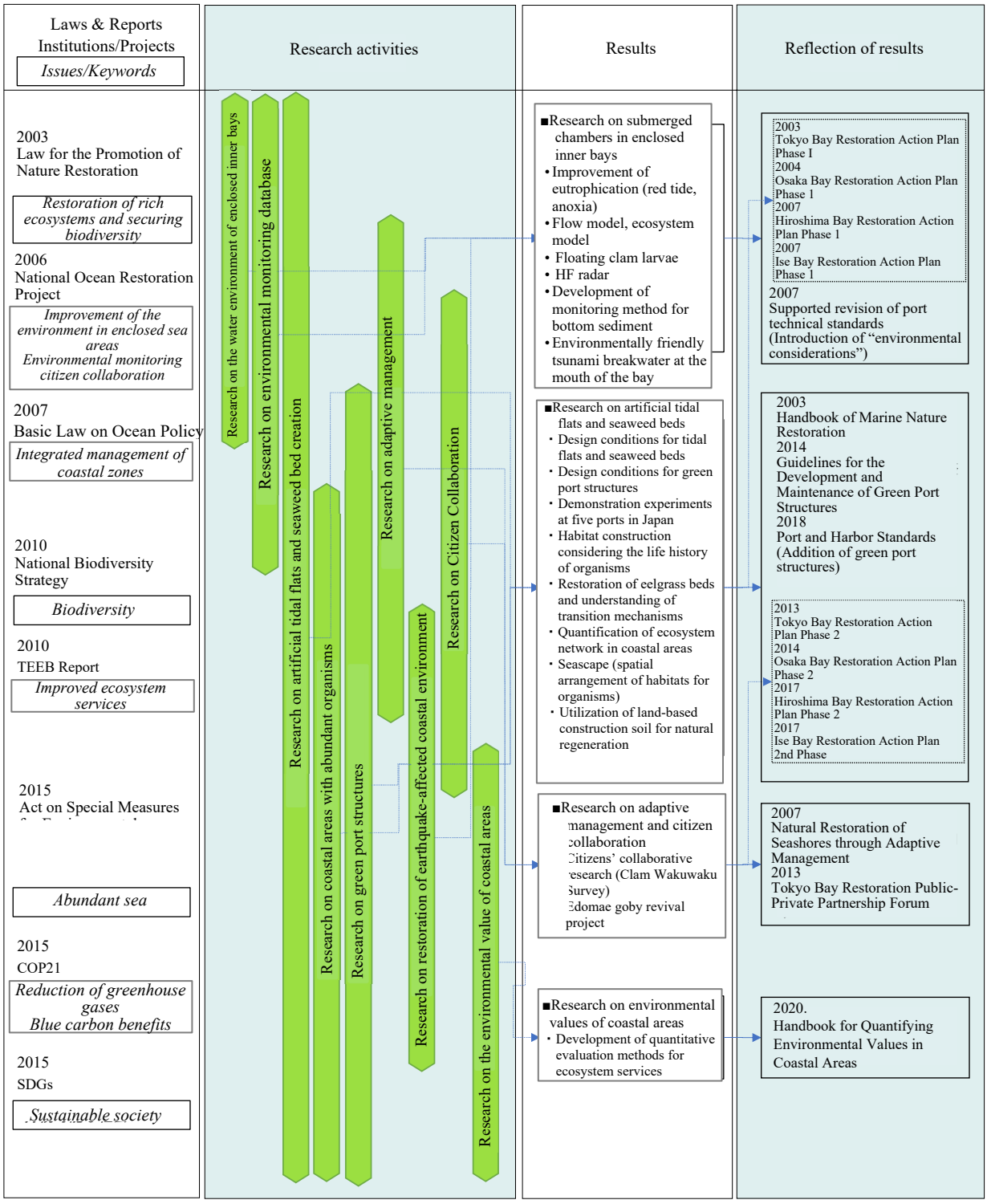
Coastal natural environment

1. Outline of Studies and Activities



Over the past 20 years, the central issue in coastal environments has changed from water quality improvement measures, such as eutrophication control, to environmental conservation, restoration, and creation. With this transition, ecosystems, fish, seaweed, and other organisms and plants have been added as new study targets, and research has been conducted by integrating engineering and biology. The coastal areas that have been conserved, restored, and created provide benefits not only to organisms but also to people. Research was also initiated on the relationship between people and coastal areas, such as citizen cooperation and improvement of ecosystem services.

■Study on water sediment quality in closed inner bays

(Background/Issues) The increase in the inflow of domestic wastewater and industrial wastewater from factories and other sources during the period of rapid economic growth has resulted in the accumulation of excessive organic matter and nutrients in water bodies, causing eutrophication of coastal waters. In harbors, the presence of port structures such as reclaimed land and breakwaters has caused the stagnation of water flow, which locally increased eutrophication. Symptoms of eutrophication include red tide, bottom sludge, and anoxia of the bottom layer, which have had a great impact on the habitat of aquatic organisms and the human-friendly environment.

(Research Outline and Results Implementation) In order to take appropriate countermeasures against the symptoms of eutrophication, surveys and studies were conducted to elucidate the mechanisms of its occurrence. Based on these mechanisms, countermeasures such as sand covering and sludge dredging have been implemented in many ports in Japan. The countermeasure techniques, water environment monitoring methods, and target values were reflected in the action plans for the restoration of Tokyo Bay, Osaka Bay, Hiroshima Bay, and Ise Bay.

■Research on tidal flats and seaweed beds

(Background/Issues) Water and sediment quality gradually improved as a result of the eutrophication countermeasures. However, the frequency of red tides and anoxia remained unchanged. In addition, the recovery of species and abundance of organisms was not remarkable. The study results revealed that the main reasons for this were a decrease in the natural cleansing capacity and a decrease in habitats due to the loss of tidal flats and shallow areas. Therefore, the goal for coastal areas has changed from improvement of water quality to restoration of rich ecosystems and protection of biodiversity (Law for the Promotion of Nature Restoration, 2003).

(Research Outline and Results Implementation) Studies were conducted on design conditions and concepts for tidal flats and seagrass beds that can sustainably maintain a variety of organisms and their biodiversity. The design conditions of tidal flats and seagrass beds were organized according to the currents, waves, and quality of the surrounding waters, and were compiled in the “Marine Nature Restoration Handbook.” In addition, we developed the “Guidelines for the Development and Maintenance of Port and Harbor Structures in Harmony with Organisms,” which provides a positive habitat for organisms even in the limited water area of ports and harbors. The technology was also reflected in the “Technical Standards for Port and Harbor Structures” (revised in 2008).

■Research on adaptive management and citizen collaboration

(Background/Issues) In order to sustainably maintain the created habitats, attention has been paid not only to the hard aspects, such as adaptive management and citizen cooperation, but also to the soft aspects (Basic Act on Ocean Policy, 2007). Unlike water and sediment quality, the challenge for living organisms is that uniform management methods cannot cope with natural fluctuations.

(Research Outline and Results Implementation) The study was not a desk study, but a practical study of how management should be conducted and how a framework for citizen cooperation should be established. The findings of the practical study

were organized as “Nature Restoration of Seashores by Adaptive Management.” The concept of citizen collaboration was reflected in the second phase of the Action Plan for the Restoration of Tokyo Bay, and habitat management by citizen collaboration has been practiced in many places.

■Research on the environmental value of coastal areas

(Background/Issues) Tidal flats, seaweed beds, and green port structures have been constructed throughout Japan. They are now recognized not only as habitats for living organisms, but also as places where people can enjoy a variety of environmental values such as food supply, water purification, daily recreation, and environmental education. In recent years, global warming countermeasures and the achievement of sustainable development goals have become universal issues (COP21, 2015; SDGs, 2015). In addition, the function of blue carbon as a global warming mitigation measure in coastal areas has begun to attract attention.

(Research Outline and Results Implementation) A method to quantitatively evaluate various environmental values in coastal areas was developed and compiled in the “Handbook for Quantification of Environmental Values in Coastal Areas.” This handbook is used as an evaluation tool for the creation of coastal areas that produce environmental values in accordance with local needs.

2. Main Research Results

■ Study on water sediment quality in closed inner bays

・Monitoring techniques and methods for water quality, sediment quality, and current conditions were developed and implemented to accurately understand actual phenomena such as the effects of open ocean water on the water quality in the bay, including anoxic water masses, and their seasonal variations.[1)-3)]

・Numerical models were developed and combined with the monitoring results to elucidate the occurrence mechanisms of red tides, anoxic water masses, and blue tides, to predict the future and to verify the effectiveness of countermeasure technologies.[4), 5)]

・Field surveys and numerical modeling of floating clam larvae were conducted (Figure-1) to demonstrate the importance of ecosystem networks for sustainable habitats.[6)]

Figure-1 Network of floating clam larvae in Tokyo Bay. The larvae migrate to tidal flats other than the one where they were born.

■Research on tidal flats and seaweed beds

・Design conditions for tidal flats and seagrass beds that match the flow, waves, and water quality of the surrounding water bodies were organized through demonstration experiments.

・We clarified the importance of continuous and diverse habitats for increasing biodiversity.[7)]

・We developed green port structures (Figure-2) that can provide habitats for organisms even in limited water areas of harbors.[8)-10)]

・We showed that the spatial arrangement of habitats (Seascape) considering the ecosystem network is important to sustain habitats with rich and diverse organisms.[11), 12)]

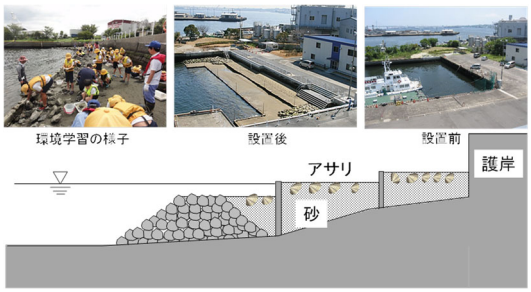


Figure-2 Tidal flat type green port structure (Shiosai Nagisa) built in the Yokohama Research and Engineering Office for Ports and Airports, Kanto Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism. Photo courtesy of the same office.

■Research on adaptive management and citizen collaboration

・The adaptive management approach was adopted to cope with natural variability and biological uncertainty (Figure-3). The adaptive management framework was incorporated into the restoration action plan for each bay.

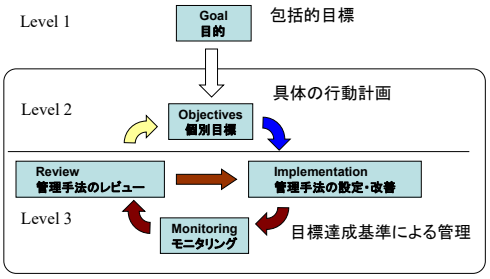


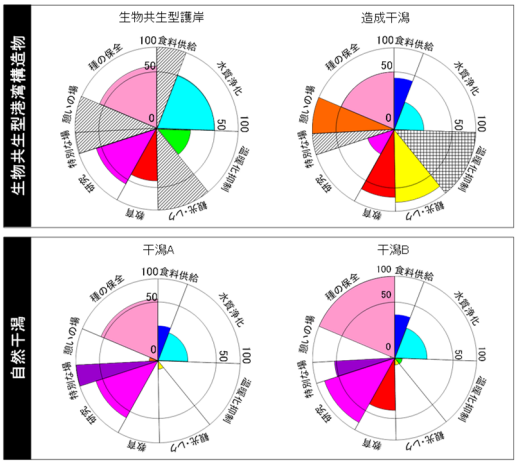
Figure-3 Adaptive management in coastal natural regeneration

・A framework for citizen collaboration to manage while using the bay and citizen-collaborative monitoring surveys were supported at various locations.[13)]

・In Tokyo Bay, we played a central role in the establishment and activities of the Tokyo Bay Restoration Public-Private Partnership Forum.

■Research on the environmental value of coastal areas

・We developed a method to quantify (visualize) various environmental values in coastal areas (Figure-4).[14), 15)] Using this method, we evaluated



the diverse values of built-up tidal flats, seagrass beds, and green port structures.

・We proposed an evaluation method that allows different actors to create and improve places in accordance with local needs while taking into account the balance of the diverse values.

Figure-4: Examples of calculations of various environmental values of tidal flats. The size of the pie section indicates the magnitude of the environmental value. Abbreviations are as follows: FP, Food provision; WI, Water quality improvement; GM, Global warming mitigation; RC, Recreation; EE, Environmental education; RS, Research; HS, Historical site; ER, Everyday relaxation; SC, Species conservation.

3. List of Related Reports and Technical Documents

1) Wind Controlled Intrusion of Kuroshio Warm Water into Sagami Bay, Japan, NILIM Research Report No. 17

2) Basic Study on the Monitoring Techniques for Bay Environment by Sensors Deployment, NILIM Research Report No. 35

3) HF Radar Measurements of M_2 Tidal Current in Tokyo Bay, NILIM Technical Note No. 212

4) Variation of Spatial Characteristics in Phytoplankton Bloom and Phosphorus Load from Rivers as Mixing Type Change in the Arakawa River Estuary, Tokyo, NILIM Technical Note No. 87

5) Water quality after tsunami generated by the "Great East Japan Earthquake of 2011," in Ofunato Bay, NILIM Technical Note No. 831

6) Larval Abundance, Distribution, and Size Composition of Planktonic Larvae of the Clam *Ruditapes Philippinarum* in the Fall Season in Tokyo Bay, NILIM Research Report No. 12

7) Report of Tidal-Flat Experiment in Hannan 2nd Section, Osaka, Japan, NILIM Technical Note No. 449

8) Design concept for a terrace type coastal revetment for habitat environment restoration, NILIM Technical Note No. 586

9) Monitoring of the ecological-type revetment on Port of Akita, Japan: A first year report, NILIM Technical Note No. 648

10) Record of habitat creation project at Shibaura Island, Tokyo, Japan, NILIM Technical Note No. 706

11) Examinations of Seascape in the Keihin Canal of Tokyo Bay – Case Study of Mollusks and Crustaceans, NILIM Technical Note No. 989

12) Habitat design for facilitating the diversity and persistence of marine organisms in an inner bay, NILIM Technical Note No. 999

13) Distribution of Juvenile Manila Clam (*Ruditapes philippinarum*) in Tokyo Bay by Citizen Participation Survey, NILIM Technical Note No. 916

14) A New Method for the Quantitative Evaluation of Services of Tidal Flats, NILIM Technical Note No. 890

15) Method for the quantitative evaluation of environmental value in tidal flat and its utilization, NILIM Technical Note No. 1077

4. Future Outlook

■Formation of coastal areas with rich habitats for diverse organisms

In recent years, the spatiotemporal bias of nutrients has become apparent, and management that includes effective utilization of the inflow load is required, taking into account the use of various stakeholders. Management of the inflow load is not a problem that can be solved only in the sea, and the viewpoint of integrated coastal zone management is becoming more and more important.

■Development of methods to assess, plan, and realize the diverse ecosystem services of coastal areas

Coastal areas are used by a variety of people. Thus, it is desirable to develop an evaluation method that contributes to the formation of a space satisfactory to everyone, and to create a framework that incorporates the results of the evaluation into project

planning and implementation.

■Incorporation of green infrastructure into port structures

The efforts made for green infrastructure in ports and harbors, i.e., green port structures, have revealed various issues to be addressed for their realization, such as environmental functions, stability, durability, and constructability of the structures, and increased costs. It is desirable to develop a system that allows green infrastructure to be considered at the planning and design stages, and to develop technologies that do not impair stability and durability and do not increase costs, even if environmental functions are incorporated.

■Development of technologies that contribute to carbon neutrality

The restoration of seaweed beds is an urgent issue in order to promote blue carbon ecosystems as an adaptation measure to global warming. On the other hand, the rise in seawater temperature due to global warming is causing the serious problem of rocky shore scorching. The development of technologies such as green port structures that facilitate the growth of seaweed beds will be beneficial for both adaptation and mitigation measures.

■Utilization of recycled materials such as construction byproducts

In order to respond to the stock-based society, various construction byproducts and recycled materials are attracting attention. They are also used as landfill materials and environmental improvement materials in coastal areas. However, the recycled materials produced in response to changes in industry change with the times. It is important to constantly collect information and pursue more effective environmental improvement materials, and at the same time, carefully verify the safety of new materials.