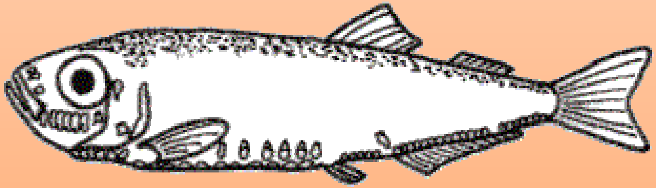
Regime shift of mesopelagic fish

- long-term biomass index change of *Maurolicus japonicus* in the Sea of Japan



←**Target species**

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- Material and Methods : Biomass index and environmental parameters
- Results : Long term biomass fluctuation
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- Perspective : How to continue monitoring?!

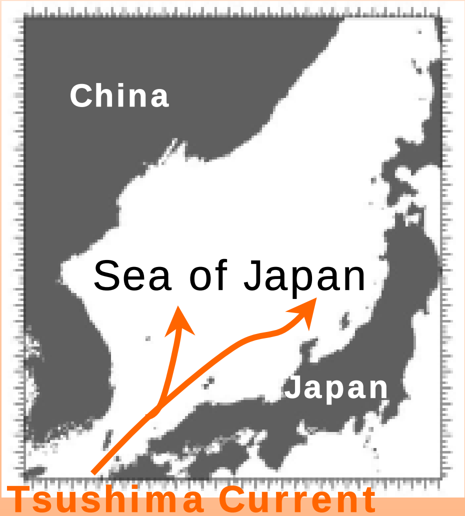
Background 1–Regime shift and fisheries

- Regime shift – A medium or long-term shift in environmental conditions that impacts the productivity of stock.
- Ecosystem based management –Manage fishing activity according to the change of the marine ecosystem.

Important to know if the stock has a "Regime shift".

If so ････ Take into consideration of Regime shift for stock management

Background 2–Sea of Japan – commercially important fish and mesopelagic fish



~Commercially important species~

Japanese common squid (*Todarodes pacificus*)

Regime shift found (Sakurai 1998, 2005)

Japanese sardine (*Sardinops melanostictus*)

Japanese anchovy (*Engraulis japonicus*)

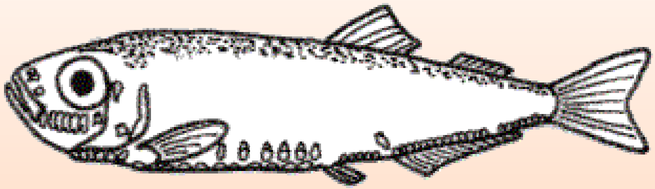
Regime shift found (Kawasaki 1983)

~Mesopelagic fish~

Maurolicus japonicus

- The only mesopelagic mickonektonic fish
- Secondary consumer
- Huge biomass

Background 3–Regime shift and Mesopelagic fish



Mesopelagic fish

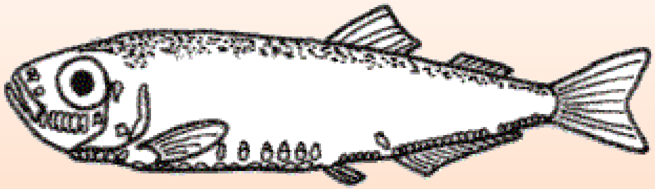
*Swimming depth 200-1000m
*Some species undergo diurnal vertical migration, reaches the pelagic zone at night.

No commercial importance

Lack of the long term stock change data

⇒No reports of regime shift for mesopelagic fish

Background 3–Regime shift and Mesopelagic fish



Mesopelagic fish

~Objective~

Investigate if there is a regime shift for a mesopelagic fish

Materials and methods 1– Index that indicate regime shift

Biological index

- Japanese common squid 1979-2004 Biomass estimation data
- Japanese sardine 1978-2004 Biomass estimation data
- Japanese anchovy 1978-2004 Catch data

（Provided by the Japan fisheries agency)

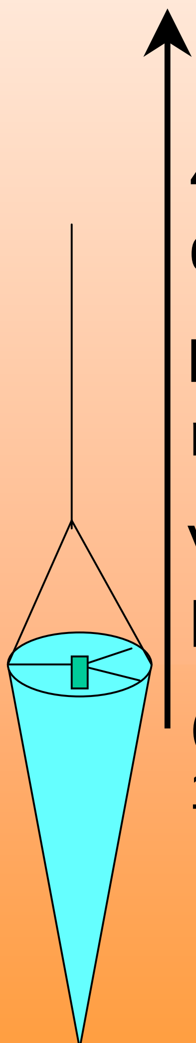
Environmental index

- Tsushima Current index 1978-2004

Main warm current in the Sea of Japan

Anomaly of the 10℃ Area at 100m depth in the whole Sea of Japan （Provided by the Japan meteorological agency)

Materials and methods 2 –*M.japonicus* biomass Index : Egg survey data

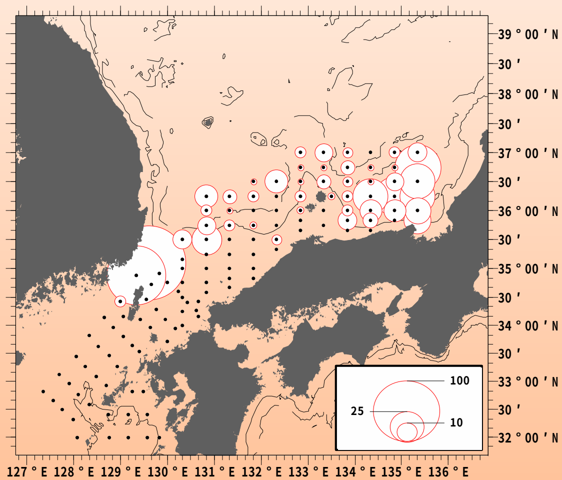


45cm dia.

Plaknton net

Vertical hauls

(Deepest 150m)



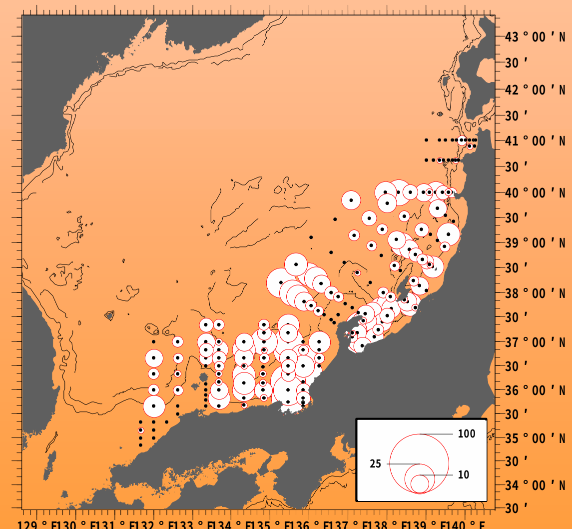
1978 ～ 2005 (28years)

Area

Southwest Sea of Japan

Season

Autumn (October)



1979 ～ 1991 (13years)

Area

Sea of Japan

Season

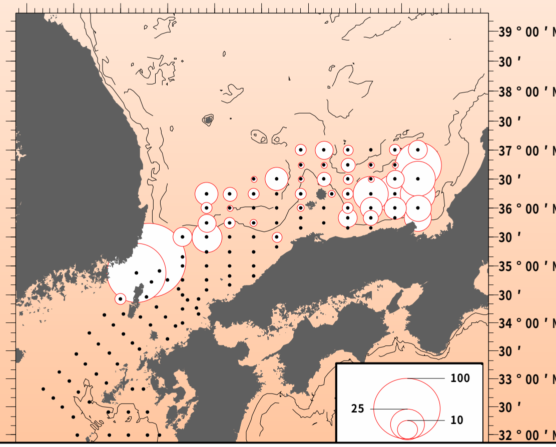
Autumn (Sep.,Oct.,Nov.)

Materials and methods 2 –*M.japonicus* biomass Index : Egg survey data

45cm dia.

Plaknton net

(Deepest 150m)

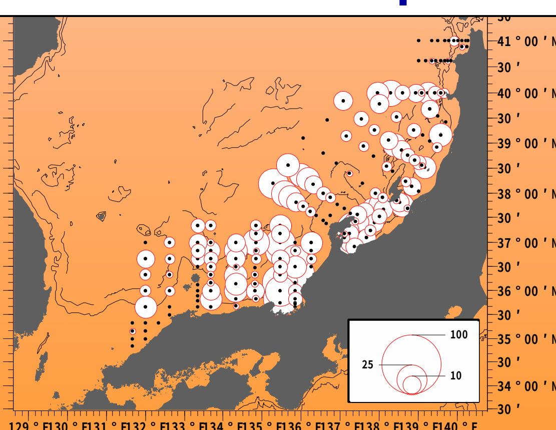


1978 〜 2005 (28years)

Area
Southwest Sea of Japan

Season
Autumn (October)

Calculate the average egg number per haul, use it as a index of spawning adults biomass.



Area
Sea of Japan

Season
Autumn (Sep.,Oct.,Nov.)

Materials and methods 3 – Comparison of the anomaly

Standardization of the different order values

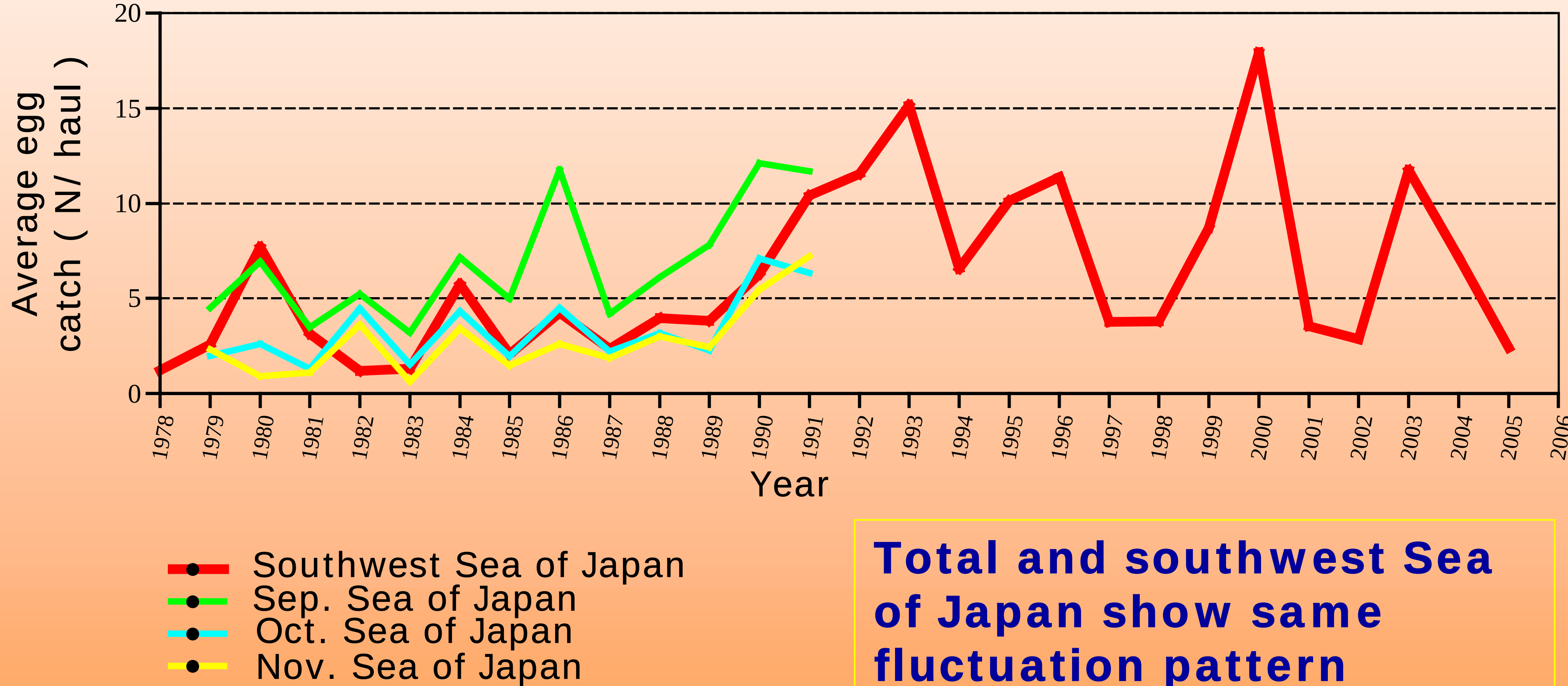
$$\frac{B_X \text{ year value- (Ave. of } B_{1978}\text{-}B_{2005} \text{ value)}}{\text{Ave. of } B_{1978}\text{-}B_{2005} \text{ value}} \times 100$$

Ex.) Anomaly 100%

=Twice of the normal value

- Japanese common squid
- Japanese anchovy
- Japanese pilchard
- Egg number of M.japonicus
- Tsushima Current index (already anomaly value)

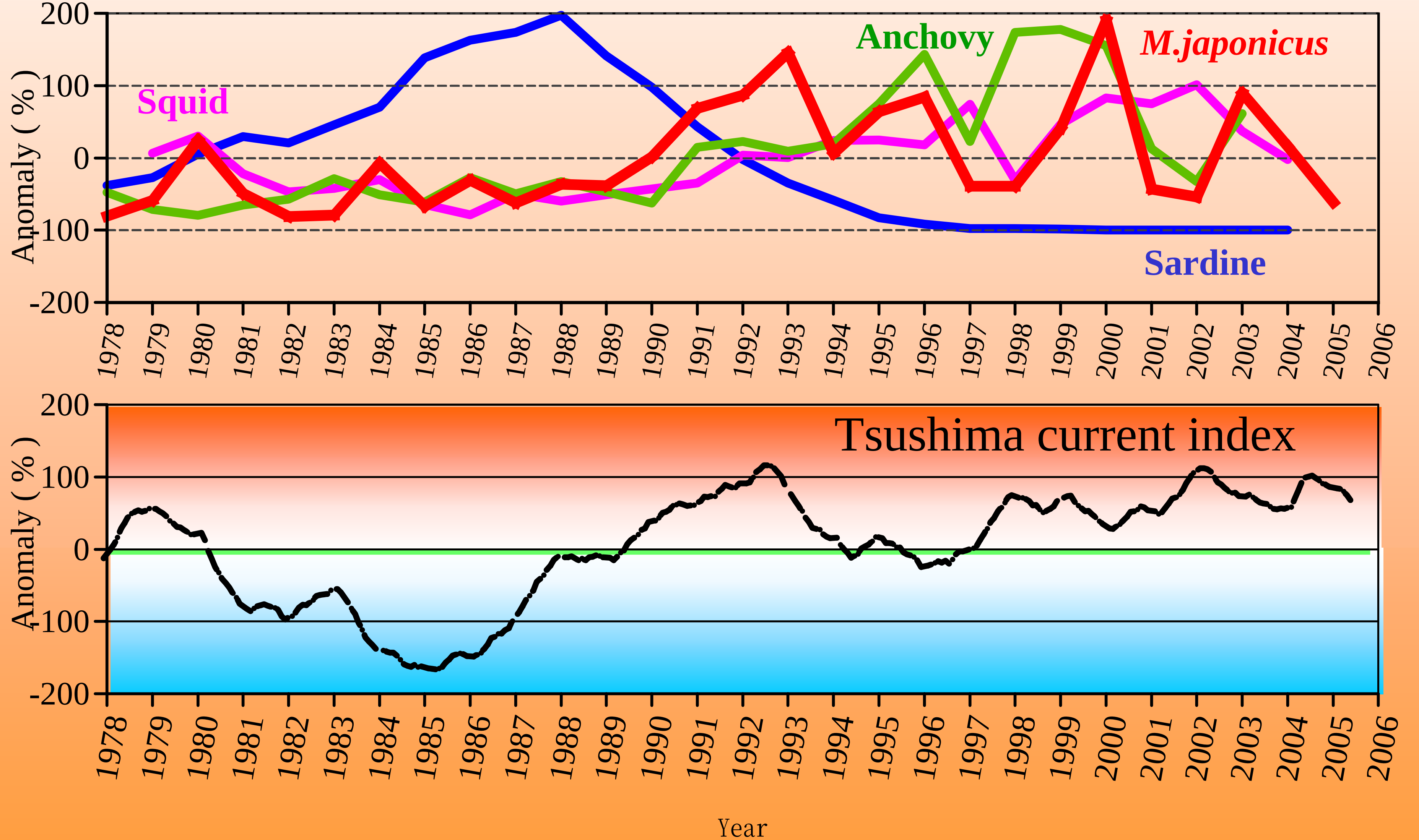
Results 1-Egg number, the whole Sea of Japan and southwest Sea of Japan



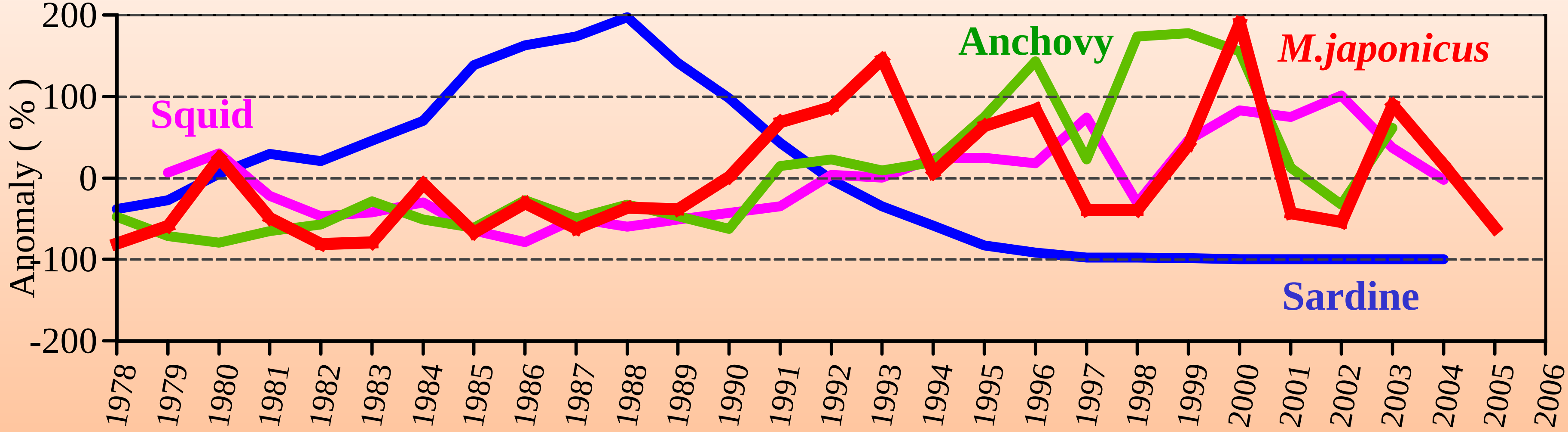
Total and southwest Sea of Japan show same fluctuation pattern

Fig. Egg fluctuation in the Sea of Japan (1979-1991 / GREEN, BLUE, YELLOW) and Southwest Sea of Japan (1978-2005 / RED)

Results 2 – Long term fluctuation of the Biomass and Environment



Results 2 – Long term fluctuation of the Biomass and Environment



~Clear long term tendency~

↑After 1987

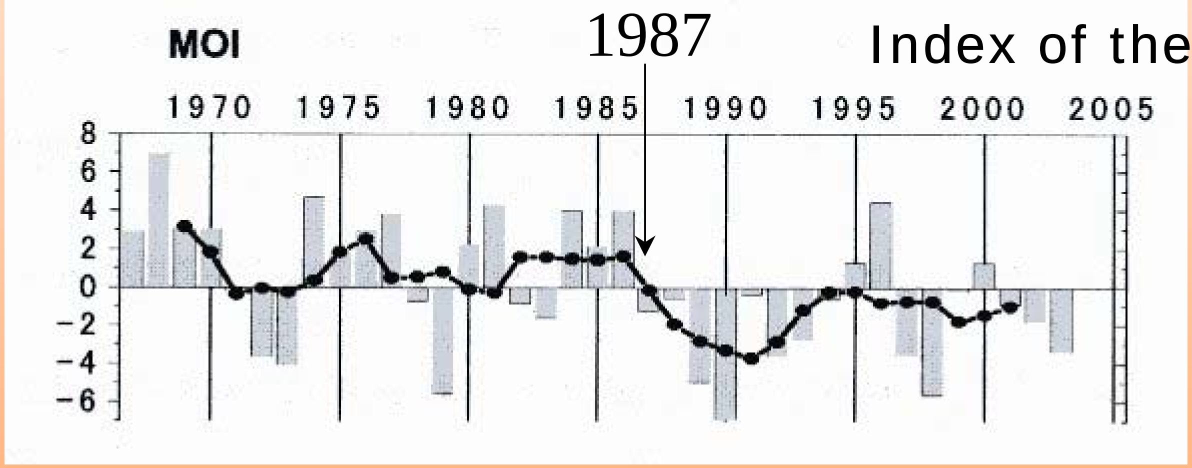
Japanese common squid, Japanese anchovy, *M.japonicus* and Tsushima current Index

↓After 1988

Japanese sardine

Discussion 1 - Regime shift in the Sea of Japan

1987 Change of the MOI (Monsoon Index: Average of Dec.~Feb.)



Index of the winter wind intensity

(Shimura 2006)

Northwest pacific

Warm to Cold :middle of 1970's / Cold to warm: end of 1980's

(Hare and Mantua 2000)

North hemisphere

Occurrence of regime shift in the 1988/89

(Yasunaka and Hanawa 2002)

Discussion 1 - Regime shift in the Sea of Japan

Shift in the late 1980's coincide,

- Fluctuation pattern of the environmental parameters
- Biomass fluctuation of the regime shift species
- Biomass fluctuation pattern of *M. japonicus*

⇒Regime shift occur for a mesopelagic fish !

Occurrence of regime shift in the 1988/89

(Yasunaka and Hanawa 2002)

Discussion 2 – Why the biomass increases?

Main prey of *M.japonicus* in the Sea of Japan

⇒ Pelagic warm water copepod species

(Ikeda et al. 1996)

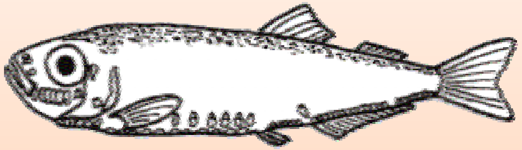
Warm regime – increase of the plankton biomass (Zhang et al. 2000, Minami et al. 1999)

A rich prey condition ⇒Biomass increase of *M.japonicus*

M.japonicus life span: 20 month (Yuki et al. 1996)

Discussion 3-How can we utilize this results?

M.japonicus



No commercial importance
||
Biomass fluctation is irrelative to fishing pressure

Features

- Biological index
- Same tropic level with some commercially important species

Pure and direct index to know the regime shift

Requirement of the index

Index used for ecosystem-based management should be

- Quantitative
- Able to achieve in a short time scale

It is better,

Obtained using current monitoring program

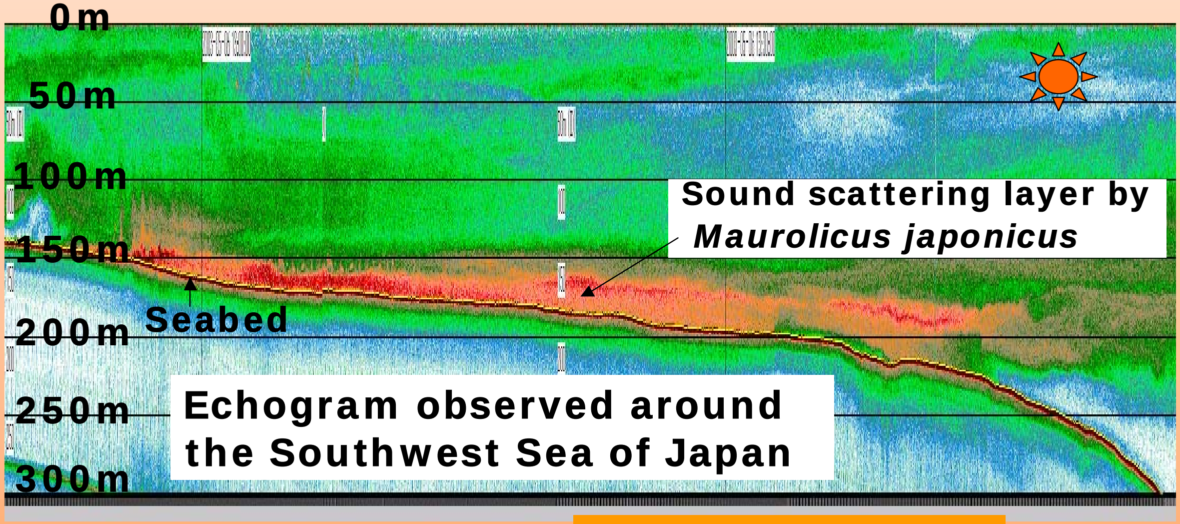
(ICES 2005, Jennings 2005, Rice and Rochet 2005)

Egg data

- Index of the matured female
- Obtained once a year
- Requires a big effort

How to conduct a better monitoring in a short time scale –1

Utilization of the acoustic data
(data collected with a quantitative echosounder)

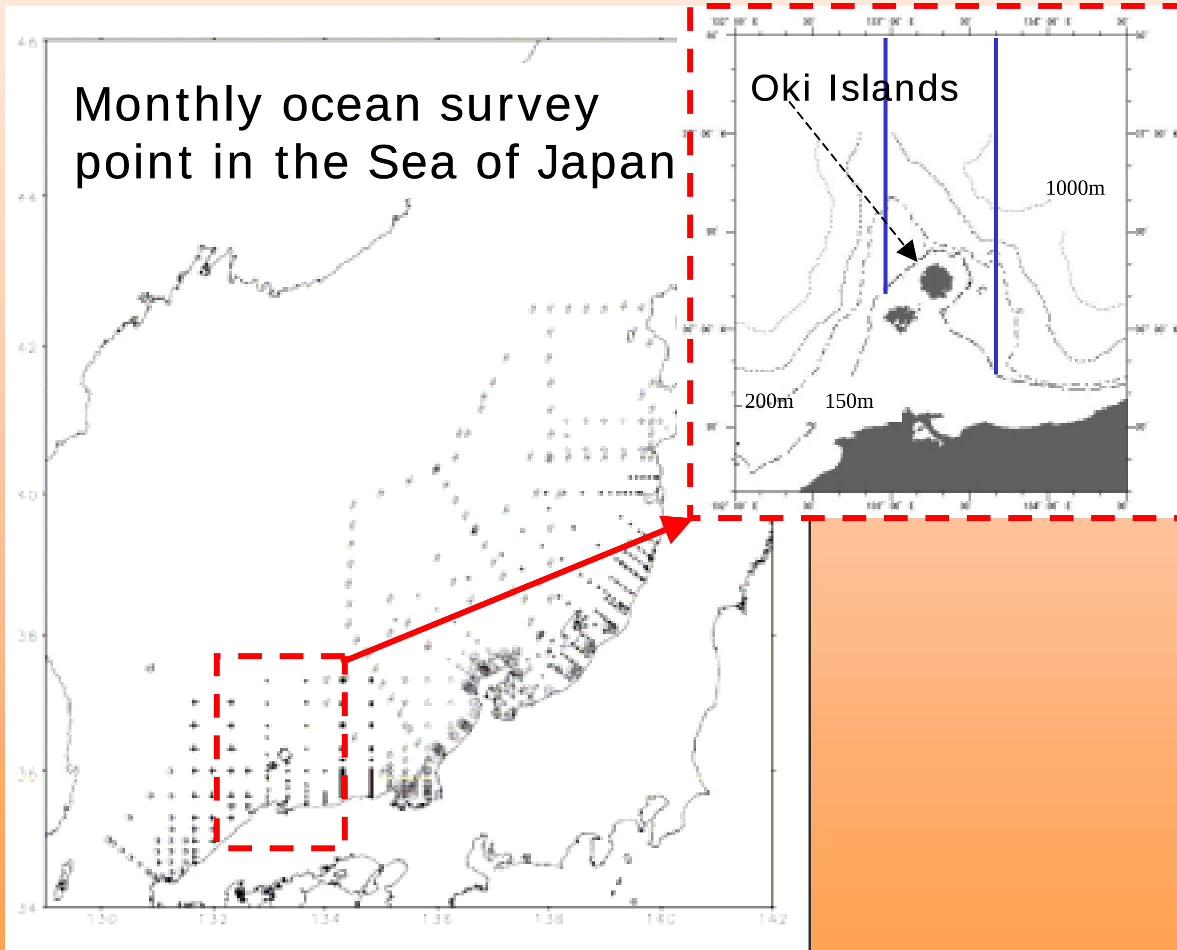


←*M.japonicus* school observed as a characteristic scattering layer

~Merits~

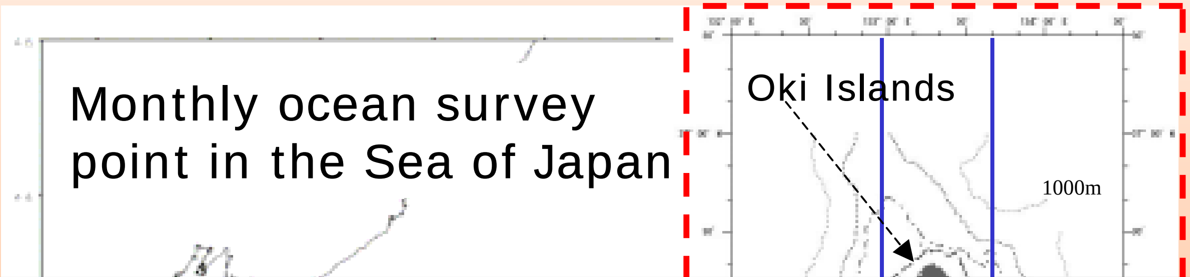
- Species identification method is clear (Fujino et al . 2006)
- Effective to collect wide area data in a short time scale
- Results can be obtained quickly by post processing the digital data.

How to conduct a better monitoring in a short time scale –2



Basic survey line of the Tottori prefectural fisheries experimental station

How to conduct a better monitoring in a short time scale –2



Basic survey line of the Tottori prefectural fisheries experimental station

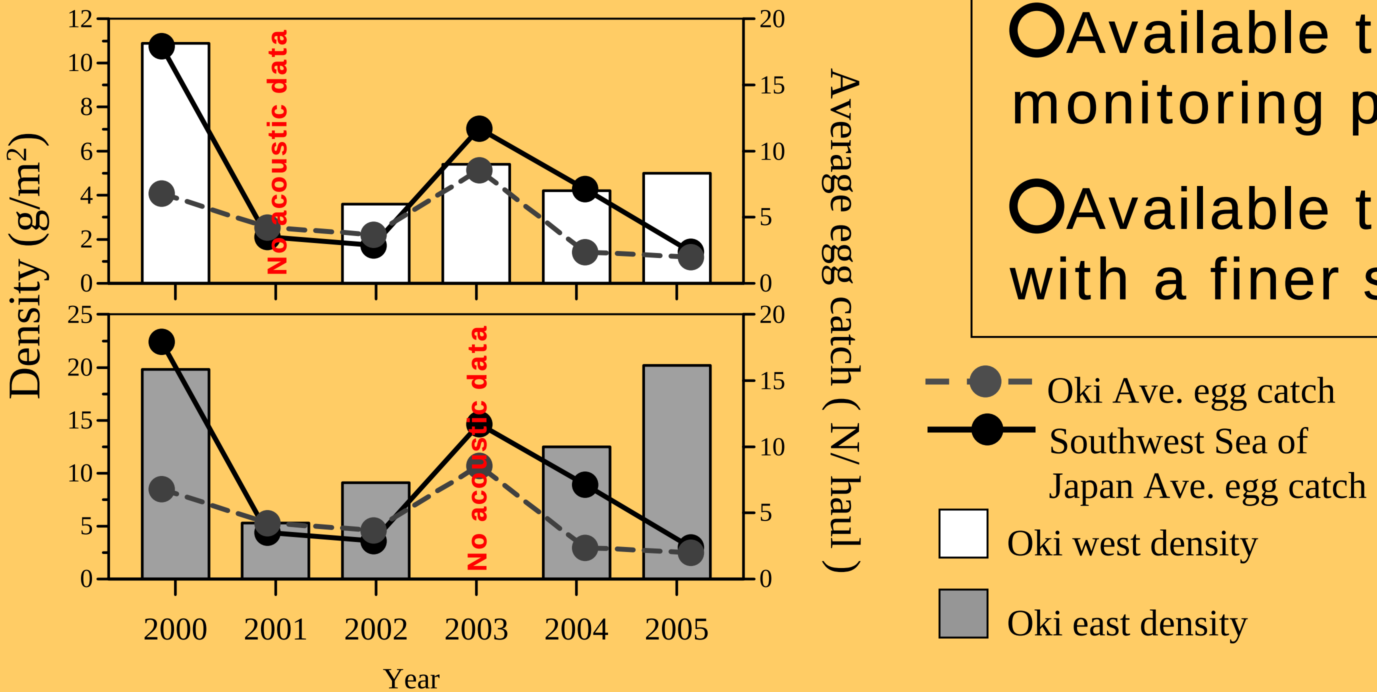


Fig. Comparison of *M.japonicus* stock index obtained from acoustics and egg number.

- ○Available to use current monitoring program
- ○Available to collect data with a finer scale

Better monitoring method

↓

Better forecast of "Regime shift"

Acknowledgement

This study was supported by the Japan Sea National Fisheries Research Institute, who collected the long term egg number data, and Tsuyoshi Shimura, who collected most of the acoustic data. We like to thank them especially for offering their data to this study.

Thank you !