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Effects of natural and anthropogenic stressors in the North Pacific ecosystems: Scientific challenges and possible solutions

Marine ecosystem responses to sporadic perturbation: their processes, social impact and possible solutions

In the case of *"fish species alternation"* responding to climate change

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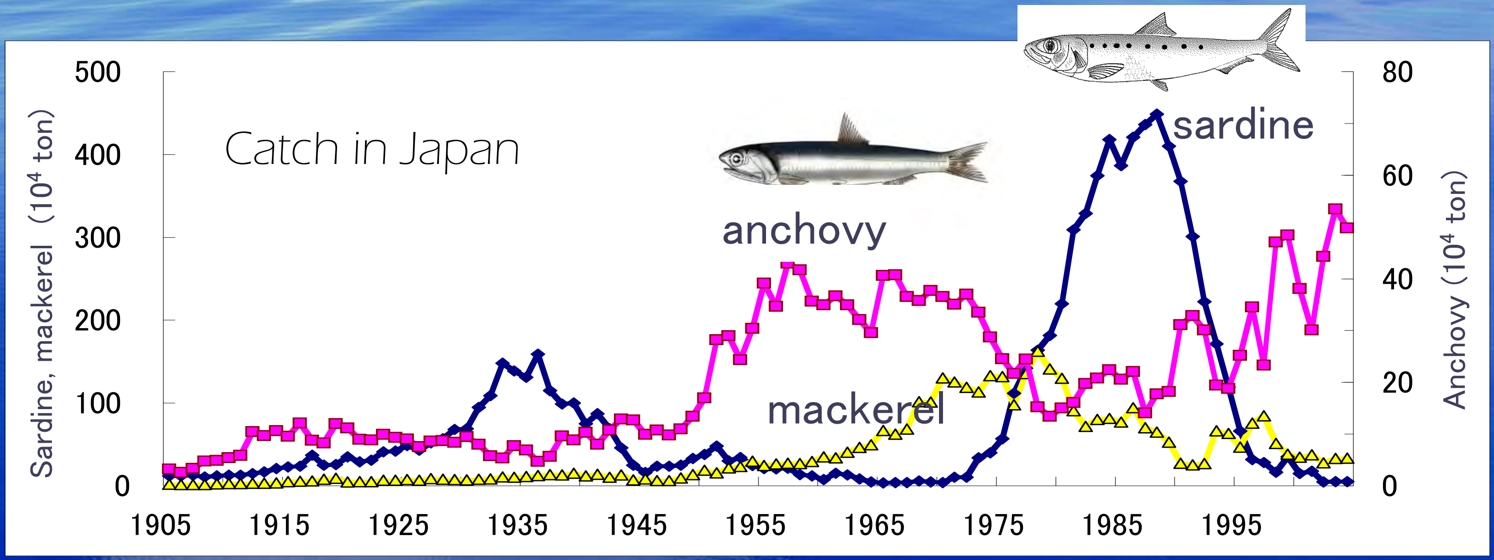
Fish Species Alternation (FSA)



Sardine landing in Japan:

1960s: 10^4 -10^5 ton

mid 1980s : >4 x 10^6 ton

1988: start declining

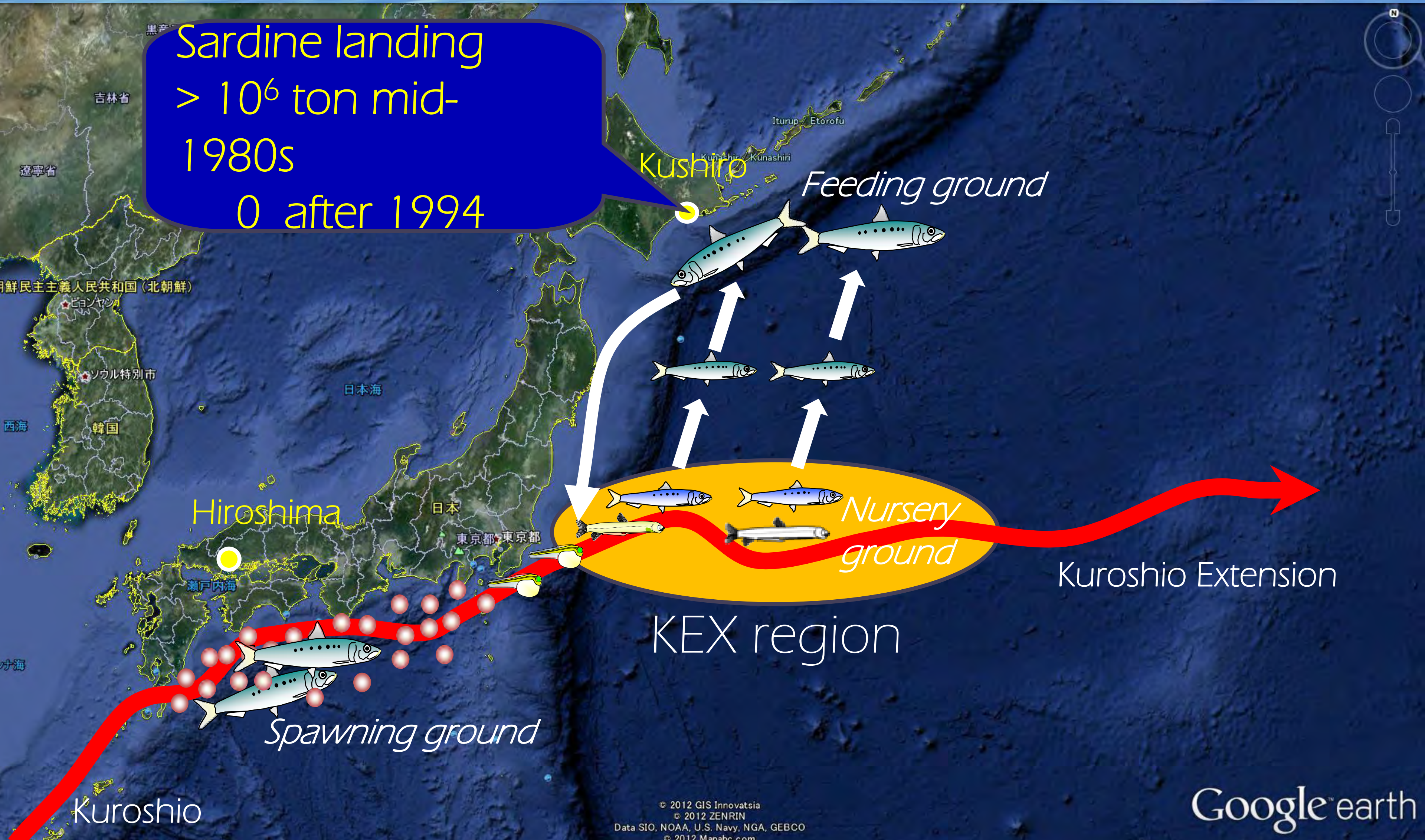
2000- : ～ 10^5 ton (<5% of peak landing)

Anchovy landing increased after the sardine stock collapse

Mackerel landing was high at the transition phase of S-A

Alternative increase of dominant fish species

Migration route of Japanese sardine



Impact of the sardine collapse to regional economy in Kushiro for 3-yeas (1990-92)

Kaneko et al
In review

Department	Economic impacts (10^6 yen) Direct	Indirect	Induced	Employment
Agriculture & Forestry	0	-1	0	0
Fishery	-9	-84	-6	-5
Mining	0	-15	-1	-1
Seafood processing	-6,339	-248	-13	-96
Manufacturing	-1,306	-190	-40	-19
Construction	0	-24	-9	-1
Electicity, gas & water	0	-202	-27	-4
Commerce	-559	-593	-135	-144
Finance & insurance	0	-173	-34	-9
Real estate	0	-101	-173	-1
Transportation & Comm.	-70	-254	-71	-32
Services	0	-396	-264	-27

- 11 billion yen -339 jobs

Impacts of FSA

- 11 billion yen   -339 jobs in Kushiro during 1990-92

25 fleets reduction (with subsidy)

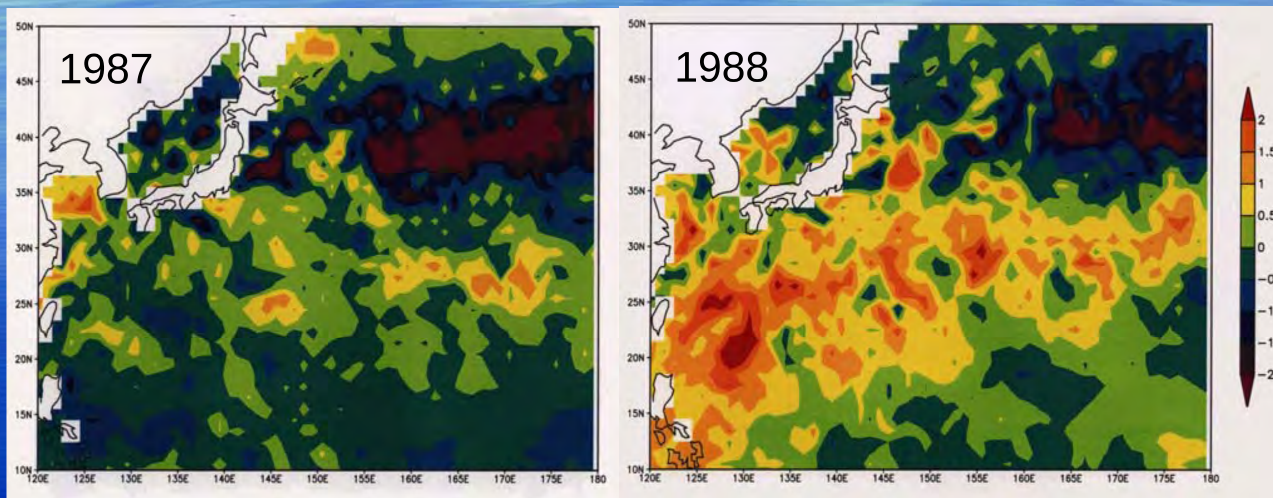
Sudden and unpredictable FSA induced serious economical and social problems

If FSA is possible to forecast, fishers are able to prepare the decrease and take appropriate investment strategy, and the government is easy to push new fisheries management policy to counteract the FSA

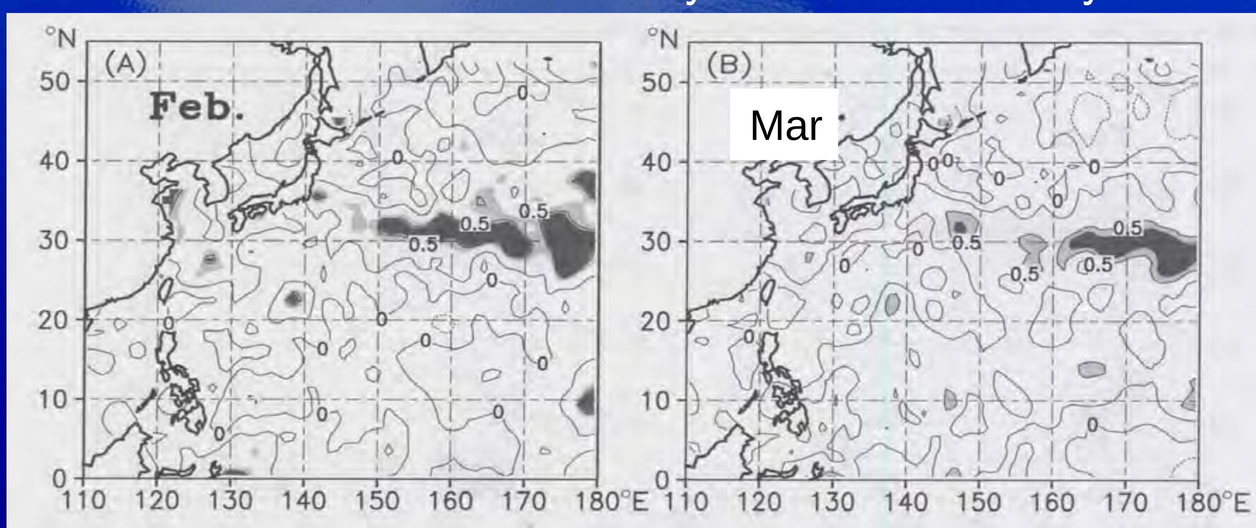
The goal of SUPRFISH programme: Understanding the mechanisms of FSA and the forecasting

What is the trigger of the FSA?

SST anomaly



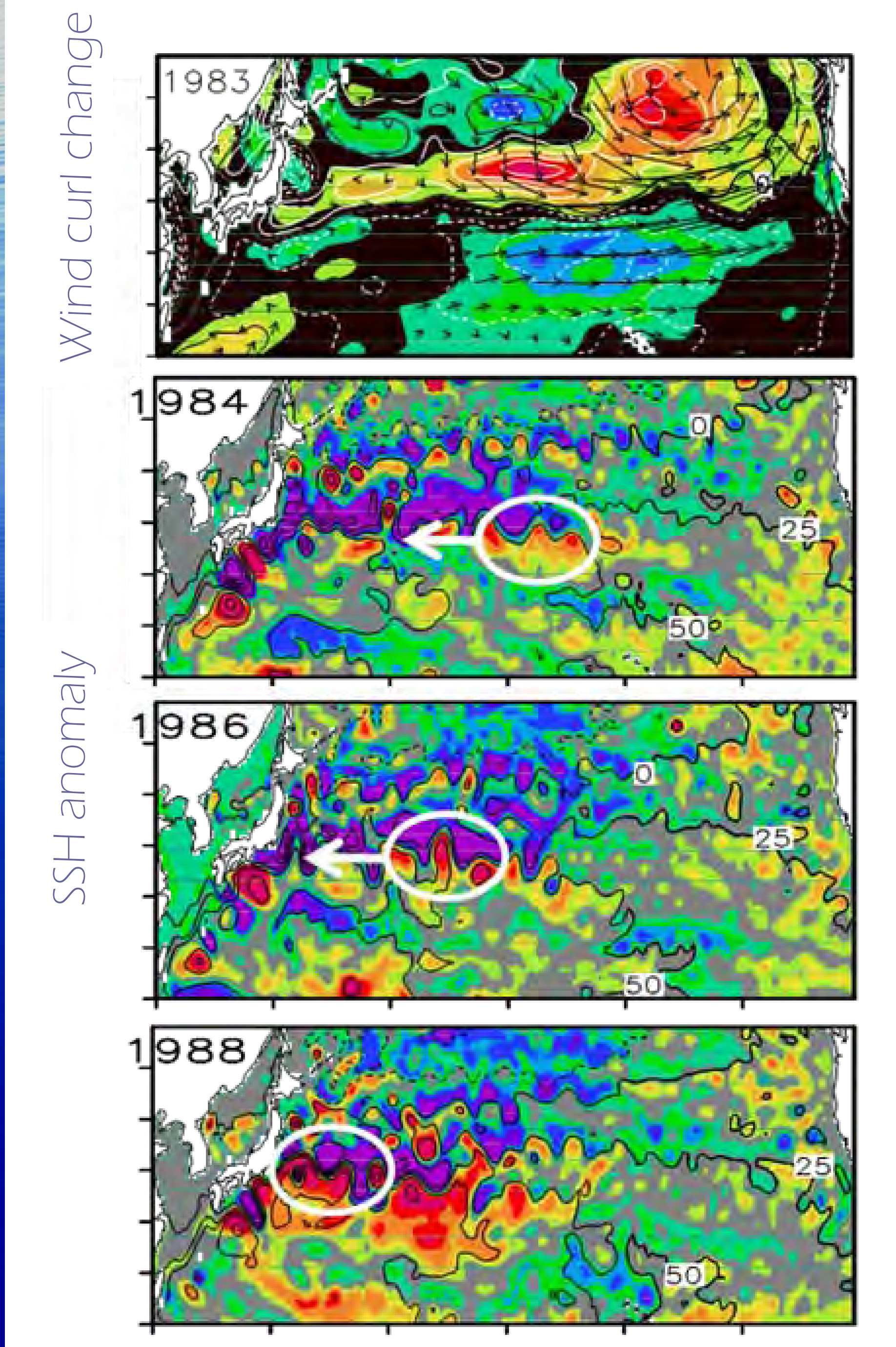
Correlation between SST anomaly and larval mortality rate



Noto &Yasuda 1999

We examined the mechanisms of the change in SST in the KEX region.

For the retrospective analysis of KEX physical status, we used a eddy resolving GOCM “OFES”



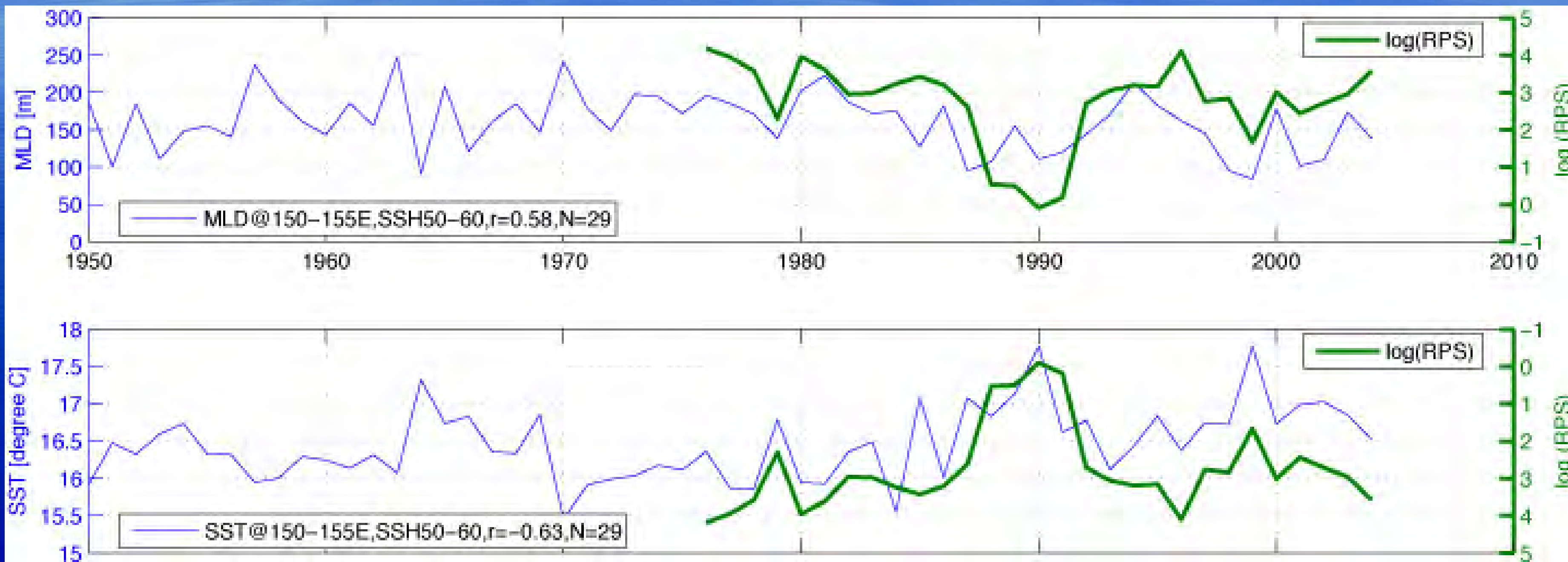
Strengthened easterly wind induced high SSH anomaly in eastern N. Pac.

SSH anomaly induced Rossby wave and propagated to west.

SSH anomaly reached to KEX in 4 years

The arrival in SSH anomaly in KEX region induced KEX acceleration and SST increase

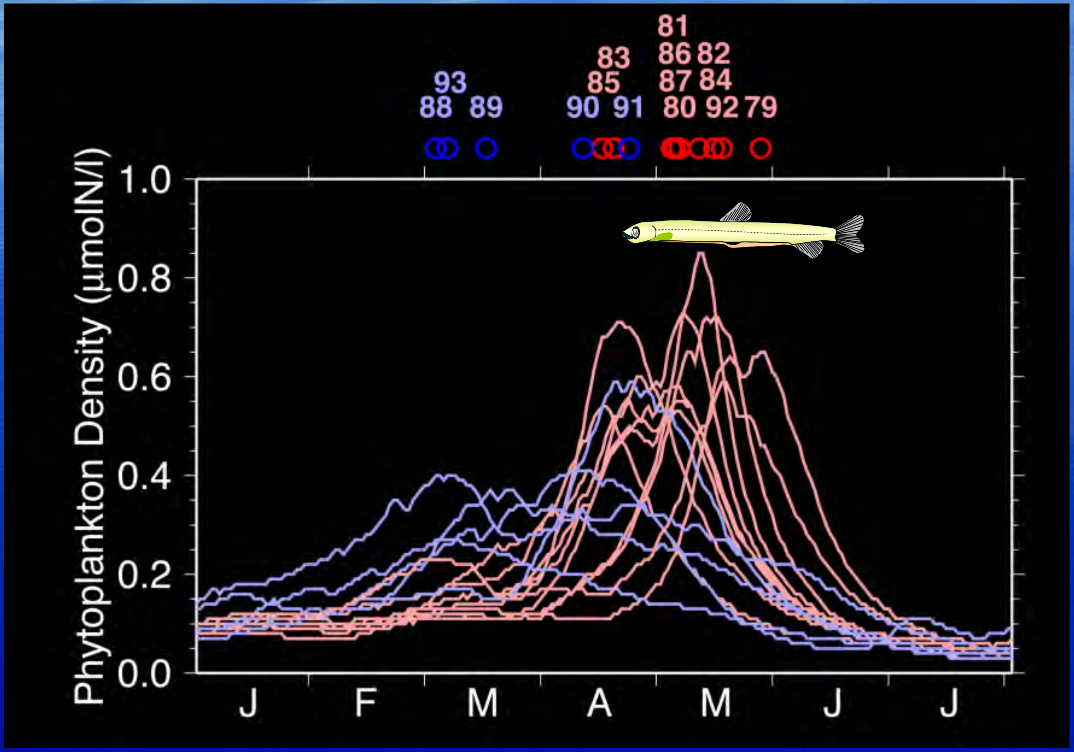
Annual variations in MLD, SST in the KEX (OFES) and RPS Recruitment per spawner



(Nishikawa, Yasuda & Itoh, FO, 2011)

Recruitment failure in the yeas of shallow MLD and high SST

Seasonal change in phytopl. (model)



1988-91,93 (blue):

years of MLD<170m

Spring bloom in shallow MLD years (1988-1991、93):
Early initiation, low magnitude, early termination (except for 1991)

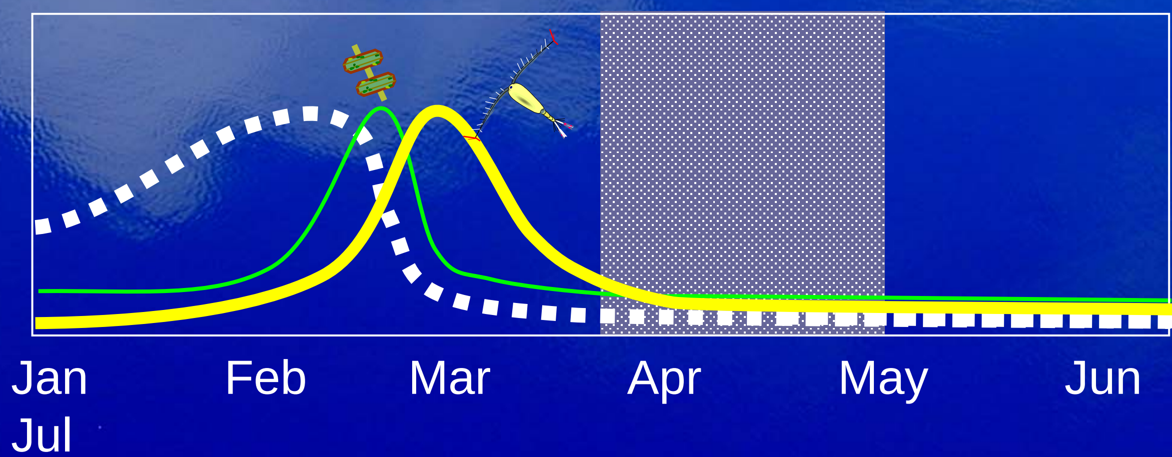
In the years of shallow MLD:

- Low growth rate due to low food conc.
- Resultant increase in mortality

The "Mismatch" was induced by the change in wind curl anomaly in the eastern N. Pacific

Years of shallow MLD

Jul



Wind off Hawaii influence the recruitment of Japanese sardine

		Time (yea
Climate change	Climate obs. system/satellite	0
SSH anomaly	Satellite/RV	0-1
Propagation	〃 ＋Model	
SST/WML in KEX	〃 ＋Model	
Ecosystem change	RV ＋Model	~4
Decline in larval growth	Egg/larvae survey	4+
Decline in recruitment	Pre-fishing season survey	4+
Stock decline	Resource assessment survey	5-7

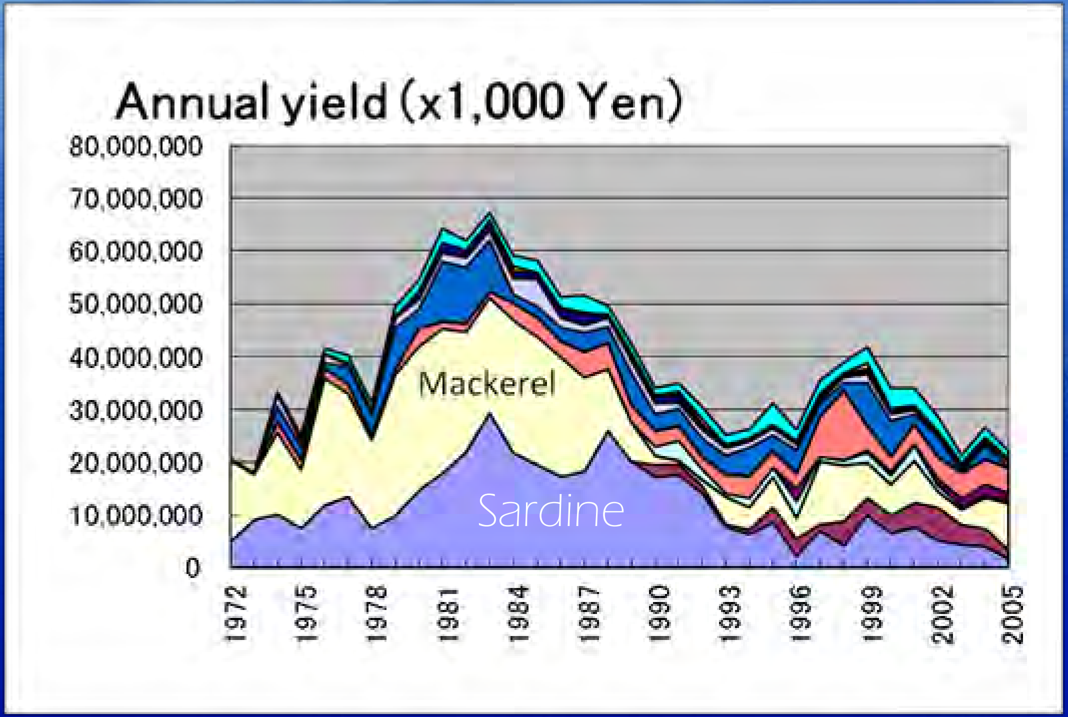
Crisis of purse seiners

- Purse seiner: National government regulates the total number of net by license (5 years)
- 72 fleets in 1987, 24 in 2010.
- Annual yield: 66 billion JPY in 1983, 26 billion in 2009

Net vessel: 135t

2xTransporter (330t class)

Purse seiner annual yield



Landing peak in 1986

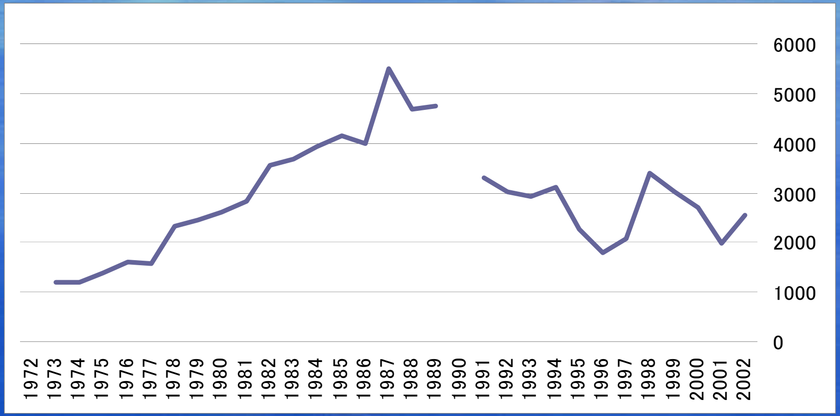
Yield peak in 1983 due to decreasing price

Annual yield in 1987decreased by 30% from 1983 (prior to FSA)

Building 62 transporters during 1987-1991 to increase landing (replaced to bigger vessels to increase yield by amount)

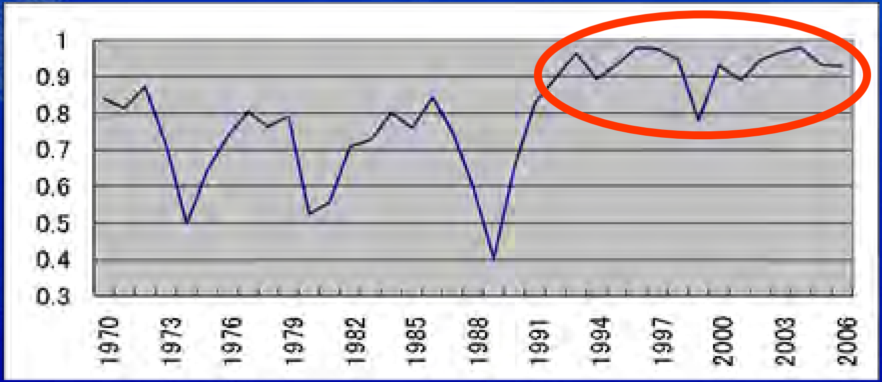
After the sardine stock collapse.....

- Overcapitalization



Running index per transporter

- Fishers targeted on mackerel after 1990.



Relative composition of immature mackerel (0-2 years)

- Strong mackerel year classes of '92, '96 were intensely harvested before maturation and the strong year classes did not improve the stock level.

Retrospective model analysis of fisheries management: For stable housekeeping of purse seiner after FSA

Tested strategies for support mackerel stock recovery:

1. Regulation of vessel building by government

2. Reduction of fishing pressure to mackerel stock

(Not fishing ban, break-even for fishers, i.e. no benefit no deficit. Purse seiners are able to continue their business to wait the recovery of resources)

Best solution

Four scenarios with reducing fleet number (cost) by 10 % in 1982 &

1)5-years ban

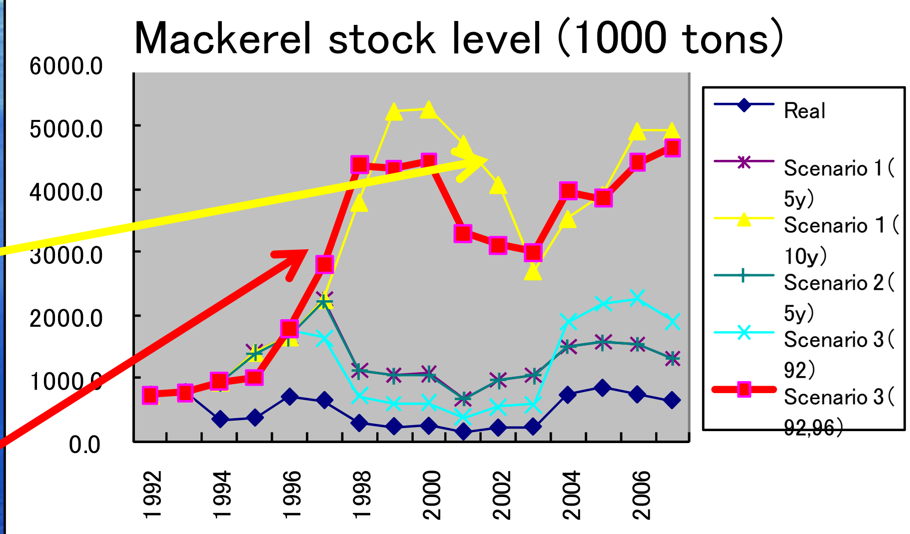
2)10-years ban

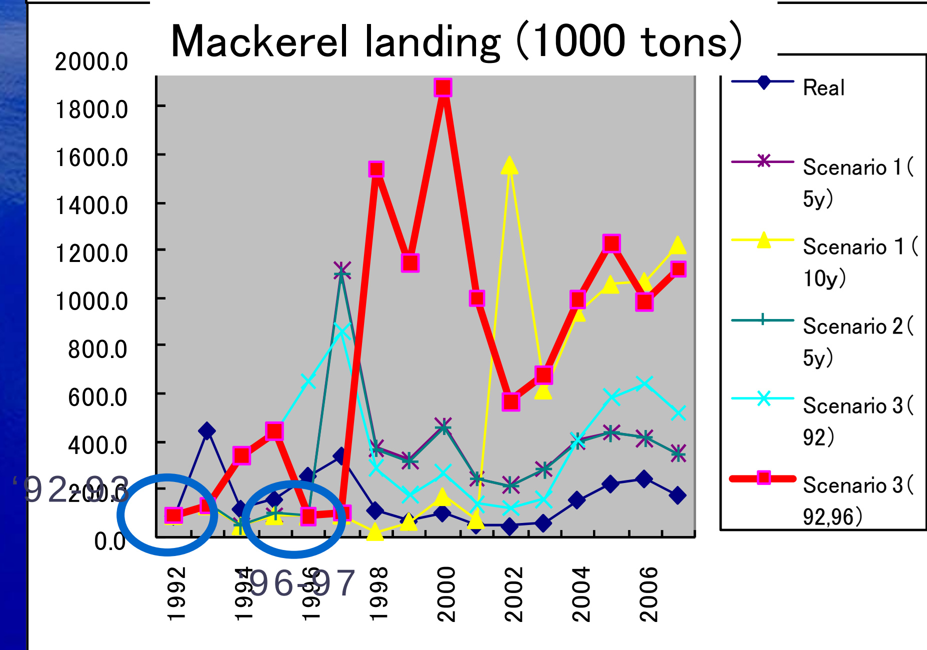
3)Reduction of fishing pressure on '92-year class for 2-years

4)Reduction of FP on '92 and "96 year classes

4) is best scenario with decreasing fleet number by 10 %

This strategy is equivalent to 10-years ban of fishing pressure





How to regulate ship building (10% decrease) during 1982-1991?

Modeling fishers investment (ship building) behavior under 4 optional conditions

1)Free investment, subsidy for the vessel reduction(as usual)

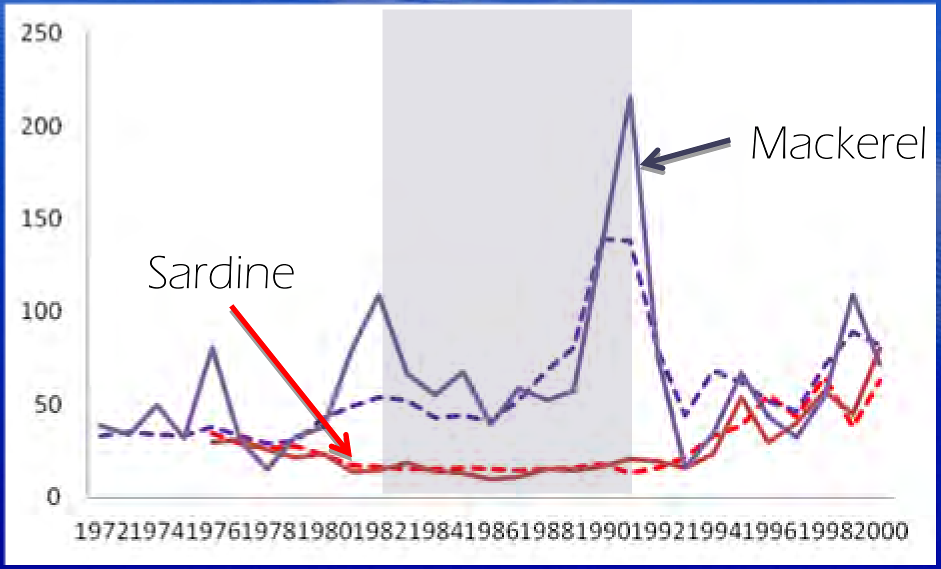
2) Governmental regulation of ship building

3) Specific duty to landing

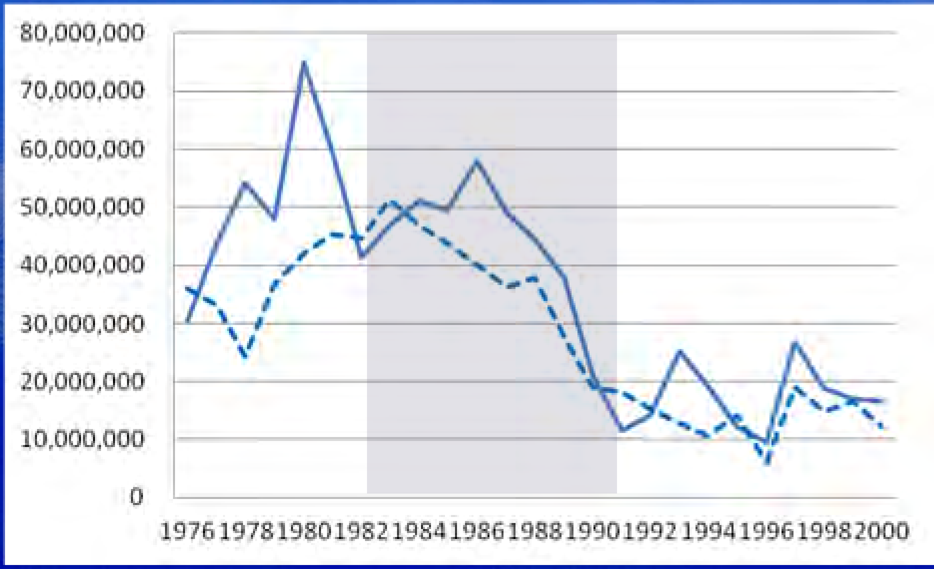
4) Expecting self-capital control mechanism inducing ITQ (Individual Transferable Quota)

Simulating the investment behaviors during 2-license duration (1982-1986, 1987-1991) and evaluate the 4 options of fishery regulation policy (solid lines: real, dashed lines: model)

Mackerel and sardine price (JPY per kg)



Gross annual income from sardine and mackerel (10^6 JPY)



Option 1: Free investment, subsidy for the vessel reduction after FSA

Effective.
In fact, 25 fleets were reduced with subsidy in 1992. Bit, it was not enough for the target.

Need more capital from public……
Benefit: Increased stock is available for use. No negative impact on regional economy.

Option 2: Governmental regulation of ship building

Effective if the regulation start before 1984.....
unrealistic? (because of SSH anomaly propagation can be cancelled by regional climate event)

Advantage: No subsidy need
Disadvantage: Negative impact of regional economy (-46.2 billion yen in Kanto region)

Option 3: Specific duty to landing

Effective if taxing 6-7 yen kg^{-1}.
It is unrealistic considering the price of sardine (ca 15 yen kg^{-1}) and mackerel (ca 80 yen kg^{-1})

If taxing 2 yen kg^{-1}, the tax income will be 35 billion yen.
Using the income, it is possible to grant a subsidy for reducing fleets (2.36 billion yen per fleets).

Tax + subsidy option is available way for the target

Advantage: Subsidy is prepared from industry
Disadvantage: Negative impact of regional economy (-60.6 billion yen in Kanto region)

Option 4: Expecting self-capital control mechanism of ITQ

Expecting to accelerate self-capital control mechanism by trading ITQ between fleets. Estimated ITQ prices is 0.35 billionYen per fleets which is too small to induce voluntary reduction.

ITQ alone is not enough to reach the target of 10 % decrease in fleets

Disadvantage: Negative impact of regional economy (-61.0 billion yen in Kanto region)

Strategy for FSA

Pre-suppression of fleet size in advance of FSA and post-reduction of fishing effort to the emergence of strong year class

For pre-suppression:
Application of FSA forecasting technique

For post-reduction to strong year class:
Accurate assessment of recruitment status and stock size of each year class (monitoring efforts)

For the application of new fisheries management policy for small pelagic fishes with FSA

Social issue: Social consensus building for how to use the resources (tax, subsidy, impact of policy to regional and national economy)

Scientific issue: Increasing reliability on the predictability of FSA

For the best use of small pelagic fishes with FSA (natural forcing induced, uncontrollable), it is essential to apply new fisheries management policy based on the societal consensus on the managing policy and the scientific reliability.


Thank you!