Surface Ocean Acidification studies using Ships Of Opportunity

Marit Norli, Richard Bellerby, Emanuele Reggiani, Pierre Jaccard, and Kai Sørensen

Norwegian Institute for Water Research (NIVA), Gaustadalleen 21, N-0349 OSLO, Norway

Contact: marit.norli@niva.no Website: www.niva.no

SHIPS OF OPPORTUNITY

Ships of opportunity (SOOP) are used as a platform for cost-efficient collection of environmental data, Ferrybox. The SOOP network operated by NIVA cover the majority of the Norwegian coastline (from Germany (54N) in the South to Svalbard (78N) in the North. This network is used in the national OA monitoring program. Globally, SOOPs are used for pCO_2 measurements and this capacity will now be extended to the Norwegian coastline and Arctic Seas.

FERRYBOX

Measurements of **salinity, temperature, Chl a fluorescence, oxygen, cDOM, cyanobacteria and turbidity** are collected autonomously and continuously with the Ferrybox system (Figure A). There are also optical and meteorological measurements on the deck for satellite validation. Water samples can be triggered remotely or manually and are stored in refrigerator until laboratory analyses. The data obtained are logged and can be seen both on-line or after processing, and are used in national and European monitoring programs. Data are transferred to MyOcean database.

Color Fantasy has one of NIVAs Ferryboxes, crossing between Kiel-Oslo.

Permanent transects operated by NIVA using ships of opportunity (SOOP). Esbjerg-Seydisfjordur (Green), Oslo-Kiel (Blue), Hirtshals-Bergen (Dark blue), Bergen-Kirkenes (Red), Tromsø-Svalbard (Orange)

OBJECTIVES

Ocean Acidification is a decrease of the seawater pH and has historically been measured from water samples using a time consuming process from fieldwork to laboratory analyses and calculations.

A pair of the variables (A_T, C_T, pH or pCO_2) can be used to calculate the marine carbonate system.

New instruments for autonomous sampling of pCO_2 and pH are being incorporated into the Ferrybox systems on all SOOPs operated by NIVA.

NEW INSTUMENTS FOR pCO₂ AND pH

Membrane based pCO_2 system (Franatech/NIVA) with solid state detector for continuous measurements of pCO_2 (Figure B). Flow through system using Ferrybox pump, water leakage detector, internal logging and on-line software. Optional on-board calibration. A **new miniature spectrophotometric detection** system (NIVA) measures underway pH (Figure C). An internal pump draws water to a custom designed cuvette (provisional patent pending. USPTO), spectral absorbance processing after dye injection provides calibration free pH of the sample with precision < 10^{-3} pH, $\pm 2.5 \times 10^{-3}$ accuracy [2], drift within precision, max 2samples/min. Ongoing developments include the integration of a **direct UV carbonate ions detection.** Sensor developments are partly performed under the EU-Jerico project.
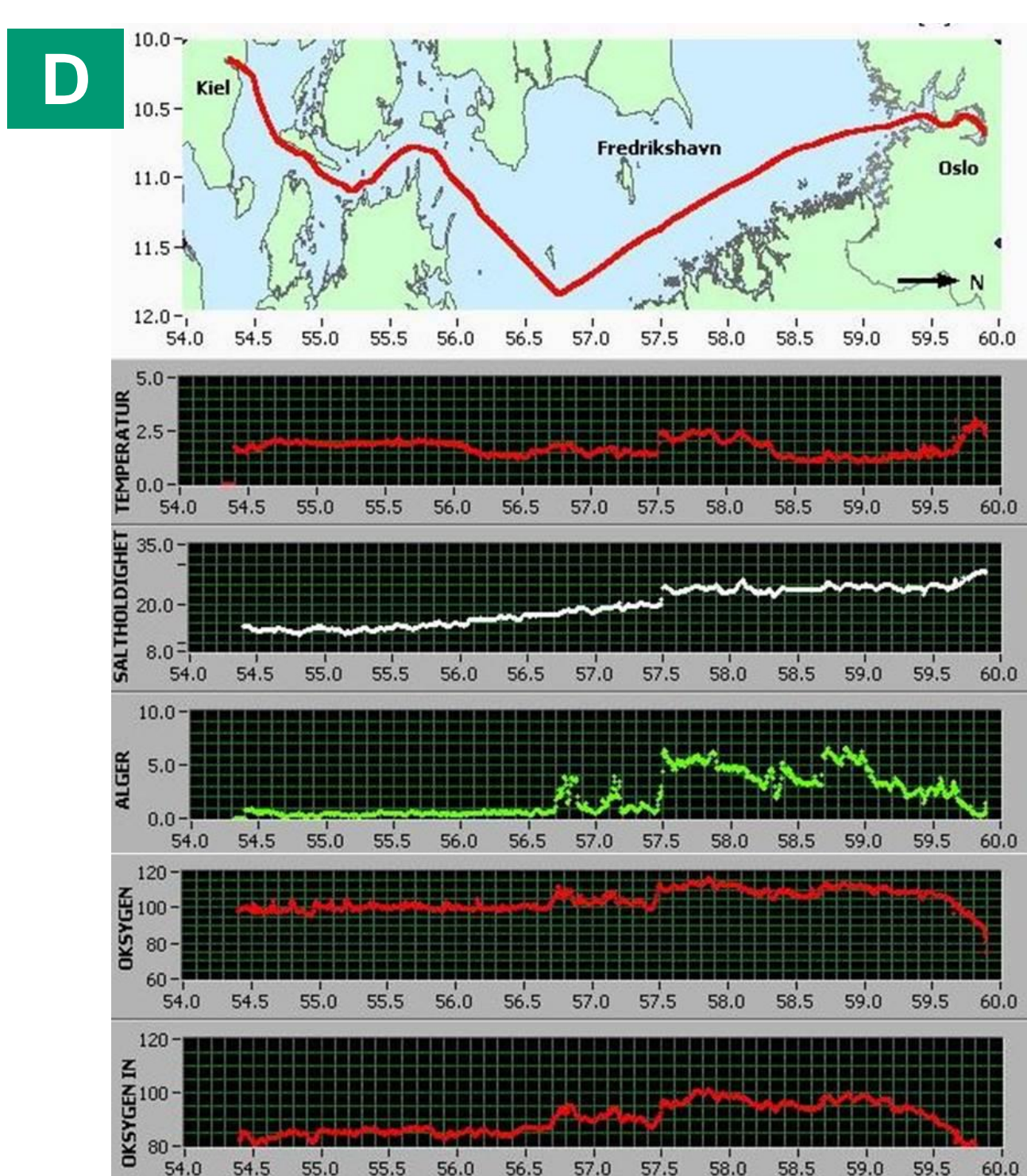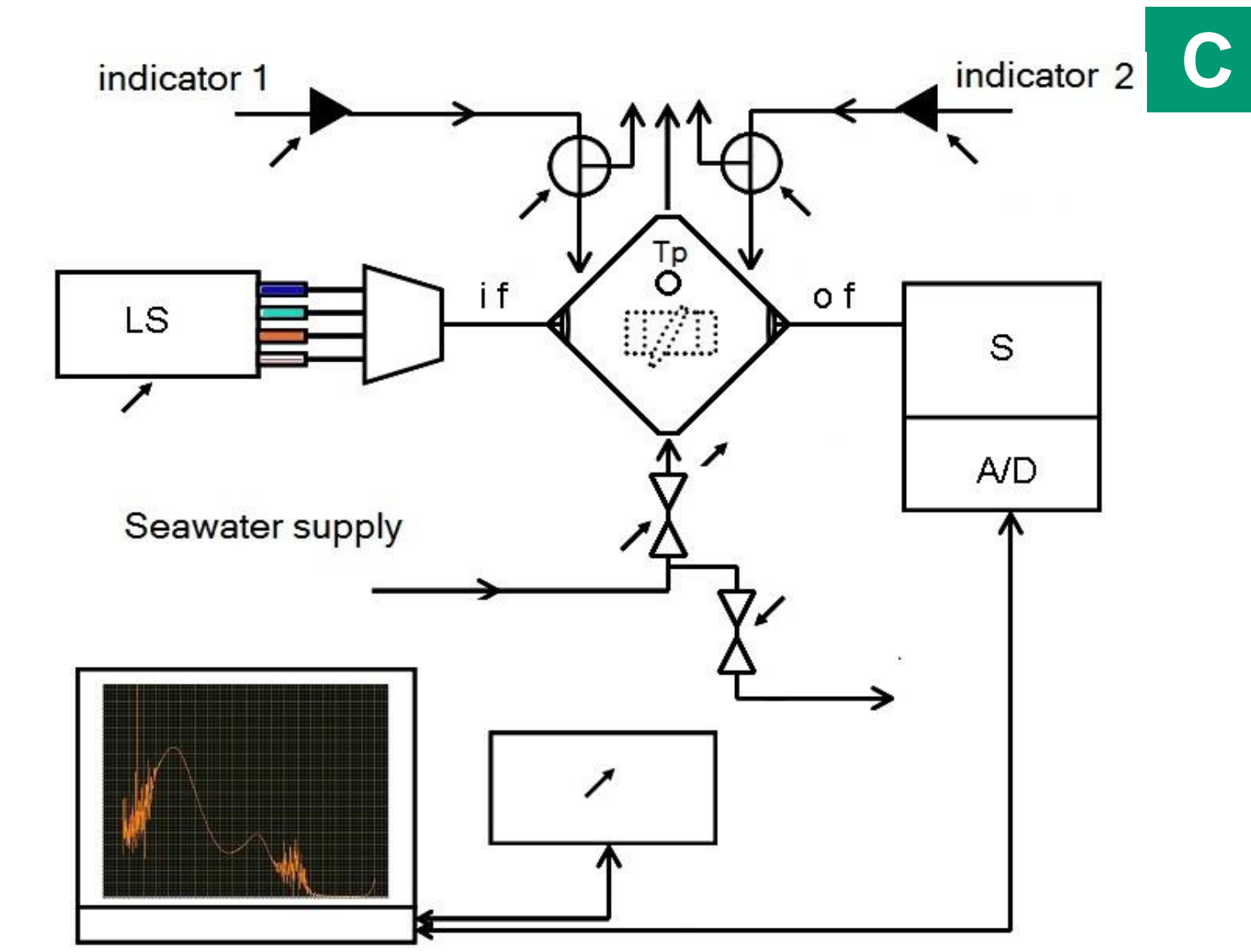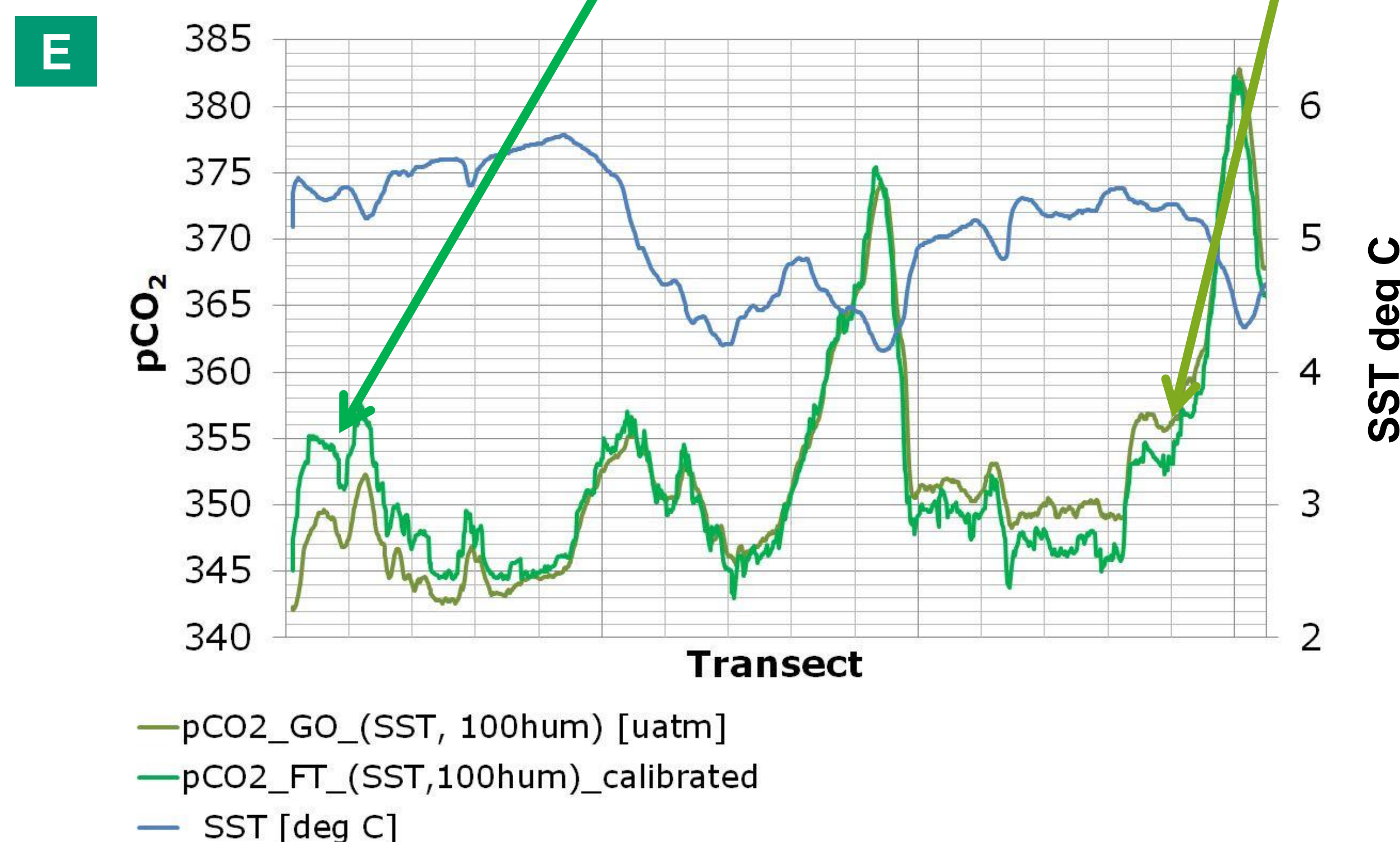

Ferrybox system

### Franatech and General Oceanographic pCO₂ system comparison
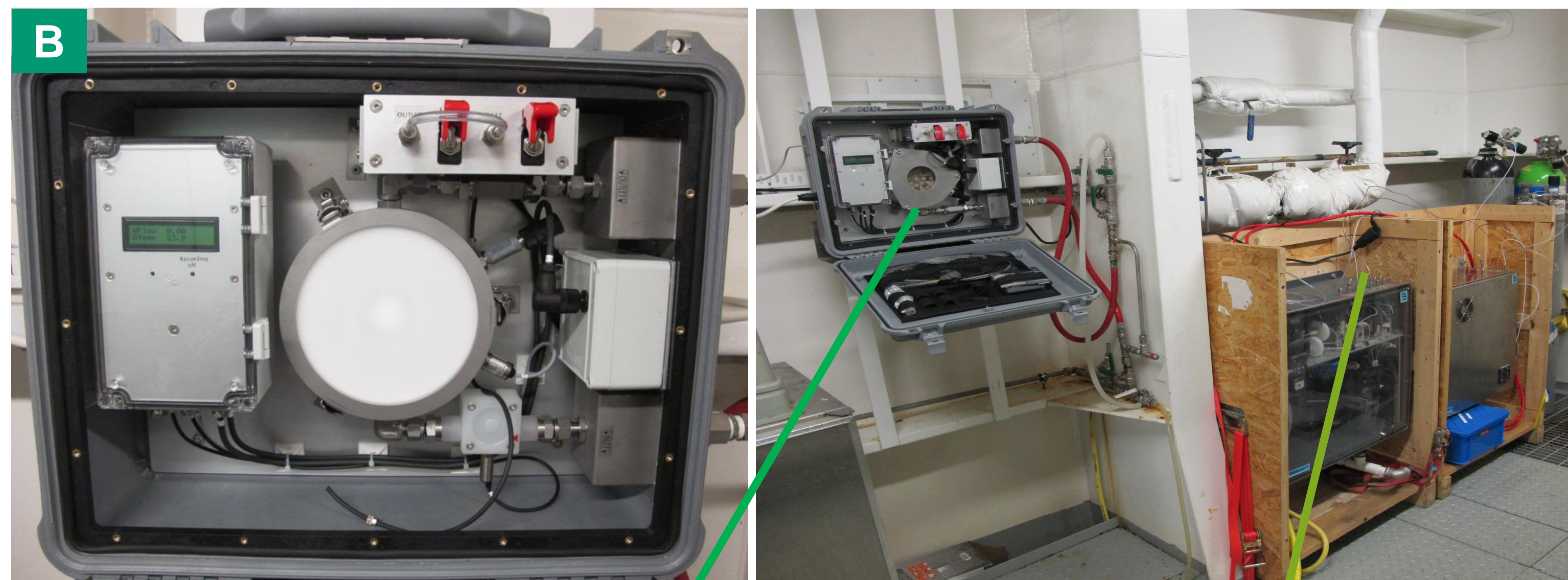
Photometric pH system

Catching the spring bloom of phytoplankton in Skagerrak with Ferrybox («Alger» (Algae) – in green and «Oksygen» (Oxygen) – in red). Biological production is important in seasonal variation of pH in the Oceans.

Franatech pCO2 system compared with GO pCO2 (GEOMAR) system show some difference. Work on calculations are still needed (how humidity, pressure and temperature affect in a membrane based system). Response test shows T90 = 4.5 min.
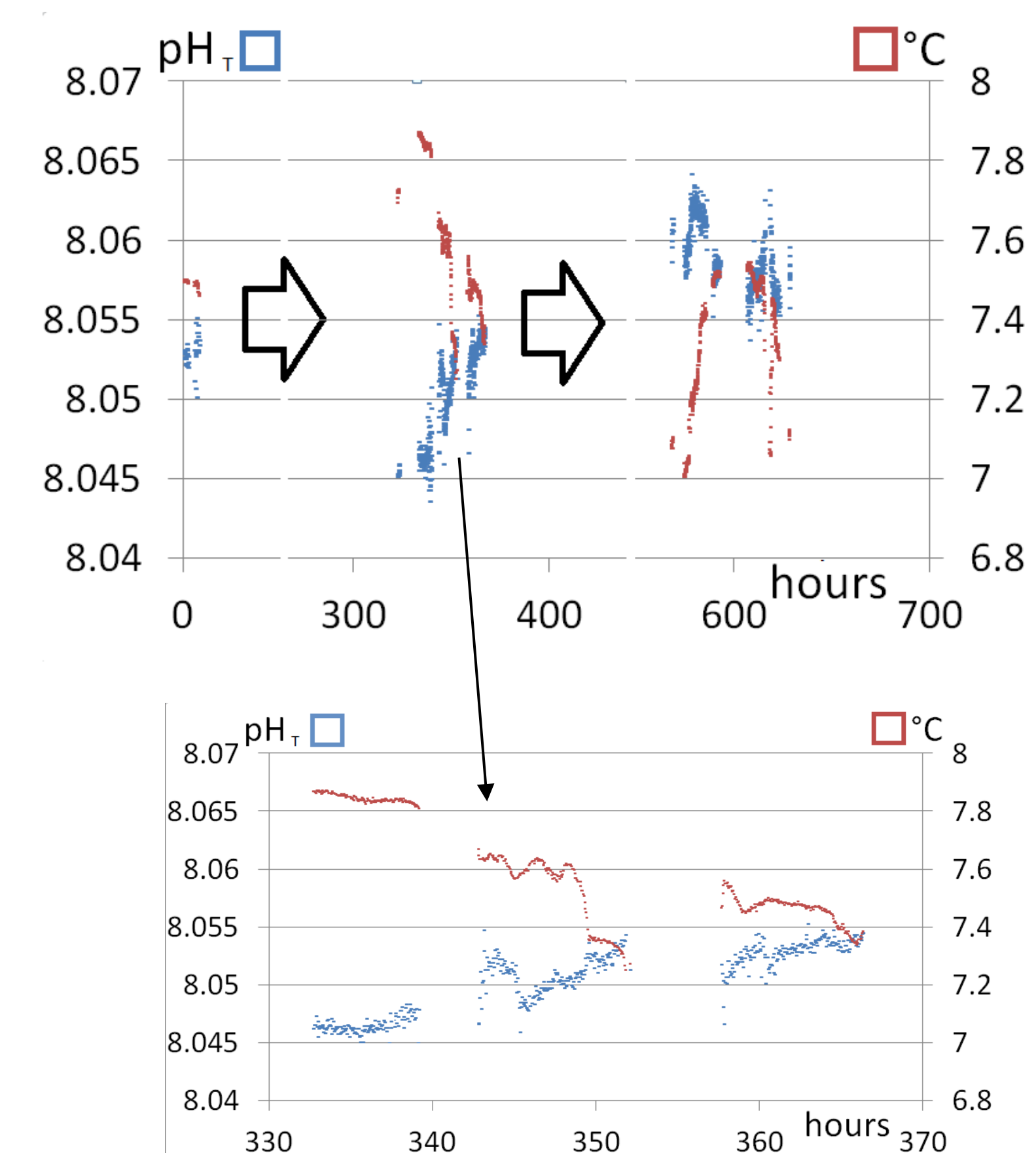
Short- and long-term precision of pH measurements at same coordinates in the Norwegian sea during time separated stations. From an early spring cruise data set.

CONCLUSIONS

- New instruments are under development that will give high resolution data on Ocean Acidification.
- Standard Operation Procedure (SOP) should be made for membrane based systems of pCO2 detection (Providing a better understanding of humidity, pressure and temperature effects)
- The pCO2 and pH data can be linked to parameters already obtained from the Ferrybox system; temperature, salinity, Chl a fluorescence, oxygen. Samples can also be obtained.

Acknowledgements