Connectivity of Hard Substrate Assemblages in the North Sea

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The INSITE CHASANS project aim is to quantify the connectivity of hard substrate marine assemblages between submerged infrastructure platforms in the North Sea and to understand the impact that removal and addition of infrastructure will have #MASTSasm2020.

@joannesporter

A major programme of decommissioning of North Sea energy installations is planned over the next 20 years and beyond. At the same time, more offshore wind developments are expected. This means that there is an urgent need for a robust scientific rationale and a strong evidence base to support environmental management strategies to make the most of potential ecological benefits of decommissioning and minimise the risks. The INSITE programme is addressing this need by tackling critical gaps in scientific understanding of the role these man-made structures play in North Sea ecosystem structure and function.

The CHASANS project team includes academic partners from Hull University, National Oceanographic Centre, Natural History Museum and Aberdeen University. Industry, Government and NGO partners include European Marine Energy Centre, Aquatera Ltd, Marine Scotland Science, Joint Nature Conservation Committee and the International Maritime Organisation.

The aim of the CHASANS project is to enhance our understanding of the connectivity of populations of marine fauna colonising artificial substrates across the North Sea. Team expertise in biofouling monitoring, oceanographic modelling, and population genetics will be used to generate a multidisciplinary dataset to validate biologically realistic models of larval connectivity between sites in the North Sea. These models will be used to predict how networks of hard substrate in the North Sea function in the dispersal and metapopulation structure of marine epifauna. One of the outputs of the research is a tool which will predict how the distribution of epifauna is affected when specific artificial platforms are removed or added into the network. Such information will help to provide environmental evidence to decision makers regarding which artificial platforms should be maintained and which ones should be removed.

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An Interdisciplinary Approach to Tackling Invasive Species Settlement on Concrete Surfaces in Harbours

Any structure deployed into the sea has the potential for marine organisms to grow on and biofoul the structure, including invasive species which pose ecological and economic threats. Concrete is the most used material in the marine environment and one of the main materials used in harbours. Harbours are hubs for marine invasive species, as the largest vector in the spread of marine invasive species is via shipping. Concrete is at particular risk of marine invasive species settlement due to its large surface area often making coating with antifouling paints uneconomical. This study is the first to investigate the possibility of making changes directly to the surface of the concrete with the aim of making the surface unfavourable for the settlement of marine invasive species. This study created 4 novel low cost, non-toxic concrete surfaces with the aim of reducing invasive species settlement. Both the physical and chemical changes to the surface properties have been characterized using a variety of techniques including XRD, XRF and microCT. Over 250 panels of the 4 novel concretes and 2 standard concrete designs have been deployed in 3 harbours on the East Coast of Scotland for 12+ months. Colonization and succession of these panels was investigated by removing panels at the intervals of 3 and 6 months. Preliminary findings of the 3 and 6-month colonization of the panels and novel concrete design will be discussed. This study provides an example of a truly interdisciplinary study working towards providing a solution, that maybe easily implemented into industry if successful, to the problems that marine invasive species pose.

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Twitter Promotional Abstract: Marine Biology and Engineering collide when marine life grows on structures in the sea. @marinemumbles PhD is all about how can be change concrete to help stop invasive species growing on concrete.

Artificial reef creation using decommissioned subsea pipeline protections - investigating scale dependent habitat complexity using 3D Photogrammetry.

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Many North Sea oil and gas installations are rapidly approaching the end of their operational lifespans. Industry is faced with the task of removing oil and gas platforms, subsea infrastructure, pipelines and pipeline protections from service. Pipeline protections include articulated concrete blocks linked with wire or rope ("concrete mattresses") and rock armoring ("rock dump"), installed to afford protection to pipelines from dropped objects, hydrodynamic forces, and snagging from trawled fishing gear.

The re-use or recycling of structures is becoming a major priority for operators and policy makers. At present, mattresses are being transported onshore, where some are crushed and re-used as aggregate, while many are rendered to landfill. One potential alternative is using mattresses to create artificial reefs (ARs), be it *in situ* or at other suitable sites such as at the bases of offshore wind turbines.

The habitat complexity of a structure is one of the most important factors structuring biological assemblages on ARs and will affect the way in which organisms use and exploit a structure (Kovalenko et al., 2012). If mattresses are used as ARs, the habitat complexity of the structures will vary depending on the deployment configuration. Habitat complexity will also vary by scale, with certain structures providing different complexity levels at different scales (Wilding, Rose and Polunin, 2010), resulting in certain deployment scenarios favoring certain species over others.

This study investigated the complexity offered by five different mattress reef creation scenarios at eight different scales (2, 4, 8, 16, 32, 64, 128, and 256 mm). The scenarios included; left *in situ* laid over a pipeline, mattress laid flat, mattress broken up and redeployed randomly, mattresses broken up and redeployed around a cylinder (representing wind turbine base), and mattresses crushed into material of a similar size to rock dump.

Using individual blocks from a decommissioned mattress, the five scenarios were each constructed, photographed, and processed in Agisoft Metashape (Agisoft, 2020) to create 3D models. From these models, metrics of complexity were extracted, including surface rugosity and porosity.

At larger scales (256 and 128 mm), there was little variation in complexity between the scenarios tested. The complexity then increased as scale decreased for all scenarios. From the 64 mm scale down to the 2 mm scale, the random and round a cylinder scenario exhibited the highest levels of complexity, with the random configuration being the highest of the two.

These results provide new insights into the potential complexity that could be achieved by re-using concrete mattresses as ARs. These findings provide evidence that mattresses could be deployed in different scenarios to achieve different levels of complexity and target different species. For example, ARs constructed using decommissioned concrete mattresses could be designed and deployed to benefit commercial species such as European lobsters and edible crabs.

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Use of ROV data to assess marine fauna associated with offshore anthropogenic structures

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In oceans and seas worldwide, an increasing number of end-of-life anthropogenic offshore structures (*e.g.* platforms, pipelines, manifolds, windfarms, *etc*.) are facing full or partial removal. As part of the decommissioning process, studies on potential importance of subsea infrastructure to marine fauna are required, but data are lacking. Dedicated scientific Remotely Operated Vehicle (ROV) surveys around offshore installations are rare, but a wealth of archived industrial data that are worthy of scientific investigation exist, and some videos of particularly interesting occurrences have been posted in publicly available repositories (*e.g.* YouTube). We have analysed dedicated industry-collected ROV footage, as well as publicly available videos to investigate colonisation through time of a single platform in the North Sea (Todd et al., 2020b; Todd et al., 2020c) as well as presence of marine megafauna (cetaceans, pinnipeds, marine reptiles, and large fish – such as sharks, rays, billfishes, and tuna) around platforms & structures globally (Todd et al., 2020a).

Around a newly installed gas-production platform, fish communities exhibited rapid colonisation, increasing in species richness and density compared to baseline pre-installation conditions (over a period of four days). By contrast, minimal change in motile invertebrate communities was found over that period. During surveys one and two years after installation, 48 additional taxa, including a rare sighting of a pompano (*Trachinotus ovatus*), were recorded. No sessile taxa were recorded on the new jacket immediately after installation; however, 17 sessile species were detected after one year (16 after two years), with species abundance expected to increase further with time. Motile species were found to favour structurally complex, sheltered sections of the jacket (*e.g.* mudmat, a seabed 'mat' preventing structures from sinking), while sessile organisms favoured exposed elements. Evidence of on-jacket reproduction was also found for two commercially important invertebrate species (*Buccinum undatum* & *Loligo vulgaris*). Moreover, reproductive-strategy composition of investigated communities exhibited substantial changes over the two-year period, with larvae-producing species dominating in 2016 and 2017 (one and two years following installation, respectively) as a result of an 8.5-fold increase compared to baseline communities (pre-construction).

As part of a separate study (Todd et al., 2020a), analysis of incidentally collected ROV and commercial diver video recordings spanning 1998–2019 globally, we also documented 67 individual sightings of 17 species of marine megafauna in proximity to offshore structures. Observations included the deepest (2,779 m) confirmed record of a sleeper shark (*Somniosus* spp.) and the first confirmed visual evidence of seals following pipelines with foraging attempts documented.

These findings present strong evidence of the importance of offshore installations to both lower and higher trophic level species, which should eb accounted for during case-by-case decommissioning processes. It is clear that more systematic research on the role offshore structures play within the broader marine ecosystem should be performed, especially with regards to marine megafauna. Results further demonstrate the importance and utility of incidentally collected or publicly available ROV footage to advance understanding of communities surrounding offshore structures.

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When speed matters: the importance of flight speed in avian collision risk models

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The Band collision risk model is sensitive to bird flight speed. Using site-specific flight speed data reduced the predicted number of collisions. Collecting better bird flight speed data will reduce precaution in future EIAs. #MASTSasm2020 @eamasden @AonghaisC @thaxalot

Renewable energy continues to grow globally, and the number of offshore wind farms is set to increase. Whilst wind energy developments provide energy security and reduced carbon budgets, they may impact bird populations through collision mortality, habitat modification and avoidance. To date, avian collision mortality has received the most attention and collision risk models have been developed to estimate the potential mortality caused by wind turbines. The utility of these models relies not only on their underlying assumptions but also on the data available to ensure the predictions are informative.

Using the Band collision risk model (Band, 2012) as an example, we explore the importance of bird flight speed and consider how the assumptions of the model influence the sensitivity to flight speed. Furthermore we explore the consequences of using site-specific GPS-derived flight speed rather than a standard generic value, with Lesser Black-backed Gulls *Larus fuscus* as an example.

Similar to the results of Chamberlain *et al*. (2006) we found that the model was most sensitive to the parameters of bird density, non-avoidance rate and percentage of birds at collision risk height, as well as bird flight speed. Using site-specific flight speed data derived from GPS tags rather than a standard value reduced the predicted number of collisions. We highlight that within the model, both the estimation of the probability of collision and, the flux of birds are sensitive to the bird flight speed; this sensitivity acts in opposite directions but the two do not necessarily balance each other out. At present, estimates of seabird collision rates in relation to offshore wind farms are impacting the future development of offshore wind energy. By using site specific flight speed estimates and, accounting for different speeds in relation to wind direction, we demonstrate that cumulative collision estimates can be reduced, highlighting the need for more accurate site-specific data.

To date, discussions around collision risk modelling have often focussed on improvements to the understanding of avoidance rates. Whilst there has been some work to better understand species flight heights and densities within proposed and operational wind farms, the potential importance of estimates of bird flight speed has been largely overlooked to date. We argue that in order to better understand collision risk within offshore wind farms, we need to develop models better able to account for spatio-temporal patterns in bird behaviour and thereby better reflect biological reality.

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