SYKE

ILMATIETEEN LAITOS

CRUISE REPORT

R/V Aranda

Cruise 06/2016

CFLUX16/CTD calibration

4 April - 15 April 2016

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This report is based on preliminary data and is subject to changes.

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CFLUX16

4 April – 15 April 2016

Chief Scientist: Kristian Spilling

1. General description of the cruise

There were two groups from the Finnish Environment Institute (SYKE) doing research on this cruise related to studies of the spring bloom and investigation of the effect of saltwater intrusions on Baltic Sea biology. In addition, a team from the Finnish Meteorological Institute (FMI) was on board for the first leg of the cruise, doing deployment of a wave buoy and CTD calibration work. Two journalists from EuroNews were also on board for the first 2 days and did a story on the EU project DEVOTES.

1.1. SYKE objective and work

1.1.2. Spring bloom studies

The spring bloom in the Baltic Sea has the highest annual productivity of phytoplankton, and this event have been much studied over the last decades. In the Gulf of Finland and Baltic Proper, the algae generally stop to grow once their source of nitrogen has been depleted, i.e. N-limited system. Further north in the Gulf of Bothnia the phytoplankton community is generally P limited.

The objective with the cruise was to document the phytoplankton spring bloom community in different parts of the Baltic Sea and to characterize basic chemical and biological parameters such as inorganic nutrients, chlorophyll *a* (Chl *a*) and plankton community composition. We also measured particular organic nutrients (carbon, nitrogen and phosphorus), size fractionated primary production, bacterial production (both leucine and thymidine incorporation), dissolved organic carbon and nitrogen, community respiration and grazing rates of bacteria and picoplankton. This cruise complements 3 previous CFLUX cruises that has taken place in 2013-15, and the four combined cruises provides an extensive data set over the spring bloom in the Baltic Sea covering different sub-basins and environmental conditions.

1.1.3. Saltwater intrusion studies

The Baltic Sea is affected by forces outside the system; hydrography driven by the water exchange with the North Sea and the river inflow from the large catchment area, and biological production dynamics driven by seasonal climate regime and anthropogenic nutrient inputs. Regarding food webs, their structure, species composition and dynamics are mostly dictated by hydrographic conditions in the water column, most important factors being temperature, salinity and oxygen content. These factors affect all trophic levels; primary and secondary producers (phyto- and zooplankton) and higher trophic levels (e.g. mysids and fish).

The saline water intrusion in December 2014 was exceptional as it was very large (3rd strongest recorded after 1880). As saline water inflows may, but not always, have long-term consequences on the ecology of the whole Baltic Sea their monitoring is crucial for our understanding of change. The 2014 saline water inflow may be either a one-off phenomenon or more large saline water pulses may follow during next winters. The complete ecosystem effect research provides crucial information on Baltic Sea dynamics, and its recovery potential from its present poor state considering eutrophication, oxygen depletion and biodiversity. Saline water pulses may have only transient or fundamental effect on the whole ecosystem. An example of the latter is the decade long effect of saline water pulses in late 1970s.

During the cruise we carried out CTD cast tracking the salt water intrusion and we determined also the oxygen concentration at the bottom which is a good indicator of the environmental status of the sea floor. We did also take samples from the sediment to determine benthic fauna and we collected water to determine the phyto- and zooplankton community, which is affected by saltwater intrusions.

1.2. FMI objective and work

The main purpose of the FMI work on board was intercalibration of different CTD instruments and other sensors measuring temperature and conductivity. In addition a MetOcean iSVP buoy was moored near Kytö island about 10 km out from Espoo shoreline on the first day of the cruise. The buoy is one of seven FMI sea surface temperature buoys along Finnish coast. This buoy is exceptionally equipped also with an air temperature sensor at 1 m height.

The intercalibration was carried out at the station TPDEEP1 in the northern part of Baltic Proper on the 5th of April. The total water depth at TPDEEP1 was 218 m and the water below 150 m was quite homogeneous. The reference CTD used was Aranda's SeaBird SBE911 Plus. The instruments involved in the intercalibration were seven RBR XR-620 CTDs, three SBE19 CTDs, three CastAway CTDs, nine DST CTDs and six Seastar Mini temperature loggers. The instruments were kept in six homogenous layers under 150 m depth for 30 minutes in each layer with an exception of instruments with operating range under 100 m. The performance of these instruments was tested in a separate cast. Water samples were taken from the intercalibration depths for salinity analysis. All SBE CTDs and one RBR CTD instrument were equipped with an oxygen sensor and water samples for oxygen content analysis were taken in the upper layer. Titrated values were compared with oxygen content values measured by the CTD instruments. Data for the comparison of fluorometers of the three SBE CTDs were gathered also in the upper layer.

2. The observations

2.1. Sailing route and basic measurements

We left Helsinki around noon on Monday April 4 and made 2 stations before continuing to TPDEEP where we did CTD calibrations for the whole Tuesday 5 April. In the morning of Wednesday 6 April we arrived in Hanko where part of the scientific crew got off and some persons got on board. After refueling we continued with one station before heading southwards on the western side of Gotland (Fig. 1). The following days we made 3-4 stations per day and made it down to the Bornholm basin before turning northwards again. On the way back we sailed on the eastern side of Gotland and continued into the Northern Baltic Proper. On Thursday 14 April in the morning, we reached the northernmost station during the cruise in the Åland Sea where we did 4 stations before returning the Gulf of Finland. We arrived at our home port in Helsinki approximately at 15.00 on Friday 15 April.

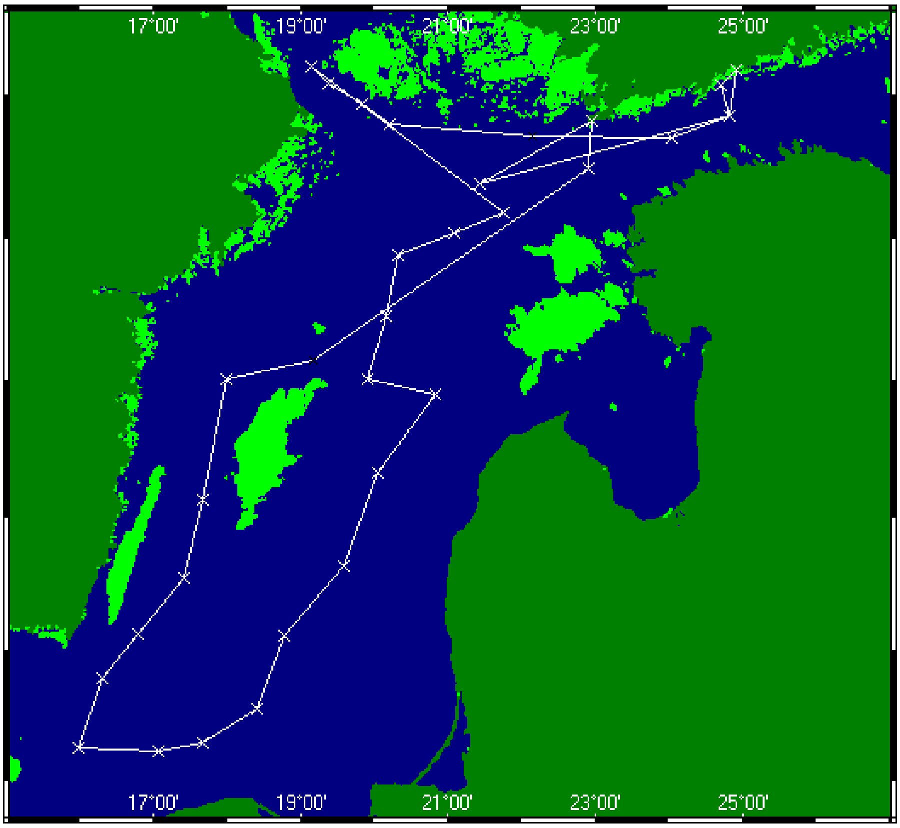


Fig 1. Sailing route, see text for details. Sampling stations are marked with x.

2.2. Inorganic nutrients

The inorganic nitrogen (NO2 + NO3) were depleted in most stations with the exception of some measurements taken in the Gulf of Finland (Fig 2). Inorganic phosphate was at a relatively high concentration in most stations, but with clearly lower concentrations in the Åland Sea (Fig 2). The low N and relatively high P was reflected in the inorganic N:P ratio which was very low (<5) in most stations and clearly in the N-limited region (Fig 3).

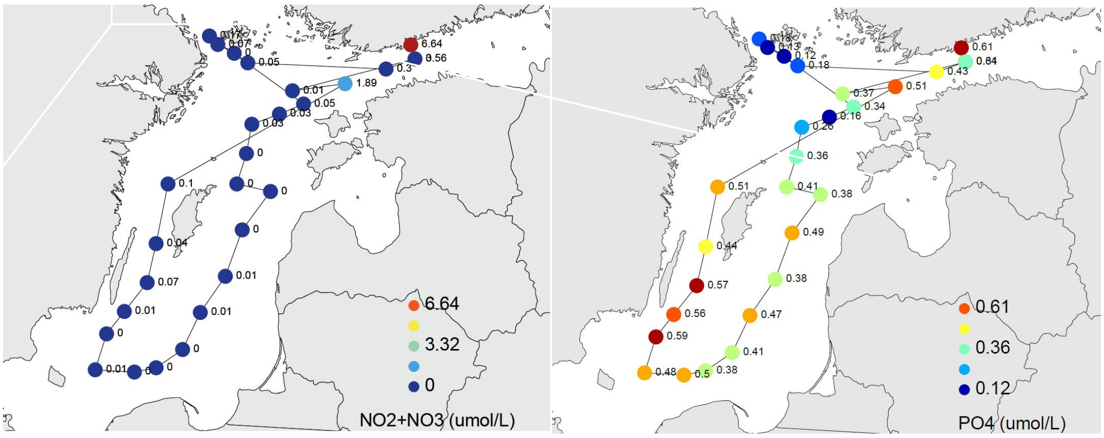


Fig 2. Main inorganic N (NO_2 + NO_3) and P (PO_4) sources measured at 3 m depth

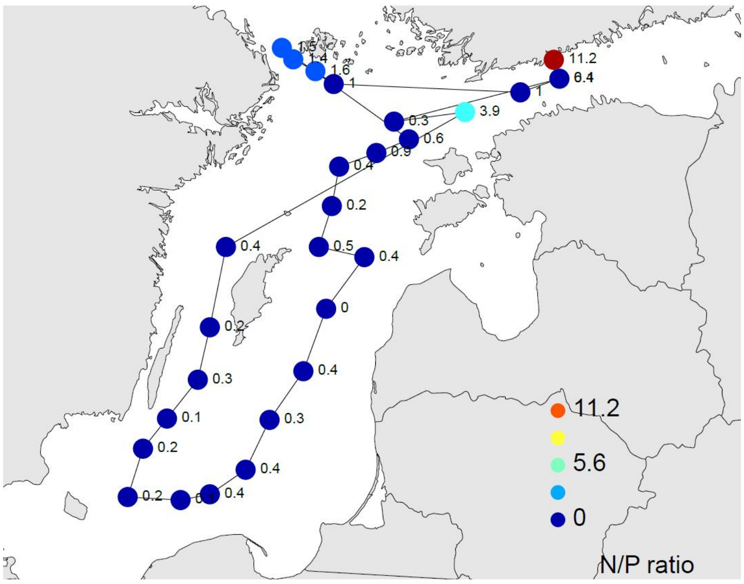


Fig 3. The inorganic N:P molar ratio at 3 m depth calculated from Fig 2.

2.3. Phytoplankton concentration and community composition

The Chl a concentration in the surface water was at spring bloom level peaks (~20 µg Chl a L^{-1}) in the Gulf of Finland both when starting the cruise and when returning (Fig

4). Further south the inorganic N was depleted and we were clearly after the peak of the spring bloom. This was also reflected in the size distribution, where a larger fraction of the phytoplankton community was found in the small (<10 µm) fraction typical of the situation after the spring bloom peak (Fig. 5).

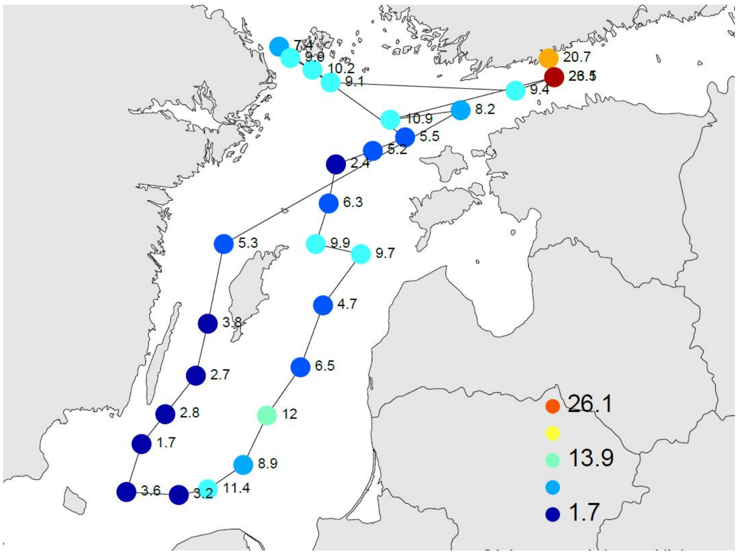


Fig 4. The Chlorophyll a (Chl a) concentration in mg m^{-3} at 3 m depth

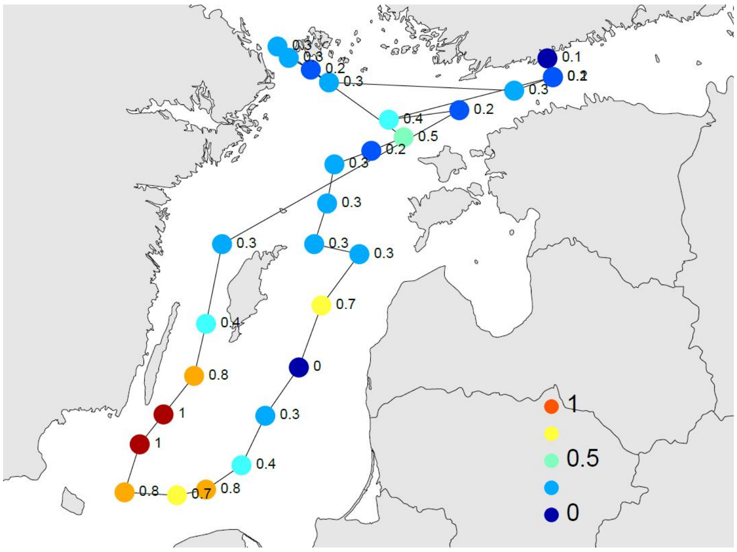


Fig 5. The fraction of Chl a (Fig. 4) measured in the <10 µm size fraction (i.e. a value of 1 indicates that all the Chl a was found in the <10 µm fraction).

2.4. Samples and data under preparation

We have quite a lot of other samples that have not been measured yet, but the results will become available during the coming months. Particulate organic nutrients (carbon, nitrogen and phosphorus), plankton and benthos samples, primary production, bacterial production and the results from a series of dilution experiment, which yields grazing rates, will need further analytical processing or data treatment before the results are ready.

2.6. Concluding remarks

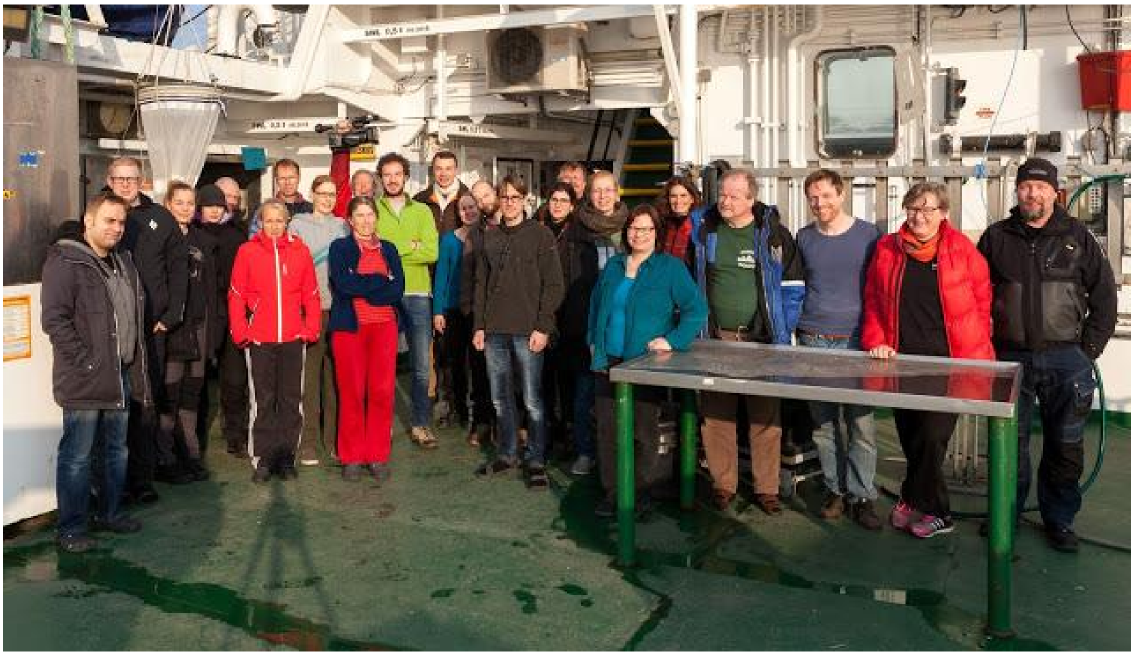
The spring bloom was at or close to the peak in the Gulf of Finland, whereas in the Baltic Proper we were sampling after the depletion of inorganic N and consequently after the biomass peak. This conclusion was supported by a very low inorganic N:P ratio and a high fraction of small phytoplankton of the total community.

We found the deep water inflow south of Gotland and this had alleviated the anoxic bottom conditions in the southernmost sampling stations. There were also signs of marine fauna that had been transported in with the saltwater inflow. North of Gotland there was no signs of high salinity deep-water.

We kept a blog during the cruise and the posts can be found at: http://cflux16.blogspot.fi/

3. Participants

Chief scientist	Kristian Spilling	SYKE
CTD chief	Jan-Erik Bruun	SYKE
Chief chemist	Ilkka Lastumäki	SYKE
	Riikka Hietala	FMI
	Teresa Camarena	SYKE
	Henrik Hedberg	SYKE
	Anna-Stiina Heiskanen	SYKE
	Susanna Hyvärinen	SYKE
	Heini Jalli	FMI
	Markku Jansson	FMI
	Jarkko Jyrälä	FMI
	Pertti Jämsén	FMI
	Tarja Katajisto	SYKE
	Pekka Kosloff	FMI
	Maiju Lehtiniemi	SYKE
	Tobias Lipsewers	SYKE
	Jonna Piiparinen	SYKE
	Tero Purokoski	FMI
	Tuomo Roine	FMI
	Laura Uusitalo	SYKE
	Pia Varmanen	SYKE
	Riina Klais	Univ. Tartu
	Tobias Tamelander	Univ. Helsinki
	Antonio Fuentes	Univ. Vigo
	Mari Vanharanta	Univ. Helsinki
	Denis Loctier	EuroNews
	Thierry Winn	EuroNews
	Maria Uyarra	AZTI
	Alicia Martinez	Univ Glasgow



Leg one, 4-6 April

Leg two, 6-15 April

4. List of stations

Table 1. List of the stations. The observations are explained in chapter 2 and were CTD, nutrients from surface and bottom waters and plankton samples from 3 m depth. The positions indicate where the CTD casts were made.

Index	Station	Position (°N; °E)	Depth	Date and time (UTC)
180	**MET_ESPOO**	**60.0578, 24.71582**	**16**	**2016-04-04T10:55:00**
181	**LL7S**	**59.85018, 24.83012**	**77**	**2016-04-04T13:12:00**
182	**TPDEEP1**	**59.37833, 21.44118**	**217**	**2016-04-05T03:49:00**
187	**LL12**	**59.4835, 22.89683**	**82**	**2016-04-06T12:28:00**
188	**BY32**	**57.99985, 17.99685**	**171**	**2016-04-07T07:35:00**
189	**BY38**	**57.11668, 17.66668**	**109**	**2016-04-07T14:44:00**
190	**WGB1**	**56.54002, 17.42**	**72**	**2016-04-08T05:49:00**
191	**O**	**56.113, 16.7882**	**42**	**2016-04-08T09:52:00**
192	**F96AW**	**55.78165, 16.29673**	**61**	**2016-04-08T13:40:00**
193	**BY5**	**55.25002, 15.98333**	**91**	**2016-04-09T05:10:00**
194	**BY7**	**55.21667, 17.06667**	**92**	**2016-04-09T11:30:00**
195	**5STO12B**	**55.28, 17.66673**	**84**	**2016-04-09T16:00:00**
196	**BCSIII10**	**55.55002, 18.4**	**90**	**2016-04-10T05:21:00**
197	**BOSEXC1**	**56.09828, 18.89037**	**120**	**2016-04-10T11:05:00**
198	**BY10**	**56.63333, 19.5833**	**144**	**2016-04-10T14:59:00**
199	**BY15**	**57.32008, 20.0501**	**238**	**2016-04-11T05:32:00**
200	**X15**	**57.88833, 20.83333**	**90**	**2016-04-11T13:25:00**
201	**F80**	**58.0, 19.90003**	**194**	**2016-04-11T16:46:00**
202	**F79**	**58.44997, 20.16668**	**103**	**2016-04-12T05:17:00**
203	**BY29**	**58.88333, 20.31668**	**163**	**2016-04-12T10:45:00**
204	**LL17**	**59.03332, 21.07948**	**171**	**2016-04-13T05:16:00**
205	**LL15**	**59.18332, 21.74683**	**131**	**2016-04-13T11:05:00**
206	**F64**	**60.189, 19.14252**	**286**	**2016-04-14T05:18:00**
207	**S4B**	**60.06332, 19.37497**	**180**	**2016-04-14T08:01:00**
208	**F67**	**59.93335, 19.83005**	**210**	**2016-04-14T10:35:00**
209	**NOL27**	**59.79172, 20.205**	**180**	**2016-04-14T14:04:00**
210	**LL9**	**59.70017, 24.03018**	**67**	**2016-04-15T04:50:00**
211	**LL7S**	**59.85017, 24.83018**	**76**	**2016-04-15T09:30:00**