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Why do I criticize MSY theory in ecosystem approach?

- Hiroyuki MATSUDA (Yokohama Nat'l Univ.)
  - Program Committee for 5th World Fisheries Congress 2008
  - Since 2004 Sci. Committee of Shiretoko World Heritage
  - 2003-2006, Chief Editor of Jpn. J. Cons. Ecol.
  - Since 2003 Standing Committee of Ecol. Soc. of Japan
  - Since 2002, Committee for Stock Assessment, Fisheries Research Agency, Japan
  - Since 2002 Advisory Committee, WWF Japan
  - 2001-2003 IWC/SC, Japan deligate

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Notes on Demystifying Ecosystem Approaches

- I still encourage adaptive *population* management.
- MSY theory is not based on EA
- Understand difficulty of EA (Indeterminacy in indirect effects; Mystifying approach)
- Target switching is robust and efficient
- Make a falsifiable prediction
- Adaptive management may not work in EA

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Seek simplicity, but distrust it

–Begon, Harper & Townsend (1986) "Ecology: Individuals, Populations and Communities"

- **Make a simple model that only includes statistically/biologically evident to obtain reasonable results.**
- **Include process- & measurement- errors.**
  - Risk management is needed
- A **simple model with errors** can explain the data if it does not include wrong factors.

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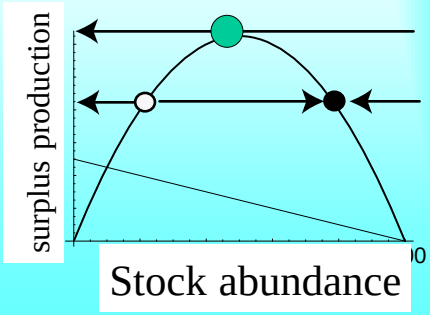
"Community (multispecies) model is needed when either…

- Species interactions (prey-predator, …) probably affect stock dynamics and coexistence…, and like to make a multispecies conservation or management plan; or
- Population dynamics of each species is mutually (positively or negatively) correlated;
- **Myth #1: complex model including EA is always powerful.**

Requiem to Maximum Sustainable Yield Theory

- Ecosystems are uncertain, non-equilibrium and complex.
- MSY theory ignores all the three.
- Myth #2 MSY theory guarantees species persistence…



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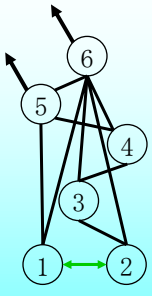
Unconstrained MSY that maximizes the total yield from the community
(Matsuda & Abrams 2006)

- We choose fishing effort e_i independently;
- 6-species systems including 2 prey
- random matrix with 50% probabilities;
- we seek **r** having a positive equilibrium;
- price **p** is 0-1 for prey, 0-10 for predators
- Unconstrained MSY that may result in extinction;



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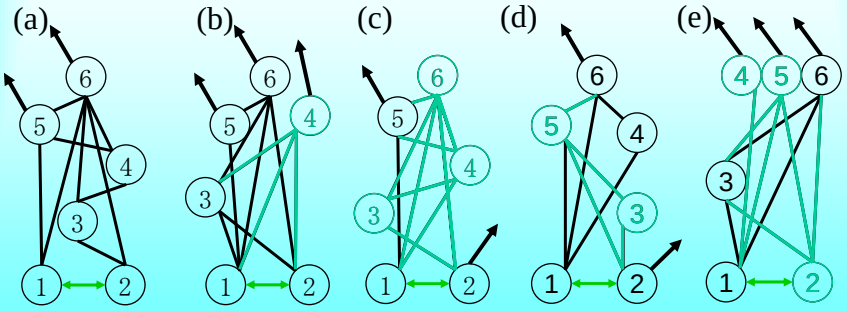
Some resultant biological communities at MSY (Matsuda & Abrams 2006)

Solution maximizing total yield from community

MSY solution usually reduces species and links;



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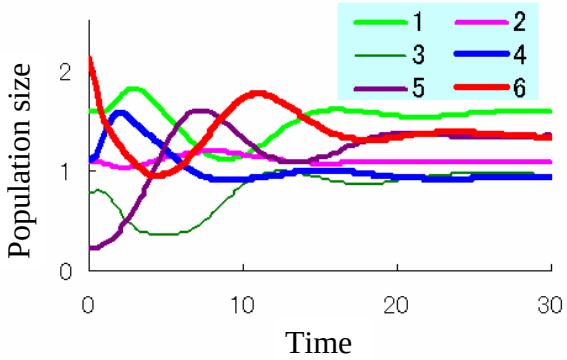
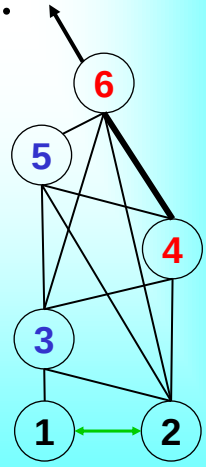
Difficulties & hopelessness in ecosystem modeling

- We need many unverified assumptions and intuitive understanding is usually difficult
- *"Ecosystem models without errors" often overfit observed data and predict a unique future.*
- Indirect effects via the third species or adaptive change in traits is often counterintuitive and not negligible in the long-term effect (see Abrams, Polis…);
- Indeterminacy (Yodzis 1988): Results (+/-) vary with small change in parameter values

Catch of top predators may decrease its prey fish.





- Myth #3 Trophic cascade: decrease of predator always increases its prey.

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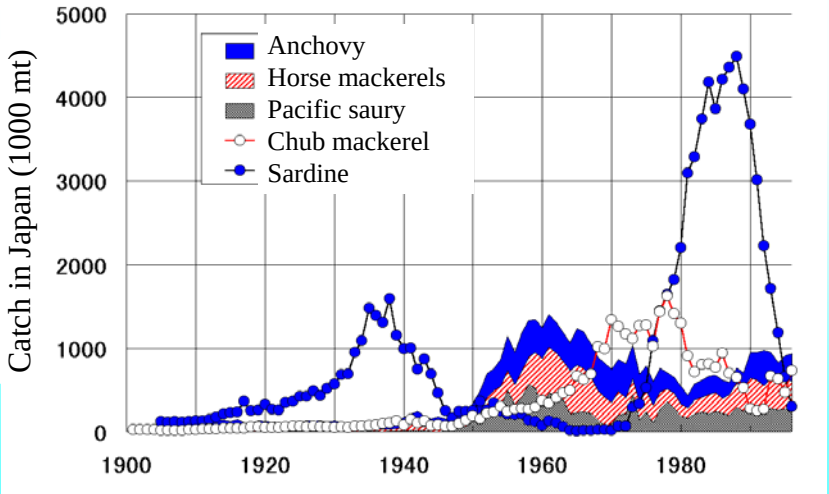
Species Replacement of Pelagic Fishes



Target switching of multispecies fisheries (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)

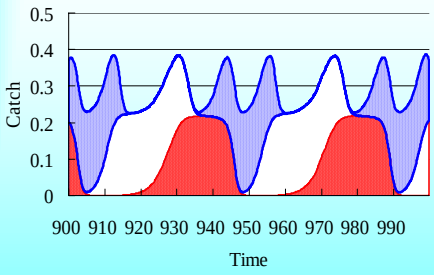
Policy 2 (switching; SF)

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

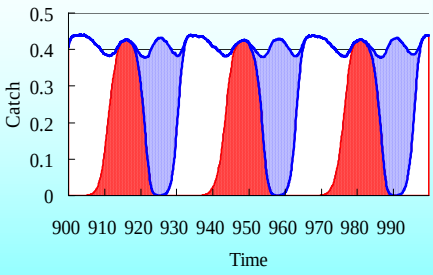
Fishers focus on relatively abundant fish species.

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

No Switching



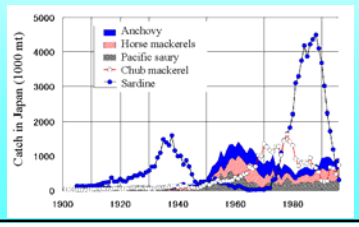
Switching

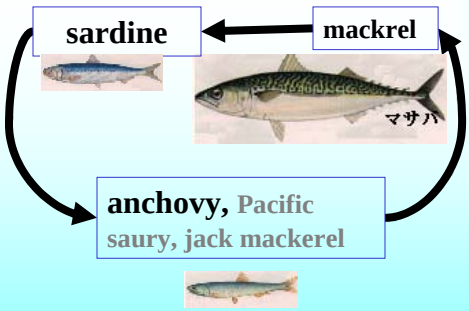


- If stock fluctuations of alternative fish are negatively correlated or independent

Cyclic Advantage Hypothesis based on ecosystem approach (species interaction)

The next dominant to sardine is anchovy –
Yes! As I predicted
The second next is chub mackerel
Many people agree now





Matsuda et al. (1992) Res. Pop. Ecol. **34**:309-319

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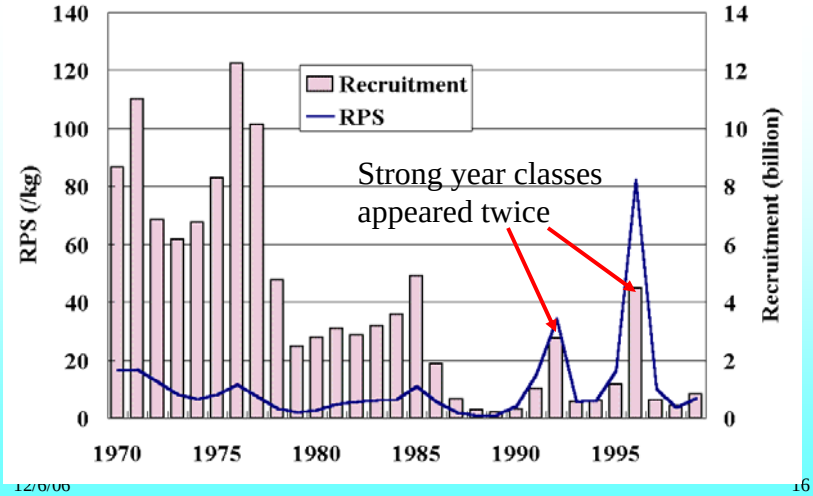
Large fluctuation of recruitment in chub mackerel (Kuroshio stock)



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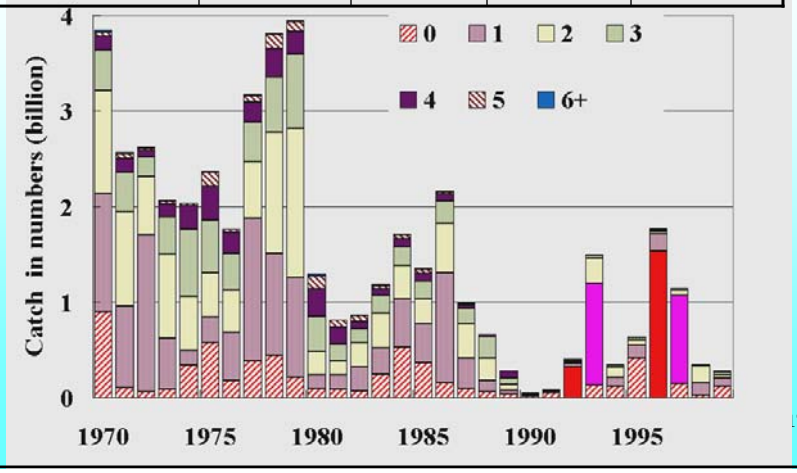
Immatures were heavily caught before the age at maturity

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



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Future of Pelagic Fish Populations in the north-western Pacific:

- If overfishing of immatures continues,
  - –chub mackerel will not recover forever.
  - –Fishers did not agree to my recommendation.
- If cyclic replacement hypothesis is true,
  - –sardine will not recover forever either.
- Do not catch immatures too much!
  - –The overfishing is an **experiment** for my hypothesis. (adaptive mismanagement)
  - –In 2003, fishers agreed to stock recovery plan!

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Feedback control in fishing effort is powerful...

Stock size

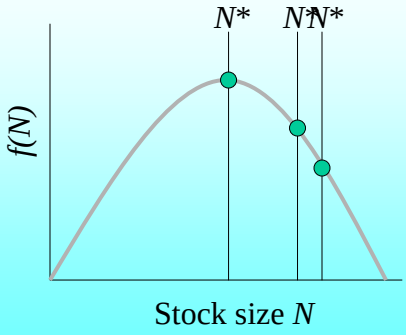
$$\frac{dN}{dt} = f(N) - qEN$$

Fishing effort

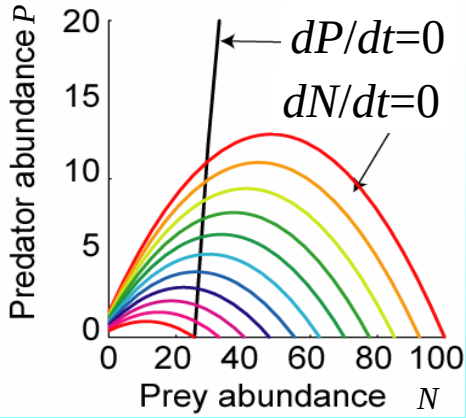
$$\frac{dE}{dt} = U(N - N^*)$$

Myth #4

- 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.)



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

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

no adaptation (C is constant)

$dE/dt = U(N-N^*)$

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

sardine *N*

Fishing effort must be controlled by the predator density *P*

- $dE/dt = U(P$ – Target predator density)
- $E = E(N, P)$, $\partial E/\partial N > 0$, $\partial E/\partial P > 0$
  e.g. $E = E_{target}\,(1 + a \log NP/N_{target}P_{target})$
- In this case, feedback control guarantees persistence of the target stock and its predators.
- Adaptive *multi-species* management is sometimes needed (seek simplicity, but distrust it).

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Conclusion of today's my talk

1. Do not catch fishes that are at low stock levels;
2. Do not catch immature fishes but catch adult fishes;
3. Catch fishes that are temporally dominant;
4. In order to achieve Principles 1-3, improve the technology for selective fishing gear;
5. Monitor not only a target species, but its prey and predator and the ecosystem;
6. We must remind that our temporal decision may be wrong. (a key concept of adaptive management)

Seek simplicity, but distrust it

Thank you for attention!

- In Shiretoko World Natural Heritage inscribed in 2005, we try to include Ecosystem perspectives (esp. endangered species protection and material circulation) in coastal fisheries management;