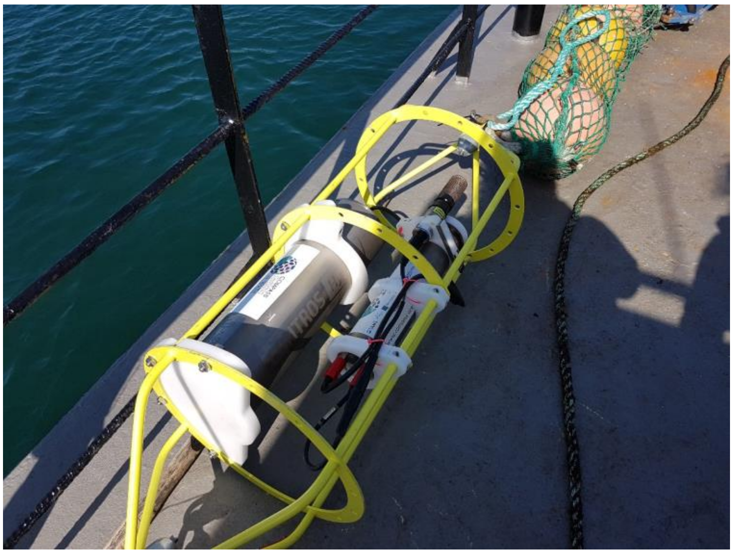
Report for Collaborative Oceanography and Monitoring for Protected Areas and Species (IVA5015)

T1.3.3

Phase 1 – October 2020.
The Implementation of new monitoring technologies within the COMPASS network

Date: May 2020

Report by: COMPASS Oceanographic Work Package



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1. Executive Summary

The Summary and Executive Summary will be written for the completed Phase 2 report.

The Phase 1 report summarises new technology integration within COMPASS oceanographic platforms up to mid-2020. Activity to integrate and deploy new technology is ongoing, and specific sections of this report will be completed in Phase 2 when deployments are fully established.

Contents

2. Scope

This Phase 1 report summarises the status of new technology implementation in the COMPASS oceanographic network at the time of writing, but will be updated before the project close to capture all developments and new technology implementation as work is on-going and in some cases behind schedule due to project delays and the impacts of COVID-19. Project staff turnover in the 6 months preceding this report combined with the restricted activity due to the COVID-19 pandemic has delayed some of the new technology integration and the subsequent reporting. Workshops and meetings to facilitate the integration, assessment of performance and progress the work packages objectives have been cancelled through 2020 due to the ongoing health concerns which have impacted on the timing of the delivery of this report.

The COMPASS partners have demonstrated an eagerness to adapt to the pressures they have faced, and planning and financial budgets are being developed with the PMO and SEUPB to support the delivery of the projects goals in full. A Phase 2 report will follow to update and complete elements of this report. Recruitment within AFBI, the Marine Institute and Marine Scotland is underway to support T1 activity, and the re-structuring of activity and hardware is underway at SAMS to facilitate moorings losses and logistical challenges associated with vessel availability.

This report details new technologies that may not have been implemented at every site, nor by every partner; in order to maximize the potential for legacy an adoption into longer term monitoring strategies, each partner institute had some latitude to identify the priority technologies to focus on for their given monitoring site. The report captures the experience of each partner with implementing any new technology to record how accessible and valuable the new technology is, and to help understand the future requirements to be able to use and maintain it. The report should be in context with the T1.5.1 Integration report to get a more complete picture of how moored technologies and activities have integrated within the COMPASS project across different disciplines.

3. Introduction

Oceanography provides our understanding of how the oceans form a critical part of the global climate system, regulating atmospheric processes and distributing heat, salt and organisms throughout the global ocean. Oceanographic monitoring around the UK and Ireland supports the management of the marine environment, our marine resources, and with increasing regional and global cohesion through GCOS and the many Ocean Observing System (OOS) initiatives, oceanographic monitoring contributes to services essential to everyday life such as weather forecasting as well as the science to understand emerging risks such as climate change and ocean acidification. Globally, there are numerous initiatives operating an increasingly sophisticated network of marine observation systems. These are often integrated with meteorological observation systems and extensive observations have been carried out for decades by the UK and Irish marine research laboratories. Many of the observation programmes have changed little since their inception, but the observations have expanded as the laboratories adopt an 'ecosystem approach', and environmental concerns such as climate change have grown alongside technology developments. The number and scale of observatories has expanded considerably with the increased involvement of the UK and Irish Meteorological Offices.

Climate change presents risks to human health and wellbeing, such as physical impacts through flooding and disease and wider sociocultural effects such as the loss of heritage sites and changes in tourism and recreation. A wide range of economically important marine and coastal industries are being affected by climate change, with impacts on food availability, infrastructure, seasonal operating windows and the movement of goods. Coastal erosion, flooding, sea-level rise and potential changes in storminess present multiple risks to UK industries and coastal communities. The World Economic Forum currently identifies environmental issues as constituting 8 out of the top 10 risks to global economics. The environment should no longer be considered as separate components each with the potential to assigned an intrinsic monetary value; it is perhaps now starting to be considered as a whole, being beyond crude measures of monetary valuation, and as such is beginning to be appreciated as non-negotiable and essential to our economic and societal welfare. In order to refine estimates and reduce uncertainty in projections of climate change in the marine system, it is necessary to have a sustained programme of research activity to include basic research on the marine system, long-term monitoring of essential climate variables and strengthening of our ability to accurately project future climate scenarios using computer model simulations. Climate change impacts on industry and society and their responses to these drivers are modulated by wider external factors such as government policies, economic fluctuations, demographic changes and societal values. While uncertainty remains over the nature and magnitude of expected changes, there is agreement that some of these changes will require adaptation and mitigation measures on the part of governments around the globe. The cost of adapting and employing mitigation strategies is likely to be lower if action is taken in a systematic and timely manner, therefore knowledge and understanding about how we exist alongside and interact with our environment is critical. The COMPASS oceanographic work programme aims to support important long-term marine environmental monitoring time-series in the region, assess the potential for new technology to enhance these activities, and improve the coherence and collaboration between regional partners. The project European Funding delivered through the project enables the research centres responsible for oceanographic monitoring in the region to connect a number of activities with the potential for a more coherent legacy.

The COMPASS Oceanographic work package differs from other work programmes within the project in that it aims to align, integrate, develop and enhance existing oceanographic monitoring activities across the region. In this sense, it is a hybrid work-package that brings a number of elements of logistical and historical legacy as it adopts existing infrastructure, as is not possible (nor optimal) to sustainably deliver identical instrument packages at each of the proposed monitoring locations. In other COMPASS work-packages such as T3 (Salmonid Fish) or T4 (Marine Mammals) a more focused activity has been targeted using a single technology to develop a new more standardized monitoring strategy that can be applied and potentially adopted across the region. Because of the logistical considerations, the costs and the diversity of oceanographic monitoring sensors, the technology packages are bespoke to each partner as the logistics and scientific support required to operate them must be tailored to fit the partner's capacity. Equally, COMPASS aimed to establish the potential for a longer term and more regionally integrated monitoring legacy, so the implementation of technology that was less likely to be maintained beyond the projects lifespan had to be avoided.

Non-standardised technology and bespoke integration of hardware results in a more challenging task in deploying and delivering coherently across partners. The sensor packages were selected by the partners to be those most appropriate for their monitoring locations – the instruments in these packages have been selected to 1) maintain and support some of the valuable existing time-series of data, 2) to explore the viability of societal and future policy requirements for oceanographic monitoring, and 3) to apply and test some of the latest sensor technologies.

Whilst most of the participating partners are supporting regionally important monitoring time-series such as at Loch Ewe (MSS), Tiree (SAMS) and the Western Irish Sea (AFBI), the project has supported the delivery of new monitoring locations such as Mace Head (MI) and the Firth of Lorne (SAMS). Adding the new technologies into existing moored oceanographic stations is being undertaken at Loch Ewe and the Western Irish Sea which has been challenging as the existing platforms have to be modified (or entirely replaced), and the existing logistical infrastructure has had to be adapted to facilitate the deployment and recovery of the sensors. Deploying new state-of-the-art technology at some of the more remote existing moorings was not seen as an optimal strategy for some sensors (such as pCO2) due to the requirements for validation to assess the effectiveness of the sensors. Where new platforms have been deployed (Mace Head and Firth of Lorne) there have been some advantages of planning and entirely new logistical operation, but these have been tempered by challenges such as vessel availability, operating in a new and unproven routine, and in one unfortunate case the repeated theft of equipment. The Tiree mooring has also been lost in its entirety during 2019, but SAMS are currently exploring the options to re-instrument and re-deploy this mooring under the COMPASS project umbrella.

Partner	SUNA	McLane RAS	SeaFET	SeaphOx	CTD	Wave	HydroC pCO2	Met Station	ADCP	New Buoy/telenetry
AFBI, Northern Ireland			N			N	N	N		N
MI, Ireland	N		N		N		N	N	N	N
SAMS, Scotland				N			N			N
MSS, Scotland							N			N

Table 1. Summary table of technologies to be deployed by COMPASS partners. Green indicates inclusion in partners mooring(s), red indicates and absence, whilst "N" indicates if this is a new sensor type for the platform.

Progress on the roll-out of new-technologies across the T1 work package has therefore not been synchronised due to the completely different technological and logistical challenges faced at each location. Across the partnership, the COVID-19 Pandemic has impacted operational activities as well as the supply chain required to service, replace and renew equipment being deployed in the T1 work package. The partner institutes have shown the resilience typical of the marine sector and have adapted to make sure delivery is still achieved despite delays and losses incurred to this point. The content of this Phase 1 report is being published as a status update at the time of writing - not all of the "new" technology has been deployed at all sites at this point and this report should capture that status. The Phase 2 report is anticipated later in 2021 when it is expected that the project will have delivered all of the new technology into the operational environment, and a coherent view of these experiences from across the partnership can be captured.

4. SUNA

4.1 Introduction

The SUNA V2 UV nitrate sensor is Seabird's solution for real-time nutrient monitoring. This sensor measures nitrate over a wide range of environmental conditions, from blue-ocean nitraclines to storm runoff in rivers and streams. Full UV spectrum range is used in the instrument electronics & calculations for maximum accuracy. Real-time nitrate calculation is done internally in the sensor, logged to memory, and output via serial for collection/transmission by a datalogger. The sensor has an integrated wiper brush to prevent fouling of the optics window.

The advantages of the SUNA are that it does not require regular replacement of reagents, it does not require pumps or moving parts so theoretically is less likely to encounter mechanical problems in a difficult working environment, and it has a broad linear working range and reasonable sensitivity. SUNA is a single parameter device however, and other technologies such as the McLane RAS sampled deployed at the AFBI mooring are capable of sampling water for multiple chemical determinands (Nitrate, Nitrite, Phosphate, Silicate, Ammonia). Mechanical water samplers have been deployed effectively for a considerable amount of time, but in addition to their maintenance and laboratory support requirements they are limited to a total of 48 samples per deployment, meaning the SUNA sensor offers the opportunity for higher frequency sampling over much longer time periods.

Nitrogen (in the form of nitrate) is one of the key nutrients required for primary production in the marine environment, but as it is often the limiting factor for primary productivity in the marine environment the introduction of excess nitrogen into the system is monitored to identify problems that can be associated with nutrient enrichment. Eutrophic impacts in the marine environment have led to an increase in "dead-zones" globally where oxygen concentrations are reduced due to the effects of nutrient enrichment. The risks associated with eutrophic impacts may be exacerbated by climate change impacts, and enhancing the data available on Nitrates in combination with other ocean climate variables will result in an improved understanding of the potential ecosystem impacts

4.2 Partners involved

Partner	Status at Phase 1 report	Status at Phase 2 report
Marine Institute, Ireland	Deployed	

4.3 Costs

Two Seabird Scientific SUNA V2 nitrate sensors were purchased (serial numbers: SN 1114 and SN1120). The cost of purchasing two SUNA sensors in 2017 was approx. €90,000. In addition to initial purchase cost, there is also an annual calibration cost of approx. €1500.

4.4 Logistics

The SUNA unit is installed on the Mace Head buoy at 53.3307N, 9.9326W. The unit is mounted on the subsea instrument frame in the central spar of the buoy, approx. 1m below sea level. It is held in place by 2 plastic clamps (Stauff clamps) with stainless steel bolts. A cable with rubber molded connectors runs from the SUNA to a subsea junction box. From there, a larger cable brings all subsea connections to the DAS (data acquisition system) box in the top section of the buoy. Data is collected, stored on SD card, and transmitted via email over 3G by a Campbell CR6 datalogger. The data is archived in MI databases upon being received on shore. Seabird UCI software is used to set up the instrument for deployment.

The unit is swapped out for service & calibration every 6 months. In tandem with the in-situ measurements, there is a program of water sampling by MI personnel every 2 weeks – analysis of these samples provides a source of validation for the time series data provided by the buoy instruments.

4.5 Performance

4.5.1 Laboratory verification

Two SUNA sensors were used for the COMPASS project (SN 1114 and SN 1120). Both these sensors were tested in the laboratory prior to deployment at the Marine Institute COMPASS buoy at Mace Head. The SUNA sensors were tested in the laboratory using certified reference solutions of known nitrate concentration (both seawater and estuarine).

The *Limit of Detection* (LoD) and *Limit of Quantification* (LoQ) were determined for both sensors by analysing seawater solutions with known low nitrate concentrations. The calculated LoD and LOQ were 1.05 µmol/L and 3.51 µmol/L for SN 1114 and 0.82 µmol/L and 2.72 µmol/L for SN 1120. The calculated LoD and LoQ for SN 1120 compares favourably with the manufacturer’s specifications of 0.3 µmol/L and 2 µmol/L, respectively.

The certified nitrate concentrations in four certified reference materials (CRMs) were measured using the SUNA sensors to assess the *accuracy* or *trueness* of the instrument. The CRMs were three coastal (salinity 35 psu) and one estuarine (salinity 11.1 psu) water.

The results indicated a mean measured concentration of nitrate for the coastal and estuarine water CRMs in good agreement with the certified values for these CRMs. With a lZl score (as defined by the QUASIMEME laboratory proficiency testing scheme) of < l2l this would be well within the acceptable range for laboratory analysis.

The same data was also used to determine *precision*. A coefficient of variation (CV) of <10% was achieved for all CRMs measured for both SUNA sensors.

The results of these CRM measurements are summarised in Tables 4.1 and 4.2.

Sample	Mean value (µmol/L)	CV	n	Assigned value	% difference	z score
CRM SW 4.1 (35 psu)	13.59	2.39	66	14.10	-4%	-0.59
CRM EW 3.1 (11.1 psu)	11.48	3.09	64	11.5	-0.2%	-0.03
CRM CD-1813 (35 psu)	5.01	7.68	65	5.5	-9%	-1.37
CRM CJ-2469 (35 psu)	16.29	2.24	66	16.2	+1%	+0.09

Table 4.1: Summary statistics for measurement of nitrate in CRM samples for SUNA SN 1114.

Sample	Mean value (µmol/L)	CV	n	Assigned value	% difference	z score
CRM SW 4.1 (35 psu)	12.84	2.67	74	14.10	-9%	-1.45
CRM EW 3.1 (11.1 psu)	10.83	3.8	101	11.5	-6%	-0.94
CRM CD-1813 (35 psu)	4.97	7.14	98	5.5	-10%	-1.5
CRM CJ-2469 (35 psu)	15.72	2.14	85	16.2	-3%	-0.48

Table 4.2: Summary statistics for measurement of nitrate in CRM samples for SUNA SN 1120.

Overall the results suggest a negative bias for instrument SN 1120in three out of four samples. These results show that the QUASIMEME acceptance criteria holds true all CRMs measured for both sensors.

4.5.2 Field testing

SUNA sensors were deployed on the COMPASS buoy at Mace Head as part of a suite of oceanographic sensors on three separate occasions as detailed below:

Deployment Date	SUNA Sensor
Jun 2018–Jan 2019	SN 1120
Jan 2019–Sep 2019	SN 1114
Sep 2019–July 2020	SN 1120

During the periods of sensor deployment, sample were taken for analysis of nutrients. Planned sampling was every two weeks, but this was not always possible.

Unprocessed data from data acquisition system (DAS) for the three deployment periods are presented in Figure 4.1. The datasets were cleaned up by removing intermittent data, data spikes and data gaps. The data have been averaged into 30-minute intervals by the DAS. Note the data have not been corrected for temperature and salinity (measured by Seabird CTD). The seasonal variation in nitrate concentration over the deployment period is clearly visible.

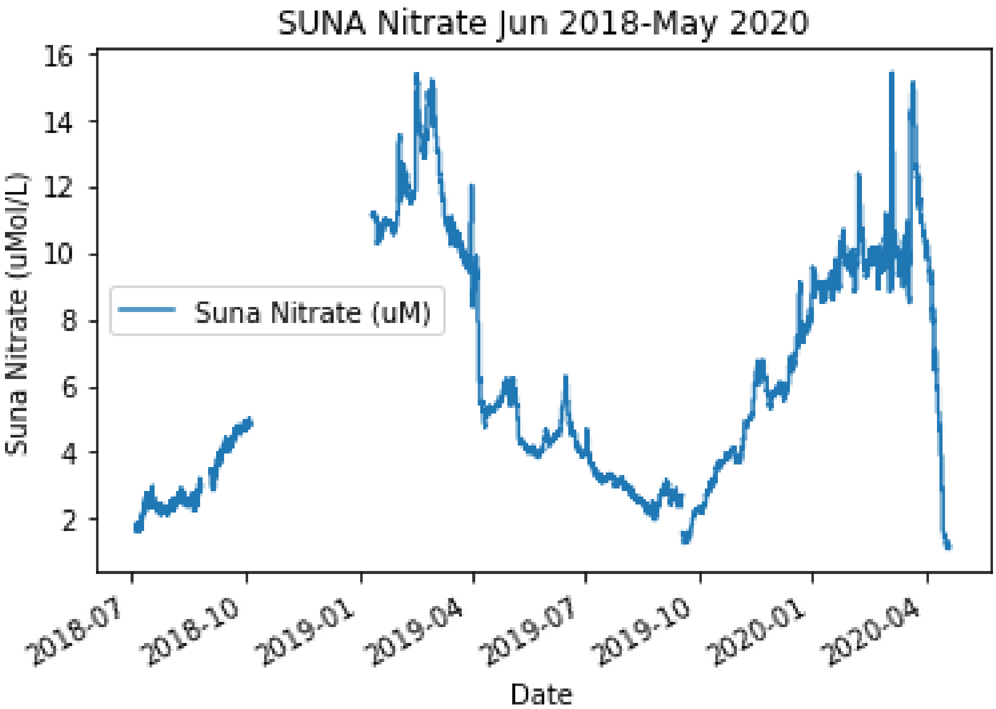


Fig. 4.1. Unprocessed (cleaned) nitrate data collected by SUNA (SN1120+ SN1114) deployed at MI COMPASS buoy from June 2018 to May 2020.

Figure 4.2 shows SUNA data plotted over time with the nitrate results from samples taken at the COMPASS buoy site. There appears to be good agreement between sample nitrate data and SUNA data, particularly for the deployment period Sep 2019 to April 2020. The SUNA data for the period Apr 2019 to Sep 2019 does not match very well with the corresponding sample data. The nitrate concentration is depleted during this period, as expected, but this nitrate depletion is not reflected in the SUNA data. The SUNA data for this period is questionable and should, therefore, be used for any future assessment of the nutrients status.

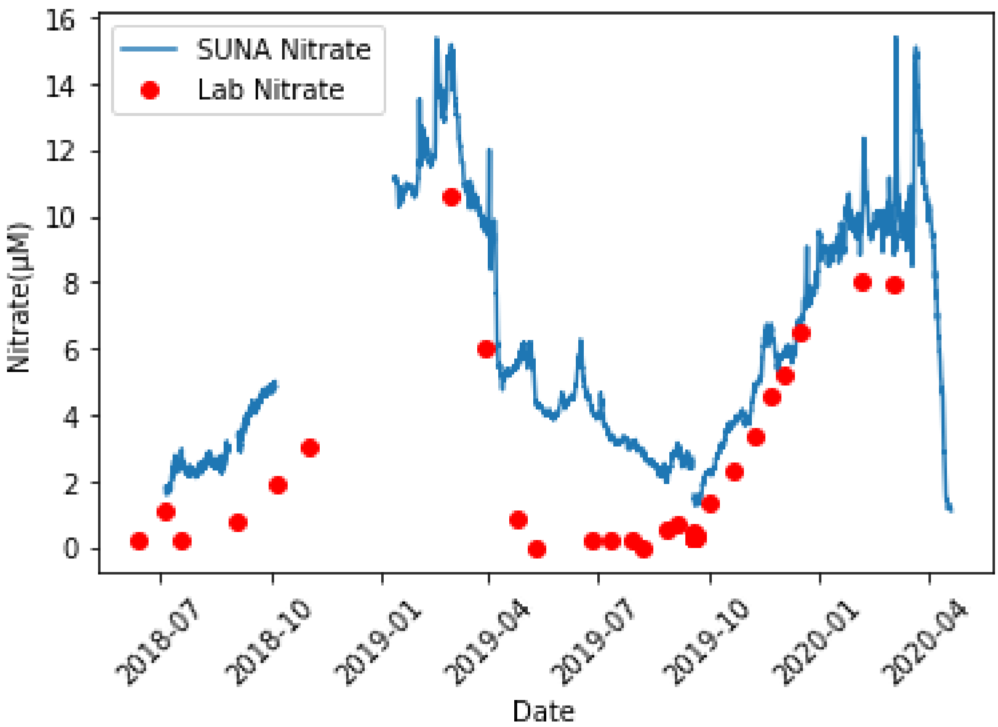


Fig. 4.2. Unprocessed (cleaned) nitrate SUNA data with sample data overlaid at MI COMPASS buoy from June 2018 to May 2020.

Figure 4.3 shows the correlation between sample and sensor data. There was good agreement between laboratory and sensor measurements. Figure 3 indicates a good correlation ($R = 0.975$) across a concentration range of approximately 1–10 µmol/L nitrate but with a slope of 1.16 and an intercept of 0.97. The SUNA appeared to generally overestimate the nitrate concentration compared with laboratory measurements. This positive bias should be corrected for when using nitrate data from this sensor.

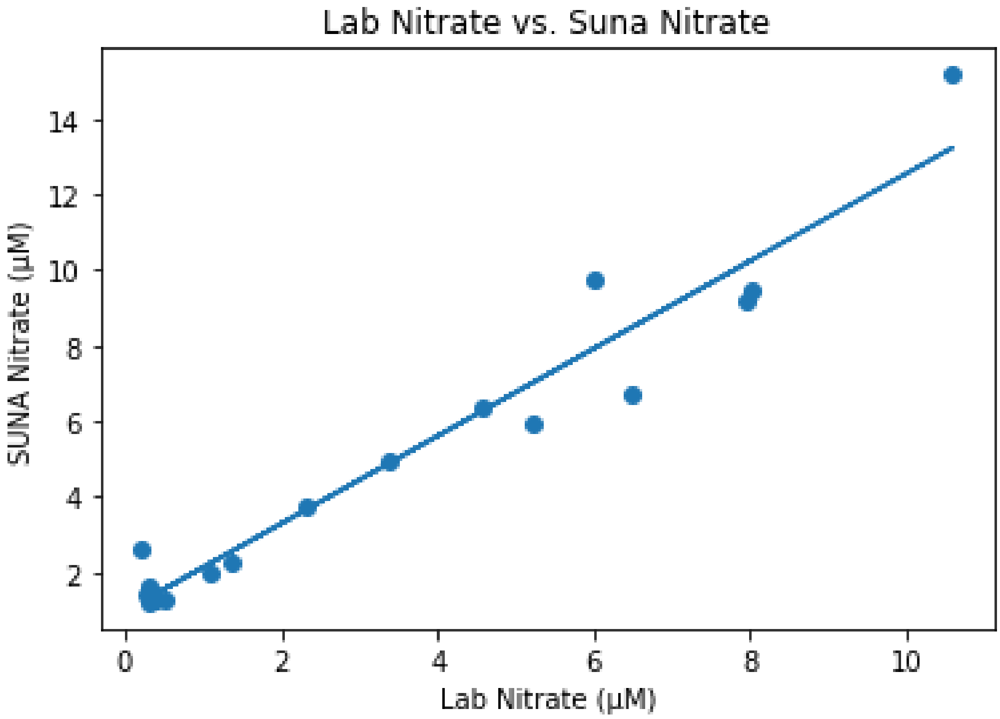


Fig. 4.3. Correlation between sample and sensor data. Note, the SUNA data for the period Apr 2019 to Sep 2019 is not included.

4.6 Summary

Overall, there was good agreement between laboratory and sensor filed measurements. The SUNA appeared to generally overestimate the nitrate concentration compared with laboratory measurements. This positive bias should be corrected for when using nitrate data from this sensor for any subsequent data assessment. The seasonal variation in nitrate concentration over the deployment period is clearly visible and shows that there is an important role for autonomous nutrient sensors in transitional and coastal water monitoring.

5. HydroC pCO_2 Sensor

5.1 Introduction

Carbon Dioxide (CO_2) in the Marine Environment

Ocean acidification is a chemical change caused primarily by the uptake of anthropogenic atmospheric CO_2 by the ocean, which results in an alteration in the chemistry of the seawater. When carbon dioxide dissolves in seawater a chemical reaction occurs and hydrogen ions are released resulting in a decrease in the waters pH. Associated with this change are increased concentrations of bicarbonate ions (HCO_3) and decreased concentrations of carbonate ions (CO_3^{2-}), which control the saturation state of calcium carbonate ($CaCO_3$). There are four parameters of the marine carbonate system which can be measured directly; total alkalinity (TA), pH, partial pressure of CO_2 in solution (pCO_2) and total dissolved inorganic carbon (DIC). Measurements of any two components allow the concentration of the other components of the system to be calculated.

Measurement of CO_2

Natural variability of the marine carbonate system is most pronounced in shelf seas and coastal regions. To distinguish natural variability from changes as a consequence of anthropogenic inputs it is important to undertake high frequency, year round, long-term monitoring, and to obtain the required number and frequency of samples needs the deployment of reliable automated instrumentation.

Contros HydroC Measurement Principle

In the Contros HydroC unit, dissolved gas diffuses from the seawater through a specialised membrane into an internal gas circuit. The gas concentrations are then measured by non-dispersive infrared spectroscopy. The sensor measures in real time - data is stored internally and transmitted via telemetry or downloaded at a later date. Post-deployment, measurement accuracy can be improved through post-processing to correct for instrument drift over time. The instrument can be powered from a cabled installation (ie data buoy) or by a standalone battery pack.

Measurement Range:	200 – 1000 µatm
Resolution:	< 1 µatm
Accuracy:	± 1% of reading
Temperature Range:	+3 to 30°C

5.2 Partners involved

Partner	Status at Phase 1 report	Status at Phase 2 report
AFBI, Northern Ireland	Not deployed	
MI, Ireland	Deployed	
SAMS, Scotland	Deployed	
MSS, Scotland	Deployed	

5.3 Costs

Approx. cost of HydroC Unit:	€25,000
Approx. cost of maintenance/calibration:	€2,500
Approx cost of supporting frame	€3,800
Approx cost HydroC Extra large battery Housing	€7,500
Approx. cost of batteries	€1,500
Approx Cost Internal data logger	€2,200
Approx Cost Copper anti-fouling flow head	€500
Deployment Costs:	Location Specific

5.4 Logistics

<u>Marine Institute</u>

The MI Contros HydroC unit is installed on the Mace Head buoy at 53.3307N, 9.9326W. The unit is mounted on the subsea instrument frame in the central spar of the buoy, approx. 1m below sea level. It is held in place by 2 plastic clamps (Stauff clamps) with stainless steel bolts. A cable with rubber molded connectors runs from the Contros to a subsea junction box. From there, a larger cable brings all subsea connections to the DAS (data acquisition system) box in the top section of the buoy. Data is collected, stored on SD card, and transmitted via email over 3G by a Campbell CR6 datalogger. The data is archived in MI databases upon being received on shore.

The unit is swapped out for service & calibration every 6 months. In tandem with the in-situ measurements, there is a program of water sampling by MI personnel every 2 weeks – analysis of these samples provides a source of validation for the time series data provided by the buoy instruments.

Marine Scotland Science (MSS)

The MSS Contros HydroC is located in Loch Ewe at 57 50.88N, 005 38.94W. Loch Ewe is a sea loch on the west coast of Scotland. The loch has a narrow entrance and is sheltered from the worst of Atlantic storms by the Hebrides Island chain. The coastline outside of Loch Ewe is exposed in a northward direction to the North Atlantic. It is relatively shallow for a Scottish sea loch and has a round shape, only 11 km long, giving it a low aspect ratio (length to width). The loch faces north and has variable exchange with the North Minch, which is influenced by influxes of Atlantic water. There is some riverine influence with 9% of the flow in the loch coming from freshwater (Edwards and Sharples, 1986). The Loch Ewe monitoring site is 40 m in depth and located in the outer basin of the loch, which has a maximum depth of 62 m and a sill depth of 33 m. As the water sampling site is close to the northerly opening of the sea loch, this is an exposed site.

The Hydro C $p\mathrm{CO_2}$ system, which was originally designed integral to the oceanographic mooring, was deployed on a separate adjacent mooring, to facilitate handling and to accommodate a different service schedule. The Hydro C, pump and extra-large battery pack are deployed within an inline mooring frame (See Fig 1) The system has been in place since 26/06/2018, deployed at depth of ~5 m beneath the surface. The system was serviced on a quarterly basis until March 2020.

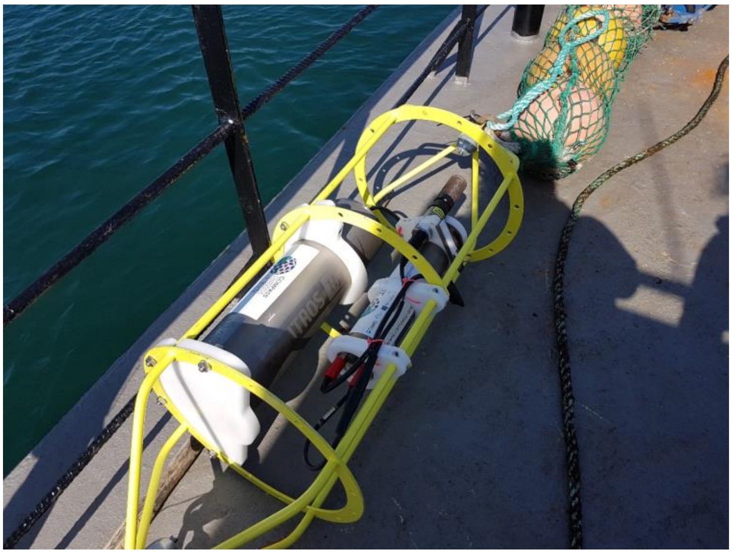


Fig 1. HydroC, pump and extra-large battery pack fitted within inline mooring frame.

References

Edwards, F., Sharples, F. (1986) Scottish sea lochs: a catalogue. Scottish Marine Biological Association; 1986.

Scottish Association for Marine Science (SAMS)

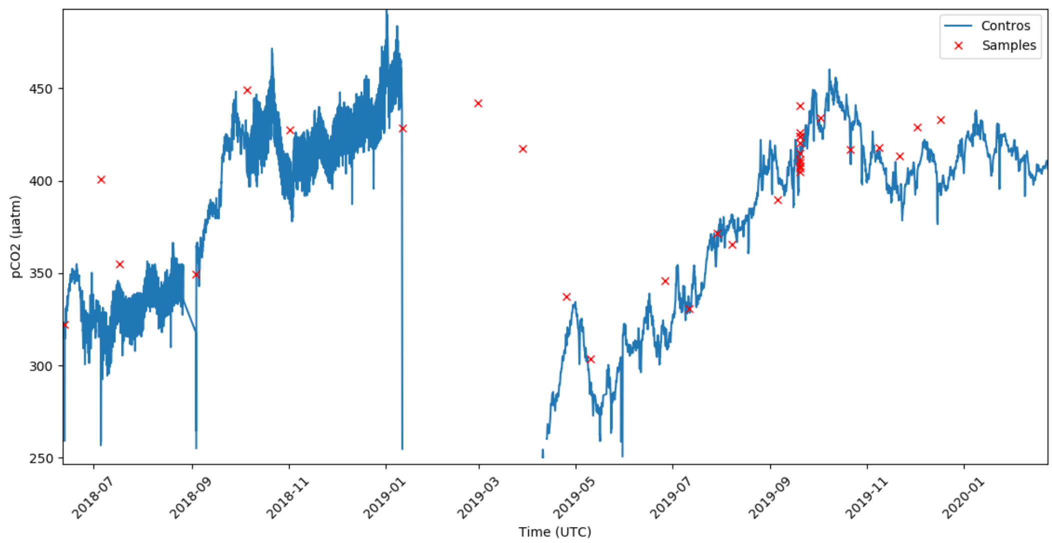
This package has only just been deployed at time of writing. This section to be completed in the Phase 2 report when the deployment logistics are appropriately established.

Agri-Food and Biosciences Institute (AFBI)

This package has not yet been deployed at time of writing and integration into the platform is still underway. This section to be completed in the Phase 2 report when the deployment logistics are appropriately established.

5.5 Performance

The Contros has performed well compared to sample data (see figure) for the Marine Institute at Mace Head, but performance has not yet been evaluated at either MSS or SAMS due to analytical capacity and COVID impacts. Discrete water samples collected in Loch Ewe on weekly basis for Total Alkalinity (TA) and Dissolved Inorganic Carbon (DIC) and it is anticipated will be analysed by at SAMS to allow data comparisons.



MSS identified issues with Hydro C sensor data measuring cycle following the June 2019 download and data review which resulted in drifting measurements. The manufacturer reported they had updated the Hydro C firmware during the instrument calibration at the beginning of 2019. The update in firmware resulted in the instrument no longer going through the initial warmup and flush cycle required when the instrument is not used continuously. The resultant impact was inconsistent measurements. The firmware update could not be removed and an alternative workaround was found and was instigated during the September 2019 maintenance visit. This information was disseminated to the other project partners. This issue only affected the institutes whose instruments were on battery packs and not run continuously. MSS replaced the sensor membrane during a routine visit due to bio-fouling of the membrane. MSS staff followed the guidance given during the initial training workshop and procedures in the instrument manual. However, water ingress as a result of this maintenance resulted in catastrophic damage to the electronics within the Hydro C. All electronic components within the sensor were replaced. It has been recommended to other project partners that institutes do not replace the membrane on their devices even if there is biofouling. The MSS HydroC at Loch Ewe is powered by an external battery pack which limits observations to twice per day.

5.6 Summary

The Phase 1 report summarises new technology integration within COMPASS oceanographic platforms up to mid-2020. Activity to integrate and deploy new technology is ongoing, and specific sections of this report will be completed in Phase 2 when deployment is well established.

6. SeaFET type pH sensors

The Phase 1 report summarises new technology integration within COMPASS oceanographic platforms up to mid-2020. Activity to integrate and deploy new technology is ongoing, and specific sections of this report will be completed in Phase 2 when deployment is well established.

6.1 Introduction

The SeaFET™ V2 is the next generation pH sensor, upgraded from the original SeaFET™. The sensing element is an ion sensitive field effect transistor (ISFET). This class of device has been used for pH sensing in industrial processes, food processing, clinical analysis and environmental monitoring. The advantages of the ISFET include robustness, stability and precision that make it suitable for ocean pH measurement at low pressure. The ISFET potential is measured against two separate reference electrodes: one bearing a liquid junction (internal reference) and a solid state reference electrode (external reference), providing the user with the ability to assess instrument performance and ultimately achieve a greater understanding of the state of acid/base equilibria in seawater.

The SeaFET™ V2 Ocean pH sensor has been used for:

- ocean acidification research
- coral reef research
- coastal marine biology
- environmental monitoring.

6.2 Partners involved

Partner	Status at Phase 1 report	Status at Phase 2 report
AFBI, Northern Ireland	Not deployed	
MI, Ireland	Deployed	
SAMS, Scotland	Deployed	

6.3 Costs

SeaFET V2:
SeapHOx

6.4 Logistics

Marine Institute

The SeaFET unit is installed on the Mace Head buoy at 53.3307N, 9.9326W. The unit is mounted on the subsea instrument frame in the central spar of the buoy, approx. 1m below sea level. It is held in place by 2 plastic clamps (Stauff clamps) with stainless steel bolts. A

cable with rubber molded connectors runs from the SeaFET to a subsea junction box. From there, a larger cable brings all subsea connections to the DAS (data acquisition system) box in the top section of the buoy. Data is collected, stored on SD card, and transmitted via email over 3G by a Campbell CR6 datalogger. The data is archived in MI databases upon being received on shore.

The unit is swapped out for service & calibration every 6 months. In tandem with the in-situ measurements, there is a program of water sampling by MI personnel every 2 weeks – analysis of these samples provides a source of validation for the time series data provided by the buoy instruments.

Scottish Association for Marine Science (SAMS)

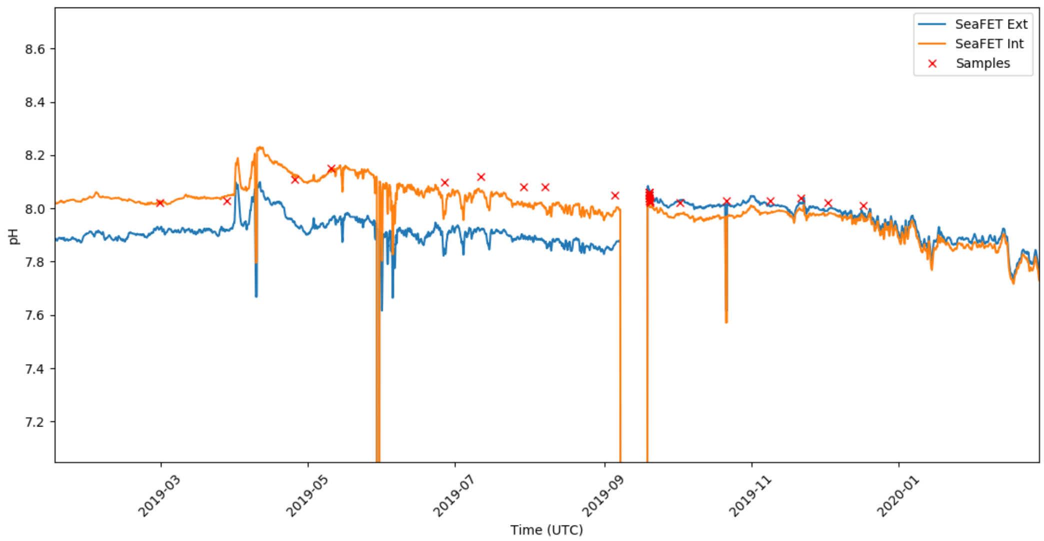
The SeapHOx unit is installed…

Agri-Food and Biosciences Institute (AFBI)

The SeaFET unit is installed…

6.5 Performance

Marine Institute



SeaFET data generally correlates well with sample data, however during one deployment period (see figure above), there was significant discrepancy between internal and external electrode readings, with internal reflecting the true value more accurately. These 2 measurements should be close (<1%??? Verify!) to one another, the discrepancy in this case may have been due to prolonged storage of the sensor.

There was a period (approx. 3 months) in one of the earlier deployments when data became erroneous and the memory appears to be corrupted from that time. The manufacturer has not seen this before, and we are awaiting results of servicing.

SeaFET data may be post-processed to correct for salinity readings of a co-located sensor (CTD). This should improve the accuracy of the pH data.

6.6 Summary

The Phase 1 report summarises new technology integration within COMPASS oceanographic platforms up to mid-2020. Activity to integrate and deploy new technology is ongoing, and specific sections of this report will be completed in Phase 2 when deployment is well established.

7. Platforms

7.1 Introduction

Marine Institute, Mace Head – The platform at Mace Head comprises a Mobilis DB8000 buoy anchored by a dual point mooring. The buoy has been in place since August 2018, apart from a brief redeployment to repair moorings in summer 2020. The buoy is equipped with 1000W of solar panel capacity and two banks of lead-acid rechargeable batteries.
The buoy houses a subsea sensor frame with instruments including CTD, Contros, SeaFET & SUNA. Along with weather data from the mast, data from these are collected by a datalogger and transmitted by 3G modem to MI databases. Data is stored on SD card in the datalogger as well as logged internally in the subsea sensors, so even if telemetry is lost data is still recorded.

MSS, Loch Ewe - The original Data Buoy (offered as in-kind contribution to the project) did not function, therefore an oceanographic mooring with current meters and temperature/salinity sensors was designed and deployed, in addition to a shore-based meteorological station located nearby. Instruments are turned around approximately every 3 months, when deployed instruments are returned to Aberdeen for maintenance and download, and replacement pre-programmed instruments are taken to Loch Ewe for deployment. MSS are took delivery of a new Oceanographic Buoy (OSIL 1.9m Fulmar Buoy) in September 2020 to replace the original Data Buoy, which will in due course replace the metocean sensors currently in place and which will allow real-time access to the raw (un-processed) data via a telemetry system. After initial deployment of the new Data Buoy, anticipated deployment in December 2020, instrument and data access should be more efficient than the current set up and may not require a quarterly instrument turn around. MSS will aim to maximize the compatibility of the new Data Buoy (e.g. in terms of data dissemination) with the AFBI/MI systems.

SAMS, Firth of Lorne –

The Phase 1 report summarises new technology integration within COMPASS oceanographic platforms up to mid-2020. Activity to integrate and deploy new technology is ongoing, and specific sections of this report will be completed in Phase 2 when deployment is well established.

AFBI, Western Irish Sea (38a) –

The Phase 1 report summarises new technology integration within COMPASS oceanographic platforms up to mid-2020. Activity to integrate and deploy new technology is ongoing, and specific sections of this report will be completed in Phase 2 when deployment is well established.

7.2 Partners involved

Partner	Status at Phase 1 report	Status at Phase 2 report
AFBI, Northern Ireland	Not deployed	
MI, Ireland	Deployed	
SAMS, Scotland	Deployed	
MSS, Scotland	Replacement not yet deployed	

7.3 Costs

<u>MSS - Loch Ewe (approx costs)</u>
OSIL 1.9m Fulmar Buoy – TBC

<u>MI - Mace Head Buoy (approx costs)</u>

Refurbishment of Mobilis buoy - €5000
Power System - €5000
CR6 Datalogger - €2000
Telemetry - €1000
Sensors – Weather station €1500, subsea sensors as described in other sections
Integration and build – Undertaken in-house

<u>SAMS – Firth of Lorne (approx costs)</u>

The Phase 1 report summarises new technology integration within COMPASS oceanographic platforms up to mid-2020. Activity to integrate and deploy new technology is ongoing, and specific sections of this report will be completed in Phase 2 when deployment is well established.

<u>AFBI – Western Irish Sea (approx. costs)</u>

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7.4 Logistics

MSS - Loch Ewe

The OSIL 1.9m Fulmar Buoy is used extensively in coastal, estuarine and fjordic environments in water depths from 10m to 100m or more. Deployment of the buoy will require the use of a vessel larger than the one used to service the current mooring in place. Planned deployment from the Marine Scotland vessel MRV Scotia was October 2020 but had to be delayed to December 2020 due to logistical reasons. All electronics housing used are IP68 rated and fitted with Subconn wet mateable connectors to ensure they are water tight and serviceable in the field. The Buoy is self-ballasting making deployment in shallow waters easier and the buoy more stable in adverse weather conditions. The buoy benefits from a large moon pool that allows the safe installation of sensors within the buoy.

The 1.9m Fulmar buoy is supplied with 2 x 119Ah Lead Acid batteries that are securely housed within the buoy top section and are easily replaced via the service hatch. The buoy is also fitted with 4 x 75W solar panels and solar regulator for autonomous operation 24/7. Based on OSIL's preservative calculations the 1.9m Fulmar buoy would be operating at 45.5% capacity with meteorological and oceanographic sensors powered 24/7. The buoy would also have a 6 day back up assuming zero input from the solar panels. The OSIL Fulmar buoy has 1.8A surplus current based on winter daylight hours and solar intensity for Aberdeen allowing plenty of scope for additional sensors to be added in the future. All sensors proposed are powered from the buoy so are not limited to their battery capacity for deployment periods.

The OSIL Fulmar Buoy is 1.9m in diameter. The buoy weighs approx. 960kg and has ~2000kg of buoyancy with a reserve buoyancy of ~1000kg. The Buoy hull is manufactured from UV stabilised polyethylene hull sections that surround a painted steel central structure with anodic protection, this provides a very strong yet lightweight buoy that is easily handled by small craft. The top section is manufactured from marine grade aluminium to keep weight to a minimum and remain able to withstand rough sea conditions.
The 1.9m Fulmar buoy is supplied as standard with a Carmanah M650 Marine Beacon which has a 4NM range. The buoy is also supplied with an Echomax EM180 Radar Reflector giving a maximum of 8.1sq.m of radar cross section area.

The OSIL 1.9m Fulmar buoy has a moon pool structure which allows sensors to be deployed in a protected environment. The Moon pool has a set of guide wires and sensor frame that can slide up and down the wires allowing instruments to be lowered and recovered from the moon pool without recovering the buoy. The brackets that attach to the deployment frame are relatively inexpensive (~£350 per instrument) and can be ordered for different sensors if we wish to add or use different sensors in the future.

Sensors to be deployed initially include a MaxiMet GMX500-GPS for meteorological observations, an Aquadopp 400kHz profiler for currents, an SBE37 for temperature and salinity, and a Brizo X wave sensor.

<u>MI - Mace Head Buoy</u>

The Mobilis DB8000 buoy at Mace Head was in use in previous years for various other projects in the Marine Institute. For the COMPASS project, the buoy structure was refurbished (rewelded, repainted, inspected for any defects), and equipped with new solar panels (Victron 100W mono-crystalline). A new subsea frame and hold-down mechanism was also installed to house the sensors. Dual battery boxes were outfitted with 12V AGM lead-acid batteries. Eight of these at 125Ah each gives a total power capacity of 1000Ah. The batteries are charged by 5 Victron MPPT charge controllers – each of these controls the charging from one face of the buoy (5 faces each with 2 x 100W solar panels connected in series).

Buoy electronics are housed in an 800 x 500 x 400mm aluminum waterproof box which was built in-house for purpose. Power from the batteries is supplied to a Campbell CR6 datalogger which then powers the various sensors via relays. Connection to the subsea frame is by a SubConnn 21 core cable with rubber molded connectors. This connects to a subsea junction box mounted on the sensor frame from which smaller cables are connected to the individual instruments. Topside, the CR6 is also connected to a Gill GMX600 weather station (earlier in the deployment the weather station was an Airmar WX200). The electronics box also houses a Campbell COM111 3G modem, which is used to transmit data by email twice daily. The buoy is fitted with a Carmanah navigation beacon and St. Andrews cross (special mark).

The buoy is moored with a dual point mooring system – each leg of the mooring comprise a 3T sinker, 50m of 38mm ground chain, and 30m of 26mm chain. These are connected to the buoy with 26mm chain bridles. Anodes are bolted to the mooring along the chain to minimize corrosion, and these are replaced at regular intervals. Total weight of the mooring is almost 10T, and the buoy weighs around 3T. This requires quite a large vessel for deployment, as a crane with sufficient lifting capacity and large deck space are needed. One leg of the mooring is deployed first, then the buoy is transferred to the water, then the second leg is slowly deployed, and then pulled to stretch the mooring to a catenary shape.

The subsea sensor frame is housed within the buoys moon pool, and fitted on a pulley system so that the frame can be lifted and replaced without recovering the buoy. Sensors are attached to the frame using plastic clamps and stainless steel bolts. The frame is swapped out every 6 months to allow for service and calibration of instruments.

7.5 Performance

MSS - OSIL 1.9m Fulmar Buoy – not yet deployed so performance compared with existing mooring set up cannot be compared

MI Mobilis Buoy – The buoy has performed very well over 2 years on site, with numerous Atlantic storms directly impacting the area. The mooring was damaged in one of these storms (February 2020) when the western leg of the mooring was broken and the buoy drifted to the east. The eastern leg held the buoy in place until a temporary repair was carried out in March 2020. In July, the buoy was brought in for maintenance/inspection and was redeployed with a full new mooring.
There were several brief data outages over the course of the 2 years due to telemetry service issues, but these were quickly solved. There has been plenty of power on the buoy, with full battery charging from the solar panels every day even through the winter months.

<u>SAMS – Firth of Lorne</u>

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<u>AFBI – Western Irish Sea</u>

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7.6 Summary

The Phase 1 report summarises new technology integration within COMPASS oceanographic platforms up to mid-2020. Activity to integrate and deploy new technology is ongoing, and specific sections of this report will be completed in Phase 2 when deployment is well established.

8. Telemetry

The Phase 1 report summarises new technology integration within COMPASS oceanographic platforms up to mid-2020. Activity to integrate and deploy new technology is ongoing, and specific sections of this report will be completed in Phase 2 when deployment is well established.

8.1 Introduction

8.2 Partners involved

Partner	Status at Phase 1 report	Status at Phase 2 report
AFBI, Northern Ireland	Not deployed	
MI, Ireland	Deployed	
SAMS, Scotland	Not Deployed	
MSS, Scotland	Replacement not yet deployed	

8.3 Costs

8.4 Logistics

<u>MSS</u>

The CR6 datalogger is supplied with a 16GB SD card for internal storage of all data. The system as standard comes with GSM/GPRS hardware (SIM is an additional cost) and Campbell Scientifics Loggernet software. The Loggernet software allows a connection to the buoy from your PC and set up automatic download schedules. You can also update settings and measurement schedules remotely as well as check the function of the system. OSIL have quoted as an option a Fixed Public IP SIM to facilitate the GSM telemetry. We have also quoted as an option a secure hosted web platform that provides a graphical display of real-time data. This can be accessed by multiple users via any PC or mobile device with internet connection, the page is password protected for. The Web hosted service also allows alarms to be set against any measured parameter including GPS and emails sent to clients in the event of thresholds been broken. Historic data can be downloaded in a variety of formats including Excel.

Marine Institute

Data from all sensors is sampled half-hourly and stored internally on an industrial grade 8GB single layer SD card by the CR6 datalogger. Data is also logged internally by each sensor. Every 12 hours, data is transmitted by email (3G modem) to an MI email account and a gmail account. From there, the data tables are automatically downloaded and incorporated into MI databases.

8.5 Performance

Marine Institute

Data was initially sampled at 10 minute frequency, and transmitted every 4 hours. This was scaled back to half-hourly samples and 12-hourly transmission in January 2019. The high volume of data was taking up large amounts of memory and deemed unnecessary. Performance of the system has been very good, with only minor outages due to service issues.

8.6 Summary

The Phase 1 report summarises new technology integration within COMPASS oceanographic platforms up to mid-2020. Activity to integrate and deploy new technology is ongoing, and specific sections of this report will be completed in Phase 2 when deployment is well established.

9. Data Processing

The Phase 1 report summarises new technology integration within COMPASS oceanographic platforms up to mid-2020. Activity to integrate and deploy new technology is ongoing, and specific sections of this report will be completed in Phase 2 when deployment is well established.

9.1 Introduction

The data generated by the SUNA and SeaFET sensors and can be re-processed post deployment using Seabird software: UCI software for the SUNA and SeaFET.com software for the SeaFET. The user may wish to re-process the data collected if separate water temperature and salinity (T/S) data are collected, for example using a Seabird CTD. The T/S data can be added to the spectral data from the SUNA to get more accurate nitrate data. Likewise, SeaFET pH data can be improved by providing external T/S data from a Seabird CTD.

9.2 Partners involved

Partner	Status at Phase 1 report	Status at Phase 2 report
AFBI, Northern Ireland	Not deployed	
MI, Ireland	Deployed	
SAMS, Scotland	Not Deployed	
MSS, Scotland	Replacement not yet deployed	

9.3 Methods

<u>SeaFET data processing</u>

SeaFETCom is an interactive graphic software application that can be used to:

- Review and modify SeaFET operational settings
- Schedule SeaFET data collection activity

- Manage and retrieve logged SeaFET data
- View SeaFET data in real time
- **Reprocess SeaFET data and graph results**

To re-process SEAFET data files:

1. Load data files (data files are downloaded from sensor, saved in folder and loaded to software)
2. Load SeaFET calibration file (this can be taken from the SeaFET data file header)
3. Specify T/S data (T/S data from an external file in .csv or .cnv format)

4. Specify output directory
5. Process selected files

Note: The csv file should be in the following format:

YYYY-MM-DD hh:mm:ss, temperature,salinity

e.g. 2019-04-25 15:22:48,10.8326,34.8974

The figure below shows a graph of unprocessed and processed pH data (Int and Ext) for SeaFET data for April 2019.

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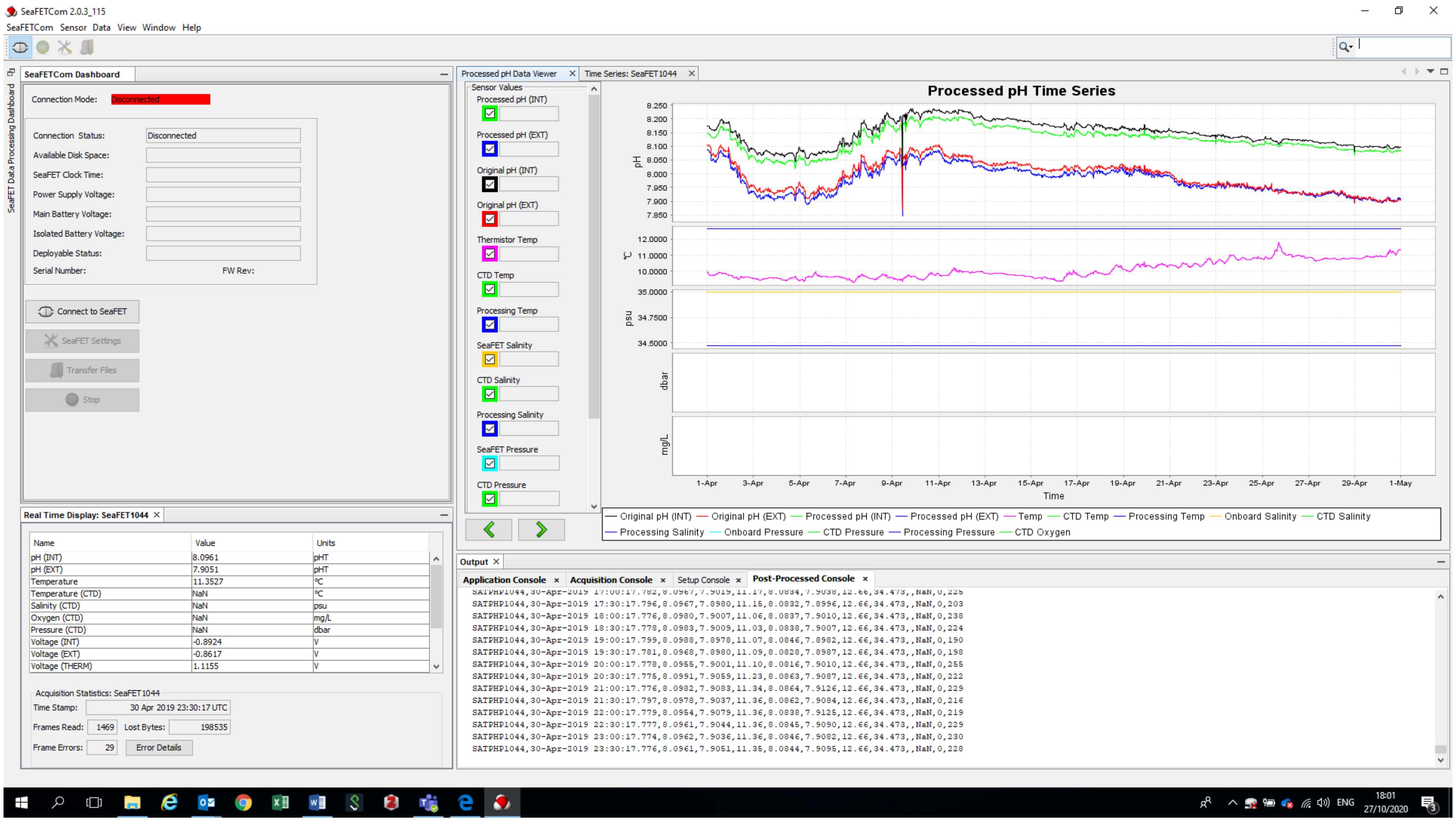

afbi AGRI-FOOD & BIOSCIENCES INSTITUTE
SAMS
The Scottish Government
marine scotland science
Iascach Intíre Éireann Inland Fisheries Ireland
Marine Institute Foras na Mara

SUNA data processing

SUNA data is re-processed in a similar way th seaFET data. The Seabird software UCI is used to re-process SUNA data. To re-process SUNA data files:

1. Load nitrate data files (data files are downloaded from sensor, saved in folder and loaded to UCI software)
2. Load "Instrument Package File" (an.xml file that describes the data from the sensor)
3. Load "Calibration File" (Use the calibration file that matches the time during which data was collected. Calibration files are stored in the sensor unless the user erases them).
4. Specify T/S data (T/S data from an external file in .csv or .cnv format)
5. Specify output directory
6. Process selected files

The figure below shows a graph of unprocessed and processed nitrate data for SUNA for 1st Jan 2019.

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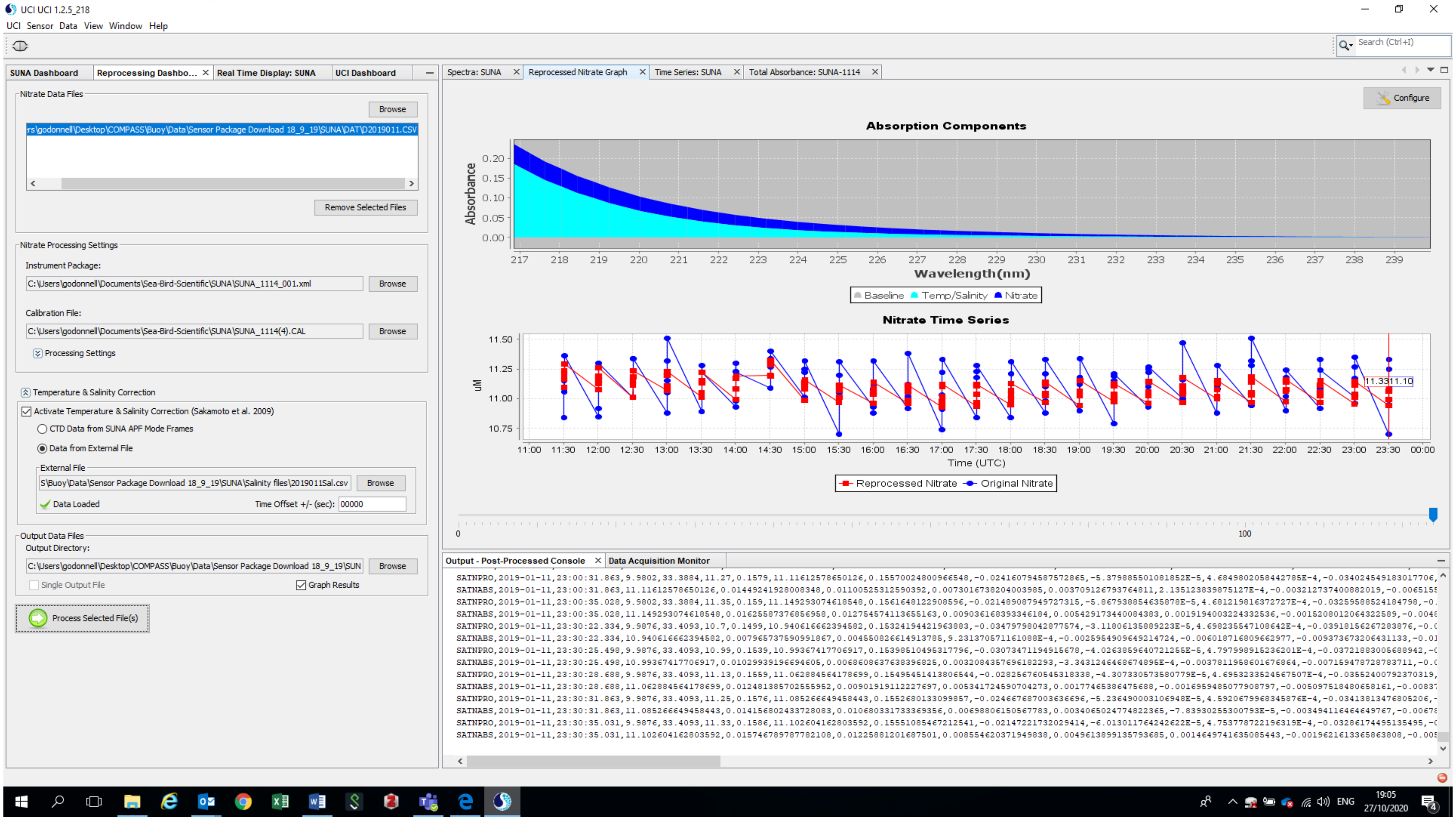

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9.4 Summary

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10. Summary

The Phase 1 report summarises new technology integration within COMPASS oceanographic platforms up to mid-2020. Activity to integrate and deploy new technology is ongoing, and specific sections of this report will be completed in Phase 2 when deployment is well established.