Over the past 30 years, sea ice in the Arctic has declined by 3-4% per decade, making the Arctic the area experiencing the most rapid ecological changes due to climate change. As a consequence of rapid sea-ice loss and increasing temperatures, the abundance, diversity and distribution of low trophic level organisms will be inevitably altered, generating cascading effects through the entire marine food chain from phytoplankton to apex predators. Despite their crucial role as bio-indicators of the Arctic marine ecosystem, the capacity of Arctic cetaceans to adjust their behavior and physiology to climate-induced perturbations remains poorly understood. In this context, the WARMM project addressed the following questions:

Q1: What are the expected behavioral responses of Arctic whales to climate change (e.g., movement patterns and geographical shift)?
Q2: What are the expected physiological responses of Arctic whales to climate change (e.g., thermal balance and heat dissipation)?

To address these questions, a multi-species long-term dataset covering 25 years and including 3 Arctic (beluga, narwhal and bowhead whale) and 1 sub-Arctic (harbour porpoise) apex predators was compiled. This large existing dataset was augmented by physiological data collected during the project to (1) identify the foraging strategies from acoustic and accelerometry data, (2) link the behaviors and physiology to the environment, to finally (3) predict the future responses of apex predators in terms of thermal stress and geographical range.

By collecting concurrent information on presumed foraging activity (through buzz detection) and successful prey captures (through drops in stomach temperature), we provided the first estimates of feeding efficiency in narwhals in summer. Compared to the daily number of buzzes (707 ± 368), the daily rate of feeding events was particularly low in summer (19.8 ± 8.9) and only 8–14% of the foraging dives were successful (*i.e.,* with a detectable prey capture). This extremely low success rate resulted in a very low daily food consumption rate (less than 0.5% of body mass), suggesting that narwhals rely on body reserves accumulated in winter to sustain year-round activities, therefore reinforcing the critical role of their wintering grounds. The expected changes or disappearance of their wintering habitats in response to climate change may therefore have severe fitness consequences for narwhal populations.

To better anticipate the behavioral responses of Arctic cetaceans to sea temperature rise, their distributions were then projected based on their environmental associations and using two climate change scenarios. (ii) While contrasting responses were observed across species and seasons, long-term predictions suggest northward shifts (243 km in summer vs. 121 km in winter) in distribution to cope with climate change. Current summer habitats are expected to decline (mean loss: -25%), while some expansion into new areas (mean gain: +3%) is likely. However, comparing gains versus losses raises serious concern about the ability of these polar species to deal with the disappearance of traditional colder habitats.

Regarding sub-Arctic species, we recently found that harbour porpoises living around Greenland time their diving behavior according to daylight. Unlike classical diel vertical migration observed in the ocean, the porpoises dove three times deeper at night and the frequency of deep dives (>100 m) increased tenfold as they entered the darkest months. The daily mean depth was negatively correlated with daylength, confirming this reverse diel migration and suggesting an increased activity—presumably to target prey at greater depths—when approaching the polar night. Our findings illustrate a light-mediated strategy in which harbour porpoises would maximize energy gain during long periods of darkness while minimizing energy expenditure by accessing vertically migrating prey, which are otherwise inaccessible in deep waters.

In addition to the behavioral responses, the development and testing of the brand-new heat flux tag made possible the collection of the first thermal profiles of body heat regulation in both non-Arctic cetaceans (bottlenose dolphins) and Arctic whales (belugas) to shed light on how cold-adapted species will physiologically cope with sea temperature rise.

This project is crucial and timely as it will constitute an unprecedented scientific baseline to advise the EU and the Intergovernmental Panel on Climate Change in mitigating the effects of climate change and safeguarding the Arctic marine biodiversity.