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Artificial enhancement of sea-forest for reducing the Isoyake degree along the north coast of China

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Abstract: Sea-forest plays an important role in offshore biological production, remediating marine ecological environment and recruitments of fishery resources, etc. With the influence of marine environment, over exploration, global climate change, sea-forest resources are seriously reduced in the northern coast of China. Artificial reefs play important roles in retorting the sea-forest and coastal ecosystem. From 2006, the local government initiated projects with input of about 160 M RMB for artificial reef construction for the enhancement of shallow natural resources and for Isoyake alleviation along the coast of Shandong Peninsula (Weihai, Yantai, Rongcheng, Qingdao etc). With establishment of ten artificial reef sites for the sea-forest enhancements, they aim to construct 3000 ht sea-forests along the local coast areas, and the economic and ecological effects of artificial reef were evaluated ideal after the construction. Here, the present situation of artificial reef construction was summarized and introduced, and existed problems were either pointed out. In addition, the implementation of artificial reef and the continuous development were discussed, either the assessments of effects of artificial enhancement were mentioned.

Key words: sea-forest, artificial reef; colonization

Introduction

Sea-forest formed by macroalgae on rocky bottoms has been recognized to be significant in ecological and biological function. It provides a habitat for fish and shrimp spawning-beds, breeding and feeding grounds for coastal fish and shellfish, as well as for other important fisheries enhancement (Largo and Ohno 1993, Terawaki *et al.,* 2001). In order to achieve sustainable coastal development, protecting sea-forest has been emphasized as one method to conserve a healthy coastal environment and marine resources (Choi 2000). Usually, "Isoyake" areas become to "deforestation" in sea-water environments, which mainly caused by intensive grazing by herbivorous animals (Harrold and Pearse 1987). During the process of sea-forest's rehabilitation, the artificial algal reefs provide the places for seaweed attachment to form the alga superiority population within the short time (Falace and Bressan 2002, Ohno *et al.,* 1990).

Artificial reef is a kind of artificial facility which is used to build marine ranch, control and optimize marine ecological environment and proliferate biological resource. It has been used for over 200 years to enhance fishery resources (Baien 2001, Lewis and MaKee 1989, Tsumura *et al.,* 1999). The design of artificial algal reefs is an important and complex, and the shape and material of reefs influence recovery of sea-forest (Grigg 1994, Zhang *et al.,* 2008). Historically, the Japanese conducted the inventive works on artificial reef construction from 1950's, with the effective deploring of the artificial reef, it increased of output and quality of fish catches (Mottet 1985).

Comparatively, the present sea-forest destruction (Isoyake) along the north coast of China is serious, and it may ascribe from the deterioration of coastal environment and the possible global climate change effects. The implementation of artificial reef was

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started from 1970's (Zhang and Sun 2001), even though the preliminary works carried out and needs improvements, the yielded results are positive. So far, attentions were paid by both the governments and companies, and more input will be put in the future.

Here in this paper, the artificial reef project of Shandong and the problems of artificial reef building in China were reviewed and summarized.

The implementation of artificial reef project in Shandong peninsula

In China, fishery resources has declined rapidly for many reasons from the last seventies. Over 30,000 tons of shrimp production were obtained annually in Shandong coastal areas, but now reduced to merely 1,000 tons in recent ten years. Except to the controlling of over exploration and fishery catch, artificial reefs are considered as an important method to solve these problems, because it will enhance the shallow natural resources and remediate the coastal ecosystem. From 2005, the local provincial government initiated one project with about 160M RMB for artificial reef building for Isoyake alleviation along the coast of Shandong Peninsula (Weihai, Yantai, Rongcheng, Qingdao etc, Fig.1.), so far, eleven artificial reef sites were established for the sea-forest enhancements, with total of 3000 ht sea-forests implementation locally.

Before 1980's, the construction of artificial alga reefs was extensive, simply put the worn ships and blocks into the sea directly. In recent years, the design of reefs developed to intensify effects locally north coasts of China. The concrete was the most commonly used material during the construction of reefs, and the coal ash, steel, the shell, the lumber were either applied. Reefs of various shape reefs

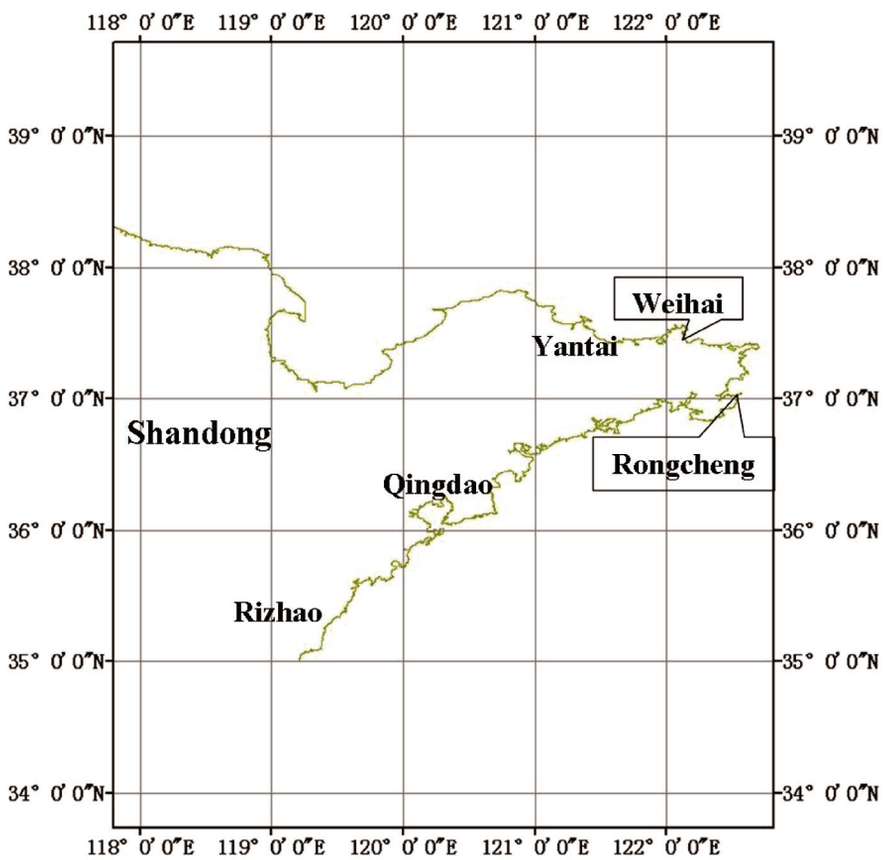

Fig. 1. Layout of artificial reefs in Shandong.

were constructed (Fig.2.) and the surface was concave-convex and the superficial and internal was vesicular structure, with aim to enhance the seaweed attachment easy and promote growth. After the implementation, fish and shellfish increased obviously. Through the 3 years rehabilitations and efforts, the marine biodiversities increased (fish, sea cucumber, shrimp, crab etc, Fig.3.) obviously, and the reduction of fishery were relieved, and the serious degree was prevented. For examples, the fishery catch in deep artificial reefs areas in Weihai is 15–20 times of that in other areas, and it

Fig. 2. 1-6 Various types of concrete reefs applied in north coasts of China.

is estimated that the fishery products increased 225 tons with 3039 x 10^4 RMB, and the estimated the fishery production is 1446 tons.

The problems of artificial reef building and study in north China

1. Quantitive investigation and survey for the degree of Isoyake and rehabilitations needs to be carried out, so far, the situation of Isoyake along the north China coast is not clear yet. Therefore, it needs to evaluate and optimize the design and construction of artificial reefs, because there are relationships between the marine ecosystem and deplored artificial reefs.

2. So far, there isn't a system for the criterion of artificial reefs in north coasts of China, it needs to construct one typical coastal system or pattern for the evaluation of the enhancement. Moreover, filed study and survey should be carried out for evaluation of the effects of the work.

3. New materials for artificial reefs construction are found for more durable and low cost purpose. Figure optimization of artificial reefs should be conducted, and the sites selection for the artificial reefs should either be evaluated before and after the action.

4. There are many factors for the consideration before artificial reef construction, such as, position selection, material and style, the style of deposition

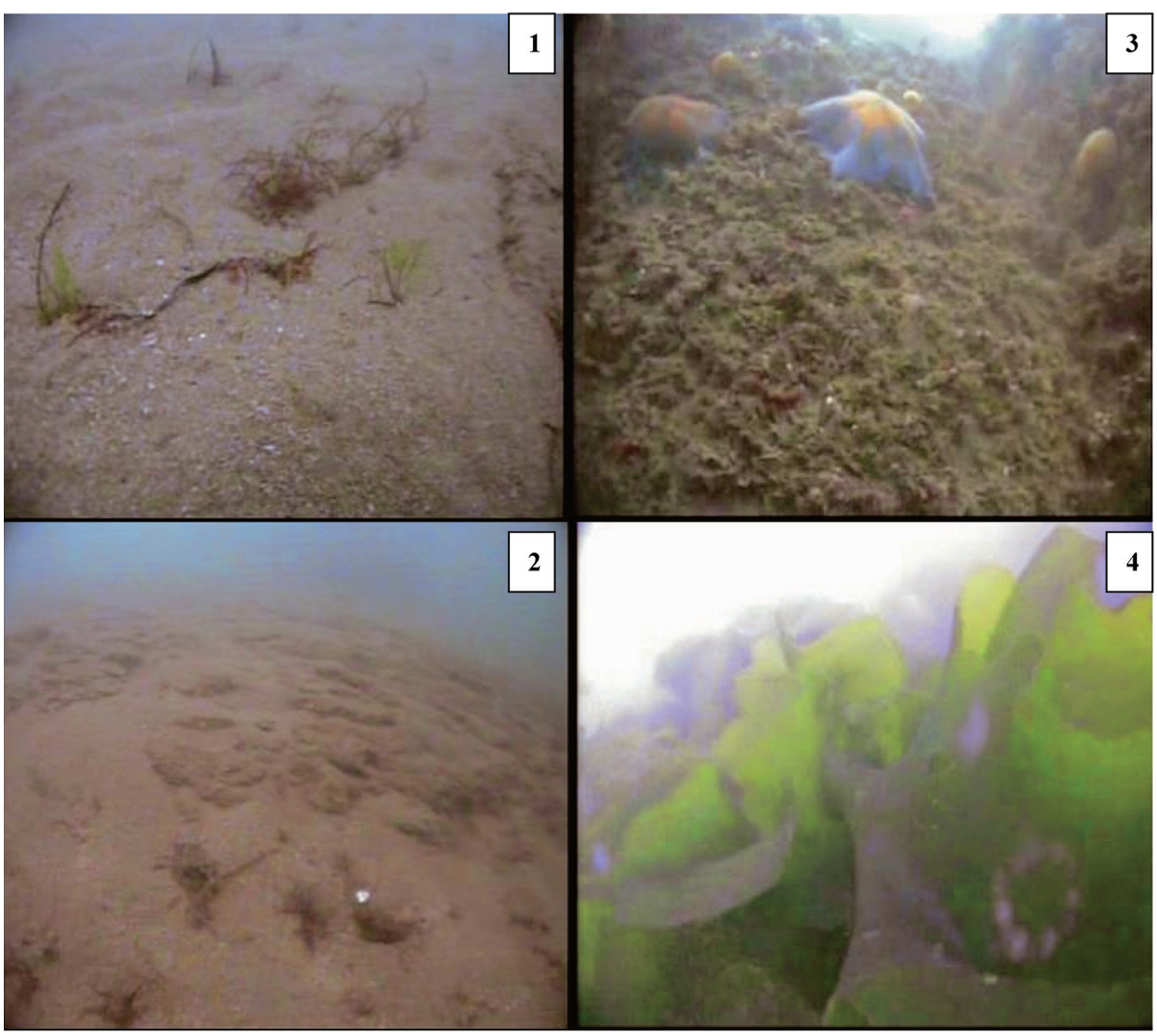

Fig. 3. 1-2 Before artificial reef construction, 3-4 After artificial reef construction.

and arrangement, the species of fishery resources in deposited area, weather conditions, the situation of sea floor, etc.

5. So far, there are no legislations to protect the construction of artificial reefs, it needs to draft the chapters or legislation formula for the effective protection of artificial reefs and eventually to the coastal bioresources.

6. Even though the support of government for the implementation of the work, it needs to continuously to support the work with the long plan.

Summery

Sea-forest is a common habitat in coastal inshore ecosystems. Macroalgae provide primary productivity to biological communities and provide the food web. Macroalgae offer ideal habitats for many plants and animals in coastal ecosystem. These beds provide spawning and feeding grounds for fish or shrimp, and refuges for many fish species as well as micro and macro aquatic organisms (Komatsu and Tatsukawa 1999). Artificial reef can provide the places for macroalgal attachment to rebuild sea-forest in a short term.

So far, many artificial reefs were built and studied both in China, and it showed the ecological and economic profit in many coastal regions in China. Comparing with the technology of advanced countries, there is still improvements and continues hard work for artificial reefs construction in China. Only in this way, we can reach the goal for the improvement of coastal or marine environment and the enhancement of marine resources.

It is urging for the government to enlarge the investment for investigation and survey of coastal system and for improvement of marine environment, to bring the attention of public awareness of sea-forest role and importance.

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