Estimating Abundance

Reading: Chapter 10

- Survey design
- Visual censuses
- Acoustic methods
- Trawl surveys
- Depletion estimates
- Mark-recapture estimates
- Egg Production Methods
- Fishery-dependent CPUE

Estimating Abundance

Why do we need to estimate abundance?

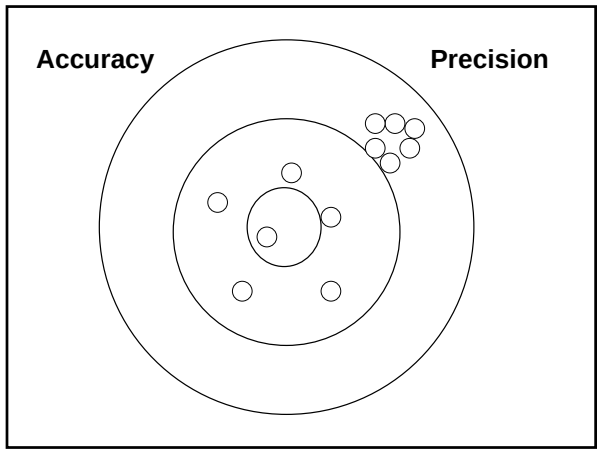
To estimate:

1. Stock size
2. Recruitment
3. Mortality
4. Spatial distribution

Estimating Abundance

Survey design

- A central problem is obtaining an abundance index that is proportional to stock size
- Well-designed survey should provide estimates of:
  - average fish abundance or density and
  - Spatial distribution (survey boundaries?)
- Accuracy vs. Precision

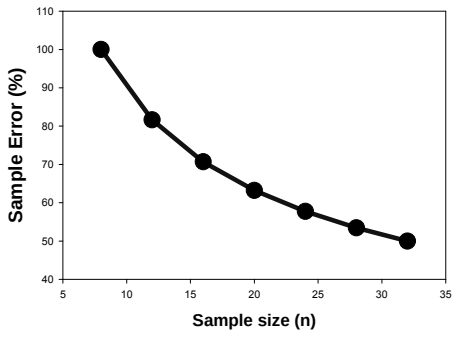


Estimating Abundance

Survey design

- A central problem is obtaining an abundance index that is proportional to stock size
- Well-designed survey should provide estimates of:
  - average fish abundance or density and
  - Spatial distribution (survey boundaries?)
- Accuracy vs. Precision
- Bias vs. Variance
- ↑ precision (↓ error) = ↑ $

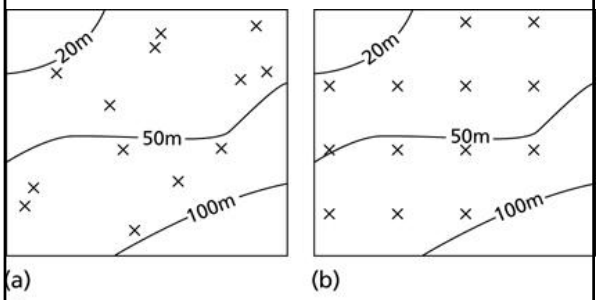
Sample error vs. sample size



Estimating Abundance

Survey design

- Stratification by habitat type or depth
- Combine abundance estimates across strata
- Increases precision
- Systematic vs. Random sampling
- Systematic can be more precise and generally reduces costs

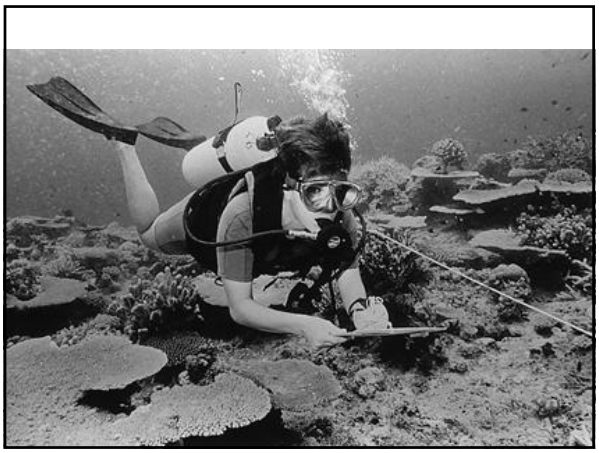


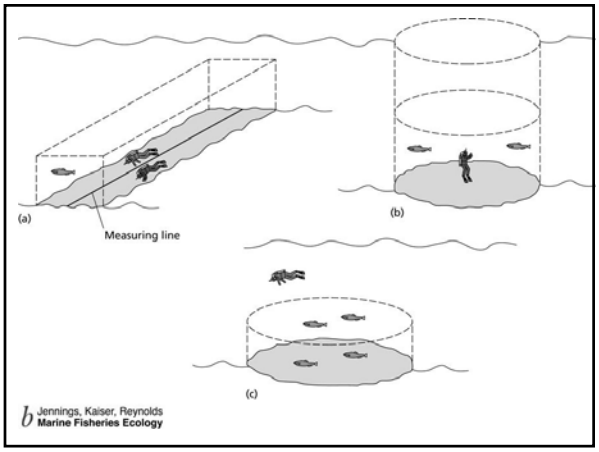
Jennings, Kaiser, Reynolds
Marine Fisheries Ecology

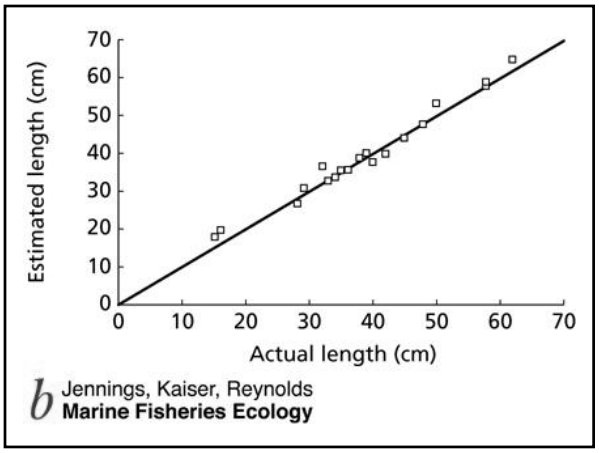
Estimating Abundance

Visual censuses

- Require clear, shallow waters
- Best with non-cryptic fish that don't avoid divers
- Can see fish and habitat
- Transects most common
- Point counts (timed or instantaneous)
- Behavior



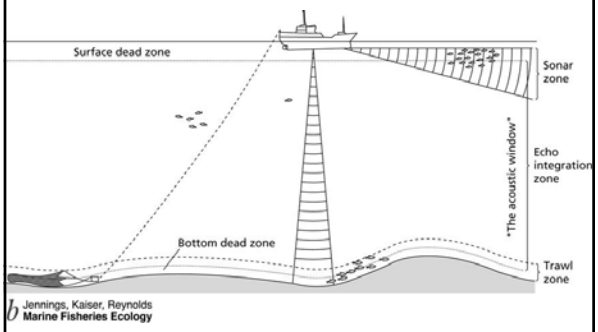

(a)
Measuring line
(b)
(c)
Jennings, Kaiser, Reynolds
Marine Fisheries Ecology


Estimated length (cm)
Actual length (cm)
0
10
20
30
40
50
60
70
Jennings, Kaiser, Reynolds
Marine Fisheries Ecology

Estimating Abundance

Acoustics

- Use of sound waves to detect fish (swim bladder)
- Best for pelagic fishes
- Target strength is species-specific and must be determined experimentally
- Simultaneous trawling to 'ground-truth' catch
- Problems with acoustic shadows and avoidance
- Very promising for well understood pelagic stocks



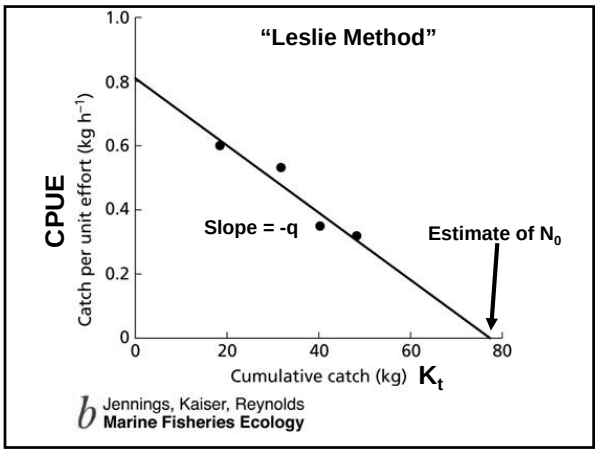
Estimating Abundance

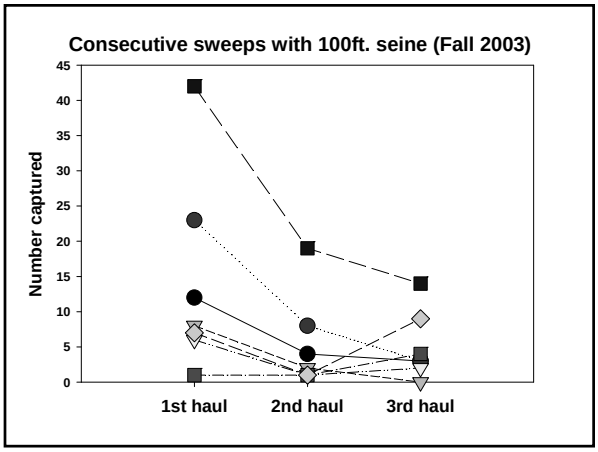
Depletion (or Removal) estimates

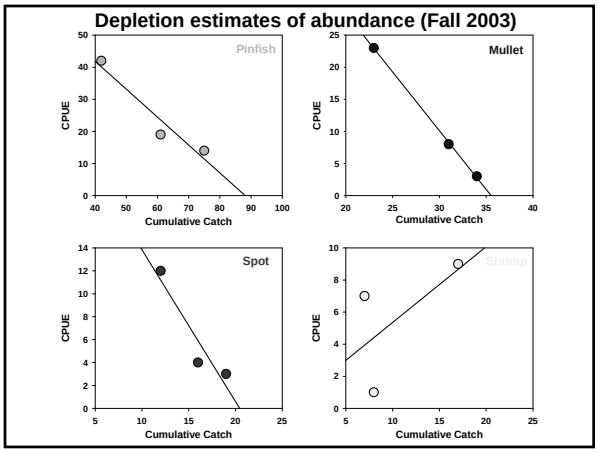
- Relation between abundance and catch rate
- Requires:
  - Closed population
  - Short fishing period (no recruitment)
  - Catchability proportional to abundance

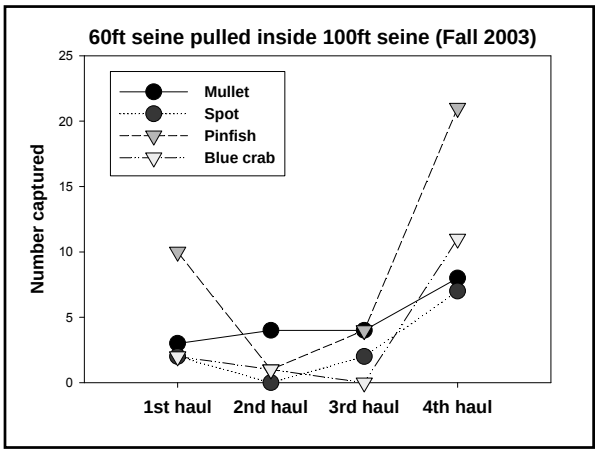
$$CPUE\ (C/f) = qN_t$$
$$N_t = N_0 - K_t$$
$$CPUE\ (C/f) = qN_0 - qK_t$$

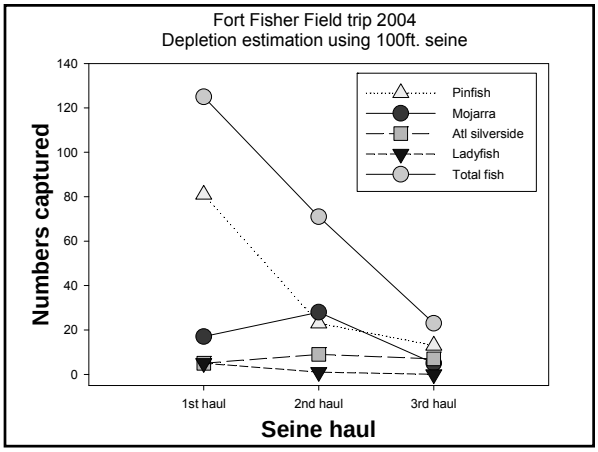
Plot CPUE vs. cumulative catch (K) **(known as Leslie method)**

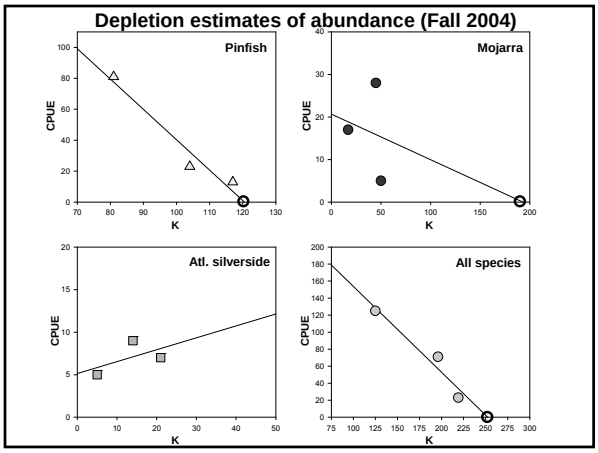

"Leslie Method"
CPUE
Catch per unit effort (kg h^{-1})
1.0
0.8
0.6
0.4
0.2
0
0
20
40
60
80
Slope = -q
Estimate of N_0
Cumulative catch (kg) K_t
Jennings, Kaiser, Reynolds
Marine Fisheries Ecology


Consecutive sweeps with 100ft. seine (Fall 2003)
Number captured
45
40
35
30
25
20
15
10
5
0
1st haul
2nd haul
3rd haul

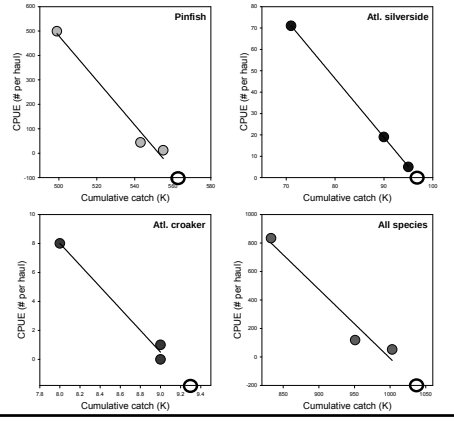

Depletion estimates of abundance (Fall 2003)
Pinfish
Mullet
Spot
Shrimp
CPUE
Cumulative Catch


60ft seine pulled inside 100ft seine (Fall 2003)
Number captured
Mullet
Spot
Pinfish
Blue crab
1st haul
2nd haul
3rd haul
4th haul

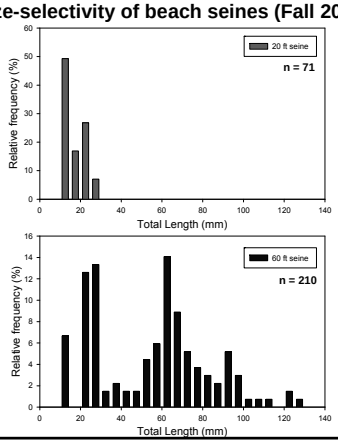

Fort Fisher Field trip 2004
Depletion estimation using 100ft. seine
Numbers captured
Pinfish
Mojarra
Atl silverside
Ladyfish
Total fish
1st haul
2nd haul
3rd haul
Seine haul


Depletion estimates of abundance (Fall 2004)
Pinfish
Mojarra
Atl. silverside
All species
CPUE
K

Depletion estimates of abundance (Fall 2005)



Size-selectivity of beach seines (Fall 2005)



Estimating Abundance

Depletion (or Removal) estimates

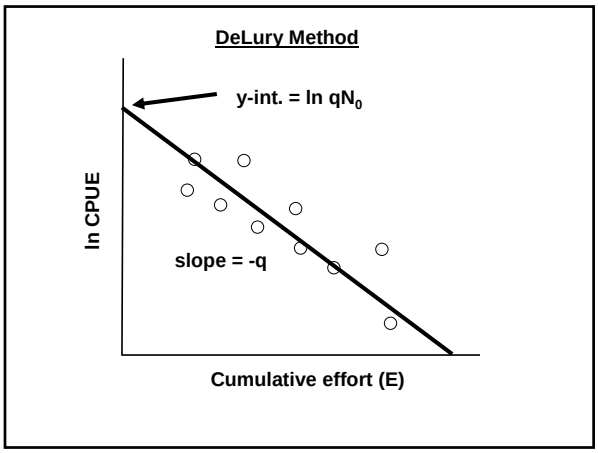
- DeLury Method

$$CPUE\ (C/f) = qN_t$$
$$CPUE\ (C/f) = qN_0(N_t/N_0)$$
$$\ln CPUE = \ln qN_0 + \ln (N_t/N_0)$$

Substitute $N_t/N_0 = e^{-qE}$

$$\ln CPUE = \ln qN_0 - qE$$

Plot ln CPUE vs. cumulative effort (E)



Estimating Abundance

Trawl surveys

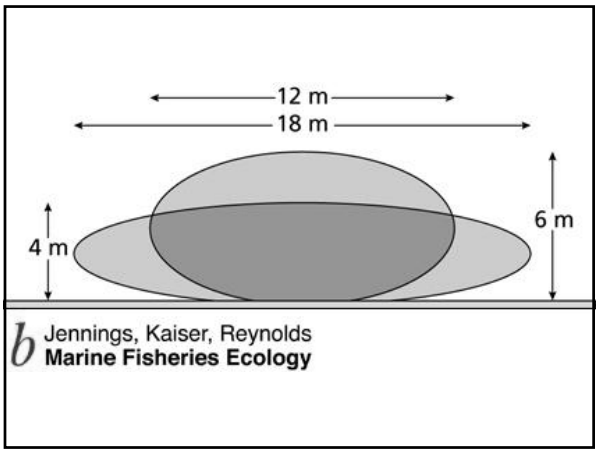
- Very widely used, most common
- Mesh size regulates fish size
- Constant catchability (q) essential; lack of standardization is major problem
- Consistent gear design, tow speed, duration help to maintain q

C = qfN
CPUE = qD
Stock biomass = D x area

Estimating Abundance

Trawl surveys

- Many factors affect catchability (q)
  - Tow speed
  - Depth
  - Time of day
  - Vessel noise
- Mostly, q is unknown, but…..
- If q is constant, then estimated stock biomass will be proportional to actual stock size



Estimating Abundance

Mark-recapture methods

- Successful in terrestrial and freshwater systems
- Can also provide growth and movement data
- Assume:
  - Tagged fish mix randomly with untagged fish
  - Catchability equal
  - No tag loss or mortality due to tagging
  - Relatively closed population

T/N = R/C
so, N = TC/R

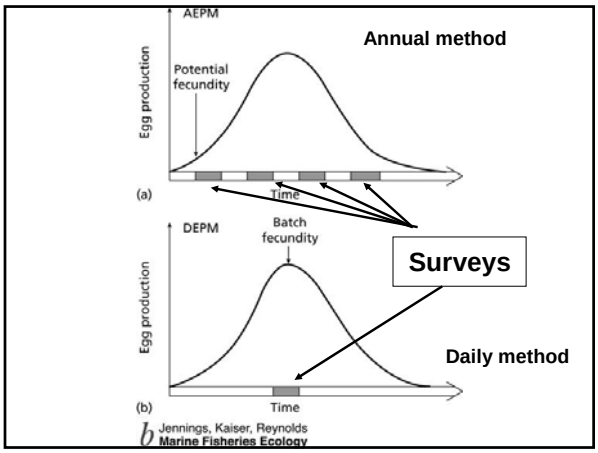
Estimating Abundance

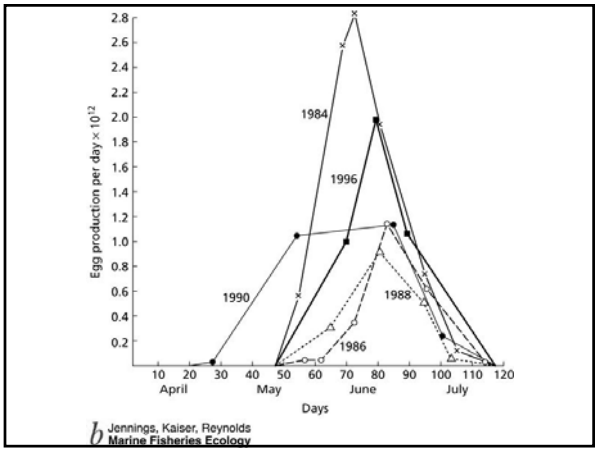
Egg production estimates

- Provide estimate of size of spawning stock
- Used for large pelagic fish stocks
- Annual method for determinate spawners
- Daily method for indeterminate spawners

$$P_{rod} = B_{iomass} R_{atio} F_{ecundity}$$
so, B = P/RF

- **Need to account for atresia, mortality, age**





Estimating Abundance

What's wrong with using CPUE from fishery?

- It provides catch and effort data from large areas over long time scales, so why not use it?
- Often times it is used, only data available
- Landings data omits discards (bycatch, undersize)
- Catch/effort data hard to get for every boat
- CPUE (LPUE) rarely proportional to abundance
  - No gear standardization
  - Capture efficiency increases with time
  - Fishers don't fish randomly

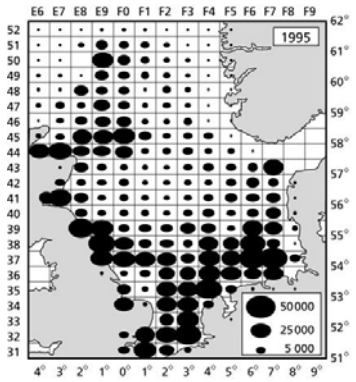


Fig. 10.15. Spatial distribution of commercial trawling effort (hours per year) in the North Sea

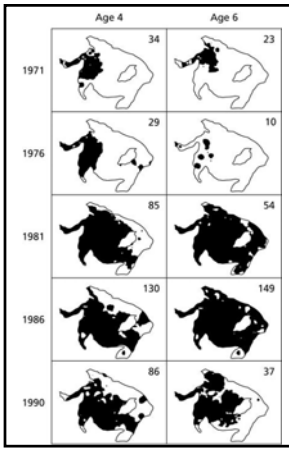


Fig. 4.16. Distribution of Atlantic cod in the Gulf of St. Lawrence, showing range expansion and contraction over twenty years

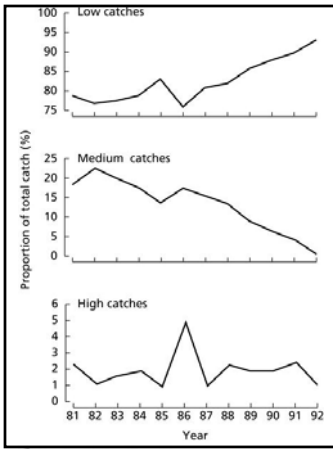


Fig. 4.17. Occurrence of low, medium, and high catches of Atlantic cod in research vessel surveys as the fishery collapsed

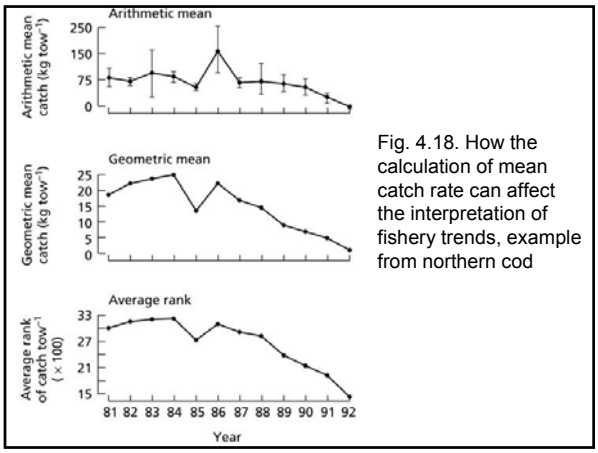
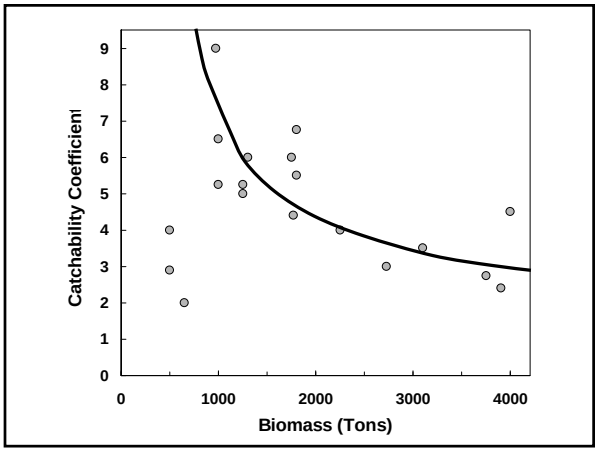
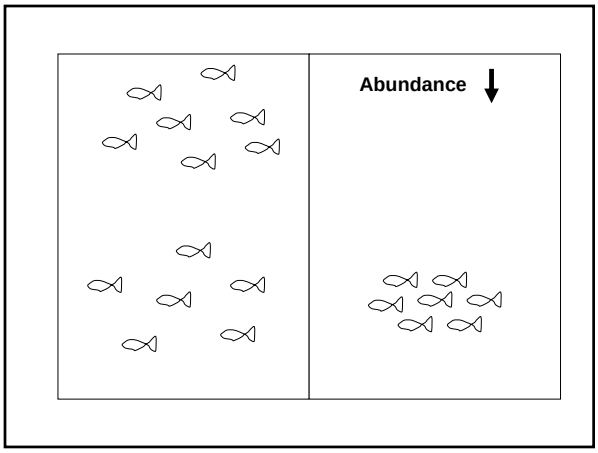
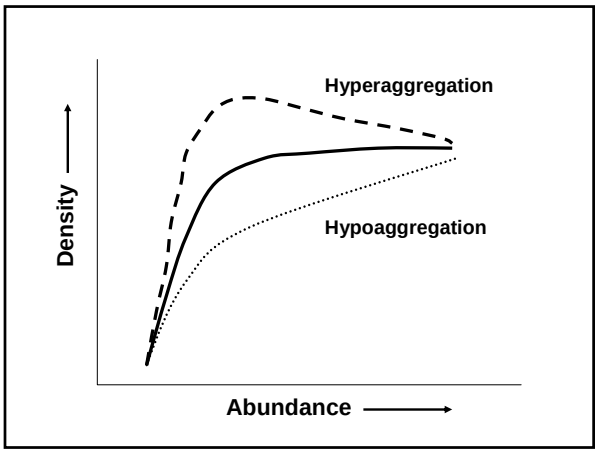
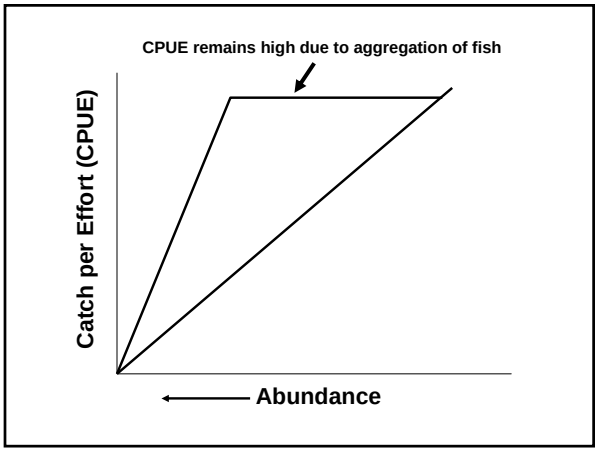


Fig. 4.18. How the calculation of mean catch rate can affect the interpretation of fishery trends, example from northern cod






Hyperaggregation
Hypoaggregation
Density
Abundance


CPUE remains high due to aggregation of fish
Catch per Effort (CPUE)
Abundance