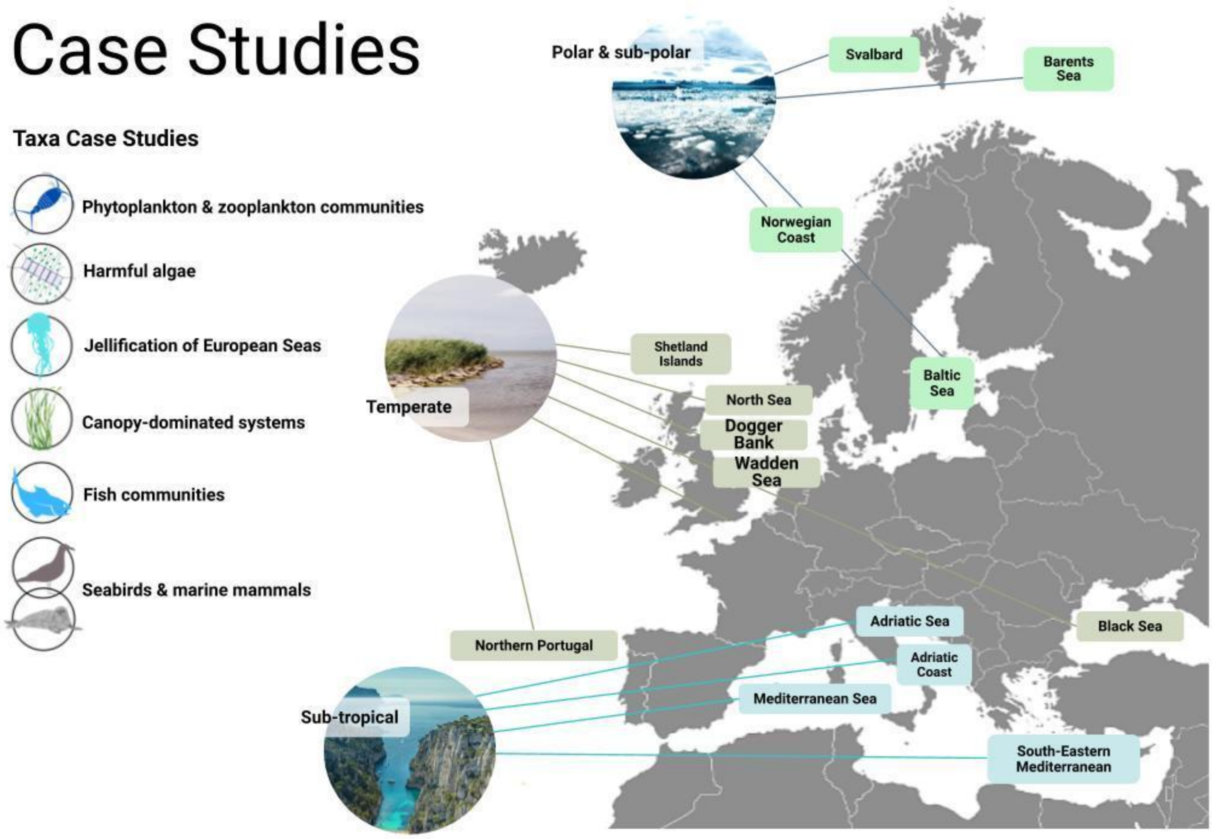
Case Study 2
Polar & Sub-Polar

Norwegian Macroalgal Systems



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 3: Norwegian Macroalgal Systems

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Description

Sub-polar and polar regions – 4 CSs. A CS in Svalbard (CS1), the Barents Sea (CS2) and the Norwegian coast (CS3) cover a region spanning a gradient from 65oN to 80oN that supports some of the world's largest fisheries. CS3 investigates multi-driver impacts on coastal ecosystems that are founded on kelp forests along coastal Norway

Services

Service provided by Norwegian clue forest ecosystems include:

· Regulating: carbon sequestration

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

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

· Supporting: biodiversity, fuelling adjacent Norwegian shelf habitats, and offering connectivity between marine and freshwater habitats.

The information in this document should help inform key stakeholders such as national and regional managers, Norwegian Environment Agency, Fisheries directorate making decisions on ecosystem management,, kelp and urchin harvesting companies, aquaculture and mariculture companies,

Interacting Drivers of Biodiversity Change

Norwegian kelp forests are vital marine ecosystems that provide numerous ecological and economic benefits. These underwater forests, composed of species like *Laminaria hyperborea*, are crucial for maintaining biodiversity, serving as habitats and nurseries for various marine species, including commercially important fish and invertebrates. Additionally, they play a significant role in carbon sequestration, helping mitigate climate change by absorbing CO_2 from the atmosphere. Kelp forests also protect coastlines by dampening wave energy, thereby reducing threats to infrastructure and coastlines.

However, Norwegian kelp forests face significant challenges from multiple stressors. Climate change is one of the most pressing threats, causing ocean warming and acidification, coastal freshening and darkening which can weaken kelp systems and resilience. Increased sea temperatures can also lead to the proliferation of invasive species and pathogens that outcompete or damage native kelp. Pollution, particularly from agricultural runoff and industrial activities, introduces excessive nutrients and harmful chemicals into the water, further stressing these ecosystems. Overfishing disrupts the balance of marine ecosystems, affecting species that are integral to kelp forest health. Additionally, coastal development, harvesting and human activities may contribute to habitat destruction.

Addressing these challenges requires a comprehensive approach, including sustainable fisheries management, and the protection of kelp habitats through marine conservation initiatives.

Regional Context

Kelp harvesting in Norway has a long history, dating back to at least the 17th century. Traditionally, kelp was collected and burned to produce potash, which was used in glass and soap production. By the 19th century, kelp became a crucial source of alginates, substances extracted from the kelp's cell walls used in various industries, including food, pharmaceuticals, and textiles. The Norwegian kelp industry peaked during World War II when kelp was extensively harvested for iodine and alginates.
In modern times, kelp harvesting in Norway is a regulated industry that balances economic interests with environmental sustainability. The primary species harvested is *Laminaria hyperborea*, valued for its alginates. The industry operates under strict management guidelines to ensure sustainable practices. Harvesting is regulated by quotas, which are determined based on scientific assessments of kelp biomass and ecosystem health. Only specific areas are permitted for harvesting, with rotations allowing kelp beds time to regenerate.
Management practices also include monitoring of kelp forest health and the effects of harvesting on marine biodiversity. Recent developments in the industry focus on minimizing environmental impact, including the use of more selective harvesting techniques and research into the potential impacts of climate change on kelp forests. Norway's approach serves as a model for sustainable marine resource management.

Research Planned in ACTNOW

● T1.1 We will develop a series of scenarios to reflect present and anticipated challenges to kelp assemblages and associated ecosystems. These will be targeted at activities and stressors that may impact coastal kelp ecosystems and also key species that play an important role in success and functioning.

● T1.2 Indicators used by the Norwegian Environment Agency, Fisheries Department and other national to local regulators will be evaluated for relevance to kelp ecosystems. Additional stressors, where appropriate, will be identified.

● T1.3 We will combine data sets present ranges and combinations of climate and local stressors of topical and anticipated relevance to Norwegian kelp systems. These will be gained from existing and on-going historical and future coastal model projections, state and trends from national water framework directive reporting, expert advice from practitioners, managers and regulators.

● T2.1. Canopy thinning experiments will be performed in a kelp forest in mid-Norway to identify thresholds and identify early warning signals for regime shifts from kelp to turf-dominated systems. Kelp forests at the edge of areas colonised by algal turfs will be selected.

● T2.3 We will first evaluate the effects of heatwaves on macroalgae species using intertidal chambers. The intertidal chambers allow for precise control of water temperature, tide, and ligh to simulate heatwaves lasting 3-4 days. The key parameters to be measured include photosynthetic activity, water pH, nutrient levels, oxygen levels, and the organic carbon to nitrogen (C:N) ratio. The first experiment is planned to be conducted during August & September 2024 on *F. vesiculosus, A. nodossum* and *Saccharina latissima*. Further experiments will evaluate the characteristics of heatwaves including cumulative intensity, repetition, and recovery period and include other kelp species. Multiple stressor experiments including temperature-PAR, temperature-nutrients, temperature-salinity will be undertaken.

Figure X Intertidal chambers with kelp undergoing warming experiments

● T2.4 We will investigate response and effect traits under single and multiple drivers from T2.1 experiments and existing literature data

● T3.3 We will build an Ecosim model focused on the kelp forest community for a northern Norwegian fjord including climate responses for key species groups.

● T6.1 We will co-develop and organise a series of stakeholder activities. The first will be held in northern norway in late 2024 with regulatory, industrial, NGO and academic institutions under the umbrella of the Norwegian Blue Forest Network.

● T6.4 Strong collaboration with this study is anticipated with EU Horizon and Mission projects with common study challenges. Interactions and co-working has already started with OBAMA-NEXT, G4SEAS, C-BLUES,, A-AAGORA. INVEST4NATURE, BLUEMISSIONAA and national projects including the FRAM projects CLEAN and C2C.

Pictures, graphs and maps

Images from the canopy-thinning experiment at Vega, June 2024.