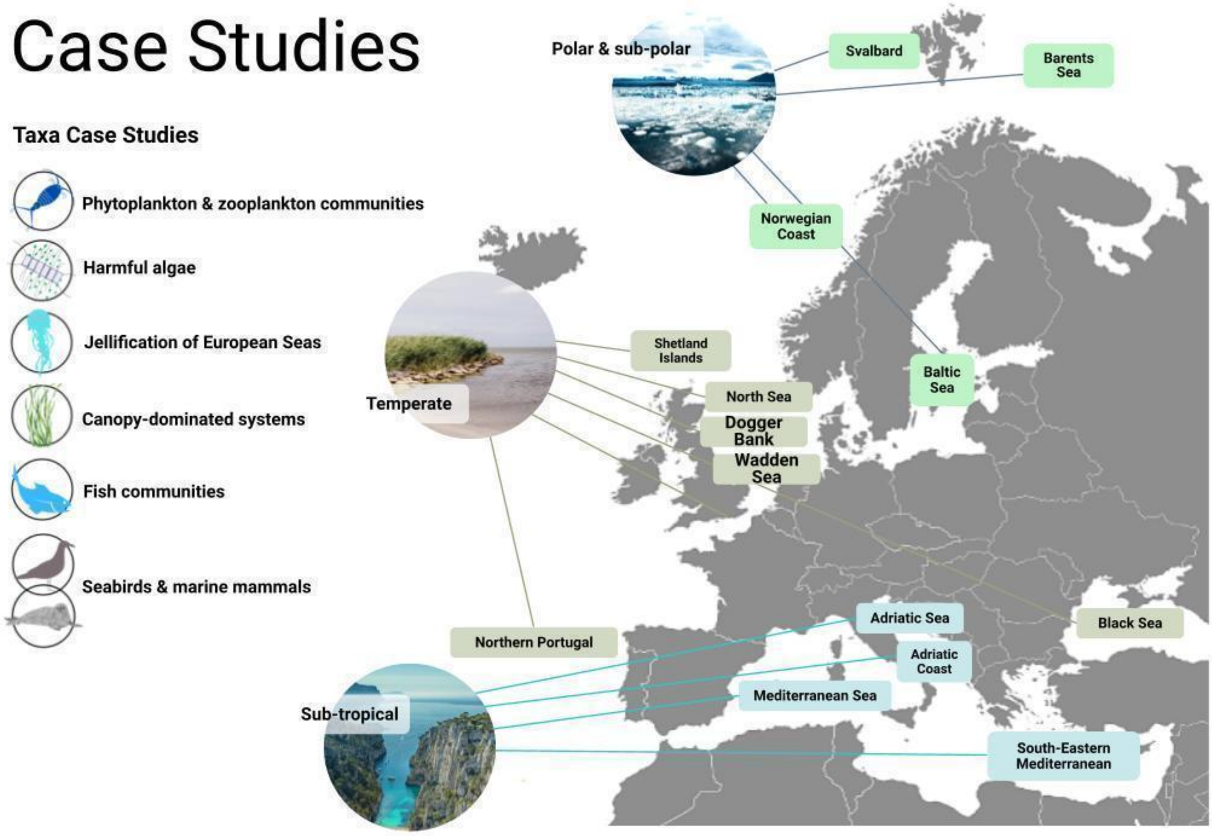
Case Study 17
Taxa

Seabirds & Marine Mammals



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 17: Seabirds & Marine Mammals

Leader

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Description

Work on seabirds and marine mammals makes use of data on foraging trips of various species across the European region (collected from specific bird colonies, seal haul out sites, etc.).

Seabirds are wide-ranging, major predators that can be severely impacted by CC and human activities. However, they are markedly different from other 'top predators' in moving fast, able to cover extraordinary distances to react to changing conditions, including those instigated by man. For this reason, the study approach requires high resolution (sub-second) bird-attached technology (accelerometers, magnetometers, pressure and temperature sensors) coupled with GPS to examine how bird behaviour changes with circumstance. The seabird work will, first, clarify what tag-based data are indicative of behavioural decisions being made (e.g. sudden changes in flight direction, speed, DBA metrics etc.) and link them, where possible, to human activities. GPS-enabled dead-reckoning will enable us to pinpoint exactly where, in 3D space, decisions have occurred. Further inspection of e.g. fishing vessel movements should enable us to pair behavioural responses to elicitors. Bird responses to elicitors at a regional level can then be examined using agent-based modelling.

For marine mammals, a probabilistic approach to calculate prey encounter rates through history will be developed and linked to environmental conditions, population trends and dietary information to quantify how close each species (and site) is to the tipping point of breeding failure. Many marine mammals such as pinnipeds are site-based foragers while others (some cetaceans) make long-distance migrations between feeding and reproductive areas. Multiple driver impacts on prey fields of marine birds and mammals are emphasised in ACTNOW.

Services

Understanding the use of space by seabirds and marine mammals is directly relevant to coastal and marine tourism (including hiking, birdwatching, pleasure boating etc.). In its simplest form, this means that the use of space can inform tourism where to look for what species. However, the identification of seabird and marine mammal behaviour with respect to space can inform people what they are likely to see or might want to see. At a more fundamental level, linking activities to space also informs where animals are likely to be most disturbed. This can be highlighted for conservation purposes and, again, inform tourist-linked bodies. Overall, this work should hugely catalyse heritage, sense of place, aesthetic values, and educational values

Interacting Drivers of Biodiversity Change

Interacting drivers of biodiversity change can be examined by looking at how animal movement decisions—such as turns in response to environmental cues—may interact with key factors influencing biodiversity. Specifically, as marine ecosystems face growing challenges like habitat fragmentation, climate change, and increased human activities (wind- and tidal turbines, oil rigs, fishing and non-fishing vessels etc.), understanding how animals navigate through their environment is crucial for predicting species distribution, interactions, and resilience. The identification of “fundamental step lengths” and “turn angles” provides insights into how species adapt their movement in response to environmental shifts, which can affect biodiversity patterns and ecosystem dynamics. The value of this will become more apparent as we identify species-specific, and area-specific patterns (work in progress)..

Regional Context

In regions such as the North Sea or other heavily fished and industrialised marine areas, understanding animal movement patterns can help predict the impacts of habitat alteration, including those caused by offshore developments like wind farms or changes in prey distribution due to warming seas. By linking movement to environmental changes, the study provides a framework to anticipate how marine species might respond to anthropogenic influences, supporting conservation strategies and management policies aimed at preserving marine biodiversity in the face of complex and interacting drivers of change.

Research Needs

Thus far, our research needs are covered (purchase of tags and associated equipment) and access to a high spec computing system for analysis of data.

Research Planned in ACTNOW

● T1.1 The movement behaviours being derived in 2.2 vary across species and environments and these can inform the overview by identifying how different stressors (e.g., resource availability, habitat structure) influence specific movement traits, like step lengths and turn angles, across marine species.

● T1.2 The findings on movement behaviour from 2.2 could serve as a novel indicator of biodiversity health, where deviations in normal movement patterns might signal changes in species abundance or ecosystem functioning due to environmental stressors.

● T1.3 T2.2 highlights gaps in understanding the fine-scale movement responses of species to changing environments, which can help prioritise future research scenarios that aim to fill these knowledge gaps within the context of multiple stressors.

● T1.4 T2.2's findings can contribute to refining GES criteria by establishing baseline movement behaviours for key species, which can then be used to detect deviations that may indicate ecosystem health issues.

● T2.1 The analysis of movement behaviours, including step lengths, turn angles, and pauses, has implications for **Task 2.1**. The high-resolution tracking data on seabirds and fish align with this task's goal of understanding species' responses to multiple stressors. By documenting how movement behaviours change under different conditions, the findings can help identify resilience thresholds and ecological tipping points for marine species, thus contributing valuable empirical data for examining stressor impacts.

● T2.2 The seabird research (RPW, ML, ED) continues during 2024 with biologging deployments on northern gannets in northern France (July) and southern Ireland (August). Specifically, breeding individuals have been equipped with GPS-enabled Daily Diary loggers (in Ireland and France) to provide sub-second resolution on the behavioural responses of birds foraging for chicks to man-produced phenomena within the foraging areas (e.g. fishing vessels, wind turbines). Aside from the ongoing analysis of this work for potential for interactions with respect to other tasks, we are also actively looking to expand our research area and species constellation into Scotland (in tandem with the RSPB), which has extensively man-perturbed habitats.

● T2.3 In relation to **Task 2.3 (Mechanistic Single-species Physiological Responses)**, the findings on the energy expenditure associated with turns and straight-line movement can enhance mechanistic models predicting species' physiological responses to multiple stressors (which are, in part, dependent on energy expenditure). Understanding how movement patterns correlate with energy use can inform models estimating how factors like temperature, food availability, and oxygen levels affect survival, growth, and reproduction.

● T2.4 The study's emphasis on linking movement patterns to environmental contexts and behaviour adds depth to **Task 2.4 (Trait-based Niches & Functional Biodiversity)** by providing a basis for assessing how movement traits, such as step length and turn frequency, differ across species and environmental conditions. These trait-based analyses can help identify species that may be particularly vulnerable or adaptable to changing marine environments.

● T3.1 The work being done within T2.2 can help identify how individual species' responses to environmental cues contribute to the broader community's resilience, especially by showing which species are more adaptive or vulnerable to changes.

● T3.2 For **Task 3.2 (Food-web Responses)**, the ms provides data on how predators like seabirds respond to prey availability through changes in movement behaviour, such as area-restricted search patterns. This information is essential for understanding how predator-prey dynamics are influenced by environmental variability, which is a key factor in food-web modelling. The ms currently produced links directly into big ecosystem models like ECOPATH and ECOSIM and this topic is covered within the ms.

● T3.3 - T2.2 provides data that can be used to link movement patterns to ecosystem functions, such as energy transfer through trophic levels, by analysing how species' foraging strategies change in different environments. This is especially relevant since the technology used in T2.2 gives indications of energy acquisition.

● T4.1 The work described in 2.2 supports **Task 4.2 (Biodiversity Risk Framework)** by providing data that can be used to assess how changes in movement patterns might signal increased risk for biodiversity due to cumulative stressors. By documenting how animals adjust their paths in response to environmental cues, the research provides a mechanistic basis for evaluating species' resilience to habitat changes and other anthropogenic impacts.

● T4.2 The work being conducted within 2.2 can support this task by offering movement data that reveal behavioural responses to stressors, which could be incorporated into the risk framework to assess potential impacts on biodiversity more accurately.

● T4.3 Movement data gathered using techniques used within T2.2 could help identify high-risk areas by highlighting regions where animals exhibit signs of stress or altered behaviours (also derived from high frequency tri-axial accelerometers), serving as early warning indicators for biodiversity risks.

● T5.1 Detailed movement data as collected within T2.2 can be integrated into projections to model how species distributions and behaviours might shift under different future climate or management scenarios.

● T5.2 The ms produced within 2.2 also contributes to **Task 5.2 (Decision-support Tools for Biodiversity Policy Actions)**, where the insights into species movement behaviours can be used to predict the effects of management interventions, such as marine protected areas (MPAs), on species distribution and energy expenditure. The detailed understanding of movement patterns could help refine spatial planning tools by identifying areas where certain species are more likely to exhibit intensive foraging or escape behaviours.

● T5.3 The insights into movement being provided by T2.2 could guide the development of targeted conservation actions, such as the placement of MPAs, by identifying critical areas for foraging or migration that need protection.

● T6.1 The findings within T2.2, which are already revealing important and highly significant patterns across and within species and lifestyle, could be used to communicate complex scientific ideas about movement and behaviour to stakeholders, helping them understand the importance of movement ecology in conservation planning.

● T6.2 The information collected within T2.2 provides a rich dataset and theoretical framework that could be used in training workshops to teach students and researchers about advanced techniques in movement ecology and their applications in conservation.

● T6.3 The movement findings could be showcased in outreach materials (e.g., animations or videos) to illustrate how animals navigate their environments, making the science accessible and engaging to a broader audience.

Pictures, graphs and maps

Figs taken from the ms compiled within T2.2 to show cross-species trends according to lifestyle, highlighting that general rules across taxa may be applicable in understanding animal movements with respect to man-induced changes and making predictions.

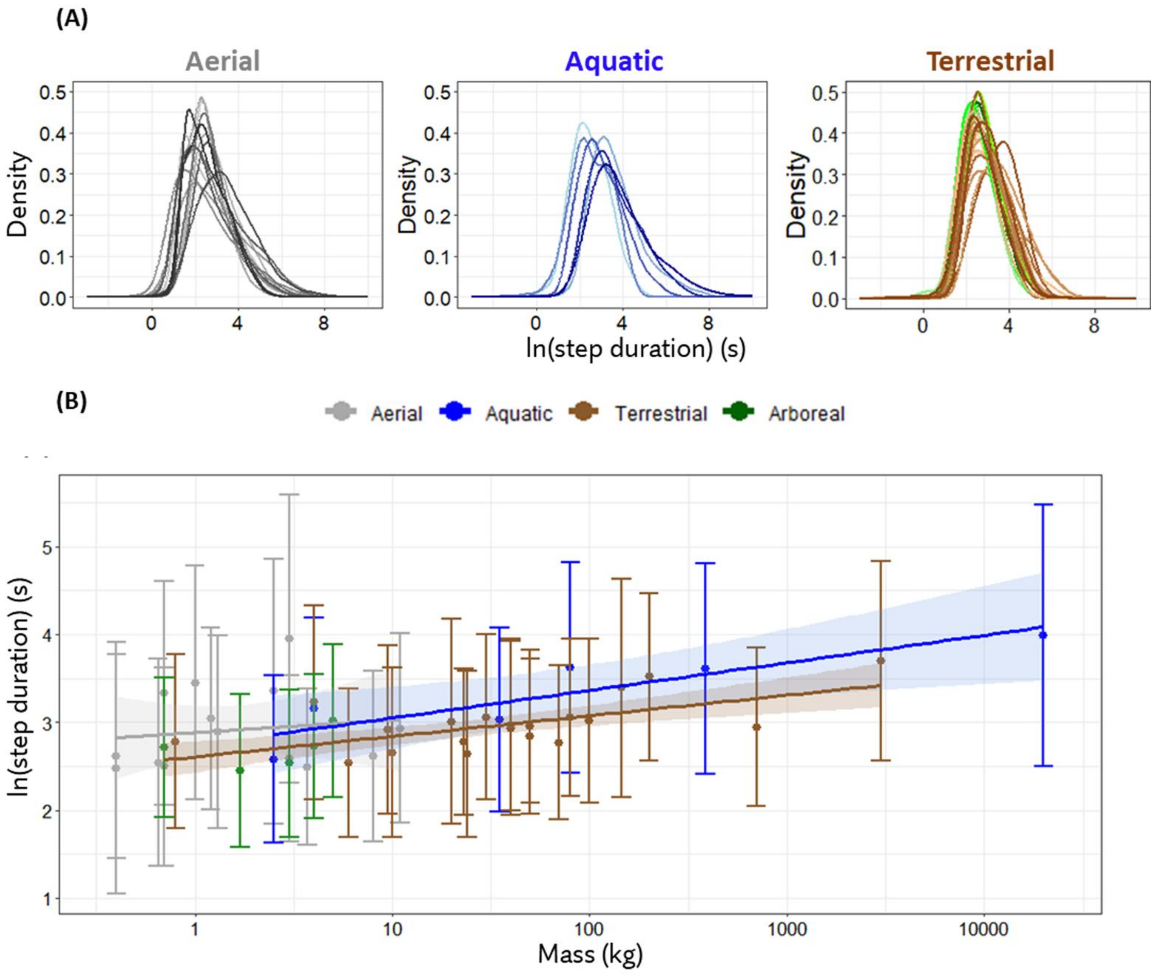

Fig. 1. Illustration of how fundamental step durations vary with lifestyle and animal mass. (A) Frequency distributions of ln(step duration) for the different species used in this study, color-coded according to their dominant mode of locomotion; aerial, aquatic or terrestrial. A). Distinct shades of each colour represent different species. (B) Relationship between ln(step duration) and species body mass across different lifestyle/travel mode (± 1 SD).

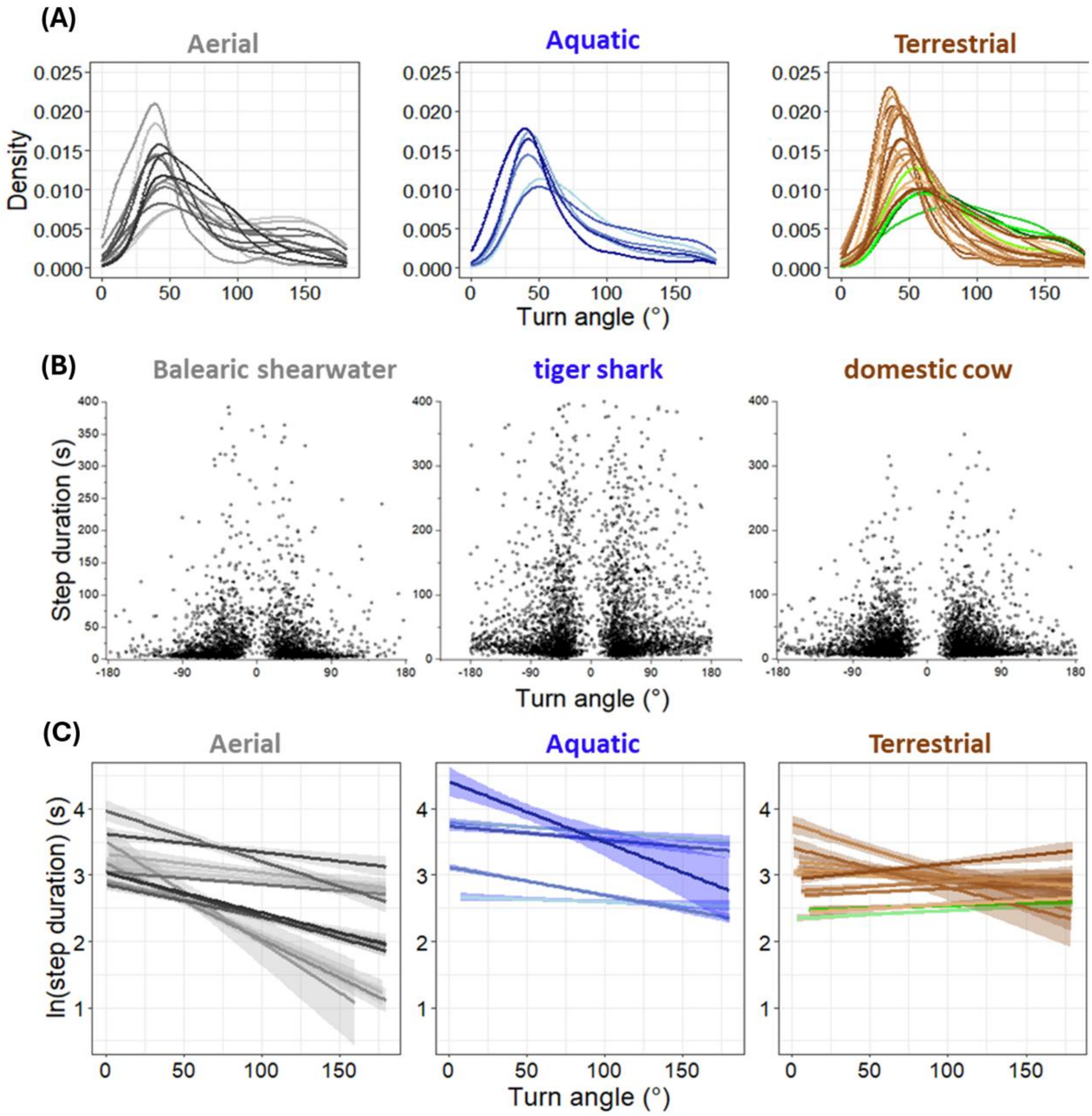

Fig. 2. (A) Frequency distribution of $F_{turnangle}$ for the 43 species examined during movement trajectories according to lifestyle, (B) examples of how $F_{stepdurations}$ relate to $F_{turnangles}$ in example aerial, aquatic, and terrestrial animals and (C) best fit lines between $F_{stepduration}$ and $F_{turnangle}$ for those species where the two parameters were significantly correlated ($p < 0.05$). The best fit lines are derived from linear models, and the shading around these regression lines represents the standard error. Note, in panels A, B, and D, turn angles are presented as absolute values (ranging from 0° to 180°), and in panel C, turn angles are signed (spanning from -180° to +180°).

References

Gunner, R. M., Wilson, R. P. et al (54 authors) (submitted). High resolution data reveal fundamental steps and turning points in animal movements. Elife.