ECSA 2021 FOCUS MEETING

FROM CATCHMENT TO COAST WITH AN EMPHASIS ON THE ESTUARIES AND COASTAL WATERS OF SOUTHWEST ENGLAND

Abstracts

On Line meeting 28 April 2021

Meeting sponsored by Planet Ocean Ltd

Organised on behalf of ECSA by: Gillian Glegg, University of Plymouth; Steve Mitchell, University of Portsmouth; Reg Uncles, Plymouth Marine Laboratory; Andrew Wither, National Oceanography Centre (Liverpool)

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List of Abstracts

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MARINE BIOGEOCHEMISTRY OF NITROGENOUS OSMOLYTES

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Nitrogen-containing osmolytes (N-osmolytes) include glycine betaine, trimethylamine N-oxide and choline. These organic nitrogen-containing compounds have been linked to several functions within marine cells; although primarily osmolytes, they also play a role in chemoattraction, and as carbon or energy sources for marine bacteria. Nitrogen osmolytes can also be metabolic precursors of methylated amines, which are volatile components able to cross the sea-air interface where they are thought to be important for particle formation and/or growth, which is a key uncertainty for the production of cloud condensation nuclei. Thus, these compounds are relevant for both marine biogeochemical cycles, and climate. Nevertheless, our knowledge of environmental N-osmolyte concentrations in marine systems is severely limited to some Southern Ocean and a few coastal samples, globally. Therefore, knowledge of the seasonality of these compounds, or the mechanisms underpinning their seasonality and distribution, which are important to develop a predictive capacity, is lacking. Here, we present a seasonal cycle of N-osmolyte measurements in surface waters at the Western Channel Observatory (www.westernchannelobservatory.org). We report trends observed in terms of biogeochemical parameters, including nutrients and phytoplankton composition. Finally, we introduce a modelling approach to test the environmental drivers of the seasonal cycle observed.

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HOW MIXED IS MY SWIMMING POOL? INTERACTIONS BETWEEN AN ESTUARINE COASTAL EMBAYMENT AND COASTAL PROCESSES

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The Plymouth Sound area forms a coastal embayment on the south coast of the UK. The northern end of the embayment is connected to the upper Tamar Estuary and River Plym whilst exchange with the adjacent coastal sea is restricted by a man-made breakwater. The area is important both for commercial activities and recreation, and is one conservation feature in the Plymouth Sound National Marine Park.

Results from one year of simulation from a validated 3-d unstructured grid hydrodynamic model are used to study the dynamics of this area. We use the tidal phase averaged currents to describe the dominant features in the sound area, including the jets either side of the breakwater and circulation within the sound. The sub-tidal ocean exchange flow into the sound area and between it and the upper estuary are calculated, indicating episodic features of elevated exchange. Both the tidal and sub-tidal dynamics are then related to wider coastal processes and we consider the implications for water quality in the sound area.

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BETTER CATCHMENT, BETTER ESTUARY; WORKING TOGETHER FOR POOLE HARBOUR

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Poole Harbour, the largest natural estuarine harbour in the UK is heavily protected for its wintering birds and wetlands but has suffered declining water quality due to the intensification of agriculture and population growth within its catchment. Rising nitrate levels led to a ban on development under the Habitats Regulations which in turn provided an impetus for change from 2011. The initial strategic partnership involving authorities, a water company and the agricultural industry was widened with the formation of the Poole Harbour Catchment Initiative, focusing on the need for water quality, morphological and biodiversity improvements within the Harbour and its river catchment. The paper briefly summarises the impacts of eutrophication on the Harbour and reviews the role of NGOs, the Courts, the water industry and the catchment partnership in tackling the problem since 2011. The prioritisation and funding of multi benefit measures and collaboration evolved, through a judicial review process, to include industry led initiatives for nutrient reduction. The case study shows the problems of engaging on eutrophication in a ground water fed system and restoring the freshwater and estuarine systems, once the tipping point appears to have been passed.

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Investigating the cause of excess macroalgae growth and solutions to deliver Water Framework Directive objectives across the Poole Harbour transitional water body and protected area through source apportionment and TELEMAC and Combined Phytoplankton modelling

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The intertidal habitats and coastal waters of Poole Harbour are of international nature conservation importance, but are failing a number of environmental targets. In 2013 the Environment Agency (EA) and Natural England concluded nitrogen was the key limiting nutrient and for "favourable condition" to be restored, N loads entering the harbour from non-marine sources should be returned to the levels observed in the early 1980's levels (c1730 tonnes N/yr). A nutrient management plan (NMP) was produced, which concluded that nitrogen inputs from the agricultural sector should be reduced by c550 tonnes N/yr and any nutrient that result from future development are offset.

Over the last 2 years, the EA have reviewed these recommendation against updated UKTAG guidance, where average modelled macroalgae biomass of <c500g/m2 is required across the available intertidal habitat, to ensure there are no adverse effect.

As part of these investigations, the EA commissioned the development of the TELEMAC model and with CEFAS, updated a combined phytoplankton and macroalgae model (CPM). These models were used to predict the macroalgae density that would result from reduction in N and P from both point and diffuse sources. A range of scenarios were modelled which now suggested that the harbour is limited by both N and P. From this a new interim target of 1500 tonne/N/yr and P 22 tonnes/P/yr has now been recommended. Further reductions in N to ≤1000 tonnes N/yr may be required in the future if interim target is not successful in delivering the outcomes required. Sector targets have also been set.

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MANAGING EMERGING FISHERIES IN THE INSHORE COASTAL WATERS – THE WHY, WHAT, AND HOW?

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D&S IFCA leads, champions and manages the inshore marine environment and its fisheries within its District by finding the right balance between social, environmental and economic benefits to ensure healthy seas sustainable fisheries and a viable industry. In recent years challenges have arisen through the emergence or predicted emergence of fisheries which have the potential to impact the features or communities of Marine Protected Areas within the D&S IFCA's District. The presentations will framework the background to these fisheries and their importance to the inshore fishing fleet. It will also outline what information and evidence is available that will help inform management measures and, where this is lacking, how these evidence gaps can be filled. The talk will outline why management is necessary, what measures have been or will be introduced to fulfil the IFCA's duties, and the process through which this is achieved. The presentation will focus on Wrasse and Spiny Lobster fisheries.

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The morphological evolution and sedimentological processes in a non-engineered coastal wetland restoration scheme

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Managed realignment (MR) sites, implemented to restore and compensate for the loss of coastal wetlands, have been shown to have lower biodiversity and vegetation coverage than natural saltmarshes. These differences have been associated with variations in the physical functioning of the restored sites. However, previous analysis of the morphology and sedimentological processes in MR sites has focused on sites which have undergone engineering work and landscaping during site construction in order to support a targeted range of intertidal habitat types. As a result, the evolution of these sites may be influenced by the design processes, and not representative of the sedimentological processes without these interventions. This study presents analysis of the rate and patterns of sedimentation, and the morphological development, in a non-engineered MR site in order to assess site development without the influence of pre-breach site landscaping. Measurements were taken at Cwm Ivy Marsh, on the Gower Peninsular, which breached in August 2014 as result of the defensive sea wall no longer being maintaining. Consequently, there was no engineering works carried out prior to site breaching. Measurements of the change in bed elevation and suspended sediment concentration (SSC) were taken and compared to repeat high resolution (<0.2 m/pixel) digital surface models and orthophotography, collected using an Unmanned Aerial System. The accretion of the sediment above the terrestrial surface, and the subsequent geochemical evolution, was also identified through analysis of sediment cores. Results indicate a developing intertidal morphology, with a sedimentation rate of 3-7.5 cm/year. Subsurface geochemical profiles indicated little evidence of reduced hydrological connectivity, which has been found in engineered MR sites. The SCC decreased during the flood and increased during ebb tide, whereas bed elevation increased and then decreased during the flood tidal phase with this pattern repeating during the ebb tide. These findings are discussed in terms of the importance of studying the sedimentological processes in MR, and provide an insight into the evolution of older areas historically breached during storm and extreme weather events.

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Sustainably managing human activities in estuaries and along coasts is essentially a risk and opportunity assessment and management process

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Performing any operation which interacts with, and has an ability to affect, the environment positively or negatively requires the operator to understand many aspects. This includes the nature of the operation, the behaviour of the environment, the governance framework and the interaction with other actors and stakeholders in the system. As the result of natural and anthropogenic hazards, there are risks to the environment, such as adversely affecting the ecological structure and functioning through increasing contamination or obstructions. There are also risks from the environment such as the effects of storms and climate change. There are also opportunities such as providing clean energy, culturing new species, exploiting natural resources, creating habitats for fish, etc. Hence these risks and opportunities are to both the natural and the human uses of the seas and so the operators, regulators and other interested bodies require defendable ways of addressing those risks and opportunities. This talk shows the fundamental concepts and methods involved in addressing these features and the way this framework can be used to synthesise our current knowledge. As an example, it presents the industry standard and industry compliant (ISO accredited) Bow-tie technique (Cormier et al., 2018, 2019) which shows the causes, consequences, and management actions (including mitigation, compensation) linked to human activities and their environmental repercussions.

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Release of Metal Contaminated Sediments from a Disintegrating Estuarine Impoundment: River Plym (SW England)

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Estuaries and coasts are under increasing pressure from sea-level rise, the frequency of storm surges and wave activity. Protection of coastal infrastructures is becoming an important consideration, including whether to maintain existing structures, create new defences or allow deliberate collapse. Salt marshes where realignment, or impoundment, has taken place are particularly vulnerable since they have served as natural barriers for habitat preservation.
An impoundment on the Plym Estuary (SW, England), constructed in 1850, was fitted with a regulated tidal exchange system in 1996 and the area converted into a natural reserve for birds. Currently, the original brick-built barrier separating the impounded area from the estuary is collapsing due to erosion induced by wave action, with the potential the loss of the impounded sediments to the estuary. To quantify the contaminant loadings in the sediments, the concentrations of As, Cu, Cr, Pb, Sn, W and Zn, and the sediment geochronology, were determined in sectioned sediment cores from the impoundment and the adjoining estuary. Below the surface layer, and post-1963, metal concentrations were elevated due to the infilling with industrial waste during the original construction. The Canadian Sediment Quality Guidelines confirmed the impounded sediments were significantly contaminated, particularly with As, Cu and Pb. Given the ecotoxicological implications, options are discussed in relation to the potential consequences of the loss of contaminated sediments from the Plym impoundment and other climate-vulnerable estuarine impoundments found elsewhere.

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TRANSFER OF ORGANIC C (OC) FROM CATCHMENT TO SEA; WHAT DOES OC-COLOUR TELL US ABOUT PROCESSING?

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We have examined a unique dataset of dissolved organic matter (DOM) comprising seasonal observations in upland streams, 14 UK estuaries, estuarine sediments, marine algal cultures and open ocean samples as well as experimental studies. We focus on the coloured or chromophoric DOM fraction (CDOM) and its optical properties. These properties can be easily determined offering potentially unique insight into the transformation history of DOM. Our experiments show that these properties are affected by three processes acting on DOM along the catchment to sea continuum: a) flocculation, b) photolysis and c) mineralization of DOM. We show that the in situ distribution of CDOM optical properties reflects mixing between distinct end-members and the transformation processes acting on them.

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CATCHMENT TO COAST AND INTEGRATED ECOSYSTEM MODELLING – A NORTHERN IRELAND PERSPECTIVE

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Since 2007 the Agri-Food Biosciences Institute for Northern Ireland (AFBI) has been working to investigate the impact of aquaculture on ecosystem health through a suite of ecosystem models designed for shellfish management supported by the outputs from other activities. Over this period models have been used to support DAERA WFD studies, Harbour Developments and the Modiolus restoration effort in Strangford Lough. More recently the modelling efforts have begun to investigate the utility of coupling catchment Soil and Water Assessment Tools (SWAT Modelling) with marine ecosystem models to provide integrated management tools from headwater to Lough mouth. The modelling chain is interfaced with Sewerage Network Models (DAPs) at all key points, i.e. in the catchment, lough areas, and adjacent marine system. The results will be explored to show sub-catchment scale source-apportionment of pollution. The aim is to deliver an integrated coastal resource modelling system for whole catchments, thus providing management tools for both aquaculture and water quality management. Integrating the outputs from ecosystem modelling and aquaculture as described above has allowed the study of the role of bivalves and other filter feeders as possible ecosystem engineers. Opening up the possibility of offsetting nitrate inputs from agriculture and WWT by shellfish production. The areas currently being modelled are the catchment, body, and adjacent coasts of Lough Foyle and Carlingford Lough, Belfast Lough and Dundrum Bay. The outputs and associated sampling/monitoring are targeted at delivering sustainable land use and WFD objectives.

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USING REMOTE SENSING TO UNDERSTAND THE ESTUARIES AND COASTAL WATERS OF SOUTHWEST ENGLAND

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A striking development in remote sensing is the increased availability of satellite Earth Observation (EO) data resulting from an increase in commercially developed missions being matched by free to access government-funded missions such as the European Copernicus programme. As a result, there is an increased wealth of tasked high to very high spatial resolution datasets (from sub 10 m to sub 1 m), alongside systematically capture medium resolution radar and optical sensors (from 20 m to 10 m) alongside the global coverage from lower spatial resolution (300 m to 1 km) missions.

This wealth of EO data allows not only the systematic monitoring of coastal waters but also the estuaries that feed into them. Pixalytics has developed a water extent product, using Copernicus Sentinel-1 radar data, which was designed initially for mapping floodwaters but has since been expanded to extract the coastal land-water boundary. The next step is combining this with biogeochemical properties determined through EO-derived temperature and watercolour information so that the environmental state can be classified. This presentation will showcase results for southwest England.

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EVIDENCE BASED SOLUTIONS TO MOORING RISK TO THE SEAGRASS *ZOSTERA MARINA*

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Moorings can cause direct physical disturbance to the subtidal seagrass species *Zostera marina* by potentially scouring the seafloor, resulting in meadow fragmentation and degradation. The ecological importance of seagrass meadows is widely recognised, consequently these habitats are protected by law in many countries.

Balancing conservation obligations with the needs of the maritime leisure industry is often problematic for environmental managers, especially when maritime safety is paramount. Various eco-mooring designs have therefore been trialled to reduce the impacts upon seagrass meadows, but few studies have been undertaken in areas of increased tidal fluctuation or specifically focus on the seagrass species *Zostera marina*.

In contrast to previous studies, this study examined the effectiveness of simply modifying existing moorings within a *Zostera marina* meadow in the Salcombe Ria, UK. Small floats were attached along the chain of a swing mooring to prevent contact with the seabed. The study then focused on monitoring the seagrass under the modified swing mooring with reference to a traditional swing mooring, over 3 years.

The study showed that mooring impacts on seagrass meadows can be reduced through a simple modification to existing swing moorings. The design modification accounted for tidal influence, and crucially in terms of practical application, did not compromise the structure or function of the mooring and therefore did not affect moored vessel insurance requirements. These results have the potential to be of interest to coastal managers as a practical and cost-effective alternative to installing new eco-moorings in their efforts to conserve seagrass habitats.

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ESTUARINE AND COASTAL MANAGEMENT USING VERY HIGH RESOLUTION DATA FROM LOW ALTITUDE AERIAL PLATFORMS SUCH AS DRONES

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Remotely Piloted Aircraft Systems (RPAS, also known as drones) are effective when data of very high spatial resolution are required. They are able to collect data over localised areas in short time frames and, due to their low altitude flying, clouds are rarely a problem. In estuarine and coastal environments, RPAS are usually used to acquire image data using RGB cameras to aid the mapping of foreign species, to monitor water quality and pollution and to generate models of the river channel and flood risk. However, they are also the ideal platform for deploying scientific instruments in hazardous or hard to reach areas that can be used to give information, for example, to generate accurate classifications of algal blooms or identify harmful bacterial species.

Applying Structure from Motion (SfM) techniques to data from RGB cameras, allows orthomosaics and a three-dimensional model of the terrain to be built from the photographic images in an automated workflow. This 3-D mapping method provides a powerful tool for estuarine and coastal management to characterise erosion and changes in the environment. Moreover, it is relatively cheap and easy to repeat the same flight pattern and create time series to derive seasonal effects compared to more traditional in situ or airborne surveys. In this talk, we will introduce RPAS derived products with a case of study of PML's capabilities acquiring and analyzing data over regions of the tidal river Dart in South Devon.

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QUANTIFYING THE FLUXES OF INORGANIC CARBON AND ALKALINITY THROUGH UK ESTUARIES

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The contribution of estuaries to the global carbon cycle is poorly quantified. There are two key challenges in improving estimates of inorganic carbon flux through estuaries. Firstly, sampling several estuaries at a sufficient resolution to determine seasonal changes is logistically difficult. Secondly, there is no consensus on the most appropriate measurement and calculation techniques for carbonate system variables across a large salinity range (i.e. 0 to 35). To help address these challenges, we collected water samples from 14 inner estuaries across Great Britain from 2017 through to 2020 for the NERC-funded LOCATE (Land Ocean Carbon Transfer) programme. We analysed these samples for dissolved inorganic carbon (DIC) and total alkalinity (AT), adapting existing seawater AT measurement and calculation techniques to better suit the large salinity range. Our data show that the carbonate chemistry of estuaries is strongly linked to the upper catchment bedrock lithology. In particular, the presence of limestone seems to cause the alkalinity of low-salinity water samples to increase from approximately 0 to 5000 µmol kg^{-1}, driving a similar-magnitude increase in DIC. There is strong seasonality in many estuaries, sometimes sufficient to switch from a negative correlation between salinity and DIC/AT in the spring to a positive correlation in the autumn and winter. We quantify for the first time the fluxes of inorganic carbon and alkalinity through the sampled estuaries and consider their importance in the context of the overall carbon budget of the surrounding shelf seas.

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Citizen science reveals microplastic hotspots within tidal estuaries and the remote Scilly Islands, United Kingdom

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The identification of microplastic hotspots is vital to our long-term understanding of their environmental fate and distribution. Although case studies have increased globally, sampling campaigns are often restricted geographically, with poor spatial resolution. Here, we use citizen science to increase our geographical reach, which improved our understanding of microplastic distribution in estuarine and beach sediment along the south-west coast of England. Sediment samples, collected by the Clean Seas Odyssey team, from estuaries near Plymouth, Fowey, Falmouth and two beaches on the Isles of Scilly off the Cornish coast were sent to the shore-based team at the University of Birmingham for microplastic analyses. Microplastics, between 63 and 5000 µm, were extracted using a Sediment Microplastic Isolation unit. The extracted supernatant was digested with hydrogen peroxide, stained with Nile red, and visualised using a stereomicroscope in fluorescence mode. Hotspots (> 700 particles per kg dry sediment) were identified on the Scilly Islands and in close proximity to major metropolitan hubs (i.e. Falmouth and Plymouth). Particles extracted from the Scilly Island sites were composed of polyethylene and polypropylene. With low population density on the Isle of Scilly, hotspots may suggest that microplastics originate from distant sources, while Falmouth and Plymouth, on mainland UK, are locally supplied. This information supports the design of future campaigns and targeted mitigation strategies in areas of highest concentrations.

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EFFECTS OF RIVERINE NUTRIENT FLUXES ON COASTAL WATERS

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OVERVIEW AND HIGHLIGHTS OF THE LOCATE PROJECT

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SEASONALITY IN BENTHIC/PELAGIC FLUXES OF DISSOLVED AND PARTICULATE MATTER IN TEMPERATE COASTAL ENVIRONMENTS

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The exchange of particulate and dissolved matter between benthic and pelagic environments is an important part of the cycling of biologically important substances in the coastal marine environment. While individual drivers of exchange are well understood, their interdependencies at the ecosystem level are not, thus restricting our understanding of the exchange processes as a whole.
This study aims to define seasonal patterns of benthic/pelagic exchange by combining experimental measurements of *in-situ* exchange processes and their drivers with long-term time-series data describing average patterns of seasonality of the various drivers throughout the year.
As the drivers of particle exchange differ from those of solute exchange, the two processes are at first investigated separately using particulate organic carbon and dissolved inorganic nutrients as examples, before interactions between the two are explored further.
In the case of benthic/pelagic exchange of particles, processes driving both resuspension and deposition of particulate matter showed strong seasonal patterns. Physical drivers were found to be of critical importance in winter, especially during storm events strong enough to incite seafloor resuspension. In spring and summer months, biological drivers played a larger role. The seasonality of solute exchange processes was mainly driven by biological mixing and inter-seasonal differences in diffusive flux potential.
The results of this study indicate that at strongly seasonal coastal sites such as this, seasonal timing has to be taken into account in the experimental design of future studies due to not only direct environmental differences but also shifts in the importance of indirect drivers of ecosystem processes.

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STRONG GRADIENTS IN SEAWATER pCO_2 IN COASTAL WATERS REVEALED BY HIGH FREQUENCY MEASUREMENTS

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We used a seawater CO_2 system with a fast-response equilibrator to continuously measure seawater CO_2 fugacity (fCO_2) on the Plymouth Marine Laboratory vessel (RV Quest). Data were collected between June and September 2016 along transects between the Plymouth Breakwater and the L4 station (part of the Western Channel Observatory). The fast-response fCO_2 system was able to resolve small scale features that cannot be observed using the showerhead equilibrators commonly used by the research community. We observed strong fCO_2 gradients that can be linked to riverine water flowing into the Plymouth Sound. The spatial and temporal extent of the river plume is controlled by the tide and the fCO_2 levels are thus highly dynamic. We observed a strong relationship between fCO_2 and salinity, suggesting that mixing is the dominant control on fCO_2 in coastal waters in and around the Plymouth Sound. Freshwater pulses with high fCO_2 can be detected at station L4. These data demonstrate that tidal and riverine outflow dynamics may influence the air-sea flux in coastal regions.

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Harmful Algal Bloom detection using ocean colour satellites in coastal waters of the English Channel.

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Harmful Algal Blooms (HABs) are naturally occurring phenomena caused by excessively high growth of microscopic marine algae, which can release toxins into the marine environment that can harm or kill fish, shellfish and humans. The frequency and magnitude of HABs is increasing globally, and therefore poses high risk to human health and shellfish industries. HABs often start in one area and evolve to become problematic in another.

Each HAB species has a preferred set of environmental conditions for growth and by understanding these conditions locally, better prediction of the timing and location of HABs may be possible. HABs can be detected using ocean colour satellite data. As part of the project S-3 EUROHAB we have developed a web alert system for the detection of local HAB events in coastal and shelf areas of the French-English Channel. The system provides near real time risk indicator maps of three HAB species (Karenia mikimotoi, Phaeocystis globosa, Pseudo-nitzschia spp.) and a suite of other environmental parameters (including Chlorophyll-a, Particulate Inorganic Carbon and Turbidity, rainfall, wind speed and direction, sea water temperature, salinity and ocean mixed layer thickness) using data from the Copernicus European satellites.

In this talk we assess the extent of HAB risk events using satellite data over the past decade. In relation to this, we also assess changes in phytoplankton biomass in English Channel coastal waters over the past 20 years, and the reasons for this. We also demonstrate the use of satellite data to track the development, magnitude and spread of HABs and assess the environmental drivers that cause them. Multiple satellite data are combined to develop proxies for HAB species that occur at very low cell density.

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OVERVIEW AND HIGHLIGHTS OF THE UK WESTERN CHANNEL OBSERVATORY

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THE TAMAR OPERATIONAL MODEL: OPPORTUNITIES, CHALLENGES AND FUTURE DEVELOPMENTS

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Within the context of the Interreg Atlantic Area MyCoast project, PML has implemented a nowcasting and forecasting system of the Tamar estuary and adjacent coastal area for storm surge and baroclinic flow and associated coastal risks. The operational model simulations support the implementation of coastal risks tools developed within MyCoast such as water quality and debris dispersion and search and rescue applications. The MyCoast tools are all transferable across all seven coastal observatories involved in MyCoast because of the common standards adopted for the operational model results, data archiving and tool development approaches.

The system consists of three separate components; 1) a dynamically downscaled GFS (Global Forecasting System) atmospheric short forecast that uses the WRF (Weather Research and Forecasting) model at 3km resolution, 2) a neural network river forecast calibrated against gauged flows that uses WRF's rainfall over the catchment areas and 3) oceanic boundary information from the latest 1.5km resolution MetOffice ocean forecast model (NEMO) as provided by the EU forecast service CMEMS (Copernicus Marine environment monitoring service (http://marine.copernicus.eu/). The hydrodynamics are resolved with FVCOM, a prognostic, unstructured-grid, finite-volume, free-surface, 3D primitive equation coastal ocean circulation model, which is well suited to simulating flows within estuaries and around complex coastlines. The model domain has 30m resolution in the upper reaches of the estuaries increasing to a maximum of 8km in the most offshore regions some 60km from the coast. It resolves the coastal intertidal areas which are present inside the estuarine area. The system is completely automated and operates unattended at pre-scheduled intervals. The system provides daily 48-h forecasts forward. The system has been validated in both hindcast and nowcast/forecast modes using water level, current velocities, salinity and temperature data from a variety of sources and has been found to run robustly during the test periods. Low level products (e.g., raw output datasets) are disseminated using THREDDS. Example of applications of MyCoast coastal risk tools will be presented and future plans for the operational system will be discussed.

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ATMOSPHERIC TRACE METAL AND NUTRIENT DEPOSITION IN TEMPERATE SHELF SEAS: IMPACTS OF NATURAL AND ANTHROPOGENIC FLUXES

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The atmospheric transport and deposition of essential trace elements (e.g. iron and manganese) and inorganic macronutrient species (phosphate, nitrate and ammonia) have important implications for marine and freshwater biogeochemical cycles. The importance of these fluxes to primary producers in any given water mass will vary both spatially and seasonally. This is further confounded by the variability of air masses between continental and marine sources. This presentation will discuss total and water soluble trace metal and nutrient atmospheric fluxes from weekly atmospheric observations between 2014 - 2018 from Penlee Point Atmospheric Observatory (PPAO). The PPAO is a coastal site recently established in Cornwall, UK where the regular collection of samples from targeted air masses from various sectors is possible, including those influenced by European continental, industrial, agricultural and marine sources. The results demonstrate the extreme variability in atmospheric deposition of trace metal and nutrient species in this region and the potential impact of these fluxes to the shelf sea marine environment, particularly during summer periods of intense stratification and nutrient depletion.

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EARTH OBSERVATION in ESTUARINE AND COASTAL ENVIRONMENTS

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In recent years provision of open access and free Earth observation data has greatly increased. With this gain in data there has also been an improvement in spatial resolution with some of the newer satellites such as ESA Sentinel-2 providing free-at-source reflectance data at 10 m resolution. This higher resolution allows smaller water bodies to be discerned and is of clear interest to those wanting to capture the state of coastal and estuarine zones.

During 2018 – 2020, PML demonstrated a monitoring service for the UK coastal and inland water bodies, using data from the Sentinel-2 mission, including a 5-day 100 m resolution turbidity product. With continual improvements to algorithms and instrument technology remote sensing of smaller water bodies is becoming a reality.

In this talk we present satellite and drone data, used to derive water quality information, generated for a selection of projects, and a time series case study undertaken in the St John's lake region of the River Tamar system where we try and identify seasonal macrophyte growth within the lake.

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Three Decades of Trace Element Sediment Contamination: The Mining of Governmental Databases and the need to Address Hidden Sources for Clean and Healthy Seas

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Trace elements (TEs) frequently contaminate coastal marine sediments with many included in priority chemical lists or control legislation. These, improved waste treatment and increased recycling have fostered the belief that TE pollution is declining. Nevertheless, there is a paucity of long-term robust datasets to support this confidence.

By mining UK datasets (100s of sites, 31 years), we assess sediment concentrations of arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), nickel (Ni), lead (Pb) and zinc (Zn) and use indices (PI [Pollution], TEPI [Trace Element Pollution] and Igeo [Geoaccumulation]) to assess TE pollution evolution. PI and TEPI show reductions of overall TE pollution in the 1980s then incremental improvements followed by a distinct increase (2010–13). Zn, As and Pb Igeo scores show low pollution, whilst Cd and Hg are moderate, but with all remaining temporally stable. Igeo scores are low for Ni, Fe and Cr, but increasing for Ni and Fe. A moderate pollution Igeo score for Cu has also steadily increased since the mid-1990s. Increasing site trends are not universal and, conversely, minimal temporal change masks some site-specific increases and decreases. To capture this variability we strongly advocate embedding sufficient sentinel sites within observation networks. Decreasing sediment pollution levels (e.g. Pb and Hg) have been achieved, but stabilizing Igeo and recently increasing TEPI and PI scores require continued global vigilance. Increasing Ni and Fe Igeo scores necessitate source identification, but this is a priority for Cu. Local, regional and world analyses indicate substantial 'hidden' inputs from anti-fouling paints (Cu, Zn), ship scrubbers (Cu, Zn, Ni) and sacrificial anodes (Zn) that are also predicted to increase markedly. Accurate TE input assessments and targeted legislation are, therefore, urgently required, especially in the context of rapid blue economic growth (e.g. shipping).

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INSIGHTS FROM YEAR-LONG MEASUREMENTS OF AIR–WATER CH_4 EXCHANGE IN A COASTAL ENVIRONMENT

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Air–water CH_4 fluxes was directly measured using the eddy covariance technique at the Penlee Point Atmospheric Observatory on the southwest coast of the United Kingdom from September 2015 to August 2016. The high-frequency, year-long measurements provide unprecedented detail on the variability of this greenhouse gas flux from seasonal to semi-diurnal (tidal) timescales. Depending on the wind sector, fluxes measured at this site are indicative of air–water exchange in coastal seas as well as in an outer estuary. For the open-water sector when winds were off the Atlantic Ocean, CH_4 flux was almost always positive (annual mean of ~ 0.05 mmol m^{-2} d^{-1}) except in December and January, when CH_4 flux was near zero. CH_4 emission demonstrates a tidal influence, with larger fluxes during rising tide than during falling tide. At times of high rainfall and river flow rate, CH_4 emission from the estuarine-influenced Plymouth Sound sector was several times higher than emission from the open-water sector. The implied CH_4 saturation (derived from the measured fluxes and a wind-speed-dependent gas transfer velocity parameterization) of over 1000% in the Plymouth Sound is within range of in situ dissolved CH_4 measurements near the mouth of the river Tamar.

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