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Role of Fish Catch in Fishery Stock Assessments

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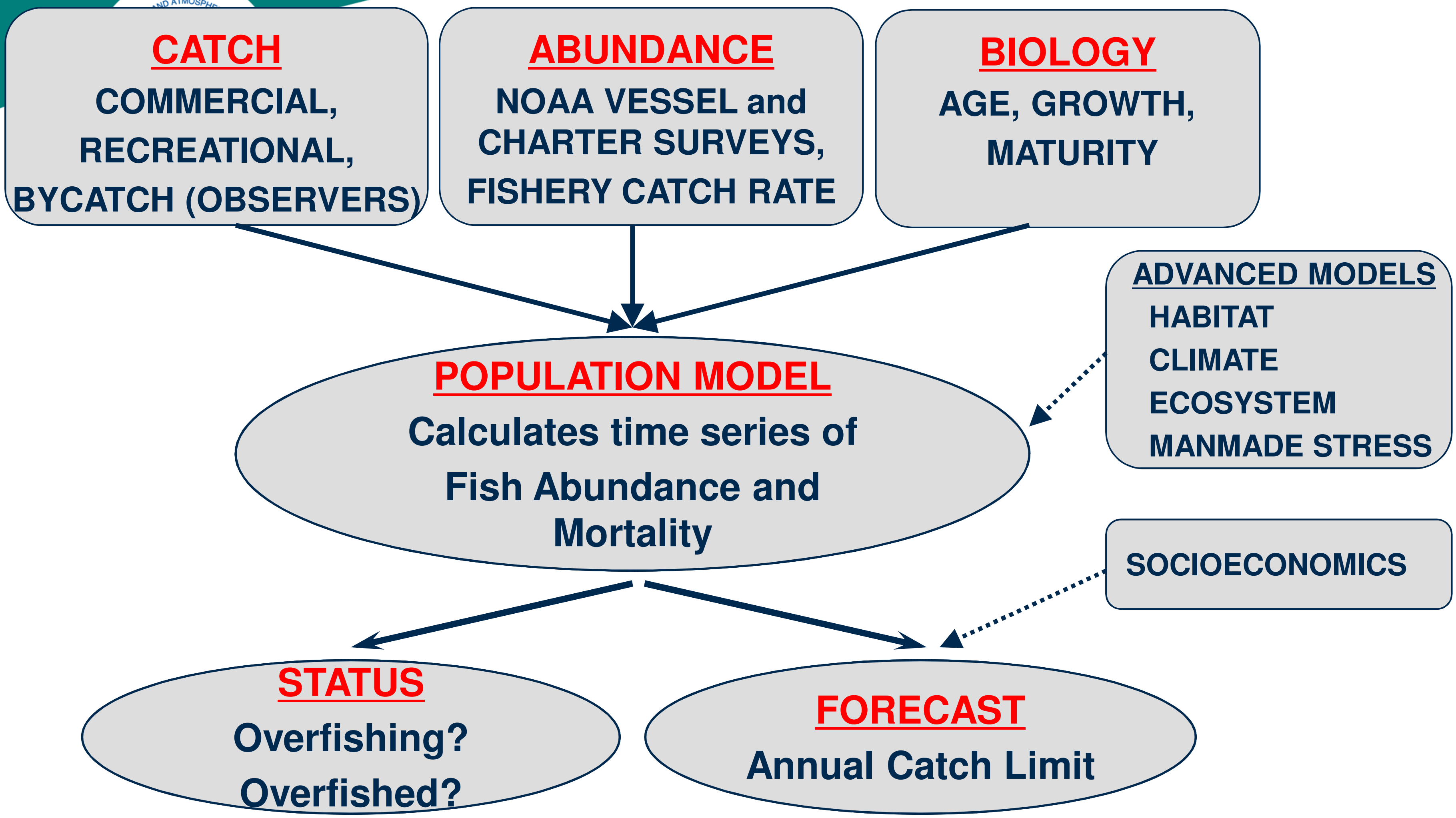
Stock Assessment



Fishery Catch

- Components:
  - Commercial landed catch
  - Commercial discarded bycatch
  - Recreational kept and release
- Quota monitoring
  - Near real-time capability for landing receipt based commercial catch monitoring
  - Slower and less precise for observer-based bycatch monitoring and for recreational monitoring
- Assessment models use all catch components and biological characteristics of each component on approximately annual basis
- Some assessments also use catch per unit of fishing effort as a proxy measure of trends in fish abundance

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Why Fishery-Independent Surveys?

Catch rates by fishermen

- Should go up and down with fish abundance
- But fishermen are businessmen looking to be profitable
  - Adjust fishing methods
  - Adjust fishing locations
- So, difficult to standardize as an index of stock size

Fishery-independent surveys of fish abundance

- Cover range of the stock, even areas with lower abundance
- Select sample locations with spatial statistical plan
- Use highly standardized sampling methods
- With advanced technology (acoustics, optical, robotics, smart tags) can achieve even higher degrees of calibration

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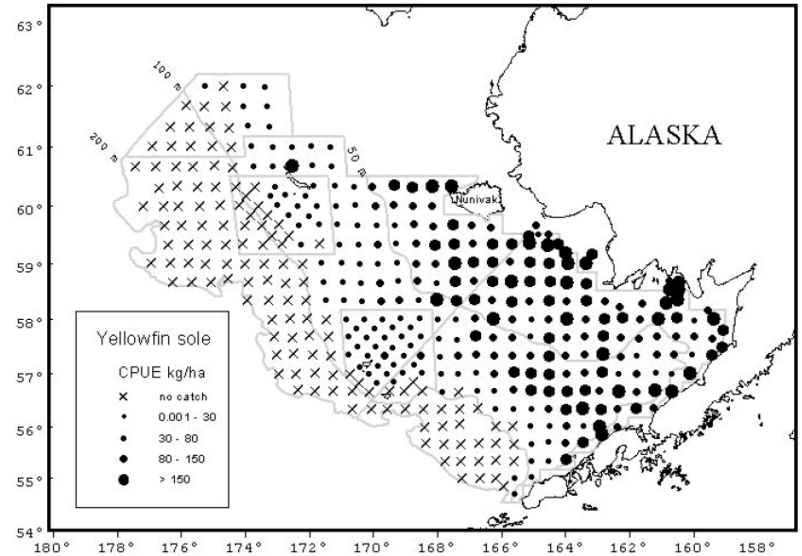
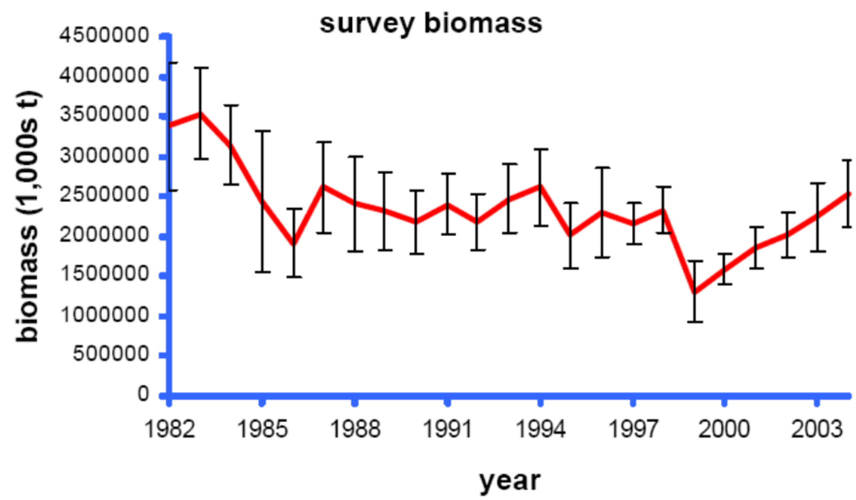
Example: Bering Sea bottom trawl survey



Count fish at 100s of locations each year

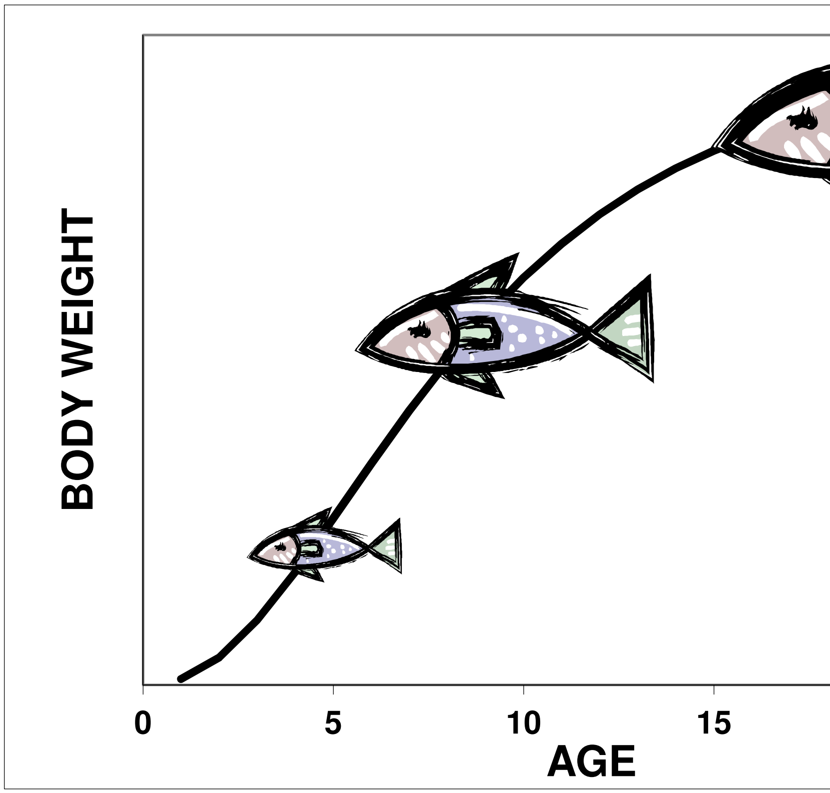


Average count with error bars for each year of survey

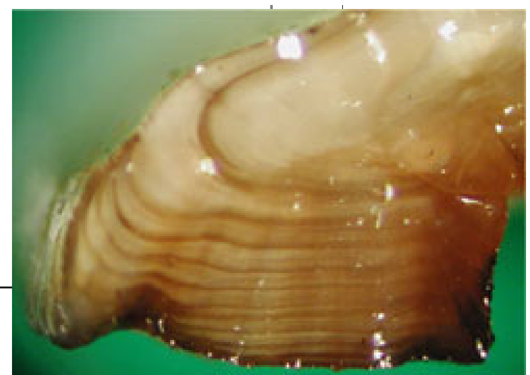
- **Comparable bottom trawl surveys in Northeast, Gulf of Alaska, Pacific Coast, Gulf of Mexico provide data for assessment of many stocks**
- **Other survey methods provide data for additional stocks**

Fish Biology and Life History

Age, length, weight, maturity, fecundity, natural mortality



Otolith (ear bone) with annual marks



Some examples….

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Basic Assessment Approach

How large must the population have been,

- **in order to have exhibited the observed trend in relative abundance over time,**
- **while the observed absolute amount of catch was removed?**

If observed decline was steep, then catch must have removed a large fraction of the stock. So stock is small and fishing mortality is high.

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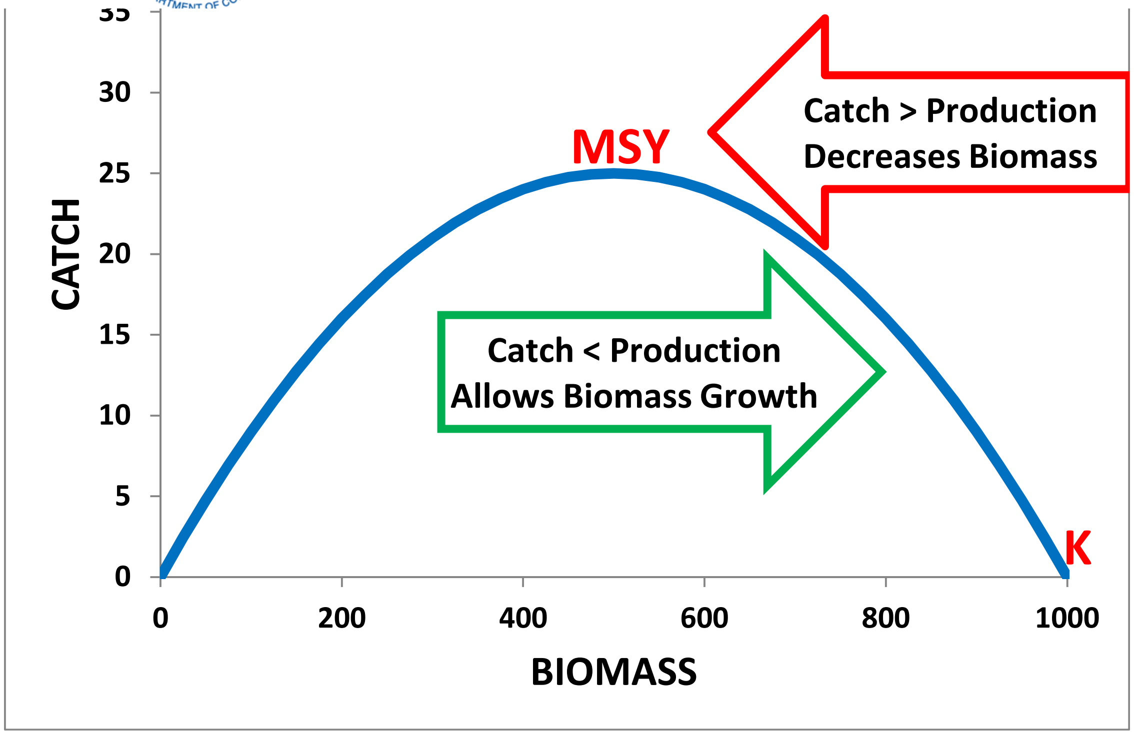
Production Model - Theory



- Population production slows as the population approaches its carrying capacity (K).
- If removals can be replaced by production each year, on average, the fishery is sustainable at that level
- If stock size is maintained near half its carrying capacity, the production is greatest, and sustainable yield is maximized (*MSY*).

Putting green suburban lawn prairie

Clearcut managed forest old growth

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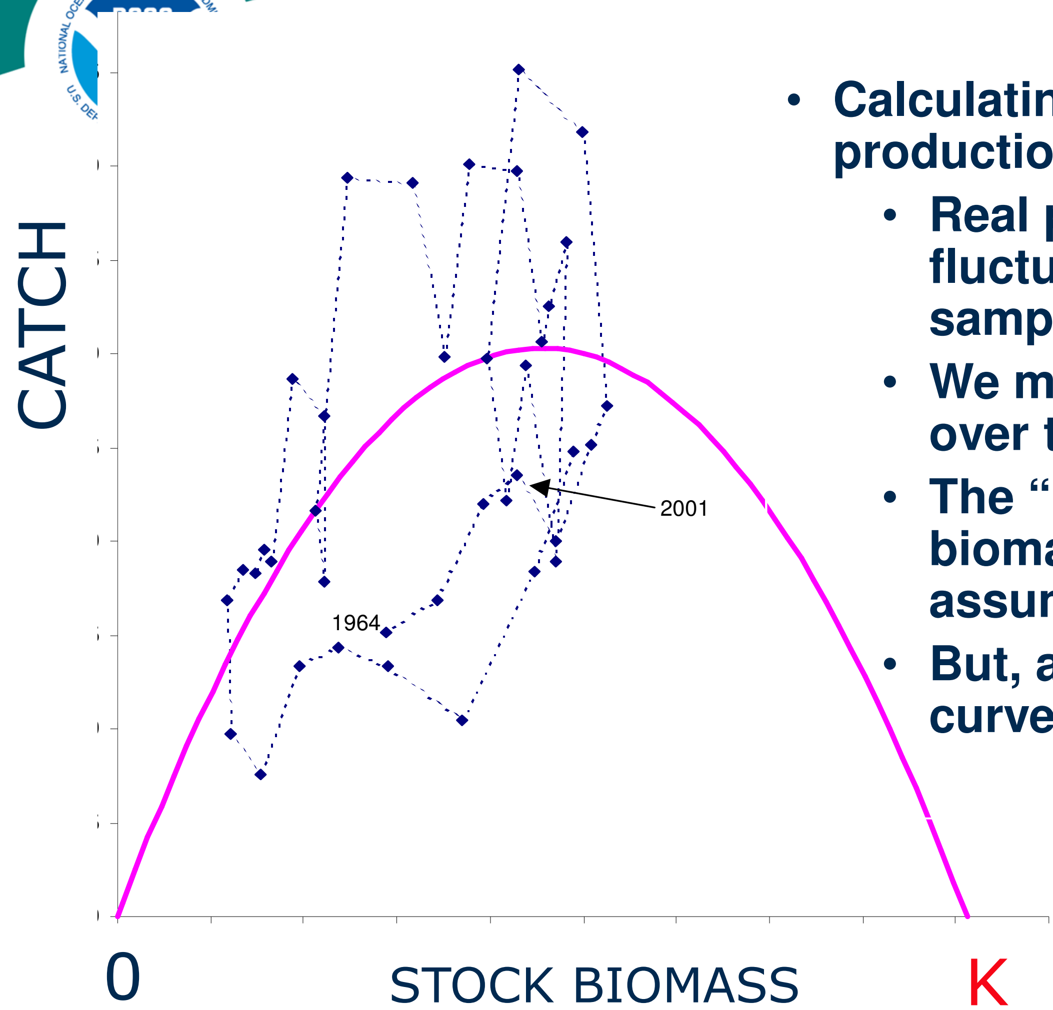
Production Model - Reality



- Calculating the shape and level of the production curve is difficult because:
  - Real populations show much natural fluctuation and real data have sampling error
  - We may not have observed stock over the full range of biomass levels
  - The “biomass” is not actually biomass, instead it is an index assumed proportional to biomass
  - But, absolute catch helps scale the curve

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Biological Reference Points

- BRP: based on the MSY concept
  - $F_{lim} = F_{msy}$ demarks overfishing
  - $B_{lim} < B_{msy}$ demarks overfished
- In the biomass production model, MSY and F_{msy} are explicit
- With age-based models, focus is on estimation of each cohort, so production function is not explicit
  - With enough contrast in the spawner-recruitment model output, then MSY can be estimated
  - If not, then proxy usually based on preservation of a fraction of spawner biomass per recruit; such as $F_{35\%}$. Uses body weight, maturity, natural mortality and fishery selectivity-at-age in calculation.
- With age-based integrated analysis models, spawner-recruitment is again included and direct MSY estimates are feasible
- When proxy approach is used, catch does not affect the BRP

Importance of Catch

- Because surveys provide a time series index, not absolute biomass, the scaling of the assessment result is strongly influenced by the absolute level of catch
- This is most logical for commercial fisheries where landing receipts provide a census of total landed catch
- Less so for fisheries with substantial contribution from sample-based estimates of at-sea discard, or sample-based estimates of recreational catch
- From assessment perspective, only total catch and the measured, or assumed, age composition of the catch matter. Commercial vs. recreational only matters if they catch different pattern of ages

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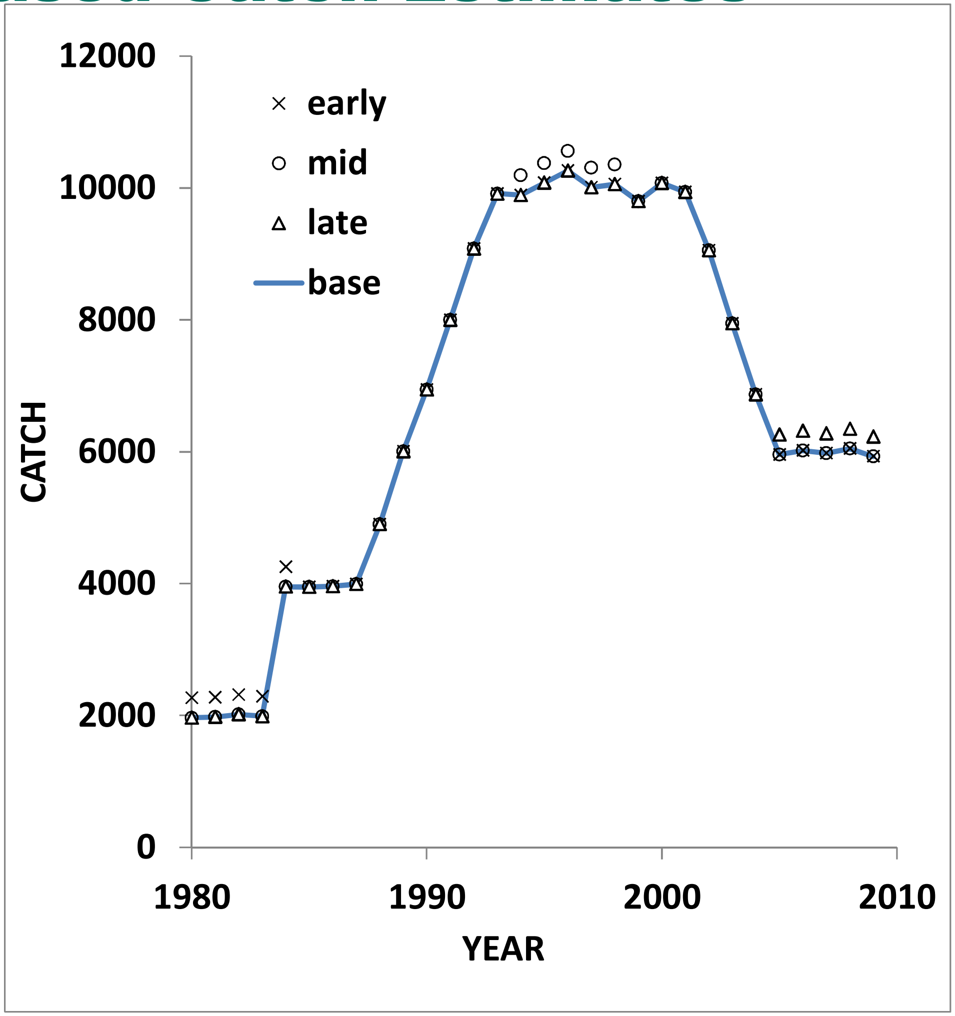
Impact of Biased Catch Estimates

- Simulation analysis used to investigate impact of biased catch levels
- Base case, and three alternatives:
  - Early – add 300 mt per year for 5 years at beginning
  - Mid – same added level during peak catch period
  - Late – same added level for 5 years at end.



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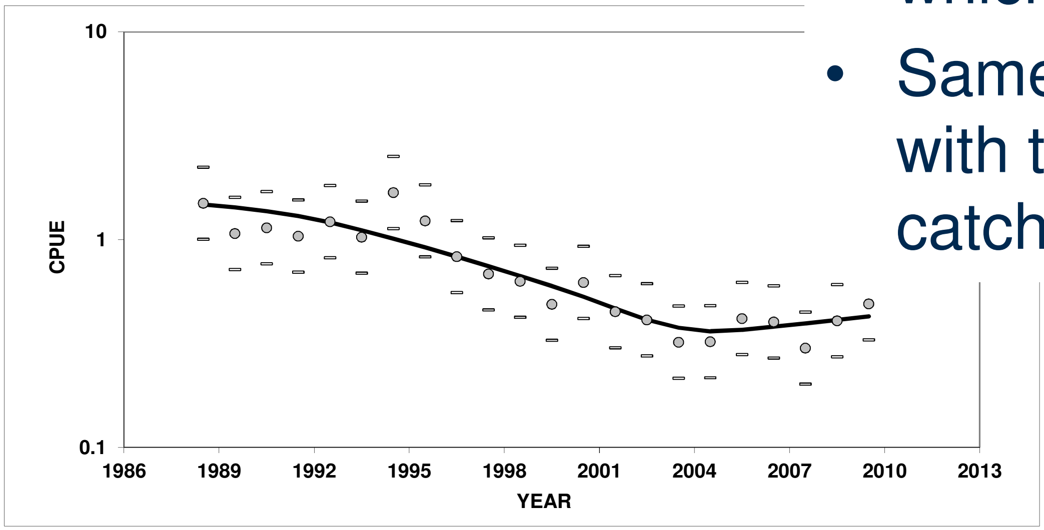
Abundance Index

- Abundance index, with 20% error bars
- Fitted line from the base catch which uses the correct catch
- Same abundance index used with the three alternative, biased catch data series



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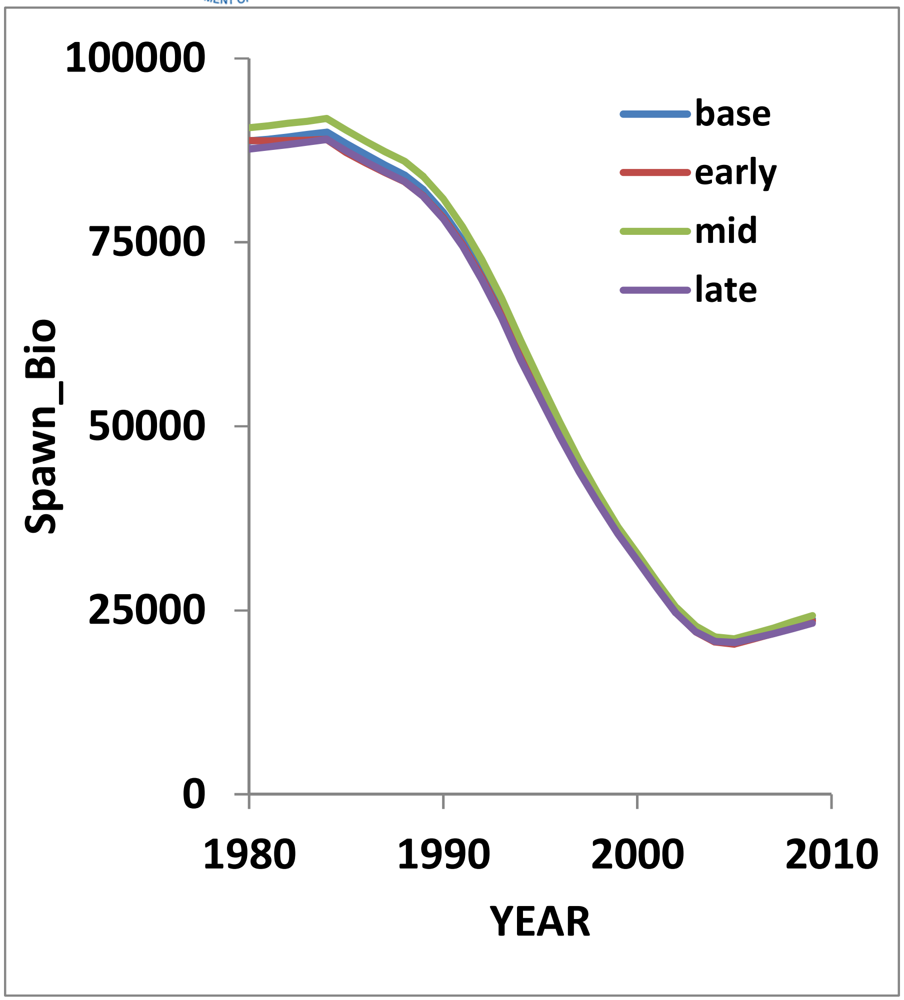
Estimated Spawning Biomass



- Catch Bias was small
- So the change in estimated spawning biomass is also small
- Mid (green) is consistently high

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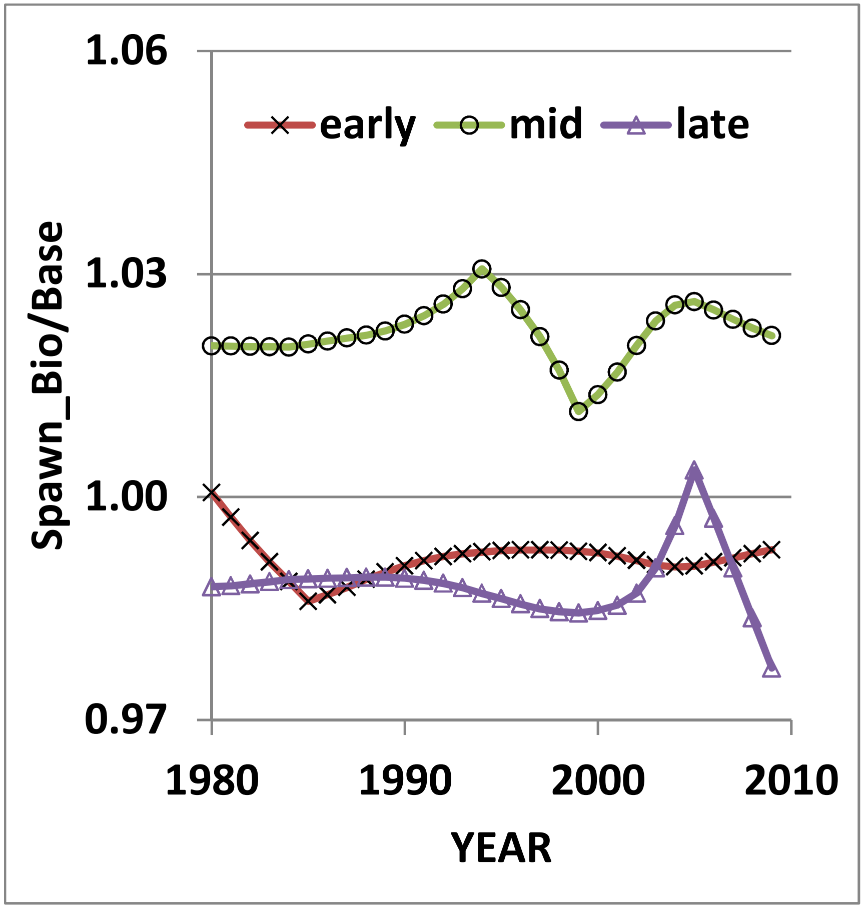
Zoom In – Relative Changes

- Greatest decline during period of overestimated catch
- Mid has 3% +bias in catch and nearly the same in biomass estimate
- Early and Late had 10-15% +bias in catch, but negative bias in biomass



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Impact on Biol. Ref. Points

	Base	Early	Mid	Late
SSB_unfished	110561	110613	112528	109608
steepness	0.929	0.930	0.913	0.957
SSB_MSY	26004	25980	27245	24400
SSB_MSY/SSB_u	0.235	0.235	0.242	0.223
SPR_MSY	0.250	0.249	0.260	0.231
F_MSY	0.264	0.264	0.252	0.286
MSY	6821	6829	6833	6944
OFL_2010	3866	3845	3937	3774

Speculation for Late alternative: the use of biased high catches needed higher recruitment near end of the time series to offset these catches and maintain good fit to the abundance index. The model achieves this higher recruitment by estimating a higher steepness. Because of this higher steepness, the stock is more resilient and the MSY is higher and the B_{msy} is lower.

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Conclusion

- Absolute level of catch is important assessment input
- Comm and Recr have cumulative effect, only differ if age range of catch differs
- Biological Reference Points based on proxies are not sensitive to catch, but MSY-based BRP are
- Catch biased high during period of high stock change and available index data will cause positive bias in biomass estimates
- Catch biased high at end of time series is likely to just reduce the biomass estimates
- If bias is only for a portion of the total catch, or if change in catch is random across years, then less effect on assessment outcome

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Questions?

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