Book of Abstracts

CoastGIS 2021

Sustainable Coastal Management in a Changing World

Novia University of Applied Sciences

Online from Raseborg, Finland

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Welcome

On behalf of the International and National CoastGIS 2021 organising committees, I would like to take this opportunity to welcome you all to CoastGIS 2021 in Raseborg, Finland.

As you are all probably very well aware by now, this is the first virtual CoastGIS event we have held in the CoastGIS series! COVID-19 and the pandemic took everyone by surprise 18 months ago, in the end having a far greater impact on peoples' lives around the World than was at first ever imagined.

Despite valiant attempts to deliver CoastGIS in 2020, in the end the decision was finally made to postpone it until 2021 to allow enough time for us to plan for a return to some sort of normality, possibly even hosting a face-to-face event, and if not, then a virtual conference. Circumstances have naturally led us to pursue planning of a virtual event because of the ongoing pandemic and travel restrictions.

As you will soon see, however, the organising committees, especially the local organisers from Novia University of Applied Sciences in Raseborg, Finland, have been working tirelessly over the past year to put together an excellent conference programme for you which continues the unique tradition of the CoastGIS series of events that first started out in 1995.

This year, the programme once again provides an international mix of scientific research in the form of Keynotes, Parallel Sessions, and Workshops. As so typifies this specialist event, the focus in 2021 is very much on the role and application of geospatial tools, techniques, and technologies for the monitoring, mapping, and modelling of the coastal environment.

The programme includes presentations on GIS, mapping, remote sensing, drones, and decision-support as applied to species mapping and habitat, coastal management, marine spatial planning, coastal change, society, and Big Data – to name a few of the diverse topics.

We do hope that you will enjoy what CoastGIS 2021 has to offer and will make the very best of this opportunity to once again join and network with the international CoastGIS community hosted by Novia in Finland.

In the meantime, our sincere thanks to all the people who have – once again – made CoastGIS 2021 possible in these challenging times.

David R. Green

Aberdeen, September 2021

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Keynote speakers

are presented on the following pages.

Prof. Sheila JJ Heymans

Coastal planning needs for the UN Decade of Ocean Science for Sustainable Development

European Marine Board, Belgium
University of the Highlands and Islands, Scotland

In this talk, I highlight the importance of GIS in different tools used to underpin coastal planning in the context of the UN Decade of Ocean Science for Sustainable Development (Ocean Decade). The talk highlights the societal needs and decision support tools needed for the Ocean Decade by looking at the recommendations given from European Marine Board (EMB) Working Groups in this regard. It explains the main societal outcomes, challenges and research needs identified for the Ocean Decade, and how EMB documents such as Navigating the Future, Enhancing Europe's capability in Marine Ecosystem Modelling, and Big Data in Marine Science have addressed the Ocean Decade, but also how GIS can ensure that these recommendations are realized. The talk also gives some examples of where GIS has been instrumental in Ecosystem modelling studies.

Prof. Heymans is Executive Director of the European Marine Board – the leading European marine science policy think tank – and Professor in Ecosystem Modelling at the Scottish Association for Marine Science and the University of the Highlands and Islands in Scotland. Prof. Heymans has 30 years' experience in research on the environmental impacts of ecosystem change and has published more than 90 peer-reviewed publications. Prof. Heymans is Co-Chair of the EOOS Steering Group and on the External Advisory Board for EMBRsea, EuroFleetsPlus and the EU Blue Cloud projects. She is also the editor of EMB Policy documents.

Prof. Sanna Kaasalainen

Prof. Kaasalainen is the Director of the Department of Navigation and Positioning at the Finnish Geospatial Research Institute at the National Land Survey of Finland. The Department of Navigation and Positioning carries out innovative research on novel navigation and positioning solutions, such as new localization algorithms and the adaptation of new positioning sensors. Prof. Kaasalainen's research interests are optical sensors related to positioning and situational awareness. Prof. Kaasalainen is a board member of the Nordic Institute of Navigation and of the Terrestrial Laser Scanning Research Coordination Network (TLSRCN) funded by the United States National Science Foundation NSF. She is an Associate Editor of the ISPRS Journal for Photogrammetry and Remote Sensing.

Dr. Rodolphe Devillers

Dr. Devillers works as a Senior Research Scientist for the French National Research Institute for Sustainable Development IRD. His work is generally at the interface between geomatics/ GIScience and the marine and coastal environments, using GIS, spatial analyses and statistics, modelling and geovisualization to help support marine conservation and ocean management. Some of his research focuses on mapping seafloor habitats, helping design marine protected areas (MPAs), modelling the distribution of species at risk, and assessing the vulnerability of those species to anthropogenic threats. Dr. Devillers is also on the board of several environmental NGOs in the field of marine conservation and is Associate Editor of the journals Geomatica and Marine Geodesy.

Workshops

are briefly introduced as follows.

Big data opens new possibilities for coastal management

Helena Åström

SCALGO, Denmark

In her SCALGO Live workshop, Dr. Åström introduces a new kind of planning tool for spatial assessments, based on three decades of research at Aarhus University. Workshop participants will get the chance to test SCALGO Live's tools and analyses through an interactive exercise.

UAVs for coastal monitoring, mapping and modelling

David R. Green[1] and Romi Rancken[2]

[1]University of Aberdeen, Scotland, UK
[2]Novia University of Applied Sciences, Finland

This workshop examines some of the current and future UAV, AUV, and USV technologies and sensors being used, for aerial and marine data collection, image processing, soft-copy photogrammetry, and AI tools and techniques for the collection, processing and extraction of information from UAV imagery. The session is illustrated with a number of example applications from Scotland, UK and Finland with an emphasis on off-the-shelf practical solutions. Some information sources are provided, together with some short example videos, the launch of a new SI on UAVs for Coastal Surveying, and a call for interest in collaborative funding.

And finally, session abstracts

begin on the following page.

Mapping and modelling of the spatial dynamics of mangroves in the Sassandra-Dagbégo Ramsar site

Léocadie Marie-Claude Akadje-Konan,
Célestin Hauhouot and Daouda Sylla

University of Cocody, Côte d'Ivoire

The Ramsar site of Grand-Bassam, on the outskirts of Abidjan, a large metropolis, is subject to strong anthropic pressures due to urban expansion. The result is a degradation of natural environments, shelter for many species, and eventually a regression of the ecosystem services it provides.

This work proposes, to make the state of the evolution of the environment, in order to update the cartography of the Ramsar zone and to predict the possible futures, in order to contribute to the efficient management of the existing natural resources.

Using remote sensing, a multi-date mapping of land use was first developed, based on Sentinel satellite images from 2016 and 2020. An assessment of the forest environment was then made and the changes that have occurred in this environment were quantified. Finally, a predictive model of the land use in 2040 was developed to predict the evolution of the wetland in the near future.

The results reveal a regression of the natural vegetation, in Grand-Bassam's Ramsar site. Specifically, mangroves and forests have lost huge areas to cropland and built-up areas. The predictive modelling of land use, of the Ramsar site, foresees a strong progression of the built-up area, to the detriment of natural vegetation formations, by 2040; if the current practices of exploitation of natural resources are maintained. As a consequence, we will witness a reduction of the vital space of certain species, with as ultimate consequence, their disappearance.

Big data opens new possibilities for coastal management

Helena Åström

SCALGO, Denmark

In conventional GIS tools, handling large data sets, such as elevation data, is a time-consuming and difficult process. Big data analytics provide new possibilities for large scale assessments with improved access to data. SCALGO Live is a new kind of planning tool for spatial assessments, that allows the planner to dive into large elevation models seamlessly and interactively. The tool is based on three decades of research into big data and algorithms at Aarhus University, and is an excellent example of how research can become a real-world application. SCALGO Live gives several advantages for those using elevation data and other large data sets in surface water and coastal planning. Firstly, the user gets immediate access to nationwide elevation models without having to conduct any data handling. Secondly, the planning tool provides nationwide analyses for creating an overview of the area and an understanding of how water and terrain interacts. Examples of national analyses accessible through SCALGO Live are sea-level rise, watersheds, and flow paths. Lastly, SCALGO Live includes a large variety of terrain editing tools that the user can utilize to test the impact of different ideas, such as building dikes, placing temporary flood protection, creating wetlands and basins etc. Bringing big data analytics into spatial and terrain planning provide new possibilities for coastal managers by creating a set up where the planner can interact with data and analyses, gain a rapid understanding of a problem at hand, easily test different solutions, and ultimately, create feasible plans for coastal areas.

An integrated decision support system for the resilience assessment of eastern Baltic Sea coasts

Mojtaba Barzehkar[1], Kevin E. Parnell[1] and Tarmo Soomere[1,2]

[1]Tallinn University of Technology, Estonia;
[2]Estonian Academy of Sciences, Estonia

Selecting a logical framework for resilience planning is a significant coastal management problem. The main objectives of this study are 1) to develop an integrated decision support system (DSS) that could assist decision-makers to mitigate coastal hazards; 2) to employ an integrated DSS to demonstrate how decision making with respect to coastal resilience can be better informed. This study considers a hybrid DSS, using fuzzy logic, the analytical hierarchy process (AHP), a weighted linear combination (WLC), and a geographical information system (GIS) integrated with an artificial neural network (ANN) to develop a coastal resilience index (CoRI) for the eastern Baltic Sea. In the first stage, the most important environmental and socioeconomic parameters for evaluating coastal resilience assessment based on the experts' perspectives are identified. In the next stage, raster layers of each parameter are prepared using ArcGIS software. After preparing the raster maps of each parameter, fuzzy logic is applied to standardize each raster layer between 0 and 1. The relative weights of different parameters are calculated using super decision software (SDS) based on prioritizing parameters using AHP. In the following stage, the WLC method is employed to combine raster layers in ArcGIS to prepare the CoRI map. An ANN using multilayer perceptron is then implemented to classify the coastal resilience. It can be concluded that investigating and comparing the outcomes from the hybrid computer-based DSS is a more satisfactory framework than using individual tools for the development of maps of coastal resilience classification in the eastern Baltic Sea.

Multiple marine and coastal ecosystem services assessment in the Adriatic Sea (Italy)

Laura Basconi, Silvia Rova, Alice Stocco and Fabio Pranovi

Ca' Foscari University of Venice, Italy

Marine coastal ecosystem services (MCESs) assessment represents a multi-facets metrics of the natural environment, capturing the multiple ways in which human well-being depends upon the structures and functions of ecosystems. The joint assessment of multiple MCESs represents a widely accepted holistic approach that contributes to shed light on the complexity of socio-ecological systems. In this work, a spatially-explicit assessment of seven ecosystem services has been carried out across the Adriatic coastal-marine system. Each ES has been assessed for its capacity and flow. The assessed MCES include three cultural services, namely coastal tourism, recreational boating and recreational fishing, two regulating services, CO2 sequestration and coastal erosion prevention, and three provisioning services, fishery, mussel and whitefish aquaculture. The spatially explicit nature of the assessment allows to explore the spatial correlation among ESs and how their composition changes in different socio-ecological context. This could inform management strategies over the seascape scale (scale for the ecosystem-based management (EbM)) resulting in suitable methods for maintaining multiple ESs in the long-term.

Assessing morphodynamics and vulnerability of a Northern Portuguese coastal stretch in support of erosion risk management

Ana Bio[1], Isabel Iglesias[1], Luísa Bastos[1], José Luís Pinho[2], Helena Granja[1] and José A. Gonçalves[1]

[1]University of Porto, Portugal; [2]University of Minho, Portugal

Coasts are complex and dynamic zones, susceptible to natural hazards and anthropogenic pressures, and coastal erosion is a growing concern, particularly in the light of climate change effects. For a sound and informed management, coastal dynamics needs to be monitored at adequate scales.

Digital elevation models (DEM) of a N-Portuguese coastal stretch of about 14 km, collected between 2008 and 2019, were used to assess short- to medium-term local beach and dune morphodynamics, computing sediment budgets and beach areas. Morphodynamics was subsequently related with meteo-oceanic conditions, geologic features and human interventions.

Overall, the studied beach and dune systems showed accretion over the 10 year period (5.6% in volume and 3.3% in area). However, most of that accretion took place on an estuarine sand spit, which has been steadily growing since the construction of a detached breakwater, shortly before the analysed DEM series. Excluding the spit, beach volume was overall stable (+0.6%) and the area decreased (1.5%). Seasonal and inter-annual dynamics varied markedly and locally, with neighbouring beach sectors frequently showing contrasting behaviour. Erosion and accretion patterns were related to beach type, with beaches defended by rocky outcrops being more stable than sandy beaches. The shoreline orientation and the presence of defence structures also influenced local and neighbouring erosion/accretion patterns.

Results suggest that although the studied beaches are overall stable in terms of sediment budget, they have lost area and are susceptible to local, short-term changes, with contrasting erosion and accretion patterns, which is challenging for coastal managers.

Sea-level rise impacts in sheltered coastal systems: a comprehensive GIS-based framework proposal for physical vulnerability assessments

Jarbas Bonetti[1] and Allan de Oliveira[2]

[1]Federal University of Santa Catarina, Brazil;
[2]Federal University of Rio Grande do Sul, Brazil

Assessments of the physical vulnerability to the impacts of marine hazards have been extensively carried out in many sectors of world's coastlines since the 1990s. Among the available alternatives, index-based spatial analysis using GIS is probably the most adopted methodological approach. They are based on the integration of structural and dynamical variables and, although the general proposed framework fits well to most exposed coasts, few examples can be found in the literature regarding the selection of dynamical descriptors (variables of process) particularly relevant for sheltered coastal systems, such as lagoons. Considering it, this study proposes a novel approach to determine the physical vulnerability to sea-level rise in lagoons. After implementing a numerical model for a southern Brazilian lagoon, dynamical descriptors were obtained to satisfactorily reproduce the hydrodynamic characteristics of the studied system. Moreover, different sea-level rise scenarios proposed by the (IPCC) for the years 2050 and 2100 were simulated. The calculated maximum level oscillations revealed the importance of the winds and tides (both astronomical and meteorological) as the main triggering processes of local dynamics. The physical vulnerability spatial distribution, obtained by the integration of maximum level variations associated to future projections, allowed the recognition and classification of the sectors within the lagoon which are more prone to suffering impacts. The identification of areas with different degrees of susceptibility can be a valuable tool for coastal planning and management actions to be performed in sheltered systems, which have been more neglected than those applied in open coasts.

Advancing sustainable coastal planning through effective use of open-access biodiversity information systems: Where getting names right always matters!

Robert M. Branton

International Ocean Institute, Canada

Understanding individual species' roles in ecosystems' provision of services to humans is vital to cooperative international decision making. The 'OceanLife-2021' website provides ocean governance professionals and others with freely available, globally relevant materials for demonstrating the use of open-access biodiversity information systems, including: World Register of Marine Species (WORMS), Ocean Biodiversity Information System (OBIS), Global Biodiversity Information Facility (GBIF), iNaturalist, etc. The 'OceanLife-1859' pamphlet by J.M. Sommerville and Smithsonian Life's '5 Invasive Species You Should Know!' websites provide a practical basis for demonstrating interaction with biodiversity information systems. Presentation includes: history of biodiversity information systems; challenges associated with querying such systems; and demonstration of visualizing invasive species data from multiple sources at national to global scales. Technologies include: Chromebook, Jupyter notebook, R-Spocc, R-ggplot, R-Shiny and Github.

Critical overview of data portals supporting Marine Spatial Planning

Juliette Davret and Brice Trouillet

University of Nantes, France

Marine/Maritime Spatial Planning (MSP) largely lays on geographic information at all of its implementation stages. In this presentation, we emphasize on the role of information in MSP, viewed from a perspective rooted in critical GIS/cartography, critical data studies and STS. More specifically we focus on data portals which support MSP. Based on a thorough analysis of about one hundred MSP data portals throughout the world, we explore their content, role and purpose using an analysis framework built according to a literature review. Practically speaking, we examine the type of data, the functionalities offered, the available visualizations, and finally the use of the portal itself as a planning tool or as a supporting device. By doing this, we explore the relationship between the tool and its use(s) in the operational framework of MSP. We show how things are captured, coded and formatted (intentionally or not). In some cases, data portals may even replace documents or at least outdo the simple role of governance support. Thus the limit between a data portal and a planning document may be blurred with obvious consequences into the spatial planning system. This work also proposes a first typology of data portals and associated informational issues in MSP realm and more generally in spatial planning.

Ecosystem-based Integrated Coastal Zone Adaptation and Management: synergies and added value in four European coastal regions

Patrick de Klerck[1] and Alexia Semeraro[2]

[1]Dept of Environment and Spatial Planning, Flemish Government, Belgium;
[2]Research Institute for Agriculture, Fisheries and Food (ILVO), Belgium

The Ecosystem-based Integrated Coastal Zone Adaptation & Management project aims to contribute significantly to the implementation of climate change adaptation plans that address specific climate change vulnerabilities in coastal areas. Synergies between terrestrial and aquatic issues and challenges of the coastal environment are central themes in this project, using Ecosystem-based Adaptation (EbA) approaches in Denmark, Italy, Spain and Belgium. Despite increasing deterioration of the natural, socio-economic and cultural resources of our coastal zones, coastal planning activities or development decisions still take place in a sectoral, fragmented way, leading to inefficient use of resources, conflicting claims on space and missed opportunities for a more sustainable and resilient ecosystem-based coastal development. Bridging the gaps between multi key stakeholders by addressing the problems and needs using cocreation techniques will give structure and help implementing coastal climate adaptation programmes. It will give a joint commitment to develop Local Green Deals by working on the path towards climate-neutrality. Raising awareness of the societal added-value of building with nature projects (Nature-based Solutions) will support improvements in biodiversity in the climate change adaptation strategies. To accomplish this, a multitude of synergies need to be sought at different levels and within various contexts: with other environmental and climate policies (e.g., between climate change adaptation, disaster risk reduction of sea-level rise, biodiversity support, green recovery), between terrestrial/ aquatic issues and challenges of the coastal environments, between ecosystem-based tailor-made best practises, pilots and demonstration projects and between building with nature participative implementation techniques.

Exploring and visualizing oceans in a virtual marine environment

R.E. de Vries

Van Hall Larenstein University of Applied Sciences; The Netherlands

Advances in geospatial technologies and vast numbers of new oceanographic satellite missions lead to an abundance in geodata and provide the opportunity to increase knowledge and understanding of the ocean system. Virtual Reality (VR) seems a promising technology to visualize and analyse this data, making vulnerable or difficult to access environments accessible in a Virtual Environment (VE).

By visualizing marine data in a voxel environment using the gaming engine Minecraft, a Virtual Ocean was created to test navigational aids to help in understanding the virtual marine environment. By getting a better understanding of the VE, the potential of using such a platform to prepare or even replace fieldwork was also tested in particular. The system was tested by 50 participants using a desktop and a VR device by performing specific tasks, followed by a questionnaire to share their experiences.

The choice of using Minecraft provided an intuitive and user-friendly platform, as well as a very efficient way to visualize data, the addition of a VR device provided more engagement and realism opposed to the desktop setup. The use of a VR device did not prove to be of added value on the perception of scale and orientation.

The proposed system was deemed promising to visualize and explore marine data in the context of preparing, reflecting on, and executing fieldwork. Whether the provided aids were of added value was not conclusive under the current circumstances, however the use of verbal instructions and maps were appreciated and actively used by all participants.

Investigating larval spillover from oyster aquaculture through geospatial Habitat Suitability Index modeling: A Damariscotta River case study

Daniel Delago, Marcia Moreno-Baez, Seth Theuerkauf, Adam St. Gelais, Barry Costa-Pierce, Damian Brady, Alix Laferreiere, Brian Beale and Chris Davis

University of New England, USA

The Eastern oyster (C. virginica) supports ecological function by creating biogenic reef habitat, and positively influencing coastal biogeochemistry in intertidal, and subtidal environments. As anthropogenic impacts continue to influence the health of marine environments globally, oyster reef restoration is gaining increased attention as a means of maintaining the function of estuarine systems. While larval spillover from aquaculture has proven viable as a means of population restoration in the green lipped mussel (P. canaliculus), the role oyster aquaculture may play in population restoration has yet to be explored.

Habitat suitability index (HSI) models have proven effective in facilitating population restoration of the Eastern oyster in estuaries of the eastern United States by providing spatially explicit information regarding the quality of habitat over broad areas of interest. This study employs a GIS based HSI model for the eastern oyster to investigate a recent population resurgence in an estuary where oysters were once extirpated, and oyster aquaculture is a multi-million-dollar industry: the Damariscotta River, Maine, USA. As a means of internal validation, we combine HSI model predictions with local ecological knowledge gained through participatory interviews of local harvesters targeting eastern oysters, and surveys of oyster aquaculture producers operating within the estuary.

By assessing the viability of participatory restoration resulting from larval subsidy from oyster aquaculture, this study explores the implications of low-cost restoration strategies which integrate fisheries, aquaculture, and conservation interests within in a reciprocal conservation paradigm.

Remotely sensed mapping of the intertidal zone: a Sentinel-2 and Google Earth Engine methodology

James M. Fitton[1], Alistair F. Rennie[2,3], Jim D. Hansom[2] and Freya M.E. Muir[2]

[1]University College Cork, Ireland;
[2]University of Glasgow, Scotland, UK;
[3]NatureScot, Scottish Government, Scotland, UK

International concern over increases in coastal erosion is focused on the risk to coastal assets, but there is also increased recognition of the impact on intertidal ecosystem services that may accompany increased erosion. Accurate time series mapping of the intertidal zone is key to understand the risks posed by erosion yet, due to high cost and logistical complexities, the intertidal zone remains a difficult environment to regularly survey and map at national scales. We present here a new approach that is accurate, rapid, cost-effective, easily updated and has the potential to become a powerful tool to inform the understanding and management of this dynamic zone. We map the intertidal zone by measuring water occurrence frequencies using tidally calibrated satellite imagery (Sentinel-2), processed within Google Earth Engine (GEE) and presented as a complementary approach to support traditional aerial or ground surveying. Using the UK and the Republic of Ireland as a test case, the resulting output, termed Coast X-Ray, compares favourably with the outputs from high-resolution digital elevation models. Coast X-Ray provides an up-to-date insight into the morphology of the intertidal zone across the UK and the Republic of Ireland. Due to the increasing societal importance of the impact of climate change and rising sea level on the coast, it is imperative that the intertidal zone is mapped regularly and accurately. Methods such as Coast X-Ray offer rapid and cost-effective potential solutions to the longstanding logistical complexities and economic costs associated with national mapping of such a dynamic environment.

FAIR data in support of Coastal GIS

Shayla Fitzsimmons

CIOOS Atlantic, Canada

A science-based approach is core to successful marine spatial planning activities, and requires volumes of complex data to create the necessary forecasts and models. And while Canada undertakes significant ocean observation activity from coast-to-coast, with initiatives led by numerous sectors, widespread use of data is impaired by a lack of coordination and visibility: what data is collected, where, and how does one find it?

In line with other regions addressing this challenge, Fisheries and Oceans Canada (DFO), in partnership with the Marine Environmental Observation Prediction and Response Network (MEOPAR), is collaborating with pan-Canadian ocean observing organizations to develop a Canadian Integrated Ocean Observing System (CIOOS). The system is expected to improve collaboration, be findable and accessible, improve interoperability through data and metadata standards, and enable the widespread reuse of data.

Key components of this system are three regional associations, located in the Pacific, Gulf of St. Lawrence and Atlantic. The latter is CIOOS Atlantic, a consortium of partner institutions committed to the development of a data management and dissemination approach for oceanographic data from the Atlantic Seaboard – an approach which is nationally consistent, but which also accounts for the unique needs of the local oceanographic community.

To ensure development of a system which benefits all Canadians, both CIOOS and CIOOS Atlantic place much emphasis on meaningful and ongoing engagement with stakeholders, including the coastal GIS community. CIOOS is well-positioned to provide a consistent and transparent framework for complex data which enables sound marine spatial planning, and more.

Using connectivity for benthic habitats to select marine protected areas in Denmark

Cordula Göke[1], Asbjørn Christensen[2] and Karsten Dahl[1]

[1]Aarhus University, Denmark; [2]DTU Aqua, Denmark

The aim of the project was to identify potential marine protected areas (MPAs) in parts of the Danish waters with the help of the site selection tool Marxan. The task description prepared by the Ministry of Environment and Food defined that the analyses should be based on selected EUNIS broad scale habitat types and specific species. As conservation target, the suggestions for MPAs should protect at least 40% of the habitats and species.

With a rather poor data situation for the target features, especially the invertebrates, a major focus was to identify potential MPAs that have a high connectivity with the surrounding international MPA network.

The connectivity was modelled from first principles using operational hydrographic data and formed together with the other ecological data input for a Marxan analysis.

The approach to include connectivity data, made it possible to use the benthic habitats as target layers for the Marxan modelling. As a result, the conservation targets could be met by identifying 14 suitable areas in the North Sea-Skagerrak and 12 in the Baltic Sea around Bornholm. The outcome has formed part of the scientific background for a decision to designate new MPAs in Denmark.

The setup is a promising approach, where the available observation data does not meet the criteria to be used in a Marxan analysis. To meet the connectivity targets even better, we suggest iterative steps of connectivity analysis with Marxan or full integration of the two model frameworks.

Will the MSP Challenge simulation platform be the digital twin of the sea?

Magali Goncalves, Harald Warmelink and Igor Mayer

Breda University of Applied Sciences, The Netherlands

With this presentation, BUas aims to give the audience an introduction to the MSP Challenge Simulation platform and what it can look like in the future. The MSP Challenge Simulation Platform simulates the Marine Spatial Planning process in its multi-sectoral, cross-border and ecosystem-based aspects. The platform has already been developed for the North Sea, Baltic Sea, and Clyde Marine Region. Real-life geodata and planning objectives are incorporated for each area. Users can co-plan for different maritime activity sectors (shipping, energy, recreation, fisheries and nature conservation) and see the effects of the plans enabled by three dedicated simulations: shipping, (green) energy production and ecosystem. The platform includes a knowledge base, centralising information about a marine region in one place. It helps users understand the complex marine system and plan for a sustainable future. BUas also developed a prototype that transforms users' plans into a 3D scene that can be visited, helping users understand their plans' magnitude and impacts. Current developments to include a shipping risk model are being made to assist in planning infrastructures at sea and accessing their effect on shipping safety. A feasibility study of incorporating a physical currents model to improve the ecosystem model and the decision making progress was recently carried out. BUas is currently finalising the Adriatic Sea Edition of the platform. More than a decision-support system, MSP Challenge is (slowly) developing into a digital twin of the sea as more information, data and models are incorporated into the platform.

Monitoring, mapping and modelling the coast using UAVs

David R. Green[1], Dmitri Mauquoy[1], Andrew Smith[1], Alex R. Karachok[1], Billy J. Gregory[2], Jason J. Hagon[3] and Ray Lawrenson[4]

[1]University of Aberdeen, Scotland, UK;
[2]DroneLite, Scotland, UK; [3]GeoDrone Survey Ltd., England, UK;
[4]Siskin Asset Management Ltd., Scotland, UK

Low-cost, off-the-shelf fixed-wing, multi-rotor and VTOL platforms are potentially useful small airborne platforms for environmental remote sensing applications for monitoring, mapping and modelling the coast. These are ideal for applications where aerial coverage requirements and operating budgets are relatively small. With advances in battery technology, navigational controls, payload capacities, and autonomous flight these smaller platforms are now capable of utilising a number of different sensors to collect photographic data, video footage, multispectral, thermal and hyperspectral imagery, and LiDAR data and imagery. Specialist digital image processing (DIP), soft-copy photogrammetry and GIS software can be used to process imagery into a number of different products including ortho-photos, mosaics, and Digital Elevation/Surface Models (DEM/DSM) to extract useful information and undertake analyses. This paper presents a few examples of work undertaken at the University of Aberdeen to illustrate studies of the coast.

Aspects of Monitoring, Mapping, Modelling & Removing Beach Litter

David R. Green, Thomas Danks, Laura Walker and Crawford Paris

University of Aberdeen, Scotland, UK;
East Grampian Coastal Partnership (EGCP Ltd.)

Firstly, this presentation briefly outlines the work of the East Grampian Coastal Partnership (EGCP) Turning The Plastic Tide (TTPT) project in relation to pioneering community beach cleans along the Aberdeen and Aberdeenshire coastline. Secondly, the presentation highlights some of the monitoring, mapping and modelling studies that EGCP has been involved in using the geo-spatial technologies of remote sensing, Geographical Information Systems (GIS), Mobile-GIS, Mobile Phone Apps, Digital Mapping and Analysis, Web-GIS, and spatial modelling tools to help to understand the spatio-temporal distribution of different types of beach litter observed.

Land Suitability Assessment for growing early potato, apples, pastures and cultural cereals in the coastal Uusimaa Region

Eduardo Grisales

Novia University of Applied Sciences, Finland

Matregion Nyland (Food Region Uusimaa) is a project that aims at strengthening the region Food Strategy Plan by enhancing the production and market opportunities of local products. There are significant steps for achieving this objective; for instance, the development of a geospatial method for identifying potential areas for growing the crops mentioned above. A Multi-criteria Evaluation (MCE) is the chosen tool for analysing multiple criteria for each of the crops. Collected data on criteria such as land surface temperature (LST), soil texture, soil use, slope, water proximity, etc., was used to perform a land suitability assessment and traffic-light classification of potential fields. The data processing software produced four different maps (one per crop). Areas of optimal and acceptable conditions vary from crop to crop but showing a pattern for Land Surface Temperature; this criterion is of high importance for most crops in this analysis, therefore, a higher weight assigned by the Spatial Decision Support System (SDSS). The results showing suitable fields are being validated by locals (where possible). It is important to note that areas with low suitability can still be used for agricultural purposes, but performance can vary. This method can be adhered to existing methods of evaluating land conditions such as soil chemical test for supporting the decision-making process of farmers with high accuracy.

Does local water quality affect people's life quality? A case study in a coastal community

Ruslan Gunko[1,2], Patrik Karell[2,3], Lauri Rapeli[4], Matias Scheinin[5] and Timo Vuorisalo[1]

[1]University of Turku, Finland; [2]Novia University of Applied Sciences, Finland; [3]Lund University, Sweden; [4]Åbo Akademi University, Finland; [5]Tvärminne Zoological Station, Tvärminne, Finland

Worldwide people pursue happiness and life satisfaction. However, most of the studies of life quality are concentrated on a country level scale and local differences within a country or area are often less studied. Thus, the effect of the environment on life quality on a local scale is less known. In my project, I investigated the effect of objectively measured environmental factor and its subjective reflection (assessment of the visual conditions) on life quality. The study aims to understand if there is an effect of environment on local scale well-being and is it driven by actual state or psychological factor (perception of environment from locals). The study area is a coastal community Raseborg located in the Baltic Sea archipelago.

For coastal communities, the state of water quality plays a more important role in comparison with other reflections of the state of the environment. The objective measurements consist of high-resolution water quality data, including nutrient concentrations causing eutrophication, and were collected throughout the archipelago during an ice-free season. The subjective data collected by surveying inhabitants' environmental and socio-demographic parameters in 2018-19. Additionally, respondents evaluated their life satisfaction. Both types of data were georeferenced.

Analysis indicated a significant role of environment on life quality on a local level. However, this effect is significantly stronger for the perception of the environment, while the objectively measured state of the environment has a small effect on people's life satisfaction on this scale. Thus, the psychological factor should be accounted for measuring life quality in the coastal community.

Mapping the cumulative effects of human activities on marine mammals in UK waters: informing management, planning and conservation efforts

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Marine mammals are widespread in UK waters and are vulnerable to a variety of acute and chronic anthropogenic disturbances, including underwater noise, strike and entanglement. The effects of disturbance can vary both inter- and intra-specifically, with some populations potentially more prone to certain impacts. Our limited understanding has meant the approach to evaluating the effects of multiple stressors formally within a Cumulative Effects Assessment (CEA) has most commonly been to assess the impact of each stressor separately, using practitioner expert opinion rather than utilising quantitative tools. The shortcomings of the qualitative approach are increasingly recognised by industry and academia, though the availability of quantitative tools for analysis of impacts on marine mammals is limited. The implementation of GIS tools into policy and practice would allow a more in depth spatio-temporal analysis of multiple stressors. Species-specific vulnerability maps will provide a new and exciting way for a variety of stakeholders to visualise how natural and anthropogenic stressors overlap in marine systems, increasing awareness and understanding in relation to the extent of some species potential exposure. This innovative approach will support the long-term conservation of marine mammals in UK waters, and help inform the future sustainable use of the marine environment.

Enhancing the Wisconsin Coastal Atlas as a resource to support adaptive coastal management

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Adaptive management of dynamic coastal resources involves applying a structured, iterative process of decision-making under high levels of uncertainty and enables collective action to solve complex and challenging problems. The Wisconsin Coastal Atlas (https://wicoastalatlas.net/) is a technology platform that enables people to better understand coastal issues, share coastal data and inform decision-making about coastal management. The atlas includes six modules: Maps, Catalog, Tools, Learn, Topics and About. These modules work together to provide access to resources that can guide adaptive management of the challenging issues facing the Laurentian Great Lakes. The Maps module provides a gallery of interactive maps with customized perspectives related to specific coastal issues. The Catalog module provides multiple pathways to discover, assess, and download relevant geospatial data. The Tools module serves as a gateway to spatial decision-support tools relevant to coastal issues. The Learn module serves as a repository for resources that support place-based learning. The Topics module provides quick access to maps, tools, data and learning resources relevant to specific coastal management issues. Finally, the About module shares information about the project team and partners and frames the atlas as a research project that supports interoperability and a coastal spatial data infrastructure for Wisconsin and the Great Lakes. This presentation will showcase recent enhancements to the Wisconsin Coastal Atlas to better support adaptive coastal management influenced by a competitive analysis of 10 U.S. state coastal web atlases and a user survey with stakeholders from those states about their experiences with and opinions on atlas design.

Design and evaluation of coastal web atlases: Best practices and future opportunities for map representation, interaction, and usability

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As defined by the International Coastal Atlas Network (ICAN), a coastal web atlas (CWA) is a collection of digital maps and datasets with supplementary tables, illustrations, and information that systematically illustrate the coast, oftentimes with cartographic and decision support tools. CWAs have emerged as a resource to organize maps and geospatial data in support of education, exploration, and decision-making about coastal issues. Many U.S. states have launched custom CWAs for adaptive management of coastal problems ranging from flooding and erosion to pollution and habitat loss. Specifically, we conducted a needs assessment that bridges adaptive coastal management user needs with three tenets of interactive cartographic design relevant to CWAs: map representation, interaction, and usability. The needs assessment included two stages: a competitive analysis of 10 state CWAs and a user survey with stakeholders from those states about their experiences with and opinions on CWA design. Findings addressed best practices and unmet needs for cartographic representation and interface functionality in CWAs, as well as target user perceptions of usability and utility in CWAs. Examples of gaps that CWA developers can address in the future include expanding the use of thematic maps, using hybrid basemaps to provide greater context about the land and water sides of the coastline, implementing spatial calculations and temporal sequencing for analysis and exploration, using narrative maps to support CWA learnability, improving responsiveness between mobile and non-mobile devices, and creating advanced analytical tools that support decision making about the most pressing issues facing our coasts.

The macrophyte story:
What can macrophytes tell us about water quality?

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One of the most serious problems facing the Baltic Sea is eutrophication which is mainly caused by diffuse loading from land. To be able to improve mitigation and management measures in coastal areas we need a diverse toolbox and sound knowledge regarding both causes and consequences. Macrophytes have previously been shown to be good indicators of the environmental state of water bodies. In this study we relate high resolution spatial data on water quality parameters as BOD and chlorophyll a to occurrences of key macrophyte species, assemblages or communities. We utilize both multivariate methods as canonical correspondence analyses (CCA) as well as species/assemblage-specific generalized additive models (GAMs). The first step is to define different assemblages along the environmental gradients and the second step is develop predictive models for key species or combined species assemblages based on the results from the first step. The aim is to find out if and how we can use macrophytes to define the water quality or the other way around if we can predict macrophyte distributions with the help of water quality parameters? The results and knowledge we gain in this study is useful in the management of the local Natura 2000 area dedicated partly due to the occurrences of different macrophyte species. Generally, a better understanding of the relationship between the species and their environment will help us to define baselines for future assessments of Good Ecological Status as required by for example the Marine strategy Framework Directive.

Nadir and oblique imaging to observe intertidal oyster populations using UAS photogrammetry

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Challenges in accessing declining, yet essential intertidal oyster habitat and a lack of resources to systematically monitor this fishery-independent habitat have precluded historical data collections to inform resource restoration plans. However, unoccupied aerial systems (UAS) offer a viable approach to overcoming intertidal restoration monitoring barriers. With a variety of platforms and payloads available, they can be customized to fit niche restoration and monitoring needs. For example, while fixed wing UAS are often limited to capturing habitats from above (at nadir), multi-rotor UAS can hover at low altitude to capture habitats from oblique angles. Structure from Motion photogrammetry can then be used to provide accurate orthomosaics, which can be rendered into centimeter-scale 3D models of habitat structure. In this project, five oyster clusters, acting as proxies for future subsampled reefs, were manually imaged at nadir in a transect pattern, akin to what a fixed-wing UAS would capture, and in a 360^0 pattern, simulating multi-rotor UAS. The images were then imported into Agisoft Metashape to render 3D texturized habitat models. Abundance counts were subsequently performed on the models and physical clusters. While both oblique and nadir methods underestimated the total number of oysters present by 65 and 72.5%, respectively, they did so with notable consistency, achieving standard deviations of 12 and 5%. The mean percent error for estimations made by oblique and nadir methods were -1.7% and -1.8%, respectively, indicating that the methods may be comparable. Such results have important impacts on ongoing studies that extrapolate subsampled data to larger, landscape habitat.

Observation via satellite imagery of contaminated sediment deposition in a coastal region downstream of historic gold mines

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In the mid-19th to early 20th centuries, millions of tonnes of ore were extracted from over 60 gold mining districts in Nova Scotia, Canada. This ore rock invariably contained high levels of arsenic-bearing minerals like arsenopyrite. The ore was crushed into a fine, sandy material to facilitate gold extraction. In many cases, this extraction was performed by a mercury amalgamation process which imbued sediment with high levels of this toxic element. The waste material, called tailings, was typically discarded into streams, wetlands, or depressions near the mining operations. These tailings fields remain a century later and may be leaching arsenic and mercury into stream systems which lead to coastal environments. Some areas downstream of historic mines have been found to contain arsenic levels so high that shellfish harvesting has been banned.

In this study we employ remote sensing techniques to indicate areas that may contain tailings. By combining remote sensing and GIS methods we can trace streams that pass through these contaminated sites and analyse potential areas of deposition. The goal of this remote approach is to help identify priority sites for additional research and eventual remediation of these contaminated sites.

Experiences from working with a collaborative GIS in Maritime Spatial Planning

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In the BONUS BASMATI project (2017-2020), we developed Baltic Explorer, a collaborative GIS (CGIS) for Maritime Spatial Planning (MSP). The system was designed and developed to study the usefulness of GIS for supporting face-to-face collaboration in MSP. The system provides a map platform on which multiple workshop participants can share their ideas and views and collaborate on drawing and editing spatial data as well as viewing a collection of pre-loaded data in a shared map environment that can be accessed simultaneously from multiple devices. The system is designed for novice GIS users with an easy-to-use and intuitive user interface. The combination of editing, browsing, and viewing data in a multi-user collaborative map environment enables quick visualisations of problems and can support discussion of complex topics in MSP. Because the system does not set a stepwise workflow, it allows for flexible exploration of problem spaces and problem definitions. The system has been tested in several use cases to collect data about the utility of CGIS in MSP, including two real-world use cases in MSP workshops and two university MSP courses. The system was also used to study benefits from integrating analysis tools into Baltic Explorer, providing more flexibility to the use of the analysis tools. The source code of Baltic Explorer has been made available in GitHub free and open source. The system can therefore be modified and developed further by anyone. Also, the code can be used to set up new instances of the system online or locally. An instance of Baltic Explorer is also running online (http://balticexplorer.eu).

Evaluating geospatial data needs for accurate temporal monitoring of coastal habitats in Florida, USA

Vincent Lecours and Michael Espriella

University of Florida, USA

Coastal habitats such as coral reefs, oyster reefs, and salt marshes provide critical ecosystem services in Florida. However, many of these habitats are threatened by factors such as human uses, rising sea levels, and more frequent and stronger storms. There is a critical need to develop analytical approaches and tools that can provide managers with high spatial and temporal resolution data to assist with the monitoring of coastal habitats and resources.

Here we evaluated the characteristics of different coastal datasets and the type of information they provide and developed semi-automated workflows for delineating and characterizing coastal habitats. Drone-based lidar and multispectral data were collected over a mosaic of oyster reefs, salt marshes, and mudflats off the Gulf of Mexico coast of Florida. Orthomosaics, Digital Terrain Models (DTMs), and Digital Surface Models (DSMs) were produced. The spatial accuracy and information content of the different datasets were compared. Multiscale measures of terrain attributes (e.g., rugosity, relative topographic position) were derived from the DTMs and DSMs using the WhiteBoxTools software to characterize the structure of the different habitat types. A feature-space optimization combined with an object-based image analysis workflow was applied to map coastal habitats and inform on their spatial distribution.

Results showed that while coastal habitats can successfully be characterized using only multispectral information, accounting for the topographic structure of the different habitats improves classification accuracy. Results also showed that using very-high-resolution data (mm-scale) over broader-scale data (sub-meter scale) does not necessarily improve classification accuracy but significantly increases processing time.

Seafloor modelling and change detection using Global Mapper

David McKittrick

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Recent innovations in 3D mapping technology have largely focused terrestrial applications. Spurred by the proliferation of lidar data and the rapidly increasing use of drone-collected images for photogrammetric analysis and surface generation, geospatial software developers have introduced a slew of tools for visualizing and analysing the terrain. While the availability of comparable high-resolution seafloor data is not at the same level, many of the tools designed for terrestrial use, are equally applicable for bathymetric analysis. In this presentation, we will explore the use of Global Mapper - a multi-faceted GIS application developed by Blue Marble Geographics - for seafloor modelling and change detection. Working with a variety of data types including near-shore lidar and sonar-derived point cloud data, we will demonstrate a procedure for improving the quality of the data by identifying and removing noise points and other irregularities. This data will subsequently be transformed into a three-dimensional raster surface model, which is the basis for a variety of analysis procedures, including bathymetric contour generation and volume calculation. Using terrain sculpting tools, we will then simulate the dredging process by creating a channel along the seafloor, which recalculates the per-pixel depth values and lateral slopes along a buffered linear path. Finally, a difference model will be generated to measure and display the offset between the original seafloor and the channel bottom. The aim of this presentation is to show that, although high-resolution bathymetric data is a relatively rare commodity, the tools for processing and utilizing this data are readily available.

Copernicus land monitoring service for coastal zones

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Copernicus is the Programme for the establishment of a European capacity for Earth Observation. European Environment Agency (EEA) is a European Union public body that has been delegated the implementation of the pan-European and local components of the Copernicus Land monitoring service (CLMS). CLMS recently published a new, very high resolution Land cover/Land use dataset, addressing the 10 km wide land area adjacent to the coast of the EEA-39 member countries. The dataset covers a total area of more than 720.000 km2, with 71, partially coastal zones specific, thematic classes and a minimum mapping unit 0.5 ha. Three layers are available: (1) Status 2012, (2) change 2012-18, and (3) status 2018, allowing a detailed monitoring of pressures on Europeans coastal areas. The new product presents synergies with existing Copernicus land monitoring products, such as Urban Atlas (coastal cities), Riparian zones (riverine discharge areas) and Natura 2000 areas (inside coastal zone) and will aim at update frequency of 6 years. To implement a comprehensive set of monitoring products for coastal zones, CLMS and the Copernicus Marine Environment Monitoring Service (CMEMS) are coordinating their activities and future product developments. The new coastal zone data product is disseminated via Copernicus land monitoring service website https://land.copernicus.eu/ and analysis of the new data sets will support European Green Deal initiatives, such as EU Biodiversity Strategy 2030, EU adaptation strategy and others.

A methodological framework for mapping marine ecosystem services: first experiment in Dunkerque, France

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Following the work of the Millenium Ecosystem Assessment several studies have focused on the implementation of methodological frameworks to provide structure to assess ecosystems and their services. However, few studies have been devoted to the mapping of ecosystem services (ES), especially in marine areas where the lack of available data and their heterogeneity limit our ability to capture the spatial variability of services provided by nature. In the context of marine spatial planning, the spatial representation of ES becomes an essential data to highlight priority areas to exploit or preserve.

The main objective of the presented approach is to provide a generic method for mapping marine ecosystem services, through a spatialisation of ES supply potentiality. It consists of a phenomenological approach, based on ecosystemics process and functions indicators combination. These indicators were built with a literature-based normalised scoring system of several environmental variables. This approach was tested on three ES, corresponding to the three mains ES types: food provision (provisioning service), life cycle maintenance (regulating/ maintenance service), and recreation and tourism (cultural service).

In the case of Dunkerque, this method allowed to map marine ES supply in an offshore wind-farm context, potentially useful for impact assessment. This “nature based” approach seems suitable to map provisioning and regulating ES, but still face some difficulties with cultural services. With some adjustments, this could become a generic method for mapping marine ES, appliable to various contexts and scales.

A methodology for real-time monitoring and prediction of coastal erosion

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Coastal erosion threatens nearshore infrastructure, ecological systems and people's livelihoods. The risks associated with coastal erosion are expected to increase in severity in the near future due to anticipated sea level rise and increased frequency and severity of coastal storm events. An early warning system is therefore desirable to establish which coastlines are most vulnerable to erosion presently and from upcoming storm events. Our ability to make believable predictions of short-term coastal change relies on an understanding of processes across different coastal types, coupled with records of past change under known conditions. Traditional prediction methods have applied a number of parameters representing real-world processes to a series of equations solving for shoreline change rates. This project aims to circumvent the need to empirically inform these parameters, by making use machine learning which finds patterns in past shoreline change data to inform future predictions. The software solution for coastal managers and decision-makers will train a neural network with national past shoreline positions automatically extracted from satellite imagery such as Sentinel-2 and Landsat 5/7/8. The predictions for future shoreline positions will then be made using the trained network and short-term predictions of upcoming wave conditions from the Copernicus Marine Service. Current sites of interest lie in Scotland due to shoreface dynamism and important coastal assets. However by using a framework built on remotely sensed near-global measurements, and the potential for automated data extraction and prediction, this storm erosion prediction system is applicable across a range of coastal environments and spatiotemporal scales.

Dynamic Coast:
Updating Scotland's understanding of coastal change

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Coastal erosion currently affects 46% of Scotland's erodible shores. Although highly dynamic, Scotland's coast has experienced a doubling in the average rate of coastal erosion since the 1970s. Climate change is impacting local coastal communities, key coastal infrastructure, natural and cultural tourism and delicate ecosystems due to sea level rise and increases in the frequency and severity of storm-driven erosion and related flooding. To manage these coastal areas, mitigate the negative effects of climate change and enhance resilience and adaptation, our understanding of coastal change needs to improve. The Dynamic Coast project, launched in 2017, aims to quantify and monitor coastal change across the entirety of Scotland, presenting the first national assessment of coastal change and providing knowledge support to decision-makers and local stakeholders. The award-winning Scottish Government-commissioned project is now in its second phase and builds on its first phase datasets of national mean high water spring (MHWS) changes over the last century by shifting to a more 3D timeseries approach. Digital elevation models, satellite imagery, and vegetation surveys were analysed at key 'supersites' chosen for their cross-sector significance, as well as nationally deployed updates to MHWS positions. Latest research outputs include: pan-Scotland automatic extraction of natural erosion and flood barriers; projections of shoreline positions to 2100 under different sea level rise scenarios; and identification of socioeconomic vulnerability to coastal erosion. The Dynamic Coast outputs help inform coastal managers at multiple governmental scales and identify areas requiring support and further investigation.

Taxonomic and functional diversity of coastal benthic assemblages in Placentia Bay, Newfoundland

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Benthic species assemblages refer to species that co-occur in a region. Linking them to physical environmental variables allows us to model continuous maps assessing the spatial distribution of these habitats. The use of marine habitats as proxies for biodiversity is also becoming increasingly common to marine management efforts, however, studies mainly use a taxonomic approach based on species identity and abundance to assess their diversity. Considering functional traits, which capture the life history, behaviour, and morphology of a species is important since benthic fauna are key drivers of various ecosystem services including nutrient cycling, maintaining biodiversity, and provisioning of food and habitat. This study used biological traits analysis (BTA) to compare five benthic species assemblages observed across two coastal sites in Placentia Bay, Newfoundland, and Labrador, in addition to comparing the spatial patterns of taxonomic and functional diversity metrics. Trait data were compiled from databases and the functional composition was identified per assemblage using the community weighted mean. Species and functional diversity metrics were calculated and modelled as full-coverage maps. Spatially, patterns of species and functional diversity depicted contrasting patterns, indicating alternate hotspots of diversity. Taxonomically distinct assemblages exhibited similar trait compositions for two assemblages, meanwhile one assemblage exhibited a unique set of potentially sensitive traits which could limit its ability to resist disturbance. Overall, results indicate that incorporating both taxonomic and functional components may better inform management efforts and help to understand the state of coastal habitats.

An assessment of newly available Copernicus sea surface wave products for mapping wave energy in Irish and UK waters

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Accurate and up-to-date wave energy resource assessments are crucial to wave energy project developers. High resolution products for representing sea surface wave parameters in European waters are now available via the Copernicus Marine Environment Monitoring Service (CMEMS). Here, the accuracy of two such products is assessed against in-situ wave buoy measurements at specific sites of interest to the wave energy sector. Each product is then used to map the parameters pertinent to the wave energy sector, these are; the significant wave height and the wave energy period. Based on these parameters, a spatial calculation of the wave energy resource is performed using both products for comparison and spatio-temporal analysis. The study area focused on Irish and Western UK waters and the time series of data used was 20 years. In the accuracy assessment, both models perform well overall for representing both parameters. The overall difference in significant wave height bias between the two products is found to be on the order of 8 cm, and the difference in wave energy period is 0.02 s. Spatially, the highest resource values were seen along the west coast of Ireland, particularly the northwest, and the temporal analysis revealed winter to be the season with the most abundant resource. This work can be used to inform wave energy farm site selection and project feasibility analysis.

A WebGIS tool to support application of management scenarios in the framework of Marine Spatial Planning

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A wide range of activities take place in marine areas that are continuously growing in number and intensity. These activities are highly competitive, resulting in conflicts and adverse effects among different marine uses. Maritime Spatial Planning (MSP) has been established as a policy framework suitable to minimize conflicting activities, improve synergies among uses and optimize the distribution of marine space. Therefore, in this framework, there is need for appropriate tools able to support decision-makers to delineate conflicting uses and foresee appropriate future scenarios in order to adopt effective management plans. In this paper, a user-friendly WebGIS application is proposed for delineating the conflicting activities in the case study area of Cyclades, Aegean Sea, Greece and mapping the change of their extent when different management scenarios are applied. The adopted scenarios foresee changes in the boundaries of the fishing and protected areas in Cyclades. WebGIS technology is used for the development of the proposed application since it is a powerful tool that facilitates the cooperation of different groups involved in MSP (i.e., stakeholders, decision-makers, public etc.). Finally, mapping of the results of various management scenarios is an important contribution towards effective decision-making and therefore successful implementation of MSP.

Shoreline retreat management: Mapping the impact of avoided coastal erosion and flooding due to the construction of a detached breakwater

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The Central Portuguese littoral is dominated by a sandy coast, often impacted by high energy events, with a typical northwest wave climate and wave-driven alongshore sediment transport. It shows a generalised erosion trend due to the deficit in sediment supply caused mainly by human interventions in the hydrological cycle and littoral area. Vagueira Beach, in Central Portugal, is a prominent case study as the shoreline has been gradually retreating over the last decades and suffers from frequent overtopping events. The aim of this study is to determine and map, in a GIS-based environment, the avoided coastal erosion and flood damage with the potential construction of a submerged detached breakwater in front of Vagueira Beach. The numerical modelling of the wave-breaking structure impact is performed using the LTC software, which forecasts the shoreline evolution and consequent eroded and flooded areas for each pre-defined scenario, considering specific hydrodynamic and topo-bathymetric data. Second, elements at risk are assembled into the uniform classes of the Land Use and Land Cover (LULC) map for Portugal - COS2018, and the exposure of these classes to coastal erosion and flooding is assessed by intersecting the LULC map with LTC projections, using geographic information systems. The outcomes are cross-checked with local knowledge on the interest area and data from the video monitoring system operating during the project design phase. Results show that all tested scenarios of intervention have a positive balance, halting land losses and reducing flood risk due to the increase of the emerged beach width.

Assessing the structural complexity of submerged aquatic vegetation: A comparison of estimates derived from small unmanned aerial aircrafts and snorkel transect surveys

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Quantifying the scale of ecosystem services is important for understanding the value of a system and deciding where to prioritise management efforts. For seagrass, this process relies on the assessment of meadow structural complexity, including coverage and species composition. Small unmanned areal vehicles (sUAV) are increasingly used to survey the structural complexity of seagrass meadows because they are able to survey relatively large areas in less time compared to more conventional methods, such as snorkel/SCUBA quadrat sampling. However, differences in survey results between sUAV and snorkel/SCUBA quadrat sampling are seldom evaluated. In this study, we surveyed three eelgrass meadows in Newfoundland, Canada by flying an sUAV equipped with an RGB camera at 115m altitude. Images were analyzed using random forest supervised image classification and compared to species composition from snorkel quadrat surveys. Our results show that sUAV can detect coverage and configuration of submerged aquatic vegetation (~3m deep). However, discrimination between seagrass and other submerged aquatic vegetation using these models result in different estimates of coverage compared to snorkel quadrat data, and accuracy depends on contrast between features within a site, rather than flight altitude. Therefore, our study confirms that sUAV can be used for monitoring seagrass meadows. However, RGB imagery alone may be insufficient to discriminate between seagrass and other submerged aquatic vegetation in the coastal zone.

Destructive Flooding of Cultural Heritage: Our Future and New Normal? An Investigation of Vulnerabilities in Ekenäs Old Town

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Higher and more common coastal flooding, due to sea level rise and changes in wind patterns, may endanger Ekenäs Old Town in Raseborg, Finland by year 2100. Cultural heritage, including protected buildings and archeologically significant areas, will likely become at greater risk due to flooding.

Finnish Meteorological Institute (FMI) data and projections have been adapted to Ekenäs Old Town. Sea level rise and storm surge projections, sea level records, and minimum recommended building elevations have been modeled and analyzed using a geographic information system (GIS). Potentially affected areas of Ekenäs Old Town have been further analyzed through study of the Finnish Heritage Agency's 2002 archaeological inventory of Ekenäs Old Town and targeted field work. Data and information have also been collected from the City of Raseborg and a local resident.

Due to already existing risks to cultural heritage, the Ministry of Agriculture and Forestry of Finland must designate Ekenäs Old Town as a significant flood risk area in accordance with legislation governing flood risk management (620/2010). The Ministry must establish a flood management group to create flood maps and develop a flood risk management plan.

Further study and investigation of flood risks in Ekenäs Old Town is recommended. Wave monitoring should be conducted around Ekenäs Old Town to better understand local sea level fluctuations. Building specific investigation is needed to understand flooding risks. Absent protection measures, damage from coastal flooding will likely increase. Protection measures must be careful to respect cultural heritage and the local environment.

Using conservation prioritization tool MARXAN to find key areas for marine biodiversity in Åland

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The archipelago around the Åland Islands presents a unique region in the Baltic Sea. The landscape that varies from sheltered bays to small rocky outer-archipelago skerries, creates a mosaique of underwater habitats. In parts of the area, the human activity can be considered low, but potentially expanding activities, such as wind energy production and fish farming, pose a threat to the marine environment. To date, the lack of spatially comprehensive knowledge on underwater biodiversity has hindered true ecosystem-based management of the marine areas in Åland. In addition, the current IUCN and EU goal of protecting 10% of the marine areas has not been reached.

During the recent years, extensive marine inventories have been carried out in Åland, with the work ongoing in the ÅlandSeaMap project (2019-2023). A key aim of the project is to identify the most valuable areas for marine biodiversity in Åland and to support the development and the expansion of the marine protected area (MPA) network. The Government of Åland (also a project partner) is committed to the establishment of new MPAs during and after the project. To achieve the aim, a site-selection analysis building on both new and existing spatial biodiversity data, as well as extensive data on human activities, will be run in late 2021 using MARXAN. As transparency and communication with stakeholders and local people are of central importance in the project, analysis criteria and data are opened for discussion prior to and after the analysis, with e.g., online seminars and workshops.

Maritime spatial plan 2030 for Finland

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The very first Maritime Spatial Plan 2030 for Finland was approved by the administrative authorities of coastal regional councils in Dec 2020. The plan covers territorial waters and exclusive economic zone and has been prepared in an extensive collaboration process between coastal regional councils and various stakeholders. The plan is illustrated by a map that outlines areas of significance and potential and indicates the connections and connection needs of the maritime areas. Characteristics of the digital plan are the extensive use of spatial data and analysis provided by scientific institutes and other stakeholders that have collected information and material about the Finnish marine areas and maritime sectors for decades. As spatial data plays a key role in the digital plan, its accessibility and usability has been contributed by designing a data model that binds spatial data and written plan together. In addition, the data model includes different sea use classification models, which enables the wider use of the harmonized data e.g., in the data portals like HELCOM Basemaps and EMODnet. The aim of the plan is to reconcile the needs of different maritime sectors and to enhance the management of maritime industries and the state of the marine environment. The plan is not part of the land use planning system and has no legal effect, but it provides information to serve in the background of more detailed planning and to support regional development work and licensing procedures.

High-resolution and high-frequency *in situ* measurements as decision support for coastal management

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A substantial part of the carbon and nutrients in soils runs off to coastal waters, in dissolved and particulate forms. As the soils become less fertile, the waters get eutrophied and release more greenhouse gases into the atmosphere. Thus, terrestrial loading deteriorates ecosystem structure, function and services not only in the terrestrial but also in the aquatic and aerial realms. As a central interface among them, coastal waters play a key role in mediating the flow of carbon and nutrients within and among a wide range of ecosystems.

We have developed a novel *in situ* approach for assessing the loading status of coastal waters with high spatiotemporal resolution. The model builds upon simultaneous registration of data on a comprehensive suite of environmental variables, some indicative of loading and others depicting the physical circumstances. Continuous underway measurements are used for generating a data set for defining detailed and environment-specific reference values for each indicator. By focusing on the anomalies, or the deviations from the expected, bias from confounding variables such as freshwater input and mixing can be handled, resulting in detailed picture of the actual loading status. The approach is being used as a cost-efficient tool for environmental management along the entire coast of SW Finland, with main emphasis on diffuse loading and especially the role of direct runoff. The concrete applications include localizing hotspots of carbon and nutrient loading, targeting subsequent countermeasures, evaluating their efficiency and quantifying other anthropogenic influences. Coasts are complex and dynamic zones, susceptible to natural hazards and anthropogenic pressures, and coastal erosion is a growing concern, particularly in the light of climate change effects. For a sound and informed management, coastal dynamics needs to be monitored at adequate scales.

Mapping whale-watching effort using AIS data in the Canadian Pacific Coast

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Commercial boat-based whale-watching is a very important touristic sector in the Canadian Pacific coast, taking thousands of people to view and experience up close the natural beauty and wildlife of the area. This sector provides economic benefits to local communities and opportunities for education and increase awareness for nature protection. The recent growth of whale watching activities also can bring potential negative effects such as disturbances to wildlife. To achieve sustainable whale-watching activities, it is important to reach a balance between economic, environmental and cultural objectives. For this, we assessed the spatiotemporal distribution of whale watching activities and their overlap with sensitive ecological areas. First, we developed an algorithm that classifies AIS vessel data from known commercial whale-watching vessels into wildlife viewing and transiting positions based on vessel speeds. Data analysed included AIS data was collected in 2019 along the Canadian Pacific coast. Wildlife viewing positions were used to map whale-watching intensity using kernel density estimator. We then used marine protected areas and area-based conservation measures to determine the degree of overlap between whale watching intensity and ecologically sensitive areas. Results show areas consistently visited by whale-watching vessels during the study period, while other whale-watching hotspots are more dynamic and vary depending on the time of the year and targeted species. We conclude that the presented methodology applied to AIS data can provide a valuable tool to assess whale-watching activities and their potential effect to coastal environments.

How does uneven spatiotemporal distribution of coastal in-situ measurements affect error estimates for supervised learning algorithms? A Baltic Sea remote sensing example

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Supervised learning methods, from simple linear models to sophisticated machine learning algorithms, are commonly used to link satellite measurements with variables measured in-situ, such as chlorophyll a. The accuracy of such algorithms is typically estimated using a validation set consisting of randomly selected hold-out observations. However, the in-situ data available are often spatially auto-correlated and clustered, for example along ship tracks or near research stations. This can in theory lead to the selection of too complex models and an underestimation of prediction errors. This presentation aims 1) to quantify the magnitude of this statistical problem using remote sensing of chlorophyll a in the Baltic Sea as a case study, and 2) to compare random hold-out validation methods with validation approaches designed for applications when data are auto-correlated. Various satellite algorithms predicting chlorophyll concentrations were trained and validated with 1,000s of artificial data sets created by combining real in-situ measurement locations with chlorophyll concentrations from a biogeochemical model. On average, random hold-out validation designs underestimated errors by up to 40%. Validation designs that spatially separated training and testing observations, such as spatial block cross-validation, provided less biased error estimates, but still often underestimated errors. Furthermore, while in truth, a simple linear model worked best on the generated data, calculated error estimates almost always supported using a more complicated (and in fact, less accurate) machine learning algorithm. These results illustrate an often-overlooked statistical pitfall in coastal remote sensing and highlight a need for renewed discussion of validation methods for satellite algorithms.

Using remote sensing to assess the role of coastal ecosystems in the protection against erosion in the Caribbean

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CARIB-COAST is an international project lead by the French Geological and Mining Research Bureau (French Geological Survey). Its ambition is to pool, co-construct and disseminate approaches to monitoring, coastal risk prevention and adaptation to climate change in the Caribbean. Various sites have been identified in Guadeloupe, Martinique, Saint-Martin, Jamaica, Puerto Rico and Trinidad and Tobago to assess the role of coastal ecosystems like mangroves, seagrass and coral reefs in the protection against coastal erosion.

Given the extent of the area of interest, the diversity of pilot sites, and the intent to develop a common approach for all areas, this study has taken advantage of current available remote sensing data to construct a vulnerability index involving several complex and interacting parameters, represented by diverse data types.

To do so, this study (1) produces maps of mangroves, seagrass and coral reefs distribution using high resolution Sentinel 2 data in a supervised classification approach, (2) uses very high resolution Pleiades and PlanetScope images to produce surface metrics (e.g., texture, density, fragmentation) describing ecosystems at a fine scale, and (3) applies a multi-criteria analysis to these metrics combined with other variables (e.g., geomorphology, socio-economics) in order to develop an ecosystem-based index of coastal vulnerability (EBCVI) for each pilot site. The knowledge of local partners will allow a weighting of the importance of each criterion in the index.

This index has the potential to be used as a management tool to assess impacts of climate change on Caribbean coasts.

Designing a Web-GIS platform for Marine Spatial Planning in the Romanian Black Sea

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European seas are subject to rapid development. With its Blue Growth strategy and Maritime Spatial Planning Directive, the European Union seeks to strengthen the economy, increase jobs, income, and secure long-term wealth by "unlocking the potential of the sea". This triggers interest in interactive platforms, with complex features like technology, governance, financial, socio-economic, and environmental aspects. The perception of maritime subjects and issues are different between groups of people and depends on the information available to either party. The communication of scientific results is thus crucial to increase literacy and allow informed decision-making. From this perspective, our paper presents a Free and Open-Source Web-GIS application developed within TEAM4SEAS project and the advantages of this tool. The platform is based on Geographic Information Systems (GIS) which consists in some essential steps: collection, storage, processing, analyses and display of geospatial data (e.g., output maps and graphs). Results illustrate how a web-GIS tool can be applied as a sound basis for practically incorporating the participatory approach within maritime spatial planning process in Romania. It enables stakeholders and the public easy access to spatial and temporal distribution of human activities in marine areas. The web-GIS application also allows searching, viewing, and downloading Romanian Black Sea GIS data and metadata and users can create or edit layers for their own maps in a user-friendly way. Key-benefits include effective data management, increased spatial understanding and the definition of conflicts across the Romanian Black Sea region.

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are gratefully acknowledged on the following pages.

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Thank you

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