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Editor: Kelvin Passfield, P.O. Box 244, Apia, Samoa. [Tel.: +685 25506; fax: +685 20037; e-mail: passfield@lesamoa.net]. **Production**: Information Section, Marine Resources Division, SPC, B.P. D5, 98848 Noumea Cedex, New Caledonia. [Fax: (687) 263818; e-mail: cfpinfo@spc.org.nc]. **Printed with financial assistance from the Government of France.**

EDITORIAL

Welcome to the first *Trochus Information bulletin* for the year 2000. Yes, after more than two years since the last issue, we finally have enough material to justify issue number 6. And what a battle it has been to get people to contribute!!

In this issue we have articles from Cook Islands, Solomon Islands, Tokelau, Samoa, and New Caledonia, as well as an update on the ACIAR reseeding project. There are also a few abstracts describing trochus research that has occurred in recent years, as well as information on a new manual on marine snail (trochus and green snail) seed production and restocking**.** I was hoping to get a few contributions from other countries that I KNOW are doing a lot of work, such as Tonga and Vanuatu, but no doubt other pressing priorities have not left time for these countries to contribute?

As I do not yet seem to have learnt the trick of extracting articles from all you researchers out there, and due to heavy work commitments (yes, I do now have a real job, at least for the next 2 years), this first issue for 2000 will also be the final issue with yours truly as Technical Editor. For the next issue, the reins have been passed over to Dr Chan Lee, currently with Western Australian Fisheries. As a researcher who is in close contact with what is happening in the ACIAR project, as well as other trochus research, he will be in a better position to see that these pages are filled and bulletins issued on a more regular basis. However, to ensure that the bulletin does not become a purely 'scientific journal' I would encourage the Pacific Island researchers, as well as those involved in marketing and processing, of trochus and green snail to continue (or begin!!) to submit their articles on what is happening in their own country.

Inside this issue

A little side issue. On a recent visit to Rarotonga for home leave, I noticed a large increase in trochus abundance in the four marine protected areas (*ra'ui*) established there two years ago. It really was incredible how many large trochus could be found at some of these sites, though the sites were quite small. At one particular site, approaching the reef flat in Nikao, they were so abundant you had to be careful where you put your feet for fear of stepping on them. To me, this really confirms the value of having reserves for trochus and other marine animals. These *ra'ui* sites were established in Rarotonga on the initiative of local traditional leaders, and have been well respected by the community. I encourage other communities to take the initiative to establish small reserves where possible, and not wait forever for governments to pass legislation. The breeding populations that thrive in such reserves will assist in replenishing stocks in other areas, leading to a more valuable fishery in what can sometimes be a remarkably short time.

On that final note, I will now step down from my soapbox, and wish you all the best in your marine resource management efforts in the new millenium. I would also like to wish Dr Lee all the best with his new role as Editor, and thank those of you who have assisted me in the past by making contributions.

Kelvin Passfield

ews from the Cook Islands

Trochus transhipment to Atiu, Mauke and Takutea islands, Cook Islands

Benjamin E. Ponia[1]

The history of the trochus (*Trochus niloticus*) introduction in the Cook Islands has been one of success. It began in the late 1950s, when several hundred animals were transhipped from Fiji to Aitutaki. That population is now established at Aitutaki in numbers of hundreds of thousands. Since then, transhipments from the Aitutaki stock have resulted in subsequent populations becoming established in most of the islands in the Cook group.

The trochus is an important resource. On Aitutaki it is harvested commercially. On the main island of Rarotonga the trochus is one of the main subsistence fisheries and has become a substitute for traditional reef foods that are no longer abundant. Thus the introduction of trochus has the effect of relieving pressure on some food resources which may otherwise have been harvested into near extinction. We are unaware of any wide-scale ecological impacts to the reef which are attributed to the introduction of trochus. This leaves one with the conclusion that the benefits of a trochus transplant outweigh the risks.

A current phase of trochus introduction has targeted the southern group islands. Transhipments from Rarotonga to the three islands of Mauke, Atiu and Takutea has recently occurred (Mitiaro and Mangaia are the next islands to be targeted), (refer Figure 1). The reef sites where the animals were transplanted often shared several common attributes. In particular, it was not extremely dry during low-tide periods and it was a habitat area frequented by ***ariri*** (Rough Turban-shell, *Turbo setosus*), as this animal shares a similar habitat preference. A summary of the transplants can be made as follows:

1. Director of Research, Ministry of Marine Resources, Cook Islands

1. Mauke (October 1997). A total of 500 animals (average basal length 8 cm) were airfreighted from Rarotonga. The population was deployed at three locations—200 animals at Aanga, a further 200 animals at Anaue and 100 along the passage of Taunganui landing. A television bulletin was run on the island for several nights to advise of the transhipment. Three days later, sites were revisited and the trochus found to be alive and in good health.

2. Atiu (May 1998). A total of 180 trochus (average basal length 12 cm) were airfreighted from Rarotonga. All the animals were resettled at Te Vai site. A check five days later revealed the animals to be in a healthy condition.

3. Takutea (May 1998). The Takutea transhipment of 170 animals (average basal length: 12 cm) coincided with the Atiu trip. Takutea is an uninhabited island approximately 20 kilometres north-east of Atiu. The trochus targeted for Takutea were first airfreighted from Rarotonga to Atiu. They were then transported on a small boat to Takutea and all the animals deployed at Au Matangi site.

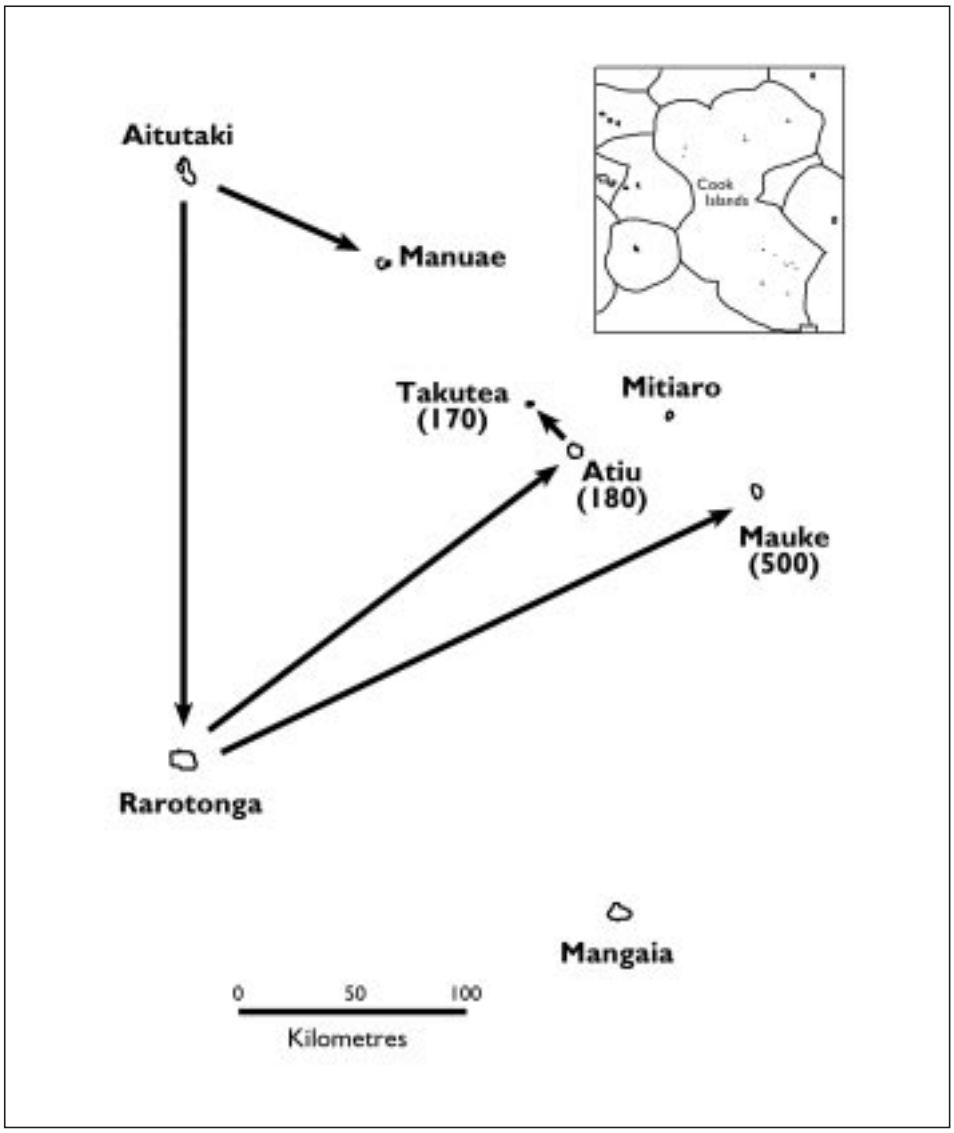


Figure 1

Map showing the history of trochus introduction in the Southern Cook Islands (the Manuae introduction was not successful). The recent phase of introductions has targeted Mauke, Atiu and Takutea. A further transhipment from Rarotonga to Mitiaro and Mangaia is planned.

Rarotonga trochus over-harvesting fears

A Ngatangiia resident has complained to the Ministry of Marine Resources about people harvesting trochus in the sea around Rarotonga for their meat.

Contacted Marine Resources official Nooroa Roi told *Cook Islands News* that there is really no regulation to stop people from taking trochus in the sea around Rarotonga. *CI News* understands that people should realise that some trochus needs to be left alive to continue the population of the species. Roi said trochus shell is important for export and Aitutaki island is getting overseas buyers for its stocks.

Aitutaki has local regulations for harvesting on a periodical basis. Roi said [in Aitutaki] people are asked to only select those shells whose bottoms (the base where the snail's 'head' is) measure between 8 cm to 11 cm in diameter.

If Aitutaki can do it, so can Rarotonga. Which is another reason why the Marine Resources Ministry is asking main island public to be more sophisticated about harvesting trochus.

'Our island will benefit from this if we know how to look after the trochus,' Roi pointed out. He told *CI News* that people like harvesting those shells under 8 cm, because their meat is more tender than the older snails. Trochus were mass introduced to Aitutaki from Fiji in 1957 by the likes of the late Ron Powell, and in 1981 to Rarotonga, says Roi.

The ministry's last survey between 1997 and 1998 showed that the trochus appeared to be increasing. However, there are fears that there is currently over-harvesting which may ruin Rarotonga's trochus population. The ministry has draft regulation concerning the harvesting of trochus. The regulation requires periodic bans on the collection of trochus until a specified 'open season'. However, it still has to be dealt with by the Crown Law Office for legalities, says Roi. 'That will be done this year.' Meanwhile the ministry is asking the public for their cooperation on the matter.

CI News also understands that trochus bans and harvesting periods may be a responsibility that the yet to be fully established Rarotonga Local Government could handle.

Source: Rose Akava / AJS, *Cook Islands News*, 8 January 1999

Aitutaki trochus converts to English-made buttons

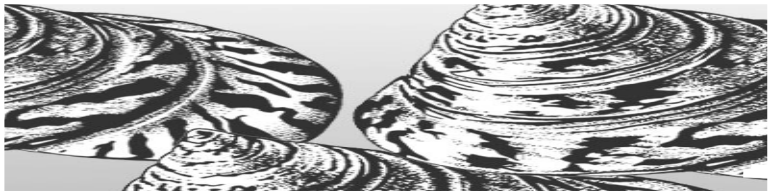
Thirty-two tons of Aitutaki trochus shells are now being turned into millions of buttons in England, and the Island Council believes another harvest is possible at the end of the year.

Every family on Aitutaki which filled their trochus quotas earned an average of NZ$ 600 just before Christmas—money that was welcomed by the island where so many are unemployed.

Mayor Tai Herman says they harvested a lot more (trochus) than what was recommended by Marine Resources. He believes taking an extra four tons of trochus wasn't irresponsible because harvesting used to happen only every three years. And this year's trochus collection won't be as big as last year's, assures Herman.

Aitutaki exported mostly A grade shells to England earning the island NZ$ 300,000.

Source: Manava Media. *Cook Islands News*, 27 January 1999



News from the Solomon Islands

Social dimensions of trochus fishery management in Solomon Islands

Dr Simon Foale[1]

Abstract

A study of social factors underpinning trochus fishery management strategies of Nggela customary reef owners is summarised here. Abundance data generated by the mark-recapture method showed that densities of trochus on ten reefs around Sandfly Island, in the Nggela Group, in Central Province, Solomon Islands, were low on most reefs, and indicated that recruitment overfishing was occurring. Customary Marine Tenure is shown to be a prerequisite, but not a guarantee, of good management. Gaps in local knowledge, especially concerning the processes involved in population replacement, have lead to some poor management practices. Supplementation of local knowledge with certain facets of scientific understanding about trochus biology and ecology is recommended, along with adequate enforcement of the minimum size limit, to give existing stocks some opportunity to breed prior to entering the fishery. However, no practical measures have yet been made to achieve the former goal in Solomon Islands.

Introduction

Customary reef owners in the Nggela Group in Solomon Islands, like those in most other parts of the country, regulate fishing of trochus through a system of serial prohibitions, known locally as *tambus*. These are typically imposed by people who possess primary rights (which by definition include rights of exclusion) to coastal reefs, and last from anywhere between three months to two years. The most common duration is about 9 or 10 months, with an annual harvest just before Christmas. Most of the trochus habitat on Nggela reefs is subtidal, and trochus are harvested by breath-hold diving. No quota limits are set by the reef owners or community leaders. Harvested trochus are cooked, and the meat consumed locally. The shells are sold to a number of buyers in the national capital, Honiara, approximately 50 km by sea from West Nggela. This paper comprises an abbreviated version of a study published in the journal, *Ocean and Coastal Management* (Foale, 1998) in which stock density data for ten reefs around Sandfly Island in the Nggela group is explained in terms of local knowledge, the customary marine tenure (CMT) system, and socio-economic factors. For the sake of brevity, I have omitted detailed descriptions of the methods used for analysis of tenure, knowledge, and socio-economic factors.

The customary marine tenure system in Solomon Islands is basically an extension of the customary land tenure system, i.e. coastal fringing reefs, offshore reefs and reefs around offshore islands are regarded simply as underwater extensions of coastal estates, and the same systems of rights apply (Baines, 1990). Primary rights to land and sea at Nggela, along with clan affiliation, are inherited matrilineally. However, because women usually move to their husband's village after marriage, Nggela people very often inherit land (and reefs) that are quite remote from where they have grown up. This dilemma is usually resolved via a traditional rights transfer mechanism known as the *Huihui*. In most cases, this institution is used to acquire primary rights over one's father's land. It involves a public feast, at which food, pigs and

1. Senior Technical Advisor, WWF Solomon Islands Community Resource Conservation and Development Project, P.O. Box 21, Gizo, Solomon Islands. Email: wwf@welkam.solomon.com.sb

(increasingly) cash are exchanged for rights over specified territories, in the presence of senior clan members (including chiefs).

Because CMT is essentially a private property system, with rights being held, and inherited, by corporate clan groups, it has been hailed for some time as a system that should facilitate good management of sedentary marine resources, since the 'tragedy of the commons' that typically befalls open access systems is theoretically avoided (Ruddle & Johannes, 1990; South *et al.*, 1994). However, CMT is clearly not the only factor that determines whether or not a fishery is managed effectively. Management decisions are influenced by economic pressures and constraints, which in turn are contingent on the price obtainable for the resource, and the effort required to obtain and then market it. Management is also informed by fishers' knowledge of the biology, ecology and population dynamics of the target species. Such local knowledge may comprise several different categories of information, each of which may, or may not, be relevant and useful to the management of the species. In this paper I also discuss the various categories of ecological knowledge about trochus, possessed by Nggela fishers, and examine how this knowledge may or may not be useful for managing the fishery.

Stock abundance and density

The Peterson mark-recapture technique (Seber, 1982; Nash *et al.* 1995) was used to estimate trochus abundance on 10 reefs in the Sandfly / Buena Vista area (Table 1). Trochus were marked with pencil on the nacre of the shell just inside the aperture. The mark-recapture method was found to be particularly convenient at West Nggela, because the dates of most end-of-*tambu* harvests were planned with some certainty. Thus marking could be timed to precede harvests by two or three weeks. This was long enough to give marked animals the time to mix with the rest of the population, and brief enough to ensure that marks were not lost due to overgrowth by new nacre. After the owners harvested the reef, all trochus in the harvest were measured and inspected for marks.

Densities of trochus were calculated using the area of trochus habitat at each site. Habitat areas were plotted on a digitiser from high-resolution black-and-white aerial photographs. Natural features marking ownership boundaries were easily distinguished on the photographs. Areas containing predominantly sand and seagrass were excluded from the measurements. Distances between two or more recognisable points on each reef were measured while in the field using a handheld GPS receiver (Garmin 45) to calibrate the scale.

Table 1. **Trochus density estimates from mark-recaptures on reefs in the Sandfly/Buena Vista area of Solomon Islands**

Reef	Density* (per hectare) (>8 cm / >6 cm)	Poached	Disputed	Remote
A	NA	Yes	No	Yes
B	NA	Yes	Yes	No
C	NA	Yes	Yes	No
D	NA	Maybe	No	No
E	NA	Yes	No	Yes
F	ND / 39.5	Maybe	No	Yes
G	27.6 / ND	No	No	No
H	13.5 / 32.3	No	No	No
I	42.5 / 76.9	No	No	No

(NA = densities too low to be measured with adequate precision; ND = no data).

* The density figures are given for shells in two size categories (>6 cm & >8 cm, basal diameter) because the legal minimum size limit is 8 cm. However, most reef owners harvested everything down to 6 cm, and were always able to sell these undersize shells.

Results and discussion

Stock assessment

Trochus density estimates from mark-recaptures are presented in Table 1.

Another large reef, 'J', was calculated to support a density of between 90 and 135 shells (>6 cm) per hectare, based on harvest size and assuming a similar exploitation rate (i.e. 1/3 to 1/2) as for other reefs. The data in Table 1 show that reefs that supported harvestable quantities of trochus tended to be those that were undisputed and located in front of villages.

Reefs subject to an ongoing, public dispute over primary rights were invariably overharvested. This is because it was regarded as pointless for either of the contesting parties to attempt to exercise rights of exclusion, via a *tambu* over the disputed reef, if another group refused to respect those rights. Similarly, reefs at some distance from a village centre were much more likely to be poached, though the level of poaching may have varied depending on the vigilance of the primary rights owners.

With the possible exception of 'J', the densities presented here are low compared with well managed trochus fisheries elsewhere in the Pacific (Adams *et al.*, 1992; Nash *et al.*, 1995). Poaching is widely acknowledged as a common problem on reefs which are out of sight of settlements, and where regular surveillance is difficult or impossible. This includes the reefs marked 'remote' in Table 1.

Trochus are relatively easy to find, hide and sell (see economic priorities section below), and most reefs are easily accessed by anyone with a small dugout canoe and diving goggles. A large proportion of rural Solomon Islanders have few alternative means of obtaining cash, and the pressure to obtain cash by whatever means is high throughout the rural sector.

Size-frequency data corroborated the stock density data, and also clearly showed the large proportion of undersize shells in harvests (shells were routinely harvested down to 6 cm basal diameter and sometimes even smaller on most reefs).

The bimodality of most size frequency distributions, with modes at around 7 cm, and 8.5–10 cm, also demonstrated that a large proportion of the shells in each harvest (up to half in most cases) was recruited subsequent to the previous annual harvest, a further indication of heavy fishing pressure.

What factors contribute to overfishing of trochus at Nggela?

Customary Marine Tenure

As indicated above, disputes over reef tenure tended to render any traditional management measures on those reefs useless, since neither party to the dispute was prepared to respect the other's authority to make a prohibition. Land (and reef) disputes are very common in Melanesia wherever development is occurring, and usually, the more lucrative the development, the hotter the dispute. There is now an abundance of examples, and accompanying analyses, in the literature (Turner, 1994; Filer, 1997). The rules of land tenure in Melanesia tend to be complex, flexible, context-sensitive, unwritten, and subject to differing interpretations by protagonists to disputes. I believe they are likely to be difficult to codify in any detail, although various attempts at this are proceeding in Solomon Islands and PNG at present. The work on which this short report is based included case studies of two land disputes that were heard in the local court, and provincial court. Both disputes were triggered by proposals for a tourist resort development, and one concerned one of the reefs listed in Table 1. Details of the case studies can be found in Foale (1998) and Foale and Macintyre (in press).

Economic priorities

A survey of villagers on Sandfly Island, in which people were asked to name their most important source of income over the course of a year, revealed that trochus was of quite minor importance as an income earner for most individuals, in the general scheme of things. Sales of finfish to Honiara were most commonly rated as the top earner. However, most people believed that trochus gave the highest return for effort of the available income options. It is relatively easy to obtain, needs no processing (apart from removing the meat, which is really a subsistence bonus), can be stored indefinitely at no cost, sold quickly and in any quantity, and is relatively easy and cheap to transport. For most of 1994 and 1995, villagers were receiving an approximate equivalent in local currency of USD 3.50–4.35 per kg for whole trochus shell delivered to Honiara. Most villagers in Nggela regard trochus as 'pure cash just sitting on the reef'.

Although the money derived from sales of trochus can be, and often is, used for individual purposes, proceeds from harvests following a *tambu* are commonly earmarked for family or communal purposes, such as the cementing of a grave, paying school fees or maintaining a clinic or church.

Local knowledge about trochus at Nggela

The following items of local knowledge relevant to trochus were widely agreed upon by West Nggela fishers:

- Trochus are easiest to find two or three days after full moon. This is a period known as '*dantega*'—a compound of '*dani*' (day) and '*tega*' (to perch), and referring to a moon that is 'perched' just above the horizon at daybreak at this time of the month.

- If reefs are closed to fishing for longer than a year, too many trochus are lost to shell borers ('rotten top' or *mboro vuvuha*) and hermit crabs (*komba*) (occupation of shells by hermits results in degradation of the shell, rendering it unsaleable if the hermit has been resident for more than a few weeks).

- Cyclone Ida, in 1972, was the main reason trochus are relatively scarce at Nggela today.

- A greater abundance of juvenile trochus can be found on the rubble zone (inshore of the reef crest) than on the reef crest and outer platform.

- Trochus abound on the deeper slopes of the reef (where the reef slopes away gradually, as on the north side of Sandfly and Buena Vista islands), beyond the reach of breath-holding divers, and migrate upwards to replace those removed by diving on the shallower part of the reef crest.

A regular survey of trochus on one reef, over a month and a half, lent some observational support of my own to the Nggela fishers' assertion that trochus are easier to find during the *Dantega* period (i.e. shortly after full moon). A large number of new trochus were recorded on the reef at this stage of the lunar cycle. It was during the *Dantega* period that I also obtained a photograph of a wild male trochus spawning (specifically, during the evening of the first night after full moon in December 1995).

It may be that a significant proportion of most trochus populations actually spend most of their time out of sight, relatively deep in recesses and holes in the reef, even at night, and only come up to the top of the reef around full moon, to spawn. They may remain near the surface for a few days before wandering deeper into the three-dimensional structure of the reef again.

Borer damage was very rare, with only one trochus affected from all the harvests examined during the study.

Abundant anecdotal evidence from older fishers indicates that trochus harvests prior to Cyclone Ida in 1972 were considerably larger than those at the time of fieldwork, in some cases by at least an order of magnitude. If trochus abundance did in fact drop significantly following the cyclone, as reported, it seems reasonable to assume that this would be due mainly to massive habitat destruction caused by the cyclone. Given that trochus grow to legal size (8 cm maximum basal shell diameter) in three years, and the plate coral, *Acropora hyacinthus,* grows at up to 10 cm per year, there should have been ample scope for substantial recovery of both trochus populations and suitable shelter for trochus in the ensuing 23 years, assuming no other factor, such as high fishing mortality, was acting to keep populations depressed.

These facts, and the evidence presented here, of constant and heavy fishing pressure on trochus at Nggela, makes it doubtful that Cyclone Ida is the sole reason for recent low harvest sizes.

A great deal of research has demonstrated that juvenile trochus are indeed more abundant (or at least are easier to find) on the rubble areas of reef flats than on the outer platform and reef crest (Smith, 1987; Bour, 1990).

Most trochus reside shallower than 8 m, which puts them well within reach of most breath-holding divers. Although trochus have been reported from as deep as 13 m, they are not common at such depths (McGowan, 1956).

The categories of biological information important for management

Most of the local knowledge of subsistence fishers in Melanesia is focused on locating target species in time and space, and then capturing them. Relatively little is focused on sustaining or maximising yields. The above examples are no exception. The other striking feature of Nggela local knowledge about trochus is that some of the axioms constitute, or lend support to, a denial of human agency over resource abundance. The story about Cyclone Ida, and the idea that populations are replenished from deep-water stocks, are examples.

Several categories of information are required for efficient management of tropical marine fisheries, such as trochus. They include the following:

1. lifespan and natural mortality rate;
2. reproductive biology, age/size at maturity, and potential fecundity;
3. growth rate;

4. sex ratios and fertilisation ecology;
5. dispersal range and settlement ecology of larvae;
6. habitat (including food) requirements, for both juveniles and adults;
7. other life-history features, including migrations, aggregations, habitat change;
8. other factors influencing recruitment, such as currents, and the location of fished (and unfished) populations with respect to these.

Both male and female trochus become sexually mature when they are between 5.5 cm and 7 cm basal diameter. If the size at which trochus become fishable is smaller than, or equal to, the size at which they mature, then heavy fishing pressure on a regional scale will result in recruitment failure and stock collapse. Enforcement of the 8 cm minimum size limit should go some of the way to mitigating this problem in the absence of any other practical measures. I am not sure at this stage how well the size limits are being enforced in Solomon Islands. They obviously were not being enforced in the mid 1990s.

That trochus have separate sexes, and are broadcast spawners, means that when stock densities decline below a certain threshold, populations become vulnerable to fertilisation failure (the Allee effect: Allee *et al.*, 1949). This could possibly be prevented or ameliorated by the creation of multiple, small reserves, on a scale smaller than the average dispersal range (one estimate was about 10 km for the majority of trochus larvae, which remain planktonic for about three days) (Heslinga, 1981).

A good knowledge of local currents would inform the optimal placement of reserves. Recent experience in Solomon Islands, however, suggests that, while marine reserves are undeniably a great idea, their deployment in Solomon Islands is still fraught with difficulties. These include the resolution of disputes over tenure, and the enormous handicaps involved in enforcing whatever does succeed in becoming established. However, we remain optimistic. Nelson Kile (pers. comm.) tells me that he has tried spawning trochus in tanks and then just tipping the larvae out into a lagoon. This technique appeals to me but I'm not sure how easy it will be to measure its success.

I am convinced that considerable improvements to the management of commercial invertebrates, especially trochus, can be achieved through a concerted effort at collaboration between custodians of local knowledge and fisheries biologists. Such collaboration is clearly not a simple matter, however, particularly given the vastly different contexts in which local ecological knowledge and fisheries biology are respectively situated. While the latter is typically a highly abstracted and explicit form of information, local knowledge is most often part of a 'system of knowing' which is fluid, context-sensitive, task-oriented and predominantly implicit (Borofsky, 1994). To be able to convey their information in a practical and demonstrably useful way so that it will be embraced by rural fishers and combined productively with local knowledge to improve fishers' own management strategies, is the challenge before us.

I am still trying to organise a video that clearly explains broadcast spawning, external fertilisation, dispersal, and settlement in trochus (and other commercial species). The video could be taken on tour in rural Solomon Islands, as I am sure this information has the potential to transform attitudes, and management strategies, of rural trochus fishers for the better.

Conclusions

The Customary Marine Tenure system has been shown, both here and in the work of others, to be a requirement for, but not a guarantee of, good management. The poor performance of the trochus fishery on many of the reefs at West Nggela, and elsewhere in Solomon Islands (Adams *et al.*, 1992) is adequate testament to this. The advent of a strong financial incentive (i.e. high return relative to effort) has led to high levels of fishing pressure, on particular stocks, which would not have occurred in a purely subsistence economy.

Despite the existence of local knowledge about trochus, some of the important categories of information needed to underpin a sound management strategy are lacking at West Nggela. Of particular concern is the apparent lack of knowledge about the planktonic dispersal larval phase of many reef fauna (including trochus) and the implications this has for recruitment failure when adult stock densities are very low over a wide area. This gap in local knowledge has clearly contributed to poor management practices.

Consequently some collaboration or consultation with adequately trained fisheries or NGO extension staff would clearly benefit the custodians of high value marine resources, such as trochus, in this context. Information delivery would of course have to be appropriately contextualised given the disparities between scientific and traditional Melanesian ways of thinking. The synergistic combination of the specialised expertise of both fishery biologists and rural fishers can hardly fail to bring about significant improvements to community-based management strategies.

It is also clearly important for any outside experts, working in Melanesia, to understand the complexities of the local property tenure system, and to appreciate the economic and social pressures on, as well as the aspirations of, rural fishers in Solomon Islands.

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Solomon Islands trochus project brief

by Michelle Lam (michelle.lam@ffa.int)

In 1996 a multi-million dollar project on trochus and green snail called the Atoll Project started in the Solomon Islands. It is funded by the Overseas Fishery Cooperation Foundation (OFCF) of Japan. The aim of the Project is to enhance the over-exploited species by mass seed production in hatcheries and reseeding of reefs. The Project is headed by a Japanese expert, Toru Komatsu, based at Aruligo here in the Solomon Islands. The hatchery work has been quite successful to date, and in November 1999, we tried our first reseeding. I was also fortunate enough to be sent to Okinawa, Japan, to learn mass seed production techniques for trochus and green snail in July/August this year, together with a fisheries officer from Kiribati.

News from Samoa

Introduction of the Green snail *Turbo marmoratus* to Samoa

Anne Trevor[1]

Introduction

The Green snail *Turbo marmoratus* was introduced into Samoa to enhance the depleted inshore resources. A feasibility study for the introduction of the Green snail into Samoa was carried out by a consultant from Vanuatu, funded by the South Pacific Aquaculture Development Project (SPADP) in 1996. As a result of this study the first shipment of 300 three-year-old green snails was imported from Tonga (again funded by SPADP) on 28 April 1999.

General background

It was suggested by Amos (1996) that potential habitats for the Green snail should have the following characteristics:

- Reef areas exposed to regular heavy wave action and strong tidal currents;
- Reef areas with the following topographical features:
  - spur and groove system in shallow areas,
  - smooth rocky surfaces covered with red coralline algae, macroscopic algae and/or any other microscopic algae rather than live coral, and
  - extensive areas without complicated microstructure in deeper water down to about 20 metres;
- Reef areas do not necessarily have to be well-developed reefs;
- Nutrient supply from island(s) adjacent to habitat;
- Reef without extreme dilution by freshwater run-off or pollution;
- Microhabitats for juveniles on the reef crest;
- Gentle reef slopes and terraces less than 20 m depths, providing a wide area for adult habitat.

The *T. marmoratus* stocks were quarantined in the Fisheries Division raceway ponds and then introduced into the following sites:

- Papa-I-Palauli, Savaii (100 shells) 18 May 1999
- Namua Is. (170 shells) 27 May 1999
- Saoluafata (30 shells) 10 June 1999

These sites were selected because:

- they were suitable areas according to the criteria suggested by Amos (1996),
- they were recommended by the AusAID Aquaculture Adviser, and
- they belonged to villages having an active village management committee in the Community-based Fisheries Management Programme.

The overall average aperture length for all specimens measured was 36.01 mm. On the day following introduction into Papa-I-Palauli, the villagers and Fisheries Extension staff recovered one dead shell. This mortality may have been due to transportation stress, harsh handling, shock of being in a new environment and possibly predators. On 2 June 1999, one snail marked PT1 was recovered on the windward side of Namua Island.

T. marmoratus are estimated to be sexually mature at 3–4 years of age and grow 2–3 cm in shell diameter per year (Yamaguchi, 1993). It is planned that all sites will be assessed within six months of introduction to monitor the survival and growth of the Green snails.

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1. Fisheries Division, Department of Agriculture, Forests, Fisheries and Meteorology, Apia, Samoa

News from Tokelau

The current status of introduced trochus in Fakaofo, Tokelau

Kelvin Passfield[1] *& Mose Pelasio*[2]

Introduction

In late 1997, Tokelau requested assistance from the Secretariat of the Pacific Community (SPC) to conduct a stock assessment of marine resources in Fakaofo as a first step towards producing a management plan for the lagoon. SPC recruited a consultant to conduct the survey in conjunction with local staff, and the survey was undertaken in July and August 1998. The consultant travelled on the *Forum Tokelau*, departing Apia on 27 July, arriving at Fakaofo on 29 July. The total duration of the stay on Fakaofo was 21 days. The other two atolls (Nukunono and Atafu) were not visited. This brief paper on trochus is extracted and modified from the larger report covering a greater range of marine resources of Fakaofo (Passfield, 1998).

Geography

Tokelau consists of three atolls stretching in a north-westerly direction from 9°23'S and 171°14'W for a distance of 170 km to 8°30'S and 172°30'W. The southern most atoll of Fakaofo is 65 km from Nukunono, with a further 105 km to Atafu, the northern most atoll. The total land area for the three atolls is only 10 sq. km., in an Exclusive Economic Zone (EEZ) of 290,000 sq. km. None of the three lagoons has deep-water entrances, and access for the artisanal fleet of small aluminium skiffs and traditional canoes is through shallow passages in the reef, often inaccessible at low tides. Figure 1 shows the location of Tokelau and Fakaofo.

Demography

The population of Tokelau consists of approximately 1500 people, with between 400 and 600 people on each of the three atolls. A further 5000 Tokelauans live in New Zealand (SPC, 1998), with an unknown number living in Australia and Samoa. In 1996, Fakaofo, the location for this study, had a population of 564, living in 87 households, on two islands (SPC 1998). The island of Fale currently has a population of about 340 living in 51 households, with approximately 220 people in 33 households living on the other inhabited island of Fenua Fala (M. Pelasio, pers. comm.).

Survey methods

Ten areas around the lagoon perimeter were surveyed for marine resources. There were usually three men either walking or swimming in the shallow water on the reef flat. Observations of fish life were made, and transects were undertaken in areas where there were sedentary resources of interest, e.g. trochus, clams, sea cucumbers and sea urchins. An intensive search for trochus was conducted in one area where anecdotal reports indicated they were abundant. Snorkelling over the reef was undertaken where conditions permitted. Figure 2 shows the ten survey sites.

Results

Although extensive surveys for trochus were not conducted all around the atoll, the fact that

1. Currently C/- Samoa Fisheries Project, P.O. Box 244, Apia, Samoa. E-mail: passfield@lesamoa.net
2. Tokelau Department of Natural Resources and Environment, Fakaofo, Tokelau.

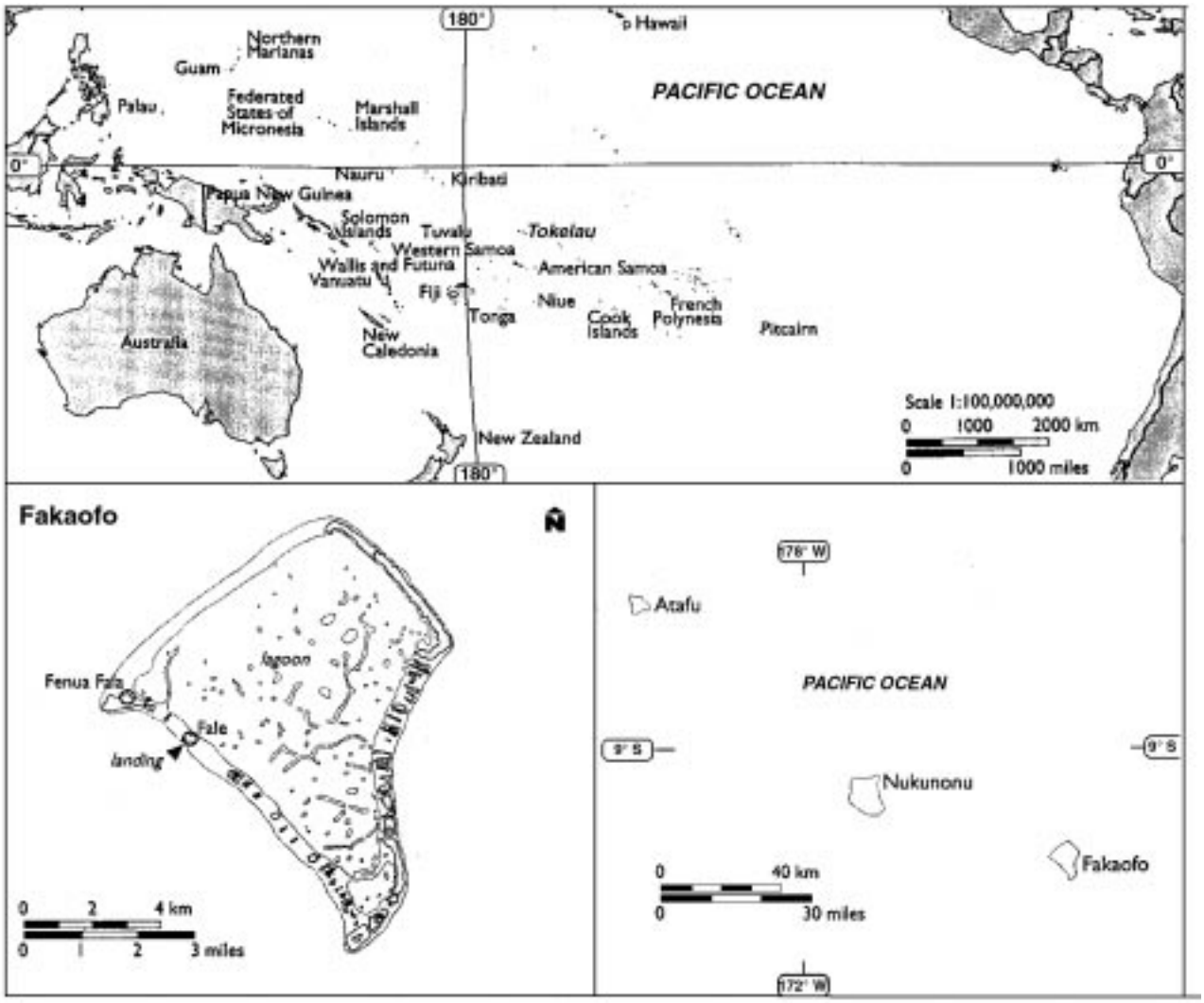

Figure 1.

Map showing the locations of Tokelau and Fakaofo

trochus were not observed at any of the survey sites other than from south-east of Fale to Fenua Fala (around site 9) suggests that they are still not widespread. The reef crest and inner reef flat were searched. Juveniles were searched for under rocks. A total of 162 trochus were measured and tagged by writing on the inside bottom nacre of the shell with a pencil.

All trochus were found in the area from Fale to the Catholic Island. Most were found in a 400-metre stretch from the powerhouse towards the Catholic Island. Sea conditions did not permit searching over the reef in this area, where Gillett (1994) found more trochus of an average larger size than those on the reef flat. Figure 3 shows the size distribution for the trochus found during the 1998 survey. Most were in the 9 to 10 cm size range. During the 1994 survey by Gillett, trochus were most abundant in the 6 to 7 cm category on the reef flat. This large cohort is unlikely to be the same one four years later, as growth would be expected to be around 2 cm per year at the 6 to 7 cm age class, decreasing to about 1 cm per year at the 10 cm age class (Nash, 1985). Gillett's 6 and 7 cm trochus would now be around 12 cm. It is possible these have moved over the reef flat into deeper water, as Gillett's survey found trochus of an average larger size over the reef.

Discussion and recommendations

Trochus are not native to Tokelau, but were transplanted there in the hope that they would become established and provide a source of income for the islands. They were transplanted to Fakaofo in 1986 (586 and 283 trochus on two separate occasions) and again in 1988 (578 trochus) (Gillett, 1986,

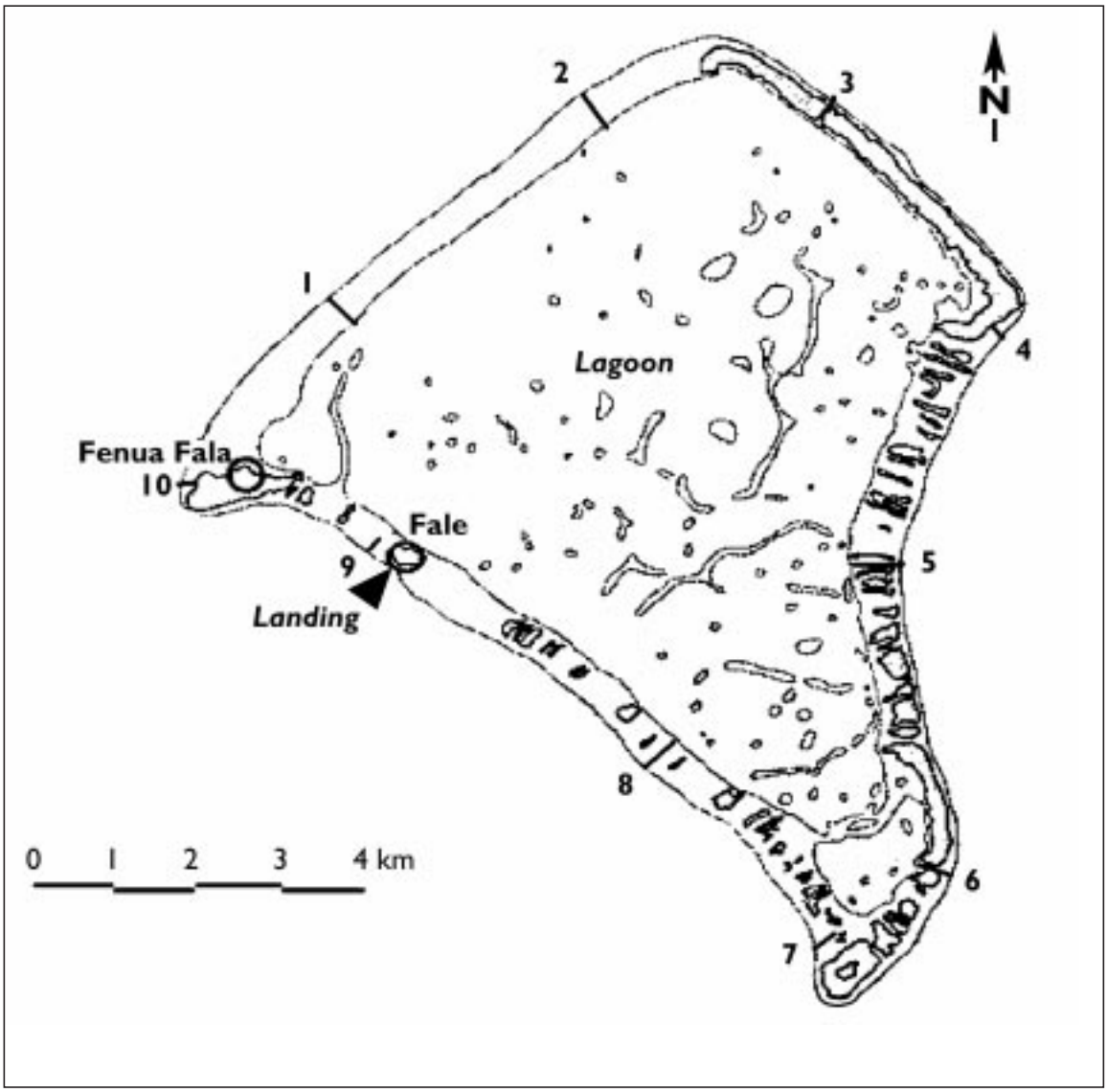

Figure 2.
Fakaofo, showing the ten survey sites

1988). Several subsequent trochus surveys have been carried out, the last in June 1994 (Gillett, 1988, 1994).

This survey indicated that trochus are continuing to do well, and increase in numbers. However, they have still not managed to become established in most of the reef area, despite the apparently suitable habitat in many locations. It is still far too early to have a commercial harvest. However, trochus could be collected from the area where they are abundant, and transplanted to other areas around the island containing suitable habitat, in an effort to increase overall abundance. A total ban on the harvesting of trochus currently in place should be continued for at least the next five years, after which the situation should be reassessed.

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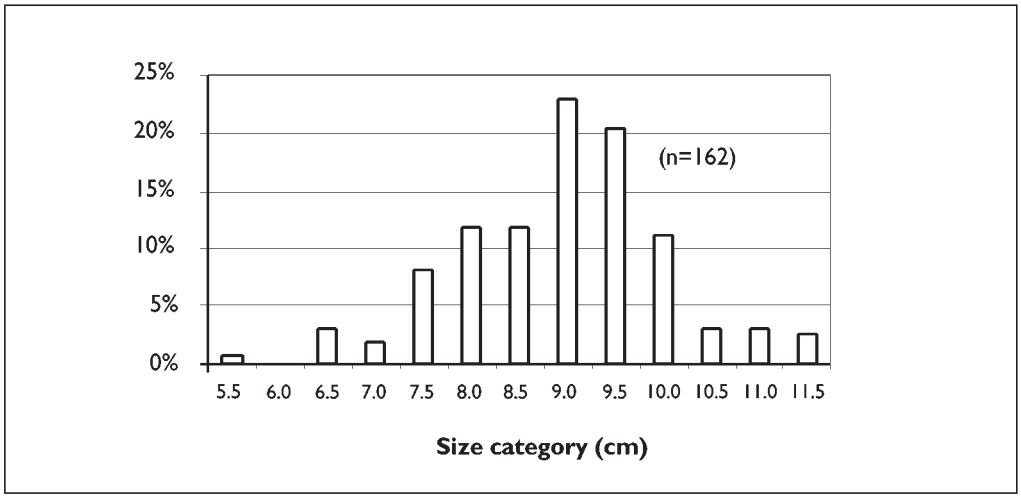

Figure 3.

Trochus size distribution from the 1998 survey

Mose Pelasio (right) and other members of the survey team measuring trochus on Fakaofo reef flat

News from the ACIAR Trochus Reseeding Research Project

ACIAR Trochus Reseeding Research Project in northern Australia, eastern Indonesia and the Pacific extended for another two years

Dr Chan L. Lee[1]

The Australian Centre for International Agriculture Research (ACIAR) has extended its trochus reseeding research project involving Australia, Indonesia and Vanuatu for another two years, from January 1999 to December 2000. Dr Chan L. Lee, who moved from the Northern Territory University to Fisheries Western Australia (FWA), has been reappointed as the project coordinator with FWA as the commissioned organisation. The country coordinators for Vanuatu and Indonesia are Mr Moses Amos and Dr Sigit Dwiono respectively.

During the two-year extension, the project will focus on the following activities:

- site-specific and country-specific research linked to the implementation of appropriate management regimes to ensure success in reseeding research;
- the research to be conducted on larger spatial scales;
- further development of enclosures for intermediate culture of small trochus, fisheries closures to protect breeding stocks, and broodstock manipulation to enhance recruitment to the fishery.

Research activities

The Australian node will carry out the research on selected sites in King Sound, Western Australia. The Indonesian node will carry out the research in Morella, Ambon, while Vanuatu will conduct its work in the trochus fishing area in Erakor where Customary Marine Tenure (CMT) is in place.

The research project will develop suitable methodologies for reseeding trochus. It will lead to:

- the development of a sound strategy for enhancing stocks via seeding hatchery-produced juveniles and translocation of broodstock to over-exploited reefs;
- the implementation of a site-specific approach to reseeding;
- the incorporation of appropriate management regimes working in tandem with traditional management practices; and
- the formulation of a follow-up development/technology transfer proposal for conducting large-scale reseeding work running hand in hand with complementary country and/or site-specific management strategies to enhance trochus stocks in Australia, Indonesia and the Pacific.

Australia

As part of the research in Australia, a pilot hatchery to produce juvenile trochus for the reseeding research was constructed at One Arm Point in July 1999. The hatchery was funded by ACIAR, Fisheries WA, Bardi Aborigines Association and Aboriginal and Torres Strait Islanders Commission (ATSIC).

The first hatchery cycle produced >140,000 small 2–4 mm size class juveniles. A second production cycle is currently running.

For field reseeding research, Dr Steven Purcell was recruited to the project in August 1999. He will implement the field studies involving reseeding with hatchery juveniles and enhancing the fishery using mature broodstock and releasing them in selected sites. Monitoring of the released animals will be conducted regularly over the next 15 months.

1. Project Coordinator, ACIAR Trochus Reseeding Research Project, Fisheries Western Australia, WA, P.O. Box 71, Broome 6726, WA, Australia. Fax: +61 8 91935470; Phone: +61 8 91921121; E-mail: clee@fish.wa.gov.au

Indonesia

In Ambon, the project node managed by Dr Sigit Dwiono of LIPI (Indonesian Institute of Sciences) will concentrate on standardising the use of concrete cages for producing larger juveniles (30–50 mm) in coral reefs off the township of Morella for reseeding. A pilot hatchery was set up at Morella and managed by the villagers under the guidance of LIPI. Villagers were involved in the daily activity pertaining to the care and maintenance of the juveniles in the hatchery and providing security to the reseeded sites.

The Indonesian node will assess the impact of reseeding with different size class of juveniles (30, 40 and 50 mm) on the reseeded reefs.

Vanuatu

In Vanuatu, the trochus hatchery belonging to the Fisheries Department continues to work well under the guidance of Mr Moses Amos, the Director of Fisheries, and Kalo Pakoa, the project scientist. A large number of juveniles has currently been produced for research involving studies on:

- mass reseeding with small (1–3 mm) juveniles in natural and manipulated habitats;
- determining suitable types of cages and optimum densities for stocking in cages for intermediate culture of trochus to 30–40 mm for subsequent reseeding.

Conclusion

The success of the proposed research work will establish simple methodologies for reseeding with hatchery-produced juveniles and restocking with mature broodstock. In conjunction with appropriate management regimes and traditional management practices, it will provide a pathway for restoring and re-establishing trochus in depleted reefs. However, whether the research will lead to the establishment of a sustainable trochus fishery in the three countries involved will be a real challenge.

News from New Caledonia

Recent developments in trochus shell export from New Caledonia

Régis Etaix-Bonnin

The oldest statistics on trochus exploitation in New Caledonia date back to 1907 and concern the export of raw shells for the food preparation market.

These data indicate a strong variability in exports over time (saw-tooth curve), thereby demonstrating the fragile nature of the trochus stock, with periods of low export succeeding periods of significant harvests (1946–1954 and 1975–1984), which themselves had been made possible by previous periods allowing regeneration of the stock (Second World War and the mining boom of the 1960s).

Since the second half of the 1980s, tonnage levels have remained low, i.e. less than 300 tonnes annually. In addition, over the past five years, there has been a drop in exports as shown in Table 1.

This drop in exports is apparently not due to tension on the market as the average per-kilo prices remained quite steady over this period.

The persistence of low tonnage levels for more than a decade at levels far below the 400 tonnes given in an ORSTOM (now the IRD- French Re-

1. Ingénieur chargé des pêches. Service de la Marine Marchande et des Pêches Maritimes. Noumea. E-mail: etaix-bonnin@territoire.nc

search Institute for Development) report as the optimal level for New Caledonia's trochus stock exploitation raises a bit of concern about this stock's current state of health.

In any event, it is certain that the study of this resource requested by New Caledonia's Northern Province will make it possible to get a more precise idea of the status of the local trochus stock, which will then allow the current regulations setting the minimum harvest size for these molluscs at 9 centimetres to be modified.

Table 1. **Trochus exports from New Caledonia, 1994–1998**

	1994	1995	1996	1997	1998
Quantity (tonnes)	273.7	250.0	197.4	124.7	151.3
Value (US$)*	1,129,504	1,057,635	860,994	603,717	700,227
Average price (US$ per kilo)*	4.13	4.23	4.37	4.84	4.63

* For US$ 1.00 = 115 CFP

new publications & abstracts

KIKUTANI K. & H. YAMAKAWA. (1999). **Marine snails seed production towards restocking enhancement basic manual.** Field Document no. 14. South Pacific Aquaculture Development project (II), Food and Agriculture Organization of the United Nations. GCP/RAS/116/JPN, Suva Fiji, and Tonga Aquaculture Research 58 p.

This manual has been produced to help aquaculturists in seed production of marine snails in their respective tropical island nations. It was produced by the participants to regional training workshops held in Tonga in February–March and March–April 1998. It has been conceived with the following objectives:

- to help other aquaculturists in the region to produce the marine snail seed which is an important resource for the region;
- to provide a simple, easy-to-follow guide on seed production and restocking methods for marine snails; and
- to create awareness of the importance of stock enhancement.

Contents:

4. Suggestions for stock enhancement

4.1 Tagging and measuring Green snails seeds
4.2 Site survey
4.3 Transplanting procedures
4.4 Monitoring and recovering methods
4.5 Management strategies

5. References

+ 12 Appendices.

DEVARAJ, M. (1996) **Sea-farming and conservation of molluscan resources of India**. In: Proceedings of the sixth Workshop of the Tropical Marine Mollusc Programme, Annamalai University, India, 12–20 June 1995. Ed.: J. Hylleberg & K. Ayyakkannu. No. 16: 71–78

Aquaculture, depuration, sea-farming, conservation, and landing of molluscs in India are reviewed. Greater emphasis is placed on the activities of the Central Marine Fisheries Research Institute (CMFRI). Pearl oysters, *Pinctada fucata* and *P. margaritifera*, give maximum revenue per unit area when compared to other aquaculture systems. The edible oysters *Crassostrea gryphoides* and *C. madrasensis* are cultured in Indian waters. With raft culture technique the production reaches 60–80 t/ha/year. Seed production and raft culture of mussels (*Perna viridis* and *P. indica*) have been developed by the CMFRI. Culture and harvest of clams are confined to *Anadara granosa, Villorita cyprinoides, Meretrix meretrix, M.casta, Paphia malabarica, Katelysia opima*, and the giant *clams Tridacna crocea, T.maxima, T.squamosa*, and *Hippopus hippopus*. The annual yield of clams is estimated at 45,000–50,000 t. In 1993–94 a total of 769 t of frozen clam meat (mostly *P. malabarica*), valued at US$ 0.74 million, was exported. Fishery independent factors are a source of major concern in the management of clam resources. Fishermen are conscious of the need for the management and conservation of clam resources. The overall harvest of chank, *Xancus pyrum* is about 1,256,000 individuals per year. The annual harvest of top shell (*Trochus niloticus*) is estimated at 400–600 t and turban shell (*Turbo marmoratus*) at 100–150 t. The total quantity of whelk meat (*Babylonia* spp.) exported from India during 1993–94 was about 300 t. Culture of squids has been attempted, but provision of live food was considered a major constraint for the success. However, the potential squid fishery within the Indian EEZ is estimated at 1.8×10^5 tons.

DORAIRAJ, K & R. SOUNDARARAJAN. (1998). **Status of molluscan resources of the Andaman Islands**. In: Island Ecosystem and Sustainable Development. Eds.: B. Gangwar, K. Chandra. Andaman Science Association, Port Blair, India. 106–115.

A large variety of molluscan forms are distributed along the coastal and offshore areas of Andaman and Nicobar Islands. The important among them are the top shell (*Trochus niloticus*) turban shell (*Turbo marmoratus*), blacklip pearl *oyster (Pinctada margaritifera*) giant clams (*Tridacna* spp.) green mussel (*Perna viridis*), edible oysters *Crassostrea* and *Saccostrea* spp.), five finger chank (*Lambis lambis*), scorpion shell (*L. chiragra*), cowries (*Cypraea* spp.), abalone (*Haliotis* spp.), pearly nautilus (*Nautilus* sp.) and other cephalopods comprising of squids, cuttlefish and octopi. In order to safeguard and regulate the shell fisheries of the islands, three important acts, namely, Fisheries Regulation, 1938, Fishing Rules, 1939, and Andaman and Nicobar Shell Fishing Rules, 1978, have been promulgated by the Island Administration. For the exploitation of the shell fisheries, the coastal waters of Andaman and Nicobar Islands, have been demarcated into 9 zones and these zones are auctioned and given on lease to the highest bidder for the collection of shells in alternate blocks of two years. In this paper, all the basic information pertaining to fishing zones, shell collection methods, resource status of important molluscan forms, together with notes on ecological and biological aspects are presented and discussed. Some workable measures have also been suggested for the development of Andaman shell fisheries to ensure sustainable production.

CASTELL, L.L. (1997). **Population studies of juvenile *Trochus niloticus* on a reef flat on the north-eastern Queensland coast, Australia**. Mar. Freshwat. Res. vol. 47, no. 3, 211–217.

Transects and quadrats were used to sample the distribution and density of *Trochus niloticus*, recruitment, growth rates of juveniles, and characteristics of the microhabitat, on an intertidal reef flat at Orpheus Island between 1993 and 1995. Individuals between 1.5 and 62 mm shell width (SW) were found in all parts of the reef flat. Their density averaged 0.178 and 0.115 individuals/m^2 in 1993 and 1994, respectively. Juveniles were found in groups of 2–4 individuals/m^2 more frequently than would occur by

chance, but denser aggregations were rare. As juveniles increased in size, there was a change in microhabitat: from small rubble (<10 mm) to larger rocks and coral bench and from shallow pools (<10 mm deep) to deeper pools. The size-frequency distribution was bimodal during parts of the year, suggesting seasonality in recruitment. Growth rates ranged between 2.3 and 2.6 mm SW/month. In relation to the seeding of cultured juveniles for population enhancement, the results indicate that seeding densities should be <5 individuals/m^2. Shallow areas with abundant small rubble may represent favourable conditions for individuals of <15 mm SW, but deeper areas are better for individuals of greater than or equal to 15 mm SW.

CASTELL, L.L. & H.P.A. SWEATMAN. (1997). **Predator-prey interactions among some intertidal gastropods on the Great Barrier Reef.** J. Zool. 1997 vol. 241, no. 1, 145–159.

On an intertidal reef flat at Orpheus Island on the Great Barrier Reef, the gastropods *Turbo brunneus* and juvenile *Trochus niloticus* share the same habitat with the predatory gastropod *Thais tuberosa*. To determine if the two prey species differed in their antipredator behaviour and interactions with the predator, we examined: (1) the distributional pattern of the three species in the field; (2) the proportion of mortality attributable to non-crushing predators (i.e. *Thais tuberosa*) in *T. brunneus* and *T. niloticus*, determined by the frequency of freshly dead and undamaged shells; and (3) the response of *T. brunneus* and *T. niloticus* to *T. tuberosa* in laboratory and field experiments. We compared the responses of hatchery-reared and wild juvenile *T. niloticus* to determine if lack of previous exposure to the predator affected the behaviour of cultured juveniles. Finally, (4) we studied prey choice by *Thais tuberosa*. We found that: (1) the field distribution of all three species showed high overlap and prey and predator were often found in close proximity; (2) the proportion of recently-killed, undamaged shells was 28% for *T. brunneus* and 10% for *T. niloticus*; (3) *T. brunneus* and *T. niloticus* responded very differently to the predator: *Turbo brunneus* showed a conventional flight escape response, moving nine times faster than normal when close to *T. tuberosa*. The flight response was observed in all trials with *T. brunneus* in the laboratory, but only in 52% of trials in the field. In contrast, *T. niloticus* did not change speed but instead released a white mucus in the presence of the predator. Response in the field was also less intense than in the laboratory. Cultured and wild *T. niloticus* showed the same response when exposed to *T. tuberosa*, although cultured juveniles were, on average, slightly more active than wild juveniles. Lastly, (4) *Thais tuberosa* showed a strong preference for *T. brunneus* as prey. Food value, expressed as dry flesh weight, did not explain this preference. Capture rate of the preferred species *T. brunneus* fell to zero in water containing mucus released by *T. niloticus*. The results indicate that predation by *T. tuberosa* is more intense for *T. brunneus* than *for T. niloticus* and that a likely cause for this difference lies in the antipredator responses of the two prey species. The mucous response of *T. niloticus* appeared to be more effective for avoiding predation by *T. tuberosa* than was the flight response of *T. brunneus*.

SPC *Trochus Information Bulletin* on-line

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PIMRIS is a joint project of 5 international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the Secretariat of the Pacific Community (SPC), the South Pacific Forum Fisheries Agency (FFA), the University of the South Pacific (USP), the South Pacific Applied Geoscience Commission (SOPAC), and the South Pacific Regional Environment Programme (SPREP). 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

Pacific Islands Marine Resources Information System