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

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.

Social dimensions of trochus fishery management in Solomon Islands

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(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>
<thead>
<tr>
<th>Reef</th>
<th>Density* (per hectare)</th>
<th>Poached</th>
<th>Disputed</th>
<th>Remote</th>
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<td></td>
<td>(&gt;8 cm / &gt;6 cm)</td>
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<td>A</td>
<td>NA</td>
<td>Yes</td>
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<td>F</td>
<td>ND / 39.5</td>
<td>Maybe</td>
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<td>Yes</td>
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<td>G</td>
<td>27.6 / ND</td>
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<td>H</td>
<td>13.5 / 32.3</td>
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<td>I</td>
<td>42.5 / 76.9</td>
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(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.

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

References


Solomon Islands trochus project brief

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 (OCFC) 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.