UNIVERSITY OF GOTHENBURG

**DEPARTMENT OF MARINE SCIENCES**

# Cruise Report

MAR440 – BOX PROJECT
INVESTIGATION OF THE STATUS OF BYFJORDEN AND HAVSTENSFJORDEN

DATA COLLECTED ABOARD THE R/V SKAGERAK
22 September 2020

# Table of contents

**Data document**

The aim of the cruise was to investigate the differences in hydrography between Byfjord and Havstensfjord. Furthermore, the cruise investigated possible water exchanges over the sill between the two fjords and the distribution of nutrients and dissolved oxygen.

**MAR440 - Box Project Participants**

R/V Skagerak, 22 September

*Ship Crew*

| | |
|---|---|
| Christian NN | Captain & CTD-operator |
| Anders Oleander | Captain & CTD-operator |

*Scientific Personnel*

| | |
|---|---|
| Marcel du Plessis | Postdoctoral researcher, University of Gothenburg, Sweden<br>Project supervisor, CTD-management |
| Sebastiaan Swart | Associate Professor, University of Gothenburg, Sweden<br>Project supervisor, CTD-management |

*Students*

| | |
|---|---|
| Anna Alklid | University of Gothenburg, Sweden (Assisting Scientist) |
| Marica Andersson | University of Gothenburg, Sweden (Chief Scientist) |
| Doris Björling | University of Gothenburg, Sweden (Assisting Scientist) |
| Klara Bladin | University of Gothenburg, Sweden (Assisting Scientist) |
| Marty Breidenbach | University of Gothenburg, Sweden (Assisting Scientist) |
| Linnea Brokmar | University of Gothenburg, Sweden (Assisting Scientist) |
| Tristan Dickinson | University of Gothenburg, Sweden (Assisting Scientist) |
| Isabelle Johansson | University of Gothenburg, Sweden (Assisting Scientist) |
| Max Kankainen | University of Gothenburg, Sweden (Assisting Scientist) |
| Mikael Lindström | University of Gothenburg, Sweden (Chief Scientist) |

## Scientific objectives

Numerous marine regions are increasingly exhibiting states of hypoxia and anoxia (Richirt et al. 2020). The potential environmental consequences of anoxia have since been monitored in Byfjorden, a small sill fjord on the Swedish west coast. In one study surface water has been pumped down below the sill depth in order to counteract the anoxic tendencies presented in previous Baltic deepwater oxygenation (BOX) as well as looking up excess phosphate in solid particles accumulating in the sediment (Stigebrandt et al. 2014).

As Byfjorden have been monitored like this in the past in conjunction with the course MAR440 and through means of a higher scale (e.g. Stigebrandt et al. 2014), a new cruise was conducted with the aim of comparing physical and chemical variables between Byfjorden and Havstensfjorden as well as their relation to each other.

The present cruise report contains a synopsis of scientific monitoring executed in Byfjorden and Havstensfjorden aboard R/V Skagerak. On the 22 september, 10 students along with the cruise crew and 2 project supervisors conducted sampling of hydrographic variables, nutrients and oxygen across a 8 km transect. As CTD-data was collected at 9 locations along the transect (4 points in Byfjorden, 5 in Havstensfjodrden), water samples were collected in 6 (3 points in each area). The collected data was accordingly presented within individual reports and discussed in a seminar with all students present. The brief data compilation within this cruise report is not intended to be interpreted or cited as a final result.

## Daily cruise narrative

*Weather*
General weather conditions were good. The wind was in a South to South-Easterly direction at speeds of ~6 m/s (based on station data from Såtenäs). The sea state was smooth or slight throughout the entire day, with the weather conditions dry with cloud and sunny spells. Visibility was good throughout the entire day.

*Daily activities*
Groups of three students were assigned into either communications, CTD sampling or CTD operations. The communications team was responsible for logging depth, latitude and longitude of the stations, the time of CTD deployment, as well as maintaining a line of communication with the crew and the CTD operations team. The CTD sampling team was responsible for labelling vials and collection of water samples from the Niskin bottles, as well as resetting the CTD for the next station. The CTD operations team was responsible for choosing the depths at which the Niskin bottles should be closed, based on live telemetry of the water parameters. Additionally, box sediment cores were taken from two stations.

*Crew changes*
Group 1, consisting of Marica, Klara and Linnea, was originally assigned to communications. Group 2, formed of Marty, Max and Tristan, was originally assigned to CTD sampling. Group 3, formed of Mikael, Anna and Doris, was originally assigned to CTD operations. Groups rotated every two stations.

*Problems encountered*
Group positions should have been fully assigned before boarding the ship and only Group 1 had been assigned to communications. Assigning individuals to groups resulted in lost time on the cruise day. Additionally, group roles were not clarified until arrival at station A, and so time was also lost due to this. This was solved relatively quickly, and no further problems occurred. Furthermore, labelling of samples should have been better planned. The labelling system that we had needed to be adjusted onboard the ship which caused confusion and delayed our sampling. This was solved at station A, and no further issues arose. We did not factor in lunch for the ship crewmates, but fortunately this did not hinder sampling. Handling and sampling of the box corer was tricky due to lack of prior experience. A significant amount of time was lost resetting the box core each time; one station (C) did not supply an adequate amount of sediment for analysis and so another station (B) was selected. Instead, time could have been better utilized by taking additional CTD samples to achieve more accurate transect data. We had planned to analyse nutrients from the pore water of the sediment samples, but the water content was too low and no nutrient data could be extracted. Neither could the secchi depth be determined as planned since there was no secchi disk onboard the ship.
An additional problem was that there was an error in the filtering of the CTD-data from station H so the data could not be included in the analysis.

## Cruise overview

A total of 9 stations were sampled during the cruise onboard R/V Skagerak (fig. 1). All stations were sampled for CTD-data and additional sampling was made at certain stations as listed in table 1. At four of the stations we collected water samples from Niskin bottles to analyse nutrients in the water and at two of the stations we collected water samples in winkler bottles for an illustrative overview of the oxygen concentration. Accurate oxygen concentration would have been retrieved through the Winkler titration method. Optimally, we would have wanted to perform oxygen calibration through Winkler titration using water from all sampled depths where CTD readings reported stable oxygen concentrations above zero. However, due to the current pandemic we were unable to analyse the samples in the lab.

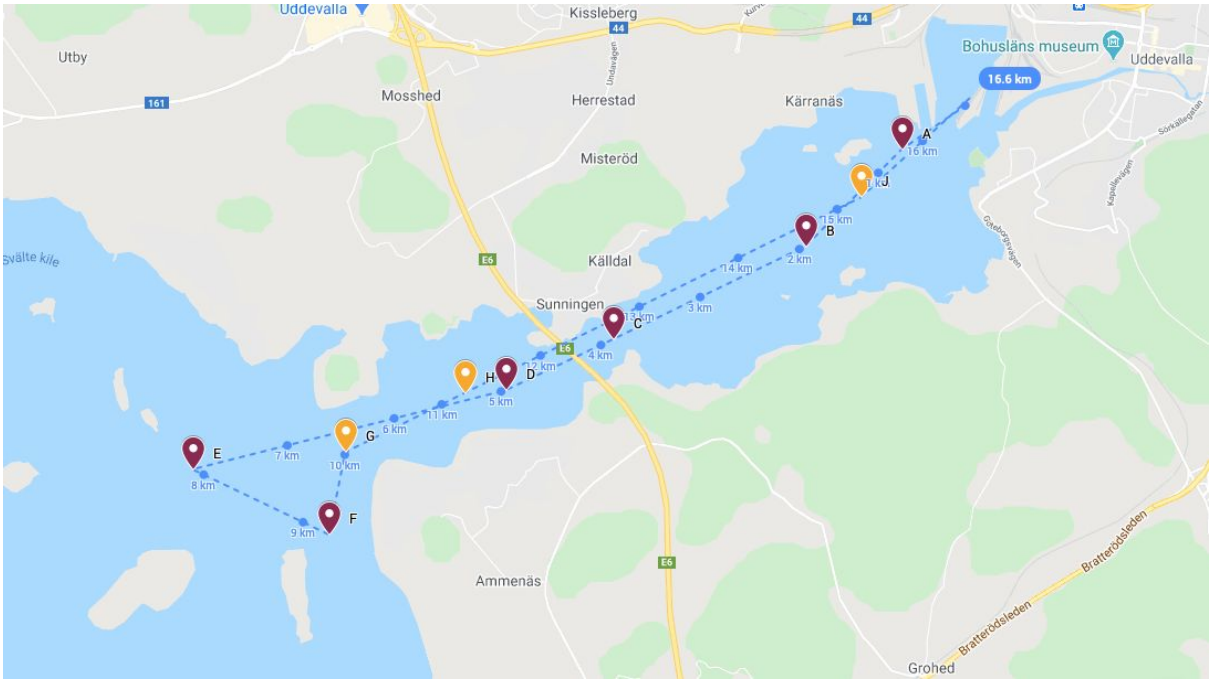


***Figure 1**. Sampling stations along the cruise track, additional stations for only CTD sampling are in orange.*

**Table 1.** *Sampling stations during the cruise. The sampling equipment used at each station are marked with a "x".*

| Station | Date | Time (GMT+2) | Max depth | Latitude | Longitude | Location | CTD | Water samples | Oxygen sample | Box corer |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 2020-09-22 | 10:30 | 34.5 | 58.34241 | 11.89531 | Byfjorden | X | X | | |
| B | 2020-09-22 | 11:15 | 45.7 | 58.33450 | 11.88040 | Byfjorden | X | X | | X |
| C | 2020-09-22 | 11:47 | 14.2 | 58.32687 | 11.85043 | Byfjorden | X | X | X | |
| D | 2020-09-22 | 12:30 | 15.8 | 58.32268 | 11.83392 | Havstensfjorden | X | X | | |
| E | 2020-09-22 | 12:55 | 35.3 | 58.31626 | 11.78529 | Havstensfjorden | X | X | X | |
| F | 2020-09-22 | 13:25 | 20.5 | 58.31093 | 11.80644 | Havstensfjorden | X | X | | X |
| G | 2020-09-22 | 13:55 | 28.2 | 58.31766 | 11.80899 | Havstensfjorden | X | | | |
| H | 2020-09-22 | 14:08 | 20.8 | 58.32250 | 11.82750 | Havstensfjorden | X | | | |
| J | 2020-09-22 | 15:00 | 39.78 | 58.33848 | 11.88895 | Byfjorden | X | | | |

## Preliminary results

CTD-measurements were carried out at every station. From the gathered data a transect was created, beginning at station F in Havstensfjorden and ending at station A close to the inner harbour in Byfjorden (fig. 1). The preliminary results were analysed and illustrated using the program Ocean data view (ODV).

Salinity and temperature demonstrate a clear stratification between deepwater and surface water, separated by a strong pycnocline (fig. 2 & 3). The pycnocline lies around the sill depth for Byfjorden (13m) at an interval between 10-25m. Above the pycnocline the salinity is stable at 22 PSU and below the pycnocline it stabilizes at 31 PSU. Temperatures above the pycnocline is around 16 °C and below the pycnocline around 8 °C.

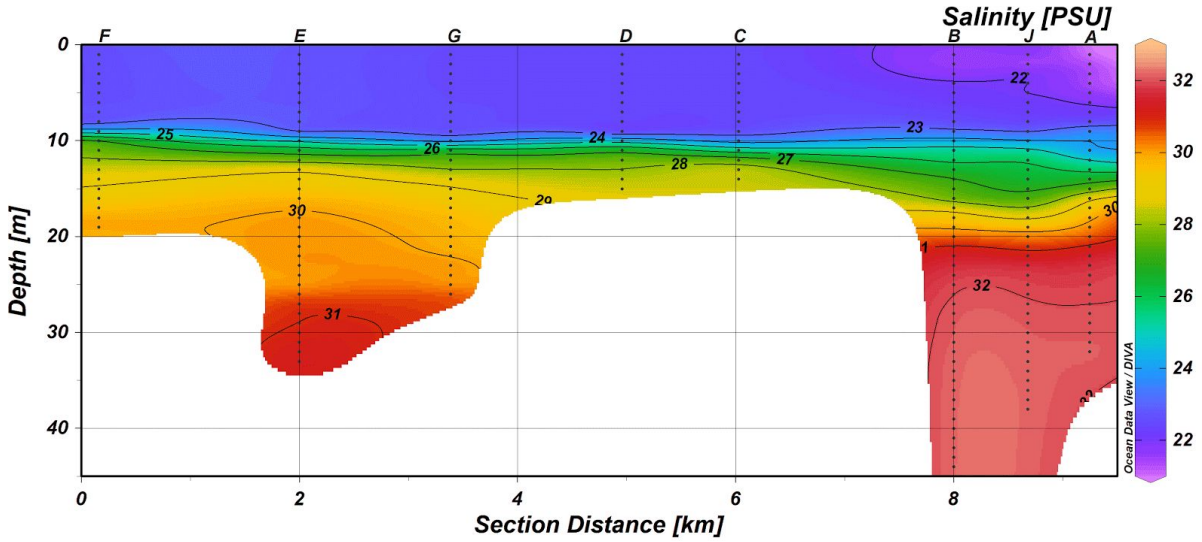


**Figure 2.** *Salinity measurements from the study area. Havstensfjorden is situated to the left of the figure and Byfjorden to the right. Station names are visualized at the top of the figure.*

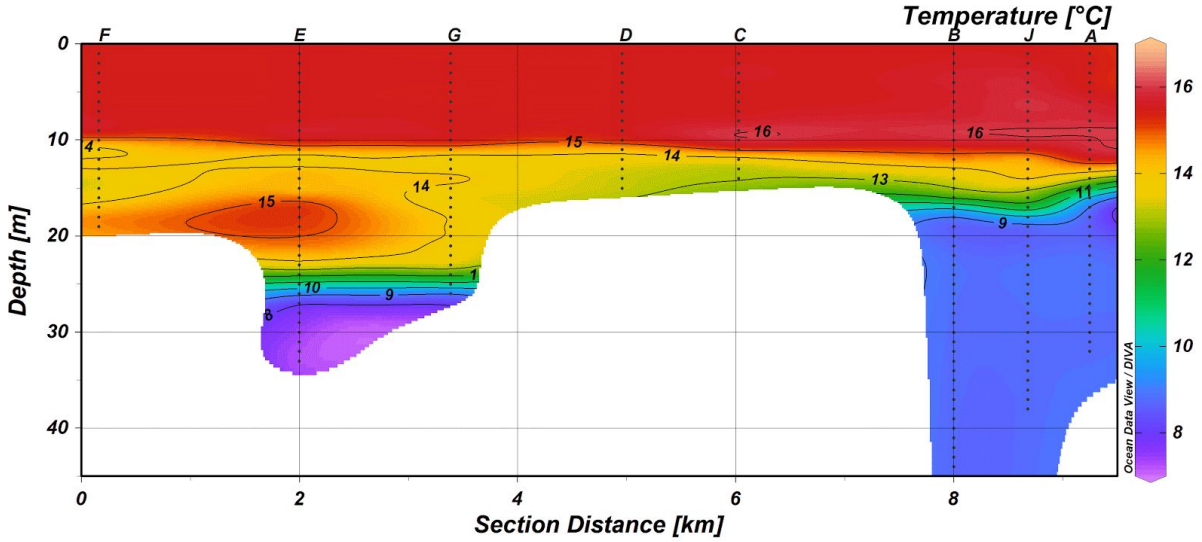


**Figure 3.** *Temperature measurements from the study area. Havstensfjorden is situated to the left of the figure and Byfjorden to the right. Station names are visualized at the top of the figure.*

Oxygen levels also show a clear stratification. The oxycline conforms to the upper limit of the pycnocline but only reaches down to 3 meters (fig. 4). Above the oxycline the oxygen levels are fairly high at 6 ml/l, and below the oxycline they are between 0-1 ml/l, reaching zero at the bottom of both fjords.

Fluorescence is generally low throughout the transect (fig. 5). In Byfjorden at around 21 meters there is a zone with heightened fluorescence values. This zone lies directly under the pycnocline. Another area with heightened fluorescence values lies in the surface water of station A. This area has the closest proximity to the inflowing Bäveån (fig. 1).

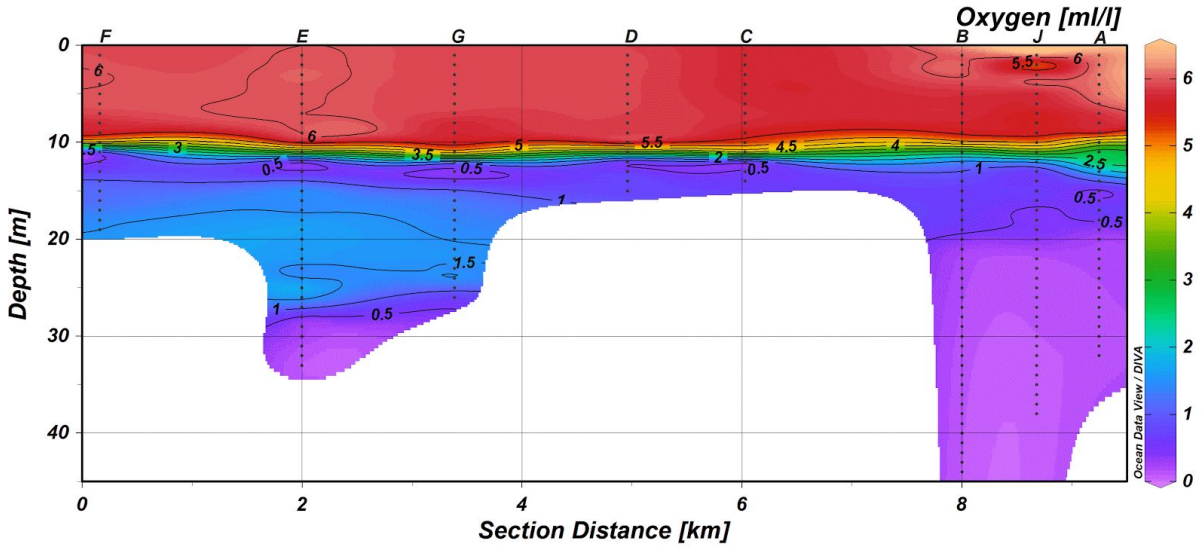


**Figure 4.** *Oxygen measurements from the study area. Havstensfjorden is situated to the left of the figure and Byfjorden to the right. Station names are visualized at the top of the figure.*

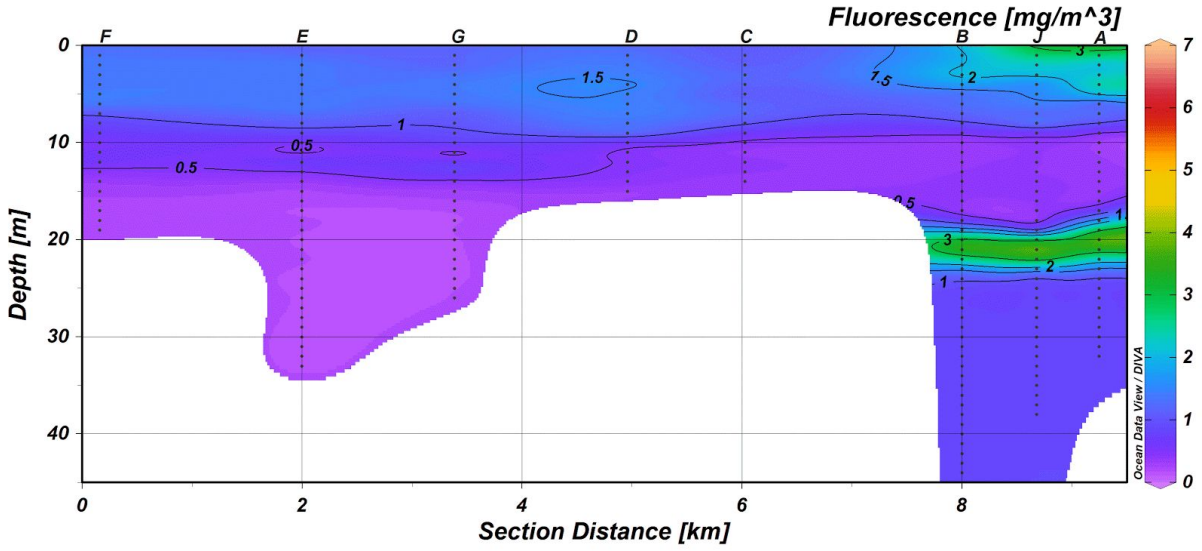


**Figure 5.** *Fluorescence measurements from the study area. Havstensfjorden is situated to the left of the figure and Byfjorden to the right. Station names are visualized at the top of the figure.*

## References

Richirt, J., Riedel, B., Mouret, A., Schweizer, M., Langlet, D., Seitaj, D., … Jorissen, F. J. (2020). Foraminiferal community response to seasonal anoxia in Lake Grevelingen (the Netherlands). *Biogeosciences*, *17*(6), 1415–1435. https://doi.org/10.5194/bg-17-1415-2020

Stigebrandt, A., Liljebladh, B., de Brabandere, L., Forth, M., Granmo, Å., Hall, P., … Viktorsson, L. (2014). An Experiment with Forced Oxygenation of the Deepwater of the Anoxic By Fjord, Western Sweden. *Ambio*, *44*(1), 42–54. https://doi.org/10.1007/s13280-014-0524-9