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PROPOSAL OF A FLOATING-TYPE ENVIRONMENTAL PURIFICATION FACILITY INCORPORATING THE FUNCTION OF TIDELAND

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ABSTRACT: Landfill in Tokyo Bay has a direct effect on the disappearance of tideland and shallow waters. Former tideland is a habitat for benthic creatures with the function of decomposing organic substances flowing out from the land area, which were eaten by small fish and served as a feeding point for migratory birds feeding them. Also, in recent years, aquatic plants such as combs forming seaweed beds are being reviewed as being superior to onshore plants in function to absorb CO2 and produce oxygen. In addition, since seaweed is also expected as a fuel for biomass power generation in recent years, this economic value is great.

In other words, regenerating tidal flats and seaweed beds in Tokyo Bay will contribute not only to the environmental improvement of the sea area but also to a CO2 reduction as well as alternative energy source, which will greatly contribute to our lives.

In this study, we propose a floating type purification facility incorporating the functions of tideland and shallow waters in the northwestern coast of Tokyo Bay and proposing artificial tideland and seaweed bed regeneration.

Keywords: Tideland, Seaweed bed, Environmental improvement, Alternative energy source, Floating type purification facility

1. INTRODUCTION

Japan has become a blessed country by the high economic growth of the 1960s. As a result, various forms of land use such as logistics, transportation, commerce, residential, heavy industry, and park were extensively conducted. On the other hand, it faced many environmental problems such as air pollution, global warming, marine pollution, illegal dumping of waste, exhaustion of resources, etc.

In Tokyo Bay, reclamation in the coastal area was activated for land use from the 1960s, and 15% of the surface area was landfilled [1]. On the land landfilled, environmental problems such as red tide and blue tide caused by domestic wastewater and industrial wastewater have become frequent in the waters while logistics and industries are developing.

Landfill in Tokyo Bay has a direct effect on the disappearance of tideland and shallow waters [2]. Former tideland is a habitat for benthic creatures with the function of decomposing organic substances flowing out from the land area, which were eaten by small fish and served as a feeding site for migratory birds feeding them. In these waters, fish and shellfish played an important role as a spawning place for laying eggs. Furthermore, decomposition of phosphorus and nitrogen was carried out in algae formed by seaweed spreading in shallow waters.

In response to these circumstances, the Tokyo Metropolitan Government has been implementing policies for water quality purification through the expansion of sewage treatment plants in the land area to improve the quality of water in Tokyo Bay. However, such measures to improve water quality only in the land area are currently not a direct countermeasure for the entire sea area.

Also, in recent years, aquatic plants such as alga forming seaweed beds are being reviewed as being superior to onshore plants in the function to absorb CO2 and produce oxygen. In addition, seaweed is also expected as a fuel for biomass power generation in recent years, so this economic value is great.

In other words, regenerating tidal flats and seaweed beds in Tokyo Bay will contribute not only to the environmental improvement of the sea area but also to CO2 reduction as an alternative energy source, which will greatly contribute to our lives. In this research, we propose a floating type purification facility incorporating the functions of tideland and shallow waters in the north-west of Tokyo Bay. This aims to improve the environment including the ecology of Tokyo Bay. In addition, the tideland and seaweed bed of this floating structure are planned to be an offshore resort of Tokyo Bay. There, it becomes a new type of accommodation type resort facility that can experience and learn the environment through various researchers and power generation using seaweed. These proposals are investigations considering feasibility study.

2. BACKGROUND OF THE PLAN

2.1 Transition of Tokyo Bay by Reclamation

The area of the bay in Tokyo Bay is 138,000 ha, but due to various developments about 26,000 ha has been landfilled so far. It is said that it decreased by 20% from the former area [1].

Table 1 Landfill area by Tokyo Bay birthday

Age	1968 ~1911	1912 ~1926	1926 ~1935	1936 ~1945	1946 ~1955	1956 ~1965	1966 ~1975	1976 ~1985	1986 ~1989	1990 ~1996	Not started
Kanagawa Pref.	165	1,001	1,443	2,056	2,225	3,695	5,219	6,448	6,732	7,067	7,363
Tokyo	332	332	1,338	1,477	1,545	1,969	3,562	4,449	5,242	5,812	6,606
Chiba Pref.	63	63	63	187	370	1,671	7,891	11,975	12,076	12,076	12,151
Area by age	560	836	1,448	876	420	3,195	9,337	6,200	1,178	905	1,165
Total area	560	1,396	2,844	3,720	4,140	7,335	16,672	22,872	24,050	24,955	26,120

unit(ha)

2.2 Reduction of tideland/shallow area by landfill

In the Meiji era (1868 - 1912's), tidal flats spread continuously from the bay to the mouth of the mouth. However, to date, 26,000 ha, which is 20% of the area of the bay (138,000 ha), is landfilled, the tidal area has been lost to 8,000 ha (6% of the bay area) since the 1950s.

Tidal flats have inhabited a wide variety of benthic organisms and have been responsible for the spawning and growing areas of living creatures in the sea, the role of migratory birds' important feeds and the function to purify sewage in rivers. The functions of tidal flats are now reviewed, and the movement of tideland function conservation is increasing among citizens to conserve the rich ecosystem.

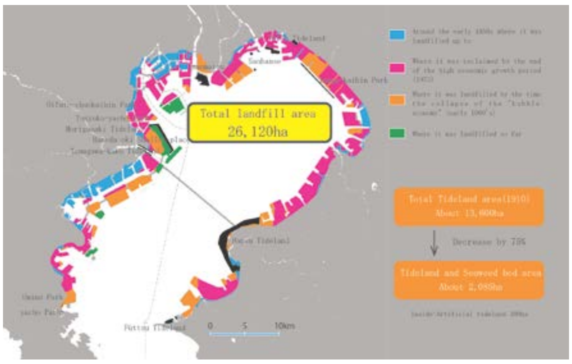


Fig.1 Landfill distribution in Tokyo Bay[3]

In addition, it has been found that there is a big difference between simply purifying water quality and the environment where living things are easy to live. Furthermore, recent studies have revealed that creatures do not increase in Tokyo Bay as long as it increases not only tidal flats but also algae fields and shallows of seaweed.

2.3 Importance of tideland

Wetlands such as tidal flats have become effective on 1975 (December 21), with the Ramsar Convention, meaning that it is very important as a waterfowl habitat, nurturing diverse organisms. Concluding countries have registered 2208 wetlands in 168 countries. In Japan, 50 places are registered, and only Yatsu tidal flat is registered in Tokyo Bay.

2.4 Reduction of migratory birds

Seabirds with wetlands as a place to relax have been confirmed to decrease by 40 to 50% due to landfill. Moreover, the data of only Yatsu tidal flats according to the data of "Tokyo Bay Seabird, plovers all over the same survey" shows a clear declining tendency in which 108 birds were confirmed in 2012, 14 birds in 2016.

2.5 Changes in Catches

In Tokyo Bay, various fisheries such as shellfish fishing, fishery, and algae fishery are still being conducted. However, it is far less than the catch as in the past, making it difficult to continue fishing. In recent reports by the Tokyo Bay Study Group, the yield has been decreasing for many fish species, suggesting the possibility that the lumps of water caused by poor oxygen have an adverse effect on the growth environment of the fish species. In addition to the lump of poor oxygen, "Reduction/disappearance of habitats such as shallow and tidal flats" is considered to be one of the causes of the slump of biological resources.

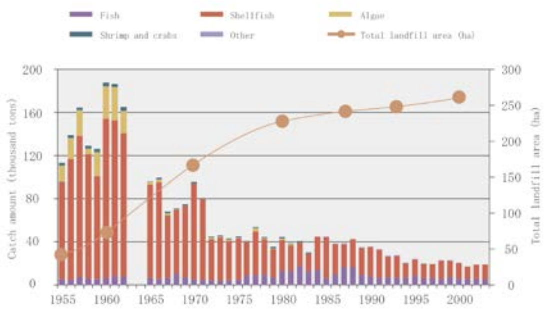


Fig.2 Changes in catches and landfill area[4]

2.6 Forest of the sea

In recent years, the phenomenon "sea breeze" which seaweed in the sea has disappeared and the surface of the rock of the seabed is covered with white or pinkish lime algae has become remarkable. This may be caused by artificial effects such as rising seawater temperature and water pollution, a supply shortage of iron required for algae growth and damage of algae useful due to sea urchins and fish.

Because seaweed beds are also the habitat for fish spawning and frying, it is easy to imagine that it will have a major impact on the underwater ecosystem. This directly leads to a reduction in catches. The "sea forest" in Tokyo Bay, which has been rich, is said to be "desertification of the sea" in recent years. This is because natural purification action of seawater is not properly performed, which indicates that artificial environmental conservation measures are indispensable.

2.7 Regeneration of "Sea Forest" by human intervention

In recent years, seaweed beds are not sufficient for natural purification action, and artificial measures for environmental conservation are required. Therefore, since 2010 Kobe Steel Group, which is a steel company, has begun to develop marine area utilization of artificial reefs by steelmaking slag in Okinawa Prefecture and Kobe City. As a result of this marine area development by this artificial reef, the effect as a population reef is demonstrated, such as the glimpse of use as a habitat for frying fish one month later.

3. ABOUT HOW TO USE ENVIRONMENTAL LOAD

3.1 About fixed amount of CO2 by algae culture device

In the "CO2 marine immobilization / effective utilization technology survey project[**5**]" participated by Takenaka Corporation and the authors, the Ministry of Economy, Trade and Industry's subsidiary research project, CO2 fixation using seaweed culturing equipment, investigated. The results are shown in the table.

In estimating the amount of CO2 fixation accompanying the cultivation of algae, the case where only green algae (Minami-aonori) was produced (44.3 t-dry / day), the case where only red algae (oni-amanori) was produced (23.0 t-dry / day) , When green algae, red algae and brown algae were produced at a ratio of 2: 1: 1 (32.1 t-dry / day) when only brown algae (seaweeds) were produced (16.8 t-dry / day), green algae In the case of producing brown algae at a ratio of 1: 1 (30.6 t-dry / day), a total of five scenarios were set and examined.

As a result, the CO2 fixed amount is the highest at about 17,500t-CO2 per year when only green algae (Minami-aonori) are produced, and it is the smallest at approximately 8,300 t-CO 2 per year when only brown algae (seaweed) are produced I found out.

Table 2 Annual carbon dioxide fixed amount by seaweed culture [**5**]

scenario	Production volume (T - dry / day)	Production days (day / year)	Carbon content (%)	CO2 fixed amount (t - CO 2 / year)
Green algae (Minami Aonori)	44.3	365	29.5	174,900
Red algae (Onia manori)	23	365	30	9,235
Brown algae (Seaweed)	16.8	365	37	8,319
Green algae: red algae: brown algae□ (2: 1: 1)	32.1	365	-	13,533
Green algae: brown algae□ (1: 1)	30.6	365	-	13,617

Note: CO2 fixed amount = production amount × carbon content × 44/12

3.2 New biomass energy

Regarding the use of renewable energy and renewable energy, development of more efficient production technology is definitely required. In recent years, bioethanol made from seaweed has been recognized as renewable energy and attracts attention as it contributes to the maintenance of the global environment and reduction of GHG (greenhouse gas).

3.3 Biofuel production

Biofuel production from soybean is 1,900 L per hectare per year and palm oil 5,950 L per year. On the other hand, biofuel production from seaweed is remarkably high at 98,500 L, and it is known that it has the ability to absorb ten times more CO 2 than trees.

3.4 Green tide

In recent years, environmental problems called "green tide" have occurred in various coastal areas. This is a phenomenon in which the seaweed red tide grows abnormally and accumulates on the coastline, and various adverse effects such as the deterioration of the landscape of the coastal area, the bad smell accompanying the decomposition of the seaweed, the death of shellfish such as clams are occurring. As shown in 2.4.1, it is thought that it is useful for the global environment in a dual sense that energizing environmental problems can reduce expenses for removal and further produce profits through production.

3.5 Thalassotherapy

By introducing a facility incorporating natural remedies such as seaside bathing seawater, blood circulation promotion massage using seaweed and esthetics using sea mud, the effect of deepening interest in the ocean by guests is there.

4. PLANNING POLICY

4.1 Floating Flats

4.1.1Floating function

① Artificial tidal land: Improve the migration of migratory birds and the work of natural purification

② Seaweed bed: Water purification and recovery of DO value Creation of ecological environment

③ Securing solar radiation: securing solar radiation to the sea area by subdividing the floating body

- Supposed introduction function -

④ Resort hotel: induce publicity of Tokyo Bay problem and measures

⑤ Company: Make maritime countermeasures by entering business in similar fields

⑥ Research: artificial tidal flats, biomass, plankton, seaweed

⑦ Biomass: regenerate seaweed as a useful resource

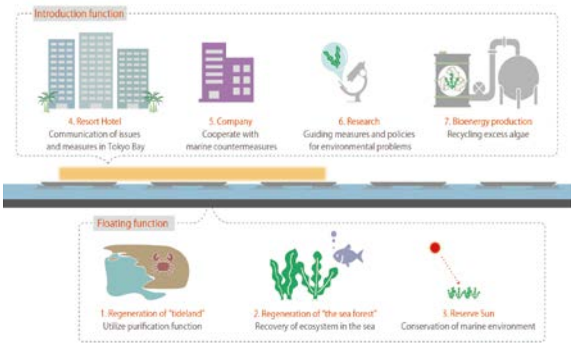


Fig.3 Conceptual diagram of green floating

4.2 Introduction function

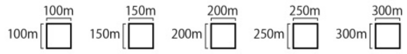
By using the floating function in 3.1.1 as the central function of this plan, the functions to be introduced in other places can have diversity.

We plan to introduce facilities to produce bioethanol from seaweed using biomass power generation as well as commercial and tourist facilities such as aquarium and hotel as assumed use.

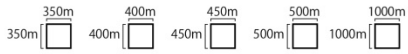
5. BASIC PLAN

5.1 Calculation of the size of artificial tidal flats

In this project, we plan a floating body of 300 m × 300 m, assuming that the area of the tidal flat is 9 ha. By doing so, we plan to recover 0.005% of the area of tidal flats lost in Tokyo Bay so far. As stated above, by installing floating bodies having various functions at ten locations, it is assumed that 0.75% of the area of the tidal flat is recovered.



	Diameter 100m	Diameter 150m	Diameter 200m	Diameter 250m	Diameter 300m
Piece (ha)	1.00	2.25	4.00	6.25	9.00
Increase rate(%)	0.06	0.13	0.24	0.37	0.54
Recovery rate(%)	0.001	0.001	0.002	0.003	0.005
Five pieces (ha)	5.00	11.25	20.00	31.25	45.00
Increase rate(%)	0.30	0.67	1.19	1.86	2.68
Recovery rate(%)	0.042	0.094	0.168	0.262	0.377



	Diameter 350m	Diameter 400m	Diameter 450m	Diameter 500m	Diameter 1000m
Piece (ha)	12.25	16.00	20.25	25.00	100.00
Increase rate(%)	0.73	0.95	1.21	1.49	5.96
Recovery rate(%)	0.103	0.134	0.170	0.210	0.839
Five pieces (ha)	61.25	80.00	101.25	125.00	500.00
Increase rate(%)	3.65	4.77	6.04	7.45	29.82
Recovery rate(%)	0.514	0.671	0.849	1.048	4.194

Fig.4 Increase due to tidal flats size in Tokyo Bay, Calculation of Recovery Rate

5.2 Site selection criteria

① Area where river exists and inland water crosses sea water

② Waters where characteristic landscapes exist

③ Area where the DO value is low, poor oxygen water mass is generated

④ Sea area with floating structure possible depth of water

⑤ waters where concern about environmental impacts such as sewage treatment plants are concerned

Based on the above conditions and the consideration of the marine environment based on the "Tokyo Bay Water Quality Survey Report", we will select the sea area off the Tokyo Disneyland at the B type T22 point described in the report as the site of this project.

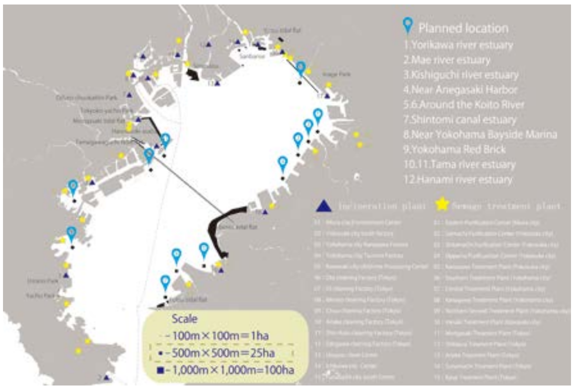


Fig.5 Plan map in Tokyo Bay [6]

5.3 Overall plan

The whole floating body is zoned into L letters, and it is classified into three types of migratory birds, tideland, and architecture. By doing so, we plan to place restrictions on the rate at which human intervention is intervened. As a result, shellfish such as clams in areas for migratory birds will be protected from the collection of human beings. In the tideland, it is planned that tourists can observe the ecological system of valuable Tokyo Bay closely. The second level headings should be in 10pt, bold, justified, and First Characters of Each Word are in Capital font. Leave one blank line both before and after the heading, respectively.

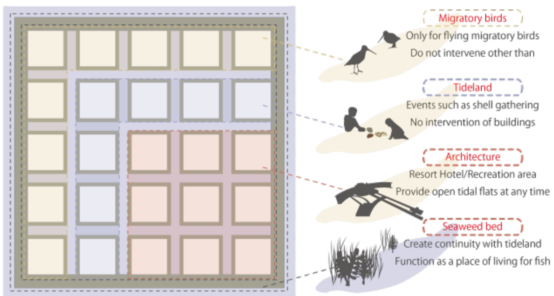


Fig.6 Conceptual diagram of floating body plan

6. BUILDING PLAN

6.1 Introduction function and scale calculation

In this project, we plan to classify it into 3 buildings, hotel building, research building, power generation building. We calculated the scale by referring to the area ratio of various categories of existing resort hotels and other departments responsible for functions such as drinking, banquet, kitchen, and management. The number of rooms is assumed to be 128 rooms, and a thalassotherapy function incorporating marine resources is introduced.

Table3 Introduction function and scale

Introduction function and scale			Major room name				
Hotel Faculty	21,091	㎡	Room	Banquet hall	Restaurant	Pool	Gym
Power generation Faculty	1,709	㎡	Power generation room	Boiler room	Processing room	Sewage treatment room	Drying room
Research Faculty	1,905	㎡	Laboratory	Incubation room	Lecture room	Library	Nature observation room
BackSide Faculty	4,085	㎡	Office Room	Central Monitoring Room	Reception Room	Restroom	Warehouse
total scale	28,790	㎡					

6.2 Securing an area to deliver light to the ocean floor

By planning a large floating body of 300 m × 300 m, a wide area shadow appears in the waters under the floating body. For this reason, the floating body is subdivided into 25 squares, and each is shifted at regular intervals, thereby securing an area for delivering light to the seabed. In this project, when the floating body of 60 × 60 m is moved 3 m at a time, the area where light is delivered is calculated, and when it is shifted by 12 m, the strength of the floating structure and the area where light is delivered to the seabed are optimal I found out something. Other seaweed beds are supposed to illuminate the ocean floor by providing LED light as an alternative function of sunlight.

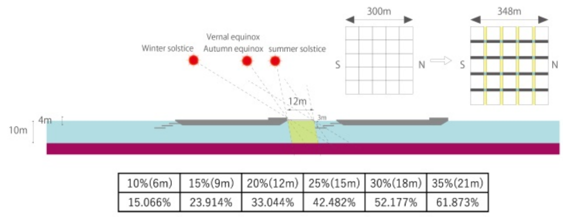


Fig.7 Percentage of appearance of light-transmitting layer when 25 masses are separated by 5%

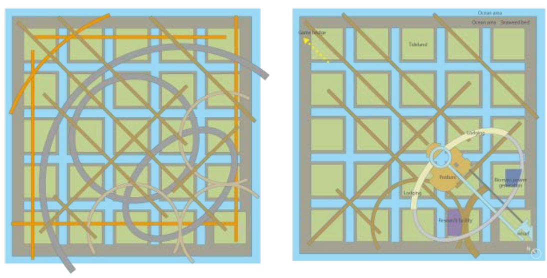


Fig.8 Left: Connection relationship between floating bodies Right: Placement plan

6.3 Incorporate artificial tidal of tideland

By adopting the water depth adjustment function by ballast water for the floating type structure, we made it possible to artificially create a tidal difference which is characteristic of tideland. This will be a directing to the guests to see the tide difference as a landscape while staying in the center of Tokyo Bay.

6.4 Arrangement plan for seaweed bed

Place a 25 m wide seaweed bed on the outer side of the 16 squares located on the outer periphery of the floating structure. Also, in the 9 squares arranged in the center, seaweed beds are spirally arranged on each of the four sides. These seaweed beds are supposed to adhere to the larvae flowing from the surrounding seas and have a floating structure with continuity with the tidal flats.

6.5 Flow line planning

The flow line of general customers and the flow line of loading goods are done from the same docking station, but we plan to separate them into a hotel flow line and a carry-in flow line extending in a straight line. In the interior of the building, we arranged plans that divide the categories and other functions such as drinks, banquets, kitchens, management, etc., into plans that emphasize the privacy of the resort hotel.

6.6 Planning of planning and arrangement of watersheds

We designed a plan for connecting floating bodies subdivided into 25 squares based on the overall plan of 4.3 and introduced the necessary functions for construction purpose to it.

We arranged rooms to provide both the urban dynamic landscape of Tokyo spreading to the north side and the natural landscape of the sea spreading to the south. The accommodation building, the power generation building and the research building to be introduced in this program are connected by a corridor integrating solar power generation units. Moreover, by making production and research facilities publicly available, it becomes a facility that will be utilized not only as a resort but also as a place for learning. In addition, the tidal flat on the front of the hotel is open to guests all the time, and in addition to enjoying maritime recreation in places facing the sea area, it also functions as a place to conduct educational experiences through lectures by researchers.

6.7 Section planning

In the center of the guest room etc, plan a large void to incorporate solar radiation into the seaweed bed. Also, as the difference in level between construction and water level changes due to the change in water level due to tides, we planned the entire building as a high floor type like a pier.

Considering the influence of the sea breeze on the accommodation building, we adopted a design that blows the wind upward by raising the building of other functions.

7. CONCLUSIONS

①Coastal areas are already under development by landfilling of tidal flats and shallow fields, and there is little room for regenerating these.

②In the central part of Tokyo Bay, there is plenty of room to build tidal flats and shallow spaces if you remove the shipping routes for ship navigation.

③When building floating tidal flats in the central part of Tokyo Bay, it is necessary not to disturb the ship's sailing and consider consideration to the seabed part so that there is no influence on the natural environment and fishery.

④ In order to transmit light to the bottom of the sea while sufficiently satisfying the function of tideland and shallow, it is necessary to devise arrangement and design of facilities.

⑤ It is quite promising in Japan to use seaweed to fix carbon dioxide. Because Japan's land area is about 380,000 square kilometers, which is 60th in the world, it has eleven territorial glasses of water and EEZ.

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