Algae
Volume 15(3): 179-182, 2000

[Note]

Construction of Artificial Seaweed Beds; Using the Spore Bag Method

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Kelp forests and *Sargassum* beds not only are commercially important in themselves but also play an important role in spawning, breeding and feeding grounds for many kind of fish, shellfish, lobster and other important fisheries resources (Komatsu *et al.* 1982; Komatsu 1985; Ohno *et al.* 1990; Watanuki and Yamamoto 1990; Terawaki *et al.* 1998). The distributions of kelp forests comprising of the *Ecklonia* and *Eisenia* species are restricted to warm-water regions. A number of ecological studies on these plants have been undertaken with particular attention focused the re-establishment of kelp forests. This is due to declining populations that are a result of various factors, including human activities (Tsutsui *et al.* 1996). Thus, there has been development of construction techniques of artificial foundation, for kelp forests, and transplanting techniques of seed and adult marine algae, on artificial foundations (Hasegawa *et al.* 1995).

Techniques of formation for seaweed bed may fall under either of the following classifications: 1. Spore dispersal technique; 2. The spore bag technique; 3. Rope-seeding technique; 4. Adult-plant transplantation method; 5. Concrete blocks; 6. The threading technique; 7. Gravel-bag technique; and 8. Transplantation of young plants (Largo and Ohno 1993).

In this study, we used the spore bag on the roof of an artificial iron reef and a natural rock for a seaweed bed. The present paper describes the formation of seaweed beds by the spore bag method on an artificial iron reef and a natural rock (habitat).

The experiments were conducted at Ikata, Tei and Usa, Shikoku in the southern part of Japan. A large number of perennial seaweeds such as *Sargassum horneri, S. macrocarpum* and *Ecklonia kurome* grow on natural substrata around the experimental site at Ikata. But *Ecklonia cava* was not occurring in the natural condition at Tei and Usa.

The growth of seaweed was observed monthly or bimonthly by scuba diving. Photographs were taken by digital video camera, video camera and 35mm camera.

Twelve different types of plates made up of various materials were fixed on the artificial iron reef at Ikata. They were arranged in the following manner 1) steel plate, 2) steel plate with big hole, 3) plate shaped an iron bar, 4) steel plate with irregularity, 5) steel plate with a triangle shaped irregularity, 6) steel plate with a irregularity of A shape, 7) plate fixed pebble, 8) plate to accumulate wood, 9) steel plate with small hole, 10) concrete plate, 11) concrete plate of water permeability and 12) concrete plate of coal fly-ash, respectively. Also, One type of plate made up of zeolite was used at Tei (Fig. 1). These blocks were placed on the location where those plants had not been distributed.

A mature *Sargassum* spp. was transplanted in May 1999 and *Ecklonia cava* was transplanted in Nov. 1999 at Tei and Usa using the spore bag technique. The spore bag was packed with fertile *Sargassum* spp. and *Ecklonia cava* and fixed on the artificial iron reef and natural rock (Fig. 2).

The percentage coverage of *Sargassum* species at Ikata is shown in Table 1. Within three months of placement of the spore bag on the reef, *Sargassum* found the experiment plates. In October, the *S. macrocarpum* coverage on substrata averaged 20% on the steel plate, 50% on the plate fixed pebble and 10-35% on the concrete plates. Yamauchi (1984) reported the number of laterals on each

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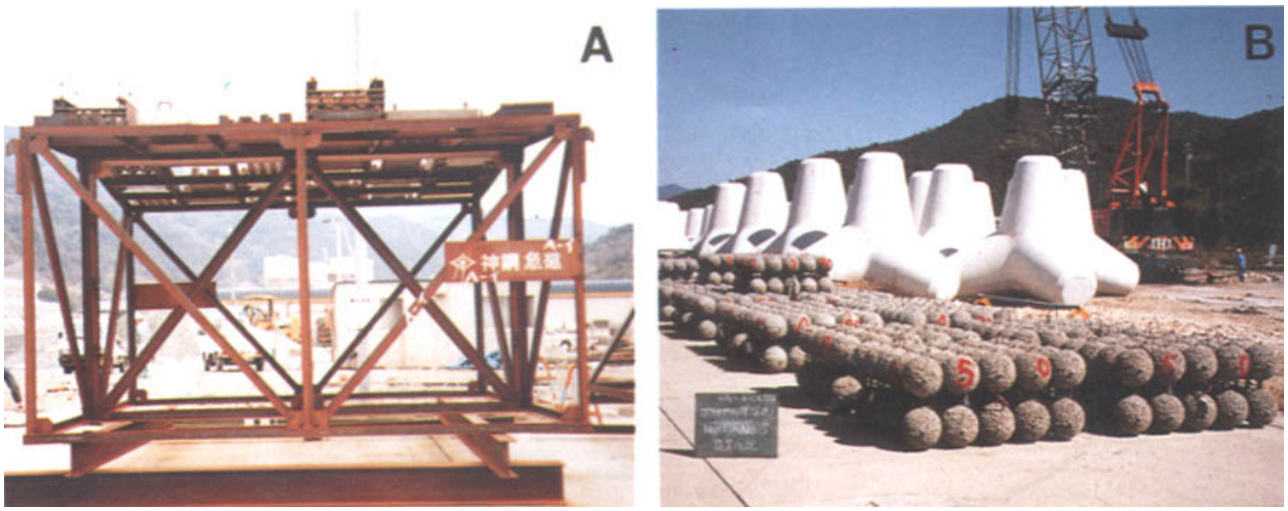

Fig. 1. Artificial reef used in establishing survey sites. A; Artificial iron reef at Ikata, B: Zeolite reef at Tei.

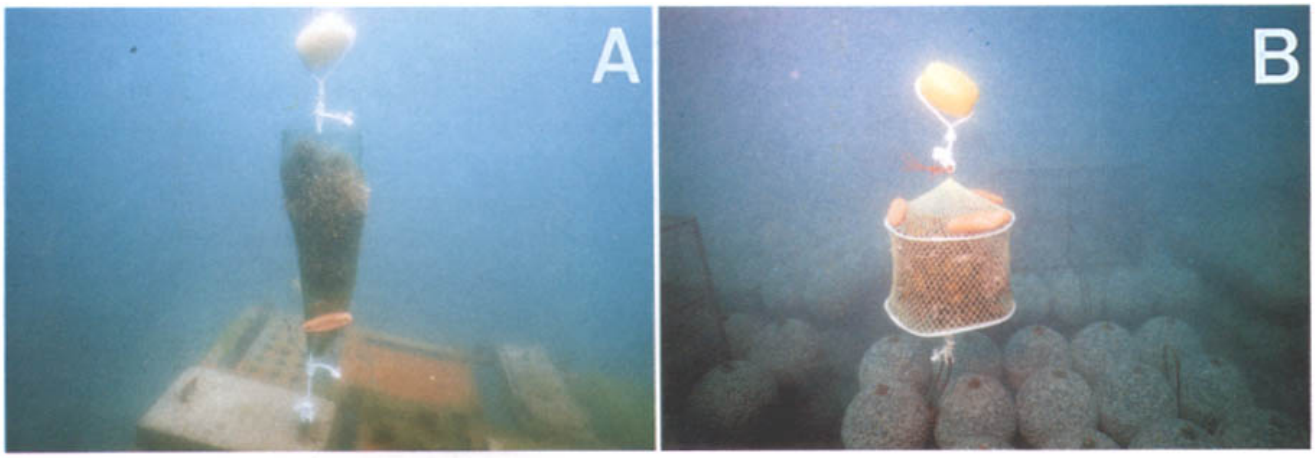

Fig. 2. The spore bag fixed on the artificial reef. A: Ikata, B: Tei.

frond increased to 7-13 by the beginning of September. After that the fronds elongated and branched profusely until the middle of April.

During the survey period, *S. macrocarpum* appeared remarkably on the steel plate (20-40%), on the plate fixed pebble (50-60%), and on the concrete plate (35-45%, No. 11). In February 2000, *S. macrocarpum*, *S. horneri* and *Sargassum* sp. were found on the reef. Coverage on the plate shaped iron bar is about 5%, 40% on the steel plate, 50% on the plate fixed pebble and 20-50% on the concrete plates.

The young plants appeared after four months from the adult plants of the spore bag on the artificial reefs and rocks at Tei (Fig. 3). The young plants of *Ecklonia cava* on the reef showed coverage of approximately 30% within 1m from spore bag and lower coverage of less than 10% on other part of the artificial reef. The size of young plants was 3-10 cm in length.

In Usa, *Ecklonia cava* young plants are attached to natural rocks by means of a discoid holdfast upon which a few short stems or stipe arise. The young plants of four to six individuals were attached with a buoy, spore bag and anchor and young plants were also observed on the rocks near the spore bag. These plants were observed on 11 individuals, below 2 m and 8 individuals, below 5 m. The longest plant from the spore bag was 11.6 m. The sizes of young plants were between 4-28 cm in length and between 1-3 cm in stipe length.

According to Ohno (1993), growth of seaweed on the concrete blocks might be promoted with less chances of failure by transplanting mature thalli. In the present study, we agreed with the observations made in the artificial reefs by Ohno (1993). Ohno *et al.* (1990) reported the most cost-efficient method is the use of spore bags

Table 1. Mean coverage of *Sargassum* species measured from each material substance plate

Date	Species	Iron							Stone	Wood	Concrete		
		SP	SB	PI	SI	ST	SA	SS	PP	PW	CP	CW	CC
1999 Aug.	*S. macrocarpum*	+	-	+	-	-	+	-	+	-	+	+	+
	S. horneri	-	-	-	-	-	-	-	+	-	+	+	-
Oct.	*S. macrocarpum*	20	5	5	5	10	5	5	50	-	10	35	10
	S. horneri	-	-	-	-	-	-	-	-	-	-	5	-
Nov.	*S. macrocarpum*	38	13	-	-	13	10	5	60	5	15	40	20
	S. horneri	-	-	-	-	-	-	-	-	-	-	8	-
Dec.	*S. macrocarpum*	40	20	-	-	20	10	5	60	5	15	40	20
	S. horneri	-	-	-	-	-	-	-	-	-	-	10	-
2000 Feb.	*S. macrocarpum*	40	20	5	20	13	23	10	50	15	50	45	20
	S. horneri	-	-	-	-	-	5	-	5	-	-	-	-
	S. sp	5	-	-	-	-	-	-	-	-	-	-	-

+: rare, -: not shown.

SP: steel plate, SB: steel plate with big hole, PI: plate shaped an iron bar, SI: steel plate with irregularity, ST: steel plate with a triangle shaped irregularity,SA: steel plate with a irregularity of A shape, SS: steel plate with small hole, PP: plate fixed pebble, PW: plate to accumulate wood, CP: concrete plate, CW: concrete plate of water permeability, CC: concrete plate of coal fly-ash

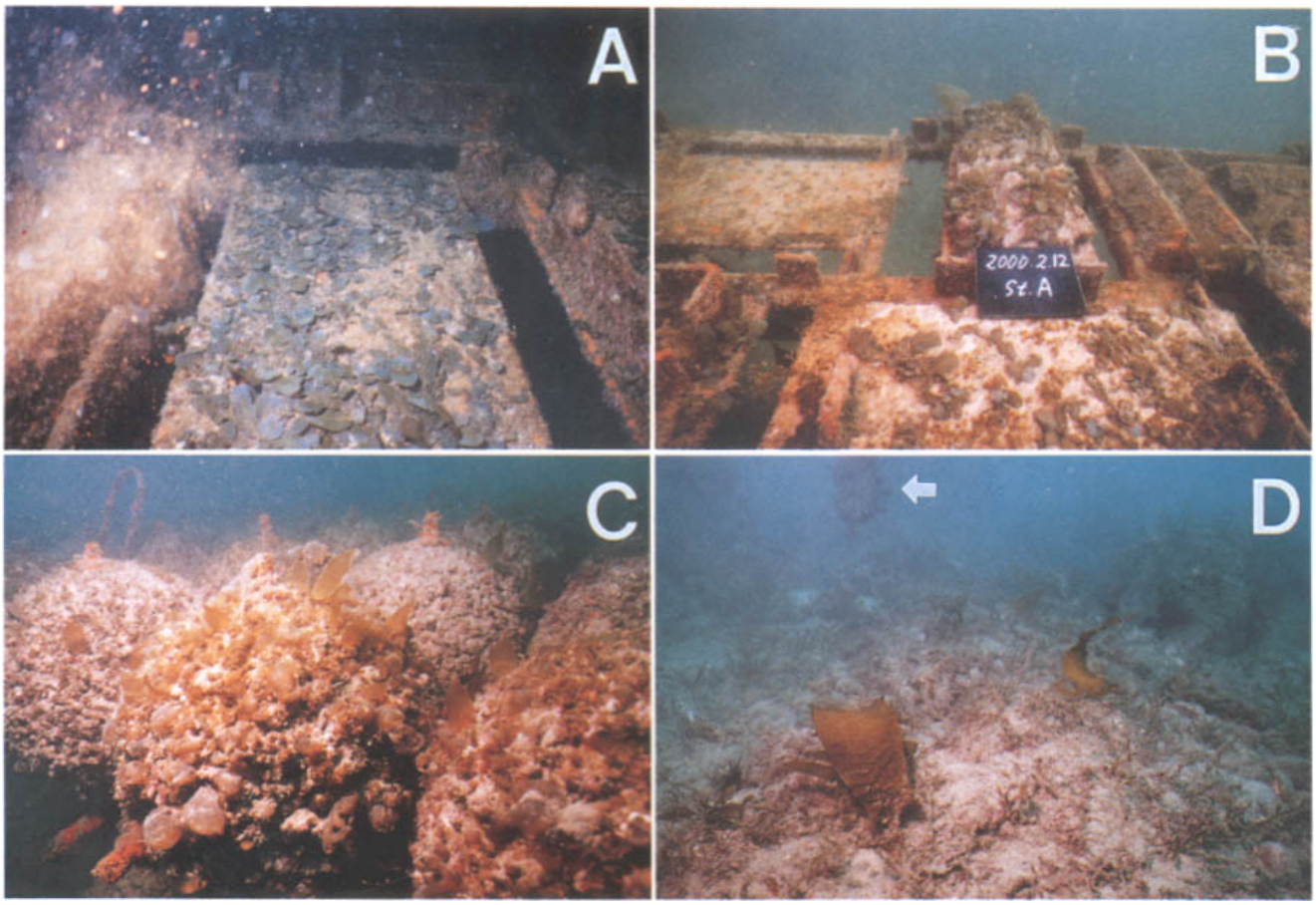

Fig. 3. Growth of *Sargassum* spp. and *Ecklonia cava* on different survey sites.
A : Aug. 1999 at Ikata B : Feb. 2000 at Ikata C : Mar. 2000 at Tei D : Jun. 2000 at Usa (Arrow indicate spore bag)

and natural release of spores. Ohno *et al.* (1983) reported the young plants of *Ecklonia cava* appeared 35-40 m from their transplanting area, but higher coverage of young plant within 10 m from center of transplanting.

The transplantation by means of the spore bag method on the artificial reef and natural habitat has proved to be a most successful for established of new algal beds.

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Accepted 19 August 2000