Transport of subarctic large copepods from the Oyashio area to the mixed water region by the coastal Oyashio intrusion

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with

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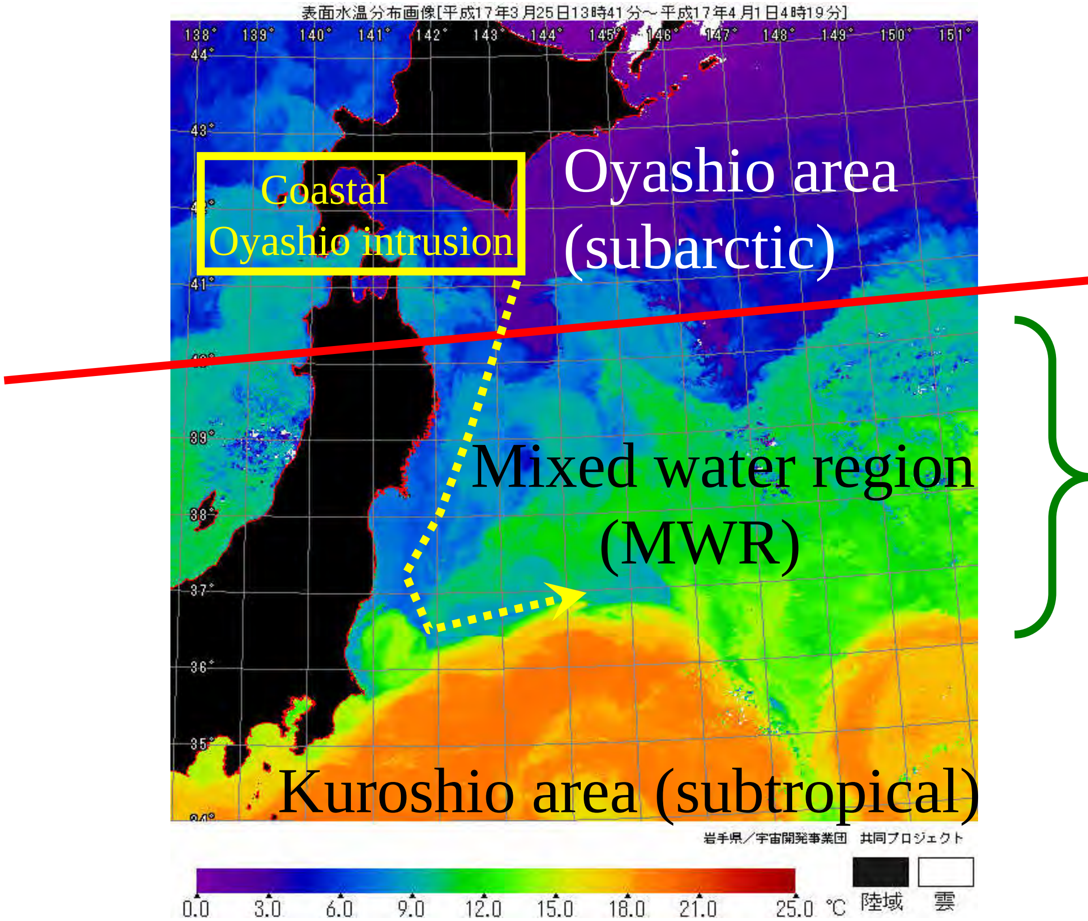
Oceanographic structure off northeast coast of Japan



Wind-stress curl = 0

MWR is regarded as
a part of subtropical area.

Image of Sea Surface Temperature in April 2005

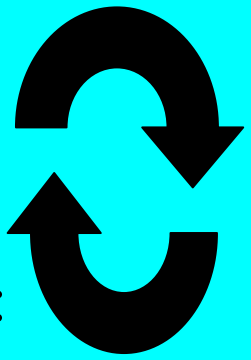
Oyashio water is advected southward into subtropical area
through the coastal Oyashio intrusion

Subarctic large copepods analyzed in this study

* *Neocalanus cristatus*
N. flemingeri
N. plumchrus
Eucalanus bungii

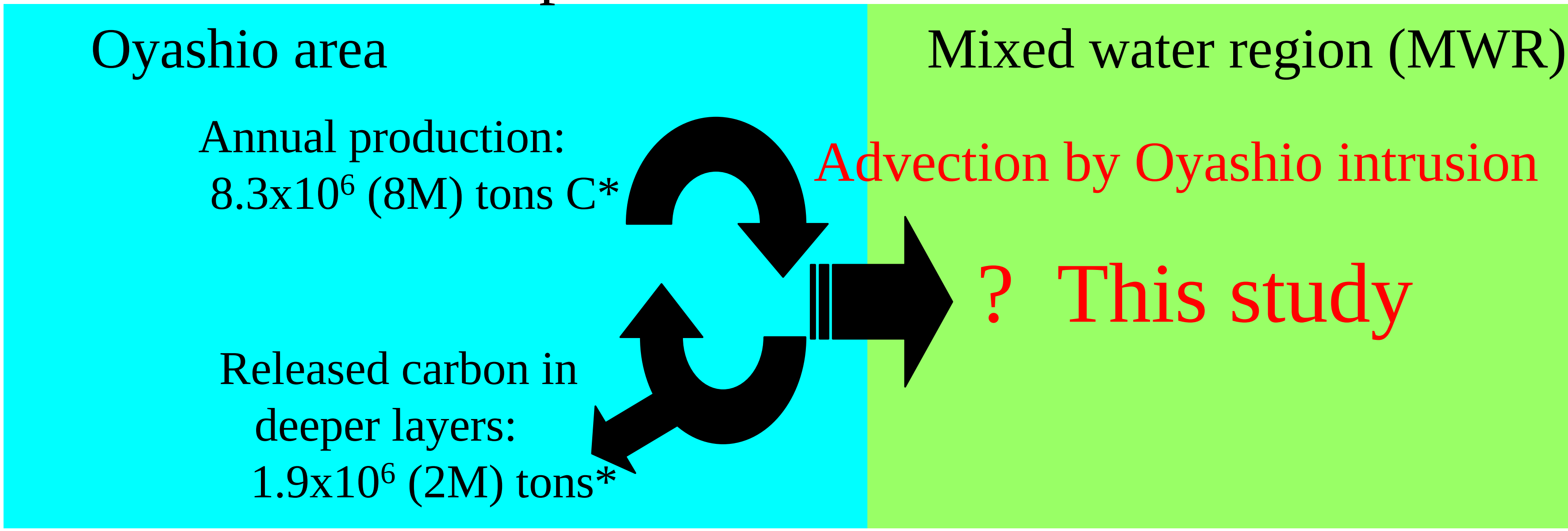
- They are major copepod species in the Oyashio area because their biomass accounts for 60% of total zooplankton biomass there.
- They make an ontogenetic (seasonal) migration.

Spring~summer: Produce and graze near sea surface



Autumn~winter: Diapause in deeper layers

<*Neocalanus* species>



* Estimated by a unit area's vertical carbon flux for *Neocalanus* species (Kobari et al. 2003 etc.) and Oyashio area about 4.3x10^{11}m^{2} (Tadokoro et al. 2006)

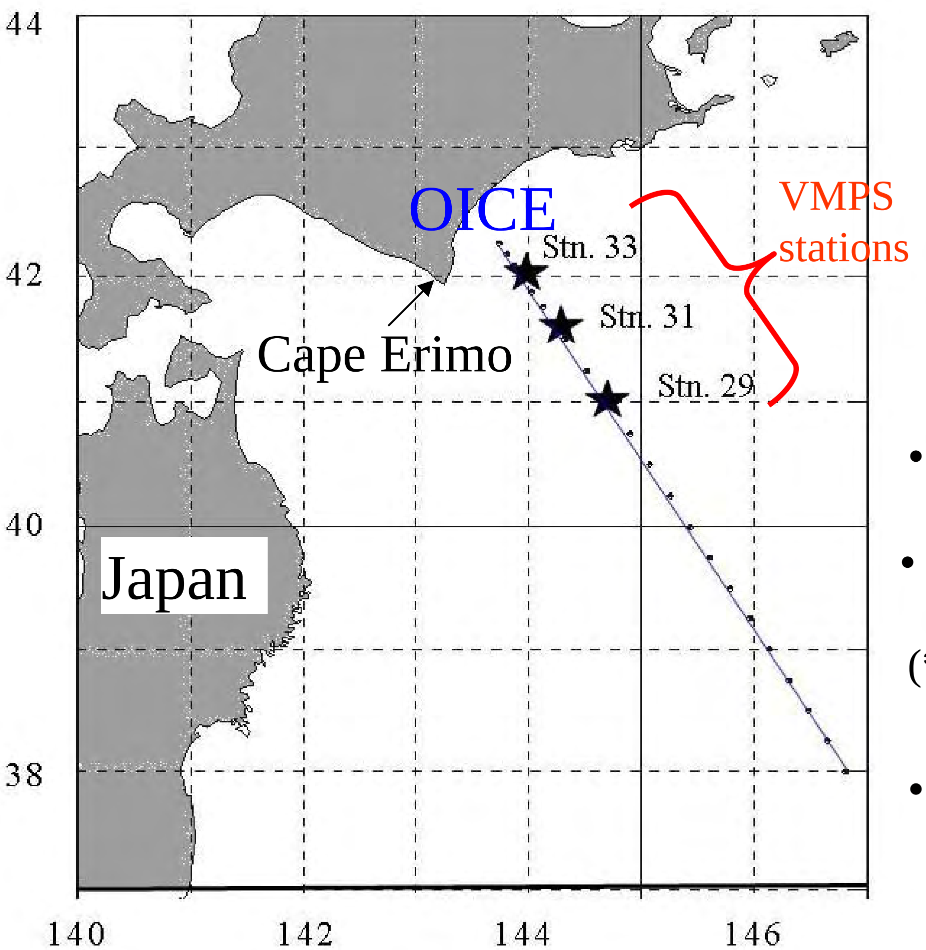
Purposes of this study

- estimate the lateral transport of copepods by the Oyashio intrusion.
- compare the advection with their production and vertical transport, and predation pressure by Pacific saury in mixed water region.

➔ Importance of advection

Data

• Observation data on OICE (Oyashio Intensive observation line off Cape Erimo)



Five OICE cruises in 2001 - 2002

June 2001	(WK0106)
August 2001	(TR0108)
November 2001	(WK0111)
January 2002	(WK0201)
April 2002	(WK0204)

• CTD observation at each station (1500 dbar)

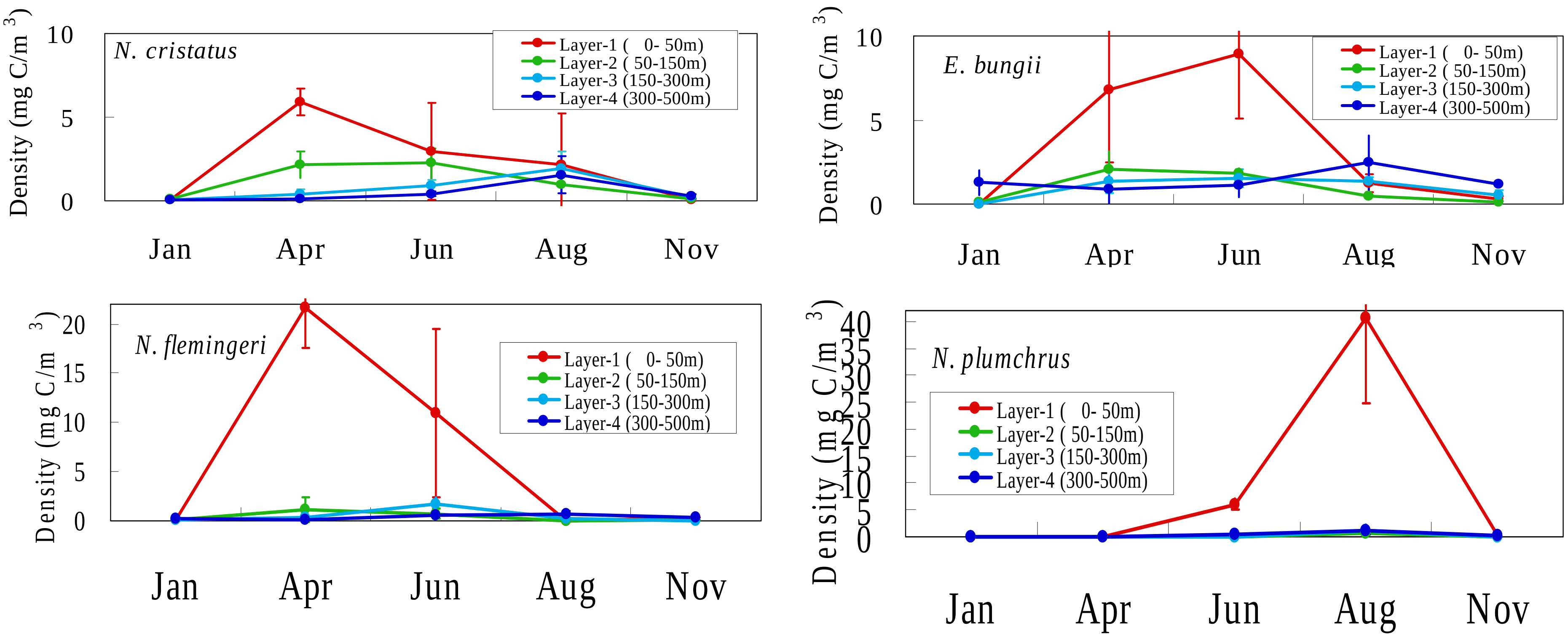
• Copepods were sampled at three VMPS* stations.

(*VMPS: Vertical multiple-opening plankton sampler)

• VMPS had four sampling layers;
0-50m, 50-150m, 150-300m, 300-500m.

Copepod biomass in Oyashio area: *B*

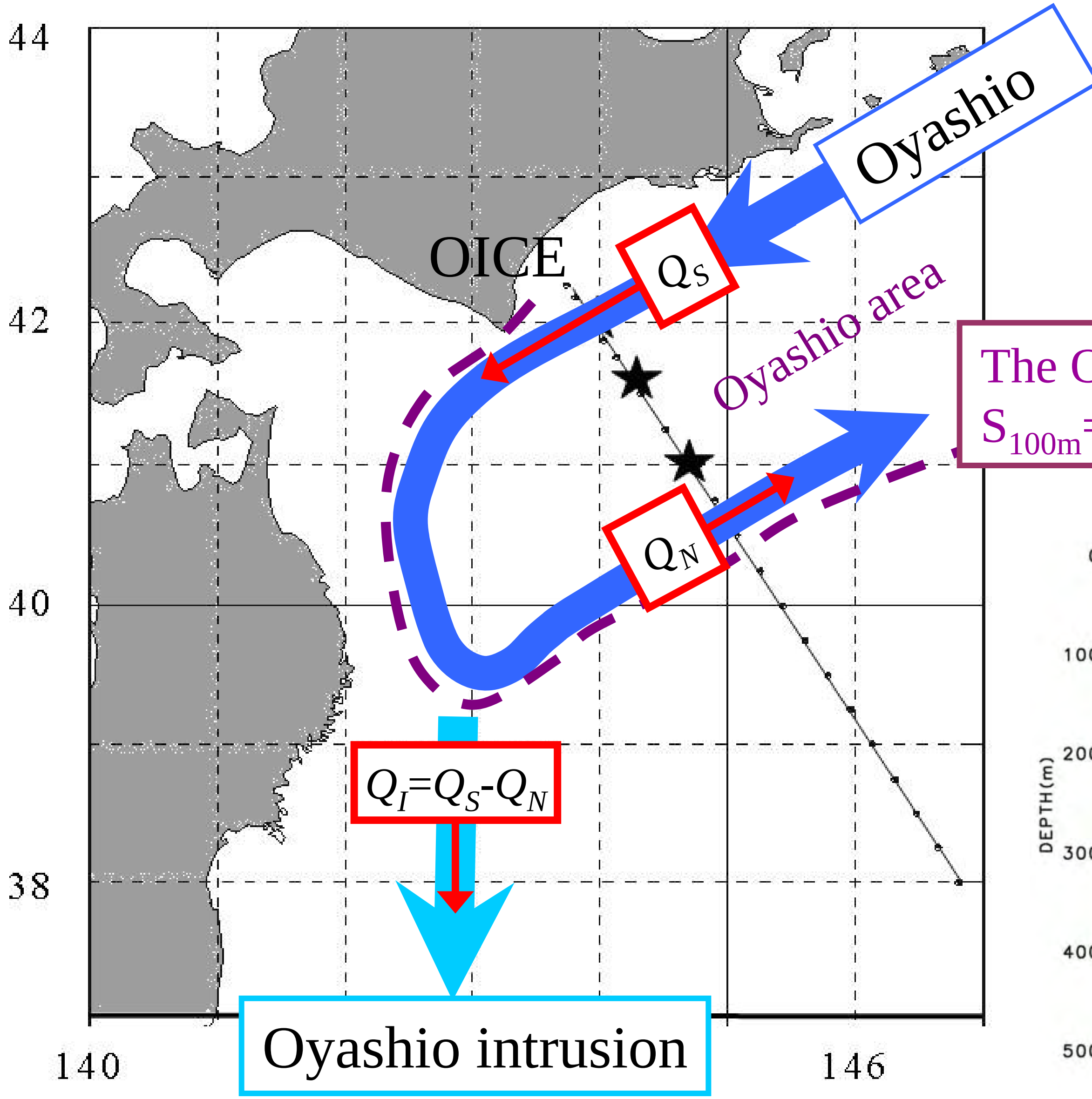
- Averaged at VMPS stations with salinity at 100 m depth < 33.6 (Oyashio area).
- VMPS sampling layers: 0-50m, 50-150m , 150-300m , 300-500m.



- *N. cristatus*, *N. flemingeri* and *E. bungii* have maximum at surface in spring, whereas *N. plumchrus* has maximum at surface in summer.

- Increase in deeper layers is seen in autumn to winter because of vertical migration.

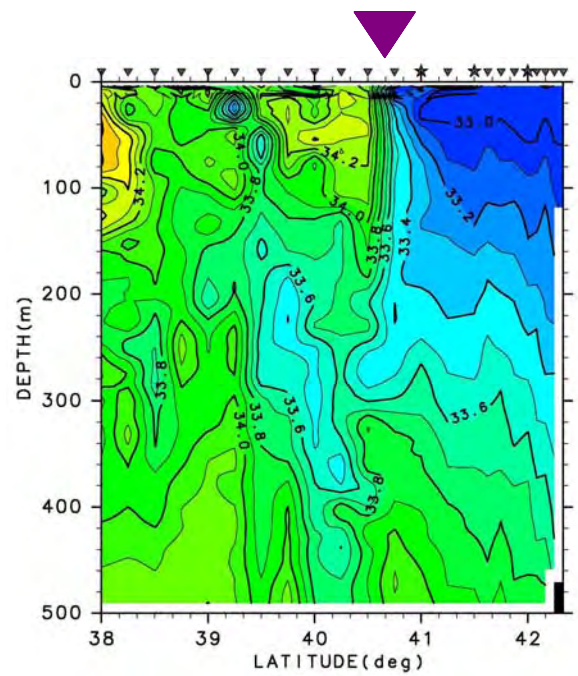
How to estimate the transport of Oyashio intrusion



Volume transport of Oyashio intrusion

$$Q_I=Q_S-Q_N$$

The Oyashio front defined as $S_{100m}=33.6$ (Kawai 1972)



Salinity along OICE in June 2001

Transport of Oyashio Intrusion: Q_I

- 1500 dbar referred geostrophic transport
- Southwestward –Northeastward components where $S_{100m} < 33.6$

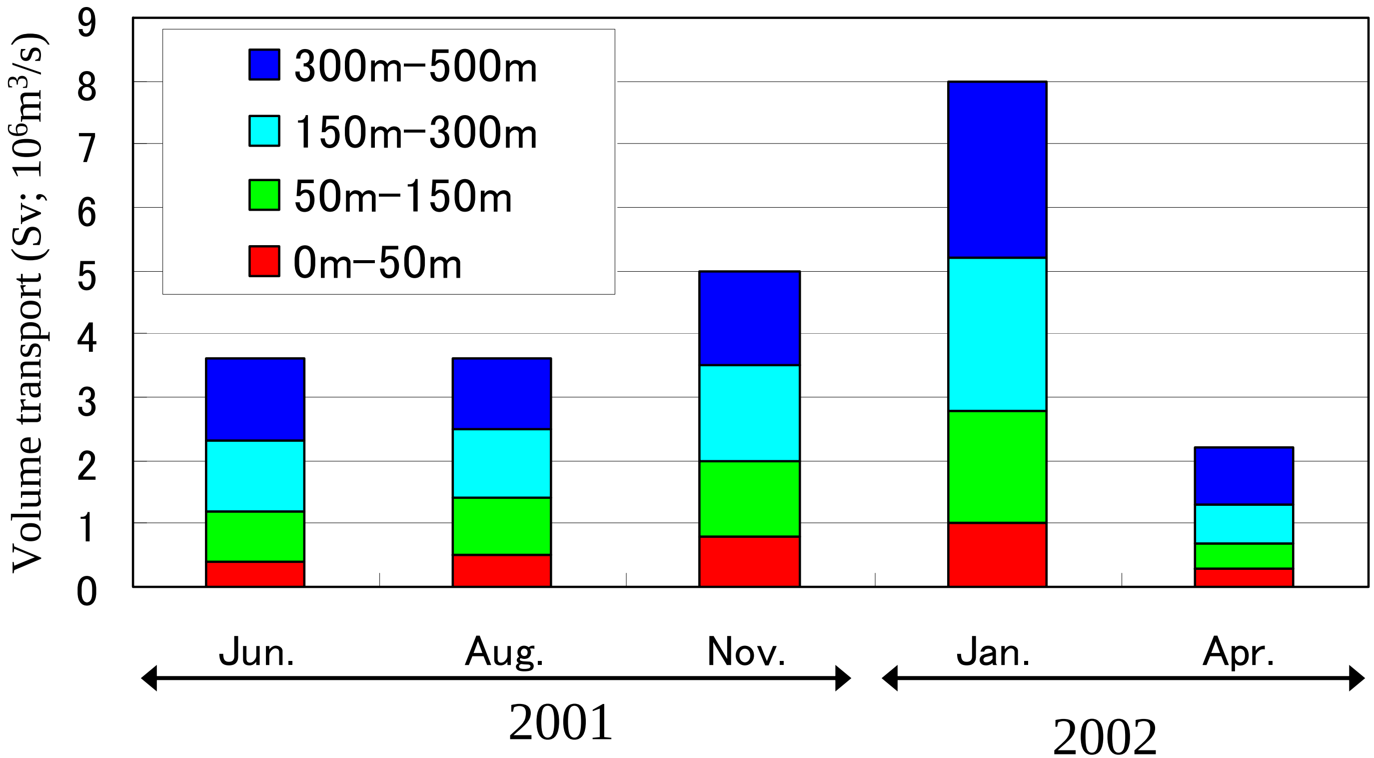


Fig. Transport of coastal Oyashio intrusion

Transport of Oyashio intrusion reached maximum in January 2002.

Annual transport of copepods to MWR

Integrating the <u>carbon flux</u> annually : $C_I = \int_{t_1}^{t_2} B \cdot Q_I dt$

Layer	*N. c.*	*N. f.*	*N. p.*	*E. b.*	*N.* & *E.* total	*N.* total
0–50 m	26	71	141	41	279	238
50–150 m	25	10	3	19	57	38
150–300 m	24	17	9	31	81	50
300–500 m	19	17	14	65	115	50
Total	93	115	167	156	**531**	**375**

Annual transport of four copepods is 531 kilo tons (0.5 Mt) (375 kt (0.4Mt) for *Neocalanus* species).

Flow pattern and travel time from OICE to MWR

Five Profiling floats (APEX isopycnal, Webb Res. Co.) deployed in the Oyashio in 2001, 2003 and 2005.

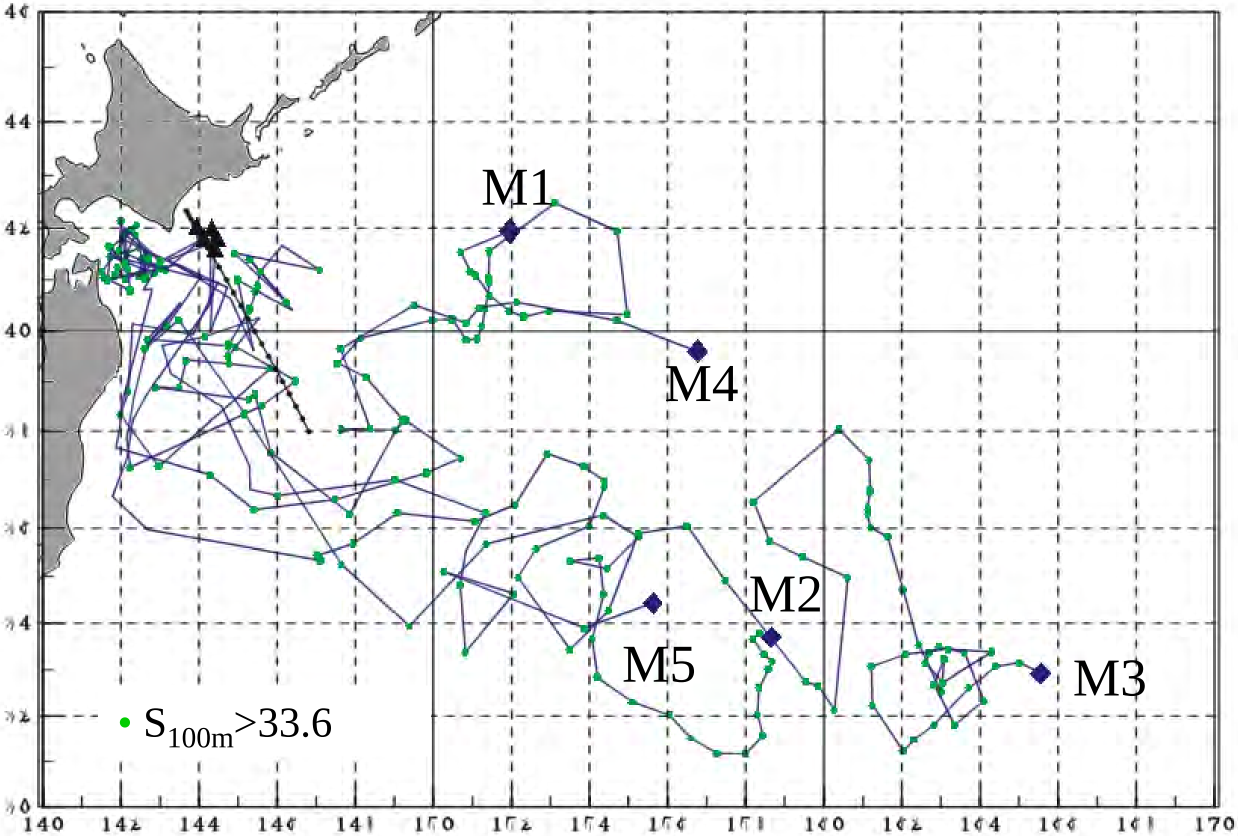


Fig. 1-year trajectories of 5 APEX floats from OICE.

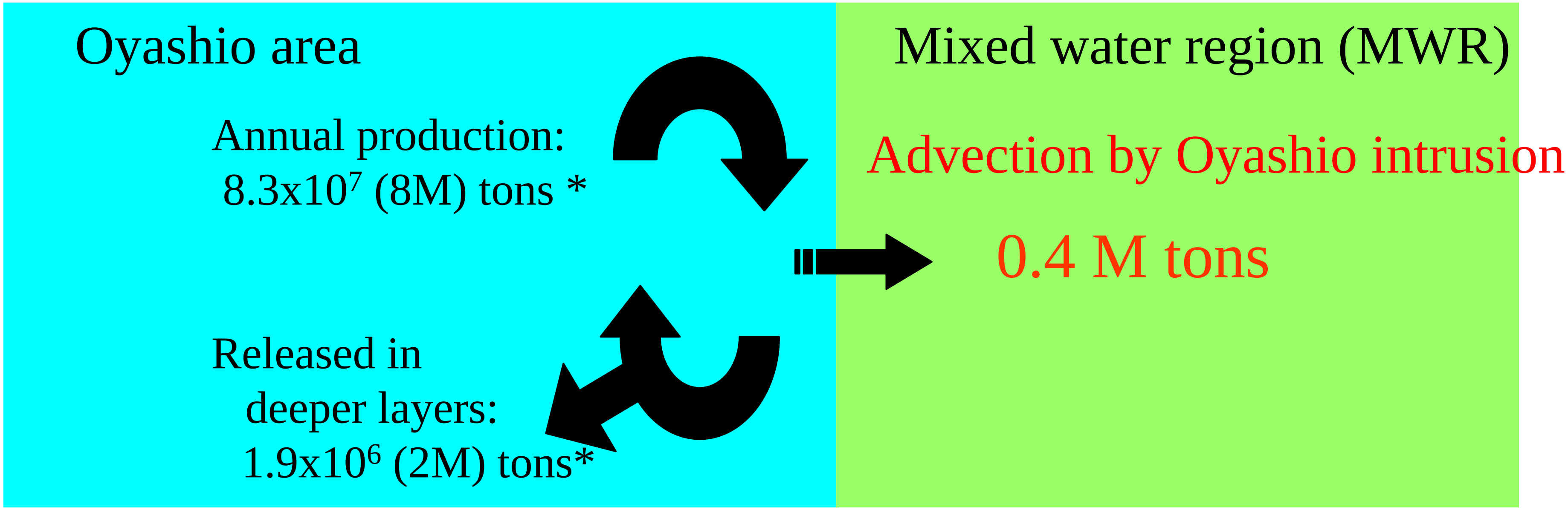
Float	Parking density	Travel time (day)
M1	26.7	14
M2	26.7	21
M3	26.8	30
M4	26.6	50
M5	26.6	60
	Ave.	35

- Travel time from OICE to MWR is 35 days in average.
- Copepods would be advected to MWR within 2 months at most.

Comparison with production and vertical transport

- Annual transport of *Neocalanus* species from Oyashio area to MWR was estimated to be 0.4Mt C.

- It corresponds to 5% of their annual production and 20% of their vertical transport in the Oyashio area.



(*Neocalanus* species)

Comparison with predation by Pacific saury in MWR

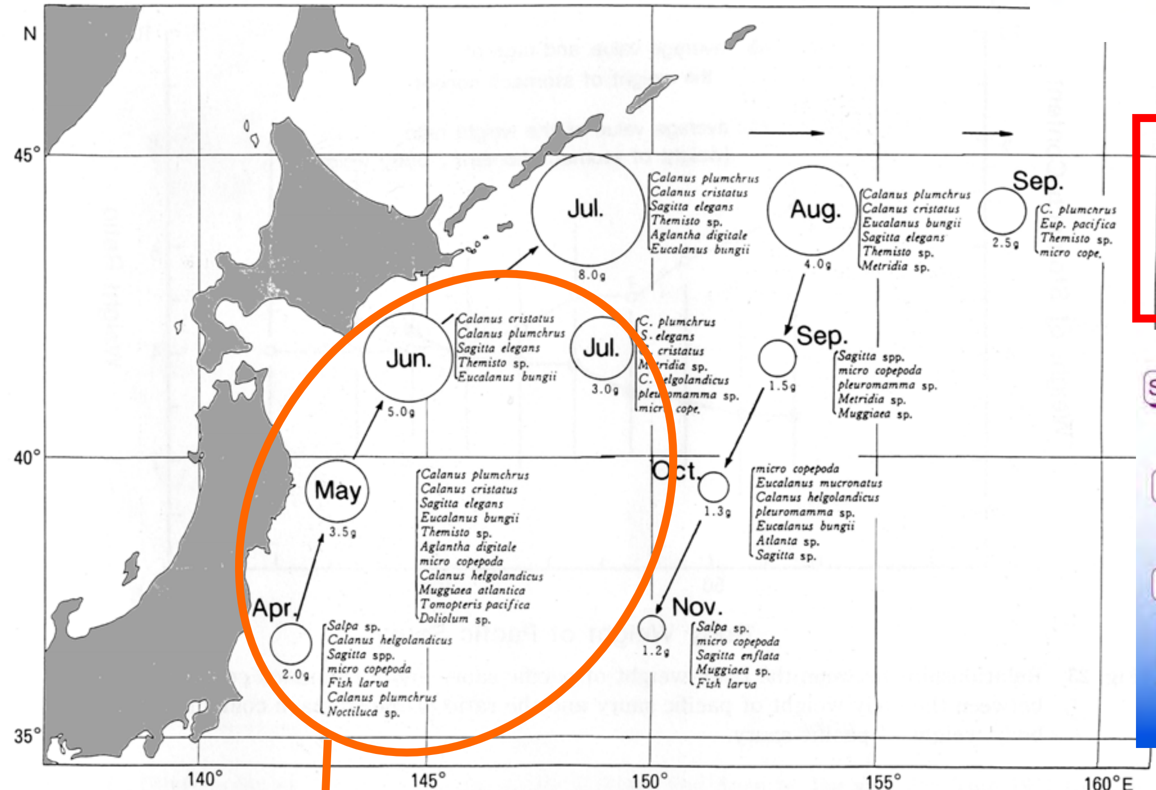
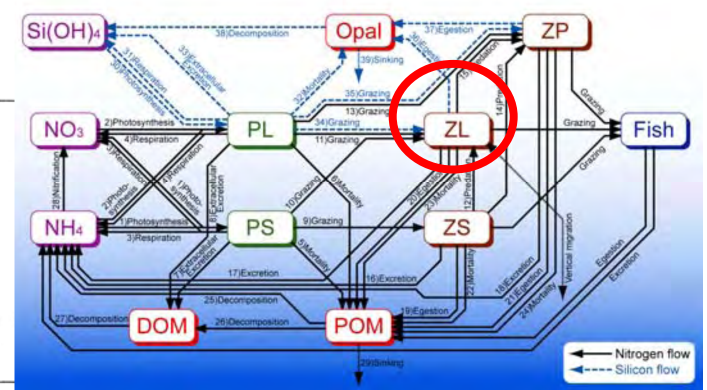


Fig. 22 Changes of the zooplankton biomass (wet weight, g/net) and the dominant species of zooplankton in the Tohoku Sea Area according to the feeding migration of pacific saury.

Estimate ZL in NEMURO.FISH (an ecological model) inputting saury resource data in 2002



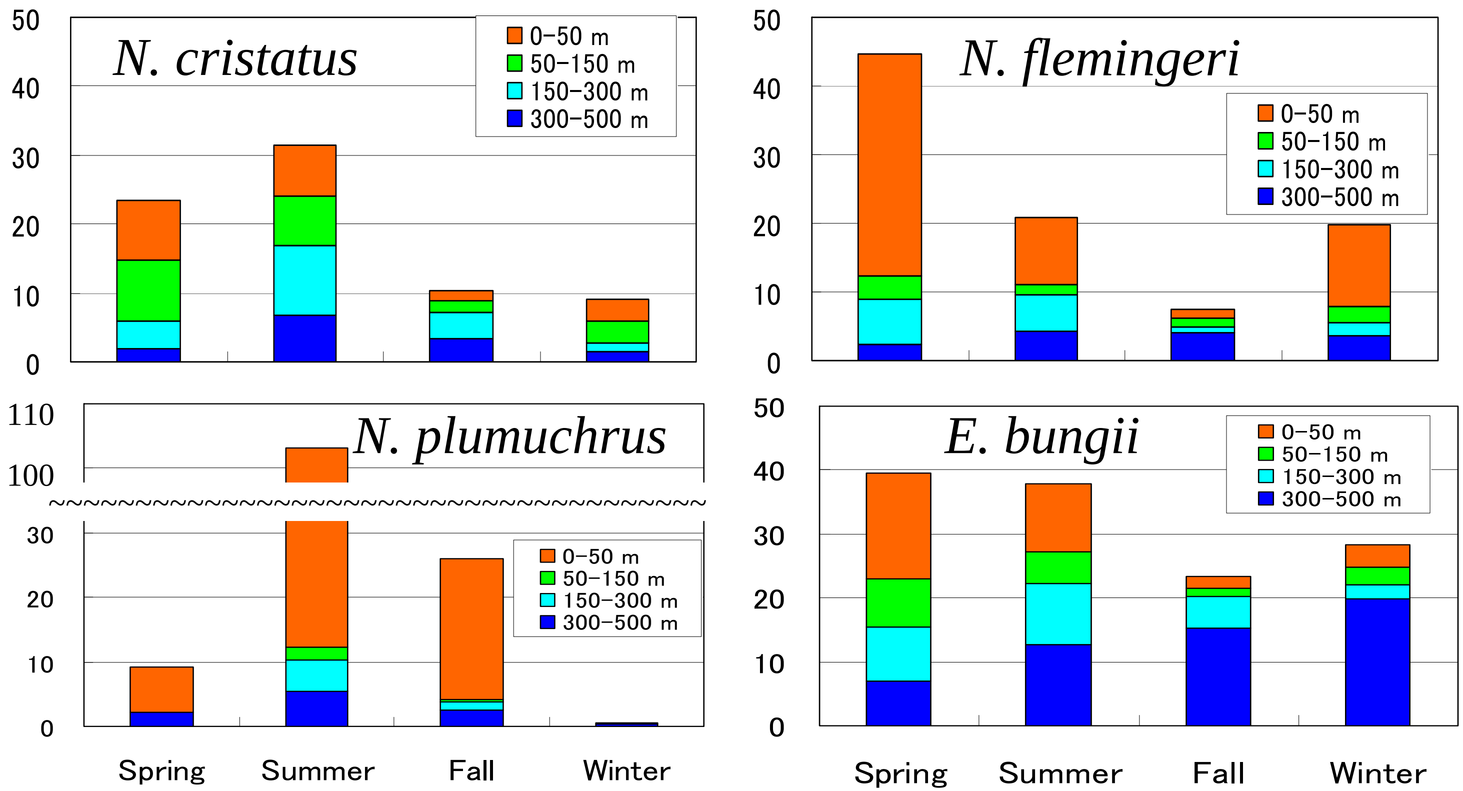
NEMURO.FISH

Large zooplankton consumption by northward migrating Pacific saury in MWR in spring to summer was estimated to be 1.9 M tons wet weight

Seasonal transport of copepod to MWR

Integrate seasonally: $C_I = \int_{t_1}^{t_2} B \cdot Q_I \, dt$

* Spring: Apr-Jun, Summer: Jul-Sep,
Fall: Oct-Dec, Winter: Jan-Mar.



Surface copepod transport in spring to summer = 3.3 Mt wwt (0.22 Mt C)

➔ Larger than the saury's predation pressure

Summary

- The transport of subarctic large copepods by the coastal Oyashio intrusion was estimated to be 0.5 Mt C/ year, based on the observational data.
- For *Neocalanus* species, the advection accounted for 5% of their production in the Oyashio area (5% loss due to advection).
- Advection time scale from OICE (Oyashio area off Hokkaido) to MWR (mixed water region) would be 1-2 months, shorter than the ontogenetic cycle of copepods (1 year).
- The amount of advected copepods into MWR is larger than the consumption by northward migrating Pacific saury, according to the estimate using the model NEMURO.FISH.

Acknowledgement

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- The paper was published in *Fisheries Oceanography* :
  Shimizu et al. (2009): *Fish. Oceanogr.* 18:5, 312–327

Thank you!