UNDP/GEF PROJECT ENTITLED "REDUCING ENVIRONMENTAL STRESS IN THE YELLOW SEA LARGE MARINE ECOSYSTEM"

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Summary of SAP Demonstration Activities

Table of Contents

Introduction

Following the completion of the Strategic Action Programme (SAP) for the Yellow Sea, the YSLME project focused on demonstration activities in 2009, with strong support from the participating countries. The main purpose of the demonstration activities is to test the usefulness and effectiveness of the management actions defined in the SAP.

During the inter-sessional period, over 20 Strategic Action Programme (SAP) Demonstration Activities were implemented throughout the region (see Table 1 below). Contractors for the activities were selected through the UNOPS bidding procedure, as with all project activities. Details of each activity (some with results) are explained further in this document.

Geographic Location	**Name**
Center part of YS	1. Monitoring Jellyfish Bloom in the Yellow Sea - NFRDI[1]
Qingdao, China	2. Assessing impacts of N:P:Si change on the Yellow Sea ecosystem - FIO[2]
Qingdao, China	3. Assessing and Monitoring the Impacts of Climate Change on the Yellow Sea Ecosystem - FIO
Qingdao, China	4. Management of Recreational Waters - NMEMC[3]
Dalian, & northern Yellow Sea, China	5, Monitoring and Assessing Atmospheric Deposition of Pollutants - NMEMC
Yalu River estuary, China	6. Calculation of Nutrient Loads in Hot Spot Areas - NMEMC
Zhuanghe, China	7. Monitoring and Assessing Sea-Based Sources of Nutrients - LOFSRI[4]
Rongcheng, China	8. Environmentally friendly mariculture: Integrated Multi-Trophic Aquaculture - YSFRI[5]
Rongcheng, China	9. Improved biodiversity management in Rongcheng Seagrass beds - Rongcheng Ocean and Fishery Bureau
Weihai, China	10. Stakeholder training in critical habitat of the Rongcheng Seagrass Beds - Shandong University at Weihai
Weihai, China	11. Improved public awareness of the benefits of biodiversity conservation at the Rongcheng Seagrass Beds - Association of Emeritus Professionals Weihai
China	12. Effectiveness of closed fishing areas/season in reducing fishing effort - YSFRI

[1] NFRDI = National Fisheries Research and Development Institute, ROK
[2] FIO = First Institute of Oceanography, China
[3] NMEMC = National Marine Environment Monitoring Center, China
[4] LOFSRI = Liaoning Ocean & Fisheries Science Research Institute, China
[5] YSFRI = Yellow Sea Fisheries Research Institute

Geographic Location	Name
China	13. Effectiveness of stock enhancement in rebuilding fish stocks - YSFRI
Taean, ROK	14. Environmentally friendly mariculture: Limited water exchange shrimp culture - WSMRC[6]
ROK	15. Assessment of the Effectiveness of Improved Fisheries Management - Pukyong National University, ROK
Ganghwa Island, ROK	16. Improved biodiversity management of the Tidal Mudflats south of Ganghwa Island - Aqualab
Ganghwa Island, ROK	17. Stakeholder training in critical habitat of the Tidal Mudflats south of Ganghwa Island - Aqualab
Ganghwa Island, ROK	18. Improved public awareness of the benefits of biodiversity conservation for the Ganghwa tidal mudflat - Aqualab
Southern Ganghwa, ROK	19. Managing Pollution in Critical Habitats around the Yellow Sea - Academy-Industry Cooperation Foundation
Ganghwa Island, ROK	20. Economic analysis of the SAP demonstration activity in Ganghwa - YSLME Project
Shandong Province, China	21. Cost-benefit Analyses of Strategic Action Programme Demonstration Activities: Improvement of Sustainable Mariculture Techniques - FIO

Table 1. List of SAP demonstration activities.

1. Monitoring Jellyfish Bloom in the Yellow Sea[7]

Demonstration on the Management Action in the SAP: ***Management action 8-4: Monitor the transboundary impact of jellyfish blooms***

This activity aims to:

- Develop national and regional monitoring methodologies for jellyfish that will be accepted and used in the future.
- Monitor jellyfish in the Yellow Sea by co-ordinating some of the monitoring events with existing projects.
- Monitor using ship of opportunities.
- Establish an international network for monitoring jellyfish in the Yellow Sea.

Monitoring in the eastern part of the Yellow Sea was carried out in August 2008. Using visual counting, *Nemopilema nomurai* and *Aurelia aurita* were observed on this survey, although the number of *N. nomurai* was extremely low with maximum abundance of 9 individuals in 10,000m^2, compared to previous years' observations of 162, 13, and 45 individuals in 2005 to 2007. *A. aurita* was observed at only 1 station with maximum

[6] WSMRC = West Sea Mariculture Research Center, ROK
[7] **Data and figures provided by Dr. YOON Won-duk, NFRDI.**

abundance of 64 individuals in 10,000m^2 (Figure 1). The acoustic survey was able to reveal the presence of some jellyfish, and also distinguish jellyfish from fish (Figure 2).

Surveys were also carried out in September and October 2008. Visual counting revealed very few jellyfish, while acoustic surveys did not reveal the presence of any jellyfish.

The underwater acoustic camera has been developed and tested. While no jellyfish were present when the equipment was being tested *in-situ*, the camera was able to detect bubbles, implying that it would be even easier to detect jellyfish and polyps if these were to be present.

Additional surveys were carried out in 2009. Results are expected in December. Monitoring using ship of opportunities along an east-west transect between Incheon to Qingdao is expected to start in summer 2010 under the national project run by NFRDI.

At the end of this project, it is expected that a network of cross-basin monitoring and recommendations on how best to monitor jellyfish will be provided, as this emerging issue has been recognized as a new transboundary issue for the region to address.

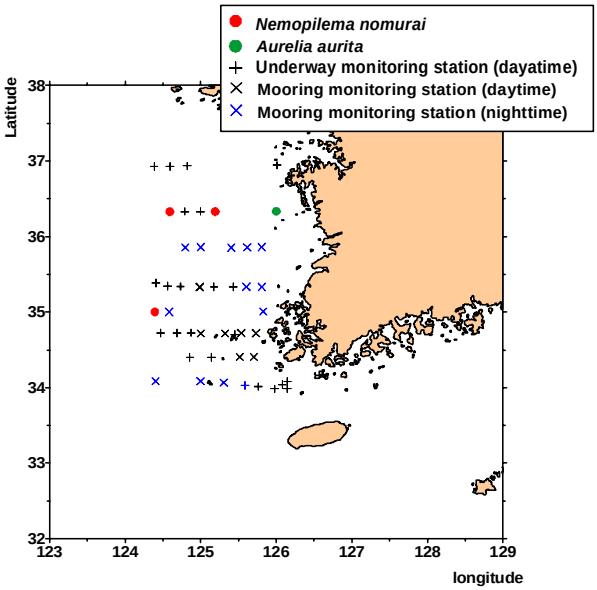


Fig. 1. Survey area and abundance of jellyfish estimated by visual counting in August 2008.

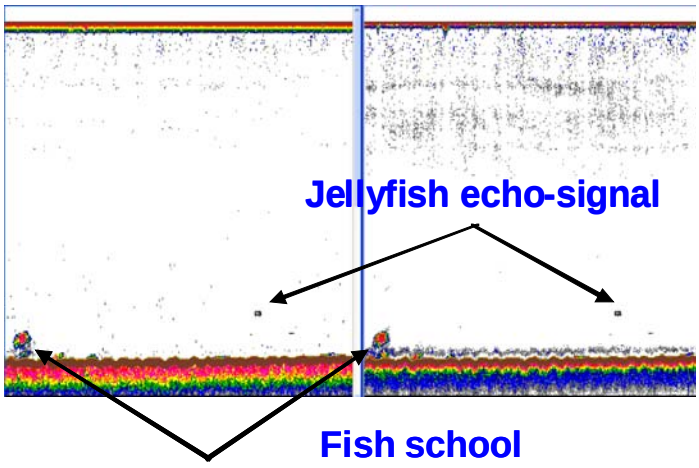


Fig. 2. Jellyfish detected by echosounder during the August 2008 survey.

2. Assessing impacts of N:P:Si change on the Yellow Sea ecosystem[8]

Demonstration on the Management Action in the SAP: ***Management action 8-1: Assess and monitor the impacts of N/P/Si ratio change***

This activity investigates the effects of nutrient ratio changes and response of phytoplankton and zooplankton. Relevant results from the co-operative cruises are being analysed together with historical data, and lab and mesocosm experiments where different concentrations and ratios of the elements are being added to the experimental chambers.

Preliminary results are as follows:

[8] Results provided by Dr. Wang Zongling, FIO.

- By comparing with historical data, the researchers observed that the concentration of DIN in Yellow Sea has increased.
- P limitation prevailed in surface waters of Yellow Sea especially during autumn and summer.
- The range and mean value of N:P from various studies carried out from 1997-2007 showed annual and seasonal variations. Due to the differences in research objectives, and different sampling stations, the comparison of N:P should be made with caution. Thus far, no clear trend of N:P was revealed by the collected data.
- Compared to Lin et al. (2005) who studied the changes in the environmental features of Yellow Sea during the last 25 using a set of seasonally monitored data along a transect at 36°N, results from the demo activity showed that the annual mean water column temperature and surface seawater temperature were within the range of temperature variations during 1976~2000, but the annual mean of the sea bottom layer temperature increased to over 9C.
- Annual mean value of P concentration did not change a lot although the concentration in the bottom layer slightly increased compared with the value in 2000. Average concentrations of Si significantly increased compared with the values after 1985.
- The results suggest that changes in environmental variables in the Yellow Sea might deviate from the trends revealed by Lin et al. Further evaluation of environmental change and the response of the ecosystem are being undertaken.

Based on the current understanding, the demonstration project started a meaningful process to monitor and study the impacts of N:P:Si change on ecosystem structure. Although there is a need for more monitoring and research work to gain better understanding in this field, the preliminary results provide useful tools to implement relevant management actions in the future. In order to find a clear relationship between changes in N:P:Si and plankton community, long-term and systematic monitoring is necessary.

3. Assessing and Monitoring the Impacts of Climate Change on the Yellow Sea Ecosystem[9]

Demonstration on the Management Action in the SAP: ***Management action 8-3: Forecast ecosystem changes in the long-term scale***

This activity is examining the impacts of climate variability on the Yellow Sea ecosystem, particularly the impacts on the Yellow Sea Cold Water Mass and on phytoplankton and zooplankton. Historical climate and plankton data from China and Republic of Korea have been collected. Data from the YSLME Co-operative Cruises are being used to compare past and present plankton community structure. Mesocosm experiments are being implemented in Maidao (next to Qingdao City) to examine the effects of Asian dust on plankton (Figure 3).

The mesocosm experiments showed that dust promotes the growth of phytoplankton at low nutrient concentrations, but has little impact in higher nutrient concentration areas, such as the offshore area.

Most past surveys in the Yellow Sea showed that phytoplankton abundance was high in winter and summer, but in recent years, phytoplankton has been abundant in spring. *Calanus sinicus* samples were collected in the southern Yellow Sea in January and August 2008. Developmental stage composition, body length, dry weight, and fatty acid composition of the samples are being analysed now.

[9] Results provided by Drs. Li Ruixiang and Pu Xinming, FIO.

To complete the activity, the researchers will:

- Compare their results compared to historical data from other studies post-2000, at the 35°N and 36°N latitude.
- Model phytoplankton bloom in spring in the northern Yellow Sea.
- Model the Yellow Sea Cold Water Mass impacts on zooplankton.

Fig. 3. White coloured buoys denoting the location of the mesocosms in Maidao.

The studies suggested that understanding the impacts of climate change on ecosystem structure needs more systematic monitoring and research. The current demonstration project has made a preliminary attempt to address the complicated issues in studying climate change impacts. It was indicated in initial results, that any prediction of the impacts of climate change on the marine ecosystem needs more systematic monitoring and well-designed analyses and research.

4. Management of Recreational Waters[10]

Demonstration on the Management Action in the SAP: ***Management Action 7-2: Control pollution in bathing beaches and other marine recreational waters***

The activity is demonstrating how a good management framework can improve stakeholder's environmental awareness and enhance public confidence in health and safety issues in select Qingdao beaches. The activity also will review the existing water quality monitoring system and provide recommendations to improve the monitoring regime. Water samples collected from the 3 sites (Figures 4 and 5) are being analysed for bacteria (mainly enterococcus) and faecal coliform. Results are being compared to historical data to determine the trend in water quality. The impacts of rain on water quality as well as impacts from direct discharge outlets are also being investigated.

Results to date showed that 4 to 7 hours after rain, one can see an increase in poorer water quality. After 3 days, the water usually reverted to its previous quality. Other problems observed included jellyfish being collected almost daily, the occasional macroalgae bloom, and a recent oil spill. The current monitoring programme may be revised to be more relevant to the needs of monitoring water quality of recreational waters. If the monitoring programme is recommended to Qingdao Ocean and Fishery Bureau for revision, it will be based on results from the activity, the frequency of monitoring will be changed, and additional indicators will be included.

[10] Results provided by Dr. Wang Juying and Zhang Weiwei, NMEMC.

Fig. 4. Activity sites.


Fig. 5. Field sampling in No. 1 Beach.

It was suggested by the demonstration activity that monitoring and control pollutants in recreational waters is a critical issue that is relevant to human health. Preliminary results on increased bacteria in swimming areas after rain has proven that the management action defined in the SAP is very useful. The study has also indicated that the regulating and cultural services of the ecosystem have complementary roles.

5. Monitoring and Assessing Atmospheric Deposition of Pollutants[11]

Demonstration on the Management Action in the SAP: ***Management Action 5-2: Control total loading from non-point sources and sea-based sources***

The activity will calculate the amount of contaminants, evaluate major sources of PAHs, and evaluate atmospheric contribution to the overall trace metal and nutrients input in the study areas. Island sampling sites will be compared with polluted land areas to determine if pollution is from land or sea. The activity may also suggest improved monitoring methods and inform them to policy makers.

The current knowledge is that there is available basic data from 2006, but it is not enough, and from limited areas, mostly from the Bohai Sea. Thus, there is a need to determine the amount in the Yellow Sea.

Rainwater samples are collected from monitoring stations in Zhangzi Island, Laohutan, and Xiaomai Island (Figure 6). Zhangzi Island, being further from land, has shown less deposition than the other 2 places. It was observed that metals had highest concentration in Laohutan due to the existence of various industries. Meanwhile, Hg and total PAHs were highest in Xiaomai Island which is close to Qingdao where there is a large oil refinery. Overall, there is ample data to determine the sources of PAHs, and it is also fairly easy to determine the sources of metal deposition. However, the nutrients sources are more difficult to pinpoint, since the sources and compounds vary quite a bit. Furthermore, wind from land and sea can affect the trends and deposition amounts.

The project is trying attempting to determine the ratio of atmospheric deposition vs. the total pollutants discharged to the sea, and to identify the sources of the pollutants.

[11] Results provided by Drs. Yao Ziwei and Wang Zhen, NMEMC.


Fig. 6. The sampling station of Laohutan.

Working towards completion, this activity will:

- Collect more data for statistical analyses and to determine the sources and loads of atmospheric deposition.
- Separate the effects of wind from land and sea.
- Examine seasonal changes in deposition amounts.
- See the effects of deposition on production of mariculture goods.

The activity's results will provide information on the sources and amounts of atmospheric deposition, and enable managers to control one of the sources of pollutants. Regulating services of the ecosystem can be better maintained when policy makers understand the sources and amount of pollution threats to the Yellow Sea. This activity, together with Activities 6 and 7 will allow managers to better control pollutants in the Yellow Sea.

6. Calculation of Nutrient Loads in Hot Spot Areas[12]

Demonstration on the Management Action in the SAP: ***Management Action 5-1: Control total loading from point sources***

This activity is being implemented in the Yalu River basin, estuary, and coastal area of Dandong City. This site suffers from nutrients and oil as the main pollutants, with frequent HAB occurrences. The activity will examine pollutants from land- and sea-based sources, identify major nutrient sources, and use models to estimate total loads. Researchers are monitoring direct discharge outlets (ddo) along the river for better understanding of nutrient sources (Figures 7 and 8). In the Yalu River, the main sources of nutrient input are from agriculture and sewage and other point sources. A calculation model for determining the total pollution load has been developed. Initial model development revealed that different models are required for different situations, e.g. distinguishing different water flow volume vs. nutrient load. Information from remote sensing and data from other similar projects will be used to determine loads from non-point sources and water flow amount, respectively. Results will be used in a proposal to local government agencies to include certain monitoring and management actions for the reduction of total nutrients loading into the Yalu estuary, and also in development plans of the area.

[12] Information provided by Dr. Zhang Zhifeng, NMEMC.

Fig. 7. Sampling stations along the Yalu River.

Fig. 8. One of 14 direct discharge outlets along the Yalu River.

Historical data, monthly data of ddo obtained from Dandong local government, and data from 3 surveys are being analysed, and the point and non-point sources will be identified to aid in management and policies. Some initial results showed that in winter, there was a higher concentration of nutrients in the river, perhaps due to less plant uptake and more rain and snow runoff from barren land. This issue is being investigated.

With the results from Activities 5 and 7, this activity will use all results to engage policy makers and resource managers to work together in controlling pollution to the Yellow Sea. The activity has illustrated that regulating services of the ecosystem will be maintained only if all sources of pollutants are viewed together and controlled at all sources.

7. Monitoring and Assessing Sea-Based Sources of Nutrients[13]

Demonstration on the Management Action in the SAP: ***Management Action 5-2: Control total loading from non-point sources and sea-based sources***

Researchers are investigating pollution from mariculture sites and total nutrient load from mariculture farms, and how to reduce nutrient loads by 10% as stated as one of the SAP targets. Qingduizi Bay as one of the main mariculture areas (jellyfish, sea cucumber, clam) in the northern Yellow Sea, warrants research into its potential contribution of sea-based sources of nutrients into the ecosystem (Fig. 9). The activity's objectives are as follows:

1) Carry out 4 surveys in the demonstration area of Qingduizi Bay, and also collect historical data as the basis for better understanding of the bay's conditions;
2) Provide information to the mariculture industry from where major sources of sea-based nutrients are released;
3) Assess the contribution of sea-based discharge of nutrients to total loadings;
4) Provide management suggestions on how to reduce sea-based discharge of nutrients by 10%.

Monitoring of chemical, physical, and biological variables have been carried out in the mariculture ponds and the bay. Nutrient concentrations were generally higher in the bay-head (near land and mariculture ponds) and in the estuary, and were lower in the bay-mouth

[13] Data and photo from Ms. Li Ai and Mr. Wang Nianbin, LOFSRI.

and outside the bay. Results to date showed that the NO_3 and NH_4 concentration in the bayhead area was higher near land, while NO_2 concentration did not differ much area- or season-wise. Indoor ponds are growing juvenile sea cucumber, while outdoor ponds raise jellyfish from the juvenile stage until maturity. In the ponds, plankton is used as feed, but artificial feeds are also added for higher production; thus, there might be high nutrient outflow from the ponds during water exchange.

Fig 9. Mariculture distribution in Qingduizi Bay.

Remaining tasks will include calculation of nutrient load from coastal sewage outfalls which havs not yet been considered. The researchers will then model the load from shellfish farms, verify sea cucumber data provided by mariculture industry, and test the EM strain of biological bacteria as "nutrient absorbers."

Through the 3 demonstration projects on control pollutants from different sources, it is clear that the relevant management actions should be considered collectively, as pollutants, e.g. nutrients, are contributed from different sources. For future implementation of SAP, the demonstration projects provide useful technical information on the monitoring and control of pollutants from all possible sources, to achieve the management target set by the SAP.

8. Environmentally friendly mariculture: Integrated Multi-Trophic Aquaculture

Demonstration on the Management Action in the SAP: ***Management Action 3-1: Develop environment-friendly mariculture methods and technology***

This activity aims at demonstrating the effectiveness of Integrated Multi-trophic Aquaculture (IMTA) and the use of carrying capacity modelling in reducing the nutrient load in surrounding waters, and providing training and raising public awareness of the environmental and economic benefits of this type of aquaculture.

Sanggou Bay was traditionally a centre for longline kelp (seaweed culture), but with efforts to increase revenue farmers are diversifying to other forms of shellfish and fish cage culture at sometime unsustainable densities that are detrimental to both growth and survival. To combat this YSFRI aims at promoting the use of IMTA (Fig. 10), so that the waste products of one trophic level can be utilised by another.

Moreover the relative densities of the various culture organisms will be set using ecosystem carrying capacity models. These models estimate the densities of organisms that can be supported by the ecosystem so that competition for resources is minimized and hence growth and survival is maximised and productivity and profitability increased.

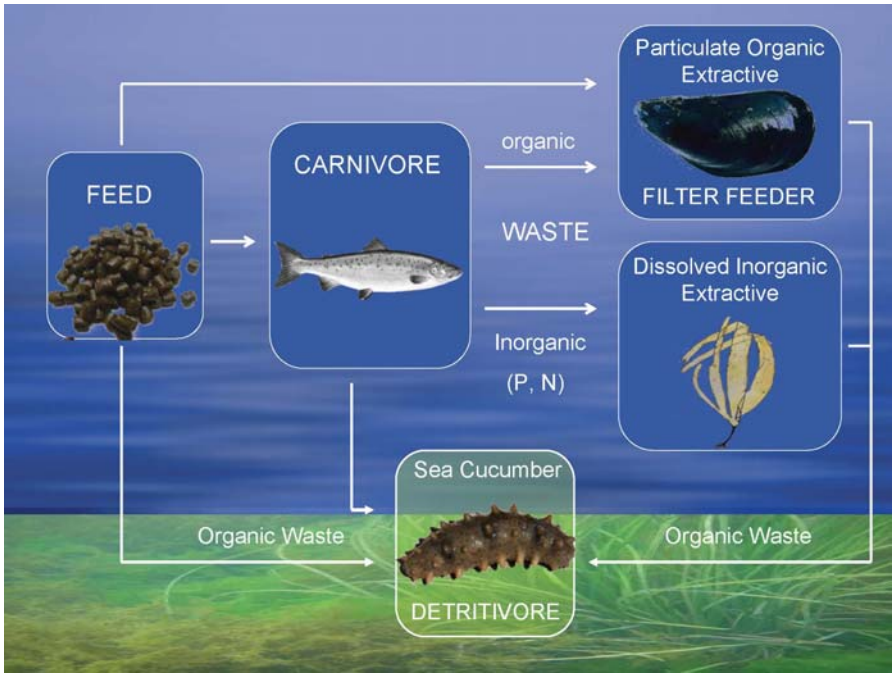


Fig. 10. IMTA concept: The particulate waste in the water column is removed by filter feeding bivalves, while the portion that ends on the seafloor is utilised by sea cucumbers. The dissolved inorganic nutrients (N, P & CO2) are absorbed by the seaweed that also produces oxygen, which in turn is used by the other cultured organisms.
Modified from (Fang et al. 2009)

The initial results show that the benefits of these two culture methods are currently being demonstrated to the farmers and fishery managers from Sanggou Bay both in terms of the increase in productivity and profitability and the environmental benefits compared with monoculture. It further indicated that the management action defined in the SAP has correct direction. The IMTA can be applied in other places if certain geographic and natural conditions are met.

9. Improved biodiversity management in Rongcheng Seagrass beds

Demonstration on the Management Action in the SAP: ***Management Action 9-1: Establish and implement regional conservation plan to preserve biodiversity***

This activity should assess the effectiveness of existing and proposed management plans, identify environmental targets and formulate an integrated management plan to reach the targets. The Rongcheng seagrass beds (Figs. 11-12) have previously been surveyed by First institute of Oceanography and the current state and problems reported in The Critical Habitat survey report, available on the YSLME website.

The problems facing this habitat and environmental, management and public awareness targets have been identified that are require to restore and sustain seagrass bed health. Previous management plans have been reviewed, gaps identified and a new management plans presented to stakeholders.

It is expected that through this activity the management of this critical habitat will be improved, protection of the seagrass is being proposed and this will help meet the ecosystem quality objective (regional target) No. 9: Maintenance and improvement of current populations/distributions and genetic diversity of the living organisms including endangered and endemic species; and No. 10: Maintenance of habitats according to standards and regulations of 2007.

Fig. 11. Present location of seagrass beds in Rongcheng (green stars) and historical location (orange stars).

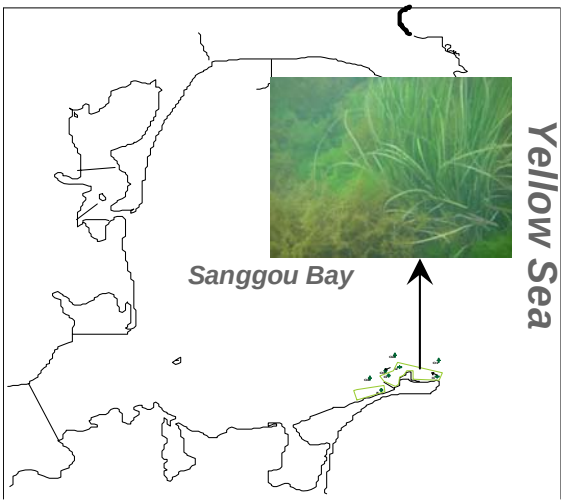


Fig. 12. More detail of the southern location of the seagrass beds in Sanggou Bay, nr Rongcheng.

10. Stakeholder training in critical habitat of the Rongcheng Seagrass Beds

Demonstration on the Management Action in the SAP: ***Management Action 10-4: Promote public awareness of the benefits of biodiversity conservation***

This activity targeted local stakeholders that work in and around critical habitats. The activity focused on providing training that encourages more sustainable use of the resource, reduces the environmental impact of activities in and around these habitats, and promotes ecotourism opportunities.

To this effect a volunteer "Yellow Sea Guard" has been formed that is being employed to disseminate knowledge and train different stakeholders. A variety of different stakeholders have been targeted including: the Rongcheng Fisheries Bureau and other local government officers were educated on the ecological significance of seagrass, the threat it faces and the need for its conservation and how it can be protected, local fishermen were taught about the benefits of conserving the seagrass for the ecosystem and for their livelihoods, primary school students and secondary school students were taught what was a seagrass bed, how to recognize it, why and how they can as students protect it, local communities were informed of the causes of seagrass destruction and what impacts that will have on the ecosystem. Further events are planned including: a seagrass symposium to which government officials from seagrass areas will be invited, training on the monitoring of seagrass beds for local fisheries officers and the initiation of a seagrass website.

It is expected that through training local stakeholders the increased understanding of the benefits of conserving the seagrass beds will contribute to the Regional Target 10: Maintenance of habitats according to standards and regulations of 2007.

11. Improved public awareness of the benefits of biodiversity conservation at the Rongcheng Seagrass Beds

Demonstration on the Management Action in the SAP: ***Management Action 10-4: Promote public awareness of the benefits of biodiversity conservation***

This activity targets visitors and local communities to increase the environmental awareness of seagrass beds and the benefits they bring to the community. Leaflets emphasising the benefits of seagrass the local communities in terms of improving fisheries and biodiversity and reducing nutrients were distributed directly to the public and through tourist agencies with the aim of raising awareness and promoting ecotourism. Bulleting boards have been erected and information on the biodiversity associated with seagrass, the flora and fauna, and conservation of seagrass have been posted.

Feed back has been obtained from the local population on the effectiveness of the boards through face to face interviews and through questionnaires. These activities have attracted the attention of local media, and articles on seagrass have now started to appear in newspapers, radio programmes and on television.

It is expected that through training of visitor and local communities the increased profile of seagrass beds will contribute to the conservation of the seagrass and hence Regional Target 10: Maintenance of habitats according to standards and regulations of 2007.

12. Effectiveness of closed fishing areas/season in reducing fishing effort

Demonstration on the Management Action in the SAP: **Management Action 2-2: Enhance stocks**

This activity assesses the effectiveness of closed seasons/areas in reducing the fishing effort and enhancing fish stocks, as major management actions. The western part of the Yellow Sea is closed for fisheries by the Chinese government between June and September in order to protect fisheries resources.

Researchers assessed the change in catch composition, age, size and weight before/after closure by the monthly sampling a single haul from local trawl fishermen. Immediately following the reopening of the closed fishing area the biomass for a single haul was over 80 kg and dominated by two fish species; *Chelidonichthys kumu* and *Coilia mystus.* However, by the next month these species have declined and the octopus (*Octopus ochellatus)* and shrimp (*Crangen affinis)* become more dominant. Moreover, the biomass has significantly reduced to around 20kg/haul at which level it remains over the following months (Fig. 13).

It is unclear whether the change in catch composition and biomass is related to fishing pressure or to seasonally migration patterns in fish stocks. Interviews with fishermen suggested that most fishermen were aware of the benefits of the closed fishing season but reported illegal fishing was common as fines were not sufficiently heavy to act as a deterrent as even after paying the fine the fishing was still profitable.

Many fishermen supported an extension to the closed season, even though the September catches did not always improve between seasons. In addition, most thought that enforcement of the closed season should be improved.

This activity will demonstrate the effectiveness of the seasonal closure of fishing areas. We hope that the results from this can be used to guide more effective closures that contribute to the regional target No 1: 25-30% reduction in fishing effort and No. 2: Rebuilding of over-exploited fish stocks.

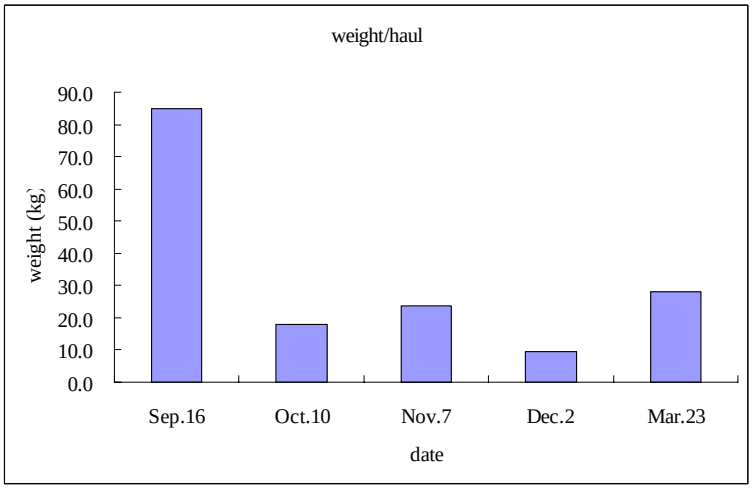


Fig. 13. Biomass of a single haul before and after closing the fishing season/area.

13. Effectiveness of stock enhancement in rebuilding fish stocks

Demonstration on the Management Action in the SAP: ***Management Action 2-2: Enhance stocks***

This activity assessed the contribution of stock enhancement in rebuilding fish stocks; researchers investigated the contribution of the release of hatchery raised juvenile olive flounder (*Paralichthys olivaceus*) (Fig. 14) to the fisheries harvests of olive flounder and assessed whether the restocking was of a put and take approach (sea ranching) or whether the restocked individuals survived long enough to contribute to the spawning stock.

In 12,496 juvenile olive flounder divided into 3 size groups (50 – 100mm standard length) were tagged and allowed to recover in tanks for a few days to assess mortality and tag loss, before being released in to the Taozi Bay, a historical spawning and feeding ground for olive flounder (Fig. 15). Results suggested that small (50-70mm) suffered the greatest mortality and tag loss in the acclimatisation tanks at 12.5% and 5.4% respectively with large juveniles suffering less at 4.2% and 3.2%. Tags carried information to identify the fish and a telephone number for reporting the capture of the fish.

Recapture rates were very low despite the production of more than 4000 posters that used to publicise the reward offered for tagged flounders, help from the local fisheries agency, the monthly purchase of a day's catch from a trawler operating in the area and two trawl surveys in the bay. Only 43 tagged olive flounders were recaptured, the low recapture rate means that only very general inferences can be made. Growth was found to be slow in the first month after which the standard length increase approximately 1mm per day and growth stopped during the winter non-feeding months of during January and February. The largest individual was recaptured at 352 mm after 290 days, the mean size at maturity is 300mm for males and 400mm for females indicating that these restocked flounder could contribute to the spawning stock.

This activity will demonstrate how effective the release of hatchery raised juveniles is rebuilding fish stocks and what contribution they make to the spawning stock. We hope that this activity can be used to guide more effective stock enhancement and contribute to Regional Target 2: Rebuilding of over-exploited fish stocks.

Fig. 14. A tagged juvenile olive flounder ready for release

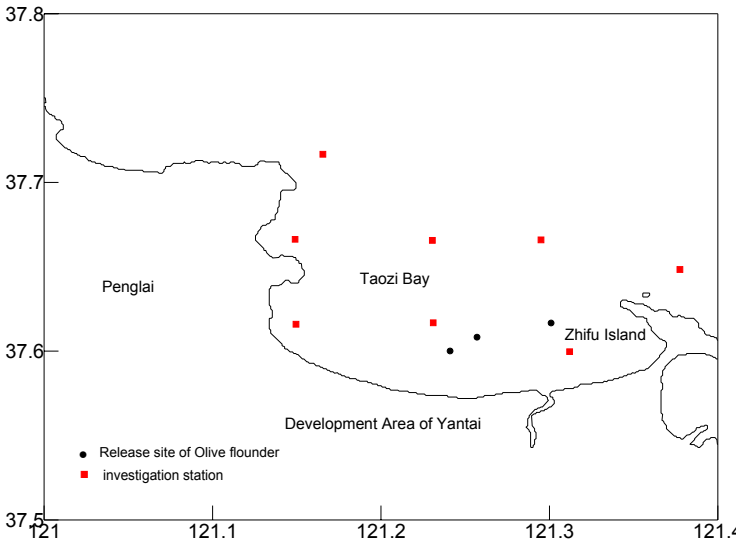


Fig. 15. The release sites and survey stations in the Taozi Bay

14. Environmentally friendly mariculture: Limited water exchange shrimp culture

Demonstration on the Management Action in the SAP: ***Management Action 3-1: Develop environment-friendly mariculture methods and technology***

Shrimp culture is one of the most important mariculture industries in both China and R. Korea but traditional methods using intensive or semi-intensive technology have a number of associated environmental impacts that have tainted the industry such as:

- The release of nutrients and particulates from the pond during water exchange can cause coastal eutrophication and smother benthic organisms.
- Outflows can also contain disease causing pathogens or parasites that may affect wild stocks.
- Large amounts of fish protein are used in production of cultured shrimp, competing with the local population for fish catches.
- Large areas are required for shrimp cultivation often competing with other users such as farmers or with natural coastal habitats. The conversion of these habitats can have unforeseen consequences due to the loss of ecosystem services.

Recently the industry in both China and R. Korea has suffered from decreased productivity due to disease and water quality problems. Limited water exchange shrimp culture using heterotrophic conditions (heterotrophic culture) aims at addressing these problems.

Heterotrophic shrimp culture is a more stable method of shrimp culture that encourages the growth of bacterial flocs through addition of a carbohydrate source and intensive aeration that keeps particulates in suspension. These bacterial flocs use the eaten food and shrimp wastes as a nitrogen source to increase biomass and hence recycle the food as they are consumed by the shrimp. This in turn reduces the percentage of fish protein required in diet hence reducing the amount of fish protein used in the production of shrimp as the food is used more effectively and food conversion ratios (FCRs) become closer to 1 (i.e. 1 kg shrimp produced using 1 kg feed).

This recycling of nutrients means that the water quality remains stable and no water exchange is needed, except some freshwater to allow for evaporation, which reduces the outflow of nutrients, pathogens and chemicals to the environment. It also means that there

are no incoming diseases, therefore survival is much higher. The stability of the water quality means that much higher culture densities can be obtained, reducing the need for the huge pond areas, and the competition for space with other users.

Initial trials are very promising, stocking densities of 300 *Litopenaeus vannamei* juveniles per m2 (traditional stocking densities are 15-30 shrimp/m2) in outdoor lined ponds resulted in a production of almost 2.72 kg/m2/crop and FCRs of 1.39 over 3 month's culture achieving an average body weight of 12.5 g with survival rates in excess of 70%. Indoor raceways have achieved a production of >20 kg/m2/year with 2.5 crops per year, this more than 70 times higher than traditional pond culture (Jang 2009). Nursery culture has also been very successful resulting in even lower FCRs at densities of up to 5000 post larvae /m2.

This activity aims at simplifying the management of these systems so that they are more easily managed by farmers and demonstrating the system and training farmers to use them.

From the outcomes of this demonstration project, together with Project Number 8 mentioned above, it is clearly demonstrated that if appropriate management were put in place, it is possible to have good harvest of seafood, and in the meantime, reduce discharge of pollutants into the marine environment.

15. Assessment of the Effectiveness of Improved Fisheries Management

Demonstration on the Management Action in the SAP: ***Management Action 2-3: Improve fisheries management***

This activity examined the impacts of boat buy-back and self management fisheries cooperatives on Fish stocks. Researchers at Pukyong University assessed status of selected fish stock and fisheries to examine over-capacity and over-exploitation and used questionnaires to survey the impacts on fishermen.

Results suggested suggest that (i) red fish, monkfish, anchovy, sea bass, yellow tail, pen shell, and Spanish mackerel are not in overexploitation/overcapacity, (ii) hairtail and skate ray are in overexploitation but in non-overcapacity, and (iii) yellow croaker and flounders are in non-overexploitation but in overcapacity (Fig. 16). However, considering stock fluctuations and assessment uncertainties, the average optimal fishing effort over the last three years (2005-2007) on and criteria was evaluated at 73.4 – 90.2. This result suggests that the current level of total fishing capacity in the Yellow Sea be reduced by 9.8 – 26.6%.

Interviews of offshore Yellow Sea fishermen indicated that 70% of the respondents thought that the programmes have had significant effect on resource recovery. This suggests that fishermen recognize the buyback programs are useful policy instruments of restoring fishery resources. In addition, where the government implements the buyback programs in parallel with TAC (total allowable catch) schemes, 70% of the respondents replied that implementing the two policies at the same time would be more effective on resource restoration than the buyback programs alone.

It appeared that the fish species on which the buyback programs have the largest positive effect are in order; bottom fish (63.3%), middle-layer fish (30%) and pelagic fish (3.3%).

From the initial result on analysis of this demonstration project, it justified that the Management Target of the SAP to reduce fishing efforts by 25-30% is scientifically correct. It also showed the effectiveness of boat buy-back has different impacts to the different fishes.

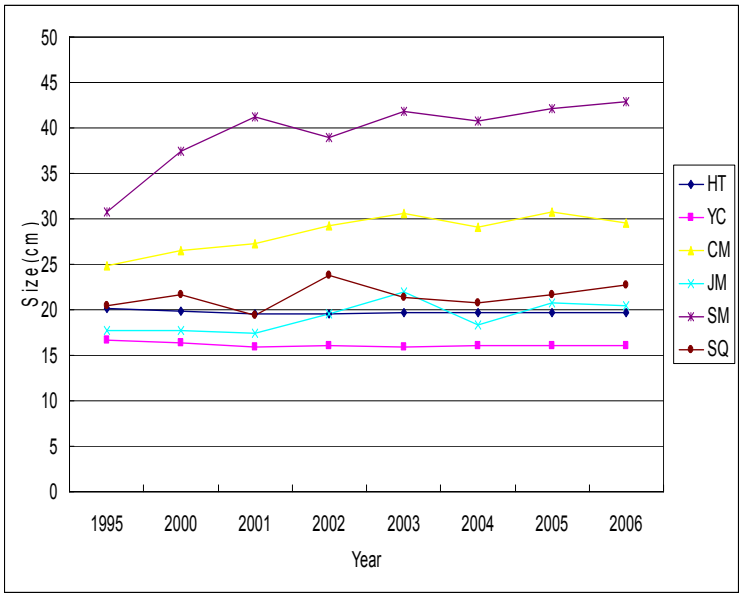


Figure 16: Size change in fish species over time (hair tail (HT), yellow croaker (YC), cub mackerel (CM), Spanish mackerel (SM) and common squid (SQ)). (Source: Internal Data Base of Department of Fishery Resource Research, Division of Fishery Resources and Ocean Environment, NFRDI).

16. Improved biodiversity management of the Tidal Mudflats south of Ganghwa Island

Demonstration on the Management Action in the SAP: ***Management Action 10-1: Develop regional guidelines for coastal habitat management*** and **Management Action 10-2: Establish network of MPAs**

Following the assessment of critical habitats on the west coast of R. Korea and the Ganghwa tidal flat was identified as the biodiversity demonstration site. The benthic biodiversity was surveyed and the impacts assessed. The major human impacts that will have the most effects on the biodiversity and critical habitats in the Yellow Sea are:

- Nutrient pollution
- Tidal power plants and associated reclamation
- Solid wastes

Pollution loads (produced loads and discharge loads) into the habitat and nearby Gyeonggi Bay from the three watershed regions have been assessed using pollution source data collected from the survey of local government agencies.

The results show that the discharge loads of BOD are higher in the watersheds of Han River and Shiwa Lake area than Incheon metropolitan city (Fig. 17). This suggests the habitat quality of the Ganghwa tidal flat is heavily influenced most prominently by the discharge from the Han River, downstream of which the Ganghwa Tidal Flat is located. To improve the surface water quality in the habitat, reduction in the nutrient input is necessary, for which enforcement of total maximum daily load (TMDL) would be most effective measure. Currently, TMDL has been introduced in 2002 by MOE in three major river watersheds (Geum River, Sumjin River, and Nakdong River Basin), in which some provinces have already been implementing TMDL. However, TMDL has not been introduced in Han River basin due to objection of the residents, except for Gwangju City in Gyeonggi Do, in which TMDL has been implanted since 2003 with a goal of reducing BOD level to 5.5 mg L-1 by 2007 in Sooh-an bo of Gyung-ahn cheon (stream), one of the major streams flowing to Paldang Dam, a major freshwater reservoir of drinking water for the citizen of Seoul and Gyeonggi Province.

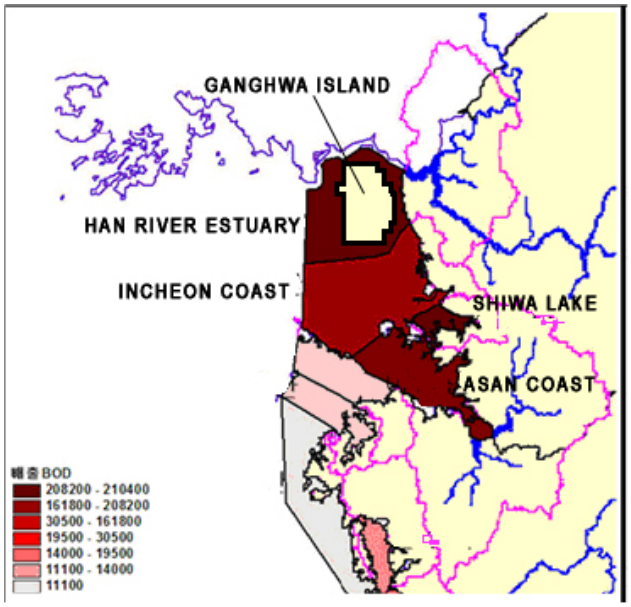


Fig. 17. Biological oxygen demand loadings in the water bodies surrounding the Ganghwa tidal mudflat.

On 2nd November 2009 a stakeholder meeting was held in the Ministry of Land Transport and Maratime Affairs (MLTM) to introduce the new management plan, it was favourably received, and will be revised according to the comments received.

It is expected that by improving management, through the introduction of a new management plan to control pollution and conserve the biodiversity that is present on the mudflat it will contribute to the Regional target 9: Maintenance and improvement of current populations/distributions and genetic diversity of the living organisms including endangered and endemic species; and No. 10: Maintenance of habitats according to standards and regulations of 2007**.**

17. Stakeholder training in the critical habitat of the Tidal Mudflats south of Ganghwa Island

Demonstration on the Management Action in the SAP: ***Management Action 10-4: Promote public awareness of the benefits of biodiversity conservation***

This activity aimed to train local residents and stakeholders (pension managers, fishermen) to become ecotour guides, thereby integrating them into the process of conservation of the Ganghwa Tidal Flat

The first training was held over 3 days and 16 stakeholders, mostly pension owners took part. The training was very well received with 100% willing to take more environmental courses offered by the Tidal Flat Center and be involved in other environmental activities such as pollution monitoring or waste collection. Two further courses are planned for different stakeholder groups (farmers and fishermen).

It is expected that through training local stakeholders, the increased understanding of the benefits, both economical and ecological, of conserving the Ganghwa tidal mudflats will contribute to their conservation and hence Regional Target 10: Maintenance of habitats according to standards and regulations of 2007.

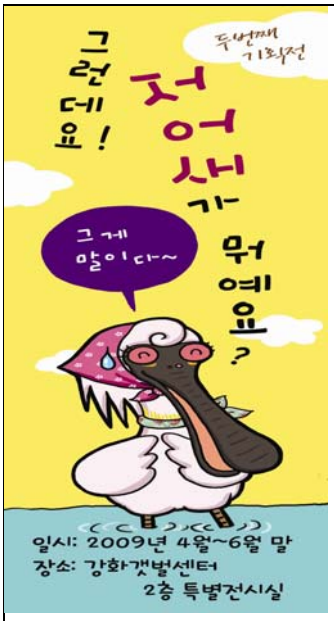
18. Improved public awareness of the benefits of biodiversity conservation for the Ganghwa tidal mudflat

Demonstration on the Management Action in the SAP: ***Management Action 10-4: Promote public awareness of the benefits of biodiversity conservation***

The activity aimed to improve public awareness of the habitat by helping the public recognize that conservation of biodiversity in this region is a win-win strategy not only for the nature but also for the public.

Using the black faced spoonbill as a flagship species the Ganghwa tidalflat centre produced a number of information materials on the importance of this habitat in conserving spoonbills, how they use it and what they use it for (Fig.18). This material is available at the tidal flat visitor center and is distributed to the local pensions (the owners of which took part in the training) to educate their guests.

The tidal flat centre also aims to produce an ecomap for Ganghwa tidal flat and update the ecoguidebook for Ganghwa Island. Again these materials will be available at the tidal flat center and at local pensions.



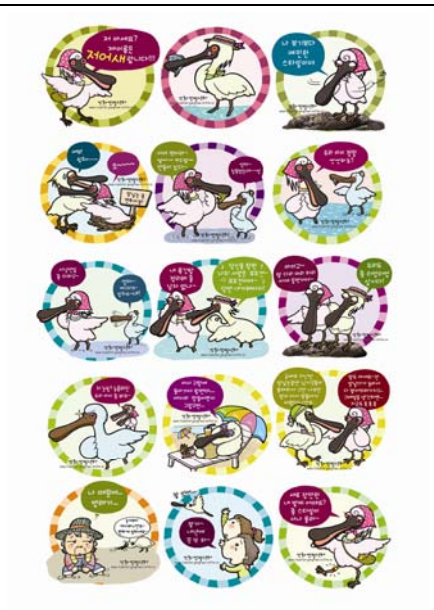


Fig. 18. Part of the publicity material produced by the Ganghwa tidal flat center.

It is expected that through raising the awareness of the biodiversity that is supported by the Ganghwa tidal mudflats and the services that are offered by these mudflats it will contribute to their conservation and hence to Regional Target 10: Maintenance of habitats according to standards and regulations of 2007.

19. Managing Pollution in Critical Habitats around the Yellow Sea[14]

Demonstration on the Management Action in the SAP: ***Management Action 10-1: Develop regional guidelines for coastal habitat management***

This activity intends to identify the effectiveness of how regular monitoring and assessment of the ecosystem and exchange of information across different responsible agencies can help improve marine habitats through controlling marine pollution in the Yellow Sea.

Pollution loads (produced loads and discharge loads) into the habitats in Ganghwa Southern tidalflats and nearby Geoynggi Bay from the three watershed regions were assessed using pollution source data collected from the survey of local government agencies. The relationship between discharge loads and reaching loads was quantified by comparing monitoring data and river water flux data. Produced loads and discharge loads were computed for the three constituents of biological oxygen demand (BOD), total nitrogen (TN), and total phosphorus (TP), which are indicative of organic pollution.

Results showed that the discharge loads of BOD, TN, and TP are higher in the watersheds of Han River and Shihwa Lake than in Incheon Metropolitan City. This suggests that the habitat quality of the Ganghwa tidal flat is heavily influenced by the discharge from the Han River. Future tasks include identifying the pollution load by source(s), and setting the limit of the allowable amount of load from each source to be discharged daily (i.e., setting total daily maximum load) in an effort to reduce pollution.

A microcosm study is testing whether the inorganic/organic pollution in the tidal flat negatively affects benthic community such as decreased biodiversity and abundance and proliferation of species that are indicative of pollution (Figure 19).

Results of this study will be presented to stakeholders, along with a management plan to protect the habitats.

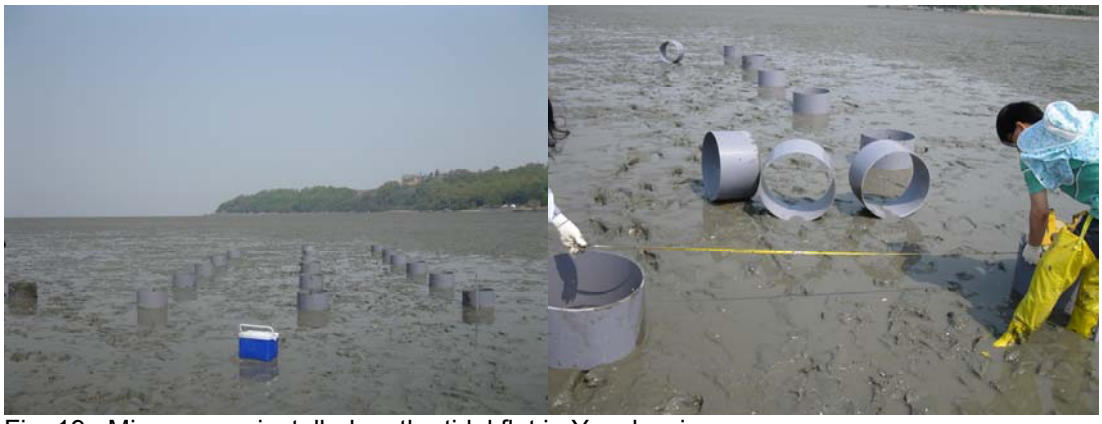


Fig. 19. Microcosms installed on the tidal flat in Yeocha-ri.

Knowing the sources and amounts of pollution around Ganghwa will enable policy makers to control pollution and hence protect the habitats that will be affected. The regulating and supporting services of the ecosystem are closely interlinked, and will be maintained by decreasing pollutants and increasing habitats protection around Ganghwa Island.

[14] Information and photos provided by Academy-Industry Cooperation Foundation.

20. Economic analysis of the SAP demonstration activity in Ganghwa

Demonstration on the Management Action in the SAP: ***Management Action 10-3: Control new coastal reclamation***

This study aims to examine the benefit of preserving biodiversity in Ganghwa, ROK, as suggested by the management plan that the SAP demonstration activity has developed. (For more information about the demonstration activity, see Section 17 in this document.) The change in economic value of recreational opportunities that the tidal flat provides will be estimated according to different environmental qualities and based on relevant socioeconomic data collected from visitors to the site and from organisations that managing beaches and other tourist attractions in the Ganghwa Island.

Survey instruments consisting of a questionnaire, visual aids, and interview guidelines were developed. The questionnaire was designed to collect information from the visitors individually on the departure place for the trip, the number of visits to the site per year, the duration of the visit, and other demographic factors such as the age, education level, and annual income of the visitors. An on-site pretest was conducted to check the draft questionnaire, and a workshop was organised to train the enumerators with the guidelines used as training materials. The questionnaire and visual aids were finalised after the findings from the pretest and the comments from the interviewers during the workshop were incorporated.

On-site and face-to-face questionnaire surveys were conducted in the summer and autumn of 2009 (Figs. 20-21). The trained enumerators interviewed visitors to the Dongmak Beach and the Ganghwa Tidal Flat Center. As a result, total 400 samples were collected.

Fig. 20. Interviewers examining the questionnaire and visual aids in the training workshop.

Fig. 21. An interviewer collecting information from visitors to Ganghwa.

A recreation demand will be estimated with regression analysis; the number of visits to the site is modeled as a function of travel cost to the sites, respondent's demographic factors, and environmental quality at the site. Coefficients of the function will be estimated under different conditions, including the followings: (i) actual current environmental quality, (ii) hypothetical future environmental quality without management, and (iii) hypothetical future improved environmental quality with management. Then, a consumer surplus as economic benefits of conserving the biodiversity will be calculated based on the estimated model. Early results indicate that improving the tidal flat management with the introduction of the proposed plan would generate economic benefits.

The management actions will develop management plans and networks to protect critical habitats in the Yellow Sea. Developing one of those plans, the demonstration activity in Ganghwa tests whether the actions, before they are adopted on a widespread basis, will achieve the management target of maintaining the habitats according to the standards and regulations of 2007. The proposed plan suggests a set of policies and countermeasures, including the reduction in nutrient input to improve the surface water quality in the tidal flat. The early results of the economic analysis on the demonstration activity show that it will be economically reasonable to improve the environmental quality of the habitat by introducing the management plan. This result provides a strong incentive for investing in the proposed management actions.

21. Cost-benefit Analyses of Strategic Action Programme Demonstration Activities: Improvement of Sustainable Mariculture Techniques

Demonstration on the Management Action in the SAP: ***Management Action 3-1: Develop environment-friendly mariculture methods and technology***

This project aimed at assessing the cost-benefit performance and sustainability of the integrated multi-trophic aquaculture (IMTA), an SAP demonstration activity implemented in the Sanggou Bay, China. (For details on the demonstration activity, see Section 8 in this document.) Questionnaire surveys were conducted with two large-scale mariculture farms implementing the demonstration activity and with other small-scale farmers around the Bay. The surveys collected economic data such as the volume and cost of producing cultured species, including seaweeds and kelp. Commercial and environmental benefits in the following three different modes of mariculture were calculated based on the collected data: the monoculture of kelp, the monoculture of scallop, and the IMTA of those two species. Additionally, the sustainability of different modes was measured with the “emergy” approach taken as an evaluation method.

The results show that the IMTA will be more profitable and sustainable than the monoculture. The commercial benefit (net) of the IMTA per unit area is approximately 3 to 4 times higher than that of the monoculture (Fig. 22). The IMTA not only removes nutrients from seawater when cultured species are harvested, but also reduces environmental impacts by recycling waste products from different trophic levels. The IMTA diversifies financial risks associated with the monoculture. The sustainability index of the emergy approach favours the IMTA, indicating this mode of mariculture provides a certain level of outputs with less environmental impacts.

The final report of this project provides specifics and guidelines on how to conduct the analysis, describing the step-by-step process of collecting, analysing, and interpreting data. The report will be used as a reference for future similar assessments. Following the process described in the report, one can examine the efficiency of improving mariculture techniques.

Two training workshops were organised to enhance the capacity of stakeholders: one for local mariculture farmers and one for government officials. The first workshop encouraged the farmers to introduce the IMTA, explaining its merits to increase the profitability of and reduce the environmental impacts from their businesses. The second workshop, explaining the method and process of the CBA, facilitated relevant authorities to integrate economic analyses into their workplan.

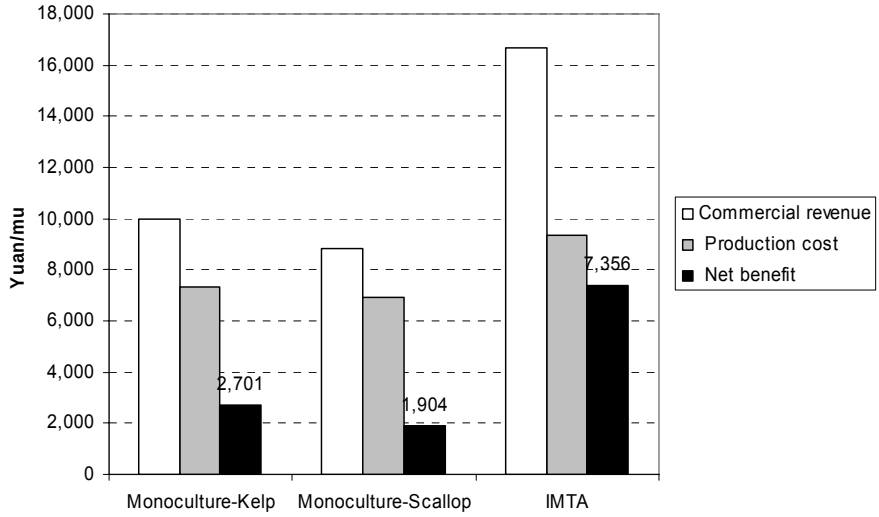


Fig. 22. Economic benefits according to different mariculture modes.

The management action will develop environment-friendly mariculture methods and technology. Taking the IMTA as an example, the demonstration activity in the Sanggou Bay tests whether this proposed action will achieve the management target of reducing environmental stress from mariculture. Compared with monoculture, the IMTA is expected to not only increase the productivity of farming, but also mitigate the environmental impacts from the industry on the ecosystem. The results of the economic analysis show that the IMTA will be economically reasonable and sustainable, suggesting adopting this mariculture method widely in the Yellow Sea.