Successful cage design for intermediate culture of trochus for restocking

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Abstract

A new design for reef-based cages for the intermediate monoculture of juvenile trochus, using an aluminium frame and plastic mesh, was tested at two locations in Western Australia. The design proved to be much improved from previous cage types, providing high survivorship and no escape of juveniles. The robust cages are inexpensive, easy to construct and allow hatchery-produced juveniles as small as 12 mm to be advanced to sub-adult size for restocking.

Introduction

Trochus restocking projects in the past decade have used different approaches for advancing hatchery-produced juveniles to adulthood on reefs for replenishing stocks. The simplest of these, seeding of small juveniles from the hatchery, has had varied success. A recent ACIAR project (see Purcell and Lee 2001) has shown that releasing small (1-4 mm) juveniles can enhance stocks, but modifications are needed to improve survivorship. Intermediate culture in sea cages is a further approach, aiming to grow trochus to a larger size before seeding.

Survival of trochus released onto reefs is higher for large juveniles than for small ones (Castell 1996; T. Crowe, unpubl. data). Predation experiments conducted by Vermeij (1976) and Dobson (2000) show that reef crabs cannot kill trochus juveniles larger than 25-40 mm. Trochus also appear to gain a size refuge from gape-limited predators, like wrasses (e.g. *Choerodon* sp.), triggerfishes and pufferfishes (Order: Tetraodontiformes).

Intermediate culture of trochus in sea cages has proven to be a viable way to advance small, hatchery-produced animals to a 'sub-adult' size of 40 mm for restocking. In Solomon Islands, Clarke et al. (in review) successfully grew juvenile trochus to >40 mm in sea cages with giant clams, achieving high growth and survival. Amos and Purcell (in review) showed that juvenile trochus could also be mono-cultured in high numbers to 40 mm in reef-based cages in Vanuatu. However, for this latter work, deficiencies in cage materials allowed entry of predators and escapement of juveniles.

In the present study, a new, robust cage design was developed to minimise mortality and escape of trochus, while allowing high numbers of juveniles to reach sub-adult size. Repeated monitoring of caged juveniles in trials, conducted at two sites for up to 10 months, suggests that this design is optimal for monoculture of trochus for restocking.

Materials and methods

Two sites were selected for the caging trials: Bowlan reef, near the One Arm Point community, King Sound, and Middle Lagoon on the west coast of Dampier Peninsula in northern Western Australia (see map in Purcell and Lee 2001). The sites were selected on the basis of their habitat suitability and proximity to Aboriginal communities that expressed interest in cage culture.

Bowlan reef is a large, biogenic coral reef, probably with a significant contribution of the reef matrix built by coralline algae. It has an intertidal zone covered mainly by short macro-algae and experiences strong currents (5 to 10 knots) during every spring tidal cycle. The reef at Middle Lagoon is a sandstone, platform reef with an intertidal zone covered in short algae and experiences high wave energy on its reef crest.

The new cages designed for the trials were 0.93 m x 0.93 m x 0.15 m in size and made with a frame of angle aluminium, fastened by rivets. The

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walls, floor and roof were made of pieces of 8 mm x 8 mm plastic mesh (oystermesh) that were fastened to the frame using plastic cable ties. A separate, hinged lid was made for each cage to cover one quarter of the roof and allow access of workers to trochus and substrates (Fig. 1). Each cage costs about AUD 40.00 in materials and takes about three hours to construct, using simple tools.

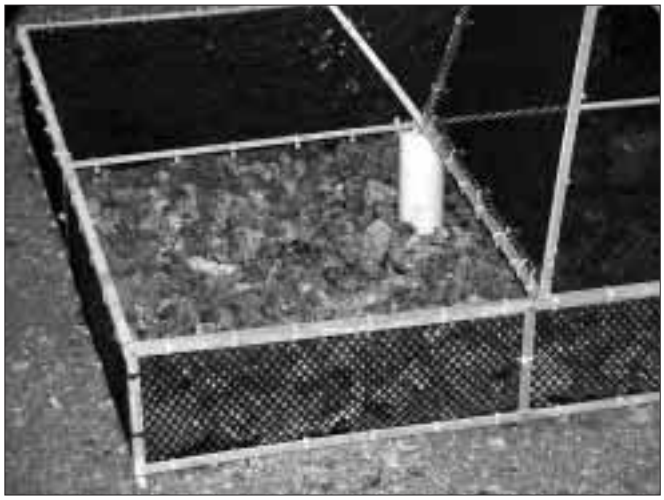

Figure 1. Cage with lid up and bottom covered with a layer of coral rubble with algae.

Cages (n = 3) were placed on the intertidal zone on Bowlan reef, approximately 30 m behind the sub-tidal coral zone (Fig. 2), and on the intertidal reef flat at Middle Lagoon reef, approximately 30 m behind the reef crest. The cages were secured to the reef with roofing spikes and galvanised wire, fastened to each corner and centre-bar. Approximately 15 litres of coral rubble was placed into each cage; enough to cover the cage floor. Epilithic algae covering the coral rubble provide a productive food source for the juvenile trochus. Larger pieces of coral rock, covered in algae, were also put into cages at Middle Lagoon after one month.

Figure 2. The three cages at Bowlan reef, near the sub-tidal zone at incoming tide.

Juvenile trochus were produced at a pilot hatchery at One Arm Point, north of Broome, Western Australia. The initial size of the hatchery-cultured juveniles ranged from 12 to 20 mm, which is smaller than juveniles caged in Vanuatu (Amos and Purcell, in review) or Solomon Islands (Clarke et al., in review).

The cage grow-out trial was initiated on Bowlan reef on 3 July 2000 and at Middle Lagoon Reef on 1 August 2000. Juveniles were individually tagged with plastic tags (Hallprint, FPN shellfish tags, 8 mm x 4 mm) attached to the outer whorl with cyanoacrylate glue (Loctite #454) (Fig. 3). Juveniles were measured to the nearest mm with vernier callipers and averaged 15.12 mm (± 0.12 SE; n = 75). They were transported to cages on the reef in small containers lined with damp paper towel. A total of 25 juveniles were placed into each cage, equating to a density of 30 juveniles m^{-2}, as suggested by Amos and Purcell (in review). After one month, additional tagged and measured juveniles were placed into cages to replace dead animals, but this was not done on subsequent occasions.

Figure 3. Tagged juvenile trochus next to callipers, prior to placing into cages.

Monitoring occurred after approximately 1, 3, 6 and 9 months from commencement of the trials. Each time, the cages were opened, the basal shell width of live trochus in cages was re-measured, and any dead or escaped trochus recorded. Coral rubble and rock accumulated around the walls outside the cages were removed to mitigate decreased water movement and sediment build-up inside cages.

Results

For both sites, growth rates for juveniles over the initial two time periods averaged about 2 mm month-1 (Table 1). At Middle Lagoon, one cage was accidentally pulled off the reef at high tide by a tourist's anchor during the first month and the remaining two cages were swept off the reef by a passing cyclone after five months.

Growth of juvenile trochus during the first month at Middle Lagoon Reef was markedly lower than at Bowlan Reef (Fig. 4), but subsequently was comparable over the following time period. The low initial growth at Middle Lagoon Reef was thought to be due to piling of rubble in the cages and low algal biomass on the rubble. The addition of larger pieces of coral rock in the cages appeared to rectify the problem and brought average growth rates to comparable levels (Table 1). On Bowlan reef where cages were not damaged, juvenile shell growth slowed through time and was low in the final period of intermediate culture (Fig. 4; Table 1). Two important findings were the low rates of mortality and escape (Table 1).

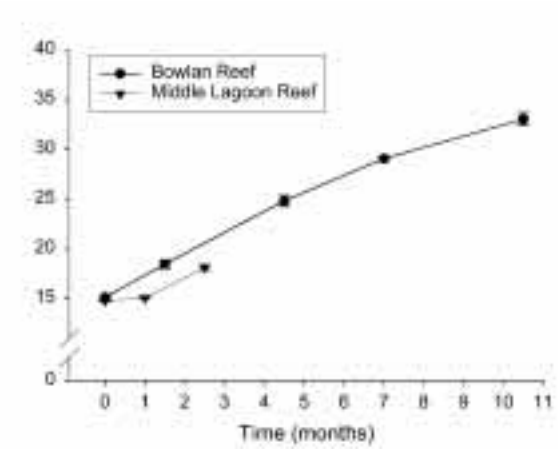

Figure 4. Line plot of mean growth of juvenile trochus in cages at Bowlan Reef and Middle Lagoon Reef. Points are mean shell diameter of trochus from mean sizes in the replicate cages ± SE.

At the end of the 10.5-month culture period, the cages on Bowlan reef were in very good condition and could have been used immediately for a repeat culture cycle of trochus. After the culture period of 10.5 months, the trochus (n = 80) were released at two sites on nearby reefs with depleted trochus stocks. The animals ranged in size from 29 to 39 mm, with an average of 33 mm.

Conclusions

The trials showed that the design of the new cages solved the problems of escape of juvenile trochus and entry of predators, encountered with the two cage types used in Vanuatu (Amos and Purcell, in review), and allowed juveniles to reach a sub-adult size for restocking. The cages proved to be highly durable and reusable, with an expected life span of at least three years, allowing repeated culture cycles of trochus. However, it is difficult to make cages that are anchor- and cyclone-proof. The damage to cages at Middle Lagoon indicates that future cage culture in cyclone-affected regions should be conducted on semi-sheltered reefs. Further, on reefs frequented by tourists, the sites should be marked and tourists informed of the location of cages.

The growth rates shown for both sites were lower than growth rates for juveniles at similar stocking densities in reef-based cages in Vanuatu (2.6 mm month-1; Amos and Purcell, in review) or Solomon Islands (3.3 mm month-1; Clarke et al., in review). I attribute this result to poor food supply

Table 1. Summary statistics for rates of mortality, escape and shell growth of juvenile trochus in cages at the two sites. Means and standard errors (SE) are calculated from cage means.

Site	Time (months)	Mortality rate[1]	Escape rate[2]	Growth rate[3]	*n*
Bowlan Reef	1.5	13.1 (± 4.6)	0	2.3 (± 0.5)	3
	4.5	1.9 (± 1.9)	0	2.1 (± 0.2)	3
	7.0	0	0	1.8 (± 0.3)	3
	10.5	0.7 (± 0.4)	0	1.3 (± 0.2)	3
Middle Lagoon Reef	1.0	3.6 (± 3.6)	0	0.2 (± 0.1)	3
	2.5	2.9 (± 0.1)	0	2.0 (± 0.1)	2

1. Mortality rate: % deaths • month^{-1} ± SE
2. Escape rate: % escaped • month^{-1} ± SE
3. Growth rate: mm • month^{-1} ± SE

because algae on the rubble substrates appeared to be kept at a very low biomass. Future trials should use pieces of coral rock, with established algae, that are large enough to avoid being piled up on one side of the cage and won't be easily covered by sand. Pieces of coral rock with high surface area and minimum weight should be chosen.

In the 10.5-month trial of cage culture on Bowlan reef, the cages were checked and cleaned once by members of the One Arm Point aboriginal community. Conditions on the reef, such as strong tidal currents or intense grazing by herbivores, prevented the cage mesh from becoming fouled by algae. In other regions, this may not be the case and reef-based cages are likely to require cleaning every two weeks. Provided that indigenous communities are committed to husbandry practices, intermediate culture in sea cages of the type presented here can be an effective approach for progressing juvenile trochus from the hatchery to the reef for stock replenishment. This approach is particularly suited for situations where stocks on neighbouring reefs are too low to justify collecting and translocating broodstock to depleted reefs.

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