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Appropriate release number of juvenile red spotted grouper, *Epinephelus akaara*, into nursery reef and fishing port habitats

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Abstract Six nursery reefs of ca. 20m^3 were installed off Shiraishi Island, central Seto Inland Sea, Japan in July 2000. Juvenile red spotted grouper were released into the reefs on October 2001. The densities of released juveniles were arranged at three levels, 500, 1,000 and 2,000 fish per reef. Part of the reef was salvaged from each reef three times to estimate the number of residual fish. The numbers of residual fish were directly proportional to the numbers of released fish until one month after release; however they were nearly even among the three levels at four months after release. Retention rates were inversely proportional to the released number. Release experiments into a fishing port were carried out in Ishima West Port located in central Seto Inland Sea, Japan. A total number of 15,000 and 1,500 juveniles were released into the port on October 1998 and November 1999, respectively. Respective recapture operation took place 16 and 28 days after the release using 16 and 20 fishing traps in the port. CPUE were 0.38 and 0.05 directly proportional to the number of released juveniles.

Key words: red spotted grouper, release experiment, stock enhancement, nursery reef, fishing port

Introduction

The red spotted grouper is a temperate grouper which is distributed from Southeast Asia to Far East. It has a high market price and seems to be a prominent species for stock enhancement because of its non-migratory habitat and relatively small stock size. Stocking efficiency was obvious when 1+ year old fish were released into natural conditions; however 0+ year old fish release had little efficiency in this species (Okumura *et al*., 2002). It was a large problem that how to care the released 0+ year fish and nurse them to 1+ year old. One of the solutions of this problem is caring the juveniles by using artificial nursery reef or fishing port. In this paper, three release experiments were introduced and discussed on the carrying capacity of the nursery reefs and fishing port.

Release experiment into nursery reefs

Materials and Methods

Prior to this experiment, materials and structure of the nursery reef were designed in the laboratory (Okumura *et al*., 2002) and under natural conditions (Okumura *et al*., 2003a). Fig. 1. shows schematic diagram of the nursery reef. The nursery reefs consisted of a 3.6 m square concrete base, 4 iron poles of 1.6 m tall, and a top panel. Top panel was filled up with oyster shells (250 kg/m^3) to enhance the food organisms for released fish. Each nursery reef had 6 test units of 75 cm cube. Test unit was consisted of iron frame and 25 mesh pipes, 15 cm in diameter and 75 cm long. Each pipe had a string of scallop shells in it. The mesh size of the pipe and space between the shells were planed to match with the released fish size. These test units

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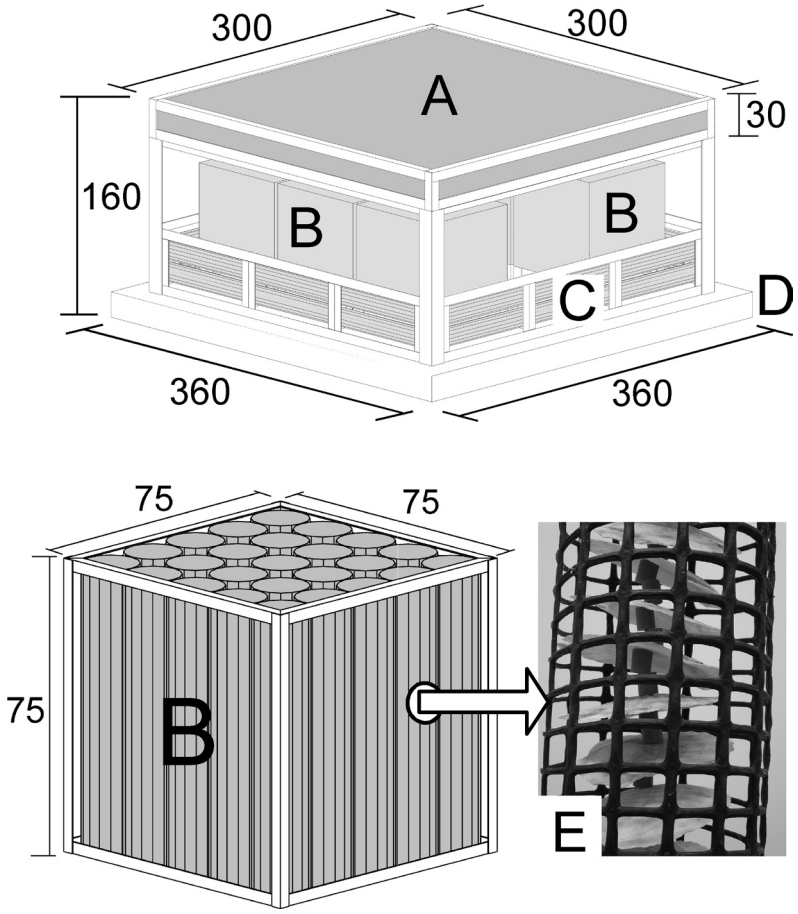

Fig. 1. Structure of the nursery reef.
A, top panel; B, test unit; C, side panel; D, concrete base; E, mesh pipe filled with string of scallop shells. Values are in cm.

were detachable from the nursery reef in order to estimate the number or conditions of the residual fish by salvage operation. Side panel was attached to prevent the fish escaped from the reef and/or propagate the food organisms. Six nursery reefs were built and installed on the bottom (5-6 m in water depth) off Shiraishi Island, central Seto Inland Sea, Japan (Fig. 2., 3.) in July 2000. Artificially reared red spotted grouper juveniles (67.6 ± 7.0 mm in total length) were released into the reefs on 16 October 2001. All fish were marked by clipping the left or right ventral fin. The fish were packed in a basket and divers delivered the basket into the reef and opened it in each reef. The densities of released juveniles were arranged at three levels, 500 fish per reef, 1,000 fish per reef and 2,000 per reef, and each density level tested at 2 reefs. Underwater observation took place five times, 7, 27, 56, 92, and 119 days after release to count the number of residual fish in the reefs. A test unit was salvaged from each nursery reef three times, 7, 27, and 128 days after release, to estimate the number of residual fish. Salvaged test units were took apart on the boat and each number of the recaptured fish was counted. After the operation, the test units were rebuilt and returned to the original reef. Recaptured fish were also re-released into their own reef.

Results and Discussion

Each number of fish in the reefs observed underwater is shown in Fig. 4. At first operation

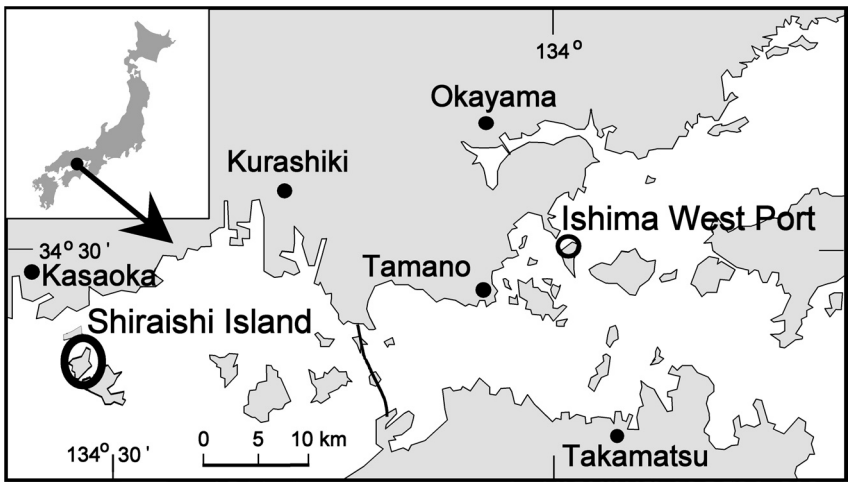

Fig. 2. Location of the experimental area.

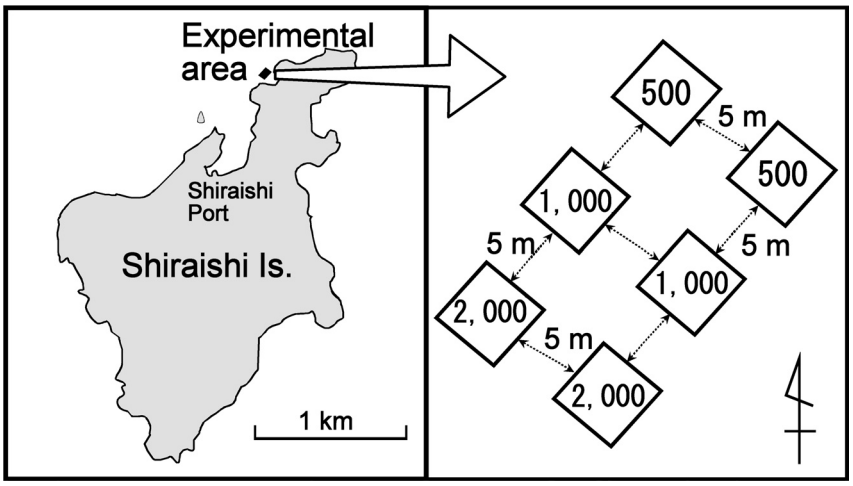

Fig. 3. Experimental area, nursery reefs arrangement, and release number of juveniles into each reef.

the numbers of observed fish were parallel to the released density. From the second observation, the observed numbers of fish in 2,000 fish per reef group decreased and were close to 1,000 fish per reef group. At 92 days after release, numbers of fish decreased to 4-10 per reef and were close to each other. At the final observation the observed numbers were almost even and partly reversed like 8 fish in 500 fish per reef group versus 0 in 1,000 fish group. Fig. 5. shows the results of three salvage operation. The upper figure shows transition of the estimated number of fish per reef, number of recaptured fish multiplied 6 (number of test units in each reef). In this figure, tendency of the decrement was the same as Fig. 4. The lower figure of Fig. 5. shows transition of the retention rates which were calculated from estimated number of residual fish divided by numbers of released fish. The retention rates were almost inversely proportional to the released number through the experimental duration. These results indicate that releasing 2,000 fish per reef is effective to retain a large number of released fish in a reef for a month; and releasing 500 fish is efficient to obtain a high retention rate at four months after release. Thus the appropriate number of released fish should be determined depending on the duration spent in the nursery reef.

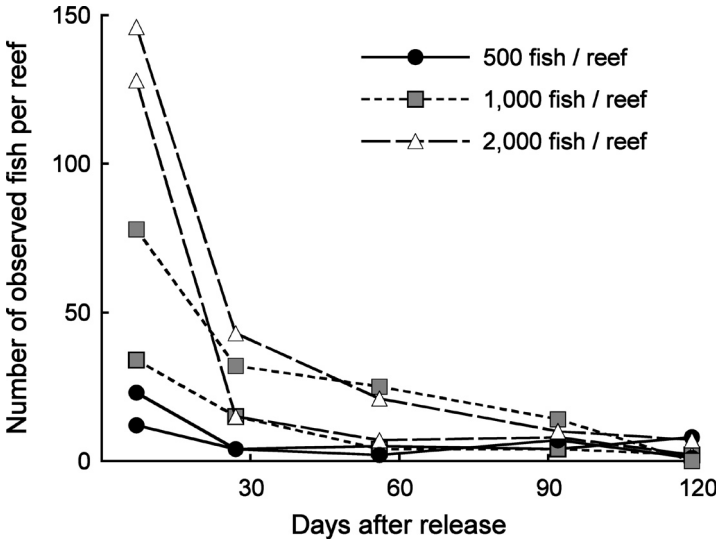

Fig. 4. Number of residual fish observed under water.

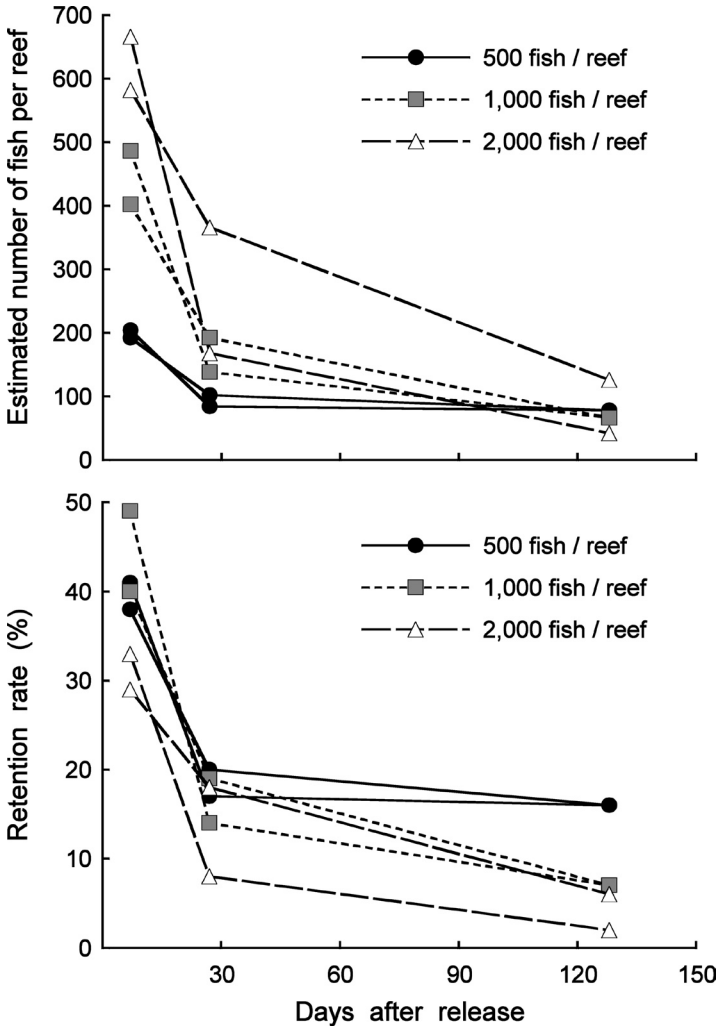

Fig. 5. Number of the residual fish and retention rate estimated from salvage operations.

Release experiment into fishing port

Materials and Methods

These experiments were carried out in Ishima West Port (Fig. 6.) which is shallow (2-4 m) and small (4500 m^2) port located in central Seto Inland Sea, Japan (Fig. 2.). The port had many crevices on its wall and bottom, since it was mainly built of rock arrangement. A total number of 15,000 artificially reared juveniles (69 mm, mean total length) were released into the port on 13 October 1998. Recapture operation took place 16 days after the release using 16 fishing traps (60 × 45 × 20 cm) in the port. All traps with bait fish were spaced evenly on the seabed in the port along a pier on noon 28 October. The traps were salvaged 24 h after setting and organisms in it were caught. A total number of 1,500 juveniles (109 mm) were released into the same port on 11 November 1999. Recapture operation was similarly conducted using 20 traps 28 days after the release.

Results and Discussion

Table 1. shows the results of these release experiments. Total number of recaptured fish in 1998 was 6 and catch per unit effort (CPUE) was calculated as 0.38 (6 fish per 16 traps). Only one fish was recaptured in 1999 and CPUE was 0.05 (1/20). Although these operations were experimental and the calculated figures were estimates, CPUE seemed to be directly proportional to the number of released juveniles. The retention rate may be fixed unrelated to the number of released fish within the limits of 1,500-15,000 fish per port. Further release experiment, less than 1,500 fish or more than 15,000 fish into the port, will be useful to estimate the carrying capacity of the port.

Acknowledgements

The nursery reef study was granted by Fishery

Fig. 6. Ishima West Port.

Table 1. Results of the recapture operations in Ishima West Port

Release		Recapture			
Date	No. of fish	Days after release	No. of fish	No. of traps	CPUE*
13 Oct. 1998	15,000	16	6	16	0.38
11 Nov. 1999	1,500	28	1	20	0.05

* No. of recaptured fish / No. of traps

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