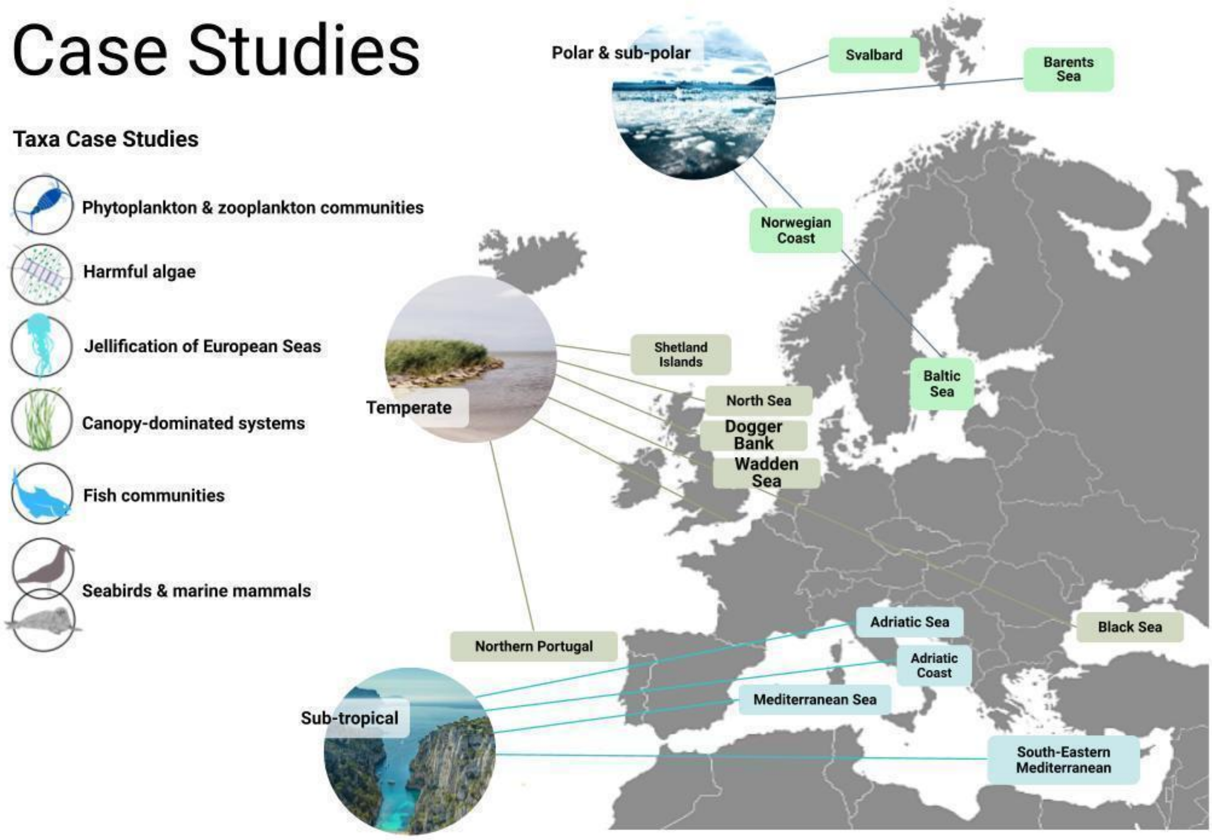
Case Study 14
Taxa

Jellification of European Seas



• 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.

- **Case Study 14: Jellification of European Seas**

Leader

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Description

Jellyfish are top consumers in pelagic ecosystems, competing with other high trophic level species including commercially important fish. An increasing number of invasive and outbreak-forming jellyfish species are highlighted as major concerns for marine biodiversity and ecosystem services. ACTNOW examines physiological responses of jellyfish to CC-related stressors and develops ecosystem-based operational and modelling approaches to understand ecological, biodiversity and socio-economic consequences of jellyfish blooms, and to identify surveillance and mitigation measures.

Services

Jellyfish provide severals services:

- **Supporting biodiversity**: 1) as food source for various top predators and threatened species (sea turtles, birds, fishes), 2) biological regulators of invasive species, and 3) as shelter and trophic resources to juvenile fish, thereby improving their survival rates.
- **Regulating**: 1) Jelly-falls have a significant capacity to fuel carbon sequestration, highlighting a crucial role amidst the ongoing climate crisis. 2) In quite exceptional cases, jellyfish can maintain water quality and prevent dystrophic crises through a top-down control process.
- **Provisioning**: 1) Human consumption. 2) Used as organic fertilizers, insecticides, animal feed for terrestrial or aquaculture farming, or bait for fishermen. 3) Biomaterial for medical applications and research. 4) Potential alternative for replacing fossil-based plastics. 5) Jellyfish mucus might be used as bio-flocculation material for trapping and sequestering plastic micro- and nanoparticles from contaminated waters of factories where microplastic is produced.
- **Cultural:** Aquarium trade.

Interacting Drivers of Biodiversity Change

Jellyfish blooms seem to be driven by multiple factors. Yet, the existing evidence relating jellyfish success with these stressors is scarce, and most is limited to few species and locations. The wide variability of species-specific responses to such impacts is yet to be determined, and multi-stressor analyses on broad time-space scales are inexistent. The key pressures include:

1. Warming: Rising temperatures alter the physical and chemical conditions of the Mediterranean Sea, accelerating growth and reproduction rates of jellyfish, finally impacting species distribution and ecosystem functions.
2. Overfishing: Operates removing jellyfish competitors and predators.
3. Eutrophication: Excessive nutrient input increases food supply and hypoxia in the marine environment, conditions for which jellyfish are more competitive than other metazoans.
4. Ocean sprawl: Coastal development leads to an increase of substrates available for the settlement of the benthic stages, which has been pointed as beneficial for jellyfish populations.
5. Invasions: The changing environment has also provided favourable conditions for non-indigenous jellyfish.

Regional Context

The Mediterranean Sea is one of the largest oligotrophic seas in the world. It is a temperate semi-enclosed ecosystem located between 30-45°N, connected to the Atlantic Ocean by the Strait of Gibraltar, to the Black Sea by the Sea of Marmara and to the Red Sea *via* the artificial Suez Canal. The Mediterranean basin is considered as a biodiversity hotspot in terms of the number of species per area, where a large number of endemic and migratory marine species coexist. Unfortunately, due to the intense maritime traffic and the rise of sea temperature, numerous species are settling in this area and are affecting the ecosystem functioning. So far, ca. 1000 alien species have been introduced in the Mediterranean Sea, including jellyfish species. The Mediterranean Sea accounts for a wide diversity of jellyfish species, with 22 species of scyphozoan described. Problems associated with jellyfish therein have been related to the common native species, including *Aurelia* spp., *Cotylorhiza tuberculata* and *Rhizostoma pulmo*, among others, but also with invasive *Rhopilema nomadica*. As tourism and fisheries are among the most important economies for Mediterranean countries, these blooms have produced important economic losses in local coastal communities. Due to the wide variability of species-specific responses, eco-physiological lab experiments and *in situ* monitoring of natural populations are key research directions to provide accurate parameters to be implemented in predictive models for future expected scenarios in the Mediterranean Sea.

The Baltic Sea is a semi enclosed marginal sea that is subject to a high degree of human and climate induced perturbations. Most characteristic for the Baltic Sea is the extended salinity gradient ranging from nearly freshwater conditions in the North-East to marine conditions at the transition to the North Sea in the West. The Baltic Sea used to harbour an important local fishery, that has lately suffered considerably. The Baltic Sea hosts a large population of the moon jellyfish *Aurelia aurita*, as well as the non-indigenous comb jelly *Mnemiopsis leidyi*. The latter species is especially problematic in higher saline areas of the SW Baltic Sea (as reviewed in Jaspers et al. 2021 and Jensen et al. 2023). It is important to understand how these key species respond to global change pressures to predict how their population density will respond in the future, especially in the face of de-oxygenation.

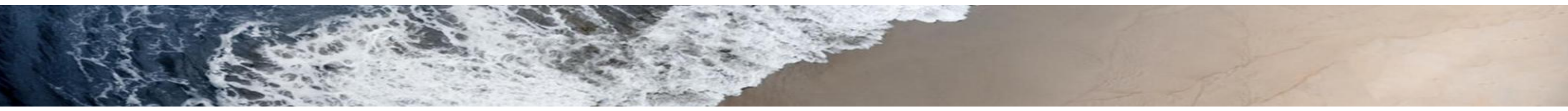
The North Sea is an important water system that suffers high degree of change and human induced perturbations. Especially expansion of offshore wind activities introduce ocean sprawl that might impact species community composition by providing additional settling substrate that is otherwise limiting in this area. To allow for detecting biodiversity changes over time, ongoing monitoring activities are devoted to fisheries as well as jellyfish in this area.

Research Needs

Different correlative and manipulative experiments will be performed on native and allochthonous species, to study their responses to changing environmental conditions. Eco-physiological experiments will be used to identify species responses to multiple environmental conditions at different life stages (polyps, ephyrae and medusae) in the laboratory. In parallel, field surveys will be performed to identify environmental conditions (temperature, salinity, oxygen, primary production, food availability) under bloom development, and the trophic impacts of jellyfish on the food web throughout all pelagic developmental stages.

Research Planned in ACTNOW

Changing temperature, salinity, oxygen and feeding conditions are some of the stressors to be tested in the correlative and manipulative experiments in the field and in the laboratory across Europe covering the Mediterranean, North and Baltic Seas. The effect of warming has been evaluated on the metabolic responses of the polyp stage of the non-indigenous jellyfish *Cassiopea andromeda*, to identify its spread potential in future scenarios of climate change. These experiments are expected to be tested in the pelagic stages of *C. andromeda* as well as in native jellyfish species during 2024. Further, oxygen impact on feeding rates in different jellyfish species and life stages has been tested in the laboratory and are currently compared with feeding rates of coastal fish species under the same laboratory conditions to address competitive interactions between jellyfish and fish.



Further, the feeding rates of the jellyfish polyps of the non-indigenous *Aurelia solida* and the native *Cotylorhiza tuberculata* are tested under different temperature conditions, which is among the ongoing and future experimental work conducted within the ACTNOW project. In addition, correlative experiments in the field are being performed to understand the population dynamics of one of the most common and abundant jellyfish in the northern Mediterranean Sea, *Rhizostoma pulmo*. In order to understand its impact on the food web, gut content and stable isotope analysis are being performed across the whole size range of the jellyfish during the years 2023-2024. Similar work is conducted in the Northern range, where the non-indigenous comb jelly species *Mnemiopsis leidyi* as well as the native jellyfish species *Aurelia aurita* are investigated to understand their impact on food web structure and functioning, especially considering deoxygenation. Special attention is further devoted to the potential utilisation of jellyfish biomass as resource for protein production and overall biodiversity changes in relation to jellyfish blooms.

● T2.1 Lab experiments on *Cassiopea andromeda* jellyfish eco-physiology (species response to temperature and salinity); ii) Lab experiments on *Aurelia solida* and *Cotylorhiza tuberculata* on feeding rates under different temperature conditions (these results will be also used in T2.3) iii) Field survey of *Rhizostoma pulmo* (population dynamics and trophic impact) (results on trophic ecology would be also used in WP3).

Similarly, lab experiments with *M. leidyi* and key hydromedusa species on feeding under different oxygen conditions (these results will also be used in T2.3) have been conducted. Field survey of the entire gelatinous macrozooplankton community have been conducted in the extended North Sea region (Jensen et al. in prep 1, 2). These results on trophic ecology (Andreasen et al. submitted) would be also used in WP3 and later work packages will use this information for gelatinous zooplankton trait analyses. A MSc thesis investigating gelatinous macrozooplankton traits is underway (Camilla J.D. Jensen, DTU Aqua, Denmark).

- T3.1 Apply a Marine Heatwave (MHW) algorithm and utilise satellite-derived ecological indicators, such as metrics of phenology (bloom timing, [Racault et al., 2012]) for a region of the Eastern Mediterranean Sea (Corinthian Gulf) to investigate the ecological impacts of MHWs on jellyfish outbreaks (NKUA).

Pictures, graphs and maps

Figure 1. Field and laboratory work.

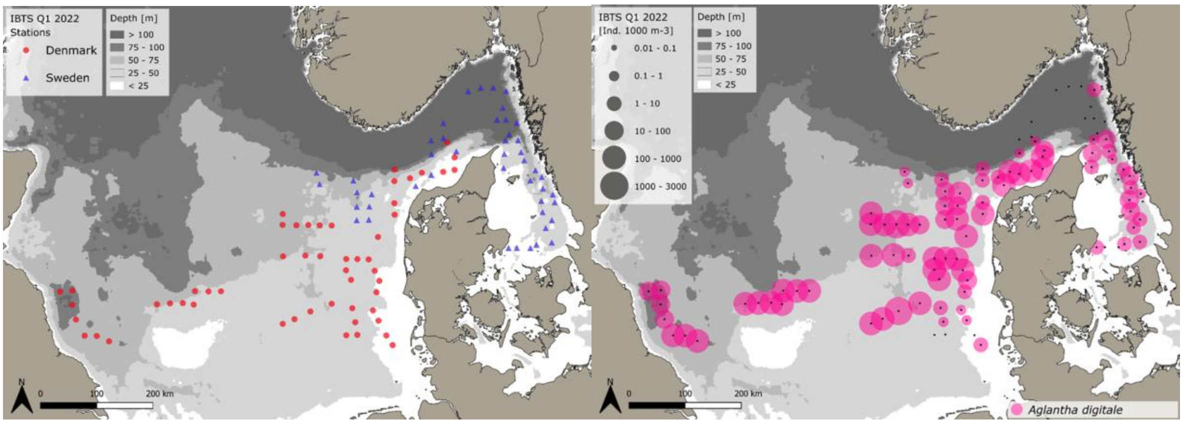


Figure 2. Field investigation conducted in the extended North Sea with map of Aglantha digitale abundances (Jensen et al. 2024,a).

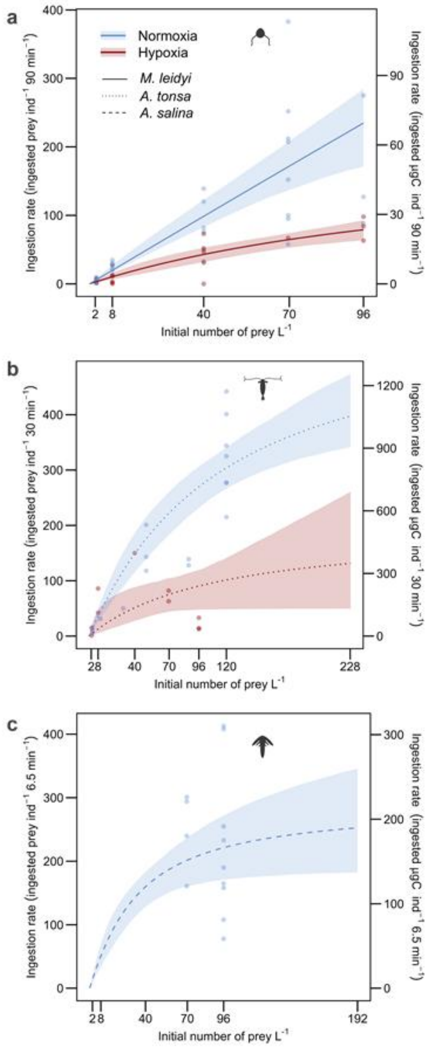


Figure 3. Feeding rates of sticklebacks on different prey types under low oxygen conditions, in comparison to normoxia with *M. leidyi* (a); *Acartia tonsa* (b) and *Artemia salinia* (c) from Andreasen et al. (in prep.).

References

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