Future of Kuroshio/Oyashio ecosystems: an outcome of the CFAME Task Team and WG20

FRA
Fisheries Research Agency

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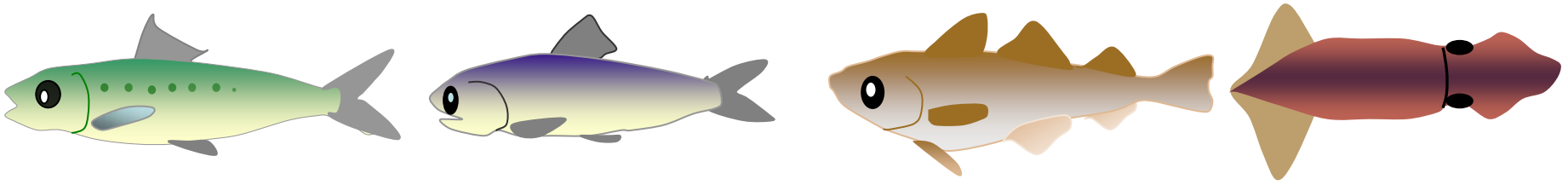
Outline

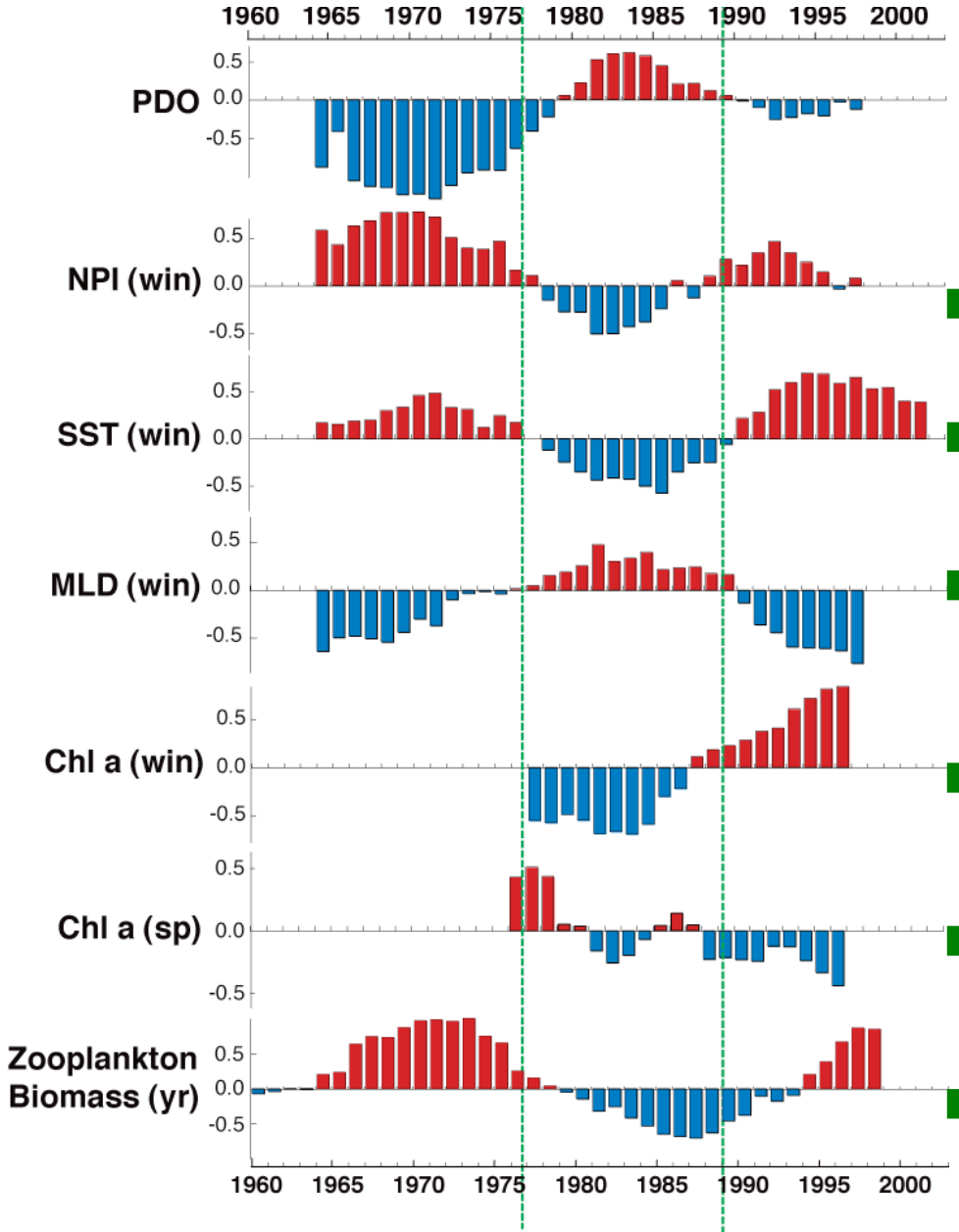
Mechanisms of population dynamics 3 fishes and a common squid as a predator of juveniles of the 3 fishes were hypothesized from data during past 4 ducades (e.g., Yatsu et al. 2008 PiO), including physics, nutrients, lower ecosystem, biology.

Outlook of future physical conditions of Kuroshio and Oyashio (WG20)

Outlook of future of the ecosystems

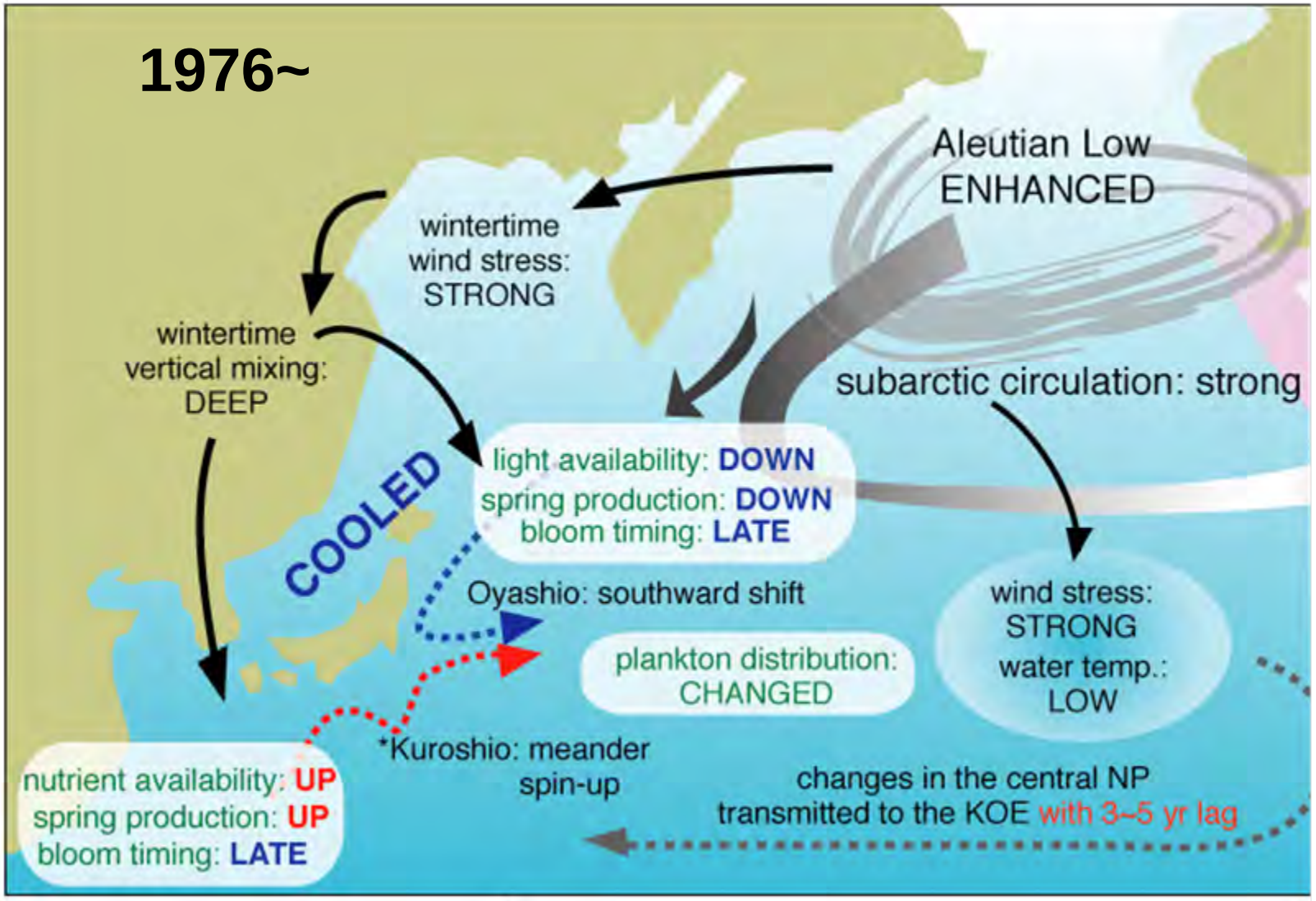


Anomaly of the climatic, hydrographic and lower trophic indices in the Oyashio during 1960-2000 (10 yr smoothed)

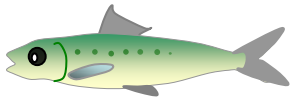


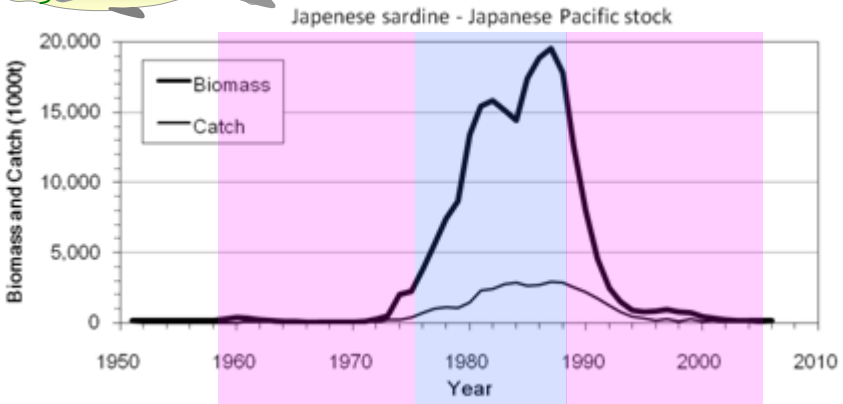
	1976-1880s	1990s
Wind	**Strong**	**Weak**
Temp	**Cool**	**Warm**
Mixing (Light (Nutrient	**Deep** Low ?	**Shallow** High) Low)
Winter PP	**Low**	**High**
Spring (and yr) PP	**Low**	**Lower**
ZP	**Low**	**High**

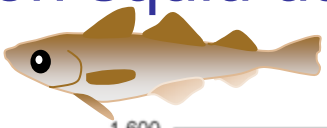
Hydrographic and lower trophic level responses to the 1976 regime shifts: “Cool Period”

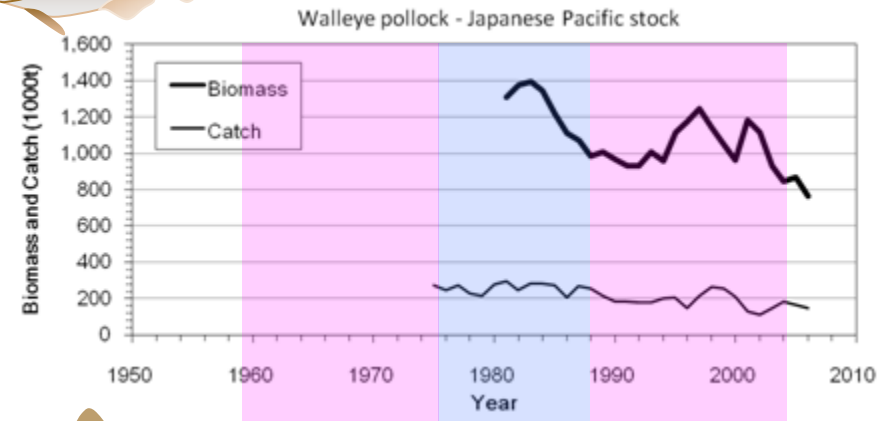


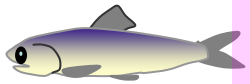
Biomass and Japanese catch of Pacific stocks of Japanese sardine, anchovy, walleye pollock and winter cohort of common squid during 1950s-2000s

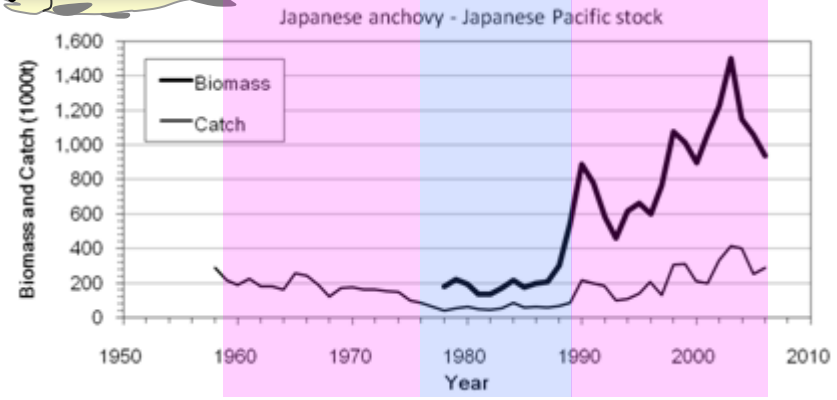


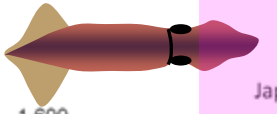


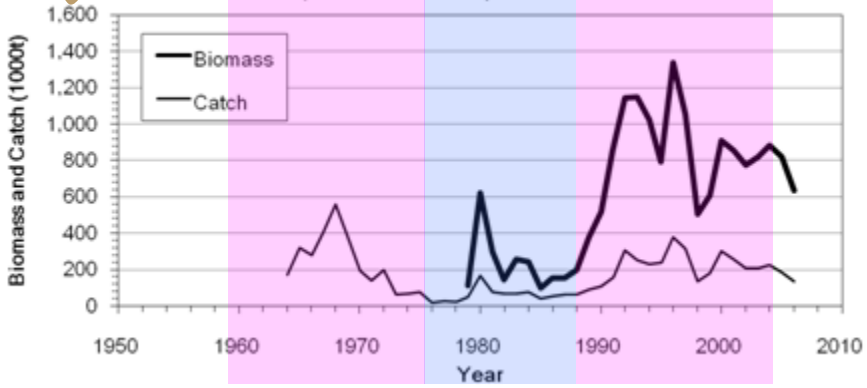


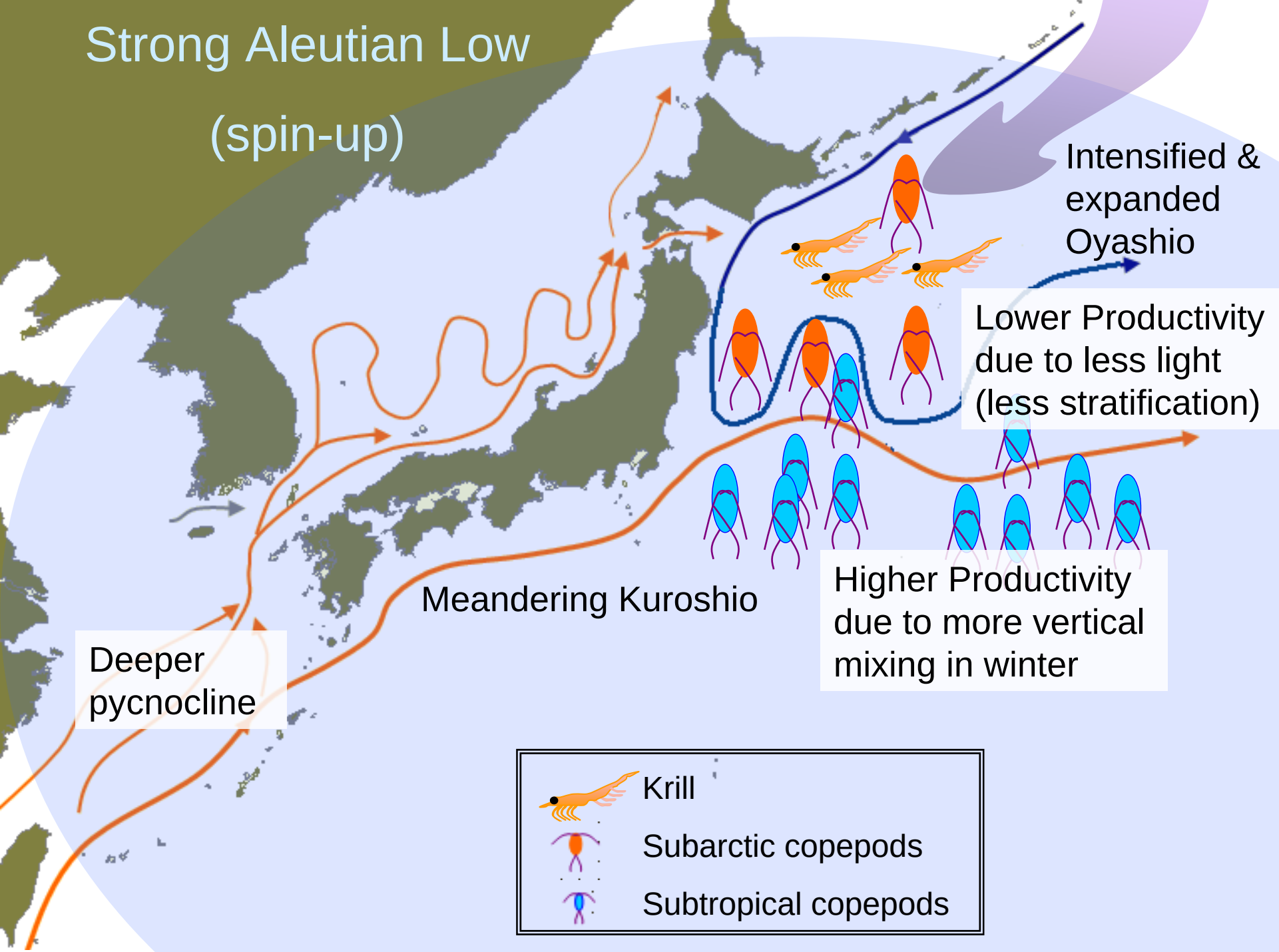


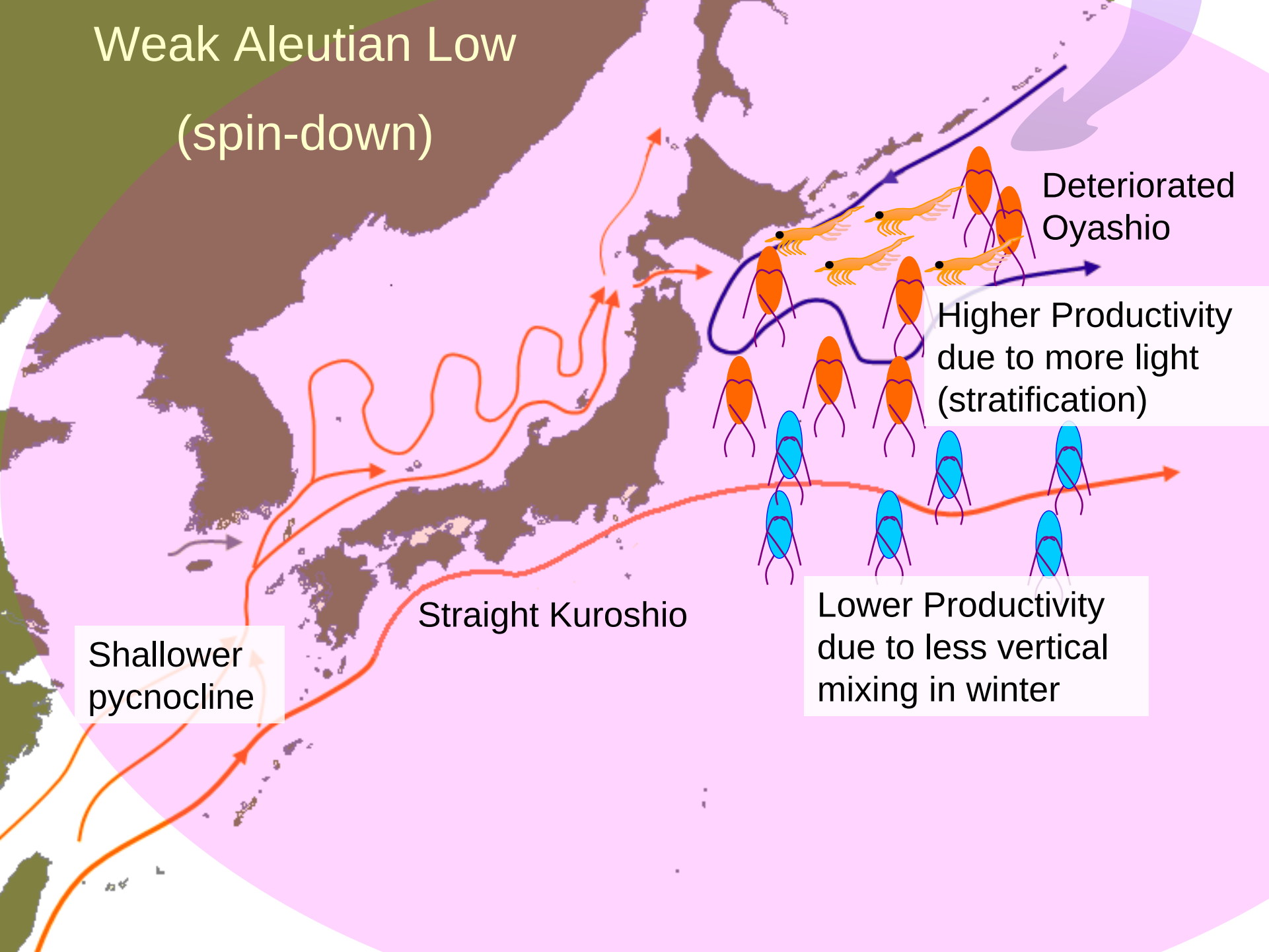




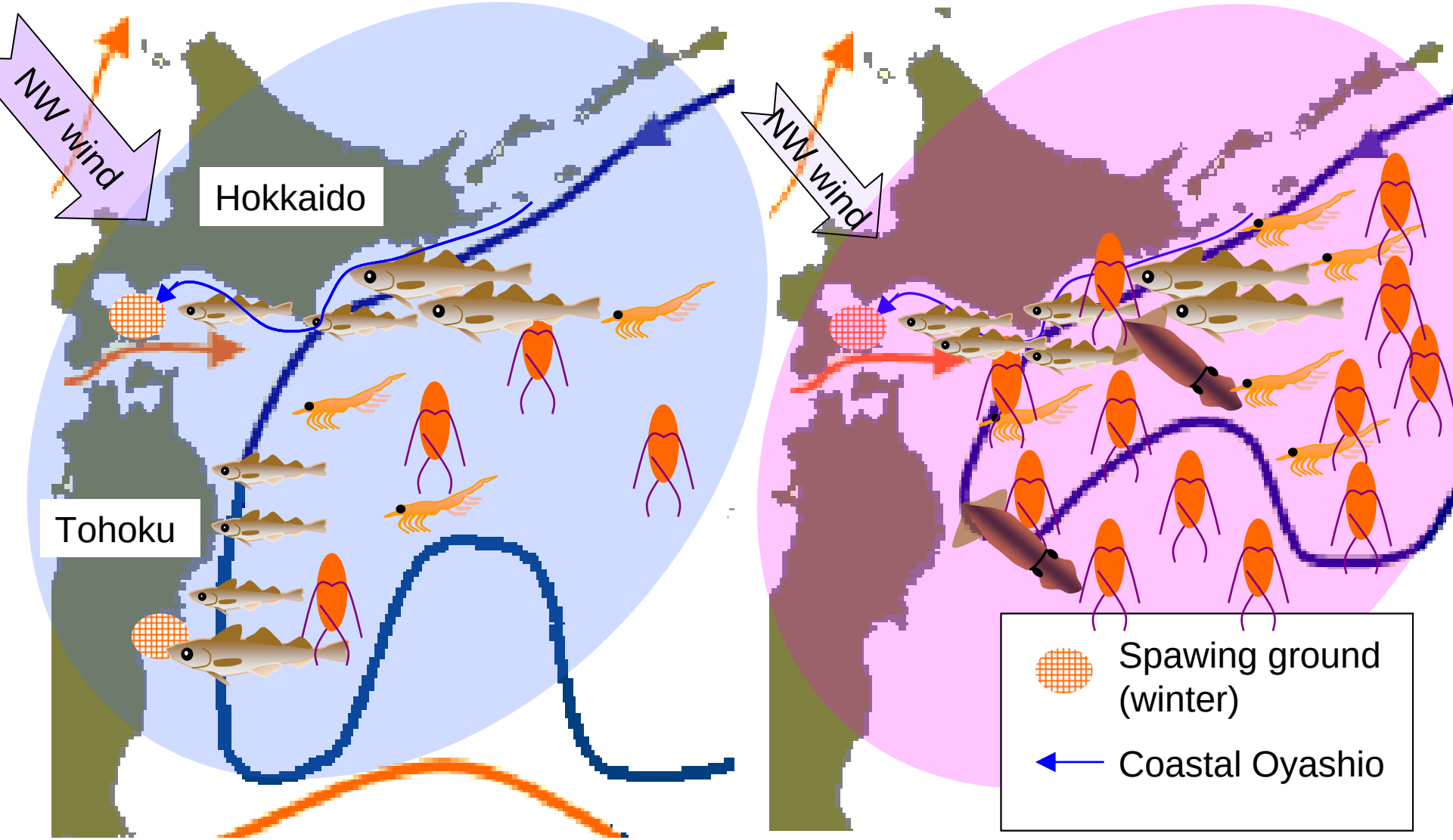




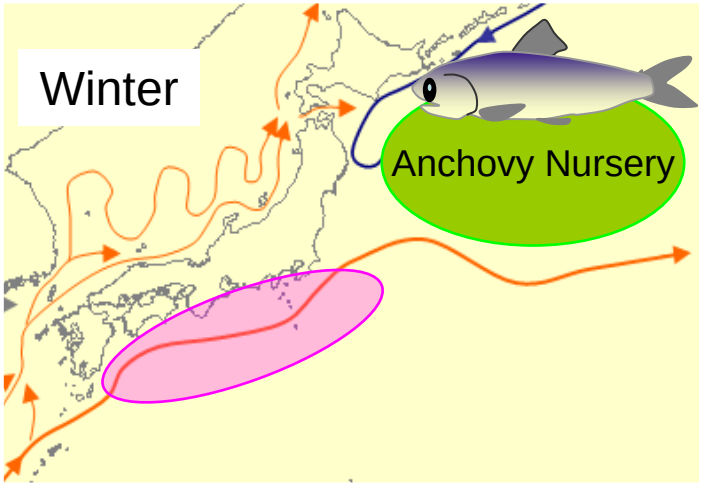

Strong Aleutian Low
(spin-up)
Intensified & expanded Oyashio
Lower Productivity due to less light (less stratification)
Higher Productivity due to more vertical mixing in winter
Meandering Kuroshio
Deeper pycnocline
Krill
Subarctic copepods
Subtropical copepods

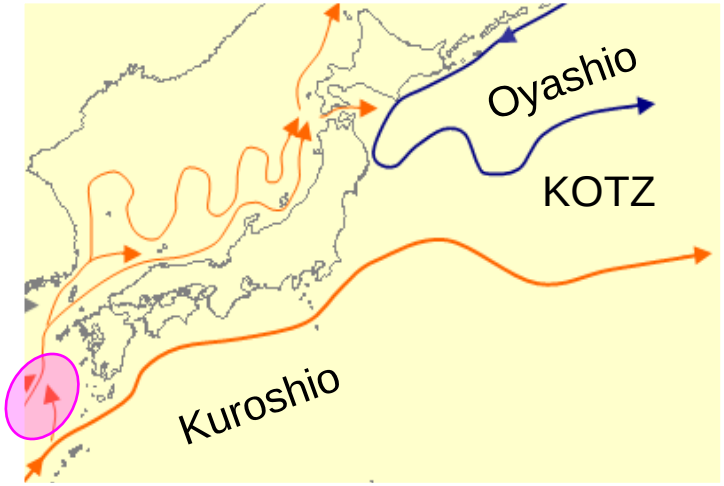

Weak Aleutian Low
(spin-down)
Deteriorated
Oyashio
Higher Productivity
due to more light
(stratification)
Straight Kuroshio
Shallower
pycnocline
Lower Productivity
due to less vertical
mixing in winter

Conceptual recruitment model of walleye pollock (Japanese Pacific Stock) (Shida et al., 2007, etc.)



Migration and interactions of Japanese sardine, anchovy and common squid



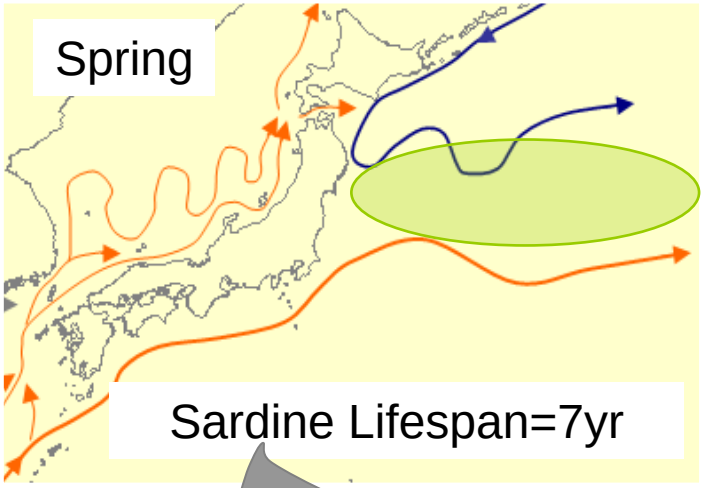


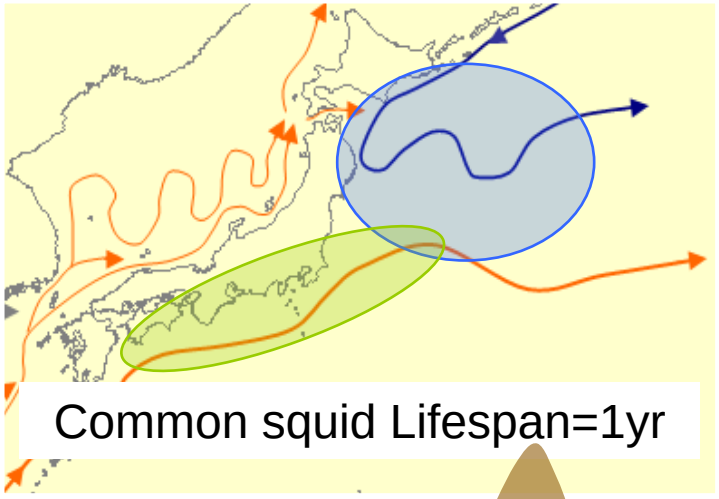
Legends

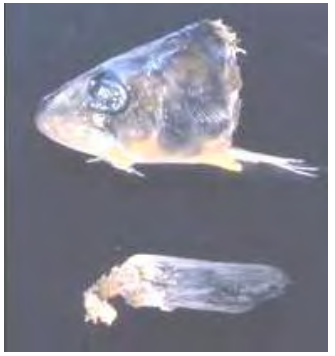
Spawning

Nursery

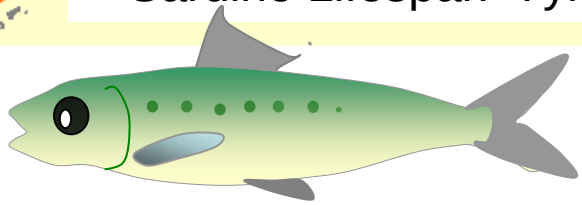
Feeding

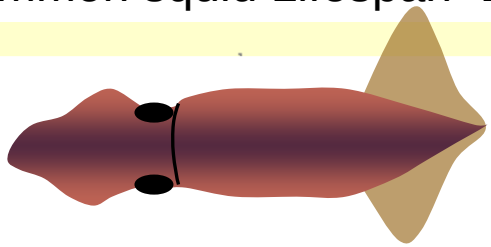




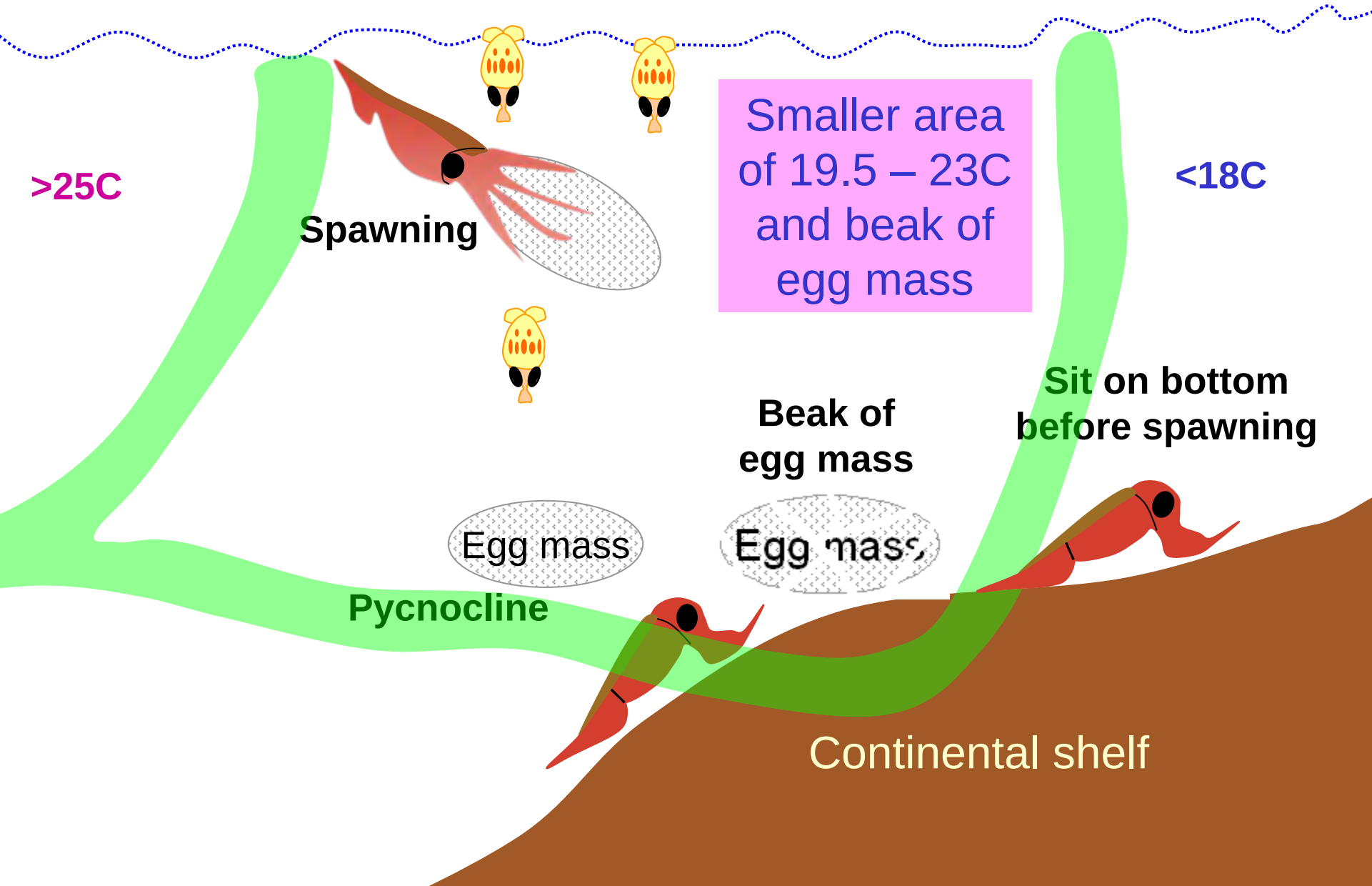


Discarded head and fin of sardine by common squid



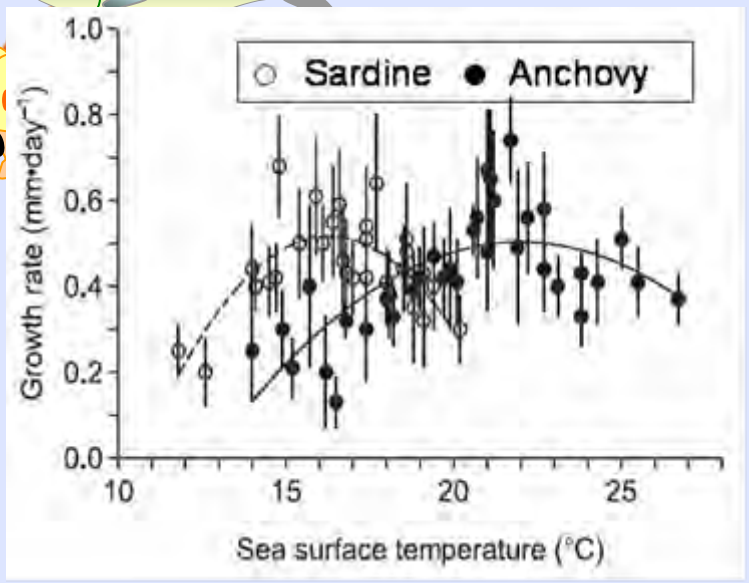


Conceptual reproductive model of common squid in East China Sea – cool years (Sakurai, in prep)



Strong Aleutian Low

(spin-up)

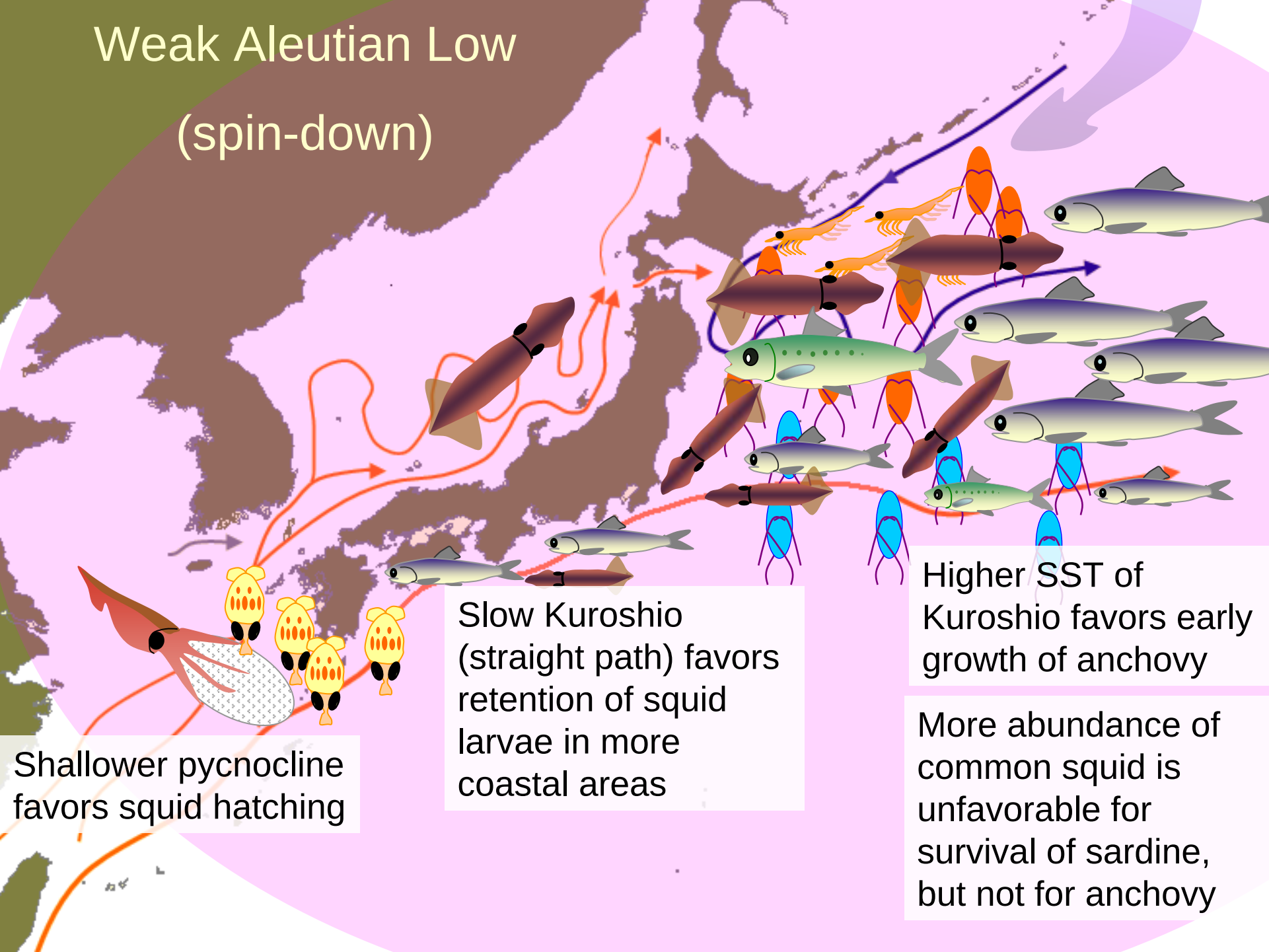


Deeper pycnocline unfavorable for squid hatching

Lower SST of Kuroshio favors early growth of sardine

(Takasuka et al.2007)

Less abundance of common squid favors survival of sardine


Weak Aleutian Low
(spin-down)
Shallower pycnocline favors squid hatching
Slow Kuroshio (straight path) favors retention of squid larvae in more coastal areas
Higher SST of Kuroshio favors early growth of anchovy
More abundance of common squid is unfavorable for survival of sardine, but not for anchovy

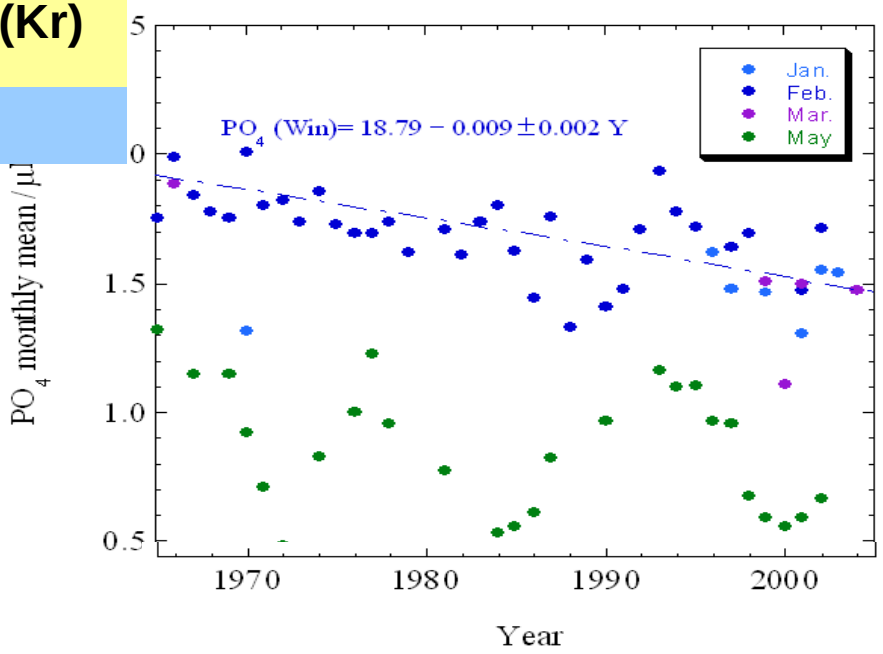
SCENARIOS and IPCC-AR4 descriptions for Kuroshio and Oyashio

- PDO is likely to continue to exist during 21st century. However, the change in the mean background SST field under anthropogenic influences will surpass the magnitude of natural PDO variability.
- Kuroshio and Oyashio is likely to be intensified (spin-up) according to MIROC (Model for Interdisciplinary Research on Climate).
- Caveat: MIROC is the only high resolution (20km) model that can be applied to Kroshio and Oyashio, but it has several problems (e.g. the global SST increase is the highest among the IPCC-AR4 models)

Possible effects of global warming on productivity in Kuroshio(Kr) and Oyashio (Oy)

Productivity of area/species	Temperature rise	Spin-up of currents
Oyahsio	+	+ (Areal expansion)
Kuroshio	-	+
Pollock	+(Hokkaido)	+ (Tohoku), - (Hokkaido)
Sardine	+ (Oy), - (Kr)	+ (Oy), ? (Kr)
Squid	+?	-

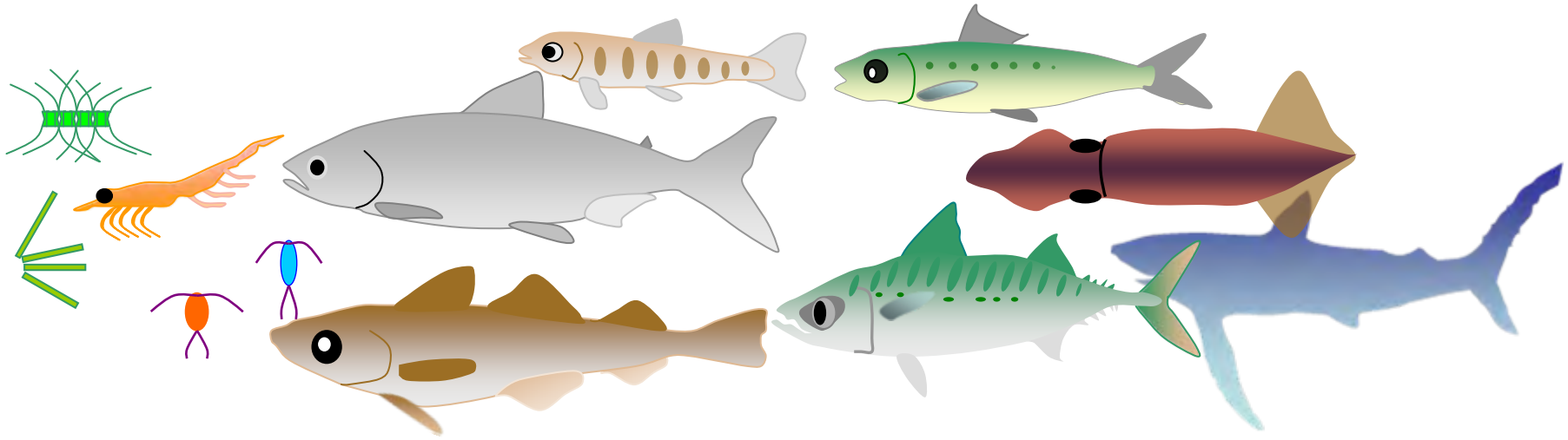
- Productivity of Oyashio will decrease due to freshening
- More temperature rise will delay the spawning period of squid, and subsequently may cause a temporal mismatch with blooming



Phosphate concentration in Oyashio (Ono et al. 2002)

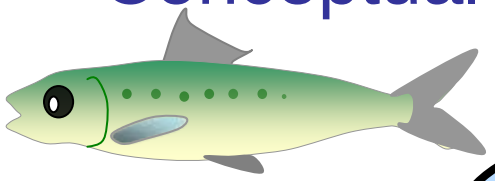
Problems in Predicting Changes

- Each species will react differently, according to the ability of tolerance and adaptation in terms of distribution, life-history and productivity.
- Such different responses of each species will increase uncertainties, through ecological interactions that have never been observed before.
- Therefore, predictions of resiliency of species and ecosystems with “newcomers” is difficult.



Conceptual Model Diagram for Japanese Sardine

(Japanese Pacific Stock, Yatsu 2004)



Positive SOI, etc.

Aleutian Low Intensification

Winter MLD Deepening in Kuroshio, Expansion of Oyashio area

Lower SST of Kuroshio and Oyashio

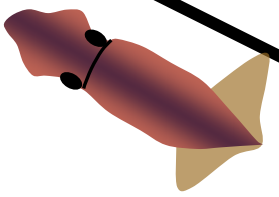
Less Arrival of Subtropical Predators (Common Squid, etc.)

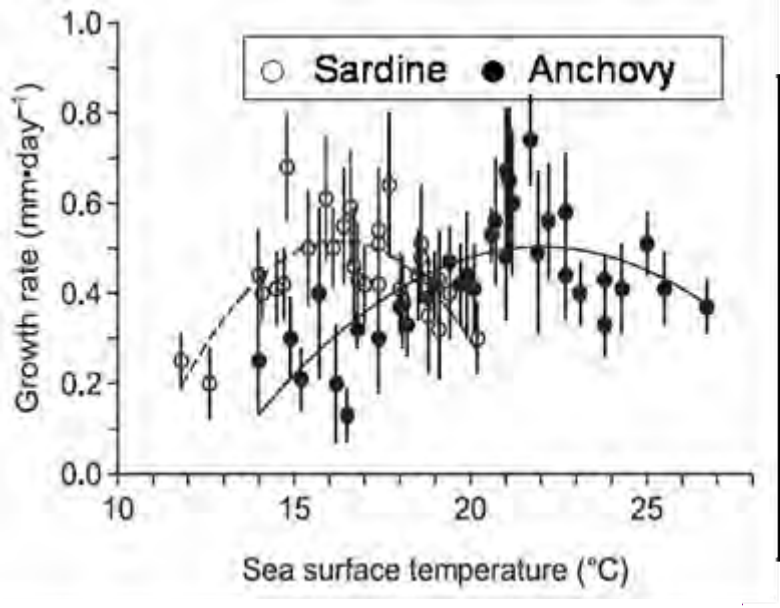
Improved Early Growth

Improved Early Surv

Accumulation of Bio

Alternate to Ancho

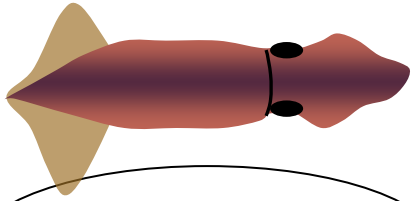




Optimum temperature for early growth of sardine and anchovy (Takasuka et al., 2007)

Conceptual Model Diagram for Common Squid

(Winter cohort)



Negative SOI

Aleutian Low Weakening

Reduced NW Wind in Winter

Higher SST of Tsushima Current, incl. East China Sea

Shallower Pycnocline in East China Sea

Slower Kuroshio Current

Expanded Spawning Area

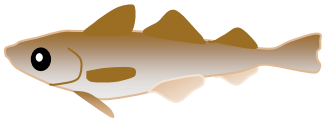
More Retention of Larvae in Kuroshio Extension

Improved Early Survival

Accumulation of Biomass

Conceptual Model Diagram for Walleye Pollock

(Pacific stock)



Other Factors

PDO/Victoria or else ?

Intensified NW Wind

Predator abundance and Mismatch Match

Higher SST of Southern Hokkaido

Strong Oyashio, & Coastal Flow

More Larval Transport to Funka Bay & Tohoku Area

Improved Early Survival

Improved Primary Production and Match with Copepods and Krill

Accumulation of Biomass

Deterioration of Early Survival through Predation, incl. Cannibalism