The Fish, the People, and the Tradeoffs:
Social-Ecological Coupling in the Wetfish Fishery of Monterey Bay, California

Stacy Aguilera and Rachel Zuercher

Pacific Sardine Management:
A brief overview of the current equations employed by the Pacific Fishery Management Council

This information is brought to you directly from the PFMC CPS Fishery Management Plan

The annual HG is calculated as follows:

$$HG = (BIOMASS - CUTOFF) \bullet FRACTION \bullet DISTRIBUTION$$

HG = (BIOMASS – CUTOFF) • FRACTION • DISTRIBUTION

- Harvest guideline (HG) = the total U.S. quota for the period
  - Example of a period: July 2015 to June 2016
- BIOMASS is the stock biomass (ages 1+) projected
  - as of, for example, July 1, 2015
- CUTOFF (150,000 mt) is the lowest level of biomass for which directed harvest is allowed
- FRACTION (5-20%) is the percentage of biomass above the CUTOFF that can be harvested
- DISTRIBUTION (87%) is the average portion of BIOMASS assumed in U.S. waters

HG = (BIOMASS – CUTOFF) • FRACTION • DISTRIBUTION

For example, stock biomass is projected to be below the 150,000 mt threshold.
Therefore, HG for 2015-2016 is calculated to be 0 mt.

- The sardine fishery managers decided to allocate the quota seasonally, as below:

1) A seasonal allocation structure with 35% of the HG to be allocated coastwide on January 1

2) 40% of the HG, plus any portion not harvested from the initial allocation, is reallocated coastwide on July 1

3) On September 15 the remaining 25% of the HG, plus any portion not harvested from earlier allocations, is reallocated coastwide

The formula:

- Uses the estimated biomass for the whole stock in 1 year (BIOMASS)
- Sets the harvest for the whole stock in the following year (H)
- BUT abundance index values or other data can be used instead
- BIOMASS is only an estimate
- BIOMASS is a NOT a perfect measure of abundance
- Efforts to develop a harvest formula consider probable levels of measurement error in BIOMASS

- The general harvest control rule for CPS (Coastal Pelagic Species) is compatible with the Magnuson Stevens Act and acknowledges these fisheries as FORAGE FISH

- If the CUTOFF is greater than 0, then the harvest rate (H/BIOMASS) declines as biomass declines

- By the time BIOMASS falls as low as CUTOFF, the harvest rate is reduced to 0

- The CUTOFF provides a buffer of spawning stock that is protected from fishing & available for use in rebuilding if a stock becomes overfished

- The combination of a spawning biomass buffer equal to CUTOFF and reduced harvest rates at low biomass levels means that a rebuilding program for overfished stocks may be defined implicitly.

- Moreover, the harvest rate never increases above FRACTION

- If FRACTION is approximately equal to FMSY, then the harvest control rule harvest rate will not exceed FMSY

- In addition to the CUTOFF and FRACTION parameters, it may be advisable to define a maximum harvest level parameter (MAXCAT) so that total harvest specified by the harvest formula never exceeds MAXCAT

- MAXCAT is used to:
  - Guard against extremely high catch levels due to errors in estimating biomass
  - Reduce year-to-year variation in catch levels
  - Avoid overcapitalization during short periods of high biomass and high harvest
  - Prevent the catch from exceeding MSY at high stock levels and spreads the catch from strong year classes over a wider range of fishing seasons

- Annual Catch Limits (ACLs) will be set no higher than Acceptable Biological Catch (ABC)
- ACLs may be sector-specific
- Harvest control rules and other Optimum Yield (OY) considerations will be used to set an H
- The HG cannot exceed the ACL or ABC
- In cases where the HG DOES exceed the ABC, the Council will set a lower ACL, HG, or ACT (annual catch target) in response
- A HG or ACT may be utilized below a ACL or sector-specific ACL to account for:
  - management uncertainty
  - discard or bycatch mortality
  - research take
- These provisions will be considered on an annual basis in response to changing resource status & fishery dynamics

Options

Sardine Management Model (SIMREZ)

Larry Jacobson's Model

Age structured dynamic pool model
    1 cohort per year : Adults (ages 1-6+)
Single box model (no spatial resolution)
Numbers based model (Biomass calculated)
Base run produces 9260 different 1000 year simulations

SST-dependent Ricker Spawner-Recruit model

The SST time series has mean, variance, and auto-regression term derived from the Scripps Pier data that the recruitment model was based on. Random variance from the SST-dependent Ricker model has the same percentage of error variance as the fitted SST-dependent model.

Slides by Richard Parrish

Sardine Management Model

Growth is age dependent.
Natural mortality is constant (M=0.4)
Fecundity is age-dependent

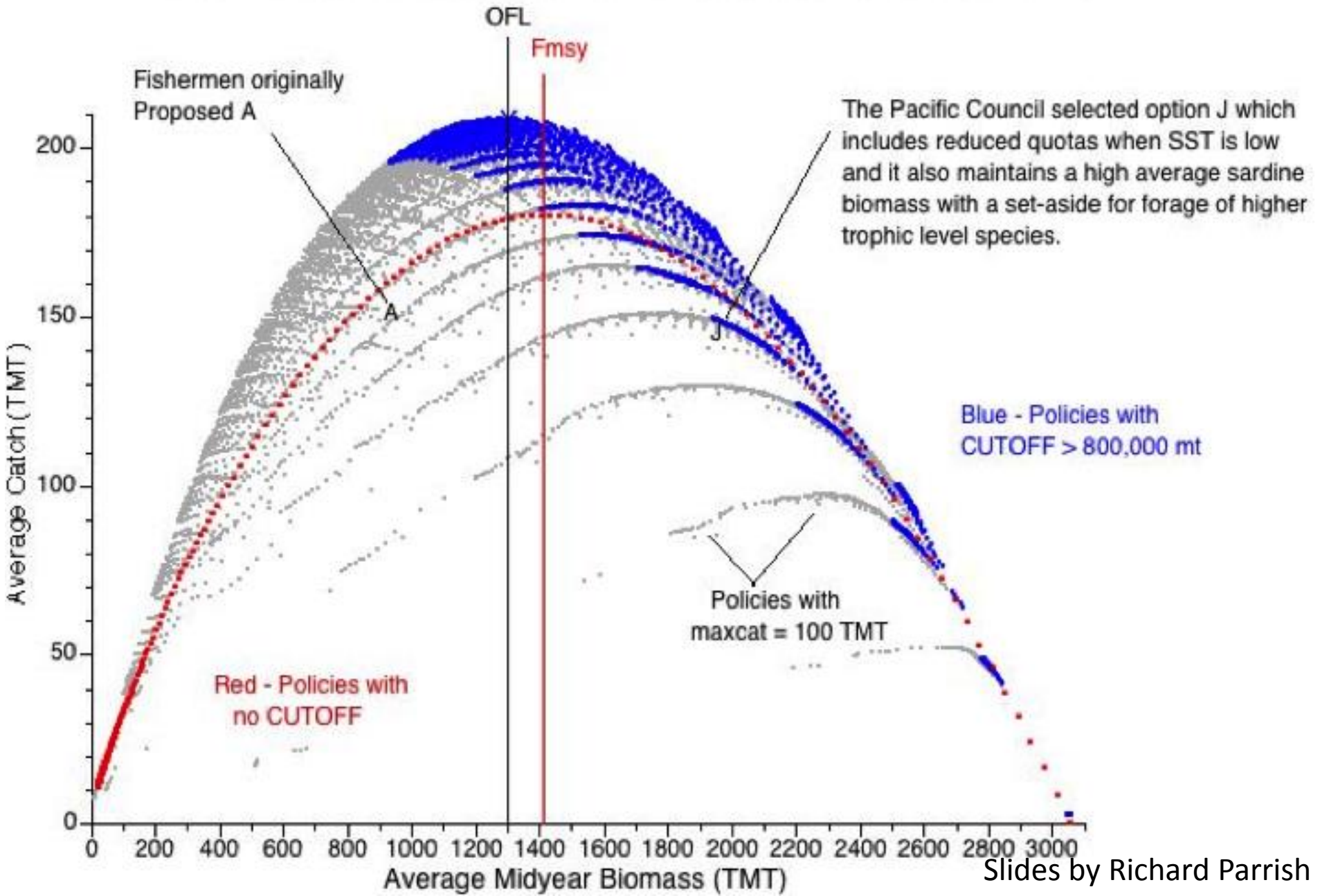
Catch is based on a control rules which establish annual quotas based on age 1+ biomass and SST
However, the biomass is not "known", i.e. the biomass used to set the quota has a simulated error term based on the standard errors of recent sardine stock assessments.

Control rules use CUTOFF, FRACTION, MAXCAT
Some use SST-dependent FRACTIONS (5-15%, 10-30%)

Output: mean, median, ln and SD of catch and biomass.
years with no fishery,

Slides by Richard Parrish

Sardine Fishery Simulation Results: Average biomass vs average catch for 13 proposed management policies, 240 exploitation rates (0.0025-0.6) and 9260 policies with a wide range of cutoffs (0-1000 TMT), constant fractions (0.05-1.0) and maxcats.(50-1000 TMT).

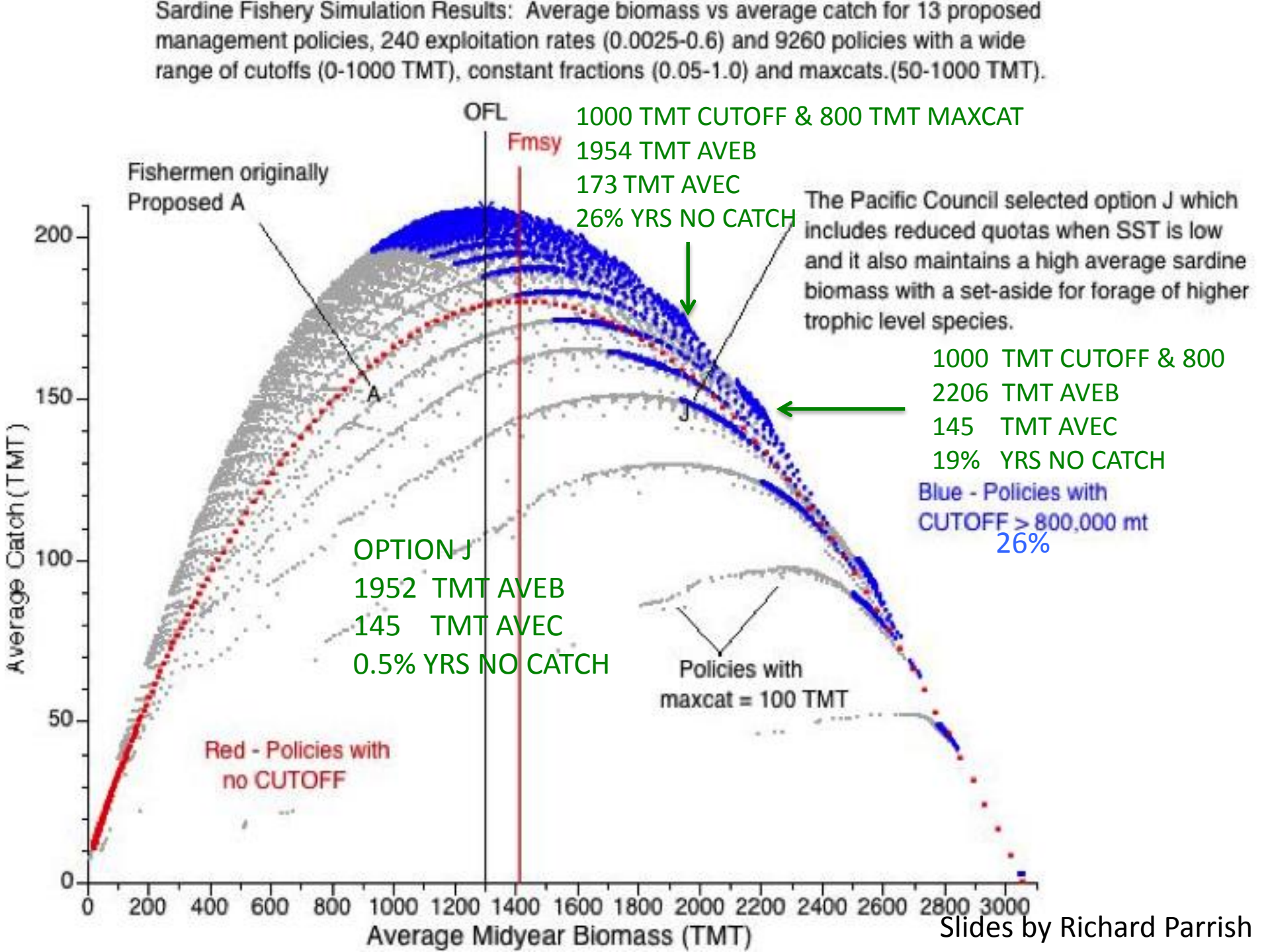


Slides by Richard Parrish

Originally presented Management Polices with addition of a policy with the same maximum catch and cutoff but with a constant 15% fraction instead of a fraction based on sea surface temperature (i.e. 0.05-0.15%).

	OFL Max. Catch	Stochastic MSY	Fishermen's Preferred	Science team Preferred	Deletion SST Fraction
Cutoff	1000	50	50	150	150
Slope	0.45	0.12	0.2	0.05-0.15	0.15
Maxcat	1000	0	400	200	200
Ave. catch	208	180	151	145	147
SD Catch	306	180	137	67	67
Median catch	16	128	103	182	193
Ave. Biomass	1307	1408	598	1952	1825
Ave. Depletion	43%	46%	20%	64%	60%
% No catch	47%	0%	5%	0.5%	0.3%
% Years Bio. >0.4 MMT	94%	84%	61%	96%	91%

Slides by Richard Parrish



Slides by Richard Parrish