Isoyake Recovery Technique using artificial substrata in Japan

Osamu Hashimoto, Motobumi Manabe, Akira Watanuki, Masaru Kawagoshi, Takeshi Hosozawa, Fumihisa Okashige, Yasuyuki Gonda, Syouichi Ito, Takeshi Tajima, Yousuke Fukui, Tomomi Terajima, Hirokazu Nishimura, Tetsuya Shirokoshi and Toru Aota (Association for Innovative Technology on Fishing Ports and Grounds)

Introduction

In recent years, a large-scale disappearance of the seaweed bed called "Isoyake", which has been observed in many coastal areas throughout the country, has a significant impact on the Japanese fish industry. Although various causes have been pointed out for the occurrence of isoyake, it has become clear that the effects of feeding damage from sea urchins and herbivorous fish are significant.

The Japanese Fisheries Agency published Isoyake Recovery Guideline[1] in 2007. This guideline summarizes treatment methods for diagnosing marine conditions and what measures should be taken. Since then, the idea has been reflected in the business for isoyake recovery. In addition, since some of the elemental technologies listed in the guideline have evolved, the guideline was revised in 2015[2]. In particular, it has been pointed out that it is important to generate a phase shift in the balance between herbivores and seaweeds as a countermeasure goal. These guidelines are centered around techniques for fishers to restore seaweed beds. On the other hand, there are no detailed descriptions in the guidelines for hardware measures such as the installation of artificial substrata for the formation of seaweed beds implemented by local governments.

Therefore, our study group organized by private companies gathered the technologies and products owned by each participating company and categorized isoyake recovery methods. A guide on how to use artificial substrata for isoyake recovery was created. This article introduces the contents.

Materials and methods

In the Isoyake Recovery Guidelines, elemental technologies are organized according to factors that inhibit the formation of seaweed beds. In addition, the technical flow was shown so that each elemental technology that matched the site conditions could be selected. We extracted the elemental technologies that can be handled by artificial substrata and made the technologies and products owned by each company correspond. A collection of case studies of seaweed bed recovery using each technology and product was created. These contents were compiled into a booklet entitled “Measures against Isoyake Using Artificial Substrata”.

Results

The isoyake recovery technologies using artificial substrata include protection from herbivores, removal of floating mud, transplantation to increase seaweed, and promotion of seaweed deposition by processed substrata (Fig.1). The following introduces technologies and issues using artificial substrata for each category.

Isoyake recovery technologies Using artificial substrata

- 1.Defence against herbivores
- 2.Clearing of floating mud
- 3.Planting seeds and transplantation
- 4.Growth promotion by processed substratum

Fig.1 Elemental technologies that can be handled by artificial substrata

1. Defense against herbivores

Protection techniques from herbivores include protection against feeding damage by sea-urchins and herbivorous fishes.

As measures against feeding damage to sea urchins, concrete columnar artificial reefs have been developed to promote flow by reducing water depth and reduce feeding pressure of sea urchins (Fig.2). If the water depth at the top of the columns is reduced, many sea urchins cannot climb to the top, leaving seaweed at the top. In sea areas where many herbivorous fish are distributed, attempts are being made to protect the columns with cages and needles. In addition, a method to prevent sea urchin entry using needle mats was developed (Fig.3). There are already examples of protecting corals from the damage caused by Black long spine urchin. Currently, tests are underway to protect the kelp field from the damage caused by Northern sea urchin.

As a facility for protecting seaweeds from herbivorous fish, caged blocks have long been adopted (Fig.4). It is expected that seaweed seeds will be supplied from the cage to the surrounding area. In order to increase the effectiveness, it is necessary to periodically clean the cage deposits and remove the surrounding herbivorous fish. Spiny defenses have been developed to protect seaweed from feeding by herbivorous fish (Fig.5). Rather than protecting the whole seaweed, it protects the minimum necessary parts for survival, such as seaweed juveniles and growth points.

2. Clearing of floating mud

When floating mud accumulates on the substratum, the seaweed seeds cannot be settled on. In the sea area with a large amount of mud, an inverted trapezoidal projection "Kelp Knob[3]" (Fig.6) is installed on the surface of the block. Then, places where the floating mud is hard to accumulate are secured, and it is effective for the growth of seaweeds[1),2),4)].

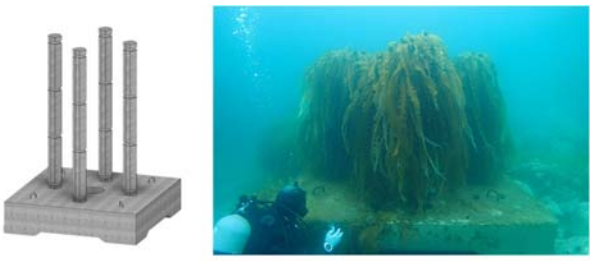

Fig.2 Columnar leaf that sea urchin cannot climb

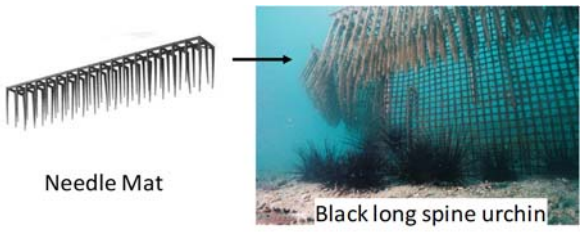

Fig.3 Needle Mat to prevent sea urchins entering

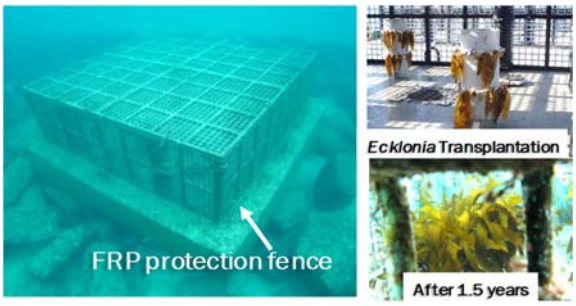

Fig.4 Block with cage to protect against herbivorous fish

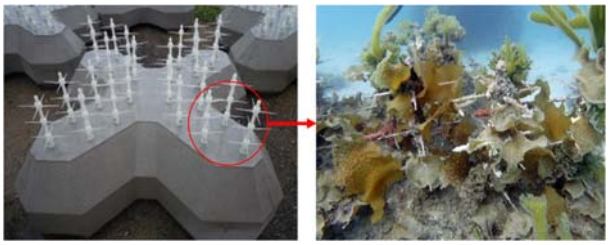

Fig.5 Spiny defenses protects seaweed growth from herbivorous fish

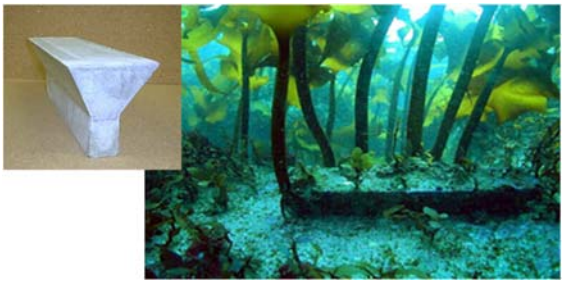

Fig.6 *Ecklonia cava* growing on Kelp Knob where mud is hard to accumulate[4)]

3. Planting seeds and transplantation

If the decline of seaweed continues over a wide area, there may be a shortage of mother algae that supplies seeds. In such areas, it is necessary to plant seaweed seeds or transplant seaweed seedlings. For some time, seaweed has been germinated on a small plate and transplanted to the seabed. Recently, removable substratum, Seaweed Cartridge (Fig.7), has been developed. This substratum can be used any number of times.

4. Growth promotion by processed substratum

Seaweeds (such as kelp) tend to settle on the convex part of the substratum. Since the spores of these seaweeds are as small as several μm, it will be easy to survive if there are projections where the substratum is exposed by waves or flows so that they will not be buried in the floating mud. Also, the spore that has flowed will adhere more frequently if there are bumps (edge effect). In anticipation of this effect, devices have been made to provide convex on the surface of the block. Typical examples are grooved blocks and blocks made of porous concrete. Groove formation forms edges on both sides of the recess, providing a place where seaweed is likely to settle. Porous concrete is concrete with less sand, which is fine aggregate. It is also called No Fine Concrete (NFC) and has continuous voids. Porous plates using ceramic and shells as coarse aggregates have been developed (Fig.8, Fig.9). Semi-spherical porous substrata have been developed (Fig.10). Porous concrete has a very complex surface and creates a large surface area compared to a flat substratum. Porous concrete is not high in structural strength, so it is placed on the strong block as seaweed substrata.

Since it is difficult to form complex protrusions on concrete blocks, cast iron substrata have also been developed (Fig. 11). Since seaweeds change the species composition depending on the water depth, step-like blocks have been developed in anticipation of the formation of seaweed beds with various species composition (Fig. 12). A variety of constituent species can be expected at the Sargassum bed.

On the other hand, concrete containing amino acid, arginine, which promotes seaweed growth was developed. A lot of microalgae tend to settle on the concrete substratum where arginine is eluted from the surface. According to experiments, microalgae increased 5 to 10 times compared to the normal concrete substratum (Fig.13). Since small seaweeds serve as prey for herbivorous animals, it is expected that the possibility of survival of large seaweeds will increase.

Fig.7 Seaweed Cartridge

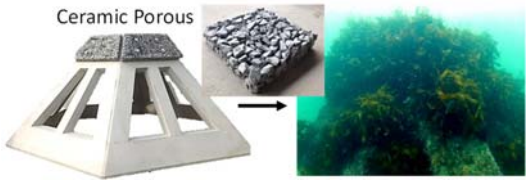

Fig.8 Ceramic Porous Block

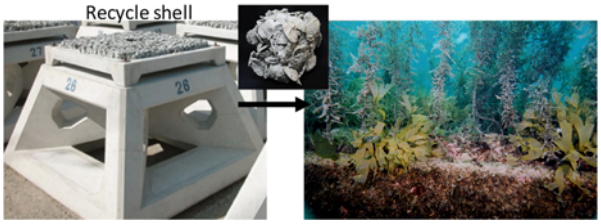

Fig.9 Porous panel using shell

Fig.10 Hemispherical porous substratum

Fig.11 Cast iron seaweed substratum

Fig.12 Step-like block for seaweed adhesion

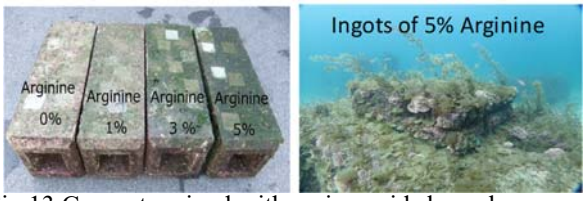

Fig.13 Concrete mixed with amino acids has a large distribution of micro algae

Discussions

In conventional seaweed bed development, detailed maintenance management in consideration of change of coastal environment has been entrusted to fishermen. Unfortunately, if the seaweed maintenance function of the fishing ground facility deteriorates due to various factors, the fishing ground is devastated, left untouched and is no longer used.

When constructing artificial reefs, we have grasped the environmental conditions of the target areas and have designed them optimally. However, it has been observed in various places that seaweed is decreasing due to unexpected circumstances. The environment surrounding the seaweed bed not only changes over time, but is also affected by water temperature fluctuations, such as global warming. Therefore, after construction of the fishing ground facilities, it is important to observe the effects regularly and to carry out maintenance so that the effects can be demonstrated.

Recently, the isoyake phenomenon has become a national problem, and the importance of software measures, such as removal of herbivores and seeding and transplanting in areas where seeds are lacking, has come to be recognized again. The proper maintenance of natural fishing reef has increased the number of cases of seaweed recovery in many places. Using the techniques introduced here, it is possible to restore natural seaweed beds and the function of artificial reefs for aged seaweed beds.

Cooperation between hardware measures and software measures is very important. How to specifically plan and act in Japan is a trial and error stage. Under the initiative of the Fisheries Agency, local governments nationwide are in the process of formulating a “Seaweed Bed Vision”. A vision that considers excellent hardware countermeasures and software countermeasures that effectively use them is desirable.

This paper introduced isoyake recovery technology using artificial substrata in Japan. However, it was limited technology of companies belonging to our group. The Fisheries Agency is planning a third revision of the Isoyake Recovery Guideline. It is hoped that more hardware technologies will be introduced and specific cooperation between hardware and software measures will be described.

References

1) Fisheries Agency: Isoyake recovery guideline. 213pp., 2007(in Japanese)

2) Fisheries Agency: Isoyake recovery guideline. 199 pp., 2015(in Japanese)

3) Terawaki T.: Preliminary study for creation of kelp forest. Ⅱ. On relation between surface form of artificial algal substratum and colonization of young Ecklonia cava plant., *CRIEPI Report,* U88037, 26pp., 1988 (in Japanese)

4) Shibata S., A. Watanuki and H. Kuwahara: Techniques and Problems for Construction of Seaweed Bed with the Artificial Substrate, *Fishery Engineering* 51(3), pp.263-269, 2015(in Japanese)