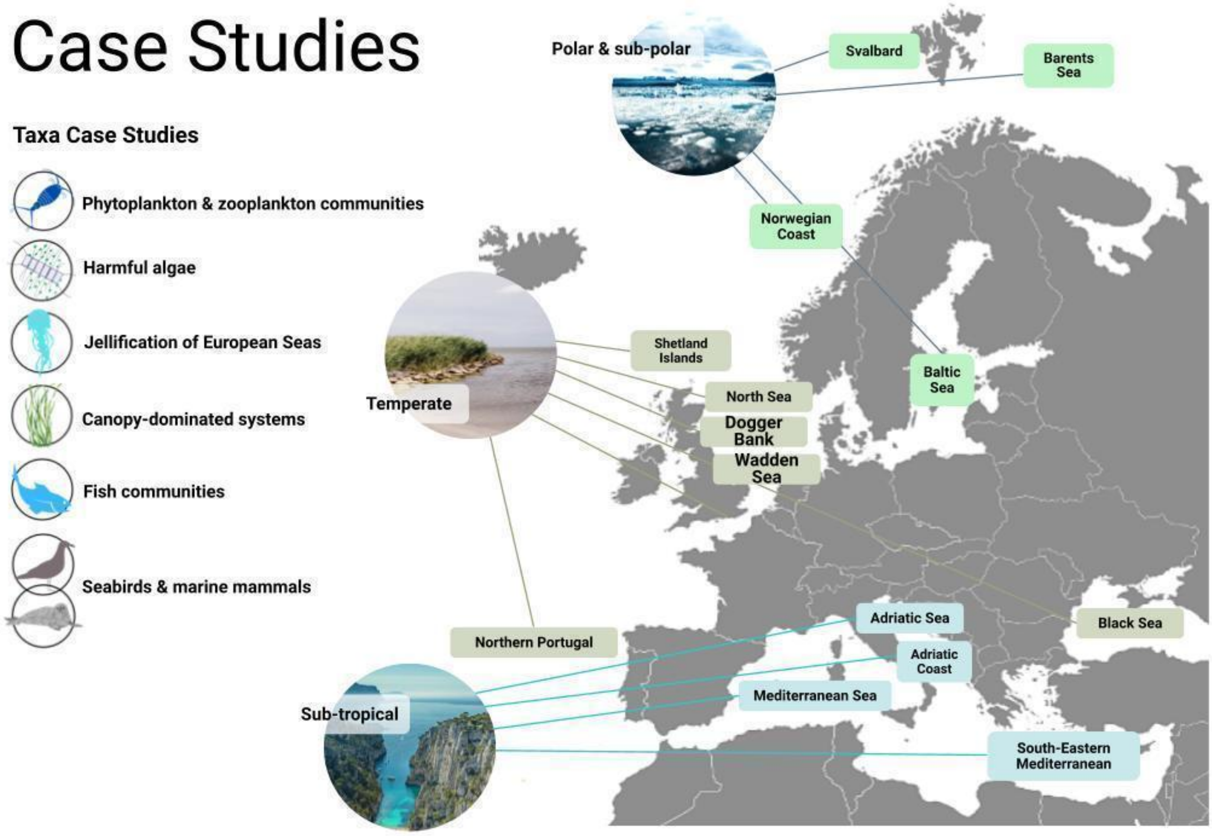
Case Study 15
Taxa

Canopy-dominated 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 15: Canopy-dominated Systems

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Description

This case study within ACTNOW addresses the issues of stability, resilience and thresholds articulated in the call through field experiments and the validation of early warning indicators of regime shifts in macroalgal forests and seagrasses. It is directly linked to the activities and objectives addressed in WP 3.1. Macroalgal forests and seagrasses are the most common macroscopic form of life flourishing in marine environments along the world's temperate coasts. These canopy-dominated systems provide three-dimensional habitat to many species, maintaining biodiversity and contributing important functions and services, including high primary production, provision of nursery areas, human food resources and protection from coastal erosion. Macroalgal forests and seagrasses are vulnerable to global threats such as ocean warming and to regional stressors resulting from intensifying human activities along the coast, including habitat degradation, pollution, eutrophication, and spread of invasive species. The compounded effects of global and regional stressors are eroding the resilience of these systems, making regime shifts and population collapses more likely. Regime shifts such as the replacement of canopy-dominated ecosystems by less productive, low-diversity assemblages of turf-forming algae and barren habitat are increasingly observed in many areas around the world. Developing tools and indicators to anticipate these undesired transitions will be key for the sustainable use of these iconic marine coastal ecosystems.

Services

Services provided by macroalgal dominated ecosystems include:

- Supporting biodiversity through the provision of habitats and providing connectivity between intertidal and subtidal habitats.
    - Including nursery habitats

  - o Include how it does these? I.e, Abiotic amelioration, predation protection etc?

- Cultural: coastal and marine tourism (hiking, birdwatching, pleasure boating), culture heritage, sense of place, aesthetic values, educational values
- Provisioning: coastal fisheries, sea food and relevant products from aquaculture
- Regulating: coastal protection and Carbon sequestration

Regional Context

The information obtained from this work should help inform key stakeholder authorities within Europe in taking decisions on ecosystem management. This includes the European wide, national and regional Environmental Authorities, Managers of Marine Protected Areas, Conservation groups and the Global Ocean Observing System (GOOS), NGOs, Local and regional tourist operators. For example within the Tuscan Archipelago DA the Tuscan archipelago national park authority (TANPA).

Research Needs

A previous study has shown how the RL can be successfully quantified to anticipate a regime shift in rocky intertidal macroalgal forests (Rindi et al. 2017). Here, we probe the generality of the RL together with more classical spatial indicators through a distributed experiment along a latitudinal gradient, using subtidal canopy-dominated macroalgal forests and seagrasses as model systems. Probing the RL and the other spatial indicators experimentally over broad spatial scales is the first step towards the implementation of a simple, cost-effective and manipulation-free early warning system in marine coastal environments.

Research Planned in ACTNOW

Simple canopy thinning experiments are implemented in macroalgal forests and seagrasses (Figs. 1 and 2) to identify thresholds in these systems and to probe recovery length and generic spatial indicators of loss of resilience at the pan-European scale. Canopy thinning manipulations reproduce the effects of multiple stressors impinging on these systems, including pollution, eutrophication, sedimentation and overgrazing. Spatial indicators are appealing for both researchers and managers since they do not rely on lengthy timeseries and can readily inform on degrading environmental conditions. In addition to the classical spatial indicators of an approaching regime shift (e.g., spatial variance, autocorrelation and skewness), the Recovery Length (RL) has been proposed as the spatial analogue of recovery time, a direct measure of loss of resilience (Day et al. 2013). The RL is the distance necessary for connected populations to recover from a spatial perturbation (Fig.3). For example, if one region of a macroalgal forest or seagrass meadow suffers from increased pressure from an invading competitor (e.g., algal turfs) spreading from a low-quality patch, then neighbouring patches may also become invaded, but far away from invader's original patch there will be no effect (Fig. 3). The recovery length then quantifies the distance that one must go from the point in space where invasion starts (the low-quality patch) to the point where invasion ceases. The expectation is that the RL should grow (algal turfs penetrate more into canopy-dominated habitats) as the environment deteriorates.

Current/completed experimental setup:

Institution	Experimental set-up	Habitat	Lon	Lat
UNIPI	2023	Macroalgal forests	11.110800	42.262932
IBER-BAS	2023	Macroalgal forests	27.696700	42.427100
CIIMAR	Jan 2024	Macroalgal forests	-8.872471	41.729244
UNINA	2023	Macroalgal forests	14.944153	40.285288
USTAN	2023	Macroalgal forests	TBC	TBC

Potential new experimental sites/ repetitions:

Institution	Experimental set-up	Habitat	Lon	Lat
UNIPI	2024	Macroalgal forests	11.110800	42.262932
HCMR	2024	Posidonia meadows	23.901451	37.731506
HCMR	2024	Macroalgal forests	24.386888	37.605099
IOLR	2024	Macroalgal forests	-8.872471	41.729244
NIVA	2024	Macroalgal forests	TBC	TBC
CONSIMA	2024	Macroalgal forests	13.289824	38.212459

Pictures, graphs and maps

Figure 1 Locations where canopy thinning experiments will be performed and spatial early warning indicators tested.

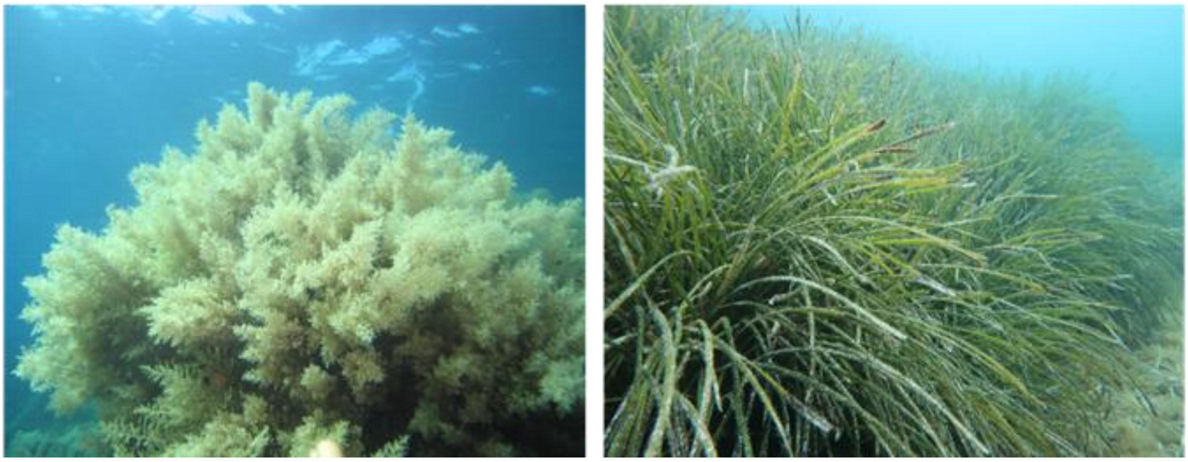

Figure 2 Macroalgal forests (a) and seagrasses (b) are iconic along the world's temperate coasts (Photo by L. Benedetti-Cecchi).

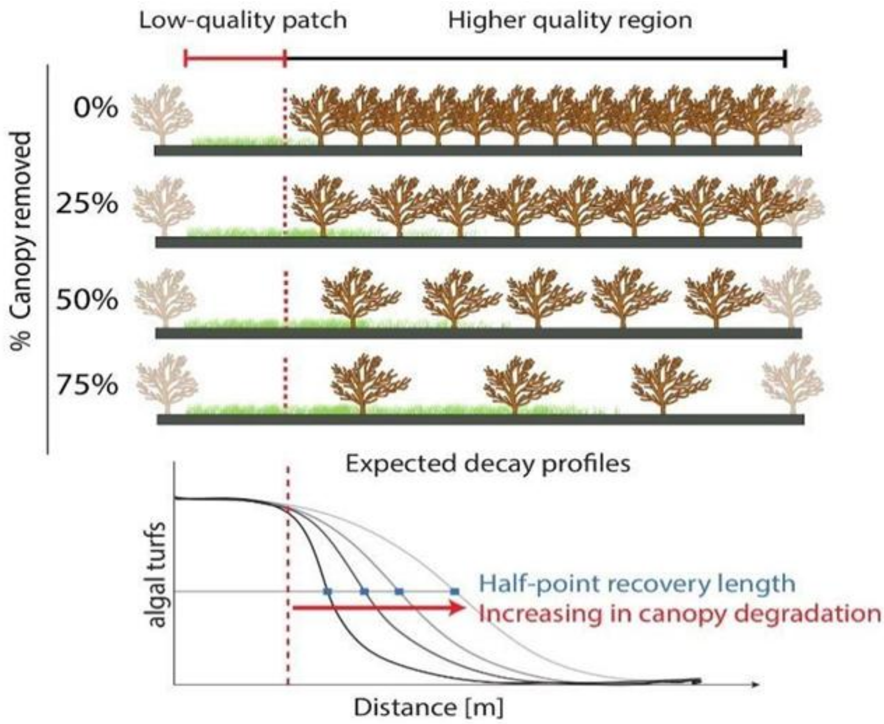

Figure 3 Diagram of a canopy thinning experiment and computation of the half-point recovery length indicator. The half-point recovery length is the distance at which a spatial perturbation (e.g., the spread of a competitor) declines to 50% of its abundance in the low-quality patch.

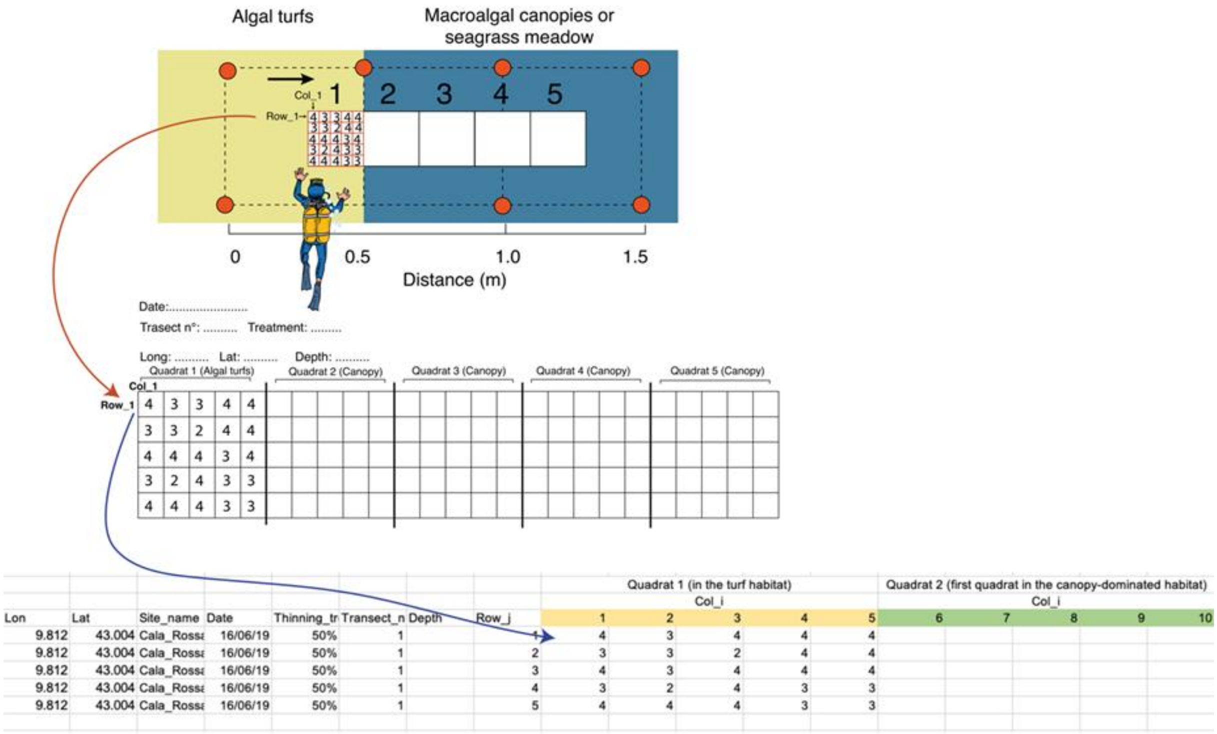

Figure 4 Scheme indicating the sampling protocol for the experiment

References

Dai, L., Korolev, K. S. & Gore, J. Slower recovery in space before collapse of connected populations. Nature 496, 355-358, doi:10.1038/nature12071 (2013).

Rindi, L., Dal Bello, M., Dai, L., Gore, F., Benedetti-Cecchi, L. 2017. Direct observation of increasing recovery length before collapse of a marine benthic ecosystem. Nature Ecology and Evolution. doi:10.1038/s41559-017-0153.