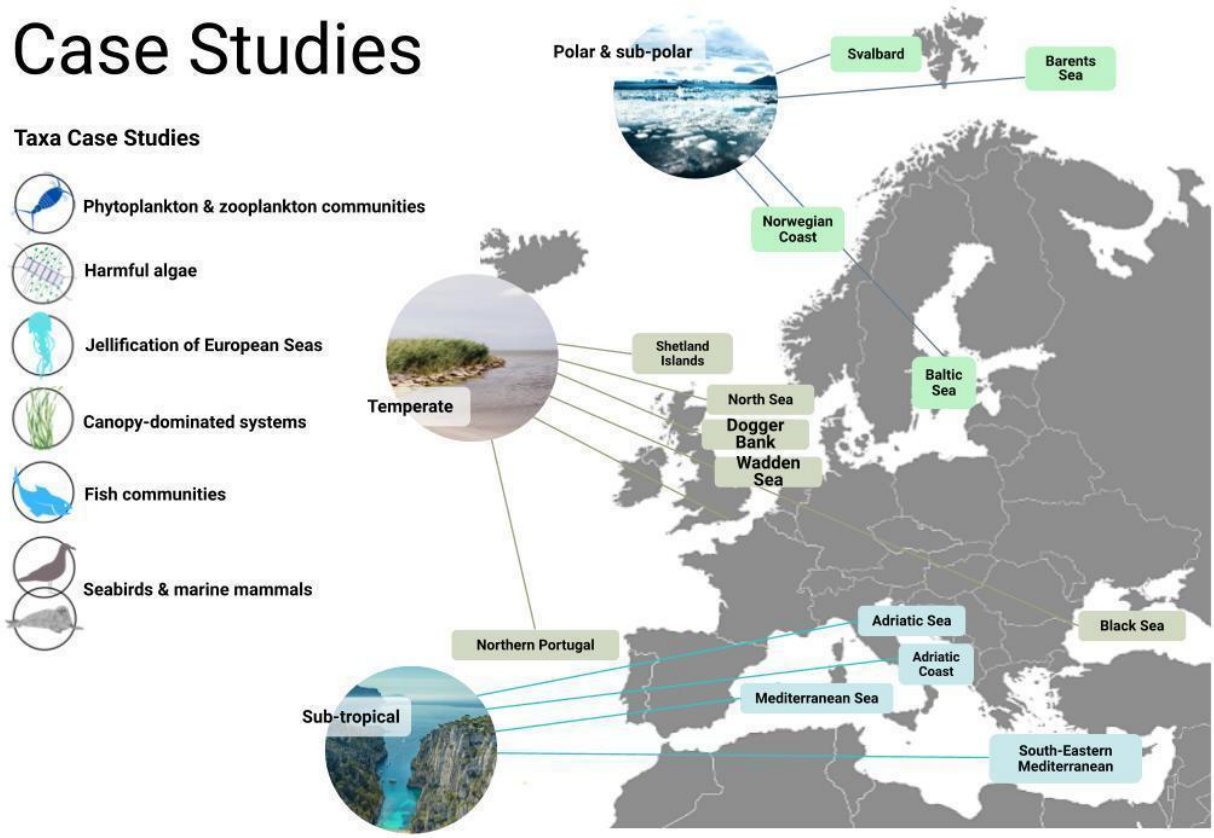
Case Study 4
Temperate

Shetland Islands Food Web



ACTNOW

ACTNOW is an EU-funded research project aimed at understanding the cumulative impacts on European marine biodiversity, ecosystem functions, and services for human wellbeing. The project equips regulators and decision-makers with essential knowledge and tools to combat biodiversity loss in coastal and marine habitats threatened by climate change and other regional drivers.

Conducted across various Case Study Regions in Europe, ACTNOW focuses on delivering scientific support for adaptation and mitigation measures, sustainable blue economy expansion, and contributions to the UNFCCC.

The project is structured into six Workpackages: WP1 (Data, Indicators and Scenarios), WP2 (Marine Organisms under Multiple Drivers), WP3 (Community, Food-Web and Ecosystem), WP4 (Cumulative Risks & Biodiversity Assessments), WP5 (Synthesis, Impacts & Solutions Options), and WP6 (Communication and Dialogue).

Objectives include developing 'what if' scenarios, understanding combined impacts on ecosystems, employing advanced biologging and molecular methods, and enhancing awareness of the links between marine biodiversity and human health.

ACTNOW has 17 CSs, 11 are regional CSs while 6 are pan-European (group / taxon) CSs. All are designed to deliver a cause-and-effect understanding, build predictive capacity in models, and to develop indicators and tools for decision-makers charged with the stewardship of European marine biodiversity under threats from multiple drivers (stressors in call) (see fig below). In each case, drivers examined represent the local/regional priorities from regulators who co-create what-if scenarios of interacting drivers including envisioned management actions.

1. Case Study 4: Shetland Islands Food Web

Leader

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Contributors

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Description

Shetland is an area of intense and increasing resource acquisition. As well as being key area of oil and gas development, there are active and planned marine renewable installations (Figure CS4-1). Other anthropogenic activities are many and varied (e.g. oil & gas exploitation, hydrogen generation, tidal energy, carbon capture and storage). All Temperate region CSs apply big data statistical approaches to identify patterns and trends of marine communities (benthos, plankton, fish, seabirds and marine mammals) and associated stressors to identify thresholds above which significant biodiversity impacts are exerted. Changing patterns of species distribution in the past and future are modelled using biogeochemical hindcasts and forecasts with scenarios on human pressures. ECOSPACE will be used in a mechanistic and empirical study across systems (rivers to open ocean) and spatial scales to explore how external subsidies (nutrients, detritus, migrating prey species) and contaminants affect ecosystem structure and function.

Benthic analysis: this research work has been carried out with the cooperation of the Shetland oil terminal environmental advisory group with further analysis of their data by the university of St Andrews. On Shetland, data on seabird populations intertidal rocky shore assemblages and marine benthic grab samples have been collected since the 1970s. There has been a considerable task, completed by the SOTEAG organisation (https://soteag.org.uk/), in collecting all of this information and making it available through internationally recognised databanks such as MEDIN. The first meta-analysis of this data concentrates on the benthic assemblages but further work is planned on seabird and rocky shore communities. ActNow (DMP) contribution to this work has resulted in a soon to be issued publication in Global Change Biology correlating sea surface temperature with the diversity and functionality of benthic assemblages. This publication is still under embargo but will be released shortly.

Predators and Prey: Shetland hosts ~ 10% of Britain and Ireland's seabirds and harbour seals. Despite a drop in harbour seal abundance by ~40% in the early 2000s (Thompson et al. 2019), the island still holds around a fifth of the Scotland harbour seal metapopulation. The reasons for the decline in harbour seal numbers are unknown. Trends differ regionally within Shetland and between the two Special Areas of Conservation (SACs) designated for harbour seals (Figure CS4-2) (Russell et al. 2022). Understanding the drivers of these differing trajectories is essential in predicting the impact of continued and increasing resource acquisition in Shetland. Harbour seals can be impacted by marine renewable development (Hastie et al. 2015, Russell et al. 2016) and operation (Onoufriou et al. 2021). An additional stressor and key potential driver of population trends is reduced prey quantity or quality. Prey may be impacted by both top-down processes such as fishing and predation, and bottom-up processes through impact of climate change near the bottom of the food web, and both aspects are vulnerable to anthropogenic impacts. Shetland suffered a catastrophic decline in sandeel abundance (a key seabird and marine mammal prey) in the late 1990s, with the current stock status unknown (Figure CS4-4).

In this case-study we plan to take advantage of data collection conducted by SMRU and collaborators University of Highlands and Islands in Shetland (SUHI). SMRU will contribute seal count data, a detailed historic diet data set (Wilson and Hammond 2019) and will carry out metabarcoding of recent faecal samples collected as part of a telemetry tracking study (Carter et al. In Press). As part of a collaboration with SUHI, the first sandeel trawls in over 20 years were conducted in Southeast Shetland (2023 and 2024). Specifically, we will examine spatio-temporal trends in seal diet and sandeel survey data, and variation in sandeel quality (energy value). We will investigate the degree to which the sandeel stock (Southeast Shetland) has recovered since the crash in the late 1990s; and the implications of changes in sandeel abundance and energetic content for predator populations.

Services

Ecosystem services provided by the marine environment around the Shetland Islands are recognised as essential to the economy of the maritime island society, including

· Regulating: carbon sequestration

· Provisioning: coastal fisheries, sea food and relevant products from aquaculture

· Cultural: coastal and marine tourism (hiking, birdwatching, pleasure boating), culture heritage, sense of place, aesthetic values, educational values

. Increasing renewables development

. Supporting biodiversity including the conservation of protected marine mammal and bird species, fuelling adjacent North Sea habitats, and offering connectivity between marine and freshwater habitats.

Interacting Drivers of Biodiversity Change

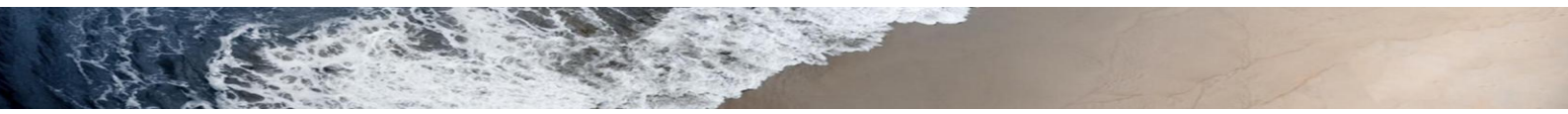
The interacting drivers of biodiversity change are considered to be dominated by climate change but include aspects of marine management including fisheries and agriculture. Additionally, shipping, tourism, construction and the direct and indirect impacts on visitor numbers from large cruising vessels are an emerging topic. New licences for oil exploration, the further development of onshore and offshore wind and the changing patterns of marine transport are all issues of interest.

Regional Context

The regional context in terms of the Shetland Islands cannot be overestimated. The area has historically supported large populations of sandeels and dependent predators such as seabirds, and encompasses one of only 3 sandeel MPAs currently in Scotland. The geographic location, the dependence on the marine environment and the strong identity of the Shetland Islands in its history, culture and people must be recognised.. An excellent example is that the development of the oil industry, including formally one of the largest oil terminals in Europe, (Sullom Voe) was locally hard fought and greatly influenced by the then “Zetland Islands council” who argue successfully for control over the Shetland waters and for a very progressive programme of environmental monitoring in order to accept the oil development. This led to the development of the SOTEAG organisation and the longitudinal studies that have created and curated the datasets which help to support this case study.

Research Needs

- Understanding and predicting the impacts of climate change
- Providing baseline analysis of community change
- Understanding the spatio-temporal trends in sandeels, a key prey species of seals and seabirds. In particular, its recovery (if any) since the collapse in the late 1990s.
- Impact of environmental change on biodiversity of apex predators, including changing availability of their key prey species
- Assessing the dangers of future multiple stressors including pollutants, chemicals and plastics on the ecosystem services provided.



Research Planned in ACTNOW

● T1.1 Curation of benthic data for functional analysis (completed by PA)

●T1.2 Analysis of this data to assess impact of sea surface temperature (competed, Armitage 2024 in press)

● T2.1 Collation of rocky shore data (RS)

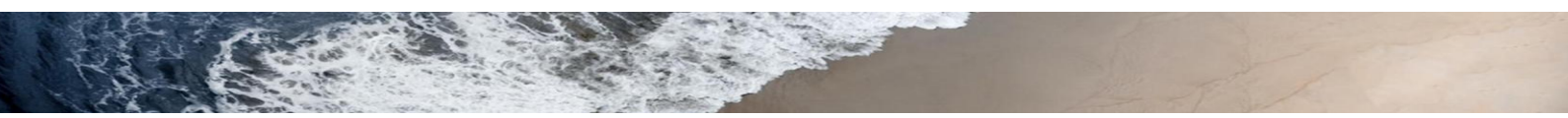
● T2.2 Analysis of the RS data to assess impact of sea surface temperature

● T2.3 Estimation of prey diet from faecal samples of harbour and grey seals (2021) using metabarcoding

● T.2.4 Estimation of the calorific value of sandeels in Shetland, by size and species

● T2.5 Collation and analysis of recent and historic sandeel trawl survey data (1990s, 2022-2023): spatiotemporal variation and environmental drivers

● T2.6 Analyses of the fine-scale spatio-temporal trends of harbour seal diet in Shetland, in the context of changes in sandeel availability and differing regional trends in seal populations (stable and declining)



Pictures, graphs and maps

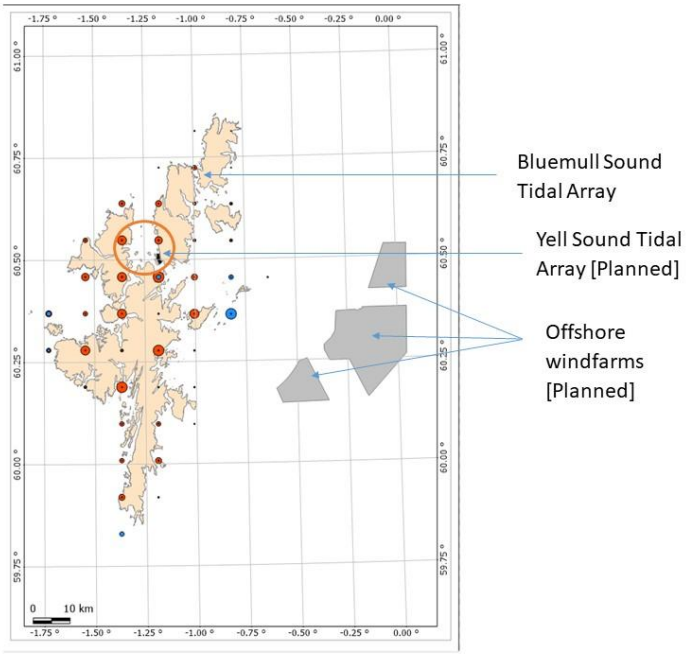


Figure CS4-1: Map of Shetland showing the harbour seal SACs (orange is Yell Sound SAC and black is Mousa SAC). Area of marine renewable energy development are also shown.

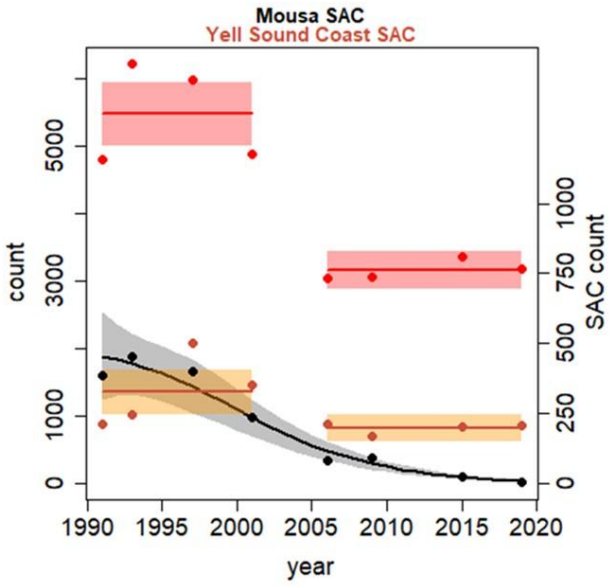


Figure CS4-2 Trends in harbour seal August moult counts in Shetland (red) and in the two Special Areas of Conservation (SACs) designated for harbour seals within the Shetland Isles: Mousa (black curve) and Yell Sound (red curve). 95% confidence intervals are shown with shading.

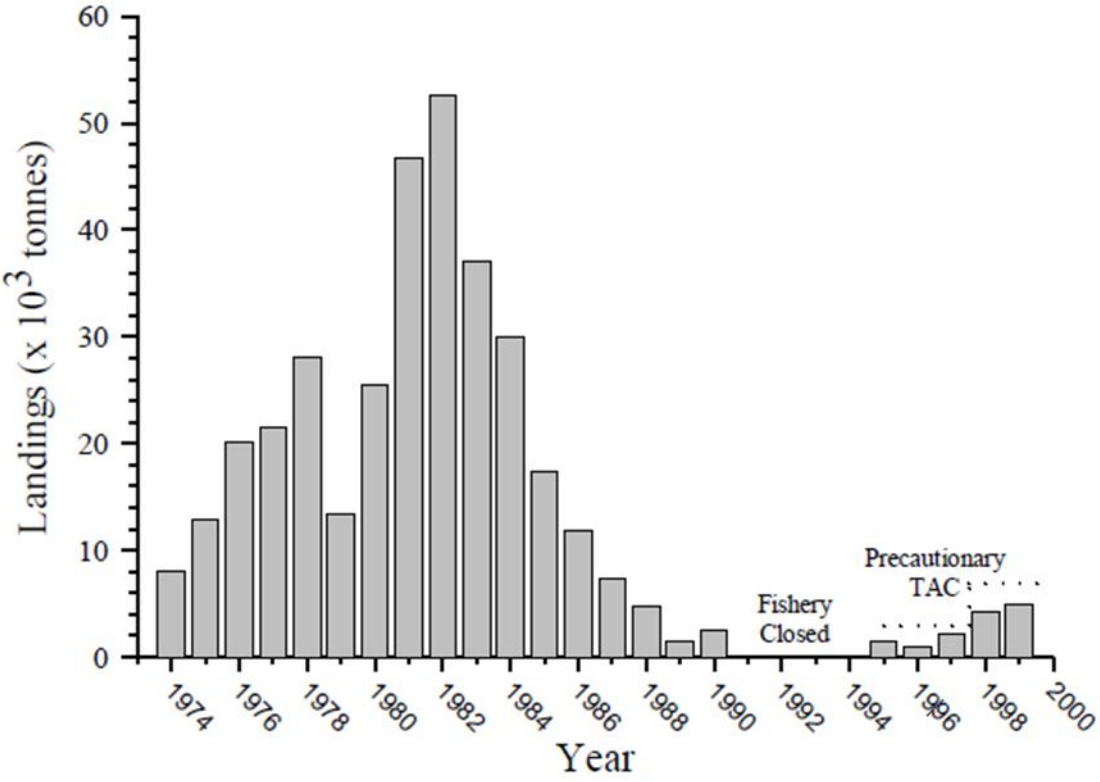


Fig CS4-3 Commerical sandeel catches in Shetland waters. From NAFC [now SUHI] & FRS Marine Laboratory (2020).

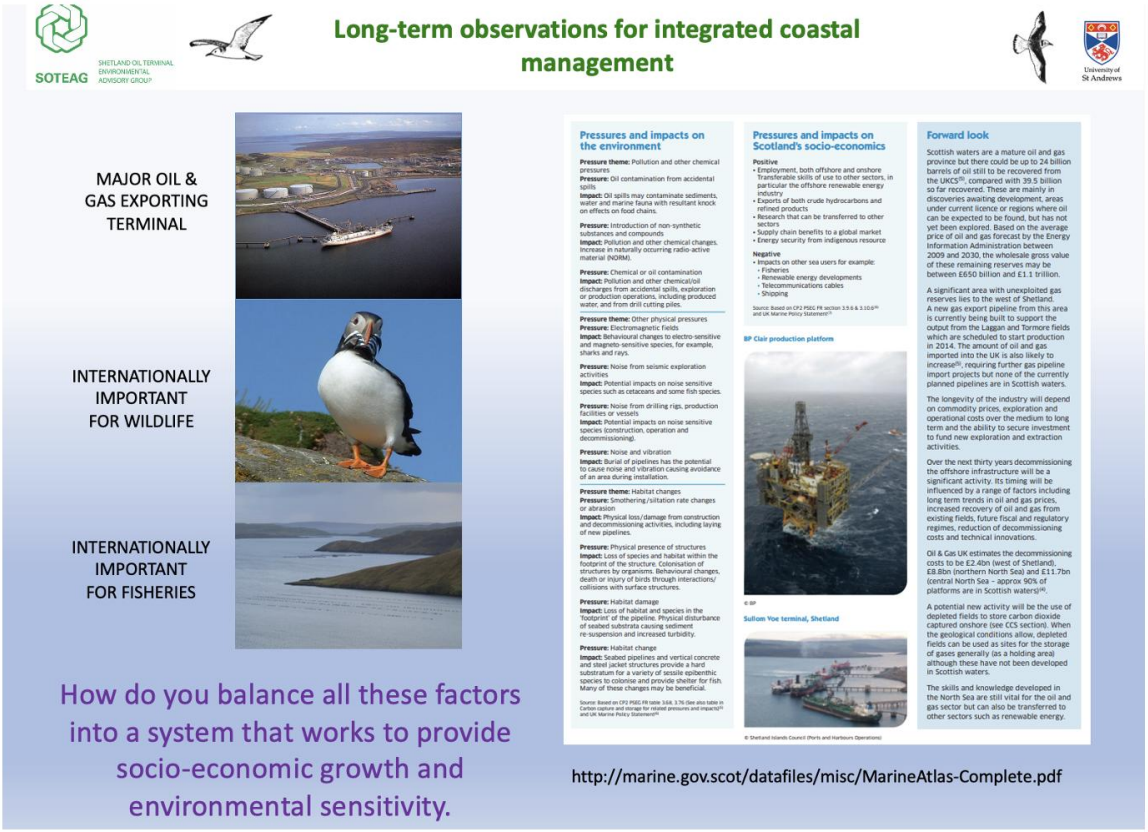


Figure CS3-4 SEOTAG project: Environmental monitoring to support ecosystem-based coastal management in Shetland

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