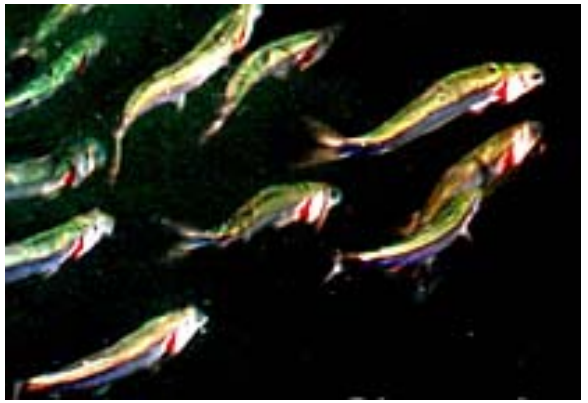
The Future of Marine Animal Populations

Visions for the Integration of Models and Data





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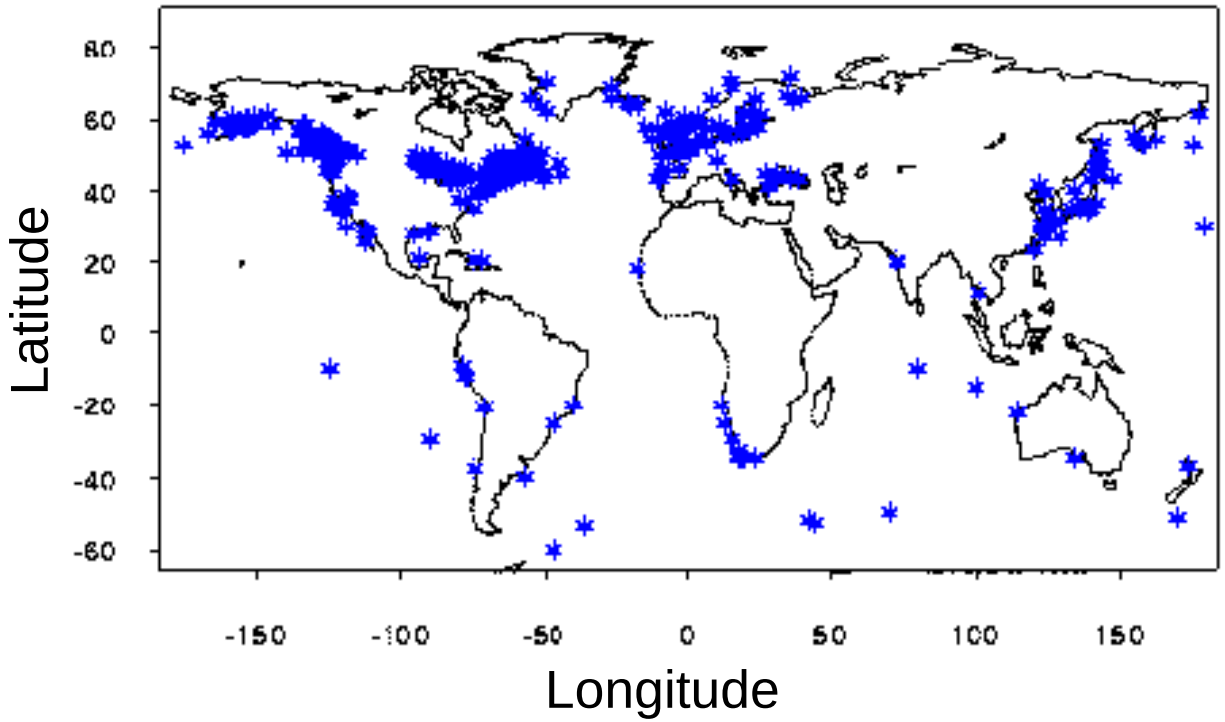
Testing for general patterns

http://www.fish.dal.ca/welcome.html



The Present Baconian Approach

- Francis Bacon (1600's) suggested science would proceed by compiling of data: science would simply become clear as a result.
- A census relies primarily on the collection of a large amount of data, without a clear hypothesis.
- Should CoML and OBIS be primarily hypothesis driven?
- Numbers do not become data until they are analyzed.

Purpose of FMAP

- Statistical Design of CoML - Efficiency and cost of scientific surveys can often be greatly enhanced by careful statistical design. FMAP will serve to improve future survey and experimental design.
- Data-Model Interface - Complex models require data format and access standardizations that will be provided in this project.
- Analysis - FMAP will serve as a central clearing house for important advances in analysis of present and future CoML projects.

Purpose of FMAP (next page)

- Understanding - Science progresses fastest with the formulation of simple models that increase understanding.
- Synthesis - Recent meta-analytic methods have revolutionized interpretation of medical and scientific research. FMAP will adapt and bring to CoML the latest of such techniques.
- Prediction - We will attempt to predict the future of marine life.

Statistical Design and Consulting

- SWAT (Statistical Wizards Advisory and Training (SWAT) Team)
- Data Quality Control Models for OBIS, HMAP, and field projects.
- Standard Programs for Extrapolation of Samples to Total Biomass and Numbers

Data-Model Interface

- Fisheries Data into OBIS
- Standard Data Exchange Formats
- Archiving of Non-Fisheries

Synthesis

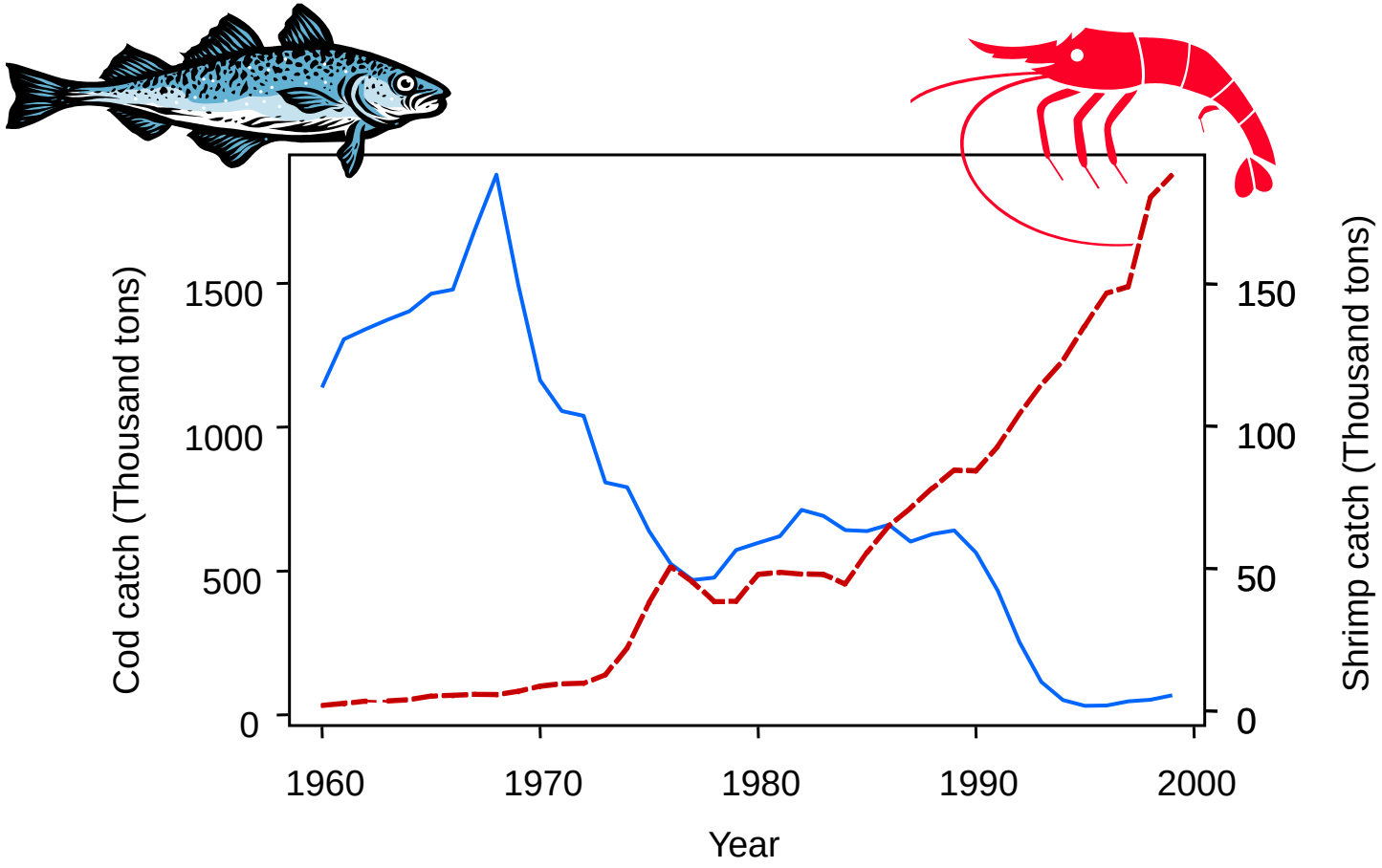
- Meta-Analysis of Interactions
- Workshop Joint with NCES

Problem

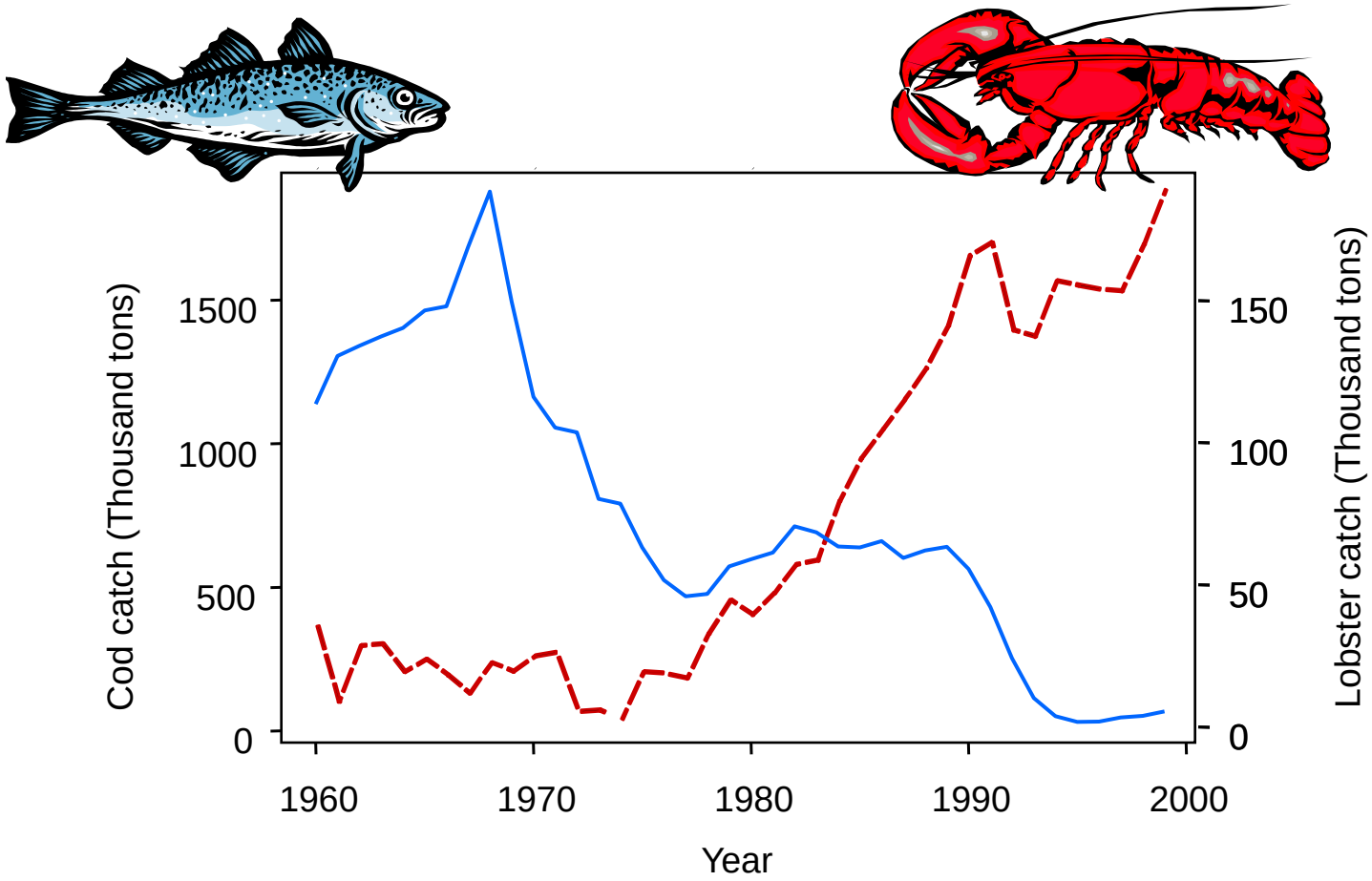
"There is still no accepted procedure for investigating the effects of fishing, and many other anthropogenic activities, in the marine environment. In particular, marine scientists lack unfished control sites, […] and a good statistical framework for hypothesis testing."

Source: Jennings and Kaiser 1998

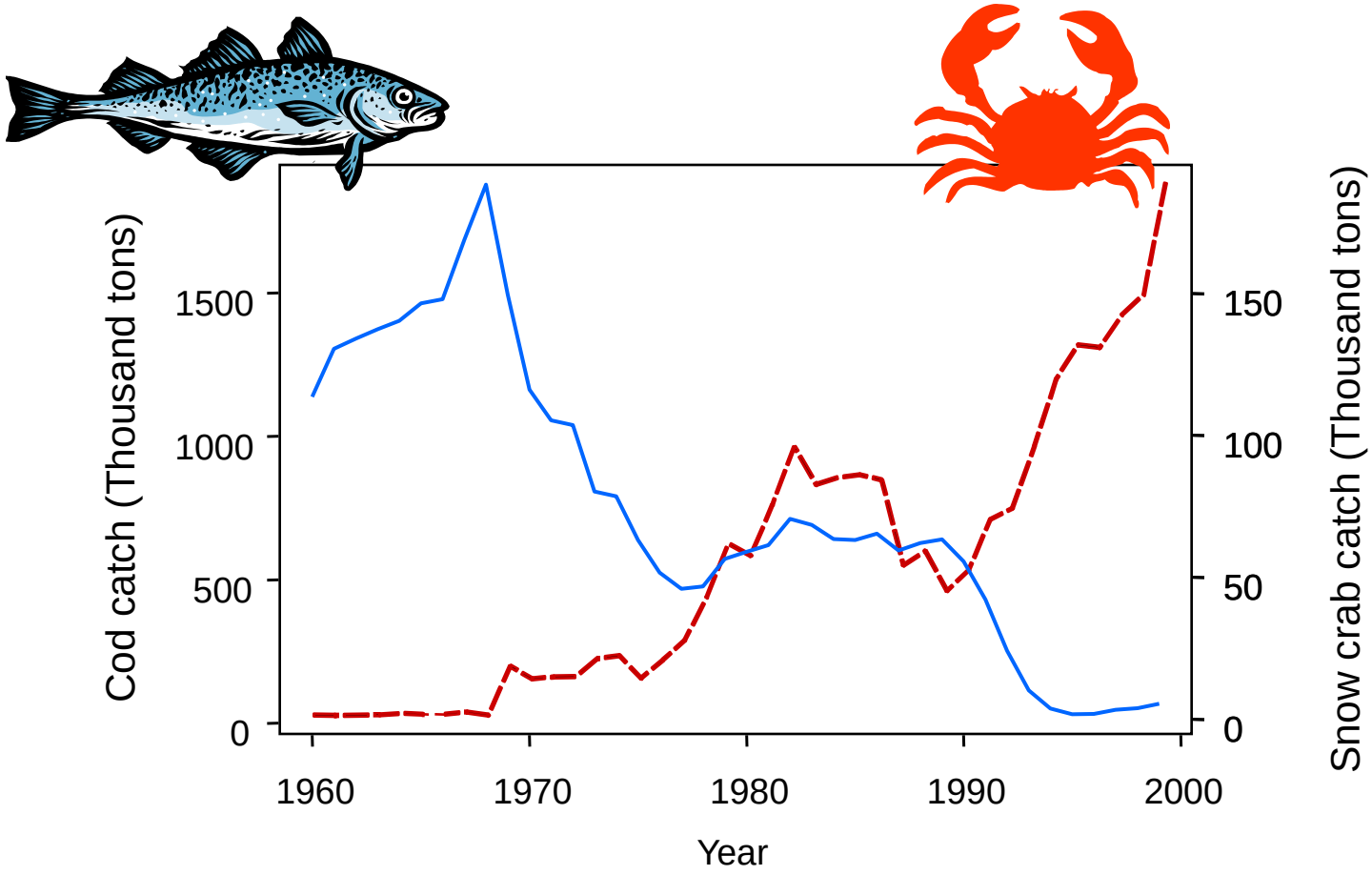
Cod versus shrimp catches in all NAFO areas combined



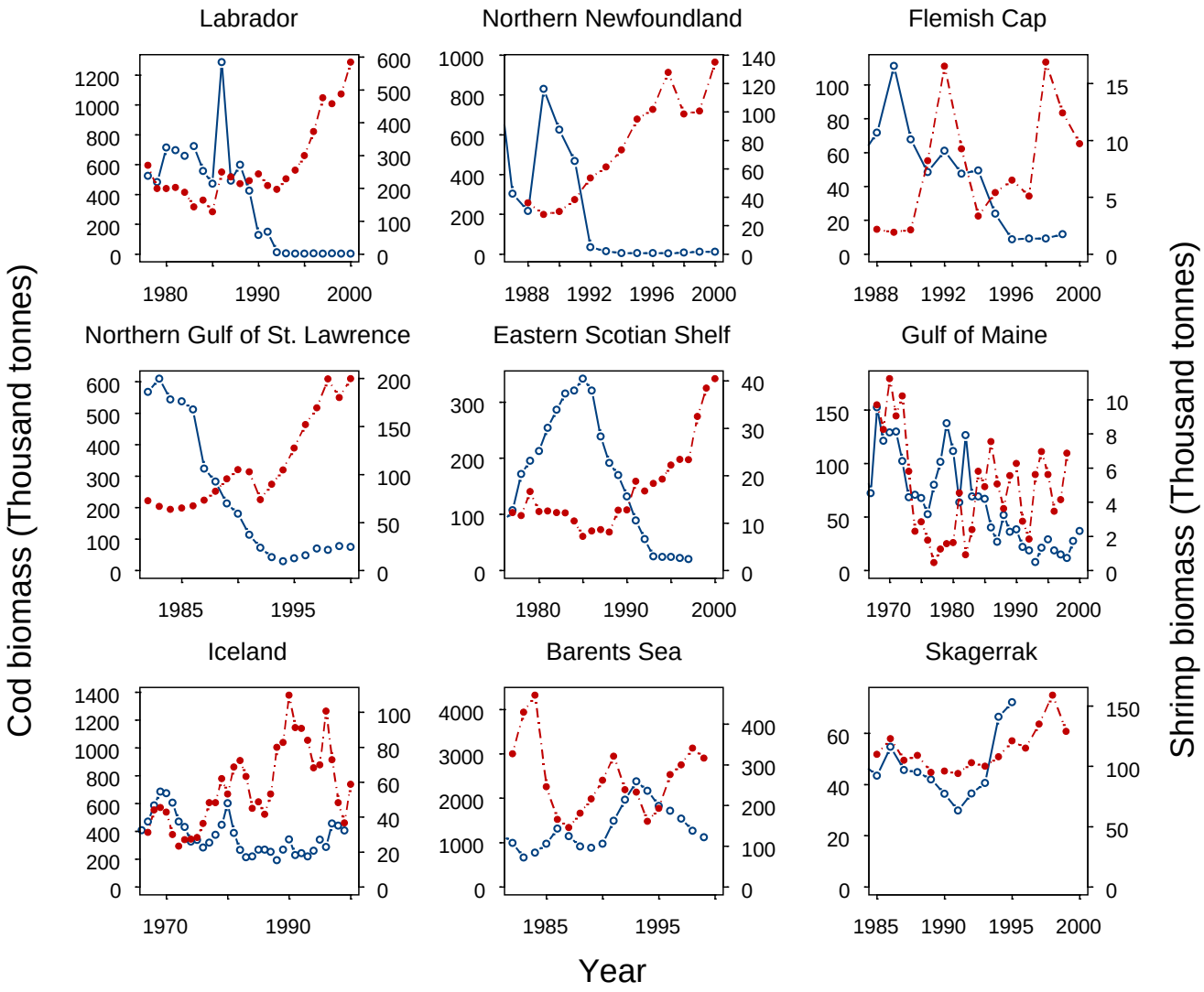
Cod versus lobster catches



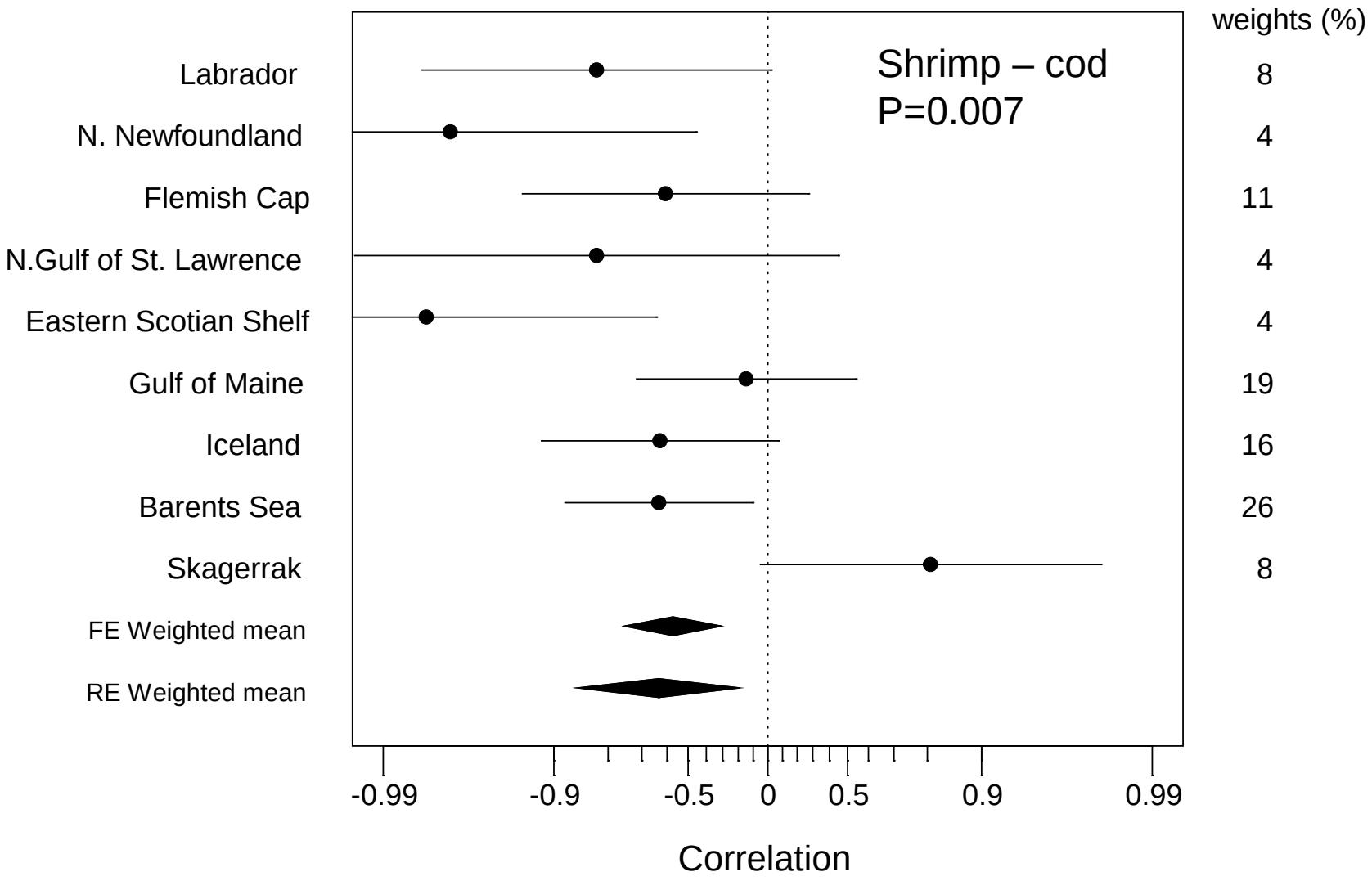
Cod versus crab catches



Cod and shrimp biomass in the North Atlantic: time series



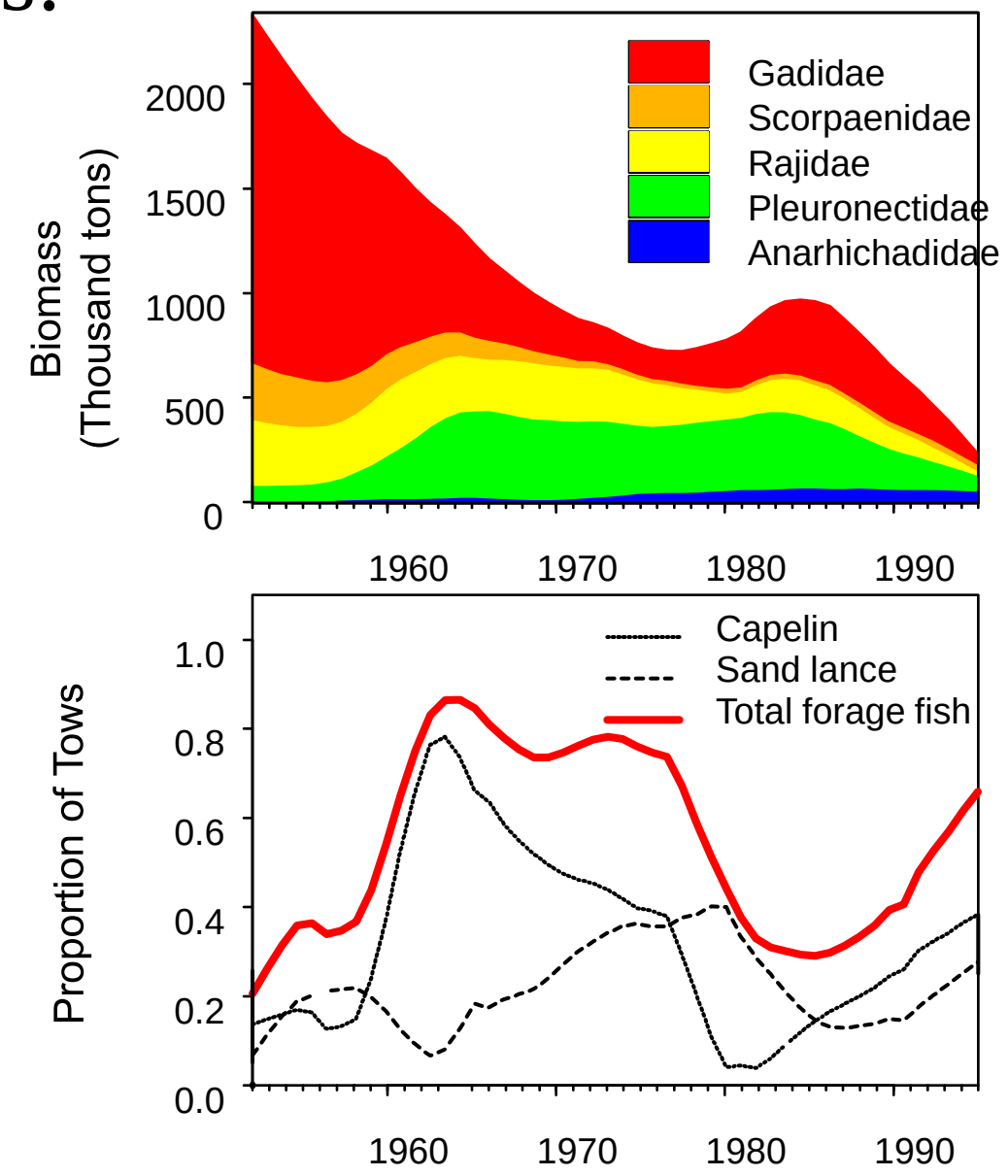
Step 2: Random-effects meta-analysis

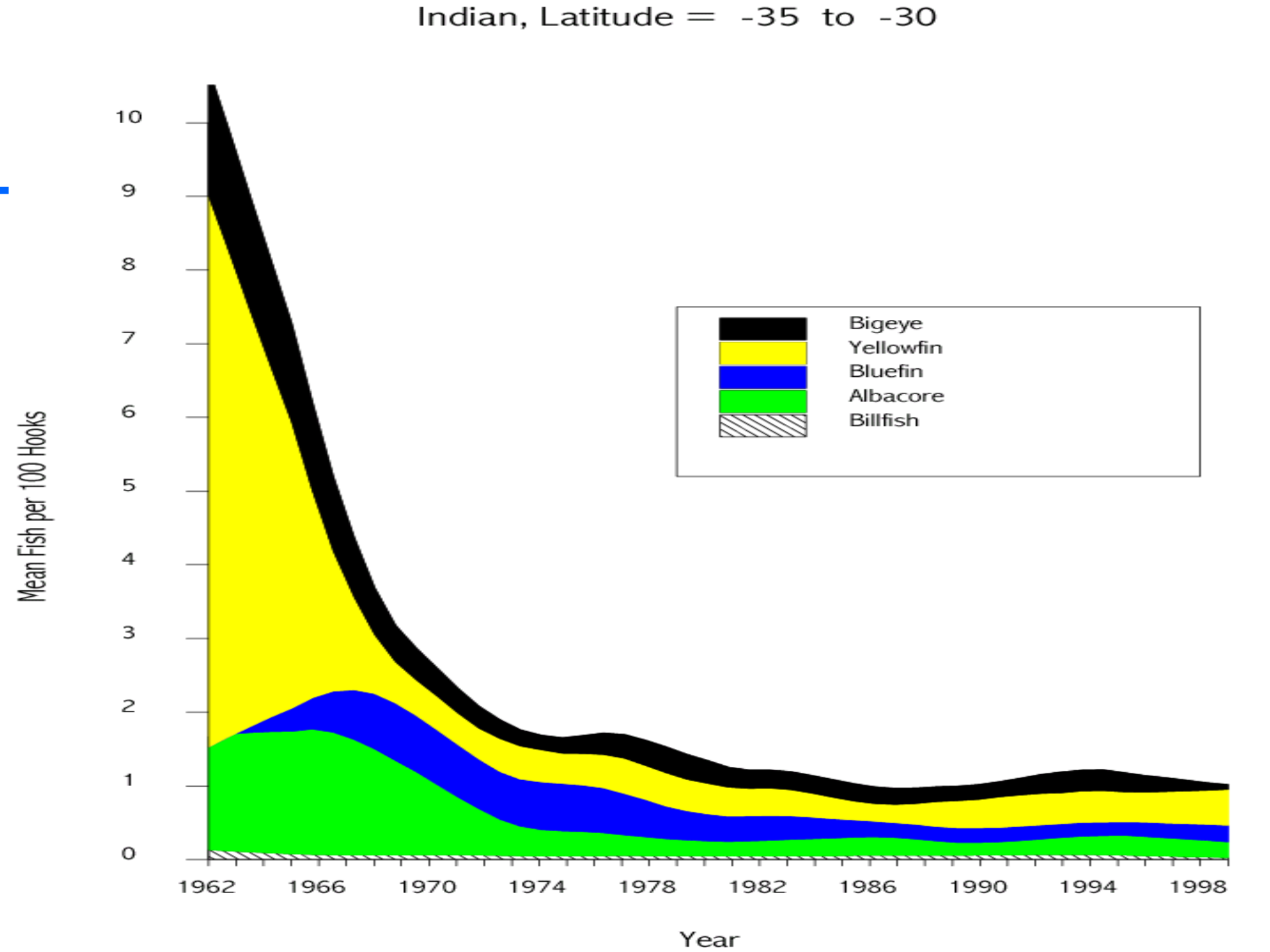


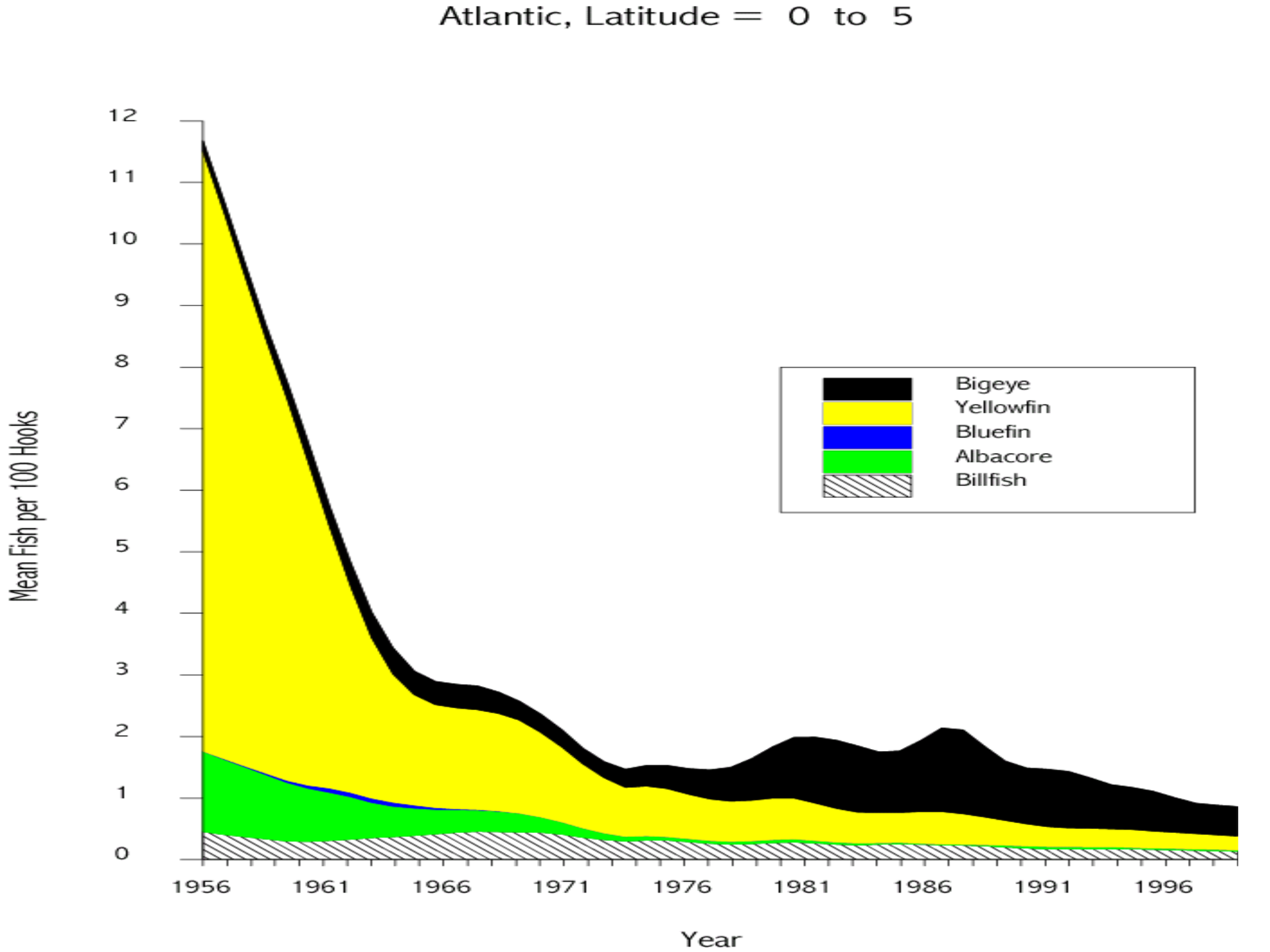
Other prey species: Grand Banks

- Groundfish and small forage fish biomass are inversely correlated

Source: Casey 2000




Indian, Latitude = -35 to -30
Mean Fish per 100 Hooks
10
9
8
7
6
5
4
3
2
1
0
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
Year
Bigeye
Yellowfin
Bluefin
Albacore
Billfish


Atlantic, Latitude = 0 to 5
Mean Fish per 100 Hooks
12
11
10
9
8
7
6
5
4
3
2
1
0
1956
1961
1966
1971
1976
1981
1986
1991
1996
Year
Bigeye
Yellowfin
Bluefin
Albacore
Billfish

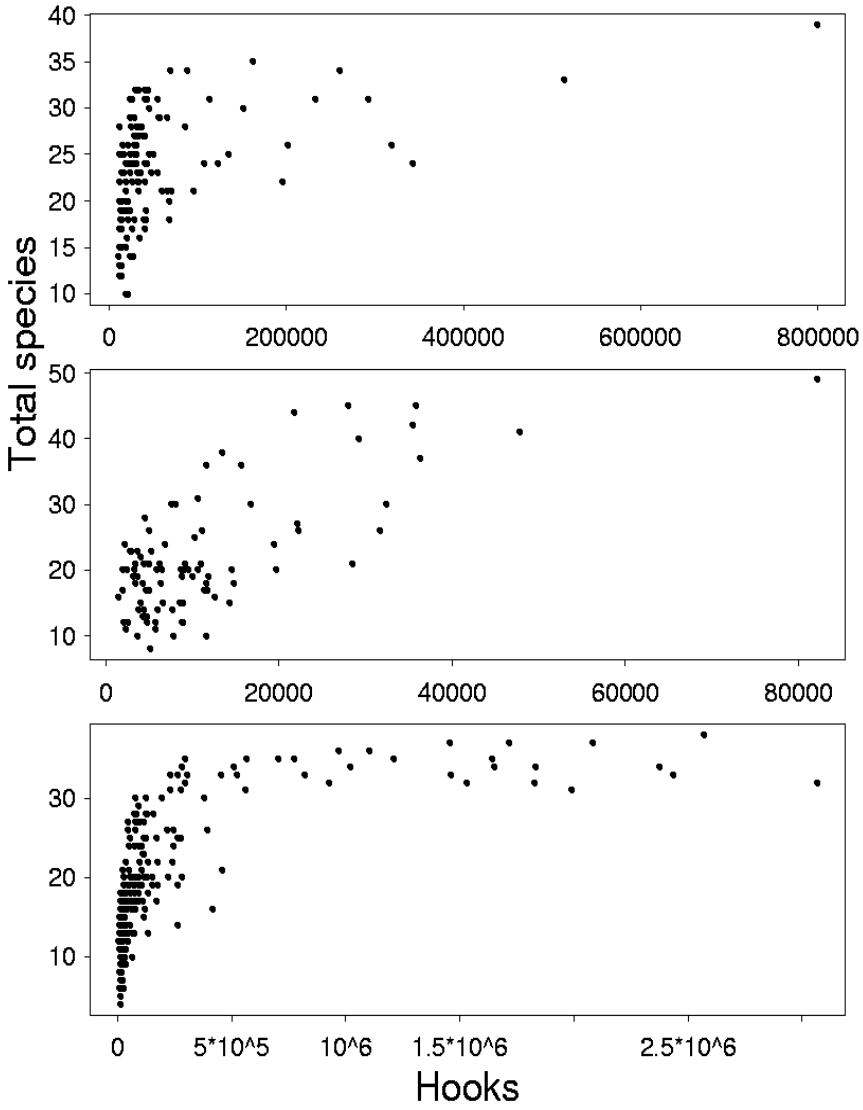
Analysis and Understanding

- Interpolation and Overlap (using methods developed in epidemiology to put data on a common sampling frame)
- Biogeographic Modelling (improved estimates using inferred zeros).
- Pelagic Fish Biodiversity
- Movement Models
- Spatial Multispecies Models

How to measure diversity?

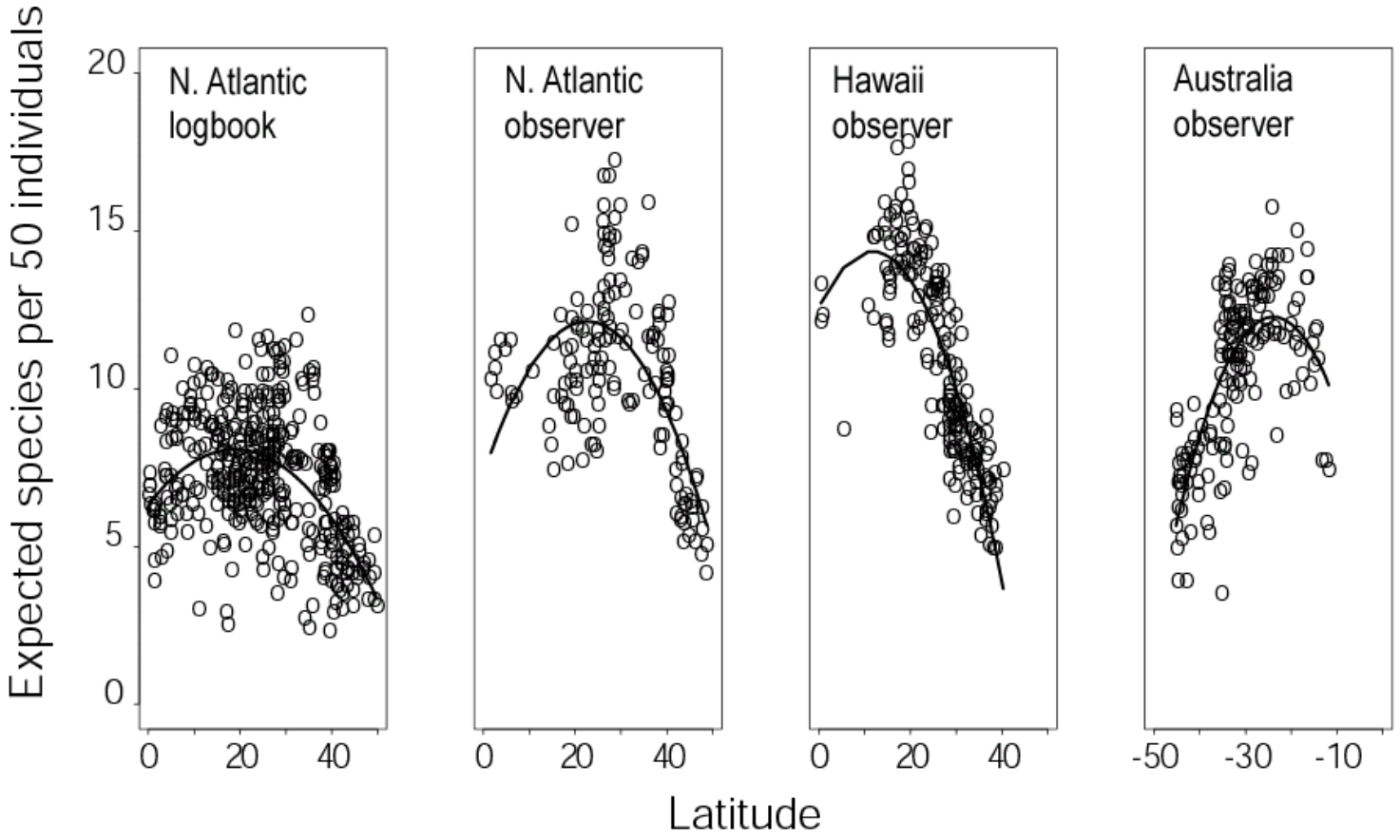
- Number of species recorded depends on effort (hooks)
- Rarefaction method (Hurlbert, 1971)
- "expected number of species encountered from a sample of X individuals

„



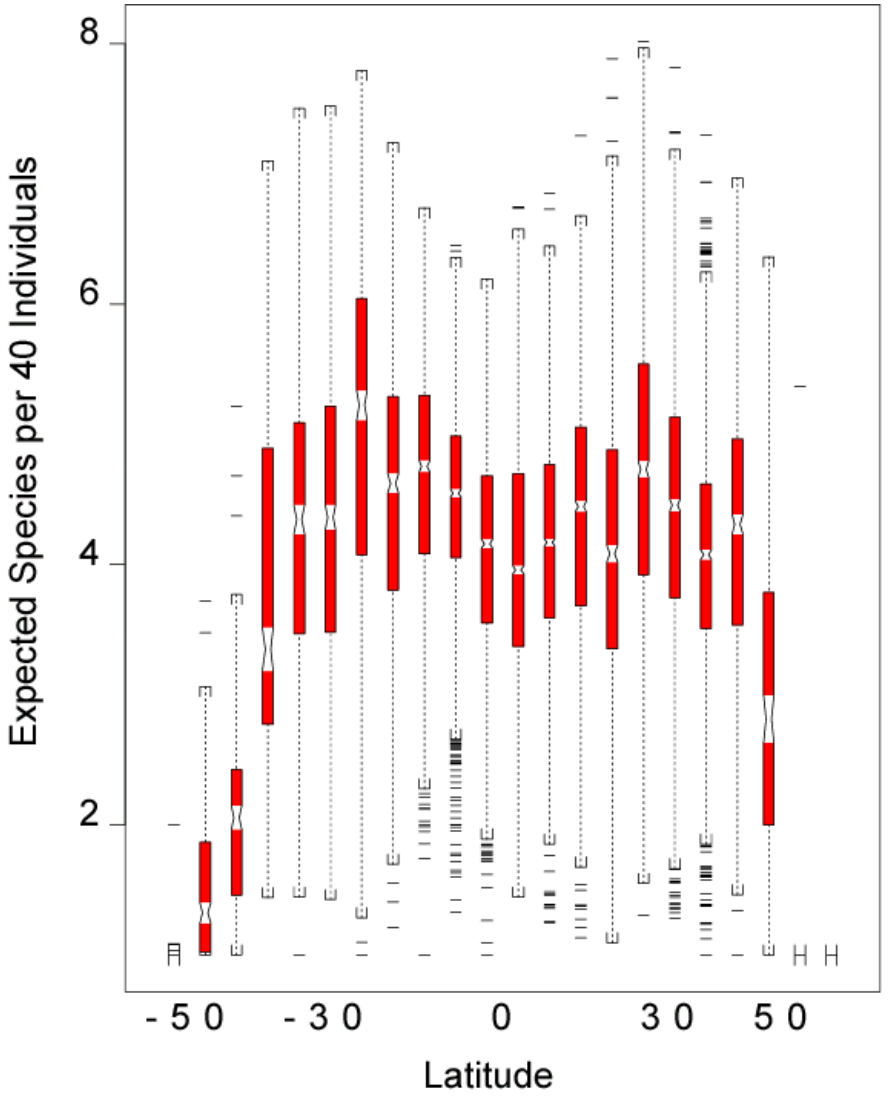
Latitudinal gradients

- Diversity peaks at 20 –30 degree latitude



Latitudinal gradients: a global feature

- Diversity of target species peaks at 20-30 degree latitude
- Independent data set: Japanese logbooks 1962-1980

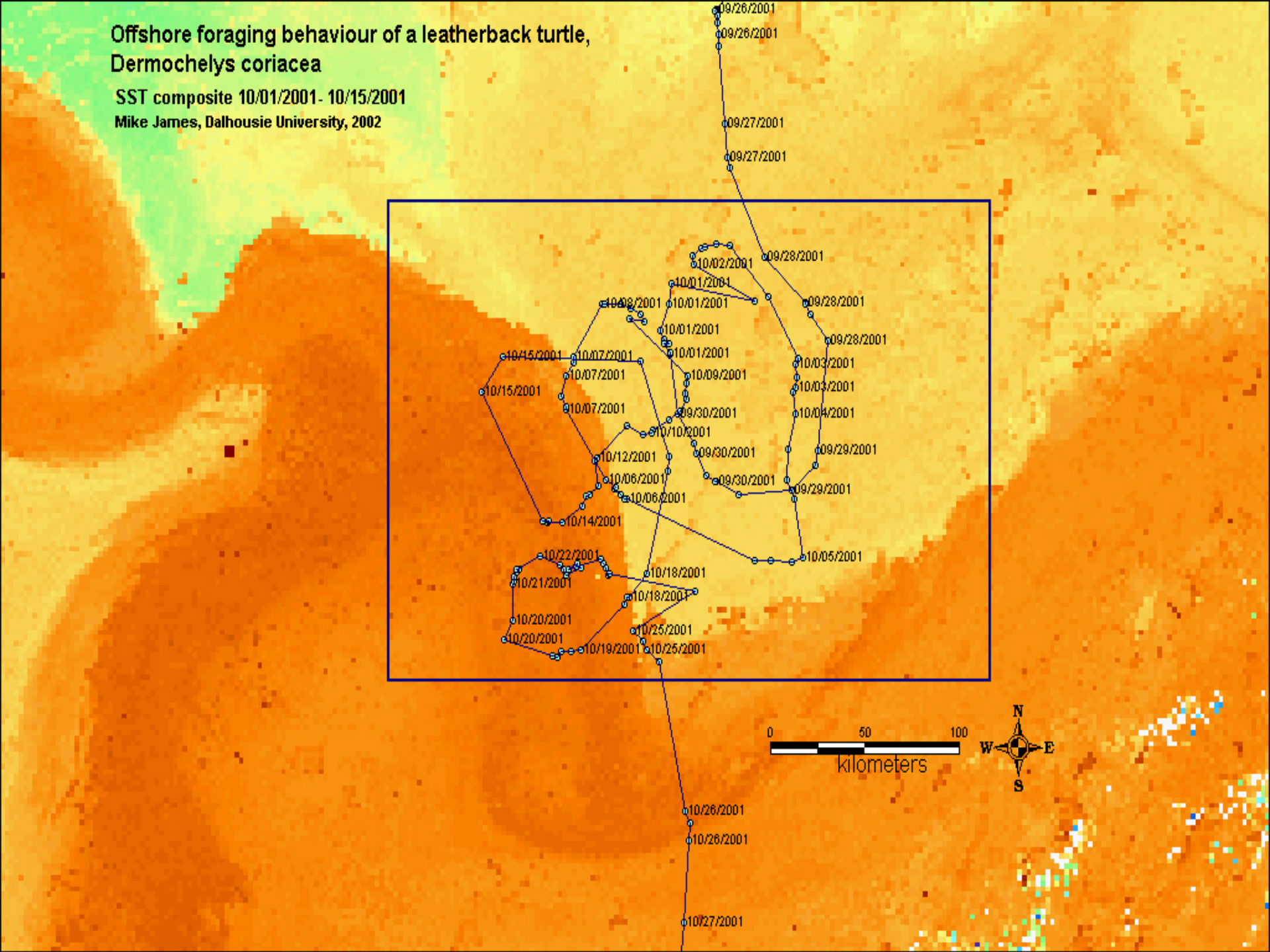


The Analysis of Animal Movement Using Nonlinear State-Space Models

Ransom A. Myers

Ian D. Jonsen

Joanna Mills Flemming


Offshore foraging behaviour of a leatherback turtle, Dermochelys coriacea
SST composite 10/01/2001- 10/15/2001
Mike James, Dalhousie University, 2002
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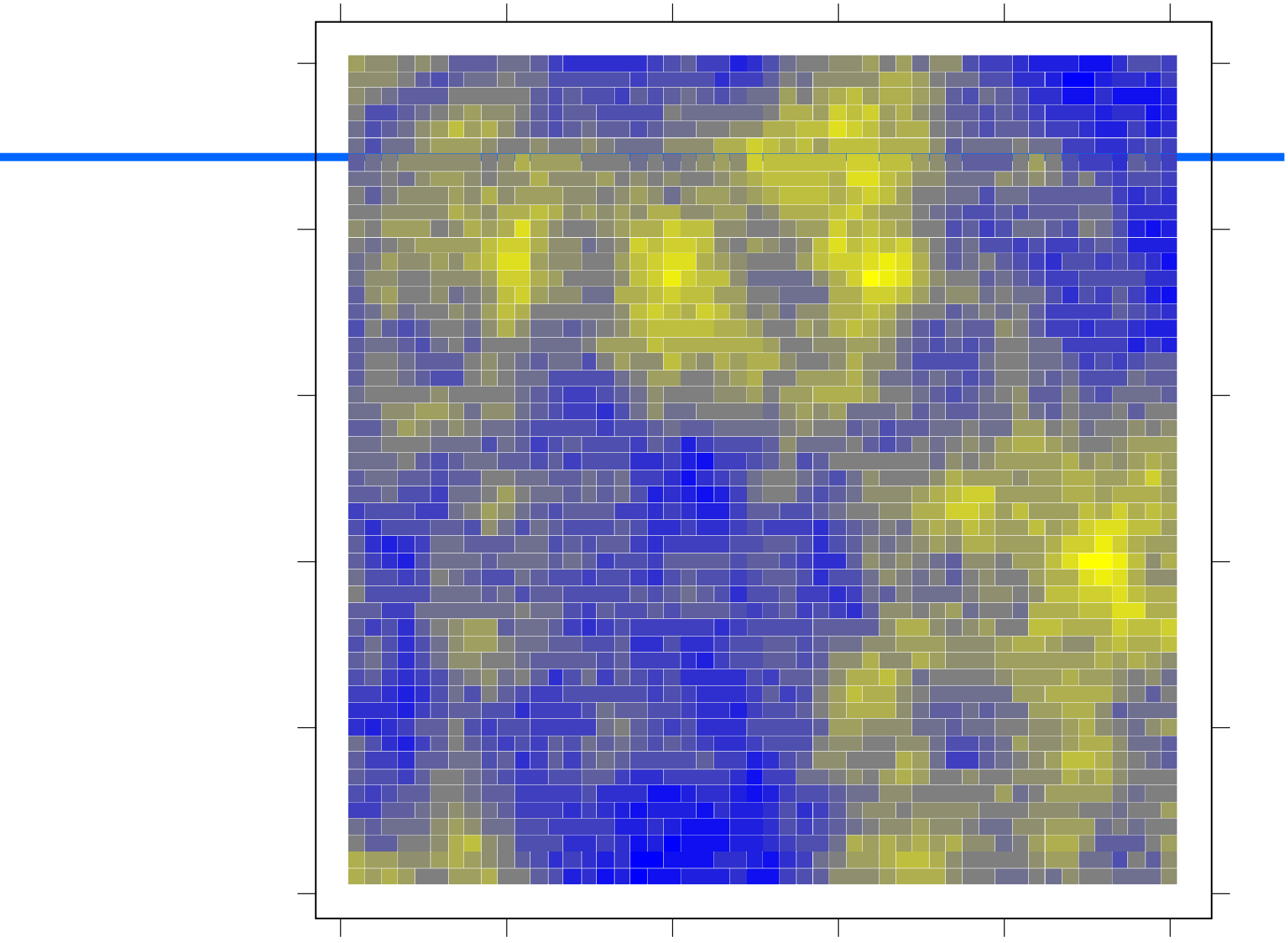
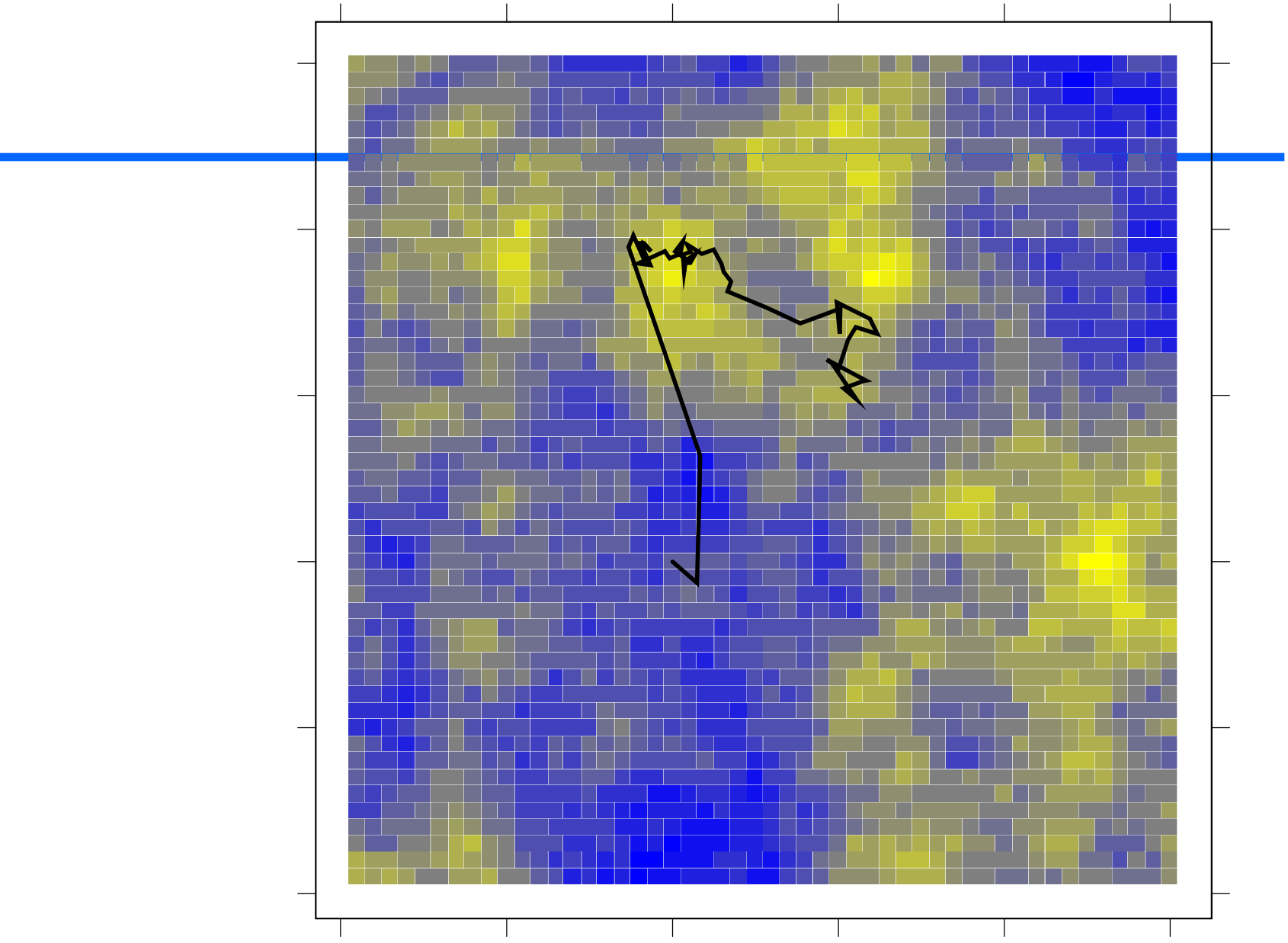
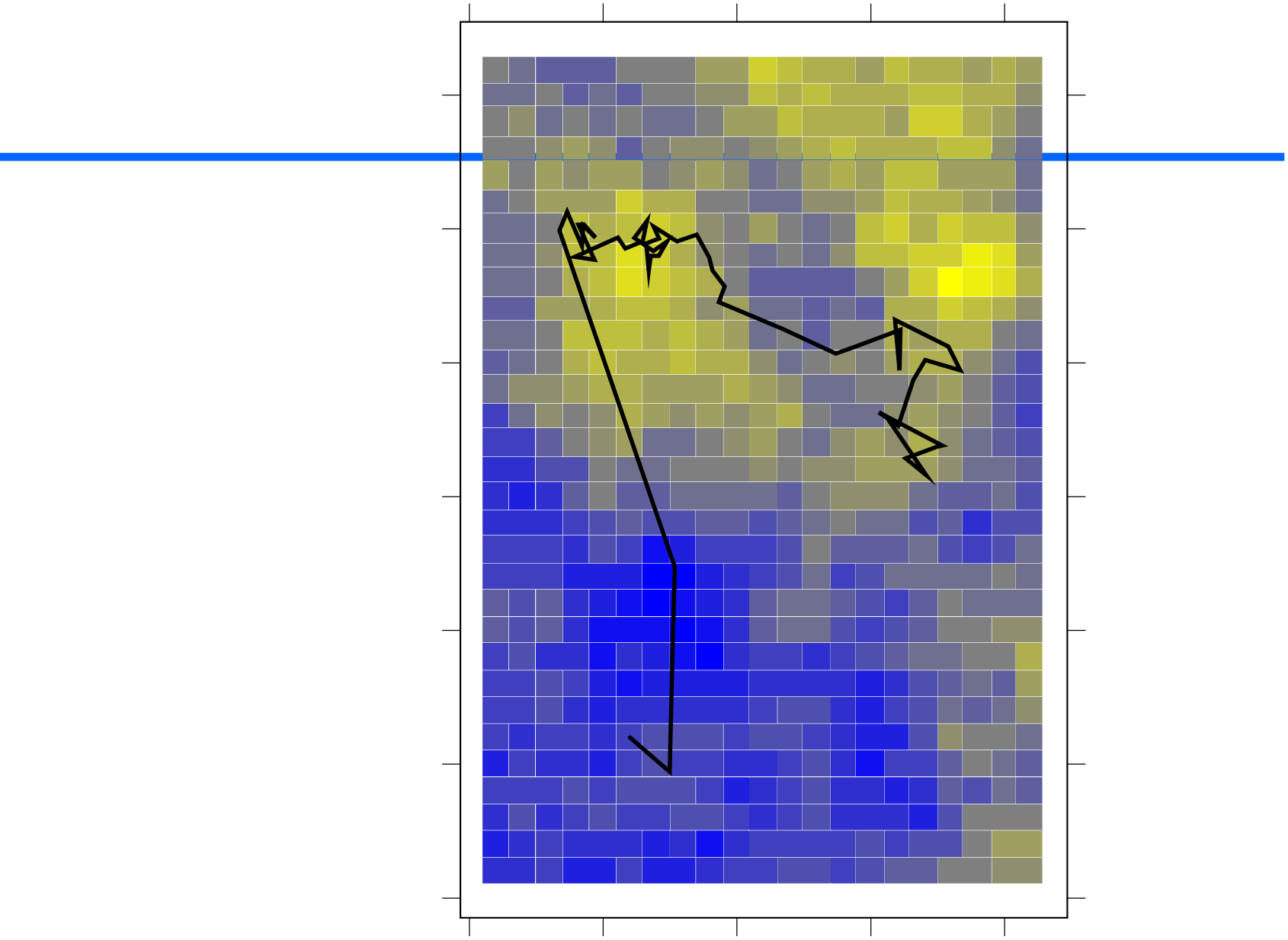
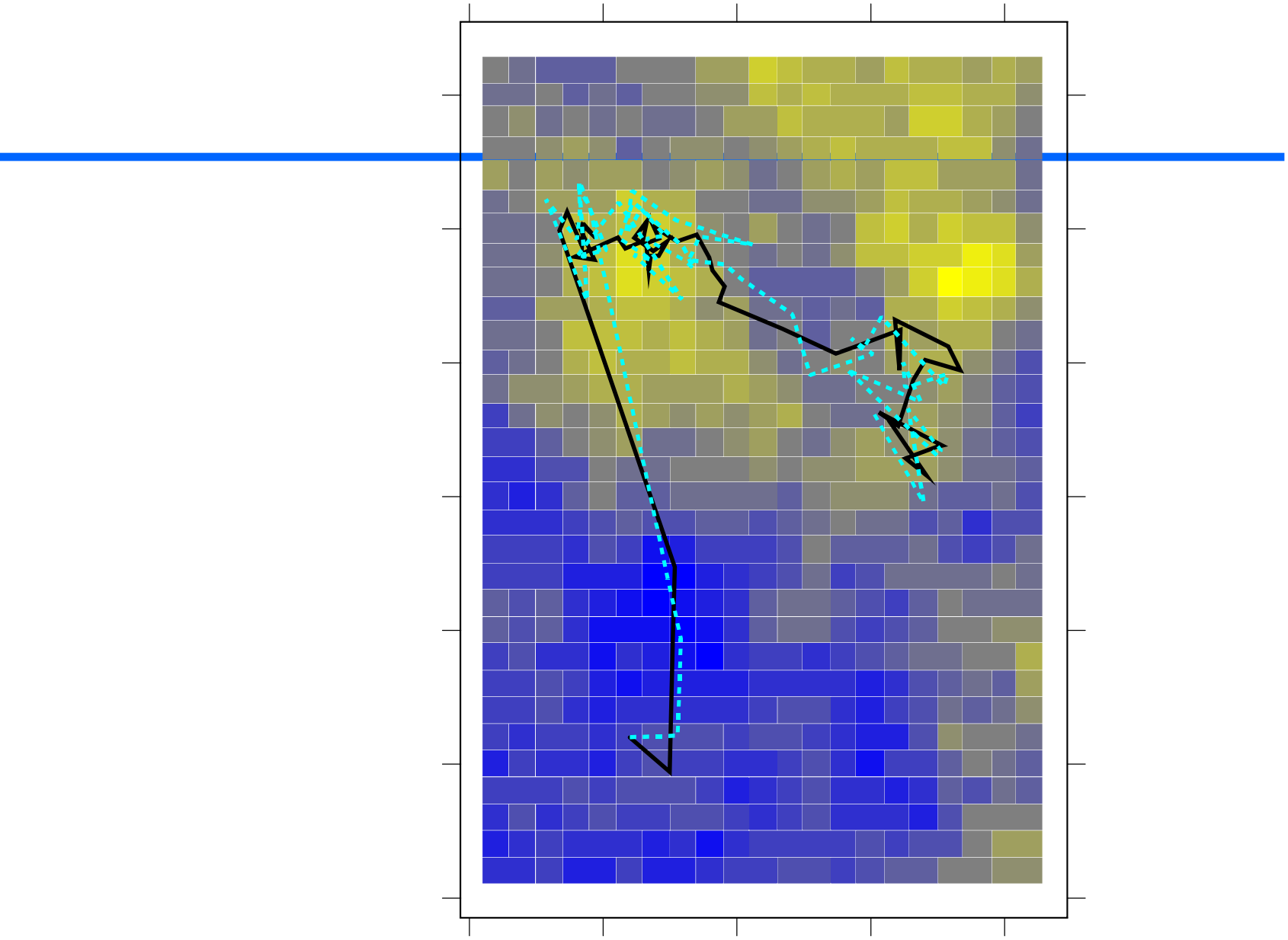
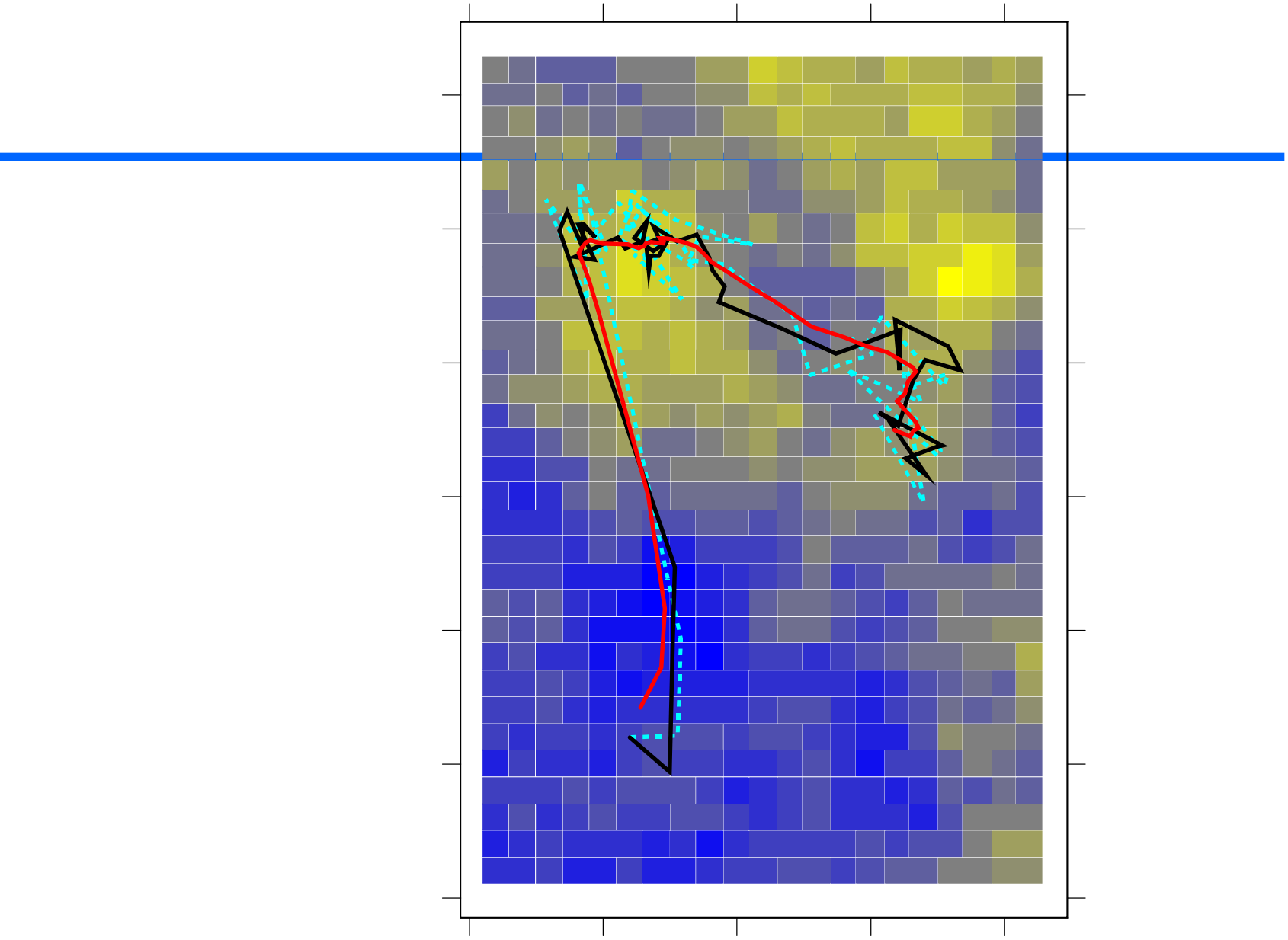
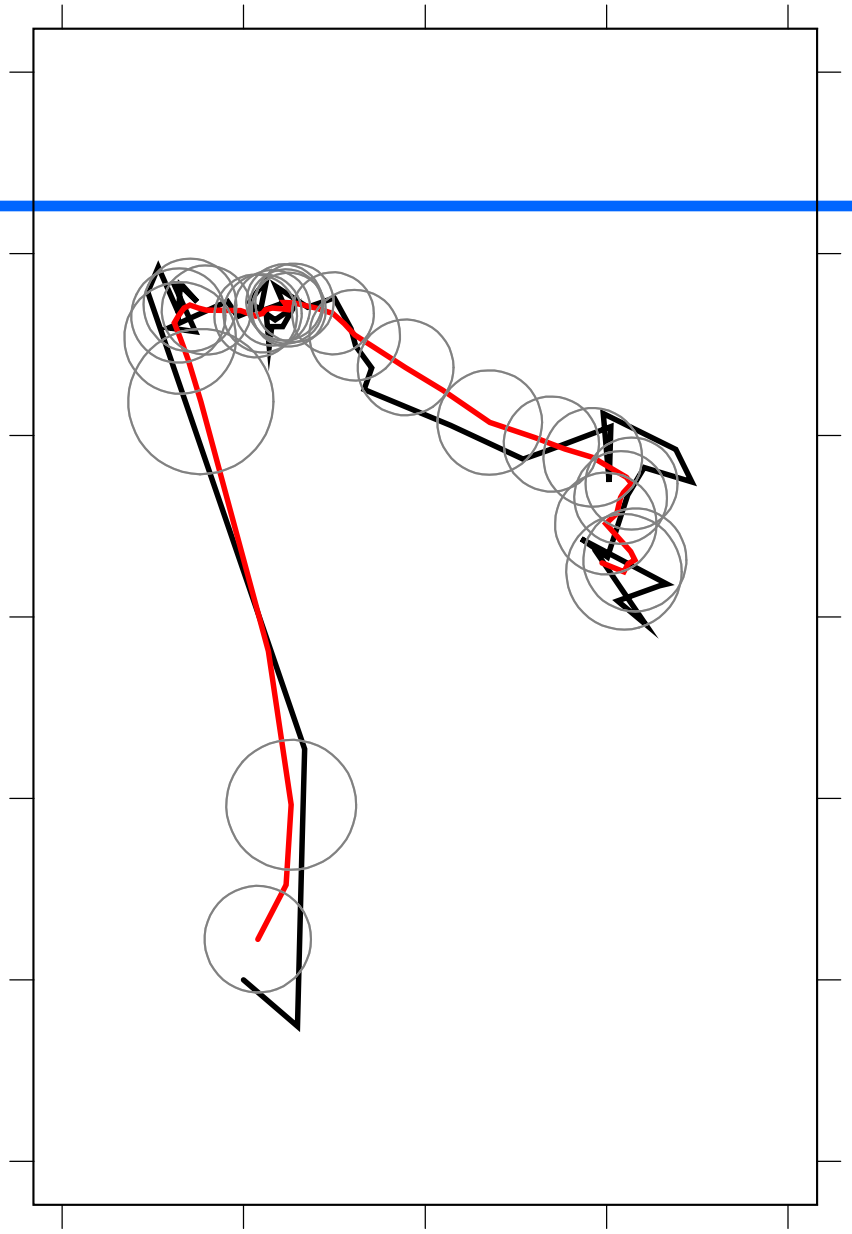












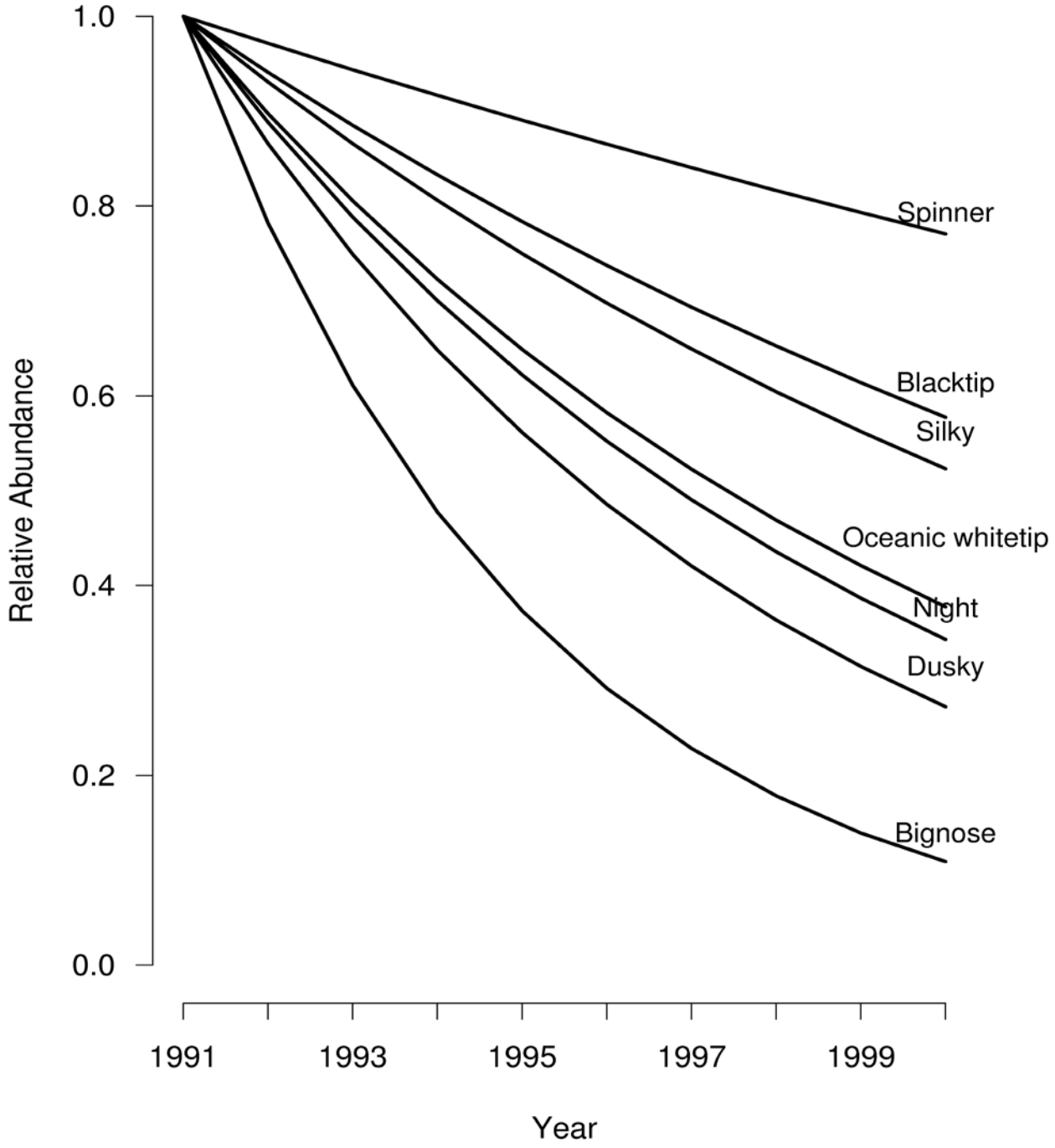
WinBUGS Code

```
{
#vague priors...ie assume we do not know process
      error
sigma[1]~dgamma(.001,.001)

#strong priors...ie assume we know error of our
      observations
tau[1]~dgamma(1,1)

#prior for alpha
alpha~dnorm(0,.000001)
#prior for beta
beta~dnorm(1.25,1)
```

```
#iterate transition equation
for(i in 2:N){
for(j in 1:2){
sig2[i,j]<-sigma+alpha*(0.5+exp(-beta*temp[i-1]))
Y.true[i,j]~dnorm(Y.true[i-1,j],sig2[i])
}
}
# iterate measurement equation
for(i in 1:N){
for(j in 1:2){
Y.obs[i,j]~dnorm(Y.true[i,j],tau)
}
}
}
```

Prediction

- Global Fishing Prediction
- Models for Biodiversity
- Spatial-Temporal Prediction
- Extinction Models


1.0
0.8
0.6
0.4
0.2
0.0
Relative Abundance
Spinner
Blacktip
Silky
Oceanic whitetip
Night
Dusky
Bignose
1991
1993
1995
1997
1999
Year

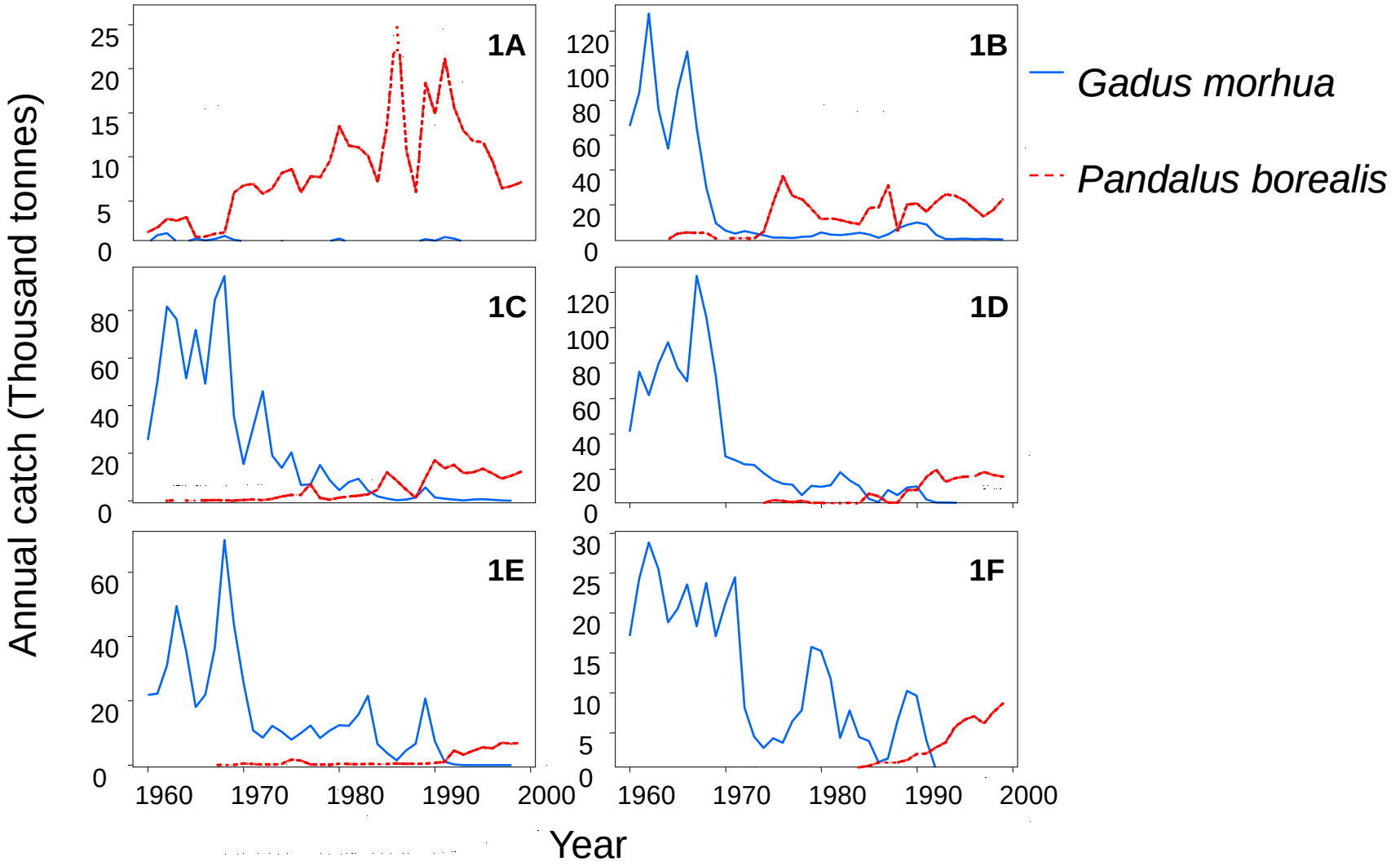
Major Goals for the Future:

- A modeling framework to guide the CoML: how are data and models to be integrated?
- A statistical design for future data collection.
- Analysis and synthesis tools for present and future field projects.

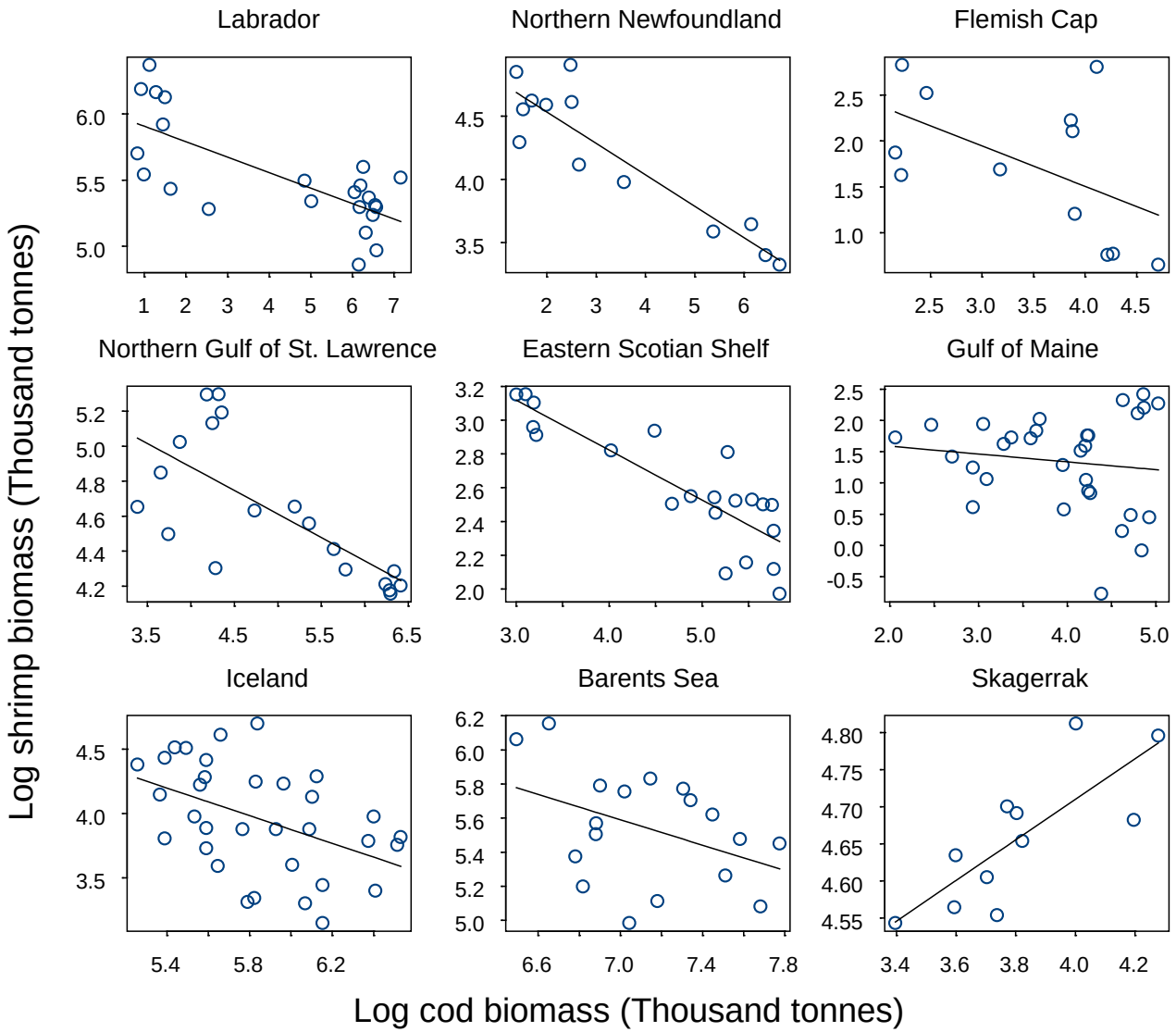
Problems:

- The large scale patterns of the most abundant large animals in the ocean has not been studied.
- Example: Diversity of large pelagic animals (e.g. tunas, sharks, billfish, turtles) peaks between 20 and 30 degrees (north or south) in the worlds oceans.

Serial increases in Greenland shrimp



Cod and shrimp biomass in the North Atlantic: correlations

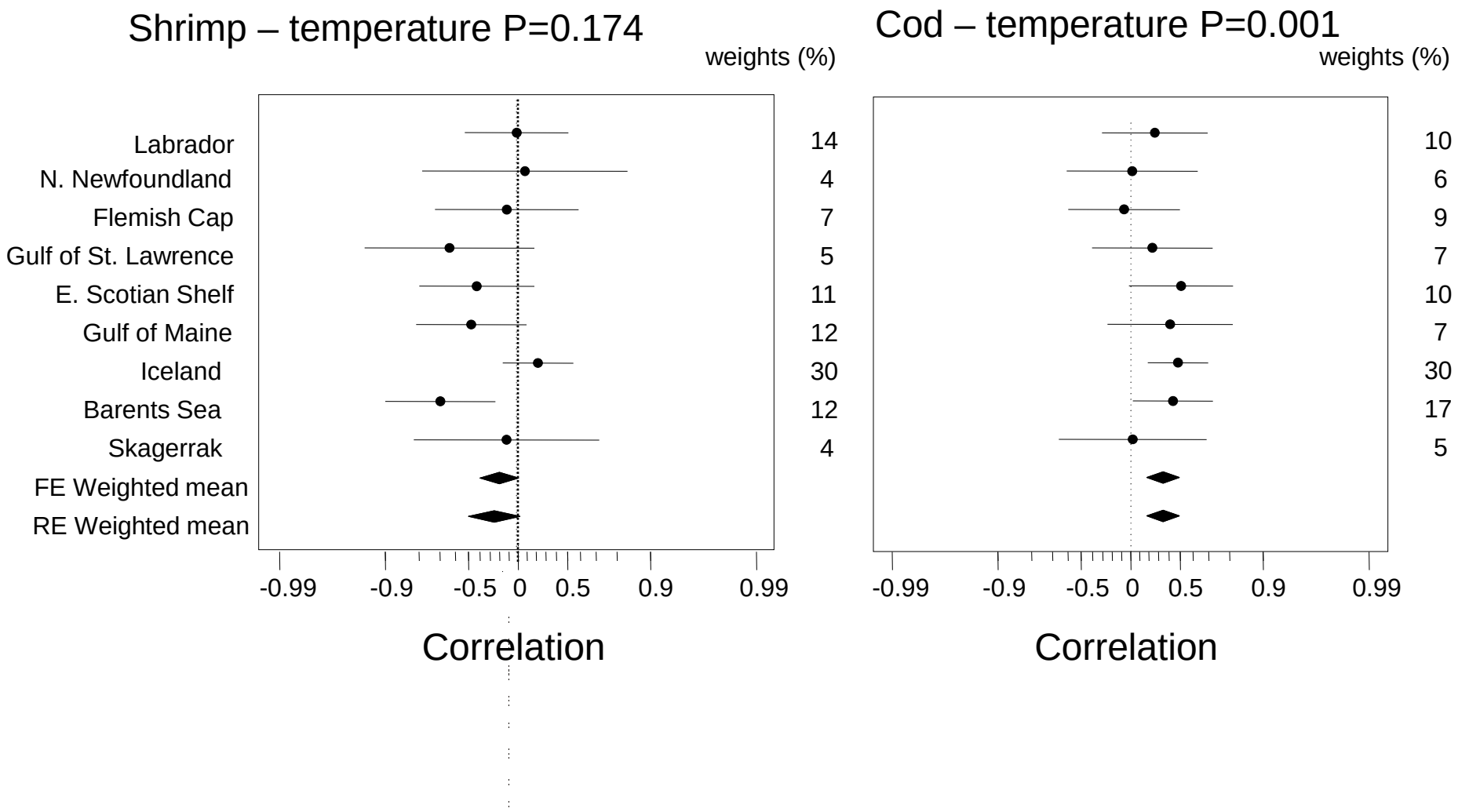


Step 1: Dealing with autocorrelation and measurement error

	Simple analysis			Corrected analysis		
Region	*r*	*N*	*P*	*r**	*N**	*P**
Labrador	-0.746	23	0.000	-0.827	4.8	0.054
N. Newfoundland	-0.911	13	0.000	-0.976	3.3	0.012
Flemish Cap	-0.526	12	0.073	-0.607	6.3	0.161
N.Gulf of St. Lawrence	-0.708	19	0.000	-0.827	3.4	0.165
Eastern Scotian Shelf	-0.856	21	0.000	-0.982	3.5	0.004
Gulf of Maine	-0.131	31	0.485	-0.147	9.3	0.701
Iceland	-0.459	33	0.006	-0.63	8.2	0.075
Barents Sea	-0.412	18	0.087	-0.635	11.7	0.023
Skagerrak	0.788	11	0.002	0.808	5.0	0.061

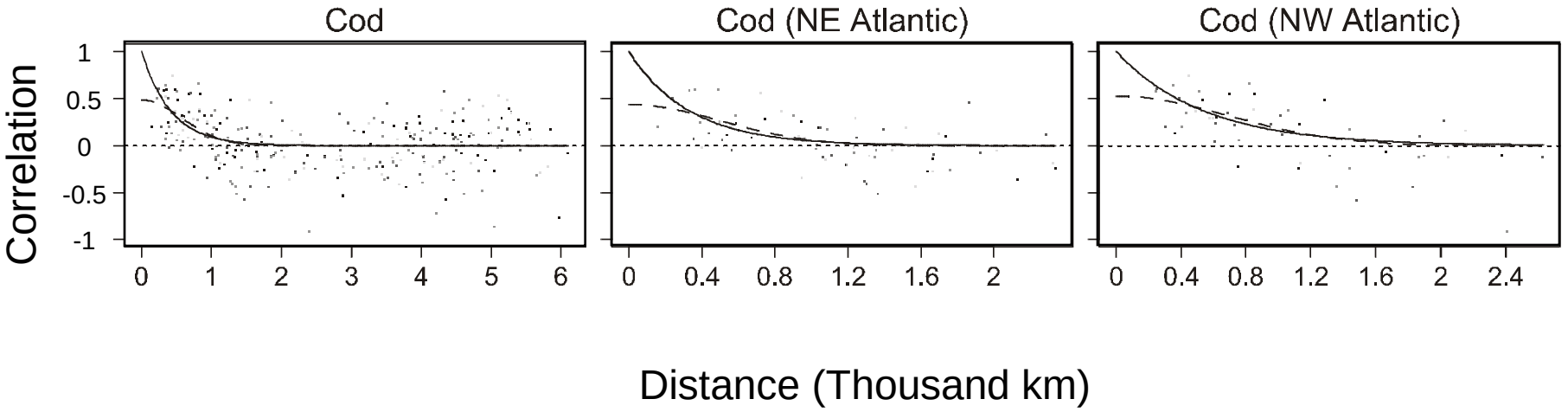
Source: Hedges & Olkin 1985, Pyper & Peterman 1998

Step 3: Testing environmental forcing



Step 4: Examining spatial correlation

- Cod recruitment is correlated on scales <500 km
- Stocks are not entirely independent
- Sensitivity analysis shows that this does not change results



Source: Myers et al. 1997

Step 5: Testing for latitudinal gradients