Ecosystem functioning of epifaunal communities associated with natural and man-made hard substrates in the North Sea

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Historical overexploitation of the European flat oyster *Ostrea edulis* has led to a severe reduction of biogenic *O.edulis* reefs that were once widespread[1] in the North Sea (NS), resulting in a loss of ecosystem functions provided by associated epifauna[2]. However, incidental and intentional anthropogenic activities, including ship wreckage and oil and gas (O&G) exploitation, has resulted in the introduction of scattered artificial hard habitat into the NS, providing habitat for epifaunal species that perform similar functions to oysters and their associated epifauna[3].

The Oslo-Paris Commission (OSPAR) requires all O&G infrastructure under 10,000 tons to be removed once decommissioned, subsequently removing epifaunal assemblages. Epifaunal colonisation of artificial structures is dependent on factors including oceanographic currents, geographical location and larval duration[4].

We compiled spatial data for historic and contemporary *O.edulis* reefs, natural hard substrates, shipwrecks, offshore wind farm (OWF) and O&G infrastructure to quantify and contrast available hard substrate surface areas across three different temporal scenarios; Historic scenario with natural hard substrate, shipwrecks and historic *O.edulis* reefs, set at 1883[1]; Contemporary scenario with current anthropogenic structures and natural hard substrates; Future scenario under current OSPAR decommissioning regulations, with O&G infrastructure removed and proposed OWF introduced. A biophysical particle tracking model[5] was utilised to quantify the connectivity between hard substrates in the NS under the three scenarios described.

The historical scenario had the largest surface area of hard substrate (83,378 km^2), comprised mainly of *O.edulis* reefs (80,068 km^2). This dropped by 96% to 3,380 for the contemporary scenario, with *O.edulis* reefs only contributing 12.56 km^2 of hard substrate for the entire NS. Shipwrecks have the largest total surface area out of all anthropogenic structures in the contemporary and future scenario (38.54 km^2). Between the contemporary and future scenario, O&G hard substrate is projected to decline by 75% from 16.55 km^2 to 4 km^2. However, OWF infrastructure, currently at 2.50 km^2 of hard substrate, is projected to increase by 150% to 6.23 km^2 in the future. The total hard substrate availability in the NS is projected to decline by only 0.26% under current OSPAR decommissioning scenarios, to 3,371 km^2.

The biophysical particle tracking model indicates a high degree of connectivity between hard substrates in the NS for the contemporary scenario due to the spatial configuration of anthropogenic structures throughout the NS. Connectivity between structures becomes reduced in the future scenario due to OSPAR decommissioning regulations. Connectivity was lower for the historical scenario as there were no 'stepping stone' hard substrate between larger areas of hard substrate.

The results of this project indicate that although the surface area of NS anthropogenic hard substrate are small by comparison to historical substrate, the spatial configuration of these anthropogenic hard substrates, including O&G infrastructure, across the NS has created a network of interconnected hard substrate that may become disrupted under current OSPAR regulations. Results gathered in this project shall be used to assist in management decisions on the decommissioning of anthropogenic structures in the NS, including O&G infrastructure.

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Do peat organics facilitate estuarine dissolved Fe transport? A case study from Loch Etive

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The importance of Fe as an essential micronutrient in marine biogeochemistry is undisputed[1], and has driven many of the recent efforts to refine knowledge of Fe sources and fluxes to the ocean[2]. Riverine transport is typically considered an unimportant source of dissolved Fe to coastal waters because estuarine processes remove ≥95 %[3]. However, complexation to dissolved organic carbon (DOC) is gaining attention as a mechanism for Fe to survive flocculation across estuarine salinity gradients[4,5]. Recent efforts to quantify the riverine Fe flux have identified humic substances (HS) as the dominant transport vector[5], specifically fulvic acids[4], with observations of substantially increased HS-bound Fe fluxes (~4 times greater) in northern European rivers over the last 20 to 40 years[6] mirroring the general increase in DOC observed in Northern Hemisphere rivers[7], albeit potentially due to a geographical bias in sampling.

Here we focus on the behaviour of dissolved Fe in Loch Etive, a sea loch on the West Coast of Scotland supplied with river waters draining peat-dominated catchments. We carried out direct measurements and mixing experiments of dissolved Fe in two size fractions (<0.4 μm, <5 kDa) and DOC (<0.7 μm). We use these data to address two key questions: (1) What is the transport efficiency of dissolved Fe across the salinity gradient? (2) What is the dominant carrier phase of dissolved Fe?

While the colloidal fraction (<0.4 μm to >5 kDa) carries greater absolute Fe concentrations across the salinity gradient, the <5 kDa fraction is more efficient at transporting Fe. It also has a constant Fe/DOC ratio, implying mainly organic complexation, compared to the decreasing trend in the <0.4 μm fraction. Further work is required to conclusively identify the nature of these organics to refine the implications for riverine dissolved Fe fluxes in the future, especially under different temperature and precipitation regimes associated with climate change.

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Optimising the decommissioning of concrete mattresses and subsea protection structures in the North Sea

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Subsea protection structures including concrete mattresses, grout bags, rock dump and fronded concrete mattresses are used to protect and support pipelines and other subsea structures on the seabed. Subsea protection structures are not covered by the OSPAR 98/3 decision to ban offshore disposal of decommissioned installations. However, current UK guidelines state that subsea protection structures should be removed and disposed of onshore. With the expected number of protection structures ranging from 35,000 - 40,000 in the North Sea (Cumming, 2015), alternatives to the current end-of-life landfill should be taken into consideration. The reuse or recycling of concrete mattresses and subsea protection structures could lead to a reduction in cost for both the taxpayer and oil and gas sector, improving sustainable management by promoting a circular economy.

Before considering decommissioning options for subsea protection structures, policy-makers and industry need to understand the environmental costs and benefits of different strategies, including how mattress could potentially be reused or recycled in the ecosystem. To support these environmental assessments, the current state of subsea protection structures in the North Sea are being characterised in term of number, location, integrity and contaminations status

Primary results from the collation of some major operators have already shown 44,835 subsea protection structures (concrete mattresses, fronded mattresses and grout bags) exist in the North Sea. As such, the current estimation numbers of subsea protection structures are higher than anticipated and will have an impact on the total cost incurred by the company from decommissioning. This characterisation of the current state of subsea protection structures will give operators informed options to help choose a suitable decommissioning methodology. The results will contribute to the evidence-base to enable comparative assessments in relation to the potential reuse or recycling of concrete mattresses and subsea protection structures for renewable energy, coastal defence and artificial reef creation.

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Epifaunal colonisation and the potential benefits of a 'rigs-to-reef' programme in the Gulf of Thailand

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There are ~450 offshore oil and gas platforms ('platforms') in the Gulf of Thailand (Rig Zone, 2016). The platforms lie in waters 55-75m deep and are up to 36 years old. The environmental consequences of complete removal versus 'artificial reef' (AR) creation being considered for eight of these structures. AR creation would involve relocation to a 30m deep 'reefing site' located in the western Gulf of Thailand (GoT), just north of Ko Pha Ngan island (9.89°N, 100.12°E).

Many platforms act as de-facto ARs by providing attachment points for encrusting species and habitat and shelter for juvenile and adult fish. In some circumstances, platforms can enhance local-to-regional scale fisheries by habitat provision and by facilitating fishing-effort management (e.g. red-snapper, Gulf of Mexico, US; Ajemian et al., 2015).

Fishers in the GoT experienced declines in catch per unit effort of 87% over the period 1966-2003 because of poor management (Khaewwongian & Kim, 2012) and the loss of coral reef habitat through bleaching and human interference (Yeemin et al., 2013). Shallow-water ARs have been deployed, in the GoT, since the 1970s, in an effort to combat fishery-declines. However, over-exploitation of the ARs, including juveniles of fishery species, has further reduced incomes particularly for artisanal fishers (Khaewwongian & Kim, 2012).

Net Environmental Benefit Analysis (NEBA) is a process that evaluates the environmental effects of anthropogenic activities, here applied to decommissioning. We used remotely operated vehicle (ROV) footage, collected to inform NEBA, from four platforms in the GoT, to quantify encrusting communities growing on the steel-substructure. Percentage cover was assessed visually using 'coral-point-count' (CPCe) software (Kholer & Gill, 2006). Cover was assessed at 128 stratified random points superimposed on ROV-images extracted at 5m intervals (seabed to sea-surface). Preliminary results identified ~100% cover with dominance by soft corals, hydroids, algae, sea fans and sponges. The stony coral *Tubastrea* was also identified and high densities of fish were noted around the platforms substructures at depths shallower than 35m.

We conclude that platforms in the GoT are acting as de-facto ARs. Further research, as part of NEBA, will provide insight into the extent to which existing platforms are contributing to local-to-regional-scale ecosystem-service provision and the likely consequences of various decommissioning options to a range of stakeholders including fishers.

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Epifaunal secondary productivity associated with North Sea oil and gas platforms: consequences of decommissioning

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Since the 1970s oil and gas extraction in the North Sea has had a substantial economic impact in the UK but due to declining profits and ageing infrastructure the industry is now facing an enormous task of decommissioning the obsolete structures. While OSPAR Decision 98/3 prohibits wholly or partially leaving disused offshore installations in place except in specific cases, regulators and other stakeholders need to understand the environmental impacts of different decommissioning options to ensure sustainable management of North Sea resources, and guide future policy decisions.

As most offshore platforms are placed on areas where natural hard substrates are scarce, these large structures provide new attachment sites for epifaunal organisms, locally increasing secondary productivity (Forteath et al. 1982). Decommissioning of platforms by fully or partially removing them will, therefore, lead a loss of secondary productivity. In order to quantify this loss, data on the nature and biomass of epifauna associated with platforms, and the extent of habitat provided by individual platforms are required.

The surface area of steel jackets in the northern North Sea was calculated based on OSPAR approximations for surface areas and jacket weight (IMSA Amsterdam 2011). For each platform, the volume of epifauna was obtained by multiplying the surface area by a thickness estimate, derived from standard algorithms used by industry for engineering purposes. Volumes were converted to biomass by using published data on epifaunal zonation and percentage cover to estimate the relative contribution of different taxa to the epifauna volume. Species-specific volumes were multiplied by faunal density data to provide an estimate of biomass, which was then converted to production values using existing production to biomass ratios. The effects of three different decommissioning options (leave in place, partial removal and full removal) on epifaunal biomass and secondary production were then compared.

The total surface area of steel platform jackets in the northern North Sea was calculated as around 1.8km^2. The total epifaunal biomass was estimated as 140,000 tonnes and productivity as 24,000 t km^{-2} year^{-1}. Partial removal of platform jackets at 55 m would lead to loss of around 80,000 tonnes, or around 60%, of total platform-associated biomass and productivity.

The results will help in understanding the role of hard surfaces provided by the oil and gas structures in the North Sea, which can be used to guide management of decommissioning processes, and the formation of marine spatial plans within the UK continental shelf.

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Using mobile phone technology to capture small scale fisheries data – is this the future?

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The total number of fishing vessels in the world in 2014 was estimated at about 4.6 million, with 85% of motorized fishing vessels less than 12 m in length overall and unmotorised vessels accounting for about 36% of all fishing vessels, numbering around 1.66 million. These small vessels dominated in all regions. (FAO, 2016).

Small Scale Fisheries (SSF) globally represent the largest number of vessels and people engaged in fishing activities. The majority of SSF activity is unreported and is largely unregulated. The artisanal and dispersed nature of SSF coupled to poor infrastructure, governance and communications combine to challenge coherent and meaningful data collection.

Access to mobile telephones and related technologies, even in some of the least developed countries, provides opportunities to collect SSF data and offers the infrastructure needed to facilitate step changes in fisheries management, conservation, marine planning and commerce.

As part of the European and Maritime Fisheries Fund, Scottish Inshore Fisheries Integrated Data Systems (SIFIDS) project, we are developing and testing an open source mobile application designed to allow fishers to record their catch, vessel track and observational data. In combination, these data can provide information on fishing footprint, area and intensity of fishing activities, the duration of fishing trips, type and amount of fishing gear deployed, the amount of landed catch and thus measures of catch per unit effort. A number of similar applications are being developed for different fisheries and the use of this technology could revolutionise management of the SSF sector and offer the potential for more dynamic and imaginative management.

This work illustrates the functionality and data outputs from the SIFIDS app and explores both the response of fishers who used the app and future opportunities to harness a suite of mobile functionalities to capture fisheries and related environmental data. In addition, there is potential to integrate these data to use mobile technology as the primary platform for managing transactions with a view to improving traceability, enhancing provenance, securing better financial returns to artisanal fishers. The widespread adoption of such technology could ultimately improve both food security and the economic wellbeing of some of the world's poorest people aligning with, and supporting, many of the United Nations Sustainable Development Goals.

In a wider context, access to natural resources at all levels will require increasing accountability and management as they are impacted by the combined pressures of population growth and climate change. Many of these pressures will have the greatest impact in those countries least able to adapt and may reverse hard-won advances made through international development programmes. The use of (mobile) disruptive, low-cost open source solutions to collect and analyse environmental data and perhaps, in the future, provide decision support empowering localized management, may subvert the need for top-down governance approaches. More efficient use of resources and waste reduction will be key to feeding a projected 9.7 billion population by 2050. New cashless and secure transaction methods may reduce corruption and facilitate more equitable wealth distribution.

Artificial reef creation using decommissioned pipeline protections – environmental performance and fisheries enhancement potential in the North Sea.

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Are you a student? Yes

Many offshore oil and gas fields are reaching the end of their production life and will soon require decommissioning (Ahiaga-Dagbui, 2017). From 2017 to 2025 decommissioning is forecast to take place on 349 fields across all regions of the North Sea, including six fields on the Danish Continental Shelf, 23 fields on the Norwegian Continental Shelf, 106 on the Dutch Continental shelf and 214 fields on the United Kingdom Continental Shelf (Oil and Gas UK, 2017). Within these fields around 200 platforms and 7,800km of pipeline are due to be decommissioned. It is estimated that these operations will cost £17 billion between 2017 and 2025 on the UKCS alone (Oil and Gas UK, 2017).

Many of the pipelines present exhibit some form of pipeline protections. These include rock dump, grout bags and concrete mattresses that serve to safeguard pipelines from possible damage due to dropped objects, collisions with trawled fishing gear and hydrodynamic forces. It is estimated that there are over 40,000 concrete mattresses in the North Sea, all of which need to be accounted for in the decommissioning process. At present, the mattresses are being removed and transported onshore, where they are recycled and re-used in other capacities such as coastal protection or as an aggregate. One potential alternative that has not been studied is using mattresses to create artificial reefs, be it *in situ* or at other suitable sites such as at the bases of offshore wind turbines.

To ensure decommissioning of mattresses for the purpose of artificial reef creation is cost-effective and meets environmental and stakeholder needs, we need to know to what extent mattresses are providing habitat for marine species including commercially targeted species, the effect of physical and chemical properties of the mattresses including structural complexity and contamination status, and understand the impact of the structures on ecosystems of the North Sea on various spatial scales.

Using high definition ROV footage obtained from integrity surveys, interactions between North Sea pipelines, benthic fauna and fish will be quantified and offer understanding of habitat provision from mattresses. Using inductively coupled plasma mass spectrometry (ICP-MS) the concentration of heavy metal ions in concrete samples from decommissioned mattresses will determine contamination levels from across the North Sea region and ecosystem modelling will provide a valuable insight into the impacts of reef-creation and reef-removal over a range of spatial scales within the North Sea.

With this work, we gain new insights into re-purposing pipeline protection and further inform industry and policy makers by providing an evidence base for the decommissioning process.

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The occurrence and behavior of harbor porpoises (*Phocoena phocoena*) around fish farms on the west coast of Scotland

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The harbour porpoise (*Phocoena phocoena*) has a widespread coastal distribution throughout the northern hemisphere, where there is potential for exposure to anthropogenic activities. In Scotland the species may interact with an expanding Atlantic salmon (*Salmo salar*) aquaculture industry. Scottish salmon farms are mainly situated on the west coast, and off northern and western islands, which also have some of the highest harbour porpoise densities in Europe. Possible impacts to the species have been brought further into focus through the recently established Inner Hebrides and Minches Site of Community Interest (SCI). This protected area will cover 13,539km² of porpoise habitat and has significant overlap with existing salmon farm sites.

The impacts of salmon farming on the harbour porpoise are not well understood, and study efforts mainly focus on the effect of Acoustic Deterrent Devices (ADDs) deployed to prevent seal depredation. The signals produced by ADDs overlap with the hearing frequency of the harbour porpoise, which has a range of best hearing between 13 to 140kHz, and maximum hearing sensitivity at 125kHz (Kastelein *et al*., 2015). Therefore it is likely that harbour porpoises can perceive and react to ADDs, and research thus far indicates that some brands indeed have the potential to induce habitat exclusion and displacement (Olesiuk *et al*., 2002; Brandt *et al*., 2013a; b). In Scotland, it is presently unclear what effect, if any, the current widespread ADD usage at salmon farms may have on porpoises. The significance of general farm activity and the presence of farm-associated wild fish aggregations to these small cetaceans has also received limited attention to date.

To address these knowledge gaps, the present study will use Passive Acoustic Monitoring (PAM) to identify whether harbour porpoise occur near Scottish salmon farms, and if so, establish temporal variation in usage patterns. Additional PAM will investigate evidence of behaviours such as foraging. Potential attractants such as wild fish aggregations will also be assessed using a combination of video and acoustic techniques. Finally, the potential effects of ADDs and other fish farm-associated noise sources on porpoise occurrence and behavior around salmon farms will be assessed. The study will ultimately present multiple small-scale, site-specific examinations on the relevance of salmon aquaculture for harbour porpoises in Scotland, with an aim to inform activity management within the SCI.

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How to assess the ecological cost/benefit of future climate vs large scale anthropogenic changes using joint modelling of mobile marine predators and their prey at different spatial scales.

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Preferred presentation medium (i) oral

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The marine environment is changing rapidly due to climate change and increasing anthropogenic activities, in particular the addition of very large scale renewable energy extraction. Understanding how the usage of spatial habitat by highly mobile marine predator (seabirds, mammals) and prey (fish) species may change with both of these pressures is essential for the predictions of possible population trends and current decision making on sustainable spatially oriented management. Where both predator and prey species are highly mobile – it is important to predict how well their preferred habitats continue to overlap in future scenarios.

The diversity of individually preferred habitat variables are all be changing quite differently under the different pressures of climate change vs anthropogenic activity. Therefore it is essential to try to predict the ecological costs/benefits of future combination of predator-prey species habitat spatial overlap.

To predict ecological costs/benefits we have used a spatial statistical Bayesian hierarchical approach called Joint Modelling with INLA (integrated Nested Laplace Approximation). Joint Modelling, as compared to typical single-species spatial distribution modelling, allows a more complete understanding and assessment of the ecological cost/benefit of the possible overlap in both predator-prey distributions in the future (Sadykova et al. 2017).

In this talk we present the degree of change within common spatial trends between contrasting seabird (common guillemot, black-legged kittiwake, northern gannet) and competing marine mammal species (common and grey seals and porpoise) and two common prey species (herring and sandeels). We have used the approach with six important physical and biological variables (2 types of primary production, stratification, temperature, vertical and horizontal speed) that are predicted to change with both climate change scenarios in a 'business as usual' climate model for 2050 as compared with the largest possible scale of tidal energy extraction.

We will also present the differences that spatial scale can make in interpreting the effects of climate change vs very large scale energy extraction by focusing in on predicted regional level effects vs whole North Sea costs/benefits.

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Population impact frameworks: Identifying sensitivities, strengths and weaknesses using a simulated environment

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Area being submitted to Understanding the Influence of Man-made structures in the Ecosystem - progressing the science

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The abstract should be submitted to masts@st-andrews.ac.uk, in an editable format, by 16:00 Friday 27th July 2018.

The potential environmental impacts of renewable energy developments in the marine environment are highly varied. Very large scale (VLS) energy extraction will have direct and indirect effects on seabirds and marine mammals and their prey (fish) species. The cumulative impact of multiple factors (disturbance, displacement, death due to collision risk) will influence an individual's usage of these areas, having likely consequences for impacts at the population level through changes to energetic budgets, foraging efficiency and direct mortality rates. Current approaches to estimating the population effects of offshore renewables are species, and somewhat, location specific with no consensus on a cumulative modelling framework across offshore impact types. This project is focused on creating a generic, multi-species framework built on the best practice of the range of current population level impact models.

The initial stage of this project is to identify the most parsimonious population level model possible via a formal comparison in parameter sensitivity and outputs using a standardised (simulated) dataset for the following current leading models of mammal and seabird populations: Potential Biological Removal (PBR), interim Population Consequences of Disturbance (iPCoD), Disturbance Effect on the harbour Porpoise population of the North Sea (DEPONS) and Centre for Ecology and Hydrology (Seabird) Displacement Model.

The work presented will cover the construction methodology and reasoning of the simulated datasets and how they will be used to identify a generic multi-species population level impact model. The initial dataset will describe tidal energy sites using real data from multi-year studies with known prey (fish), seabird and marine mammal distributions and their relationships with fine temporal and spatial scale physical (speed, turbulence, etc.) variables. The simulated datasets will allow the first multi-model standardisation of comparisons of the sensitivity of key parameters in population impact models such as survival, species-of-interest changes in movement and prey distributions. The sensitivity analysis or benchmark approaches used will enable consideration of the required scales (temporal and spatial) of information to also be tested. These outputs will inform the most appropriate temporal and spatial scaling in the final generic, multi-species framework.

The development pathway to applying this approach to wind and wave energy developments will also be presented. Producing a robust but simplified approach and creating a generic population level impact modelling framework. Considering appropriate data requirements will ensure usability at the many new and rapidly expanding renewable energy sites across the globe, where the detailed data on species will be sparse.

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Passive acoustic monitoring of cetacean movements around operational tidal turbines

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Tidal turbines are currently being installed in tidally energetic coastal sites. However, there is a high level of uncertainty surrounding the nature of any environmental impacts on marine mammals. Concerns derive primarily from the potential for collisions between marine mammals and turbines. To understand this risk, information on how animals respond to tidal turbines is urgently required.

To address this, we deployed an array of 12 hydrophones, capable of localising small cetacean sounds in three dimensions, on an operational turbine in the Pentland Firth, Scotland. The hydrophone array exploits turbine infrastructure to produce the necessary geometric configuration for localisation. Data from individual hydrophones are digitised at the turbine with a sampling rate of 500kHz and then streamed to shore where data are processed in real time for the detection of echolocation clicks and whistles from small cetaceans. Detected clicks are then further processed using time of arrival methods to estimate animal locations and to provide fine scale animal tracks in three dimensions around the turbines.

During the data collection period (mid-October 2017 - end of May 2018; ~8 months), the monitoring system has been fully operational; operational efficiency was relatively high with between 82 and 100% of time monitored each month.

Analyses of small cetacean detections showed that, between mid-October 2017 and the end of May 2018 (~8 months), a total of thirteen dolphin and 392 harbour porpoise (*Phocoena phocoena*) encounters (events with at least 30 echolocation clicks) were made. There has been relatively high monthly variation in encounters rates; porpoise encounters increased from 27 (2.2/day) in October 2017 to peak at 96 (3.1/day) in December 2017 and subsequently declined to 10 (0.3/day) in May 2018. Numbers of dolphin encounters were relatively low throughout the monitoring period. Further, preliminary localization analysis indicates that porpoises move within tens of metres of the turbine structure. We describe the advantages and limitations associated with these monitoring systems and discuss the implications of the tracking results for collisions risks with tidal turbines.

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Modelling the Population Dynamics of *Nephrops norvegicus* and *Hematodinium* in the Firth of Clyde

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Nephrops norvegicus is a mud dwelling crustacean of great commercial importance to the Scottish economy. The Firth of Clyde on the west coast of Scotland supports a substantial *Nephrops* fishery, with annual landings from this area currently in excess of 5000 tonnes. However, *Nephrops* in the Firth of Clyde are infected by a parasitic dinoflagellate known as *Hematodinium sp*. The flesh of patently infected individuals is in a state of advanced autolysis that renders it bland, of poor quality, and of low market value. *Hematodinium* prevalence in the Clyde follows a seasonal cycle with a peak in the late winter and spring and low levels throughout summer and autumn.

Here we explore a recently developed mathematical model that describes the population dynamics of *Nephrops* and *Hematodinium* in the Firth of Clyde. This model includes a new method for modelling *Nephrops* growth, based upon the dynamic energy budget framework, which includes distinct moulting events crucial for accurately modelling parasite transmission. We show that our model fits survey length distributions of *Nephrops* in the Firth of Clyde and is also able to simulate the seasonal cycle of *Hematodinium* prevalence. This model will be used to explore the population dynamics of *Nephrops* and *Hematodinium* under a number of different fishing management scenarios, including altering fishing discard policies, to prevent the discard of heavily infected individuals. This will help identify an optimal fishing strategy that reduces *Hematodinium* transmission and ensures the sustainable exploitation of this commercially important species.

Marine bacteria as a source of renewable biopolymers

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Marine environments are the most biologically diverse, yet underexploited source of new sustainable materials [1]. These environments impose unique stresses on the microorganisms that inhabit them, requiring unique adaptations. The production of polysaccharides is one common adaptation, helping to protect marine bacteria, plants and animals from extreme conditions. These complex chains of sugars are emerging as promising candidates for industrial application, with a range of polysaccharides from animals, plants, algae and terrestrial bacteria widely used in the food, pharmaceutical, household, construction and textile industries [2]. Polysaccharides isolated from marine bacteria possess a number of unique adaptations over current materials, but high development costs and low yields have limited their use. However, global efforts and the emergence of new technologies have revealed numerous new species capable of producing industrially relevant yields and biotechnology firms have invested in the equipment necessary to cultivate them [3]. Additionally, new high value applications are emerging in the medical and nanotechnology fields, but require the development of new materials, for which polysaccharides possess many of the necessary properties [4,5]. In this work, we describe a new polysaccharide isolated from a novel bacterial species. The polysaccharide is extracted in yields up to 8 g/L and shows properties of interest to the biotechnology industry. Functional analysis has revealed gelling behaviour and the capacity to form flexible, plastic-like films. Continuing work is studying the genetic mechanisms underpinning polysaccharide synthesis and the potential to tailor the polysaccharide based on its predicted applications.

Acknowledgements

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The relationship between inshore and offshore physical conditions on the East coast of Scotland

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Dating back to 1997 Marine Scotland Science has been undertaking weekly sampling at a coastal monitoring station 5 km offshore from Stonehaven, on the east coast of Scotland. This dataset allows us to study both the seasonal and interannual variability at this site in a range of environmental variables, including temperature and salinity, but it would be useful to know how representative these inshore observations are of conditions further offshore in the North Sea. Here we investigate how temporal patterns observed at Stonehaven relate to offshore conditions observed through recent occupations of the “AlterEco line”, a zonal hydrographic section between the coastal monitoring station and 002ºE. The AlterEco line was first occupied in October 2017, and has been since occupied on 2 further cruises – December 2017 and May 2018, and will be occupied again in October 2018. This line was introduced as part of the NERC-funded Alternative Framework to Assess Marine Ecosystem Functioning in Shelf Seas (AlterEco), where MSS is a partner, but some stations coincide with those of the Aberdeen-Hanstholm standard hydrographic section sampled by the Norwegian and German oceanographers.

Data from weekly CTD (conductivity, temperature, depth) profiles at Stonehaven have been analysed alongside the lower temporal resolution AlterEco section CTD data to determine to what extent Stonehaven replicates the offshore conditions at the time of the cruises.

MSS have occupied another zonal hydrographic section in the North Sea, the JONSIS line, at 59.3ºN, running from the eastern coast of Orkney to 000ºW in the central northern North Sea since the late 1980’s. The temperature along the JONSIS line shows considerable variability over an annual cycle – there are almost no thermal gradients, either horizontally or vertically, throughout the winter months, but in the summer a strong thermocline develops offshore (Sheehan *et al*., 2017). The salinity is less seasonally variable; lower salinity water exists near the Scottish coast and higher salinity water at depth offshore persists throughout the year (Sheehan *et al*., 2017). The extent to which this is mirrored within the AlterEco line and at Stonehaven will be explored. This will enable the Stonehaven sampling site to be put into the context of both the nearby AlterEco line, but also the more northerly, and data rich, JONSIS line.

Acknowledgements

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