Fisheries

Reading: Miller Ch. 15

Supplementary:

Levinton, Ch. 18

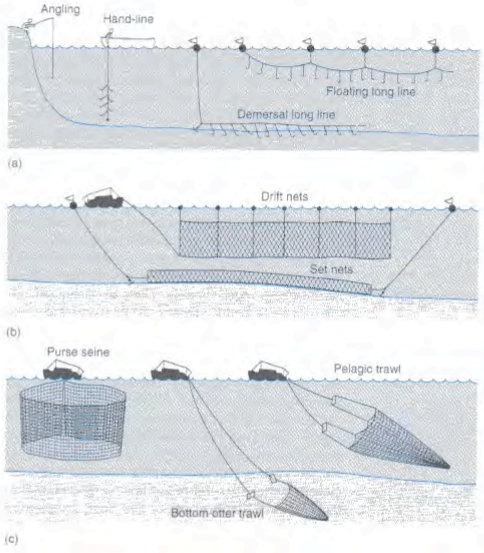
Krkošek et al. Epizootics of wild fish induced by farm fish. Proceedings of the National Academy of Sciences (2006) vol. 103 (42) pp. 15506

Lehodey et al. Climate variability, fish, and fisheries. Journal of Climate (2006) vol. 19 (20) pp. 5009-5030

National Research Council. Marine Protected Areas: Tools for Sustaining Ocean Ecosystem . (2001) pp. 1-26

Fisheries

- Fisheries includes all animals captured for food: fish, crustaceans, mollusks, etc.
- World capture fisheries production has remained about 90 million metric tons per year from 2000-2007 (FAO)
- About 1/3 of this is discarded bycatch



Factors influencing production

- Size of the stock
  - Environmental conditions
  - Life history
  - Mortality
- Fishing effort
  - Fishing technology
  - Number of fishers
  - Time spent fishing
- Production is the only factor regularly measured, but it is hard to interpret

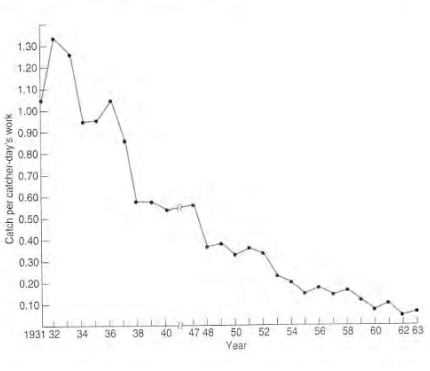
What is a stock?

- Historically
  - A functional class (i.e. flatfish, rockfish) caught by a particular type of gear and returned to a particular port
  - Can include multiple species, or multiple populations with different breeding habits that respond differently to fishing and environmental factors
  - May only sample part of a breeding population
- Modern biological definition
  - A genetically distinct population within a species
  - Management is logically based upon the biological definition
- Fisheries data don't reflect or identify biological stocks
- Scientific surveys are limited
- Data are usually inadequate for rational management

Fishing effort

- As the stock declines, the yield declines
- Catch per unit effort, CPUE

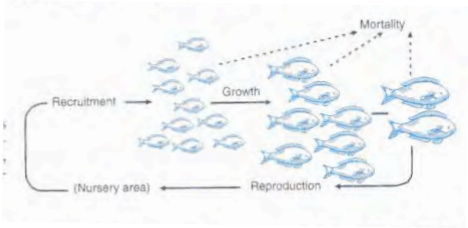
Blue whale fishery



Levinton, J.S. Marine Biology: Function, Biodiversity, Ecology 2001 Oxford Press

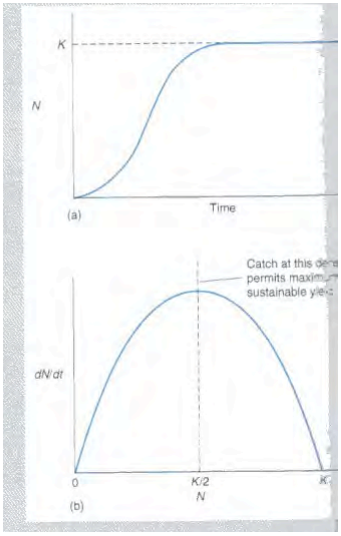
Life History

- Frequency of reproduction
- Fecundity
- Rate of growth
- Impacts on nursery habitat
- Life history can respond to fishing



Maximum sustainable yield

- N=population size
- K=maximum supportable population
- dN/dt is rate of change or growth rate
- In theory, fishing the stock to K/2 results in “Maximum Sustainable Yield”, MSY
- In practice this has not proved effective in general
- K, and r (maximum growth rate) and non-fishing mortality can fluctuate due to environmental factors, K can be hard to measure accurately
- Political pressure to overfish



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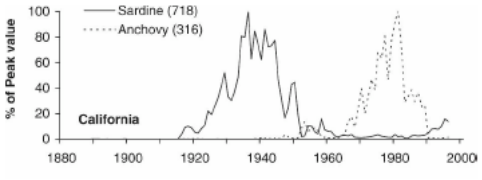
Measuring stocks

- Landings
  - Retrospective
  - Influenced by fishing effort,
    - gear modifications, economic factors, market demand and regulatory limits
- Tagging
  - The proportion of tagged fish re-caught is a function of the population size
- Scientific fishing surveys
  - Rational design

Independent data

- Crash of the sardine fishery off California in the 1950s

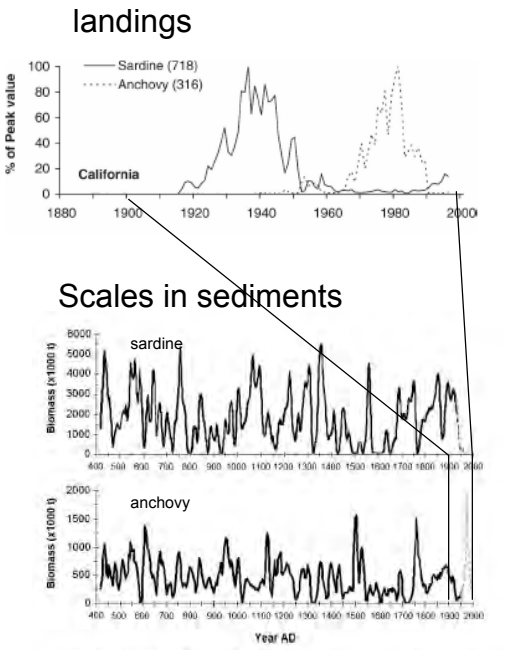
landings



Lehodey et al. Climate variability, fish, and fisheries. Journal of Climate (2006) vol. 19 (20) pp. 5009-5030

Independent data

- Crash of the sardine fishery off California in the 1950s
- Fish scales in Santa Barbara Basin sediments
  - SB Basin is permanently anoxic, little bioturbation, good preservation
- Conclusion: overfishing may have been a factor, but other environmental factors are even more important



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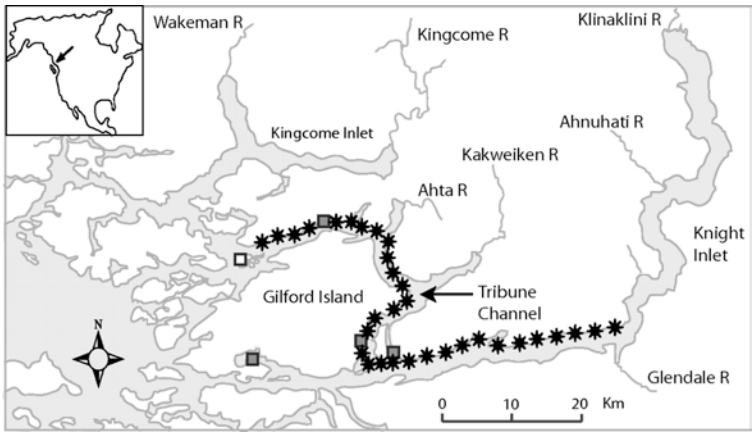
Modelling

- Predicting stock abundance

- $\Delta P/\Delta t = R(P,A) + G(P,A) - M(P,A) - F(X,P,A)$
- P = mass of total population
- A = age structure, can be affected by fishing
- R = recruitment (appearance of juveniles on the fishing ground at catchable size - influenced by gear and regulations). Recruitment rate can vary wildly in response to environmental variables
- G = growth
- M = natural mortality
- F = fishing mortality
- X = fishing effort

Mariculture

Study area and sample sites for one of the data sets (April 28 to May 8, Tribune Channel; Fig. 2)

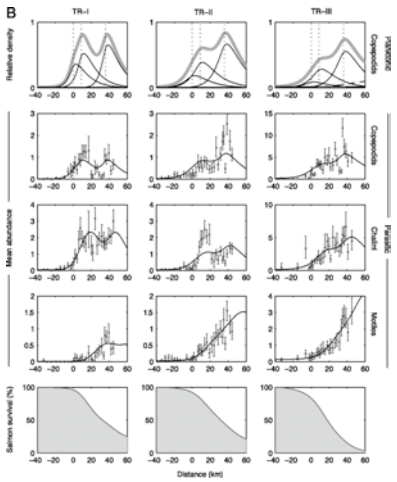


Krkošek M et al. PNAS 2006;103:15506-15510

PNAS

Study area and sample sites for one of the data sets (April 28 to May 8, Tribune Channel; Fig. 2). Approximately 50 pink and 50 chum salmon were collected at each sample site (stars) and nonlethally assayed for sea lice. The remaining Tribune Channel data sets had a similar structure. The three active salmon farms under study are identified by filled squares. An additional farm (white square near the western end of Tribune Channel) could have contributed lice but was excluded from the analysis because of its peripheral position relative to the sample sites. Fallow and smolt farms are not shown. Gilford Island is situated east of northern Vancouver Island, BC, Canada.

Sea lice transmission dynamics and survival of juvenile chum salmon (A) and pink salmon (B) migrating past three active salmon farms



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Sea lice transmission dynamics and survival of juvenile chum salmon (A) and pink salmon (B) migrating past three active salmon farms. The seaward migration of salmon is from left to right, and the farm locations are shown by vertical dotted lines in the first row. The data were collected along the Tribune Channel migration corridor in 2004 (see Fig. 1). The three columns correspond to three replicate sets of samples taken April 18–28 (TR-I), April 28 to May 8 (TR-II), and May 21–29 (TR-III), 2004 (note the change in scale). The first row shows the estimated spatial distributions of planktonic copepodids originating from all sources (thick gray line), from farm salmon (three thin curves), from ambient sources (horizontal thin line), and the second generation of farm-origin lice (dashed curve, TR-III only). Reproduction of lice parasitizing the juvenile salmon was not considered in TR-I and -II because of the absence of gravid female lice in those data sets. The middle three rows depict the mean abundances of lice (±95% bootstrap confidence interval) and maximum-likelihood model fits (black lines) along the migration route for the developmental progression through parasitic copepodid, chalimus, and motile stages. The bottom row depicts the estimated remaining juvenile salmon population that survived sea lice infestation. Temperature and salinity were measured at each site and averaged 9.0°C and 30.2‰ (TR-I), 10.4°C and 26.1‰ (TR-II), and 12.3°C and 22.2‰ (TR-III).

Marine Protected Areas

- National Research Council
  - "Based on evidence from existing marine area closures in both temperate and tropical regions, marine reserves and protected areas will be effective tools for addressing conservation needs as part of integrated coastal and marine area management."