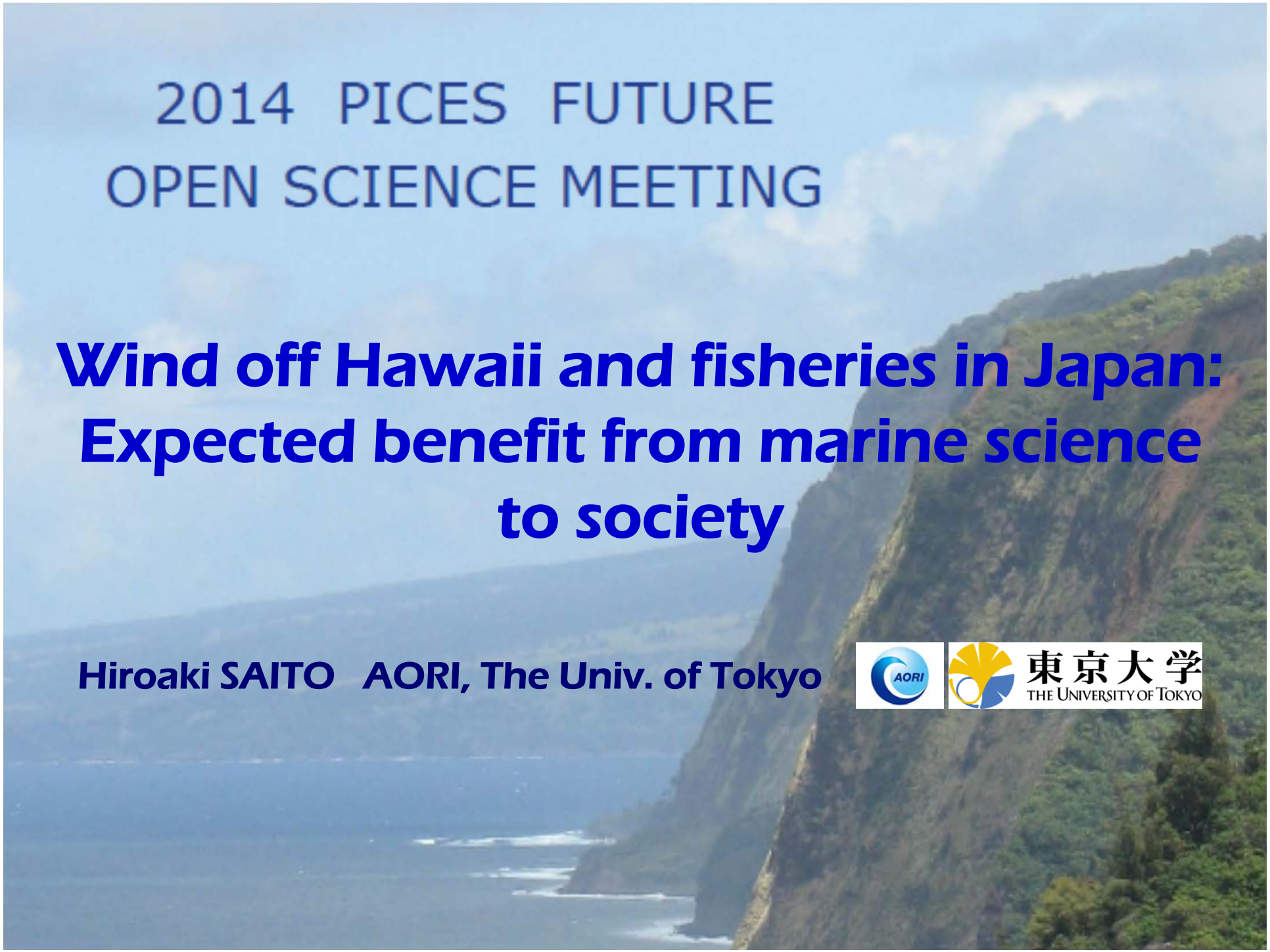
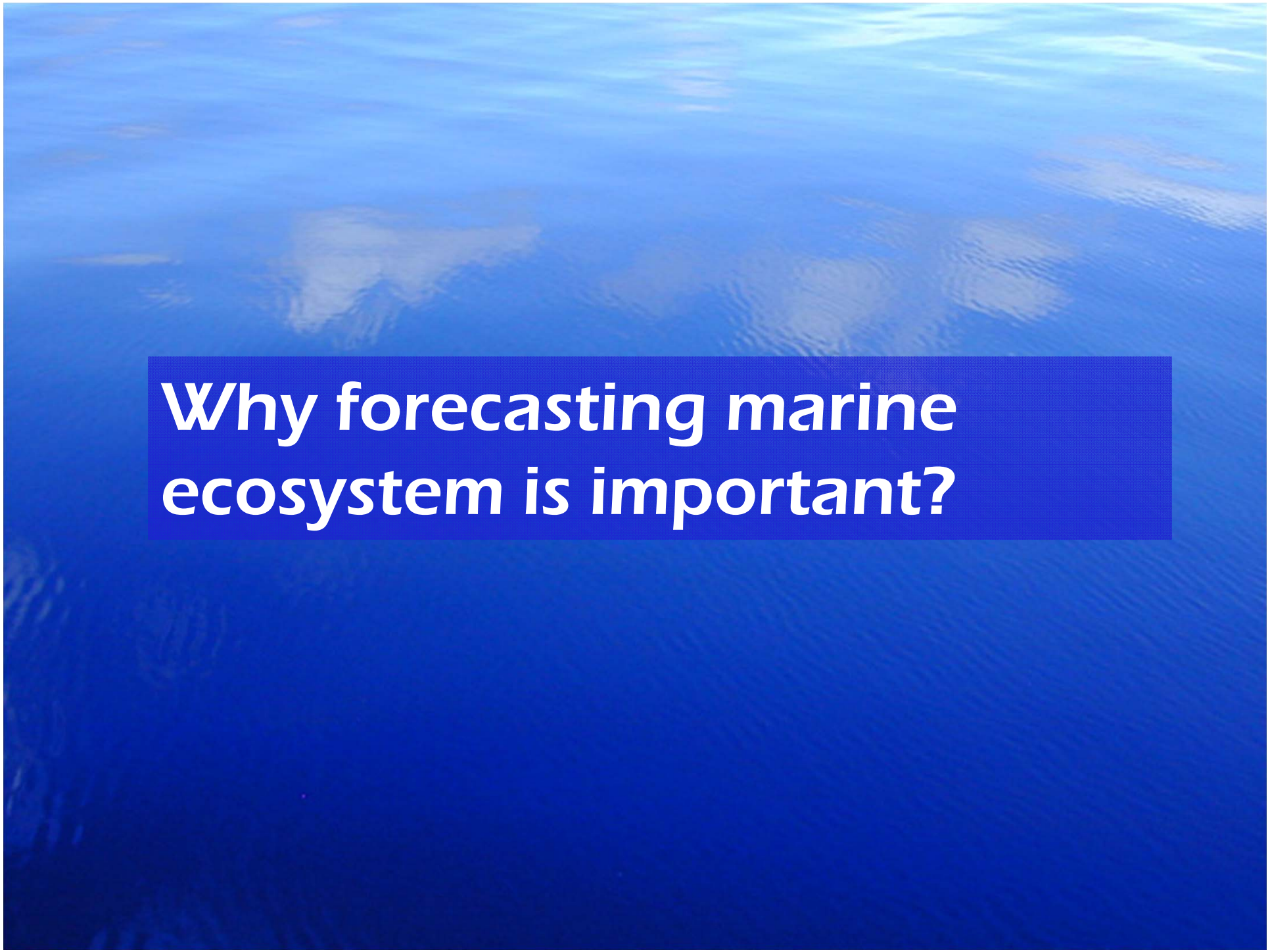


Wind off Hawaii and fisheries in Japan: Expected benefit from marine science to society

Hiroaki SAITO AORI, The Univ. of Tokyo

AORI 東京大学 THE UNIVERSITY OF TOKYO


Why forecasting marine ecosystem is important?

Acknowledgements:

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Human society expects stable ecosystem services

- One of advantages of agriculture is "large amount" and "scheduled" supply of products compared with hunting/gathering. The productivity per man x day is much larger than hunting/gathering.
- Based on the "schedule", it is possible to manage the use of redundant man power for infrastructure, warfare, art, religion, etc.
- Stable climate in Holocene is one of important factors of the development of strong regimes and empires under scheduled supply of food through agriculture.
- To minimize unexpected variability in agricultural production, human society has been developed stabilizers, such as bank, irrigation system, pesticide, fertilizer, etc.

Fisheries: still unstable production

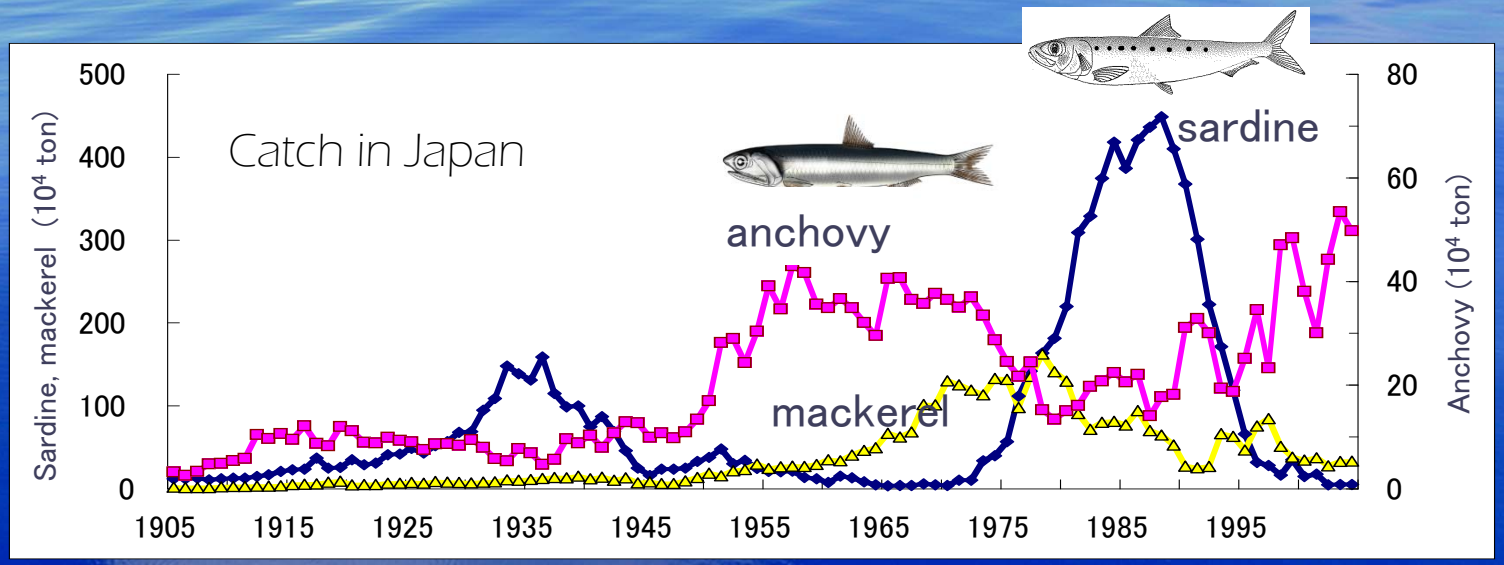
- Recent studies revealed the collapses of ancient regimes were related to long-term climate variability (100s years) which induced starvation, riot, invasion of different ethnic groups, etc.

- Fisheries are targeting natural resources which supply is from ecosystem service.
- Fishermen know seasonal timing of fish migration, fishing point, fish behavior, etc. from their experience, but are unable to predict whether big or poor catch in next fishing season.....*Mother nature only knows*

Natural science and society

- Marine scientists are preparing obtained knowledge to fishermen, managers and society such as stock size, recruitment success/failure, ocean circulation status, expected migration route, etc. However, forecasting the degree of recruitment success and landing (and many others) are still difficult.
- Most drastic change in fisheries production is induced by fish species alternation observed in small pelagic fishes such as sardine, anchovy.

Fish Species Alternation (FSA)



Sardine landing in Japan:

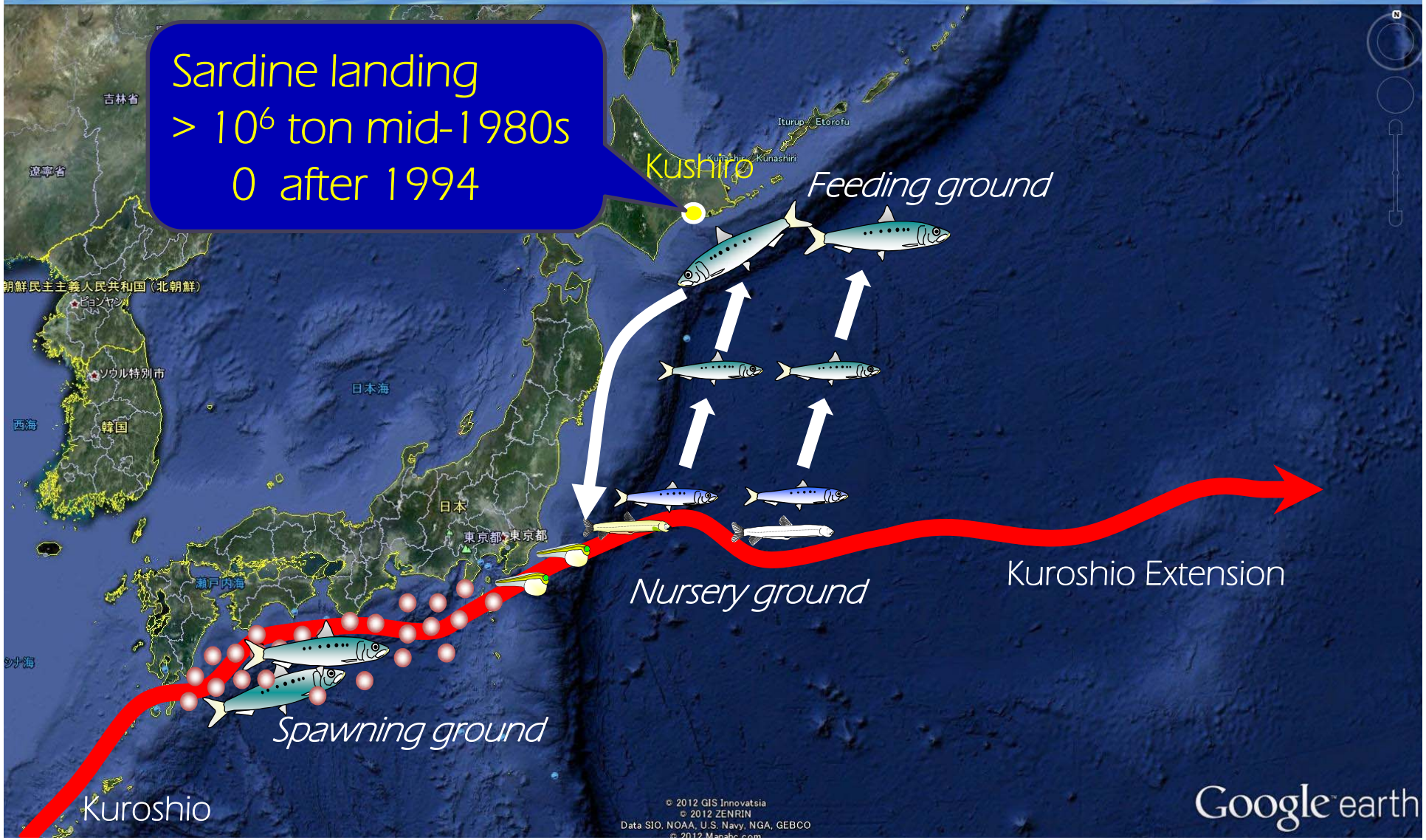
1960s: 10^4 -10^5 ton

mid 1980s : >4 x 10^6 ton

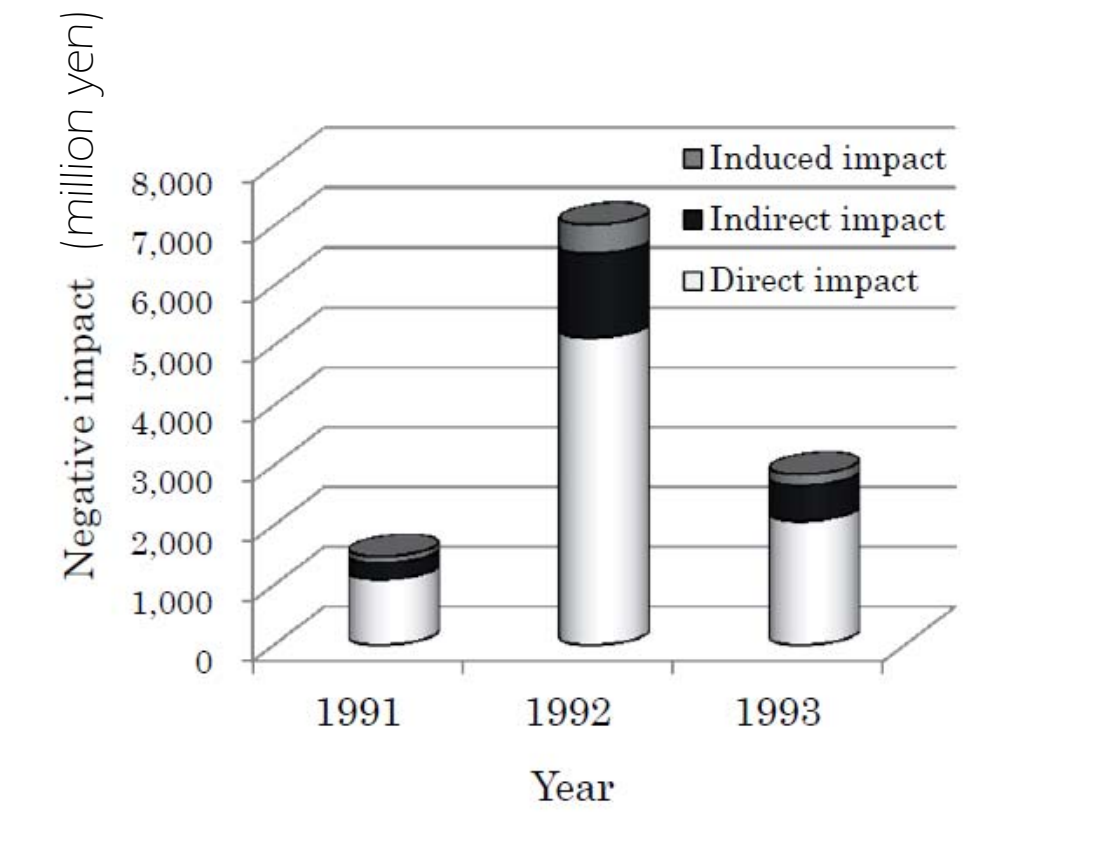
1988: start declining

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

Migration route of Japanese sardine



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



Kaneko et al. 2012

Direct impact to purse seiners is not included
(all the officers/crews are based in other regions)

Impacts of FSA

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

24 fleets were disbanded

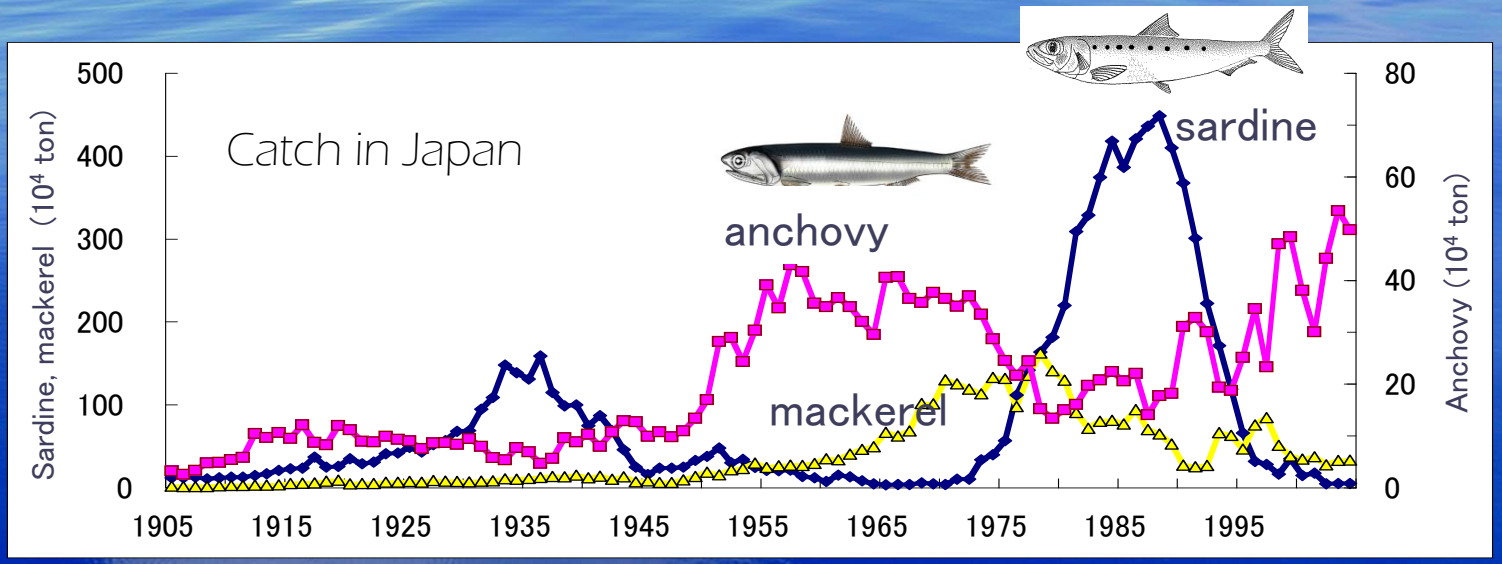
Sudden and unpredictable FSA induces economical and social problems

Fishery: highly variable production

- *"Mizu-shohbai"* in Japanese means unstable (like water "mizu") business (shohbai) such as fisheries.....not really respectful word.
- Unpredictability and high variability in fisheries production prevents direct (boats, nets, gears, etc.) and indirect (e.g., branding, developing new market) investment to the industry. This also prevents investment to infrastructure for value addition (e.g., cold store, transporting system of high quality fresh fish from harbor to market).

Scientists' efforts to understand the mechanism of FSA and the forecast contribute stable fishers housekeeping, more effective investment and easier application of fisheries management policy (based on fishers' confidence in manager and scientists)

Fish Species Alternation (FSA)



Sardine landing in Japan:

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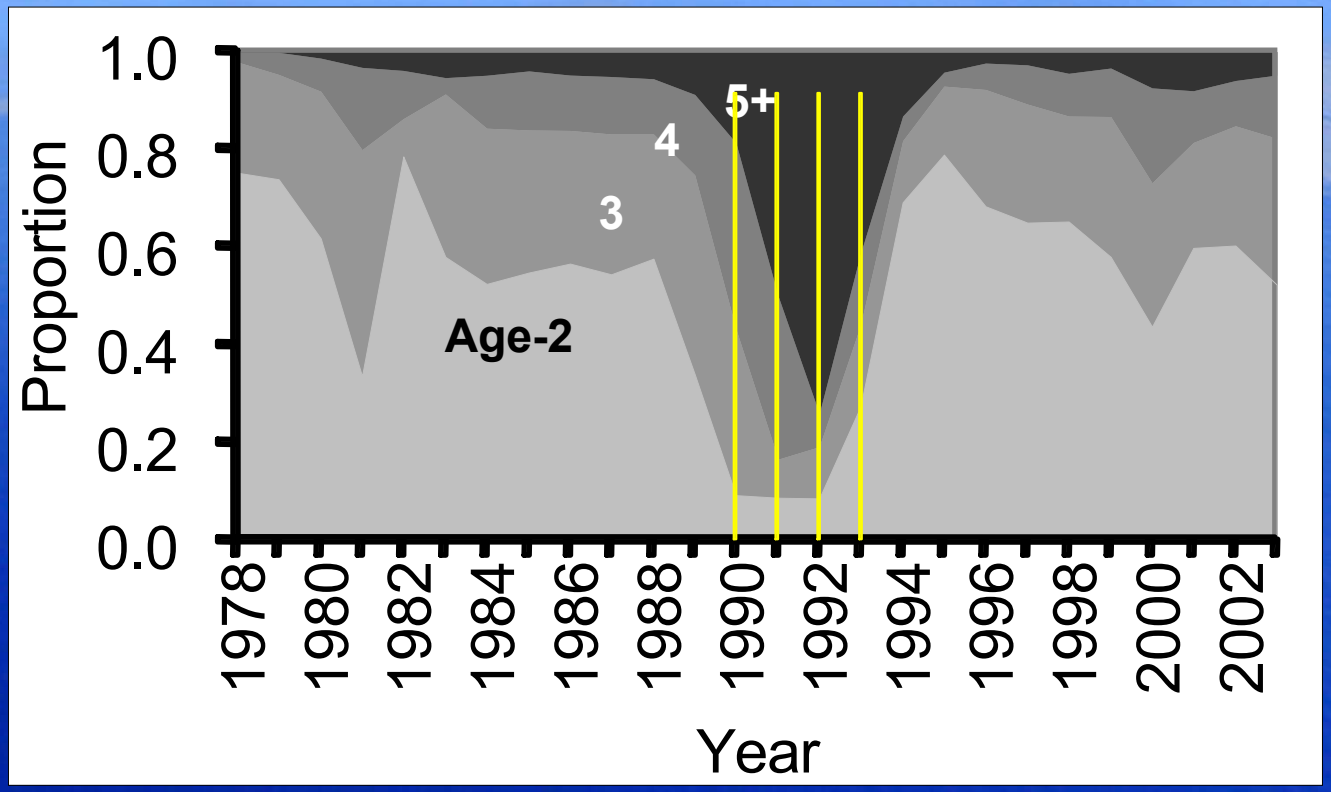
Anchovy landing increased after the sardine stock collapse

Age composition of sardine

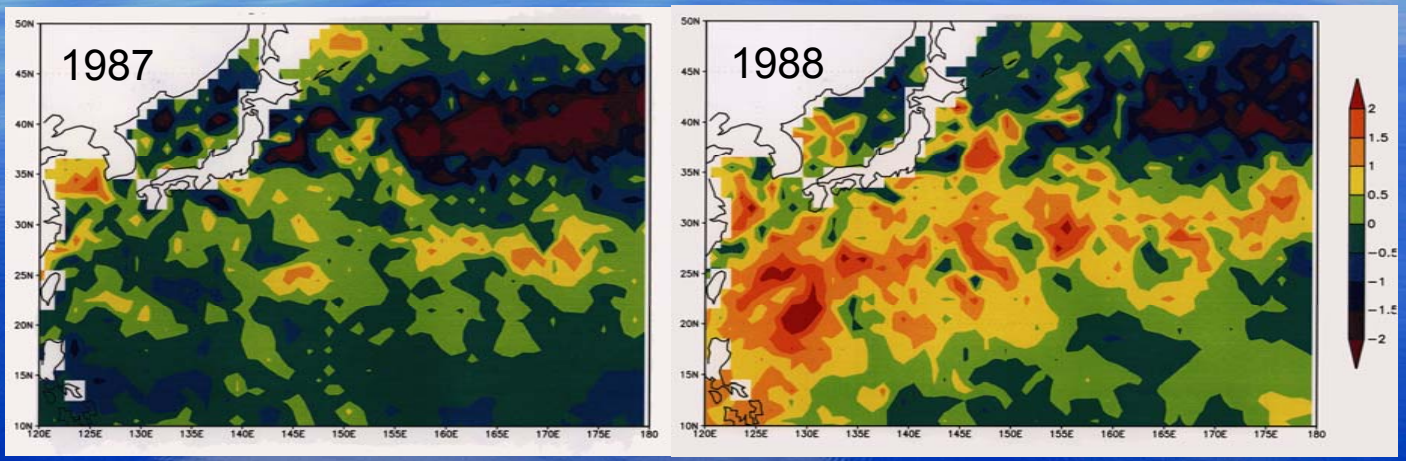


- Sudden increase in aged fish & decrease in recruitment from 1988
- No. of eggs spawned were >10^{15} during 1988-1992

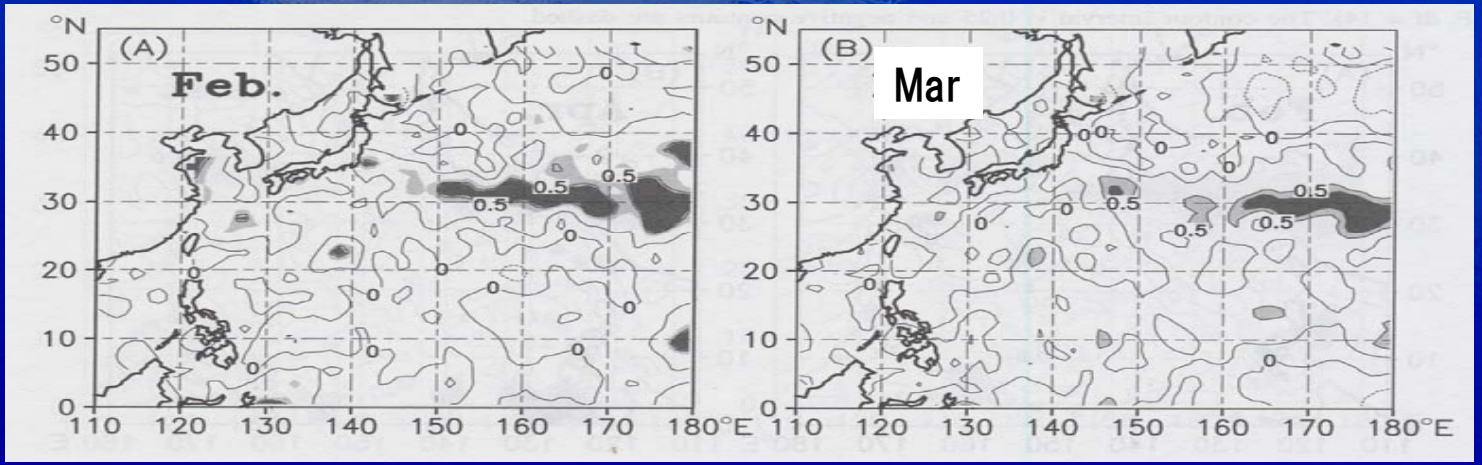
Juvenile sardine did not grow to age+1 after 1988

What is the trigger of the FSA?

SST anomaly

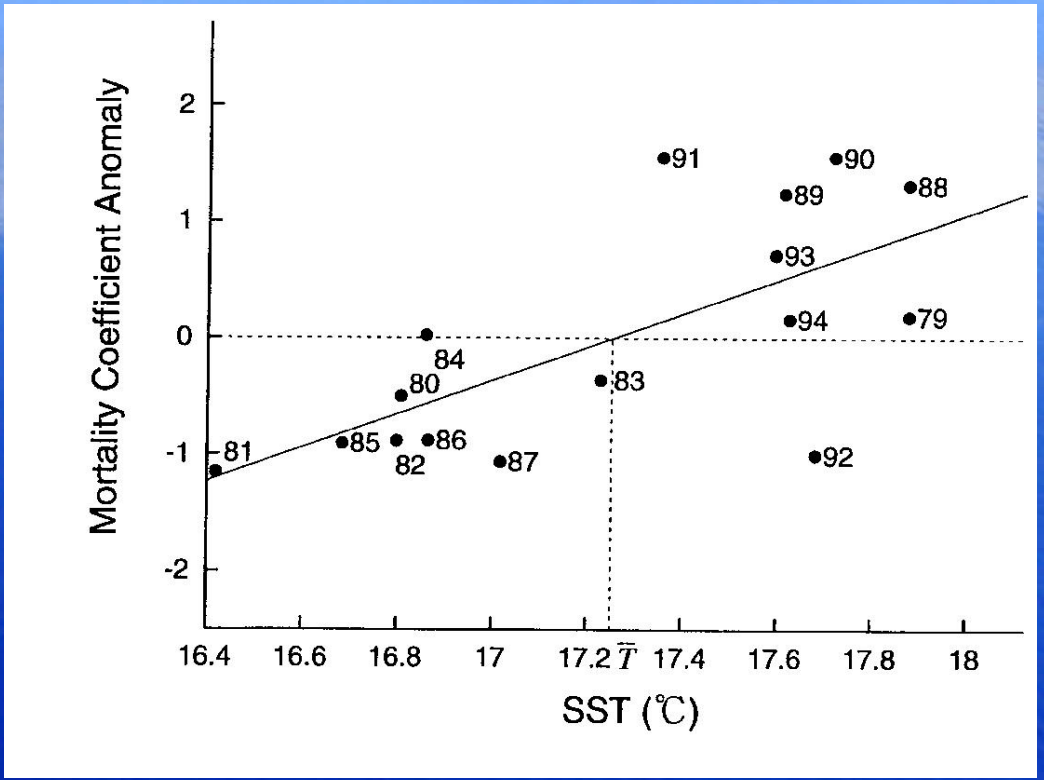


Correlation between SST anomaly and larval mortality rate



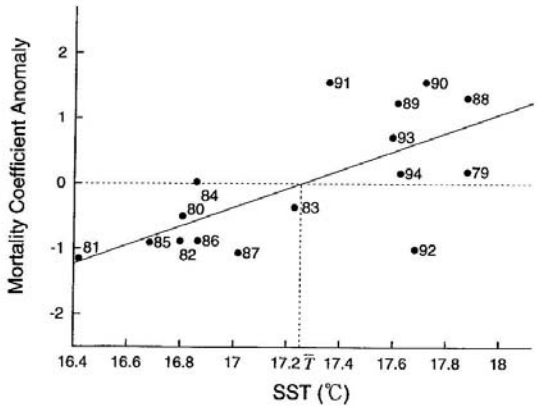
Noto &Yasuda 1999

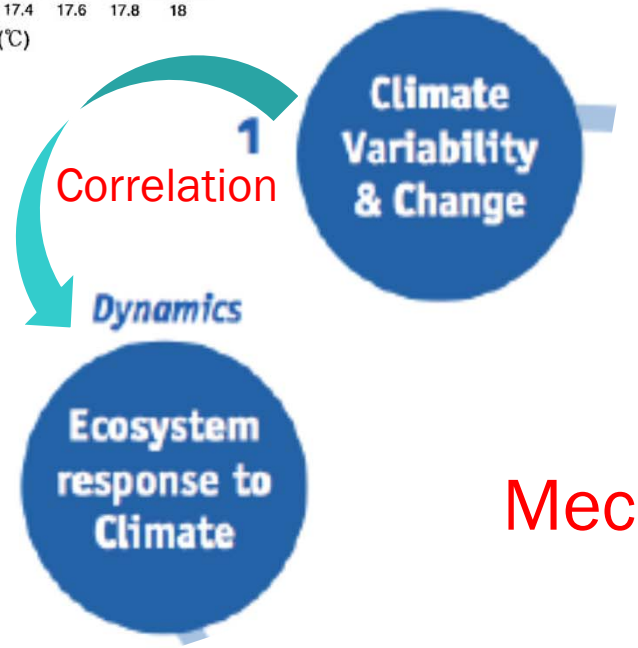
Mortality Coefficient Anomaly vs winter SST



Noto and Yasuda 1999

Juvenile sardine (distribute in KEX region) did not grow to age+1 after 1988


Mortality Coefficient Anomaly
SST (℃)
91
90
89
88
93
94
79
84
80
83
81
85
86
82
87
92


1
Correlation
Climate Variability & Change
Dynamics
Ecosystem response to Climate

Mechanisms


We carried out retrospective analysis of KEX physical status by means of eddy resolving GOCM OFES to understand the mechanisms of the change in SST and sardine recruitment variability responded to the SST change.

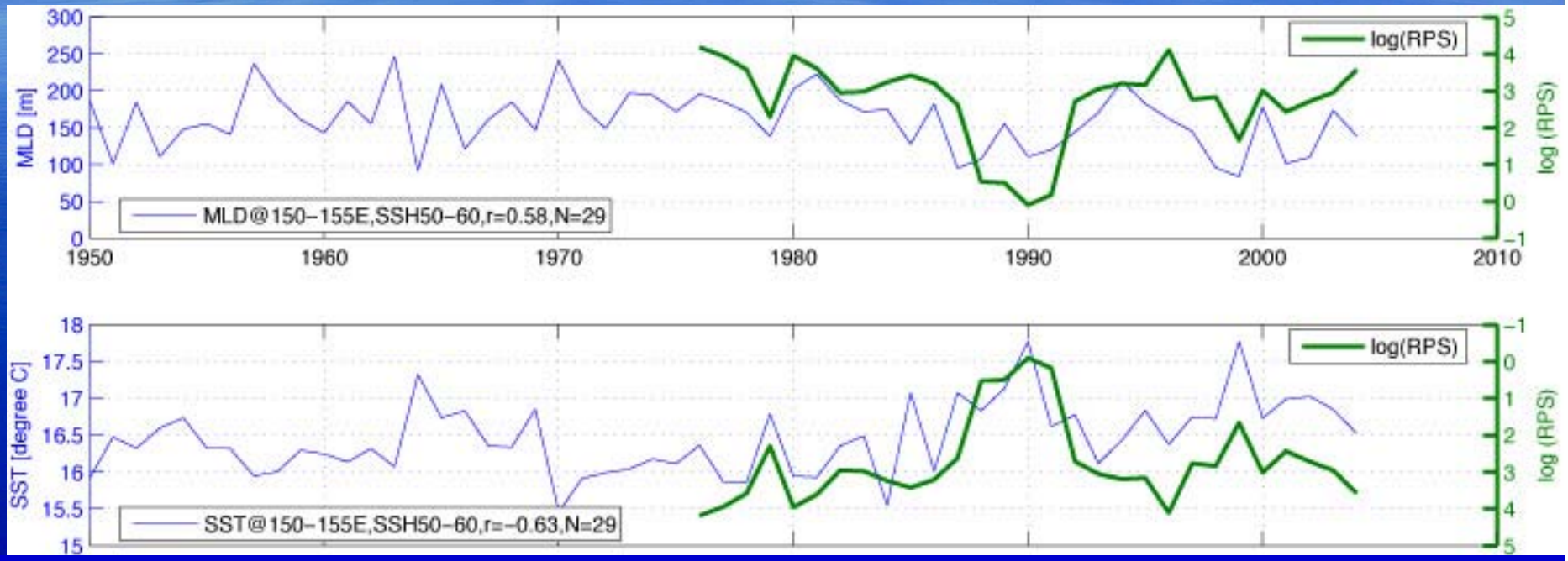
Strengthened eastrnary wind induced high SSH anomaly in eastern N. Pac.

SSH anomaly induced Rossby wave and propagated to west.

SSH anomaly reached to KEX in 4 years (1988)

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

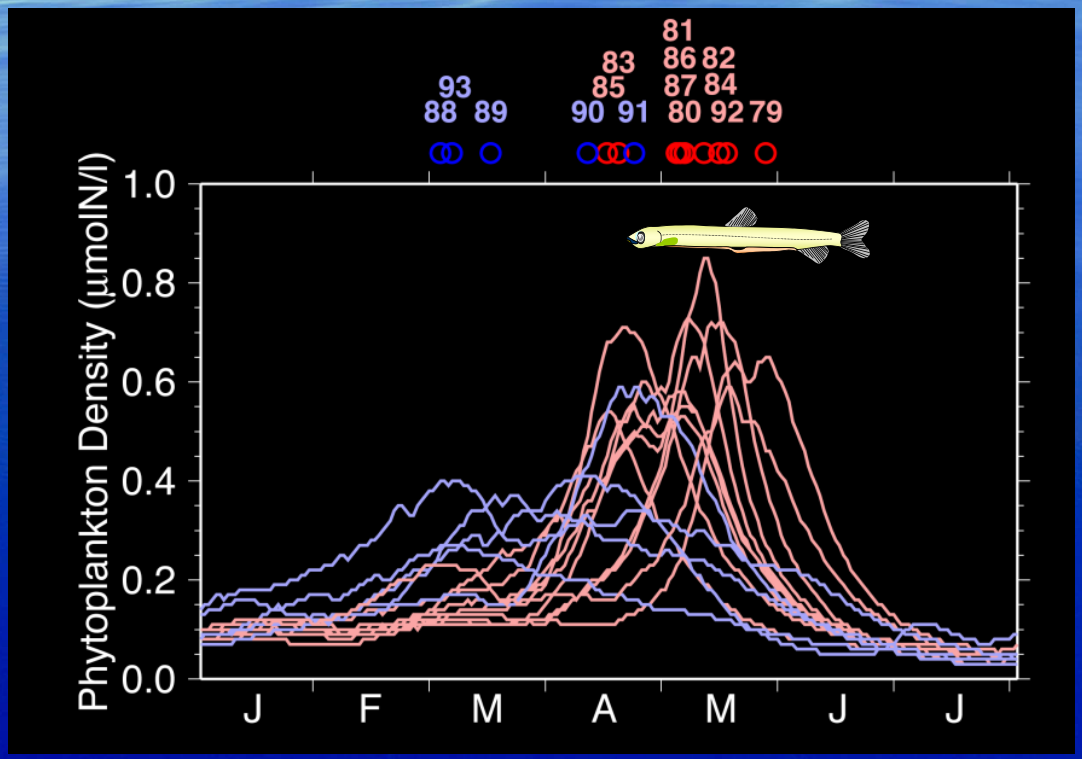
Annual variations in MLD, SST in the KEX (OFES) and RPS Recruitment per spawner



(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

(Nishikawa, Yasuda 2008)

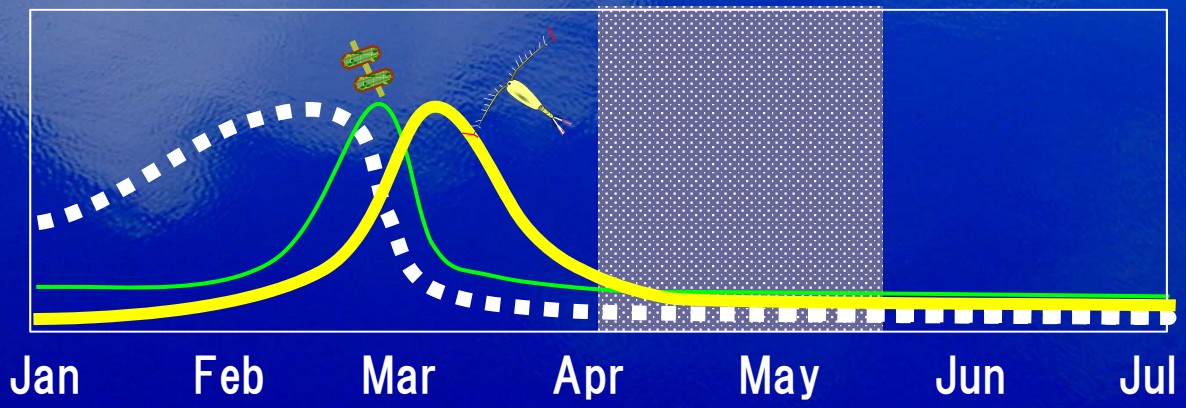
Spring bloom in shallow MLD years (1988-1991、93):
Early initiation, low magnitude, early termination (except for 1991)

In the years of shallow MLD:

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

"Mismatch" induced by the change in wind curl anomaly in the central N. Pacific

Years of shallow MLD



Wind off Hawaii influence fisheries and fisheries-related industry in Japan

+4~6 years time lag

Monitoring precursor of FSA

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

Conclusions

- Innate problem of fishery as a modern industry is that the production is not based on planning by human being. Human society and economics expect stable or scheduled supply. Fishery is often unable to response to the request due to the high variability.
- Forecasting future change in stock is most useful to enable stable fishers' housekeeping and wise use of ecosystem fisheries production.
- Based on SUPRFISH findings, monitoring the change in ocean status to forecast the FSA is one of the ways to utilize natural scientific knowledge to societal benefits.
- Our understanding on the mechanisms of ecosystem variation is still limited. Further scientists' efforts on "understand the mechanisms" and "forecasting future" are essential way of science contribution to society.