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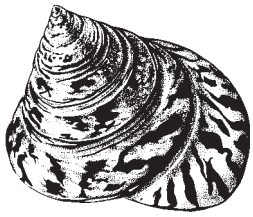

# TROCHUS

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## EDITORIAL

Welcome to the fourth Trochus bulletin. We are fortunate in this issue to have several informative articles from around the region. The bulk of these have come from the recent joint South Pacific Commission / Forum Fisheries Agency Workshop on the Management of South Pacific Inshore Fisheries which was held in Noumea in June–July this year. These give us a useful insight into different approaches to trochus resource management.

In the next issue we should have a summary of a World Bank study on aspects of trochus industries, trade and marketing relevant to the Pacific Islands which is currently underway. This will hopefully answer some of the questions many of us have on what happens to our trochus after it leaves our shores.

Please keep this bulletin in mind when you are writing up your internal country reports, and share your experiences with other members of this Special Interest Group.

Kelvin Passfield

## Inside this issue

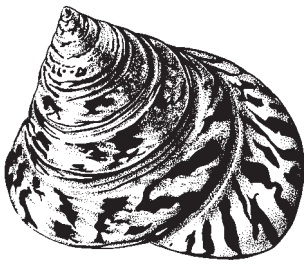


PIMRIS is a joint project of 4 international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the South Pacific Commission (SPC), the South Pacific Forum Fisheries Agency (FFA), the University of the South Pacific's Pacific Information Centre (USP–PIC), and the South Pacific Applied Geoscience Commission (SOPAC). Funding is provided by the International Centre for Ocean Development (ICOD) and the Government of France. This bulletin is produced by SPC as part of its commitment to PIMRIS. The aim of PIMRIS is to improve the availability of information on marine resources to users in the region, so as to support their rational development and management. PIMRIS activities include: the active collection, cataloguing and archiving of technical documents, especially ephemera ('grey literature'); evaluation, repackaging and dissemination of information; provision of literature searches, question-and-answer services and bibliographic support; and assistance with the development of in-country reference collections and databases on marine resources.

PIMRIS

**P**acific **I**slands **M**arine **R**esources **I**nformation **S**ystem

# TROCHUS INFO



## The January 1995 transplantation of trochus from Fiji to Tonga

*by Robert Gillett*

This article describes transplantation of trochus from the Lau Group in Fiji to Ha'apai, Tonga. Work started in early December with preparations with three airlines, with the divers on Lakeba island in Lau, and with the purchasing of gear. To avoid the difficulties encountered in previous trochus work, the Suva-based organisers traveled to Lakeba on two different flights and arrangements for the trochus cargo were negotiated directly with the Chief Executive Officer of Air Pacific.

The first flight to Lakeba was made on 5 January 1995. Final confirmation was made that evening with divers from four villages: Tubou, Nasagalau, Nukunuku and Vakano. The flight the following day carrying the second Suva-based organiser was, however, cancelled. The fallback arrangement for the charter of an aircraft was pursued, but fortunately the regular carrier put on an extra flight the following day.

Trochus diving commenced on 6 January. Targeting a specific number of trochus dictated by a rigid budget is difficult, as there is a risk of obtaining too many or too few trochus. To resolve this difficulty, a quota of 130 trochus per village was established. Because of the credibility established by paying the villagers in cash for two previous operations (May 1994, August 1992), the collection proceeded ahead of schedule. By the end of 6 January more than enough trochus (594) had been collected. Most were medium-sized shells, with few of the very large ones encountered on previous trips to Lakeba.

The trochus were placed in seven plastic net bags and hung off a skiff at the Lakeba wharf in deep water. A few hours before the flight to Suva, the trochus were retrieved and examined for signs of mortality. The bags were weighed, individually covered with thick plastic sheeting, placed in a thick plastic bag, sealed with inner-tube rubber, placed in another plastic bag, sealed similarly, and finally placed in a waxed fish export carton sealed with duct tape. The total weight of each of the seven boxes ranged from 15.5 to 17 kg. Six of the boxes contained 85 trochus and one contained 81, for a total of 591 live trochus.

One dead trochus was detected (by smell) on the afternoon of 8 January and two were found when the shells were being packaged on the morning of 9 January.

Although the flight from Lakeba to Nausori was delayed, the shipment arrived in time to make the flight to Tonga. At 2200 hrs (Fiji time) the trochus were unpacked and placed in tanks of circulating water. The shells were inspected the following day at noon and no mortality was detected. Four live trochus were donated to the JICA aquaculture project. The shells were re-packaged and taken to the airport for the flight to Ha'apai. They were all placed at about 1600 hrs (Fiji time) on the north side of Ava Auhanga Mea between Uoleva and Tataga islands. The location as determined by GPS equipment was 19°51'S, 174°25'W. The habitat was chosen during a survey carried out in March 1994.

In summary, the 587 trochus placed in Ha'apai spent from 3 to 4.5 days out of the reef habitat. They were held dry in transit on the first occasion for 32.5 hours, followed by 14 hours in tanks of circulating aerated seawater, and finally held dry again for 5.5 hours. Three trochus died after collection in Lakeba but there was no mortality during transportation.

## Current paradigms in trochus management and opportunities to broaden perspectives

*by Raymond P. Clarke & James N. Ianelli*
*National Marine Fisheries Service and*
*National Oceanic Atmospheric Administration*

### Introduction

Trochus (*Trochus niloticus*) are coral reef-associated, gastropod molluscs that provide the basis of important inshore fisheries in many areas of the Pacific (Indo-Australian archipelago, Melanesia, Micronesia and, more recently, Polynesia). Trochus, or topshell, have aragonite shells which are the primary raw material for mother-of-pearl buttons and decorative inlay work. The meat is edible and is typically cooked, dried or occasionally canned for consumption. Annual demand for raw trochus shell is estimated at between 3,000 and 5,000 t (Bour, 1990). Most raw material is exported to processors in Japan, South Korea or Taiwan.

Dalzell & Adams (1994) estimate that 80 per cent of all harvests from inshore fisheries in the South Pacific are taken for subsistence purposes. They also note that most of the commercially important inshore invertebrates are harvested for export markets. Trochus fisheries thus form a substantial opportunity for social and economic development in Pacific Island countries. Indeed, much of the literature related to nearshore Pacific Island marine resource development has focused on trochus.

Trochus have been translocated to at least 70 new settings during the past 65 years (Eldredge, 1994). Typically translocations have been supported by public sector (government) initiatives. However, the fact that several early trochus transfer activities were also undertaken by independent fishermen indicates that the resource has long been perceived to have excellent development potential (e.g. in Guam, as noted by Smith, 1987).

Examples of economic success stories for trochus reseeding programmes (also referred to as translocation) are perhaps best exemplified by the Aitutaki fishery in the Cook Islands (Sims, 1988). Adams (in prep.) estimates that between 6,500 and 12,000 t of trochus have been harvested over the past 50 years due to successful transplanting programmes. As successful translocations occurred, research flourished, leading trochus to become one of the most well-studied inshore fishery resources in the Pacific (cf Preston & Tanaka 1990).

Experience with the resource dynamics has increased over the years (see Bour, 1990 and Nash, 1993 for reviews) and a number of truly innovative investigations on alternative approaches to managing the resource have begun (e.g. Nash et al, 1995). However, while trochus reseeding programmes have been a clear fishery development success, examples of success in managing sustainable trochus fisheries are much less common.

A cursory review of the literature provides a number of cogent examples of dramatically variable landings. If landings are viewed as proxies for abundance, then populations have changed dramatically, given that fishery landings have fluctuated by at least three orders of magnitude (Figure 1).

Many people have concluded from these trends that, because trochus are sessile invertebrates, they are extremely vulnerable to exploitation and easily overfished. Fortunately, one of the more encouraging aspects of trochus management is that mistakes, such as overfishing, can potentially be corrected through trochus transplant programmes.

However, responsible resource management policy implies that steps should be taken to harvest the resource at a sustainable level while maximising social benefit and minimising costs. With the substantial and growing amount of marine resource management experience, we feel that a review of trochus fishery management is timely.

To undertake such an analysis, we reviewed historical trends and drew from examples of trochus management techniques applied throughout Micronesia during the 20th century. Micronesia has the longest proactively managed and documented (in English) trochus fishery in the Pacific.

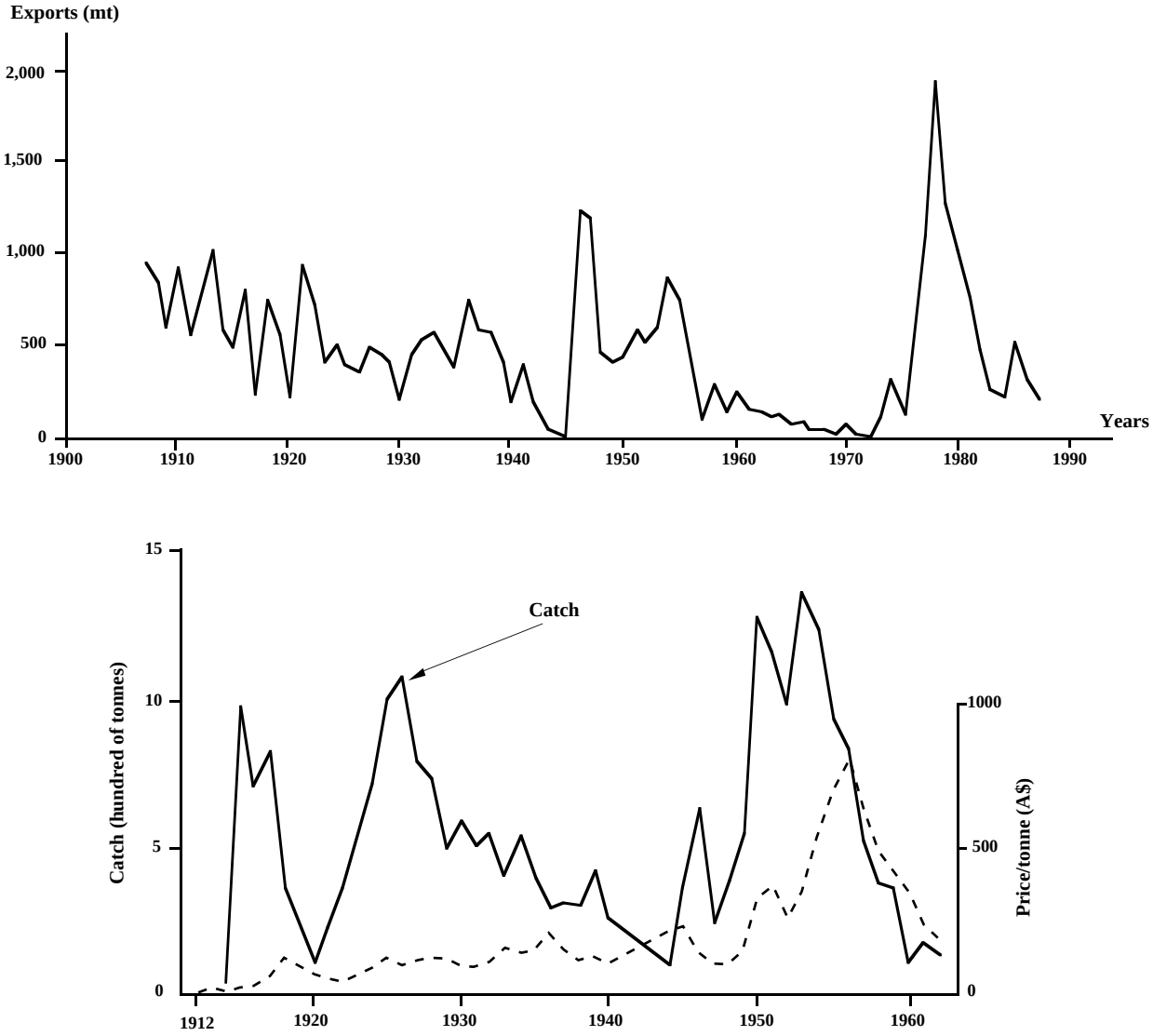



**Figure 1: Trochus landings for New Caledonia (top) and Australia (bottom)**
**Source: Bour, 1990**

## Overview of Micronesian Trochus Fisheries Management

### *Republic of the Marshall Islands (RMI)*

Trochus were introduced into the Marshalls during 'Japanese times' (1915–1945) and now appear to be established on at least six atolls (Jaluit, Majuro, Ailinglaplap, Arno, Mili, Enewetak). At least four surveys have documented the trochus fishery in the Marshall Islands (McGowan, 1957a and 1958; Wright et al, 1989; and Curren, 1993) with the latter two concentrating on Enewetak Atoll. Trochus were initially translocated to Jaluit Atoll via an ocean liner and were later spread to least seven atolls (Eldredge, 1994 and Gillett, 1991). Historical records of harvests in the Marshall Islands are especially poor and warrant further investigation (Smith, 1992a).

The harvest of trochus in the Marshalls Islands is currently regulated by the Marine Resources (Trochus) Act of 1983 (P.L. 1983-15§1). The origins of the Act are linked to US Trust Territory of the Pacific Administration (TTPI) laws and apply to all internal and territorial waters of the Marshall Islands. The Act makes the Cabinet of the President responsible for declaring harvesting seasons for trochus anywhere in the Marshall Islands, and each harvest period (season) is not to exceed three months in any twelve-month period. Only citizens of the RMI are allowed to harvest trochus,

and consideration is afforded to customary law regarding access.

In addition, no shell with a basal diameter of less than 7.6 cm (3 in) is to be harvested. The transplanting of trochus requires a written permit from the Minister of Resources and Development and there is provision for the removal and transplanting of trochus in the event of a disturbance (i.e., construction) at cost to the responsible party.

Currently the actual implementation of the Act is decentralised, with control given to the local atoll or its representative, either a democratically elected Atoll Council or a mayor. The local atoll government, typically an Atoll Council, decides when to initiate a trochus season. For logistical purposes, the season is timed according to appropriate tidal fluctuations (in late northern summer in the RMI). The Atoll Council then makes a request to the Nitijela, the legislative body of the RMI, through its representative Senator, who obtains the permission of the Cabinet. The Cabinet will set the season timing (initiation date and length) and may provide specifics on areas to be harvested or other restrictions (such as locations for buying). Typically the recommendations from the Senator or the Atoll Council are accepted without modification.

Despite trochus shell's apparent economic significance as an export income-earner, ranking second or third behind copra and aquarium fish through most of the 1980s, records of the level of removals and the amount of effort expended are lacking. Smith (1992a) reports that 'accurate production figures are not available' and there is no resemblance between existing records, even on production from a specific atoll such as Enewetak (eg, compare Wright et al 1989, with Curren, 1993 or see Smith, 1992a). The only 'consistent' records are those from the RMI Office of Planning and Statistics (Table 1).

Smith (1992a) indicates that open seasons, each for the maximum period of three months, were approved in 1987 on all atolls for the period between August and October, in 1989 for Enewetak only between September and November, and in 1990 for Enewetak for the same period as in 1987. There have been no harvests on Enewetak since 1990, despite a survey by Curren (1993) in 1992 recommending, as did Wright et al (1989), that a 100 t quota be established. The lack of an ensuing harvest on Enewetak is as much due to concern for the resource as to general lack of confidence that fishers will obtain a fair price. The lack of a coordinated buying scheme is also believed to have inhibited the initiation of harvests on

**Table 1: Estimated trochus production and value for the Republic of the Marshall Islands, 1987–1994.**

| Year | US$ (000) [1] | Weight (mt) | Location |
|---|---|---|---|
| 1987 | 179,000 | 100 | Enewetak |
| 1988 | 350,000 | 150 | Enewetak |
| 1989 | 467,000 | 145 | Various |
| 1990 | 179,000 | 100 | Various |
| 1991 | 176,000 | ? | Various |
| 1992 | 176,000 | ? | |
| 1993 | 0 | No landings [1] | |
| 1994 | 0 | No landings | |

[1] provided by D. Jack, MIMRA, 1995

Source: RMI Office of Planning and Statistics, with weight and location data from Smith, (1992a) and Curren, (1993)

other atolls, such as Ailinglaplap (K. Hart, pers. comm.). Sources at MIMRA indicate that there has been no harvest of trochus during the past two years. Based on the research and recommendations from Wright et al (1989) and Curren (1993) the RMI sustainable trochus harvests appear to be in the vicinity of 100 t annually.

***Federated States of Micronesia (FSM)***

According to a variety of sources, trochus naturally occurred in the FSM only in Yap proper. It has been harvested commercially at least since 'German times' (1898–1914) (Smith, 1992b; McGowan, 1958; Asano, 1938 as translated by Izumi, 1987). The trochus resource apparently had particular value to the Japanese and was the subject of substantial translocation efforts between the late 1920s and the 1940s.

The Japanese began translocating trochus from Palau to Chuuk Lagoon in 1927, with efforts continuing at least until 1931. After this, based on what was apparently observable success, the Japanese Government undertook an aggressive translocation programme in many of the islands and atolls in the FSM, with seed stock coming from either Palau or Yap proper.

Current records of FSM transplants can be found in a number of sources (Gillett, 1991; Bour, 1990; Nash, 1993; Smith, 1992b; Eldredge, 1994; Izumi, 1987). By the end of the 'Japanese times' most of the high islands and many of the populated atolls had undergone trochus transplantations by the Japanese. To a lesser extent these efforts continued under the US Trust Territory of the Pacific Islands (TTPI) administration (eg, to Kosrae) (Smith, 1992b).

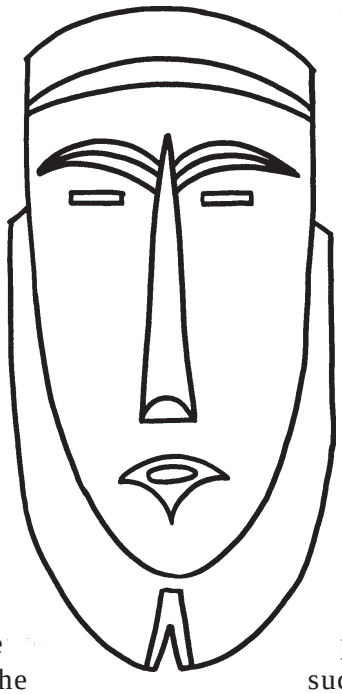
Trochus introductions were re-started in earnest in the early 1980s as a result of regional research on trochus, based mainly in Palau. The Pacific Fisheries Development Foundation, located in Honolulu, Hawaii, undertook a number of trochus reseeding projects in the mid-to-late 1980s, mainly focusing on the outer atolls of Chuuk, Pohnpei and Yap States. These efforts continued into the 1990s, and there are plans to expand the translocations in late 1995 in some areas of the outer atolls of Yap State.

It appears that at least through 'Japanese times', and later under US administration, the trochus resources of the FSM were managed under regulations that were regional in scope. For a considerable portion of the Japanese period there appears to have been a minimum size limit of 7.6 cm, which, according to Asano as quoted in McGowan (1958), was based on 'experience'. In 1937, the minimum size was raised to 8 cm based on 'research' but, as McGowan (1958) states, this 4 mm increase 'failed to have long term results'.

The Japanese also employed seasons ranging from two weeks to one month and in 1922 declared a moratorium on trochus fishing throughout the region. But the results of the moratorium were ambiguous, as landings data from Palau and Yap indicate; the catches in the following year were 'quite high' in Palau but were clearly not so in Yap (McGowan, 1958). However, these data are difficult to interpret without information on effort levels.

After World War II the first trochus management documentation by US authorities can be found in the reports for the US Commercial Company (USCC) *circa* 1946. Bascom (1946) reports that trochus had not been exported from Pohnpei prior to the war, and there was no evidence that the Japanese prohibited trochus fishing at any time (but it was assumed that they would have once an export trade had been established). In the absence of any data specific for Pohnpei, an open season in May and June 'which the Japanese allowed in other parts of the Carolines' was adopted by the USCC and a minimum size of 8 cm invoked.

Hall and Pelzer (1946) report for Truk (Chuuk) that, despite substantial efforts by the Japanese administration in trochus seeding, they appeared not to have 'profited greatly from this work'.They recommended that the pre-German pattern of vested reef ownership be re-established to ensure equitable and efficient trochus harvests in Truk.



Management 'under the principle of a sustained yield economy, subject to regulations passed for reasons of conservation' was the recommended management objective. But in May 1946 the US Government notified the chiefs of Truk that it considered all trochus beds to be the property of the US since they had been planted by the Japanese and were considered the property of the Japanese South Seas Government prior to the war. The USCC's first season, and in turn first commercialisation of the resource on Pohnpei, occurred in June 1946 when Okinawan and Truk 'natives' collected large quantities of trochus; 50 per cent of this had to be rejected because of worm damage or other defects.

The first region-wide review of the trochus resource was by Smith (1946, 1947) who reviewed all marine resources in Micronesia and their use just after the end of the war. Smith reported that the collection of trochus was done by the 'natives', who were permitted to harvest individuals over 7.6 cm in base diameter (note difference from USCC size of 8 cm reported above) during a two-week period during May or June.

None were collected between 1942 and 1946, but 100 t were purchased by the USCC during 1946. McGowan's work (1958) provides the basis for much of the management employed by the TTPI Administration through most of the 1960s, 1970s and 1980s. On the basis of his two and a half years of research in Micronesia, McGowan breaks management regimes down into three basic categories: moratoriums, seasons, and minimum size limitations. He does not endorse moratoriums and is ambiguous on the appropriate minimum size regulation, while recognising the need for seasonal openings / closures. The 7.6 cm (3 in) size employed by that time in the FSM (and Micronesia in general) was not endorsed as being effective but nor was an increase from 3 in to 4 in because of an anticipated 55 per cent decline in landings based on length-frequency analysis.

Declines in trochus population, and in turn of landings, recorded during the 1950s were attributed by McGowan to the lack of large individuals, leading to what he interpreted as reduced spawning stock biomass, and to densities that were reduced to the point where spawning was unsuccessful.

This hypothesis resulted in the recommendation that sanctuaries be implemented; by 1958 there were sanctuaries reportedly established in Yap, Truk (Chuuk) and Pohnpei (along with Palau). The TTPI management regime was later reviewed by Parkinson (1980) who found that the trochus sanctuaries were 'sited in fairly arbitrary fashion' (in Palau and Chuuk in particular). He also reported there was little or no enforcement of these areas.

Modern management (late 1970s to 1992) of trochus in the FSM, by state, is reviewed in detail by Smith (1992b); therefore, only relevant sections are reported here. Each state in the FSM is responsible for managing inshore resources, and while there is an FSM code dealing with trochus exploitation (Title 23, Section 108-115) this code is regarded as unnecessary, except for Chuuk State where the current management regime is ambiguous.

*Yap State*

Yap State, in which trochus occur naturally, has the longest record of exploitation in Micronesia (along with Palau) and historical landings have had to be compiled from a number of

sources (Figure 2), yet significant gaps remain. During the later 1980s there were a number of proposals to build a trochus hatchery on Yap proper, but a feasibility study questioned the long-term benefit of such a facility (Uwate, 1986; Heslinga, 1988).

Yap State currently manages trochus under Title 18, Section 1009 of the State Code, which calls for the Governor to determine harvest levels, areas and seasons. Practically speaking, the Yap State Marine Resources and Management Division of the Department of Resources and Development works closely with the Governor's Trochus Protection and Harvest Review Committee to determine actual regulations.

For 1994, the basic regulatory framework involved minimum and maximum size limits of 7.6 and 10.2 cm respectively, a season lasting at most one week, registration of all harvesters (who must be FSM nationals), a non-transferable US$ 5.00 permit fee, a ban on scuba-aided collection and acceptance by buying stations of live specimens only. These same regulations are applied to the outer atolls, but the actual season may vary according to particular conditions, typically associated with the scheduling of appropriate transport of buyers and product (Smith, 1990). Currently viable fisheries are known to occur on at least two outer atolls (Ulithi and Woleai), and it is believed that fisheries may soon be initiated on a number of additional outer islands.

Also under consideration by Yap State is the creation of a centralised, government-supported Trochus Marketing Authority. This Authority is envisioned to have sole buying and selling rights of the trochus resource in Yap, with the objective of 'close-coupling the cost of managing the resource with the economic benefits generated by the resource'. The proposed Authority is to be made up of five Directors, with a manager and a secretary. It will be responsible for resource assessment and the introduction of new management schemes (e.g. Individual Transferable Quotas, ITQs), the purchasing and marketing of all trochus products, and, research, along with any future reseeding efforts. These activities would be defrayed through 'the buying and selling of trochus... less the cost of operations'. The current status of this proposal is unknown.

In 1994, the total trochus harvest was 32 t, valued at approximately US$ 70,000. A target of 25 t was anticipated to be harvested, but the 7 t difference was landed because of inability to comprehensively monitor and control harvests during the open season (J. Fagolimul, pers. comm., 1995). For Yap proper, the long-term sustainable yield has been tentatively

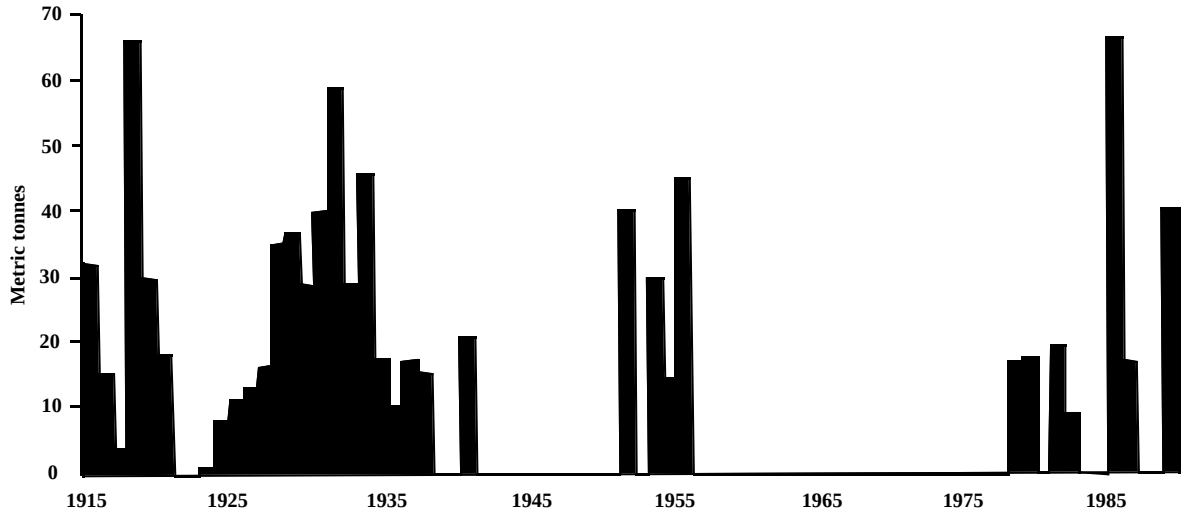



**Figure 2: Time trend of Yap trochus harvests**

Sources: Asano, 1939; McGowan, 1958; Smith, 1947; Smith, 1990.
Note: Yap MRMD indicates 32 t harvested in 1994.

estimated at 23–25 t, based on historical landings. With the addition of sustained harvests at Ulithi and Woleai Yap State landings could exceed 30 t annually (J. Fagolimul, pers. comm., 1995).

*Pohnpei State*

In Pohnpei State, the trochus fishery was first exploited after World War II. Historical landings were compiled from a variety of sources and are depicted in Figure 3.

Currently in Pohnpei State the Director of the Conservation and Resource Surveillance designates open seasons (not to exceed 60 days), and the areas in which harvesting may take place. Specimens between 7.6 and 10.2 cm (3 and 4 in) basal diameter are the only size allowed to be harvested and the use of scuba equipment is outlawed. Specimens must be brought alive to buying stations, where a receipt is issued detailing the number of live, dead, and undersized trochus landed and designating the volume that may be sold for cash.

All trochus are cleaned by the producers. There are no data available on how much of the meat is sold or consumed, but it is believed that much of the meat is not utilised (Curren, pers. comm.). Pohnpei has several sanctuaries, but the integrity of these areas has been compromised during several recent harvests (Smith, 1992b).

Pohnpei is relatively unique in the FSM in that it uses discrete seasonal openings in an attempt to limit catch in the face of continually increasing effort and declining abundance. Based on density surveys, a Total Allowable Catch (TAC) is estimated, along with anticipated effort (number of harvesters), to determine *pro forma* the time needed to harvest the TAC. The length of the season is modified accordingly and recent trends show a dramatic decline in duration (Table 2).

**Table 2: Pohnpei trochus season (in days) and relative production in weight and value in US$, 1986**

| Year | Days | mt/day | US$/day |
|---|---|---|---|
| 1984 | 30 | 4.51 | 7,450 |
| 1985 | No harvest | | |
| 1986 | 20 | 9.07 | 23,000 |
| 1987 | No harvest | | |
| 1988 | 3 | 62.70 | 168,666 |
| 1989 | No harvest | | |
| 1990 | 1 | 86.00 | 862,000 |
| 1991 | 0.33 | 185.00 | ? |
| 1992* | 0.25 | 144.00 | ? |
| 1993 | No data | | |
| 1994 | No data | | |

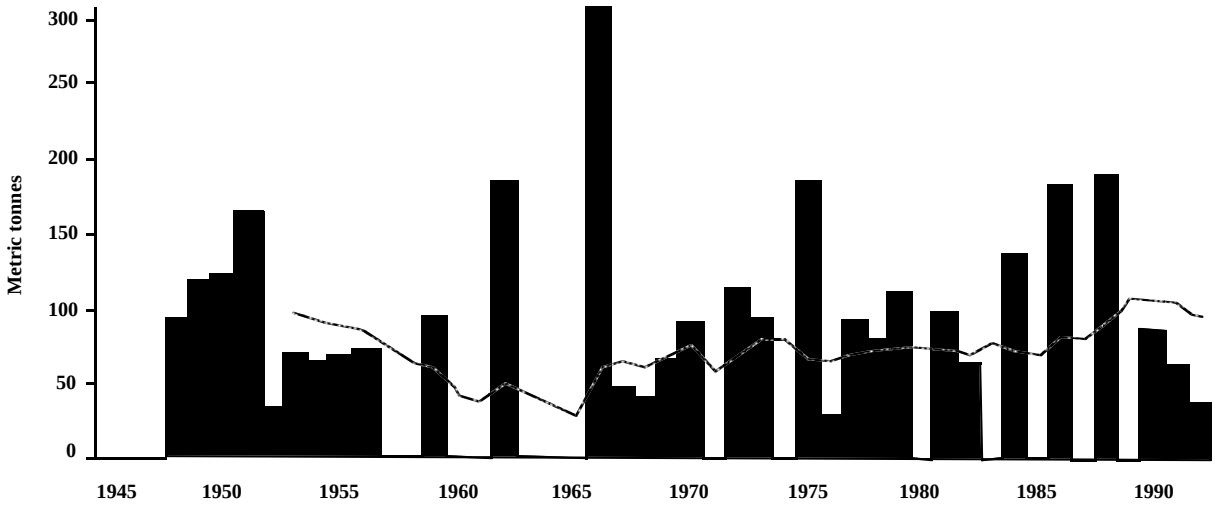



**Figure 3: Time trend of Pohnpei harvest. Bars represent estimated landings, line represents a moving average of removals.**

Sources: McGowan, 1958; Smith, 1992b; Parkinson, 1980

The Pohnpei State Government, through its Marine Resource Division, in conjunction with the Pacific Fisheries Development Foundation, supported trochus hatchery and juvenile release research in the late 1980s, but the results appeared not to have been cost-effective and were discontinued in early 1993. No estimates of the long-term sustainable harvest were made, but historical data indicate that the trochus resource of Pohnpei State is potentially one of the largest inshore fisheries in all of FSM. Figure3 suggests that 50–60 t annual harvests may be sustainable over the long term, depending on the various management tools employed, but this is suggested as a very provisional target.

*Kosrae State*

For Kosrae, the Director of the Department of Conservation and Development regulates the time, place and method by a permit system, but the actual harvest is monitored by the Kosrae Marine Resources Division. Kosrae has a minimum-and-maximum size regulation (7.6–10.2 cm), all harvesters must be registered, no scuba equipment is allowed, and seasons are typically less than two weeks.

There is a sanctuary on Kosrae that is reportedly used for restocking or seeding other areas on the island. Trochus hatchery work has reportedly gone on at the FSM National Mariculture Facility in Kosrae for several years now, but no details were obtained for this study. Smith (1992b) reports that, between 1984 and 1992, four trochus harvests occurred (1984–8.1 t, 1985–16.1 t, 1988–10.2 t and 1992–5.5 t). No long-term estimates of sustained harvest were obtained, but the stock appears to be expanding and 8–10 t per year may prove a sustainable target in the short term.

*Chuuk State*

In Chuuk State, trochus is managed under the vestiges of the TTPI code; however, new management and regulatory regimes may have been instituted recently. The TTPI regime involved a minimum size of 7.6 cm, and seasonal openings between May and September. Chuuk had several sanctuaries during the 1980s and between 1986 and 1992 no legal trochus season was declared (Smith, 1992b). The status of the resource is unknown, but in recent years there have been proposals to build a trochus hatchery in Chuuk to mitigate against overfishing. No long-term landing data were compiled and no estimates of the long-term sustainable harvest were found. A cursory review of Smith (1992b) reveals that landings have fluctuated recently between 0 and 110 t, suggesting that 30–40 t per year may prove a viable target for sustained harvests.

While the FSM has implemented a set of relatively wide spectrum of management strategies, fisheries' staff is still facing overfishing problems. For example, virtually every state in the FSM has enforcement problems (Smith, 1992b). In fact, this problem is not unique to the FSM; it represents one of the major costs incurred for all management regimes, as highlighted in the discussion section below.

***Republic of Palau***

Trochus are found naturally in Palau and have a long history of being exploited. Reports (e.g. McGowan, 1958) indicate that exploitation occurred on a regular basis in the late l900s; however, harvest records date to the early twentieth century and are particularly strong for the period referred to as the 'Japanese times' (Figure 4).

During this period the Japanese appeared to manage the fishery with minimum size and season limitations, along with enforcement by the central government and local village systems (Gail & Demambez, 1958). Motoda (1938) reported during this period that only 'natives' were allowed to harvest trochus, for the 'protection of native life'.

The fishing season was initially restricted to between May and June and the fishing grounds were restricted to particular areas 'according to the circumstances'.

Minimum size regulations of 7.6 cm (3 in) were imposed. Harvesting was by 'bare' diving and sometimes the meat was eaten but 'not usually'. The fishing season was limited to July, August and September in 1916, but shifted to May and June in 1921. While the fishery ap

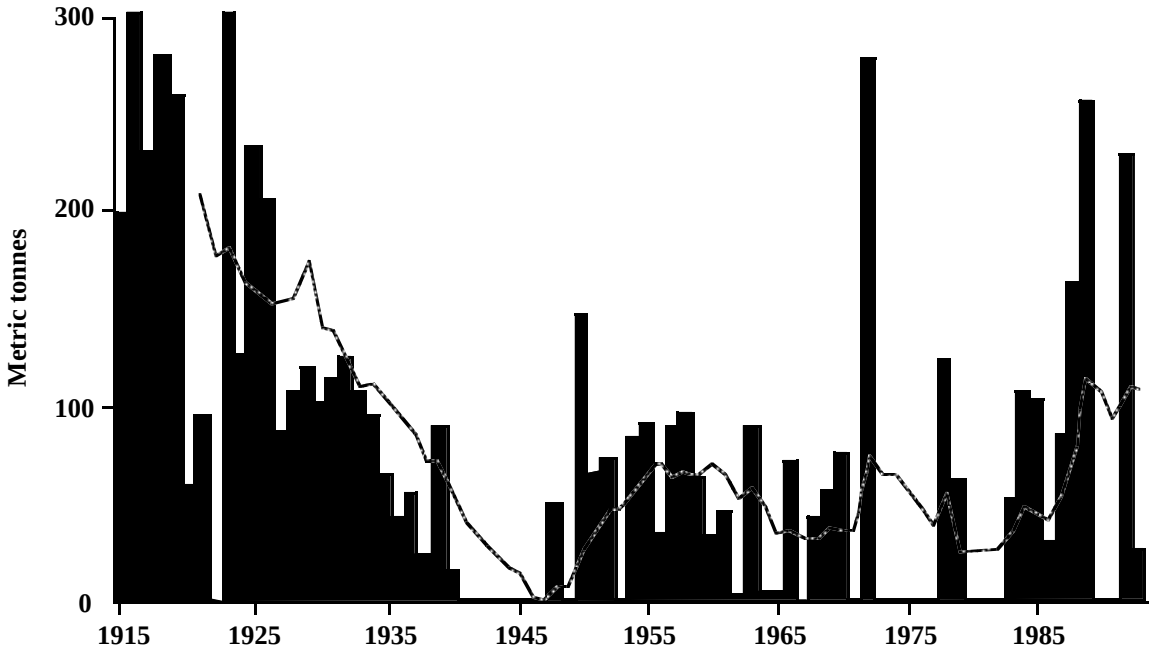



**Figure 4: Time trend of Palau harvest. Bars represent estimated landings, light line represents a moving average of removals.**

Sources: McGowan, 1958; Heslinga, 1981; Nichols, 1991; Smith, 1947; and Parkinson 1980

pears to have been actively monitored and proactively managed during Japanese times, catches fluctuated considerably and there were problems similar to those reported today. For example, Motoda (1938) reports that in March 1937 a vessel from Takao, Formosa (Taiwan) was apprehended by the South Seas Government (Japanese) for poaching trochus. The vessel carried 20–30 Loochoo fishermen, who were reportedly on their way to trochus fishing grounds in the Koringal Islands, Great Barrier Reef or New Caledonia.

After World War II, trochus management fell to the US administrators of the Trust Territories, as cogently summarised by McGowan's extensive work in 1956–58. McGowan's proposal to establish a sanctuary system on each island or atoll was implemented in the 1960s in most of the TTPI (Truk, Pohnpei, and Yap). This management tool was based on what, at the time, was hypothesised to be the importance of a short-term, lecithotrophic larval span and allele effect in the eventual recruitment success of trochus.

It was recommended that one sanctuary be established for each five miles of barrier reef (McGowan, 1958). Sanctuaries were eventually established in several states in Palau by members of the 'local Conservation Division' (Heslinga et al, 1984).

When Palau became a Republic in 1980, trochus management and monitoring responsibilities which were formerly vested in the TTPI Administration were devolved to the state level (of which Palau has 16), but the Palau Marine Resources Division (PMRD) was (at least in theory) available to assist each state by providing advice on the appropriate levels of harvest, population assessments and the establishment of sanctuaries. During this period also, a moratorium system in which a particular state or village stopped collecting trochus for more than one year was established in several states; e.g. Kayangle in 1979, Angaur and Ngeremlengui in 1980, Koror, Kayangle, and Peleliu in 1983 (Heslinga et al, 1984).

Trochus sanctuaries were one of the first examples of modern use of the sanctuary concept as a management tool in Micronesia (though they have a long history in traditional management systems—see Johannes, 1981, 1991). However, the effectiveness of the modern trochus sanctuary system in Palau was investigated in the early 1980s and found to be of questionable

merit, partly because surveys indicated that trochus densities were greater outside sanctuaries, in areas open or subject to fishing, than within them (Heslinga et al, 1984). This was hypothesised at that time to be caused by sub-optimal habitat within the designated sanctuary areas.

Heslinga et al (1984) emphasise the importance of placing an effective sanctuary in proximity to appropriate authorities (whether modern or traditional) to allow effective and efficient monitoring and enforcement. The sanctuary concept could have performed better in Palau (specifically Koror State) if the sanctuary areas that McGowan originally recommended had been established and enforced.

However, the recommended areas were based on biological considerations and apparently did not take into account cultural or socio-economic factors (Heslinga, pers. comm., 1995). The effectiveness of sanctuaries has always been dependent on enforcement, which has been problematic, especially in the urban centres, as recently documented by Johannes (1991).

During the late 1970s and early 1980s, enforcement of existing management regulations was noted as particularly difficult; e.g. in a number of locations in Palau trochus were fished to 'extinction' (Heslinga, 1981a).

In 1979, 20 per cent of the trochus harvested in Palau were below the 7.6 cm minimum size and, despite a one-month fishing season, many fishers routinely collected trochus out of season and hid the shells until they could be legally sold.

Commensurate with the tenor of the times in several areas in the Pacific, Heslinga (1981a, 1981b) alludes to the prospects of aquaculture and reef reseeding or artificial enhancement to augment overfished stocks in Palau. Heslinga notes that:

> 'efforts to protect trochus stocks through conventional regulatory measures have been only marginally effective in the Pacific where enforcement capabilities are almost universally inadequate' and
>
> 'reseeding of selected reefs should be investigated as a potential means of conserving this valuable resource'.

At that time the complete biology of the species was not fully understood, nor had it been reared on a consistent (much less commercial-scale) basis anywhere in the Pacific. Artificially augmenting trochus stocks was partly justified because of the socio-economic importance of trochus to remote Pacific Islands. For example, Heslinga (1981a) indicates that the 1979 ex-vessel price in Micronesia of US$ 0.55 / kg represented 'a 500% increase in the last decade'.

Stock augmentation by rearing juveniles for release on to reef flats was also investigated, because the fishery had considerable socio-economic benefits: the skill, capital investment, and technological levels for participation in the fishery were relatively low and appropriate for rural Pacific Island settings. Research during the early 1980s explored the feasibility and cost-effectiveness of trochus mariculture as a management option. Consistent production of hatchery-reared trochus was quickly attained (Heslinga, pers. comm., 1995).

However, during the late 1980s the effectiveness of releases, as well as a concrete demonstration of cost-effectiveness, continued to elude researchers in Palau . In 1992 the PMRD shifted emphasis away from the mariculture / reef augmentation approach, since research and empirical evidence indicated that 'conventional methods of management were considered a more cost effective approach to managing Palau's trochus fishery than artificial stock enhancement through mariculture'.

Recent personnel changes at PMRD have apparently resulted in the re-evaluation of this policy, in that efforts are now under way to restart trochus propagation activities at the Palau Mariculture Demonstration Center and a stock augmentation programme is expected to be in place by the end of 1995 (D. Otobed, pers. comm., 1995).

While investigations on artificial rearing were increasing and hatchery methods were being further developed in the early 1980s Palau's trochus fisheries underwent severe declines (see Figure4). Much of the lack of control over the fishery during this period could be attributed to the decentralisation of management authority. The individual states of Palau had difficulty effectively managing the trochus resource 'as concerns about the ability of the resource to sustain itself arose as the fishing pressure increased throughout the 1980s'.

In August 1989, these concerns led to the passage of legislation by the Third Olbiil Era Kelulau (OEK) (Under the Palau National Code title: Environmental Protection, Subchapter IV: Trochus) which returned control to the central government and initially established a three-year harvest moratorium in all states (except Sonsorol and Tobi States). Subsequent Executive Orders and OEK legislation established seasons, typically of one month, and confined harvest rights to Palauans, while maintaining the 7.6cm minimum size. Koror State still maintains six sanctuaries, while at least one other state (Ngaraard) has established at least three.

Palau's Ministry of Resources and Development (of which the Division of Marine Resources is part) is currently responsible for monitoring the status and harvests of the trochus resource. The most recent trochus survey was conducted by PMRD in 1991 and encompassed surveys (via visual census) in eight states. From standardised transects using visual census, Ngiramolau et al (1991) estimated there were 40.9 $km^2$ of optimal trochus habitat in Palau, with densities of 12,400 trochus per $km^2$. Using an average weight of 0.32kg (0.7 lb) per trochus they estimated total biomass at 160 t.

Application of a 40 per cent exploitation rate to this estimated biomass gives a potential sustained yield of 64 t. Nigiramolau et al suggested that an export quota be established, based on a pre-fishery assessment, allocation of the quota between buyers, and the utilisation of the trochus meat being discarded.

The data suggested that the 1989 harvest of 257t was excessive, as had been the 1985–1989 average harvest of 130 t. Ngiramolau et al report that, during the 1989 season, fishers worked day and night and many undersized shells were harvested. They also indicate that remote sensing (satellite imagery) will be used in the future to better quantify habitat for trochus, in order to refine these data. This initiative has seen little subsequent progress.

In 1992, at the direction of the OEK, the first trochus season in three years yielded approximately 250t (see Figure4) (the exact figure ranges from 229 to 265 t). Most (76%) was sold as raw (uncleaned) shell for approximately US$2.65 / kg. The harvest was composed of 86 per cent shells between 7.6 and 10.2 cm in diameter, indicating the importance of first-year recruits to the fishery. Of particular interest is the fact that 1,438 individuals (10% of the population) sold trochus on 2,214 occasions to two local buyers, with an average of 83 kg or US$220 per transaction (or US$335 per individual). The total harvest brought in US$645,000 (ex-vessel).

With the exception of Koror State, which has obvious logistic advantages, the importance of the trochus harvest is demonstrated by the fact that the more remote states harvested and sold

proportionately greater amounts of trochus per transaction. The reported catch rate of 9.1 kg / fisher / hour (or US$24 / hr) compares favourably with the estimated rate of 2.3 kg / fisher / hour for the period 1936–1941. The higher catch rate was attributed in part to increased numbers of trochus, but also to the fact that the use of larger boats with larger engines has made even the most remote areas accessible to harvest.

The 1992 harvest had a reported export value of US$1.1 million. Trochus was Palau's second leading export item, after tuna. PMRD records indicate that, for the 1992 harvest, only about 300 kg of trochus meat entered the standard commercial marketing channel; it was sold for US$1.00 per pound. Approximately 600 kg were exported as personal luggage by air carrier. Additional quantities may have been sold commercially and an unknown quantity was harvested for subsistence consumption.

In 1993 a fishing season was declared by the OEK, but only two states (Koror and Peleliu) chose to open the resource to fishing, with 29 t valued at US$59,000 being harvested (no export value is reported). There were no trochus harvests during 1994. Currently no major changes are expected in the management of the trochus resources in Palau. A season is currently underway in Palau (June), with fishing effort reported as high (N. Idechong, pers. comm.).

*Guam*

Trochus was introduced to Guam from Saipan in the l950s, reportedly by private fishers, and has become widespread in most reef areas. Little information was found on the historical aspects of trochus management in Guam after introduction, but the management regime during the 1960s most likely resembled that found in other US Territories. In 1989, trochus regulations were revised to take into account the growingly different stakeholders participating in the fishery.

Currently, the regulatory regime in Guam is unique for Micronesia in that it is broken into commercial and recreational / subsistence seg

**Table 3: Commercial and subsistence trochus harvests, Guam, 1979–1995**

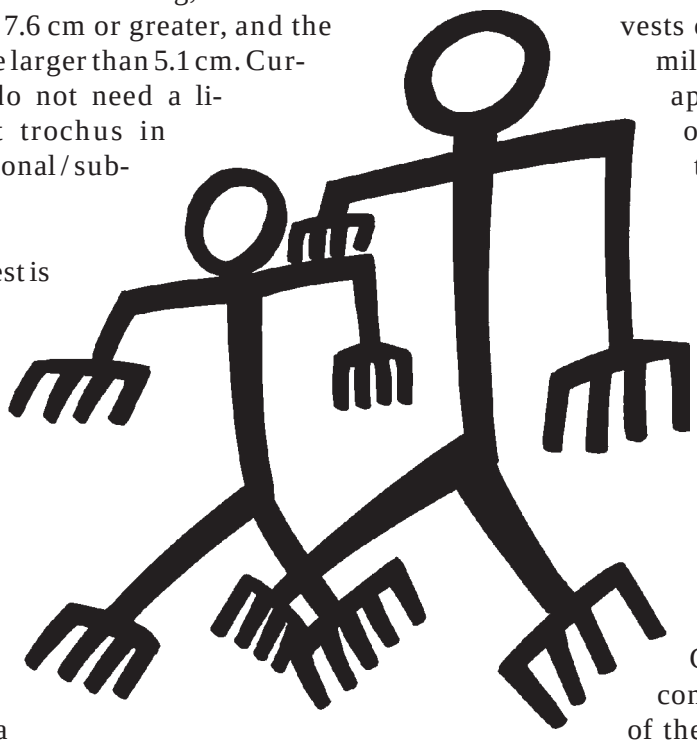
| Recreational/subsistence [1] | | Commercial | | |
|---|---|---|---|---|
| **Year** | **Weight (kg)** | **Fishers** | **Seasons** | **Pieces** |
| 1979 | 1,661 | | | |
| 1980 | 1,025 | | | |
| 1981 | 961 | | | |
| 1982 | 4,730 | | | |
| 1983 | 700 | | | |
| 1984 | 7,300 | | | |
| 1985 | 1,430 | | | |
| 1986 | 1,350 | | | |
| 1987 | 840 | | | |
| 1988 | n / a | | | |
| 1989 [2] | 900 | 9 | 1 May – 15 June | 10,300 |
| 1990 | 982 | 7 | 1 – 28 May | 10,300 |
| 1991 | 690 | 6 | 1 May – 5 June | 10,110 |
| 1992 | n / a | 7 | 1 May – 20 June | 10,000 |
| 1993 | n / a | 6 | 1 May – 27 June | 10,000 |
| 1994 | 300 | 0 | | 0 |
| 1995 | | 0 | | 0 |

[1] Recreational / subsistence landings based on creel surveys. Numbers should be taken as indicative, rather than absolute measure of landings.

[2] Prior to 1989, regulations for commercial and recreational harvests were identical.

Source: Guam Division of Aquatic and Wildlife Resources.

ments. Regulations allow year-round harvesting for home consumption, as long as no more than 22.7 kg (50 lb) of wet weight are harvested per person per day. Of the 22.7 kg, at least 18.1 kg (40 lb) must be 7.6 cm or greater, and the remainder must be larger than 5.1 cm. Currently residents do not need a licence to harvest trochus in Guam on a recreational / subsistence basis.



Commercial harvest is restricted to animals larger than 10.2 cm (4 in) and is regulated by the requirement for a permit (cost: US$ 25) from the Guam Division of Aqua-tic and Wildlife Resources. There is an island-wide quota (10,000 pieces), which does not fluctuate from year to year and is based on what is believed to be the long-term sustainable harvest, but there have been no recent efforts to adjust or modify the quota.

All shells are to be collected from outside the reef margin and there is a 50-piece-per-day limit. Prior to 1989 the commercial harvest of trochus is believed to have been small, with the majority of the commercial fishers being Korean or Filipino (G. Davis, pers. comm., 1995). Recent commercial and recreational / subsistence landings are shown in Table 3. On the basis of the 10,000 piece limit, Guam is capable of producing 3–4 t of trochus each year.

***Commonwealth of the Northern Mariana Islands (CNMI)***

Trochus were originally brought from Palau to Saipan during 1937–38 by the Japanese and reportedly were very successful in spreading and reproducing (Asano, 1938), so much so that by the early l950s specimens were being transported to Guam for translocation efforts there. Commercial fishing in Saipan occurred approximately 13 years later, with trochus being transported to several other islands (Rota, Tinian and Agrihan) in the Mariana.

McGowan (1958) reported harvests of 2.3 (short) tons per mile of reef in Saipan, with approximately 13 miles of good habitat, for a total harvest of 30t in 1956. He related these high production rates to the relatively unexploited conditions, and noted their remarkable similarity to those seen in other Micronesian trochus fisheries (eg, Palau, Yap, Chuuk, Pohnpei) during peak production years.

Commercial harvests continued through most of the 1960s and 1970s, although records specifically for the Marianas are not available; Marianas harvests are believed to be reported with total TTPI harvests (Adams et al, 1994).

During the US TTPI administration the minimum size limit of 7.6 cm was in effect, as well as seasonal openings / closures. Due to what was apparently heavy fishing pressure during the late 1970s and early 1980s, a moratorium on trochus fishing was established in 1982 by the CNMI Division of Fish and Wildlife.

In 1986, regulations were modified and two sanctuaries were established (around Garapan channel and Tank Beach), along with the establishment of a permit system for the commercial harvesting, buying or selling and a catch report.

The effectiveness and enforcement of current laws appear problematic; for example Adams et al (1994) report that 14.65t of trochus were imported to Japan from the 'Marianas Islands' in 1989, indicating a significant breach of the commercial moratorium, but they also allude to the fact that this report may represent transhipping from another port of origin.

Despite the moratorium, it appears that exploitation levels near population centres in the CNMI are considerable and that trochus are typically kept if found during reef fishing or gleaning activities by local residents. Adams et al (1994) note, that while effort was diffuse, it was difficult to control and that trochus were at best 'moderately abundant in areas far from shore, near sharp coral or urchins or close to Government offices'.

There have been at least two assessments of trochus resources in the Northern Mariana Islands (McGowan, 1958); however, both appear to be qualitative in nature and neither is based on statistically verifiable results. In 1994, the South Pacific Commission completed a survey and resource assessment of the trochus stocks in the areas of Saipan, Rota and Tinian using a team of experienced biologists employing predominantly transect methods. The results indicated that the trochus resource at any location was not 'dense' and appeared to be 'maximally' exploited (Adams et al, 1994).

Substantial fishing pressure, along with lack of appropriate habitat, were proposed as limiting factors in many portions of the Mariana Islands, and a precautionary approach was recommended for the few reserve areas in which trochus were found in moderate numbers. The report estimates that a harvest of 11–13t/year may be sustainable from the three areas combined, with the caveat that this number includes all sources of harvest mortality.

The DFW has formulated a number of general recommendations as a result of the 1994 survey. They exclude commercial harvest and the use of artificial breathing devices, maintain the 7.6 cm minimum size, require all harvesters to obtain a licence from DFW, allow 10 pieces to be harvested daily (and a maximum of 200 in possession), and require that catch-and-effort information be supplied to the DFW. For Saipan specifically, seasons are limited to October and November, with a maximum of 100 licences and fishing confined to a particular area. For Rota, two one-month seasons are recommended, along with area closures and a limit of 50 permits. For Tinian, a season in August and September is recommended, along with limits on the areas fished and a limit of 50 licences. The current status of these recommendations is unknown and it appears that no commercial production can be expected from the CNMI in the near term.

**Discussion**

We begin our discussion by attempting to draw on the experiences of the different fisheries management practices presented in the first section in order to formulate management alternatives. Much of this work follows on from accepted parameters (Nash, 1993 and Bour, 1990) and trochus management tools described in the Micronesian case studies. We review the costs and benefits of the various methods employed, attempting to evaluate possible tradeoffs. Finally, we review the various indirect management measures applied.

Trochus landings for those areas in Micronesia where data exist or were compiled appear to mimic more pan-Pacific trends. Landings are extremely variable, suggesting that market conditions and resource constraints place compelling demands on fishery managers to control exploitation. This has been done using a variety of direct and indirect methods. During most of this century, trochus management in Micronesia has been relatively consistent, involving seasonal openings, minimum size regulations and, more recently, a variety of other measures. Current management measures are summarised in Table 4.

***Quotas***

There are several factors which affect direct quota management systems. Since many natural marine populations display a high degree of variability in stock size and recruitment, information on the current absolute abundance is often critical. Experience in Micronesia, from the inception of exploitation, has included workers attempting to determine stock size. More recent efforts have focused on the importance of recruitment. For trochus, Nash (1993) reports that quotas are commonly based on apparent historically sustainable harvests. This appears to be the case in Guam, Palau and Yap. In fact, this rough-and-ready approach is used for species in many parts of the world, espe

cially where little is known about absolute abundance and key biological parameters are poorly estimated.

Using biological parameters given by Nash (1993), we performed a simple modelling analyses of trochus harvest rates based on some basic demographic information. We assumed a fixed instantaneous natural mortality rate of 0.3 (Nash cites a range between 0.1 and 0.77). Growth was modelled to follow a trajectory (with variability) as shown in Figure 5.

**Table 4: Summary of current fishery management regulations for trochus (*Trochus niloticus*) in Micronesia and the Cook Islands (Aitutaki Atoll).**

| Country | Min.size (cm) | Max.size (cm) | TAC | Seasons | ITQ | Sanctuaries | Moratorium | Permit | Live inspection | Rec./subsis. regulations[1] |
|---|---|---|---|---|---|---|---|---|---|---|
| FSM | | | | | | | | | | |
| Chuuk | 7.6 | | | X | | X | X | | | X |
| Kosrae | 7.6 | 10.2 | | X | | X | X | | X | |
| Pohnpei | 7.6 | 10.2 | | X | | X | X | | X | |
| Yap | 7.6 | 10.2 | | X | | | | X | X | |
| Palau | 7.6 | | | X | | X | X | | | |
| RMI | 7.6 | | | X | | | X | | | |
| CNMI [2] | 7.6 | | | X | | | X | | | X |
| Guam | 5.1 | 10.6 | X | X | | | | X | | X |
| Cook Is. | 8 | 11 | X | X | (IQ) | X | X | X | X | |

[1] Recreational / subsistence regulations

[2] Includes currently proposed regulations

Adapted from Nash (1993)

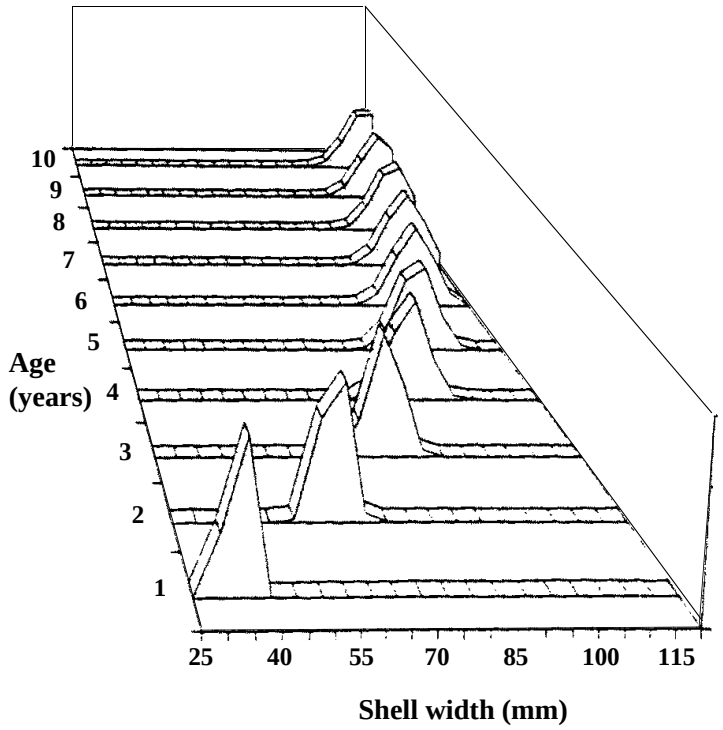



**Figure 5: Generalised age-size relationship for trochus, based on Nash (1993); average basal diameters of 33, 58 and 76 mm for 1, 2 and 3 year-old trochus respectively**

Furthermore we then assumed that trochus mature with size, as depicted in Figure 6.

From this combination of parameters, calculations using various minimum size limits make it possible to evaluate the reduction of spawning output per recruit caused by different harvest rates. Note that this type of calculation is independent of any stock recruitment relationship.

For example, if exploitation represents 40 per cent of Age 3 and older trochus, and a minimum size limit of 8 cm is used, this results in a reduction in spawning output per recruit of about 44 per cent of unfished levels. Taking into account data for any species of groundfish stocks around the world, and given the assumptions of natural mortality, etc. this rate would probably provide sustainable yields.

A major pitfall with this approach is that uncertainty about the harvest rate is usually greatly overshadowed by uncertainty about the absolute abundance.

For example, if the figure of 40 per cent was applied to an estimated stock size of one million individuals when the true stock size was only half as big, there could be severe implications. In these situations it is ideal to evaluate decisions on setting harvest levels by making careful analyses of the consequences of being wrong!

Risk assessment is currently one of the major areas of emphasis for heavily-exploited, temperate-water resources. In instances where numerous demands are placed on fishery resources by varied and numerous stakeholders, not only one must determine appropriate levels for quotas, but also the inherent risk involved in the various levels of exploitation taken as given in many fisheries.

Size regulations appear to be a simple, yet important trochus management tool. Our case studies show that size regulations (along with seasons) have been the most universally accepted trochus management method in Micronesia. This also appears to be the case for other regions of the Pacific.

Size limits have a sound biological basis in that, if done properly, they can conserve spawning stock biomass above critical levels.

Growth rate and size at sexual maturity of trochus vary substantially, both between and within sites (Nash, 1993). We consider that universal recommendations of minimum size limits are inappropriate and that trade-offs in financial yield and biological yield per recruit should be evaluated for specific situations.

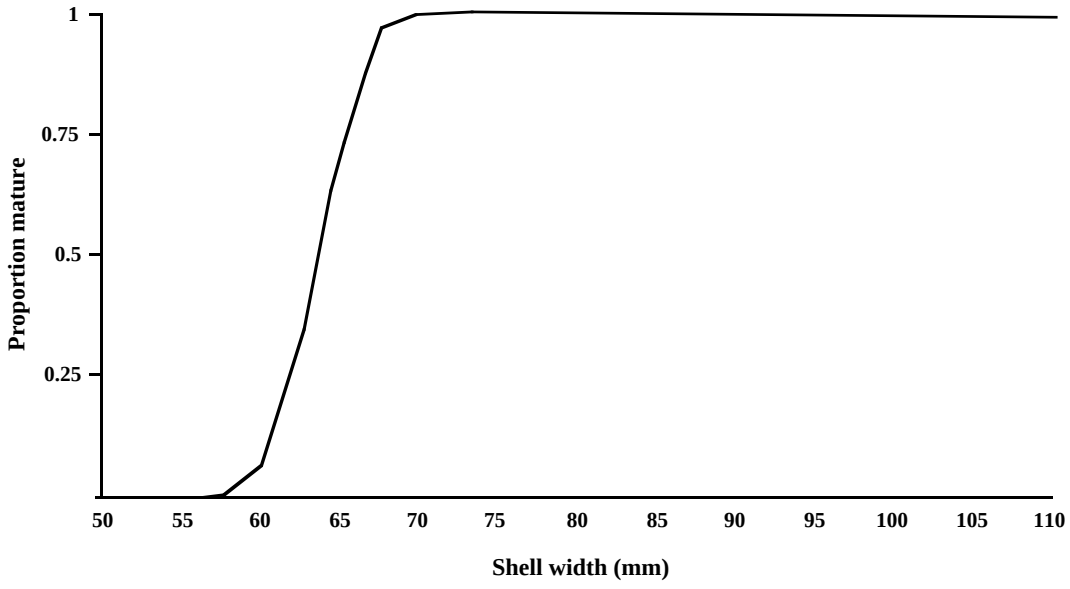



**Figure 6: Assumed relationship between the proportion of the population that is mature and size, for trochus-based data published by Nash (1993)**

In Micronesia, the minimum size for trochus harvests has been amazingly consistent across the region, at 7.6 cm for almost 90 years. The first application of this technique by the Japanese was based on 'experience'.

The more recent literature indicates that this size is not unreasonable given maturation and growth patterns observed in trochus. Importantly, the harvests in these regions have been highly variable but remained at a relatively consistent level until recently. Clearly, size limits are an effective conservation tool.

However, if fishing mortality is too high, population densities can drop to levels where the population is not able to replace itself even with size limits in place. If an adjustment is believed to be warranted, a movement from 7.6 cm to 8.0 appears to be one option and has been recommended by some (Bour, 1990).

Economic factors need explicit consideration when size limit regulations are being established. Trochus shell buyers and button blank producers prefer shell as small as 6.4 cm and not much larger than 11.5 cm (Philipson, 1989; Adams et al, 1992).

Nash (1993) suggests a size-limit-only approach to trochus management. Under high levels of fishing pressure (which appear to exist throughout Micronesia) the minimum size should be in the range of 11.0 to 12.0 cm. Such large minimum size limits would render trochus exploitation uneconomic for all but subsistence fishing. This could be viewed as a way of nominally 'having a fishery' while effectively calling for a moratorium.

Options for developed economies such as the CNMI and Guam are a little different from those for developing countries. In developed areas the importance of commercial trochus fisheries is relatively minor.

In the CNMI, for example, where stock abundance appears to be low (Adams et al, 1994), perhaps a recreational / subsistence only fishery may be the best path for recovery (with a high size-limit regime). As has been realised in many areas of the world, greater social benefit can be sometimes derived from reducing or eliminating commercial catch rather than recreational or subsistence fisheries.

The use of maximum size limits occurs in at least in three areas within Micronesia and appears to be a recent phenomenon. Historically, market conditions limited the take of large trochus (> 14 cm) because the quality of the shell decreases due to sun bleaching, deterioration by boring organisms, and reduced button production per unit area. This economic constraint appears to fit well with the animals' increasing fecundity as correlated to age (or size).

However, while the fecundity of the trochus increases at a geometric rate relative to basal diameter (below 110 mm), maximum size limits are believed to contribute only marginally to spawning stock biomass–especially in heavily exploited fisheries.

In areas where stocks are severely depleted, a reduction of maximum size limits is not recommended. In these cases, the minimum size limit should be increased and other measures to reduce the total catch are preferable. The current maximum size of 10.2 cm in Yap, Pohnpei and Kosrae may have questionable economic and biological implications, particularly if the total catch is quite high relative to stock size.

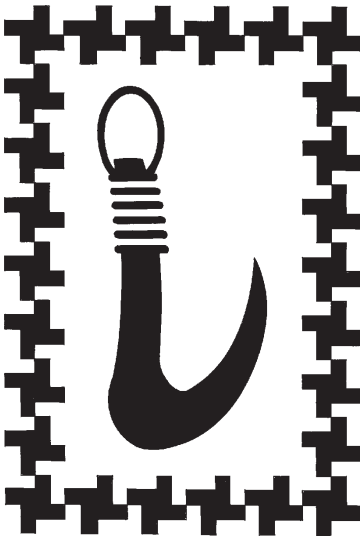
***Seasons***

Seasons or openings were historically applied by the Japanese in Micronesia to protect trochus from what was felt to be critical periods related to defined spawning events. The Japanese undoubtedly applied this regulation as a result of experience in other, temperate-water fisheries where this behaviour is more typical. However, even in Japanese times a desire to control effort seems to have been one of the reasons for seasonal openings.

The historical data reveal that exploitation rates were potentially great enough to drive the resource to very low abundance levels or extinction. Secondly, as the reproductive biology of trochus has become more apparent with the work of Heslinga and others, the use of seasons has gained region-wide salience as an

essential tool for maintaining the biological integrity of trochus resources. Nash (1993) reviews behavioural characteristics related to spawning in trochus and concludes that a quota-managed fishery (TAC) based on reproductive conditions alone would be difficult to support and, due to the frequency of spawning in most locations, impossible to manage.

Of concern is the contemporary use of seasons to attempt to limit ever-increasing effort. As is demonstrated in the case of Pohnpei, the ability of the local population to harvest the resource is tremendous. Short fishing seasons make it impossible to monitor and in many instances enforce either size limits or TAC. This trend is not unique to Pohnpei; it has been documented in the Cook Islands (Sims, 1988; Nash et al, 1995) and has been reported in Palau and Yap.



In both Yap and Palau, a good portion of the Marine Resources Division staff, plus resources from other agencies (public health and safety), is required to control and monitor trochus seasons. The cost is considerable and several fishery managers have stated that trochus seasons are a real drain on departmental resources. An additional lost opportunity (and as such a cost) is the reported waste of considerable volumes of trochus meat. It has been reported for Pohnpei that the smell of rotting trochus coincides with any opening.

***Moratoriums***

Moratoriums or complete bans on fishing have been applied since at least 1922 in Micronesia with varying degrees of success. Some commercial fishing moratoriums have been induced, such as that between 1940 / 41 and 1946 as a result of the war, while others have apparently lasted 6–7 years (Chuuk), with a duration of one to two years being more common. The complete cessation of fishing or elimination of seasonal openings is usually a response to either actual or perceived overfishing.

Heavily overfished populations may require several years to return to levels or population densities deemed appropriate for exploitation. The appropriate population densities will vary from place to place. Adams et al (1992) cite, levels of at least 100 exploitable shells per hectare of suitable habitat and up to 300 per hectare for areas 'that are not heavily fished'.

It was noted that in Aitutaki, densities must reach 600 per hectare before the Island Council authorises a harvest. With few exceptions, densities throughout Micronesia appear to fall between the lower threshold (100) and that reported as a minimum level for exploitation in the Cook Islands (cf Smith, 1992b; Curren, 1993; Adams et al, 1994).

Moratoriums provide a convenient tool for resource managers. They are relatively easy to enforce and monitor. If rigidly enforced, they are the most effective biological way to allow a resource to recover. They also have intuitive appeal to resource users. Despite a recent three-year fishing ban, many fishermen in Palau indicated that they would support a moratorium if it ensured healthy recovery of trochus stocks (Johannes, 1991). There have also been instances in which fishers have voluntarily refrained from requesting a trochus season, despite being eligible to do so, reportedly because of concern for the resource (Idechong, pers. comm.).

However, the imposition of a moratorium may bring significant social and economic costs. As demonstrated for Palau, trochus are a rather egalitarian resource–a wide array of individuals typically partakes in trochus fishing. At

least at the production level, benefits are typically spread throughout the community. In several locations within Micronesia, trochus fishers are from the lower portions of the socio-economic stratum of society. Many depend on trochus harvests as an important windfall or pulse income, defraying schooling, clothing or housing costs. Trochus income may also provide resources important for religious or cultural events.

Of additional concern is what is referred to by economists as the time-value of money or 'discounting effects'. This premise relates to continually rising prices or the high rates of inflation in most areas. It basically implies that a dollar today is worth more than a dollar next year or two years from now.

In Pacific insular settings inflation rates of 10 per cent per year for imported products are not uncommon. In the case of a three-year trochus moratorium, a fisherman needs to receive at least 31 per cent more for his landings in Year three than Year one, all other factors being equal. And the problem is that all other factors do not remain equal, thereby making a precise calculation of the costs and benefits of moratoriums impossible.

However, the conceptual tradeoff is more straightforward: the health of the trochus stock, and its intrinsic ability to grow (or recover), versus the socio-economic needs of the stakeholders most dependent on the fishery. A precautionary approach dictates error on the side of caution to ensure the health of the resource.

***Sanctuaries***

Sanctuaries differ from area closures in that it is assumed that no exploitation whatsoever occurs within a defined area. The effectiveness of sanctuaries as a management tool for sessile invertebrates depends on better survival rates (due to lack of harvests) and the likelihood of increased abundance both within the area designated and potentially in the exploited population. Increased abundance within the sanctuary is envisioned to provide greater spawning output which would propagate to fished areas via larval dispersion.

The effectiveness of sanctuaries therefore also depends on oceanographic conditions and habitat. The biggest impediment to sanctuaries as an effective management tool is the difficulty of keeping the area free from fishing. Often, the economic and social costs of establishing sanctuaries is underestimated by resource managers.

Trochus sanctuaries are intuitively appealing and have been implemented in several locations throughout Micronesia. McGowan first advocated the use of sanctuaries as a management tool for trochus in response to what was felt to be low adult abundance and reduced probability of successful spawning (fertilisation).

Subsequent research has confirmed the importance of threshold levels of adult densities to ensure reasonable fertilisation rates (allele effect). However, while the 'solution' of sanctuaries has intuitive appeal, their effectiveness in practice during the past 35 years has been, at best, limited.

In several settings in Micronesia trochus sanctuaries have been established in areas that had been hypothesised to be areas of sub-optimal habitat, as was demonstrated for Palau. Furthermore, the integrity of the sanctuaries appears to be continually compromised (Palau, Pohnpei, CNMI). This is especially disconcerting given the fact that trochus were either introduced or not heavily exploited by traditional peoples.

Imposing sanctuaries appears to impart significant social costs, without a commensurate demonstration of benefit. This finding has significant implications in areas or situations where resources have been intensively utilised by traditional or contemporary cultures. Smith (1992b) suggests that the establishment of sanctuaries in Yap proper would be inappropriate due to current tenure practices.

This contrasts with Pohnpei's open-access inshore fisheries, where sanctuaries are often violated by poachers during seasonal openings and have had to be abandoned to reduce conflicts (Smith 1992b).

Associated with the cost of completely foregone benefits of traditionally exploited resources, is the need to address the question of marginal effectiveness, both ecologically and economically. Or, simply stated, how large and how far apart do trochus sanctuaries have to be to ensure maintenance of appropriate levels of spawning stock biomass?

Some (McGowan, 1958) suggest one sanctuary of undetermined size for every five linear miles of barrier reef but we, like Heslinga et al (1984), conclude that this is a rather 'arbitrary' recommendation.

Heslinga et al (1984) recommend that if sanctuaries are to be at all effective, whole reefs (channel to channel) be designated as such. These considerations appear to have as much to do with limiting enforcement and monitoring costs as with biological matters. Evaluations of marginal cost and benefit are scarce for tropical inshore fisheries. Nonetheless, responsible resource management policy, in the face of varied demands by constituents, requires this type of analysis.

Our review of the literature on experiences in Micronesia for trochus over the past 35 years suggests that the effectiveness of sanctuaries is inconclusive. While they are a biologically attractive means of managing the resource, the costs of effectively implementing sanctuaries in many areas may outweigh benefits, particularly if other management options are available.

A final caveat: our review has focused on the use of sanctuaries for trochus under exploitation. Clearly sanctuaries have other applications and potentially wider benefits that are not amenable to cost/benefit analysis (e.g. biodiversity considerations).

***Stock replenishment—hatchery rearing and juvenile releases***

Nash (1993) proposed two possible management objectives for hatchery rearing of trochus: seeding reefs depleted from overfishing and to compensate for overfishing in the absence of other conservation measures. In Micronesia, stock replenishment through the release of hatchery-reared juvenile trochus has been of questionable effectiveness. Hatcheries in general are mitigation measures for poor management practices or habitat degradation. In many cases the number of juveniles released has had an undetermined or unrelated effect on subsequent fishable stock levels. That is, natural mortality at critical life history stages, coupled with poor settlement timing, has limited the impact of hatchery-reared individuals on the adult population.

Thus, with technical effectiveness still unproven, the economic effectiveness cannot be addressed. Experience, especially in Palau and to a lesser extent in Pohnpei and Kosrae, suggests that the overtaxed capital and human management resources of typically small marine resource divisions are best allocated to alternative methods of trochus management, as opposed to being spent on a trochus hatchery for reseeding purposes.

There is an intrinsic appeal to artificial rearing, in that it provides demonstrable proof to stakeholders that 'something is being done' in the event of stock depletion or overfishing. Fishery administrators must weigh the benefit derived from public perceptions against the drain on departmental resources. In addition to direct costs to support rearing activities, there are also costs associated with monitoring releases and enforcing regulations promulgated to ensure survivability until recruitment into the fishery.

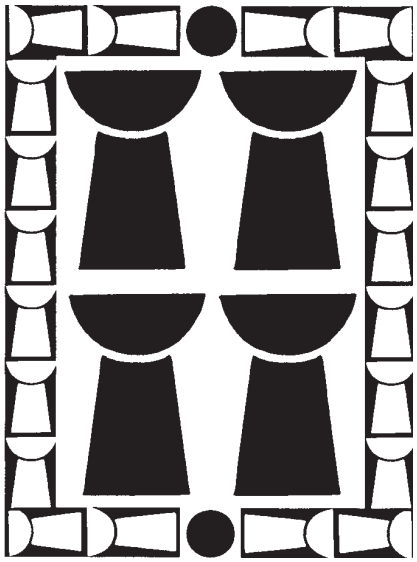
Even in instances where international donors are willing to assist either technically or financially, resource managers must examine the opportunities foregone, when considering the development of hatchery programmes for trochus. If hatchery techniques are to be pursued, we suggest this be done collaboratively, in regional centres, where costs and risks can be spread over a number of potential benefactors.

We should reiterate that while hatcheries have not led to demonstrable results in terms of augmentation of fishery production, there have been clear secondary benefits through the determination of basic biological factors useful for management.

With the considerable body of literature demonstrating the effectiveness of translocations (though there have been numerous failures) within Micronesia and Pacific-wide, if in fact augmentation is required, it is best carried out using adult trochus (> 8.0 cm) in a passive programme.

The costs of translocations, while not insignificant, are discrete and not of the recurrent variety needed to support a hatchery. Experience in Micronesia suggests that it may take between 6 and 10 years, possibly up to 15 years, to establish a new fishery.

Translocation programmes also incur long-term costs. Often it is essential that a complete moratorium or ban be imposed on the harvest of any trochus after translocation or reseeding takes place (cf Gillett, 1994). This regulation requires assiduous enforcement which can be obtained on a least-cost basis in instances where traditional systems are still active. In those areas where traditional systems of control and governance are no longer active, or are only marginally effective, the central government will incur enforcement costs.



These costs may prove significant and should be taken into account in the planning process. Translocation or reseeding programmes appear to be most successful in areas where the people understand that short-term yields must be foregone in order to attain a sustainable productive fishery in the future. Therefore an information and education programme is critical to the success of any attempts to initiate new fisheries or rebuild depleted ones.

There are costs associated with the monitoring of both augmentation and translocation programmes. For translocation programmes the cost is relatively discrete and there is a growing body of literature on methods (cf Nash et al, 1995).

However, releases of juvenile trochus require more rigorous procedures, particularly to monitor the pre-recruit phases, and may also require commensurately greater resources.

Finally, from a biological perspective, the merit of transplanting trochus to different areas to mitigate overfishing of the local stock may be questionable, given genetic problems. For example, genetic diversity can help organisms adapt to specific habitats, tidal conditions, water temperatures. Also, maintaining genetic diversity can also help to combat diseases and maintain unique spawning characteristics. Little is known of these processes in trochus. However, this is a fertile area for future investigation.

***Other management methods and considerations***

While trochus has been demonstrated to be a relatively important and equitably distributed cash crop for Micronesia (e.g. Palau), there are certain tendencies that should be avoided, such as over-capitalisation. In some developed economies large investments have been made in vessels and equipment to harvest trochus resources, with few alternative means of generating income. With the need to service large capital investments comes a tendency to fish at levels beyond those sustainable.

This situation is not unique to trochus; there is a plethora of examples where fisheries evolve to situations in which total costs equal or exceed total benefits and resource levels are driven extremely low.

A derivation of this trend has been experienced in several Pacific settings. For example, button-cutting factories require between 100 and 150 t of trochus shell per year (depending on the number of machines that must be supplied).

In settings in which these factories have been built, there have been 'strong pressures' to have seasons each year along with reduced minimum size regulations (Adams et al, 1992). The need to recoup the investment puts pressure on the resource and typically drives stocks to much lower densities. Pohnpei had a button factory, but it recently closed, reportedly due to lack of constant supply.

Our review suggests that there are no settings in Micronesia which can support a button factory with purely local stocks. Therefore, we suggest that efforts to expand trochus fishery benefits would be best spent optimising management to suit local conditions and to coordinating with regional organisations, such as the Forum Fisheries Agency, to determine appropriate markets and pricing schedules.

This broaches the final issue in our discussion: that of the role of government in the actual sales and transaction of trochus fishery products. With the considerable variability of annual volume coming from the various sites within the region, as well as in aggregate, there will be inherent variability in the economic and social benefits potentially derived from the resource.

One tendency is for government to assume the role of buyer, in an attempt to provide better and more equitable prices to producers. Local and national governments do have a role to play in the management, enforcement and monitoring of trochus activities in attempts to maximise local benefits. However, government and, in turn, marine resource divisions should assiduously avoid getting involved in roles traditionally left to private enterprise.

The Trochus Marketing Authority proposed for Yap State presents an extreme example. With an estimated annual production of 30 t, the gross value of the resource is clearly insufficient to provide the basis for an independent board with exclusive purchasing and marketing powers. Even if trochus production were to grow (as a result of expanded translocations), experience in the region has been that, while governments qualify and certify buyers, the premise that a part-time government board will time markets and provide better prices to producers, without additional subsidies, is questionable.

Governments' most appropriate role here may be to monitor fishery activities and enforce regulations, while promoting or fostering competition by encouraging a reasonable (and manageable) number of interested buyers. Regional fishery organisations appear to have a role also in information dissemination, management advice, and training. To this end, the *SPC Trochus Information Bulletin* is a very good example of coordination and information on activities. A more frequent 'Infofax' detailing world prices, market trends and available responsible buyers, might also be of value to producing countries.

**Summary**

The history and current experience of trochus fishery development and management in Micronesia appear to mimic wider trends in other Pacific Islands countries. Micronesia provides tremendous variety and richness in terms both of the trochus fisheries and of the societies exploiting them. In this study we have attempted to highlight these nuances.

There is an incredible volume of research that has been carried out on trochus; this was in part why it was chosen for this study. More recent efforts by W. Nash, W. Bour, T. Adams, and others provide a wealth of information and act as model studies for other inshore

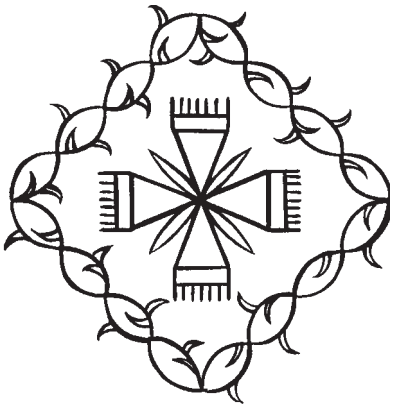
marine resources. Here we use trochus fishery experiences in Micronesia as a case study to broaden management perspectives, while adding to this considerable pool of knowledge.

However, for Micronesia there is considerable variation in the volume and quality of the data available for analysis. Efforts must be redoubled in a number of areas to better monitor and document current fishery trends—even the most basic types of data may be difficult to obtain. Initiatives by the Pacific Island countries and the Forum Fisheries Agency to compile eclectic reports and data sources are an especially good start to this end. The utility of marine resource departments' annual reports cannot be overemphasised. These data provide the basic tools required for sustainable fishery management.

It appears that Micronesia, as a region (excluding the CNMI) is currently capable of producing 300–310 t of trochus per year on a sustained basis under current management regimes. Most of the current management tools employed appear to focus on the biological attributes of the fishery. While this has ensured the ecological sustainability of the resource, it appears that adjustments can be made to optimise management.

Policy-makers and fishery managers need to look beyond biological factors and incorporate long-term economic and social considerations into management regimes. Our review suggests that a number of management tools, while theoretically valid, have been of questionable utility when one broadens the perspective to include social and economic factors.

The use of sanctuaries and artificial augmentation programmes may require re-evaluation, especially when effectiveness and enforcement costs are included in the decision calculus. The heavy dependence on seasons to maintain appropriate levels of spawning stock biomass has been demonstrated to be of questionable long-term merit. An effort must go into rationalising the quota between users. Moratoriums are effective but potentially incur heavy costs to those most in need. The establishment of trochus button factories should be evaluated in terms of competitiveness and the ability of the local resource to support the vital jobs which are created.



Size limits have proven useful to fishery managers because they are easy to understand and enforce, are amenable to incremental change, and can be modified given other (economic and social) considerations. However, there are drawbacks—as the Micronesian experience demonstrates they cannot be relied on at least for trochus to ensure sustainable nor consistent harvests. In the case where the market demands smaller, potentially sub-adult specimens, there are continual downward pressures on the minimum sizes.

All measures impose costs, as well as providing some benefit. The real questions have to do with tradeoffs; and these are what we have attempted to highlight.

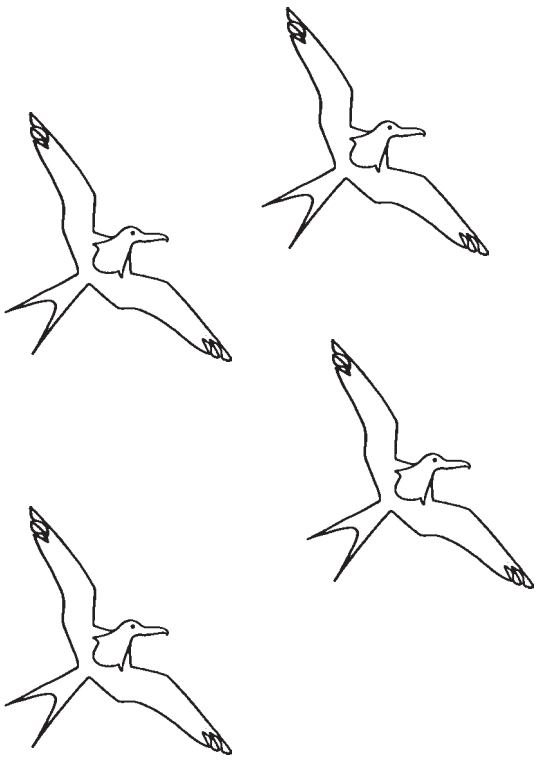
Proper management of trochus resources can provide a model for other inshore resources. They provide a real opportunity for resource managers and governments to provide benefits for all stakeholders. Government clearly has a role to play in the management of trochus fisheries, as does the private sector. However tendencies by either to enter into the other domain should be viewed with caution. In most of the areas of Micronesia today we believe that central authority is required for sustainable fishery management.

For many settings there has been an irreversible movement toward modernisation, which has seriously compromised the ability of traditional systems to manage the resource effectively. Parochial interests have proven too

strong to revert to traditional forms of management. Therefore, modern management regimes will probably continue; governance regimes must be modified accordingly.

For the more economically developed portions of Micronesia, the complete cessation of commercial harvests may be appropriate, given the alternatives and demands placed by the various resource users. Where traditional systems continue to be exercised, marine resource agencies should look to these as possibilities rather than constraints. These systems need to be supported and encouraged. The opportunity for community-wide quotas, determined cooperatively by modern and traditional methods, divided under traditional means, represents an alternative that may provide considerable benefits at minimum costs.

The Aitutaki fishery should continue to be monitored both economically and socially, as well as biologically. Some have recently suggested the appointment of 'fish wardens' from the local community of fishers (Adams et al 1994; Johannes, 1991). These options warrant further investigation. Central governments and fishery divisions need to support local efforts to assist in managing their resources. By doing so, all involved will benefit.



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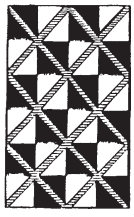

*NOTE: This and the following five articles were presented during the SPC/FFA Workshop on the Management of South Pacific Inshore Fisheries which was held in Noumea in June/July 1995. Two volumes of country and background papers from the Workshop will be published by SPC in early 1996.*

## Case study: the application of traditionnal management to the trochus fishery in Vanuatu

*by Robert A. Jimmy*
*Fisheries Department*
*Port-Vila, Vanuatu*

The people of Vanuatu are Melanesian in origin and traditional values still govern village life. This enables the people to live in harmony with their physical environment. Customary rights over sea and land areas exist in Vanuatu and are recognised by Vanuatu Government legislation. In fisheries, the clans or the village chief have the customary right over nearshore areas, especially coral reefs. The village chief sets customary law for fisheries in his area and this can be in the form of closed fishing seasons in particular areas or of particular species. The idea is to impose some form of control on the fishery in ways which will ensure that the resources will continue to yield net benefit to the community.

The Vanuatu Fisheries Department respects and encourages traditional management practices at village level. The Research Division of the Fisheries Department has been working closely with the community by providing information on basic biological aspects of inshore resources and the types of management available, while allowing the community to choose which management option suits it best. An example of such management practice is at Siviri village.

The village of Siviri is situated on the coast about 25 km from the capital, Port-Vila, on the northern part of the island of Efate. The population is approximately 150 and agriculture and fishery are widely practiced for a living. The community usually transport their crops by trucks to the main market in Vila, where they are sold. Marine resources are also considered very valuable to this community, where the people rely very much on a 2 km reef which extends along the village area.

The site has been known as an important area for trochus fishing, with the resource owners selling their catch to the existing shell-processing factories in Port-Vila. However, concerns were raised among the resource owners on the depletion of this resource and the need to set up management regimes in order to sustain it before it became over-exploited. For these reasons, the village Chief approached the Department of Fisheries for management advice.

In responding to the request, the Research Staff undertook a site selection survey to see whether the area would be biologically suitable for a reseeding trial. Other parameters, such as physical parameters, were also considered. Based on the results, Research Division suggested that trochus fishing be banned in the area for two years so that a reseeding trial could take place.

On 17 August 1992, a total of 1,000 hatchery-reared juveniles (average size: 2 cm basal length), produced by the Fisheries Department Hatchery, were reseeded at Siviri Reef. An agreement between the Fisheries Department and the community on the security and protection of the site was drawn up. The agreement includes a five-year ban on trochus fishing set by the community. Usually, the Fisheries Department would advise resource owners to set a ban of a minimum of two to three years

In cases like this, the village Chiefs assign their village police to enforce the taboo and to bring to the Chiefs' attention anyone breaching it. A fine is usually set upon anyone breaking the taboo. Such a fine is traditional and usually entails presenting to the Chief and the community a pig, with several kinds of raw food such as yams and bananas, kava and some cash (10,000 to 20,000 Vatu – about AUS $120-240.00). The Research Staff usually go back to the area to carry out transect surveys to determine the stock currently present. A survey carried out early this year on the reef flats of Siviri village indicated that a maximum dry weight of 700kg to 1,000 kg of legal sized trochus shells could be harvested.

It is believed that through such cooperative work, the villagers will feel that they are part of a country-wide management team on policy-making for the sustainability of inshore marine resources. It is also hoped that this will create a good working relationship between the government and the community.

# The present status of introduced trochus and green snail in the Tongatapu Island Group

*by Ken-ichi Kikutani, 'Ulunga Fa'anunu and Naita Manu*

## Introduction

Trochus, *Trochus niloticus*, and green snail, *Turbo marmoratus*, are widely distributed in the Indo-west Pacific region. Both species are commercially important marine resources in the sub-tropics and tropics as export commodities. The trochus shells are used for button and shell jewellery (Heslinga et al. 1984). The green snail are used for inlay work, especially for Korean traditional inlay work 'Raken Zaiku' and shell jewellery (Yamaguchi, 1988). The meat of both species can be used in many sea-food dishes.Transplantation of trochus had been successfully carried out in the Micronesian Islands since 1927, before World War II, by Japanese fisheries authorities. Thereafter, many other Pacific Island countries which did not possess trochus resources successfully introduced them.

A strong demand and high market price for green snail have caused heavy overfishing in many countries, and as a result, the green snail population is rapidly declining. Transplantation attempts of this important gastropod were not common in the past. One trial undertaken from the New Hebrides (now Vanuatu) to French Polynesia in the 1950s, successfully established a resource (Yen, 1991). Other transplantation trials (to New Caledonia and elsewhere) either failed or their status is unknown (Gillett, pers.comm.).

## Transplantation

Although there are suitable habitats for them, neither species occur naturally in Tonga. Thus after a series of surveys, their transplantation was carried out. A total of 1,092 trochus (24 dead) were brought from Fiji. Fifty (9 dead) and 320 (69 dead) green snail were brought from Vanuatu and Japan respectively. Five hundred trochus were released at Fukave Island and 400 were released at 'Euaiki Island. One hundred and forty-one trochus were kept as spawners in the raceway tanks at the Ministry of Fisheries hatchery in Sopu. Twenty green snail were released at Vaini beach and 195 were released at 'Euaiki Island. Seventy-six individuals were kept as spawners in a raceway tank at the Sopu hatchery.

## Follow-up survey of introduced trochus and green snail in Tongatapu

Recovery surveys of trochus and green snail were conducted at the Fukave Island and 'Euaiki Island sites. The results showed recovery rates for trochus of 23.3 per cent after 3 months at Fukawe Island, 61 per cent after 4 months between Fukave Island and Nuku Island, and 17 per cent after five months at 'Euaiki Island. The recovery rate for green snail was 23.4 per cent, 11 months after the release. We have not been able to conduct a recovery survey at Vaini beach because of rough sea conditions. All the recaptured trochus and green snails had formed new shell growth on the lip. The recovery surveys showed that these two species have adapted successfully to the reefs around Tongatapu. We consider that our management strategy to protect these important species so far has been effective.

## Management strategy for introduced trochus and green snail

### *Public awareness*

Integral to any successful transplantation is the need to protect these species against poachers and to obtain the understanding and cooperation of the local people. Without the people's cooperation, management of these species would not be successful. Therefore, prior to transplantation, we conducted a series of public awareness programmes aimed at protection of these species. Through TV, radio and newspapers we announced the importance of these new resources and how they would benefit the people. For example, the headline of the *Tonga Chronicle* on 23 September 1993 was that 'Green snail could provide a new source of income within 12–15 years'. In line with this, on 30 May 1994 a releasing ceremony was conducted in the presence of HRH Prince

'Ulukalala Lavaka Ata on board *Pangai* to publicise the trochus release nation-wide. A TV station and two newspapers sent their reporters to document the ceremony (Naita et al, 1994). The *Tonga Chronicle* reported the releasing ceremony as follows: 'A trochus plantation of 1,070 animals imported from Fiji will be established on the outer reef of Fukave Island following a planting ceremony on 30 May by his Royal Highness Prince Lavaka Ata 'Ulukalala from the deck of the VOEA Pangai'. This ceremony meant that the introduced species belonged to the king just like the national estate. If we had not indicated this fact, we would not have been able to warn against poaching of the introduced species, because Tonga does not have institutions of customary marine tenure (Mangisi, 1994),and the people can fish anywhere.

### *Community-based management*

To assist in management of the introduced species at 'Euaiki Island, we held a meeting with island residents to promote a better understanding of the introduced species via a traditional 'Kava Tonga Party' whenever we visited. As a result of these meetings, released green snail and trochus at 'Euaiki Island have been protected by the island's people. A church minister on this island watches the shellfish release sites every day and records daily fishing activities there. He submits the record forms to our project whenever he visits Tongatapu. We also provided 'Euaiki village with a small boat with an outboard engine for patrolling against poachers.

## Future directions

It will take a long time (10 years or more) to establish a harvestable resource on Tongatapu reefs. Therefore, we continue to conduct recovery surveys combined with patrol against poachers on calm days when we suspect poachers may come. We have already succeeded in rearing trochus and green snail spawners and the preliminary seed production of both species. We are preparing to conduct a seed-releasing trial programme of both species to facilitate their establishment. For the transplantation project to succeed, we need to establish a regulation banning capture of the species until the stock is well-established and ready to harvest. Needless to say, it is necessary to continue to ensure that the public is aware of the activities of the Ministry of Fisheries through various campaigns.

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# Current management policies and problems of the inshore fisheries resources in Vanuatu

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## Introduction

The Republic of Vanuatu is an archipelago of over 80 islands, twelve of which are described as major islands and sixty-seven inhabited. Traditional values still govern village life, with over 100 indigenous languages spoken.

The National language is Bislama and there are two official languages, English and French. The estimated population for 1991 was 165,000, with 60 per cent of the population engaged in subsistence farming.

The main sources of income in the rural areas are copra, cocoa, coffee, cattle, kava and green vegetables. In 1982, the first development plan for the country highlighted the need to reduce dependency on copra and look into developing other potential economic resources. One of the major items was the development of a village fishing development project for the offshore resources.

During the early 1990s, Vanuatu was experiencing a decline in its main exports, namely copra and cocoa. This decline was in the main producing areas, the Central and Southern regions, because of unfavourable weather conditions (*Quarterly Economic Review*, 1994). In such cases, the coastal communities have to look into ways of making quick money in order to re-build their homes after cyclones. As a result, village communities have been turning towards inshore fishery resources in their coastal areas for economic benefits.

In other islands where copra and cocoa are scarce, marine resources can be the only source of income. The other reason is that there has been a decreasing trend in the number of boats engaged in bottom fishing, which may indicate an increase in pressure on the inshore resources. In addition, the current influx of tourism has caused increased fishing pressure on certain inshore resources, such as coconut crabs which are considered a delicacy and priced very highly in the local restaurants and hotels.

Due to these factors, the Fisheries Department in Vanuatu is faced with certain management difficulties in trying to link the biological bases of inshore resources and the current legislation with the communities for effective management of these resources on a sustainable level.

The way in which this information can be translated to the understanding of resource owners / communities, while still allowing them to benefit from their existing traditional and cultural systems and values, is what is considered important. Resource owners don't like to be told how to manage their resource. They want to be made aware of the types of management available and current legislation involved and choose the management regimes which suit them best.

## Trochus

Trochus harvesting in Vanuatu for subsistence and commercial purposes is a mature fishery. It is seen as one of the major inshore resources that generate revenue to the coastal communities. The major use of trochus is the shells; these are sold to the existing shell processing factories for the production of button blanks, which are then sold overseas. The price offered for shells is usually between 170 and 300 Vatu (AU$ 2–3.00) per kilogram of shell. The processed shells are sold to overseas countries such as Korea.

Surveys carried out by the Fisheries Department in the early 1990s indicated that there was a decline in trochus abundance in certain locations, thus leading to the need for tighter management controls to be implemented to ensure the sustainability of the resource (Bell & Amos, 1993).

The trochus fishery in Vanuatu has been managed by a variety of methods. These include size limits, limited fishing seasons, quota, trochus sanctuaries, closed season and export criteria. The only management tool used for the trochus fishery in Vanuatu at the moment

is a size limit, which is set at 9 cm basal length. Up to 1983, trochus shells with a lower size limit of 5 cm were harvested. The current legislation / policy regarding trochus exploitation under Fisheries Regulation 17 prohibits taking, harming, possessing or purchasing trochus shells less than 9 cm basal length. The exportation of whole shell is illegal without written permission from the Minister. A fine of 100,000 Vatu (AUS$1,200) is payable by anyone who contravenes any of these provisions.

Several management issues and problems have occurred which have become of great concern for fisheries officers when enforcing the regulations with resource users and resource owners. It appears that one of the main management problems is the failure by the resource owners and resource users to respect the current minimum size limit.

The existing shell processing factory, Hong Shell Products, could be forced to abide by the 'undersized limit' if resource owners were to supply the legal-sized shells. However, trochus shells less than 9 cm shell length (5–7 cm) produce high-quality button blanks in the export market. Besides, the shells are much thinner and easier to cut, thus having much better quality, whereas shells of a size greater than 9 cm basal length are often much thicker and can easily be affected by burrowing organisms.

There is growing concern that several tonnes of undersized trochus shells are shipped occasionally from outer islands to the shell processing factories and that the people concerned are not being prosecuted by the Department of Fisheries. This is probably due to the lack of experience of the Enforcement Officer who is responsible for such matters. Several sections within the Department of Fisheries are still facing the effects of the 1993 National Public Servants' Strike, which saw several of its experienced staff who went on strike, including the Enforcement Officer, not being recruited back to the Department. Some have been replaced by new staff who require further training in the required field.

To ensure sustainable harvest of trochus resources, several tasks need to be carried out. Licenceholders must be screened and those who have been violating the current legislation should be prosecuted under the Fisheries Act. The requirement for shell processors to submit monthly reports on commercial catch to the Fisheries Department should be enforced.

It was realised that in order for the resource owners, resources users and the community as a whole to comply with the existing management policies, greater awareness programmes needed to be emphasised continuously, especially in the rural communities. Fisheries Officers see the importance of providing the villagers with basic information on trochus biology and giving advice on such issues as why the minimum size limit is desirable and for how long the trochus fishery should be closed to rebuild stock.

Furthermore, educating the current field Extension Officers in the region is also essential. Such officers are more in contact with the community, as they represent the Fisheries Department at village level. Providing them with such tasks would also be effective.

**Green snails**

Like trochus, green snails have been used traditionally as a source of protein. However, there are no figures available on the production of this species for local consumption. The shells themselves are of great

value and provide revenue and employment for coastal communities in the country. The production of green snail is small compared with that of trochus; however, the price is higher. The current price for green snail is between 1,700 and 2,000 Vatu (AUS$20-24.00) per kilogram.

Between 1966 and 1982, exports of green snail shells averaged 21 t annually. The export of whole shell has been banned and the majority of the shells are now directed to the local button factory for the production of button blanks. In fact this resource has been poorly managed, as there are no data available to indicate the appropriate level of harvesting. However, the sharp decline from 44 t in 1991 to 7.35 t in 1992 indicates a decline of green snail in the archipelago.

The only management tool used in Vanuatu for this resource is the minimum size limit. Under the current legislation, Fisheries Regulation 17 prohibits taking, harming, possessing or purchasing green snails less than 15 cm basal length. The exportation of whole shell is also illegal without written permission from the Minister. Anyone who contravenes any part of these provision is liable to a fine of up to 100.000 Vatu (AU$1,200). The current export quota for green snails is 2 t per factory per annum. However, this does not control how much snail the buyers can obtain from the resource owners.

The problems faced with green snails are similar to those with trochus, especially with the current size limit. Most resource owners are still not aware why the size limit is desirable and continue to supply the button factories with illegal-size shell. This, of course, does not pose any problem for the factories as shells of less than 15 cm basal length are much thinner and easier to cut and in fact have more value in the export market. In additions, shells with a basal length of 15 cm and more do face problems with burrowing organisms, which destroy their quality and value.

To help keep track of the catch and the stock of green snails bought from each area, a monthly report is required to be presented by the factories to the Fisheries Department. However, the response from factories is currently poor and there have been no effective enforcement officers to enforce such issues at present due to the effects of the 1993 National Strike of the Public Servants. Most of the experienced staff of the department went on strike and have not been re-recruited.

There is concern at present that green snails may be becoming scarce in the archipelago. Although no assessment has been done yet to quantify this, four button-blank factories have been closed, leaving only one shell-processing factory, Hong Shell Products, still in operation in the whole country.

To ensure better management of this resource, prevent it from being over-exploited and have some control over its fishery, it is best to encourage the chiefs and the community to continue practising traditional banning of fishing in their areas for a certain period of time. However, this objective could be better achieved through cooperative work with the Fisheries Department Research Unit to create more understanding and awareness of the biological basis and of the legislation involved.



# Combination of different management principles for *Trochus niloticus* resources in Vanuatu

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*The full title of this article, when presented at the SPC Workshop on the Management of Pacific Island Inshore Fisheries, was: 'Combination of fisheries management regulation, traditionnally-based management and wild stock enhancement using hatchery-reared trochus juveniles as a precautionary management principle for* Trochus niloticus *resources in Vanuatu'.*

## 1. Background

### *Country*

The Republic of Vanuatu comprises over 80 islands, 67 of which are inhabited. These islands lie between latitudes 13° and 20° South and longitudes 166° and 172° East in the Western Pacific Ocean (Fig. 1). The total land area is 12,200km $^2$, of which 5,500 km$^2$ (45%) is considered potential arable land. The areas of inner reefs and lagoons have been estimated to be approximately 448 km$^2$ and mangroves 25 km$^2$. The Exclusive Economic Zone covers an estimated area of 680,000 km$^2$.

### *People*

The people of Vanuatu are Melanesian in origin. The 1979 census indicated that 93 per cent of the total population were Melanesian ni-Vanuatu. In the 1989 census the total population of Vanuatu was recorded at 142,630, an increase of 28 per cent from the 1979 census.

### *Culture*

Traditional values still govern village life, and stress living in harmony with the physical environment.

## 2. Introduction

Distribution of *Trochus niloticus* in Vanuatu is dependent upon the existence of favourable reef habitats surrounding each individual island within the archipelago. Islands that are surrounded by large areas of hard coral substrates and reef flats harbour more trochus populations than those with small or no reef flats.

Trochus resources in Vanuatu have been harvested for subsistence and commercial purposes since the beginning of the 19th century. It is a small but significant form of cash crop, generating revenues for mainly coastal communities in Vanuatu. Recently trochus resources in Vanuatu have been under tremendous fishing pressure as a result of the increase in demand for the shells by overseas markets.

The consciousness of possible complete depletion of trochus resources in the archipelago resulted in the implementation of the Fisheries Management Act Cap 158 in 1983. Regulation 17 of this Fisheries Act sets a minimum size limit of 9.0 cm for trochus shells. This regulation was and is continually violated regardless of a fine of VT 10,000 for anyone who contravenes it.

The Fisheries Department Research Division, faced with the problem of trochus mis-management, addressed the need for an holistic management approach towards the trochus resource and the importance of the development of the trochus fisheries within the framework of an integrated management and development strategy that includes the application of the 'precautionary principle'.

The Fisheries Research Division investigated three management options that are available for trochus resource management. These are:

- Existing Fisheries Management Regulation;
- Existing traditionally-based management system; and
- Wild stock enhancement using hatchery-reared juvenile trochus.

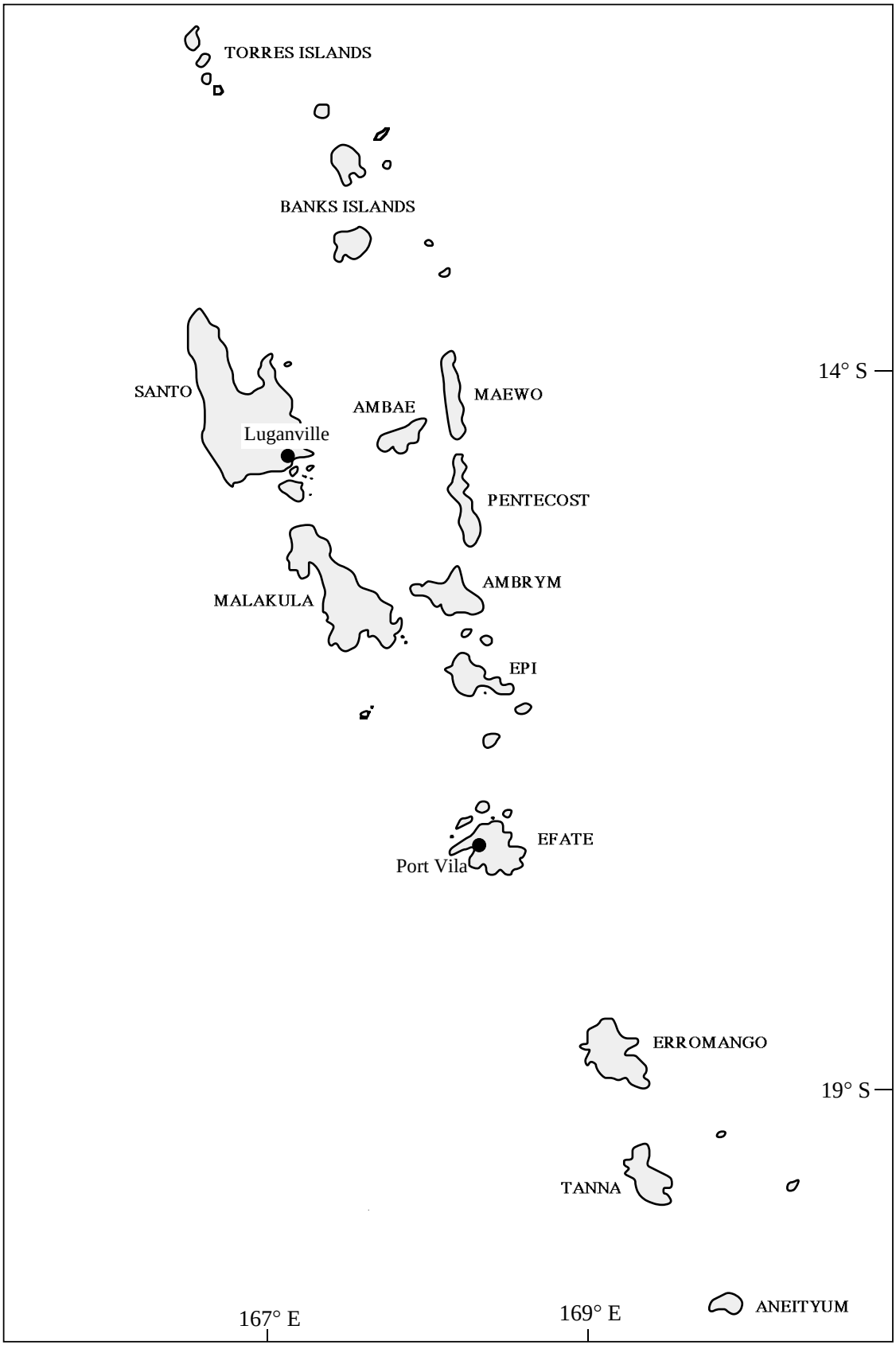



**Figure 1 : Vanuatu**

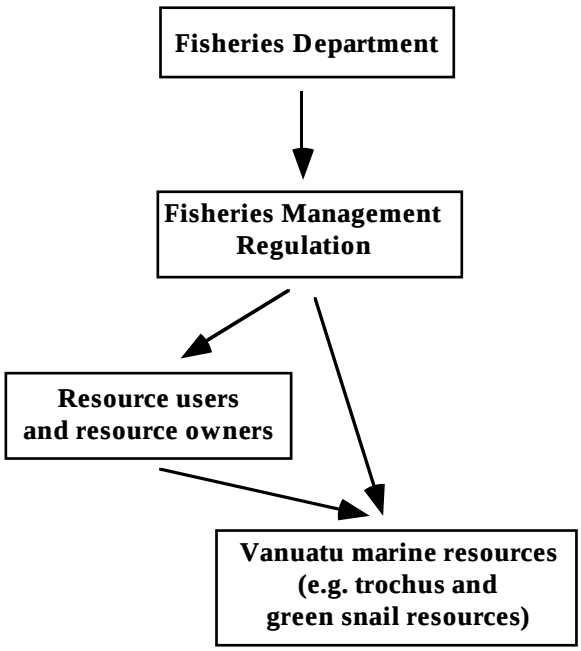
This report will endeavour to throw light on the precautionary management principle for trochus resources in Vanuatu.

### 3. Fisheries Management Regulation

The purpose of implementing the Fisheries Management Regulation is to impose some form of control of the trochus resource so that it will continue to yield benefits to the community and the country as a whole. The primary aim of this regulation is:

- to provide trochus fishing at both economically and biologically sustainable levels;
- to conserve trochus resources for future generations; and
- to provide a means for better utilisation for trochus resources.

**Fisheries Management Regulation**




The minimum size limit (9.0 cm) for *Trochus niloticus* instigated by the Fisheries Act provides an adequate protection of the trochus stocks. It allows the trochus to breed a sufficient number of times to maintain the population before being harvested.

However, the minimum size limit is new to the resource users and resource owners. They interpret the Management Regulation as unfair play by the Government. In their view, the Government is putting up a barrier to prevent the people from making money. The people fail to see the importance of the Regulation and thus refuse to respect it. This results in continuous violation of the Regulation. The Fisheries Department retaliates by arresting the culprits and criticising them for their ignorance and lack of concern for the trochus resources. Who is to be blamed for this negligence and ignorance: the people, the Fisheries Department or both the Fisheries Department and the people?

***Failures of the Fisheries Department***

The primary role of the Fisheries Department is to ensure that the marine resources are sustainably exploited through implementation of management systems that are cost-effective and will produce results that are commensurate with the value of the resources, both in economic terms and in the eyes of the people.

The minimum size limit of 9.0 cm allows the trochus to breed a sufficient number of times to maintain the population before being harvested. From the viewpoint of sustainable management, the management system protects the trochus resource. However, in the eyes of the 'grass-root' people who depend on marine resources to generate their income, this view of sustainable management is non-existent.

The people do not understand the relationship between the minimum size limit of 9.0 cm and sustainable management. What has a size limit of 9.0 cm to do with sustainable management; and why a size limit of 9.0 cm and not 8.0 cm or 7.5 cm? The people do not understand the biological concepts linking the minimum size limit of 9.0 cm and sustainable management.

*Failure 1*

The Fisheries Department concentrated only on enforcing the Fisheries Regulation and overlooked one very important aspect of sustainable management, that is, going out to the people in rural areas and explaining to them in simple language the importance of respecting the minimum size limit of 9.0 cm and why it is important to promote trochus fishing at both

economically and biologically sustainable levels.

*Failure 2*

Attempts to raise public awareness through the media (radio and newspapers) are not very helpful. This is because the information is given out through a monologue and not a dialogue system. The people cannot voice their questions through a monologue information dissemination system. The person who is giving out the information is speaking to a microphone and looking at his / her reflection in the studio mirror glass and not speaking and looking directly at the people who will be indirectly affected by the information.

*Failure 3*

The Fisheries Department concentrated on enforcing the Management Regulation and failed to discuss management alternatives that would help those who depend mainly on marine resources as their main source of income.

Legislation will always be necessary as a basis for legal action to curb wilful resource destruction and environmental damage. However, education is the ultimate key to a general appreciation of how each person relates to environment and resources and what that person's obligations are. More knowledge and understanding is needed if the constitutional obligation is to be met. Among the fundamental duties which the Constitution of Vanuatu (Section 7) lays upon 'every person . . . to himself and his descendants and to others' is the duty:

> 'to protect Vanuatu and to safeguard the national wealth, resources and environment in the interests of the present generation and of future generations'.

The best way to disseminate information is to go out and meet with the people. This is very important because in the eyes of the people, the Fisheries Officer has some concern over their marine resources and thus has lowered himself / herself to their level, is willing to eat and sleep with the people and to sit with the people in their Nakamal (meeting house) to discuss sustainable management. This is how a Fisheries Officer can gain respect from the people, especially the Chief (which is very important) and establish a working cooperation with the people.

## 4. Traditional management practices

Traditional practices in Vanuatu have a long history. These practices were established in prehistoric times and they are still used today. Traditional ownership of nearshore areas, particularly coral reefs, is hereditary. The ownership is handed down from generation to generation. Customary Law in Vanuatu dictates that most nearshore areas, especially coral reef flats owned by clans or larger communal groups, are not subjected to open-access fisheries.

In prehistoric days, our ancestors lived in harmony with the physical environment. Our ancestors had a determination to use the resources wisely. Thus the primary aim of traditional practices is to conserve marine resources for future generations. This is achieved through restrictions instigated by the resource owners. These restrictions include limited entry, closed seasons and restricted harvests.

The major feature of customary rights is that controls are expected at a local level, not from outside. Controls exerted at local levels are much more effective than controls exerted from the outside, such as the Vanuatu Government Fisheries Management Regulations. Controls exerted at local levels are set and implemented by the people directly affected by the controls. This promotes self-confidence amongst members of the community and can create a good working partnership for trochus resource management between the Fisheries Department and the community.

## 5. Trochus enhancement using hatchery-reared juveniles

Enhancement of wild trochus stocks using hatchery-produced trochus juveniles is an alternative form of trochus resource management. The Fisheries Department Research Division has been carrying out experimental studies to determine the viability of this management approach. Even though it is still too early

at this stage to speculate, experimental results of released hatchery-reared trochus juveniles were very good. For example, on 17 August 1992, a total of 1,000 trochus juveniles with an average basal length of 2.5 cm were released on a reef flat where intensive pre-assessment surveys indicated no wild trochus. (This reef flat has had no trochus for the last three years, the trochus were completely fished out in 1988). In February 1994, the site was re-surveyed. A total of 3,200 trochus shells (size range 4.5–9.5 cm) was counted.

This management option can only work if working cooperation is established between the Fisheries Department and the resource owners. This is because the Fisheries Legislation provides no protection against people damaging the reseeded sites. The Fisheries Research Division therefore relies on the cooperation of the resource users and resource owners for the protection of the sites. This working cooperation can only be achieved through negotiations with the people, which involves talking, listening to, and learning from them.

**6. The 'precautionary management principle' for trochus resource**

Without basic scientific knowledge of trochus resources and environment and without natural resource planners and managers being aware of the traditional environment and resource management skills and knowledge of ni-Vanuatu, it will not be possible to make the best use of the country's trochus resources, in a way which sustains societies and cultures and protects the environment.

Marine tenure systems in Vanuatu are not, as is widely suggested, necessarily hindrances or problems in themselves. The problem is the apparently irreconcilable gap between these systems and modern concepts of natural resource development and of financial security; and the difficulty which some foreigners have in understanding the true nature and cultural significance of communal tenure.

The difficulties and complexities of incorporating a cost-effective management system that will produce results that are commensurate with the value of the resources, both in economic terms and in the eyes of the people, have meant that efforts to develop procedures for accommodating customary tenure systems have had to be put aside. The difficulty, however, is not only local.

The pervasive influence of bilateral and multilateral aid agencies is such that the Fisheries Department inevitably becomes geared to the needs of these external agencies and of their criteria for trochus and other marine resource management. And the criteria of funding agencies are overwhelmingly economic, despite recent efforts by some to make allowance for the more conspicuous environmental and social dis-benefit of the management options.

Traditional environment and resource management knowledge is particularly important for long-term (sustainable) resource management, especially trochus resource management. There is a need to tap custom knowledge for development. In Vanuatu many traditional ways of using the resources of land and sea had the effect of conserving these resources so that they were not wasted and could be used indefinitely.

Some farmers, for instance, used techniques of clearance and cultivation which made it possible to grow crops on steep slopes, the soil from which would otherwise be washed downhill. Seasonal taboos on coastal waters where certain fish were known to gather for breeding ensured that harvests elsewhere could be sustained.

Introduced, modern, forms of resource development tend to overwhelm custom environmental knowledge and practices. This process of extinction of custom knowledge is reinforced to some extent by a mistaken belief that custom knowledge is not relevant to modern development needs.

The 'precautionary management principle' is a management development procedure for trochus resources which incorporates the best of the modern management systems and customary systems. It allows those who retain custom environmental practice and who are skilled in custom conservation practice to con

tribute to a form of marine environmental management of trochus resources which is appropriate for a modern Vanuatu. Such people are assured by the Fisheries Department Research Division that their knowledge is respected. They are encouraged to share this knowledge with the Division so that it can be applied to modern development practice. The application of custom knowledge through the precautionary management principle also provides a form of support for Vanuatu cultures, boosting pride in their value and relevance.

Combining the modern and customary management systems is a straightforward process. The two management systems have the same objectives, even though methods of implementation may be different.

For example:

The primary aim of the Fisheries Management Regulation is to:

- provide fishing at both economically and biologically sustainable levels;
- conserve resources for future generations; and
- provide means for better utilisation of resources.

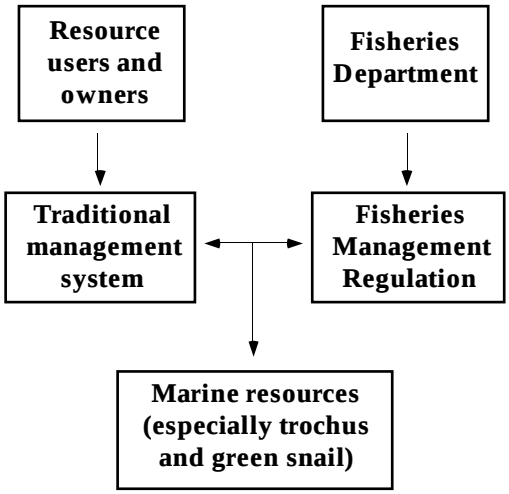
The primary aim of the traditional management system is to:

- conserve resources for future generations;
- provide fishing at both subsistence and biologically sustainable levels;
- provide a means of harmonised living with the environment; and
- ensure a more socially desirable distribution of the economic benefits obtained from the marine environment.

The difficult part of the combined management system is establishing a working relationship between the Fisheries Department and the resource users and resource owners. The management procedure is purposefully termed: 'precautionary management principle', because precaution is required when discussing and addressing appropriate sustainable management systems and establishing a from of working partnership with the people. The people get very defensive and apprehensive if their views concerning the management of their resource are overlooked or considered not relevant for modern development needs.

The purpose of the 'precautionary management principle' is to encourage the resource users and resource owners to manage their marine resources, especially trochus and green snail (*Turbo marmoratus*), resources using whatever traditionally-based management system they see fit. They are encouraged not to overlook or violate the Fisheries Management Regulations which are purposefully implemented by the Government purely for biologically sustainable and recruitment purposes.

**Precautionary management principle**




The 'precautionary management principle' is a perfect management system for hatchery-reared juvenile trochus reseeding trials. Juvenile trochus reseeding experiments in Vanuatu are proving to be a viable means of trochus management. However, this alternative cannot work without the cooperation of the resource owners and resource users. This cooperation can only be achieved through the precautionary management principle. Once the juveniles are reseeded, the people take up the responsibility of protecting the release sites

and the shells, making sure that no one disturbs or collect the shells for subsistence purposes. This is achieved through the instigation of taboos (bans) on the reefs by the resource owners, which may last for up to three years.

Advice on the period for which a reef should be closed is provided by the Fisheries Department, depending on the type of marine resource involved. For example, for *Trochus niloticus*, the resource users and owners are advised to place a taboo of three years. Some resource owners have gone a step further by instigating a taboo on all marine resources on their reefs for periods up to five years. Some resource owners divide their reef into two halves, with fishing allowed on one half and prohibited on the other. Through the 'precautionary management principle', the resource users and resource owners can either:

(i) place a no-fishing taboo on all marine resources on their reefs for a certain number of years;

(ii) place a no-fishing taboo for trochus and green snails only on their reefs for a period of time;

(iii) divide their reef into two parts, where

  (a) fishing is allowed on one part and not allowed on the other part; or

  (b) fishing trochus and green snails is not allowed, but fishing for other resources is allowed, on one half of the reef, while on the other half of the reef fishing of all marine resources is prohibited; or

  (c) fishing for trochus and green snails, but not for other resources, is allowed on one half of the reef, while on the other half of the reef fishing of all marine resources is prohibited.

The precautionary management principle aims at providing management alternatives to suit the subsistence and financial needs of the people. It provides measures by which marine resources can be managed at local level, thereby ruling out the risk of overlooking the subsistence needs of the people. If this system works effectively, the costs of enforcement of management measures are minimised, as are social and political conflicts between the government and the community. However, the main advantage of the precautionary management principle is that the fishing communities are likely to have a better understanding and appreciation of management principles if they are discussed at a local level.

## 7. General remarks

### *A failure to recognise subsistence needs*

It is tempting for fisheries officers and environment groups which have concerns over marine resources to instigate strict management controls that do not take into account the subsistence needs of the people, but rather management controls that are confusing and complicated for the resource owners and resource users. Management controls that are confusing and complicated for the people satisfy only the desires of the fisheries officers and environmentalists, not the people whose subsistence needs will be affected by controls.

It is a pure waste of time and money to concentrate on producing awareness programmes and implementing strict management controls, and at the same time fail to devise income-generating alternatives for the people who depend heavily on the resources concerned. If the people are not provided with alternatives that will ensure that their subsistence and financial needs are met, they will continue to do whatever they were doing to the resource, regardless of the management controls.

# The Aitutaki experience in the development of management strategies for the trochus fishery

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*Cook Islands*

## Management of the Aitutaki trochus fishery

Currently the Marine Resources Act 1989 and the Aitutaki Fisheries Protection By-Laws 1990 are the only two statutes which apply to the trochus fishery . From the establishment of the trochus fishery on Aitutaki, a management plan was developed by drawing on examples from trochus fisheries elsewhere and experience from past harvests on Aitutaki (FFA Report No. 93/25).

The aim for the development of an effective management plan was to maintain a catch as large as possible which would be profitable to the community and not biologically jeopardise the renewability of the resource. Table 1 illustrates the development of management strategies for the Aitutaki trochus fishery in chronological order.

The management strategies put into practice for the Aitutaki trochus fishery are briefly summarised below.

## Harvest season

The harvesting seasons following the 1981 harvest were very limited in duration, ranging from one day to three months. Initial harvest seasons were declared arbitrarily. However, due to actual yields grossly exceeding the set quota, harvest duration was then determined by the estimated time needed to attain the allocated quota.

This system alone proved ineffective in controlling the allocated catch quotas. In 1987 the harvest durations were allocated as separate 24-hour periods. The harvest season was then closed when yields were fairly close to the allocated total catch quota. The introduction of 24-hour pulse fishing periods appears to have successfully minimised quota overruns.

## Catch limits

It has been difficult to determine how the first two catch quotas were achieved, however after the second harvest season, quotas were calculated as approximately 30 per cent of the assessed biomass of 8–11cm shells. During the 1990/91 and 1992 harvests, the total allowable catch quotas were set at 60 per cent of the assessed standing stock of legal-size shells. Trochus harvest inspectors are required to monitor all landing sites as the harvest progresses. This has proved logistically impossible (Sims, 1988).

## Trochus reserve

A breeding reserve was introduced in 1983 which covers a 3 km stretch of the windward reef of Aitutaki. The location of the reserve was designed to promote retention of plankton larvae in the lagoon (Sims, 1988). Pre- and post-harvest surveys suggest that poaching has occurred in the reserve (Sims, 1988).

## Size limits

Legal size limits were introduced after the establishment of the fishery and have changed over the years from the experience gained in each harvest. A minimum size limit of 8cm was imposed during the first harvest (Clark, D., pers. comm.).

Experience from other trochus fisheries has indicated that trochus reach reproductive maturity at around 6–7cm basal diameter. A minimum size limit of 8cm allows most young trochus the opportunity to spawn before becoming vulnerable to fishing pressure.

During the first harvest season trochus buyers were reluctant to purchase large, wormy shells. The outcome of this was the introduction of a maximum size limit of 12.5cm (basal diameter) during the 1983 harvest season. In 1984 the maximum size limit was reduced to 11cm (Bour, 1988). This appears to have successfully improved the value of the total catch. The maximum size limit was designed to limit the taking of low-value (wormy) shells and preserve the more fecund animals within the population.

**Licensing**

Licensing of divers was first introduced in 1983 and is currently a requirement under law.

**Trochus kept alive**

There is a requirement that all harvested trochus must be kept alive until approved by a harvest inspector. This allows for the illegally harvested shells to be returned to the water.

**Individual Transferable Quotas**

During the 1990/91 harvest an Individual Transferable Quota (ITQ) system was introduced to control the problems with quota overruns. To determine the ITQ, the allocated total catch quota is divided evenly between all resident individuals of Aitutaki during the allocated harvest season, regardless of the desire to participate, age or actual ability to harvest trochus (Zoutendyk, 1990).

The ITQ as a management tool appears to be most favoured by the community, as all individuals receive an equal share of the economic benefits. The introduction of ITQs was a success in reducing quota overruns.

It also minimised the risk of stock-piling prior to harvest seasons. ITQs also have the added potential to increase the value of the total catch (fishers are more inclined to fill their quota with high-value shells). ITQs will most certainly be used in future harvests.

**Table 1: A chronological history of the development of management strategies for the Aitutaki trochus fishery (tonnes expressed as dry shell weight)**

| Management strategies practised during each harvest | Actual occurrence during each harvest season | Comments |
|---|---|---|
| **1981/82 harvest season** | | |
| A short harvest season of 3 months was declared. | The actual harvest season was 15 months. | The harvest season was decided arbitrarily. |
| Harvestable quota was set as 30 t. | Approximately 200 t of trochus shell was collected. | Records do not show how this quota was determined, probably by speculation. |
| Size limits | | A minimum size limit of 8 cm (basal diameter) was imposed. |
| **1983 harvest season** | | |
| 3 months was declared as the harvest season. | The actual duration of the harvest was 3 months. | The harvest season was determined by estimating the time to attain the set quota. |
| Harvestable quota set as 20 t. | Total of 35.7 t harvested. | This quota was probably determined by speculation. |
| Legal size limits | Illegal-sized trochus harvested were confiscated by harvest inspectors prior to processing. | The minimum size of 8 cm was maintained. A maximum size limit of of 12.5 cm basal diameter was introduced to remove poor-grade (wormy) shells from the total catch. |
| Trochus reserve established. | Poaching occurred in the reserve. | Three kilometres of windward reef was designated as a trochus reserve. The size of the reef was decided arbitrarily. Harvesting occurred in the reserve, due to poor enforcement efforts. |
| Licences issued. | 42 licences issued. | Licences cost NZ$ 1.00. |
| Trochus must be kept alive prior to inspection. | Illegal-sized shells were confiscated prior to processing. | Confiscated shells were returned to the lagoon. |

**1984 harvest season**

| | | |
|---|---|---|
| 3 months declared as the harvest season. | The actual harvest season was 12 days. | The harvest season was reduced due to the total catch grossly exceeding the set quota. |
| Harvestable quota set as 20 t. | Total of 45.7 t harvested. | The quota was calculated as 30% of the harvestable stock (8–11 cm size range). |
| Legal size limits | Inspectors removed undersized and oversized shells prior to processing. | The minimum size limit was maintained. However the upper size limit was reduced to 11 cm (Bour, 1988), probably due to parasitic infestation on large shells. This has successfully improved the total catch value. |
| Maintained trochus reserve. | Poaching occurred in the reserve. | Harvesting occurred in the reserve due to poor enforcement. |
| Licences issued. | 300 licences issued. | Licences cost NZ$ 1.00. |
| Trochus must be kept alive prior to inspection. | Illegal-sized shells were confiscated prior to processing. | Confiscated shells were returned to lagoon. |

**1985 harvest season**

| | | |
|---|---|---|
| 3 days was declared as the harvest season. | The actual harvest season was 3 days. | The harvest season was determined by estimating the time needed to attain the set quota. |
| Harvestable quota was set at 20 t. | Total of 27 t was harvested. | Quota was set at 30% of the harvestable stock. |
| Legal size limits | Illegal-sized trochus harvested were confiscated by harvest inspectors. | The legal size for trochus was maintained as animals with a basal diameter of 8–11 cm. |
| Maintained trochus reserve. | Harvesting occurred in the reserve. | Harvesting occurred in the reserve due to poor enforcement. This was suggested by surveys conducted in the reserve before and after the harvest season. |
| Licences issued. | 250 licences issued. | Licences cost NZ$ 1.00. |
| Trochus must be kept alive prior to inspection. | Illegal-sized shells were confiscated prior to processing. | Confiscated shells were returned to the lagoon . |

**1987 harvest season**

| | | |
|---|---|---|
| 2 days declared as the harvest season. | The actual harvest season was 2 days. | The season was divided into 2 separate 24-hour periods till the quota was reached. This was introduced to prevent harvest overruns. |
| Harvestable quota set at 40 t. | Total of 45.1 t was harvested. Stock-piling took place prior to the opening of the fishing season (O. Terekia, pers. comm.). | Quota set at 30% of the harvestable stock. Stock-piling prior to any harvest allows the fishers to achieve a large catch during the the harvest duration. |
| Legal size limits | Illegal-sized trochus harvested were confiscated by harvest inspectors prior to processing. | The legal size for trochus was maintained as animals with a basal diameter of 8–11 cm. |
| Maintained trochus reserve. | There were rumours that poaching occurred in the reserve just before the harvesting (O. Terekia, pers. comm.). | More effort was placed on enforcement. |
| Licences issued. | 190 licences issued (day 1)<br>233 licences issued (day 2) | Licence issued for the first 24-hour harvest period was valid for the second 24-hour period. The cost of licences remained at NZ$ 1.00. |
| Trochus must be kept alive prior to inspection. | Approximately 350 kg of processed shell was confiscated since it was processed without the knowledge of harvest inspectors. | The confiscated shells were later returned to the fishers, as ordered by the Island Council, without any form of prosecution (O. Terekia, pers. comm.). |

**1988 harvest season**

| | | |
|---|---|---|
| One day declared as the harvest. | The actual harvest season was one day. | |
| Harvestable quota was set at 20 t. | Total of 18 t harvested. | Quota set at less then 30% of the harvestable stock (8–11 cm) (Zoutendyk & Passfield, 1989). |
| Legal size limits | Illegal-sized trochus harvested were confiscated by harvest inspectors. | The legal size for trochus was maintained as animals with a basal diameter of 8–11 cm. Confiscated animals were distributed throughout the lagoon. |
| Maintained trochus reserve. | Poaching occurred in the reserve just before the harvest. | More effort was placed on the enforcement of the reserve during the harvest. |

**1990/91 harvest season**

| | | |
|---|---|---|
| 5 days declared as the harvest season. | The actual harvest season was 5 days. | |
| Harvestable quota set at 25 t. | Total of 26.2 t harvested. | The quota was set at 60% of the harvestable stock, 8–11 cm size range. The introduction of ITQs seems to have solved the problem of excess quota overruns. |
| Legal size limits | Inspectors removed undersized and oversized shells from the catch prior to processing. | The minimum size limit was maintained at 8 –11 cm basal diameter. |
| Maintained trochus reserve. | Harvesting occurred in reserve. | More effort was exerted in enforcing the reserve. The total ITQ allocated to fishers who were caught poaching the reserve were confiscated by the inspectors, however they were later returned as ordered by the Island Council without any form of prosecution. |
| Licences issued. | 2,250 licences issued. | The cost of licences remained at NZ$ 1.00. |
| Trochus must be kept alive prior to inspection. | Illegal-sized shells were confiscated prior to processing. | |
| Introduced Individual Transferable Quotas (ITQ). | 15 kg allocated to all individuals, regardless of age, actual ability or desire to participate in the harvest. | It was difficult for fishers to reach their allocated quota, therefore a large proportion of wormy shells was collected. |

**1992 harvest season**

| | | |
|---|---|---|
| Pulse fishing of 24-hour periods. | Actual harvest season was 17 days. | A series of 24-hour pulse fishing periods was declared until the catch approached the allocated quota. |
| The quota was set at 25 t. | Total of 27 t harvested. | Because of the nature of the harvest, few fishers participated. It therefore became difficult to achieve the allocated quota. |
| Legal size limits | Inspectors removed undersized and oversized shells prior to processing. | The minimum size limit was maintained at 8 cm, however during the progress of the harvest the maximum size limit was increased from 11 cm to 12 cm to allow for the allocated quota to be attained. |
| Maintained trochus reserve. | Harvesting occurred in reserve. | Poor reserve enforcement resulted in poaching. This was probably due to the efforts and results of the enforcement officers being overlooked during past harvested seasons. |
| Trochus must be kept alive prior to inspection. | Illegal-sized shells were confiscated prior to processing. | Confiscated shells were returned to the lagoon. |

During 1992 there was a great need for finance to complete an Aitutaki community project. It was decided that the revenue received from the trochus harvest for that year be directed towards the completion of the community project. A series of 24-hour pulse fishing periods was declared till the allocated quota of 25 t was achieved. However, as the harvest progressed it became difficult to obtain the allocated quota with legal-sized shell. The upper size limit was then increased to 12 cm basal diameter.

Stock assessment results after the 1992 harvest indicate that the standing stock of trochus to date has not reached commercially exploitable levels (Figure 1).

Possible reasons and causes for the slow recovery in the population are as follows:

- the assessment of the trochus population *or* interpretation of the assessment result could have been incorrectly performed;

- the use of 60 per cent of the assessed biomass as a guideline by which quotas are currently set may be an unreasonable figure, as a means of determining the allowable catch,

- from a more cynical point of view, pressure from short-sighted bureaucrats who required a quick source of cash in order to complete a community project could have played a role in the determining of a high quota.

Figure 1 shows that harvests occurred annually between 1983 and 1985 and should have occurred in 1986. This would have allowed for five successive annual harvests. Harvestable quotas for the period were determined as approximately 30 per cent of the standing fishable biomass.

## Conclusion

During the development of the trochus fishery, established management tools were improved and others introduced. This has evolved into a management plan for the fishery which has proven to be a very effective mechanism in achieving most of its goals. In the near future there is a need to further investigate a more

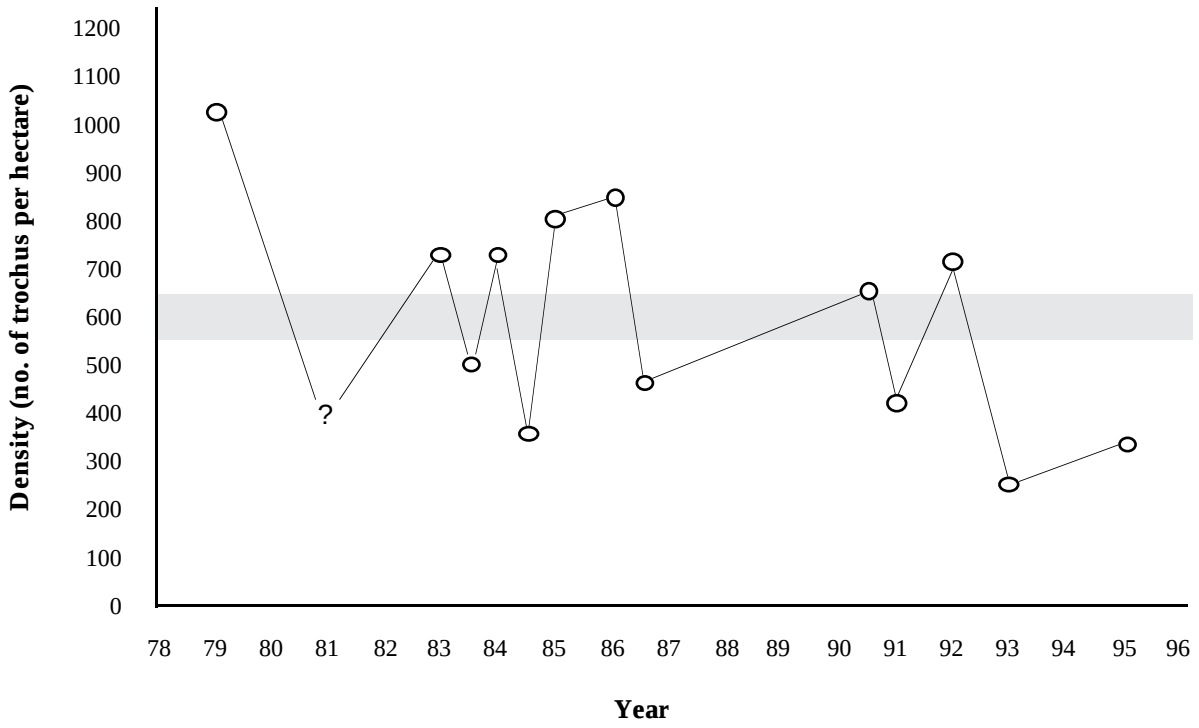


**Figure 1. The history of density estimates (individuals/hectare) for the Aitutaki trochus resources. The closed circles represent post-harvest density estimates. The shaded bar indicates the approximate density guideline in which trochus harvest are declared.**

applicable figure (between 30 and 60%) from which harvest quotas can be calculated. There is also a need to ensure that the reserve is strictly enforced and poachers prosecuted, in order to reduce future poaching.

Further trends in the future are to produce a simple handbook on how to assess the trochus population and interpret field data on Aitutaki and possibly the development of a computer program in which catch quotas and individual transferable quotas are determined. This would most certainly reduce the risk of errors in stock assessment and analysis. Hopefully this will ensure that it becomes difficult for bureaucrats to tinker with the system.

It is anticipated that these goals will be achieved prior to the exploitation of trochus resources on other islands within the Cook Islands.

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## Spatial distribution of trochus population size structure around Aitutaki barrier reef

***by Tim Adams***
***Fisheries Resource Adviser***
***South Pacific Commission***

One result of the MMR/SPC Aitutaki trochus fishery case study in 1992 (see Nash et al., 1995) was a large set of shell diameter-frequency data from various sites around the reef. This arose both from transect surveys to assess pre-harvest stock abundance (thus covering the whole size range of trochus apart from the first, more cryptic age-class), and from harvest sampling (thus covering only the legally fishable size range between 80 and 110, later 120, mm diameter).

In total, 11,582 shells were measured during the transect surveys and 7,232 shells were measured during the harvest. It was estimated, from a mark-recapture experiment, that the population just prior to the August 1992 harvest was around 315,000 shells (not including the cohort from the previous summer spawning), and it is known that 49,000 shells (in the 80–120 mm size-range) were collected during the harvest.

One interesting property of these size-frequency data is the great variation in size structure at the different sites around the barrier reef (see Figure 1). This is not haphazard variation, but follows a consistent cline around the reef, with the greatest proportion of juvenile shells on the northeast face of the reef and the greatest proportion of large shells on the southern face.

This is shown clearly by the histograms that were published in Figure 3 of Nash et al. (1995) and is summarised in Figure 2 here.

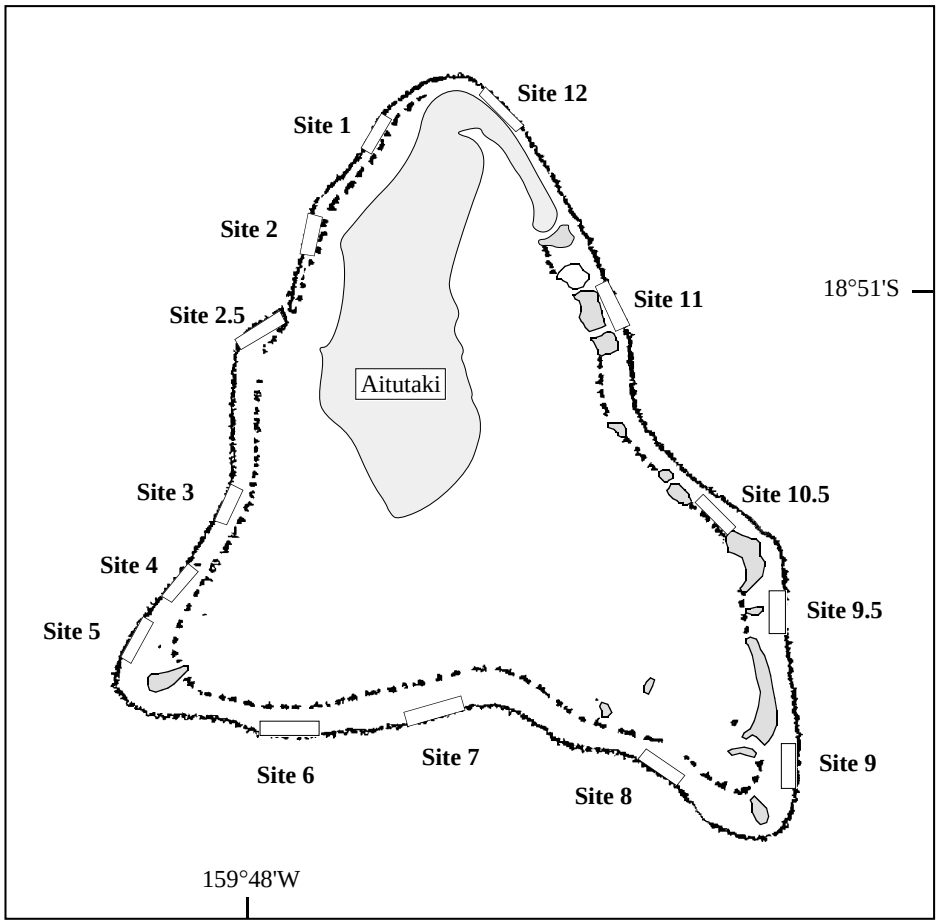


**Figure 1. Map of Aitutaki showing survey stations**

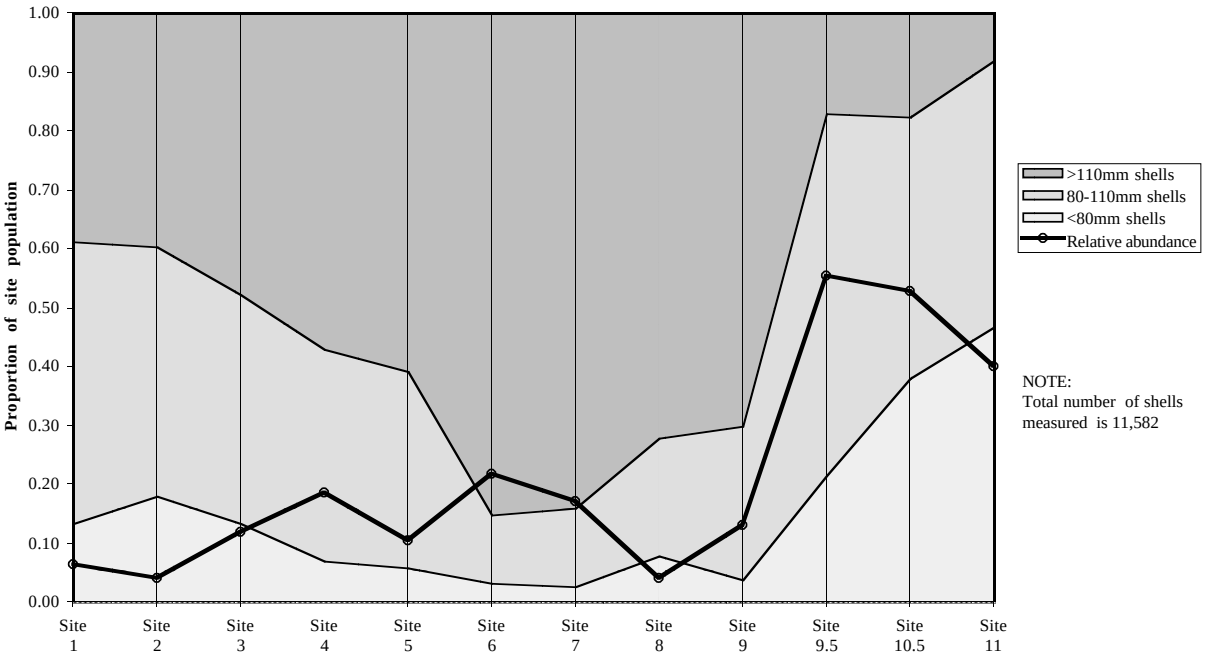


**Figure 2: Trochus size composition at different sites around Aitutaki barrier reef**

Just why these differences in size structure occur is not clear. The possible factors involved are as follows:

- The prevailing winds at Aitutaki are the southeast trades, but the windrose has a substantial vector from the north. The prevailing wind direction will presumably have an effect on lagoon water circulation and the transport of trochus larvae during their short time in the plankton. Aitutaki lagoon is almost completely enclosed, apart from a small-boat passage on the western reef face, between Survey Sites 2 and 3. However, the eastern and southern faces of the reef are wider and more elevated than the leeside western face;

- Aitutaki lagoon is very shallow overall, with a maximum depth of around 10 m in the southwest. The northeast bay, near to the area where the trochus population has the greatest proportion of juveniles, is the shallowest part of the lagoon;

- Trochus is an introduced species at Aitutaki (brought from Fiji in 1957) and the first individuals were planted at Akaiami motu on the eastern reef face (Site 10, not actually surveyed here). This area was chosen since it is the island closest to the end of the seaplane landing strip. Akaiami is now a trochus reserve, with no harvesting of this particular species permitted at any time (some poaching is reported to occur however);

- The southern reef face is less accessible to casual harvesters than the other areas, and is known to have had a lower fishing pressure during the previous harvest season. The southern face is both devoid of motus, thus island-hopping is difficult, and is difficult to navigate because of the high coral walls running radially across the lagoon from the island to the southern reef-face.

The size-structure pattern is thus likely to result from a combination of differences in both harvesting pressure and recruitment (larval settlement), and it is even possible that migration may play some part (since no segment of the barrier reef is isolated).

A measure of the relative abundance (density per area of trochus habitat) of shells at each site, derived from transect survey data, has also been included, and is represented by the line in Figure 2. The much higher abundance of shells on the northeast face of the reef is notable, not just in the reserve itself, but in the area extending to the north of the reserve.

A transect survey had also been performed after the previous harvest in early 1991, and it was noticeable that whilst the reserve area (Site 10) retained a high abundance of shells, the area to the north of the reserve (Site 11) had been heavily fished and had a much lower abundance.

Since Site 11 proved to have a high population of juvenile shells in the August 1992 survey described here, is this a result of it being downstream of the reserve? Does the surrounding area benefit from a spillover effect from the reserve, or is this coincidentally an area which traps a high concentration of larvae from spawning populations all around the reef?

The South Pacific Commission and the Cook Islands Ministry of Marine Resources will be spending a little more time with this dataset, and will be gathering some new information, in conjunction with a project to develop a management plan for Aitutaki 's coastal fisheries, over the next two years. We would be very interested to hear if anyone else has similar experiences of spatially variable size-frequency structure in a trochus population.

Reference

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## Trochus survey training, March 1995, Penryhn Island

*by Kelvin Passfield*

Penryhn (Tongareva), with a population of around 600, is the northern-most atoll of the Cook Islands, situated about 9° south of the equator. It has a very large lagoon, and pearl farming using black-lip pearl oysters (*Pinctada margaritifera*) has recently been initiated there. *Trochus niloticus* were first introduced to Penryhn from Aitutaki in 1984, with approximately 384 trochus surviving the voyage (N. Sims, pers comm).

A training exercise was conducted in March 1995 for research trainees at the Tongareva Marine Research Centre (TMRC) in the tag / recapture method of estimating abundance of trochus. Although a closed population is normally a prerequisite for this type of survey method, it was decided that it would be appropriate in this case because of the relatively sessile nature of trochus and the short period of time between samplings. It was therefore assumed that migration in and out of the survey area was minimal.

113 trochus in a 1.5 km stretch of the lagoon side reef were measured and tagged by marking the inside nacreous layer with a pencil. The surveyed area was adjacent to the TMRC, and approximately 7 km from the site of the original 1984 translocation site. The same area was resurveyed 2 weeks later. 84 trochus were found, 23 of which had been previously tagged.

The tag / recapture method of estimating abundance gave a result of 420 trochus in this stretch of reef.

Trochus less than 8 cm were found predominantly in the coral rubble on the inner lagoonal reef flat. Larger trochus were almost exclusively found within 2 m of the lagoonal reef drop-off, or on the drop-off itself. Interestingly, although 41 trochus less than 8 cm were originally tagged, none of these were recaptured. 14 trochus less than 8 cm were found during the second survey. This would suggest that there is a significant number of young trochus, which are not being found because of their cryptic nature and their more extensive habitat. The abundance of trochus is likely to be considerably higher than our estimate using the tag / recapture method.

While this brief training exercise did not give any indication of the total size of the trochus stock in Penryhn lagoon, it did indicate that the trochus transplant of 1984 was successful. Trochus are considered abundant in certain areas of the reef, although an island-wide survey has yet to be attempted. Trochus are not commonly found on the ocean side of the reef, but on the inner lagoon flat and the drop-off into the lagoon proper.

As most of the trochus transplanted were greater than 12.5 cm (Sims, pers comm), the trochus found in our survey can be all assumed to be second- and third-, and perhaps even fourth-generation trochus. With exponential growth of the population, another 10 years could see trochus present in commercial quantities.

Meanwhile, Penryhn has a flourishing handicraft industry utilising black-lip pearl oyster shell, and the use of trochus shells in locally manufactured jewellery could be an option for moderate exploitation now. The number utilised for this should not significantly affect the standing stock.

## Three countries involved in Vanuatu trochus shell reseeding project

It is common knowledge that trochus shells are overfished in most countries. The shells are used in tourist markets for souvenirs and for the production of buttons throughout the Pacific.

Australia has commenced a trochus shell reseeding project in Vanuatu and the region, in response to the need for the management of this resource.

In a three-year project, Vanuatu, Australia and Indonesia will take part in the undertaking which will involve a variety of institutions, including the Western Australian Fisheries Department, Aboriginal communities in Western Australia, the Indonesian Institute of Sciences, and Pattimura and Nusa Cendama Universities in Eastern Indonesia.

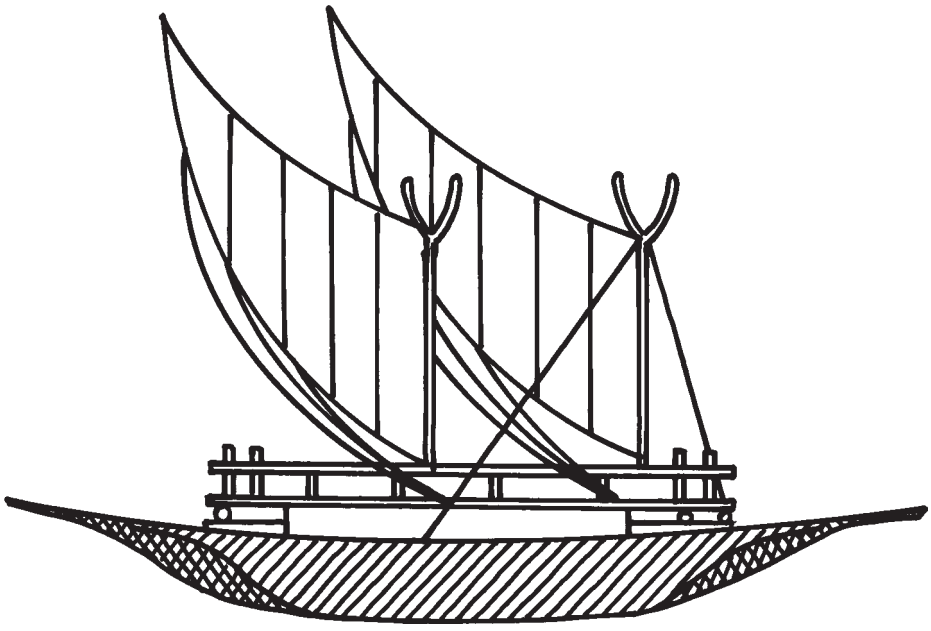
A total of $A 107,335 has been allocated by AusAid to the Vanuatu section of the project and will be used to upgrade the hatchery at the Department of Fisheries and provide support of fisheries staff in the production of juvenile trochus shells for release into three selected sites around Vanuatu.

The research will determine the optimum size and sites for reseeding the reefs, the nature and effect of predators, and what competition there is for the shell to survive. Following collection of these data the information will be transferred to the other participating countries.

Analysis of the research will be carried out by the Northern Territory University in Darwin.

With the reseeding of the reefs around Vanuatu with young trochus, and the new information that will come to light from this project, it is hoped the shell will be able to survive and continue to provide an income to the people of Vanuatu without threatening the extinction of the species.

Source: *Australian–South Pacific Newsletter*



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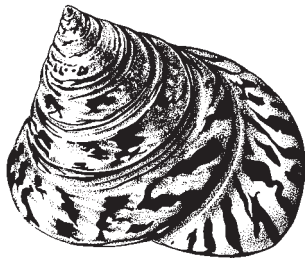

*This section was intoduced for the first time in the Trochus Information Bulletin #2. It presents articles published in several regional magazines (*Pacific Islands Monthly, South Pacific Bulletin*)—a good way to compare problems from the past with the ones encountered today. Careful readers will have noticed that first and last articles of this Bulletin talk about transplantations (or transplantings, as they said in the old days) of trochus... There is just a 38-year gap between them...*

## Transplanting trochus in the eastern Pacific

***Source: H. Van Pel***
***Fisheries Officer, South Pacific Commission***
**SPC Quarterly Bulletin, *July 1957***

Trochus shell is a commodity much in demand on the world market and it can be relied on to command a good price. So a good cash income can be earned in many islands of the South Pacific where the shell is found.

In most of the western half of the area where the South Pacific Commission is working, the island reefs are inhabited by *Trochus niloticus*, but there still remain many other reefs where this useful money-spinner has never been seen. In the island waters east of Fiji (longitude 176°W), there is no record of *Trochus niloticus*, but we have inspected reefs where the living conditions would be suitable for them.

Accordingly, acting on our advice, the Cook Islands Administration has gone ahead with transplantation of trochus from Fiji to Aitutaki. Two transplantings have now been made, and, although some trochus did not survive the journey, both are reported to have been successful.

The second transplanting was made by two students of the South Pacific Fisheries Training Course, R. Powell and I. Marsters, and they and the Resident Agent from Aitutaki have confirmed that the trochus previously transplanted were alive and had moved out over the reef, some being already beyond the breakers.

The shells of the first transplanting were carried in tins of sea-water; those for the second transplanting were carried dry in crates. Both transplantations were made by aircraft.

During the second transplanting aircraft flew at 5,000 feet (≈ 1500 m), where the temperature dropped to 68°F (20° C), but with six 24-volt bulbs around the crates the temperature was kept up to 75°–85°F (≈24–29° C). These shells were planted on the reef, and, from inspections made the following day and three days later, seemed to be settling into their new quarters.

On a visit to French Oceania in last March–April, a number of reefs were found in various islands where trochus could be established with good expectation of success. As a result of some advice given in this regard at the end of our visit, the Territory of French Oceania has made plans for a transplantation of 1,000 trochus to commence in late May.

It is expected that more transplantings of trochus will take place in the South Pacific. However, it would be advisable in each case to have an investigation carried out by a qualified expert before any plans are made for the actual introduction of the shell, in order to ensure it will take place under the best possible conditions.