Centre for
Data Analytics

Insight

Cost effective sensing platform for the detection of phosphate in natural waters

Andrew Donohoe, Margaret McCaul, Gareth Lacour,
Dermot Diamond

Ireland's European Structural and Investment Funds Programmes 2014-2020
Co-funded by the Irish Government and the European Union

European Union
European Regional Development Fund

ENTERPRISE IRELAND
where innovation means business

sfi

Insight Centre for Data Analytics

Subscribe To SFI | Online Award Application

- Home
- About SFI
- Funding
- Investments & Achievements
- Working With Enterprise
- Researcher Database
- International
- SFI Discover
- News & Resources
- Publications
- Contact Us
- Search

NEWS AND RESOURCES

- Press Releases
- Archive Press Releases
- Events
- Science In The Future
- Noticeboard
- Jobs
- SFI Logo And Guidelines
- Media Contact
- Links & Resources
- Media Gallery

MINISTER BRUTON LAUNCHES €88 MILLION SFI RESEARCH CENTRE, BRINGING NEW INSIGHTS TO DATA ANALYTICS

- Insight, the Centre for Data Analytics, will position Ireland at the heart of global Data Analytics research
- The largest investment in a single research centre in the history of the state
- Uniting universities, 30 industry partners and 200 researchers in the multi-location research centre
- Creating 300 direct jobs through 12 funded spin outs, as well as creating indirectly thousands of other job opportunities

12th December 2013: The Minister for Jobs, Enterprise and Innovation, Mr Richard Bruton T.D. and Minister for Science, Education and Innovation, Mr Sean Sherlock T.D. launched the Science Foundation Ireland (SFI) Research Centre for Data Analytics. In a joint initiative between DCU, NUI Galway, UCC and UCD, Insight, and other partner institutions, brings together more than 200 researchers from these and other Higher Education institutions, with 30 industry partners, to position Ireland at the heart of global data analytics research.

The Centre will receive funding of €58 million from the Department of Jobs, Enterprise and Innovation through SFI's Research Centres Programme, along with a further contribution of €30 million from 30 industry partners. Insight represents a new approach to research and development in Ireland, by connecting the scientific research of Ireland's leading data analytics researchers with the needs of industry and enterprise.

'Insight Centre for Data Analytics'

- **Biggest single research investment ever by Science Foundation Ireland**
- **Biggest coordinated research programme in the history of the state**
- **Focused on 'big data'**

The image cannot be displayed. Your computer may not have enough

DCU UCC OÉ Gaillimh NUI Galway UCD DUBLIN

Adaptive Sensors Group

Principal Investigator - Professor Dermot Diamond

Create cost effective sensors that can obtain accurate, real-time information about environmental status (mainly related to water quality) from the highly local to global scale.
This can only be realised through 'deploy and forget' models of use, in which the analytical platforms are:

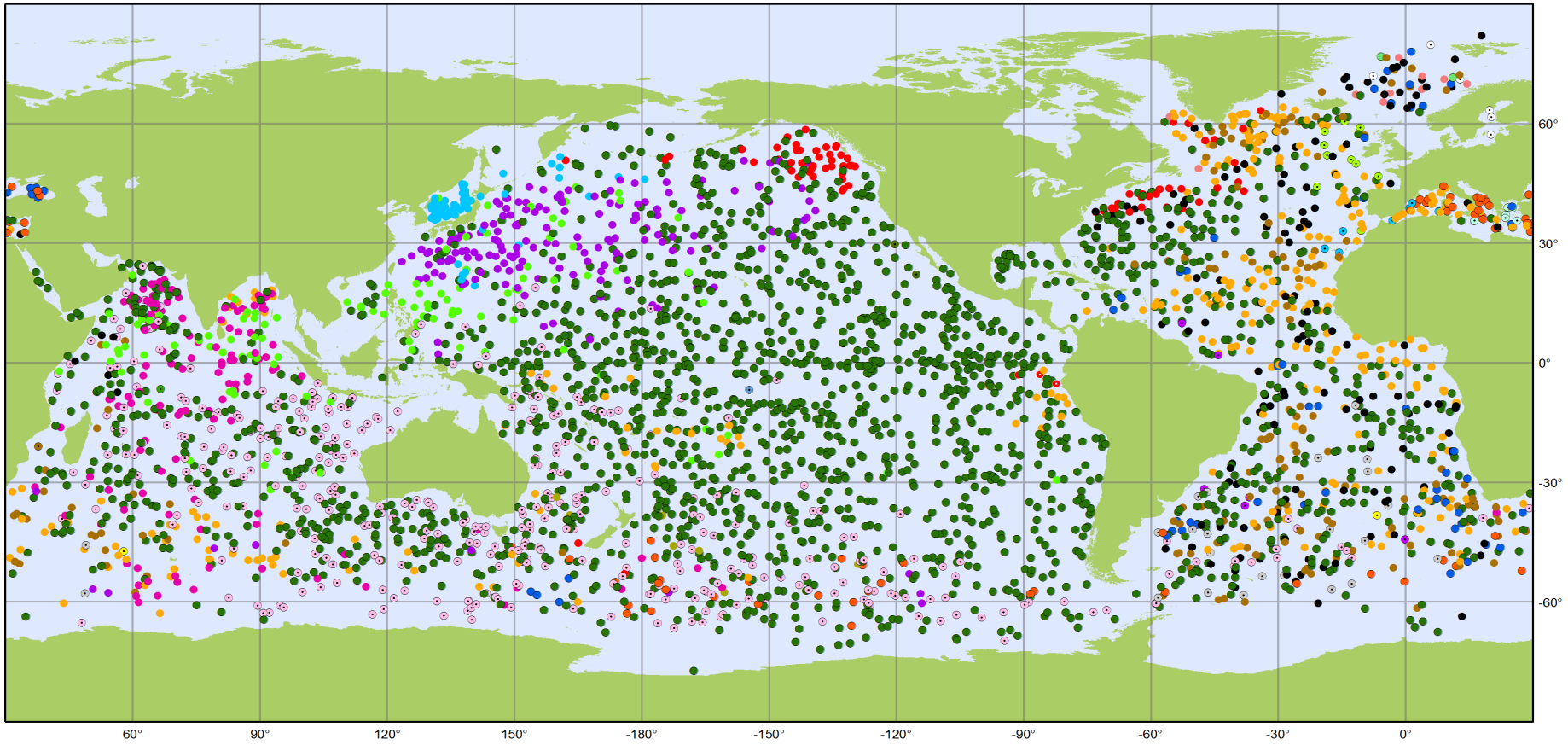
i) capable of autonomous function for periods of months between servicing intervals;
ii) provide validated analytical data over this period,
iii) are relatively inexpensive to buy and maintain

NCSR National Centre for Sensor Research

Insight

DCU

Argo project – National Contributions



Argo

National contributions - 3904 Operational Floats

Latest location of operational floats (data distributed within the last 30 days)

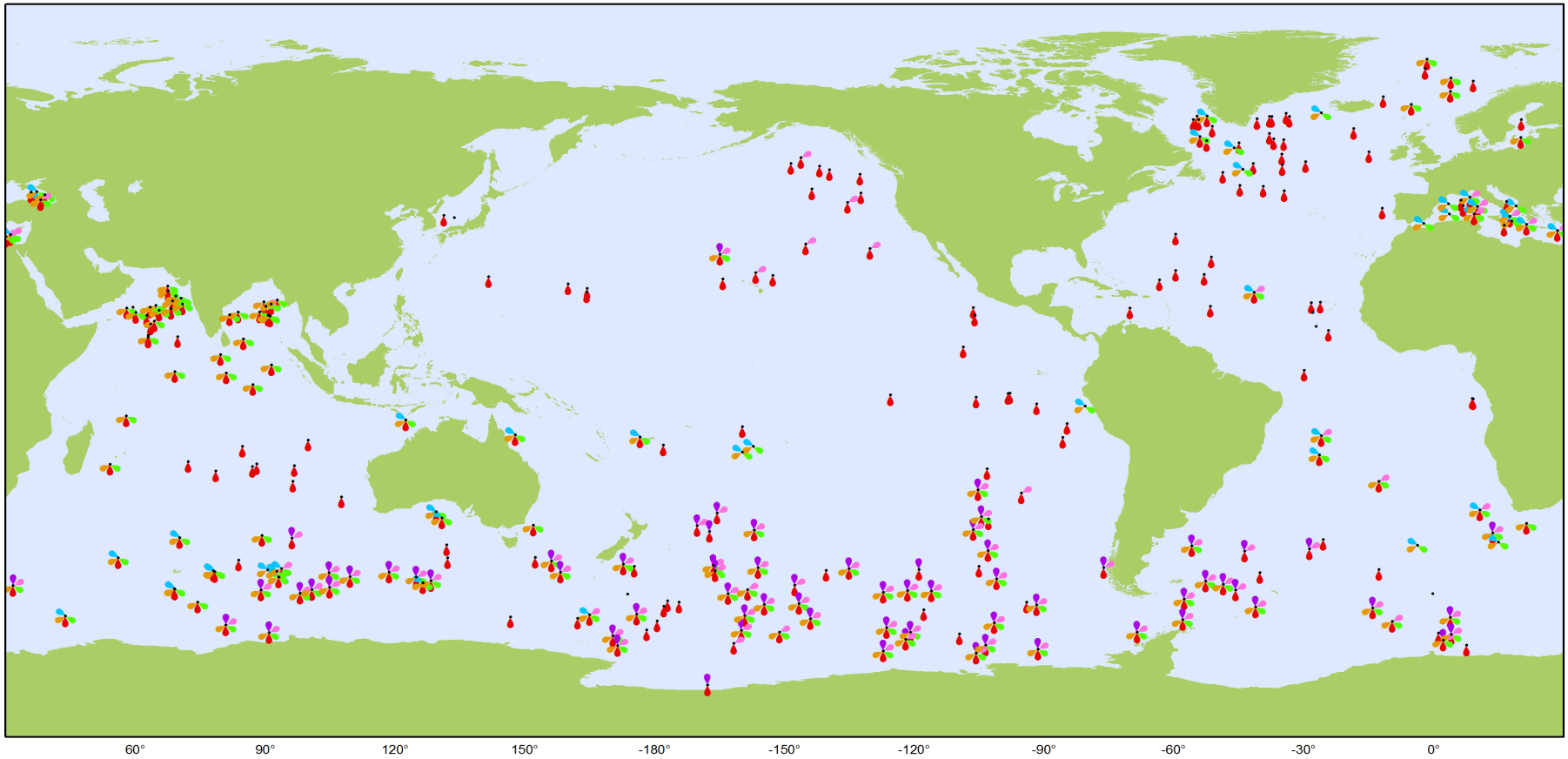
May 2017

ARGENTINA (2)	ECUADOR (1)	GREECE (8)	KENYA (1)	NORWAY (10)	UK (156)
AUSTRALIA (370)	EUROPE (59)	INDIA (130)	MAURITIUS (1)	PERU (3)	USA (2142)
BRAZIL (6)	FINLAND (6)	IRELAND (10)	MEXICO (2)	POLAND (2)	
CANADA (74)	FRANCE (319)	ITALY (70)	NETHERLANDS (26)	KOREA, REPUBLIC OF (62)	
CHINA (116)	GERMANY (143)	JAPAN (171)	NEW ZEALAND (7)	SPAIN (7)	

Accessed 19 June 2017 ; http://www.jcommops.org/board?t=Argo

Generated by www.jcommops.org, 02/06/2017

Argo project – Biogeochemical Sensors



Biogeochemical Argo

Sensor Types

Latest location of operational floats (data distributed within the last 30 days)

May 2017

· Operational Floats (284)

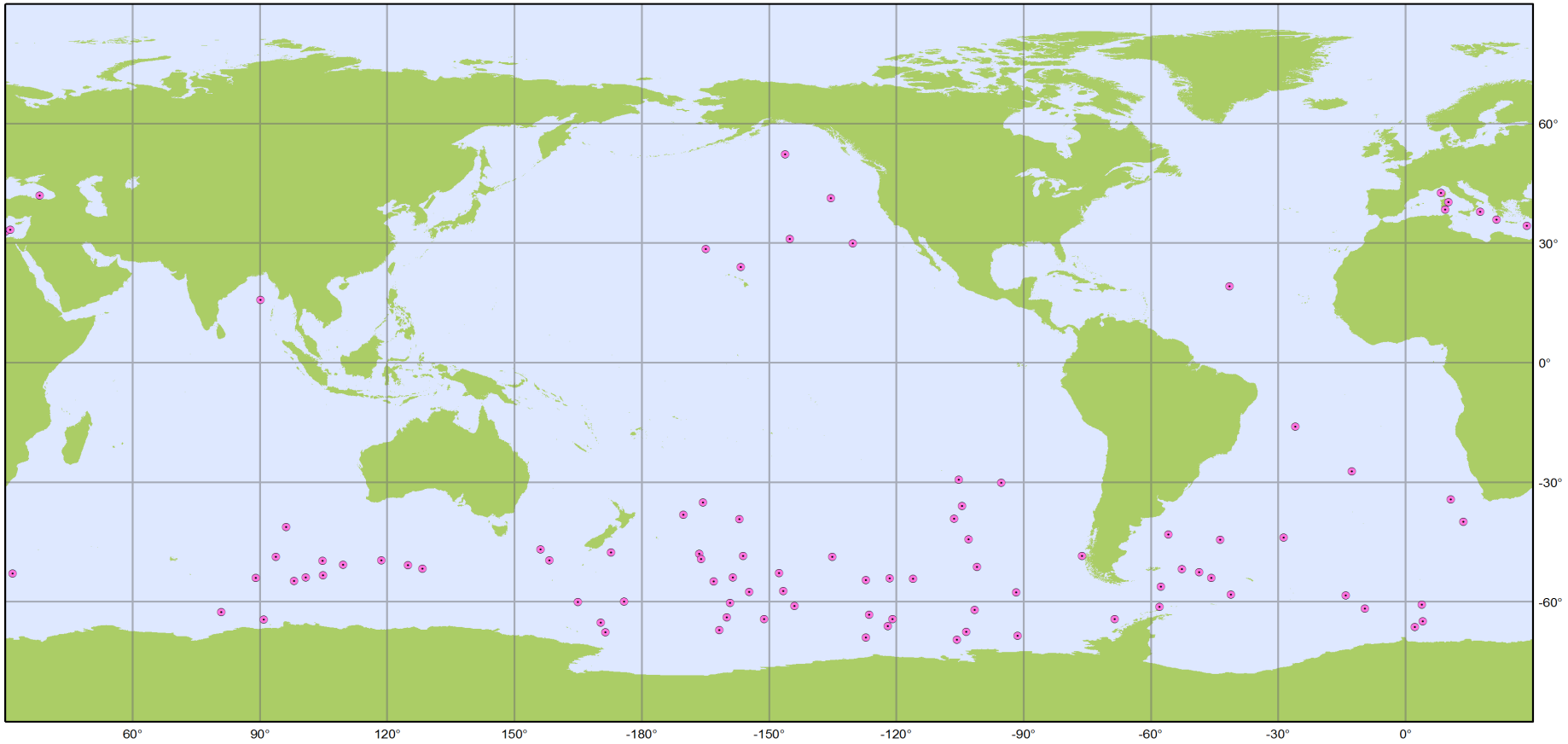
Suspended particles (149)
Downwelling irradiance (47)
pH (70)

Nitrate (93)
Chlorophyll a (150)
Oxygen (264)

Accessed 19 June 2017; http://www.jcommops.org/board?t=Argo

Generated by www.jcommops.org, 02/06/2017

Argo project – Nitrate Sensing



Argo **BioGeoChemical Argo - Nitrate** **May 2017**

Latest location of operational floats (data distributed within the last 30 days)

Cost €60,000 per Sensor

SPECTROPHOTOMETER_NITRATE/BISULFIDE (93)

Accessed 19 June 2017 ; http://www.jcommops.org/board?t=Argo

Generated by www.jcommops.org, 02/06/2017

COMMON SENSE
marine sensors - marine monitoring

Title: Cost-effective sensors, interoperable with international existing ocean observing systems, to meet EU policies requirements

Total Budget: €6,074,497

Duration: 40 months

Consortium: 15 partners from seven different countries

(the COMMON SENSE consortium comprises six SMEs, five research development institutes, three universities and one foundation)

Common Sense - Aims

Develop innovative, cost-effective sensors that will increase the availability of standardised data on:

- **Eutrophication** DCU Responsible for Nutrient Detection
- **Concentrations of heavy metals;**
- **Micro-plastic fraction within marine litter;**
- **Underwater noise**
- **Parameters such as temperature and pressure.**

Sensors will assess environmental conditions affecting marine ecosystems:

- **Mitigating the anthropogenic impacts**
- **Climate change impacts**
- **Promoting basic research of marine science**

European Legislation

COMMONSENSE and the Marine Framework Directive

Under the **Marine Strategy Framework Directive (MSFD)**, EU Member States are expected to assess the overall status of their marine environments and to put in place the necessary measures to achieve Good Environmental Status (GES) by 2020. Member States must implement cost-effective monitoring programmes in order to achieve MSFD monitoring objectives, as well as other European maritime and environmental policies such as the Common Fisheries Policy (CFP).

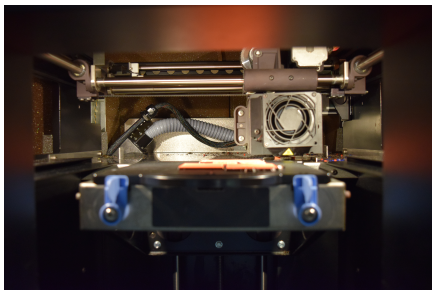
http://science.gu.se/digitalAssets/1322/1322948_nodularia-blomning_460px.jpg

Sensor Development

Develop Sensors for nutrients (nitrite, nitrate and phosphate) based on:

- Colorimetric chemical assays
- Rapid Fabrication and Prototyping
- Fluidic Control
- LED Based Microfluidic systems
- Wireless Communications

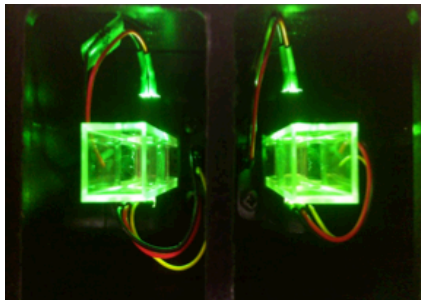
Colorimetric Detection of Phosphate



In-house 3D printing

Prior to Integration

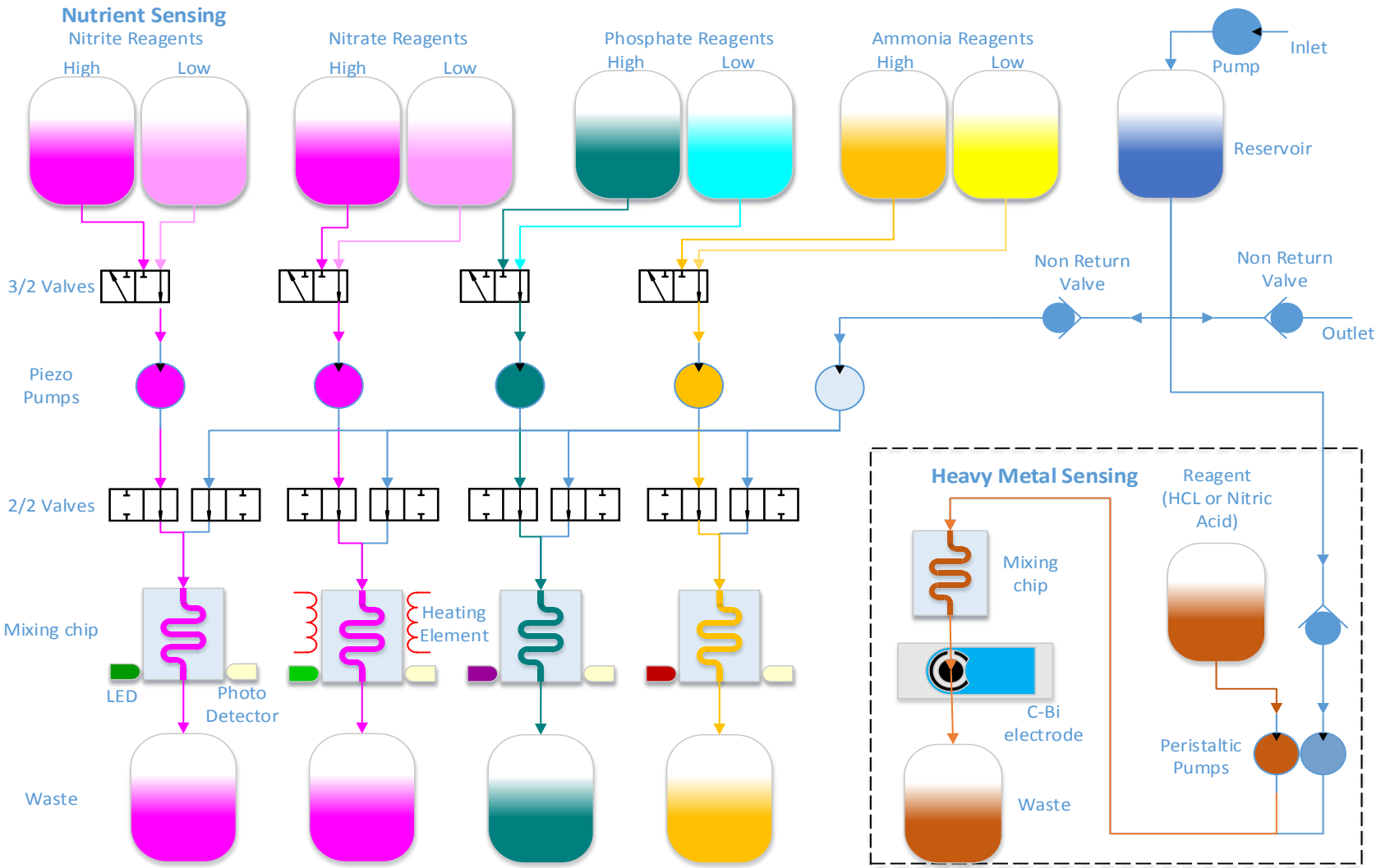
- Individual Component testing and Validation
- Validation of Colorimetric Assays



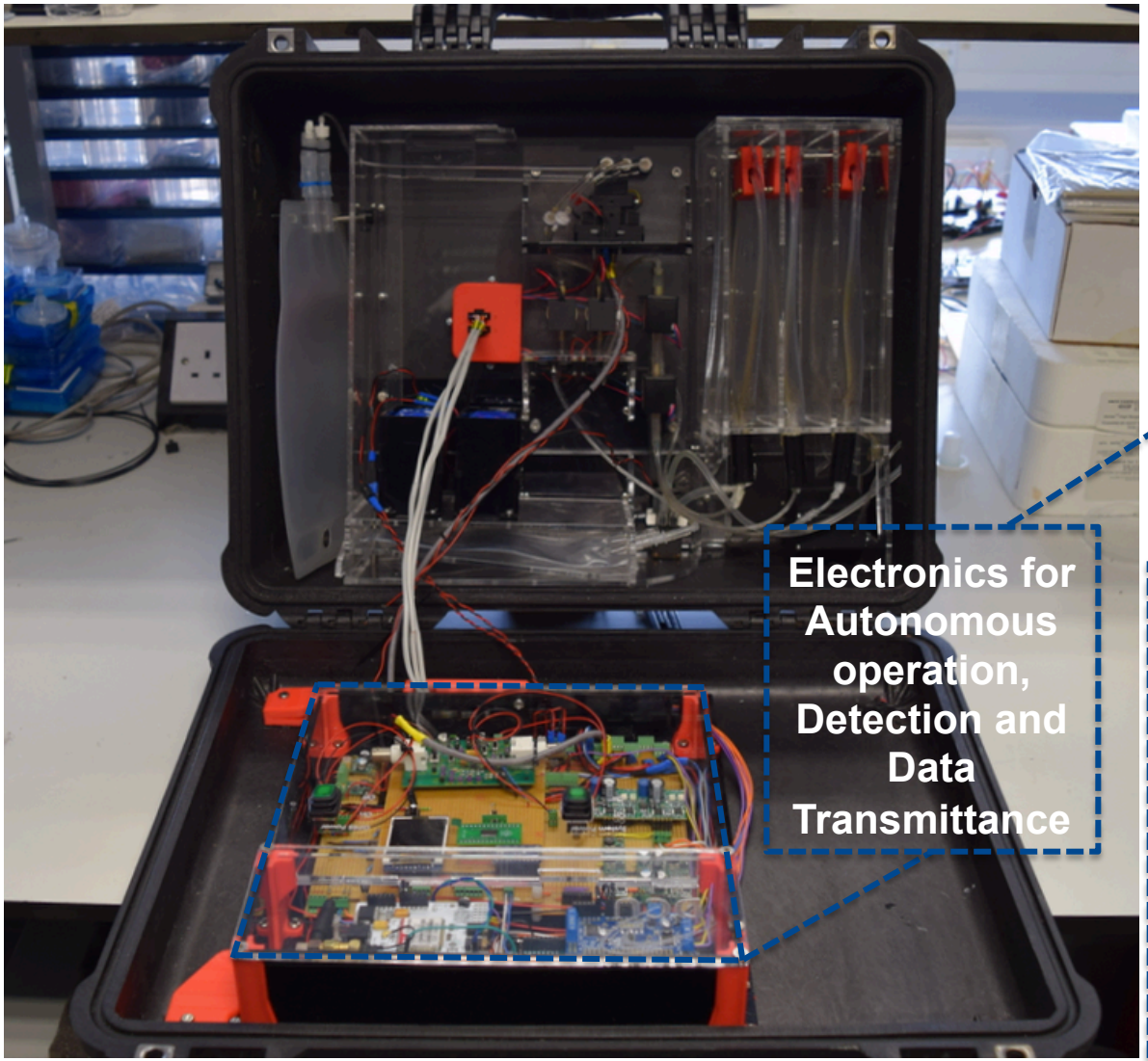
LED Based Detection

Nutrient System Schematic

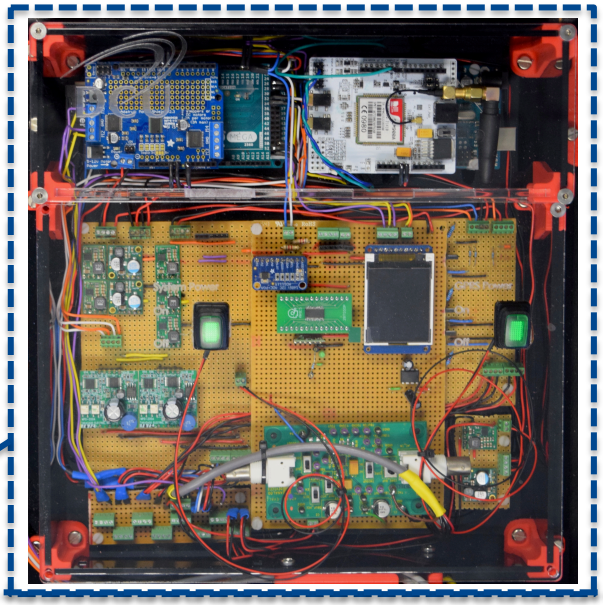
8 Pumps, 12 valves, 5 Microfluidic Chips

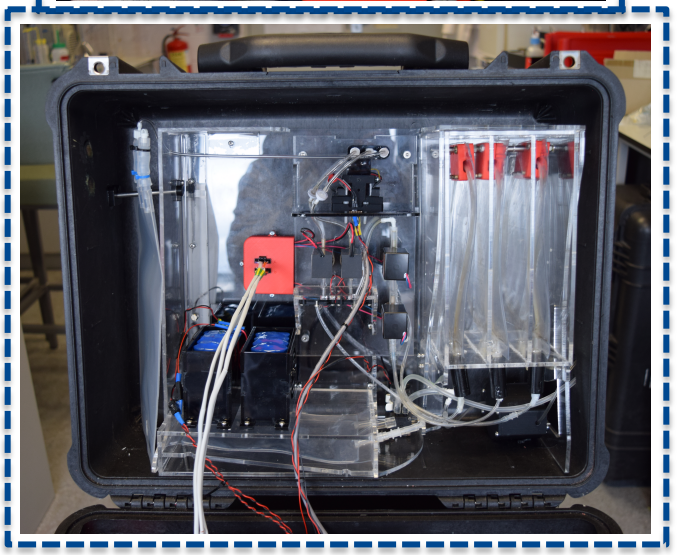


System Overview



Electronics for Autonomous operation, Detection and Data Transmittance





Colorimetric Chemical Assay's - Phosphate

Prioritised due to

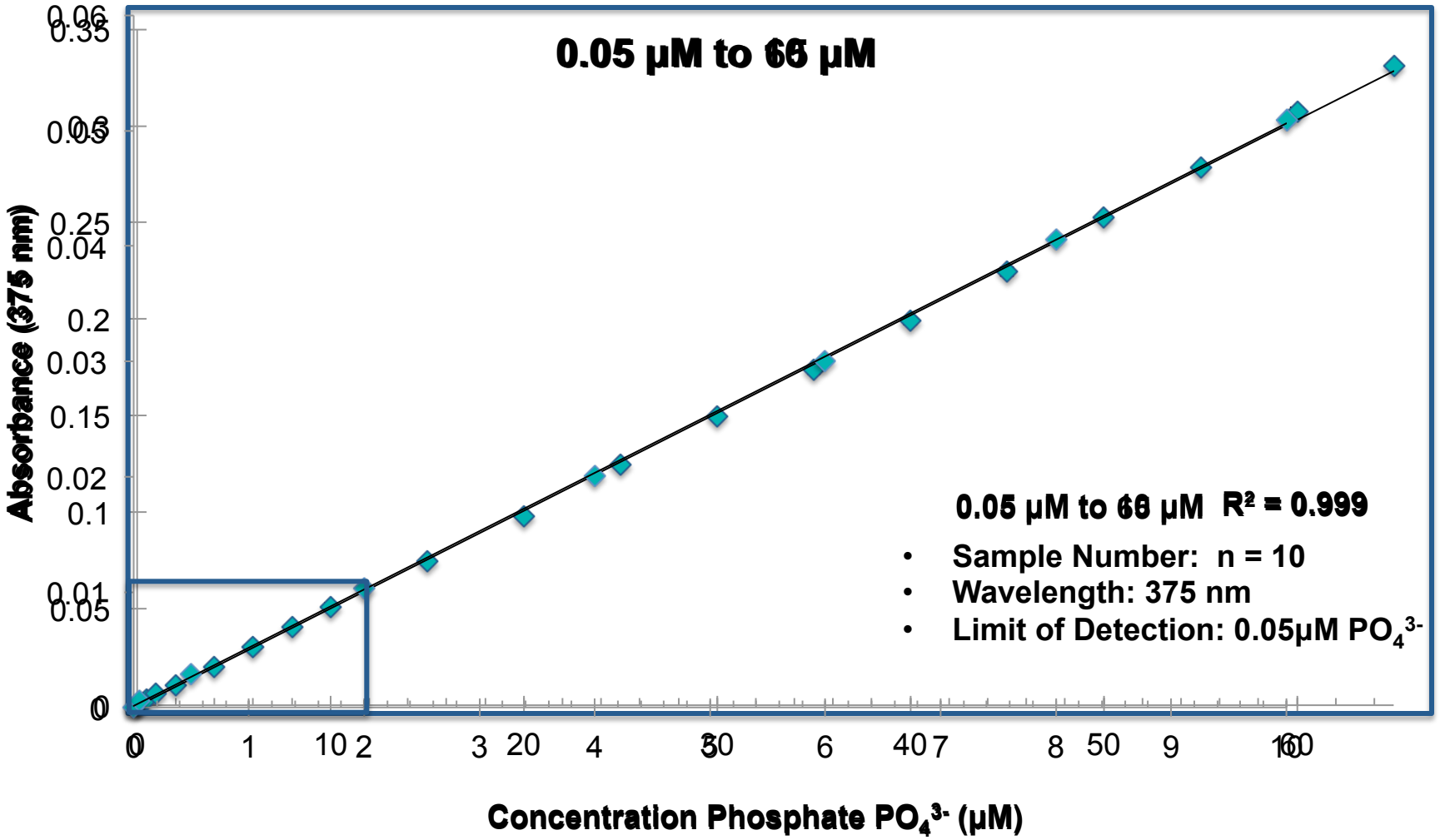
- Increasingly high demand for monitoring
- Typically the limiting nutrient in freshwater ecosystems
- Non-renewable resource – increasing attention on recovery from waste

Yellow method (vanadomolybdophosphoric acid)

- Simple colorimetric method – Single reagent 1:1 ratio
- Highly stable reagent (>1 year in solution)
- Fast reaction time
- Absorbance-based detection using UV-LED (375nm) and photodiode

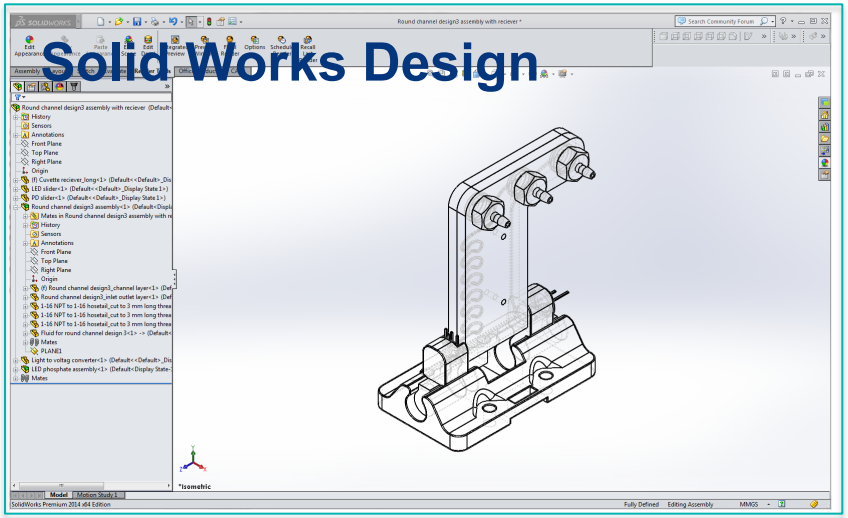
Colorimetric Chemical Assay's

Phosphate Analysis in Artificial Seawater

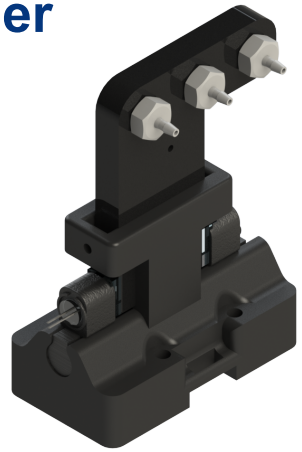


Rapid Prototyping

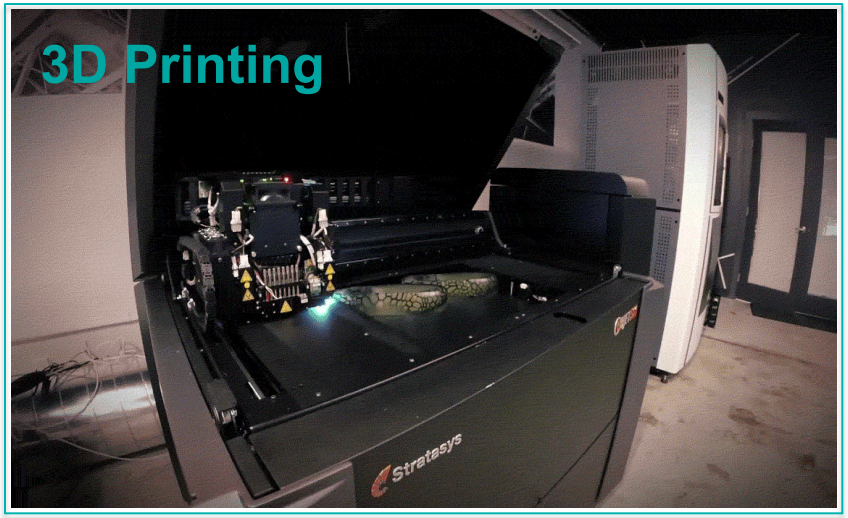
Solid Works Design



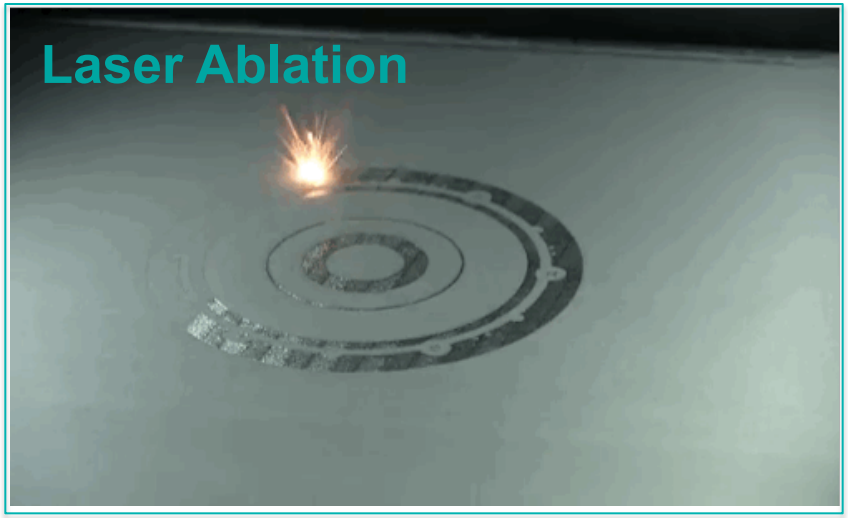
3D Render



3D Printing



Laser Ablation



Rapid Prototyped Components

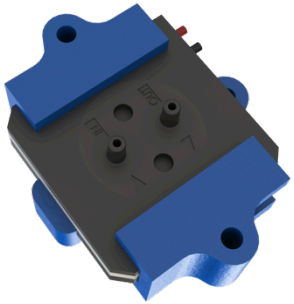
Use of 3D Printing, Laser Ablation and Micro milling techniques for rapid Prototyping

- Parts quickly and easily manufactured in house
- Reduces manufacturing time
- Reduces cost

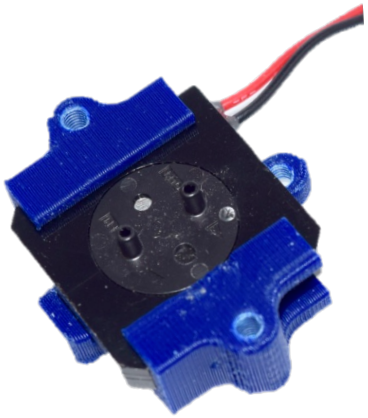
3D Render

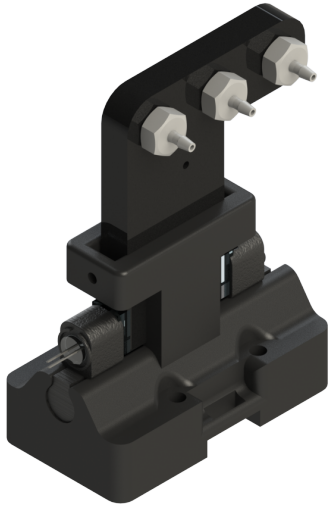
Manufactured part

Cuvette Holder with Led Alignment

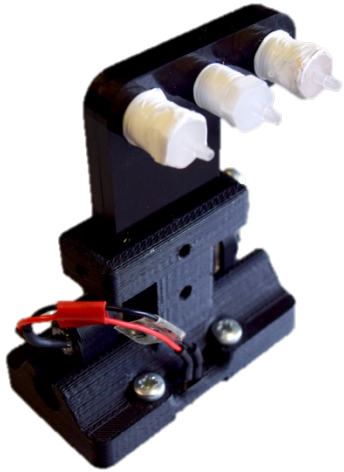


Piezo Pump Mountings

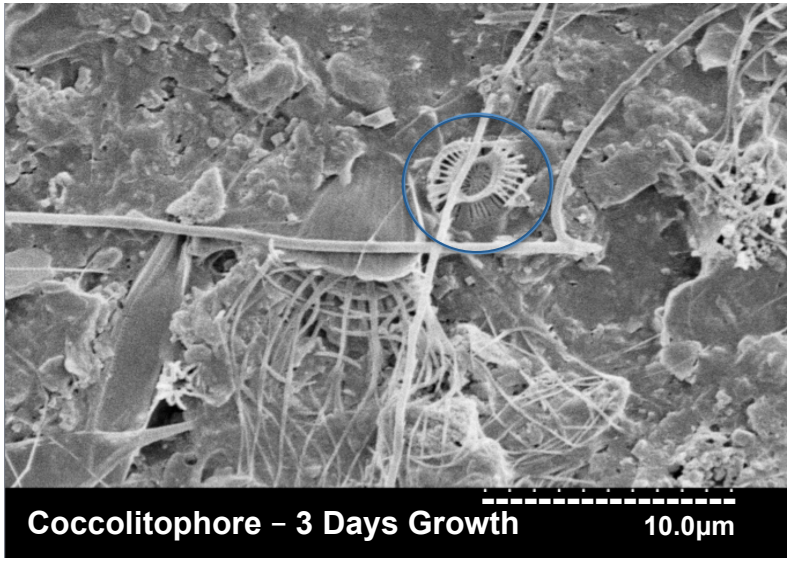


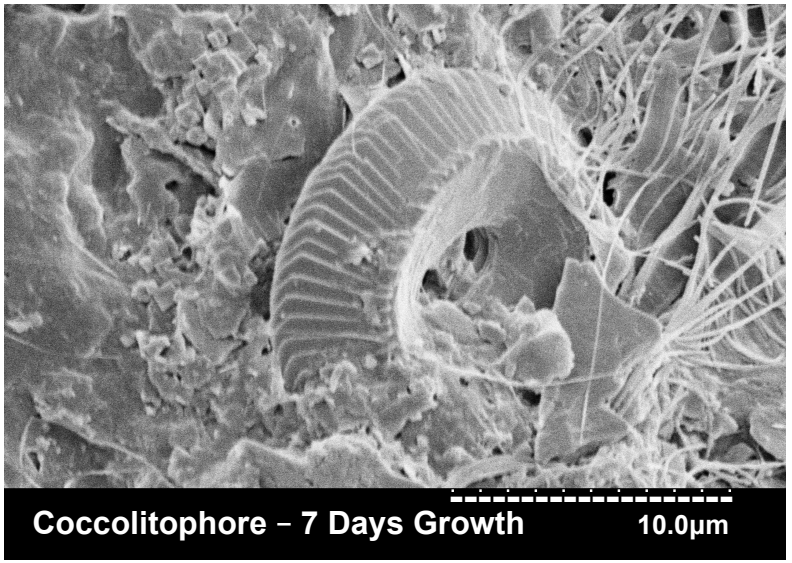


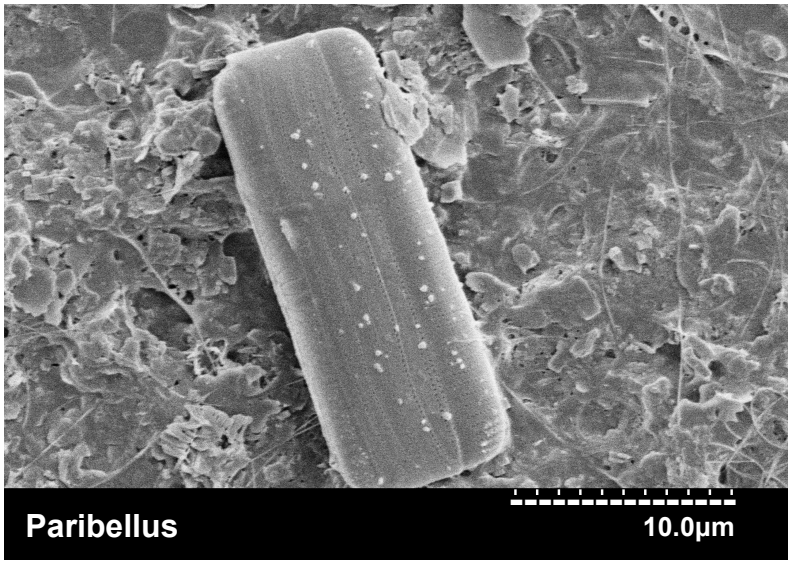
Microfluidic Optical Chip

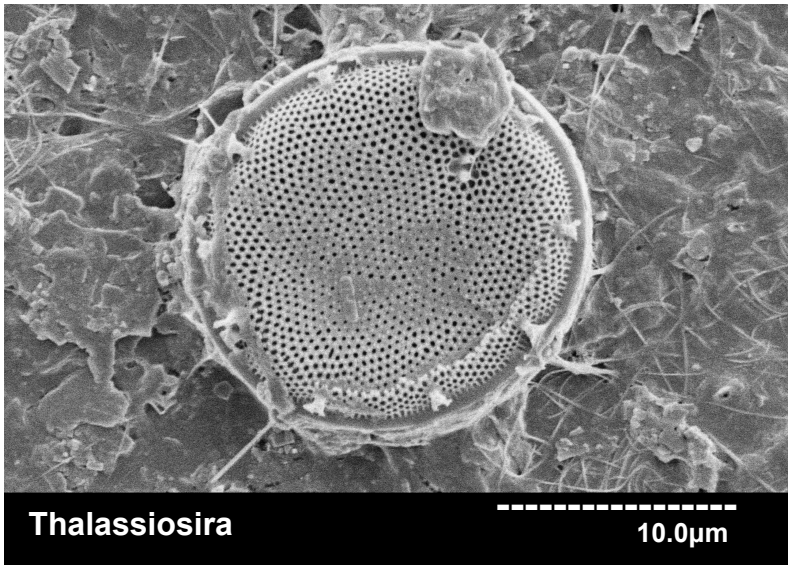


Membrane Characterisation - Diatoms







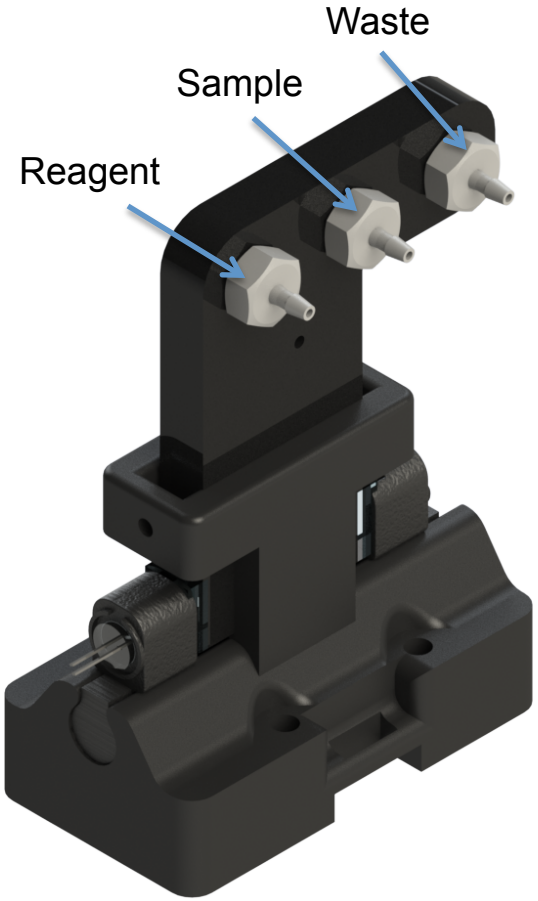


Microfluidic Detection

Overview:

- Complete integration of Fluidic Handling within a microfluidic chip.
- Manufactured using Micro milling and Laser cutting.
- Serpentine channel for Sample and Reagent Mixing.
- Minimal Fluid Volume per assay.
- Optical Detection on chip.

Detection on Chip Validated against Spectrophotometer when integrated into bench top system and Autonomous System



CS Nutrient Sensor

Generation 1

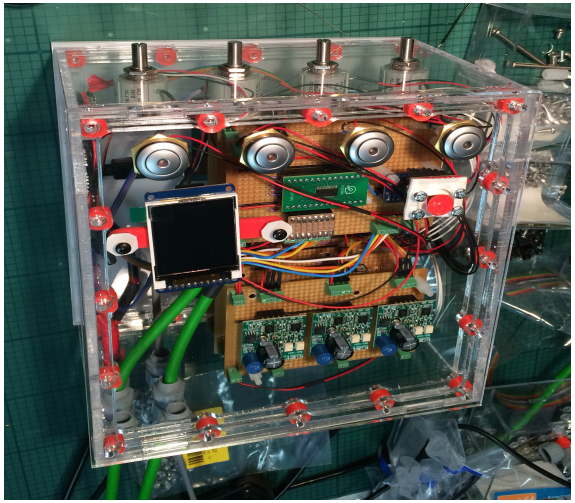
- Benchtop prototype
- Integrated electronics
- Optical detection
- Deployed November 2016

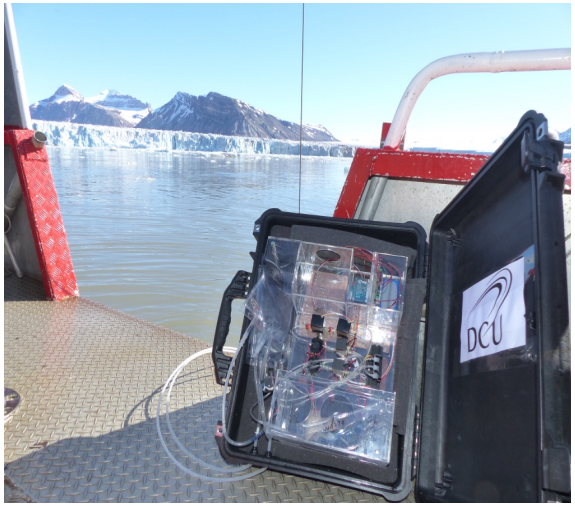
Generation 2

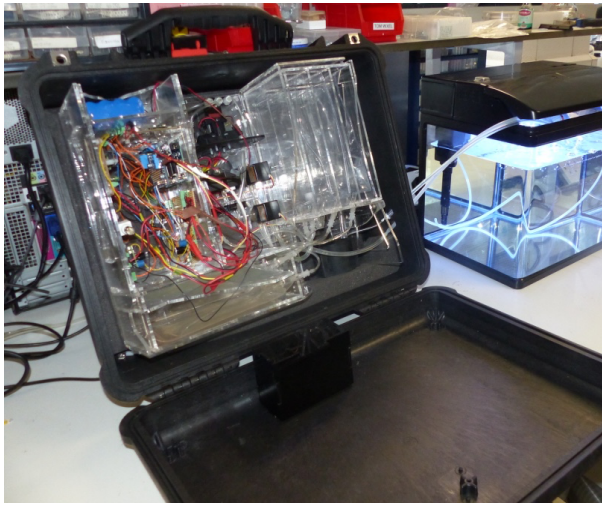
- Integrated fluidics
- Sample inlet
- On chip detection
- Sampling Rate every 2 hours
- Battery powered
- Deployed Ny-Alseund June 2016
- 6ml reagent per assay

Generation 3

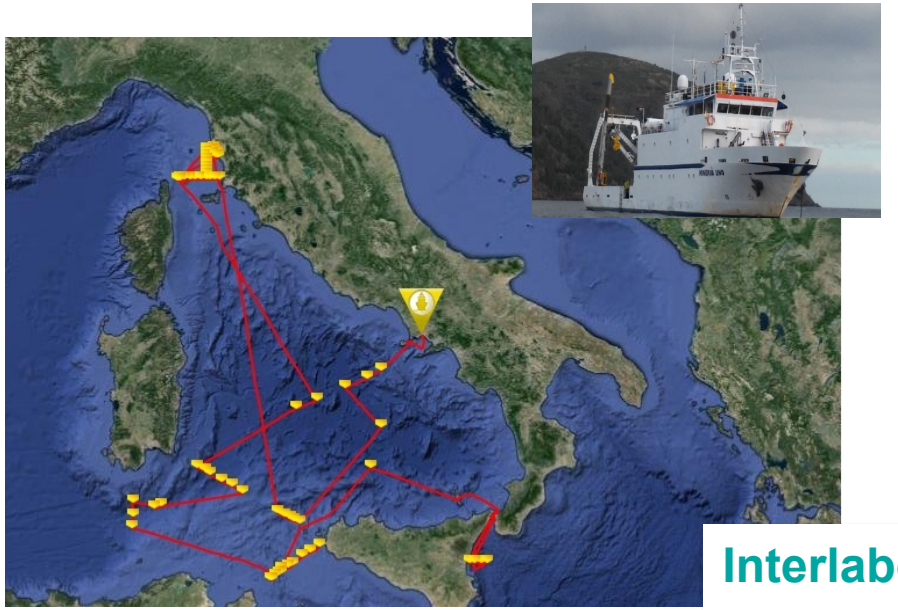
- Integrated fluidics
- Sample inlet
- On chip detection
- Sampling Rate every 1 hour
- Battery powered
- Wireless communication
- Deployed Milan WWTP
- 1.3ml reagent per assay



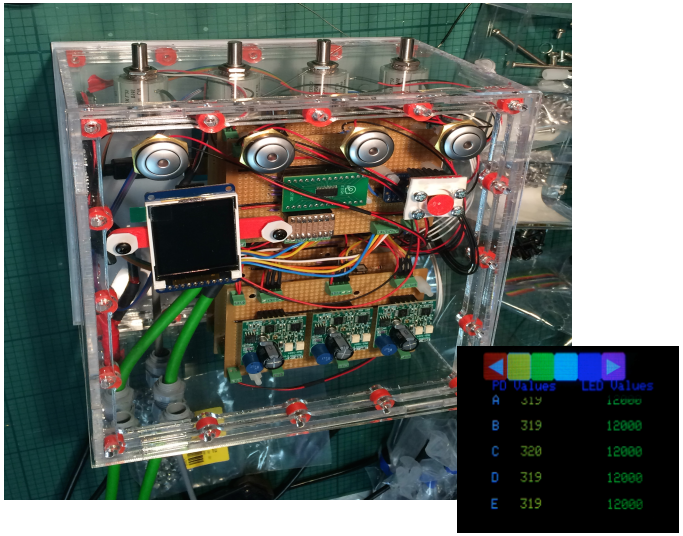




Prototype Testing - Generation 1



- Deployment onboard Ichnussa 2015 Research Cruise 24th – Dec 17th
- Water samples were collected for nutrient and heavy metal analysis, over 95 samples analysed onboard for Nitrite and Nitrate. Samples not analysed were stored at -22°C for subsequent analysis.



Interlaboratory validation

National Research Council of Italy

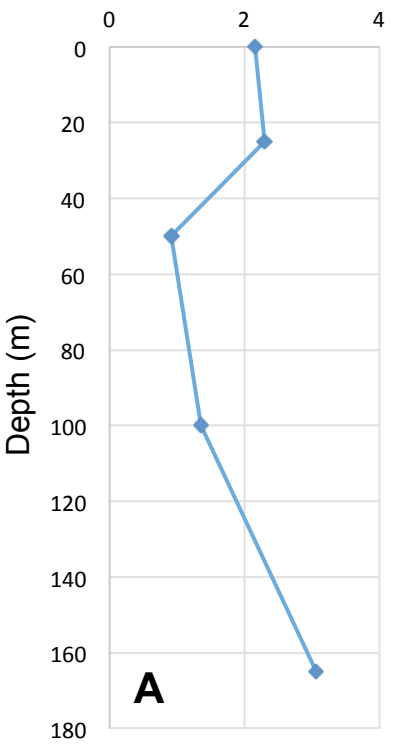
CNR-Italy All stations (48)
DCU All stations (48)
TelLab 10 stations

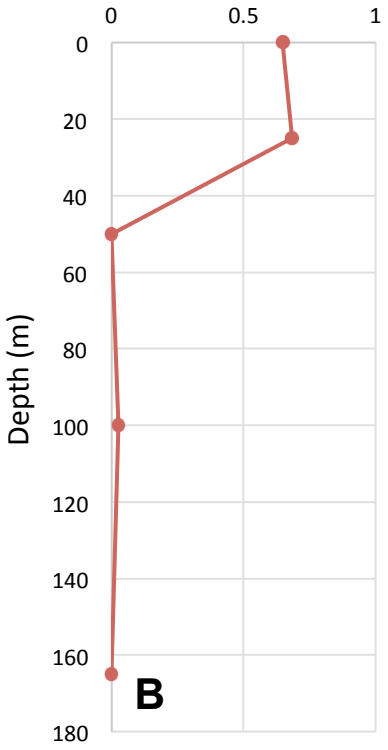
TelLab

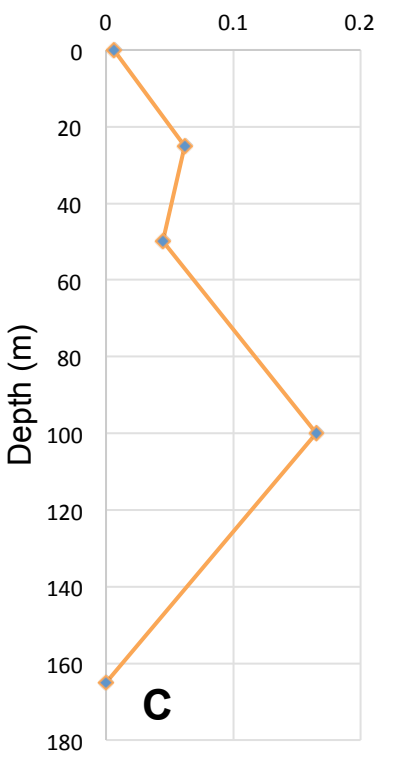
DCU

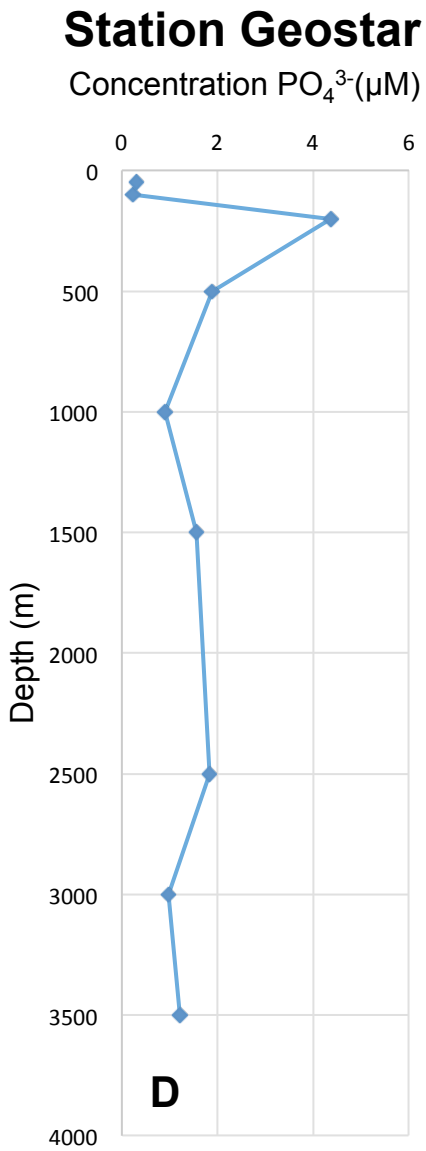
- Approximately 400 samples analysis CNR, DCU, 50 TelLabs
- Parameters: Phosphate, Nitrite , Nitrate
- DCU – CS bench-top system and UV-Vis
- Approximately 1200 measurements

Results - Ichnussa 2015







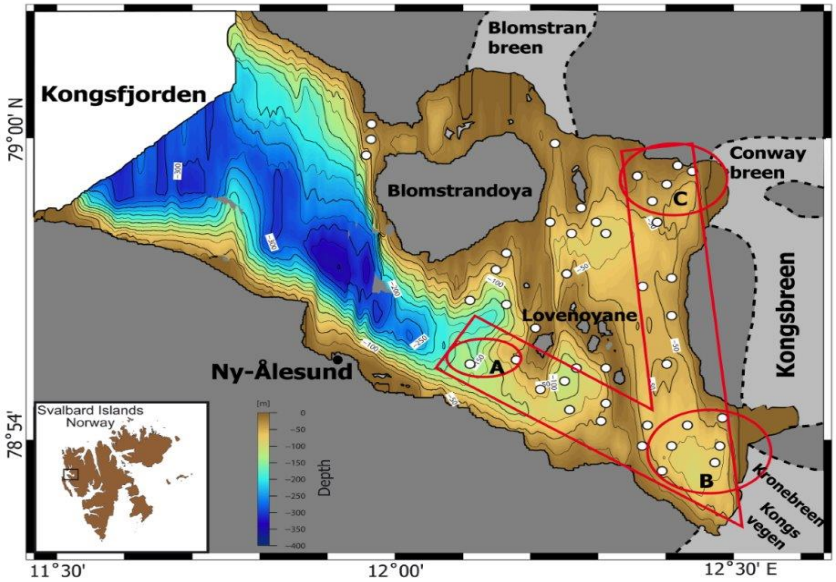


A) Phosphate **B)** Nitrate and **C)** Nitrite concentrations at along a depth profile from 0 to 166m at station 432.

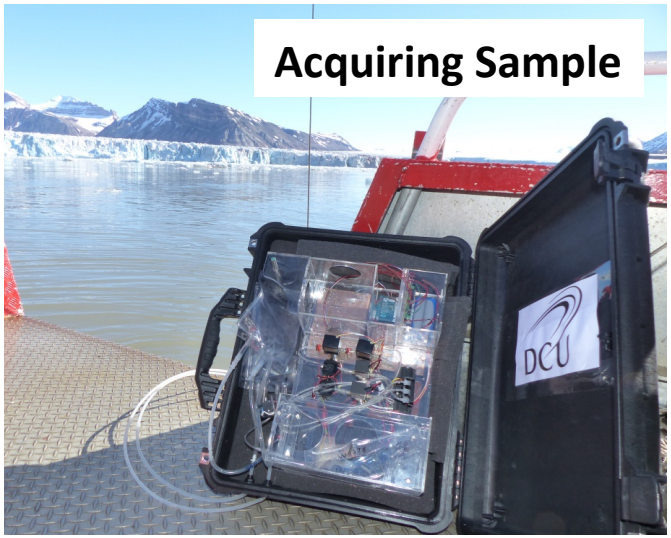
D) Phosphate concentrations at along a depth profile from 0 to 3500m at station Geostar

Prototype Testing – Generation 2

Deployed Ny-Alseund June 2016



Lab Validation



National Research Council of Italy

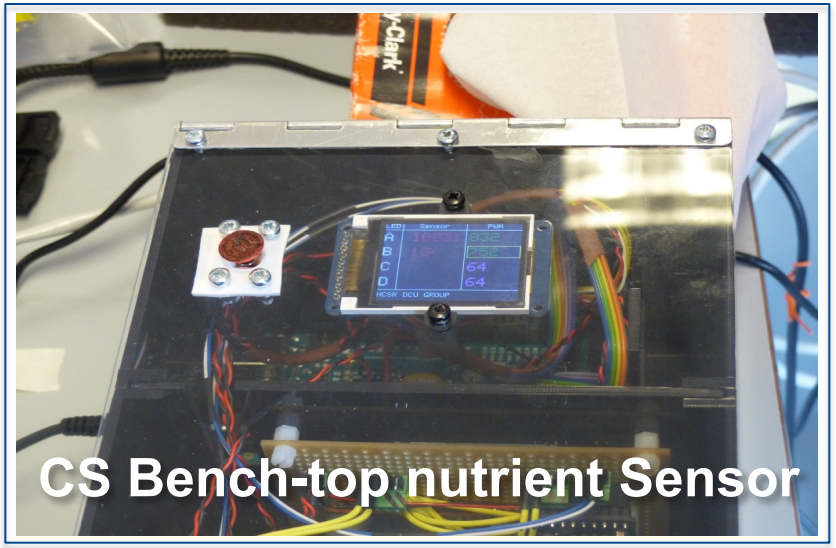
DCU

Prototype Testing – Generation 2

Deployed Ny-Alseund June 2016

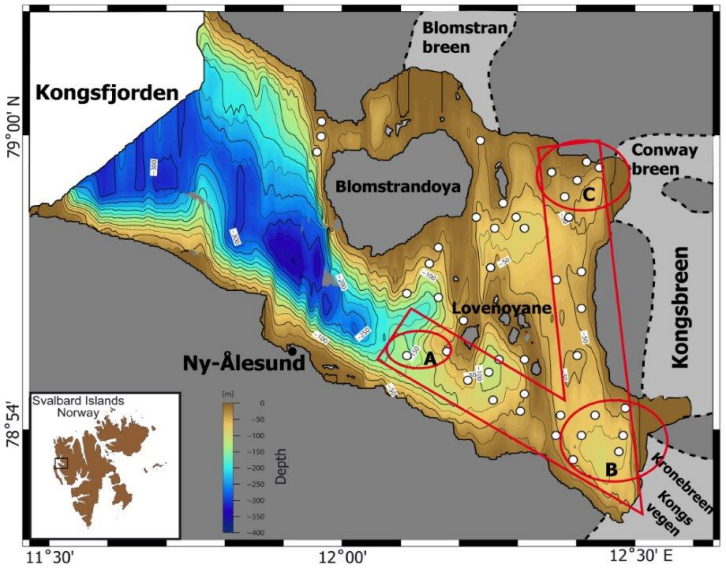
Laboratory Testing in Ny-Alesund

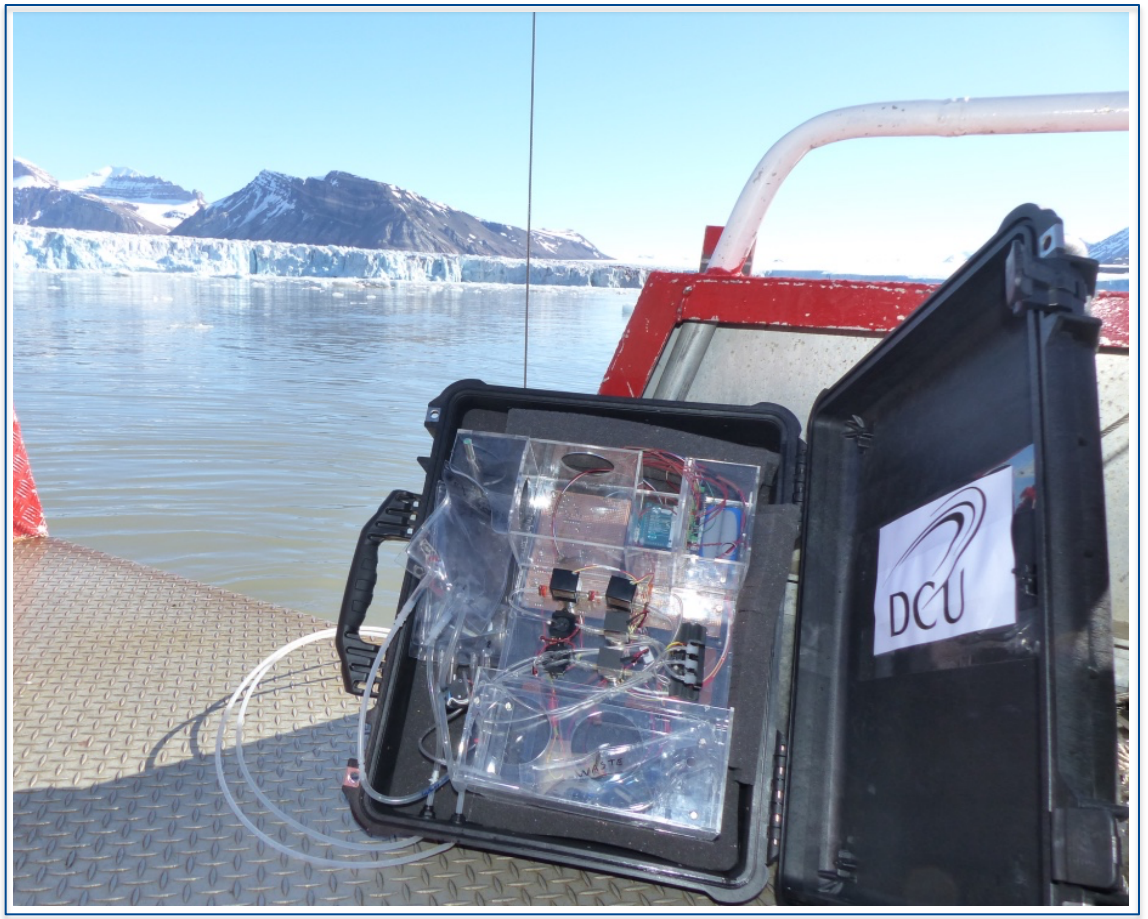
- System Validation prior to deployment
- Sample was taken from 10 liters of artificial seawater spiked with a known concentration of each nutrient
- Subsamples were taken and measured using the CS bench top system



Prototype Testing – Generation 2

Deployed Ny-Alseund June 2016





In-situ Measurements

- Kongsfjorden Fjord, Savlbard
- Sample Plan stations from A-B-C
- CNR Italy measuring CTD at each station

CS Deployable system acquiring samples on board the MS Teisten beneath the of Kongsvegen glacier

Prototype Testing – Generation 3

Milano San Rocco WWTP

Available Sampling Points:

1. Output water after Sand Filtration
2. Output water after the Clarifier
3. Activated Sludge (Biological Tank)
4. Input Water

Sampling Location- Sampling Point 2

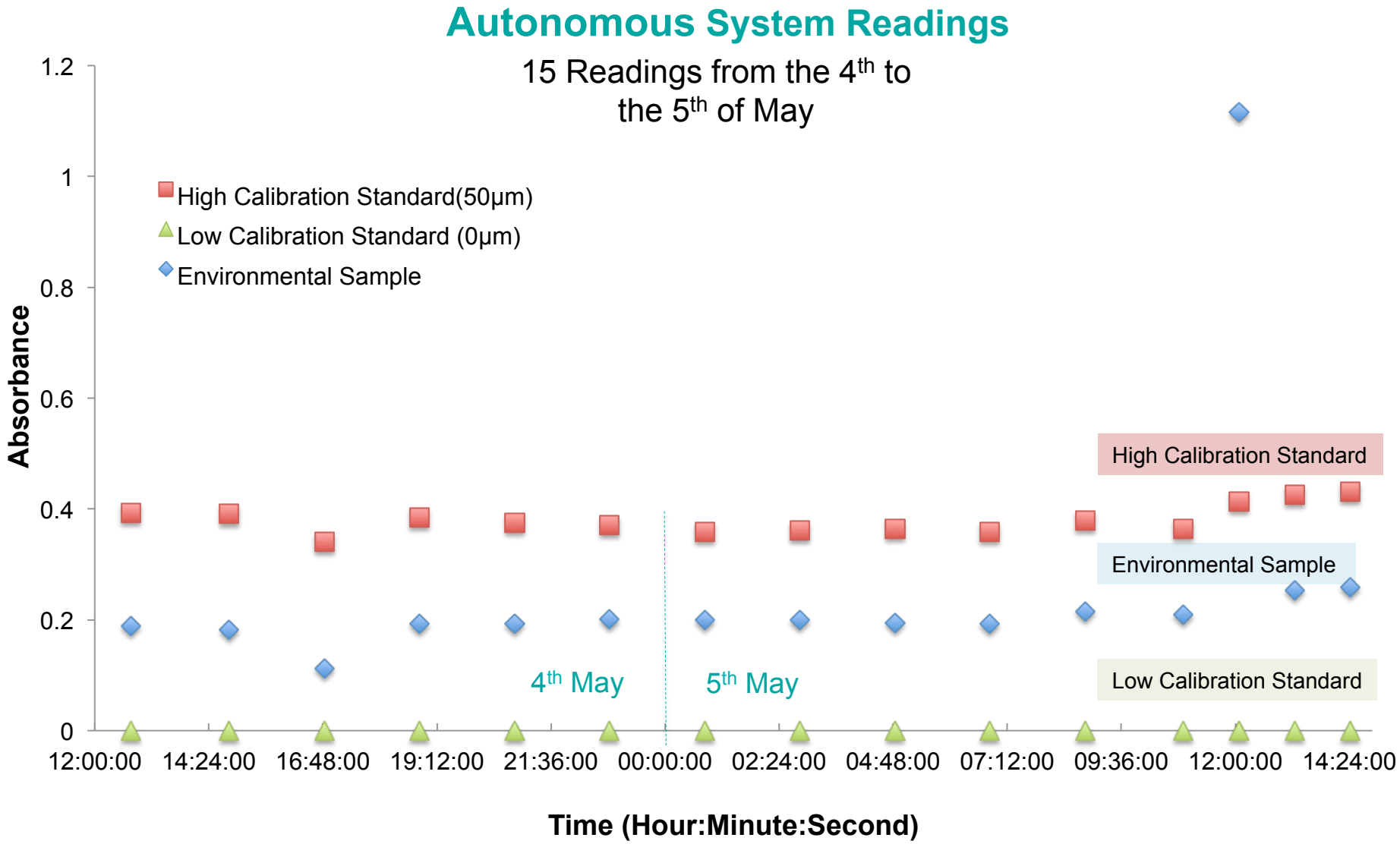
Available Sampling Points:

1. Output water after Sand Filtration
2. Output water after the Clarifier
3. Activated Sludge (Biological Tank)
4. Input Water

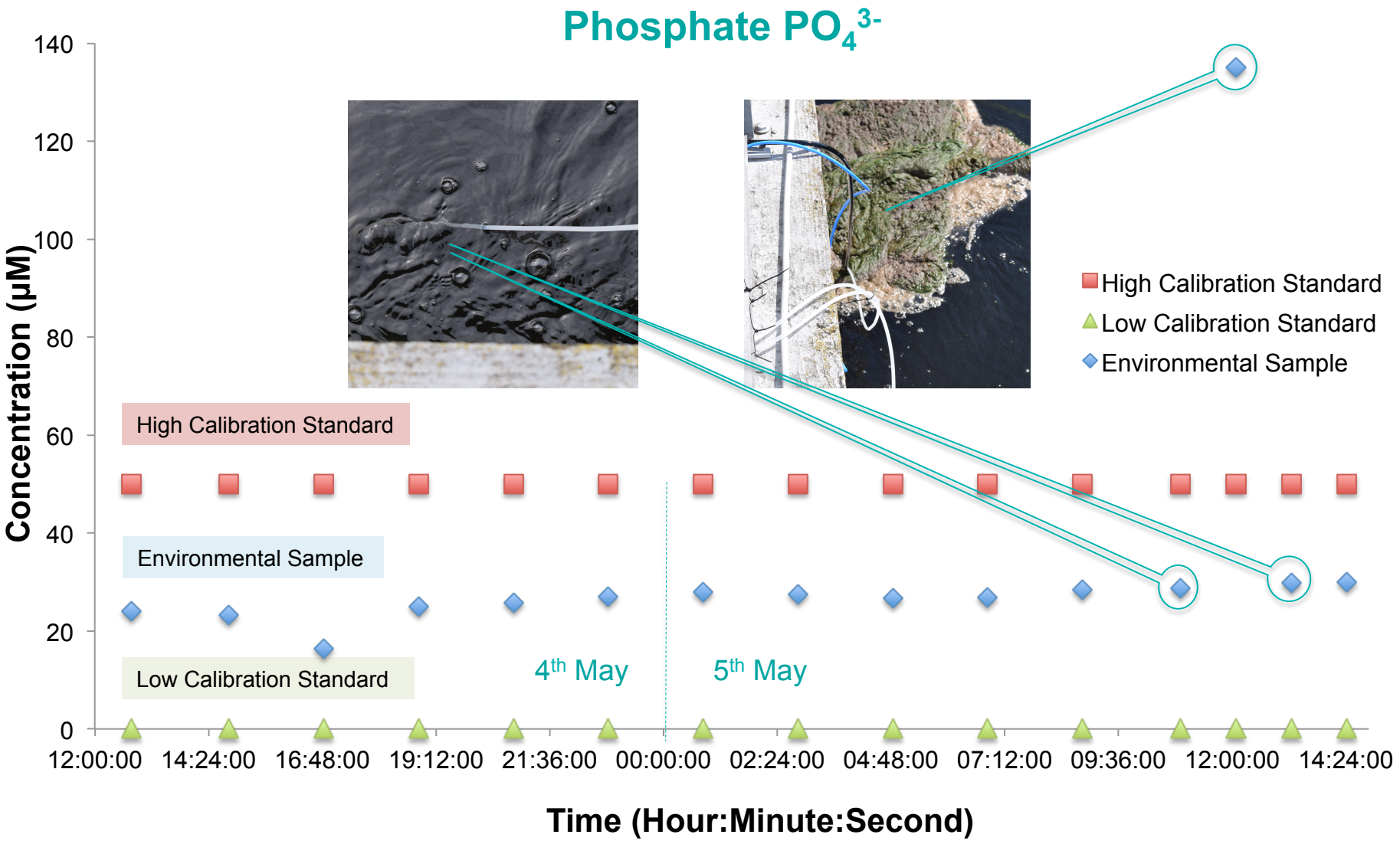
Output water after the Clarifier:
Typical Parameters

- Low detectable Nitrites
- 5mg/L Nitrates
- 1.5mg/L Phosphates
- 10mg/L Suspended Solids

Results Obtained from Output after the Clarifier

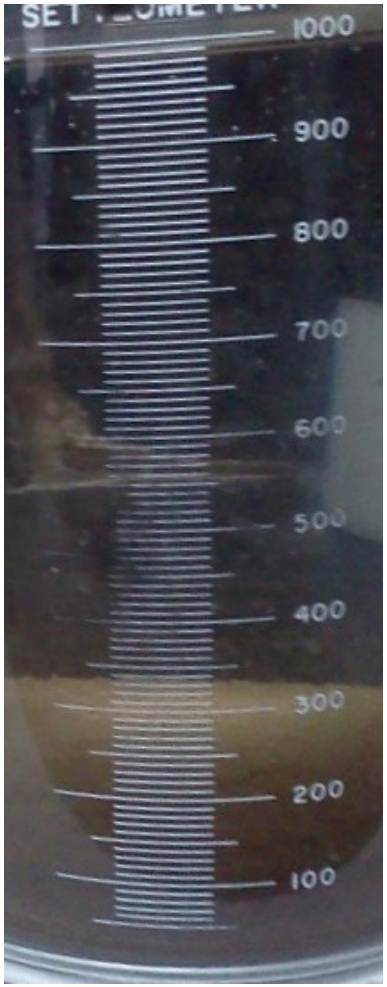


Results Obtained from Output after the Clarifier



Inlet System- Durapore 0.45µM

- Approximately 5.25L sampled during deployment.
- Sample was taken for 2 ½ minutes every 2 hours.



Acknowledgements

Science Foundation Ireland sfi For what's next

Insight Centre for Data Analytics

ENTERPRISE IRELAND where innovation means business

COMMON SENSE marine sensors - marine monitoring

NAPES NEXT GENERATION ANALYTICAL PLATFORMS FOR ENVIRONMENTAL SENSING

National Research Council of Italy

Thanks to:
Prof. Dermot Diamond, Dr. Margaret McCaul, Adaptive Sensors Group, All in N205 DCU

This Research is co-funded by the European Regional Development Fund (ERDF) under Irealnd's European Structural and Investment Funds Programmes 2014-2020