Restoration of kelp beds on an urchin barren: Removal of sea urchins by citizen divers in southwestern Hokkaido

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Restoration of kelp beds on an urchin barren : Removal of sea urchins by citizen divers in southwestern Hokkaido

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Abstract: Along the southwestern coast of Hokkaido, urchin barren dominated by a sea urchin *Strongylocentrotus nudus* and nongeniculate coralline algae has persisted for a long time (locally > 80 years) while kelp beds comprised of *Saccharina japonica* var. *religiosa* and *Undaria pinnatifida* has been restricted in shallow waters largely less than 2 m in depth. Although previous studies have revealed that *S. nudus* is the causative grazer of the barren state by removal of and/or defense from the sea urchin, no practical efforts have been done for the improvement of fisheries ground. As the fishermen on the coast are aged and depopulated, the authors introduced citizen volunteer divers (CVD) for the removal of the sea urchin. The attempt was practiced on an urchin barren near Kamoenai Fishing Port on the southern coast of Shakotan Peninsula in September 2005. Twenty CVD (including a few instructors and staffs) removed sea urchins from two blocks (50 x 50 m, 4-8m in depth) during two dives (ca. 1 hr/dive) beside the control block; subsequent monthly removal by monitors (i.e., researchers) was done in one of the two blocks. In May 2006, the average standing crops of the seaweed (largely kelp) were 865g/m^2 (monthly removed after the CVD activity) and 150g/m^2 (removed once by CVD) but 0g/m^2 in control, while the density of sea urchin were 0.1, 3.5 and 4.2/m^2, respectively. The results show that the introduction of CVD can aid the restoration of kelp beds.

Key words: grazing, *Saccharina japonica* var. *religiosa*, sea urchins, *Strongylocentrotus nudus,* kelp beds, monitoring, removal

Introduction

Urchin barren is a well known non-productive state on the shallow rocky coasts in the world. Southwestern coast of Hokkaido contains the largest urchin barrens in the Sea of Japan coast (Fujita 1998), introduced not only in the domestic (Fujita *et al.,* 2008) but also the foreign review (e. g., Harrold & Pearse 1987). Along the southwestern coast of Hokkaido, urchin barren dominated by a sea urchin *Strongylocentrotus nudus* and nongeniculate coralline algae has persisted for a long time (locally > 80 years, Fujita 1998) while kelp beds comprised of *Saccharina japonica* var. *religiosa* and *Undaria pinnatifida* has been restricted in shallow waters largely less than 2 m in depth. Although previous studies (Agatsuma, *et al.,* 1997, Kawai *et al.*, 2002) have revealed that *S. nudus* is the causative grazer of the barren state by removal of and/or defense from the sea urchin, no practical efforts have been done for the improvement of fisheries ground. As the fishermen on the coast are aged

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and depopulated, the authors introduced citizen volunteer divers (CVD) for the removal of the sea urchin among various methods (e.g., removal by diver, catching using box glasses and the fishing gear from the side of a boat, and catching using trap cages, see Fisheries Agency 2007). On the rocky coast where the topography of the seabed is complex, the removal by divers is considered to be the most efficient method. Employment of professional divers is not economical due to their expensive wages, but recent increase of amateur divers encouraged us to use them because some of them are searching for the opportunity to use their skill of diving for contribution to the society. In this paper, we report on the first trial of removal of sea urchins in an urchin barren Kamoenai Village to suggest their potential for the restoration of seaweed beds.

Materials and Methods

Location of the study site

The study site is located near Kamoenai Fishing Port on the southwestern coast of Hokkaido, facing to the Sea of Japan (Fig. 1). Because of high density of sea urchins, kelp beds are restricted to onshore rocks shallower than 2 m in depth. Three 50m × 50m square blocks (A, B and C) were framed using ropes on urchin barren boulder beds at depths between 4 and 8m. The CVD removed sea urchins from the blocks A and B in September 2005. After that, in the block A, monitors (i.e., researchers) removed sea urchins once a month. Block C is a control where no sea urchins were removed.

The method of sea urchin removal

Removal of sea urchins by CVD was carried out in September 23 and 24, 2005. Ten CVD (six men and four women) participated in the removal. Including the instructors and staffs, a total of 20 divers were separated into 2 teams and each 10 divers treated one of two blocks (A and B). They spent 1 hr/day for two days. Their goal was the perfect removal of the sea urchin in blocks A and B. Removed sea urchins were transplanted to an artificial fish shelter deployed in shallower waters where non-kelp algae were abundant (Fig. 1).

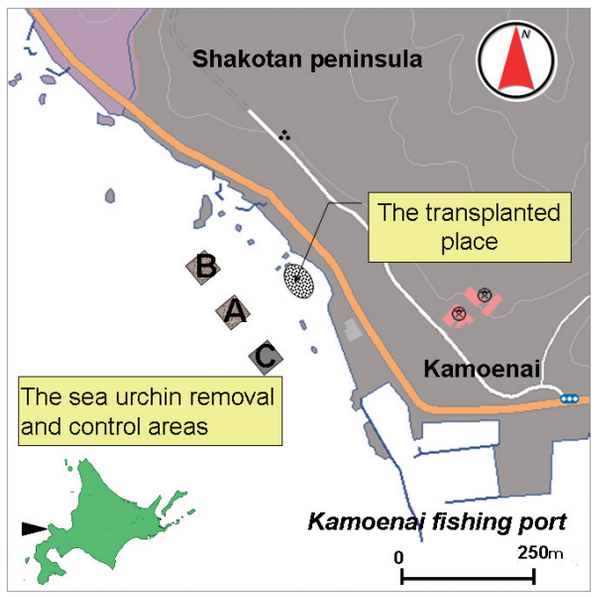

Fig. 1. Location of sea urchin removal experiment site A (removal each month, n=4), B (removal once, n=1), C (control) and the transplanted place to which sea urchins were transplanted from A and B areas.

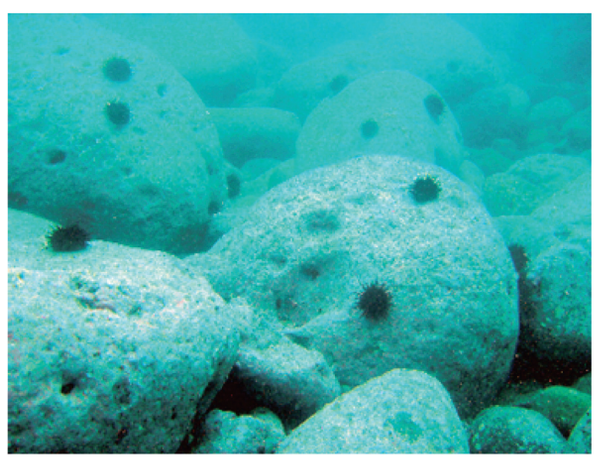

Fig. 2. The view on the sea bottom *S. nudus* and coralline algae

Fig. 3. Sea urchin removal by a citizen diver

The monitoring investigation

For monitoring after the removal of sea urchins, fixed ropes were used as guidelines which had 10 marks every 5 m at the center of each block. A 1m × 1m quadrate was installed at 10 marked points and the number of sea urchin and the coverage of the seaweed within the quadrates were recorded. 21 quadrates samplings were made in each block. After the removal by CVD, the monitors (i.e., researchers) measured the density of the sea urchin in each block and repeated removal of sea urchins in the block A once a month. In May 27, 2006, the standing crop of seaweed and the number of sea urchin in each area were recorded.

Results

The removal of sea urchin by the citizen divers

The state of the sea bottom of the study site is shown in Fig. 1. It was a typical urchin barren dominated by a sea urchin *S. nudus* and crustose coralline algae (Fig. 2). In addition, *S. intermedius* sparsely occurred. The dominant seaweed distributing in shallower zone is *S. japonica* var. *religiosa*. During the 2 days, sea urchins were removed to the degree that they could not be readily observed and the goal was achieved (Fig.3 and 4). Among the removed sea urchins, 90 urchins were landed for the measurement of test diameter, body weight and gonad weight by the participants. The averages of test diameter, body weight and gonad index (gonad weight/body weight x 100) were 47.6 mm, 44.3 g and 12.2 %, respectively. These were small sea urchins with unmarketable immature gonads. The total wet weights of the removed sea urchins were 710.6 kg in the block A and 746.5 kg in the block B. A total of 32,900 sea urchins (1,645 urchins per person) were removed during the two days.

Results of the monitoring investigation

The change of the sea urchin density of each block is shown in Fig. 5. In the control block C, sea urchin density varied from 4 to 5 per 1 m^2, but in the block B (removed only once by CVD in Sept.), the sea urchin density was approximately half of that in the block C. In the block A where sea urchins were monthly removed, the density could be reduced to almost less than 1/ m^2. In the observation in February 20, 2006, the seaweed had not germinated yet but diatoms and small green algae formed a mat on the hard substrata. In May 27, 2006, the average

Fig. 4. The participating citizen divers and staff

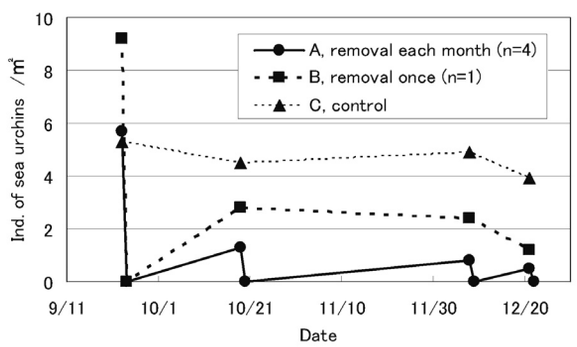

Fig. 5. The change of the sea urchin density of each area

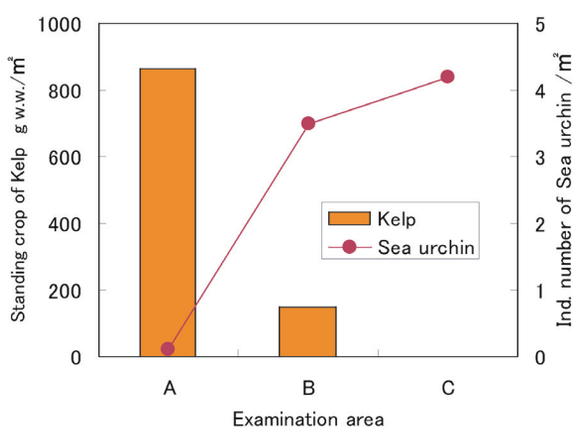

Fig. 6. Results of the monitoring in May, 2006. A (removal each month, n=4), B (removal once, n=1), C (control)

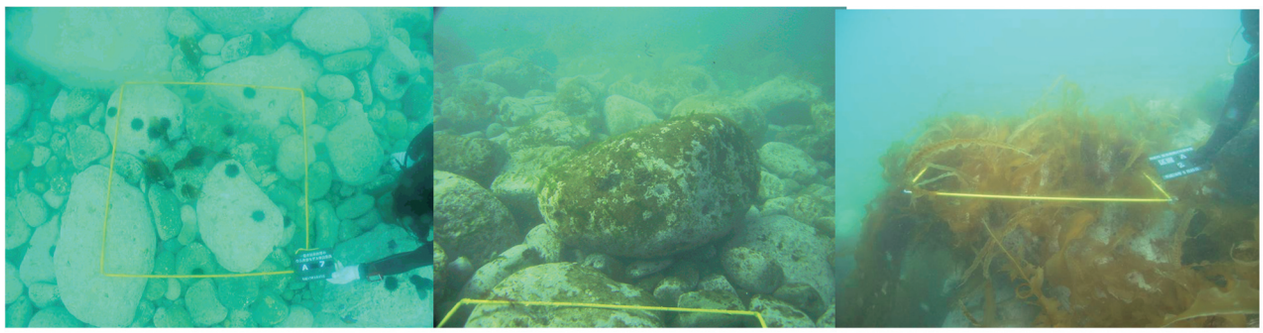

Fig. 7. The state of the early stages and the sea bottom after sea urchin removal

of standing crop of the kelp in each block and the number of the sea urchin are shown in Fig. 6. The standing crop of the kelp in the blocks A, B and C were 865g/m^2, 150g/m^2 and 0g/m^2, while the density of sea urchins were 0.1, 3.5 and 4.2 /m^2, respectively. The results show that CVD can contribute more or less to the restoration of kelp beds on urchin barrens by the removal of the sea urchin (Fig. 7).

Problems and perspective of sea urchin removal by citizen volunteer divers

Because CVD has no fishing rights, they need the agreement of the fisheries cooperative and the permission from the prefectural government to remove sea urchins because of strict limitation by the prefectural fishery adjustment rule. Furthermore, CVD may be mistaken as poachers if not well informed among the related offices. Therefore, further understanding and permission should be need for CVD to support their diving activities on management of seaweed beds. Even a temporal and local introduction of CVD can bring the success in restoration of kelp beds in an appropriate time of the year. In the southwestern coast of Hokkaido, the timing should be autumn, namely usually before inactivation of *S. nudus* in cold winter and in and before the maturation of kelp *S. japonica* var. *religiosa*. To enlarge the activity, introduction of CVD not only compensates the lack of fishermen divers, but activates fishing villages by promoting human exchanges and information. Further monitoring is needed to establish the management of the restored kelp beds (e.g. frequency of the subsequent removal, the best way to enlarge the restored kelp beds), Infrastructure for divers in port area as well as new educational system and services are also needed to enlarge these activities to the other parts of the coasts.

Conclusion

In this report, we introduced a possibility of restoration of kelp beds by removal of sea urchins by citizen volunteer divers. The sea urchin *S. nudus* was again confirmed to be the causative grazer to disturb re-colonization of kelp. This should be a breakthrough which coincided with the central dogma of Isoyake Taisaku Guideline (2007), referring to the priority of reduction of limiting factors in colonization of seaweeds, and should be replaced of deployment of concrete blocks or rubble stone beds, which provide habitats of sea urchins. We hope this trial will be the first step of collaboration between fishermen, citizens and researchers in the restoration of kelp beds on urchin barren.

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References

Agatsuma, Y., K. Matsuyama, A. Nakata, T. Kawai and N. Nishikawa 1997. Marine algal succession on coralline flats after removal of sea urchin in Suttsu Bay on the Japan Sea Coast of Hokkaido,

Japan. *Nippon Suisan Gakkaishi*, **63(5)**: 672–680. (in Japanese)

Fisheries Agency 2007. Isoyake Taisaku Guideline, 208p. (in Japanese)

Fujita, D. 1998. Strongylocentrotid sea urchin-dominated barren grounds on the Sea of Japan coast of northern Japan. *In:* Mooi, R. and M. Telford (eds), *Echinoderms: San Francisco,* 659-664. Rotterdam, A.A. Balkema Publishers.

Fujita, D., Y. Machiguchi and H. Kuwahara 2008. Recovery from Urchin Barrens, Ecology, Fishery and Utilization of Sea Urchins, *Seizando-Shoten* 296pp. (in Japanese)

Harrold, C & J. S. Pearse 1987. The ecological role of echinoderms in kelp forests. *In:* Jangounx, M., and M. Lawrence (eds) *Echinoderm Studies vol.2.* p.137–233., Rotterdam, A.A. Balkema.

Kawai, T., T. Kaneta, S. Arai, and H. Kuwahara, 2002. Afforestation of the kelp, *Laminaria religiosa,* in coralline flat using fence with development of gonad of the sea urchin, *Strongylocentrotus nudus*. *Fisheries Engineering,* **39(1)**:15–20. (in Japanese)