Koljoe Fjord observatory
YSI EXO2 and AADI Seaguard
October 2012 — April 2013

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May 7, 2013

The purpose of this document is to give a summary on YSI EXO2 and AADI Seaguard (sensor functioning and data quality) while the instruments were deployed as a part of Koljoe Fjord observatory from October 26, 2012 till April 24, 2013 (180 days).

Figure 1: Koljoe Fjord. Koljoe Fjord is a small fjord on the Swedish west coast and a part of a larger fjord system. Max depth is around 50 m. Koljoe Fjord is connected to the ocean (Skagerrak) and the fjord system via two narrow sills, max sill depth around 15 m. Fjord surface water can go in and out of the fjord due to winds and surface currents. Fjord basin water (below 20 m) is permanently anoxic until major water renewal which may occur every 1–3 years. Last time water exchange occurred was in Dec 2010–Jan 2011, and next time expected is winter 2013–2014.

Figure 2: Koljoe Fjord observatory. As Koljoe Fjord is a part of monthly sampling program run by SMHI (Swedish Meteorological and Hydrological Institute). SMHI takes samples every 1 month (or as ice permits in winter). SMHI sampling station is around 100-200 m away from the observatory position. Parameters measured by SMHI are salinity, temperature, oxygen, hydrogen sulfide, and nutrients. Data are available on the web from the SMHI SHARK database.

Seaguard and EXO2 before deployment (left) and on recovery (right). Water depth was about 5 m. EXO2 configuration/sensors:

- EXO2 Sonde, S/N 12E101339, FW 1.0.3
- pH/ORP, S/N 12H102556, FW 1.0.15
- Optical DO, S/N 12H101110, FW 1.0.8
- Total Algae BGA-PC, S/N 12H100744, FW 1.0.7
- fDOM, S/N 12H100041, FW 1.0.6
- Conductivity/Temp, S/N 12H101783, FW 1.0.5
- Wiper, S/N 12H101304, FW 1.0.3
- Depth Non-Vented 0-250m, S/N 12C101691, FW 1.0.4

Seaguard #67 configuration/sensors:

- CO_2 Optode 4797#21
- CO_2 Optode 4797#23
- DCS #43
- Conductivity #084
- Wave and Tide #239
- O_2 Optode 4835#154

Figure 3: EXO2 sensor tips on recovery, before any washing or cleaning. Sensor sockets were populated with: C/T, fDOM, TA/BGA, ODO, sacrificial anode, and pH/ORP sensor. All sensors looked nice and clean after 6 months in sea water due to wiper brush cleaned working surfaces. Some consumption of sacrificial anode metal occurred.

Figure 4: YSI EXO2 sonde, sacrificial anode before and after deployment (6 months under water).

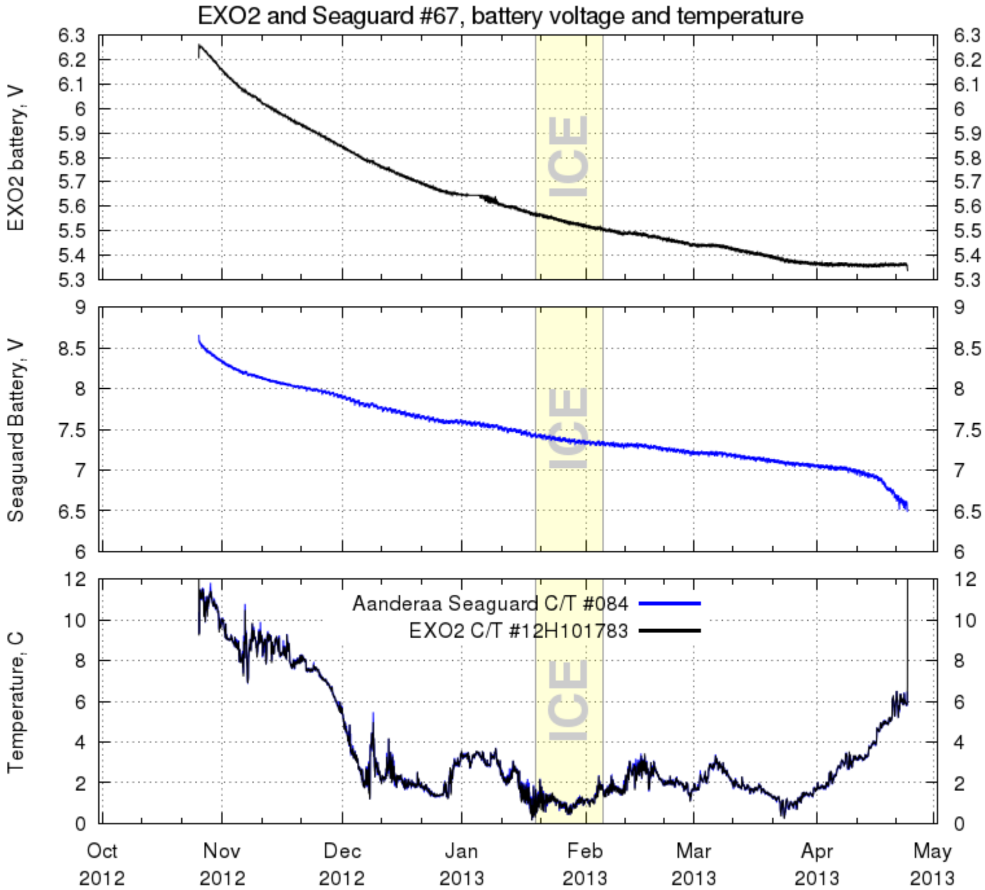

Figure 5: Seaguard and EXO2 Battery voltage. Seaguard was measuring every 30 min, EXO2 every hour. When water was quickly cooling down in Nov–Dec 2012, battery decline became faster. When water temperature increased, like in the end of December, in mid-February and 1st decade of March, battery decline became slower. EXO2 Voltage on recovery of 5.3 V corresponds to a single cell voltage of 1.33 V. Obviously EXO2 might work for much longer time, especially taking into account warmer temperature during the coming spring and summer time.

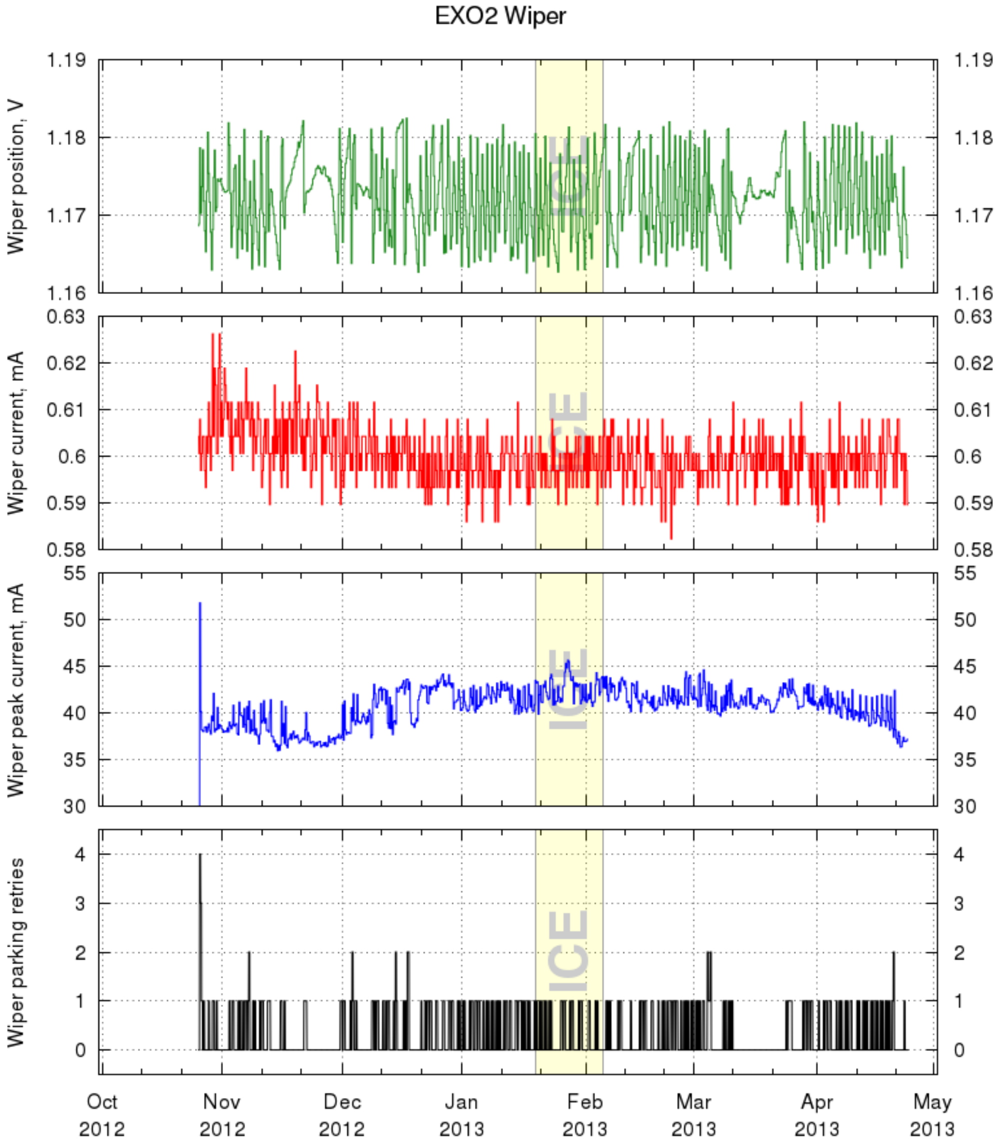

Figure 6: EXO2 Wiper.

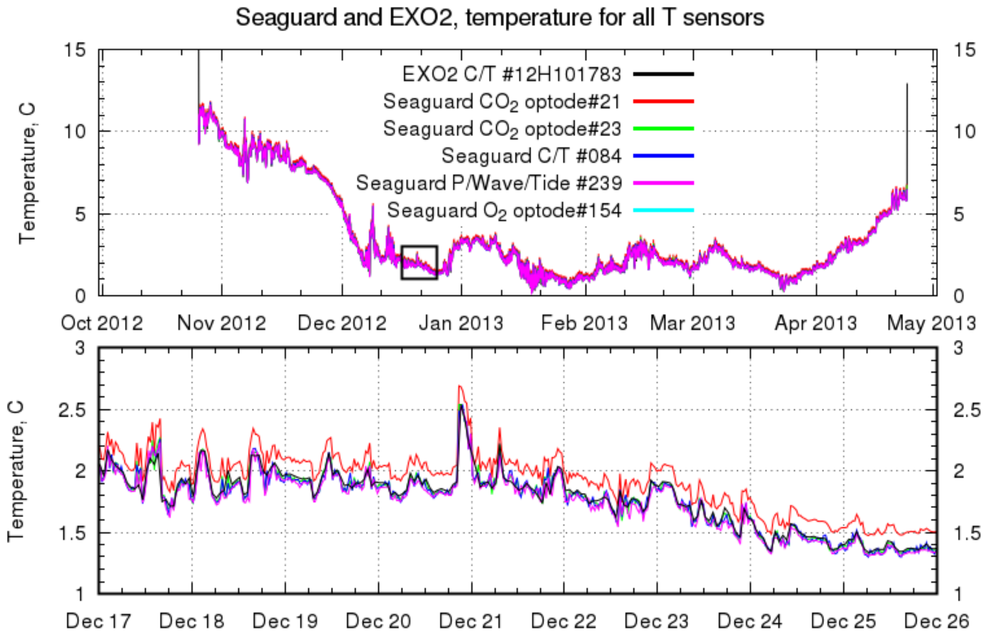

Figure 7: EXO2 and Seaguard, temperature from all sensors. pCO_2 optode #21 readings were always higher by 0.15 C. All other T sensor readings seem to agree very well.

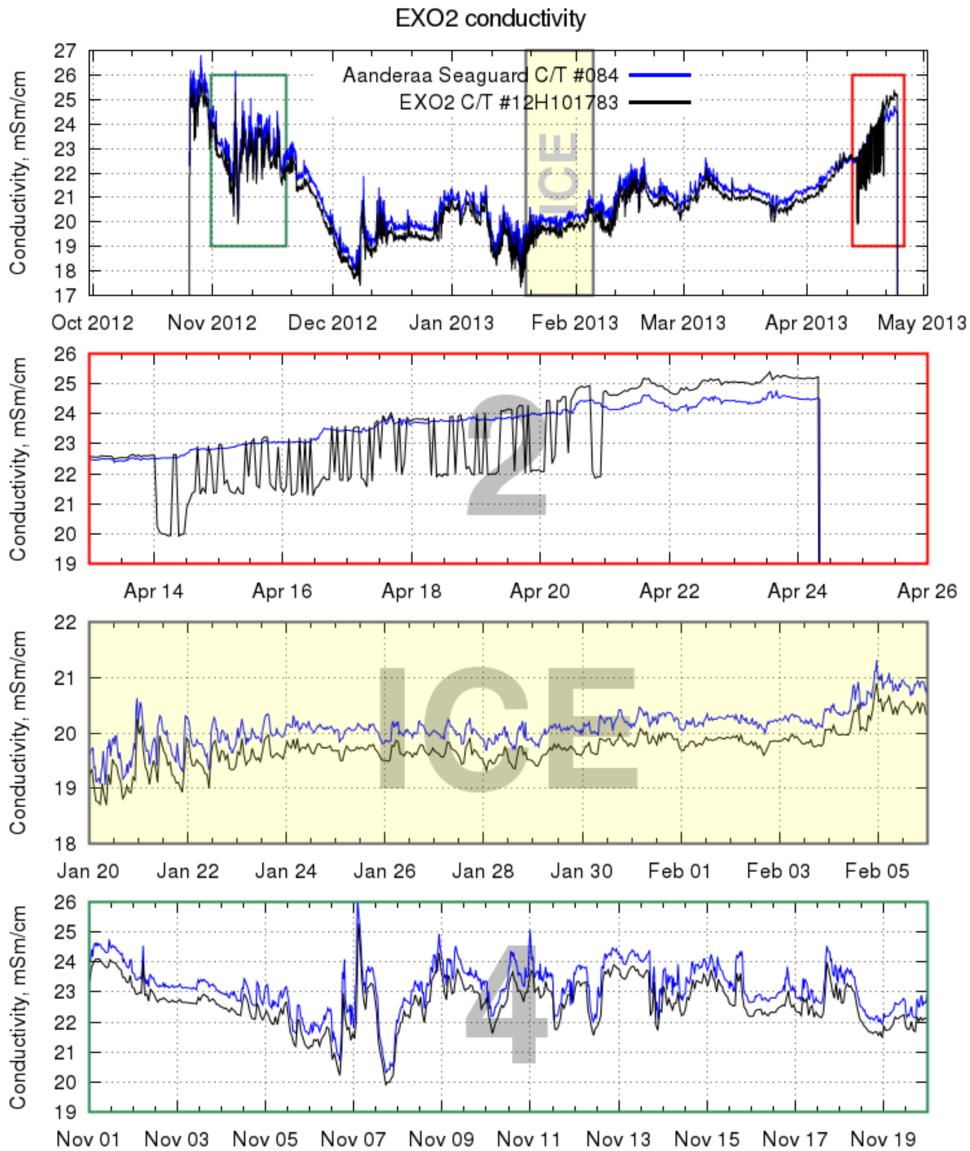

Figure 8: EXO2 Conductivity. Panel 2 show some strange oscillations shown by EXO2 condictivity, but not by Aanderaa conductivity sensor. The oscillations could have been due to some algae which could have entered the C cell and washed out by currents later. Usually EXO2 conductivity showed a negative offset of around 0.5 mSm/cm against Aanderaa conductivity except in April 2013, see panels ICE and 4 as examples. In April 2013 Aanderaa C sensor could have been affected by fouling, which decreased Aanderss conductivity readings. That's probably the reason for the offset between EXO2 and Aanderaa gradually changed and became positive.

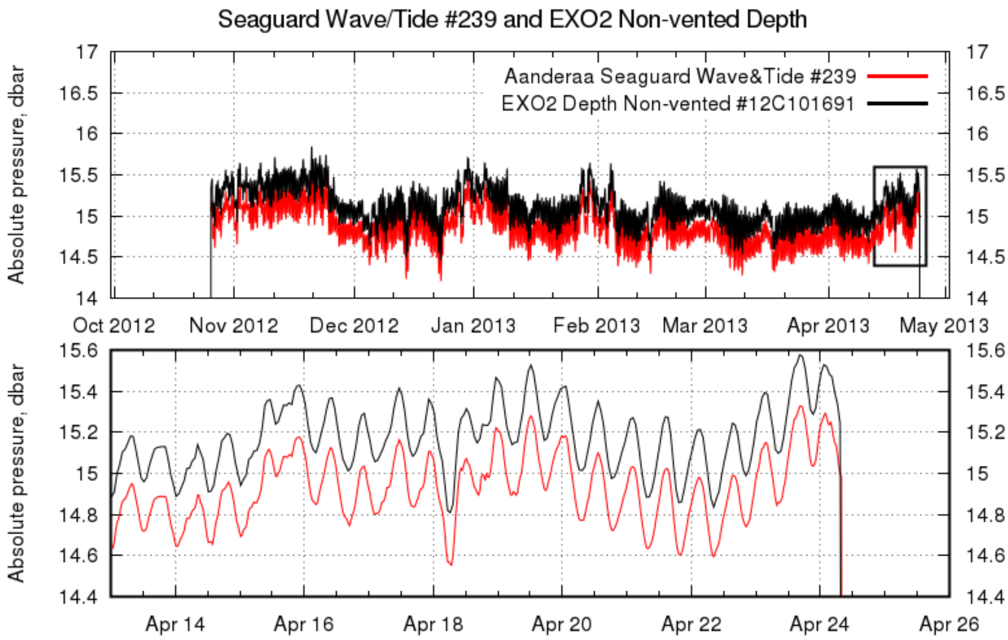

Figure 9: EXO2 Pressure. Periodical oscillations due to tidal movements of sea level (shown on lower panel). Permanent offset of approx 22 cm suggests difference between depth levels of pressure sensors on EXO2 and Aanderaa Seaguard.

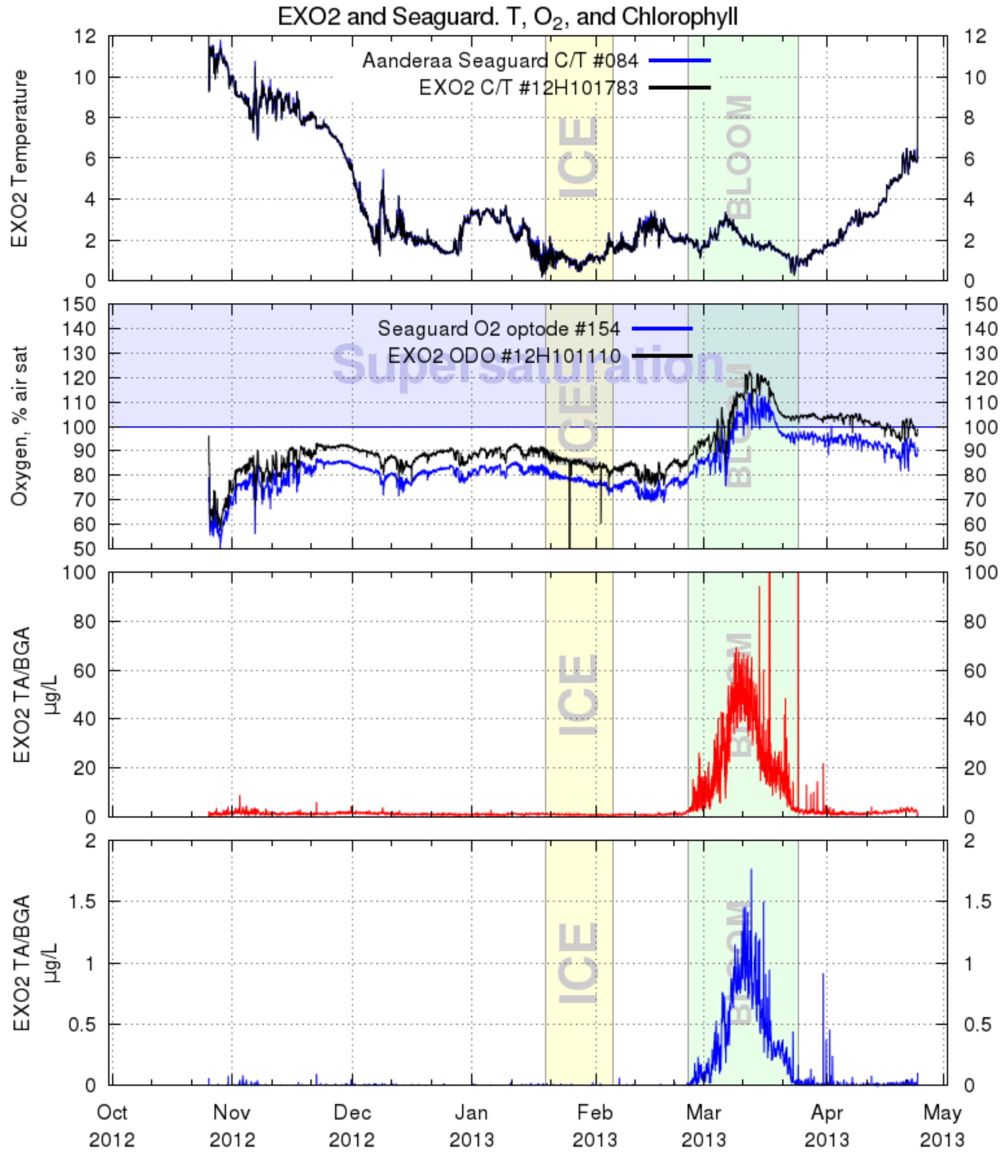

Figure 10: EXO2 oxygen and temperature. Two negative spikes shown by EXO2 ODO in Jan and Feb 2013 were probably due to sacrificial anode protection at very low currents when the fjord was covered with ice. The peak of O_2 supersaturation in March 2013 correponds to the peak of chlorophyll confirming spring algal bloom in March 2013. Cyanobacterial chlorophyll (BGA) was a very small fraction of total chlorophyll (TA). After the end of bloom water temperature started to increase keeping O2 levels close to full saturation, while absolute concentrations of oxygen decreased. EXO2 ODO saturation readings on deck on recovery after the bloom (with wet protective cap on) were always around 100%, while Aanderaa oxygen optode readings were approximately 5% lower.

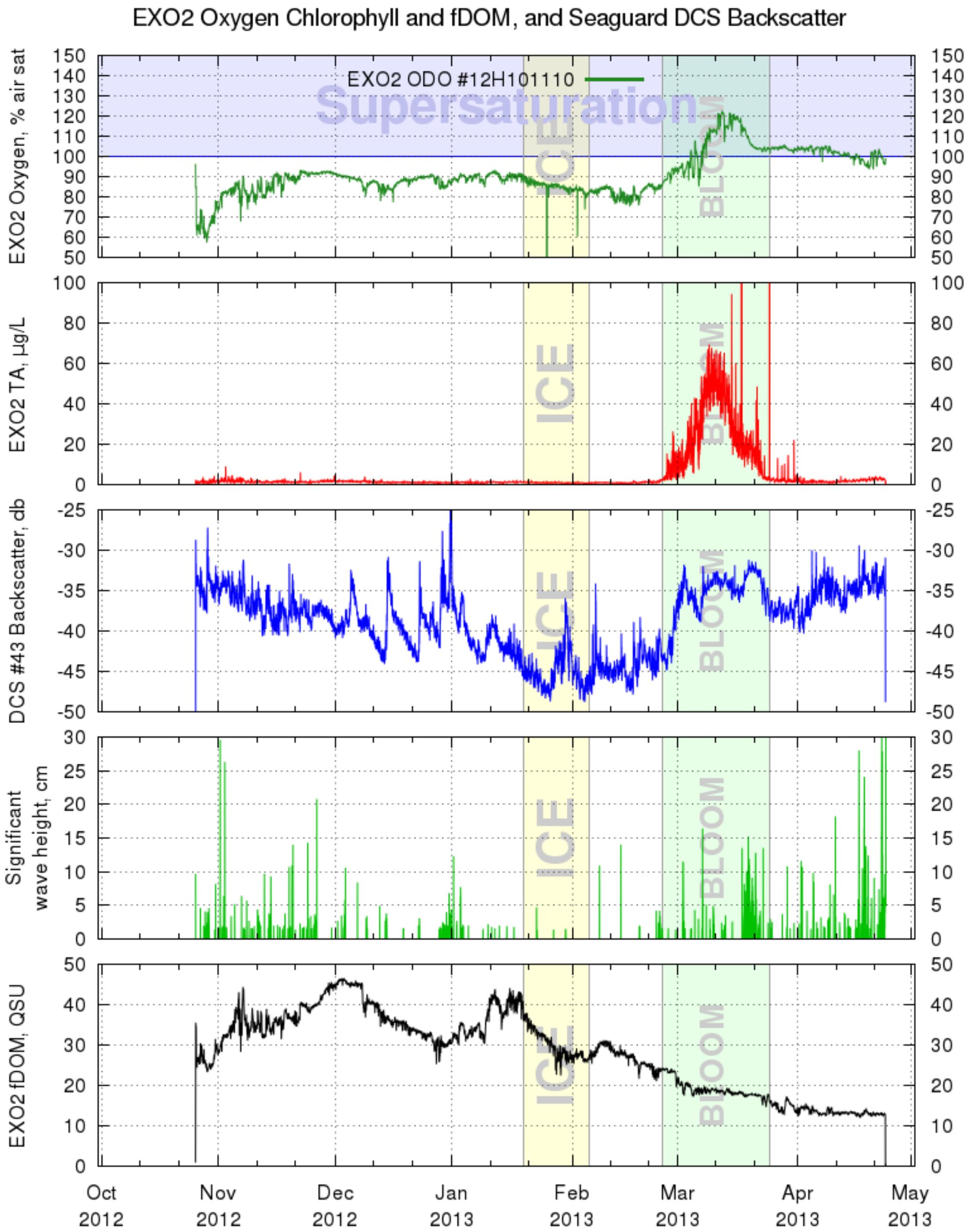

Figure 11: EXO2 and Seaguard. Oxygen, chlorophyll, fDOM and backscatter intensity from acoustic pulses emitted by Seaguard DCS (current sensor). Acoustic signal got improved due to organic matter produced by the bloom (oxygen and chlorophyll peak). Oxygen decrease from above 120% supersaturation down to 100% at the end of bloom (decreasing TA values) was most likely due to wind-induced waves and currents. There seems to be no relation to fDOM signal.

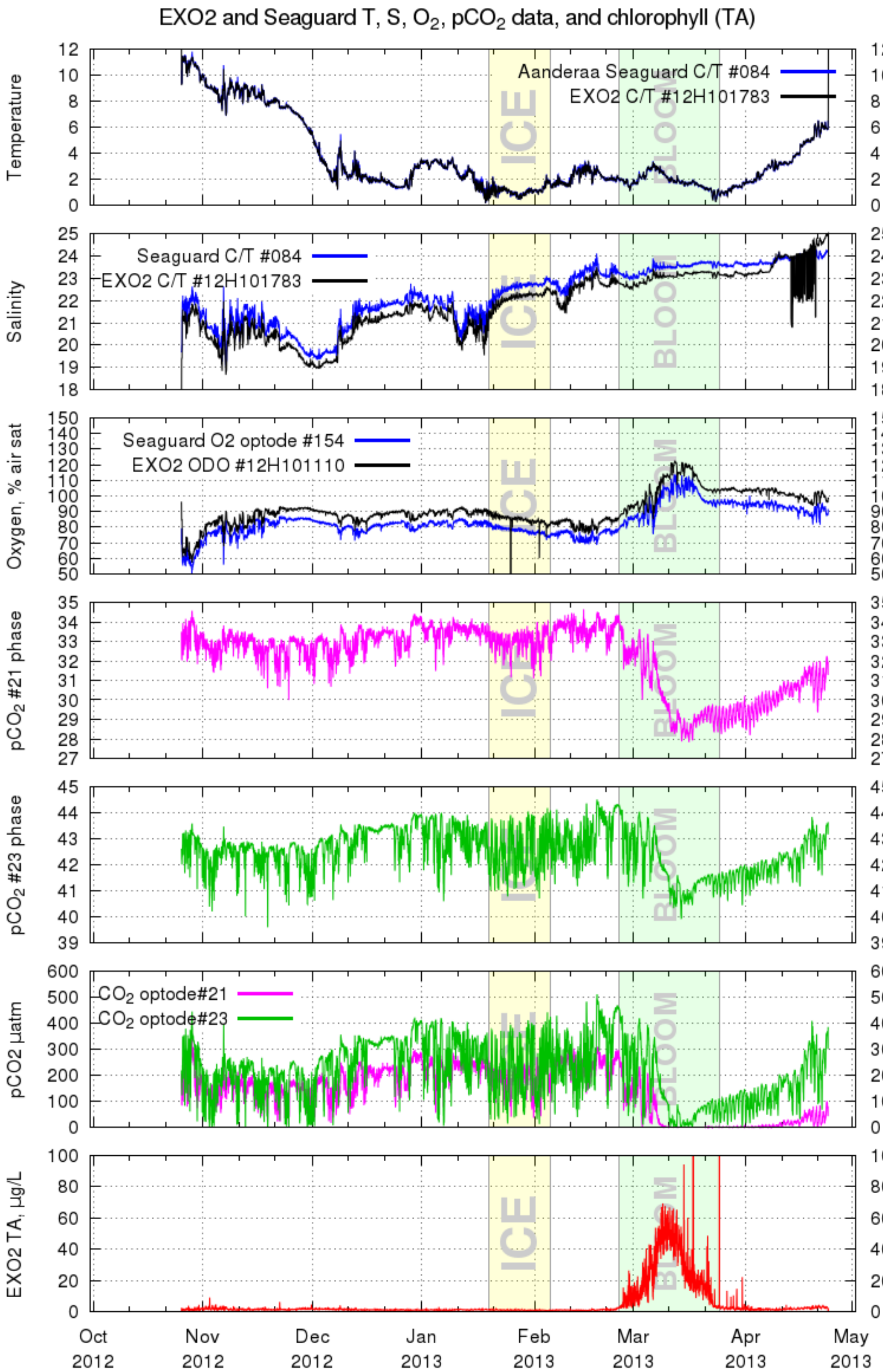

Figure 12: Seaguard and EXO2. T, S, oxygen, CO_2, TA and BGA Chlorophyll data. O_2 supersaturation peak during the bloom corresponds to the minimum on CO_2 data. Raw CO_2 data look good, but calibration for CO_2 optode #21 is most likely not valid.

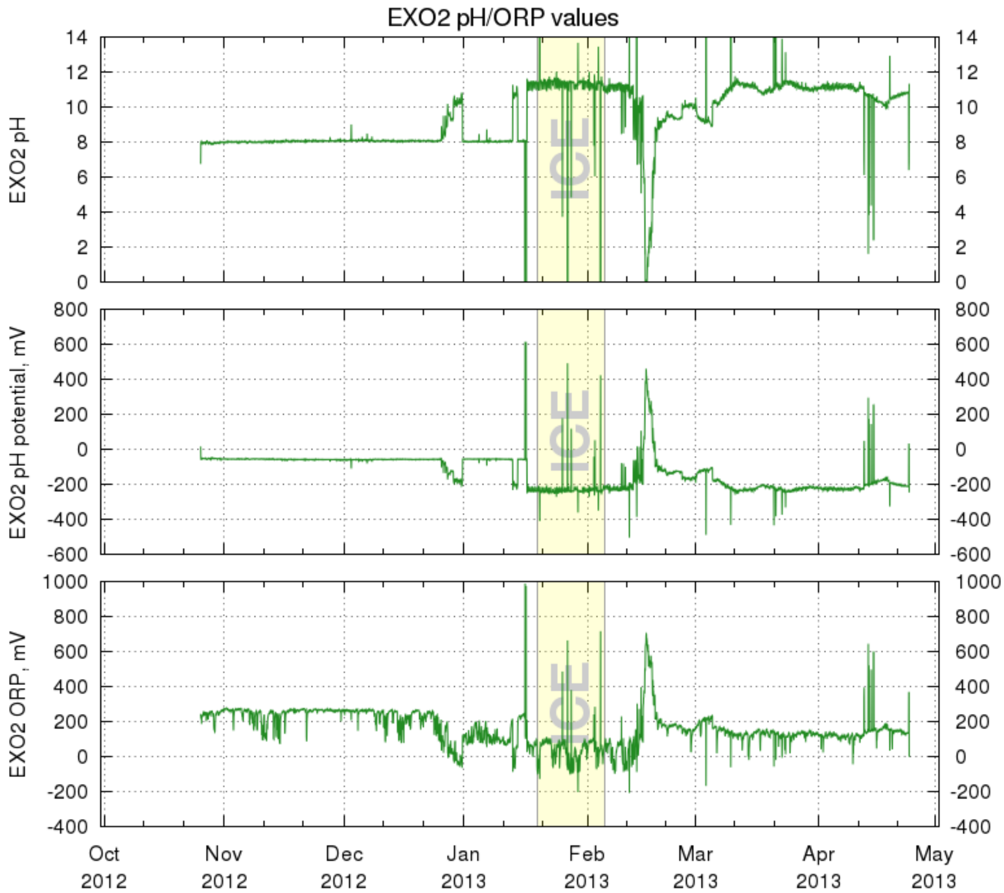

Figure 13: EXO2 pH/ORP. Something went really wrong first in the end of December, then in mid-January. After recovery when testing pH readings in lab with small protective cap on, filled with buffer solution, pH was good and stable: for pH 4 readings were 4.0, for pH 7 readings were 7.2, for pH 9.2 readings were 9.4. pH/ORP values immediately went wrong (pH about 2 pH up and unstable) as soon as electrical contact between the pH sensor and the metal of sensor body was re-established (via the solution inside the calibration cap, or just by touching the edge of protective cap and metal of sensor body with wet fingers of the same hand).

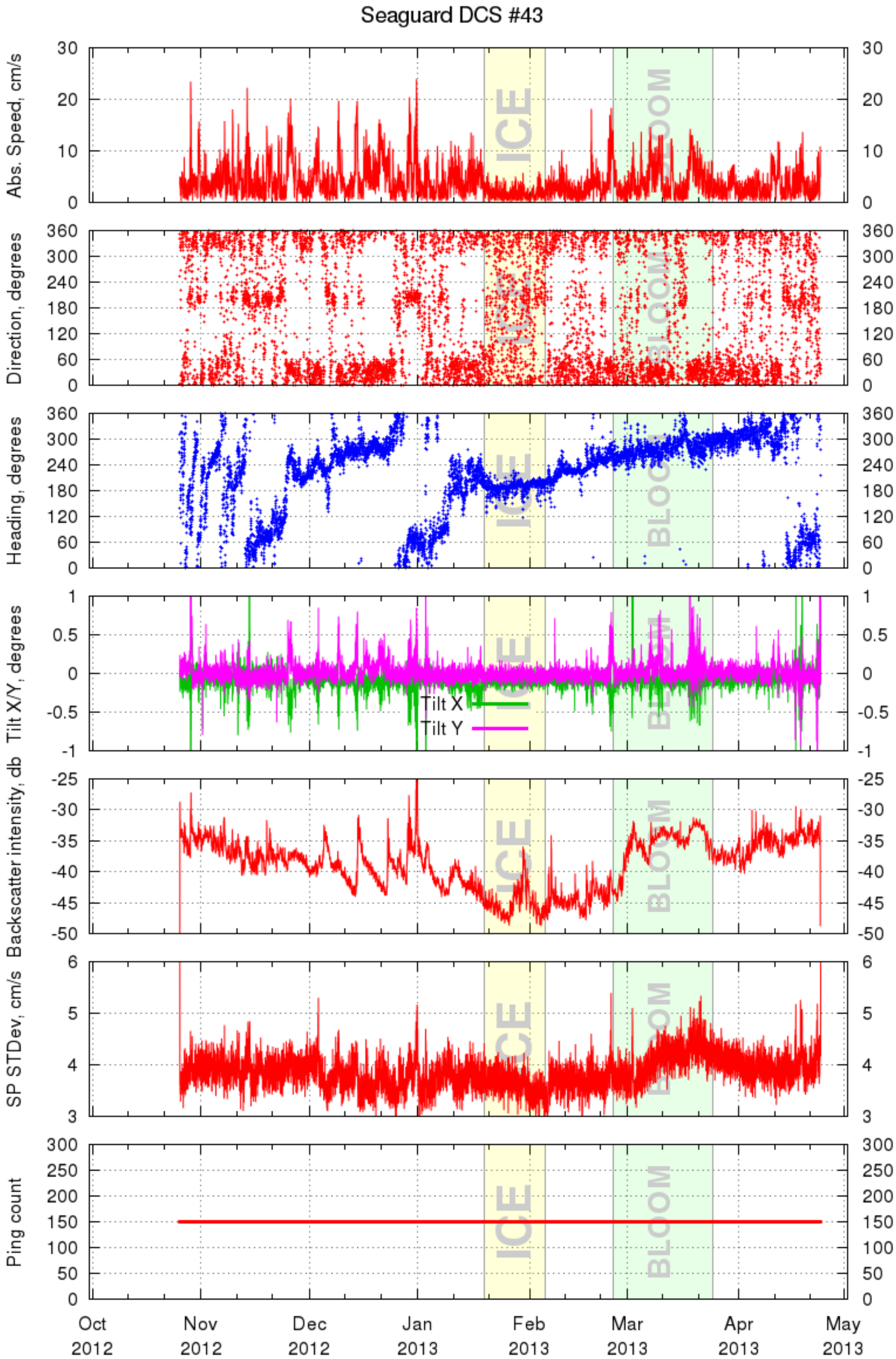

Figure 14: Seaguard DCS #43 data. Weak currents, chaotic direction and quite stable heading under ice.

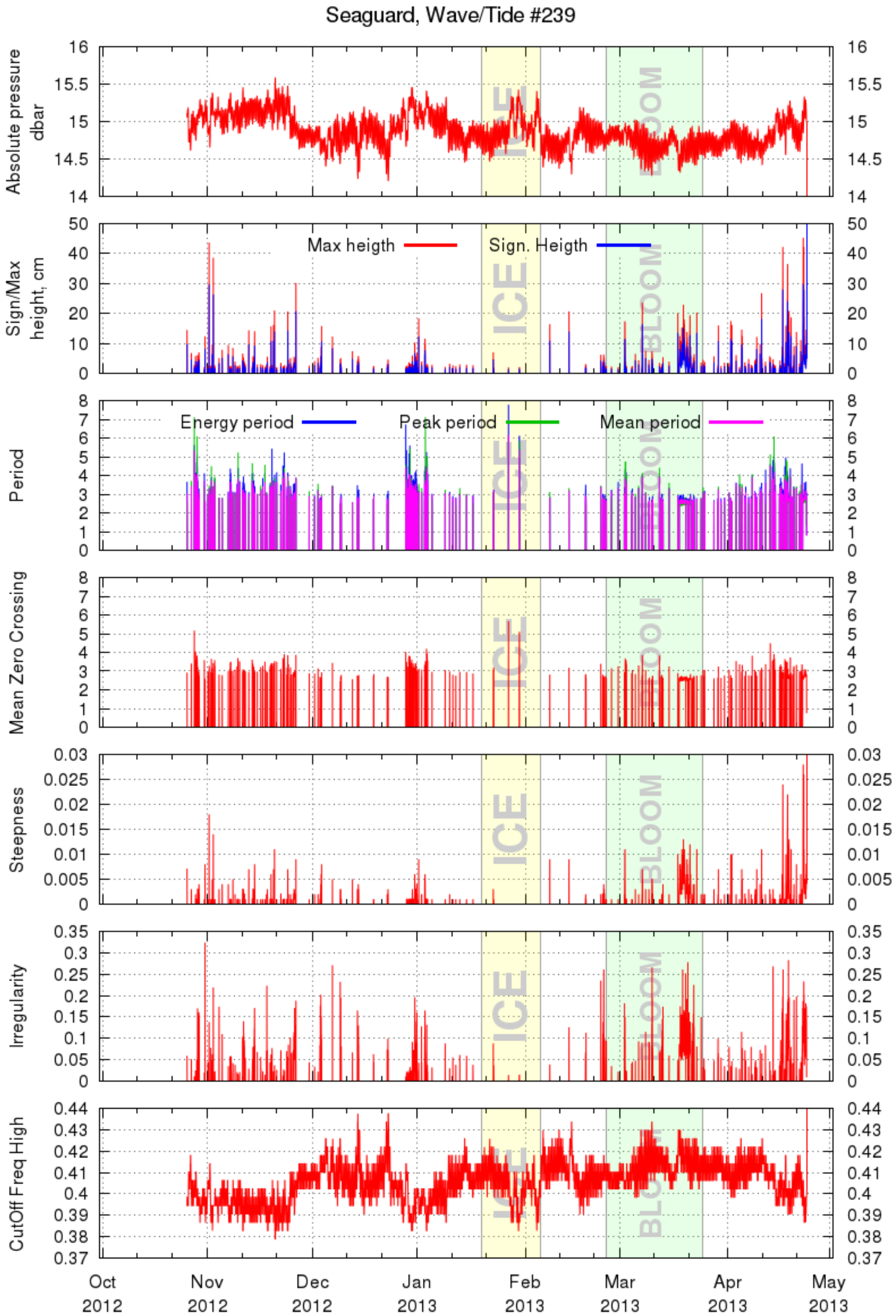

Figure 15: Seaguard Wave/Tide sensor #239 data. A period with strong waves in mid-March 2013 at the end of the bloom.

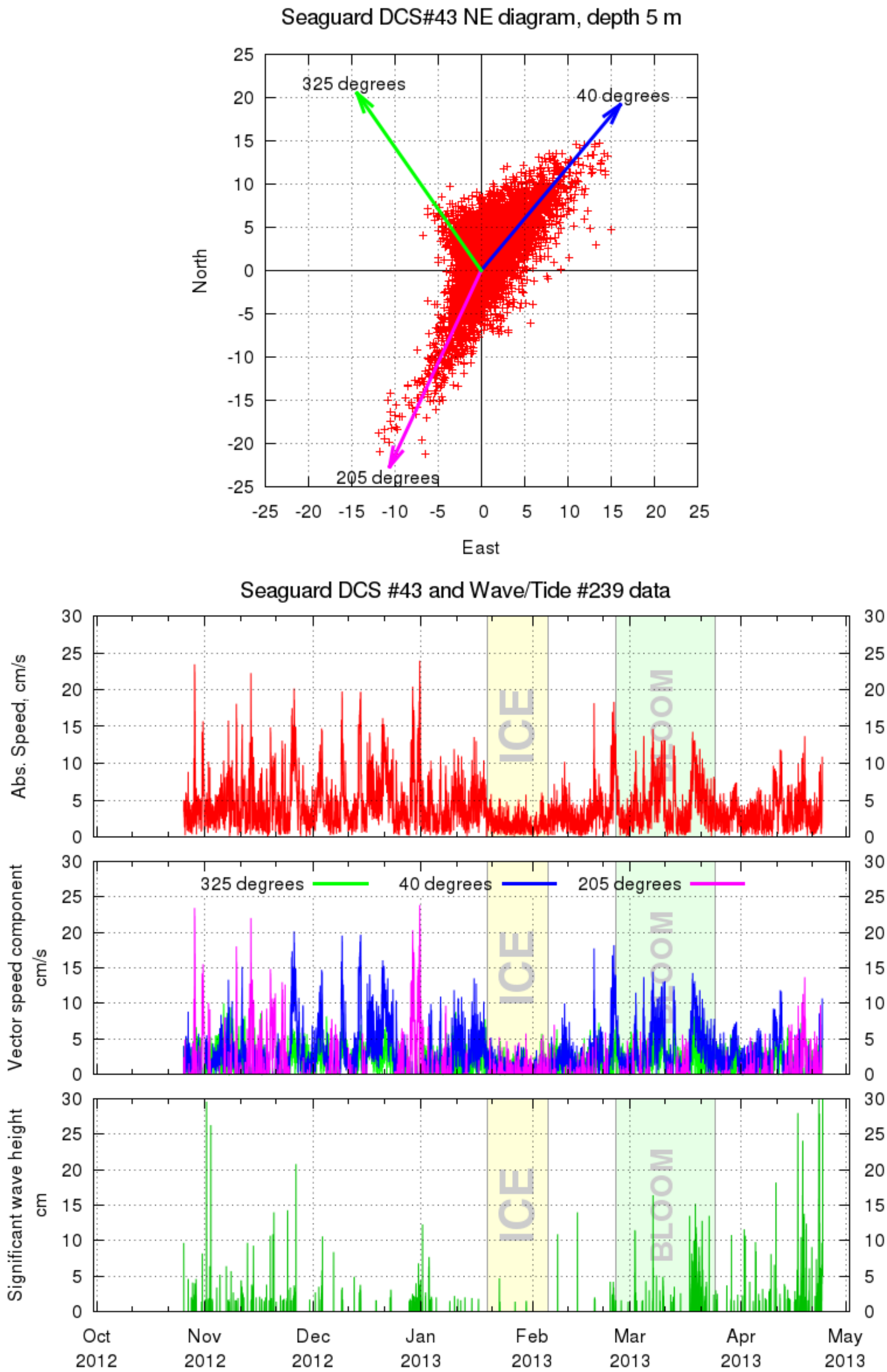

Figure 16: Seaguard DCS #43 and Wave/Tide #239, current and wave data. Very weak currents under ice. A period with strong waves in mid-March 2013 at the end of the bloom.

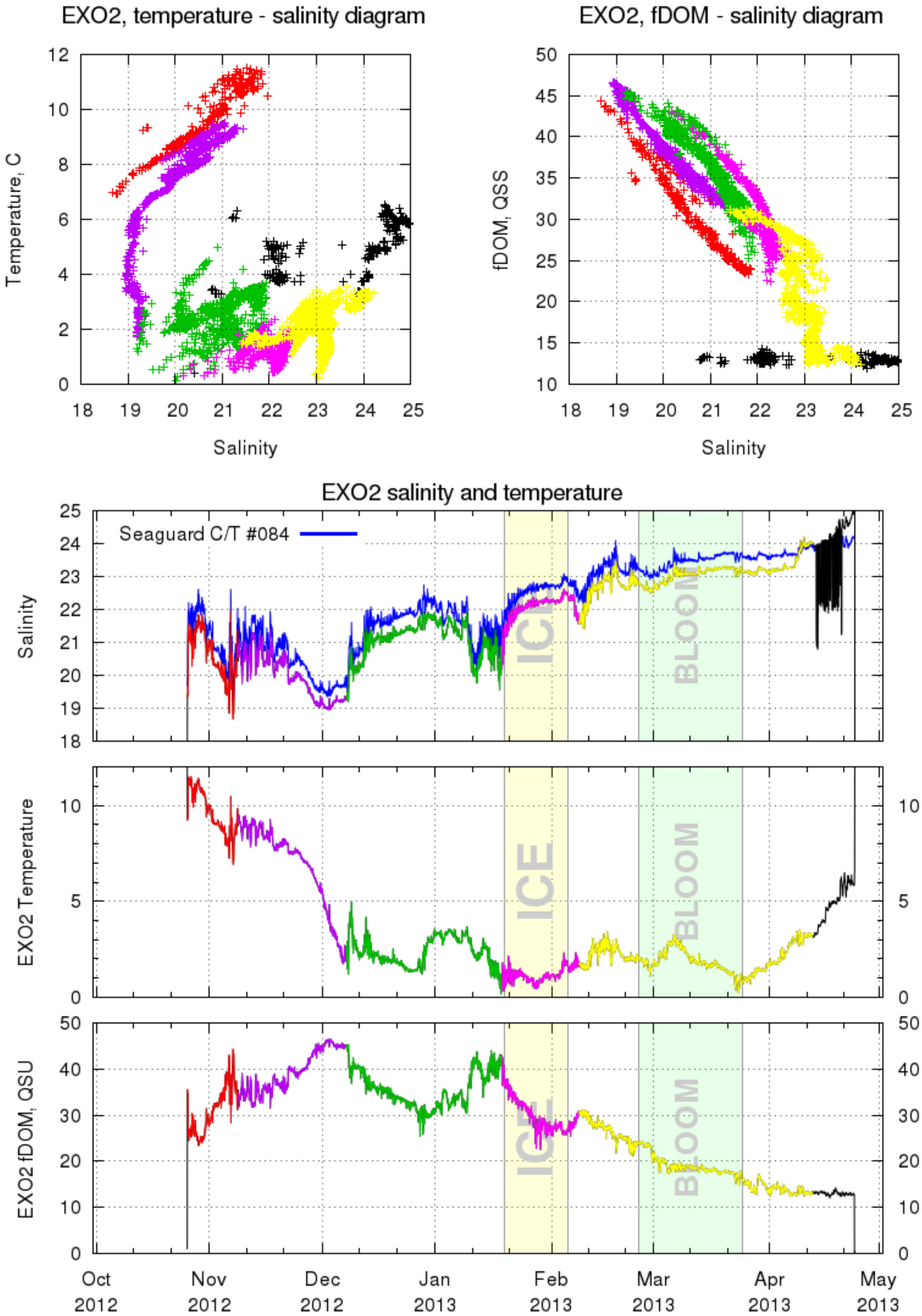

Figure 17: EXO2 temperature, salinity, and fDOM as indicators of water exchange/mixing.