International Conference on Science and Technology for Sustainability 2009:
Global Food Security and Sustainability
during 9:10-9:50, on September 18, 2009

Can we get more fish?

Degradation and recovery of fisheries resources.

松田裕之 Hiroyuki Matsuda
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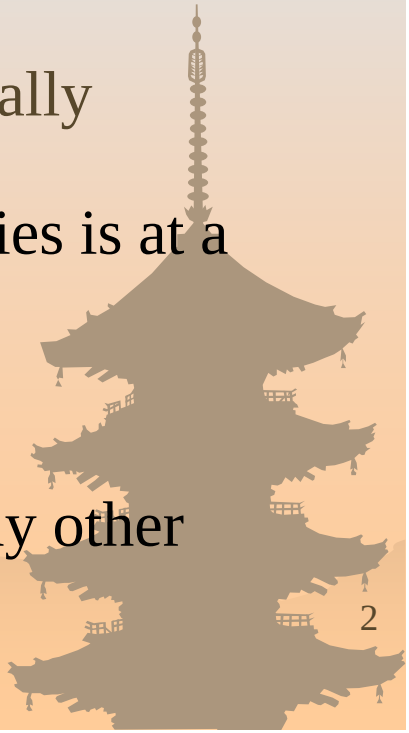
COE Eco-Risk Asia Program Leader
Pew Marine Conservation Fellow 2007

Special thanks to: Drs. J. C. Castilla, Y. Hiyama, H. Ijima, T. Katsukawa, Y. Katsukawa, C. Kikuchi, M. Makino, T. Obara, M. Williams, B. Worm, A. Yatsu,

My 11 recommendations

1. Do not eat high value fish too much!
2. Catch more fish at lower trophic levels;
3. Do not use too much fish as fish meal;
4. Reduce discards before and after landings;
5. Establish food markets for temporally fluctuating fishes at lower trophic levels;
6. Improve the food-processing technology used on small pelagic fishes;
7. Switch the target fish to correspond to the temporally dominant species;
8. Conserve immature fish especially when the species is at a low stock level;
9. Conserve both fish and fishers;
10. Say goodbye to traditional MSY theory;
11. Monitor not only the target stock level but also any other indicator of the “entire” ecosystem.



1. Do not eat high value fish too much!

POINT OF VIEW / *Hiroyuki Matsuda*

Japan can no longer keep eating so much tuna

The Asahi Shimbun

Calling for lower fishing quotas of tuna while others bemoan the soaring price of tuna have been making headlines recently. People in Europe and the United States blame Japan's love of sushi for this threat to one of the world's favorite fish.

The decline in tuna resources has prompted international organizations to limit catches in waters around the world over the past decade or more.

While Japan and other countries are cutting their tuna boats numbers, however, other countries have entered the industry.

This is a sign that, unlike a quarter century ago, when many countries argued for and against a ban on whaling, the love of tuna and sushi is spreading internationally.

What is at stake in the tuna situation is not a ban, but how to sustain tuna fisheries.

It is clear that Japanese can no longer keep eating much tuna the way we have in the past. From now, Japan must share this delicacy with the world. In addition to reducing global catches, we need to cut down on Japan's share.

There is some evidence that Japanese simply eat too much tuna. Total worldwide tuna catches, which stood at 240,000 tons in 1950, had reached 1.84 million tons in 2000. Japan ate 580,000 tons of tuna in 2004, of which 370,000 tons was imported.

In the old days, this was not the case. But today, even inns in the mountains serve up fresh tuna sashimi. This situation runs counter to the philosophy of local foods for local consumption, an idea often promoted by local business communities.

And indeed, fatty tuna is a treat that ought to be enjoyed only occasionally, in small amounts.

In December last year, news reports said Japanese fishing vessels were overfishing southern bluefin tuna, source of the much-sought-after fatty type of flesh. The Fisheries Agency admitted that Japan's actual catches in 2005 exceeded its quota by 1,800 tons.

If we hope to manage this precious resource, it is outrageous for the tuna industry to understate its catches. By doing so, Japan has lost international trust and respect. No matter how much Japan cuts back on catches and consumption now, it cannot conserve tuna stocks alone. Other countries must also comply.

Hiroyuki Matsuda

It is also important to clearly distinguish overfished tuna from tuna caught under proper management. We must consume only the latter.

To achieve that, we need to monitor fishing vessels and countries that operate illegally and stop them.

We should also only import tuna from countries that operate certified fishing vessels. We can set up a certification system to label "environmentally friendly fishing vessels" so consumers can make a conscientious choice.

Last month, five international organizations that manage tuna resources met for the first time in Kobe under an initiative by the Fisheries Agency. The government and fisheries officials are to be commended for taking a serious step toward sustainable resource management.

As the world's largest importer of seafood, some part of which are caught by illegal and irresponsible means, Japan has a large responsibility to control marine resources. Up to now, lawmakers with vested interests have concentrated on narrowly protecting their fishing industry interests and providing subsidies.

Consumers, too, are to blame, remaining blind to whether they were eating domestic or imported fish so long as trading companies kept their plates full.

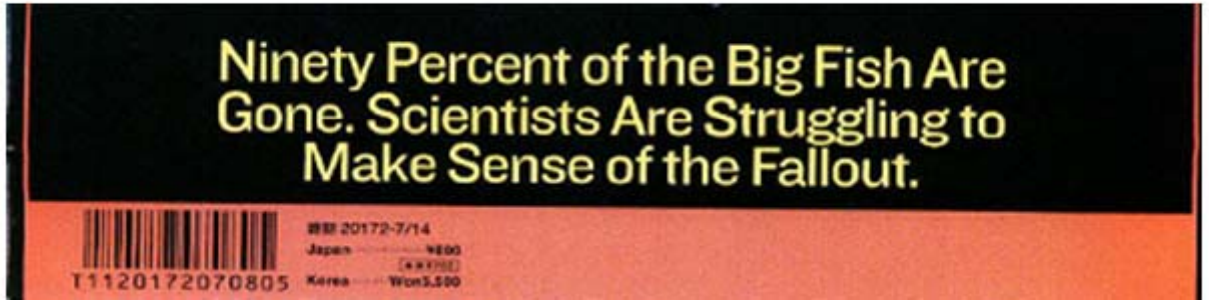
Lawmakers must become environmentally conscious and work toward sustainable fishing and conservation of the marine ecosystem. I hope they do it soon.

It is not possible to attain this goal under the existing production, distribution and consumption systems.

If we can change with the times, however, Japan may be able to lead the world in a simultaneous pursuit of sustainable fishing and environmental conservation.

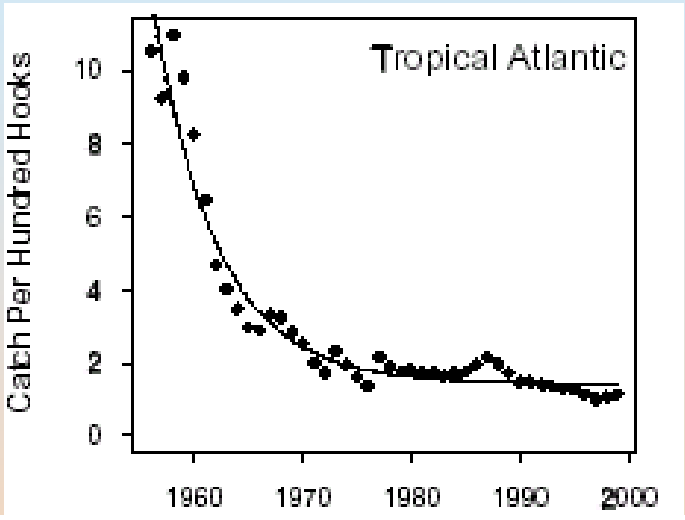
The author is professor of environmental risk management at Yokohama National University.

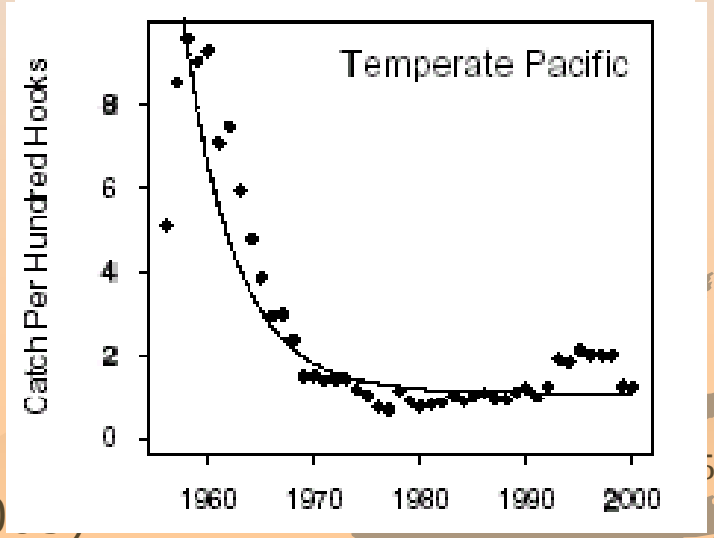
Newsweek 2003.7.14



R. A. Myers & B. Worm (2003)

Rapid worldwide depletion of predatory fish communities

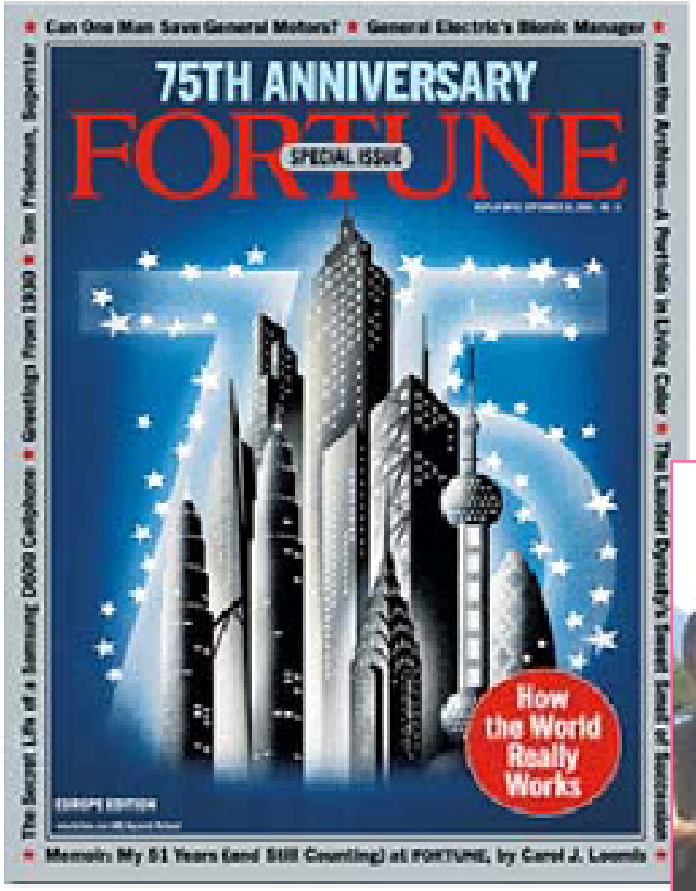




…We conclude that declines of large predators that initially occurred in coastal regions, have extended throughout the global ocean, with potentially large consequences on ecosystems.

Nature 423:280-283 (20

Fortune Magazine Names Ransom Myers One Of World's "Top Ten To Watch"

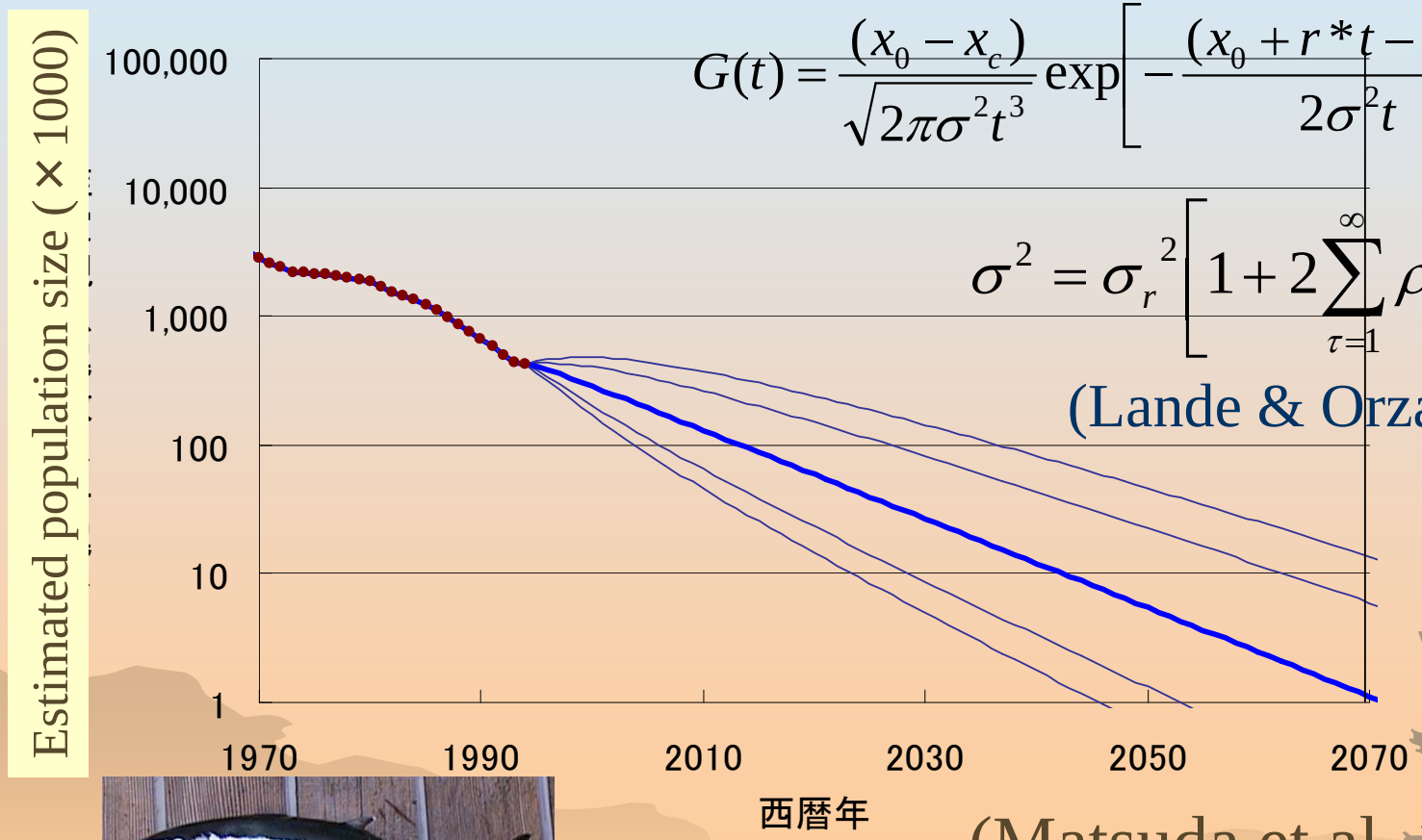


October 2005

This October, Ransom Myers was chosen by **Fortune** magazine as one of the world's top ten movers and shakers: people who will change the way the world operates over the next 75 years. The prominent business magazine predicts that Myers' work on fish population dynamics and the depletion of sharks, tuna and other fish species will foster "new and better ways to husband the wealth beneath the sea."

http://as01.ucis.dal.ca/ramweb/

Even if the past reduction rate continues, SBT will not go extinct within 50 years, not high extinction risk in the immediate future.



$$G(t) = \frac{(x_0 - x_c)}{\sqrt{2\pi\sigma^2 t^3}} \exp\left[-\frac{(x_0 + r*t - x_c)^2}{2\sigma^2 t}\right]$$

$$\sigma^2 = \sigma_r^2\left[1 + 2\sum_{\tau=1}^{\infty}\rho(\tau)\right]$$

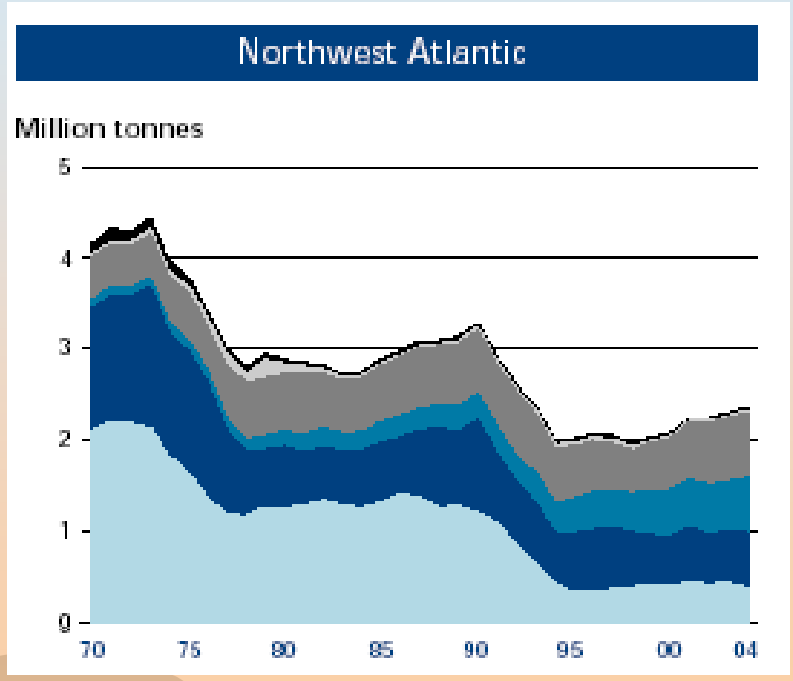
(Lande & Orzack 1988)

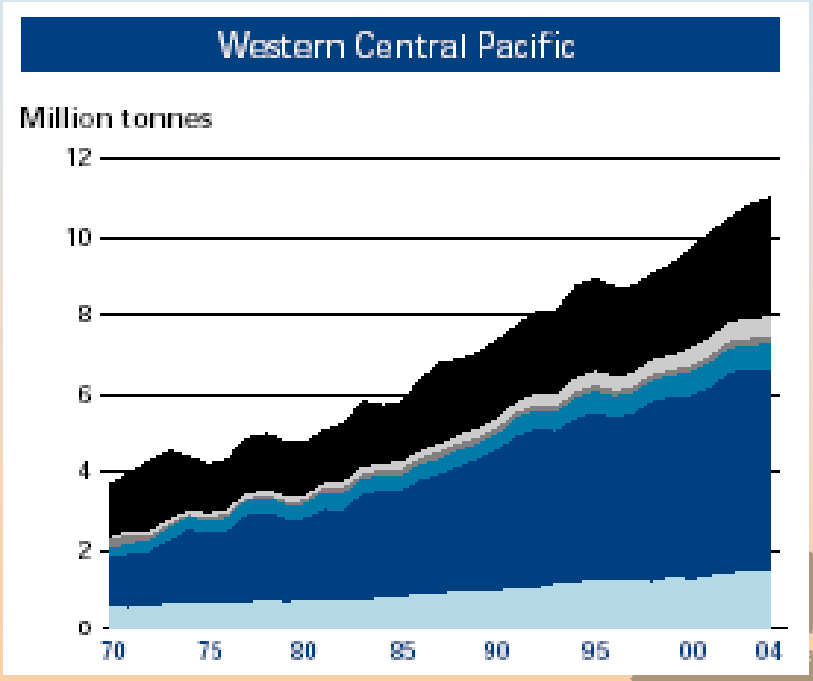
(Matsuda et al. 1996)

Photo by Fisheries Research Agency, Japan

Is the ocean really dying?

- The total catch decreased in northwest Atlantic.
- It is increasing in western central Pacific.





Demersal marine fish
Pelagic marine fish
Crustaceans
Molluscs
Cephalopods
Other species NEI

(FAO, SOFIA2006)

Meryl Williams (CoML member) invited talk "Marine ecosystem services and fishing: agreements and disagreements between fisheries scientists and ecologists" October 21, 2009, Yokohama, 5th World Fisheries Congress

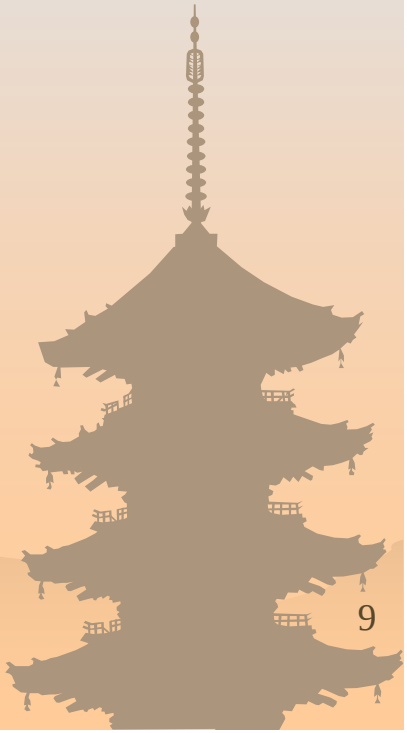
Walters *Can J Fish Aquat Sc* 2003

Atlantic Ocean

Pacific Ocean

Indian Ocean

Data: Japanese longline
- Interpolated line
- Myers & Worm method
- Mean catch rate, fished cells



Rebuilding Global Fisheries (Worm et al. 2009)

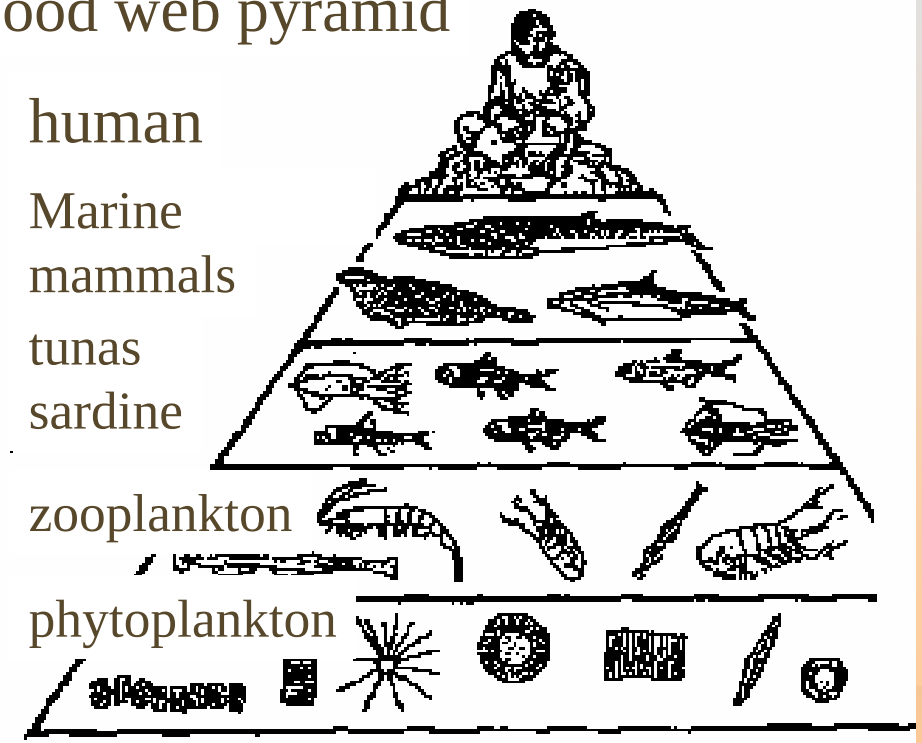
Trends of biomass (B) & exploitation rate (u) for 166 individual stocks.

Current exploitation rate versus biomass for 166 individual stocks.

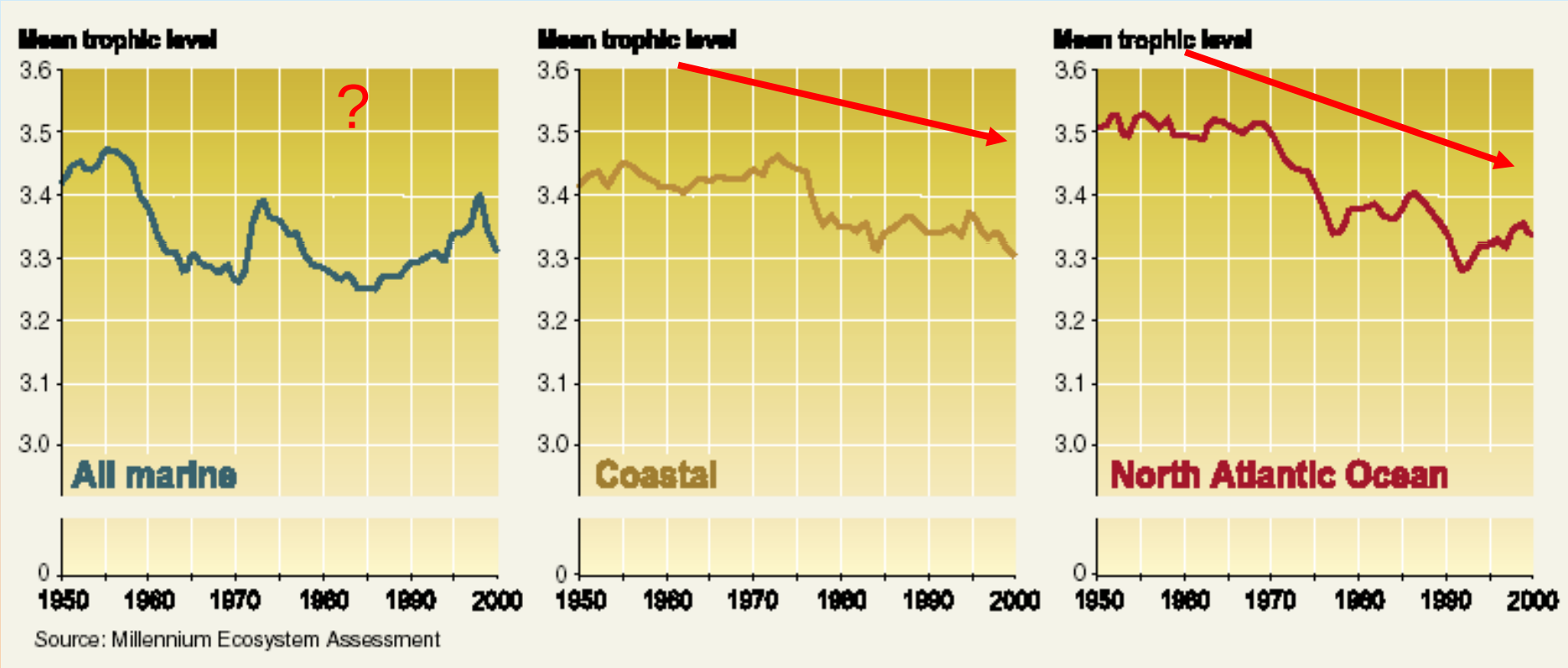
2. Catch more fish at lower trophic levels;

- Biomass of lower trophic levels is much larger than biomass of top predators.

Food web pyramid



Fishing down (MA 2005) by Daniel Pauly



Source: Millennium Ecosystem Assessment

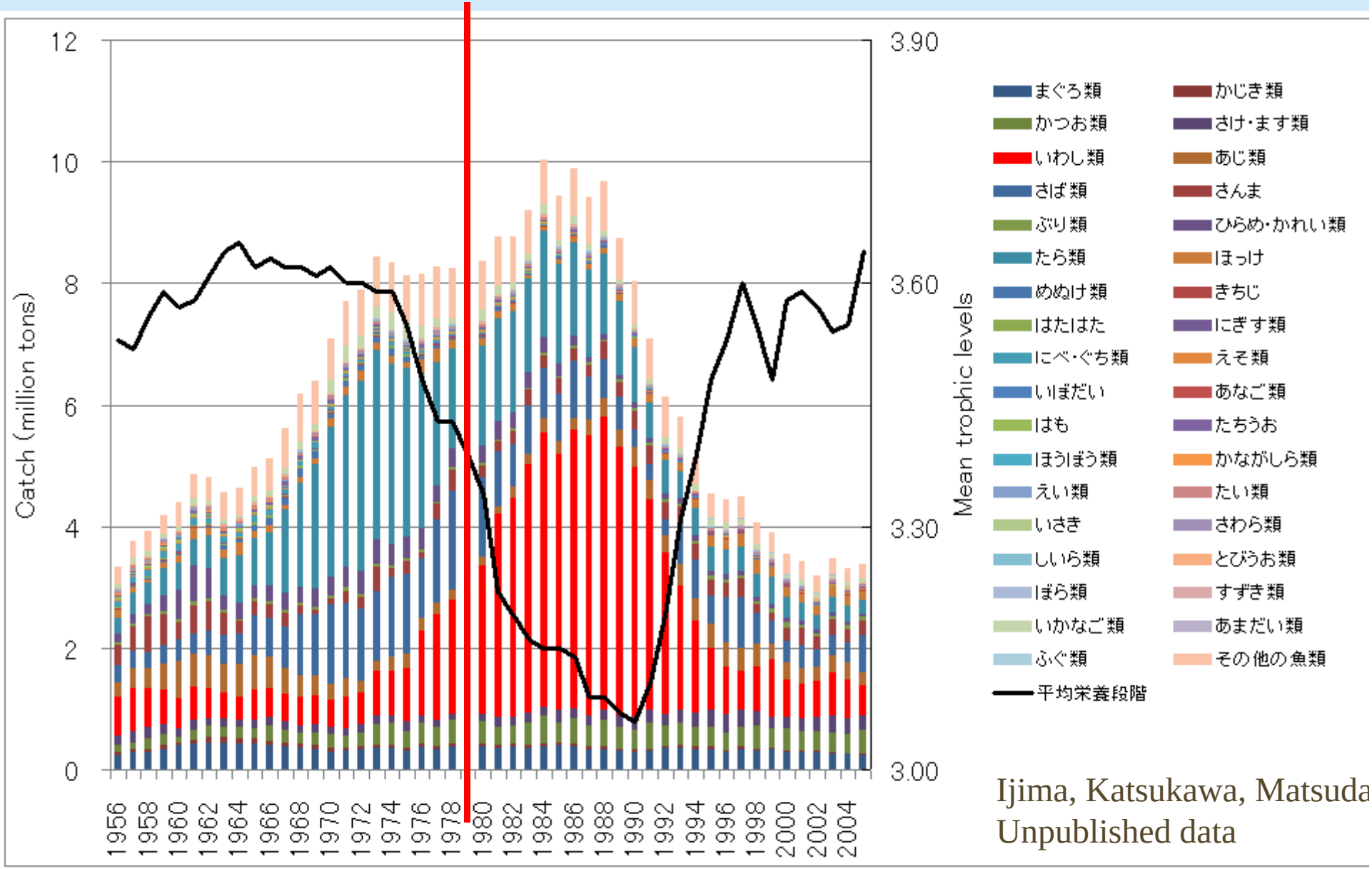
- Mean Trophic Level is calculated from FAO FISHSTAT and FISHBASE
- MTL depends on stock fluctuation of sardine and anchovy, rather than overfising.

By D.Pauly

Fishing down in China

Change in China's Marine Trophic Index over the Years (from Xu et al. 2009)
(Source China's Fourth National Report)

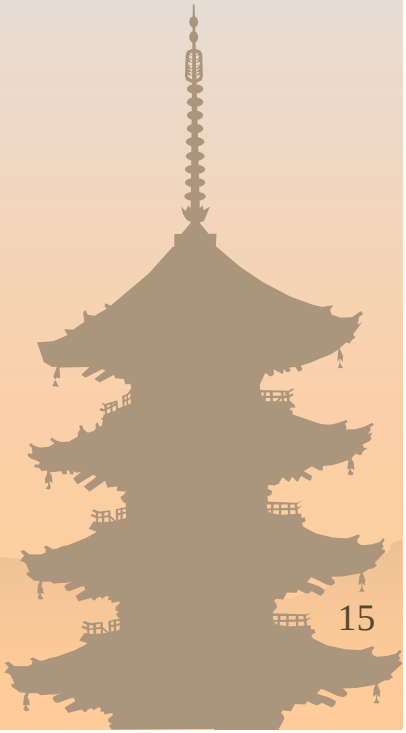
No fishing down in Japan



Ijima, Katsukawa, Matsuda
Unpublished data

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

Source: Fisheries Research Agency, Japan



New Zealand imports
Pacific saury (samma)

http://kaiseki.ori.u-tokyo.ac.jp/~katukawa/blog/2008/07/post_378.html

Developed countries people eat high value fishes,
Developing countries people eat low value fishes.

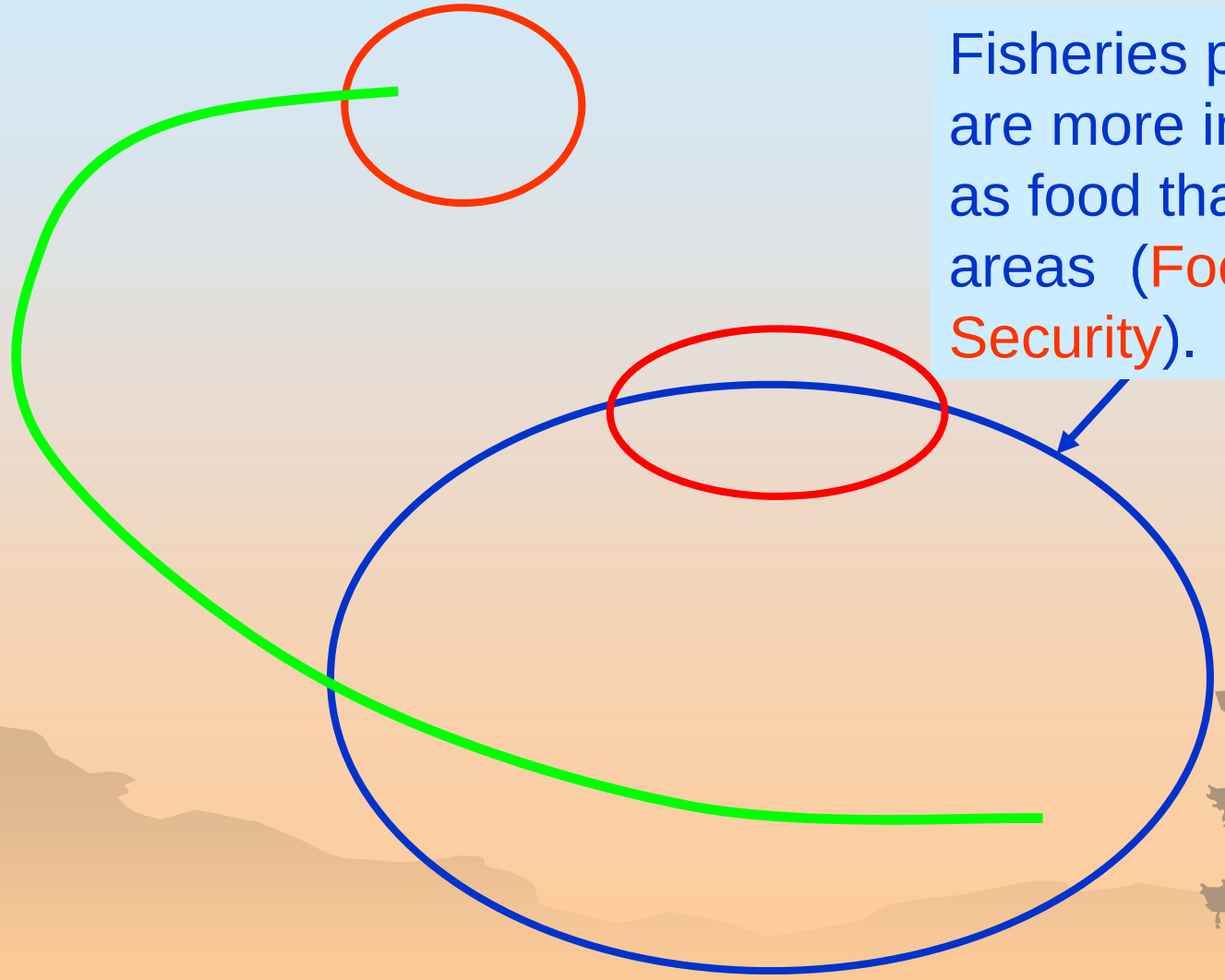
USGS

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

Percentage of Seafood as the source of Animal Protein



Fisheries products are more important as food than other areas (Food Security).

Data Source: FAO Food Balance Sheet

My typical lunch menu

(for 2 persons)

650 yen (US$6) with coffee

3. Do not use too much fish as fish meal;

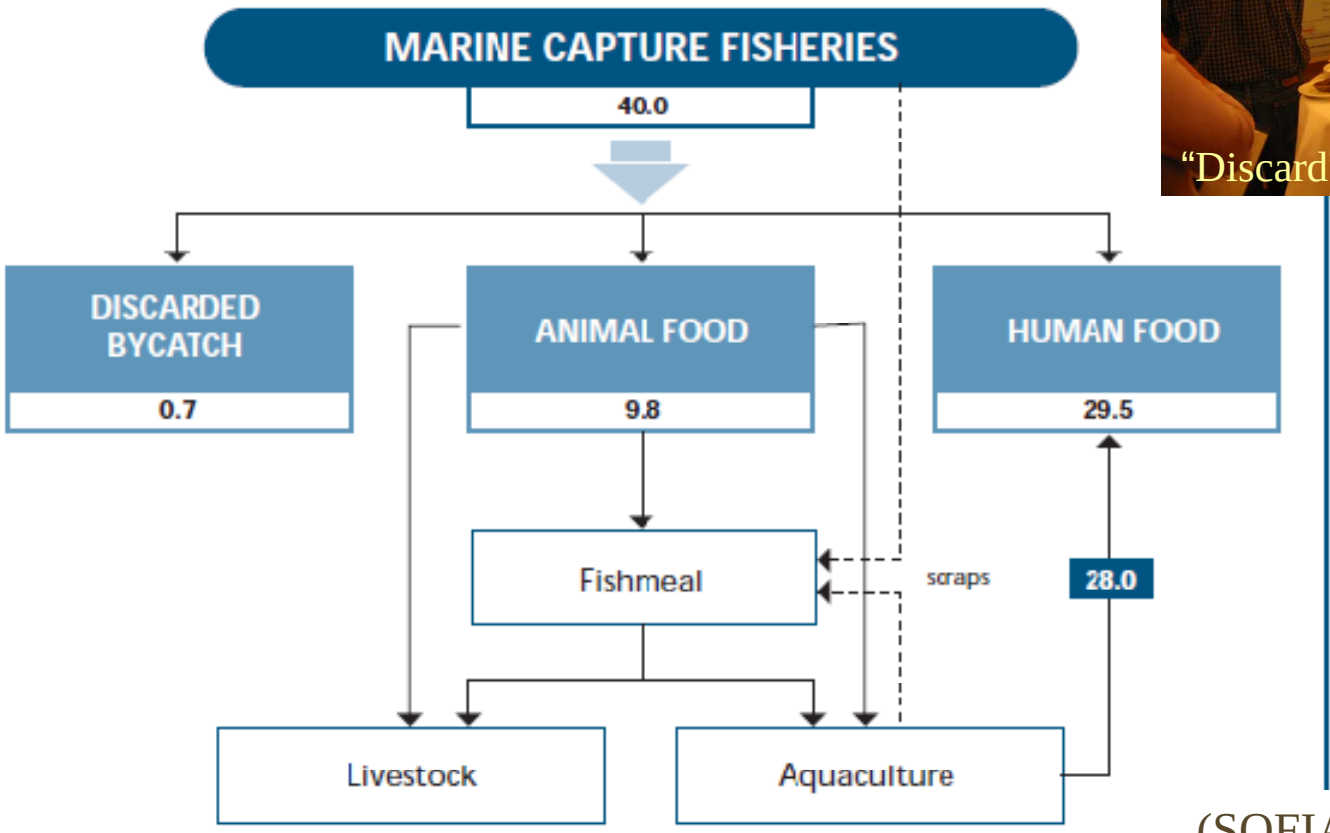
- 7 kg of sardine make ca. 1 kg of yellowtail in aquaculture.
- 20 kg of chub mackerel make ca. 1kg of tuna in fish farm
- To eat sardine or mackerel is more environmentally friendly than to eat tuna.

Beyond beef – Jeremy Rifkin:

Feed cows on grass, not corns (“Beyond Beef”)

4. Reduce discards before and after landings;

Production flows in the Asia–Pacific region, by major categories of fish
(million tonnes, live weight equivalent)




"Discard" in academic meeting

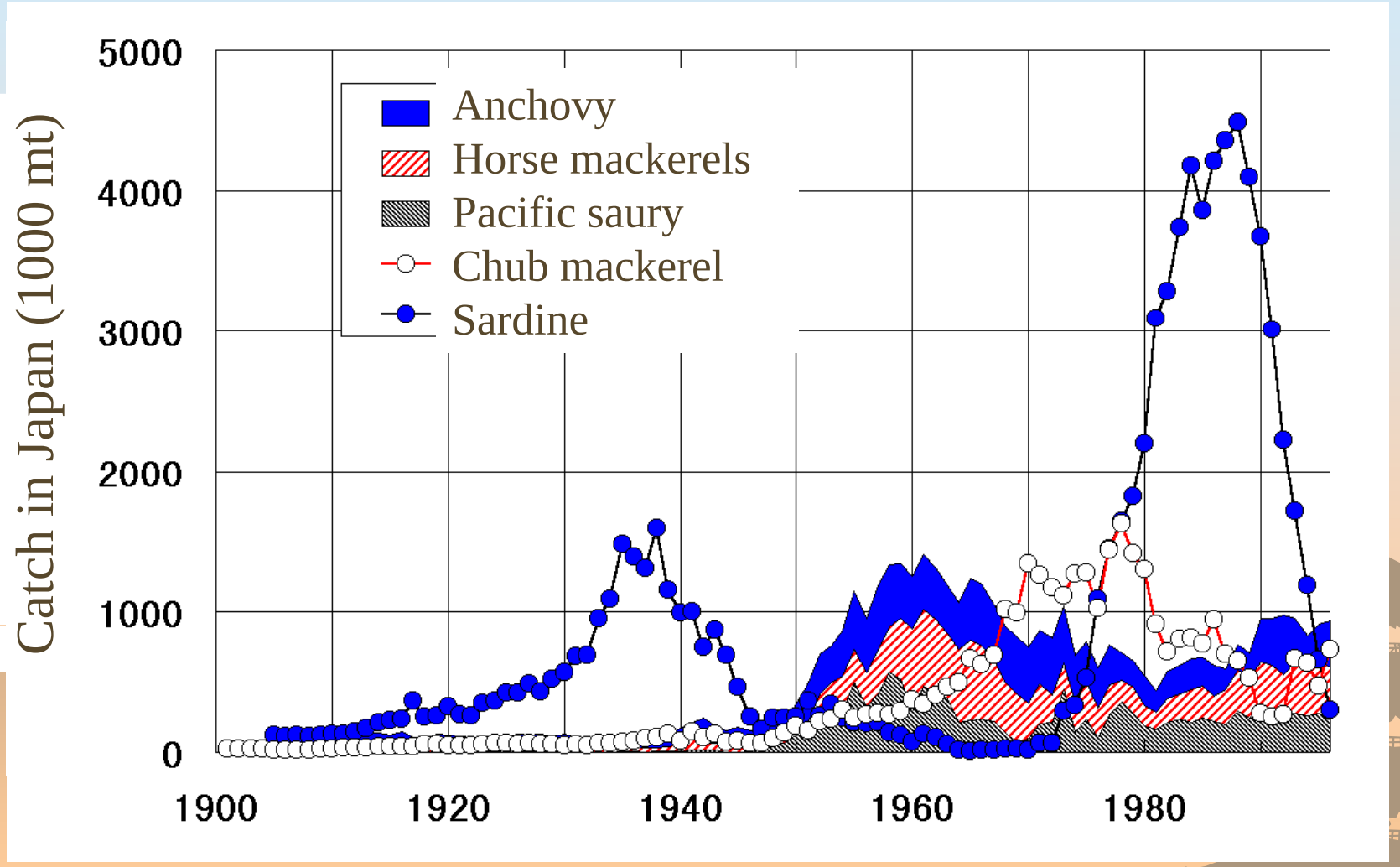
(SOFIA 2006)

5. Establish food markets for temporally fluctuating fishes at lower trophic levels;

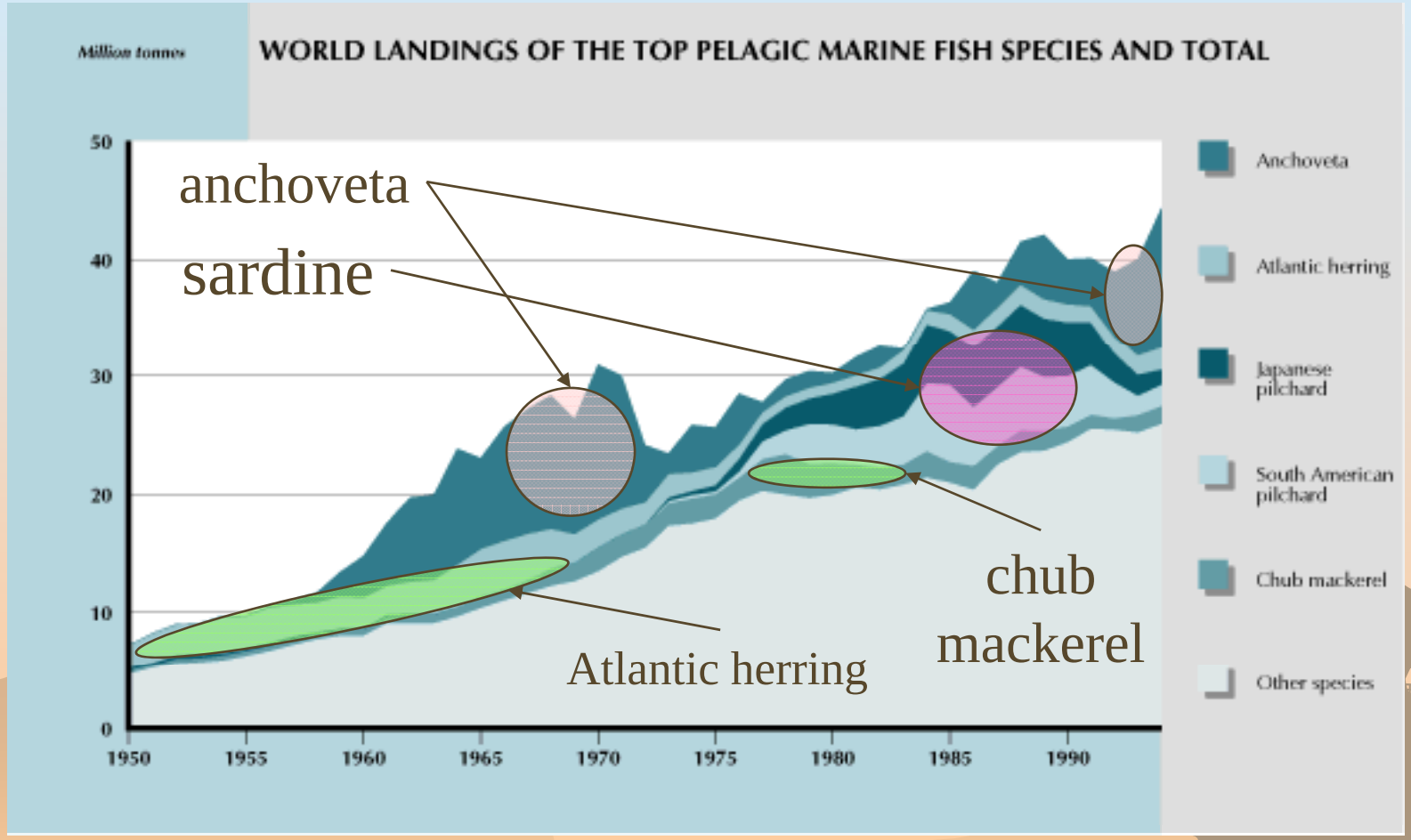
- “We can still get many fish such as Pacific saury and jack mackerel in Japanese waters. We should eat fish that is temporally abundant by a variety of cooking methods. Do not decide dinner menu (e.g. fried mackerel) before coming to fish market. Think fish and its cooking method after seeing fishes in the market.” (K. Ikuta at Tsukiji fish market)

http://www.uogashiyarou.co.jp/

Species Replacement of Pelagic Fishes

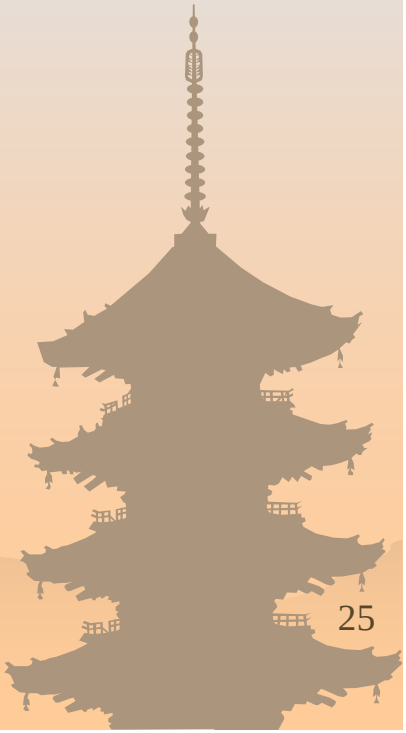


Landings of small pelagic fish fluctuate from species to species.



http://www.fao.org/WAICENT/FAOINFO/FISHERY/publ/sofia/fig4e.asp

6. Improve the food-processing technology used on low value fishes;



7. Switch the target fish to correspond to the temporally dominant species;

(Katsukawa & Matsuda, Fish.Res. 2002)

Policy 1 (no switching; NSF)

Fishing effort $E_i = e_i/3$ (constant)

Or $E_i = E_i(x_i)$ (independent of x_j)

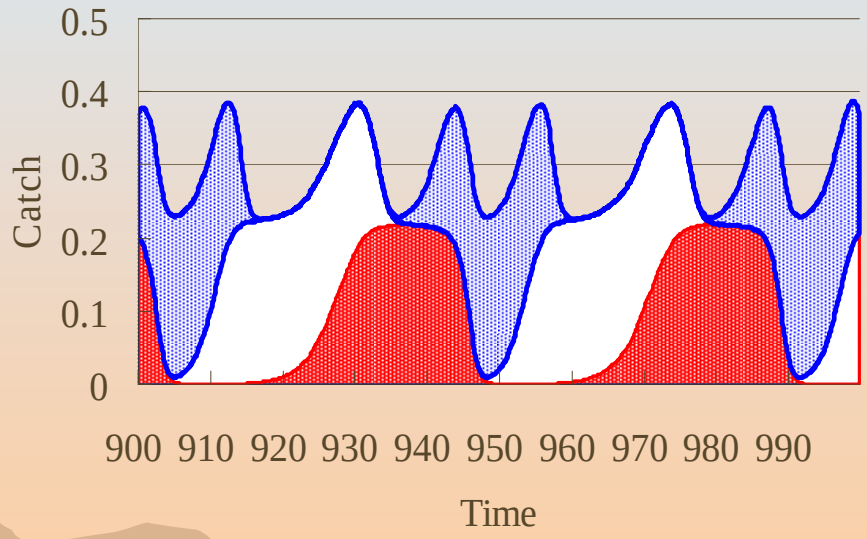
Policy 2 (switching; SF)

$E_i = e_i\, x_i/(\Sigma x_i)$ ($\propto$ stock abundance)

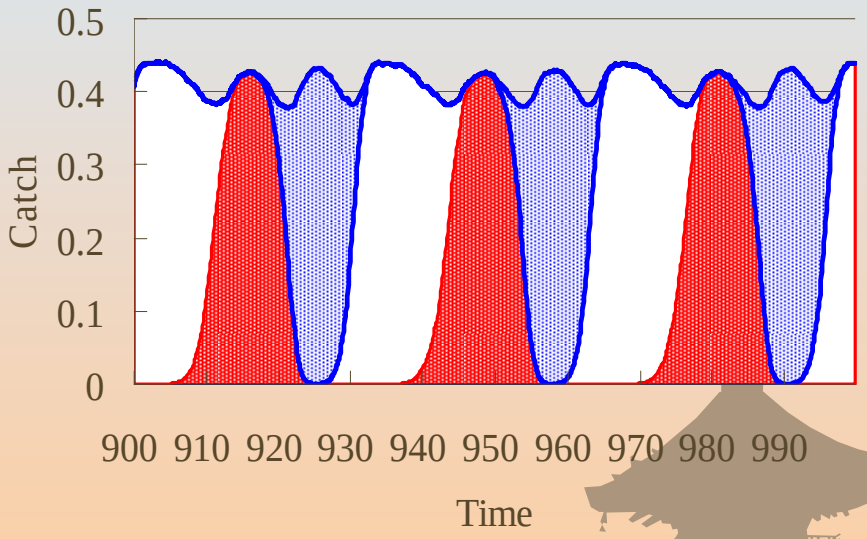
Fishers focus on relatively abundant fish species.

Switching increases & stabilizes total catch, save it at low levels

No Switching



Switching

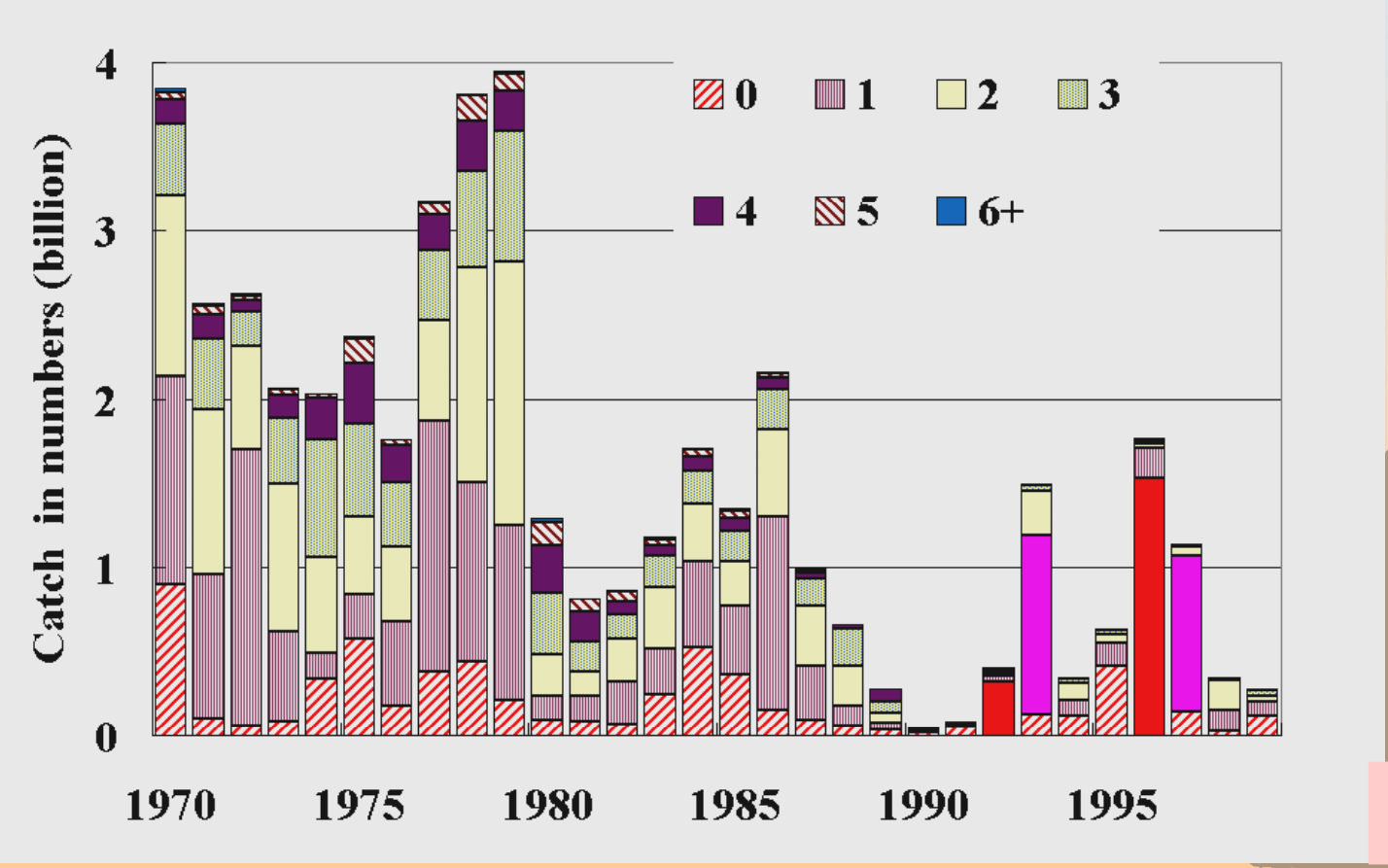


- If stock fluctuations of alternative fish are negatively correlated or independent

http://kaiseki1.ori.u-tokyo.ac.jp/~katukawa/blog/blosxom.cgi/study/article/switching.wikieditish

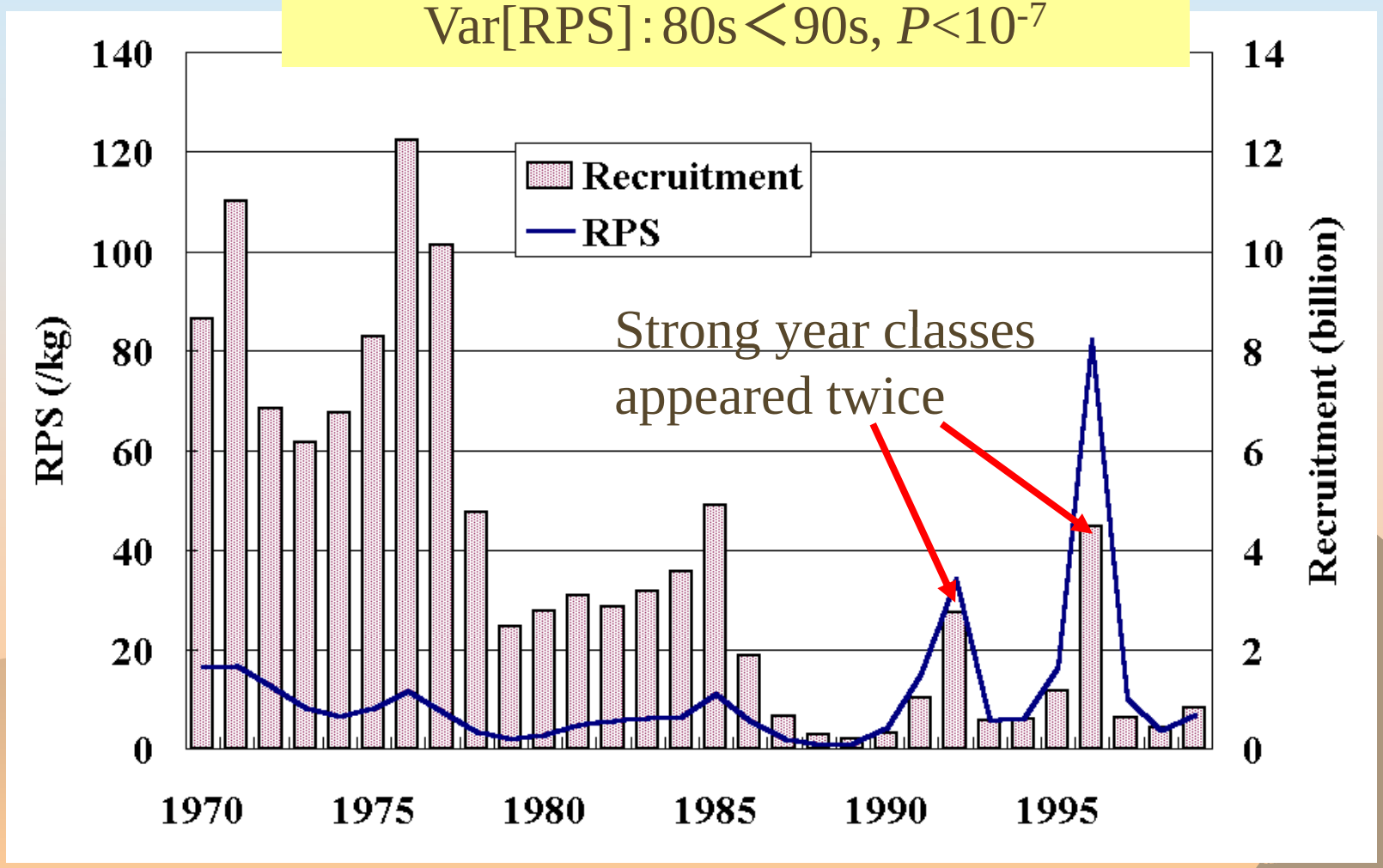
8. Conserve immature fish especially when the species is at a low stock level;

	1970s	1980s	1990s	1993-
%immatures	**65.0%**	**60.0%**	**87.0%**	**90.6%**



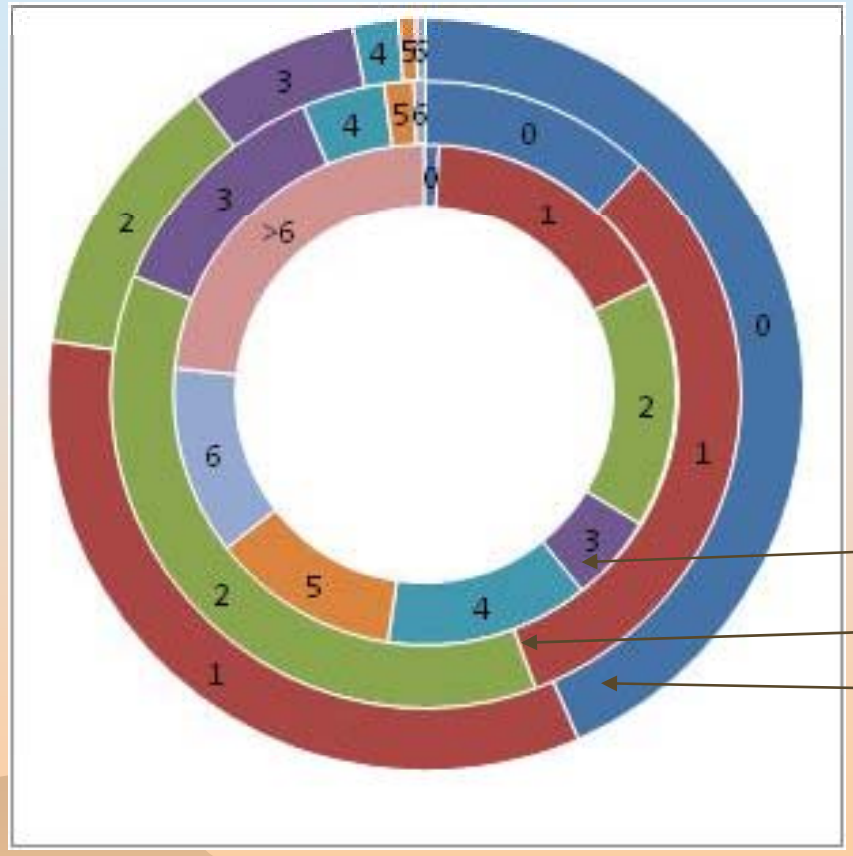
Large fluctuation of recruitment

Var[recruitment] : 80s > 90s, P<0.3%
Var[RPS] : 80s < 90s, P<10^{-7}



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

Overfishing in chub mackerel immature fish!



Chub mackerel fisheries
Norway = Individual Quota
Japan = Dirby competition

Age composition of chub mackerel landings

North Atlantic 2000-2004

Japan 1970

Japan 1995

Quiz
Which is Pacific chub mackerel?

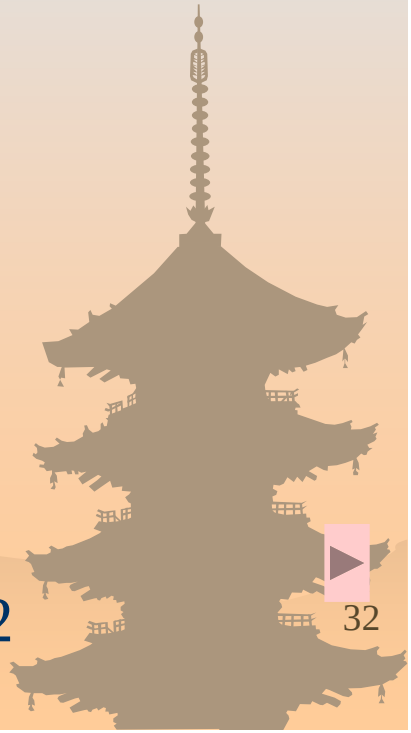
- Recently, Japan import Atlantic chub mackerel. Japanese often eat Atlantic chub mackerel than Pacific chub mackerel.

① ②

Photos, see Matsuda (2009, Bun-ichi, Tokyo)

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

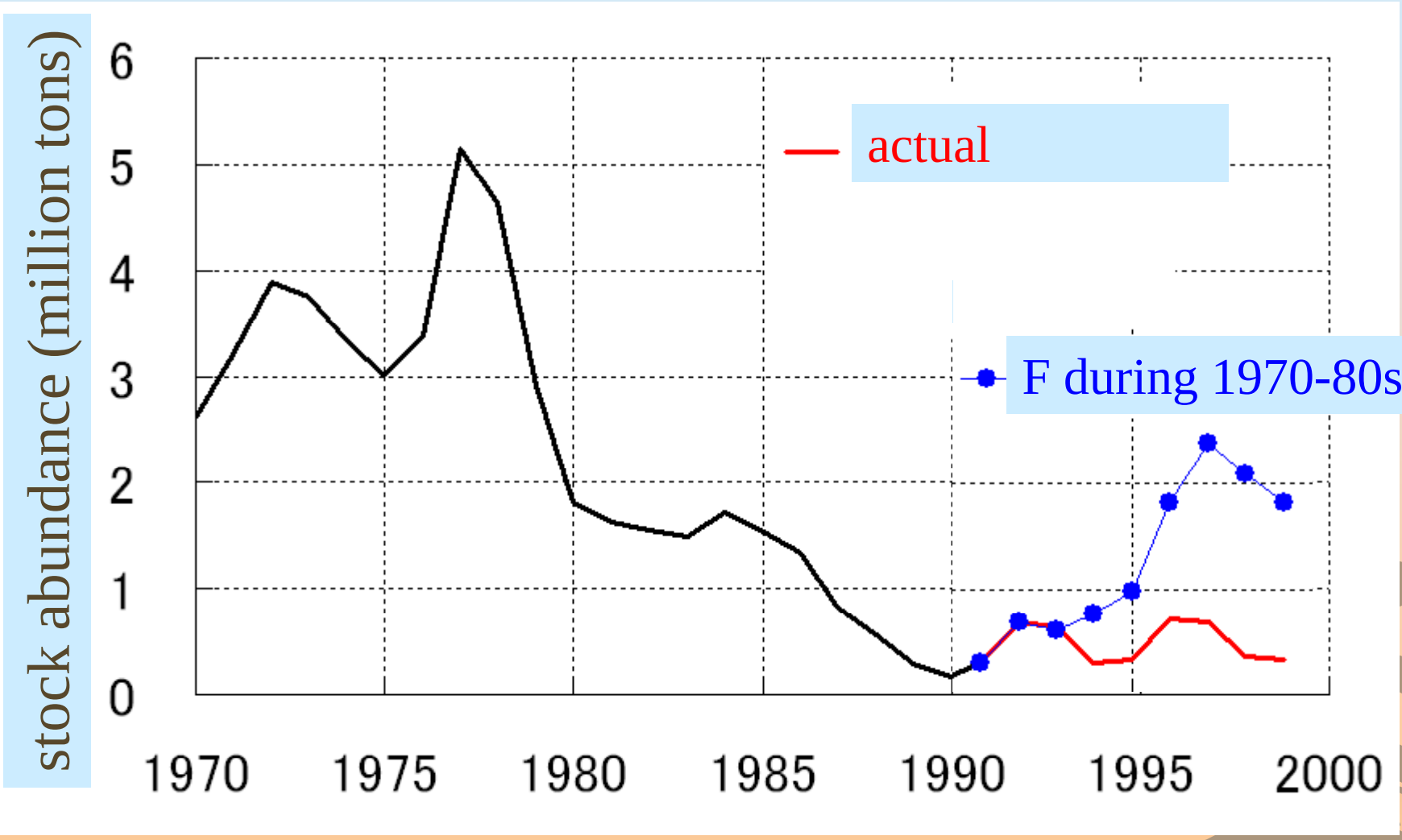
- Start age structure of the current stock;
- Future RPS (α_t) is randomly chosen from the past 10 years estimates of RPS. (include process errors)
- $N_{0,t} = \mathrm{SSB}_t \, \alpha_t/(1+\beta \, \mathrm{SSB}_t)$
- $N_{a+1,t+1} = N_{a,t} \exp[-M-F_a]$ (a=0,1,...5, "6+")
- $C_{a,t} = N_{a,t} \, e^{-M/2}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



Kawai,…,Matsuda, Fish. Sci. 2002

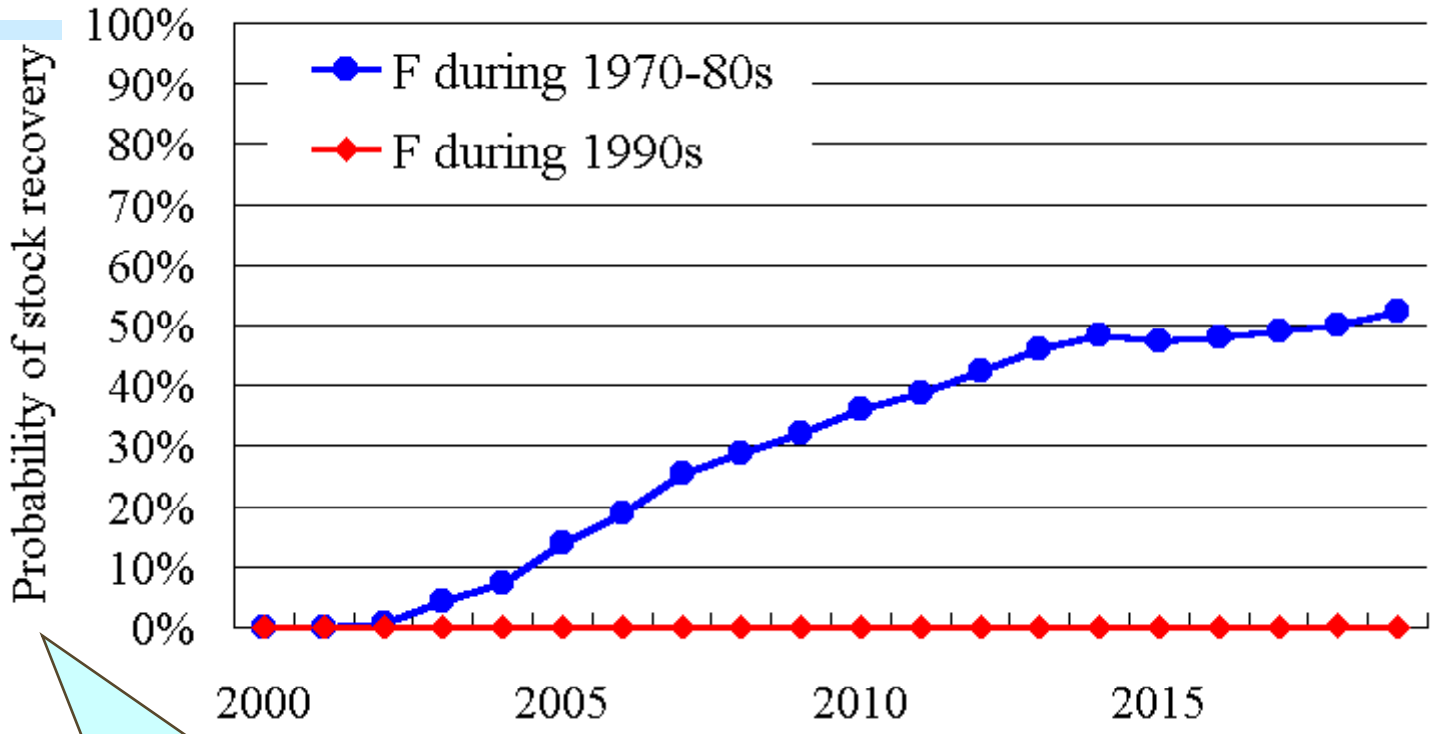
Fishers missed chance of recovery

Kawai,…,Matsuda, Fish. Sci. 2002



Probability of stock recovery

Kawai et al. (2002: *Fish. Sci.***68**:961-969)



Do not predict a single future

9. Conserve both fish and fishers;

- Can whaling be managed to protect whales and whalers? – Plenary talk by Judy Zeh* at International Mammalogical Congress at Sapporo, 2005
- Conserve diversity of flora, fauna, language and culture!! These are source of future human development

*Ms. Judy Zeh: past chair of Scientific Committee of International Whaling Commission (IWC)

Artisanal fisheries

Country	No. Fishers	No. Vessels	% Artisanal Fishers
Iceland	6,300	826	0.63
Norway	22,916	8,664	0.89
Denmark	4,792	4,285	0.86
U.K.	19,044	9,562	0.82
France	26,113	6,586	0.78
Canada	84,775	18,280	0.74
NZ	2,227	1,375	0.74
Spain	75,434	15,243	0.76
U.S.A.	ca. 290,000	27,200	0.53
Korea	180,649	50,398	0.9
Japan	278,200	219,466	0.98
Australia	13,500	C.A. 5,000	N.A.

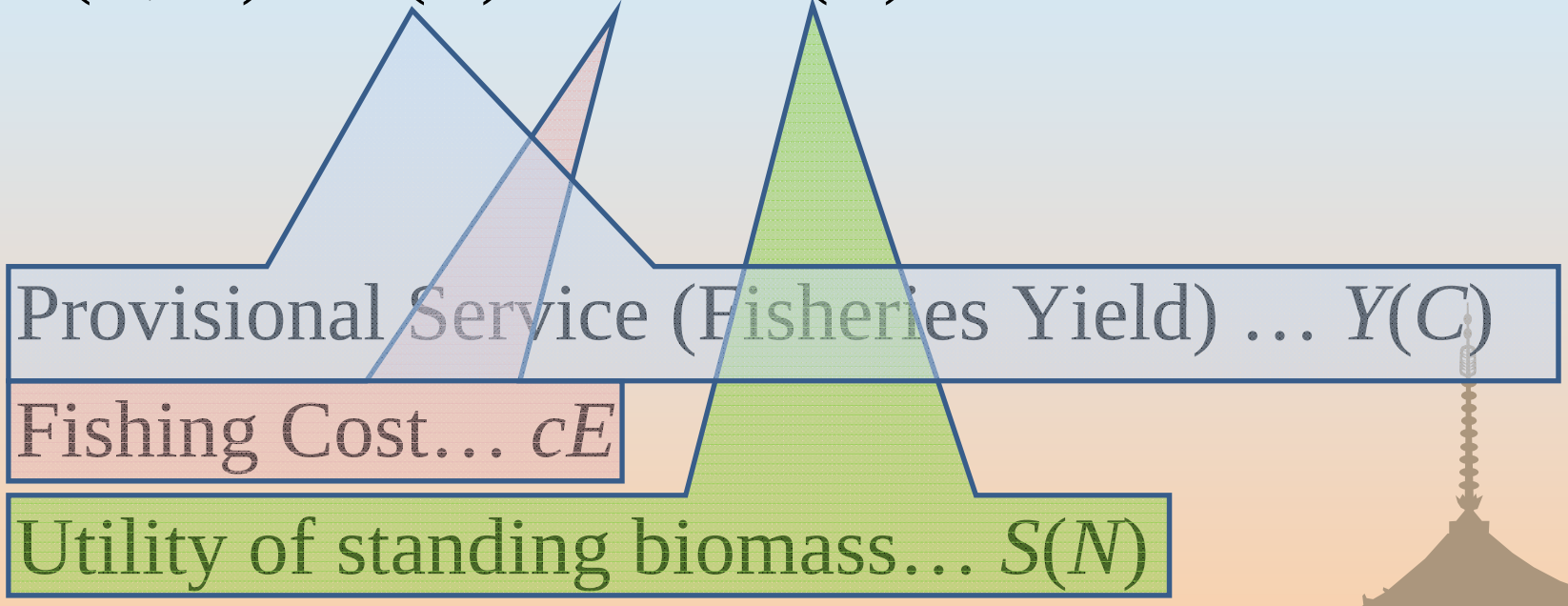
SSF < ISCFV 25 (the International Statistic Classification of fishery Vessels)

Ecosystem Services and Natural Capital

- Ecosystem services (air, water) including provisioning services (resource of agriculture etc.) are estimated to be in US$16-54 trillion per year, most of which is outside the market

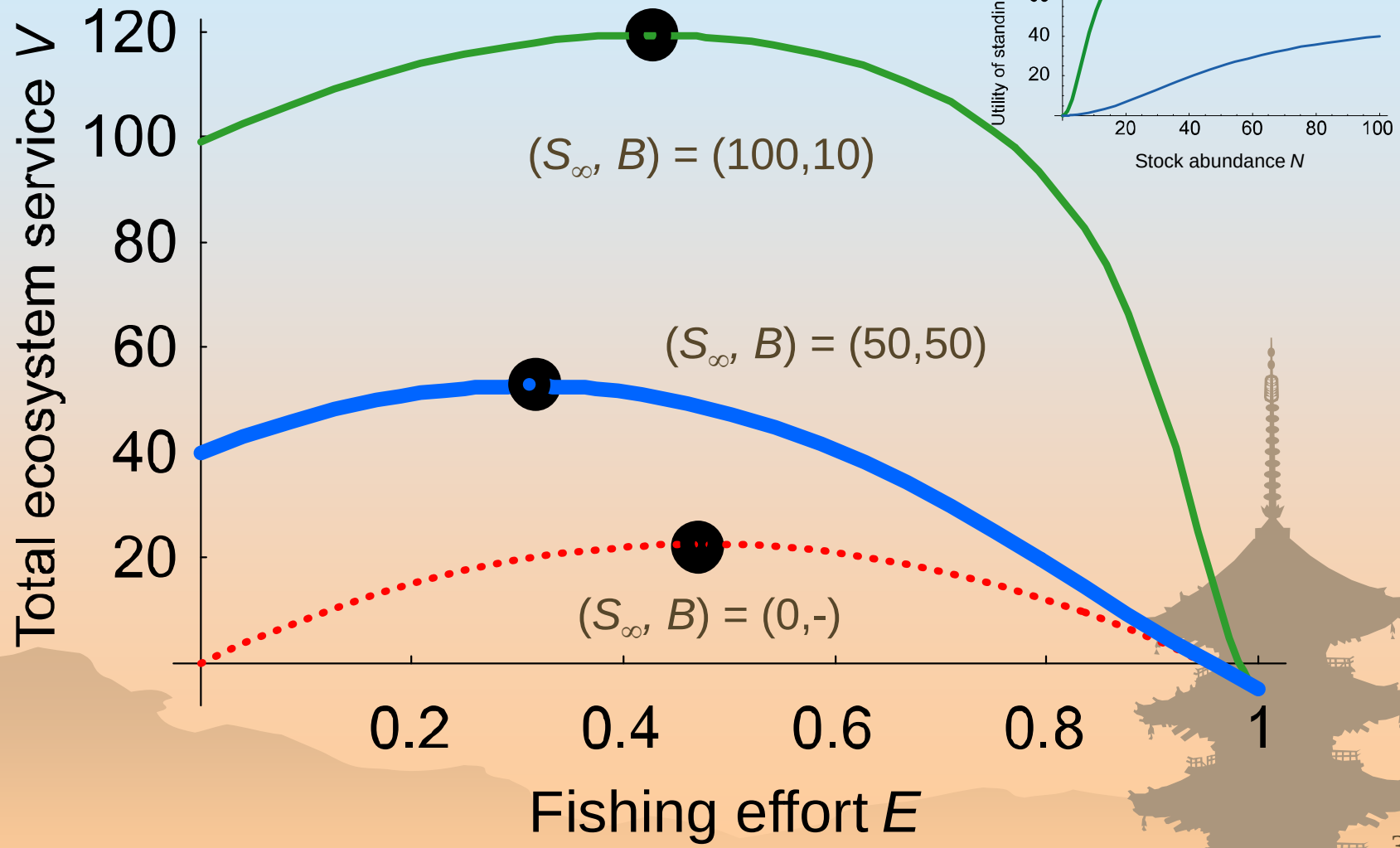
Ecosystem services $V(N, C)$

- $V(N, C) = Y(C) - cE + S(N)$

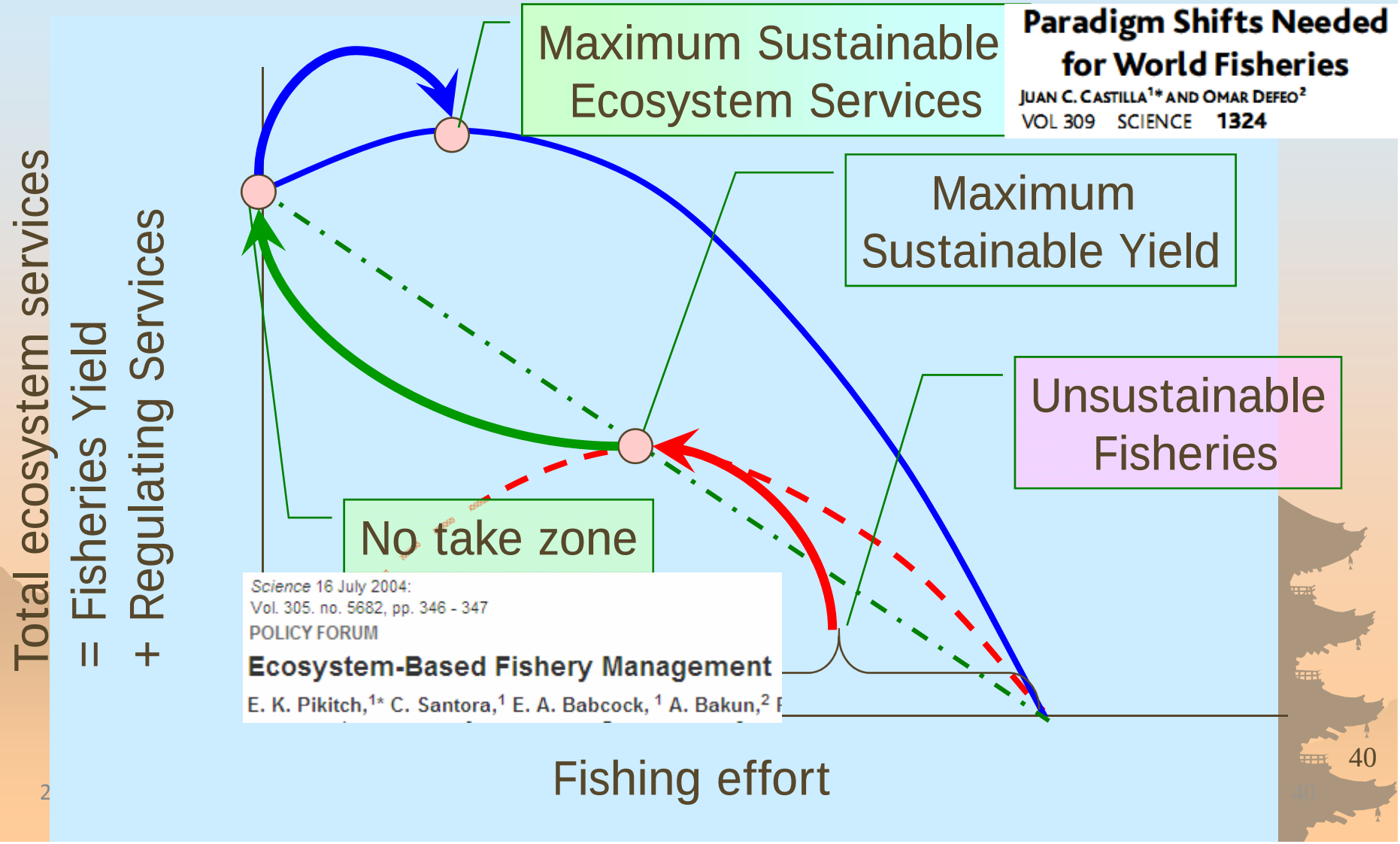


- Provisional Service (Fisheries Yield) … $Y(C)$
- Fishing Cost… cE
- Utility of standing biomass… $S(N)$
- C… catch; E… fishing effort; N… stock biomass

Maximum Sustainable Ecosystem Service



Paradigm Shift…

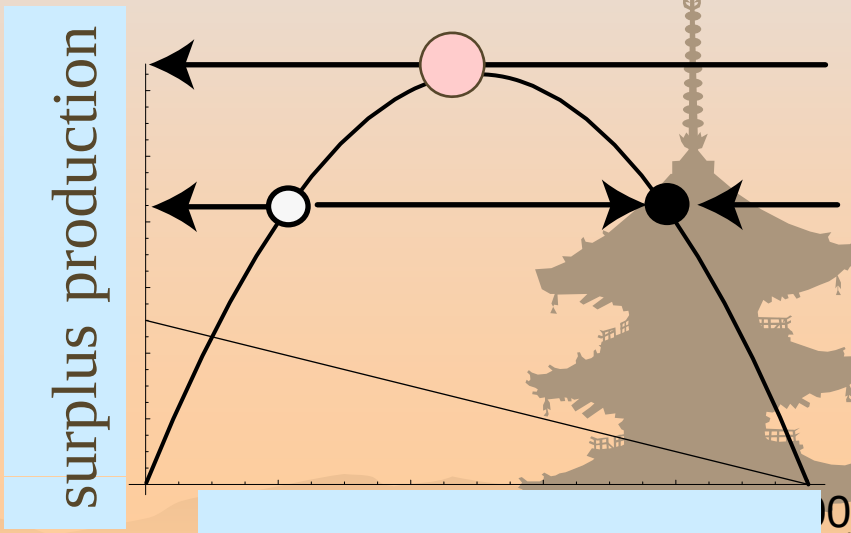


Paradigm Shifts Needed for World Fisheries
JUAN C. CASTILLA[1]* AND OMAR DEFEO[2]
VOL 309 SCIENCE 1324

Science 16 July 2004:
Vol. 305. no. 5682, pp. 346 - 347
POLICY FORUM
Ecosystem-Based Fishery Management
E. K. Pikitch,[1]* C. Santora,[1] E. A. Babcock, [1] A. Bakun,[2]

10. Say goodbye to traditional MSY theory;

- Ecosystems are uncertain, non-equilibrium and complex.
- MSY theory ignores all the three.



11. Monitor not only the target stock level but also other indicators of the ecosystem.

- Classical MSY theory ignores uncertainty, non-equilibrium, and complex of ecosystems.
- Adaptive management (AM) is robust against uncertainty and non-equilibrium of ecosystems.
- Monitoring of fish biomass is indispensable for adaptive fisheries management.
- But it is not enough for complex ecosystems.

Feedback control in fishing effort is robust against uncertainty...

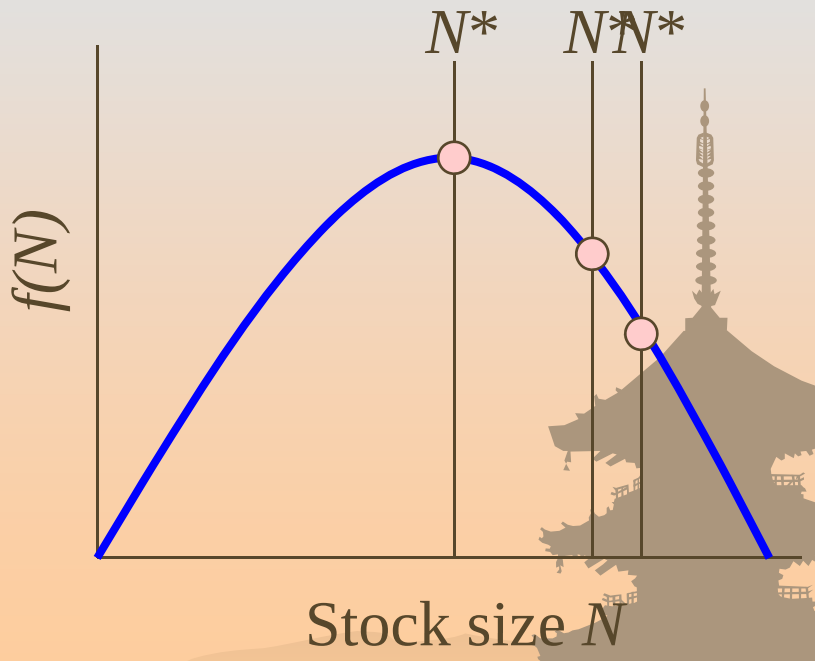
Stock size

$$\frac{dN}{dt} = f(N) - qEN$$

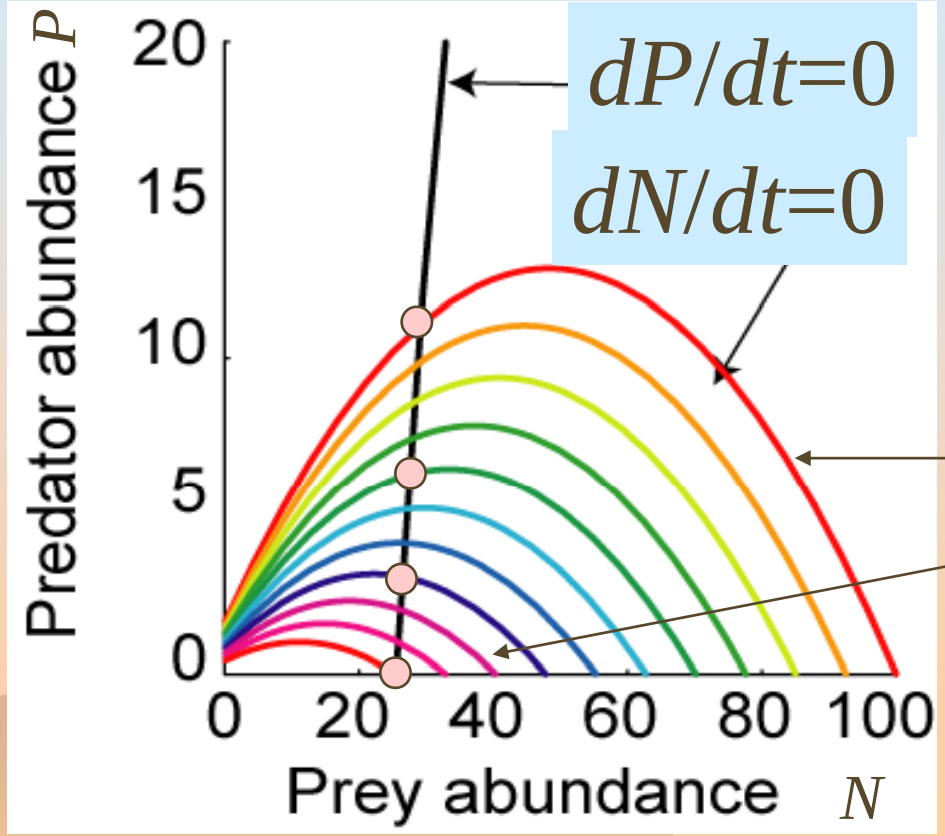
Fishing effort

$$\frac{dE}{dt} = U\left(N - N^*\right)$$

Even though the MSY level is unknown, the feedback control stabilizes a broad range of target stock level .



If prey is exploited and fishing effort is feedback control, ...(Matsuda & Abrams in prep.)



$$\frac{dN}{dt}=r\left(1-\frac{N}{K}\right)N-\frac{fCN}{1+hCN}P-qCEN$$

$$\frac{dP}{dt}=\left\{-d-gP+\frac{bfCN}{1+hCN}\right\}P$$

Fishing effort E is small

E is large

predator *P* **fishery *E***

sardine *N*

My 11 recommendations

1. Do not eat high value fish too much!
2. Catch more fish at lower trophic levels;
3. Do not use too much fish as fish meal;
4. Reduce discards before and after landings;
5. Establish food markets for temporally fluctuating fishes at lower trophic levels;
6. Improve the food-processing technology used on small pelagic fishes;
7. Switch the target fish to correspond to the temporally dominant species;
8. Conserve immature fish especially when the species is at a low stock level;
9. Conserve both fish and fishers;
10. Say goodbye to traditional MSY theory;
11. Monitor not only the target stock level but also any other indicator of the “entire” ecosystem.