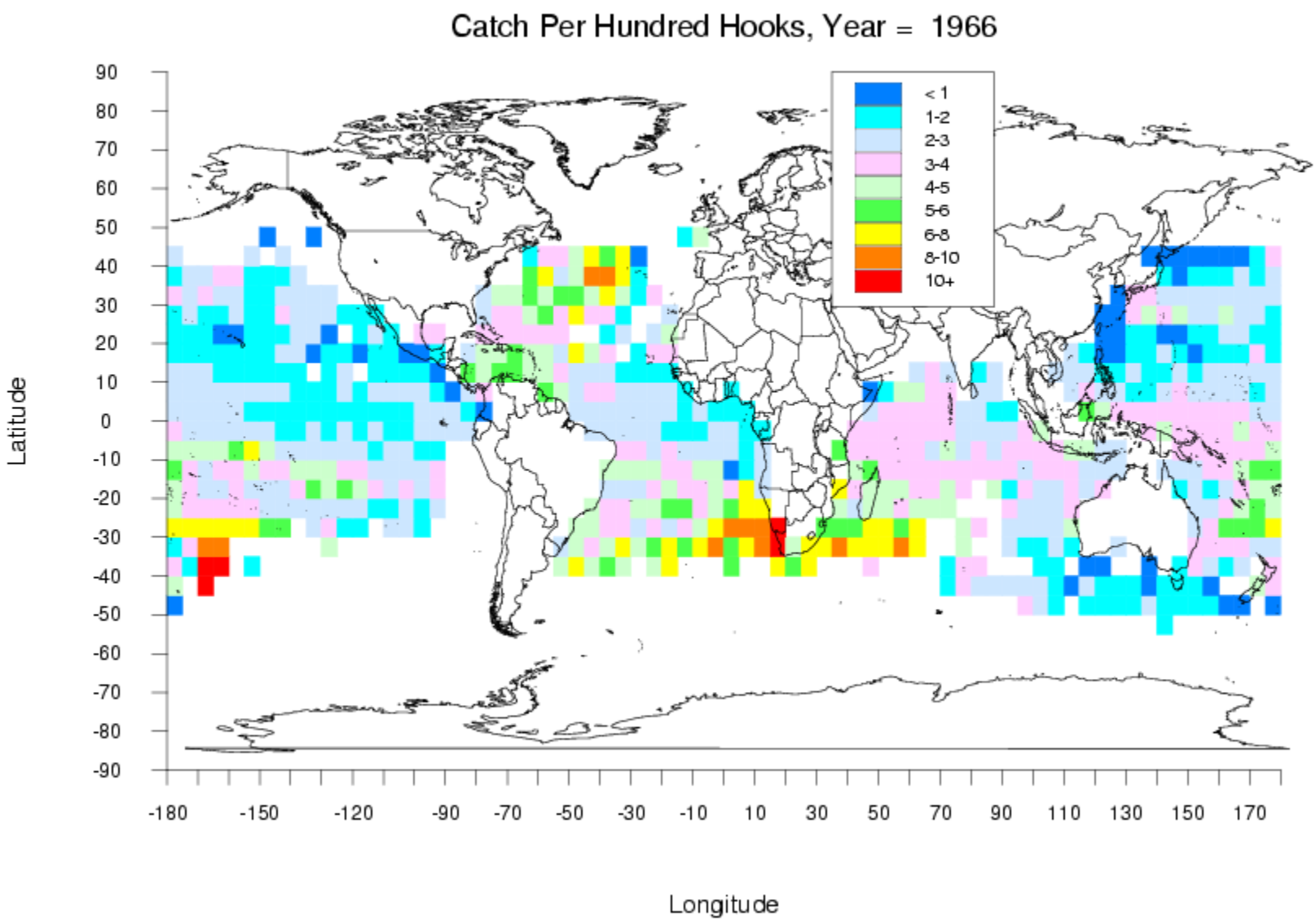
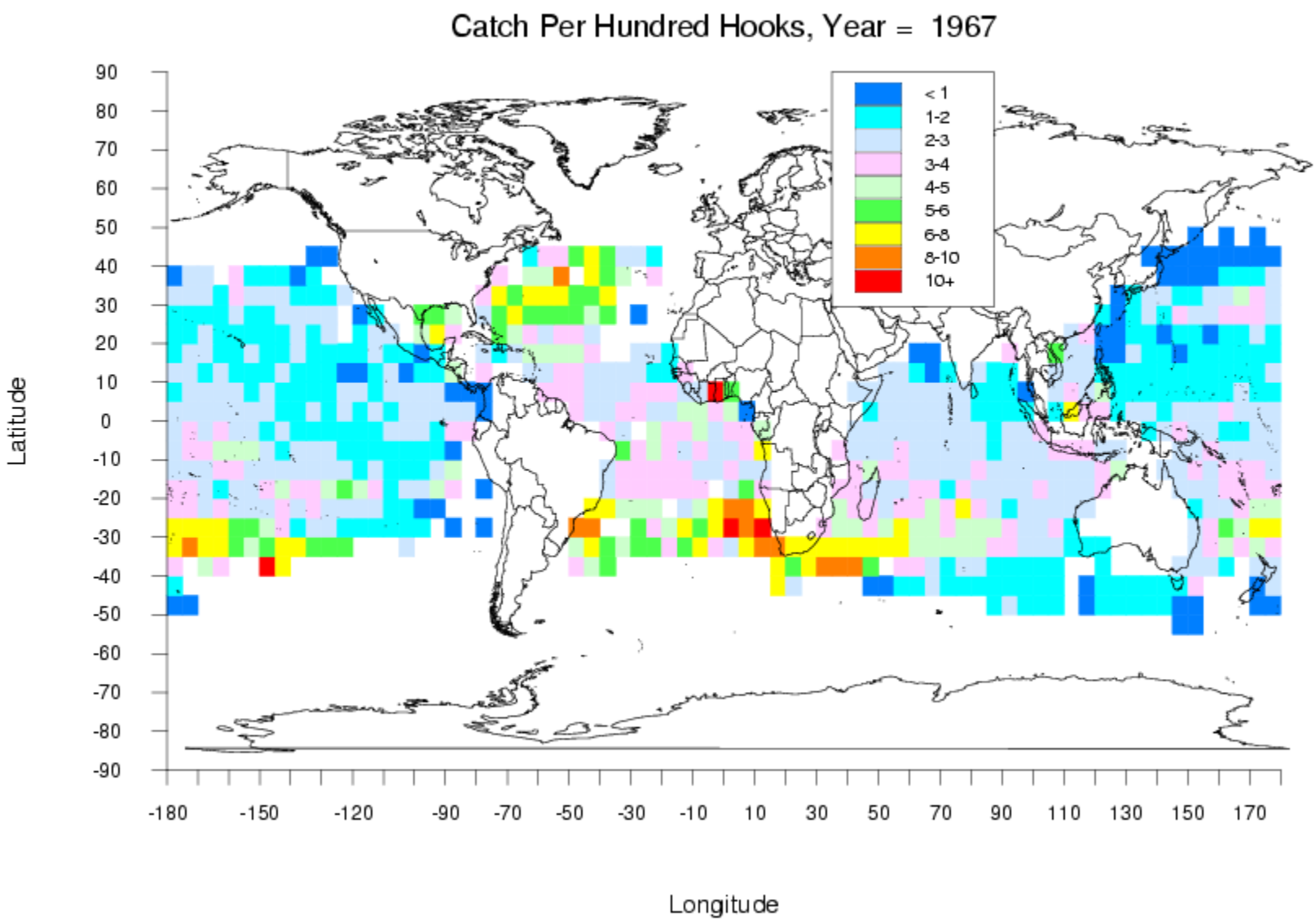
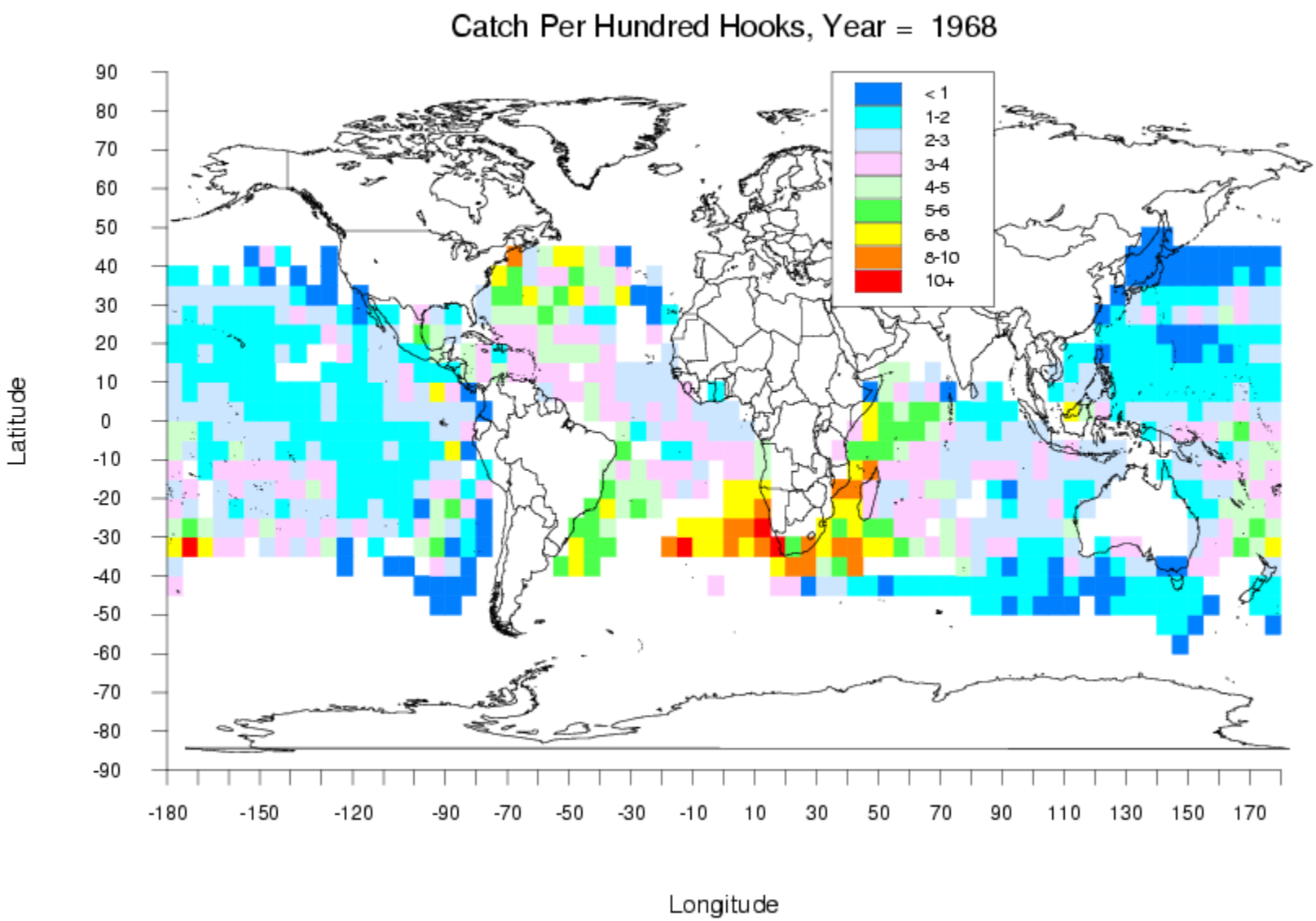
-80
-90
-180
-150
-120
-90
-70
-50
-30
-10
10
30
50
70
90
110
130
150
170
Longitude


Catch Per Hundred Hooks, Year = 1966
< 1
1-2
2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-180
-150
-120
-90
-70
-50
-30
-10
10
30
50
70
90
110
130
150
170
Longitude


Catch Per Hundred Hooks, Year = 1967
< 1
1-2
2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-180
-150
-120
-90
-70
-50
-30
-10
10
30
50
70
90
110
130
150
170
Longitude


Catch Per Hundred Hooks, Year = 1968
< 1
1-2
2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-180
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130
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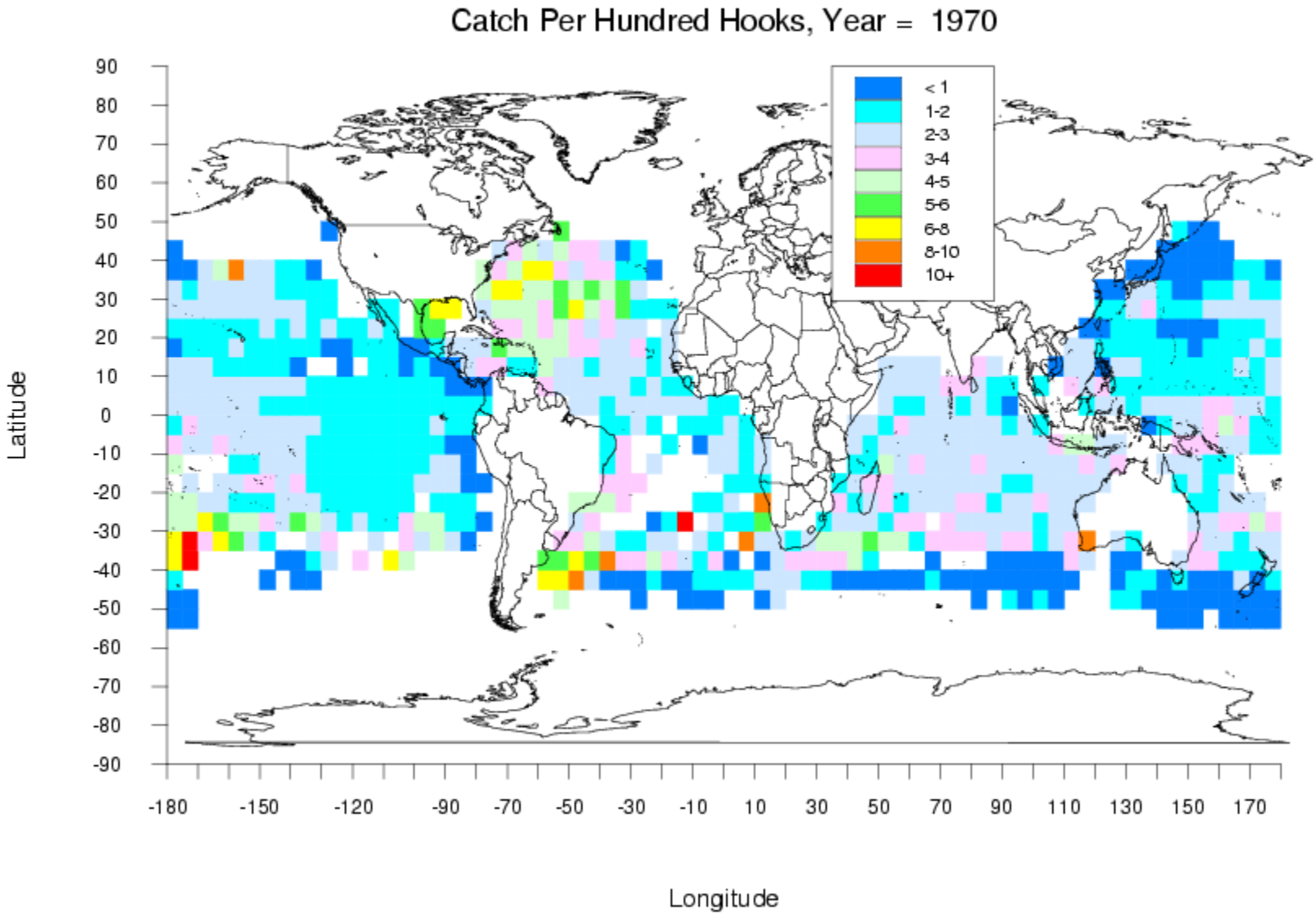
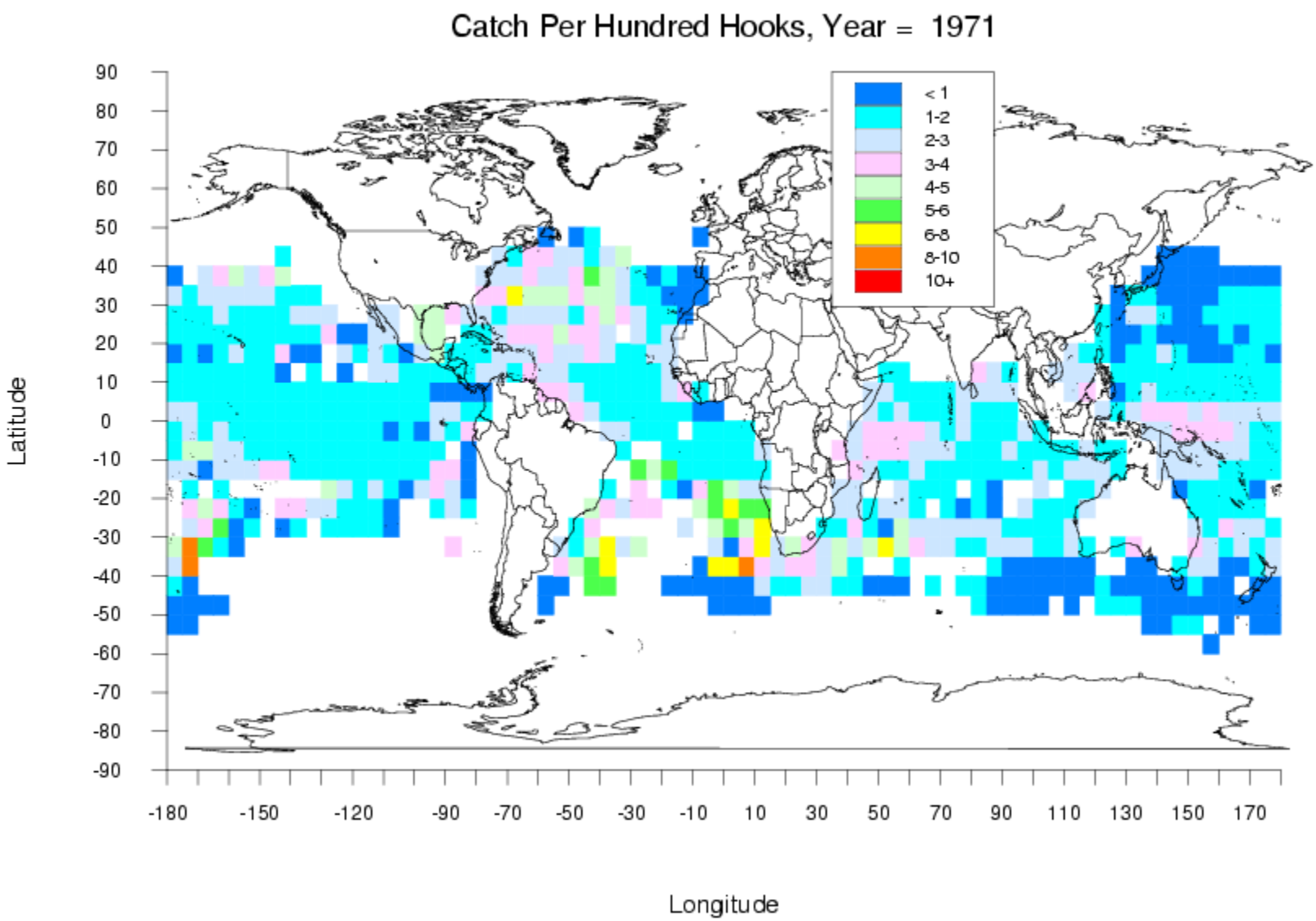
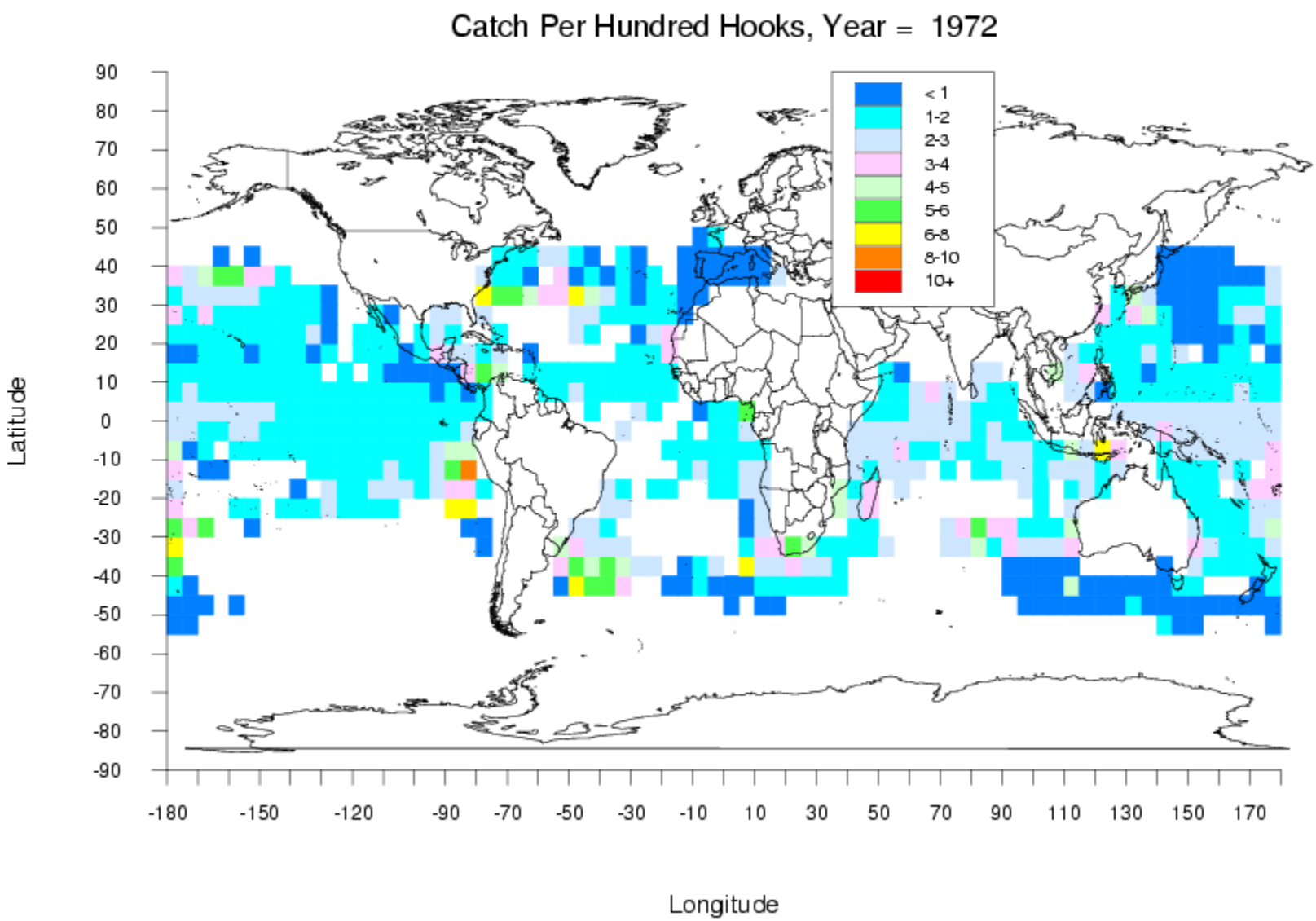
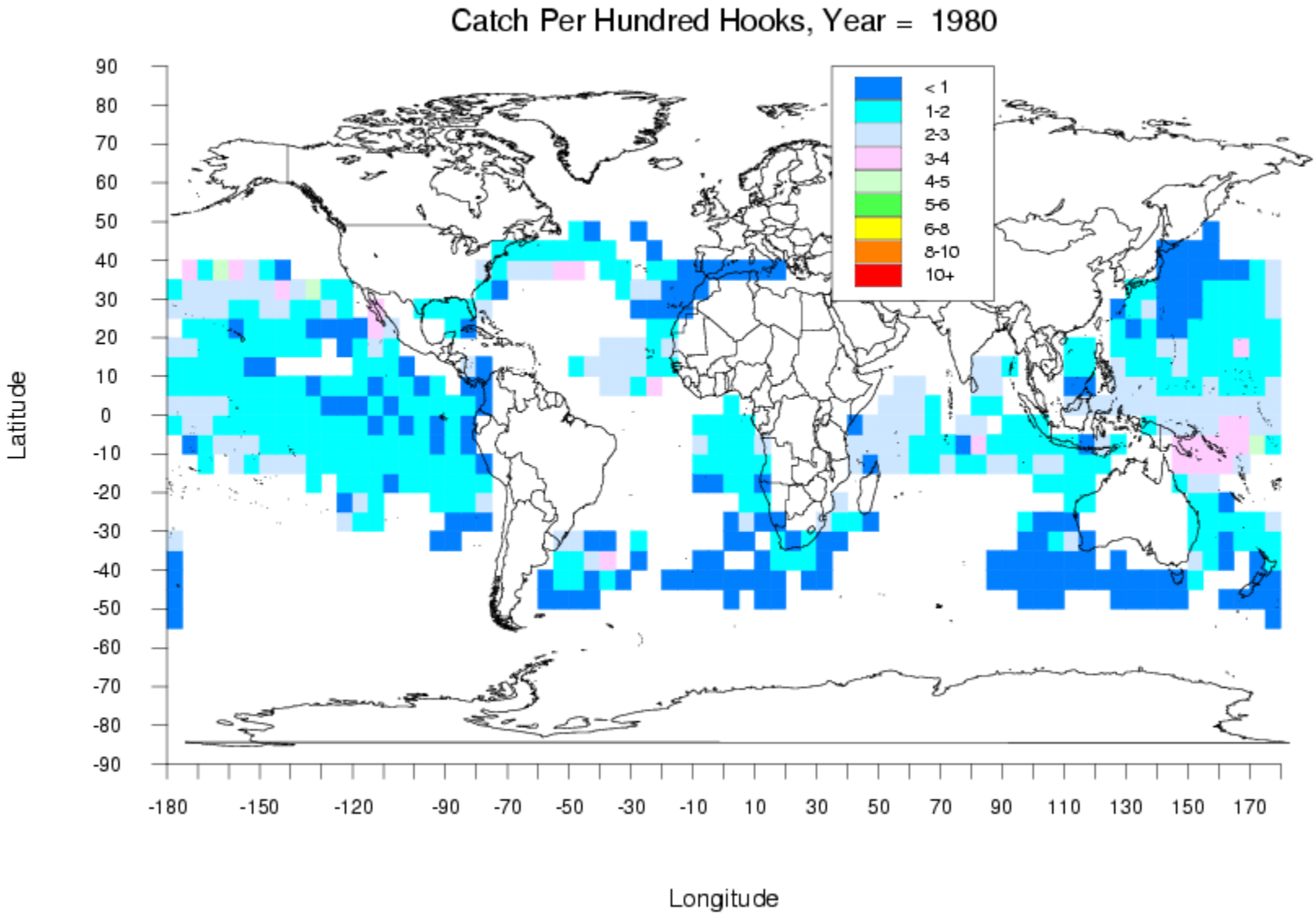
170
Longitude


Catch Per Hundred Hooks, Year = 1970
< 1
1-2
2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-180
-150
-120
-90
-70
-50
-30
-10
10
30
50
70
90
110
130
150
170
Longitude


Catch Per Hundred Hooks, Year = 1971
< 1
1-2
2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-180
-150
-120
-90
-70
-50
-30
-10
10
30
50
70
90
110
130
150
170
Longitude


Catch Per Hundred Hooks, Year = 1972
< 1
1-2
2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-180
-150
-120
-90
-70
-50
-30
-10
10
30
50
70
90
110
130
150
170
Longitude


Catch Per Hundred Hooks, Year = 1980
< 1
1-2
2-3
3-4
4-5
5-6
6-8
8-10
10+
Latitude
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-180
-150
-120
-90
-70
-50
-30
-10
10
30
50
70
90
110
130
150
170
Longitude

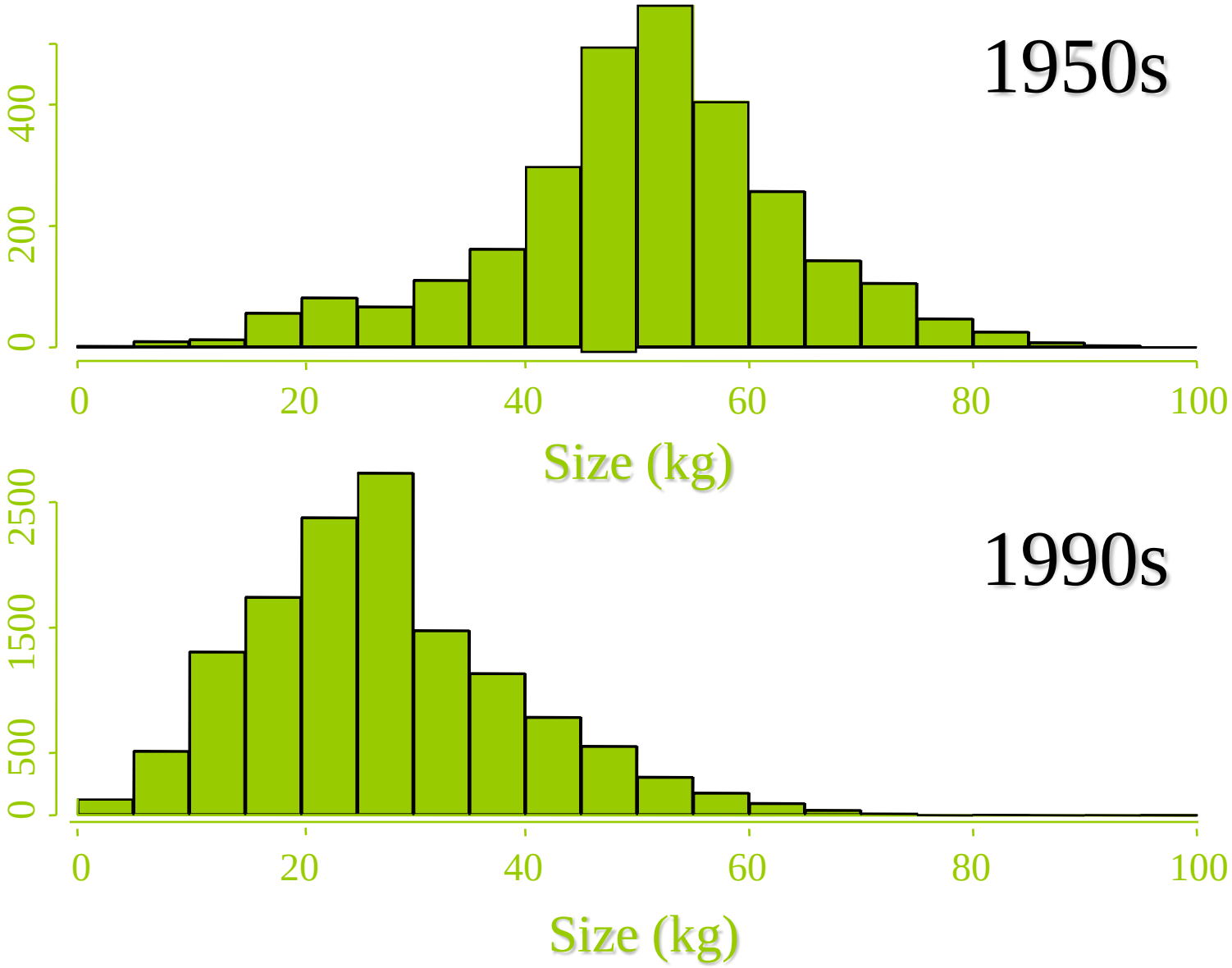
Ask the right question

The WRONG Question:
Tuna agencies have never
Corrected for an obvious, and
Important source of bias:

~25-30% of tropical tunas were initially not counted because of shark damage.

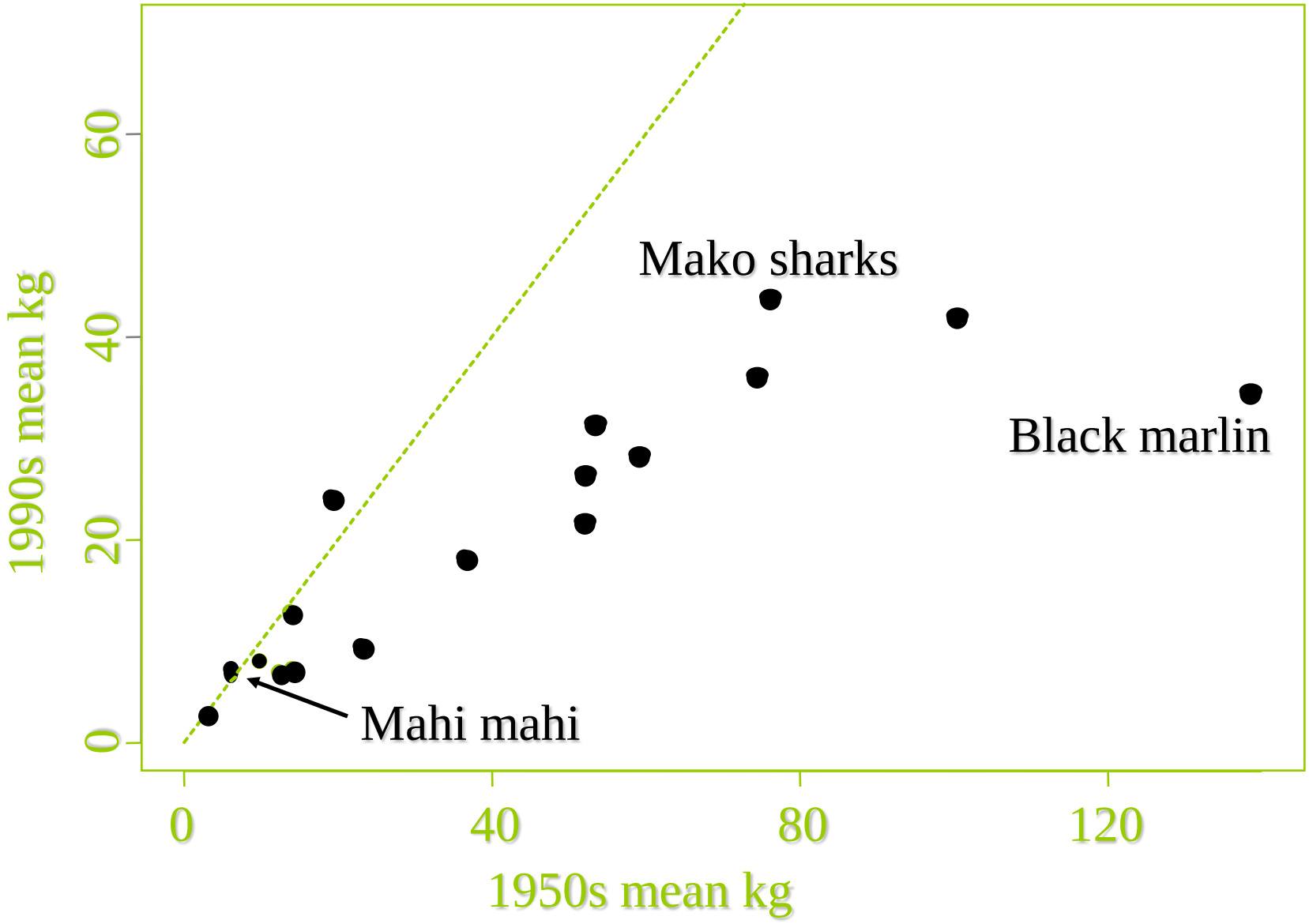
The WRONG Question

Tuna are now smaller



Yellowfin tuna – equitorial Pacific

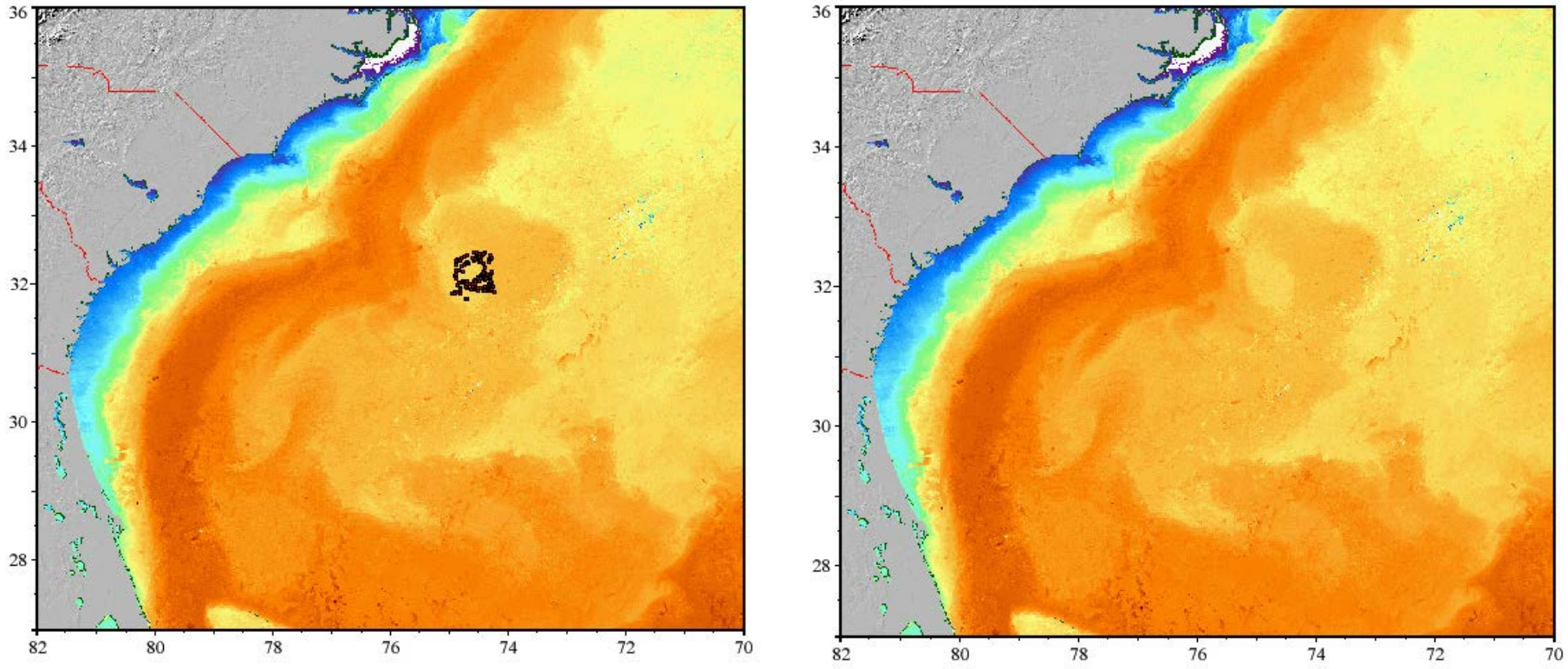
Change in body size



The oceans were not virgin when data began.

- 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.
- Species that migrate long distances (e.g. southern bluefin tuna, northern bluefin tuna, and albacore) would have reduced by these harvests.

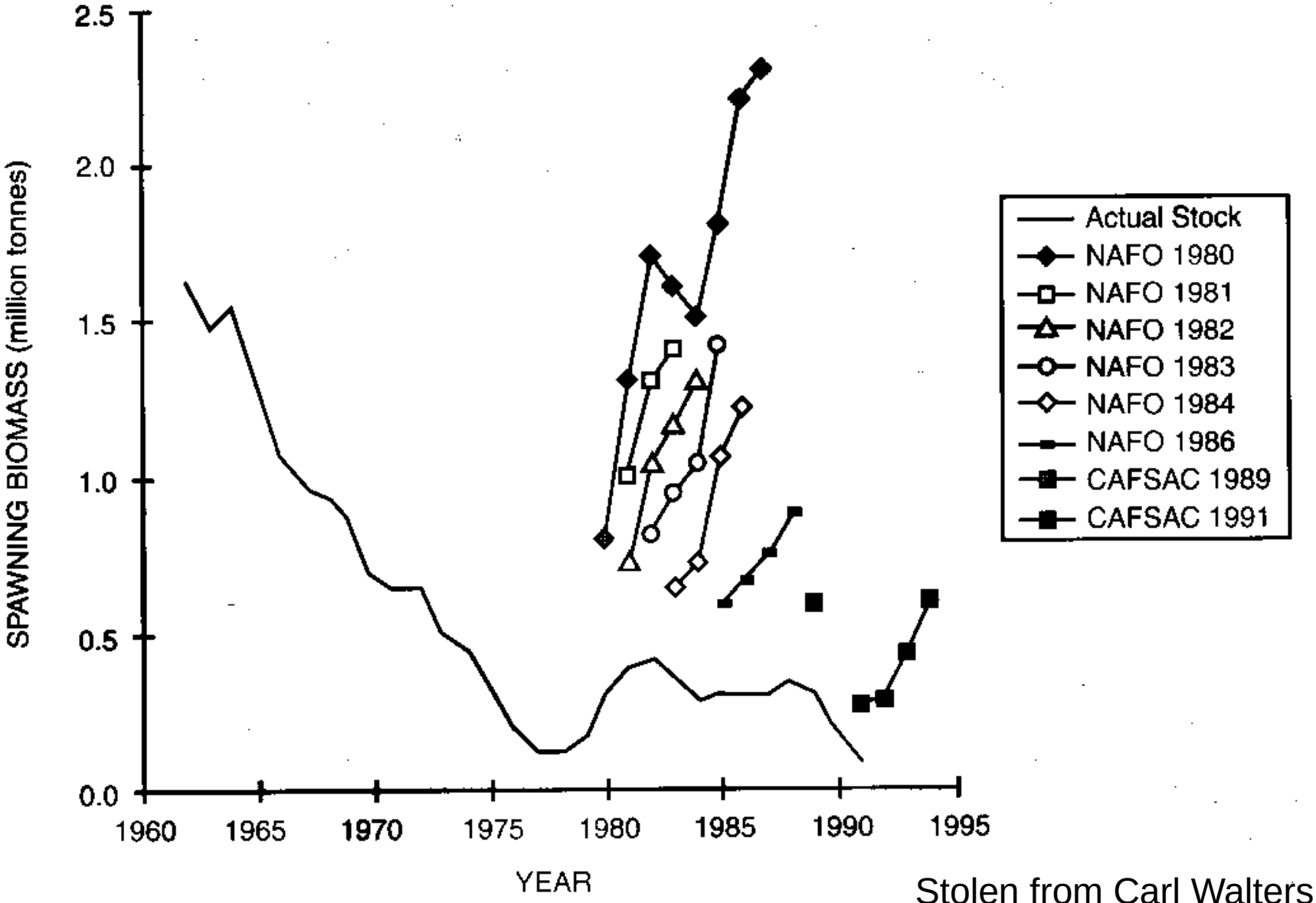
Another WRONG question: Does GPS, satellite information, **ACDP** (Acoustic Current Doppler Profiler)).



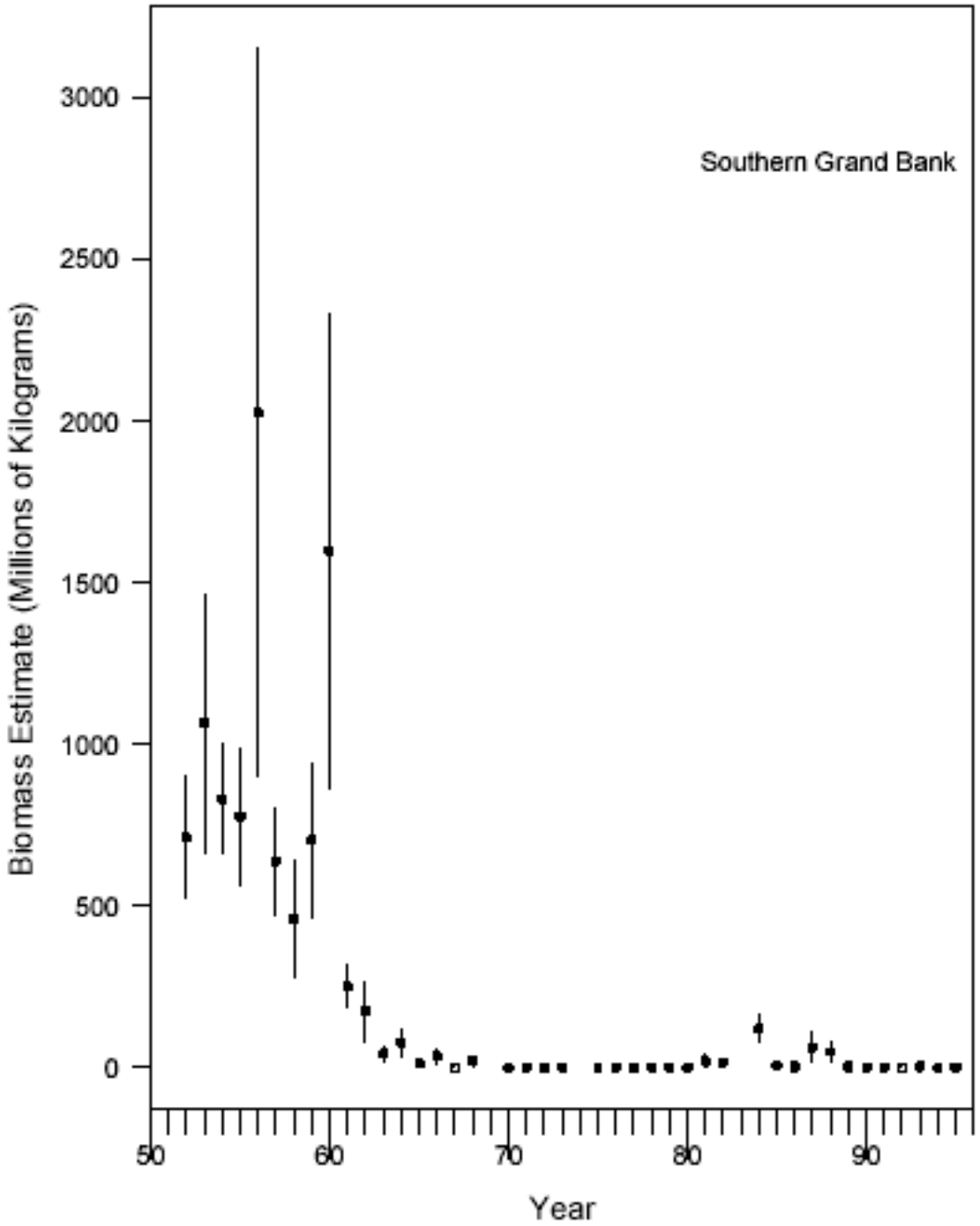
Locations of a leatherback turtle over a two week period tagged by my student Mike James that maintains its position within a cold core ring (somehow).

However, fish may be a lot smarter too (the stupid ones were caught).

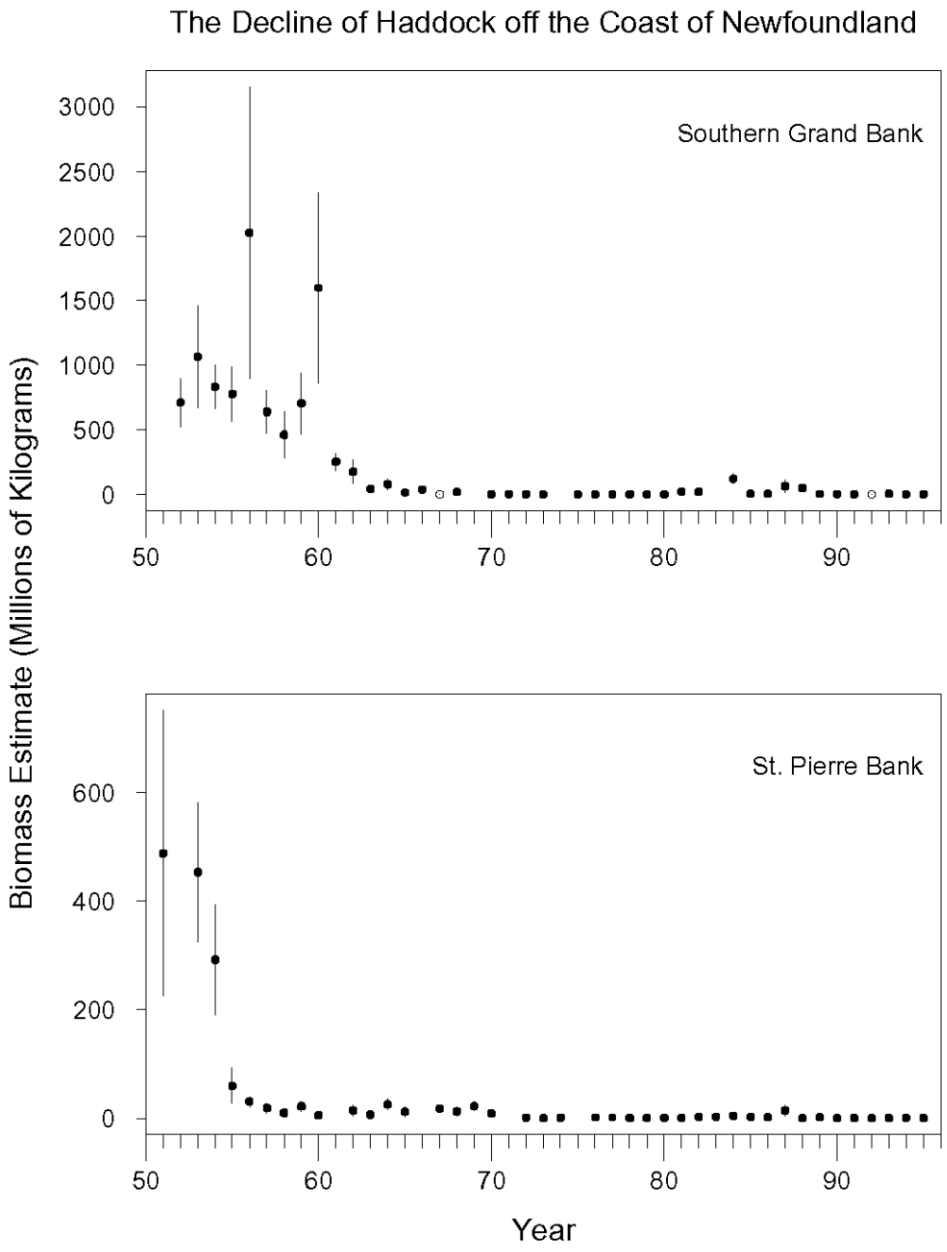
Government science was consistently wrong, and there was no effective voice from universities.

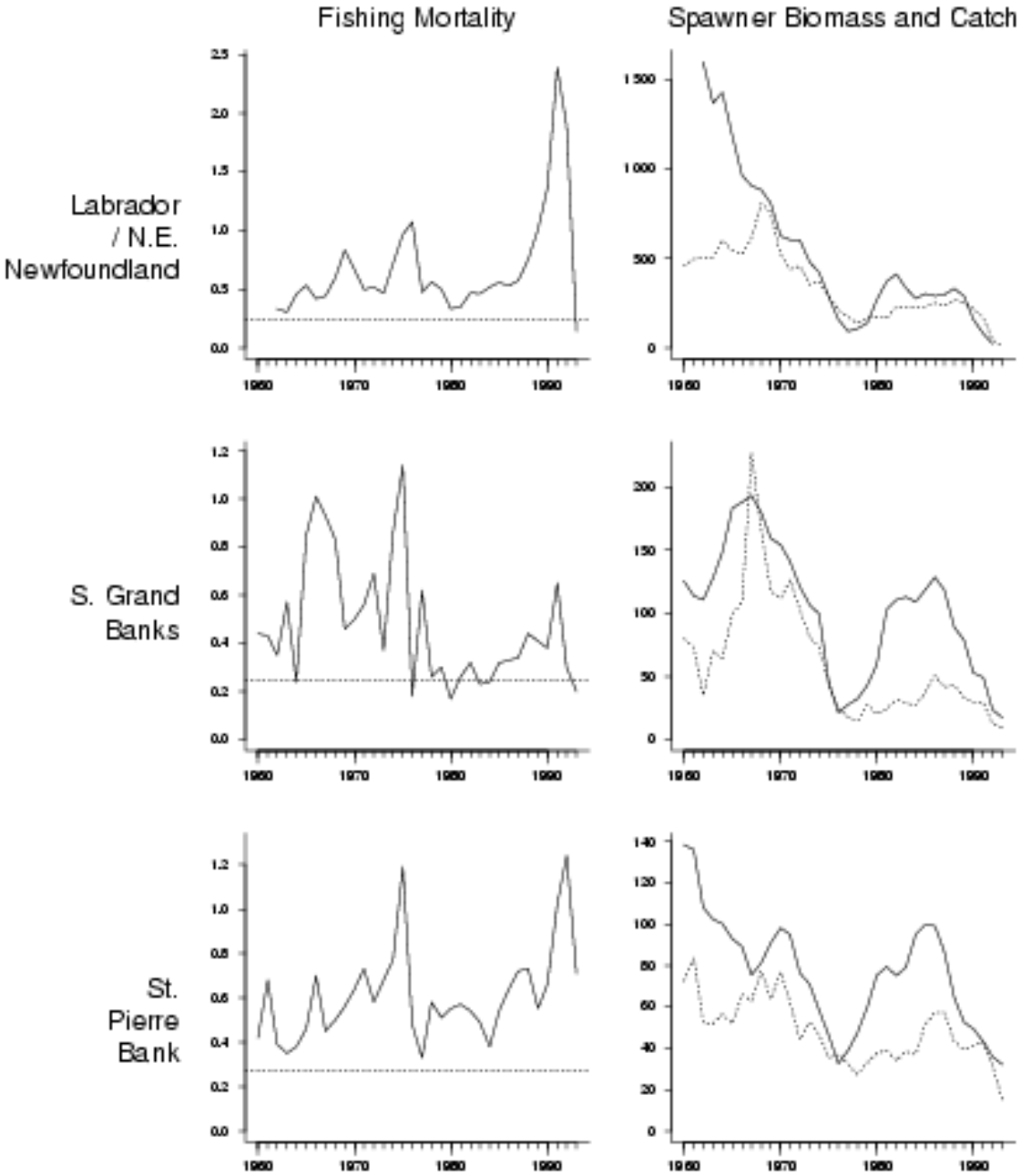


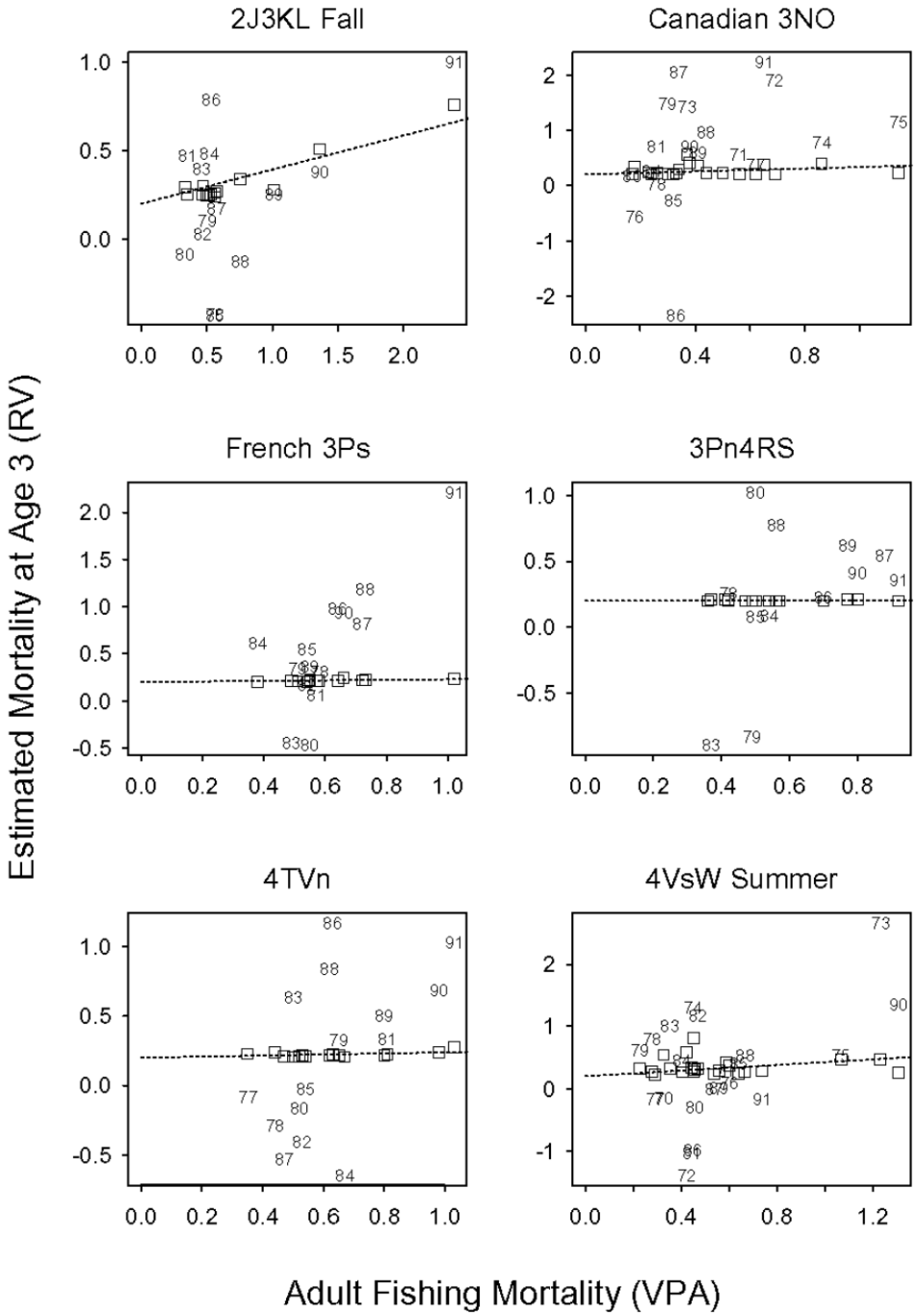
Stolen from Carl Walters



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


The Decline of Haddock off the Coast of Newfoundland
Southern Grand Bank
St. Pierre Bank
Biomass Estimate (Millions of Kilograms)
Year
0
500
1000
1500
2000
2500
3000
200
400
600
50
60
70
80
90


Fishing Mortality
Spawner Biomass and Catch
Labrador / N.E. Newfoundland
S. Grand Banks
St. Pierre Bank
Year


2J3KL Fall
Canadian 3NO
French 3Ps
3Pn4RS
4TVn
4VsW Summer
Estimated Mortality at Age 3 (RV)
Adult Fishing Mortality (VPA)

How to carry our a grossly incompetent assessment: get a useless opinion from someone who has not read the paper.

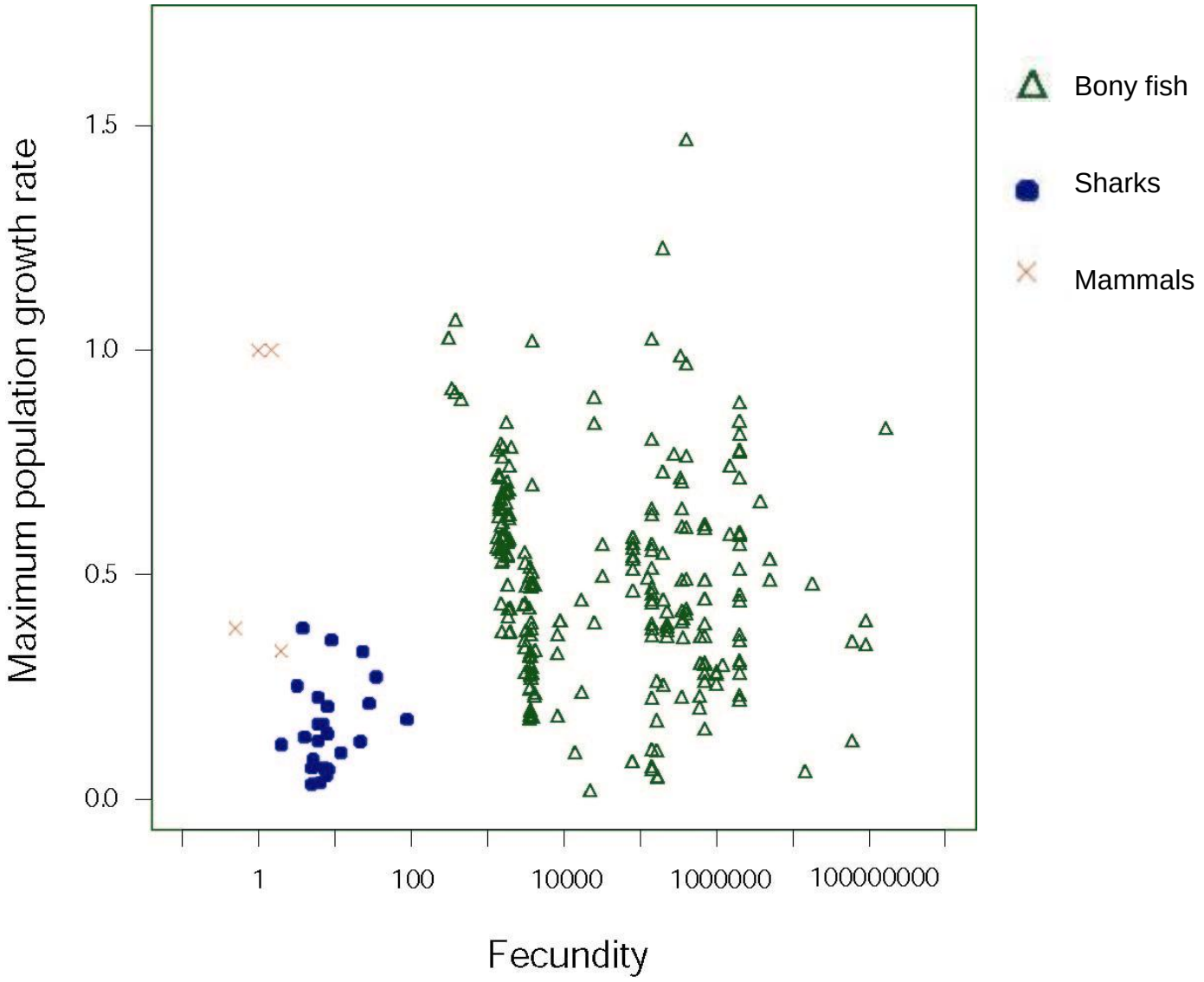
- “The Panel learned that the first United States Atlantic Shark Management Plan, which came into effect in 1993, contained new reporting requirements that can explain the breakpoint in the time-series (Karyl Brewster–Geisz, National Marine Fisheries Service, pers. comm.).”

Collapse and Conservation of Shark Populations in the Northwest Atlantic

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

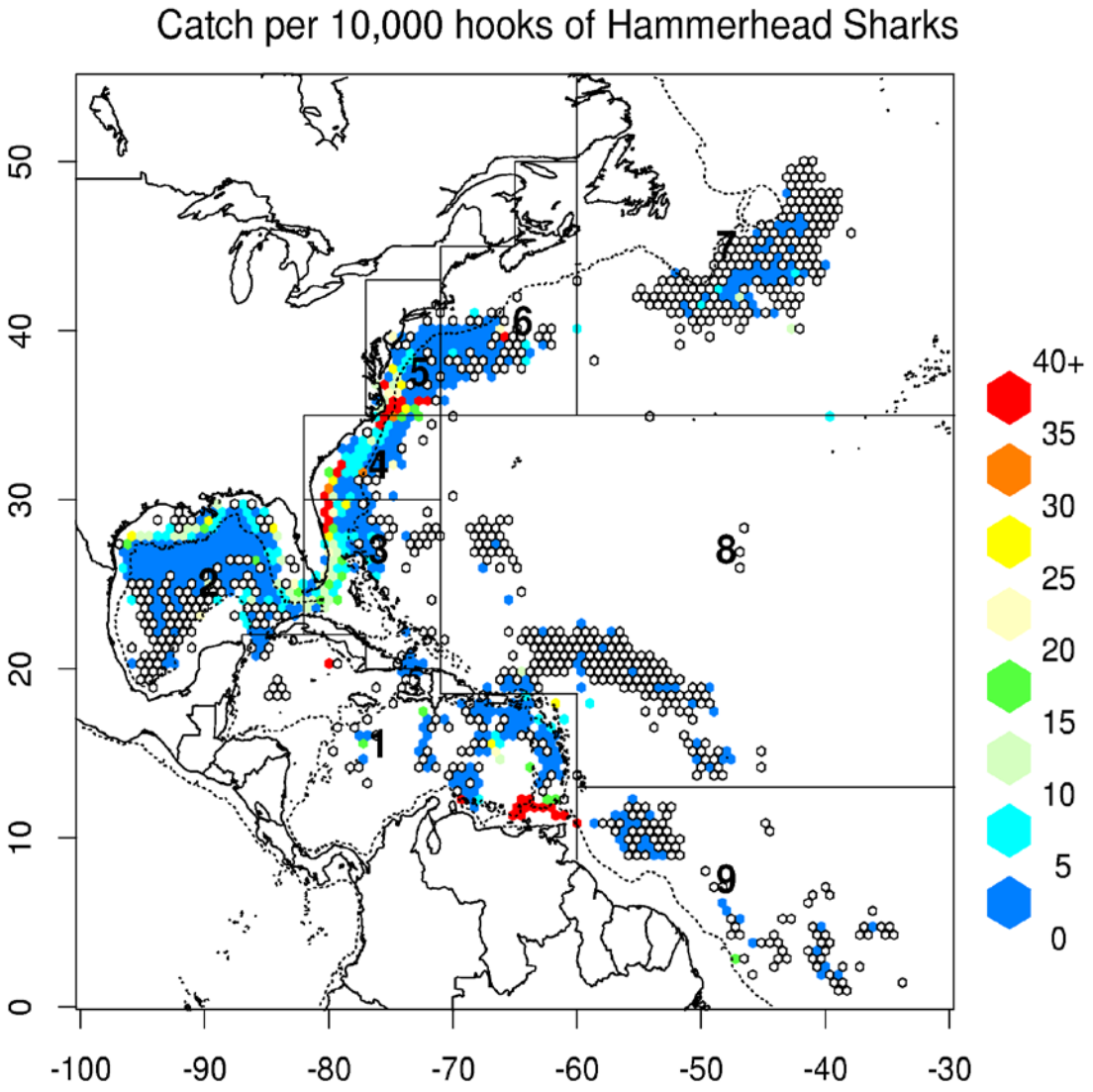
DALHOUSIE
University

Life history of sharks…



Hammerhead sharks

Sphyrna spp.



Data Analysis

- Assume catch follows negative binomial distribution
- Analyse positives only $\rightarrow$ zero-truncated distribution

$$f(y_T) = \frac{\Gamma(y+\theta)}{\Gamma(y)}^{y_T} \left(\frac{\mu}{\theta+\mu}\right)^{y_T} \left(\frac{\theta}{\theta+\mu}\right)^{\theta} \Bigg/ 1-\left(\frac{\theta}{\theta+\mu}\right)^{\theta}$$

Data Analysis

Parameter estimation: Generalized linear models:

TNB with fixed θ is a one-parameter exponential family of distributions

Base model

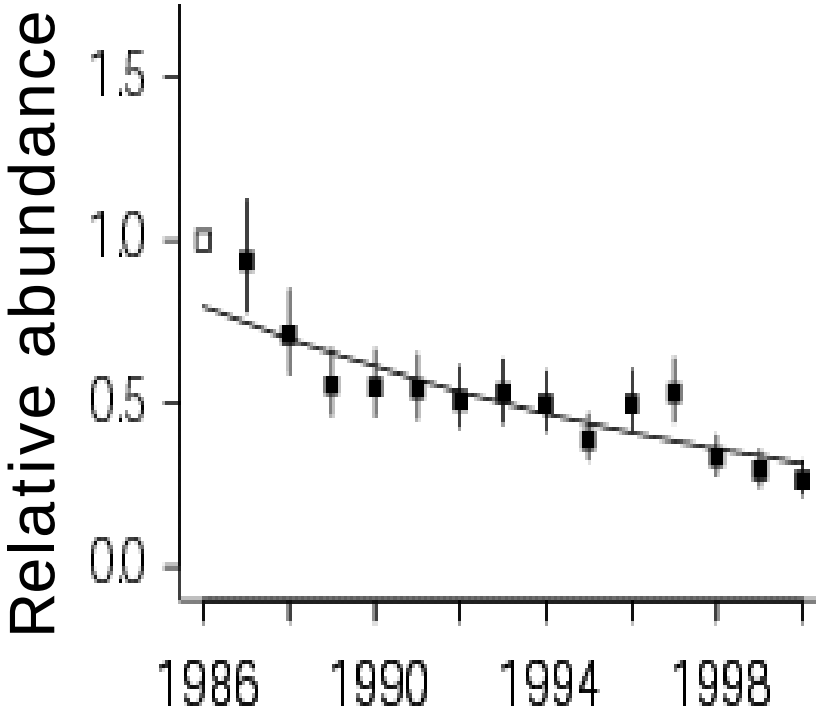
Main effects: area, season, light sticks, temperature and year

Interactions: area*season, area*light

Results

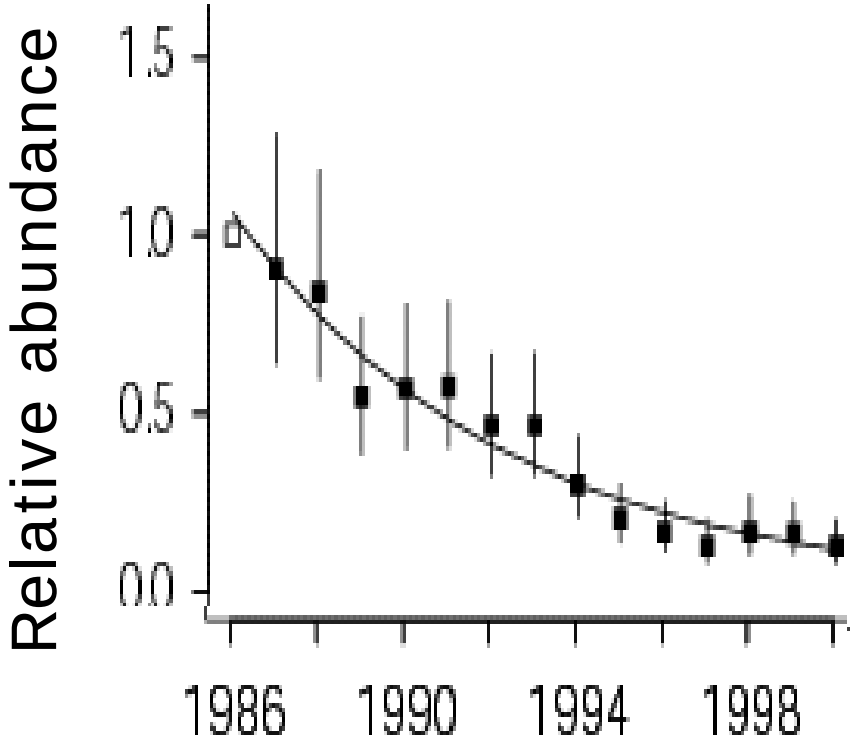
Blue shark

Prionace glauca

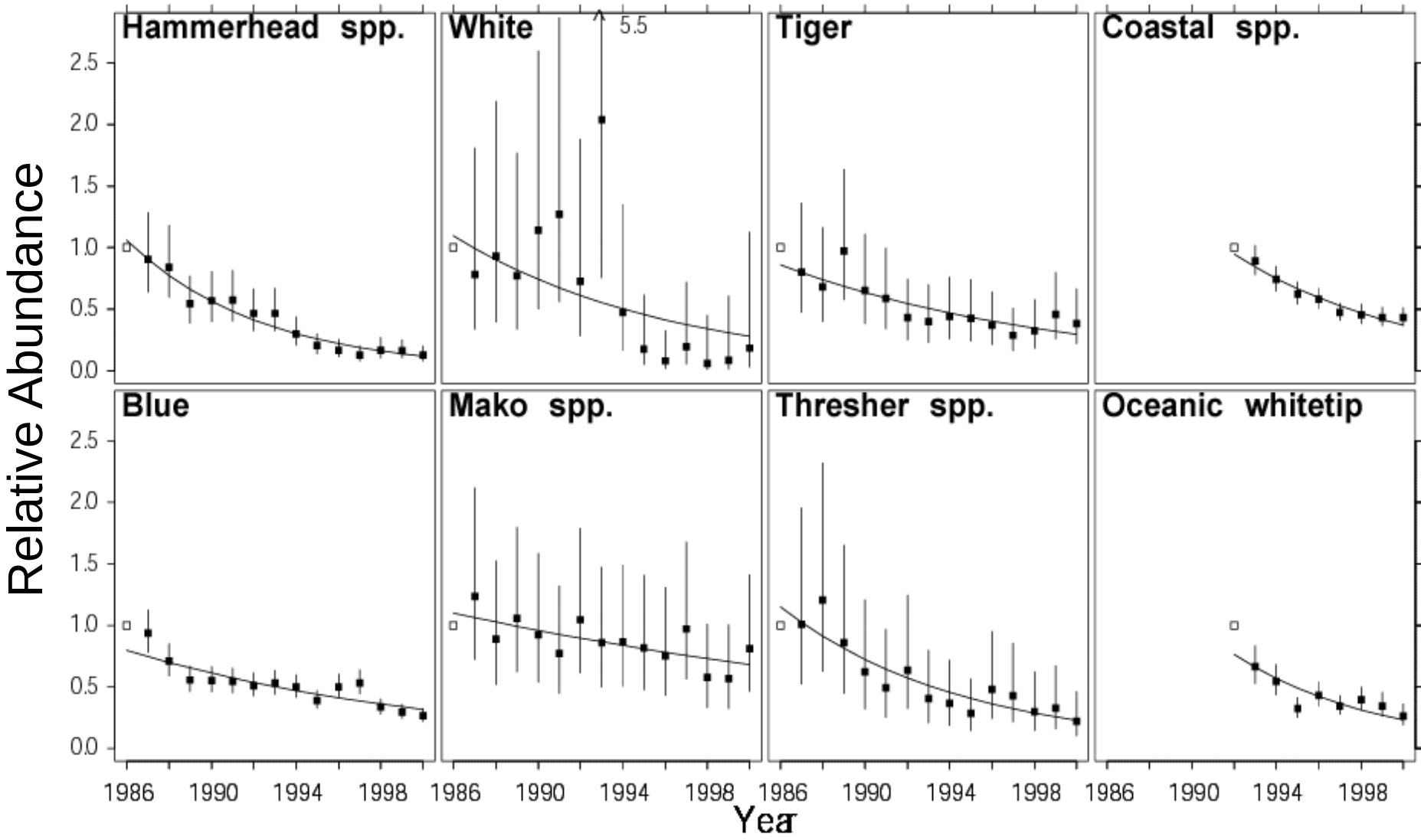


Hammerhead sharks

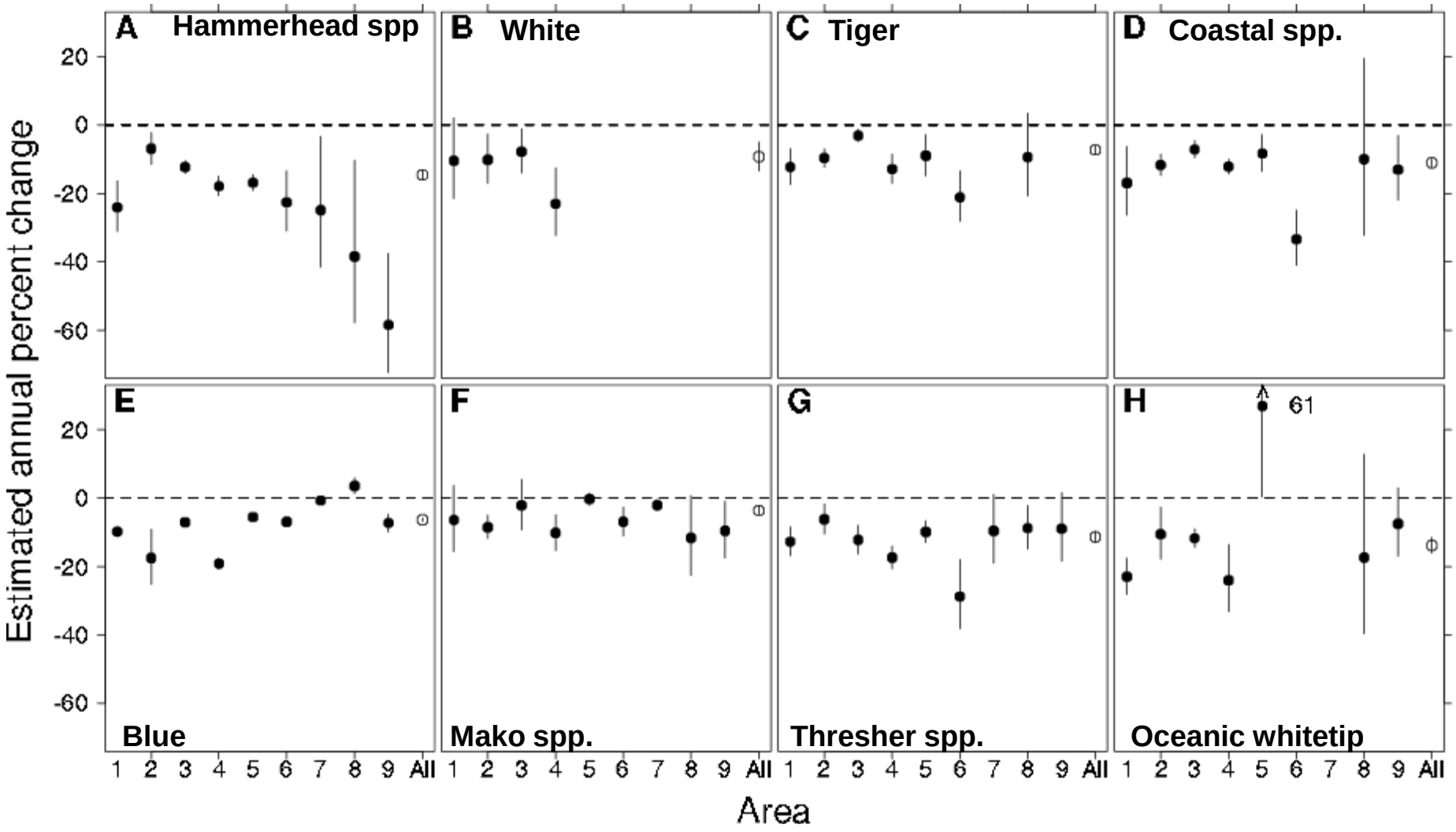
Sphyrna lewini



Results


Hammerhead spp.
White
5.5
Tiger
Coastal spp.
Blue
Mako spp.
Thresher spp.
Oceanic whitetip
Relative Abundance
2.5
2.0
1.5
1.0
0.5
0.0
1986
1990
1994
1998
Year

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



Robustness Analyses

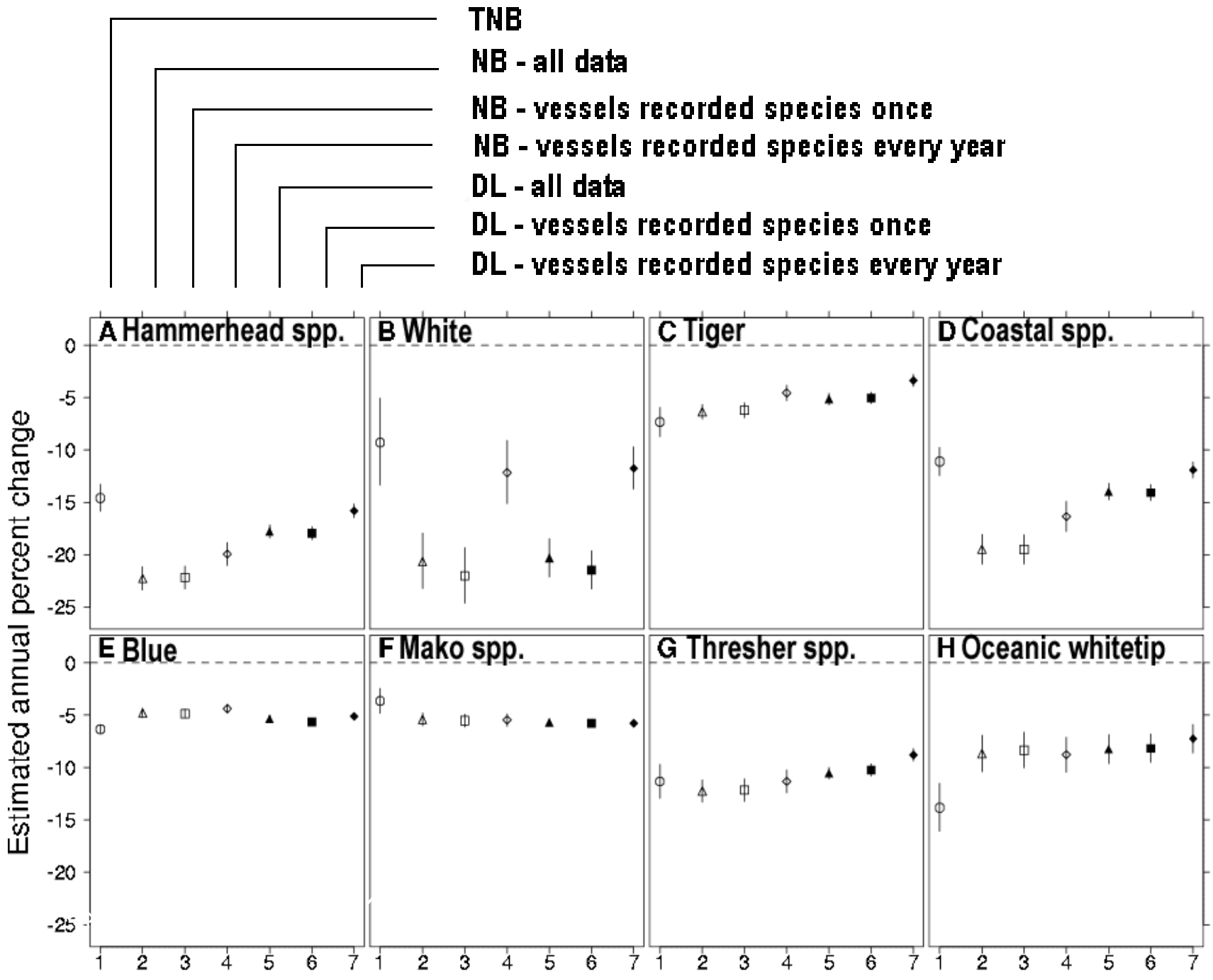
Assume reporting rate has stayed constant for:

- full dataset
- for a subset of vessels: recorded species at least once
  recorded species at least once in a given year

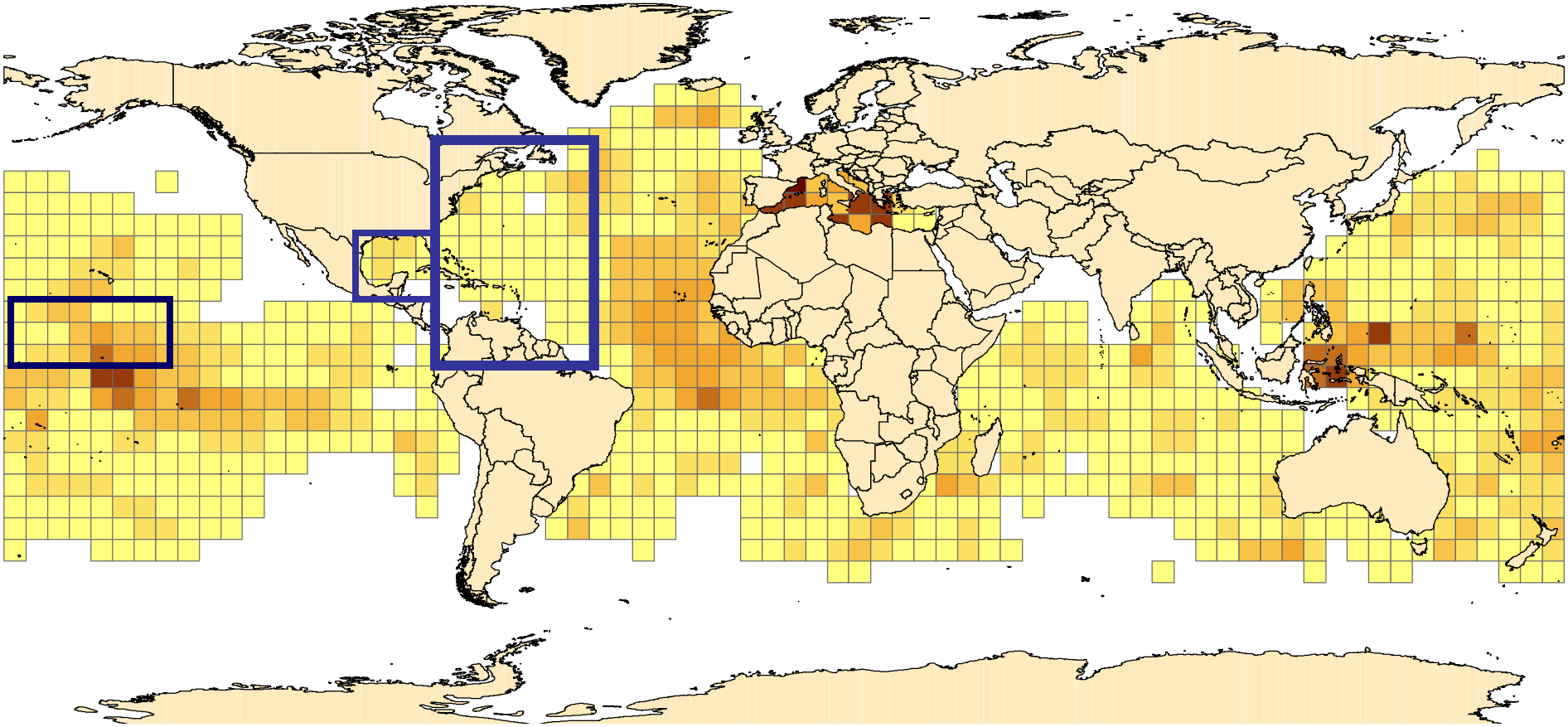
Negative binomial models

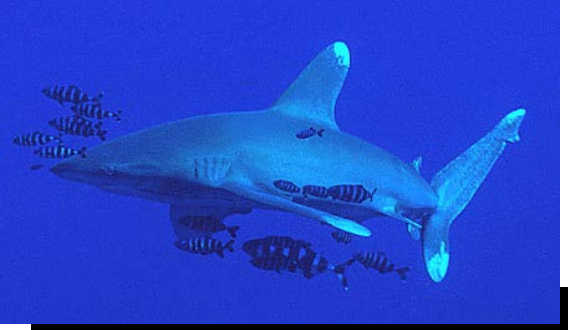
Delta-lognormal models

- proportion of positives modelled separately from positives
- standardized CPUE is the product of the two


TNB
NB - all data
NB - vessels recorded species once
NB - vessels recorded species every year
DL - all data
DL - vessels recorded species once
DL - vessels recorded species every year
A Hammerhead spp.
B White
C Tiger
D Coastal spp.
E Blue
F Mako spp.
G Thresher spp.
H Oceanic whitetip
Estimated annual percent change
0
-5
-10
-15
-20
-25
1
2
3
4
5
6
7

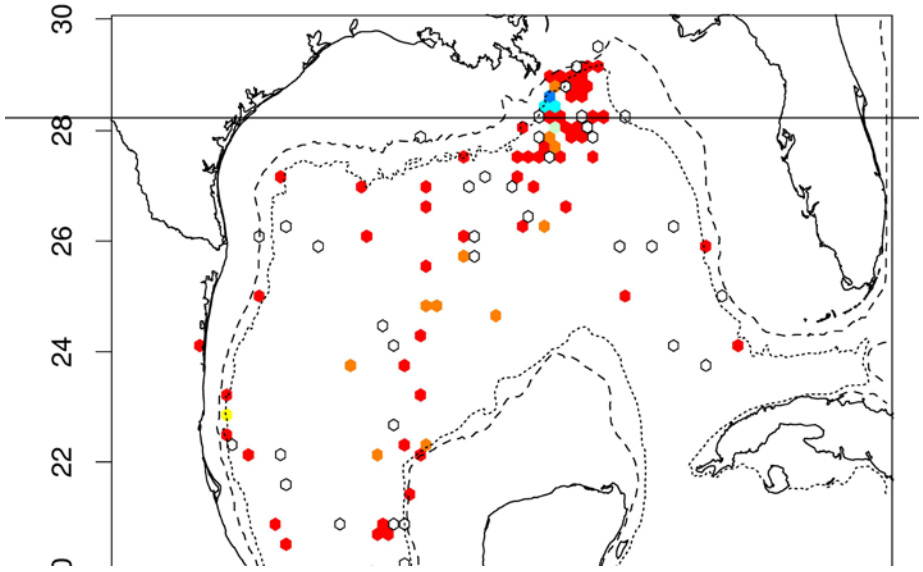
Annual Pelagic Longline Fishing Effort



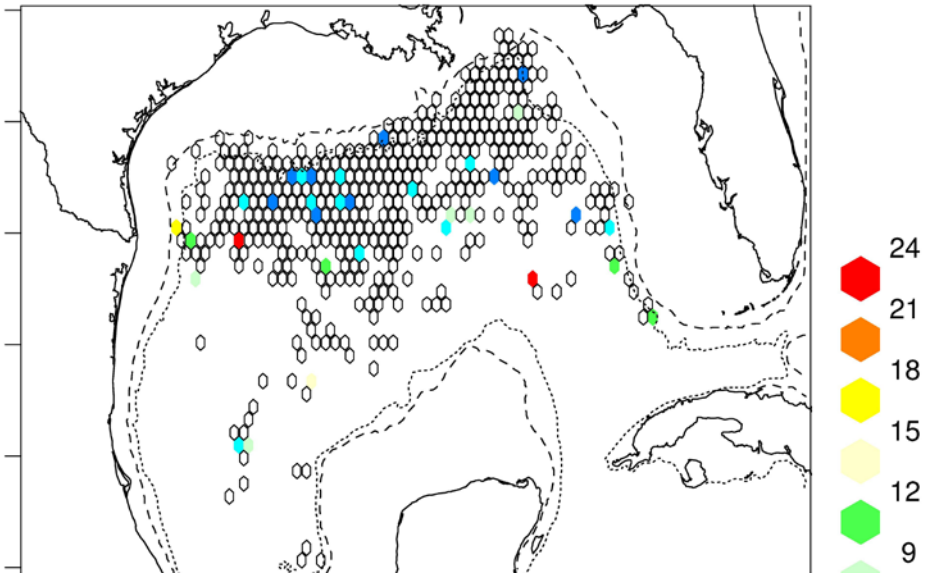


Loss of sharks in the Gulf of Mexico

300 fold decline – no one noticed



1950's



1990's

Oceanic Whitetip captures per 10,000 hooks

Baum and Myers, 2004 Ecology Letters

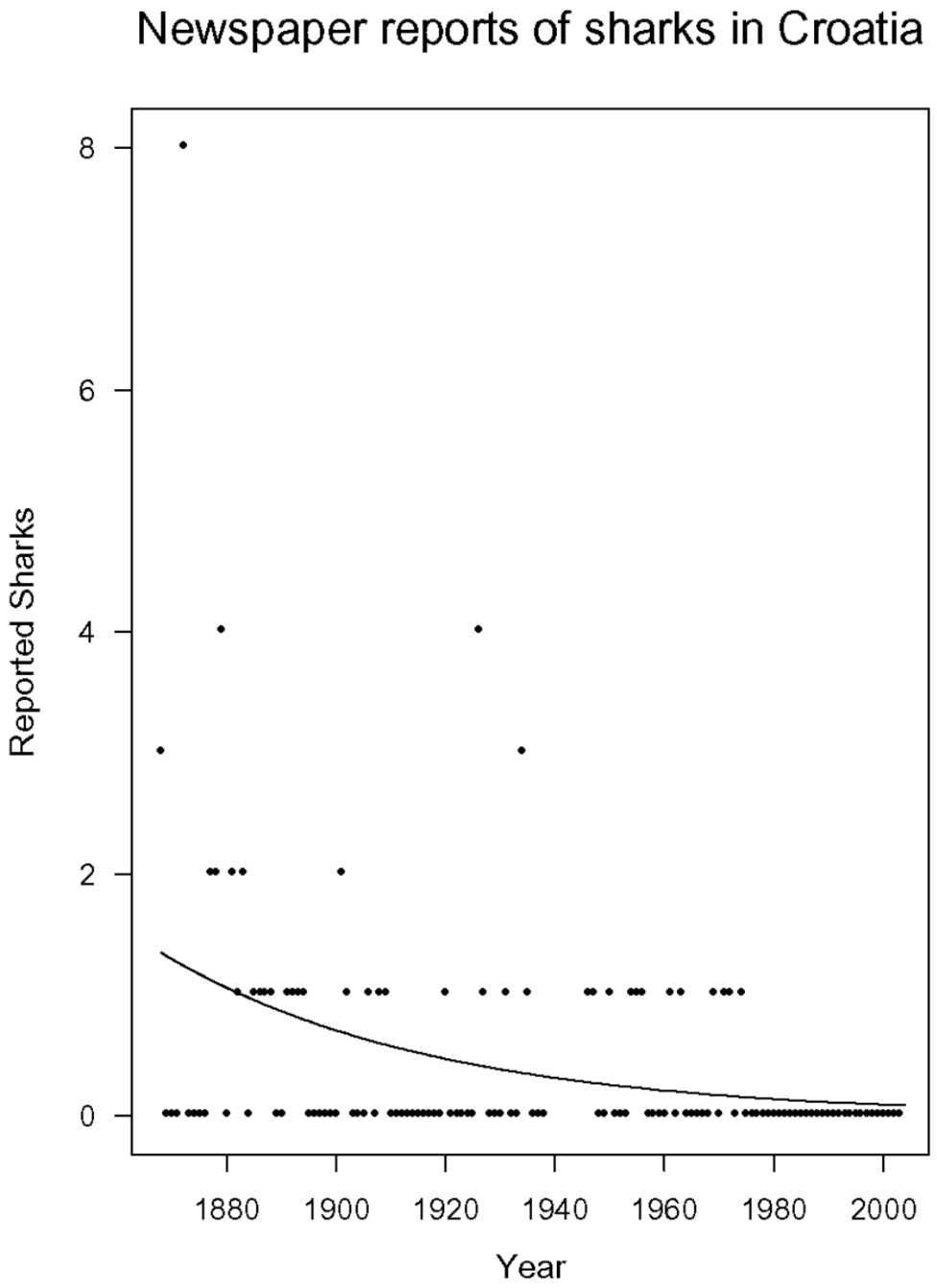
How to carry our a grossly incompetent assessment: get a useless opinion from someone who has not read the paper.

- “The Panel learned that the first United States Atlantic Shark Management Plan, which came into effect in 1993, contained new reporting requirements that can explain the breakpoint in the time-series (Karyl Brewster–Geisz, National Marine Fisheries Service, pers. comm.).”

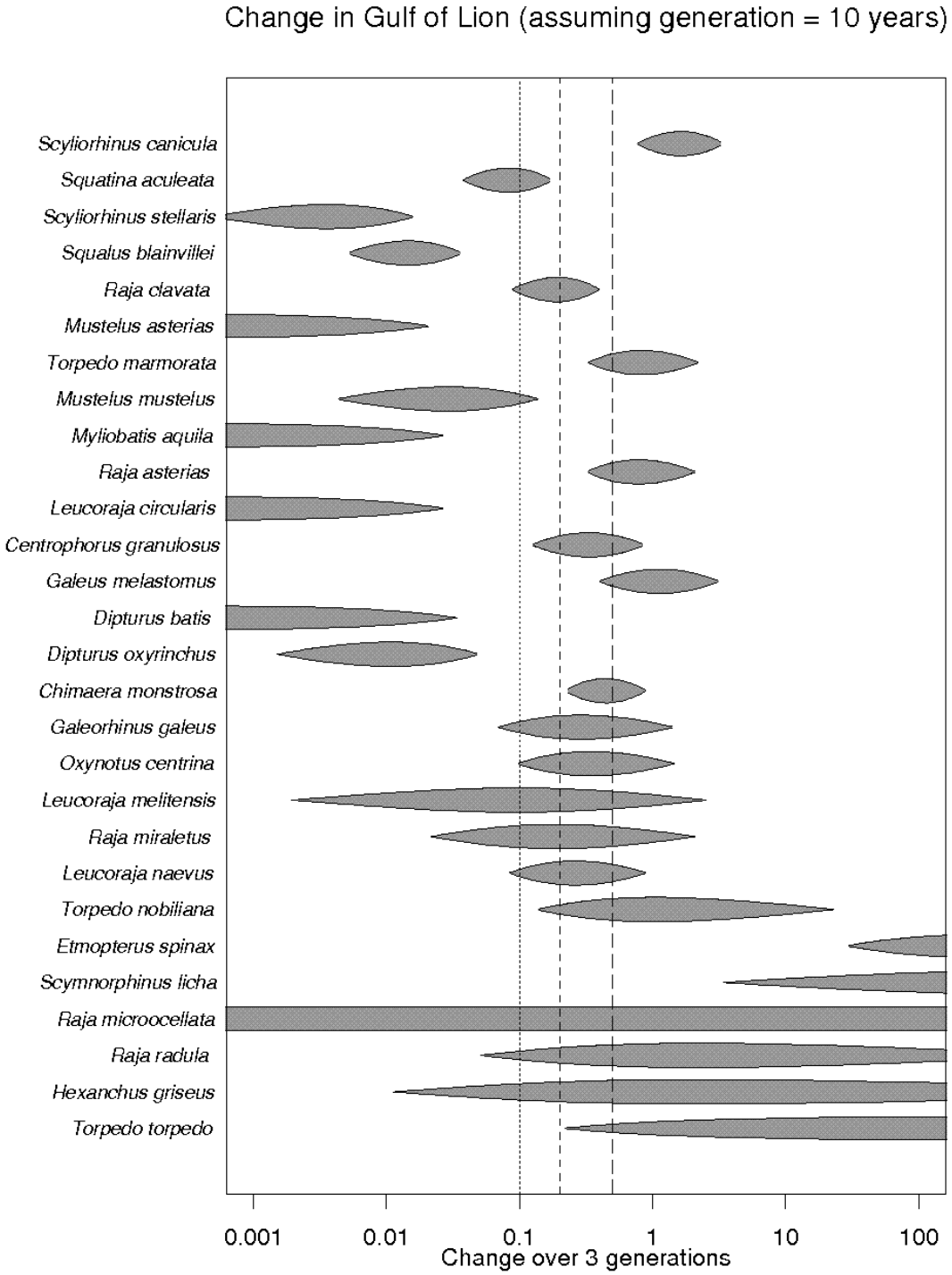
From the methods of our paper:

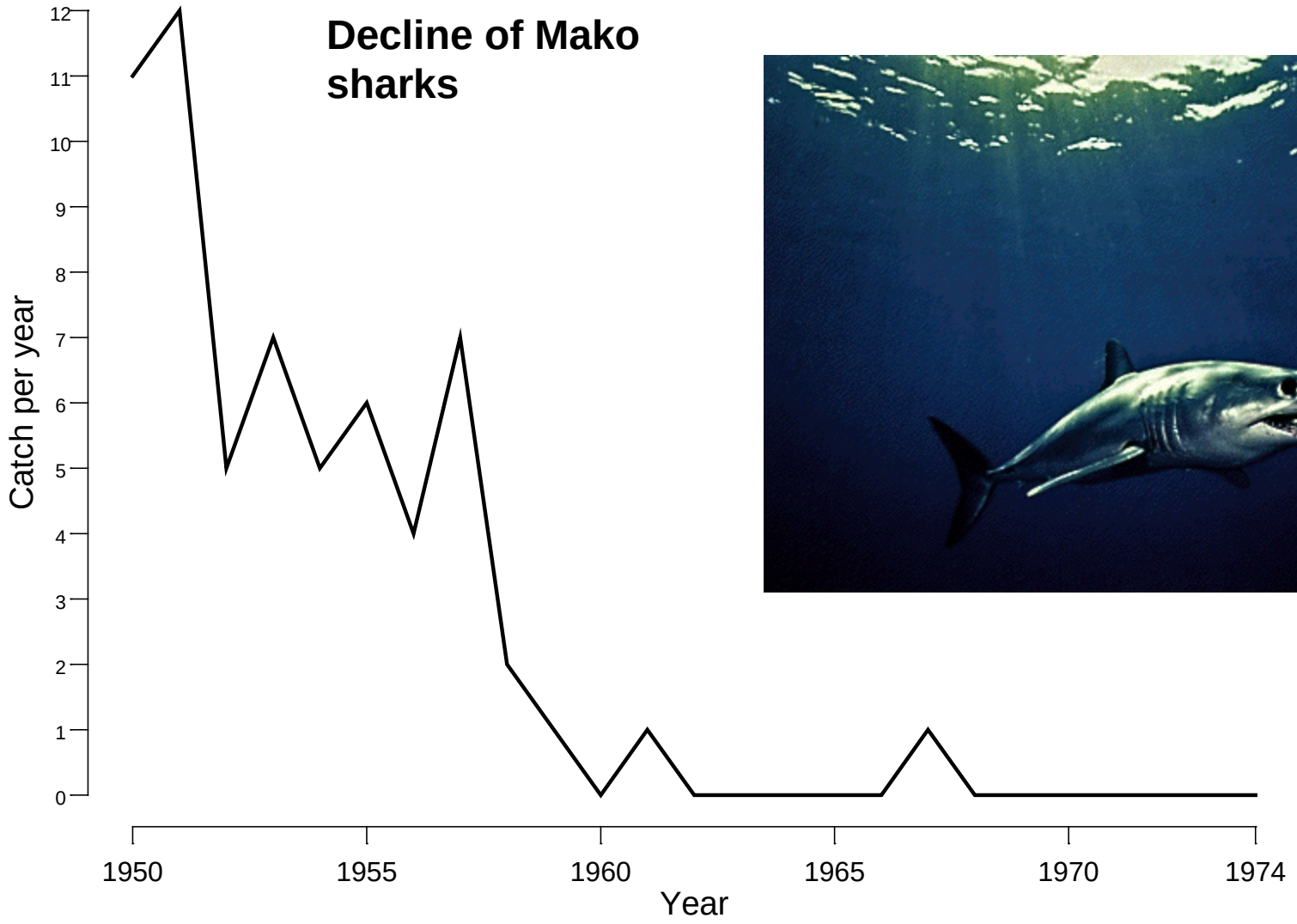
- We present an analysis of logbook data for the U.S. pelagic longline fleets targeting swordfish and tunas in the Northwest Atlantic.
- We eliminated the shark directed sets, which were bottom longline sets; which would have been clear if the “experts” had not actually read the paper.

Fitting a simple model to crazy data can yield reliable, and very powerful conclusions



Analysis of old survey data from the Gulf of Lion (where we only have partial data, i.e. the number of positive counts) show that 12 species of sharks and rays meet the IUCN criterion for endangered.





Boero F. & A. Carli 1979 – Boll. Mus. Ist. Biol. Univ. Genoa (47)

With training, “experts” can ignore the most obvious of data:

1872 - Man's head and leg and dolphin in stomach

1872 – 8 Great White Sharks reported caught

1888 - Woman's body and lamb in stomach

1894 - Preserved at Zagreb Nat. Hist. Mus.

1926 - Woman's shoes, laundry in stomach

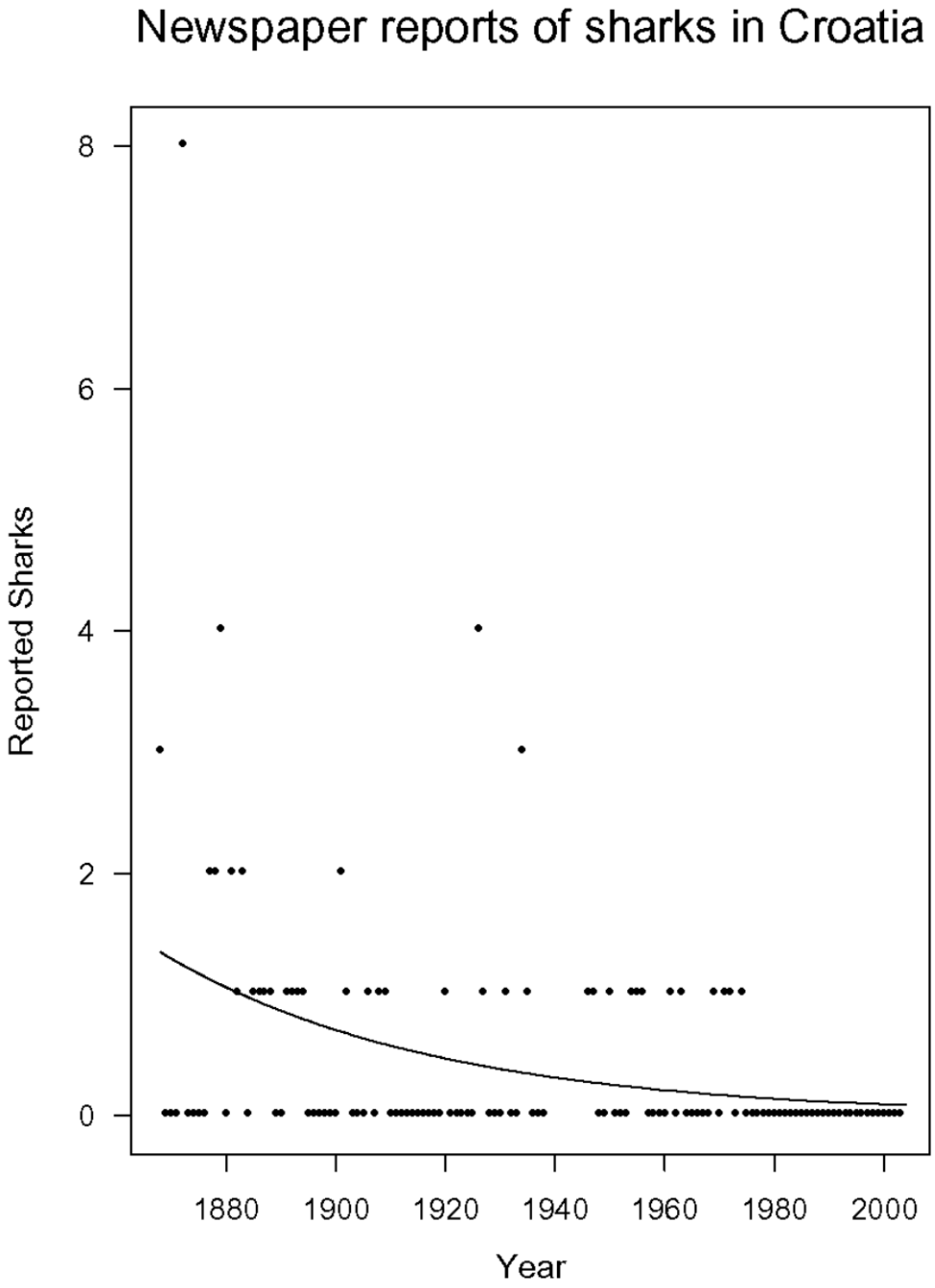
1946 - Pig of 10 kg in stomach

1950 - Encounter during eating a dead calf

1954 - Attack on boat

1975+ -No sightings.

Soldo and Jardas, Periodicum Bologorum, 2002


Newspaper reports of sharks in Croatia
Reported Sharks
0
2
4
6
8
1880
1900
1920
1940
1960
1980
2000
Year

POLICY FORUM

ECOLOGY

Hatcheries and Endangered Salmon

Ransom A. Myers,[1] Simon A. Levin,[2] Russell Lande,[3] Frances C. James,[4] William W. Murdoch,[5] Robert T. Paine[6]

The role of hatcheries in restoring threatened and endangered populations of salmon to sustainable levels is one of the most controversial issues in applied ecology (*1*). The central issue has been whether such hatcheries can work, or whether, instead, they may actually harm wild populations (*2*, *3*). A new and overriding issue, however, has arisen because of a recent judicial decision.

On 10 September 2001, U.S. District Court Judge Michael Hogan revoked the listing, by the National Marine Fisheries Service (NMFS), of all Oregon coast coho salmon under the Endangered Species Act (*4*). He ruled that, if hatchery fish were included in the same distinct population segment as the wild fish with which they are genetically associated, then they must be listed together. This approach could have devastating consequences: Wild salmon could decline or go extinct while only hatchery fish persist. Petitions are now pending to delist 15 other evolutionarily significant units (ESUs) (*5*).

An ESU is defined as a genetically distinct segment of a species, with an evolutionary history and future largely separate from other ESUs (*6*). For taxonomic purposes, one could use genetic similarity to classify hatchery fish as part of the ESU from which they were derived. However, for assessing ESU extinction risk and/or potential listing under the Endangered Species Act, including hatchery fish in an ESU confounds risk of extinction in the wild with ease of captive propagation and ignores important biological differences between wild and hatchery fish.

We define "hatchery fish" as fish fertilized and/or grown artificially in a production or conservation hatchery. Inevitably, hatchery brood stock show domestication effects, genetic adaptations to hatchery environments that are generally maladaptive in the wild. Hatchery fish usually have poor survival in the wild and altered morphology, migration, and feeding behavior (*7*). On release, hatchery fish, which are typically larger, compete with wild fish (*1*). Their high local abundance may mask habitat degradation, enhance predator populations, and allow fishery exploitation to increase, with concomitant mortality of wild fish (*1*, *8*). The absence of imprinting to the natal stream leads to greater straying rates, and that spreads genes not adapted locally (*1*). Also, hybrids have poor viability, which may take two generations to be detected (*9*).

Interagency draft criteria (*10*) describe hatchery fish most appropriate for inclusion in an ESU as those founded within two generations or those that had regular infusions of fish from the wild population. However, fish grown in hatcheries for even two generations may not assist population recovery; their rate of survival in the wild is much lower than that of wild fish (*11*). Regularly infusing hatchery stocks with natural fish may also be a drain on the natural system. Hence, even these hatchery fish should not be included in an ESU, even if they are indistinguishable at the quasi-neutral molecular genetic loci typically used to identify an ESU.

Much evidence exists that hatcheries cannot maintain wild salmon populations indefinitely (*7*). In the inner Bay of Fundy in Eastern Canada, hatchery supplementation of Atlantic salmon occurred for more than a century (*12*). Despite the longevity of this program, it failed to maintain viable natural populations. Hatcheries effectively disguised long-term problems, which probably contributed to the near extirpation of native Atlantic salmon. Moreover, as recommended by the World Conservation Union (IUCN), long-term reliance on artificial propagation is imprudent, because of the impossibility of its maintenance in perpetuity (*13*).

Although their effectiveness has not been shown (*14*), conservation hatcheries may play a role in future salmon recovery. However, to avoid the dysgenic effects of domestication, even conservation hatcheries should be strictly temporary and should not prevent protection of wild populations under the Endangered Species Act.

To address one of the subsidiary lawsuits, NMFS has pledged to complete a review of eight ESUs by 31 March 2004. NMFS should continue to pursue its current recovery goal of establishing self-sustaining, naturally spawning populations. The danger of including hatchery fish as part of any ESU is that it opens the legal door to the possibility of maintaining a stock solely through hatcheries. However, hatcheries generally reduce current fitness and inhibit future adaptation of natural populations. Hence, the legal definition of an ESU must be unambiguous and must reinforce what is known biologically. Hatchery fish should not be included as part of an ESU.

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15. We thank R. S. Waples for explaining aspects of the problem and C. A. Ottensmeyer for assistance.

CREDIT: NATALIE FOBES/CORBIS

26 MARCH 2004 VOL 303 SCIENCE

POLICY FORUM

ECOLOGY

Hatcheries and Endangered Salmon

Ransom A. Myers,[1] Simon A. Levin,[2] Russell Lande,[3]
Frances C. James,[4] William W. Murdoch,[5] Robert T. Paine[6]

How to change mainstream biologists into “Radical Environmentalists*”.

1. **Formally appoint you to the the Recovery Science Review Panel (for salmon), vetted by National Academy of Science; Ask for your “expert” advice.**

*Term used for Bob Paine, Bill Murdock, Simon Levin, Fran James, Russ Lande and myself

How to change mainstream biologists into “Radical Environmentalists*”.

2. Ignore your advice.

"We were trying to do an honest job and we were called radical environmentalists," said Ransom Myers, a fisheries biologist from Dalhousie University in Canada. "It was troubling to administrators we objected to the policy that habitat did not need to be protected. There was a clear implication if we continued to talk about policy, the group would be disbanded."

LA Times, Kenneth Weiss (3/26/04)

*Term used for Bob Paine, Bill Murdock, Simon Levin, Fran James, Russ Lande and myself

How to change mainstream biologists into “Radical Environmentalists*”.

3. Tell you that you are not qualified to speak about “policy” but only “science”.

- Six of the world's leading experts on salmon ecology complained last month in the journal *Science* that fish produced in hatcheries cannot be counted on to save wild salmon. The scientists had been asked by the federal government to comment on its salmon-recovery program but said they were later told that some of their conclusions about hatchery fish were inappropriate for official government reports.

. *Washington Post, Blaine Harden (4/29/04)*

How to change mainstream biologists into “Radical Environmentalists*”.

4. Deep six (“censor”) your advice.

*Term used for Bob Paine, Bill Murdock, Simon Levin, Fran James, Russ Lande and myself

How to change mainstream biologists into “Radical Environmentalists*”.

5. In December, we contacted an editor (Andy Sugden) of Science with idea for “Policy Forum” to link with upcoming political/legal decision on March 31, 2004.

(Quick action absolutely essential)

*Term used for Bob Paine, Bill Murdock, Simon Levin, Fran James, Russ Lande and myself

How to change mainstream biologists into “Radical Environmentalists*”.

5. Write policy forum, working hard to achieve consensus amongst the six authors. Submit.

*Term used for Bob Paine, Bill Murdock, Simon Levin, Fran James, Russ Lande and myself

How to change mainstream biologists into “Radical Environmentalists*”.

6. Science accepts. Call Nancy.

*Term used for Bob Paine, Bill Murdock, Simon Levin, Fran James, Russ Lande and myself

How to change mainstream biologists into “Radical Environmentalists*”.

7. Prepare press release very carefully – this contains quotes that can be inserted into newspapers directly, and gives crucial background.

*Term used for Bob Paine, Bill Murdock, Simon Levin, Fran James, Russ Lande and myself

How to change mainstream biologists into “Radical Environmentalists*”.

8. Target critical press and contact them individually. Spend week before release during interviews with the press.

*Term used for Bob Paine, Bill Murdock, Simon Levin, Fran James, Russ Lande and myself

How to change mainstream biologists into “Radical Environmentalists*”.

9. The Radical Environmentalists publish in Science and incite a wave of media outrage.

*Term used for Bob Paine, Bill Murdock, Simon Levin, Fran James, Russ Lande and myself

26 MARCH 2004 VOL 303 SCIENCE

POLICY FORUM

ECOLOGY

Hatcheries and Endangered Salmon

Ransom A. Myers,[1] Simon A. Levin,[2] Russell Lande,[3]
Frances C. James,[4] William W. Murdoch,[5] Robert T. Paine[6]

Action to Protect Salmon Urged

Scientists say their advice was dropped from a report to the U.S. fisheries service.

By Kenneth R. Weiss
Times Staff Writer

Six leading marine scientists, who were hired as government advisors only to find their recommendations stripped from an official report, went public today with their views — that federal action is urgently needed to protect more than a dozen populations of West Coast salmon and steelhead trout from the threat of extinction.

The scientists published their recommendations in today's issue of the journal Science after their advice was dropped from a scientific review of salmon recovery methods commissioned by the National Marine Fisheries Service.

"We were trying to do an honest job and we were called radical environmentalists," said Ransom Myers, a fisheries biologist from Dalhousie University in Canada. "It was troubling to administrators we objected to the policy that habitat did not need to be protected. There was a clear implication if we continued to talk about policy, the group would be disbanded."

[See Salmon, Page B12]

Scientists Urge Federal Action to Protect Salmon

[Salmon, from Page B1]

The group, built in its initial review and in Science, recommended that the agency rewrite its regulations to ensure the continuation of federal protections for salmon and steelhead in California, Oregon and Washington state in the wake of a federal court ruling that put those safeguards in jeopardy.

William Hogarth, director of the National Marine Fisheries Service, disputed the scientists' claims that their views were squelched. "We don't censor our scientists," Hogarth said. "They were simply asked to separate out the policy opinions and send them to [Northwest Regional Administrator] Bob Lohn or myself and not make it part of the scientific report, which is put on the website."

The report left intact the scientists' review of a variety of approaches to sustaining both wild and hatchery-raised salmon.

The dispute echoes similar complaints by other scientists working for the federal government, including the U.S. Environmental Protection Agency.

Recently, EPA staff members said that 21 months of research on mercury pollution from power plants was ignored in favor of industry recommendations that called for looser regulations of emissions. The wording of the regulation adopted by the EPA incorporated the exact language provided by a research and advocacy group that represents 21 power and transmission companies.

A group of 20 Nobel laureates and several science advisors to past Republican presidents last month wrote an open letter accusing the Bush administration of "suppressing, distorting or manipulating the work done by scientists" at various federal agencies.

"This administration has developed such a reputation for scientific censorship that it wouldn't be a surprise if this had been ordered removed from Washington," said Donald Kennedy, former president of Stanford University and now editor of Science.

Kennedy described the six scientists as top-notch and noted that their article easily withstood review by scientific peers before publication.

"Differences on scientific issues should be argued on the merits," Kennedy said, "and censorship isn't the way to conduct an honest debate."

The debate in this case involves the fate of 15 populations of salmon and steelhead trout that spend most of their lives in the ocean and then return to spawn in rivers and streams along the West Coast from Central California to the U.S.-Canada border.

All 15 of these distinct populations are sufficiently diminished to be listed as threatened or endangered under the U.S. Endangered Species Act. However, the protected status of all 15 is now being challenged by developers, farmers, ranchers, timber interests and private property advocates who want to end restrictions on activities that the government says can harm streams that these fish use to spawn and raise their young.

For instance, the government forbids logging and tilling of soil in a buffer zone around streams and can limit water drawn from rivers for irrigation if it's needed for salmon to swim upstream.

The challenges to the restrictions were inspired by a 2001 federal court decision that ordered the removal of coho salmon in southern Oregon from the endangered species list. The reason, wrote U.S. District Judge Michael Hogan, was that salmon raised in hatcheries could be included in the count of wild fish because they are associated genetically and swim in the same river. And given that the hatchery produces the fish in abundance, the judge concluded there was no need for salmon in those rivers to be protected.

The fisheries service declined to appeal the ruling. Subsequently, fishing and environmental groups intervened, but lost their appeal last month when the U.S. 9th Circuit Court of Appeals ruled that an appeal was premature because of evolving policy.

Meanwhile, the fisheries service appointed six university scientists to review all efforts to help recover salmon populations. The panel was led by Robert Paine, an ecologist at the University of Washington, and included Myers of Dalhousie University; Russell Lande of UC San Diego; William Murdoch of UC Santa Barbara; Frances James of Florida State University; and Simon Levin of Princeton University.

Levin, a professor of ecology and evolutionary biology, said the group quickly focused on the "ridiculous situation" in which federal protections of salmon and its spawning grounds are removed because the fish populations are being propped up by hatcheries.

"Just because you have captive breeding programs doesn't mean salmon are restored," Levin said. "If you have animals in the zoo, you don't call the natural populations restored."

Hatcheries have been trying for more than a century to restore salmon populations. However, this group of scientists cites evidence that hatchery raised fish can do more harm than good.

When hatchery fish are first released, they are often larger than their wild cousins and can cannibalize them or outcompete them for food in rivers. Over time, the hatchery fish are much less likely to survive in the wild. They tend to feed near the surface, waiting for pellets of food to drop from the sky as they do in hatcheries, missing them easy pickings for kingfishers and other birds.

Those that do survive often interbreed with wild fish and dilute the gene pool with altered behavior related to finding food, avoiding predators and finding their way home to spawn.

Moreover, maintaining the genetic diversity of wild stocks is key to ensuring salmon's survival in face of environmental and climate changes, scientists say. Much like the stock market, a population that produces well one year can be a bust the next. It's best to hedge bets on a broad portfolio of different genetic stocks to ensure long-term success.

So the scientists, in their article, recommend that the fisheries service rewrite its rules and definitions to distinguish between wild salmon and hatchery raised fish both to satisfy the legal concerns of the federal judge and to make sure wild salmon remain protected.

The fisheries service must find a legally defensible definition, the scientists wrote, or face "devastating consequences: Wild salmon could decline or go extinct while only hatchery fish persist."

Hogarth dismissed the scientists' recommendations, saying the agency is pursuing another approach by reworking its hatchery policy. He declined to explain what the new policy will say when it is released in coming months, but he acknowledged it may lead to removing at least some salmon stocks from the list of protected species. "To say how many, I don't know," he said.

The service faces a March 31 court deadline to decide whether to remove eight populations of salmon in Washington state from the list of endangered species because those rivers have an abundance of hatchery fish. Federal officials have requested a 90-day extension, not yet granted by the judge presiding in the case brought by the Building Industry Assn. of Washington.

Concerned about this deadline, the panel of scientists offered the fisheries service a draft of its report. At a subsequent meeting in Santa Cruz, the panel members said they were shown an e-mail from a fisheries service administrator stating he was not interested in the policy opinions of these "radical environmentalists," and ordering the first section about policy to be deleted.

"I was deeply offended," Paine said. "We were scientifically accurate. We were trying to be constructive."

Paine, like the other scientists, declined to name the administrator who wrote the e-mail.

The recommendations of the scientists were applauded by Glen Spain, northwest regional director of the Pacific Coast Federation of Fishermen's Assns.

"The Endangered Species Act was not intended to protect fish in tanks. It was intended to protect them in the wild," which includes the rivers and streams where they spawn, Spain said. "The fishing industry has suffered enormous loss due to overlogging, over-grazing, over-water and polluting the rivers."

Russ Brooks, a Pacific Legal Foundation attorney representing property owners and ranchers, said he doubted that the scientists' policy recommendations would be adopted by the fisheries service or would make much difference.

"The fisheries service really has a hot potato in its lap," Brooks said. "The fisheries service is going to try to please everyone and will not please anyone at all. I know the environmentalists are not going to be happy, and the people I represent will be unhappy. The only thing I feel confident in forecasting is more litigation."

'Differences on scientific issues should be argued on the merits, and censorship isn't the way to conduct an honest debate.'

Donald Kennedy,
former president of Stanford University and now editor of Science

Associated Press

Scientists criticize government over salmon rules

March 26, 2004
Gene Johnson

SEATTLE -- Scientists appointed by the government to review salmon- recovery efforts are lashing out at federal court rulings that require both wild and hatchery-raised fish to be counted when determining whether a species is threatened.

In an editorial being published in Friday's edition of the journal Science, the six scientists also criticized the National Marine Fisheries Service, saying the agency must do more to protect wild salmon.

"One hundred years of hatcheries have not brought back wild Atlantic salmon to Maine," lead author Ransom Myers, a fisheries biologist at Dalhousie University in Nova Scotia, said in a news release Thursday. "Once we lose the wild populations of salmon and the natural habitats that support them, we will never get them back."

At issue is a debate over whether hatchery-raised salmon help or hinder salmon conservation efforts. The hatchery fish are generally bigger than their wild counterparts, and thus can compete more easily for food upon release, but in the long run, their instincts are worse. They die at much higher rates than wild fish, so their survival as a species is less likely, the scientists wrote.

In eastern Canada, the scientists wrote, "Hatcheries effectively disguised long-term problems."

But in 2001, U.S. District Judge Michael Hogan of Eugene, Ore., ruled that the fisheries service could not give Endangered Species Act protection just to wild fish if it had previously lumped hatchery fish into the same population - which the fisheries service does. It counts both hatchery and wild fish in its "evolutionarily significant units" of salmon, because the wild and hatchery fish in those units are genetically indistinct.

Last month, the 9th U.S. Circuit Court of Appeals dismissed an environmental group's appeal of that ruling, effectively dissolving the threatened species listing for coho salmon off the Oregon coast and prompting similar lawsuits challenging salmon listings elsewhere in Oregon, California and Washington. The fisheries service is reviewing its policy on protecting wild fish.

The six scientists - Simon A. Levin of Princeton University, Robert Paine of the University of Washington, Russell Lande of the University of California at San Diego, Frances James of Florida State University, William Murdoch of UC-Santa Barbara, and Myers - were hired more than two years ago by the National Oceanic and Atmospheric Administration's Northwest Fisheries Science Center, at a rate of $800 each per day.

The New York Times

Science Times

THE NEW YORK TIMES, TUESDAY, APRIL 4, 2004

Birthplace Is Crucial Issue for Scientists Counting Salmon

By MATTHEW PREUSCH

SEATTLE, April 3 — Ever since the advent of hatcheries, not all salmon have been created equal, at least in the eyes of conservation biologists.

But federal officials, under pressure from property rights advocates, are planning a classification change that could result in the loss of protection under the Endangered Species Act for many types of Pacific salmon.

Historically, the National Marine Fisheries Service counted hatchery fish along with naturally spawning fish only when a particular salmon run was nearly extinct. In some cases hatchery fish are almost identical genetically to their wild cousins, but many times hatchery stock bears little resemblance to the native fish.

In 2001, Judge Michael R. Hogan of Federal District Court in Oregon said that practice was "arbitrary and capricious," ruling in a lawsuit brought by a coalition of property owners unhappy with building restrictions mandated by the act.

In February, the United States Court of Appeals for the Ninth Circuit upheld the ruling, and the fisheries service began reviewing almost all the 27 Pacific salmon and steelhead populations listed as endangered or threatened under the Endangered Species Act.

Scientists for the fisheries service, also known as NOAA-Fisheries, said the practice of including hatchery fish along with wild fish will become much more common, possibly affecting the status of many endangered salmon runs.

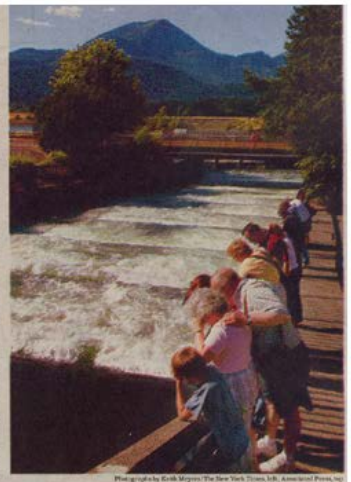
Wild salmon advocates see Judge Hogan's ruling and the NOAA review as potential disaster for many subspecies of Pacific salmon.

Last month, an independent review panel of scientists appointed by NOAA to oversee their policy review broke ranks with the agency to publish a critique in the journal Science.

The scientists warned against any use of hatcheries to restore wild fish, calling the question "one of the most controversial issues in applied ecology."

Dr. Ransom A. Myers, professor of ocean studies at Dalhousie University in Halifax, Nova Scotia, and a member of the panel, said NOAA was walking a slippery slope.

"I think the most dangerous road that I'd like to see National Marine Fisheries Service not go down is that you have fish in a hatchery that's as good as wild fish," Dr. Myers said.



Photographs by Keith Meyers/The New York Times; left, Associated Press, top

Dr. Myers and other biologists maintain that a population can recover only if its habitat is preserved and that farm-raised fish can be a detriment, not a supplement, to their wild kin.

Salmon and steelhead are valued symbols in the Northwest, in part because they are born in rivers or lakes as far inland as Idaho then make their way to the ocean before returning years later to spawn and die in their home waters.

Salmon, mostly hatchery-born, have returned in huge numbers to Northwest rivers in recent years, largely because of improved ocean conditions.

In light of the huge runs, critics of the Endangered Species Act consider the policy review a chance to infuse the regionwide recovery efforts with a dose of common sense.

The Pacific Legal Foundation, a property rights law firm, represents various groups challenging salmon listings across the Northwest. Robin Rivett, a foundation lawyer, said restrictions on property use because of endangered species requirements make little sense when the rivers have plentiful salmon, even the hatchery kind.

"You have to look at the hatchery fish, and they have largely been ignored," he said.

NOAA's hatchery policy has been based on a consensus that, instead of supplementing wild salmon runs, hatchery fish can damage them. Aside from eating up millions in salmon recovery dollars, hatcheries and hatchery fish pose two challenges to wild fish. First, they compete ecologically, vying for limited food and even preying on their gener-

How to change mainstream biologists into “Radical Environmentalists*”.

10. More interviews, organize call with NGO’s. NGO’s get on board and push hard.

*Term used for Bob Paine, Bill Murdock, Simon Levin, Fran James, Russ Lande and myself

How to change mainstream biologists into “Radical Environmentalists*”.

11. Governments true agenda is revealed.

Drafts of the administration's sweeping new hatchery policy leaked to the press show the government for the first time will consider the abundance of both artificially produced and wild fish when assessing the health of troubled salmon stocks.

Seattle Times, Craig Welch (4/30/04)

*Term used for Bob Paine, Bill Murdock, Simon Levin, Fran James, Russ Lande and myself

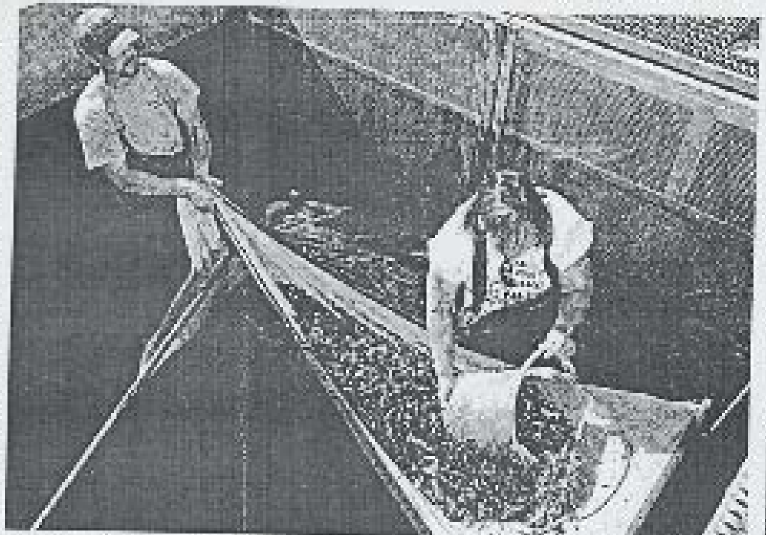
The New York Times

Shift on Salmon Reignites Fight on Federal Species Law

Shift on Salmon Reignites Fight On Species Law

By TIMOTHY EGAN

From Page 1

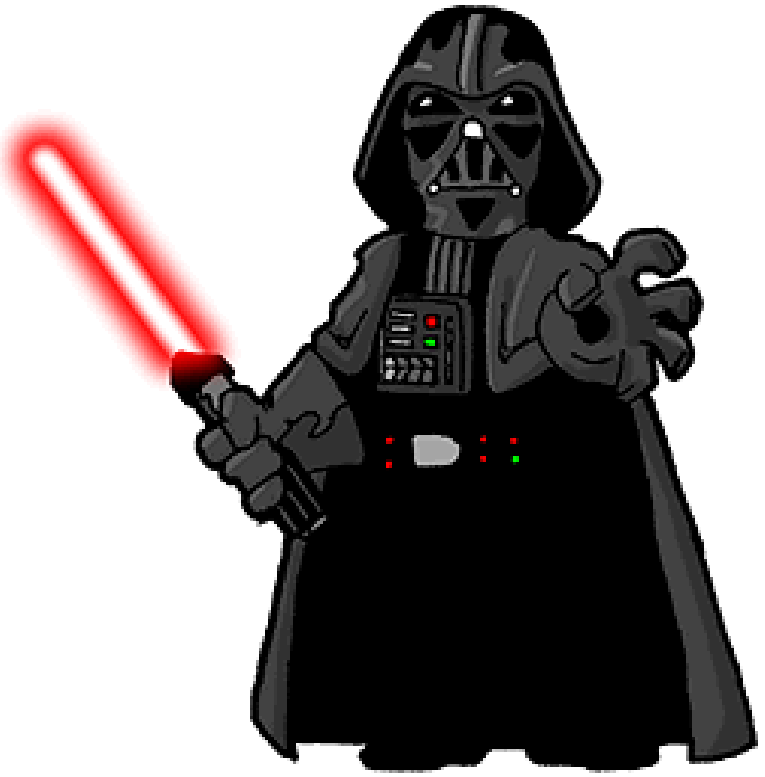


Workers transferred fingerling chinook salmon Friday at the Lyons Ferry Fish Hatchery on the Snake River near Starbuck, Wash. Some 2.3 million are raised there each year, and are released into waterways.

A furor over counting hatchery fish to judge whether wild salmon are endangered.

Continued on Page 14

The lawyer who gave us the attempt to delist the Northern Spotter Owl is now trying to work his magic on Pacific Salmon; however, now he is in change of Endangered Species Legislation from within NOAA Fisheries (after launching a lawsuit against NOAA).



The New York Times

Saving Wild Salmon

May 15, 2004, Saturday
Editorial Desk

One of the great virtues of the Endangered Species Act -- and the main reason for the bitter opposition the act has engendered over the years -- is that in the interests of saving species, it requires the protection of the habitats where the species live. That usually means constraining human behavior in ways that help preserve a healthier environment all around. Humans themselves often come to appreciate that intervention, though not always. In the case of wild salmon, for instance, commercial interests have long resented the restrictions on logging, farming and development necessary to protect the fragile watersheds where salmon spawn.

The Bush administration has now found a novel way around these inconveniences: a new policy on counting fish. Its practical effect would be to eliminate the distinction between wild salmon and hatchery salmon, which can be churned out by the millions. This sleight of hand would instantly make wild salmon populations look healthier than they actually are, giving the government a green light to lift legal protections for more than two dozen endangered salmon species as well as the restrictions on commerce that developers and other members of President Bush's constituency find so annoying.

Policy makers at the National Marine Fisheries Service say they are merely obeying a federal judge who was unhappy with the way the government distinguished between wild and hatchery fish. But in drawing up the new policy, the service ignored the scientists who urged that the protections remain in place. It relied instead on a Washington-based political team whose key player was Mark Rutzick, a former timber industry lawyer.

Such a step may be good politics for the Bush administration. But it is bad science and bad news for wild salmon. Hatchery-raised fish represent a narrowing of the genetic diversity present in wild runs of salmon, and are makeshift at best. Few scientists believe that hatchery-raised fish can make a serious and lasting contribution to protecting wild salmon runs, which have been crashing under the pressures created by habitat destruction in the coastal streams where they breed. Indeed, this new policy has nothing to do with protecting salmon. Its only purpose is to circumvent the Endangered Species Act, without whose protections the wild runs will almost surely vanish.

How to change mainstream biologists into “Radical Environmentalists*”.

12. Work with congressional aides to get a congressional letter to NOAA Fisheries.

*Term used for Bob Paine, Bill Murdock, Simon Levin, Fran James, Russ Lande and myself

SCIENCE & SPACE

Salmon protection dodges bullet

Monday, May 31, 2004 Posted: 9:41 AM EDT (1341 GMT)

SEATTLE, Washington (Reuters) -- Federal officials scaled back plans Friday to reduce protections for endangered Northwest U.S. salmon, but proposed boosting wild salmon populations with salmon raised in hatchery tanks, a move that environmentalists said could harm wild stocks.

The proposal, which will be submitted to the scientific community and public for comment, could potentially lead to some species being taken off the Endangered Species Act list.

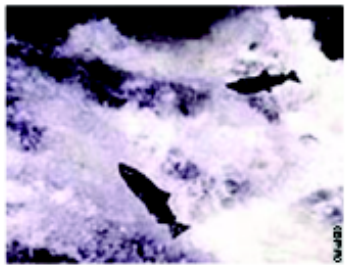
Originally, the Bush administration leaned toward immediate removal of some species off the endangered list. It did not take that step and in fact proposed the addition of 27 new species to the list.

Despite the apparent compromise, however, a local environment group said that the newly proposed policy and its application could lead to delistings further down the road and also harm the genetic health of wild salmon species.

"Salmon have, at least temporarily, dodged a bullet," said Jan Hasselman, Seattle counsel for the National Wildlife Federation. "The real question is whether this policy leads to a weaker application of the endangered species or delisting of salmon that have **not really** recovered."

Moreover, scientists say that using hatcheries to supplement wild salmon populations could harm wild species by introducing genes that make it harder for them to survive in the wild.

Advocates of the original plan also lashed



Federal officials dropped rules to count hatchery salmon with wild populations.

13. Be in the fight for the long haul – you rarely “wi from one battle.

From “**Deep Trout**”, Email from a trusted political insider and ally.

Ram,

I do think this is Act I, scene 1 in a very long-running passion play.

It is entirely possible that in the end, even after litigation, many or most may stay listed, but that the really bad stuff happens in the recovery plans (RPAs), when you can just pump category 2 hatchery fish into the ESU system (at the same time that you may be allowing continued development or hydropower) and thereby prevent the entire hatchery/wild ESU from becoming extinct (even as hatchery fish become 80% of the ESU). Remember, the new policy has as its goal prevention of the extinction of the ESU!!

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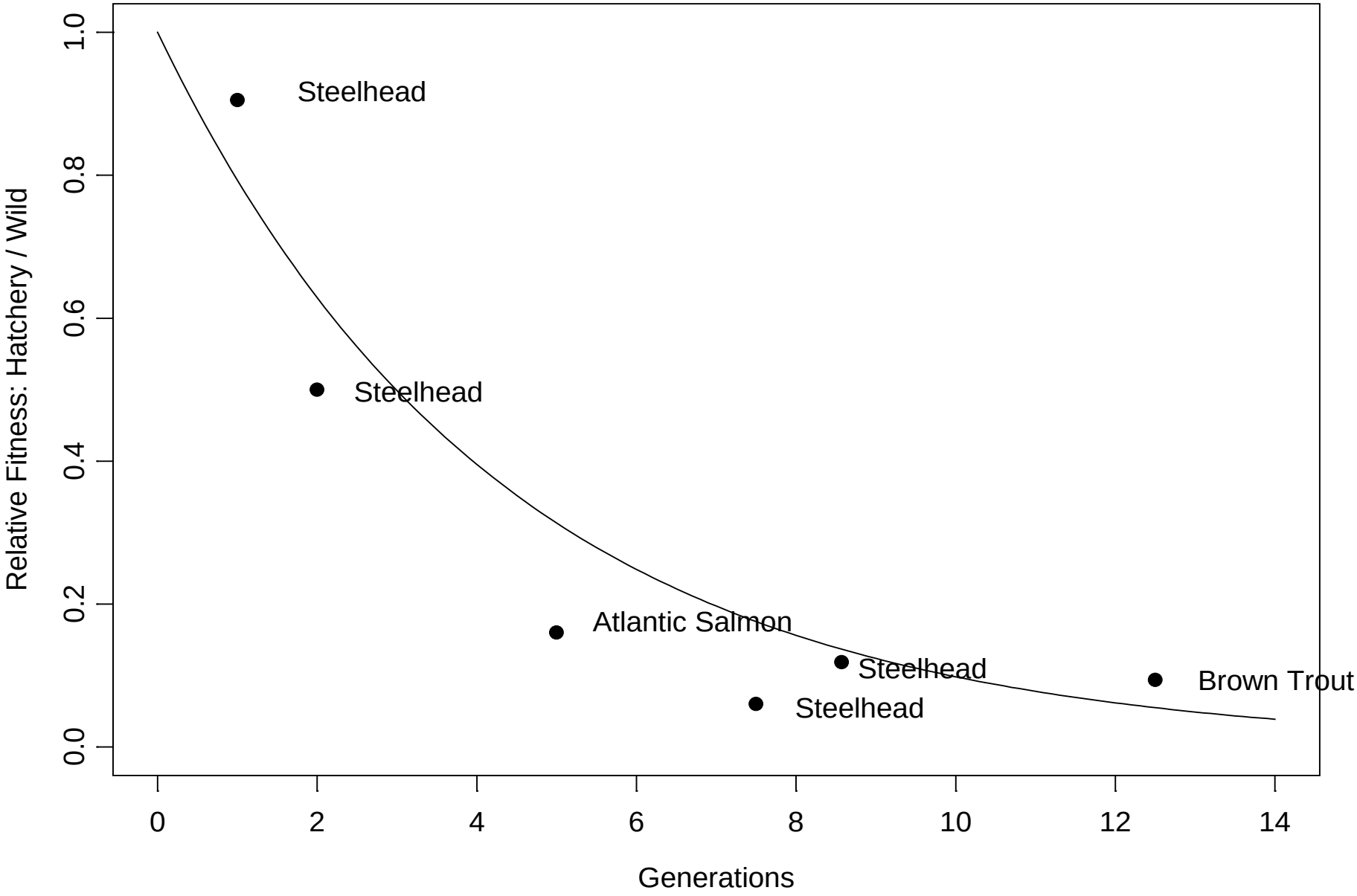
So what is the critical question? What is the critical parameter?

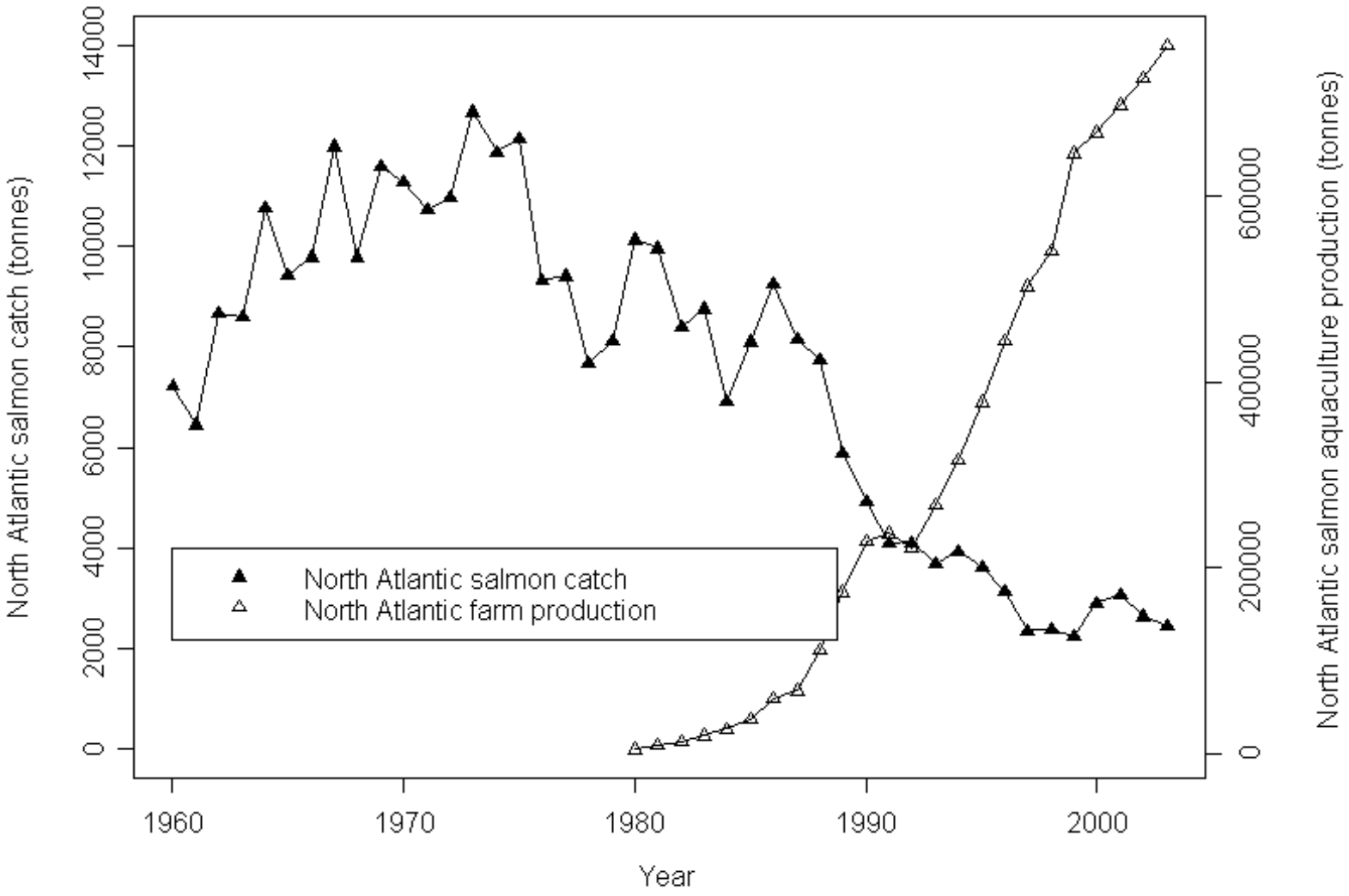
- The rate of loss of fitness in the wild caused by domestication.
- Loss of fitness = exp(-δ generations in hatchery)

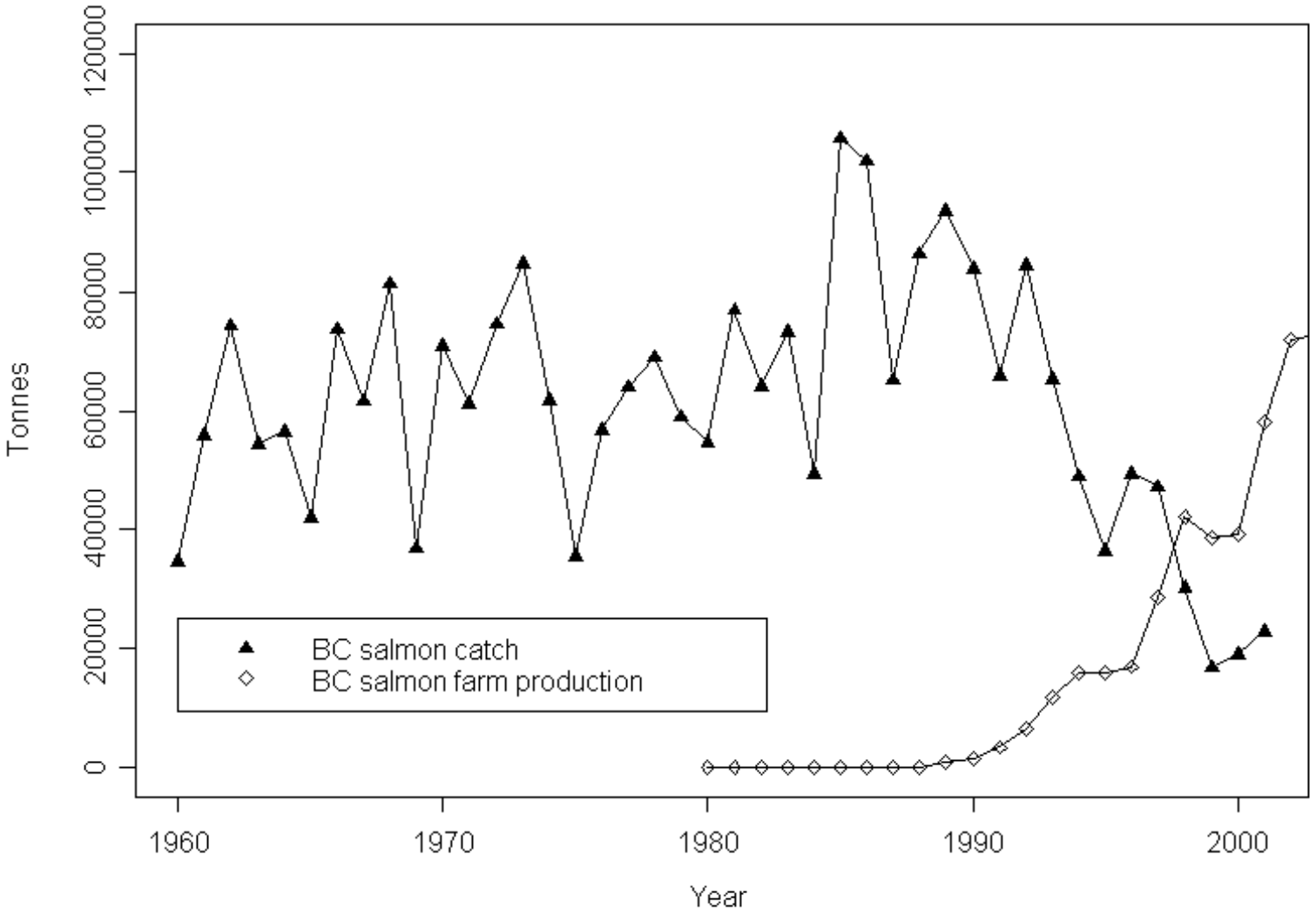
There is always a rapid loss of fitness in the wild with hatcheries; after a few generations hatchery salmon may be useless for recovery.



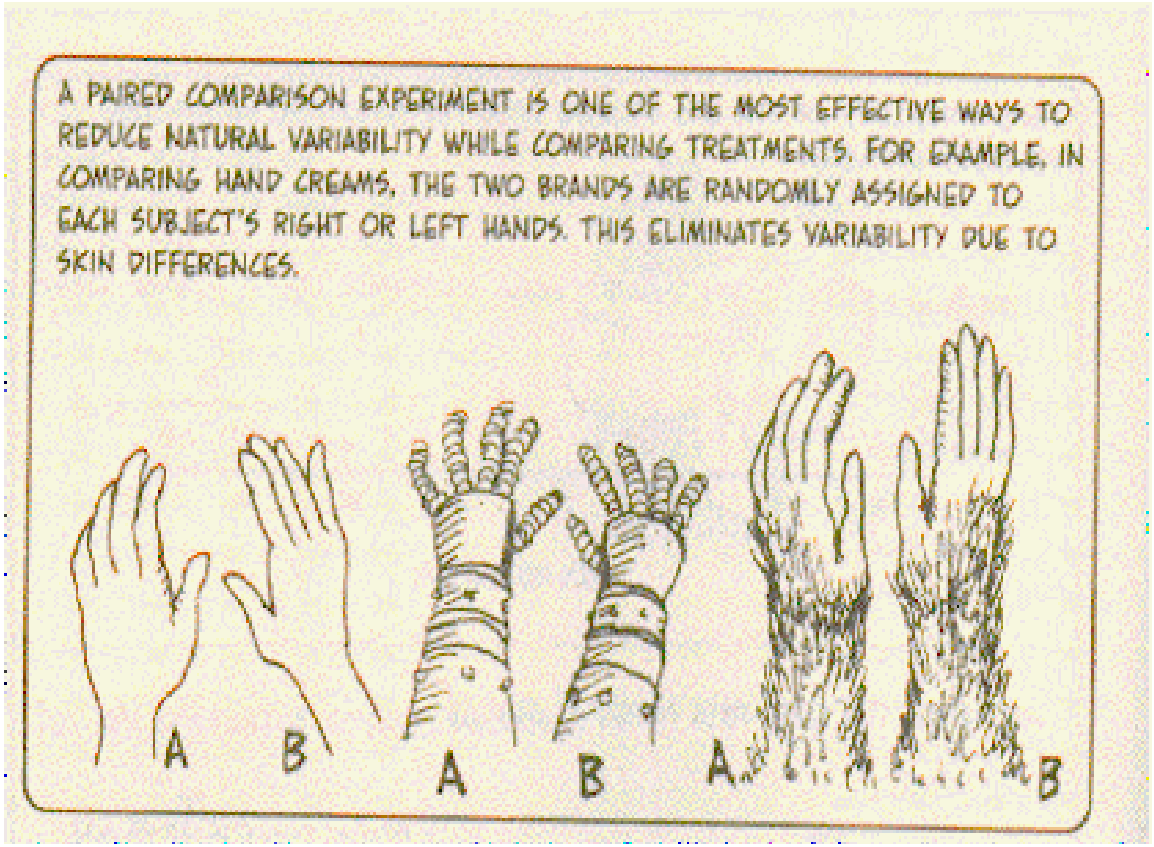
Can wild salmonid populations survive salmon aquaculture?

Jennifer Ford and Ransom Myers


North Atlantic salmon catch (tonnes)
0
2000
4000
6000
8000
10000
12000
14000
North Atlantic salmon aquaculture production (tonnes)
0
200000
400000
600000
1960
1970
1980
1990
2000
Year
North Atlantic salmon catch
North Atlantic farm production


Tonnes
0
20000
40000
60000
80000
100000
120000
1960
1970
1980
1990
2000
Year
BC salmon catch
BC salmon farm production

Use paired comparisons.



Source: Cartoon Guide to Statistics, Larry Gonick & Woolcott Smith

A simple model

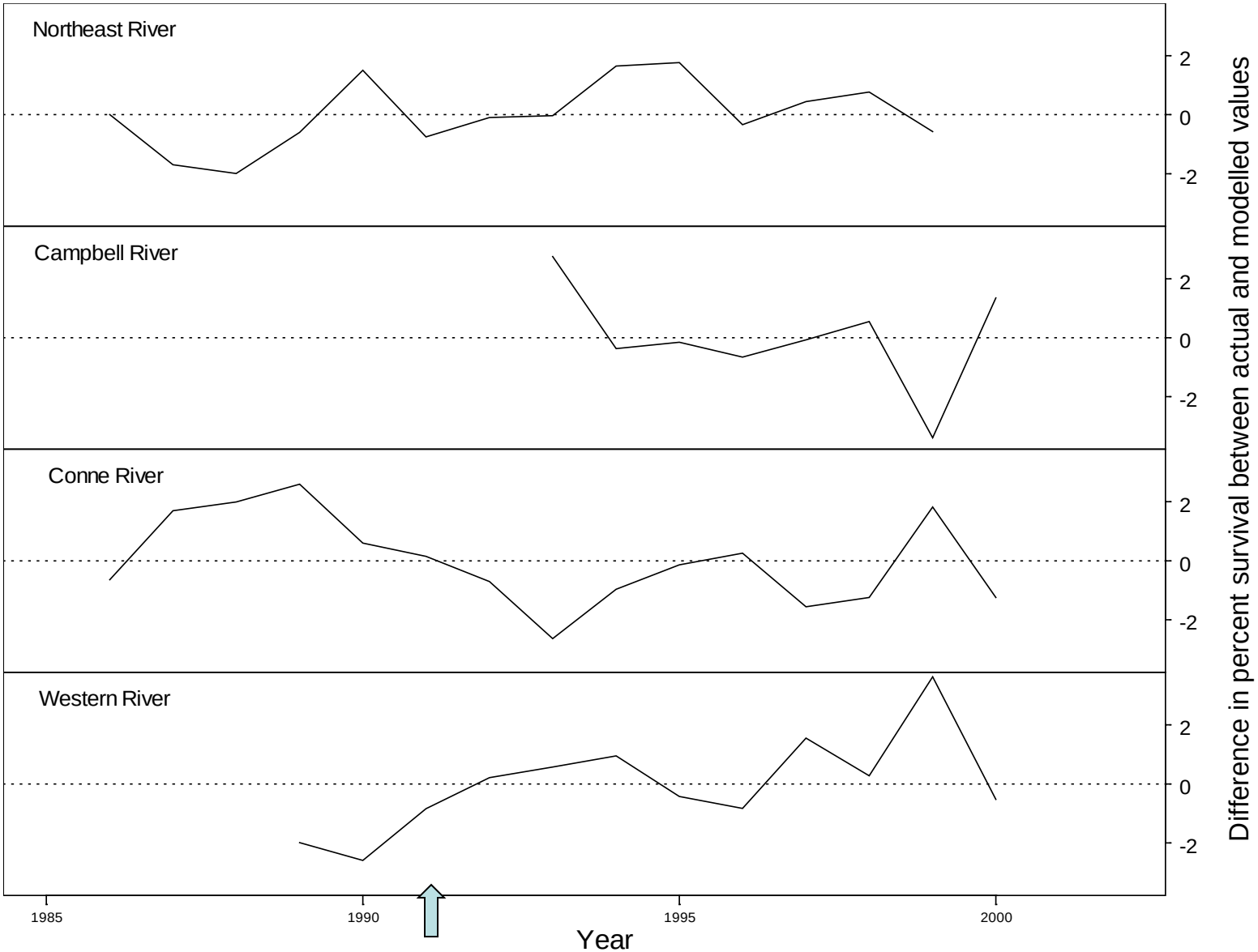
$$S_{i,t} = G_{i,t}/R_{i,t} = exp\,(-(\mu_0 + \mu_i + \mu_t + F(\theta, P_{i,t}) + \varepsilon_{i,t}))$$

i – River
t – Smolt year
S – Survival
G – Grilse
R – Smolts

μ_0 – Mean mortality
μ_i – River mortality
μ_t – Year mortality
θ – Aquaculture effect
$P_{i,t}$ – Aquaculture production
$\varepsilon_{i,t}$ - error

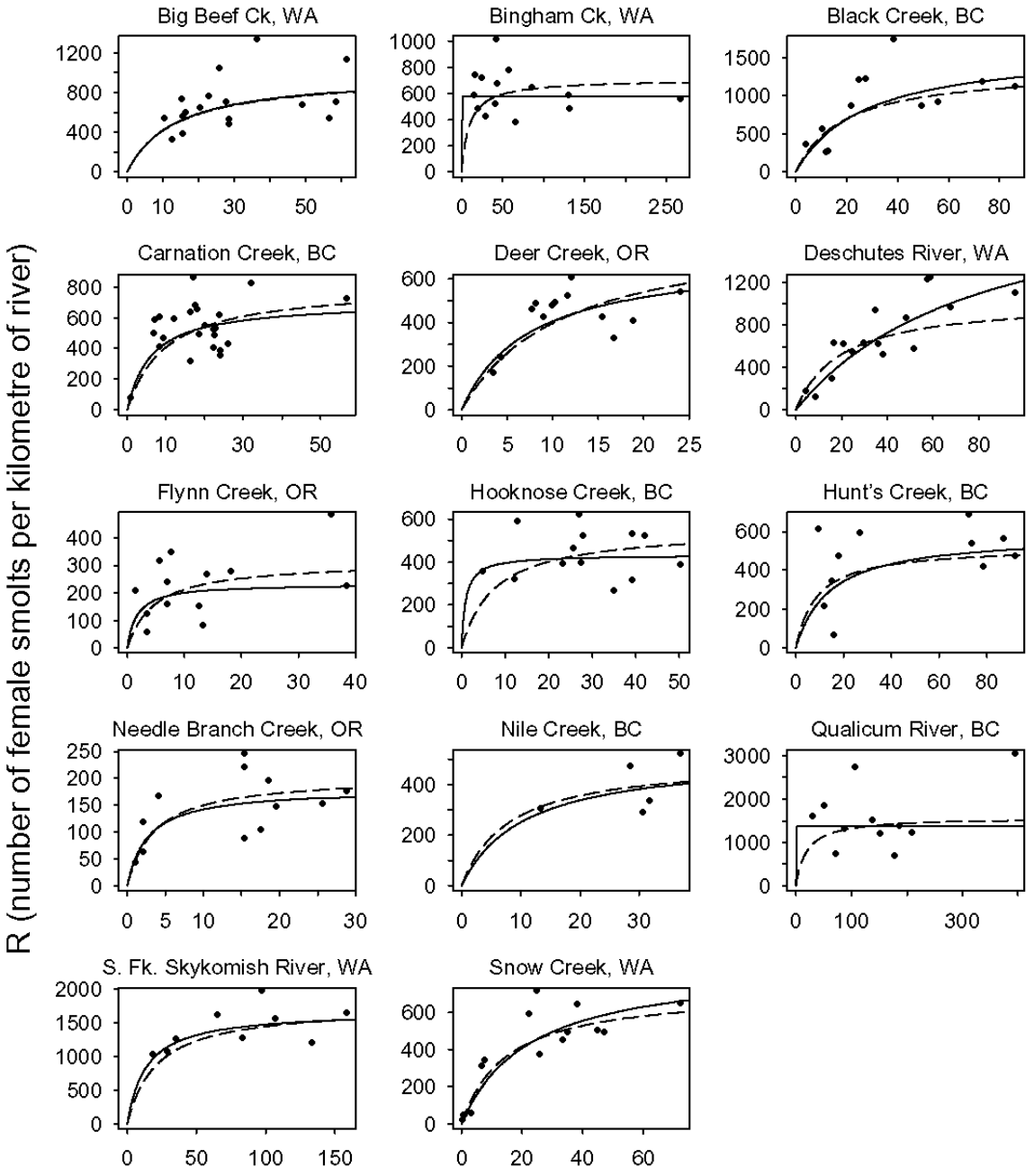
An example - Newfoundland

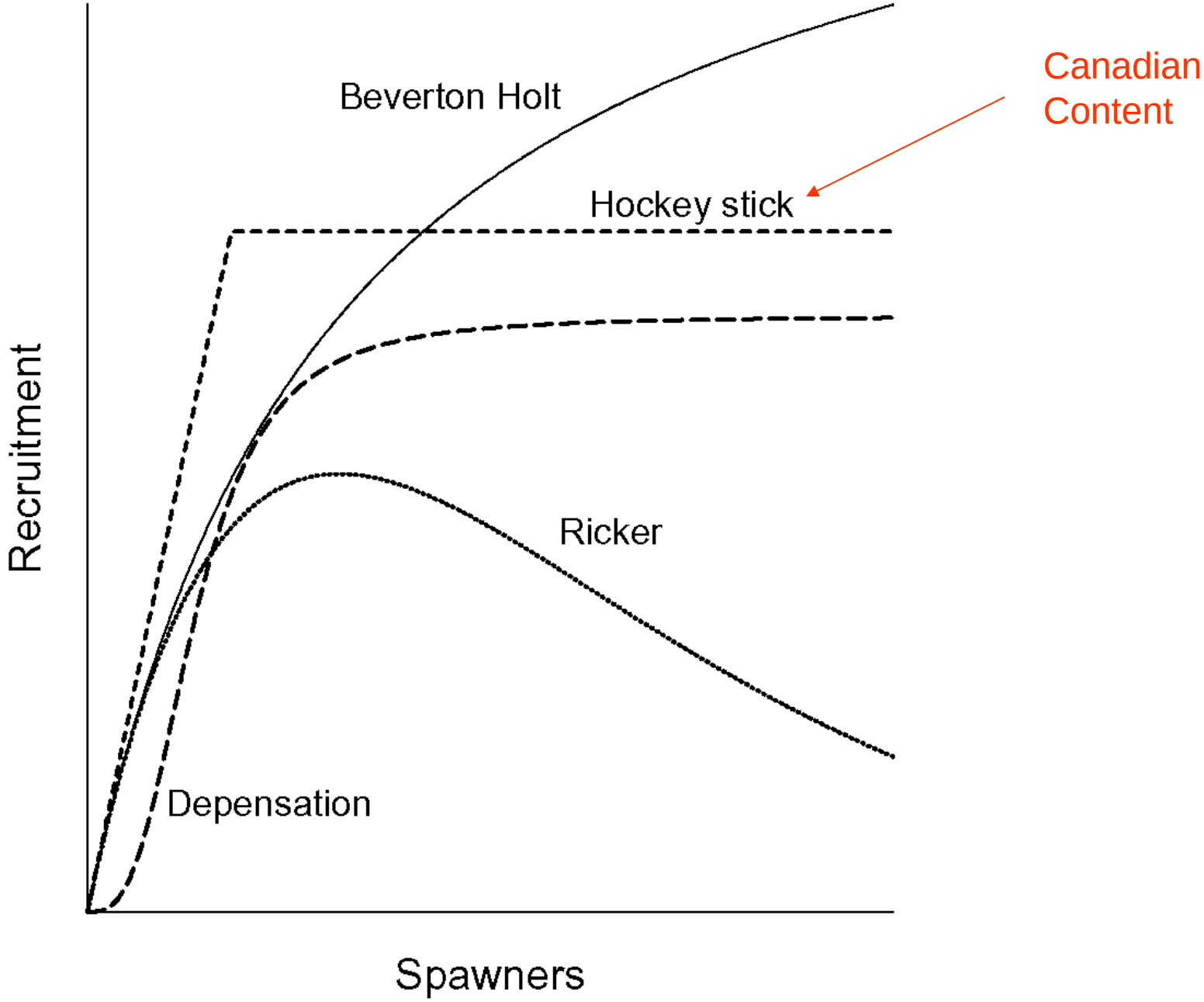
- Used survival estimates from 4 rivers, 1986-2001
- Conne River salmon migrate past cages
- Assumed effect of aquaculture to be proportional to square root of production
- Estimated effect of aquaculture: $e^{1.08}$, a decrease in survival of 66% at highest volumes

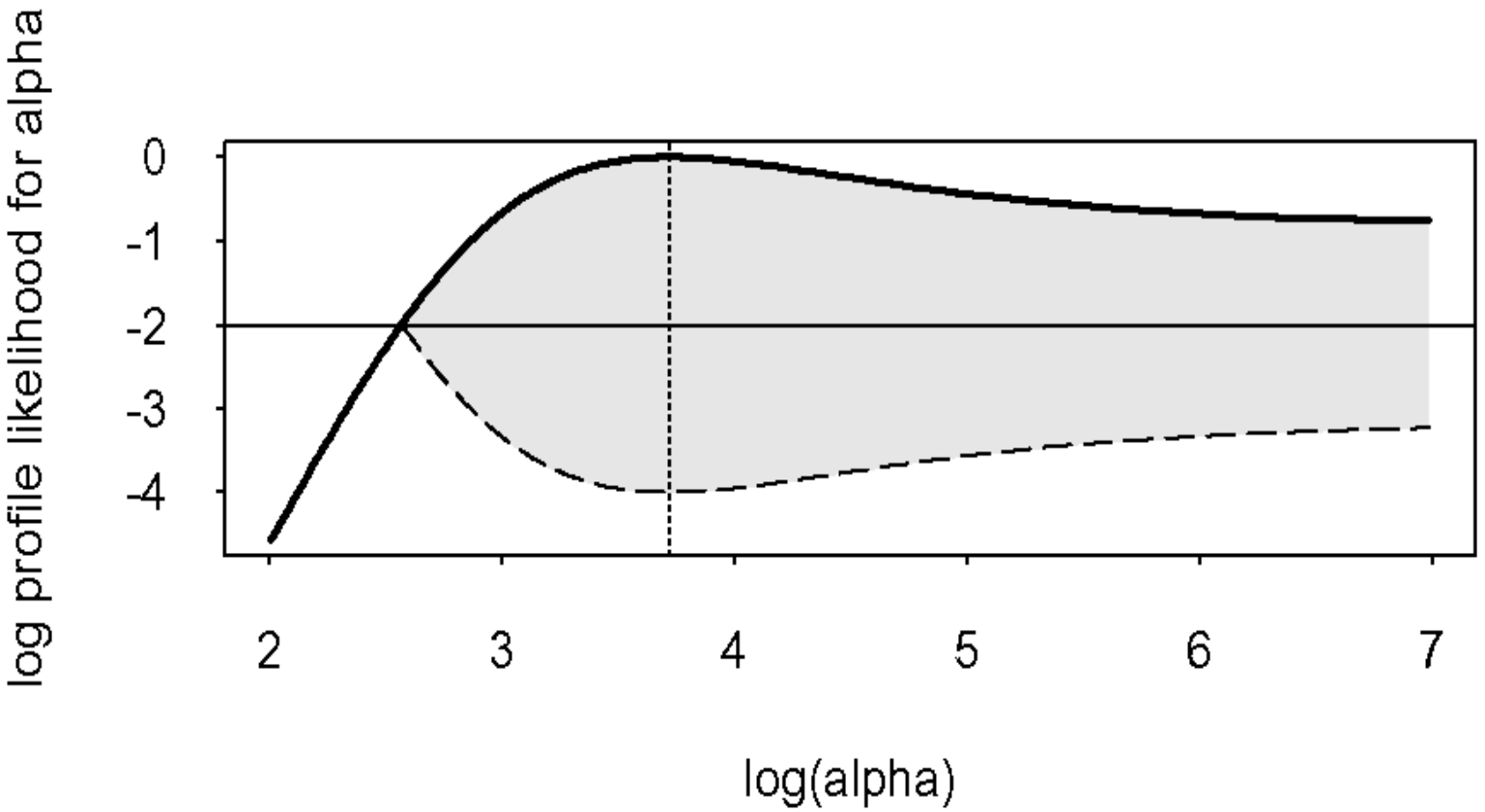


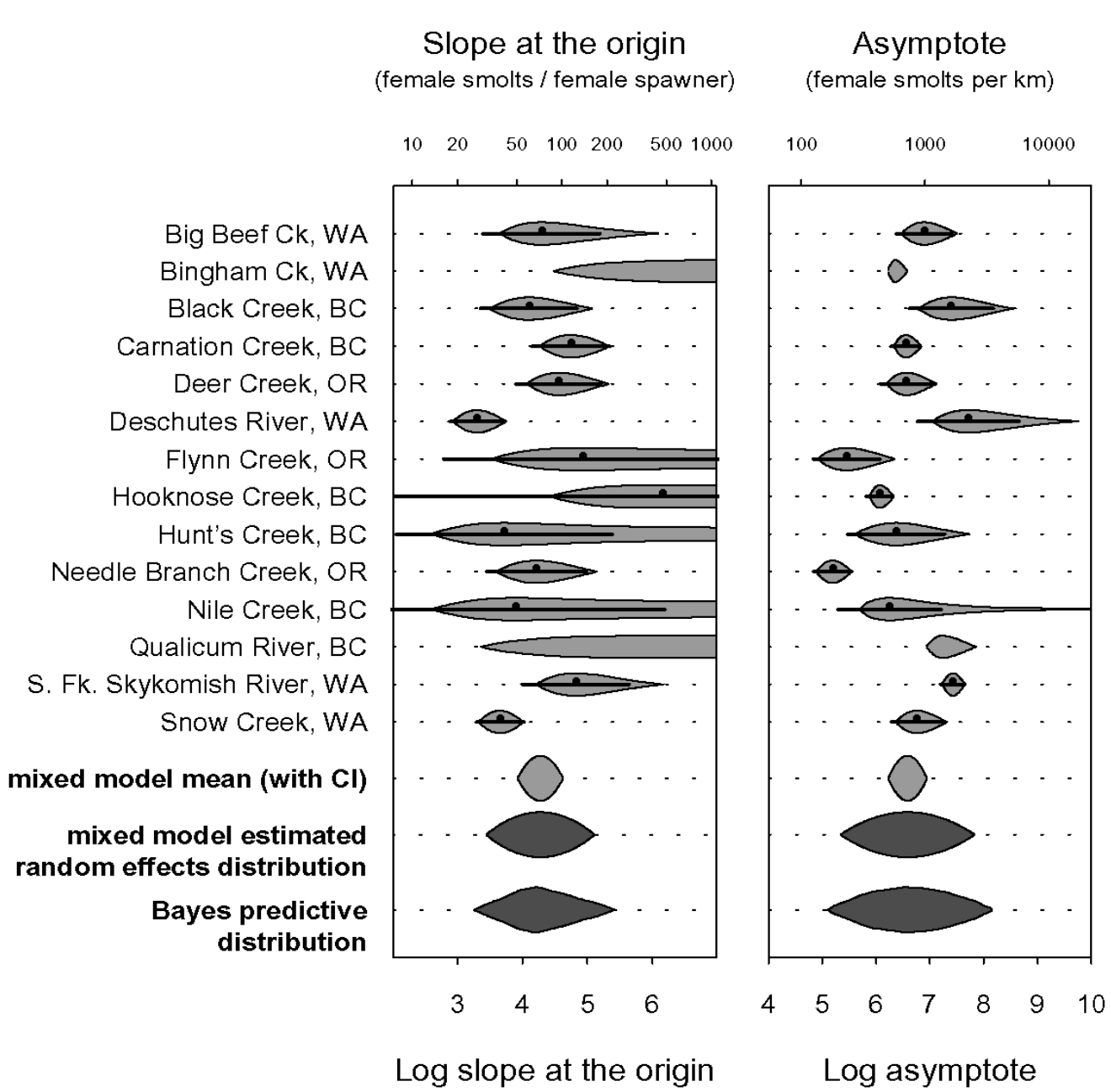
Difference in percent survival between actual and modeled values. Average survival over the time period is 5%. Aquaculture begins in the Conne River in 1991 (blue arrow).

Parameters are random variables
All parameters are hierachical.

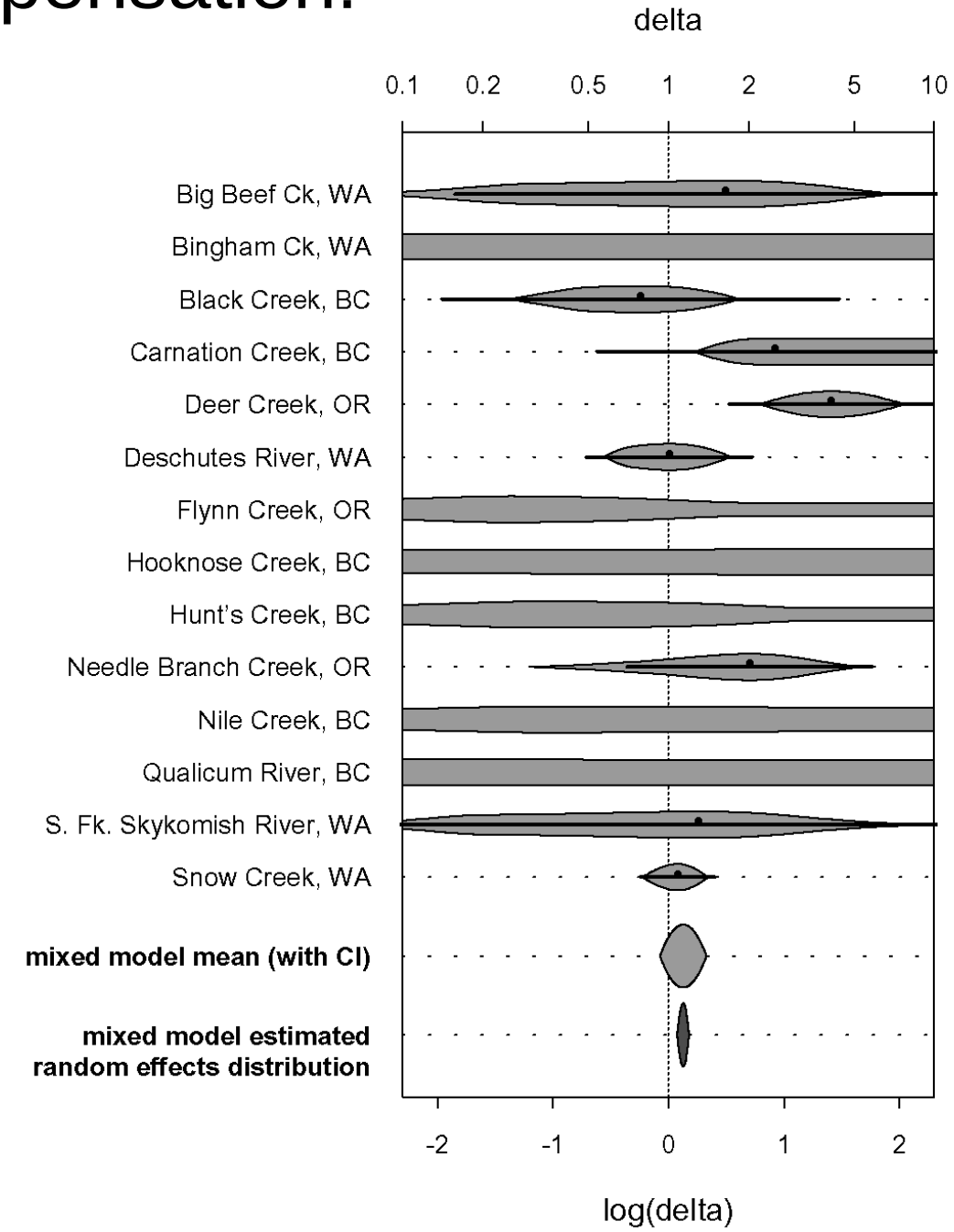

Big Beef Ck, WA
Bingham Ck, WA
Black Creek, BC
Carnation Creek, BC
Deer Creek, OR
Deschutes River, WA
Flynn Creek, OR
Hooknose Creek, BC
Hunt's Creek, BC
Needle Branch Creek, OR
Nile Creek, BC
Qualicum River, BC
S. Fk. Skykomish River, WA
Snow Creek, WA
R (number of female smolts per kilometre of river)
S (number of spawning females per kilometre of river)

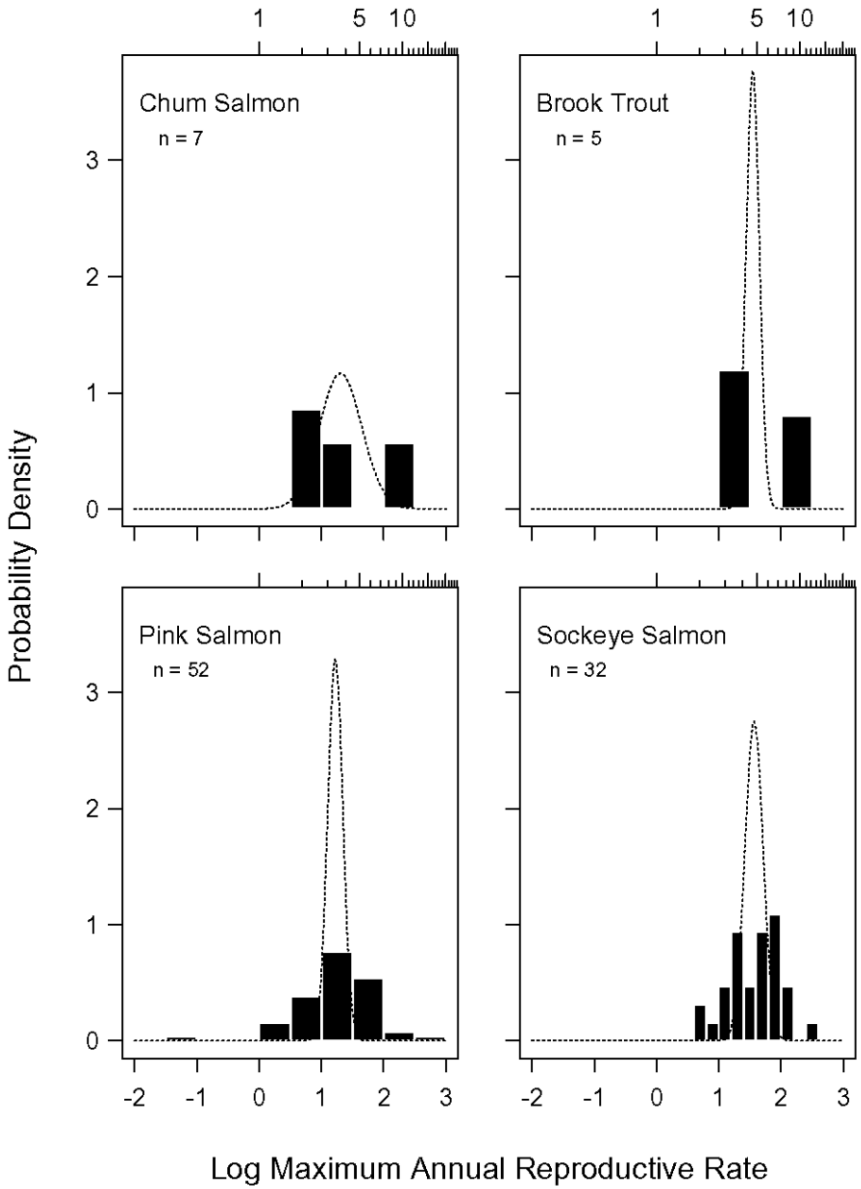

Canadian Content
Beverton Holt
Hockey stick
Ricker
Depensation
Recruitment
Spawners

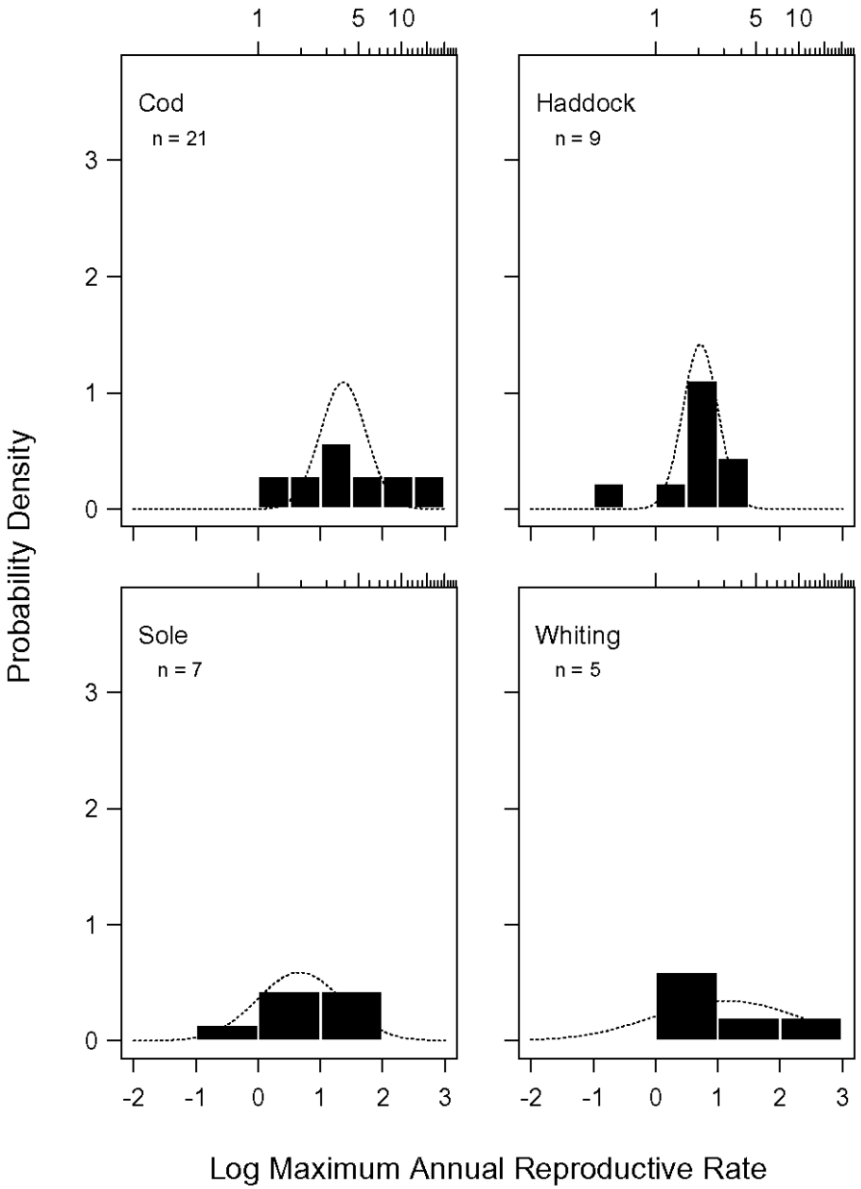

log profile likelihood for alpha
0
-1
-2
-3
-4
2
3
4
5
6
7
log(alpha)


Slope at the origin
(female smolts / female spawner)
Asymptote
(female smolts per km)
10 20 50 100 200 500 1000
100 1000 10000
Big Beef Ck, WA
Bingham Ck, WA
Black Creek, BC
Carnation Creek, BC
Deer Creek, OR
Deschutes River, WA
Flynn Creek, OR
Hooknose Creek, BC
Hunt's Creek, BC
Needle Branch Creek, OR
Nile Creek, BC
Qualicum River, BC
S. Fk. Skykomish River, WA
Snow Creek, WA
mixed model mean (with CI)
mixed model estimated random effects distribution
Bayes predictive distribution
3 4 5 6
4 5 6 7 8 9 10
Log slope at the origin
Log asymptote

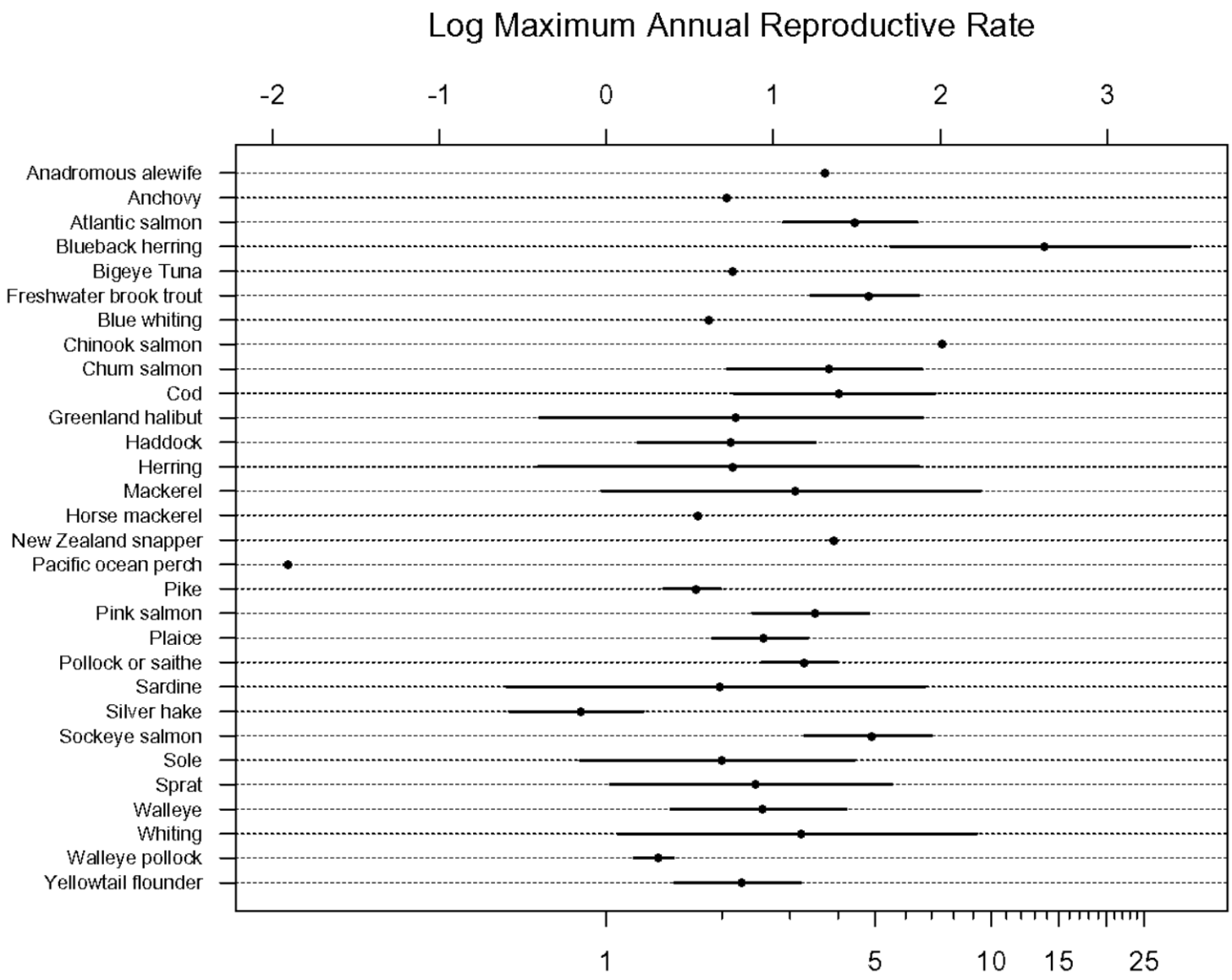
Estimation of Depensation:



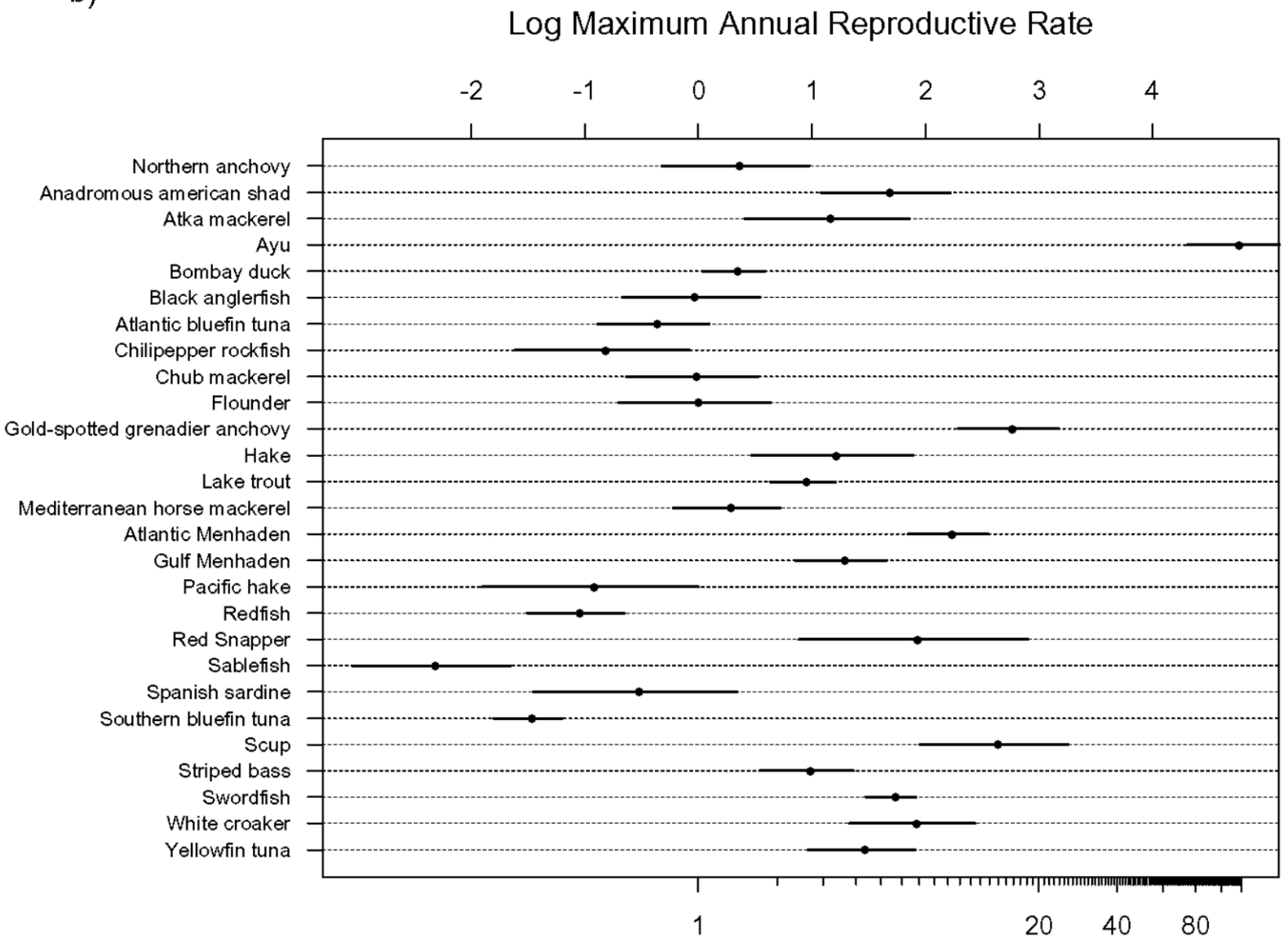

Chum Salmon
n = 7
Brook Trout
n = 5
Pink Salmon
n = 52
Sockeye Salmon
n = 32
1
5
10
0
1
2
3
-2
-1
0
1
2
3
Probability Density
Log Maximum Annual Reproductive Rate


1
5
10
Cod
n = 21
Haddock
n = 9
Sole
n = 7
Whiting
n = 5
Probability Density
0
1
2
3
-2
-1
0
1
2
3
Log Maximum Annual Reproductive Rate

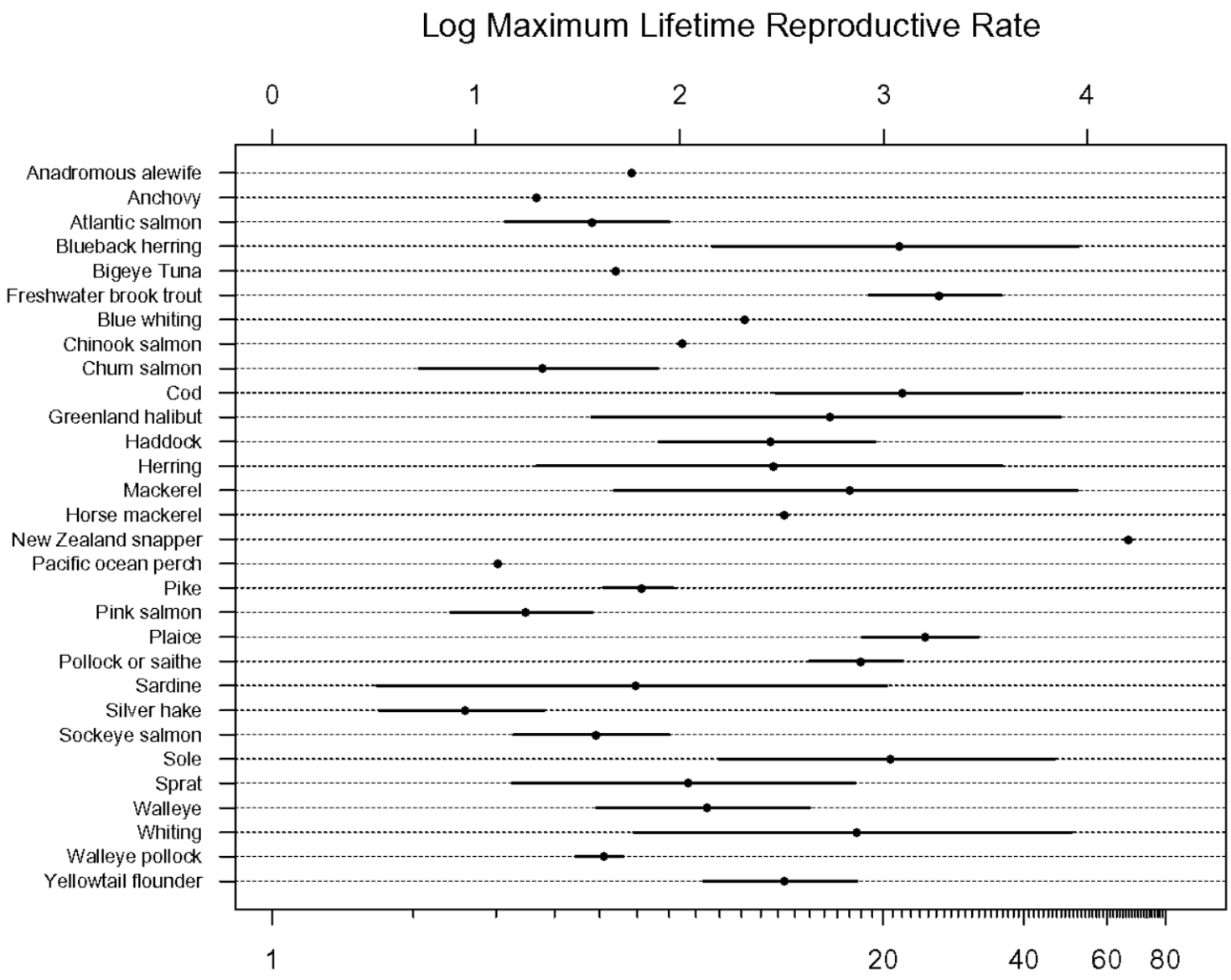
a)


Log Maximum Annual Reproductive Rate
-2
-1
0
1
2
3
Anadromous alewife
Anchovy
Atlantic salmon
Blueback herring
Bigeye Tuna
Freshwater brook trout
Blue whiting
Chinook salmon
Chum salmon
Cod
Greenland halibut
Haddock
Herring
Mackerel
Horse mackerel
New Zealand snapper
Pacific ocean perch
Pike
Pink salmon
Plaice
Pollock or saithe
Sardine
Silver hake
Sockeye salmon
Sole
Sprat
Walleye
Whiting
Walleye pollock
Yellowtail flounder
1
5
10
15
25

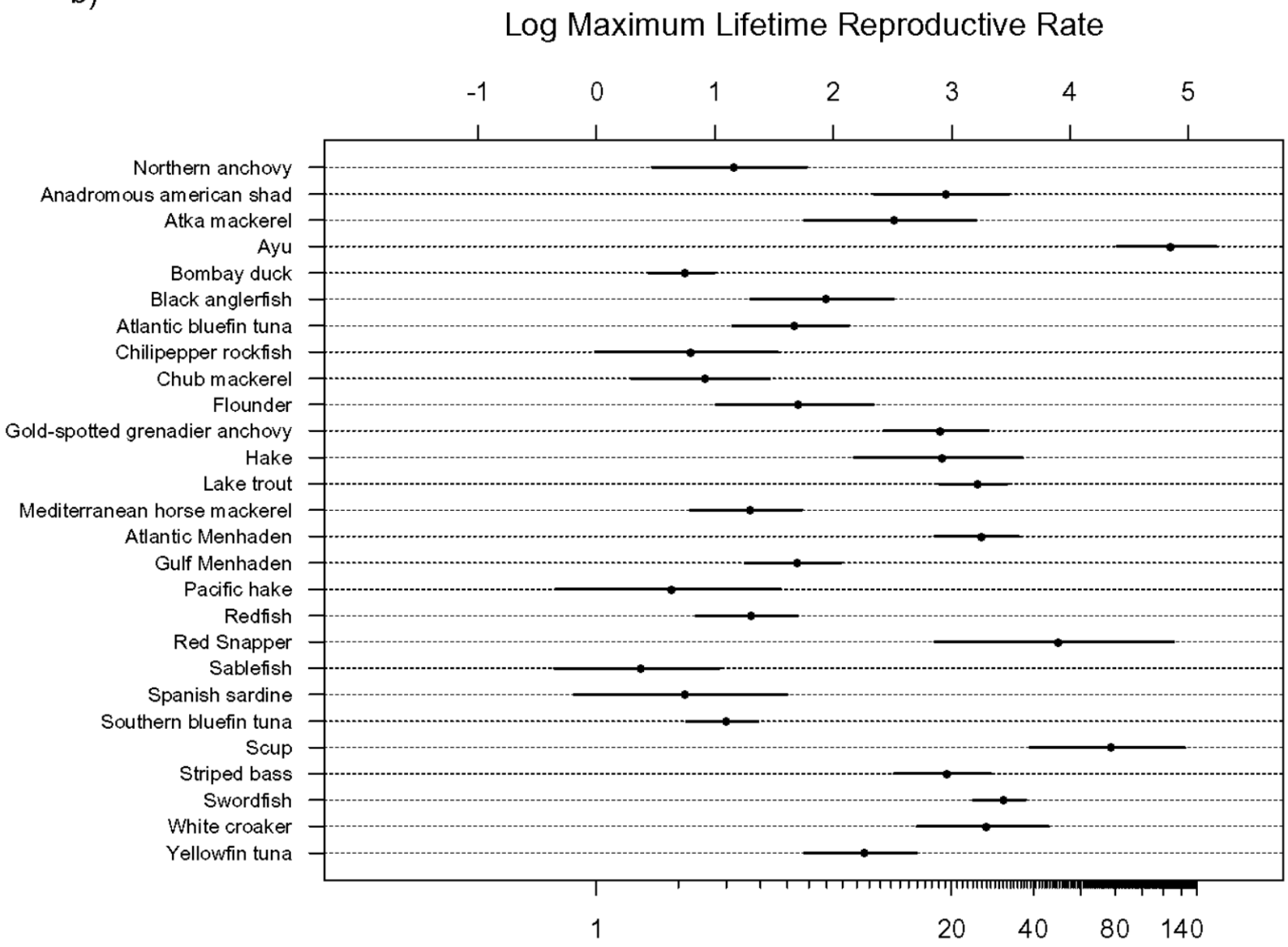
b)

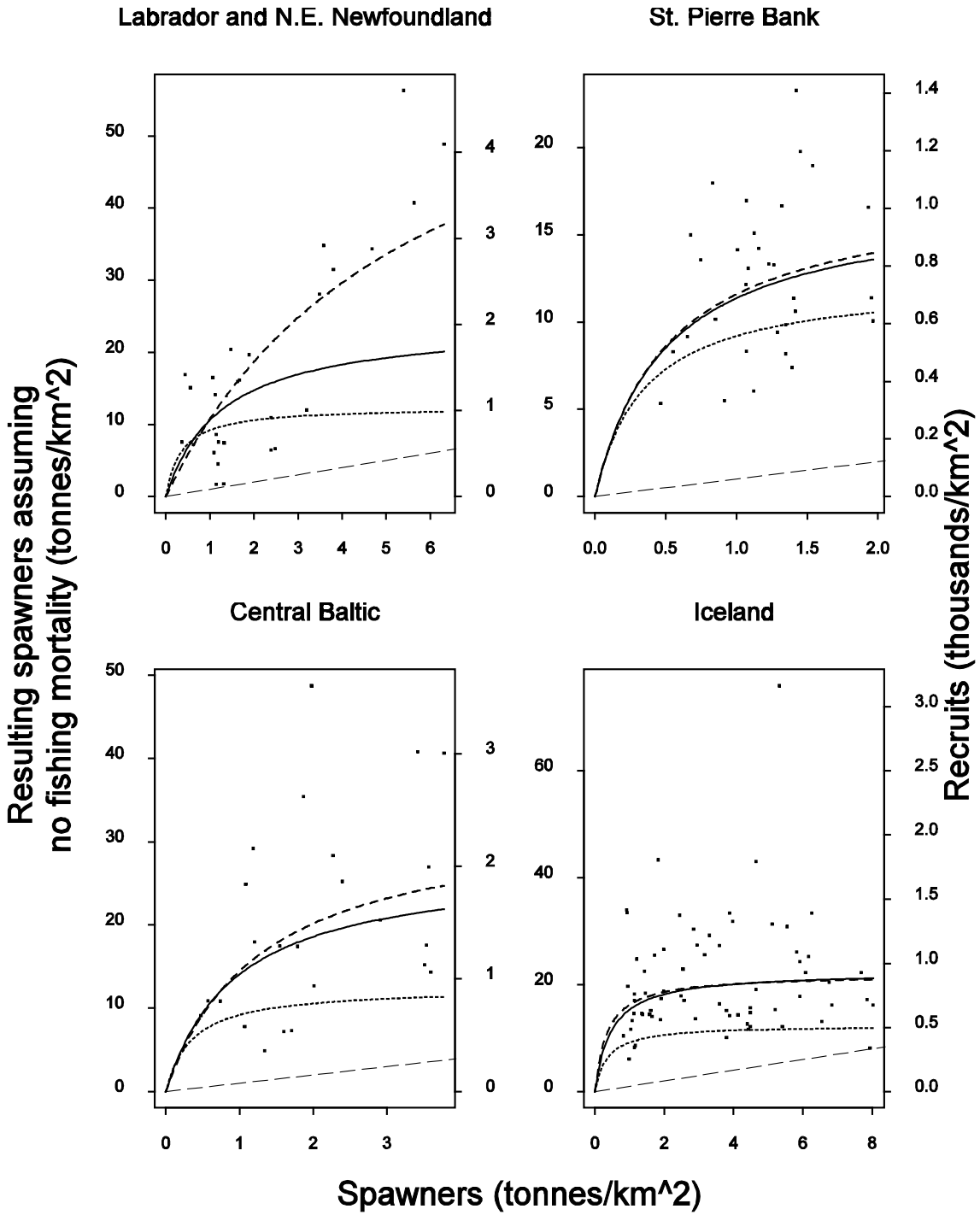

Log Maximum Annual Reproductive Rate
-2
-1
0
1
2
3
4
Northern anchovy
Anadromous american shad
Atka mackerel
Ayu
Bombay duck
Black anglerfish
Atlantic bluefin tuna
Chilipepper rockfish
Chub mackerel
Flounder
Gold-spotted grenadier anchovy
Hake
Lake trout
Mediterranean horse mackerel
Atlantic Menhaden
Gulf Menhaden
Pacific hake
Redfish
Red Snapper
Sablefish
Spanish sardine
Southern bluefin tuna
Scup
Striped bass
Swordfish
White croaker
Yellowfin tuna
1
20
40
80

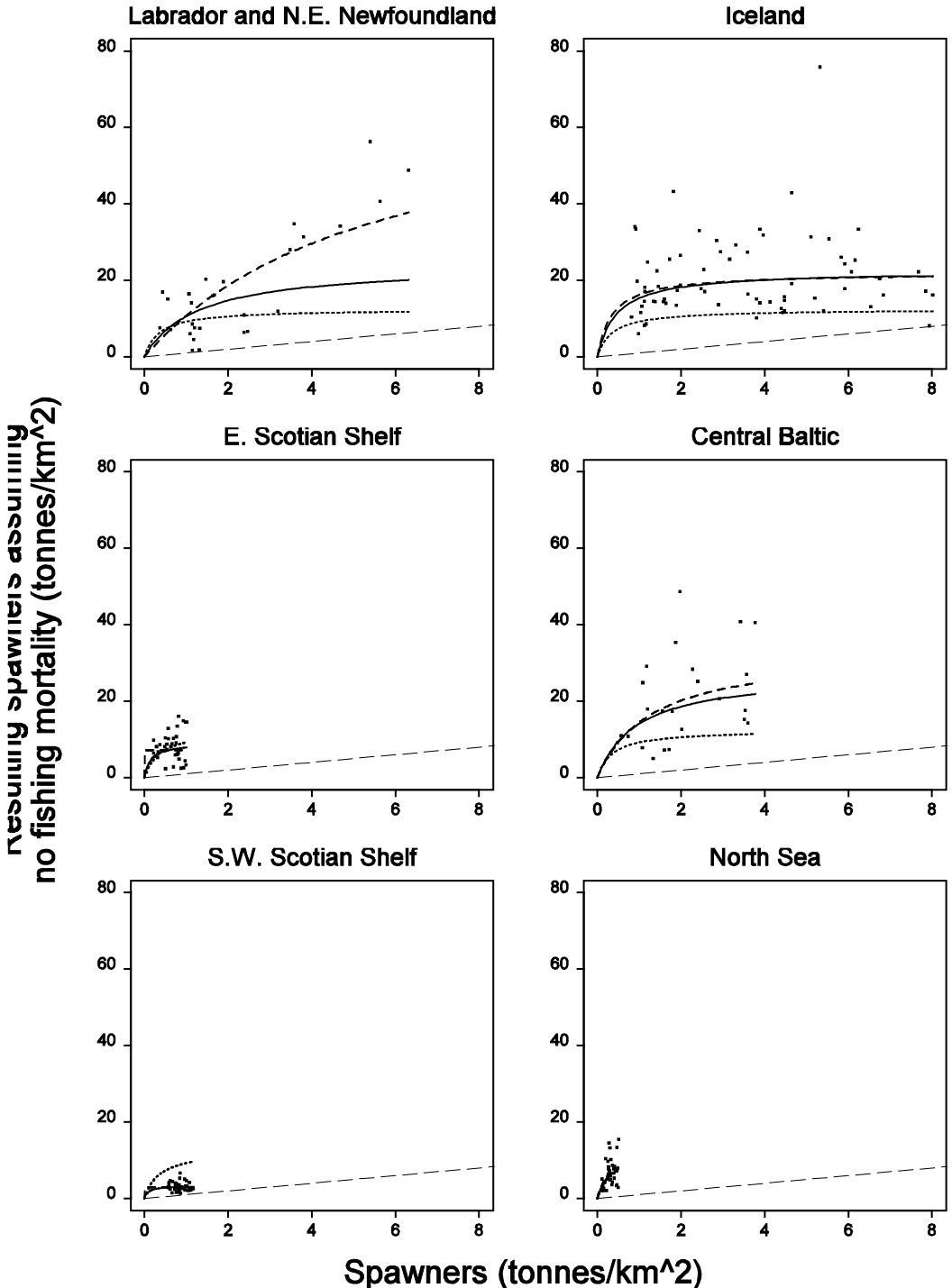
a)


Log Maximum Lifetime Reproductive Rate
0
1
2
3
4
Anadromous alewife
Anchovy
Atlantic salmon
Blueback herring
Bigeye Tuna
Freshwater brook trout
Blue whiting
Chinook salmon
Chum salmon
Cod
Greenland halibut
Haddock
Herring
Mackerel
Horse mackerel
New Zealand snapper
Pacific ocean perch
Pike
Pink salmon
Plaice
Pollock or saithe
Sardine
Silver hake
Sockeye salmon
Sole
Sprat
Walleye
Whiting
Walleye pollock
Yellowtail flounder
1
20
40
60
80

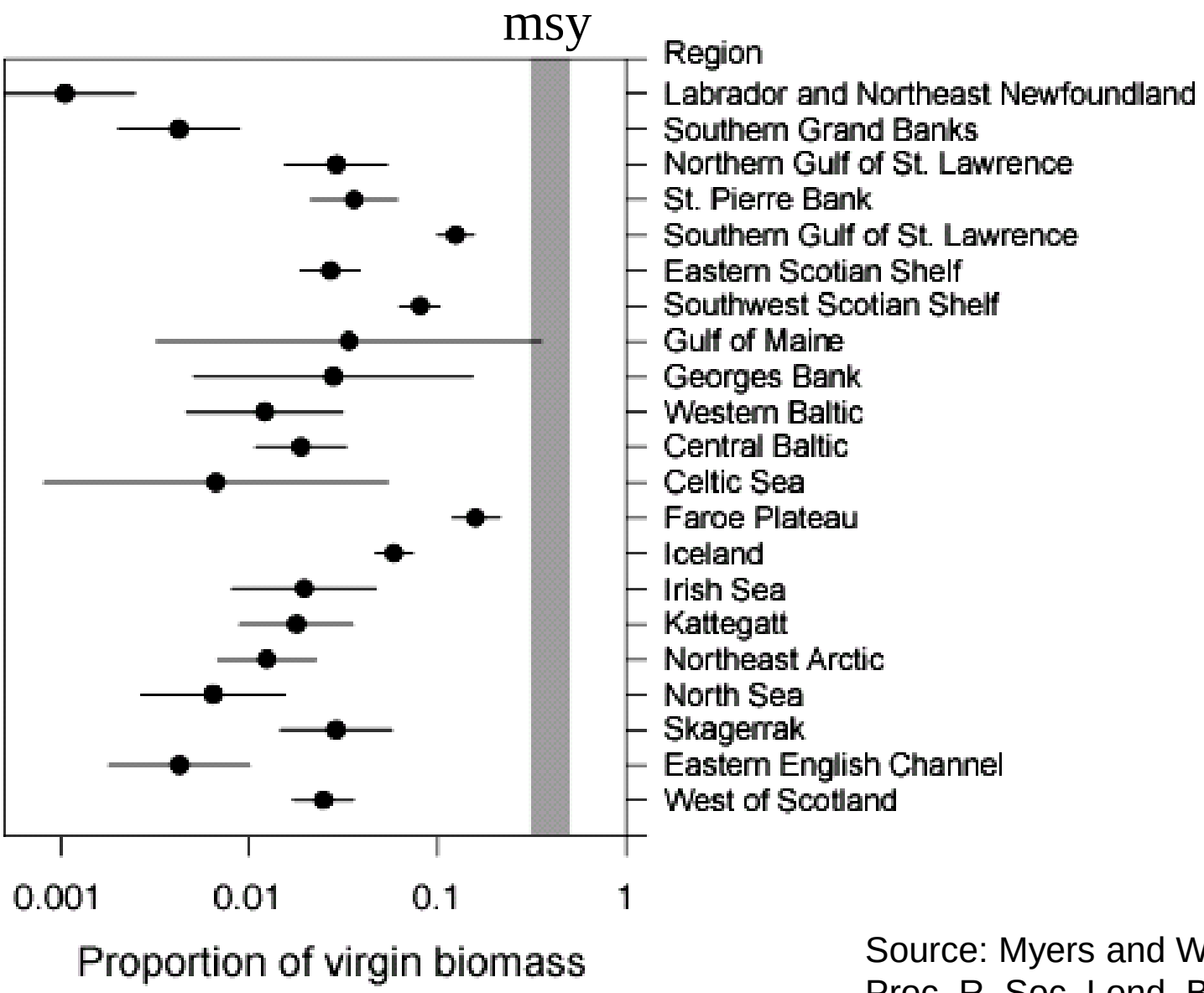
b)


Log Maximum Lifetime Reproductive Rate
-1
0
1
2
3
4
5
Northern anchovy
Anadromous american shad
Atka mackerel
Ayu
Bombay duck
Black anglerfish
Atlantic bluefin tuna
Chilipepper rockfish
Chub mackerel
Flounder
Gold-spotted grenadier anchovy
Hake
Lake trout
Mediterranean horse mackerel
Atlantic Menhaden
Gulf Menhaden
Pacific hake
Redfish
Red Snapper
Sablefish
Spanish sardine
Southern bluefin tuna
Scup
Striped bass
Swordfish
White croaker
Yellowfin tuna
1
20
40
80
140


Labrador and N.E. Newfoundland
St. Pierre Bank
Central Baltic
Iceland
Resulting spawners assuming no fishing mortality (tonnes/km^2)
Recruits (thousands/km^2)
Spawners (tonnes/km^2)

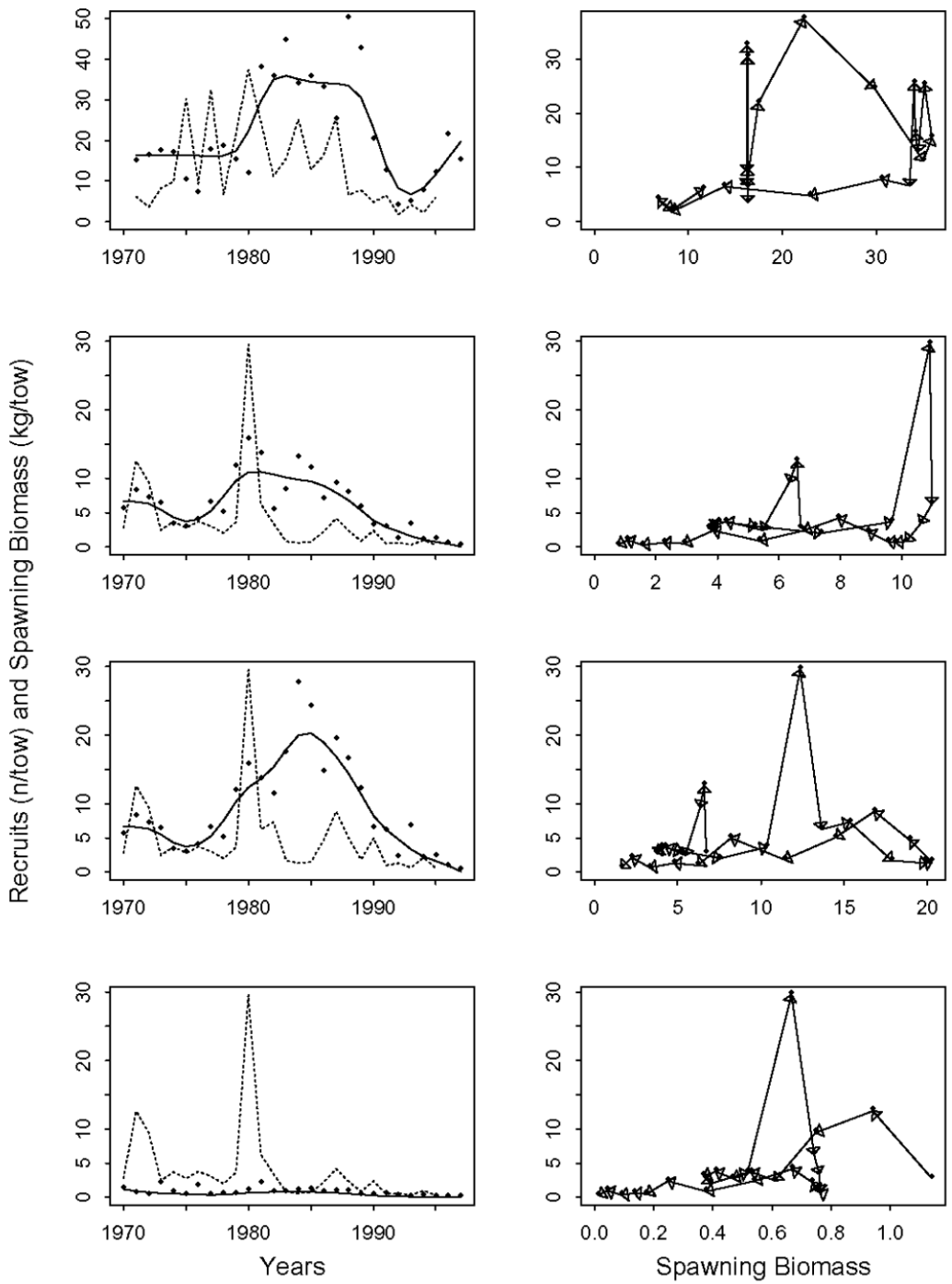

Labrador and N.E. Newfoundland
Iceland
E. Scotian Shelf
Central Baltic
S.W. Scotian Shelf
North Sea
Resulting spawners assuming no fishing mortality (tonnes/km^2)
Spawners (tonnes/km^2)
0
20
40
60
80
0
2
4
6
8

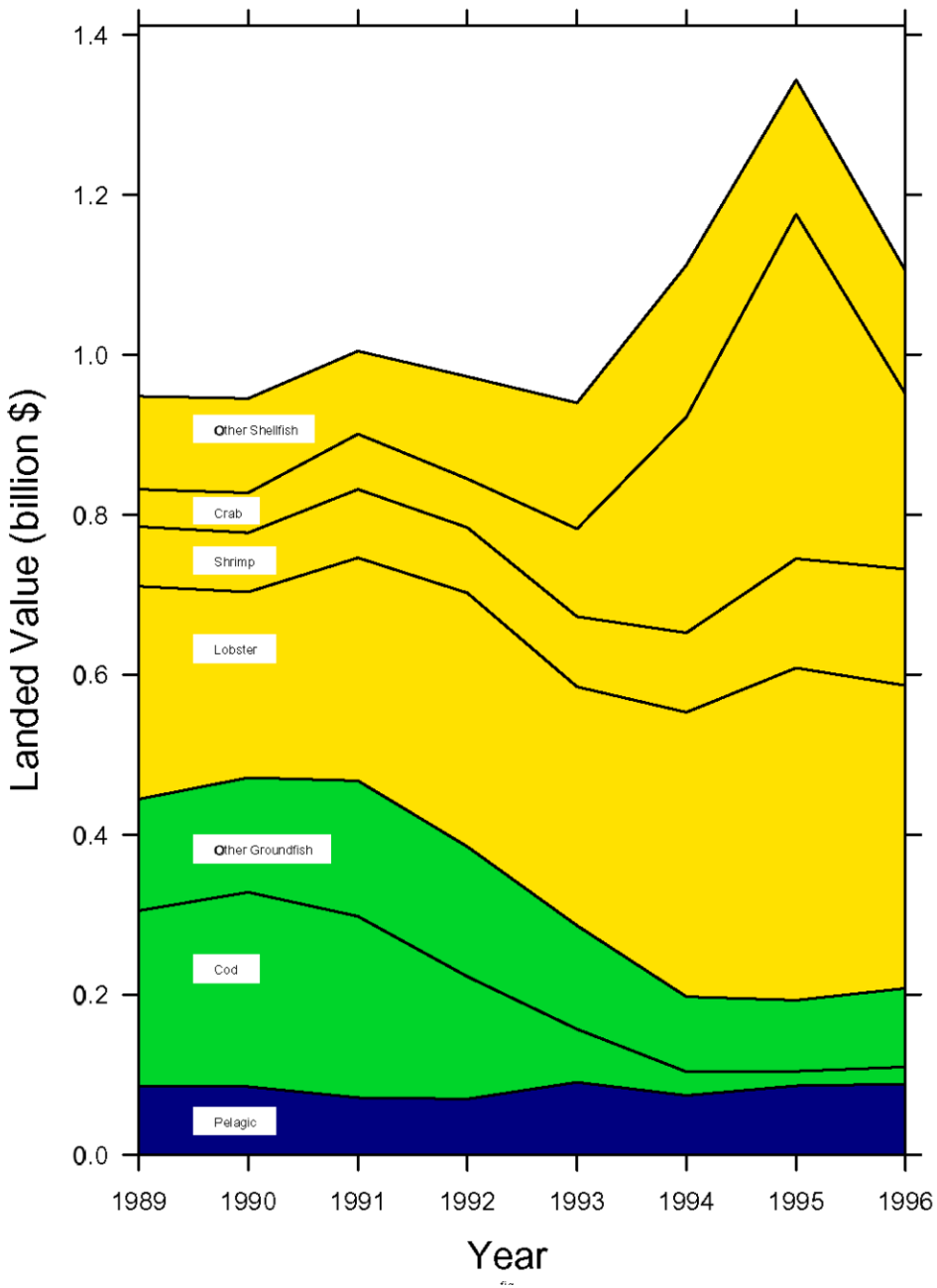
There is much less than 10% of cod left -

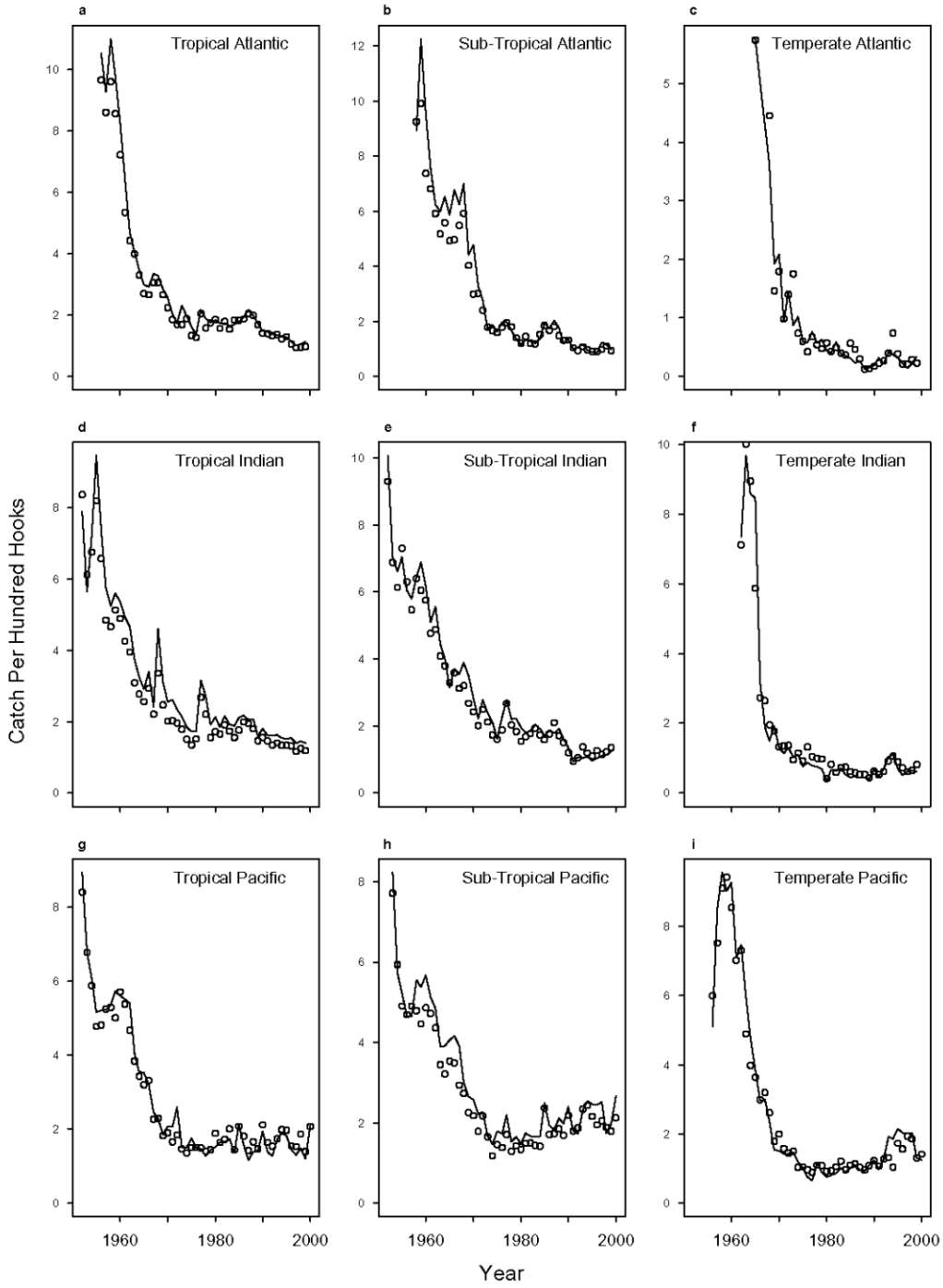


Source: Myers and Worm 2004.
Proc. R. Soc. Lond. B (in press)

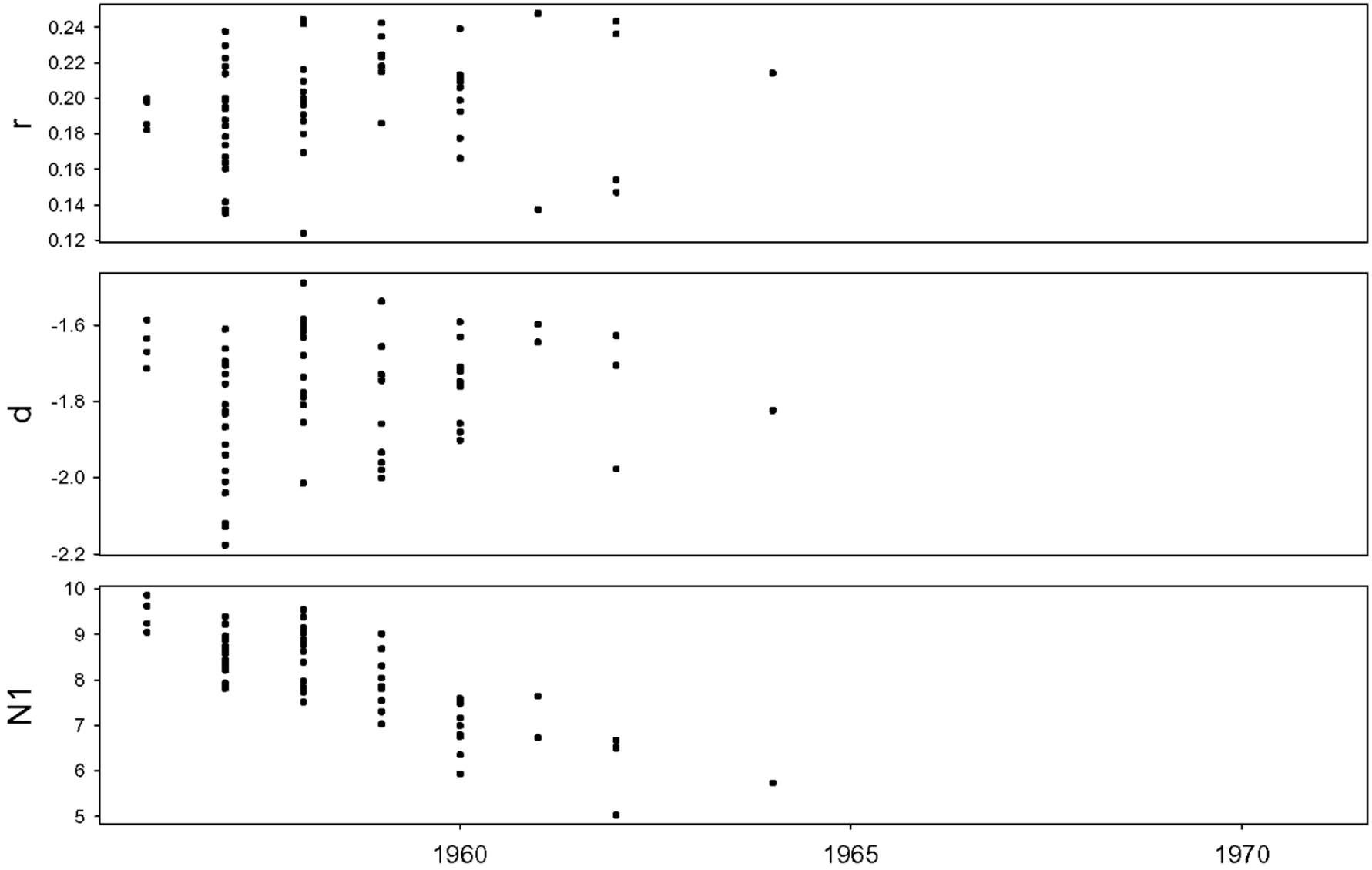
“One thing I’ll say for us, Myers- we never stooped to popularize science.”


Recruits (n/tow) and Spawning Biomass (kg/tow)
Years
Spawning Biomass

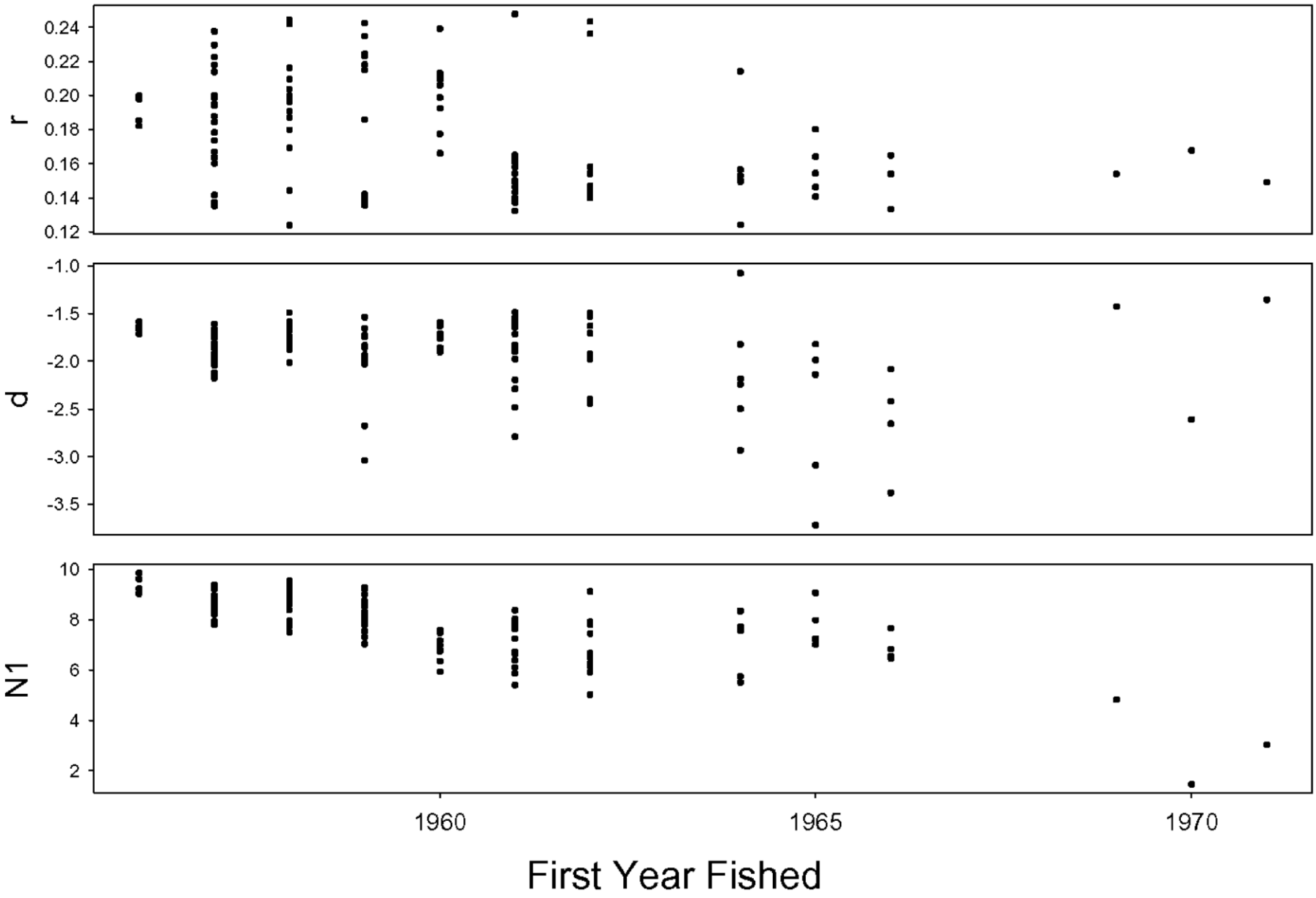

Value of Fisheries After Cod Collapse
Landed Value (billion $)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Other Shellfish
Crab
Shrimp
Lobster
Other Groundfish
Cod
Pelagic
1989
1990
1991
1992
1993
1994
1995
1996
Year


a
Tropical Atlantic
b
Sub-Tropical Atlantic
c
Temperate Atlantic
d
Tropical Indian
e
Sub-Tropical Indian
f
Temperate Indian
g
Tropical Pacific
h
Sub-Tropical Pacific
i
Temperate Pacific
Catch Per Hundred Hooks
Year
1960
1980
2000

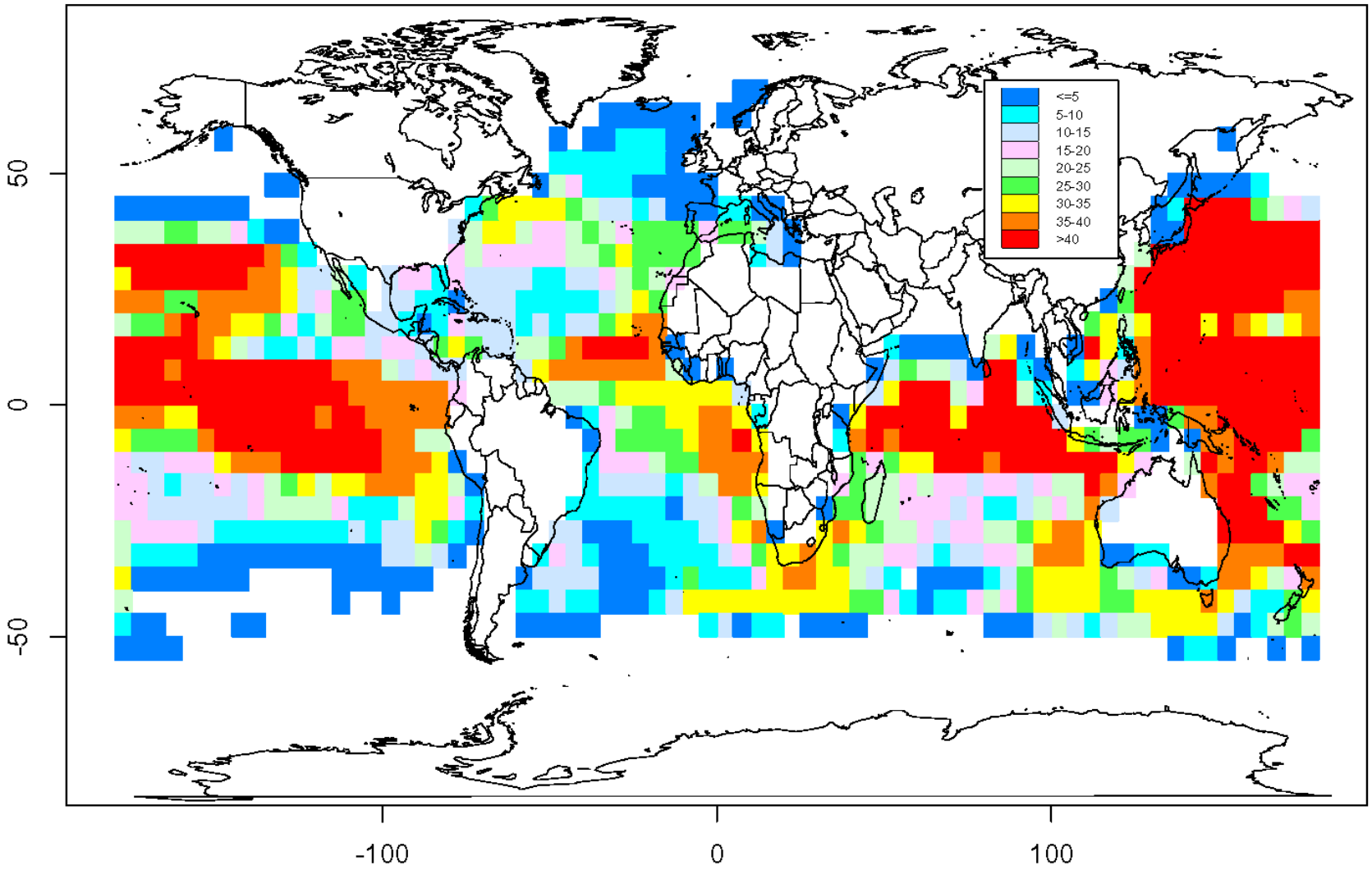
Atlantic Subtropical

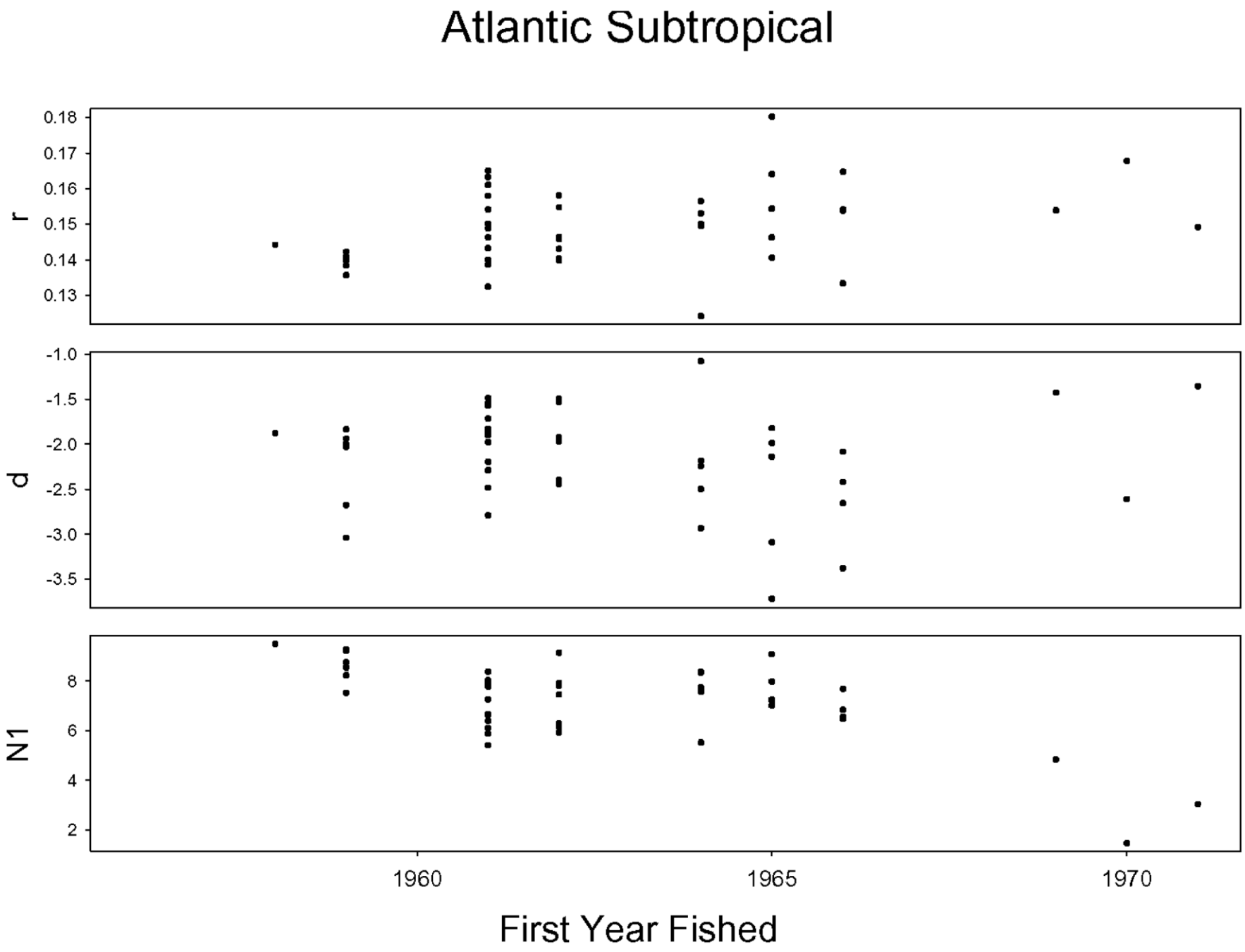


All Areas

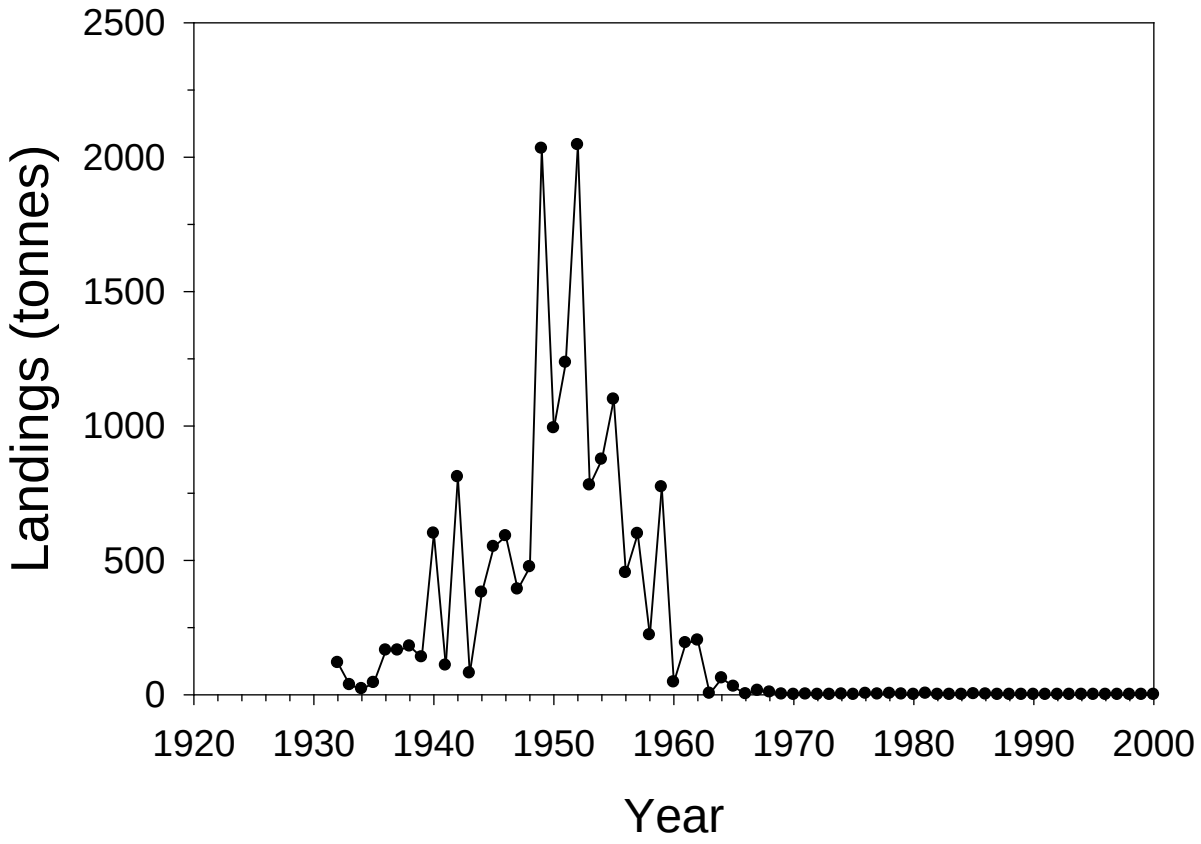

r
0.24
0.22
0.20
0.18
0.16
0.14
0.12
d
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
N1
10
8
6
4
2
1960
1965
1970
First Year Fished

Number




Atlantic Subtropical
r
0.18
0.17
0.16
0.15
0.14
0.13
d
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
N1
8
6
4
2
1960
1965
1970
First Year Fished

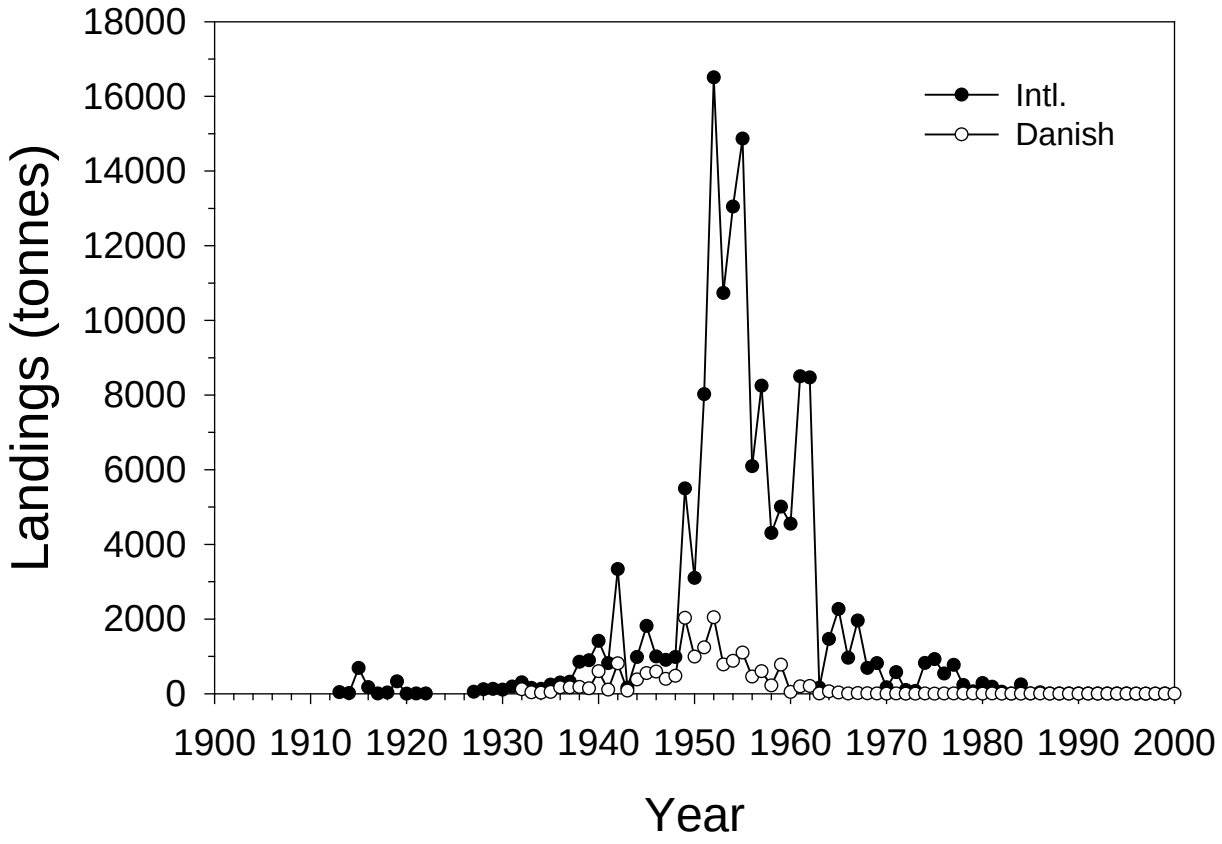
Danish Landings of Bluefin Tuna
Thunnus thynnus



DIFRES

Data source: DIFRES, ICES, FAO

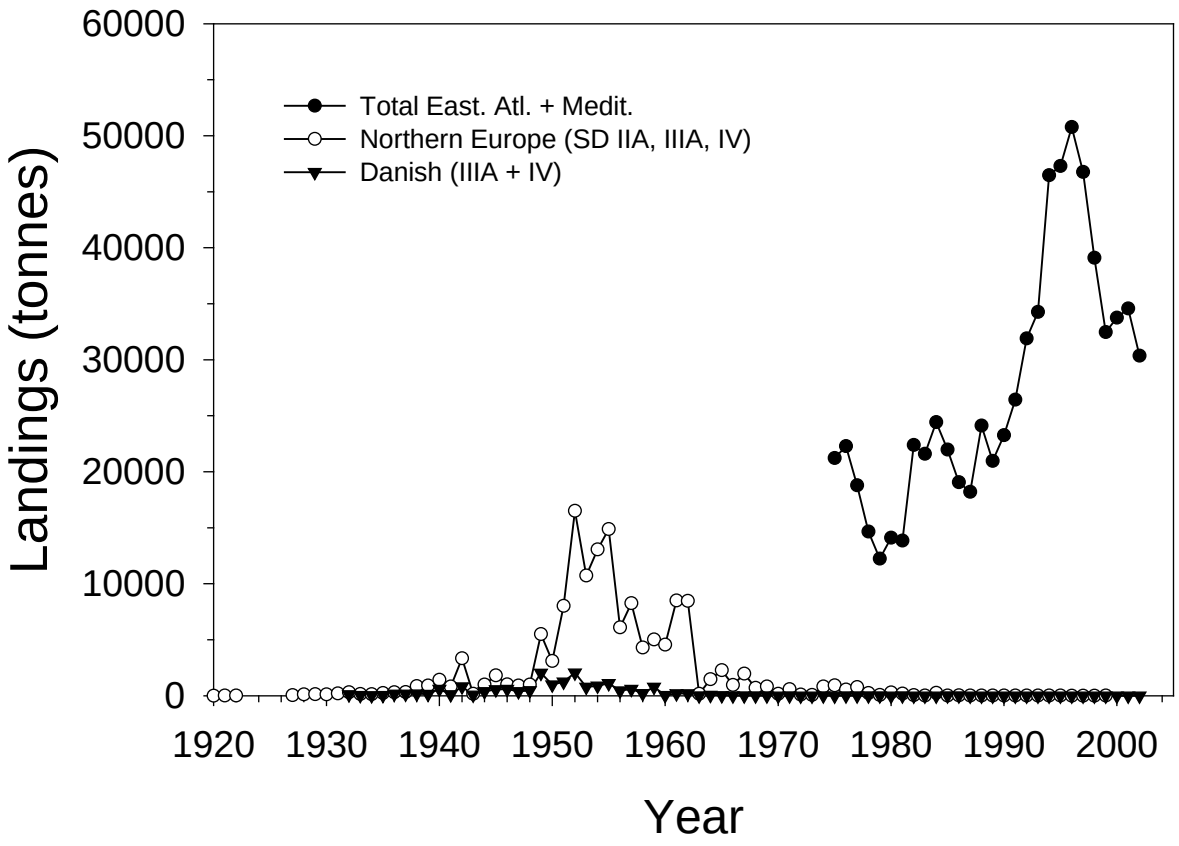
Landings of Bluefin Tuna *Thunnus thynnus* in Northern Europe*



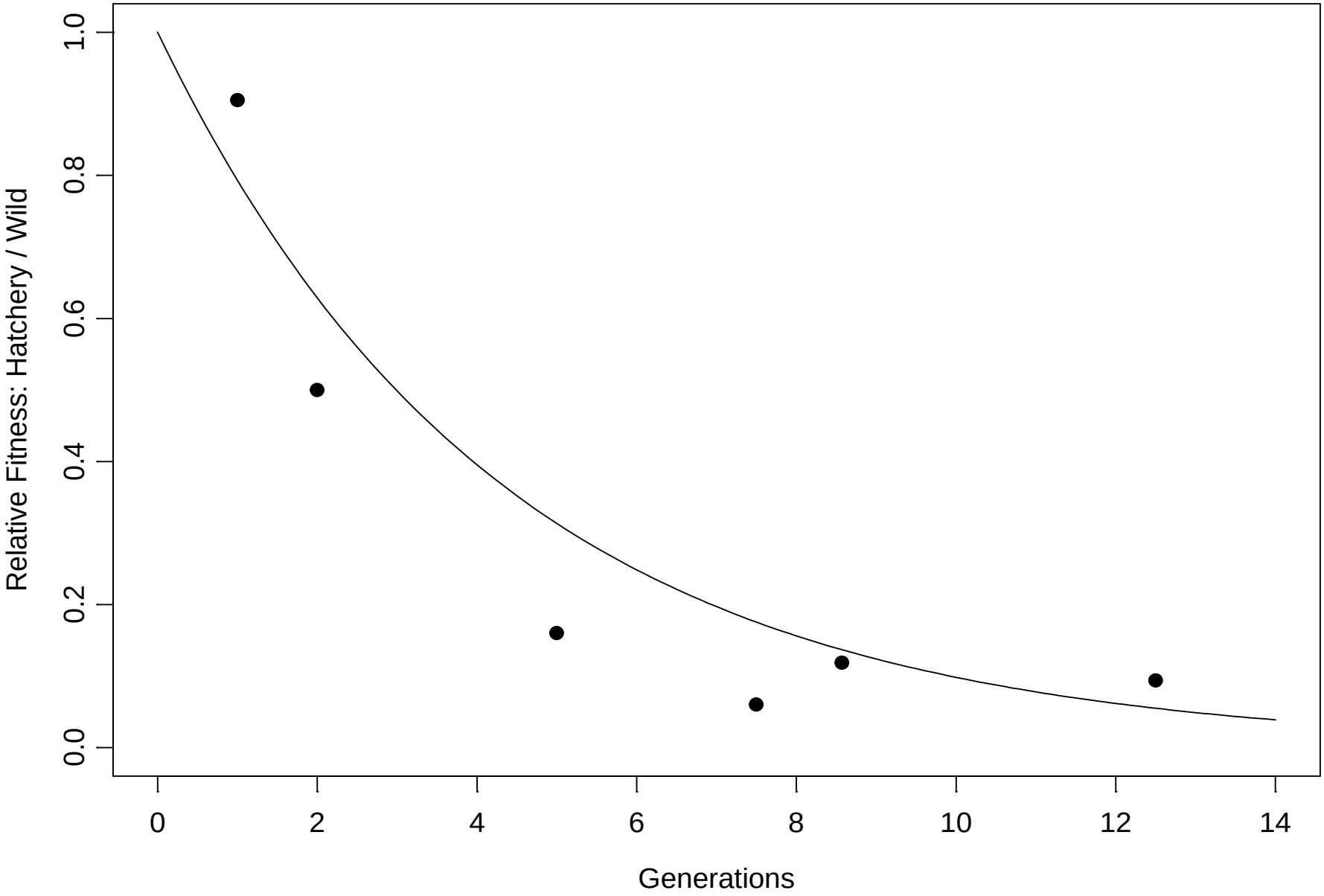
* = Norwegian Sea, North Sea, Skagerrak, Kattegat, Øresund

DIFRES

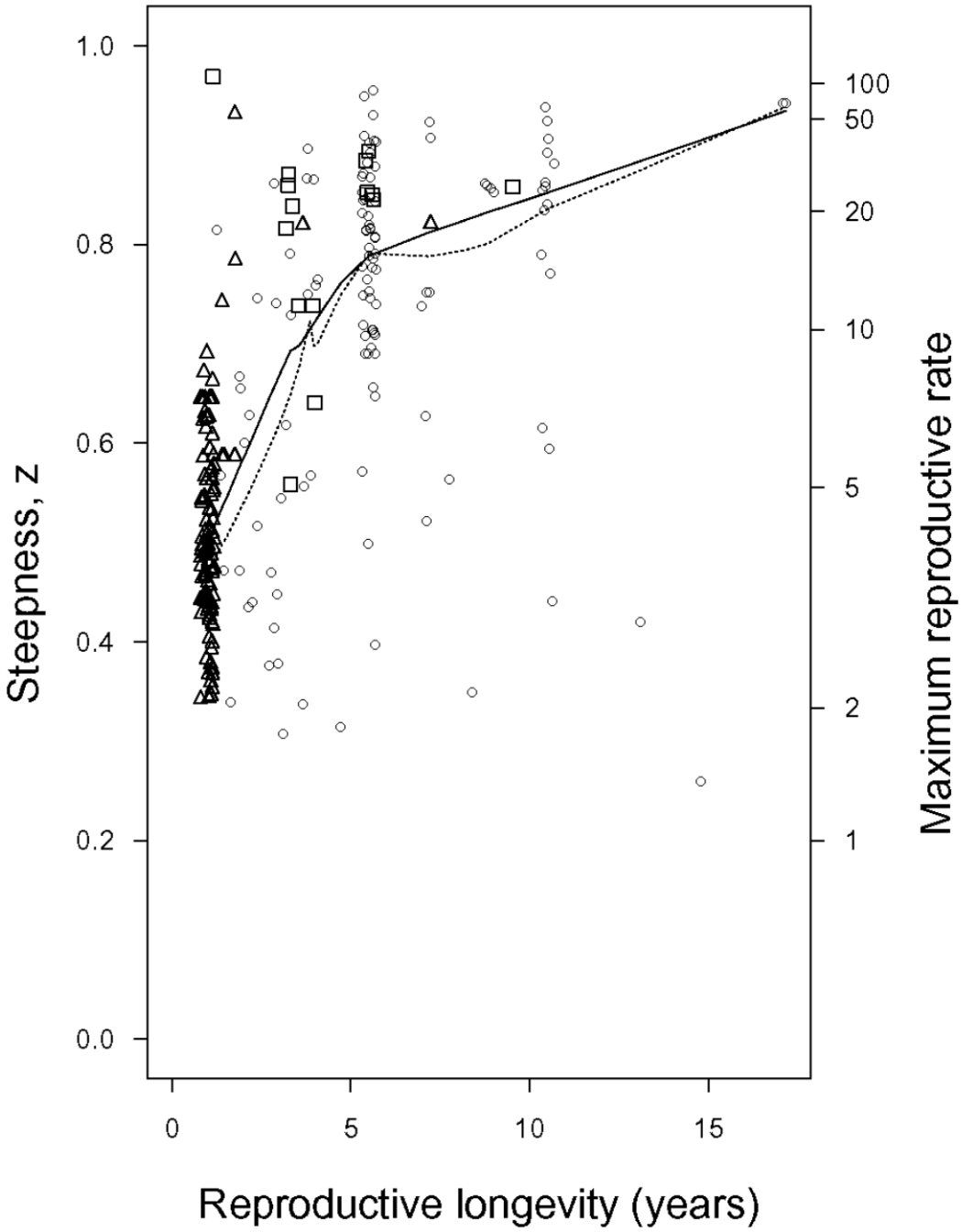
Landings of Bluefin Tuna
Thunnus thynnus in Northeast Atlantic

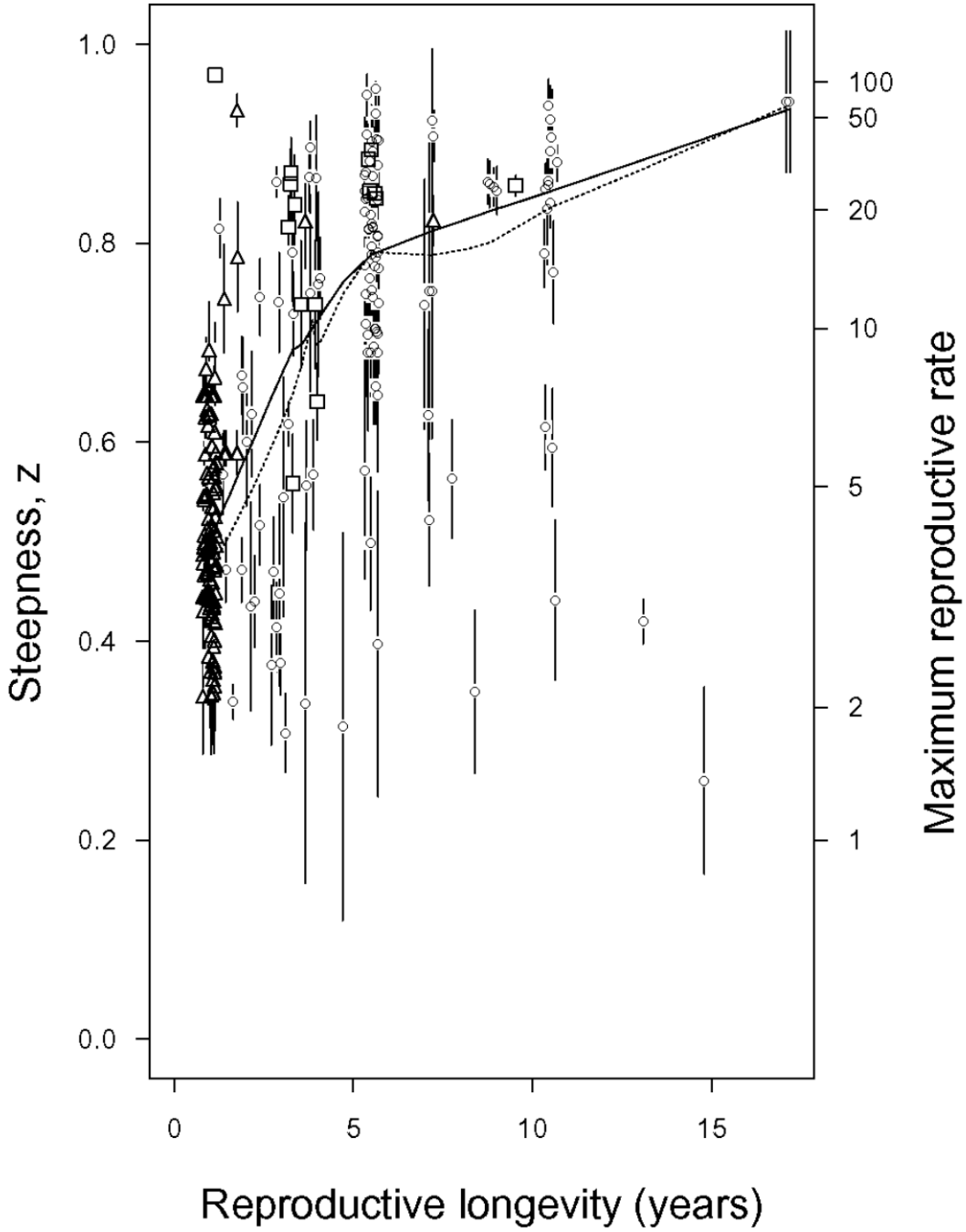


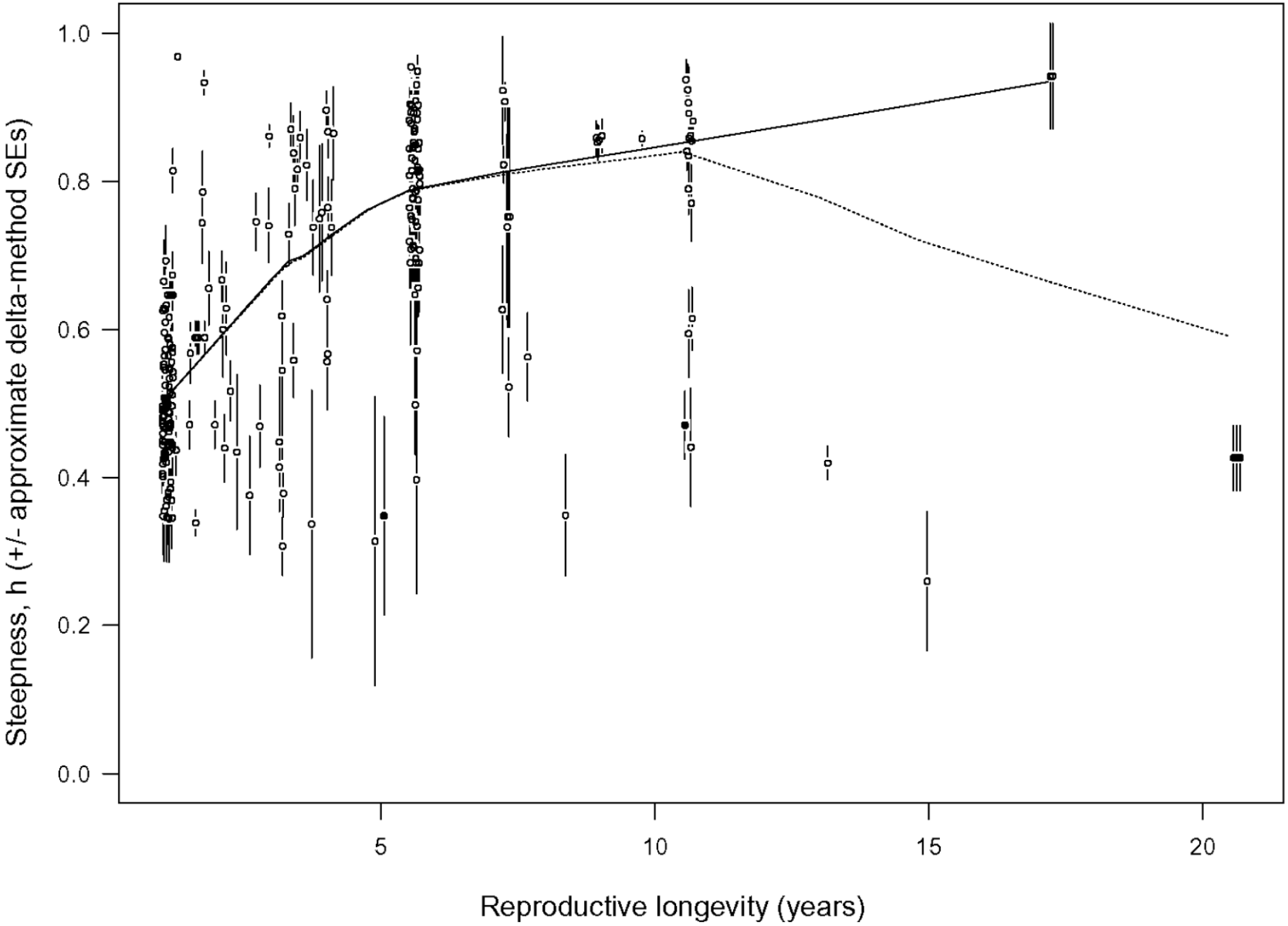
DIFRES

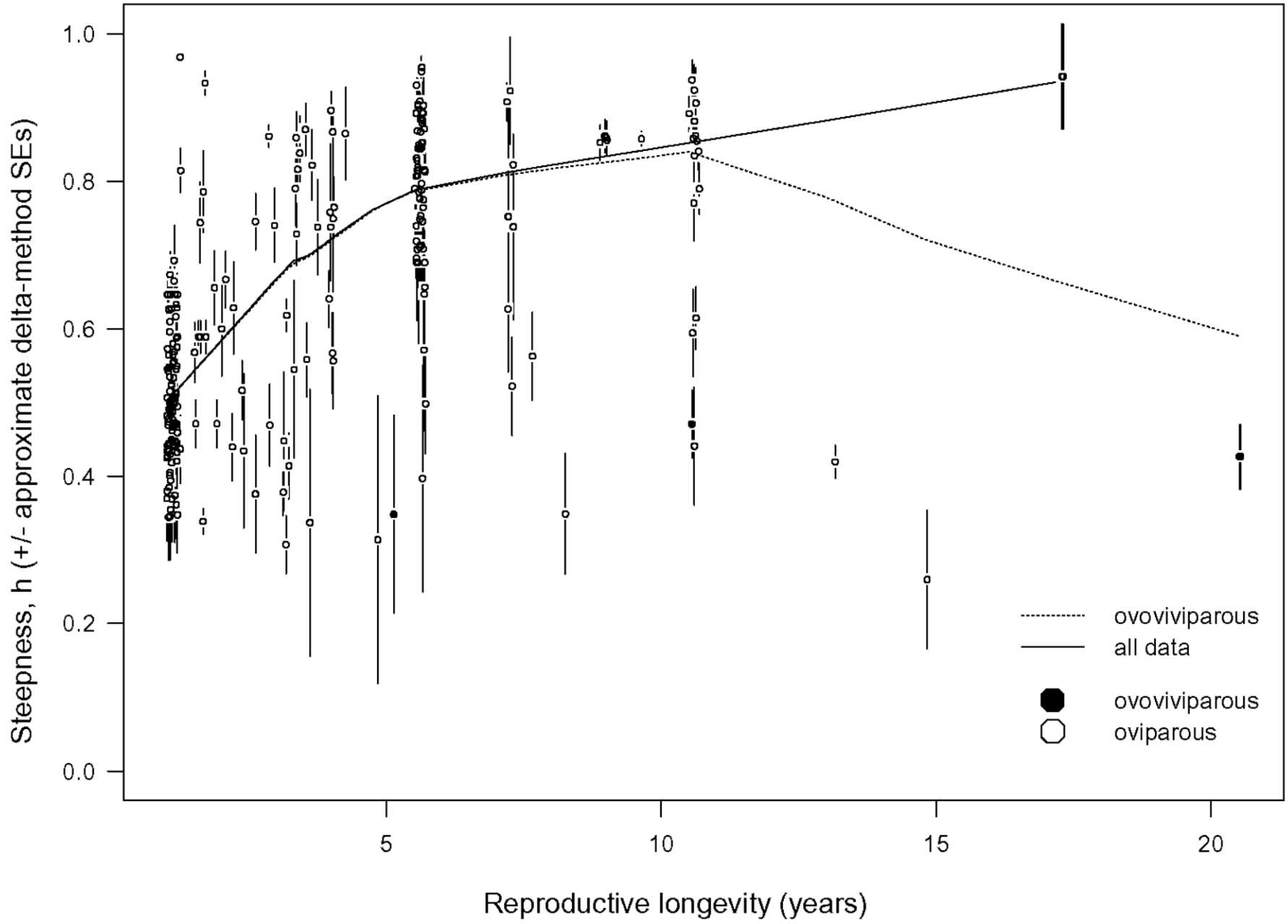

Relative Fitness: Hatchery / Wild
0.0
0.2
0.4
0.6
0.8
1.0
0
2
4
6
8
10
12
14
Generations

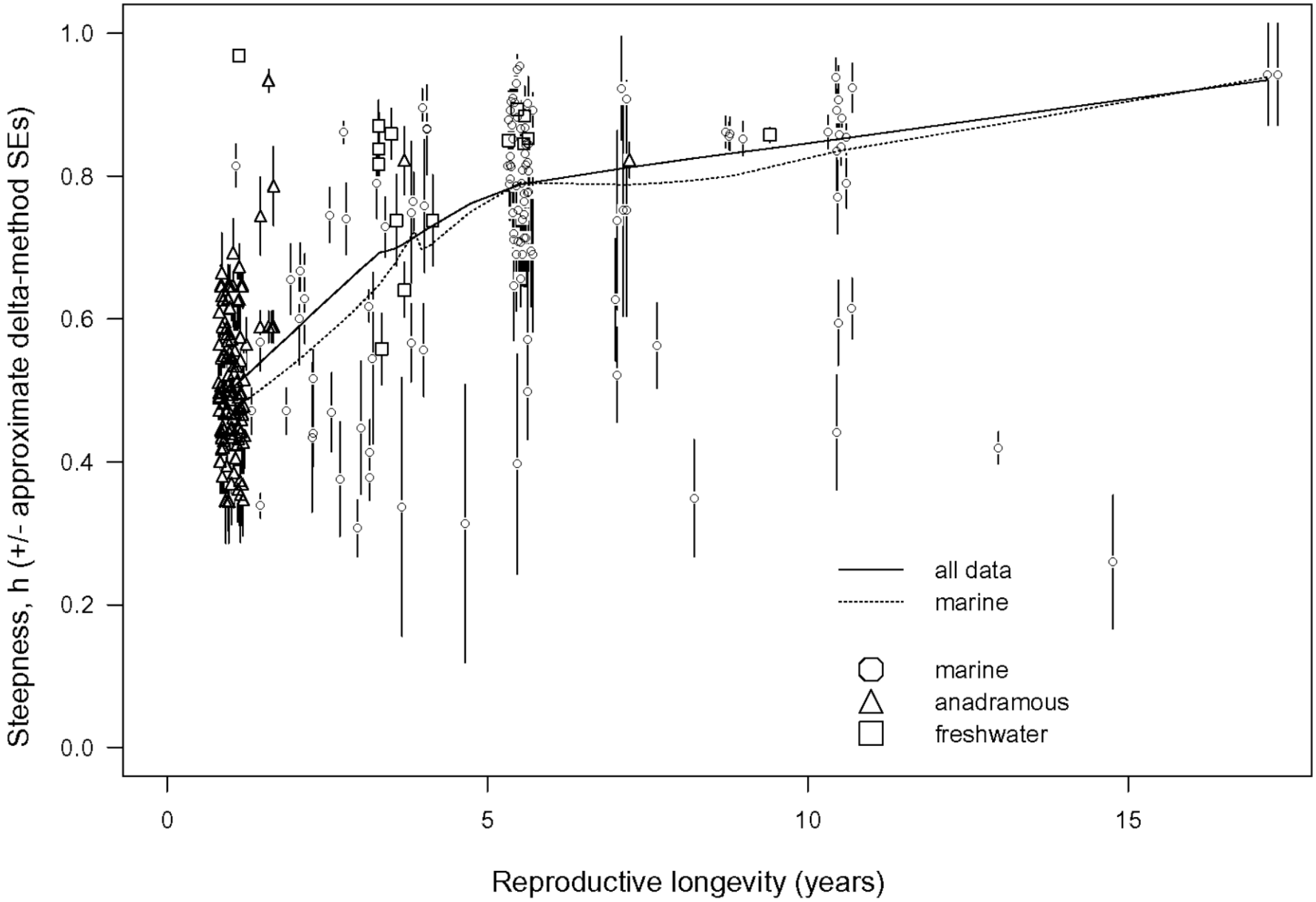

555
lbs.
LBS.
1135
CABO
BLANCO

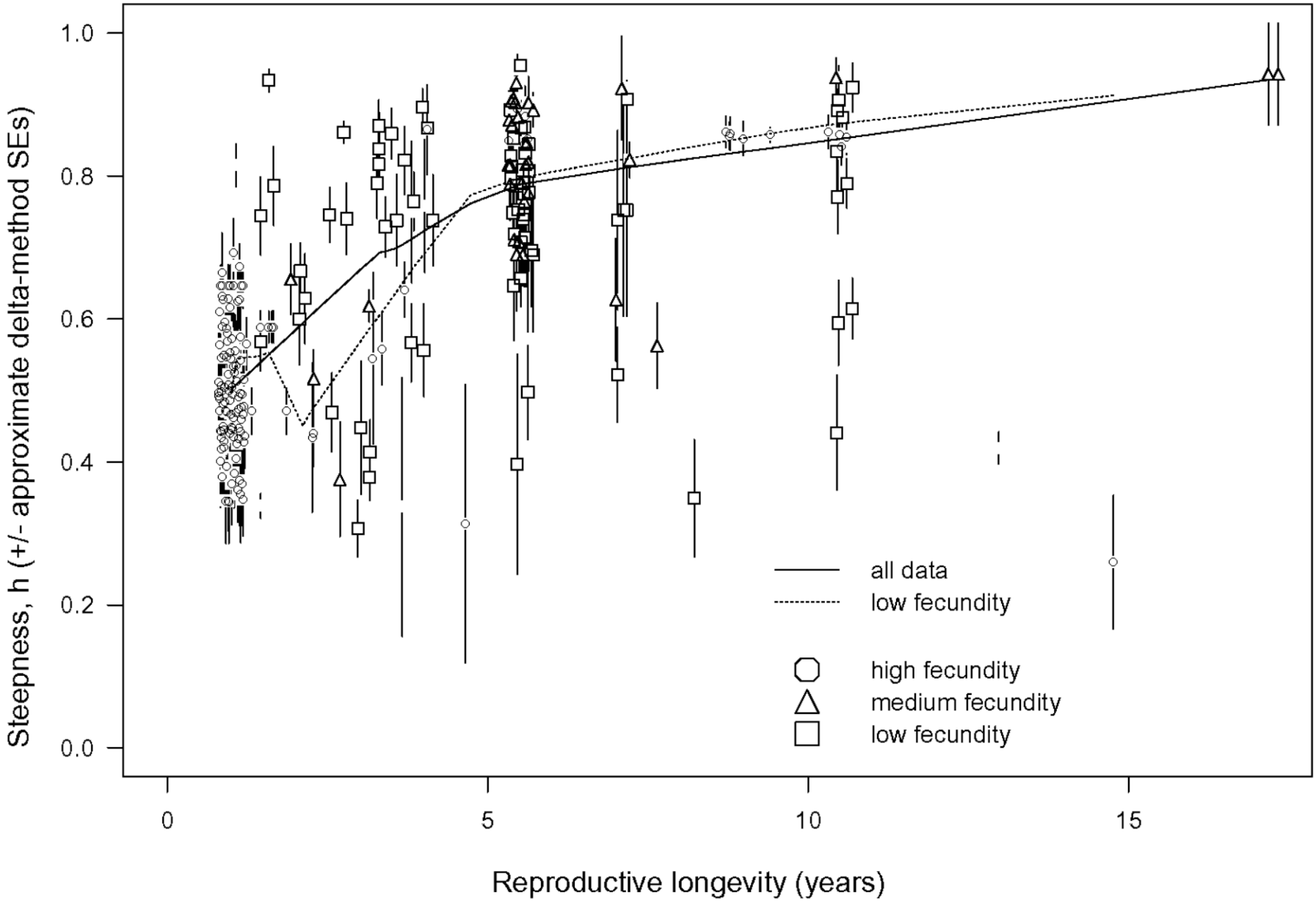

Steepness, z
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
Reproductive longevity (years)
100
50
20
10
5
2
1
Maximum reproductive rate

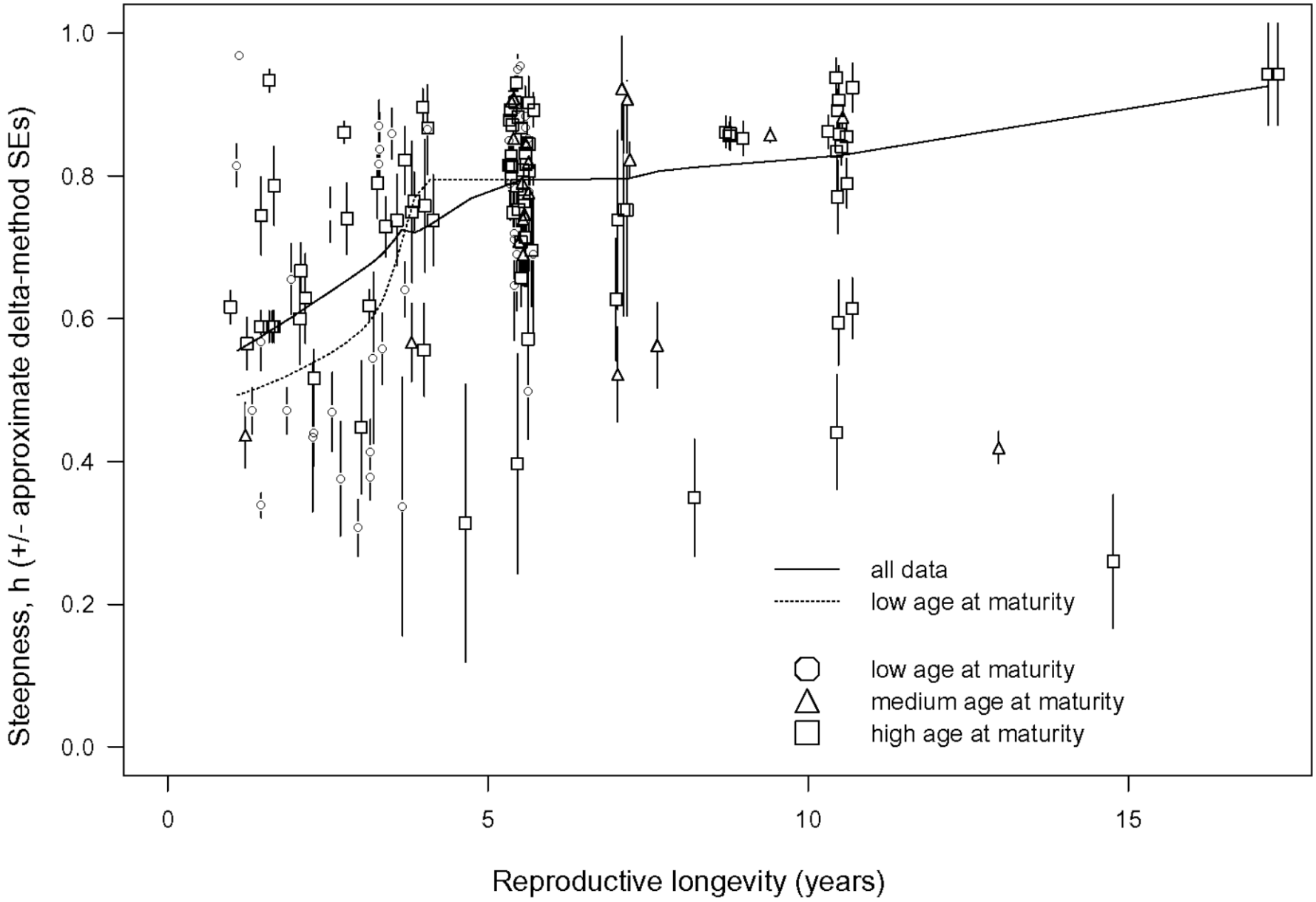

Steepness, z
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
Reproductive longevity (years)
100
50
20
10
5
2
1
Maximum reproductive rate

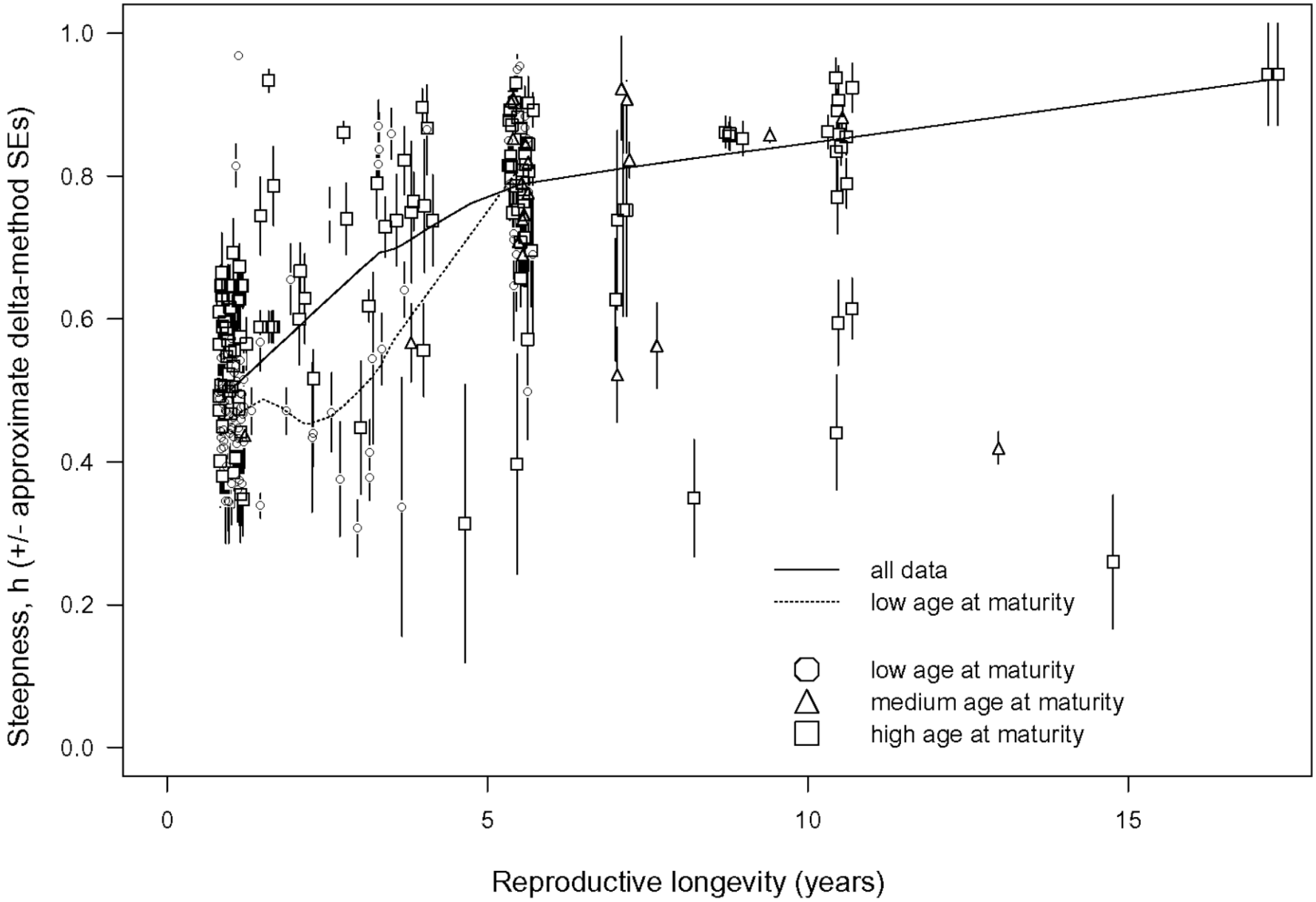

Steepness, h (+/- approximate delta-method SEs)
1.0
0.8
0.6
0.4
0.2
0.0
5
10
15
20
Reproductive longevity (years)

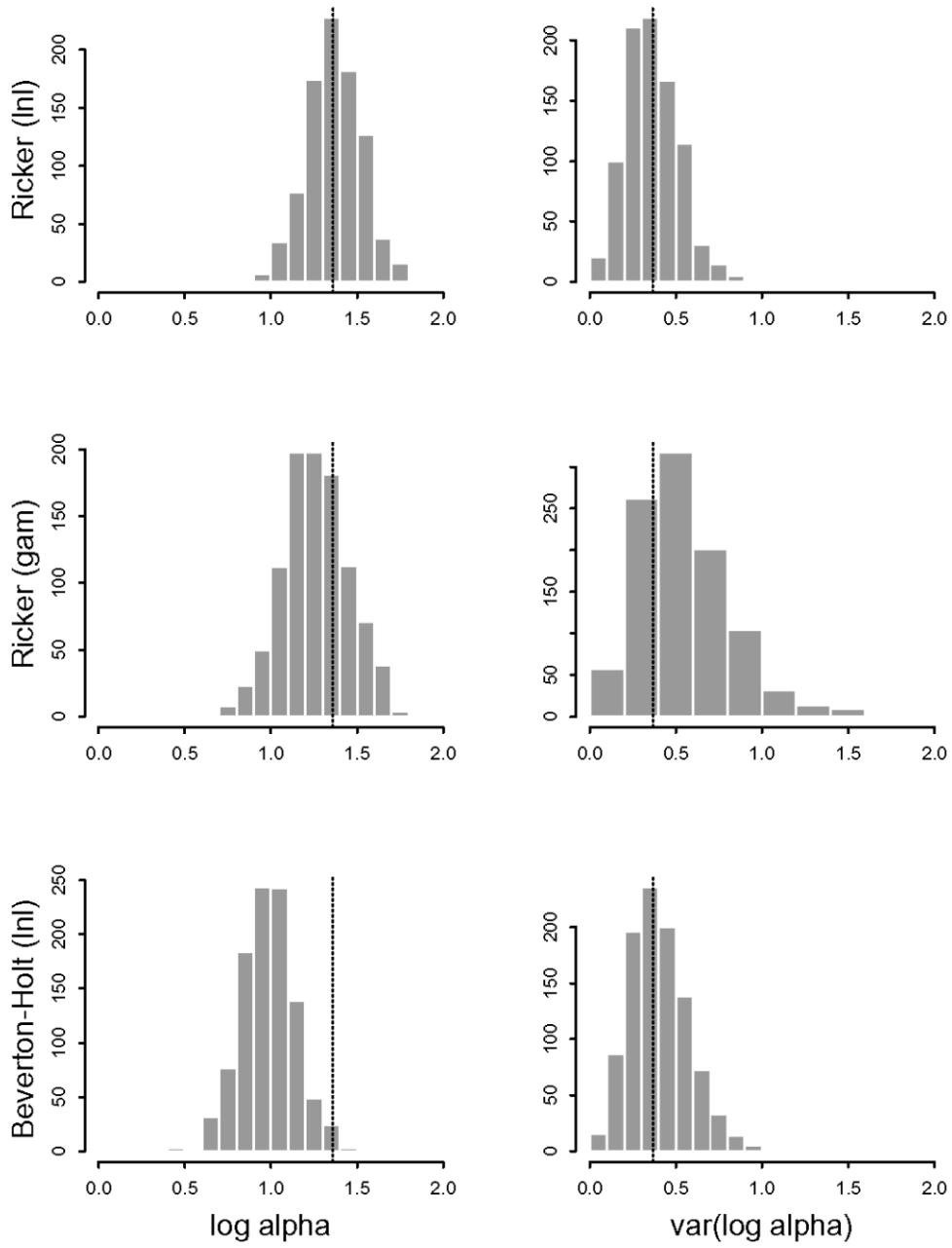

Steepness, h (+/- approximate delta-method SEs)
1.0
0.8
0.6
0.4
0.2
0.0
5
10
15
20
Reproductive longevity (years)
ovoviviparous
all data
ovoviviparous
oviparous

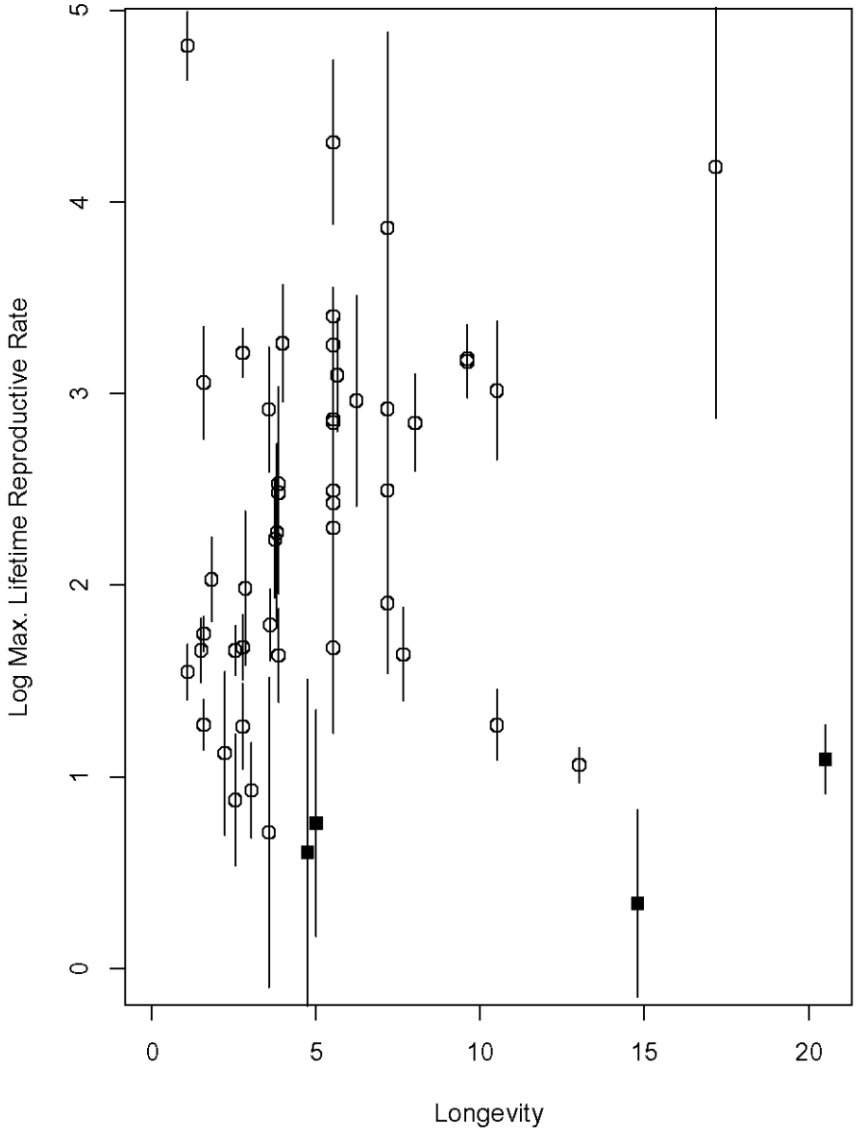

Steepness, h (+/- approximate delta-method SEs)
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
Reproductive longevity (years)
all data
marine
marine
anadramous
freshwater

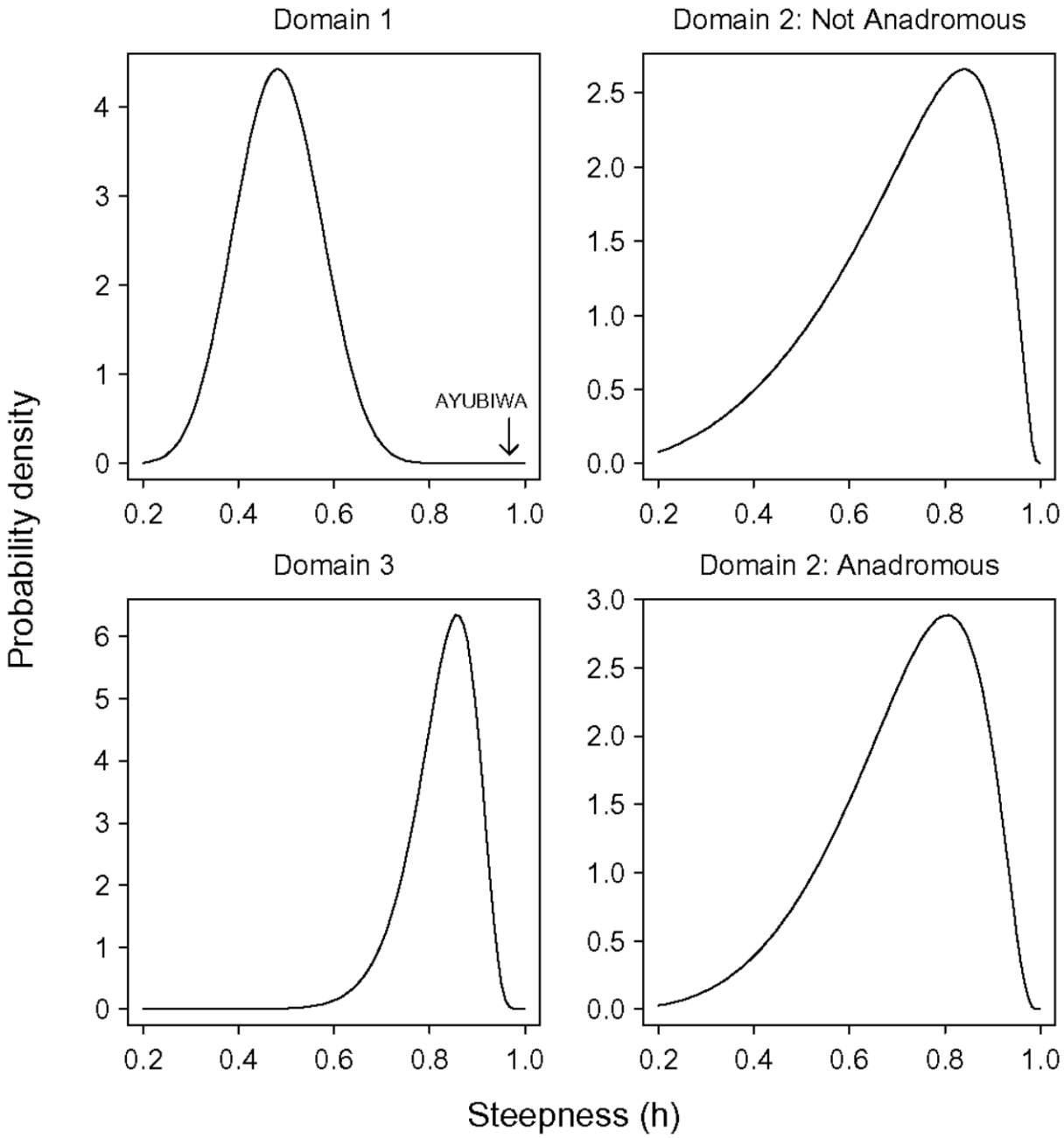

Steepness, h (+/- approximate delta-method SEs)
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
Reproductive longevity (years)
all data
low fecundity
high fecundity
medium fecundity
low fecundity

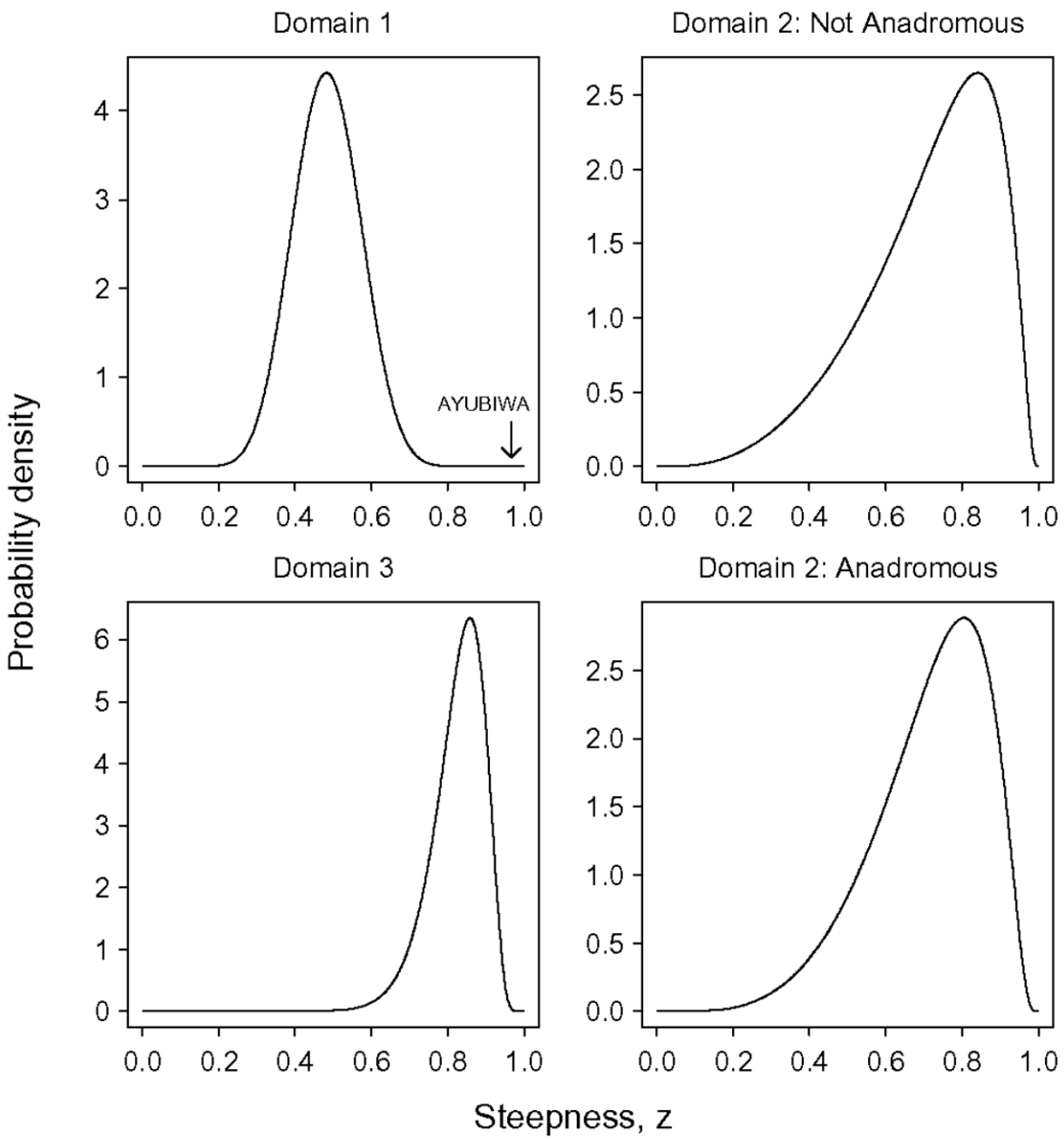

Steepness, h (+/- approximate delta-method SEs)
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
Reproductive longevity (years)
all data
low age at maturity
low age at maturity
medium age at maturity
high age at maturity

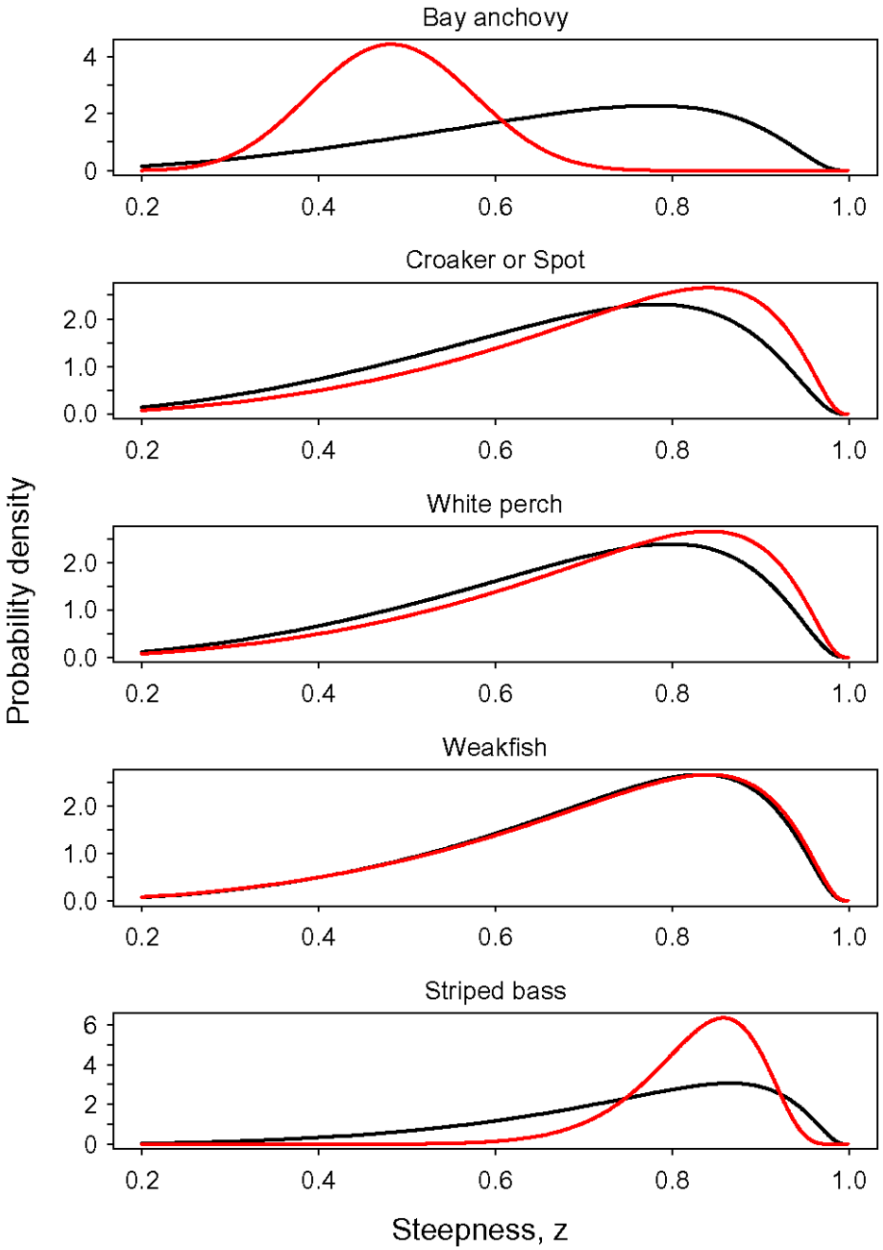

Steepness, h (+/- approximate delta-method SEs)
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
Reproductive longevity (years)
all data
low age at maturity
low age at maturity
medium age at maturity
high age at maturity

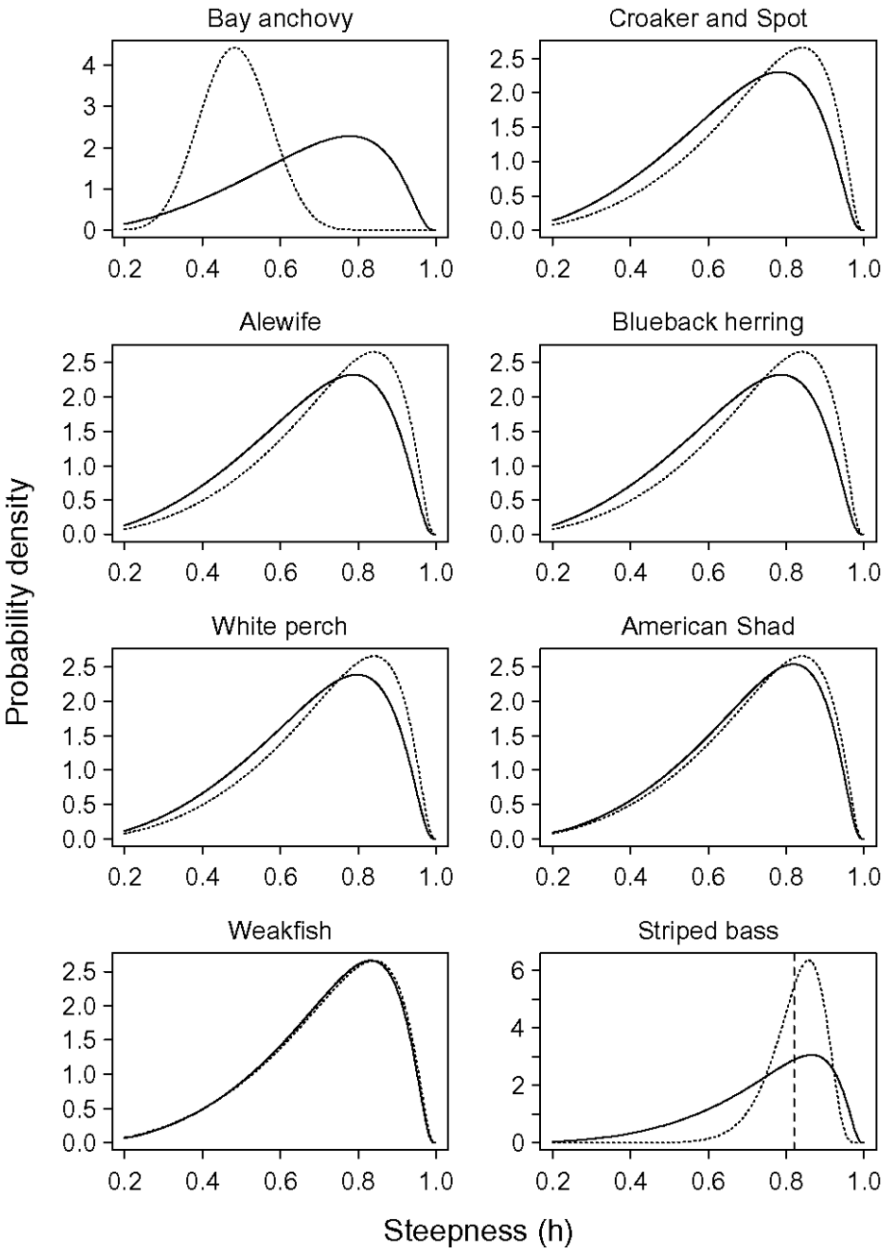

Ricker (lnl)
Ricker (gam)
Beverton-Holt (lnl)
log alpha
var(log alpha)
0
50
100
150
200
250
0.0
0.5
1.0
1.5
2.0

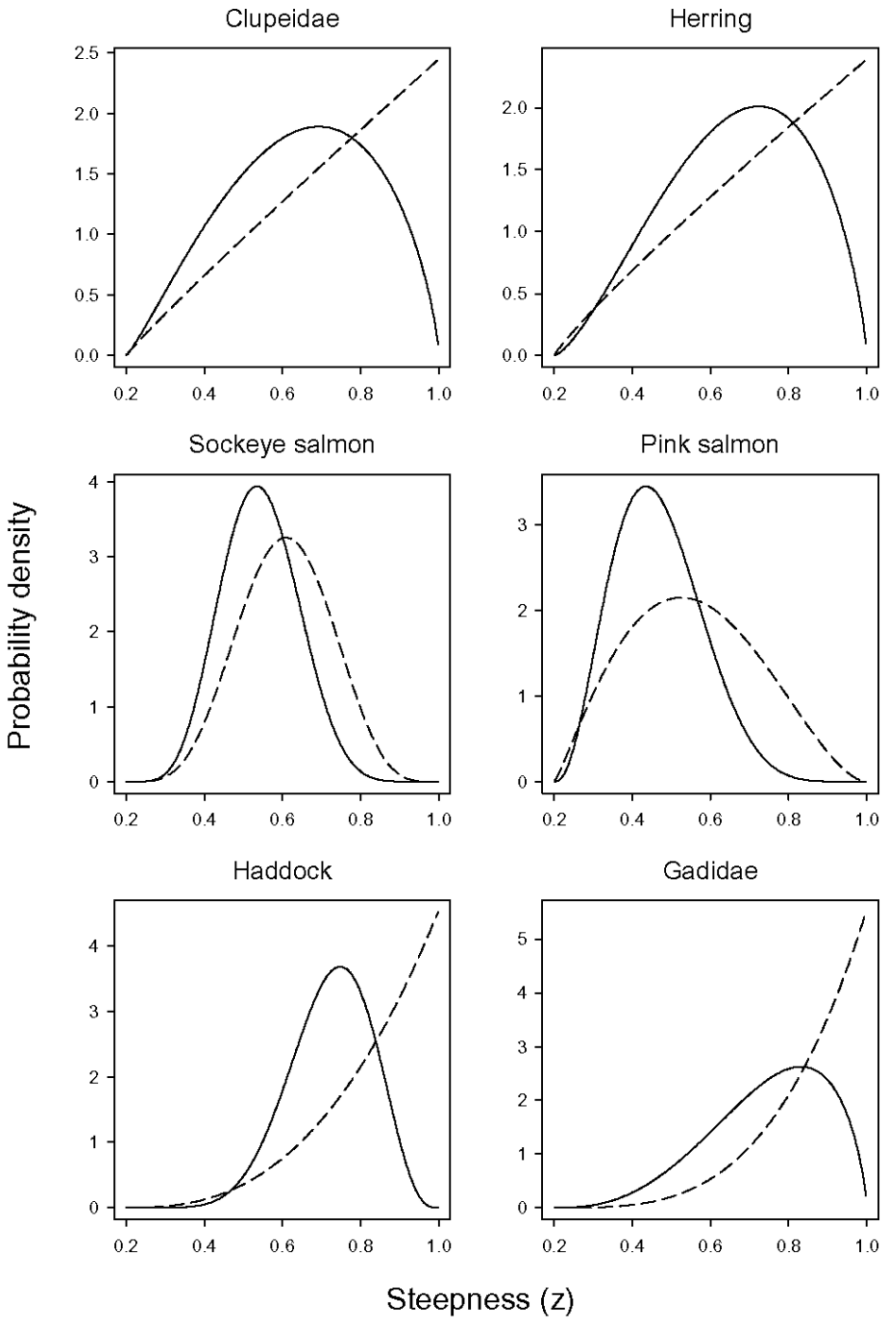

Log Max. Lifetime Reproductive Rate
0
1
2
3
4
5
0
5
10
15
20
Longevity

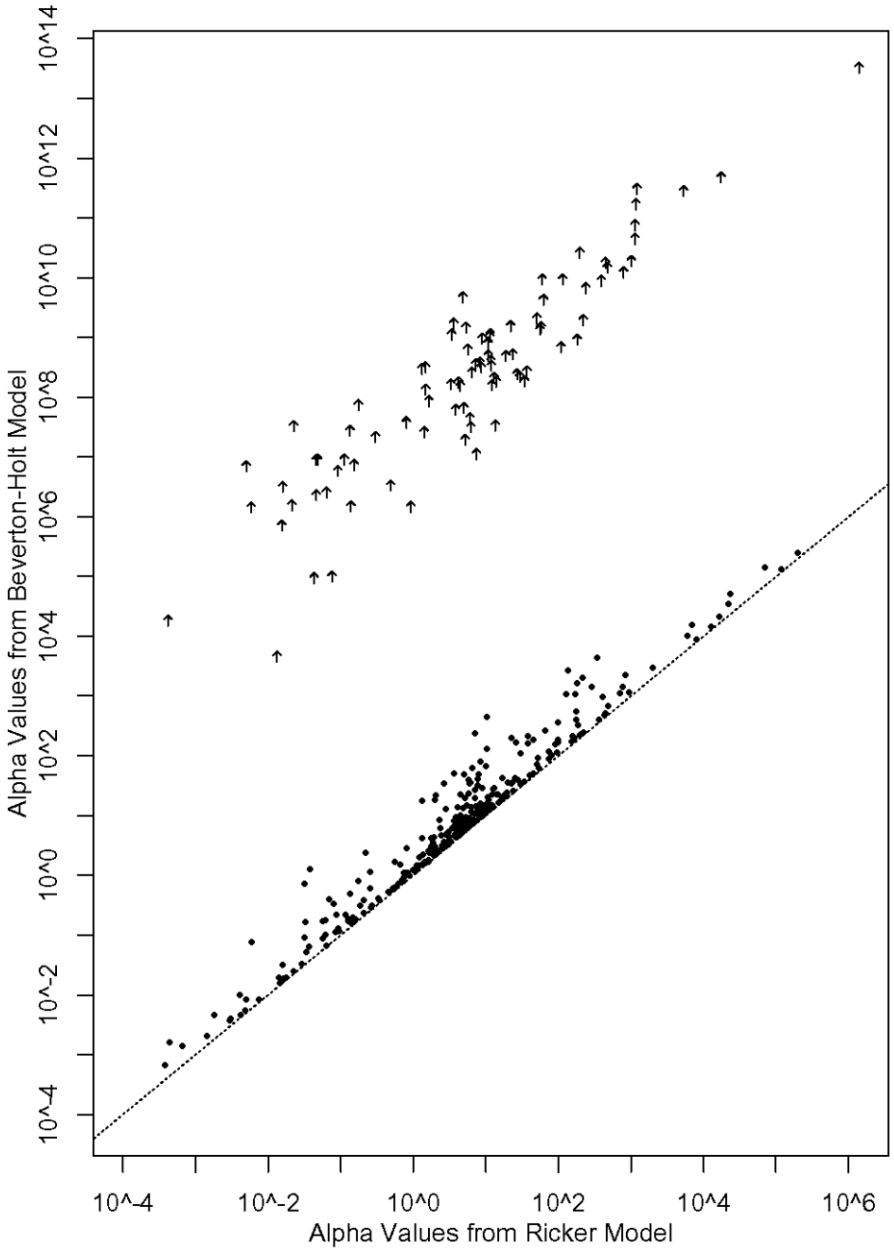

Domain 1
Domain 2: Not Anadromous
Domain 3
Domain 2: Anadromous
AYUBIWA
Probability density
Steepness (h)
0
1
2
3
4
0.0
0.5
1.0
1.5
2.0
2.5
3.0
5
6
0.2
0.4
0.6
0.8
1.0

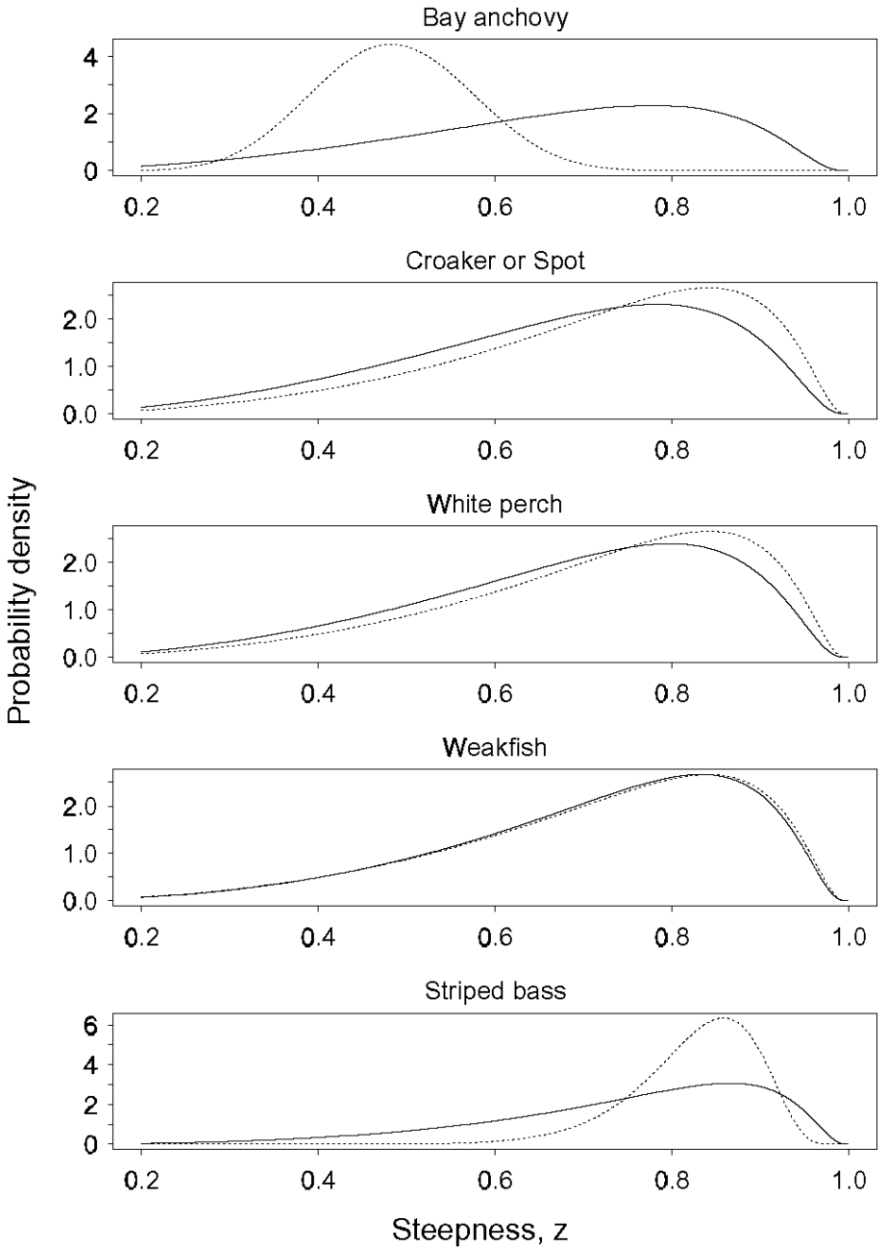

Domain 1
Domain 2: Not Anadromous
Domain 3
Domain 2: Anadromous
AYUBIWA
Probability density
Steepness, z
0.0
0.2
0.4
0.6
0.8
1.0
0
1
2
3
4
0.5
1.5
2.0
2.5
5
6

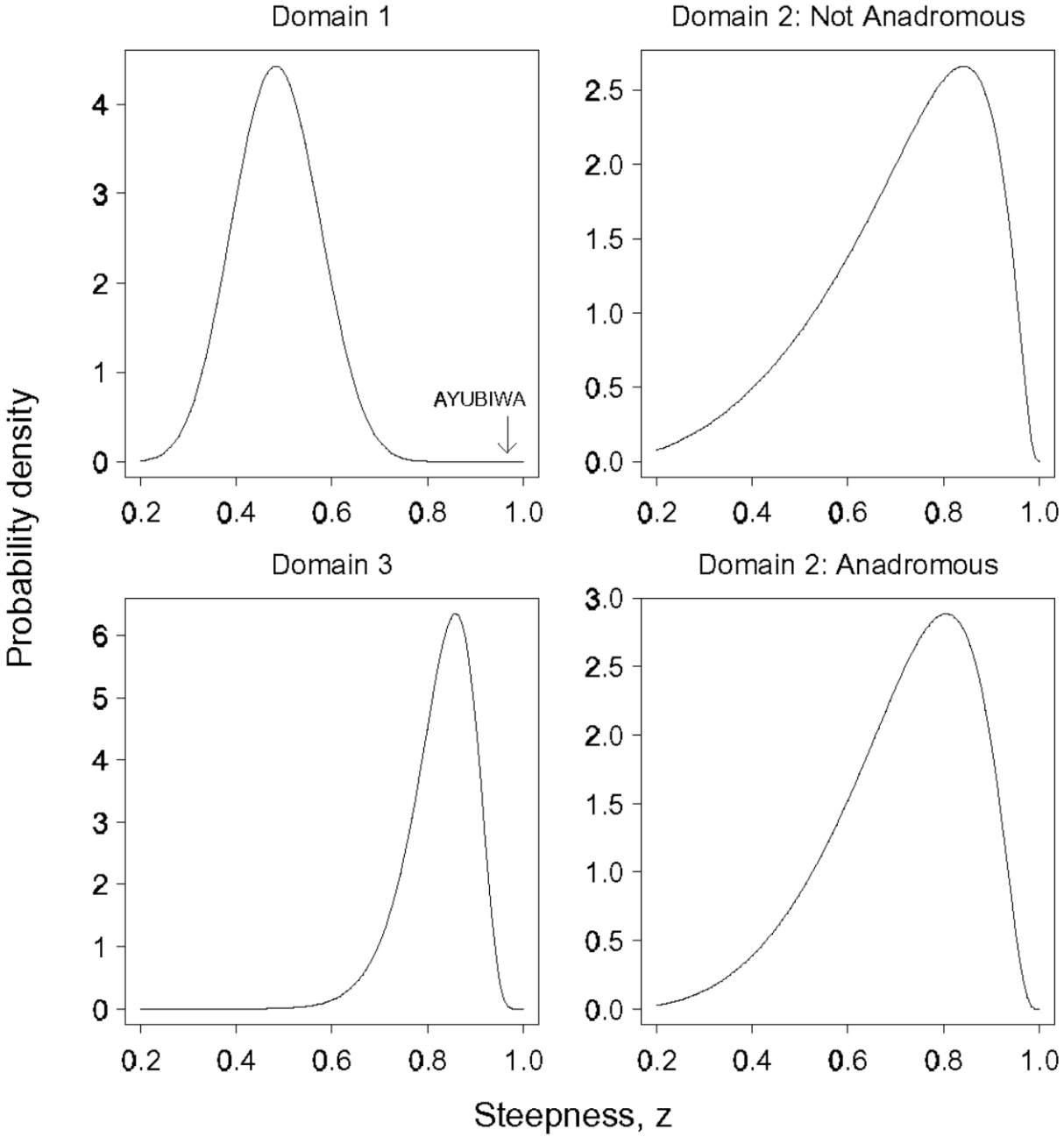

Bay anchovy
Croaker or Spot
White perch
Weakfish
Striped bass
Probability density
Steepness, z
0.2
0.4
0.6
0.8
1.0

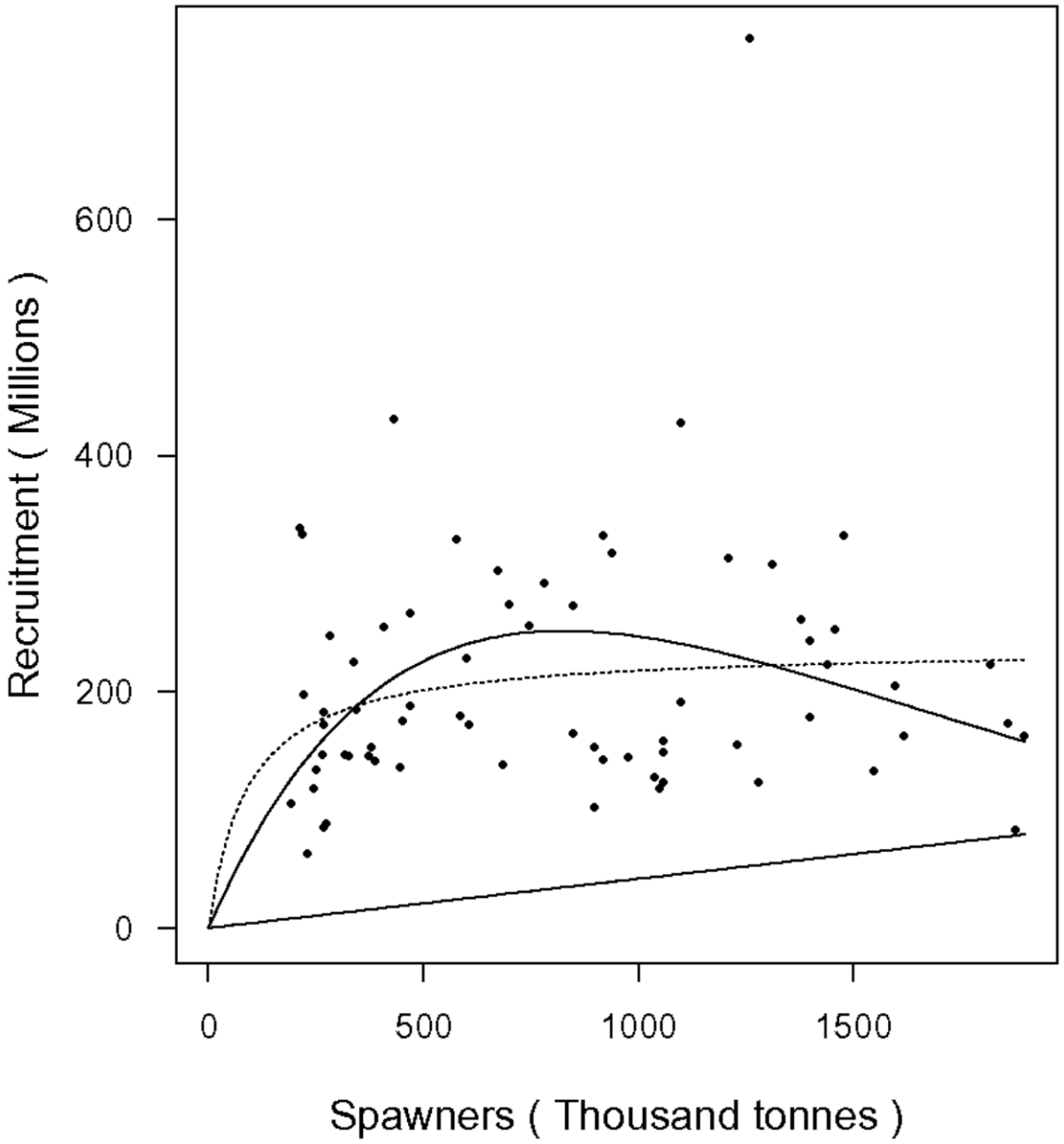

Bay anchovy
Croaker and Spot
Alewife
Blueback herring
White perch
American Shad
Weakfish
Striped bass
Probability density
Steepness (h)

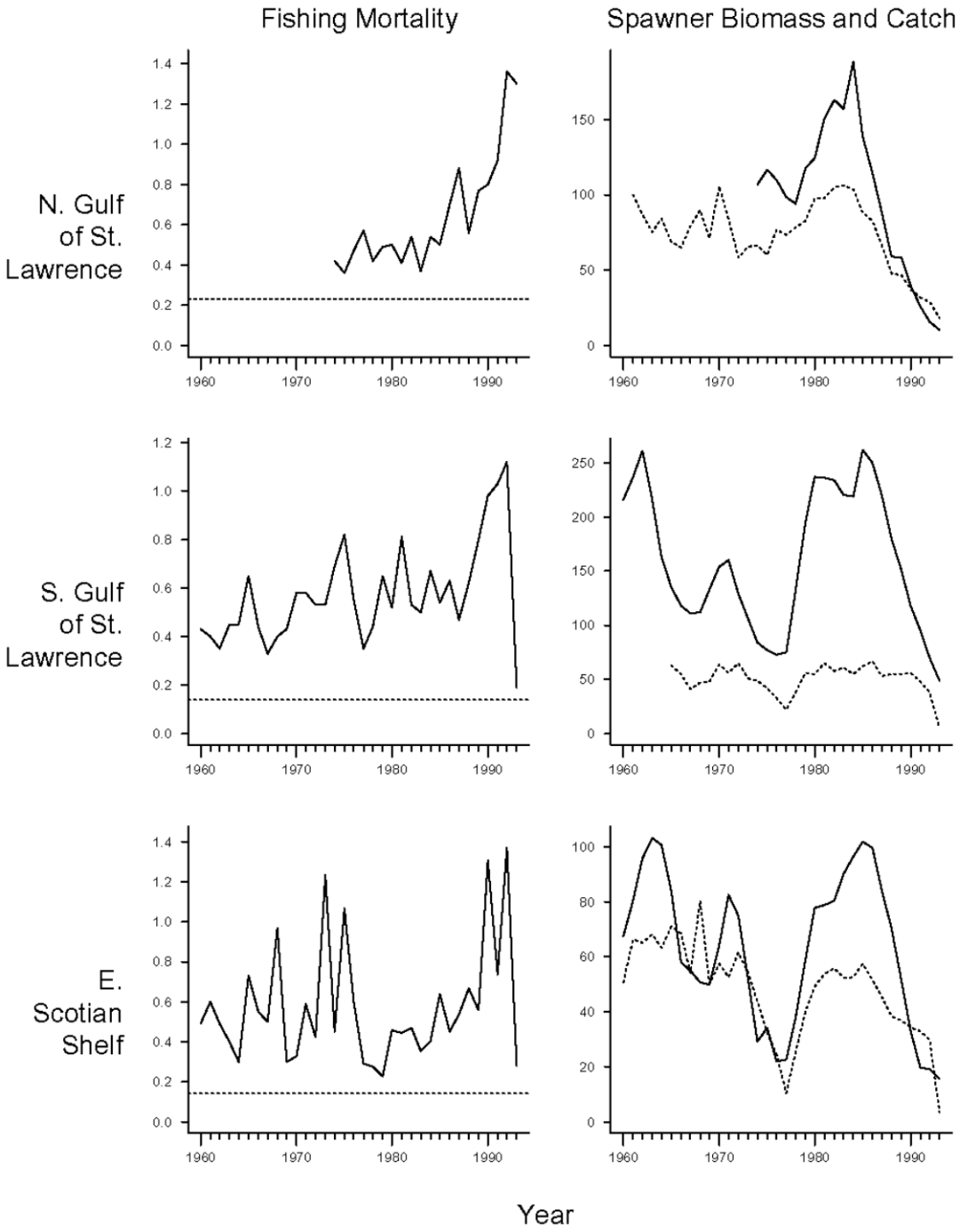

Clupeidae
Herring
Sockeye salmon
Pink salmon
Haddock
Gadidae
Probability density
Steepness (z)


Alpha Values from Beverton-Holt Model
10^14
10^12
10^10
10^8
10^6
10^4
10^2
10^0
10^-2
10^-4
10^-4
10^-2
10^0
10^2
10^4
10^6
Alpha Values from Ricker Model


Bay anchovy
Croaker or Spot
White perch
Weakfish
Striped bass
Probability density
Steepness, z
0.2
0.4
0.6
0.8
1.0


Domain 1
Domain 2: Not Anadromous
Domain 3
Domain 2: Anadromous
AYUBIWA
Probability density
Steepness, z
0
1
2
3
4
0.0
0.5
1.0
1.5
2.0
2.5
3.0
5
6
0.2
0.4
0.6
0.8
1.0


Recruitment (Millions)
600
400
200
0
0
500
1000
1500
Spawners (Thousand tonnes)


Fishing Mortality
Spawner Biomass and Catch
N. Gulf of St. Lawrence
S. Gulf of St. Lawrence
E. Scotian Shelf
Year

3: you can only catch one fish on a hook.