An MSE for Pacific Sardine

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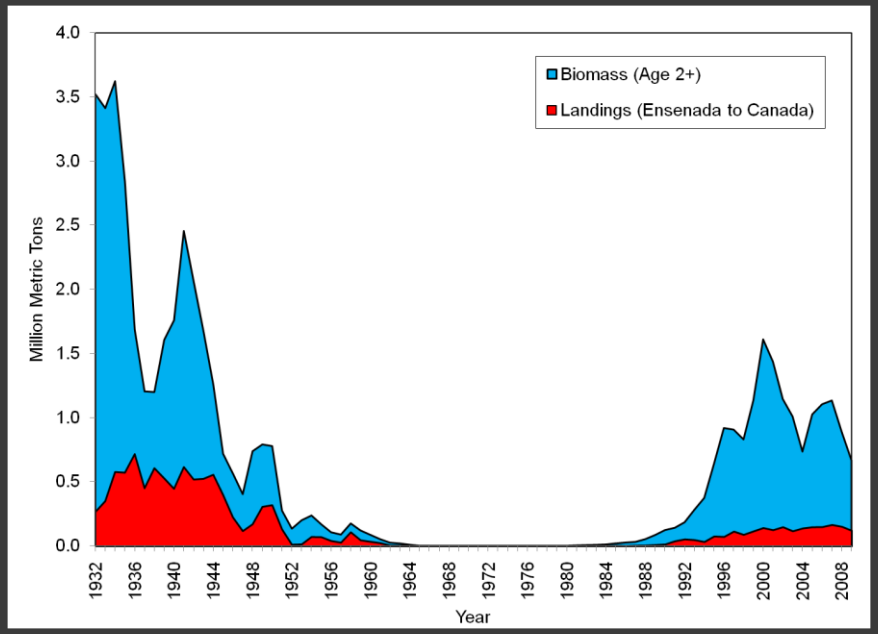
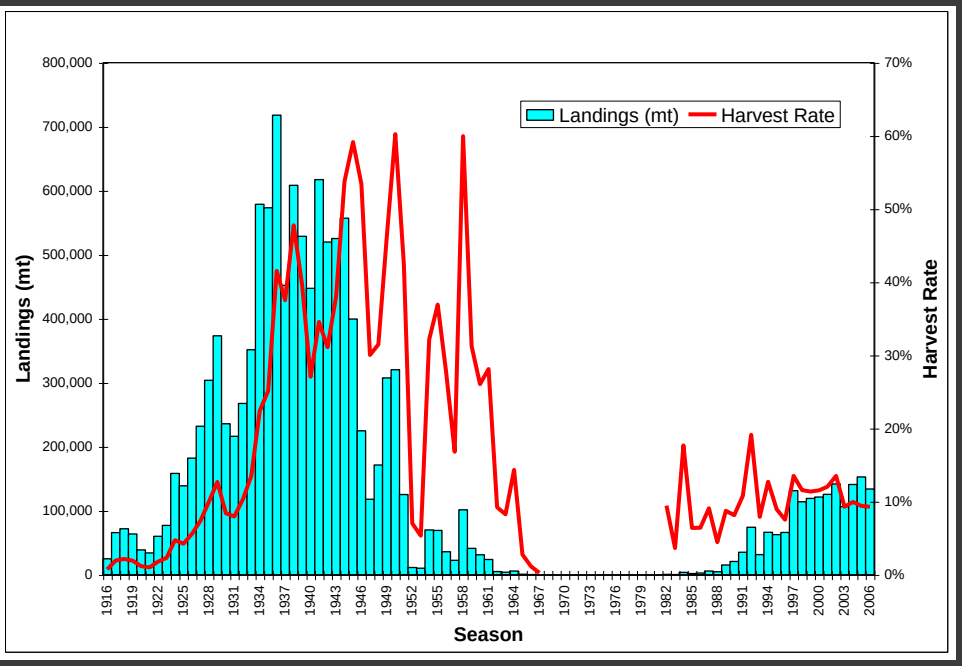
Fisheries Management (or what goes up must…)





Murphy (1966) & Hill et al. (2009)

Fishery Development and Management-I

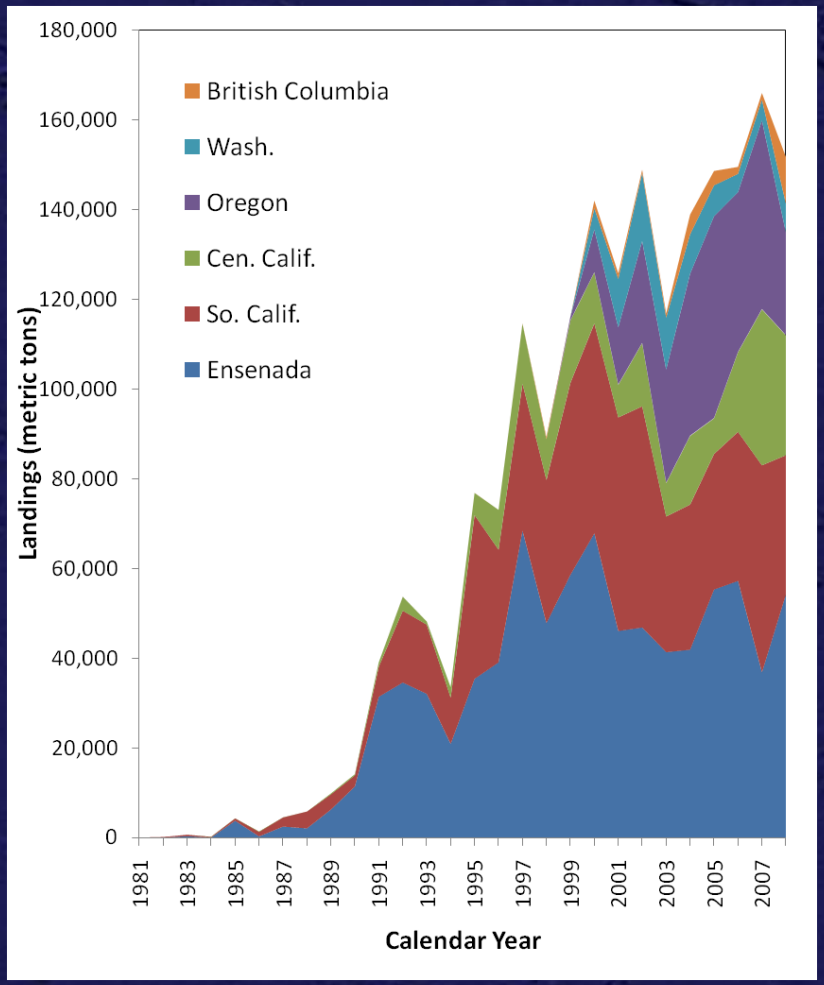
- Fishery developed during World War I
- Peak catch over ~700,000t (largest fishery in the western hemisphere in the 1930s and 1940s).
- Southeast shift in catch as fishery collapsed. Landings stopped in
  - 1947-48 in the Pacific Northwest
  - 1953-52 off San Francisco

Fishery Development and Management-II

- In the early 1980s, sardines were taken incidentally with Pacific and jack mackerel
- Incidental fishery for sardines ended in 1991
- Management authority for the fishery transferred to the Pacific Fishery Management Council (PFMC) in January 2000
- The Coastal Pelagic Species Management Plan includes:
  - Pacific sardine, Pacific mackerel, jack mackerel, anchovy, market squid

Pacific Sardine Recovery and Expansion

- **1980s:**
  - low abundance, confined to SCA; minor fisheries in SCA & Mexico
- **1990s:**
  - Expansion offshore and north to Central California;
  - CCA fishery begins;
  - Pop'n growth = 33%;
  - Sardine in Oregon Washington and Canada
- **2000s:**
  - Fisheries in PNW
  - Seasonal movements N-S, inshore/offshore

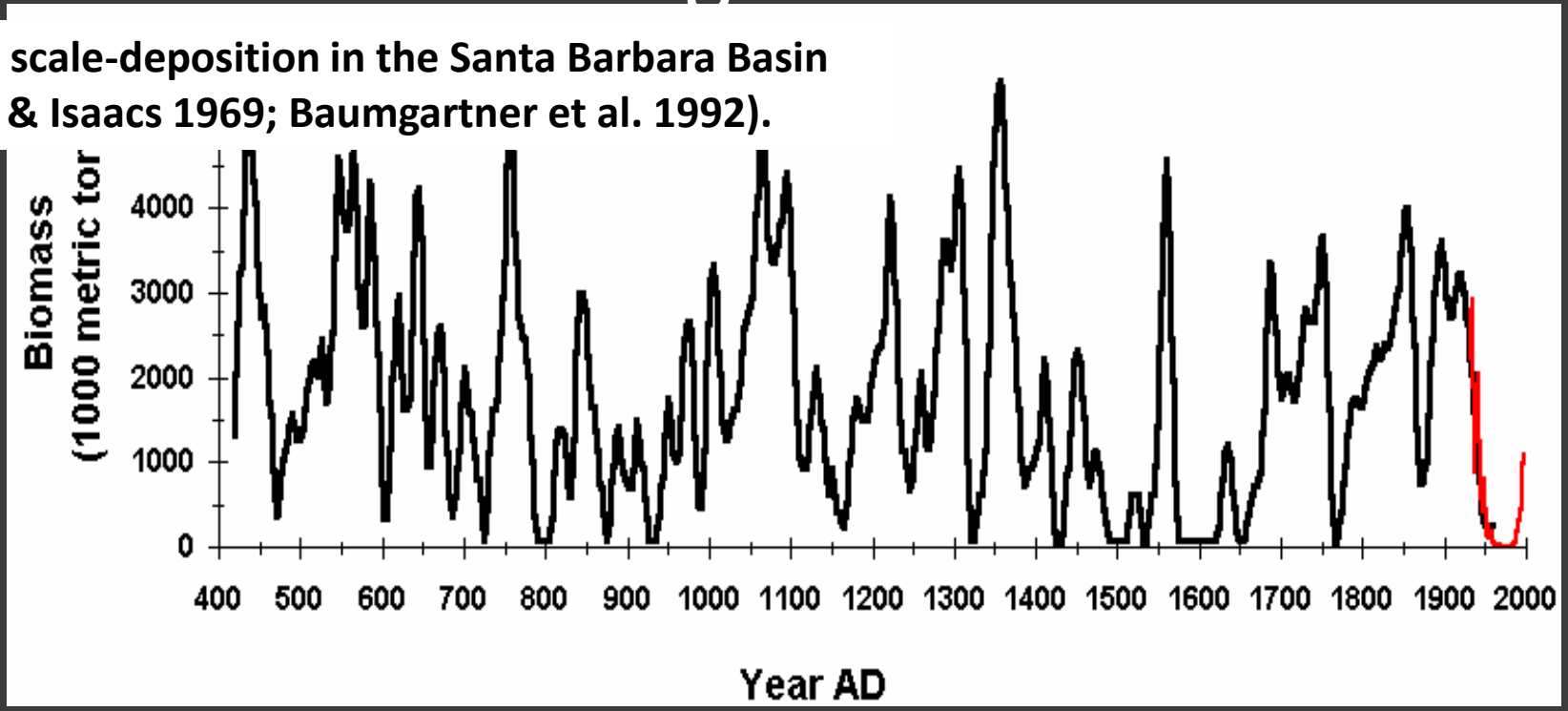


Challenges for Assessment and Management-I

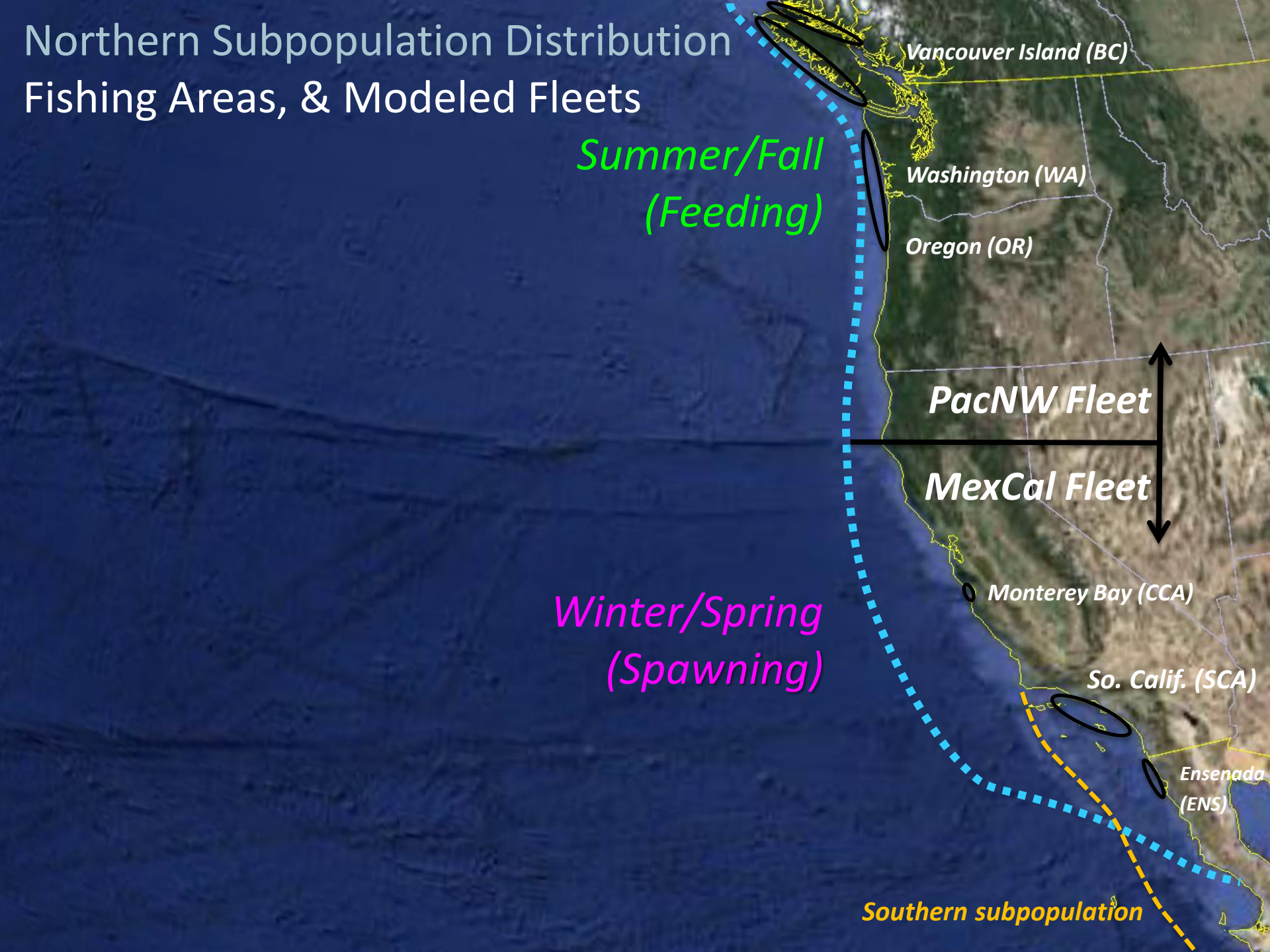
- Multinational fishery:
  - US, Mexico, Canada
- Time-varying migration
- Multiple fisheries in the US (Southern California, Central California, Pacific Northwest)
- Environmental-related variation in biomass

Challenges for Assessment and Management

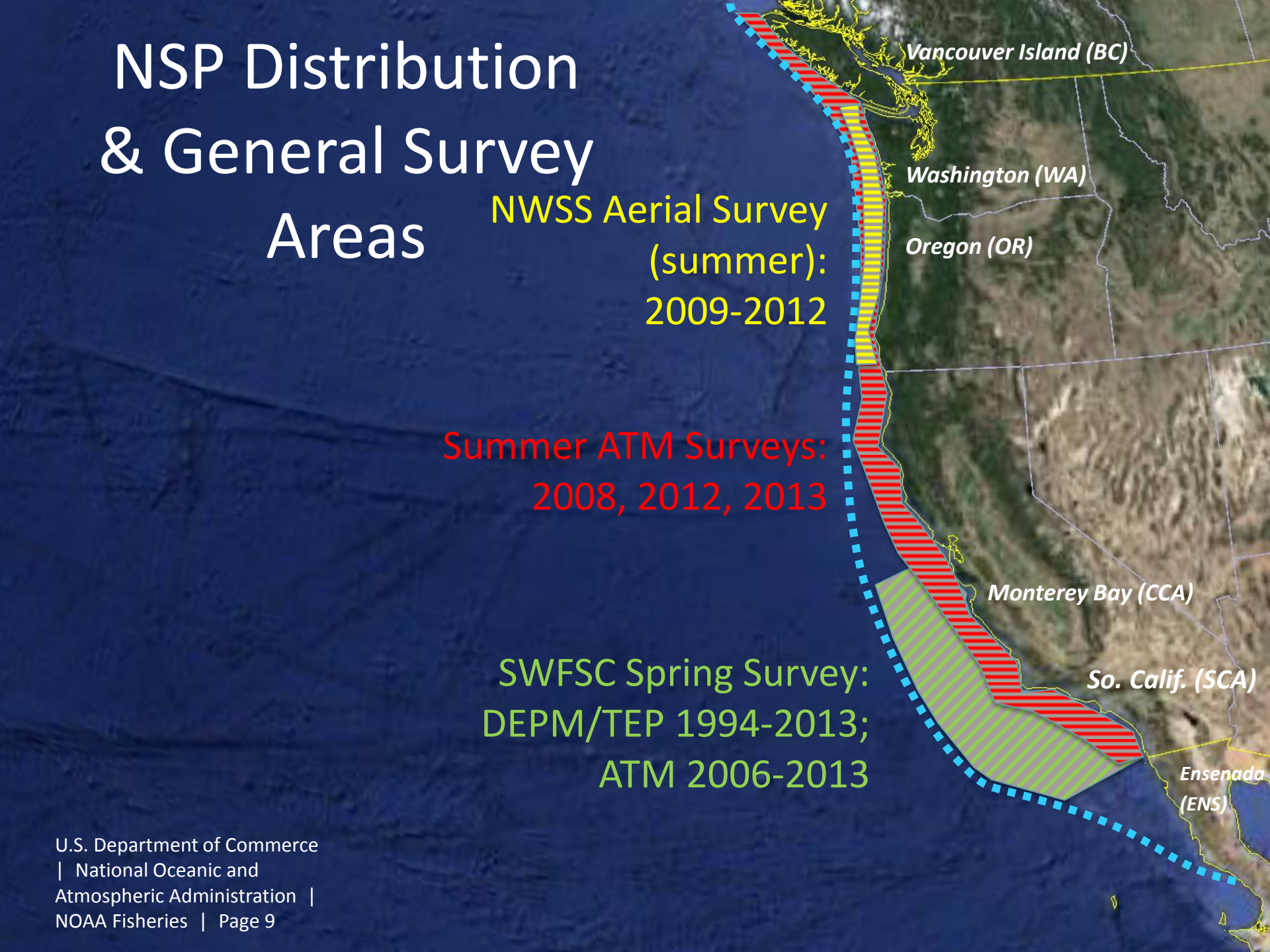
Sardine scale-deposition in the Santa Barbara Basin (Soutar & Isaacs 1969; Baumgartner et al. 1992).



- **Extreme population variability even in absence of fishing;**
  - **periods of peak abundance ~ 50-60 years**
  - **link to environmental forcing is assumed**
- **Typical population dynamic for an 'R-selected' species:**
  - **small body, rapid growth, early maturation, high fecundity, short generation time, and the ability to disperse offspring widely**


Northern Subpopulation Distribution
Fishing Areas, & Modeled Fleets
Summer/Fall
(Feeding)
Winter/Spring
(Spawning)
Vancouver Island (BC)
Washington (WA)
Oregon (OR)
PacNW Fleet
MexCal Fleet
Monterey Bay (CCA)
So. Calif. (SCA)
Ensenada
(ENS)
Southern subpopulation

NSP Distribution & General Survey Areas

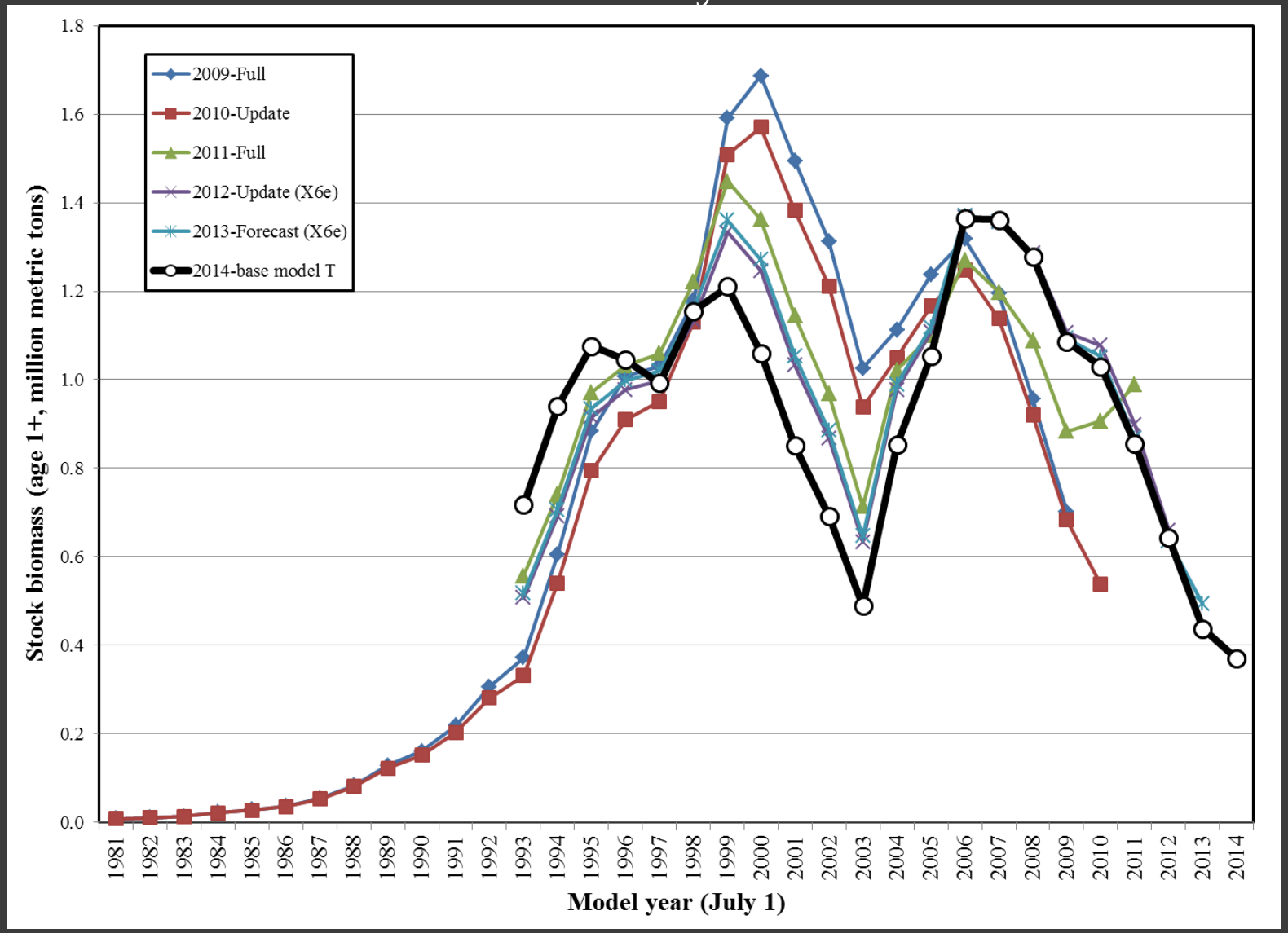


NWSS Aerial Survey (summer): 2009-2012

Summer ATM Surveys: 2008, 2012, 2013

SWFSC Spring Survey: DEPM/TEP 1994-2013; ATM 2006-2013

Estimated Stock Biomass Series from Base Model and Previous Stock Synthesis Models



Harvest Control (US)

$HG_{2010} = (BIOMASS_{2009} – CUTOFF) • FRACTION • DISTRIBUTION$

To determine an appropriate (sustainable) FRACTION value:

$F_{MSY} = 0.248649805(T^2)−8.190043975(T)+67.4558326$

where T (°C) is the running average sea-surface temperature at Scripps Pier during the three preceding seasons (July-June), and exploitation FRACTION is bounded between 5% and 15%.
Maximum catch allowed = 200,000 mt

Stock biomass (age 1+, mt)	Cutoff (mt)	Harvest Fraction	U.S. Distribution	U.S. Harvest for 2011 (mt)
537,173	150,000	0.15	0.87	50,526

Pacific Sardine: Management Process

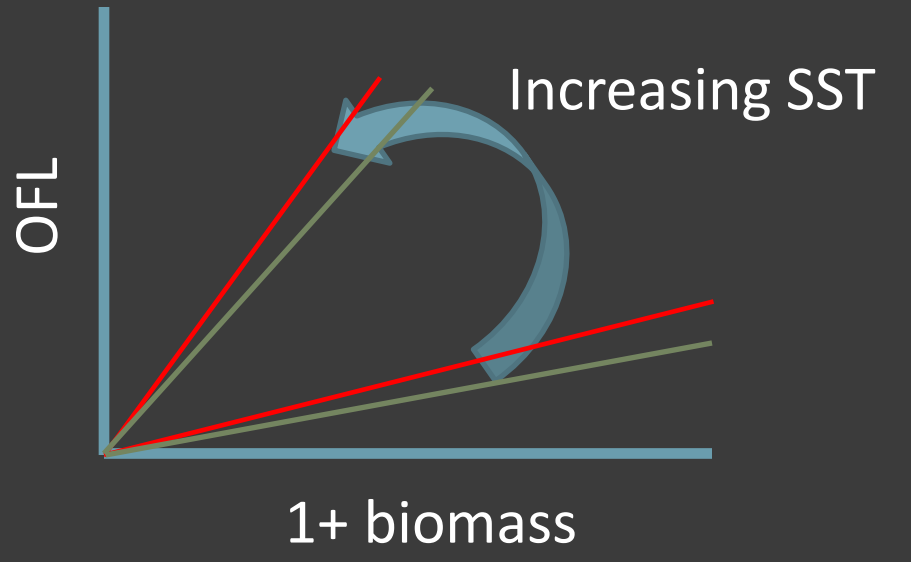
(Amendment 8 & 13)

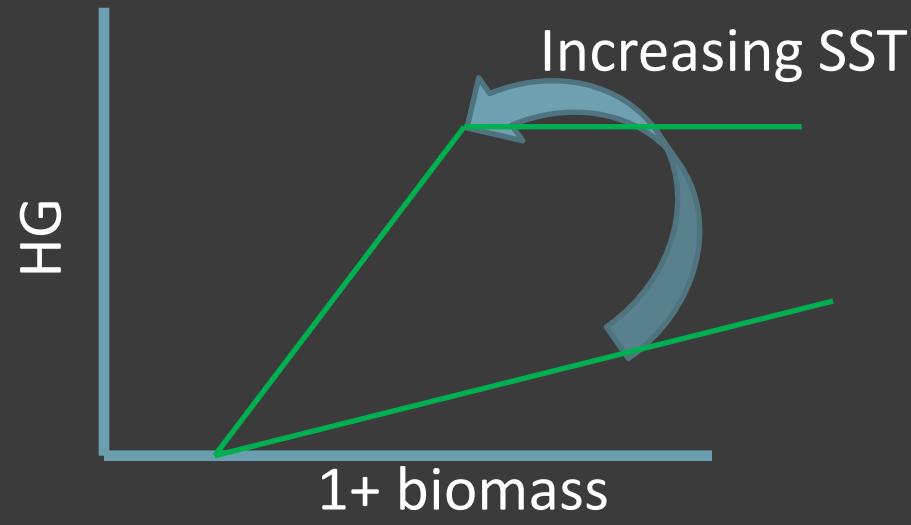
Overfishing Level (OFL)

*P**

Acceptable Biological Catch (ABC)

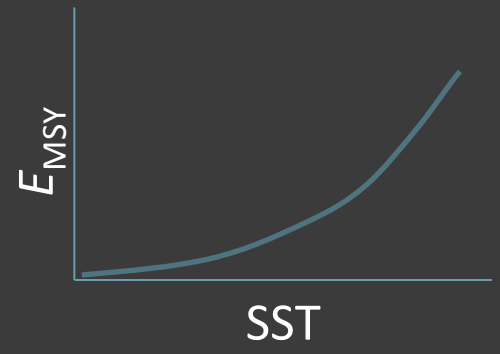
Harvest Guideline (HG)





The HG is set following this basic process

SST



Calculate OFL
OFL=Biomass*Fraction*Distribution

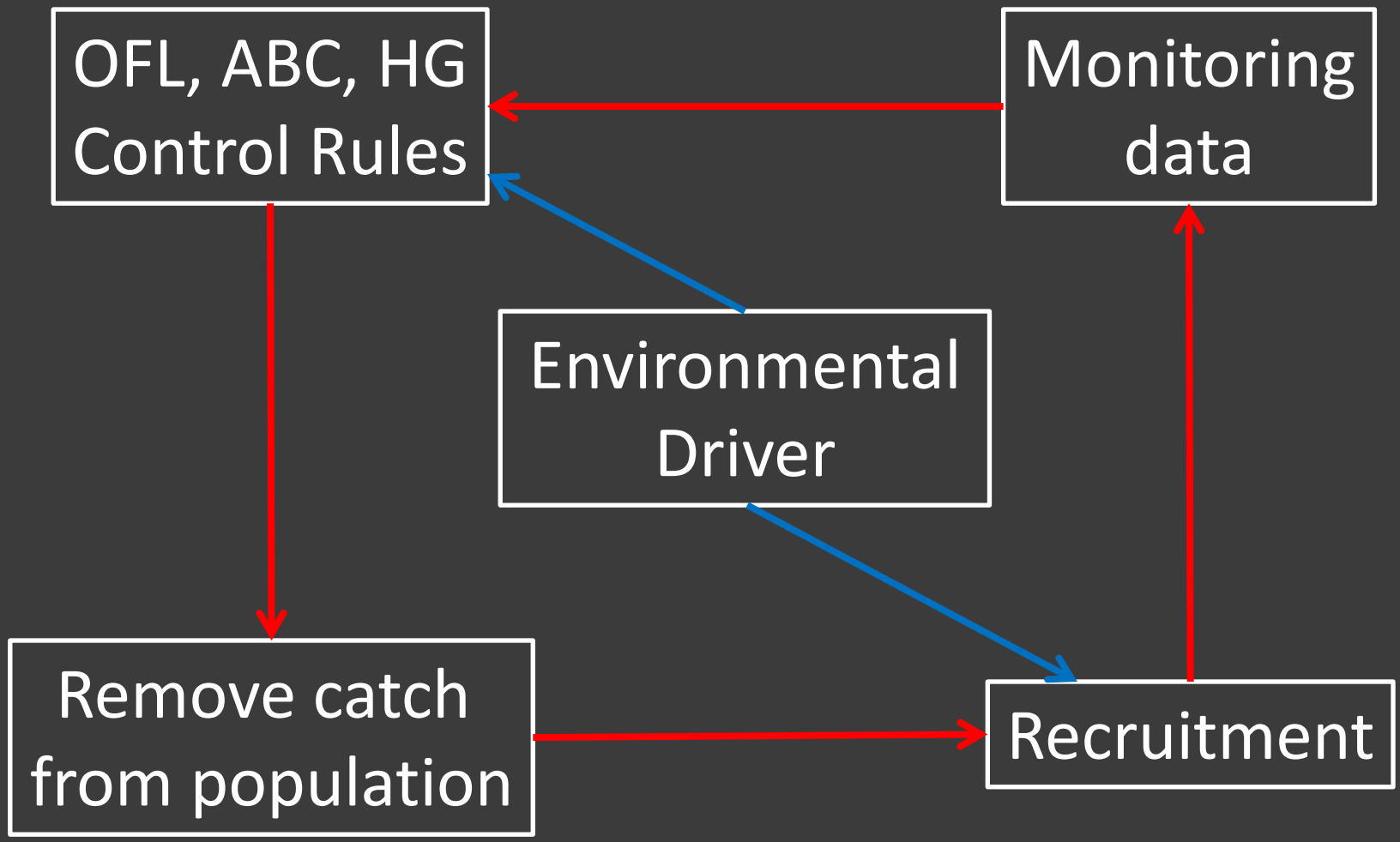
Calculate ABC
ABC=OFL*P*

Calculate HG
HG=(Biomass-Cutoff)*
Fraction*Distribution

Select the minimum from these two quantities

Final HG

Risk Assessment Framework

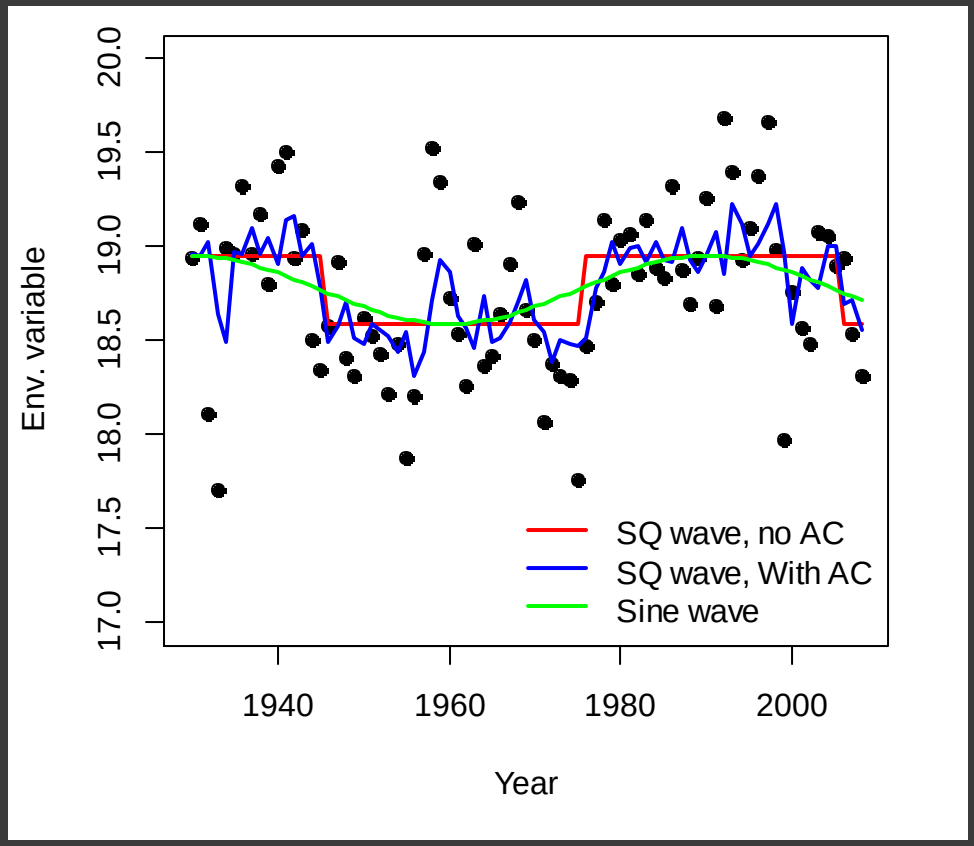


Performance measures

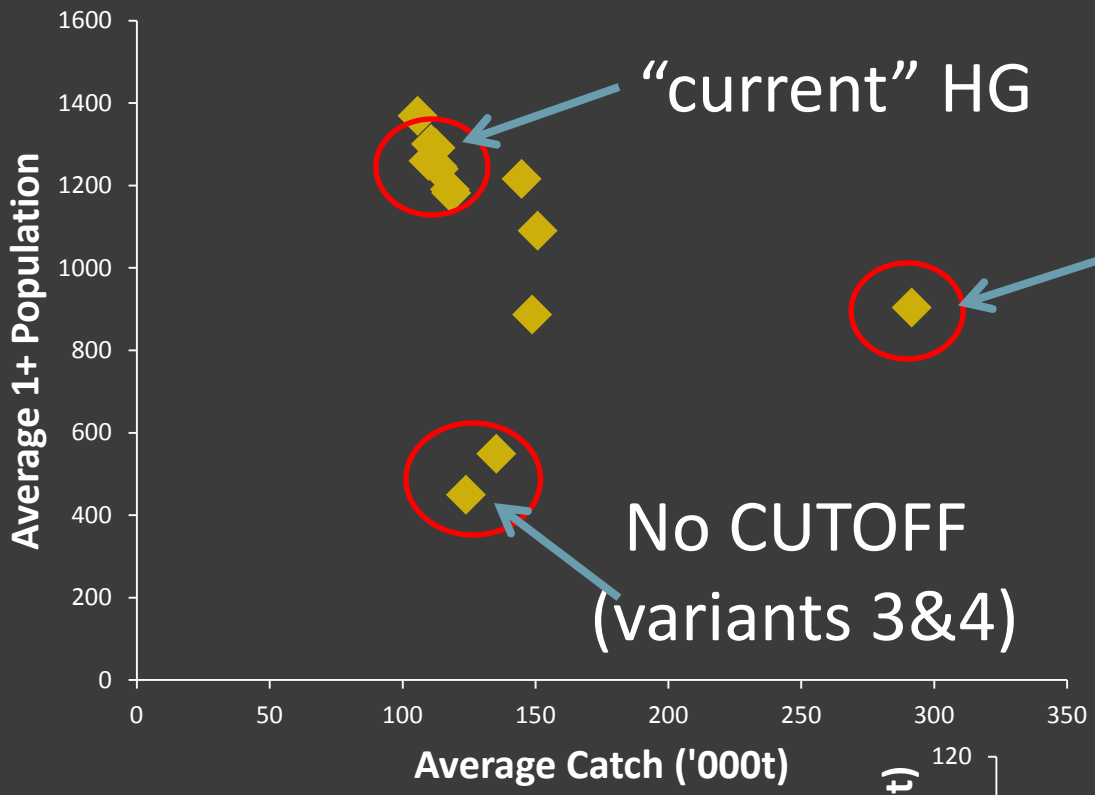
The performance measures are selected to quantify performance relative to [some] management goals.

- Average catch (total)
- Average population size (1+ biomass)
- Probability [total] catch is less than some threshold (e.g. 50,000t)
- Probability 1+ biomass is below a threshold.

Modeling environmental drivers



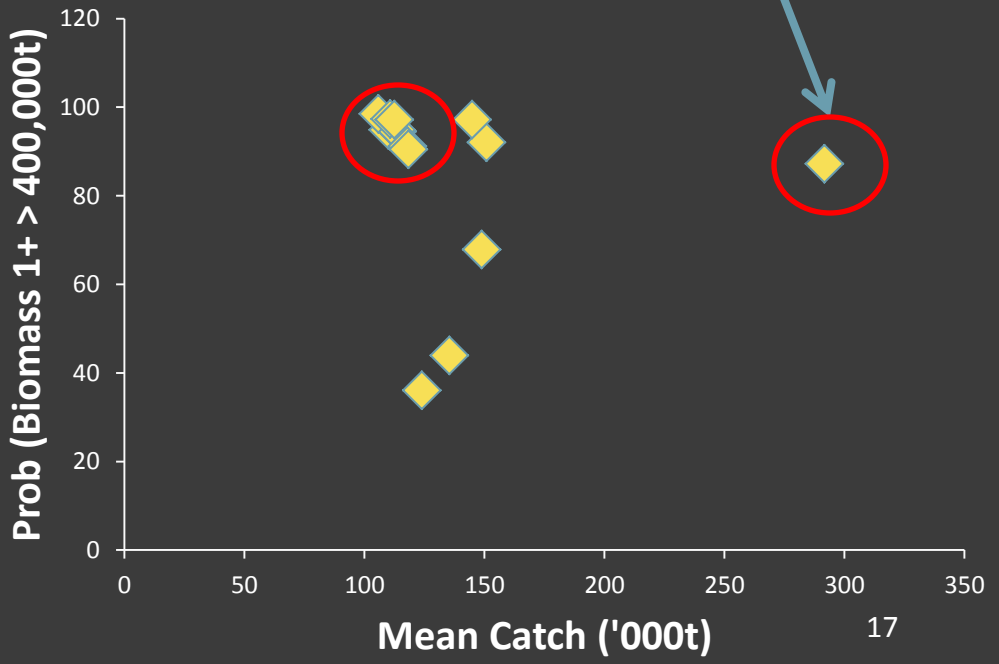
Fit the environmental variable to the ERSTT time series



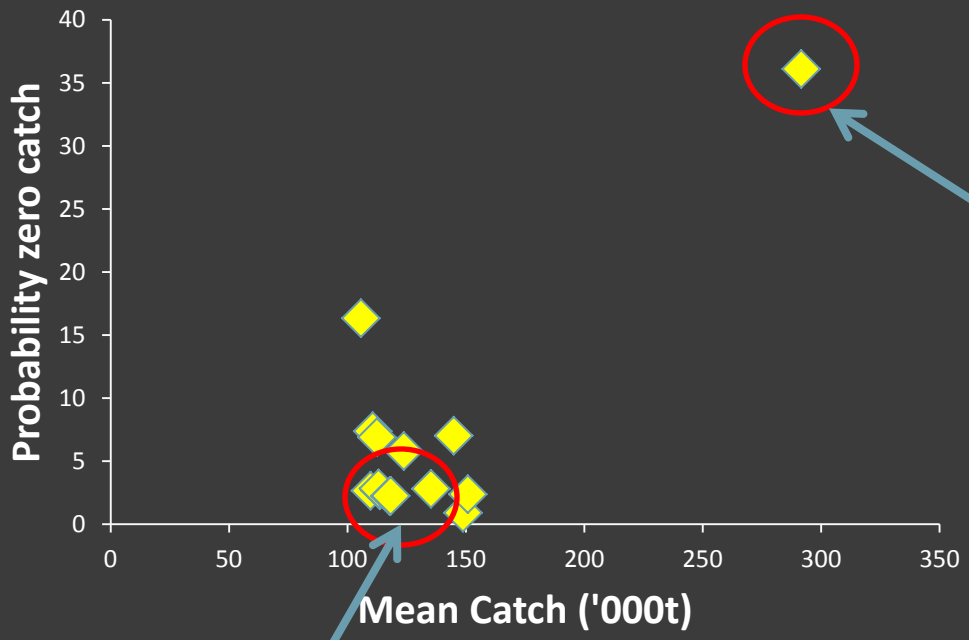
"current" HG

45% harvest rate & high CUTOFF (variant 5)

No CUTOFF (variants 3&4)



Performance measures are defined over many cycles of the environmental variable and are not predictions of short-term catches / biomass.



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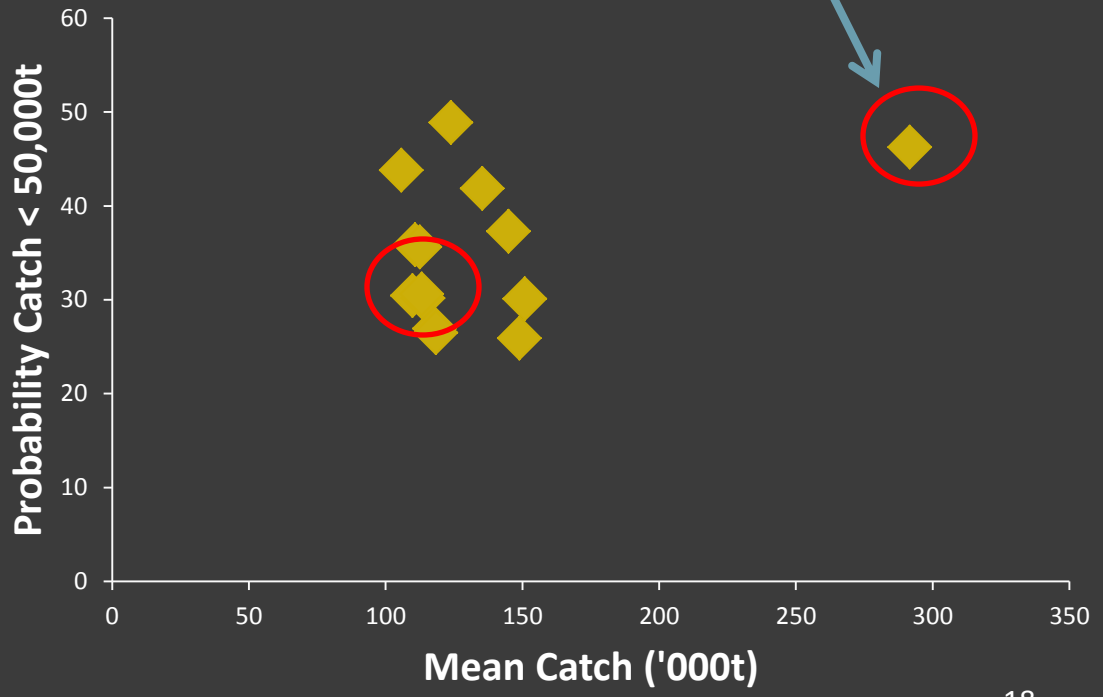
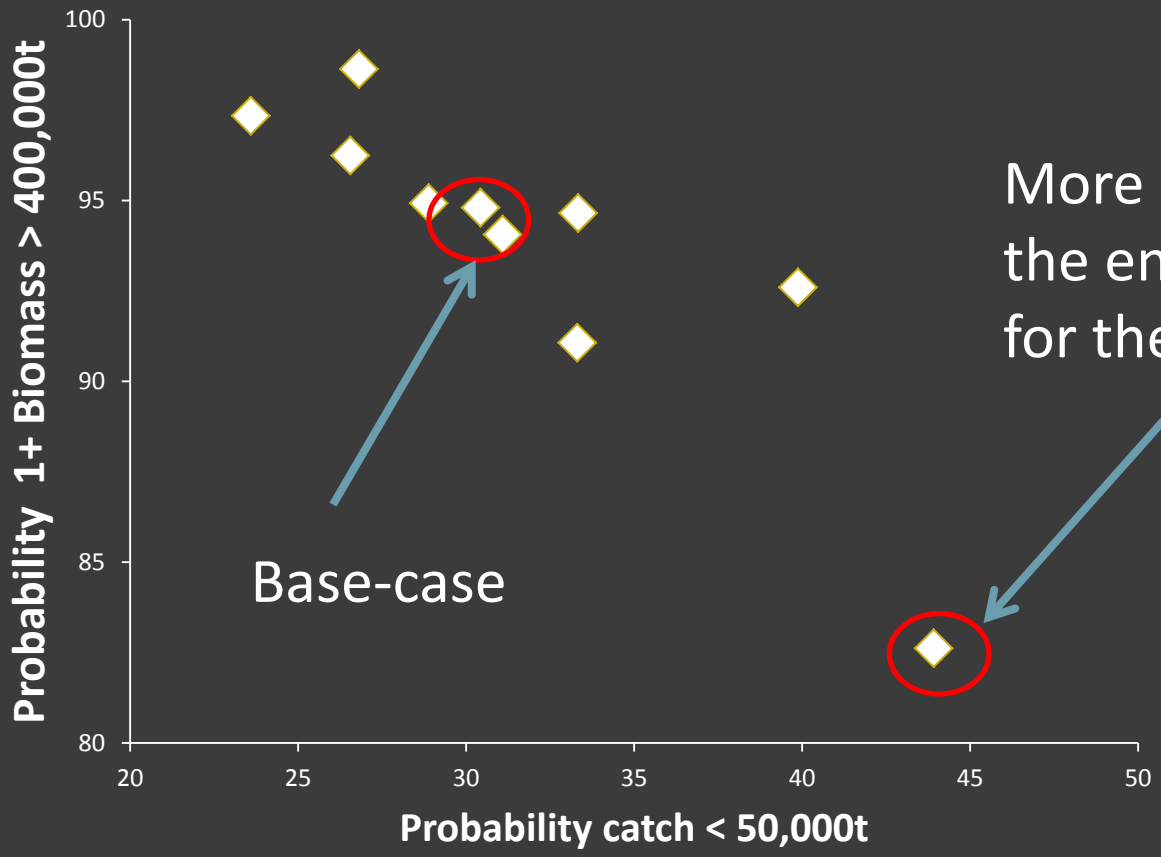
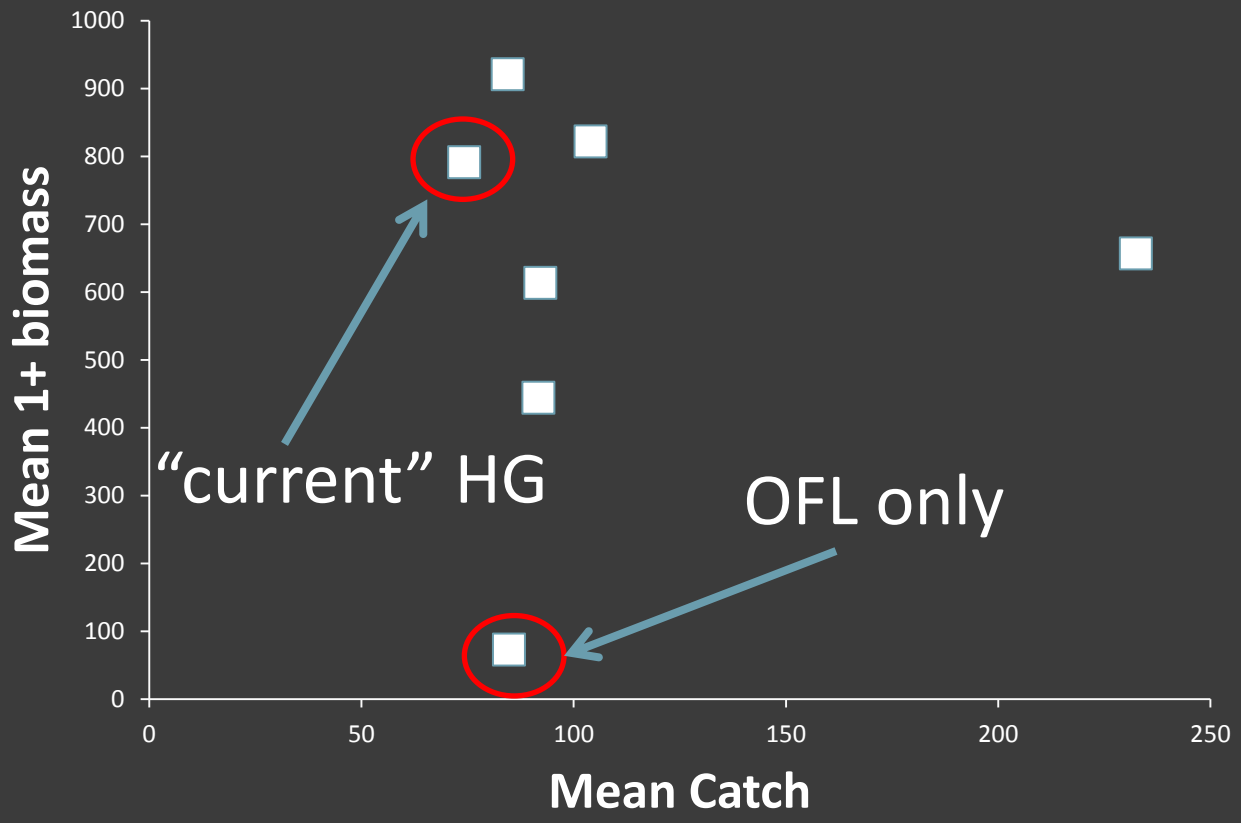




Performance depends on the values for the parameters determining, for example, how the environment impacts recruitment.



Key Major Sensitivity: The assumption everyone follows the US control rules (for this test Mexico and Canada are assumed to have a constant fishing mortality rate no matter what)

Control Rules and MSE-I

- Design of the operating model
  - Single-species: Workshop with Council involvement (Council members, staff, SSC, advisory bodies)
  - Multi-species: Ongoing – currently being funding through a Packard grant
  - Operating model reviewed by the Council Scientific and Statistical Committee (SSC)
- Selection of OFL control rules: the SSC!

Control Rules and MSE-II

- Selection of HG control variants:
  - Initially based on those considered when the current Harvest Guideline control rule was adopted
  - Additional options added by:
    - The Coastal Pelagic Species management team
    - The public (via the Council)
  - Software made available to the public who provided suggestions based on their analyses.

Control Rules and MSE-III

- Performance measures for the MSE:
  - Initially based on those considered when the current Harvest Guideline control rule was adopted
  - Performance statistics added based on input from the:
    - Coastal Pelagic Species Management Team,
    - Coastal Pelagic Species Advisory Subpanel, and
    - Public (NGOs, industry).

Questions?