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The effect of shellfish, kelp and seagrass beds on flood risk and coastal erosion in Scotland

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Aim of the Project

The project aimed to evaluate how well selected shallow marine habitats (specifically kelp forests, seagrass beds, oyster reefs and blue mussel beds) protect the Scottish coastline from erosion and flooding. Consequently, a secondary aim was to assess the need and feasibility for protection and/or restoration of these habitats in relation to their potential role in Natural Flood Management (NFM) and erosion control. The following research tasks were undertaken:

1. Gathering and standardising available information on the location and extent around Scotland's coast of the 4 habitats.
2. Predicting the reduction of waves and wave run-up by the 4 habitats using recently developed computer simulations.
3. Applying these predictions to specific Scottish locations to assess the degree of flood and erosion control by these habitats.
4. Acquiring information from stakeholders through a workshop to inform the project direction.
5. Assessing the effects of harvesting on the 4 habitats.
6. Assessing the potential for coastal protection through restoration of the 4 habitats.

Background

Coastal flooding and erosion are increasing problems around the Scottish coastline resulting from climatic changes such as increased storm frequency and intensity, as well as rising sea levels. These pose risks to human life, infrastructure and properties, with negative consequences for the national economy. Besides ecosystem services such as habitat for threatened and commercial species, fisheries production, nutrient cycling, sediment stabilisation, water purification and carbon storage, marine vegetation canopies and shellfish habitats can dampen waves and currents, with the possibility of reducing risk of coastal flooding and erosion. However, there is a lack of consolidated information relating to the distribution and extent of such habitats at a national scale. In addition, evaluation of the potential for NFM by these habitats in a Scottish context has not been done. The present project set out to address these knowledge gaps by focusing on 4 key habitats: kelp forests; seagrass beds; oyster reefs; and blue mussel beds.

Key Findings

Importance of habitats for coastal protection

Our computer simulations demonstrate that all of these habitats dampen waves. Kelp beds were the most effective, followed by seagrass beds and, lastly, shellfish beds. Hence, vegetated habitats are more important for NFM than shellfish habitats. Model sensitivity

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analysis suggests that key factors influencing wave damping and therefore wave runup and wave setup induced flooding are habitat extent and density, blade width, height, water depth, morphology and flexibility of species.

Case studies locations

The computer simulations for kelp forests (the most effective wave-damping habitat) were applied to two areas (Sanday in Orkney and the Uists in the Outer Hebrides) selected because of their high exposure to large waves and low-lying land at risk of coastal flooding. Our model simulations predicted potential wave damping by kelp of up to 25% in Sanday in Orkney and up to 70% in the Uists in wave height, emphasising the importance of kelp for coastal protection under some storm conditions.

Habitat distribution and extent

We collated data from numerous sources to develop habitat distribution maps of each marine habitat from the whole of the Scottish coast. Kelp beds have a wide-spread distribution in sheltered and exposed areas, seagrass is found in sheltered areas largely on the west coast and the northern Isles. Data suggests the occurrence of blue mussel and oyster beds is sparse. All habitats had more records on the west coast and the islands than on the east.

Habitat restoration and harvesting

Habitat restoration of oyster reefs or seagrass beds may enhance coastal protection by stabilising sediment, for example, but needs careful planning and integration into policy, especially since suitable restoration sites are often relatively sheltered, implying less influence on NFM through waves and wave run-up than storm surge. Restoration is also not always successful or predictable. It is therefore important to protect existing habitat to maintain NFM function. Restoration of kelp, which can occur in more wave-exposed locations, has not yet been developed. Historically, harvesting occurred of all 4 of these habitats, especially shellfish, evidenced by the virtual disappearance of oysters from Scottish waters. Any future harvesting (most likely relating to kelp) must be carefully planned, regulated and controlled to avoid habitat degradation, particularly where habitat wave-damping potential is greatest.

Constraints and Opportunities

Information on seasonal and year-to-year variation in organism density, size and growth was lacking. Further collection of data on these variables at different seasons and years, together with in situ wave height reduction, would improve simulation of wave-damping effects and enable effective planning which accounts for seasonal and annual variation and climate change effects. Simulation of successive storms, taking account of habitat damage after each event should also be investigated.

Recommendations

- **Habitat Protection and Restoration**
  Prioritise protection of key habitats around Potentially Vulnerable Areas (PVAs) in relation to flooding/erosion. Habitat protection and restoration need to be integrated into coastal planning processes. Increased mapping effort is vital to facilitate these recommendations.
- **Data Collection and Research**
  Update, extend and centralise distribution maps of key habitats to underpin knowledge of where these are important for coastal protection. Streamline processes for making data rapidly accessible from a single source. Investigate and monitor regrowth rates of species in key habitats. Further refine the computer simulations for interactions between waves, currents, tide-surges and vegetation.
- **Sustainable Harvesting Practices**
  Develop the knowledge to underpin guidelines for sustainable harvesting of key habitats to enable balancing of ecological, commercial interests and coastal protection.
- **Policy Integration**
  Incorporate Nature-based Solutions into coastal defence strategies through better cross-sector collaboration and commitment to long-term (decadal) funding.
- **Public Engagement and Awareness**
  Increase awareness amongst stakeholders and the public of the ecosystem services (e.g. NFM) provided by these habitats. Promotion of local community involvement through citizen science could have the added benefit of improvements in availability of habitat distribution data.