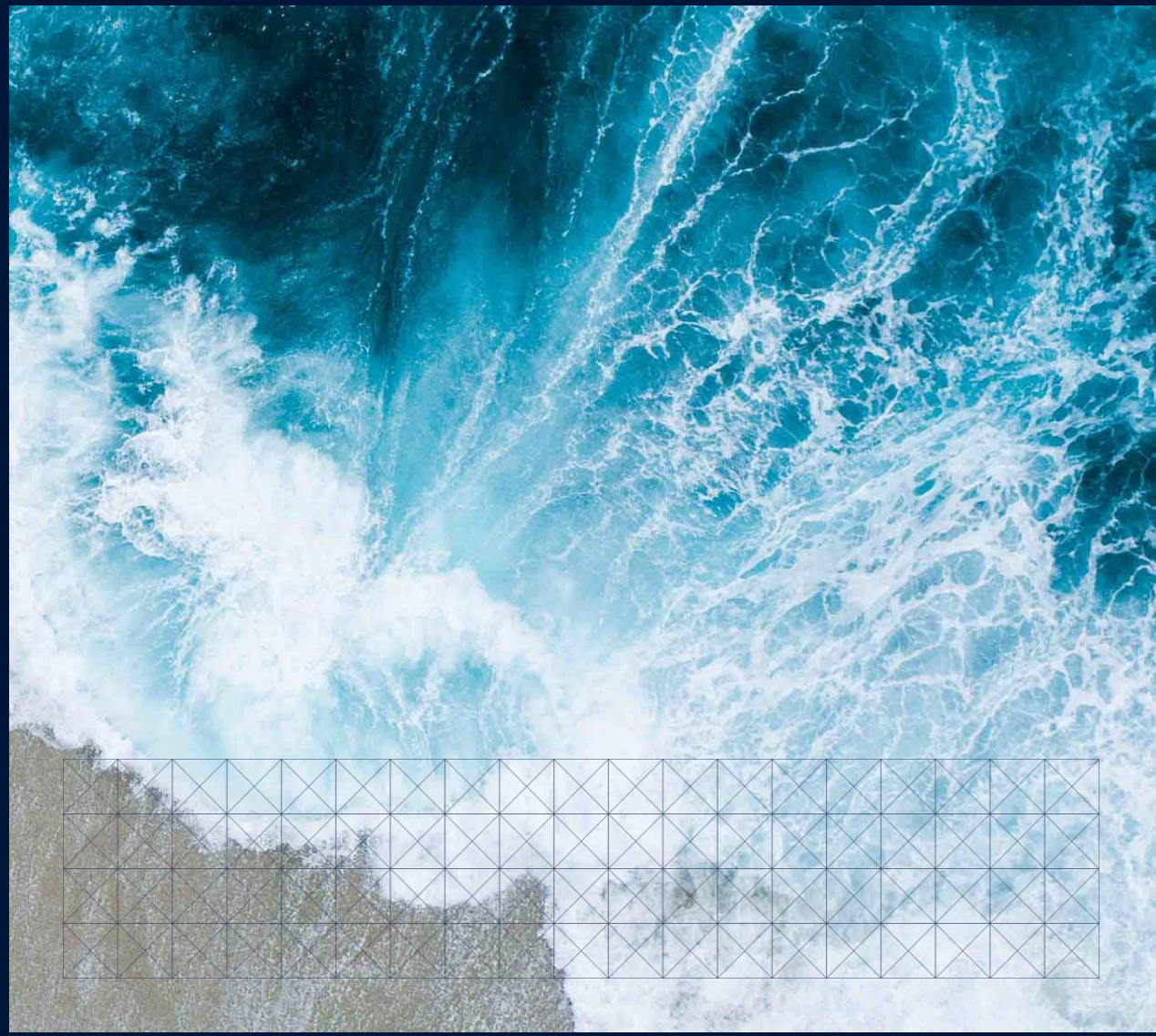
KONGSBERG

KONGSBERG MARITIME CONTROS GMBH

Advances in chemical sensor developments

24 April 2019

Steffen Aßmann, Product Manager



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Overview

- Overview
- CONTROS HydroC CO_2
- CONTROS HydroFIA pH
- CONTROS HydroFIA TA
- Summary
- Outlook

CONTROS® SENSORS

Products

HydroC CH_4

Dissolved methane sensor
3000 meters
High accuracy
Long-term stability

HydroC CO_2

Dissolved carbon dioxide sensor
6000 meters
Fast response time
High versatility

HydroC CH_4 FT and CO_2 FT

Flow-through applications
User-friendly
Maintenance interval of 12 months

HydroFlash O_2

Dissolved oxygen sensor
6000 meters
High accuracy
Very fast response time

HydroFIA TA & pH

Total alkalinity and pH
Autonomous analyzer
Easy setup
High accuracy

CONTROS® SENSORS

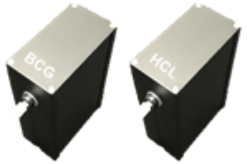
Add-ons

Anti Fouling

Enhanced anti fouling strategy for deployments in strongly growing areas e.g. coastal waters

Pumps

Pumped water flow for fast response time



Cartridges

Customer friendly handling of chemicals in plug-and-play cartridges

Cross-Flow Filter

Clean water supply for CONTROS HydroFIA

Batteries

Power solutions for applications up to 1000 m water depth

Frames

Mountings for the sensors on request

Cables

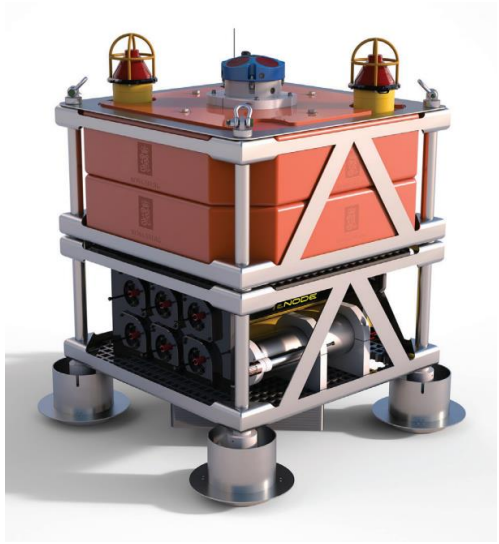
Custom cables for all CONTROS sensors

Pressure Tank

- Used for complete design test
- *d* = 350 mm, *h* = 1000 mm; approx. 95 ltr.
- Maximum pressure 1000 bar (800 bar currently realized)
- Fresh and seawater fillings possible
- Temperature stabilized (-3 °C to 30 °C)
- Tank fluid is physically separated from pressure generating liquid → no contamination → beneficial for gas sensor tests
- Option for controlled gas enrichment of the tank liquid

CONTROS® SYSTEMS

Products



K-LANDER

Stationary platform
Long-term deployments 2+ years
Open sensor integration policy
Modular & scalable design
2000+ meters

MELDS

Early leak detection system
Measurement of CH_4, PAH, CTD
Easy ROV/ AUV integration
2000 meters

DPU

Flexible and adaptable subsea data logger
In-situ processing
Optimized for low power consumption
2000 meters

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CONTROS HydroC® CO_2

CONTROS HydroC® CO_2

Benefits

- High quality, versatile and robust
  - → Can be used in water depths up to 6000 m and under harsh conditions
  - → Easy integration with almost every oceanographic measurement system and platform
- Fast response time
  - → First signal derived on a sub-minute scale
  - → Capture even small signals in a short time
- Reliable technology
  - → Proven track record in scientific publications
  - → Robust and traceable data quality

Application

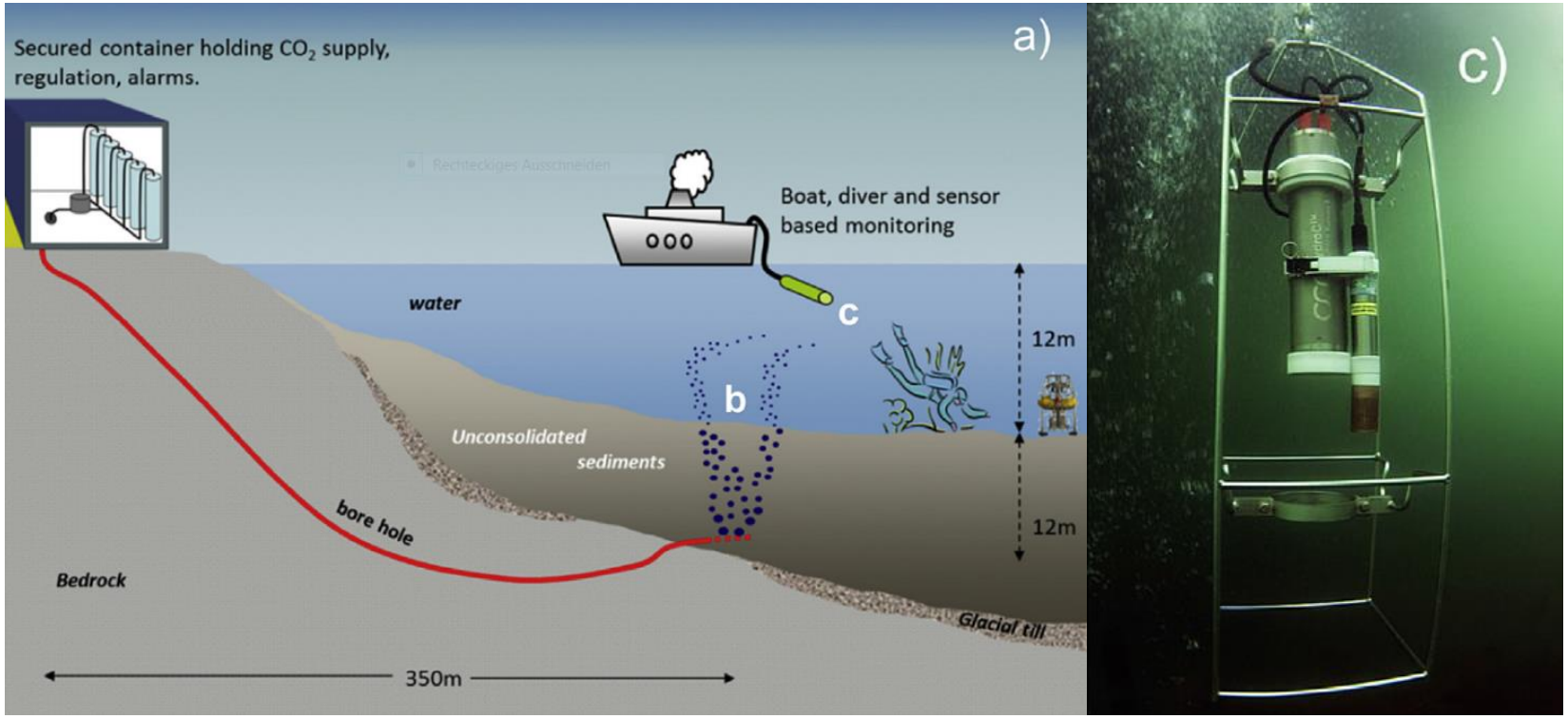
Shipborne Measurements at Gas Release Site (Scotland)

Google Earth

Application

Shipborne Measurements at Gas Release Site (Scotland)

- CO_2-release experiment in Ardmucknish Bay, Scotland, 2012:
  - Release started with 90 kg CO_2/day
  - later 150 kg/day
  - two weeks in total
- Sensor used in a CTD frame from a boat
- Vertical profiling and horizontal towing at the release and at reference sites

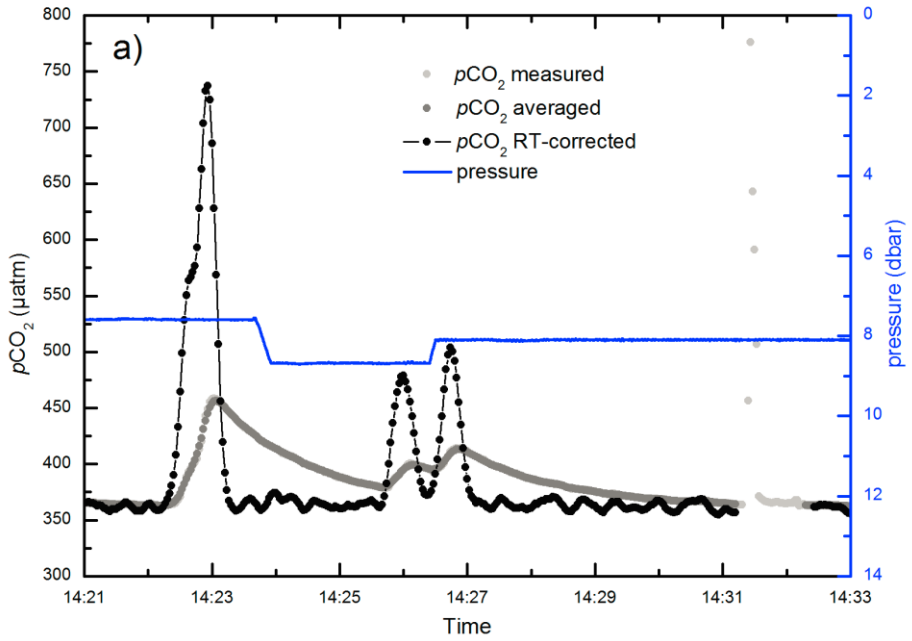


Atamanchuk et al., 2014

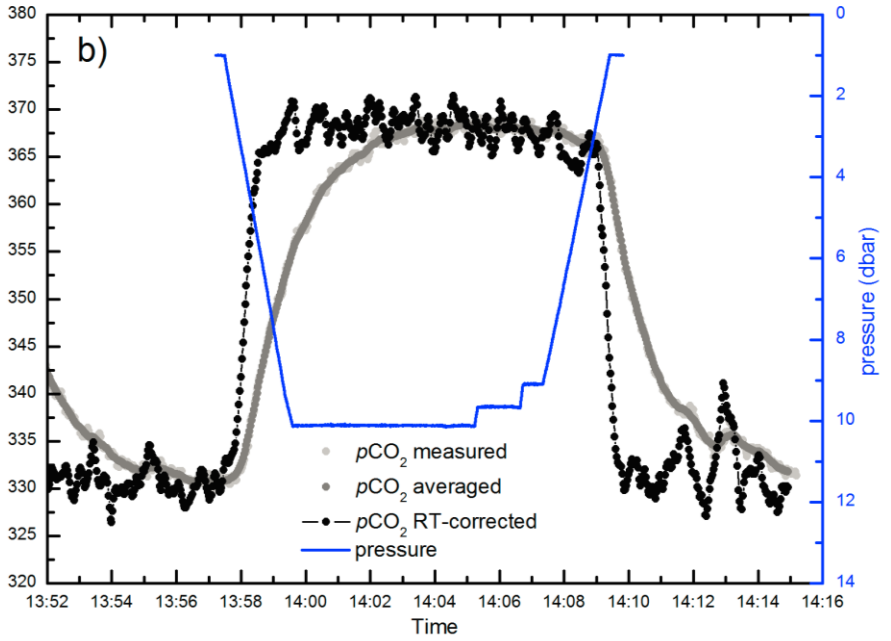
Application

Shipborne Measurements at Gas Release Site (Scotland)

Horizontal towing through active area



Profiling after CO_2 release



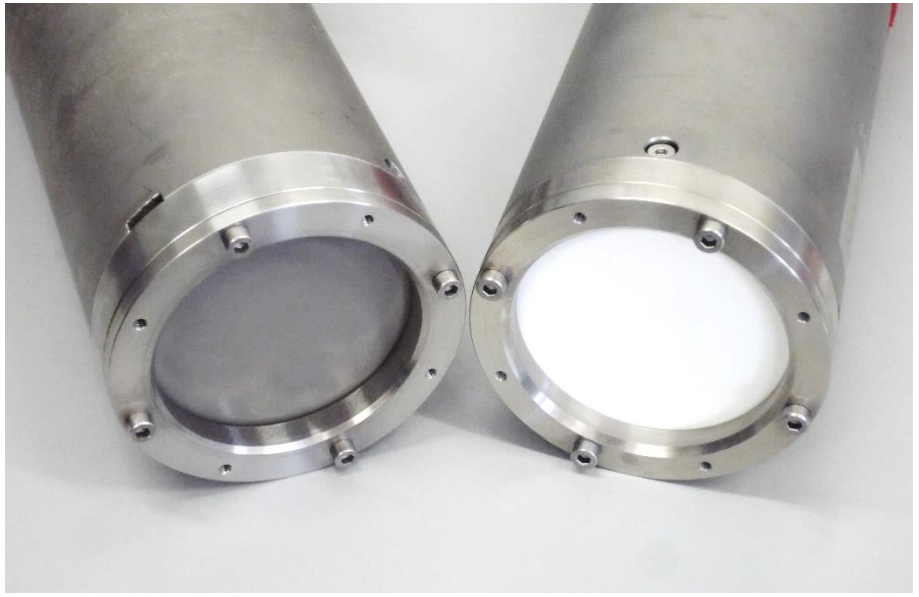
Atamanchuk et al., 2014

- Gas bubble detection
- Event detection on a sub-minute scale and profiling capability through response time correction

CONTROS HydroC® CO_2 / CH_4 TOUGH / Gen 3

Benefits

- Robust TOUGH membrane produced in-house
  - → Withstands harsh conditions and mechanical stress
  - → Easy handling of the membrane
  - → Very low maintenance
- Enhanced gas-cycle management
  - → Deep-sea and long-term applications



CONTROS HydroC® CO_2 FT COMPACT / Gen 2

Benefits

- Compact design
  - → Even easier to integrate into flow trough systems
- Robust TOUGH membrane produced in-house
  - → Long-term deployments over one year
  - → Easy handling
  - → Very low maintenance
- Temperature sensor in the flow head
  - → Possibility to correct for warmed water when pumping to the sensor
- Reliable technology
  - → Proven track-record in scientific publications
  - → Robust and traceable data quality

CONTROS HydroC® CO_2

Summary

- **Continuous** and **direct measurements** of dissolved gas parameters.
- Small, individually **in-water calibrated**, **fast** and including drift correction means.
- **High quality production**, calibration and measurements incl. **peer-reviewed publications**.
- **User-friendly** through comprehensive, easy-to-use **software** as well as application-oriented features (logger, sleep-mode, etc.).
- Strong **customer support**.
- **Reliability** and ruggedness is proven during many missions and on various platforms.
- In the new compact FT version a **temperature measurement** in the equilibrator head is included as well as the new **TOUGH membrane**.

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CONTROS HydroFIA® pH

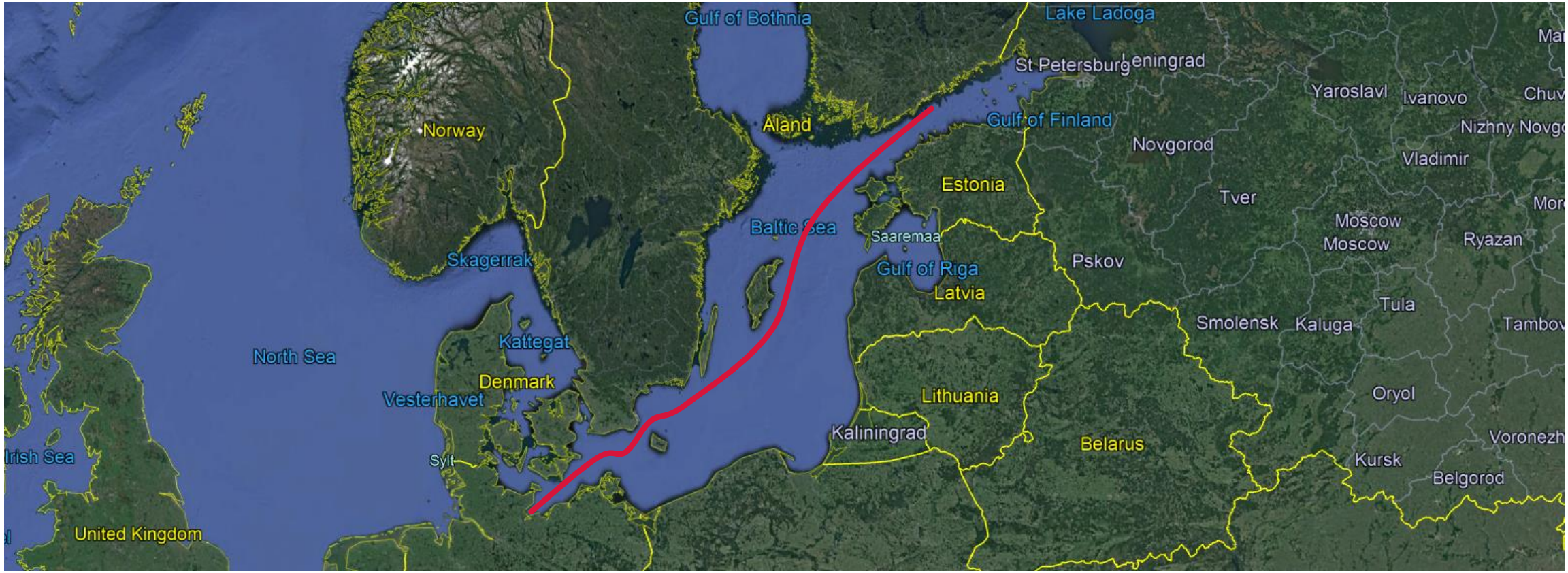
CONTROS HydroFIA® pH

Benefits

- High quality continuous pH measurements
  - → Carbonate chemistry applicable
  - → Suitable for ocean acidification studies
  - → Global change monitoring
- Easy setup for autonomous use
  - → Deployment longer than one month possible
  - → No more bottled samples
  - → Save time and analyses cost
  - → Replacing the sophisticated lab setup
- Low sample / reagent consumption
  - → Decreased cost per measurement
- Calibration and drift free
  - → Low maintenance efforts

Application

Spring Bloom Observation on a Ferry (Baltic Sea)



Google Earth

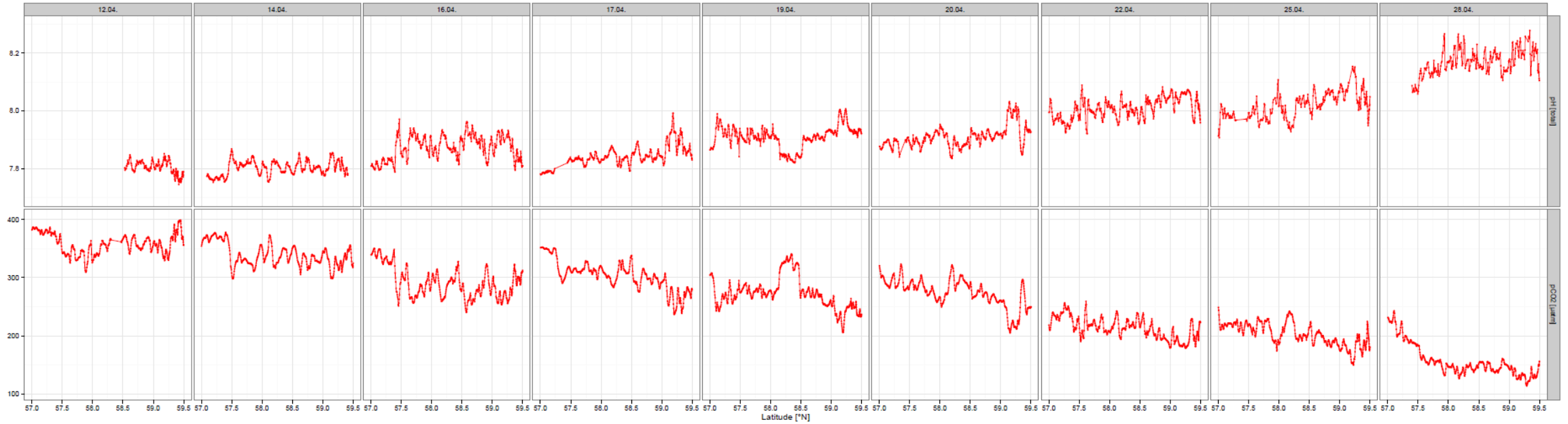
Application

Spring Bloom Observation on a Ferry (Baltic Sea)

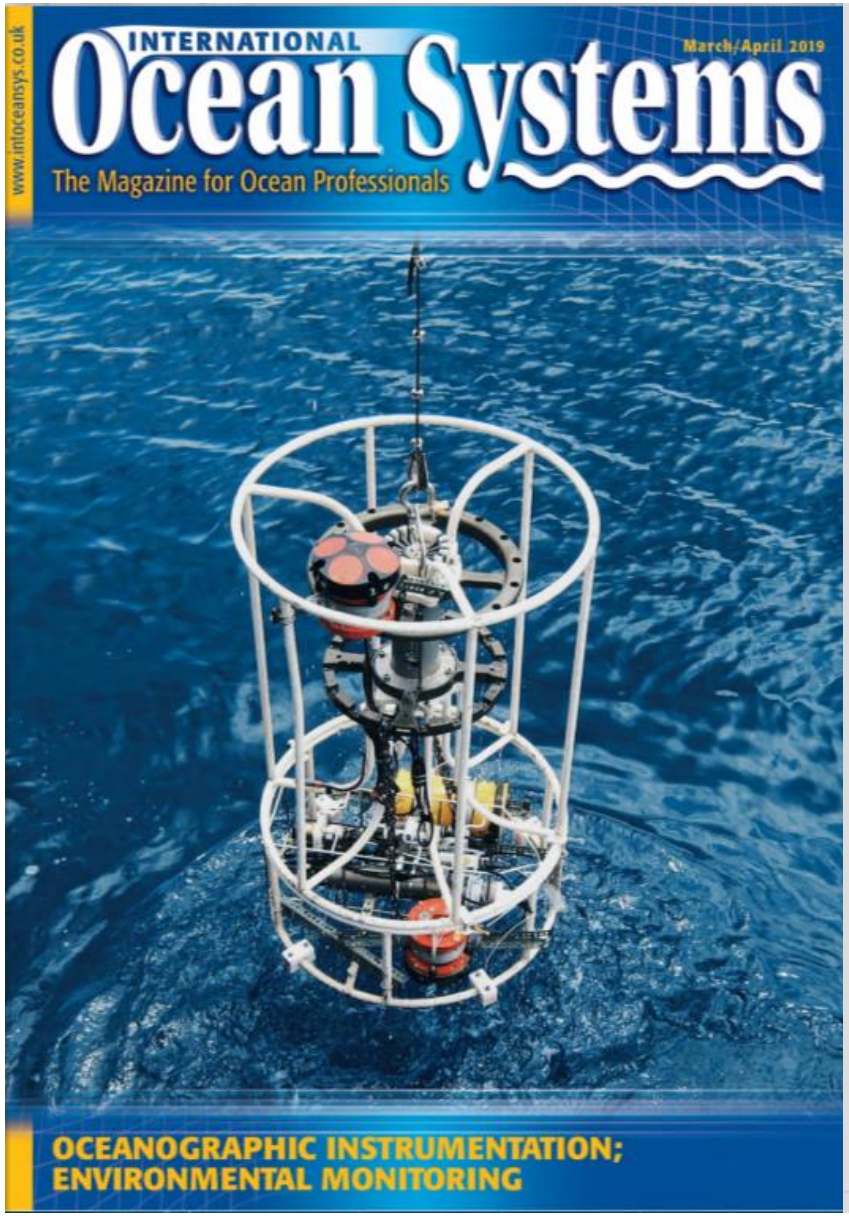
Courtesy of FleetMon

- Measurements of pCO_2 (CONTROS HydroC CO_2) and pH (CONTROS HydroFIA pH prototype)
  - Low salinities of approx. 7 psu
  - Wide measuring range and high dynamics for pH and CO_2

12 April → 28 April



Courtesy of Jens Müller , IOW



Great advancement for pH monitoring in the Baltic Sea

Researchers adapt optical pH measurement method for brackish waters

Is the Baltic Sea acidifying? To better observe possible acidification trends in brackish waters, Jens Daniel Müller, marine chemist at the Leibniz Institute for Baltic Sea Research Warnemünde (IOW), Germany, together with several partners, adapted the highly precise optical pH measurement technique, previously only applicable for the high salinity levels of the open ocean, for use in regions with low salinities. This has led to the development of a ready-to-use device from the sensor technology company Kongsberg Maritime Contros, Germany. The newly adapted method is highly suitable for routine applications in the field, for instance as part of the Helsinki Commission's (HELCOM) environmental monitoring of the Baltic Sea as well as for the pH monitoring of other coastal seas with low salinities. The work is a result of the EU and nationally co-funded project BONUS PINBAL.

Excessive anthropogenic CO_2 emissions are not only a problem for the global climate, but also for the oceans: carbon dioxide dissolves in seawater, forms carbonic acid and thereby releases hydrogen ions, which leads to acidification. Since the Industrial Revolution, the average pH of the oceans has dropped from 8.2 to around 8.1. Also known as "the other CO_2 problem", this pH decrease affects almost all biogeochemical processes in the ocean.

Above: The optical pH measurement method newly adapted for brackish waters, including a prototype (the 'Red Box'), was thoroughly field-tested by IOW scientist Jens Müller – here in the engine room aboard the ferry Finnmaid. Photo: IOW/J.D. Müller.

The BRIESE Prize for Marine Research 2018 was awarded today at the IOW to Dr. Jens Daniel Müller (m.). Captain Klaus Küper (r.) from the BRIESE shipping company, IOW Director Ulrich Bathmann (l.). (Photo: IOW / K.Beck)

Source: www.io-warnemuende.de

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CONTROS HydroFIA® TA

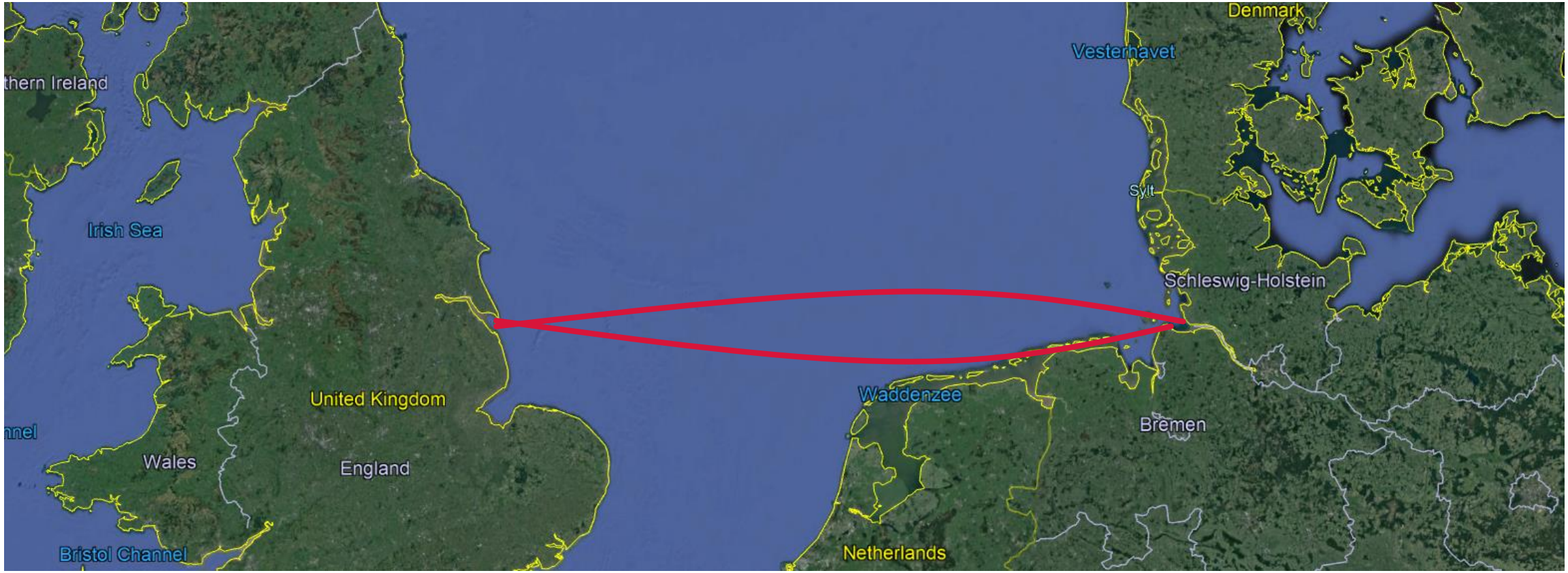
CONTROS HydroFIA® TA

Benefits

- Worlds first commercially available autonomous TA analyzer
  - → Game changer in biogeochemical studies involving TA
  - → Carbonate chemistry applicable
  - → Suitable for ocean acidification studies
  - → Global change monitoring
- Low sample / chemicals consumption
  - → Decreased cost per measurement
- Easy setup for autonomous use
  - → Deployment longer than one month possible
  - → No more bottled samples
  - → Save time and analyses cost
  - → Replacing the sophisticated lab setup

Application

Monitoring coastal alkalinity in FerryBox (Wadden Sea)

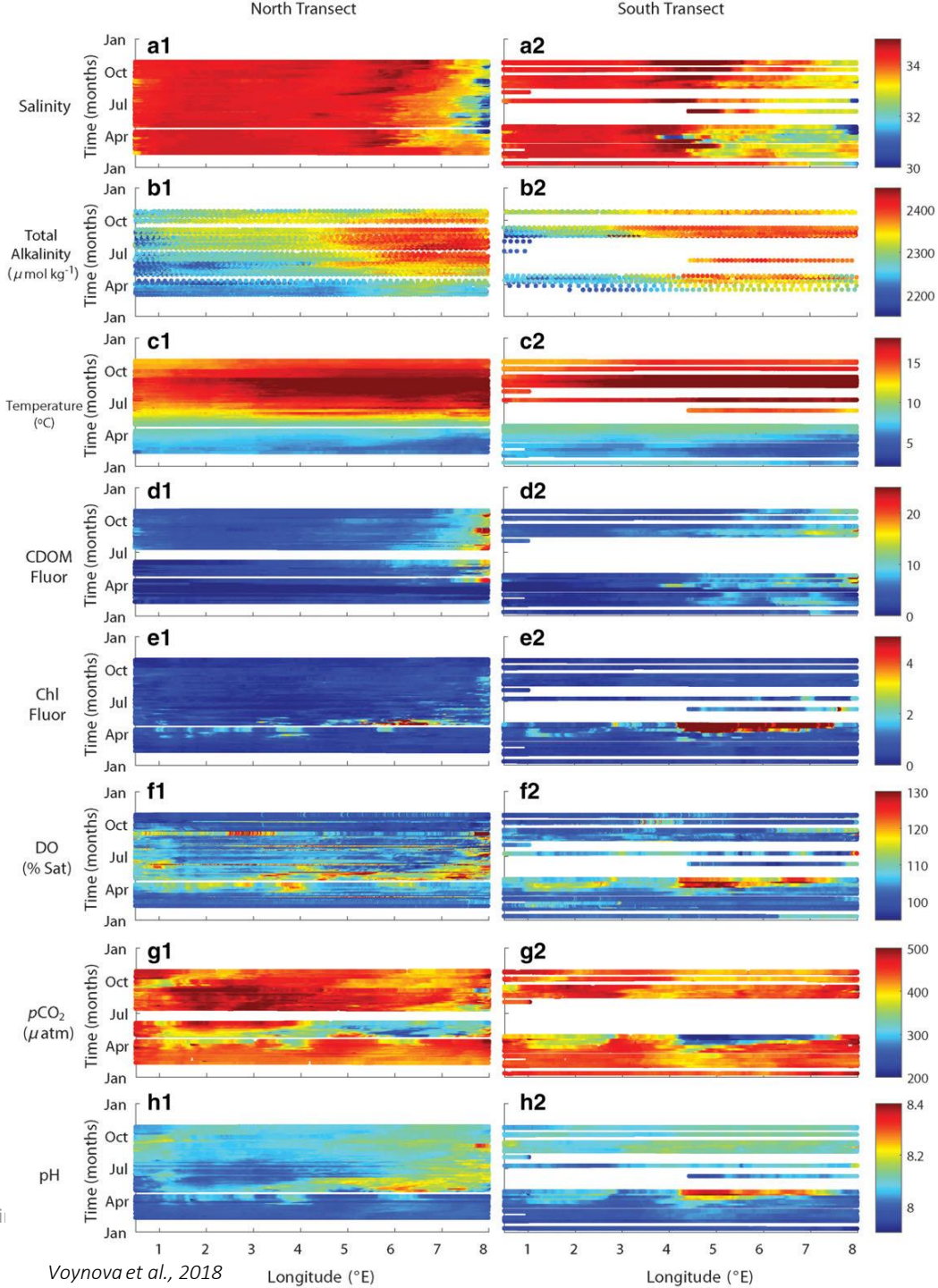


Google Earth

Application

Monitoring coastal alkalinity in FerryBox (Wadden Sea)

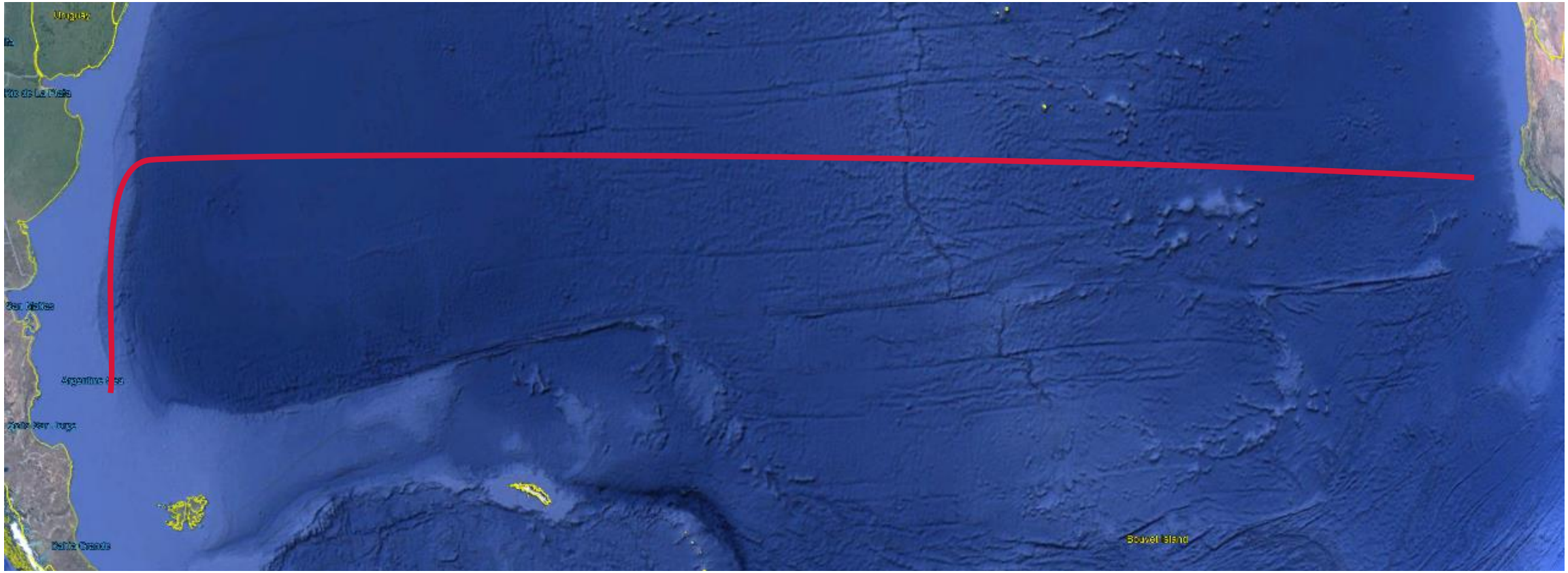
- FerryBox approach with broad sensor setup
  - Total Alkalinity (CONTORS HydroFIA TA)
  - Carbon Dioxide CO_2 (CONTROS HydroC CO_2 FT)
  - pH
  - Oxygen O_2
  - Salinity, Temperature
  - CDOM, Chlorophyll
- Installed on a Ferry sailing between Cuxhaven (GER) and Immingham (UK)
- **First long-term (11 months) high resolution dataset for TA**
- TA flux calculation from Wadden Sea into North Sea → Carbonate System



Voynova et al., 2018

Application

Monitoring Ocean Alkalinity – Sothern Atlantic Ocean



Google Earth

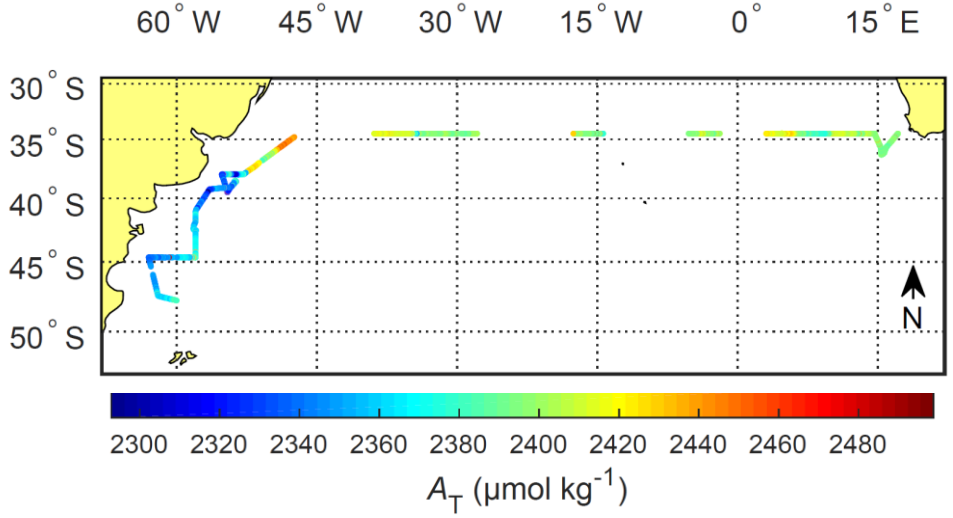
Application

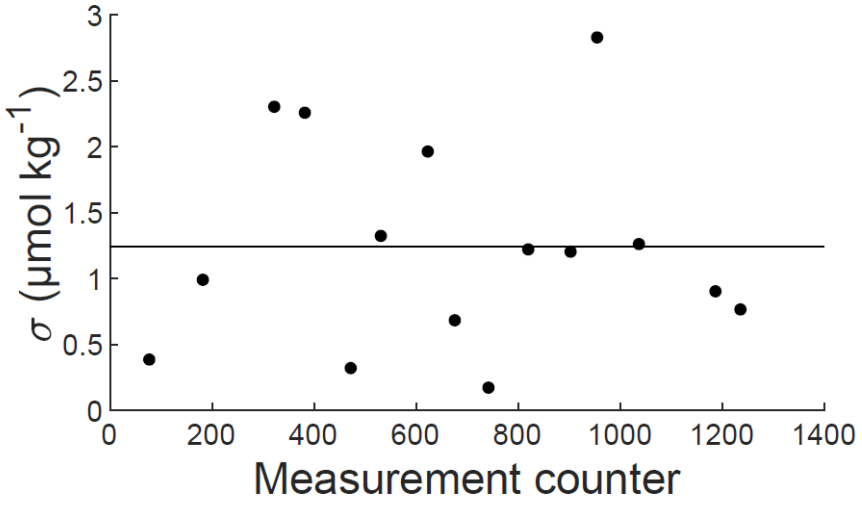
Monitoring Ocean Alkalinity – Sothern Atlantic Ocean

- Using regular CRM measurements over the course of the cruise (standard deviation of 5 repetitive CRM measurements)

→ Average field precision: 1.1 µmol kg^{-1}

Seelmann et al. , 2019 (submitted)





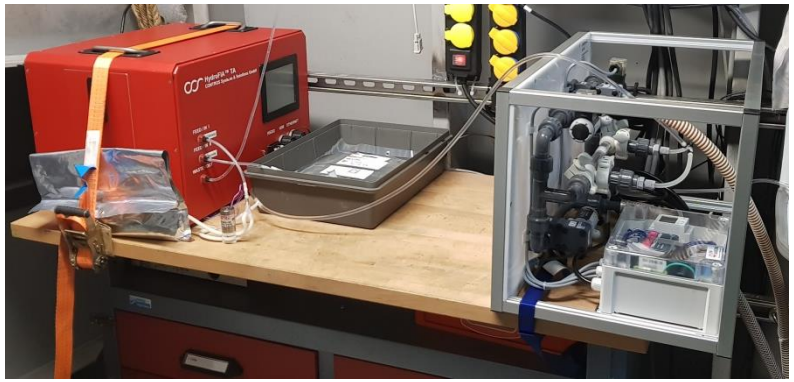
Application

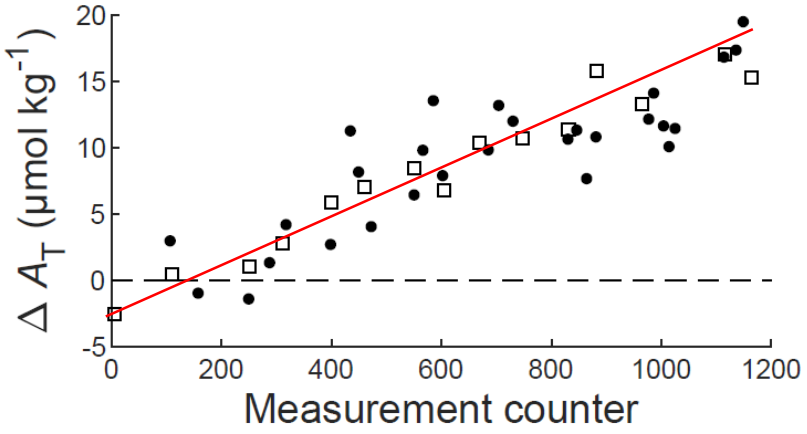
Monitoring Ocean Alkalinity – Sothern Atlantic Ocean

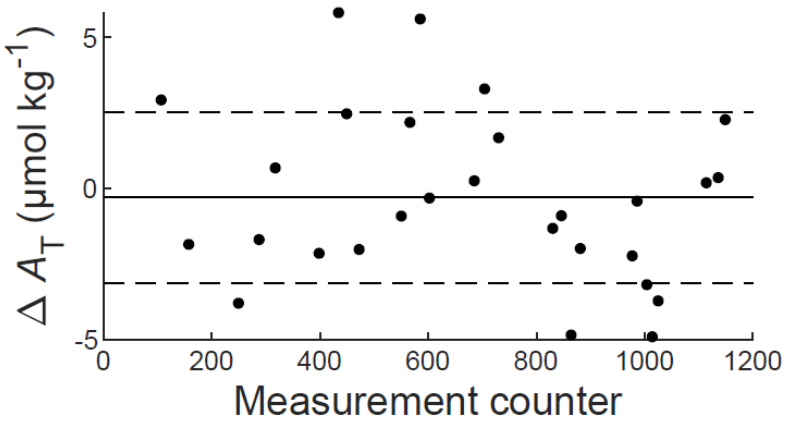
- Using regular CRM measurements (□) and discrete samples* (●)
- Raw data (drifted) can be corrected using CRM measurements or discrete sample measurements.

→ Field accuracy: (-0.3 ± 2.8) µmol kg^{-1}

Seelmann et al. , 2019 (submitted)







CONTROS HydroFIA®

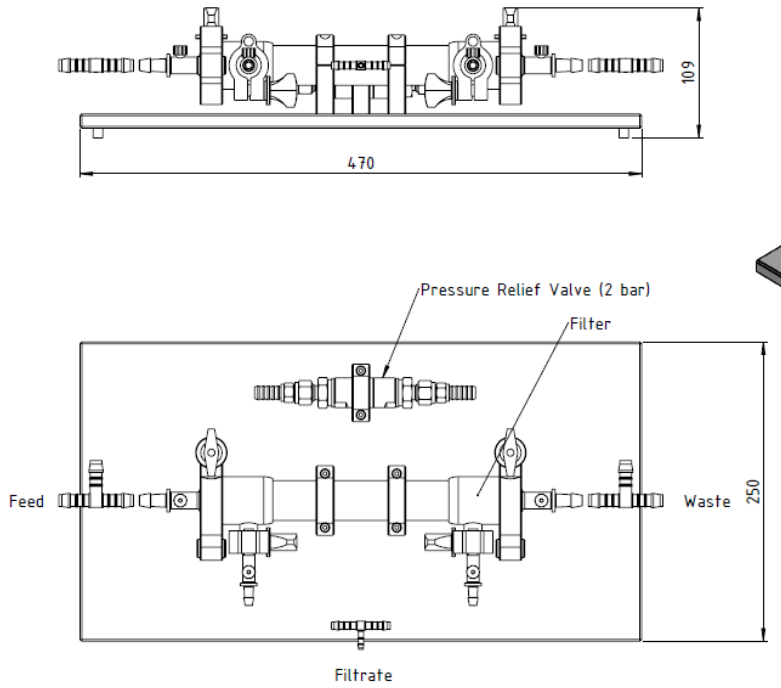
Cartridges

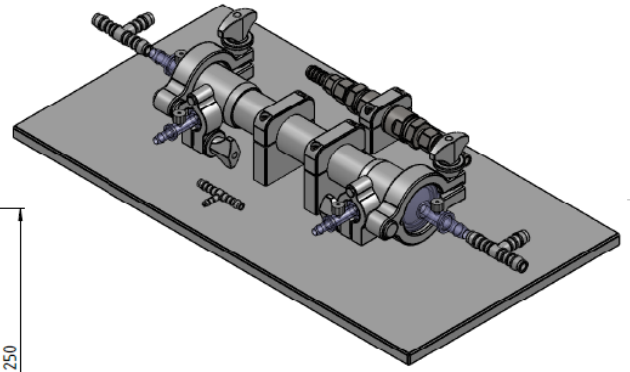
- Chemicals are provided in cartridges
  - Separate indicator and acid
- User friendly and robust design.
- Usage of gas-tight bags to avoid the introduction of a head space during operation/consumption of the chemicals.
- No gas exchange with surrounding air.
- No degradation of the substances due to light.
- One cartridge set lasts for
  TA: 2500 measurements / pH: 16000 measurements

CONTROS HydroFIA®

Cross-Flow Filter

- Important for particle loaded waters to avoid clogging
- 0.2 µm pore size filter removes stray light particles in the visible light spectrum
- Reduction of bio-fouling





CONTROS HydroFIA®

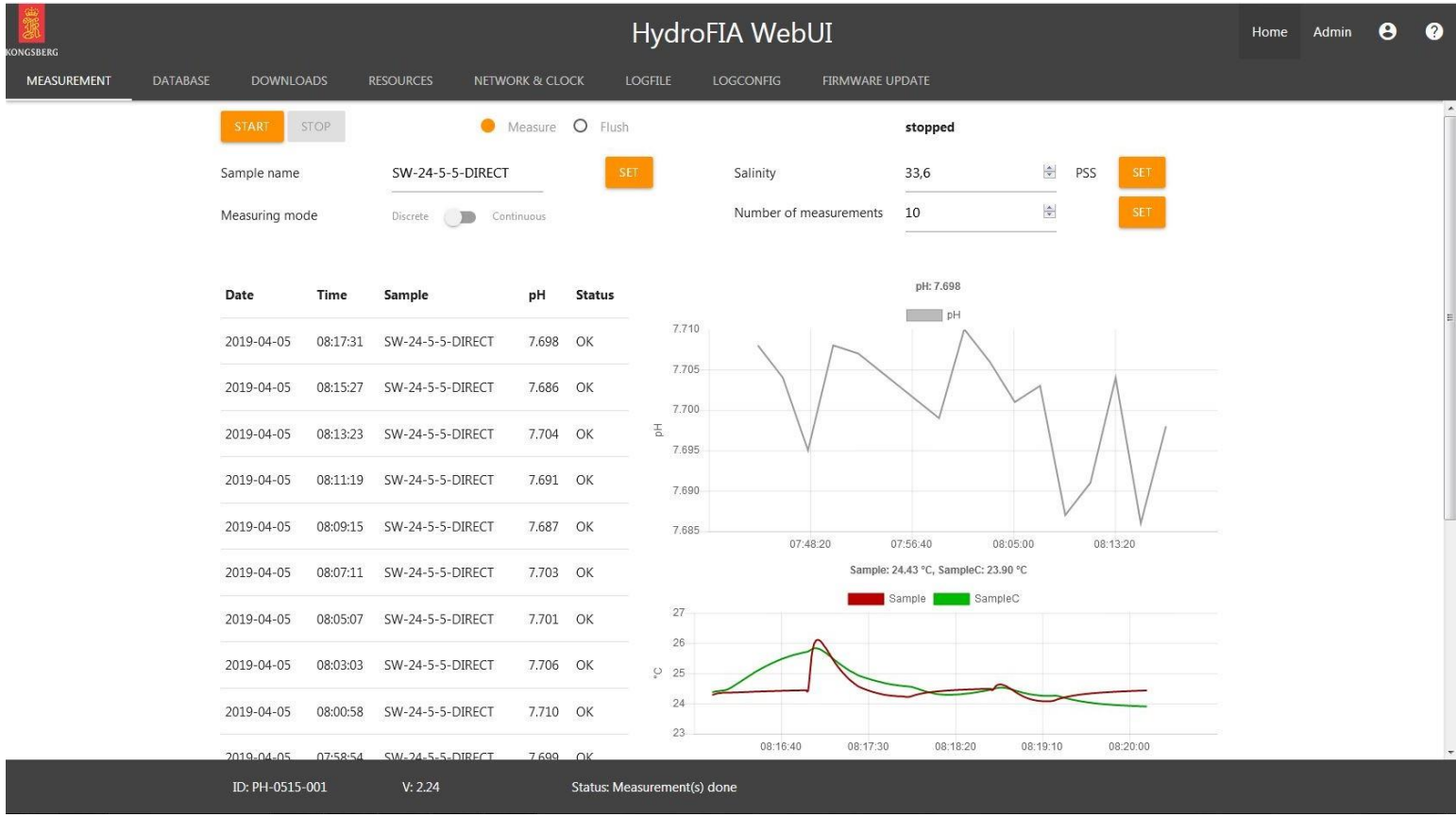
Summary

- **Continuous** and **automated** measurement of pH and TA in seawater.
- **Calibration:** **pH → calibration free** detection principle.
  TA → One-point calibration doable by operator.
- Calibration and measurements tested and further developed in **R&D projects**.
- **High quality** systems: **pH** → precision ±0.001 pH units, accuracy ±0.003 pH units (overall uncertainty depends on indicator dye and pH reference)
  TA → precision <±2 µmol kg^{-1}, accuracy <±5 µmol kg^{-1}
- **User-friendly** through comprehensive, easy-to-use and continuously improved **firmware** as well as application-oriented features (e.g. addition of second inlet for regular standard measurements).
- Chemicals are provided in **cartridges** for easy operation and maintenance.
- **Low sample and reagent consumption** of approx. <20 mL (pH) and 50 mL (TA) per sample.

Outlook

CONTROS Sensors

- **New laser detector** for CH_4 and CO_2 improving
  - Accuracy
  - Stability
  - Response time
- **Compact wet-chemical analyzers** for
  - Simplified integration into existing flow-through systems
- **Web interface** on upcoming product generations for
  - User-friendly sensor configuration
  - Live data monitoring
  - Remote operation of the instruments



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Thank you

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