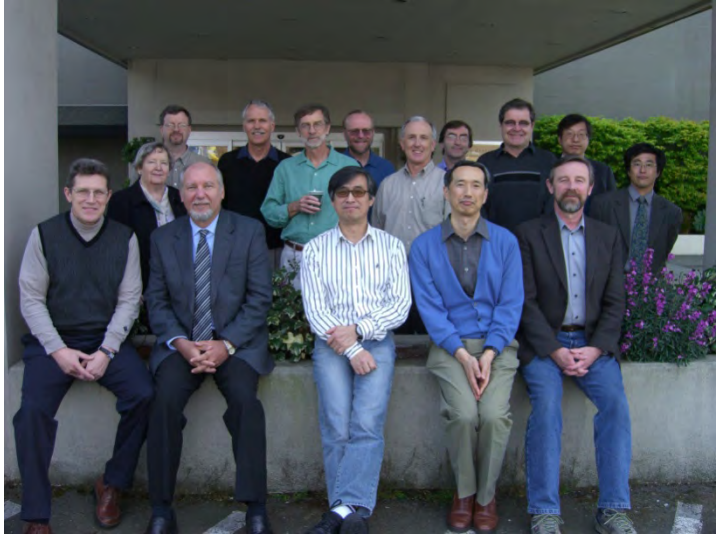
A review of the NEMURO.FISH model applications to marine ecosystem investigations and its ability to evaluate responses of fish to future climate change (A1B senario)

Michio J. **Kishi**, Shin-ichi Ito, Bernard A. Megrey, Kenneth A. Rose, and Francisco E. Werner



Brains were provided from friends

Models were run my students

Fund managers and
Spokes man also by my colleague

I was idling

Chum salmon

Already spoken by Kaeriyama-san

Kishi,M.J., M.Kaeriyama, H.Ueno and Y.Kamezawa (2010): The effect of climate change on the growth of Japanese chum salmon (Oncorhynchus keta) using a bioenergetics model coupled with a three-dimensional lower tropic ecosystem model (NEMURO). Deep-Sea Research 2, doi: 10.1016/j.dsr2.2009.12.013

Common squid

Already spoken by Sakurai-san

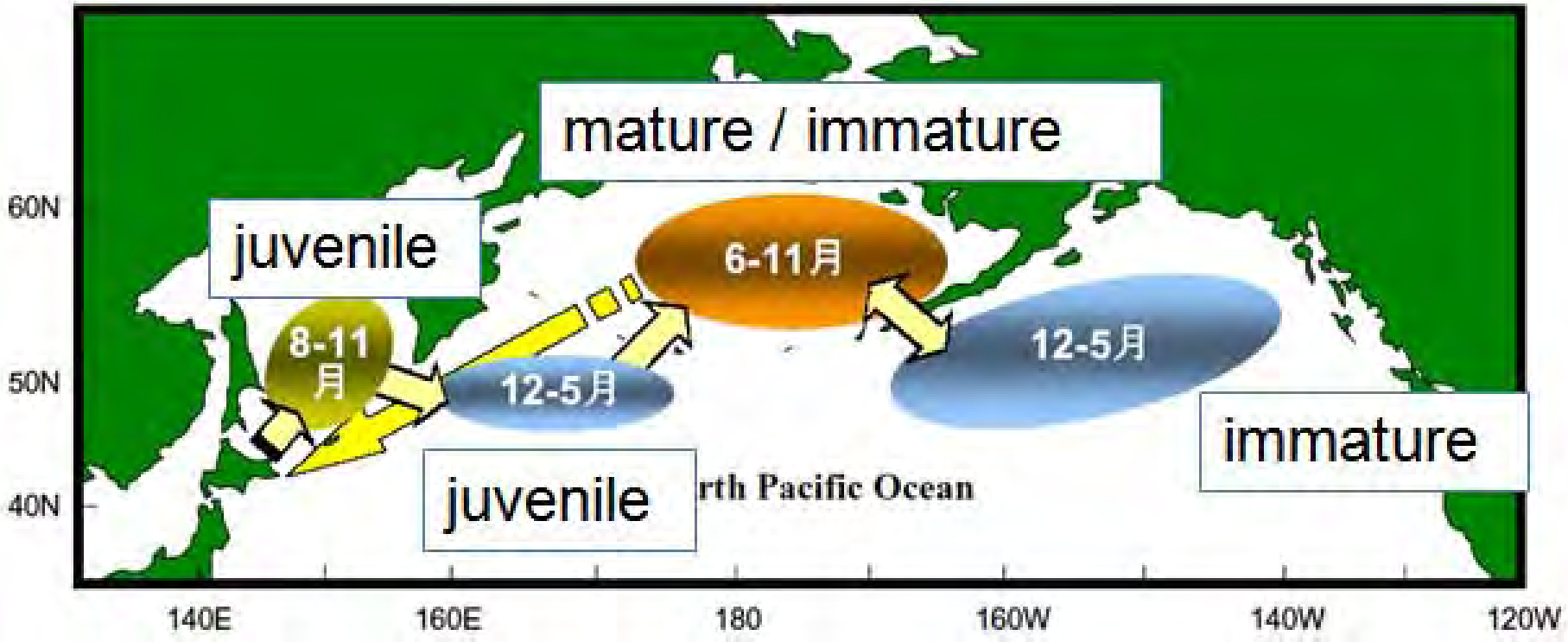
Kishi,M.J., K.Nakajima, M.Fujii and T.Hashioka (2009):Environmental factors which affect growth of Japanese Common Squid, *Todarodes pacificus*, analyzed by a bioenergetics model coupled with a lower trophic ecosystem model. *Journal of Marine Systems*, 78, 278-287.

Pacific saury

Ito et al. (2010) Ito S., K. A. Rose, A. J. Miller, K. Drinkwater, K. M. Brander, J. E. Overland, S. Sundby, E. Curchitser, J. W. Hurrell and Y. Yamanaka, 2010, Ocean ecosystem responses to future global change scenarios: A way forward, In: M. Barange, J.G. Field, R.H. Harris, E. Hofmann, R. I. Perry, F. Werner (Eds) Global Change and Marine Ecosystems. Oxford University Press., 287-322, pp440.

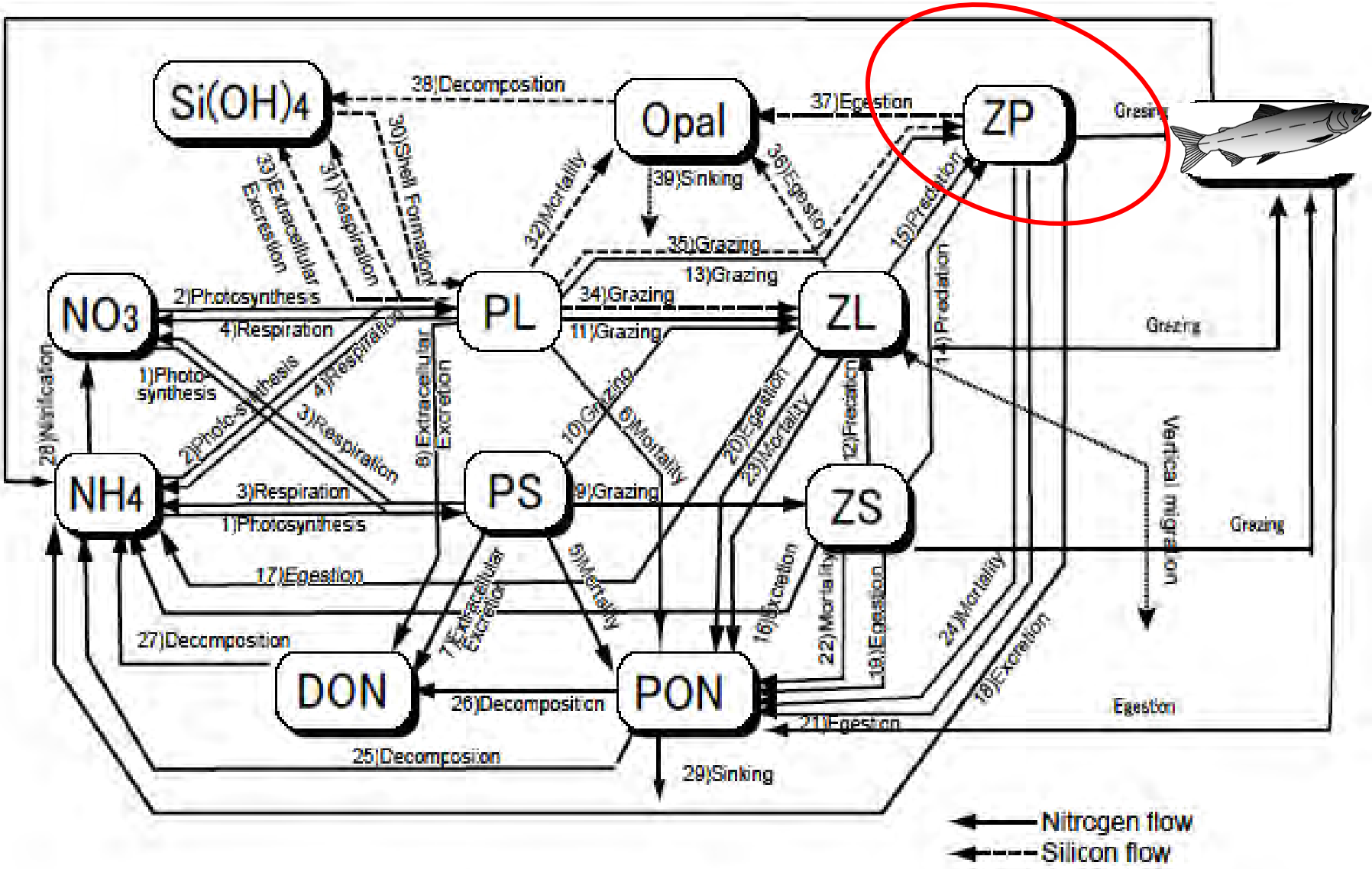
Already spoken by Ito-san

§ 1. Chum salmon



Urawa（2000）Migration route of Japanese salmon. National Salmon Resources Center (NASREC) Newsletter No.**5**pp.3-9, in Japanese

NEMURO. FISH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Opal
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38)Decomposition
37)Egestion
30)Shell Formation
31)Respiration
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34)Grazing
11)Grazing
19)Predation
14)Predation
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16)Excretion
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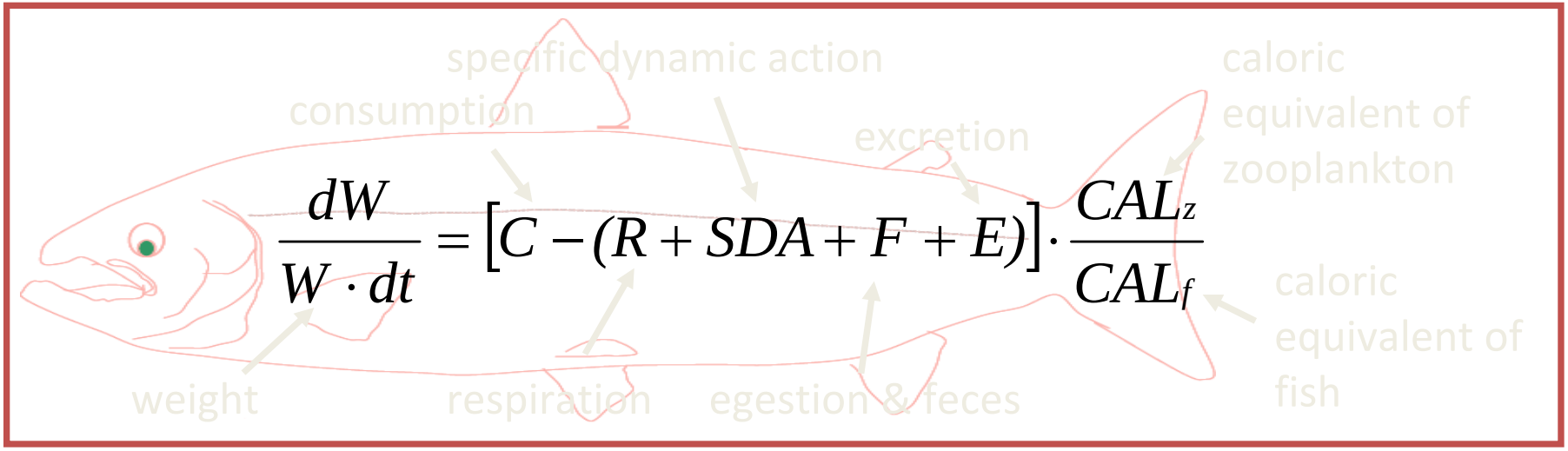
5)Mortality
27)Decomposition
26)Decomposition
21)Egestion
18)Excretion
Egestion
25)Decomposition
29)Sinking
Nitrogen flow
Silicon flow

Rudstum(1988)

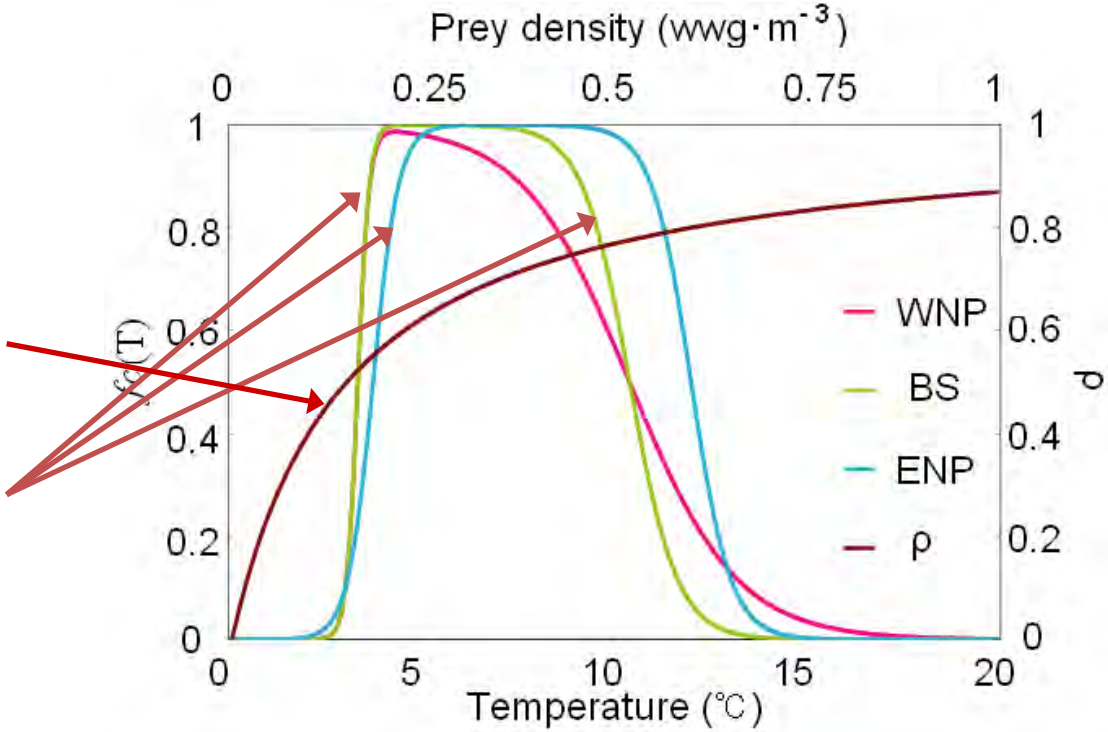


$$C = C_{MAX} \cdot \rho \cdot f_c(T)$$

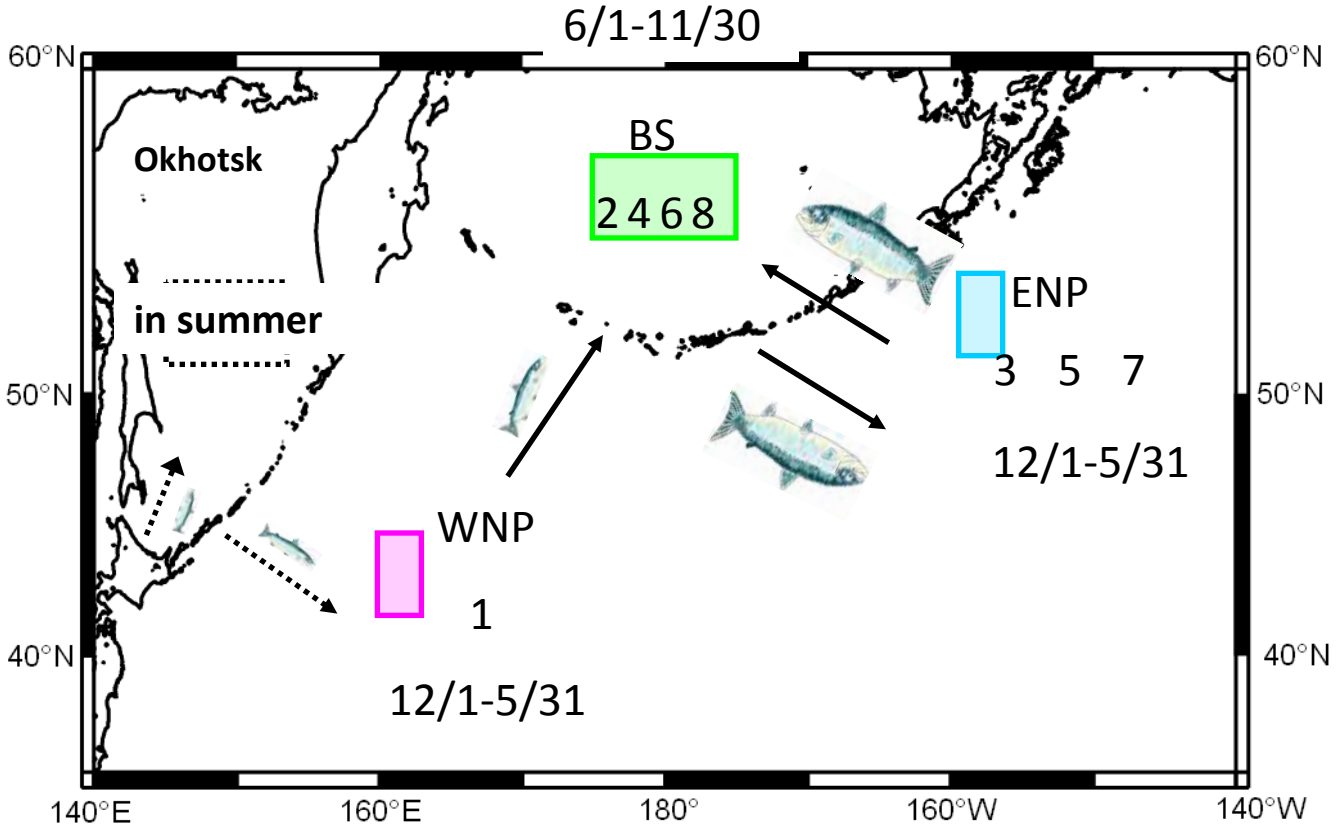
C_{MAX}: maximum consumption rate ($C_{MAX} = ac \cdot W^{bc}$).

ρ: prey density dependence function **(0<ρ< 1).**

$f_c(T)$: temperature dependence function **(0< $f_c(T)$ < 1).**



Kamezawa,Y., T,Azumaya, T.Nagasawa and M. J. Kishi(2007): Bull. Japan. Soc.Fish.Oceanogr., 71,87-96. *North Pacific Anadromous Fish Commission Technical Report No. 7: 95–98*



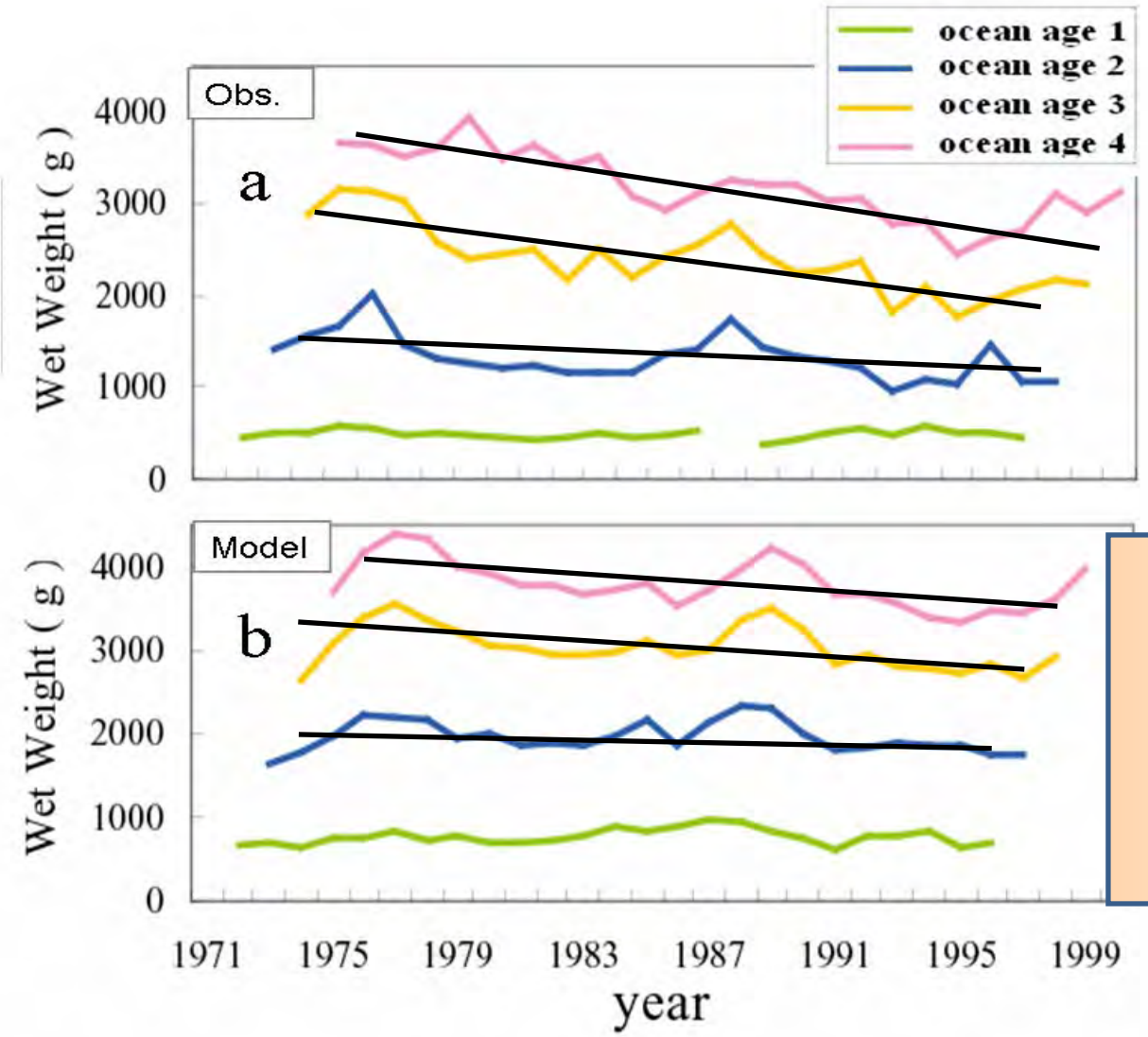
(drawn from Urawa,2000)

In summer : Feeding & Growth , In winter : Wintering.

Result 2/2

Observed

Model



(Time-dependent features of body size in the Bering Sea in summer from 1971 to 1999.)

What will happen by global warming on salmon migration?

“Poikilotherm” No adaptation / dissilency

朝日新聞 2007年(平成19年)4月30日 月曜

サケの回遊 姿消す？

知に挑む 海

実際、サケが回遊し、豊かな生態系をもつオホーツク海で温暖化が進んでいる確かなデータも蓄積されつつある。北大低温科学研究所の研究者たちは、オホーツク海を含む北太平洋の過去50年間の海水温などを分析した。その結果が最近、米国の専門誌に発表された。

魚など海の生物が生きていくのに不可欠な栄養分の源になっている水深300～500㍍ほどの中層部で、オホーツク海の水温が50年間に平均約0・6度上昇していることがわかったという。

この「サケの温暖化シナリオ」を先取りするように、対馬暖流が冲合に回り込む韓国と岩手県で、温暖化の影響とみられる兆候が現れていると帰山教授は指摘する。

韓国へのサケの回帰率は90年代後半から下落傾向。岩手県のサケも放流

1 温暖化シナリオの警鐘

遊楽部川にサケの稚魚の調査に訪れた帰山さん。「サクラマスの方が多いなあ」＝26日午後、八雲町栄町で、川津陽一撮影

地図上に、緯度と経度で1度ごとに区切った黄色の小さなマス目が、日本の近海を北上していく。

黄色はサケが生息できる水温の海域。サケの生態研究に取り組む北海道大学水産科学研究院の帰山雅秀教授が、国連の「気候変動に関する政府間パネル（IPCC）」による地球温暖化のシナリオの一つを当てはめて解析した。

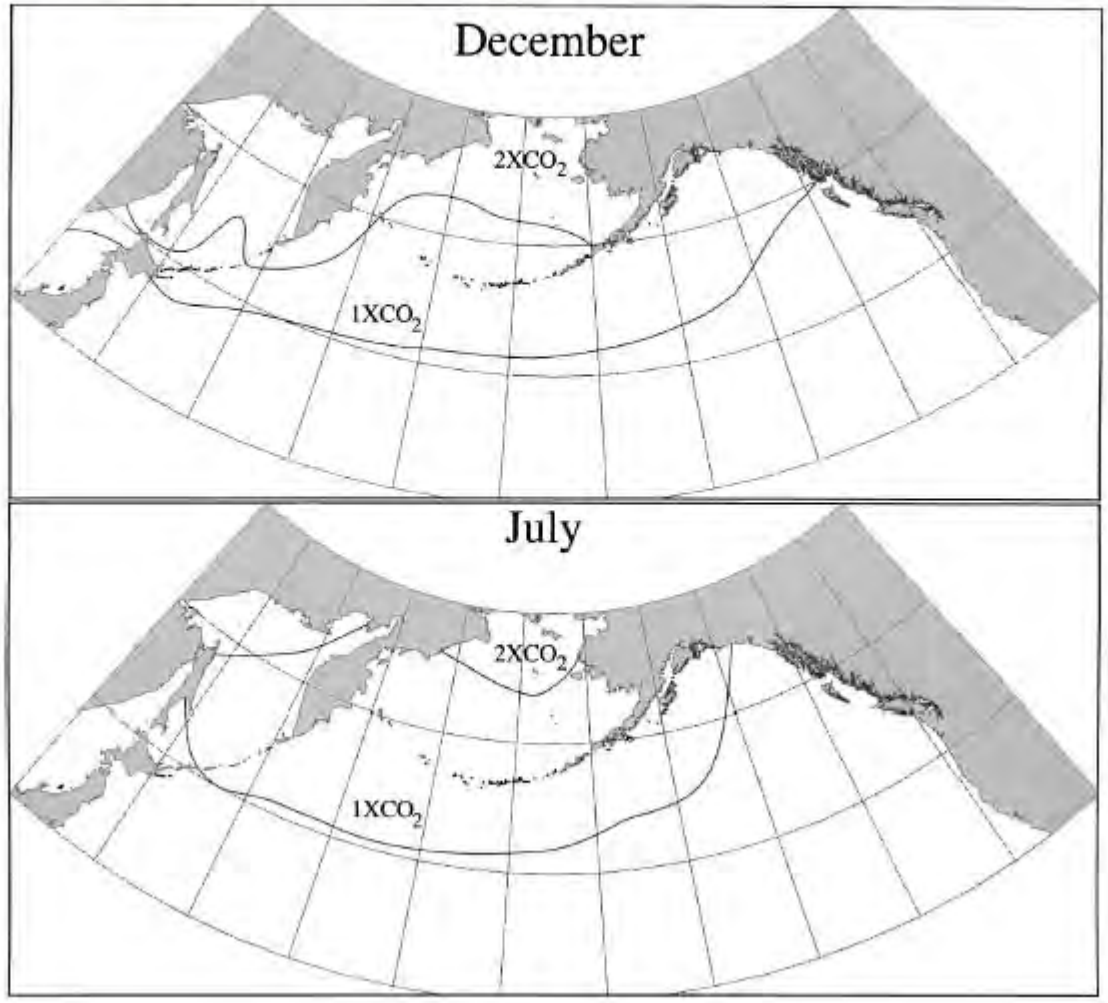
2050年。海水温が平均2度上がるシナリオでは、黄色のマス目は北海道のオホーツク海沿岸を離れ、はるか沖に遠ざかってしまう。

温度に敏感な魚にとって、1度の上昇は大きな事件だ。人間にとっては5～10度の上昇に相当するという。「川を下ったサケの稚魚は水温が高すぎると海に出られなくなる。サケが海に戻る回遊ルートが失われ、次第に川に帰るサケもいなくなるかもしれない」。帰山教授の温暖化の予測だ。

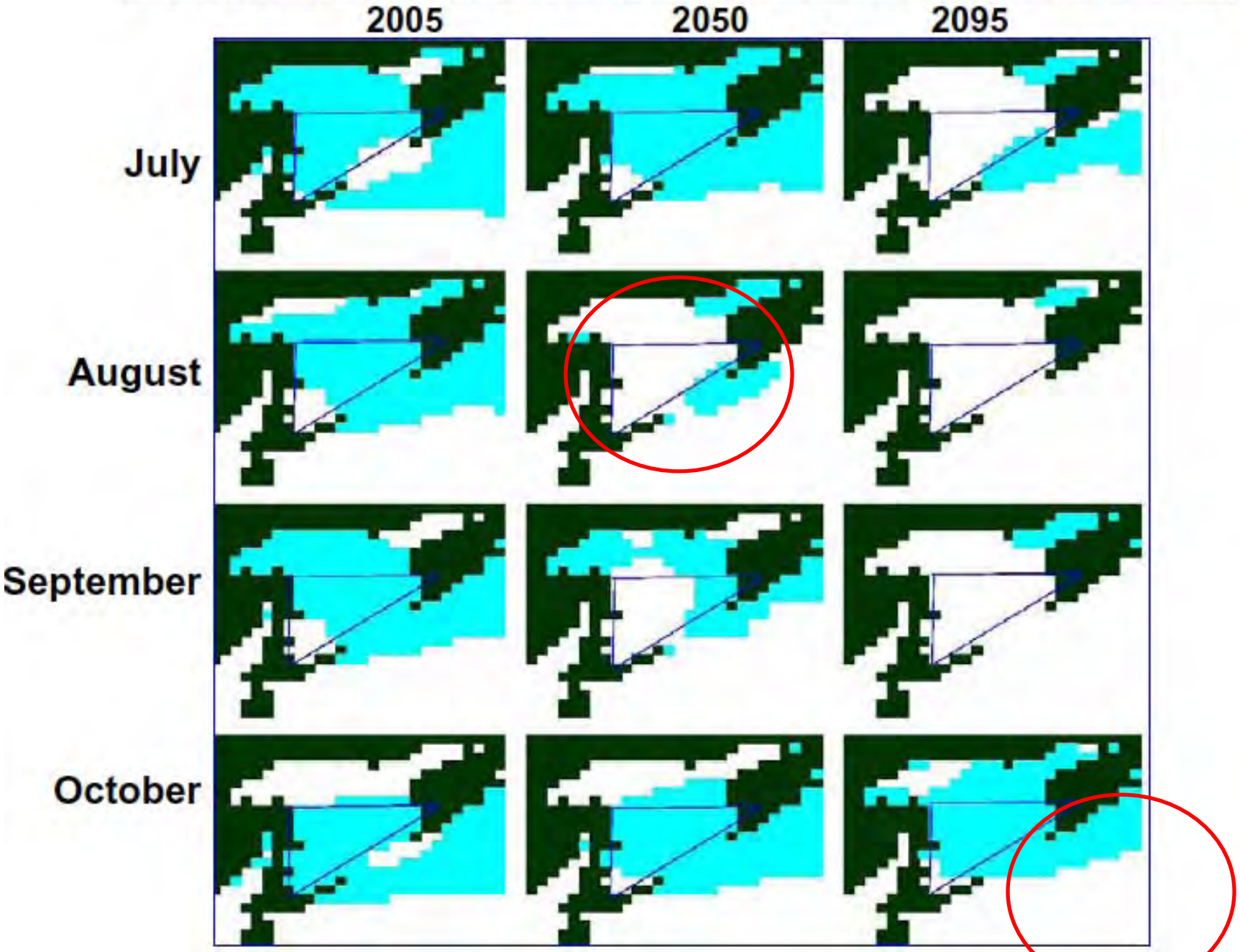
水ぬ

D.W. Welch, Y. Ishida, and K. Nagasawa(1988) Can. J. Fish. Aquat. Sci. 55, 937-948

Fig. 11. Comparison of the predicted winter (7°C) and summer (12°C) positions of the sockeye salmon distribution under current and fu climates (Albers equal area projection). Under a doubling of atmospheric CO_2 the area of acceptable thermal habitat in the North Pacific predicted to decrease to zero in summer and decline sharply in winter. The predictions are based on the Canadian Climate Centre's coup ocean–atmosphere general climate model (Boer et al. 1992; McFarlane et al. 1992).



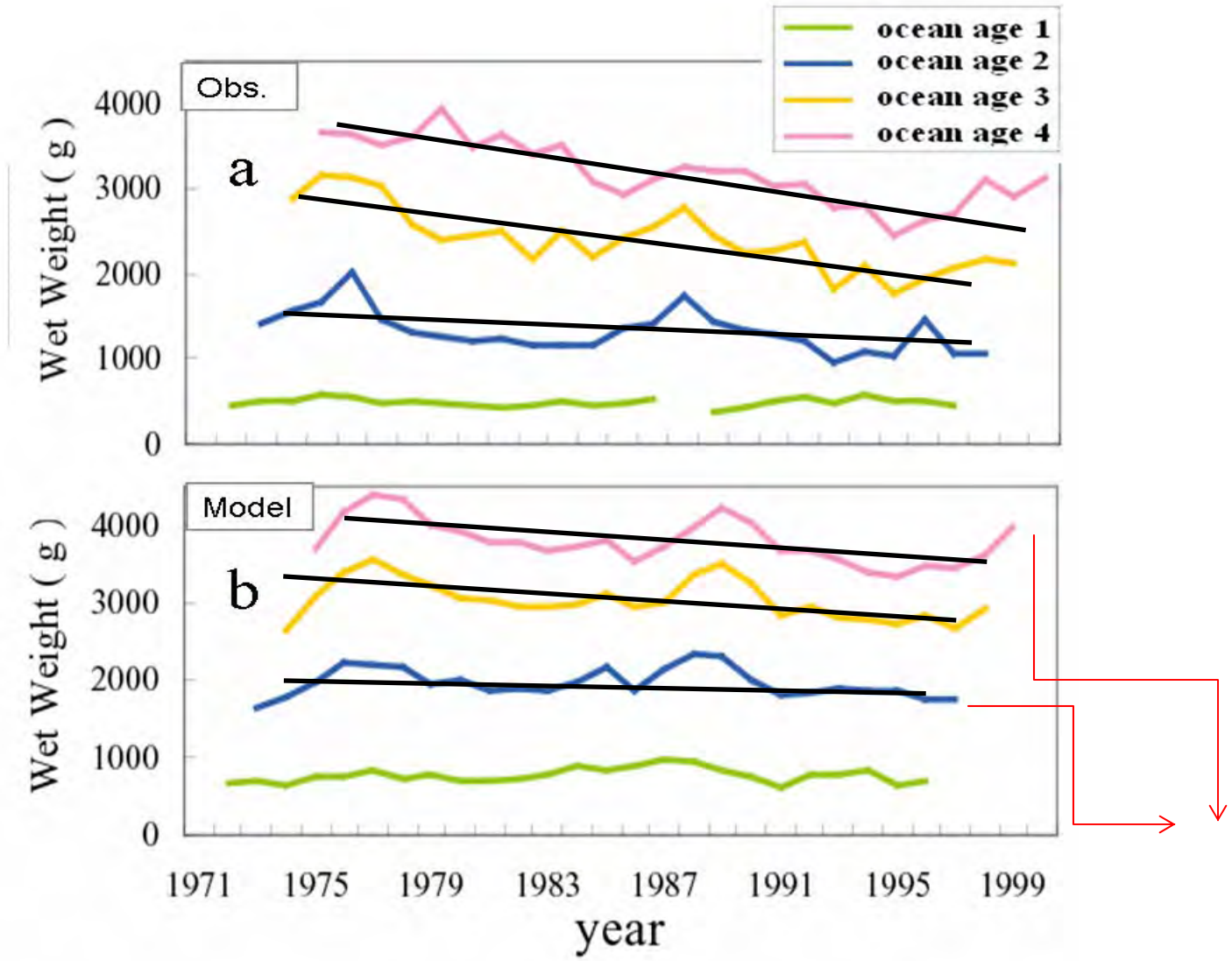
Hokkaido chum salmon in the Okhotsk Sea



Result 2/2

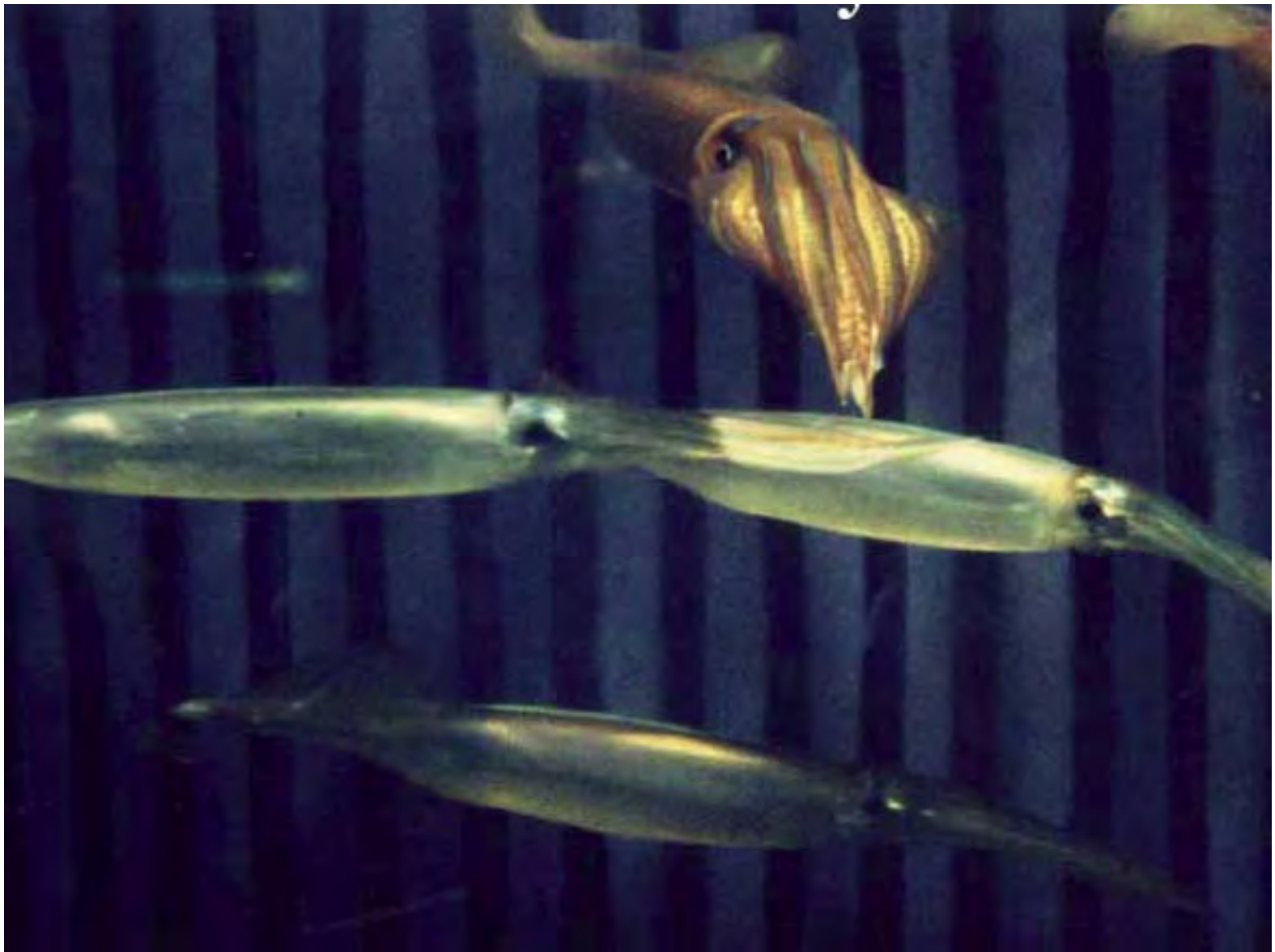
Observed

Model

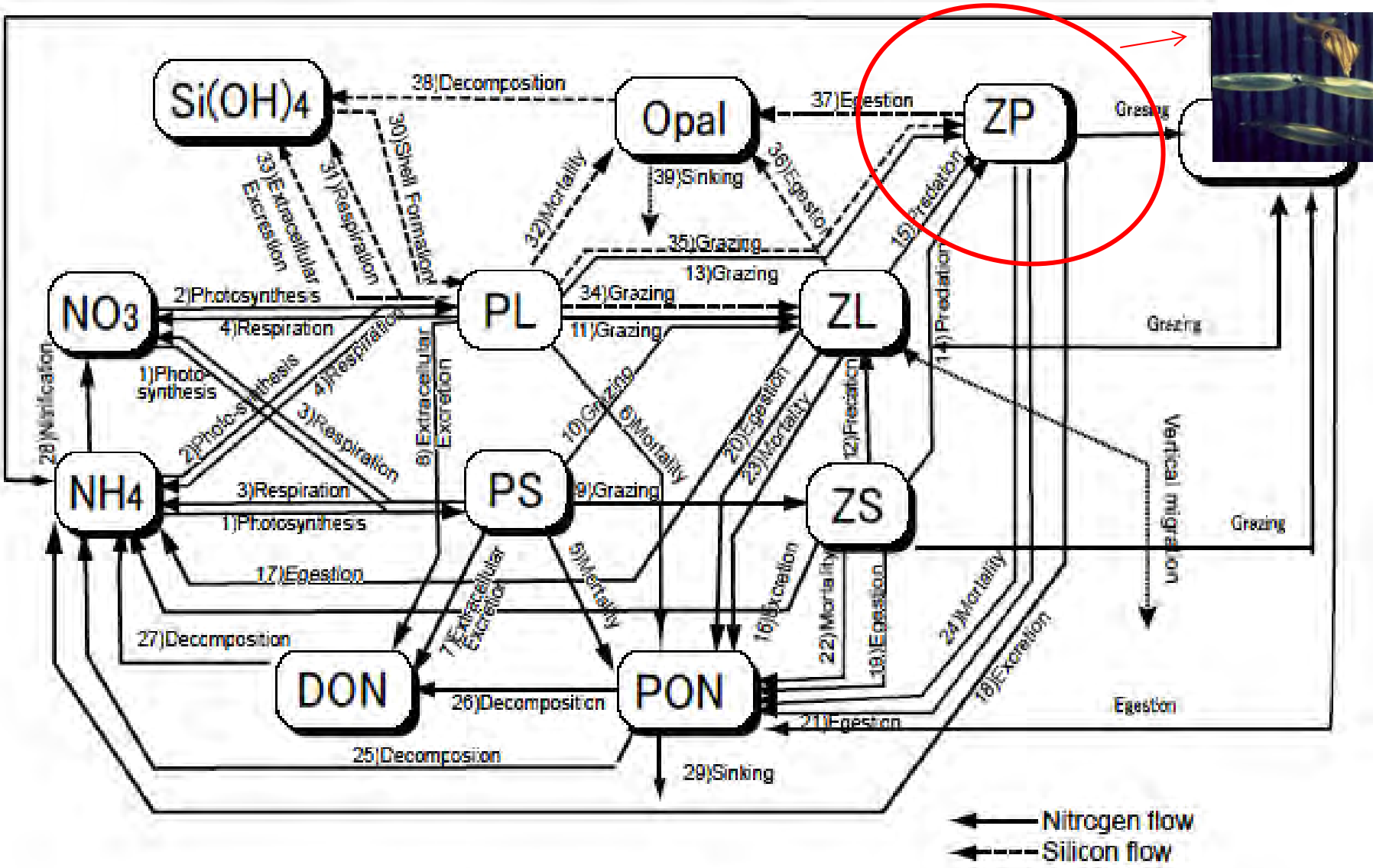


(Time-dependent features of body size in the Bering Sea in summer from 1971 to 1999.)

§ 2. Common squid



NEMURO. FISH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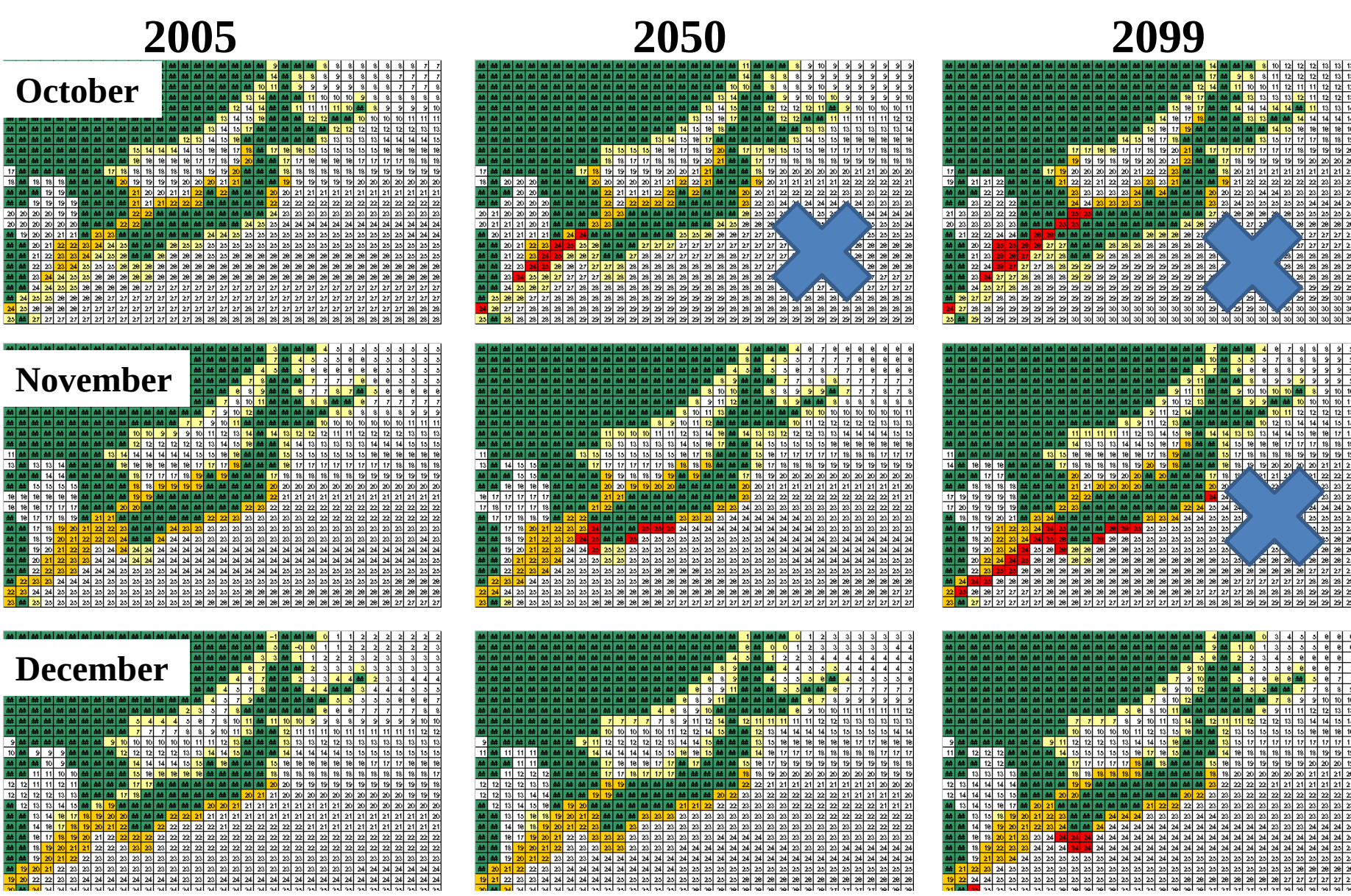
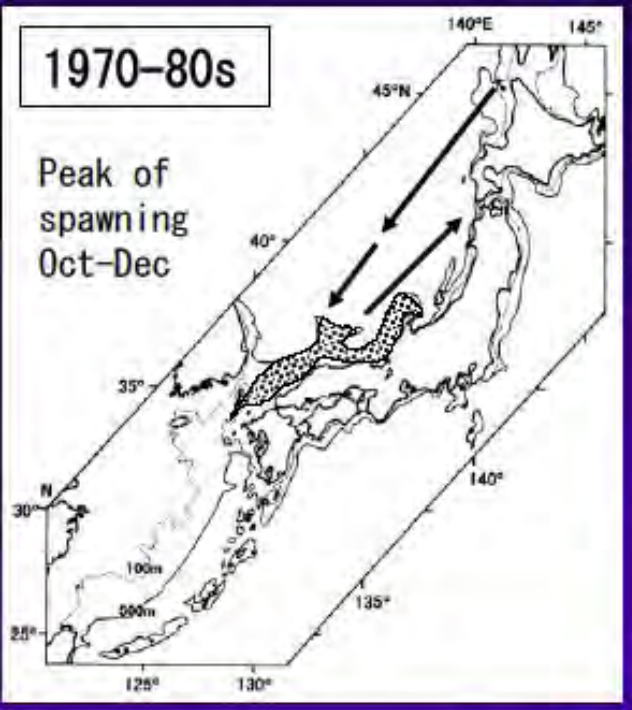
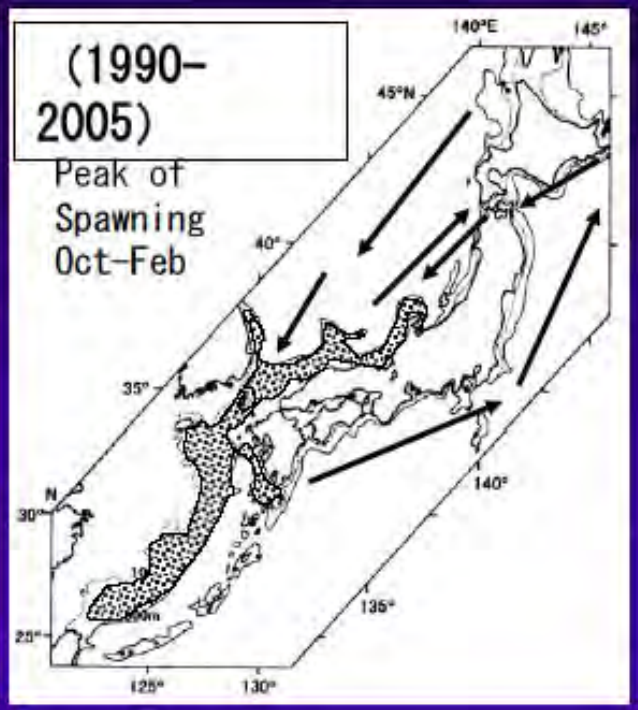
27)Decomposition
26)Decomposition
21)Egestion
Egestion
25)Decomposition
29)Sinking
Nitrogen flow
Silicon flow

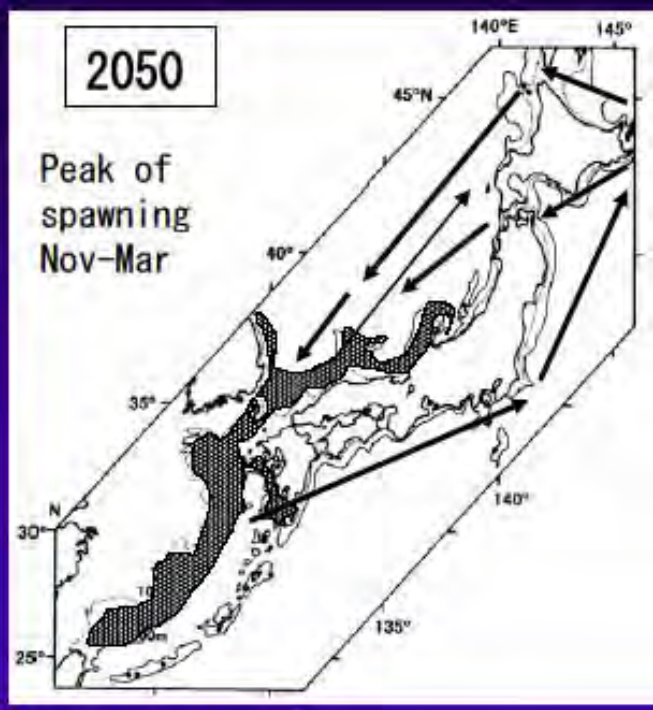
Changes of inferred spawning areas of *Todarodes pacificus* based on the Global Warming Scenario by the Earth Simulation System (FRCGC, Japan)



Green cell: land area, orange cell: inferred spawning area, red cell: disappeared spawning area with global warming







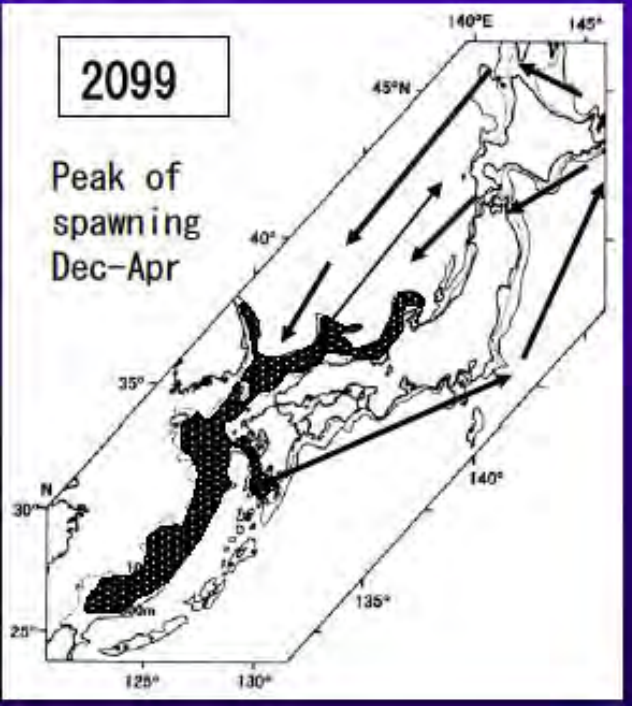
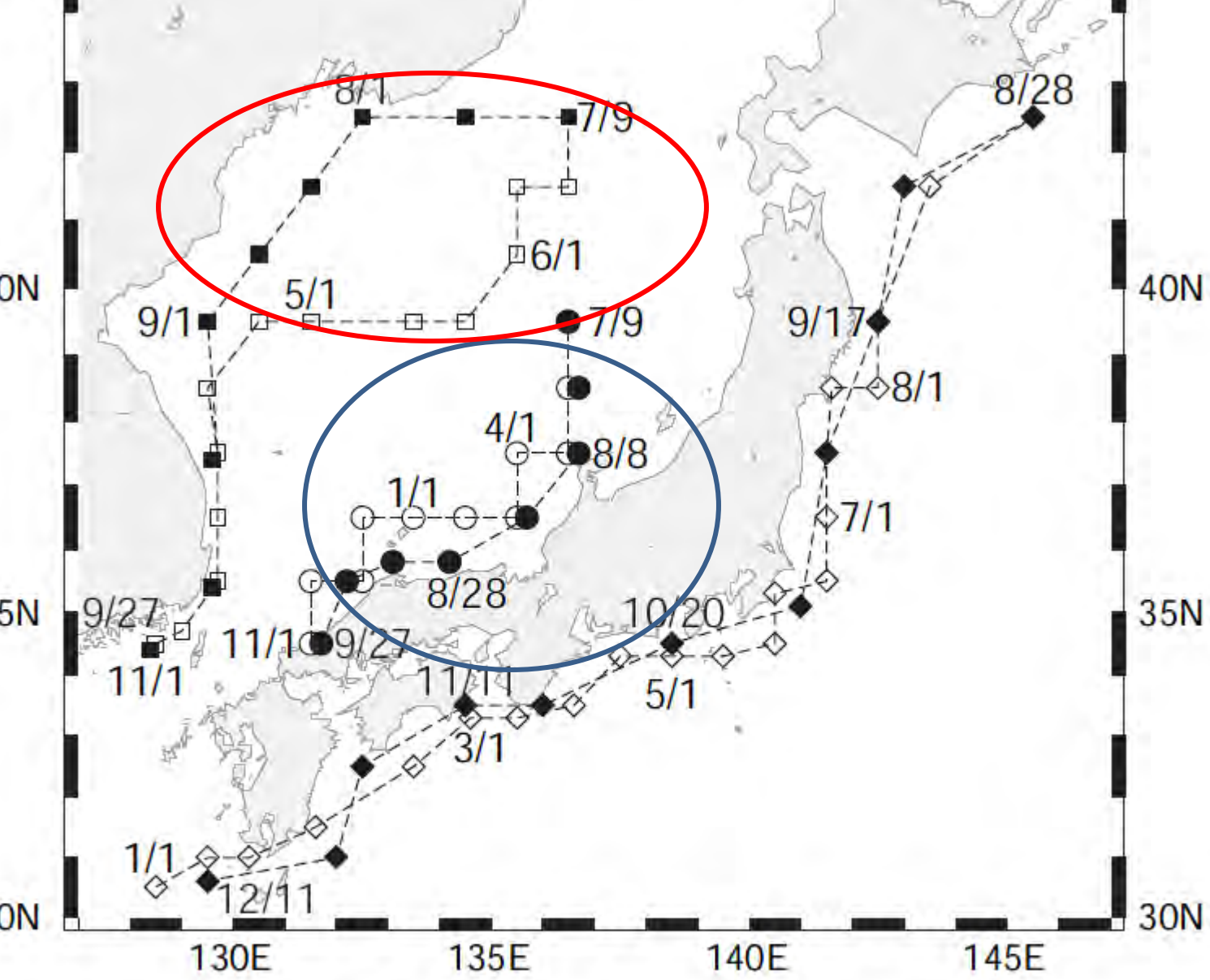


Fig. Predicted spawning periods,areas, and migration routes of *T. pacificus* during 1970-80s(cool regime),1990-2005(warm regime),2050(SST: 2℃ increase), 2099(SST: 4℃ increase). Estimated environmental changes in waters around Japan based on the IPCC global warming scenario (Kawamiya et al., 2007)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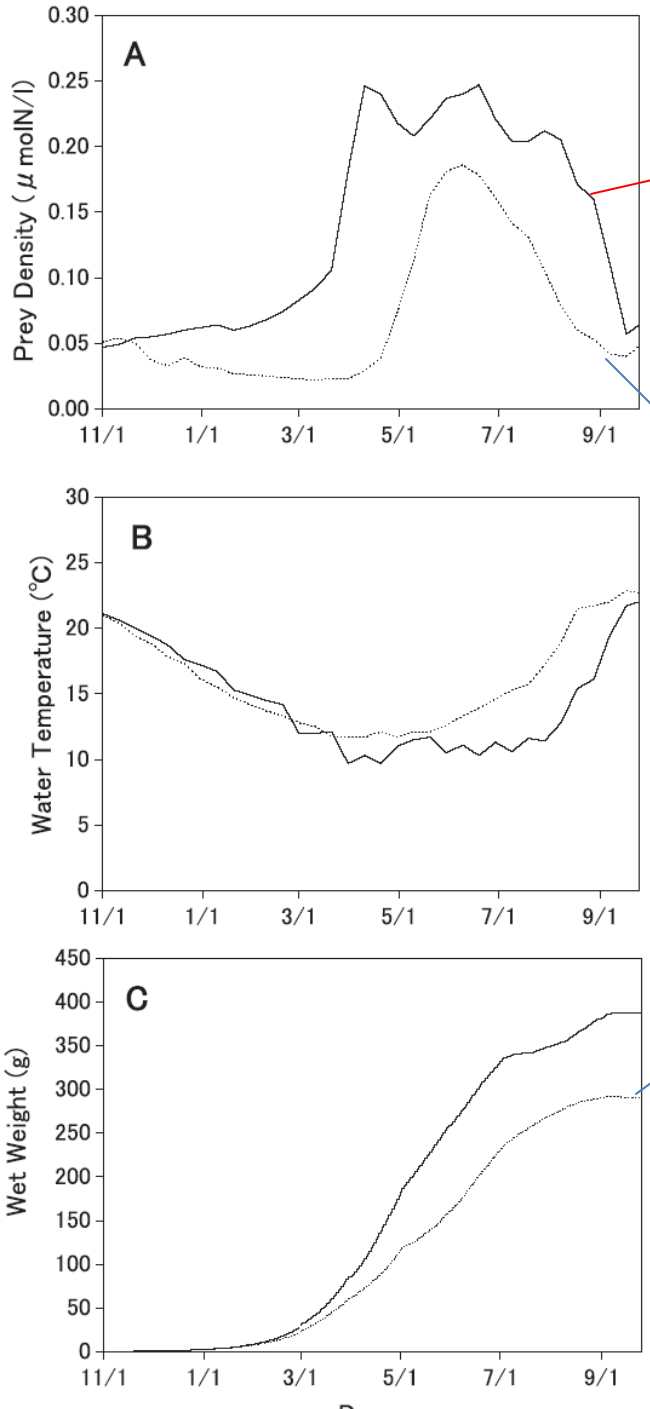
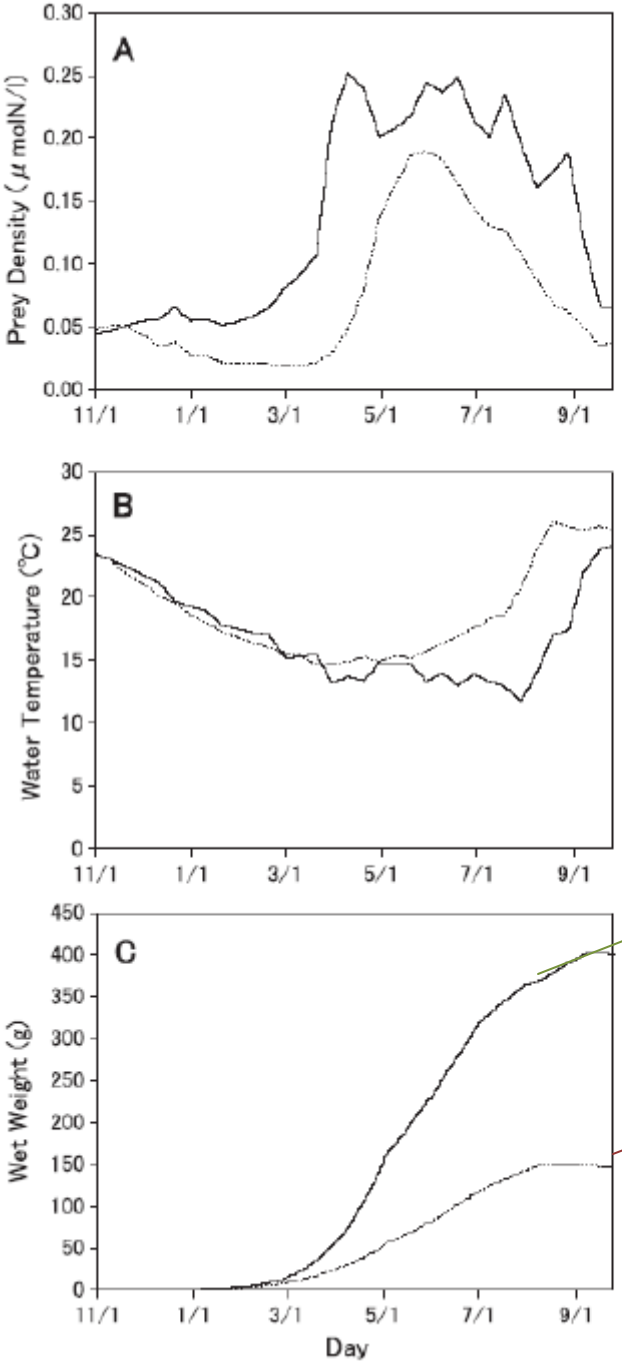


Subarctic Group

Tsushima Grorp

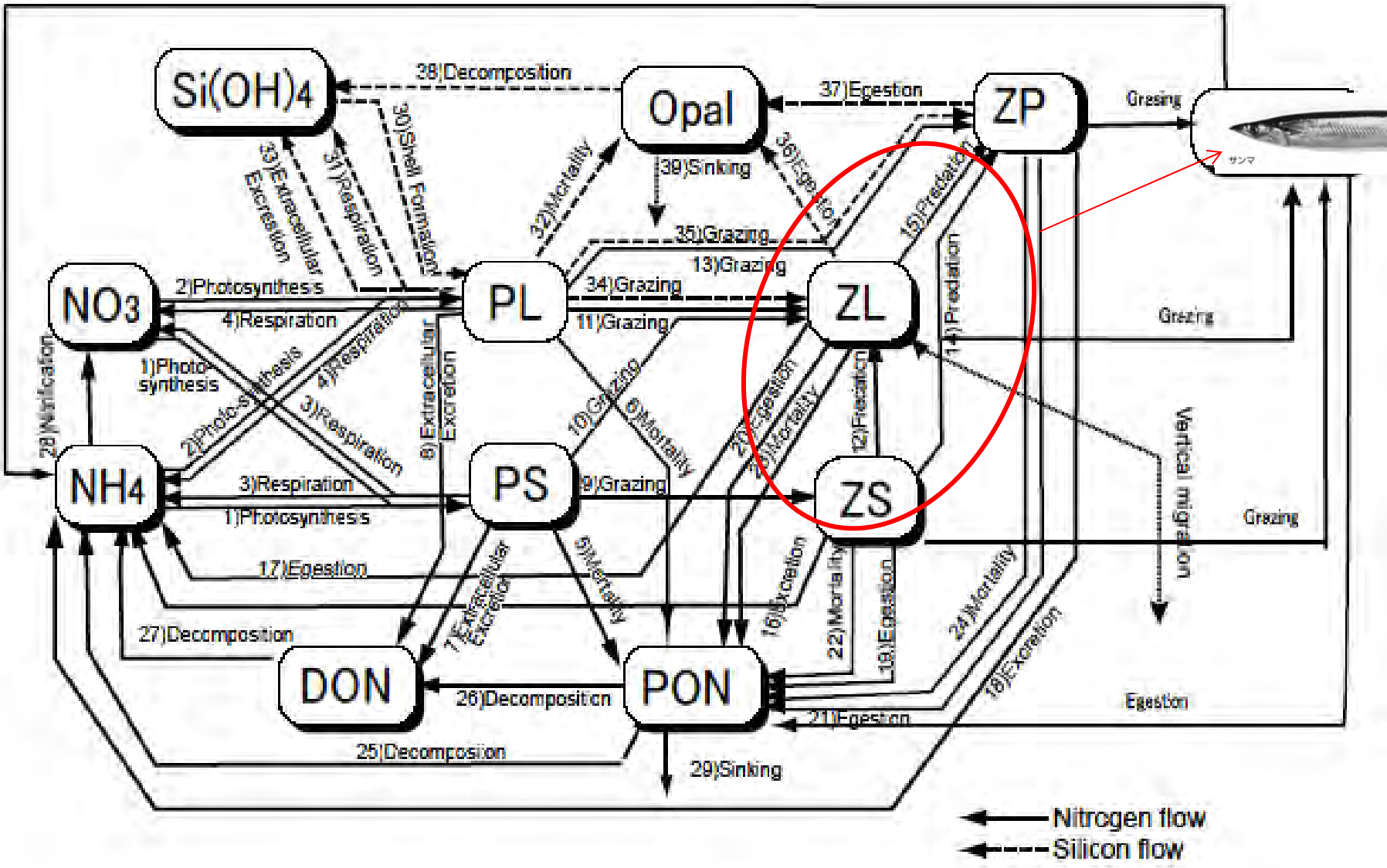
Subarctic Group
In GW



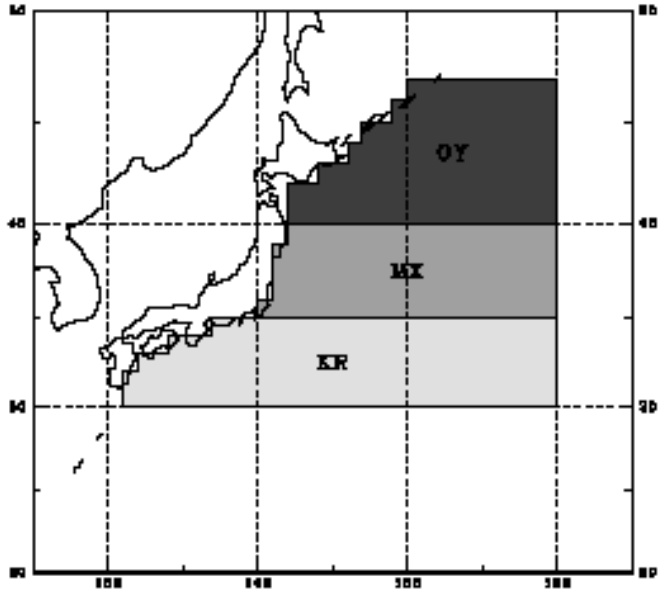
present

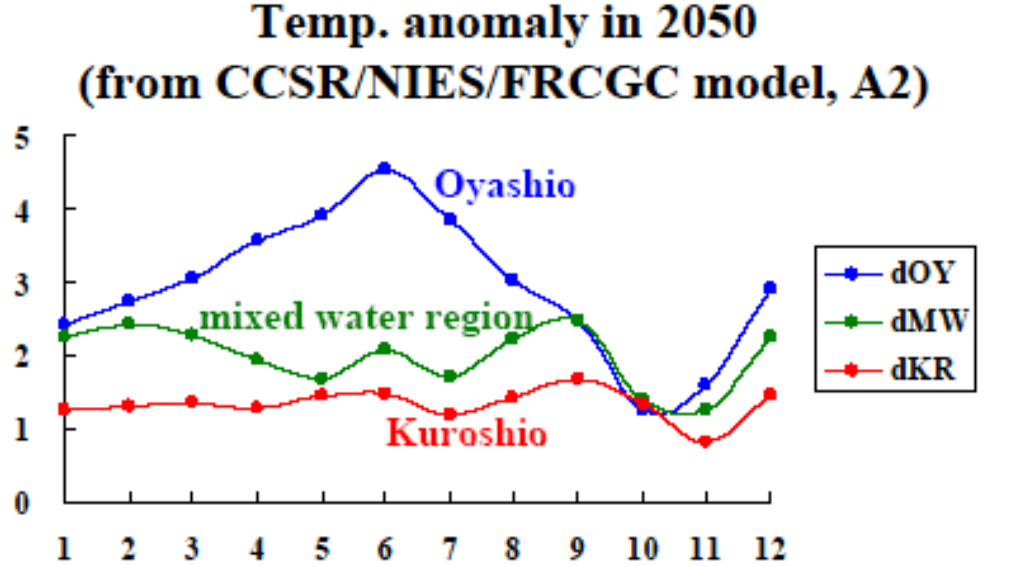
GW

§ 3. Pacific saury



Pacific saury: Global warming experiment



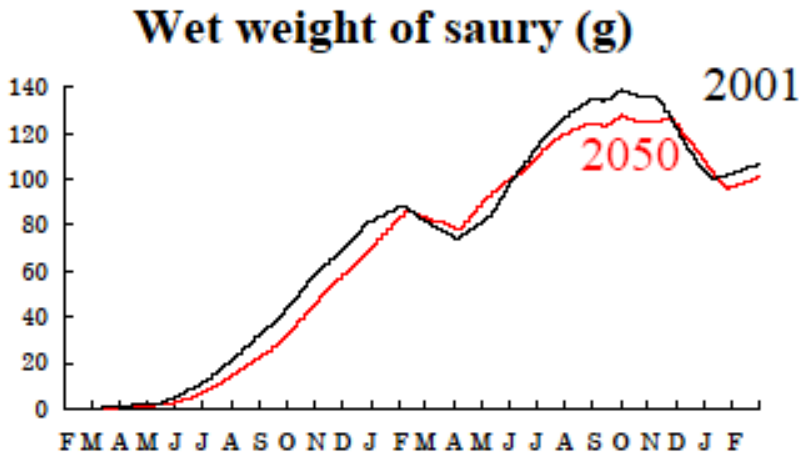


Ito (2007b), Ito et al. 2010)

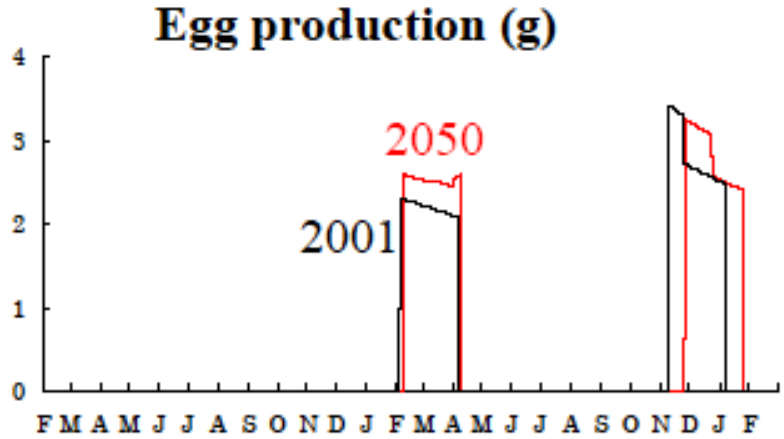
numerical experiment

1. **Averaged SST anomaly in three ocean domains.**
2. **Estimate future SST field by adding SST anomaly with current SST.**
3. **Integrate NEMURO.FISH with future SST.**

Pacific saury: Global warming experiment



Under global warming, the wet weight of adult saury was reduced about 10 g because of the decrease of prey zooplankton.



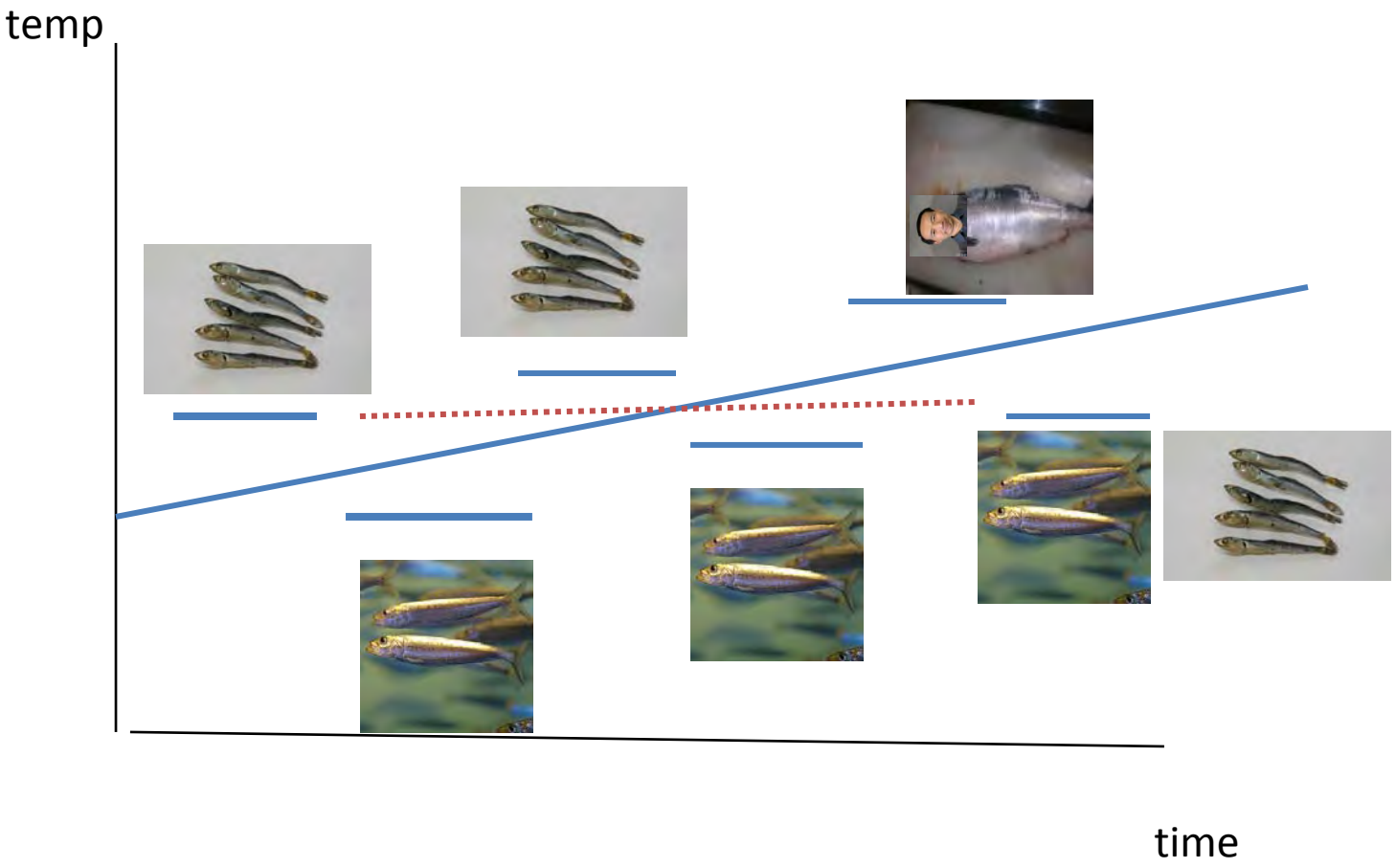
However, the egg production was enhanced by global warming.

Ito (2007b), Ito et al. (2010)

We cannot predict future only based on the present / past experiments and observations.

Can we predict the change of behavior? They may sink/ move vertically. They may change spawning season/area. The may change food.

We can predict what will disappear but cannot predict what will appear.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