PICE2009 Annual meeting Science Board Symposium (S1)
Understanding ecosystem dynamics and pursuing ecosystem approaches to management

Understanding the interactions between ecosystem structure and fisheries structure:
case of sardine, anchovy, chub mackerel, and purse seine fishery in Japan

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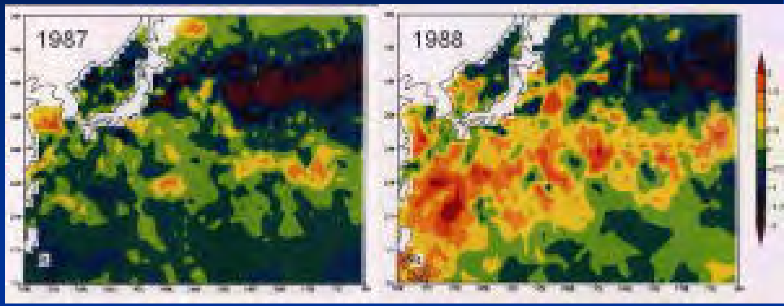
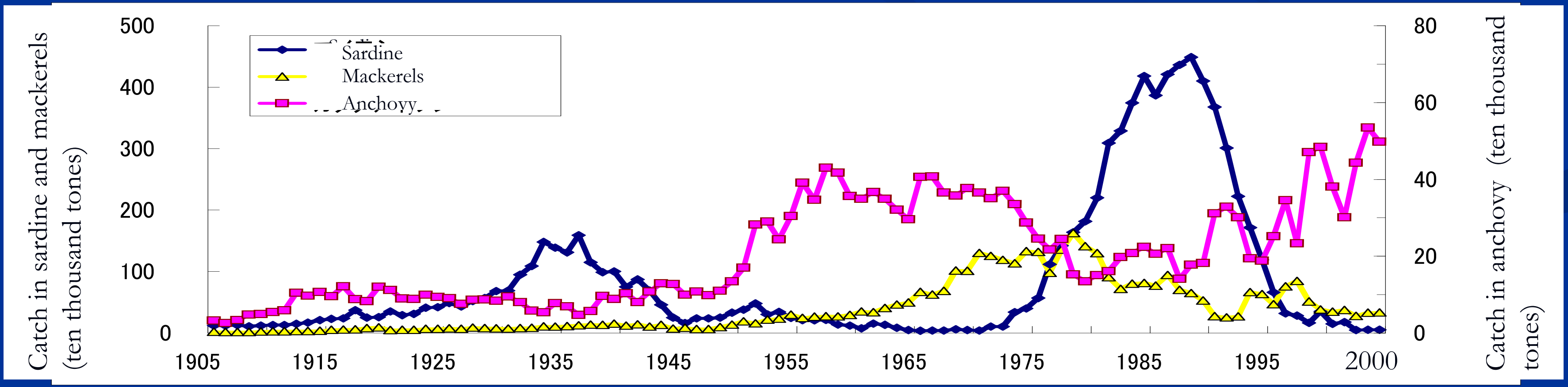
Background

- It has been known the relationship between climate regime shift and the fish species alternation (ecosystem dynamics).

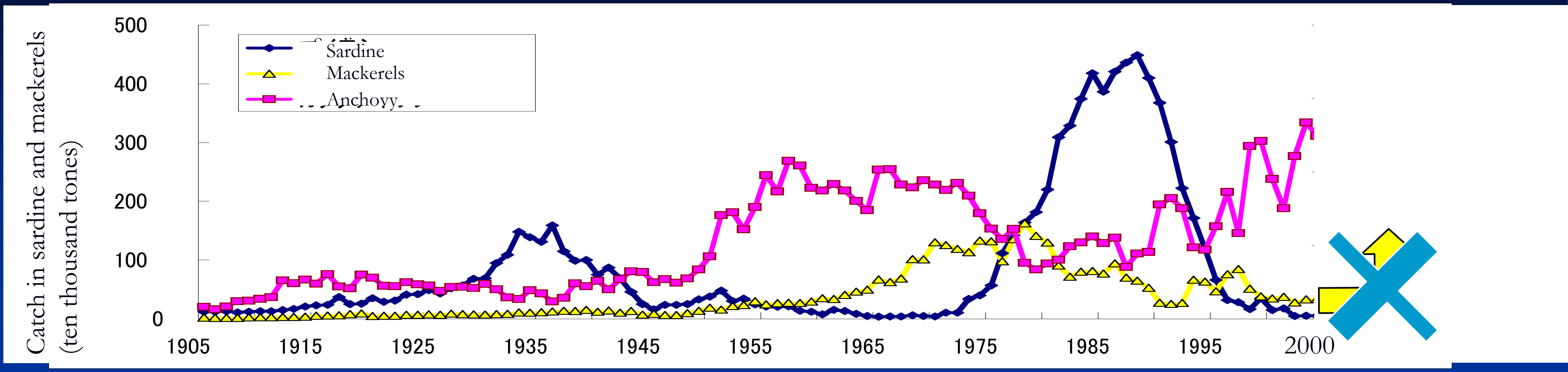


SST anomaly in Feb (Noto & Yasuda 1999)

- In the northwestern Pacific, it appears sardine, anchovy and mackerels show the species alternation phenomena of c.a. 50 years cycle.



Changes in Japanese catch (MAFF)



• If the species alternation theory between 3 species are true, the mackerels catch should have been increased since around the end of the1990s.

•However, we have not observed such a dramatic increase in mackerel's catch.

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Disruption of the fish alternation phenomena (ecosystem dynamics) in the northwest Pacific.

Let’s look at the inter-relationships btw species alternation and purse seine fisheries

Purse Seine Fisheries in Japan (North Pacific)

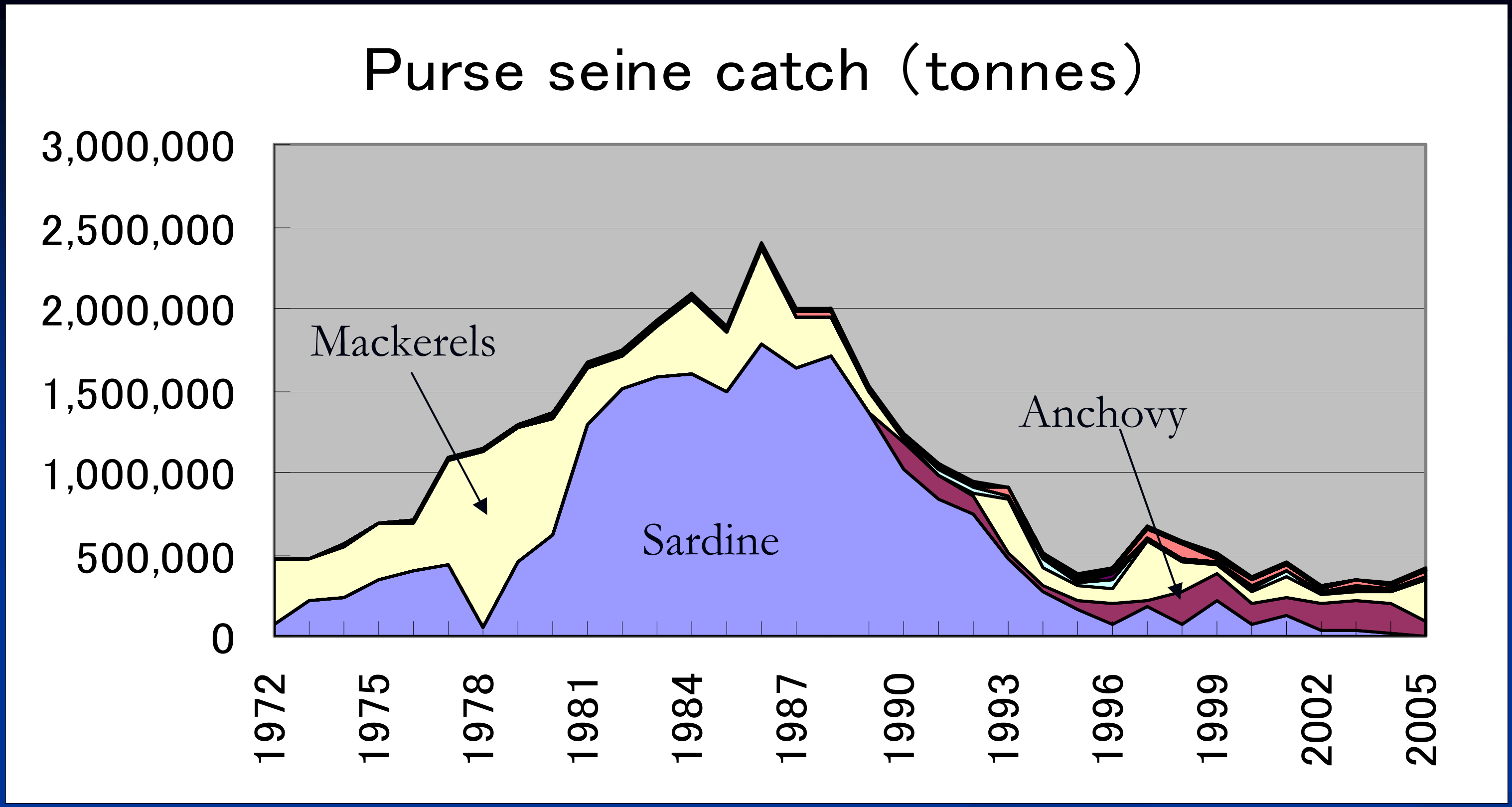
- One of the biggest fisheries sectors in Japan.
- Managed by license from the Minister (5 years).
- In 2005, it produces 413 thousand tonnes, \22.2 billion (US$ 241 million).
- In 1987, 72 operation units.

Main ship (net fish): 135t type

2* Transportation ship: 330t type

Search ship: 99t type

http://www.souhou.jp/fukushima

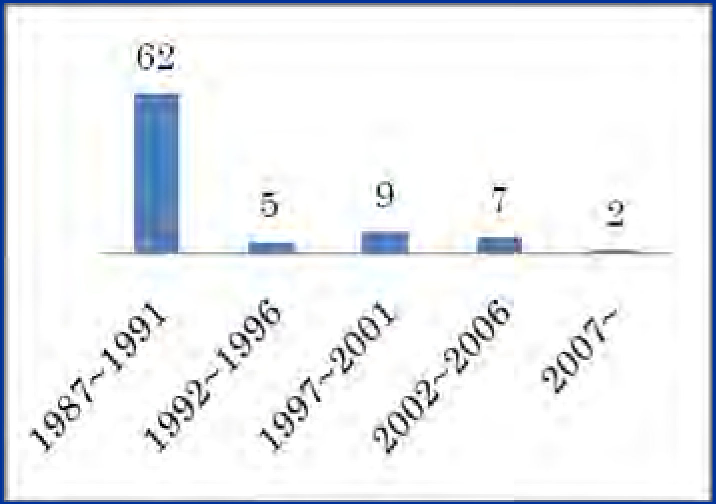


- The peak in catch was 1986. In this period, too much sardine existed in the fishing ground, and sometimes broke purse seine nets.
- Total number of fleets (operation units) are regulated by licenses. So, the major limiting factor was the capacity of transport from the fishing ground to ports.

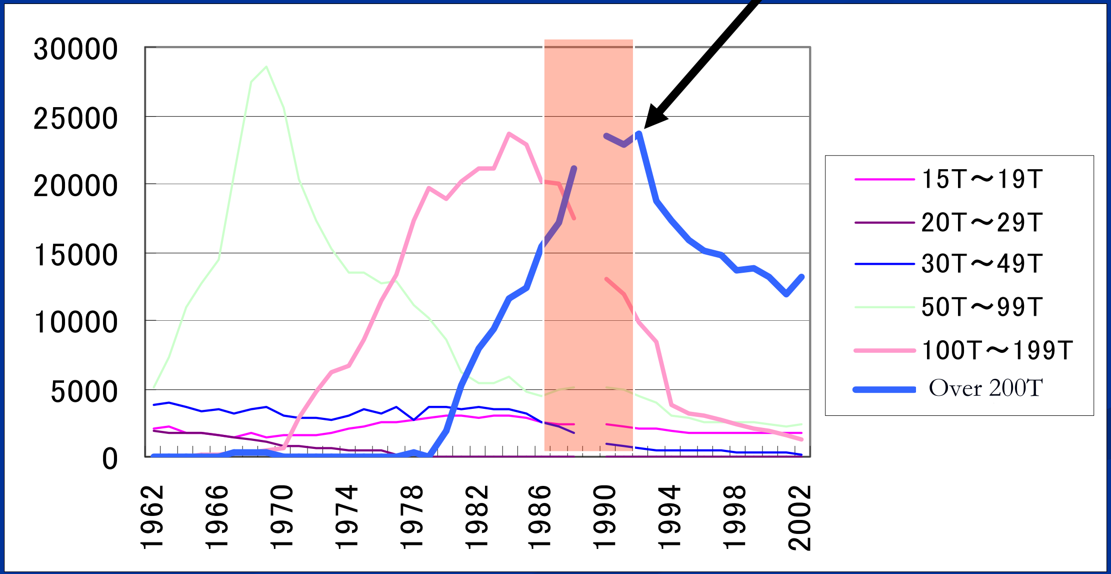
Purse seiners' response

- Since the around the peak in catch (1986), they constructed many new vessels, esp. large transport ships.
- Also the Japanese economy was in the economic bubble, and banks were very happy to lend money for purse seiners.

Transport ship: 330t type

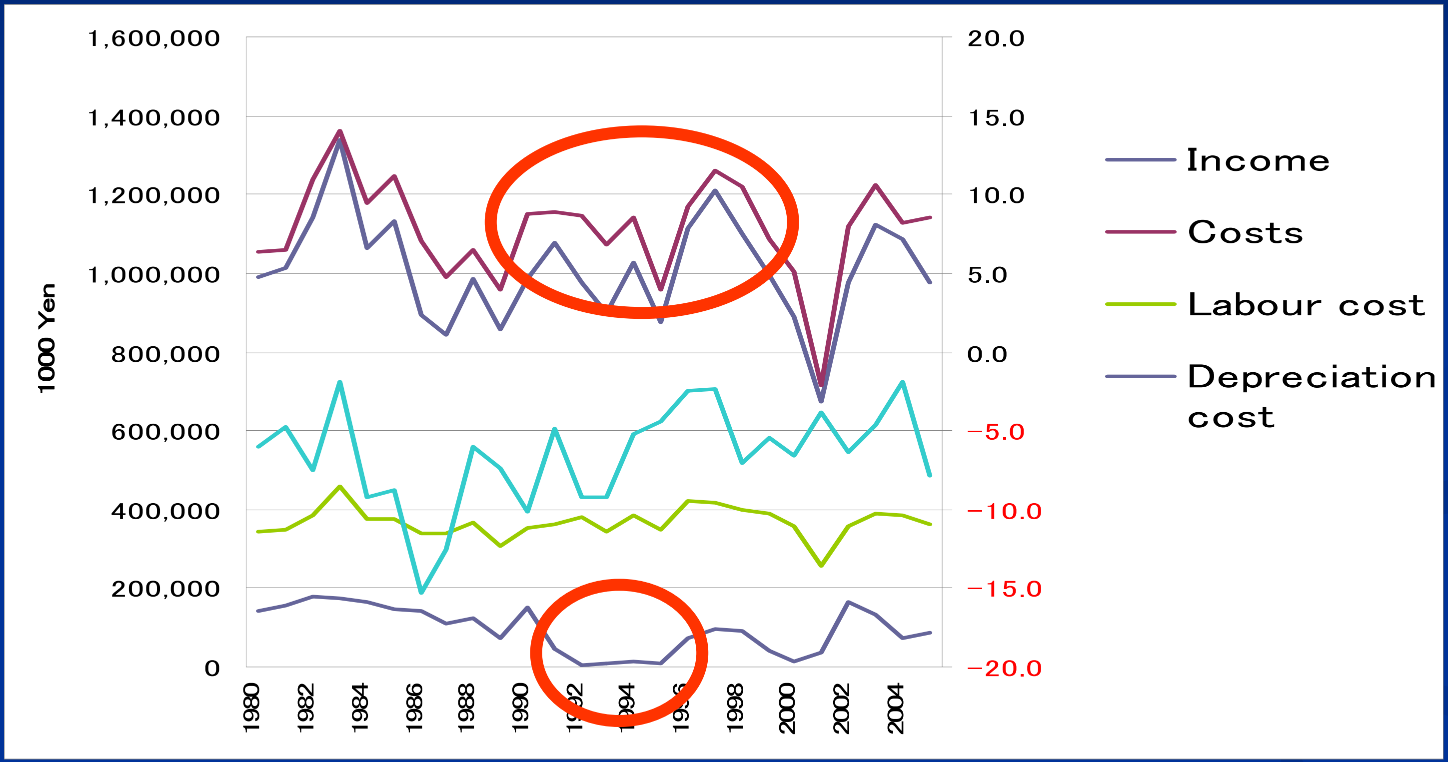


Number of vessel construction by the license period.



Total gross tonnes of transport ships by size class

- It inevitably led to the increase in costs, which then became the serious burden since around 1990 after sardine was gone.

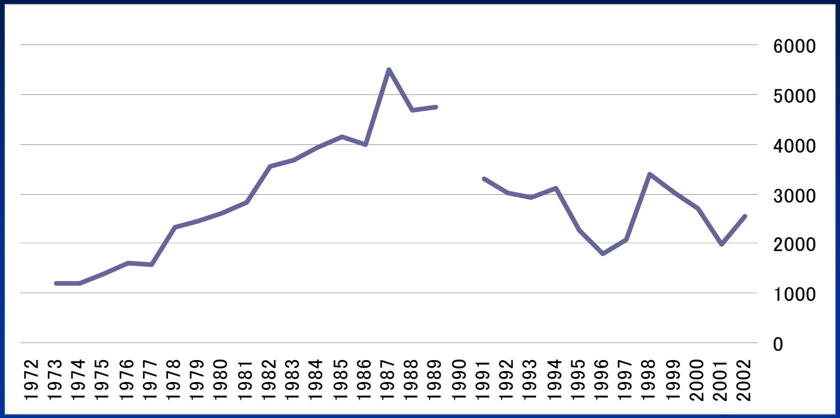


Average balance sheet of sampled purse seine units (MAFF)

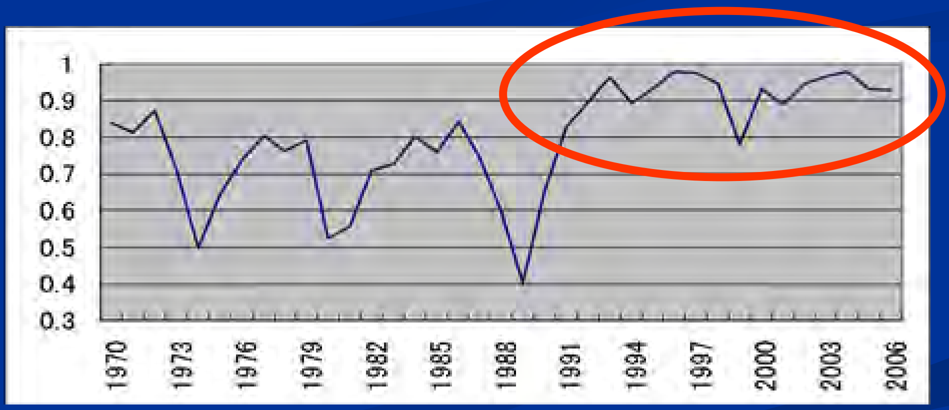
- In order to keep the balance of business, they cut depreciation (the real costs were much higher).

In the end

- Too much capacity (esp. transport vessel) and high costs with no sardine in the sea.
- However, purse seiners had to pay back the debt. In order to avoid bankruptcy, they had no choice but increasing fishing efforts for mackerels in the 1990's.
- In '92, '96, there observed strong year classes of chub mackerels, but most of them are harvested at young ages, and did not led to resource increase.



Average annual catch (tonnes) per one transport ship



Ratio of the small mackerels (0~2 years) in the catch

- To sum up, resource fluctuation of sardine and fishing fleet dynamics are closely related to resource status of chub mackerels.

- There were enough anchovy in 1990s, but the price of anchovy is cheaper than small mackerel (about a half price). This economic condition prevented anchovy from being the substitute for sardine.

- Then, if we had known/forecasted the species alternation phenomena, what could we have done to keep the species alternation?

We assumed combinations of two policy interventions

1. Restrictions on new vessel constructions during the license period of 1987-1991 (right after the catch peak in 1986).

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Cost reduction

2. Restriction on fishing operations for mackerels

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Mackerel stock protection

Three management scenarios

Scenario 1: 10% reduction of new vessel construction (cost reduction) + regulated mackerel catch of each year at the break-even point (no profit, but no negative).

Scenario 2: 25% reduction of new vessel construction + regulated mackerel catch of each year at the break-even point.

Scenario 3: 10% reduction of new vessel construction + break-even catch of mackerel only for 2 years after the emergence of strong year classes (in other years, the real fishing pressures were assumed, i.e., adaptive).

We calculated changes of catch, spawning stock biomass (SSB), and total biomass of chub mackerels.

Assumptions

- Depreciation period for fishing vessel is 20 years
- According to the fishing capacity reduction level, catches of other species shrinks.
- Price of mackerels:
  f (mackerel catch (tonnes), ratio of small mackerel (%))
- Amount of mackerel catch at the break-even point in each year = necessary break-even income from mackerels in each year /estimated price of mackerel in each year
- Natural mortality, selectivity at ages, weight at ages, etc., were according to the official resource assessments.

Assumptions (cont.)

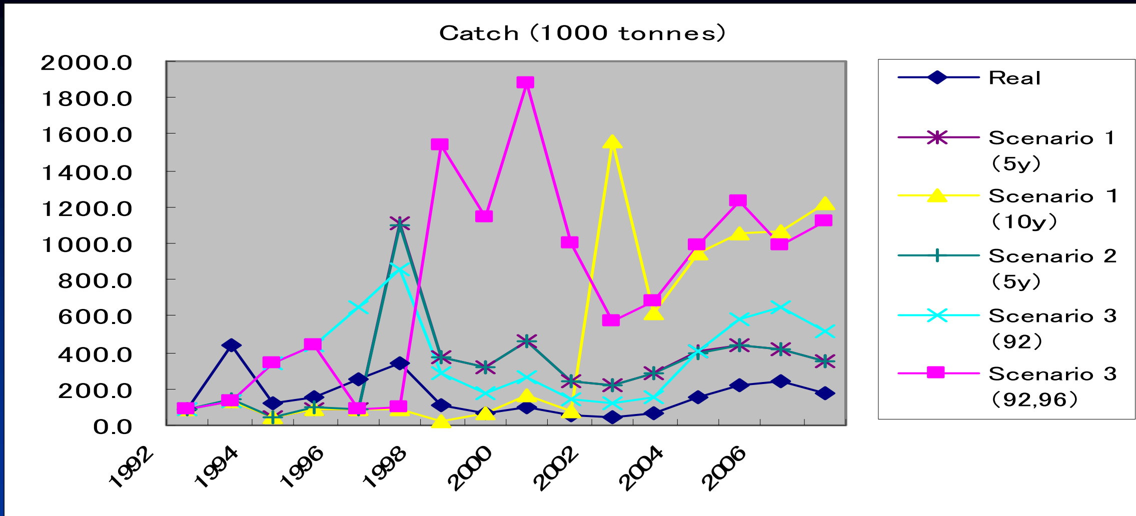
- The recruitment-spawning relationship (RPS) was assumed as follows, according to the level of SSB in each year.

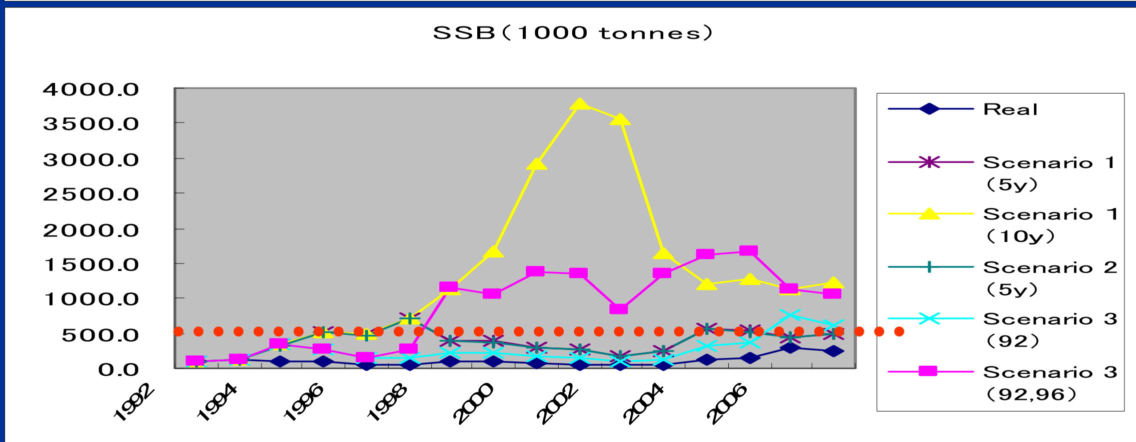
1) when SSB in year y is lower than 450 thousand tonnes, recruitment is calculated form the SSB and RPS in year y,

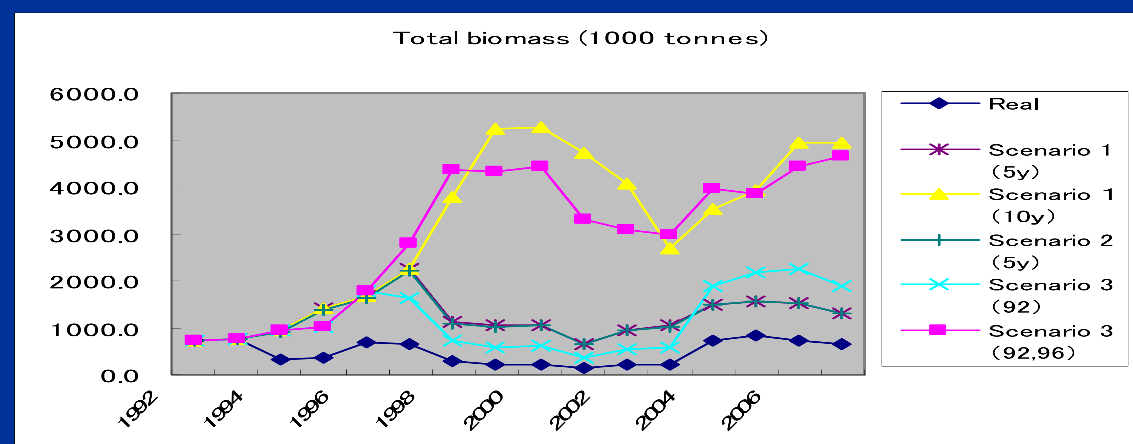
2) when SSB is among 450~1000 thousand tonnes , recruitment is calculated from the Ricker-type recruit-spawning relationship in 1979 - 1985,

3) when SSB is larger than 1000 thousand tonnes, recruitment is calculated from the Ricker-type relationship in 1970-1978.

- After the stock in number at ages in the next year is estimated, the age composition in the next year is applied to the price estimation function, and calculated the "break-even catch of chub mackerel" in the next year. We repeated these procedures.







- S1 (10%) for 5 year B-E operation to mackerels leads to tentative recovery of SSB over Blim, and catch and total biomass are about twice of the real.
- S1 for 10 year B-E operation to mackerels leads to enough recovery.
- S2 (25%) is slightly better than S1, but basically the performance is same.
- In S3 (10%), protection of '92 year class is not enough, lower than S1 or S2.
- In S3, protection of '92 & '96 year classes (4 years) leads to enough recovery.

Conclusion

- Under the species alternation phenomena, the combination of

1) regulation on new vessel construction (capacity regulation) around the alternation period, and
2) adaptive protection of strong year classes for more than once,

are the best choice amongst various management scenarios in this study.

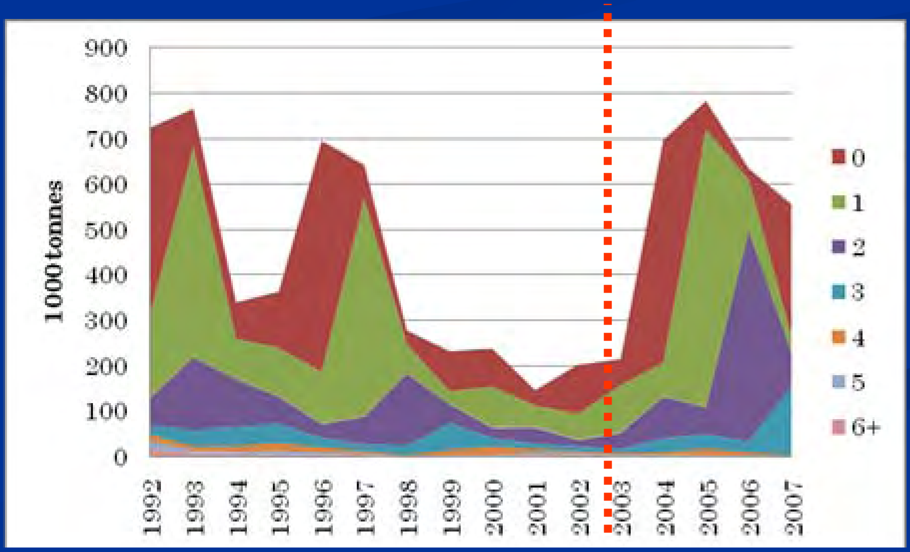
Conclusion (cont.)

  - Especially, observation/forecast of regime shifts and strong year classes are highly valuable for fisheries management context.

- As this case study shows, both the natural science on ecosystem mechanisms and social science on human responses are indispensable for understanding the ecosystem dynamics and sustainable use of ecosystem services.

Supplemental information

- The purse seiners in the north pacific gradually reduced fishing vessels. Now the total number of operation units are 27.
- Also, they introduced Resource Recovery Plan for chub mackerels in 2003, protected strong year class of 2004.
- The estimated SSB shows good recovery, but not enough.
- Protection of one more strong year class would lead to the recovery, and subsequent species alternation.



Estimated biomass in 1992~2007

(Data from official stock assessment report)

Thank you very much

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