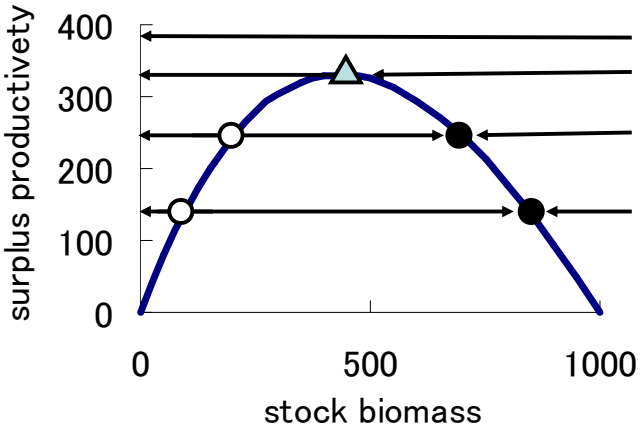
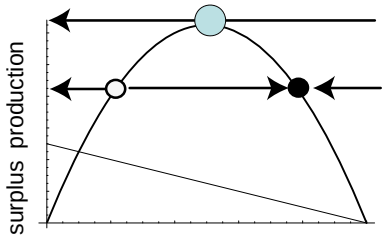
Classic MSY theory



Requiem to Maximum Sustainable Yield Theory

- Ecosystems are uncertain, non-equilibrium and complex.
- MSY theory ignores all the three.
- Does MSY theory guarantee species persistence?
  - No!!



The tragedy of the commons (Hardin 1960)

- Open access fisheries promotes overexploitation
- EEZ by UNCLOS (1996)

$dR/dt = (K - E_1 - E_2 - R)\,R$

R: stock size; E_1, E_2 :fishing effort of 2 fishers

Equilibrium $R = K - E_1 - E_2$

Catch $F_1 = RE_1 = (K - E_1 - E_2)E_1$ $F_2 = (K - E_1 - E_2)E_2$

Nash sol. $\partial F_1/\partial E_1 = (K - 2E_1 - E_2) = 0$, $\partial F_2/\partial E_2 = 0$

$F_1 = F_2 = K^2/9$ at $E_1 = E_2 = K/3$, $R = K/3 < R_{MSY}$

The tragedy of the commons

Try by yourself			④The tragedy of the		
Equilibrium N		333	Equilibrium N		333
	e	Catch		e	Catch
A	4	1,333.3	A	4	1,333
B	4	1,333.3	B	4	1,333
Total	8	2,667	Total	8	2,667
r=	12		K=	1000	

1.Moderate e at MSY

平衡資源量		500
	漁獲努力	漁獲量
A国	6	3,000
B国	0	0
合計	6	3,000

2.Equal division for both profit

平衡資源量		500
	漁獲努力	漁獲量
A国	3	1,500
B国	3	1,500
合計	6	3.000

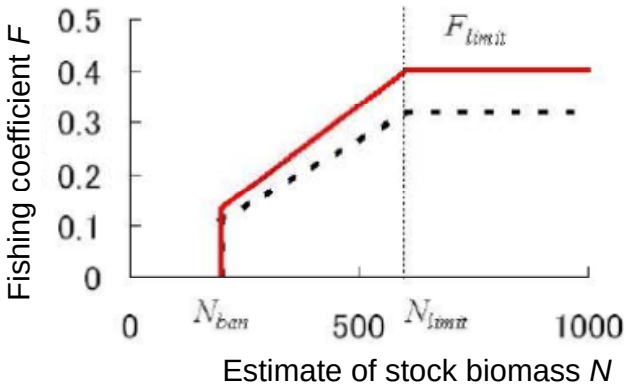
3.If A do cheating, B lose

平衡資源量		417
	漁獲努力	漁獲量
A国	4	1,667
B国	3	1,250
合計	7	2,917

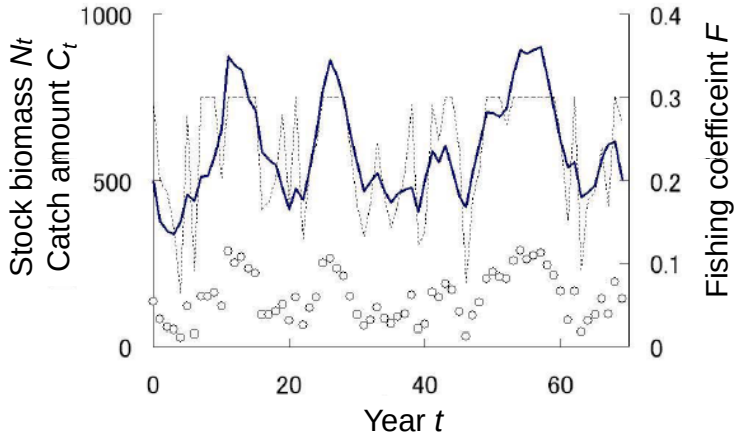
5.If A do cheating more, both

平衡資源量		250
	漁獲努力	漁獲量
A国	5	1,250
B国	4	1,000
合計	9	2,250

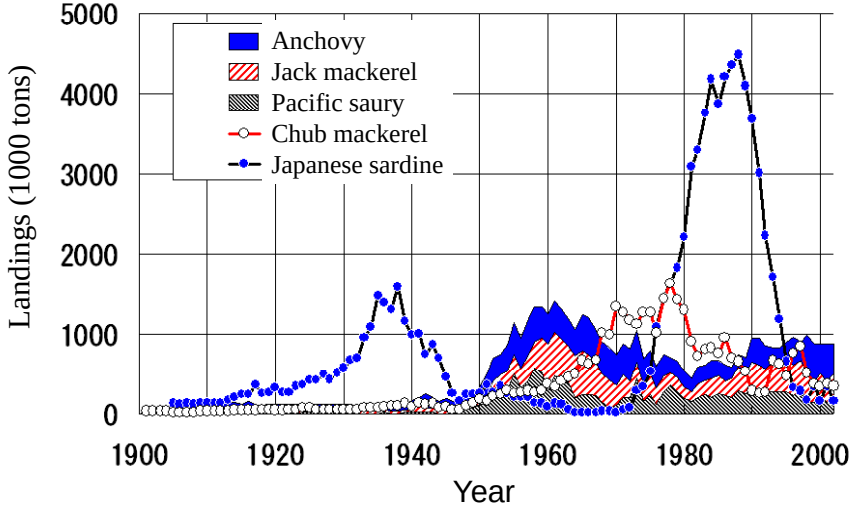
ABC decision rule



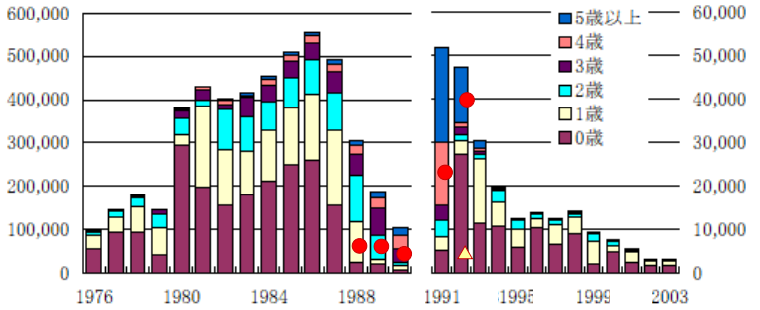
A simulation result of fisheries management



Species replacement of plankton-feeding pelagic fish in Japanese waters



"Aging" of Japanese sardine during 1988 to 1991

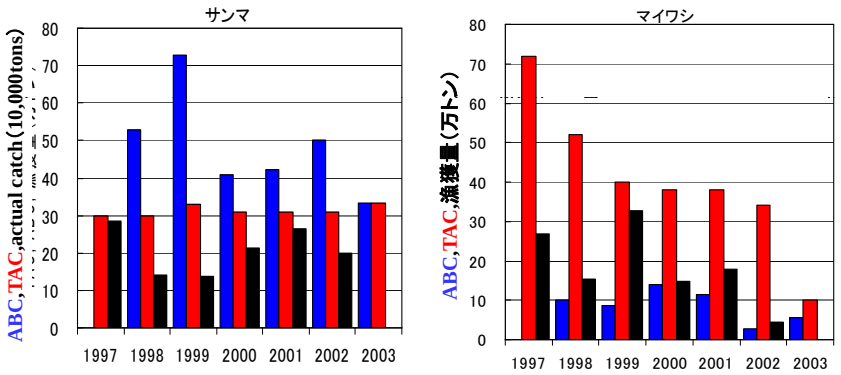


Estimate of stock abundance of Japanese sardine in Kuroshio region (million tonnes), age 0 to >5 yrs.

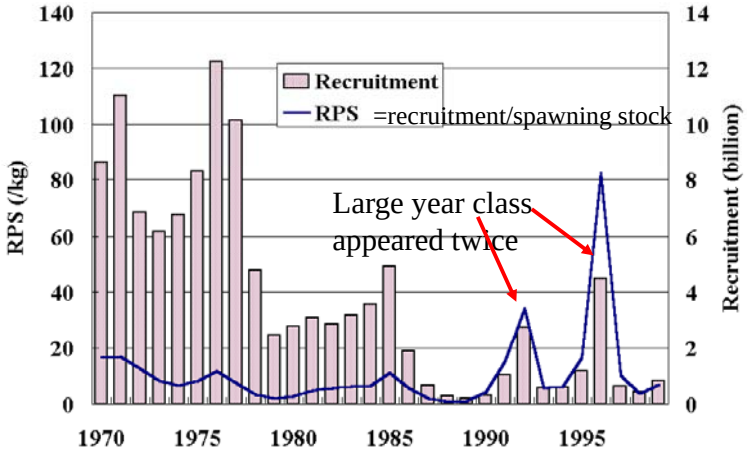
http://abchan.job.affrc.go.jp/digests15/details/1503.pdf

Japan Government agreed overfishing of sardine (TAC > ABC >> catch)

- Pacific saury　　Japanese sardine



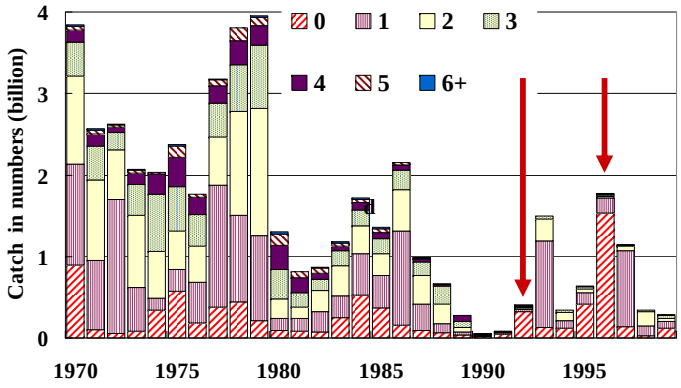
Recruitment of chub mackerel temporally fluctuated



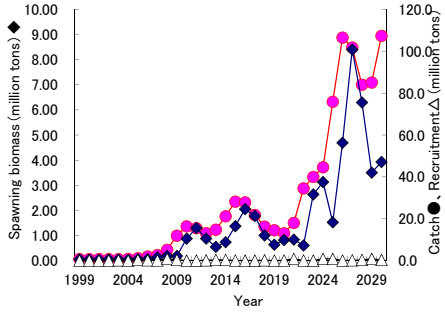
Stock of Kuroshio Region

Overfishing of immature chub mackerel

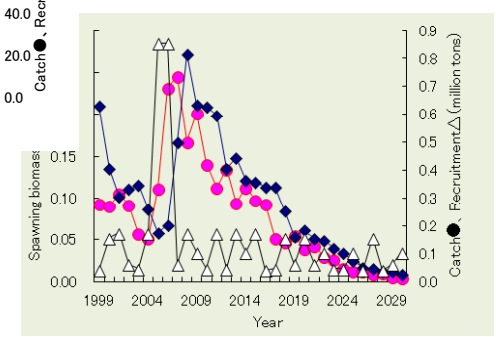
	70年代	80年代	90年代	93年以降
尾数	**65.0%**	**60.0%**	**87.0%**	**90.6%**



If fishers conserve immatures like 1970-80s



If fishers continue the overfishing of immatures like 1990s

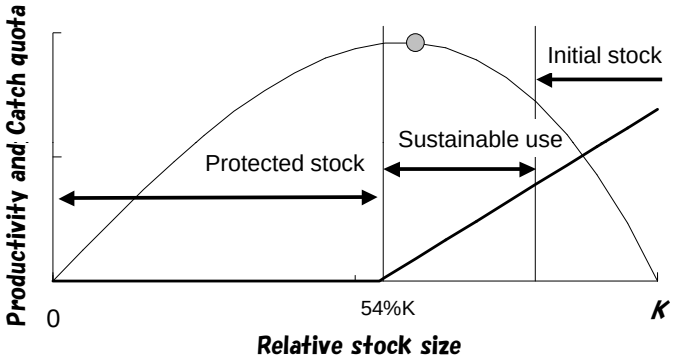


Risk assessment of stock recovery plan ("SMwE Operating Model")

- Start age structure of the current stock;
- Future RPS (α_t) is randomly chosen from the past 10 years estimates of RPS. (include process errors)
- $N_{0,t} = \mathrm{SSB}_t\ \alpha_t/(1+\beta\,\mathrm{SSB}_t)$
- $N_{a+1,t+1} = N_{a,t} \exp[-M-F_a]$ (a=0,1,...5, "6+")
- $C_{a,t} = N_{a,t}\, e^{-M/2}\, F_a\, w_a$

Kawai,…,Matsuda, Fish. Sci. 2002

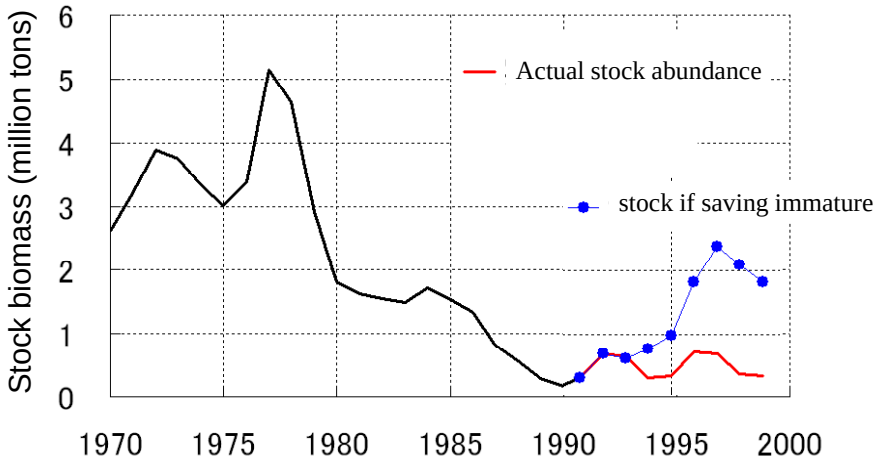
Revised Management Procedure in International Whaling Commission



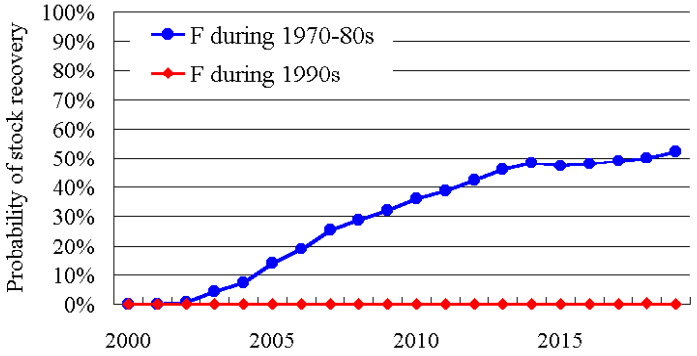
Bayesian approach for measurement uncertainty

Yes, it should have recovered.

(Kawai et al 2002)

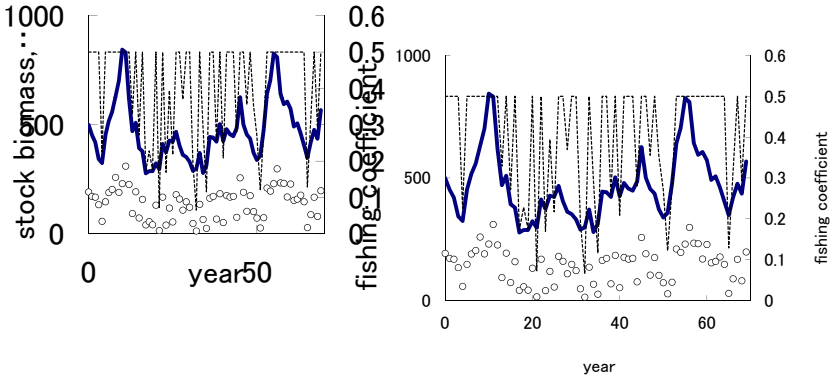


Probability that the stock recovers above 1 million tons (Kawai et al 2002)

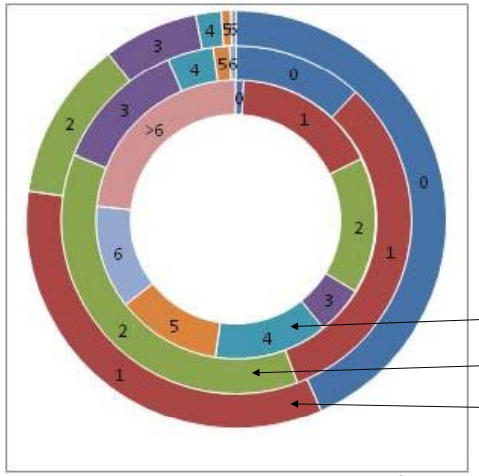


We need another two decades for recovery

Management Strategy Evaluation(MSE) Simple version



Age composition of landings between Japan and north Atlantic



North Atlantic Fishery has IQ (individual quota)
Japan is still "Olympic" competition

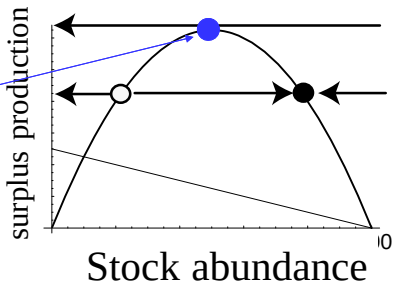
ドーナツの内側から
North Atlantic2000-2004
Japan 1970
Japan 1995

http://www.ices.dk/marineworld/fishmap/ices/pdf/mackerel.pdf

Ecosystem services *V*(*N*, *C*)

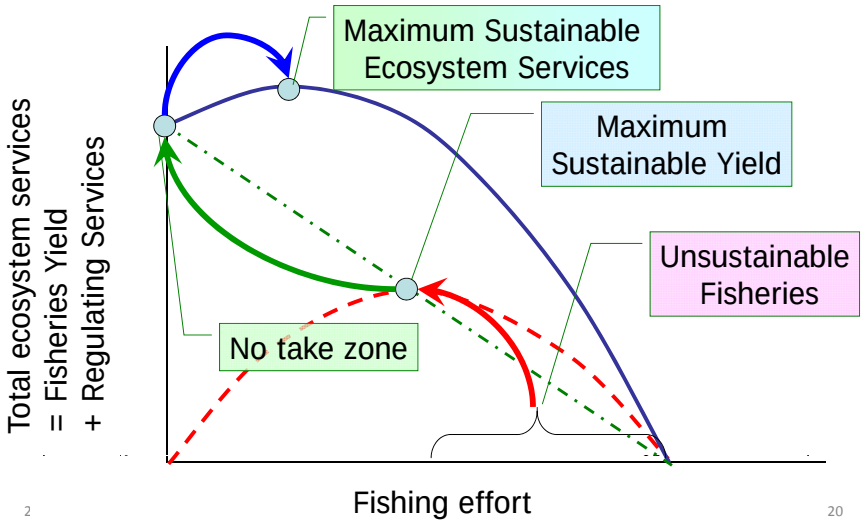
"Maximum Sustainable Ecosystem Services" = maximizing V

Maximum Sustainable Yield = maximizing Y(C)

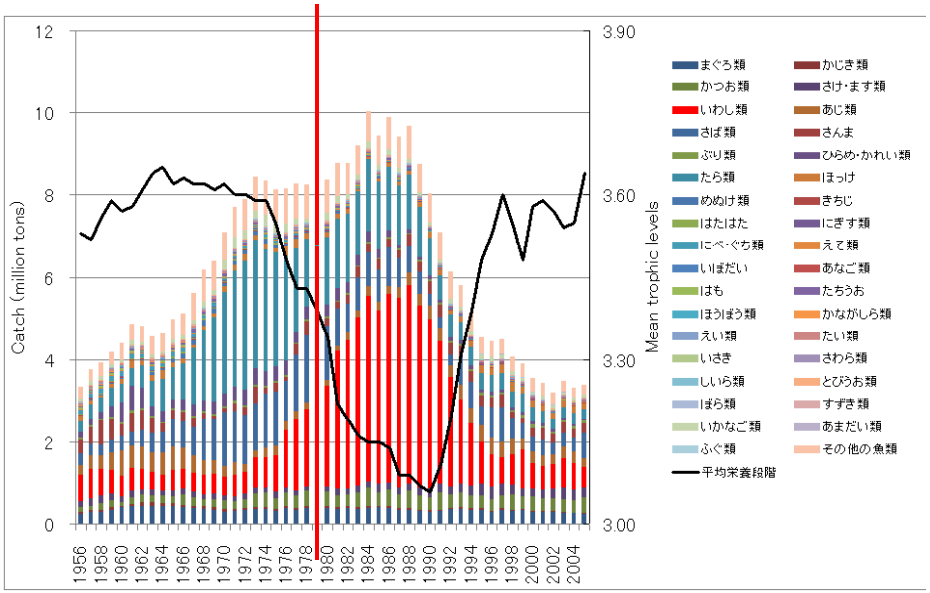


- $V(N, C) = Y(C) + S(N)$
- $N = K(1 - qE/r)$
- $C = qEN$
- Provisional Service (Fisheries Yield) … $Y(C)$
- Utility of standing biomass… $S(N)$
- *C*… catch; *E*… fishing effort; *N*… stock biomass
- *K*… Carrying capacity, *r*…Malthusian parameter, *q*…

Paradigm Shift from MSY to MSES

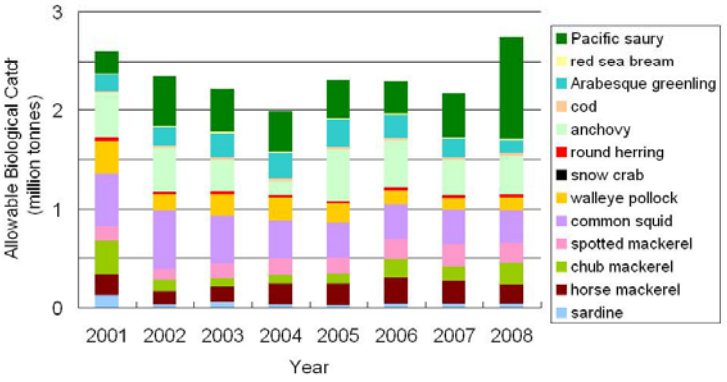


Catch and mean trophic level in Japan



We can use >2 million tons of pelagic fishes sustainably in Japanese EEZ.

- But demand-supply mismatch: overfishing and underuse.

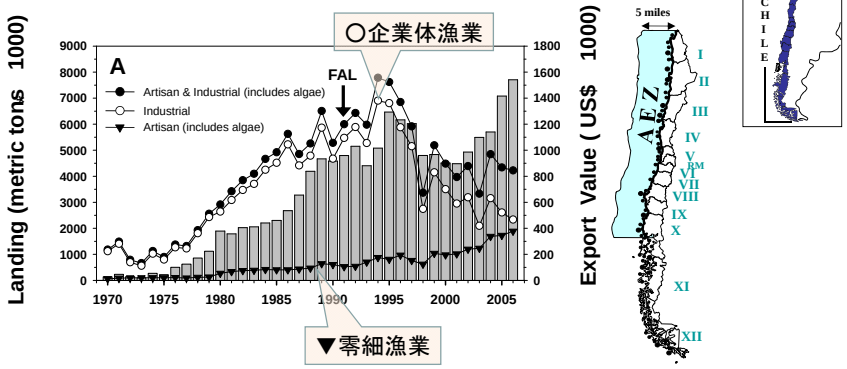


source: Fisheries Research Agency, Japan

Source: Fisheries Research Agency, Japan

JC Castilla氏

Chile encourages artisanal fisheries

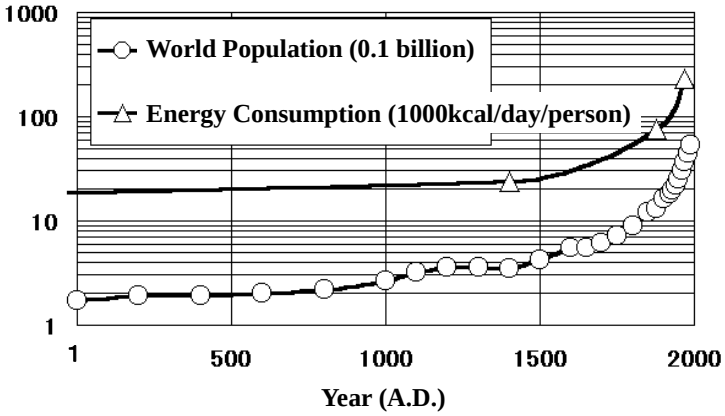


5 miles AEZ = Artisan Exclusive Zone (*ca.* 27.000 km^2)

Territorial User Rights for Fishers (TURFs) are allocated to communities with MEABRs.

•MEABRs = Management and Exploitation Areas for Benthic Resources

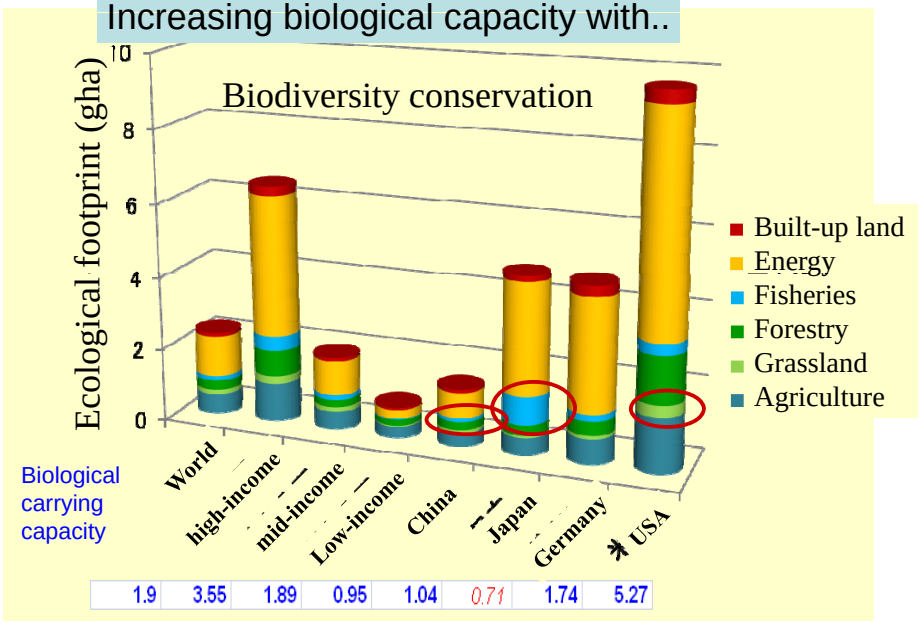
Super-Malthusian Increase of population and per capita energy consumption



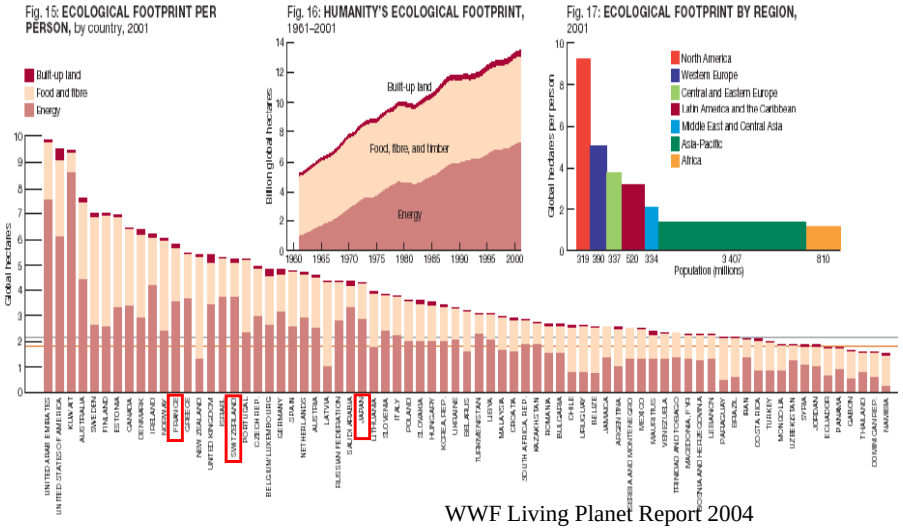
Data: Earl Cook (1971) and Joel E. Cohen (1995)

WWF 2002

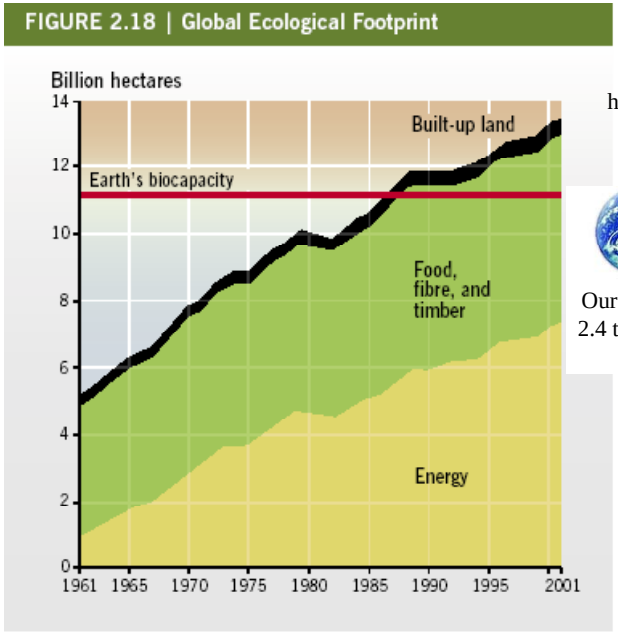
Decreasing Ecological footprint, Increasing biological capacity with..



Ranking of per capita EF



WWF Living Planet Report 2004



http://www.ecofoot.jp/

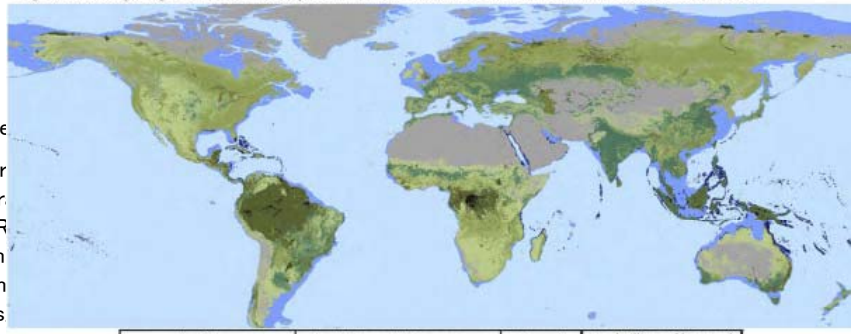
Our life step upon the size of 2.4 the Earth, we have to goal to size of one that.

WWF 2004

Measuring natural value

(Costanza et al 1997)

Figure S1. Map of global annual ecosystem services based on 2011 land areas and 2011 unit values



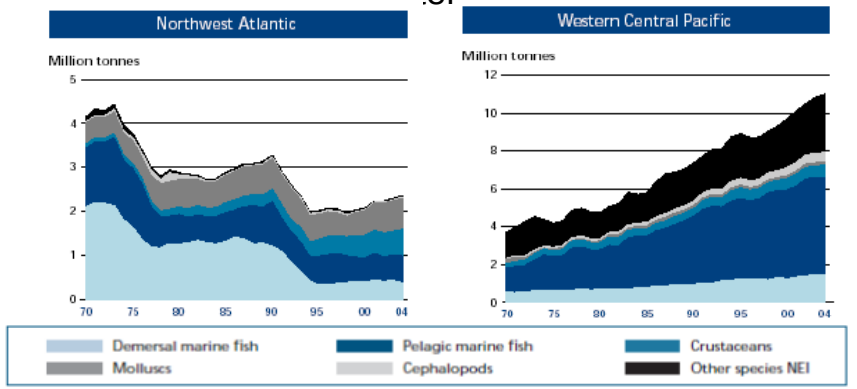
biome
deser
tundr
Ice/R
Open
marin
grass
tempe
lakes,
tropic
cropl
urban
swam
tidal r
coral

LandCover	Flow Value per Hectare per year	Legend	Area (millions of hectares)
Desert	$0		2159
Tundra	$0		433
Ice/Rock	$0		1640
Open Ocean	$491		33200
Marine Shelf	$2,222		2660
Grass/Rangelands	$2,871		4418
Temperate/Boreal Forest	$3,013		3003
Lakes/Rivers	$4,267		200
Tropical Forest	$5,264		1258
Cropland	$5,567		1672
Urban	$6,661		352
Swamps/Floodplains	$25,682		60
Tidal Marsh/Mangroves	$193,845		128
Coral Reefs	$352,249		28

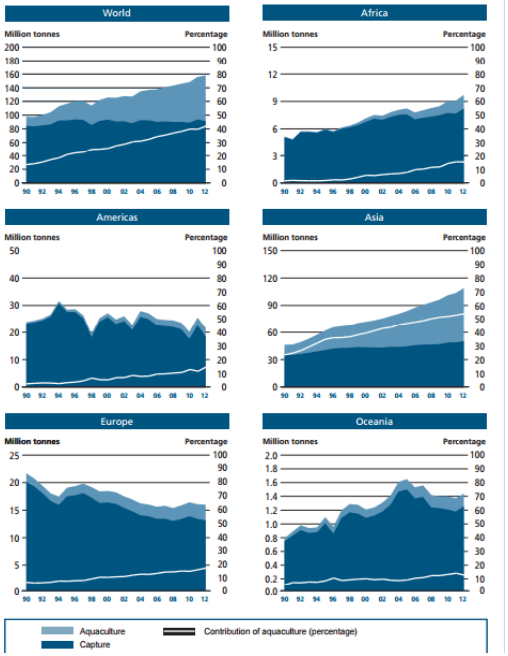
R. Costanza et al. / Global Environmental Change 26 (2014) 152–158

Capture fisheries production in marine areas (FAO, SOFIA2006)

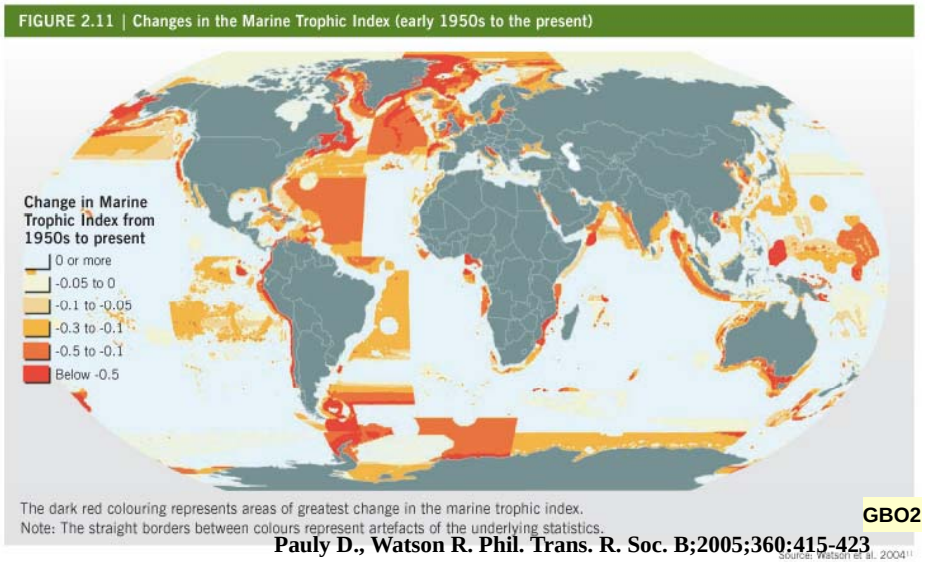
- Landing is decreasing in Northwest Atlantic, but...
- It is increasing in Western Central Pacific!



- SOF



Changes in the Marine Trophic Index



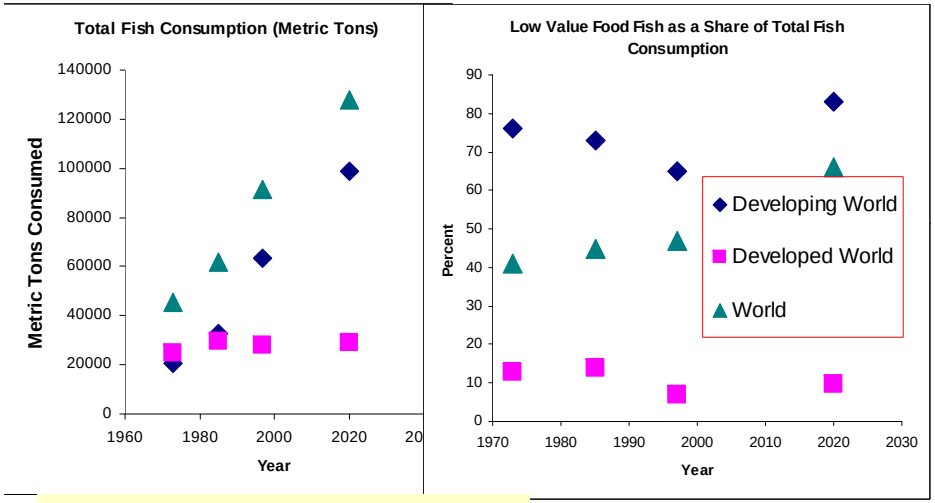
GBO2

Pauly D., Watson R. Phil. Trans. R. Soc. B;2005;360:415-423

Difference in fish consumption between countries

USGS

After Doug Beard



From Delgado et. al. 2002, Fish to 2020, Table E.14

From Delgado et. al. 2002, Fish to 2020, Table 3.3

LETTER

国際的に批判され始めた海洋栄養段階

The trophic fingerprint of marine fisheries

12月速報

Trevor A. Branch[1], Reg Watson[2], Elizabeth A. Fulton[3], Simon Jennings[4,5], Carey R. McGilliard[1], Grace T. Pablico[2], Daniel Ricard[6] & Sean R. Tracey[2]

Biodiversity indicators provide
guiding policy development an
adopted marine indicator is me
intended to detect shifts from l
level invertebrates and planktc
reported trends in human impa
("fishing down marine food we
expand ("fishing through marir
catch MTL measures changes
Here we combine model predi
catches, trawl surveys and fish
catch MTL does not reliably pr
Instead, catch MTL trends ofte
obtained from surveys and ass
of rapid declines in catch MTL
survey and assessment MTL.
are rising, which can intensify
are stable or increasing. To de
we recommend greater efforts to measure true ab
marine species, especially those most vulnerable
an ecosystem approach to fisheries

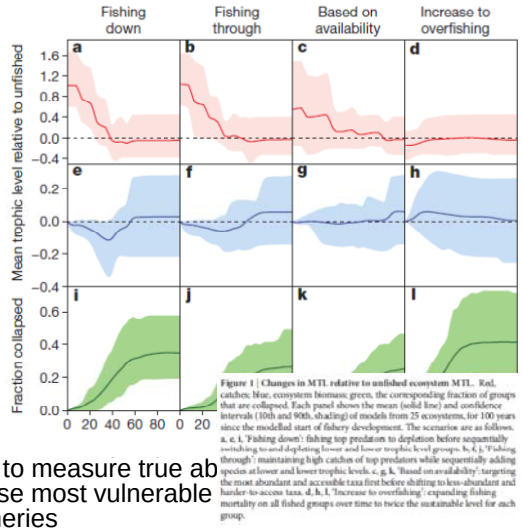


Figure 1 | Changes in MTL relative to unfished ecosystem MTL. Red, catches; blue, ecosystem biomass; green, the corresponding fraction of groups that are collapsed. Each panel shows the mean (solid line) and confidence intervals (10th and 90th, shading) of models from 25 ecosystems, for 100 years since the modelled start of fishery development. The scenarios are as follows. a, e, i, 'Fishing down': fishing top predators to depletion before sequentially switching to and depleting lower and lower trophic level groups. b, f, j, 'Fishing through': maintaining high catches of top predators while sequentially adding species at lower and lower trophic levels. c, g, k, 'Based on availability': targeting the most abundant and accessible taxa first before shifting to less-abundant and harder-to-access taxa. d, h, l, 'Increase to overfishing': expanding fishing mortality on all fished groups over time to twice the sustainable level for each group.