Geographic variation in fish growth responses to regime shifts in the North Pacific using a fish growth - ecosystem coupled model NEMURO.FISH

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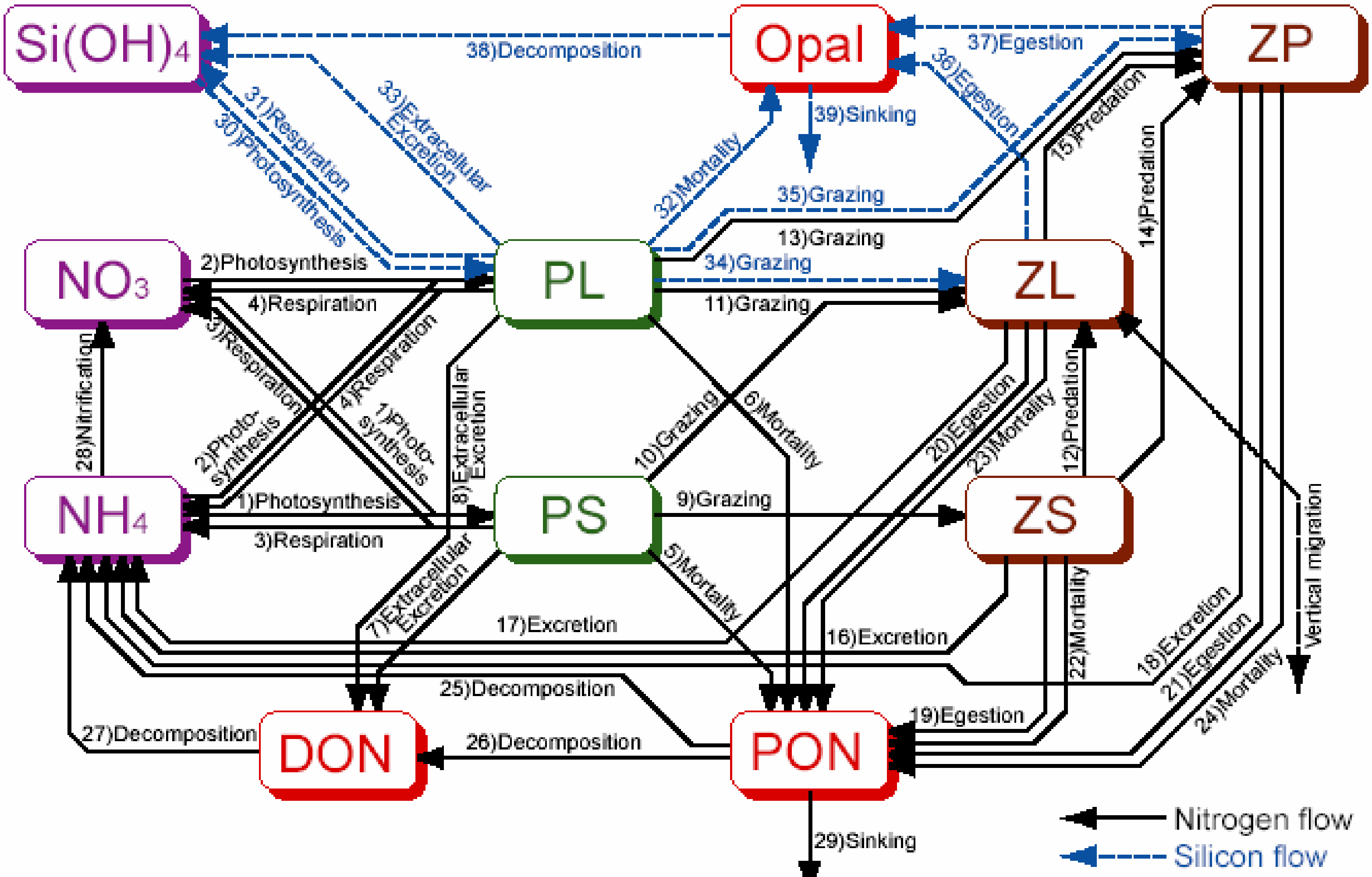
1. An example of geographical comparison of biological response to climate changes
2. Link to marine mammals and seabirds as prey (small pelagic fishes)

NEMURO

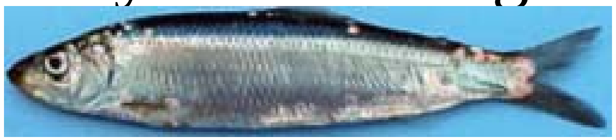
North Pacific Ecosystem Model for Understanding Regional Oceanography

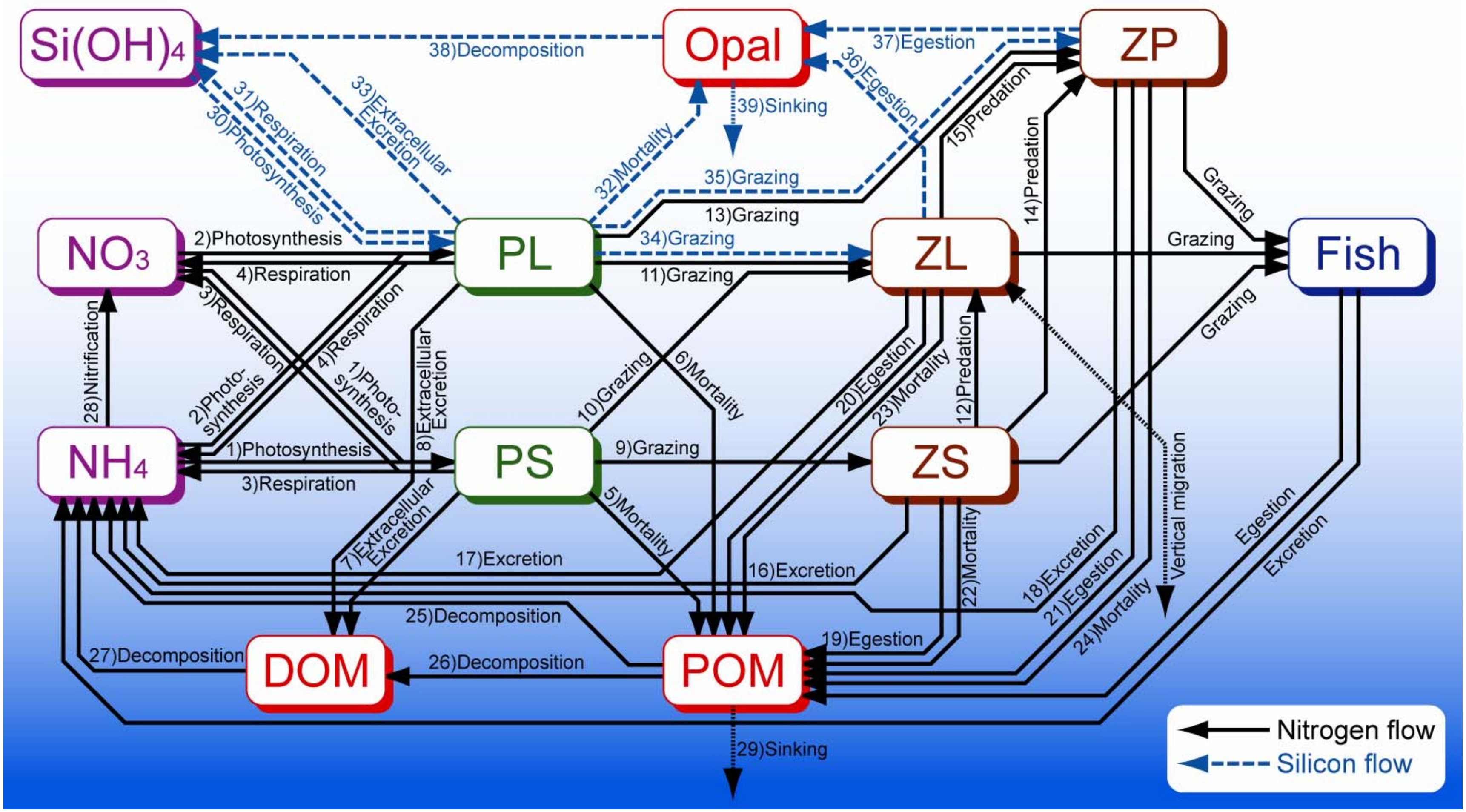


Kishi et al. (2001), Kishi et al. (in press)

NEMURO.FISH

NEMURO for Including Saury and Herring





Ito et al. (2004), Megrey et al. (in press), Ito et al. (in press) etc.

Bioenergetics Model for herring and saury

$$\frac{dW}{W \cdot dt} = \left[C - (R + S + F + E + P)\right] \cdot \frac{CAL_z}{CAL_f}$$

change of weight

C: consumption

R: respiration (loses through metabolism)

S: specific dynamic action (digesting food)

F: egestion

E: excretion

P: egg production

Today's Contents

0. **3D-NEMURO (zooplankton)**
   lower trophic level ecosystem response

1. **3D-NEMURO (zooplankton)**
   + NEMURO.FISH (herring)
   geographical comparison of fish response

2. **3D-NEMURO (zooplankton)**
   + NEMURO.FISH (saury & herring)
   geographical & species comparison of fish response

3D-NEMURO

Aita et al. (2003), Yamanaka et al. (2003), Aita et al. (in press)

Physical model

CCSR Ocean Component Model 3.4

Resolution

Horizontal: 1 degree by 1degree (360x180)

Vertical: 54 levels from the surface to 5000 m

Real climate forcing since 1948

daily surface heat flux NCEP reanalysis

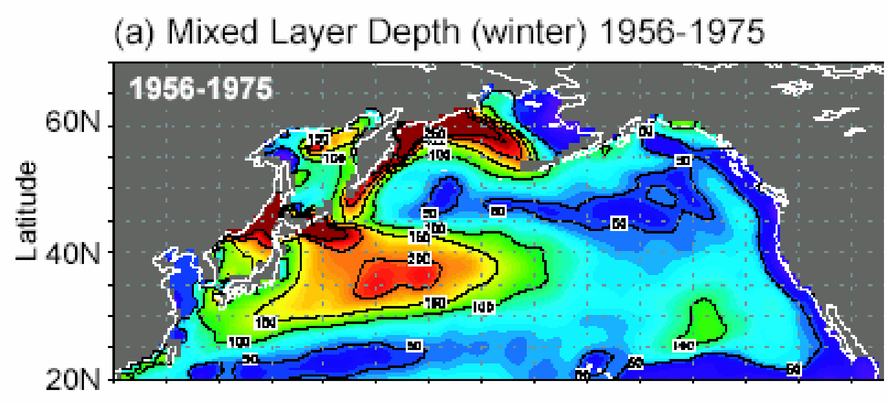
fresh water flux

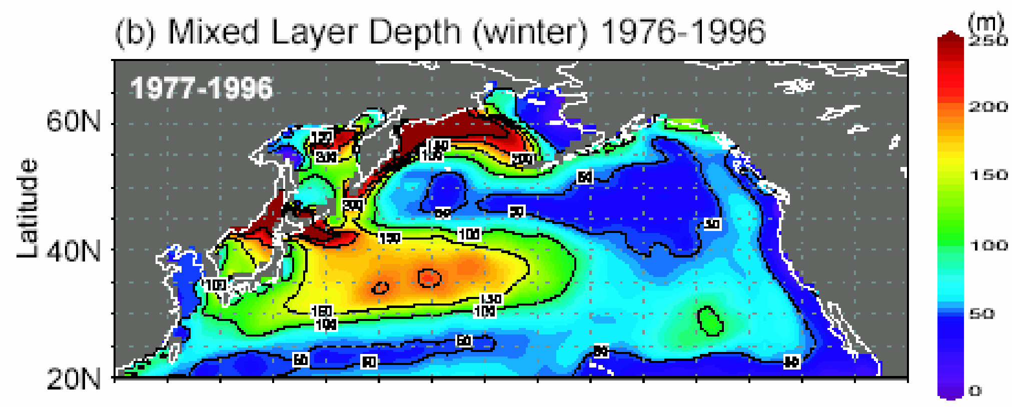
wind stress

light intensity

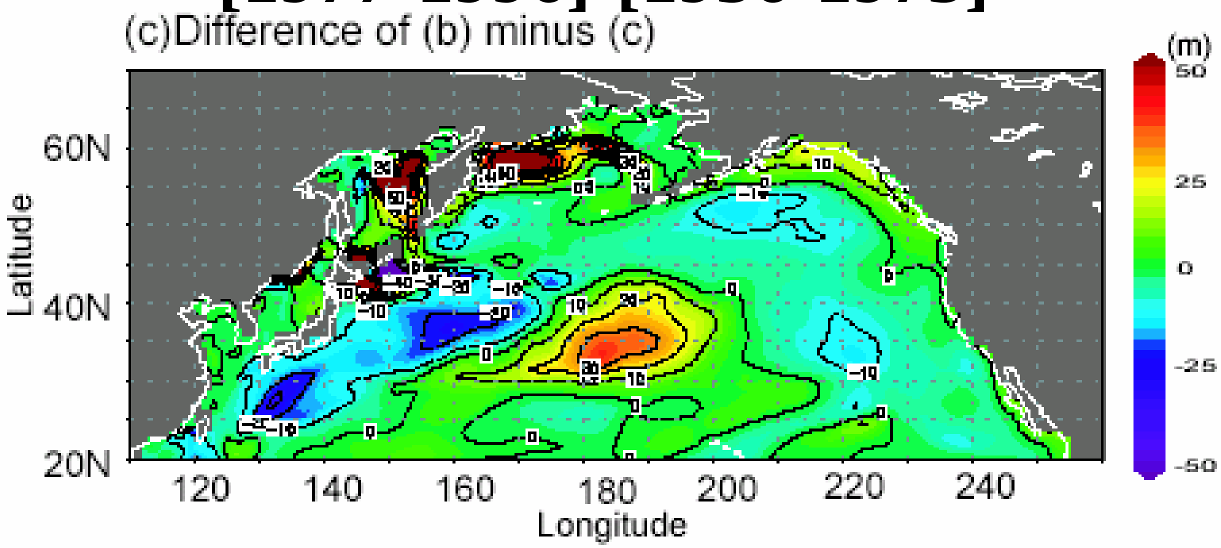
Winter mixed layer depth in 3D-NEMURO

1956-1975 **1977-1996**





[1977-1996]-[1956-1975]



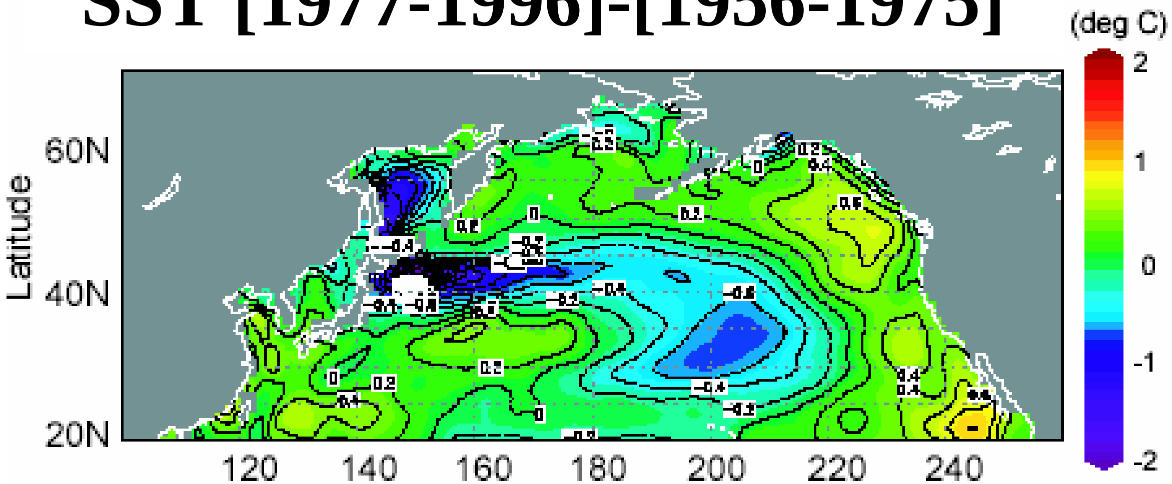
Increase in
- **CP**
- **coastal GA**

Decrease in
- **WP**
- **GA**

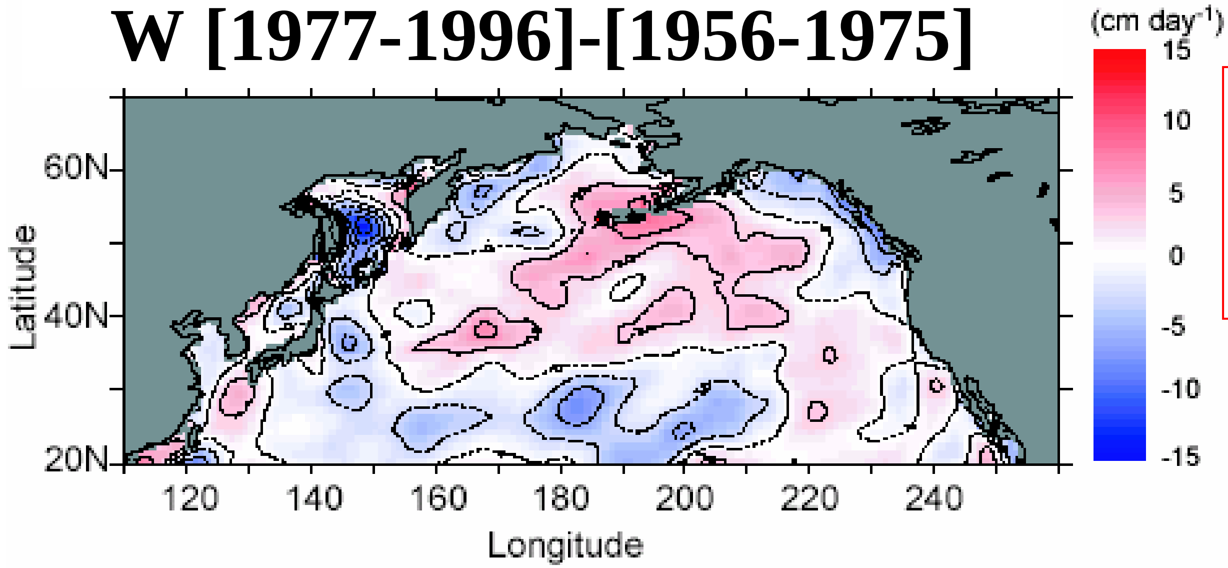
Aita et al. (in press)

SST & upwelling in 3D-NEMURO

SST [1977-1996]-[1956-1975]



W [1977-1996]-[1956-1975]



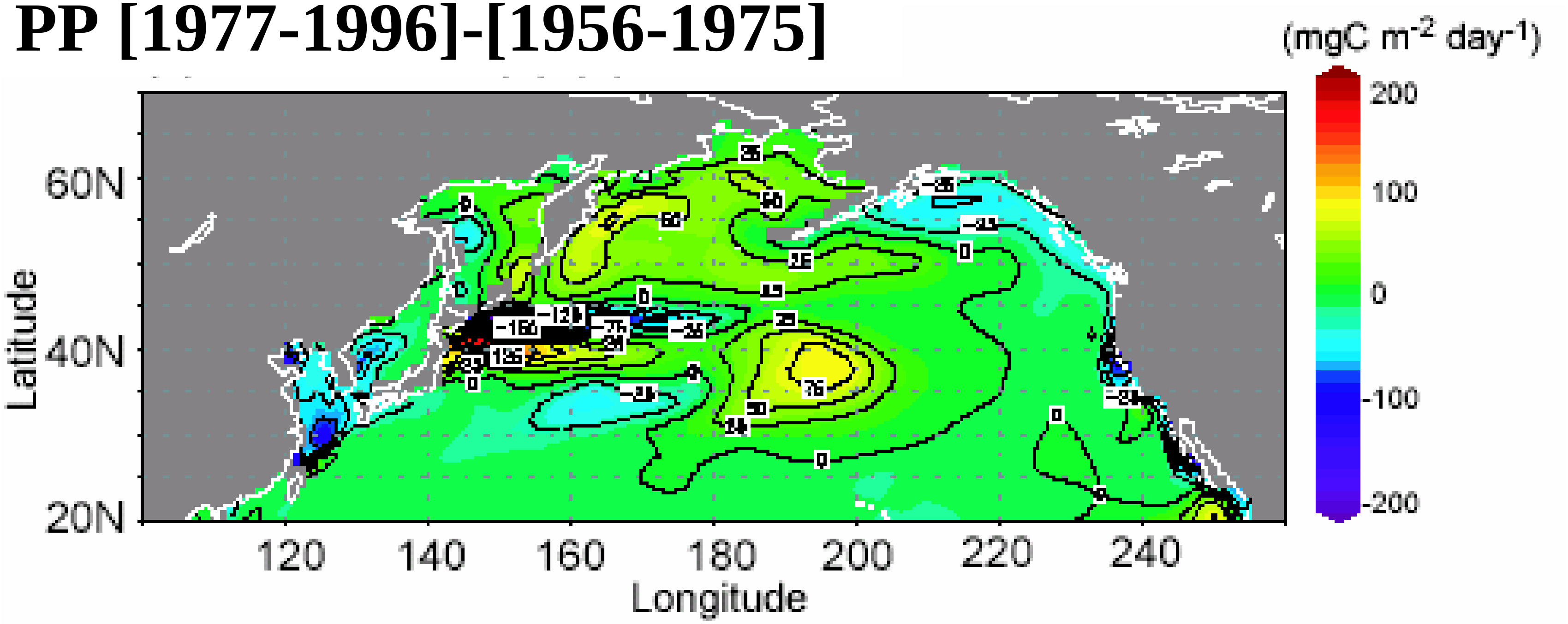
SST:
colder in CP &
warmer in other area
similar to observation

upwelling:
enhanced in north of
30N

Aita et al. (in press)

Primary production in 3D-NEMURO

PP [1977-1996]-[1956-1975]



PP:

there is negative bias

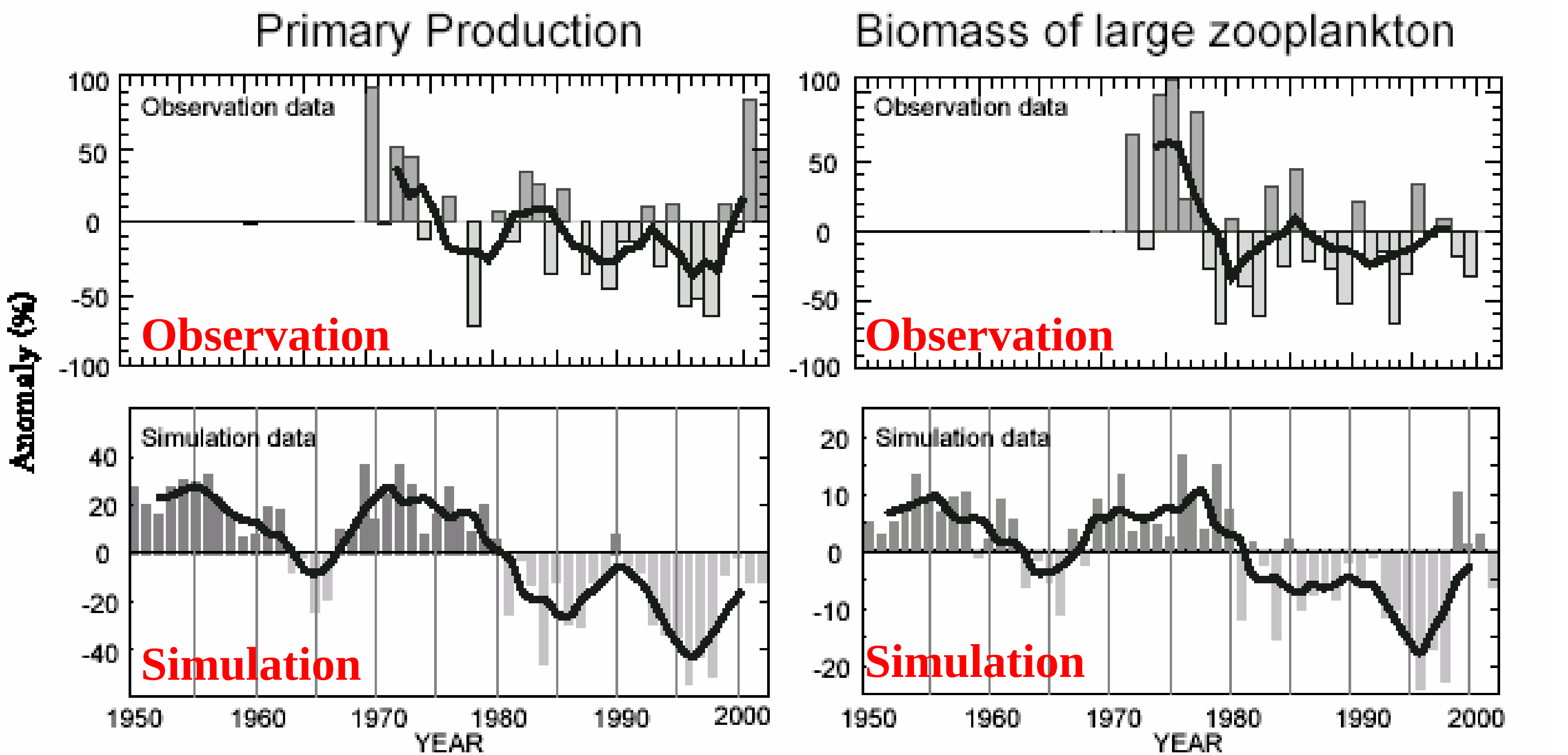
increase in CP: consistent with observation

decrease in GA: consistent with observation

increase in BS: inconsistent with observation

Aita et al. (in press)

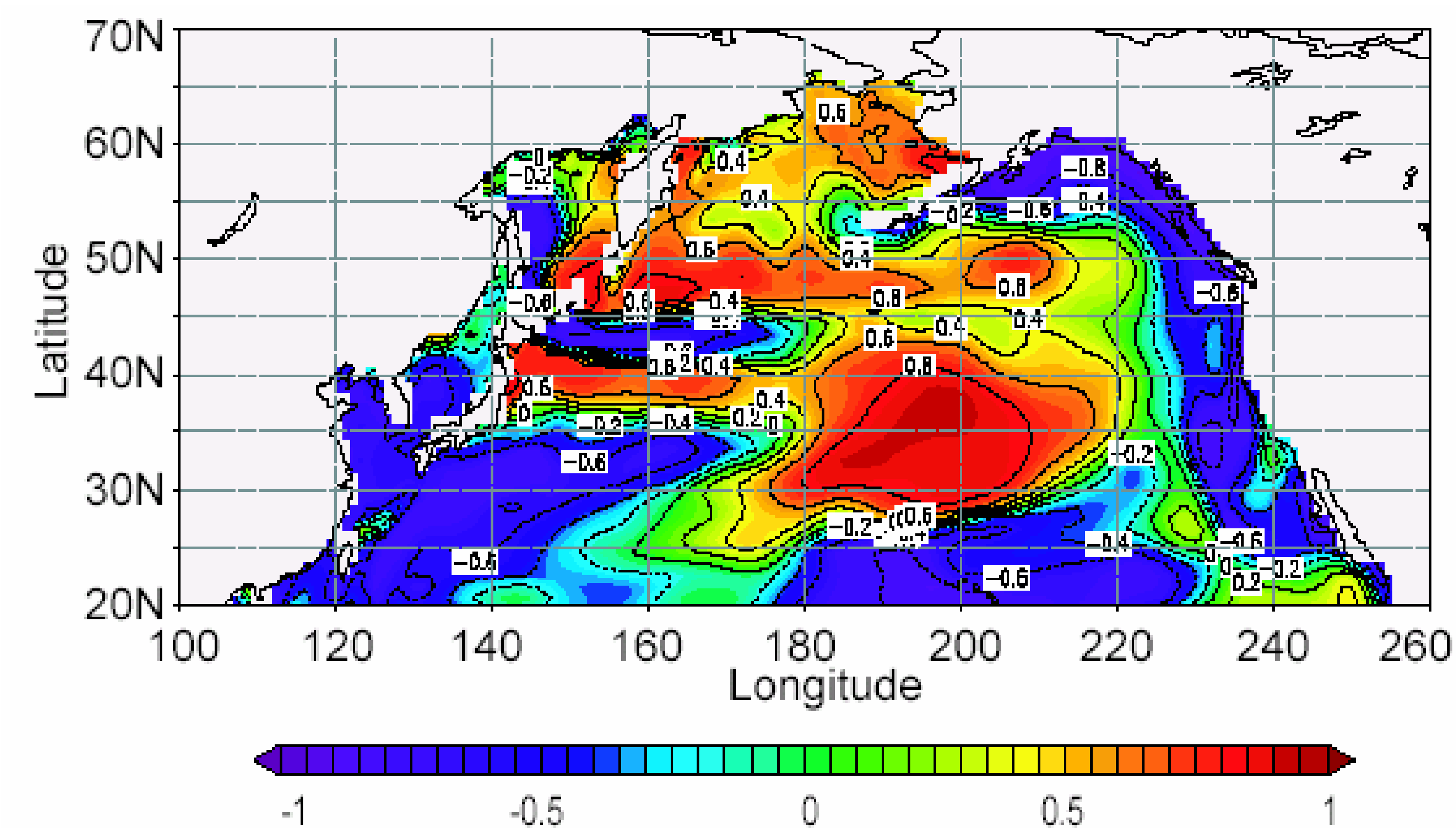
Comparison with observation (C. Pacific)



Much smaller than observational values.
However, the variability is consistent with observation.
The variability shows high correlation with PDO (>0.6).

Aita et al. (in press)

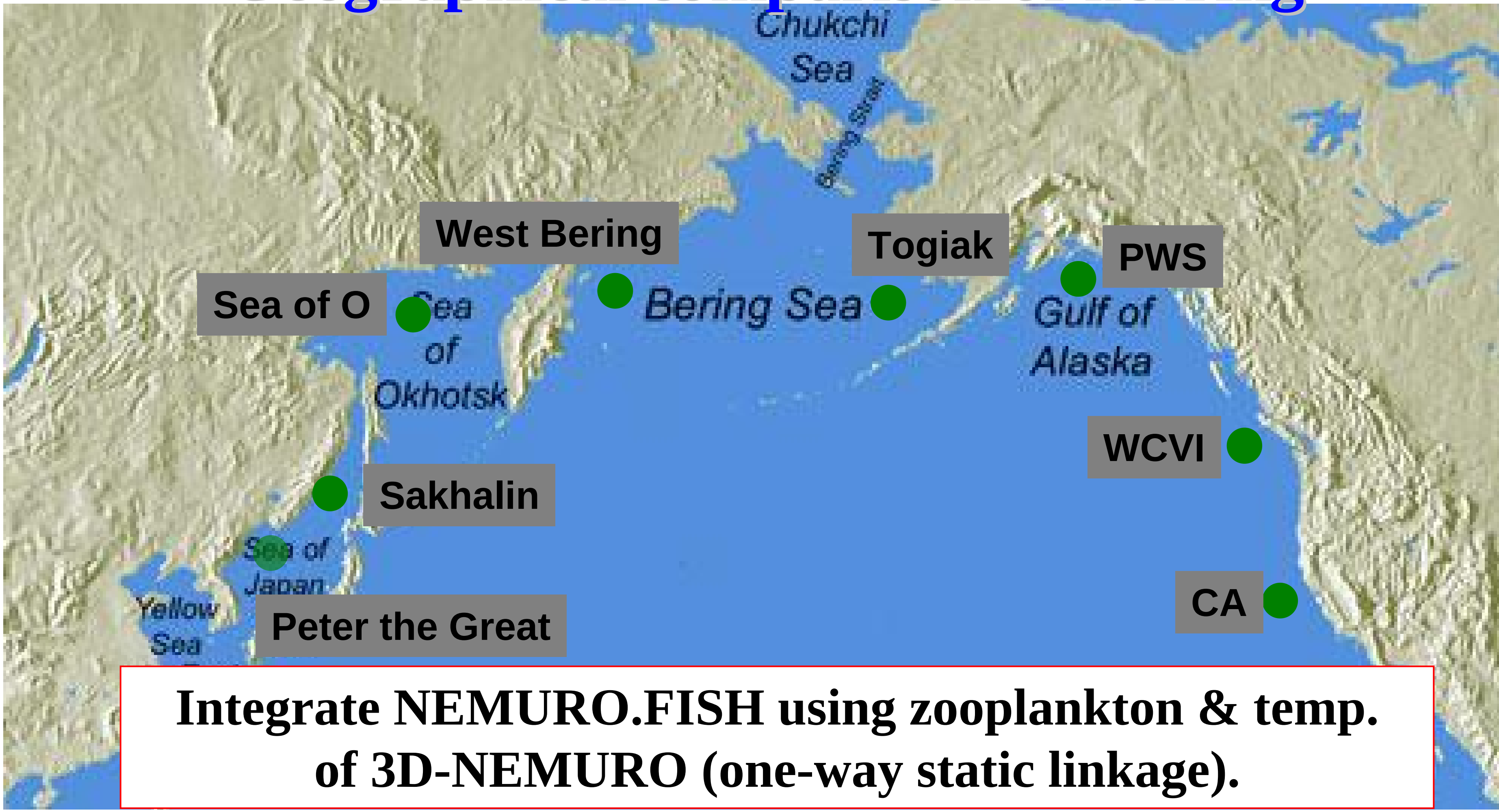
Correlation coefficients between PP and PDO



Positive in C. Pacific.
Negative along eastern boundary of Pacific.

Aita et al. (in press)

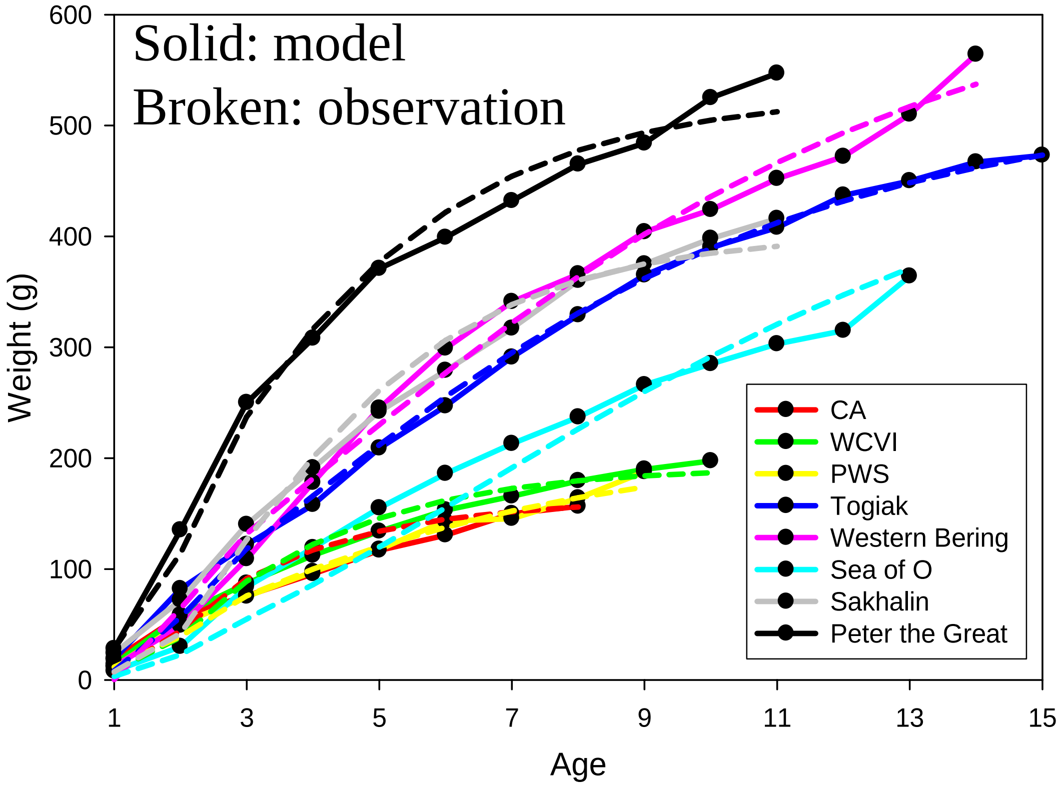
Geographical comparison of herring



Integrate NEMURO.FISH using zooplankton & temp. of 3D-NEMURO (one-way static linkage).

Partly reported in Rose et al. (in press)

Calibration with PEST
using Climatological Steady-state weights-at-age



In 3D-NEMURO, the zooplankton density is much smaller than observation. Therefore, the herring cannot grow sufficient.
Need to calibrate bioenergetics model parameters.

Automated calibration software PEST to calibrate parameters.

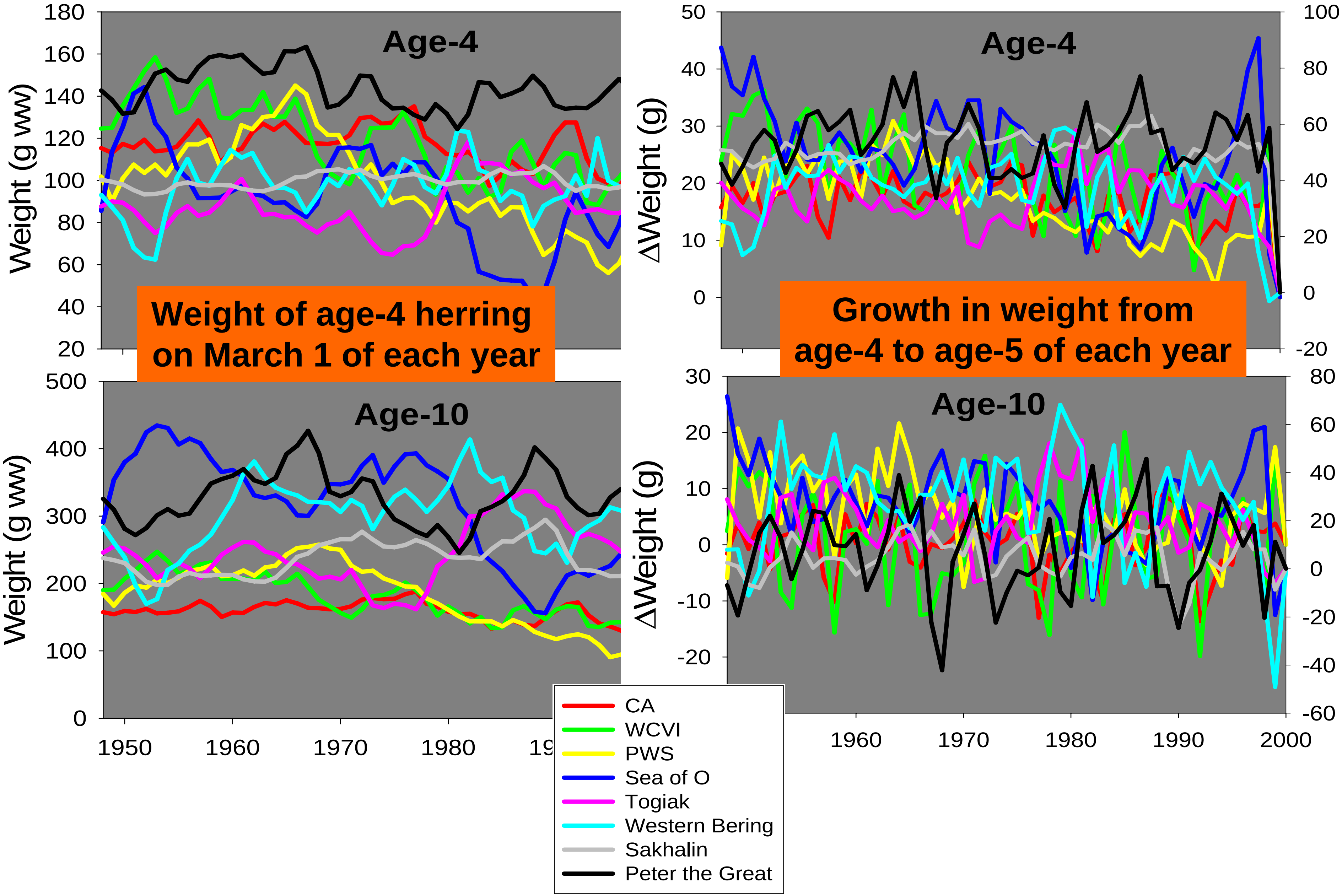
Weights-at-age from:

Naumenko (2002) Report 20 ADFG stock assessments

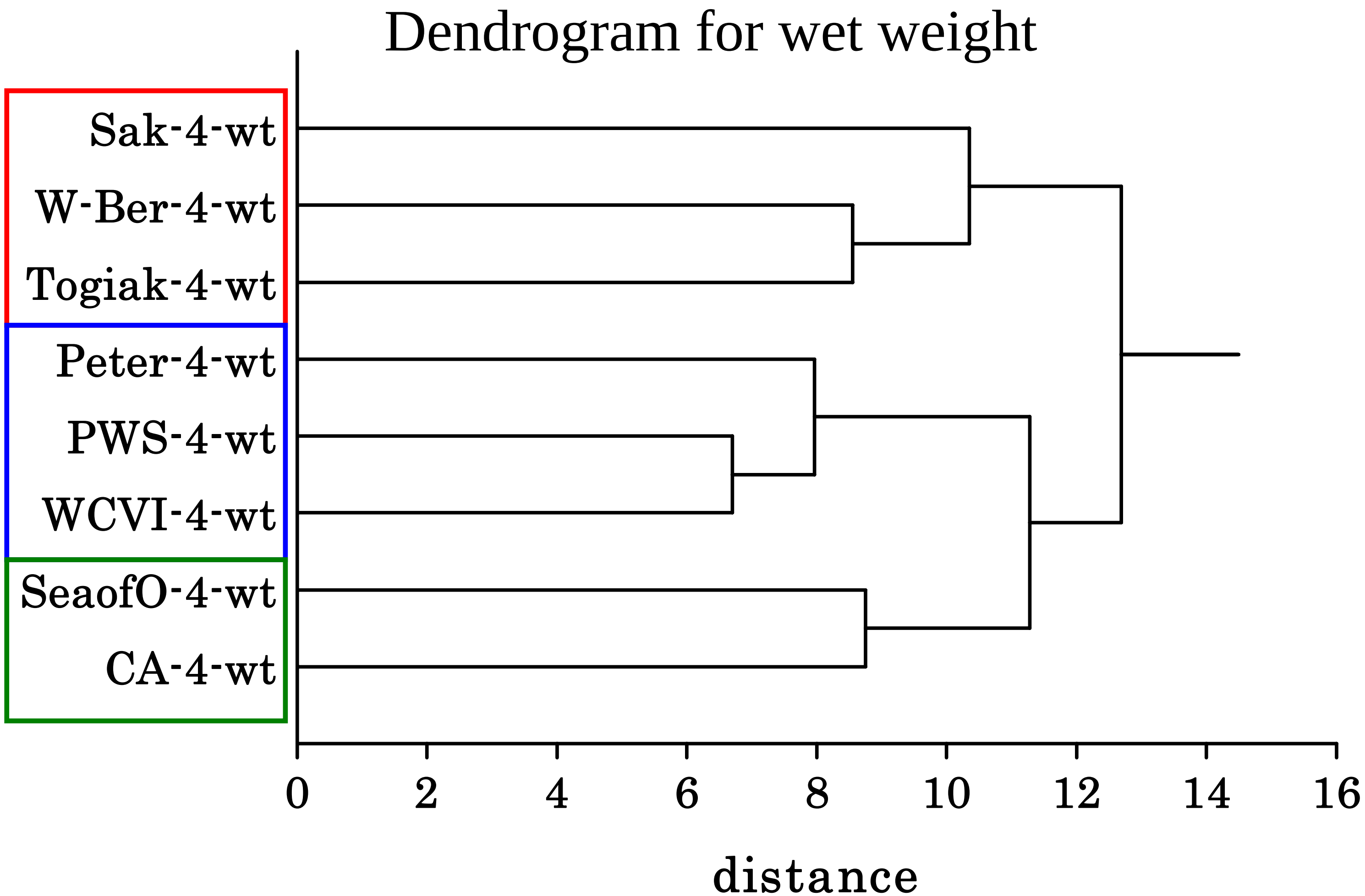
Schweigert et al. (2004)

Lassuy (1980)

Herring growth by NEMURO.FISH



Cluster analysis for wet weight of herring



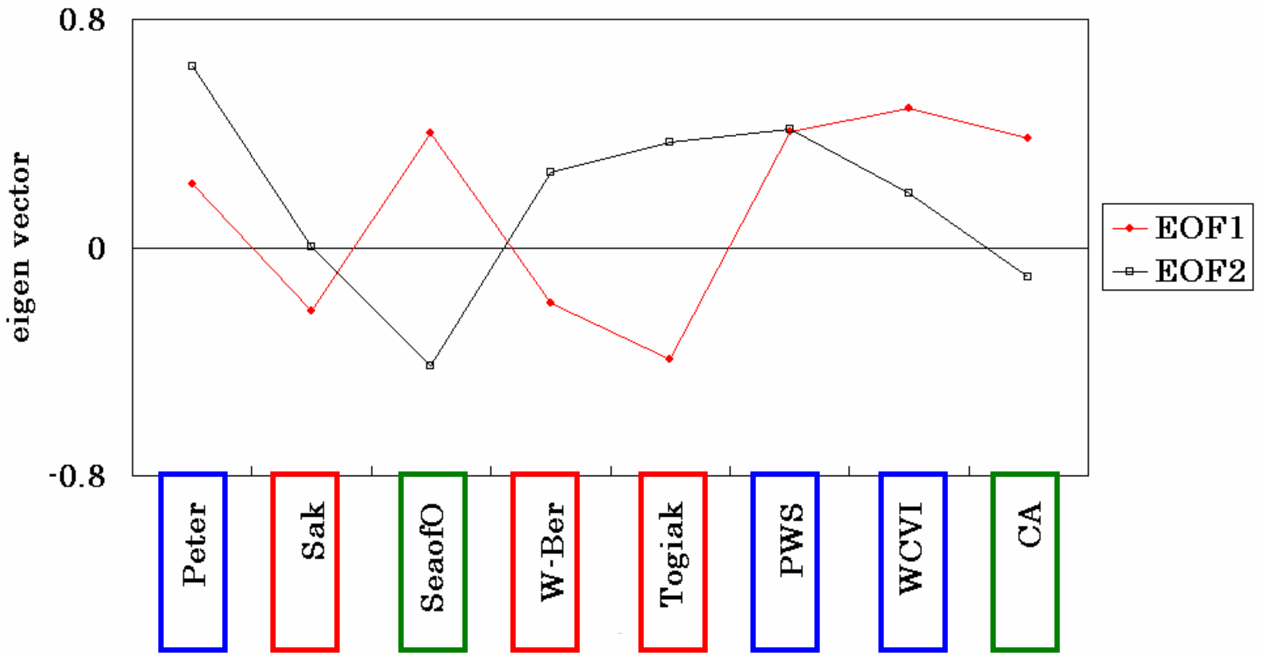
Use complete connection method
with standardized Euclidian distance

EOF for wet weight

EOF1 38.1%

EOF2 19.4%

	EOF1	EOF2
group 1	–	+
group 2	+	+
group 3	+	–



Time series of score

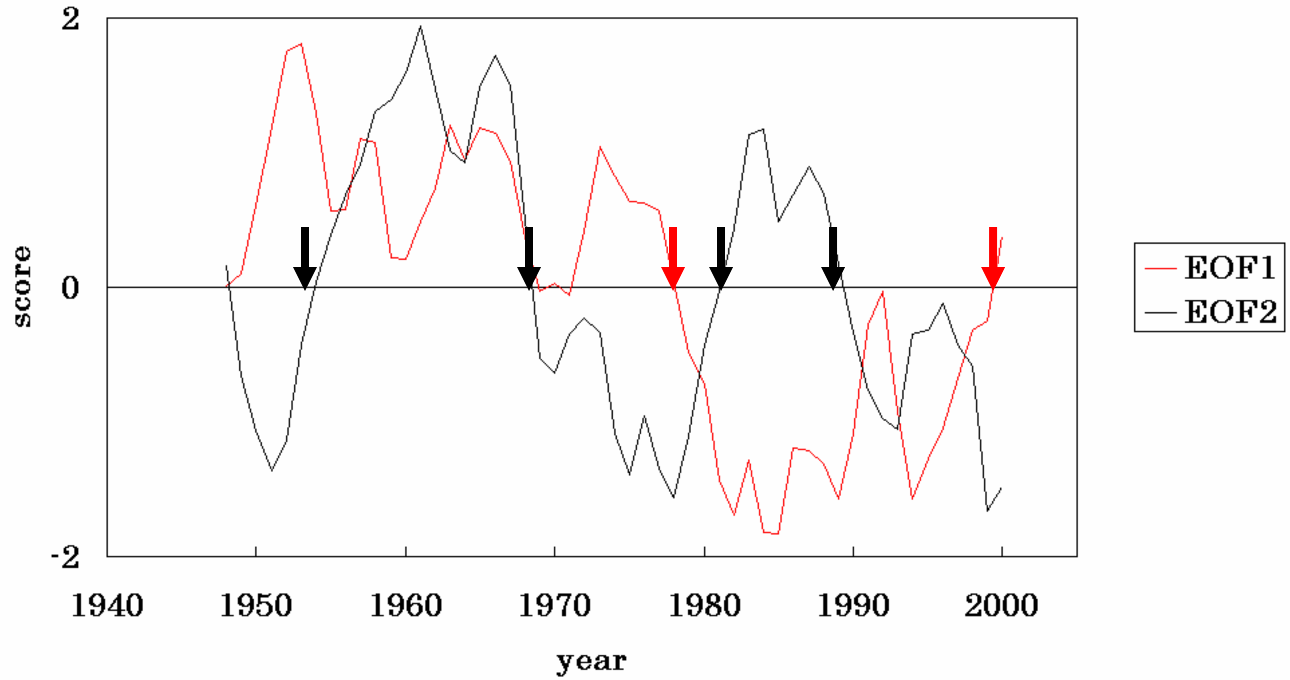
EOF1:

1978-79, 99-2000

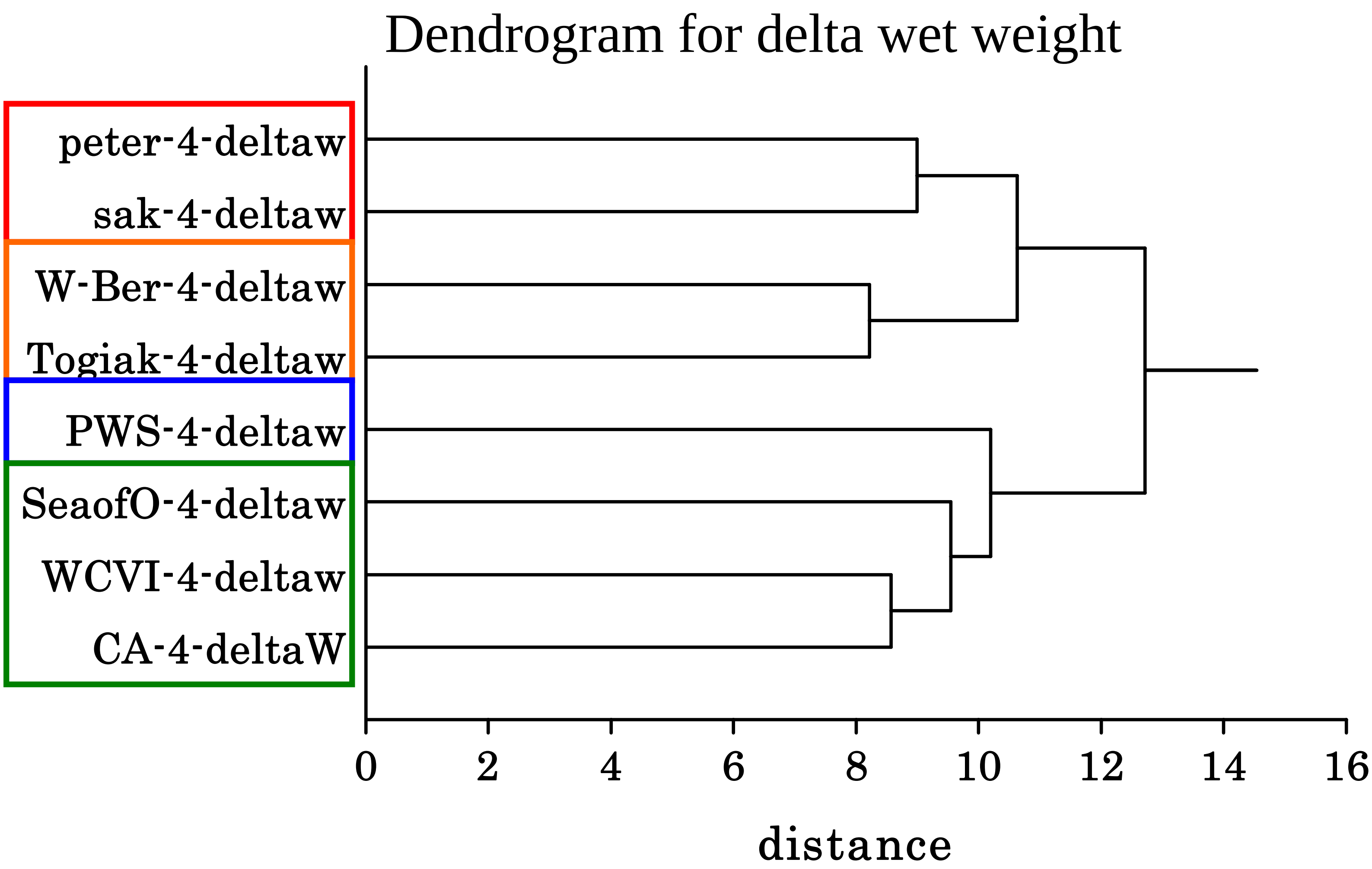
EOF2:

1953-54, 68-69,

81-82, 89-90



Cluster analysis for wet weight change of herring



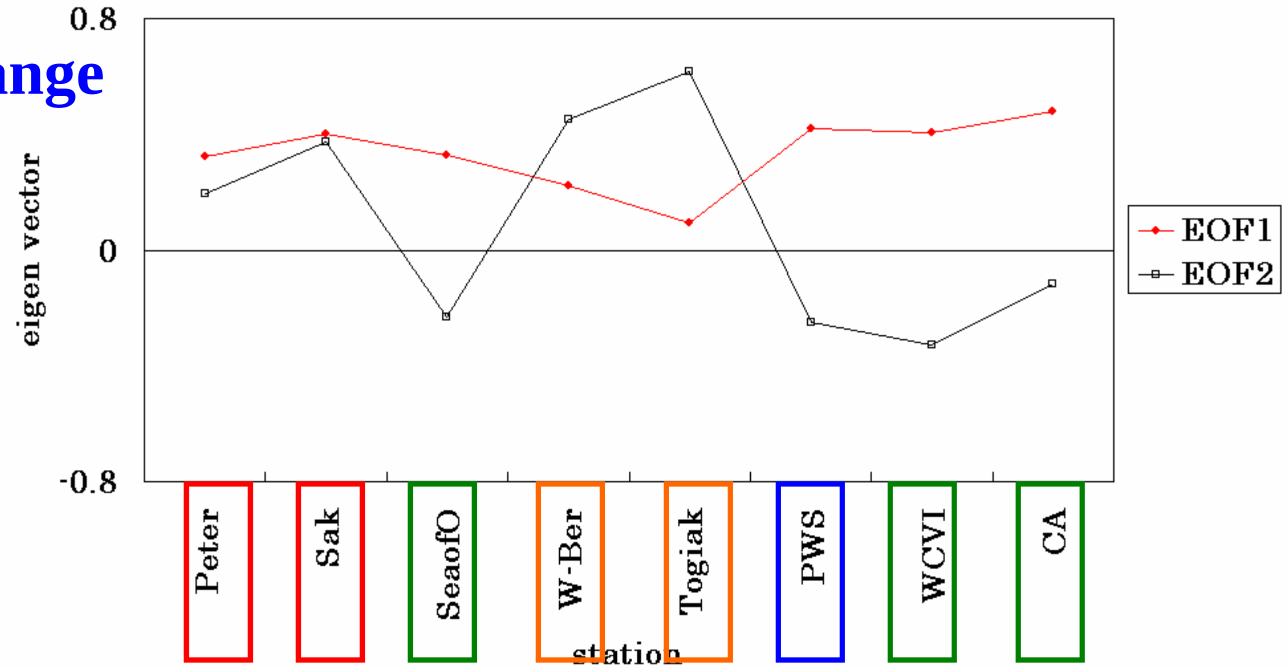
Use complete connection method
with standardized Euclidian distance

EOF for weight change

EOF1 35.2%

EOF2 24.7%

	EOF1	EOF2
group 1	+	+
group 2	+	+
group 3	+	–
group 4	+	–



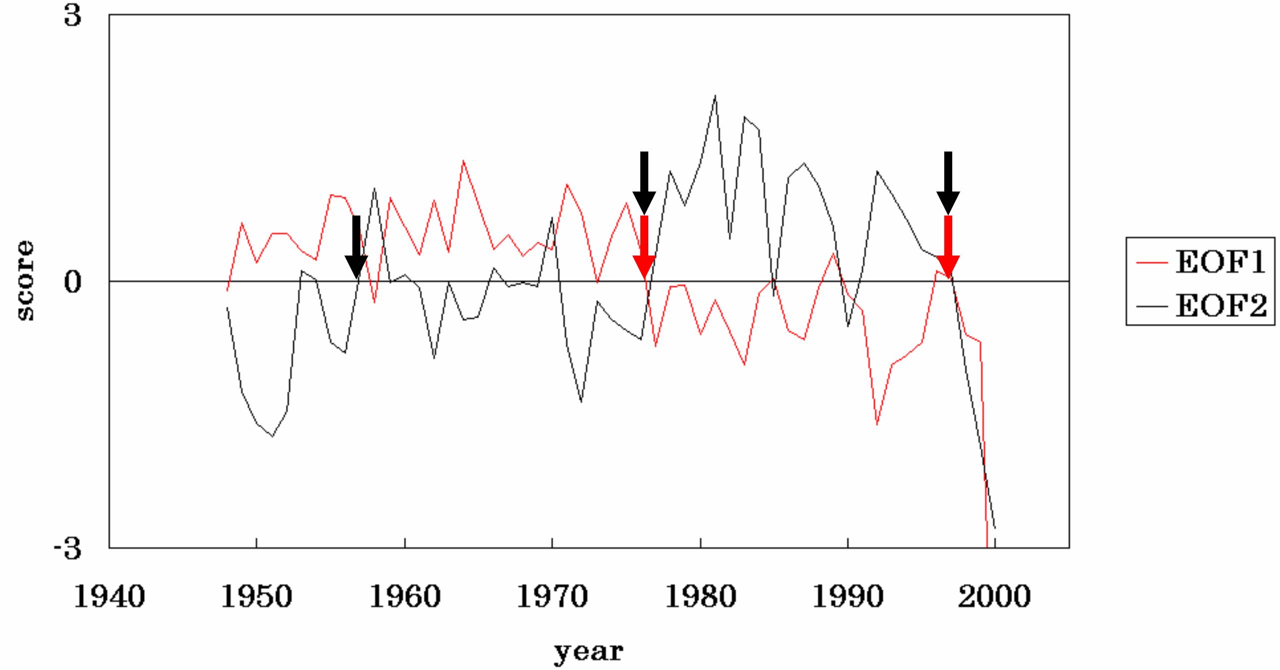
Time series of score

EOF1:

1976-77, 99-2000

EOF2

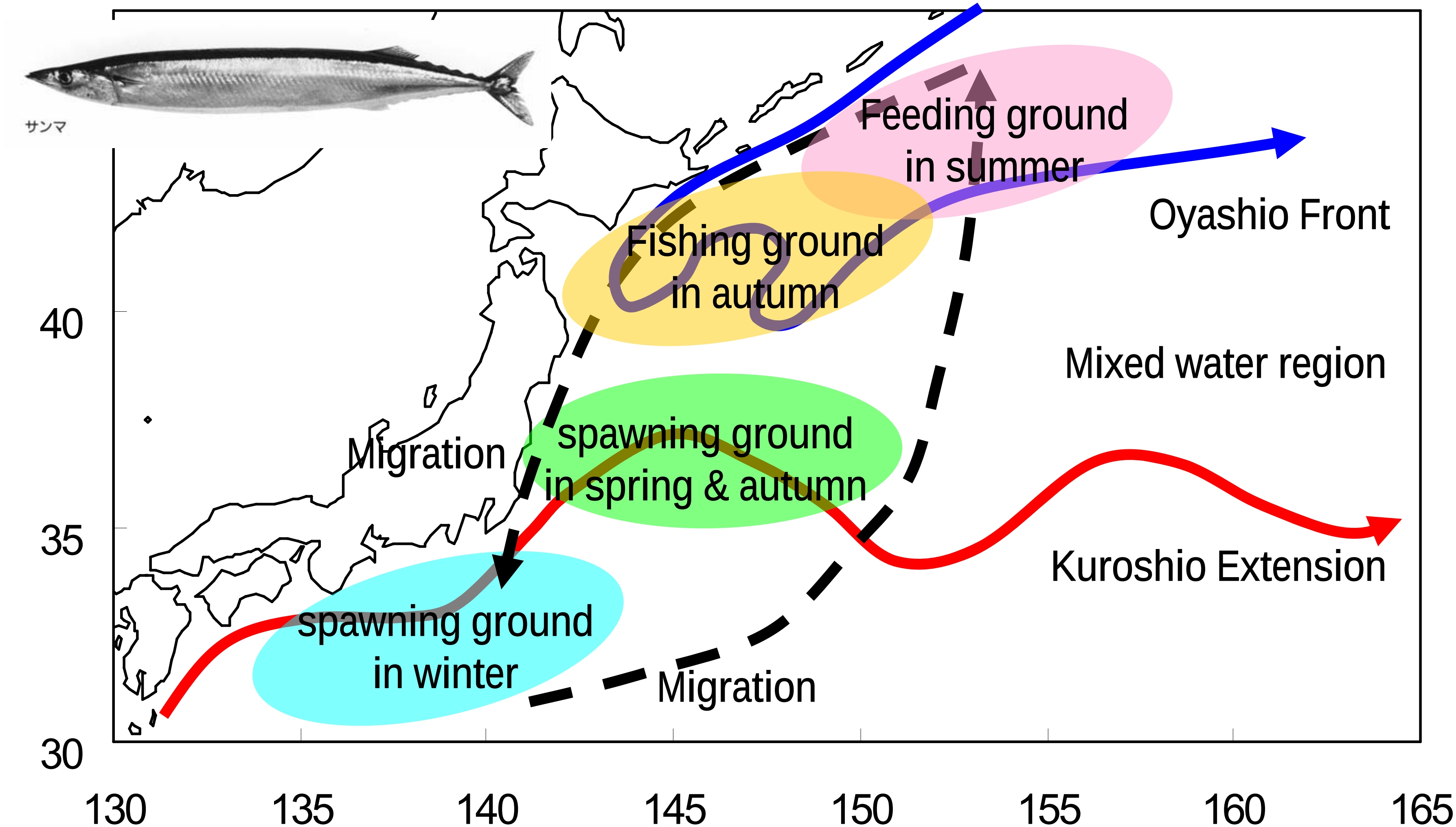
noisy



Geographical comparison of herring

1. We should be careful about the meaning of data.
   weight & weight increment show different result
2. Model result showed
   basin scale synchronicity &
   east & Sea of O vs Bering & west asynchronicity

Life History of Pacific Saury with Oceanographic Features



Modified from Watanabe et al. (1989)

3-box version

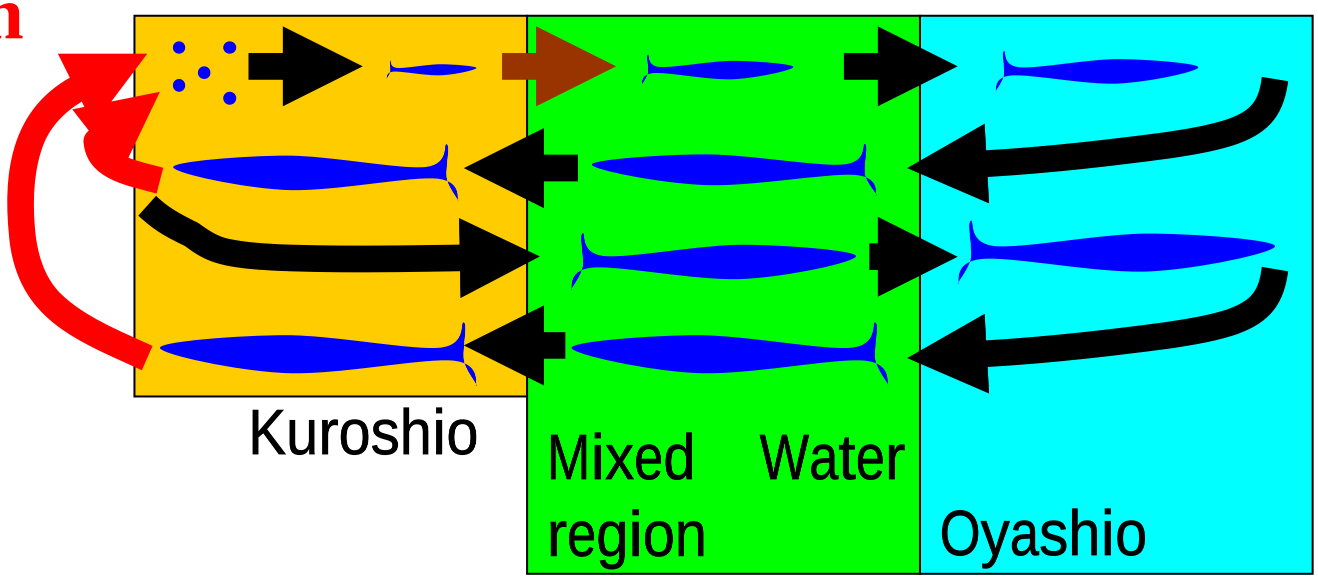


Table 2. Life stages of Pacific saury in the saruy bioenergetics model

Stage	region
larvae	Kuroshio
juvenile & young	mixed region
small	Oyashio
adult	mixed region
adult matured	Kuroshio
adult	mixed region
adult	Oyashio
adult	mixed region
adult matured	Kuroshio

9 life stages

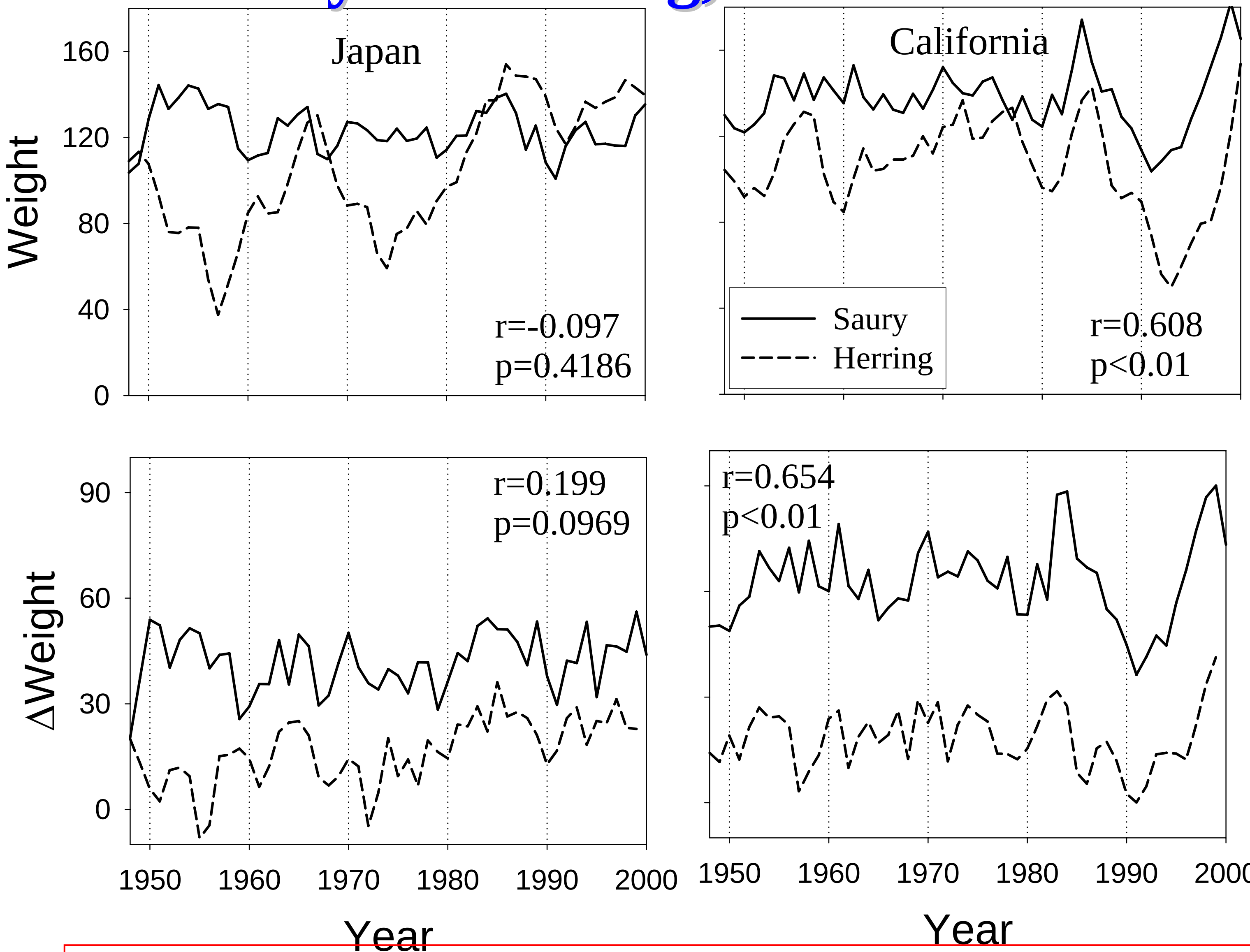
Ito et al. (2004)
Ito et al . (in press)
Mukai et al. (in press)

Species comparison between saury and herring

Herring is assumed to live in the northernmost box, even though they do not live there in nature (virtual comparison). For saury, the geographical comparison is realistic.

Megrey et al. (in press)
Ito et al. (in prep.)

Saury vs Herring, West vs East



Saury and herring show synchronicity in East.

Megrey et al. (in press)

Saury vs Herring, West vs East (Model)

Zooplankton

synchronized in subarctic and transition in east

asynchronized in subarctic and transition in west

Saury and Herring

synchronized in east

asynchronized in west

Saury

saury migrate from subtropical to subarctic

Ito et al. (in press): zoo in transition & SST in subarctic are important

complicated because integrating signals in wide area.

Herring

complicated because integrating signals during several years

The response depends on both location and life history.

Conclusion and Future perspectives

1. The biological response depends on both location and life history.
2. To make geographical comparison, time derivative data is useful.
3. Model approaches are immature to compare with realistic variations. However, those will become powerful tools to understand the biological responses. Therefore, we will continue.
4. Biological nesting “rhomboidal” approaches (deYoung et al., 2004) seems to be appropriate way to model marine ecosystems.

    increase resolution near target species, and decrease resolutions up and down trophic ecosystem levels.

Drive marine mammals & seabirds model based on NEMURO.FISH seems interesting.