



1st International Workshop on Arctic Ocean Observation Future Collaboration by Research Vessels and Icebreakers

Name of session:

Science: Addressing Knowledge Gaps and Future Research Collaboration

Co-chairs: Takashi Kikuchi (Japan Agency for Marine-Earth Science and Technology, JAMSTEC) and Jackie Grebmeier (University of Maryland)

On the first day of the workshop (November 17), we held the session titled “Science: Addressing Knowledge Gaps and Future Research Collaboration” in Hall A, following the ECS session. There were two time slots allocated for this session, during which ten presentations were delivered by scientists from Japan, India, the UK, Canada, Norway, Germany, and the US. Each presenter was requested to cover the following topics in their oral presentations:

1. Presenter’s ongoing and planned Arctic Ocean observations.
2. Presenter’s insights on research collaboration.
3. Knowledge gaps that can be addressed through international collaboration and the utilization of Japan's new research icebreaker as a global research platform.
4. Presenter’s wishes and/or comments concerning Japan's new research icebreaker as an international research platform.

Dr. Takashi Kikuchi (JAMSTEC: Japan) and Dr. Jackie Grebmeier (University of Maryland: US) served as co-chairs for this science session. Dr. Kikuchi commenced the session by introducing its purpose and all invited speakers.

As the first speaker, Takashi KIKUCHI presented his vision for future Arctic observations from a physical oceanographic perspective. Addressing a fundamental question in physical oceanography, he explored how the Arctic Ocean responds to changes in sea ice properties, atmospheric conditions, advection, and freshwater forcing. KIKUCHI emphasized the critical role of international collaboration in Arctic Ocean observations to comprehensively understand the rapid environmental changes occurring in the Arctic, which are integral to global concerns. Notably, he expressed a desire for Japan's new research icebreaker to facilitate land-to-land, full-depth observations across the Arctic Ocean.

Dr. Amane FUJIWARA (JAMSTEC: Japan) highlighted the significant impact of decreasing sea ice and ocean warming on the Arctic marine ecosystem, a phenomenon known as "borealization." This process involves the migration of subarctic organisms from the

Atlantic and Pacific Oceans to the Arctic region due to changing environmental conditions. Drawing on his extensive observational experience aboard R/V Mirai and T/S Oshoromaru, Dr. Fujiwara emphasized the importance of conducting observations in icy regions and during periods previously inaccessible to Japan. These efforts are crucial for gaining a comprehensive understanding of marine ecosystems, particularly in elucidating predator-prey relationships.

Dr. Jun INOUE (NIPR: Japan) provided insights from the perspective of meteorology and climatology, emphasizing the importance of understanding the Arctic climate tipping point in relation to the Arctic-midlatitudes linkage. He highlighted various significant topics in atmospheric science, including changes in precipitation patterns from snow to rain, cloud formation, the development of Arctic cyclones, intensification of the water cycle, Atmospheric Rivers, increasing forest fires, and aerosol transportation. Dr. Inoue emphasized the collaborative efforts with land stations and ships in Arctic countries and underscored the crucial role of Japan's new icebreaker in advancing our understanding of the Arctic's next stages. This collaboration aims to bridge the knowledge gap between the current state and the unprecedented conditions expected in the near future.

Drs. Manish TIWARI and Nuncio MURUKESH (both NCPOR: India) shared insights into their Arctic research endeavors and outlined their future plans. They raised a thought-provoking question regarding the global implications of Arctic changes: "How will changes in the Arctic impact the rest of the world?" Highlighting the significance of ocean-ice-atmosphere interaction in the Arctic, they emphasized its role in understanding tropical variability, particularly in relation to sea-level rise and atmospheric circulation. Additionally, they expressed their anticipation for Japan's new research icebreaker to serve as an international research platform and to foster enhanced research collaboration with India.

Dr. Jeremy WILKINSON (BAS: UK) presented the United Kingdom's research initiatives in the Arctic, which encompass the utilization of the UK's new icebreaker, RRS Sir David Attenborough, and marine autonomous platforms. He underscored the importance of fostering knowledge exchange and international collaboration in addressing current research needs. Furthermore, he expressed support for Japan's new research icebreaker to function as an international research platform, advocating for a reciprocal approach. He emphasized the need to facilitate access to infrastructure for the international research community and to jointly develop research programs.

Dr. Bill WILLIAMS (IOS: Canada) presented Canadian initiatives for Arctic Ocean observations, in particular focusing on long-term observations in the Canadian Beaufort Sea. These efforts have been conducted for two decades under international collaboration, including Japan, amidst significant sea ice loss and changing oceanographic

conditions. Dr. Williams highlighted various findings from the ongoing project and emphasized the necessity for intensive observation and sampling in the Beaufort Gyre. These insights were informed by presentations and discussions held during the workshop titled "The Arctic Ocean's Changing Beaufort Gyre."

Dr. Arild SUNDFJORD (NPI: Norway) presented Norway's activities of the Nansen Legacy project and outlined plans for the new research icebreaker RV Kronprins Haakon. Norwegian scientists have been engaged in both monitoring and process-focused observations, primarily in the Atlantic sector of the Arctic Ocean, but with insights extending across the entire Arctic region through international collaboration. For example, the Synoptic Arctic Survey (SAS) conducted between 2020-2022, led by the University of Bergen, and the ongoing development of the Atlantic-Arctic Distributed Biological Observatory (A-DBO) illustrate Norway's commitment to comprehensive marine observing networks. Dr. Sundfjord stressed the importance of international collaboration and long-term coordination to maximize the utilization of resources. Additionally, he highlighted the significance of personnel exchange, involving both Early Career and senior researchers, across institutions and countries, which fosters mutually beneficial outcomes.

Dr. Michael KARCHER (AWI: Germany), a senior scientist at AWI and the project coordinator for the EU Arctic project "Arctic PASSION," presented on behalf of Germany and the European Union. Dr. Karcher emphasized the need for coordinated multi-disciplinary research and monitoring in the Arctic Ocean within the larger coupled system. He highlighted the significance of multi-ship experiments to cover ice-covered regions of the central Arctic Ocean effectively. Additionally, he underscored the importance of supporting existing, newly developed, and planned observation projects/programs such as Pan-Arctic DBO, SAS II, and IPY capabilities. Dr. Karcher also introduced planned research and monitoring activities in the Arctic Ocean under German and EU projects. Notably, he shared the significant information that POLARIN (POLAr Research Infrastructure Network) has received funding from the EU for five years (March 2024 to February 2029), enhancing Arctic Ocean observation capabilities.

Jackie GREBMEIER has spearheaded the international collaborative observation program, Distributed Biological Observatory (DBO), since 2010, which has successfully monitored the status and trends of marine ecosystems in the northern Bering, Chukchi, and Beaufort seas. The concept has recently expanded into a pan-Arctic network, including Atlantic, Davis Strait/Baffin Bay, and Siberian DBOs, enhancing our ability to observe, track, and model ecosystem impacts of a warming climate and ocean synergistically. Despite this progress, there are still numerous knowledge gaps in both the Arctic marginal seas and deep Arctic basins. Dr. Grebmeier emphasized the need for the scientific community to develop a comprehensive science program to solicit national and international support for joint activities, leveraging the new icebreaker as an initial research endeavor.

Finally, Dr. Craig LEE (University of Washington: US) highlighted the necessity for sustained, climate-scale observing. He discussed new developments in autonomous platforms tailored for year-round operation in the Arctic, such as Argo profiling floats and long-endurance underwater gliders, which provide persistent, distributed sampling and extend the capabilities of traditional ship-based observing. Dr. Lee reviewed recent achievements and outlined plans for the deployment of autonomous floats and gliders, as well as the acoustic infrastructure supporting them. He also summarized efforts to coordinate sustained Arctic observing through the establishment of a Global Ocean Observing System (GOOS) regional Alliance for the Arctic (Arctic GRA).

In the wrap-up session on Day 2, Takashi KIKUCHI and Jackie GREBMEIER reviewed all presentations from the science session on Day 1, summarizing suggestions and comments for future international collaborations and the role of Japan's new research icebreaker as an 'International research platform.'

Research collaboration and coordination are deemed essential for studying recent changes in the Arctic system (physical, biogeochemical, biological) amidst ongoing climate warming, enabling the investigation of system status and the development of models for projecting future climate and ecosystem changes. Regarding the gateways and marginal seas in the Arctic, Borealization (Atlantification & Pacification) could lead to ecosystem reorganization with climate change, increased human usage for commercial shipping, and resource extraction through the Arctic, necessitating monitoring through international collaboration observation programs like DBO. In contrast, monitoring fisheries resources and ecosystem parameters in ice-covered waters remains crucial for providing management advice, as evidenced by initiatives such as the Central Arctic Ocean Fisheries Agreement (CAOFA); however, apparent knowledge and data gaps persist in the central Arctic Ocean. Sharing ship observation capabilities and conducting international projects, including the use of autonomous platforms, offer capacity for studying the impact of retreating sea ice cover and Borealization even during summer and shorter seasons in the central basins.

To address the identified knowledge gaps, workshop participants concurred on the need to leverage international activities and planning bodies to develop multi-disciplinary programs using Japan's new research icebreaker as a focal platform for collaborations, coordinated with observation capabilities provided by other research vessels. The second international workshop is planned for 2025, during which discussions will focus on the types of observations and projects/programs to be conducted, and how Japan's new research icebreaker can serve as the international research platform for Arctic science.