



# ARCTIC OCEANOGRAPHY

ISTAS workshop session :

## Oceanography: Atmosphere-Ocean Exchange, Biogeochemistry & Physics

### Authors

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### Overview

The Arctic Ocean is, on average, the shallowest of Earth's oceans. Its vast continental shelf areas, which account for approximately half of the Arctic Ocean's total area, are heavily influenced by the surrounding land masses through river run-off and coastal erosion. As a main area of deep water formation, the Arctic is one of the main «engines» of global ocean circulation, due to large freshwater inputs, it is also strongly stratified. The Arctic Ocean's complex oceanographic configuration is tightly linked to the atmosphere, the land, and the cryosphere. The physical dynamics not only drive important climate and global circulation patterns, but also control biogeochemical cycles and ecosystem dynamics. Current changes in Arctic sea-ice thickness and distribution, air and water temperatures, and water column stability are resulting in measurable shifts in the properties and functioning of the ocean and its ecosystems. The Arctic Ocean is forecast to shift to a seasonally ice-free ocean resulting in changes to physical, chemical, and biological processes. These include the exchange of gases across the atmosphere-ocean interface, the wind-driven circulation and mixing regimes, light and nutrient availability for primary production, food web dynamics, and export of material to the deep ocean. In anticipation of these changes, extending our knowledge of the present Arctic oceanography and these complex changes has never been more urgent.



**Fig. 1.** Arctic oceanography is strongly influenced by sea-ice formation and melt, fluxes from the land, and circulation patterns, which in turn control and interact with the oceanic biosphere.

Over the last decades there have been significant developments in Arctic oceanographic research, yet we still lack an in depth understanding around some of the key environmental processes and at varying spatial and temporal scales. Combining new technologies (i.e. autonomous platforms, satellites, evolving biological methods, etc.), and bringing together oceanographic sub-disciplines, will be crucial to successfully understanding the Arctic Ocean as a coupled environmental system, and how it should be managed in the future.



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## RESEARCH PRIORITIES APPROACHES AND RECOMMENDATIONS

### ► Carbon and nutrient cycling

- Establish the fate of terrestrial carbon in the ocean (thawing permafrost, weathering, river discharge, coastal erosion).
- Investigate factors that enhance or suppress nutrient inputs to the upper ocean.
- Understand how environmental changes are affecting primary production, carbon export, and carbon sequestration.
- Assess two-way fluxes through the sediment-water interface; including particles, pore fluids and gases, and the impact of bioturbation.
- Integrate studies on the role of microbes in biogeochemical cycles associated with both the water column and the seabed.
- Assess the role of terrestrial organic carbon in the ongoing acidification of Arctic shelf seas.

### ► Biodiversity and Biogeography

- Understand changes in species distributions and/or community composition linked to changing environmental factors by monitoring biology alongside physics and chemistry; and assessing the impact of these shifts on biogeochemical cycling (see also ART priorities 'Arctic Biodiversity').
- Describe the temporal dynamics of the vertical distribution of pelagic organisms across daily to seasonal scales.
- Develop automated tools for monitoring biological components.
- Increase efforts in assessing the microbial loop, micro-zooplankton and detrital components of the food web, and its link to the classical food web.
- Use a whole ecosystem approach: transfer of energy through trophic levels, combining isotope technologies, biomarkers, and modelling approaches.

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### ► Freshwater influence

- Characterise the evolving freshwater budget and its potential to change of oceanic chemical composition, especially salinity, alkalinity and pH.
- Quantify and monitor changes in regional and global sea level, and the Arctic's role in sea level rise.
- Assess the stability of the halocline and the nutricline on a seasonal timescale.
- Focus on the impact of water column stability associated with the changes in freshwater inputs, and the resultant impact on deep water formation and circulation.

### ► Air-ice-sea interactions

- Improve the temporal and spatial understanding of gas exchanges across interfaces. Utilise satellite and autonomous/robotic technologies.
- Better connect, and constrain, the biological influence on the release and uptake of gases.
- Combine models and observations to gain a basin-wide assessment of aerosol deposition, pollution and their impact on primary production.
- Ground-truth the extent of light penetration and photochemical reactions; utilise improving satellite opportunities for wider coverage.

### ► Anthropogenic interactions

- Develop an interdisciplinary approach to link plans for future societal use of the Arctic Ocean, e.g., shipping, fishing commercialisation, to climate change, ecosystem and biogeochemical studies (see also ART priorities 'Law in the Arctic').
- Assess the potential impact of invasive species arriving from ballast water and shipping activities.
- Assess the risks of increased ship traffic and establishment of marine infrastructure (e.g., oil spills, increased underwater noise).
- Assess potential pollutants, the transportation of these pollutants into the Arctic, and the impact on local species and communities including local peoples.

