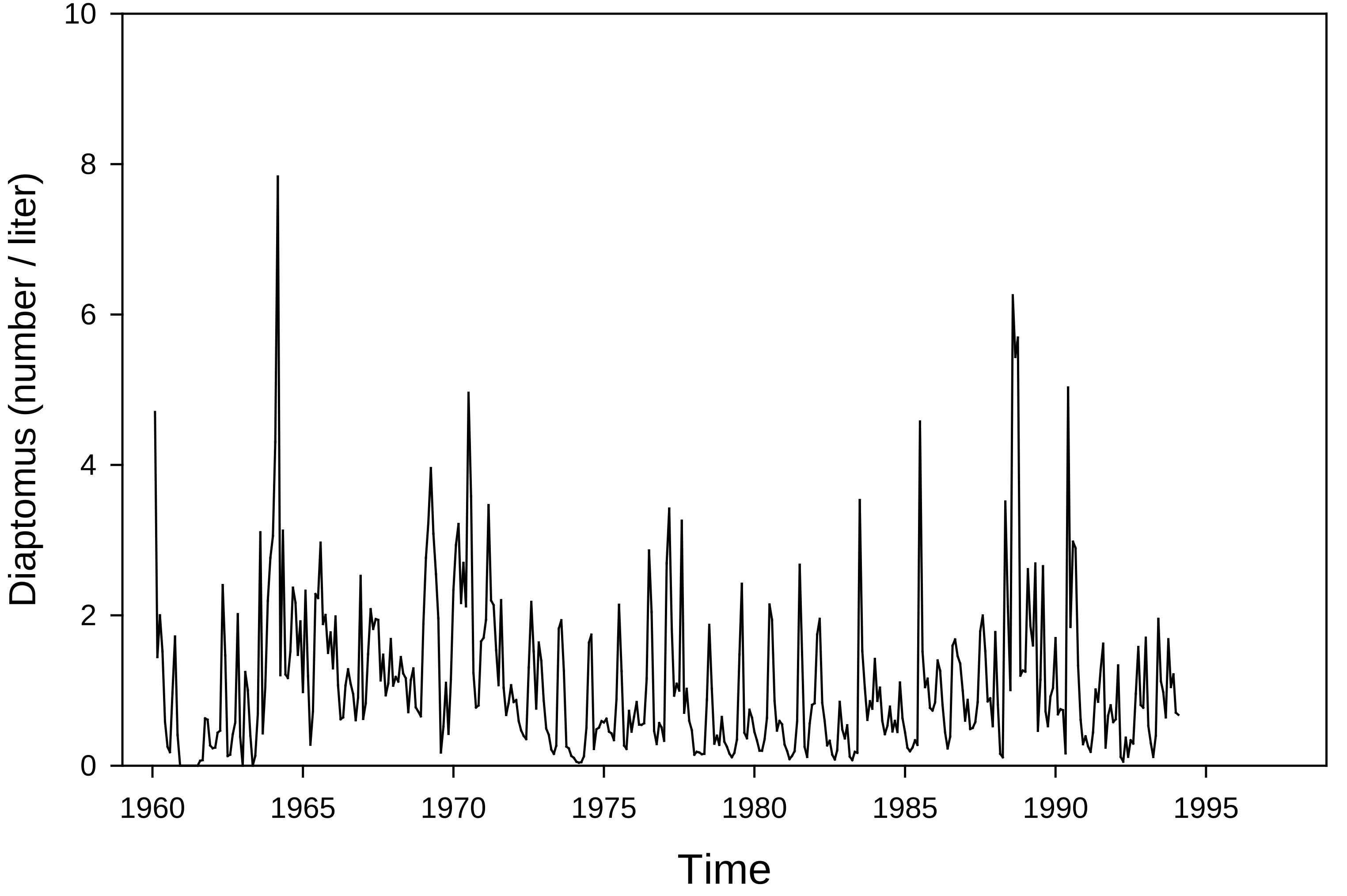
Why do we need to estimate abundance?

Relative Numbers

Long-term and short-term trends

Comparisons between sites

Copepod Dynamics in Lake Washington



Edmonson and Schindler

Why do we need to estimate abundance?

Absolute Numbers

Setting harvest rates

Quantifying nutrient / energy flux

Estimating reproductive success

Counting fish is just like counting trees…except that they are invisible and they move

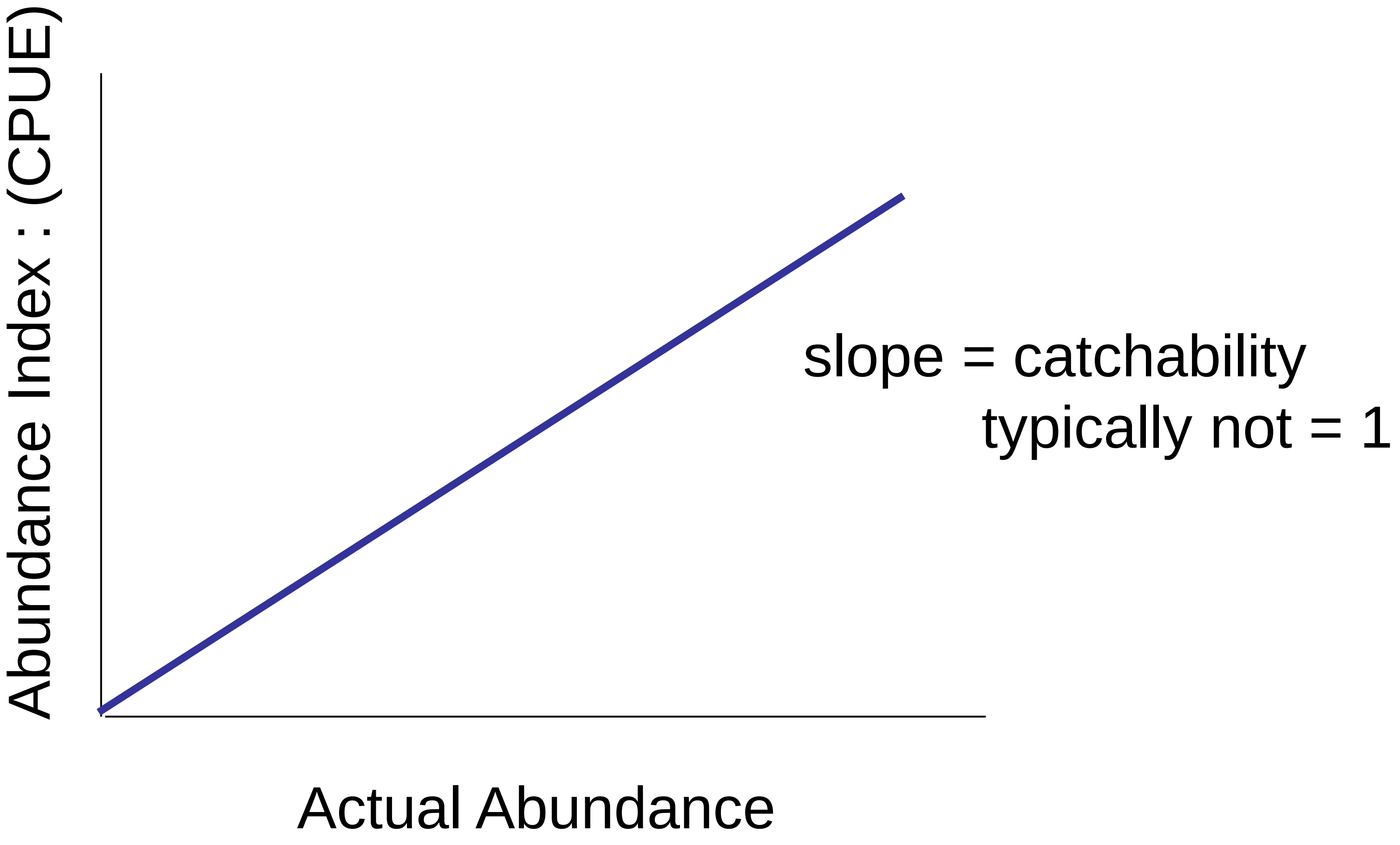
Abundance Indices:

Fisheries

Surveys

Typical Index: Catch per unit effort (CPUE)

Fundamental Assumptions:

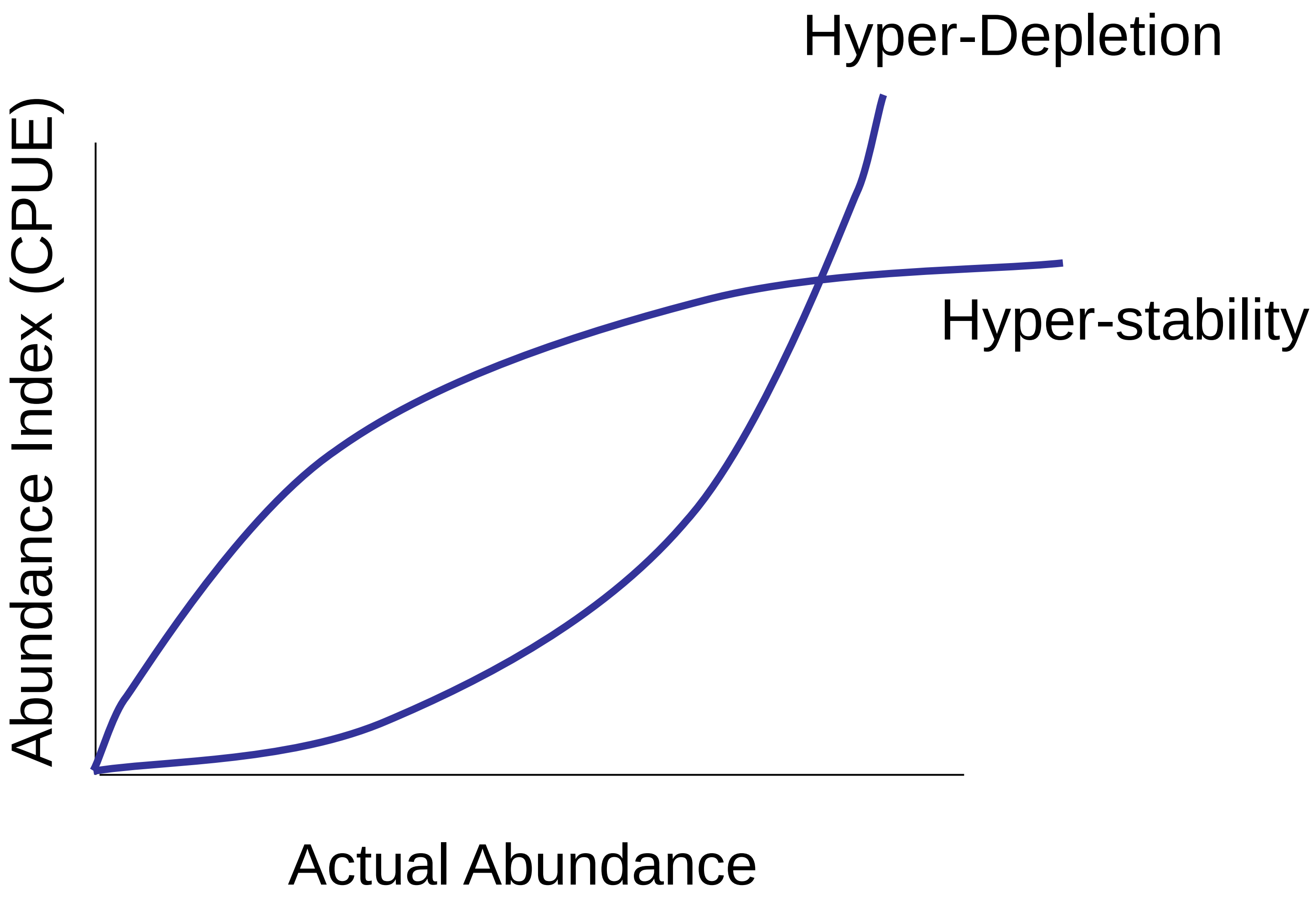


Fundamental Assumptions:

Typically we assume that:

1. Relationship is linear
2. Relationship is stationary
3. Index represents the entire population

Common Problems:



What causes this?

Changes in catch composition

Changes in species distribution

Changes in gear effectiveness

Worm and Myers, 2003. Rapid worldwide depletion of predatory fish communities.

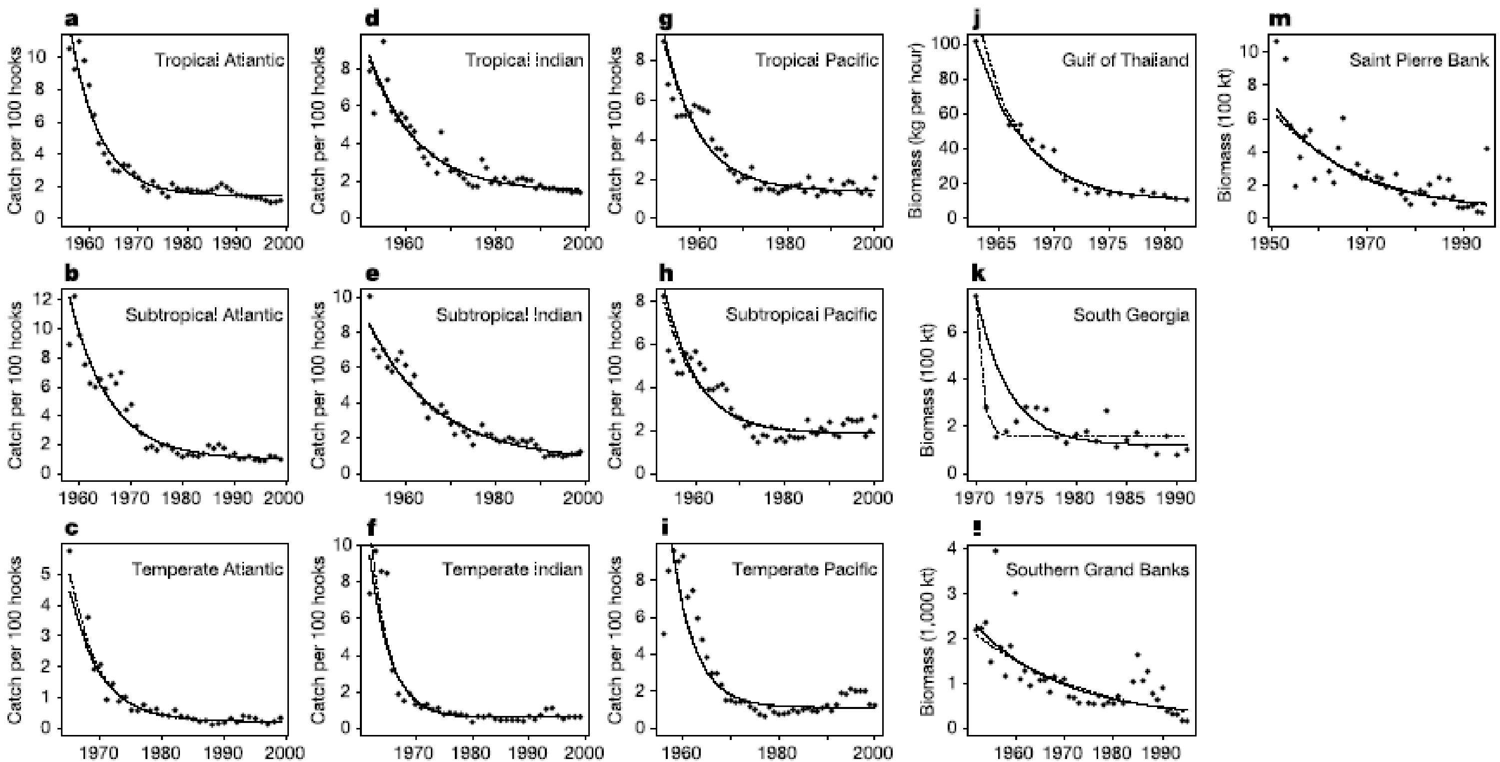
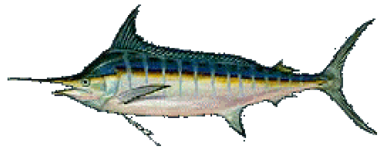


Figure 1 Time trends of community biomass in oceanic (**a–i**) and shelf (**j–m**) ecosystems. Relative biomass estimates from the beginning of industrialized fishing (solid points) are shown with superimposed fitted curves from individual maximum-likelihood fits (solid lines) and empirical Bayes predictions from a mixed-model fit (dashed lines).

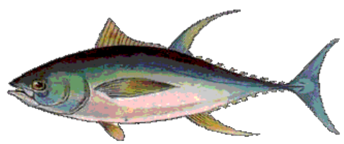
Swordfish



Blue Marlin

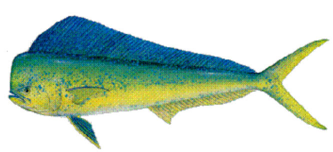
Striped Marlin

highly vulnerable



Yellowfin Tuna

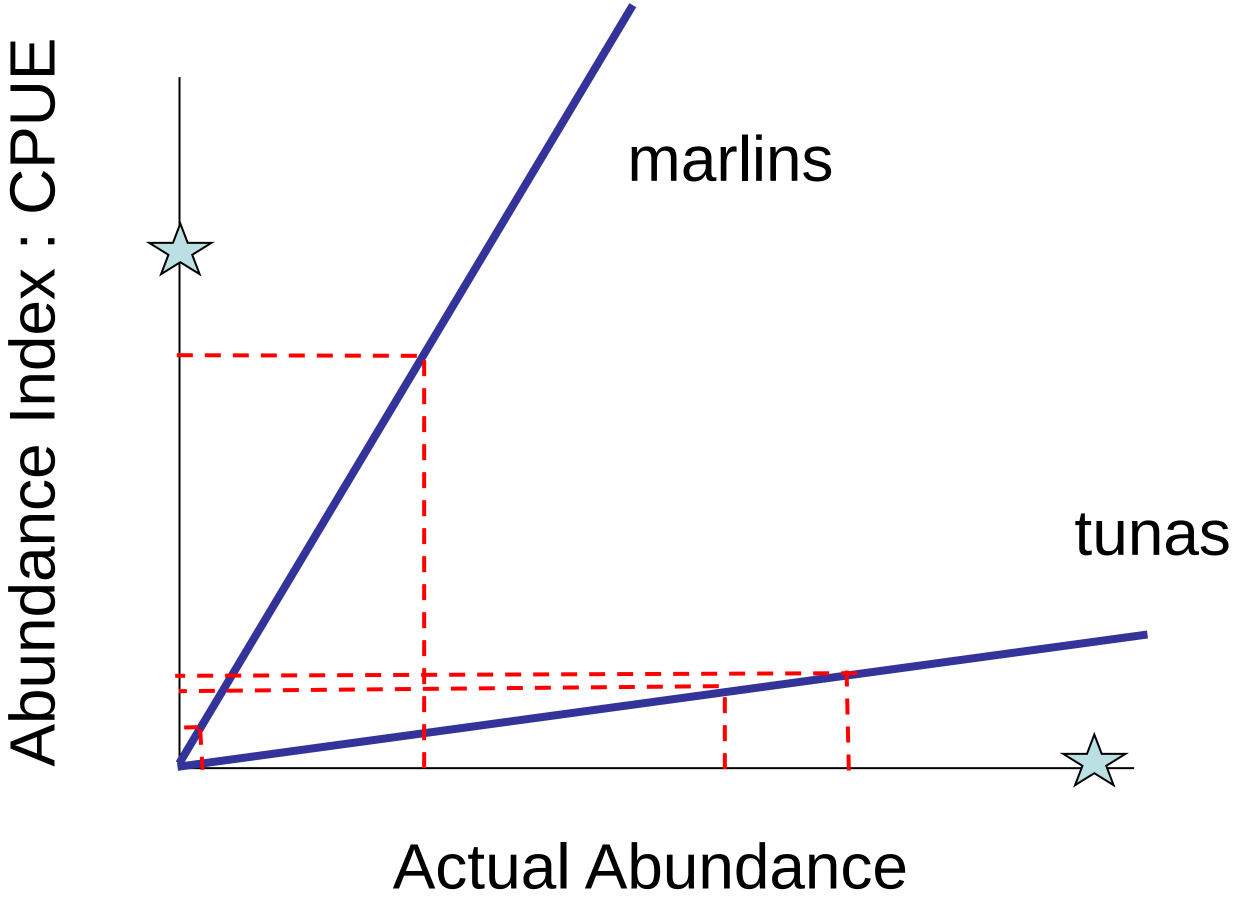
Bigeye Tuna



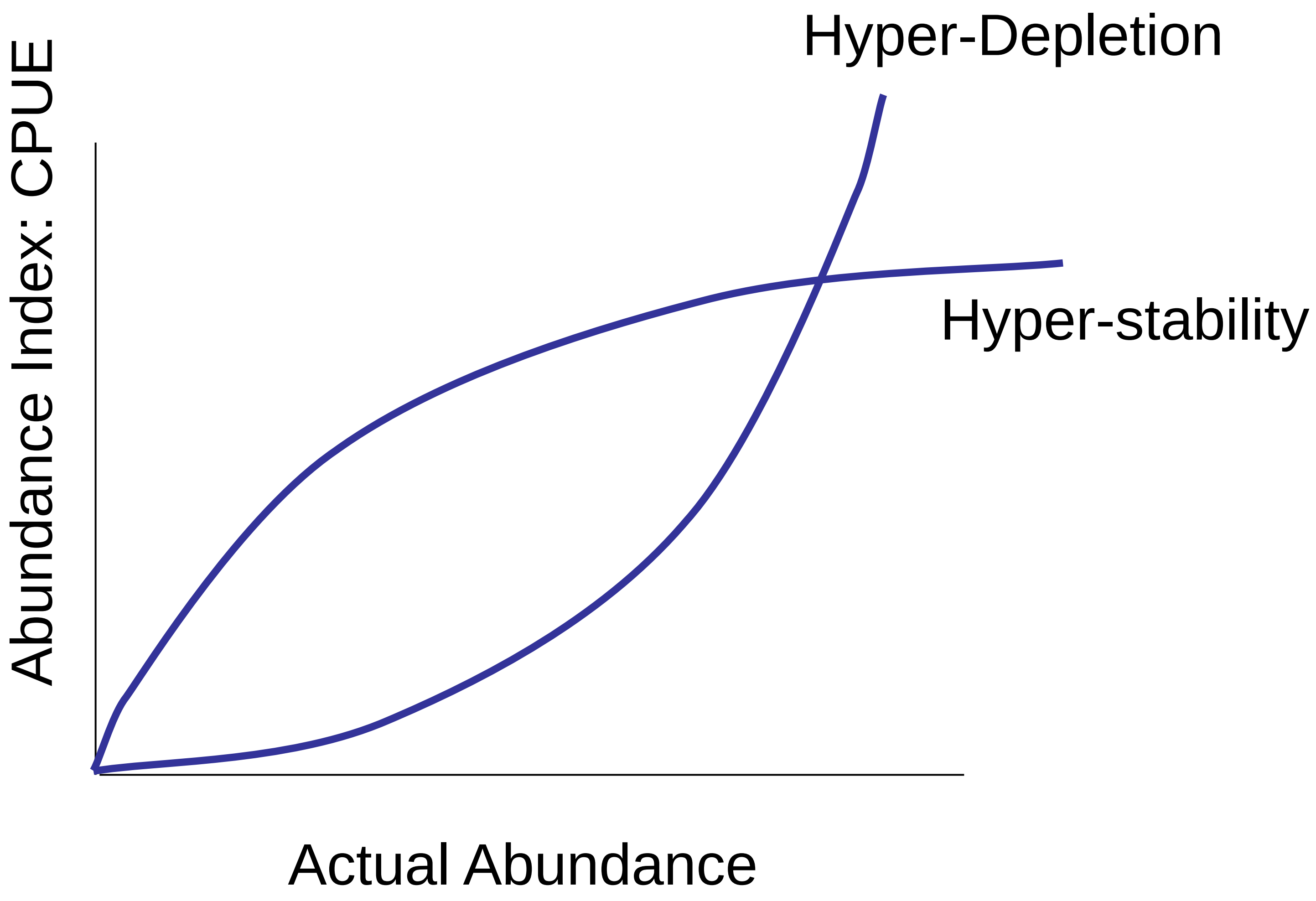
Dolphinfish

Blue Shark

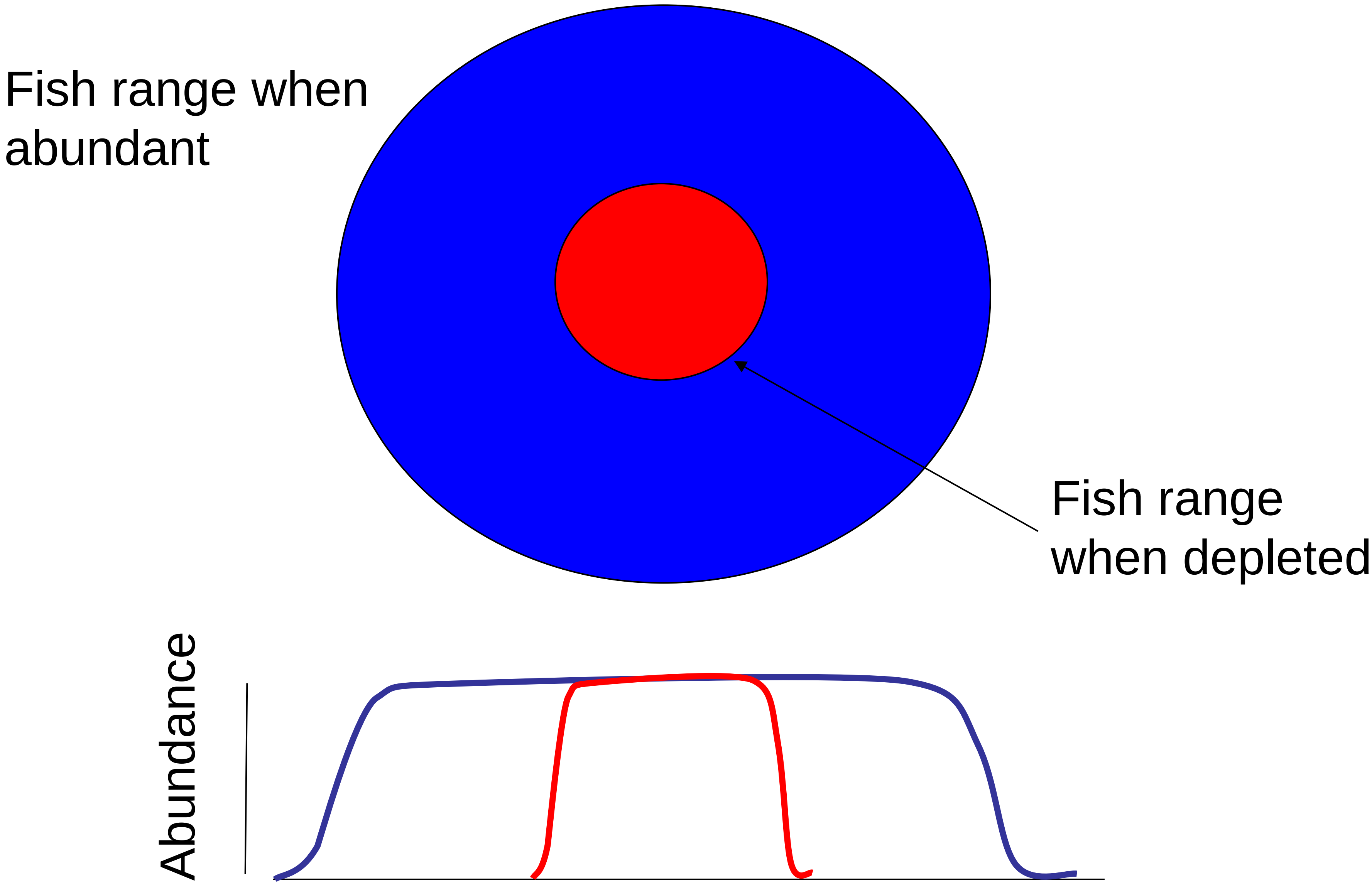
Possible Explanation for Hyper-depletion



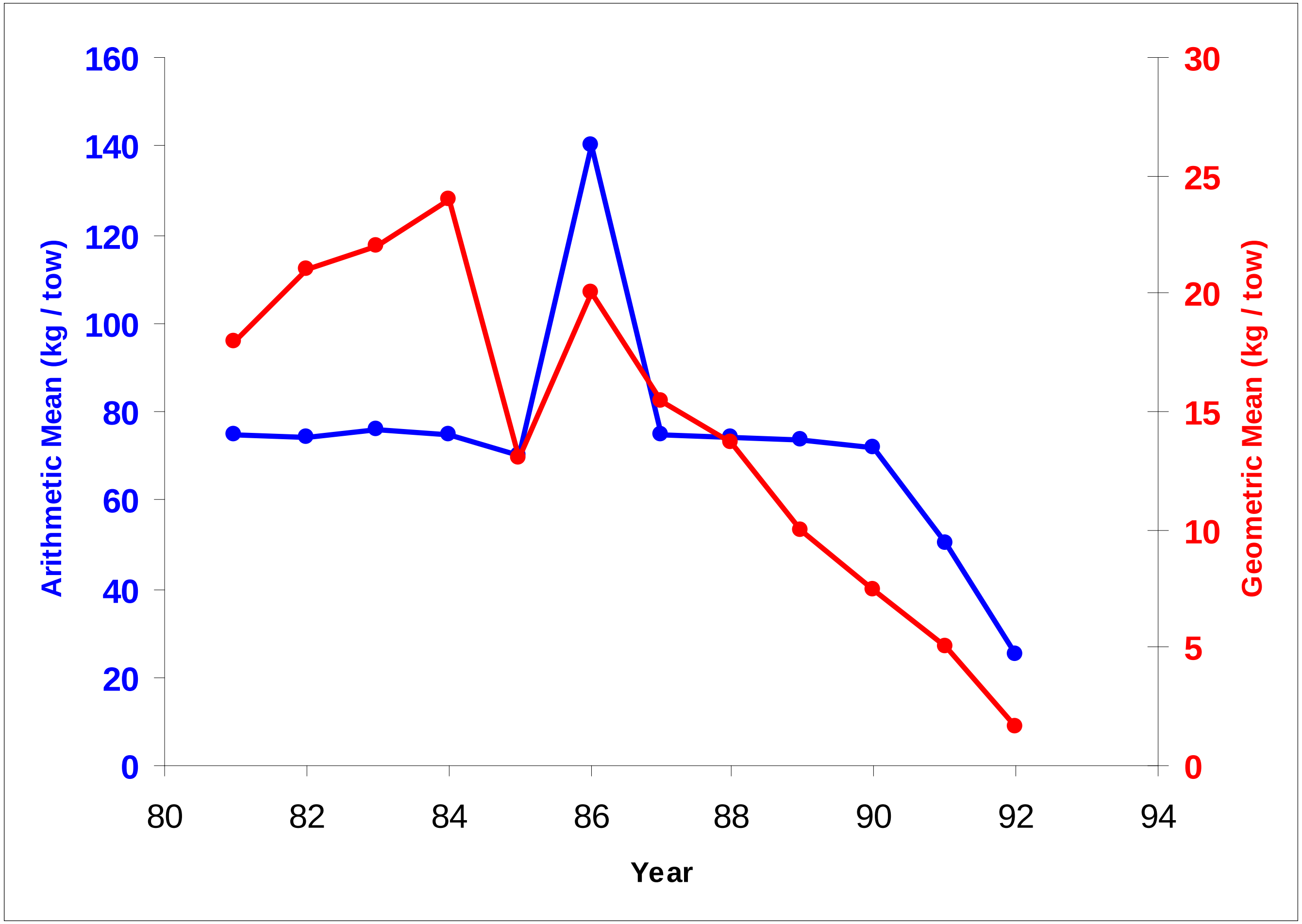
Common Problems:



Spatial Processes and Hyperstability



Hyper-stability and Newfoundland Cod Crash



Abundance Indices:

Fisheries

Surveys

Bluefish: The Terminator IV

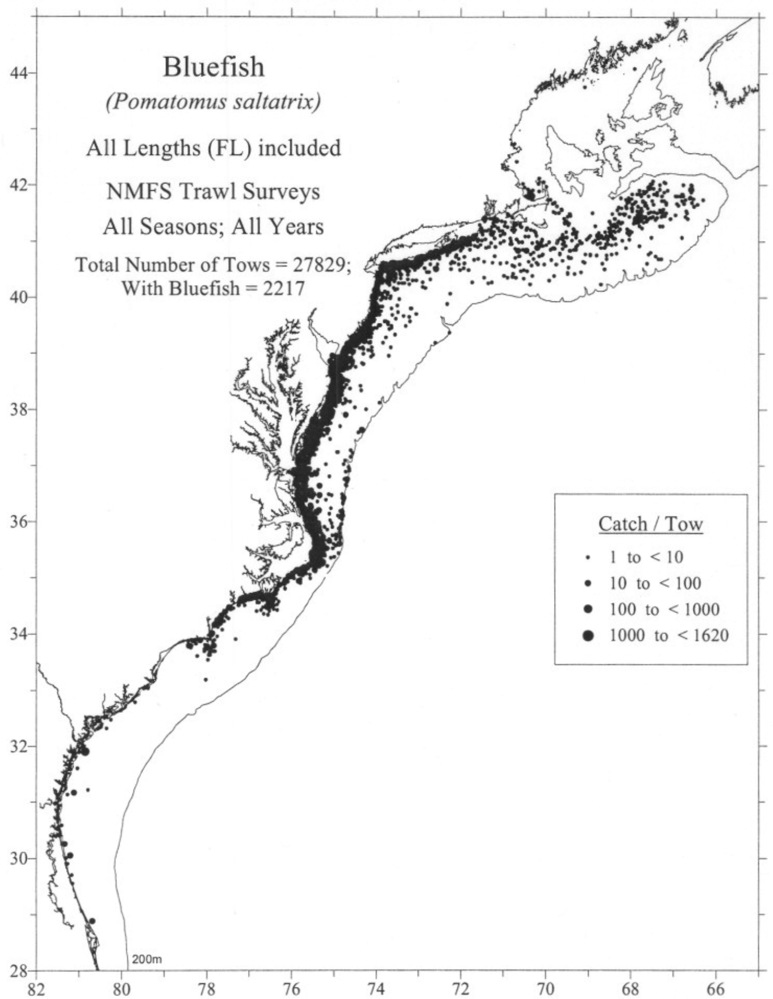
"…it is perhaps the most ferocious and bloodthirsty fish in the sea, leaving in its wake a trail of dead and mangled mackerel, menhaden, herring, alewives, and other species on which it preys."

Bigelow and Schroeder, 1954

"…not content with what they eat, which is itself of enormous quantity, rush ravenously through the closely crowded schools, cutting and tearing the living fish as they go, and leaving in their wake the mangled fragments.""

Goode, 1884

Standardizing Sampling Effort



Is Catch / Effort a good indicator of abundance?

Northeast Fisheries Science Center

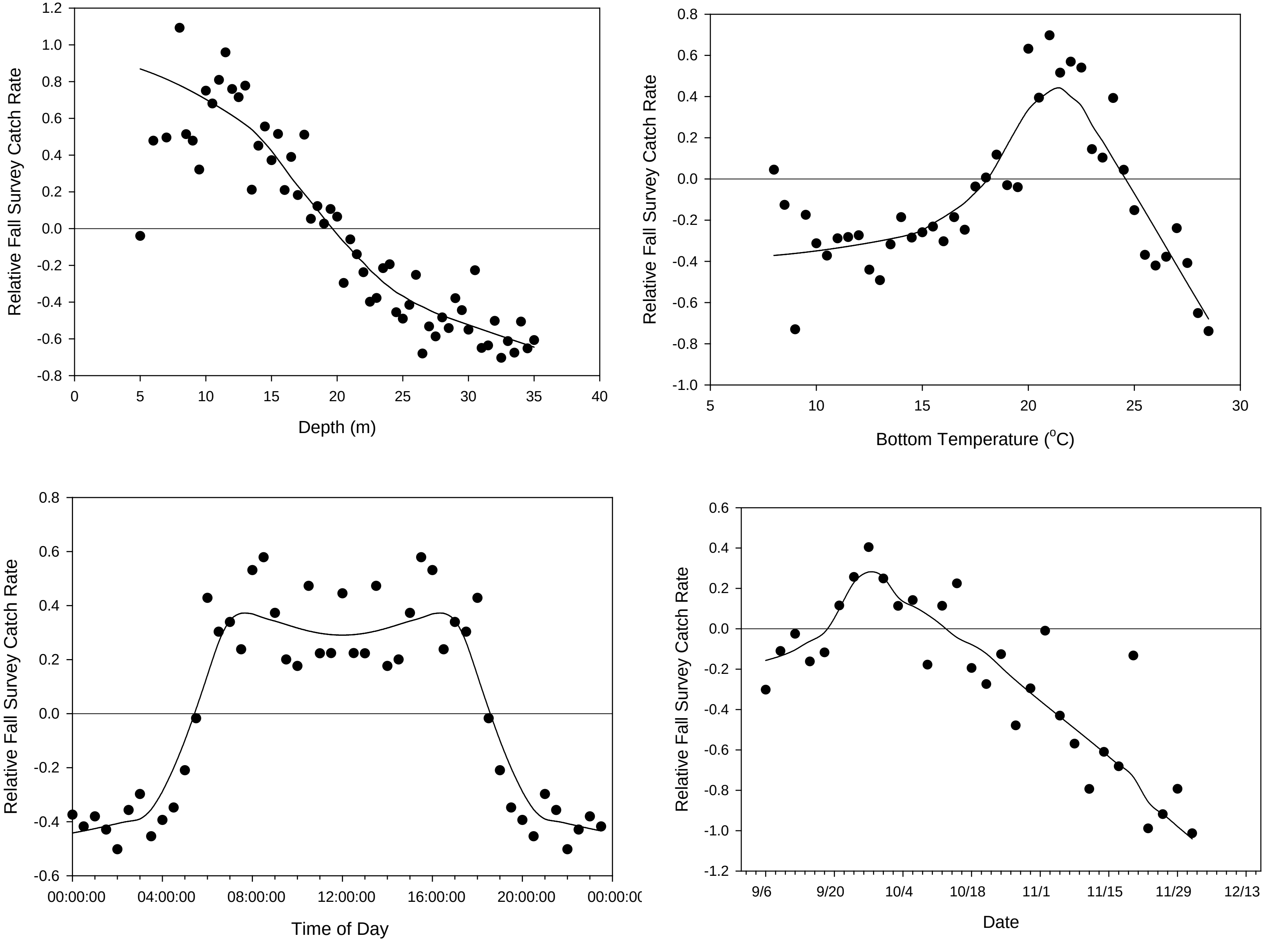
Step 1: Correlate Catch Rate with tow characteristics:

Depth

Temperature

Time of Day

Date


Relative Fall Survey Catch Rate
Depth (m)
Relative Fall Survey Catch Rate
Bottom Temperature (^{o}C)
Relative Fall Survey Catch Rate
Time of Day
00:00:00
04:00:00
08:00:00
12:00:00
16:00:00
20:00:00
Relative Fall Survey Catch Rate
Date
9/6
9/20
10/4
10/18
11/1
11/15
11/29
12/13

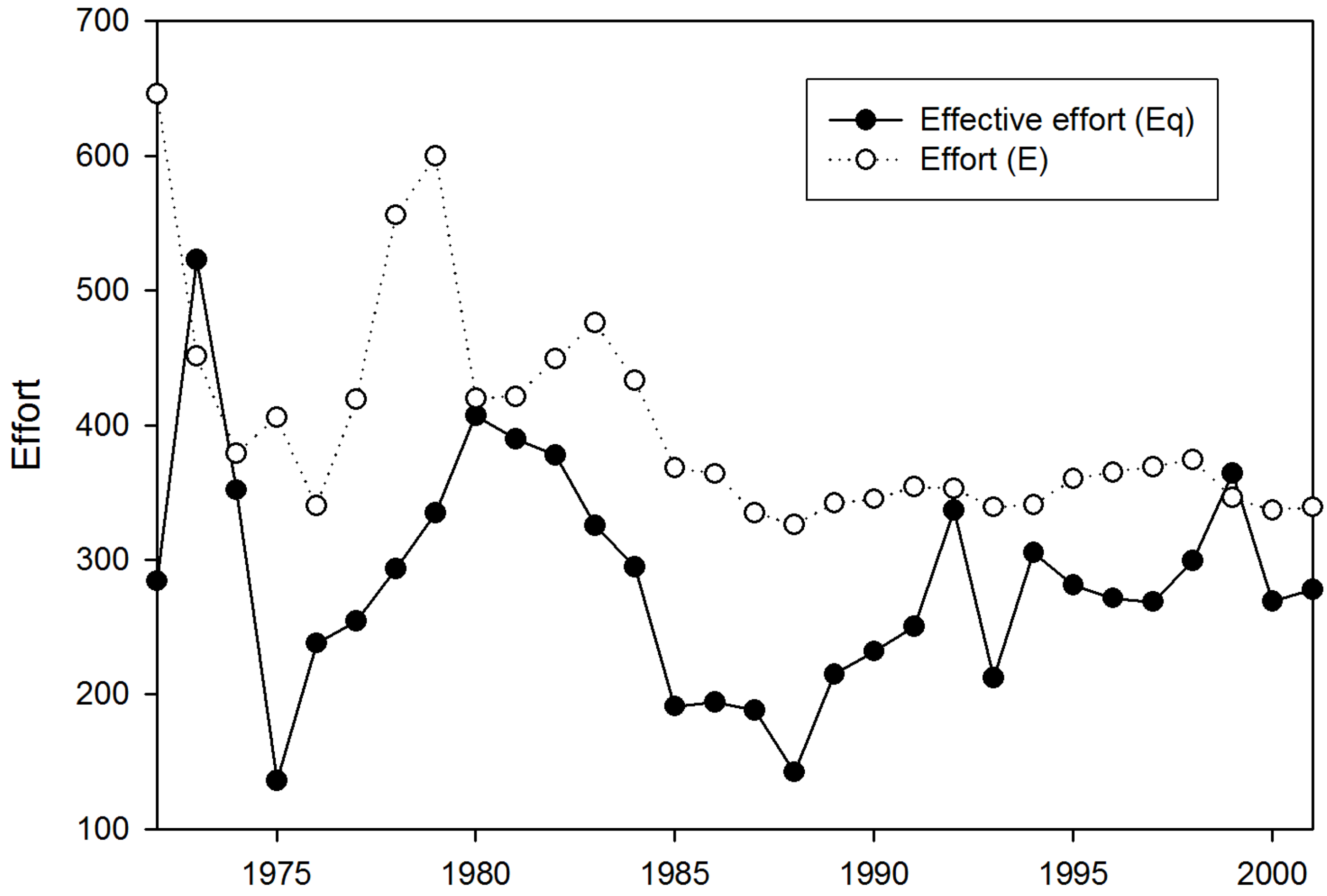
Step 1: Correlate Catch Rate with tow characteristics:

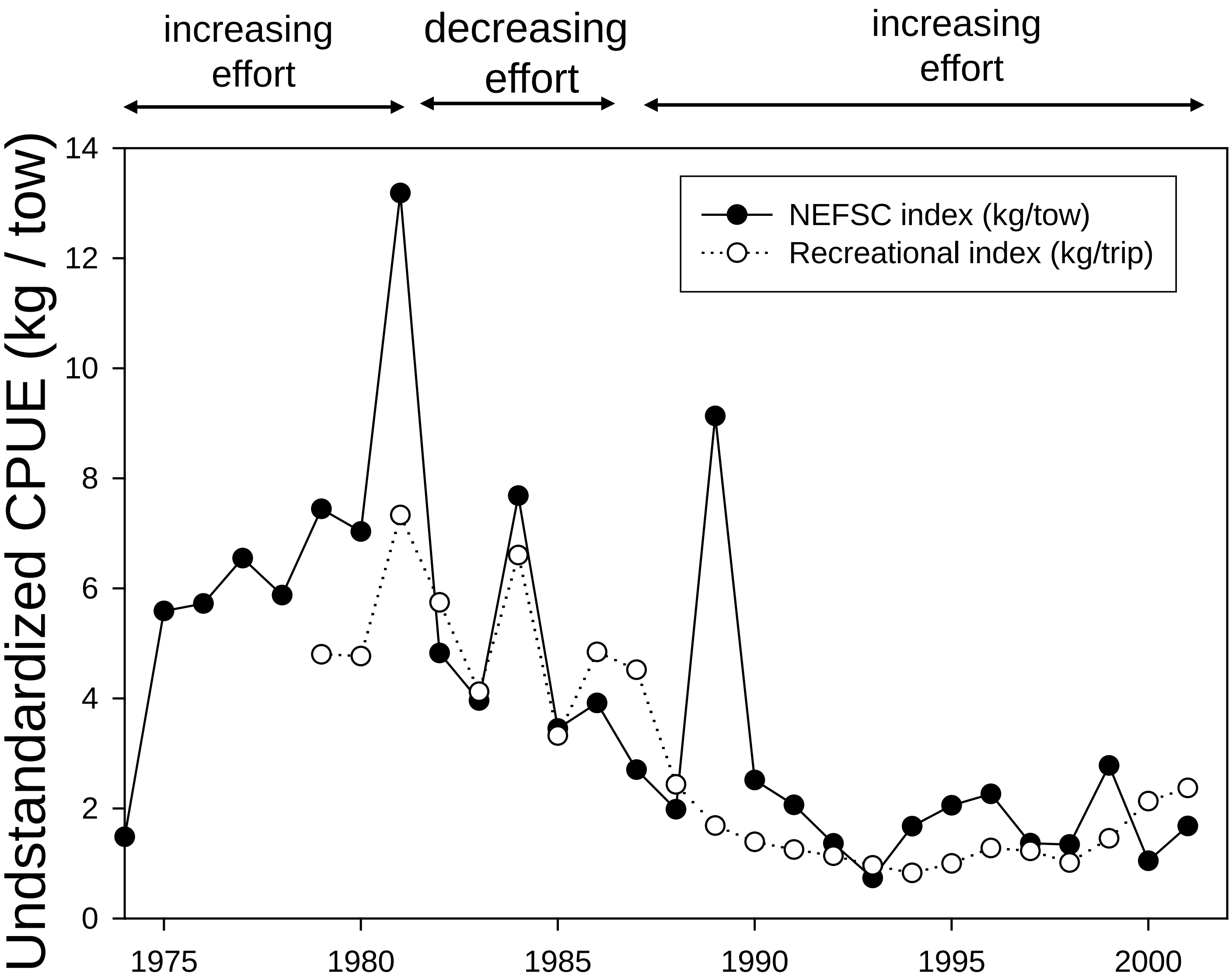
Depth
Temperature
Time of Day
Date

Step 2: Calculate Effective Effort

Effective effort is higher when sampling in areas likely to catch bluefish

Effort and Effective Effort





increasing effort
decreasing effort
increasing effort
Undstandardized CPUE (kg / tow)
NEFSC index (kg/tow)
Recreational index (kg/trip)
0
2
4
6
8
10
12
14
1975
1980
1985
1990
1995
2000

Bottom Line:

Always be very careful in evaluating abundance indices!

Why do we need to estimate abundance?

Absolute Numbers

Setting harvest rates

Quantifying nutrient / energy flux

Estimating reproductive success

Counting fish is just like counting trees…except that they are invisible and they move

How To Estimate Absolute Abundance

Extrapolating local samples

Depletion Estimates

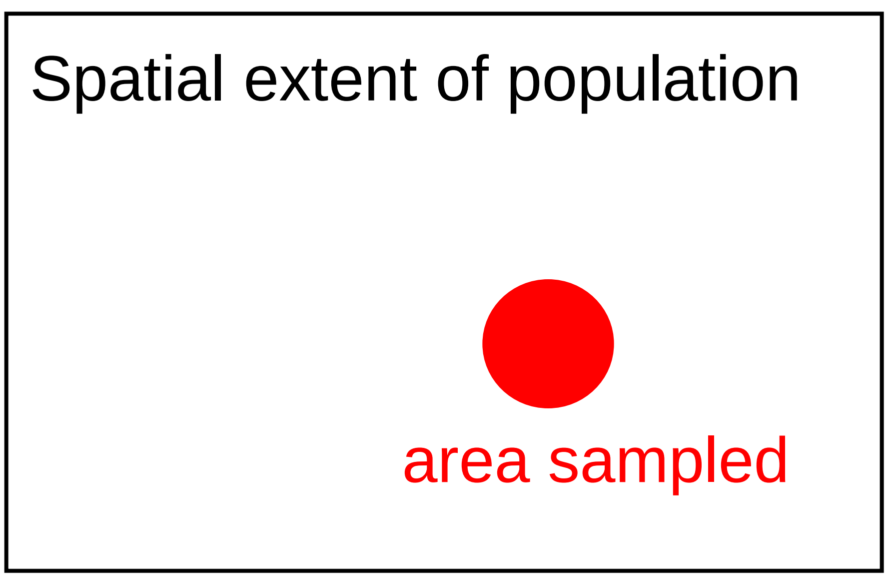
Mark – Recapture methods

Stock - Assessments

Extrapolating local samples

1. Need to sample organisms

2. Need some way to extrapolate this sample to the entire population



1. Need to sample organisms

Active Capture Gears

Zooplankton Haul
Benthic Grab
Seine / Trawl
(sample some known volume / area)

Passive gears are inappropriate
gill net
insect trap

Active Capture Gears

Typically assume 100% catchability

probability of being captured by gear, if present, is 100%

Bias results from variation in catchability

large organisms vs. small organisms
good swimmers vs. poor swimmers

1. Need to sample organisms

Visual Surveys

Line – Transect

Point counts - Quadrat

Line - Transect

Continous sampling along a line

Spatial extent of population

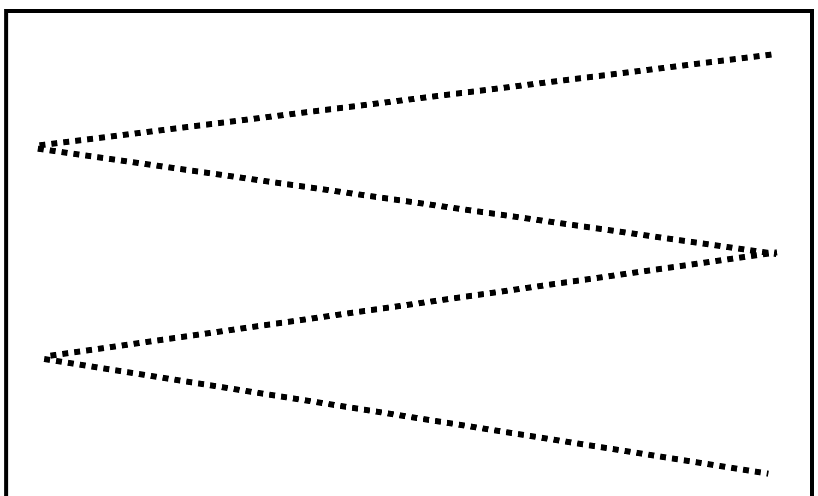
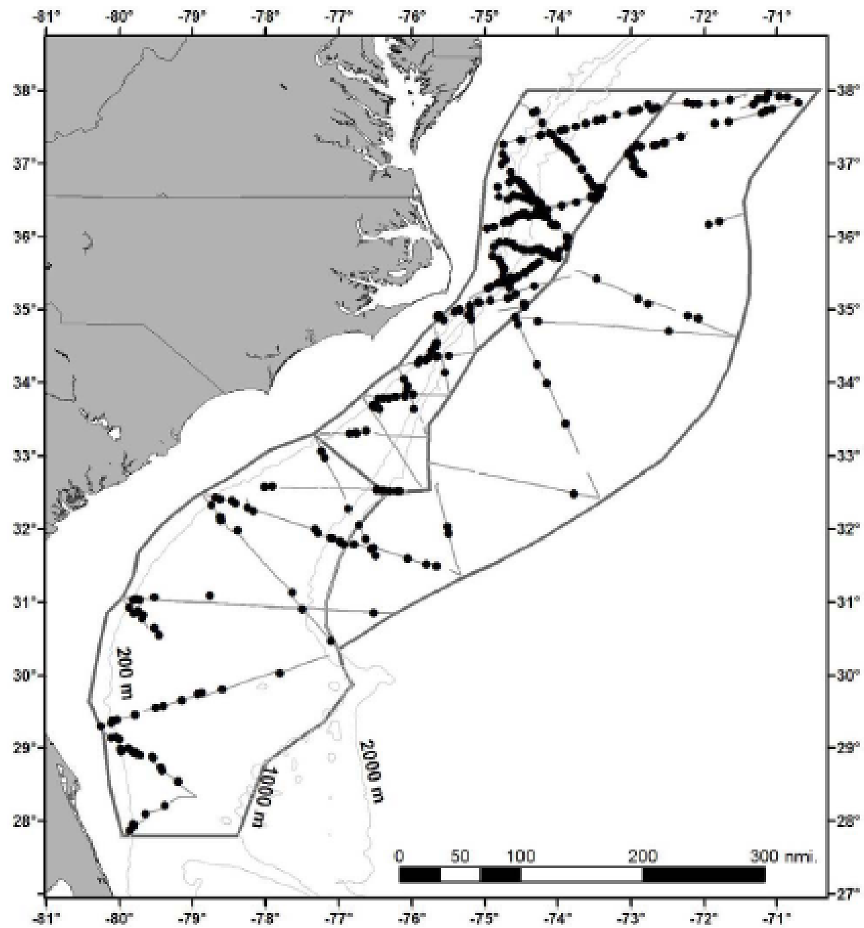


Figure 3. Locations of cetacean sightings in the U.S. Atlantic during the Atlantic Cetacean Survey. Survey strata are indicated by dark gray lines. The 200, 1000, and 2000 meter bathymetry contours are shown.



Cetacean survey, NMFS

Point counts - Quadrat

Discrete visual surveys at individual locations

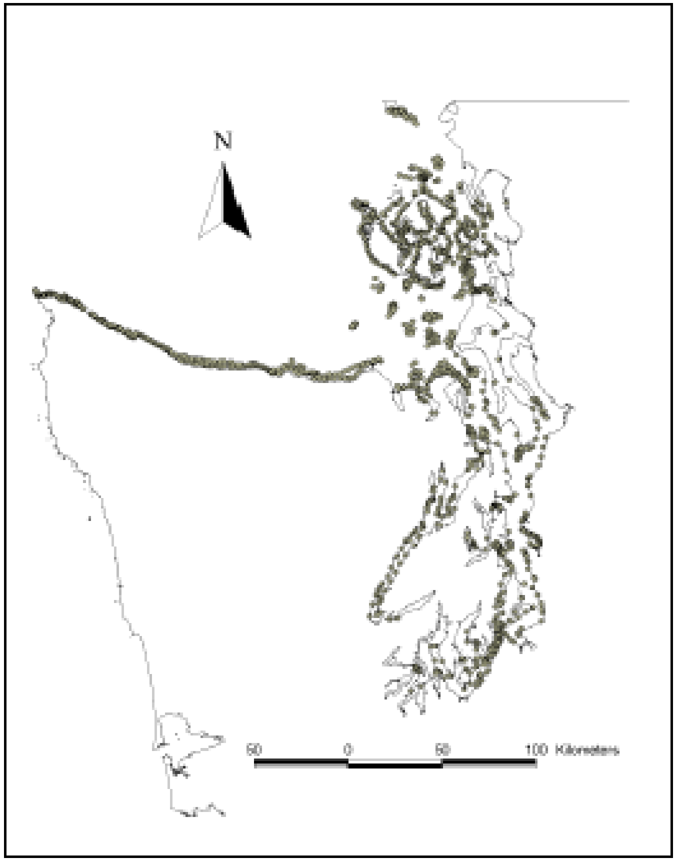


Figure 1. Video deployment locations (filled circles) from Fish and Wildlife bottomfish surveys of Puget Sound (n=2,558)

Video Survey of nearshore fishes
Pacunski and Palsson

Visual Surveys

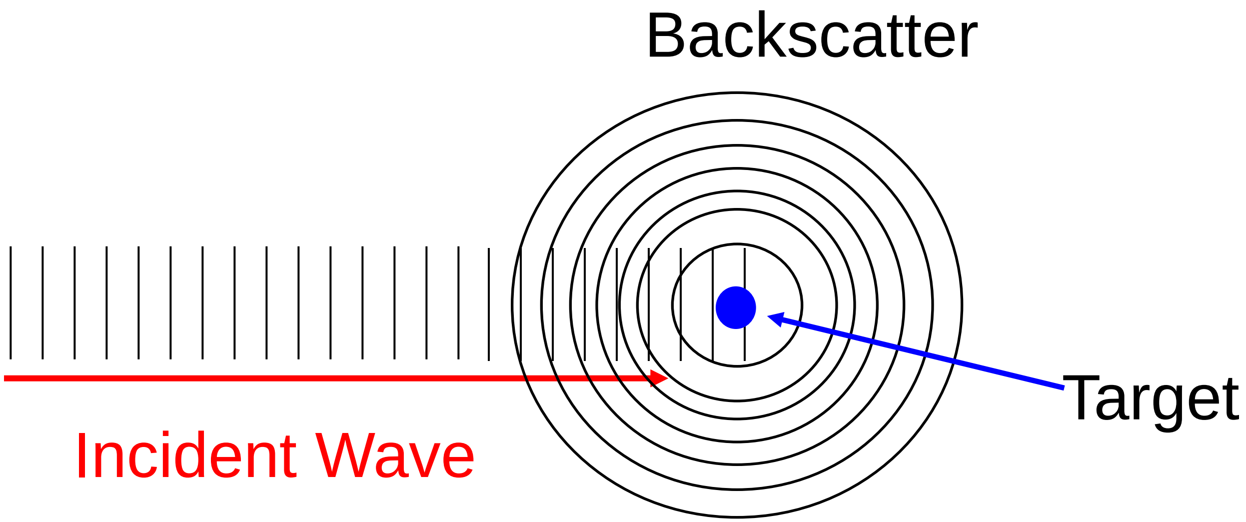
Bias arises through different encounter probabilities

Cryptic vs. Conspicuous Species

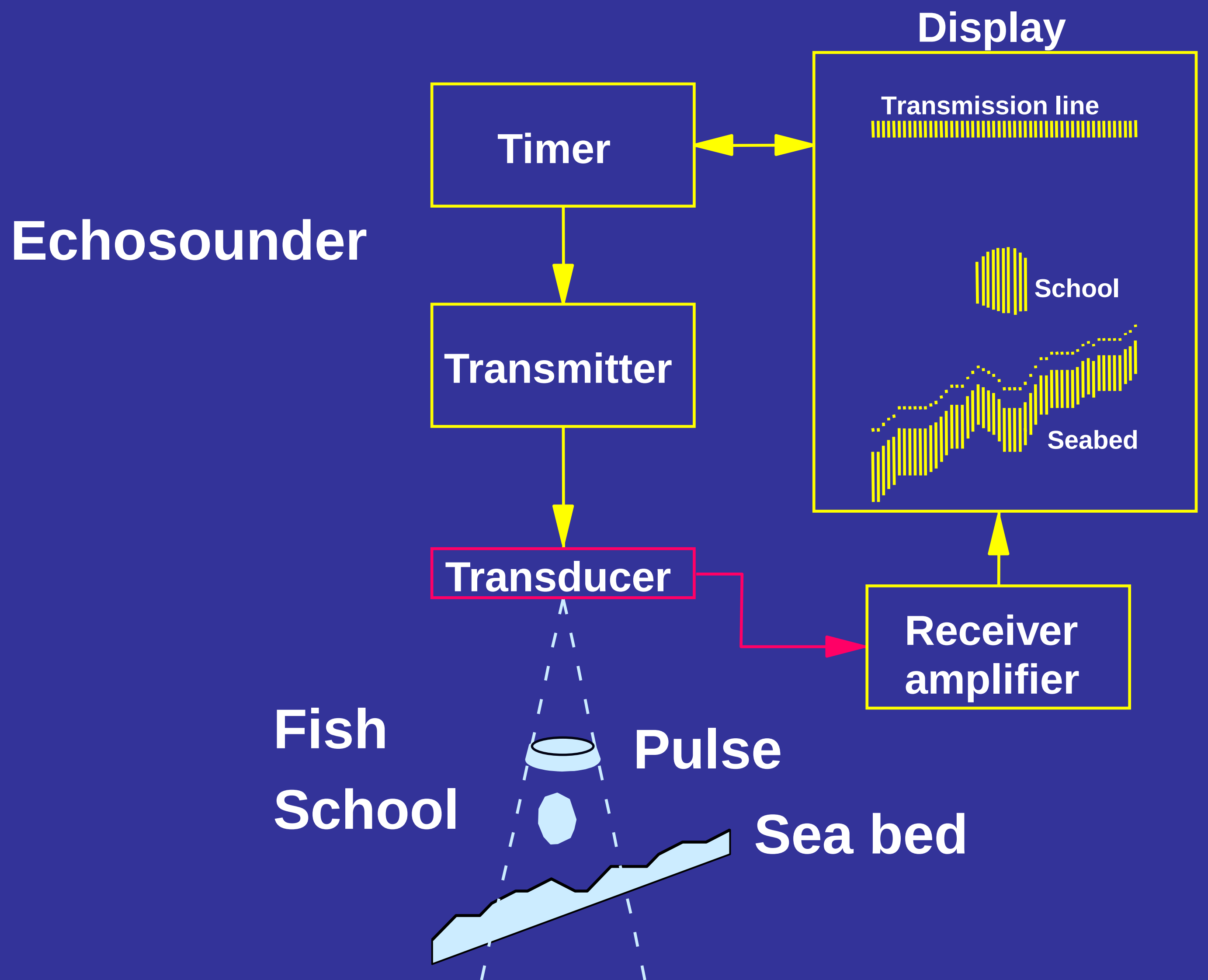
Hard to know the probability of encounter

1. Need to sample organisms

Hydroacoustics



The Echosounder



Hydroacoustics

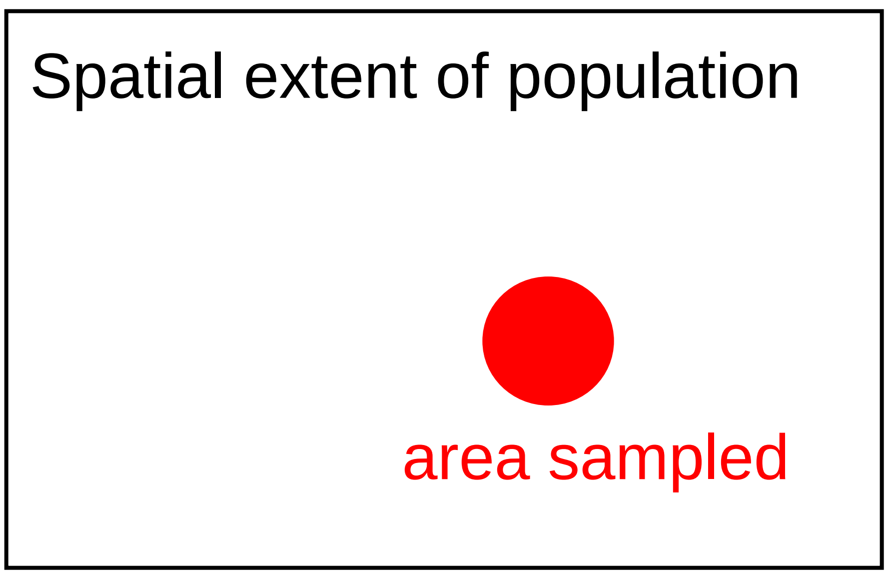
Bias results from different target strengths

Need to directly sample to verify species composition

Extrapolating local samples

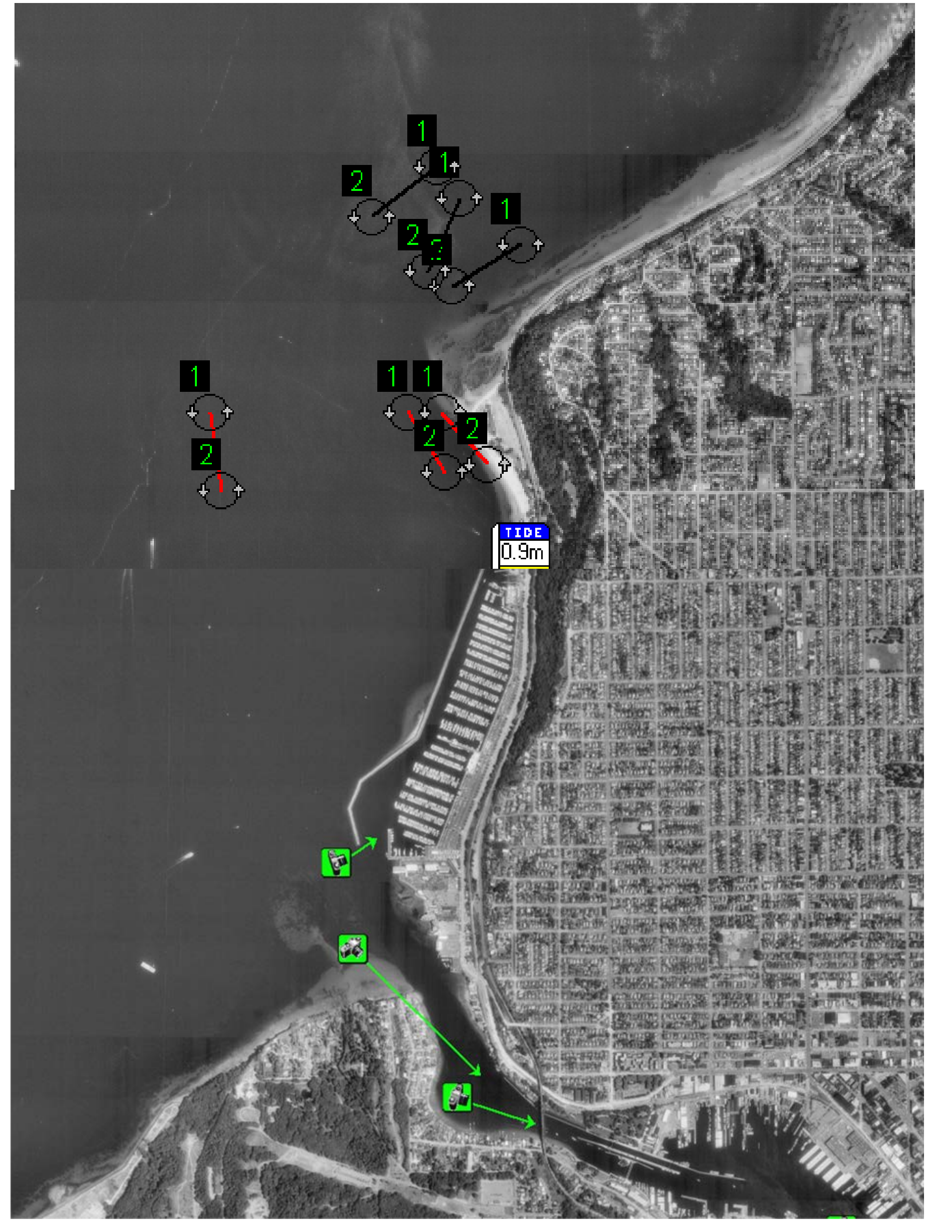
1. Need to sample organisms

2. Need some way to extrapolate this sample to the entire population



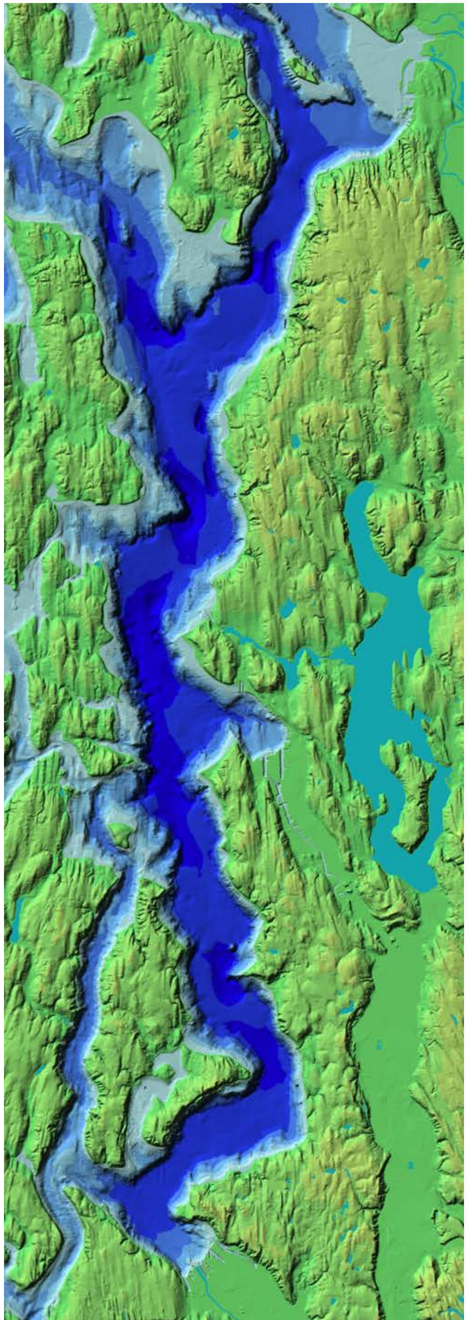
Sample Design is Critical

Need to understand spatial and temporal variation of population



Meadow Point

If you know that depth is important:



Stratified Random Design

Stratify sample locations by depth

Obtain estimates of fish density for each depth

If you know that depth is important:

Depth Strata	Total Area (m^2)	E. Sole Density (kg / m^2)
0 – 10	a_1	d_1
10 – 20	a_2	d_2
20 – 40	a_3	d_3
40 – 160	a_4	d_4
> 160	a_5	d_5

Total Biomas = $\Sigma\ a_i d_i$