National Oceanography Centre

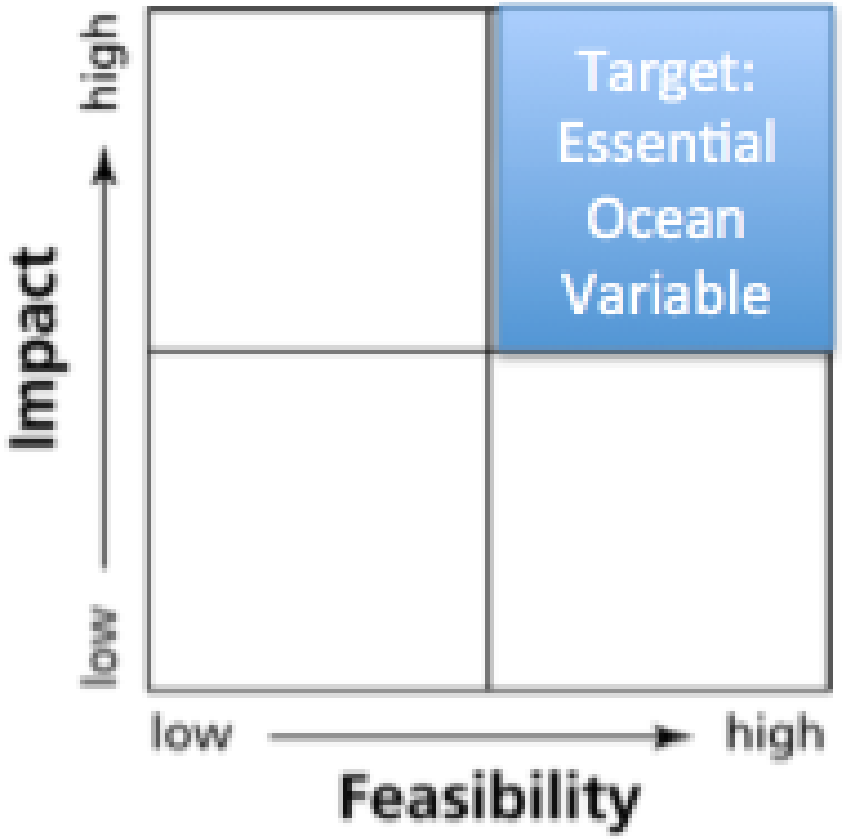
Ocean Technology and Engineering Group

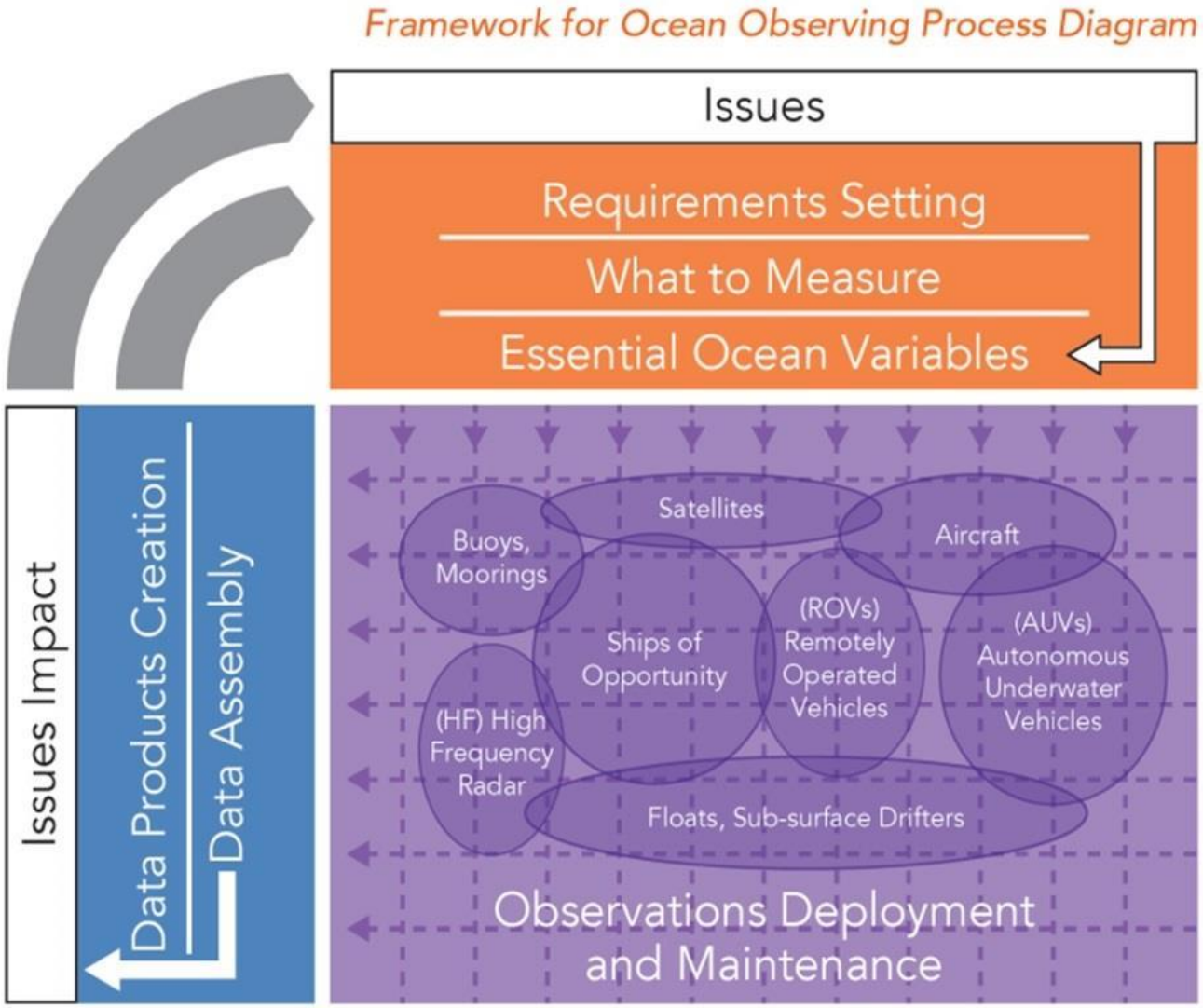
Sensors and instrumentation for biogeochemical, biological and ecosystem variables

Drivers

The Global Ocean Observing System

Essential Ocean Variables: A component of the Framework for Ocean Observing (FOO)

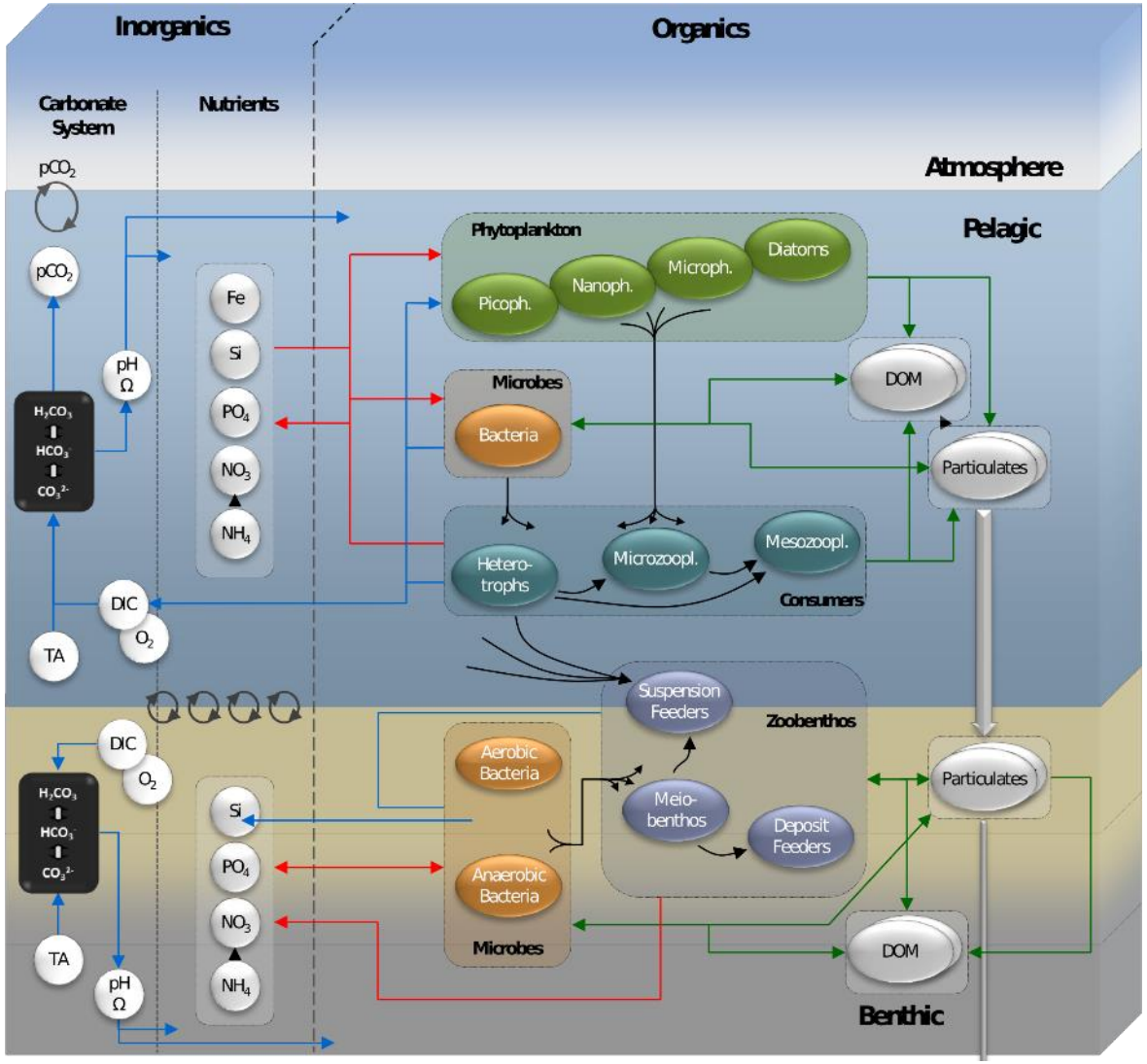




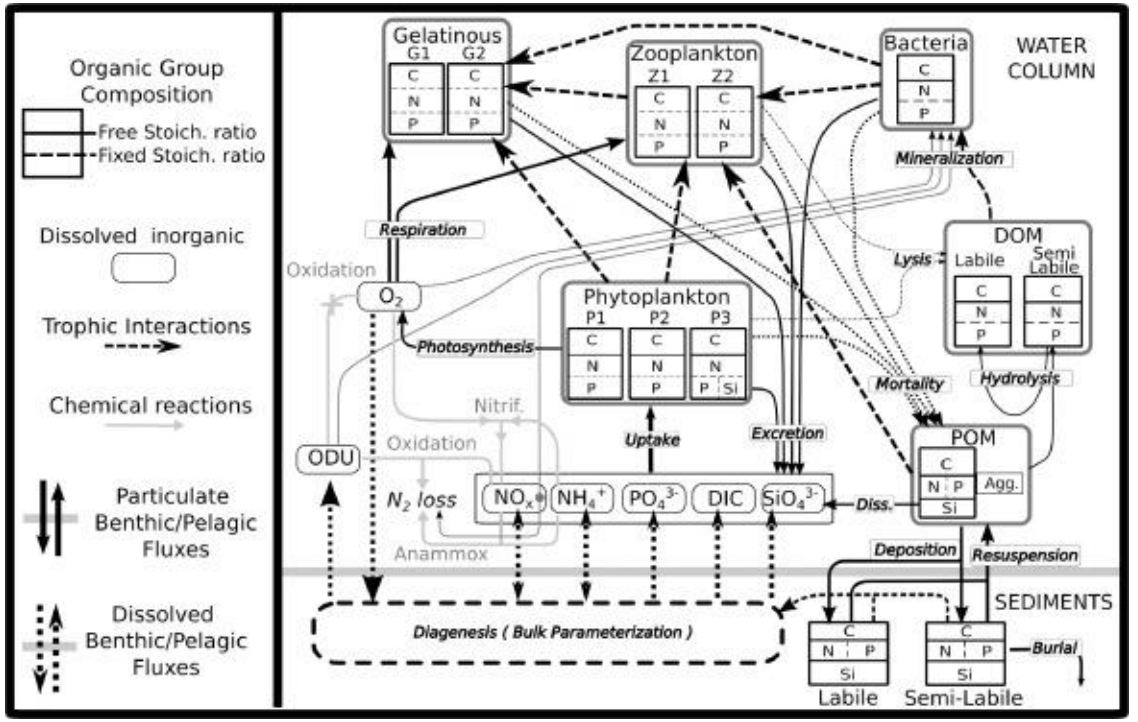
Essential Ocean Variables

PHYSICS	BIOGEOCHEMISTRY	BIOLOGY AND ECOSYSTEMS
Sea state	Oxygen	Phytoplankton biomass and diversity
Ocean surface stress	Nutrients	Zooplankton biomass and diversity
Sea ice	Inorganic carbon	Fish abundance and distribution
Sea surface height	Transient tracers	Marine turtles, birds, mammals abundance and distribution
Sea surface temperature	Particulate matter	Hard coral cover and composition
Subsurface temperature	Nitrous oxide	Seagrass cover and composition
Surface currents	Stable carbon isotopes	Macroalgal canopy cover and composition
Subsurface currents	Dissolved organic carbon	Mangrove cover and composition
Sea surface salinity		Microbe biomass and diversity (*emerging)
Subsurface salinity		Invertebrate abundance and distribution (*emerging)
Ocean surface heat flux		
CROSS-DISCIPLINARY		
Ocean colour	Ocean Sound	

Biogeochemical and Ecosystem models

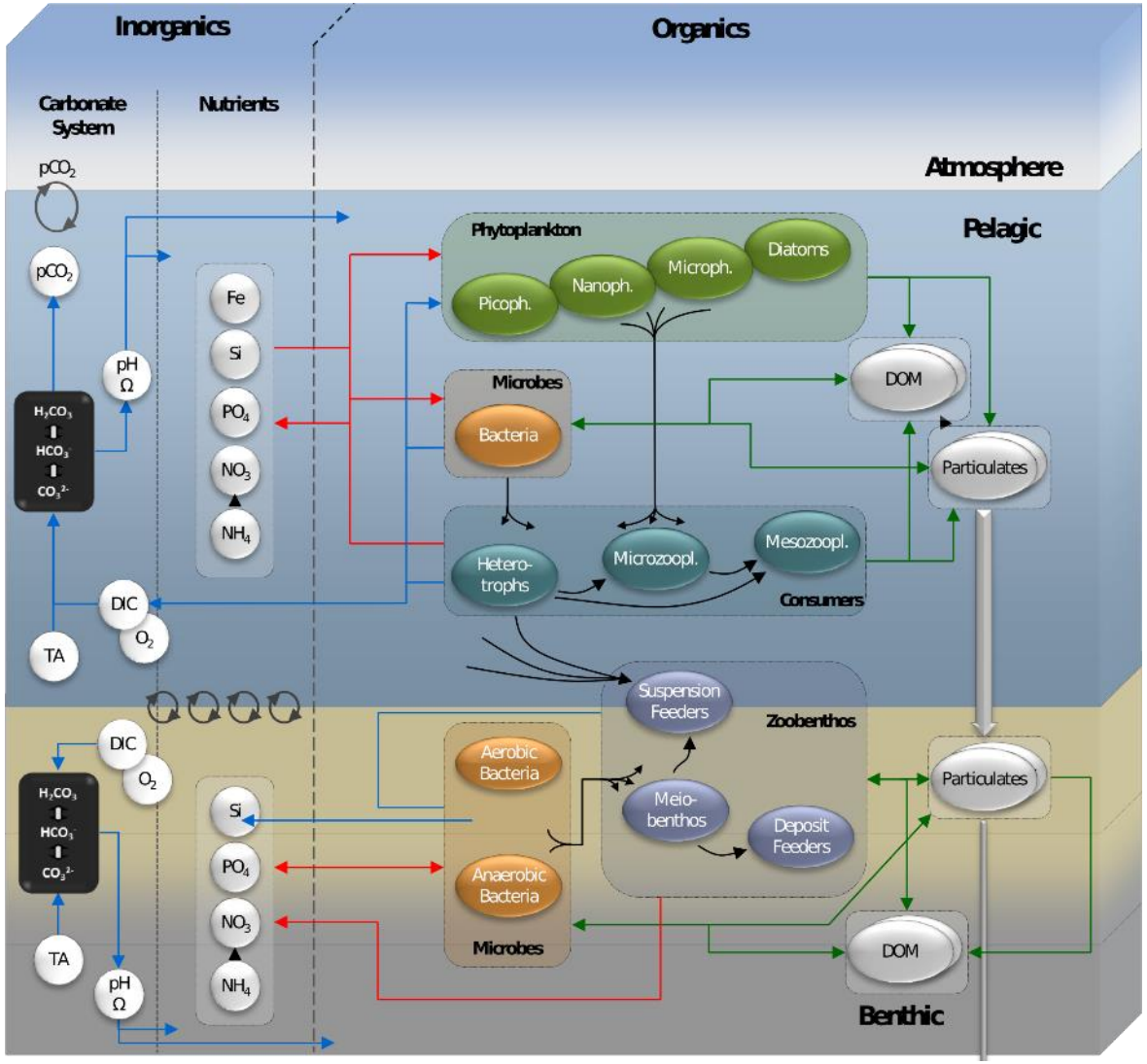


Butenschön, M. *et al.* (2016). *Geosci. Model Dev.* 9.;



Capet, A. *et al.* (2016). *Ocean Modelling* 101.;

Biogeochemical and Ecosystem and fish stock models



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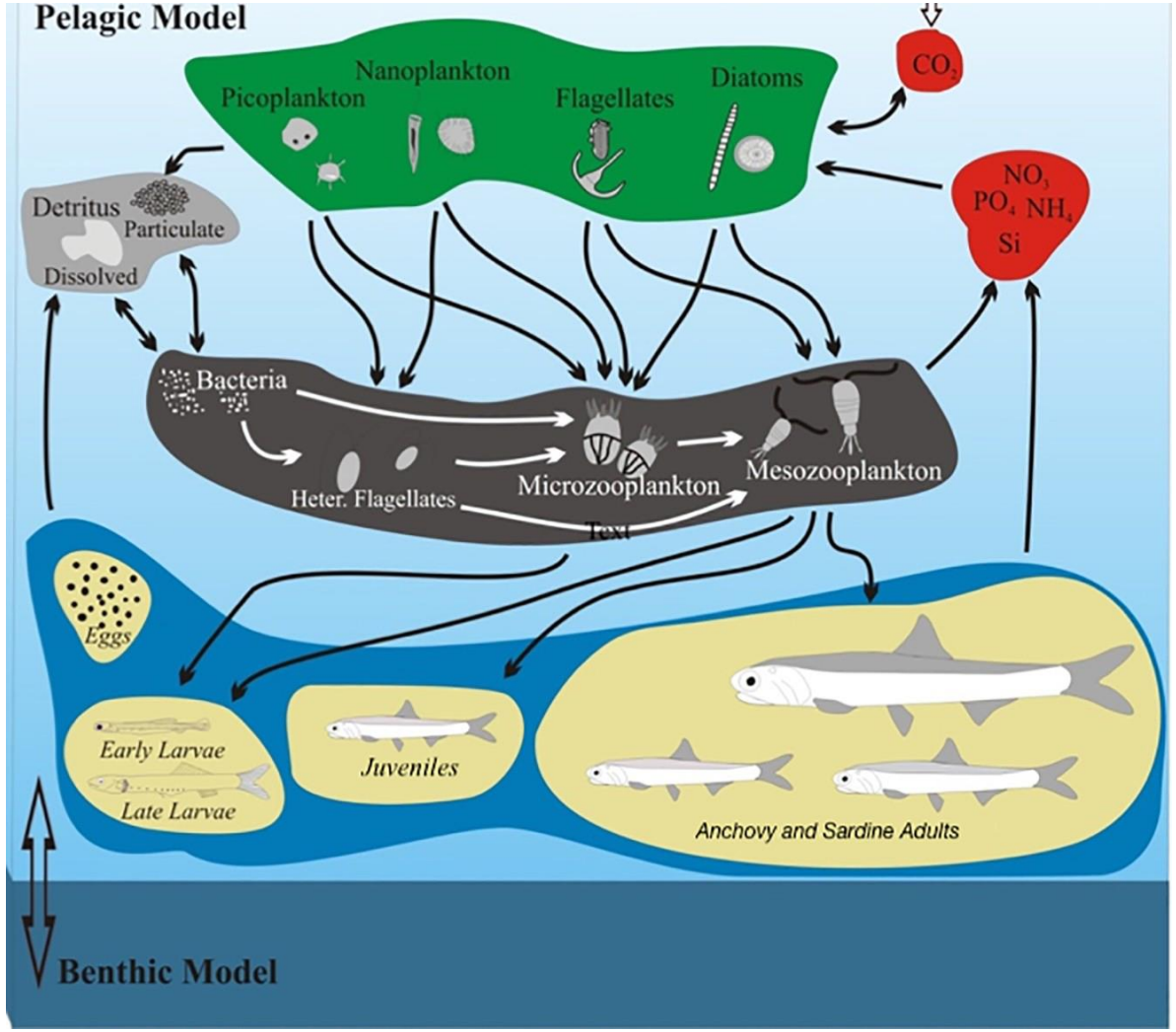

Gkanasos, A. *et al.* (2019). *PLoS One* 14.;

Essential Ocean Variables: Traffic light colour coded for current feasibility on widespread autonomy

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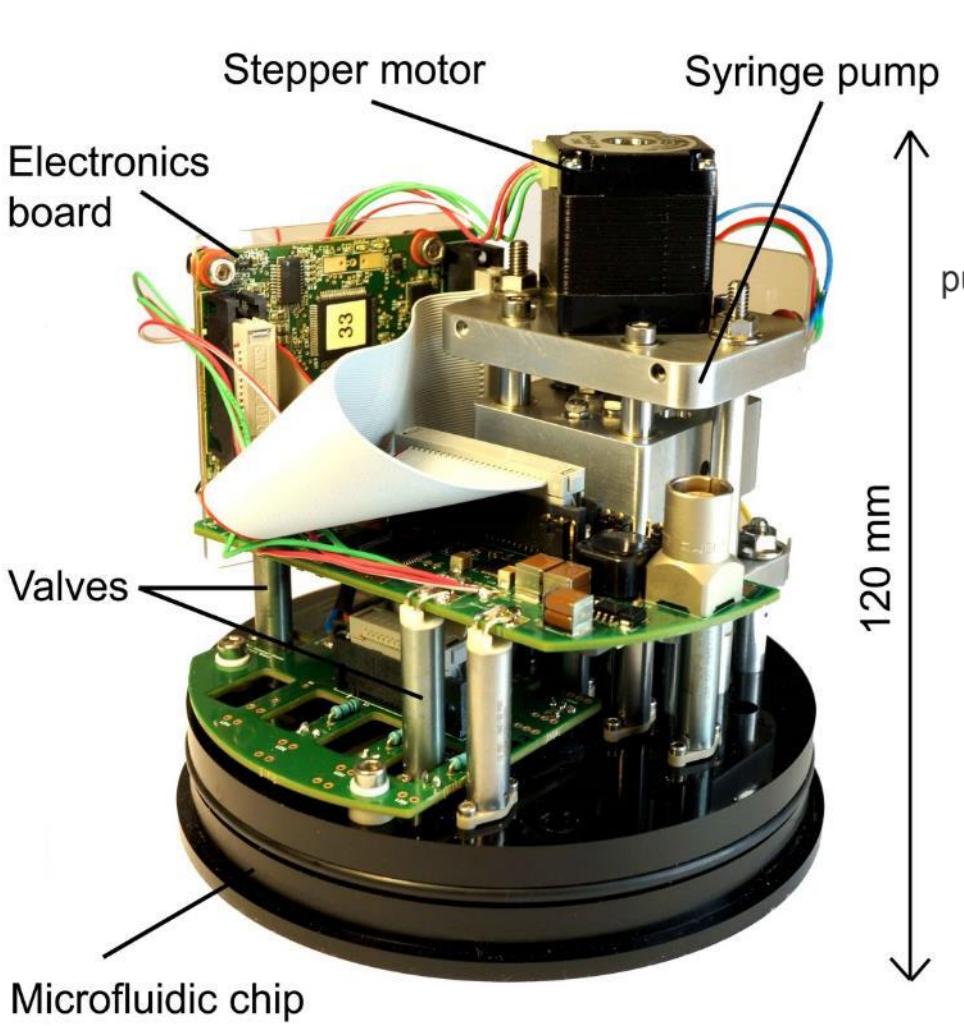
CROSS-DISCIPLINARY		
Ocean colour	Ocean Sound	

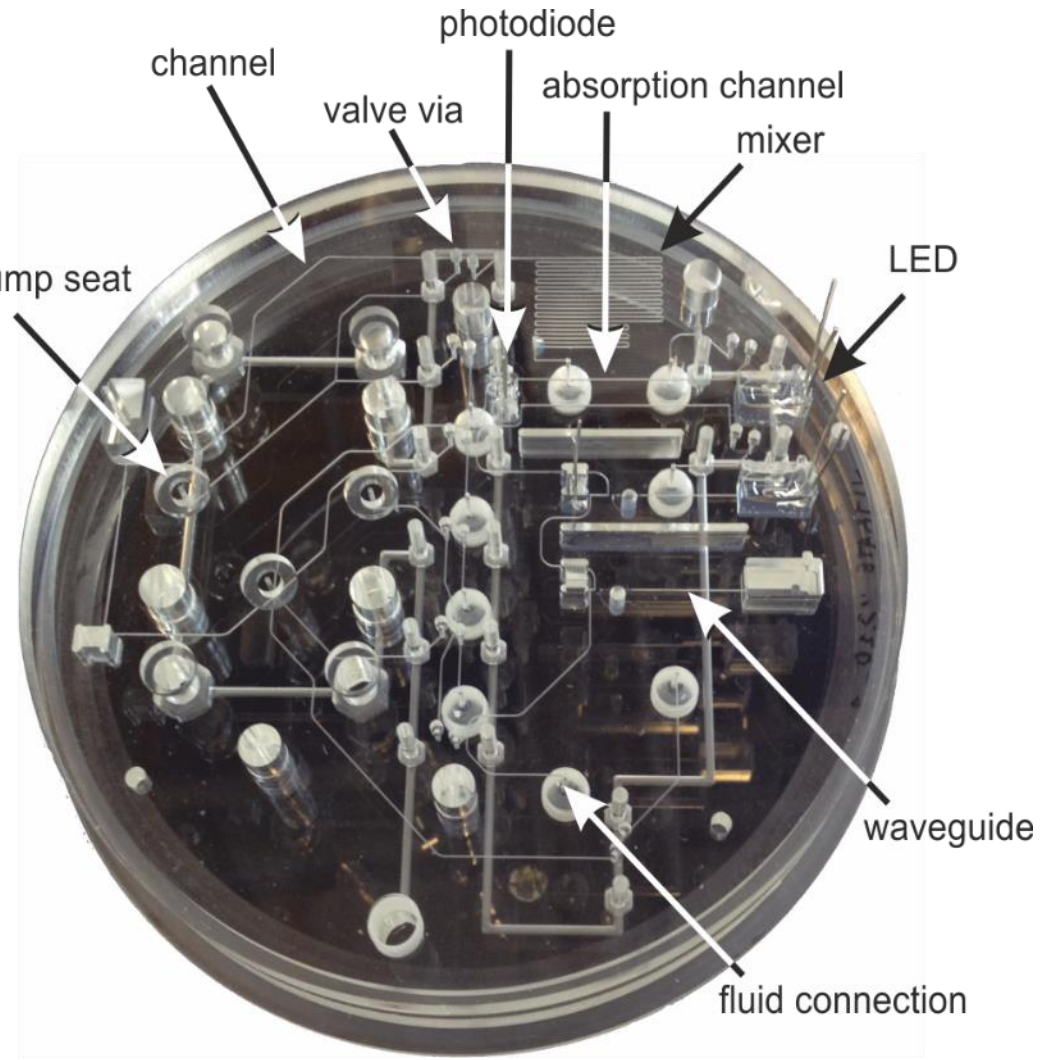
TechOceanS

European Commission | Horizon 2020 European Union funding for Research & Innovation

technology	Dual assay LOC sensors	Bio-assay enabled LOC	Ecogenomic sensing & sampling	Imaging (BioCam)	Imaging (Underwater Vision Profiler)	Microcytometer	MuSTAF (Single Turnover Active Fluorometry)
Lead Partners / EOV	NOC, UoS	DCU, NOC, UoS	FORTH, DCU, NOC, UoS, AWI, SZN	UoS, NOC, GEOMAR	SU, GEOMAR, NOC	UoS, NOC	Chelsea, NOC
Nutrients	x						
Inorganic carbon	x						
Particulate matter					x	x	
Phytoplankton biomass and diversity			x		x	x	x
Zooplankton biomass and diversity			x	x	x		
Fish abundance and distribution			x	x			
Marine turtles, birds, mammals abundance and distribution			x				
Hard coral cover and composition			x	x			
Seagrass cover and composition			x	x			
Macroalgal canopy cover and composition			x	x			
Mangrove cover and composition			x	x			
Microbe biomass and diversity (*emerging)			x	microbial mats		x	x
Invertebrate abundance and distribution (*emerging)			x	x			
MSFD: Water contaminants: e.g. pharmaceutical, insecticide, oil pollutant		x					
MSFD: Toxigenic phytoplankton abundance, biomass and taxonomy		x	X		x	x	
Microplastics/ Marine litter			sampling	x	x	x	

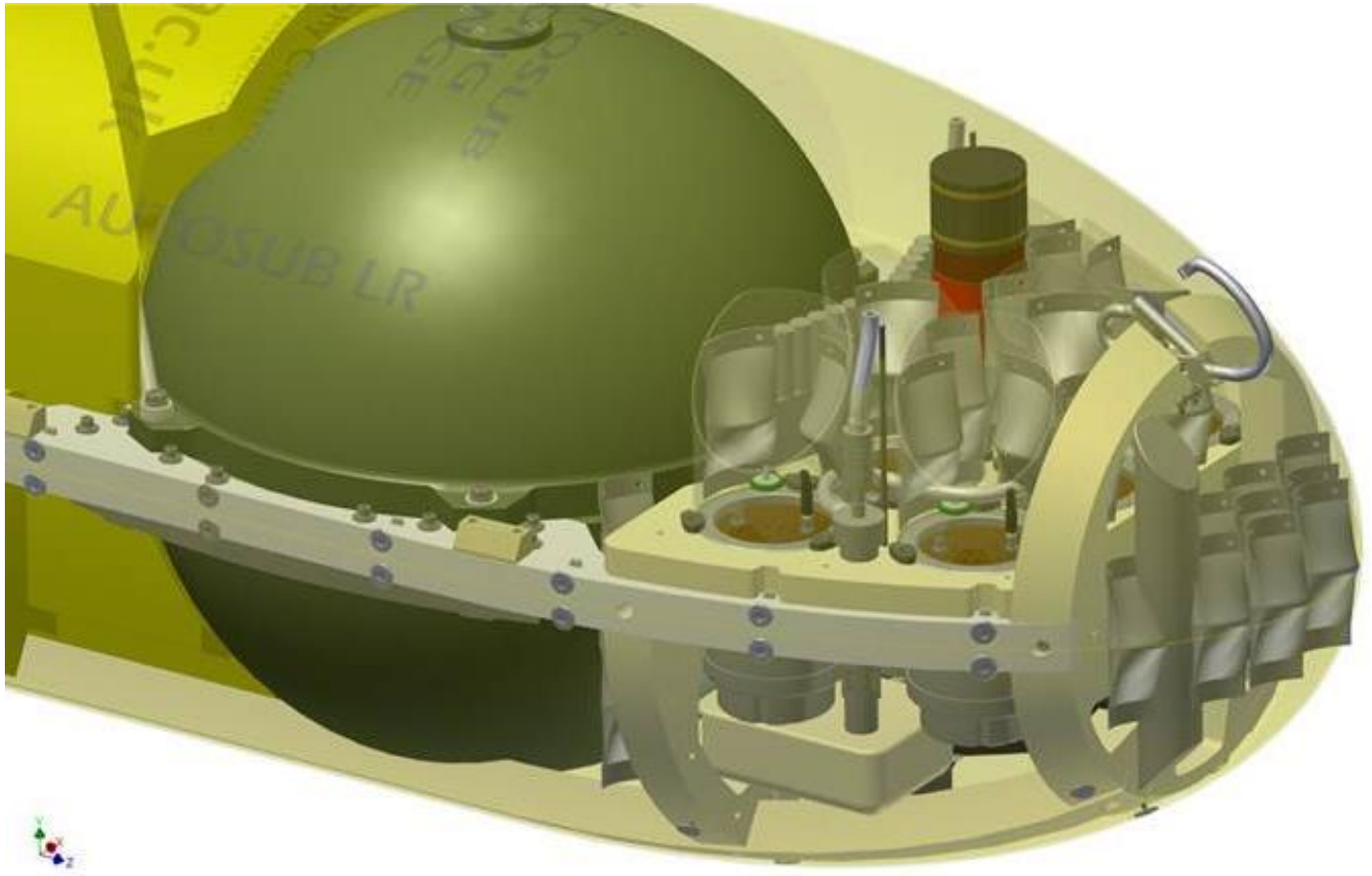
Microfluidic microsensors





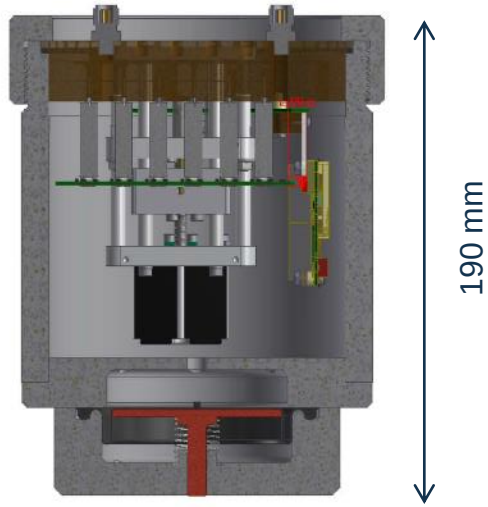
LOC Nutrient Sensors on Autosub Long Range

- 7 LOC nutrient sensors integrated into nose of ALR
  - Nitrate
  - Nitrite
  - Phosphate
  - Silicate
  - Ammonia
  - Iron
  - Trace Iron

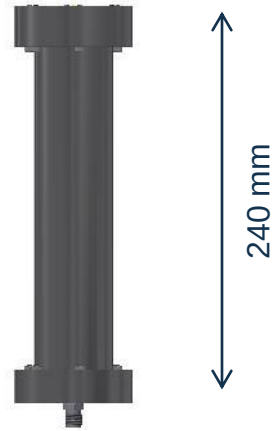


Lab-on-Chip nutrient sensor suite

LOC Sensor	Analytical method	Measurement type	LOD/precision*
Nitrate + nitrite	Griess assay (with Cd reduction)	Colourimetry (absorbance)	20 nM
Phosphate	Molybdenum blue (modified)	Colourimetry (absorbance)	20 nM
Iron (II), Iron (III)	Ferrozine (with ascorbic acid reduction for Fe (III))	Colourimetry (absorbance)	1 nM
Silicate	Silicomolybdic acid	Colourimetry (absorbance)	100 nM
Iron	Luminol with pre-concentration	Chemiluminescence	Sub-nanomolar
Ammonium	OPA + membrane	Fluorescence	(1 nM)



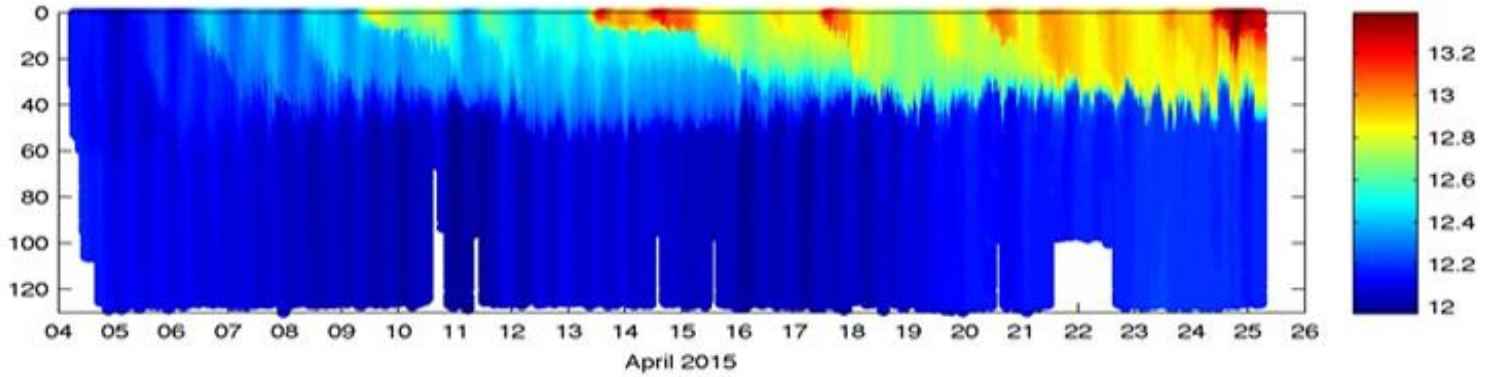
Generic LOC sensor housing



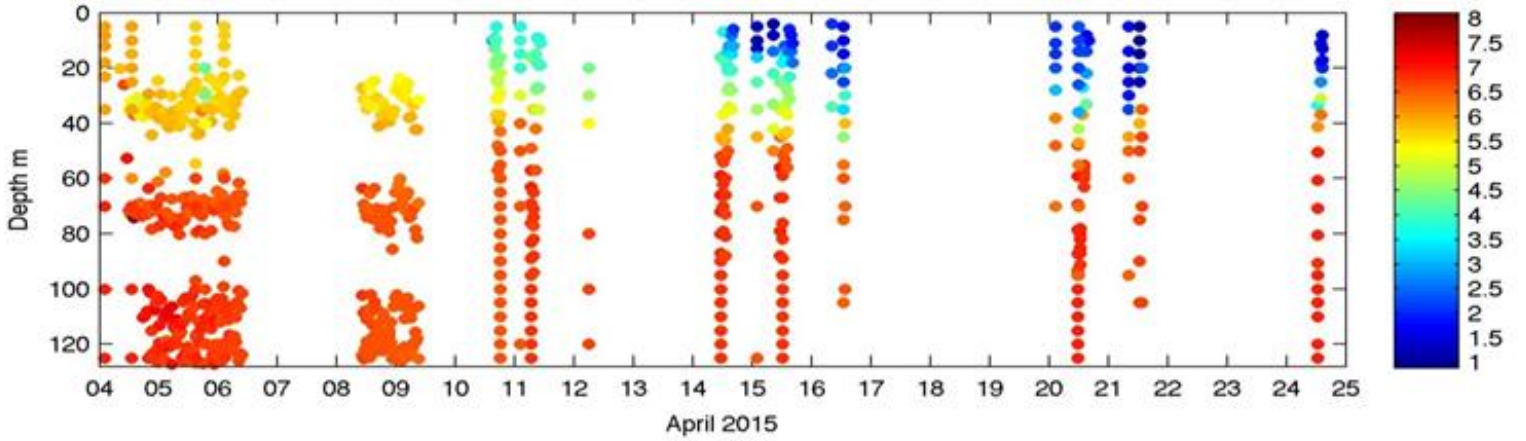
Photomultiplier tube (PMT) module for iron and ammonia sensors

LOC Nutrient Sensors on Kongsberg Seaglider

Temp (degC)

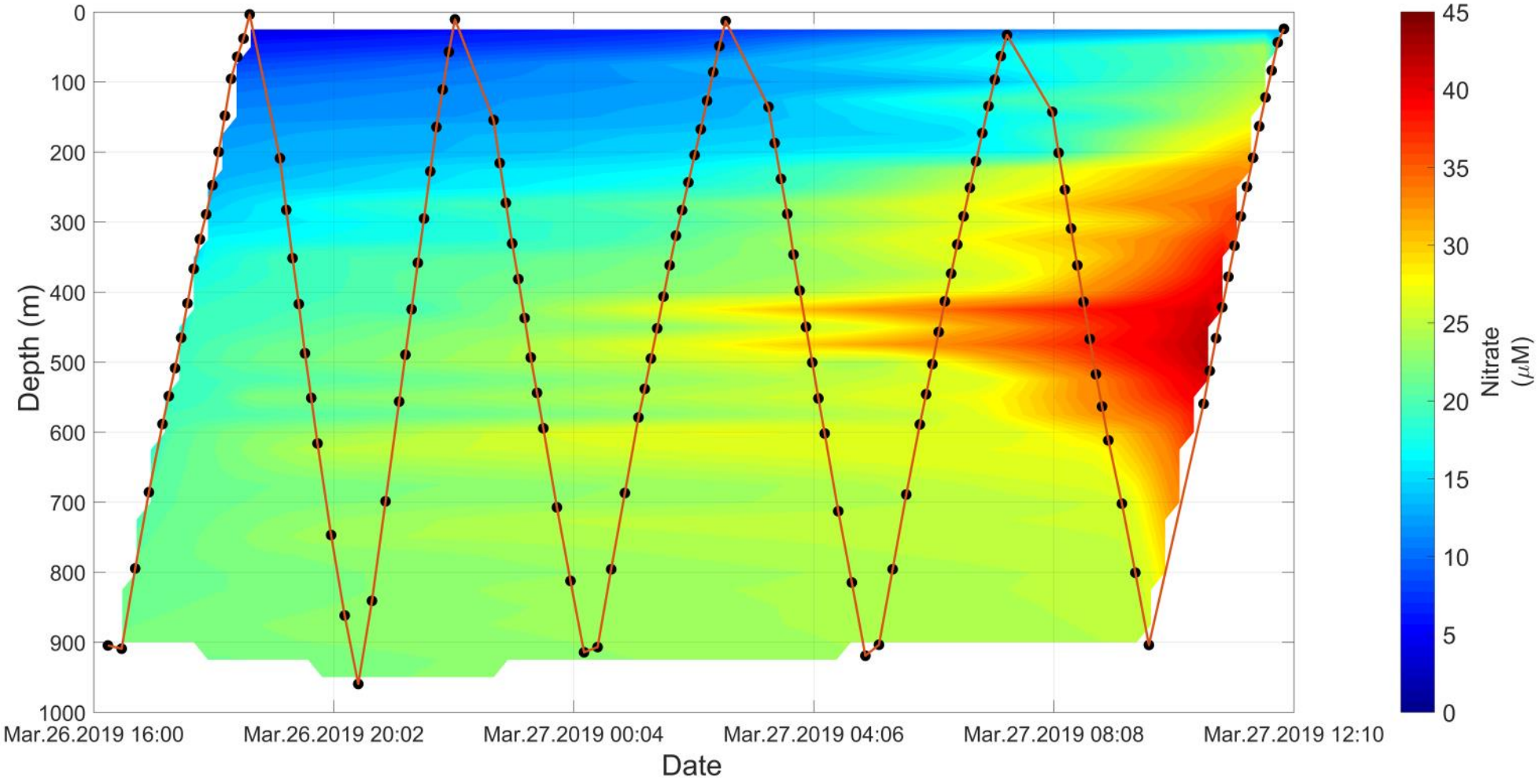


Nitrate (µM)

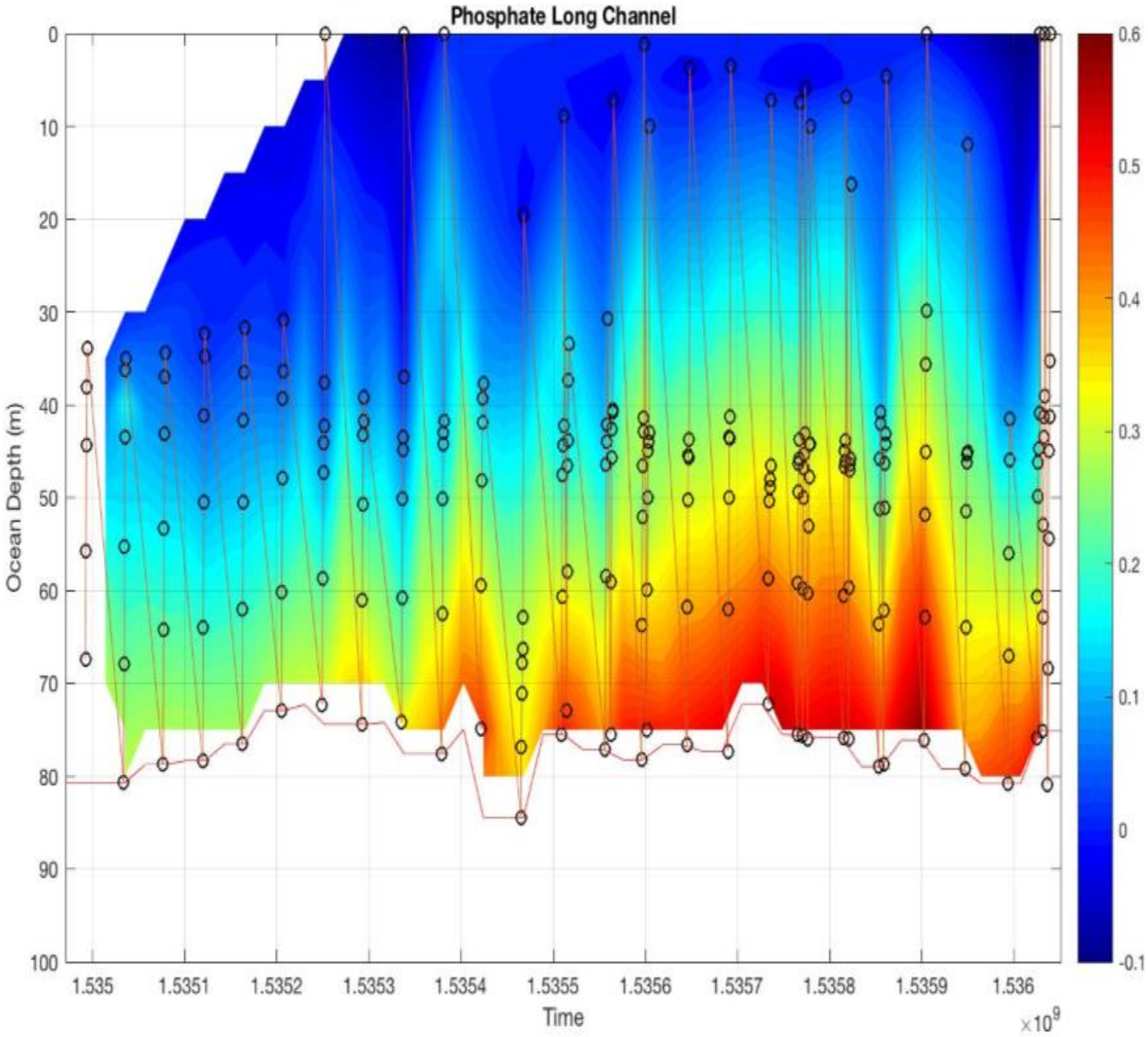


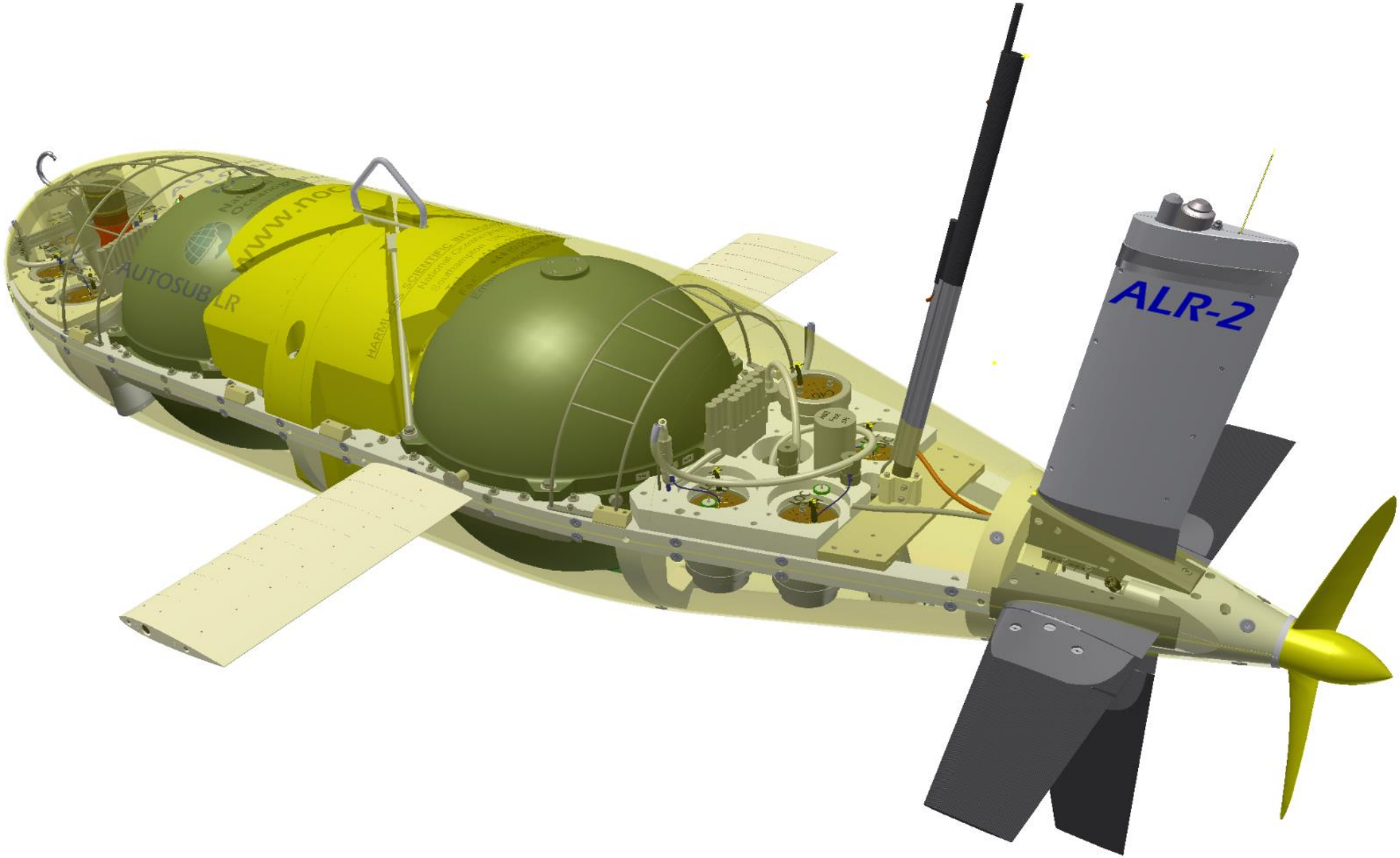
Vincent 2018

LOC Nutrient Sensors on Kongsberg Seaglider



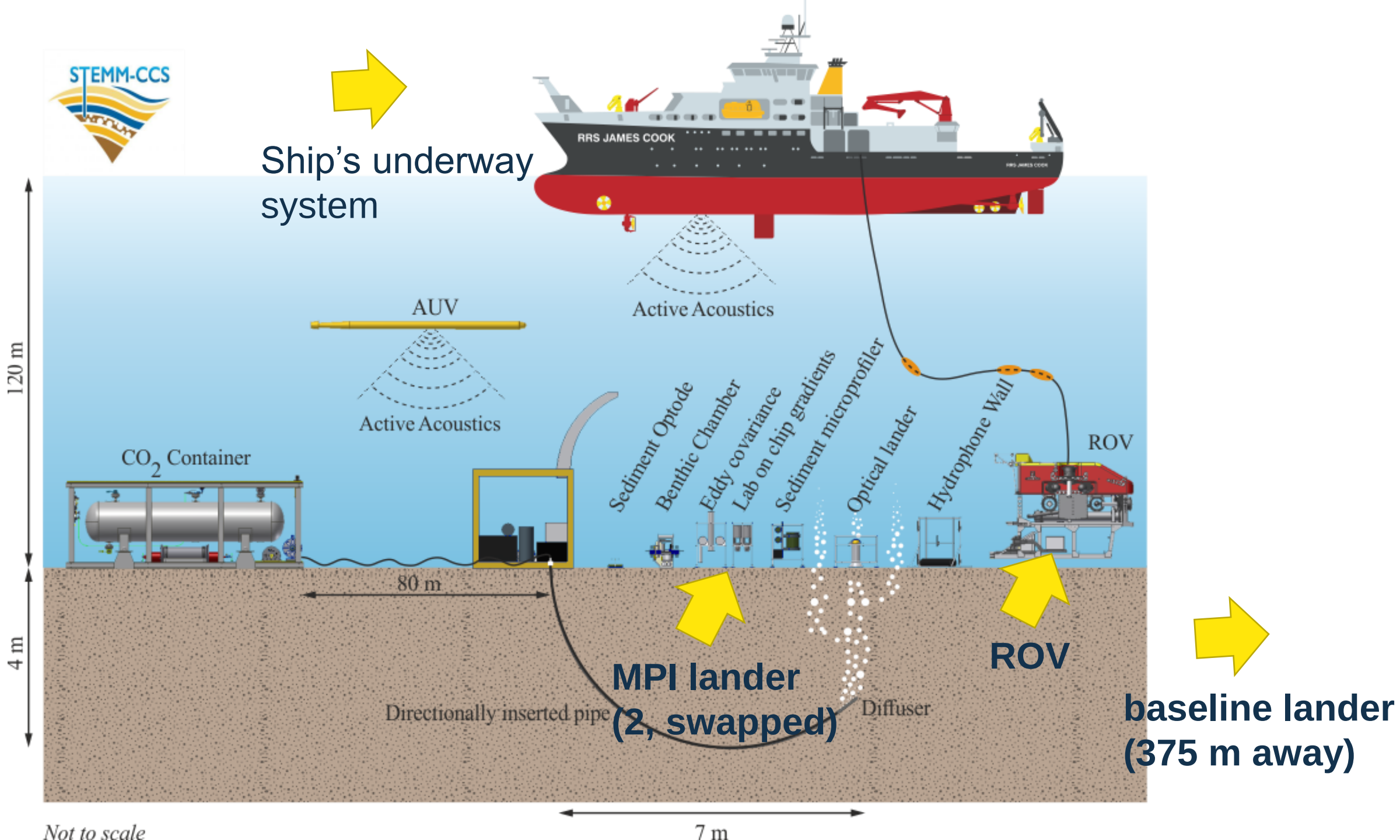
Sample of data from Eastern Cape deployment, South Africa (SOLSTICE project)


Phosphate Long Channel
Ocean Depth (m)
0
10
20
30
40
50
60
70
80
90
100
1.535
1.5351
1.5352
1.5353
1.5354
1.5355
1.5356
1.5357
1.5358
1.5359
1.536
Time
×10^9
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1

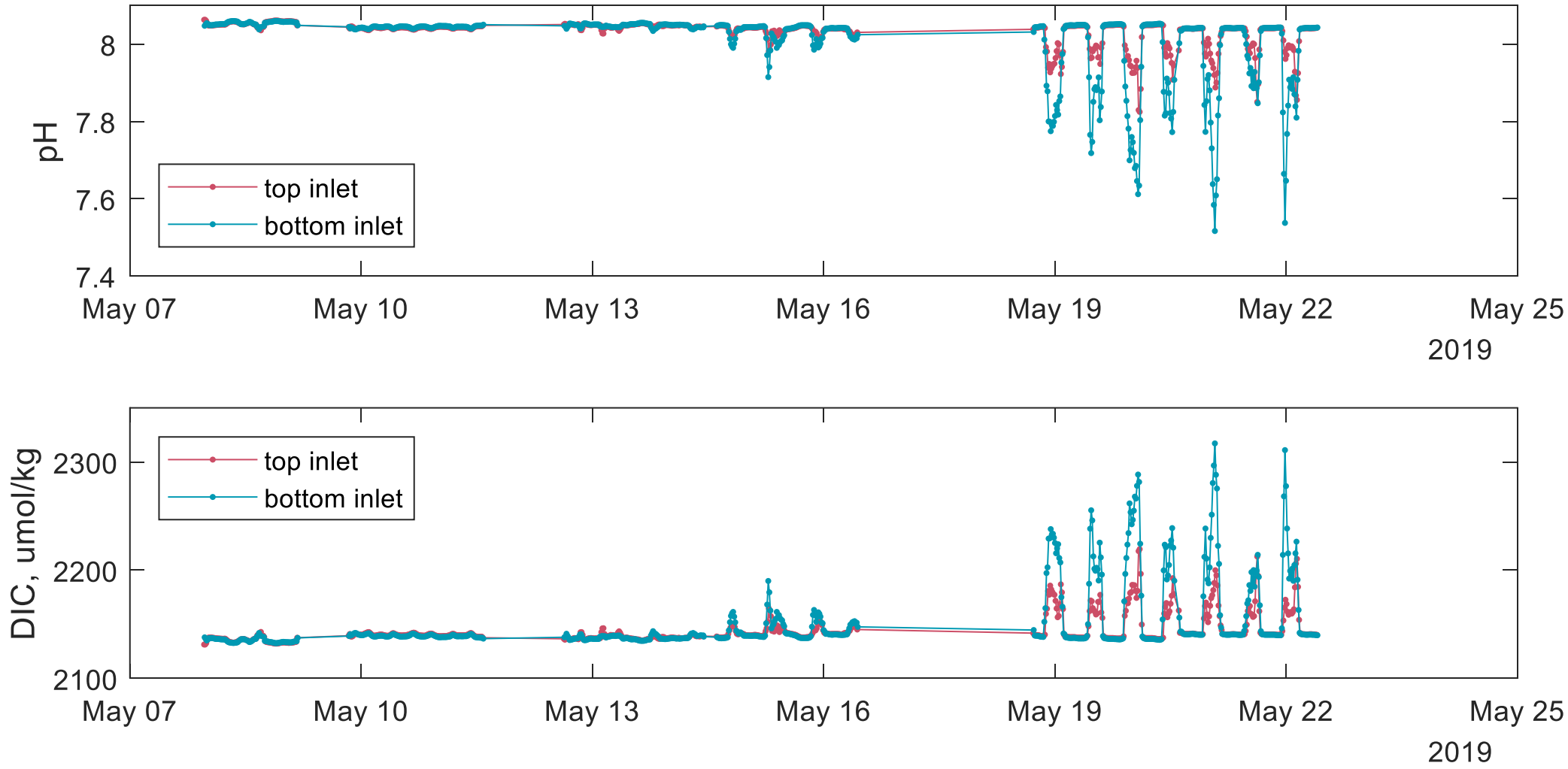

AUTOSUB LR
ALR-2

pH, TA, DIC on NOC v3 LOC platform

	Analytical method	Reproducibility	Depth	Energy consumption J/measurement	Max sampling frequency	TRL 2019
DIC	Gas extraction and conductivity of NaOH	5 µmol Kg^{-1}	Full ocean	~1500	10 minutes	6
TA	Single step titration/spectrophotometry BPB	2 µmol Kg^{-1}				7
pH	Spectrophotometry mCP	<0.001 pH				8


STEMM-CCS
Ship's underway system
RRS JAMES COOK
Active Acoustics
AUV
Active Acoustics
120 m
CO_2 Container
Sediment Optode
Benthic Chamber
Eddy covariance
Lab on chip gradients
Sediment microprofiler
Optical lander
Hydrophone Wall
ROV
80 m
4 m
MPI lander
(2, swapped)
ROV
Directionally inserted pipe
Diffuser
baseline lander
(375 m away)
Not to scale
7 m

Data


pH
8
7.8
7.6
7.4
top inlet
bottom inlet
May 07
May 10
May 13
May 16
May 19
May 22
May 25
2019
DIC, umol/kg
2300
2200
2100
top inlet
bottom inlet
May 07
May 10
May 13
May 16
May 19
May 22
May 25
2019

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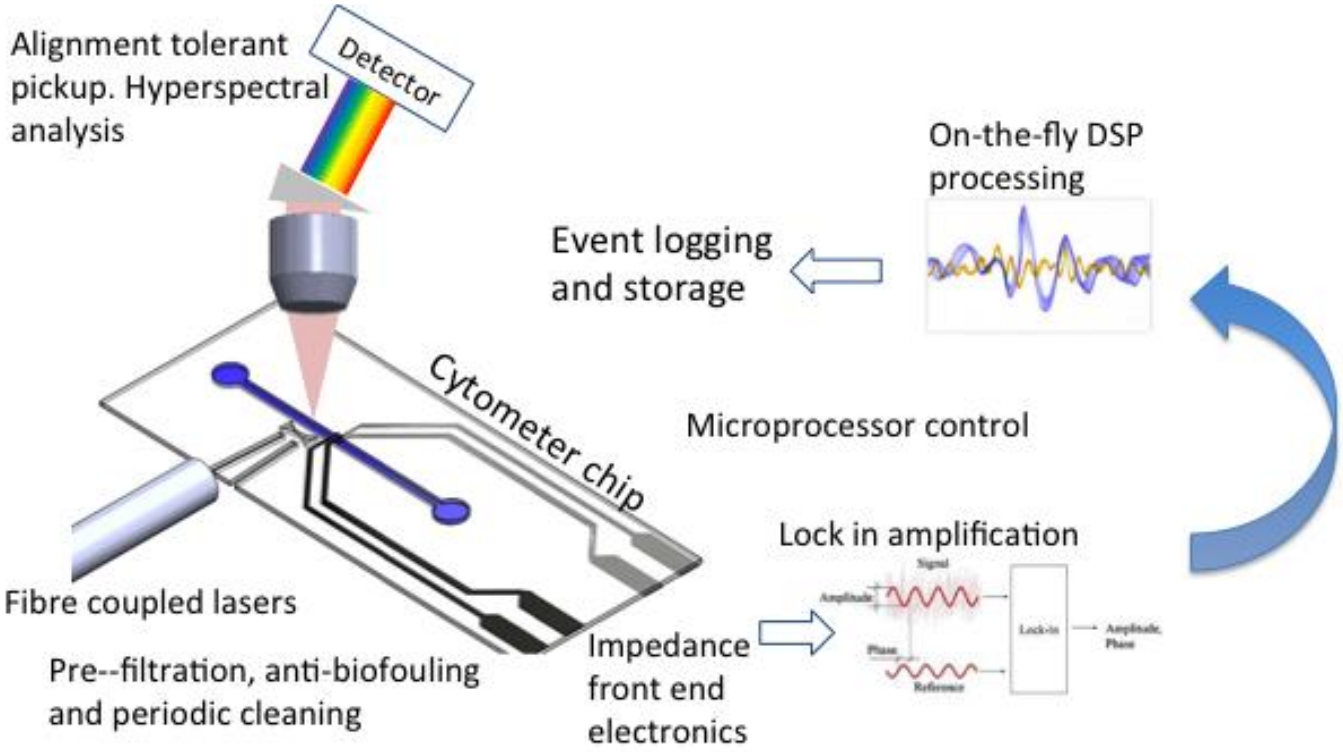
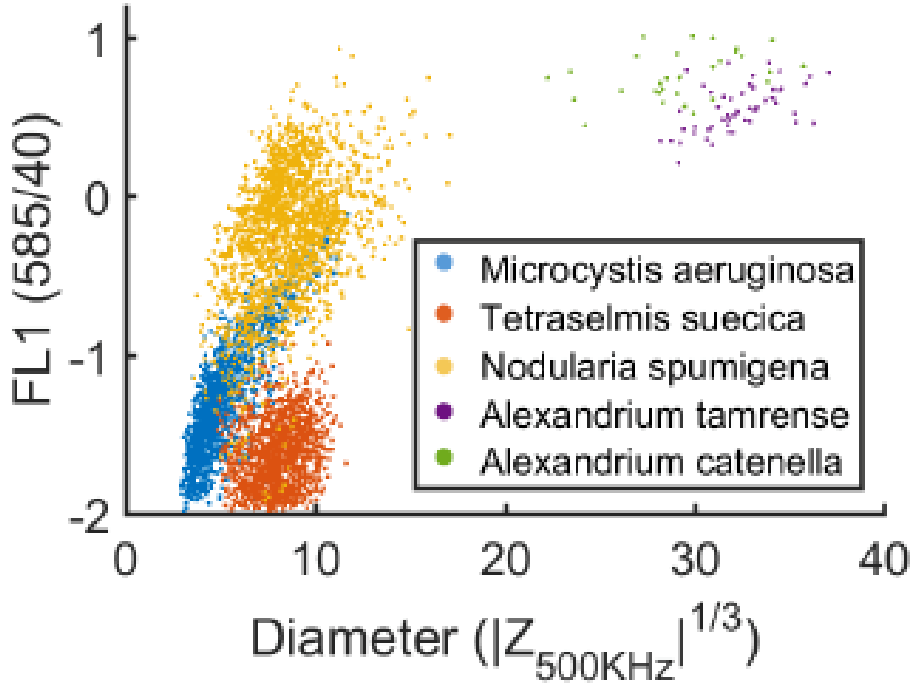
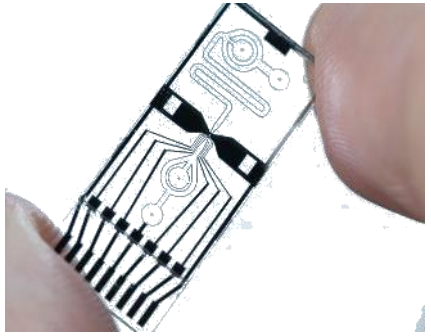
CROSS-DISCIPLINARY		
Ocean colour	Ocean Sound	

MicroCytometer

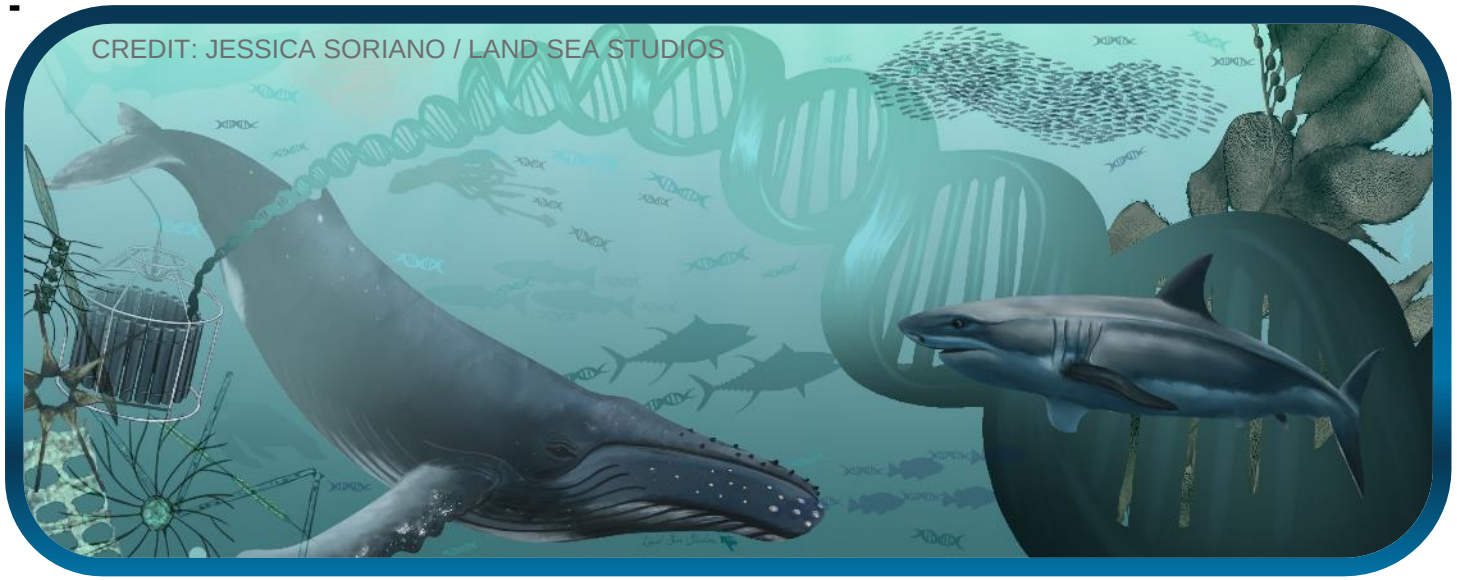




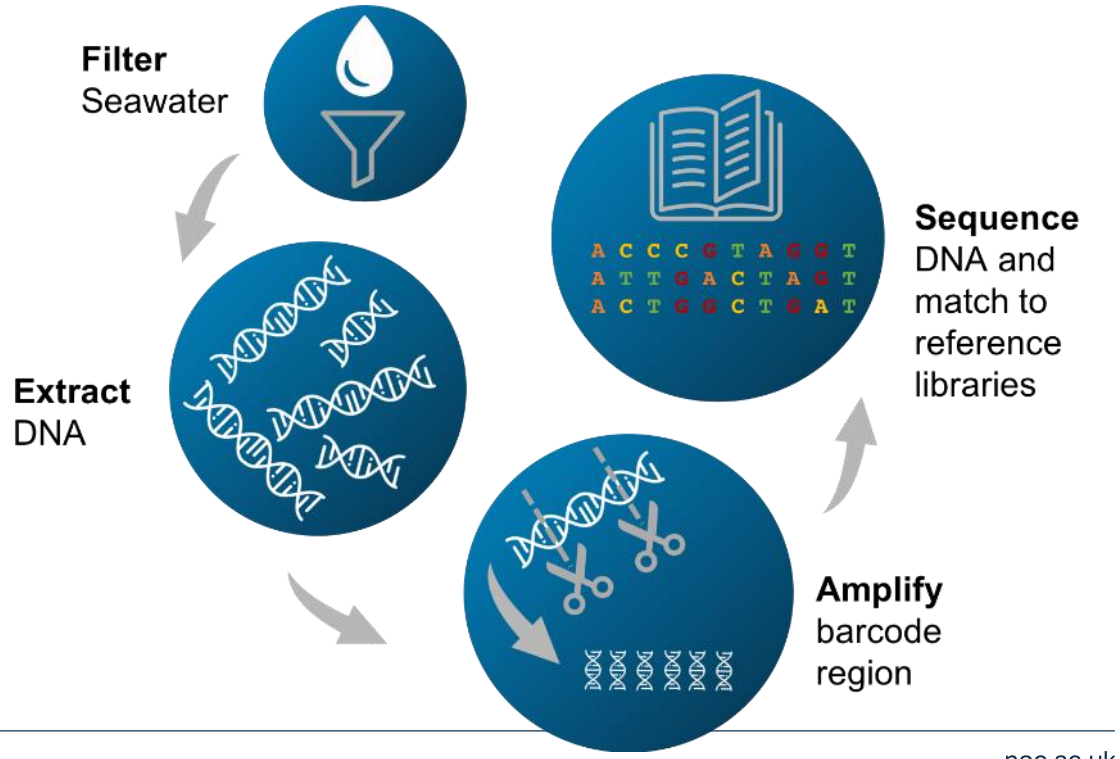
Microchip Technology



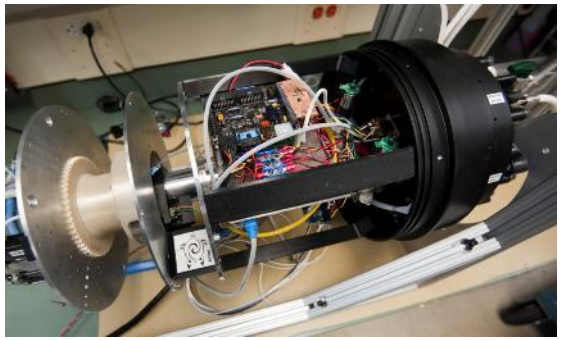
Environmental DNA

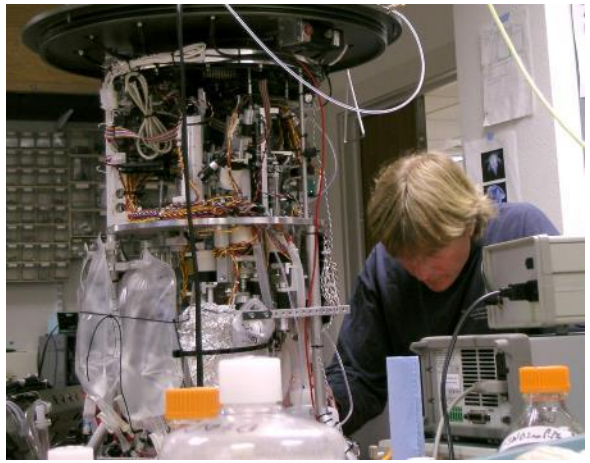


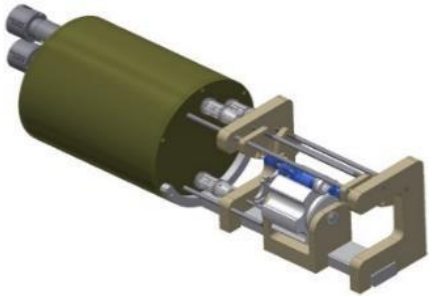
- Cellular material containing DNA in the environment.
- Specific gene region (barcodes) are amplified using the polymerase chain reaction (PCR)
- qPCR for species specific quantification
- Metabarcoding for community composition – presence/absence

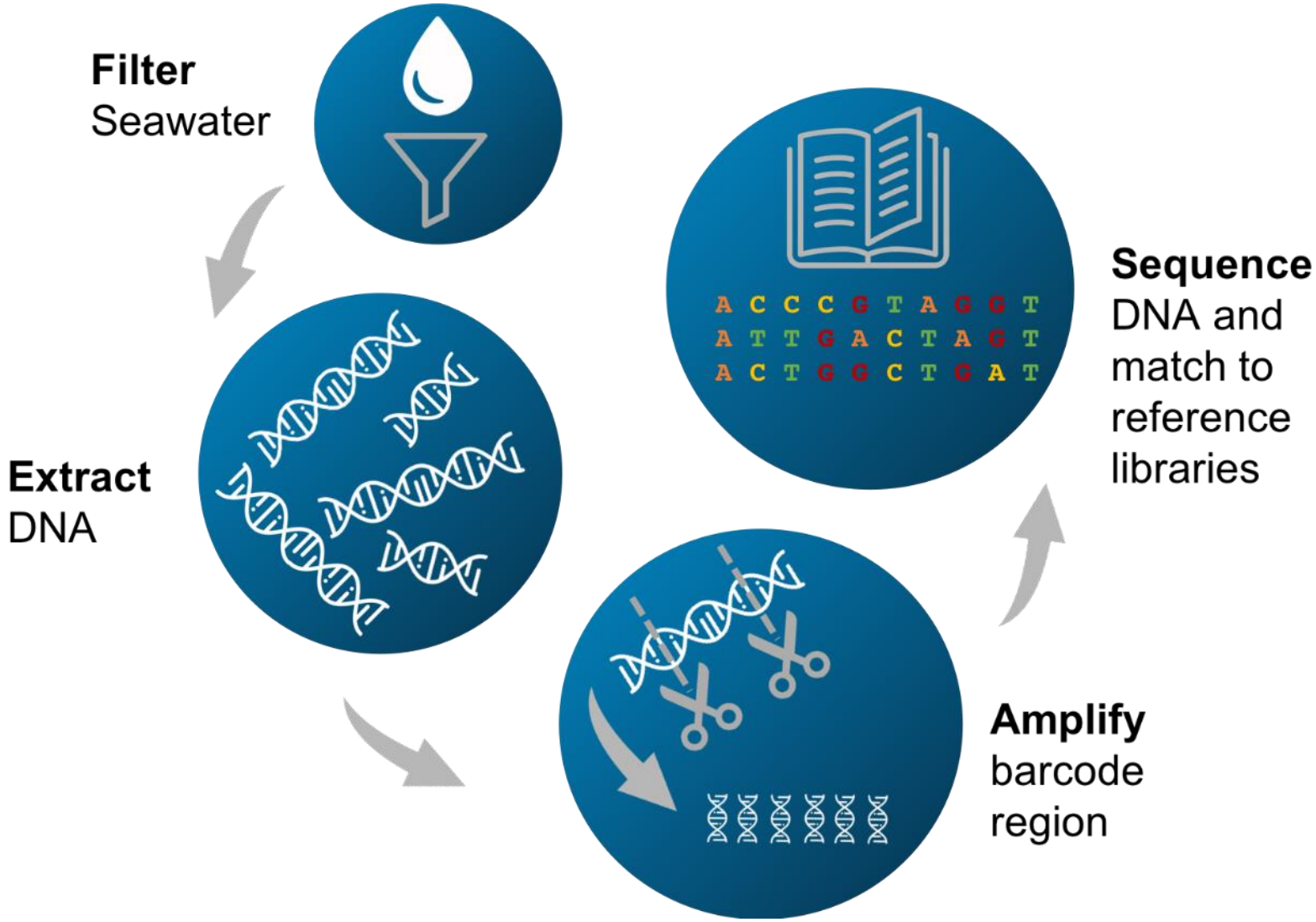


DNA/RNA and eDNA workflow









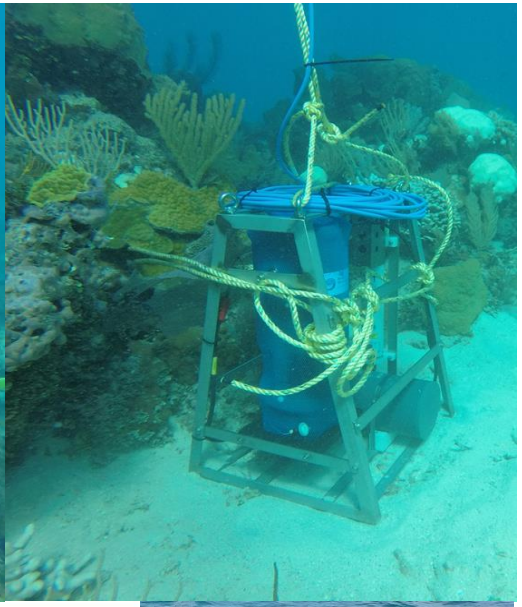
International collaborations

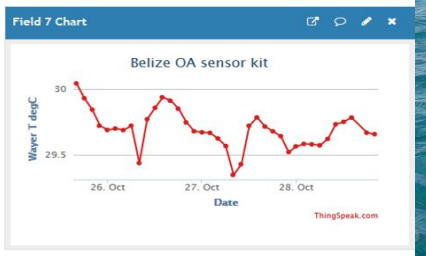
Current Examples

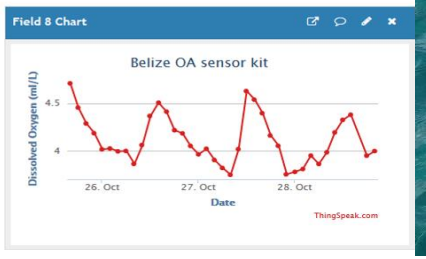
- Ocean acidification monitoring Belize (left) and Fiji
- Small Island Developing States
- Bangladesh (salt intrusion, biogeochemistry, pathogens, aquaculture water quality)

Opportunities

- Collaborative technology development
- Applications and demonstrations
- Technology transfer and commercialisation







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Thank you