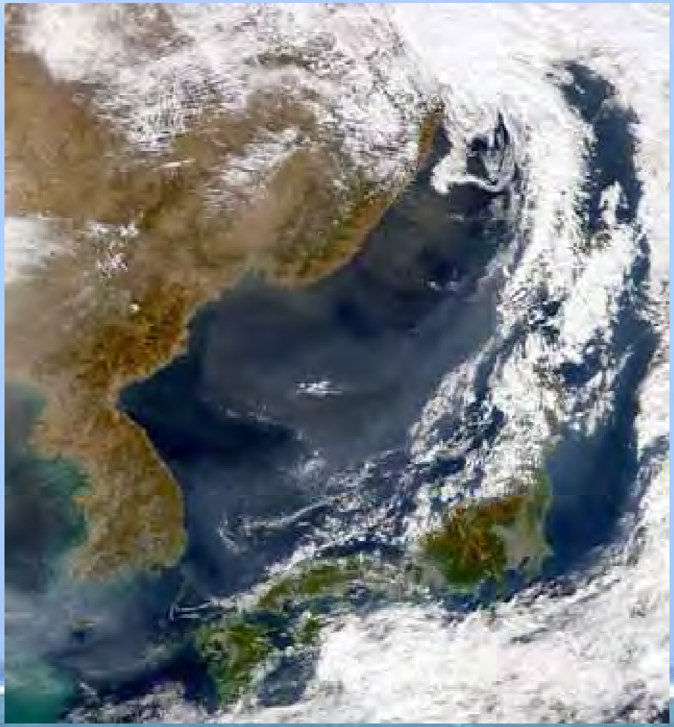
Vertical in situ profiles of nitrate and oxygen in the northern Japan Sea



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Usage of in situ spectrophotometers



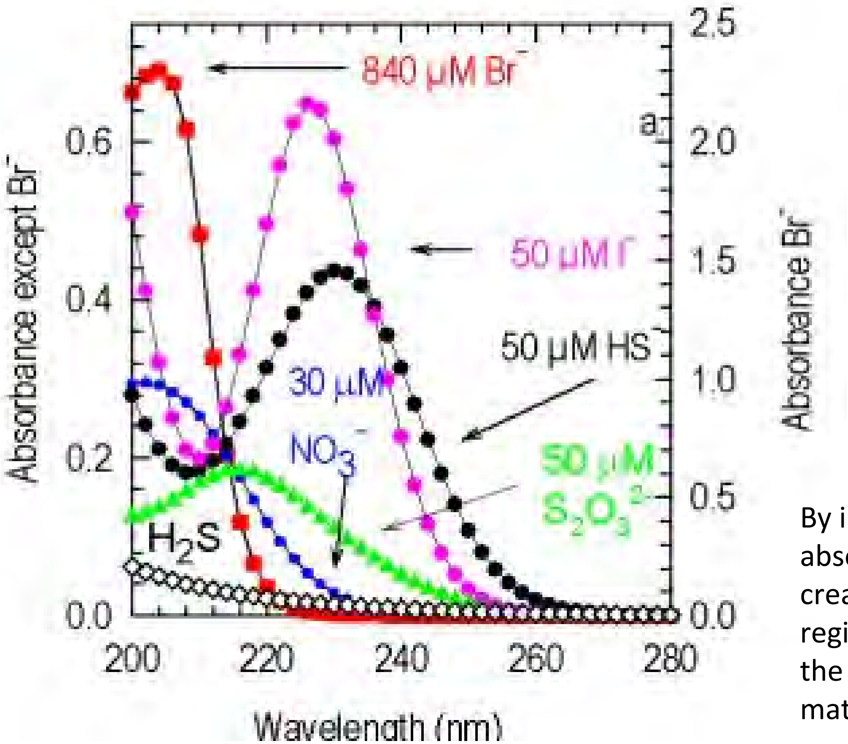
Usage of in situ spectrophotometers

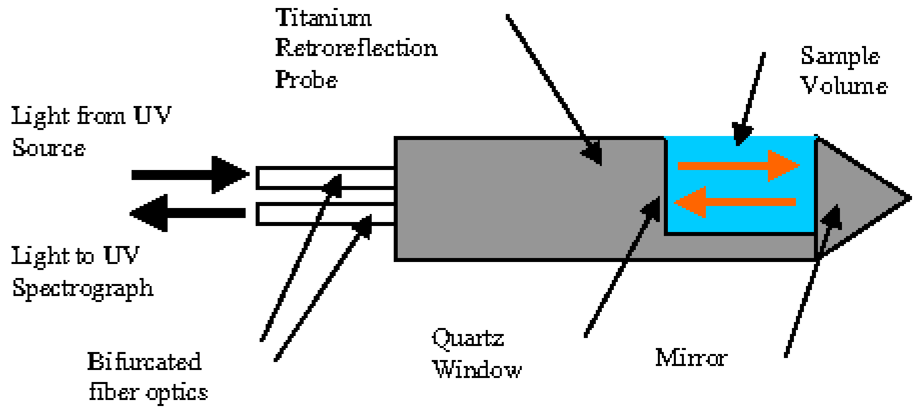
Why and what is MBARI-ISUS?

MBARI - Monterey Bay Aquarium Research Institute
ISUS – In Situ Ultraviolet Spectrophotometer

It makes possible to collect rapidly UV spectra with wavelength resolution better than 1 nm for extended periods of time. This allows one to obtain information on concentration of nutrients dissolved in the sea water. The MBARI ISUS is a real-time, chemical free system designed to overcome the traditional challenges associated with nitrate analyses in the open ocean. The instrument provides easy, accurate and continuous nitrate concentration measurements essential to the study of physical, chemical and biological processes in harsh ocean environments

ISUS Background





By illuminating a sample of seawater with UV light onto a UV spectrometer, the absorption spectra can be measured. The calibration process of the system creates a library of absorption spectra for the main absorbing species in this region of the spectrum. Using an optimization process, the concentrations of the calibrated species spectra are adjusted until the computed spectrum matches the measured one.

The standard method for measuring nitrate in the past was to collect samples at sea, freeze them and bring them back to a lab, using a system called an autoanalyser. The autoanalyser relies on mixing chemicals with the sample to create a reaction that results in a coloured solution that can be quantitatively measured.

MBARI-ISUS Specifications

- **Perfomance**
- Precision: ± 0.05 µM
- Accuracy: ± 2 µM
- Detection range: 0.5 to 200 µM
- **Optics**
- Path length: 1 cm
- Wavelength range: ***200 – 400 nm***
- Lamp type: Deuterium
- Lamp lifetime: 1000 hours to 50% intensity at 240 nm
- **Electrical Characteristics**
- Input Voltage: 9 – 24 VDC (Non-isolated power input port)
- ***19 – 75 VDC (Isolated power input port)***
- 11 – 36 VDC (Optional isolated input range)
- Current requirement: 1 Amp @ 12 VDC (nominal)
- Power consumption: 12 Watts (nominal)
- Data storage: 128 MB
- Sample rate: 0.5 Hz (typical)
- Telemetry options: ***Analog output 0 – 4.096 VDC***
- ***RS-232/RS-422 serial output***
- ***User selectable baud rates (default 38400 bps)***

Physical Characteristics

Anodized Aluminum pressure case

Depth rating: ***1000 meters***

Length: 19.10 inches (485.1 mm) – housing only

22.85 inches (580.4 mm) – including anode and

standard probe guard

23.95 inches (608.3 mm) – including anode and

biofouling guard

Diameter: 4.5 inches (114.3 mm)

Weight: With standard probe guard:

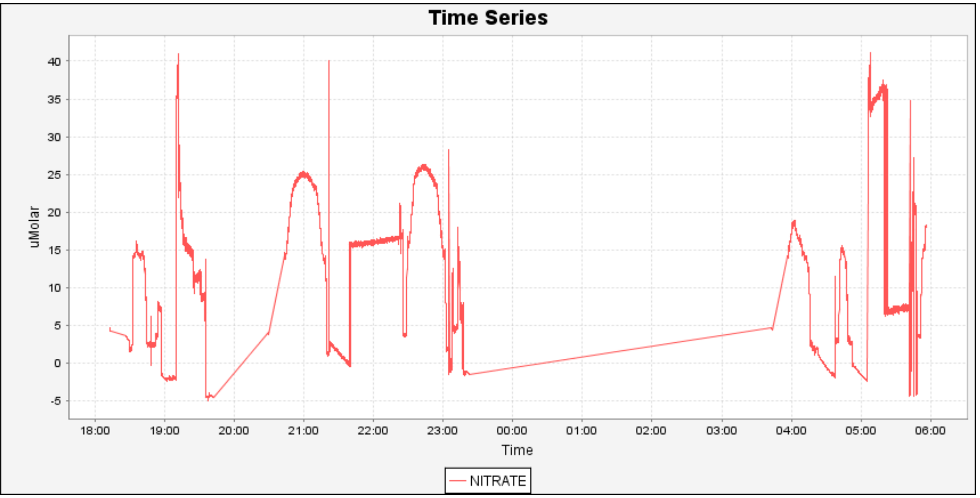
12.8 lbs in air (5.8 kg), 1.5 lbs in water (0.68 kg)

With biofouling guard

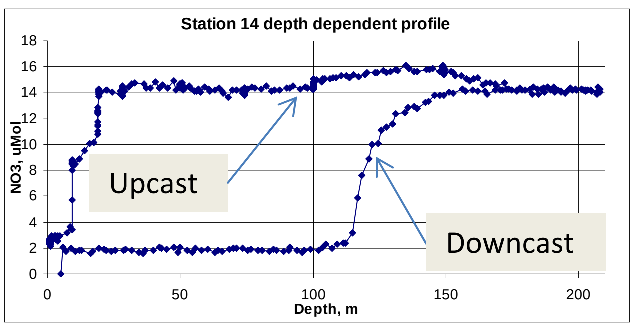
13 lbs in air (5.9 Kg), 1.7 lbs in water (0.77 Kg)

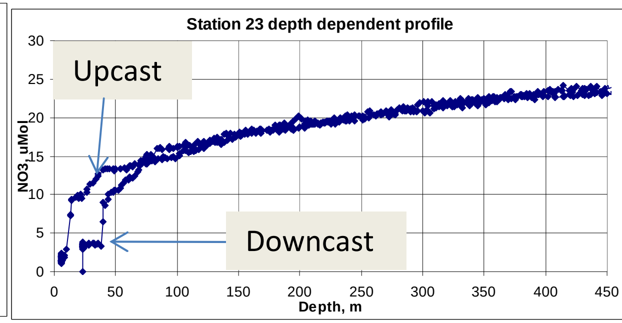
Operating temperature range: 0° to 35° C

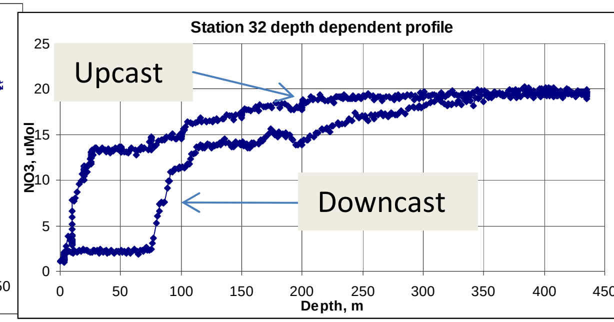
Original time-dependent (TD) and converted depth-dependent (DD) profiles

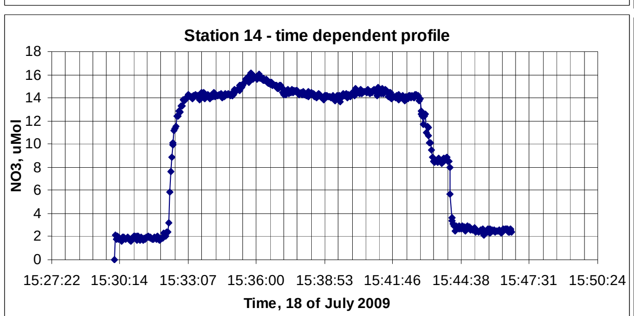


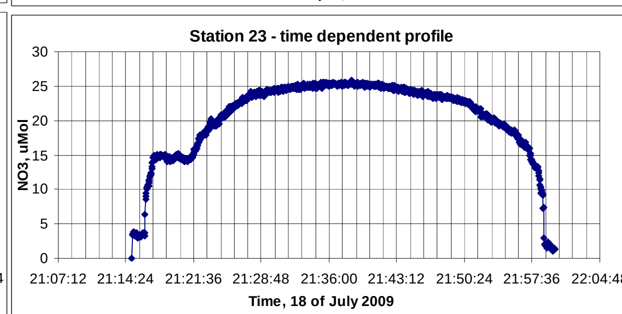
- Analyzed measurements was made during the upcast with the speed 0.5 m/sec
- Mbari-ISUS have been used in autonomous mode and provided only TD-profiles.
- After measurements TD was converted to DD profiles. The CTD-data of SBE-911 have been applied with the synchronization by the timescale.

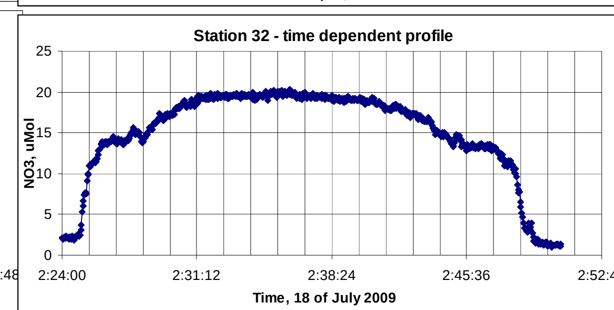




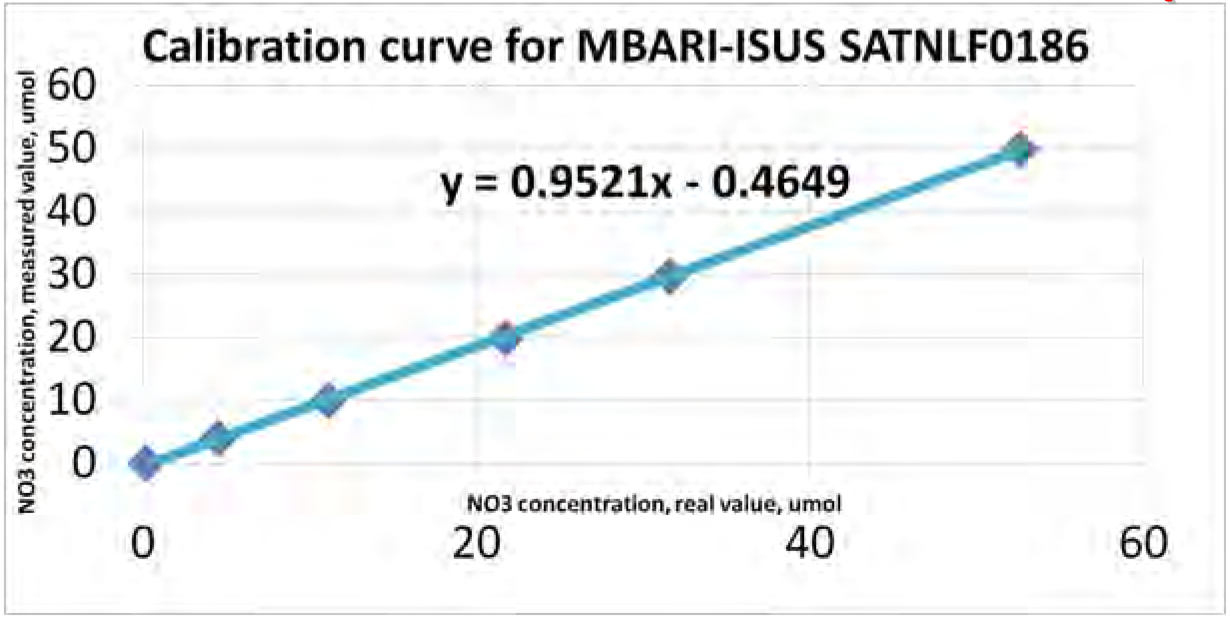




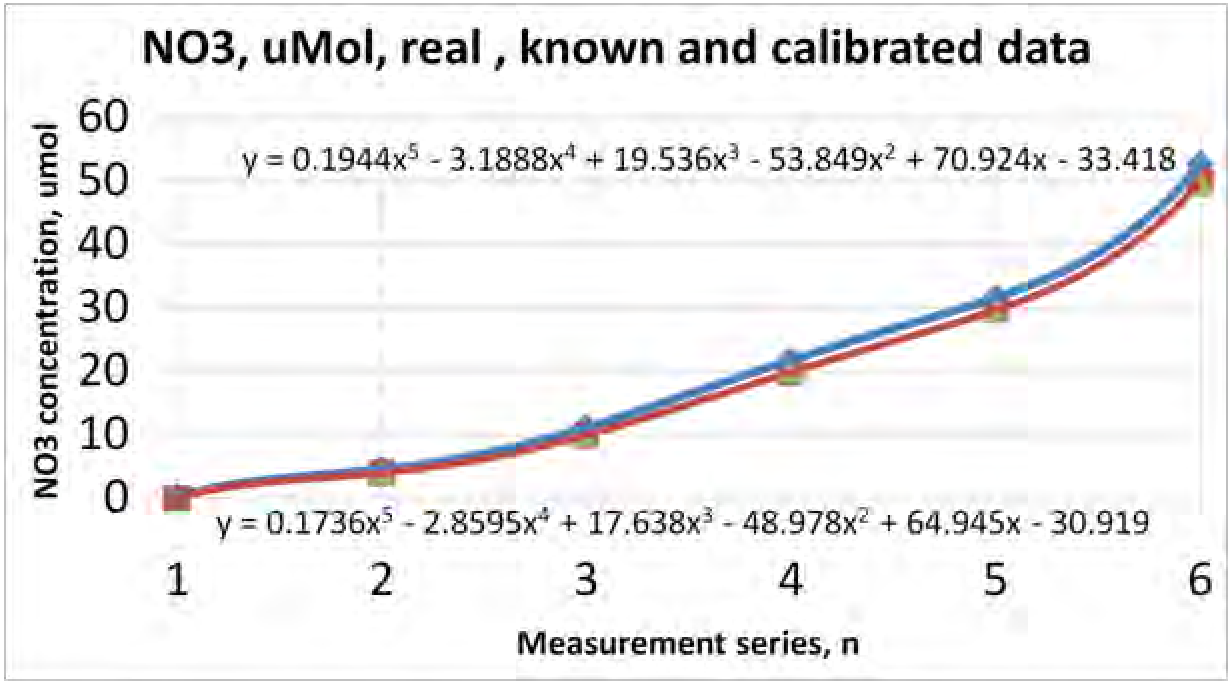




MBARI-ISUS calibration (Lab./Real cond.)

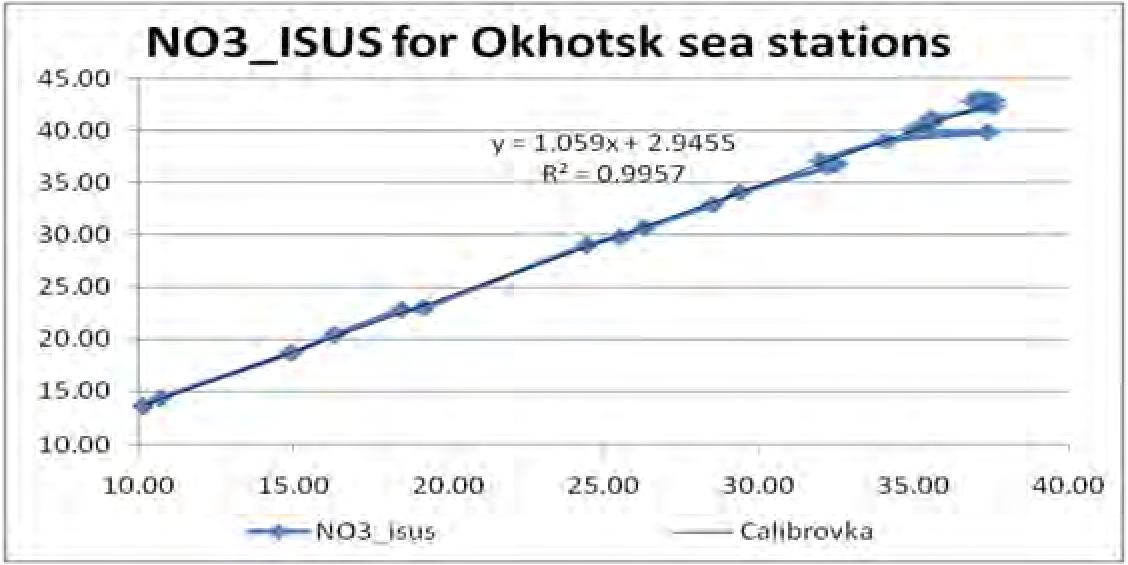


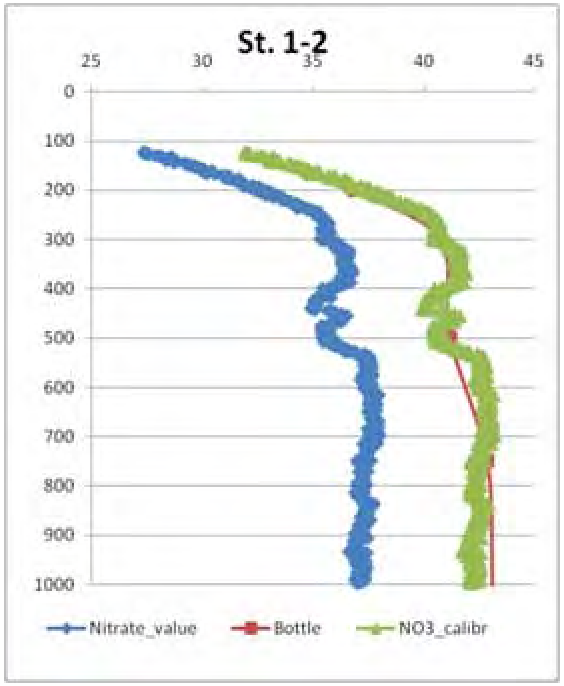
Calibration was made in Laboratory Conditions, using Solutions with the known NO3 Content: 0, 3.969, 9.924, 19.849, 29.614, 49.813 umol for each of them.
Every measurement was taken as mean value obtained during the 3 min. mesurement for temperature 25°C. Results of Calibration is shown it table below.

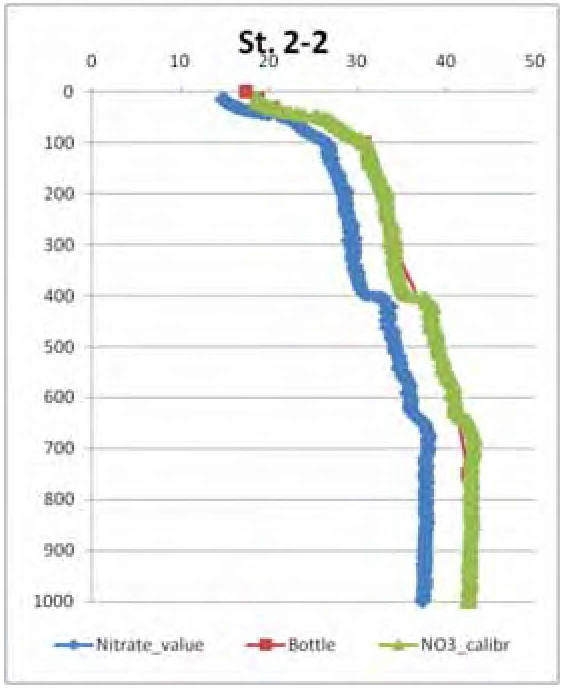


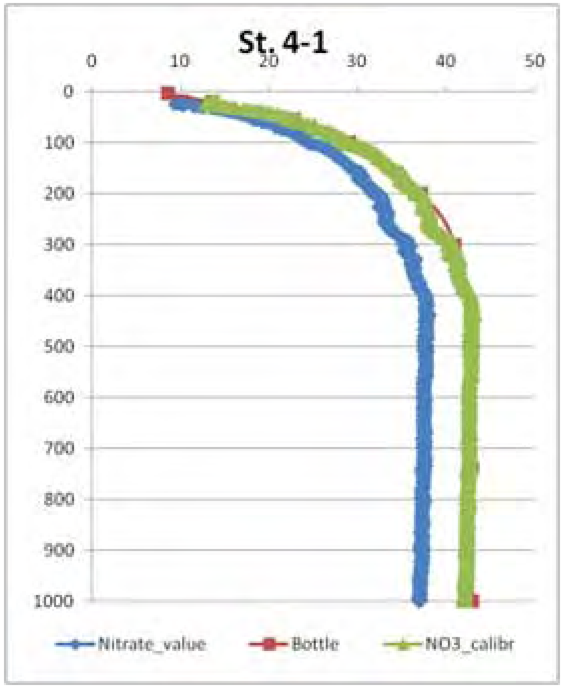
No.	NO3 (ISUS)	Std. dev (ISUS)	NO3 Known solution	NO3 calibrated ISUS
1	0.20	0.11	0	0
2	4.52	0.23	3.97	3.84
3	11.13	0.19	9.92	10.13
4	21.75	0.20	19.85	20.25
5	31.58	0.15	29.61	29.60
6	52.60	0.19	49.81	49.62

MBARI-ISUS calibration (Lab./Real cond.)

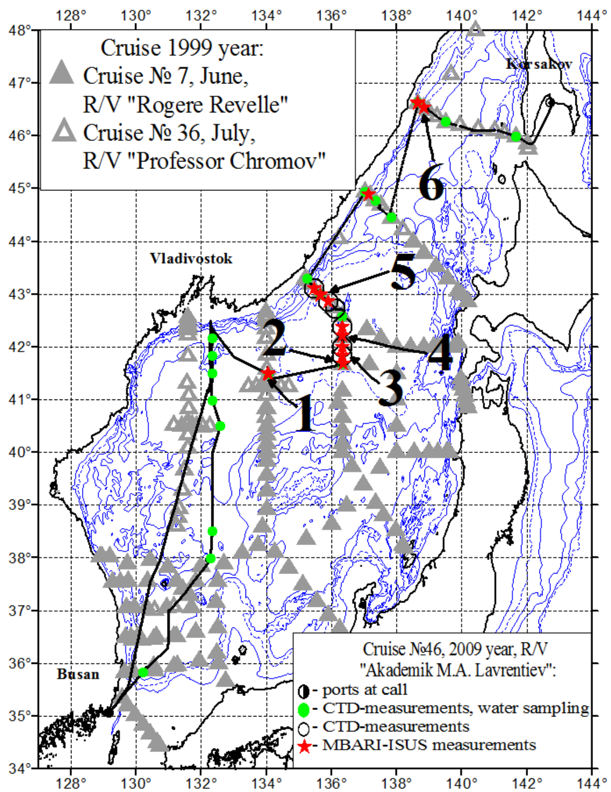




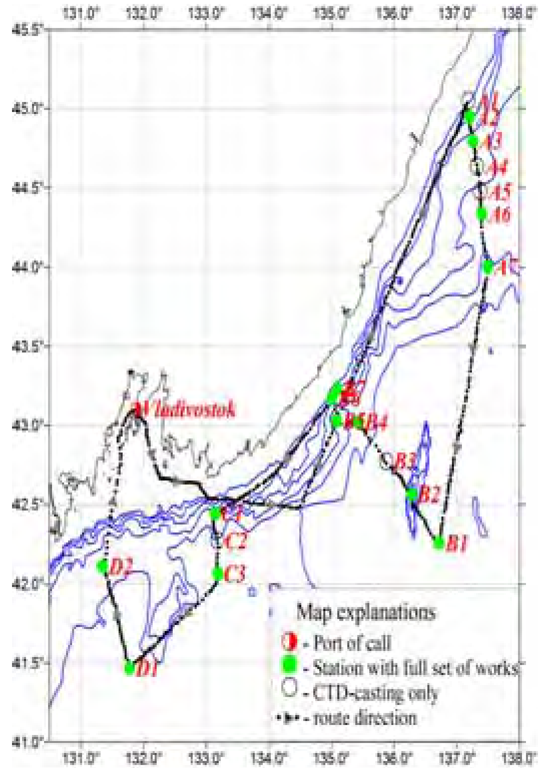




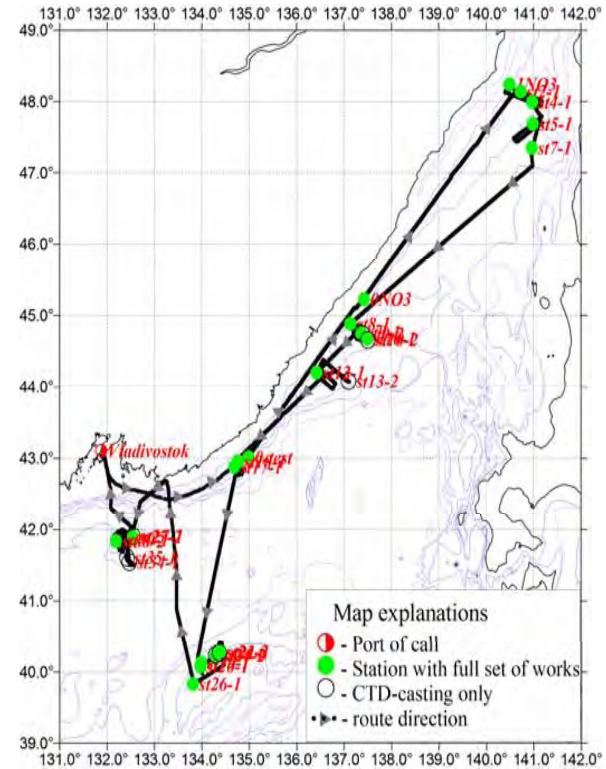
Cruises to the Northern East/Japan Sea



July 2009
(16 stations)

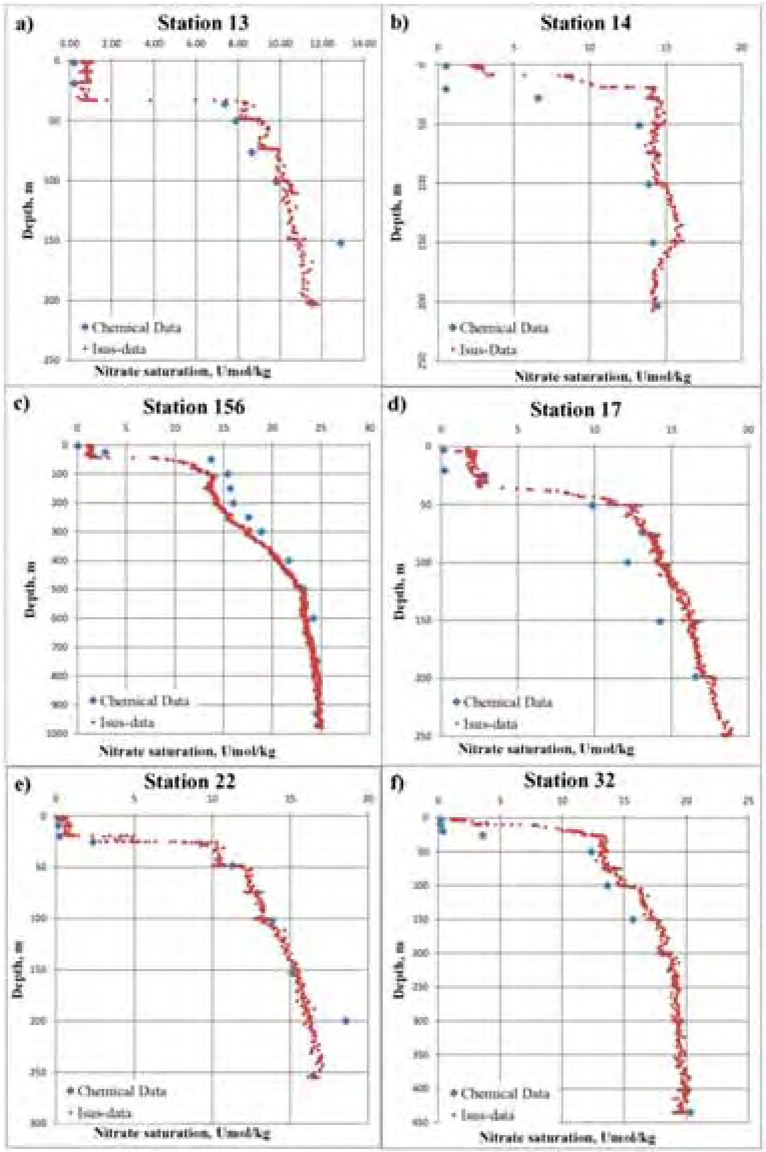


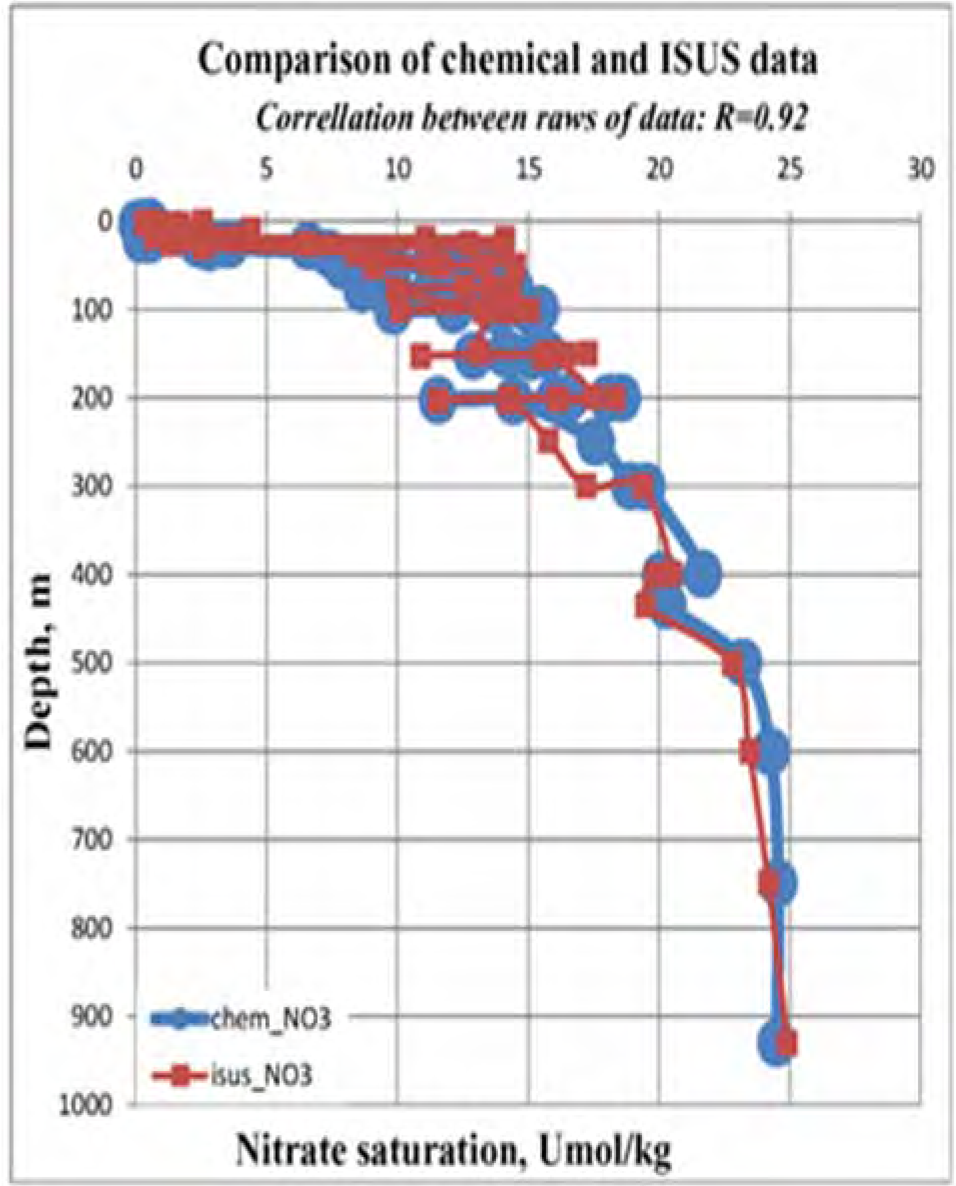
August 2010
(19 stations)



October/November 2010
(20 stations)

Measurements for full range of depths

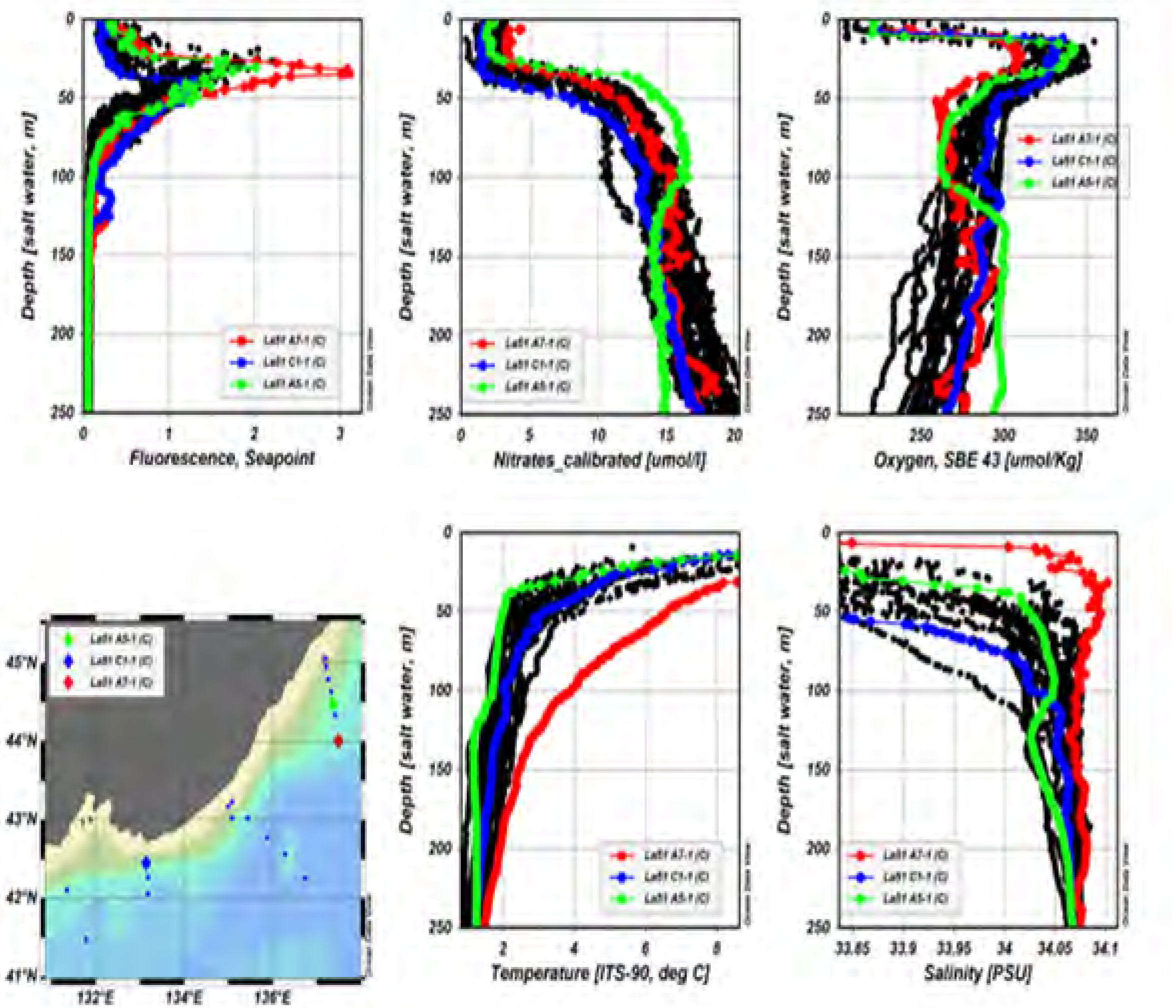




Measurements for full range of depths

- The analysis of curves shown hear informs that in situ measurements made by the ISUS have a good matching to data obtained by the chemical analysis.
- The most essential difference in measurements values can be found at the subsurface layer on the depth until the 250 meters. The results for depths more than this depth look more close to each other.
- As it shown in paper of Johnson and Coletti (2002), the difference between measurement of ISUS and chemical analysis data could be the result of ‘chronic undersampling of episodic processes’ which have a place in sub-surface layer during the observation time.
- The ISUS data and derived from the chemical analysis in laboratory is highly correlated to each other
- The correlation between points of ISUS measurements have been calculated for the correspondent to points of chemical data analysis. Correspondent points was picked up according with their depth of measurement.
- The correlation coefficient was calculated using the 58 pairs of data points and has a value R=0.92.

Distribution of chlorophyll-a, density, nitrates, oxygen, temperature, salinity in cruise #51 R/V “Akademik M.A. Lavrentiev” in August 2010 at depths before 250m

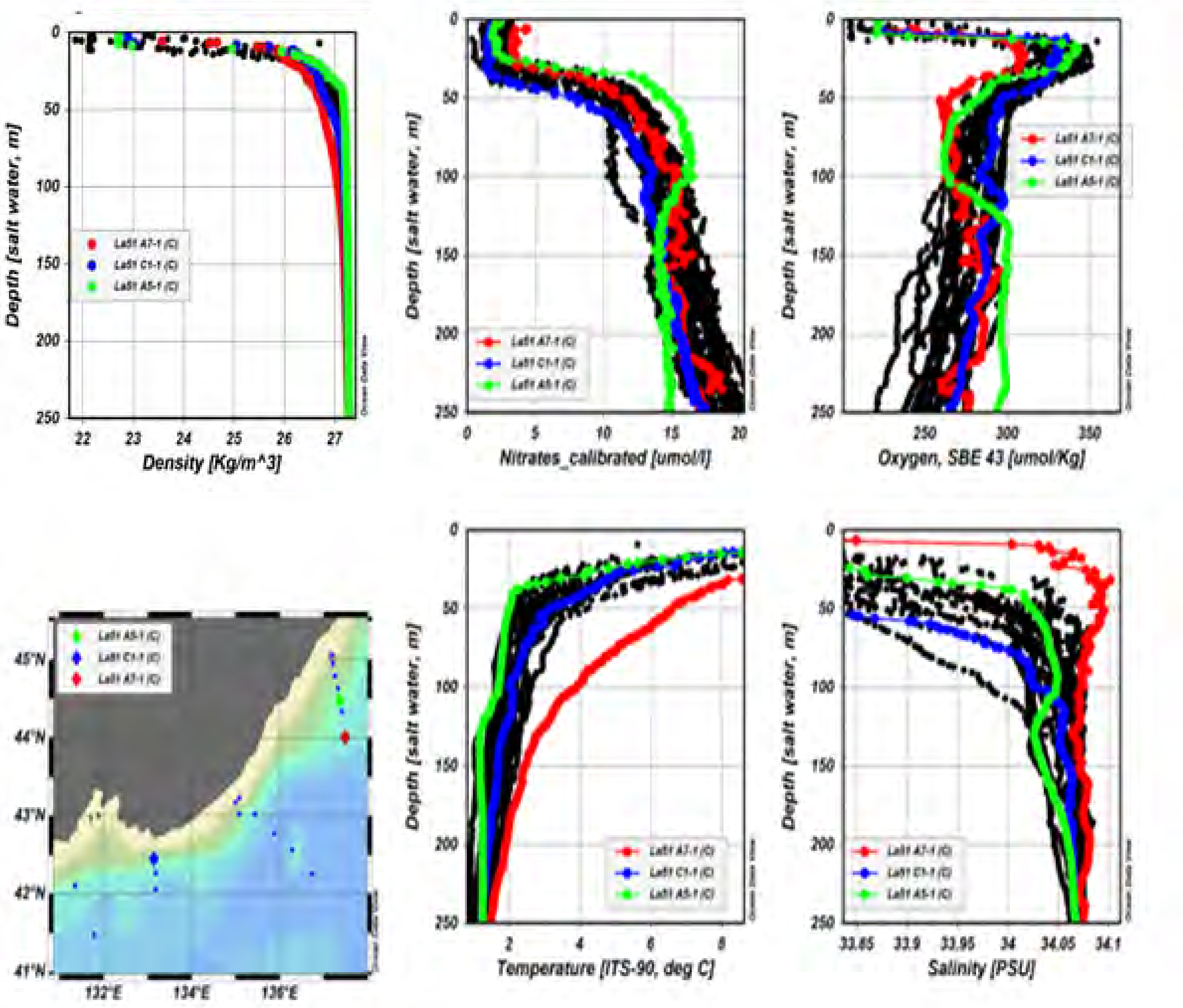


During the analisys of ISUS profiles was found :

- The presence of backward “stepped” structure between profiles of nitrates and oxygen

- The presence of nitrates maximum concentration under the picnocline in the upper layer during the warm season

Distribution of chlorophyll-a, density, nitrates, oxygen, temperature, salinity in cruise #51 R/V “Akademik M.A. Lavrentiev” in August 2010 at depths before 250m



During the analisys of ISUS profiles was found :

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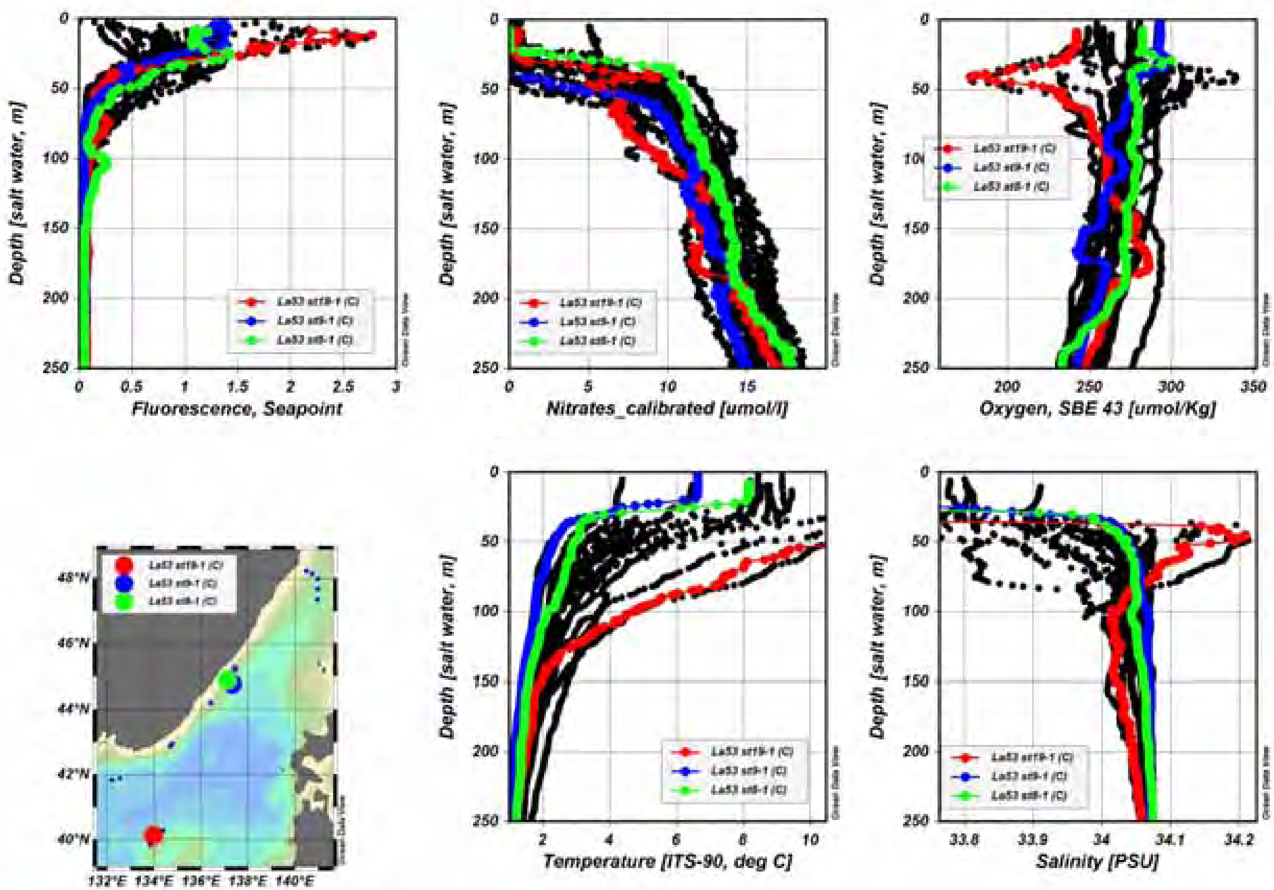
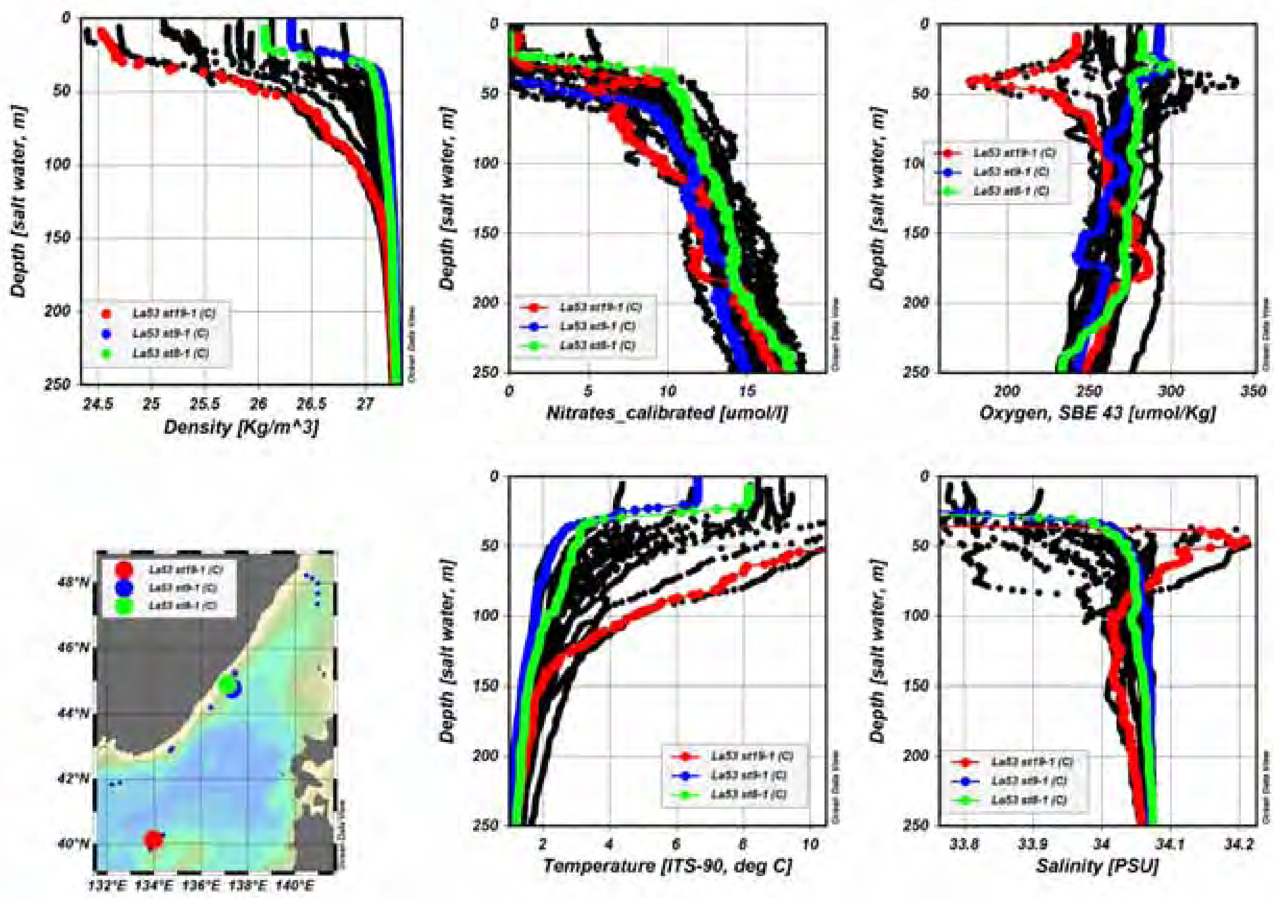
- The presence of nitrates maximum concentration under the picnocline in the upper layer during the warm season

Distribution of chlorophyll-a, density, nitrates, oxygen, temperature, salinity in cruise #53 R/V "Akademik M.A. Lavrentiev" in October-November 2010 at depths before 250m



During the fall season, at the presence of convection this may be changed and nitrates reach the upper layer above the picnocline, with a big amount of chlorophyll.

Distribution of chlorophyll-a, density, nitrates, oxygen, temperature, salinity in cruise #53 R/V "Akademik M.A. Lavrentiev" in October-November 2010 at depths before 250m



During the fall season, at the presence of convection this may be changed and nitrates reach the upper layer above the picnocline, with a big amount of chlorophyll.

Conclusions

- NO3 in situ profiling can provide a detailed structure of nitrate vertical profile which is impossible to obtain during bottle data analysis
- In general in situ profiles is correspondent to chemical (bottle data) in the same positions of measurements with good correlation but affected to measurements conditions (speed of profiling, sensor position, calibration, etc.)
- The observed step-like structure of NO3 profiles has not been observed before during the bottle sampling in the previous cruises for NJES area and in most cases is opposite to the oxygen profile structure
- The step-like structure might be caused by coupling of dynamic and biogeochemical processes within the studied layer of sea.