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Determining the activity patterns and potential seabed impact of aquaculture: The example of blue mussel culture in Belfast Lough, Northern Ireland.

Adele Boyd[1], Annika Clements[1], Heather Moore[1], Rhys Cooper[2], Meredith Scanlon[2] and Matthew Service[1].

[1] Fisheries & Aquatic Ecosystems Branch, Agri-Food and Biosciences Institute (AFBI), UK; [2] British Geological Survey (BGS), UK. Presenter contact details: annika.clements@afbini.gov.uk, Phone: +44(0)2890255153

Summary

The ongoing sustainable management of aquaculture activities in Belfast Lough requires a holistic approach, incorporating assessment of both seabed and wider ecosystem impacts. "Black box" data from mussel dredgers has been utilised to ascertain levels of activity across licensed sites, as a proxy for determining seafloor abrasion. A multibeam echosounder survey provided unique seabed texture imagery that allowed the distribution of dredge marks to be examined and compared to black box data. In addition, an ecosystem model permitted assessment of impact to wild species from blue mussel cultivation. Together, these allow monitoring of the wider impacts of mussel cultivation and how such tools should be utilised in management.

Introduction

Belfast Lough is the busiest waterway in Northern Ireland, approximately 130 km^2 in size, with the inner lough harbouring notable Natura 2000 conservation designations (Special Protection Sites (SPAs) for overwintering birds). These Natura 2000 sites are co-located with the largest subtidal blue mussel (*Mytilus edulis)* bottom cultivation in Northern Ireland. 21 licensed beds now occupy approximately 1270 hectares - a third of the inner lough's seabed.

To assess "Good Environmental Status" for the Marine Strategy Framework Directive (MSFD, 2008/56/EC), a number of descriptors are required as evaluated through indicators. 'Seabed integrity' (descriptor six) indicators are currently under development, with a core component being a measure of "physical damage", linked to the most common benthic pressures, such as abrasion. It is proposed to utilise fishing vessel location and speed data, as recorded by Vessel Monitoring Systems (VMS) or, for vessels <12m length, "black box" data, as a proxy for fishing impacts at a regional scale.

"Black box" data have been made available from the mussel dredgers in Belfast Lough; when examined alongside recorded activity and seabed texture imagery these data provide an opportunity to ascertain their effectiveness in assessing seabed abrasion. These data, in combination with ecosystem modelling, provide an insight into the sustainability and footprint of subtidal aquaculture operations within Belfast Lough.

Materials and Methods

Black Box data from mussel dredgers were provided by the Department of Agriculture and Rural Development (DARD). These data were filtered for vessel speed (<3.5 knots) and month, and processed in ESRI ArcGIS 10.0 using Spatial Analysis tools to provide the number of logged positions per square kilometre – a measure of activity intensity.

A multibeam echosounder survey (Kongsberg EM3002 TD) was completed throughout the inner lough by BGS and AFBI in 2013, providing seabed texture imagery derived from the acoustic backscatter data. Processed black box data were overlaid within ArcGIS and correspondence between datasets examined. In addition, logs of mussel tonnage harvested and seed laid (by month) were referenced to assess persistence of dredge marks.

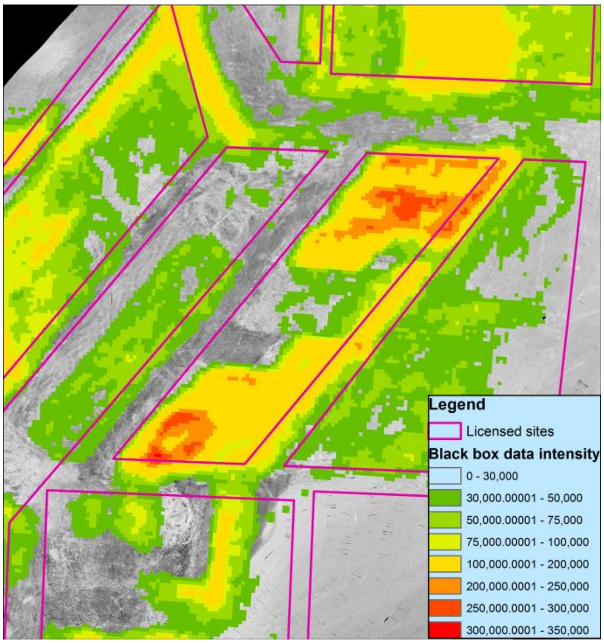
The Sustainable Mariculture in northern Irish Lough ecosystems (SMILE) model combines field data, experimental results and several model types to assess ecosystem impacts of aquaculture. The SMILE model used Chlorophyll a as a proxy for phytoplankton biomass, through two runs: Run 1 with no aquaculture within the Lough (only wild species present); and Run 2 with all currently licensed aquaculture sites activated.

Results and Discussion

The multibeam backscatter imagery showed distinct dredge marks, ranging from high reflectivity, curved narrow marks, to wider, paired linear marks (Figure 1). Black box data coincided spatially with the majority of marks, and high concentrations of dredge marks found in areas of high black box data intensity (Figure 1). At three licensed sites, no activity was recorded for three months prior to the multibeam survey, and for approximately 30% of the seabed where dredge marks were clear on the seabed imagery, no black box data were recorded in the year preceding. This suggests that such marks have persisted for over a year, and/or the black box data does not capture all dredging activities. Seeding, re-laying, harvesting and starfish mopping are undertaken in mussel culture, which will have different seabed impacts. Longevity of dredge marks on the seabed is dependent upon (a) sediment type, and (b) hydrodynamic regime (DeAlteris *et al.*, 1999; Løkkeborg, 2005). Most dredge marks were restricted to within the licensed site boundaries; however there are instances where linear dredge marks are found between sites, perhaps from starfish control activities (Figure 1).

It is clear that black box data is a valid proxy for seabed abrasion; however it may fail to capture the full spatial extent of abrasive activities. The study suggests that to assess "physical damage", data from time periods in excess of a year are required in softer sedimentary regions, due to longevity of seabed impact.

Figure 1. Backscatter imagery with black box data and licensed aquaculture sites overlaid.



Comparing the SMILE model output data from Run 1 and Run 2 demonstrated that cultivated mussels reduce the overall ecosystem phytoplankton biomass within the Lough by up to a maximum of 56%. These data indicate that if all licensed sites are active, mussel production within three of the model boxes will be at the ecological threshold. However, at current levels, where not all sites are active, there is not a significant impact upon wild species.

Regular assessment of stocking levels and the spatial extent of dredging activities will allow seabed aquaculture to maximise yield while minimising, and constraining, impacts to the wider ecosystem.

References

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