Formation of offshore ecological hotspots and its fluctuation in the western North Pacific

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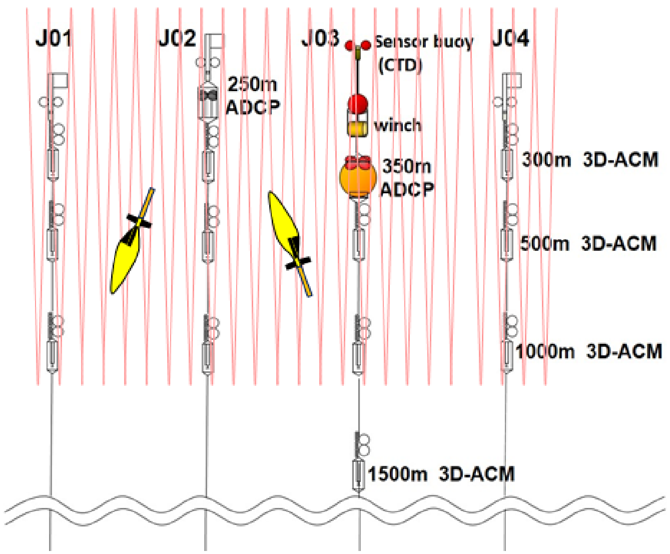
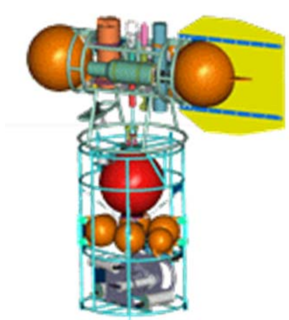
1. Characteristics of western North Pacific
2. Isoguchi Jet and Transition Region Mode Water
3. ecological hotspot
4. decadal oscillation of Isoguchi Jet
5. Future perspectives



Hot spot in climate system



http://ocean.nichigi.com/products/products_002.html

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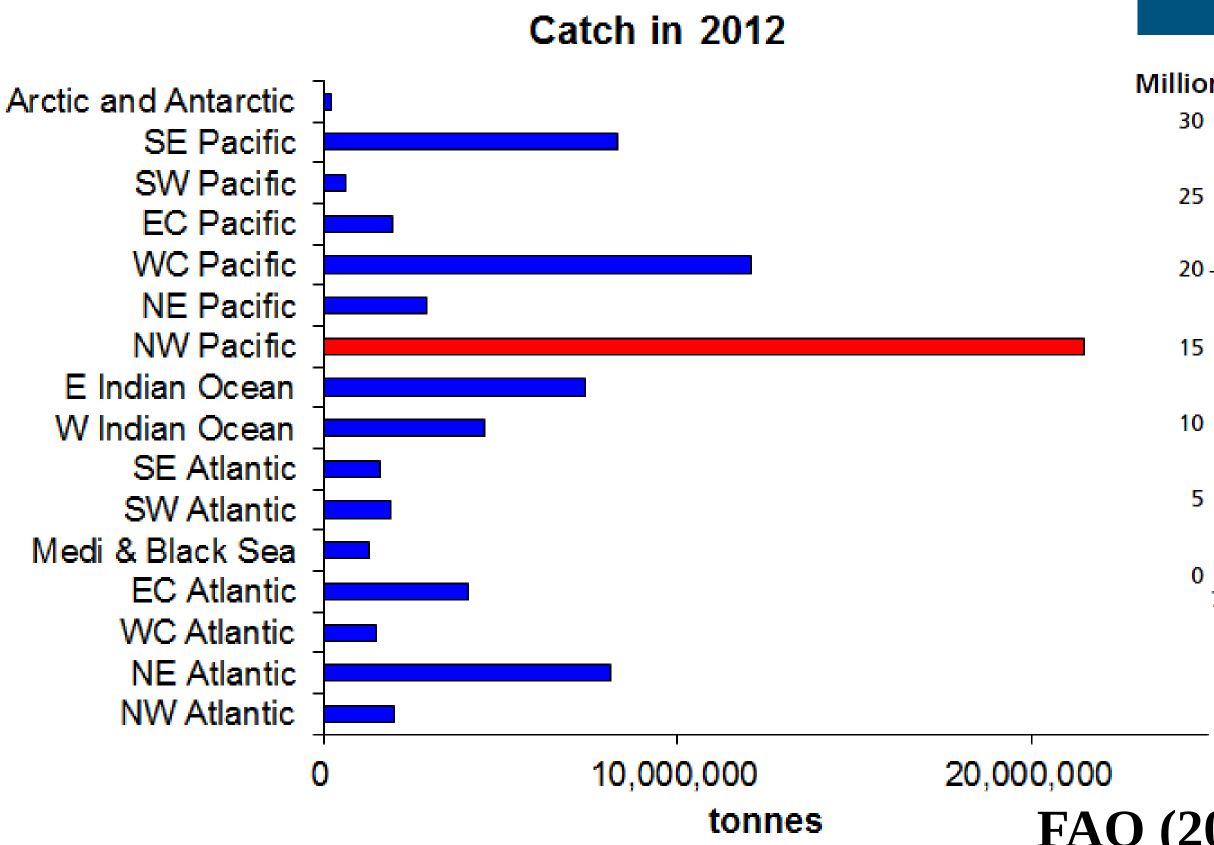
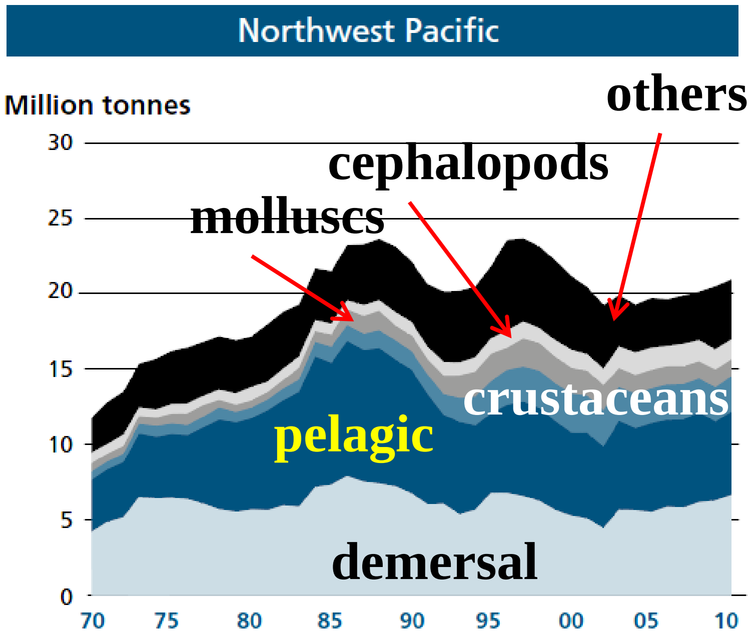
Okunishi T., S. Ito, D. Ambe, A. Takasuka, T. Kameda, K. Tadokoro, T. Setou, K. Komatsu, A. Kawabata, H. Kubota, T. Ichikawa, H. Sugisaki, T. Hashioka, Y. Yamanaka, N. Yoshie and T. Watanabe, 2012, A modeling approach to evaluate growth and movement for recruitment success of Japanese sardine (*Sardinops melanostictus*) in the western Pacific, Fish. Oceanogr., 21, 44–57, 2012, doi:10.1111/j.1365-2419.2011.00608.x

Western North Pacific



FAO (2014)

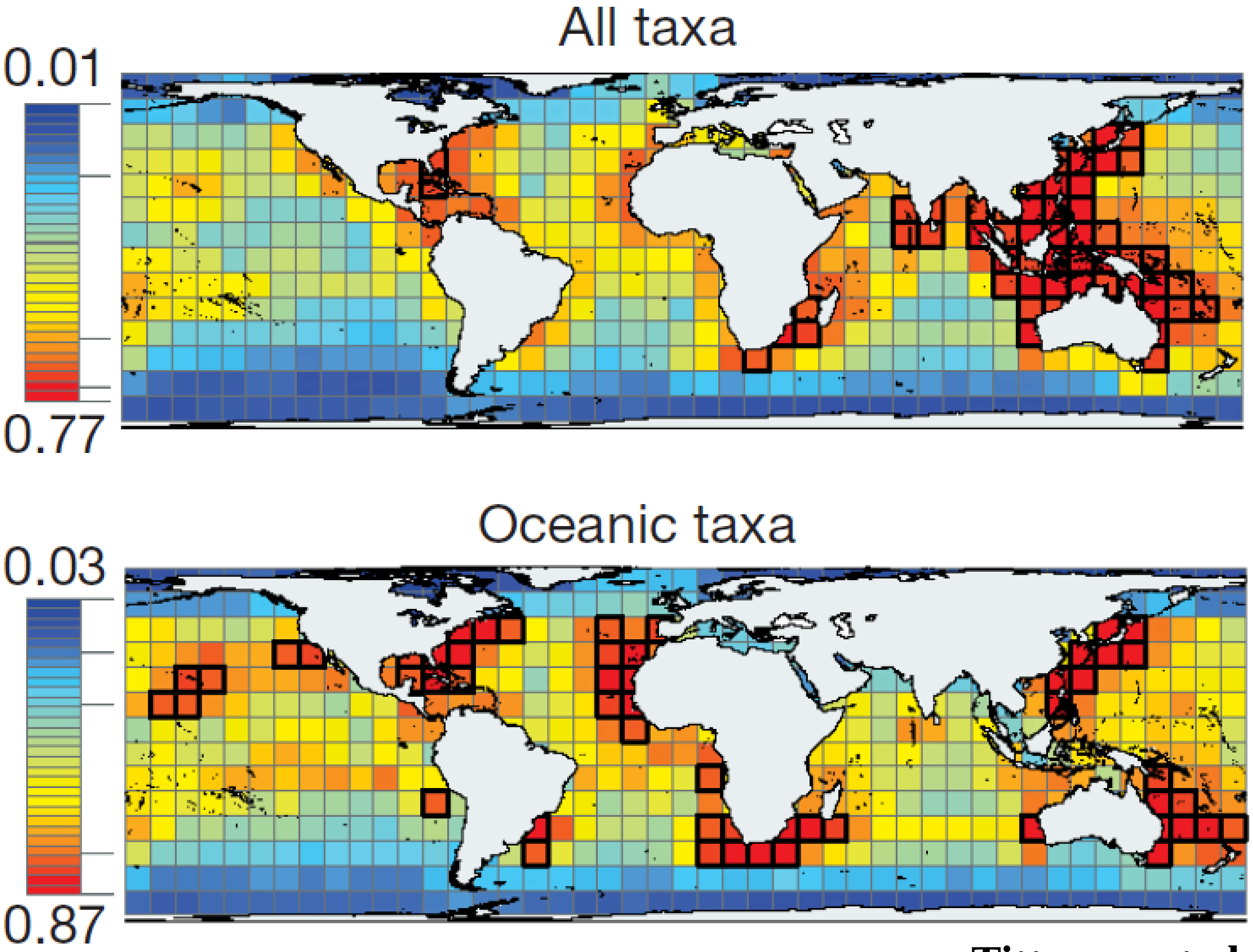


FAO (2012)

- Although the area of WN-Pacific occupies only 6 % of the world ocean, WN-Pacific products 25 % of catch of the world.
- Not only continental shelf but also offshore catch is quit large.

Western North Pacific

high bio-diversity: not only in oceanic but also in coastal taxa

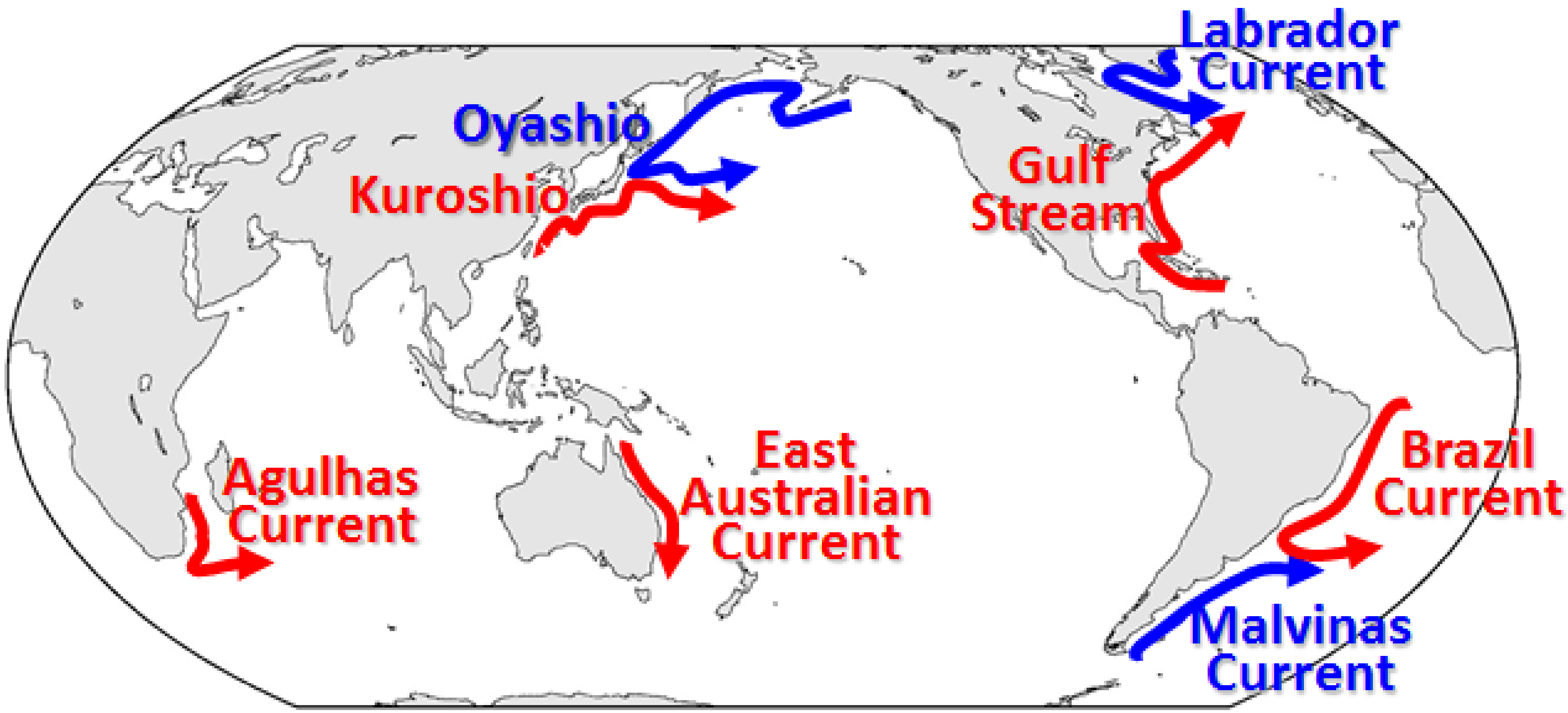


Tittensor et al. (2010)

Why the western North Pacific has rich productivity and diversity?

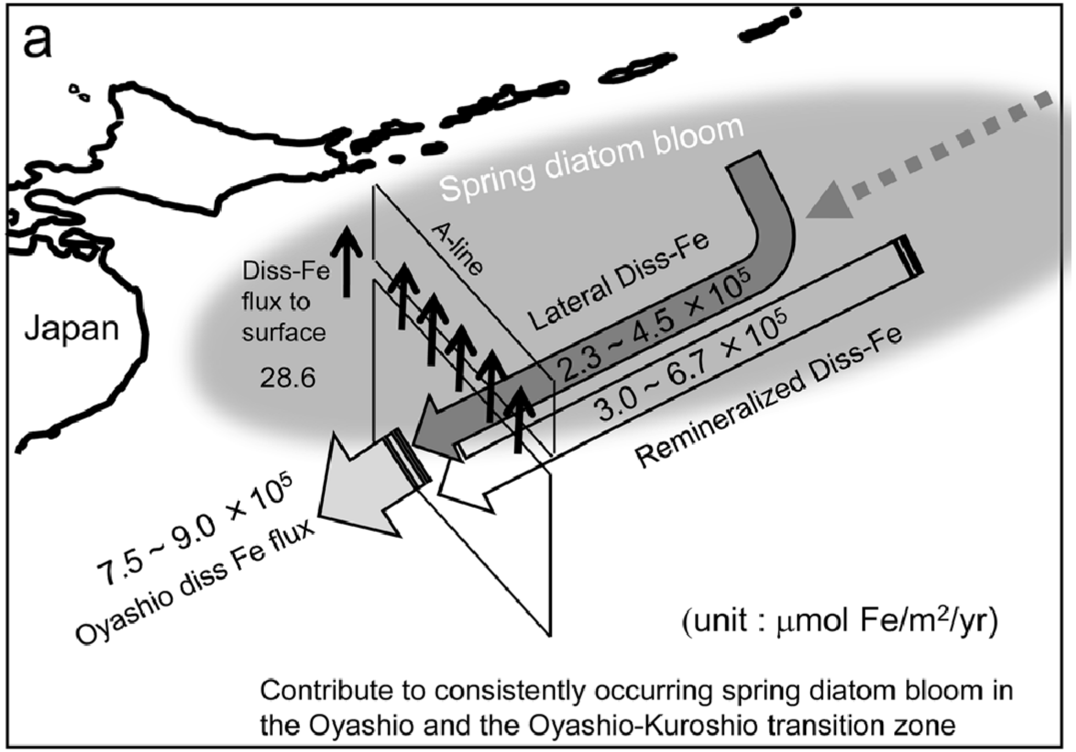
Characteristics of western North Pacific

Subarctic & Subtropical western boundary current
nutrient rich + warm temperature



Characteristics of western North Pacific

surrounded by marginal seas



Nishioka et al. (2011)

WN-Pacific is surrounded by marginal seas (Bering Sea, Okhotsk Sea, Japan Sea, East China Sea).

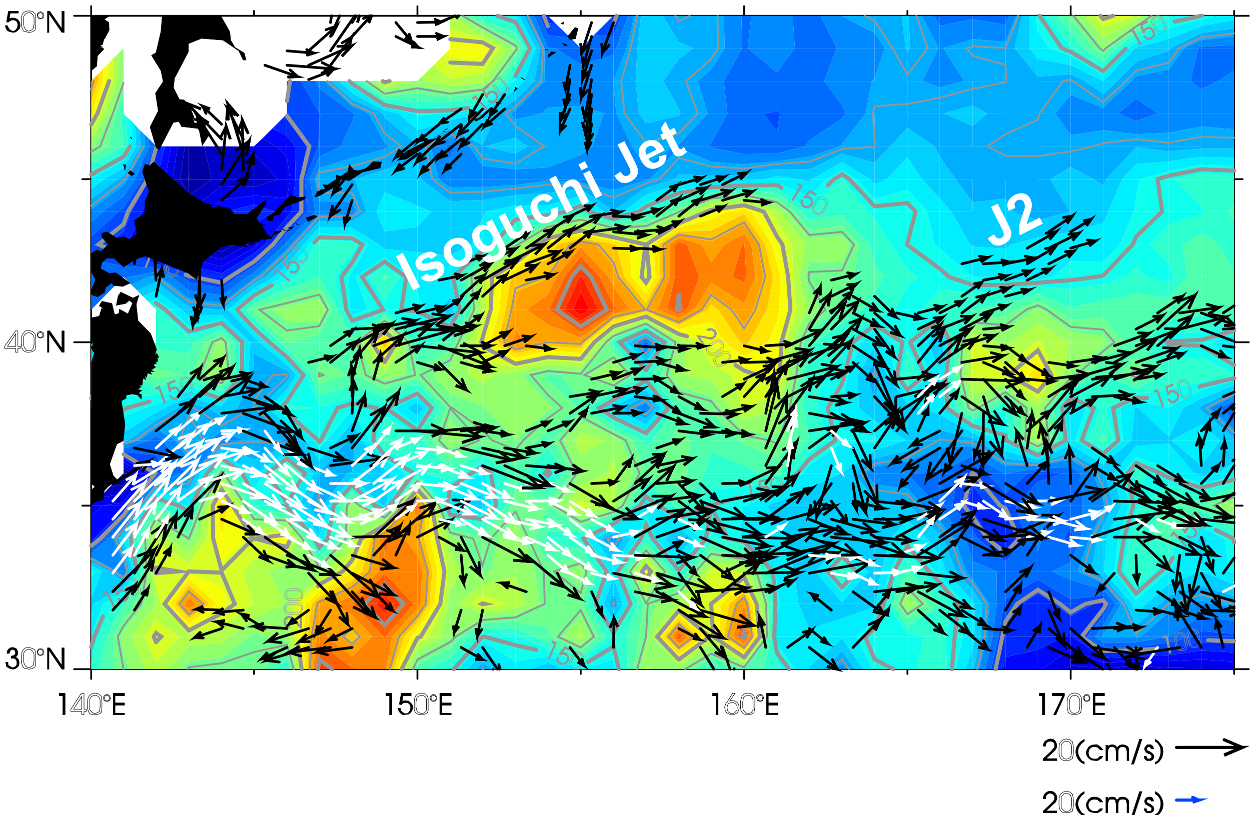
Okhotsk Sea supplies dissolved iron through the intermediate water and the iron stimulates spring bloom production in the WN Pacific (Nishioka et al, 2011).

However, what mechanisms are sustaining the other seasons' production?

Additionally, Oyashio and Kuroshio don't directly meet each other.
We don't know the actual process to enhance the productivity in the WN-Pacific.

Hypothesis

Kuroshio transports larvae offshore.
Quasi steady jets produce offshore ecological hotspots and transports larvae and juveniles to the hotspots.
Larvae utilize offshore ecological hotspots.



From
Isoguchi et al. (2006)

Wintertime MLD &
strong currents

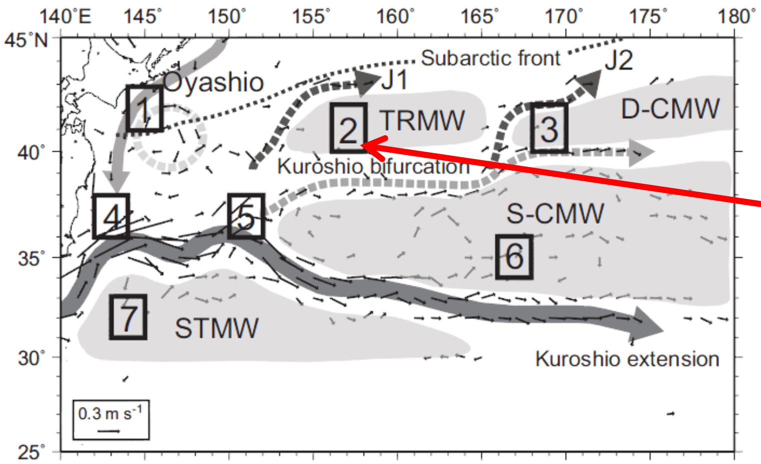
1. Suga et al. (2004) found deep winter mixed layer south of the subarctic front.
2. Isoguchi et al. (2006) found quasi-steady warm streamers on the north boundary of the deep MLD region (Isoguchi Jet).
3. Saito et al. (2007) found weak stratified thick layer in the deep MLD region and named as Transition Region Mode Water (TRMW).

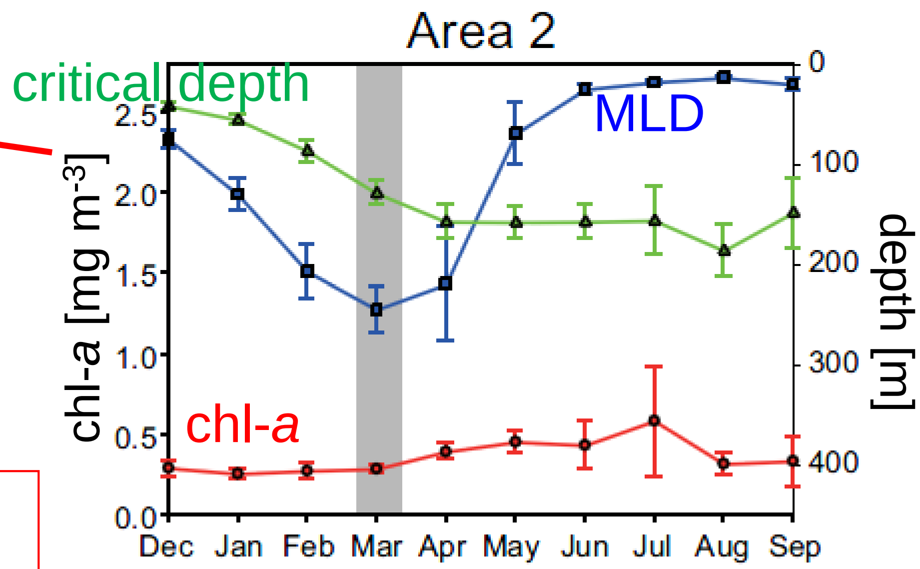
They hypothesized that Isoguchi Jet supplies saline water and contributes to the formation of TRMW.

Formation of mode water supplies nutrient to the surface layer.
Isoguchi Jet has a potential to transports larvae of small pelagic fish.

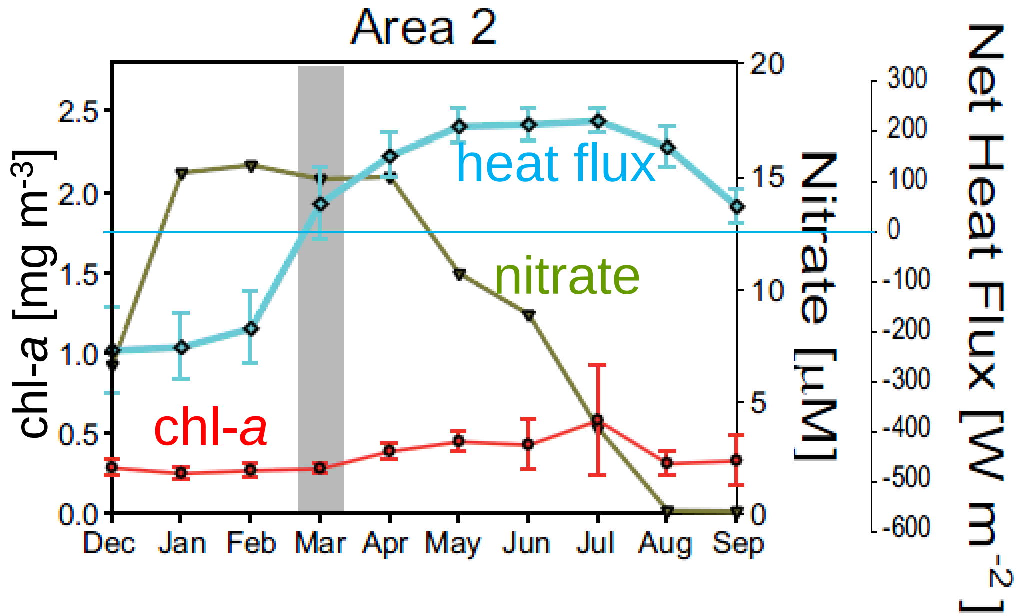
seasonal variation (climatology)

Shiozaki, Ito et al. (2014, J. Geophys. Res.)



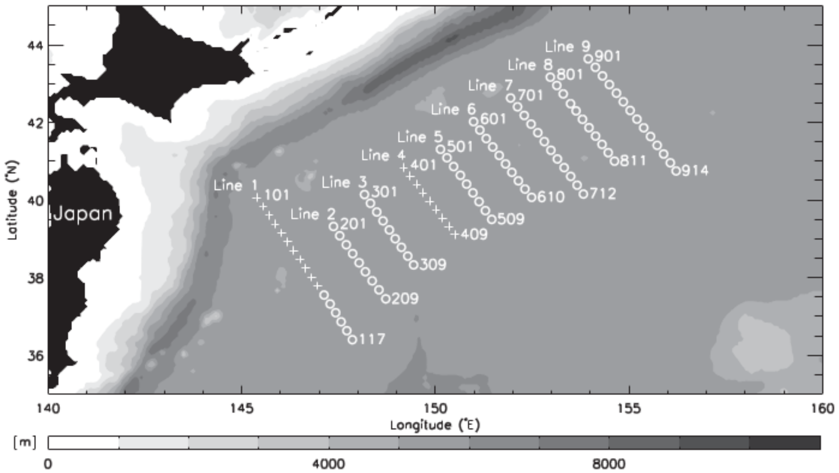


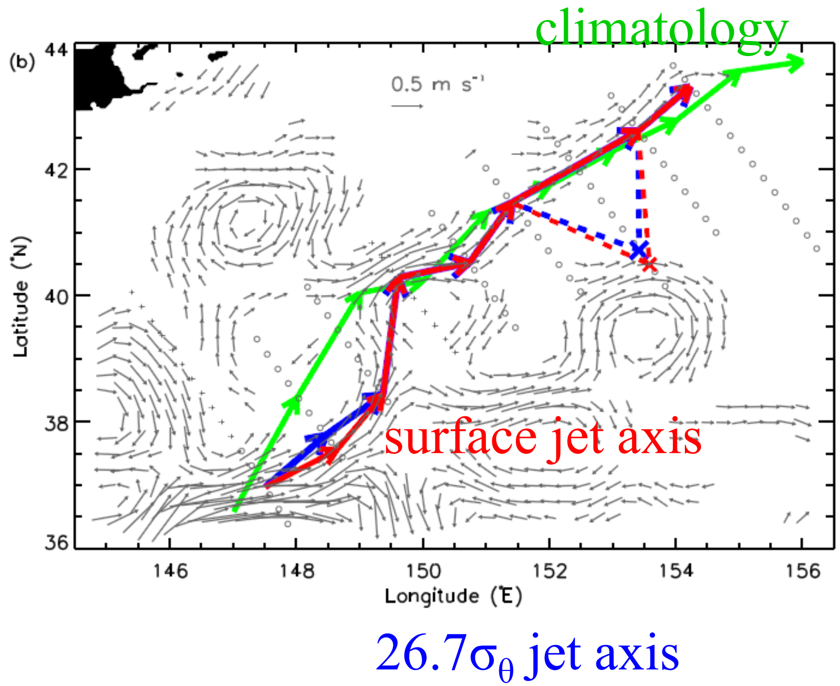
1. The initiation date of the bloom (significantly higher than the minimum value in winter) is not regulated by MLD but heat flux.
2. Bloom is elongated until summer (pelagic fish migration season).

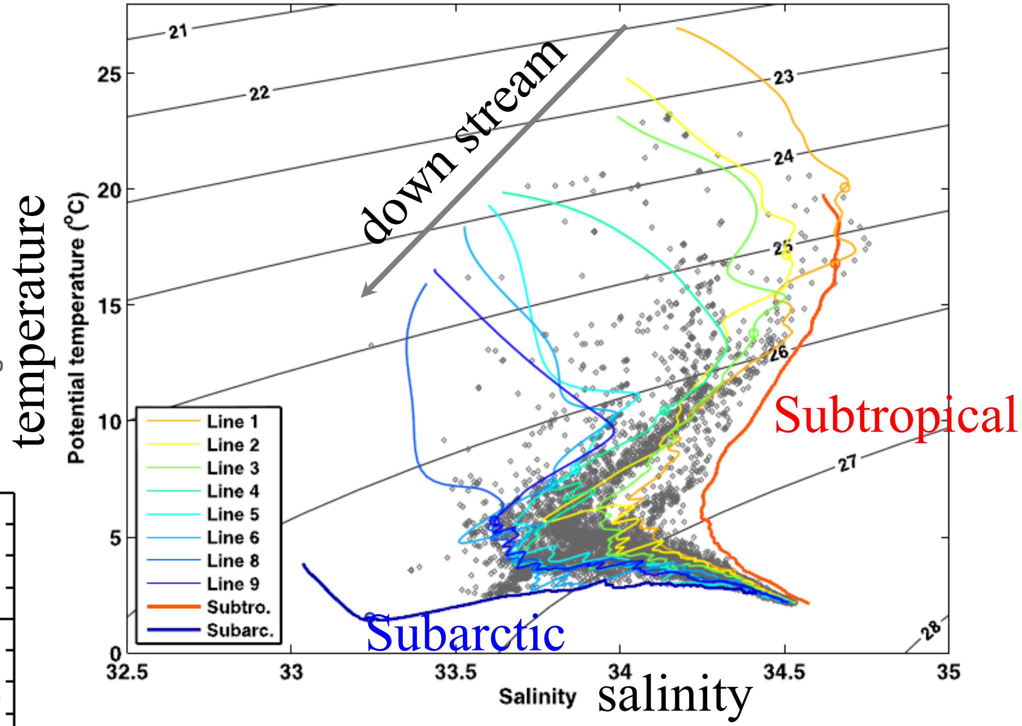


synoptic survey

Wagawa, Ito et al. (2014, J. Phys. Oceanogr.)







By hydrographic observations, the Isoguchi Jet was detected as a continuous streak line.

The water property of the Isoguchi Jet was modified from Subtropical type to Subarctic type.

synoptic survey

Alkalinity-salinity relation was applied to estimate the water composition of the Isoguchi Jet (mixing ration between subtropical and subarctic waters).

From the upstream to the downstream, subarctic water was entrained to the Isoguchi jet and nutrient concentration increased (and hence Chl-*a* concentration).

Kakehi, Ito et al. (submitted to J. Oceanogr.)

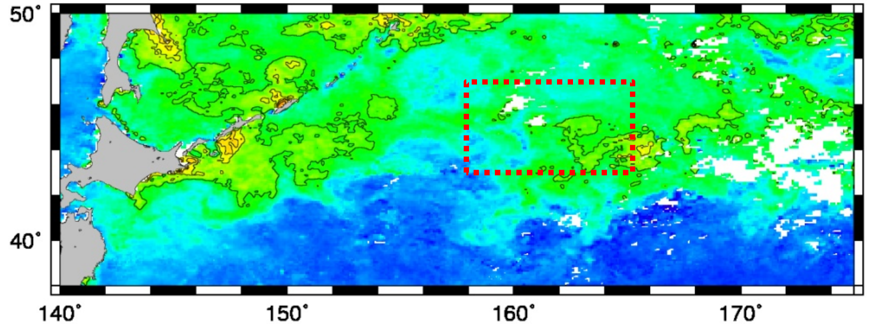
the figure is not available since it is before the publication on the peer-reviewed journal

Ecological hot spot : jet terminal

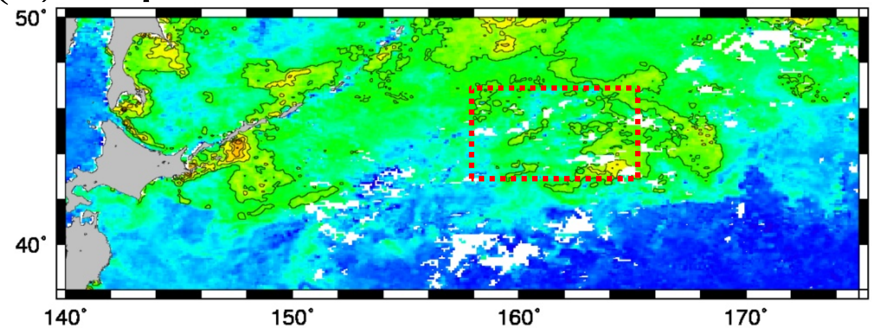
Okunishi, Ito et al. (2012, Fish.Oeanogr.)

(a) Sep. 2005

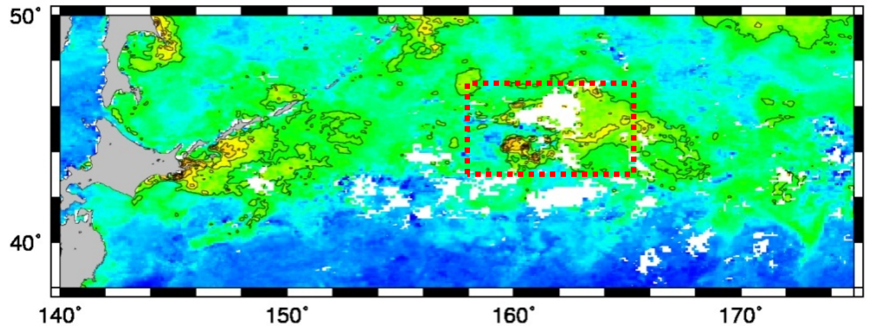
SeaWiFS Chl-a



(c) Sep. 2006



(e) Sep. 2007



A Chl-*a* maximum is formed in autumn at the termination point of the Isoguchi Jet.

an evidence of ecological hot spot in the offshore.

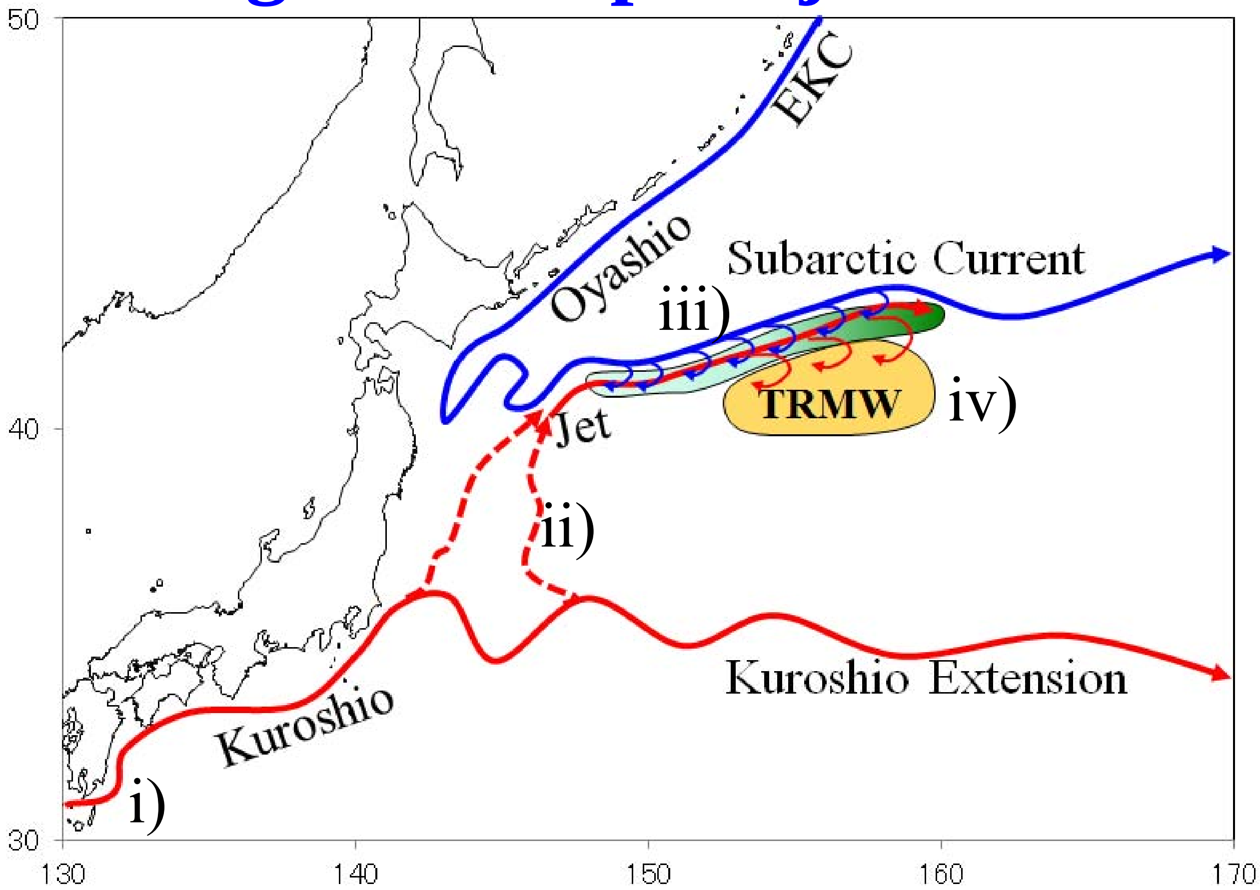
Distributions of Japanese sardine juveniles

Kawabata et al. (2008)

the figure is not available since it is before the publication on the peer-reviewed journal

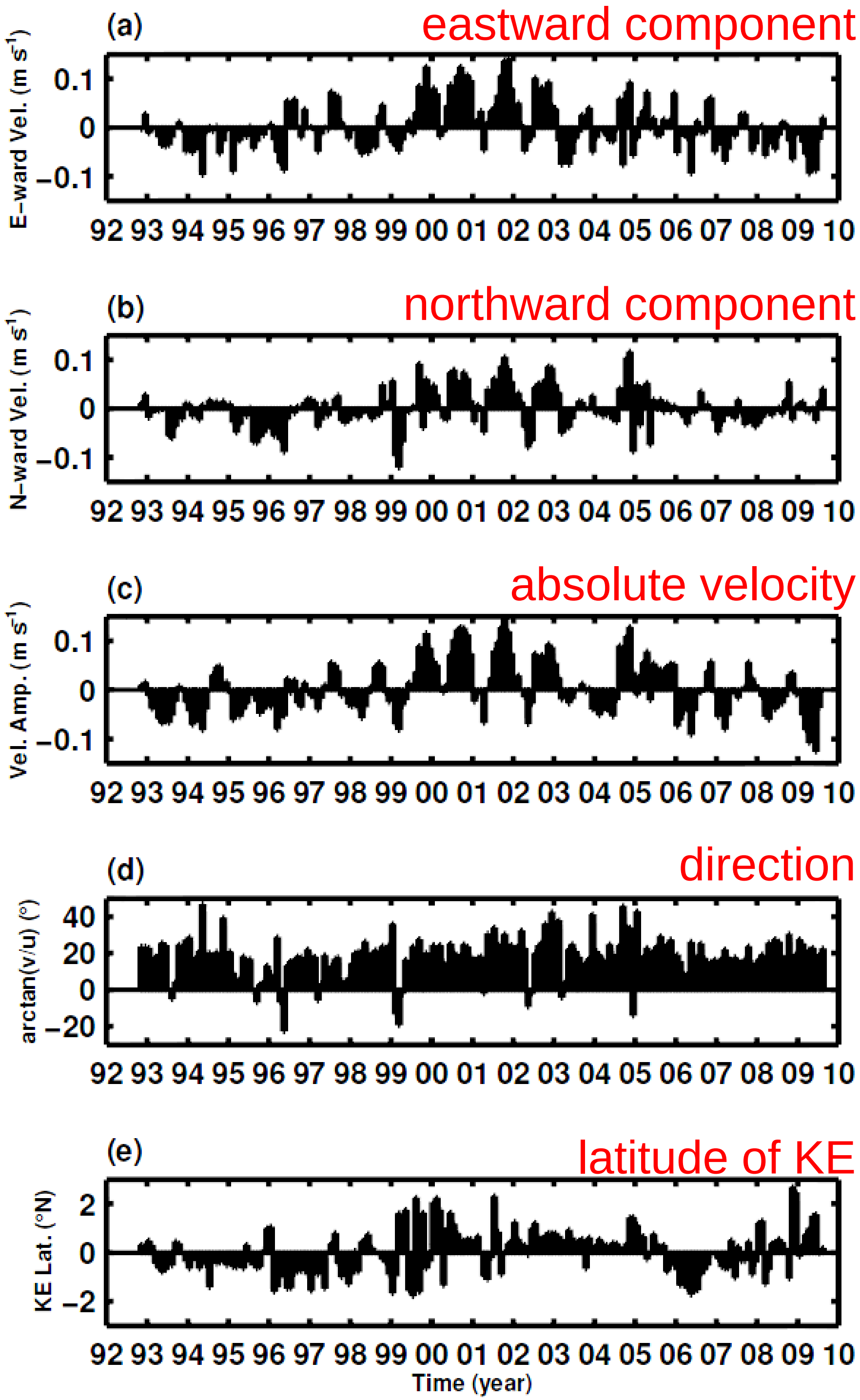
In autumn the juvenile aggregates to the terminal of the Isoguchi Jet.

Ecological hot spot : jet terminal



Ito et al. (in prep.)

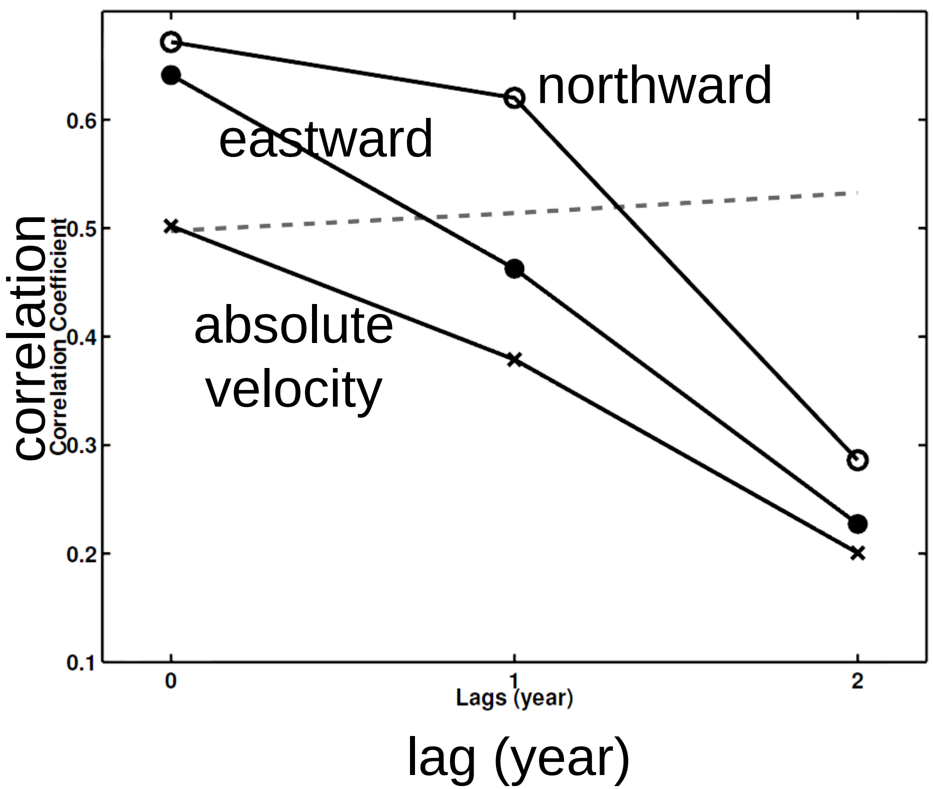
i. spawning ground in the upstream of Kuroshio
ii. Isoguchi Jet
iii. strong mixing between Isoguchi Jet and Subarctic Current
iv. delay of bloom peak and iron supply by mode water formation



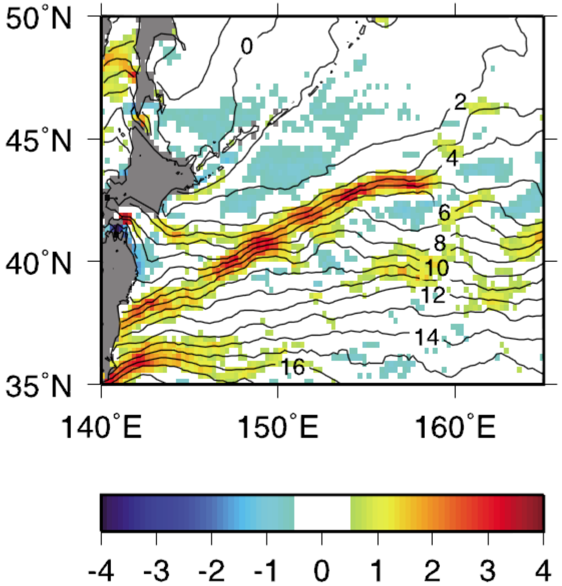
variability of Isoguchi Jet

Direction of IJ is steady.
Velocity showed decadal variability.
Northward component and lat. of KE
showed high correlation with no lag.
May influence on recruitment of fish

Wagawa, Ito et al. (2014), J. Phys. Oceanogr.



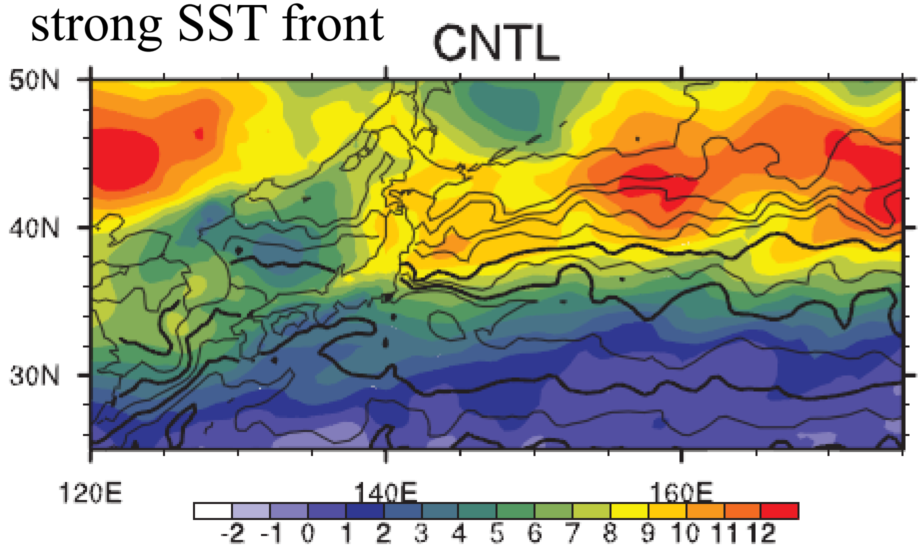
Influence of Isoguchi Jet on storm activity



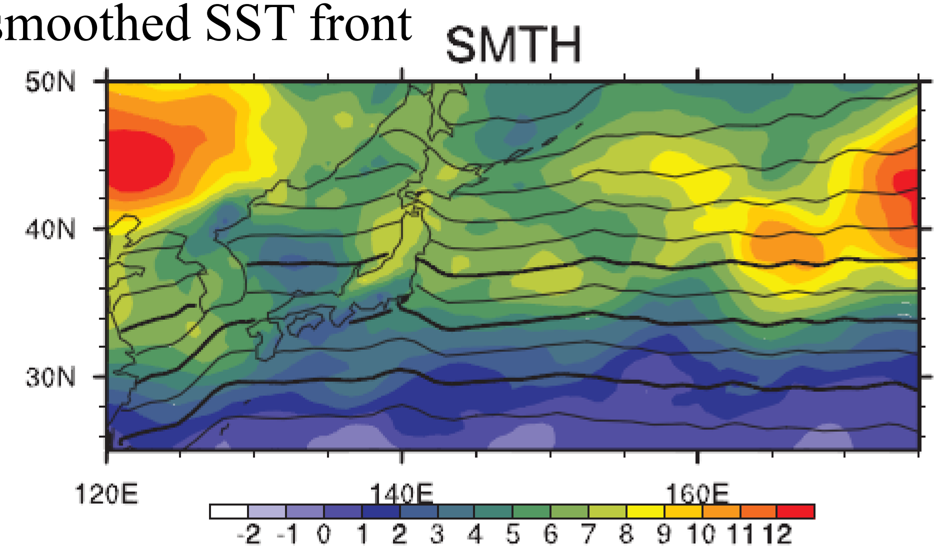
Tomita et al. (2012)
SST (hence heat flux to atmosphere) gradient is extremely strong in the Isoguchi Jet area.

Taguchi et al. (2009)
The sharpness of SST front influences on storm activity.

strong SST front



smoothed SST front



poleward eddy heat transport in spring

Formation of offshore ecological hotspots and its fluctuation in the western North Pacific

- Blend of subtropical, subarctic and Okhotsk Sea waters was accomplished by Isoguchi Jet and TRMW.
  high temp., nutrient rich, & iron sufficient
- Kuroshio and Isoguchi Jet transport fish larvae to the hotspot.

Isoguchi Jet is a local current, however,

- shows decadal variability,
- has a potential to modify storm activity (and hence Aleutian Low, then maybe ocean circulation),
- has a potential to influence on juvenile recruitment of small pelagic fish.

Remaining issues

- **mechanism of jet formation**
- **mechanism of decadal variability of Isoguchi Jet**
- **influence of decadal variability of Isoguchi Jet on fish stock**

It is a big challenge to investigate impacts of fluctuations in limited local key areas to large marine ecosystems.

As a FUTURE related work.