Can satellite surface data predict subsurface primary production?

Arianna Zampollo[1], Thomas Cornulier[1], Jacqueline F. Tweddle[1], Rory B. O'Hara Murray[2], Beth E. Scott[1]

[1] *Institute of Biological and Environmental Sciences, University of Aberdeen, Thilldrone Ave, AB392TZ, UK – a.zampollo.18@abdn.ac.uk*
[2] *Marine Scotland Science, Aberdeen, UK*

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Oceanographic and ecological analyses require standardized ocean-colour (OC) satellite data for different variables, whose level of uncertainties are related to a multitude of factors that vary between regions and across time (Le Traon et al., 2019). Chlorophyll-a (Chl-a) concentration is one of the most demanded OC products, it is often the only information we have about primary production in the oceans, but it can be considered meaningless for ecological studies without some certainty about how it estimates the up to 50% of primary production that is found in subsurface (> 10 m) chlorophyll concentrations. In this study, we investigated the ability of applying a post processing analysis to satellite data in order to adjust the subsurface representation of Chl-a. Thanks to the tight interaction of Chl-a to physical variables and topography, we estimated the uncertainties associated with Chl-a concentration by investigating different predictors within a statistical framework. We sought a subset of covariates to improve the prediction accuracy of Chl-a concentration over the OC-CCI Chlorophyll products (OC5, 1 km) from vertical profiles of *in situ* samples and mesoscale horizontal/vertical currents from oceanographic models. This method has been applied to the region of Firth of Forth and Tay (east coast of Scotland, UK) due to its heterogeneous structure of the bathymetry, patchiness of the primary production, and the ecological and economic interests of this area.

Twitter abstract #MASTSasm2020

@AriannaZampollo

The poor representation of subsurface features of chlorophyll-a (Chl-a) from satellite data can lead to underestimating issues during the environmental impact assessment of primary production. In this study we highlighted how much Chl-a information is missed and how to recover this.

Acknowledgements

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Modelling seaweed invasion: a theoretical approach for *Sargassum muticum*

Anai Aude Valdivia[1], Douglas Speirs[1], Michael Heath[1], Bingzhang Chen[1], and Andrew J Blight[2]

[1] *Department of Mathematics and Statistics, University of Strathclyde – anai.aude-valdivia@strath.ac.uk*
[2] *Scottish Oceans Institute, School of Biology, University of Saint Andrews*

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The highly invasive macroalgae *Sargassum muticum* has spread effectively outside of its native region for over 50 years and is a latent threat to the Scottish coastlines (Harries, Cook et al. 2007). Recent data provides evidence of future northward expansions of the species under different climate change scenarios (Chefaoui, Serebryakova et al. 2019).

Here, we present a mathematical model of the spread of an invasive species, parameterized for the life-cycle of *S. muticum*. The model is based on the known ecology of the seaweed, whose invasiveness is enhanced by the survival of adults, a long fertile season and a high reproductive output (Engelen, Serebryakova et al. 2015).

As part of a larger modelling study of wireweed invasion, our aim in the work reported here was to develop and analyze a strategically simplified system. The model dynamically represents three key life-history stages - adults, spores and drifting fragments. It describes an invasion along a linear coastline of a settled plant population, and is used to examine the velocity of such a spread. We use the model to identify the life stages that are most important for the invasion process, and the role of rare, but long-distance, transport in determining the invasion speed.

We conclude that the critical process for invasion is the long-distance dispersal of detached fronds which float in the water and continue to produce spores.

Acknowledgements

This studentship has been funded under the NERC Scottish Universities Partnership for Environmental Research (SUPER) Doctoral Training Partnership (DTP) and University of Strathclyde.

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Tweetable abstract

#Sargassum is a latent threat to the Scottish coastlines. We modelled an invasion presenting the key life history stages of the seaweed, and it showed long-distance dispersal of detached fronds appears to be critical.

#invasivespecies #climatechange #MASTSasm2020 @Anai_AValdivia

Restoration of tropical mangroves: Can we avoid repeating past mistakes?

Thorsten Balke[1], Alejandra Vovides[1], Mohammad Basyuni[2]

[1] *School of Geographical and Earth Sciences, University of Glasgow, Glasgow, UK – thorsten.balke@glasgow.ac.uk*
[2] *Department of Forestry, Universitas Sumatera Utara, Indonesia*

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Mangrove restoration became a priority for many coastal countries in Asia after the 2004 (boxing day) tsunami. However, success rates have reportedly been very low despite the millions of mangroves that were planted. This has largely been attributed to a lack of planning and site assessments prior to planting. Restoration failure has been especially high where direct planting of non-pioneer species (e.g. *Rhizophora* spp.) was attempted on exposed tidal flats where landownership is usually not disputed. Many glossy brochures and social media posts about mangrove restoration published today still show the same direct seashore planting of *Rhizophora* propagules. With a renewed focus on the ecosystem services of mangrove forests for coastal protection, carbon storage and the importance for coastal livelihoods, regional and global initiatives promoting large-scale mangrove restoration are ever increasing. Here, we will focus on the progress that has been made in understanding bottlenecks to establishment, succession and restoration of tropical mangroves and how this can be utilized in planning mangrove restoration. We will discuss recent advances in process understanding of mangrove ecosystem functioning and mangrove bio-geomorphology from propagules to mature forests. Drawing from existing restoration manuals and new modelling/monitoring tools we will summarize how suitable restoration sites can be identified and how hydrological conditions can be assessed in-situ, prior to restoration, using cost-efficient tools. Benefits and limitations of available methods to ameliorate site conditions for mangrove restoration will be discussed along the socio-ecological contexts in the global south.

Tweetable abstract: Restoration of tropical mangroves: Can we avoid repeating past mistakes?

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Photo-adaptation of the deepest living macroalga at the limit of the photic zone

Voerman, S.E.[1, 2]; Marsh, B. C.[1, 2]; Pereira-Filho, G.H.[3]; Amado-Filho, G. M.[4]; Turnbull, G. A.[5]; Samuel, I.D.W.[5]; Ruseckas, A[5]; Burdett, H.L.[1, 2]

[1] *Lyell Centre for Earth and Marine Sciences, Edinburgh, UK. S.voerman@hw.ac.uk*
[2] *School of Energy, Geoscience, Infrastructure and Society, Heriot-Watt University, UK*
[3] *Departamento de Ciências do Mar, Universidade Federal de São Paulo, Brazil*
[4] *Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Brazil*
[5] *School of Physics & Astronomy, University of St Andrews, UK*

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References

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Tweetable abstract: @sofie_voerman @HLBurdett @LyellCentre @PhysAstroStAnd @LeverhulmeTrust

Seaweeds can live hundreds of m below the sea surface, but we don't know how they do this! By analysing samples where light is <0.01% of that on land, we unlocked their secrets to efficicent photosynthesis @Sofie_Voerman @HLBurdett @LyellCentre @PhysAstroStAnd @LeverhulmeTrust

Abstract:

As light attenuates through water, there is a progressive reduction in both the quantity and quality (spectral composition) of bottom irradiance as depth increases. The potential depth distribution of macroalgae is limited by *in situ* light availability and a species' light requirements. It was therefore long believed that macroalgal depth distribution was limited to very shallow depths. However, we are increasingly aware macroalgae occur much deeper (and therefore darker) than previously thought possible. In particular, red coralline algae (RCA) are the deepest known photosynthetic organism in the ocean, down to 300+ m, where light levels are <0.01% of those found at the surface. How RCA survive under extreme low light conditions remains largely unknown. We hypothesized that a highly specialized photo-apparatus aids efficient light harvesting and minimal light requirements.

To test this hypothesis, we made use of a steep depth gradient in the occurrence of free-living RCA nodules (rhodoliths /maerl) at Fernando de Noronha, Brazil. Rhodoliths were collected across a 70m depth gradient – spanning two orders of magnitude in irradiance – and were analyzed for photosynthetic characteristics and tissue pigment composition. We identified photosynthetic adaptation such as increased photosynthetic efficiency and reduced light requirements for photosynthesis with depth, enabling optimization of photosynthetic output as light levels became limiting. A long-term laboratory experiment confirmed a highly adaptive photo-apparatus to low-light conditions. Our results provide a first integrated understanding of the *in situ* light environment and the mechanisms that aid RCA to survive at depths towards the lower limit of the ocean's photic zone.

Acknowledgements

We would like to thank the Fernando de Noronha Atlantis divers' team for their contribution to the fieldwork, in particular Zaira Matheus and Ismael Escote. This work was funded by a Leverhulme Research Project Grant (RPG-2018-113)

Establishing intertidal benthic macroinvertebrate baselines for 13 sandy shores in Orkney (1974-2016)

Kakkonen J.E.[1,2], Bell M.C.[2,3], Fernandes T.F.[3] and Baxter J.M.[3]

[1]*Orkney Islands Council, Marine Services, Harbour Authority Building, Scapa, Orkney KW15 1SD, Scotland, United Kingdom – jenni.kakkonen@orkney.gov.uk*
[2]*International Centre for Island Technology, , Institute of Life and Earth Sciences, School of Energy, Geoscience, Infrastructure and Society, Heriot-Watt University, Robert Rendall Building, Orkney Research and Innovation Campus, Stromness, Orkney KW16 2AN, Scotland, United Kingdom*
[3] *Institute of Life and Earth Sciences, School of Energy, Geoscience, Infrastructure and Society, Heriot-Watt University, Edinburgh, EH14 4AS, Scotland, United Kingdom*

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A long-term study of sandy shores on Orkney has led to the establishment of baseline conditions based on the prevalent macroinvertebrate communities. This study highlighted the importance of long-term annual monitoring to assess temporal changes in coastal systems. #MASTSasm2020

(279 characters)

A long-term shoreline monitoring programme by Orkney Islands Council was initially aimed at assessing impacts from oil and gas related activities, including spills and other marine pollution incidents. Assessment of the long-term monitoring data, with no major incidents taking place over the study time, have provided a unique opportunity to establish macroinvertebrate baselines and to determine the noise within the baseline conditions (Kakkonen, 2019). Sandy shore macroinvertebrate samples were collected from 13 beaches on Orkney. Sampling took place annually over the periods 1974-1989 and 2002-2016.

We have used data from one of these sites (Congesquoy) to demonstrate how a baseline using macroinvertebrate community was established. Non-metric multidimensional scaling (nMDS) and hierarchical clustering of the annual samples were complemented with similarity percentage (SIMPER) analyses to determine contribution of each species to contrasts in community composition. The dominant and rare taxa were compared across a range of years (1983-1989 and 2002-2016) to characterise the baseline community against which any future perturbation in macroinvertebrate abundance and community composition could be measured.

Results showed annual variation in both the composition of taxa and in the characterising taxa identified by SIMPER analysis. Even with this annual variation present, the dominant taxa (>1% of total abundance of fauna present (Atkins et al. 1985)) remained the same over time. These results provide a comprehensive description of baseline conditions, demonstrating the importance of long-term annual monitoring of sandy shore sites to fully understand the extent of macroinvertebrate community variability over time.

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Self-regulation processes in kelp forest

Cabanillas, Alejandra G[1], Adams Thomas P [2], Begg Tracey [3], Burrow Michael T[2], Speirs Douglas C[1], and Heath Michael R[1]
[1] *Marine Population Modelling Group, Department of Mathematics and Statistics, University of Strathclyde – a.g.cabanillas@strath.ac.uk*
[2] *Scottish Association for Marine Science*
[3] *Scottish Natural Heritage*

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Kelp forests are a significant feature of costal ecosystems, but relatively little studied. To understand how a forest is sustained we need to determine what regulates the density and growth, recruitment and density of the individual plants. The processes explaining self-regulation can be grouped into competition for light, for space and for nutrients.

Some investigators have drawn parallels between marine and terrestrial forests e.g. Dean et al, (1989), with competition for light producing a strong density dependent response in recruitment of young individuals and the growth of established plants. In kelp farms (Neushul & Harger, 1985), denser stands lead to smaller plants with lower biomasss yield. Disturbance events such as storms or harvesting which thin out the population disrupt the recruitment and growth patterns (Edwards & Connel, 2012). Competition for nutrients is also a feature of both terrestrial and marine forest systems (Reed, 1990).

Despite the empirical evidence for strong competitive interactions between individual kelp plants, leading to regulation at the forest-scale, there are very few models of kelp which adequately incorporate these processes. Here we explain the development of an individual-based modelling approach which resolves the age-size trajectories of competing kelp plants over time in a forest. The aim is to be able to predict the consequences of harvesting and natural disturbances for the dynamics of whole forests.

Initial results from the model show variations in individual growth trajectories between successive annual cohorts when the system is disturbed from its steady state, resulting in fluctuations in forest productivity. Developing the model also raises many questions about the mechanism of interactions between plants both within and between annual cohorts.

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Twitter Abstract:

@AlexGCabanillas

We developed an IBM approach which resolves the age-size trajectories of competing #kelp plants over time in a forest. This raised questions about the mechanism of interactions between plants. #MASTSasm2020 #QuantitativeEcology

Investigating sediment stability in intertidal habitats: A CBESS case study on mudflats and saltmarsh habitats

Rounce, J.M.[1], Manning, A.J.[1,2], Paterson, D.M.[3] and Blight, A.J.[3]

[1] *School of Biological and Marine Sciences, Plymouth University, Plymouth, United Kingdom – juliet.rounce@postgrad.plymouth.ac.uk*
[2] *HR Wallingford, Howbery Park, Wallingford, Oxfordshire, OX10 8BA, UK*
[3] *Sediment Ecology Research Group, Gatty Marine Laboratory, School of Biology, University of St Andrews, St Andrews, KY16 8LB, UK*

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Muddy sediments dominate many aquatic environments. Common constituents of these cohesive sediments include mud, sand and organic matter. Complicated interactions arise, determined by varying bio-physical properties. Numerical models, utilised for monitoring and managing marine environments, rely on calibrations from quantitative erodibility and depositional data to accurately predict sediment transport processes. Facilitating this requires an understanding of the complex interactions within cohesive sediment, and the corresponding biological influences that affect erosive behaviour. Flocculation processes of muddy sediments combine influences from complex sedimentary and hydrodynamic interactions. The degree to which flocculation occurs is reliant on forces, such as bonding cohesion, between turbulent shear stress and suspended particulate matter (Manning *et al.*, 2007). Habitat biodiversity also plays a major role, with microbial assemblages specifically noted as controlling factors in erodibility and deposition processes (Paterson *et al*., 2018).

The Coastal Biodiversity and Ecosystem Service Sustainability (CBESS) programme investigated links between biodiversity and the services provided by intertidal ecosystems. Here, the sediment stability dataset collected with the Cohesive Strength Meter (CSM) has been utilised to address stability of surface sediments in intertidal habitats (saltmarshes and mudflats), investigating various sediment compositions and vegetation abundances (Paterson *et al*., 2015). The field-derived data facilitates exploration of spatial and seasonal variation, including employing spatial analysis to investigate inter-site / habitat variation. The interactions between physical and biological processes are also explored. Improving quantitative knowledge of sediment erodibility in intertidal habitats, and the corresponding interactive processes for cohesive sediments under different sedimentary and hydrodynamic conditions, enables further development of reliable and accurate predictive numerical models, particularly by improving the delineation of bio-physical sedimentary processes.

Acknowledgements

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