Data-Poor Stock Assessment and Fishery Management

Alec MacCall

NMFS/SWFSC Santa Cruz, CA

Why Are Some Fisheries Data-Poor?

- Monitoring is expensive and lacks “glamour”
  - Monitoring has no political “payoff”
  - Politicians prefer to fund “new” and “different”
- The data requirements for stock assessment are not related to stock size or value
  - Requirements are the same for all stocks, large or small
    - Assessment requires long-term information
    - There is little value in short-term “targeted” studies
  - Naturally, we monitor the big and valuable stocks
    - Some stocks will always be too small to be worth monitoring

“Assessment-Resistant” Stocks

- Not all stocks can be assessed, and some stocks pose special problems
  - They appear data-rich but are information-poor
- Nearshore coastal stocks
  - Local variability, numerous local substocks, no mixing
    - E.g., Blue rockfish, gopher rockfish
- Deepwater stocks
  - Serial depletion of localities, age structure is constant
    - E. g, Cowcod, Bronzespotted rockfish
- Climate-driven, and coastal migratory stocks
  - Interdecadal climate variability, transboundary issues
    - E.g., White seabass, California sheephead, lobster, sardines

What is "Data-Poor Assessment"?

A relative term

- Data-rich
  - Inputs

    Catches, comps, abundance indexes, survey estimates
  - Outputs

    Status quantities: current biomass (B), current fishing intensity (effort, F), population age structure, historical recruitment patterns

    Management Reference Points (MRPs):

    e.g., Bunfished, Bmsy, Fmsy, MSY, Catch at Fmsy
- Data-poor
  - Inputs

    Approximate catches, some life history information
  - Outputs

    Incomplete, imprecise status and some MRPs

    Often as broad probability distributions, with no clear answer

"Data-Poor" requires a new attitude
Glass is half-full, not half-empty

- Data-rich thinking: Quantities being estimated are knowable—but we just need more or better data
  - Data-rich management expects a simple number
  - Hidden problem: Conventional data-rich assessments severely under-estimate uncertainty!
- Data-poor thinking: Quantities are not precisely knowable, but given the possibilities based only on the data we have, <u>what is a good policy?</u>
  - I intentionally did not say "What is the best policy?"
  - Methods must show imprecision, not hide it
  - This is a more sensible approach, even for data-rich
- Don't think of data-poor as a "dumbed-down" data-rich assessment
  - It may work sometimes, but tends to cause paralysis

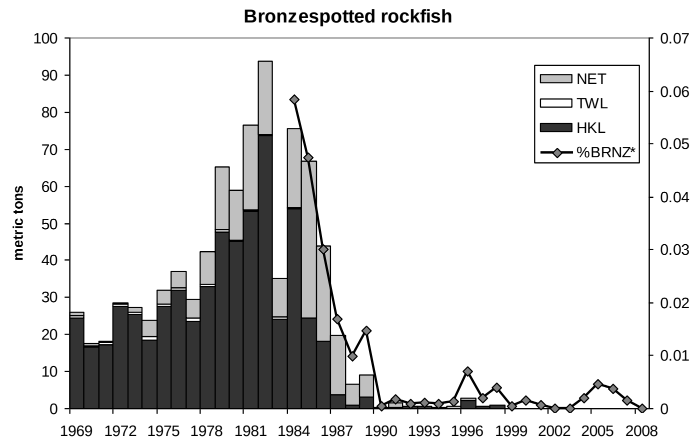
Principles of Data-Poor Assessment
(but we cannot assume there is always a way)

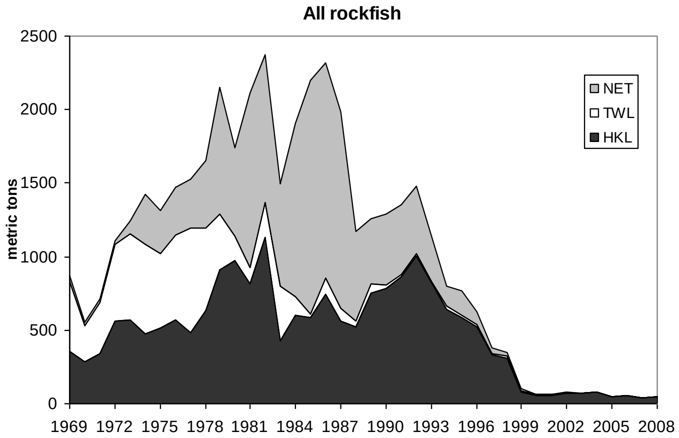
- Get whatever data you can
  - Information can be found in unusual places
- Find a way to use the data you have
  - Adapt models to unconventional data inputs
  - Try out new models, test them against "known" cases
- Borrow needed information (prudently) if possible
  - Prior parameter distributions, e.g., Bayesian analysis
  - You can even borrow <u>data</u> from other assessments!
    - Fishing effort is borrowable—this can work well if catch is known
    - But "Indicator stocks" are unreliable—don't borrow abundance
- Explore the "what-if" possibilities thoroughly

Some Examples of Data-Poor Analyses and Assessments

- These are intended as example approaches, drawn from my own experience
- Some technical discussion is unavoidable
- Topics:
  - Data borrowing
  - Prior parameter distributions
  - Monte Carlo exploration
  - Some new management approaches

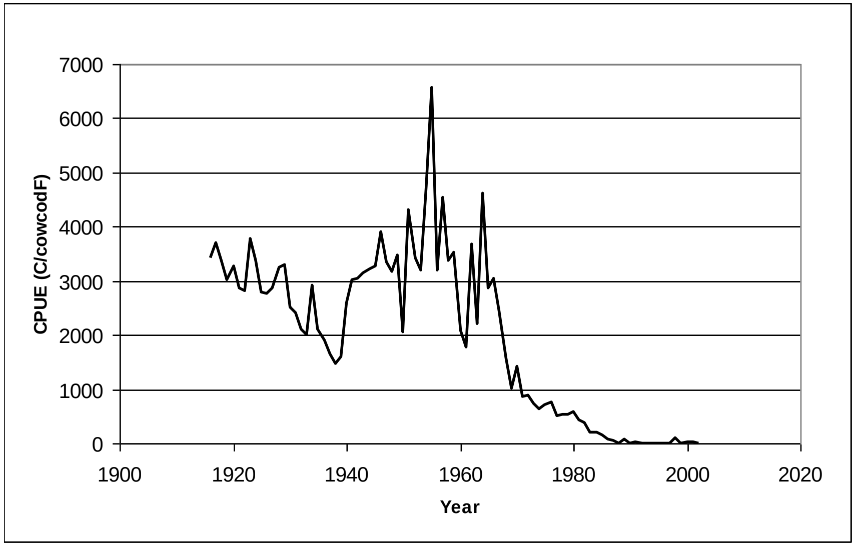
Borrowing Data
An example: Bronzespotted rockfish

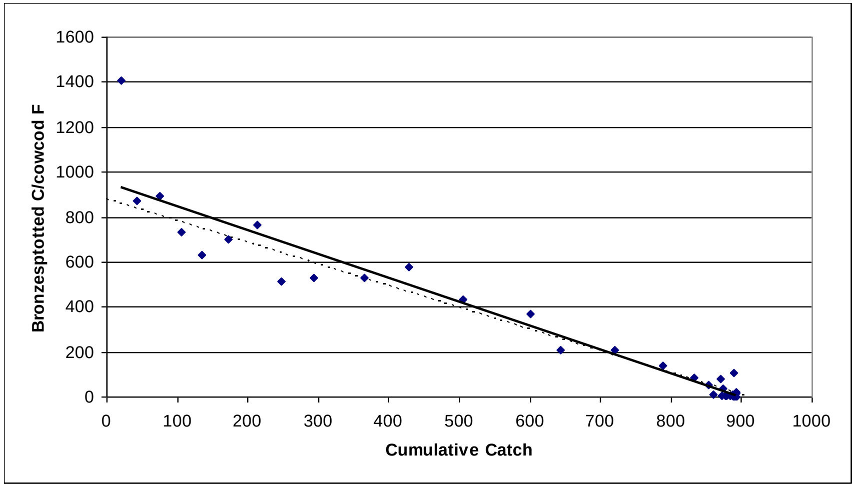




- Extremely limited data
- Estimated landings dropped to nearly zero ca. 1990 (upper)
- This is 10 years earlier than the general west coast rockfish decline (lower)
- What happened?

Borrowing Data (cont.)





- Borrow effort (F) from the cowcod assessment
- CPUE (C_{BRNZ}/F_{COW}) shows stability, then decline
- Use Leslie depletion model (CPUE vs. sumCatch)
  - Model est. B_{2002} is 47 tons
- Compare with BRNZ seen in submersible survey for cowcod
  - Survey est. B_{2002} is 68 tons
- Total catch was 900 tons from 1960s to 1980s

What if we only know catches?

(and a little bit else, e.g., maximum age, age at maturity from a small sample)

- Conventional practice has been to use recent average catch, and apply an ad-hoc precautionary reduction (Restrepo et al. 1998)
  - But this may be more precautionary than is needed
- If we have an approximate catch history from the beginning of the fishery, we can do a lot better
  - Depletion-Based Stock Reduction Analysis (DB-SRA)
  - This approach was use by the PFMC to set ACLs

Borrowing Parameters
How can we determine M?

- Natural mortality rate (M) is a key to all dynamics
- Hoenig (1983) showed that estimates of M are closely related to maximum age
  - There are many other ways
- We can get an M estimate (range) by aging a small number of fish
  - From this sample we also learn about growth rates, age at maturity etc.

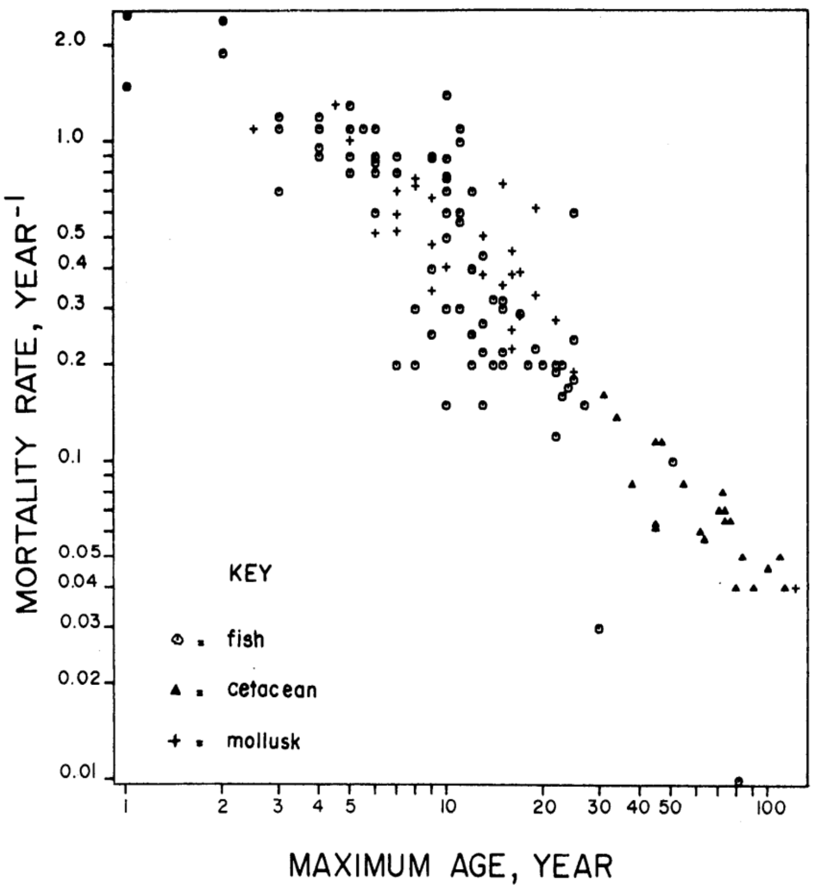
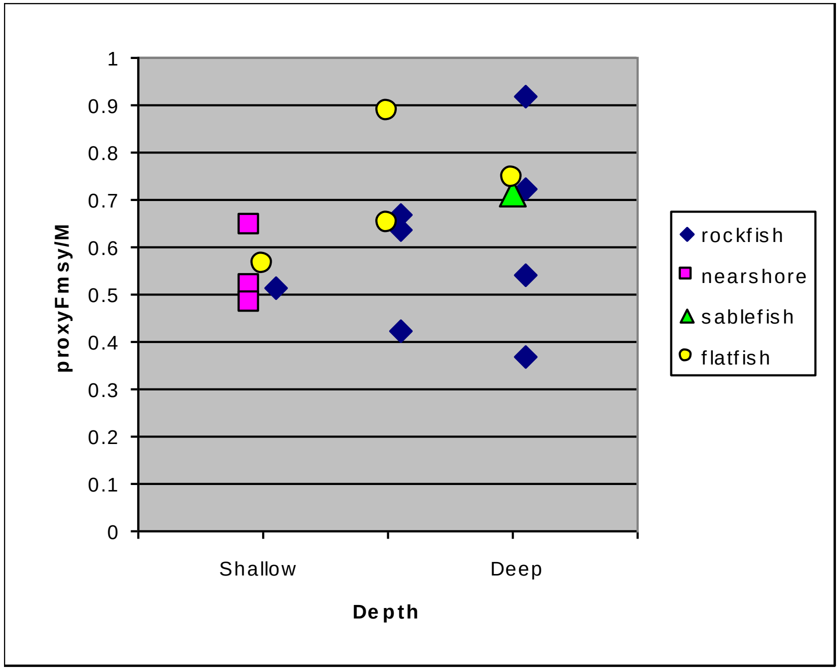


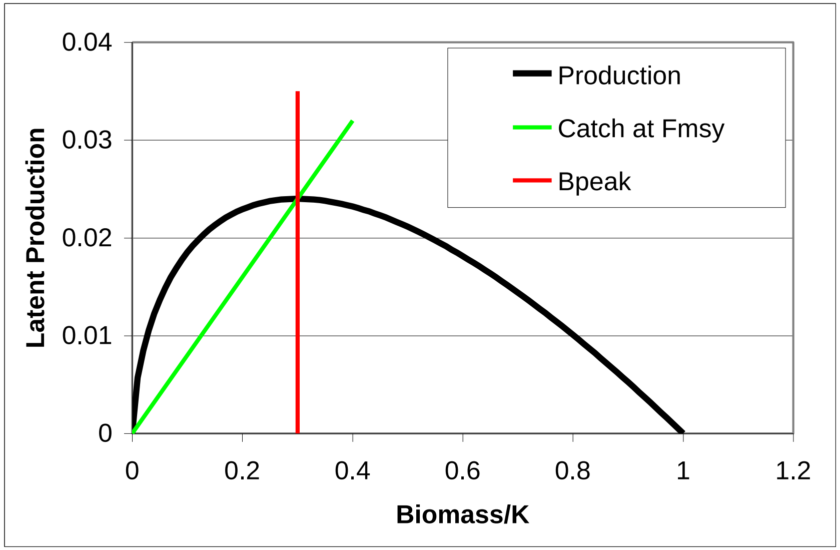
FIGURE 1.—Plot of instantaneous mortality rate (yr^{-1}) against maximum observed age (yr), both on logarithmic scales.

Borrowing Parameters
Fmsy is closely related to M

- Walters and Martell’s book:
  0.6<Fmsy/M<1.0
- West Coast groundfish are at the low end of this range
  - This may be regional
    - East coast Fmsy/M > 1?
  - Species groups differ
    - Flatfish have higher relative Fmsy
- Now combine M and Fmsy/M to get Fmsy
  - The distribution of values reflects the two input distributions



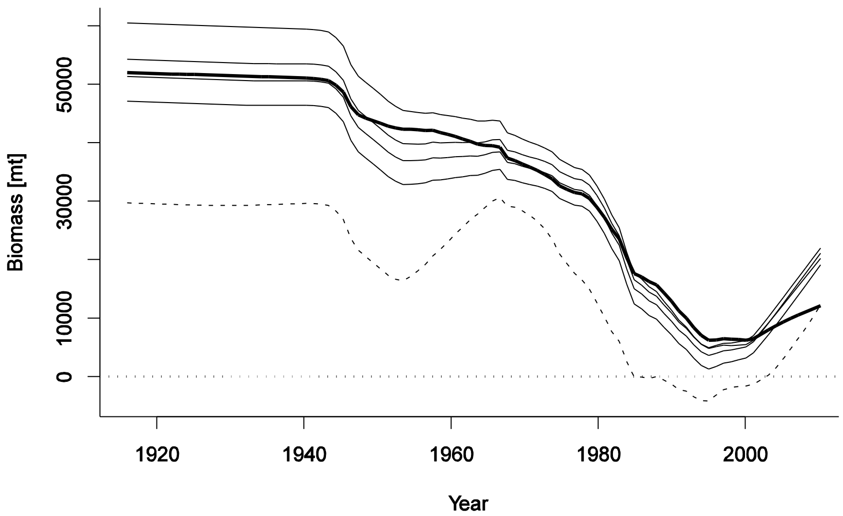
The Production Function



- The combination of assumed M and assumed Fmsy/M gives an assumed Fmsy
  - The diagonal green line is catch at Fmsy
- Assume Bmsy occurs at a specified fraction of Bunfished
  - The vertical red line (here at 0.3)
- Intersection is MSY, Bmsy
  - The only remaining unknown is Bunfished
  - Based on our assumed inputs, we already “know” 2 out of 3 parameters of the production function

Depletion-Based Stock Reduction Analysis

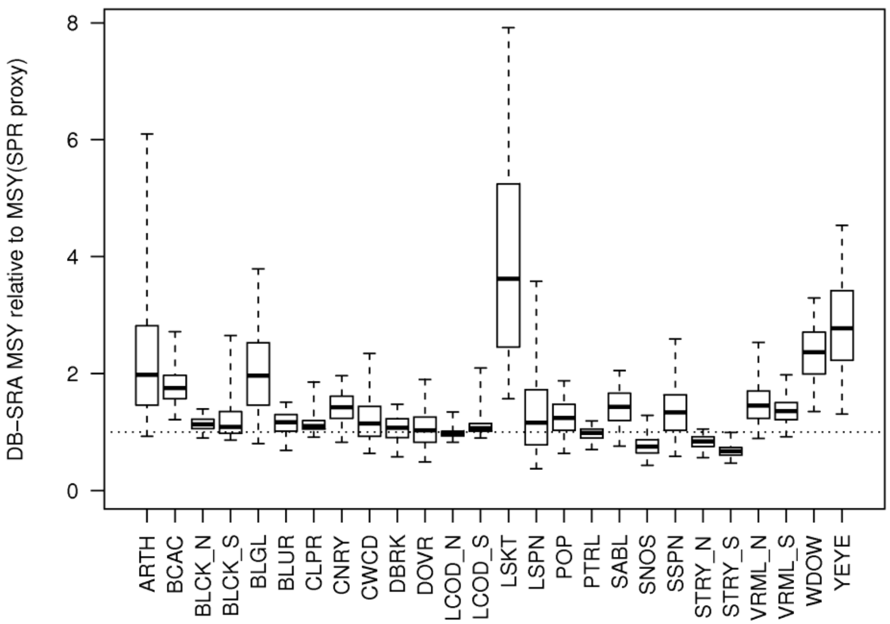
Final Step: Estimate $B_{unfished}$

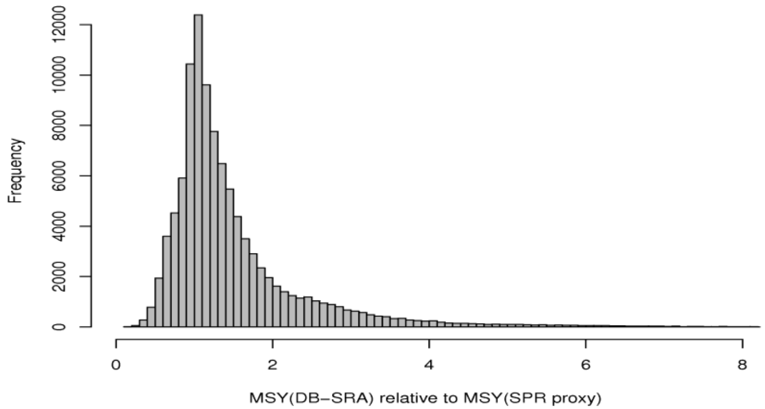


Example: Canary rockfish
dark line is from data-rich assessment
Here, assumed end-point is different:
DB-SRA used 0.4, assessment was 0.24

- Given historical catches, solve for the value of Bunfished so that ending biomass is at the assumed depletion
  - Discard cases where biomass goes negative (case shown by dotted line)
  - Discard any other cases that cannot hit the target
- No single result is of much use
  - The information is in the entire collection of results

How Does DB-SRA Perform?

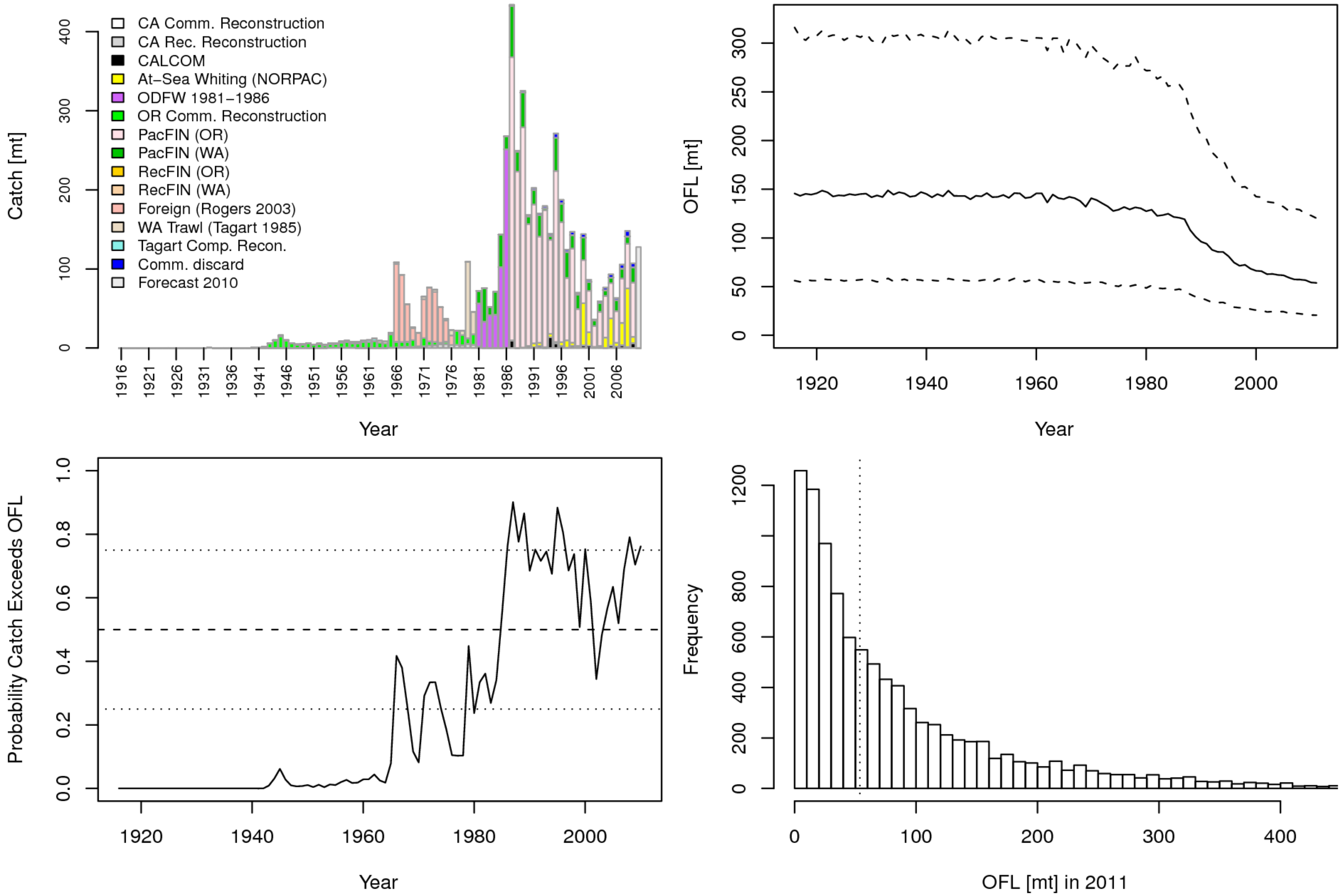




- Test 28 data-rich assessments
  - All cases assume depletion to 0.4

  (Note: if truly data-poor, we would not know value, our default=0.4)
- DB-SRA tends to agree with data-rich, but imprecise
  - Main purpose is to advise on current yields (ACLs)
- Some cases of overestimation
  - Correction factors for "rebuilding species" can be developed
  - Lightly fished species (not depleted as much as assumed)
    - Low risk for these cases

Example DB-SRA Output – Rougheye rockfish



Even when we assume the stock is healthy (B=40% ofBunfished), 75% of the model draws say we are overfishing (F>Fmsy)

Data-Poor Management

- Our management systems tend to assume data-richness, and may not be well suited for data-poor fisheries
  - US now requires setting Annual Catch Limits on everything
  - Widespread interest in an ecosystem approach presumes data-rich capabilities
    - Is a data-poor ecosystem approach even possible?
- We need to develop (and allow) data-poor management systems
  - This may require taking some risks
  - Open access (including recreational) is a problem for data-poor management
    - The less you know, the more restrictive you have to be

Data-Poor Management
Without Stock Assessments

- Have a plan – “If-then” decisions should be made in advance, not as they arise
  - Ad-hoc management feels good, but performs poorly
  - This is a fundamental rule of all management
    - Not just fisheries, but business and investing for example
  - This is not a massive document – perhaps only one page long!
- Some fisheries on the East Coast are managed on the basis of annual survey results, with no stock assessment
  - San Francisco Bay herring could be a similar case
    - It may be possible to manage many fisheries based directly on year-to-year changes in CPUE, e.g., from partyboat logbooks
  - The less reliable the indicator, the more you need a plan
    - Use simulation and evaluation to develop a good plan

Data-Poor Management

MPAs may provide <u>information</u>

- MPAs have been “sold” as insurance, etc.
  - Emphasis on passive benefits
- Alternative: For species that don’t move too much, we should be able to use outside vs. inside comparisons with MPAs as equivalent to stock assessments
  - Compare fish densities
    - Measure of biomass status
  - Compare age or length compositions
    - Measure of fishing intensity status
  - Can be multispecies (ecosystem approach)

MPA-Based Management

- This approach has a unique potential to address several problems that assessment cannot do
  - Addresses local variability
    - Comparison and management can be on a local spatial scale
  - Addresses interdecadal climate variability
    - Fished and reference sites share the same (unknown) factors
- We may need to wait 10-20 years
  - MPA sites have to recover from effects of fishing
    - Length compositions respond faster than density
    - Monitoring is still needed for all this (not strictly data-poor)
- Some strategy evaluations are already done
- Feasible for California state management
  - Federal compatibility is a problem to be resolved