Manolis Ntoumas - Hellenic Centre for Marine Research (HCMR)

12th FerryBox Workshop

Helsinki,1-2 October, 2024

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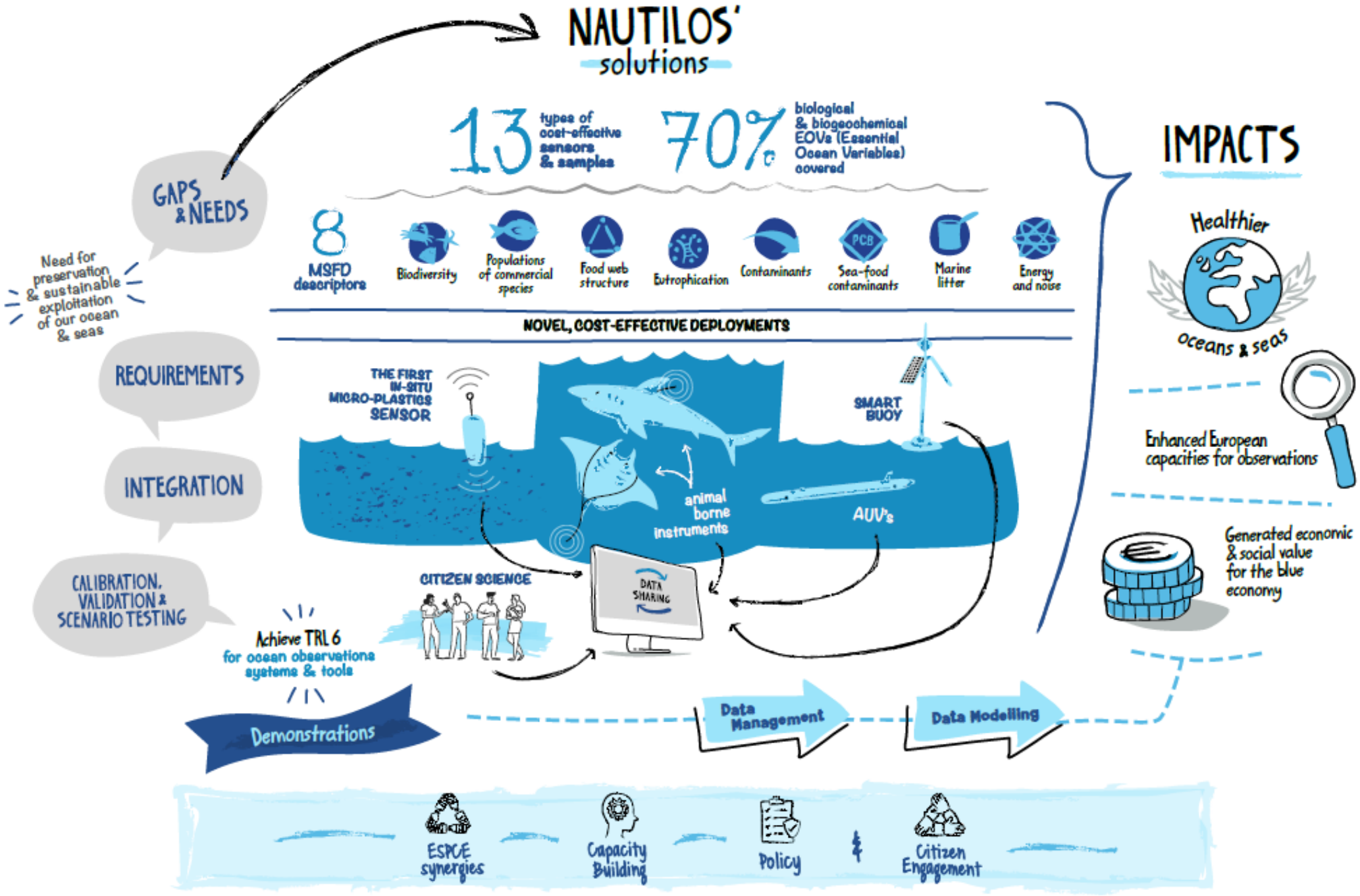
NAUTILOS, a **Horizon 2020** Innovation Action project funded under EU's the Future of Seas and Oceans Flagship Initiative, aims to fill in marine observation and modelling gaps for biogeochemical, biological and deep ocean physics essential ocean variables and micro-/nano-plastics, by developing a new generation of cost-effective sensors and samplers, their integration within observing platforms and deployment in large-scale demonstrations in European seas.

The principles underlying **NAUTILOS** will be those of the development, integration, validation and demonstration of new cutting-edge technologies with regards to sensors, interoperability and embedding skills. The development will always be guided by the objectives of scalability, modularity, cost-effectiveness, and open-source availability of software products produced.


NAUTILOS' solutions
GAPS & NEEDS
Need for preservation & sustainable exploitation of our ocean & seas
REQUIREMENTS
INTEGRATION
CALIBRATION, VALIDATION & SCENARIO TESTING
13 types of cost-effective sensors & samples
70% biological & biogeochemical EOVs (Essential Ocean Variables) covered
8 MSFD descriptors
Biodiversity
Populations of commercial species
Food web structure
Eutrophication
Contaminants
Sea-food contaminants
Marine litter
Energy and noise
NOVEL, COST-EFFECTIVE DEPLOYMENTS
THE FIRST IN-SITU MICRO-PLASTICS SENSOR
SMART BUOY
animal borne instruments
AUV's
CITIZEN SCIENCE
DATA SHARING
Achieve TRL 6 for ocean observations systems & tools
Demonstrations
Data Management
Data Modelling
ESFRI synergies
Capacity Building
Policy
&
Citizen Engagement
IMPACTS
Healthier oceans & seas
Enhanced European capacities for observations
Generated economic & social value for the blue economy

Revolutionising ***underwater sensing*** and ***sampling technology*** for **ocean observation**

Microplastic sampler

Microplastic Sensor

WiSens TD – Chl-a

Deep Ocean CTD Sensor

Silicate Electrochemical Sensor

Oxygen Sensor

Submersible Sampler for Nanoplastics and Microplastics – SuNaMips

Carbonate Sensors

Phytoplankton Sampler

Downward Looking Sensors

Deep ocean low-level radioactivity sensor

Passive broadband acoustic recording sensor for noise monitoring

Fluorometric Oxygen Sensor

Animal-borne tracking device for ocean data monitoring

DEMONSTRATIONS

- Fisheries Observing Systems
- Aquaculture Observing Systems
- Acoustic Marine Mammal Monitoring System
- Platforms of opportunity
- Augmented Observing Systems
- ARGO Platform
- Animal-borne instruments

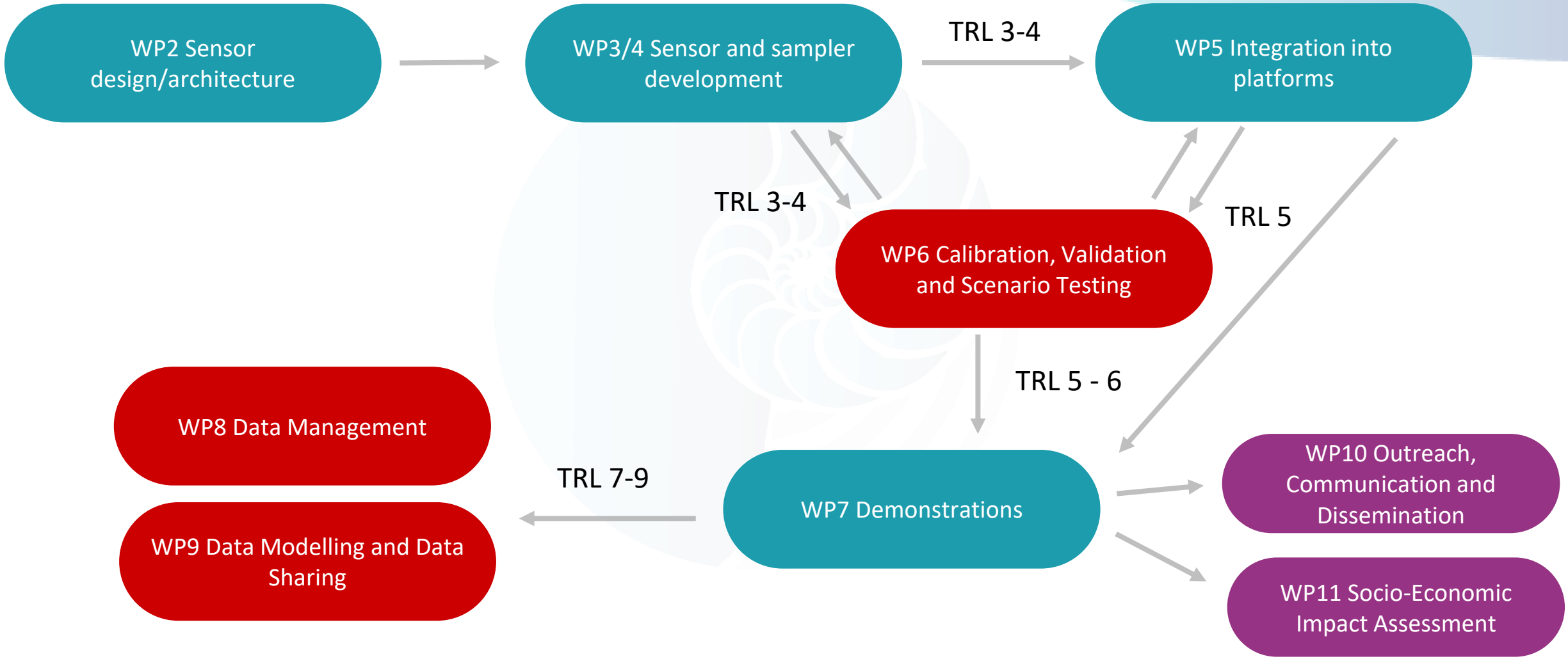
Research

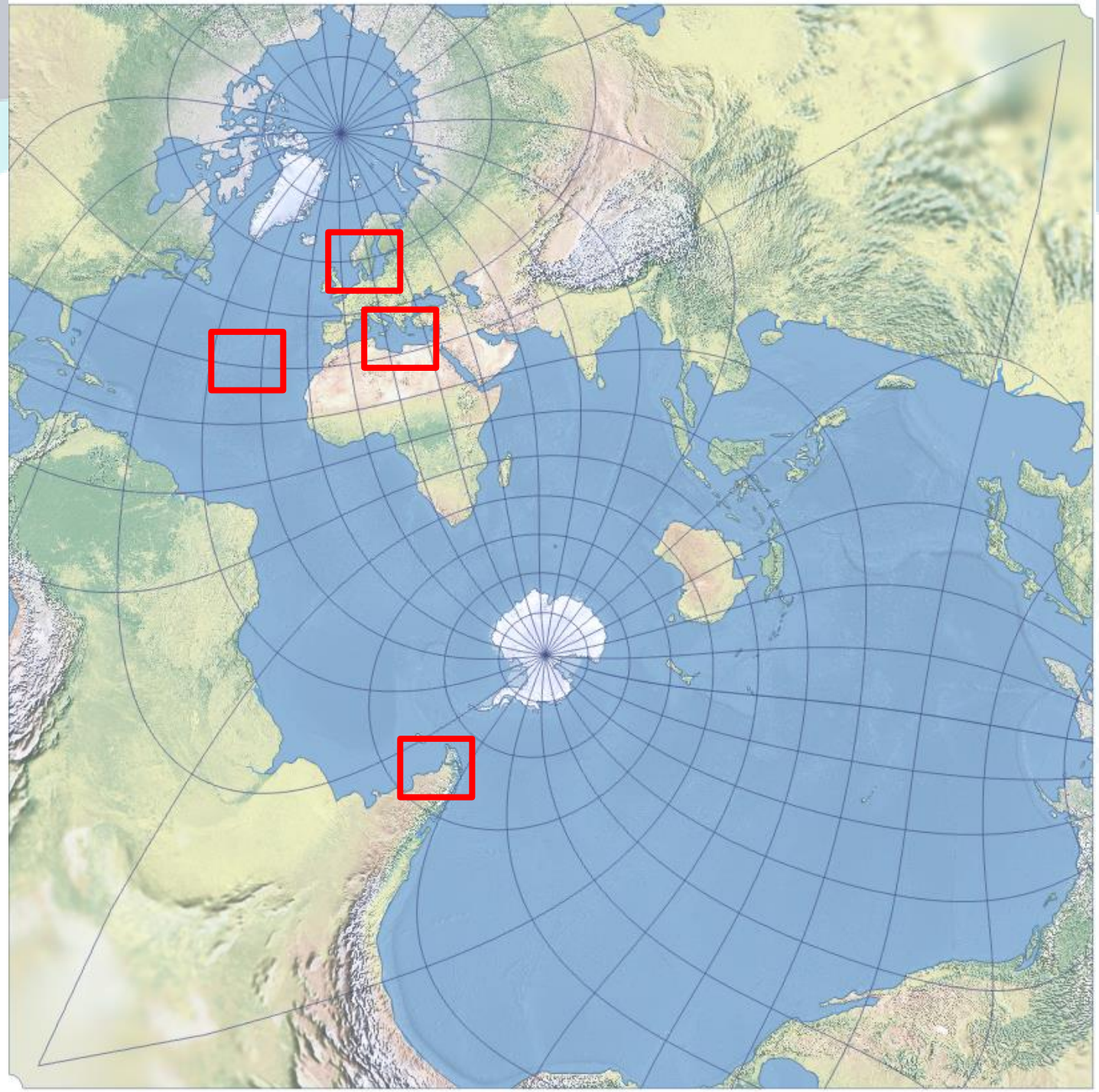
…..and society

CITIZEN SCIENCE

- Crowd-sourcing for visual marine image annotations
- Creation of Diving Associations Network
- NIR Scanner micro and macro-plastic campaigns
- Citizen Science Plastics-Related Campaigns
- Italian Marine Protected Areas Campaign

NAUTILOS strategy - WPs Interactions (TRL scheme)





NAUTILOS

Fisheries Observing Systems

- *Adriatic Sea*: Fishery and Oceanography Observing System (FOOS) device/platform on commercial fishing vessels;
- French waters: on commercial fishing vessels

Aquaculture Observing Systems

- *Coastal Norway and Greece*

*Marine **Mammal** Monitoring Systems*

- *Swedish Sound/Kullaberg/Lysekil waters*: Commercial Fisheries; Italy: Portofino MPA cetaceans' sanctuary.

Platforms of Opportunity

- *Coastal Norway*: NorSOOP FerryBoxes on M/S Trollfjord;
- *Gulf of Finland*: Ferryboxes cruising across Gulf of Finland;
- *Eastern Mediterranean (Cretan Sea):* Poseidon FerryBox

Augmented Shelf-Seas, Open Sea and Deep-sea Observing Systems

- Shelf sea - POSEIDON Heraklion Coastal Buoy (HCB) Open sea - E1M3A station Deep sea experiment - Aegean sea

Argo Platform

- *Mediterranean Sea, up to 2000 m*

Animal-borne Instruments

- *Azores islands*: combination of long and short duration deployments
- *Valdes Peninsula, Argentina*

Instrumentation for platforms of opportunity

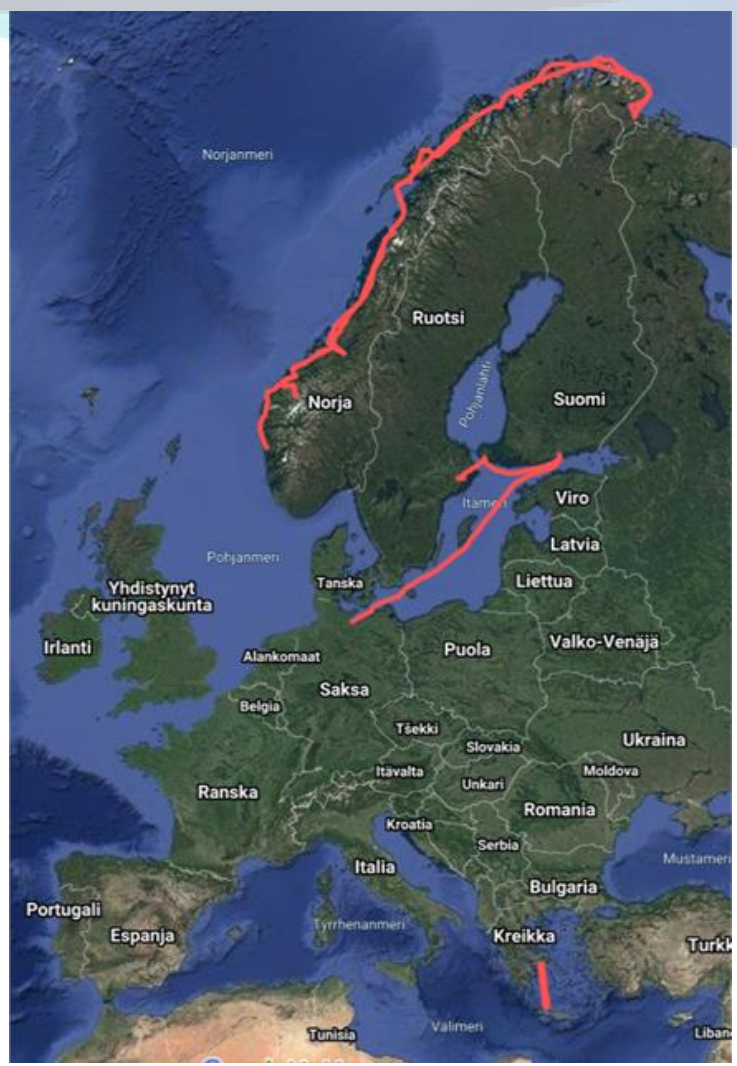
Objectives

Demonstration of the operational use of sensors in FerryBox/ SOOP/ R/V /Robotic platforms

Where; overview

<u>Platforms of Opportunity</u>

- Coastal Norway: NorSOOP FerryBoxes on M/S Trollfjord, M/S Color Fantasy;
- Gulf of Finland: Ferryboxes cruising across Gulf of Finland;
- Eastern Mediterranean (Cretan Sea): (Poseidon FerryBox) / R/V Philia



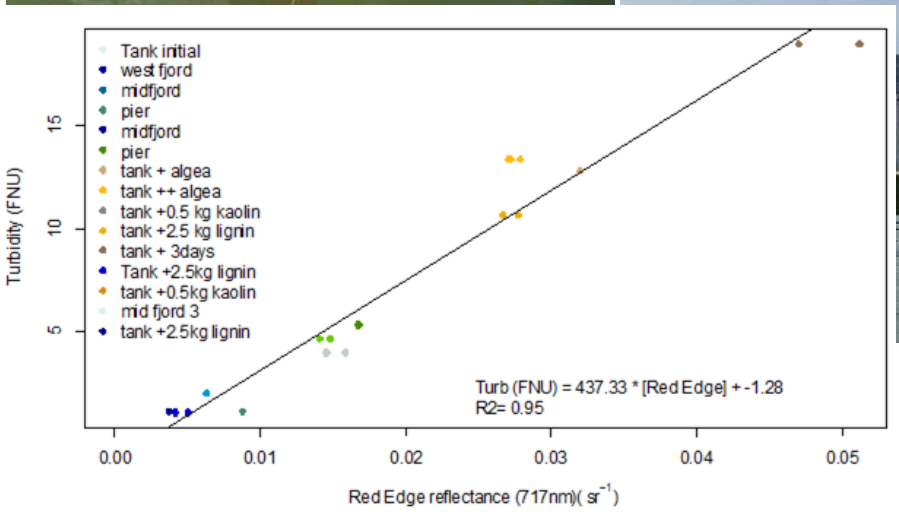
Sensors included in the demo

- Downward-looking multi/hyperspectral and laser induced fluorescence sensors
- Sampler for phytoplankton and other suspended matter.
- Carbonate system/ocean acidification sensors
- Low-cost Microplastic sensors based on selective Nile Red staining and fluorescence detection

Downward-looking sensors - NIVA

Multi- and Hyper- spectral cameras

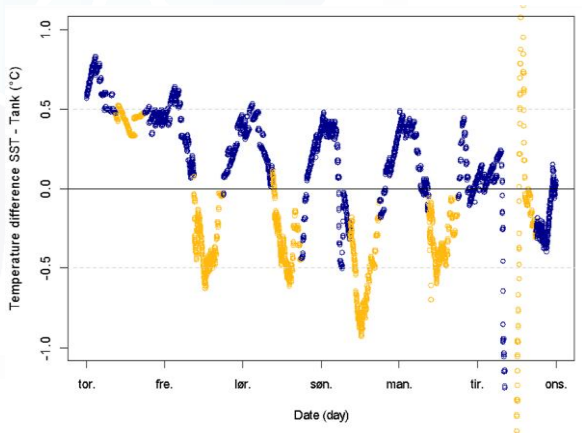
50 m^3 outdoor tank filled with sea water at NIVA research facility. Modification of its optical properties, by combining different concentration of phytoplankton, organic coloured material (lignin) and mineral particles (kaolin).



TRL: 5

IR temperature sensor

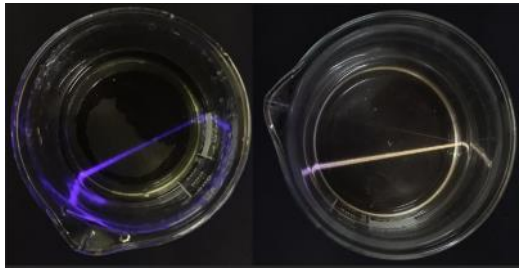
IR temperature sensor (for SST) lab calibration - validated outdoor.
Installation height effect characterized



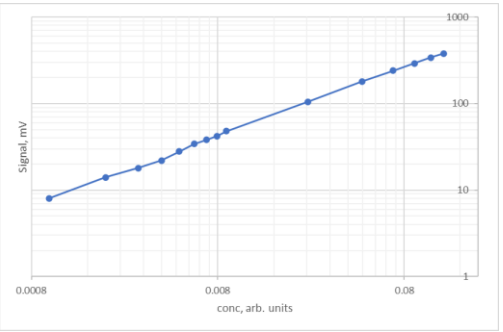
TRL: 5

LIF LIDAR

Low cost LIF LIDAR response characterized in lab using fluorescent pigment .



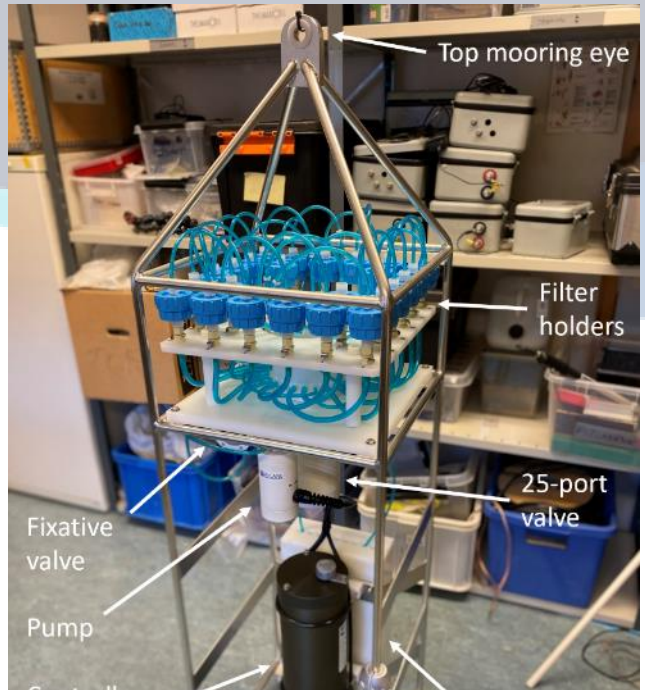
Pure water fluorescent pigment

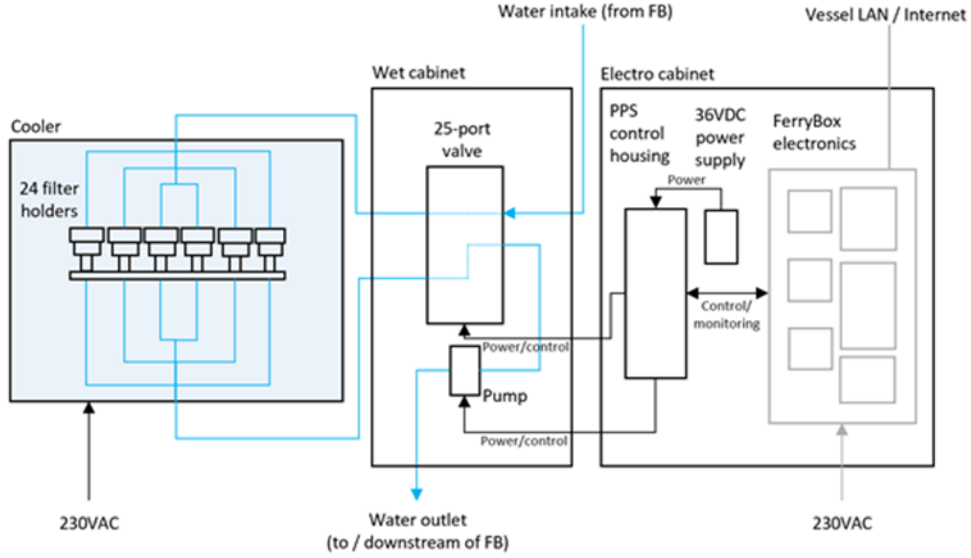


TRL: 4

Phytoplankton and suspended matter sampler- NIVA

- Several autonomous suspended matter samplers and custom-made solutions were investigated
- The Mclane PPS was the only sampler that met the requirements for multiplatform implementation in NAUTILOS and to be able to autonomously filter samples for chl a, DNA/RNA.
- A programmable pump pulls water through filters held in 24 filter holders; a reagent/fixative bag can be used to rinse the filters after sampling

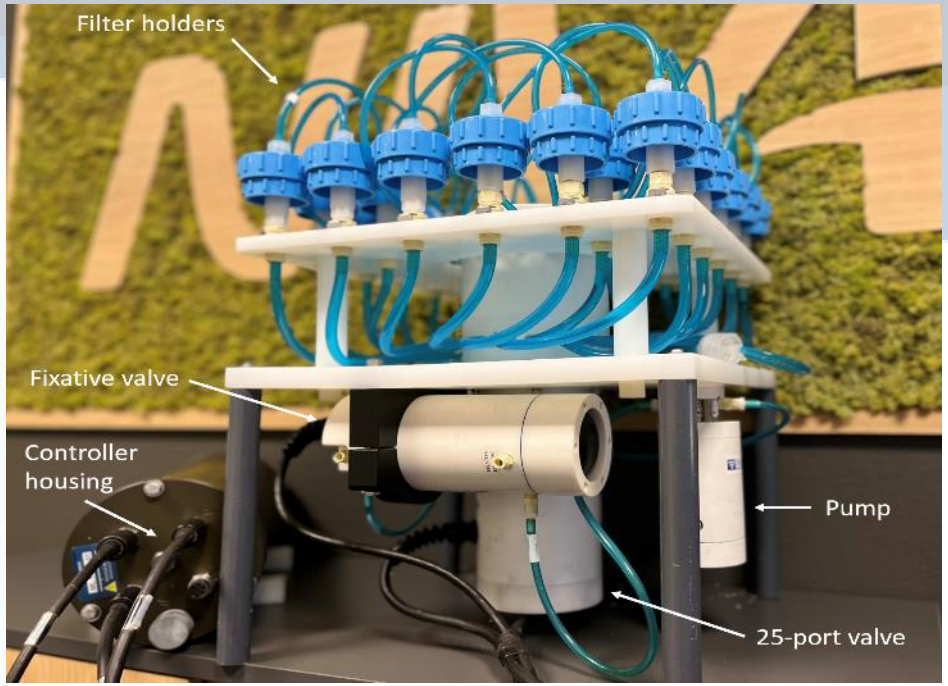




Phytoplankton and suspended matter sampler- NIVA

Methods

- Natural seawater, spiked with cultures of 3 selected phytoplankton species and filtered on 0.45 µm PES membrane filters
- Various preservation methods systematically applied: ATL buffer, RNAlater, 96% ethanol and storage at 4°C for different durations before freezing to -20°C.
- DNA isolated from filters with commercial kits and quantified with species-specific quantitative PCR assays



Results

- Preservation has strong effect on DNA quantification.
- Low variability between filter triplicates, good recovery
- Ethanol identified as preferred preservation method for suspended matter sampler:
  - Acceptable DNA concentration (though 3 to 10 lower concentrations than ATL)
  - Less expensive, more easily available and more predictable viscosity than ATL
  - No freezing of the samples needed

TRL: 6

Carbonate system/Ocean acidification sensor

Task leader: NIVA
Other partners involved: SCT, HCMR
Timing: M1 – M24

Objective:

- Better understand natural variability in oceanic C cycling and the impact of rising CO2 and declining pH in the oceans

Activities:

- Develop cost-efficient, low power, and modular carbonate system sensors

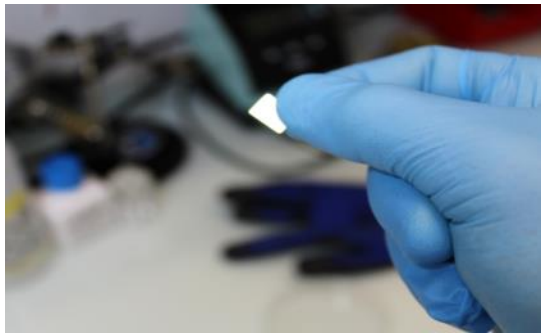


Photo credits: NIVA; SubCtech; Fluidion

pH/pCO_2 sensors selected for further development

- Primary selection criteria:
  - **Low cost**, <10 kEuro and better if <5 kEuro
  - **Easy to use, small, ability to connect to smartphones/tablets** via USB/Wifi/Bluetooth; e.g., by aquaculture, citizen scientists, etc.
  - **High enough precision/accuracy** to be able to detect and understand dynamics at relevant scales – seasonal variability, aquaculture scenarios, surface/bottom variability, decadal scale OA impacts – some sacrifices on very small “climate” level uncertainties

- pH sensors: ISFET (ion-sensitive field-effect transistor) style sensor – Honeywell Durafet and Endress Memosens sensors.
- pCO_2 sensor: membrane-equilibrator NDIR (non-dispersive infrared) detector – Franatech CO2-HR handheld sensor

Norsk institutt for vannforskning

hcmr
ΕΛΚΕΘΕ

subCtech
Subsea Technologies

Carbonate system/Ocean acidification sensor

- Versatile and low-cost logger system which allow integration on any type of platform or discrete readings and user friendly for aquaculture or citizen science activities.
- Improve sensor performances with integrated calibration system
- pH: pressure case
- pCO2: pump head system to increase response time

Durafet probe in its pressure case

Franatech sensor with its logger and pump head

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Carbonate system/ocean acidification sensors - NIVA

- The calibration tests were conducted at NIVA's research facility.

TRL: 5

Results

pCO_2

- Mean absolute error of CO2-HR (relative to bottle samples) ± 74 µatm.
- Within GOA-ON "Weather" quality requirements in high pCO_2 scenarios (aquaculture and coastal systems), similar to other reference sensors
- t90 was approx. 11 minutes for +700 ppm (large) shift in pCO_2, which was shorter than for reference sensors

pH

- Mean absolute error for Durafet and Endress were 0.028 and 0.02, respectively.
- Close to GOA-ON "Weather" quality requirements of ±0.02 pH units
- t90 was approx. ~4 minutes for ~0.3 (large) shift in pH

Microplastic sensor

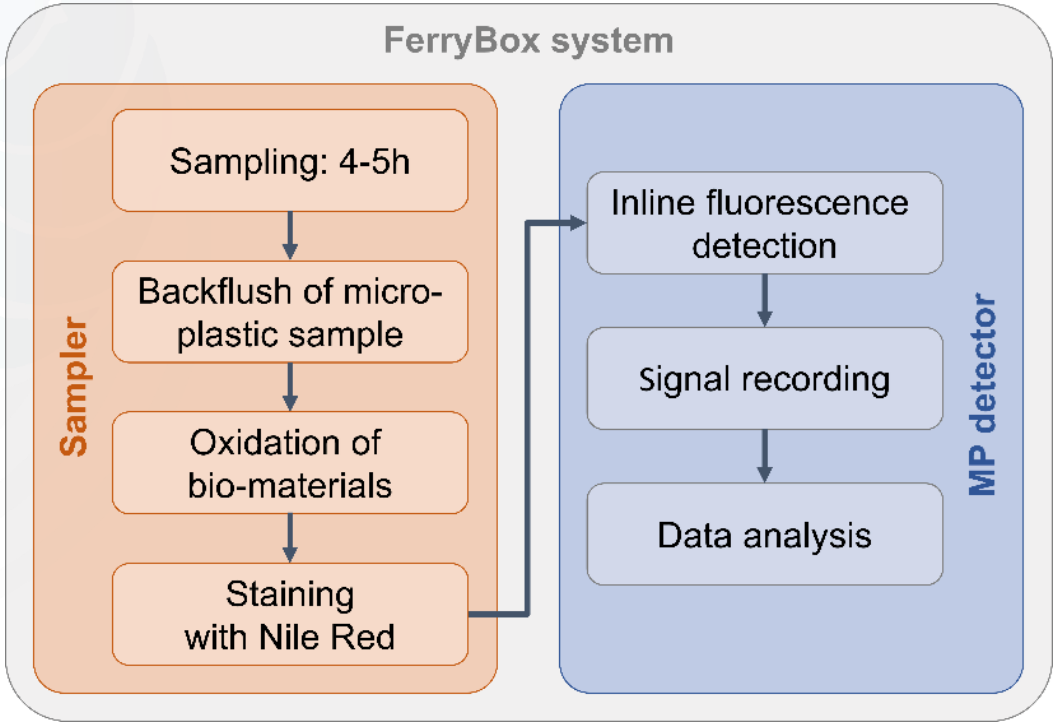
Task leader: CSEM
Other partners involved: NIVA, CNR
Timing: M1 – M24

Objectives:

- **Fluorescence sensor for microplastics detection and quantification**: new approach based on selective fluorescent staining using Nile Red
- The sensor used as autonomous system on several platforms (implementation on FerryBox)

Main Results:

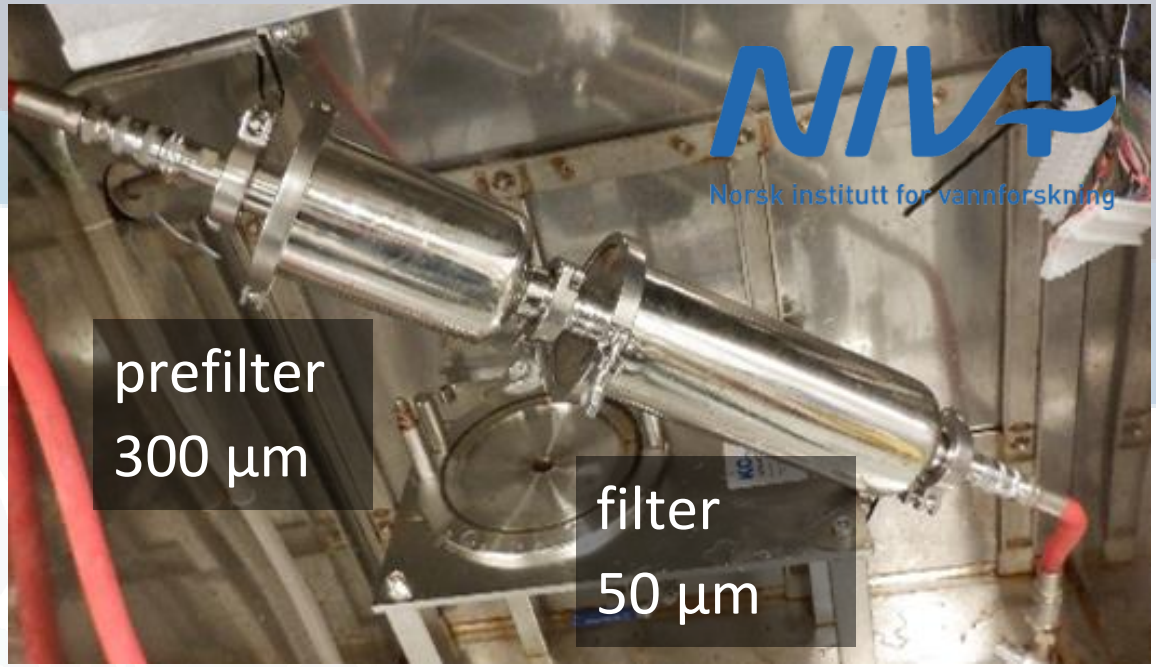
✓ Sampler and oxidation unit tested
✓ MP detector built and tested
✓ Integration of sampler and MP detector started
✓MP detector system testing: ongoing



Microplastic sensor - sampler

- Sampler and oxidation unit tested
  - Tested on Colourline Fantasy ferry
  - Sampling works well
  - Oxidation of biomaterials needs improvement (depending on season)

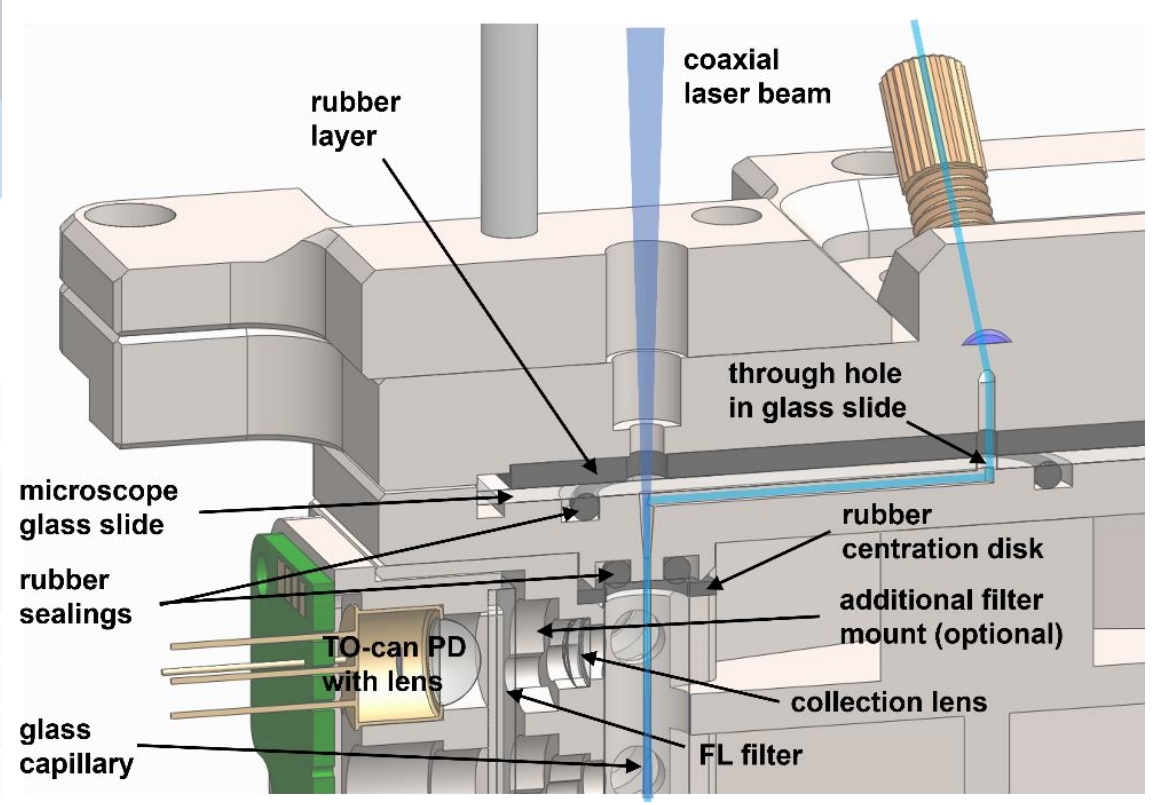
- Marine water provided by FerryBox
- Pump flow rate: 1000 - 2000 L/h
- Filter mesh size: 50 µm
- Heated staining chamber
- Several reservoirs for reagents

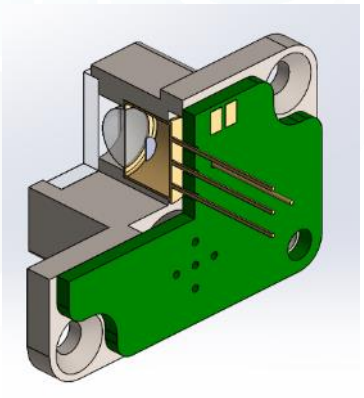


The MP detector

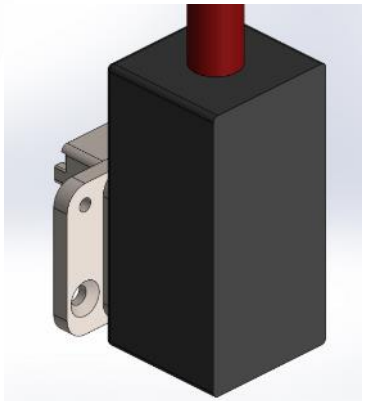
- Low-cost fluorescent particle measurement platform built and tested
- Software and GUI developed, data analysis and plotting works
- MP detector characterisation done with lab samples, system tests ongoing
- Integration into FerryBox started

- 500 µm flow capillary
- Inline fiber laser 465 nm with TEC
- Integrated electronics and RPi
- FL channels: up to 6 PDs with integrated TIA and 2 PMTs (optional)
- 5 kS/s data rate per detector

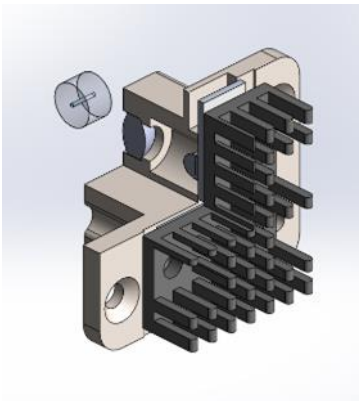




2x PD + TIA

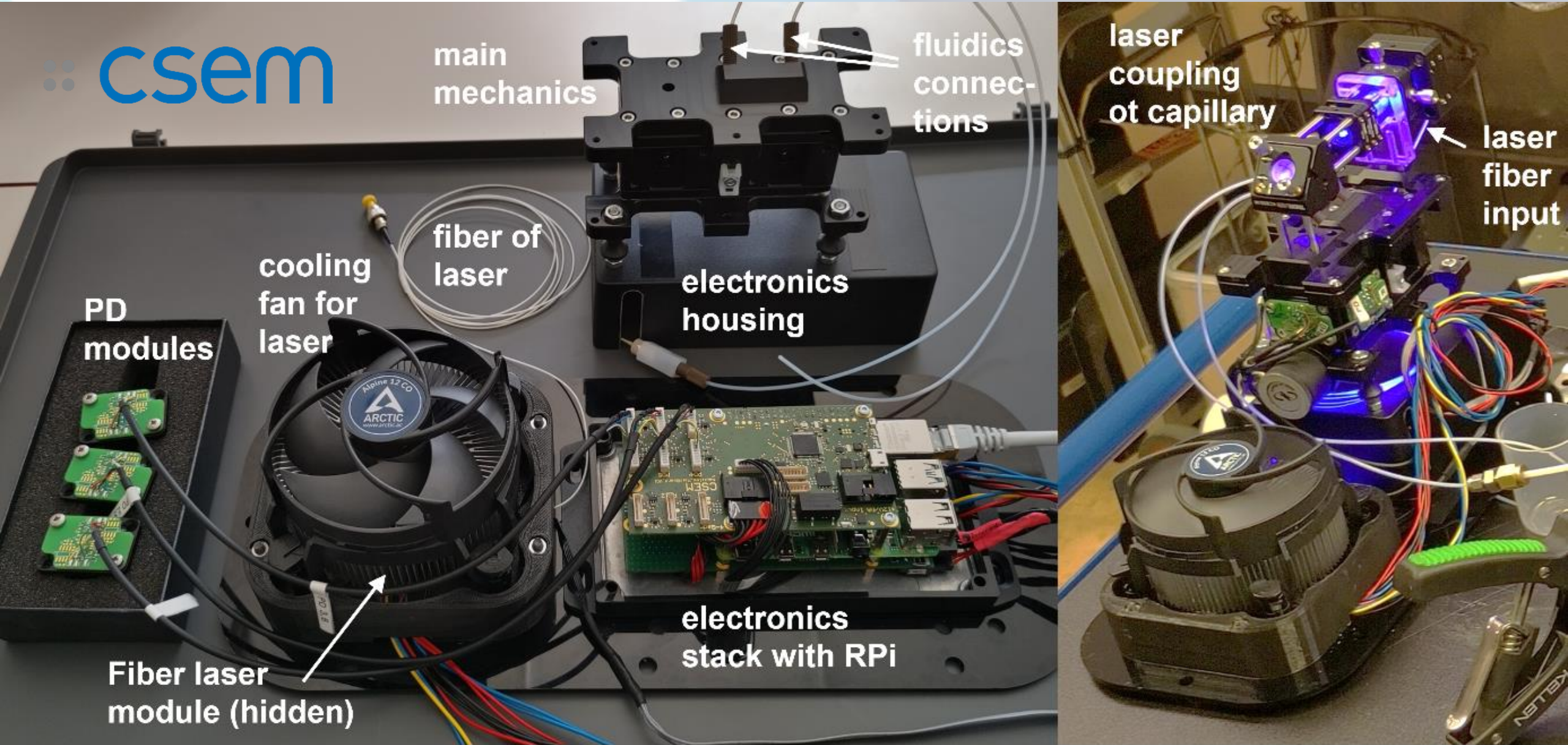


PMT



UVC LED

Microplastic sensor - detector



Integration of sensors/samplers on FerryBox ships of opportunity

- **Sampler for phytoplankton and other suspended matter (T3.5):**

NIVA ferrybox: [Oslo – Kiel] (Optional: NIVA [Bergen – Kirkenes])

Integrated with a stationary FerryBox system at NIVA's Solbergstrand field station in Drøbak, Norway as well as on NIVA's M/S Color Fantasy (Oslo, Norway-Kiel, Germany) FerryBox for testing. The sampler will be integrated with an analogous FerryBox system on M/S Richard With (Bergen-Kirkenes, Norway) for WP7 demos.

- **Downward-looking sensors (T3.2):**

HCMR [Heraklion- Athens]

Infrared sea surface temperature sensor integration procedure carried out on HCMR R/V.

- **Carbonate Sensors (T4.1):**

SYKE ferrybox: [Helsinki-Stockholm]

A flow through system for a pH sensor has been developed and tested and installed on SYKE FerryBox Silja Serenade, sailing between Helsinki-Stockholm for WP7 demo.

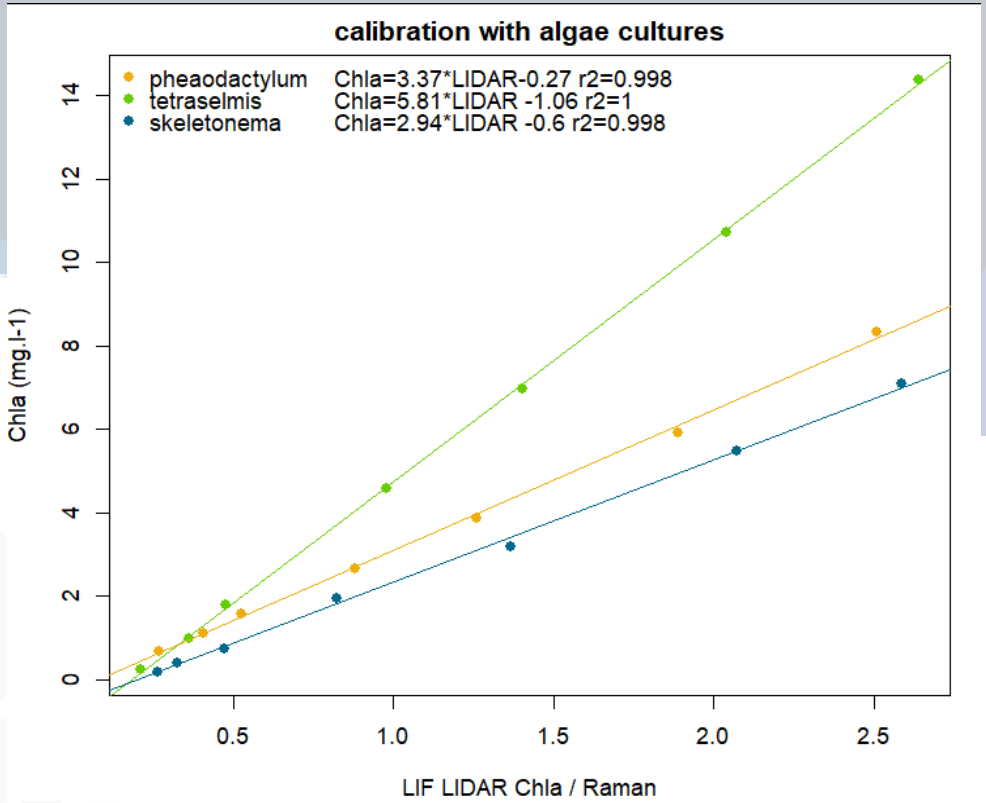
- **Low cost Micro plastic sensor (T4.4):**

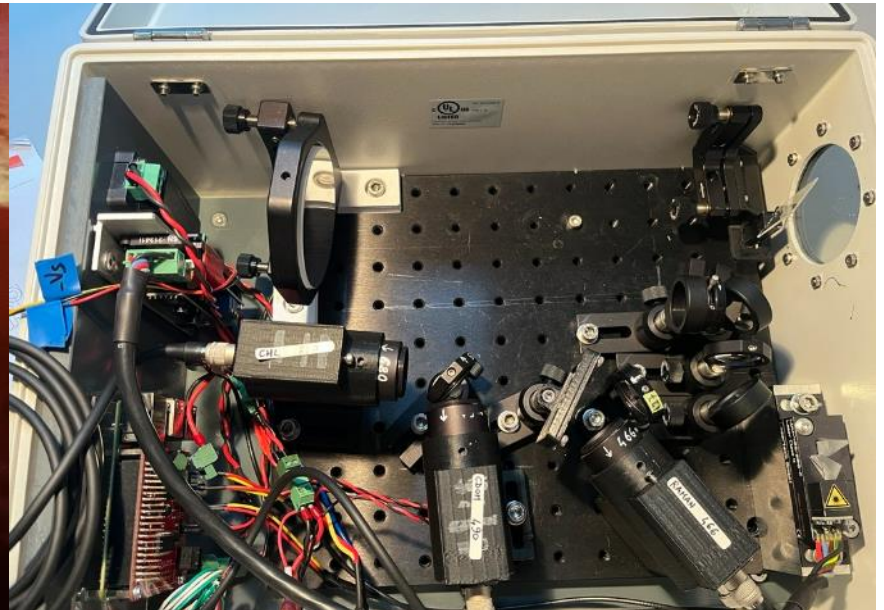
NIVA ferrybox: [Oslo – Kiel]

Sampler integration tests in sept 2021 on M/S Colorline Fantasy. Integration of the sampler on the Hurtigruten M/S Trollfjord in the beginning of June 2023.

LIF LIDAR demonstration

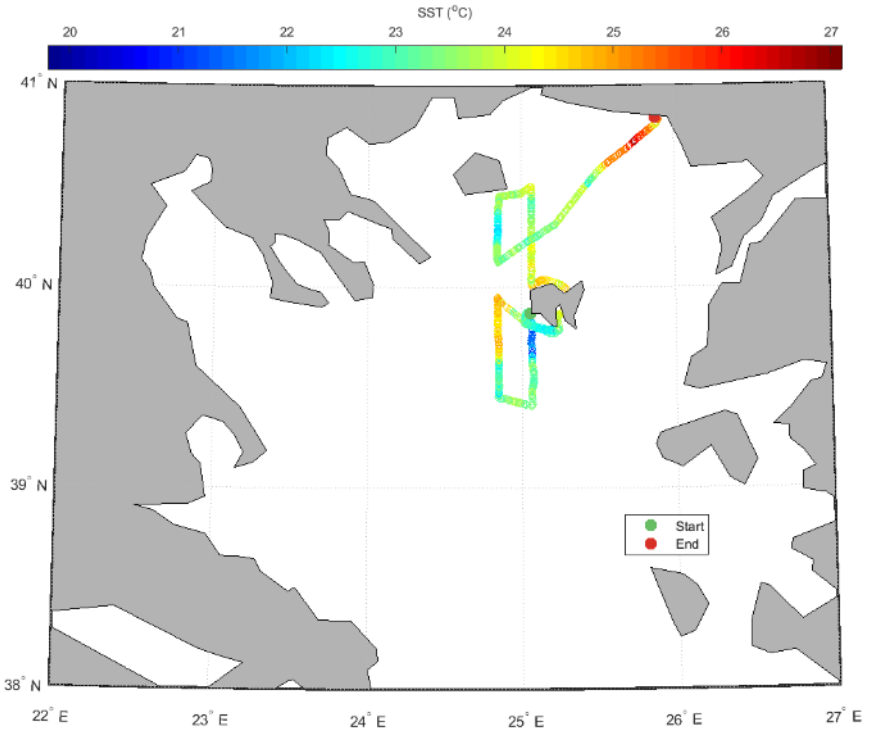
- Deployment in the Oslofjord September 2024 integrated on NIVA's ASV.
- Additional extensive calibration performed

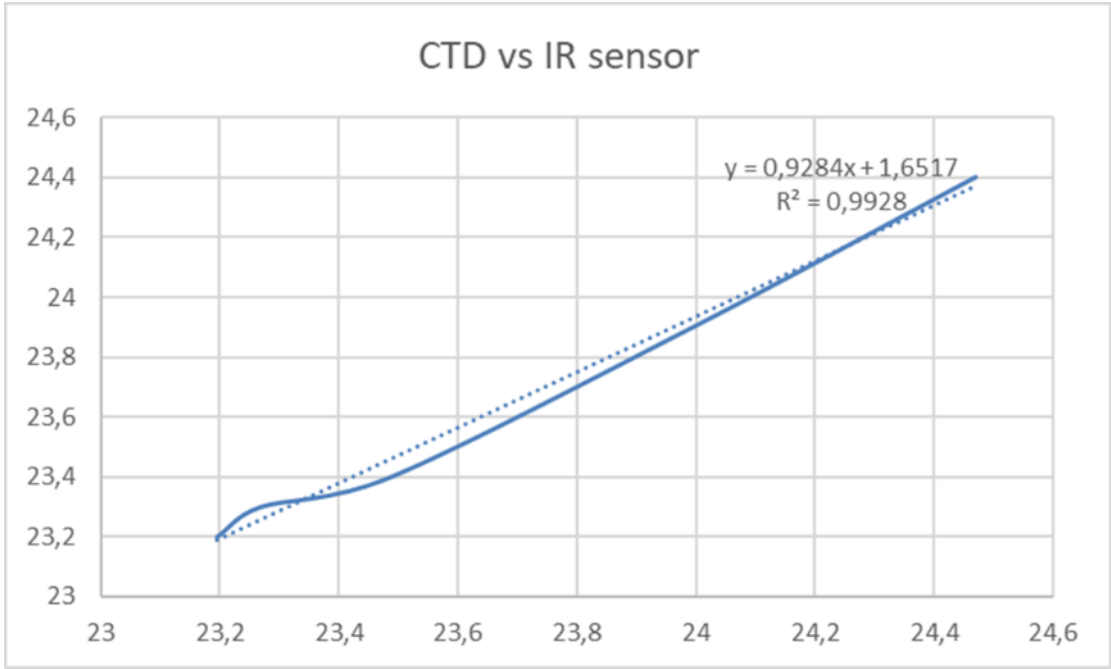




IR temperature sensor demonstration

The sensor is now installed in the R/V Philia (26/05/2024). First tests and field calibration of the sensor using the surface measurements of the R/V CTD started. So far the sensor has been collecting data in the North Aegean, South Aegean, Ionian and Lybian sea.






Thank you! (mntou@hcmr.gr)