

3. External Evaluation Report

External Evaluation of the Atmosphere and Ocean Research Institute of the University of Tokyo

I. Introduction

The external evaluation of the Atmosphere and Ocean Research Institute (AORI) took place on the Kashiwa Campus of the University of Tokyo during March 5-7, 2014. The external evaluation team assessed the materials that were provided to it before the evaluation as well as material presented to the team orally while at the AORI. Questions and discussions took place between the team and the AORI leadership and faculty. The evaluation team was asked to consider the present situation at the institute, as well as outcomes, future plans and challenges to be addressed, covering the period FY2007- FY2012. This included the activities of the former Ocean Research Institute (ORI) and the former Center for Climate System Research (CCSR), the AORI's two predecessor organizations. These two entities merged in 2010. The evaluation team was asked to respond to nine key questions about the AORI and its future. The team also provided recommendations on several other issues.

The evaluation team wishes to express its profound gratitude to the leadership, faculty and staff of the AORI who put together the excellent summaries of the activities of the AORI since 2007. They provided us with presentations on various AORI departments, centers, and programs, answered our many questions, and participated in our many discussions. We also appreciated very much the outstanding hospitality and kindness shown to each of us during our time spent in Kashiwa and Tokyo.

II. Basic Principles of the Atmosphere and Ocean Research Institute

Following are the basic principles of the AORI that were presented to the evaluation team. The team's report is based on considerations that have these basic principles as their foundation.

The AORI promotes basic research on the ocean and atmosphere, both of which play important roles in the earth's surface environment, climate change, and evolution of life. Our organization conducts research with the aim of providing solutions to key problems regarding the survival of humanity and the biosphere using state-of-the-art field observations, experimental verification, numerical modeling of the earth surface system, and biosphere fluctuation analysis. In addition, as a world leader in atmospheric and marine sciences, the AORI aggressively promotes joint usage and research within and beyond Japan. Based on these cutting-edge research activities, the AORI actively engages in graduate education to cultivate the future leaders of atmospheric and marine sciences and to develop human resources equipped with a rich scientific understanding of the ocean, atmosphere, climate, and biosphere.

The basic aims of the AORI are as follows:

- To comprehensively understand the fundamental fluctuation mechanisms of the earth surface system, the foundations of our survival.
- To take measures against and make reliable predictions for emerging global environmental problems.

To do this it is necessary to have a deep understanding of the diverse basic processes associated with the variability of the oceans, atmosphere, climate and biosphere through both domestic and international collaborations. Based on such knowledge and by considering its geographic variation as well as by using global and whole-earth-history viewpoints, the AORI elucidates the mechanisms within the earth surface system.

Research:

The AORI promotes basic research investigations of the ocean, atmosphere, and climate. We aim to create a new academic discipline, that of atmospheric and marine sciences, that comprehensively deals with the atmosphere, ocean, and life science through collaboration in cutting-edge field observations, experimental verification, and numerical modeling, transcending the traditional frameworks of existing academic fields. We also communicate broadly our scientific findings, which serve as the basis for the societal response to various problems related to the survival of humanity and the biosphere that exist in the earth surface system.

Education:

The AORI produces the future leaders of the atmospheric and marine sciences. Through diverse collaborations within and beyond the university, we aim to develop human resources with the necessary scientific knowledge to respond to various environmental challenges that exist on the earth.

Joint usage/research:

As a research center for atmospheric and marine sciences, the AORI promotes research on the atmosphere, ocean, climate, and biosphere through joint usage of scientific infrastructure facilities such as research vessels and computers, and through diverse joint-research projects, thereby contributing to the scientific community at large.

International joint research/international contribution:

The AORI contributes to the activities of international governmental, and nongovernmental organizations that investigate the ocean and climate under intergovernmental and other types of agreements, and it promotes international joint research, academic exchanges, and the cultivation of young researchers.

Social contribution:

The AORI shares research findings with the broader public in a prompt and easy-to understand manner and produces scientific findings that can serve as a foundation for administrative policies through councils, committees, and academic societal events.

Administration:

The AORI respects free thinking that is essential for the development of research and education, and takes compliance with laws and ordinances and energy saving into consideration. We administer the organization in a transparent and efficient manner under the sound leadership of our director, while ensuring that we listen to the voices of both our staff and communities beyond the organization.

III. Overarching Issues

Before responding to the nine questions that the external evaluation team was asked to address, we discuss several overarching issues that we believe are also of particular importance to the AORI as it plans for its future.

A. Strategic Planning

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 merger of the former Ocean Research Institute and the former Center for Climate System Research is now four years old. We believe now would be a good time to evaluate how well the merger has worked, but more importantly, what are the intellectual plans for its future - what new scientific and societal issues are on the horizon for the atmospheric and oceanic sciences, and how will the AORI respond to them? Timing is also right because a new director will shortly be needed, a number of senior faculty will be retiring within the next several years, and the grant and university funding for the AORI is decreasing. All of these argue strongly for a comprehensive strategic plan to address the future.

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

B. Marine Policy Involvement

Today it is more clear 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, for 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 Great East Japan earthquake, tsunami, and associated Fukushima disaster converged to demonstrate just how important are the science and education conducted at the AORI. It is essential that the people and government of Japan 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 interest for both parties. Good ocean and coastal policy is founded on good science that the AORI is uniquely qualified to provide. Marine policy faculty can and ought to be among the strongest advocates for the science of the AORI.

C. Virtual Centers of Excellence

The evaluation team was highly impressed with the actions of the AORI faculty in undertaking responsibility to ensure 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 International Coastal Research Center is sharing 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 that 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 communities.

Such centers could also provide for inter-college, -school, and -departmental collaboration, something not encouraged by the traditional academic structure.

D. New Director Considerations

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 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 a search for a new director is undertaken, it be wide-ranging, including both internal and external candidates.

E. New Building for the Division of Climate System Research

When the former Ocean Research Institute and the former Center for Climate System Research joined to form the AORI four years ago, the new building that was constructed for the AORI was only large enough for 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 AORI difficult. This served to negate one of the strongest reasons for the merger - the importance of the 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 is co-located with the other divisions of the AORI.

IV. 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 founding in 1962 and the ORI's merger with the Center for Climate System Research in 2010. The current structure is a hybrid of discipline-based divisions and departments, and interdisciplinary/multidisciplinary centers. As of April 1, 2014, the AORI will consist 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, a 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 development of a strategic plan;

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 University of Tokyo and other Japanese scientists that guides the Institute scientifically. 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>); etc.).

Such advisory groups provide extraordinary opportunities for supporting institutions beyond traditional means. If such an external advisory boards 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 also give useful suggestions as to potential non-governmental sources of funds for the AORI and its research programs.

We recommend that the AORI form a broad-based advisory group, complementing the current AORI Council and perhaps with 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, 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 doctors degrees among the multiple graduate schools prevent 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 that 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>).

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 doctors courses; to give clarity to what masters and doctors degrees awarded to AORI students mean; to enhance recruitment of top-quality graduate students; to build the AORI brand; to build links among the various AORI divisions, departments, and centers; to foster interdisciplinary and transdisciplinary education and research; to position the AORI as the natural leader of the UT Ocean Alliance; to take advantage of the expertise in JAMSTEC; and to develop joint graduate programs with other organizations.

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 turnover of approximately one-third of the members over the next decade, providing the opportunity for significant staff and scientific renewal.

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

In a 2011 assessment of the global top 30 research institutions in oceanography conducted by Thomson Reuters, on the basis of 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>). Publication and citation metrics, however, 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 fraction of Associate Professors and Professors are not at the level that would warrant appointment to similar positions at peer institutions abroad.

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.

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 did 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 University of Tokyo alumni specifically and the Japanese talent pool (<2% of the world's population) in general stands in marked contrast to increasing internationalization of peer institutions abroad and of the oceanographic sciences. Recognized challenges to internationalization of the AORI include language, culture, and lifestyle. Nevertheless,

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

Question 3. Evaluation and 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.

The Center for Earth Surface System Dynamics (CESD) was established in April 2010 at the same time that the AORI was constituted from merging the former Ocean Research Institute, which specialized in basic research on oceans through observation and experimental research, and the former Center for Climate System Research, which specialized in research on climate systems via climate models, primarily numerical simulation. CESD has since led a series of innovative collaboration research projects.

CESD was established with the goal of creating a synergistic outcome from the merger of the two institutions. CESD includes of four research sections: paleo-environments, ecosystems, genetics, and atmosphere and ocean. It integrates and develops next-generation field observations, experimental and analytical methods, and state-of-the-art modeling based on novel ideas generated by basic research in each research section.

CESD has had numerous research achievements in its short four-year history. These include the reproduction of ocean circulation by climate modeling using paleo-environmental data; simulation of nitrite concentration using the marine model COCO and comparison of the results with field data; development of a fish gene database and

assessment of genetic transition and environmental impact; and typhoon simulation using the NICAM atmosphere model and the development of the coupled NICAM-COCO model. CESD has also developed simulations of the transport of atmospheric pollutants, developed a data assimilation system, and developed a simulation of the Fukushima nuclear plant accident and compared the simulation results with field data. CESD has created an Earth-surface system database of field data and modeling results, which also includes a shipboard observation database and a database of the simulation and field results for air pollution and nuclear plant accidents.

We recognize that the CESD has initiated an excellent new type of research initiative in Japan, which greatly enhances scientific research through an integrated understanding of atmospheric and oceanographic science, both in Japan and internationally. CESD is clearly one of the most outstanding synergistic outcomes from consolidation of ORI and CCRS. We are particularly impressed with the enthusiastic communication between modelers and specialists collecting data in CESD. Such successful communication is commonly quite challenging because the two groups have traditionally quite different approaches to their science.

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

We agree with the CESD's future plan to reinforce science-driven research through the following three grand challenges: (1) Multi-scale interactions (high resolution atmosphere-ocean interaction, global-regional multi-scale, interlinking of micro and macro processes); (2) Nitrogen cycle and ecosystem variations in a changing climate (ecosystem responses to climate change, climate modeling and ecosystem variations); and (3) Symbiotic evolution of life and environment (life and gene evolution, modern and paleo-environment). We also agree that the current (or expanded) size of CESD is required to maximize use of the expertise of the four research sections so they can carry out the research necessary to address successfully their grand challenges outlined above. As CESD develops further it will be important to make certain that space in the AORI building is available for its increased research and educational activities, and that adequate computer resources are available for increasing simulation, data analysis, and database construction.

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 *Hakuho Maru* and *Tansei Maru*. The *Tansei Maru* has recently been retired and replaced by the *Shinsei Maru*. The other excellent activity is a visiting researcher program at the Kashiwa campus and at the International Coastal Research Center, 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 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 Great East Japan Earthquake on March 11, 2011, significantly damaged the International Coastal Research Center 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 make certain that the necessary support can still be provided.

Two research vessels, *Hakuho Maru* and *Tansei Maru*, were transferred to the JAMSTEC in April 2004. Since then, the AORI has publicly advertised and considered research plans and 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 *Hakuho Maru*, which was launched in 1989, is another large concern, as it will require replacement in the near future.

The *Hakuho Maru* is used for long, deep-water research voyages, while the *Shinsei Maru* is used for short research voyages lasting from a few days to two weeks around the Japanese islands. The voyage plan for the *Hakuho Maru* is formulated every three years, and that for the *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 the *Hakuho Maru* and the *Tansei Maru* (superceded by *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.

We recommend that the AORI work with MEXT and JAMSTEC to ensure that *Hakuho Maru* and *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.

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

Joint usage research voyages involving the *Tansei Maru* and the *Hakuho Maru* have played an important role in graduate education in Japan. In the past several years approximately 70% of the researchers aboard both vessels were graduate students. These vessels made significant contributions through interactive shipboard education in addition to helping the 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 an ongoing status as a joint usage/research center for the next year.

All nation-wide shipboard joint usage programs have been successfully conducted since amalgamation of the former ORI and CCSR in 2010. They have clearly provided excellent support to researchers as well as 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 considered for continuation over the next decade.

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

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.

The AORI, as a part of the University of Tokyo, is engaged in teaching graduate students. The faculty members belong to five graduate schools and deliver eleven course lectures to them. The AORI is unique in that it is the only high-level institute in Japan where both education and research in the basic marine sciences and numerical climate modeling are undertaken. Therefore the AORI has a responsibility to foster good researchers and experts in those areas to maintain and increase the level of research activity not only in the AORI but also in Japan.

Faculty members of the AORI are free from responsibility for course lectures for third and fourth year undergraduate students. While this allows more research time for the faculty members of the AORI, it lessens the opportunity for undergraduate students to communicate with faculty members of the AORI through lectures. The AORI has distinct disadvantages in enhancing participation of good undergraduate students in its programs in two respects compared with the Graduate School of Science on the Hongo campus; one is the significant geographical disadvantage, and the other is that the faculty members of the Graduate School of Science on the Kashiwa campus are less known to undergraduate students than those on the Hongo campus. (There are meteorology and oceanography courses in the Graduate School of Science on the Hongo campus, and these courses could be one possible choice for those undergraduate students who are interested in meteorology/oceanography and climate.)

As a strategy to overcome the disadvantages mentioned above and to succeed in enhancing participation of good undergraduate students in the AORI (which is essential to foster outstanding graduate students) the AORI has introduced several programs. The all-campus independent seminars and all-campus hands-on experience seminars for the first and the second year undergraduate students inform them of the range of research activities at the AORI. As students must determine the specific area of education they want to focus on in the third and fourth years before finishing the second year, the two seminar programs are given at an appropriate time. The Atmospheric and Marine Sciences Internship Program, which is given for the third year students, provides good opportunities for students to communicate with the AORI faculty and learn about the importance of engaging in graduate course at the AORI. Postgraduate Study Guidance for fourth year students also helps to emphasize to undergraduate students the importance of engaging in graduate courses at the AORI and helps to cultivate an interest in the ocean and atmospheric sciences.

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.

The AORI plans to strengthen its involvement further in the education for the first and second year students by proposing the following to the University of Tokyo:

- i) Seminars of small size for the first and second year students;
- ii) Kashiwa Campus Winter Program for the first year students.

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.

Currently about 200 graduate students are supervised by the faculty members of the AORI, roughly equally divided between PhD and MS students. About 30% of the students are female. Each faculty member supervises, on average, about three graduate students. This number is appropriate, and this level should be kept or increased slightly in the future. The number of MS students at the AORI in the Graduate School of Science has decreased from 53 to 38 in the past several years, while no such decrease is seen in other Graduate Schools. The reason for this decrease is not clear.

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.

The AORI has introduced the Director's Prize for new doctorate recipients as a response to a recommendation in the previous review of the CCSR. This is effective in encouraging graduate students.

We recommend that the Director's Prize be continued.

There are currently 80 postdocs at the AORI. This number is surprisingly small compared to the number of the faculty members. The contribution of postdocs in generating important research results is highly significant. However, postdoc positions are unstable and there is no long-term career path, with a maximum employment period of five years.

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

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?

International research activities are a major part of the AORI's research portfolio. These efforts are primarily focused on two organizations within the AORI - The Center for International Collaboration (CIC) and the International Coastal Research Center (ICRC). The latter organization is discussed in the response to Question 9. Individual faculty members in the departments and research centers also carry out numerous international research activities. The AORI faculty have been involved in a number of highly successful international projects. The AORI has concluded academic exchange agreements with 16 research organizations in 10 countries in Asia, Australia, Europe, and North America, including the US, the UK, and South Korea. It continues to promote academic exchanges by dispatching and inviting researchers to and from these and other nations, and there have been a significant number of exchange visits between the AORI and foreign institutions. The number of Japanese scientists going to foreign institutions has been increasing recently. However, the number of visiting scientists coming to the AORI has been continually decreasing each year, largely because the Multilateral Cooperative Research Program "Coastal Oceanography" ended in 2010. Human resource development and academic exchanges with other Asian countries have been promoted through the JSPS's Asia Core Program.

The ocean and atmospheric sciences, by their very nature, are international and global in character. The Center for International Collaboration will thus continue to play a critical role in making certain that the AORI and its faculty and students are intimately involved in international activities. The leadership provided by Japanese scientists in developing oceanography programs in the Southeast Asia region has been, and will continue to be, of particular importance. Nations in this region recognize the strength and breadth of the marine programs in Japan in general and AORI in particular, and they look to Japan and the AORI to continue their aid and support of the developing marine programs in this region. The coastal waters of southeast Asia will continue to be heavily impacted by the large population centers in the region, and continuing and growing research programs to evaluate the impact of human activities on marine biogeochemistry, fisheries, climate change, etc. will be especially important. Due to its geographical position and its widely recognized scientific expertise, the AORI and its scientists should play an important leadership role in this region. Joint research programs and active exchange programs should be common. The AORI should also play a leading role in education programs in this region, focusing on training of graduate students from Southeast Asia and encouraging postdoctoral students to spend time at the AORI. Faculty exchange programs between the AORI and research institutions in Southeast Asia should also be encouraged strongly.

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

The Center for International Collaboration is also a key domestic center for large-scale international research projects. It promotes and supports inter-governmental agreements on academic activities related to the ocean and climate, and it promotes international integrated research in the ocean and atmospheric sciences. It also serves as the organizational base for international academic exchanges and for training young scientists from overseas, as mentioned above.

CIC continues to fulfill their responsibility as a coordinator for governmental agencies and for the atmospheric and marine research community in Japan that operate under the rubric of intergovernmental agreements on oceans and climate, such as the UNESCO/Intergovernmental Oceanographic Commission (IOC), the North Pacific Marine Science Organization (PICES) and the Intergovernmental Panel on Climate Change (IPCC). Professors in CIC have leading roles in Japan's membership in the IOC, with Prof. Uematsu chairing the Japanese delegation and Prof. Michida serving as a Vice Chairman of IOC. CIC faculty have also played a leading role in several programs of the International Geosphere Biosphere Program (IGBP) as well as leading the development of the research and

education network in coastal oceanography in Southeast Asia. Other AORI faculty members have had important leadership roles in other international programs such as INQUA and PAGES.

The new International Council for Science (ICSU) Future Earth Program, which combines the old IGBP, International Human Dimension Program (IHDP), and Diversitas, will be getting underway shortly. Japan should have a central role in Future Earth, and the CIC is in an excellent position to make certain that the AORI and its scientists are involved. Several AORI faculty members have been significantly involved with the older ICSU programs, and this should continue in Future Earth. Of particular importance will be bringing young scientists from the AORI into the program right as it is beginning. They will then be in a position to have leadership roles in the various parts of Future Earth. CIC is in an excellent position to help the AORI faculty be involved in creating and promoting integrated international research in Future Earth and other international research efforts.

Faculty in the Department of Ocean Floor Geosciences have contributed significantly to the recently completed Integrated Ocean Drilling Program. Japan has made a major commitment to the new International Ocean Discovery Program, both in terms of scientific support, but also through the operation of the drillship *Chikyu*. The AORI faculty and their outstanding climate models have contributed significantly to IPCC assessment reports and that should continue and expand in the future if possible. The AORI clearly has had a strong presence on the international research scene.

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.

Of some concern is that several members in the leadership of CIC are approaching retirement age, and active continuation of CIC and its programs is critical for the AORI.

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.

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.

The AORI has made great strides in public engagement and outreach since the 2008 external review. The robust combination of community education activities is truly impressive and creative. Combined with this are the many publications written to enhance public understanding and appreciation of ocean and coastal systems and their importance to Japan's well being. This is also matched by service by AORI faculty on government committees and councils that has provided the broader society with useful scientific findings that serve as a foundation for good public policy. We comment on three particular areas of strength.

Graduate Education :

A fundamental component of the AORI's mission is the training of future leaders in atmospheric and marine sciences through its graduate education program. It produces human resources who will develop and contribute to understanding the Earth system and lead to actions that address environmental challenges. It is clear that the AORI has been highly successful in training many outstanding scholars. Nevertheless, the AORI has no database listing these alumni, both former faculty and graduate students whose success the Institute and its resources made possible.

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

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.

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.

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

The AORI is part of the University of Tokyo Ocean Alliance, which engages a large number of faculty and researchers from a variety of graduate schools, research institutes and one research center in a broad range of ocean-related topics. Ocean Alliance is developing human resources in marine science through such programs as the Interdisciplinary Education Program in Ocean Science and Policy. The aim is to address contemporary ocean-related issues in an interdisciplinary and comprehensive way, to deepen the understanding of the oceans, and to develop new ideas, technologies and industries, and cultivate new academic disciplines that integrate these connected fields.

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.

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.

Public Engagement and Outreach (Public Relations) :

The AORI is to be highly commended for establishing a Public Relations Office in 2010. It comprises technical officers who aid students and faculty to prepare manuscripts. They also support the Institute's website, which is aimed both at the general public and at undergraduate students who are interested in graduate study. It outlines research activities, makes available the catalog and newsletters via download, and reports on the restoration status of the International Coastal Research Center and of the town of Otsuchi. The staff also hosts visitor events at the AORI facilities and an impressive variety of public engagement activities. The "Science Sushi Bar" is particularly creative. These activities range from its annual, widely distributed bilingual catalog, which summarizes research activities and accomplishments, to its three impressive newsletters. Universities exist to support the public good, and the efforts of the Public Relations Office are demonstrating the value of the AORI to its public.

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

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.

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.

Public Engagement with Government :

The AORI is contributing to policy planning by the government through provision of faculty members' expertise on ministerial councils and committees. In a most impressive example of public engagement, the AORI faculty has undertaken responsibility to ensure a rigorously scientific understanding of the destruction caused by the 2011 tsunami. The AORI is supporting the use of science to assist the restoration processes of ecosystems and the fisheries industry in the Sanriku Region. The aim is to clarify the status of ecosystems destroyed by the tsunami, determine what is required for restoration, and transmit findings internationally. The AORI's response to the recent earthquake and tsunami is a truly outstanding example of science for the public good.

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.

The impacts of hazards, climate change and human activities on coasts and their communities are multifaceted and require an integrated multidisciplinary response.

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.

The best public engagement involves a two-way communication between the Institute and its stakeholders, including the general public and their government institutions.

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.

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.

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.

The AORI appears to have a good support system for joint usage/research compared with other institutions inside and outside Japan. The institute undertakes research support through three different sections of the Center for Cooperative Research Promotion. These sections include Field Research Support, Laboratory Research Support, and Coastal Research Support. The Field Research Support Section primarily handles the operation of equipment for research cruises, and is primarily a shipboard activity. It also develops or improves equipment shoreside. The Laboratory Research Support Section supports laboratories at the AORI that are used by many individuals and groups and also promotes the use of new technologies. The Coastal Research Support Section operates from the Otsuchi campus and provides research support to both the AORI and external researchers. Recently this section has been focusing on the restoration of the damaged facilities on that campus, including ships. There has recently been a significant decrease in the technical support personnel of these sections, and this is a cause for considerable concern.

The AORI presently has 14 technical staff members for field research (11 in the Field Research Support Section and 3 in the Center for Cruise Coordination), but only one staff member exists who is related directly to physics. This does not provide sufficient support for investigators who require that expertise.

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

For the continuous improvement of services by technical staff it is necessary that the staff know about recent advances and changes in their technical field. This requires active training and reading about changes made within the technical groups. An annual report by the technical staff providing information on the improvement of technology in their areas can be valuable, e.g., see <http://www.riam.kyushu-u.ac.jp/gikan/>.

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

The age distribution of the present technical staff is a challenge for the future technical service system because many older technical staff members will retire in the near future and the succeeding employment of younger staff will likely be difficult due to budget problems. The number of technical staff in the AORI is already insufficient for providing scientific services in the joint usage/research system. To increase the number of technical staff, the AORI

must try to obtain external funds because support from the University of Tokyo and MEXT will likely continue to decrease.

Question 9. The International Coastal Research Center, which was badly damaged by the Great East Japan 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.

The International Coastal Research Center is located in Otsuchi Town, Iwate Prefecture. The ICRC suffered major damage by the Great East Japan Earthquake and the subsequent Tsunami on March 11, 2011. However it was fortunate for ICRC that the 3rd floor of the main building escaped major damage, although the first two floors were destroyed. ICRC established the new Coastal Ecosystem Restoration Section in April 2012 to address issues related to the disaster. The ICRC has continued its research activities, including “Project Grand Maillet”, under the umbrella of TEAMS (Tohoku Ecosystem-Associated Marine Science), which is based on the 3rd floor of the building. The Great East Japan Earthquake and the subsequent tsunami constituted a major disaster, but it provided an opportunity for establishing a new style of joint usage/research program. TEAMS is being developed from this perspective. The ICRC is now conducting extensive monitoring research related to the restoration of ecosystems in Otsuchi Bay and the Sanriku coastal area after the major damage arising from the earthquake and tsunami as part of Project Grand Maillet.

Many of the primary current studies at ICRC concern ecosystem changes in Otsuchi Bay. However, these changed ecosystems may induce changes in material cycling in that region, especially bio-active elements such as phosphorus, nitrogen, silicon, etc. Moreover, changes in material cycling in turn will cause ecosystem changes.

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.

Otsuchi Town plans to conserve the coastal low land area where the elevation is less than 14.5 m above sea level, allowing no residences in that area.

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.

Related to Project Grand Maillet, public involvement and engagement are also important for the recovery of human well-being in the Tohoku district from the tremendous damage by the great earthquake and tsunami. Involving the public in gathering the appropriate scientific information and knowledge for the restoration of the coastal environment there is very important. This type of scientific outreach by the AORI is particularly valuable in the Tohoku district of Japan.

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.

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