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A review of destruction of seaweed habitats along the coast of the Korean Peninsula and its consequences

Rae-Seon KANG [*1]

Abstract: Large seaweeds can form dense underwater forests. These forests provide a physical structure that supports marine communities by providing animals with food and shelter. Until the end of 1980, *Sargassum*, *Laminaria* and *Ecklonia* forests were abundant all along the Korean Peninsula except the coastal zone of the Yellow Sea where the sea bottom is composed of mud. From the beginning of 1990s, however, these forests had been decreasing due to various reasons such as global warming, sea urchin grazing, industrialization near the shores, and over releasing of abalone without consideration of carrying capacity of rocky habitats, and by the end of 2004, ca. 13% of the East Sea and 31.4% of Jeju island in the South Sea became barren ground with crusty pink algae and little else covering the rocks. Construction of artificial seaweed beds, therefore, is presently looked into as a necessary factor for the recovery of natural resources. Of the seaweed species, *Sargassum, Laminaria* and *Ecklonia* are of interest in Korea. Various techniques have been applied to construct artificial seaweed beds. This paper reviews the extent of destruction of seaweed habitats along the Korean Peninsula and several techniques applied to construct artificial seaweed beds in Korea.

Key words: Barren grounds, Seaweeds, Artificial reefs, Korea

Introduction

The Korean Peninsula is surrounded by the East Sea on the east, the South Sea to the south, and the Yellow Sea to the west and influenced by the two main currents, the Tsushima Warm Current and the North Korea Cold Current. Since the northern part of the East Sea above 38° N is strongly affected by the North Korea Cold Current flowing southward along the northeast coast of the Korean Peninsula, boreal seaweed species such as *Costaria*, *Laminaria,* and *Coccophora* are abundant. In contrast, since the southern part of the East Sea between 36 and 38°N is affected by both the East Korea Warm Current branching off from the Tsushima Warm Current at the eastern end of the Korea Strait and the North Korea Cold Current, temperate seaweed species such as *Undaria, Sargassum*, and *Pachymeniopsis* are abundant. In both the northern and southern part of the East Sea, however, coastal lines are mostly composed of sand beaches and, thus, seaweeds species are found only in shallow exposed rocky areas. Since the South Sea including Jeju Island which is located at the southeastern most of the Korean Peninsula is strongly affected by the Tsushima Warm Current and coastal lines are mostly composed of sandstones and conglomerate outcrops, temperate seaweed species such as *Undaria, Ecklonia*, and *Sargassum* form dense subtidal algal forests. In contrast, the costal line of the Yellow Sea is mostly covered by mud or sand and few seaweed species can survive. The destruction of seaweed habitats, therefore, is mainly occurred along the coastal line of the South and East Sea. Particularly, rocky habitats in the southern part of the East Sea (i.e., the eastern part of Gangwon, Gyeongbuk and Gyeongnam province) and Jeju Island, where fishing villages are well organized

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*1 Marine Living Resources Research Division, KORDI, Ansan P.O. Box 29, Ansan, Gyeonggi-do 425-600, Republic of Korea

and release diverse marine organisms (e.g., abalone) to enhance fish production, are widely suffering the destruction of seaweed habitats (Fig. 1)

Areas of barren ground

The ecological and economical problem related to the destruction of seaweed habitats (i.e., barren ground) began to be issued from the end of 1980's, but surveys on the distribution of barren grounds started in 1997 due to the lack of research funding. Until 1997, barren grounds were found only in Gangwon and Gyeongbuk province and the percent of barren grounds to total rocky habitats in these two provinces was less than 2.6% (Table 1). In 1998, however, barren grounds spread into Gyeongnam and Jeju province and the percent of barren grounds to total rocky habitats in Gangwon, Gyeongbuk, Gyeongnam and Jeju province was more than 7.7%. In 2004 when the survey was stopped, the area of barren ground in Gyeongbuk and compared to 1998, whereas that in Gangwon and Jeju province was slight increased as compared to 1998. The percent of barren grounds to total rocky habitats of Gangwon, Gyeongbuk, Gyeongnam and Jeju province was 8.3, 15.6, 17.1 and 31.4%, respectively.

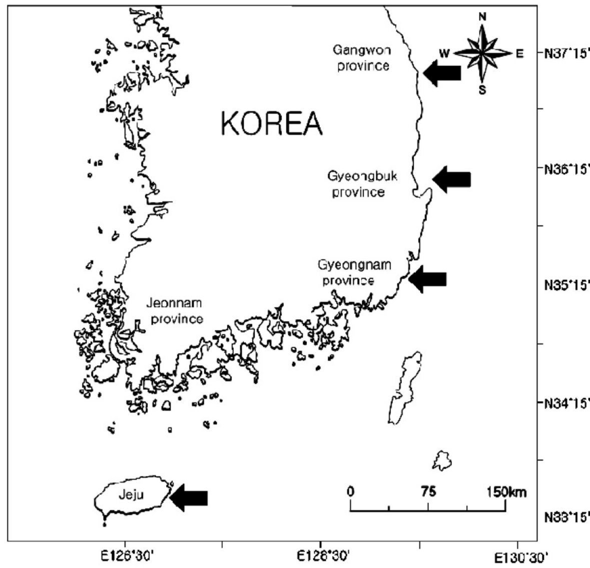

Fig. 1. Map showing the area suffering the destruction of seaweed habitats in Korea.

Reduction of fish production

Fig. 2 shows the yearly changes in the production of commercial animal species (i.e., *Nordotis discus, Sulculus diversicolor supertexta, Turbo* (*Batilus*)

Table 1. Yearly changes in the percent of barren grounds to total rocky habitats (from NFRDI, 2007)

Province	City name	Area (ha)	Year									
			1997		1998		1999		2001		2004	
			ha	%	ha	%	ha	%	ha	%	ha	%
Gangwon	Goseong	3489	0	0	0	0	20	0.6			48	1
	Sokcho	551	0	0	60	10.98	10	1.8			15	2.7
	Yangyang	1854	0	0	62	3.3	2	0.1			26	1.4
	Gangneung	2890	0	0	15	0.5	15	0.5			118	4.3
	Donghae	573	0	0	206	36	206	36			182	31.8
	Samcheok	1859	155	8.3	523	28.1	523	28.1			540	29.1
	subtotal	11216	155	1.4	866	7.7	776	6.9			929	8.3
Gyeongbuk	Uljin	2730	112	4.1	190	7	179	6.9			340	12.4
	Ulleung	793	0	0	134	16.9	134	16.9			102	12.9
	Yeongdeok	1372	20	1.5	99	7.2	95	6.9			225	16.4
	Pohang	2973	83	2.8	1106	37.2	1106	37.2			571	19.2
	Gyeongju	554	0	0	13	2.3	260	47			73	13.2
	subtotal	8422	215	2.6	1542	18.3	1774	21.1			1311	15.6
Gyeongnam	Ulsan	1012			366	36.26	336	33.2			173	17.1
	subtotal	1012			366	36.2	336	33.2			173	17.1
Jeju	Jeju	646			36	0.2			36	0.2	244	1.7
	North Jeju	7113			738	5.1			591	4.1	1750	12.1
	Seoguipo	1661			598	4.1			598	4.1	741	5.1
	South Jeju	5031			1559	10.8			1308	9.1	1806	12.5
	subtotal	14451			2931	20.3			2533	17.5	4541	31.4
Total		55751	740	1.8			5436	13.5	2533	17.5	9367	16.8

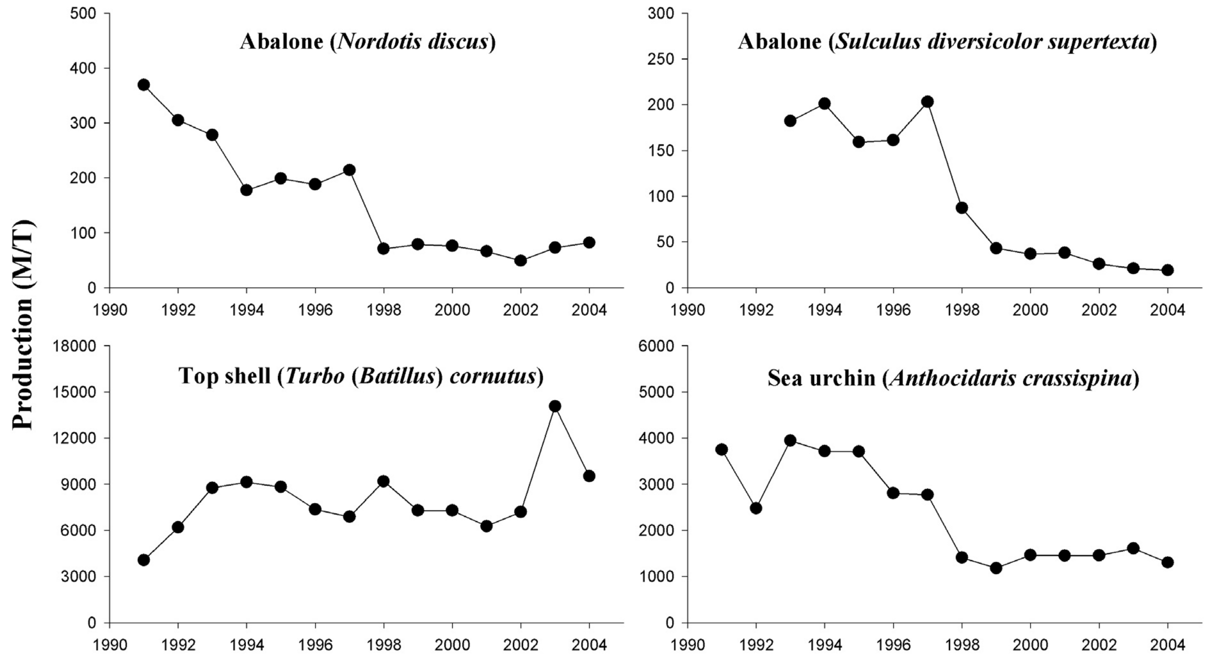

Fig. 2. Yearly changes in the production of commercial animal species living in rocky habitats during 1991 to 2005 (from Ministry of Land, Transport and Maritime Affairs, 1991-2005).

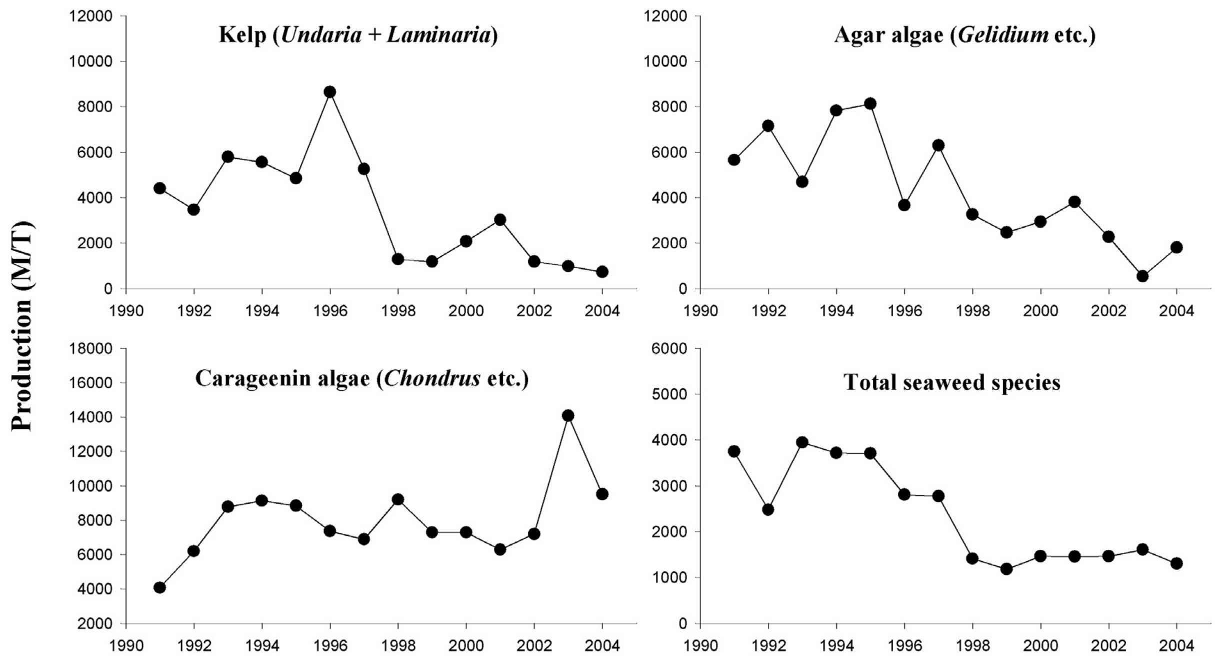

Fig. 3. Yearly changes in the production of commercial seaweed species during 1991 to 2005 (from Ministry of Land, Transport and Maritime Affairs, 1991-2005).

cornutus and *Anthocidaris crassispina*) living in rocky habitats during 1991 to 2005. Except top shell *Turbo* (*Batilus*) *cornutus*, the production of the animal species sharply decreased from 1997 in accordance to the increment of barren grounds. Likewise, the production of seaweed species sharply decreased from 1997 in accordance to the increment of barren grounds (Fig. 3).

Causality of destruction of seaweed habitats

Probably, a lot of biotic and abiotic factors have

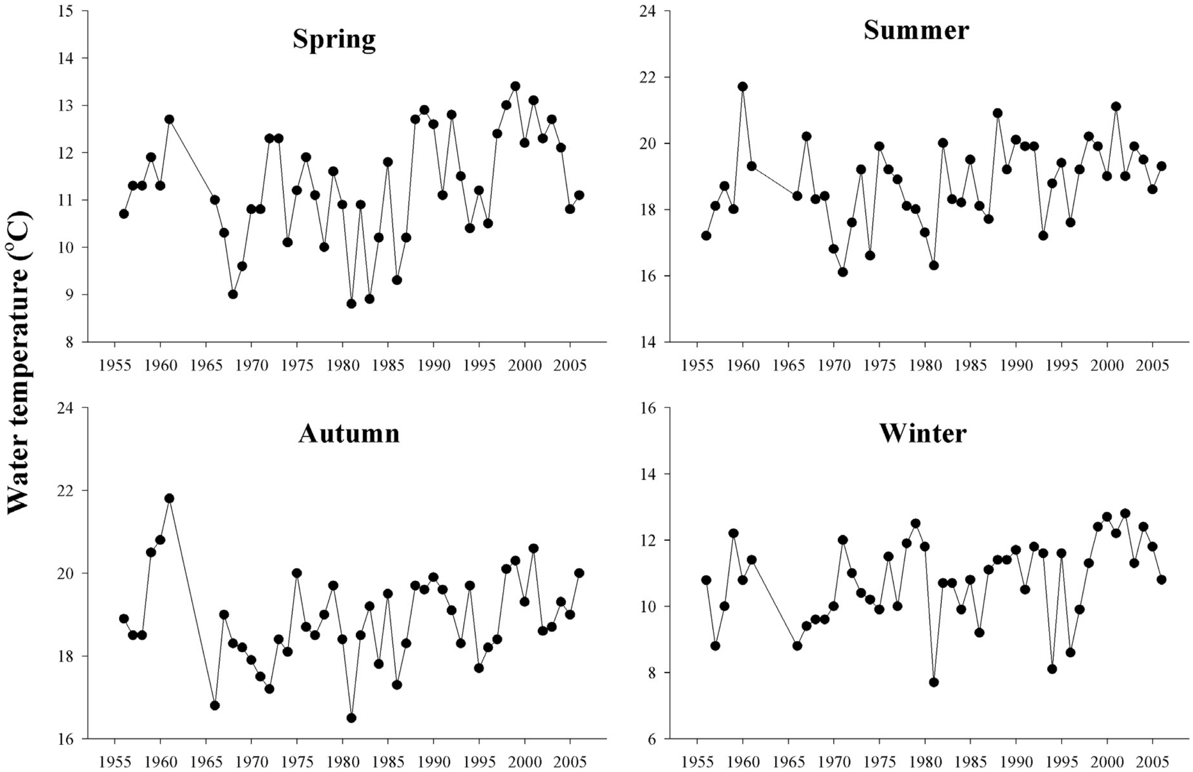

Fig. 4. Yearly changes in seawater temperature of the coast of Uljin city in Gyeongbuk province during the period from 1955 to 2005.

affected seaweed communities, causing barren grounds. These factors are likely to be global warming, industrialization near the shore, sea urchin grazing, and over releasing of abalone without consideration of carrying capacity of rocky habitats. For example, Fig. 4 shows the yearly change in seawater temperature of the coast of Uljin city in Gyeongbuk province where 12.4% of rocky habitats was changed to barren ground in 2004 (please see Table 1). During the period from 1955 to 2005, seawater temperature was apparently increasing, suggesting that global warming is a key factor causing barren grounds in this area. In addition, some coastal zone of Uljin city is also affected by thermal pollution caused by the discharge of the Uljin Nuclear Power Plant. Surveys on 12 fishing villages adjacent to the power plant indicate that species diversity and biomass of seaweed communities of the 12 villages are apparently lower than those of the control (ca. 30 km away from the power plant) and that some villages near the power plant are clearly changed to barren grounds, suggesting that industrialization near the shore is also important in the destruction of seaweed beds (Figs. 5, 6). Furthermore, over releasing of abalone without consideration of carrying capacity of rocky habitats is a problem in this area. Fig. 7 shows the number of juvenile abalones released into Korean

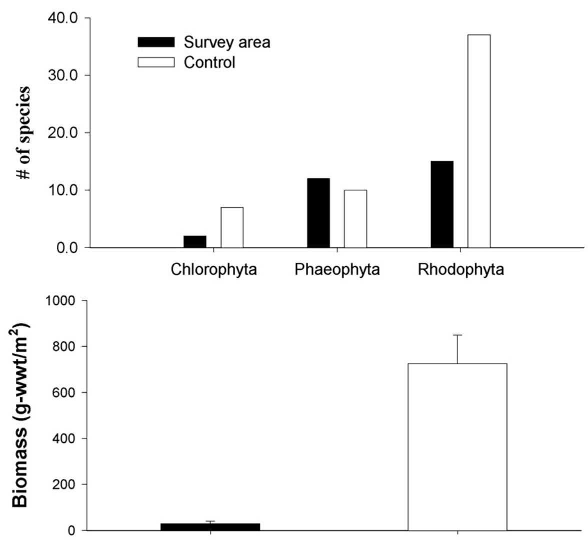

Fig. 5. Comparisons of species diversity and biomass between 12 fishing villages adjacent to the Uljin Nuclear Power Plant and the control located ca. 30 km away from the power plant.

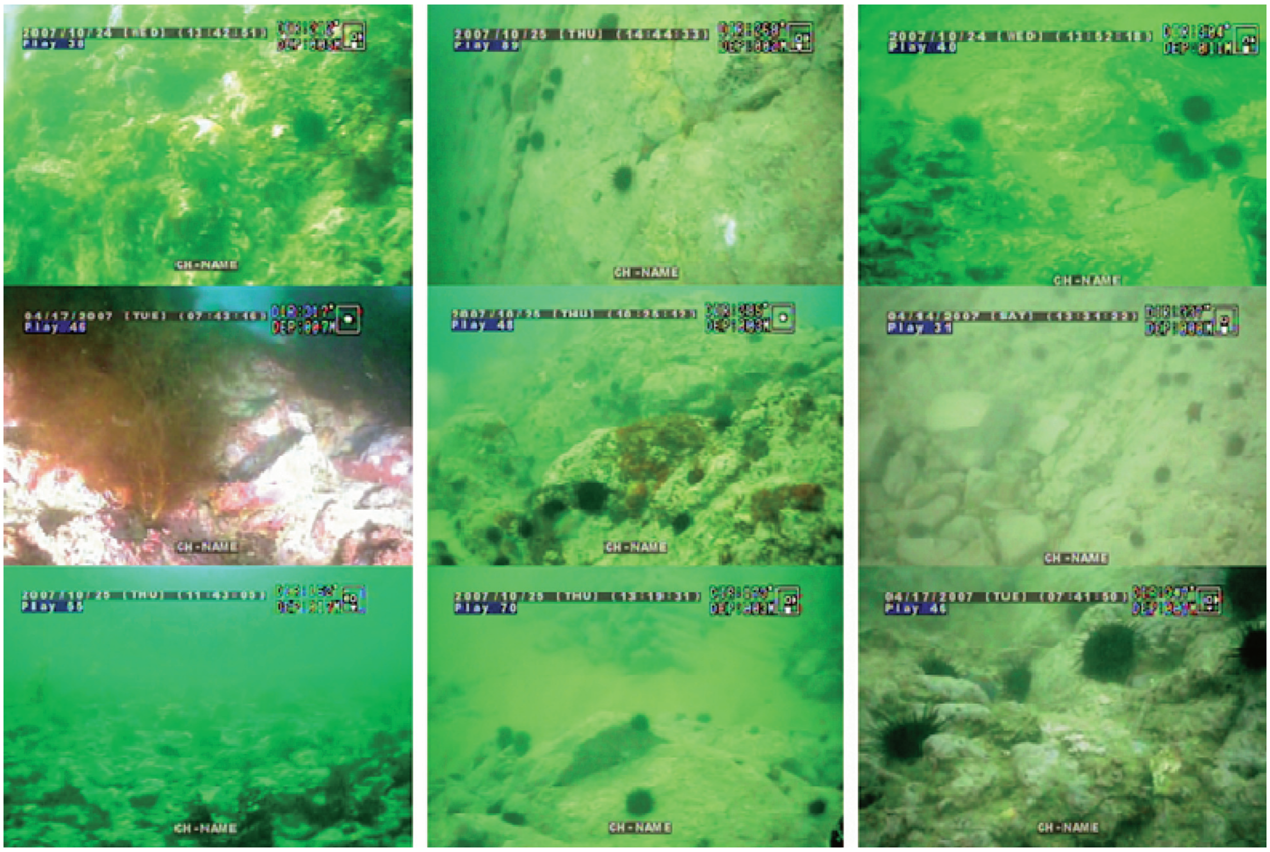

Fig. 6. Barren ground on subtidal zones of some fishing villages near the the Uljin Nuclear Power Plant.

waters during the period from 1996 to 2005. The number of released juvenile abalones explosively increased between 1999 and 2005, and this is also true for Uljin city including the 12 fishing villages. Taken together, changes in seawater temperature, the effect of thermal pollution and over releasing of abalone are all important factors destructing seaweed beds along the coast of Uljin city.

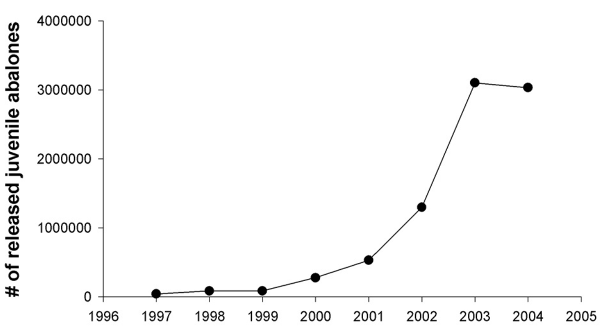

Fig. 7. The number of juvenile abalones released into Korean waters during the period from 1996 to 2005 (from Ministry of Land, Transport and Maritime Affairs, 1996-2004).

Construction of artificial seaweed beds

Korea's interest in artificial seaweed beds began at the end of 1990's and several techniques for constructing artificial seaweed beds have been applied (Figs. 8, 9). Some of these techniques are relevant to the recovery of damaged seaweed beds but others are not in terms of persistence or environmental-friendly purpose.

1. Spore-bag technique

The spore-bags packed with fertile, adult plants are usually suspended over rocky substrata or artificial reefs during the reproductive season (Fig. 8A-D). During this time, spores are released naturally and eventually settle on the hard bottom surface. This method has proven to be a successful method for the establishment of *Sargassum* beds.

2. Rope-seeding technique

Fertile thalli of *Laminaria* may be allowed to

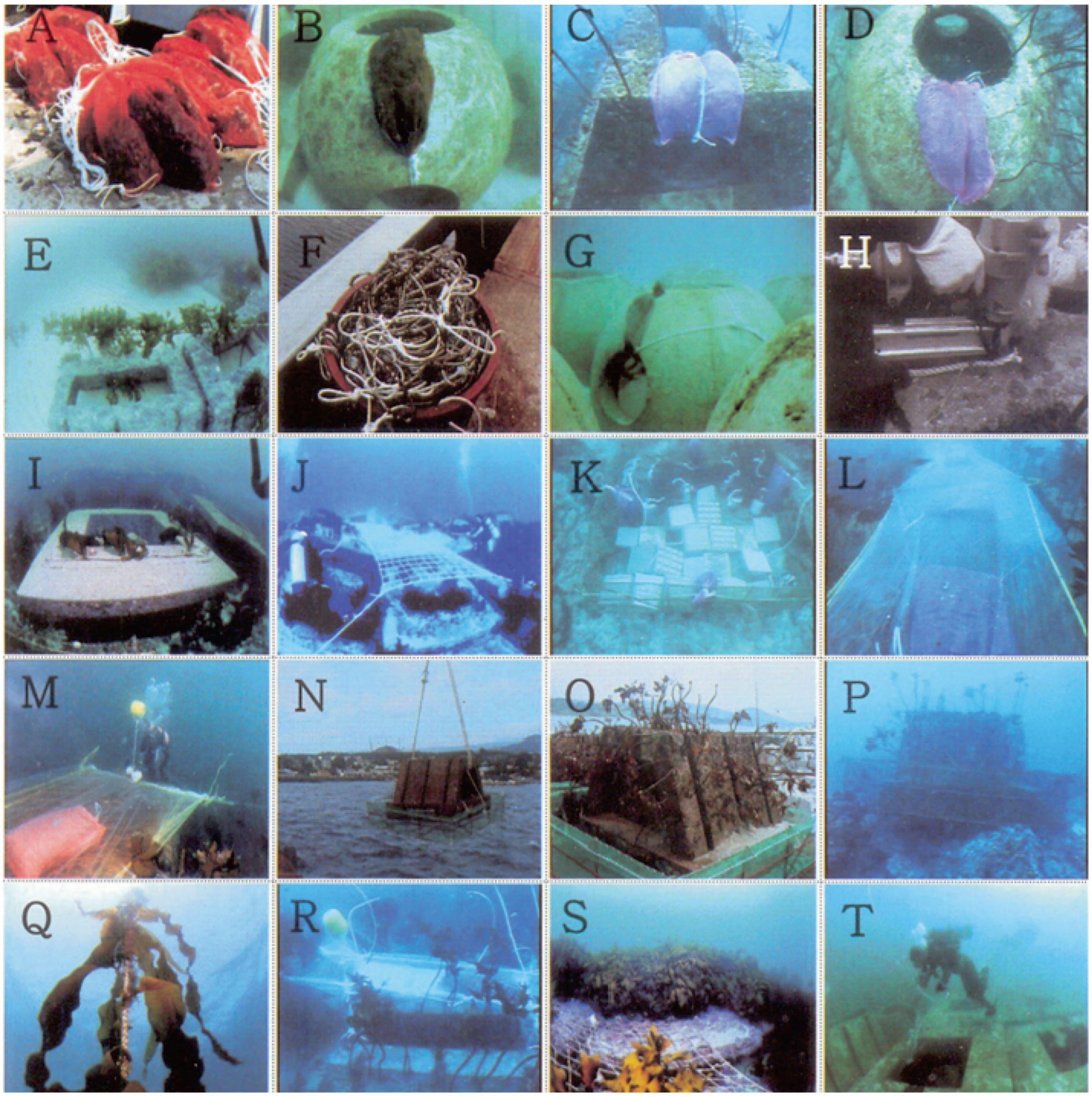

Fig. 8. Construction of artificial seaweed beds (A-D: spore-bag technique, E-G, Q: rope-seeding technique, H-P, R-T: adult-plant transplantation method (from Kim, 2006).

sporulate in indoor tanks. Once ropes are seeded, the seeded ropes are then firmly attached to concrete blocks for growing (Fig. 8E-G, Q).

3. Adult-plant transplantation method

Fully reproductive adult *Ecklonia* are transplanted in September to December (Fig. 8H-P, R-T). One or two adult individuals can be attached to concrete blocks with strong rubber bands or ropes. In some cases, to increase the area of the attachment surface, the concrete blocks may be covered with coils of plastic material. Whichever case is used the plants are then covered with plastic sheets or placed in large cages for protection against fish grazing. The holdfasts of *Ecklonia* are found to attach to the blocks after one month of growth. Juveniles developed from meiospores released from the transplanted sporophytes appear in late December and become young plants in early January. In May, new beds of *Ecklonia* are formed around the blocks. A transplanted area of 9 m^3 can be expected to form a new *Ecklonia* bed of about 3000 m^2 area. Although many plants gradually disappear (due to grazing and wave action during summer), surviving plants begin to form spores until the end of August. Thereafter, a new community of *Ecklonia* can be

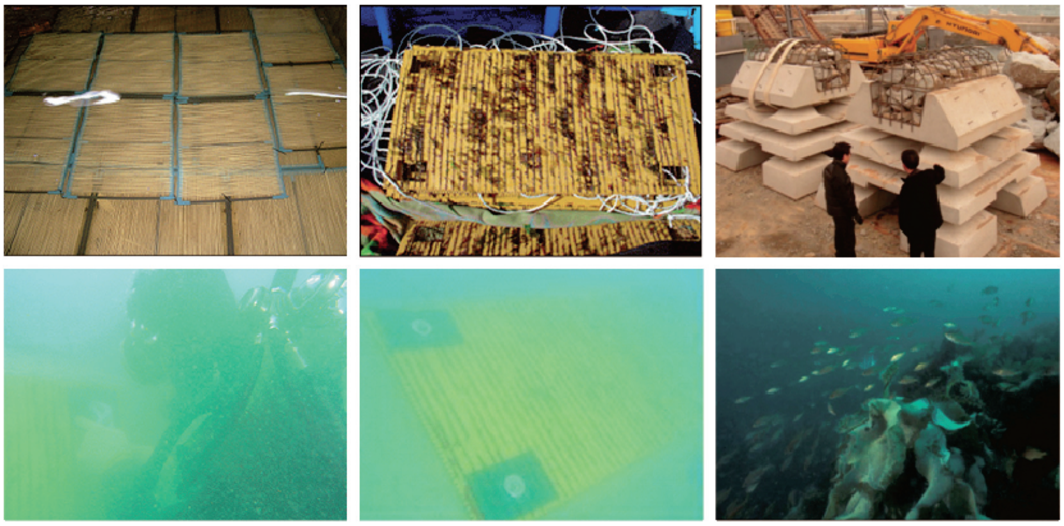

Fig. 9. Construction of artificial seaweed beds (transplantation of young plants).

expected to become established on the same rocks. Transplantation, by attachment of adult plants on concrete blocks, has proven to be a most effective method of establishing new algal beds in Korea.

4. Transplantation of young plants

Young plants, particularly of *Laminaria* and *Undaria*, can be anchored using concrete blocks or ropes as substrata. The substrata with attached young plants are transplanted on the bottom of rocks or artificial reefs after they are seeded (Fig. 9).

References

Kim, D. G. 2006. A study on the restoration of marine forests using artificial reef in barren grounds of along the coast of Jeju. Ph' D Thesis, Jeju National University. 151pp.

Ministry of Land, Transport and Maritime Affairs. 1991-2005. Statistical year book of maritime affairs and fisheries.

National Fisheries Research & Development Institute. 2007. The manual for the construction of seaweed forest on the east coast of Korea. SP-2007-RE-006. 51pp.