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Re-Assessment of *Sargassum* Beds at Hon Chong Area, Nha Trang Bay, Vietnam

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Abstract *Sargassum* beds play an important role in terms of ecology and economic likelihood ("ecosystem services") for coastal communities along the Hon Chong area, in the bay of Nha Trang, Vietnam. It is a matter of concern that the *Sargassum* beds at Hon Chong, in particular, and Vietnam, in general, have strongly decreased due to anthropogenic perturbations including land reclamation. Our research focused on a reassessment of *Sargassum* beds including coverage, occupied area, species composition, branch length frequencies and output (production) over the last 30 years. Remotely-obtained (satellite) information and field data processed through GIS software were used during this study. Results show that the area covered by the *Sargassum* beds was reduced by 49%. In 1980 the coverage of *Sargassum* was 75% for all the area (30 ha), but now we observed that 75% of the coverage occurred in area of only 2.2 ha. The average length of *Sargassum mcclurei* and *S. serratum* branches recorded in 2009 were reduced by 58% and 65%, respectively, compared with data recorded in 1980. Moreover, in 1980 *Sargassum crassifolium* was very common in this area, however, during this study it was not found.

Key words: Nha Trang Bay, *Sargassum* beds, degradation, re-assessment, GIS

Introduction

The brown macroalgae, *Sargassum* spp. (Family Sargassacea, Order Fucales, Phylum Heterokontophyta) form dominant and important seaweed beds along the coast of Vietnam (Dai, 1997; Thanh, 2003; Tsutsui et al., 2005). *Sargassum* populations have been declining in some countries in the world (Aratake et al., 2007; Hiraoka et al., 2005). Only five of fourteen species of Fucales reported at the end of the 19th century are currently present in the Albères Coast (France, NW Mediterranean) (Thibaut et al., 2005). In Japan, between 1978 and 1991, 6400 ha of sea-grass and seaweed have been reported along the Japanese coast, of which *Sargassum* beds accounted for 22% (Terawaki et al., 2003). In the southern area of the Miyazaki Prefecture in Kyusyu, for example, nearly 90% of local *Sargassum* beds have been lost (Aratake et al., 2007). *Sargassum* spp. grow on rocky shores and dead corals, with strong light intensity and wave action, from mid-tide level to depths of 2-4 meter, they are commonly found around the islands of Vietnam (Dai, 1997; Mo, 1998; Tri, 1994). *Sargassum* spp. have contributed to the highest seaweed production in Vietnam with 12kg m^{-2} in some case (Dai, 1997; Dai, 1999), with peaks between January to June (Dai, 1997; Dai et al., 1997; Tri, 1994), and a total production of about 75,000 ton $year^{-1}$, where central Vietnam exhibits the highest output with 35,000 ton $year^{-1}$ (Thanh, 2003). The total area of *Sargassum* beds at Hon Chong reached about 30 ha, and it was considered one of the most important primary producers in the bay of Nha Trang with an average biomass of 7 kg m^{-2} and a peak production of 900 tons (fresh weight) in March (Dai, 1980). Six species of *Sargassum* were recorded in the Hon Chong area, where *Sargassum mcclurei, S. serratum* and *S. polycystum* were the dominant species (Dai, 1980). Most species matured in April but *S. serratum* matured in March. However, there is no report about the status of the *Sargassum* bed at the Hon Chong area since 1980. The present study reassesses the *Sargassum* beds at the Hon Chong area including its total area (ha), species composition, distribution and biomass, branch

lengths, production and coverage. These data are compared with those recorded in 1980 by Dai.

Materials and Methods

Area description

The general ecology of Hon Chong (12˚16' N and 109˚12' E) is well described by Dai (1980). The total yearly rainfall ranges from 1,300-1,600 mm and the mean air temperature equals 26.3℃. Two seasons are recognized, i.e., the dry season (from February to September) and the rainy season (from October to January) (Metero-Hydrographic Agency, 2008). The area is covered with seaweed where *Sargassum* spp. are dominant. Also some small patches of the sea-grass species *Thalassia hemprichii* occur. *Sargassum* spp. are found on rocky shores and dead coral flats while the sea-grass grows on sand or sand-dead coral substratum. On bare substratum is sometimes also found. New boulevards and several public buildings and private houses have recently been constructed in the western portion of area. A river mouth is located at the southern part of Hon Chong.

Data collection

In order to collect representative data of each *Sargassum* bed, eight transects were surveyed at Hon Chong. These transects were parallel to each other, perpendicular to the shore and separated from each other by a reasonable distance (English et al., 1997). The length of transects depended upon the width of the *Sargassum* bed and extended to the outer limits of the beds where *Sargassum* disappeared (Fig. 1). In total, 72 points (8 transects x 3 stations/transect x 3 points/station) were established with their coordinates recorded using a GPS. At each station the presence or absence of *Sargassum* was recorded. GPS was used to record polypoint data in the field by walking or boat, then converted to polygons by MapInfor, version 7.5. These data were inputted into a GIS software to calculate the total area and polygon of each species of *Sargassum* beds. Further, the data recorded in 1980 and 2009 were also digitalized and over-laid to visualize the reduction of the *Sargassum* beds at Hon Chong.

The coverage of *Sargassum* at the study sites was estimated at 5 m intervals along the transect using English et al.'s methods (1997). A quadrat (50×50 cm^2) divided into 25 squares (10×10 cm^2) was placed on the substratum, and the coverage of *Sargassum* in each of the 25 squares was scored

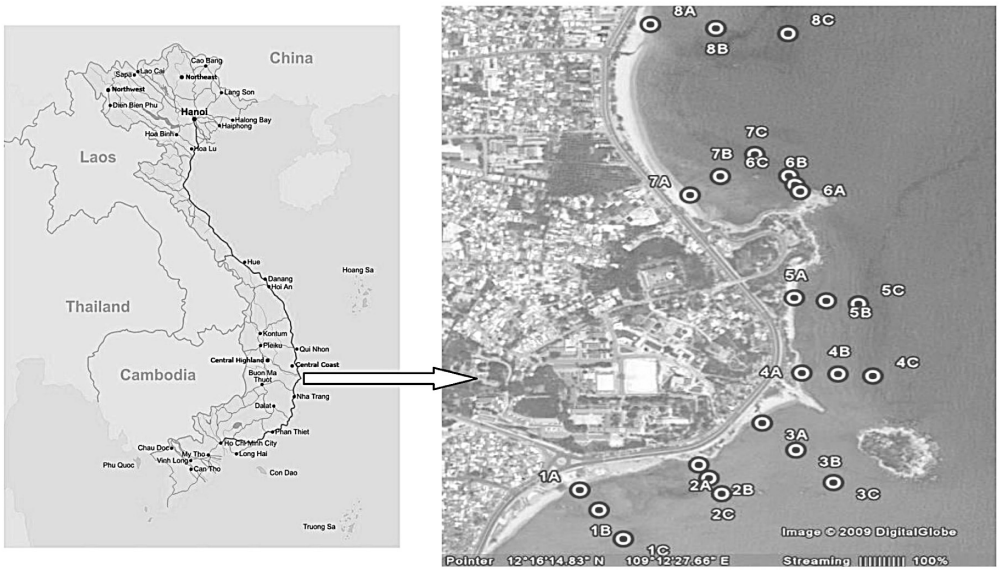

Fig. 1. Vietnam map and study sites

using the classes developed by Saito and Atobe (1970). The percentage cover of Sargassum in each quadrat was estimated according to the weighted average of the scores of 25 squares following the methods of Saito and Atobe (1970). Production of Sargassum was calculated by equation: $P = BxAxC$ [where P (kg): production; B (kg m^{-2}): fresh biomass; A: total area (m^2); C (%): coverage]

Samples for biomass determinations were also collected at each sampling date at Hon Chong, weighted and transported to the laboratory. In the laboratory, these biomass samples were rinsed with fresh water, and the length of branches was measured before drying. *Sargassum* samples were then dried at 60℃ for 24 hours to constant dry weight.

Results

Reduction of the area of *Sargassum* beds and change in the species distribution

The total area of *Sargassum* beds recorded in 1980 was 30 ha, however, our data showed that the total area occupied by the *Sargassum* beds was 15.35 ha, that is a 49% reduction. It was noted that a vast area of *Sargassum* beds south of Hon Chong has fully disappeared due to the loss of substrata (Fig. 2). In addition, a decrease in the coverage of the *Sargassum* bed was also recorded. In 1980 *Sargassum* populations formed dense beds with a coverage of 75%, however, our research showed that a 75% coverage was only found in 2.2 ha while a coverage of 10% was found in 13.15 ha (Fig. 3) in 2009. Hence, not only a reduction of the area occupied by the *Sargassum* beds was found but also of the coverage.

In terms of species composition, three species of *Sargassum* were dominant in the area in 1980, i.e., *S serratum, S. mcclurei* and *S. polysystem*, however, our study found only *Sargassum serratum* and *S. mcclurei* to be dominant in 2009. While *Sargassum polysystem* was common anywhere in 1980, it was rarely found during our study. Besides, *Sargassum crassifolium* was very common in the

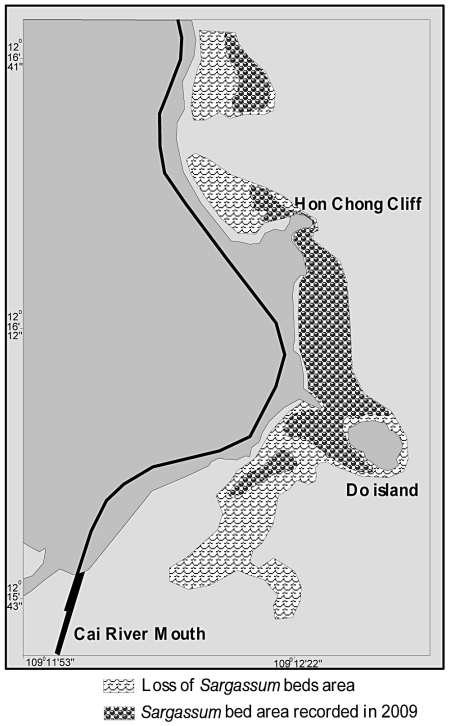

Fig. 2. Reduction of *Sargassum* beds

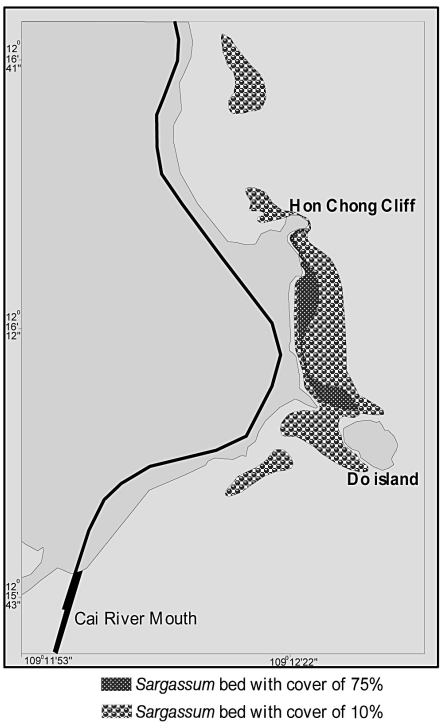

Fig. 3. Cover of *Sargassum* beds at studied site

southern reaches of the *Sargassum* beds forming a monospecific bed. However, the disappearance of the main *Sargassum* bed in the south apparently caused the disappearance of this species too. The change of species distribution is presented in Figs. 4 and 5.

Reduced biomass, production and length of branches

Results showed that biomass of *Sargassum* peaked in March and April with 6.5 kg m^{-2} (SD = ±1.9; n = 18) and 5.4 kg m^{-2} (SD = ±1.2; n = 18), respectively. *Sargassum* biomass was lower in February with 4.2 kg m^{-2} (SD = ±1.5; n = 18) and lowest in May with 2.1 kg m^{-2} (SD = ±1.0; n = 18). *Sargassum* biomass was low in February because in this month the growing season starts; here seaweed withers in May. In general, the *Sargassum* biomass in 2009 was substantially lower than the biomass in 1980. On the contrary, *Sargassum* production was very different in both years. While *Sargassum* production reached the high value of 950 ton in March 1980, it reached only 193 ton in March 2009 that is about 20% of the 1980 production. The reduction of *Sargassum* bed area and coverage caused the reduction in production. Results are presented in Figs. 6 and 7.

Sargassum mcclurei was one of the dominant species in the study area. Their branch lengths were 24, 41, 63 and 62 cm in February, March, April and May, respectively. However, *Sargassum mcclurei* was gone in June. Compared with data recorded in 1980, we found that the branch length of *S. mcclurei* was reduced by 57% (from 150 cm down to 63cm) on March. Moreover, the length of *Sargassum serratum* branches was also reduced. They were 24, 36 and 28 in February, March and April 2009, respectively. Comparing with data from 1980, we also found that the average branch length of *Sargassum serratum* had diminished by 66% (from 105 cm down to 36 cm). This species vanished sooner than *Sargassum mcclurei* in April. Results are presented in Figs. 8 and 9.

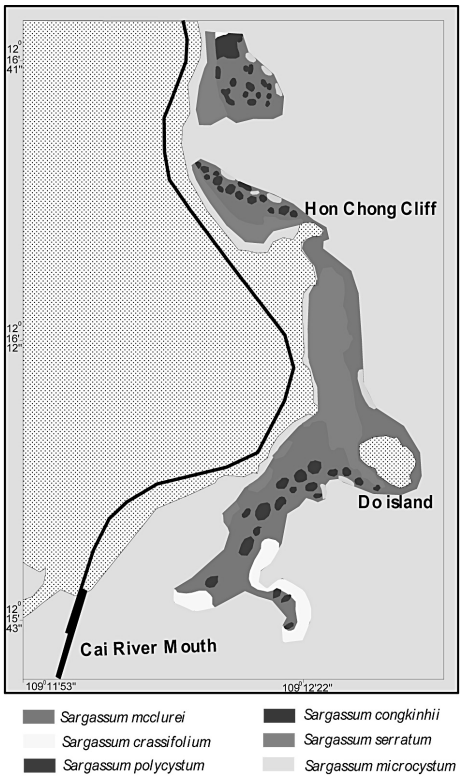

Fig. 4. Species distribution in 1980

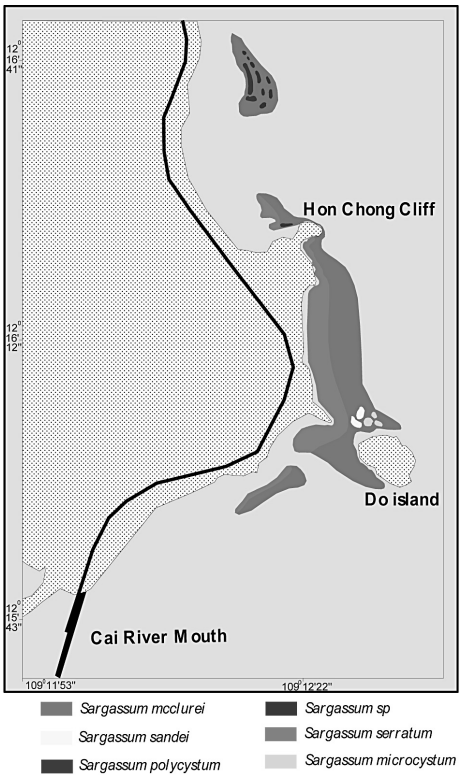

Fig. 5. Species distribution in 2009

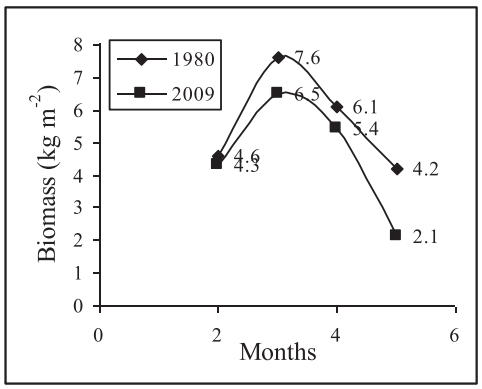

Fig. 6. Comparing biomass of *Sargassum* in 1980 and 2009

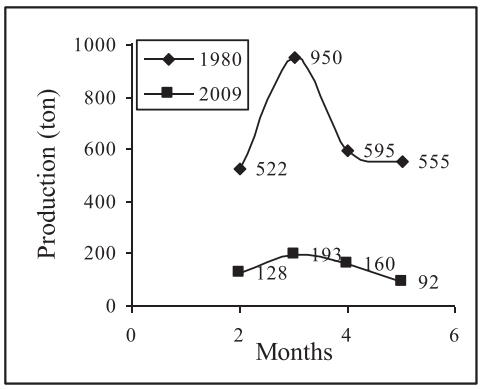

Fig. 7. Comparing production of *Sargassum* in 1980 and 2009

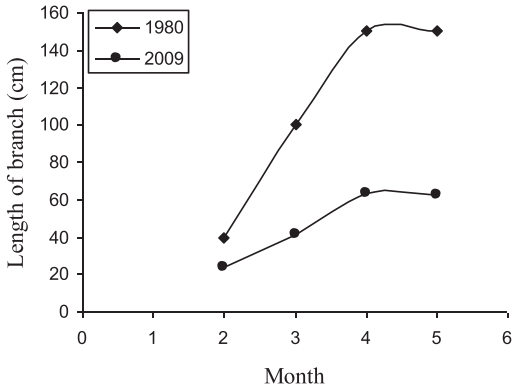

Fig. 8. Comparison of branch length of *Sargassum mcclurei* in 1980 and 2009

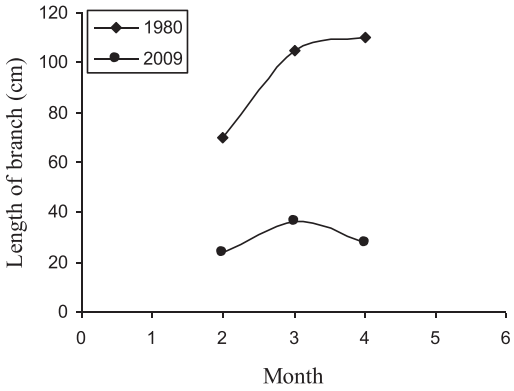

Fig. 9. Comparison of branch length of *Sargassum serratum* in 1980 and 2009

Discussion

The comparison of our data with those recorded in 1980 by Dai showed that the total area of *Sargassum* beds were reduced to 49%. We posit that the reason for the decrease was the loss of substratum, especially of the dead coral flat which is the main substratum of *Sargassum*. As previously indicated, near the southern part of Hon Chong is the Cai river mouth where the construction of embankments along beach encroaches on dead coral flats existing in this area. The cover of *Sargassum* was reduced dramatically. In 2009, only 2.2 ha (of a total of 15.4 ha) of the *Sargassum* beds had a 75% of coverage, while in 1980, most of the *Sargassum* beds had 75% of coverage. We suggest that the main cause of the reduction is the harvesting by fishermen. We found that local people harvested about 22 tons a month in this area, which led us to think that harvesting by fishermen can be considered as one of the causes of coverage reduction within the *Sargassum* beds. On the other hand, one species of the eutrophic species - *Ulva reticulata* -grows strongly in this area, competing for substrate with *Sargassum* spp. This is another cause behind the reduction of the *Sargassum* beds. If we now turn to the species composition issue, we find that although there is no change of number of species between 1980 and 2009, the dominant species have shifted. While *Sargassum polycystum* was the dominant in 1980 this species was seldom found in 2009. Further,

Table 1. Comparing data in 1980 and 2009

Years	Production (ton)	Cover (%)	Area (ha)	Biomass ($kg\ m^{-2}$)	Length (cm)		No. Species	Sources
					S. serratum	*S. mcclurei*		
1980	950	75	30	7.6	105	150	6	Dai (1980)
2009	193	10	15.4	6.5	36	63	6	This research

while in 1980 *Sargassum crassifolium* was very common in the southern reaches of the *Sargassum* beds, we did not find it anymore in 2009 south of Hong Chong where the *Sargassum* beds have nearly disappeared. The reduction of *Sargassum* beds at Hon Chong is summarized in Table 1.

Conclusion

Our research showed that *Sargassum* beds at Hon Chong have strongly decreased in terms of branch length, total area, biomass, coverage and production over the last 30 years. The reduction of total area, biomass, coverage and branch length affected production. Nearly 50% of the *Sargassum* beds disappeared because of several factors such as loss of substratum, and competition with the green sea-weed - *Ulva reticulata*. Behind these factors are of course anthropogenic factors such as construction of embankments along the beach and over-harvesting. In this case study we can consider reclamation and anthropogenic perturbations as the main causes.

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