Cruise Report
Byfjorden & Havstensfjorden

MAR440 - Marint projekt - från idé till handling
Period 1, Autumn 2023
Tue 05 Sept 2023
Supervisor: Sebastiaan Swart

Abstract

The Byfjord, on Sweden's West coast, has a unique water mixing pattern, dependent on water exchange. Salt-stratification causes anoxic bottom layers. Efforts like the BOX project tried to restore the bottom layers by pumping oxygen to the anoxic bottom layer from 2010-2012.

For this cruise sampling coordinates were chosen based on their bathymetry and fjord characteristics in both the Byfjord and the Havstensfjord, and under the E6 bridge. When sampling, a CTD was utilized to measure the parameters conductivity, temperature, depth, and fluorescence. Additionally, samples of microplastics at three predetermined transects were collected using a Manta trawl. Sampling was made at six spots out of thirteen planned, due to difficulties in coordination management as well as technical complications throughout the day.

Despite these obstacles, significant data was gathered from these six sites. Preliminary analyzes on the data show there are distinct differences in oceanic characteristics between the two fjords. Further analysis, via students in study groups, will reveal deeper insights.

Keywords: BOX Project, Fjord, Oxygen, CTD, Salinity, Temperature, Fluorescence, Microplastics.

Participants:

Students:
Position: Master Student, Marine Sciences
Organization: Gothenburg University, Department of Marine Sciences
Participated in all cruise legs, focused on navigation and first crew communication: Lizeth Alcocer, Mats Heitzmann and Ethan Jezek.
Participated in all cruise legs and focused on communication: Alexandra Cronholm.
Participated in all cruise legs: Emmelie Alm, Saga Alsterlind, Alice Anderstedt, Arvid Bengtsson Persson, Mohammad Hekmatafshar, Felix Brox, Thomas Cunial, Paulina de Jesús Álvarez, Sofia Kamperin, Erik Fransson, Pia Goecke, Filip Leander.

GU professors:
<u>Sebastiaan Swart</u>
Position: Professor
Organization: Gothenburg University, Department of Marine Sciences
Participation: All cruise legs

<u>Milad Pourdanandeh Hosseini</u>
Position: Doctoral Student
Organization: Gothenburg University, Department of Marine Sciences
Participation: Focus on Niskin bottle sampling, specifically on fluorescence belt

<u>Karin Mattsson</u>
Position: Researcher
Organization: Gothenburg University, Department of Marine Sciences
Participation: Conducted microplastics sampling via Manta Trawl

Background

Byfjord is a deep salt-stratified fjord situated on the West coast of Sweden with a narrow and shallow sill. These characteristics have a large impact on the circulation and mixing of these bodies of water; instead of typical seasonal mixing, circulation of water layers is caused by influx of freshwater or saltwater over the sill due to storm activity or other phenomena. A consequence of this is that the residence time of the dense water can be as long as 5 years and the low renewal of water causes a layer of anoxic water to form at the bottom, giving rise to the release of phosphorus (P). Increases in P levels (both internal leakage and of land origin) give rise to cyanobacterial blooms, which, together with the absence of oxygen, lead to the loss of fauna, landscape value, etc. The increase in the internal phosphorus source was first recorded in 1950. Studies have been made to improve the situation by oxygenating the bottom layers. One such study was the Baltic deepwater oxygenation project (BOX project), performed between 2010-2012, where surface water, rich in oxygen, was pumped down to the deep layer in Byfjord (Stigebrandt. Et al., 2015; Stigebrandt & Andersson, 2022). Routine sampling has been conducted in both Byfjord and the adjacent Havstensfjord since the implementation of the BOX project, aiming to gain a better understanding of the regenerative program's impact.

The extensive knowledge of the Byfjord characteristics allows educational institutions to teach basic field experimentation. The main focus in this cruise was to study the circulation in the fjords, the oxygen levels, the concentration of microplastics, comparing the results between Byfjord and Havstensfjorden, and to study the mysterious fluorescent layer in the Byfjord. Therefore, CTDs, manta trawls and collection of water samples with Niskin bottles were carried out during the cruise.

Cruise Overview

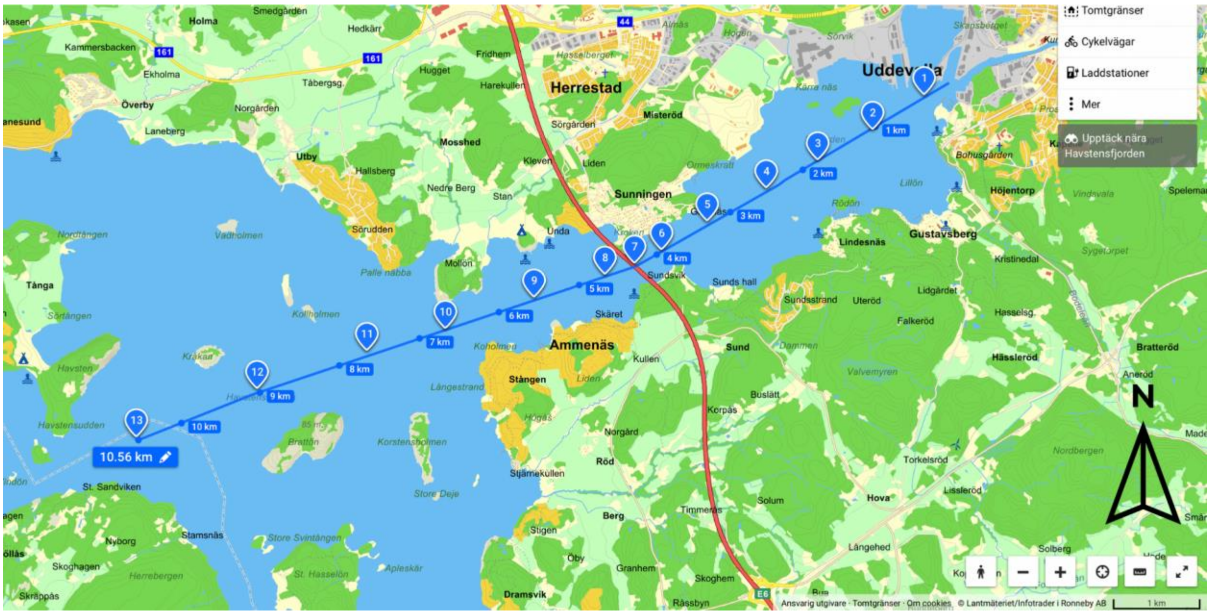

Figure 1. Map of Byfjorden and Havstensfjorden with the 13 originally planned sampling sites. (modified screenshot eniro.se)

The initial cruise itinerary encompassed a total of 13 designated sampling sites, comprising six stations within the Byfjord, six within the Havstensfjord, and one station positioned on the sill beneath the E6 highway bridge (Figure 1). At each of these stations CTD (conductivity, temperature, depth and fluorescence) measurements were scheduled to be conducted.

Additionally, the utilization of a box corer, a commonly employed sediment sampling methodology, was slated for stations 4 and 13. These stations were specifically chosen for their representation of the greatest depth within their respective fjord systems, making them ideal locations for sediment analysis and collection. To collect microplastic samples we used a device called manta trawl, which were intended for deployment between stations 1 and 2, 6 and 7, as well as 12 and 13 (Figure 2).

During the outbound leg of the cruise, the plan involved navigating and piloting the even-numbered stations, along with station 7, and finishing on station 13. Conversely, the remaining stations, those with odd numerical designations, were earmarked for piloting during the return journey.

Cruise Diary

For the cruise the ship R/V Skagerak was used. The weather forecast for the cruise day was overall ideal with cloudy conditions and a calm sea with small waves. At departure into the Byfjord, the wind was moving in a north-west direction at a speed of 14mph. An increase in wind for the afternoon was expected in the Havstensfjord.

A site-sampling schedule was made, where smaller but rotating groups were in charge of sampling methods: CTD, manta trawl and box corer. A map with the different sampling sites was provided to the captain, along with a briefing of the plan with the remaining crew (Figure 1).

We ran into a few issues during sampling, the first of which was a coordinate format error for the deepest sampling site. While correcting, the ship was still and time was lost. Secondly, very limited information of manta trawling was provided before planning. This resulted in time consuming on-site planning before lift-off which created further confusion and miscommunication between the crew and the microplastics scientist onboard. Further issues occurred during trawling. First, the lack of proper information resulted in the first manta sample being done incorrectly. The second trawl contained a high number of comb jellies. Lastly, weather and water conditions picked up a bit during the third trawl. To combat this, a research technician on the vessel tied a plastic rope to the front of the manta to increase stabilization. This may have unknowingly disrupted the results of the trawl as pieces of the plastic rope could have fraid and fallen into the manta during trawling introducing plastic not belonging to the fjord into the collection. Further analysis in the lab is needed to confirm this.

Issues surrounding the lack of information on manta trawl specifics also impacted other sampling techniques. Of the 13 originally planned CTDs, only 6 CTD-samples were performed (Table 1). The lengthy time of the first manta trawl caused some sites at the beginning of the transect to be skipped. However, in attempts to recapture lost time, communication became difficult as there was no one cruise member chosen specifically to direct sampling activity, which made it unclear to know if the sampling sites were reached along with giving crew members signals for the different sampling methods. Moreover, some system failure occurred for CTD-sample 4 which had to be redone due to data not being saved (Table 1).

Water samples were taken by a doctoral student in site 4 at depths of 44m, 22m, 15m and 5m. At the same site, the box corer was used, but despite multiple attempts, it proved unsuccessful (see Table 1 for sampling comments). As a result, the sampling method was discarded and no sediment samples were taken.

Since everything took longer than expected, the sampling plan was continuously changed throughout the day (Figure 2). Without a designated person in charge of communication, new changes were not immediately given to the captain for all instances.

Lastly, there was an error with the ferry box such that it did not collect any data on the way out, resulting in data on the way in being the only information gathered.

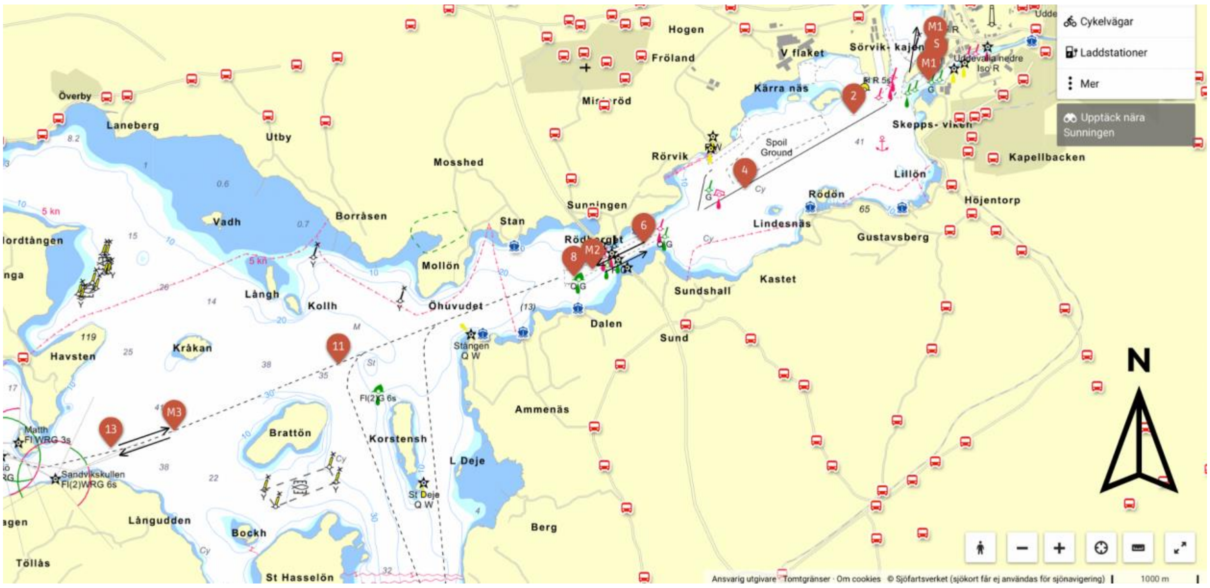

Figure 2. Map of Byfjorden and Havstensfjorden with all sampling activity sites marked: S - Start, M1 - Manta Trawl 1, 2 - Station 2, 4 - Station 4, 8 - Station 8, M2 - Manta Trawl 2, 11 - Station 11, 13 - Station 13, M3 - Manta Trawl 3 (modified screenshot eniro.se)

Table 1. Activities log detailing all sampling deployments including station name, sampling activity, latitude, longitude, maximum depth, start time, and comments.

Activity log for the Scientific Cruise on the 5th of September 2023						
Station name:	Sampling activity:	Longitude:	Latitude:	Max depth:	Time (UTC+2):	Comment:
Station 1	Manta trawl	Start: 58° 20.669 N	Start: 011° 54.524 E		10:27	Trawl upside down half way.
		Turn: n/a	Turn: n/a			
Station 2	CTD	58° 20.459N	011°53.609E	37 m	09:02	
Station 4	Box corer	58°19.1941N	011° 52.227E	46 m	09:55	Failed attempt, did not close. three attempts were made.
	CTD + water samples	58°19.1941N	011° 52.227E			Failed to archive the CTD data, reran the CTD-cast.
Station 6	CTD	58° 19.625N	011° 51.019E	12 m	10:39	
Station 8	CTD	58°19.437N	011° 50.237E	14,6 m	10:56	
	Manta trawl	Start: 58° 19.457N	Start: 011° 50.371E		~11:10	
		Turn: 58° 19.62N	Turn: 011° 51.034E			
Station 11	CTD	58° 18.839N	011° 47.244E	35 m	13:16	
Station 13	CTD	58° 18.310N	011° 44.497E	39 m	12:05	
	Manta trawl	Start: 58° 18.310N	Start: 011° 44.497E			Plastic rope attached to the trawl.
		Turn: 58° 18.407N	Turn: 011° 45.282E			

Operations:

CTD

Design: Skagerak's CTD (Sea-Bird SBE 911) includes 24 Niskin bottles 12L and sensors underneath that measure depth, fluorescence, salinity, temperature and oxygen. Skagerak's CTD can go down to 6000m but the length of the wire on the ship limits the sample depth to 4000m. The Niskin bottles are used to take water samples from the required depth.

Process: The CTD is being operated by LARS (Launch And Recovery System) which is the machine that moves and controls the CTD using either a winch or cable system.The CTD is lowered into the water and it continuously records the measurements required on its way to the seafloor. The bottles are opened on the way down to avoid getting imploding due to the increasing pressure from the depth. The bottles also remain open on both sides (top and bottom) to create a flow to only sample the water from the desired depth. On the way back to the surface, and at the desired depth, the bottles close via the software in the control room. The lids are closed to prevent the water from being contaminated on the way to the surface.

Analysis of CTD-data: The CTD data were analyzed with a program called: SBE Data Processing. The raw data (Figure 4) were processed in 8 steps (Figure 3) in order to get more easily understandable data (Figure 5). The data processing converted the data from binary to text file, smothered the high-frequency data, aligned the data to the exact depth, removed outlying and irrelevant data, adjusted measurements to account for the CTD itself, and used several measurements to calculate several oceanographic parameters.

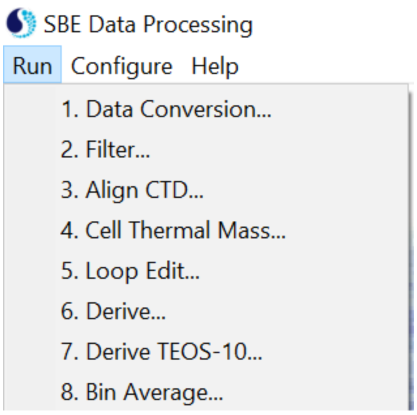

Figure 3. The 8 data processing steps in SBE Data Processing

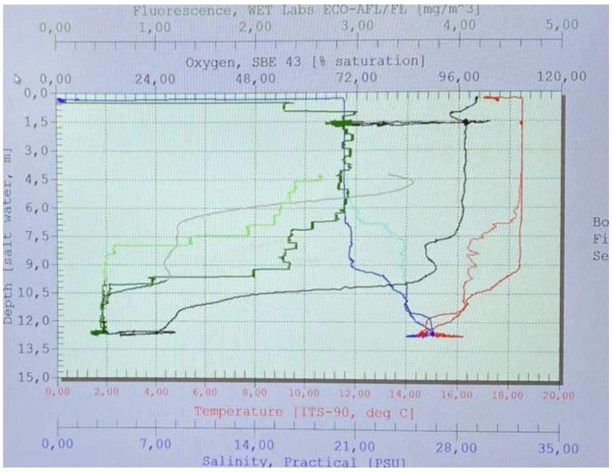

Figure 4. Picture of unprocessed data (CTD 8) from computers on board of Skagerak. CTD went to a depth of 13,3m.

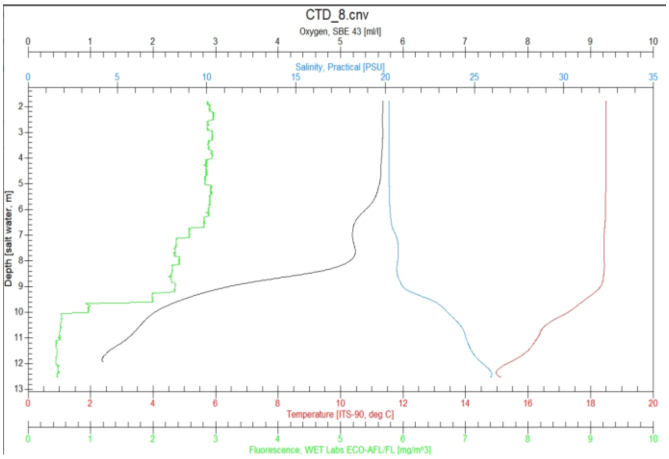

Figure 5. Processed and clean data from the same CTD 8.

Microplastic sampling (manta trawl)

Design*:* The "Manta Trawl" is a specialized instrument utilized in marine biology, oceanography, and microplastic sampling for the collection of plankton and other small marine organisms. The Manta Trawl is composed of aluminum, it is 1.5 meters in width and has a 3-meter-long fine-mesh net. Two floating wings on either side of the trawl's 60 centimeter-wide mouth measure 45 centimeters each. It can be used to catch floating plastic on the water's surface and filter debris via a fine mesh net while being towed behind a boat or set up in a river.

Process: A cable system lowers the manta trawl from the research vessel, towing it slowly near the water's surface to permit water to flow through the net, filtering its contents. As the net moves through the water, it captures plankton, marine organisms, and microplastics. The mesh size is 300 nanometers. Trawling is performed for a desired distance. In order to correctly calculate flow rate into the trawl, once the desired distance is met, trawling must occur over the same path back to the starting point. After a set distance or time, the manta trawl is retrieved onto the vessel. Collected samples are carefully extracted from the net and covered with aluminum sheets to prevent material loss. The collected samples, including microplastics, are analyzed in a laboratory. This examination is aimed at not only identifying the presence of microplastic samples but also determining their quantity, size, shape, and composition.

Box Corer Sampling Methodology

Design*:* A rectangular or square metal frame with hinged lids or doors on the top and bottom. The frame is often quite heavy and robust to withstand the pressures and conditions of the deep ocean.

Process: Lowered into the sea to the ocean floor by a metal wire through a winch. The box corer reaches the bottom and penetrates the sediment which fills the box corer, it is designed to be as gentle as possible to avoid disturbing the sampled sediment. The box corer closes due to a release mechanism that is activated on impact with the bottom. The layering of the sediment is preserved and further contamination is prevented as the box corer is closed. The box corer is lifted back to the surface and the sample is examined. Examples of things that can be examined are sediment composition, grain size distribution, geochemistry, biology (such as the presence of organisms), and environmental conditions (such as the presence of pollutants).

Preliminary results

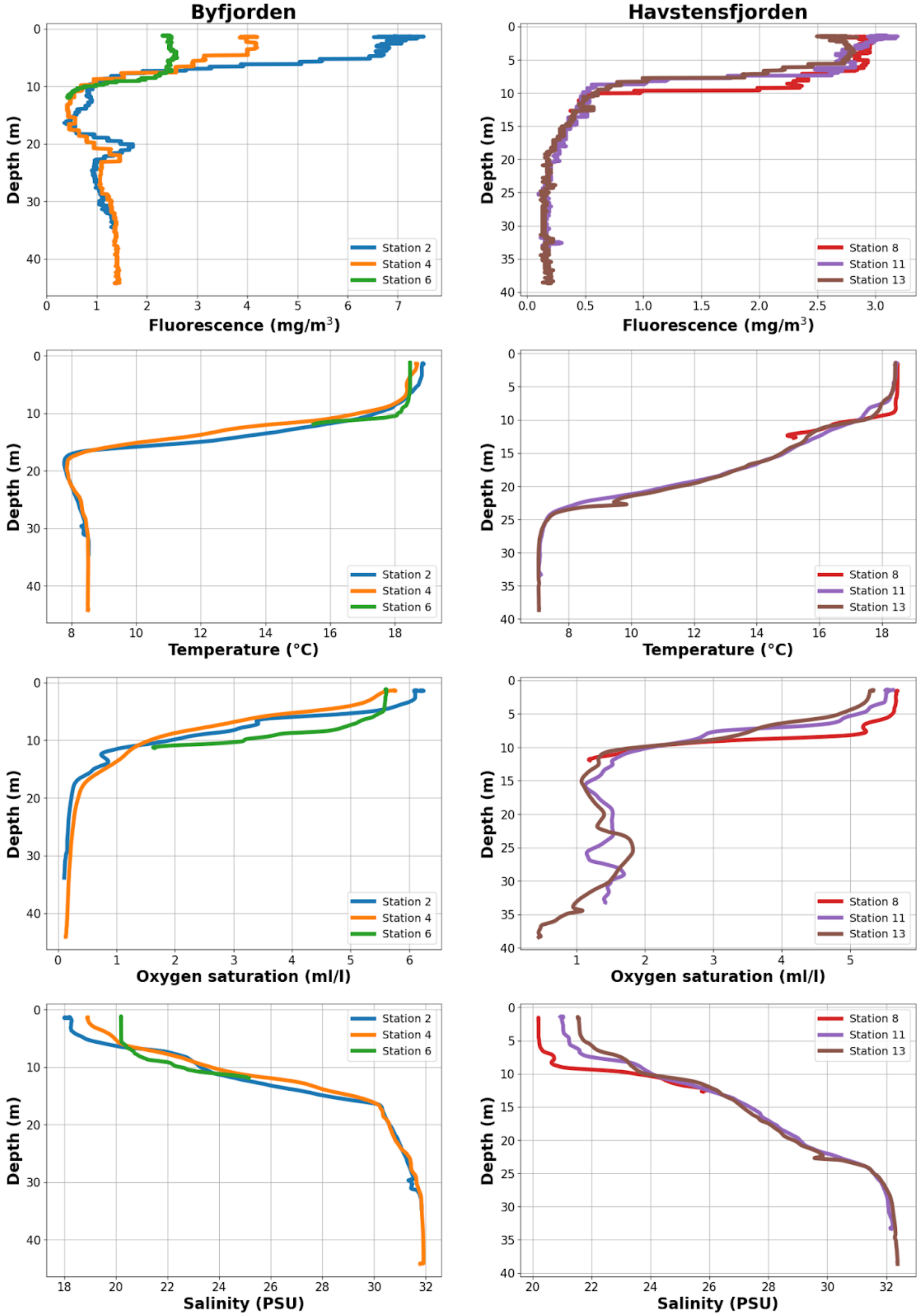

Figure 6. The CTD data is depicted in eight graphs divided by fjord and variable. The left column represents Byfjorden and the right column Havstensfjorden. From top to bottom, Fluorescence (Mg/m3), Temperature (°C), Oxygen (ml/l), Salinity (PSU). The sampling sites are color-coded.

As shown in figure 6, the CTD data collected on the cruise September 5th 2023 reveal the highest fluorescence concentrations at the surface of station 2, and a minimum at the depths of station 11 and 13. Surface temperature between stations were all close in value, but values at station 2 tend to be a little higher. Water temperature was found to be coldest in the Havstenfjord, stations 11 and 13. Highest oxygen concentration was observed at the surface water layers at station 2. The lowest measured oxygen concentrations were also found at the maximum depths of station 2 but also at 4. The lowest salinity measurement was taken at the surface of station 2, and highest at the depths of stations 11 and 13. The graphs imply that the mixed layer depth is approximately 10 meters across the transect of the Byfjord and the Havstensfjord.

Therefore, the deep water in Havstensfjorden seems to be colder and more oxygenated than in Byfjorden.

References:

1. Stigebrandt, A., Liljebladh, B., de Brabandere, L. et al. An Experiment with Forced Oxygenation of the Deepwater of the Anoxic By Fjord, Western Sweden. AMBIO 44, 42–54 (2015). https://doi.org/10.1007/s13280-014-0524-9.
2. Stigebrandt, Anders & Andersson, Ambjörn. (2022). Improving oxygen conditions in periodically stagnant basins using sea-based measures -Illustrated by hypothetical applications to the By Fjord, Sweden. Continental Shelf Research. 244. 104806. 10.1016/j.csr.2022.104806.
3. Eniro. (n.d.). Retrieved [08.09.2023], from https://www.eniro.se