

# Defining overfished stocks

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# Structure of the talk

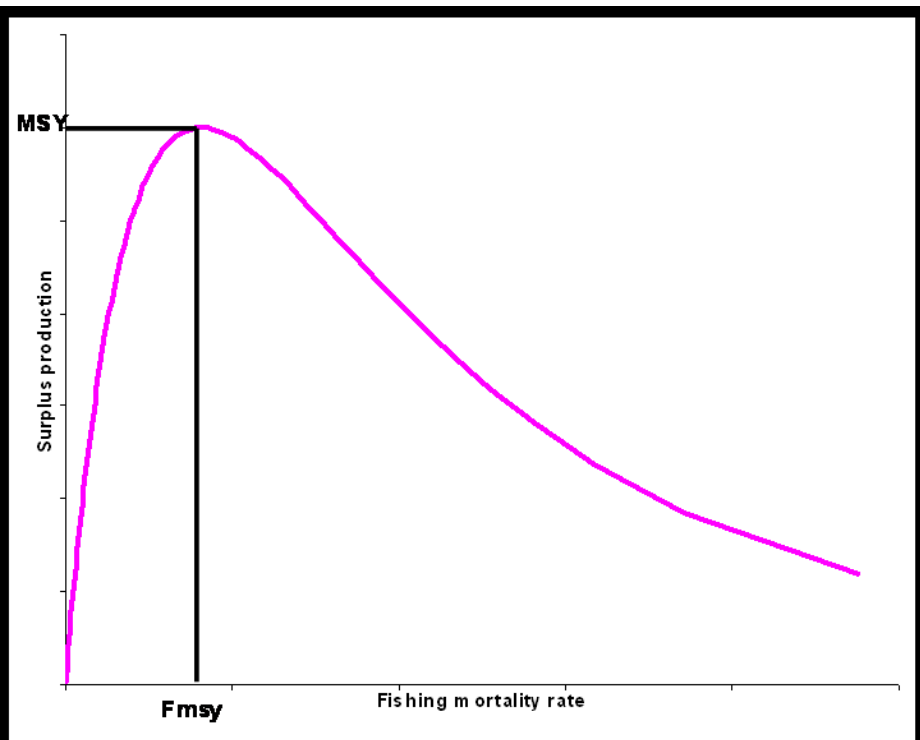
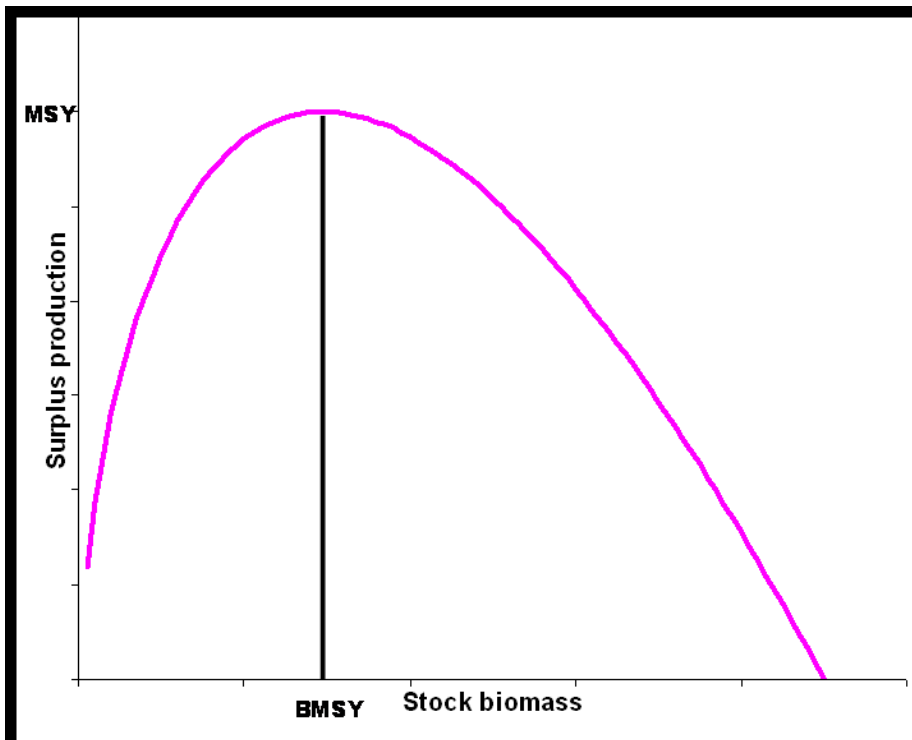
- History and significant events
- MSY and biomass levels corresponding to overfished
- Economic and ecosystem overfishing

# Where did the ideas come from?

- Long history of scientific thought
  - Petersen 1903 “What is Overfishing?”
  - Graham 1935 “Modern theory of exploiting a fishery, and application to North Sea trawling”
  - 1950s – Beverton-Holt, Ricker, Schaefer

# Basic scientific theory

Equilibrium yield vs biomass and fishing mortality



This theory was translated into  
international and national legislation

# UNCLOS Article 61.3

“Such measures shall also be designed to maintain or restore populations of harvested species **at levels which can produce the maximum sustainable yield**, as qualified by relevant environmental and economic factors, including the economic needs of coastal fishing communities and the special requirements of developing States, and taking into account fishing patterns, the interdependence of stocks and any generally recommended international minimum standards, whether subregional, regional or global.”

# Peter Larkin

## “An Epitaph for the Concept of Maximum Sustained Yield” 1977

“The basic idea was enshrined in national policy documents, incorporated in international treaties, and, in effect, became synonymous in most people's minds with sound management. Most fishery managers and politicians engaged in a steady dialogue of explaining why they had to compromise a bit on MSY for "social reasons" but, in so doing, they usually sounded apologetic. They knew they were sinning. “

# The sin

- Lost yield due to overfishing
- Not willing to accept “the short-term pain for long-term gain”



# Magnuson-Stevens Fisheries Management and Conservation Act

section 301 98-623

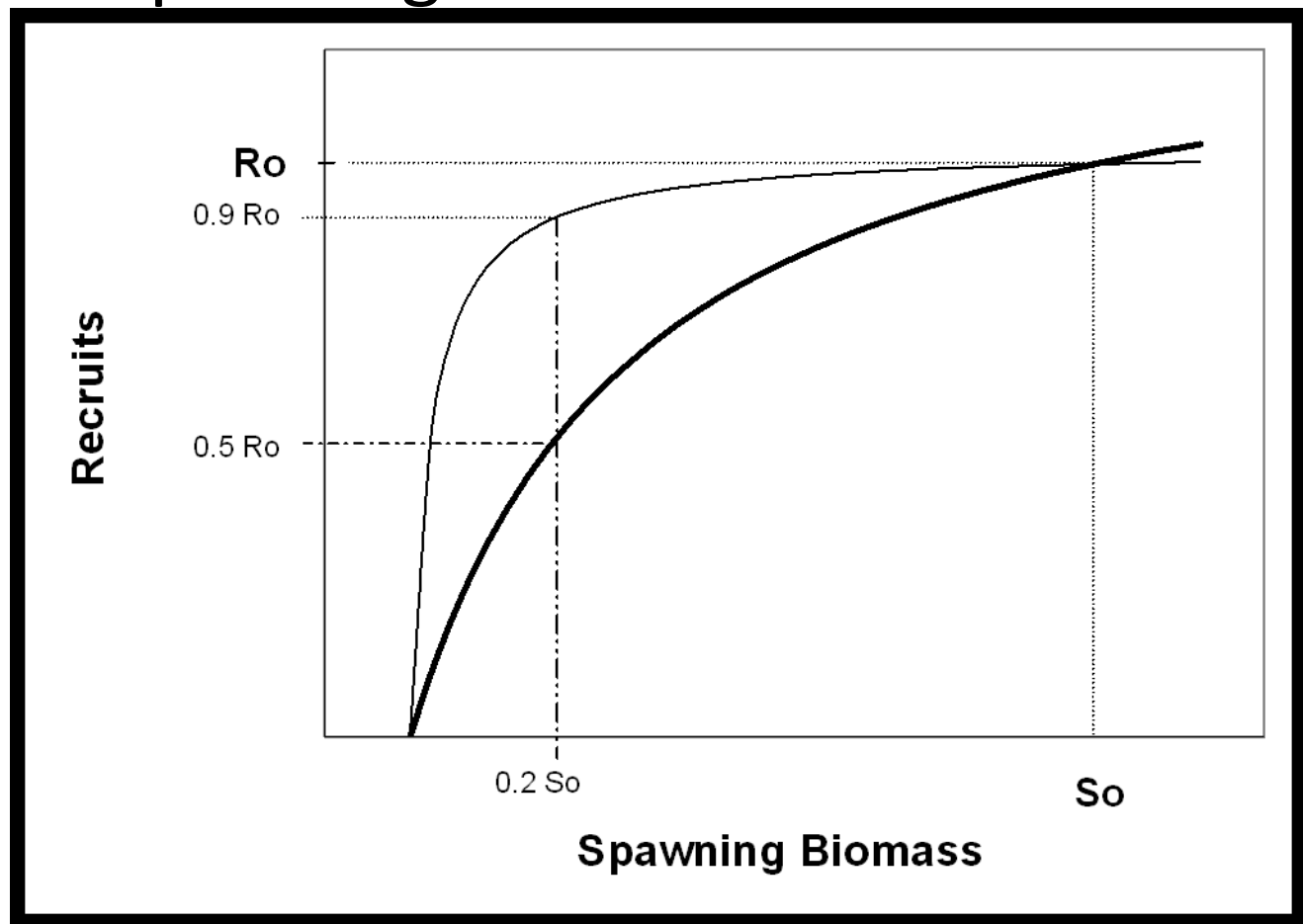
Conservation and management measures shall **prevent  
overfishing** while achieving, on a continuing basis,  
the optimum yield from each fishery for the United States  
fishing industry .

# NOAA National Standard Guidelines

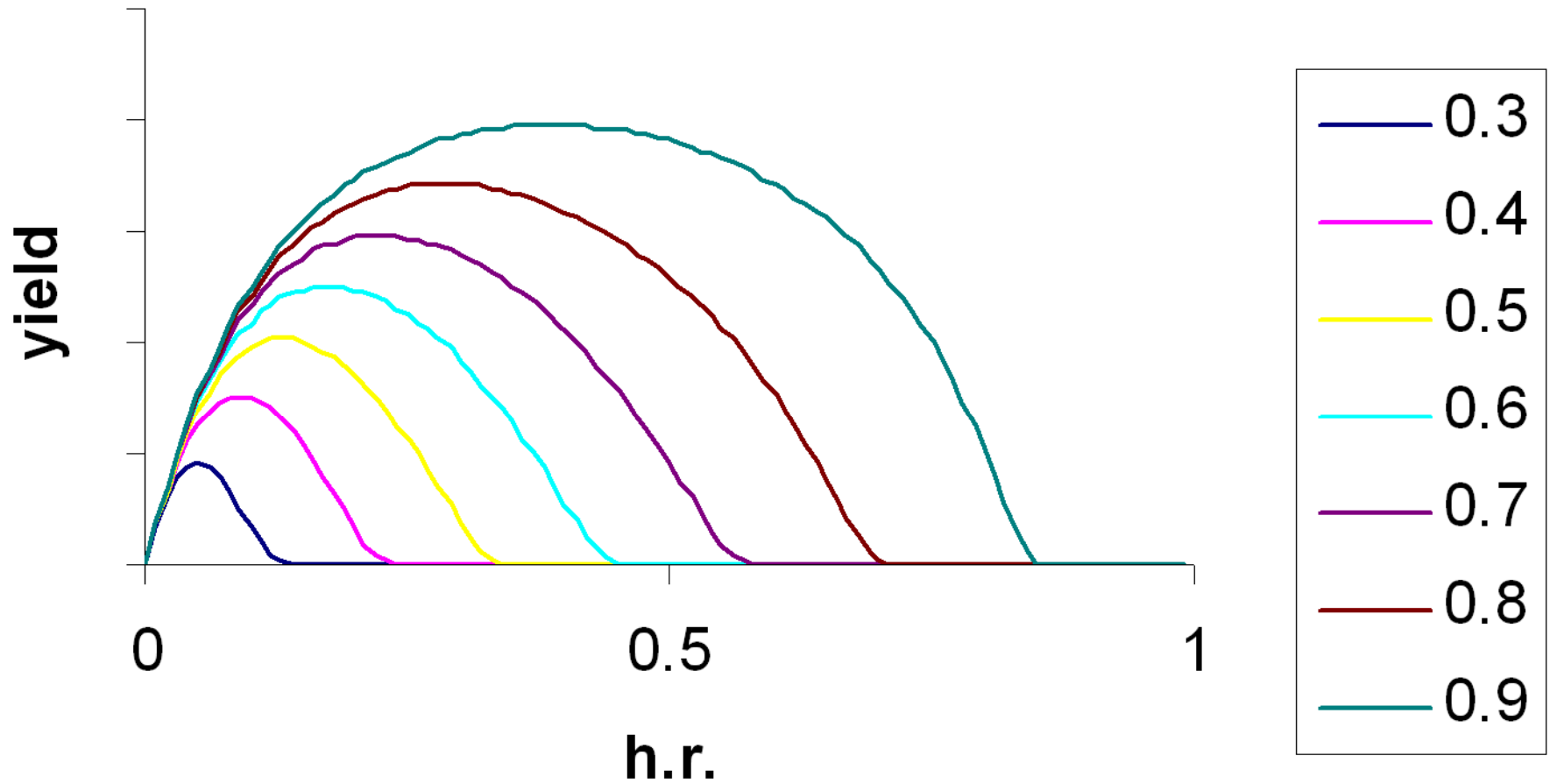
(xxi) MSY stock size (BMSY) means the long-term average stock abundance level of the core stock or stock assemblage, measured in terms of spawning biomass or other appropriate [sic], that would occur while fishing according to the MSY control rule. The MSY stock size is the target stock size to which depleted stocks must be rebuilt.

# Steepness in recruitment

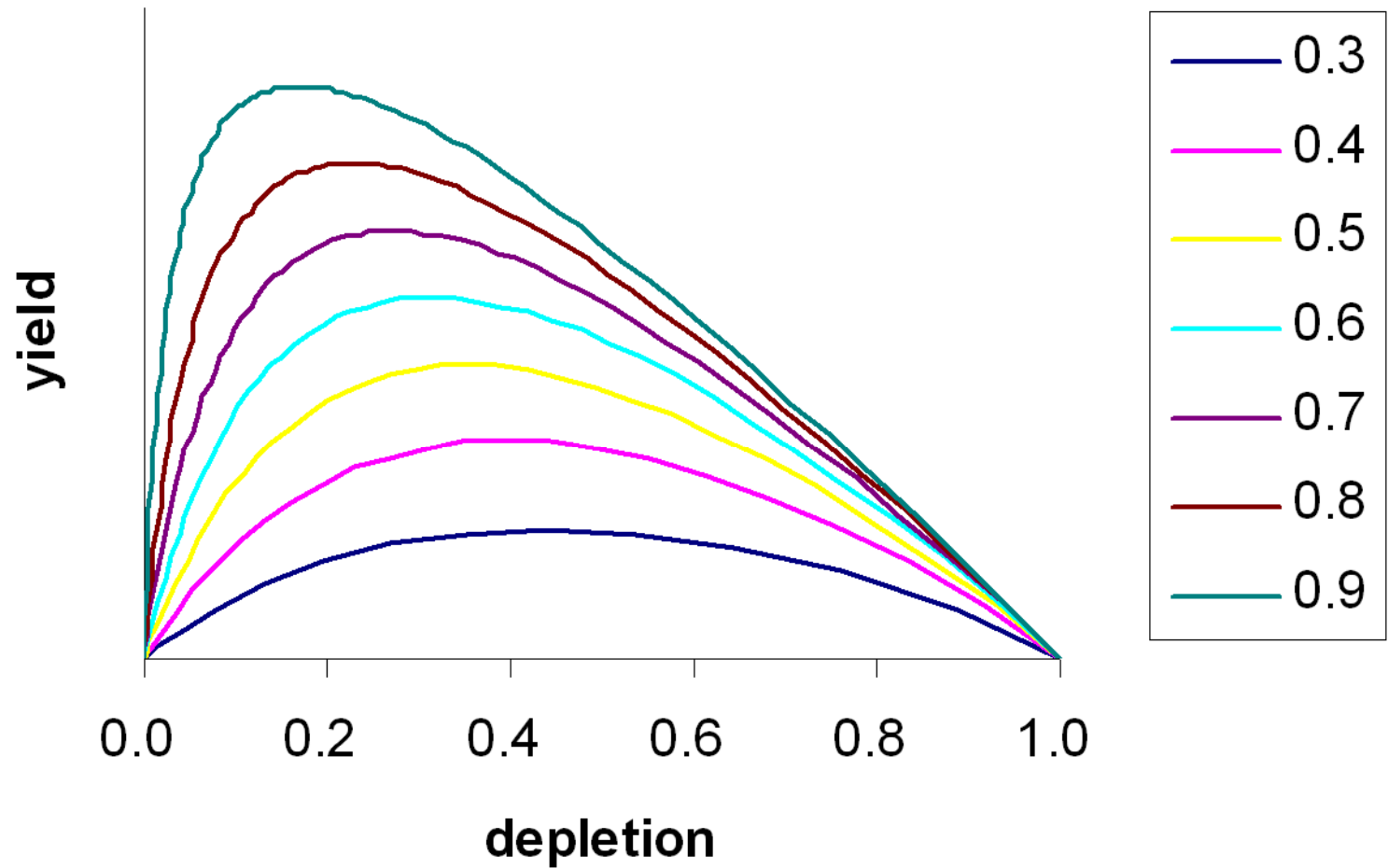
- How much recruitment declines at 20% of unfished spawning stock



## steepness



# Yield vs. depletion ( $B/B_0$ )



# Defining BMSY

PFMC 25% overfished definition

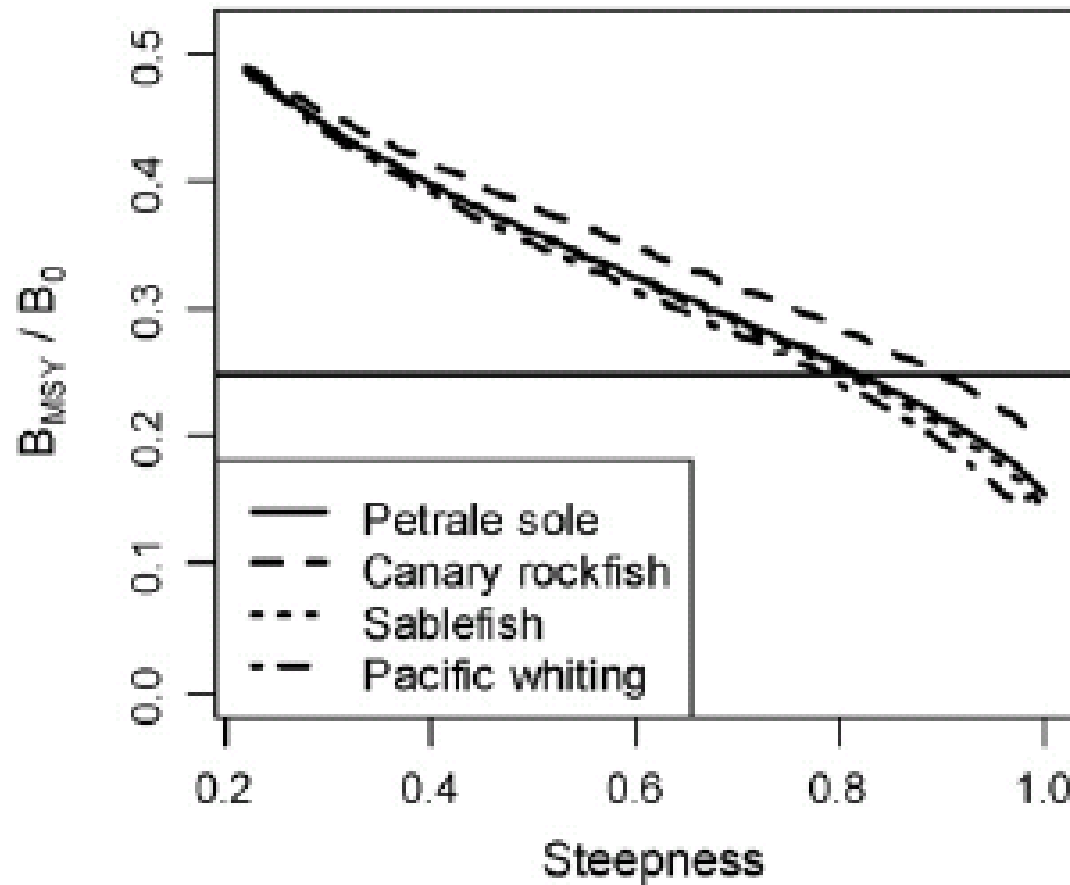


Figure from Punt et al in press

# Meta analysis of steepness

from Myers et al. 1999

Taxon	Number of data sets	Lower 20% bound	Midpoint	Upper 80% bound
Clupeidae	39	0.49	0.71	0.86
Gadidae	49	0.67	0.79	0.87
Pleuronectidae	14	0.71	0.80	0.87

# Defining BMSY

PFMC 25% overfished definition

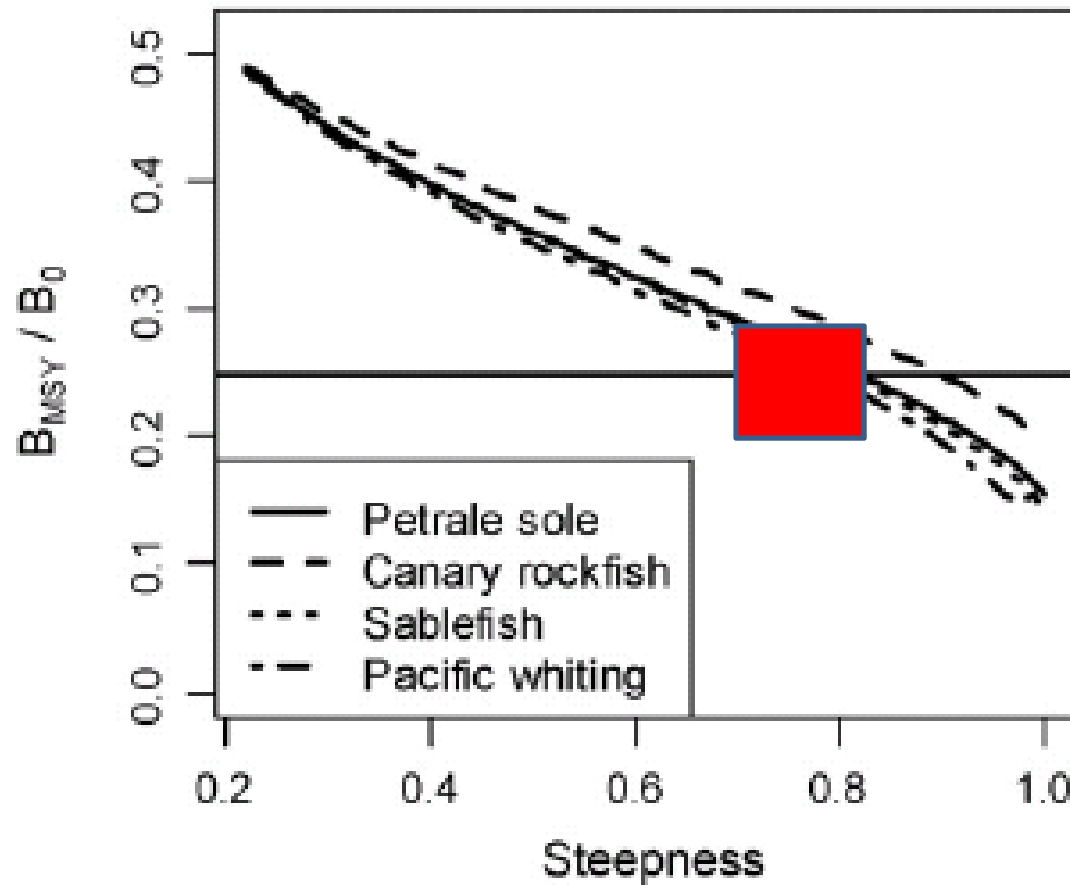


Figure from Punt et al in press



# Defining overfished

- PFMC 25% B0
- NOAA national standard  $\frac{1}{2}$  BMSY
- Australia and New Zealand (proposed) 20% B0 end to directed fishing
- 20% B0 seems to be emerging as an “International Standard”

# Myers et al 1994

“Methods based on 20% B0 were included in this study because they have been widely applied (Beddington and Cooke, 1983; Francis, 1992); however, based on both empirical and theoretical considerations **we do not recommend them for general use.** These methods often placed the critical point well beyond the range of the observations (e.g. in 36% of cases for BHv). In addition, they suffer from two other related problems: inaccuracies in the estimates of virgin biomass, and the inappropriateness of applying the 20% level universally. Estimates of virgin biomass calculated by the method used here are inaccurate because they assume stationarity (e.g. no density-dependent processes) to calculate the  $F=0$  replacement line and generally rely on extrapolating the S-R data beyond the range of the observations. Similarly, a threshold of 20% B0 will not be universally applicable since different stocks have different degrees of compensation (i.e. density-dependence) in recruitment and other life-history processes.”

# Impact of steepness

Steepness	BMSY	% potential Yield at 1/2	% potential Yield at
		BMSY	25% B0
0.3	0.45	0.75	75%
0.4	0.38	0.73	87%
0.5	0.36	0.83	93%
0.6	0.31	0.85	98%
0.7	0.26	0.87	100%
0.8	0.22	0.88	100%
0.9	0.16	0.93	97%*

# A logical definition of overfished

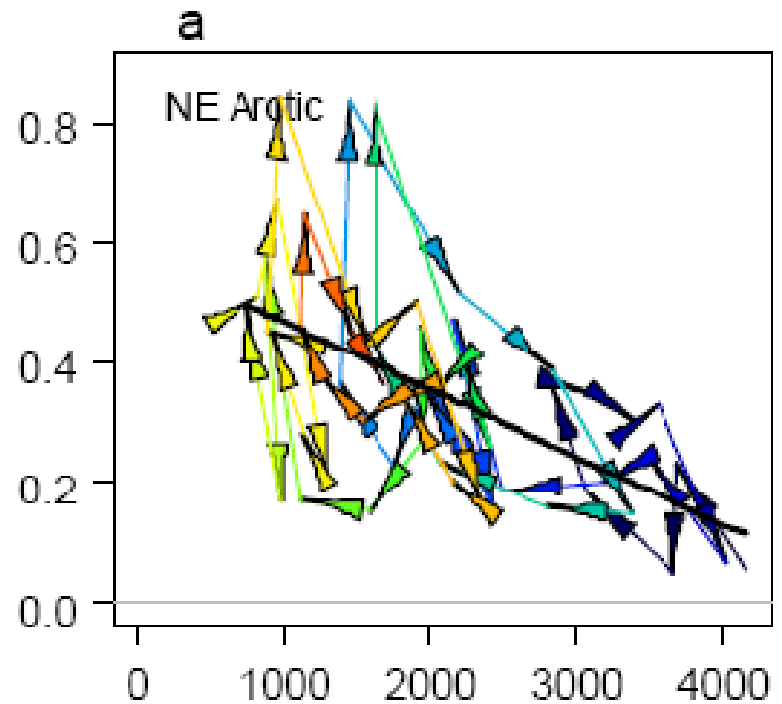
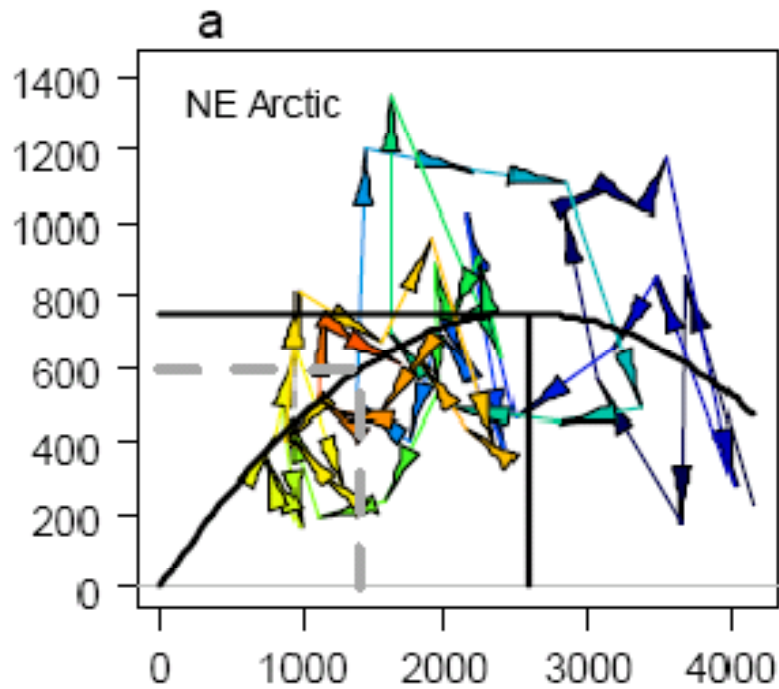
- Stock size below which some fraction of potential yield is lost (20% perhaps)
- The lower limit of a stock fluctuating under a FMSY strategy, perhaps the lower 10% or 5%

# You have to ask why

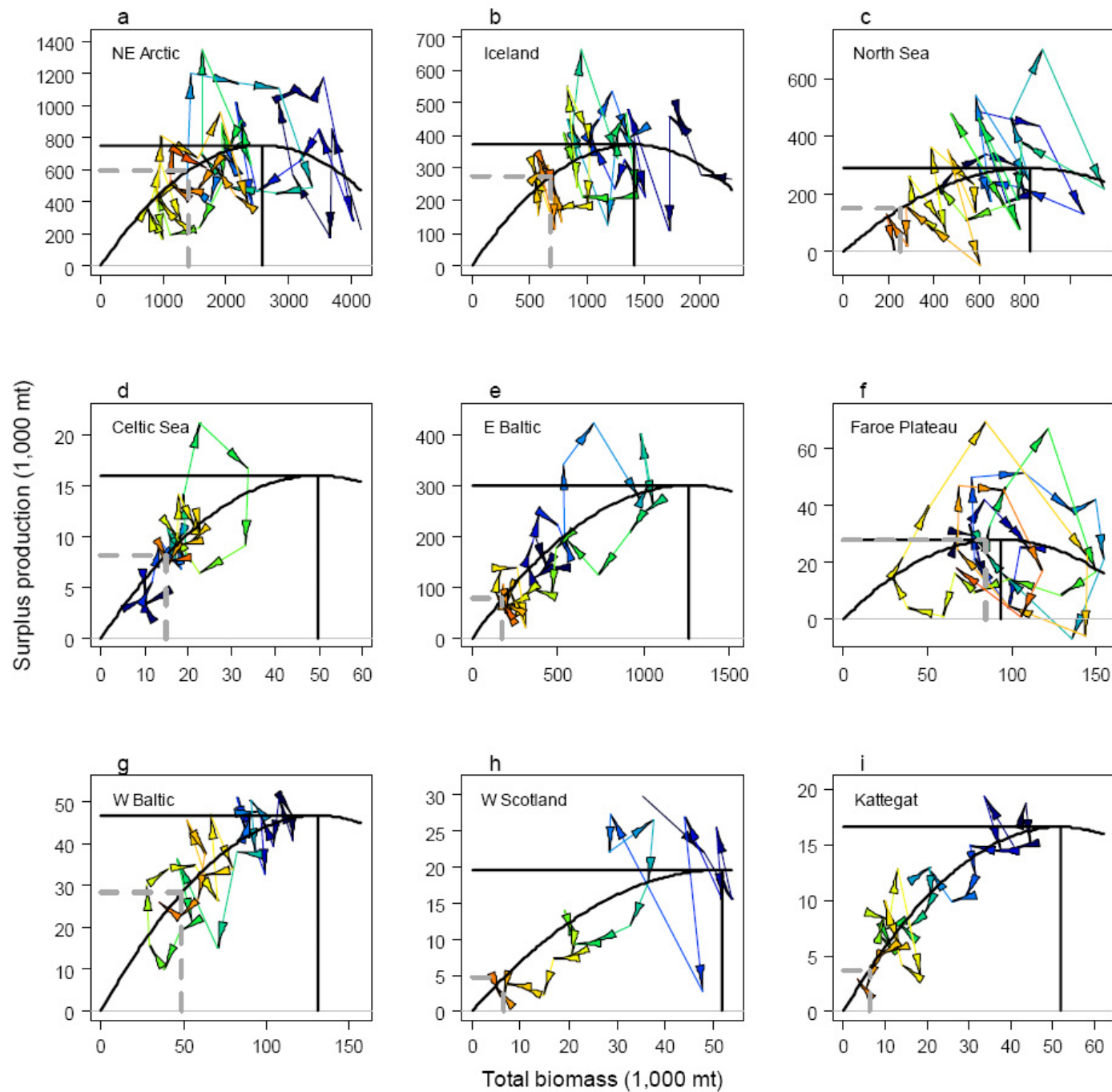
- Councils and NOAA define “overfished” in a way that doesn’t make biological sense for many stocks
  - For instance many stocks would be frequently classified as overfished in the absence of fishing
- And then the most important performance measure they report to congress is % of stocks overfished?



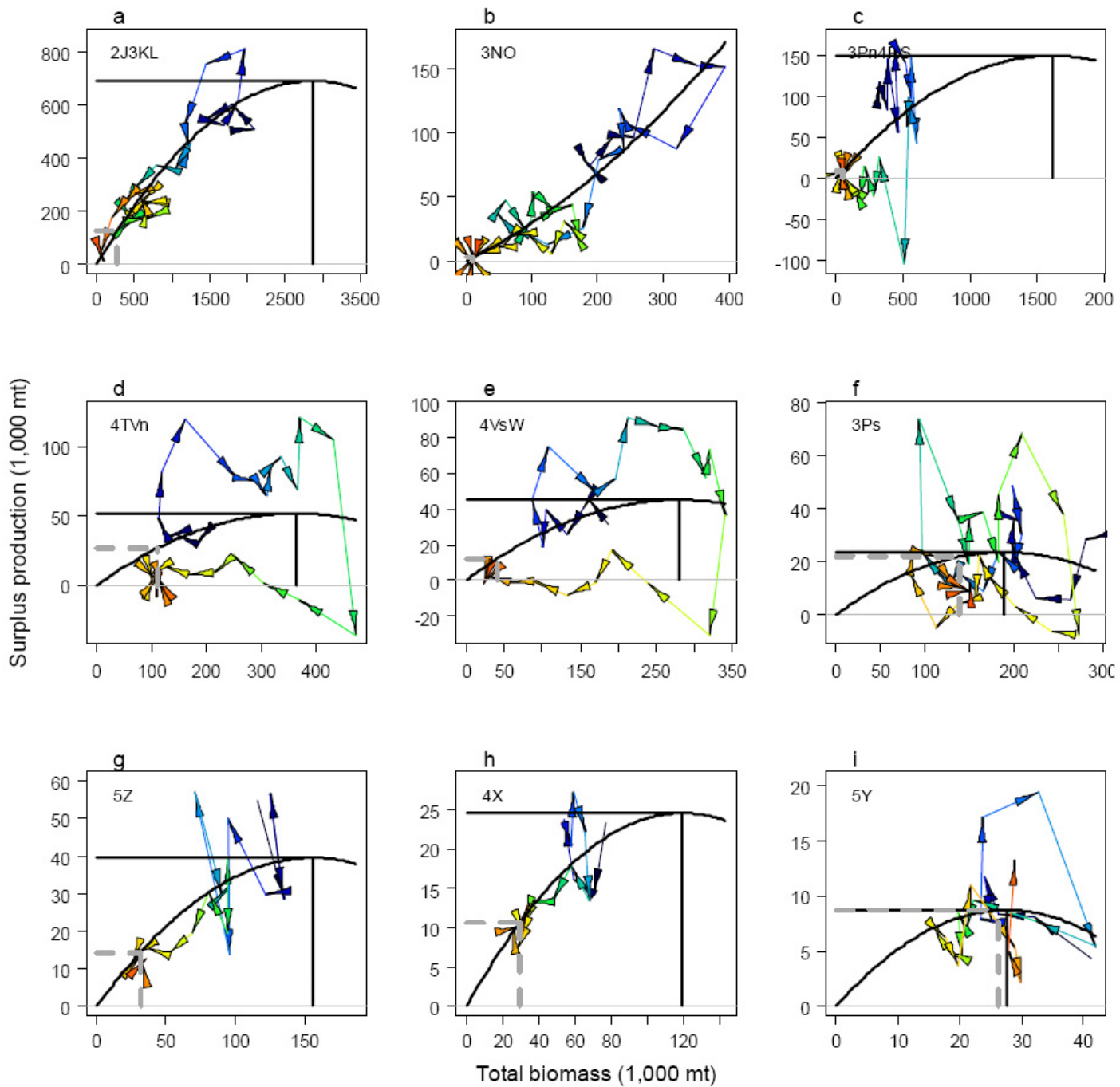
# Is productivity actually related to biomass?



$$\text{Surplus production}(t) = \text{biomass}(t+1) - \text{biomass}(t) + \text{catch}(t)$$





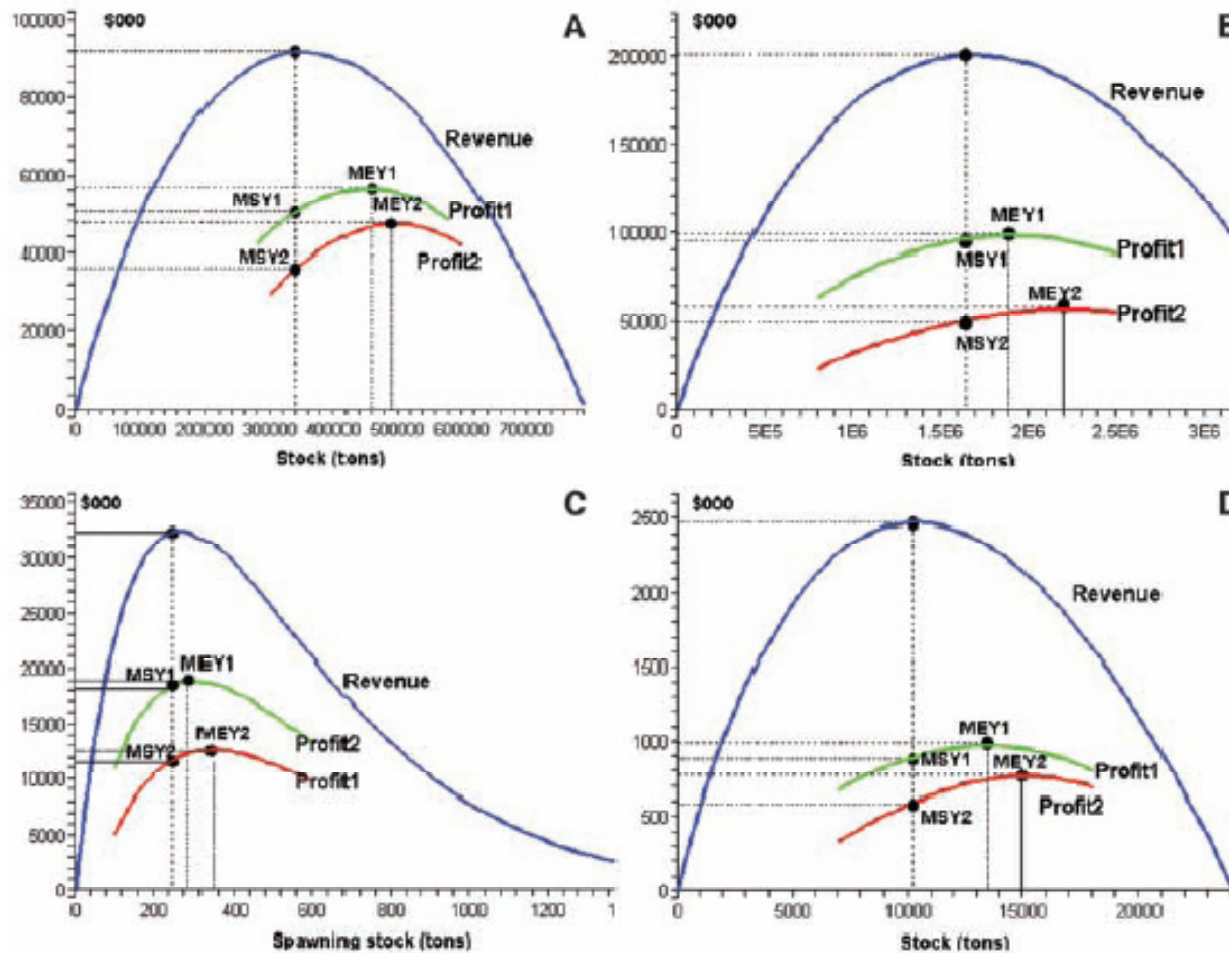


# Alternative hypotheses regarding productivity

- Related to spawning biomass – the basis for existing reference points
- Comes in climate regimes – with little impact of spawning stock
- A combination of both
- Is random – just varies from year to year

# Economic overfishing

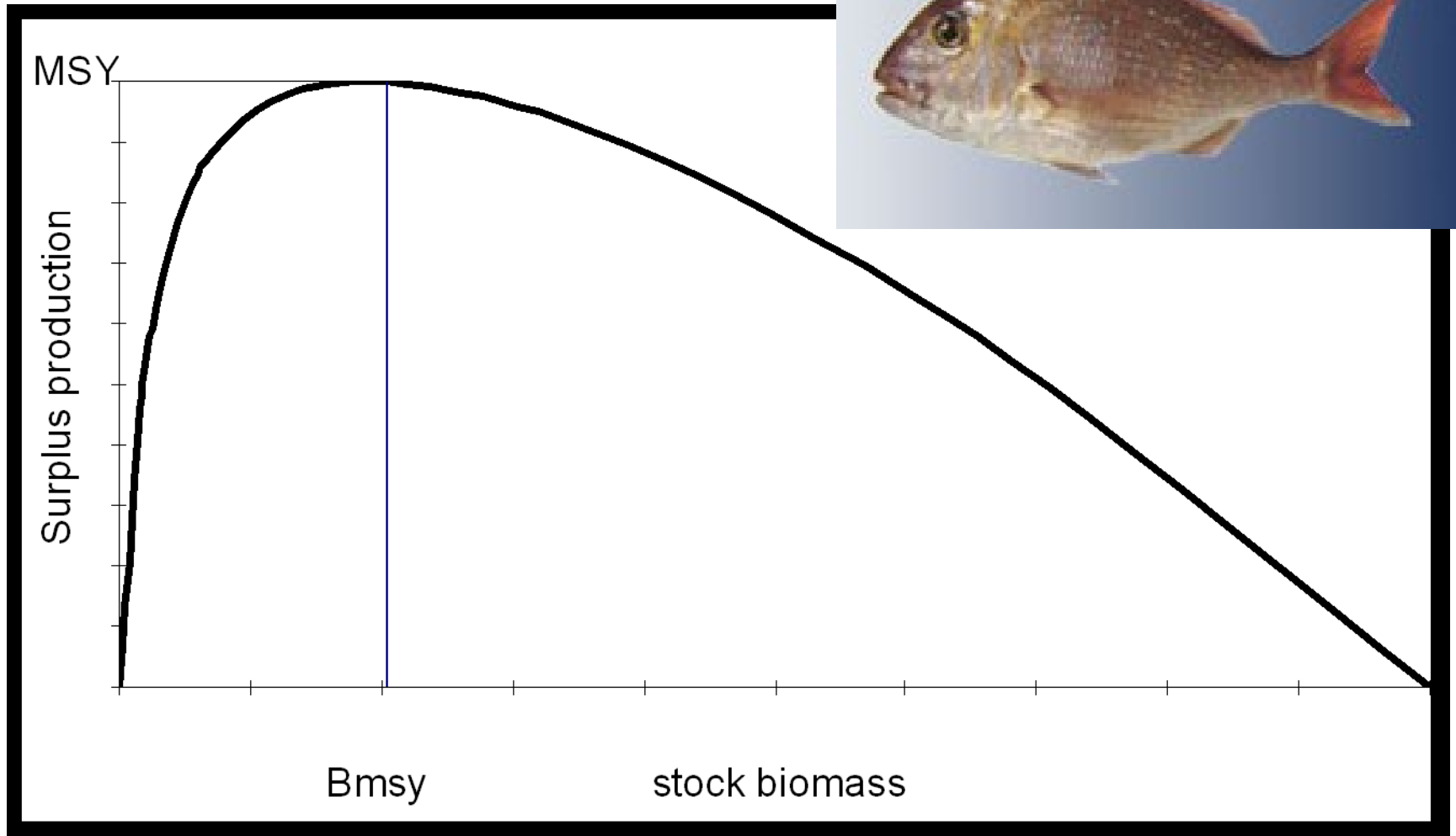
## From Grafton et al Science 2007



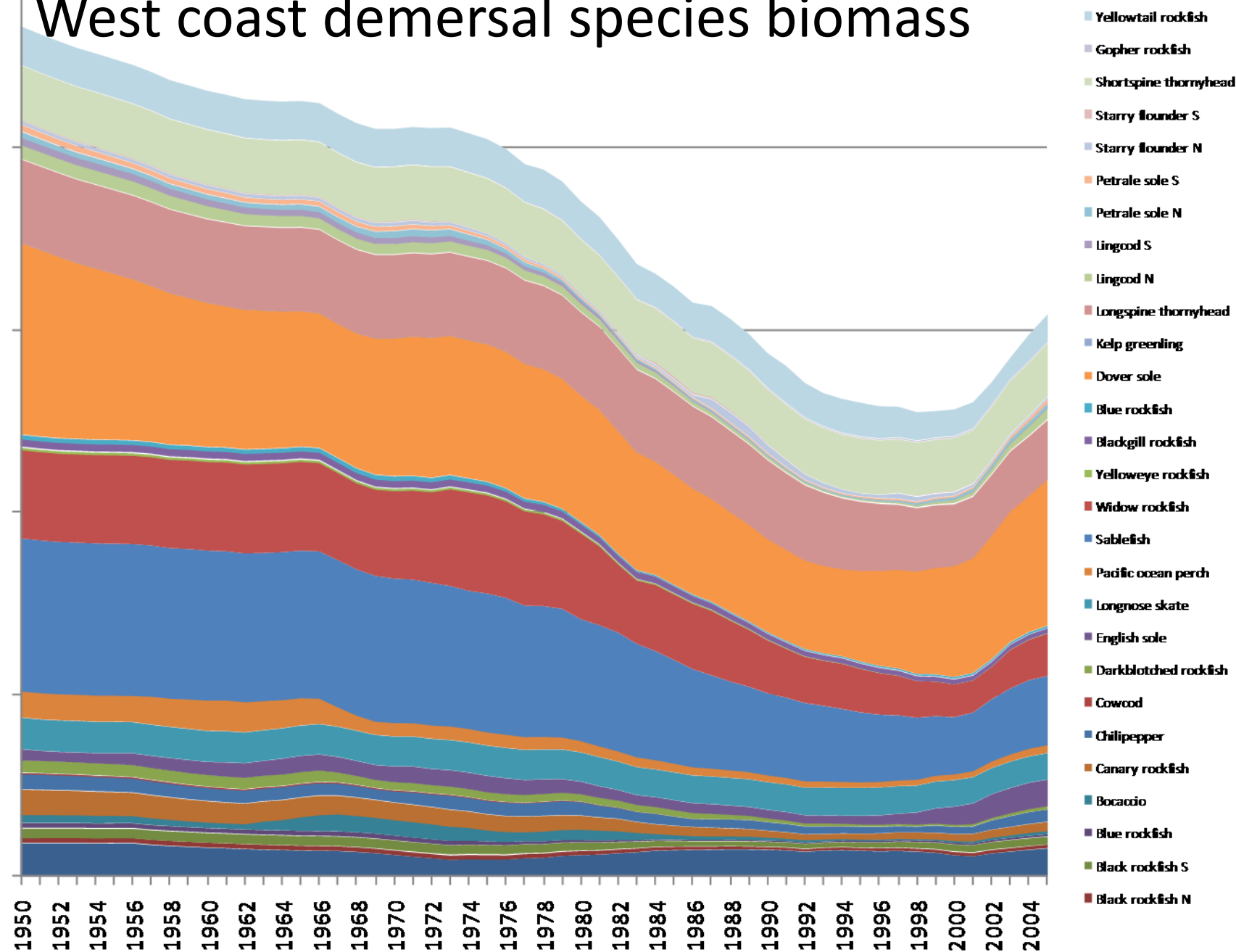
**Fig. 1.** (A)  $B_{MEY}$  and  $B_{MSY}$  of Western and Central Pacific big eye tuna. (B)  $B_{MEY}$  and  $B_{MSY}$  of Western and Central Pacific yellowfin tuna. (C)  $B_{MEY}$  and  $B_{MSY}$  of Australian northern prawn fishery. (D)  $B_{MEY}$  and  $B_{MSY}$  of Australian orange roughy fishery.

# The New Zealand snapper 1 fishery

- Estimated to be at 50% of BMSY producing 92% of MSY (1996-7 assessment)
- To rebuild to BMSY would have required a 40% catch reduction for 20 years,
- in order to achieve an 8% catch increase after 20 years
- Would you accept a 40% pay cut if economists said they thought it would result in an 8% increase 20 years later?

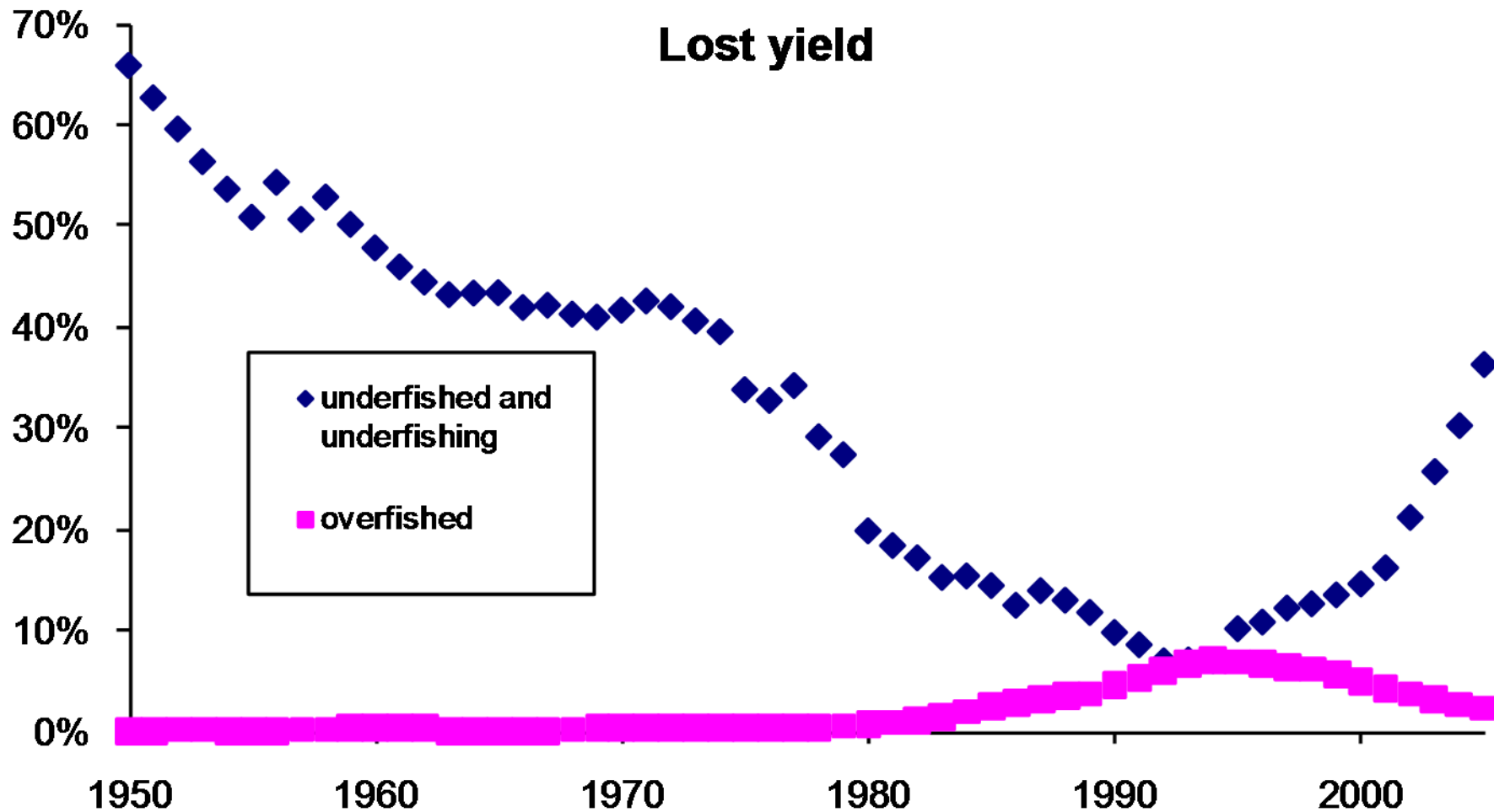


# West coast demersal species biomass



# What is the cost of overfishing?

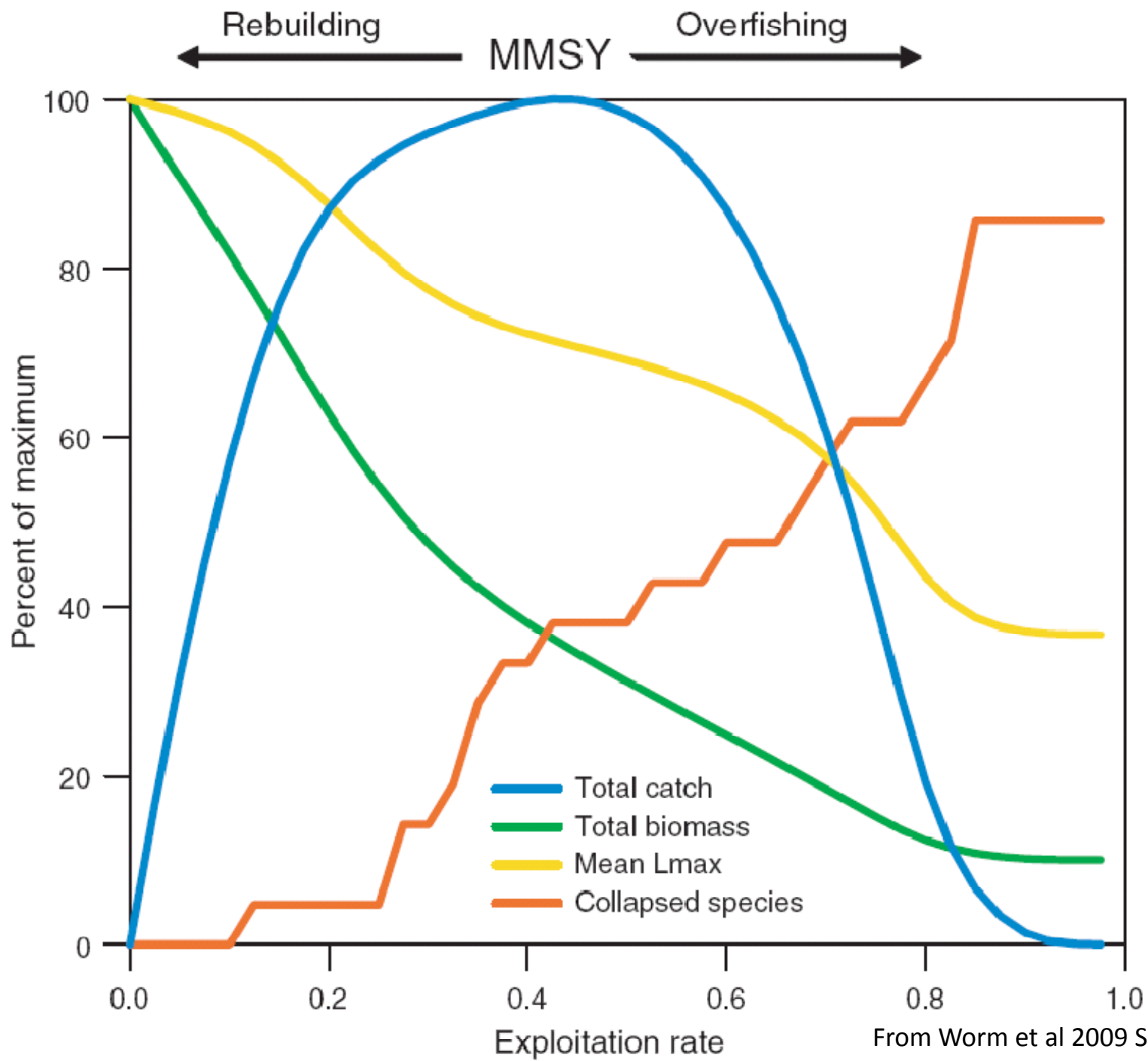
## California current demersal fish



# U.S. National Performance

- 25-30% of stocks are overfished
- We lose perhaps 10% of potential yield from overfishing
- We almost certainly lose more than that from underfishing





From Worm et al 2009 Science

# Key issues

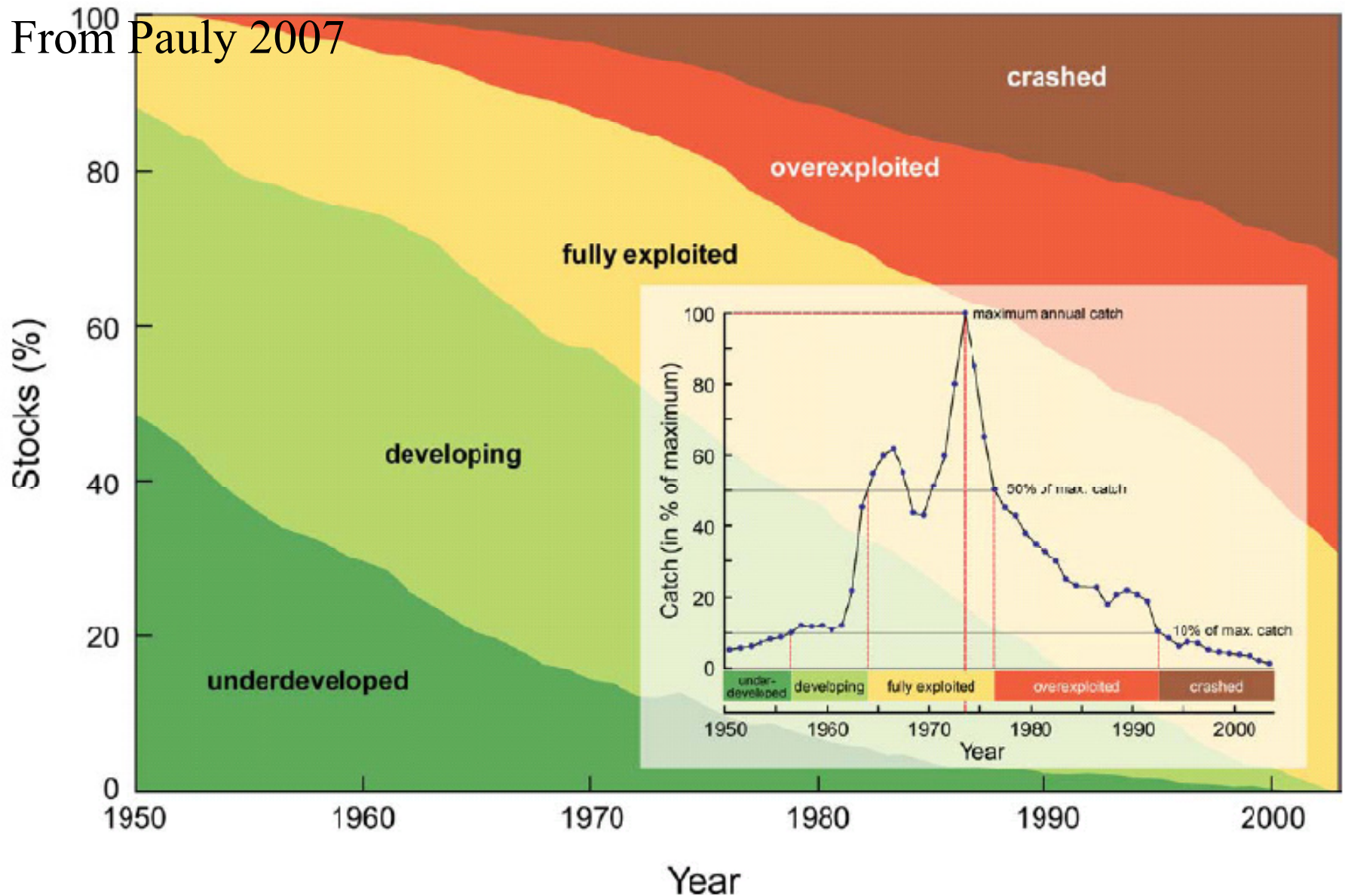
- Generally little lost yield at current overfishing definitions
- Economic and ecosystem impacts are better when fishing pressure is less than FMSY
- Trying to keep all stocks above BMSY will mean considerable lost yield for productive stocks

# A cost of underfishing

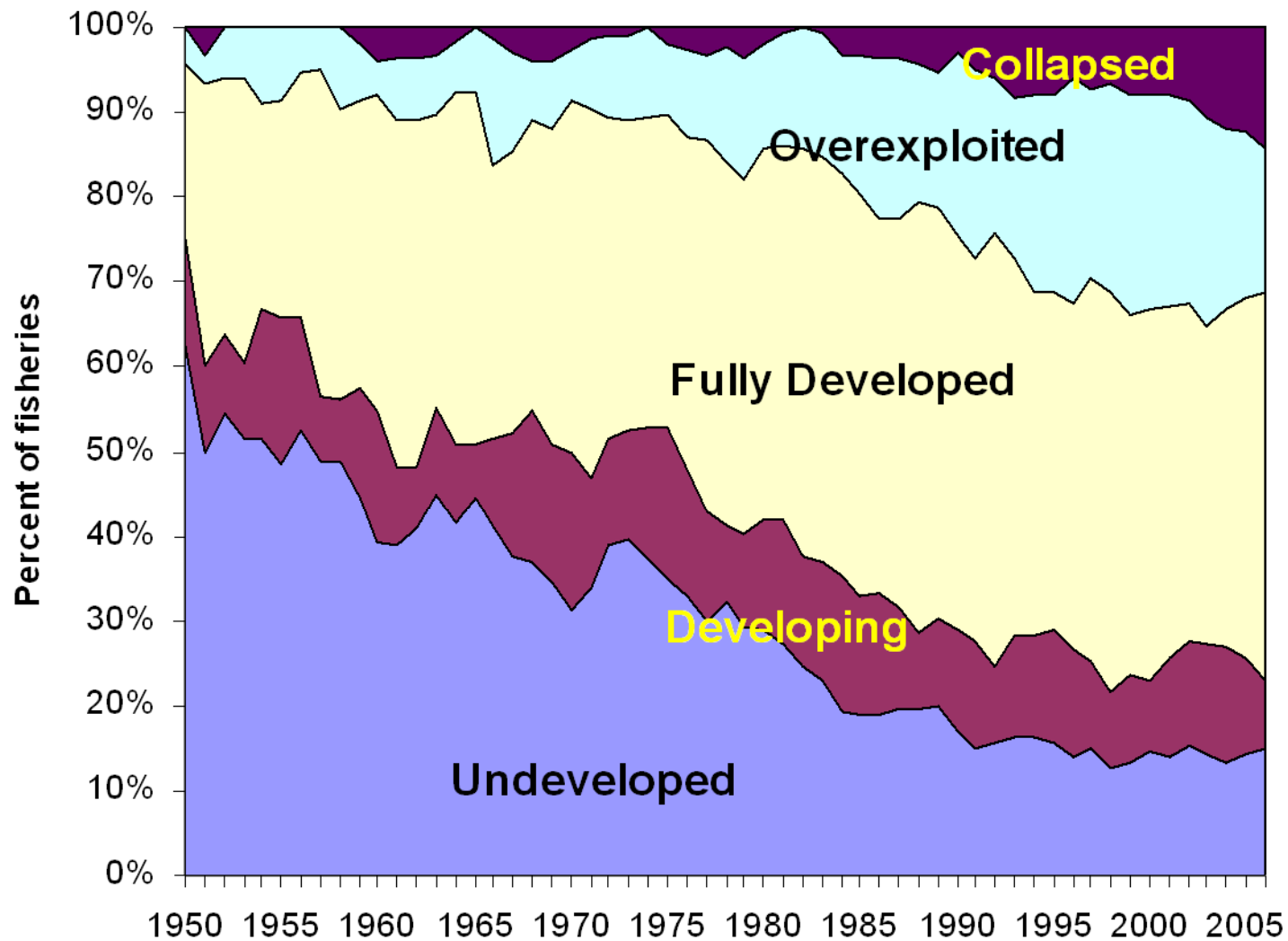
- Capture fisheries account for about 25% of world animal protein production
- Capture fisheries do have environmental impacts, but livestock production generally has more significant impacts
  - Energy efficiency, CO2 footprint, water, pollutants
- If we forgo fisheries yield to “protect the environment” we may be having more significant effects from the livestock that is substituted

# Pauly's "status of fisheries" from catch data

From Pauly 2007



# A more realistic appraisal



# Summary

- The emerging standards of 40% and 20% are often biologically unrealistic
- For most stocks we can't estimate  $B_0$
- They have no basis in the legislative mandate of MSY
- They can be justified on economic or ecosystem grounds, but if so those proposing such standards need to say so and not hide behind the legislative mandate of MSY.

# Sustainable development

**Sustainable development** is a pattern of resource use that aims to meet human needs while preserving the [natural environment](#) so that these needs can be met not only in the present, but in the indefinite future. The term was used by the [Brundtland Commission](#) which coined what has become the most often-quoted definition of sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs."

# Final remarks

- Sustainability is generally recognized to include sustainability of the resource and the human communities that depend on them
- The discussions of harvest strategies and certification (MSC, Monterey Bay Aquarium etc) make no reference to human communities and does not consider “meeting the needs of the present”
- We need a national discussion of the objective of marine fisheries management and performance measures