Western North Pacific Integrated Physical-Biogeochemical Ocean Observation Experiment: Summary of the Intensive Observation around the Biogeochemical Mooring S1 (S1-INBOX)

Toshio Suga[1,2], Ryuichiro Inoue[1], Shinya Kouketsu[1], Shigeki Hosoda[1], Taiyo Kobayashi[1], Kanako Sato[1], Hiroyuki Nakajima[3], Makio Honda[1], Tetsuichi Fujiki[1], Kazuhiko Matsumoto[1], Takeshi Kawano[1] and Toshiro Saino*

1: JAMSTEC; 2: Tohoku University; 3: MWJ *Deceased

POC Paper Session
PICES-2014
October 16-26, 2014, Yeosu, Republic of Korea

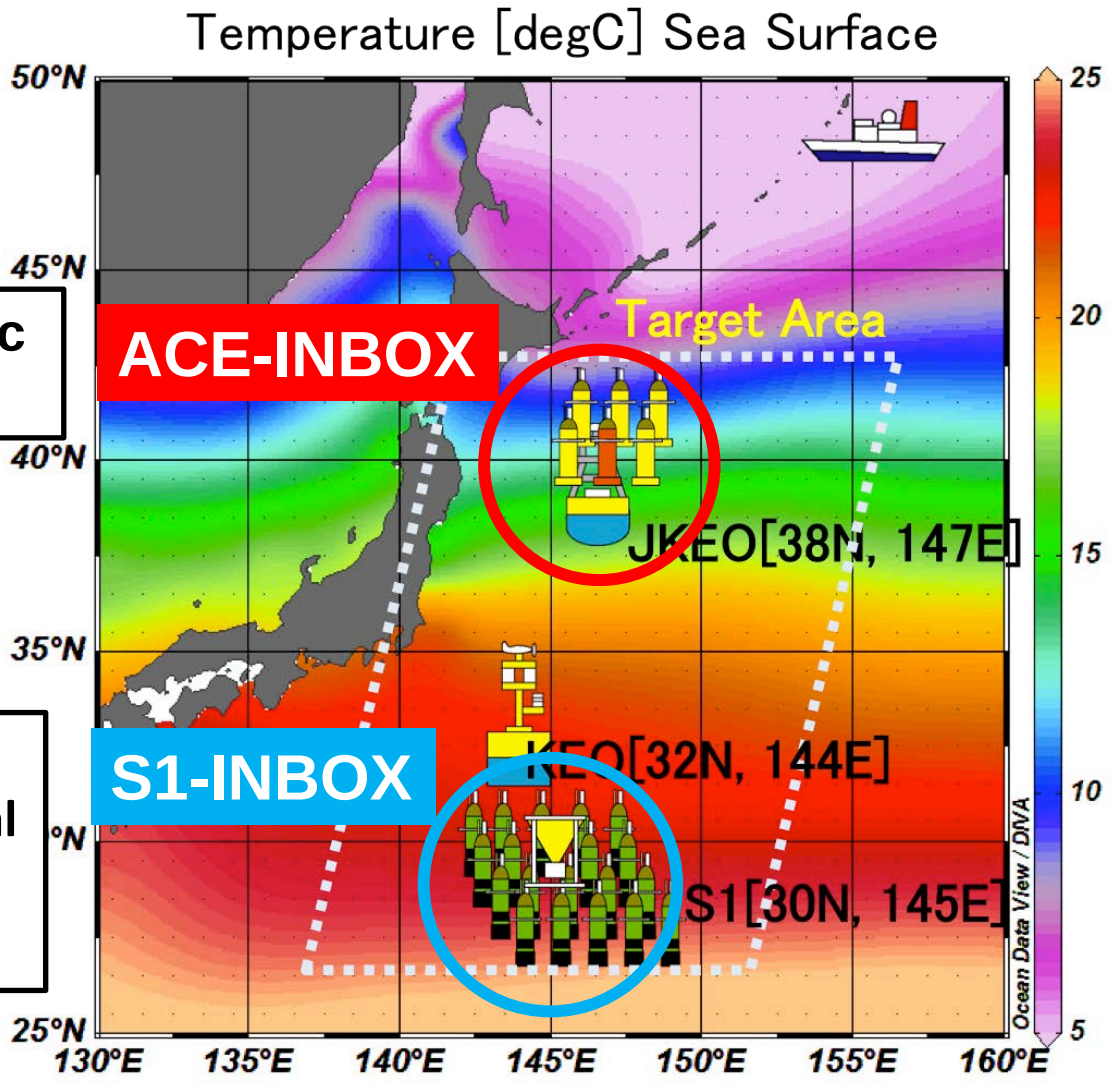
Western North Pacific Integrated Physical-Biogeochemical Ocean Observation Experiment (INBOX):

JAMSTEC interdisciplinary project launched in 2011

- **Combining intensive observation by autonomous platforms and ship/mooring/satellite observations**

- **to acquire physical-biogeochemical data which could resolve mesoscale or smaller-scale phenomena**
- **to quantify impacts of physical processes on biogeochemical phenomena**
- **to acquire scientific/technological knowledge as a basis for future observing system such as Bio Argo**

Western North Pacific Integrated Physical-Biogeochemical Ocean Observation Experiment (INBOX)



AntiCyclonic Eddy

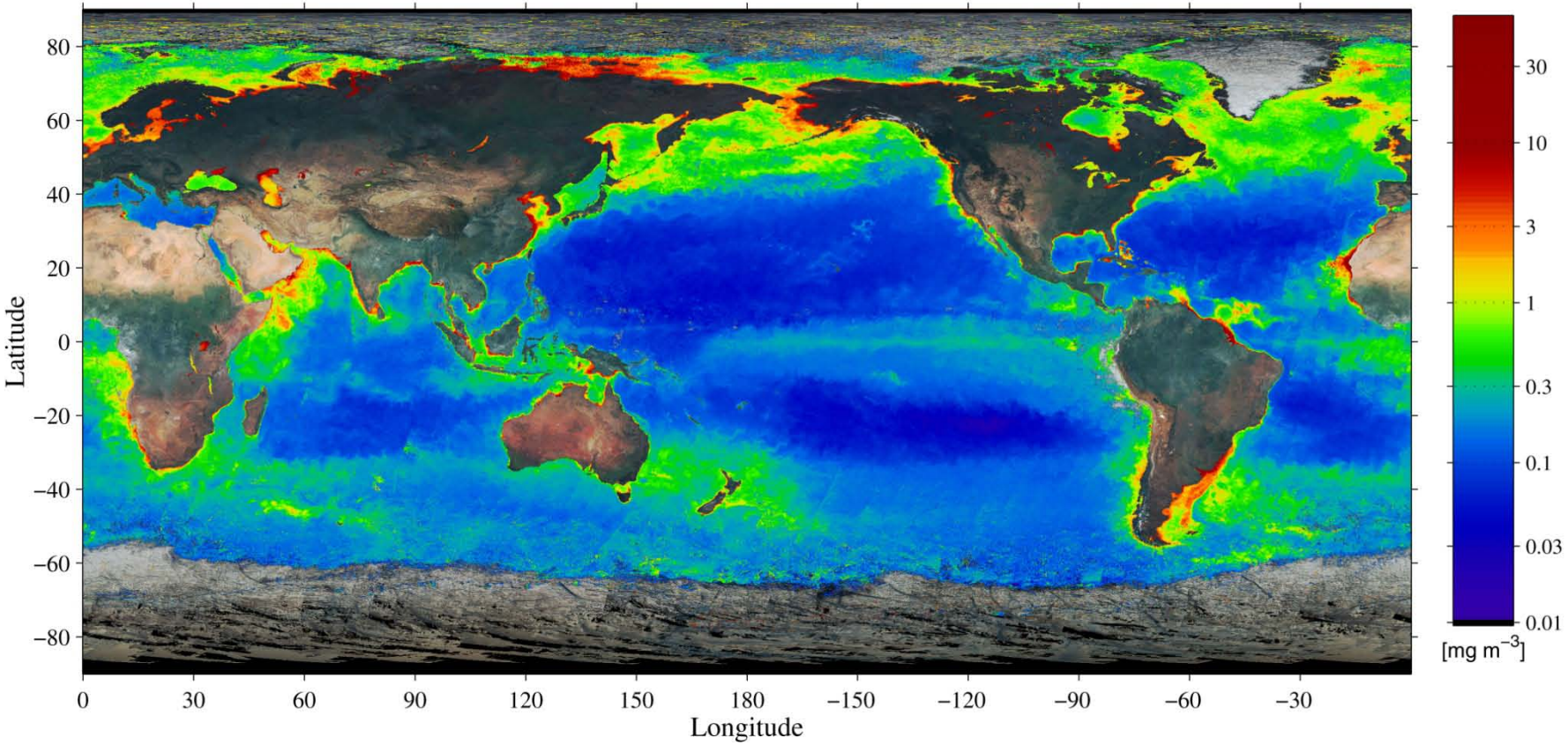
around Biogeochemical Mooring S1 (30N, 140E)

Observations and main outcomes from S1-INBOX are summarized.

Primary production in subtropical oceans

"The question of whether the plankton communities in low nutrient regions of the ocean, comprising 80% of the global ocean surface area, are net producers or consumers of oxygen and fixed carbon is a key uncertainty in the global carbon cycle." (Riser & Johnson, 2008)

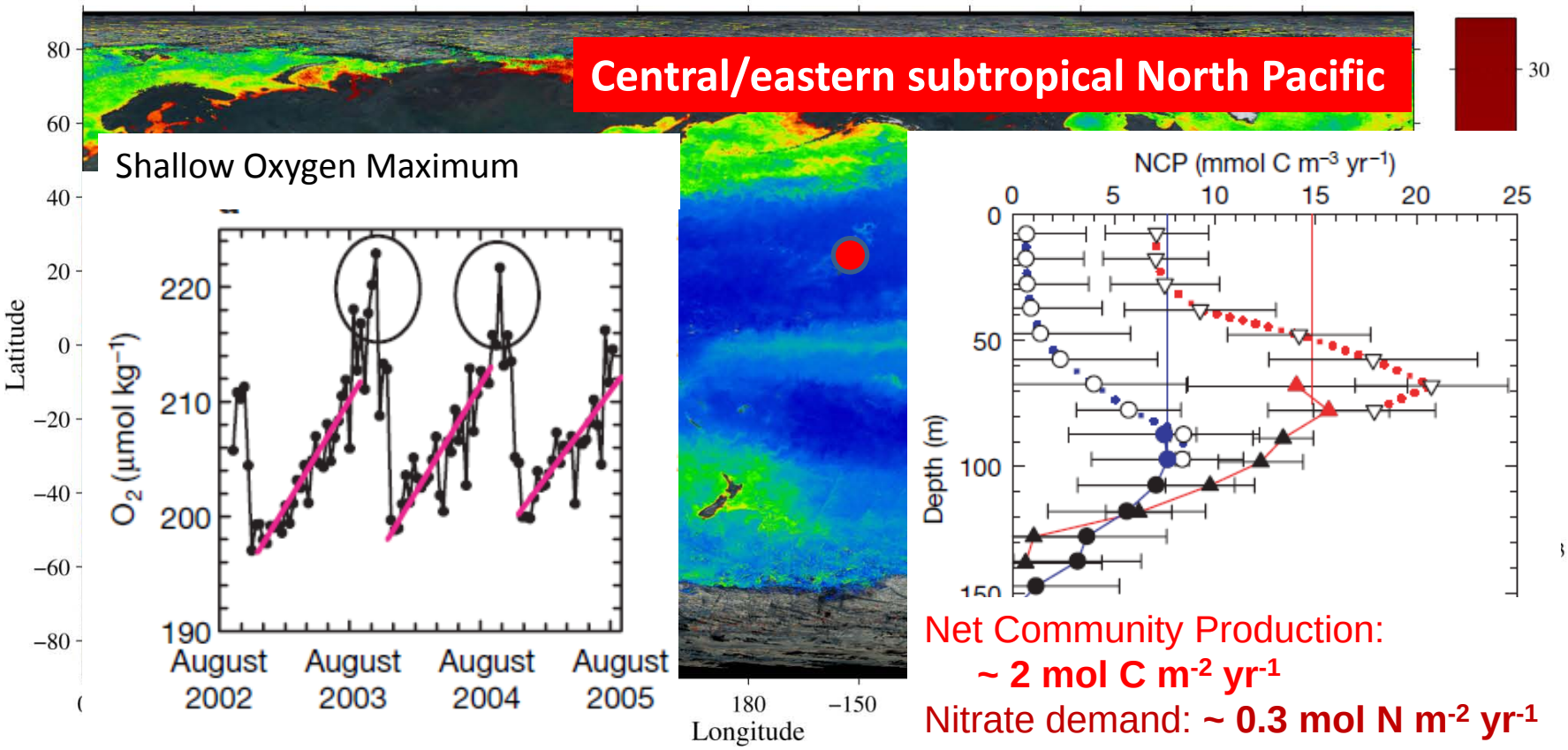
Chlorophyll-a, October 2003 (ADEOS-II)



Primary production in subtropical oceans

"The question of whether the plankton communities in low nutrient regions of the ocean, comprising 80% of the global ocean surface area, are net producers or consumers of oxygen and fixed carbon is a key uncertainty in the global carbon cycle." (Riser & Johnson, 2008)

Chlorophyll-a, October 2003 (ADEOS-II)

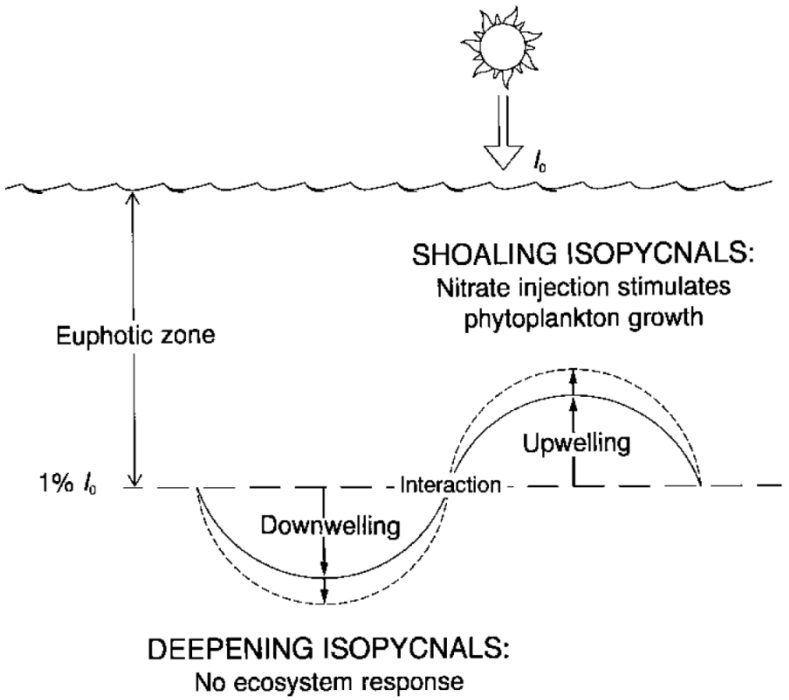


Net Community Production:
~ 2 mol C m^{-2} yr^{-1}

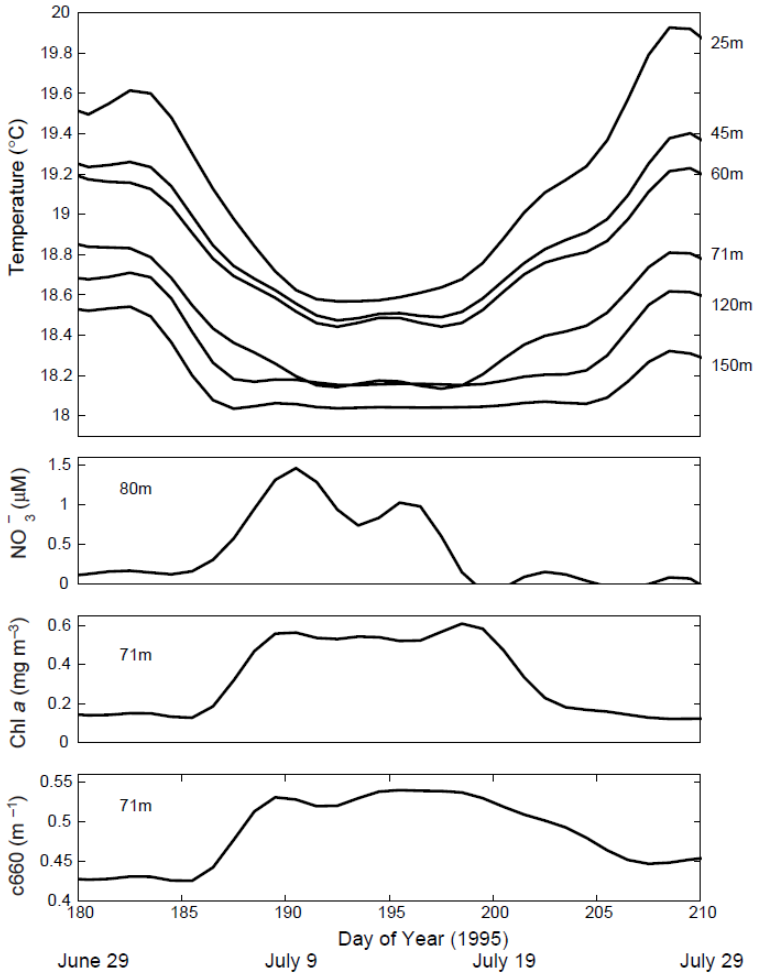
Nitrate demand: **~ 0.3 mol N m^{-2} yr^{-1}**

Eddy upwelling: a possible key process

McGillicuddy et al. (1998)



Bermuda Testbed Mooring



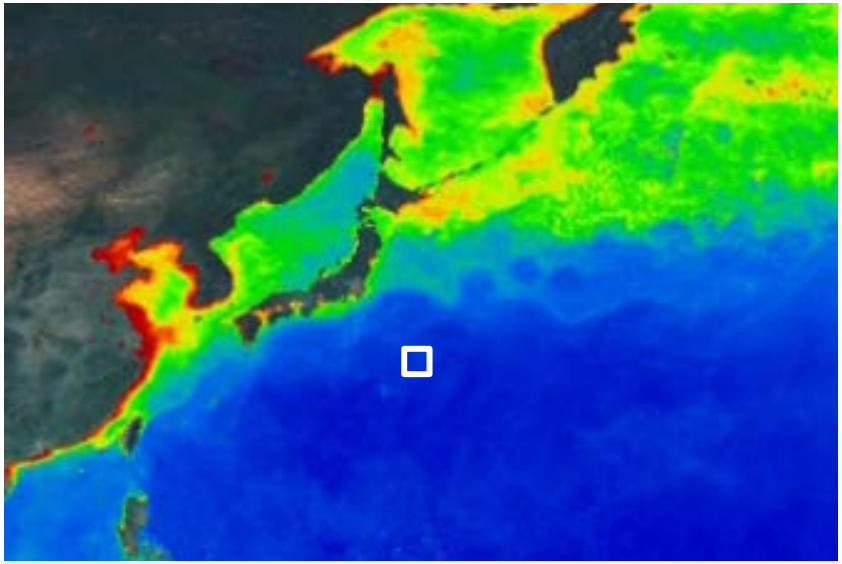
Annual nitrate flux into euphotic zone is estimated combining this observation and satellite-derived sea level anomaly.

~ 0.19 ± 0.10 mol N m^{-2} yr^{-1}

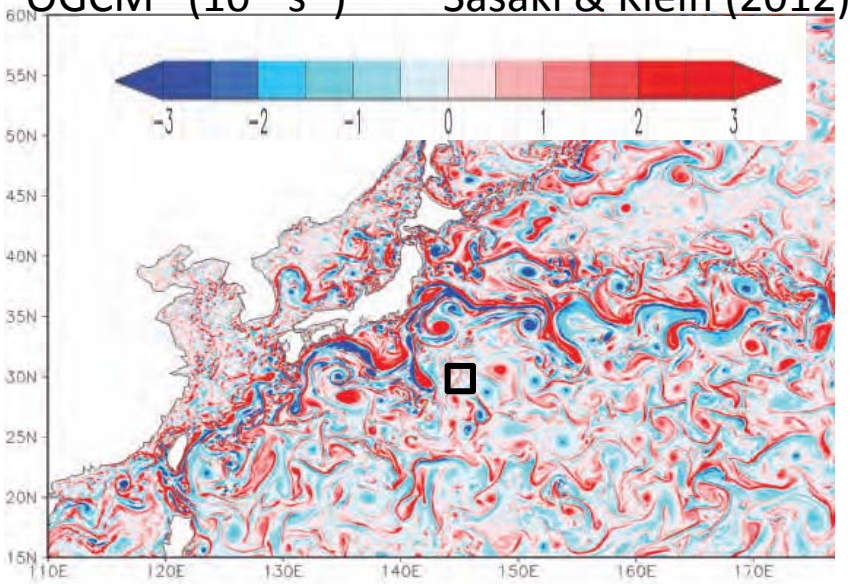
However, episodic phenomena continue to be **undersampled** for more complete assessment of the influence of mesoscale processes on biogeochemical cycling.

S1-INBOX：Western Subtropical North Pacific

Chlorophyll-a, October 2003 (ADEOS-II)



Relative vorticity from high-resolution (~3km) OGCM (10^{-5} s^{-1}) Sasaki & Klein (2012)



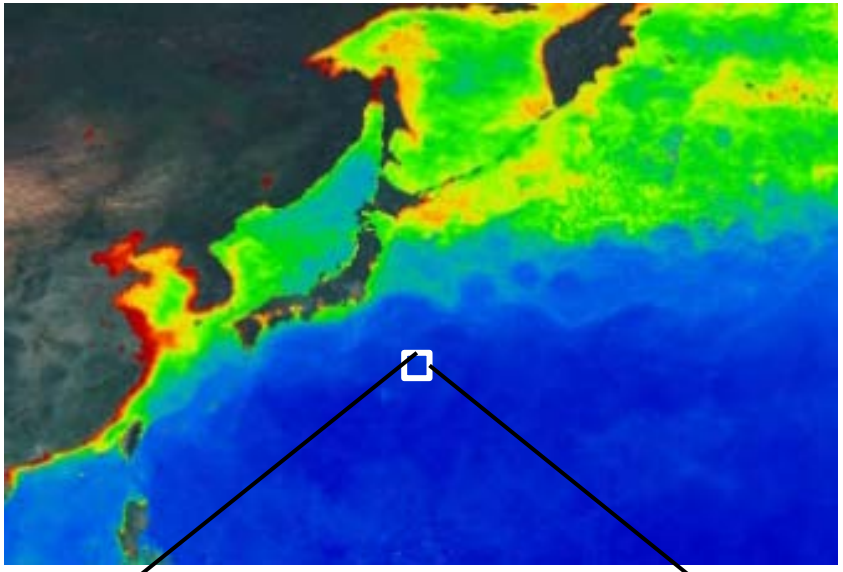
Biogeochemical mooring site S1 (30N, 140E)

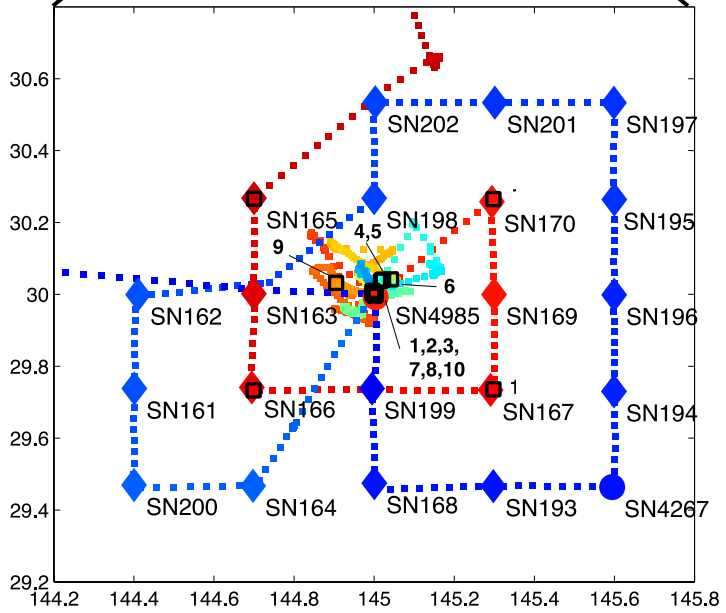
Oligotrophic region

Weak direct influence from the energetic Kuroshio Extension

Suitable to examine effects of physical phenomena of mesoscale or smaller scale and atmospheric disturbances on biogeochemical processes

S1-INBOX : Western Subtropical North Pacific





8/1

R/V Mirai Cruise MR11-05
late July - early August, 2011

22 Profiling floats with DO sensor

150 km square area around S1
Deployment spacing: 30 km
Sampling period: 2 days
Profiling depth: 2000 dbar
Parking depth: 1500 dbar

Shipboard measurements

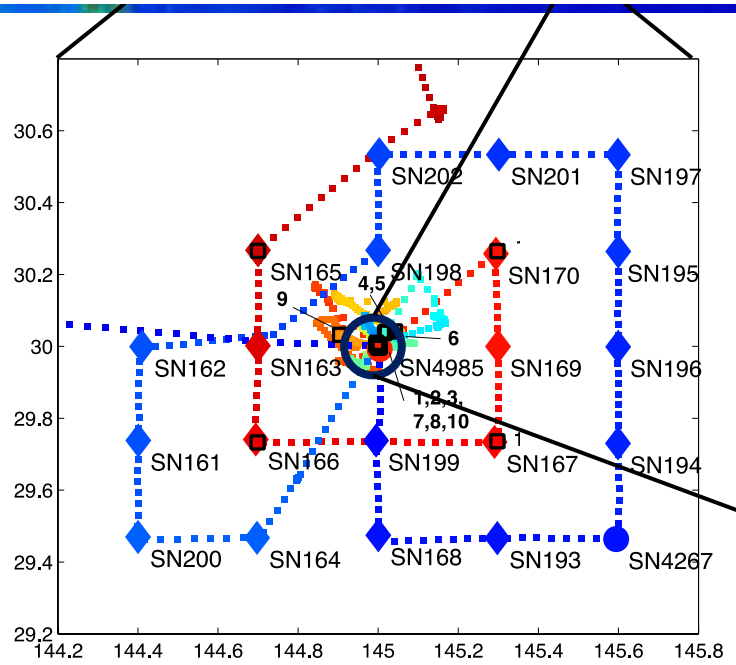
CTD and water sampling
10 casts at S1, 4 around it
Drifting sediment trap near S1

7/22

S1-INBOX : Western Subtropical North Pacific

Time-series observations with mooring system at S1

- -Underwater profiling buoy:
  Primary Productivity Profiler (FRRF) and CTDO for the top 200 m [every 3 days]
- -ADCP for 50-600 m [every hour]
- -Sediment traps [every 12 days] at 200 m, 500 m & 5000 m



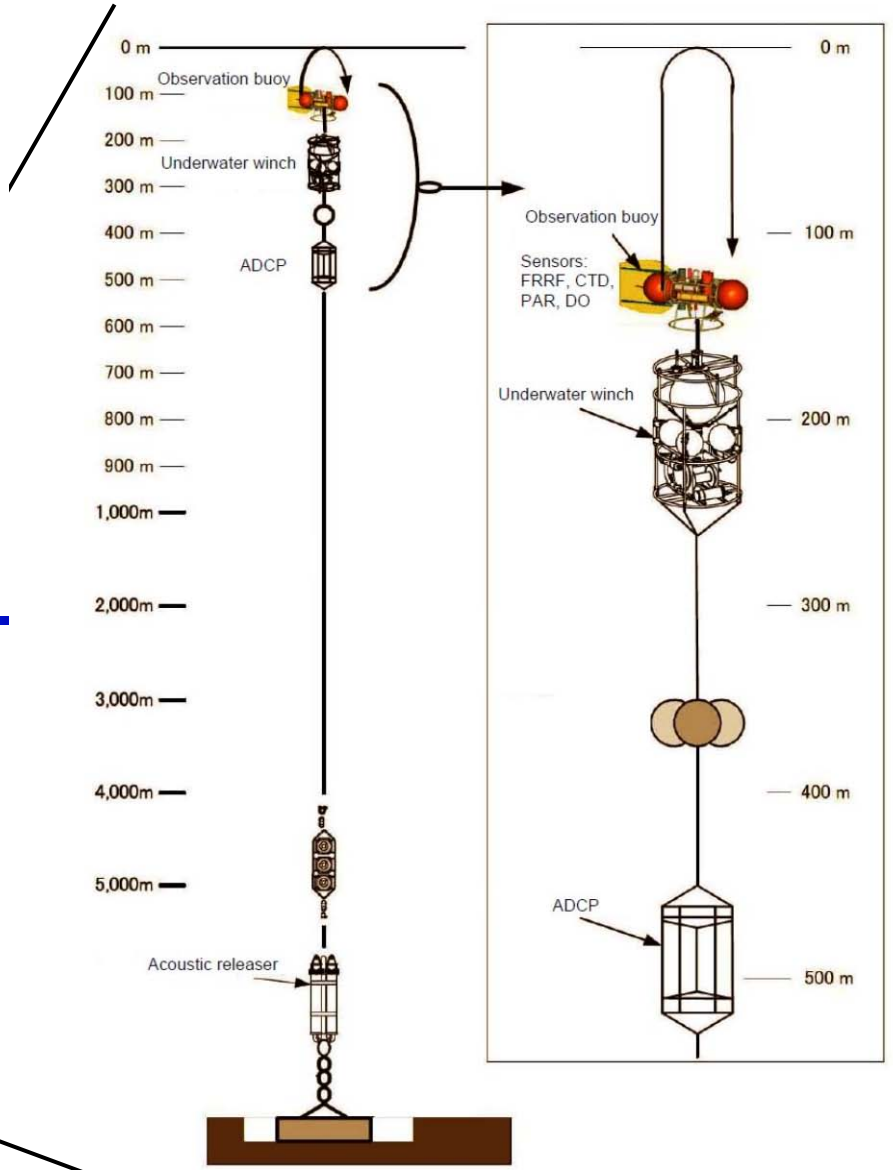
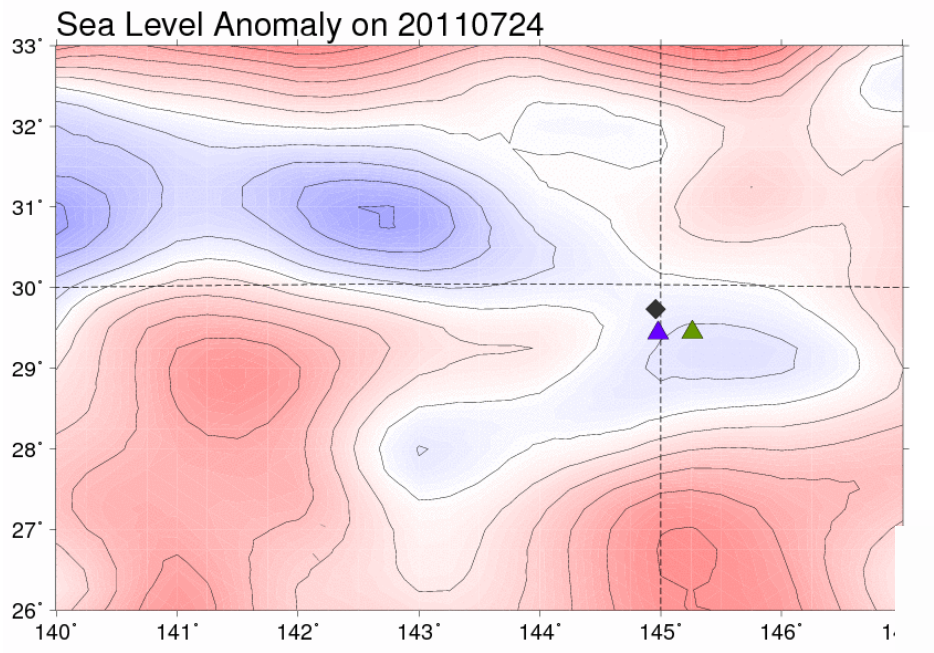


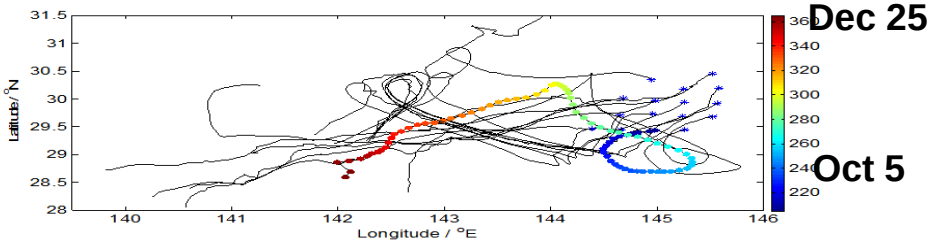
Figure 1. Schematic diagram of the primary productivity profiler.

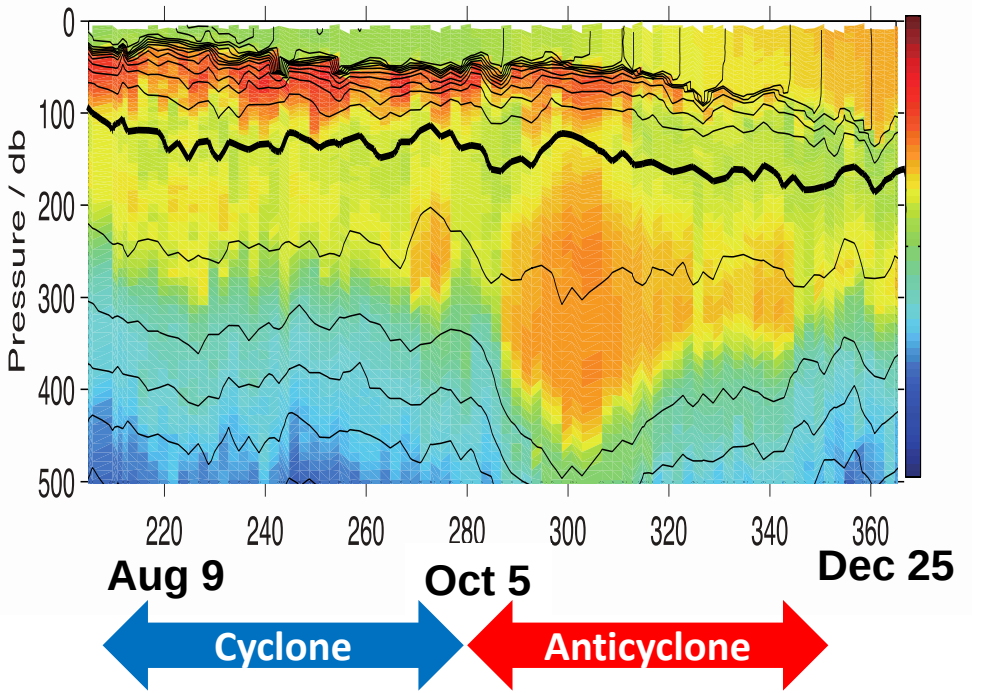
Floats drifting among cyclonic and anticyclonic eddies

SSHA: July 30, 2011 – May 25, 2012



Trajectory of the float array





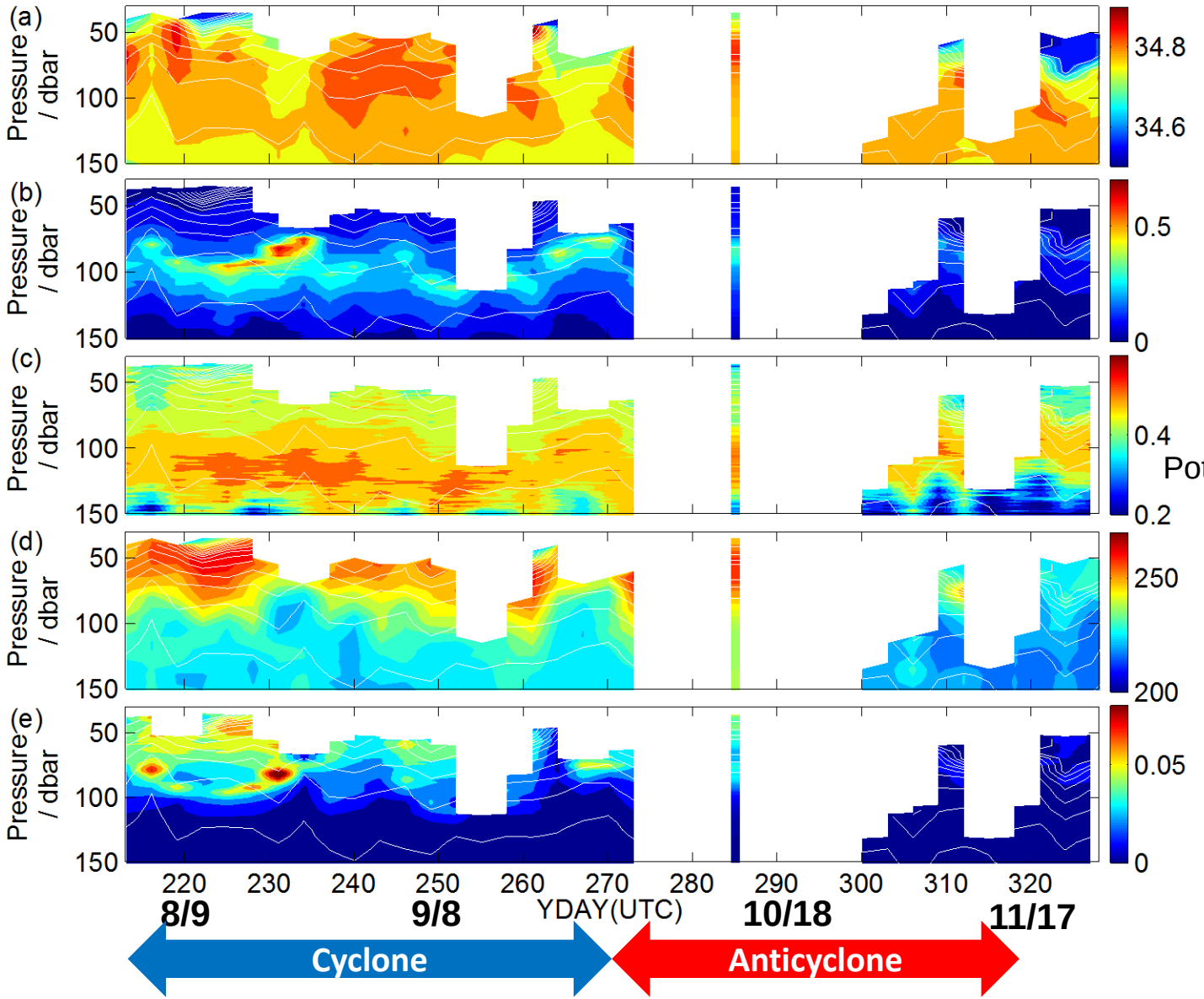
August-September

Cyclonic eddy passed south of S1

October-November

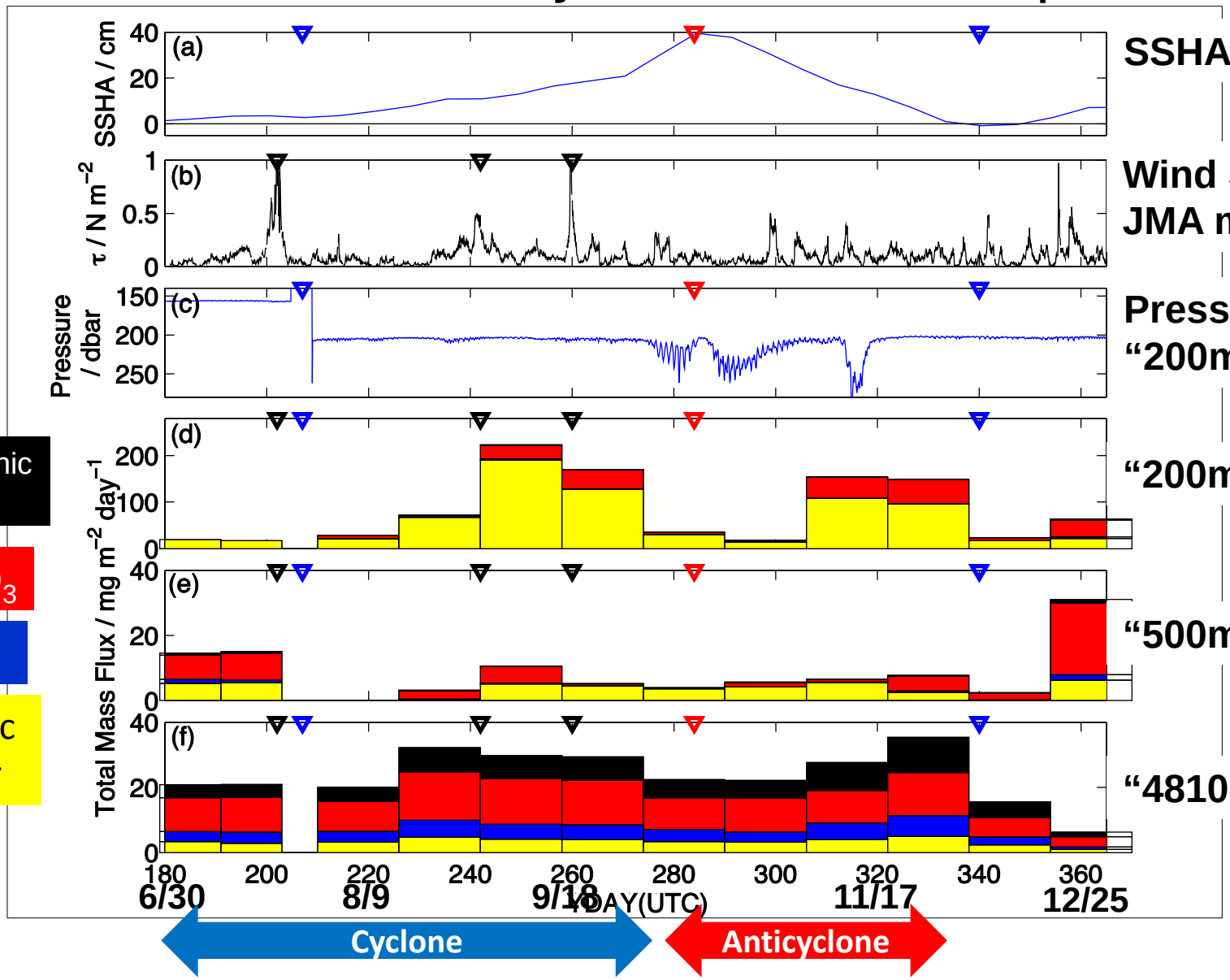
Anticyclonic eddy (Mode water eddy) passed thorough S1

Time series date by the underwater profiling buoy at S1



High Chl-a and high oxygen production rate appearing near the edge of the cyclonic eddy on time scale shorter than a week

Time series data by the sediment trap at S1



Lithogenic matter

$CaCO_3$

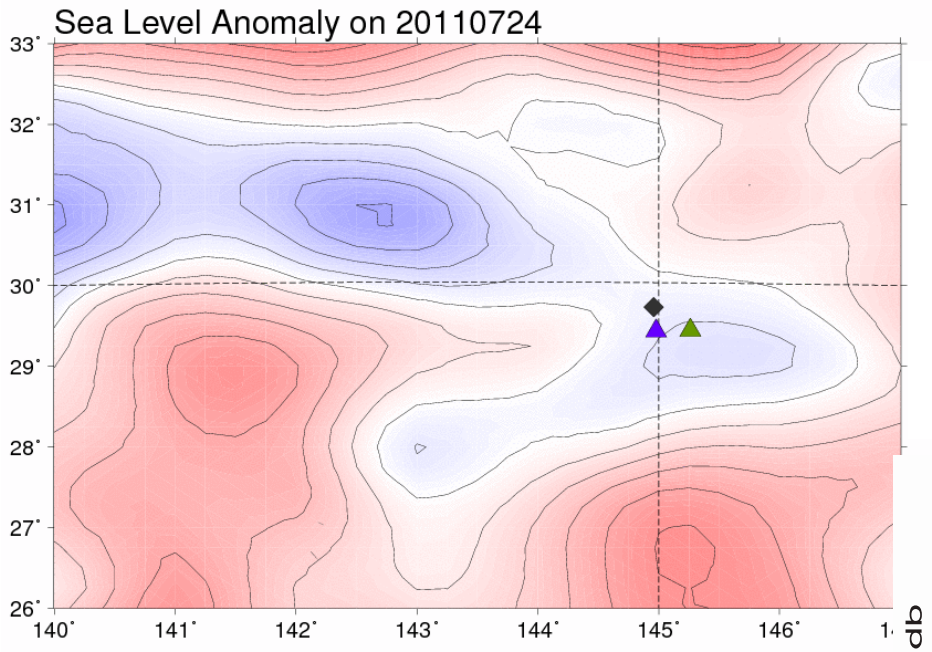
Opal

Organic matter

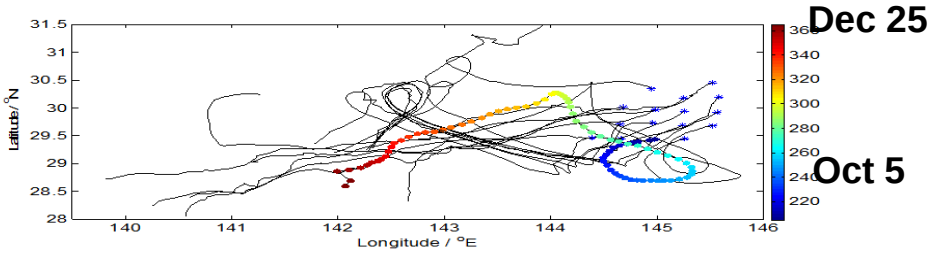
Large mass flux at 200 m during passage of cyclonic eddy and anticyclonic eddy, comparable to that during spring broom

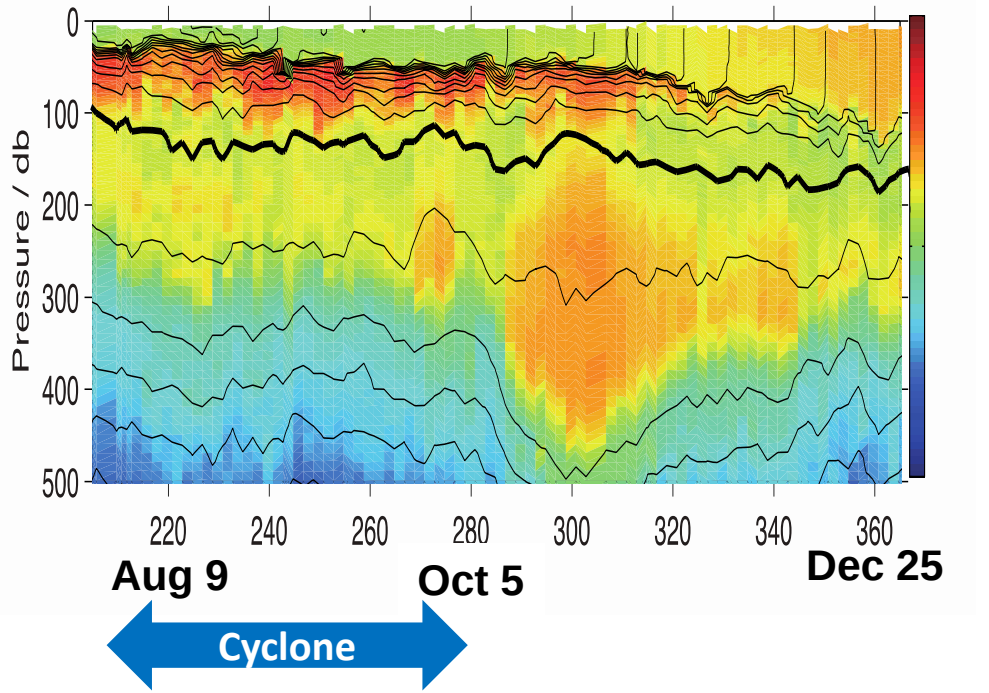
Analysis of the float array data during the period cyclonic eddy passed

SSHA: July 30, 2011 – May 25, 2012



Trajectory of the float array

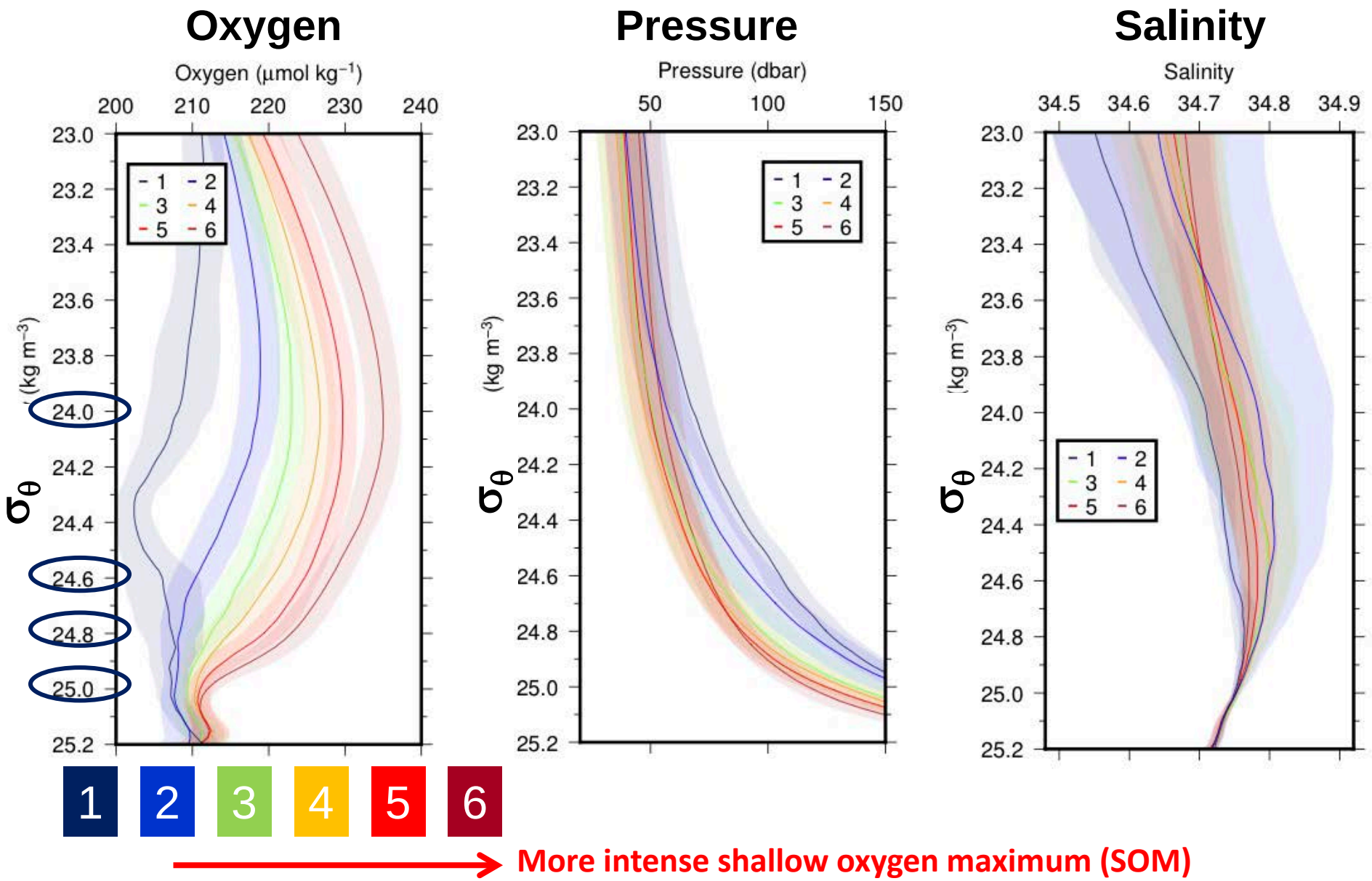




August-September

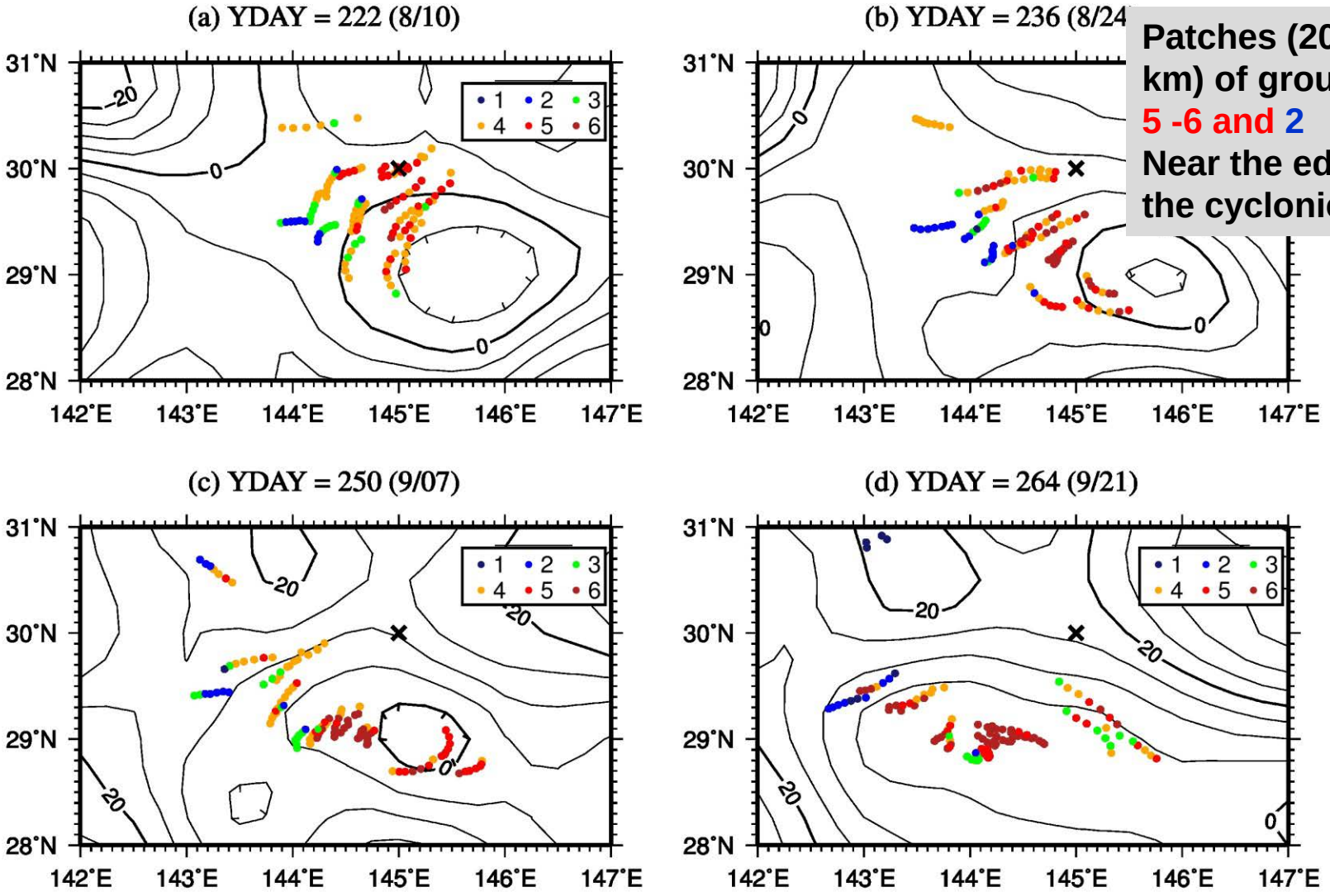
Cyclonic eddy passed south of S1

Grouping of DO profiles based on cluster analysis



Spatial distribution of profiles in each groups

1 2 3 4 5 6



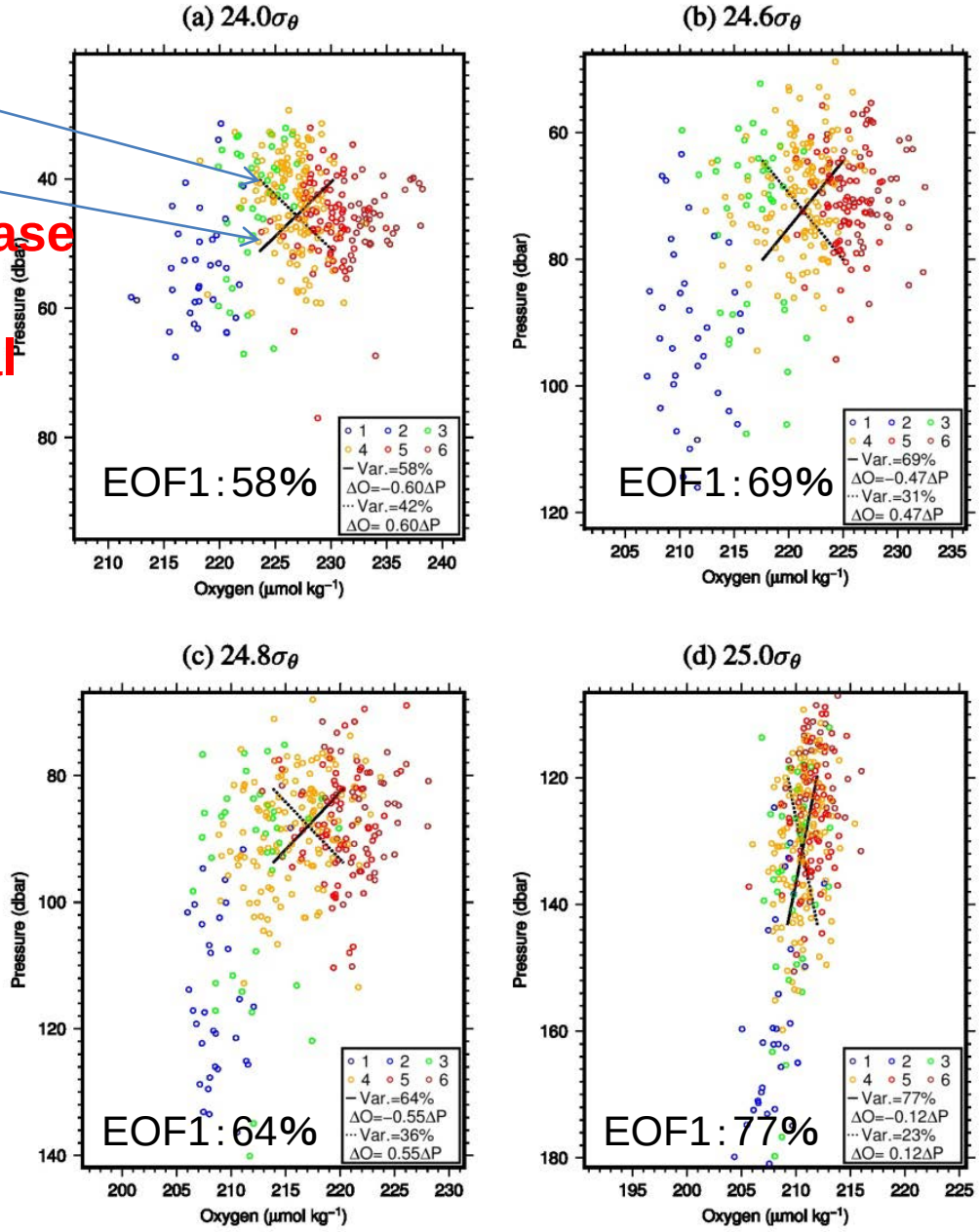
Patches (20-40 km) of group 5 -6 and 2 Near the edge of the cyclonic eddy

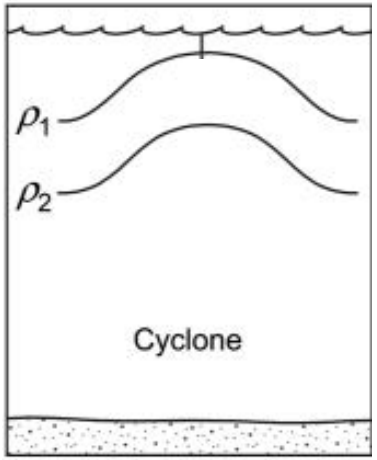
Oxygen vs Depth on isopycnal surfaces

EOF2

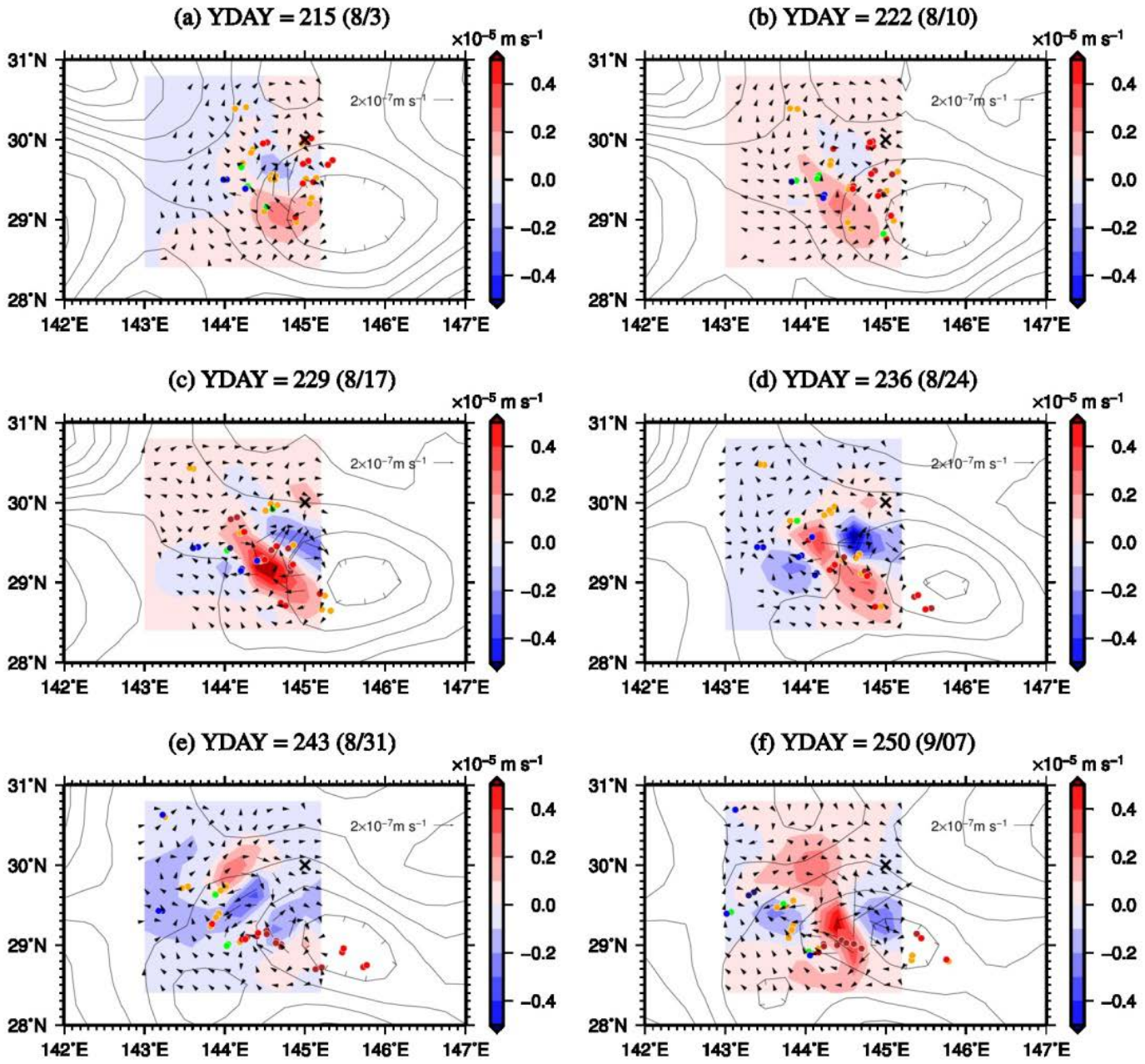
EOF1

Oxygen increase associated with isopycnal heaving





Vertical velocity at 80 m (weekly mean gridded data)



→ horizontal velocity non-geostrophic component

Events of upwelling on scale smaller than mesoscale (20-40 km, week), causing oxygen increase

subsequent horizontal advection can contribute to EOF2

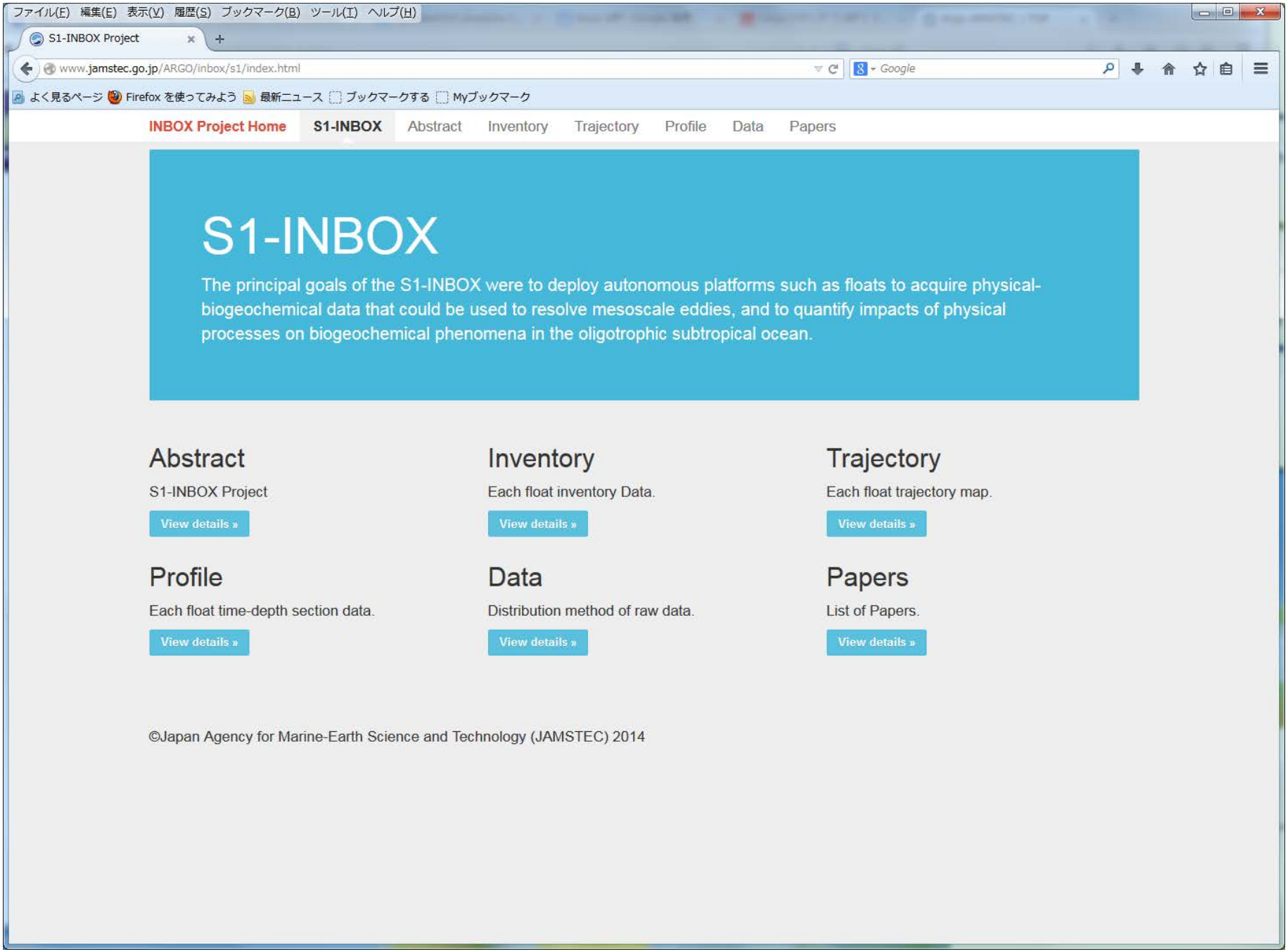
Summary 1

- Data acquired by S1-INBOX
  - “Eddy-resolving” temperature/salinity/oxygen profile data
  - BGC time-series data at S1 mooring site
  - Sediment trap time-series data at S1 mooring site
  - Shipboard observation data during float deployments

Summary 2

- Main results of S1-INBOX
  - Oxygen increase in the SOM layer associated with isopycnal heaving during the passage of the cyclonic eddy:
    - implying nitrate supply of 1.0×10^{-1} mol N m^{-2}
    - one third of the nutrient demand for the subtropical subsurface NCP suggested by Riser and Johnson (2008).
    - consistent with export production estimated by sediment traps
  - Contribution of submesosclae disturbances:
    - Patches (20-40 km, week) of oxygen increase around the edge of cyclonic eddy captured by the float array
    - The oxygen-rich water advected from the edge to the center of the eddy contributing to high oxygen concentration there
  - Contribution of atmospheric forcing:
    - Contribution of enhanced vertical mixing through internal wave generation associated with typhoon passages

http://www.jamstec.go.jp/ARGO/inbox/



Papers

Results of the S1-INBOX project are reported in three submitted papers, which include results from the S1 biogeochemical mooring and shipboard measurements.

Inoue, R., T. Suga, S. Kouketsu, S. Hosoda, T. Kobayashi, K. Sato, H. Nakajima, and T. Kawano, Western North Pacific Integrated Physical-Biogeochemical Ocean Observation Experiment (INBOX): Part 1. Specifications and Chronology of the S1-INBOX floats, J. Mar. Res., submitted.

Inoue, R., M. Honda, T. Fujiki, K. Matsumoto, S. Kouketsu, T. Suga, and T. Saino, Western North Pacific Integrated Physical-Biogeochemical Ocean Observation Experiment (INBOX): Part2. Biogeochemical responses to eddies and typhoons revealed from shipboard measurements and the S1 biogeochemical moorings during S1-INBOX, J. Mar. Res., Submitted.

Kouketsu, R., T. Suga, and R. Inoue, Western North Pacific Integrated Physical-Biogeochemical Ocean Observation Experiment (INBOX): Part 3. Mesoscale variability of dissolved oxygen concentrations observed by multiple floats during S1-INBOX, J. Mar. Res., submitted.