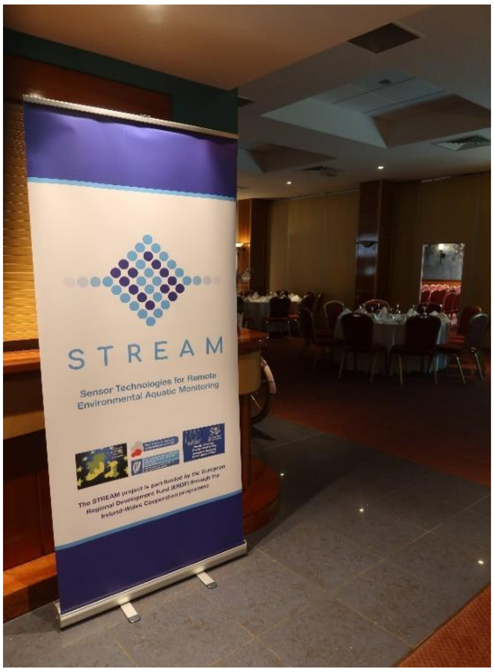
STREAM End of Project Conference 21st June 2023

Sensor Technologies for Remote Environmental Aquatic Monitoring

Dooleys Hotel Waterford



STREAM

Sensor Technologies for Remote Environmental Aquatic Monitoring

The STREAM project is part-funded by the European Regional Development Fund (ERDF) through the Ireland-Wales Cooperation programme

Sensor Technologies for Remote Environmental Aquatic Monitoring (STREAM) end-of-project conference was held at Dooleys Hotel, Waterford, on June 21st, 2023

The STREAM project is a partnership between Ireland and Wales focusing on cross-border collaboration, cost-effective marine observation, and climate change monitoring. The conference brought together experts from the South East Technological University (SETU), Munster Technological University (MTU), and Swansea University (SU), which has contributors from the Welsh Centre for Printing and Coating (WCPC) and the Centre for Sustainable Aquatic Research (CSAR).

STREAM had secured substantial funding of €4.3 million over five years from the European Regional Development Fund (ERDF), specifically under Priority 2 - Adaptation of the Irish Sea and Coastal Communities to Climate Change. To support its work on developing cost-effective systems for seawater analysis, methodologies for harmful algal bloom monitoring, deployment of an environmental network of sensors broadcasting live data, and conducting fish behavioural studies in the light of environmental change. See: www.marinestream.eu STREAM has also received significant guidance from WEFO and the Southern Regional Assembly.

The conference aims were to share the project's advancements and promote an understanding of the importance of measuring and assessing environmental/ water quality change to help coastal communities and stakeholders better comprehend climate change. The conference also provided an excellent opportunity to meet with various specialists, state agencies and commercial companies to discuss and see the available technologies.

Contents

STREAM is part funded by the European Regional Development Fund (ERDF)

Registration for STREAM end of project conference at Dooleys Hotel Waterford 21st June 2023

At 9:00 the registration opened for the day and this was managed by Ailish Tierney (SETU).

STREAM project introduction and presentations

The STREAM conference proper began at 9:30, and Dr Peter McLoughlin, Head of School (Dean) of Science & Computing at the South East Technological University and Principal Investigator in the Pharmaceutical and Molecular Biotechnology Research Centre (PMBRC) made the opening welcoming remarks for the conference.

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Dr Joseph O'Mahony, Principle Investigator (SETU) then provided greetings and an introduction to the STREAM project and delivered his appreciation and an acknowledgement of all that had contributed to the project. Dr O'Mahony also outlined the threat of climate change.

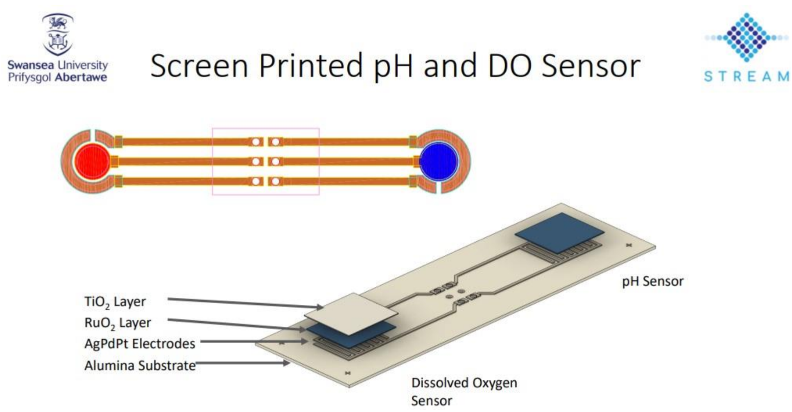
Welsh Centre for Printing and Coating (WCPC) Swansea University

Dr Ben Clifford (SU, WCPC) then presented a talk on "2D Printed Sensors and Their Applications" on behalf of his colleagues Prof David T Gethin, Dr Tim Mortensen and Dr Y C (John) Lau.

Ben spoke about seawater monitoring challenges and that currently available commercial systems are accurate but very expensive. For example, a multiparameter Sonde and sensors can typically cost £30k. This price tag prevents widespread monitoring of aquatic environments as it is too costly for farm adoption. But printable sensors offer the potential for lower-cost solutions. For these sensors to measure a range of parameters, they can be fabricated as an integrated system. But the challenges include the accuracy of measurements, so they need calibration against laboratory and commercial devices. They must also be robust to survive in a harsh environment with a good working duration.

The potential for printed sensors are as follow:

1. Temperature (5 - 25°C)
2. Conductivity
3. pH (6-10)
4. Dissolved oxygen (0-20mg/l)
5. Salinity (0-50pss) – via conductivity
6. Total dissolved solids (0-60g/l) – via conductivity and temperature



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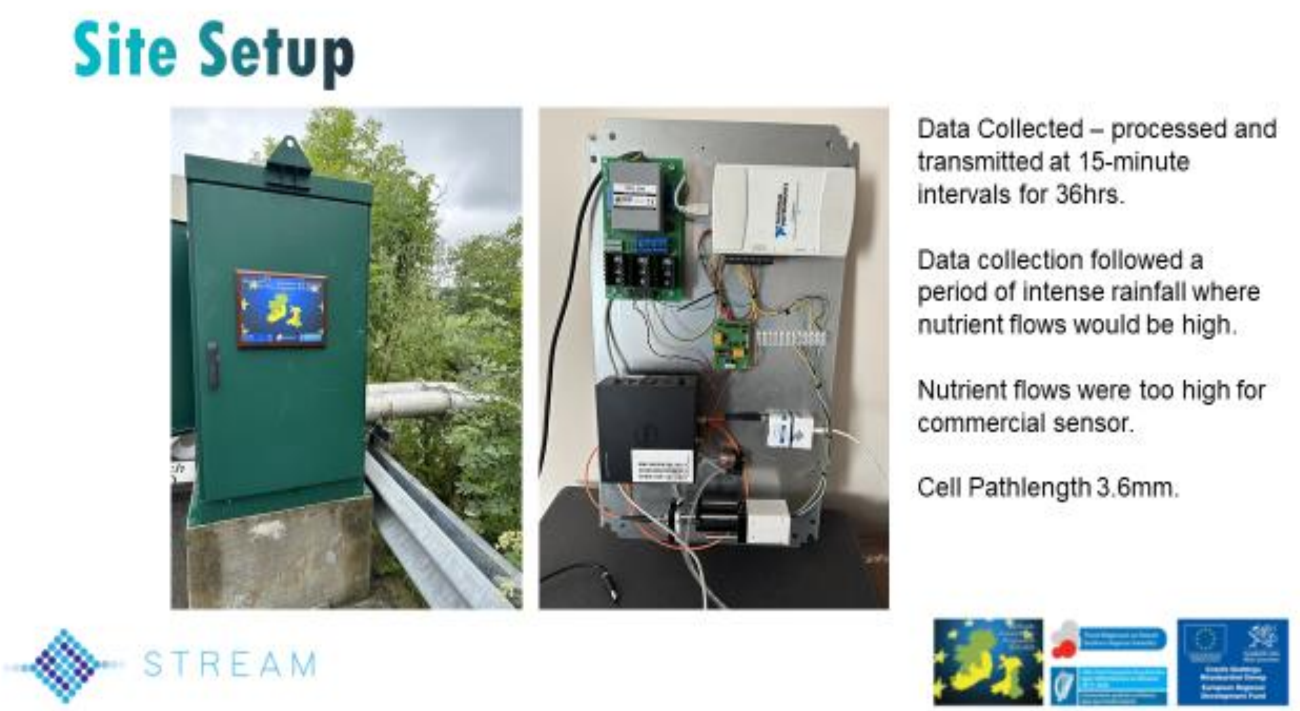
South East Technological University (SETU)

Dr Joseph O’Mahony (SETU) discussed MEMS Spectrometers with Edge Processing for Nutrient Evaluation in seawater as a SETU presentation of optical sensors. Nutrients are obviously very important to any healthy ecosystem however if found in too high levels, eutrophication occurs with excessive amounts of plant and algae growth in estuaries and coastal waters. These events are obviously detrimental to aquatic life and can result in a significant decline in biodiversity.



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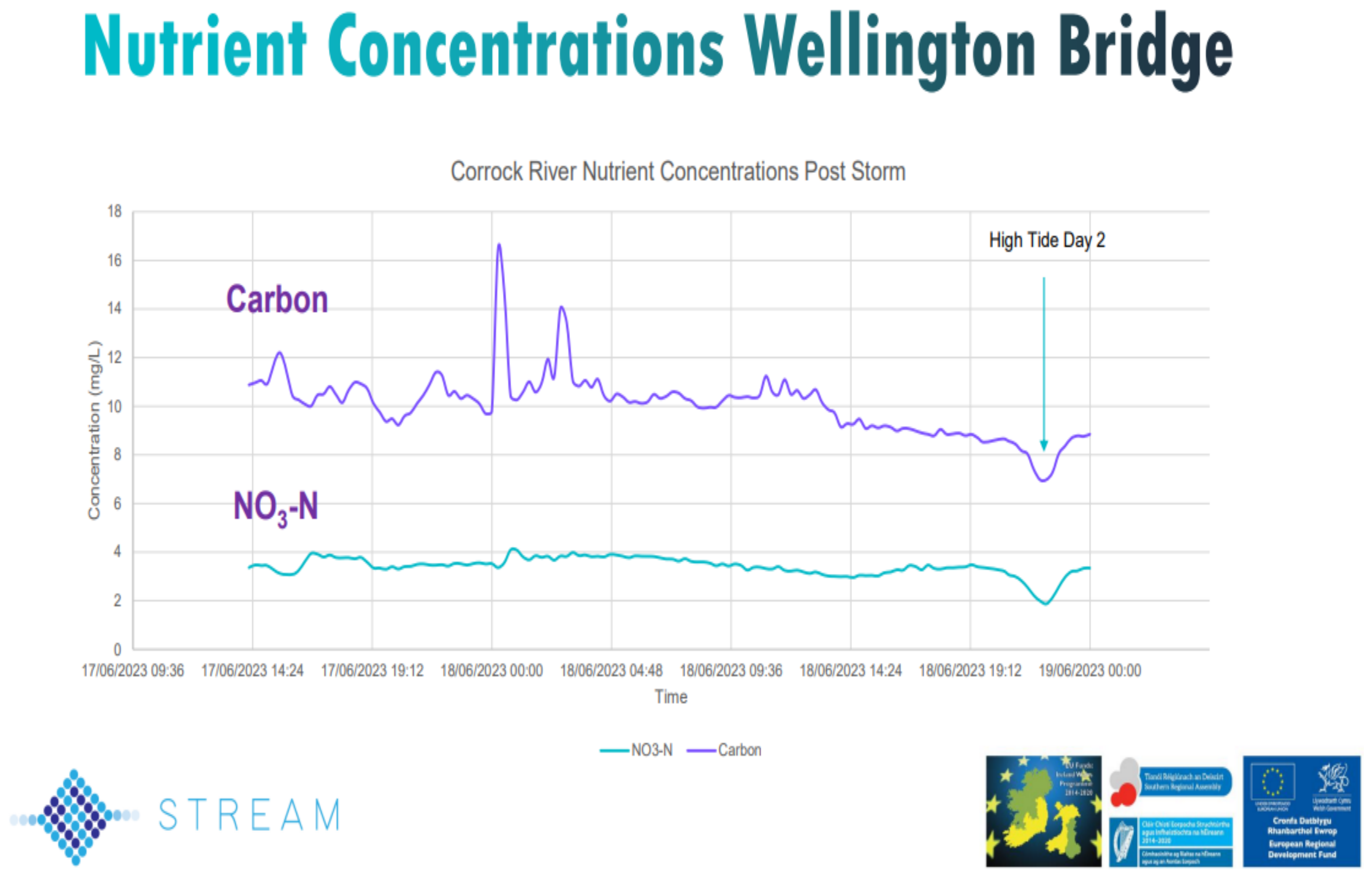
Dr O'Mahony then described a trial deployment of his nutrient sensor over several days in June 2023 at Wellington Bridge and provided slides showing his sensor's readings. These readings he explained are similar to those that were recorded on a more costly commercial sensor unit and also the results are in keeping with those from accredited laboratory analysis.



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STREAM (South East Technological University)

Dr Ronan Browne (STREAM) recounted the objectives of STREAM and what is being learnt from the STREAM project, using sensors to monitor and assess the environment. Only by monitoring and measuring can we understand the actual localised impacts of climate change.

Ronan also described the experience from ongoing work in Bannow Bay, where STREAM generated data using a commercial sonde that provides helpful information to oyster farmers with information available from their personal computers. Oysters are grown in mesh bags on the shore and their environmental greatly influences there development and survival.

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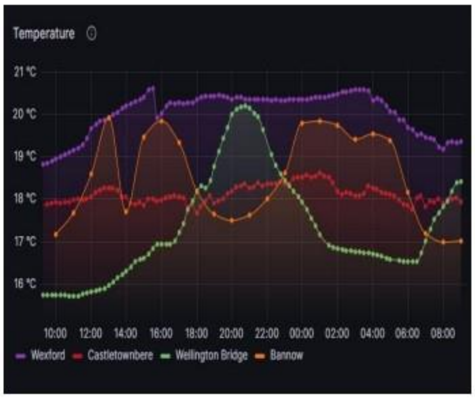
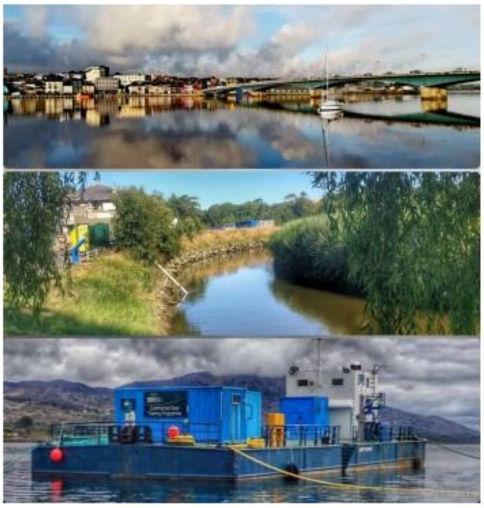
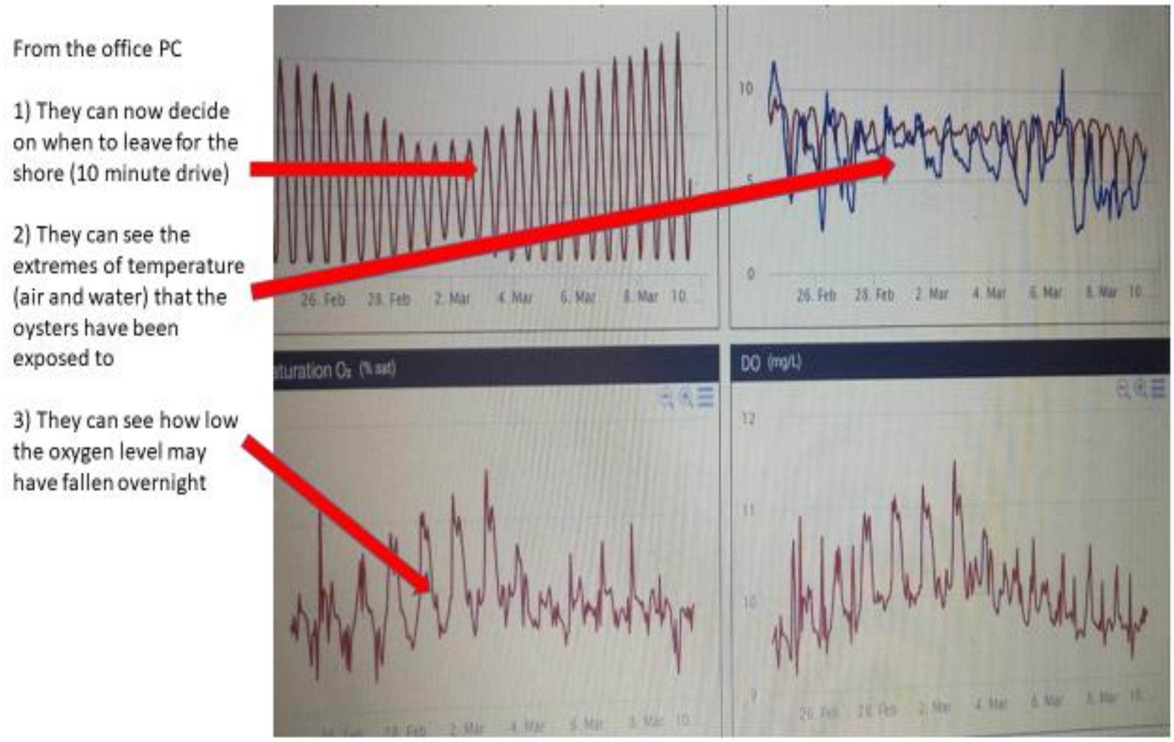
Data for sites available live and also historically (an excel file each month)





This data shown from Bannow bay below includes the height of the tide in relation to the oysters, the temperatures against which oyster growth can be measured and the amount of dissolved oxygen at a given time.



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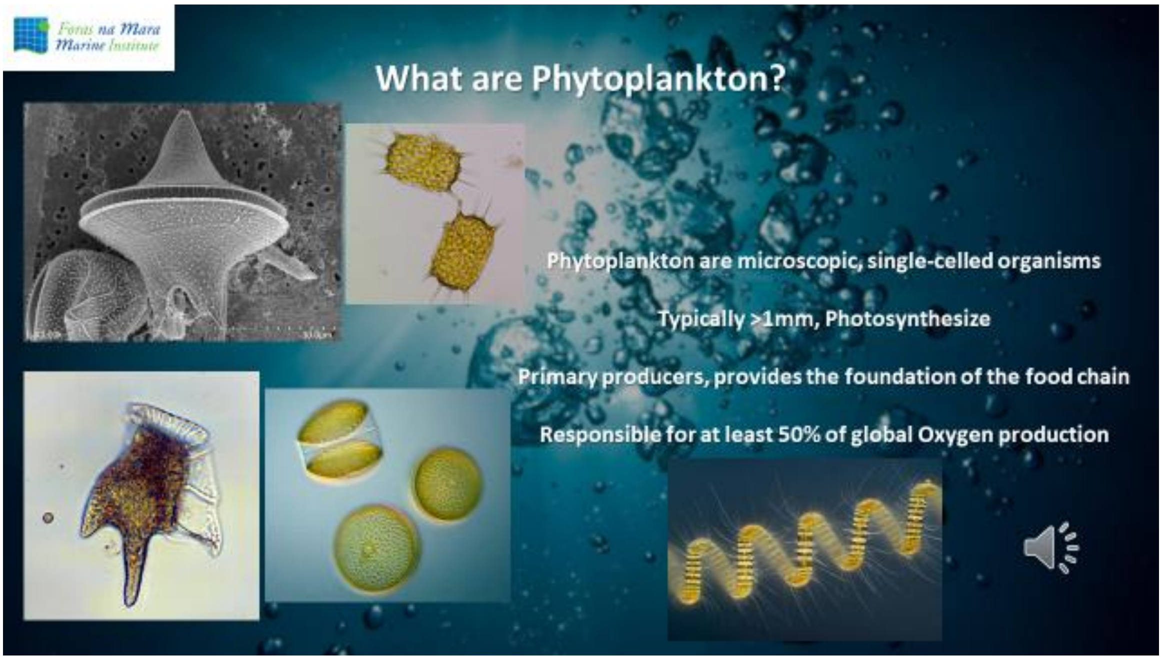
Marine Institute (MI)

Jonathan Kelly, a phytoplankton taxonomist at the Marine Institute (MI), subsequently provided an interesting recorded talk about the work of the MI and the monitoring for harmful algal blooms (HABs) around Ireland.



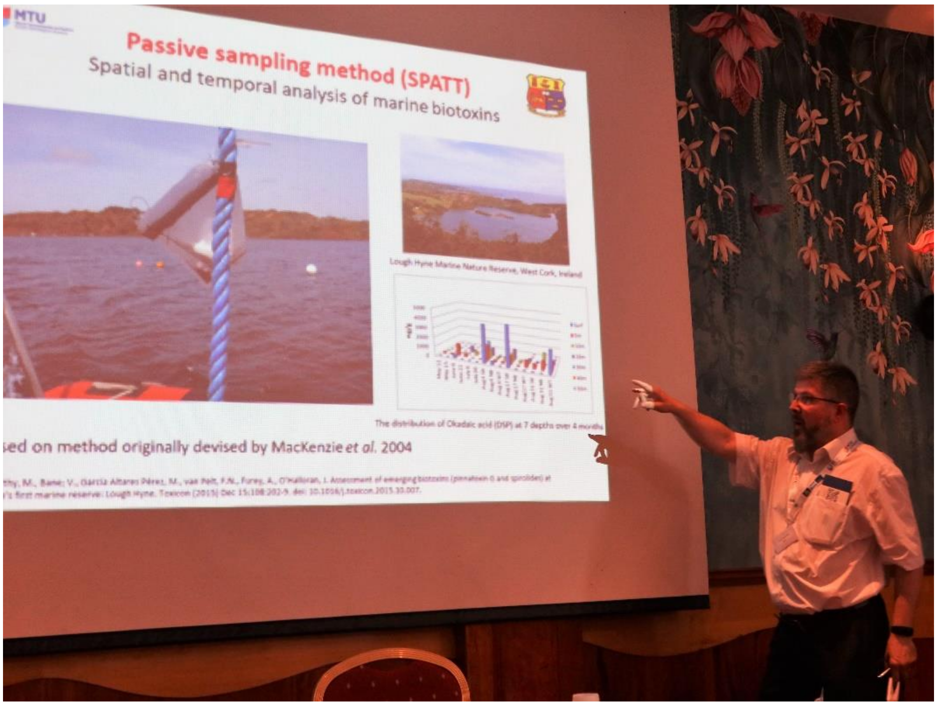
Phytoplankton are essential to the functioning of aquatic habitats and deliver essential services to our planet, such as the oxygen we breathe (at least 50% of the oxygen in our atmosphere). They also draw down significant portions of the carbon dioxide from the air, pride the basis of the marine food chain and cycle nutrients.

Jonathan noted that phytoplankton in coastal waters are abundant from February to October and that diatom blooms occur in both spring and autumn, with higher abundances in the spring. There is an overall increase in monthly cell abundance for the total Phytoplankton community from 2012 to 2020 compared to 2003 to 2011. He also mentioned that there have been higher levels of phytoplankton are observed in late autumn and winter (October to January). Johnathan also reported that the MI are seeing some changes in community structures, increases in Diatom abundance with a reduction in diversity and abundance of dinoflagellates, with the exception of *Alexandrium* sp.

Munster Technological University (MTU)

After the Marine Institute presentation Dr Ambrose Furey and Mike Grew (MTU) gave an informative presentation on 'marine biotoxin sampling and the active accumulation with preconcentration and passive sampling, supporting aquaculture decision-making with coastal and estuarine environmental data.'

Dr Furey described the five major toxic syndromes, which include Diarrhetic Shellfish Poisoning (DSP), Azaspiracid Shellfish Poisoning (AZP), Amnesic Shellfish Poisoning (ASP), Paralytic Shellfish Poisoning (PSP) Saxitoxin and Neurotoxic Shellfish Poisoning (NSP) Brevetoxins. MTU are working on an early warning system using Solid Phase Adsorption Toxin Tracking (SPATT) allowing for an in-situ adsorption sampling can notify stakeholders when a harmful toxic algal bloom is imminent.



Mike Grew provided an in depth description of the equipment and methodologies for modular biotoxin bulk sampling’ on the BIM barge (Castletownbere) that will collect and concentrate phytoplankton using submersible pumps and with sensors.

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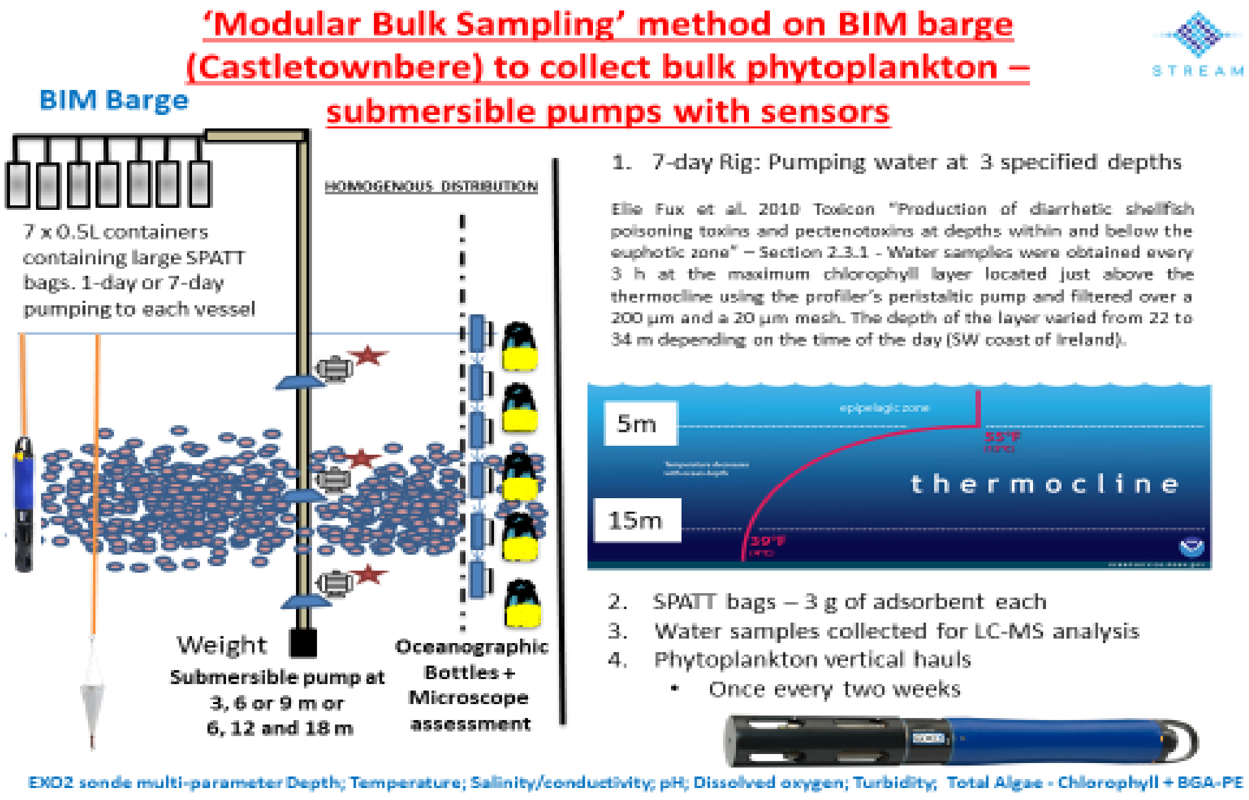
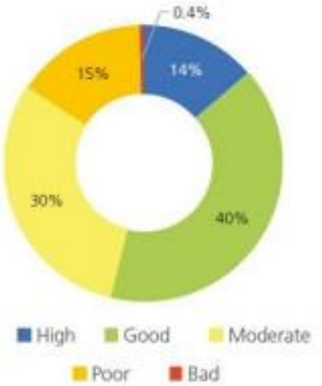

'Modular Bulk Sampling' method on BIM barge (Castletownbere) to collect bulk phytoplankton – submersible pumps with sensors
STREAM
BIM Barge
7 x 0.5L containers containing large SPATT bags. 1-day or 7-day pumping to each vessel
HOMOGENOUS DISTRIBUTION
1. 7-day Rig: Pumping water at 3 specified depths
Elie Fux et al. 2010 Toxicon "Production of diarrhetic shellfish poisoning toxins and pectenotoxins at depths within and below the euphotic zone" – Section 2.3.1 - Water samples were obtained every 3 h at the maximum chlorophyll layer located just above the thermocline using the profiler's peristaltic pump and filtered over a 200 µm and a 20 µm mesh. The depth of the layer varied from 22 to 34 m depending on the time of the day (SW coast of Ireland).
5m
15m
thermocline
Weight
Submersible pump at 3, 6 or 9 m or 6, 12 and 18 m
Oceanographic Bottles + Microscope assessment
2. SPATT bags – 3 g of adsorbent each
3. Water samples collected for LC-MS analysis
4. Phytoplankton vertical hauls
• Once every two weeks
EXO2 sonde multi-parameter Depth; Temperature; Salinity/conductivity; pH; Dissolved oxygen; Turbidity; Total Algae - Chlorophyll + BGA-PE

Lunch

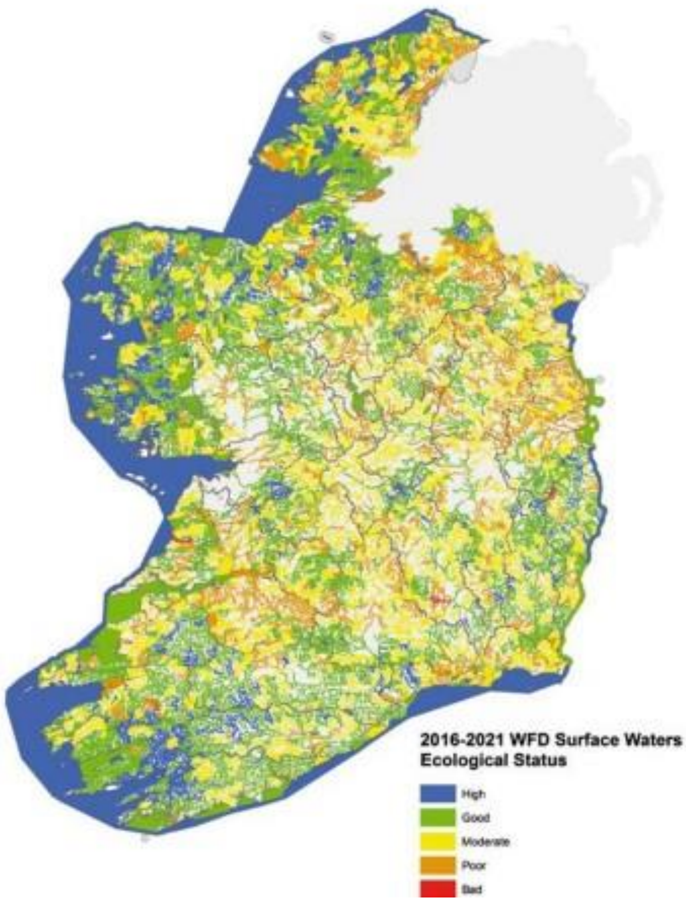
Environmental Protection Agency (EPA)

Dr Robert Wilkes of the Environmental Protection Agency (EPA) Ecological Monitoring and Assessment unit, provided a comprehensive view of Irish coastal and transitional waters monitoring, and their findings which show the deterioration in water quality.

Dr Wilkes drew the audience's attention to the EPA report "Water Quality in Ireland 2016 to 2021" in which it was reported that the "assessment shows that over half (54%) of our surface waters are in good or better ecological status which means that nearly half (46%) are in unsatisfactory condition. Overall, our water quality has declined. The number of water bodies in satisfactory condition in our estuaries and coastal waters has declined by almost 16 percent and 10 percent respectively since the last assessment (2013-2018).



Proportion of all surface water bodies in each ecological status class 2016-2021



Wexford County Council

Brendan Cooney of Wexford Co. Co. presented a great insight into some of the work that is being done by his colleagues and the council in monitoring our environment.

Brendan engagingly spoke about the challenges facing Wexford County's environment, past, present and future. He described the environmental department's commitment to protecting the environment and many related responsibilities, such as protecting water and air quality while managing various other concerns. The environmental department in Wexford was also at the forefront in Ireland of establishing cost-effective air quality monitoring units that changed the use of solid fuels in the region. Wexford Co. Co. has also provided sites and the infrastructure needed for STREAM-deployed sensors in the country.

Board Iascaigh Mhara (BIM)

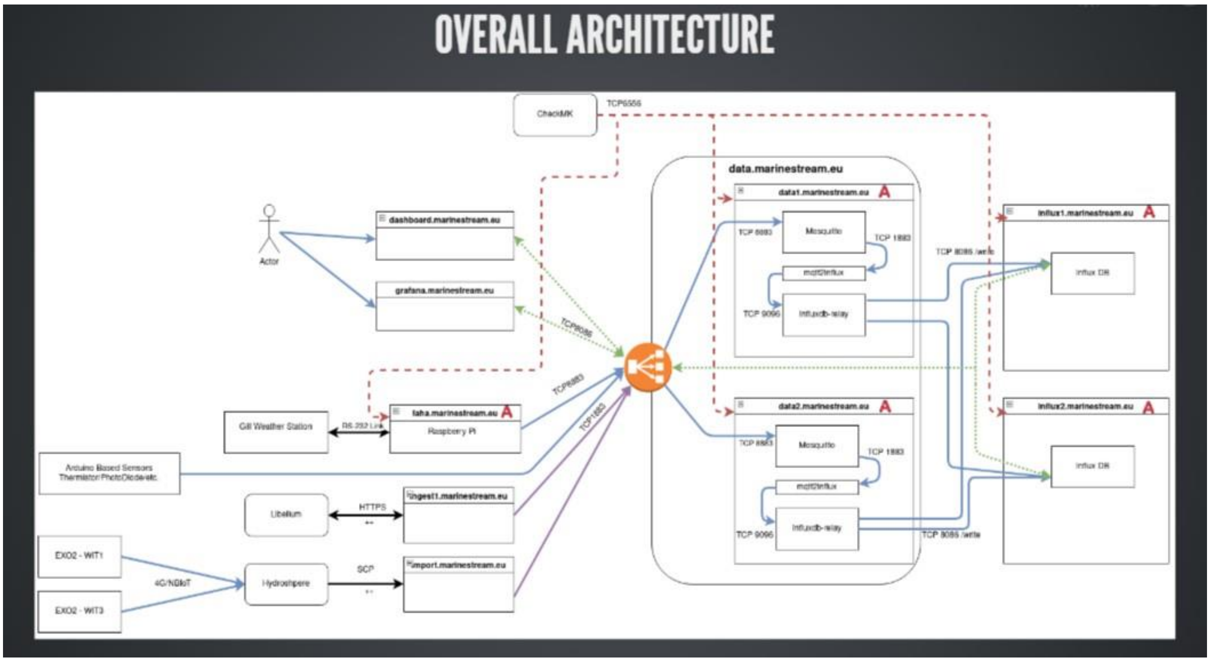
Geoffrey Robinson from BIM described the use of remote monitoring technologies for assessing water quality and in particular the use of sensors in close proximity to aquaculture sites.

Geoff outlined the reasons to care about the cultivation of marine fish and shellfish as they contribute as they generate €180-200 million per annum and employ 2,000 people. The cultivation process also involves operating in an uncontrolled environment. He explained that at the outset of mariculture activities around Ireland there was very little environmental data and now he and his colleagues are working on developing the amount of data occurred where projects are taking place but that there are massive swaths of the coastline not monitored.

BIM now have, and are developing a network of 2m diameter buoy with mooring assembly, marine navigation lights, fencing and alarm. Beneath these they have multiparameter sensors with a communications system active around the coast. BIM have also set the alarm capability on the sensors to various thresholds according to the parameter being measured. There is an accessibility to the data for stakeholders via an online portal that is password protected.

SETU/ Walton Institute

John Ronan (SETU, Walton) comprehensively described the work being done by the STREAM project with weather stations, water sensors, telemetry and the accumulation of data. He provided a schematic of the overall architecture of the systems, which graphically depicts the various inputs (such as sensor data), its storage, backup, the visualisation software of the data and its presentation to the marinestream.eu website.



John also systematically appraised the use of Arduino circuit boards used in a Libelium pH/ temperature sensor and in association with a string of thermistors. These electrical sensors are based on changing conductivity at different temperatures. He then addressed the uses of Raspberry PI, which are miniature computers and the importation of telemetry data from Exo2, RS Hydro and AquaTroll sondes to an independent server. As the STREAM project is also concerned with collecting and importing meteorological data, John described how weather information is being taken from Gill Stations and imported into the STREAM database. He then spoke about the Open Source interactive data-visualisation platform developed by Grafana Labs, allowing users to see their data via charts and graphs in a dashboard for straightforward interpretation and understanding.

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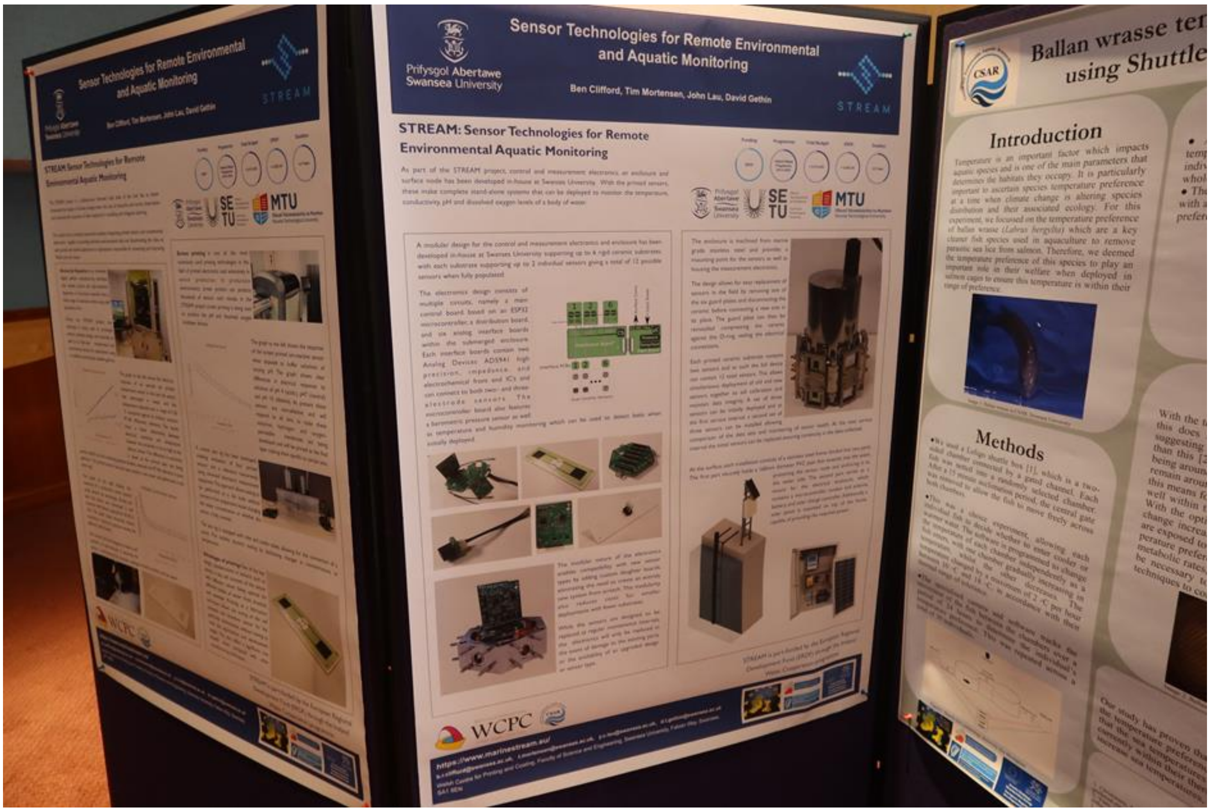
After the STREAM conference there was a brief STREAM project management partner meeting.

Trade show and poster session

STREAM poster, demonstration, weather stations, telemetry and water quality sensors.



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Centre for Sustainable Aquatic Research (CSAR) Shuttle Box poster

Ballan Wrasse Temperature Preference Using Shuttle Box Technology

Introduction

Temperature is an important factor which impacts aquatic species and is one of the main parameters that determines the habitats they occupy. It is particularly important to ascertain species temperature preference at a time when climate change is altering species distribution and their associated ecology. For this experiment, we focussed on the temperature preference of ballan wrasse (*Labrus bergylta*) which are a key cleaner fish species used in aquaculture to remove parasitic sea lice from salmon. Therefore, we deemed the temperature preference of this species to play an important role in their welfare when deployed in salmon cages to ensure this temperature is within their range of preference.

Image 1: Ballan wrasse in CSAR, Swansea University

Methods

- We used a Loligo shuttle box [1], which is a two-sided chamber connected by a gated channel. Each fish was netted into a randomly selected chamber. After a 15 minute acclimation period, the central gate was removed to allow the fish to move freely across both chambers.

- This was a choice experiment, allowing each individual fish to decide whether to enter cooler or warmer water. The software is programmed to change the temperature of each chamber independently as a fish enters, with one chamber gradually increasing in temperature, whilst the other decreases. The temperature changed by a maximum of 2 ◦C per hour between 10 ◦C and 18 ◦C, in accordance with their thermal range of tolerance.

- The specialised camera and software tracks the movement of the fish between the chambers over a period of 24 hours to determine the individual's temperature preference. This was repeated across a total of 30 individuals.

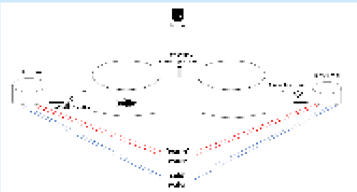

Figure1: Shuttle box technology drawn by Isla Monaghan

Results

- Across most individuals there was an initial fluctuation across temperatures, which then plateaued after several hours. However, for some individuals there was large variation in temperature preference across the whole 24 hour period.
- There was a large variation in temperature preference across individuals, with a range of between 9.97 ◦C and 15.19 ◦C and the median temperature preference for the ballan wrasse was 12.8 ◦C.

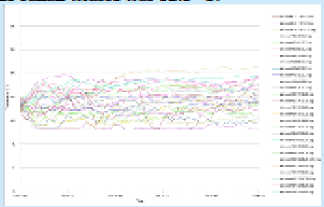

Figure 2: Relationship between temperature and time across 30 ballan wrasse

Discussion

With the temperature preference of the wrasse appearing to be 12.8 ◦C, this does seem to contradict the current literature, although limited suggesting their temperature preference would be significantly higher than this [2]. However, due to the temperature of their homing tanks being around 12 ◦C, it could be the case that the fish are pre-disposed to remain around the temperature of their original tanks. In regards to what this means for aquaculture, our results suggest that the ballan wrasse are well within their range of preference when deployed in salmon farms. With the optimal range of ballan wrasse being so narrow and climate change increasing sea temperature, it is likely the water ballan wrasse are exposed to in salmon farms may exceed the higher end of their temperature preference [3]. As a result, this can increase respiratory stress, metabolic rates, and oxygen demand [4]. Therefore, in the future it may be necessary to deploy other cleaner fish species or use alternative techniques to control sea lice infestations in warmer waters.

Image 2: Ballan wrasse movement being tracked in shuttle box during an experiment

Conclusion

Our study has proven that the shuttle box has been a useful tool to determine the temperature preference of ballan wrasse. This has allowed us to identify that the sea temperatures ballan wrasse are exposed to in salmon cages are currently within their thermal niche. However, as climate change continues to increase sea temperatures, this is not likely to remain the case.

References

1. Christensen, E.A., Andersen, L.E., Bergsson, H., Steffensen, J.F. and Killen, S.S., 2021. Shuttle-box systems for studying preferred environmental ranges by aquatic animals. Conservation physiology, 9(1), p.28
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4. Filice, M., Imbrogno, S., Gattuso, A. and Cerra, M.C., 2021. Hypoxic and thermal stress: many ways leading to the NOS/NO system in the fish heart. Antioxidants, 10(9), p.1401.

Sarah Weller, Isla Monaghan, Jack Van Eker and Ben Overland

STREAM is part funded by the European Regional Development Fund (ERDF)

Welsh Centre for Printing and Coating (WCPC) 2D printing of sensors

Sensor Technologies for Remote Environmental and Aquatic Monitoring

Ben Clifford, Tim Mortensen, John Lau, David Gethin

Prifysgol Abertawe Swansea University

STREAM

STREAM: Sensor Technologies for Remote Environmental Aquatic Monitoring

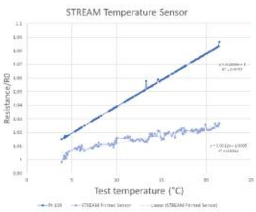
Funding: ERDF | Programme: Ireland Wales Programme 2014-2020 | Total Budget: € 5,410,225 | ERDF: € 4,328,181 | Duration: 4.5 Years

The STREAM project is a collaboration between both sides of the Irish Sea to better understand the impact of climate change; lower the cost of estuarine and marine observation and accelerate the acquisition of data required for modelling and mitigation planning.

The project aims to develop stand-alone systems integrating printed sensors and conventional electronics capable of providing real-time environmental data and disseminating this data via web portals and mobile applications to organisations responsible for protecting and improving Welsh and Irish waters.

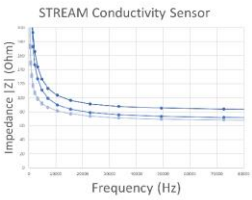
Aerosol Jet Deposition is an innovative digital additive manufacturing technique that enables precise and high-resolution deposition of functional materials onto a wide range of substrates whilst using small quantities of ink.

Within the STREAM project, the technique is being used to prototype sensors, evaluate designs and materials, as well as to fabricate temperature and conductivity sensors for deployment using a modified commercially available gold ink.

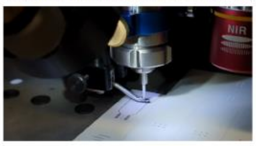


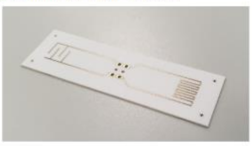
The graph to the left shows the electrical response of an aerosol jet printed temperature sensor. In this test the sensor was submerged in water and the temperature adjusted over a range of 5-20 °C compared against an industry standard PT100 (Platinum) reference. The results show a linear relationship between electrical resistance and temperature however the sensitivity is not as high as the refence sensor. This difference in sensitivity is down to the printed layer not being purely metallic but also containing polymer binders, whereas the PT100 reference is pure platinum. The printed sensors have also been tested in salt water and performed in the same way.

The graph on the right displays the response of a conductivity sensor printed using aerosol jet technology. During the test, the sensor was submerged in salt solutions with salinity ranging from 20-30 (2 -3%). The graph clearly illustrates distinct variations in electrical response among the different salinity levels.

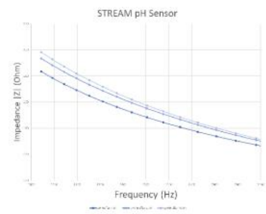


This sensor has been designed to have a cell constant of approximately 3 ensuring the sensor is well-balanced for accurate readings in fresh, brackish, and sea water.





Screen printing is one of the most commonly used printing technologies in the field of printed electronics used extensively in sensor production. In production environments, screen printers can produce thousands of sensors each minute. In the STREAM project screen printing is being used to produce the pH and dissolved oxygen multilayer devices.

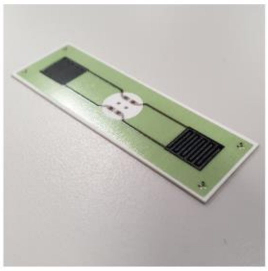


The graph to the left shows the response of the screen printed ion-reactive sensor when exposed to buffer solutions of varying pH. The graph shows clear differences in electrical response to solutions of pH 4 (acidic), pH7 (neutral) and pH 10 (alkaline). At present these sensors are non-selective and will respond to all ions, to make these selective, hydrogen- and oxygen-permeable membranes are being developed and will be printed as the final layer making them specific to certain ions.

A custom test rig has been developed, enabling evaluation of four printed sensors and a reference concurrently using advanced laboratory measurement equipment. This approach allows testing to be performed at a lab scale without concerns from evaporative losses changing the water concentration or whether the sensor is fully covered.

The test rig is equipped with inlet and outlet tubes, allowing for the connection of a pump. This enables dynamic testing by facilitating changes in concentrations or temperature.

Advantages of printing: One of the key design considerations in sensors such as salinity is the cell constant of the sensor with different values being optimal for different bodies of water; fresh, brackish, and seawater. Printing as a fabrication technique allows the tuning of the cell constant and therefore sensor for the particular environment without having to redo the optimisation and development stages. This also offers a significant cost benefit when compared with other manufacturing techniques.



WCPC CSAR

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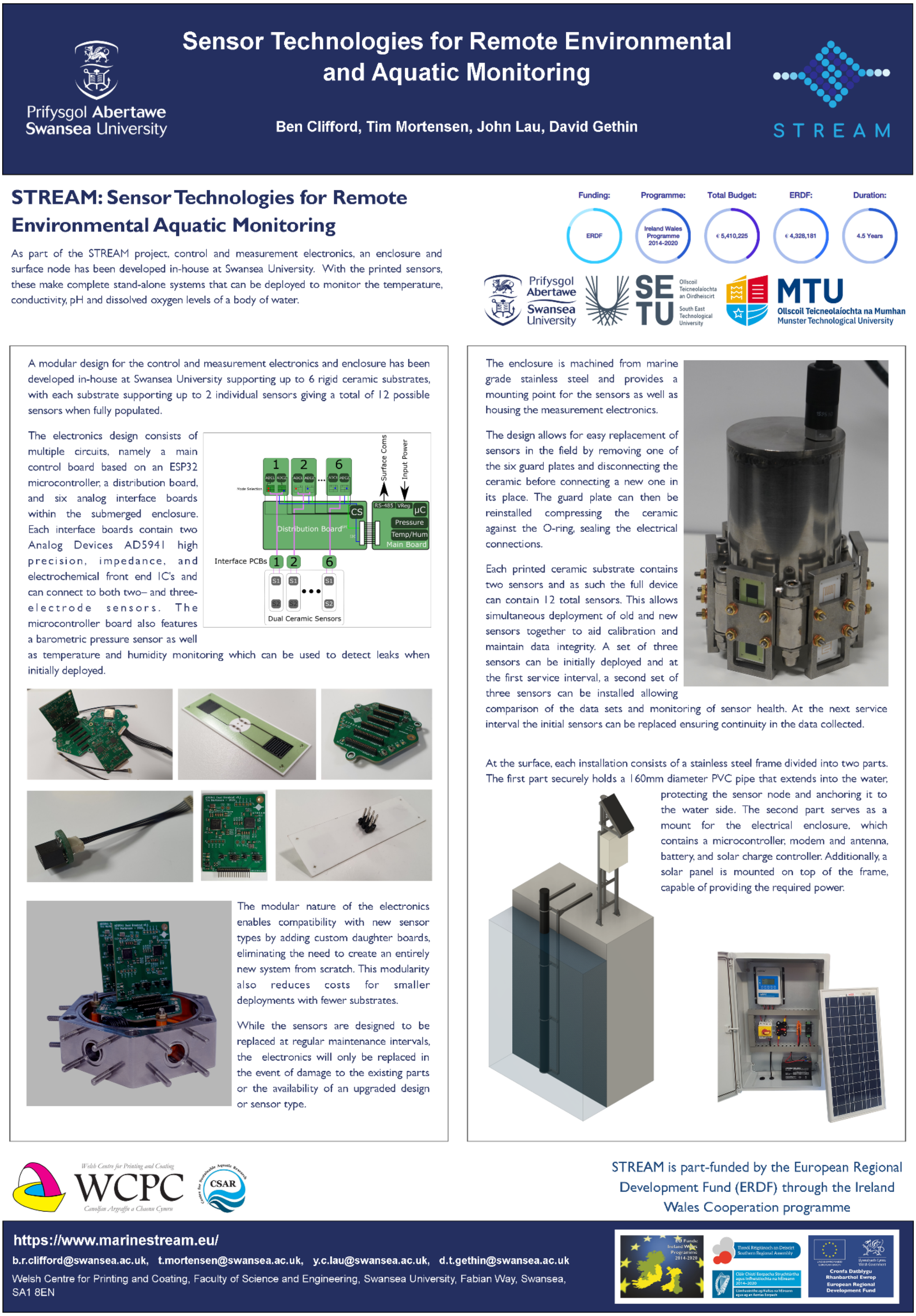
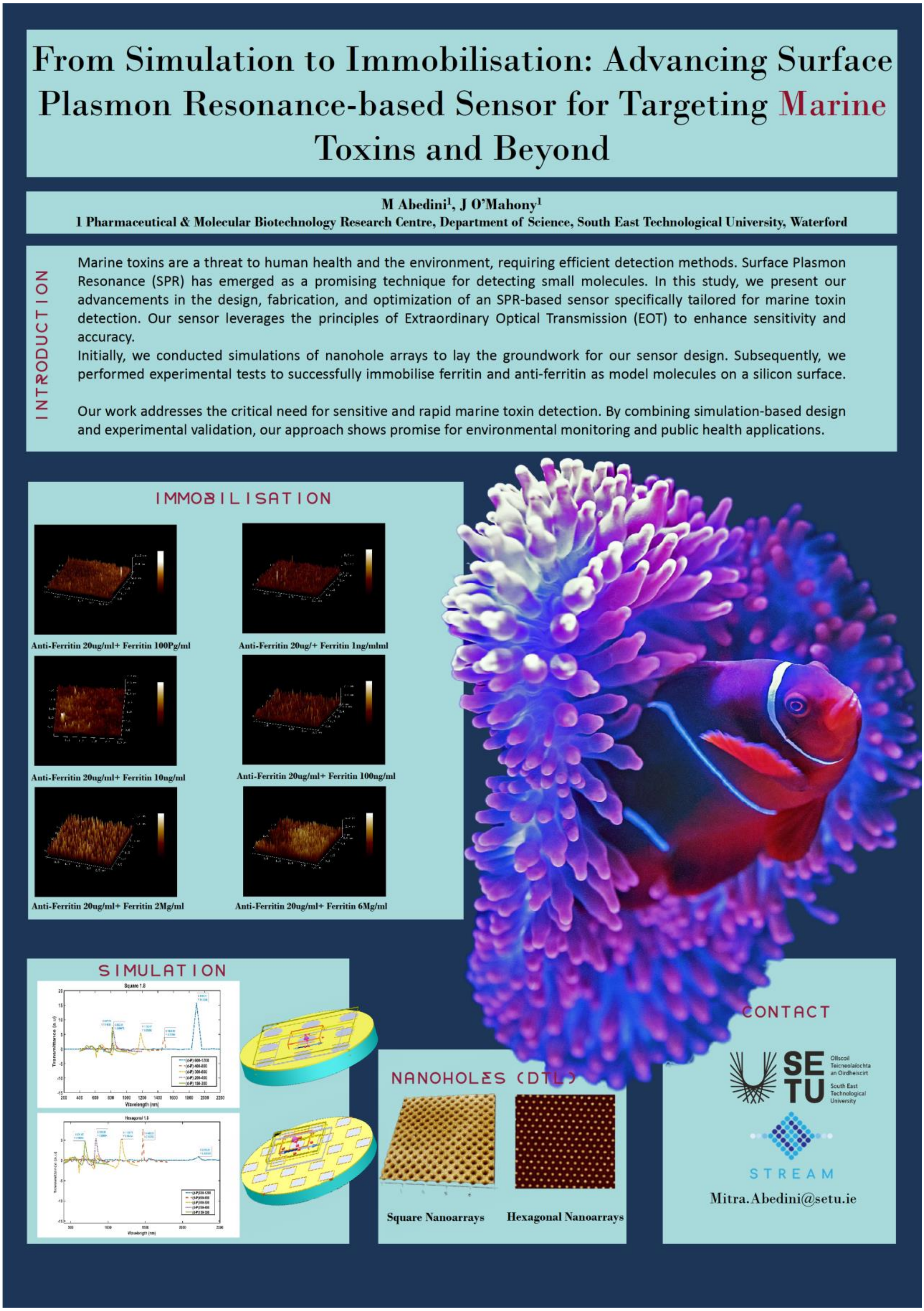
Welsh Centre for Printing and Coating (WCPC), Sensor housing poster



South East Technological University (SETU) Plasmon Resonance poster



From Simulation to Immobilisation: Advancing Surface Plasmon Resonance-based Sensor for Targeting Marine Toxins and Beyond

M Abedini[1], J O'Mahony[1]
1 Pharmaceutical & Molecular Biotechnology Research Centre, Department of Science, South East Technological University, Waterford

INTRODUCTION

Marine toxins are a threat to human health and the environment, requiring efficient detection methods. Surface Plasmon Resonance (SPR) has emerged as a promising technique for detecting small molecules. In this study, we present our advancements in the design, fabrication, and optimization of an SPR-based sensor specifically tailored for marine toxin detection. Our sensor leverages the principles of Extraordinary Optical Transmission (EOT) to enhance sensitivity and accuracy.
Initially, we conducted simulations of nanohole arrays to lay the groundwork for our sensor design. Subsequently, we performed experimental tests to successfully immobilise ferritin and anti-ferritin as model molecules on a silicon surface.

Our work addresses the critical need for sensitive and rapid marine toxin detection. By combining simulation-based design and experimental validation, our approach shows promise for environmental monitoring and public health applications.

IMMOBILISATION

Anti-Ferritin 20ug/ml+ Ferritin 100Pg/ml

Anti-Ferritin 20ug/+ Ferritin 1ng/mlml

Anti-Ferritin 20ug/ml+ Ferritin 10ng/ml

Anti-Ferritin 20ug/ml+ Ferritin 100ng/ml

Anti-Ferritin 20ug/ml+ Ferritin 2Mg/ml

Anti-Ferritin 20ug/ml+ Ferritin 6Mg/ml

SIMULATION

Square 1.8

Hexagonal 1.8

NANOHOLES (DTL)

Square Nanoarrays

Hexagonal Nanoarrays

CONTACT

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STREAM is part funded by the European Regional Development Fund (ERDF)

South East Technological University (SETU) Optical Nutrient Sensor

Sensor Technologies for Remote Environmental Aquatic Monitoring

Benyuan Yu
Supervisor: Dr. Joseph O'Mahony
South East Technological University, Waterford, Ireland

"The STREAM Project is part-funded by the ERDF through the Ireland-Wales Cooperation programme".

Overview

The STREAM project is a collaboration between both sides of the Irish Sea to better understand the impact of climate change by lowering the costs of marine observations and accelerating the provision of information from different sites. The work described in this poster is on the development of a relatively low-cost optical sensor system using multiple narrow spectra response photodiodes with a function for remote aquatic monitoring and live data transmission for further assessment of saline water quality. The result of these studies is a mobile network cloud-connected Micro-Opto-Electro-Mechanical System (MOEMS) that can be used remotely to determine Nitrate (NO_3-)and Dissolved Organic Carbon (DOC) in estuarine waters. Prototype sensor units have been built and deployed for field testing.

Optical Nutrient Sensor

Advances in MEMS technology have allowed the utilisation of UV photodiodes with interference filters that are sensitive to monochromatic light at 220nm, 254nm, and 275nm. These short wavelength are known for their strong absorption by nitrate at 220nm and DOC (which covers the whole region)[1]. These units offer high sensitivity and low power consumption, which makes them suitable for remote nutrient measuring in marine waters.

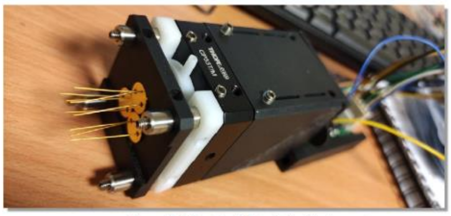


Figure 2. UV optical photodiodes flowing system.

3D printing and Electronics Methodologies

Stereolithography 3D printing technology was used to create bespoke components to a 50-micron level of precision. These 3D printed objects had a variety of purposes, such as protecting optical and electronic devices, mesh filters and also flow through tubes for optical measurement. The electronics sensors design is summarised in the R.H.S. Figure 4 for controlling multiple devices and converting light response into digital outputs so that analytical instruments can recognise and translate to values.

Figure 1. SLA 3D printed objects.

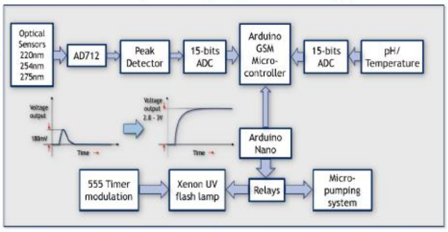


Figure 4. Electronics design of Multi-Sensors for Aquatic monitoring system.

Mobile Network Cloud Platform

Arduino MKR GSM series smart cloud-compatible microcontrollers were used as they can effectively shift between wireless communication protocols incorporating programmable software changes. The data transmission is through GSM/3G/4G mobile network using MQTT protocol and database support from the Walton Institute Data Centre, SETU-Waterford, which provides advanced server data storage and platform design techniques.

Figure 3. MQTT mobile network data transmission.

Optical System Layout

The main components of the system are a smart micro-pumping unit produced by Radionics, which is used to pump water samples from a site and a bespoke 3D-printed flow cell ring for optical absorption measurements. This flow cell ring allows for different detection path lengths and is also a replaceable unit to reduce issues from bio-fouling. The pumping unit and UV Xenon flash lamp are synchronised by the control of Arduino Nano microcontroller and communication between the controlling board and GSM board. Figure 5 shows the layout of the whole system, and the latest optical system is displayed in Figure 2.

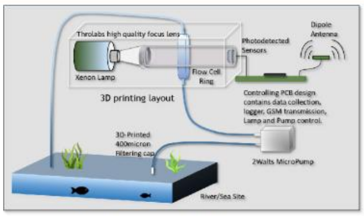


Figure 5. Optical nutrient system layout.

Figure 6. System deployment at Castletownbere shore.

Algorithm Analysis

Data analysis was used to quantify the relationship between different absorbance readings in seawater. The sensors were calibrated using standard laboratory solutions and generated a linear regression that provides correlation between light responses in the UV range and Nitrate content. Using the Partial Least Squared Regression (PLSR)[3] analysis, the Nitrate and DOC contents in six estuarine samples (Figure 7, 8) demonstrated a high degree of correlation with sensor readings (R_2=0.978 to Nitrate and R_2=0.912 to DOC) and the regression coefficient was used for programmable linear predictive algorithm models for field sample measurements.

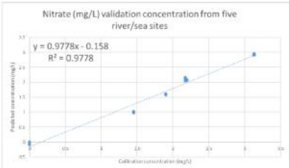


Figure 7. Nitrate content validation in estuarine and marine samples using CLS analysed results.

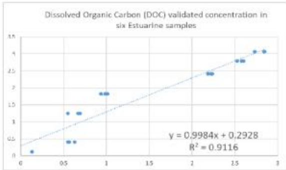


Figure 8. DOC content validation in estuarine and marine samples using CLS analysed results.

Conclusion and future work

As part of these studies seawater samples were collected from five sites around Wexford and Waterford counties. Using the regression model developed, the STREAM-developed instrument's nutrient results were confirmed by comparing them with accredited laboratory analysis of the same water samples. The prediction model for Nitrate and DOC provides an average R^2 of 97.78% and 91.16% for the PLS2 model, respectively. With these results, the regression models showed high prediction accuracies of nitrate and DOC contents. This system has undergone a preliminary stage of estuarine water testing at a pontoon in Waterford City.

The next phase of work will include sensor deployment at different sites for testing, data analysis and comparison with commercial sensor findings. Other work will include calibrating the sensor for temperature, voltage and power consumption, testing them in higher saline waters, and further optimising the system design.

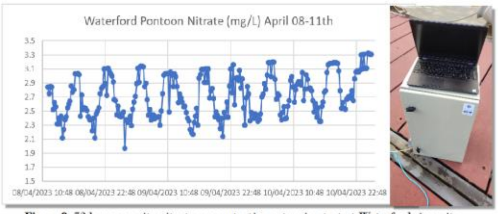
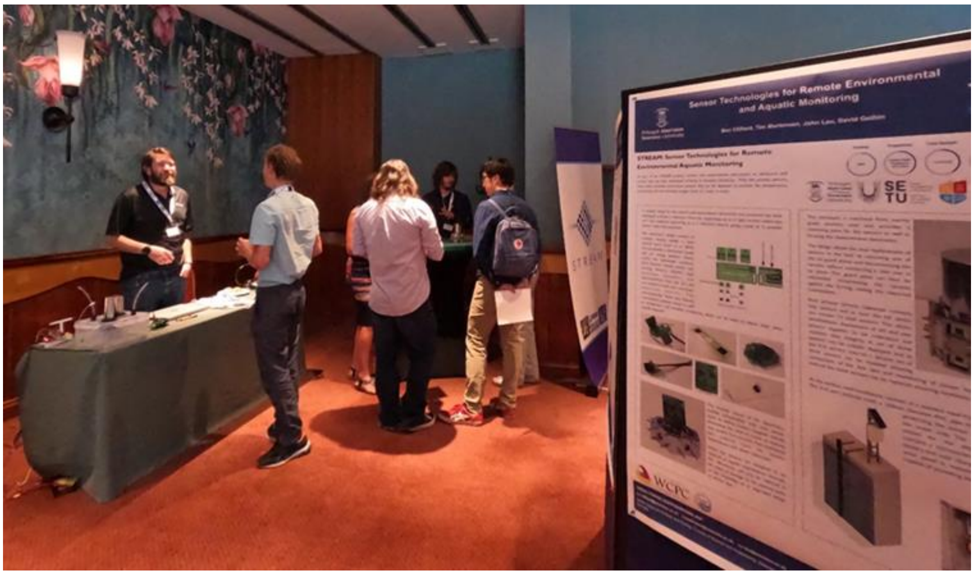


Figure 9. 72 hours on-site nitrate concentration estuarine test at Waterford river site.

References

[1] Anthony, E. C., Peter, H. S., & Yvonne, C. (2001). Determination of Nitrate in Water Containing Dissolved Organic Carbon by Ultraviolet Spectroscopy. International Journal of Environmental Analytical Chemistry, 49-59.
[2] Pierre, F., Gabriel , D., & Ricardo , R. (2022). Influence of the conservation mode of seawater for dissolved organic carbon analysis. Marine Environmental Research.
[3] Wang, H., Ju, A., & Wang, L. (2021). Ultraviolet Spectroscopic Detection of Nitrate and Nitrite in Seawater Simultaneously Based on Partial Least Squares. Molecules, 3685.

STREAM is part funded by the European Regional Development Fund (ERDF)



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aqua monitrix


Thinglabs

Thursday 22nd June 2023 boat tour and demonstration of STREAM sampling equipment and site.

The Barrow Princess was chartered for the STREAM conference delegates on the 22nd of June (the day after the STREAM conference).

The objectives were provide access to a STREAM water sensor site along the estuary and facilitate sampling for water analysis.

Delegates were shown how to collect samples (Van Dorn, plankton net, sonde measurements) and they will obtain first-hand data observations. The experience was aimed at promoting collaboration, and immersive learning.

The STREAM delegates were given a practical insights into sensor technologies and the challenges of monitoring aquatic environments.

It was to provide a valuable networking event and showcase the waterbodies around Waterford.

Publicity Links

https://www.setu.ie/news/monitoring-climate-change-in-our-local-coastal-communities

https://crm.waterfordchamber.ie/news/details/monitoring-climate-change-in-our-local-coastal-communities

STREAM end of project Agenda

STREAM

Sensor Technologies for Remote Environmental Aquatic Monitoring

The STREAM project is part-funded by the European Regional Development Fund (ERDF) through the Ireland Wales Cooperation programme

Times, speakers and the order of presentations may change.

STREAM end of project conference

SENSOR TECHNOLOGIES for REMOTE ENVIRONMENTAL AQUATIC MONITORING
Monitoring Climate Change

Event Date - 21st of June 2023

RSVP by Friday 16th June to ronan.browne@setu.ie **and** ailish.tierney@setu.ie

Location: Dooleys Hotel, Waterford
https://www.dooleys-hotel.ie

09:00	**Registration opens**
09:30	Dr Joseph O'Mahony (SETU, PI) - Welcoming remarks and introduction to the STREAM project.
	Julie James, Minister for Climate Change, Opening address.
10:00	Prof. David Gethin (SU, WCPC) - Drs Tim Mortensen, Ben Clifford and John Lau; Printable Sensor Design and Manufacturing WCPC presentation on the fabrication of sensors by printing and the associated systems Demonstration of sensor printing systems, sensor calibration and deployment.
10:30	Dr Joseph O'Mahony (SETU) -MEMS Spectrometers with Edge Processing for Nutrient Evaluation SETU presentation of optical sensors.
11:00	**Tea/ Coffee Break**
11:30	Dr Ronan Browne (STREAM) - What are we learning from the STREAM project? The use of sensors to monitor and assess the environment.
12:00	Jonathan Kelly - Marine Institute (MI) - Monitoring for harmful algal blooms the work the MI is undertaking.
12:30	Dr Ambrose Furey, Mike Grew (MTU) –Marine biotoxin sampling: active accumulation with preconcentration and passive sampling; Supporting aquaculture decision-making with coastal and estuarine environmental data.'
13:00	**Lunch (provided)**
14:00	Dr Robert Wilkes - Environmental Protection Agency (EPA) – Monitoring by the EPA of Irish coastal and transitional waters.
14:30	Brendan Cooney - Wexford Co. Co. - The work that is being done by the council in monitoring our environment.
15:00	Geoffrey Robinson - BIM – The use of remote monitoring technologies for assessing water quality.
15:30	**Tea/ Coffee Break**
16:00	John Ronan (SETU, Walton) Weather Stations, water sensors, telemetry and accumulating data.
16:30	**Discussion and Conclusion**

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STREAM invitation to end of project conference

Invitation to STREAM end of project conference 21st June 2023

STREAM

Sensor Technologies for Remote Environmental Aquatic Monitoring

The STREAM project is part-funded by the European Regional Development Fund (ERDF) through the Ireland-Wales Cooperation programme

You are cordially invited to:

Sensor Technologies for Remote Environmental Aquatic Monitoring (STREAM) end-of-project conference at **Dooleys Hotel, Waterford, on June 21st, 2023**

(Registration at 9 am – Conference begins at 9:30 am).

STREAM is a partnership between Ireland and Wales focusing on cross-border collaboration, cost-effective marine observation, and climate change monitoring. The project has brought together experts from the South East Technological University (SETU), Munster Technological University (MTU), and Swansea University (SU), which has contributors from the Welsh Centre for Printing and Coating (WCPC) and the Centre for Sustainable Aquatic Research (CSAR).

STREAM secured substantial funding of €4.3 million over five years from the European Regional Development Fund (ERDF), specifically under Priority 2 - Adaptation of the Irish Sea and Coastal Communities to Climate Change. To support work on developing cost-effective systems for seawater analysis, methodologies for harmful algal bloom monitoring, deployment of an environmental network of sensors broadcasting live data, and conducting fish behavioural studies in the light of environmental change. See: www.marinestream.eu STREAM has also received significant guidance from WEFO and the Southern Regional Assembly.

The conference aims to share the project's advancements and promotion of collaboration in understanding, measuring, and assessing environmental/ water quality change to help coastal communities and stakeholders better comprehend climate change. The conference will allow you to meet with various specialists, state agencies and commercial companies to discuss and see the available technologies.

STREAM would like to thank all of those that have contributed to the ongoing work unfortunately too many to mention here.

If you wish to attend, please RSVP by Friday, June 16th.
To ronan.browne@setu.ie and ailish.tierney@setu.ie

As a lunchtime meal will be provided, we will require confirmation of your attendance in advance.

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Diolch i bawb a helpodd ac a gymerodd ran yn y digwyddiadau; roedd yn bleser mawr cael cyfarfod a gweithio gyda chi.

Míle buíochas do gach éinne a chabhraigh agus a ghlac páirt sna himeachtaí; ba mhór an pléisiúr é bualadh leat agus oibriú leat.

Thank you to all that helped and participated in the events; it was a great pleasure to have met and worked with you.

Acknowledgment of some of the project team members and partners

Wexford County Council - Brendan Cooney

EPA – Dr Robert Wilkes

BIM - Brian O'Loan

BIM Shane Begley - Weather Station and Barge (Castletownbere), Dave Millard, Geoff Robinson

Marine Institute - Dave Clarke, Jonathan Kelly

STREAM – Hugh O'Sullivan

Tramore Coast Guard

Dunmore East Harbour - Monitoring sites

Waterford City River Rescue - Monitoring sites

Southern Regional Assembly - Breda Curran

Walton, SETU - Lisa Bodden