

# 20 year's of FerryBox developments at NIVA

«From a single Ferrybox line in Skagerrak to several Expedition ships in Antarctica and Great Lakes»

Kai Sørensen, Pierre Jaccard, Louise Valestrand, Caroline Mengeot, Sabine Marty, Elizaveta Protsenko, Helene Frigstad, Therese Harvey, Bert van Bavel, Nicolas Roden and Andrew King.

# A postulate that we have experienced

*Niccolo Machiavelli "The Prince," (1513)*

"It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage, than the creation of a new system.

# History

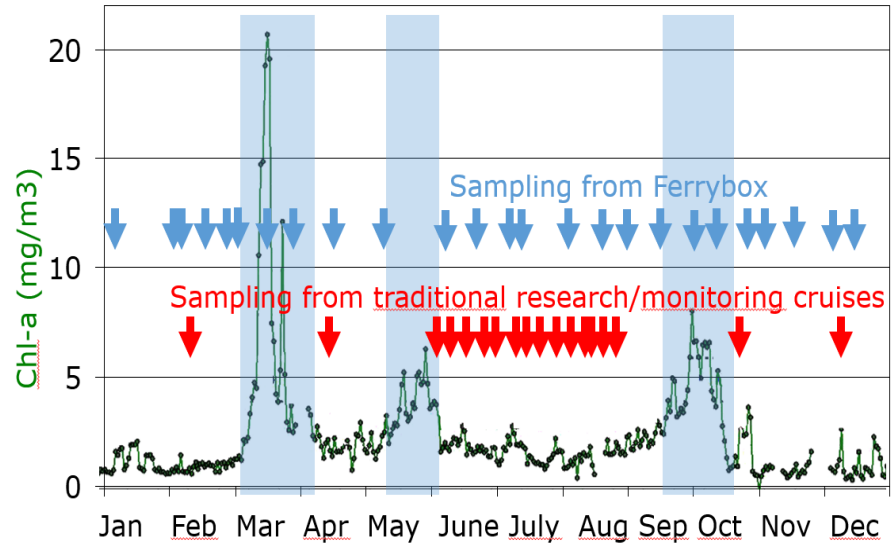
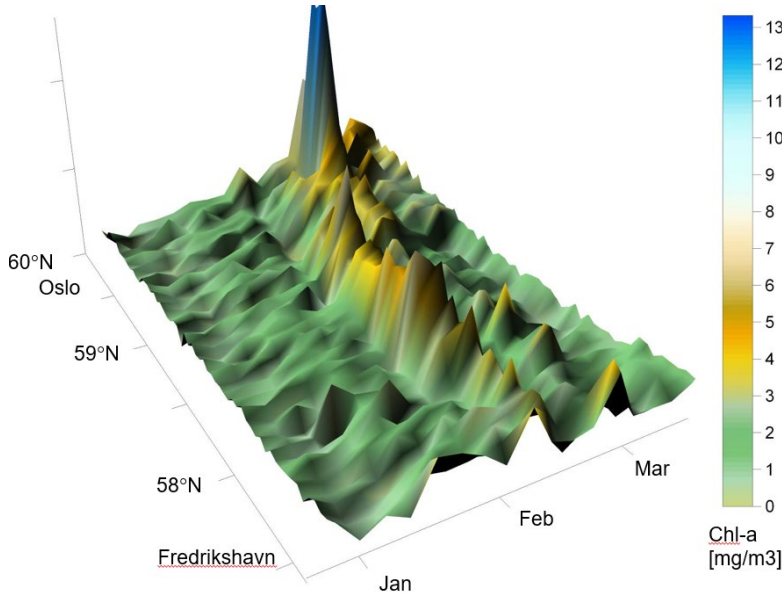
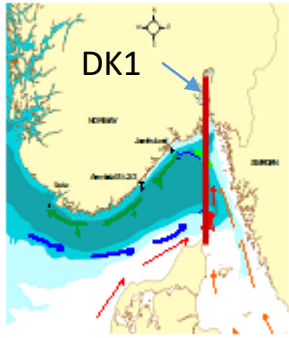
- Tried to get funding from Environment Agency mid 1990 when Alga line started
- Project funded in 2000 from the Norwegian Research Council
- Invited to the FerryBox consortium here at Hereon trying for the 3 time with a EU-proposal
- Kickoff in December 2002 on the EU-FerryBox project here at the campus
- NIVA was invited to several EU and ESA project with the FerryBox infrastructure
- Made it possible to develop the system and increase the number of FerryBox installations
- Important when we got the FerryBox into the large national and local monitoring projects
- In 2018 we got 5+5 year Research Infrastructure project NorSOOP with 4 partners NIVA, IMR, Apn and met.no
- Status at NIVA and in NorSOOP are that we have been involved 14 FB-installation including 2 microFerrybox and on 3 Expedition ships.
- Running now 9 FB installations and 1 installation will come in 2011 and 1 in 2023.

# The first versions of the NIVA Ferrybox from 2001/2002

- Temperature and salinity (Seabird SBE 45 Micro TSG)
- Chlorophyll-a fluorescence (Seapoint)
- Turbidity (Seapoint)
- Added the Turbidity sensor with a wiper (Polymetron)



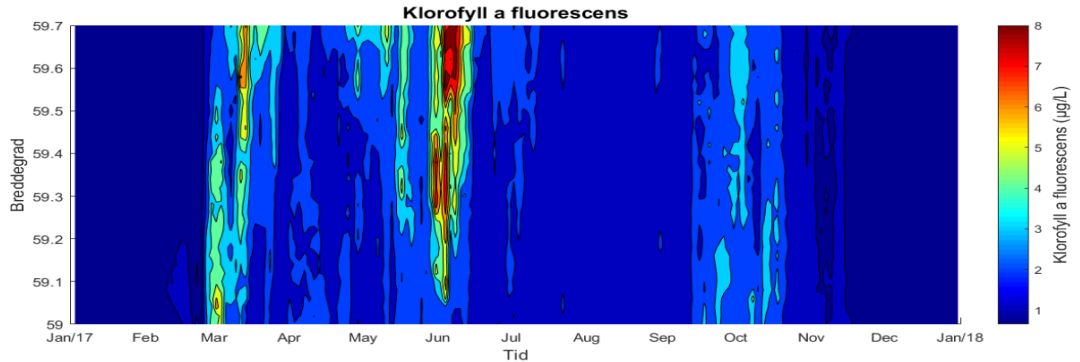
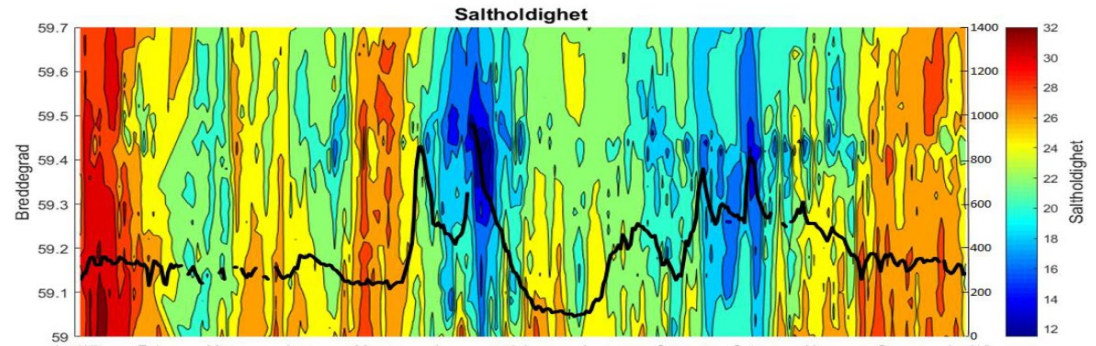
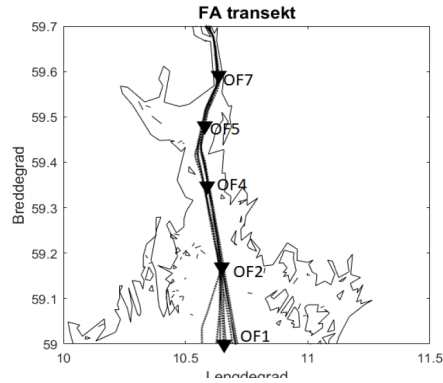
# Early results used to demonstrate the potential of the Ferrybox data. Data from the Oslofjord with Color Festival



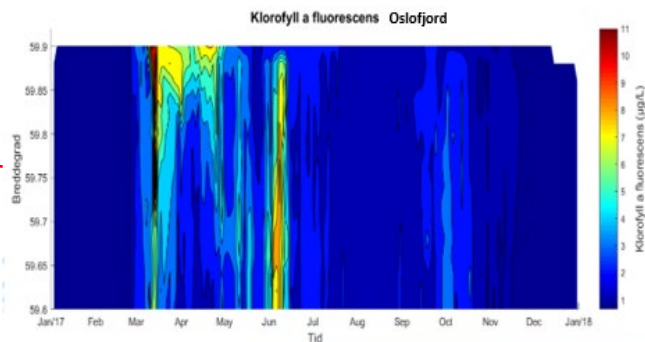
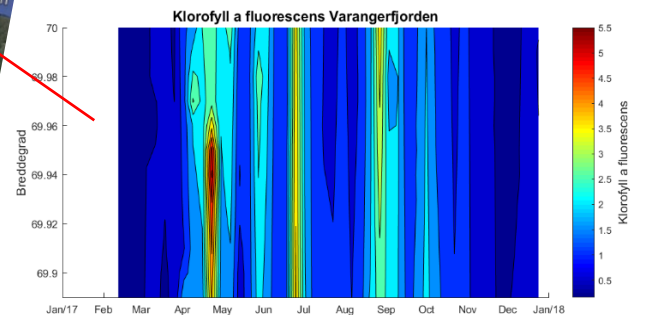
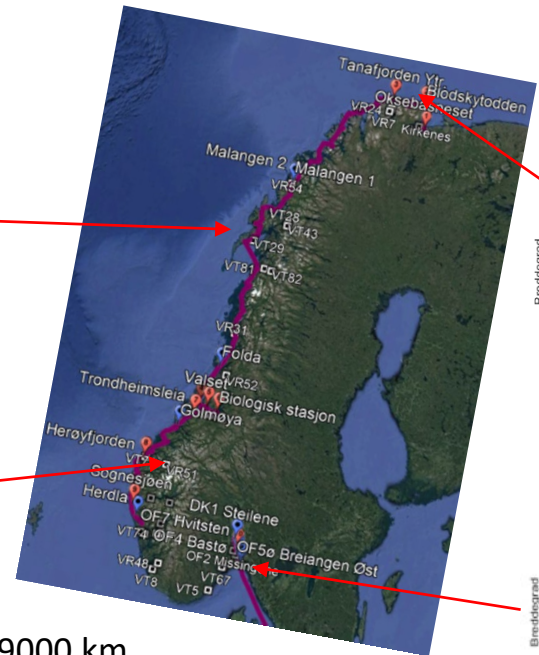
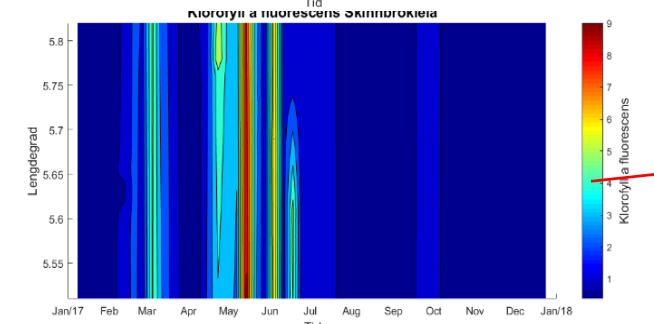
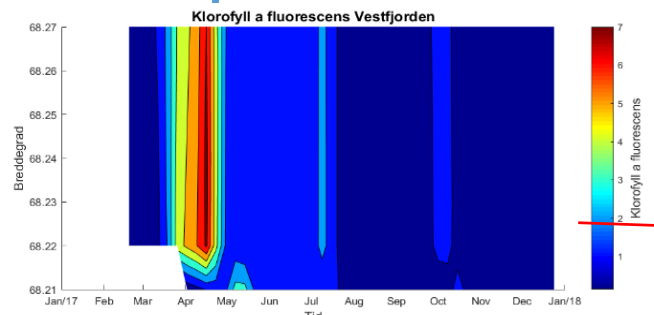
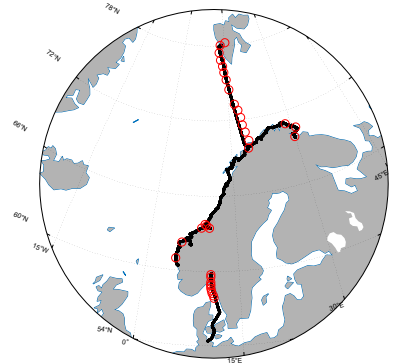
Monitoring station Dk1 in Inner Oslofjord

# We got the FB systems into local programs

## Plankton blooms in the Outer Oslofjord in 2017



# Important that we got FerryBox into the National Monitoring programs for Eutrophication and Ocean Acidification



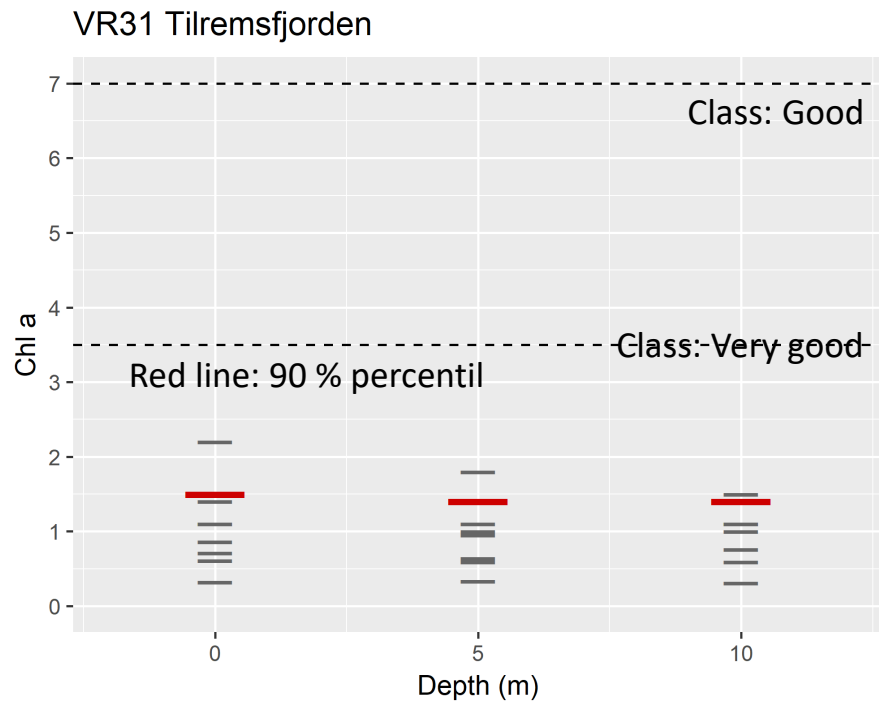
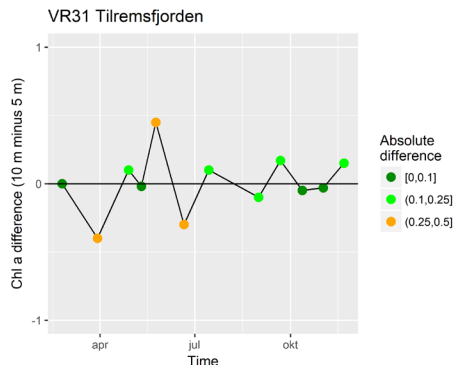
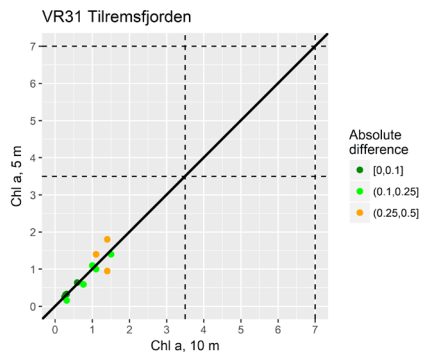
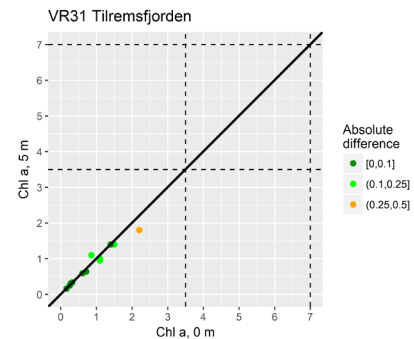
Coast line of 29000 km  
 That should be monitored by 35-40 WFD  
 stations and about 20-25 OA stations



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# Representativity of the one FB-depth for WFD of open exposed stations

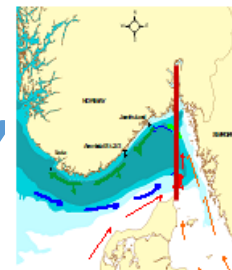
Example 1: Tilreimsfjord: 5m versus 0m and 10m using Chl a water sample data





# Chl a Fluorescence

## “Chl-a\_fluorescence as proxy for Chl-a”



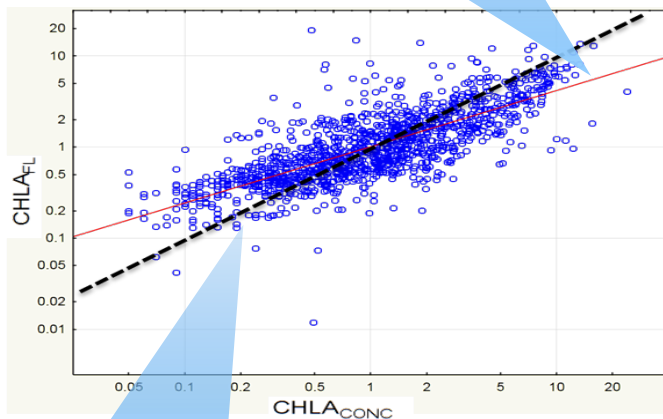
Chl-a also a proxy for estimation of phytoplankton biomass

- Day light, length of day
- Seasonal variations
- Species composition

1400 datasets over 6 year (2003-2008) from the same ship in a transect including night and day.

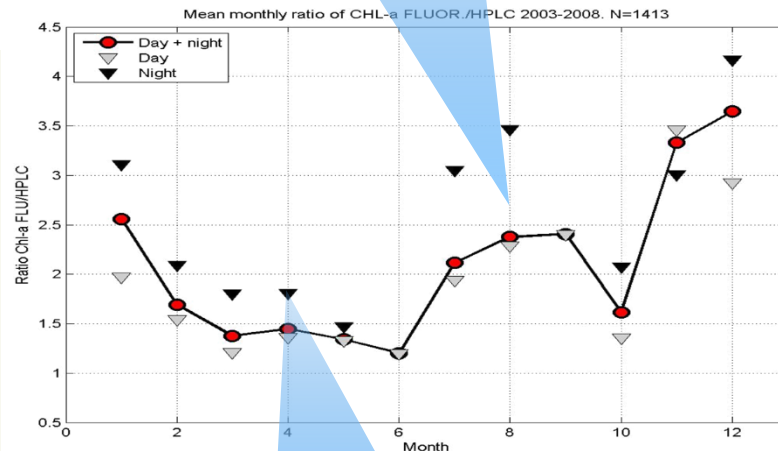
«Control» of the Chl\_a-Fl /Chl-a ratio we can improve the use as Chl\_a-fl as proxy for Chl-a

Fluorescence low at high concentrations



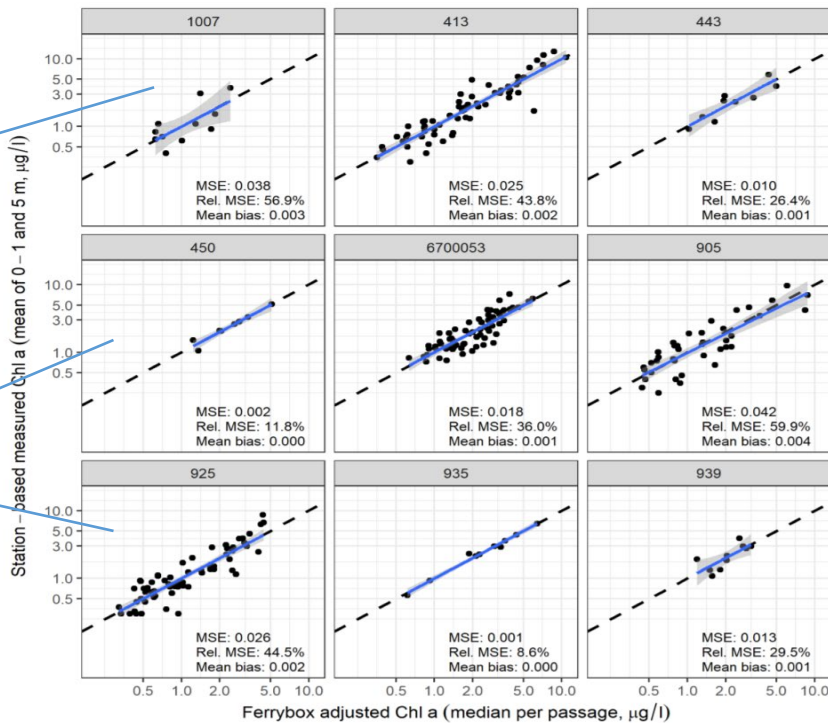
Fluorescence high at small concentrations

Day-night variation larger during bloom - high production



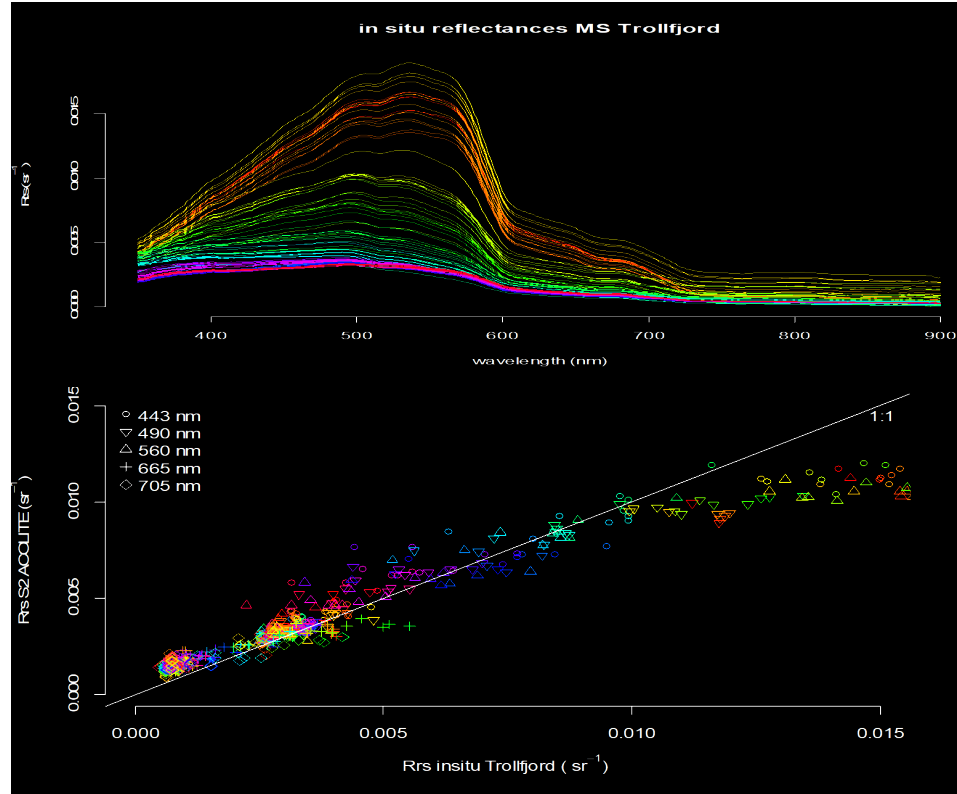
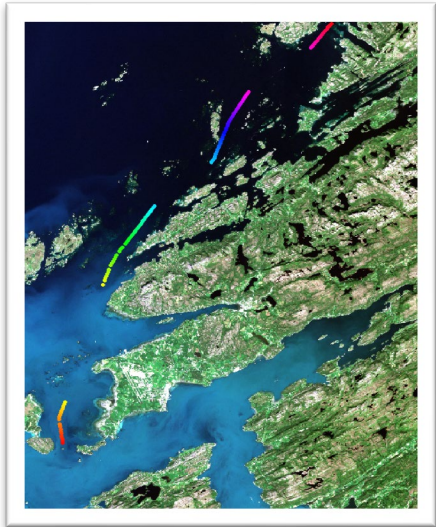
Fluorescence high during night

# Comparison of FB Chl-a<sub>fl</sub> and station Chl-a Data from the Oslo-Kiel 2012-2015 on 9 stations in Kattegat

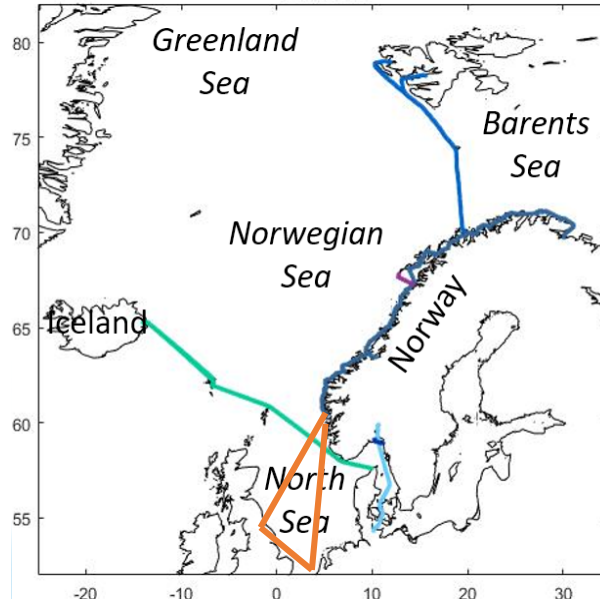
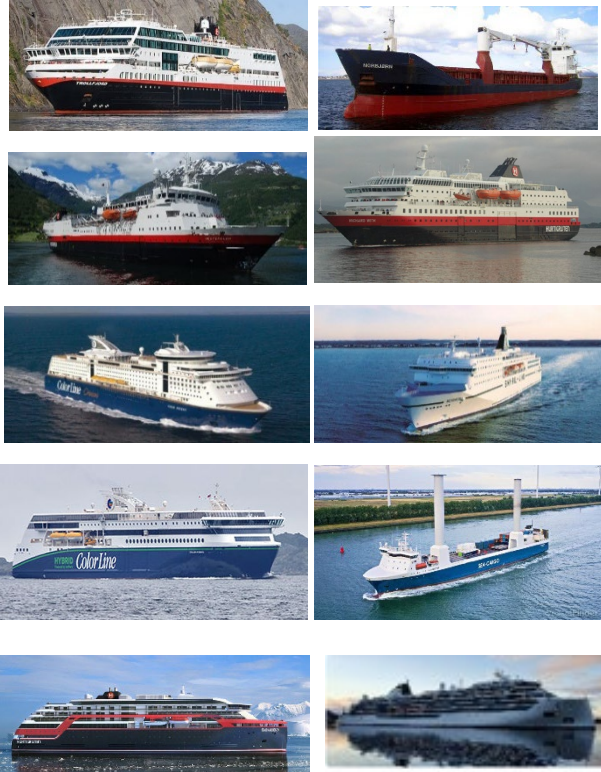


Jesper Andersen et.al, report  
7167-2017 DK7 (2017)

# Validation of satellite data with FerryBox deck mounted reflectance sensor data



# NorSOOP: Norwegian Ships of Opportunity Program extended with Expedition ships and ships from collaborating partners

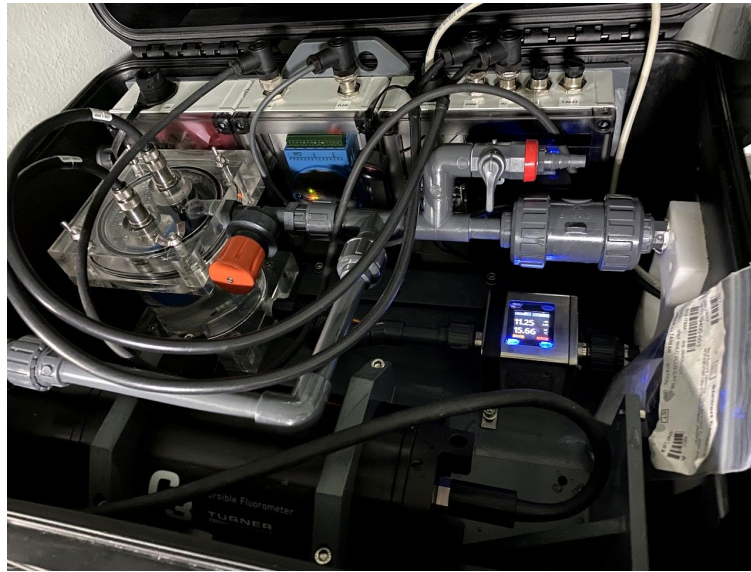


- NIVA (lead), IMR, Akvaplan-niva, Met NO
- NFR INFRASTRUKTUR (2018-2023)

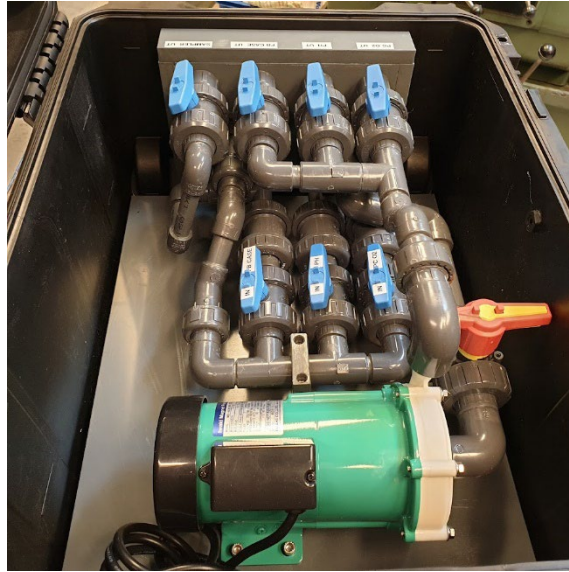


Bonus installation on the Statsraad Lehmkühl

# MicroFerrybox (uFB) developed during the Covid. Used on one of the Coastal Steamers



uFB: Temp, Cond/Sal, Oxygen, Chl-a\_FI, Turb, fDOM, Electronics and a microcontroller



Pump box supporting also pH and pCO2



Installed at Kong Harald with a pH box

# Moved into the Expedition ships in 2019

## Information to the passenger will be important

### Bringing ocean science on board



Kai Sorensen  
Senior Researcher  
at NIVA

#### The FerryBox

An unassuming grey box sits in the engine rooms of some of our Coastal Express ships. As the ship sails the Norwegian coast, the sound of a pump can be heard each minute, sucking up seawater from outside and into the mysterious cabinet through a small intake.

This is the FerryBox measuring device. Housed within its casing are a variety of fascinating sensors that analyse seawater temperature, salinity, oxygen, chlorophyll, organic carbon, particle content, and other ocean factors.

As part of a global initiative to learn more about our seas, the data collected by the FerryBox is then transferred via satellite back to The Norwegian Institute for Water Research (NIVA). Researchers there then pore over the figures to monitor and understand variations in the marine environment. The data is key in making more accurate models and in predicting the state of the seas in the future.

Kai Sorensen, Senior Researcher at NIVA, was one of the first people to introduce the FerryBox to Norway twenty years ago. According to Sorensen, without the cooperation of The Hartigruten Coastal Express, this important research would be much harder to achieve.

"The ships are able to collect data on a weekly basis, which makes the results more accurate and speeds up the process. The alternative would have been to use many separate boats to do it, which would have been less frequent", he says.

#### Observing changes

The data collected has revealed some poignant discoveries. One of them is the increase in coastal darkening. "On the surface, you might not think a darker looking ocean means anything", Sorensen says. "But actually, what's happening is that as winter temperatures get milder due to climate change, freshwater from the inland swamps and rivers trickles out into the ocean, bringing more and more organic material with it", he explains.

"As the nutrients from the inland freshwater mixes with salt water, it can sometimes lead to larger algae blooms which darken the sea. These algae blooms can become toxic and poison the nearby fish. We've already had issues with this connected to aquaculture in Northern Norway", Sorensen warns.

He offers some optimism. "Thankfully, we've got consistent, valuable data from FerryBoxes on The Coastal Express ships. This allows scientists like me to check on seasonal and long-term ocean warming, and the timing and duration of algae blooms", Sorensen continues. "The FerryBox is equipped to measure chlorophyll a fluorescence which correlates to algae biomass. It can also take readings on pH, which is an indicator of the impact of fossil fuels and carbon dioxide on the oceans, known as ocean acidification."

"We're also testing one of the latest features of the FerryBox system which allows it to collect microplastic samples along The Coastal Express route. These samples can be further analysed in NIVA laboratories," he adds.

#### At your fingertips

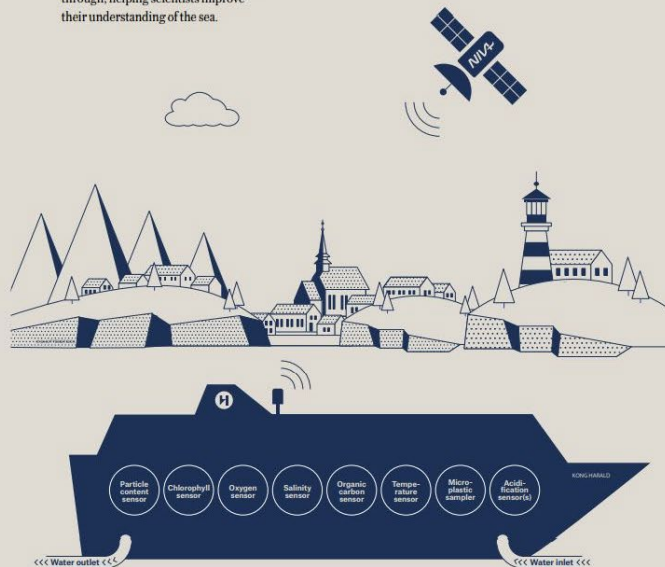
As a guest on board with us, you have the opportunity to learn about the sea you're sailing through in more detail. Data from the FerryBox is displayed directly on an interactive touchscreen console located on selected ships, raising awareness about pressing environmental issues.

Sorensen is very happy about the engagement from guests. "We thought they might be interested in seeing how the surrounding sea is doing, but we didn't expect people to be this enthusiastic. We included information about our research into the consoles, and the guests seem to enjoy taking their time to learn more", he says cheerfully.

"New technology has made a big difference in our ability to understand the ocean. The data gathered from FerryBoxes on The Hartigruten Coastal Express has played an important role in where we are today, and it will continue to do so going forward," concludes Sorensen.

"Combined with advanced research, I believe the data collected will help us rise to meet the challenges of climate change, and be key in navigating us towards a sustainable future."

Ever since the 1930s, our ships have been collecting data about the waters we sail through, helping scientists improve their understanding of the sea.



# Ships of opportunity at Expedition ship

Console for  
Ocean Literacy

Laboratory  
for Citizen  
Science



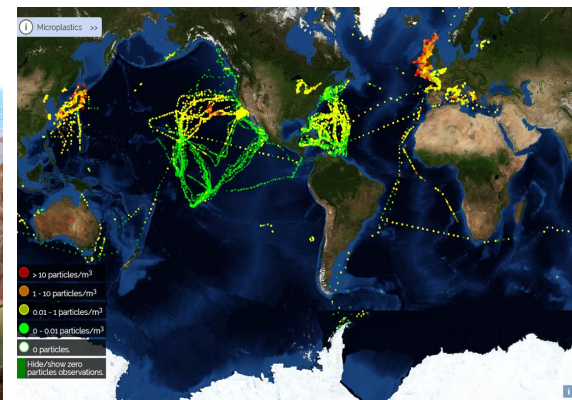
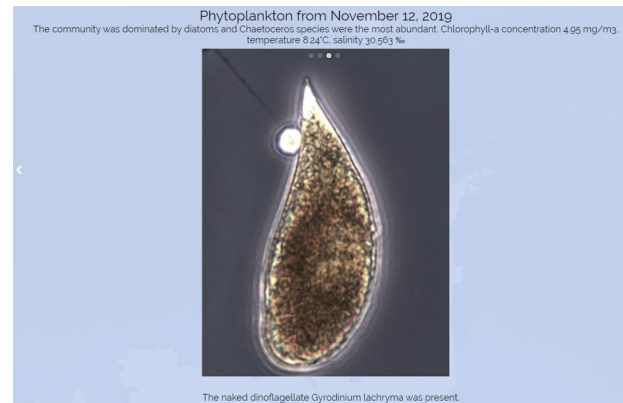
Meteorological  
observations

Deck sensors  
for satellite  
validation

FerryBox sensor  
system

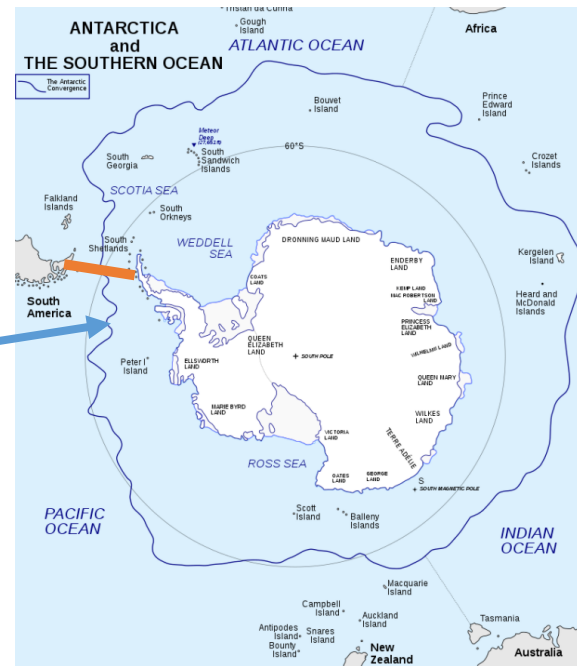
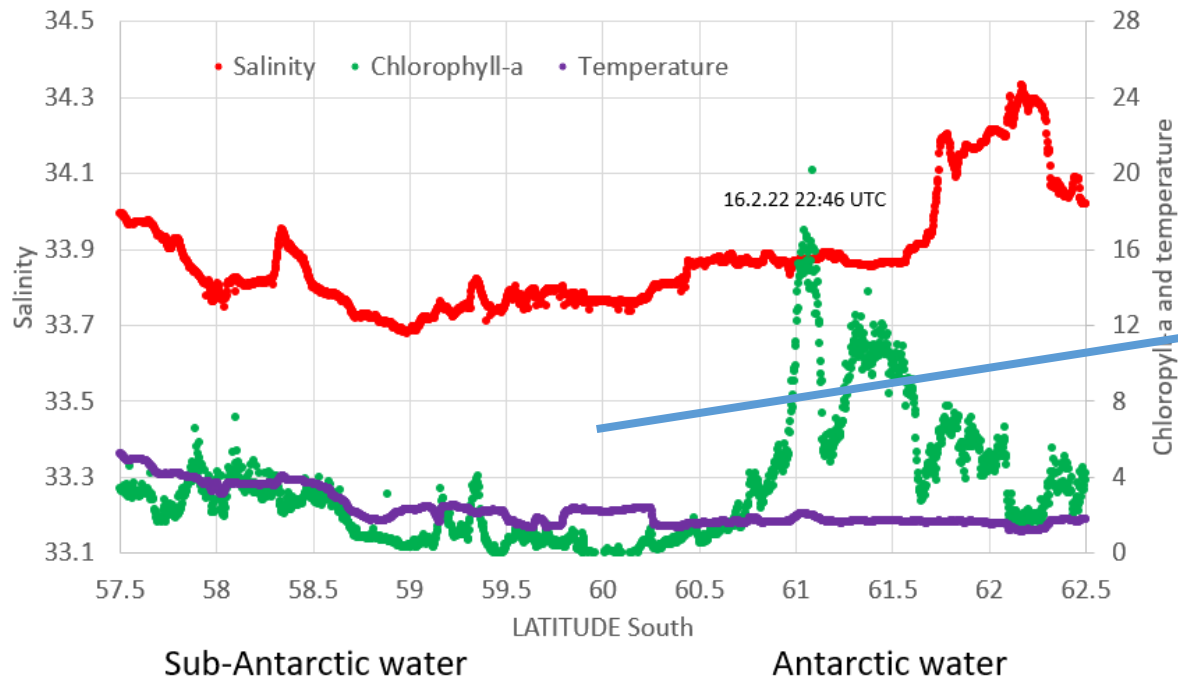
Advanced water  
samplers

# Science Center on board Roald Amundsen

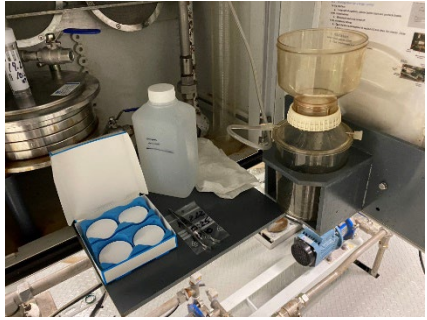




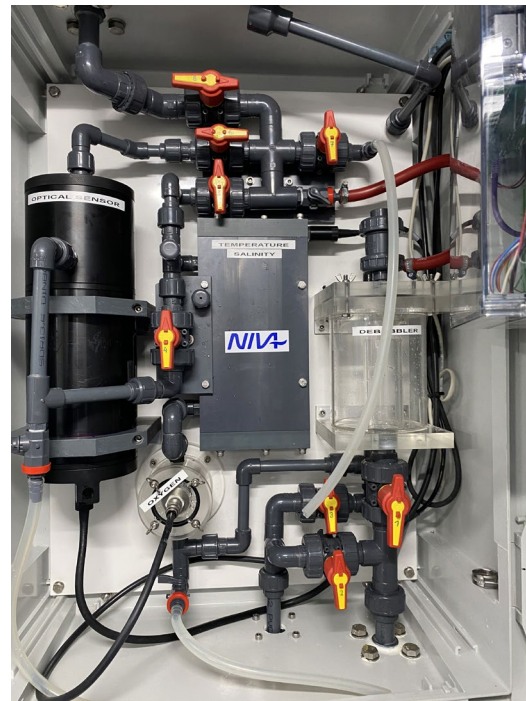
# Massive plankton bloom when we passed the «Antarctic convergence zone» 16. February-22



# Trained the Expedition Team in preservation of Chl-a, phytoplankton and Microplastic samples and maintenance and controls of the FerryBox



# The Ferrybox installation on Viking Octantis with Laminar flow cabinet for Microplastic sample preservation



# Viking Octantis Laboratory for passenger with Microscopy and FTIR spectrometry for plastic analysis



# Present and near future

- The Ferrybox systems is an excellent costs effective system for water quality monitoring of surface water
- One depth data are representative for the surface (0-10m) water masses (WFD) in open exposed areas along the FerryBox route in Norwegian waters/Kattegat
- The Norwegian ships used in WFD and Ocean Acidification monitoring can replace/supplement traditional stations monitoring.
- The core sensor like Temp., Sal., O<sub>2</sub>, Chl\_a\_FI, PC\_FI, PE\_FI, cDOM\_FI and turbidity works well with proper maintenance, biofouling handling e.g. the SOP
- Water sampling for phytoplankton, nutrients and BGC-parameters are possible
- The FerryBox systems can be used for some atmospheric research and satellite validation (SST, reflectance, water quality products)
- The ships can host several advanced sensor systems like ADCP, CPR, XBT
- Advanced carbon systems sensors (pH, pCO<sub>2</sub>, Alkalinity) are used
- New sensors like PSICAM, FRRF, flowcytometry and nutrients to be tested/implemented
- Advanced sampling for microplastic are possible. Advanced sensors in the future?
- The passenger should have visualization system of data and environmental info

The logo for NIVA, consisting of the letters 'NIVA' in a bold, blue, sans-serif font. The letter 'A' is stylized with a curved tail that extends to the right.

Norsk institutt for vannforskning