Opportunistic investigation of the impacts of recreational catch-and-release on the post-release behaviour of a Critically Endangered elasmobranch

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Catch-and-release can expose the Critically Endangered flapper skate to exceptional changes in depth and temperature, but movement timeseries pre- and post-capture reveal no consistent, discernable effects on depth use or vertical activity. #ElevateTheSkate # MASTSasm2020 @edward_lavender

Recreational catch-and-release is widespread in aquatic environments. However, for many elasmobranchs, little is known about the physical, physiological or behavioural impacts of this practice. Off the west coast of Scotland, the Critically Endangered flapper skate (*Dipturus intermedius*) is a popular target among recreational anglers and the subject of a movement ecology research programme, but the impacts of catch-and-release on skate movement remain poorly understood. In this study, archival (depth and temperature) timeseries, comprising observations before and after recreational catch-and-release events, were used to investigate whether catch-and-release leads to disturbed post-release behaviour in flapper skate. During capture, the rate and magnitude of the changes that skate experience in depth and temperature were compared to those experienced during undisturbed activity as metrics of the potential stress that catch-and-release might induce. Subsequent capture-induced changes in movement were examined by comparing depth and vertical activity timeseries immediately following release to timeseries sampled from undisturbed sections of each individual's timeseries, using distance metrics. For the five recreational catch-and-release events that were identified within available (n = 21) archival records, the sustained ascent rate and temperature change exceeded naturally observed variation. However, there were no discernible, consistent changes in depth use or vertical activity post-release, although one individual rapidly re-ascended towards the surface following release, possibly indicating disturbance by capture. These results may suggest that flapper skate are relatively undisturbed by capture, but the limited sample size and scope of available data caution against premature conclusions.

Acknowledgements

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Generating planktivore prey fields from continuous plankton recorder data

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The dynamics of planktivores are often closely linked to those of their zooplankton prey. Not only the abundance, but also the species composition, size and phenology of the available prey may affect planktivore ingestion rates, and subsequent growth and survival. As such, prey fields of high taxonomic and spatio-temporal resolution are required in order to fully understand variation in the food conditions for a planktivore. However, these type of data are generally not readily available at the right scale for foraging planktivores.

Here, we develop an approach for generating planktivore prey fields based on zooplankton data collected by the continuous plankton recorder, a dataset which is unmatched in terms of spatial and temporal coverage. The approach involves temporal interpolation of spatially aggregated data corrected for taxon-specific sampling efficiency and diel vertical migration of the plankton. By pairing it with collated prey trait data, the approach can generate both species-based and community-trait-based descriptions of planktivore prey fields.

To illustrate the approach, we present a case study based on the lesser sandeel *Ammodytes marinus* in the North Sea. We generate daily abundances of key taxa, as well as aggregate metrics such as total energy availability and prey image area (which directly determines prey encounter rates), for years and locations where data coverage is sufficient. These values can then be extracted for the exact extent of the sandeel feeding period for locations and time periods of interest to be used to explore the relationship with sandeel dynamics. We show that when the generated prey fields are used as input to a growth model, the model predictions agree with observed spatial variation in sandeel size, and the model also reproduces an observed decline in size in the north-western North Sea.

The described approach can also be applied to other planktivores, and while the generated values at a given time point in a given location may not reflect actual abundances, it still goes a long way to producing prey fields of the resolution required to understand large-scale and long-term changes in food conditions. Understanding the dynamics of zooplankton and how their predators respond to these dynamics is crucial considering the impact of ongoing rapid environmental change on zooplankton.

Acknowledgements

This work is partly funded by MASTS. We gratefully acknowledge the communal effort involved in gathering and analysing the CPR samples.

Twitter abstract:
We used @CPRSurvey data to develop prey fields for foraging planktivores which can be used in statistical and modelling approaches to better understand the impact of food conditions on planktivores **#MASTSasm2020**
Twitter handle: @agnesbirgitta

Effect of season on nutritional composition in Atlantic mackerel (*Scomber scombrus*)

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Tweetable abstract (max. 280 characters) for #MASTSasm2020: @Anneli_Lof01 explores effect of season on nutritional composition in #mackerel. Results show that October- caught mackerel have a higher omega-3 content.

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Abstract:

Fish and fisheries products play a vital role in global food security and human nutrition. They contain several essential amino acids, vitamins, trace elements and fatty acids. Mackerel (*Scomber scombrus*) are a particularly rich source of omega-3, shown to reduce risks of cardiovascular disease. This migratory fish is commercially caught in the North East Atlantic in October and January. Here we investigated the effect of season on nutritional composition (fatty acids, vitamin D, micronutrients and amino acids). Sixty mackerel were sourced from a pelagic fish processor in Peterhead across both seasons. Raw muscle samples were used for mass spectrometry and proximate analysis. Initial results show October caught mackerel have a significantly higher fat content (%) that those caught in January. Similar results were reported for vitamin D. Seasonal differences in protein, fatty acid profile and micronutrient content were also examined. Such findings indicate seasonal differences in nutritional content in Atlantic mackerel; with October caught mackerel showing a more desirable nutritional profile for human nutrition.

Acknowledgements

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References

NA

Modelling extreme fish catch observations

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#MASTSasm2020 Modelling extreme fish aggregation events in fishery distribution models. We extend the hurdle model through a spliced Negative Binomial-Generalized Pareto model. As a result, we simultaneously describe the probability of occurrence, the bulk and the tail of fish abundance distribution.

Abstract

Outliers caused by atypically high catch observations are common in fisheries. While extensive literature has focused on modelling the average abundance of fish, very little effort has focused on understanding extreme catch events and appropriately including them into fishery models. The drivers behind these high fish aggregation events are generally unknown and may respond to different processes such as nursery grounds, spawning events, presence of predators, etc.

Extreme and non-extreme fish abundance are predicted using a flexible spliced Negative Binomial-Generalized Pareto model [1]. Particularly, we used the Integrated Nested Laplace Approximation (INLA) approach [2] to predict the spatiotemporal distribution of cod recruits in the North Sea. Given the zero inflated nature of cod recruits data, we conjugated the spliced Negative Binomial-Generalized Pareto model with a Bernoulli model that also describes the probability of occurrence. Consequently, our resulting Cumulative Density Functions (CDFs) combine three different processes: absence probability, bulk fish abundance probability and extreme fish abundance probability.

Acknowledgements

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References

[1] Castro-Camilo, D., Huser, R., & Rue, H. (2019). A spliced Gamma-Generalized Pareto model for short-term extreme wind speed probabilistic forecasting. Journal of Agricultural, Biological and Environmental Statistics, 24(3), 517-534.

[2] Rue, H., Martino, S., & Chopin, N. (2009). Approximate Bayesian inference for latent Gaussian models by using integrated nested Laplace approximations. Journal of the royal statistical society: Series b (statistical methodology), 71(2), 319-392.

Integrating Wind Turbines and Fish Farms: An Evaluation of Potential Risks to Marine and Coastal Bird Species

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A thought experiment: Which marine and coastal bird species might be most at risk if we integrated wind turbines into Scottish salmon aquaculture? Answer: probably large gulls and European shags, but large knowledge gaps remain re: aquaculture site use by birds. #MASTSasm2020 @StevenBenjamins @eamasden @maucollu.

Abstract: Significant growth of the global marine finfish aquaculture industry, as witnessed over the last 20 years in the face of continuing pressure on wild fish stocks, is expected to continue (FAO 2018). This expansion will likely be achieved at least partially by the sector moving into more remote, exposed coastal waters. Fish farms traditionally rely on diesel generators for off-grid electrical power, but there is increasing interest in using different renewable energy (RE) systems, including wind turbines, to reduce reliance on fossil fuels. Wind turbines are attractive RE candidates for integration (co-location) into fish farm operations given their technological maturity, but can pose significant risks to flying birds through collisions with rotating turbine blades (Drewitt & Langston 2006). Such risks could be exacerbated by placing turbines near fish farms, which are already considered attractive to birds.

In this study, we undertook a thought experiment to assess the potential for increased collision risks to local marine and coastal bird species of integrating four small wind turbines (combined rated power 80kW) into a generalised marine salmon farm in western Scotland (UK). Potential risks to 82 coastal and marine bird species were assessed using a bespoke Sensitivity Index (SI), following the general method described by Garthe & Hüppop (2004), based on 12 factors including population size in Scotland, adult survival rate, UK conservation status, flight manoeuvrability, nocturnal flight activity, habitat preference, sensitivity to wind farms, attraction to fish farms for feeding and/or resting, and attraction to other marine anthropogenic structures/activities.

Final SI scores varied substantially between species, but large gulls (*Larus* sp.) and European shag (*Phalacrocorax aristotelis*) were expected to be at greatest potential risk based on confirmed use of fish farm infrastructure and conservation status. Various knowledge gaps were identified regarding the nature and extent of many bird species' use of fish farm sites, which complicated assessment of their potential sensitivity to integrating wind turbines into fish farm operations. These knowledge gaps will need to be addressed to improve future risk assessments of co-location of aquaculture and marine RE sectors.

Acknowledgements

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References

Food and Agriculture Organisation (2018). The State of World Fisheries and Aquaculture 2018—Meeting the Sustainable Development Goals. FAO, Rome, Italy, xiii + 210.

Drewitt, A.L., & Langston, R.H.W. (2006). Assessing the impacts of wind farms on birds. Ibis, 148, 29-42.

Garthe, S., & Hüppop, O. (2004). Scaling possible adverse effects of marine wind farms on seabirds: Developing and applying a vulnerability index. Journal of Applied Ecology, 41, 724-734.

Estimating connectivity and vulnerability in a seabird metapopulation

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Please provide an additional tweetable abstract first (max. 280 characters) to assist online promotion. #MASTSasm2020.
Many #seabirds form metapopulations but are assessed as closed colonies in EIA. Here we provide estimates of a regional metapopulation of kittiwake derived from empirical data & highlight potential disparities between closed & metapopulation assessment **#MASTSasm2020 #renewables**

Seabird colonies have long been acknowledged as forming metapopulations, but due to difficulties in sampling frequency, technology and accessibility, the underlying connectivity between them has not been empirically measured. Due to this knowledge gap, as part of a precautionary approach, environmental impact assessment (EIA) required for many licenced marine activities, evaluates the viability of single seabird colonies as if they were closed populations. However, following metapopulation theory, we understand that connectivity may enhance viability of populations or conversely, dynamics such as source-sink may confer overlooked vulnerabilities to sub-populations in a network. Using hierarchical Bayesian state-space modelling, I provide a method of theoretical quantification of the connectivity in a regional metapopulation of black-legged kittiwakes (Rissa tridactyla) in Shetland, UK.

Preliminary results from model fitting to time-series of demographic variables indicate transfer from one colony to another is moderated by distance, breeding success and regulation from density-dependence. Subsequent metapopulation viability analyses, under additional anthropogenic mortality scenarios, found spatial disparity in the persistence of colonies under closed and metapopulation simulations. This work provides the first estimates of a regional metapopulation derived from empirical data and highlights, via sensitivity analyses, potential disparities between closed and metapopulation assessment and may offer a route for metapopulation dynamics to be considered in future impact assessments

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Seabird foraging associations with localised coherent surface flow structures

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#Seabird foraging associations with #turbulent surface #flow structures quantified using #drone tracking, #PIV and hidden Markov models #HMMs. @BrydenCentre_EU @RolandLangrock @unibielefeld @AlexNimmoSmith @PlymUni #OceanEnergy #animalmovement #Tech4Wildlife #UAVs #MASTSasm2020

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Understanding physical mechanisms underlying marine predator foraging helps predict responses to man-made change [1]. Coastal environments are undergoing unprecedented anthropogenic change, including the installation of man-made structures to fuel the blue economy (e.g. ocean & offshore wind energy extraction, mariculture). This can lead to new synergies between predators and installations and may even result in the generation of new foraging patterns [2],[3]. Assessing how free-ranging animals fine-tune their foraging movements in highly complex and dynamic environments such as coastal waters is therefore fundamental to understand how they may respond to anthropogenic change as movement strategies may vary in response to physical changes in local conditions.

Here, we present the extraction of highly localised and evolving turbulent flow structures and their role in shaping seabird foraging movements. Surface-foraging terns (*Sternidae*) were tracked by hovering drones across a turbulent vortex street in the wake of a monopile structure set in a tidal channel.

The individual bird trajectories were tracked using a newly developed feature extraction approach. Particle image velocimetry (PIV) techniques were then applied to the same drone imagery to map the underlying surface velocity field, thereby capturing the evolution of vorticity, di- and convergence present in the surface flow. We incorporated these dynamic turbulence structures as covariates within a hidden Markov model framework to quantify tern foraging associations with underlying physical cues, accounting for 'time-to-contact'.

Speed and (log-)tortuosity allowed us to differentiate two states, active and transit foraging, respectively. We show that terns were more likely to actively forage as the strength of the underlying vorticity feature increased, while strong divergence (upwelling) ahead of the flight path increased the probability of terns occupying the transit state.

Our drone-based approach, tracking seabirds and evolving physical structures in synchrony, provides a novel method to analysing localised animal motion in relation to dynamic changes of the underlying environment. It therefore offers the opportunity to unlock knowledge gaps in seabird sensory ecology and lays the foundation to help inform the sustainable implementation of ocean energy structures.

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References

[1] Hazen EL et al. (2019) Marine top predators as climate and ecosystem sentinels. *Front Ecol Environ*. **17** (10): 565–574
[2] Russell DJF et al. (2014) Marine mammals trace anthropogenic structures at sea. *Curr. Biol*., **24** (14): R638–R639
[3] Lieber L, Nimmo-Smith WAM, Waggitt JJ, and Kregting L (2019) Localised anthropogenic wake generates a predictable foraging hotspot for top predators. *Commun. Biol*., **2**:123