Polhavet Arctic Ocean 2050

Implementation plan

2026-2028



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This Implementation Plan was written by the *Polhavet 2050/Arctic Ocean 2050* working group established by the 18 partner institutions. We appreciate financial support from the Norwegian Research Council (project number 363568), valuable feedback from the Research Council of Norway's evaluation panel, the International Advisory Board, organizational and technical support from Erik Sandquist and Maria Teresa Bezem (University of Bergen), Suet Chan (NORCE Research), Yasemin V. Bodur and Anna Nikolopoulos (UiT The Arctic University of Norway), as well as input from the many researchers who read and commented upon this plan during its preparation and multiple hearing rounds.

How to cite this plan: Årthun, M., Dodd, P., Jentoft, S., Renaud, P., Müller, M., Dankel, D., Bertino, L., Bluhm, B., De Lucia, V., Ellingsen, K., Husum, K., Ingvaldsen, R., Jensen, Ø., Jørgensen, L. L., Jørgensen, S. L., Langehaug, H., Mooney, P., Olsen, A., Østhagen, A., Øverjordet, I. B., Oye, V., Pedersen, M. P., Skodvin, K. E., Søreide, J. E., Sørensen, A., Storelvmo, T., Thorsnes, T., Tjiputra, J., Wilson Rowe, E. & Yoccoz, N. 2026. Arctic Ocean 2050 Implementation Plan 2026-2028, University of Bergen, 110 pp.

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Polhavet
Arctic Ocean
2050

A 10-year programme for Arctic Ocean research

Implementation Plan (2026-2028)

Vision: Science for a sustainably managed Arctic Ocean

Mission: *Arctic Ocean 2050* unites Norwegian and international scientific expertise in a 10-year programme to understand the present and guide the future of the Arctic Ocean. Through interdisciplinary research and innovation and international collaboration, the programme will deliver knowledge and tools for sustainable use, conservation, and geopolitical resilience in a changing Arctic.
Arctic Ocean 2050 will pursue its mission through the following overarching research questions:

- What are the mechanisms, trajectories, and impacts of changes in the Arctic Ocean?
- How can scientific and technological breakthrough developed within *Arctic Ocean 2050* contribute to innovative monitoring strategies and next-generation predictive capacities?
- What are the best practices for engagement at all levels and forms of governance to increase awareness and mitigation of risks?

Synopsis of content: how to read this plan

This Implementation Plan covers the period 2026-2028 and details the specific tasks the 18 partner organizations in the Norwegian Consortium plans to work on in this period. The scientific basis for the Implementation Plan and for the *Arctic Ocean 2050* programme can be found in the accompanying Science Plan (Olsen et al. 2026). The structure of the Implementation Plan follows that of the Science Plan. Tasks are organized underneath Priority Topics within each of the six Research Themes (see *Research Themes* below). Task 2.1.1, for example, thus belongs under Research Theme 2, Priority Topic 1.

At the beginning of each Research Theme (RT) and Priority Topic, these are briefly summarized as per the Science Plan; they apply to the entire 10-year period. Underneath each Priority Topic follow several tasks. Each task describes: how part of a given Priority Topic will be implemented in 2026-28; the collaborating consortium partners in that task in alphabetical order after the task leading partner; links to other tasks in the present plan; and – for 2026 only – planned deliverables. The six RTs are all active at the same time and throughout the 10-year period, while individual tasks may start in different years and have variable duration. Future implementation plans/updates will specify continued and new tasks. Although this is an Implementation Plan for 2026-2028, a detailed overview of person months (see Appendix 1) and recruitment positions (see Education and Capacity building) are only provided for 2026. An important task and deliverable for 2026 will, therefore, be to identify and clarify the tasks, deliverables, person-month needs, responsible partners, and resources available (including recruitment positions) for the following years, with a special emphasis on the first half of the programme. The development of the extended Implementation Plan during 2026 will be done by the programme and RT leader group (Table 1).

Programme structure, leadership and funding model

Arctic Ocean 2050 is a nationwide consortium consisting of 18 universities and research institutions (Table 2), in response to ongoing climate change in the Arctic Ocean and its influence on environmental, industrial, and political development. The complexity of these challenges necessitates this large national initiative that goes beyond the time and funding framework of more traditional research projects. Unprecedently, *Arctic Ocean 2050* unifies not only environmental but also law/governance/security research across Norway in a concerted programme to understand the Arctic Ocean in all its aspects. The complementary skills and collective expertise of the consortium will enhance national collaboration and create opportunities for pioneering research in the Arctic Ocean.

The **organizational structure** of *Arctic Ocean 2050* is summarized in Figure 1. The **director and administration** of *Arctic Ocean 2050* will be based at UiT-The Arctic University of Norway in Tromsø. The programme will furthermore have **four co-leaders** that will coordinate activities within natural science, governance/security/international law, technology, and international cooperation (Table 1).

Arctic Ocean 2050 has **six Research Themes** (RTs, Table 1). Each RT has a **leader and a co-leader** (listed under the respective RTs), representing different institutions and science disciplines to ensure an integrative perspective and cooperation within and across the research themes. The director, the programme co-leads, and the RT-leads constitute the leader group of *Arctic Ocean 2050*. Except for the programme director, all other positions will rotate according to a defined rotation scheme that ensures both continuity and flexibility to adjust to new programme phases. The primary contact of the RT leaders with *Arctic Ocean 2050* researchers is via **Task Leaders**. Task Leaders coordinate the work in the tasks on behalf of the programme, and ensure the tasks align with the Science Plan. Note that RTs are not necessarily equal in size; in this Implementation Plan, RT2 and RT5 are particularly large while RT4 and RT6 are smaller with relative sizes anticipated to vary over the course of the programme period.

Arctic Ocean 2050 has a **programme board** that will govern the programme's strategic plans. The board has members from seven consortium partners. Three of those are permanent and four rotating. The board is currently led by Jørgen Berge, UiT, and co-led by Tore Furevik, NERSC. Those consortium partners that do not have a board member at a given time have institutional contacts that are regularly briefed and can provide input to strategic matters.

The results, relevance and progress of the *Arctic Ocean 2050* programme will furthermore be overseen by an **International Advisory Board** (IAB) of internationally recognized scientists. In the first programme phase these are: Henry Burgess (NERC, UK), Heidi Dierssen (University of Connecticut), Klaus Dodds (Middlesex University, UK), Thomas Funck (GEUS, Denmark), Maria Grigoratou (European Polar Board, Sweden), Martin Jakobsson (Stockholm University, Sweden), Maribeth Murray (Arctic Institute of North America, Univ. of Calgary, Canada), Shigeto Nishino (JAMSTEC, Japan), Rolf Rødven (AMAP, Norway), Malene Simon Hegelund (Greenland Institute of Natural Resources, Kingdom of Denmark), Sarah Strand (Association of Polar Early Career Scientists, Norway), Jens Terhaar (University of Bern, Switzerland), David N. Thomas (Helsinki University, Finland), Abbie Tingstad (US Coast Guard Academy, USA),

Jeremy Wilkinson (British Antarctic Survey, UK), Eun-Jin Yang (Korea Polar Research Institute, South Korea). The IAB will provide a top-level international network for the programme's pan-Arctic integration. Given the 10-year duration, the IAB will follow a rotation with a tenure of 3 years, with an option for a second term.

A **data management team** will be formed with a core team at partner institutions with national expertise and a mandate to manage large data streams; a group of contact persons from all other consortium partners will be associated. Data management – described in the data management plan - will follow FAIR and CARE standards and practises; financial resources are allocated to data management.

Similarly, a **communication group** consisting of contacts at all consortium partners is formed, with a core group and a leader. The full-time communication group leader position, with employment in the programme office, is included in the resources dedicated to communication. A communication & outreach plan will be developed that describes the strategy and implementation.

Day-to-day coordination of the programme will be managed by the director, supported

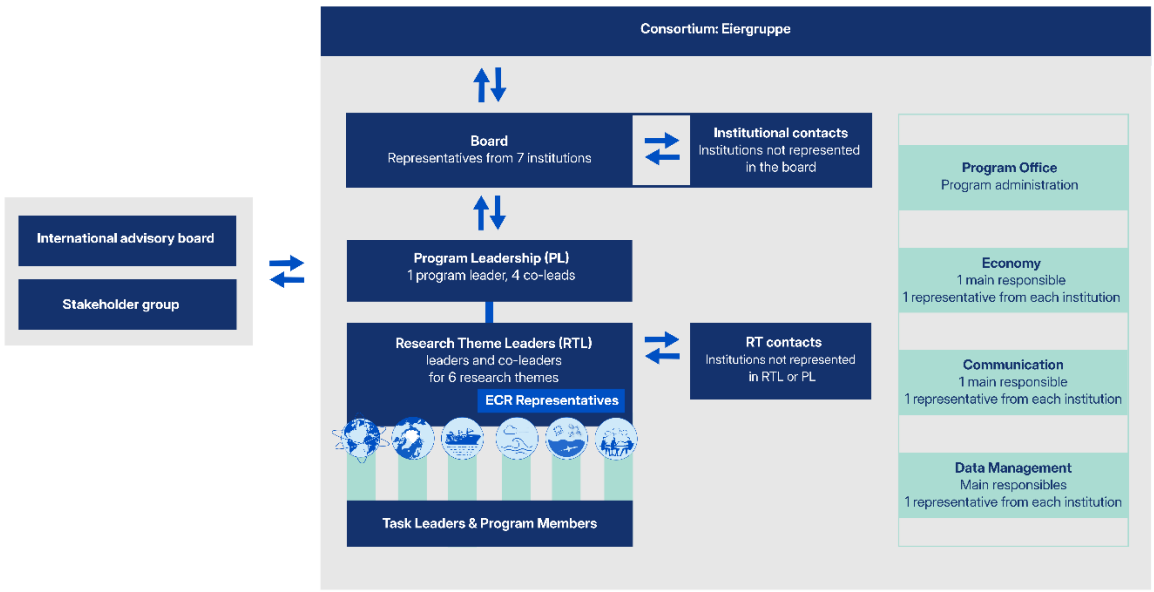


Figure 1: Organisation of *Arctic Ocean 2050*. Organigram representing the Board and institutional contacts, programme leader group, Research Theme Leader group and members, as well as the International Advisory Board, Transdisciplinary actors (in formation), Data management, Communication group, programme office and economic support.

by the four programme co-leaders and the administrative staff. Programme activities will be planned, coordinated, implemented, and evaluated in close collaboration with all RT leaders and co-leaders. The programme leader team will hold generally monthly online meetings, with two of these meetings conducted in person each year. Early Career Researchers will have two representatives in the programme and RT leader group meetings, one PhD candidate and one post-doc. Administrative tasks are supported by a full-time staff position as well as a 50% financial expert position. The latter communicates with an identified team of financial experts across the entire consortium.

A **funding structure** is in place comprising a total of two billion NOK over the 10-year period. Half of that amount is made available by the Research Council of Norway through a combination of core funding (750 million NOK) and two open calls (125 million NOK each), the latter are anticipated for 2027, and 2030 or 2031. The other half is contributed as in-kind funding by consortium partners. Twenty percent of that in-kind is to be ship time contributions by partners holding time for *R/V Kronprins Haakon* and the remainder is composed of other sources, mostly a combination of person time and PhD positions. The ratio of in-kind (category II) to Research Council funding is at a ratio of 1:1 and 1:10 for partners in government-and private sectors, respectively; in-kind category III is other sources not coupled to that ratio. More on the funding model can be found at `Polhavet2050_program- og finansieringsplan_nov2024.pdf`

Table 1. *Arctic Ocean 2050* leadership during the phase of the present implementation plan. RT: research theme. Affiliations (in parentheses) are explained in Table 2.

Director	Bodil Bluhm (interim) (UiT)					
Programme co-leads	Elana Wilson Rowe (NUPI)	Helene R. Langehaug (NERSC)	Asgeir Sørensen (NTNU)	Arild Sundfjord (NPI)		
	RT1	**RT2**	**RT3**	**RT4**	**RT5**	**RT6**
RT Lead	Marius Årthun (UiB)	Paul Dodd (NPI)	Sissel Jentoft (UiO)	Paul Renaud (APN)	Malte Müller (MET)	Dorothy Dankel (SINTEF)
RT Co-lead	Kari Ellingsen (NINA)	Bodil Bluhm (UiT)	Janne E. Søreide (UNIS)	Priscilla Mooney (NORCE)	Laurent Bertino (NERSC)	Geir Hønne-land (FNI)

Table 2. *Arctic Ocean 2050* consortium partners throughout the entire 10-year period.

Akvaplan-niva	APN
Fridtjof Nansen Institute	FNI
Geological Survey of Norway	NGU
Institute of Marine Research	IMR
Nansen Environmental and Remote Sensing Center	NERSC
Norwegian Defence Research Establishment	FFI
Norwegian Institute for Nature Research	NINA
Norwegian Institute of International Affairs	NUPI
Norwegian Meteorological Institute	MET

Norwegian Polar Institute	NPI
NORCE Research	NORCE
Norwegian University of Science and Technology	NTNU
SINTEF Ocean AS	SINTEF
Stiftelsen NORSAR	NORSAR
UiT The Arctic University of Norway	UiT
University Centre in Svalbard	UNIS
University of Bergen	UiB
University of Oslo	UiO

Research Themes

The six research themes (RTs) collectively ensure **interdisciplinary** (within academia) perspectives and have **transdisciplinary** (involving non-academic societal groups) elements (Figure 2). The first four RTs focus on closing key knowledge gaps on the region's environmental conditions and influences, marine life, human use and governance, the fifth focuses on advancing technological solutions for better research and management, and the sixth will integrate and co-produce knowledge together with stakeholders and knowledge holders. This process will ensure that we provide actionable advice and allow us to continually reassess the key knowledge gaps, which will help guide priorities of the programme during its 10-year lifetime. All RTs build on available knowledge and actively integrate what is known already; several tasks in the start-up phase are specifically designed to take stock of the known.

Research Themes 1 through 4 explore the Arctic Ocean from four complementary perspectives. Combined, these provide the information that is needed to understand the Arctic Ocean, how our actions shape it, and what is needed to ensure a safe and sustainable future. In RT1, we take a large-scale perspective. This is necessitated by the global and hemispheric nature of both the drivers of change and variability impacting the Arctic Ocean, and of the impacts of Arctic Ocean changes on the rest of the world. In RT2, we focus on the Arctic Ocean itself. Here, we will close existing knowledge gaps on the state of the Arctic Ocean, determine its sensitivity to climate change in terms of the nature of impacts and rates of change, and evaluate how this challenges current regulatory frameworks and how these may be revised. In RT3, we turn to specific ongoing or likely forms of human activity in the future, the risks and benefits that will accompany such increased human activity, and how these activities can be monitored and managed. Finally, we acknowledge that hard-to-predict abrupt change and extreme events can define the evolution of natural, as well as societal systems, and evaluate the likelihood and impacts of the unanticipated in RT4.

While the research in RT1-4 will initially be based on well-established technologies, RT5 will improve our capability to observe and model the Arctic Ocean by designing and testing fit-for-purpose sensors and observing systems. We will develop techniques for AI-assisted integration of data into next-generation model systems for better reanalysis, predictions and projections of the Arctic Ocean, ultimately leading to improved Decision Support Systems such as digital twins that can be used to guide management decisions.

These novel tools developed in RT5 will be increasingly adopted into the programme as it progresses.

Research Theme 6 focuses on actionizing the knowledge generated in *Arctic Ocean 2050*. This will be achieved through extended peer community, transdisciplinary engagement around co-production of scenarios with rightsholders, stakeholders and policy communities that will, in turn, inform policy and further directions for research within the programme. A key aim is to assess regional and local management options in the context of diverse climate change scenarios. To achieve this, RT6 will take advantage of the knowledge generated in RT1-4 and the Decision Support Systems developed in RT5 in a post-normal science framework.

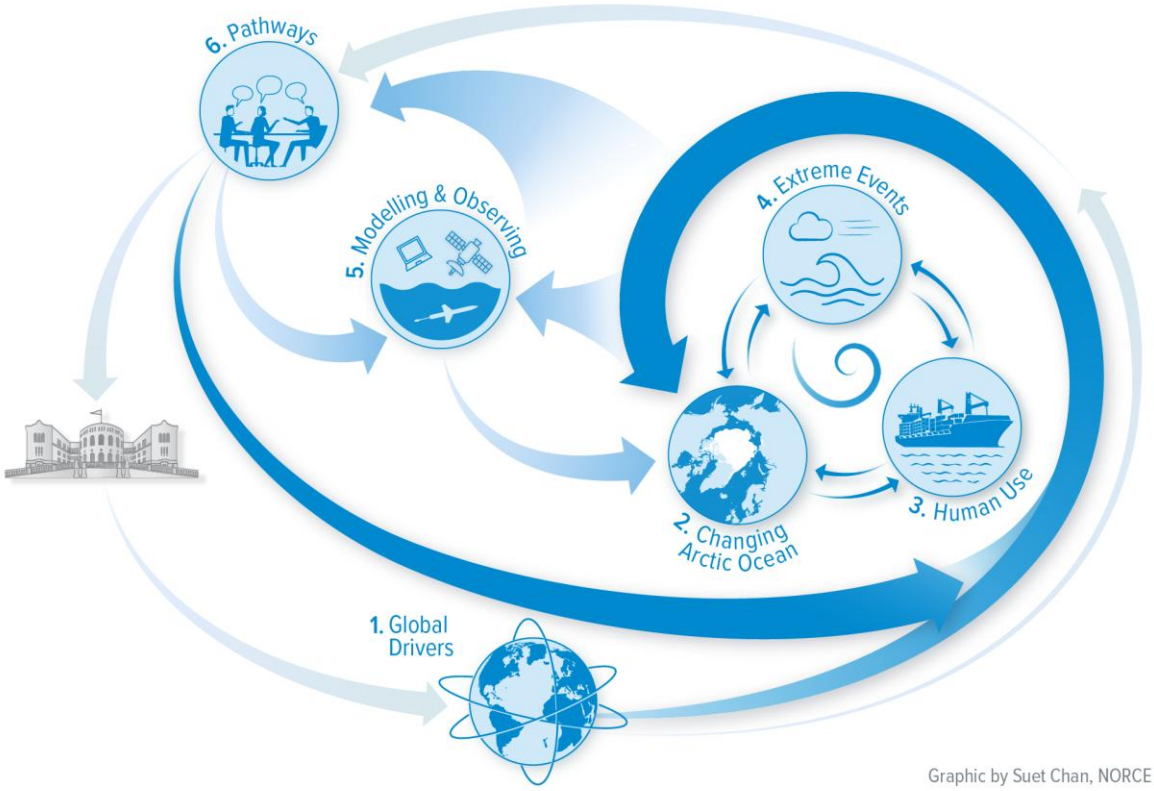


Figure 2: **Research Theme structure of *Arctic Ocean 2050***. The *Arctic Ocean 2050* programme is organized into six research themes (RTs) that collectively ensure a transdisciplinary approach.

RT1: The Arctic Ocean in the World

Lead: Marius Årthun (UiB). Co-lead: Kari Ellingsen (NINA)

Objective: Understand the interplay between external processes and ongoing and potential future changes in the Arctic Ocean.

Priority topics:

1.1 How are key global and extra-regional processes (political and environmental) driving changes in the Arctic Ocean - and how are and can they be governed?

1.2 To what extent are sub-seasonal to decadal changes in the physicochemical environment in the Arctic Ocean and associated changes in productivity and species distributions predictable?

1.3 How will climate drivers and feedbacks shape the evolution of the Arctic Ocean toward 2050 and beyond, and what are the impacts on species distributions and productivity?

1.4 How will changes in the Arctic Ocean influence environmental and governance systems outside the Arctic?

These priority topics (PTs) form the basis for the tasks outlined below.

Priority Topic 1.1: Identify key political and environmental drivers originating outside the Arctic Ocean

PT1.1 will identify the major external sociopolitical and environmental drivers that have or are likely to have a large influence on the Arctic Ocean. These include global efforts to govern a transforming planet from biodiversity through pollution regulation to ocean governance, the dynamics and regional impacts of broader security-political concerns and rivalries, as well as large-scale inflows of heat, moisture, carbon, nutrients and pollutants to the region.

T1.1.1. Scoping exercise Arctic Ocean geopolitics and security research state of the art

PI: NUPI. **Participants**: FNI, FFI, NORSAR, UiO, UiT, others as relevant

Work description: This activity aims to provide a baseline assessment of existing scholarships on Arctic Ocean security dynamics and map key avenues for interdisciplinary research, with a particular emphasis on the geographical focus area of *Arctic Ocean* 2050. The field is currently characterized by a wide literature, but a lack of synthesis (Jacobsen and Wilson Rowe 2026) and lack of precision about geographical variation in security challenges and strategic conditions across the Arctic (see Østhagen 2026 for more on this point). Empirically, the rapidly changing physical environment, abrupt advances in technology and a shifting geopolitical environment ensure that there is no shortage of critically important developments to address. To address these challenges and to provide a steppingstone for more issue-specific studies of pressing relevance to *Arctic Ocean 2050*, short, topic-focused chapters will briefly summarize and characterize existing research (publications and ongoing

projects) and specify the most pressing research questions in their field, taking a departure from the *Arctic Ocean 2050* Science Plan.

The activity has the secondary aim of fostering collaboration amongst Norway's Arctic security research milieus, which have had few opportunities for cross-institution cooperation or assessment of the state of the art. A policy note identifying the most important empirical issues and avenues for addressing them (to the extent identified by the literature review) will provide an early policy-oriented output of the programme, as well as contribute insights on key drivers for scenario work in RT6 (6.2.1, 6.3.1) and impacts of abrupt change (4.1.2, 4.4.1).

Links to other Tasks: 4.1.2, 4.4.1, 6.2.1, 6.3.1

Deliverables in 2026:

- Workshop/scoping exercise.
- Three of six chapters published in draft or final form.

T1.1.2. Scoping exercise Arctic Ocean governance and legal dynamics

PI: FNI. **Participants**: NUPI, SINTEF, UiO, UiT, others as relevant

Work description: This activity aims to provide a baseline assessment of existing scholarship on global governance frameworks pertaining to the Arctic Ocean, exploring the extent to which and how global governance frameworks/regimes are addressing or can address ongoing changes in the Arctic (physical, socio-economic). While the field of scholarship is less fragmented than what we see in Arctic security studies, research on global frameworks pertaining to the Arctic often remain siloed by sector (with a singular focus on biodiversity, fisheries, conservation, shipping and so on). This assessment aims to characterize the baseline of scholarly understanding on key aspects of Arctic governance that are (or are set to be) addressed in global governance settings and to examine the state of literature and research options for capturing interplay across regimes/frameworks. Research in this task will examine the policy inputs and impacts of actors engaged in shaping global governance relevant to the Arctic, including Indigenous organizations and their diplomacy, states, the private sector and civil society. Taking a starting point in the *Arctic Ocean 2050* Science Plan, each chapter will briefly characterize the relevant literature and knowledge milieus/projects and identify and prioritize key questions for further research. This exercise complements and has synergy with Task 3.3.1 (Scenario development for future activities).

A policy note identifying the most critically important empirical issues and avenues for addressing them (to the extent identified by the literature review) will provide an early policy-oriented output of the programme, as well as contribute insights on key drivers for scenario work in RT6 (2027).

Links to other Tasks: 3.3.1, 4.1.2, 4.4.1, 6.2.1, 6.3.1

Deliverables in 2026:

- Workshop/scoping exercise on Arctic Ocean governance.
- Two of six chapters published in draft or final form.

T1.1.3. Determine how large-scale oceanic and atmospheric circulation changes impact the Arctic Ocean

PI: IMR. **Participants**: NERSC, NORCE, UiB, UiO, UiT

Work description: Warm Atlantic Water enters the Arctic Ocean through the Barents Sea and Fram Strait, while warm Pacific Water flows into the Arctic Ocean through Bering Strait (Tsubouchi et al. 2024). Changes in ocean heat transport are known to affect Arctic sea ice extent and thickness, which, in turn, has wide-ranging impacts on Arctic marine ecosystems (Ingvaldsen et al. 2021). Arctic temperatures and sea ice melt are also strongly affected by poleward advection of warm and moist air (e.g., Bintanja et al. 2023). A complete mechanistic understanding of Atlantic-Arctic and Pacific-Arctic connectivities is, however, lacking.

In T1.1.3 we will determine how large-scale circulation changes in the ocean and the atmosphere impact the Arctic and whether the connectivity between lower latitudes and the Arctic changes in the future. We will specifically address shifts in volume, heat, salt, carbon, and nutrient transport to the Arctic Ocean through the Fram Strait and the Barents Sea. This work will involve collaboration with Alfred Wegener Institute and the University of Alaska Fairbanks. We will also investigate the processes governing poleward energy transport by the atmosphere, including the "upstream" influence of Arctic amplification on different spatiotemporal scales of exchange that affect long-term trends. The work in T1.1.3 will rely on a combination of available observations, high-resolution models and reanalyses, and coupled climate models.

Links to other Tasks: 1.2.3, 2.1.7, 4.1.6

Deliverables for 2026: None

T1.1.4. Horizontal transfer of freshwater, heat, terrigenous material (nutrients, carbon, contaminants) from river runoff and land-ocean interactions

PI: NINA. **Participants**: APN, IMR, NORSAR, NPI, UiO

Work description: This task will focus on delivering robust estimates of horizontal transport of freshwater, heat, and terrigenous material (including nutrients, organic and inorganic carbon, contaminants) from rivers, glaciers, and the Greenland ice sheet to the Arctic Ocean. Building on observational data and existing model-derived estimates, this task will provide improved estimates of land-ocean inputs of freshwater at the pan-Arctic scale (including their timing, magnitude, location and geochemistry). By coupling land-ocean inputs to physical and chemical ocean models, we will develop improved assessments of distribution, transport, fate and potential ecosystem impacts of these inputs in the Arctic Ocean. Targeted biogeochemical analysis of water samples collected on cruises will provide important ground truthing data and additional insight into these inputs by tracing water, nutrients, and organic matter of terrestrial origin. This work will also be directly linked to activities in RT2 related to impacts of freshwater and land-ocean inputs on physical and chemical conditions in the central Arctic Ocean, as well as Earth System Modelling activities.

Links to other Tasks: 1.4.1, 2.1.4, 2.3.3

Deliverables in 2026: None

T1.1.5. Assess extra-regional (NATO, EU, Nordics) pathways for ameliorating current and future risks to critical infrastructure

PI: NUPI. **Participants**: FFI, FNI, UiO, others as relevant

Work description: This task will focus on identifying avenues for policy/governance response and ameliorating human and environmental threats to critical infrastructure in and around the Arctic Ocean (cables, satellite/space infrastructure, petroleum infrastructure). The task focuses on institutions that are 'extra-regional' settings – without a specifically Arctic focus in their mandate – yet with significant capacity to address security and safety concerns in the Arctic Ocean (for example, NATO, EU, Nordic cooperation). It addresses the policy efforts and inputs of all actors seeking to shape Arctic Ocean security. A workshop will be held to facilitate conversation across natural and social science on the ways in which environmental change poses risks to (or opportunities for) critical infrastructure development and protection. A policy note identifying the most critically important empirical issues and avenues for addressing them (to the extent identified by the literature review) will provide an early interdisciplinary output of the programme, as well as contribute insights on key drivers for scenario work in RT6 (2027). This task addresses global and extra-regional elements relevant to Task 3.3.2 (Infrastructure challenges in an increasingly active Arctic: Preparedness and risks).

Links to other Tasks: 3.3.2, 4.3.1, 4.3.2, 6.3.1

Deliverables in 2026: None

T1.1.6. Assess key areas of global governance impacting Arctic Ocean governance

PI: FNI. **Participants**: NUPI, SINTEF, UiO, UiT, others as relevant

Work description: This task focuses on original empirical research analysis of the areas of global governance identified in Task 1.1.5 (scoping) as being of critical importance to regulating human activity and governing the Arctic Ocean. While a wide range of global governance settings may, in the longer-term, have implications for Arctic Ocean governance in keeping with ocean governance globally, this task supports research on areas of global governance undergoing comparatively rapid political/legal developments and of immediate relevance to the Arctic Ocean, and the effectiveness and developments of the Arctic Council. For example, the rise of the shadow fleet, which transports sanctioned Russian oil and gas on poorly insured/uninsured vessels under flags of convenience, is undermining and reshaping global shipping regimes and norms, as well as representing an environmental threat to the Arctic environment. The implications of the provisions of the Biodiversity Beyond National Jurisdiction (BBNJ) treaty, The Central Arctic Ocean Fishing Agreement (CAOFA), a possible future global plastics treaty, developments in the International Seabed Authority, and comparatively novel tools for conservation deriving from these, such as Area Based Management Tools, including Marine Protected Areas (MPAs), and Environmental Impact Assessments (EIAs), have gained heightened momentum and have an immediate import for governing human activity in the Arctic Ocean. Empirically, the task addresses the policy inputs and impacts of all actors seeking to shape Arctic governance, from Indigenous governance organizations and leaders through state actors and to private sector governance efforts. This task has synergy with Task 3.3.1 (Scenario development for future activities) and Task 4.1.2 on mapping sources of resilience to abrupt change.

Links to other Tasks: 1.1.5, 3.3.1, 4.1.2

Deliverables in 2026: None

Priority Topic 1.2: Assess near-term predictions of the Arctic Ocean environment

PT1.2 will explore and improve the predictability of the physical climate, biogeochemical processes, and biota in the Arctic Ocean, how it relates to extra-regional drivers, and how this information can improve Arctic Ocean management.

T1.2.1 Expert solicitation to identify key climate variables of interest to *Arctic Ocean 2050*, and identification of corresponding observational data

PI: UiO. **Participants**: all partners

Work description: Before using global climate models for the purpose of Arctic climate predictions and projections, a critical first task is to evaluate the models' fidelity when it comes to simulation of past Arctic climate evolution. This evaluation requires the establishment of a set of variables identified by the *Arctic Ocean 2050* interdisciplinary consortium as critical to answer *Arctic Ocean 2050* research questions, i.e., the variables that we collectively agree must be simulated well in order for us to place confidence in the models. This will be achieved through an expert solicitation, which should be carried out early in 2026, ideally at a general assembly. It requires preparation to ensure inclusive decision making and will be followed by the establishment of a comprehensive set of observational data sets, including both remote sensing and in situ data, that should be used for model evaluation.

Links to other Tasks: 1.2.2, 1.2.3, 1.3.1, 4.1.5, 4.2.2, 5.2.1, 5.2.2, 5.2.3

Deliverables in 2026: Report/publication on set of key variables and associated observational data sets.

T1.2.2. Model evaluation using historical and paleo-data of key variables

PI: UiO. **Participants**: NERSC, NORCE, UiT

Work description: This task will evaluate numerical models used in *Arctic Ocean 2050*, including CMIP7 and Arctic CORDEX models in general and NorESM in particular, with respect to the key Arctic climate variables and using the observational data sets established in T1.1.2. Evaluation will be based on (i) paleoclimate model simulations, for example of the Pliocene, as an analogue for the emerging Arctic climate, and (ii) historical simulations, for which both present-day mean state variables and recent trends can be used for evaluation purposes. An important goal of this task is to identify a subset of CMIP7 and Arctic CORDEX models that are deemed fit-for-purpose for *Arctic Ocean 2050*. Notably, if NorESM is not among these models, an additional goal would be to identify which key variables are misrepresented in NorESM and propose a strategy to mitigate these shortcomings. This task will also include evaluation of ocean and atmospheric reanalyses products.

Links to other Tasks: 1.2.1, 1.2.3, 1.3.1, 4.2.1, 4.2.2, 5.2.2

Deliverables in 2026: None

T1.2.3. Evaluate sub-seasonal to decadal prediction skill in the Arctic Ocean

PI: UiB. **Participants**: NERSC

Work description: While it is well known that the Barents and the Nordic Seas exhibit strong predictive skill in physical and biogeochemical properties on multi-year timescales (Passos et al. 2023; Fransner et al. 2023), our understanding of the predictability of the Arctic Ocean remains limited. In particular, there is a need to assess how predictive skill differs among existing prediction systems, how it may evolve in a future with a diminishing sea-ice cover, and how predictable physical and biogeochemical signals may influence or transfer to Arctic Ocean ecosystems.

In T1.2.3 we will conduct a comprehensive assessment of the predictability and underlying mechanisms of both the physical and the biogeochemical components of the present and future Arctic Ocean. This will be achieved through analysis of the latest simulations from the Decadal Climate Prediction Project (DCPP) as well as perfect model experiments initialized from future scenarios. Several prediction systems (including data-driven models if available) will be analysed to inform future model development of the Norwegian Climate Prediction Model (NorCPM; Bethke et al. 2021). Decadal predictions from NorCPM will further be used to force ecosystem models to create the first ecosystem predictions of the Arctic Ocean.

Links to other Tasks: 1.1.3, 1.2.1, 1.2.2, 1.3.1, 4.1.3, 4.2.2, 5.2.2

Deliverables in 2026: None

T1.2.4. Identify ongoing changes in biodiversity and connectivity in regions adjacent to the Arctic Ocean as a basis for future northward expansions

PI: UiO. **Participants**: APN, IMR, NINA, NORCE, NPI, UiB, UiT, UNIS

Work description: Since the potential future northward redistributions of species into the Arctic Ocean will originate from the adjacent regions, including the continental shelves, this task will examine spatiotemporal biodiversity changes in these regions. Knowledge on biodiversity patterns (including hotspots) and changes over space and time, as well as understanding the mechanisms at work in such neighbouring areas, is crucial to understanding the effects of climate change on Arctic Ocean ecosystems over time. We will, for example, use time-series data from tracking and monitoring of seabirds in collaboration with the ongoing SEATRACK and SEAPOP programmes, as well as existing trawl data of both commercial and non-commercial fish species and already collected environmental DNA metabarcoding/metagenomics data from water samples. Additionally, we will use new data from sampling campaigns organized within this programme and international collaborative efforts. These data will be used to characterize changes in biodiversity, distribution, and abundance of species. We will also examine how these alterations are associated to shifts in main prey items for

seabirds and fish. Moreover, we aim at taking full advantage of the recent developments in high throughput sequencing technologies to characterize the genetic diversity, sub-population structuring and connectivity of key fish species in the pan-Arctic region, to further evaluate if some sub-units of the stocks are more likely to contribute to the northward expansions (via interconnections between the Arctic Ocean and adjacent regions) than others (Theissinger et al. 2023, Bernatchez et al. 2024). Genetic characterization will also include planktonic and meroplanktonic taxa.

Links to other Tasks: 1.2.5, 1.3.3, 2.4.3, 2.4.4, 2.4.5, 2.5.3, 2.5.4, 3.1.2, 3.2.5

Deliverables in 2026: Compilation of available datasets, including international collaboration.

T1.2.5. Investigate near-term predictability of northward expansions of species

PI: NINA. **Participants**: APN, IMR, NPI, UiB, UiO, UiT, UNIS

Work description: In the upcoming years, species from adjacent areas may establish permanent or temporary populations in the Arctic Ocean, or they may use the Arctic Ocean during different life stages. This task will explore the predictability of climate-driven near-term poleward redistributions of species (e.g., fish, seabirds, marine mammals, benthos, plankton), using different approaches depending on whether the species are redistributed by active migration or passively transported. We will establish competence within the consortium and provide an overview of relevant models (hybrid workshop, Tromsø 2026). We will evaluate these approaches, such as species distribution models including habitat-suitability or climate-envelope models (Isaac et al. 2020, Karp et al. 2025). We will develop models suitable for high latitude environments, including phenology and light conditions. The likelihood that fish redistributions will occur can be examined by models including physiology, food requirements, prey encounter and risks. Seasonality can be integrated as a key driver in the models to realistically predict life-history adaptations. We will examine transport of plankton and fish larvae in hindcast and downscaled climate predictions from climate models. We will investigate the importance of sea-ice habitats and examine what the Arctic Ocean and adjacent regions will look like with less sea ice, in terms of oceanography and prey availability, for example for seabirds. For the modelling, we will provide an overview of relevant time-series survey and tracking data, existing data from the Arctic basin and from international initiatives (see T1.2.4), and we will also use new data from the *Arctic Ocean 2050* cruises.

Links to other Tasks: 1.2.4, 1.3.3, 2.4.3, 3.1.2, 3.2.5

Deliverables in 2026: Short workshop note (overview of relevant models)

Priority Topic 1.3: Assess long-term projections of the Arctic Ocean environment

PT1.3 will use Earth system models to develop plausible storylines for the long-term (toward 2050 and 2100) Arctic Ocean climate evolution and project associated long-term species redistributions into the region. Identifying which changes are robust across

model ensembles is important to this activity, and we will use both novel (e.g., machine learning) and established tools to identify the most credible models based on observational constraints. Relevant past climate change inferred from paleoclimate data will be applied to assess the integrity of model projections and guide further improvements of Earth system models, including NorESM.

T1.3.1. Assess future projections of the Arctic Ocean in NorESM and CMIP7

PI: UiO. **Participants**: NERSC, UiB

Work description: T1.3.1 will assess climate and climate change in the Arctic during the recent past and toward 2050 and 2100 using the next generation of Earth System Models (CMIP7) in general, and NorESM in particular. Data from these models is scheduled to be released during 2026 and will make a timely contribution to *Arctic Ocean* 2050. This subtask will analyse simulations of relevant oceanic (e.g., hydrography and stratification), cryospheric (e.g., sea ice concentration and thickness), atmospheric (e.g., air temperature and precipitation), and biogeochemical (e.g., nutrients and carbon fluxes) variables, and identify robustness and spread in outcomes across models and emission scenarios. The relative roles of model uncertainty, scenario uncertainty, and internal variability for future change will be quantified. We will also attribute projected changes in the Arctic to large scale (e.g., Atlantic Meridional Overturning Circulation (AMOC); links to T1.1.3) and regional (e.g., sea ice loss; links to T2.1.7) drivers, and use this understanding to find physics-based emergent constraints that reduce the uncertainty in the future projections.

Links to other Tasks: 1.1.3, 1.3.4, 2.1.7, 3.1.2, 3.2.5, 4.1.3, 4.2.2, 5.2.2, 5.2.5

Deliverables in 2026: None

T1.3.2. Calculate Arctic climate feedback processes and how they evolve with climate state

PI: UiO. **Participants**: MET?

Work description: Arctic climate change is the result of anthropogenic forcing, amplified by Arctic climate feedback mechanisms, and shaped by the transport of heat and moisture from lower latitudes. This task focuses on the role of physical climate feedback processes, and specifically surface albedo feedbacks mediated by the reduction of sea ice and snow-covered land, and atmospheric feedbacks associated with changes in aerosols, moisture and clouds. Such feedbacks can be calculated with the help of radiative kernels using standard model output from CMIP7/NorESM, and will shed light on the relative roles of these processes in driving Arctic amplification, as well as how we can expect these roles to change in the future under different scenarios. Observational constraints on the different feedback strengths will allow us to assess model realism when it comes to simulation of different physical climate feedbacks in the Arctic.

Links to other Tasks: 1.3.1, 2.1.2, 4.1.1, 5.3.1

Deliverables in 2026: None

T1.3.3. Explore long-term projections of climate-driven poleward redistributions of species

PI: NINA. **Participants**: APN, IMR, NPI, UiB, UiO, UiT

Work description: Several extra-regional drivers are expected to influence the future physical and biogeochemical properties of the Arctic Ocean, potentially affecting shifts in species distributions. This task focuses on the predictability of climate-driven poleward redistributions of species in the long-term. How far north will different ecosystem components, such as, for example, fish or seabirds, reach in 2050 or beyond? We will first establish competence within the consortium and compile an overview of available models that can be used to investigate potential northward expansions of species. This work will be coordinated with T1.2.5 on near-term predictions (hybrid workshop, Tromsø 2026). Relevant climate scenarios (existing or new from *Arctic Ocean 2050*) will serve as input for species distribution models to generate long-term projections of redistributions for both commercial and non-commercial species into the Arctic Ocean. The role of the new light conditions (linked to changes in sea-ice) for long-term changes in species distributions will be examined, and we will develop models suitable for high latitudes. Different functional groups and trophic levels as well as the typical depths inhabited in the water column will be included in the investigation.

Links to other Tasks: 1.2.4, 1.2.5, 2.4.3, 3.1.2, 3.2.5

Deliverables in 2026: Short workshop note (overview of relevant models).

T1.3.4. Past climate states as analogues for the future Arctic

PI: UiB. **Participants**: NGU, NORCE, UiO, UiT, UNIS

Work description: Task 1.3.4 will constrain a warmer Arctic ocean-climate state, its variability, and impacts. We will establish a paleo-observational baseline for different periods of past warmth for contextualizing ongoing changes and constraining models and storylines. We will reconstruct sea ice, ocean, and climate conditions, along with Atlantic Water inflow strength in past warm periods by analysing key climate proxies (e.g., grain size analysis, biomarkers, faunal assemblages, isotopes, trace metals, clumped-thermometry, sedimentary DAN (sedDNA)). Individual foraminiferal analysis will be used to investigate how high frequency variability in climate and Atlantic Water inflow properties, extremes, and ocean stratification changes in a warmer Arctic. Ecosystem impacts due to changing sea ice conditions will be explored on historical to geological timescales through sedDNA. Clumped isotope analysis in conjunction with classical oxygen isotope analysis will enable us to disentangle temperature and salinity signals in different water masses. To improve paleo-proxy calibrations specifically for the Arctic region, we will use a transect of modern to Holocene sediments (targeting available oceanographic observation sites) to compare proxy signals and observations and establish a modern baseline. Building on this ground-truthing work, new and

existing high resolution sediment cores will be used to establish the climate-ice-ocean-ecosystem responses to past warmer periods (e.g., MIS 5, 11, Pliocene).

Links to other Tasks: 1.3.1, 2.2.1, 4.1.1, 4.2.1

Deliverables in 2026: None

Priority Topic 1.4: Identify external impacts of a changing Arctic Ocean

PT1.4 will investigate the external impacts of a changing Arctic Ocean with a transdisciplinary approach, ranging from physical, chemical and biotic changes in neighbouring seas and up to global physical and governance systems.

T1.4.1. Investigate the export and impacts of Arctic surface and dense waters

PI: UiB. **Participants**: APN, NORCE, NPI

Work description: As the transition towards a seasonally ice-free Arctic Ocean continues, enhanced convection and dense water formation can be expected, leading to a possible strengthening of the Arctic overturning circulation (Årthun et al. 2025). The Arctic overturning circulation could therefore be a stabilizing factor in a weakening AMOC, but the larger scale impacts of increased Arctic dense water formation remain to be determined. In T1.4.1 we will accordingly investigate the downstream pathways, modification, and impacts of Arctic dense waters. The export pathways of freshwater from the Arctic Ocean and their downstream impacts on convection in the Nordic Seas and subpolar North Atlantic will also be investigated. Transports, pathways, and downstream impacts of Arctic surface and dense waters will be quantified using Lagrangian simulations (TRACMASS; Döös et al. 2017) together with output from high-resolution models and reanalyses, and new NorESM simulations with realistic freshwater fluxes from the Greenland ice sheet. Timeseries of sea ice and freshwater transport from the Fram Strait Arctic Outflow Observatory will provide insights into ongoing Arctic Ocean changes and will enable to understand the implications of a change in the ratio of solid (sea ice) to liquid freshwater export. Changes in freshwater export from the Arctic Ocean and associated circulation changes downstream will also be assessed in paleoclimate records that provide robust analogues for future changes. The circulation and formation of dense waters will also be evaluated by using different chemical tracers such as transient tracers (SF6, CFC-12), oxygen, nutrients, and inorganic carbon.

Links to other tasks: 1.1.4, 1.3.1, 2.1.4, 2.1.7

Deliverables in 2026: None

T1.4.2. Atmospheric pathways of the impacts of a changing Arctic Ocean

PI: NERSC. **Participants**: UiB

Work description: Rapidly warming sea surface temperatures in the Arctic Ocean and the concurrent sharp decline in sea ice cover can alter meridional temperature gradients

in the atmosphere, lower-tropospheric stability, and surface heat and moisture fluxes, thereby perturbing large-scale atmospheric circulation and energy exchange with the mid-latitudes (Vihma 2014). In particular, for the North Atlantic sector, Arctic surface anomalies can modulate the position and strength of the jet stream and the North Atlantic Oscillation, which, in turn, influence weather and climate over Europe and the North Atlantic coasts (Overland et al. 2016). This task will investigate the atmospheric pathways through which amplified Arctic surface changes impact the mid-latitudes, with particular emphasis on Atlantic-region weather and extremes. Specifically, we will assess how modified Arctic surface conditions reshape large-scale circulation features such as the polar jet stream, planetary waves, storm tracks and blocking patterns. New simulations with prescribed observed Arctic surface conditions of interest will be configured and performed using the latest version of NorESM. These simulations, together with observations and reanalysis products, will be used to isolate and quantify the downstream atmospheric response.

Links to other tasks: 1.1.3, 2.1.1, 4.1.3, 4.1.6

Deliverables in 2026: None

T1.4.3. Analysis of how Arctic Ocean change is shaping security and foreign policy in key Arctic and non-Arctic states and NATO

PI: NUPI. **Participants**: UiO, UiT, others as relevant

Work description: The projections and predictions explored in PT1.2 and PT1.3, as well as ongoing environmental and political change, are shaping how states view the security and defense dynamics in and around the Arctic Ocean. This task will examine how Arctic and key non-Arctic states – as well as the NATO alliance – are assessing Arctic change in their foreign and security policies and will analyse the knowledge milieus and policy networks shaping these positions. The extent to which security/foreign policies are informed by accurate understandings of ongoing and expected natural change will be assessed and form one of the early interdisciplinary conversations within *Arctic Ocean 2050*.

Links to other tasks: 1.1.1, 1.1.2, 3.3.1, 3.3.2

Deliverables in 2026: None

T1.4.4. Assessment of Arctic-specific climate interventions and ongoing efforts/state of governance around these, including Arctic actors' position

PI: NUPI. **Participants**: UiO, UiT, others as relevant

Work description: This task will evaluate the eventual global normative and policy repercussions of potential Arctic specific climate interventions, e.g., technologies to refreeze the Arctic Ocean sea ice, and address environmental safety, governance, and legal concerns. The work will also include simulations of broader scale climate consequences of such interventions, with emphasis on assessments of the associated risks. The governance of possible climate interventions remains a complex question and

falls partly between several legal global legal regimes. This task involves a study of the state of precautionary governance of climate interventions in the Arctic and an analysis of the positions taken by different milieus/actors (private, public, rightsholders) shaping the Arctic conversation on climate interventions. In conversation with modelling work on plausible Arctic climate interventions and investigating their impact in NorESM3, this study also will facilitate a conversation on risks and the need for a precautionary approach through an early and critically important interdisciplinary conversation on this rapidly developing policy and technology field.

Links to other tasks: 1.1.1, 1.1.2, 3.3.1, 3.3.2

Deliverables in 2026: None

Table 1.1. Summary of Tasks in RT1 (2026-2028).

Tasks - RT1	**Partners**
T1.1.1. Scoping exercise Arctic Ocean geopolitics and security research state of the art	NUPI, FFI, FNI, UiO, UiT, others
T1.1.2. Scoping exercise Arctic Ocean governance and legal dynamics	FNI, NUPI, SINTEF, UiO, UiT, others
T1.1.3. Determine how large-scale oceanic and atmospheric circulation changes impact the Arctic Ocean	IMR, NERSC, NORCE, UiB, UiO, UiT,
T1.1.4. Horizontal transfer of freshwater, heat, terrigenous material (nutrients, carbon, contaminants) from river runoff and land-ocean interactions	NINA, APN, IMR, NORSAR, NPI, UiO
T1.1.5. Assess extra-regional (NATO, EU, Nordics) pathways for ameliorating current and future risks to critical infrastructure	NUPI, FFI, FNI, UiO, others
T1.1.6. Assess key areas of global governance impacting Arctic Ocean governance	FNI, NUPI, SINTEF, UiO, UiT, others
T1.2.1. Expert solicitation to identify key climate variables of interest to *Arctic Ocean 2050*, and identification of corresponding observational data	UiO, all partners
T1.2.2. Model evaluation using historical and paleo-data of key variables	UiO, NERSC, UiT
T1.2.3. Evaluate sub-seasonal to decadal prediction skill in the Arctic Ocean	UiB, NERSC

T1.2.4. Identify ongoing changes in biodiversity and connectivity in regions adjacent to the Arctic Ocean as a basis for future northward expansions	UiO, APN, IMR, NINA, NORCE, NPI, UiB, UiT, UNIS
T1.2.5. Investigate near-term predictability of northward expansions of species	NINA, APN, IMR, NPI, UiB, UiO, UiT, UNIS
T1.3.1. Assess future projections of the Arctic Ocean in NorESM and CMIP7	UiO, NERSC, UiB
T1.3.2. Calculate Arctic climate feedback processes and how they evolve with climate state	UiO
T1.3.3. Explore long-term projections of climate-driven poleward redistributions of species	NINA, APN, IMR, NPI, UiB, UiO, UiT
T1.3.4. Past climate states as analogues for the future Arctic	UiB, NGU, NORCE, UiO, UiT, UNIS
T1.4.1. Investigate the export and impacts of Arctic surface and dense waters	UiB, APN, NORCE, NPI
T1.4.2. Atmospheric pathways of the impacts of a changing Arctic Ocean	NERSC, UiB
T1.4.3. Analysis of how Arctic Ocean change is shaping security and foreign policy in key Arctic and non-Arctic states and NATO	NUPI, UiO, UiT, others
T1.4.4. Assessment of Arctic-specific climate interventions and ongoing efforts/state of governance around these, including Arctic actors' position	NUPI, UiO, UiT, others

RT2: The Changing Arctic Ocean



Lead: Paul Dodd (NPI). Co-lead: Bodil Bluhm (UiT)

Objective: Explore the atmosphere, sea ice, water column, and seabed within the Arctic Ocean.

Priority topics:

2.1 How will increased poleward transport of heat, momentum, salt/moisture in the ocean and atmosphere affect the sea ice cover, light environment, stratification, and water mass transformation and circulation inside the Arctic Ocean?

2.2 What are the physical properties of the seafloor and how quickly do the processes change? What do the paleoclimatic record and present biota tell us about the past and present functioning of the Arctic Ocean?

2.3 Which processes control the transformations and flows of carbon and nutrients through the Arctic Ocean today and how are these changing? Will the future Arctic Ocean be a carbon sink or source?

2.4 What spatial and temporal variability in biodiversity is found in sea ice, water column, and seafloor habitats? Which processes are steering that variability, and how will on-going environmental changes affect biodiversity and ecosystem functioning?

2.5 How are trophic interactions and resource competition shaped by resident, migrating, and advected species, and how may this change in the future?

These priority topics form the basis for the tasks outlined below.

Priority Topic 2.1: Physical Interactions between the Ocean, Sea Ice and Atmosphere

With a regional focus on the Arctic Ocean, PT2.1 will investigate the roles of oceanic and atmospheric properties in determining sea ice cover, including the roles of clouds, radiation, net precipitation minus evaporation, and local atmospheric systems such as the Beaufort High. In the ocean, exchanges with adjacent regions are highly relevant, especially changing inputs of run-off and brine from the peripheral shelves and inputs of heat and salt via major currents which provide a link to work in RT1. PT2.1 will investigate the Atlantic Water boundary current, where we will study both exchanges with the basins in the central Arctic Ocean and the potential for enhanced local dense water formation as air-sea interactions intensify under increasingly ice-free conditions. As the Arctic Ocean shifts from perennial to seasonal sea ice cover, the release of seasonal meltwater will affect the seasonal stratification. This PT will evaluate the collective impact that changes in ice-type, snow cover, and surface stratification will have for air-sea heat and gas exchange, propagation of sound and light, micro- and macronutrient availability for biota, exposure to physical and chemical stressors, and how these changes affect the niches in which key species can operate. PT2.1 will use *existing*, in-situ, remote sensing and modelling tools to deliver science results needed

for management decisions on the horizon; development of next-generation tools is the mandate of RT5.

T2.1.1. Waves and winter sea-ice growth in the central basins

PI: UiB. **Participants:** MET, NERSC, NORCE, SINTEF, UNIS

Work description: The summer open water areas inside the Arctic Basin are presently projected to freeze by CMIP6 models that show March sea-ice area above ~8 million km² until the 2080's (Keen et al 2021). The re-freezing area may thus more than double from the ~3 million km² today. In these areas the wind forces waves where they have never been before, and there is a fundamentally new and unknown situation when new sea ice forms. With open water and enough wind, the surface quickly becomes wavy and frazil and grease ice forms (Smedsrud 2011). This grease ice layer behaves like a layer of grease or oil with higher viscosity than water and dampens surface waves. This wave-ice interaction is not well understood, global models do not resolve grease ice and wave processes, and this will therefore be the primary focus of Task 2.1.2. The work in Task 2.1.2 will rely on a combination of new observations of sea-ice, waves and atmospheric fluxes as well as high-resolution ocean and wave models which also are important processes for biology and the incorporation of life into the Arctic pack ice when sea ice forms.

Links to other Tasks: 2.1.3, 2.1.6

Deliverables in 2026:

- In situ measurements of sea ice and snow physical properties during the 2026 Eurasian Basin Transect cruise.
- Ship-based meteorological measurements during 2026 Eurasian Basin Transect cruise.
- Contributions to 2026 Eurasian Basin Transect cruise report.

T2.1.2. A new sea ice regime: Sea-ice physical characteristics and their role in atmosphere-ice-ocean interactions

PI: NPI. **Participants**: MET, NERSC, NORCE, NTNU, SINTEF, UiO, UNIS

Work description: Sea ice governs mass and energy exchanges between the atmosphere and the ocean. Sea-ice pack characteristics including snow cover, melt ponds and leads/fractures are important for freezing and melting processes, albedo and light penetration to the ocean and ultimately shape conditions for primary production and the marine food web. Here we aim to characterize the contemporary mobile sea ice pack across all seasons on multiple scales, with aid from observations in RT5, to infer critical properties of the ice pack that control these exchange processes. For example, sea-ice surface roughness from a hierarchy of observations from above and below (RT5) plays an important in momentum transfer and mixing in the atmospheric boundary layer whose structure and evolution under rapid warming and moistening are poorly understood, as are the microphysical and radiative properties of mixed-phase clouds that strongly influence surface energy budgets.

The heterogeneous and transient response of sea ice to atmospheric phenomena such as warm and moist air intrusions (WAI), including the interplay between surface melt, refreezing, and ocean–ice heat exchange, also remains poorly characterized. Furthermore, current coupled atmosphere–ice–ocean models inadequately resolve fine-scale feedbacks and often misrepresent the frequency and intensity of these intrusions. Together, these gaps constrain our capacity to predict the short- and long-term impacts of such phenomena on Arctic amplification and its linkages to mid-latitude weather systems (link to RT1). This work will evaluate the role of ocean-ice-atmosphere interactions in sustaining or damping the impacts of atmospheric phenomena such as WAIs on surface conditions using existing and new in-situ observations from *RV Kronprins Haakon*, reanalysis, and model experiments.

Links to other Tasks: 2.1.1, 2.1.5, 2.1.6

Deliverables in 2026:

- In situ measurements of sea ice and snow physical properties during the 2026 Eurasian Basin Transect cruise.
- In-situ meteorological measurements during 2026 Eurasian Basin Transect cruise.
- Contributions to 2026 Eurasian Basin Transect cruise report.

T2.1.3. Seasonality of light availability in the central Arctic Ocean

PI: UiB. **Participants**: APN, NPI, NTNU, UiT

Work description: Sunlight is a key factor for physical and biological processes in the upper ocean. It is a primary source of energy for primary production and for sea ice melt, is crucial for vision, and shapes zooplankton and fish behaviour. Sea ice plays a crucial role in underwater light conditions, including altering the spectral composition that affects biodiversity and light penetration (Sandven et al. 2026). Here, we will utilize year-round direct measurements in the Central Arctic to observe seasonality of light conditions in the upper ocean and use satellite data to upscale to a pan-Arctic context. Contrasting lightscapes may be seen across the basins due to sea ice conditions (e.g., ice types, thickness, leads) and water properties, which will be measured by upward-looking sonars, bio-optical sensors and satellites (RT5). Imaging sensors will provide observations of zooplankton and marine snow, allowing us to study how contrasting lightscapes shape Arctic biodiversity (RT2.3).

The Nansen Basin will likely experience ice-free conditions in the coming decade; transitioning into a rare seasonally ice-covered region close to the North Pole. This will have an immense effect on light-driven physical and biological processes. We will provide data to develop spectrally resolved radiative transfer models to estimate the seasonal light climate in the current and future Arctic and to validate existing radiation schemes in coupled ice-ocean models (PT2.3, RT5). Recent satellite missions have great potential to improve estimates of how spatially variable sea ice covers influence the under-ice light field. In 2026, we will build a sensor-set to deploy sensitive PAR

sensors on moorings in the Central Arctic to acquire data from 2026 to 2028, and begin analysing existing satellite sea-ice data to distinguish different ice types and leads.

Links to other Tasks: 1.2.3, 1.2.5, 1.3.3, 2.5.4, 2.6.1, 3.2.1, 3.2.6, 5.2.1, 5.2.4

Deliverables in 2026:

- Assembly of PAR sensors and deployment on moorings in the Nansen and Amundsen Basins.
- Contributions to 2026 Eurasian Basin Transect cruise report.

T2.1.4. Atmospheric and oceanic hydrological cycles in the central Arctic Ocean

PI: NPI. **Participants**: NERSC, SINTEF, UiB, UiO

Work description: The atmospheric hydrological cycle is changing as the Arctic warms (e.g., Nygård et al. 2020) with increased evaporation from expanding open water areas and more precipitation projected (McCrystall et al. 2021). These changes are altering the freshwater regime in the Central Arctic Ocean in ways that models and observations struggle to characterize, but without a robust freshwater budget for the ocean, we cannot fully understand what is driving changes in stratification, circulation, nutrient, carbon or contaminant concentrations in the Central Basins. This task investigates how changes in the atmospheric and oceanic components of the ocean freshwater budget are affected and influence circulation as sea ice cover declines in the Central Arctic.

Previous studies have shown value in gaining insight into ocean-atmosphere coupling using stable water isotopes as a conserved tracer, measured across the ocean-atmosphere system (Sodemann et al. 2024), helping to understand what drives dynamical changes. New tracer measurements during the 2026 cruise and onward (including d2H & d18O) of water vapor, snow, sea ice and seawater will be used to quantify the role of leads and polynyas in the atmospheric water budget as well as contributions of sea-ice, snow, net P-E and freshwater advected from the peripheral shelves and the Pacific inflow to the oceanic water budget. Both atmospheric (water vapor, clouds and precipitation) and oceanic observations will be compared with simulations from high resolution regional models. This task will inform Task 2.1.7 (on ocean stratification) and 2.2.3 (on ocean acidification) about the contributions of separate freshwater sources.

Links to other Tasks: 1.1.4, 1.4.1

Deliverables in 2026:

- Collection of seawater samples for stable water isotope measurements.
- Onboard measurement of salinity and water vapor isotope ratios during 2026 Eurasian Basin Transect cruise.
- Shore-based stable isotope ratio analysis of central Arctic Ocean water samples.
- Contributions to 2026 Eurasian Basin Transect cruise report.

T2.1.5. Cross-scale interactions

PI: UiB. **Participants**: APN, IMR, NORCE, NPI, SINTEF, UiO, UiT, UNIS

Work description: Recent findings underscore the importance of cross-scale interactions, spanning mesoscale, sub-mesoscale, and finescale flows, in driving turbulent mixing, with implications for energy conversion pathways, water mass transformations, sea ice melt, and primary production in a changing Arctic (Reifenberg & Fer 2025). Quantifying the processes contributing to vertical mixing of Atlantic Water, and interactions between different scales of dynamical forcing, is critical to our understanding of the Arctic climate system (Rippeth & Fine 2022). Projected increases in eddy energy in the Arctic Ocean, coupled with a more seasonal ice cover (Manucharyan & Thompson 2022) have increased relevance for cross-scale interactions. Their implications for setting the upper-ocean stratification, circulation and ecosystem dynamics remain largely unknown. In this task we will combine existing and new observations to address the questions: what are the dominant oceanic processes controlling the evolution of stratification and its response to different external forcing mechanisms, and what are the role and magnitude of energy transfer between processes operating at different scales? We will conduct complementary analyses in the central deep Arctic Ocean and the Whaler's Bay and upper continental slope region north of Svalbard during both winter and summer. The processes of cross-scale interactions and the target study regions have strong links with the tasks below.

Links to other Tasks: 2.1.6, 2.1.7, 2.1.8, 2.1.9

Deliverables in 2026:

- Collection of vertical microstructure profiles during 2026 Eurasian Basin Transect cruise.
- Contributions to 2026 Eurasian Basin Transect cruise report.

T2.1.6. Stratification and internal circulation in the deep Eurasian Basins: impact of Boundary Current signatures

PI: IMR. **Participants**: APN, NORCE, NPI, SINTEF, UiB, UiT, UNIS

Work description: This task focuses on the thermodynamic and dynamic oceanographic processes in the deep Eurasian Basins and how they influence stratification, mixing, and the vertical distribution of heat, nutrients, and contaminants (Polyakov et al. 2020). We expand on Task 2.1.5 by incorporating surface dynamical forcing (Brenner et al. 2021) and the influence of inflowing Atlantic Water (Muilwijk et al. 2023). This task will examine the interplay between Atlantification, changes in freshwater budget (T2.1.5) and the mechanical connection to sea ice and atmosphere. Collaboration with Tasks 2.1.6 and 2.1.8 will connect deep-basin processes to Atlantic Water inflow dynamics.

Using CTD and ADCP time series from Arctic Ocean (2022–present) and A-TWAIN moorings (2012-present), repeated Arctic Ocean CTD sections, high resolution regional model results (Task 2.3.2), and reanalysis products we: a) investigate how Atlantic Water in the central basins is modified by boundary current variability; b) assess the influence

of large-scale atmospheric forcing on surface stratification, including thermodynamic and dynamic air-ice-ocean coupling; and c) investigate deep circulation and residence times. Results will provide a physical basis for the contribution of Atlantic inflows to heat, nutrient, and contaminant budgets in Atlantic and surface layers. We will make use of a range of chemical tracers including SF6, CFC-12 (measured in Task 2.3.4), oxygen and nutrients (core parameters) to complement circulation change assessments.

Links to other Tasks: 2.3.4, 2.6.1

Deliverables in 2026:

- Collection of high-resolution CTD section during the 2026 Eurasian Basin Transect cruise.
- Processing and publication of CTD profiles.
- Contributions to 2026 Eurasian Basin Transect cruise report.

T2.1.7. Quantify water mass transformation in the Atlantic Water boundary current

PI: UiB. **Participants**: APN, NORCE, NPI, SINTEF, UNIS

Work description: The combined effects of recent sea-ice loss and Atlantification along the Atlantic Water boundary current have led to enhanced ocean-atmosphere heat loss (Moore et al. 2022) and water mass transformation (Pérez-Hernández et al. 2019) north of Svalbard. In a warming climate with concomitant reductions in dense-water formation, wintertime water mass transformation along the ice-free stretches of the boundary current system around the Nordic Seas and Arctic Ocean have substantial implications for the supply of dense water to the lower limb of the AMOC. This may impart resilience to the large-scale overturning circulation (Våge et al. 2018; Moore et al. 2022; Årthun et al. 2025).

The main purpose of this Task is to quantify the amount of water mass transformation that takes place north of Svalbard and provide the observational foundation to assess the importance of the Whaler's Bay region for the overturning north of the Greenland-Scotland Ridge. We propose to obtain wintertime observations, from a research cruise on *RV Kronprins Haakon* along the ice-free Atlantic Water boundary current and the marginal ice zone north of Svalbard, of the air-sea-ice interactions that force deep convection. The cruise should take place in February-March, when the atmospheric forcing is most intense, and the ocean mixed layer is at its deepest and densest. Chemical tracers such as SF6, CFC-12, oxygen, nutrients, and inorganic carbon will also be collected and used to infer ventilation time scale and spatial extent.

Links to other Tasks: 1.4.1, 2.1.4, 2.1.5, 2.1.8

Deliverables in 2026: Outline plan for a winter fieldwork programme to quantify the amount of water mass transformation that takes place north of Svalbard.

T2.1.8. Continental slope dynamics and eddy exchange mechanisms linking the shelf, slope and the deep Arctic Ocean

PI: UNIS. **Participants**: APN, IMR, NPI, SINTEF, UiB, UiO

Work description: Because currents in the Arctic Ocean (AO) tend to follow continental slopes and ridge systems, exchanges across AO ridges and between shelves and deep basins are restricted. Here, cross-shelf exchanges of heat, salt, and nutrients are driven by mesoscale eddies that link the warm Atlantic layer with colder shelf waters and shaping the deep basins and Arctic halocline. However, mechanisms governing the eddy-driven cross-slope exchange remain poorly quantified (Timmermans and Pickart 2023; Shu et al. 2023). This task investigates the dynamical processes governing shelf–slope–basin coupling north of Svalbard and around the Eurasian Basin, focusing on eddies and their role in cross-slope transport. We will identify hotspots of eddy generation driven by instabilities and their control on cross-slope transport. We will compile and analyse eddy-resolving model data, subsurface profiling floats, repeated AO CTD/LADCP sections together with observations from A-TWAIN, Yermak Plateau, Nansen Legacy, and Fram Strait moorings to examine short-time variability and eddy vertical structure in hydrography and currents. Using historical and new data, we will identify Topographic Rossby Wave modes, detect instability events and associated eddy structures, and link these to bathymetric variations and local forcing mechanisms (atmosphere, tides, and dense water downslope flow) to better characterize lateral fluxes.

Links to other Tasks: 2.1.5, 2.1.6, 2.1.7

Deliverables in 2026: A quantitative description of short-time current variability (tidal and sub-inertial), eddy events and characteristics, and circulation structure along the continental slope north of Svalbard with quality-controlled historic mooring observations, CTD/LADCP transects, and eddy-resolving model output.

Priority Topic 2.2: Seafloor and Geosphere Interactions

PT2.2 will explore the seafloor and continental margins of the Arctic Ocean and identify past and present processes shaping seabed habitats and submarine landscapes. PT2.2 will also establish paleoclimatic records (including biodiversity and environmental parameters), which will determine past thresholds and species-specific responses to warmer Arctic.

T2.2.1. Identify structure and heat flow of European Arctic Ocean's continental margins

PI: UiT. **Participants:** NORSAR, NPI, UiB, UiO, UNIS

Work description: High-resolution mapping of the seafloor will be carried out. With this knowledge of seafloor topography, underlying morphology and the composition of bedrock and sediments, continental margin models will be developed. The continental margin models will elucidate the stability of the margins by identifying processes

forming the seafloor and continental margins, e.g., faulting and gas seepage in addition to climate processes related to warmer-than-present conditions.

Links to other Tasks: 2.2.2, 2.2.3, 2.3.6, 3.1.3, 3.2.5, 4.3.3

Deliverables in 2026: None

T2.2.2. Identify geology and evolution of Gakkel and Lomonosov Ridges

PI: UiO. **Participants** NGU, NORSAR, UiB, UiT, UNIS

Work description: Geophysical methods and ROV mapping and sampling will be used to investigate the seafloor and its deep underlying morphology. This will give new knowledge of hitherto poorly investigated areas of present and past plate boundaries in the Arctic Ocean, including the Gakkel Ridge and neighbouring segments in the Fram Strait, processes of seafloor formation such as volcanism, tectonism, sedimentation and hydrothermal venting directly influence climatic variations through their connections to ocean currents, and geochemical cycles. The new models of seabed morphology will complement overall Arctic Ocean basin configuration models and can be further used for high resolution coupled climate models. The new knowledge about seafloor morphology and processes will be also used to evaluate the distribution of deep seafloor habitats and resources of the Arctic Ocean.

Links to other Tasks: 2.2.3, 2.3.6, 2.4.4, 3.1.1, 3.1.3, 5.1.4, 5.1.8, 5.2.4

Deliverables in 2026: None

T2.2.3. Determine nature of seafloor and identify habitats

PI: NGU. **Participants**: APN, NORSAR, NTNU, UiB, UiO, UiT, UNIS

Work description: We will determine the nature of the seabed and identify habitat characteristics across the major geomorphological units (mid-ocean ridges, seamounts, abyssal plains, continental slopes and canyons), and minor features such as hydrothermal vents and cold gas seeps, supporting the work on hot and cold spots of diversity. The first phase of this work is based on existing regional (bathymetry, oceanography) and sample data. From 2027, high-resolution acoustics (MBES, SBP), physical seabed sampling, visual observations, and biological data from other PTs will be incorporated for further characterization and modelling of habitats. These results will help identify processes affecting habitats, e.g., sediment transport across continental shelf-slope-deep sea transects and provide a foundation for assessing the impact of climate-induced changes.

Links to other Tasks: 2.4.1, 2.4.2, 2.4.3, 2.4.4, 2.4.5, 3.1.1, 4.1.2

Deliverables in 2026:

- Review available bathymetric, oceanographic, and other regional datasets for the study area and determine which will be used in characterizing physical habitats.

- Initial testing and selection of methods for delineation of relevant geomorphic features and classification of habitat characteristics.
- Short status report.

Priority Topic 2.3: Biogeochemical cycles: baseline, pathways, responses, impacts, and feedback

The cycling of biogeochemical constituents, such as carbon, nutrients, and oxygen, in the Arctic Ocean is essential for regulating environmental states and habitats that the ecosystem relies on. The unprecedented environmental changes in the Arctic Ocean will transform the biogeochemical cycles, prominent among those, the carbon pumps (MacGilchrist et al. 2014). Despite its small area, the Arctic Ocean's role in the global carbon sequestration has increased in the last decades (Yasunaka et al. 2023). Yet, our inadequate knowledge of the current biogeochemical state and understanding of its dependence on physical drivers hinders the ability to predict future changes. An in-depth understanding of the biogeochemical dynamics in the Arctic Ocean across different regimes requires high resolution observational data sets covering key seasons and fit-for-purpose regional coupled models.

T2.3.1. Primary & bacterial production in sea ice, ocean and sediment habitats

PI: UiT. **Participants**: APN, NPI, NTNU, UiB, UiO, UNIS

Work description: This task will determine the primary production and respiration by microalgae, and bacterial production across different habitats within sea-ice, open water, and sea-ice margins. These production estimates will provide a baseline of spatial variability and identify potential biological hotspots in the otherwise production-limited central Arctic Ocean. Observations of microbial communities will range from the millimetre (e.g., brine-channel) to pan-Arctic scale to constrain the scales of variability. Physical-biogeochemical drivers of this variability will be identified and empirically tested in controlled experiments, and generate numerical parameterizations developed for inclusions in marine biogeochemical models. Microbial production associated with chemosynthetic pathways on the seafloor will also be explored given reduced chemicals are present in high concentrations at hydrocarbon seeps and hydrothermal vents. The relative role these deep-sea systems represent for carbon standing stocks will be explored given they occur without passing the water column filtering processes and are not as seasonally variable as autotrophic production. Microbial community interactions with sediment porewater chemistry will be described to provide insight into the largely unquantified role of seafloor carbon fixation in the Arctic Ocean. The labile and recalcitrant components of the organic carbon pools will be characterized through improved sampling, analytical technique, and modelling. In 2026, experiments for production estimates are to be conducted for some microbial communities on the 2026 cruise.

Links to other Tasks: 2.3.2, 2.3.5

Deliverables in 2026:

- Incubation experiments to determine production estimates during the 2026 Eurasian Basin Transect cruise.
- Contribution to 2026 Eurasian Basin Transect cruise report.

T2.3.2. Primary and secondary production modelling

PI: NPI. **Participants**: MET, SINTEF, UiT

Work description: We will use a 3D regional coupled ice-ocean physical-biogeochemical model (S4K_bgc) covering the projects geographic domain, based on the Regional Ocean Modelling System (ROMS) and the Los Alamos Sea Ice Model (CICE) coupled through the Metroms framework developed by MET (Duarte et al. 2022). This model will be benchmarked against observations of physical, chemical, and biological variables. In addition to the existing 4 km configuration, we will use a higher-resolution version to resolve mesoscale processes and a complementary 1D setup for efficient evaluation of alternative parameterizations of mixing, light, and biogeochemistry. The model will upscale basin-wide processes that cannot be quantified from measurements alone (e.g., Castro de la Guardia et al. 2023), including pelagic and sea ice primary production, and the present and future role of the central Arctic Ocean as a carbon sink. Downscaled simulations to our model resolution will cover ~5-year periods between present and 2030, 2045-2050, and 2095-2100, under different Socio-Economic Pathways. The following questions will be answered: 1) How will primary and secondary production in the ocean and the sea ice change under contrasting Socio-Economic Pathways? 2) How may these changes affect the production of harvestable resources? 3) How will these changes be feedback on the physical system?

Links to other Tasks: 2.3.1, 5.2.2

Deliverables in 2026: None

T2.3.3. Drivers of ocean acidification and climate change impacts

PI: IMR. **Participants:** NORCE, NPI, UiB, UiT

Work description: We will assess spatial and interannual variability of air–ice–sea CO2 fluxes and ocean acidification (OA) in the central Arctic basins, margins, and shelf seas using new and historical carbonate system (DIC, TA), nutrients, and high-frequency surface fCO_2 and ancillary data. The study will investigate CO_2 uptake and OA in the upper approximately 400 metres during the transition to a sea-ice–free Arctic, considering sea-ice processes (brine release, melt, leads, open water), freshwater input, water mass distribution change, and biological processes. OA will be characterized through aragonite saturation, pH, and buffering capacity, with emphasis on how contrasting water masses (Arctic shelves, Pacific, Atlantic) advance acidification in the central Arctic Ocean. Regional model ensembles will be applied to evaluate the likelihood of biogeochemical regime shifts under sea-ice–free and high-CO_2 scenarios. Trends and rates of acidification will inform future ecosystem impact assessments.

Links to other Tasks: 1.1.4, 2.3.4, 2.3.5

Deliverables in 2026:

- Collection of seawater samples for total alkalinity and dissolved inorganic carbon measurements during 2026 Eurasian Basin Transect cruise.
- Contributions to 2026 Eurasian Basin Transect cruise report.
- Shore-based analysis of water samples for total alkalinity and dissolved inorganic carbon.

T2.3.4. Physically driven pathways of inorganic carbon sequestration

PI: UiB. **Participants:** IMR, NORCE, NPI, UiT

Work description: We will investigate the impact of an increasing influx of anthropogenic carbon saturated water masses from the Atlantic. We will determine full depth water column concentrations and inventories of dissolved inorganic carbon (DIC) in the Arctic Ocean, separated into natural and anthropogenic components, and determine the underlying processes for carbon storage and temporal changes in storage efficiency. We will furthermore investigate the importance of changes in ventilation (deep water formation and/or circulation of the Atlantic waters) based on in situ observations collected on the 2026 cruise of DIC, total alkalinity, oxygen and nutrients, CFC12, SF6 as well as temperature and salinity. Lastly, we will apply observations-calibrated regional models to project the impact of changing deepwater formation and circulation pathways on future carbon sequestration rates.

Links to other Tasks: 2.3.5, 2.3.6

Deliverables in 2026:

- Collection of seawater samples for SF6 and CFC12 measurements during 2026 Eurasian Basin Transect cruise.
- Contributions to 2026 Eurasian Basin Transect cruise report.

T2.3.5. Biologically driven carbon export in the water column

PI: UiT. **Participants:** APN, NORCE, NTNU, SINTEF, UiB, UiO, UNIS

Work description: This task will investigate and quantify the role of biological-mediated carbon pump (surface productivity, sinking and remineralized organic matters) on shaping the Arctic Ocean carbon balance and consequences of its future changes on the efficiency of CO_2 sink. We will quantify organic matter vertical export quantity, composition and the respective governing processes. In collaboration with Tara Polaris, we will deploy long-term traps and short-term traps at different depths (down to 100 m) to quantify the particulate organic carbon export and the composition of export material from the euphotic zone along the transpolar drift path in a seasonal perspective. We will apply long-term sediment traps in the Nansen- and Amundsen Basin to provide insight into seasonal changes in carbon fluxes and composition in material reaching the deeper seafloor in the two contrasting basins impacted by Atlantification and the transpolar drift, respectively. Quantified annual export rates will be combined with analysis of the composition of exported matter that reflects sources and processes of importance for

regulating the passive sinking part of biological carbon pump (Iversen 2023). A marine snow catcher will be used to quantify and characterize carbon export by fast- and slow-sinking suspended particles and further address factors determining sedimentation. Reconstruction of the biological carbon pump will also be performed with ancient plankton DNA utilizing sedimentary DNA. We will determine future impacts of changes in ecosystem structure and functioning as well as their seasonal characteristics on the biological carbon pump. This task will also measure elemental (C, N, Si, Ca, P, K, Fe etc.) composition and concentration in particles and plankton in ice, water and sediments using X-ray Fluorescence (XRF) spectrometre - a cross-cutting activity between PT2.3, PT2.4 and PT2.5.

Links to other Tasks: 2.3.1, 2.6.1, 2.3.4, 2.3.6, 6.3.1

Deliverables in 2026:

- Preparation and deployment of sediment traps on moorings in the Nansen and Amundsen Basins.
- Collection of sample material for elemental (C, N, Si, Ca, P, K, Fe etc.) composition measurements.
- Contributions to 2026 Eurasian Basin Transect cruise report.

T2.3.6. Seafloor Carbon sequestration

PI: UNIS. **Participants:** APN, UiT

Work description: In this task, remineralization at the seabed (i.e., the regeneration of organic matter into inorganic nutrients and carbon dioxide) will be quantified. Determining remineralization rates allows us to then determine the extent to which carbon is stored and sequestered or regenerated into the pelagic realm. Oxygen consumption, representing the stoichiometric end of carbon remineralization, will be used to determine seafloor remineralization rates and thereby, the extent to which the seafloor can function as a carbon sink. Sediment incubations under controlled conditions will be made at different locations (basins, ridges, etc.; established in T3.2.2) to determine seafloor remineralization rates and to link latitude, topography and water depth (among other variables) to remineralization rates. Climate induced changes impacting larger scale input of carbon due to the sediment due to increased run-off, remineralization, or shelf-basin exchange will be up-scaled and evaluated using regional and global ESM. Elemental analysis of sediments, tracers to detect changes in sediment conditions (e.g., declines in redox potential), and rare-earth element (REE) analysis can support geochemical assessments.

Links to other Tasks: 2.2.2, 2.2.3, 3.2.2

Deliverables in 2026:

- Sediment incubations to determine oxygen consumption rates during 2026 Eurasian Basin Transect cruise.
- Contributions to 2026 Eurasian Basin Transect cruise report.

Priority Topic 2.4: Biodiversity and stocks across habitats

Exploring and understanding the dynamic biodiversity and ecology of Arctic biota provides key knowledge for evaluating status and change of the Arctic Ocean, for effective and urgent management and conservation actions, and geopolitical preparedness for Arctic and global communities. Currently, however, large knowledge gaps remain regarding the biodiversity, distribution, abundance and biomass, and basic biology of all organism groups, including viruses, bacteria, microalgae and other microbes, invertebrates, fish, seabirds, marine mammals, and their parasites (CAFF 2017). Also, biological responses to environmental gradients are poorly known across sea ice, water column and seafloor habitats, especially in the deep ocean (Skjøldal 2022). These knowledge gaps severely limit our ability to link biodiversity to ecosystem functioning and services, anticipate the future Arctic Ocean, and advise stakeholders dealing with Arctic biodiversity components.

T2.4.1. Microbes: Taxonomic and functional diversity and stocks in sea ice, water column and seafloor

PI: UNIS. **Participants**: APN, IMR, NINA, NORCE, NPI, NTNU, UiB, UiO, UiT

Work description: Microbial biodiversity is the largest of any organism group with knowledge gaps across realms and habitats of the Central Arctic Ocean and adjacent slopes (Ibarbalz et al. 2023). Microbes collectively 'make the ocean go around' through performing a myriad of functions from producing oxygen, making DOC available to consumers, to degrading organic matter and certain contaminants (Piontek et al. 2021). This task will obtain knowledge of diversity, distribution and functional roles of all microbial groups including viruses, prokaryotes, protists, and fungi including host-virus interaction in sea ice, the water column and at the seafloor. Primarily molecular – but also traditional microscopic - approaches will be used to map microbial biodiversity including marker and genome sequencing (e.g., metabarcoding and metagenomics). We will compare past microbial diversity from existing sediment cores with present day diversity to identify how microbial diversity has changed over time. Abundance/biomass estimates will be provided by flow cytometry where applicable. Algal biomass will be quantified using chlorophyll *a* measurement. The expression of key genes involved in various functions including biogeochemical cycles (link to PT 2.3) will be quantified for selected organism groups using state-of-the art –omics techniques. Contrasting gene expression under differing conditions – whether seasons, temperatures, habitats (e.g., sea ice versus water column versus sediment) will shed light on Arctic Ocean functioning. For protists, experimental and literature work will be conducted to complement ongoing efforts for a biological traits database.

Links to other Tasks: 2.3.1, 2.3.5, 2.3.6, 2.5.1, 2.5.4

Deliverables in 2026:

- Manuscript on pelagic protist diversity from previous cruises.
- Arctic Ocean cruise participation and contribution to 2026 cruise report.
- Workshop on molecular biodiversity approaches and protocols (–omics, eDNA).

T2.4.2. Zooplankton and ice fauna: Taxonomic and functional diversity, distribution and stocks

PI: UNIS. **Participants**: APN, IMR, NPI, NTNU, UiB, UiO, UiT

Work description: Zooplankton communities differ across depth layers in the Central Arctic Ocean and adjacent slopes, and their biodiversity is broadly characterized (Kosobokova et al. 2011, Wold et al. 2025). This task will fill some of the large spatial and seasonal gaps across the study area. In sea ice habitats, the task will fill species identity gaps and characterize adaptation mechanisms to the extreme conditions. Parasite occurrence across metazoans urgently requires attention given its relevance for nearby Norwegian fisheries and protected/threatened species. Zooplankton will be sampled via traditional nets, with acoustics (larger species), imaging techniques and perhaps drones or remote sensing. Ice fauna will be sampled by nets, trawls and ROV video transects and sea ice cores and baited traps. Analysis approaches will include integrated taxonomy combining metabarcoding of whole communities and environmental samples (eDNA) and metagenomics with microscopic techniques, and analysis of acoustic data. Particular attention will be dedicated to the detection, distribution and abundance of boreal taxa and potential 'new arrivals'. Sequence reference databases will be expanded by barcoding individual, well-identified specimens to increase the match rate of sequences with taxon identity. An existing traits database will be expanded and improved.

In 2026, the task will summarize data from 2021-2024 cruises. Also, new zooplankton and ice fauna samples will be collected in the Nansen and Amundsen basins. In later years, the generated data will be used to identify biodiversity hot spots.

Links to other Tasks: 2.3.1, 2.4.3, 2.4.6, 2.5.3, 3.2.2, 3.2.6, 5.1.8

Deliverables in 2026:

- Cruise participation and contribution to cruise report 2026.
- Workshop on molecular biodiversity approaches and protocols.
- Manuscript on zooplankton and sympagic meiofauna from previous collections.

T2.4.3. Fish: Taxonomic and functional diversity, biology, distribution and stocks

PI: NPI. **Participants**: APN, IMR, NINA, UiB, UiO, UiT

Work description: Anticipation of exploratory fish stocks in the Central Arctic Ocean (CAO) has led to the CAO Fisheries Agreement (CAOFA), with a moratorium to prevent unregulated high seas fisheries. Pelagic fish, e.g., capelin and juvenile redfish, are abundant on the shelves and slopes but diminish into the deep CAO. Mesopelagic fishes occur in the mesopelagic layer (300-500 m), but fish abundance and diversity are very low in both the water column and at the seafloor of the CAO (Mecklenburg et al. 2013, Ingvaldsen et al. 2023). The task will focus on filling spatial and seasonal gaps related to fish in all habitats in line with the Joint Program of Scientific Research and Monitoring developed by the CAOFA. Morphological, molecular, and acoustic methods will be applied to characterize biodiversity, distribution, biological traits, and stock sizes.

Analysis approaches will include integrated taxonomy combining analysis of eDNA from water, ice, and sediment samples, and genomics from tissue samples, advanced imaging/microscopic techniques, and analysis of acoustic data. Data from hydroacoustic surveys combined with pelagic trawling conducted with *RV Kronprins Haakon* in the Arctic Ocean since 2021 will be used. In addition, instrumentation for fish detection will be deployed on moorings and drifting sea-ice platforms.

Links to other Tasks: 1.2.4, 1.2.5, 2.4.2, 2.5.2, 3.2.1, 3.3.3, 6.1.1

Deliverables in 2026:

- Contribution to cruise report 2026.
- Workshop on molecular biodiversity approaches and protocols.

T2.4.4. Benthos: Taxonomic and functional diversity and stocks

PI: NORCE. **Participants**: APN, IMR, NINA, NPI, UiB, UiO, UiT, UNIS

Work description: Benthic invertebrate communities differ across depths and habitat types of the Central Arctic Ocean and adjacent slopes. Recently summarized Arctic deep-sea benthic diversity (Ramirez-Llodra et al. 2024) indicates high discovery potential for new species, uncharted assemblages and genetic resources (e.g., bioactive molecules) in chemosynthetic habitats, a gap to be filled in this task. Also, spatial distributions of vulnerable marine species will be determined since they are relevant for conservation planning. Sampling of the seabed will be via traditional corers, complemented by imaging techniques (camera, ROV). Analysis approaches will include integrated taxonomy combining analysis of sediment eDNA, metabarcoding of whole communities, metagenomics, and advanced imaging/microscopic techniques. As with zooplankton, quantification of boreal taxa and 'new arrivals' will also be a focus. Sequence reference databases will be improved by adding barcodes of well-identified specimens.

In 2026, the task will use data from 2021-2024 cruises, complemented by new collections to be made in 2026 in the Nansen and Amundsen basins. In 2027, field work may focus on the Yermak Plateau and the region north of Svalbard where vulnerable benthic species and habitats are targets.

Links to other Tasks: 1.2.4, 1.2.5, 2.2.3

Deliverables in 2026:

- Contribution to cruise report.
- Manuscript on benthic meiofauna from 2021 collections.
- Workshop on molecular biodiversity approaches and protocols.

T2.4.5. Ice-dependent top trophic species

PI: NPI. **Participants:** APN, IMR, NINA, UiB, UiT

Work description: All Arctic endemic marine mammals rely on sea ice as their primary habitat. The Marginal Ice Zone (MIZ) is a critical foraging habitat for endemics, seasonal migrants, and several seabird species (Cusset et al. 2019; Hamilton et al. 2021). Intensified Atlantic inflows and concomitant declines in sea ice are altering habitat structure and prey communities (RT2), while increased anthropogenic activity is elevating the risk of vessel strikes, oil spills, pollution, entanglement, and disturbance from chronic ocean noise (RT4). The proposed cruise tracks offer the opportunity of collecting complementary upper-trophic level data in this sensitive habitat. A proposed 2027 survey of the marginal ice zone would offer the opportunity to undertake concerted abundance survey effort via helicopter for Arctic species (polar bears, bowhead whales, narwhal, and ivory gulls), including biopsy sampling (for T3.2.3) and cetacean tagging (adding to our distributional time series). To maximize detection opportunities, additional tools, such as utilizing drones, towed hydrophones, PAM devices placed at key-sites, blood and feather sampling, and baiting and tagging of seabirds at the ice edge, can create further high-value data. Opportunistic sightings, supported by high-zoom digital cameras, eDNA sampling (Task 2.4.3) and passive acoustic monitoring in 2026/28, can document species occurrence and latitudinal patterns, particularly boreal species shifting northward.

Links to other Tasks: 1.2.4, 2.1.2, 3.2.3, 3.2.6

Deliverable in 2026: None

T2.4.6 Life cycles, reproduction, physiology and behaviour across taxa

PI: UiB. **Participants**: APN, NTNU, UiO, UiT, UNIS

Work description: The diversity of taxa inhabiting the very different habitats in the study area exhibits a broad suite of different biological and functional traits including reproductive, physiological, behavioural and other traits. Some of these traits are known, some have been inferred from related taxa, or adjacent regions, but many are unknown (Durazzano et al. 2025). These traits shape ecosystem functioning including carbon uptake, storage and sequestration, system productivity, the degree to which communities are resilient or vulnerable, to name a few (Souster et al. 2020). In this task we study life cycles and seasonal timing of key pelagic, ice-associated and benthic taxa, behavioural aspects of select zooplankton, fish and other vertebrates, and reproductive ecology of critical benthic Vulnerable Marine Ecosystem (VME) species. Time and frequency of reproduction, fecundity and longevity are just some aspects that critically determine productivity and vulnerability of these taxa. We will apply a wide array of approaches such as experiments, models, classical histology and anatomy studies, and literature surveys. Trait compilations will feed into established open biological trait databases and will aid in addressing vulnerability versus resilience to possible perturbations. An in-depth modelling study of *Calanus* spp. life history traits and adaptations in response to gradients in light, turbidity, food availability and predation risk will be performed, which in turn will inform likely pan-Arctic spatiotemporal distribution patterns of this species complex. In 2026, this task will begin with collections of material during the 2026 field period.

Links to other Tasks: 2.4, 3.2.3, 3.2.6

Deliverables in 2026: Cruise report contribution.

Priority Topic 2.5: Ecosystem food web – pathways and functioning

Knowledge on how the Arctic Ocean ecosystem's food web works today is currently sparse but is a prerequisite for establishing, and evaluating, conceptual and model scenarios for future functioning under reduced ice-cover, potential harvesting regimes, and other potential interventions. The structure, function, and controls of the Arctic Ocean food web must therefore be characterized to anticipate responses to such perturbations. Sea ice decline, contaminants, toxic algal blooms, diseases, and parasites could potentially have detrimental impacts that spread through the ecosystem. Knowledge of species migrations and transports inside the central Arctic Ocean will further elucidate how strongly coupled ice-water-seafloor and basin-slope/shelf habitats are. None of these ecosystem functions and processes are currently well constrained, in particular for the central Arctic Ocean (Wiedmann et al. 2020).

T2.5.1. Resource competition at the base of the food web

PI: UiB. **Participants**: IMR, NINA, NTNU, UiO, UiT

Work description: This task aims at resolving mechanisms at the base of the food web of the Central Arctic Ocean, namely to delineate controls of the balance of phytoplankton-bacteria competition for mineral nutrients. This balance contributes to determining the magnitude of primary production and pathway of organic material at subsequent trophic levels (Müller et al. 2021). Field experiments and incubations will be conducted to reveal nutrient limitations, competition, and microbial food web structure. Seasonality in the microbial food web is substantial and is to be resolved as much as possible. In 2026, experiments will be started in the field to test bacterial growth limitations with a focus on selected habitats (surface water, sea ice ridges and under-ice freshwater). Protocols for testing phytoplankton growth limitations and carbon transfer will be developed for subsequent years.

Links to other Tasks: 2.1.3, 2.3.1, 2.4.1

Deliverables in 2026: Contribution to cruise report.

T2.5.2. Pathways and carbon sourcing in the classical food web

PI: APN. **Participants**: IMR, NINA, UiB, UiO, UiT, UNIS

Work description: Understanding food web structure is key to understanding carbon flows in the present and future Arctic Ocean. This knowledge must be established to be able to evaluate effects of ongoing and potential perturbations including sea ice decline, fisheries, diseases, parasites, toxic algal blooms and contaminants etc. The few studies that have addressed food web links in the deep Arctic Ocean show a combination of photosynthetic (broadly) and chemosynthetic (locally at the seabed) sourcing, long food webs and diverse feeding guilds (Zhulay et al. 2023, Eilertsen et al. 2024). This task will characterize the structure of the food web in the Central Arctic Ocean, including the

relevant carbon sources and their proportions. The work will address the 'who-eats-whom' using a suite of approaches including traditional diet studies, grazing experiments, trophic markers, molecular tools as well as food web, predator-prey and migration models. In 2026, the goals are twofold: to begin synthesizing existing knowledge on trophic links, and to collect physical material from the 2026 cruise as a basis for new analyses.

Links to other Tasks: 2.5.1, 3.3.4, 3.2.7

Deliverables in 2026: Analyse existing stable C and N isotope samples and publish the data.

T2.5.3. Secondary production

PI: UiT. **Participants**: APN, NPI, UiO, UNIS

Work description: The amount of primary production and advection in the Central Arctic Ocean sets the stage for potential secondary production by subsequent consumer levels. While the primary functional groups in the system are broadly known, the secondary production is essential totally unknown, much in contrast to the well-studied Barents Sea. The exception is the area just north of Svalbard where some estimates for select groups exist (e.g., for some copepod species, Gawinski et al. 2024). This task will generate estimates of secondary production and its controls. Those are to cover gradients of open ocean to high ice-cover, and include consumers in ice, water and seafloor. We plan to combine approaches such as in-situ experiments, age/size-based, energy balance, and other model estimates. In 2026, material will be collected from the 2026 cruise on early life stages of selected copepods and for size-based estimates of pelagic secondary.

Links to other Tasks: 1.2.4, 2.3.2, 2.4.2, 2.4.6

Deliverables in 2026:

- Estimation of *Calanus* egg production and nauplii survival in Amundsen and Nansen basins.
- Contribution to the 2026 cruise report.

T2.5.4. Ecosystem connectivity inside the Arctic Ocean

PI: APN. **Participants:** IMR, NINA, NORCE, NTNU, UiB, UiO, UNIS

Work description: Within the Arctic Ocean, connectivity between biological communities can be strong between shelves and basins, upper ocean and seafloor, and disjointly distributed habitat types (Grebmeier et al. 2005). In this task, we will characterize system connectivity mediated through migration and transport of small-to-large organisms *within* the Arctic Ocean (while RT1 focuses on external connectivity). Mechanisms mediating horizontal connectivity to be studied include linking ice biota to sea ice drift trajectories, identifying biotic dispersal routes among disparate Arctic Ocean habitats such as basins separated by ridges, or between habitats with island

character (sea mounts, vents), tracking amount and composition of biotic transports along the Atlantic Water inflow, examining shelf-basin interactions, to name a few critical links. eDNA results from PT2.4 will be used here to investigate connectivity among habitats. Vertical connectivity will be studied for zooplankton, and marine mammals through, e.g., acoustic methods identifying vertical migrations, or using tags to study diving behaviour; meroplankton in water samples indicated benthic-pelagic connectivity. Particle tracking models will be used to estimate spreading velocities. An important aspect of the task will be to characterize biotic response to key drivers of connectivity, such as response to light, sea ice, hydrographic properties and advection, to name just a few.

Links to other Tasks: 1.2.4, 2.2.3, 2.4.4

Deliverables in 2026: None

Priority Topic 2.6: Enabling Multidisciplinary Observations in the Central Basins

This topic will coordinate multi-disciplinary, in-situ observation campaigns that will compliment international observing efforts in the central Arctic Ocean. As well as coordinating work between different disciplines, a key task will be to establish a set of core parameters that are needed by most RTs and provide the resources to enable these to be delivered quickly and in a consistent manner.

T2.6.1. Maintenance of Sustained Observing System

PI: NPI. **Participants**: IMR, UiB, UiO, UiT, UNIS

Work description: This task will continue a programme of sustained observations in the Eurasian Basin which comprises two mooring sites where year-round observations have been collected since 2022, plus a transect which has been repeated in summers of 2021, 2022 and 2024. In summer 2026, we expect to recover two moorings deployed for the period 2024-2026 and plan to deploy two new moorings at the same sites for the period 2026-2028. Many of the instruments used for the 2024-2026 deployment will be equipped with new batteries and redeployed supported by new mooring hardware.

Raw measurements from the 2024-2026 deployment period will be processed and a time series of temperature, salinity, water velocity, sea ice thickness and sea ice drift measurements will be made available to the consortium. New measurements and sample material collected along the repeated transect in 2026, including hydrographic profiles, in-situ meteorology, nutrients, total alkalinity, dissolved inorganic carbon, oxygen, CFC-12 and SF6, particulate organic carbon and nitrogen, chlorophyll-A and environmental DNA (eDNA), will be analysed and the results made available to the consortium.

This task will also compile a protocol book after reviewing and, where appropriate, refining protocols used during Nansen Legacy, SUDARCO, and MOSAiC cruises. This

will contribute to a smooth transition from previous projects and contribute to consistency and efficiency within *Arctic Ocean 2050*.

Links to other Tasks: 2.1.4, 2.1.7, 2.1.8, 2.3.5, 3.3.2, 5.1.3,

Deliverables in 2026:

- Protocol handbook describing sample collection and analysis procedures for the *Arctic Ocean 2050* programme.
- Organization and execution of 2026 Eurasian Basin Transect cruise.
- Compilation, editing and publication of cruise report.
- Deployment of scientific moorings in the central Nansen and Amundsen Basins with a planned deployment period of two years.
- Collection of samples to enable measurement of core parameters, including nutrients and Chlorophyll-A during 2026 Eurasian Basin Transect cruise.

Table 2.1. Summary of Tasks in RT2 (2026-2028).

Tasks - RT2	**Partners**
T2.1.1. Waves and winter sea-ice growth in the central basins	UiB, MET, NERSC, NORCE, SINTEF, UNIS
T2.1.2. A new sea ice regime: Sea-ice physical characteristics and their role in atmosphere-ice-ocean interactions	MET, NERSC, NORCE, NTNU, SINTEF, UiO, UNIS
T2.1.3. Seasonality of light availability in the central Arctic Ocean	UiB, APN, NPI, NTNU, UiT
T2.1.4. Atmospheric and oceanic hydrological cycles in the central Arctic Ocean	NPI, NERSC, SINTEF, UiB, UiO
T2.1.5. Cross-scale interactions	UiB, APN, IMR, NORCE, NPI, SINTEF, UiO, UiT, UNIS
T2.1.6. Stratification and internal circulation in the deep Eurasian Basins: impact of Boundary Current signatures	IMR, APN, NORCE, NPI, SINTEF, UiB, UiT, UNIS
T2.1.7. Quantify water mass transformation in the Atlantic Water boundary current	UiB, APN, NORCE, NPI, SINTEF, UNIS
T2.1.8. Continental slope dynamics and eddy exchange mechanisms linking the shelf, slope and the deep Arctic Ocean	UNIS, APN, IMR, NPI, SINTEF, UiB, UiO
T2.2.1. Identify structure and heat flow of European Arctic Ocean's continental margins	UiT, NORSAR, NPI, UiB, UiO, UNIS
T2.2.2. Identify geology and evolution of Gakkel and Lomonosov Ridges	UiO, NGU, NORSAR, UiB, UiT, UNIS
T2.2.3. Determine nature of seafloor and identify habitats	NGU, APN, NORSAR, NTNU, UiB, UiO, UiT, UNIS

T2.3.1. Primary & bacterial production in sea ice, ocean and sediment habitats	UiT, APN, NPI, NTNU, UiB, UiO, UNIS
T2.3.2. Primary and secondary production modelling	NPI, MET, SINTEF, UIT
T2.3.3. Drivers of ocean acidification and climate change impacts	IMR, NORCE, NPI, UiB, UiT
T2.3.4. Physically driven pathways of inorganic carbon sequestration	UiB, IMR, NORCE, NPI, UiB
T2.3.5. Biologically driven carbon export in the water column	UiT, APN, NORCE, NTNU, SINTEF, UiB, UiO, UNIS,
T2.3.6. Seafloor Carbon sequestration	UNIS, APN, UiT
T2.4.1. Microbes: Taxonomic and functional diversity and stocks in sea ice, water column and seafloor	UNIS, APN, IMR, NINA, NORCE, NPI, NTNU, UiB, UiO, UiT
T2.4.2. Zooplankton and ice fauna: Taxonomic and functional diversity, distribution and stocks	APN, IMR, NPI, NTNU, UiB, UiO, UiT, others
T2.4.3. Fish: Taxonomic and functional diversity, biology, distribution and stocks	NPI, APN, IMR, NINA, UiB, UiO, UiT
T2.4.4. Benthos: Taxonomic and functional diversity and stocks	NORCE, APN, IMR, NINA, UiB, UiO, UiT, UNIS,
T2.4.5. Ice-dependent top trophic species	NPI, APN, IMR, NINA, UiB, UiT
T2.4.6 Life cycles, reproduction, physiology, and behaviour across taxa	UiB, APN, NTNU, UiO, UiT, UNIS
T2.5.1. Resource competition at the base of the food web	UiB, IMR, NINA, NTNU, UiO, UiT
T2.5.2. Pathways and carbon sourcing in the classical food web	APN, IMR, NINA, UiB, UiO, UiT, UNIS
T2.5.3. Secondary production	UiT, APN, NPI, UiO, UNIS
T2.5.4. Ecosystem connectivity inside the Arctic Ocean	APN, IMR, NINA, NORCE, NTNU, UiB, UiO, UNIS
T2.6.1. Maintenance of Sustained Observing System	NPI, IMR, UiB, UiO, UiT, UNIS

RT3: Human Impact and Sustainable Use

Lead: Sissel Jentoft (UiO). Co-lead: Janne E. Søreide (UNIS)

Objective: Evaluate the prospects and consequences of future human activity in the Arctic Ocean, to secure sustainable Norwegian and international governance and management of this region.

Priority topics:

3.1 What are the prospects for sustainable activities and resource exploitation in the Arctic Ocean in the next and coming decades?

3.2 What are the synergistic effects, cumulative consequences and risks of increased human-induced pressures in the Arctic Ocean, and adjacent ecosystems and societies?

3.3 What future national and regional governance and regulatory mechanisms will be required to ensure sustainable human activity while safeguarding vulnerable biota in the Arctic Ocean and its adjacent seas and societies?

These priority topics form the basis for the tasks outlined below.

Priority Topic 3.1: Scientific foundation for sustainable use of the Arctic Ocean

As the Arctic Ocean becomes increasingly accessible, an in-depth evaluation is needed to assess stakeholders' and industries' interest in utilizing the region, particularly with regard to emerging shipping routes for commercial vessels (cargo and tourism), fisheries, and other activities. This evaluation must also consider how to manage these increased activities in a sustainable manner (Jørgensen 2025). The main focus will be on how the ecosystems in the region will be affected by e.g., chemical pollution, increased underwater noise, changing light-scapes, as well as expansion of fishing grounds due to altered species distribution and migration routes. Additionally, the exploitation of other economically valuable marine resources – such as bioactive compounds, seafloor minerals, and wind/wave energy – will be considered.

T3.1.1. Characterize the current status and potential interest in future activity and exploitation of the Arctic Ocean

PI: IMR. **Participants**: co-lead NTNU, APN, FNI, NINA, NUPI, SINTEF, UiB, UiO, UiT, NORCE, UNIS

Work description: First, we will do an in-depth mapping of the past and current trends in the Arctic Ocean Space Utilization (OSU), including shipping and tourism, as well as other industries, focusing on the Norwegian sector. Next, we aim at investigating the interest in future use as well as exploitation of the Arctic Ocean. This work will be done in close collaboration with RT6. Here, we plan to conduct, a series of cross-sectoral workshops which will include all the main actors (industries, companies, rightsholders and institutions) currently operating in the neighbouring seas (e.g., the Norwegian Sea and the Barents Sea), including commercial vessels (cargo and tourism) and fisheries, as well as emerging industries such as bioprospecting and mineral extraction that are

expected to expand into the Arctic Ocean. We will, together with the industries, policy communities, rightsholders and stakeholders, identify the challenges as well as potential possibilities, based on short- and long-term perspectives, i.e., sub-seasonal/decadal predictions vs. long-term climate projections, for the physical and biological systems in the Arctic Ocean (with input from RT1 and RT2).

Links to other Tasks: 1.1.4, 1.1.5, 1.4.3, 2.3.3, 2.5.2, 3.1.2, 3.3.1, 3.3.2, 6.1.1, 6.2.1

Deliverables in 2026:

- First screening and hand-out of questionaries at the Arctic Frontiers in Tromsø, February 2026 and/or at UArctic in Torshavn, Færøyene, 26-29 May 2026.
- Stakeholder workshop planned in connection with the Arctic Security Conference at SALT in Oslo, in September 2026.

T3.1.2. Evaluate the prospects and implications of increased exploitation of northward expanding key commercial fish species in the future Arctic Ocean

PI: UiO. **Participants**: IMR, UiB, UiT and others

Work description: Here, we will use an integrative approach, i.e., combining ecological modelling with genomic information (generated in RT1) from key commercial fish species (and their sub-populations) that are likely to establish themselves permanently or seasonally in the Arctic Ocean. This approach will be used to evaluate their responses to environmental transitions and their vulnerability to intensified perturbations, including harvesting (see Task 3.2.6). These analyses will for instance include in-depth investigation of the well-known sub-Arctic and Arctic pelagic fish species such as capelin and polar cod, as well as mesopelagic species, including lanternfish species and northern shrimp species (*Pandalus* sp.).

Moreover, we will assess the prospects for increased exploitation of marine resources utilizing ecosystem models like e.g., NORWECOM.E2E (Skogen et al. 1995) and an observational driven dynamic food-web modelling framework CaN (Planque and Mullon 2020). The assessment will involve both present and future changes and focus on energy budgets and flow, trophic structure, climate impact and vulnerability including effects of long-transported pollution.

Links to other Tasks: 1.2.4, 1.2.5, 1.3.3, 2.4.3, 3.2.5

Deliverables in 2026: None

T3.1.3 Evaluate potential areas for other human activities by input from the mapping of the seafloor and subseafloor

PI: UiB. **Participants**: SINTEF, UiT, UNIS and others

Work description: Here, we will identify potential areas for other increased human activities by input from the mapping of the seafloor and subseafloor (input from RT2). Likely areas include environments in and along spreading ridge systems and on the slopes of seamounts, both areas where mineral deposits are formed (Pedersen et al.

2021). In addition, bioresources suitable for commercial use are typically found in areas that host extreme life, such as hydrothermal systems also found at or near spreading ridge systems (Stokke et al. 2020).

Links to other Tasks: 2.2.1, 2.2.3, 2.4.4, 3.2.2, 3.2.5

Deliverables in 2026: A detailed workplan for the mapping of the seafloor and subseafloor starting in 2027 in collaboration with RT2 task 2.2.2.

Priority Topic 3.2: Consequences and risk assessment of increased human activity

An extensive knowledge base and novel analytical tools for risk assessment are urgently needed to determine how cumulative anthropogenic perturbations, including global warming, impact the sensitivity and vulnerability of key species as well as the food-web dynamics in the Arctic Ocean (Jørgensen et al. 2025). An improved understanding on how different stressors impact different components of the Arctic marine ecosystems, i.e., the living biota and their interplay and thus, the overall ecosystems functions, is essential to fuel predictive models, prioritize future monitoring, understand bioaccumulation processes (e.g., for seafood safety). Such knowledge will truly aid in determining the effect thresholds (Scheffer et al. 2015, Dijkstra et al. 2025) and further identify possible future scenarios of the highly complex and fragile Arctic ecosystems.

T3.2.1. Establish a detailed assessment programme for pollutant/contaminant levels and other perturbations

PI: SINTEF. **Participants**: APN, IMR, NERSC, NINA, NORCE, NPI, NTNU, UiO, UiT, UNIS

Work description: The overall goal of this task is to establish a detailed assessment programme for pollutants and other disturbances in the Arctic Ocean to track their presence, transport (oceanic, atmospheric) and distribution in the abiotic compartments and food webs (in close coupling to Task 3.2.2) throughout the programme period. First, a review of available data of pollutants in the polar ocean, coupled to existing knowledge about water and air transport (i.e., atmospheric) to and from the polar ocean (modelling), as well as tracking of pollutants in functional food webs based on trophic markers (stable isotopes), will be conducted. This work will aid in the design of the assessment programme which will include a priority pollutant list considering future pollutants (AMAP; legacy POPs; chemicals of emerging Arctic concern (CEAC), mercury and rare earth elements REE), and macroplastics and microplastics). We will also analyse the historical and present-day observations and simulations of radioactive pollutants as well as anthropogenic carbon and industrial byproducts from man-made sources on their transport pathways, residence times to assess its impact on the Arctic marine environment. Additionally, comprehensive targeted, non-target and suspect screening of chemical marine pollution in various compartments of the environment in the Arctic Ocean using agnostic methods and state-of-the-art analytical tools, including high-resolution mass spectrometry, will be used for future data mining and retrospective analyses to identify and quantify contaminants that are not yet recognized. Other disturbances including underwater noise and changing light conditions will be assessed

using state of the art in situ observational technology, with gathered data serving as input for footprint models.

Links to other Tasks: 1.1.3, 1.1.4**,** 1.4.4**,** 2.5.2, 2.5.4, 2.6.1, 3.2.2, 3.2.3, 3.24, 3.2.6, 3.2.7, 4.1.4, 6.4.1

Deliverables in 2026:

- Organize a workshop during the spring 2026 – with a goal of summarizing available data on pollutants coupled to existing knowledge about water and air transport to and from the polar ocean as well as tracking of pollutants in functional food webs based on trophic markers – aiming to establish an assessment programme to be used throughout the *Arctic Ocean 2050*.
- Set up and implement the assessment/sampling programme for the 50-day cruise in 2026, developed as part of the workshop mentioned above.
- Collect and prepare samples for baseline assessments from the Amundsen basin (i.e., defining the impact of transpolar drift) and the Nansen basin as part of the summer cruise 2026.

T3.2.2. Determine the effect thresholds of cumulative anthropogenic perturbations on microbial organisms, key invertebrates and Arctic fish species in an ecosystem setting

PI: UiT. **Participants**: APN, IMR, NTNU, SINTEF, UiB, UiO, UNIS

Work description: Within this task we aim at determining the effect thresholds for relevant single stressors (including contaminants/pollution, ocean warming, ocean acidification, oxygen content and changes in carbon flux) as well as the cumulative impacts of these stressors on sympagic (i.e., ice associated), pelagic and benthic and subseafloor key components of the food web via controlled multi-stressor experiments. In detail, we will be using a comprehensive approach, combining both *ex situ* (using laboratories) and mesocosms as well as *in situ* by establishing test sites on the seafloor. For these investigations we will take advantage of omics approaches (metagenomics, RNAseq, and proteomics). Moreover, multigeneration effect studies of oil spills on key species will be conducted. Target pollutants and key species selected based on data collected in the first year of the programme. These studies will provide valuable input for cumulative risk and vulnerability assessments of anthropogenic pressures on biodiversity and food webs (Task 3.2.4 and Task 3.2.5). The first experiments are planned to take place during the summer cruise 2026, aiming at characterizing the cumulative effects of ocean warming and nano/microplastic on *Calanus* grazing, reproduction and growth, a key grazer and secondary producer in the Arctic Ocean.

Links to other Tasks: 2.4.6, 2.5.3, 3.2.1, 3.2.3, 3.2.4, 3.2.5, 4.2.3

Deliverables in 2026: Conduct multi stressor experiments aiming at characterizing the cumulative effects of ocean warming and nano/microplastic on *Calanus*, key grazer in the Arctic Ocean, as part of the summer cruise 2026.

T3.2.3. Launching in vitro and ex vivo approaches to assess cumulative anthropogenic impacts on Arctic key vertebrates

PI: NPI. **Participants**: APN, NINA, UiB, UiO, UiT, UNIS, and others

Work description: Within this task we aim to investigate the cumulative impacts of human-induced pressures on vertebrates inhabiting the Arctic Ocean and adjacent ecosystems. We will investigate the responses and thresholds to legacy and emerging contaminants – both alone and in combination with other stressors (e.g., pathogens, ocean warming, acidification, nutritional stress, human disturbance) – in marine mammals, seabirds, and fish. This will be done using cell cultures, molecular assays and tissue slice techniques (Vazquez et al. 2024). In addition, we will use in silico approaches to mine genes involved in contaminant metabolism and responses, i.e., mapping of the chemical defensome *in silico* for key Arctic species (Franco et al. 2025), to further predict species-specific responses and to provide insights into vulnerability within a changing ecosystem. These methods and pipelines have been recently established and validated for polar bears, boreal whales, and fish. The sampling will be done in collaboration with Arctic whale fieldwork planned for 2026 (Coastguard or Fram Strait cruise), Task 2.4.5, and as a part of ongoing research programmes such as polar bear and seabird monitoring.

Links to other Tasks: 2.4.5, 3.2.6, 3.2.7, 4.4.3, 6.4.1

Deliverables in 2026:

- Experiments on existing cell cultures.
- Establishment of new Arctic whale cell cultures.

T3.2.4. Determine the impact of cumulative anthropogenic perturbations on food-web dynamics

PI: UNIS. **Participants**: APN, IMR, NINA, NTNU, SINTEF, UiO, UiT

Work description: Per- and polyfluoroalkyl substances (PFAS) and other long-lived contaminants present a potential but under-investigated risks to marine food webs. Combined understanding of their sources, main transport pathways uptake mechanisms and impacts through the food web are important in developing mitigation and regulatory strategies. Here, we aim to include ocean and atmospheric modelling, analyses of contaminants in organisms from different trophic levels to investigate food-web transfer, experiments testing for effects, and policy studies. We will also investigate Hg and Pb fluxes, effects of brine formation on mercury cycling, and assess emerging organic and inorganic contaminants in the water column and sediments. Moreover, we will include biomagnification studies of selected pollutants will be performed on targeted species from different trophic levels (from sea ice, pelagic, benthic and seafloor habitats). The targeted species/organisms will be sampled from the planned cruises in 2026 and 2027 as well as subsequent campaigns, and contaminant levels analysed together with stable isotopes (13C; 15N), the latter in close collaboration with food web studies in RT2. Such improved knowledge, combined with insight gained from the other Tasks of this RT, we aim at identifying the cumulative risk of climate change combined with other

anthropogenic pressures on the biodiversity and food-web dynamics of the Arctic Ocean.

Links to other Tasks: 2.5.1, 2.5.2, 2.5.3, 3.2.1, 3.2.7

Deliverables in 2026:

- Begin collecting and preparing samples for biomagnification analyses starting with the summer cruise 2026. These analytical results will determine the accumulation of persistent organic pollutants (POPs), chlorinated environmental contaminants CEAC, petroleum hydrocarbons and heavy metals, in key Arctic biota tracked through the food web using stable isotope techniques.
- Planning for the subsequent sampling campaigns, such as the summer cruise in 2027 north of Svalbard.

T3.2.5. Assessment of how physical and other disturbances impact Arctic biota

PI: IMR. **Participants**: APN, NINA, NTNU, SINTEF, UiO, UiT

Work description: Impact and vulnerability of physical disturbance will be identified. Benthos from the remote offshore Arctic deep-sea bed (e.g., Ramirez-Llodra et al 2024, Zhulay et al. 2019) has until now been affected only weakly by anthropogenic activities, but the predicted ice-free summer in the Arctic in the near future may change that situation (Grebmeier and Jørgensen 2022). The Yermak Plateau and the slopes shallower than 1000 m and facing the Central Arctic Ocean north of Svalbard are populated by vulnerable species such as *Umbellula encrinus* (Jørgensen et al. 2016). Based on these "shallow" records of vulnerable marine species, an area north, west and east of Svalbard was tentatively closed (Jørgensen et al 2020). Since only few records have been made deeper than 1000 m north of Svalbard (but see MAREANO) more information is needed if the large area in the high north may be further protected. Using video recordings from the northern slopes of Yermak plateau will allow us to record possible physical disturbance of the seabed and vulnerable species deeper than 1000 m, while by demersal trawling we will be able to continue long term monitoring of the Plateau shallower than 1000 m.

Underwater noise and changes in natural lightscapes (e.g., from ice retreat, artificial light at night, darkening) can impact Arctic ecosystems. We will, as a first step gather available information and data on natural sound- and lightscapes, integrate currently gathered data where possible, and identify knowledge gaps, (e.g., together with baseline assessments in Task 3.2.1). This will inform further field measurements and monitoring conducted (e.g., continuation/upscaling of long-term passive acoustic monitoring on deployed moorings). Experimental assessments (lab and field) of underwater noise and changes of light conditions are envisaged.

Links to other Tasks: 2.2.3, 2.4.3, 2.4.4, 3.1.3, 3.2.2, 4.3.3

Deliverables in 2026: None

T3.2.6. Characterize the vulnerability of key species in the Arctic Ocean

PI: UiO. **Participants**: APN, IMR, NINA, NORCE, NTNU, SINTEF, UiT, UNIS and others

Work description: Here, we aim at identifying key species that are likely impacted by human perturbations, including the ongoing ocean warming, using already available data. We will also take advantage of sedDNA from already preserved in-house sediment cores as well as sediment cores from new expeditions, that will be used to document ecosystem changes over the last centuries, and thus, illuminate the sensitivity and vulnerability of the Arctic biota to combined stressors of climate change and other anthropogenic perturbations. Additionally, we will evaluate the vulnerability of the key fish species (identified in RT1) as well as invasive species, that are likely to establish themselves in the Arctic Ocean at a temporal (e.g., seasonal) or more permanent scale. For instance, will these alterations in species/population distribution impact the ecosystem dynamics in the Arctic Ocean (e.g., shifts in inter and/or inter specific competition, parasite load)? Additionally, will these changes again impact their genomic signature and diversity (i.e., adaptive capacity)? Combining ecological data with genomic information and input from multi-stressor experiments will enable a deeper understanding of the genotype vs. phenotype variation of a species, and thus, their vulnerability and sensitivity to increased perturbations (e.g., intensified fisheries; Theissinger et al. 2023, Bernatchez et al. 2024). Moreover, with the identification of response traits for key ecosystem components, we will further assess which biota and ecotypes are most vulnerable to increased human activity. This will aid in the establishment of approaches to predict and evaluate the individual and combined impact of both indirect and direct human-induced stressors to guide the development of sustainable management programmes.

Links to other Tasks: 1.2.4, 1.2.5, 1.3.3, 2.4.3, 3.1.2, 3.2.5

Deliverables in 2026:

- Roll-Up at the UArctic Conference (May 2026) informing about Human activities, Pressures and Ecosystem vulnerability.
- Human activities, Pressures and Ecosystem vulnerability workshop 17-18 September 2026, Oslo, back-to-back to the Arctic Security Conference at SALT in Oslo and with the stakeholder workshop (Task 3.1.1), to illuminate the vulnerability of the key species that are likely to take advantage of the warming Arctic Ocean.

T3.2.7. Systematic risk and impact assessments of human activities and exploitation of the Arctic Ocean

PI: SINTEF. **Participants**: NINA, NORCE, NTNU, UiO, UiT, and others

Work description: Via risk assessment frameworks we will use the knowledge gained from the other Tasks from this RT to identify Chemicals of Emerging Arctic Concern (CEACs) posing the greatest risk to Arctic food webs and supporting long-term monitoring and management. Additionally, we will perform systematic and integrated risk assessment of how intensified human activities (including oil spill, deep sea mineral

mining, and other physical disturbances) and exploitation of the Arctic Ocean based on data from this RT and RT2 (i.e., the biodiversity assessments and the development of improved ecosystem/food web models), will impact the vulnerable Arctic Ocean ecosystems. These assessments would further aid in the development of area-based risk maps of particular vulnerable habitats/ecosystems and associated resources providing management perspective on the impact of increased human activities and the subsequent alteration of the Arctic ecosystem services and functioning. For example, hot spots of taxonomic, habitat and functional diversity (RT2), as well as areas rich in metal and carbon storage, will be identified and linked to specific habitats, and thus, providing a scientific basis for targeted sustainable management efforts and conservation (i.e., establishment of Ecologically or Biologically Significant Marine Areas).

Links to other Tasks: 2.2.3, 3.1.1, 3.1.2, 3.1.3, 3.3.1, 3.3.2, 3.3.3

Deliverables in 2026: None

Priority Topic 3.3: Preparedness, Governance, and Conservation needs

Growing human activity in the Arctic Ocean is expected to place increasing pressure on both national and international governance systems (Wu & Li 2025). To keep pace, sustainable regulatory and management frameworks must be designed around projected uses of the region and their ecological consequences (as assessed in PT3.1 and PT3.2). Cooperative Arctic institutions have historically supported political stability and shared management practices (De Lucia 2022, Wilson Rowe 2025, Stokke and Hønneland 2007). However, intensifying geopolitical tensions among Russia, China, and the United States now complicate multilateral decision-making and challenge the long-standing notion of "Arctic exceptionalism" (Bertelsen 2024). Evaluating whether existing cooperation models remain fit for purpose – and identifying potential alternatives – is therefore critical (Khorrami 2025). In this PT, we will examine regulatory developments in the context of these evolving geopolitical dynamics.

T3.3.1. Scenario development for future activities

PI: UiT. **Participants**: APN, FNI, NTNU, NUPI, SINTEF, UiO

Work description: Here we will analyse how emerging global political, legal, and economic trends are likely to shape the scale, distribution, and character of human activities in the Arctic. This assessment will integrate geopolitical shifts, evolving international legal norms and technological developments that collectively influence access to Arctic resources and routes. A key component of this work will be the development of forward-looking scenarios that explore plausible futures for maritime activity – including commercial cargo traffic, destination and expedition tourism, and trans-Arctic shipping – as sea ice decline continues to alter navigability. In parallel, we will examine how climate-driven ecosystem changes may reshape fisheries patterns, including potential northward shifts of commercially important species and corresponding governance challenges. Additionally, we also want to illuminate how

environmental and anthropogenic pressures on the Arctic Ocean could support the co-production of knowledge and inclusive governance with local and Indigenous communities that depend on and care for these marine ecosystems.

Links to other Tasks: 1.1.2, 1.2.5, 1.4.3, 2.4.3, 3.2.7, 4.4.2, 6.3.1, 6.4.1

Deliverables in 2026:

- Joint effort with Taks 3.1.1 and the workshop planned in connection with the Arctic Security Conference at SALT in Oslo, in September 2026.
- Summary report from workshop identifying future scenarios (e.g., shipping traffic, fisheries patterns, climate change impacts).

T3.3.2. Infrastructure challenges in an increasingly active Arctic: Management and Preparedness

PI: UiT. **Participants**: FNI, NTNU, UiO, UNIS,

Work description: Here we will identify, evaluate, and minimize risks that accompany increasing levels of human activity in the Arctic. We will map existing and planned infrastructure relevant to maritime traffic, tourism, fisheries operations, scientific activity, and safety, with particular attention to strategic logistical hubs such as Svalbard. The analysis will assess gaps in emergency response capacity, search-and-rescue systems, medical services, communications networks, and port and logistics facilities. In parallel, we will examine potential nature and human health risks associated with expanded activity, including exposure to extreme weather, accidents and pollution events in close collaboration with PT4.2. The work will integrate these assessments with broader global political, legal, and economic trends to understand how external forces may intensify or mitigate regional risks to be able to establish effective tools for adaptive management.

Shipping traffic has increased in the Arctic Ocean during the past decades (Jørgensen et al. 2025). In this task, we will follow the development in ship traffic and investigate which category of ships that increases (i.e., cargo, tourism, oil transport, military) and the societal response that follows. In addition, we will look into the potential use of automated ships and other high-risk technology development to prevent accidents that could be devastating both for humans and the vulnerable environment. Further, we will investigate how we can reduce pollution, disturbance, and risk for accidents by providing better ice charts and systems to ease navigation and reduce human mistakes by improving technology and how technology can enhance situational awareness and decision making. We aim to develop an online GIS platform that presents Arctic marine accidents as concise, engaging case narratives. Each case will include ship details, weather and ice conditions, direct links to relevant documentation and reports, and story-driven learning modules designed to strengthen preparedness and risk awareness.

Links to other Tasks: 1.1.5, 1.2.5, 1.4.3, 2.6.1, 3.3.1, 4.2.3, 6.4.1

Deliverables in 2026:

- Journal paper on ship traffic "Shrinking sea ice, shifting shipping and stricter standards: Svalbard's changing maritime landscape over the last decade".
- Report from stakeholder workshop arranged in Sept 2026.

T3.3.3. Advancing ecosystem-based conservation

PI: UiT. **Participants**: APN, FNI, IMR, SINTEF, UiO

Work description: Here we will identify key Arctic conservation needs by integrating risk maps of vulnerable ecosystems with an assessment of Norway's role in relevant international and regional processes (CBD, CAOFA, BBNJ, OSPAR, NEAFC, etc.). We will evaluate the need for new management measures and structures – including dynamic tools as well as nature-based solutions and establishment of MPAs – and examine whether existing frameworks, including UNCLOS, can support them, especially for species that straddle jurisdictional boundaries during their life cycle. The work will assess the effectiveness of bilateral and regional agreements, explore options for a post-CAOFA regional fisheries arrangement, and review sectoral regimes to ensure safe and sustainable activity. We will also evaluate institutional adequacy under increasing geopolitical competition and consider alternative cooperation models. Potential tensions between arctic conservation and climate interventions specifically targeting the Arctic and sea-ice management will also be addressed, given their disruptive potential on local arctic ecosystems and local communities.

Links to other Tasks: 1.1.2, 2.2.3, 2.4.5, 3.2.1, 3.2.5, 3.2.6, 3.2.7, 4.2.3, 4.3.1, 6.3.1

Deliverables in 2026:

- Joint effort with Task 3.1.1 and the workshop planned in connection with the Arctic Security Conference at SALT in Oslo, in September 2026.
- Preliminary assessment of gaps in knowledge, governance, or management frameworks.

T3.3.4. Assessing governance needs for pollution management

PI: FNI. **Participants**: APN, SINTEF, UiO, UiT

Working description: Here we will assess governance needs for managing pollution in the Arctic, including contaminants, shipping-related spills, cargo releases, and waste. We will evaluate whether existing instruments—such as the Polar Code and the Ballast Water Management Convention—are sufficient to address these risks or whether amendments or complementary measures, and which ones, are required. The analysis will identify regulatory gaps, examine potential enhancements to international and regional frameworks, and provide recommendations to strengthen pollution prevention and control in the Arctic Ocean, also with regards to black carbon regulation, heavy fuel oil and the ongoing negotiations towards a net zero emission framework.

Links to other Tasks: 3.2.1, 3.2.2, 3.2.6, 3.2.7, 4.4.1, 4.4.3, 6.4.1

Deliverables in 2026: None

Table 3.1. Summary of Tasks in RT3 (2026-2028).

Tasks - RT3	Partners
T3.1.1. Characterize the current status and potential interest in future activity and exploitation of the Arctic Ocean	IMR, APN, FNI, NINA, NTNU, NUPI, SINTEF, UiB, UiO, UiT, NORCE, UNIS, and others
T3.1.2. Evaluate the prospects and implications of increased exploitation of northward expanding key commercial fish species in the future Arctic Ocean	UiO, IMR, UiB, UiT, and others
T3.1.3 Evaluate potential areas for other human activities by input from the mapping of the seafloor and subseafloor	UiB, SINTEF, UiT, UNIS, and others
T3.2.1. Establish a detailed assessment programme for pollutant/contaminant levels and other perturbations	SINTEF, APN, IMR, NERSC, NINA, NORCE, NPI, NTNU, UiO, UiT, UNIS, and others
T3.2.2. Determine the effect thresholds of cumulative anthropogenic perturbations on microbial organisms, key invertebrates and Arctic fish species in an ecosystem setting	UiT, APN, IMR, NTNU, SINTEF, UiB, UiO, UNIS, and others
T3.2.3. Launching in vitro and ex vivo approaches to assess cumulative anthropogenic impacts on Arctic key vertebrates	NPI, APN, NINA, UiB, UiO, UiT, UNIS, and others
T3.2.4. Determine the impact of cumulative anthropogenic perturbations on food-web dynamics	UNIS, APN, IMR, NINA, NTNU, SINTEF, UiO, UiT
T3.2.5. Assessment of how physical and other disturbances impact Arctic biota	IMR, APN, NINA, NTNU, SINTEF, UiO, UiT
T3.2.6. Characterize the vulnerability of key species in the Arctic Ocean	UiO, APN, IMR, NINA, NORCE, NTNU, SINTEF, UiT, UNIS and others
T3.2.7. Systematic risk and impact assessments of human activities and exploitation of the Arctic Ocean	SINTEF, NINA, NORCE, NTNU, UiO, UiT, and others
T3.3.1. Scenario development for future activities	UiT, APN, FNI, NTNU, NUPI, SINTEF, UiO
T3.3.2. Infrastructure challenges in an increasingly active Arctic: Management and Preparedness	UiT, FNI, NTNU, UiO, UNIS
T3.3.3. Advancing ecosystem-based conservation	UiT, APN, FNI, IMR, SINTEF, UiO,
T3.3.4. Assessing governance needs for pollution management	FNI, APN, SINTEF, UiO, UiT



RT4: Abrupt and extreme events

Lead: Paul Renaud (Akvaplan-niva). Co-lead: Priscilla Mooney (NORCE)

Objective: Assess the nature and potential consequences of disruptive events by improving our skill in their prediction, characterizing their impact, and providing insight into system resilience.

Priority topics:

4.1 How do we identify disruptive events, their drivers over different scales of time and space, and their consequences for physical, biogeochemical, ecological, and geopolitical systems?

4.2 What are the risks/benefits associated with different disruptive events?

4.3 What are the potential consequences of different low likelihood, high-impact events, and how can we be prepared for these events?

4.4 How can we develop prevention, mitigation, and adaptation strategies for managing abrupt and extreme events?

These priority topics form the basis for the tasks outlined below.

Priority Topic 4.1. Identifying drivers and consequences of disruptive events

Abrupt and extreme events have different characteristic time scales. Over geological time scales, the Arctic Ocean has gone from ice-free to ice-covered conditions. On shorter time scales we see ongoing climatic, ecological, and geopolitical changes (e.g., altered phenology and biological community composition, and increases in military activity) that suggest that presumed driver thresholds have been passed. In most cases, however, the driver thresholds, either singly or in combination with other drivers, are not known. Understanding the drivers of disruptive events over different scales of time and space, and their consequences, is, therefore, critical to developing better prediction, mitigation, and prevention strategies.

T4.1.1. Establish database to map past naturally occurring extreme events (data values) to identify threshold values and consequences

PI: NPI. **Participants**: NGU, UiB, UiT, UNIS

Work description: This task will develop a comprehensive knowledge base of extreme events in the paleontological, climate, and socio-ecological systems and the values/variability of drivers likely responsible for these changes. We will identify likely ecological and geopolitical thresholds (where drivers are quantifiable) and consequences that can be directly linked with events. Many consequences of change are predicted but we will evaluate the statistical, mechanistic, and other documented evidence for direct and indirect causal links to better understand the processes involved, and potentially how negative change can be prevented, and positive change encouraged.

Links to other Tasks: 1.1.1, 1.3.4, 2.2.1

Deliverables in 2026: Database coupling past extreme events, key drivers, and consequences.

T4.1.2. Mapping of knowledge on characteristics of species, communities, ecosystem processes, and governance regimes that confer resilience to change or potential to reverse changes

PI: UiT. **Participants**: APN, NINA, NUPI

Work description: We will use empirical and theoretical studies to identify physiological, ecological, and food-web traits/characteristics that are linked with resilience in ecosystem components. These characteristics can include phenotypical plasticity, genetic diversity, and food-web connectivity and compartmentalization. Similarly, we will identify inherent properties of geopolitical/governance regimes that promote stability, such as treaties and memberships in international governance organizations.

Links to other Tasks: 1.1.2, 1.1.6, 2.4.5, 3.2.4, 3.2.6, 4.1.4

Deliverables in 2026: Beginning of multi-disciplinary resilience database / literature review documenting traits conferring resilience in physical, ecological, and geopolitical systems

T4.1.3. Identifying modelling gaps for assessing climate and weather extremes in a changing Arctic using Earth Observations and *in situ* data.

PI: NORCE. **Participants**: NERSC, UiT

Work description: To assess the likelihood of extreme events in the future (both in long-term climate projections and near-term climate prediction), there is a need to understand the strengths and limitations of existing climate models as well as high-resolution atmospheric transport models to represent extreme events in recent decades. We will endeavor to develop physically based metrics to assess the representation of extremes in models (Zhang et al. 2025). This task will exploit state-of-the-art Earth Observations and in situ observations from recent aircraft surveys and previous and new cruises in *Arctic Ocean 2050* to identify modelling gaps that provide a strong basis for assessing future changes in extremes and research directions for modelling extreme events in the Arctic.

Links to other Tasks: 1.2.1, 1.2.3, 1.3.1, 1.4.2, 4.1.6

Deliverables in 2026: Assessment of needs for improving climate models to better represent extremes.

T4.1.4. Assess resilience status of Arctic Ocean species, communities, ecosystem processes, and governance regimes based on knowledge of traits of resilient systems

PI: APN. **Participants**: UiT, UiO

Work description: Using results from Task 4.1.2, we will generate resilience-related trait matrices for species, communities, processes, and governance regimes currently known for Arctic systems. This activity will be continually updated as new knowledge becomes available. Results will provide a resilience report card for Arctic socio-ecological systems. Comparison with systems that are better known than the Arctic Ocean, and have or have not undergone some abrupt change, can provide a proof-of-concept for this approach.

Links to other Tasks: 2.4.5, 4.1.2, 4.4.3

Deliverables in 2026: None

T4.1.5. Compare statistical and observational/experimental evidence linking changes in driver values to thresholds and early-warning indicators of shifts for ecological and socio-ecological change.

PI: TBD. **Participants**: APN, NPI, UiT

Work description: Various early-warning indicators such as increased variance or higher autocorrelation (slowing down) have been suggested to forecast abrupt changes or shifts in climate or ecological systems. We will assess based on observations and models if changes in these indicators can be estimated and if they are associated with abrupt and irreversible changes. We will compare approaches that can be applied to physical, ecological, and social/political systems, and the spatial and temporal scales that are relevant to assess changes and warning indicators. Continued after 2027, but more emphasis on the drivers in the future climate system and using climate projections from Polar CORDEX and CMIP.

Links to other Tasks: 1.2.5, 4.2.2

Deliverables in 2026: None

T4.1.6. Investigate the role of large scale transport of heat and moisture into the Arctic on extreme changes in the Arctic environment using modern reanalyses and observations.

PI: NERSC. **Participants**: NORCE

Work description: Identify multi-scale drivers of extreme events that can improve predictions and projections of extreme events in the future. For example, a recent study showed that the physical processes in charge of marine heatwaves (MHWs) vary geographically and seasonally, but most MHWs are caused by surface heat fluxes (Richaud et al. 2024). However, close to the openings to the Arctic Ocean, such as the Fram Strait, ocean heat transport can play a larger role than air-sea interaction (e.g., Williams-Kerslake et al. 2026). This points to the need to understand the role of large scale atmospheric and oceanic drivers, both from the Atlantic and the Pacific sector, of extreme events in the Arctic Ocean under the present climate. How oceanic temperature anomalies spread into the Nansen-Amundsen basins will be investigated in models and observations. Furthermore, key features in extreme atmospheric transport (such as

Warm Air Intrusions) will also be investigated. This will contribute to a better understanding of the drivers of Arctic extremes in a future 'ice-free' Arctic.

Links to other Tasks: 1.1.3, 2.1.4, 2.1.6, 4.2.2

Deliverables in 2026: None

T4.1.7. Assess statistical and observational/experimental evidence linking reversibility of driver values to reversibility of ecological and socio-ecological change

PI: UiT. **Participants**: APN, NINA, NUPI

Work description: Internal variability in the climate system leads to short-term reversibility – long-term warming is interspersed with short-term cooling or stasis periods ("hiatus"). Is there evidence that such short-term reversions translate into similar reversions in the ecological or social systems? To what extent is there hysteresis (irreversibility even if driver pressure is relaxed) in ecological and social systems or are abrupt changes reversible as was the case for some components of the fish communities in the Barents Sea (Ellingsen et al. 2025)?

Links to other Tasks: 4.1.4, 4.1.5, 4.2.1

Deliverables in 2026: None

Priority Topic 4.2. Assessing the risk associated with abrupt and extreme events

Risk assessment is a key element of planning for surprises associated with abrupt or extreme events. It combines a quantification of the likelihood of surpassing expected thresholds in environmental drivers, human activities, and geopolitical events with an understanding of the consequences for the system. For the near-future, we can rely on climate predictions and projections of change in key environmental drivers (atmospheric phenomena such as storm tracks and altered precipitation patterns, Atlantic Water inflow, freshwater fluxes, sea ice loss, non-native species). But each model has its own assumptions and uncertainties that must be considered when drawing any conclusions.

T4.2.1. Evaluate historical and paleo- ranges and variability in key ecosystem drivers with potential to lead to abrupt changes

PI: NPI. **Participants**: NORCE, UiB, UNIS

Work description: By reconstructing ecosystems on historical and geological time scales and evaluating the ranges and variability of the systems, it is possible to identify the drivers in natural pre-impacted settings. This identification will show the ecosystem drivers' potential to lead to abrupt changes.

Links to other Tasks: 1.2.2, 1.3.4, 2.2.1, 4.1.1

Deliverables in 2026: Database identifying driver thresholds leading to abrupt change on historical and paleo- time scales.

T4.2.2. Determine statistical likelihoods of surpassing identified or assumed thresholds in environmental drivers based on model predictions and projections

PI: NERSC. **Participants**: NORCE, UiT

Work description: A way to prepare for climate and weather extremes is to estimate the likelihood of climate and weather extremes. Both climate predictions (seasonal to decadal time scales) and climate projections (longer timescales) will be analysed to determine the statistical likelihood of exceeding defined environmental thresholds. Compile an ensemble of simulations (e.g., climate, hydrological, or air-quality models), apply bias correction, and calculate the probability of surpassing each threshold across time and scenarios. Use empirical exceedance frequencies, confidence intervals, or extreme value analysis to quantify uncertainty. Assess sensitivity to threshold definitions and model variability. Summarize key risks and confidence levels, highlighting where and when thresholds are most likely to be exceeded under future climate predictions and projections (e.g., using near-term predictions from NorCPM and long-term projections from NorESM).

Links to other Tasks: 1.2.3, 1.3.1, 4.1.5, 4.1.6

Deliverables in 2026: None

T4.2.3. Assess risk for and from increases in economic/industrial activities, including ecological effects of pollution events, safety/preparedness issues, etc.

PI: NTNU. **Participants**: SINTEF, UiT, UNIS

Work description: Arctic operations carry unique risks compared to those at lower latitudes, and emergency preparedness and response are more difficult. Hence, there is a need for risk assessments considering human life-safety, technical system risks and ecological risks. Using information sources like industry projections, insurance statistics, governmental preparedness plans, and new methods that holistically consider maritime accident consequences across ecological and human life-safety dimensions, we will determine relative risk levels for different locations and time horizons for the Arctic marine system. These analyses will consider pollution, human safety, habitat disturbance/destruction, as well as ecological sensitivity from existing and new data. In contrast to T3.3.2 which focuses on adapting regulations and preparedness to changing patterns of use, this task will focus on the risk (likelihood and consequences) of accidents given these changes and new knowledge of potential impacts determined from experimental studies and scenarios developed elsewhere in *Arctic Ocean 2050*. The goal is to provide risk-informed decision-support for stakeholders, such as regulators, policy makers, and operators. Results can contribute to development of regulatory and governance strategies to reduce risk to humans and the environment.

Links to other Tasks: 3.2.2, 3.2.3, 3.2.4, 3.3.1, 4.4.3

Deliverables in 2026: None

Priority Topic 4.3. Low-likelihood, high-impact events

Low likelihood, high impact (LLHI) events can profoundly affect ecosystems and human societies at regional or global levels but are challenging to model or even conceptualize for effective planning or mitigation. Whereas abrupt or extreme events can be modelled and have quantifiable likelihood and impacts, LLHI events are deeply uncertain and occur outside the range of normal variability, making it especially difficult to determine both their triggers and their consequences. Thus, LLHI events require different methods for their investigation, assessment, and planning. Additionally, many LLHI events may not be linked with climate change. Recent history (COVID-19 pandemic, invasion of Ukraine) clearly shows the global impacts of such events, with consequences extending well into the Arctic.

T4.3.1. Horizon scan identifying potential LLHI events and their consequences for physical, ecological, and societal dimensions

PI: APN. **Participants**: IMR, NORCE, NUPI

Work description: Through literature studies, questionnaires to stakeholders, and workshops including project participants across broad disciplinary perspectives we will explore potential LLHI events impacting the Arctic Ocean region, ecosystems, and governance structures. The inherent difficulties in discussing unpredictable events are clear, but low-likelihood events are somewhat easier to envision and discuss in defensible scientific contexts. Results of these horizon scans will form the basis for Task 4.3.2.

Links to other Tasks: 1.1.5, 4.3.2

Deliverables in 2026: Identification and evaluation of potential LLHI events and their consequences.

T4.3.2. Scenario analyses for identifying causes/triggers and potential impacts of LLHI events

PI: TBD. **Participants**: APN, UiT

Work description: A series of disciplinary workshops that address the potential LLHI events discussed in Task 4.3.1 will identify specific triggers/causes/driver values responsible for initiation of such events so they can be better predicted. Where appropriate data exist, we will explore whether current conditions/trends indicate coming LLHI events. Pathways to impact will also be addressed to explore potential mitigation pathways to limit the severity of impacts, if possible.

Links to other Tasks: 1.1.5, 4.3.1

Deliverables in 2026: None

T4.3.3. Continental slope instability and submarine landslides: implications for sea floor morphology, tsunamis, and other hazards

PI: UiT. **Participants**: NGU, UNIS

Work description: Using new knowledge and models of the continental slopes from RT2 (Task 2.2.2), the implications of slope failures will be evaluated. These will, for example, include assessing potential abrupt changes in habitats due to permafrost thawing, gas hydrate instability, and sea-level changes due to glacial isostatic adjustment, in addition to potential tsunamis triggered by slope failure, e.g., potential geographical extent.

Links to other Tasks: 2.2.1

Deliverables in 2026: None

Priority Topic 4.4. Planning for abrupt change and extreme events

Understanding the risks, uncertainties, thresholds, and consequences of abrupt change and extreme events is key to developing strategies for managing the physical, ecological, and geopolitical elements of the Arctic Ocean. We need to avoid surpassing identified thresholds where negative consequences are expected to result wherever possible. We also need to use management tools to enhance the natural resilience of both environmental and socioecological systems. Key to achieving this objective is embedding natural science knowledge within the societal context that drives broader understanding and drives action. Minimizing negative consequences and maximizing positive outcomes must be integral elements of mitigation and adaptation strategies in the region.

T4.4.1. Identify relevant stakeholders and international advisory bodies with and through which to effectively communicate risk, mitigation, and conservation strategies to manage abrupt change

PI: APN. **Participants**: NUPI, SINTEF, UiT

Work description: In collaboration with RT6, we will participate in workshops and conferences where relevant stakeholders - including industry, managers, representatives of local and indigenous communities, and policymakers - will be present. We will identify the kinds of data and formats for presentation of this information that will facilitate incorporation of new results into developing strategies and roadmaps to minimize risk, mitigate impacts, and protect the environment from identified threats.

Links to other Tasks: 1.1.1,1.1.2, 3.3.1, 4.4.2, 6.2.1

Deliverables in 2026: List of relevant stakeholders for developing policy to minimize, manage and mitigate impact of abrupt change.

T4.4.2. Mapping needs of stakeholders for planning for abrupt changes

PI: APN. **Participants**: SINTEF, UiT

Work description: Diverse stakeholders, including environmental managers, industry, policy makers, and northern peoples, are affected differently by abrupt changes. Understanding these needs will help us develop strategies that will help prioritize actions, both to prevent and to respond to abrupt change. Communication of scientific knowledge developed in this project with relevant stakeholders across the pan-Arctic realm, and our education as to the consequences of change for diverse actors will improve decision making. The results of this task will feed into activities in RT6.

Links to other Tasks: 4.4.1, 6.2.1

Deliverables in 2026: None

T4.4.3. Determine environmental strategies and policy tools that can promote resilience in ecological and societal/governance systems

PI: TBD. **Participants:** APN, UiT

Work description: Knowledge gained in this RT will further our understanding of how systems have changed, drivers and consequences of that change, and elements of resistance to and recovery from change in complex systems. Combined with information from other RTs in this project, we will significantly improve our understanding of what makes systems resilient to change. This can lead to development of concrete strategies and tools for promoting resilience in ecological and societal systems via dialogue among scientists, managers and policy makers.

Links to other Tasks: 4.1.2, 4.1.4, 4.1.7, 4.2.3

Deliverables in 2026: None

Table 4.1. Summary of Tasks in RT4 (2026-2028).

Tasks - RT4	Partners
T4.1.1. Establish database to map past naturally occurring extreme events (data values) to identify threshold values and consequences	NPI, NGU, UiB, UiT, UNIS
T4.1.2. Mapping of knowledge on characteristics of species, communities, ecosystem processes, and governance regimes that confer resilience to change or potential to reverse changes	UiT, APN, NINA, NUPI
T4.1.3. Identifying modelling gaps for assessing climate and weather extremes in a changing Arctic using Earth Observations and *in situ* data.	NORCE, NERSC, UiT
T4.1.4. Assess resilience status of Arctic Ocean species, communities, ecosystem processes, and governance regimes based on knowledge of traits of resilient systems	APN, UiT, UiO

T4.1.5. Compare statistical and observational/experimental evidence linking changes in driver values to thresholds and early-warning indicators of shifts for ecological and socio-ecological change	APN
T4.1.6. Investigate the role of large scale transport of heat and moisture into the Arctic on extreme changes in the Arctic environment using modern reanalyses and observations	NERSC, NORCE
T4.1.7. Assess statistical and observational/experimental evidence linking reversibility of driver values to reversibility of ecological and socio-ecological change	UiT, APN, NINA, NUPI
T4.2.1. Evaluate historical and paleo- ranges and variability in key ecosystem drivers with potential to lead to abrupt changes	NPI, NORCE, UiB, UNIS
T4.2.2. Determine statistical likelihoods of surpassing identified or assumed thresholds in environmental drivers based on model predictions and projections	NERSC, NORCE, UiT
T4.2.3. Assess risk for and from increases in economic/industrial activities, including ecological effects of pollution events, safety/preparedness issues, etc.	NTNU, SINTEF, UiT, UNIS
T4.3.1. Horizon scan identifying potential LLHI events and their consequences for physical, ecological, and societal dimensions	APN, IMR, NORCE, NUPI
T4.3.2. Scenario analyses for identifying causes/triggers and potential impacts of LLHI events	APN, UiT
T4.3.3. Continental slope instability and submarine landslides: implications for sea floor morphology, tsunamis, and other hazards	UiT, NGU, UNIS
T4.4.1. Identify relevant stakeholders and international advisory bodies with and through which to effectively communicate risk, mitigation, and conservation strategies to manage abrupt change	APN, NUPI, SINTEF, UiT
T4.4.2. Mapping needs of stakeholders for planning for abrupt changes	APN, SINTEF, UiT
T4.4.3. Determine environmental strategies and policy tools that can promote resilience in ecological and societal/governance systems	APN, UiT

RT5: Advances in Observing and Modelling

Lead: Malte Müller (MET). Co-lead: Laurent Bertino (NERSC)

Objective: Make optimal use of emerging technologies, numerical models, machine learning methods, and data assimilation techniques to fill observational gaps and enhance our ability to predict and understand interconnected physical, biogeochemical, biological and societal processes in the rapidly changing Arctic Ocean.

Priority topics:

5.1 How can autonomous and modular sensor platforms, in situ sampling technology, and remote sensing products, be advanced and integrated in real time to enhance Arctic environmental monitoring and modelling.

5.2 How can a hierarchical, flexible numerical model framework be developed to efficiently downscale global climate model outputs into high-resolution regional simulations that improve representation of Arctic physical and biogeochemical processes?

5.3 How can machine learning models that integrate multi-source data be developed and validated to efficiently downscale Arctic climate scenarios, improve forecasting, and reduce uncertainties in extreme event predictions?

5.4 How can user-centered marine digital twins be co-developed to integrate multi-source data, provide interactive scenario-testing capabilities, and support informed decision-making for sustainable Arctic environmental management?

These priority topics form the basis for the tasks outlined below.

Priority Topic 5.1: Develop modular and Interoperable Observation Systems

We will develop and test modular and interoperable observation systems for the central Arctic, integrating multiple observational sources (including in situ platforms, autonomous systems and satellite products). The activity includes tool development and assessment to support operations, improvements of long-term archived observation records using AI/data fusion/data assimilation approaches, and autonomous multi-scale sea-ice mapping and under-ice/deep-ocean observing capabilities. Most of the tasks below are split between the first design phase and a subsequent development phase, except for Task 5.1.4.

T5.1.1. Central Arctic observational monitoring and decision support (Phase 1: Design)

PI: NTNU. **Participants**: APN, MET, NERSC, NGU, NINA, NORCE, NORSAR, NPI, UiT, UNIS

Work description: We will assess the current status of sea ice, ocean, atmospheric, and ecosystem observations and how multi-source remote-sensing observations, i.e., satellite, airborne, ship-based can be combined to enhance operational safety and scientific analyses in the central Arctic. Opportunities for new platforms and products

will be explored. For example, year-round sea-ice-thickness monitoring, and retrieval of sea ice and snow properties as well as surface currents, and key atmospheric variables will be evaluated for integration into *Arctic Ocean 2050* activities, including fieldwork planning and physical analysis. Multi-frequency high-resolution SAR, Laser platform, cameras, navigational ship radar, electromagnetically-derived ice thickness and optical data, combined with autonomous ice buoy data, will be explored for real-time sea-ice mapping and machine-learning-based prediction of the presence and density of leads, ridges, as well as floe size distribution. We will assess which zooplankton species contribute to ocean color remote sensing signals in polynyas and the large ice-free areas of the Arctic Ocean, thereby significantly expanding the potential of satellite remote sensing of key ecosystem components. The potential for mapping phytoplankton blooms on high spatial and temporal scales using multi-sensor fusion will also be assessed. We will optimize use of biological sensors on fixed and moving platforms, such as echosounders, plankton imagery systems, next-generation photophysiology sensors, and automatic camera systems observing seabirds and sea mammals, using AI pipelines. Our assessment will identify data-fusion needs and interoperability pathways to integrate these with in-situ and shipborne sensors, ensuring direct scientific relevance to RT1–RT4 and future Marine Digital Twins (PT 5.4).

Links to other Tasks: 2.1.1, 2.1.2, 2.6.1

Deliverables in 2026: Scoping workshop with short report and input to follow-up tasks in PT5.1.

T5.1.2. Climate and ecosystem data records (Phase 1: Design)

PI: UiT. **Participants**: MET, NORCE, NORSAR, NPI

Work description: We will assess the status of archived records of sea ice, ocean, atmosphere, and ecosystem parameters to support long-term climate studies, identify trends, and calibrate & validate model hindcasts in the Central Arctic. This includes investigating in situ and multisource remote sensing observations, i.e., satellite, airborne, ship-based and autonomous sensors, to support multi-decadal analyses. Long-term climate data records of certain sea ice properties, such as ice thickness distribution, roughness/ridging, and melt properties, are often of insufficient accuracy or lack the timescale to support such studies. Similar assessments will be performed for ocean and ecosystem parameters. Novel approaches, such as using AI or advanced data assimilation methods, can lead to major advances in the quality or integration of archived records. The assessment will identify data fusion needs and interoperability pathways to integrate in situ, shipborne, and Earth Observation datasets to meet the needs of *Arctic Ocean 2050* research questions.

Links to other Tasks: 1.1.3, 1.2.1, 1.2.2, 1.3.1, 4.1.6

Deliverables in 2026: Scoping workshop with short report and input to follow-up tasks in PT5.1.

T5.1.3. Multi-scale observations and autonomous mapping of sea-ice

PI: NPI. **Participants**: MET, NERSC, NORCE, NTNU, UiT, UNIS

Work description: This task integrates analysis of observations with different spatial and temporal resolution to investigate the physics and biology of level and deformed sea ice through coordinated above-ice, in-ice, and under-ice measurements. Work will target deformation and ridge systems, as well as level ice of varied age and season. Using a wide range of observing techniques with complementary spatial and temporal resolutions, we will document ice morphology, potential deformation processes, habitat structure, and associated biological presence, composition, and activity. Surface observations will include high-resolution remote sensing (from ship radar, SAR, SWOT and ICESat-2 also in 5.1.1), UAV surveys, aircraft campaigns, drones, and ship-based sensors. In-ice and on-ice measurements will incorporate drilling, sampling, electro-magnetic induction surveys (PT2.1), distributed networks for measurement of snow surfaces and instrumented drifting buoys that record position, temperature, light, and internal snow and ice properties. Below the ice, ROVs and AUVs equipped with multibeam sonars, hyperspectral and optical cameras, and environmental sensors will conduct detailed mapping of ridge keels, under-ice topography, and biophysical conditions. These will be coupled to physical on-ice surveys of coupled physical-biogeochemical properties, including hyperspectral light conditions and algal photophysiological status, as well as lab-based experimentation to further investigate drivers of observed biological variability. Simultaneous localization-based mapping (SLAM) will enable autonomous platforms to detect rapid changes in ridge structure and track deformation across temporal baselines. Existing moorings (sea-ice draft, velocities, CTD in RT2) and datasets from, for example, MOSAiC and other ongoing monitoring programmes will provide essential context and enable cross-scale process modelling. By combining multi-platform observations with autonomous sensing, this task strengthens links to RT2 by improving understanding of ice mechanics, supporting safer autonomous navigation, and providing key environmental data for marginal-ice-zone process studies.

Links to other Tasks: 2.1.1, 2.4.5

Deliverables in 2026: Contribution to cruise report with descriptions of current methods used for sea ice observations and ice station work.

T5.1.4. Autonomous platforms for under-ice, deep-ocean, and MIZ observation systems (Phase 1: Design)

PI: NTNU. **Participants**: APN, IMR, MET, NERSC, NPI, UNIS

Work description: We will evaluate the operational, technical, and scientific requirements for deploying autonomous platforms in the Central Arctic, under ice, in deep-water basins, and in the Marginal Ice Zone (MIZ). Building on state-of-the-art knowledge and platform experience across partner institutes, we will compile an assessment of navigation, communication, endurance, and sensor integration requirements for gliders, AUVs, ROVs, mini-ROVs, ASVs, and buoys. The assessment will define mission objectives provided by other RTs, including required spatial and

temporal resolution for ice conditions, physical oceanography, and ecosystem observations (water column, under ice, and seabed). We will evaluate the compatibility of payload sensors (acoustic, optical, chemical, biological) with Arctic platform constraints and identify gaps that must be addressed before long-endurance deployments begin. Special attention will be given to requirements for under-ice glider navigation (acoustic networks), real-time echosounder processing for ice-edge navigation, and deep-ocean AUV mission planning. The output will be a technical roadmap that guides the development and implementation of Tasks 5.1.8 and 5.1.9 in 2027–2028 and beyond.

Links to other Tasks: 2.1.2, 2.1.5

Deliverables in 2026: Workshop on the use of acoustic geolocation under ice for gliders and other autonomous devices.

T5.1.5. Multi-platform robotic observations (Phase 1: Design)

PI: SINTEF. **Participants**: APN, NTNU

Work description: We will prepare the foundation for large-scale robotic network deployments by designing, testing, and evaluating multi-platform observation strategies for the Central Arctic. Using existing models, past field data, and operational constraints, we will assess coordinated missions involving gliders, AUVs, USVs, drones, satellites, and ship-based sensors. The goal is to determine how heterogeneous platforms can jointly observe key processes (fronts, eddies, ice deformation, productivity gradients) while meeting constraints in communication, endurance, and environmental hazards. The task will assess requirements for collaborative control, probabilistic mission planning, and data-sharing between platforms, as well as evaluate the feasibility of integrating physics-informed scaling and multi-modal data fusion across spatial and temporal scales. We will also review existing data workflows to identify what is needed for real-time onboard processing (e.g., acoustic/optical data for adaptive sampling). The output will be a structured implementation plan specifying observation scenarios, platform roles, sensor payload combinations, and priority regions. This ensures the 2027–2028 activities in Tasks 5.1.8 and 5.1.9 can begin with well-tested, realistic mission concepts.

Links to other Tasks: 2.1.5, 2.6.1

Deliverables in 2026: None

T5.1.6. Central Arctic observational monitoring and decision support (Phase 2, Developments and implementation)

PI: NTNU. **Participants**: APN, MET, NERSC, NGU, NINA, NORCE, NORSAR, UiT, UNIS

Work description: Building on the outcomes of Task 5.1.1, we will develop, refine, and integrate observational tools and methods that demonstrate clear potential to support *Arctic Ocean 2050*'s operational, scientific, and modelling objectives. Using the assessment of existing in-situ systems, autonomous platforms, and multi-source remote

sensing products, we will implement upgraded sensor technologies and processing approaches to improve the monitoring of key sea-ice, ocean, and ecosystem variables across the Central Arctic and marginal ice zone. Tool development will target high-resolution characterization of sea-ice roughness, thickness, snow depth, open-water and melt-pond distributions, as well as biological indicators such as phytoplankton, zooplankton, seabirds, and marine mammals. These will be supported by multi-frequency SAR, optical sensors, airborne and shipborne measurements, and AI-enabled classification pipelines identified in Task 5.1.1. Integration of these tools will emphasize interoperability between autonomous platforms, drifting buoys, moorings, ship-based sensors, and satellite datasets. Outputs will include metre- to kilometre-scale products suitable for coupled modelling, data assimilation, and Marine Digital Twin development across RT1–RT6. The task will also explore real-time processing of echosounder and biological sensor data to enhance situational awareness during field operations and provide ground-truthing for Earth Observation products. Together, these developments will translate the assessments of Task 5.1.1 into tangible observing capabilities for *Arctic Ocean 2050*.

Links to other Tasks: 2.1.1, 2.1.2, 2.6.1

Deliverables in 2026: None

T5.1.7. Climate and ecosystem data records (Phase 2: Developments and implementation)

PI: UiT. **Participants**: MET, NORCE

Work description: Building on the assessment performed in Task 5.1.2, we will develop and integrate improved methods to upgrade archived long-term climate records for the Central Arctic. The focus is on enhancing multi-decadal datasets of sea ice, ocean, and ecosystem parameters that are essential for trend analysis, evaluation of long-term variability, and calibration and validation of model hindcasts within *Arctic Ocean 2050*. We will target key variables where existing Climate Data Records are incomplete, inconsistent, or lack sufficient accuracy, such as sea-ice thickness, roughness and ridging, melt properties, ocean stratification, and ecosystem indicators, including phytoplankton, zooplankton, and biogeochemical tracers. To improve these archives, we will develop tools for systematically integrating in situ observations, shipborne measurements, autonomous platform data, and multi-source remote sensing (satellite, airborne, and historical records). Advanced techniques identified in Task 5.1.2 including AI-assisted reprocessing, enhanced data assimilation methods, and harmonization of heterogeneous datasets, will be adapted, tested, and transitioned into operational workflows. Emphasis will be placed on increasing temporal continuity, reducing biases, and improving cross-platform interoperability. The upgraded records will provide robust, quality-controlled datasets for modelling efforts, contribute to future Marine Digital Twins, and support RT1–RT6 by placing new field observations into a reliable long-term climate context.

Links to other Tasks: 1.1.3, 1.2.1, 1.2.2, 1.3.1, 4.1.6

Deliverables in 2026: None

T5.1.8. Autonomous platforms for under-ice, deep-ocean, and MIZ observation systems (Phase 2: Developments and implementation)

PI: NTNU. **Participants**: APN, IMR, MET, NERSC, NPI, UNIS

Work description: We will design and deploy the next generation of autonomous sensor platforms to enable year-round observations of the ocean, sea ice, seabed, and associated biological components in the Central Arctic and Marginal Ice Zone (MIZ). Building on state-of-the-art developments, we will define mission objectives in dialogue with other RTs to ensure adequate spatial and temporal coverage for ice conditions, physical oceanography, ocean ecosystems (water column, under ice, and seabed), and geochemical properties of the seafloor. Platforms will include gliders, AUVs, ROVs, mini-ROVs, landers, buoys, ASVs, ships, drones, aircraft, and small satellites. Matching of payload sensors (acoustic, optical, chemical, biological) with specific platforms will be carried out to address these objectives. A key focus is enabling long-endurance under-ice glider operations using acoustic telemetry networks for navigation and communication in regions without satellite access. To increase autonomy and scientific return, we will develop on-board real-time processing of echosounder and acoustic data, allowing platforms to map ice edges, estimate ice thickness, navigate safely in ice-edge systems, and provide fine-scale measurements for satellite validation. Deep-ocean investigations in the Nansen and Amundsen basins will employ ROVs and AUVs to map geology, biodiversity, and biogeochemical fluxes. This integrated approach supports multi-platform data fusion, durable operations in extreme environments, and contributes essential datasets for RT2 and future Marine Digital Twins.

Links to other Tasks: 2.1.2, 2.1.5

Deliverables in 2026: None

T5.1.9. Multi-platform robotic observations (Phase 2: Developments and implementation)

PI: SINTEF. **Participants**: APN, NTNU

Work description: Following Task 5.1.5, we will advance collaborative, multi-platform robotic systems to support efficient mapping and adaptive ecosystem observations across the Arctic Ocean. Building on the concept of “observation pyramids,” we will coordinate AUVs, gliders, USVs, drones, small satellites, ship-based platforms, and aircraft into heterogeneous networks that operate across spatial scales from metres to hundreds of kilometres, and temporal scales from minutes to seasons. Mission objectives will be aligned with other RTs to target dynamic processes including fronts, mesoscale eddies, ice–ocean interactions, and transitions in biological productivity. Sensor configurations will integrate acoustic, optical, chemical, and biological systems, including eDNA and photophysiology sensors matched to the requirements of each platform. A central focus is research on collaborative control, probabilistic modelling, and AI-based reasoning that allows platforms to share information, update situational awareness, and adapt sampling strategies in real time. Physics-informed methods will

guide multi-scale fusion of observations from satellites, aircraft, AUVs, and surface vehicles. Efficient handling of multimodal data streams will be developed to support near-real-time analysis and model integration. Ice properties will be used as cues for light conditions and productivity, enabling targeted ecological sampling beneath and around sea ice. This distributed robotic network strengthens links with RT2, RT5.3, and RT5.4 and delivers a transformative capability for Arctic process studies and decision-support systems.

Links to other Tasks: 2.1.5, 2.6.1

Deliverables in 2026: None

Priority Topic 5.2: Establish a hierarchical numerical model framework for global model downscaling

We will assess and coordinate existing Arctic modelling infrastructure and develop a hierarchical downscaling framework enabling the translation of global climate information to high-resolution regional and local Arctic scenarios. The work will provide a coordinated framework for downscaled Arctic climate scenarios that can support process studies, operational needs and downstream decision-support applications.

T5.2.1. Assessment and coordination of existing Arctic climate modelling infrastructure that can be used for downscaling of climate scenarios

PI: MET. **Participants**: IMR, NERSC, NORCE, NPI

Work description: We will assess, document, and coordinate the existing modelling infrastructure in Norway that can contribute to a hierarchical Arctic Ocean modelling framework for downscaling climate scenarios. The work will focus on evaluating the readiness, strengths, and complementarity of numerical models covering ocean, sea ice, atmosphere, and ecosystem components at pan-Arctic and regional scales. An overview of the already available model simulations will be compiled, including their temporal and spatial resolutions, forcings, boundary conditions, and coupling configurations. In addition, a set of existing reanalysis products (or historical runs) will be listed for the evaluation. Model quality and representativeness of key physical (such as snow and sea-ice thickness distributions, sea-ice dynamics, stratification, deep water formation, and air-sea interactions, light) and biogeochemical (such as nutrients, oxygen and carbon concentrations, primary production, carbon sources and sinks) processes, will be systematically evaluated through comparison with available observations, focusing on the mean states, seasonal cycle, and observed long-term trends. A list of required output variables, including those relevant for ecosystem and biogeochemical applications (e.g., light conditions, sea-ice properties, and production), will be compiled for upcoming simulations and to be discussed with RT2 to coordinate field observation needs. The outcome will be a synthesis report providing an overview of current downscaling capacities, uncertainties and a roadmap for future model development and integration within the *Arctic Ocean 2050* framework.

The plan is to create an overview document detailing models relevant for Arctic climate downscaling, including their domains, resolutions, boundary conditions, and coupling configurations. These models will be assessed based on their performance in reproducing key variables such as sea level, sea surface temperature, sea ice concentration, and biogeochemical variables. Evaluation metrics, including RMSE, correlation, and Taylor diagrams, will be used to compare model outputs with observations. Tools and scripts for model evaluation will be available on GitHub. The work will proceed in phases, starting with categorizing models and compiling detailed information, followed by evaluation of models.

Links to other Tasks: 1.1.3, 1.2.2, 1.3.1, 2.1.3, 2.3.2, 4.1.3

Deliverables in 2026: Coordination workshop and report summarizing current downscaling capacities, model uncertainties, and a roadmap for future improvements, along with recommendations for addressing biases in atmospheric forcing and boundary conditions.

T5.2.2. Downscaling and bias correction of existing climate scenarios for the Arctic Ocean

PI: MET. **Participants**: IMR, NERSC, NORCE, NPI

Work description: Building on the assessment in Task 5.2.1, we will perform regional downscaling of existing climate scenarios including those from NorESM and NorCPM to produce high-resolution atmosphere, ocean, sea-ice, biogeochemical, and ecosystem projections for the Arctic. The activity will be guided by scientific priorities and feedback from RT1 and RT2. Bias correction of large-scale atmospheric and oceanic boundary conditions will be undertaken. The downscaling will employ model systems, focusing on processes relevant for ecosystem and biogeochemical modelling, including sea-ice dynamics, light penetration, and ocean stratification. The results will contribute to a coordinated archive of scenario simulations supporting the development of Marine Digital Twins (RT5.4) and providing forcing data for ecosystem simulations and assessments.

Links to other Tasks: 1.1.3, 1.2.2, 1.2.5, 1.3.1, 2.1.3, 2.3.2, 4.1.3

Deliverables in 2026: None

T5.2.3. Application of model systems to identify regions of interest for field observations

PI: MET. **Participants:** IMR, NERSC, NPI,

Work description: This task will apply the model systems evaluated in Task 5.2.1 to support the planning and implementation of field campaigns within *Arctic Ocean 2050*. The models will be used to identify spatial and temporal "hotspots" of scientific interest, e.g., regions characterized by strong gradients, high variability, or potential physical/ecosystem relevance. In addition, we will develop a capability for rapid post-fieldwork reanalyses (days–weeks) combining multi-source remote sensing and in-situ

data, to support interpretation and scientific exploitation of campaign observations shortly after field operations. Collaborating closely with RT2, the results will also provide baseline fields and context for interpreting in-situ measurements and satellite observations.

Links to other Tasks: 2.1.7, 2.1.8, 2.3.1

Deliverables in 2026: None

T5.2.4. Implementation and testing of new parameterizations in numerical models

PI: NERSC. **Participants**: IMR, NORCE, UiT, NTNU

Work description: This task will test new parameterizations of physical and/or biological processes into models of the Arctic, as suggested by field observations and experiments (RT2) and satellite observations and – similarly to Task 5.2.3 - collaborate with RT2 to refine the observational strategies accordingly. Examples of such processes include (but are not restricted to): sea ice deformation, ice-ocean and ice-atmosphere drag, ocean currents below sea ice, waves-in-ice, grease ice, snow-ice interactions, and light transmittance and attenuation. Improvements in biogeochemical processes, including i) implementation of prognostic alkalinity and CaCO3 production in the regional model that allows us to better project consequences of ocean acidifications, and ii) refining of photosynthetic and respiratory parametrizations for sea ice productivity. Improve biogeochemical process representations with potential for climate feedback, such as production and emissions of dimethyl sulfide (DMS).

Links to other Tasks: 1.2.2, 1.2.3

Deliverables in 2026: None

T5.2.5. High resolution NorESM3 historical and future scenarios

PI: NORCE. **Participants**: in discussion

Work description: We will implement an improved resolution NorESM model with better physical and biogeochemical parameterizations, assess the impacts of improved Atlantic water inflows representations and other remote processes on the projection of the Arctic Ocean. We will prepare, test, and produce NorESM3 simulation with ¼ degree ocean or better. Improve physical parameterizations, focusing on reproducing the observed Atlantic inflow and deepwater formation characteristics. Produce improved historical and future scenarios with CO_2 emissions that align with the latest international policy that will provide more reliable future projections to be downscaled by regional models in *Arctic Ocean 2050*. Investigate improvements and long-term large-scale impacts on the Arctic Ocean environment over the next centuries.

Links to other Tasks: 1.2.2, 1.2.3

Deliverables in 2026: None

Priority Topic 5.3: Develop machine learning based prediction and downscaling systems

We will explore and develop machine learning approaches for Arctic prediction, post-processing and downscaling by also using hybrid systems combining physical understanding and numerical modelling and purely data-driven techniques. The topic will support development of scalable ML-based prediction and downscaling components that can complement traditional modelling approaches and improve accessibility of high-resolution Arctic information products.

T5.3.1. Baseline setup of a graph neural network system for downscaling of atmosphere, sea-ice, and ocean variables

PI: MET. **Participants**: NERSC, NORCE, NTNU, UiO

Work description: We will establish the baseline configuration of an ML-based modelling framework for downscaling of atmosphere, sea-ice, and ocean variables, using the Anemoi graph neural network (GNN) architecture. The system will enable quasi-global simulations with a high-resolution Arctic focus (stretched grid) and will be trained later on with model outputs evaluated in Task 5.2.1 and produced in Task 5.2.2. The emphasis in this initial phase is to develop and test the core infrastructure. Activities include setting up data pipelines linking NorESM and NorCPM outputs with downscaled products, including dynamically downscaled NorESM simulations from Polar CORDEX, configuring the GNN architecture, and conducting pilot training runs to assess computational efficiency.

Links to other Tasks: 1.3.1, 5.4.2

Deliverables in 2026: None

T5.3.2. Training and evaluation of the graph neural network downscaling system

PI: MET. **Participants**: NERSC, NTNU, UiO

Work description: Building on the baseline prototype established in Task 5.3.1, this task will train and evaluate the Anemoi graph neural network (GNN) system for Arctic-scale downscaling of atmosphere, sea-ice, and 3D ocean variables. The training will use model outputs assessed in 5.2.1 and generated in 5.2.2. Activities include the design of relevant architectures, optimization of network parameters, validation against observations and reanalyses, assessment of transferability (when training data of complementary domains and scenarios are used) and comparison with the dynamical downscaling results.

Links to other Tasks: 1.3.1, 4.2.2, 5.4.2

Deliverables in 2026: None

T5.3.3. Hybrid modelling for seasonal scale forecasts

PI: UiB. **Participants**: NERSC

Work description: This task will pursue more ambitious emulators for full ocean, sea ice and biogeochemical variables as well as extended range forecasts (S2S) hybridizing the traditional NorCPM forecasts with Machine Learning developed in the Tasks 5.3.1 and 5.3.2, for example the emulator for sea ice. NorCPM has been under development for online coupling with the lightweight AI sea-ice prediction model Ice-kNN with 1° resolution for Arctic sea ice prediction on S2S timescales. The results demonstrate that online coupling significantly improves the seasonal prediction skill of Arctic sea ice. In addition, the atmosphere component of NorCPM will be coupled with a machine learning high-resolution weather forecast system (e.g., GraphCast), and the ocean component will be coupled with a machine learning high-resolution ocean forecast system (e.g., GLONET). The coupling in NorCPM remains untouched so that other components can further benefit from the improved dynamics. A benefit of such hybrid modelling is that AI-based systems enhance the representation of small-scale processes, while physics-based models constrain large-scale dynamics, ensure conservation properties, handle component coupling, and provide stability to AI models. The added value of AI-NorCPM on seasonal-to-decadal prediction will be investigated by performing the standard hindcast experiments and comparing them to those of the traditional NorCPM.

Links to other Tasks: 1.2.3, 1.2.5

Deliverables in 2026: None

T5.3.4. High resolution sea-ice prediction based on ML-based “direct-observation-predictions"

PI: NERSC. **Participants**: MET

Work description: A sea ice emulator will be trained on satellite observations only. This approach will bypass the issues related to numerical modelling (biases, spinup), thus provide more accurate forecasts, albeit restricted to observed variables only, and possibly provide new insights “learnt” from the observations.

In 2026, a data-driven algorithm trained on the following satellite observations has been developed and validated:

- Sea ice concentrations from the SSMI/S OSI-SAF passive microwave data.
- Sea ice thickness from the merged CS2SMOS dataset (completed by the TOPAZ4 reanalysis during summer).
- Sea ice drift from passive microwave and scatterometres OSI-SAF data.

With auxiliary atmospheric data from the ECMWF ERA5 reanalysis, a deterministic forecast model called IceCastNet has been validated and is expected to perform better than the TOPAZ forecasts at time scales from nowcasting to 10-days forecast.

The following steps will be to implement the forecast model on a Digital Twin Ocean cloud platform (EDITO) and demonstrate the forecast in near-real time in Task 5.4.2. The IceCastNet model will also be coupled to the Graph Neural Net weather forecast from Task 5.3.2 to provide coupled weather-ice forecasts faster than numerical models.

Links to other Tasks: 5.4.2

Deliverables in 2026: None

Priority Topic 5.4: Develop user-centered Arctic decision support systems – Digital Twins

We will develop user-centered Arctic decision support systems based on the concept of Marine Digital Twins. The work will include assessment, co-design and proof-of-concept development of digital twin capabilities that connect observations, models and prediction systems with user needs, enabling improved situational awareness and decision-making support for Arctic operations and management.

T5.4.1. Assessment and co-design of Marine Digital Twins for the Arctic Ocean

PI: MET. **Participants**: NERSC, NUPI, SINTEF, UiO

Work description: This task will assess and co-design concepts for a suite of Marine Digital Twins addressing different end-user and stakeholder needs. The goal is to determine which types of digital twins are most relevant, feasible, and beneficial for stakeholders and end-user, as well as their connection to central research questions in RT1 to RT6. Input will be collected through structured interviews and co-design workshops with end-user, policy and governance stakeholders (e.g., OSPAR, Arctic Council, BBNJ, ICES), and researchers. Feedback will be analysed together with experts and supported by literature-based reviews of existing digital-twin frameworks and technologies. Existing European Digital Twin infrastructures such as EDITO (European Digital Twin of the Ocean), Destination Earth and EOSC's BlueCloud will be exploited.

Links to other Tasks: 1.2.3, 1.2.5, 1.3.1, 1.3.3, 2.3.2, 3.1.1, 3.1.2, 3.2.5, 3.3.1, 4.1.5, 6.3.1

Deliverables in 2026: Workshop to review the intended use of the Digital Twin and the available technical solutions, a workshop summary will propose a plan for the activities ahead.

T5.4.2. Initial development and proof-of-concept of Marine Digital Twins for the Arctic Ocean

PI: MET. **Participants**: NERSC, NUPI, SINTEF, UiO

Work description: Based on the findings from Task 5.4.1, this task will initiate early development and testing of selected Marine Digital Twin concepts identified as both relevant and feasible for *Arctic Ocean 2050*. The focus will be on designing core system components, exploring data-model integration pathways, and establishing technical interoperability between observation streams, models, and AI-based prediction tools. Simplified proof-of-concept demonstrators will be created to test data workflows, visualization options, and user interaction interfaces in collaboration with scientific and operational partners. These demonstrators will not yet deliver operational products but will serve to evaluate feasibility, performance, and scientific value for different applications. The outcome will be a set of initial demonstrators, technical

documentation, and recommendations for the next development phase, forming the foundation for full prototype implementation later in the project.

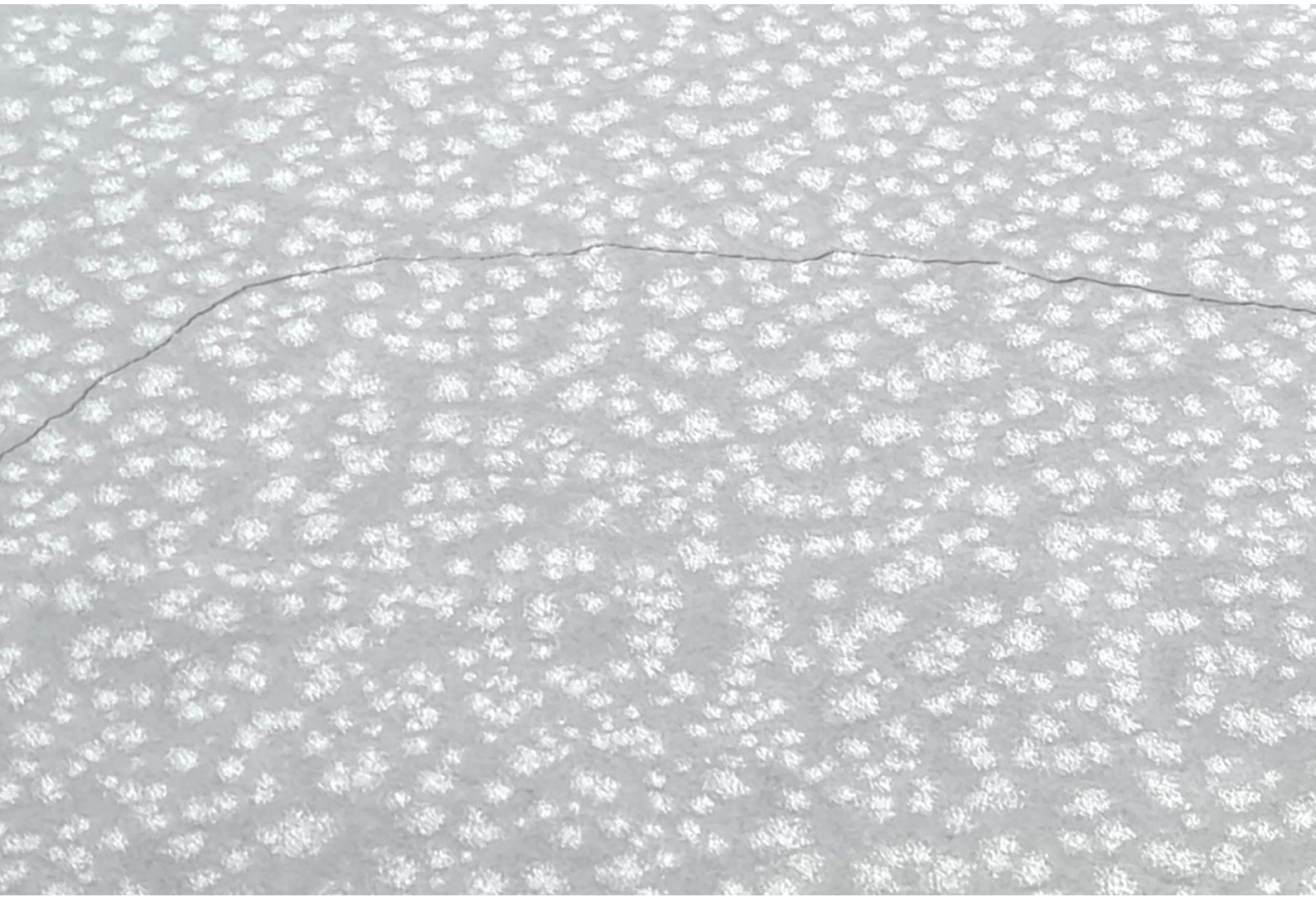
Links to other Tasks: 1.2.3, 1.2.5, 1.3.1, 1.3.3, 2.3.2, 3.1.1, 3.1.2, 3.2.5, 3.3.1, 4.1.5, 6.3.1

Deliverables in 2026: None

Table 5.1. Summary of Tasks in RT5 (2026-2028).

Tasks - RT5	Partners
T5.1.1. Central Arctic observational monitoring and decision support (Phase1: Design)	NTNU, APN, MET, NERSC, NGU, NINA, NORCE, NORSAR, NPI, UiT, UNIS
T5.1.2. Climate and ecosystem data records (Phase 1: Design)	UiT, MET, NORCE, NORSAR, NPI
T5.1.3. Multi-Scale Observations and Autonomous Mapping of Sea-Ice	NPI, MET, NERSC, NORCE, NTNU, UiT, UNIS
T5.1.4. Autonomous platforms for under-ice, deep-ocean, and MIZ observation systems (Phase 1: Design)	NTNU, APN, IMR, MET, NERSC, NPI, UNIS
T5.1.5. Multi-platform robotic observations (Phase 1: Design)	SINTEF, APN, NTNU
T5.1.6. Central Arctic observational monitoring and decision support (Phase 2: Development and implementation)	NTNU, APN, MET, NERSC, NGU, NINA, NORCE, NORSAR, UiT, UNIS
T5.1.7. Climate and ecosystem data records (Phase 2: Development and implementation)	UiT, MET, NORCE
T5.1.8. Autonomous platforms for under-ice, deep-ocean, and MIZ observation systems (Phase 2: Development and implementation)	NTNU, APN, IMR, MET, NERSC, NPI, UNIS
T5.1.9. Multi-platform robotic observations (Phase 2: Development and implementation)	SINTEF, APN, NTNU
T5.2.1. Assessment and coordination of existing Arctic climate modelling infrastructure for downscaling climate scenarios	MET, IMR, NERSC, NORCE, NPI
T5.2.2. Downscaling and bias correction of existing climate scenarios for the Arctic Ocean	MET, IMR, NERSC, NORCE, NPI
T5.2.3. Application of model systems to identify regions of interest for field observations	MET, IMR, NERSC, NPI

T5.2.4. Implementation and testing new parameterizations in numerical models	NERSC, IMR, NORCE, NTNU, UIT
T5.2.5. High resolution NorESM3 historical and future scenarios	NORCE
T5.3.1. Baseline setup of a graph neural network system for downscaling of atmosphere, sea-ice and ocean variables	MET, NERSC, NORCE, NTNU, UiO
T5.3.2. Training and evaluation of the graph neural network downscaling system	MET, NERSC, NTNU, UiO
T5.3.3. Hybrid modelling of seasonal scale forecasts	UiB, NERSC
T5.3.4. High resolution sea-ice prediction based on ML-based “direct observation predictions”	NERSC, MET
T5.4.1. Assessment and co-design of Marine Digital Twins for the Arctic Ocean	MET, NERSC, NUPI, SINTEF, UiO
T5.4.2. Initial development and proof-of-concept of Marine Digital Twins for the Arctic Ocean	MET, NERSC, NUPI, SINTEF, UiO





RT6: Arctic Ocean Pathways

Lead: Dorothy Dankel (SINTEF Ocean). Co-lead: Geir Hønneland (FNI)

Objective: Explore how environmental change, expanding human activity, and evolving geopolitical dynamics in the Arctic Ocean intersect to shape not only the Arctic region but also to catalyze broader societal transformations toward more just, sustainable, and adaptive futures.

Priority topics:

6.1 How can cross-disciplinary collaboration within *Arctic Ocean 2050* ensure that RT1–RT5 jointly identify and address the most urgent research questions related to the Arctic Ocean?

6.2 How can transdisciplinary co-production across diverse knowledge and value systems generate engagement opportunities and policy insights that are credible for and usable by policymakers (states, Indigenous leaders), industry, civil society actors and communities?

6.3 How can co-created scenarios of Arctic Ocean futures be translated into actionable pathways, policy roadmaps, and Digital Twin outputs that guide Norwegian decision-making as well as other Arctic states?

6.4 How can knowledge from *Arctic Ocean 2050* be aligned with external research projects and programmes to build a coherent pan-Arctic understanding that supports just, sustainable, and adaptive futures?

These priority topics form the basis for the tasks outlined below.

Priority Topic 6.1: Foster internal cohesion across research themes

PT6.1 aims to strengthen interdisciplinary collaboration within *Arctic Ocean 2050* by fostering internal cohesion and reflexive integration across all research themes (RT1–RT5). Operating under post-normal science principles (Funtowicz and Ravetz 1990, 1993), this priority topic addresses the need for adaptive, transparent, and pluralistic science-policy dialogues in a context of uncertainty and contested values.

T6.1.1. Cross-RT Communication Foundation and Internal Cohesion

PI: SINTEF. **Participants**: co-lead FNI, APN, FFI, IMR, NINA, NORCE, NTNU, NUPI, UiB, UiO, UiT, UNIS

Work description: Activities will include bi-monthly cross-RT coordination meetings (also known as "In-Reach" designed to co-create a common language across the *Arctic Ocean 2050* programme) and annual workshops with other RT leads and co-leads and key project personnel, to create structured spaces for dialogue, joint reflection, and knowledge synthesis. These engagements will enable colleagues in the other RTs to identify critical knowledge gaps, synthesize insights, and collaboratively map drivers shaping Arctic research priorities. In 2026 we will introduce systems thinking methodologies (Clifford et al. 2022; Dankel et al. 2020), conceptual mapping, and participatory modelling tools such as MentalModeler and Vensim to the other RTs, as

these will guide scenario development and integration from 2027 and onwards. Outputs will inform governance and policy processes, ensuring relevance and impact. Additionally, RT6 will monitor knowledge uptake and barriers to policy influence, positioning *Arctic Ocean 2050* as a leading voice in international science-policy arenas. Through iterative, interpretive, and reflexive processes, PT6.1 will create a dynamic forum for interdisciplinary sense-making, ensuring the consortium remains aligned on the Arctic's most pressing research questions with a common language. These "in-reach" efforts are also designed to foster training and awareness within the academic science community on how to engage in transdisciplinary conversations and co-production of knowledge.

Links to other Tasks: all RTs

Deliverables 2026:

- Report: State-of-the-art Arctic governance/security assessment (in collaboration with RT1 (T1.1.6).
- Workshop Reports and Meeting Minutes of the Bi-monthly RT Check-ins, Structured dialogue across RT1–RT5 through In-Reach workshops.

Priority Topic 6.2: Extending and Engaging the Peer Community

This PT focuses on engaging a diverse group of rightsholders, stakeholders and policy actors to co-produce scenarios, foresighting and actionable pathways (Ravetz 1999, Blackstock 2023, Dankel et al. 2012, 2020). Objectives are to define and engage across Research Themes and an extended peer community within a post-normal and participatory science frame (Funtowicz and Ravetz 1994; O'Brien 2018) and in keeping with the leading edge of insights about just, transdisciplinary engagement in the Arctic (IASC 2026).

T6.2.1. Peer Community Engagement for Governance

PI: FNI. **Participants**: APN, FFI, NINA, NORCE, NTNU, NUPI, SINTEF, UiB, UiO, UiT, UNIS

Work description: This task in 2026 focuses on extending and engaging the peer community to build *Arctic Ocean 2050*'s participatory approach and visibility in science-policy dialogues. The first step will involve comprehensive stakeholder mapping to identify key actors, including Indigenous peoples' organizations and representatives, industry representatives, NGOs, and policymakers, ensuring diverse perspectives are brought into productive conversation through scenario development and governance discussions. Building on this, an engagement plan will be developed using a power-interest matrix to prioritize outreach and design tailored strategies for effective collaboration. Coordination of the RT3 Human Activities/Human Impact workshop, tentatively scheduled for September 2026, will provide a platform for interdisciplinary dialogue on socio-economic drivers and their implications for Arctic futures. In addition, this task will support PT4.4 by identifying relevant policy communities and international advisory bodies with and through which to effectively communicate risk, mitigation, and conservation strategies to manage abrupt change.

To amplify the consortium's presence in policy arenas, PT6.2 will organize an extended peer community event during the Oslo Arctic Security Conference in mid-September 2026, fostering connections with international experts and decision-makers. Additionally, a seminar and networking workshop will be held in Oslo in the second half of 2026, featuring an evening session to present plans and ideas to the Research Council of Norway (NFR) and relevant ministries. These activities will demonstrate *Arctic Ocean 2050*'s commitment to inclusive, transparent, and actionable science, while positioning the consortium as a key contributor to Arctic governance and security dialogues.

Links to other Tasks: 1.1.1, 1.1.2

Deliverables 2026:

- Organize a stakeholder event during the Oslo Arctic Security Conference.
- Organize workshop on human activities/human impact (with RT3).

Priority Topic 6.3: Co-produce scenarios

This topic aims to develop co-produced scenarios that integrate climate impacts on the environment, marine habitats, and species within the Arctic Ocean and explore the social-ecological, economic, and political consequences identified through research and transdisciplinary engagement with the extended peer community. Such scenarios include environmental conservation, shifts in fishery distributions, impacts on Indigenous economies, policies and practices, changes in maritime accessibility, and emerging governance challenges of sustainable societal transformations (IPBES 2024). The goal is to inform research directions within the *Arctic Ocean 2050* programme and provide a robust foundation for future decision-making, policy development, and stakeholder engagement (Clifford et al. 2022; Dankel et al. 2020).

T6.3.1. Engagement and Scenario Co-Creation

PI: SINTEF. **Participants**: APN, FFI, FNI, IMR, NUPI, UiB, UiO, UiT

Work description: This work involves extended peer community engagement through organizing outreach sessions with key Arctic community rightsholders, stakeholders and policy communities, through *Arctic Ocean 2050* events and also via engagement at the Arctic Council, ICES, PICES, Indigenous Peoples' Dialogue, and the EU Arctic Forum. It includes interactive scenario workshops to co-produce knowledge-based scenarios that bring climate, socio-economic, and governance dimensions and different forms of knowledge into transdisciplinary conversation. Additionally, using exploratory agent-based modelling in collaboration with RT4, the task will identify unexpected disruptive combinations of technology and social evolution at an abstract level—not as predictions, but as part of a scanning exercise to anticipate possible futures. When disruptive events such as rapid environmental, technological, or social changes and new policies or laws are identified, these will be stress-tested within agent-based models to explore potential consequences and systemic risks or opportunities. The work also requires knowledge alignment by formalizing collaboration with pan-Arctic projects, Norway and Nordic-based research projects that work on coastal futures, and the EU Mission "Restore Our

Ocean and Waters" to ensure methodological coherence. Deliverables include public outputs, such as at least two synthesis reports and one peer-reviewed article on scenario development and governance implications, and conference contributions through presentations at major international forums, including the UN Ocean Conference and Arctic Circle Assembly.

Links to other Tasks: 1.1.1, 1.1.2, 1.1.5

Deliverables 2026: None

T6.3.2 Storytelling across land and sea: activating coastal connections and futures

PI: UiT. **Participants**: SINTEF, NUPI and others

Work description: This task draws inspiration from research that has shown the importance of storytelling and recovering/reclaiming Indigenous framings of land and sea that challenge and call for rethinking dominant framings based in colonial mindsets and practices (Kramvig and Salmela 2026). This can include different ways of conceptualizing land and sea and their interconnections that can be overlooked or dismissed by dominant scientific understandings and an indigenous theory of water (Simpson 2025). Decolonizing economics foster alternative ways of understanding the economy of the sea that critically questions the normative position and knowledge claim as formulated within western management system (Dutt et al. 2025).

The question of what the way will be forward for a Sami fisheries policy to expand within the Norwegian fisheries governance system, is still to be solved (Johnsen and Søreng 2018). This will be done through original research and activities, as well as through cooperation with major existing projects to enhance synergies and avoid duplication (e.g. the Horizon project 'Birgejupmi' [2025-2027; https://birgejupmi.eu/]). We will engage with counter-mapping (Chartier et al. 2024), as well as storytelling as ways of bringing diverse perspectives and experiences into conversation without seeking to forcefully integrate different knowledges or measuring one way of knowing against the other—an important policy recommendation of the recently concluded ICARP process (IASC 2026). Work with counter-mapping and storytelling inform and supplement work on scenarios and pathways to action in RT6 (and inform research directions in the program more broadly).

Links to other tasks: 1.1.1, 1.2.1, 6.2.1, 6.3.1 6.4.1

Deliverables 2026: none

Priority Topic 6.4: Actionizing Scenarios into Transformative Pathways and Roadmaps

This topic focuses on turning research-based scenarios into actionable policy recommendations and roadmaps for sustainable ocean governance and a resilient blue economy. The goal is to provide practical, implementable strategies for Norwegian policymakers, regional authorities, and business leaders, while engaging extended peer communities—policymakers, businesses, local communities, and civil society—for

legitimacy and co-ownership. Activities include collaboration with international initiatives such as the EU Mission Restore Our Oceans and Waters and the Digital Twin of the Ocean, ensuring methodological alignment and shared data. Integration with science–industry projects will strengthen innovation and sectoral practices in conservation, shipping, fisheries, offshore energy, and coastal resilience. Outputs will include targeted policy roadmaps and briefs to safeguard Norwegian and global interests in climate-resilient oceans and blue growth. PT6.4 will support evidence-based contributions to international arenas like UN processes and Arctic forums. Annual workshops with funders, user groups, and partners will validate progress and refine strategies for continued relevance and impact.

T6.4.1. Translating Scenarios into Pathways

PI: SINTEF. **Participants**: APN, FFI, FNI, UiB, UiO, UiT

Work description: This task focuses on transforming co-produced scenarios into practical tools and strategies that inform governance and decision-making across the Arctic region. The work begins by aligning knowledge generated within *Arctic Ocean 2050* research themes with external projects and programmes to build a coherent pan-Arctic understanding that supports just, sustainable, and adaptive futures. The first step is to translate scenarios into actionable policy roadmaps tailored for Norwegian ministries, Arctic states, and key industry sectors. These roadmaps will provide clear guidance for implementing sustainable practices and governance measures. In parallel, the task will integrate scenario outputs into Digital Twin platforms, ensuring that advanced modelling and visualization tools can support real-time decision-making and scenario testing.

To maintain relevance and accuracy, annual validation workshops will be organized with funders, governance actors, and international partners. These workshops will serve as calibration points to refine recommendations and incorporate emerging insights. Progress will be monitored through impact tracking, assessing the uptake of knowledge in policy and industry while identifying barriers and enablers to implementation.

Strategic communication is a core component of this task. Targeted policy briefs will be produced for politicians and state secretaries to inform UN processes and Arctic governance forums, ensuring that scientific insights translate into actionable decisions. Finally, legacy planning will secure continuity by embedding outputs within European and global ocean sustainability initiatives, creating long-term impact beyond the project's lifespan.

Deliverables 2026:

- Organize an annual reflexivity workshop.
- Contributions to major international conferences.

Table 6.1. Summary of Tasks in RT6 (2026-2028).

Tasks - RT6	Partners
T6.1.1. Cross-RT Communication Foundation and Internal Cohesion	SINTEF, FNI, APN, FFI, IMR, NINA, NORCE, NTNU, NUPI, UiB, UiO, UiT, UNIS
T6.2.1. Peer Community Engagement for Governance	FNI, APN, FFI, NINA, NORCE, NTNU, NUPI, SINTEF, UiB, UiO, UiT, UNIS
T6.3.1. Engagement and Scenario Co-Creation	SINTEF, APN, FFI, FNI, IMR, NUPI, UiB, UiO, UiT
T6.3.2 Storytelling across land and sea: activating coastal connections and futures	UiT, SINTEF, NUPI
T6.4.1. Translating Scenarios into Pathways	SINTEF, APN, FFI, FNI, UiB, UiO, UiT



Cruise planning for the period 2026-2028

The broad scope of the Science Plan will necessitate research cruises with different themes during the programme. We envision multi-disciplinary cruises repeating a transect across the Eurasian Basins every two-three years (Figure 3, orange circles). This repeated 'Eurasian Basin Transect' and the maintenance of multi-disciplinary mooring sites in the central basins (Figure 3, orange hexagons) will form the basis of a general-purpose sustained observing system that will provide time-series observations to *Arctic Ocean 2050* and complement international sustained observing efforts (Figure 3). In addition, many tasks require non-transect strategies, to be achieved in a suite of more specialized cruises focusing on specific regions and themes that will be defined as the programme progresses. These include sampling at specific habitat conditions such as the Yermak Plateau, ridges and seamounts, and areas along the core Atlantic Water inflow in the Amundsen Basin.

Concepts for four tentative cruise types are presented in Table 3. With the exception of the Eurasian Basin Transect cruise in 2026 (which has been planned in great detail) these concepts will be developed during 2026, in tandem with the implementation plan for later years.

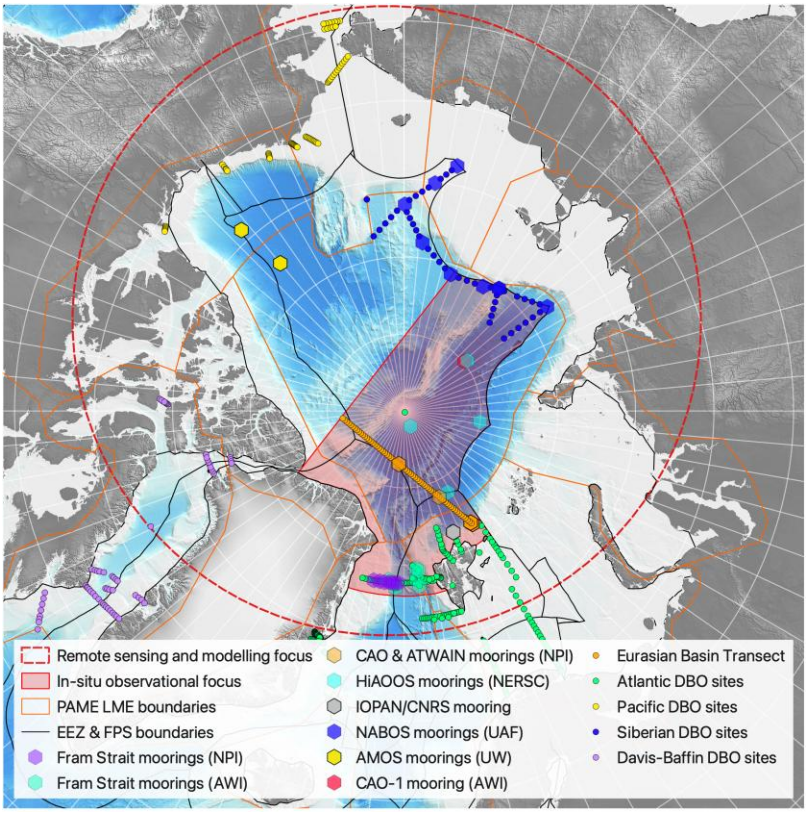


Figure 3: Overview of (some) existing observing initiatives in the Central Arctic Ocean.

Table 3: **Summary of cruise concepts**. Several may be conducted multiple times. TBD: To be decided.

Period	Concept/Region	Estimated Days	Main Theme (all necessarily multi-disciplinary)
24 July-10 September 2026, and to be repeated several times	Basin System: Eurasian Basin Transect (Figure 3)	49	Water column and sea ice focus. Contribution to international observation effort in CAO incl. SAS-II, IPY-5, Atlantic DBO.
tentative Aug 2027 (may be repeated)	Gateway System: Yermak Plateau / Nansen Basin	Approx. 25	Ecosystem survey. Fish investigations with contributions to international effort in CAOFA. Atlantic Water inflow.
tentative Aug 2028 (may be repeated)	Slope System: seabed features and processes	Approx. 25	Seabed mapping, Benthos, Solid Earth, Oceanography.
TBD	Seasonal variability: Winter and spring conditions	Approx. 30 each	Ocean, Ice & Atmospheric Physics in winter.
TBD	Fjords with ice-cover	TBD	Technology testing.

2026 Eurasian Basin Transect

The overarching aim of the 2026 Eurasian Basin Transect cruise is to collect new observations from the Amundsen and Nansen Basins needed to support work in *Arctic Ocean 2050*. The programme needs to understand the situation in the remote and relatively unstudied interior Amundsen Basin, dominated by the cold Transpolar Drift current and compare that with the situation in the Nansen Basin, which is dominated by the inflow of warm Atlantic Water from the Norwegian Atlantic Current and has been more intensively studied by recent initiatives including, NABOS and MOSAiC. Major tasks are to:

- Recover scientific moorings in the central Amundsen and central Nansen Basins which were deployed in August 2024 and redeploy for the period 2026-2028.
- Collect hydrographic, microstructure and optical measurements as well as samples of carbon, nutrient, transient tracers, phytoplankton, zooplankton, fish and eDNA along a multi-disciplinary section extending as completely as possible

across the Amundsen and Nansen Basins, including in the core of the Transpolar Drift current.

- Collect in-situ biological and physical measurements from ice floes and leads in the Nansen and Amundsen Basins and deploy autonomous drifting observatories on sea ice.
- Collect box cores to study the carbon and nitrogen systems, sediment grain size, pigments, benthic biota (incl. eDNA), pollutants, trophic markers, and to collect samples for palaeoceanographic work at key sites.
- Collect targeted multi-beam echosounder and sub-bottom profiler surveys as well as camera images of the seafloor at key sites along the cruise track that are considered candidates for further exploration during later cruises.

A preliminary list of participants and roles on board is provided in Table 4.

Priorities

Activities planned for the Amundsen Basin will be prioritized over activities planned for the Nansen Basin. There are few opportunities to complete work in the Amundsen Basin, while several research cruises visit the Nansen Basin each season. Beyond this, all activities are considered to be of similar importance, except for redeployment of moorings at the Amundsen Basin site. Mooring work at the Amundsen Basin site will be prioritized as the next foreseeable opportunity for service is earliest in 2028 and there is a high risk of losing valuable infrastructure and observations if these are not serviced in 2026.

Approach

We plan to make use of typically lighter ice conditions found from 25-30°E to rapidly reach the North Pole at the beginning of the cruise (Figure 4). From the Pole there will be a transit to the north-western end of our main transect line at CTD station 65, after which scientific operations will be completed in a south-easterly direction, working towards the ice edge north of Svalbard, following a similar pattern to similar cruises in 2022 and 2024.

Our geographical focus area is the multi-disciplinary transect, and we will prioritize reaching this early in the cruise. However, basic sampling at sparse intervals is planned during the passage north along 25-30°N to put the observations along the main transect into a wider spatial context. A stop is planned at the North Pole to deploy ice-tethered platforms in a location that maximizes their lifetime before they are expelled though the Fram Strait and stops are planned to investigate the seabed as we pass over the Gakkel and Lomonosov Ridges.

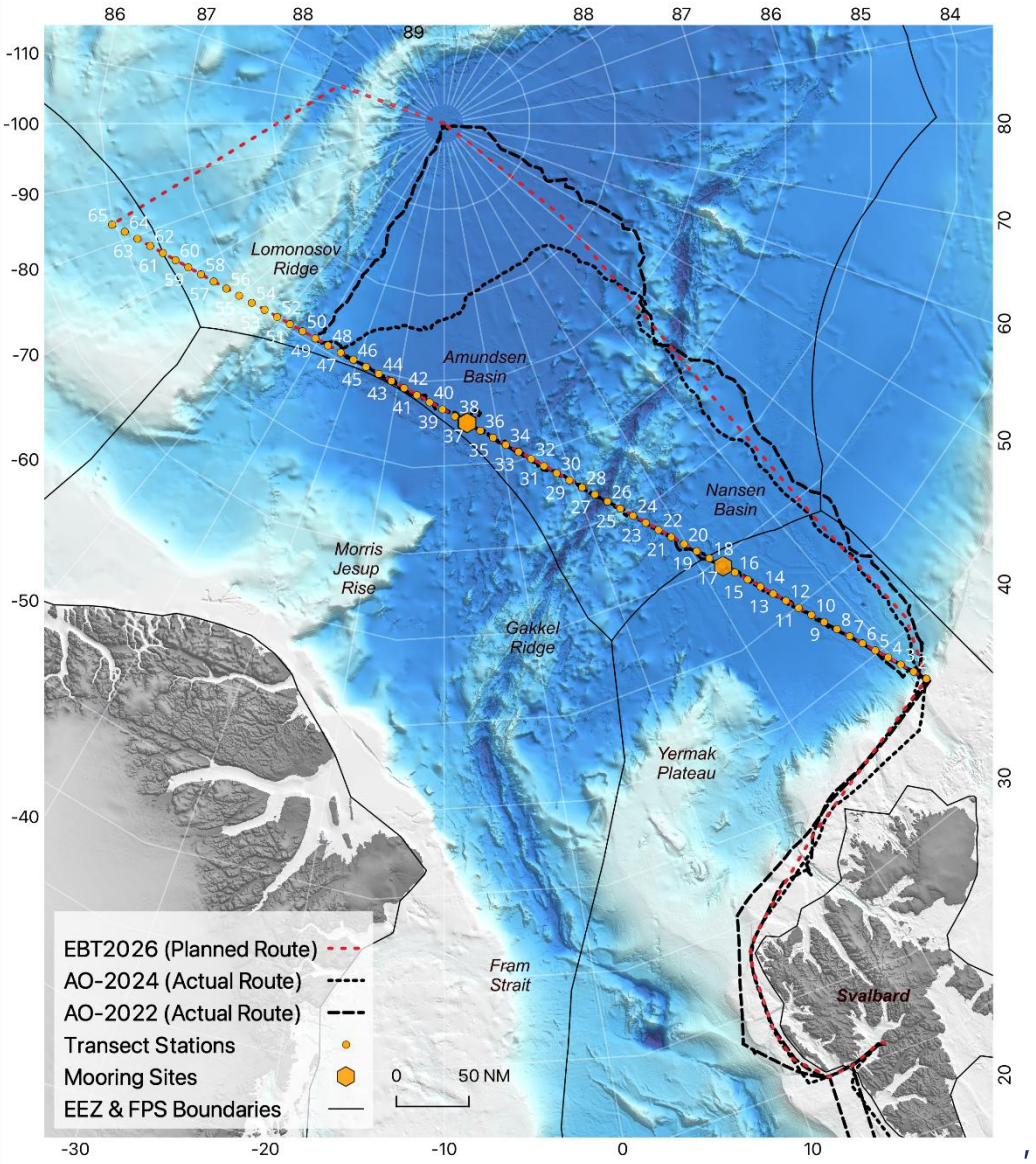


Figure 4: Planned route for 2026 Eurasian Basin Transect Cruise.

Cost Overview

Major costs

- Shiptime 35 days (cat II in-kind, NPI).
- Shiptime 15 days (9 days cat II in-kind, 6 days cat III; UiT).
- 49x12 working hours (mix of in-kind and RCN).
- Cruise allowance (mostly RCN, see Table 4).
- Medic, hired on cruise-specific contract (ca. 500 KNOK, RCN-communal funding).
- Cruise allowance & travel for Sea Ice Safety and Logistics person (ca. 150 KNOK, RCN-communal funding).

Minor costs

- Weapons, safety equipment etc. for work on ice (in-kind, NPI).

- Freight of 2-4 containers from mainland Norway to Longyearbyen and return with M/S Norbjørn (NFR, 30 KNOK per container one way; RCN communal).
- Return shipping frozen goods (-80°C, -20° C, cooled) (20 KNOK, RCN communal)
- Harbor fee.
- Separate freight of specialized instruments / samples by air (RCN).
- Hours to attend ½ day mandatory safety training, for participants that need refresher courses.
- Return travel to Longyearbyen for participants.

Table 4. Preliminary list of participants and roles on board. AO2050: *Arctic Ocean 2050*. Res fund: research funding

Institute	Initials	Participation Costs	Role
NPI	PAD	AO2050 - communal funding	Cruise leader / Physical Oceanography
NPI	AW	NPI cat 2 in-kind	Co-cruise leader / pelagic Nets and Trawling
NPI	AN	AO2050 - communal funding	Sea Ice Safety & Logistics
Shipping company	ET	AO2050 - communal funding	Medic
NPI	MB	AO2050 - Research funding (Res fund)	Mooring technician (put out NAN&AMU-24)
NPI	HEA	AO2050 - Res fund	Mooring technician (put out NAN&AMU-24)
NPI	MM	cat 3 in-kind (SUDARCO)	Physical Oceanography inc. MSS profiling
UiB	TE	AO2050 - Res fund	Water sampling, SF6, CFCs
UiB	FH	AO2050 – cat 2 in kind	Water sampling, SF6
UiO	TC	AO2050 – Res fund	Anthropogenic radioisotope sampling
UiT	SB	AO2050 - Res fund	Underwater vision profiler (UVP6)
NPI	VS	AO2050 - Res fund	Catch analysis / LSSS
UNIS	NN	UNIS (in-kind)	Net and incubation work
UiO	KD	AO2050 – Res fund	Multi-stressor experiments, zooplankton nets
UiB	KÅS	UiB	Labelled bacterial production experiments
UNIS	AV	UNIS (in-kind)	Water column eDNA & filtering
NTNU	NS	AO2050 - Res fund	POC, PON, Chl-a, FRRP, Cytosense, PAMELA

UiT	AM	UiT cat 3 in-kind (Diamond)	Primary production, sampling in leads
UiT	EC	UiT cat 3 in-kind (MicroShift)	Biodiversity (DNA/RNA) sea ice & under-ice water
UiT	NN	AO2050 - Res fund	Sea ice biogeochemistry & production
UiT	RM	UiT cat 3 in-kind (MicroShift)	Sea ice biogeochemistry
NPI	MG	AO2050 - Res fund	Sea Ice Lead & water sampling coordinator
UiB	HS	AO2050 - Res fund	Optical properties, help with PICCARO
NPI	PI	AO2050 - Res fund	in-situ physical properties of sea ice
NTNU	JEK	TBC	NTNU camera system + on ship met. Package (ceiliometre ++)
UNIS	AS	UNIS (in-kind)	Box coring lead, carbon demand experiments, macrobenthos
UNIS	CM	UNIS (in-kind)	Sediment grain size, pigments, TOC/TON, meiobenthos
UiT	IC	UiT – Res fund	Sediment biology, paleo sampling for team
US ONR	WJM	US. Off. of Naval Res.	(Via POLARIN) hyperspect. camera, meltpond geometry
US ONL	AE	US. Off. of Naval Res.	(Via POLARIN) hyperspect. camera, meltpond geometry

Risk assessment

Any activity comes with hazards, risk of failure, incomplete success or other challenges, as well as with an environmental footprint. In Arctic research planning, changes in Plan A are the norm. In the following table (Table 5), some of the more drastic risks that might be encountered in *Arctic Ocean 2050* are summarized, along with potential mitigation measures. As described, field and laboratory-related risk assessments are routinely done and are not specific to this programme. We are also conscious of environmental footprint of the programme and aim to keep it low were possible.

Table 5: High level risks associated with *Arctic Ocean 2050*, their perceived likelihood, severity and mitigation measures (to be) taken.

RCN Category	Risk	Likeli-hood	Severity	Groups involved	Mitigation measures
General	Researchers and/or consortium members leave their roles	Medium	Low	Any	Consortium partners are institutions with a long history. Should unexpected changes in commitment occur, redundancy in expertise within each organization and certainly across the consortium makes it unlikely that a task must be entirely dropped. Given the decade-long timeframe, we established a rotational scheme for all positions (but programme leader), to avoid fatigue and consider retirements.
General	A new pandemic	Low	High	All	We gained extensive experience during the covid-19 pandemic. Making use of digital communication, home office, lab use rotation plans, pre-cruise quarantines including health checks etc. we anticipate managing the programme through such an event, albeit in reduced operational space.
Excellence R&D	Insufficient sample material available to achieve objectives	Medium	High	RT2-4	Ensure to include archived material collected the previous years (2021-2024). Build international collaborations for sample sharing. Ensure efficient coordination such that material available serves as many purposes as possible. Adjust

					cruise planning to accommodate sample needs.
Excellence R&D	Insufficient data sets available to achieve objectives	Medium	High	RT1-5	Thoroughly conduct the planned scoping exercises to gain a solid overview of available data sets including unpubl. data. Share observational data sets early. Use international collaborations where appropriate.
Excellence R&D	Security restrictions on equipment and data streams	Medium	Medium	RT1-5	Clear understanding of rules and regulations on security, including acts on national security, objects, data, and infrastructure requiring protection and the needed security clearance of people. Swift and smooth processes avoiding unnecessary discrimination and unwanted exposure.
Implementation and impact	Delay in deliverables or non-performance	Medium	High	RT members	No tasks are staffed by only one partner institution, and multiple products contribute to deliverables, making it unlikely an entire deliverable is not achieved. Through regular reporting, RT meetings and task meetings we stringently review progress, allowing adjustment or re-allocation of resources to meet milestones and deliverables. Data set publication and communication to actionize knowledge are priorities.
Implementation and impact	Inavailability of ship time, RV Kronprins Haakon has extended repairs	Low	High	esp. RT2-5	We will seek ship time with *KV Svalbard, Polarsyssel,* FFI's vessel, and - for individuals - request berths on international vessels. Also, activities not requiring vessel time will be prioritized if Kronprins Haakon were to be periodically unavailable.
Implementation and impact	Failure of valuable sensors and sensor-carrying platforms during remote	Moderate	High	RT1-5	Extensive testing of new technology will be conducted in coastal waters including ice-covered fjords, to reduce risk of failure during 'real' deployments. A certain level of repair can be done at sea; more difficult issues need

	field operations				fixing back on land. Some level of redundancy is planned for during packing for cruises.
Implementation and impact	Reduction in airline flights due to fuel shortage	Medium	Medium	All	Increased digital dialog and on-line participation in conferences, workshops etc. Increase use of trains and ferries as possible (also to reduce carbon footprint).
Implementation and impact	Reduced funding (e.g. increase in fuel prices, Norway reprioritizing state budget)	Low	High	All	Time in the field would need to be reduced. Possibly philanthropic sources would carefully be considered. Already funded in-kind ECR would remain, and the number of (non-paid) MSc students can be increased. The fraction of modelling work could be enhanced relative to ship-based work.
Implementation and impact	Ship stranding far from land, in extreme weather	Low	High	All onboard	Risk assessment undertaken by ship committee and operating institution of vessel.
Implementation and impact	Risk and safety on cruises	Medium	Medium	esp. RT2-5	Health, safety & environment: Every cruise routinely conducts risk assessments for human injuries, all gear deployments and processes. We balance teams of experienced with inexperienced cruise participants to ensure safe handling of gear. All cruise participants must undergo mandatory safety training. Onboard, the science team is included in a safety drill. A responsible is assigned to handle chemicals, and MSDS are made available for all chemicals used.
Implementation and impact	Risk in labs	Low	Medium	RT1-5	Partner institutions follow their organization's procedures for risk assessment of lab work and safe use of chemicals.
Impact	Low interest and/or capacity level	Low	Medium	esp. RT6	Increase presentation and dialog at stakeholder venues instead of inviting them to us (e.g. Arctic

	of stakeholders				Circle, Arendalsuka, Arctic Frontiers, Barents Sea Conference).
Impact	Causing environmental impact through programme activities	Moderate	Medium	All	Limit travel where digital meetings work (e.g. most RTL/PL and board meetings); for physical meetings identify places with the least travel; map alternative supplies for lab ware; plan cruise tracks to minimize steaming time as ice cover allows; reduce single-use materials at meetings.



Education and capacity building

Objective: Foster a new generation of researchers with the interdisciplinary and transdisciplinary competence and versatility needed in science and outreach to address present and future management and governance issues, and to communicate effectively across disciplines, with managers and the general public.

Work plan: Early career researchers (ECRs) will be essential for the success of the *Arctic Ocean 2050* and will be integral to the science at all levels, contributing new knowledge while developing skills in research design, analysis, and critical thinking within an interdisciplinary, multi-institutional environment. To foster a stimulating and collaborative learning atmosphere, we will organize a comprehensive training and networking programme that integrates fieldwork, cross-cutting new methodology, workshops, and mentorship to support the professional and scientific growth of ECRs. The nice blend of Universities, Governmental and Private research institutions in this 10-year *Arctic Ocean 2050* programme fosters a unique platform and framework for recruits to educate, graduate and establish themselves as scientists and become the new generation of Polar scientists or managers the future needs. Key elements are given below, with a more detailed plan to be developed in the first programme year. Financial resources are associated with the planned activities, both from the joint budget and consortium partner budgets.

Arctic Ocean 2050 will:

Recruit the next generation of scientific talent. *Arctic Ocean 2050* will educate a minimum of 100 PhD candidates, hundreds of master students, and dozens of post-docs in its decade-long lifetime. Approximately 25 recruitment positions will be hired in the first year (Table 6). The majority of PhD positions form a substantial part of the mandatory in-kind contribution of consortium partners to the programme. Further recruitment is anticipated through RCN-funding from the programme budget, via Marie-Curie and other externally funded programmes, and again via partner organizations in later years. We will actively attract students by announcing relevant master thesis topics every year on the *Arctic Ocean 2050* web site and through partner institutions, with options of studying at their home universities and/or offers at our Arctic campuses, for example through a Master of Polar Science guest contract with UNIS on Svalbard. The 10-year duration of *Arctic Ocean 2050* will provide continuity and opportunities for student retention within the programme, from MSc- to post-doc levels and beyond. *Arctic Ocean 2050* will promote complementary supervision teams – spanning multiple institutions – to ensure the strongest possible support for MSc and PhD students. This approach will foster an engaging learning culture where students can draw on the diverse strengths of participating institutions, enabling them to pursue innovative, cross-cutting research.

Table 6: ECR positions. ECRs to be hired as the first cohort to *Arctic Ocean 2050* in the starting phase. Cat II is own contribution by consortium partners. Note additional ECRs work already at partner organizations. White/teal colours highlight affiliation to different Research Themes.

Home Institution	Position	Funding	Start	Task(s)
NINA	PhD	Cat II	Sep 2026	1.2.4, 1.2.5
UiB	PhD	Cat II	01.09.2026	1.2.5, 2.4.2, 2.4.6, 2.1.8
UiB	PhD	Cat II		1.3.4
UiB	PhD	Cat II	01.07.2026	1.4.1
UiB	PostDoc	Cat II	01.07.2026	1.4.1
SINTEF	PhD	Cat II	2026	2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.1.6, 2.1.7, 2.1.8
NTNU	PostDoc	Cat II	May 2026	2.1.3
UNIS	PhD	Cat II	Aug 2026	2.1.8
NPI	PostDoc	Cat II	Oct/Nov 2026	2.1.8
UiB	PhD	Cat II	01.06.2026	2.3.4
UiT	PhD	Cat II	Late 2026	2.3.5, 2.4.2, 2.5.3
UiB	PhD	Cat II	01.03.2026	2.4.1, 2.5.1
UiT	PhD	Cat II	Aug-Dec 2026	2.4.3
UiB	PhD	Cat II	01.09.2026	3.2.2, 2.3.1, 2.4.1, 2.4.6, 2.3.6
UNIS	PhD	Cat II	July 2026	3.2.2, 2.4.2, 2.4.6, 2.5.3
UiT	PhD	Cat II	Fall 2026	3.2.2, 3.2.3
UiT	PostDoc	NFR	Fall 2026	3.3.3 ++
MET	PhD	NFR	01.07.2026	5.1.1, 5.1.3
NTNU	PhD	Cat II	Dec 2025	5.1.x
NTNU	PhD	NFR	Fall/winter 2026	5.1.x
NTNU	PhD	Cat II	Fall/winter 2026	5.1.x
NTNU/NPI	PostDoc	NFR	Spring 2027	tbd
NTNU	PhD	Cat II	Fall/winter 2026	tbd
NTNU	PhD	Cat II	Spring 2027	tbd
NTNU	PhD	NFR	Spring 2028	tbd

Establish an early career researcher forum. The *Arctic Ocean 2050* secretariat will coordinate the ECR forum, which will serve as a central training and communications platform for the early career researchers of the programme. The forum will organize and provide funding for ECR meetings, training, attending international conferences, research-mobility opportunities, and other events (in person and online), in close collaboration with The Arctic Marine Ecosystem Research Network (ARCTOS network), a national network led by *Arctic Ocean 2050* partner institutions, and the international Association of Polar Early Career Scientists (APECS). Since ECRs are often the primary links across institutions and disciplines, we will devote significant resources to providing diverse forums for interaction and collaboration within *Arctic Ocean 2050*.

Building scientific knowledge through broad educational opportunities. Scientific knowledge development is central to every MSc and PhD journey. Throughout its duration, *Arctic Ocean 2050* will develop a new, PhD-level course that will be offered several times for the different cohorts, as well as summer schools, workshops, and seminars to provide both disciplinary depth and inter- and transdisciplinary perspectives. These initiatives will address key themes that will be presented and discussed from both natural and social science angles, such as extra-regional drivers (RT1); the characteristics and functioning of the Arctic Ocean (RT2); human impacts, potential uses and associated governance (RT3); as well as extreme and abrupt events (RT4). Education in cultural awareness, ethical matters, and different knowledge systems/transdisciplinary engagement will be included. The necessary field training to conduct safe field work will be offered to cruise participants. The recently funded Research Council of Norway PhD school *Climate informed*, led by UiB, together with courses within the northern Norwegian ARCTOS network and the Master of Polar Science program at UNIS will serve as important platforms for delivering this training. Educational excellence will be strengthened by drawing on expertise developed through the Centers for Outstanding Education in Biology (*bioCEED* – Centre for Excellence in Biology Education, 2014–2023) and Geology (*iEarth* – The Center for Integrated Earth Science Education, 2019–2029), as well as the many award-winning educators affiliated with these programmes.

Building transferable skills. Through the ECR forum, young researchers will be given opportunities to build relevant transferable skills inside *Arctic Ocean 2050*. ECRs will be encouraged and trained to lead science sessions in annual meetings, develop session proposals for international conferences, participate in panel discussions, and help write new research proposals. Additionally, training will be provided on how to apply post-normal science principles and "in-reach" approaches for dealing with complexity (RT6), as well as developing radical transformative leadership skills (Sharma 2017) to drive systemic change and innovation in Arctic research and governance. In outreach settings, ECRs will be required to participate in workshops on diverse topics related to analysis and publishing of data, graphical presentation, writing for professional and lay audiences, responsible engagement with rightsholders and stakeholders, effective public speaking, and other topics.

International collaboration strategy

The success of *Arctic Ocean 2050* depends on solid international collaboration, ranging from long-term partnerships with national Arctic programmes of other countries to more limited project-to-project collaboration, topical collaboration (e.g., technology development and testing, model development, improvement of remote sensing products, governance or geopolitical themes), and ECR exchange at institutions and on cruises. Discussions aiming to establish formal collaboration have been conducted with Japan's ArCS-3 and Republic of Korea's new K-Arctic Ocean program. Discussions with relevant projects in other countries have also started – through contact with leaders of international projects or organizations, and in some cases based on suggestions from members of the International Advisory Board.

Arctic Ocean 2050 has established internal guidelines for establishment of formal collaboration with international programmes and projects to ensure that we avoid duplication of work and to keep track of resources committed into collaborative efforts. If the *Arctic Ocean 2050* leader or project office – or one of the partner institutions – are contacted by international scientists, organisations or projects suggesting collaboration, an evaluation will be made with respect to feasibility and usefulness, and to make sure that we do not initiate redundant work or commit resources (e.g. ship time/berths, data, etc.) twice. The programme lead team together with the programme office is responsible for performing the necessary checks. Similarly, if programme participants, task or RT leads, or the programme lead team have suggestions for such collaboration, the same procedures will be invoked. The purpose of these guidelines is not to constrain international collaboration but to ensure relevance and efficiency. Collaboration will be formalized through letters of support, letters of commitment, collaboration agreements, or other appropriate formal documents, determined on a case-to-case consideration. Among the mechanisms we will establish for practical collaboration are sharing of data and tools, participation on cruises, an ECR support scheme for exchange visits with international collaborators or on cruises, and guest stays for international collaborators with *Arctic Ocean 2050* partner institutions.

Coordination of research cruises in the Central Arctic Ocean is a topic that requires particular attention, to ensure optimal use of resources. *Arctic Ocean 2050* will invite key institutions that operate or have cruises on research icebreakers to coordinate activities with respect both to geography, science topics and protocols, starting in autumn 2026. In particular, for the SAS-II and IPY-5 periods, coordination will be important to ensure that the international community's ambitions and expectations are met to the greatest extent possible. We will plan for a combination of online meetings and in-person meetings, e.g., at the annual Arctic Science Summit Week meetings.

Upcoming (tentatively 2027 and 2030/31) open calls for project funding associated with *Arctic Ocean 2050* through the Research Council of Norway will enable funding of international collaborators. These calls may include funding from other countries' funding agencies, further extending the possibilities for jointly funded direct collaboration. An upcoming EU call for proposals explicitly mentions collaboration with *Arctic Ocean 2050*. We envision that other opportunities for solid, well-funded

international collaboration will emerge in the coming years, e.g., through the Belmont Forum.

Data management plan

See separate document delivered with the revised Science and Implementation Plan. This plan is to be considered a living document.

Communication plan

A separate communication plan document was developed. It outlines the strategy, priorities, timelines and tracking metrics of communication activities in *Arctic Ocean 2050*.



Appendix 1 – Overview of person months and other operating costs

The following tables detail the person months (PMs) and other operating expenses (kNOK) in 2026 requested from the Research Council of Norway (RCN) and provided in-kind (category 2) by the consortium. One table is provided for each RT. The associated budget is provided via RCN's application portal. There may be small deviations between these person month tables as listed here (prepared in March 2026) and the final budget submitted.

Many tasks benefit from category 3 activities, i.e., ongoing projects by a given partner with relevance to *Arctic Ocean 2050*. Those are not specified here since they are not fully mapped yet. A preliminary overview shows that category 3 activities are relevant for all research themes, in particular RTs 1, 2, 3, and 5, and for over half of all priority themes.

Table A1: Total person months (PM) and other operating expenses (kNOK) requested from the Research Council of Norway for 2026 for each RT.

	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
RT1 NFR	0.50	0	3.00	0	2.60	100	2.00	0	6.00	0	1.00	0	2.00	0	4.70	0	8.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.50	0	2.00	0	0.00	0	6.40	60	4.75	0
RT2 NFR	2.50	0	0.00	0	1.50	37.5	4.50	0	0.00	0	6.00	0	0.00	0	2.00	0	0.00	0	0.00	0	11.40	2550	1.00	120	0.00	0	0.00	0	3.20	1450	6.00	2410	18.00	1274	4.00	500
RT3 NFR	2.00	0	2.00	0	0.00	0	2.00	0	0.00	0	0.00	0	0.00	0	1.70	0	0.00	0	0.00	0	0.00	50	0.00	0	0.00	0	3.00	100	2.00	250	3.60	165	0.00	0	4.90	0
RT4 NFR	2.90	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.20	0	0.40	0	0.00	0	0.00	0	2.70	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
RT5 NFR	0.50	0	0.00	0	0.20	0	0.50	0	12.70	0	6.00	0	0.00	0	0.20	0	0.00	0	18.40	300	0.00	0	1.00	0	13.00	1466	1.50	0	2.50	150	1.50	0	1.00	0	0.50	0
RT6 NFR	0.50	0	3.00	25	0.00	0	0.00	0	0.00	0	0.00	0	0.50	0	0.20	0	0.00	0	1.00	0	0.00	0	0.50	0	0.00	0	7.80	200	3.00	95	0.00	25	0.00	0	0.00	0
Totals	8.90	0	8.00	25	4.30	137.5	9.00	0	18.70	0	13.00	0	2.50	0	9.00	0	8.40	0	19.40	300	11.40	2600	5.20	120	13.00	1466	12.80	300	12.70	1945	11.10	2600	25.40	1334	14.15	500

Table A2: Person month (PM) overview and other operating expenses (kNOK) requested from the Research Council of Norway for 2026 for **RT1**.

RT1	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
Task	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
RT lead															1.2																		2.4			
T1.1.1			2								1		2				6																			
T1.1.2			1														2										0.5		2							
T1.1.3							1.5		2																										0.5	
T1.1.4															0.4																				0.25	
T1.1.5																																				
T1.1.6																																				
T1.2.1																																			1	
T1.2.2																																			0.5	
T1.2.3									2																											
T1.2.4	0.5						0.5								1.2																				1	
T1.2.5															1.4																				0.5	
T1.3.1									2																										0.5	
T1.3.2																																			0.5	
T1.3.3															0.5																					
T1.3.4					2.6	100																											4	60		
T1.4.1																																				
T1.4.2																																				
T1.4.3																																				
T1.4.4																																				
SUM:	0.5	0	3	0	2.6	100	2	0	6	0	1	0	2	0	4.7	0	8	0	0	0	0	0	0	0	0	0	0.5	0	2	0	0	0	6.4	60	4.75	0

Table A3: Person month (PM) overview and other operating expenses (kNOK) requested from the Research Council of Norway for 2026 for **RT2**.

RT2	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
Task	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
RT lead																					2.4								1.2							
T2.1.1																															0,5					
T2.1.2																						300		120											1	500
T2.1.3																						250							2	100			4	431		
T2.1.4																						650												143		
T2.1.5	1																																	200		
T2.1.6							1														6															
T2.1.7																																				
T2.1.8							0.5																								0.5	1400			1	
T2.2.1											2																		100							
T2.2.2					0.5						2																									
T2.2.3					1	37.5					2																									
T2.3.1																						300							200				1			
T2.3.2																																				
T2.3.3							0.5																													
T2.3.4							0.5																1										4			
T2.3.5																													100		0.25	750	2			
T2.3.6	0.5																														1	40				
T2.4.1	0.5														0.7							150									1	100	2		0.5	
T2.4.2	0.5																					150							250		1	100			0.5	
T2.4.3							1.5								0.3														200						1	
T2.4.4															0.3							150							450		0.5					
T2.4.5							0.5								0.3																					
T2.4.6																																				
T2.5.1															0.4																		3			
T2.5.2																															1					
T2.5.3																													50							
T2.5.4																																				
T2.6.1																					3	600									0.75	20	2	500		
SUM:	**2.5**	**0**	**0**	**0**	**1.5**	**37.5**	**4.5**	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**11.4**	**2550**	**1**	**120**	**0**	**0**	**0**	**0**	**3.2**	**1450**	**6**	**2410**	**18**	**1274**	**4**	**500**

Table A4: Person month (PM) overview and other operating expenses (kNOK) requested from the Research Council of Norway for 2026 for **RT3**.

RT3	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
Task	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
RT lead																															1.2				2.4	
T3.1.1							0.5								0.9												1					80			0.5	
T3.1.2																																			0.5	
T3.1.3																																				
T3.2.1							0.5								0.2												2	100			1				0.5	
T3.2.2																														100	1				0.5	
T3.2.3	1																					50														
T3.2.4	1														0.3																0.4					
T3.2.5							0.5																													
T3.2.6							0.5								0.3																				0.5	
T3.2.7																																				
T3.3.1			1																										2	50						
T3.3.2			1																											50		85				
T3.3.3																														25						
T3.3.4																														25						
SUM:	**2**	**0**	**2**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1.7**	**0**	**0**	**0**	**0**	**0**	**0**	**50**	**0**	**0**	**0**	**0**	**3**	**100**	**2**	**250**	**3.6**	**165**	**0**	**0**	**4.9**	**0**

Table A5: Person month (PM) overview and other operating expenses (kNOK) requested from the Research Council of Norway for 2026 for **RT4**.

RT4	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
Task	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
RT lead	2.4																						1.2													
T4.1.1																							0.5													
T4.1.2															0.2		0.4																			
T4.1.3																							1													
T4.1.4																																				
T4.1.5																																				
T4.1.6																																				
T4.1.7																																				
T4.2.1																																				
T4.2.2																																				
T4.2.3																																				
T4.3.1																																				
T4.3.2																																				
T4.3.3																																				
T4.4.1	0.5																																			
T4.4.2																																				
T4.4.3																																				
SUM:	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0.4	0	0	0	0	0	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A6: Person month (PM) overview and other operating expenses (kNOK) requested from the Research Council of Norway for 2026 for **RT5**.

RT5	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
Task	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
RT lead									1.2										2.4																	
T5.1.1					0.2				5		3				0.2				4						13	1466			1.5	50			1			
T5.1.2											3																		1	100						
T5.1.3																			3	300											0.5					
T5.1.4																															1					
T5.1.5	0.5																										1.5									
T5.1.6																																				
T5.1.7																																				
T5.1.8																																				
T5.1.9																																				
T5.2.1							0.5		1.5										3				1													
T5.2.2																																				
T5.2.3																																				
T5.2.4																																				
T5.2.5																																				
T5.3.1																			5																	
T5.3.2																																				
T5.3.3																																				
T5.3.4									2																											
T5.4.1																			1																0.5	
T5.4.2									3																											
SUM:	0.5	0	0	0	0.2	0	0.5	0	12.7	0	6	0	0	0	0.2	0	0	0	18.4	300	0	0	1	0	13	1466	1.5	0	2.5	150	1.5	0	1	0	0.5	0

Table A7: Person month (PM) overview and other operating expenses (kNOK) requested from the Research Council of Norway for 2026 for **RT6**.

RT6	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
Task	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
RT lead			1.2																								2.4									
T6.1.1			1.8																0.5				0.5				2.4	100	1	25						
T6.2.1	0.5			25											0.2				0.5								2	50	1	45		25				
T6.3.1																											0.5	50	0.5							
T6.4.1													0.5														0.5		0.5	25						
SUM:	0.5	0	3	25	0	0	0	0	0	0	0	0	0.5	0	0.2	0	0	0	1	0	0	0	0.5	0	0	0	7.8	200	3	95	0	25	0	0	0	0

Table A8: Total in-kind (category 2) person month (PM) overview and other operating expenses (kNOK) for 2026 for each RT.

	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
RT1 IK-C2	0.5	0	0	0	0	0	2	0	0	0	0	0	0	0	6.1	0	0	50	0	0	4.5	0	6	0	0	0	0	0	6.5	0	0.5	0	9	0	4.75	0
RT2 IK-C2	0	0	0	0	0	0	4.5	0	0	0	3	0	0	0	1	0	0	0	0	0	34.4	0	0	0	1	0	0	0	21.5	40	26.25	200	35	50	6.5	1000
RT3 IK-C2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0.5	0	0	0	7	0	2	0	9.5	0	4.75	0	5	0	2	0
RT4 IK-C2	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	3	0	0	0	0	0	0	0	1	0	1.5	0	0	0	0	0
RT5 IK-C2	0	0	0	0	0	0	0.5	0	3	0	4	0	0	0	0	0	0	0	6	800	3	0	4	0	15	0	0	0	2	0	1	0	2	0	0.5	0
RT6 IK-C2	0	0	0.6	0	0	0	0	0	0	0	0	0	2.5	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	3	0	0.5	0	0	0	1	0
Totals	1.00	0	0.60	0	0.00	0	9.00	0	3.00	0	7.00	0	2.50	0	7.90	0	0.50	50	6.00	800	45.40	0	10.00	0	51.00	0	2.00	0	43.50	40	34.50	200	51.00	50	14.75	1000

Table A9: In-kind (category 2) person month (PM) overview and other operating expenses (kNOK) for 2026 for **RT1**.

RT1	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
Task	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
T1.1.1																		25											1							
T1.1.2																		25											2.25							
T1.1.3							1.5																						0.5						0.5	
T1.1.4	0.5																																		0.25	
T1.1.5																																				
T1.1.6																													1.25							
T1.2.1																							3												1	
T1.2.2																																			0.5	
T1.2.3																																				
T1.2.4							0.5								2.85						0.5		3						1		0.25		1		1	
T1.2.5															2.95						0.5								0.5		0.25		2		0.5	
T1.3.1																																			0.5	
T1.3.2																																			0.5	
T1.3.3															0.3						0.5															
T1.3.4																																				
T1.4.1																					3												6			
T1.4.2																																				
T1.4.3																																				
T1.4.4																																				
SUM:	**0.50**	**0**	**0.00**	**0**	**0.00**	**0**	**2.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**6.10**	**0**	**0.00**	**50**	**0.00**	**0**	**4.50**	**0**	**6.00**	**0**	**0.00**	**0**	**0.00**	**0**	**6.50**	**0**	**0.50**	**0**	**9.00**	**0**	**4.75**	**0**

Table A10: In-kind (category 2) person month (PM) overview and other operating expenses (kNOK) for 2026 for **RT2**.

RT2	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
Task	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
T2.1.1																															0.5		1			
T2.1.2																					4				6						0.5				1.5	1000
T2.1.3																					2								2							
T2.1.4																					0.5								0.5				2	50	1	
T2.1.5																					0.5												1			
T2.1.6							1														2															
T2.1.7																					0.5												0.5			
T2.1.8							0.5														0.5										7	75	1		2	
T2.2.1											1										0.4								0.25		0.5					
T2.2.2											1																				0.5					
T2.2.3											1																		0.25		0.75					
T2.3.1																					0.5								1				0.5			
T2.3.2																					2															
T2.3.3							1														1												0.5			
T2.3.4																					1												7			
T2.3.5																													4.5		1	25				
T2.3.6																															3	50	0.5			
T2.4.1															1						0.5										3	25	7		0.5	
T2.4.2																					7								4		2.5		1		0.5	
T2.4.3							1.5														1.5								5						1	
T2.4.4							0.5														0.5								0.5		1					
T2.4.5																					2															
T2.4.6																															2	25	6			
T2.5.1																																	6			
T2.5.2																														20	1					
T2.5.3																													0.5	20	1					
T2.5.4																													3		0.25					
T2.6.1																					8										1.75		1			
SUM:	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**4.50**	**0**	**0.00**	**0**	**3.00**	**0**	**0.00**	**0**	**1.00**	**0**	**0.00**	**0**	**0.00**	**0**	**34.40**	**0**	**0.00**	**0**	**6.00**	**0**	**0.00**	**0**	**21.50**	**40**	**26.25**	**200**	**35.00**	**50**	**6.50**	**1000**

Table A11: In-kind (category 2) person month (PM) overview and other operating expenses (kNOK) for 2026 for **RT3**.

RT3	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
Task	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
T3.1.1							0.5								0.6										3						0.25				0.5	
T3.1.2																									3								1		0.5	
T3.1.3																									1						0.25					
T3.2.1							0.5																				2		0.25		0.5				0.5	
T3.2.2																													5.25		1		1			
T3.2.3																					0.5												3			
T3.2.4							0.5																								0.5					
T3.2.5							0.5																													
T3.2.6															0.2																0.25				0.5	
T3.2.7																																				
T3.3.1																													1							
T3.3.2																													1		2					
T3.3.3																													1							
T3.3.4																													1							
SUM:	0.00	0	0.00	0	0.00	0	2.00	0	0.00	0	0.00	0	0.00	0	0.80	0	0.00	0	0.00	0	0.50	0	0.00	0	7.00	0	2.00	0	9.50	0	4.75	0	5.00	0	2.00	0

Table A12: In-kind (category 2) person month (PM) overview and other operating expenses (kNOK) for 2026 for **RT4**.

RT4	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
Task	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
T4.1.1																					1.25								0.5		0.25					
T4.1.2																													0.5							
T4.1.3																																				
T4.1.4																																				
T4.1.5																																				
T4.1.6																																				
T4.1.7																																				
T4.2.1																					1.5										0.25					
T4.2.2																																				
T4.2.3																															0.25					
T4.3.1	0.5																0.25																			
T4.3.2																																				
T4.3.3																					0.25										0.75					
T4.4.1																																				
T4.4.2																																				
T4.4.3																																				
SUM:	0.50	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.25	0	0.00	0	3.00	0	0.00	0	0.00	0	0.00	0	1.00	0	1.50	0	0.00	0	0.00	0

Table A13: In-kind (category 2) person month (PM) overview and other operating expenses (kNOK) for 2026 for **RT5**.

RT5	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
Task	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
T5.1.1									2		2										0.5		2		38				0.75		0.5		2			
T5.1.2											2										1		2						1.25							
T5.1.3																			2	300	0.5										0.25					
T5.1.4																					0.5										0.25					
T5.1.5																																				
T5.1.6																																				
T5.1.7																																				
T5.1.8																																				
T5.1.9																																				
T5.2.1							0.5												4		0.5															
T5.2.2																																				
T5.2.3																																				
T5.2.4																																				
T5.2.5																																				
T5.3.1																				500																
T5.3.2																																				
T5.3.3																																				
T5.3.4																																				
T5.4.1									1																											0.5	
T5.4.2																																				
SUM:	0.00	0	0.00	0	0.00	0	0.50	0	3.00	0	4.00	0	0.00	0	0.00	0	0.00	0	6.00	800	3.00	0	4.00	0	38.00	0	0.00	0	2.00	0	1.00	0	2.00	0	0.50	0

Table A14: In-kind (category 2) person month (PM) overview and other operating expenses (kNOK) for 2026 for **RT6**.

RT6	APN		FNI		NGU		IMR		NERSC		NORSAR		FFI		NINA		NUPI		MET		NPI		NORCE		NTNU		SINTEF		UiT		UNIS		UiB		UiO	
Task	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC	PM	OC
T6.1.1			0.6										0.5				0.25												1.5		0.25				0.5	
T6.2.1													0.5																1.5		0.25				0.5	
T6.3.1													1																							
T6.4.1													0.5																							
SUM:	**0.00**	**0**	**0.60**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**2.50**	**0**	**0.00**	**0**	**0.25**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**3.00**	**0**	**0.50**	**0**	**0.00**	**0**	**1.00**	**0**

Appendix 2 – Task leads

RT1: The Arctic Ocean in the World		
Lead	**Marius Årthun**	**UiB**
Co-lead	**Kari E. Ellingsen**	**NINA**
PT1.1 Identify key political and environmental drivers originating outside the Arctic Ocean		
T1.1.1	Karsten Friis	NUPI
T1.1.2	Geir Hønneland	FNI
T1.1.3	Randi Ingvaldsen	IMR
T1.1.4	Amanda Poste	NINA
T1.1.5	Karsten Friis	NUPI
T1.1.6	Geir Hønneland	FNI
PT1.2 Assess near-term predictions of the Arctic Ocean environment		
T1.2.1	Trude Storelvmo	UiO
T1.2.2	Kirstin Krüger	UiO
T1.2.3	Filippa Fransner	UiB
T1.2.4	Sissel Jentoft	UiO
T1.2.5	Kari E. Ellingsen	NINA
PT1.3 Assess long-term projections of the Arctic Ocean environment		
T1.3.1	Ada Gjermundsen	UiO
T1.3.2	Trude Storelvmo	UiO
T1.3.3	Brett K. Sandercock	NINA
T1.3.4	Ulysses Ninnemann	UiB
PT1.4 Identify external impacts of a changing Arctic Ocean		
T1.4.1	Marius Årthun	UiB
T1.4.2	Lingling Suo	NERSC
T1.4.3	Elana Wilson Rowe	NUPI
T1.4.4	Elana Wilson Rowe	NUPI

RT2: The Changing Arctic Ocean		
Lead	**Paul Dodd**	**NPI**
Co-lead	**Bodil Bluhm**	**UIT**
PT2.1 Physical Interactions between the Ocean, Sea Ice and Atmosphere		
T2.1.1	Lars Henrik Smedsrud	UiB
T2.1.2	Sebastian Gerland	NPI
T2.1.3	Håkon Sandven	UiB
T2.1.4	Paul Dodd	NPI
T2.1.5	Ilker Fer	UiB
T2.1.6	Angelika Renner	IMR
T2.1.7	Kjetil Våge	UiB
T2.1.8	Frank Nilsen	UNIS
PT2.2 Seafloor and Geosphere Interactions		
T2.2.1	Stefan Bünz	UiT
T2.2.2	Carmen Gaina	UiO
T2.2.3	Terje Thorsnes	NGU
PT2.3 Biogeochemical cycles: baseline, pathways, responses, impacts, and feedback		
T2.3.1	Karley Campbell	UiT
T2.3.2	Pedro Duarte	NPI
T2.3.3	Melissa Chierici	IMR
T2.3.4	Are Olsen	UiB
T2.3.5	Marit Reigstad	UiT
T2.3.6	Arunima Sen	UNIS
PT2.4 Biodiversity and stocks across habitats		
T2.4.1	Anna Vader	UNIS
T2.4.2	Janne E. Søreide	UNIS
T2.4.3	Haakon Hop	NPI
T2.4.4	Aud Larsen	NORCE
T2.4.5	Heidi Ahonen	NPI
T2.4.6	Øystein Varpe	UiB
PT2.5 Ecosystem food web – pathways and functioning		
T2.5.1	Oliver Müller	UiB
T2.5.2	Amanda Ziegler	APN
T2.5.3	Sünnje Basedow	UiT
T2.5.4	Sanna Majaneva	APN
PT2.6 Enabling Multidisciplinary Observations in the Central Basins		
T2.6.1	Paul Dodd	NPI

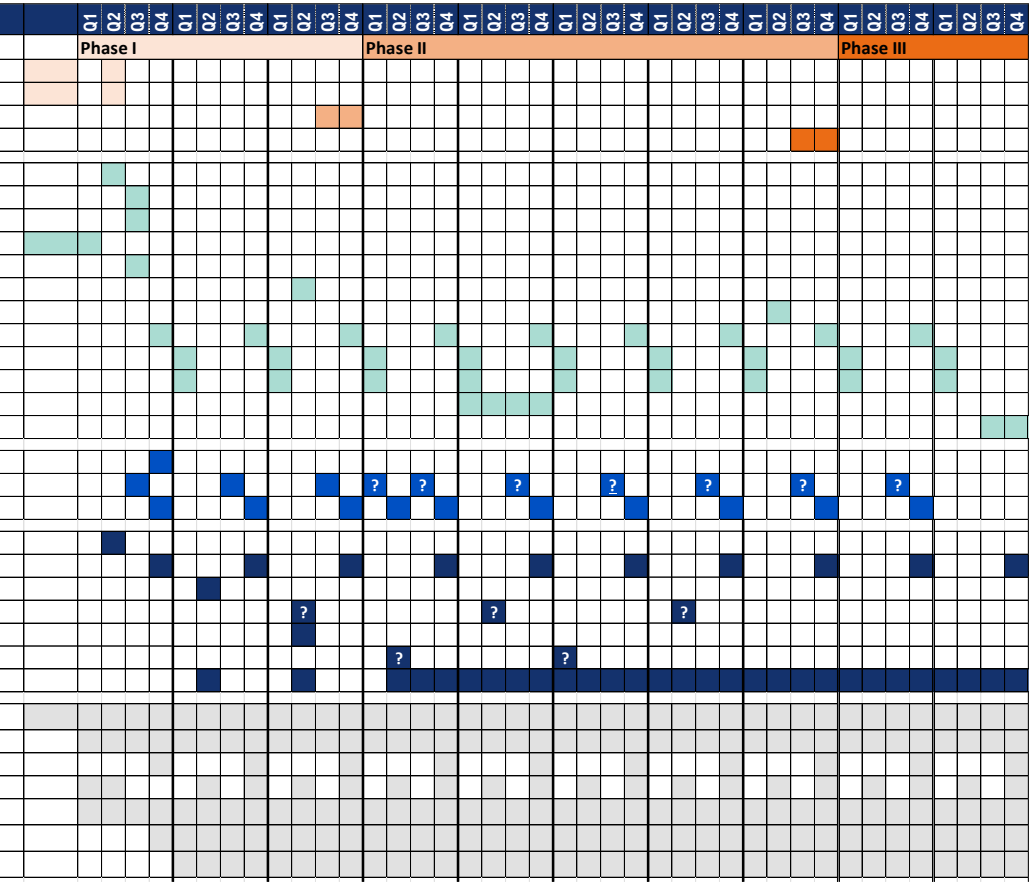
RT3: Human impact and sustainable use		
Lead	**Sissel Jentoft**	**UIO**
Co-lead	**Janne E. Søreide**	**UNIS**
PT3.1 Scientific foundation for sustainable exploitation of the Arctic Ocean		
T3.1.1	Lis L. Jørgensen	IMR
T3.1.2	Øystein Langangen	UiO
T3.1.3	Pedro Ribeiro	UiB
PT3.2 Consequences and risk assessment of increased human activity		
T3.2.1	Ida Beathe Øverjordet	SINTEF
T3.2.2	Jasmine Nahrgang	UiT
T3.2.3	Heli Routti	NPI
T3.2.4	Tomasz Ciesielski	UNIS
T3.2.5	Lis L. Jørgensen	IMR
T3.2.6	Sissel Jentoft	UiO

T3.2.7	Ida Beathe Øverjordet	SINTEF
PT3.3 Preparedness, Governance, and Conservation needs		
T3.3.1	Vito De Lucia	UiT
T3.3.2	Youri Van Logchem	UiT
T3.3.3	Eva Van der Marel	UiT
T3.3.4	Øystein Jensen	FNI
RT4: Abrupt changes and extreme events		
Lead	**Paul Renaud**	**APN**
Co-lead	**Priscilla Mooney**	**NORCE**
PT4.1 Identifying drivers and consequences of disruptive events		
T4.1.1	Katrine Husum	NPI
T4.1.2	Raul Primicerio	UiT
T4.1.3	Priscilla Mooney	NORCE
T4.1.4	Eva Leu	APN
T4.1.5	*in discussion*	
T4.1.6	Helene Langehaug	NERSC
T4.1.7	Nigel Yoccoz	UiT
PT4.2 Assessing the risk associated with abrupt and extreme events		
T4.2.1	Katrine Husum	NPI
T4.2.2	Helene Langehaug	NERSC
T4.2.3	Ingrid B. Utne	NTNU
PT4.3 Low-likelihood, high-impact events		
T4.3.1	Paul Renaud	APN
T4.3.2	*in discussion*	
T4.3.3	Jan Sverre Laberg	UiT
PT4.4 Planning for abrupt change and extreme events		
T4.4.1	Charlotte T. Weber	APN
T4.4.2	Charlotte T. Weber	APN
T4.4.3	*in discussion*	
RT5: Advances in modelling and observing		
Lead	**Malte Müller**	**MET**
Co-lead	**Laurent Bertino**	**NERSC**
PT5.1 Develop modular and Interoperable Observation Systems		
T5.1.1	Asgeir Sørensen	NTNU
T5.1.2	Martin Skjelvareid	UiT
T5.1.3	Polona Itkin	NPI
T5.1.4	Martin Ludvigsen	NTNU
T5.1.5	Emlyn Davies	SINTEF
T5.1.6	Asgeir Sørensen	NTNU
T5.1.7	Martin Skjelvareid	UiT
T5.1.8	Martin Ludvigsen	NTNU
T5.1.9	Emlyn Davies	SINTEF
PT5.2 Establish a hierarchical numerical model framework for global model downscaling		
T.5.2.1	Martina Idzanovic	MET
T5.2.2	Martina Idzanovic	MET
T5.2.3	Malte Müller	MET
T5.2.4	Annette Samuelsen	NERSC
T5.2.5	Jerry Tjiputra	NORCE
PT5.3 Develop machine learning based prediction and downscaling systems		
T5.3.1	Malte Müller	MET
T5.3.2	Malte Müller	MET
T5.3.3	Noel Keenlyside	UiB
T5.3.4	Julien Brajard	NERSC
PT5.4 Develop user-centered Arctic decision support systems – Digital Twins		
T5.4.1	Johannes Röhrs	MET
T5.4.2	Johannes Röhrs	MET
RT6: Arctic Ocean pathways		
Lead	**Dorothy Dankel**	**SINTEF**
Co-lead	**Geir Hønneland**	**FNI**
PT6.1 Foster internal cohesion across research themes		
T6.1.1	Dorothy Dankel	SINTEF
PT6.2 Extending and Engaging the Peer Community		
T6.2.1	Geir Hønneland	FNI
PT6.3 Co-produce scenarios		
T6.3.1	Dorothy Dankel	SINTEF
T6.3.2	Britt Kramvig	UiT
PT6.4 Actionizing Scenarios into Transformative Pathways and Roadmaps		
T6.4.1	Dorothy Dankel	SINTEF

Appendix 3 – Gantt Chart

The present Implementation Plan is for 2026-2028. Task-level deliverables for 2026 can be found with task descriptions. Later deliverables are under development. Same colour marks related activities.

Category	Title	End Date/Period
Milestone	Program phases	Q4 2035
Deliverable	Science Plan	Q4 2025
Deliverable	Implementation Plan phase I 2026-2028	Q4 2025
Deliverable	Implementation Plan phase II 2029-2033	Q4 2028
Deliverable	Implemenation Plan phase III 2034-2035	Q4 2033
Milestone	Group mandates and key practices	Q2 2026
Milestone	Contract and consortium agreement	Q3 2026
Milestone	Codes of Conduct	Q3 2026
Milestone	Budget phase I 2026	Q2 2026
Milestone	Budget phase I 2027-2028	Q3 2026
Milestone	Budget phase II 2029-2033	Q2 2028
Milestone	Budget phase III 2034-2035	Q2 2033
Deliverable	Annual workplans (RT, DM, COMM, PO)	Q4 every year
Deliverable	Annual technical report	Q1 the following year
Deliverable	Annual economic report	Q1 the following year
Milestone	Mid-term evaluation	2030
Deliverable	Final report	Q3-4 2035
Milestone	Long-term cruise strategy	Q4 2026
Milestone	Scientific Cruises	1-2 per year (mostly in Q3)
Deliverable	Cruise reports	Subsequent to each cruise
Deliverable	ECR plan	Q2 2026
Milestone	Early Career forum meeting	Q4 with annual meetings
Milestone	New PhD course developed	Q2 2028
Milestone	New PhD course offered	3 times in programme period
Milestone	New Summer school developed	Q2 2028
Milestone	New Summer school offered	2 times in programme period
Deliverable	Graduation of MS & PhD students	MS from 2027, PhD from 2029
Deliverable	Communication material and products [1]	Quarterly
Deliverable	Newsletters	Quarterly
Milestone	Annual meeting	Q4
Milestone	IAB meetings	Q2, Q4
Milestone	Showcasing events [2]	per their schedules
Milestone	Science dissemination at conferences [3]	per their schedules
Deliverable	Contributions to reports by target groups [4]	per their schedules



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