

Study on the environmental improvement in Nakagusukuwan Port Awase Area

This study was conducted in relation to the identification of the environmental conservation and monitoring measures for constructing a dredged material disposal site under the direct control of the Ministry of Land, Infrastructure, Transport and Tourism in the Awase area in Nakagusukuwan Port. Deliberations and analysis were made concerning the project implementation, the results of environmental monitoring and the conservation of seaweeds and algae, based on the opinions of experts.

Various deliberations were made in the fields related to this study based on the opinions of the committees and panels staffed with the persons of learning and experience listed below.

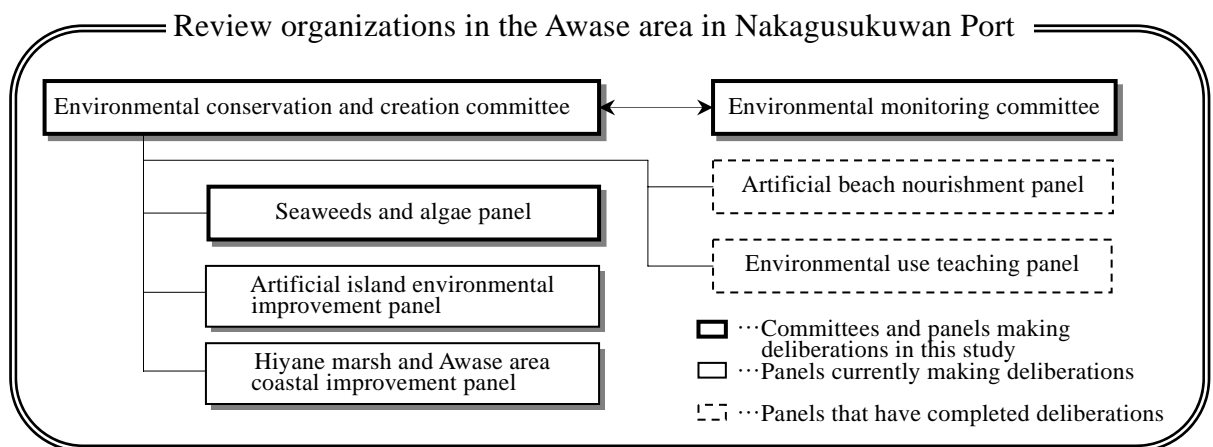


Figure 1 Correlations among review organizations

In this study, guidance was received on environmental conservation measures from the environmental conservation and creation committee and the seaweeds and algae panel. The results of environmental monitoring were reported to the environmental monitoring committee for evaluation.

In the seaweeds and algae panel, proposals were made concerning the "transplant of large seaweeds", one of the environmental conservation measures, and reports were submitted and proposals were made concerning the "creation of a field" for improving transplant techniques.

A list of conditions for the inhabitation of *kubiremidoro* (*Pseudodichotomosiphon constricta*), one of the endangered species, was presented based on the results of various tests and the analysis of relations between the oceanographic conditions and the growth of the species.

1. Study items

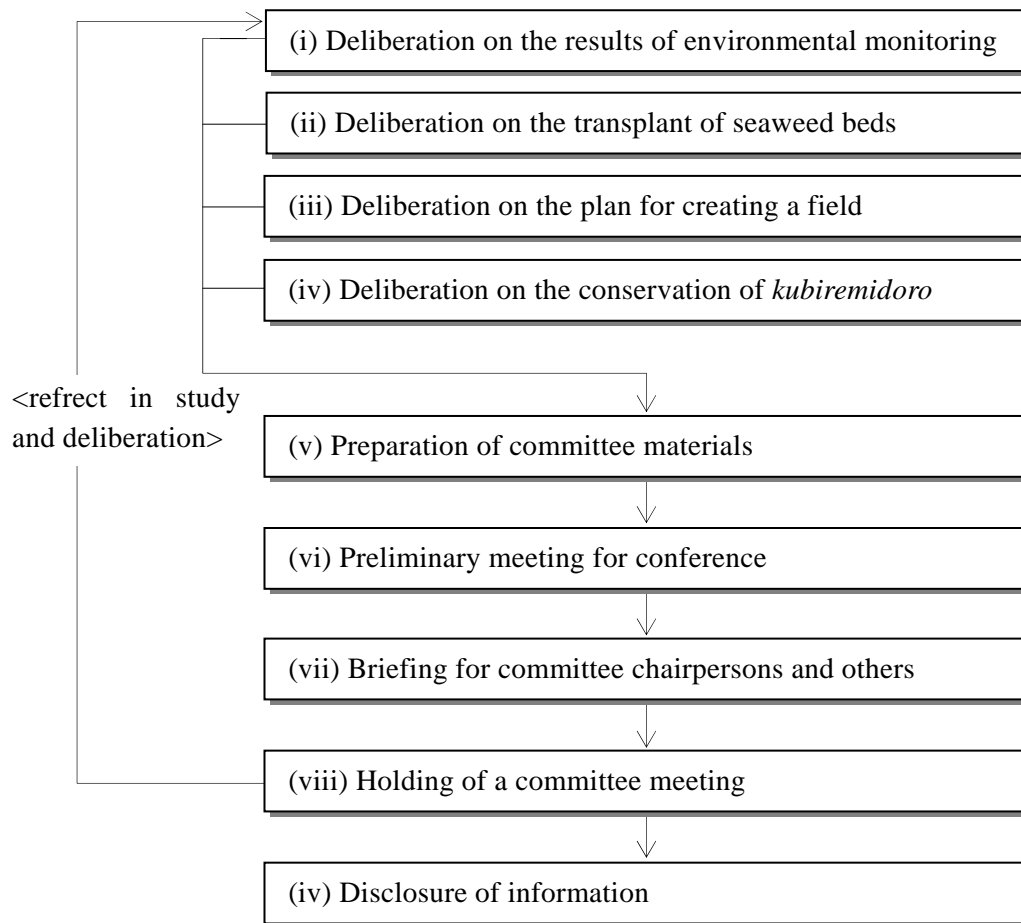


Figure 2 Flowchart of study steps

2. Method of study

(i) Deliberation on the results of environmental monitoring

The results of environmental monitoring were organized. The results were compared with the designated criteria. In the case where the results failed to meet the criteria, the effect of construction was deliberated.

(ii) Deliberation on the transplant of seaweed beds

A comparative study was made of the density of transplanted seaweeds and the obtained knowledge was organized. Sediment surveys were proposed that were required for organizing the knowledge.

(iii) Deliberation on the plan for creating a field

The state of growth and the environmental conditions such as the growth of seaweeds, oceanographic conditions and the effects of typhoons were investigated in the tests for the "creation of a field" for improving transplant techniques. Deliberations were made on the expansion of habitat and the measures to extend facilities.

(iv) Deliberation on the conservation of *kubiremidoro*

Laboratory culture tests and field tests in the Katsuren area were conducted to conserve *kubiremidoro*. The relationship of waves and flow to the area of habitat, and habitat conditions based on the external forces were organized.

(v) Preparation of committee materials through (iv) Disclosure of information

Based on the results of deliberations, materials were prepared for the committees and panels. The secretariat conference meetings were held and committee chairpersons and others were briefed on the materials. Committees and panels were held and operated, and data were developed for disclosure to the public.

3. Results of study

(i) Deliberation on the results of environmental monitoring

In relation to the items that could not meet the criteria, a comparison was made with the range of variation before construction (step 1), a comparison was made with the condition in the study area (step 2) and check was made as to whether wide-area environmental changes occurred or not (step 3). As a result, no effect of construction work was found. Monitoring items and the points of monitoring are shown in Table 1 and Figure 3, respectively.

Table 1 Outline of monitoring

Item		Number of monitoring points	Frequency
Air quality ★	Carbon dioxide	1	Four times/year
	Benzene	1	
Noise and vibration ▲		5	Four times/year
Water quality ●	COD	4	12 times/year
	SS	4	
Bird species ◆	All species	6	Four times/year
	Snipe and plover	6	
Seaweeds ○	Coverage	7	Twice/year
<i>kubiremidoro</i> □	Distribution	(Refer to Figure 3)	Four times/year
	Area of distribution		
Coral ■	Coverage	3	Twice/year
	Number of species		
Tokagehaze (Scartelaos histophorus) ◆	Population of adult fish	(Refer to Figure 3)	Four times/year
	Area of habitat		
Brackish species in the Hiyane marsh □	Diameter measurement	5	Twice/year
	Brackish water quality	2	
	Number of brackish species	2	

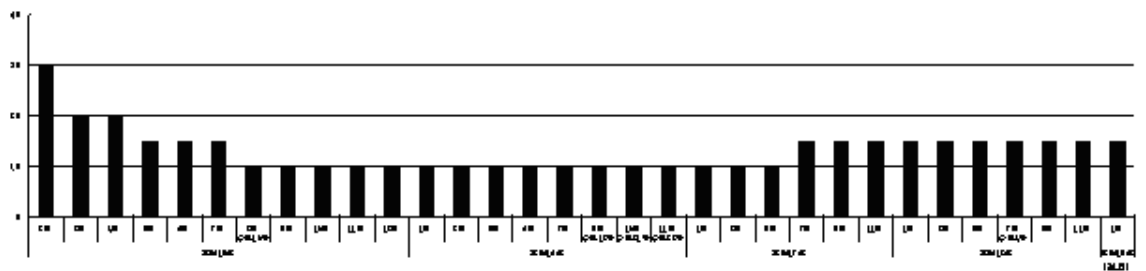


Figure 3 Monitoring positions

(ii) Deliberation on the transplant of seaweed beds

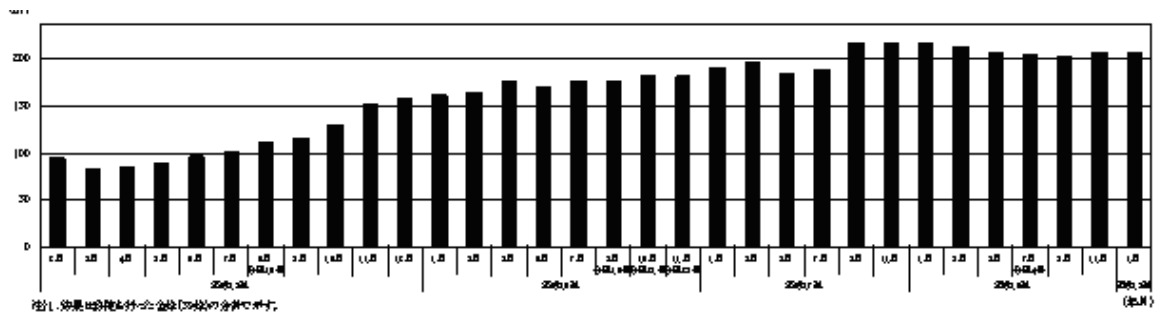
The following findings were obtained based on the results of studies conducted up to March 2006.

The coverage was once reduced after the transplant but has increased slightly up to the present. The coverage remained in the range of variation of natural seaweed beds before construction. The area and conditions of habitat were found generally satisfactory. Then, it was determined that the environment for reproduction of transplanted seaweeds and the habitat were improved. As a result of comprehensive evaluation of the condition three years after the transplant with respect to various items, it was found that the beds where seaweeds were transplanted manually grew like natural seaweed beds. From a long-term viewpoint, the beds seemed to be in progress of succession. Continuing monitoring was therefore considered important.



注1. 効果は移植した全緑藻類の平均値です。

Figure 4 Coverage by growing seaweeds in the area of transplant



(iii) Deliberation on the plan for creating a field (reporting of monitoring results)

A field was created for the conservation of the objectives of "transplant of large seaweeds".

The waves and streams in the created field and the changes in ground level elevation were identified and the data on the growth of transplanted seaweeds were organized. Topographical changes were predicted based on the wave conditions during the latest typhoon that passed the site, and the location of embankments with a low crown height was proposed when increasing the scale of the test. The results of studies of the swarming of species, one of the secondary effects of installation of embankments with a low crown height, were also reported.



Figure 6 Growth of seaweeds and swarming of fish

(iv) Deliberation on the conservation of *kubiremidoro*

The habitat of *kubiremidoro* in the Awase area overlaps part of area II of the dredged material disposal site. For improving the disposal site, *kubiremidoro* will be transplanted in the Yakena area and transplanted back to an artificial tidal flat in the Awase area from the Yakena area upon completion of the flat. Laboratory culture tests were conducted to establish propagation techniques for eliminating the risk of accidental extinction in the field. The objective was to conserve *kubiremidoro*.

1) Laboratory culture tests for *kubiremidoro*

Kubiremidoro emerge from an egg, and become filamentous and finally algal. The life cycle was reproduced in laboratory using a flask and a large water tank and varying the water temperature, duration of lighting, intensity of illumination and nutrients in the state of an egg and during budding.

As a result, an egg and a filamentous body were observed but no algal body was found in the large water tank. In the flask, the egg, filamentous body and algal body were found. But no egg produced from the algal body was observed. Only antheridia were found.

Conducting field and laboratory tests in combination is required to establish basic seed production techniques.

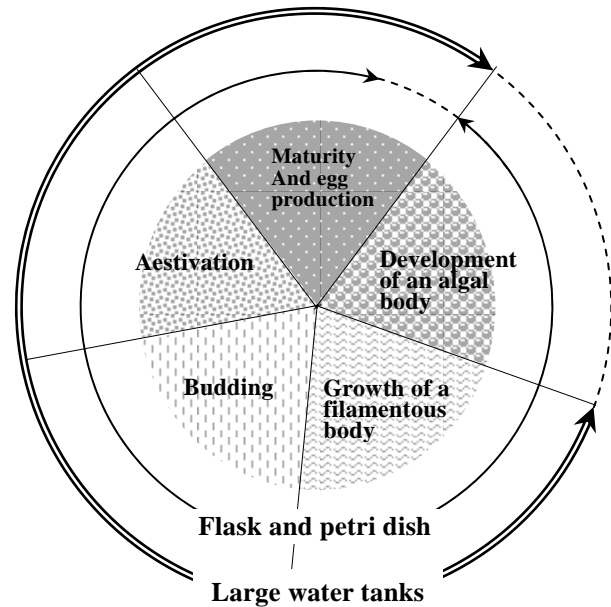


Figure 7 Life cycle and achievements in culture test

2) Deliberation on the physical disturbance factors affecting the inhabitation of *kubiremidoro*

The correlation between the area of inhabitation of *kubiremidoro* and external forces such as winds and waves was examined.

The coefficients of correlation of annual frequencies of high waves and strong winds to the area of inhabitation in March, at the height of prosperity, were -0.76 and -0.91. This suggests that high waves and strong winds have certain bearing upon the life of *kubiremidoro*.

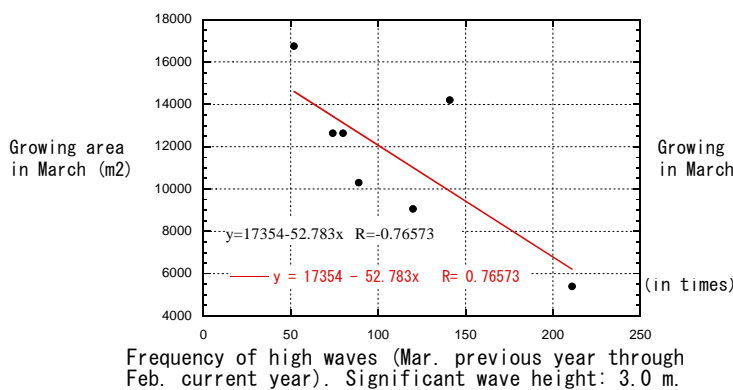


Figure 8 Correlation between the frequency of high waves and the area of growth

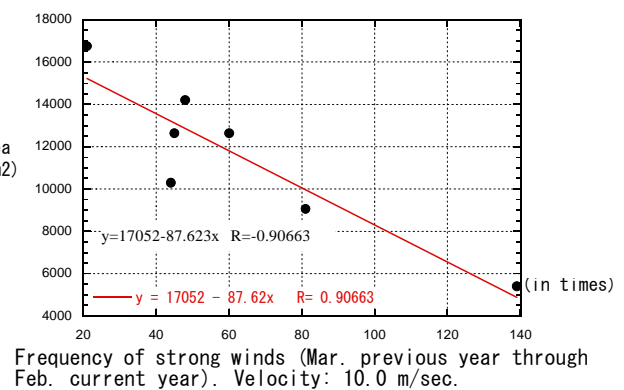


Figure 9 Correlation between the frequency of strong winds and the area of growth

3) Deliberation on the conditions for the inhabitation of *kubiremidoro*

The inhabitation of *kubiremidoro* has been confirmed in the Awase and Yakena areas in Nakagusukuwan Port. The conditions for the inhabitation of *kubiremidoro* were identified by confirming the conditions in these areas (e.g. ground level elevation, bottom materials, water quality and existence of small seaweeds). Numerical analysis was made using the results of tests conducted using the stone masonry fences in the Katsuren area and the external forces in the habitat in the Awase area. As a result of comprehensive analysis, the conditions for the inhabitation of *kubiremidoro* were identified (Table 2).

Table 2 Conditions for inhabitation of *kubiremidoro*

Item		Conditions for inhabitation
Water quality	Turbidity	Required light may be secured by creating a small water depth so as to expose the bottom during low water.
	Nutrient	The level of nutrient required for the inhabitation of <i>kubiremidoro</i> seems to be available in the Awase area.
	Salt content	Inflow of fresh water direct into the habitat should be avoided because little knowledge is available about the resistance of <i>kubiremidoro</i> to low salt content
Ground level elevation		Existing knowledge and field investigations show that <i>kubiremidoro</i> inhabit in a wide range at 0.1 through 1.0 m above chart datum level. The range of elevations vary from point to point and is likely to be determined by the distribution of small seaweed beds.
Bottom materials	Grain size distribution	Bottom materials are composed mainly of fine and medium sands and are mixed with gravel and mud in a wide area where <i>kubiremidoro</i> inhabit. Silt and clay are considered to deposit because of little disturbance to the bottom materials.
	Mineral composition	The percentage of quartz is slightly high in the places where <i>kubiremidoro</i> grow.
Small seaweeds		<i>Kubiremidoro</i> grow in the places where small seaweeds live. The existence of small seaweeds seems to be contributing to the growth of <i>kubiremidoro</i> by controlling the transport of sand and the washout of eggs.
Disturbances	Change in ground level elevation	The ground level elevation changed locally by a maximum of 20 cm due to typhoons. Studies will be made based on the state of growth during the development of an algal body.
	Oxidation reduction potential	The value is low in tranquil places where seaweeds grow because of no disturbances to bottom materials.
	Transport of sand	It has been found that the transport of surface sand is detrimental to the growth of <i>kubiremidoro</i> . Important to the growth of <i>kubiremidoro</i> are the development of no sand ripples and the control of sand transport in the surface area with a depth of a few centimeters.
	Effects of winds and waves	Disturbances to sand by waves in the bay seem to be affecting the growth of <i>kubiremidoro</i>
External forces		Shields number, the ratio between the forces of waves or streams to move particles and the resistance of particles, in the present habitat was calculated in numerical analysis as an indicator of external force. The Shields number should therefore be handled not as a condition for inhabitation but as a reference for selecting an optimum place or examining the design.

Step (v) Preparation of committee materials through step (iv) Disclosure of information

Based on the deliberations in (i) through (iv), materials were prepared for the committees and panels. The chairpersons of the committees and panels were briefed on the materials in advance for detailed inspection, and the materials were presented to the committees and panels. The Environmental monitoring committee, Environmental conservation and creation committee, Seaweeds and algae panel and Artificial island environmental improvement panel had two meetings each. Materials were prepared for information disclosure to the public.