Research Organization of Information and Systems
National Institute of Polar Research (NIPR)

GRENE Arctic Climate Change Research Project
www.nipr.ac.jp/grene/e/

June 16, 2014

Arctic

News Letter 4

The Environmental Changes in The Arctic

How will decline of sea ice affect the Arctic Ocean ecosystem? Will they become more active or more restrained?

Toru Hirawake／Associate Professor, Faculty of Fisheries Science Hokkaido University

The Arctic is now being exposed to environmental changes that have never been experienced, such as significant retreating sea ice and ocean acidification. Sea ice decline affects the primary production of phytoplankton, base of food web, and their community structure. It is also expected to alter the production and distribution of biology at higher trophic levels, such as zooplankton, fish, benthic organisms, sea birds and marine mammals, through the food web. Meanwhile, ocean acidification could enhance dissolution of the shells of shellfish and cause other direct damages to organisms. During the Arctic cruise of the training ship Oshoro-Maru from June to August 2013, we measured marine environments and collected marine organisms using trawl net and dredge to reveal effects of the marine environments to production and distribution of the organisms.

Despite the cruise was conducted in summer, we had to cancel or change several observation and our route due to high winds and pack ice. We had expected calm condition near the sea ice edge, but the high winds resulted in high waves. However, the crews helped us to engage in continuous observations day and night (it is not dark night, a midnight sun), and the researchers and students on board were able to complete most of their scheduled observations.

The research cruise allowed us to know the marine environments in detail as well as the differences in the distribution of organisms corresponded to the environments. This was the T/S Oshoro Maru's eighth trip to the Arctic Ocean. We hope to predict how marine organisms will respond to future environmental change by conducting a detailed analysis of the environmental factors that determine the distributions of organisms in comparison with past data.

Ongoing breeding and spawning of Arctic cod—a key species of the Arctic Ocean

Yasunori Sakurai / Professor, Faculty of Fisheries Science Hokkaido University

In August 2013, we collected six live Arctic cod from the Chukchi Sea and brought them back to Japan. The two females and four males were kept in a 2 °C incubator tank where we raised them. Once all of the fish matured, we artificially inseminated the females on February 2, 2014, and the next day, they spawned naturally. In both cases, the fertilization rate was nearly 100%. We examined the change of specific gravity, temperature and salinity tolerance through the egg development. We are currently raising the larvae. In our first experiment since the early 1990s, we have found the Arctic cod to be a key species in the Arctic ecosystem. With this Arctic cod breeding experiment, we will explore how the structures and functions of the Arctic marine ecosystem are changing amid progressive warming, and this should provide us with clues as to how humans can sustainably use marine resources.

Embryo in egg just before hatching (left) and Arctic cod larva just after hatching

Recent trends in the phytoplankton and zooplankton as seen from Arctic Ocean observations

Kohei Matsuno / Project Researcher, National Institute of Polar Reseach (workplace:Hokkaido University)
Amane Fujiwara / Project Researcher, National Institute of Polar Reseach (workplace:Hokkaido University)

Primary and secondary producers, such as phytoplankton and zooplankton, support organisms at higher trophic levels, including marine mammals, through the food web. Since the generation length of primary and secondary producers is short, the recent rapid decline of sea ice and changes in the hydrographic environment can cause a significant impact on them.

As part of this project, we have analyzed past observational data, but looking at the data collected from ongoing observations in the Arctic Ocean on the Mirai, the oceanographic research vessel of the Japan Agency for Marine-Earth Science and Technology, we have found that inter-annual variability of the sea ice retreat timing alter the summer water temperature and nutrient environment, and in turn, yield different types of dominant phytoplankton groups (Fig. A).

Meanwhile, the observational data collected in the Chukchi Sea by the Oshoro-maru reveals that the zooplankton communities have changed dramatically from the early 1990s to the late 2000s (Fig. B). This means the large amount of the Pacific copepods, distributed in the Pacific Ocean, has been transported into the Arctic Ocean by ocean currents. Furthermore, we found that the inflowing Pacific copepods (*Neocalanus flemingeri*) spawned based on ship board experiment.

Going forward, we will analyze the samples of phytoplankton and zooplankton collected on the GRENE-Arctic Project-led voyages of the Mirai and the Oshoro-maru to see if any other changes have occurred.

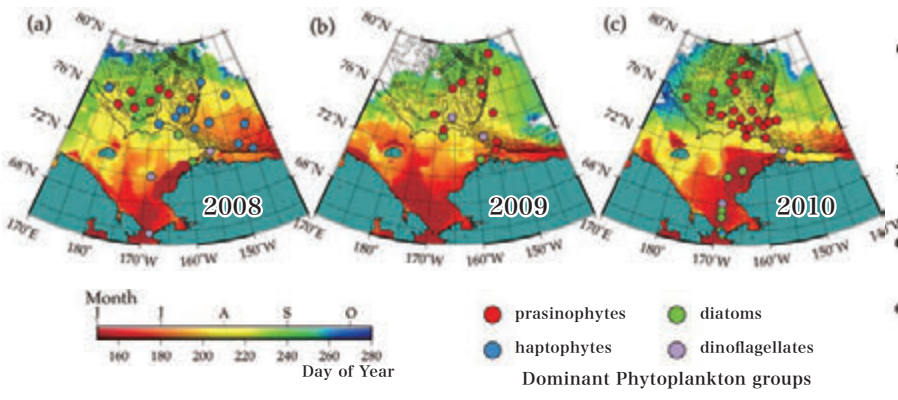


Fig. A: Spatial distribution of the timing of sea ice retreat with dominant phytoplankton groups . Haptophytes were dominated in the eastern Chukchi Sea during the summer of 2008, which timing was 1–2 months earlier than 2009 and 2010.

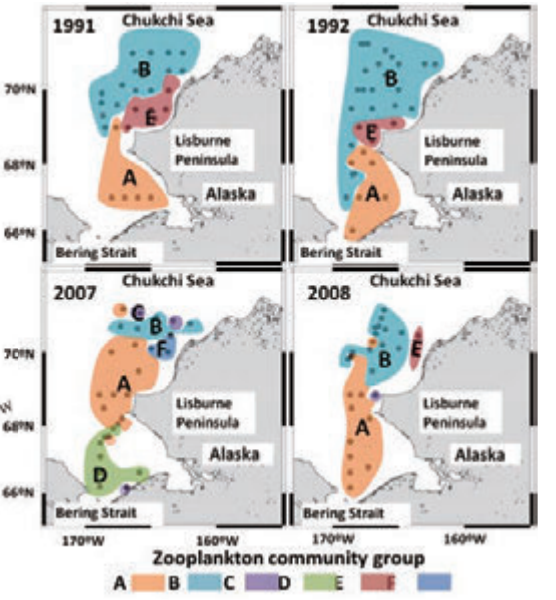
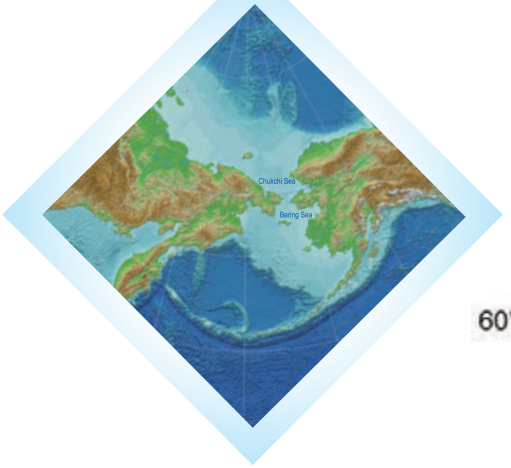
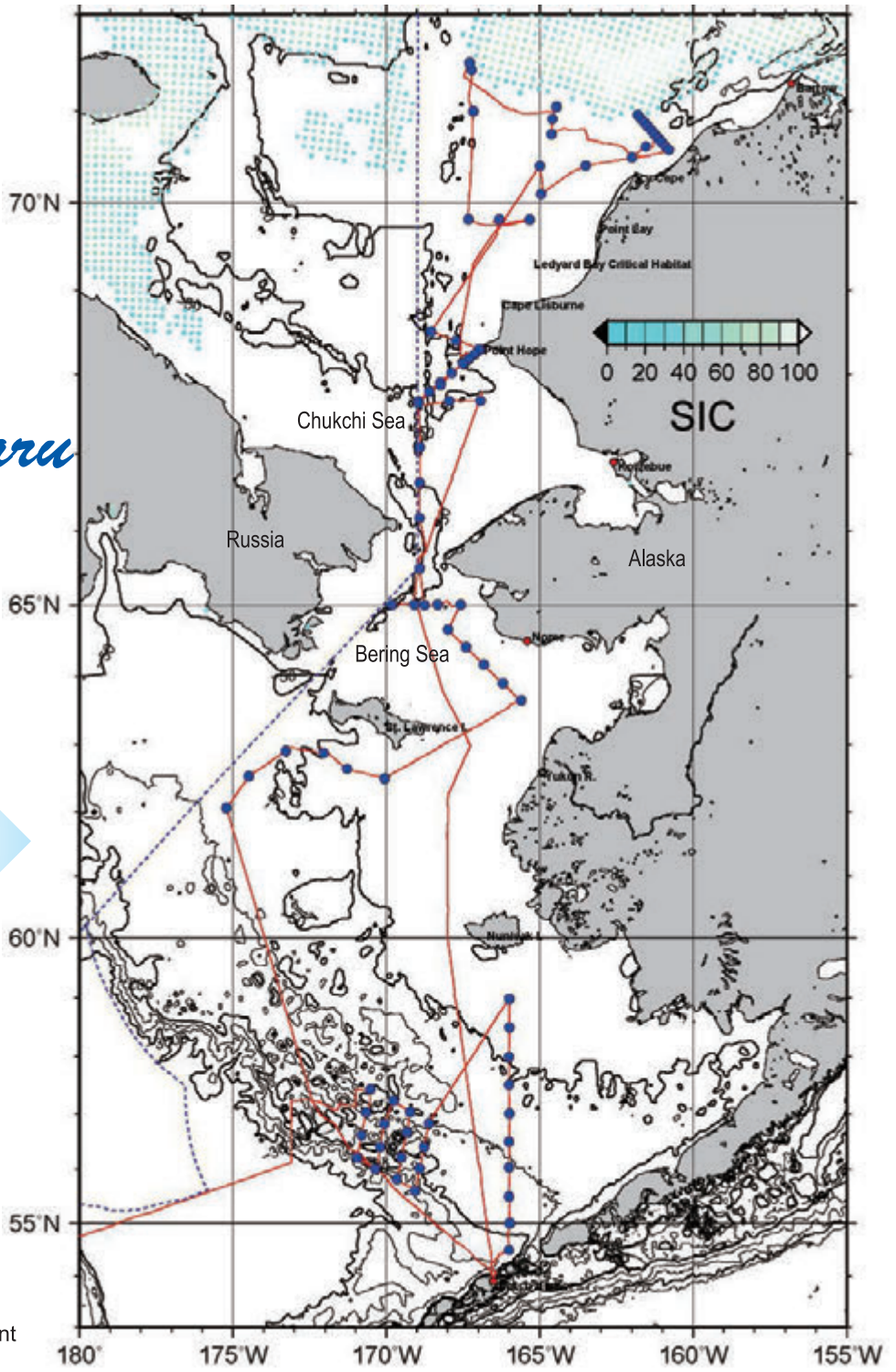


Fig. B: Results of cluster analyses of zooplankton communities in the Chukchi Sea in 1991, 1992, 2007 and 2008. Cluster D, which was only observed in 2007, was dominated by the Pacific copepods.

Arctic Cruise of the Oshoro-Maru 2013





Ocean acidification in the Chukchi Sea

Michiyo Yamamoto-Kawai / Associate Professor,
Tokyo University of Marine Science and Technology

In recent years, the problem of ocean acidification has garnered a lot of attention. One-third of the carbon dioxide that we humans discharge is absorbed by the ocean. While this helps us mitigate global warming, the dissolution of carbon dioxide in sea water gradually lowers the pH of the ocean, making it more acidic. Evidence that even the slightest decline in pH can have major effects on many marine organisms is starting to come to light. That acid may dissolve the shells of shellfish or make it harder for them to grow shells is of particular concern. The Arctic Ocean is the area where the effects of ocean acidification are appearing the earliest. However, few observations have been conducted, so very little is known about the current state of acidification and its impact on organisms. Therefore, as part of the GRENE-Arctic Ecosystem Project, we have conducted ship-based and moored observations and collected organisms in the Chukchi Sea, an area where many organisms live, to survey the actual state of acidification. We found that acidification differs significantly depending on the area of the ocean and the season, and that the situation is already severe in the surface and bottom waters from summer until autumn. We will need to conduct a detailed analysis, looking at mooring data and model calculations, to determine what kind of impact ocean acidification has on the ecosystems of the Chukchi Sea.

Bottom-dwelling shellfish collected from the Chukchi Sea on the Oshoromaru voyage

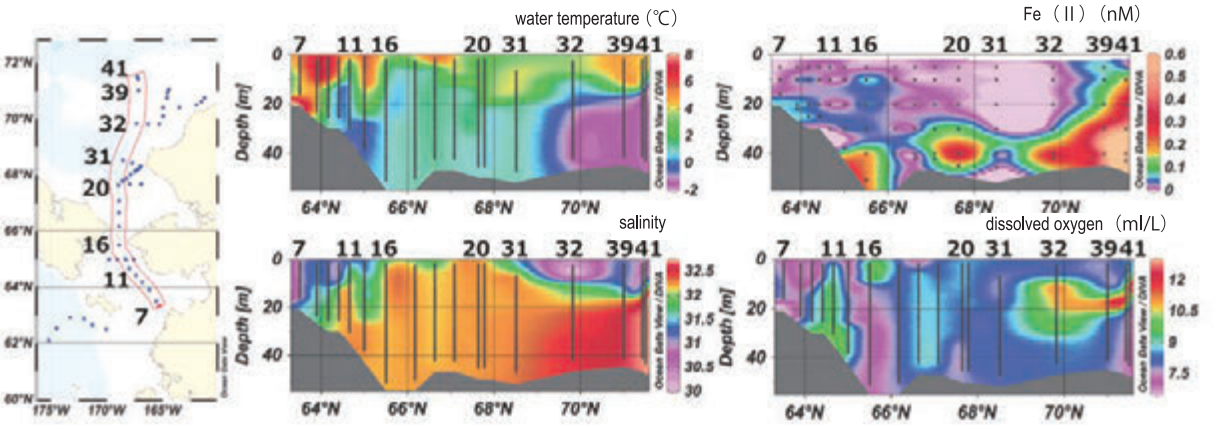
Iron transport mechanisms in the northeastern Bering Sea Shelf and Chukchi Sea

Yoshiko Kondo / Project Researcher,
National Institute of Polar Reseach (workplace:The University of Tokyo)

Iron (Fe) is an essential element for phytoplankton growth in the ocean as well as nutrients. Recent studies have suggested that Fe supplied from continental shelf sediment and river supports the primary production in the northeastern Bering Sea Shelf region and Chukchi Sea. In seawater, dissolved Fe exists as various chemical and redox forms (speciation) such as organic Fe(III)-binding organic complexes, Fe(II) and Fe hydroxide. The speciation of Fe controls the bioavailability and distribution of dissolved Fe. Therefore, understanding Fe speciation is important to elucidate the mechanism of Fe transport from the continental shelf and sediments in this region.

During the Oshoro-maru cruise from June to August 2013, seawater samples for Fe speciation were obtained from the northeastern Bering Sea Shelf, Bering Strait and Chukchi Sea including ice edge area. During the research cruise, we have determined dissolved Fe(II) in seawater onboard the ship. We found that concentration of Fe(II), reduced form of Fe, tended to be higher in near-bottom waters where dissolved oxygen were relatively lower. It suggests that elevated Fe(II) was derived from sediment and/or remineralization of the biogenic particles in the near-bottom waters.

We are currently analyzing dissolved Fe and organic Fe (III)-binding organic complexes. Furthermore, we will also determine other trace metals concentration such as manganese to understand the transport mechanisms for various trace metals in this study area.



Distributions of water temperature, salinity, Fe(II) and dissolved oxygen in the northeastern Bering Sea Shelf and the Chukchi Sea.

Changes in Benthic organisms in the Chukchi Sea: What we learned from trawl surveys on the Oshoro-Maru

Tsubasa Nakano / Graduate School of Fisheries Sciences Hokkaido University
Yutaka Watanuki / Professor, Faculty of Fisheries Science Hokkaido University

Pulling up fish and other creatures in a trawl net

Those phytoplankton and other primary producers in the ocean surface layer that are not eaten by zooplankton sink to the bottom of the sea along with the feces and carcasses of other organisms. The volume of this sinking organic matter is especially large in the Arctic Ocean, and it supports bottom-dwelling fish, such as flounder and sculpin, as well as the Benthos, which includes shellfish, crabs sea cucumbers and the like. However, the recent decline in sea ice has led to changes in sediment volume, and scientists believe this is affecting the distribution and number of benthic organisms.

The Oshoro-maru has used trawl nets to collect bottom-dwelling fish and other members of the Benthos over two periods, 1990-1997 and 2007-2009, in the waters south of Saint Lawrence Island and the southern Chukchi Sea—two areas where the decline in sea ice has been remarkable. Each time we surveyed the biological composition and biomass of each sea area, but in the summer of 2013, when we trawled these areas again, we collected Arctic cod, flounder and other fish as well as Benthic organisms including snow crabs and whelks. When we conducted these surveys , the number of bottom-dwelling fish in the Bering Sea and the number of benthic organisms in the Chukchi Sea were high in every year. In addition to these noticeable regional differences, we confirmed the increase in the Benthos in the Chukchi Sea in 2007 and found that the increase in the biomass of whelks was particularly remarkable. Compared to the 1990s, the biomass of benthic organisms remained high throughout the 2000s, but there were no major changes in the biomass of fish between both periods.

This trend appears to differ from forecasts for the northern end of the southern Bering Sea, so we intend to conduct a detailed analysis on the correlation to changes in the marine environment to see how these trends relate to the decline in sea ice.

International Exchange

Larry Hinzman
Director of International Arctic Research Center (IARC), University of Alaska Fairbanks

The fellowships for Japanese Early Career Scientists (ECSs) to visit Alaska or Canada will start from this summer. We interviewed Director Larry Hinzman to learn his expectations of these fellowships.

Expectation of a receptive institution of the ECSs.

The fellowships for Japanese Early Career Scientists (ECSs) to visit Alaska and work closely with scientists from the University of Alaska Fairbanks offer a truly career enhancing opportunity. Many years ago, when I was still early in my career, I had the opportunity to spend four weeks at the Institute of Low Temperature Science at Hokkaido University in Sapporo. I can honestly trace my path as director of the International Arctic Research Center from the important connections that I established during that short visit. I regret that I could not stay longer, but I revel in the friendships and collaborations that were started then and have continued through my entire career.

The time at IARC

IARC has welcomed many young Japanese researchers over our 15 year history. These young scientists have been among the finest and most capable young scholars that I have ever known. They have been incredibly motivated and very productive. They have all conducted leading edge science that has contributed important results and understanding of the Arctic System. They designed and executed important research projects. They learned how to conduct meticulous experiments under extreme weather conditions. They learned to work as part of a team, and to obtain the knowledge and skills needed to be successful. All of these young scientists returned to Japan with much stronger language and research ability and with well-developed collaborations that will serve them throughout their career. I have been very proud of the accomplishments and professional positions that our young Japanese colleagues have secured after they returned to Japan and I feel gratified knowing they have all appreciated the time spent here at IARC.

IARC in the University of Alaska Fairbanks

In your opinion, what are the most important gaps and needs for Arctic research?

A myriad of scientific challenges await arctic researchers. Arctic communities have adapted over millennia or grown recently as a result of resource development, but these communities provide the social structure that is the fabric of Alaska. Increasingly, changes in marine environment are driving interest in the Arctic as a cross-roads or thoroughfare. Marine shipping, ecotourism, fiberoptic cables for communications are all increasing access to the Arctic, and with that, bring challenges of oil spills, contaminants, and other consequences of globalization. The Arctic also serves as a cultural resource with iconic societies and species. Geopolitics has elevated the Arctic from the historical position of a resource warehouse to a concerned stakeholder in terms of security or access to/ownership of resources due to proximity. Policy decisions to maintain smooth international relations must be based upon the best available science and directed research. It appears that climate dynamics in the Arctic exert important influences on the weather of the more temperate latitudes. Understanding and characterizing the role of the Arctic in global climate dynamics is essential to developing a predictive capability of our changing climate. Resource extraction, environmental change, geopolitics, and cultural heritage are all interwoven in the complex Arctic system. Research conducted at the University of Alaska Fairbanks and many other institutions have revealed critically important processes and properties that are shaping the evolution of the Arctic and its growing linkages with the rest of the world.

Message to ECSs of Japan

These fellowships will open the door to a remarkable experience that will enhance the abilities, knowledge and connections of the young researcher. These fellowships will also help Japan and the U.S. improve our collective capability to adapt to this changing world. We need to build strong collaborative partnerships to allow us to address the truly international challenges of climate change, ocean acidification, and globalization in the Arctic. We need bright scientists who can work across borders and utilize the best tools, data and technology available. The best way to build these international partnerships is to exchange scientists, and provide opportunities for our researchers to share ideas, data and resources.

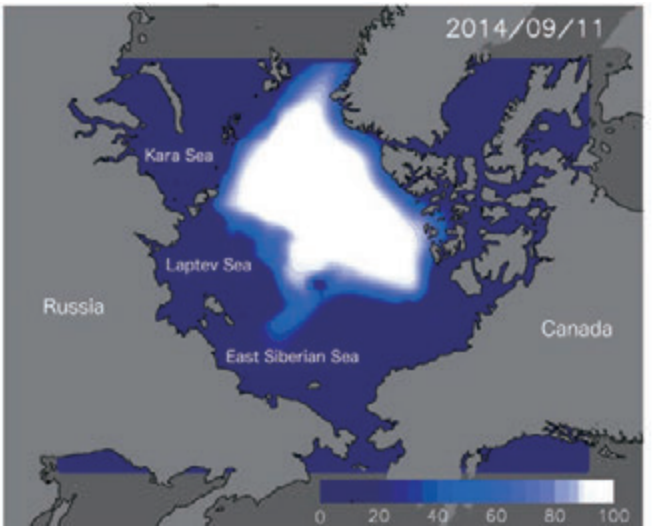
Topics Research Project 7

2014 SUMMER ARCTIC SEA ICE FORECAST

The group of the sub-research project 'Sea ice prediction and construction of an ice navigation support system for the Arctic sea routes' (Principal Investigator: Prof. Hajime Yamaguchi / The University of Tokyo) opened their 2014 SUMMER ARCTIC SEA ICE FORECAST to the public on their web page on May 30, 2014.

<Distribution of sea ice in this summer>
① Arctic sea ice area will mark a secondly minimum record after 2012.
② The sea route of The Russian side will open around 11st of August and the Canadian side will open around 26th of July.

They will present an animation showing the predicted sea ice distribution from July 1st to September 16th on web page.



Prediction of sea ice area on September 11st, 2014

GRENE-Arctic http://www.nipr.ac.jp/grene/e/
Yamaguchi's office
http://http://www.1.k.u-tokyo.ac.jp/YKWP/2014arctic_e.html

Open Lecture:

The Arctic Is Closer Than You Think -Global Warming in the Arctic-

Saturday, March 15, 2014
Myonichikan Auditorium, Jiyu Gakuen

Having just passed its halfway point, the GRENE-Arctic Project has already been producing many research results. In this lecture, researchers working at the front line of the project presented what they have found so far to general public.

The lecture was emceed by Tetsuya Muroyama, a news commentator of the NHK. Dr. Hiroyuki Enomoto (JCAR/National Institute of Polar Research) provided an overview of the project, then four researchers presented their research results.

For a start, Dr. Yoko Mitani (Hokkaido University) showed mammal behaviors in cold oceans, followed by Dr. Shin Sugiyama (Hokkaido University) on the facts on melting ice sheets and glaciers in Greenland and an acceleration of the retreat, Dr. Shinji Morimoto (Tohoku University) on the overall changes in greenhouse effect gases gleaned from comparing the data from Antarctica with that from the Arctic, and Dr. Jinro Ukita (Niigata University) on the direct effects of the changes occurring in the Arctic to our daily weather in Japan.

In the second session, the five presenters responded to a wide range of questions from the audience, such as how the global warming cycle works and information on the recent abnormal weather in Japan. It was an excellent opportunity for the participants to broaden their knowledge of polar research, as well as for the scientists to know what non-scientists have questions on the Arctic.


panel discussion

Principal Investigator's Perspective

Takashi Kikuchi

Japan Agency for Marine-Earth Science and Technology(JAMSTEC)

Ecosystem studies on the Arctic Ocean declining sea ice

As for the number of all of the research collaborators and other individuals involved in the joint research in Project Team 6, I think there are nearly 60 researchers. They can be broadly classified into two groups: the Hokkaido group (Hokkaido University Graduate School of Fisheries Science, the Institute of Low Temperature Science etc.) and the Kanto group (JAMSTEC, Tokyo University of Marine Science and Technology, The University of Tokyo, Ocean and Atmosphere Research Institute etc.). But we get to know each other well because we make several observational voyages as a team. Since we work closely together and have shared the same struggles, the ties among the members in this group are quite strong. We attend the same conferences and research meetings and stay in close contact while conducting our joint research.

Everyone has a positive mindset and is more than happy to work with each other on the actual research tasks. If I run into a problem, I can ask everyone questions, and they will always answer me. I have not experienced much difficulty in coordinating the team's research. As the Principle Investigator, I have to deal with a lot of paperwork to keep the project moving forward, but that is just part of the job. There have been a few issues so far, but at this point, I am satisfied with our progress. We are currently working on compiling our research on changes in the Arctic Ocean ecosystems and marine environment. Basically, my role is to support everyone else on this task.

Profile: with curiosity・・・

I have loved hot springs ever since I was a university student. My favorite is the Nokendo Akai Hot Springs (Kanazawa Ward, Yokohama) near my hometown. The water is a brownish-red color and is extremely hot—so hot you can barely get in the bath. Since I love hot springs, I really enjoy going to Hokkaido for research meetings. A more recent hobby is watching shogi (Japanese chess) matches. I've been doing this for about three years. I like to watch the title matches on the Niconico video site and read Shogi Sekai magazine.

When I was in the lower grades of elementary school, I wanted to be a train driver. With the train time table in hand, I used to have a short trip to faraway places by myself, which was quite unheard of at that time. Admittedly, I am still a closet train fanatic (I like to plan imaginary train trips). In the later grades of elementary school and in junior high school, I wanted to be an architect. One of my uncles was an architect, so for a long time, that's what I wanted to be.

I became interested in the climate and oceans after going to high school, which I what led me to this career, but I don't clearly remember what led me to change my mind.

Editing & Publishing : Inter-university Research Institute Corporation Research Organization of Information and Systems, National Institute of Polar Research 10-3, Midoricho, Tachikawa, Tokyo 190-8518, Japan

Cover photo : Yutaka Watanuki