The Establishment of the Marine Ecology Research Institute and Its Subsequent Development

The Marine Ecology Research Institute (MERI) was established in December of 1975 as an incorporated foundation under the joint jurisdiction of the then Environment Agency, the Ministry of Agriculture and Forestry, and the Ministry of International Trade and Industry; its aim was to carry out scientific research on the impact of power plant cooling water intake and discharge on marine organisms and their environment. Subsequently, on 1 April 2012, the institute became a public interest incorporated foundation.

At the time of its founding, the institute carried out research that focused on topics of high public concern. These studies included using transmitting tags to track fish behavior in the area offshore of power plants, and using experimental devices to manipulate water temperature and observe its effect on long-term growth and behavior.

Since then, we have expanded the scope of our research beyond the impacts of power plant cooling water intake and discharge to encompass a wide range of topics relating to marine organisms and their environment such as marine radioactivity, eutrophication, soil runoff, intensified ultraviolet radiation, and the reduction of seaweed beds.

In recent years, in addition to investigating methods for forecasting environmental impacts on marine ecosystems and carrying out experimental studies on trace chemicals in the marine environment, we have also carried out research on climate-change induced ocean warming and ocean acidification and have worked to develop monitoring techniques relating to sub-seafloor carbon dioxide storage. Furthermore, in the aftermath of the Great East Japan Earthquake, we have been studying radiation levels in the seawater, ocean sediments, and fish and shellfish within the region impacted by the Fukushima Daiichi Nuclear Power Station accident.

We at the MERI hope to continue serving the needs of society in our capacity as a public interest incorporated foundation by actively communicating our research results to the public in order to contribute to the preservation of marine organisms and their environment.
I. Organization

Head Office
Our head office is located in Tokyo’s Shinjuku Ward and is responsible for the management of the research institute as a whole as well as research planning. Moreover, the office also addresses various issues pertinent to specific regions such as assisting the adoption and operation of antifouling technologies.

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Central Laboratory
The Central Laboratory is located in Onjuku on the Sotobo Coast of Chiba Prefecture, allowing us to obtain clean seawater from the region immediately offshore from the facility. Our activities include basic research utilizing our experimental rearing facilities as well as field research and radiation surveys. Furthermore, we are actively acquiring new information for our data library, which contains experimental results from domestic and overseas research relating to thermal effluents, organisms, and the environment, and distribute this information to the public.

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Demonstration Laboratory
The Demonstration Laboratory is located in Niigata Prefecture near the Tokyo Electric Power Company’s Kashiwazaki-Kariwa Nuclear Power Plant. We have experimental facilities that can make use of the thermal effluent discharged from the power plant as well as natural seawater, and are carrying out applied research pertaining to climate change and ocean acidification. Moreover, we operate a joint facility that displays documents concerning thermal effluents, and we use this to exhibit information on thermal effluents alongside the results obtained by our research efforts.

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II. Scientific Research Overview

Central Laboratory

1. Assessment of radiation levels in the marine environment and seafood

2. Biological experiments conducted in tandem with field studies

3. Collection and dissemination of documents and information

4. Rearing and breeding of experimental organisms

5. Analysis of monitoring survey data for marine organisms and environments near power plants

6. Research on the growth and maturation of marine fish, shellfish, and seaweeds under long-term rearing and cultivation

7. Impact of trace chemicals on marine organisms

8. Assessment of the effects of entrainment by power plant cooling systems on marine organisms and marine resources in general

9. Assessment of radionuclide concentrations in marine organisms, seafloor sediment, and seawater in the principle fishing grounds in the vicinity of nuclear power plants and nuclear fuel cycle facilities

10. Investigation of antifouling technologies for use in power plant cooling systems

11. Tracking large fish species in areas near thermal effluent outfalls and fish pens to analyze the impact of thermal effluents

12. Development of research and forecasting techniques for marine ecosystems

13. Revealing the mechanism and range of impacts of thermal effluent on seaweed and benthic organisms

14. Issues relating to ocean eutrophication, oxygen depletion, and soil runoff

15. Research related to ocean warming, seawater carbon dioxide concentrations, and ocean acidification
III. Dissemination and Use of Research Results

At the MERI, we are contracted to carry out research for national and local government, and private entities. Moreover, we disseminate our research results in accordance with requests from local governments of regions with electric power generation and related industries.

Dissemination of Research Results

In addition to publishing our research results in scientific journals and the Report of the Marine Ecology Research Institute, we also offer easily understandable explanations in publications intended for a general audience such as MERI News, pamphlets, and our website.

Back issues of research reports and publications as well as video of experimental animals can be viewed on our website.

Data Library and Thermal Effluence Document Exhibit

The data library at the Central Laboratory includes information concerning power plant cooling water intake and discharge and ecological data on marine organisms collected from domestic and overseas research reports and scientific journals. This information is used to support scientific research at the MERI, and we also respond to requests from seafood and electric utility industry groups.

At the Thermal Effluent Document Exhibit located in the Demonstration Laboratory, we display information in such a way that children and the general public can have fun while learning about the ocean and thermal effluents.

Interaction with Local Communities

At the Central Laboratory, we open up the laboratory to the public as part of neighborhood events, and at the Demonstration Laboratory, we do so with the assistance of the city, neighborhood associations, and fishing cooperatives.

As part of these programs, we endeavor to educate visitors about marine organisms and their environment in a fun and easy way through tours of the laboratories, microscope observations of living organisms, fish dissection, touch pools, and a science café.

Furthermore, we also offer numerous hands-on activities including making pressed seaweed bookmarks, seafloor clay pottery, fish-patterned cloth bags, and squid-ink calligraphy. These activities help our visitors establish a deeper relationship with the sea.

Finally, we strongly value our ties with our communities and participate in environmental study programs with local elementary and middle school students.

Publications (Report of the Marine Ecology Research Institute, MERI News, and Ocean Tidbits)

The Thermal Effluent Document Exhibit

A tour of the marine organism rearing facilities

Fish dissection

Touch pools (aquaria containing marine organisms that visitors can touch directly)

Science café (a symposium where visitors can drink tea while listening to talks given by specialists)

Pressed seaweed bookmarks (visually striking seaweeds are spread onto a piece of paper, pressed and dried, and then turned into bookmarks)

Stamp cloth bags (visitors customize a cloth bag using fish-shaped stamps of their choosing)
IV. Power Plants, Marine Organisms, and Their Environment

We use field studies in the region offshore of power plants as well as laboratory studies utilizing the experimental marine organism rearing facilities at the Central and Demonstration laboratories to analyze the impact of power plant cooling water intake and discharge on the environment. Furthermore, we also investigate techniques for forecasting the impact of power plant siting on coastal ecosystems as well as technologies for preventing the fouling of cooling water intake pipes by aquatic organisms.

Combined Impacts of Thermal Effluents and Other Factors
There is some concern that high temperature and low salinity caused by power plant thermal effluents along with low oxygen and turbidity could drive compound impacts on marine organisms particularly in the littoral zone of enclosed bays or inland seas. As a result, we have carried out experimental studies on this subject. So far, we have gained an understanding of which varieties of fish, bivalves, and large macroalgae are most vulnerable and at what developmental stages, and have determined some impact thresholds. Moreover, in recent years, the northward range expansion of southern herbivores has harmed seaweeds by increasing grazing pressure and has led to the reduction of seaweed beds (rocky-shore denudation). In order to examine the relationship between this phenomenon and rising seawater temperatures, we used laboratory studies to determine how the feeding rate of the principle herbivores including rabbitfishes and Longspine black urchins on large macroalgae was affected by water temperature.

Fish Responses to Temperature
We used fish pens (photo at right) moored near power plant cooling system discharge sites on the Japan Sea to study the behavior of large fish in response to thermal effluents. The figure below indicates the water temperature distribution in the pens and the vertical distribution of yellowtail. Whereas in the summer, yellowtail avoided the thermal effluent water by swimming at mid and lower depths below the high temperature layer, in the winter yellowtail were actually drawn to the high temperature layer. We also carried out this research on anadromous migratory salmon including chum salmon and cherry salmon.

The temperature distribution within fish pens moored in the vicinity of thermal effluent outfalls and the distribution of yellowtail (black dots)
Marine Experiments on the Impact of Thermal Effluents

In order to reveal the magnitude and range of the impact of power plant thermal effluents on seaweed, we positioned settlement plates seeded with immature seaweed in locations experiencing various degrees of temperature change due to exposure to thermal effluents. We then observed the growth and maturation of this seaweed over time. As a result, we were able to observe differences in the growth and maturation of seaweed between regions in direct contact with thermal effluents (3–5°C increase in temperature relative to surrounding waters), in slight contact with thermal effluents (2–3°C increase in temperature relative to surrounding waters), and not in contact with thermal effluents.

Development of Research Methods and Forecasting Techniques for Ecosystem Impact Assessment

We are investigating the best methods and techniques for researching and forecasting the impacts of power plants on coastal marine ecosystems as part of the power plant assessment process.

We developed technology to input data pertaining to the organisms of interest within an ecosystem along with environmental factors into a database, model the relationship between organisms and environmental factors, and finally output the forecast results into a geographical information system (GIS). The figure on the lower right shows an analysis of the impact a hypothetical power plant would have on a species of interest, in this case a type of seaweed known as arame (red: high impact; yellow: low impact). Although much of the red area indicates arame extirpation due to land reclamation, there is also an area close to the discharge outfall that is also forecast to experience local extirpation.

Development of Antifouling Technologies for Cooling Water Systems

Biofouling of power plant cooling water systems can degrade heat exchange capacity in elements such as steam condensers and can damage equipment. We are investigating ways to combat this problem by using antifouling methods that have minimum impact on marine organisms.

We have carried out culture experiments using blue mussels to determine the effectiveness of chlorine dosing as well as to study the stable operation of antifouling methods using chlorine dosing.

When large planktonic organisms such as moon jellies become entrained in power plant cooling water intake systems in substantial numbers they can clog the screens and cause a decline in power generation capacity due to an inability to intake sufficient seawater for cooling. Consequently, we are studying the ecology and environmental requirements of the jellyfish’s sessile polyp stage with a view to developing a method to forecast the arrival of large numbers of jellyfish. As part of this effort, we have been able to identify nursery regions for polyps in our study area.
V. Radiation Level Surveys in Marine Organisms and Their Environment

We are monitoring radioactive substances in the water, seafloor sediments, and marine organisms in the vicinity of nuclear power plants and nuclear fuel cycle facilities to determine the safety of nearby fishing grounds as well as to assess the safety of seafood related to the accident at the Fukushima Daiichi Nuclear Power Plant.

Surveys of Marine Environmental Radiation Levels

We are carrying out radiation level surveys of seawater, seafloor sediments, and marine organisms in the regions surrounding nuclear power plants and offshore of nuclear fuel cycle facilities across the country and compiling basic data for the nation’s comprehensive assessment of marine environmental radiation.

Moreover, due to the accident at the Tokyo Electric Power Fukushima Daiichi Nuclear Power Station and following a request from the national government, we began emergency monitoring in the ocean around the Fukushima Daiichi Nuclear Power Station on 23 March 2011. In addition, after receiving the Enforced Plan on Environmental Monitoring from the Nuclear Emergency Response Headquarters, we began large-scale offshore monitoring from Miyagi Prefecture to Ibaraki Prefecture in May 2011. Finally, in November of 2013 we began monitoring in the vicinity of the Fukushima Daiichi Nuclear Power Plant. These activities continue to this day, and the monitoring results are published as preliminary figures on the Nuclear Regulation Authority website.

Seafood Sampling and Radiation Level Analysis

We are evaluating the situation following the accident by analyzing radionuclide concentrations in fish caught along the Pacific coastline, offshore, and inland water bodies.

Seafood samples are obtained from fishing cooperatives, fish markets, and national and prefectural research institutions in various regions throughout eastern Japan and sent to the Central Laboratory. After sampling the edible portions (muscle, liver, ovary, testes, etc.) and preparing the specimens, we utilize gamma-ray spectrometry using germanium semiconductor detectors to measure the concentration of radioactive substances (iodine-131, cesium-134, cesium-137). We then determine the radiation level (becquerels) per kilogram of specimen (wet weight).

The results of our measurements are quickly conveyed to the Fisheries Agency, relevant local governments, and fisheries-related organizations along with information such as the day and location of capture. These results can also be viewed on the MERI website.
VI. Climate Change Related Research

We are conducting marine environmental studies and experimental studies on the effects of carbon dioxide (CO₂) on marine organisms to investigate techniques for forecasting or mitigating the impact on marine organisms of CO₂-driven climate-change and the resulting perturbations in the marine environment.

Marine Environmental Surveys
Carbon capture and storage is a climate change mitigation strategy. The MERI is investigating the potential impacts of sub-seafloor carbon dioxide storage on water quality, bottom sediments, organisms, and other aspects of the marine environment.

CO₂ Impact Studies Using Marine Organisms
As the atmospheric CO₂ concentration increases, there is an accompanying increase in CO₂ dissolved in the oceans. This drives the gradual change in pH of seawater towards neutral conditions from basic. In an effort to determine the impact of these environmental changes on marine organisms, the MERI is conducting CO₂ impact studies on bivalve growth and fish breeding. Moreover, we are also participating in experiments at several locations across the country to determine rates of recruitment and settlement of sessile organisms in high-CO₂ water in an effort to predict the impact of ocean acidification on marine ecosystems.
VII. Chemicals in the Marine Environment

Of the many chemicals produced and used in human activities, some have harmful effects on people and wild animals. At the MERI, we not only study the impact of these chemicals on the survival and reproductive capacity of marine organisms from the standpoint of environmental conservation and marine species protection, but we also are developing testing methods to evaluate their toxicity. So far, we have studied the impact of endocrine disruptors on marine organisms as well as the bioaccumulation of dioxins in seafood across the country, and have developed biological monitoring methods to evaluate the concentration of chemicals and the state of pollutants in the ocean. Furthermore, we have also investigated experimental methods for studying the impact of chemicals on the maturation and early life-stage development of Japanese whiting as well as acute impacts on zooplankton including Tigriopus copepods and have developed methods for studying reproductive impacts, all with the objective of assessing the environmental risk of certain chemicals.

VIII. Development of Rearing and Breeding Techniques for Experimental Organisms

Healthy organisms are necessary to obtain high-quality data on the response of organisms to environmental change or the toxicity of certain chemicals. At the MERI, we are developing new techniques to ensure that we can reliably produce healthy experimental organisms. We are also making progress on the rearing and breeding of rare marine and freshwater organisms.
Rearing Facilities

The husbandry facilities at the Central Laboratory and Demonstration Laboratory allow us to raise our experimental organisms under specified, controlled seawater temperatures. Furthermore, by specifying the light conditions (i.e., light quality, amount, and day length) and water temperature, both of which impact the maturity of many marine organisms, we are able to breed a variety of species.

Central Laboratory facilities

Seawater supply facilities:
Water intake capacity: 75 m³/h
Water filtration capacity: 25 m³/h x 2 systems

Water temperature control facilities:
6 m³/h of 32 °C seawater, and 3 m³/h of 8 °C seawater

Rearing facilities:
Nursery stock tanks, spawning tanks with attached light-control devices, temperature acclimation tanks, spawning tanks for rearing broodstock, etc.

Demonstration Laboratory facilities

Seawater supply facilities:
Water intake capacity: 200 m³/h of seawater x 2 systems
Natural seawater filtration capacity: 20 m³/h x 2 systems
Thermal effluent filtration capacity: 20 m³/h x 1 system
10–35 °C seawater: 7 m³/h (marine organism husbandry experimental facilities)

Rearing facilities:
Spawning tanks for rearing broodstock, juvenile rearing tanks, etc.

Producing Experimental Organisms to Meet Research Needs

At the MERI, we have succeeded in rearing over 100 species of marine organisms. We have the capacity to rear and breed organisms to meet research objectives and separate them by life stage (e.g., eggs, larvae and juveniles, and adults) or size. We aim to achieve an even more reliable supply of healthy organisms by refining our early life-stage feed and improving our techniques.

Feeding flounder fingerlings with high-nutrient feed (red sea bream eggs)