



ews from the Cook Islands

Study of trochus introduced to Penrhyn, Cook Islands: 10 years later

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Abstract

A survey of a trochus population at Penrhyn lagoon, introduced from Aitutaki in the mid 1980s, was carried out. Trochus dimensions of dry shell weight (W) and basal diameter (L) can be expressed by the equation: $W = (3.4 \times 10^{-4}) L^{2.943}$. The sex of animals was distinguishable in animals > 50 mm basal diameter. The average basal diameter of animals was 84.0 mm (compared to 100.6 mm at Aitutaki). The density of trochus was found to be significantly higher ($P < 0.05$) in the 10 m segment fringing the reef edge. This unexpected spatial niche may explain the poor success of establishment of stocks at the original transplant sites. Trochus abundance was assessed at 21 sites. High densities of trochus were found in the north-west part of the lagoon, with low densities adjacent to it. Zones for probable areas of establishment were identified. The abundance of trochus (95% c.i.) was estimated at 27,300 (14 300) animals. A sustainable harvest of 30 per cent of the animals in the 75–110 mm size range is suggested. This equates to a harvest of 5,000 animals or 1,040 kg of dry shell weight, worth an estimated CI\$ 7,300 (≈US\$ 4,780). Four possible management options discussed include: (1) leaving stocks undisturbed; (2) a commercial harvest; (3) a harvest for restocking areas where trochus do not occur; and (4) selective harvesting of wild animals to be utilised as broodstock for hatchery rearing of trochus juveniles at Penrhyn.

Introduction

Trochus (*Trochus niloticus*) are valued for their mother-of-pearl shell. Export industries to Europe and Japan utilise the shell for buttons, jewellery/curios, paints and varnish (Bouchet & Bour, 1980; Nash, 1993).

On two occasions (in 1985 and 1986), several hundred trochus from Aitutaki were introduced to Penrhyn (also known as Tongareva).

The target sites for transplant were in the southern area (see Figure 1) but it is probable that some animals were accidentally released at the wharf in Omoka village.

The Aitutaki population itself originated from just 280 shells translocated from Fiji in 1957. They were left to breed undisturbed for more than 20 years before being fished in 1981, when 200 t were harvested (Sims, 1985).

Since then, trochus have been harvested at irregular intervals of several years. The last harvest at Aitutaki in 1995 amounted to about 25 t of dry shell.

The primary purpose of this survey was to assess the stock of trochus at Penrhyn lagoon, 10 years after its introduction, to determine the feasibility of a potential harvest.

In addition, some basic biological characteristics and distribution patterns of the trochus were investigated.

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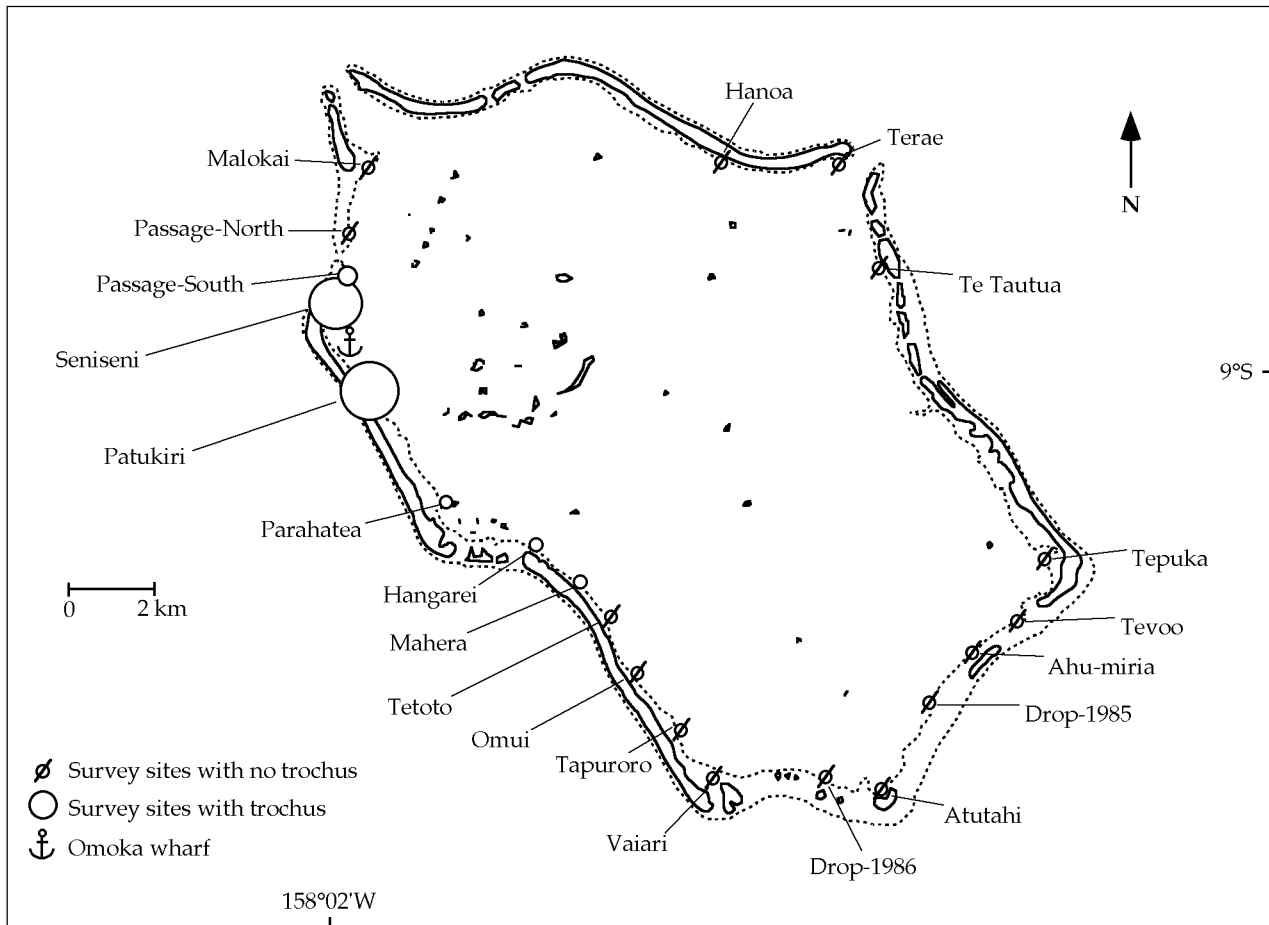


Figure 1

Map of Penrhyn showing 21 survey sites for trochus abundance. Drop-1985 and Drop-1986 were the original sites for trochus transplant, (see *Population census* section on page 21 for more details on trochus densities).

Materials and methods

The survey took place from 28 April to 1 May 1997. Field work was conducted by the Ministry of Marine Resources.

The relationship of sex and dry shell weight with basal diameter (hereafter referred to as length) was derived from a sample of 39 trochus. The morphology of the male gonad is pale brown to creamy white while the female gonad is dark green (Nash, 1993).

In addition, the size distribution of the trochus population was evaluated in a separate survey by measuring the length of 220 animals found within several random transects.

From preliminary observations it was noted that trochus were distributed with increasing density towards the edge of the inner lagoon reef. A survey was conducted at *Patukiri* site to assess the spatial distribution from the reef edge. Four replicate transects of 50 m length (with 10 m segments) were laid perpendicular to the reef edge and transects were surveyed 4 m on either side for trochus.

The census of trochus abundance at each lagoon site was assessed by laying 4 replicate 30 m long transects parallel to the reef edge in the strata where the most trochus were distributed. The transects were surveyed in a 2 m belt on either side for trochus counts. A total of 21 random lagoon sites was sampled (Figure 1).

Results

a. Length-weight relation

The relation between length and dry shell weight can be explained by a simple linear regression (i.e. shell weight = $-4.694(\text{length}) - 223.3$, $r^2 = 0.933$). However, upon further analysis it was found that a better fit of the length-weight relationship was provided by applying a natural log transformation of the data (i.e. $\ln(\text{weight}) = 2.943(\ln(\text{length})) - 7.997$, $r^2 = 0.979$) (Figure 2). Therefore, weight can be simply expressed by the equation: $W = (3.4 \times 10^{-4}) L^{2.943}$ where W = dry shell weight and L = length.

b. Sex ratio

In the 39 trochus sampled, the female sex was first noted in those animals with a length exceeding 50 mm (Figure 3). Males were not always clearly distinguished (and were assumed to consist of those not identified as females; however it is possible that animals smaller than 50 mm were not fully matured, and the sex therefore indistinguishable). The small sample size makes it difficult to assess when a consistent ratio of male to female occurs. In this instance an even ratio occurs among animals with diameters of 50–60 mm and 90–110 mm.

c. Size structure

The minimum- and maximum-sized trochus were 38 mm and 118 mm (although an individual of 123 mm length was found outside the survey area). The mean (and standard deviation) of trochus length is 84.0 mm (± 18.94 , $n = 220$). Ninety-six per cent of the population are sexually mature (> 50 mm) (see shaded segment in Figure 4).

Also indicated is a portion of the population of 75 to 110 mm length (* segments in Figure 4). Using normally distributed Z scores it is calculated that this represents 60 per cent of the por-

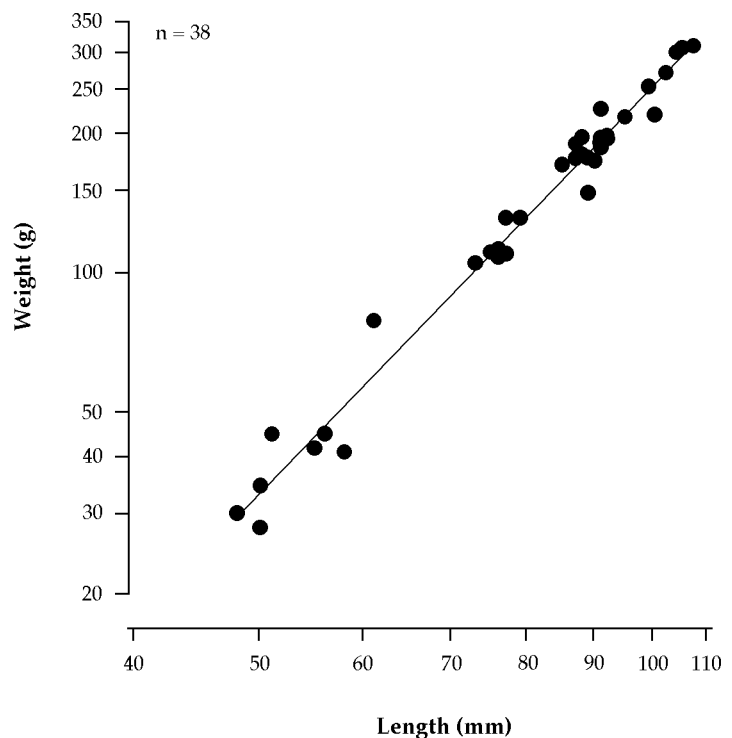


Figure 2
Relation of trochus length (L) and weight (W) after natural log transformation. The equation describing the curvilinear relationship is $W = (3.4 \times 10^{-4}) L^{2.943}$.

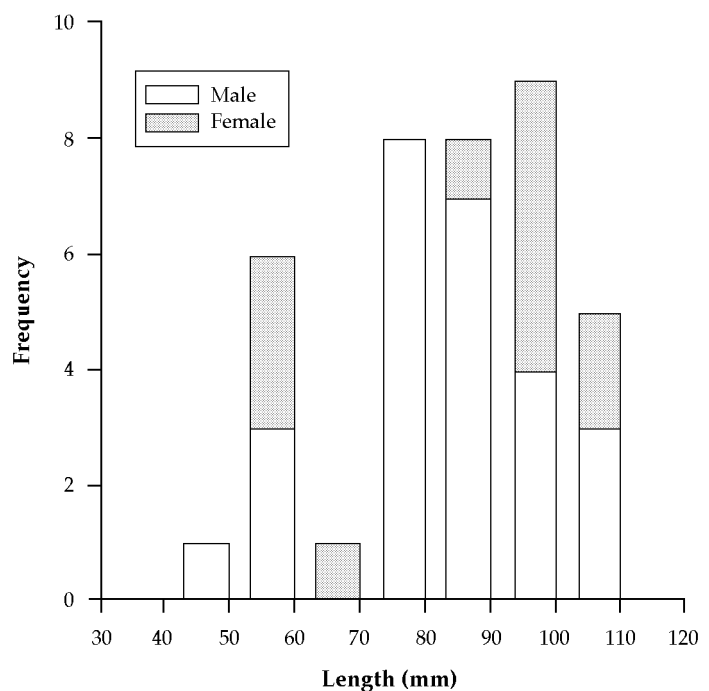


Figure 3
Trochus sex distribution, with length

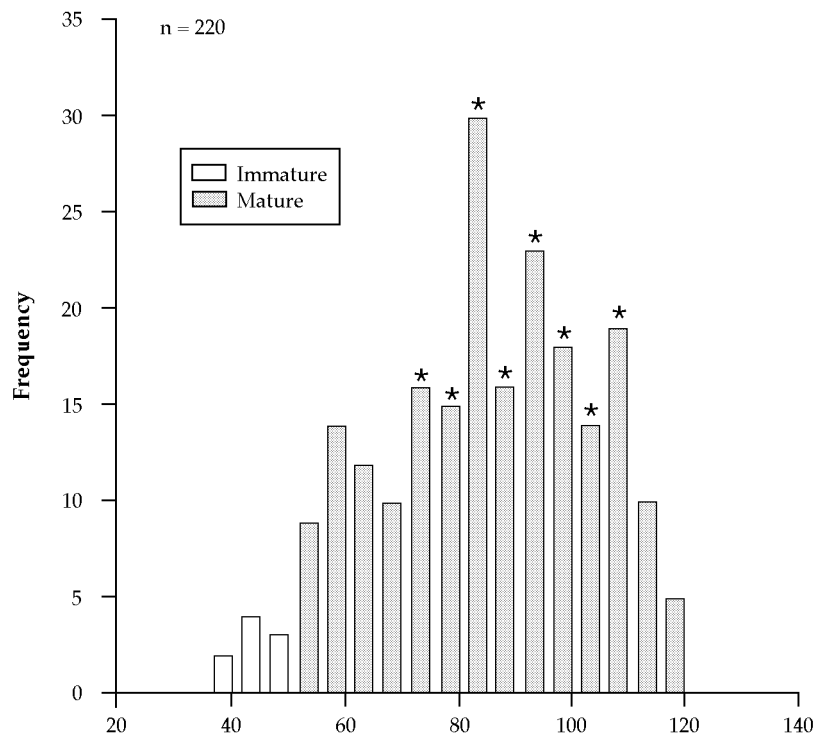


Figure 4

Trochus population size structure with a mean length = 84.0 mm. The animals considered sexually mature (i.e. > 50 mm length) (96%) are shaded. The stars (*) (60% of the population) indicate the animals within the 75 to 110 mm size range (discussed later).

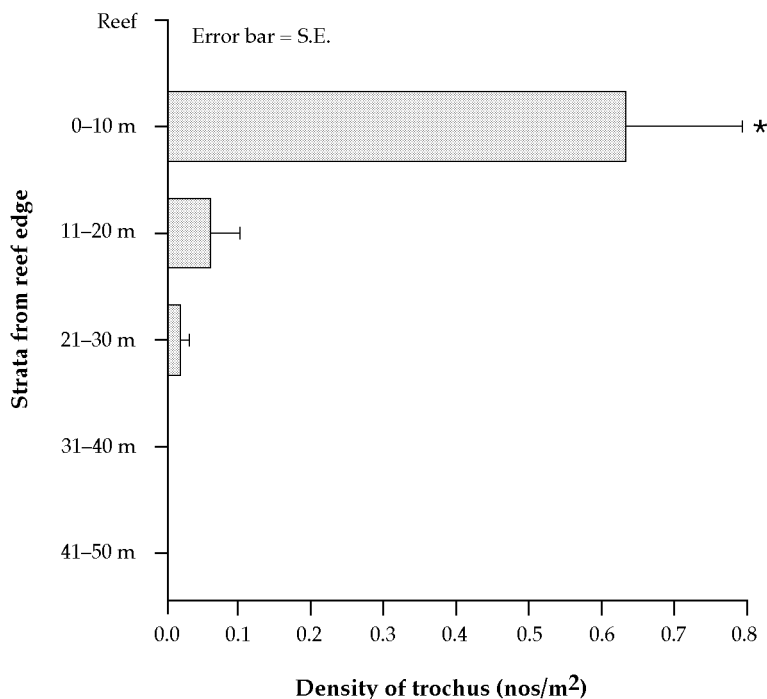


Figure 5

Spatial distribution of trochus at 10 m segments perpendicular to the edge of the lagoon reef. The high density at the 10 m stratum was significantly different ($P < 0.05$).

tion of population. This size range of the trochus population will be discussed later.

d. Distribution patterns

A clear trend of distribution emerged at *Patukiri* site (Figure 5). Most trochus were found at the 10 m segment of the transect closest to the edge of the reef. Thereafter the trochus were scarce and were not observed at a distance of 50 m perpendicular to the reef. The average (and s.e.) of density in the 10 m stratum was 0.63 (0.16) ind./m², which was significantly different (1-way ANOVA, Tukeys test, $P < 0.05$, *SPSS version 6.1* software) compared to the density of animals in the 20 m (0.06 ind./m²), 30 m (0.02 ind./m²), 40 m (0 ind./m²) and 50 m (0 ind./m²) strata.

At the edge of the reef, an exceptional number of trochus (130 animals) was noticed at one rock of approximately 3 x 3 m² area, i.e. a density of approx. 14.4 ind./m² (although this rock did not fall within the area of the survey transect).

b. Population census

Since the trochus are found mostly in the 10 m stratum closest to the reef edge, all transects to assess population abundance were laid in this stratum. At some sites without adjacent landmass, visual surveys of the atoll barrier reef area (where the animals are typically found in Aitutaki) failed to reveal the presence of trochus.

The highest trochus densities were found at *Seniseni* and *Patukiri* sites. The mean (and s.e.) of these two sites

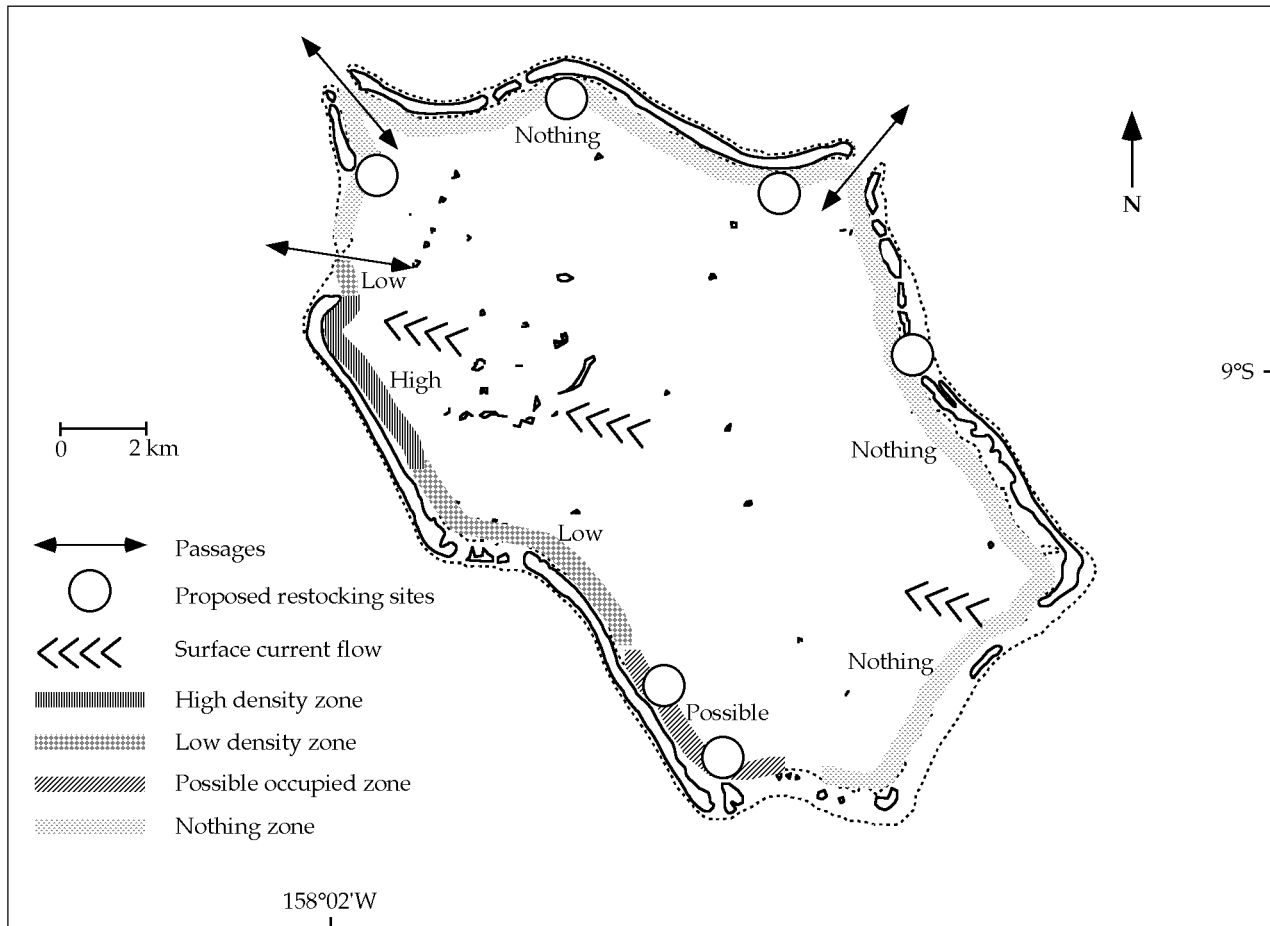


Figure 6
Zones of occupation by trochus at Penrhyn lagoon.
Also indicated are possible sites for restocking, as discussed later.

was 0.41 (0.04) ind./m². Low densities were observed at several sites adjacent to *Seniseni* (Passage north) and *Patukiri* (Parahatea, Hangarei and Mahera). The combined mean (and s.e.) of the low-density sites was 0.02 (0.01) ind./m². At other sites, trochus were not found.

The population was divided among four zones within Tongareva lagoon (Figure 6): firstly, a *high-density* zone in the north-west quadrat where most trochus occur. Adjacent to this area is a *low-density* zone with lesser trochus density. The third zone is named *possible* because there are reported sightings within this area. Lastly, the *nothing* zone on the western and far northern part of the lagoon is not considered to harbour animals because of the far distance from high densities of trochus, a general predominance of unsuitable habitat substrate (sandy or rubble), and the possible impediment to larval distribution caused by currents from wind-borne surface currents and passages.

The various zones are described in Table 1. The area of each zone was simply calculated as its distance (using *MapInfo 4* software) multi-

plied by the 10 m stratum assumed to be occupied by trochus. Based on this area a simple stratified stock assessment can be derived using the density (and 95% confidence intervals) of the high and low zones described earlier. Therefore the abundance of trochus at Penrhyn amounts to 27 300 (±14 300) animals.

Conclusions

Trochus dimensions of dry shell weight (W) and base diameter (L) can be expressed by the equation $W = (3.4 \times 10^{-4}) L^{2.943}$. The result is similar to that reported by Honman (1988) (i.e. $W = (7 \times 10^{-4}) L^{2.83}$).

The onset of female sexual maturity initially occurs among animals > 50 mm length. As the male sex was not always readily distinguished, the female sex is taken to represent size at maturity. This is within the general size range (i.e. 50–70 mm) at which trochus elsewhere typically mature, although Nash (1993) reported a mature male and female measured at 53 mm and 44 mm length, respectively.

Table 1: Area of strata occupied by trochus and abundance of animals

Strata	Area (m ²)	Density (ind./m ²)	n	s.e.	Abundance	95% c.i.
High density	63,200	0.41	2	0.04	26,100	12,100
Low density	79,000	0.01	4	0.01	1,200	2,200
Possible	87,900					
Nothing	431,100					
Total	661,200		6		27,300	14,300

Approximately 96 per cent of the population are > 50 mm diameter, suggesting a large proportion of sexually mature animals. However, this study had a small sample size (n = 39) and was unable to clearly indicate the ratio of females/males with size classification.

The length (diameter of base) of the average trochus was 84.0 mm (n = 220). Trochus at Penrhyn appear more conical than those found at Aitutaki, which have the larger, thicker base typical of the surf-zone habitat. Only one trochus at Penrhyn was found to exceed 120 mm, whereas in Aitutaki the mean length of trochus was 100.6 mm and maximum length was 151 mm (n = 767, Ministry of Marine Resources survey, 1995). This smaller average size of animals at Penrhyn is not surprising given the recently established population. Bouchet & Bour (1980) note that it takes approx. 10 years for an animal to reach 120 mm.

The trochus at Penrhyn mostly occupy the 10 m stratum at the fringe of the lagoon reef. However, the original site of transplant was in the vicinity of the barrier reef flat (because this is where they mostly occur at Aitutaki). This survey has revealed that the trochus have unexpectedly occupied a different spatial niche (in retrospect, Sims, 1985 pointed out that Aitutaki has an unusual reef topography). The lagoon reef edge at Penrhyn where trochus occur is characterised by high wave action and rocky outcrops with filamentous algal cover which probably offer protection and food.

Based on the survey results and personal observations we suggest that the trochus population abundance at Penrhyn lagoon can be divided into four strata: *high density*, *low density*, *possible* and *nothing*. Trochus predominantly occur along the north-west quadrat of the lagoon and are most likely the offspring from animals accidentally released at Omoko wharf.

Given the density of animals (and area) occupied in the *high-density* and *low-density* strata (0.41 ind./m², 63,200 m² and 0.01 ind./m², 79,000 m², respectively) a population abundance (and 95% confidence interval) of 27,300 (14,300) animals was derived.

Three management options are proposed for further action regarding the trochus population.

Option 1. *Continue the ban on commercial harvest of trochus and allow natural establishment of the existing population in Penrhyn.*

Option 2. *Allow a commercial harvest of trochus in the near future.*

Sustainable limits for harvesting of trochus in Aitutaki are set at 30 per cent of the population in the 80–120 mm size range. This allows smaller sexually mature animals to breed before attaining 80 mm size as well as 70 per cent of the harvest size, and the animals > 120 mm are a reserve of broodstock for future harvest cohorts. The same principles are proposed here but instead it is suggested that the size limits be adjusted to conform with the smaller-sized trochus at Penrhyn. The suggested size range at Penrhyn is 75 to 110 mm (recalling that animals mature at > 50 mm length and the maximum length found was 123 mm). The 75 to 110 mm animals represent 60 per cent of the portion of the population (Figure 4).

Therefore knowing,

1. Population size = 27,000 animals
2. Harvest size range of 75–110 mm = 60% of the population size = 16,200 animals
3. Sustainable limit of 30% of the harvest size = 5,000 animals

- (i) A total of 5,000 animals can be sustainably harvested.

Recalling the shell weight-versus-length relationship (i.e. $W = (3.4 \times 10^{-4}) L^{2.943}$) and assuming that the average-sized trochus harvested is 92.5 mm, the average weight of animal harvested is 208 g. The harvest can be expressed in weight or per sack (assuming 75 kg dry shell per 50 kg flour sack).

- (ii) A total of 1,040 kg of dry shell weight or 14 sacks can be sustainably harvested.

All trochus of 75–110 mm length for sex/size classification were graded as A grade (n = 30). Assuming a CI\$ 7.00 (≈US\$ 4.55) per kg for A grade product, the economic value of the harvest can be calculated.

- (iii) A total value of CI\$ 7,300 (≈US\$ 4,780) can be sustainably harvested.

Option 3. Harvest trochus from high-density areas and transplant the animals to possible sites around Penrhyn lagoon so as to encourage the establishment of trochus population.

The same amounts of animals calculated for a commercial harvest can be removed for the purpose of restocking the lagoon. Some possible sites for relocation are indicated in Figure 6. These sites acknowledge that *Te Tautua* settlement is distant from the trochus present stock, and from the potential trochus habitat in the north and south-west areas of Penrhyn lagoon.

Option 4. Selective harvest of suitably sized animals for use as hatchery broodstock.

As an exercise, trochus juveniles have been reared at the pearl oyster hatchery at Penrhyn. Hatchery-reared juveniles may supplement wild stock for harvesting and also prove useful in developing growth and recruitment models for management purposes.

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Trochus niloticus spawnings at Tongareva Marine Research Centre, Penrhyn Atoll, Cook Islands

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The commercial topshell, *Trochus niloticus*, was introduced to Penrhyn Atoll from Aitutaki Atoll about 10 years ago. In a recent survey by the Ministry of Marine Resources, the broodstock trochus were mainly found on the west side of the lagoon, along the islet where the village of Omoka, the Tongareva Marine Research Centre [TMRC] and the airport are located. At the end of the first week of November 1996, 43 trochus were collected from the corals on the reef front outside TMRC. These were cleaned and set into a tank. The following day (8 November 1996) they were induced to spawn using the heavy aeration method in a small amount of seawater. The induction method

ceased at 18.00 h and the trochus were placed into a spawning tank with clean filtered seawater (fsw). The seawater temperature was raised and lowered a couple of times until release of sperm began, followed by eggs. Large quantities of eggs were spawned, but only a small batch of eggs was kept, fertilised and placed in two hatching tanks. The following day an estimated 5,600,000 trochophore larvae had hatched and after reaching the veliger stage these were stocked in a raceway tank filled to approximately 7,000 litres. Pearl oyster spat were later placed in this raceway with the trochus juveniles and, due to movements of spat and cleaning of raceways, many of the trochus