外部評価報告書

Report of External Review

東京大学 大気海洋研究所
Atmosphere and Ocean Research Institute, The University of Tokyo

2020

Preface

The Atmosphere and Ocean Research Institute (AORI) of The University of Tokyo (UTokyo) was established in April 2010 through the merger of the Ocean Research Institute and the Center for Climate System Research. Upon the establishment, the philosophy of and the 10-year action plan for the new research institute were deliberated. The basic policies were developed including the introduction of “divisions” to the organization, establishment of the Center for Earth Surface System Dynamics to promote synergy effects through the merger, establishment of the Center for Cooperative Research Promotion (CCRP), allocation of technical staff to the CCRP, and establishment of the Education Committee. At the same time as the establishment, AORI was designated as a Joint Usage/Research Center for Atmosphere and Ocean Science by the Ministry of Education, Culture, Sports, Science and Technology under its new Joint Usage/Research Center Program. AORI has since engaged in research activities as a base for atmosphere and ocean science researchers from across the country. In 2014, AORI established the Analytical Center for Environmental Study, and has since promoted Joint Usage/Research related to high-resolution environmental analysis that uses cutting-edge analytical equipment. In March 2011, one year after the establishment of AORI, the International Coastal Research Center (ICRC) was severely damaged by the massive tsunami triggered by the 2011 off the Pacific coast of Tohoku Earthquake. Since then, with the full support of Iwate Prefecture and Otsuchi Town, as well as the help of people from all over the country, AORI and the UTokyo’s headquaters worked together to restore the ICRC. The new research and accommodation buildings were completed in February 2018. By the end of the 2019 academic year, almost all research facilities and equipment were restored at the ICRC. While being restored, AORI, as an ocean research institute located in the disaster region, has been functioning as a base of research on marine ecosystem change caused by the earthquake and tsunami using scientific knowledge accumulated over many years in the ICRC and its researchers network. Further, AORI promotes pioneering integrated research of natural science and regional/social collaboration and also development activities of next-generation regional leaders. These activities are aimed to acquire roles as AORI becoming a base for shaping the future of the Sanriku region.

Originally, this External Evaluation was scheduled to be carried out in March 2020 – 10 years after the establishment of AORI. We requested three overseas experts and three domestic experts, who all have distinguished achievements in their respective fields of

atmosphere and ocean science and lead their research communities, to become Committee Members. Dr. Kimio Hanawa, Professor Emeritus of Tohoku University (now Vice President and Trustee of Yamagata University) was appointed as the Committee Chairperson. In advance of the planned meeting, we provided external evaluation matrials in January 2020 with summaries of the institute's organization, research & education, social collaboration, Joint Usage/Research activities, data that support these, our response to the previous external evaluation in 2014, and our future plans. The Committee members were asked to submit their questions and opinions in writing. Following that, the Committee meeting was scheduled to be held at the UTokyo Kashiwa Campus on March 5 and 6, 2020. However, the emergence of the COVID-19 pandemic made it difficult for the overseas Committee members to come to Japan, and the meeting had to be postponed. While their visit to Japan continued to be hindered due to the ongoing pandemic, an online meeting system was finally established. The Committee meeting was held online on March 3, 2021, almost one year after originally planned.

The previous External Evaluation was held in March 2014. As with this time, we requested three overseas and three domestic experts prominent in atmosphere and ocean science to become Committee members, who would evaluate the post-merger activities of the institute, especially the activities of and future plan for the Center for Earth Surface System Dynamics. Since then, based on the evaluation and recommendations, AORI has been engaged in various activities as a core research institute in atmosphere and ocean science and as a Joint Usage/Research Center. However, we have not been able to address one of the recommendations, namely: *"AORI should develop comprehensive strategic plans to address the future of atmosphere and ocean science"* The main reasons for the delay are that restoration of the ICRC took more time than expected, imposing heavy human resource and financial burdens on us. In addition, President Gonokami announced The University of Tokyo Vision 2020 in 2015. As a result, we became preoccupied with significant organizational reviews and changes in budget acquisition strategies between 2016 and 2021. Upon the completion of the ICRC restoration in 2019, the Director ordered the internal Future Concept Committee to provide specific feasible proposals for the coming 10 years on how atmosphere and ocean science should be, research direction, and missions as a Joint Usage/Research Center. Now, at 10 years since the establishment of AORI and completion of the ICRC restoration, AORI needs to develop future plans that corresponds to the advancement of science, changes in social conditions and situations inside and outside the UTokyo. During the discussions held at the time of AORI's establishment, an agreement was made to *"review the organization in around ten years"*. We believe it is therefore time to comprehensively review

the direction of AORI and its organization for further development. The Future Concept Committee, in response to the abovementioned consultation, had intensive discussions between November 2019 and March 2021 and produced the Atmosphere and Ocean Research Institute Future Concept 2020, which contained recommendations on the future vision of AORI, tasks for the next 10 years, how to manage the organization to support the strategy.

For this External Evaluation, in addition to the activities of AORI in the past 10 years, we asked the Evaluation Committee to focus its evaluation on how AORI should be based on the discussions and recommendations of the aforementioned Future Concept Committee. While the Evaluation Committee evaluated AORI's activity reports that had been prepared by March 2020, we found it very meaningful that the one-year postponement of the Evaluation Committee meeting allowed the recommendations by the Future Concept Committee to be reflected in the evaluation. Again in December 2020, we sent to the Evaluation Committee members documents that described AORI's activities and future plans and received their feedback by January 2021. As time differences between domestic and overseas participants, the duration of the on-line meeting needed to be as short as possible. For this reason, on December 21, 2020, a one-day face-to-face preparatory meeting was held inviting the three domestic Committee members (the meeting was subsequently changed to a hybrid meeting, as one member was unable to come to the meeting venue), where detailed explanations and questions/answers on AORI's activities and future plans were provided. At a later date, Chairperson Hanawa shared the discussion contents with the overseas Committee members by email, so that they could use the information as a reference at the March 3 meeting. The March 3 online Evaluation Committee meeting was held between 10 a.m. and 1 p.m. During the meeting, members of the Director's Office provided a brief explanation on AORI's organization and R&D activities, the current situation of and challenges faced by its Joint Usage/Research, and AORI's future plans. The Committee members asked questions, and then the draft evaluations prepared by the Committee were presented. The External Evaluation Report on AORI's activities and future plans was submitted by the Committee Chairperson to the Director after email discussions among the Committee members following the meeting. We consider all the opinions and recommendations received quite important, reasonable, and constructive. The opinions and recommendations are consistent with the direction described in the Atmosphere and Ocean Research Institute Future Plan 2020 and present a roadmap for AORI to follow. Based on the recommendations of the External Evaluation Committee and the Atmosphere and Ocean Research Institute Future Plan 2020, the Director's Office will improve AORI's organization and activities as much as possible and develop the strategic plans with a view toward the future of atmosphere and ocean science

by March 2023 when the current institutional execution system ends.

We wholeheartedly thank the six members of the External Evaluation Committee, including Chairperson Hanawa, who sincerely engaged in discussions throughout the long period of this External Evaluation and provided many important and constructive opinions. Members of the internal Evaluation Committee, including Professor Hotaka Kawahata (Chairperson of the 2019 Evaluation Committee) and Professor Ichiro Yasuda (Chairperson of the 2020 Evaluation Committee), members of the Director's Office, including Professor Hiroaki Saito (Advisor to the Director in charge of External Evaluation), and members of the Administration Office, including General Manager Masami Saito and Deputy General Manager Takahiro Endo, prepared and implemented the External Evaluation. Several members of AORI also helped prepare documents used for the External Evaluation. Concurrently held discussions at the Future Plan Committee meetings (chaired by Professor Kyoko Okino) greatly contributed to this External Evaluation. We thank all those involved.

June 30, 2021

Tomohiko Kawamura

Director of the Atmosphere and Ocean

Research Institute, The University of Tokyo

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1.External Evaluation Committee

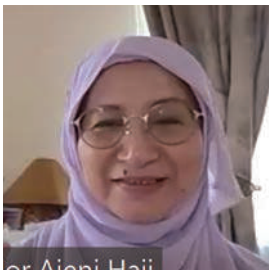
Prof. Kimio Hanawa(Chairman)

Professor Emeritus, Tohoku University
(Current affiliation: Trustee/Vice President, Yamagata University)

Dr. Julie Hall

Director - Sustainable Seas National Science Challenge
the National Institute of Water and Atmospheric Research,
New Zealand

Prof. Dato' Dr. Nor Aieni Haji Mokhtar



Vice-Chancellor, Universiti Malaysia Terengganu, Malaysia

Prof. Gregory F. Moore

Professor, Department of Earth Sciences, University of
Hawaii, USA

Prof. Shigeo Yoden

Vice Director/Program-Specific Professor, the Institute for
Liberal Arts and Sciences, Kyoto University

Prof. Noriyuki Satoh

Professor, the Okinawa Institute of Science and Technology
Graduate University

Group Photo during the Session

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1. Shigeo Yoden
2. AORI Room
3. Hiroaki Saito
4. Julie Hall
5. Tomohiko Kawamura
6. Nor Aieni Haji Mokhtar
7. Kimio Hanawa
8. Noriyuki Sato
9. Susumu Hyodo
10. Ichiro Yasuda
11. Kyoko Okino
12. Gregory F. Moore
13. Yukari Takayabu

Report of 2020 External Evaluation
-Evaluation and Recommendations-

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1. Introduction

This '2020 External Evaluation' to the Atmosphere and Ocean Research Institute (AORI), the University of Tokyo (UTokyo), was originally scheduled on March 5th and 6th, 2020. However, due to the COVID-19, all overseas travels were banned in most of the world, and the meeting had to be postponed. Since the COVID-19 pandemic still continues to the present, the meeting was newly set on March 3rd, 2021, as an on-line meeting, almost one-year later than the originally scheduled one.

During this one-year period, there were three major steps of the external evaluation. These are as follows.

1) The first: inquiries, evaluation and recommendations from the committee members based on the '(draft) Materials for External Evaluation, January 2020' version, and AORI's replies-and-responses were exchanged just before the originally scheduled meeting; 2) The second: the same process was repeated among the committee members and AORI people, based on the '(draft) Materials for External Evaluation, December 2020' version; 3) The third: the meeting by Japanese committee members, i.e., Hanawa, Satoh and Yoden, was held on December 21st, 2020, which was regarded as a preparatory meeting for the formal meeting.

This comprehensive evaluation and recommendations described below are those partly summarized based on the opinions exchange among committee members and AORI side made in above mentioned steps.

It seems that there are three ways on how to classify and align our committee's comments and recommendations: 1) Directly answer the 'Key Questions' asked by AORI to the committee; 2) Describe our recommendations along with the items and order of the 'Materials for External Evaluation'; 3) Discuss along with the items and order of the 'Future Plans' as presented by Director Kawamura in this meeting. Here we would like to adopt the third way, i.e., along with the items and order of the 'Future Plans', since it is very simple and clear for understanding.

2. Overall evaluation

First, we recognize that each of the AORI's faculty/staff members show high research performance both in quality and quantity, which is very impressive. We learned this from several indices shown in the 'Materials for External Evaluation', i.e., number of published papers, impact factors of the journals, and h-index for individual researchers, etc.

Second, we also understand that AORI's faculty/staff make enormous contributions to international research programs and academic organizations. That is, many of AORI's faculty/staff are involved in many international cooperative research programs and play active parts. Further, many faculty/staff are also involved in international organizations and take important positions. We are very impressed with the fact that many of AORI's faculty/staff take responsibilities in managements of international academic and research organizations.

Third, AORI as a Joint Usage/Research institute provides occasional usage of large cutting-edge research facilities to the research community. AORI also takes care of operations of two research vessels; R/V *Hakuho Maru* and R/V *Shinsei Maru*, and provides occasional research meetings at Kashiwa Campus and ICRC (International Coastal Research Center) at Otsuchi. A mid-term evaluation for Joint Usage/Research Institutes by MEXT (Ministry of Education, Culture, Sports, Science and Technology) was made in 2018, and AORI was awarded as highest rank of 'S'. From these facts, we can say that AORI can provide adequate opportunities to users as the Joint Usage /Research Institute.

Fourth, for education activities, AORI also provides a unique education program, 'Interdisciplinary Education Program on Ocean Science and Policy' as a potential member of the UTokyo Ocean Alliance for graduate students. This program is very good for AORI's students, who want to expand their horizon and communicate with students in other research fields.

As an overall evaluation, we would like to say that AORI is a world-class research institute, and secures appropriate researchers as a world-leading research center in atmosphere and ocean sciences.

3. Recommendations

(1)Direction of research

Recommendation 1.1: To formulate comprehensive strategic plan towards the 4th 'Mid-term Targets and Mid-term Plans' (period of 2022-2027)

Since the 4th 'Mid-term Target and Mid-term Plan' Period starts from 2022 fiscal year, it is the right time for AORI to undertake the process of formulating a future comprehensive strategic plan. This task is not a heavy load for AORI's faculty/staff, as the major part of the plan has been formulated in the process of preparation of the Self Evaluation Report, and because the 'Future Vision Working Group' has already been established and has worked. We

understand that, in the working group, young faculty/staff who are the main players in the next era, are very involved. The plan for the 4th 'Mid-term Targets and Mid-term Plans' should be announced to the public using a website and/or leaflets. The strategic plan should build on the Future Concept document and should identify key research questions which will inform the priorities for hiring staff and the purchase of equipment. It should also include consideration of hiring at least one more social scientist to increase the interdisciplinary nature of the faculty members.

Recommendation 1.2: To regularly check-and-review research fields covered and the corresponding organizational structure

This is part of Recommendation 1.1 made in the 2014 External Evaluation. We recommend that AORI regularly checks and reviews new research trends and evaluates AORI's research structure against these. Since the President of UTokyo is replaced every 6 years, and 'Mid-term Targets and Mid-term Plans' should be proposed every 6 years, the check-and-review process of the strategic plan should also be made once every 6-year period in harmony with this.

In AORI, the centerpiece center is CESSD (Center for Earth Surface System Dynamics). Since this center was established in 2010, its research direction and corresponding manpower, etc. should be reviewed at the same time.

(2)Joint Usage/Research

Recommendation 2.1: To strategically aim for replacements of cutting-edge facilities and research vessels

AORI has many cutting-edge facilities such as AMS and NANO-SIMS in ACES (Analytical Center of Environmental Study), among others, and also responsibility for replacement of its two research vessels. It goes without saying that their replacements need a huge amount of budget. In order to smoothly replace their facilities and research vessels, AORI should continuously appeal their need and importance to the Headquarters of UTokyo and MEXT.

Recommendation 2.2: To secure operation days of two research vessels

Initially, operation days of two research vessels, R/V *Hakuho Maru* and R/V *Shinsei Maru*, were set as 300 days each per year. However, at present, the operational days are reduced to less than 200 days each. Although we understand this is due to the soaring price of marine fuel, AORI should negotiate with JAMSTEC (Japan Agency for Marine Science and Technology) and MEXT to secure operation days of 300 days each per year. If they are not in operation, they are useless treasures (in Japanese, Takarano-Mochigusare).

(3)Educational activities

Recommendation 3.1: To recruit potential graduate school students utilizing various occasions

It goes without saying that recruiting enough excellent graduate school students, especially doctoral course students, is important for nurturing the next-generation researchers in atmospheric and oceanic sciences. We understand that since AORI has no direct connection with undergraduate student education in UTokyo, except for general education, recruiting of students, who are interested in atmosphere and ocean sciences is very difficult. In order to overcome this situation, AORI has already introduced various kinds of events and programs. It is recommended that AORI continue these activities. In addition, new events and programs should be explored. For example, to recruit excellent master course students, AORI should hold explanatory seminars about AORI, open to undergraduate students belonging to all universities in Japan, beyond UTokyo and universities in the metropolitan area.

Recommendation 3.2: To encourage students to take unique education program provided by UTokyo Ocean Alliance

'Interdisciplinary Education Program on Ocean Science and Policy' provided by the UTokyo Ocean Alliance is a very good program for AORI's students who want to expand their horizons and communicate with students in other research fields. Present AORI students who join this course represent only about 20% of all AORI students. The AORI should encourage students to join the education program, in order to foster researchers in atmosphere and ocean sciences who have sufficient knowledge of policy making and social sciences.

(4)International joint research

Recommendation 4.1: To further strengthen CIC (Center for International Collaboration) activities

The CIC is the center responsible for enhancement of AORI's activities in international research programs and academic organizations. At present, the CIC consists of three dedicated professors and 5 concurrent professors and associate professors. It goes without saying that to enhance the activities of the CIC requires more human resources. Although we understand that securing dedicated professors or associate professors is quite difficult, nevertheless, the CIC should seek a way to enhance staff resources, such as using project research professors or project research associate professors hired by research project money. It is also important to invite young scientists into the CIC, who are interested in or familiar with international affairs, in order to foster young scientists who will lead the AORI's international cooperation in the future.

Recommendation 4.2: To formulate AORI's contribution to 'UN-Decade of Ocean Science' and take a leadership in the Japanese contribution

We strongly believe that AORI should play a leading role in various future international programs related to atmosphere and ocean sciences, especially in UN-Decade of Ocean Science (UNDOS, 2021-2030), in order to achieve the goal of SDGs-14. In the Self Evaluation Report in 2020 for the External Evaluation in 2020, several research groups already declared their commitment to the UN-Decade for Ocean Science. The CIC should organize a comprehensive contribution of AORI, and should lead the coordination of Japanese activities which contribute to international UN-Decade for Ocean Science, as soon as possible. AORI should become a leading institute of Japanese UN-Decade of Ocean Science activities.

(5)Society-level returns from research outcomes

Recommendation 5.1: To enhance outreach activities using various kinds of tools at different levels

To disseminate the many wonderful science results achieved by AORI's staff, AORI should enhance outreach activities through various kinds of communication tools, i.e., lectures, science cafes, publications, SNS, and MOOC (Massive Online Open Course). The use of social media should also be considered.

Among others, MOOCs are becoming popular methods to transfer the state-of-the-art research and/or scientific basics of many academic field to the general public. The UTokyo already introduced MOOC lectures several years ago, and many MOOC lectures have already been released. These are available to anyone through the website or YouTube. The AORI should evaluate whether or not MOOCs are an effective way for advertisement of AORI's scientific achievements to the general public, or would be effective in recruiting graduate students.

Recommendation 5.2: To return to society from research outcomes of 'Tohoku Ecosystem-Associated Marine Sciences (TEAMS) Project'

The academic year of 2020 is the last year of the "Tohoku Ecosystem-Associated Marine Sciences (TEAMS) Project" financially supported by MEXT. Since AORI has deeply committed this project as one of three major research organizations, we highly recommend that AORI should deliver the research outcomes obtained and accumulated by the project, especially to people in the coastal disaster areas. These research results need to be translated to easily-understandable expressions for the general public. These dissemination activities should be a duty for AORI. The ICRC (International Coastal Research Center) should lead this project.

Recommendation 5.3: To build on its excellent outreach programme to develop

significant conversations with the wider community and use this information to identify key research priorities.

These outreach activities will support the wider community, policymakers and marine managers.

Recommendation 5.4: To build on their excellent outreach programme to develop opportunities for citizen science projects.

These will also increase community interest and support for research at AORI.

(6)Research environment and support system

Recommendation 6.1: To secure the space for Division of Climate System Research (DCSR)

This was also recommended by the previous 2014 External Evaluation Committee. We hope for AORI to secure the space for the Division of Climate System Research much closer to the main building of AORI, in order to enhance communication and interaction among groups. In the current severe budget situation, we understand it is very difficult to construct a new building for the Division of Climate System Research, whose building is now located on the opposite side of the campus. Nevertheless, AORI should continuously explore the solution of this matter.

Recommendation 6.2: To secure enough technical staff members

Under the condition of the continuous budget cut for hiring human resources in national universities, to secure enough technical and administrative staff is very difficult. However, in order to enhance usage of the cutting-edge facilities and to conduct high-level field observations on the research vessels, support by technical staff is essential and crucial. The AORI should pay attention to the future situation of technical staff, and should have strategic plans to secure enough technical staff, and to improve the skill and ability of individual technical staff members. The AORI should appeal more severely to the head quarters of UTokyo, that the technical staff plays a crucial role in AORI's activities as Joint Usage/Research Institute.

(7)Organization and administration

Recommendation 7.1: To improve gender balance and to hire additional international staff

At present, the number of female researchers is low, and it goes without saying that this situation has to be solved as soon as possible. In personnel matters, the Director's office

should commit to hiring more female faculty members. They should also develop mentoring programmes for female staff to provide support for their professional development.

The AORI should also consider hiring more international staff and faulty with degrees from outside UTokyo to increase staff diversity in the Institute.

Recommendation 7.2: To group present research units s larger/wider ones i.e., to break present three-layer structure in research group

The present AORI research organization has a so-called three-layer structure; that is, division, department and section. One division consists of 2 to 3 departments, and one department consists of 3 sections. In one section, in general, there are 3 faculty members: one professor, one associate professor and one research assistant. We are very concerned that since personnel funding is now gradually shrinking, this structure will not be maintained in the future. In addition, this structure may inhibit the free expansion of the research fields. We strongly recommend restructuring of the research units with more flexibility, and the abolishment of the sections.

Recommendation 7.3: To establish AORI alumni organization

Although this item was one pointed out in the previous 2014 External Evaluation, we would like to again point out the importance of establishment of an alumni organization in AORI, which is independent from those of the graduate schools. Although each student belongs to one of the graduate schools, they spend most their time at AORI. This means that for most graduate students, AORI would be the place they grow up, that is, their so-called 'old home'. In order to maintain a 'spirit of unity' and to improve networking among the alumni, the existence of an alumni organization is very important. It goes without saying that all people related to AORI, i.e., academic/research, technical and administrative staff should be involved in the alumni organization.

4. Concluding remarks

We recognize that AORI's staff have high potential in conducting research and administrative activities. As far as we heard, we can judge that the direction of future plans is surely the correct way to develop their research further, and to take a leadership in the atmospheric and oceanographic communities in Japan, and in the world.

It goes without saying that in future activities, the leadership of the Director and the Directors' office is crucial. In this evaluation process, we know that the present Director and members of Director's office deeply understand this point and want to realize it. We expect, in fact, that it will be so.

'Future Vision Committee' activities are now being undertaken and many young

researchers are involved. We believe that, in the future they will construct the next brilliant era of AORI.

Finally, we strongly hope that this present 2020 External Evaluation will be able to give some contribution to AORI's smooth-sailing progress in the future.

The Process of External Evaluation of the AORI 2021

Dec. 2019	Preparatory Committee meeting for AORI's External Evaluation
May 2019	Appointment of the External Evaluation Committee (EVC) chair and members
June 2019	The EVC meeting schedule decided (March 5-6, 2020)
Aug 2019	Request to prepare the EVC materials to the professors in charge
Dec 2019	Sending 1st draft of EVC materials to the members (asking to comment back by early Feb 2020).
Feb 2020	Decision to postpone the External Evaluation due to global pandemic of COVID-19
Aug 2020	Decision to hold the EVC online (ZOOM) on March 3, 2021
Sep 2020	Request to revise EVC materials to the professors in charge (by the end of Nov. 2020)
Dec. 2020	Sending the EVC materials to the EVC members and asking comments and questions by mid Jan., 2021.
Jan. 2021	Reply to the comments and questions from the members.
Feb. 2021	Discussion for the review comments in the EVC members through e-mail
Mar. 3, 2021	**External Evaluation of the AORI (see Agenda below)**
Mar-May 2021	Drafting the final review comments in the EVC members through e-mail
May 30, 2021	Submitting the final review comments
July 2021	Publishing "The External Review Report of the AORI, UTokyo"

External Review of Atmosphere and Ocean Research Institute, UTokyo
March 3, 2021, 10:00-13:00 (JST, +9)

<Agenda>

1. Opening

10:00-10:05 Opening remarks: Prof. T. Kawamura (Director, AORI)
10:05-10:10 Self-introduction

2. Report from AORI

10:10-10:25 Overview of AORI: Prof. T. Kawamura

10:25-10:40 Scientific achievement: Prof. Y. Takayabu

10:40-10:55 Education, Joint Research/Usage, International activities, and working environment: Prof. K. Okino

10:55-11:10 Science and Society: Prof. S. Hyodo

(Coffee Break: 20min)

11:30-11:45 Responses to comments and future plans: Prof. T. Kawamura

3. Discussion, Evaluation and Recommendation

11:45-12:35 Comments from committee members and discussion

12:35-12:55 Comprehensive evaluation and recommendations: Prof. K. Hanawa

4. Closing

12:55-13:00 Closing remarks: Prof. T. Kawamura

東京大学 大気海洋研究所
Atmosphere and Ocean Research Institute, The University of Tokyo

Materials for External Evaluation

December 2020

Atmosphere and Ocean Research Institute

The University of Tokyo

This draft is prepared in advance of the 2021External Evaluation of AORI, the University of Tokyo. The contents will be revised based on the comments from External Evaluation Committee on March 3, 2021 and embedded in the “Report of External Review”. The final report will be published in summer 2021.

Contents

1. Overview of the Atmosphere and Ocean Research Institute

1.1. History

The Atmosphere and Ocean Research Institute (AORI) was established on April 1, 2010 at the University of Tokyo (UTokyo) as a result of the consolidation of two internal organizations: the Ocean Research Institute (ORI; founded April 1, 1962), which specialized in basic research on oceans, and the Center for Climate System Research (founded April 1, 1991), which specialized in research on climate systems with climate models.

After 48 years of operation at the Nakano Campus, space limitations and aging facilities prompted the relocation of the Ocean Research Institute to the Kashiwa Campus in March 2010, allowing the organization to make a fresh start. Meanwhile, the Center for Climate System Research (CCSR), which had been relocated to the Kashiwa Campus in March 2005 from the Komaba II Campus, was in its 19th year of operation.

In April 2010, one month after the Ocean Research Institute relocated to the Kashiwa Campus, both organizations voluntarily consolidated to form the AORI (Table 1-1). AORI is a center dedicated to comprehensive atmosphere and ocean research that aims to elucidate the complex mechanisms of evolution and changes in the atmosphere, oceans, and living organisms throughout Earth's history. Its research is carried out through organic collaborations, involving field observations, experiments, and numerical simulations in order to establish a scientific basis to support the future of humanity and the global environment.

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) approved the AORI to be a center for atmosphere and ocean research under the umbrella of the new Joint Usage/Research Center Program, which aims to promote Joint Usage of the AORI by researchers from across Japan. The AORI also established the Center for Earth Surface System Dynamics to take advantage of the synergies resulting from consolidation and thus reorganized the system to comprise four research divisions and four research centers (Fig. 1-1).

The International Coastal Research Center (ICRC), located in Otsuchi, Iwate Prefecture, was seriously damaged by the tsunami triggered by the Tohoku Earthquake on March 11, 2011. Fortunately, the third floor of the damaged research building was quickly renovated by May 2011, and the lost research vessel *Yayoi* and three other lost or damaged small boats were restored to restart the Joint Usage/Research Center. Meanwhile, a new laboratory, the Coastal Ecosystem Restoration Section, was established in April 2012 with

support from the university administration to lead studies related to the effects of the earthquake and tsunami events on coastal ecosystems as well as subsequent secondary successions of damaged ecosystems. The new research building and guesthouse were completed in February 2018 at 300 m inside the former site beside the coastline. All laboratory facilities with running seawater as well as a small exhibition room, the Otsuchi Marine Study Room, are located at the former site of the institute and will be completed by the end of March 2021.

The Analytical Center for Environmental Science (ACES) was launched in April 2014 and is the only laboratory in the world that hosts a single-stage accelerator mass spectrometer (SSAMS) and a nanoscale secondary ionization mass spectrometer (Nano-SIMS). These instruments enable internal and external collaborations involving AORI research groups, including many international groups. They have yielded many important research outputs in biological and geological studies and have improved our understanding of past global climate changes. The ACES aims to continue these highly productive, cutting-edge, collaborative activities and expand its human and laboratory resources.

Table 1-1. History of the Atmosphere and Ocean Research Institute (AORI)

沿革 | HISTORY

as of April 1, 2021

1958. 1 日本海洋学会と日本水産学会の連名で海洋総合研究所設立について日本学術会議に建議
The Oceanographic Society of Japan and the Society of Fisheries Sciences jointly proposed establishment of the Ocean Research Institute.

4 日本学術会議において研究所を設置すべきことを議決
Resolution on establishment of the Ocean Research Institute adopted by the Science Council of Japan.

8 科学技術審議会における審議に基づき、文部省に所属することが適当である旨、科学技術庁長官より文部大臣に通知。文部省は、国立大学研究所協議会において設置具体案を審議
The Minister of the Science and Technology Agency recommended to the Minister of Education and Culture that the new Ocean Research Institute be established in the Ministry of Education and Culture. The Ministry of Education and Culture formulated detailed plans for establishing the Ocean Research Institute.

1962. 4 海洋研究所、東京大学に附置。海洋物理部門、海底堆積部門、研究船、設置
ORI, the University of Tokyo, established. Ocean Circulation and Marine Geology groups established, and plans for research vessels formulated.

1963. 4 資源解析部門、プランクトン部門設置
Fish Population Dynamics and Marine Planktology groups established.

6 研究船淡青丸竣工
Original R/V Tansei Maru commissioned.

1964. 4 海洋無機化学部門、海洋生物生理部門設置
Marine Inorganic Chemistry and Physiology groups established.

1965. 4 海底物理部門、資源生物部門設置
Submarine Geophysics and Biology of Fisheries Resources groups established.

1966. 4 海洋気象部門、海洋微生物部門設置
Dynamic Marine Meteorology and Marine Microbiology groups established.

1967. 3 研究船白鳳丸竣工
Original R/V Hakuho Maru commissioned.

6 海洋生化学部門設置
Marine Biochemistry group established.

1968. 4 漁業測定部門設置
Behavior, Ecology, and Observations Systems group established.

1970. 4 海洋生物生態部門設置
Benthos group established.

1972. 5 資源環境部門設置
Fisheries Environmental Oceanography group established.

1973. 4 大槌臨海研究センター設置
Otsuchi Marine Research Center established.

1975. 4 大洋底構造地質部門設置
Ocean Floor Geotectonics group established.

1982.10 淡青丸代船（469t、1995年規格変更により606t）竣工
Replacement R/V Tansei Maru commissioned.

1988. 4 日本学術振興会拠点大学方式によりインドネシア国との学術交流開始
Cooperative research with Indonesia initiated through the Core University Program of the Japan Society for the Promotion of Science.

1989. 3 測地学審議会建議に「気候システム研究体制の整備」がうたわれた
The Geodesy Council stated a need for planning a research organization focused on the climate system.

5 白鳳丸代船（3991t）竣工
Replacement R/V Hakuho Maru commissioned.

7 学術審議会建議に「新プログラム方式による重点課題（アジア太平洋地域を中心とした地球環境変動の研究）」が取り上げられた
"Studies on variations of global environment with a central target in Asian Pacific Regions" was proposed as a priority research project in the "New Program" by the Science Council.

1990. 6 海洋分子生物学部門設置
Molecular Marine Biology group established.

12 新プログラム方式による重点課題を推進するために、東京大学に全国共同利用施設として気候システム研究センターが設置されることとなった
For the further growth of the priority research project in the "New Program" proposed by the Science Council, the establishment of the Center for Climate System Research (CCSR) at the University of Tokyo was finalized as an institute for national collaboration.

1991. 4 東京大学理学部に気候システム研究センター設立準備室が設置
The Center's preparation office opened in the Faculty of Science at the University of Tokyo.

東京大学気候システム研究センターが5分野の研究部門をもって設置され、東京大学理学部7号館で発足。時限10年（2001年3月31日迄）
CCSR, comprised of 5 research sections, was established. The facilities of the center were set up in the Faculty of Science's Seventh Building at the University of Tokyo (Active until March 31, 2001).

10 寄付研究部門（グローバル気候学）を設置（1996年9月迄）
The Endowed Research Division (Global Climatology) was established (Active until September 1996).

1992. 2 気候システム研究センター建物（第1期工事631m²）が目黒区駒場4-6-1に完成、移転
The Center moved to the new building (First construction: 631 m²) in the Komaba Campus of the University of Tokyo (Komaba, Meguro-ku, Tokyo).

1993. 3 気候システム研究センター建物第2期改修工事302m²が完成
The building at the center was expanded (Second construction: 302 m²).

1994. 6 海洋科学国際共同研究センター設置
Center for International Cooperation established.

1997. 4 寄付研究部門（グローバル気候変動学）を設置（2000年3月迄）
The Endowed Research Division (Global Climate Variability) was established (Active until March 2000).

1999. 3 外部評価が行われた
External Evaluation was performed.

2000. 3 寄付研究部門を終了
The Endowed Research Division was closed.

4 16部門を6部門16分野に改組。海洋環境研究センター設置
ORI internally reconstituted into six research departments and three research centers, including the newly-

1.2. Organization

1.2.1. Research organization

An organizational chart of the AORI is shown in Figure 1-1. The AORI comprises four research divisions and four research centers. The four divisions and their departments are as follows: the Division of Climate System Research, which includes the Departments of Climate System Modeling and Climate Variability Research; the Division of Ocean-Earth System Science, which includes the Departments of Physical Oceanography, Chemical Oceanography, and Ocean Floor Geoscience; the Division of Marine Life Science, which includes the Departments of Marine Ecosystem Dynamics, Marine Bioscience, and Living Marine Resources; the Division of Integrated Ocean Research. The four research centers are as follows: the International Coastal Research Center, the Center for International Collaboration, the Center for Earth Surface System Dynamics, and the Analytical Center for Environmental Study. As an organization that supports Joint Usage/Research including the use of research vessels, the AORI also includes the Center for Cooperative Research Promotion, which consists of the Field Research Support, Laboratory Research Support, and Coastal Research Support Sections.

1.2.2. Operation

The policies, appointment of faculty members, and other important matters at the AORI are decided upon at monthly faculty meetings attended by professors, associate professors, lecturers, and members who concurrently serve as the principal faculty members at the Department of Natural Environmental Studies, Graduate School of Frontier Sciences, the University of Tokyo. Faculty meeting agendas, including items up for consideration, are proposed after deliberation in the Director’s Office, which comprises the Director, two Vice Directors, two Advisers to the Director, and the Directors of the three large divisions. Decisions are also implemented after deliberation in the Director’s Office. The Director is elected from the professors of AORI (except for concurrent professors) by a vote of the members of the faculty meeting and serves a two-year term. In turn, Center Directors are appointed by the Director, and a Steering Committee established for each center deliberates over and determines basic policies for their respective center.

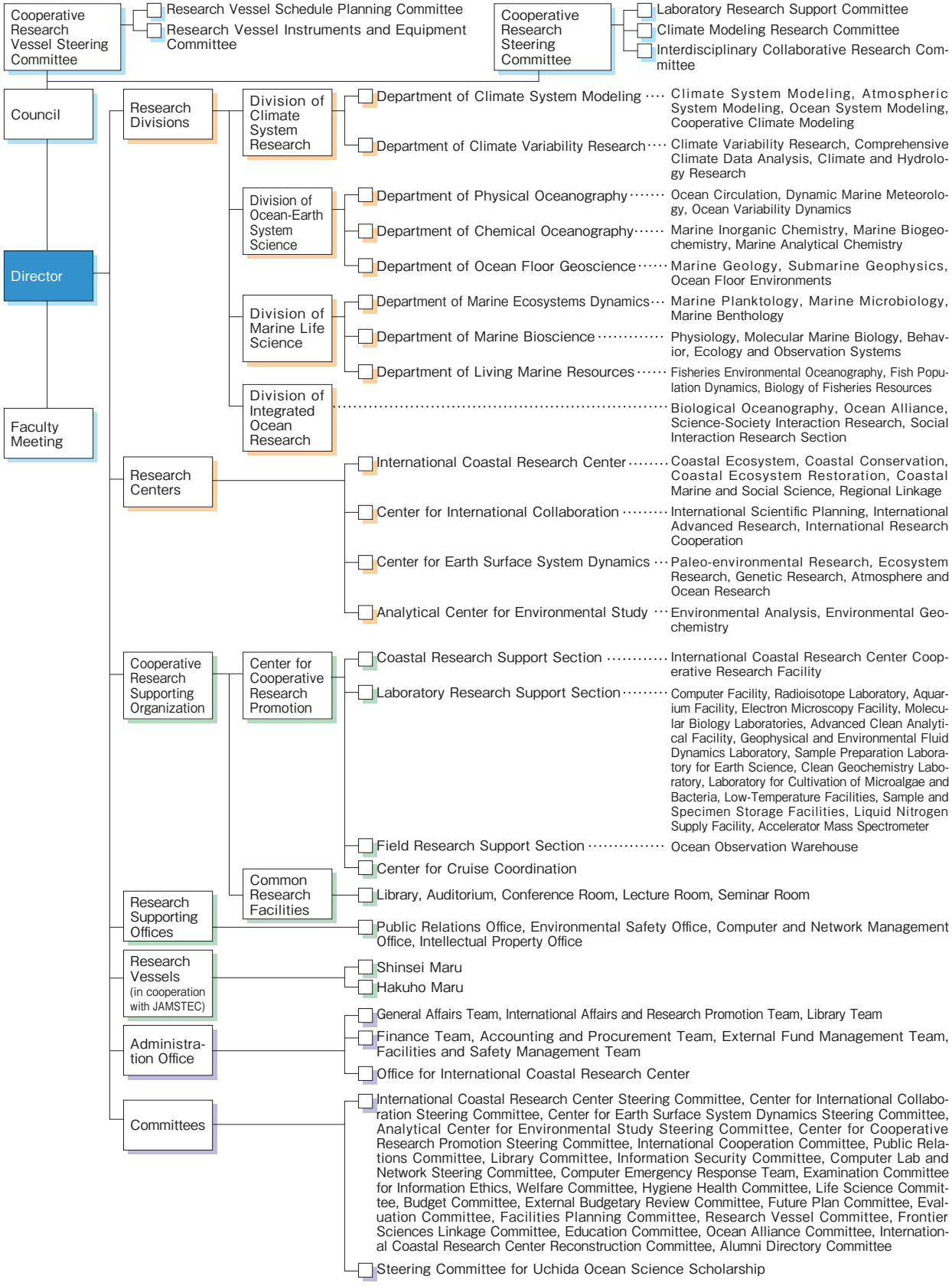


Figure 1-1. AORI organizational chart

1.2.3. Council, Cooperative Research Vessel Steering Committee, and Cooperative Research Steering Committee

Every year, the activities of the AORI are reported to the Council, which is mostly made up of members from outside the university. The Council provides advice and direction to the AORI as well as feedback on how well its research and organization are fulfilling its roles. In addition, the Council deliberates over and approves Joint Usage/Research plans involving the AORI's facilities and Cooperative Research Vessels, which are available for use by all researchers in Japan. The Cooperative Research Vessel Steering Committee, which is also mostly made up of members from outside the university, was established under the auspices of the Council and is in charge of research cruises. Specifically, this committee coordinates the use of research vessels by researchers by considering the availability of facilities and equipment, observation equipment, the type of operation, etc. The committee also solicits, evaluates, and selects the most suitable research cruise projects. Similarly, the Cooperative Research Steering Committee, which is again mostly composed of members from outside the university and established by the Council, covers subjects of Joint Usage/Research that involve the AORI's research facilities. This committee solicits, evaluates, and selects joint research meetings and joint research proposals submitted by researchers from other universities and institutes.

1.3. Financial

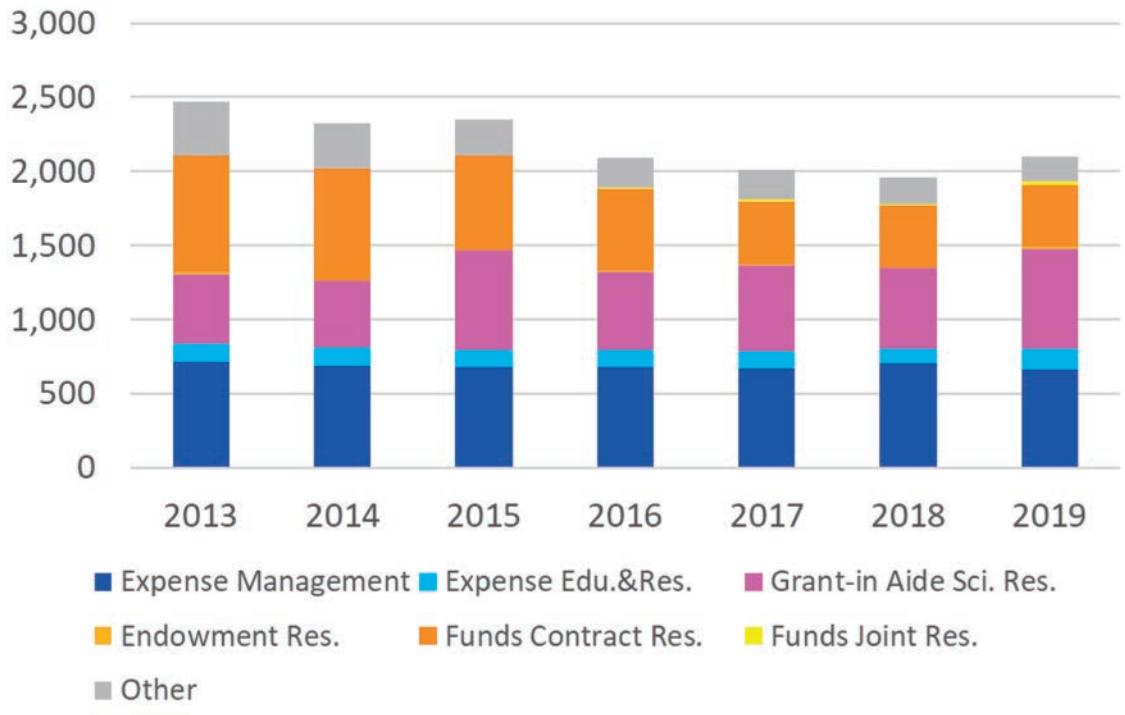


Fig. 1-2 Research budget (excluding personnel expenditures)

Changes in research budget (excluding personnel expenditures) at the AORI since the previous external review in 2014 are shown in Table 1-2. The annual total research budget has decreased from nearly 2.5 billion yen in FY2013 to approximately 2.1 billion yen in FY2019, mainly due to a decrease in contracted research projects and other grants. External funds currently account for approximately 60% of total research budget. Meanwhile, the proportion of Grants-in-Aid for Scientific Research is now nearly half of the total external funds. Funds for university management have also increased, mainly because of successful acquisition of new research projects from the University of Tokyo, and are expected to continue to increase in FY2020.

2. Research activities

The AORI promotes basic research on the Earth's atmosphere, oceans, and climate, which involves cutting-edge field research, experimental verification, and numerical modeling. We strive to create a new research area that integrates atmospheric, marine, and life sciences.

2.1. Achievements

The number of research papers, citations, and *h*-index values of each division, department, and center were calculated according to the Google Scholar database (Table 2-1). Between 2013 and 2019, each researcher published an average of 4.4 original papers per year. The median *h*-index was 18.

The most original papers published by one researcher was 443, while another researcher published 134 papers. The highest total number of citations was 12,442, while two faculty members had h-index values of 55. Research activities have been actively presented to scientific communities and the general public as evidenced by increased numbers of press releases (23 in 2019) and research topics appearing on the AORI website (12 in 2019) (Fig. 2-1).

Table 2-1. Numbers of original papers, citations, and h-index values of each division, department, and center since 2013

Departments and Centers	Fac. Number	Ave. Paper/Dept.	Ave. Paper (2013-)/Dept	Ave. Citation/Dept.	Ave. h-index	Range h-index
Department of Climate System Modeling	6	81	31	3936	25	10-53
Department of Climate Variability Research	3	106	54	5833	35	20-45
Department of Physical Oceanography	8	60	25	1507	17	7-43
Department of Chemical Oceanography	7	87	39	2595	26	17-37
Department of Ocean Floor Geoscience	9	107	31	2814	25	8-55
Department of Marine Ecosystems Dynamics	8	62	22	1827	19	5-41
Department of Marine Bioscience	9	59	23	1938	21	5-45
Department of Living Marine Resources	8	53	19	817	13	9-25
Department of Collaborative Research	2	64	24	1466	19	7-31
International Coastal Research Center	6	62	27	1329	17	8-36
Center for International Collaboration	3	94	28	2115	19	8-35
Center for Earth Surface System Dynamics	4	79	43	2769	23	14-45
Analytical Center for Environmental Study	2	255	110	9598	48	41-55
Ave. num/person/year and *Median			4.4		*18	
Total	75					

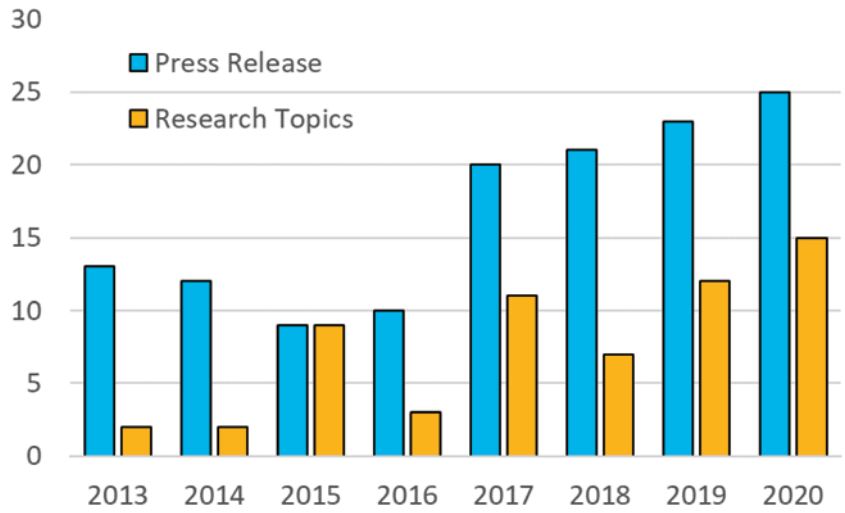


Figure 2-1. Numbers of press releases and research topics introduced to AORI's web site (2020: by Nov.25)

2.2. Acquisition of research funding

As shown in Fig. 1-2, the annual total budget decreased approximately 20% from FY2013 owing to a decrease in contracted research funding and other subsidies. Meanwhile, Grants-in-Aid for Scientific Research have remained steady at 500 million yen per year, which accounts for approximately 50% of external funding. Thus, indirect expenses paid via external funds have increased, contributing to institutional operation. Although funding for university management has been gradually decreasing, it increased in 2018 because of the launch of a project entitled, the "School for Marine Sciences and Local Hopes in the Sanriku Coastal Area." In 2019, the AORI has started two projects: "Integrative Research on Transition Zones between Coastal and Offshore Waters for Conservation and Sustainable Use of Resources" and "Research Hub for the Big Data Analysis of Global Water Cycle and Precipitation in Changing Climate." In 2020, two additional core research projects started: "Ocean DNA Project: Establishment of a Center for an Ocean DNA Archive and Analysis Unit toward the Conservation of Biodiversity and Bio-resources in the Pacific Ocean" and "Development of Advanced Human Resources based on the Interdisciplinary Education Program for Ocean Science and Policy." Also, AORI will start new research program "Subtropical-Kuroshio environmental study project -understanding the evolving environmental-cultural baseline in a changing world" from 2021. Thus, we expect a further increase in funding for university management. The University of Tokyo allocates personnel expenditures of some of these projects.

2.3. Outline of activities

Three research divisions—the Division of Climate System Research, the Division of Ocean-Earth System Science and the Division of Marine Life Science—promote cutting-edge basic research and related projects covering physical, chemical, geographical, and biological topics. Meanwhile, the International Coastal Research Center, the Center for International Collaboration, the Center for Earth Surface System Dynamics, and the Analytical Center for Environmental Study carry out their own missions to promote cutting-edge research. The research activities of the AORI's research divisions and centers are summarized below.

The Division of Climate System Research aims to develop climate system models, understand climate phenomena through simulations, and elucidate climate change mechanisms through comparison, analysis, and integration of satellite data, field data, and numerical simulations. The members of this division have been leading national research projects such as "the Program for Risk Information on Climate Change," "the Integrated Research Program for Advancing Climate," "the FLAGSHIP2020 Project", and "the Arctic Challenge for Sustainability Program (ArCS)." They also lead Japanese science teams for international or domestic Earth observation satellite missions for the Earth Clouds, Aerosols and Radiation Explorer (EarthCARE), the Global Precipitation Measurements (GPM), and the Greenhouse gases Observation SATellite-2 (GOSAT-2) and have produced significant results.

The Division of Ocean-Earth System Science comprises three departments: Physical Oceanography, Chemical Oceanography, and Ocean Floor Geosciences. The division aims to achieve an integrated and multifaceted understanding of the ocean–Earth system through basic research on ocean physics (e.g., oceanic general circulation, water formation, ocean fluctuation, air–sea interaction, and oceanic air disturbance), ocean chemistry (e.g., the biogeochemical cycle in the atmosphere, ocean, and across the ocean floor over a wide spatiotemporal scale), ocean geosciences (e.g., the mechanisms of ocean floor geographic features such as midocean ridges, back arc basins, and plate subduction zones as well as geoenvironmental records that have been preserved in ocean floor sediments), and interactions among the ocean, atmosphere, and ocean floor. The research includes observational studies using research vessels, experimental investigation, and modeling. Through these studies, the Division of Ocean-Earth System Science has contributed to human resource development and given their research achievements to society.

The Division of Marine Life Science comprises three departments: Marine Ecosystems Dynamics, Marine Bioscience, and Living Marine Resources. The members of this division have achieved striking research progress, including understanding the spatiotemporal patterns of community structure and diversity of bacteria, zooplankton, and hydrothermal-vent endemic

species; understanding the molecular, physiological, and behavioral mechanisms of marine organisms throughout their lifecycle, including habitat utilization, reproduction, and migration; and monitoring and elucidating the life history of marine organisms for their use as living resources based on the scientific knowledge and for the conservation of endangered top predators. To conduct cutting-edge research, the Division of Marine Life Science actively incorporates new techniques such as "-omics" and environmental DNA analyses, and utilizes data and samples collected during research cruises. This division also contributes to the scientific community and society in general by studying global warming and microplastics to devise countermeasures, and by monitoring marine ecosystems after the 2011 off the Pacific coast of Tohoku Earthquake. The Division of Marine Life Science's multidisciplinary approach, which involves international and domestic collaboration, has advanced knowledge of marine organisms and has cultivated human resources through educational and outreach activities, thus contributing to the "UN Decade of Ocean Science for Sustainable Development (2021-30)."

The Division of Integrated Ocean Research aims to clarify the mechanisms by which aquatic organisms respond to global environmental changes such as global warming and El Niño. In addition, the division aims to conserve aquatic organisms in coasts and rivers where nursery environments have been degraded by human activities, and to establish integrated ocean science and educational activities related to management and restoration policies. To enhance communication with society, the Science-Society Interaction Research Section was established in 2016.

All research facilities of the International Coastal Research Center (ICRC), including research vessels, were significantly damaged by the 2011 off the Pacific coast of Tohoku Earthquake and tsunami. Research vessels were returned to service by the end of October 2013, and new buildings of the ICRC were completed in 2018. Thus, the restoration of research facilities is almost finished. The "Tohoku Ecosystem-Associated Marine Sciences (TEAMS) Project," which has been continuously operating since 2012, assesses the impacts of the 2011 tsunami on coastal ecosystems and their recovery process. Scientific research such as salmon ecology, a biologging behavioral study of sea turtles, and environmental DNA in coastal areas has also been conducted. A new type of education/research/outreach program entitled, the "School of Marine Sciences and Local Hopes in the Sanriku Coastal Area," was launched in collaboration with the Institute of Social Science (ISS) of the University of Tokyo. The ICRC and ISS are collaborating to clarify the social role of scientific research institutions in rural areas experiencing drastic depopulation.

The Center for International Collaboration (CIC) promotes and supports academic

activities related to the oceans and climate through intergovernmental agreements and/or agreements, including the Intergovernmental Oceanographic Commission of UNESCO (IOC) and the North Pacific Marine Science Organization (PICES), as well as cutting-edge, integrated, international research plans related to oceanographic and atmospheric sciences conducted within international frameworks. In addition, through academic collaboration with other countries, including Japan's Asian neighbors, the CIC has been developing a foundation to support academic exchanges for youth and enhance multidisciplinary studies.

The Center for Earth Surface System Dynamics (CESD), founded in 2010 when the AORI was launched, aims to achieve an integrated understanding of the atmosphere and oceans. In its second term starting in FY2016, the CESD laid out its future plans consisting of the following four themes: (1) multi-scale processes of atmosphere–ocean interaction; (2) interdisciplinary studies of marine ecosystem dynamics; (3) multiple approaches to life evolution and environmental change; and (4) the creation of paleoclimate change dynamics by integrating models and data. Based on these themes and in collaboration with the AORI members, the CESD has proposed research projects to the University of Tokyo and MEXT; four corresponding projects have been approved. For theme (1), members conducted the highest-resolution global simulation with sub-kilometer simulations and achieved improved accuracy for the prediction of intra-seasonal variability and tropical cyclones through high-resolution numerical simulation studies using the global nonhydrostatic, "Nonhydrostatic Icosahedral Atmospheric Model (NICAM)." For theme (2), members conducted integrative research on the transition zones between coastal and offshore waters, contributing to a social science study related to marine spatial planning and the resultant conservation and sustainable use of the ocean. For theme (3), members analyzed the dynamics of marine life from bacteria to living resources by using environmental DNA in the ocean. In the next phase, the CESD will enhance collaborations among these research themes with the aid of all AORI members to develop the active roles of the joint research center in the AORI in addition to conducting high-level research that will lead the international community.

The Analytical Center for Environmental Study (ACES) was launched in April 2014 to conduct frontier research on Earth system sciences. The ACES comprises two sections: the Environmental Analysis Section (EAS) and the Environmental Geochemistry Section (EGS). The EAS studies Earth surface systems, including the cryosphere and biosphere. The in-house single-stage accelerator mass spectrometer (SSAMS)— the only one installed in Japan—is used to precisely measure radiocarbons. The system has been continuously modified, making its measurements the most precise and accurate in the entire world. Together with high-resolution, inductively coupled plasma mass spectrometry (ICP-MS) in

tandem with a laser ablation system, these instruments have been applied to reconstruct Antarctic ice sheet history, and fish and whale migration history, as well as understand geohazards such as paleo-tsunamis, etc. Meanwhile, the EGS investigates the evolution of Phanerozoic ocean chemistry with high temporal resolution by using a nanoscale secondary ion mass spectrometer (NanoSIMS) to perform high-spatial resolution isotope analyses of marine carbonates. Two-micrometer spot analyses by NanoSIMS can provide temporal resolution down to a few hours in the case of fossil giant clam shells. The EGS also investigates natural hazards such as eruptions and earthquakes on the basis of volatile isotopic compositions obtained by measuring volcanic gas and groundwater samples using stable isotope mass spectrometers.

2.4. Research staff

The AORI has been actively recruiting distinguished researchers from across Japan and currently employs more full-time researchers who graduated from other universities than any other faculty or research center at the University of Tokyo. Out of 70 faculty members, six are female, and one foreigner. The ratio of female researchers to apply AORI's recruitment is 12% (from 2017). Many contract researchers are employed using external funding to maintain high research productivity. Furthermore, visiting researchers from inside and outside Japan promote new interdisciplinary collaborative studies with external researchers.

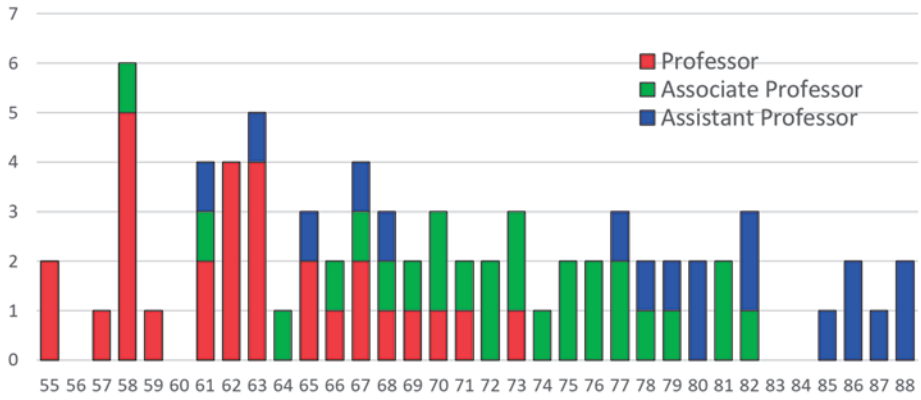
Although 10 professors have retired since 2014, the AORI hired 10 professors to maintain research and teaching activities. In addition, the AORI has hired many young faculty members, including 13 associate professors and 13 assistant professors. The age structure of the faculty members is shown in Figure 2-2. Among the 29 professors currently employed, eight will retire by 2024, and nearly one-third will reach the retirement age of 65 by 2029.

Table 2-2. Composition of members

Members employed by UTokyo Personnel Expenses	Professor*	27
	Associate Professor*	24
	Lecturer*	0
	Assistant Professor	18
	Technical Staff	16
	Administration Staff	21
	Sub Total	106
Members employed by AORI, projects or other funding	Project Assistant Professor	4
	Project Researcher	60
	JSPS Research Fellow	9
	Academic Support Specialist	3
	Research Assistant	9
	Technical Assistant	33
	Administration Assistant	43
	Sub Total	161
Visiting scientists	Visiting Professor	1
	Visiting Associate Professor	2
	Sub Total	3
	Total	**270**
	Total Researcher	**145**

*: Member of Faculty Meeting

Figure 2-2. Distribution of the birthdates of faculty members by year (in 1900s)



3. Research activities, issues and plans of Divisions and Centers

3.1. The Division of Climate System Research

3.1.1. Abstract

The Division of Climate System Research (DCSR) aims to develop climate system models, understand climate phenomena through simulations, and elucidate climate change mechanisms through comparison, analysis, and integration of satellite data, field data, and numerical simulations. The members of the DCSR have been leading national research projects such as “the Program for Risk Information on Climate Change,” “the Integrated Research Program for Advancing Climate,” “the FLAGSHIP2020 Project”, and “the Arctic Challenge for Sustainability Program” as well as the Japanese science teams for international or domestic Earth observation satellite missions for the Earth Clouds, Aerosols and Radiation Explorer (EarthCARE), the Global Precipitation Measurements (GPM), and the Greenhouse gases Observation SATellite-2 (GOSAT-2). All of these initiatives have yielded significant results.

3.1.2. Actions after the External Evaluation Report, 2014

Response to comments (III-E): New Building for the Division of Climate System Research (DCSR)

Recommendation **“We recommend that the administration of the AORI work with the University of Tokyo administration to develop plans for the construction of a new building, adjacent to the present location of the AORI, so that the DCSR is co-located with the other divisions of the AORI.”**

Response: Please see Chapter 10.1.1 Response E1:

3.1.3. Present status and achievements

The DCSR aims to develop climate system models, understand climate phenomena through simulations, and elucidate climate change mechanisms through comparison, analysis, and integration of satellite data, field data, and numerical simulations. Above all, the DCSR has been developing an original, world-class climate model known as “MIROC” together with its component models for the atmosphere, ocean, sea ice, land surface, aerosols, etc. in close

collaboration with research partners at the National Institute for Environmental Studies (NIES) and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC). The DCSR also has developed a world-class global climate model called “NICAM” in close collaboration with JAMSTEC. The models are used not only by researchers and students at the DCSR, but also by collaborative researchers all over Japan for the study of climate formation and variability, including global warming. These models are at the forefront of the global research community and have been referred to in assessment reports by the Intergovernmental Panel on Climate Change (IPCC). In addition, the DCSR promotes research using observational data, particularly satellite data, and supports global climate system monitoring.

During this evaluation period (since 2014), the DCSR has collaborated with its partner institutions to proceed in developing the integrated earth system model (ESM) version of MIROC, advance the ocean-coupled version of NICAM (i.e., NICOCO), and proceeded in developing the paleo-climate model in collaboration with the Center for Earth Surface System Dynamics. Meanwhile, owing to the increasing demand by society to understand and project climate change, regional climate model studies for the tropics, the region around Japan, and the Arctic region have been launched. Synergetic studies of numerical models and observations, attribution studies of extreme weather events, and a data service for public use have proceeded.

Simultaneously, the staff of the DCSR have acted as principal investigators in many national climate research projects such as the “Program for Risk Information on Climate Change,” the “Integrated Research Program for Advancing Climate,” the “HPCI Strategic Program,” the “FLAGSHIP2020 Project”, and the “Arctic Challenge for Sustainability Program (ArCS).” Members are also the Chief Scientists of the Japanese Science Teams for international or domestic earth observation satellite missions for the Earth Clouds, Aerosols and Radiation Explorer (EarthCARE), the Global Precipitation Measurements (GPM), and the Greenhouse gases Observation SATellite-2 (GOSAT-2). Members are also contributing as a Review Editor and a Lead Author to the IPCC AR6 as well as leading four international academic exchange agreements with Russia, India, and Norway. Thus, the DCSR and its staff have played leading roles in both national and international climate research.

3.1.4. Integrations

Developments of the ESM version of MIROC, which includes various biochemical processes, will continue in collaboration with partner institutions and in-house collaborations within the AORI. In addition, the DCSR will continue developing regional climate models for studies of

the regional climate in the tropics, the region around Japan, and the Arctic in collaboration with other divisions of the AORI. Interaction studies between such regional and global climate models will be promoted. The DCSR will also continue paleo-climate studies in collaboration with the Center for Earth Surface System Dynamics. In addition, integrations of novel Earth system satellite observations in climate studies and model developments will continue in collaboration with the Japan Aerospace Exploration Agency (JAXA), National Aeronautics and Space Administration (NASA), and European Space Agency (ESA). The DCSR will pursue strategies to effectively handle large volumes of climate data produced from observations and model experiments by utilizing the new CIT in collaboration with the Information Technology Center of the University of Tokyo as well as other institutions and universities in Japan.

3.1.5. Contributions to society

The DCSR will contribute to society by providing information on climate projections to climate change adaptation studies and contributing to IPCC assessment reports. Thus, the DCSR aims to primarily contribute to Sustainable Development Goal 13, “Climate Action,” through its research activities. Furthermore, the DCSR will continue educational activities by providing human resources for climate studies and model developments.

3.1.6. Future strategy and issues

Regarding disciplinary developments, the DCSR will maintain its primary focus to develop physical global climate models and carry out global climate variability studies. For global climate modeling studies, the DCSR will pursue upscaled numerical experiments in process-oriented studies, higher-resolution models, and large-ensemble simulations. Attribution studies and process studies on extreme climate events will also continue. Finally, the synergetic use of satellite and field observations in climate studies and improving model physics will also continue.

3.2. Division of Ocean-Earth System Science

3.2.1. Abstract

The goal of this Division is to achieve an integrated and multilateral understanding of the

ocean-earth system through basic research on ocean-physics, ocean-chemistry, ocean-geosciences, and on interactions among the ocean, atmosphere, and ocean floor. The research includes observational studies using research vessels, experimental investigation, and modeling. Through these studies, the Division has contributed to human resource development and to give back the research achievements to the society. In the future, it is planned to further foster the fusion of different research fields and the collaborations with domestic and foreign researchers in order to enhance cutting-edge scientific research.

3.2.2. Department of Physical Oceanography

3.2.2.1. Present status and achievements

This department conducts research into physical oceanography with the aim of clarifying and understanding ocean and atmospheric systems such as the general circulations of ocean and atmosphere and their variabilities, distributions, and transformation of water-masses, together with ocean-atmosphere interactions, and ocean-atmosphere disturbances.

Prof. Hiroshi Niino retired in FY 2018 and then Prof. Masaki Satoh joined the laboratory for Dynamic Marine Meteorology. Dr. Junshi Ito joined this laboratory in FY2018 as an assistant professor and was promoted as an associate professor in Tohoku University in FY2020. In 2017, Dr. Yusuke Kawaguchi joined the laboratory for Ocean Variability Dynamics as an assistant professor.

Since 2015, leading the project Grant-in Aid Scientific Research in Innovative Areas “Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem (2015-2019: PI Ichiro Yasuda, “OMIX”-project)”, interdisciplinary studies related with ocean mixing have been promoted. Basin-scale and surface to bottom turbulent mixing distribution in the northwestern Pacific was revealed by developing CTD-attached fast-response thermistor methods which is much more efficient than the previous one. This contributes to quantifying deep circulation and nutrients supply to abundant ecosystems. By leading cruises of Hakuho-maru, Shinsei-maru, Japan Meteorological Agency and Russian vessels and Argo floats, distribution of circulation and mixing and long-term mode-water variability in the northwestern Pacific were revealed.

For the studies on Dynamic Marine Meteorology, the basic processes such as boundary layer turbulence and the dynamics of eddies, including meso-cyclone, tropical cyclones and tropical disturbances, have been investigated. We participated in the supercomputer project FLAGSHIP2020 using the K computer in RIKEN, Kobe, with the

research title “Advancement of meteorological and global environmental predictions utilizing observational Big Data” and conducted very high-resolution atmospheric and oceanic simulations. We showed that the global cloud-resolving simulations using the Nonhydrostatic Icosahedral Atmospheric Model (NICAM) improve predictability of the atmosphere for the time scale of a few week to a month through better representation of the intra-seasonal variabilities including Madden-Julian oscillations. These results have been widely distributed and contributed to the society through press releases and general symposiums to public people. MOU for comprehensive research collaboration was agreed between AORI and the Meteorological Research Institute, and we started collaborative studies sharing numerical models and observational data. From 2020, the members jointed a new project "Large ensemble atmospheric and environmental prediction for disaster prevention and mitigation" using “Fugaku”, the fastest supercomputer in the world. The scale of the calculations performed in this study is approximately 500 times larger than daily ensemble-based data assimilation for weather forecasts performed by meteorological organizations throughout the world. The goal of the project is to strengthen efforts to protect people's lives and assets.

3.2.2.2. Issues

Technical support for physical oceanographic observations and laboratory experiments has been serious issue. The previous external review recommended the employment of technical staff who is directly related to ocean physics, which has not come true (4 technical staffs who majored in physical observations and experiments retired in the past 10 years, but not been replenished). Also see the response to Recommendation 8.1 in the Chapter 9.1.2.

3.2.2.3. Plans and resolutions

3.2.2.3.1. Disciplinary development

Physical oceanography is the fundamental base for the ocean and atmosphere science. This department plays roles as base for research and education for physical oceanography, especially for observational research. Technical innovation and support system for physical oceanographic instruments and laboratory experiments need to be strengthened by cooperating with other departments in AORI and Center for Cooperative Research Promotion. Collaboration on the studies of air-sea interaction and climate issues is promoted in this department.

We promote studies on Dynamic Marine Meteorology through high-resolution

numerical models covering large-eddy simulations, meso- to global multi-scale simulations, and investigate mechanisms of these scale disturbances and their predictabilities by collaborating with researchers within AORI and the other universities and research institutes.

3.2.2.4. Integration

By expanding of OMIX achievements which enable to observe diapycnal transport of water, heat and nutrients, integrated and interdisciplinary studies on biogeochemistry, ecosystem and climate are promoted by using and improving advanced physical oceanographic instruments such as microstructure profilers, gliders floats and moorings with microstructure sensors which are now available. Seeking a new unit for performing collaborative disciplinary and interdisciplinary studies by using these advanced ocean mixing instruments could be a good timing to be proposed, especially for contributing to an adopted MEXT master-plan "Improvement of climate and ecosystem forecasts by developing global deep mixing float observations" by developing mixing observation methods of autonomous deep profiling floats and expanding collaborated research on ecosystem and climate.

We promote collaborative studies through high-resolution regional/global numerical models and enhance usability of these models. In particular, we enhance international collaborations with institutes including Geophysical Fluid Dynamics Laboratory, NOAA, in the United States and the Max Plank Institute for Meteorology in Germany. We also enhance collaborative studies between numerical modeling and satellite remote sensing. Laboratory experimental apparatuses for geofluid dynamics are maintained for the use of collaborative studies.

3.2.2.5 Contribution to society

Long-term climate and ecosystem variability is important issue for society. Related oceanographic results are announced publicly by using WEB-site etc. Through graduate school education, we develop young scientists who will tackle on various scientific and societal issues.

Using the MOU between AORI and the Meteorological Research Institute, we promote collaborative studies to contribute to disaster prevention and mitigation due to severe weathers including tropical cyclones and heavy rainfalls.

3.2.3. Department of Chemical Oceanography

3.2.3.1 Present status and achievements

The oceanic environment contains various chemical components, the complex distribution and behavior of which are controlled by factors such as their intrinsic chemical properties, sources and sinks, and the physico-chemical and biological processes in the ocean. The department has been conducting field observations using research vessels in addition to performing laboratory experiments, in order to understand the biogeochemical cycles in the ocean as part of the earth system, and has also been pursuing field studies to monitor the recovery of coastal environments in the Sanriku district following the 2011 earthquake off the Pacific coast of Tohoku and resultant nuclear power plant accident. The knowledge obtained through the research has been delivered to the public to assist the efforts of local government and coastal community to reconstruct fisheries and ecosystems.

The Marine Inorganic Chemistry Section has led the international GEOTRACES program by determining trace elements and their isotopes (TEIs) in seawater accurately to investigate marine biogeochemical cycles of trace elements. Field observations using research vessels have been conducted with the established clean sampling system (e.g., R.V. Hakuho-maru KH-14-6; R.V. Shinsei-Maru KS-15-6, and R.V. Hakuho-maru KH-17-3 cruises). Mainly in the Pacific Ocean, biogeochemical cycles of trace metals (e.g., iron and zinc) have been revealed. This group also studied detailed biogeochemical processes of trace metals which control the regional and global distributions of TEIs in the ocean. For example, trace metals, like copper (Cu), zinc (Zn) and iron, are complexed with organic ligands in seawater, which influences on their bioavailability by microorganism and particle reactivity. Organic complexation of Cu and Zn in seawaters have been investigated by using electroanalytical methods in various marine environments. Moreover, studies have been started to investigate the migration pathways of radionuclides, released to the marine environment by the accident in March 2011.

The Marine Biogeochemistry Section has been promoting studies on marine ecosystems and biochemical processes, by focusing on the dynamics of biophilic elements and organic material in marine environments, their coupling with metabolisms of marine microbes, and the characterization of food-webs based on the stable isotopes of carbon and nitrogen. Specifically, this research group has contributed to the elucidation of the balance between supply and consumption of organic carbon in the oceanic meso- and bathypelagic zones; the evaluation of the role of microbes in regulating organic aggregate formation in seawater; the clarification of the transformation and remineralization processes of terrestrially-derived dissolved organic matter in marine environments; and a better understanding of material cycling processes in coral reefs and mangroves in tropical and subtropical regions. Furthermore, studies have been conducted to investigate the impacts of the great earthquake and tsunami in 2011 on Sanriku coastal ecosystems from the viewpoint of material cycling

and organic pollution.

The Marine Analytical Chemistry Section is leading isotope oceanographic studies by making the best use of state-of-the-art analytical technology, to advance multi-disciplinary studies in ocean circulation, submarine hydrothermal activity, and paleoenvironmental reconstruction. Moreover, field observations of earthquakes and volcanos have been conducted. For example, earthquake mechanisms were clarified in the 2011 earthquake off the Pacific coast of Tohoku and the 2016 Kumamoto Earthquake using geochemical tracers. Also, submarine volcanic area was found around Tokara islands using a newly developed method. Using NanoSIMS, we elucidated a mechanism of biomineralization process and element transport for a hard tissue of marine organisms, such as a statolith of jellyfish, iron sulfide scales of the hydrothermal scaly-foot gastropod, planktonic foraminifera shell, daily growth pattern of bivalve shell, and the organic materials within fish otoliths. We also found a trace of primitive life of the Earth in ancient marine environment.

3.2.3.2. Issues

There is much that is unknown, not only in relation to the spatiotemporal variations in concentrations of inorganic and organic components, their isotope ratios, and their speciation in the earth system connecting the atmosphere, oceans, and solid earth, but also in relation to the physical, chemical, biological, and ecological processes that control the biogeochemical cycles in the ocean. The department aims to conduct research within the boundary zone between the ocean and neighboring reservoirs, in relation to air-sea exchanges, submarine hydrothermalism, and riverine and ground water discharges from the land. To obtain highly accurate and original results, it is necessary to develop new technologies and their applications for use in both field observations and laboratory experiments.

3.2.3.3. Future plans

Collaboration between other fields of study such as ocean modeling, microbiology, and paleoceanography, will also be instigated to achieve interdisciplinary breakthroughs in ocean sciences. We intend to remain at the forefront of marine biogeochemistry via undertaking field observations and experiments in open oceans, as well as in coastal regions including the Sanriku districts. Our detailed aims are as follows: (i) The distributions of trace elements and their isotopes (TEIs) have not yet been revealed well in the Pacific Ocean and Indian Ocean compared with those in the Atlantic Ocean. To accelerate marine biogeochemical studies of TEIs at the global scale and contribute to the international GEOTRACES program, the Marine Inorganic Chemistry Section will investigate the distributions of TEIs especially in the Pacific

Ocean and Indian Ocean, including their marginal seas. The MIC Section will also develop new sensitive and high-precision analytical methods of TEIs in seawater to promote marine biogeochemical studies. By studying physico-chemical forms of trace metals and radionuclides in seawater, the MIC Section will deepen our understanding of those functions in the marine ecosystem. (ii) To accelerate frontier studies on the cycling of biophilic elements, up-to-date technologies that allow high-precision determination of organic compounds and the compound-specific isotope ratios will be developed. It is also important to facilitate the collaboration with adjacent research fields including microbiology and bioinformatics to develop innovative approaches to further explore the emerging interdisciplinary research area of marine biogeochemistry. (iii) To apply a high resolution and sensitive NanoSIMS to paleoenvironmental studies using carbonate fossils of marine organisms such as corals and bivalves, and also to forward studies on earthquake and volcanic activities and on abyssal circulation by precisely measuring He isotope ratios. Using high-end analytical technology and collaborating with other departments, we further accelerate inter- trance- and multi-disciplinary oceanographic sciences.

3.2.4. Department of Ocean Floor Geosciences

3.2.4.1. Present status and achievements

The Department of Ocean Floor Geosciences (OFGS) has conducted extensive research in relation to the Earth and environmental sciences, in cooperation with three sections: Marine Geology, Submarine Geophysics, and Ocean Floor Environments.

In the last seven years, we have forwarded geological and geophysical field studies on active plate margins, in particular research of the subduction dynamics around Japan. In order to understand the physical property of seismogenic zones and to reveal the history of seismic activity, we have led the international project of deep-sea drilling in the Nankai Trough, and conducted high-resolution marine exploration and sampling using ROV. We have launched a state-of-the-art seismic reflection profiling system and carried out detailed crustal structure imaging and estimation of the physical properties of the Japan Trench subduction zone. In addition to ship-based marine field surveys, we have promoted on-land geological surveys and laboratory experiments.

On the study of formation and evolution processes of the oceanic crust, we have contributed better understanding of the interaction among solid Earth, fluid circulation and deep-sea ecosystems through a series of field surveys at global hydrothermal systems. Deep-seated hydrothermal circulation in mid-ocean ridges has also been studied using metamorphic

rocks in the mantle for better understanding of the mechanism maintaining plate motion on the Earth’s surface. Further deep Earth’s interior has also been investigated from mantle rocks and marine sediments to elucidate core-mantle interaction that induces mantle heterogeneity and geomagnetic field intensity variations in the past, respectively.

With respect to the study of environments, we have investigated biogeochemical cycle at the modern condition and in the past in order to predict future environments. These studies include the relationship of climatic change with the migration and the development of the society of homo sapiens, ocean acidification, and mineral deposits under hypersaline conditions. Also, we made much effort to understand the linkage between Earth's interior dynamics and surface environments especially at the hot Earth condition (e.g., ocean anoxia, ultra-global warming).

In addition to individual scientific outputs, members of OFGS have been leaders of both academic societies in Japan and international programs, including IODP (International Ocean Discovery Program) and InterRidge, with roles as presidents, chairpersons, and various committee members. Contribution to the government and international community as a member of the Commission on the Limits of the Continental Shelf, the United Nations, is also of note.

3.2.4.2. Issues

Ocean Floor Geoscience, which targets the Earth on and below the seafloor, involves most of the disciplines of Earth sciences. For the last five years, our department welcomed three new faculties, and has fulfilled the educational need for covering all major research disciplines of marine geosciences by a limited number of faculties. Each member has accomplished high performance in individual research. In the next step, we should strengthen further interdisciplinary research among the members, and need to become an outstanding team capable to challenge breakthroughs. It is important to balance curiosity-driven science and research to respond social needs.

3.2.4.3. Future plans

To strengthen interdisciplinary research, we set a few main research themes. For the next five years, we will proceed to conduct research on geodynamics and element cycles of oceanic plates incoming subduction zones. The interactions between Earth’s interior dynamics and surface environments in various time scales (e.g., oceanic anoxia, acidification, and mass

extinction) are another important theme. We consider that curiosity driven research is of particular importance for the seeds of future research projects. Considering this aspect, we will prepare interdisciplinary proposals for surveying various places of the world ocean with the common-use research vessels. To better understand the Earth as a system, it is imperative to integrate geological observations and geophysical explorations in the field, ocean drilling, laboratory measurements and analyses, analogue experiments, and numerical simulations. As such an example, we plan paleoclimate studies combining geochemical analyses of marine sediments and climate modeling.

We continue to lead various international projects and contribute to international as well as domestic scientific communities. We contribute to the society by providing high-quality education. In particular, we intend to nurture scientists of next generation who become leaders of international projects and science communities.

3.3. Division of Marine Life Science

3.3.1. Abstract

During the last seven years, the Division of Marine Life Science has achieved striking progress in studies on marine ecosystems, biology, and resources, providing many globally leading results, such as understanding the geographic pattern of community structure and diversity of bacterio- and zooplankton, larval dispersal of hydrothermal vent endemic species, environmental adaptation of cartilaginous fishes, molecular mechanisms for habitat utilization, monitoring physical environments at the atmosphere–marine boundary using marine animals, elucidation of the early-life migration characteristics of important marine living resources, the first direct observation of the fertilization process of cephalopods, and the conservation of endangered marine mammals.

The division strives to achieve further progress by using new technologies, such as “-omics” and environmental DNA analyses, responding to the needs of society by providing information for countermeasures against global warming and microplastics, continuously monitoring marine ecosystems after the 2011 off the Pacific coast of Tohoku Earthquake, constructing systems for effective utilization of data and samples collected by research cruises, and contributing to the UN Decade of Ocean Science for Sustainable Development through multidisciplinary international and domestic cooperation. The division will also contribute to human resource development through educational and outreach activities.

3.3.2. Department of Marine Ecosystems Dynamics

3.3.2.1. Present status and achievements

The Department of Marine Ecosystems Dynamics has been conducting studies on the evolution, phylogeny, physiology, and ecology of zooplankton, phytoplankton, benthos, bacteria, and archaea living in marine environments in order to elucidate the roles of these organisms in ecosystems and biogeochemical cycles as well as the mechanisms that underlie their environmental adaptation. In particular, the development and introduction of cutting-edge methodologies based on recently emerging fields in biology, such as molecular biology and genome sciences, has contributed to the large progress in research on the phylogenetic taxonomy, population dynamics, biodiversity, and biogeography of target organisms. In addition, substantial efforts have been invested in monitoring studies after the 2011 off the Pacific coast of Tohoku Earthquake. Specific research topics are described below.

(1) Research of plankton and benthos biodiversity : Samples for a large-scale comprehensive analysis of plankton diversity were collected during *R/V Hakuho Maru* cruises from all over the Pacific Ocean, which revealed geographic patterns in the community structure and diversity of bacteria and zooplankton in the Pacific Ocean. Of note, the department developed a methodology for the metabarcording analysis of zooplankton community structure. The department also provided the world's first evidence showing that planktonic larvae of deep-sea hydrothermal vent endemic species disperse within surface layers through rearing experiments and population genetic analyses. Gastropod fauna in the deepest area below 9,000 m in the Kuril–Kamchatka Trench were found for the first time, which suggests the existence of the deepest seep ecosystem in the world.

(2) Research on biogeochemical cycles and environmental adaptation: Intensive basin-scale transect surveys were performed to identify key microbial taxa and reveal their dynamics in biogeochemical cycles of nitrogen, phosphorus, and sulfur in the ocean. The molecular markers associated with starvation and diapauses in zooplankton were identified by comprehensive gene expression analysis.

(3) Monitoring after the 2011 off the Pacific coast of Tohoku Earthquake: Continuous plankton monitoring in Otsuchi Bay in northeastern Japan showed the mega-tsunami did not have a significant or lasting impact on holozooplantkon, but reduced merozooplankton due to damage to their benthic populations. Monitoring changes in the population genetic characteristics of dominant tideland snail species and the community structures of small deep-sea crustaceans revealed high resilience to large disturbances.

3.3.2.2. Future plans

(1) Research of marine food-web structure: The Department of Marine Ecosystems Dynamics will reveal the phylogeography and trophic interactions of microbes, plankton, and micronekton in the Pacific and Indian Oceans by using molecular- and genome-based approaches. Through international collaboration with animal taxonomists and marine physicists, the department also plans to examine the larval dispersion and isolation/speciation processes promoted by the subduction of seamounts for benthic organisms endemic to trenches. In addition, systems to improve the utilization of specimens collected by research cruises will be established through the arrangement and publication of sampling information as well as the construction of a network among animal taxonomists.

(2) Research on biogeochemical cycles and environmental adaptation: The department will facilitate studies on the roles of marine ecosystems in air–sea interaction processes. The department will examine the physiological responses of zooplankton to environmental stresses in order to predict the effects of future environmental changes on their phenology and distribution. Moreover, the department will examine the responses of deep-sea organisms to rapid environmental changes in the deep-sea areas of the Sea of Japan through international and multidisciplinary collaborative studies in order to provide useful information about the expected effects of climate change on deep-sea ecosystems. Furthermore, understanding the distribution and fate of microplastics in marine environments will help advance scientific knowledge about them.

(3) Monitoring after the 2011 off the Pacific coast of Tohoku Earthquake: The department will monitor the long-term changes in the plankton and benthic communities in the Sanriku coastal area that have occurred after the mega-tsunami. The department will also continually sample environmental DNA from the Sanriku coastal area to establish DNA archives of sample and sequence data.

3.3.3. Department of Marine Bioscience

3.3.3.1. Present status and achievements

The Department of Marine Bioscience aims to understand the ocean from a biological standpoint by conducting integrative studies of marine organisms at the molecular, organismal, and populational levels with the coordination of its three sections. The department has utilized a wide variety of techniques at various scales, including genome and transcriptome analyses, genome editing, whole organismal physiology, biologging, and eDNA

analysis, to produce significant results, which have been published in high-impact journals.

Studies of the physiological processes of various marine organisms, including development, adaptation, and reproduction, are mainly conducted by the Physiology Section. In particular, considerable progress has been made in understanding cartilaginous fishes, which are representative top predators of marine ecosystems. Meanwhile, the Molecular Marine Biology Section investigates the molecular mechanisms by which marine organisms, especially those inhabiting deep-sea hydrothermal vent areas and estuaries, utilize specific habitats. Their research scope was recently to organisms in coral reefs and areas polluted by anthropogenic chemicals and microplastics. Finally, the Behavior, Ecology, and Observation Systems Section primarily conducts behavioral ecology and eco-physiological studies of higher predators in the ocean by using biologging techniques. Moreover, new techniques that utilize marine turtles and seabirds have been developed to monitor physical environments at the atmosphere–ocean boundary, such as depth–temperature profile, ocean winds, surface currents, and waves.

After the 2014 external review, three professors and one associate professor of the department retired, while other promotions and transfers also occurred. As a result, the entire faculty recently turned over. Nevertheless, the participation of new faculty members who can link molecular chemistry with physiology or physiology with behavioral ecology has greatly strengthened intradepartmental collaboration. Each section also actively participates in graduate student education at three graduate schools, fostering the future leaders of marine bioscience. In addition, academic staff are serving as committee members of various scientific societies and editors of academic journals and are also involved in outreach activities including public lectures and exhibitions.

3.3.3.2. Future plans

(1) Enhancement of cooperation: All academic positions, except two professorships, have been filled by new members from outside the Department of Marine Bioscience, outside the AORI, or have been newly assigned. The large proportion of new members is expected to increase diversity in the department as well as create opportunities to introduce new techniques and ideas. Nevertheless, the members of the Department of Marine Bioscience continue to build a deeper mutual understanding about their scientific backgrounds because of the rapid turnover. Thus, the frameworks for interinstitutional and international collaboration must also be reconstructed. Although this is a large issue, it provides the opportunity to establish a new schema of collaborative studies. To accelerate collaborating

among sections, the roles of departmental meetings and seminars will be strengthened. The frequency of departmental meetings has already been increased. Concerning departmental seminars, a Preparation Committee mainly consisting of assistant professors has started operating. These seminars are enhancing interdivisional ties. Departmental seminars with external presenters are also used to enhance collaboration with external organizations. Accordingly, a common budget for departmental seminars has been prepared to provide resources to invite external speakers. These seminars are also expected to enhance collaboration within the AORI by exposing its departments to each other.

(2) Maintenance of previous achievements: It is important to maintain the knowledge and expertise accumulated in the department and transfer them to the younger generation given the high staff turnover and need for continuous technical innovation in the field of life science. Knowledge and expertise in each section will be shared within the department or with other departments or research centers so that they are not restricted to a single section. For example, the accumulated knowledge about lifecycle and environmental adaptation of migratory fishes will be shared with the International Coastal Research Center and the Division of Integrated Ocean Research. Cooperation with the ICRC has started because one professor is concurrently a professor there and many graduate students utilize the ICRC as a base for field research. Such cooperation will be strengthened in the future. Existing knowledge about the evolution and systematics of teleosts based on whole mitochondrial sequences will be used as a foundation for genome evolution and functional evolution studies as well as ecological eDNA studies by collaborating with the Center for Earth Surface System Dynamics, the ICRC, and external research institutions. Thus, research expertise will be utilized to enhance collaboration. To achieve continuous technical innovation, the department has strategically selected academic staff to perform internationally recognized top-quality science. The new members are experts in bioinformatics, epigenetics, reverse genetics, and advanced techniques for biologging and related data analysis.

(3) Human resources: Efforts to educate graduate students must be increased to drive marine bioscience into the future and help students secure a career path after earning their degree. By properly organizing such talents, collaboration within the AORI as well as between domestic and international institutions will be coordinated as well as efforts to acquire research funds to assist young scientists to develop their careers.

Through the activities described above, the Department of Marine Bioscience aims to understand the ocean from a new perspective, covering various scales of time and space by utilizing the activities and diversity of new staff members as well as the accumulated expertise in the department.

3.3.4. Department of Living Marine Resources

3.3.4.1. Present status and achievements

The overarching goal of the Department of Living Marine Resources is to elucidate the mechanisms that underlie population fluctuations of marine living resources and to establish management methods for their sustainable use. The Fisheries Environmental Oceanography Section has investigated the mechanism that links physical environments and stock fluctuations. The Biology of Fisheries Resources Section has conducted leading studies into reproductive and early-life ecology of marine living resources. The Fish Population Dynamics Section has investigated the conservation and evolutionary ecology of marine living resources and improved their management methods. Specific research achievements are detailed below:

(1) Coupling of fish growth and migration models and otolith microchemistry: Fish growth and migration models coupled to physical and lower-trophic-level ecosystem models have been developed for chub mackerel, anchovy, and other species to investigate the response of fishes to climate variability and changes through prey plankton dynamics. While the validation of model-derived migration routes has been difficult, a new validation method was established by analyzing the otolith stable oxygen isotope ratio with weekly age resolution, which enables the estimation of the temperature that fish experienced throughout their life history. By using these coupling methods, early-life migration characteristics have been elucidated for important marine living resources such as sardine, chub mackerel, and jack mackerel.

(2) Elucidation of the reproductive biology of cephalopods: The fertilization process of cephalopods was directly observed for the first time in the smallest squid species (i.e., Japanese pygmy squid) using a glass plate as a spawning substratum. It had been difficult to observe the process of fertilization in natural spawning, because fertilization usually occurs in some hidden place within the female's body. This direct observation revealed that the female controls the fertilization process by active insemination behavior using sperm in her body. The female fertilization strategy has been elucidated for another important fishery species, chokka squid. The reproductive strategy of anchovy was also revealed.

(3) Assessment of rare wild animals: An abundance assessment of the narrow-ridged finless porpoise was conducted from Tokyo Bay to Sendai Bay off the Pacific coast of Tohoku after the 2011 earthquake off the Pacific coast of Tohoku and the resultant tsunami. The assessment results revealed that the lowest population density of the species occurred in the Northeast Pacific coast of Japan as well as a decline in its abundance by comparison with

previous assessments. The existence of two populations—Sendai Bay–Fukushima and others—was detected by the distributional gaps reconfirmed by the assessment.

3.3.4.2. Future plans

(1) Contribution to the UN Decade of Ocean Science for Sustainable Development through strong international and domestic collaborations: The objective of the Department of Living Marine Resources exactly matches the outcomes of the UN Decade of Ocean Science for Sustainable Development, specifically, “A Sustainable Productive Ocean,” “A Clean Ocean,” “A Healthy and Resilient Ocean,” and “A Predicted Ocean.” The department has been conducting international and domestic collaborations to advance the understanding of the mechanisms of the population fluctuations of marine living resources and establish management methods for their sustainable use. However, much stronger leadership is now required to achieve these outcomes. To contribute to the UN Decade of Ocean Science for Sustainable Development, the department will promote stronger international and domestic cooperation, especially to provide scientific knowledge to achieve “A Sustainable Productive Ocean.” In particular, we will collaborate with the IOC, IPCC, PICES, ICES, and other international organizations to improve our understanding of the mechanism of the population fluctuations of marine living resources.

(2) Utilizing new technologies for sub-mesoscale studies: The department has been elucidating the reproductive ecology and migration route of marine living resources and has identified the key areas for their recruitment. However, in many cases, these key areas are in frontal regions where sub-mesoscales (i.e., less than 50 km horizontal scale) dominate and fluctuate greatly. Recent development of ocean equipment, such as water gliders and underway CTD, enables us to directly observe sub-mesoscale phenomena. However, it remains difficult to observe the response of marine living resources to these sub-mesoscale phenomena. To fill the biggest knowledge gap, i.e., “responses of marine living resources to sub-mesoscale phenomena,” the department will collaborate with other departments and centers of the AORI and other organizations. In particular, by using environmental DNA in the open ocean, under the “Ocean DNA Project”, the department will investigate the responses of living marine resources to sub-mesoscale phenomena.

(3) Outreach and inreach: Fortunately, the number of students in the department has been slightly increasing despite the overall decrease in the number of graduate students in Japan. Maintaining the number of students as well as the balance between female and male students, and between domestic and foreign students, are challenging tasks for our

department. To keep our department attractive for new students, we will continue outreach activities to the general public. In particular, the department will engage students in graduate school to attend such outreach events and increase their opportunities to discuss the ocean with the public, with emphasis on the social outcomes of the UN Decade of Ocean Science for Sustainable Development. These activities will also contribute to the inreach efforts within the department. In addition, the department will continue to hold a monthly departmental seminar to spur research activities and inreach education for students.

3.4. Division of Integrated Ocean Research

3.4.1 Abstract

The Division of Integrated Ocean Research aims to establish integrated ocean science and educational activities, including those related to marine policies, as an interdisciplinary science field. The interests of the Biological Oceanography Section are the response mechanisms of commercially important fish, such as tunas and eels, to global environmental changes, including artificial environmental degradation. The Ocean Alliance Section delivers educational activities under the “Interdisciplinary Education Program of Ocean Science and Policy” with cooperation of the Ocean Alliance Collaborative Research Organization, which is an organization involving interdisciplinary departments. To further enhance communication with society, a new section, the Science–Society Interaction Research Section, was established in 2016.

3.4.1. Present status and achievements

The Division of Integrated Ocean Research primarily comprises the Biological Oceanography Section and Ocean Alliance Section. In the Biological Oceanography Section, Prof. Shingo Kimura and Assistant Professor Yoichi Miyake (moved in March 2020) of the Department of Natural Environment Studies, Graduate School of Frontier Sciences, undertake collaborative research and educational activities in the field of ocean science within their departments. Both also hold concurrent posts in the AORI and engage in activities therein. The department’s research interests are the response mechanisms of commercially important fish and shellfish to changes in the global environment, such as global warming and El Niño. The department conducts studies focusing on hydrodynamic environments. Graduate school education occurs in the Department of Natural Environmental Studies, Graduate School of Frontier Sciences, as well as in the Department of Aquatic Bioscience, Graduate School of Agricultural and Life

Sciences. Prof. Shingo Kimura has been the head of the Department of Natural Environmental Studies and Steering Committee Chairperson of the Graduate Program in Sustainability Science. The Ocean Alliance Section is a part of the Ocean Alliance Collaborative Research Organization, at the University of Tokyo, which is an organization involving interdisciplinary departments. The Ocean Alliance Section collaborates with researchers from various fields of study. Its primary role is to deliver educational activities implemented by the Ocean Alliance Collaborative Research Organization, as part of the "Interdisciplinary Education Program of Ocean Science and Policy." Project Associate Professor Mitsuo Yamamoto (promoted to Associate Professor in the Graduate School of Agricultural and Life Sciences in May 2019) and Project Professor Naoki Hosaka (installed in July 2019) have been assigned based on a grant provided by the Nippon Foundation. In addition, Prof. Shingo Kimura, who is the director of the Ocean Alliance (installed in April 2019), holds a concurrent post as the head of this section. Ocean Alliance was reorganized as Ocean Alliance Collaborative Research Organization in April 2020. In addition, the "Interdisciplinary Education Program of Ocean Science and Policy" is also supported by university regular funding directly from 2020, and Project Lecturer Seishi Hagihara and Project Researcher Ryoshiro Wakiya have been assigned by the funding.

One noteworthy achievement of the Biological Oceanography Section is research on the transport processes of Japanese eel larvae. Cruises with the *R/V Hakuho Maru* and numerical simulations have clarified the fluctuation mechanisms of glass eel recruitment to Japanese coasts, together with the physical, chemical, and biological characteristics of their spawning environment. The section has also elucidated the characteristics of the vertical and horizontal swimming behavior of *Thunnas* juveniles in relation to their migration ecology, revealing that the important factors in their survival and growth are vertical mixing caused by ocean turbulence and an increase in spawning temperature in relation to global warming and other global-scale oceanic phenomena. The section also assesses the impacts of human activities on ecosystems by studying the survival and growth of abalone and mussels in relation to their hydrodynamic environment, the ecology of aquatic organisms in relation to environmental changes due to artificial structures, and the egg and larval transport of pelagic fishes such as anchovies. One of these studies investigated the sustainability mechanism of high biological productivity and involved international collaborative research with Bangor University in the U.K. The section's studies have been highly praised: Assistant Professor Yoichi Miyake was awarded the *Achievement Award for Young Scientists* from the Japanese Society of Fisheries Oceanography. In addition, since 2014, the section has supervised 25 Master's students and six Doctoral students.

3.4.3. Issues

The Biological Oceanography Section comprises one professor and one assistant professor. It is linked to the number of possible positions offered by the Graduate School of Frontier Sciences. Therefore, cooperation from the AORI is needed to ensure employment for the assistant professor. If the funding for the employment cannot be continuously allocated, this would impede the educational activities of the Department of Natural Environment Studies. Given that the AORI is responsible for contributing to the education of this department, this issue needs to be resolved. In addition, the project teaching staff of the Ocean Alliance Section are funded by a grant from the Nippon Foundation. Therefore, continuous allocation of human resources is desirable. The AORI is expected to actively participate in the operations of the Ocean Alliance Collaborative Research Organization.

3.4.4. Future plans

The department's main topics of coastal ecosystem research are as follows: (1) the transport processes of the initial stage of the life history of important fishery species; (2) the behavioral ecology and habitats of aquatic organisms in freshwater and brackish water; and (3) the effects of global environmental changes on stock fluctuations and migratory behaviors of exploited species. To continuously advance research on these topics, the department will develop numerical simulation models by upgrading observation and analytical systems, including use of the *R/V Shinsei Maru*. The department will also introduce new methodologies such as environmental DNA and oxygen isotope ratio analyses to improve the general understanding of coast ecosystems and the conservation.

3.5. Center for Earth Surface System Dynamics

3.5.1. Abstract

The Center for Earth Surface System Dynamics (CESD) was founded when the AORI was integrated in 2010 with the aim of an integrated understanding of the atmosphere and oceans as one system. In the second term since FY2016, the CESD has based its future plans on the following four themes: (1) multi-scale processes of atmosphere–ocean interaction; (2) interdisciplinary studies of marine ecosystem dynamics; (3) multiple approaches to life evolution and environmental change; and (4) the creation of a science field on paleoclimate dynamics integrating models and data. On the basis of these themes, together with mutual collaborations with the AORI members, the CESD has proposed research projects to the

University of Tokyo and MEXT, and four have been approved. In the future, by advancing core research through these projects, the CESD will enhance collaboration with all AORI members to achieve the aforementioned themes to develop the active roles of the Joint Usage/Research Center of the AORI while conducting internationally leading research. Moving toward the third term starting in 2022, the CESD will establish a new core research project of the AORI. One is the Ocean DNA Project, which is developed in collaboration with key faculty members and established as an internationally leading research project.

3.5.2. Response to the comments by the External Evaluation Committee 2014

Recommendation: ***We recommend continuing the current highly successful activities of the CESD and its plans for further development over the next decade.***

Response: The CESD's mission is to promote advanced studies of the atmosphere, ocean, and ecosystems and enhance interdisciplinary studies of these fields by combining observations and modeling. In 2016, the CESD defined four research themes. Research projects based on these themes have been proposed to the University of Tokyo and MEXT almost every year, and many have been approved as the Future Society Initiative (FSI) of the University of Tokyo. These projects include the creation of paleoclimate change dynamics (since 2016), integrative research on the transition zones between coastal and offshore waters for resource reserves and sustainable use (since 2018), establishing a research hub for the big data analysis of global water cycle and precipitation in changing climate (proposed by the Division of Climate System Research; since 2018), and the Ocean DNA Project (since 2020). The members of CESD lead these projects with collaborations with all AORI members to conduct internationally leading research.

3.5.3. Present status and achievements

The CESD was established in 2010 as a result of the integration of the former Ocean Research Institute and the Center for Climate System Research to enhance synergy. In the second term starting in FY2016, the CESD laid out its future plans based on the following four themes (themes 1–4 hereafter): (1) multi-scale processes of atmosphere–ocean interaction; (2) interdisciplinary studies of marine ecosystem dynamics; (3) multiple approaches to life evolution and environmental change; and (4) the creation of a science field on paleoclimate dynamics integrating models and data. On the basis of these themes, in collaboration with

the AORI members, the CESD has proposed research projects to the University of Tokyo and MEXT, and four corresponding projects have been approved. The CESD have been employed four postdoctoral researchers, who execute the above themes.

The project, “Creation of a scientific field on paleoclimate dynamics integrating models and data to understand climate and ecosystem change throughout the Earth’s history,” was initiated by budgetary request in FY2016. With the support and potential collaboration from the whole institute, the Paleoclimate Dynamics Section leads paleoclimate modeling research, forming the academic foundation for understanding the mechanisms of past climate and environmental changes. This is important in order to meet the urgent academic and social demands to understand dynamics of the climate, ocean, and Earth system, which are linked towards Sustainable Development Goal 13, “Climate Action.”

The Paleoclimate Dynamics Section acquired competitive funding, i.e., a Grant-in-aid for Scientific Research (KAKENHI) for “Understanding the interaction between the ice sheets, ocean, and atmosphere under large-scale climate changes of the past.” The project aims to simulate and understand the abrupt climate changes that occurred in the past 1.5 million years, such as the glacial–interglacial cycle shift from a 40,000- to 100,000-year cycle as well as the millennial-scale climate oscillations in glacial and deglacial climates.

Furthermore, the Paleoclimate Dynamics Section also leads a project that aims to elucidate the mechanisms of the past and future climate changes of the Antarctic ice sheet and Southern Ocean, titled, “Integrative modeling of the Antarctic ice sheet, ocean, and climate,” as part of the GRAntartic Project (Giant Reservoirs Antarctica, Grant-in-aid for Scientific Research on Innovative Areas, MEXT). The MIROC climate model as well as the COCO ocean model and NICAM developed at the AORI will be applied to solve the paleoclimate mystery in the Quaternary Period (i.e., the past 3 million years) as well as the Pre-quaternary to Cretaceous Periods (i.e., the past 100 million years) through collaboration among geochemists, geologists, oceanographers, and biologists within the institute and in the international community.

Towards theme 4, taking over the observations and modeling conducted from 2010–-2015, the Ecosystem Research Section has promoted large projects such as the “Tohoku Ecosystem-Associated Marine Sciences (TEAMS) Project” supported by MEXT, the “New Ocean Paradigm Project” supported by a Grant-in-Aid for Scientific Research (KAKENHI), the “Ocean Mixing Processes Project” supported by KAKENHI, and the “Coastal Ecosystem Complex Project” supported by MEXT through intra- and inter-institutional cooperation.

An education research project of the University of Tokyo endorsed by MEXT, “Integrative research on transition zones between coastal and offshore waters for resource reserve and sustainable use,” was launched in 2018 in cooperation with several sections within the AORI as well as the Graduate School of Public Policy. This project promotes cutting-edge ocean sciences and a social science study related to marine spatial planning that will contribute to the conservation and sustainable use of the ocean as per UN Sustainable Development Goal 14 and theme 2 above.

The “Ocean DNA Project” was initiated in 2017 in order to understand the dynamics of marine life by analyzing environmental DNA in the ocean. This project is related to theme 3 above and will officially start in 2020.

In 2015, the CESD joined the supercomputer “FLAGSHIP2020 Project” using the K-computer in RIKEN, Kobe, under the research title, “Advancement of meteorological and global environmental predictions utilizing observational big data.” The CESD conducted high-resolution numerical simulation studies using the NICAM global nonhydrostatic model. This project involved the highest-resolution global simulation with sub-kilometer resolution simulation—a world first. Thus, the CESD improved the predictive accuracy of intra-seasonal variability and tropical cyclones in the extended range (i.e., more than two weeks). The regional version of NICAM was developed by the CESD for use in studies on the efficiency of solar power energy. Thus, NICAM can be used to conduct seamless atmospheric simulations from a regional to a global scale. Accordingly, the CESD database server was constructed and has successfully distributed the NICAM source code and related information to approximately 200 users worldwide.

In addition, with financial support from NOAA in the U.S., the CESD has constrained the cloud physics processes of climate models by satellite observations and evaluated their impacts on climate. Moreover, the CESD participated in the Ministry of the Environment’s S-12 Project by quantitatively evaluating the impacts of black carbon and sulfate aerosol on climate and the water cycle. In particular, the effect and mechanism of reducing black carbon on mitigating global warming were clarified, and the results were published.

In addition, to help society adapt to disasters such as heavy rains and droughts, which have occurred frequently worldwide in recent years, the CESD and the Division of Climate System Research jointly proposed creating the “Research hub for the big data analysis of global water cycle and precipitation in changing climate” to the University of Tokyo. This center aims to develop a method to more accurately predict future changes in water cycle and precipitation characteristics associated with climate change and promote research to achieve the UN Sustainable Development Goal 13 “Climate Action” as per theme 1 of the

CESD above.

3.5.4. Issues

Since 2015, the CESD has conducted studies combining observational and modeling research in each of the four themes listed above. However, during this period, interdisciplinary studies on these research topics have not been straightforward. Therefore, the CESD and the faculty members of other divisions and centers must determine how to coordinate the advanced studies on each theme.

The “Ocean DNA Project” aims to develop a collaborative research environment and requires long-term management of the data storage servers as per theme 3.

Furthermore, there is always a need for human resources to develop models for atmospheric and ocean modeling. Therefore, the CESD must continue employing postdoctoral researchers who can develop models while pursuing specific missions of the CESD as per theme 1.

3.5.5. Future plans

3.5.5.1. Disciplinary development

The CESD will continue leading and developing our paleoclimate modeling studies through the “Paleoclimate Dynamics Project” by verifying models with paleoclimate data and paleoenvironmental signals in the Earth’s history. Collaborations with geologists and geochemists in the AORI, as well as with experts in the Japanese and international community, are planned for the following topics in paleoclimate research using the models of the AORI (theme 4): past climate, ocean, Earth, and ice sheet evolution; mid-Pleistocene transition and glacial cycles; Dansgaard–Oescheger events; super-interglacials and past ice sheet mass loss; ice age termination mechanism; and the effects of past climate change on hominids and ecosystems.

The “Ocean DNA Project” can provide basic information on marine ecosystem conservation and sustainable fisheries (theme 3).

The CESD intends to participate in the flagship supercomputer project using the “Fugaku” started in 2020 to lead the Japanese research community in high-performance

computing. In particular, the CESD will focus on high-resolution atmosphere–ocean interaction processes, multi-scale disturbances from regional to the global scales, multiple views of micro- and macro-processes between cloud microphysics (including aerosols/clouds/rains) and general circulations to climate perspectives, and collaborations between observations and modeling (theme 1).

3.5.5.2. Integration

Through the advanced research projects approved by the University of Tokyo (the FSI projects), the CESD will contribute to and enhance synergetic studies in collaboration with members of various divisions in the AORI.

After 2022, the CESD will establish a new core research project of the AORI. Candidates are the two projects: “Ocean DNA Project” and “Research hub for the big data analysis of global water cycle and precipitation in changing climate”. These are being conducted in collaboration with key faculty members and established as an internationally leading research project (themes 1 and 3).

3.5.5.3. Contribution to society

The information provided by the “Ocean DNA Project” is valuable to the academic community and provides the general public with an up-to-date picture of the marine ecosystem (theme 3).

Considering the roles of marine ecosystems in relation to the UN Sustainable Development Goal 14, the Ecosystem Research Section will lead various research activities related to marine ecosystems in order to promote the conservation of environments and sustainable use of ocean resources (theme 2).

As part of the Virtual Laboratory for the Earth’s Climate Diagnostics, a collaborative effort with Tohoku University, Nagoya University, and Chiba University, the CESD will continuously hold Virtual Laboratory seminars on numerical modeling and observations (so far 13 seminars have been held) for graduate students and young researchers. Through the Virtual Laboratory, the CESD will enhance collaboration between universities to let our facilities serve as a “virtual laboratory” (theme 1).

3.6. Analytical Center for Environmental Study

3.6.1. Abstract

The Analytical Center for Environmental Science (ACES) was launched in April 2014. It consists of two sections with a designated full professor. ACES is the only laboratory in the world that holds both a single-stage accelerator mass spectrometry (SSAMS) and a nanoscale secondary ion mass spectrometry (NanoSIMS). These instruments allow collaborations both within and outside of the AORI' s research groups, including many international groups. ACES' research output has resulted in over 200 research papers in peer-reviewed international journals, including Nature, Science, and PNAS. The SSAMS has been used for both biological and geological studies, including fish ecology, evaluation of the effect of ocean acidification on shellfish, and precise reconstructions of past tsunami events, among others. The NanoSIMS has been used to understand past global climate changes. ACES aims to continue these highly productive, cutting-edge, collaborative activities in the future, with emphasis on expanding its human and laboratory resources.

3.6.2. Present status and achievements

ACES was launched in April 2014 to conduct frontier research in Earth system sciences. ACES comprises two sections: the Environmental Analysis Section (EAS) and the Environmental Geochemistry Section (EGS). The EAS studies Earth surface systems, including the cryosphere and biosphere. The inhouse single-stage accelerator mass spectrometer (SSAMS), the only one installed in Japan, is used to precisely measure radiocarbon. This system has been continuously modified, making it the most precise and accurate in the world. Together with high-resolution inductively coupled plasma mass spectrometry (ICP-MS) in tandem with a laser ablation system, these instruments have been applied to reconstruct Antarctic ice sheet history, fish and whale migration history, and understand geohazards such as paleo-tsunamis. Since 2014, the EAS has published 121 peer-reviewed papers in top journals, including one in *Nature*, two in *Nature Geoscience*, two in *Nature Communication*, two in *PNAS*, two in *Geology*, and five in *Scientific Reports*. Meanwhile, the EGS investigates the evolution of high-time-resolution Phanerozoic ocean chemistry using the NanoSIMS for high-spatial-resolution isotope analyses of marine carbonates. Two-micrometer spot analyses by NanoSIMS yield a time resolution of a few hours in the case of fossil giant clam shells. The EGS also investigates natural hazards such as eruptions and earthquakes based on volatile isotopic compositions obtained by analyzing volcanic gas and groundwater samples with stable isotope mass

spectrometers. Since 2014, the EGS has published 79 peer-reviewed papers in top journals, including *Nature*, *Nature Astronomy*, *Nature Communication*, and *PNAS* as well as 11 papers in *Scientific Reports*.

3.6.3. Issues

The EAS has limited resources. The lack of both personnel and laboratory space hinder its research efforts. A typical laboratory producing such world-class measurements requires at least three to four full-time members to efficiently operate the SSAMS. However, there is only one full professor in this section, and four other support staff employed by soft money. The EAS also shares laboratory space with the Department of Ocean Floor Geoscience, making it difficult to meet the demands of students and collaborators. Meanwhile, the EGS has limited space in the AORI building and is sharing rooms with the Department of Chemical Oceanography. Thus, the EGS requires more space to carry out additional cooperative research and educational activities. The NanoSIMS was installed at the Marine Environmental Research Center in 2004 and was transferred to the EGS in 2014. Because of the age of this instrument, critical components must be replaced to maintain the machine.

3.6.4. Future plans

The EAS has received external funding to improve its accelerator mass spectrometry systems, and a proposal was submitted together with the Department of Chemical Oceanography to install a multi-collector ICP-MS to further advance its analytical capacity. A proposal to install a positive-ion source accelerator mass spectrometer that will allow the machine to directly connect to other mass spectrometers was also submitted. This will enable a wider range of geological and biological samples to be measured precisely, even with extremely small sample quantities. The EGS applied for the Japan Society for the Promotion of Science (JSPS) funding (KAKENHI) to improve a primary beam source of the NanoSIMS, which would triple the sensitivity of the instrument. A laser-induced breakdown spectroscopy (LIBS) system was installed in 2017, and analytical procedures are under development. Combining NanoSIMS and LIBS will provide crucial information about past environmental changes at extremely high resolution by using biogenic marine carbonates and phosphates. The EGS is very keen to clarify the long-term history of natural hazards, such as volcanic eruptions, tsunamis, and typhoons, that is preserved within these materials.

4. Educational activities

4.1. Abstract

The AORI has approximately 160 graduate students, including approximately 100 in Master's courses and 60 in doctoral courses, supervised by AORI faculty members. The AORI started the Kashiwa Campus Science Camp in 2014, the Summer AORI Internship Program in 2018, and the Autumn Guidance to Graduate School at the AORI in 2018 in addition to the Spring AORI Internship Program and Summer Guidance to Graduate School at the AORI. At the end of each academic year, a symposium presented by those who are earning their PhD that year is held to showcase research activities to the members of the AORI, including faculty members, technical staff, and students, in order to promote research collaboration at the AORI. The AORI is now a large contributor to the activities of the Ocean Alliance Collaborative Research Organization and Interdisciplinary Education Program on Ocean Science and Policy, a university-wide education program of The University of Tokyo.

4.2. Response to the comments by External Evaluation Committee 2014

Recommendation 1.3. We recommend that the AORI work with the University of Tokyo toward the formation of a Graduate School of Atmosphere and Ocean Sciences, and that appropriate scientists from JAMSTEC be involved in this new school as adjunct faculty.

Recommendation 5.2 ***We recommend that this proposal be carried out as a good opportunity to deliver new knowledge emerging from interdisciplinary studies in the marine and climate sciences, and also as one of new strategies to strengthen participation of good undergraduate students in the AORI.***

Please see Response at Chapter 10.1.2

4.3. Educational activities in the 2014-2019 academic years

The AORI faculty member are affiliated with the Graduate School of Science (i.e., Earth and Planetary Science, Chemistry, and Biological Sciences), the Graduate School of Agricultural and Life Sciences (i.e., Aquatic Bioscience and Global Agricultural Sciences), the Graduate School of Frontier Sciences (i.e., Natural Environmental Studies, Computational Biology and

Medical Sciences, Integrated Biosciences, and Sustainability Science Global Leadership Initiative), or the Graduate School of Arts and Sciences (i.e., Environmental Sciences) at the University of Tokyo. They are engaged in graduate programs by lecturing and supervising graduate students. The AORI accepts both domestic and foreign research students and research fellows. The AORI has approximately 160 graduate students, including approximately 100 in Master's courses and 60 in Doctoral courses, supervised by the AORI faculty members (Table 4-1). Female students account for approximately 30% of the total.

Table 4-1. Number of students

Academic Year			2017	2018	2019	2020
Graduate School	Science	Master	42 (1)*	34 (2)	45 (4)	50 (4)
		Doctor	16 (2)	17 (3)	16 (1)	24 (4)
	Agricultural and Life Sciences	Master	19 (4)	22 (5)	21 (5)	28 (6)
		Doctor	15 (3)	16 (6)	16 (6)	19 (9)
	Frontier Sciences	Master	21 (4)	33 (7)	35 (8)	23 (6)
		Doctor	25 (5)	27 (10)	17 (9)	19 (7)
	Engineering	Master	0	0	0	0
		Doctor	0	0	0	0
	Arts and Sciences	Master	0	1 (1)	1 (1)	0
		Doctor	0	0	0	3 (3)
Post Graduate Research Student			1	0	0	2 (2)
Post Graduate Visiting Student			0	0	0	0
International Research Student			5 (5)	1 (1)	1 (1)	1 (1)
Research Student			3 (1)	2 (2)	9 (3)	5 (4)

*: Total number of foreign students are in parentheses.

Some faculty members present special lectures on general topics on atmosphere and ocean science for first- and second-year students at the Komaba Campus and at the AORI. As a strategy to overcome the two disadvantages mentioned in Chapter 10.1.2 and enhance the participation of good undergraduate students in the AORI (which is essential to foster outstanding graduate students), the AORI has been conducting several programs. These

include all-campus independent seminars, all-campus hands-on experience seminars, a special seminar for first-year students, and the Kashiwa Campus Science Camp for first- and/or second-year undergraduate students. These seminar programs can be given at an appropriate time, because the students must determine the specific discipline they want to focus on in their third and fourth years before finishing their second year.

AORI's Education Board provides a good opportunity for fourth-year students to join the Atmosphere and Ocean Sciences Internship Program, which gives them direct access to the research activities at the laboratories at the AORI as well as the opportunity to become familiar with the faculty members and graduate students.

At the end of each academic year, a symposium presented by those who are earning their PhD is held to share their research with members at the AORI. Faculty members evaluate the presenters and award the Director's Prize to an outstanding student. This symposium is valuable because it facilitates the sharing of research activities among the AORI members, including faculty members, technical staff, and students, thus promoting collaborative research at the AORI. After the symposium, an official party to celebrate the graduation, is held at the AORI attended by all members.

Another unique education and research activity is the University of Tokyo Ocean Alliance (Ocean Alliance hereafter), which was established in 2007 as a core for faculty transecting marine education and research and renamed as Ocean Alliance Collaborative Research Organization in 2020; it comprises seven graduate schools, five institutes, and one research center. Its overarching goal is the development of basic ocean sciences in order to contribute to efficient planning and execution of marine policy. This goal requires education for scientists and government officials, so they can evaluate marine policy on the basis of expert knowledge of ocean sciences. The Ocean Alliance provides an educational program, the Interdisciplinary Education Program on Ocean Science and Policy, which transects social science, natural science, and technology and is supported by university governmental funding and the Nippon Foundation. Prof. Shingo Kimura takes a lead of the activity as the director of the Ocean Alliance from April 2019. The AORI faculty members form the core of the program and greatly contribute to the activities.

4.4. Future plans

The mission for the education given at the AORI is to foster and produce knowledge professionals of atmosphere and ocean sciences. Given that current environmental problems are related to both science and social systems, education requires scientific knowledge to

respond to the various climatic and environmental challenges as well as a wide range of basic knowledge and then thinking deeply by themselves.

We would like to promote foster interdisciplinary and transdisciplinary education and research more than we have so far. Graduate students have good experience of on-board research during the research voyages by the *R/V Hakuho Maru* and *R/V Shinsei Maru*. Since ocean science is a highly interdisciplinary field, we will continue to provide the opportunity to graduate students to experience fieldwork and to become the future leaders of atmosphere and ocean science.

5. Activities as a Joint Usage/Research Center (shore-based and research vessels)

5.1. Abstract

The AORI offers a cooperative research program (i.e., Joint Usage/Research Program). Many researchers across all scientific disciplines have participated in the program. The AORI has made this program a top priority despite our decreasing total budget. Because the AORI hosts several world-class facilities and instruments, they must be maintained and upgraded more than ever. The total number of supporting staff at the Laboratory Research Support Section decreased substantially since 2010. Therefore, we continue the effort to obtain extra budget for recruiting new staff to the Laboratory Research Support Section in order to maintain and develop facilities and instruments.

Regarding national joint usage, the AORI has publicly advertised, considered research plans, and formulated voyage plans for two vessels: *R/V Hakuho Maru* and *R/V Shinsei Maru*. JAMSTEC has operated these vessels in accordance with the plans. Since 2018, the *R/V Yokosuka* and *R/V Kairei* operated by JAMSTEC have been taken into the cooperative research system, and 50 days operation of the two vessels have been supplied for national joint usage. Thus, a total of 600 days per year for cruise operations is expected. However, because of rising operational costs and other reasons, this has been difficult to maintain.

5.1.1. Response to the comments by the External Evaluation Committee 2014 to the Joint Usage/Research Center

Response to Q8:

Recommendation 8.1.: We recommend that new technical staff directly related to physics be employed.

Recommendation 8.2.: We recommend that an AORI Technical Report be published each year and that all technical support staff contribute to it.

Responses to Recommendations 8.1 and 8.2 : Please see Chapter 10.1.2

5.1.2. Joint Usage/Research Center

The AORI offers a cooperative research program (i.e., Joint Usage/Research Program) for

scientists conducting fundamental ocean research. Many researchers across all scientific disciplines participate in the program. Applications to the program are taken annually one year prior to shipboard operations, or every 3-years for *R/V Hakuho Maru,* in the case of research cruises. Each proposed research plan is reviewed by the Cooperative Research Vessel Steering Committee, which comprises the AORI and external members. Visiting scientist applications and research meeting proposals are subject to approval by the AORI Council after being reviewed by the Cooperative Research Vessel Steering Committee.

5.1.2.1. Shore-based Joint Usage/Research Center

5.1.2.1.1. Joint Usage/Research Center at the Kashiwa Campus

The Kashiwa Campus offers two programs: (1) supporting relatively large scientific meetings lasting one to two days as well as relatively small meetings lasting several days; (2) supporting visiting scientists who would like to do research at the Kashiwa Campus (Table 5-1).

Table 5-1. Joint usage/research activities (Kashiwa campus)

	2015	2016	2017	2018	2019
Number of scientific meeting	14	16	9	10	9
Total participants for scientific meeting	1039	1242	1166	929	1005
Number of users of visiting scientists system	36	59	65	63	82

5.1.2.1.2. Joint Usage/Research Center at Otsuchi (International Coastal Research Center)

The International Coastal Research Center (Otsuchi, Iwate Prefecture) offers two services: (1) in-house laboratory space and facilities to both internal and external researchers; and (2) assisting small groups holding on-site research meetings (Table 5-2).

Table 5-2. Joint Usage/Research activities (Otsuchi campus)

	2015	2016	2017	2018	2019
Number of scientific meeting	3	2	2	3	3
Total participants for scientific meeting	184	46	144	220	218
Number of users of visiting scientists system	97	128	131	119	132

5.1.2.2. Center for Cooperative Research Promotion

The Center for Cooperative Research Promotion was established in April 2010 by consolidating all of the technicians and technical support staff of the institute into a single organization (Table 5-3, Figure 5-1). The center aims to support visiting scientists who participate in cooperative research programs using the *R/V Hakuho Maru* and *R/V Shinsei Maru* and/or research facilities in the institute, introduce new equipment and technologies to the institute, and maintain the research facilities in the institute. The center consists of four organizations: (1) the Coastal Laboratory Research Support Section; (2) the Coastal Research Support Section; (3) the Field Research Support Section; and (4) the Center for Research Cruise Coordination.

Table 5-3. Number of technical staff, Center for Cooperative Research Promotion

	2015	2016	2017	2018	2019
Number of technical staff	17	15	15	16	16

5.1.2.2.1. Laboratory Research Support Section

The Laboratory Research Support Section is responsible for the overall management and maintenance of common research facilities. Its staff help maintain research instruments, provide technical advice, cooperate with users, including graduate students, and develop new techniques to improve research activities through Joint Usage/Research.

5.1.2.2.2. Coastal Research Support Section

The International Coastal Research Center, which is located in Otsuchi, Iwate Prefecture,

provides operational and facilities support to visiting marine scientists. On March 11, 2011, all facilities and equipment were destroyed by the 2011 off the Pacific coast of Tohoku Earthquake and subsequent tsunami. Fortunately, the facilities and equipment were reestablished on an adjacent eminence by February 28, 2018, and full-scale cooperative research programs have been restarted.

5.1.2.2.3. Field Research Support Section

The Field Research Support Section provides support for research cruises on both *R/V Hakuho Maru* and *R/V Shinsei Maru*. Its main task is the technical support of scientific equipment. Secondary tasks include the maintenance and enhancement of equipment for common use, expert advice on cruise planning, and dock service. The section is supervised by a manager and works with the Center for Cruise Coordination for the scientific planning of research cruises.

5.1.2.2.4. Center for Cruise Coordination

The Center for Cruise Coordination makes cooperative cruise plans for the *R/V Hakuho Maru* and *R/V Shinsei Maru*, and is supervised by the Cooperative Research Vessel Steering Committee. In order to promote harmonious cooperative cruises, this center coordinates scientists, exterior organizations (i.e., JAMSTEC), and fishermen's cooperative associations.

5.1.3. Summary of the Cooperative Research Program (Joint Usage/Research Program)

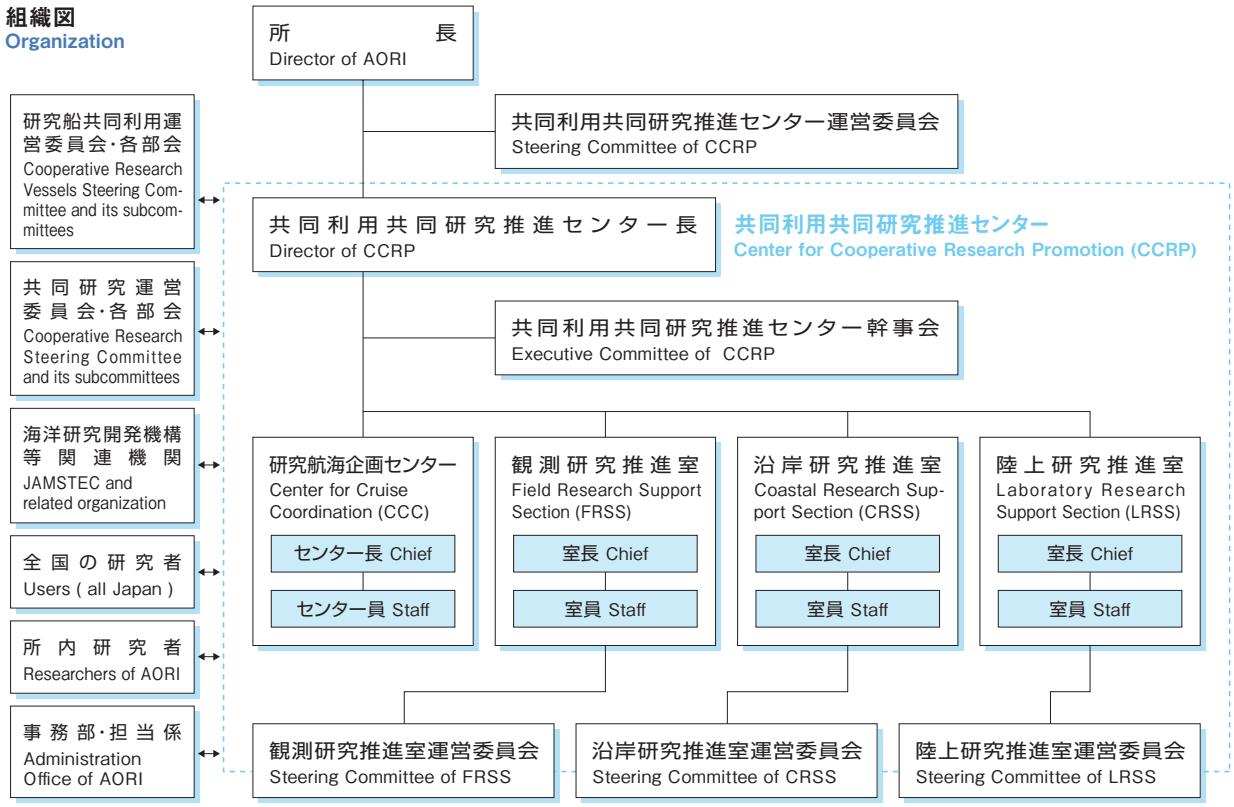
The AORI offers a cooperative research program (i.e., a Joint Usage/Research Program) for scientists from all over Japan and sometimes overseas. Each proposed research plan has been reviewed fairly and properly implemented. Many support staff continue to contribute significantly to this cooperative research program (i.e., Joint Usage/Research Program).

5.1.4. Future plans

The several world-class facilities and instruments require more maintenance and upgrading than ever, which is expensive. The AORI has made this a top priority despite the decreasing personnel expenditures subsidy and total budget. It is hoped that the Head Office of the University of Tokyo understands the current situation and raises the budget for the

cooperative research program (i.e., Joint Usage/Research Program). The total number of supporting staff was 19 in 2010 but decreased once to 15 because of fixed rate reduction of personnel expenditures subsidy from the government, and 16 in 2020. Although the Laboratory Research Support Section has additionally taken charge of the accelerator mass spectrometry facility, the number of staff decreased from 10 in 2010 to 6 in 2020 (Table 5-3). To overcome the difficulty, AORI is planning to obtain project funding from the headquarter of the University of Tokyo including the personnel expenditures of technical staff. It is hoped that several new staff members join the Laboratory Research Support Section to maintain the facilities and instruments.

Figure 5-1. Center for Cooperative Research Promotion (CCRP) organizational structure



5.2. Joint Usage of research vessels

Following the transformation of national universities and JAMSTEC into independent administrative institutions in April 2004, two national Joint Usage/Research vessels, the *R/V Hakuho Maru* and *R/V Tansei Maru*, were transferred to JAMSTEC. Since then, the AORI, as

a national Joint Usage institute for ocean science (a Joint Usage/Research Center since 2010), has publicly solicited for research plans, considered research plans, and formulated voyage plans for the *R/V Hakuho Maru* and *R/V Shinsei Maru* (which replaced the *R/V Tansei Maru*, a research vessel for Tohoku Ecosystem-Associated Marine Sciences [TEAMS]). This has been done under the auspices of its council, which consists of marine researchers from across the country and the Cooperative Research Vessel Steering Committee (previously established by the council) and the Research Vessel Operation Subcommittee. JAMSTEC has operated these vessels in accordance with the aforementioned plans. Since 2018, *R/V Yokosuka* and *R/V Kairei* operated by JAMSTEC have been integrated into the cooperative research system; 20-day operations for each vessel for a total maximum of 50 days have been supplied for national joint usage.

The *R/V Hakuho Maru* is a global class vessel used for relatively long-term, deep-water research voyages, while the *R/V Shinsei Maru* is used for relatively short research voyages lasting from a few days to two weeks for coastal waters of Japan. The voyage plan for the *R/V Hakuho Maru* is formulated every three years; the latest one is for fiscal 2019–2021, which was formulated in November 2017 at the Research Plan Planning and Coordination Symposium. The voyage plans for the *R/V Shinsei Maru*, *R/V Hakuho Maru* (for relatively small-scale, single-year research topics), *R/V Yokosuka*, and *R/V Kairei* are formulated following a public advertisement and examination process that takes place every autumn. Voyage plans are formulated and implemented by the Center for Cruise Coordination of the Center for Cooperative Research Promotion, field research is implemented by the Field Research Support Section of the same center, and observation equipment is managed and updated by the Research Vessel Operation Subcommittee and Research Vessel Field Research Subcommittee of the Cooperative Research Vessel Steering Committee.

5.2.1. Research voyages implemented

Both the *R/V Hakuho Maru* and *R/V Shinsei Maru* are expected to be at sea for 300 days per year. This is as per the commitment made when the vessels were transferred from the University of Tokyo to JAMSTEC. However, because of rising operational costs and other reasons, it has been difficult to maintain this commitment (Tables 5-4, 5-5).

Table 5-4. Numbers of operation days and researchers on board the *R/V Hakuho Maru*

Fiscal Year	Ship operation days	AORI	Outside					total
			Public Univ.	Private Univ.	Public institute	other	subtotal	
2013	248	86	67	11	17	14	109	195
2014	209	75	65	18	20	1	104	179
2015	176	44	85	3	12	1	101	145
2016	176	58	44	14	9	15	82	140
2017	185	88	69	17	23	4	113	201
2018	193	82	53	13	30	4	100	182
2019	179	62	56	9	30	7	102	164

Table 5-5. Numbers of operation days and researchers on board the R/V *Shinsei Maru*

Fiscal Year	Ship operation days	AORI	Outside					total
			Public Univ.	Private Univ.	Public institute	other	subtotal	
2013	91	95	23	8	14	0	45	140
2014	186	84	64	6	24	10	104	188
2015	174	87	49	9	24	3	85	172
2016	174	81	34	10	47	22	113	194
2017	168	72	48	12	29	29	118	190
2018	154	82	53	13	30	9	105	187
2019	172	94	90	4	23	1	118	212

Table 5-6 Numbers of operation days and researchers on board the *R/V Yokosuka*

Fiscal Year	Ship operation days	AORI	Outside					total
			Public Univ.	Private Univ.	Public institute	other	subtotal	
2019	46	9	11	8	11	5	35	44

5.2.2. Research findings from research voyages

The research findings obtained through the joint use of the *R/V Shinsei Maru* and *R/V Hakuho Maru* are reported by principal investigators to AORI's Center for Cruise Coordination immediately after each research voyage and are published on the AORI website. For the *R/V Hakuho Maru*, a preliminary cruise report is also published. The joint usage of research vessels provided by the AORI has significantly contributed to ocean science in Japan. Between 2013 and 2018, Joint Usage voyages done aboard the *R/V Shinsei Maru* and *R/V Hakuho Maru* contributed to the publication of two to six and nine to nineteen peer-reviewed papers per year (Table 5-6). In addition, the *R/V Hakuho Maru* and *R/V Shinsei Maru* have contributed to many international projects (Table 5-7). Joint Usage/Research voyages with various field research scientists on board have played an important role in postgraduate education in Japan, as 30–40% of researchers aboard both vessels at any given time are postgraduate students. Thus, these vessels not only help students collect data for their dissertations, but also create important opportunities for interdisciplinary field education for young scientists.

Table 5-6. Original papers published by the AORI faculty members by means of Joint Usage research vessels.

Fiscal Year	Tansei Maru	Shinsei Maru	Hakuho Maru	Tansei Maru・ Hakuho Maru	Shinsei Maru・ Hakuho Maru	Total
2013	8		11	3		22
2014	12		19	3		34
2015	6	2	14	3	1	26

2016	6	4	14	2	4	30
2017	5	6	13		2	26
2018	5	5	9	1	7	27

Table 5-7. Major international project-related voyages

Project	Cruise
SOLAS	KH-11-10、KH-12-1、KH-12-3、KH-12-4、KH-15-1、KH-17-3、KH-17-4、KH-17-5、KH-18-6
IMBER/IMBeR	KH-11-10、KH-12-3、KH-13-7、KH-14-3、KH-16-7、KH-17-4、KH-18-6、KH-19-6、KH-20-9, KS-16-9
GEOTRACES	KH-12-4、KH-14-6、KH-15-3、KH-17-3
IODP	KH-15-2、KH-16-5、KH-17-2、KS-15-3、KS-19-5、KS-19-14、KH-21-3、YK-20-18S
Inter-Ridge	KH-11-5、KH-14-5、KH-15-5、KH-16-1、KH-18-2、KH-19-6、KH-20-1、YK-20-18S

5.3.3. Future plans

Because of reduced government budgets, it has been difficult to afford fuel for a total of 600 days of operation of the *R/V Hakuho Maru* and *R/V Shinsei Maru*. Therefore, only 175 days of operations per vessel is possible. Accordingly, the *R/V Yokosuka* and *R/V Kairei* operated by JAMSTEC have been integrated into the cooperative research system, and 20-day operations for each vessel for a total maximum of 50 days have been supplied for the system since 2018. Thus, 400 days of operation can be supplied compared to the ideal 600 days. However, because the *R/V Hakuho Maru* is 30 years old, a large-scale overhaul is needed to ensure another 20 years of use. Thus, the AORI, JAMSTEC, and MEXT proposed the necessary funding for the overhaul in 2019 collaborate with user universities, scientific associations. The budget proposal was successfully approved (sum of 3.8 billion JPY) for fiscal years 2020-

2021. The approval is the reflectance of the successful results from *R/V Hakuho Maru* and the voices of users of the Joint Usage research vessels over the country. Since the overhaul will take one year in 2021, the planned cruised in 2021 will be postponed to 2022.

6. International Coastal Research Center (ICRC): Recovery from the 2011 off the Pacific coast of Tohoku Earthquake

6.1. Abstract

New buildings of the International Coastal Research Center were completed in 2018, and research facilities are almost fully restored. Since 2012, the Tohoku Ecosystem-Associated Marine Sciences (TEAMS) of Tohoku University, JAMSTEC, and many universities and organizations in Japan have been continuously assessing the impacts of the 2011 earthquake off the Pacific coast of Tohoku and tsunami on the coastal ecosystems and its recovery process. In addition, various scientific research, such as a study of salmon ecology, a biologging behavioral study on sea turtles, and an environmental DNA study in the coastal areas, have been started. A new type of education/research/outreach program, the "School for Marine Sciences and Local Hopes in the Sanriku Coastal Area," has been launched in collaboration with the Institute of Social Science (ISS) of the University of Tokyo. The ICRC (AORI) and the ISS would like to clarify the social role of scientific research institutions in rural areas that have experienced drastic depopulation after the disaster.

6.2. Response to the comments by the External Evaluation Committee 2014

Recommendation: ***We recommend that studies be carried out on the mutual interaction of ecosystems and material cycling change in Otsuchi Bay, and that the results of the studies in Otsuchi Bay be compared with results in other bays along the Sanriku coast.***

We recommend that a study be conducted on changes to ecosystems and material cycling around the waterfront in the coastal low land area, the transition area between land and coastal sea.

We recommend that the ICRC propose a concrete action plan for the recovery of economic activities, especially fisheries, in the Sanriku area based on the results of its scientific research.

Response to Q9:

The ICRC is located in Otsuchi Bay on the northern Pacific coast of Japan. The 2011 earthquake off the Pacific coast of Tohoku caused a massive tsunami on March 11, 2011, which seriously damaged the ICRC; most of the accumulated research data, samples, and equipment, including three research vessels, were lost or destroyed (Photo 1, taken 4 days after the disaster). Fortunately, all staff, students, and visiting researchers survived, but some

lost their homes and property. In May 2011, water and electricity were restored through the endeavors of the University of Tokyo Headquarters, and the third floor was renovated for research and administration. Meanwhile, research activities on the damage and recovery processes of the marine ecosystem from the earthquake and tsunami were started. Joint research activities also gradually resumed from autumn 2011. Although the building was still in use at that time, it was slated to be rebuilt on higher ground out of the reach of any future tsunamis. The design and planning for the new building and negotiations with the local government started in spring 2012, and a new building and dormitory, which sit 300 m inland, were completed in February 2018 (Photo 2). The opening ceremony occurred in July 2018 and was attended by honorable guests, including Mr. Takuya Tasso, Governor of Iwate Prefecture; Mr. Kozo Hirano, Mayor of Otsuchi; Mr. Toshiaki Honda, Mayor of Tono; and Prof. Junichi Hamada, former President of the University of Tokyo. The decorative ceiling painting by Ms. Maki Ohkojima and balloon artwork by Ms. Mika Suhara enlivened the ceremony and attendees. These artworks are intended to be symbolic of the collaboration in research and education between the AORI and the local community.

6.3. Present status and achievements

6.3.1. Structure

The ICRC comprises five sections: (1) the Coastal Ecosystem Section; (2) Coastal Conservation Section; (3) Coastal Ecosystem Restoration Section (established in 2012); (4) Coastal Social Science Section (established in 2018); and (5) Regional Linkage Section (which hosts visiting scientists from domestic and foreign organizations). All members work collaboratively without barriers for research, education, and outreach.

6.3.2. Research activities

The mega-tsunami on March 11, 2011 likely had significant impacts on the coastal ecosystem around the Sanriku area. To assess its impacts and monitor the recovery process, TEAMS was created by AORI, Tohoku University, JAMSTEC, and many universities and organizations in Japan to study and monitor the coastal ecosystem in the Tohoku area. Many researchers working on this project visit the ICRC for field studies, and three technical staff from the ICRC support their activities around Otsuchi Bay, with the use of three research vessels. The 2011 earthquake and subsequent mega-tsunami was the first mega-earthquake that occurred in a county with advanced ocean science capabilities. Scientific records and analysis are very

important for future disaster mitigation. Moreover, 40 years of data had been accumulated before the earthquake in Otsuchi Bay. These data are invaluable for understanding the damage and recovery process from the disaster. These studies have been published in many peer-reviewed papers, including special sections and volumes in the *Journal of Oceanography*, *Fisheries Oceanography*, and *Coastal Marine Science*.

Other studies are ongoing. Major topics include salmon ecology, sea turtle behavior, and environmental DNA. The Sanriku coast is the southern end of the major distribution area of chum salmon. Therefore, the population genetics, and physiological and behavioral differences between wild and hatchery-originating fish as well as the comparison of populations between rivers are intensively studied. Otsuchi Bay is an ideal area for comparative studies, because the river system is very small, as characterized by a regulatory impact assessment, in contrast to Hokkaido. Sea turtles have become an international icon for researchers and visitors to the ICRC. Sea turtle research is mostly conducted around spawning grounds in the tropics. Therefore, the Sanriku coast is a rare place where live specimens of major species of migrating subadult sea turtles can be found. Moreover, biologging techniques enable the elucidation of their behaviors and physiology. These studies are based on relationships of trust with local fishermen. Finally, environmental DNA analysis is an emerging and promising technique for monitoring the existence of target species. In the near future, it will be possible to determine physiological status. Fieldwork of the Core Research for Evolutional Science and Technology (CREST) and the Ocean DNA of the AORI have been carried out in Otsuchi Bay.

6.3.3. Society relationships

The ICRC has maintained good relationships with the local government and citizens. However, after the disaster, these relationships became somewhat strained. One of goals of TEAMS is to contribute scientific knowledge to the reconstruction of fisheries in the Tohoku region. Accordingly, a substantial amount of data and findings have been provided to fishermen and citizens. Moreover, ICRC staff have been debating how to further contribute to the local public. Meanwhile, the Institute of Social Science (ISS) of the University of Tokyo carried out a fieldwork project in Kamaishi City called the “Social Science of Hope” The ICRC and ISS discussed cooperation in the Sanriku area and designed a new type of education/research/outreach program, which was named “the School for Marine Science and Local Hope in the Sanriku Coastal Area.”

In this program, initiated in 2018, each bay and community along the Sanriku coast

are oceanographically, socially, and culturally characterized through intensive scientific research on local marine ecosystems along with social anthropologic approach. Then, interactive education on the oceanographic and sociocultural uniqueness of each bay and adjacent community is held at junior high schools to establish local identities for subsequent generations and to find opportunities for regional restoration or promotion by developing local human resources. The program has a good reputation with local governments, schools, and NGOs, who actively participate in our activities.

6.4. Future plans

The primary mission of the ICRC is to be a domestic and international leader in coastal marine science. Although the coastal ecosystems in Japan are small, they cover a wide spectrum of latitude, topography, freshwater inflow effects, and nutrient loads. Therefore, Japan, especially the Sanriku area, is excellent for performing comparative studies. Nevertheless, it is necessary to expand research activities beyond Otsuchi Bay to other areas in Sanriku, including the subtropical coasts, where warm currents such as the Kuroshio are dominant, in order to understand the oceanographic characteristics of the Japanese coast. To this end, cooperation with other facilities, both domestic and foreign, will soon be required. We must simultaneously continue monitoring and researching the recovery process from the disaster, because besides the ongoing recovery process, the landscape is changing owing to the resettlement of urban areas and construction of giant seawall. In particular, the Sanriku coastal area has high demand for disaster prevention and mitigation against earthquakes and tsunamis. Therefore, the ICRC must function as an earthquake-monitoring facility in cooperation with an earthquake research organization.

Finally, the School for Marine Science and Local Hope in the Sanriku Coastal Area has only just started. These activities must continue for several decades in order to foster subsequent generations to design local sustainable communities and foster hope. In particular, the ICRC would like to actively develop educational activities by conducting more events, such as interactive classes, in order to nurture future marine researchers. The ICRC would like to clarify that scientific research institutions have an important social role in rural areas that have experienced drastic depopulation.

Photo 1. The ICRC building four days after the 2011 mega-tsunami

Photo 2. The new ICRC building and dormitory, completed in February 2018

7. Center for International Collaboration and International Activities

7.1. Abstract

The Center for International Collaboration (CIC) has been actively carrying out its mission to promote international collaborative studies in atmosphere and ocean sciences. Three professors of the CIC have played leading roles in international and intergovernmental organizations and research projects, including the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the North Pacific Marine Science Organization (PICES), Future Earth of the International Science Council (ICS), and others. The CIC seriously considered how to best apply all recommendations and has succeeded in these endeavors. The UN Decade of Ocean Science for Sustainable Development (2021–2030) will greatly influence all AORI activities in the next decade, particularly those of the CIC. As the leading center charged with enhancing international collaboration, the CIC will fully contribute to the preparation and implementation of this program as well as UN SDGs.

The international activities of the AORI in the current period have been performed at a comparable level to those during the previous period, mainly through the CIC. As of November 2020, the AORI had 19 academic exchange agreements with universities and institutes in other countries. CIC has long history of capacity development with southeast Asian countries from the Multilateral Cooperative Research Program (2001–2010). After 2014, CIC has been led JSPS Core-to-core program to establish international science and educational network for the Southeast Asia marine ecosystem, which are “Research and education network on Southeast Asian coastal ecosystems” (RENSEA: 2016-2019) and “Collaborative Research and Education Project in Southeast Asia for Sustainable Use of Marine Ecosystems” (CREPSUM: 2020-2023) .

In order to develop regional implementation plan of the UN Decade of Ocean Science for Sustainable Development (UNDOS: 2021–2030) in the North Pacific and Western Pacific Marginal Seas, CIC organized a regional planning workshop for UNDOS in 2019 collaborated with IOC/WESTPAC, JAMSTEC, and MEXT. CIC will contribute to the UNDOS activities with coordinating the contribution of AORI scientists.

Recent COVID-19 global pandemic causes serious negative impacts on AORI’s international activities. It is really challenging for CIC and AORI to keep required level of international activities in such 2020 situation with COVID-19. As happen worldwide, most of international meetings and conferences including the Executive Council of IOC, 2020 annual meeting of PICES, and international academic exchanges between AORI and international institutes and universities, have been cancelled, postponed or held online. CIC will continue

the efforts to maintain and develop international collaboration under the difficult condition.

7.2. Responses to the recommendations of the External Evaluation Committee 2014

"We recommend that CIC expand its efforts in education and research exchange in Asia in general and in Southeast Asia in particular."

Response: The AORI has conducted education and research exchange activities in Asian partner countries and institutions—particularly in Southeast Asia, including Indonesia, Malaysia, the Philippines, Thailand, and Vietnam—through the JSPS Multilateral Cooperative Research Program "Coastal Oceanography" until 2010; thereafter, until 2019, these activities were conducted through the JSPS Asia Core Program and JSPS Core-to-core programs (RENSEA, CREPSUM). In these programs, CIC coordinate international joint research and capacity development activities of scientists between Japan and southeast Asian countries. To bolster capacity development efforts in ocean science, the CIC organized a series of international workshops in FY2017 that were financially supported by MEXT. The CIC organized the "AORI of the University of Tokyo Training Workshop on Harmful Algal Bloom Mitigation and Management in the WESTPAC Region" from October 31 to November 4, 2017, which had 12 participants from eight Asian countries, including China, Cambodia, Singapore, Indonesia, Malaysia, the Philippines, Thailand, and Vietnam. The CIC also organized the "International Workshop for Future Regional Training Research Center (RTRC) Networking in the WESTPAC Region" from January 23–24, 2018, which was attended by WESTPAC officers and leading scientists in the WESTPAC region. These were significant contributions to capacity development, mainly aiming to establish an RTRC for "sustainability science" to meet the regional requirements of capacity development in marine-related sciences.

"We recommend that the CIC and other AORI professors should be leaders in the development of the Future Earth Program in Japan, the new International Ocean Discovery Program, the IPCC, IOC, PICES, and other international research activities."

Response: While many faculty members of the AORI have been contributing significantly to the abovementioned international research activities—for example, as lead authors (3) and review editors (2) of IPCC AR6 reports or leading scientists in several research projects of

Future Earth (IMBeR, SOLAS, FE Coast, IGAC), WCRP, IODP, SCOR, IOC, and PICES. CIC faculty members have also done so. For example, Prof. Michida served as Vice Chair of the IOC from 2011–2015, as Co-chair of the International Oceanographic Data and Information Exchange (IODE) of the IOC from 2015–2019; he was the second Japanese Vice Chair of the IOC throughout the organization's 60-year history and the first Co-chair of the IODE from Asia. Prof. Saito served as the Chairman of the Science Board of PICES between 2016-2019, following his service as Vice-Chairman from 2013–2016. He is serving as a National Contact of IMBeR, one of global research projects (GRP) of Future Earth from 2017 and leading SKED, a regional project of IMBeR. With regard to the new initiative of the UNDOS proclaimed at the UN General Assembly in December 2017, Prof. Emeritus Uematsu, the former Director of the CIC, was selected as one of 19 global experts of the Executive Planning Group for the project's preparation. PICES and ICES are eager to contribute UN Ocean Decade of Ocean Science as leading science organizations and developed a Study Group of UNDOS in 2020. Prof. Saito and Prof. Makino are members of the study group to develop UNDOS Program proposal for endorsement by UNESCO/IOC. Prof. Makino also serve as a member of PICES Science Board and chairperson of PICES's Human Dimension Committee since 2019.

"We recommend that CIC begin to consider ways to encourage other faculty to become actively involved such that the future of CIC and its programs is secure. Individuals with interest in both science and policy-related issues would be particularly valuable as future leaders."

Response: In response to this particular recommendation, the CIC expanded the number of concurrent faculty members from three to five in 2018 to cover a wider range of scientific subjects. In addition, Prof. Makino, whose academic background is fisheries economics, joined the CIC in April 2019. Prof. Makino is strongly expected to expand the AORI's mission to meet society's emerging demands for inter- and multi-disciplinary studies related to marine policy issues by enhancing closer collaboration with other faculty and technical members of the AORI and even with those of other institutions. Furthermore, Prof. Michida was appointed as Secretary General of the Japanese Society of Marine Policy in 2018. These actions will help the AORI become a leading marine policy institute.

7.3. Present status and achievements

The Center for International Cooperation was established in June 1994 to enhance international collaboration in ocean sciences and was subsequently reorganized as the Center for International Collaboration (CIC) in April 2010. The center comprises three sections: the

International Scientific Planning Section promotes and supports inter-governmental agreements on academic activities related to the ocean and climate; the International Advanced Research Section aims to create and promote integrated advanced international research related to atmosphere and ocean sciences carried out in an international framework; and the International Research Cooperation section aims to form a base for academic exchange and the training of young scholars through academic collaboration with other countries mainly in the Asia-Pacific region. Three professors and five concurrent faculty members of the institute are responsible for achieving these aims.

Prof. Y. Michida has served as one of the five Vice Chairs of the IOC of UNESCO from 2011–2015 and then as Co-chair of the IODE of the IOC from 2015–2019. Prof. Michida has contributed to the wide spectrum of the IOC's activities as Chair of the Japanese National Committee of the IOC since 2018. Prof. M. Uematsu has actively organized and supported core projects of atmosphere and ocean sciences under the ICSU/International Geosphere–Biosphere Programme (IGBP) and most recently those under Future Earth. Meanwhile, Prof. Uematsu retired at the end of March 2018 and obtained Prof. Emeritus status at the University of Tokyo in July 2018. He has been greatly contributing to the international oceanographic community; he has been appointed as one of the 19 members of the Executive Planning Group for the preparation of the UNDOS*. Prof. H. Saito joined the CIC in 2016 and has been continuing the work of Prof. S. Nishida, who retired in 2016, by leading the creation of the research and education network of coastal oceanography in Southeast Asia. Prof. Saito launched a new research and education project "Collaborative Research and Education Project in Southeast Asia for Sustainable Use of Marine Ecosystems (RENSEA: 2020-2023)" to establish science and education network between Japan and southeast Asian countries and to contribute UNDOS and UN SDG14 "Life below water". Prof. Saito has also been involved in PICES as one of its leaders and served as Chairperson of the Science Board during 2016-2019, following his service as Vice-Chairperson of the Board from 2013–2016. With the retirement of Prof. Uematsu, Prof. M. Makino joined the center in 2019; given his academic background in fisheries economics, he has been playing a leading role in PICES, in particular, by founding the Human Dimension (HD) Committee in 2016, which aims to understand the relationship between North Pacific marine ecosystems and its inhabitants, communities, and economies. From November 2019, he started to serve as Chair of HD committee. Despite being a newcomer, Prof. Makino has been making important contributions; he is the first professor with a social science background at the AORI and is thus contributing to inter-disciplinary subjects such as sustainable fisheries and resource management.

In addition to these activities of the center's faculty members, the center is responsible for the promotion and enhancement of the international collaborative activities of

the AORI. The CIC is responsible for the program for visiting scientists/professors by inviting leading scientists from abroad. Thus, Japanese scientists including the AORI members have stimulating interchanges in all research areas and can thereby contribute to the international development of atmosphere and ocean sciences. The AORI has been establishing academic agreements with globally leading institutes to support international collaborative studies. Accordingly, the AORI has concluded seven new and renewed academic agreements since the last external evaluation in 2014; now there are 20 such agreements with 14 countries. The faculty members of the CIC support the administrative arrangements to establish these agreements from a scientific perspective.

Recent COVID-19 global pandemic causes serious negative impacts on AORI's international activities. As happen worldwide, most of international meetings and conferences including the Executive Council of IOC, 2020 annual meeting of PICES, and international academic exchanges between AORI and international institutes and universities, have been cancelled, postponed or held online. It is really challenging for CIC and AORI to keep required level of international activities in such 2020 situation with COVID-19.

[*] *The UN Decade of Ocean Science for Sustainable Development (2021–2030) was proclaimed at the UN General Assembly in December 2017 to internationally promote overall ocean sciences and services with the aim of achieving societal outcomes directly related to the Sustainable Development Goals (SDGs), particularly SDG 14 ("Life under the Sea"). Planning led by UNESCO/IOC is intensive and ongoing toward the implementation of the project starting in 2021.*

7.4. Challenges and future perspectives

In Japan, the corresponding departments of MEXT facilitate the General Assembly and Executive Council of the IOC through the IOC's National Committee. The director of the CIC has been playing a leading role in Japan's IOC-related activities as the committee chair and has received strong support from the faculty of the AORI. The faculty members of the CIC have significant roles in setting the long-term perspective and decision-making processes in international negotiations regarding the ocean sciences and policy despite frequent changes in government officers. However, there is a dearth of younger personnel who are familiar with international affairs. Thus, the development of junior faculty is urgently required. In order to enhance the basis of our international collaborative research system, Asian countries, including Japan, need to train young scientists who can work within an international

environment. This is an urgent issue for our contribution to Future Earth (an ISC initiative) and the UNDOS and UN SDGs.

The CIC is supporting exploratory research projects that involve international collaboration with the AORI members by inviting visiting scientists from abroad and holding workshops. The 20 institutions in 14 countries that have agreements with the AORI closely interact with respect to academic exchanges. However, dealing with such a multitude of tasks is very difficult for just three full-time faculty members, who also have their own research and educational duties.

The CIC intends to support and promote international collaborative projects and programs that are beyond the scale possible for individual scientists with the cooperation of the AORI members, and to coordinate close information exchanges among scientists in Japanese research communities.

The CIC will recommend suitable scientists as candidate members of international committees and organizations to support international academic activities, because these activities will enhance the international research standards of Japan. It is important that Japanese research activities have greater international visibility. Thus, the CIC should aim to foster young scientists who can work in an international context as well as establish a regional and worldwide network of scientists in atmosphere and ocean sciences. The CIC would like to request the placement of a full-time professional administrator who can support CIC activities through their international experience.

7.5. Present status and achievements regarding international activities

The faculty members of the AORI actively participate in and promote international joint research projects emphasizing the AORI's attributes as a Joint Usage/Research Center. Upon its founding in 2010 and at all institutional levels, the AORI established the CIC by reorganizing the Ocean Research Institute of the Center for International Cooperation. Furthermore, to focus on coastal waters as important research fields—waters that are vulnerable to the effects of human activities—the International Coastal Research Center (ICRC) was established in the town of Otsuchi, Iwate, where several international activities are carried out. Joint research projects and conferences have been held in concert with international organizations in which the AORI participates (e.g., GOOS, Future Earth, IODP, NanTroSEIZE, WCRP, and WESTPAC) and with overseas research institutes with which the AORI has academic exchange agreements. For details, please refer to the AORI's catalog.

International joint research projects are individually carried out by faculty members and at the department level. As a coordinator of atmosphere and ocean sciences in Japan, the CIC generates and promotes academic activities in the area of ocean and climate research under the aegis of intergovernmental agreements. It has also backed integrated, international, and cutting-edge projects on atmosphere and ocean sciences under international frameworks and promotes academic exchanges. The AORI has firmly committed to cultivating young talent through collaboration with other countries, including Japan's Asian neighbors. The AORI currently has academic exchange agreements with 20 universities and institutions from 14 countries (Table 7-1).

The numbers of researchers dispatched by the AORI to overseas institutions and vice versa over the last six years are shown in Table and Figure 7-2. The number of researchers dispatched, currently around 250, has slightly increased. Many of these researchers are sponsored by MEXT. The largest proportion have been sent to other Asian countries (33%), followed by North America (28%), and Europe (25%). Simultaneously, approximately 60 researchers are invited to the AORI each year. However, until 2010, this number was approximately 150 per year under the JSPS Multilateral Cooperative Research Program "Coastal Oceanography." The top three regions from which researchers are invited are the same as those for dispatched researchers: Asia (60%), followed by North America (19%), and Europe (12%). It should be noted that relatively few researchers are invited from or dispatched to Oceania, Latin America, the Middle East, or Africa.

7.6. Challenges and future perspectives regarding international activities

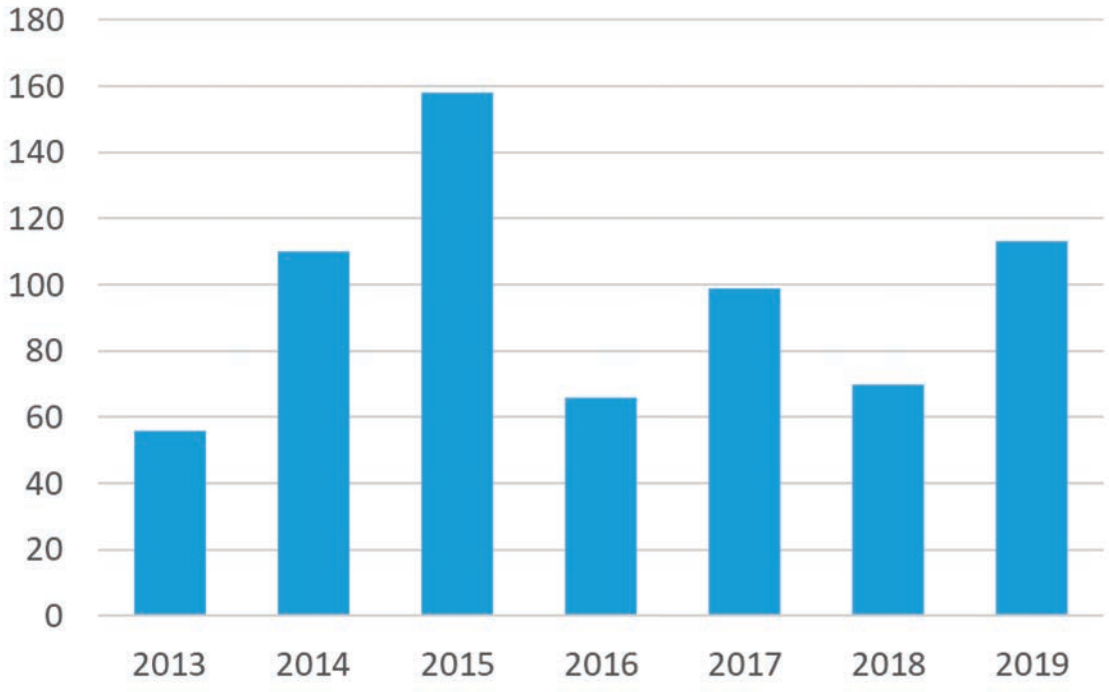
While the CIC has been keen to obtain extra-budgetary resources to promote academic exchange with other countries, it could have been funded with a relatively smaller amount than that of the JSPS Multilateral Cooperative Research Program (2001–2010). The CIC should continue its fundraising efforts to contribute more to regional capacity development activities as well as international research programs and projects. The UNDOS and UN SDGs can be a catalyst for enhancing international collaborative studies and capacity development activities in atmospheric and oceanographic research because it will prioritize its implementation plan towards the full engagement of youth and an internationally transparent and accessible ocean.

Table 7-1 Institutions that have exchanged MoUs for scientific cooperation with the AORI

Country/regions	University/Institution	Year of Conclusion
USA	Scripps Institution of Oceanography, University of California, San Diego (SIO)	May-1988
USA	Woods Hole Oceanographic Institution (WHOI)	Jan-1989
USA	School of Ocean and Earth Science and Technology, University of Hawaii at Manoa	Jan-2004
Chinese Taipei	National Taiwan Ocean University	Apr-2006
India	National Institute of Oceanography (NIO)	Oct-2006
UK	School of Biology, the University of St Andrews	Mar-2007
Australia	Australia National University	Mar-2009
France	Museum national d'histoire naturelle	May-2009
Malaysia	Universiti Putra Malaysia	May-2009
France	Universite Pierre and Marie Curie	Aug-2011
Russia	Institute of Natural Sciences, Ural Federal University	Jun-2012
Russia	Central Aerological Observatory (CAO), The federal Service for Hydrometeorology and Environmental Monitoring (ROSHYDROMET)	Nov-2014
India	Rajdhani College, University of Delhi	Dec-2014
Norway	Bjerknes Centre for Climate Research, University of Bergen	May-2015
Belgian	Katholieke Universiteit Leuven	Oct-2016
Germany	Center for Marine Environmental Sciences, the University of Bremen	Dec-2016
Italy	Institute of Atmospheric Sciences and Climate, National	Nov-2017

	Research Council of Italy	
Korea	College of Environmental and Marine Sciences and Technology, Pukyong National University	Feb-18
Indonesia	The Indonesian Institute of Sciences (LIPI)	Oct-19
Belgian	Ghent University	Oct-20

Table and Figure 7-2. The number of researchers invited to the AORI from overseas institutions



8. Science and Society

8.1. Abstract

To contribute to society through research and education, the AORI extends its research outcomes by promoting awareness of its work and findings more broadly throughout society via publications, public lectures, press releases, interactive events such as the Science Café, and social media (e.g., Facebook). ICRC has been contributed to the recovery of local society of Sanriku from 3.11 tsunami disaster by disseminating scientific knowledge. Also, ICRC's activity of "School for Marine Science and Local Hope in the Sanriku Coastal Area" successfully develops close communication between scientists and citizens in the area, and try to foster the next generation who can design local sustainable communities with "hope".

8.2. Responses to the recommendations of the External Evaluation Committee 2014

"We recommend that the AORI should continue, and if possibly expand, its excellent effort in public engagement and outreach."

Response: The AORI pays great attention to and continues to enhance its activities related to public engagement and outreach as described above. Please see 6.3.3 and 10.2.5, also.

"We recommend that the AORI may wish to consider publishing a magazine similar to 'Oceanus' that is published by the Woods Hole Oceanographic Institution and that can be purchased through a publisher."

Response: AORI recognizes the importance of having a public-domain publication as a powerful tool for public awareness of its achievements. However, this initiative is not easy to realize because of labor and publication cost. Please note AORI publishes a couple of outreach publications (Ocean Breeze, Meyu Tsushin) and the number of employee is ca. 1/8 of WHOI.

"We recommend that if the AORI is to connect to prospective students, it must develop a robust and active presence on Facebook and other social media. Undergraduate students are almost universally focused on social media as a source of information."

Response: In 2011, the AORI started to use Facebook as a channel to reach wider communities, including younger generations. Given this recommendation, the AORI is posting announcements and a wide variety of information related to its activities. The Office for Public

Relations monitors metrics of these activities, such as the number of readers and positive responses. As many followers of AORI's Facebook account are alumni, social media can be a platform for communication with and among alumni.

"We recommend that the AORI should explore other vehicles for conducting, connecting, and collaborating in research and outreach that has a demonstrated connection to the public good."

"We recommend that the AORI develop collaborations with social sciences and design disciplines such as architecture and engineering to support coastal community design that creates hazard resiliency, reduces environmental impact, and supports healthy economic development."

Response: As a partial response to these recommendations, the AORI has been leading some research projects related to better management of ocean and coastal zones as a public good by enhancing collaboration with social science researchers as described above. Successful examples of supporting local community is described in Chapter 6 (ICRC). As explained in Chapter 7, AORI recruited the first social scientist in CIC as a full professor. Also, AORI has been initiated several projects after 2014 contributing to solve social issues such as microplastic, coastal management, hazard forecasting and manipulation. AORI will continue to engage societal issue as a leading atmosphere and marine science institution.

"We recommend that the AORI build mechanisms for discovering what is of public need, interest, and concern, and for redirecting research, educational, and outreach efforts to address novel, emerging needs, challenges, and opportunities that face people who live and depend along coasts."

Response: It has been suggested that the AORI hold press conferences to facilitate closer dialogue with diverse writers and journalists, although this has not been realized on a regular basis after a trial in the early 2010s. This is one possible response to the above recommendation and should be considered as an initiative organized by the Public Relation Office. As mentioned in 6.3.3., the staff of ICRC regularly communicate with the people and hear voices of fishermen, local governmental staff and politician, teachers, students. Also, see response for the question below.

"We recommend that the AORI should continue to find additional ways to serve national and local government, both to serve the public good and to increase the

esteem and value that public officials have for the Institute."

Response: The ICRC has been one of the core members of the Iwate Ocean Research Consortium organized by the government of Iwate Prefecture. It aims to share public requirements and needs at the local governmental level and inquire about the possibility of participating research institutions to promote cooperative studies to meet those needs. Some of faculty members of the AORI have been actively participating in the Japan Society for Marine Policy as core members; one professor has been serving as Secretary General of the society, whereas others play leading roles in the Academic Committee or in some research groups. These are several ways for the AORI to make more substantial commitments to the actions of central and local governments.

8.3. Present status and achievements

8.3.1. Public relations activities

Every year, the AORI publishes a bilingual catalog (in Japanese and English) that summarizes its research activities and achievements that year and is widely distributed to relevant parties. In addition, the AORI publishes three newsletters that outline all-institute activities and contain features showcasing the activities of individual divisions and centers. One of the newsletters, *Ocean Breeze*, is aimed at a general lay audience, and some 2,000 copies are distributed per issue. The AORI website targets both the general public and undergraduate students who are interested in postgraduate studies at the AORI. The website outlines the latest research activities, provides the catalog and newsletters as downloadable PDF files, and gives updates on the restoration status of the ICRC after the 2011 earthquake and tsunami.

The AORI disseminate scientific findings to public through press release and announce research topics through the web site (https://www.aori.u-tokyo.ac.jp/english/research/index.html). The number of press release and research topic announcement increases after the last external evaluation (Fig. 2-1). Three-quarters of the website visits originated from inside Japan. As for visits confirmed to have originated overseas, the largest proportion are from Europe, followed by Asia and North America.

The AORI has held an open house during the Kashiwa Campus open house every autumn after its relocation. The open house attracted 7,786 visitors in 2019. It should be noted that the AORI has the most visitors among all institutes in the Kashiwa Campus. The ICRC in Otsuchi, Iwate Prefecture has held an open house every summer as well as before the catastrophic damage to Otsuchi caused by the 2011 tsunami. Recognizing the importance

of encouraging the local community in Otsuchi, which has been working hard to recover from the disaster, the ICRC has held an open house in summer since 2016 and made an even larger event after the reconstruction was completed in 2018. Although these events were cancelled in 2020 due to COVID-19 pandemic, AORI will continue to communicate with general public and children through these public relation activities.

8.3.2. Outreach activities

The AORI encourages its faculty and technical staff to publish books and articles targeting the general public to improve literacy about atmosphere and ocean sciences in Japan. The Center for Earth Surface System Dynamics regularly holds a “Science Café” to share its latest research findings with general public. Similar to the Science Café, the AORI has been organizing a unique, annual “Science Sushi Bar” since 2011 in close cooperation with the sushi restaurant *Hama* located on the ground floor of the institute. The event held on February 22, 2019, was at the Kashiwanoha Railway Station Satellite Campus; two AORI researchers gave scientific talks on salmon in the Tohoku Region, and sushi dishes were then served to approximately 50 participants.

8.3.3. Government engagement

Many faculty members contribute to policy discussions conducted by several committees at both central and local governments, mainly as scientific advisors from the viewpoint of atmosphere and ocean sciences. In 2020, the Faculties serve as a chair or a member of a total of 52 governmental committees and 9 regional governmental committee. Advices or recommendations from our faculties contribute to develop various policy in environment, fishery and climate. One faculty member, usually a relatively younger associate professor, has been dispatched to the Ocean and Earth Division of MEXT to serve as a scientific advisor once a week for a one-year period. This aims to keep a communication channel between governmental decision-making processes and the academic sector in atmosphere and ocean sciences. It is also mutually beneficial for both the division and the AORI: the government can design and implement better policies and actions based on scientifically sound considerations, while the AORI can give direct input to policymaking processes.

Table 8-1. List of governments and regional governments on which AORI Faculties advised. Figures in parenthesis are the number of committees, advisory bodies, etc., in 2020.

Government	Cabinet Office (5), Ministry of Environment (12), Ministry of Land, Infrastructure, Transport and Tourism (7), Ministry of Economy, Trade and Industry (2), Ministry of Education, Culture, Sports, Science and Technology (12), Meteorological Agency (12), Fisheries Agency (1), Japan Coast Guard (1)
Regional government	Iwate Prefecture(8), Otsuchi town (1)

An inter-disciplinary research project, “Consensus Development in Utilization of Marine Space,” was implemented from 2014–2017 as a core project of the Ocean Alliance, a virtual organization of multiple faculties and institutes related to the ocean that is financially supported by the Nippon Foundation. As an outcome of the project, the research team, which includes members not only from the AORI, but also from the Faculty of Agriculture and Graduate School of Public Policy, published the “Guideline for Consensus Development in Coastal Zone Utilization” in 2017. The publication was distributed among some local governments as well as the central government; this is one example of the AORI’s contribution to public engagement with governmental policy.

In 2019, the AORI started a multidisciplinary research project, “Integrative Research on Transition Zones between Coastal and Offshore Waters for Conservation and Sustainable Use of Resources,” in cooperation with the Graduate School of Public Policy. This project aims to attain seamless management of the waters from the coast to offshore based on both natural and social sciences. This is partly an initiative toward marine spatial planning in Japan.

8.4. Challenges and future plans

In regard to the recommendation to publish a magazine similar to *Oceanus*, a certain level of staffing and budget might be required. Although the AORI sincerely recognizes the importance of such efforts, this is still a challenge in terms of enhancing public relations activities.

In regard to the improvement of public engagement in ocean sciences and related issues, the AORI could consider establishing closer cooperation with the Center for Ocean Literacy and Education (COLE), a research center under the Faculty of Education, which has been playing a key role in promoting “ocean literacy” in Japan in close partnership with international organizations such as UNESCO.

9. Research Environment and Support System

9.1. Abstract

The AORI is based in the Kashiwa Campus of the University of Tokyo and also manages the Otsuchi Marine Research Center in Iwate Prefecture. The center was catastrophically damaged by the 2011 earthquake and tsunami, but a new building and adjunct facilities were completed in 2018.

The research and educational activities of the AORI are supported by 16 technical staff and 20 administrative staff. Although the most serious issue faced by the AORI is the downsizing of support staff in the University of Tokyo, the AORI hired a technical staff member in 2018. The AORI's international and outreach activities are mainly supported by the Center for International Collaboration (CIC) and the Public Relations Office. The AORI started a support system to improve the work–life balance of its constituent members in 2017. This system includes financial support for postdoctoral researchers taking maternity leave as well as researchers and technicians who are responsible for the care of children and elderly relatives.

9.2.1. Kashiwa Campus

The Kashiwa Campus is one of the three main campuses of the University of Tokyo and is regarded as the center of advanced research. The main building of the AORI is located at the western end of the Kashiwa Campus, and the Division of Climate System Research is located at the Kashiwa Research Complex at the eastern end. The main building was built in 2010, and the warehouse and laboratory for accelerator mass spectrometry were built just north of the main building (please see back cover of the Catalog). Because of the increases in facilities, samples, and members, laboratories must be rearranged to effectively utilize the limited space (Table 9-1). Another issue is merging the space in the Kashiwa Research Complex with the AORI main building to promote synergy and integration among divisions.

9.3. Otsuchi Campus

The Otsuchi Marine Research Center was established in 1977 in Otsuchi, Iwate Prefecture and was reorganized as the International Coastal Research Center (ICRC) in 2003. In March 2011, the buildings were catastrophically damaged by the 2011 off the Pacific coast of Tohoku Earthquake and the subsequent tsunami. The AORI and the University of Tokyo made every

possible effort to rebuild the center and restart coastal research. In 2018, a new research building and guest house were completed in a landward area of Otsuchi town (Table 9-2). A special opening ceremony was held in July 2018 with guests from the University of Tokyo and regional and local societies. Experimental aquariums and other adjunct facilities were also restored and rebuilt in the bay-side area where the former buildings were located. A small museum space is planned to promote outreach activities.

Table 9-1. AORI building areas

Kashiwa Campus（5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8564）

Building	Year	Floor space(m^2)
AORI Main Research Building	2009	15,250
Warehouse	2009	1,526
Laboratory of AMS	2013	313
Waste Storage	2009	131
Kashiwa Research Complex	2004	1,694
total		18,914

Otsuchi Campus（1-19-8 Akahama, Otsuchi, Iwate 028-1102）

Building	Year	Floor space(m^2)
Research Building	2017	2,687
Guest house	2017	580
Warehouse（×6）	2017	53
Facilities in bay side (total)	2019	416
Fittings warehouse	2019	132
Total		3,868

9.4. Support for research activities

The AORI now has 16 technical staff and 21 administrative staff to support its educational and research activities. Also, Divisions, Sections, or Centers employ 45 technical and 43 administrative supporting staff. Technical/engineering support is mainly provided by the Center for Cooperative Research Promotion. The center supports various types of ship-based field observations, laboratory experiments, and network/computer services (see Chapter 5). Although the most serious issue faced by the AORI is the downsizing of support staff at the University of Tokyo, the AORI hired a technical staff member in 2018. Following the suggestion of the 2014 external review, we published the "Report on the activities of 2016/2017/2018: Center for Cooperative Research Promotion," which included a list of activities and technical reports by technical staff.

The promotion of international collaboration, a key goal, is supported by the Center for International Collaboration (CIC) (see Chapter 7) and the International Affairs and Research Promotion Team, who support overseas students, exchanges of visiting researchers, and arrangements for international projects. The Public Relations Office supports publications by faculty members and students, manages the website and print materials, and supports other outreach activities.

9.5. Supporting work–life balance

In 2017, the AORI started a support system to improve the work–life balance of its constituent members. The system includes the financial support for postdoctoral researchers taking maternity leave as well as researchers and technicians who are responsible for caring for children and elderly people. In FY2019 and 2020, eight and seven members utilized this system to employ temporary support staff, pay for childcare, and outsource errands.

9.6. Team-building activities

To deepen exchanges among divisions, the AORI organizes several events throughout the year, such as a welcome party for newcomers, a barbeque party, and a table tennis tournament. A small beer party is occasionally organized by volunteers, encouraging communication between students and staff. In FY2020, online events to welcome new students and to encourage team-building were carried out under the COVID-19 pandemic.

9.7. Future plans

In order to promote synergy and integration among divisions, the AORI will continue to make efforts to combine its two separate research spaces on the Kashiwa Campus, although it is not financially feasible at present. Both technical and administrative support systems should also be improved to maintain the AORI's high performance as a collaborative research center despite severe staffing cuts. The AORI will

also try to improve its work environment to support the work- Report on the activities of 2016/2017/2018: Center for Cooperative Research Promotion life balance of all members.

10. Response to 2014 Recommendation

During the external evaluation conducted for the AORI in 2014, the evaluation panel provided a series of assessments and proposals. Descriptions of these appraisals and our responses to them can be found below.

10.1 Response to Questions on Overarching Issues

A. Strategic Planning

Comments: The external evaluation team believes that the AORI could benefit significantly if it undertook a comprehensive strategic planning effort within the next year or so. The rationale for strategic planning at this time is manifold. The merge of the former Ocean Research Institute and the former Center for Climate System Research occurred four years ago. We believe now would be a good time to evaluate how well the merger has worked. More importantly, now is an appropriate time to evaluate the future intellectual plans of the AORI - what new scientific and societal issues are on the horizon for the atmospheric and oceanic sciences and how will the AORI respond to them? The timing is also right because a new Director will shortly be needed, several senior faculty will be retiring within the next few years, and the grant and university funding for the AORI is decreasing. All of these points highlight the need for a comprehensive strategic plan to address the future of the AORI.

We recommend that the AORI undertake a comprehensive strategic planning process over the next year.

Response A:

The new president Gonokami took office and announced a new principles of the University of Tokyo "Vision 2020" (https://www.u-tokyo.ac.jp/en/about/vision_2020.html) in 2015. At the same time, the University of Tokyo started to revise the Mid-term Strategy. From 2016, the University of Tokyo reformed the organization and budgetary measures based on the 3rd phase midterm strategy of the University of Tokyo (2016-2021) and Vision 2020. Under the revision of the visions of the University of Tokyo and budget allocation rules including reduction of personnel expenditures, the Director's office (fiscal years 2011-14 Director Hiroshi Niino; 2015-2018; Director Atsushi Tsuda, 2019-present; Director Tomohiko Kawamura) has been set out various activities to make the AORI to be the center of excellence in atmosphere and ocean sciences and the Joint Usage/Research Center. In these periods of change, it was difficult to develop AORI's strategic plan. However, AORI has been continued to enforce the linkage and integration of the former Ocean Research Institute (ORI) and the former Center for Climate System Research (CCSR)(Response A1), restore the research

facilities and functions of the International Coastal Research Center (ICRC) damaged by the tsunami in 2011, promote the monitoring and study of recovery processes following the tsunami disaster (Response A2), continuously secure funding for research expenses (various external research funds, operational cost subsidies, and so on), and maintain and expand the research facilities and equipment for Joint Usage/Research activities (Response A1, A3). In a series of activity, AORI also strengthens outreach activity.

These activities successfully realize in new inter- and transdisciplinary projects and scientific papers as well as tighter linkages with general public and decision makers. In 2020, after the strategic transformation period of the University of Tokyo, AORI reactivated the Future Vision Committee mostly composed of mid-career faculties to design the 10-years strategic plan of AORI, which include Philosophy, Visions and Grand Challenge of AORI, reforming the structure of Divisions and Centers, promotion of young scientists, diversity and inclusion, etc. The Future Vision Committee will submit the recommendation to Director's office in March 2021.

Response A1:

Interdisciplinary research projects have been planned and proposed and budgetary requests have been made; these have primarily been the work of faculty members of the Center for Earth Surface System Dynamics (CESSD), which was established to promote the linkage and integration of ORI and CCSR with the aim of further activating the center and covering its research expenses. Consequently, two research projects ("Integrative Research on Transition Zones between Coastal and Offshore Waters for Resource Reserve and Sustainable Use" and "Research Hub for the Big Data Analysis of Global Water Cycle and Precipitation in Changing Climate", both for 5 years, 15,000,000 yen/year), were funded and commenced in the 2019 fiscal year. Another project (Ocean DNA Project: Establishment of a Center for an Ocean DNA Archive and Analysis Unit toward the Conservation of Biodiversity and Bio-resources in the Pacific Ocean; for 5 years, 35,000,000 yen/year, with personnel budget for one full professor and one assistant professor) was funded and commenced in the 2020 fiscal year. Further, one more project ("Subtropical-Kuroshio environmental study project -understanding the evolving environmental-cultural baseline in a changing world") will be–funded for commencement in the 2021 fiscal year (for 5 years, 15,000,000 yen/year, with personnel budget for one associate professor), which will be collaborated with International Coastal Research Center (ICRC).

Response A2:

Reconstruction of the heavily damaged ICRC has completed, and the opening ceremony was held in July 2018. Almost all the research facilities and equipment have been restored by the end of the 2019 fiscal year. The ICRC has been functioning as one of the bases for studies on the recovery processes of marine ecosystems following the earthquake and tsunami that occurred in 2011; many important research results have been produced. Furthermore, to carry out the mission of the research institute reconstructed in the disaster area, we started a new research and educational project "The School for Marine Science and Local Hopes in Sanriku" in the 2018 fiscal year (applied for and funded under the 2017 fiscal year budget requests for 5 years, 15,000,000 yen/year with personnel budget for associate professor); this project is an integration of arts and sciences and is a completely new approach at our institute based on outreach activities.

Response A3:

R/V Hakuho Maru is a flagship marine research vessel in Japan, operated by JAMSTEC. Because of the age of the vessel (completed in 1989), the AORI, JAMSTEC and users of *R/V Hakuho Maru* have sought the way for the replacement with Ministry of Education, Culture, Sports, Science and Technology (MEXT). We held a symposium at the Science Council of Japan and invited demanding papers from related societies to declare the importance of *R/V Hakuho Maru* for the past, present and future ocean sciences, and MEXT. As a result, MEXT and JAMSTEC decided that they aim to maintain the function as a Joint Use research vessel in about more 20 years by conducting large scale repair. The budgetary request (3.8 billion yen) was approved in 2020, and *R/V Hakuho Maru* will undergo large-scale repair in 2021.

B. Marine Policy Involvement

Comments: Today it is clearer than ever that what happens on land directly impacts coastal ecosystems. The impacts of natural hazards, climate change, and human activities, including development, on coasts and their communities are multifaceted and require an integrated multidisciplinary response using policies that are based on sound science. The AORI conducts science that is absolutely critical for a nation like Japan, of which coasts are a dominant feature of its geography, economy, culture, history, food supply, and recreation activities. The AORI science is necessary for understanding the interactions among climate, atmosphere, watersheds, coastal waters, and deep oceans. This is the basis for reducing the likelihood and impacts of natural disasters, and for the ability to predict the consequences once they do happen. The 2011 off the Pacific coast of Tohoku Earthquake, tsunami, and associated

Fukushima disaster converged to demonstrate just how important the science and education conducted at the AORI is. It is essential that the people and government of Japan do not forget that the diverse, but unified and complementary, capabilities of the AORI are indispensable to support the safe and sustainable continuation of economically strong, resilient, and vibrant coastal communities.

We recommend that the AORI build strong collaborative relationships with elements of the University of Tokyo engaged in marine policy. This has strong mutual interests for both parties. Good ocean and coastal policy is founded on good science, which the AORI is uniquely qualified to provide. The marine policy faculty can and ought to be among the strongest advocates for the science of the AORI.

Response B:

We recognize that it is getting more important in the global change era that the contribution of the AORI for developing better ocean policy through preparing best scientific knowledge for decision makers and marine policy scientists. To strengthen the activities related to the marine policy of the AORI, we hired a specialist in 2019, professor M. Makino, who is a specialist of fisheries economics and marine social-ecological systems. In addition to him, several faculties are active in Japan Society of Ocean Policy and other international and national organizations related to marine policy. The contribution by the AORI to fishery and marine policy is expected to be greatly enhanced through the activities. We have also carried out the educational program “Interdisciplinary Education Program on Ocean Science and Policy” in cooperation with professors studying marine policy from other departments of the University of Tokyo, in the framework of the University of Tokyo Ocean Alliance, which is a cross-cutting educational and research organization in the University of Tokyo, to develop human resources who can transfer the ocean sciences to marine policies.

C. Virtual Centers of Excellence

Comments: The evaluation team was highly impressed with the actions of the AORI faculty in taking responsibility for ensuring a rigorously scientific understanding of the destruction caused by the 2011 tsunami. The AORI supports the use of science to assist the restoration processes of ecosystems and the fisheries industry in the Sanriku region. The ICRC has shared research findings collected in Otsuchi Bay over nearly 40 years, both locally and with the international community.

We recommend that the AORI might consider organizing Centers of Excellence, drawing on the Otsuchi Bay example. These would be virtual centers that build bridges among academics from wide-ranging disciplines to address issues, problems, challenges, and opportunities that face coastal communities, and that can benefit from the AORI's scholarship. This would allow researchers to engage firsthand in the most pressing issues, directly with the involved communities. Such centers could also provide for inter-college, -school, and -departmental collaboration, something not encouraged by the traditional academic structure.

Response C:

The ICRC has been playing a major part in the research program “Tohoku Ecosystem-Associated Marine Sciences” as one of the bases for studies on the recovery processes of marine ecosystems following the earthquake and tsunami that occurred in 2011. In addition to the above tsunami-related studies, the ICRC aims to contribute to the restoration of the local fisheries by disseminating scientific results to the local community over recent years. The ICRC also started a new research and educational project, “The School for Marine Science and Local Hopes in Sanriku” in 2018, together with the Institute of Social Science at the University of Tokyo, in order to utilize our scientific activities for the development of local communities. Specifically, our research aims to identify the structures and characteristics of marine environments and ecosystems in each area (bay), allowing for town revitalization utilizing the unique characteristics of the local coastal area; this is achieved by considering the relationships between coastal marine ecosystems and adjacent local societies, and the effective utilization of local marine products and the characteristics of social-ecological systems. These activities of the ICRC, including >85 lectures/townhall meeting for local students and general public, have been carried out with the Iwate prefectural government and coastal municipalities, and thus the ICRC has been gradually regarded as a base for marine educations leading to the regional development, as well as a base for the coastal marine sciences. As the small exhibition room “Otsuchi Marine Study Room” in the ICRC will open in the early 2021 fiscal year, public relations of the ICRC and local sea will be enhanced resulting in the transdisciplinary project “the School for Marine Science and Local Hopes in Sanriku”. We have not actually organized the Virtual Centers of Excellence in relation to our activities of the ICRC, however, we believe the ICRC is now functioning as a base corresponding to COE in the area and for Joint Use/Research in Japan.

D. New Director Considerations

Comments: Within the next year, the AORI will be searching for a new Director. The new Director must have excellent vision and a clear mandate to lead the institute in whatever new directions are determined by the strategic planning process. The external evaluation team believes that the new Director should be relieved of most onerous administrative duties so that he/she can focus on the research and educational programs of the AORI and communicate the strengths and values of the AORI to the Japanese and international scientific, governmental, and business communities. To handle most of the administrative responsibilities, the AORI might want to consider appointing an Executive Associate (or Executive Vice) Director with experience in Japanese and University of Tokyo policies and procedures.

We recommend that when the search for a new Director is undertaken, it be wide-ranging, including both internal and external candidates.

Response D:

As the Director of an institute belonging to the University of Tokyo generally must be selected from the full professors within the institute under university regulations, it is actually difficult for us to include external candidates in the process of selecting a new Director. All Directors of the AORI have been selected via the conventional process, for all three elections that have been conducted following the last external evaluation in 2014 (that is, elections in January 2015, January 2017, December 2018, December 2020). Specifically, only full professors of the AORI were eligible for the elections and members of the faculty, including associate professors and lecturers, anonymously voted for the professor they wanted as the Director; the Director was then selected by majority vote.

Although two Vice Directors and two Advisers to the Director are assigned to support the Director's work, most of the Director's business hours are still unfortunately consumed by administrative tasks, work required for internal and external committees, and so on. Over the last few years, many committees within the university have been sorted and integrated, and now only managers, namely Deans and Directors, act as the members of most of the committees, which must further take the time away from the directors for the research and educational programs by themselves. However, as a result, professors and associate professors other than Deans and Directors can use more time for research and educational works. As the Director should decide the policy and direction of AORI with Vice Directors and Advisers, members of the AORI faculty should select the best person as the Director who could put the members of AORI together to more develop and evolve AORI as the center of

comprehensive atmosphere and ocean sciences in Japan and also in Asia. Thus the Director of AORI should concentrate her/his ability and time on leading and directing all the faculty members to develop a better center of excellence for the comprehensive atmosphere and ocean sciences, even if her/his own research and educational activities must be reduced instead.

E. New Building for the Division of Climate System Research

Comments: When the former ORI and the former CCSR merged to form the AORI four years ago, the new building that was constructed for the AORI was only large enough for the units of the former ORI. The new Division of Climate System Research in the AORI was housed in another building at the opposite end of the Kashiwa Campus, thus making communication and interaction between the ocean and atmospheric components of the AORI difficult. This served to negate one of the strongest reasons for the merger – the importance of strong interaction between the ocean and atmospheric scientists of the new AORI.

We recommend that the administration of the AORI should work with the University of Tokyo administration to develop plans for the construction of a new building, adjacent to the present AORI, so that the Division of Climate System Research will be co-located with the other divisions of the AORI.

Response E:

Since the last external evaluation in 2014, we have required a large amount of financial resources for the restoration of the International Coastal Research Center damaged by the tsunami in 2011. Therefore, it was difficult for us to secure the budget to construct a new research building or to extend the present AORI. Furthermore, utilization planning of the Kashiwa Campus changed during the period and the Institute of Industrial Science constructed research buildings and facilities in the northern area of the AORI, which is the area we had planned to use for our new building. Consequently, it is now impossible for us to construct a new building adjacent to the present AORI. When the present Director commenced in April 2019, extending the present AORI building to ensure space for the members of the Division of Climate System Research was considered and was estimated to cost about one billion yen. However, as we are not able to obtain this amount of money, even if we use all of the AORI's savings, we decided not to carry out an extension of the present AORI for the time being. It is also unlikely that we could successfully acquire the necessary funds from the University of Tokyo administration under the present circumstances, but we will continue to try to obtain the funds for the extension of the AORI. We currently submit a budgetary request to the

president of the University of Tokyo as one of the AORI future plans to extend the present AORI building to keep the space for the Division of Climate System Research as well as to create a new organization, Data Analytical Center. In parallel, we are now trying to create space by reconsidering the present space allocation for each laboratory and altering the organization of the AORI building under the present Director's Office. The new areas provided by the space re-allocation will be managed by the Director's Office to be used for future research projects and newly established laboratories.

10.2. Response to Key Questions

The external evaluation team was asked to provide a set of opinions that will serve as guidelines for the future development of the AORI following the 2010 consolidation, rather than an evaluation of the performances and activities of former departments, centers, etc. To do this, the team was asked to focus its evaluation and report on nine key questions. We have organized our report below based on those nine questions. Two team members were primarily responsible for the response to each question, so each team member had significant responsibility for three different questions. All team members discussed each of the questions, however, and everyone had input to our response to every question. The first three questions focused on institution research activities conducted for the three years since the 2010 consolidation took place.

Question 1. Does the AORI, following consolidation, have an organizational system appropriate to the promotion of innovative basic research on oceans and atmosphere?

The structure of the AORI has grown organically and opportunistically since the ORI's foundation in 1962 and the ORI's merger with the CCSR in 2010. The current structure is a hybrid of interdisciplinary/multidisciplinary centers and discipline-based divisions and departments. As of April 1, 2014, the AORI consists of three divisions, nine departments, three research centers, and the Center for International Collaboration. The basic building blocks of the divisions, departments, and centers are sections, which number approximately 40. Faculty membership of a typical section consists of a professor, associate professor, and assistant professor, plus or minus.

The evolving structures of the AORI and its predecessors have fostered excellent and innovative basic research on oceans and atmosphere. However, decreasing budgets since the de-nationalization of Japanese universities in 2004 have resulted in unprecedented stresses on the Institute. Furthermore, the global trend is that innovative ocean and atmospheric research is increasingly multidisciplinary, interdisciplinary, and/or transdisciplinary, which the AORI is exploiting primarily through an 'incubator', the Center for Earth Surface System

Dynamics.

In light of budgetary pressures and global trends, the question arises as to whether or not the current structure of the AORI is optimal for meeting the future objectives of the AORI. Form should follow function with regard to structure, and the AORI's function for the next five to ten years would ideally be determined through a strategic planning process as described above, which would provide a blueprint for allocation of staff and resources over a given time period.

As is the case at most universities, the AORI in general has a bottom-up decision-making process that is highly valued and admired by staff. Following the development of a strategic plan;

Recommendation 1.1: We recommend that implementation of the strategic plan described above be accompanied by a fit-for-purpose reorganization that results in a relatively flat, meritocratic, and flexible structure that can readily respond to changing external and internal circumstances.

The AORI currently has a Council consisting of the University of Tokyo and other Japanese scientists; the Council provides scientific guidance for the Institute. Peer institutions abroad are increasingly engaging philanthropists, business leaders, politicians, and celebrities to serve on formal advisory groups (e.g., Columbia Earth Institute External Advisory Council (http://www.earth.columbia.edu/articles/view/1006) and Leadership Council (http://www.earth.columbia.edu/articles/view/3125); NOC Advisory Council (http://noc.ac.uk/about-us/noc-advisory-council/members); Scripps Director' s Circle (https://scripps.ucsd.edu/giving/Directors-circle); Woods Hole Board of Trustees (http://www.whoi.edu/main/board-corporation)). Such advisory groups provide extraordinary opportunities to support institutions beyond traditional means. If such an external advisory board existed for the AORI, it could provide not only highly valuable independent advice on local and national societal issues of importance to the Japanese community, but could also give useful suggestions as to potential non-governmental sources offunds for the AORI and its research programs.

Response to Recommendation 1.1:

Please see Response A and A1, and also the response to Recommendation 1.2. below.

Recomendation1.2: We recommend that the AORI form a broad-based advisory group, complementing the current AORI Council and perhaps with the inclusion of some

international members, to increase support of the Institute in society beyond the University of Tokyo and MEXT.

The AORI and JAMSTEC are the major, dominant academic and governmental research institutions, respectively, for the oceanographic and atmospheric sciences in Japan. As such, the potential for significant synergy between the two is high. Graduate students are the lifeblood of academic research institutes, and those at the AORI are no exception. For 52 years, graduate students at the AORI and its predecessor entities have belonged to multiple graduate schools, currently five. Differing requirements for masters and doctoral degrees among the multiple graduate schools prevent a definition of what is unique about the AORI graduate degrees, does not build the AORI brand, and probably does not help in recruiting graduate students to the AORI. The multiple graduate faculties hosting the AORI academic staff inhibit multidisciplinary, interdisciplinary, and transdisciplinary efforts, which are increasingly where cutting-edge and innovative research and education are undertaken. This is especially important at the interface between science and the social sciences, which the UT Ocean Alliance has been attempting to address since 2007. The AORI is currently under fiscal stress, and these stresses do not appear to be diminishing; forming a Graduate School of Atmosphere and Ocean Sciences will be a major step in the AORI gaining more control over its destiny. Moreover, an AORI PhD program that would involve JAMSTEC scientists as adjunct faculty would capitalize on the strengths of both institutions, grow AORI student numbers, invigorate JAMSTEC, and foster increased collaboration between the AORI and JAMSTEC. Possible models include the world-leading MIT-WHOI Joint Program in Oceanography (http://mit.whoi.edu) and the CSIRO-UTAS PhD Program in Quantitative Marine Science (http://www.imas.utas.edu.au/qms).

Response to Recommendation 1.2:

We do not have a broad-based advisory group in the AORI at present. However, more than half of the AORI's Conference Committee (see page 6 of the AORI's catalog) are external members from the University of Tokyo, which is the same as that in 2014 when the last external evaluation was carried out. Although all the Conference Committee members are Japanese, about half of the External Evaluation Committee are selected from outside of Japan. The external evaluation has been carried out once every 6 years to guide the direction of the AORI in medium term. The External Evaluation of AORI is the best opportunity for us to receive advices from both inside and outside of Japan. Although it is not an own organization of AORI, the University of Tokyo Global Advisory Board (https://www.u-tokyo.ac.jp/en/about/president_council.html) gives advices on future development of the university from broad and high places. The advices are utilized for AORI's strategic plan and

management, such as usage of external monetary resources, gender balance, inclusion, etc.

Recomendation1.3: We recommend that the AORI work with the University of Tokyo toward the formation of a Graduate School of Atmosphere and Ocean Sciences, and that appropriate scientists from JAMSTEC be involved in this new school as adjunct faculty.

This new graduate school will enable the AORI to offer unique masters and doctorate courses. It will also give clarity to what masters and doctorate degrees awarded to AORI students mean; enhance recruitment of top-quality graduate students; build the AORI brand; build links among the various AORI divisions, departments, and centers; foster interdisciplinary and transdisciplinary education and research; position the AORI as the natural leader of the UT Ocean Alliance; take advantage of the expertise in JAMSTEC; and allow for the development of joint graduate programs with other organizations.

Response to Recommendation 1.3:

We acknowledge to the recommendation of establishing new graduate school. However, establishing a Graduate School of Atmosphere and Ocean Sciences within the University of Tokyo is not realistic under present circumstances and the regulations set by MEXT. Faculty members of AORI have officially as acted as cooperative faculty members supervising graduate students within four graduate schools at the University of Tokyo, namely, the Graduate Schools of Science, Agricultural and Life Sciences, Frontier Sciences, and Art and Sciences. Six faculty members of the Graduate School of Frontier Sciences belong to research departments of the AORI as concurrent faculty members and engage in both education and research activities through close collaboration between the AORI and the graduate school. In the University of Tokyo, we have many scientists studying issues related to atmosphere and ocean sciences and they belong to various departments other than the AORI. Previously, these members conducted educational and research activities independently of AORI. However, since 2009, we have organized the Ocean Alliance in the University of Tokyo, which is a cross-cutting educational and research organization, and have cooperatively educated graduate students in the educational program ”Interdisciplinary Education Program on Ocean Science and Policy”. We have invited domestic and international visiting scientists, including from JAMSTEC, to further improve the research and education provided in this program. We consider it a better decision not to establish new graduate school of atmosphere and ocean sciences but further collaborate with scientists in other departments.

One of advantages of AORI to other institutions is the diversity of faculty members and students belonging to 4 different graduate schools of the University of Tokyo. This makes it possible to have close communication between scientists belonging to different disciplines. In fact, we have been obtained funding for research and personnel expenditure for transdisciplinary projects of which the University of Tokyo is promoting. We will continue our efforts on close communication beyond scientific disciplines and to establish new research projects to solve emergent scientific issues in the Anthropocene.

The AORI and JAMSTEC have been maintained close relationships by the collaborative management of the research vessels. As Joint Usage/Research Center on atmosphere and ocean sciences, the AORI conducts selection of the proposals for *R/V Hakuho Maru* and *R/V Shinsei Maru*, and JAMSTEC operates the vessels. From 2018, the AORI also conducts the proposal selection of support vessel *Yokosuka* (for manned submersible SHINKAI 6500 and towed ocean floor survey system DEEP TOW) and *R/V Kairei* for Joint Usage. Exchange in scientists between the AORI and JAMSTEC is quite active. Several JAMSTEC scientists moved to the AORI as faculty members, and JAMSTEC is one of major organizations of employments for students and postdocs of the AORI. We have been invited domestic and international visiting scientists for joint research, including JAMSTEC scientists. The exchange of scientists plays important role of developing joint research. It is natural way for both the institutions to accelerate joint activities through the operation of RVs and human exchange. In addition, some scientists who worked at the National Institute of Advanced Industrial Science and Technology, Meteorological Research Institute, and Japan Fisheries Research and Education Agency have become faculty members at the AORI. Thus, collaborative education and research with external institutions is being promoted now more than ever.

Question 2. Has the AORI secured appropriate researchers as a world leading research center in atmospheric and marine sciences and has it begun to produce world-class research outcomes? Advice for further improvement would be appreciated.

The AORI has a strong cohort of faculty members, many of whom are internationally renowned for their research in atmospheric and oceanographic science. A demographic bulge in faculty members will result in a turnover of approximately one-third of the members over the next decade, providing the opportunity for significant staff and scientific renewal.

Recomendation2.1: We recommend that faculty renewal be aligned with an AORI strategic plan as outlined above.

The AORI currently has approximately 65 faculty members and 80 post-docs. Of the 65 faculty members, approximately two-thirds are alumni of the University of Tokyo and one is foreign-

born (but obtained a PhD at the University of Tokyo). Such a staff profile is unique among the world's major atmospheric and oceanographic research institutions. Furthermore, five percent or less of open faculty positions are advertised internationally. The AORI's heavy reliance on the University of Tokyo alumni specifically and the Japanese talent pool (<2% of the world's population) in general stands in marked contrast to the increasing internationalization of peer institutions abroad, and within the oceanographic sciences. Recognized challenges to internationalization of the AORI include language, culture, and lifestyle. Nevertheless,

Recomendation2.2: We recommend that the AORI develop and implement an internationalization strategy to exploit the global pool of talent in the atmosphere and oceanographic sciences.

Response to Recommendation 2.1 and 2.2:

Selections of the faculty members of the AORI are all through public invitation in principal, and we try to select the best person for the position from the corresponding field over the world. What kind of talented person should be selected for the vacant position is decided by the Personnel Committee and the special working group under the faculty meeting of the AORI. We consider social needs, the situation of the whole atmosphere and ocean sciences, the scientific situations of the corresponding field and the strategic plan of the AORI as well as candidates' scientific achievements. Careful considerations are needed if her/his skill in Japanese is quite limited since role-sharing by faculty members is essential for education and sustainable administration of the AORI in the present situation with continuous reduction of the fixed number of faculty members whose salaries are supported by the University of Tokyo.

International collaboration with established and emergent scientists from all over the world is essential for the AORI to proceed with cutting edge sciences and to be one of the centers of excellence in atmosphere and ocean sciences. As mentioned in the response to Recommendation 2.3 (see below), we recognize international collaboration is a key factor enhancing scientific impacts of AORI.

Institutional strategies for accelerate the international collaboration are 1) exchange MoU for scientific collaboration, 2) invite scientists as visiting Professors/Scientists. The AORI exchanges the MoU with 20 universities and institutions (Table 7-1). From 2014, the AORI exchanged new MoUs with 7 institutions. The collaborated activities carried out after 2014 were 7 joint symposiums/workshops, inviting scientists for the cruises of *R/V Hakuho Maru* and *R/V Shinsei Maru*, exchanging scientists and students including sabbatical stay and preparing postdoc positions. Visiting Professorship (terms from 1 to 12 months) is a unique scheme of the AORI which cover their travel and salary (or accommodation fee during the

stay) by the AORI's own funding. In the past 6 years from 2014, the AORI invited sum of 46 scientists for 138 months from 13 countries. The benefits of Visiting Professor system are not only collaborated studies but also giving inspiration and supervision for students and young scientists.

More than half of the faculty have experienced overseas institutions, as a member and/or as a student (39 of 74). In total, nine faculty members obtained PhD (5), Master's (4) or Bachelor (2) degrees in foreign countries. This tight relationship between the AORI's faculty members and their alumni associations in foreign countries works as a driver of international collaboration at the AORI. The number of graduate students from foreign countries increased from 19 in 2014 to 39 in 2020 (Catalog, page 26), and the percentages of international students enrolled in Master's and Doctoral courses in 2020 were 16% and 35%, respectively (Fig. 10-1). After graduation, many of them are now important counterparts of the AORI's international collaboration.

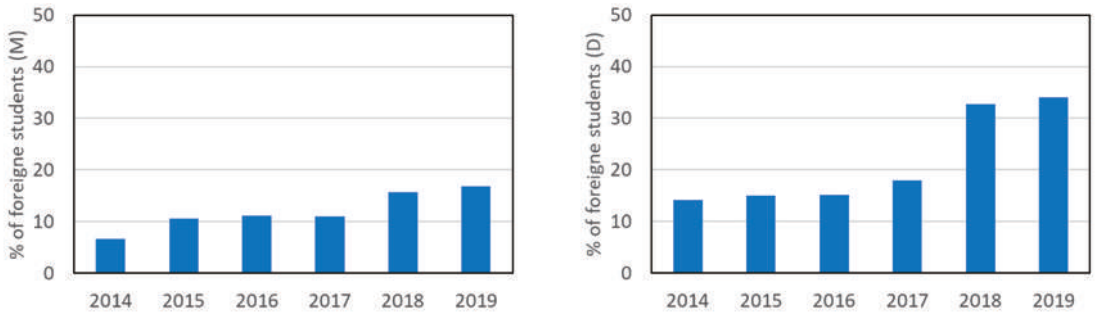


Fig. 10-1 Percentages of foreign students in a Master's course (left) and Doctoral course (right).

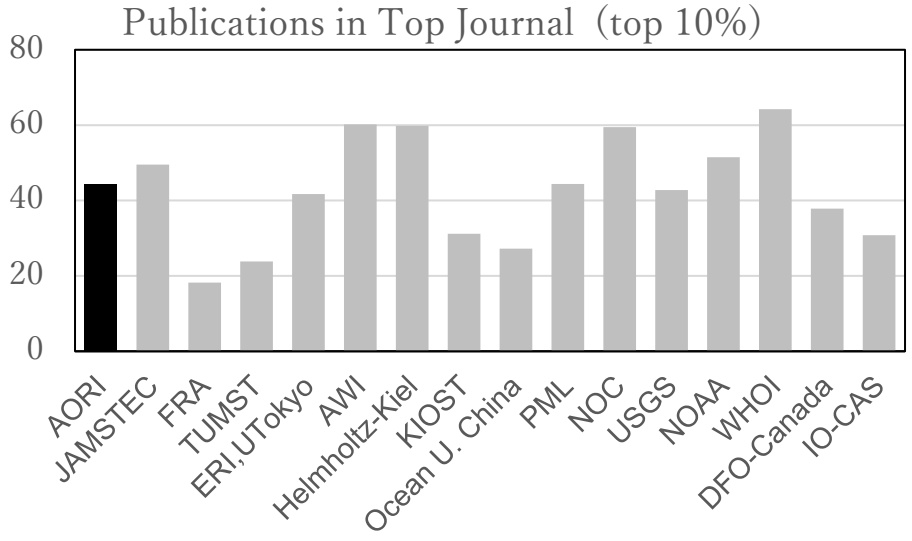
In a 2011 assessment of the global top 30 research institutions in oceanography conducted by Thomson Reuters, based on citation impact for highly cited papers (10 or more), the University of Tokyo ranked 12th, a highly respectable showing (http://www.timeshighereducation.co.uk/416012.article). However, publication and citation metrics vary by discipline and sub-discipline, and it is challenging to assess such metrics in detail in the absence of benchmarks. Furthermore, such metrics are imperfect in assessing an individual' s total contribution to science. However, publication and citation metrics for a significant minority of associate professors and professors are not at the level that would warrant appointment to similar positions at peer institutions abroad.

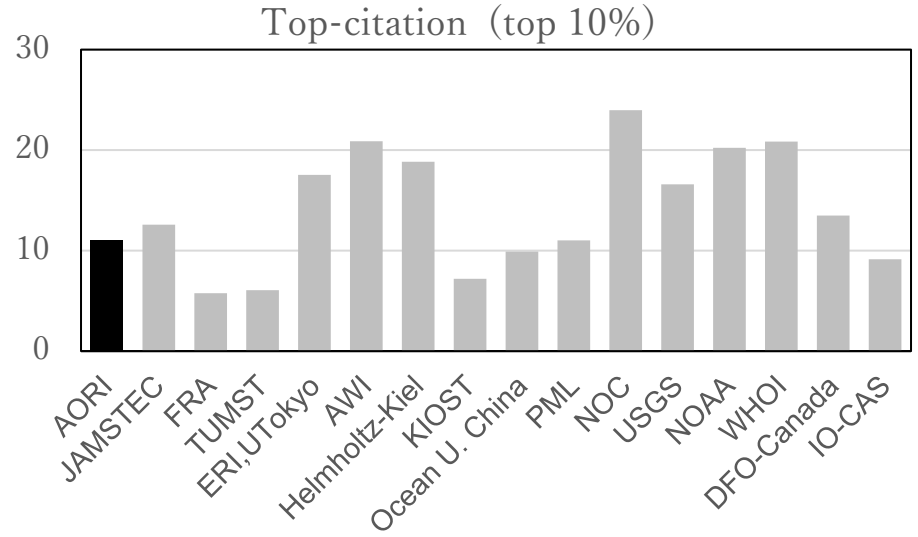
Recomendation2.3: We recommend that the AORI undertake a periodic benchmarking exercise against other leading atmospheric and oceanographic research institutions, e.g., GEOMAR Helmholtz Center for Ocean Research Kiel, National Oceanography Centre (UK), Scripps Institution of Oceanography, Woods Hole Oceanographic Institution, etc., to assess where it stands relative to peer institutions around the globe.

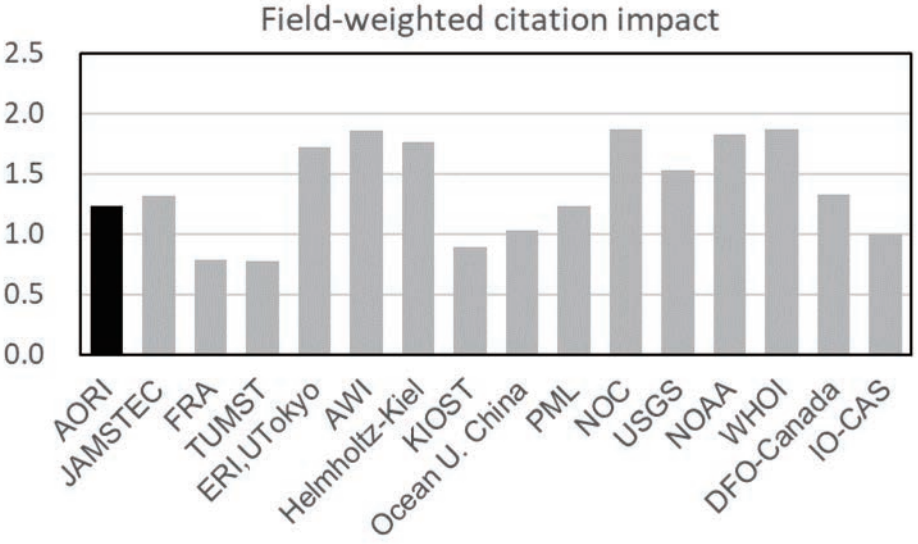
Response to Recommendation 2.3:

As described in Chapter 2.1, the faculty member published 4.4 papers per year to peer reviewed journals, and 70% was published in top 25% journals. Mean *h*-index of the faculty is 18 (from 5 to 55). There are 23 top 1% highly cited papers from 2014.

We summarized scientific performance of AORI with other leading atmosphere and ocean research institutions in the world by means of SciVal (Elsevier) for 2014-19 (Fig. 10-2). Publications in Top Journal Percentiles (top 10% by CiteScore Percentile) was 44%, publications in top citation percentiles (top 10%, field-weighted) was 12.2%, field-weighted citation impact was 1.23, and citation per publication (after 2015) for papers 13.3. These values are similar to or higher than those in Japan and Asia but lower than top institutions in the world such as WHOI, NOC. The publications based on international collaboration was 41%. Since the impact of the paper (field-weighted citation impact: 1.74) was higher than those by national collaboration (<0.94), accelerating international collaboration is one of the ways for increase the impact of AORI's scientific activities (Table 10-1).




Top-citation (top 10%)
30
20
10
0
AORI
JAMSTEC
FRA
TUMST
ERI,UTokyo
AWI
Helmholtz-Kiel
KIOST
Ocean U. China
PML
NOC
USGS
NOAA
WHOI
DFO-Canada
IO-CAS


Field-weighted citation impact
2.5
2.0
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AORI
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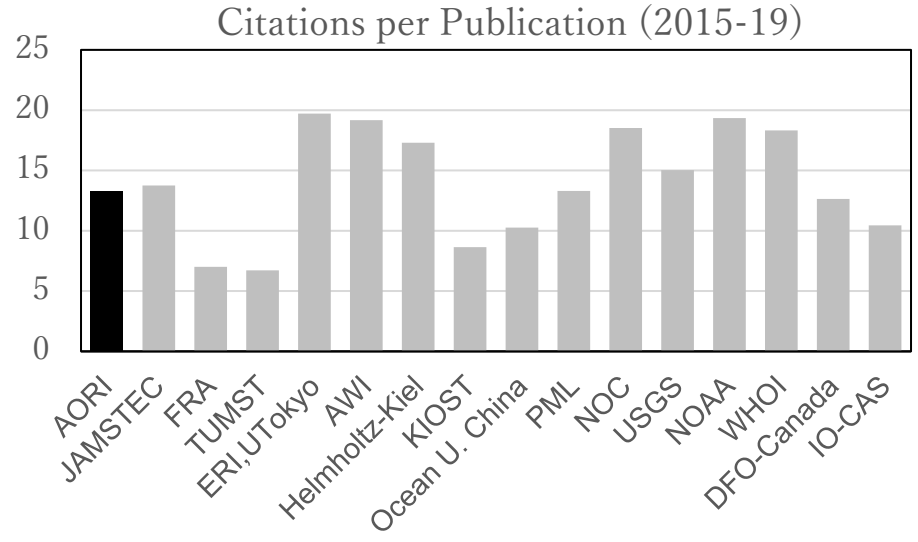
WHOI
DFO-Canada
IO-CAS


Citations per Publication (2015-19)
25
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AORI
JAMSTEC
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AWI
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KIOST
Ocean U. China
PML
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WHOI
DFO-Canada
IO-CAS

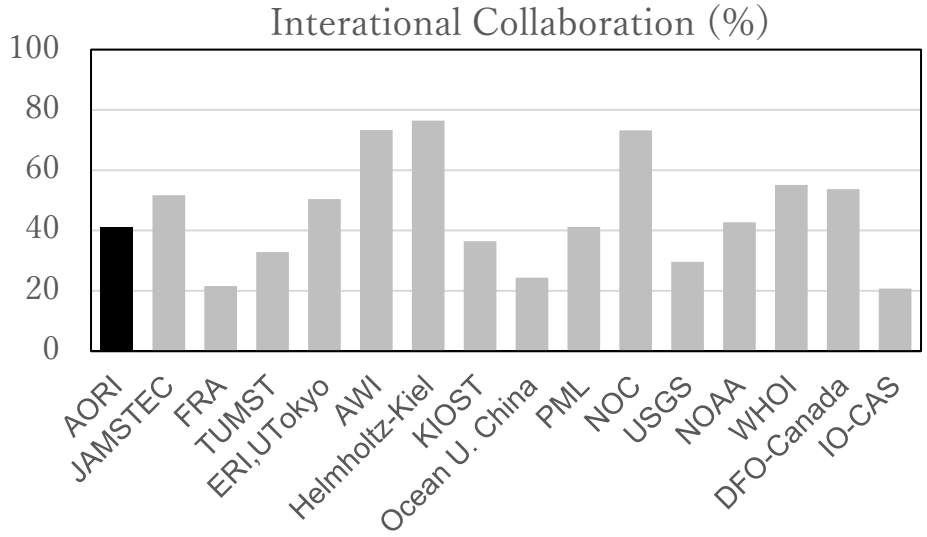


Fig. 10-1 Benchmarking exercise of AORI against other leading atmospheric and oceanographic research institutions (FRA: Fisheries Research and Education Agency, Japan; TUMST: Tokyo University of Marine Science and Technology, Japan; ERI: Earthquake Research Institute, UTokyo; AWI: Helmholtz Centre for Polar and Marine Research. AWI, Germany; Helmholtz-Kiel: GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany; KIOST: The Korea Institute of Ocean Science and Technology, Korea; Ocean U. China: Ocean University of China; PML: Plymouth Marine Laboratory, UK; NOC: National Oceanography Center, UK; USGS: U.S. Geological Survey; NOAA: National Oceanic and Atmospheric Administration, USA; WHOI: The Woods Hole Oceanographic Institution, USA; DFO: Fisheries and Oceans Canada; IO-CAS: The Institute of Oceanology, Chinese Academy of Sciences)

Table 10-1 Impacts of papers by collaborations

	%	Papers	Citations	Citations/ Paper	Field-Weighted Cit. Impact
International collaboration	43.40%	706	9,434	13.4	1.73
Only national collaboration	45.90%	747	6,521	8.7	0.94
Only institutional collaboration	9.20%	149	903	6.1	0.77

Single authorship (no collaboration)	1.50%	24	33	1.4	0.37

The contribution of the AORI faculties to atmosphere and ocean sciences are highly esteemed. The AORI faculties received many awards from 2014 including the Medal with Purple Ribbon (1), the Prime Minister's Commendations for Contributors to Promote the Country as a "Maritime Nation" (6), the Prize for Science and Technology (5) and the Prize of Young Scientist (4) from the Minister of Education, Culture, Sports, Science and Technology. Also, in international academic arena, receiving the Ordre national du Mérite, France (1), Yoram J. Kaufman Award (AGU, 1), IODE Achievement Award (1), Honorary Doctorate (3). Several faculties are elected as Fellows of scientific associations (AGU: 2, The Geol. Soc. America 1, European Geosci. Union 1). Several members contributed as chair/president and or deputy chair of international organizations such as PICES, UNESCO/IOC, IODE, etc.

Question 3. Evaluation an advice regarding the initiatives, activities, and future direction of the Center for Earth Surface System Dynamics established at the foundation of the AORI would be appreciated.

Recommendation 3.1: We recommend continuing the current highly successful activities of the CESD and its plans for further development over the next decades.

Response to Recommendation 3.1:

Please see Chapter 3.5.2

Question 4. Have the activities of the AORI, in terms of its role as a national joint usage and research center, been functioning adequately? Has the AORI been functioning adequately as a center of atmospheric and marine science research? What is expected of the AORI?

The AORI has actively provided various joint usage programs in marine and atmospheric sciences throughout Japan. The most significant program has been providing research ship opportunities for researchers from outside of the AORI, using the two research vessels R/V Hakuho Maru and R/V Tansei Maru. The Tansei Maru has recently been retired and replaced by the Shinsei Maru. The other excellent activity is the visiting researcher program at the Kashiwa campus and at the ICRC, located in the town of Otsuchi.

The Interdisciplinary Collaborative Research Committee is an open-type joint research framework launched in 2011. It has provided opportunities for individual researchers and groups of researchers across Japan to collaborate with AORI faculty members. This has occurred through specified joint research topics provided by the Committee and through general joint research topics provided by individual researchers or groups of researchers inside or outside of the AORI.

The Center for Cooperative Research Promotion supports cruise coordination, field research, laboratory research, and coastal research. The 2011 off the Pacific coast of Tohoku Earthquake on March 11, 2011, significantly damaged the ICRC at Otsuchi. However, with great effort, the center is now providing support to joint usage/research through restored research vessels. Due to budget cuts, the overall number of technical staff at the AORI has decreased, but the remaining staff have been assisting each other in acquiring the necessary skills to ensure that the necessary support can still be provided.

Two research vessels, R/V Hakuho Maru and R/V Tansei Maru, were transferred to JAMSTEC in April 2004. Since then, the AORI has publicly advertised and considered research plans and has formulated voyage plans for the two vessels across the country. JAMSTEC has operated the vessels in accordance with plans coordinated by the AORI.

The Tansei Maru was retired from service in late January 2013 and the replacement vessel, the new Shinsei Maru, was launched in June 2013. The aging R/V Hakuho Maru, which was launched in 1989, is another significant concern, as it will require replacement in the near future.

The R/V Hakuho Maru is used for long, deep-water research voyages, while the R/V Shinsei Maru is used for short research voyages around the Japanese islands lasting from a few days to two weeks. The voyage plan for R/V Hakuho Maru is formulated every three years, and that for the R/V Shinsei Maru is determined following a public advertisement and examination process. A letter of agreement made when the vessels were transferred from the ORI to the JAMSTEC in 2004 committed both R/V Hakuho Maru and R/V Tansei Maru (superseded by R/V Shinsei Maru) to be at sea for 300 days a year. However, due to rising fuel costs and reduced budgets, JAMSTEC has not been able to maintain this commitment, and in fact, the number of days of ship support has decreased year after year.

Recommendation 4.1: We recommend that the AORI work with MEXT and JAMSTEC to ensure that R/V Hakuho Maru and R/V Shinsei Maru each operate 300 days per year by giving special priority to conducting the national joint usage program as committed

to in the 2004 letter of agreement.

Response to Recommendation 4.1:

Due to reducing governmental budgets, it has been difficult for JAMSTEC to maintain fuel and operation costs for the full 600 days of operation of the *R/V Hakuho Maru* and *R/V Shinsei Maru*. As a result, the number of days of operation for each vessel is kept at a maximum of 175. Under these serious circumstances, *R/V Yokosuka* and *R/V Kairei*, operated by JAMSTEC, have been included in the cooperative research system. Under this system, 20 days of operation is permitted for each vessel (total maximum of 50 days); this arrangement has been in place since 2018. Thus, in total, we are able to provide 400 days of operation from the ideal 600 days of operation. As mentioned above, *R/V Hakuho Maru* is 31 years old and the process of large-scale repairs to ensure another 20 years will start in 2021. Next operation is planned to start in 2022.

Among 783 presentations made at the Spring Meetings of the Oceanography Society of Japan between 2008 and 2012, 17% utilized the two research vessels. Over the past five years, R/V Tansei Maru generated results in at least 10 peer-reviewed papers and R/V Hakuho Maru in 30 published papers per year. Immediately following the 2011 off the Pacific coast of Tohoku Earthquake, R/V Tansei Maru and R/V Hakuho Maru acquired many samples associated with ecosystems, the seafloor environment, and the dispersal of radioactive substances during the early days following the earthquake.

Joint usage research voyages involving R/V Tansei Maru and R/V Hakuho Maru have played an important role in graduate education in Japan. Over the past several years, approximately 30% of the researchers aboard both vessels were graduate students. These vessels made significant contributions through interactive shipboard education and through assisting students to collect data for their masters and doctoral theses. Marine science is a highly interdisciplinary field and spending an extended period of time on the same vessel and engaging in discussions with leading researchers from other fields are valuable experiences for the future leaders of marine science.

The AORI received the highest "S" rank in its 2013 interim assessment on joint usage/research conducted by MEXT. The AORI was also the recipient of a good rating in its year-end assessment, and it has been awarded ongoing status as a Joint Usage/Research Center for the next year.

All nation-wide shipboard joint usage programs have been successfully conducted since the

amalgamation of the former ORI and CCSR in 2010. They have clearly provided excellent support to researchers and have helped train graduate students who will be responsible for the future of our science. These programs have provided great benefits to both the national research community as well as the internal AORI community. We strongly believe that these joint usage programs should be continued in the future. However, we believe that their operations should be evaluated thoroughly when considering their continuation over the next decade.

Recommendation 4.2: We recommend that the data collected by the joint research cruises be kept in a database at the AORI or another suitable location.

Response to Recommendation 4.2:

Since the R/Vs *Yokosuka* and *Kairei* have been included in the cooperative research system, policies regarding data and samples obtained by the cooperative research cruises have been established and all scientists are required to adhere to these policies. In general, JAMSTEC keeps the data and samples with the cooperation of each scientist on board, and JURCAOS (Joint Usage/Research Center for Atmosphere and Ocean Science) and JAMSTEC jointly own the data and samples. The details are described in the application form and on the web site (https://www.aori.u-tokyo.ac.jp/coop/files/besshi_3_2019.pdf, in Japanese).

Question 5. We are eager to produce a regular cohort of outstanding postgraduate students. Advice on our current efforts in postgraduate education would be appreciated.

Recommendation 5.1.: We recommend continuation of all these efforts. However, since several years have passed since their introduction, we recommend reviewing their effectiveness either through questionnaires or by interviewing graduate students and then considering any necessary improvements.

Recommendation 5.2.: We recommend that this proposal be carried out as a good opportunity to deliver new knowledge emerging from interdisciplinary studies in the marine and climate sciences, and also as one of new strategies to strengthen participation of good undergraduate students in the AORI.

Recommendation 5.3.: We recommend that the AORI seek to discover the reason(s) behind this recent decrease in MS students and make efforts to grow the cohort of MS students.

Recommendation 5.4.: We recommend that the Director's Prize be continued.

Recommendation 5.5: We recommend that efforts should be made to obtain the external funds necessary to hire more postdocs.

Response to Recommendation 5.1-5.5:

Decrease in graduate students is observed throughout Japanese universities in this two decade due to various reasons such as declining population, economic stagnation, relatively low incentive of having higher academic degrees for obtaining jobs, etc. In the situation, the AORI carried out several activities to recruit outstanding students.

The External Evaluation Committee 2014 was eager to produce a regular cohort of outstanding postgraduate students. However, the AORI has two distinct disadvantages compared to the faculty members at the Hongo Campus with respect to enhancing the participation of outstanding undergraduate students in its programs: the first is a significant geographical disadvantage, as it takes approximately 1.5 hours and costs about ¥1,500 to travel between the Hongo and Kashiwa Campuses; the second is that the faculty members of the Graduate School of Science at the Kashiwa Campus are less known to undergraduate students than those at the Hongo Campus. Therefore, to overcome these disadvantages and successfully enhance the participation of outstanding undergraduate students in the AORI, we have continued to conduct all-campus independent seminars and all-campus hands-on experience seminars for first- and the second-year undergraduate students by informing them of the wide range of research activities at the AORI. Furthermore, to foster open communication and spur undergraduate students' interest in atmosphere and ocean science, we started the Kashiwa Campus Science Camp in 2014.

The Atmosphere and Ocean Sciences Internship Program (AORI Internship Program) provides good opportunities for third-year students to communicate with the AORI faculty members and learn the importance of taking graduate courses at the AORI. This kind of program has been mainly held in March for the last 10 years. Moreover, we started the Summer AORI Internship Program in 2018. Finally, we have held "Guidance for Graduate School at the AORI" since 2018 for possible candidates who are interested in taking the entrance examination for the graduate program in autumn and summer.

At the end of each academic year, a symposium presented by those who are earning their PhD is held to share their research with members at the AORI. Faculty members evaluate the presenters and award the Director's Prize to an outstanding student. After the symposium, an official party to celebrate the graduation, is held at the AORI attended by all members.

In 2020, COVID19- pandemic changed the educational situation, and the University of Tokyo decided to carry out all the lectures through on-line during spring and summer semesters. From September 2020, some lectures are carried out by means of hybrid with on-line. The pandemic eventually propelled remote attendance to lectures and many students of AORI benefited from on-line lecture in terms of efficiency and the cost. On the other hand, having face-to-face lecture is quite significant to know passions of faculties on science and also to decide their supervisor and mentors. Science camp and Internship Program continued in summer 2020 under the pandemic by means of virtual programs. Although it is unpredictable the future situation of the pandemic at present, AORI will continue to put efforts to improve the commuting difficulties.

The University of Tokyo asks students various questions to investigate their satisfaction with education and problems, including financial situation, education under COVID-19 pandemic, etc. We are planning to conduct question surveys to improve educational and scientific activities including special activities we took under the COVID-19.

Question 6. What requests and expectations does the international community have of the AORI regarding international joint research and exchanges, human-resource development and contribution to international organizations?

Recommendation 6.1.: We recommend that CIC expand its efforts in education and research exchange in Asia in general and in Southeast Asia in particular.

Recommendation 6.2.: We recommend that the CIC and other AORI professors should be leaders in the development of the Future Earth Program in Japan, the new International Ocean Discovery Program, the IPCC, IOC, PICES, and other international research activities.

Recommendation 6.3.: We recommend that CIC begin to consider ways to encourage other faculty to become actively involved such that the future of CIC and its programs is secure. Individuals with interest in both science and policy related

issues would be particularly valuable as future leaders.

Response to Recommendation 6.1-6.3:

Please see Chapter 7.2. as well as 10.2.4, where the responses to these comments and the relevant issues are explained in detail.

Question 7. Advice on the AORI's public relations and educational activities would be appreciated, including whether the AORI has provided the broader society with useful scientific findings, which serve as a foundation for government policies.

Recommendation 7.1: We recommend that the AORI should build a database of student and faculty alumni, complete with present address and professional position.

Recommendation 7.2: We recommend that the AORI should hold regular alumni events to build esprit de corps and loyalty. Interactions with these alumni can also be inspiring to current students.

Recommendation 7.3: We recommend that the AORI utilize alumni, including retired faculty, to support efforts to maintain and enhance government and private support for the Institute, and to recruit new graduate students.

Recommendation 7.4: We recommend that the AORI determine what fraction of other research institutions, JAMSTEC for example, are alumni of the Institute.

Response to Recommendation 7.1-7.4:

There are alumni associations and databases in the University of Tokyo and each Graduate School (https://www.u-tokyo.ac.jp/en/alumni/alumni.html). Also, there is an UTokyo Overseas Alumni Associations (https://www.u-tokyo.ac.jp/en/alumni/alumni_association.html). The Alumni Association hold various events every year. Established AORI's alumni association is a remaining issue from last external evaluation. The Director's office considered the strategy how to engage and collaborate with alumni in the AORI, and have started to make AORI Alumni Directory of the AORI alumni association as the first step by the end of 2020.

Recommendation 7.5: We recommend that the AORI continue and strengthen its involvement in the UT Ocean Alliance, and use it as a link to support good public policy.

Recommendation 7.6: We recommend that the AORI utilize its involvement in the UT Ocean Alliance as a means to motivate and recruit students who have a demonstrated interest in ocean and atmospheric sciences. With their multidisciplinary background, such students would be well placed to address issues of national importance in interconnected atmosphere, ocean and living systems.

Response to Recommendation 7.5,7-6:

Please see Chapter 3.4 and 4.3.

Recommendation 7.7: We recommend that the AORI should continue, and if possible expand, its excellent effort in public engagement and outreach.

Recommendation 7.8: We recommend that the AORI may wish to consider publishing a magazine similar to "Oceanus" that is published by the Woods Hole Oceanographic Institution and that can be purchased through a publisher.

Recommendation 7.9: We recommend that if the AORI is to connect to prospective students, it must develop a robust and active presence on Facebook and other social media. Undergraduate students are almost universally focused on social media as a source of information.

Recommendation 7.10: We recommend that the AORI should explore other vehicles for conducting, connecting, and collaborating in research and outreach that has a demonstrated connection to the public good.

Recommendation 7.11: We recommend that the AORI develop collaborations with social sciences and design disciplines such as architecture and engineering to support coastal community design that creates hazard resiliency, reduces environmental impact, and supports healthy economic development.

Recommendation 7.12: We recommend that the AORI build mechanisms for discovering what is of public need, interest, and concern, and for redirecting research, educational, and outreach efforts to address novel, emerging needs,

challenges, and opportunities that face people who live and depend along coasts.

Recommendation 7.13 : We recommend that the AORI should continue to find additional ways to serve national and local government, both to serve the public good and to increase the esteem and value that public officials have for the Institute.

Response to Recommendation 7.7-7.13:

Response: Please see Chapter 8 Science and Society as well as Chapter 6.2 and 6.3.3 where the responses to these comments are described in detail.

Question 8. Advice would be appreciated regarding where there is room for improvement in AORI's research support system when compared with other research institutions inside and outside the country.

Recommendation 8.1.: We recommend that new technical staff directly related to

physics be employed.

Recommendation 8.2.: We recommend that an AORI Technical Report be published each year and that all technical support staff contribute to it.

Response to Recommendation 8.1-8.2:

As described in 5.1.4, it is quite difficult to employ new technical staff of specific discipline due to continuous reduction for employment expenditures from the Headquarters of the University of Tokyo. We ask our faculty members to employ own technical staff by project funding. Our technical staff of Center for Cruise Coordination (CCC) are well skilled to operate CTD and sensors attached with CTD system. CTD and water sampling system are well maintained which make it possible to efficient field observation on research vessels. They largely help research cruises of cooperative research vessels (*RV Hakuho-Maru*) because PIs and scientists on board are not always familiar with the usage of equipment on board. We receive acknowledgements for the skills and support of our staff from the scientists on board. At the same time, we understand growing need of technical support for new instruments and sensors other than CTDs. To fulfill the request is remaining issue with considering budgetary status of the AORI (also see Chapter 5.1.4). With respect to Technical Report, although peer reviewed papers on observation/analysis techniques are published every year, it is not realized to publish technical report series, partly due to relatively small number of technical staff members in the AORI. In order to improve skills of technical staff members of CCC, the AORI has been carried out "technical check cruise" of *R/V Hakuho Maru* every year. From 2018, the AORI accepts technicians and scientists outside of the University of Tokyo to disseminate the AORI's field observation technique on board.

Question 9. The International Coastal Research Center, which was badly damaged by the 2011 off the Pacific coast of Tohoku Earthquake, has been nearly restored to its pre-disaster condition, and has resumed a research project on the secondary transition of the coastal ecosystem by reviewing the organizational system (see the evaluation document). Advice on our future course of action would be appreciated.

Recommendation 9.1.: We recommend that studies be carried out on the mutual interaction of ecosystems and material cycling changes in Otsuchi Bay, and that the results of the studies in Otsuchi Bay be compared with results in other bays along the Sanriku coast.

Recommendation 9.2.:We recommend that a study be conducted on changes to

ecosystems and material cycling around the waterfront in the coastal low land area, the transition area between land and coastal sea.

Recommendation 9.3.:We recommend that the ICRC propose a concrete action plan for the recovery of economic activities, especially fisheries, in the Sanriku coastal area based on the results of its scientific research.

Response to Recommendation 9.1-9.3:

Please see 6.2., where the responses to these comments are described. Future perspectives relevant to the activity in ICRC is as follow:

The primary mission of the ICRC is to be a domestic and international leader in coastal marine science. Although the coastal ecosystems in Japan are small, they cover a wide spectrum of latitude, topography, freshwater inflow effects, and nutrient loads. Therefore, Japan, especially the Sanriku area, is excellent for performing comparative studies. Nevertheless, it is necessary to expand research activities beyond Otsuchi Bay to other areas in Sanriku, including the subtropical coasts, where warm currents such as the Kuroshio are dominant, in order to understand the oceanographic characteristics of the Japanese coast. To this end, cooperation with other facilities, both domestic and foreign, will soon be required. We must simultaneously continue monitoring and researching the recovery process from the disaster, because besides the ongoing recovery process, the landscape is changing owing to the resettlement of urban areas and construction of giant seawall. In particular, the Sanriku coastal area has high demand for disaster prevention and mitigation against earthquakes and tsunamis. Therefore, the ICRC must function as an earthquake-monitoring facility in cooperation with an earthquake research organization.

Finally, the School for Marine Science and Local Hope in the Sanriku Coastal Area has only just started. These activities must continue for several decades in order to foster subsequent generations to design local sustainable communities and foster hope. In particular, the ICRC would like to actively develop educational activities by conducting more events, such as interactive classes, in order to nurture future marine researchers. The ICRC would like to clarify that scientific research institutions have an important social role in rural areas that have experienced drastic depopulation. As mentioned above, we have successfully obtained a fund from the University of Tokyo to conduct a new project “Subtropical-Kuroshio environmental study project -understanding the evolving environmental-cultural baseline in a changing world” and will start the project in fiscal 2021, which could expand research and outreach activities recently developed in the subarctic Sanriku Coast Area to the subtropical areas.

11. Future Plans

11.1. Direction of research

The AORI was founded upon the following principle: to establish a scientific basis for the future of humanity and our global environment by elucidating the complex interactions between the atmosphere, oceans, and organisms that live therein, as well as their evolutionary and fluctuation processes, from the earth's origins to the present day.

Atmosphere and ocean sciences, which play fundamental roles in the pursuit of this overarching mission, investigate various phenomena in physics, chemistry, geology and geophysics, biology and ecology, and bioresources related to the atmosphere and oceans, as well as the complex interactions between these phenomena. To provide answers to the questions we have, it is essential to investigate elementary processes in each scientific discipline and to obtain a comprehensive understanding of these academic fields as one integrated system. The exploration of these basic processes by our four research divisions depends upon the creativity, ingenuity, and energy of the current individual faculty members and requires the fostering of future leaders in cutting-edge atmosphere and ocean sciences.

Towards the aim of an integrated understanding of the atmosphere and oceans as one system, the CESSD was founded when the AORI was integrated in 2010. In the second term of the CESSD since FY2016, we defined the future plans of the CESSD based on the following four themes: 1. multi-scale processes of the atmosphere-ocean interaction; 2. interdisciplinary studies of marine ecosystem dynamics; 3. multiple approaches to life evolution and environmental change; and 4. creation of paleoclimate change dynamics integrating models and data. Based on these themes, with mutual collaborations between the AORI members, we have proposed research projects to the University of Tokyo and MEXT, and six corresponding projects have been approved. In the future, to enhance the core research in these research projects, we will enhance collaborations between the research themes with the aid of all AORI members; this will allow AORI members to develop active roles in the joint research center of the AORI, leading to top level scientific research which will lead the international community. Toward the third term of the CESSD, after 2022, we will continue to establish new core research projects within the AORI. One of the candidate projects is the "Ocean DNA project", which has now been developed in collaboration with key faculty members and will be established as a global research project.

The ICRC intends to lead coastal marine science domestically and internationally through comparative studies of diverse coastal environments in Japan. Therefore, it is necessary to expand the research activities that have long been concentrated around Otsuchi

Bay to other areas in Sanriku as well as along the subtropical coasts where warm currents such as Kuroshio are dominant; this will aid in further understanding of the oceanographic characteristics of the Japanese coast. As the first stage, the AORI developed a research partnership agreement with the Tropical Biosphere Research Center, University of the Ryukyus, in 2018 to prepare a system for the ICRC to promote comparative studies between ecosystems from subarctic and subtropical coasts. Also, we have successfully obtained a fund from the University of Tokyo to conduct a new research project "Subtropical-Kuroshio environmental study project -understanding the evolving environmental-cultural baseline in a changing world" which will be started in the fiscal 2021. The new project will expand research and outreach activities developed in the subarctic Sanriku Coast Area to the subtropical areas. Furthermore, we have currently submitted a budgetary request to the president of the University of Tokyo as one of the AORI future plans to construct another accessory structure (research center) of AORI on Amami-Oshima, Kagoshima Prefecture, where the above new "Subtropical-Kuroshio environmental study project" will be mainly carried out. When this plan is realized, it must have great advantages to promote the project and to further understand the oceanographic characteristics of the Japanese coast.

At the same time, the ICRC has continued monitoring and research on the recovery processes from the tsunami disaster, because reconstruction of the damaged areas has not yet been completed. Moreover, landscape changes, including re-settlement of people in urban areas and building of a giant seawall, are ongoing and these influence the costal environment and fishery. Finally, the School for Marine Science and Local Hopes in Sanriku, which began in 2018, should continue to be conducted intensively, for at least several decades, in order to foster the next generation who can design local sustainable communities with "hope". The ICRC would like to develop educational activities with a view to nurturing future marine researchers. It is obvious that we need to clarify the social role of the ICRC as a scientific research institution in rural areas with drastic depopulation.

For details on the ACES and the CIC, please see Chapter 3.6 and 11.2, and 7, respectively.

11.2 Joint Usage/Research

Joint Usage/Research provided by the AORI as a center of atmosphere and ocean science research consists of joint uses of research vessels such as *R/V Hakuho Maru* and *R/V Shinsei Maru*, joint uses of the research facilities at Kashiwa Campus and the ICRC, joint uses of numerical models related to climate systems and computers, and interdisciplinary

collaborative research. The AORI received the highest "*S*" rank in its 2018 interim assessment on Joint Usage/Research conducted by MEXT. The AORI made tremendous efforts to obtain a good evaluation in its term-end assessment and to be awarded ongoing status as a Joint Usage/Research Center for the next term.

The ACES was launched in April 2014. It consists of two sections with designated full professors. The ACES is the only lab in the world that holds a single stage accelerator mass spectrometry (YSAMS) and a nanoscale secondary ionization mass spectrometry (Nano-SIMS). These instruments allow collaborations both within and outside of the atmosphere and ocean in general public research groups, including with many international groups. The ACES research output has resulted in over 200 research papers. The YSAMS has been used for both biological and geological studies, including studies of fish ecology, evaluations of the effects of ocean acidifications on shellfish, precise reconstructions of past tsunami events, etc. The Nano-SIMS has been used to understand past global climate changes. The ACES aims to continue these highly-productive, cutting-edge, collaborative activities in the future, with emphasis on expanding its human and laboratory resources.

We will continue to promote Joint Usage/Research in order to take the lead in experimental, observational, and modeling studies in atmosphere and ocean sciences in Japan. Under the condition of dwindling subsidies to meet administrative costs over the past two decades, we have been putting in robust efforts to maintain budgets related to Joint Usage/Research. We will continue these efforts to improve the performance of Joint Research and produce excellent outcomes.

At the Center for Cooperative Research Promotion (CCRP), a decrease in the number of technical staff has been inevitable due to cutbacks in the quota for technical staff. To tackle on this situation, a system is to be established wherein technical staff can assist each other in acquiring necessary skills and complementing each other's work. Further, through such measures as the employment of reallocation requests and part-time employment of staff with necessary cutting-edge skills at the Center for High-Resolution Environmental Analysis Study and other departments, we will make further efforts to improve technical support for researchers visiting the AORI for Joint Usage/Research. As for the joint use of *R/V Hakuho Maru* and *R/V Shinsei Maru*, the management and provision of information obtained through the Joint Usage, as well as provision of onboard technical support, will be improved by linking these data with the Earth Surface System Database which is being developed at the CESSD.

Another important issue is the establishment of a data and sample management system. We have a responsibility to save the large amount of research data and samples we

collect and to disseminate these adequately. We have several advanced examples in this field, such as NICAM (Nonhydrostatic Icosahedral Atmospheric Model, https://cesd.aori.u-tokyo.ac.jp/nicam/index-e.html) and MitoFish (Mitochondrial Genome Database of Fish, http://mitofish.aori.u-tokyo.ac.jp/). However, the management of various types of ship-based observational datasets and biological/non-biological samples is still immature currently. The curation of data requires cost and time, and we need to explore an efficient and stable system of data management.

R/V Hakuho Maru was built in 1989 and has deteriorated significantly over time. To address this, the Working Group on the Replacement of *R/V Hakuho Maru* was established under the aegis of the Cooperative Research Vessel Steering Committee in order to discuss the replacement plan with oceanographers from across the country. As a result, MEXT and JAMSTEC decided that they aim to maintain the function as a Joint Use research vessel in about more 20 years by conducting large scale repair. The budgetary request (JPY 3.8 billion) was approved in 2020, and the repair will start in 2021.

11.3. Educational activities

The AORI is the only advanced research and educational institution, established by a Japanese university, that works both in the realm of comprehensive basic research in ocean science and in the field of climate modeling. We have been developing a cadre of researchers who now play leadership roles in marine and climate system research using numerical models and human resources in various other fields of atmosphere and ocean sciences. The faculty members of the AORI also serve as cooperative faculty members within four graduate schools at the University of Tokyo, namely, the Graduate Schools of Science, Agricultural and Life Sciences, Frontier Sciences, and Art and Sciences.

Six faculty members of the Graduate School of Frontier Sciences, former faculty members of the AORI, are concurrent faculty members within research departments of the AORI and engage in both education and research activities through close collaboration between the AORI and the Graduate School. We are very aware of our important responsibility to cultivate future leaders in the field of atmosphere and ocean sciences in Japan and to promote these disciplines in this country, and are fully committed to fulfilling this crucial task. Further, by hosting university-wide, hands-on and free seminars for undergraduate students at the College of Arts and Sciences, and through our atmosphere and ocean science internship program and postgraduate study guidance efforts for third- and fourth-year undergraduate students, we continue to make efforts towards attracting

outstanding postgraduate students. We constantly strive to improve the AORI as a place of research and education that is exciting and welcoming to young researchers, including postdoctoral fellows. The AORI also plays an important role in the Universities Global Campus initiative. Courses lead by the AORI's staff have allowed more than 30 postgraduate and undergraduate students to travel to the Australian National University (ANU). The efforts of the AORI staff have also promoted student and staff exchange with the National Taiwan University (NTU).

11.4. International joint research

The CIC is to play the role of being a key academic center in Japan for large-scale international research projects and initiatives such as Future Earth, the UN Decade of Ocean Science for Sustainable Development (2021-2030), UN SDGs. The CIC will respond to the challenges in atmosphere and ocean sciences, which are ever growing in scale and are increasingly a focus at the international level. The CIC will also promote human resource development and academic exchanges with other countries, mainly in the Asia-Pacific region. We are approaching this task with a long-term perspective through various efforts, including international cooperative programs supported by the Japan Society for Promotion of Science (JSPS) and MEXT.

The AORI will continue to fulfill its responsibility as a coordinator of governmental agencies and the atmospheric and ocean research community in Japan by further strengthening its contribution as Japan's representative to projects and programs that operate under the auspice of intergovernmental agreements on oceans and climate, such as those of UNESCO/IOC, the North Pacific Marine Science Organization (PICES), and IPCC.

The AORI has developed academic exchange agreements with 20 research organizations in 14 countries and continues to promote academic exchanges by dispatching and inviting researchers to and from these organizations. Additionally, by inviting outstanding researchers from overseas through flexible use of the overseas researcher invitation system, the AORI promotes international exchanges and collaboration in atmosphere and ocean science fields.

To achieve the above responsibilities and tasks, the AORI is enhancing national and international cooperation through the hub function of CIC, fully taking into account all Sustainable Development Goals (SDGs) and societal outcomes identified in designing the UN Decade of Ocean Science (UNDOS).

11.5. Society-level returns from research outcomes

In the Anthropocene, the role of scientists in achieving a sustainable society is increasing. It is essential to communicate with society at various level and to disseminate scientific information in order to support science-based decision making. The AORI will contribute to solve and/or mitigate various social issues with strong determination by preparing the best scientific knowledge with appropriate timing.

We have been continuously making efforts to disseminate our scientific findings at all levels of society in an easy-to-understand manner via a triannual newsletter ”Ocean Breeze”, the “Science News & Research Topics” page of our website, our Science Café, and open days at the institute. Many faculty members and their written articles introducing the scientific achievements of the AORI have appeared in mass media. To further enhance communication with society, a new section, the Science-Society Interaction Research Section, was established within the Division of Integrated Ocean Research. The section will attempt to develop further scientific contribution to society by scouting new talents, organizing fruitful collaborative projects, and cooperating with the University of Tokyo Ocean Alliance.

With regard to research findings covering global warming predictions and paleoclimate issues, we aim to share this work with the broader public through such means as our ongoing cooperation with the regular assessment reports of the IPCC. In particular, the AORI faculty members (6) are significantly contributing as lead authors and review editors to IPCC’s 6^{th} assessment. The AORI will lead global climate change science and prepare best evidence for decision making in collaboration with scientists from around the world.

In the research project “Tohoku Ecosystem-Associated Marine Sciences” we have contributed to the recovery of the fishing industry in the Tohoku Region by investigating the current state of marine ecosystems damaged by the 2011 tsunami and evaluating the restoration process. Although this research project will be completed in March 2021, we will continue to attempt to translate the results of this project to the global society, utilize them for the restoration and further development of the fisheries industry, and apply them to coastal management in the disaster area. The obtained results and experience are useful lessons for future similar disasters that could happen anywhere in the world. The newly commenced successive project “The School for Marine Science and Local Hopes in Sanriku” aims to practically contribute to local societies by educating the next generations who can then design local sustainable communities with “hope”.

The University of Tokyo declared they would participate in the UN SDGs to contribute to future humanity and the planet. Over the past three years, the AORI has supported various SDGs initiatives, especially through CIC faculties. The AORI will lead SDGs-related activities such as the UNDOS, collaborating with IOC/WESTPAC, PICES, international science programs, NGOs, citizen groups, and governmental organizations. For this purpose, the AORI will fully utilize the MOUs with foreign institutions and Joint Use/Research systems and will host symposiums, hold joint research and joint cruises, and send specialists to or invite scientists from developing countries for transfer of marine technology. As one of the leading institutions in atmosphere and ocean sciences in the western Pacific Ocean, many of the activities may contribute to the SDGs activities in Indo-Pacific region but are not limited to this region.

Furthermore, we will continue to contribute to government policy planning through the provision of faculty members' expertise in ministerial councils and committees.

11.6. Research environment and support system

When the former ORI was relocated from the Nakano campus to the Kashiwa campus in 2010, space shortages were alleviated, and aging research facilities were updated. However, transfer of the Division of Climate System Research, which is located on the eastern edge of the campus, to the atmosphere and ocean research building, which is located on the western edge of the vast campus, has not yet been achieved. Although construction of a new building or extension of the atmosphere and ocean research building for the Division of Climate System Research are difficult to achieve in the current budget constraints, we have tried to create space for the Division of Climate System Research by reconsidering the present space allocations for each laboratory and the organization of the atmosphere and ocean research building. The new areas provided by the space re-allocation will be managed by the Director's Office to be used for future research projects and newly established laboratories. We will also try to introduce a space charge system for research projects in order to maintain and improve our research environment. Also, we have currently submitted a budgetary request to the president of the University of Tokyo as one of the AORI future plans to extend the present AORI building to keep the space for the Division of Climate System Research as well as to create a new organization, Data Analytical Center, although we understand this request is not easy to be accepted.

Although some of the expensive research facilities and equipment, such as electron microscopes and experimental aquariums, have been renovated when the former ORI was

relocated to the Kashiwa campus, we are committed to continuing to update research facilities and introduce new facilities and equipment for Joint Use/Research to improve our research environment. These efforts will further promote our research and educational activities and will contribute to joint Usage/Research at the AORI.

Cutbacks in the quotas for technical staff have impacted not only support for Joint Usage/Research, but also support for the AORI's own research activities. However, as mentioned in Chapter 5.1.1.2, we aim to improve our work efficiency by increasing cooperation between the sections in the CCRP and between technical staff. We will also try to hire project technical staff within projects and with the use of other external funds, to complement the work of current technical staff. To further enhance research support systems, we encourage that technical staff join training courses and scientific meetings so that they can handle cutting-edge technologies.

11.7. Organization and administration

While securing external funding, including operational cost subsidies, has become increasingly difficult in recent times as a result of Japan's worsening national budgetary constraints, the AORI has been strengthening its organization system by increasing the number of assistant professors using operational cost subsidies, establishing the Analytical Center for Environmental Science, establishing a new section "Coastal Marine and Social Science" under the project "School for Marine Science and Local Hopes in Sanriku", and hiring one new dedicated associate professor to strengthen social cooperation. Although cutbacks in the quotas for faculty and other staff have become the norm, and the effects are profound, in order to achieve all the aforementioned research, education, and Joint Usage/Research goals, the AORI requires a firm vision and must maintain and strengthen the organization. The AORI will continue to maintain assistant professor posts using operational cost subsidies and will promote organizational restructuring in response to new projects. In addition, to make sound and prompt decisions in response to changes in social conditions, we aim to streamline the operations of the AORI, while maintaining and improving standards, by more precisely defining the roles of the Director's Office meetings, department meetings, and committees.

Employment and nurturing of young researchers are important and critical issues in the AORI. In present Director's office, it has been discussed that potential ways to recruit talented young scientists and to prepare more stable research environment with considering to securing a long-term budget and best human resources. In order to intensify the research

activities of young assistant and associate professors, we encourage overseas study, including the usage of the sabbatical system of the University of Tokyo. Gender balance is a remaining issue for AORI. To improve the situation, we are currently recruiting an associate professor (tenure) limited to female scientist. This is the first attempt for the AORI. We will continue to improve the gender balance of the faculty as well as researchers and supporting staff for inclusive growth of the AORI. Further, we aim to strengthen existing systems whereby faculty and other staff work together to fulfill various activities at the AORI. We believe diversity and inclusion are essential to improve the AORI's impacts on science and society.

Entrance of the International Coastal Research Center

外部評価報告書和訳

2020 年外部評価報告書

－評価・提言－

序文

東京大学大気海洋研究所は、2010 年 4 月に、旧海洋研究所と旧気候システム研究センターが統合して設立された。その設立にあたり、新研究所の理念と 10 年間のアクションプラン等についての議論が行われ、系組織の導入、統合によるシナジーを実現するための地球表層圏変動センターの設置、共同利用共同研究推進センターの設置と技術職員のセンターへの配置、教育委員会の新規設置、などの基本方針が定められた。また、統合と同時に、新しい共同利用・共同研究拠点制度のもと、文部科学省から「大気海洋研究拠点」として認定され、全国の大気海洋科学に係る研究者の拠点として活動を行ってきた。2014 年には高解像度環境解析研究センターを新設し、世界最先端の分析装置による高解像度な環境解析に関する共同利用・共同研究を推進してきた。一方、統合から 1 年を経た 2011 年 3 月には、東北地方太平洋沖地震に伴う津波により、附属国際沿岸海洋研究センターが壊滅的被害を受けた。以降、岩手県や大槌町の全面的なご協力のもと、全国の皆様のご支援もいただきながら、東京大学本部とともにセンターの施設の復旧に努め、2018 年 2 月末に新しい研究実験棟と宿泊棟が竣工した。2019 年度末までにはほぼすべての研究施設・機器を復旧することができた。施設の復旧を進めながら、被災地に立つ海洋の研究所として、長年の研究蓄積と研究者ネットワークを基礎に、地震と津波による海洋生態系の変化に関する拠点の一つとして機能してきた。さらには、三陸地域の未来を形作る拠点としての役割を持つことを目指して、自然科学と地域・社会連携を統合した先駆的な研究活動を進めると同時に、地域の未来を担う次世代の人材育成にも力を入れている。

今回の外部評価は、当初の計画では、大気海洋研究所の設立から 10 年が経過した 2020 年 3 月に行われる予定であった。大気海洋科学分野の各分野において顕著な業績を有し各研究コミュニティーをリードしておられる国外・国内各 3 名の専門家に委員を依頼し、東北大学の花輪公雄名誉教授（現、山形大学理事・副学長）に委員長をお願いした。評価委員の皆様には、予め 2020 年 1 月に、研究所の組織や研究教育活動、社会連携活動、共同利用共同研究の概要とその根拠となるデータ、前回の外部評価に対する対応、および将来計画等を書面に取りまとめてお送りし、それらに対して質問や意見を文書でご提出いただくこととした。その上で、2020 年 3 月 5〜6 日に柏キャンパスにおいて委員会を開催する予定であったが、COVID-19 の発生によって海外からの委員の来日が難しくなり、会議の延期を余儀なくされた。その後も COVID-19 の流行は収まらず海外委員の来日が難しい状況は続いたが、オンラインで会議を行う体制が整ったため、当初の予定よりほぼ 1 年遅れて、2021 年 3 月 3 日にオンライン会議の形で委員会が開催された。

前回の外部評価は 2014 年 3 月に行われた。今回と同様に、国外・国内各 3 名の著名な大気海洋科学の専門家を委員に依頼し、統合後の新研究所の活動、とりわけ地球表層圏変動研究センターの活動と将来構想について重点的に評価をいただいた。その後、その評価と提言に基づいて、大気海洋科学の中核機関として、また、共同利用・共同研究機関として様々な活動を行ってきたが、この時の外部評価で

強く推奨された「大気海洋科学の将来を見据えた研究所の戦略的計画を策定すべき」との提言にはこれまで応えられていなかった。国際沿岸海洋研究センターの復旧に予想外の時間がかかり、そのための人的・財政的負担が大きかったことに加え、2015 年に五神総長が東大ビジョン 2020 を発表し、2016 年～2021 年期に学内で大規模な組織の見直しや予算獲得戦略の変更等が実施されたことにより、その対応に追われていたことがその主な原因である。国際沿岸海洋研究センターの復旧が完了したことを機に、2019 年度に所長から所内に設置された将来構想委員会に対して、今後の大気海洋科学のありかたと研究の方向性、共同利用・共同研究拠点としての使命について、10 年後を見据えて実現可能な具体的提案を求めた。大気海洋研究所が設立されて 10 年が経過し、被災した国際沿岸海洋研究センターの復旧も完了した現在、研究所がさらに発展していくためには、科学の進展と社会情勢の変化、学内外情勢に対応した将来構想を策定する必要が生じている。設立当時の議論においても「10 年程度をめどに組織を見直す」旨の合意があり、研究所全体の方向性や組織のありかたを広く再検討する時期と考えられる。将来構想委員会では、上記の諮問を受けて 2019 年 11月から 2021 年 3月にかけて集中的な議論を重ね、研究所の将来像や今後 10 年に取り組むべき課題、それを支える組織運営のあり方などについての提言「大気海洋研究所将来構想 2020」を 取りまとめた。

今回の外部評価においては、大気海洋研究所の過去 10 年間の活動内容に加えて、上記の将来構想委員会での議論と提言に基づく大気海洋研究所のこれからのあり方について、重点的に評価をいただくようお願いした。2020 年 3 月までに書面に取りまとめた研究所の活動内容について評価をいただいていたが、評価委員会が 1 年間延期されたことに伴って、将来構想委員会での議論の内容が評価に反映されたことはたいへん意義深かったと考える。2020 年 12 月に再度、研究所の活動内容と将来構想を取りまとめた書面を評価委員の皆様に送付し、それに対する各委員からの意見を 2021 年 1 月までに書面でご提出いただいた。オンラインによる会議では海外から参加される委員との間に時差が生じるため、2021 年 3 月 3 日の委員会はできるだけ短時間で終了する必要があった。そのため、2020 年 12 月 21 日に、国内委員 3 名にご出席いただいて対面による丸 1 日の準備委員会を開催し（実際には 1 名の対面出席が難しくなり、オンラインを併用したハイブリッド会議となった)、研究所の活動内容と将来構想について詳細な説明と質疑応答を行った。後日に花輪委員長から、その議論の内容をメールベースで国外委員にも共有していただき、3 月 3 日の議論のための参考資料としていただいた。3 月 3 日のオンラインによる委員会は 10 時～13 時に開催され、所長室メンバーによる研究所の組織、研究教育活動、共同利用共同研究の現状と課題、将来構想について説明が簡潔に行われ、これに対する委員の質疑が行われた後に、外部評価委員会が作成した評価意見の原案が示された。この報告書に記載された大気海洋研究所の活動と将来構想に関する評価意見は、委員会終了後に行われた評価委員間でのメールベースでの意見交換の後に委員長から所長に最終的に提出されたものである。いずれの意見および提案も大変重要で適切かつ建設的なものと考える。将来構想委員会からの提言「大気海洋研究所将来構想2020」の方向性にも合致しており、今後の大気海洋研究所の進むべき道筋を示してくれている。所長室としては、現体制が終了する 2023 年 3 月までに間に、この外部評価報告書の提言および「大気海洋研究所将来構想 2020」の内容を踏まえて、研究所の組織や活動内容を可能な限り改善し、大気海

洋科学の将来を見据えた研究所の戦略的計画の策定を進めていきたい。

花輪委員長をはじめとする 6 名の外部評価委員の皆様には、長期にわたった外部評価の過程で終始真摯にご議論、ご審議いただき、多くの重要かつ建設的なご意見をいただいた。心より感謝申し上げる。川幡穂高教授（2019 年度評価委員長）、安田一郎教授（2020 年度評価委員長）をはじめとする所内評価委員会の皆様、齊藤宏明教授（外部評価担当の所長補佐）をはじめ所長室の皆様、斎藤正己事務長、遠藤隆弘副事務長をはじめとする事務部の皆様には、外部評価の準備と遂行にご尽力いただいた。また、外部評価に供する資料の作成には多くの所員にご協力いただいた。並行して行われた将来構想委員会（沖野郷子委員長）の議論は、今回の外部評価において重要な役割を果たした。以上の皆様に改めて感謝申し上げる。

2021 年 6 月 30 日

河村知彦

東京大学大気海洋研究所長
河村知彦

1. 評価委員

花輪 公雄（委員長）

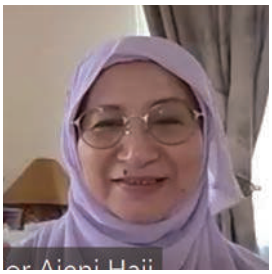
東北大学　名誉教授
（現在の所属：山形大学理事・副学長）

Julie Hall

ニュージーランド国立大気水圏研究所　ディレクター

Nor Aieni Haji Mokhtar

マレーシアトレンガヌ大学　副学長



Gregory F. Moore

ハワイ大学　教授

余田　成男

京都大学国際高等教育院
副教育院長 / 特定教授

佐藤　矩行

沖縄科学技術大学院大学
教授

会議中の集合写真

1	2	3	4	5
6	7	8	9	10
	11	12	13	

1. 余田　成男
2. AORI 会議室
3. 齊藤　宏明
4. Julie Hall
5. 河村　知彦
6. Nor Aieni Haji Mokhtar
7. 花輪　公雄
8. 佐藤　矩行
9. 兵藤　　晋
10. 安田　一郎
11. 沖野　郷子
12. Gregory F. Moore
13. 高薮　縁

2020 年外部評価報告書
-評価・提言-

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1. 序文

東京大学大気海洋研究所（AORI）への「2020 年外部評価」は、当初 2020 年 3 月 5 日及び 6 日に予定されていた。しかし、COVID-19 の発生によって世界のほとんどの国で海外渡航が禁止され、会議は延期を余儀なくされた。COVID-19 の大流行は現在も続いているため、この会議は、当初の予定よりほぼ 1 年遅れて、2021 年 3 月 3 日にオンライン会議の形で実施された。

この 1 年間、外部評価は以下の通り、3 つの主要ステップを踏んで実施された。

1)第 1 ステップ：「外部評価資料（案）」(2020 年 1 月版)に基づき委員会から質問・評価・提言、及び AORI の返答・回答のやりとりが、当初予定されていた会議日程(2020 年 3 月)の直前に行われた。2) 第 2：その後改訂された「外部評価資料（案）」(2020 年 12 月版)に基づき、委員会メンバーと AORI 関係者間で 1)と同じプロセスが繰り返された。3) 第 3：2020 年 12 月 21 日に日本の委員会メンバー(花輪、佐藤、余田)による会議が実施された。この会議は、正式会議の準備会議と位置付けられた。

以下に述べる包括的な評価・提言は、上記ステップで行われた委員会メンバーと AORI の間の意見交換に基づく部分的要約である。

委員会の指摘・提言を分類・整理する方法としては、1)AORI から委員会に寄せられた「主な質問」に直接回答する、2)「外部評価資料」の項目・順序に沿って、私達の提言を記述する、3)この会議で河村所長から提示された「将来計画」の項目・順序に沿って討議する、の 3 つが考えられる。本評価・提言においては、3 つ目の方法、すなわち「将来計画」の項目・順序に沿って討議する方法を採用する。それは、非常にシンプルかつ明確であって、理解しやすいからである。

2. 総合評価

第一に述べるのは、私たちが、AORIの教員/職員一人ひとりが質・量ともに高い研究成果をあげていることを認識していることであり、このことは非常に素晴らしいことである。この評価は、「外部評価資料」に示されたいくつかの指標、すなわち、論文発表数、掲載学術誌のインパクトファクター、個々の研究者のh指数などから判断したものである。

第二に、AORIの教員/職員が国際的な研究プログラムや学術機関に多大な貢献をしていることである。すなわち、AORIの教員/職員の多くは、多くの国際共同研究プログラムに携わり、積極的な役割を

担っている。さらに、国際機関にも多くの教員/職員が関与し、重要な役割を担っている。AORIの教員／職員の多くが、国際的な学術・研究機関の運営に責任を負っていることに、大変感銘を受けた。

第三に、AORIは共同利用／共同研究拠点として、研究コミュニティに対して大規模先端研究施設の利用機会を提供していることである。また、「白鳳丸」「新青丸」という2隻の研究船の運用に関わるほか、柏キャンパスや大槌町の国際沿岸海洋研究センター(ICRC)で研究集会を随時開催している。文部科学省による共同利用／共同研究拠点の中間評価が2018年に行われ、AORIは最上位の「S」評価を受けている。これらの事実から、AORIは共同利用/共同研究拠点として利用者に十分な機会を提供できていると言える。

第四に、教育活動についても、大学院生を対象とした「海洋アライアンス」の有力なメンバーとして、独自の教育プログラムである「海洋学際教育プログラム」を提供していることである。このプログラムは、視野を広げ、他の研究分野の学生とコミュニケーションを図りたいAORIの学生にとって非常に良いプログラムである。

総合評価としては、AORIは世界に通用する研究機関であり、大気・海洋科学分野の世界トップレベルの研究拠点として、適切な研究者を確保していると判断する。

3. 提言

(1) 研究の方向性

提言 1.1: 第四期「中期目標・中期計画」(2022～2027 年)に向け包括的戦略計画を策定する

第四期「中期目標・中期計画」は 2022 年度から始まるため、AORI が将来の包括的戦略計画の策定に着手するには今が適切な時期である。「自己評価報告書」の作成過程で同計画の主要部分がすでに策定されており、並びに「将来構想委員会及び作業部会」がすでに設置され、作業を行っているため、この策定は AORI の教員/職員にとって重い負荷ではない。同作業部会に次世代の主な担い手である若手の教員/職員が大きく関与していることを認識している。第四期「中期目標・中期計画」については、ホームページやリーフレット等を用いて公表することが望ましい。この戦略計画は「将来構想」文書に基づいて作成されるべきであり、またこの計画によって職員の採用と機材の購入の優先順位決定を検討するための主要な研究課題を特定すべきである。これには、教員の学際性を高めるために、社会科学者を少なくともう 1 人新たに雇用することの検討が含まれるべきである。

提言 1.2： 対象研究分野とそれに対応する組織体制を定期的にチェック・レビューする

これは、2014 年外部評価で行われた提言 1.1 の一部である。新規の研究動向を定期的にチェック・レビューし、AORI の研究体制をこれに照らして評価することを提言する。東京大学の総長は 6 年ごとに交代し、「中期目標・中期計画」も 6 年ごとに立案されるため、これに合わせて 6 年に 1 度、戦略計画をチェック・レビューすべきである。

AORI の目玉となる研究センターは、地球表層圏変動研究センター（CESSD）であるが、このセンターが 2010 年に設立されたことを考慮すれば、その研究方向性とそれに対応する人員等を上記期間と同時に見直す必要がある。

(2) 共同利用／共同研究拠点

提言 2.1:　最先端施設と研究船の代替を戦略的に目指す

AORI は、高解像度環境解析研究センター（ACES)にある AMS や NANO-SIMS など、先端施設を数多く保有しているほか、研究船 2 隻の更新にも関わっている。それらの更新に膨大な予算が必要であることは言うまでもない。施設や研究船の更新を円滑に行うため、AORI は常にその必要性と重要性を東京大学本部や文部科学省に訴え続けるべきである。

提言 2.2：　研究船 2 隻の運航日数の確保

当初、2 隻の研究船「白鳳丸」、「新青丸」の運航日数はそれぞれ年間 300 日であった。しかし、現在、運航日数はそれぞれ年間 200 日未満に短縮されている。海上燃料の高騰が理由であることは理解できるが、AORI は海洋研究開発機構（JAMSTEC)や文部科学省と交渉し、年間 300 日の運航日数を確保すべきである。使わなければ、それこそ宝の持ち腐れである。

(3) 教育活動

提言 3.1:　様々な機会を活用した大学院生候補の募集

大気・海洋科学の次世代の研究者を育成するためには、博士課程学生を中心とした優秀な大学院生を十分に確保することが重要であることは言うまでもない。AORI は一般教育を除き、東京大学の学部教育に直接関わっていないため、大気・海洋科学に興味のある学生を確保するのは非常に難しいと理解している。このような状況を打開するために、AORI はすでに様々なイベントやプログラムを導入している。AORI がこれらの活動を継続することを推奨する。これに加えて、新しいイベントやプログラムも検討すべきである。例えば、優秀な修士課程の学生を確保するために、AORI に関する説明セミナーを、東京大学や首都圏の大学の枠を越えて、日本全国の大学の学部生にも開放して開催するべきである。

提言 3.2:　東京大学海洋アライアンスが提供するユニークな教育プログラムの受講を学生に奨励する

東京大学海洋アライアンスが提供する「海洋学際教育プログラム」は、視野を広げ、他の研究分野の学生とコミュニケーションを図りたい AORI の学生にとって非常に良いプログラムである。現在このコースを受講する AORI の学生は、AORI の全学生の約 20%に過ぎない。AORI は、政策立案や社会科学について十分な知識を有する大気・海洋科学の研究者を育成するため、学生に本教育プログラムの受講を奨励すべきである。

(4) 国際共同研究

提言 4.1:　国際連携研究センター（CIC)の活動を一層強化する

CIC は、国際的な研究プログラムや学術機関における AORI の活動の強化を担当している。現在、CIC は専任教授 3 名と兼任教授・准教授 5 名で構成されている。言うまでもなく、CIC の活動を充実させるためには、より多くの人材が必要である。専任教授や専任准教授の確保はかなり難しいことを理解しているが、それでも CIC は、研究プロジェクト予算で雇われるプロジェクト研究教授・准教授

を活用するなど、職員を充実させる方法を模索すべきである。また、将来の AORI の国際協力を担う若手研究者を育成するため、国際情勢に関心がある、あるいは詳しい若手研究者を CIC に招聘することも重要である。

提言4.2:　「国連海洋科学の10年」に対するAORIの貢献を明確化し、日本の貢献をリードする

私達は、SDGs目標14の達成に向けて、AORIが大気・海洋科学に関する様々な将来の国際プログラム、特に「国連海洋科学の10年」（UNDOS, 2021～2030年）において主導的な役割を果たすべきであると強く信じている。2020年外部評価のための2020年自己評価報告書では、すでにいくつかの研究グループが「国連海洋科学の10年」へのコミットメントを宣言している。CICは、AORIの包括的な貢献を準備すべきであり、可能な限り早期に、国際的な「国連海洋科学の10年」に貢献する日本の活動の調整を主導すべきである。AORIは、「国連海洋科学の10年」に関わる日本における主要機関となるべきである。

(5) 研究成果の社会還元

提言 5.1:　様々なレベルで様々なツールを使用してアウトリーチ活動を強化する

AORI の職員が達成した多くの素晴らしい科学的成果を広めるために、AORI は、講演、サイエンスカフェ、出版物、SNS、大規模公開オンライン講座（MOOC)といった様々なコミュニケーションツールを通して、アウトリーチ活動を強化すべきである。ソーシャルメディアの利用も検討すべきである。

特に、MOOC は、多くの学術分野の最先端の研究や科学的基礎知見を一般市民に紹介するための、一般的な方法となりつつある。東京大学ではすでに数年前から MOOC 講座が導入されており、すでに多くの MOOC 講座が公開されている。これらは、ウェブサイトや YouTube を通じて誰でも利用できる。AORI は、MOOC が AORI の科学的実績を一般に宣伝するための効果的な方法であるか、あるいは大学院生の募集に効果的であるかを評価すべきである。

提言 5.2:　「東北マリンサイエンス拠点形成事業（海洋生態系の調査研究）(TEAMS)」の研究成果を社会に還元する

2020年度は、文部科学省が財政的に支援する「東北マリンサイエンス拠点形成事業（海洋生態系の調査研究）(TEAMS)」の最終年度にあたる。AORIは、このプロジェクトの主要3研究機関の一つとして深く関与しているので、このプロジェクトで得られ、蓄積された研究成果を、特に沿岸部の被災地の人々に届けることを私達は強く推奨する。こういった研究成果は、一般の方々にもわかりやすい表現に「翻訳」する必要があり、こうした普及活動はAORIの責務とすべきである。国際沿岸海洋研究センター（ICRC）がこのプロジェクトを主導すべきである。

提言5.3:　その優れたアウトリーチ・プログラムを通じてより広いコミュニティとの積極的対話を発展させ、得られた情報を重要な研究優先事項を特定するために利用する

このようなアウトリーチ活動は、より広範なコミュニティ、政策立案者、海事管理者にとっての助けになるであろう。

提言5.4:　その優れたアウトリーチ・プログラムを通じて、市民科学プロジェクトの機会を創出する

これはまた、AORIの研究に対するコミュニティの関心と支援を高めるであろう。

(6) 研究環境・支援体制

提言 6.1:　気候システム研究系(DCSR)のスペースを確保する

これは、前回の 2014 年外部評価委員会でも提言された。AORI がグループ間のコミュニケーションや交流を強化するため、気候システム研究系のスペースを AORI の本館にずっと近い場所に確保することを私達は期待している。現在、気候システム研究系の建物はキャンパス内の反対側にあり、現状の厳しい予算状況では新棟を建設することが非常に難しいということは理解している。とはいえ、AORI はこの問題の解決策を継続的に探るべきである。

提言 6.2:　十分な技術職員を確保する

国立大学では、引き続き人件費予算の削減が行われており、技術・事務系人材の確保が困難な状況にある。しかし、最先端施設の利用を拡大し、研究船上でハイレベルな現場観測を行うためには、技術職員による支援が不可欠であり、極めて重要である。AORI は、技術職員の将来の状況に注意を払うべきであり、十分な技術職員を確保し、個々の技術職員のスキルと能力を向上させるための戦略的計画を持つべきである。AORI は、技術職員が共同利用／共同研究拠点としての AORI の活動において極めて重要な役割を担っていることを、東京大学本部にもっと強く訴えかけるべきである。

(7) 組織・運営

提言 7.1:　ジェンダー・バランスを改善する／外国人職員を追加採用する

現在、女性研究者の数は少なく、この状況を早急に解決しなければならないことは言うまでもない。人事面では、所長室は、より多くの女性教員の採用に尽力すべきである。また、女性職員の専門能力開発を支援するためのメンタリング・プログラムを進展させるべきである。

AORI はまた、研究所の職員の多様性を高めるために、外国人職員や東京大学以外で学位を取得した教員のより多くの採用を検討すべきである。

提言 7.2:　現在の研究グループにおける三層構造を見直し、より大きい／より広い研究ユニットに統合する

現在の AORI の研究組織は、三層構造、すなわち、系、部門、分野からなる構造を有している。各系は 2〜3 部門、各部門は 3 つの分野で構成されている。各分野は、概ね、教授 1 名、准教授 1 名、研究助手 1 名の 3 名の教員構成となっている。現在、人件費が徐々に縮小しているため、今後この構造が維持できなくなることを強く懸念する。また、この構造は研究分野の自発的な拡大を阻害する可能性がある。より柔軟な研究ユニットの再編、「分野」の廃止を強く推奨する。

提言 7.3:　AORI 卒業生組織の設立

このことは前回の 2014 年度外部評価でも指摘されているが、大学院のそれとは独立した卒業生組織

を AORI 内に設立することの重要性を改めて指摘する。各学生はいずれかの大学院に所属しているが、ほとんどの時間を AORI で過ごしている。つまり、ほとんどの大学院生にとって、AORI は彼らが成長する場所、つまり、いわゆる「ふるさと」になるであろう。「結束の精神」を維持し、卒業生間のネットワークを向上させるためには、卒業生組織の存在が非常に重要である。AORI に関係するすべての人、すなわち学術/研究職員、技術及び管理職員が、卒業生組織構成員となるべきことは言うまでもない。

4. おわりに

我々は、AORI の職員は、研究や管理活動を行う上で高いポテンシャルを持っていると認識している。今回の外部評価会議での議論により、将来計画で示された方向性が、研究のさらなる発展と、日本や世界の大気・海洋コミュニティでリーダーシップを取るために正しい方法であると判断できる。

今後の活動において、所長と所長室のリーダーシップが不可欠であることは言うまでもない。この評価を通じて、現在の所長と所長室員がこの点を深く理解し、それを実現したいと考えていることを知った。私達もその実現を期待している。

現在、「将来構想委員会」の活動が行われており、多くの若手研究者が参加している。将来的には、彼らが AORI の次の輝かしい時代を築くものと確信している。

最後に、私達は、今回の 2020 年外部評価が、将来の AORI の順風満帆な発展に何らかの貢献となることを強く期待する。