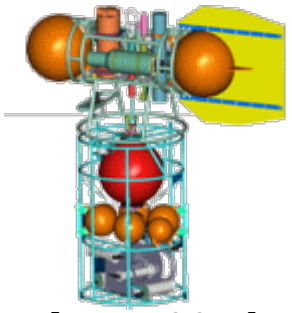
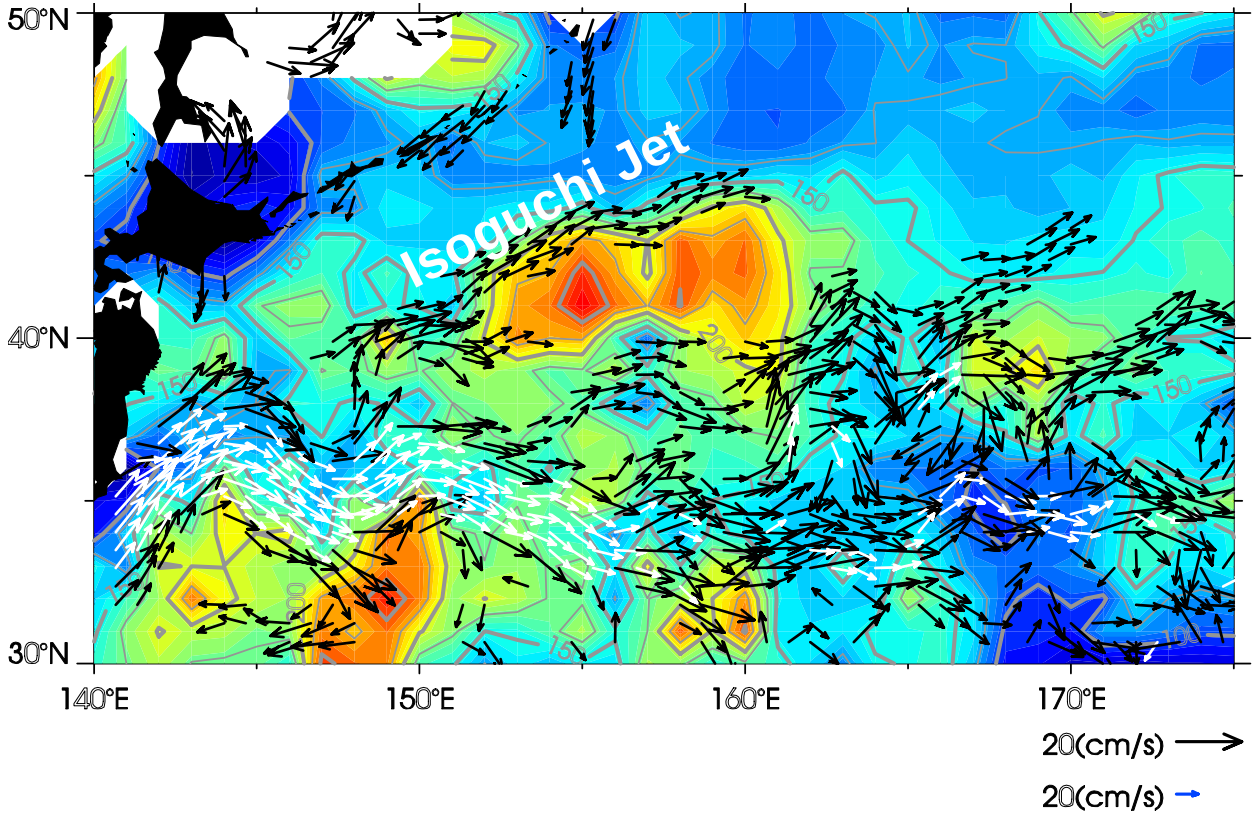
A quasi-steady warm water jet and an ecological hotspots in the western North Pacific

Shin-ichi Ito[1], Yugo Shimizu[1], Shigeho Kakehi[1], Taku Wagawa[1], Masatoshi Satoh[1], Daisuke Ambe[2], Takeshi Okunishi[2], Kazuyuki Uehara[3]
[1]Fisheries Research Agency (Tohoku), [2]Fisheries Research Agency, [3]Tokai University

1. Transition Region Mode Water & Isoguchi Jet
2. ecological hotspot
3. In situ observations (ship & profiling mooring buoy)



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



From
Isoguchi et al. (2006)

Wintertime MLD &
strong currents

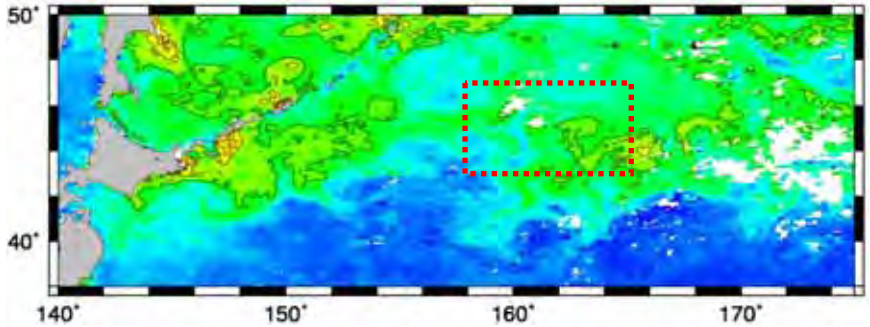
1. Suga et al. (2004) found deep winter mixed layer south of the subarctic front.
2. Isoguchi et al. (2006) found quasi-steady warm streamers on the north boundary of the deep MLD region (Isoguchi Jet).
3. Saito et al. (2007) found weak stratified thick layer in the deep MLD region and named as Transition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

Ecological hot spot : TRMW region

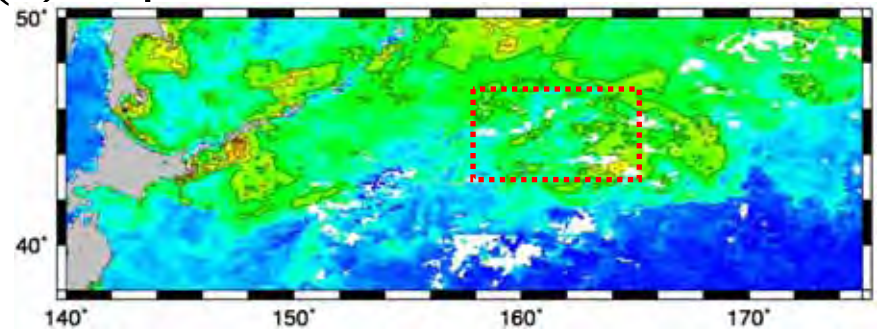
Okunishi et al. (F.O. accepted)

(a) Sep. 2005

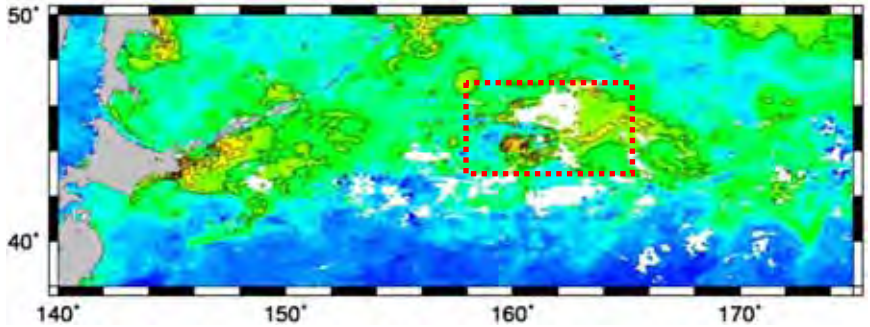
SeaWiFS Chl-a



(c) Sep. 2006



(e) Sep. 2007

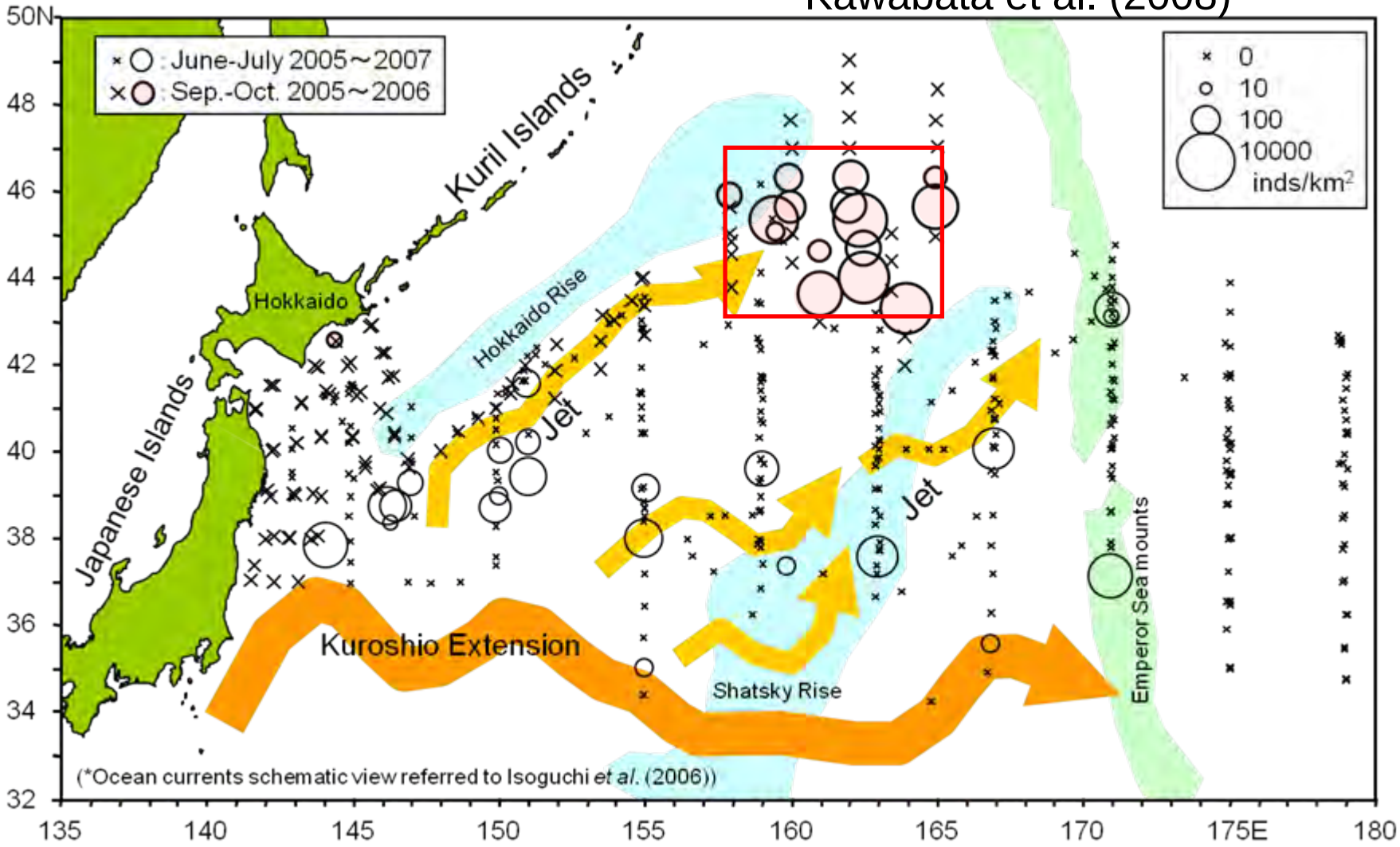


A Chl-a maximum is formed in the Transition Region Mode Water (TRMW) region in autumn.

an evidence of ecological hot spot in the offshore.

Distributions of Japanese sardine juveniles

Kawabata et al. (2008)



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

Ecological hot spot formation in the TRMW area

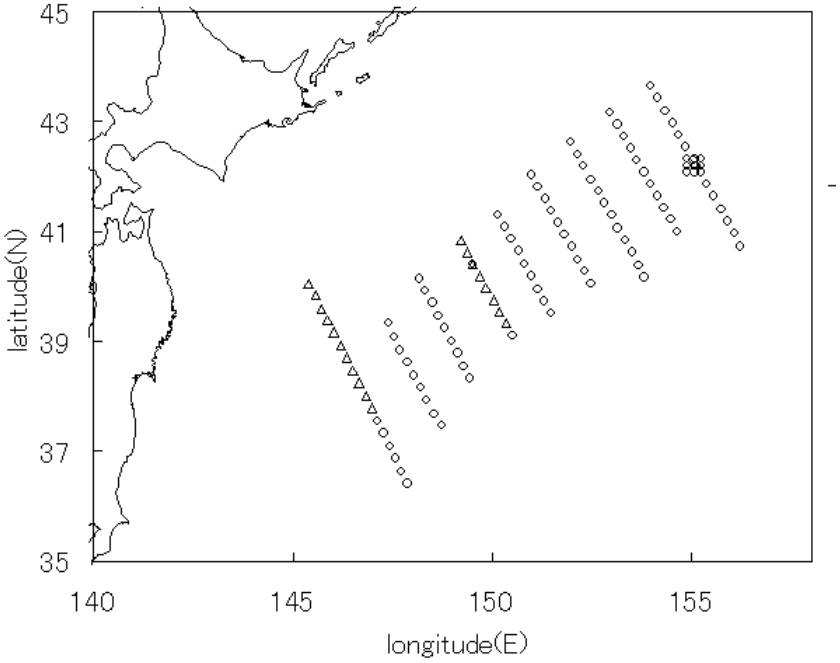
a. The Isoguchi Jet transports saltier and warmer water to the TRMW area and the deep mixed layer is formed by the winter cooling.
b. Accompanied with the deep mixed layer formation, a large nutrient supply is expected and hence higher primary production.
c. Indeed, recently, a large nursery ground for mackerel, anchovy and sardine was found near the TRMW region.
d. Therefore, the TRMW region seems as an ecological hotspot. It is important to observe the actual mixed layer formation process in the TRMW region.

However, the observations in this region have been limited to summer season because of rough sea condition in other seasons.

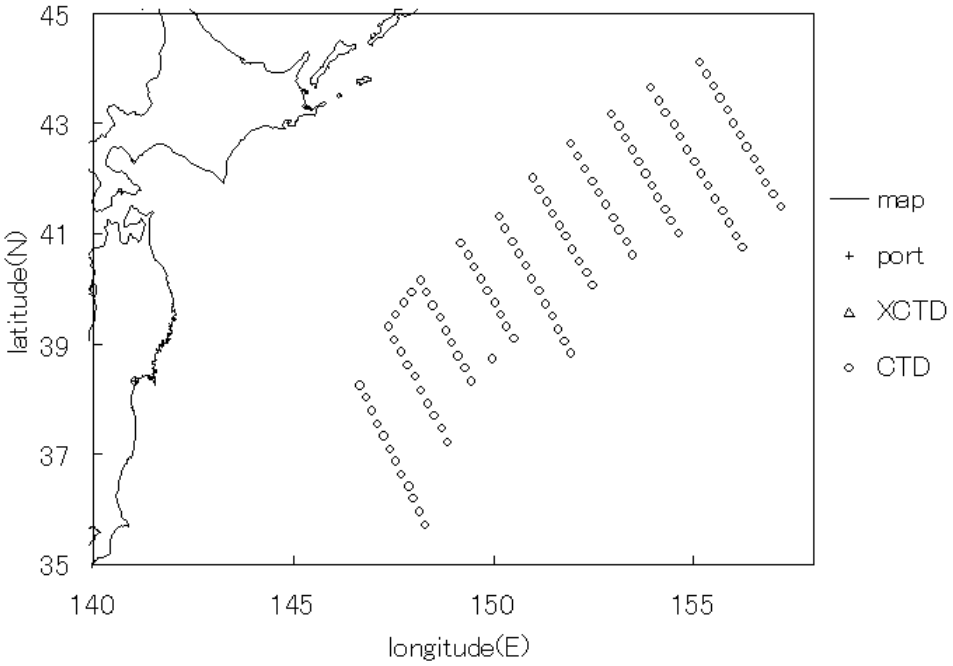
We designed observation combined by
✓synoptic survey by ship and
✓continuous observation by a profiling mooring buoy.

Hydrographic observations

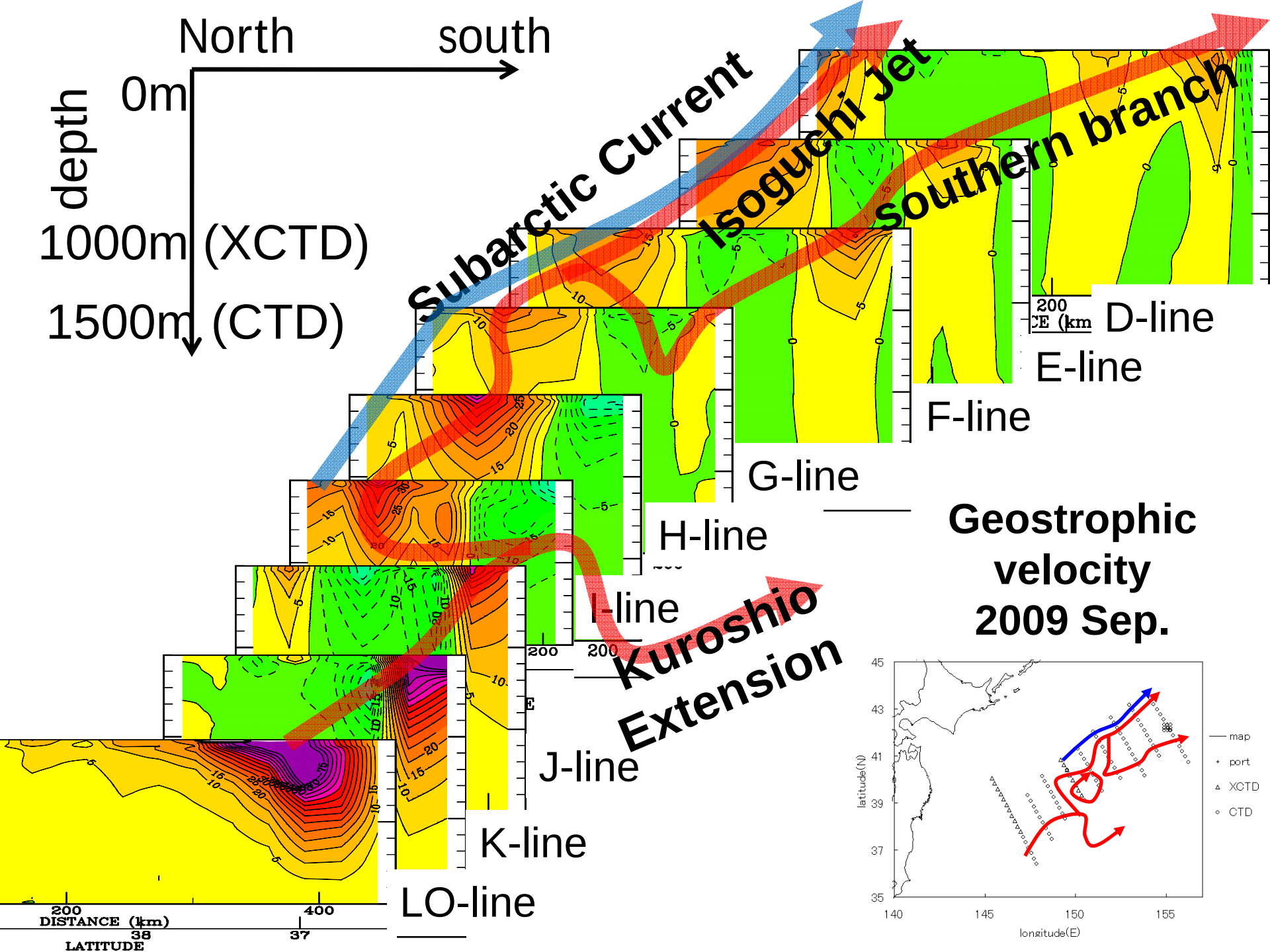
Wakataka-maru
2009 Sep.



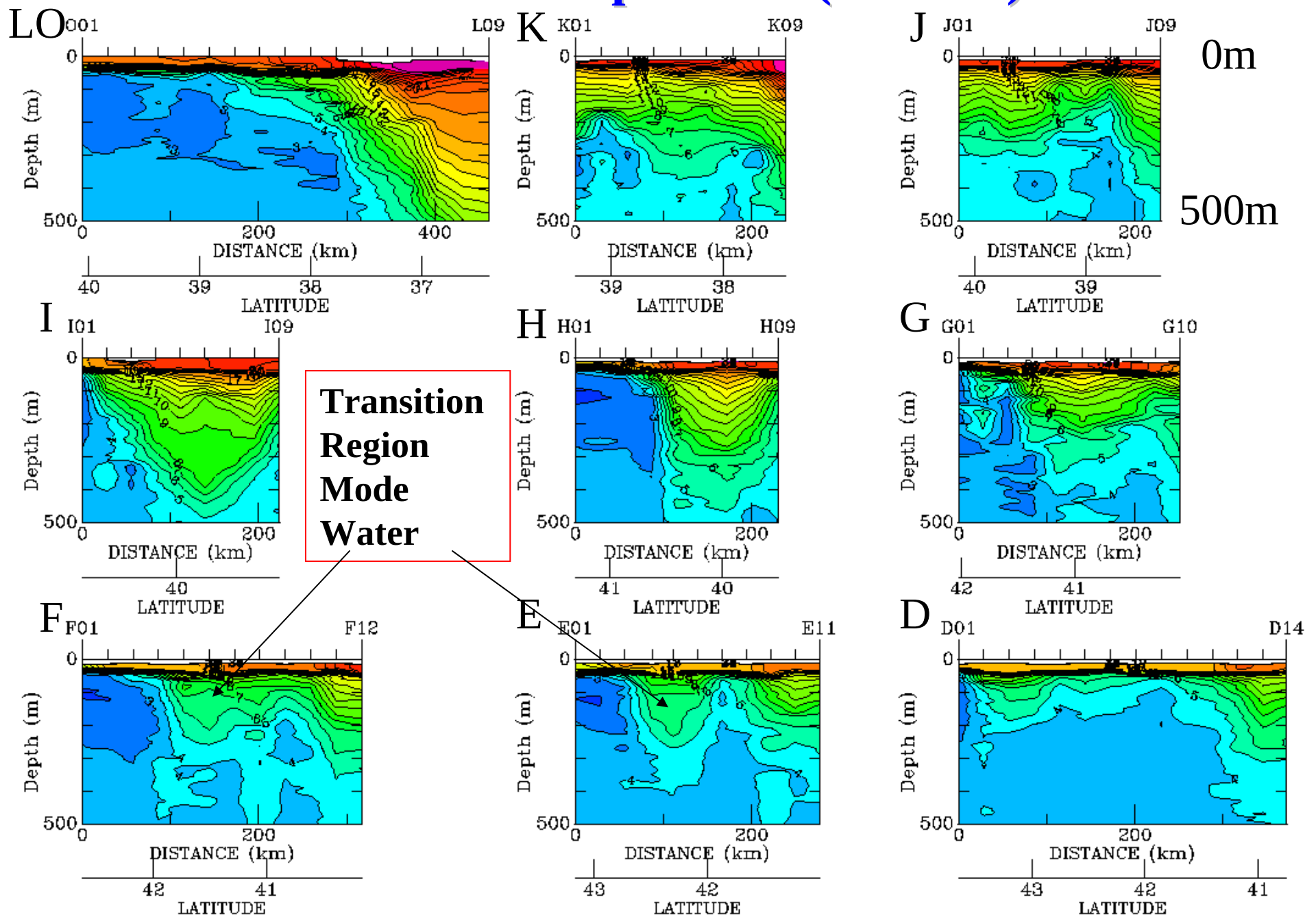
Wakataka-maru
2010 Sep.



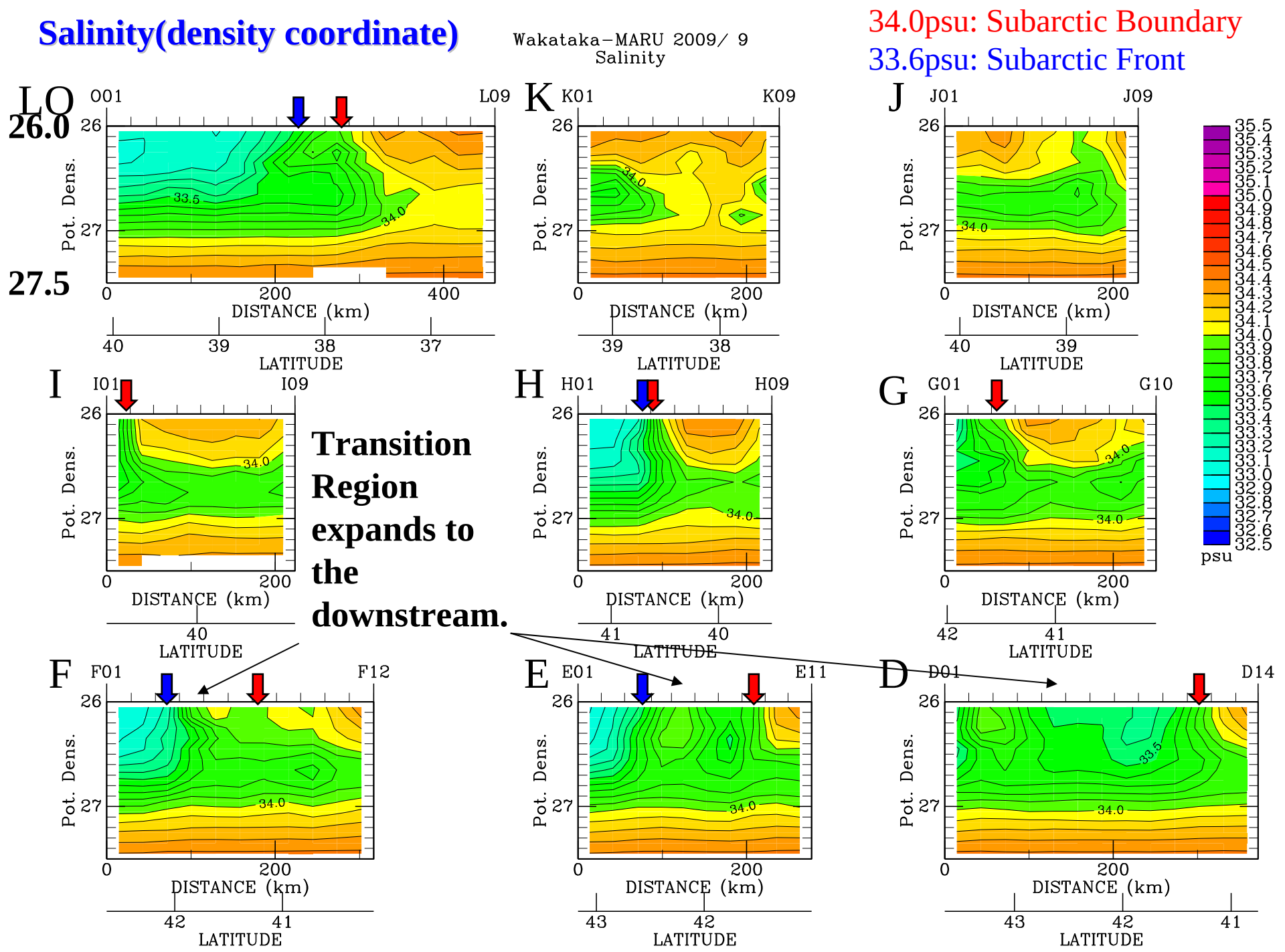
Synoptic survey of the Isoguchi Jet and the Transition Region Mode Water were conducted in 2009 and 2010.


North
south
depth
0m
1000m (XCTD)
1500m (CTD)
Subarctic Current
Isoguchi Jet
Southern branch
Kuroshio Extension
D-line
E-line
F-line
G-line
H-line
I-line
J-line
K-line
LO-line
Geostrophic velocity 2009 Sep.
DISTANCE (km)
LATITUDE
latitude(N)
longitude(E)
map
port
XCTD
CTD

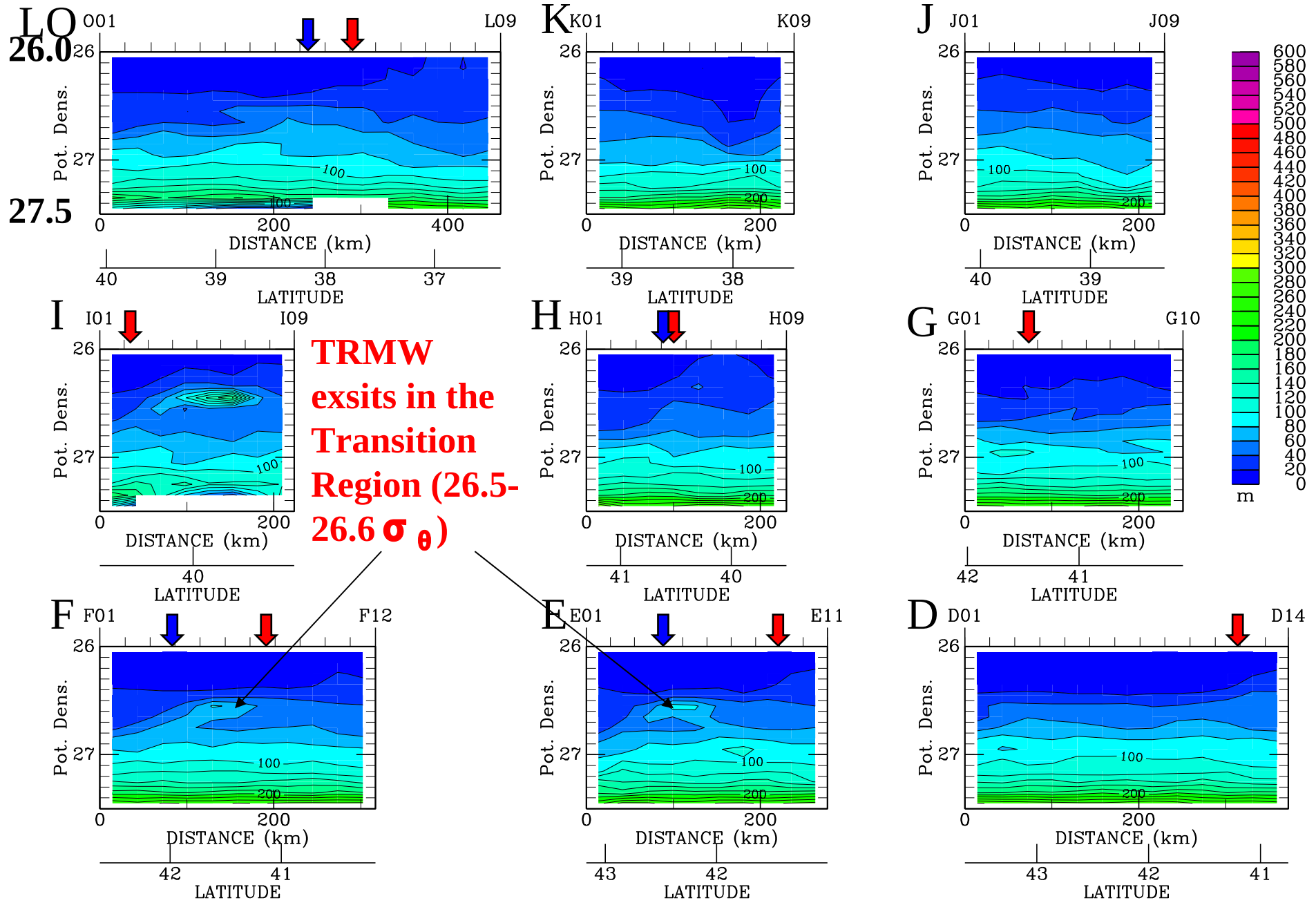
Potential Temperature (0-500 m)



Salinity(density coordinate)

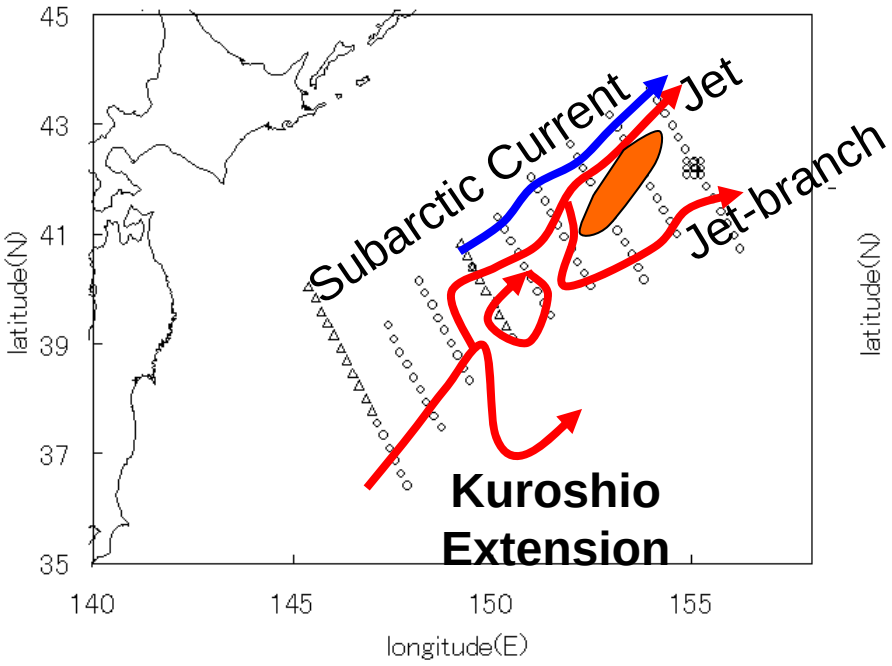


Thickness of isopycnal layer (density coordinate)

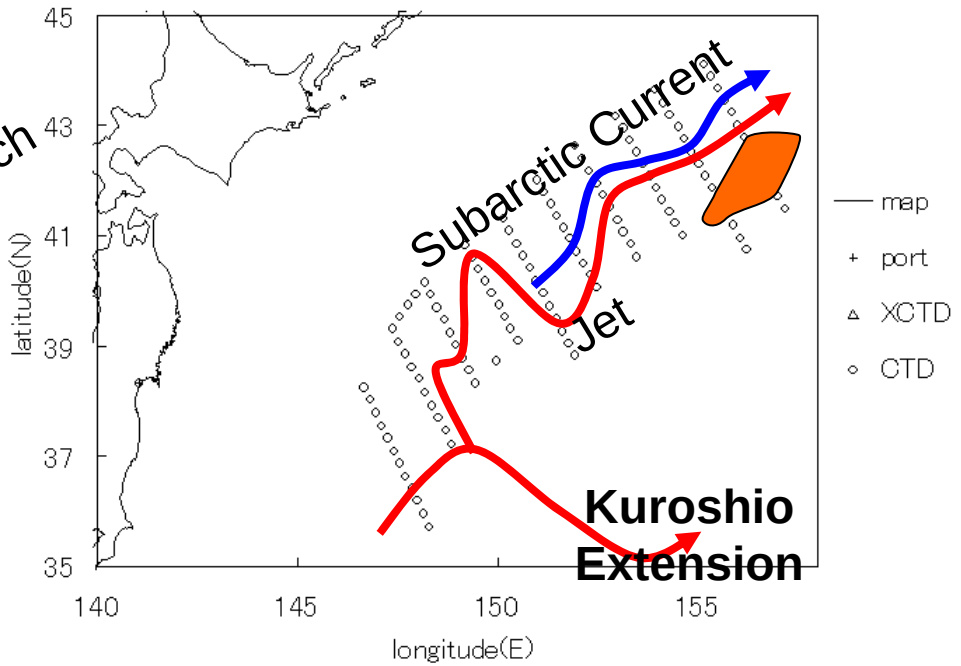


Isoguchi Jet and TRMW (Transition Region Mode Water)

2009 Sep.

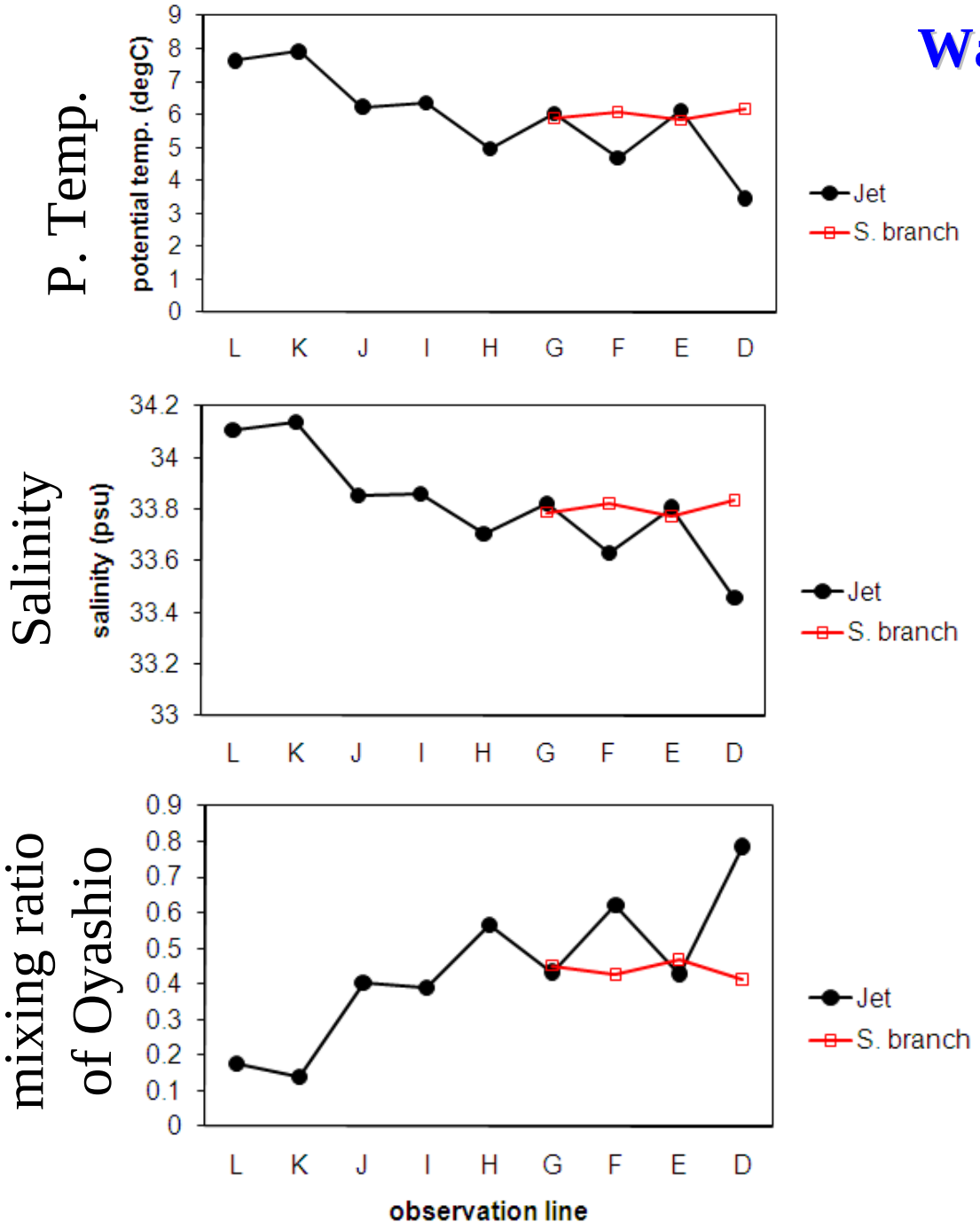


2010 Sep.



Isoguchi Jet flows parallel to the Subarctic Current.
TRMW locates in the south of the Isoguchi Jet.
TRMW appears in the region where the Transition Region becomes wider.

Water property (26.5-26.7 σ_θ) on the axis of jets

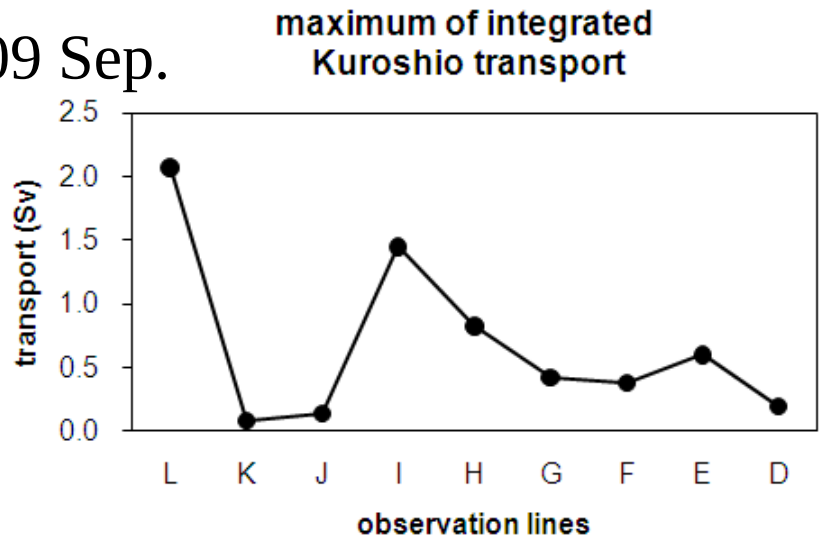


Isoguchi Jet:
become fresher and colder along to the downstream
=>water entrainment from the Subarctic Current

Southern Branch:
Steady
=>half between Kuroshio and Oyashio
corresponds to the Subarctic Boundary

Kuroshio-water component transport of Isoguchi Jet (26.5-26.7 σ_θ)

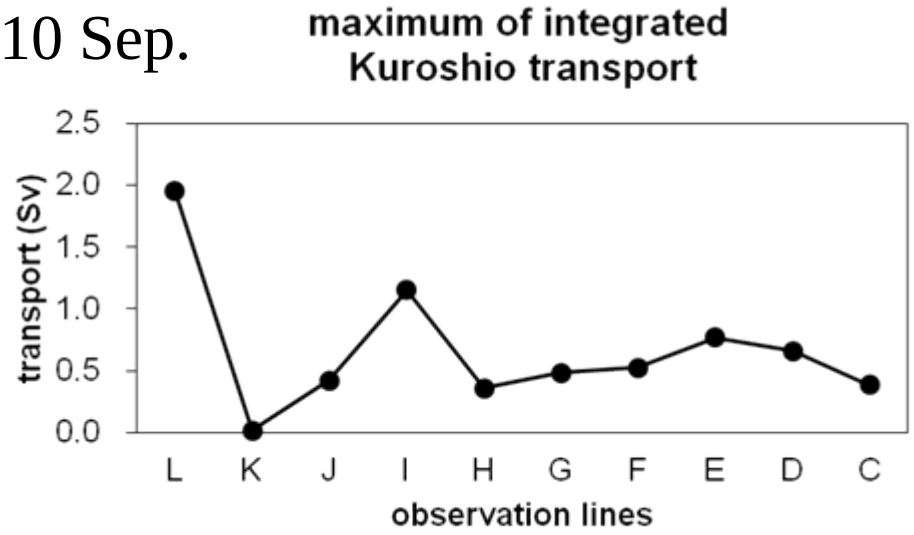
2009 Sep.



I-line 1.45 Sv
E-line 0.60 Sv
D-line 0.20 Sv

0.4 - 1.25 Sv decrease
=>input for the TRMW or Subarctic Current

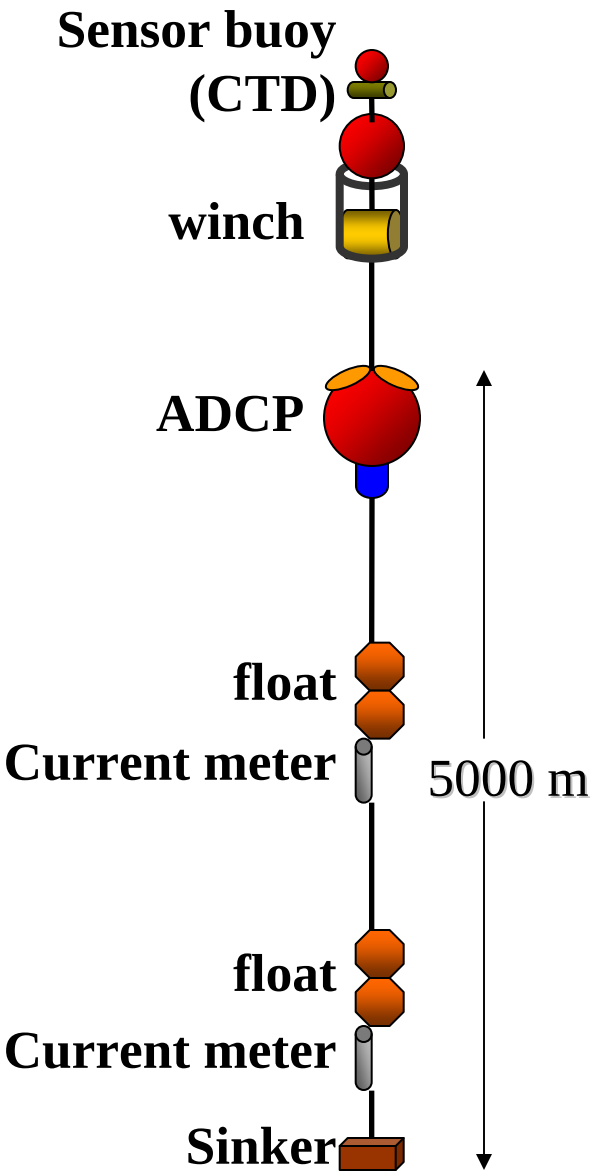
2010 Sep.

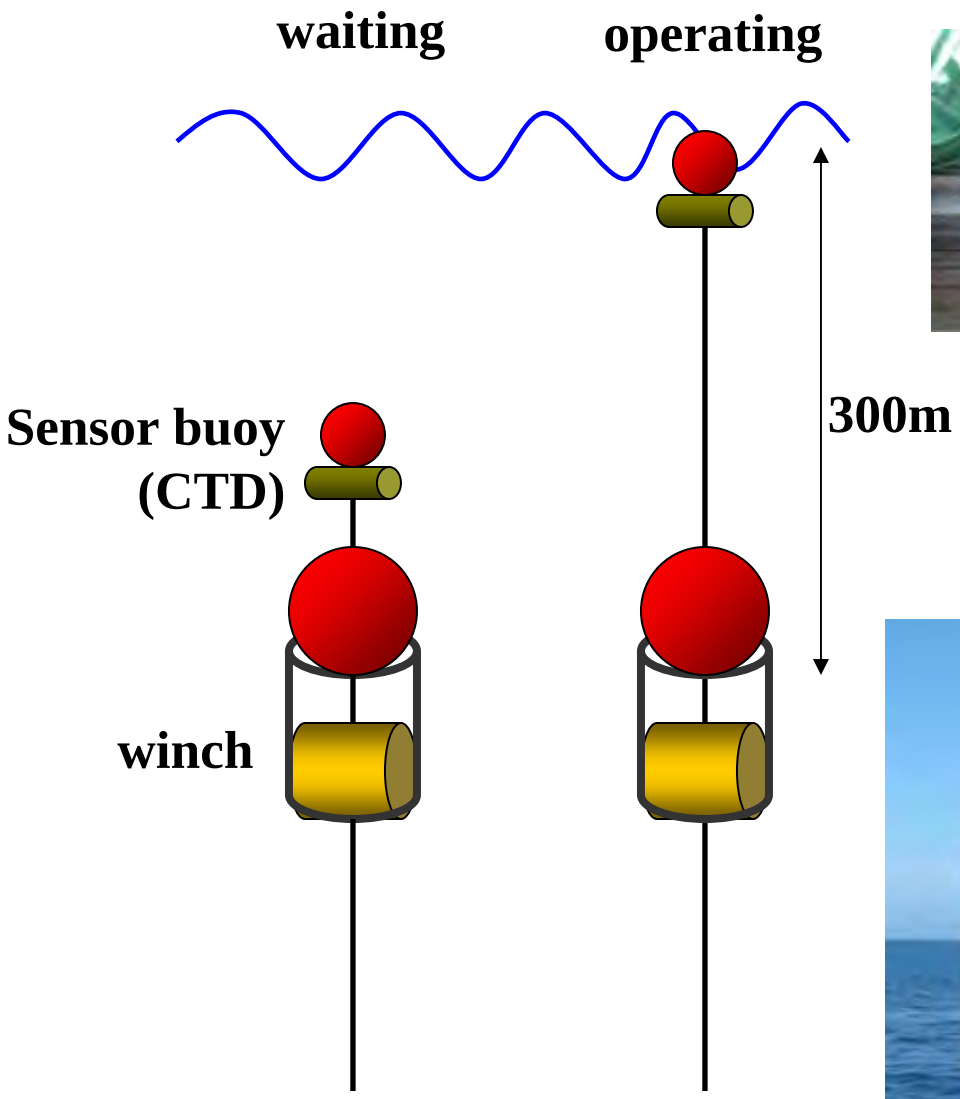


I-line 1.15 Sv
E-line 0.77 Sv
C-line 0.39 Sv

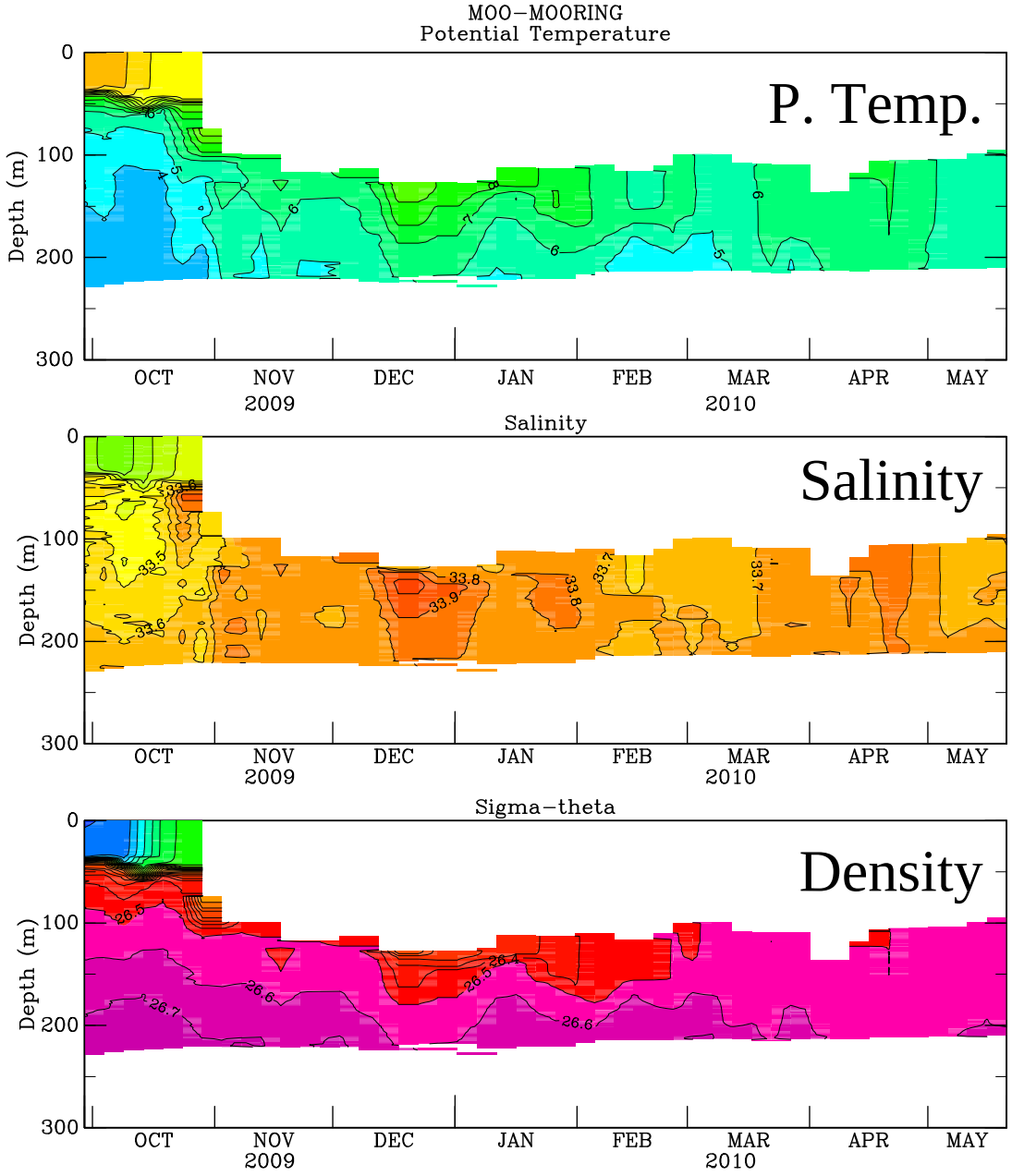
0.38 - 0.76 Sv decrease
=>input for the TRMW or Subarctic Current

Profiling mooring buoy
Automatic Elevator System (underwater winch)





Observation of TRMW region by AES



From 2009 Sep. to 2010 May.
At 42-13N 155-08E.

Upper of the 100 m could not be observed because of the mechanical problem.

Weak stratification in March.
=>Mixed layer reached more than 220 m (26.6 σ_θ).

Water becomes saltier and warmer when the mixed layer depth is deepened.
=>Kuroshio component inputs to the mode water.

Conclusion

Quasi-steady jet (Isoguchi Jet):

continuous flow (confirmed by observations)

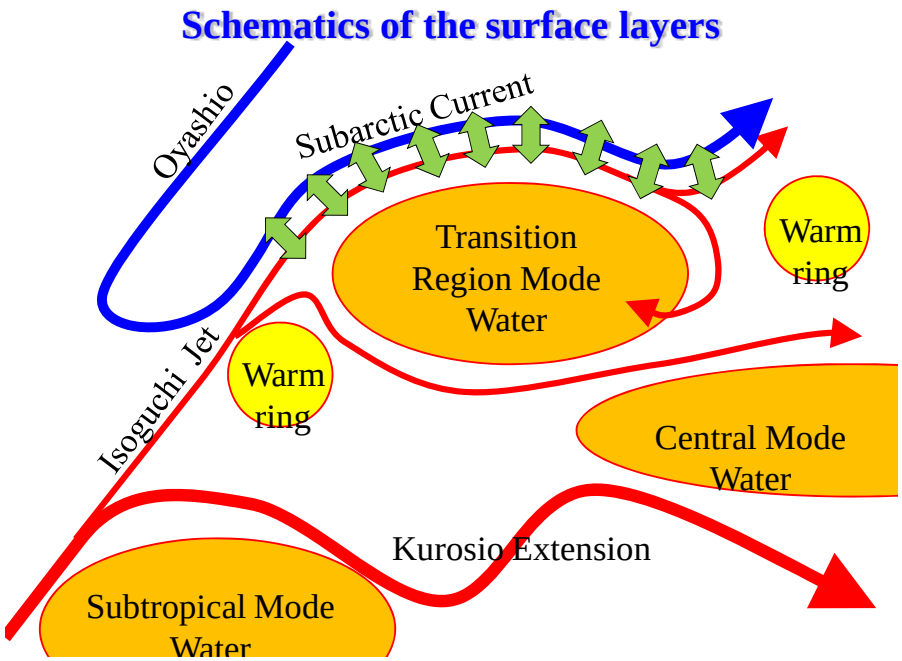
Isoguchi Jet flows parallel to the Subarctic Current.

Isoguchi Jet entrainments the Oyashio Water **=> nutrient inputs**

Transition Region Mode Water (TRMW)

TRMW locates in the south of the Isoguchi Jet.

Salinity input by the Isoguchi Jet water is essential to the deep mixed layer formation. **=>nutrient inputs**



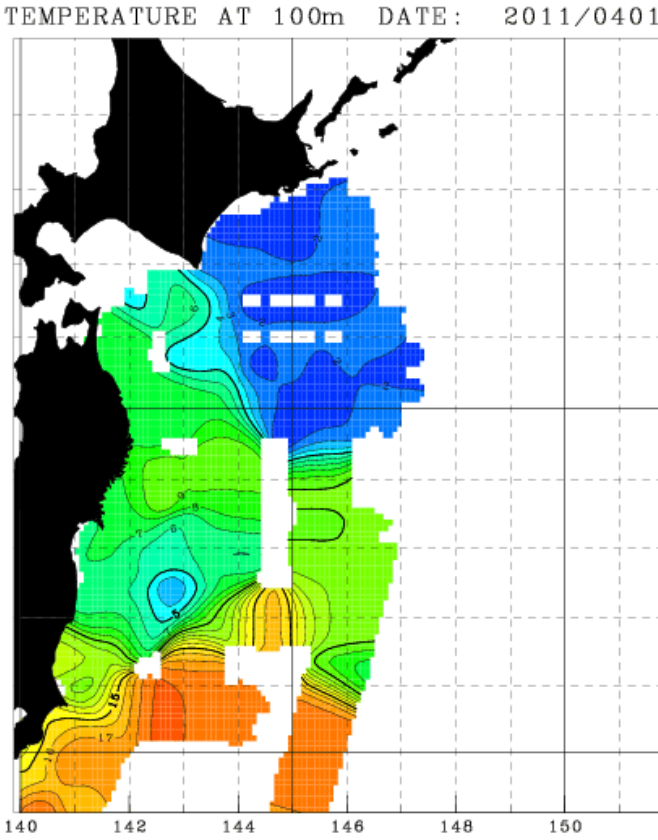
Formation of a ecological hotspot:

1.Nutrient supply from the deeper layer by the TRMW formation (contributed by salinity supply by the Isoguchi Jet).

2.Nutrient entrainments from the Oyashio Water by the Isoguchi Jet.

Tsunami

100m temp. field in Apr. 2011



The Tohoku (Northeastern) region in Japan was severely impacted by an earthquake and a subsequent tsunami. Many people lost their precious lives. Many institutes and research vessels were also destroyed.
However, many countries supported and encouraged our recovery from the disaster. We sincerely appreciate worldwide supports to us.