

Appraising the resilience of trochus and other nearshore artisanal fisheries in the Western Pacific

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Introduction

Many coastal fisheries in the Indo-Pacific region are currently experiencing serious management problems with populations of a growing number of species showing steep declines. Trochus appears somewhat exceptional in this regard. It does not appear to be threatened with stock collapse in many places and, unlike some high-value invertebrates such as the green snail (*Turbo marmoratus*) and sea cucumbers (*Holothuria scabra* and *Holothuria nobilis*), appears to respond well to serial closures as commonly exemplified by the *tambu* or *tapu* system in many parts of Melanesia. In this short essay I wish to outline some of what I believe are plausible reasons for the relative resilience of trochus fisheries, and discuss what they imply for artisanal fishery management more broadly.

A number of extensive marine resource statistics, including diver surveys and surveys of landings, have been performed in Papua New Guinea (PNG), Solomon Islands and Vanuatu in the last five years or so (Amos 2007; Lincoln-Smith et al. 2006; National Fisheries Authority (Papua New Guinea) 2005, 2007a, b; Ramohia 2006; Skewes et al. 2002, 2003). These data collectively provide an alarming reminder of the severity of overexploitation of certain high value species across the region. However, trochus stocks, while they have reportedly declined in some locations such as Vanuatu, are far from collapsed. Amos (2007) reports significant declines in overall exports for trochus between 1996 and 2004, with 157.6 tonnes processed in 2003, down from a peak of 476.4 tonnes in 1998. The PNG National Fisheries Authority (2005) reported “mollusc” landings of just over 120 tonnes at Kavieng between December 2002 and April 2004, 99% of which was trochus, and 0.6% of which comprised green snail. In Milne Bay, no green snail was landed between December 2005 and December 2006 (National Fisheries Authority, Papua New Guinea 2007b), while around 18 tonnes of trochus were landed for the same period. During the country-wide diver survey of Solomon Islands performed by the Nature

Conservancy in 2004, no green snails were sighted at all, while the overall density of trochus was calculated to be 10 per ha.

Several of the above-mentioned surveys also report sharp declines in other species, including the giant clams *Tridacna gigas* and *T. derasa*, and the sea cucumbers *Holothuria scabra* and *H. nobilis*, which will be discussed below in relation to the stock dynamics of the gastropod mollusc fisheries. First, however, I will outline an analytical framework for understanding the recent fates of the various commodity fisheries in the Western Pacific, why they have followed such different trajectories, and what this implies for management approaches in each case.

A framework for analysing pressure on, and resilience of, different commodity fisheries in the Pacific

A wide range of considerations must be taken into account when appraising the management challenges for different commodity fisheries in the Pacific. They include the following:

1. **Commodification.** Generally speaking, fishing pressure is much heavier for commodity fisheries than for subsistence fisheries. The divide between the two types of fisheries is much greater for countries with very low population densities, such as PNG, Solomon Islands and Vanuatu (Sabetian and Foale 2006).
2. **Market price** is a key determinant of the level of fishing effort applied to a fishery. As fisheries become depleted, the price frequently goes up. There are many examples of this, with perhaps one of the most spectacular being the Chinese bahaba fishery (Sadovy and Cheung 2003). The price of dried bahaba swim bladders increased from a few US dollars per kilo in the 1930s to between USD 20,000 and 64,000 in 2001, which made it more valuable than gold, even at today's (2008) prices. This inverse relationship between abundance and price sets up a vicious cycle that often drives fisheries to collapse.

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3. **Ease of storage and transport.** Non-perishable and dried commodities such as shells, shark-fins and beche-de-mer are much easier to store and transport to market than fresh fish or live fish. Species that cannot be stored and economically transported to market will inevitably be subject to less fishing pressure than those that are.
4. **Life history.** Growth rate, age at maturity, longevity and fecundity all affect the way that populations of any given species respond to fishing pressure. As a general principle, species with higher rates of population turnover tend to be more resilient to fishing pressure (e.g. Dalzell 1993; Pauly et al. 1998). Exceptions to this principle should not be ruled out, however. There are other important and often complex life-history factors that affect resilience to fishing, particularly those relating to larval dispersal and settlement behaviour.
5. **Ease of capture.** Some species are more vulnerable to overfishing because they are easier to capture. Species with limited or no mobility and shallow depth distributions tend to be overharvested more rapidly than mobile, deep and/or cryptic species.

There are of course interactions and trade-offs among these factors for most fisheries.

Trochus occupies an interesting position with respect to the above rules. It is sedentary, and its shallow distribution (most animals live at depths of less than 15 m) means that reasonably fit divers can access most of the population without SCUBA or hookah. The shell can be stored indefinitely and transported at fairly low cost. In combination with a moderately lucrative price incentive, these factors render it vulnerable to overfishing. At the same time, it grows quickly and is sexually mature by about year two or three when it has a basal diameter of around 6 cm (Foale and Day 1997; Nash 1993). It also displays a level of cryptic behaviour (detailed below) that some researchers have noted (Nash 1993; Foale 1998a; Foale and Day 1997) and that has also been observed by Pacific subsistence and artisanal fishers (Foale 1998a, b; Foale 2006). This cryptic behaviour may be pivotal to the fact that trochus fisheries have not yet experienced widespread stock collapse, in contrast to green snail (*Turbo marmoratus*) and some of the other high value invertebrates mentioned above.

Throughout much of coastal Melanesia, trochus fisheries are “managed” with serial closures – the well-known *tambu* or *tapu* system. Some authors

(e.g. Cinner et al. 2005; Hickey 2006; Johannes 2002) have argued that this “long-enduring” system (see Polunin 1984 for some important qualifications to this common assumption) constitutes a culturally appropriate and indeed “adaptive” form of fishery management for the Pacific. I would argue that the efficacy of this system is highly contingent on a host of other considerations, including all of those listed above. The *tambu/tapu* system has failed to prevent the commercial extinction or near-extinction of green snail, giant clam, sandfish and black teatfish throughout much of their range. But trochus populations, while they have clearly declined in some areas, appear not to have suffered quite the same level of depletion yet, in most places.

One of the shortcomings of the use of serial closures, particularly for commodity fisheries, is that when the closed area is opened to fishing, fishing effort can often be very intense and unrestrained – people usually harvest every last individual that they can find. In the case of trochus, it appears that a certain proportion of the population, perhaps up to a third, is hidden deep in reef crevices and out of reach of divers at any one time. Indirect evidence for this behaviour is provided by the observation that trochus populations tend to increase noticeably just after the full moon in summer months, when many animals apparently leave their hiding places and move to relatively exposed positions on the reef to spawn (Foale 1998a, b, 2000). A serial closure system means that those individuals that evade capture during a harvest (assuming all harvests are not timed to coincide with spawning) will then enjoy protection during the subsequent prohibition, and this may guarantee a level of population replacement sufficient to prevent stock collapse.

In contrast, green snail does not appear to enjoy such an ecological/behavioural refuge, and given the similar life history and depth range (Yamaguchi 1993),² it has experienced a very different fate throughout the same geographic range. White teat sea cucumbers (*Holothuria fuscogilva*) enjoy a different kind of refuge – depth. This species can be found as deep as 40 m (Skewes et al. 2002), putting a significant proportion of the population out of reach of free divers. Even using SCUBA or hookah, a diver cannot spend long at 40 m without risking decompression sickness. Consequently, white teat populations have not been depleted nearly as drastically over the past two decades as sandfish (*H. scabra*) or black teat (*H. whitmaei*) (National Fisheries Authority, Papua New Guinea, 2005, 2007a, b; Skewes et al. 2002).

2. The price offered to fishers for green snail in New Ireland Province, PNG (K 4.71 kg⁻¹) is slightly lower than for trochus (K 5.24 kg⁻¹) (National Fisheries Authority (Papua New Guinea) 2005), while in Vanuatu it is considerably higher (VUV 1,700–3,000 kg⁻¹ vs VUV 170–300 kg⁻¹) (Amos 2007).

There may well be other factors that have contributed to the differences in abundance patterns of trochus and other nearshore commodity fishery species. The minimum size limit of 8 cm basal shell diameter (9 cm in Vanuatu: Amos 2007) appears to have been reasonably well enforced in Solomon Islands since the late 1990s, and this measure ensures that each individual is sexually mature for about a year before it enters the fishery (Foale and Day 1997). Such a measure may have also contributed significantly to the prevention of stock collapse, along with the hypothesised ecological/behavioural refuge mentioned above.

Conclusions

Amos (2007) reports that there is now a 10-year ban on green snail in Vanuatu. The beche-de-mer fishery has also recently been closed there, as it has in Solomon Islands. These are drastic though obviously necessary measures, which make it clear that community-based management in the form of traditional serial closures has not been sufficient to prevent the collapse or near collapse of several high value species. What I have argued here is that by virtue of aspects of the behaviour, life-history and ecology of trochus, perhaps in combination with minimum size limits imposed by governments, stocks of this fishery have declined but not collapsed in PNG, Solomon Islands and Vanuatu. Probably the best managed trochus fishery in the Pacific is the Aitutaki fishery (Nash et al. 1995), which is run on a simple quota system, and is subject to regular stock assessments involving members of the local community. The management scheme at Aitutaki was developed over several years of collaboration between the Cook Islands Fishery Department and the Aitutaki community, which clearly enjoys a high level of social cohesion, making compliance with the regulations much less problematic than in many parts of Melanesia.

My research on trochus in the Nggela group in Solomon Islands in the 1990s showed that the *tambu* system was not a spectacularly successful system for managing trochus fisheries, and indeed yields there compared very poorly to yields at Aitutaki at the time (Foale 1998a; Foale and Day 1997). But a visit to Sandfly Island in mid-2007 made it clear to me that the trochus fishery at Nggela continues to deliver a modest but steady yield. While differences in reef type between Nggela (fringing reefs) and Aitutaki (an atoll) make it difficult to be too assertive about the differences in productivity of these fisheries, it does appear that trochus fisheries could perform much better with a quota-based management system in Melanesia. Setting up and enforcing such a system would probably be more challenging than it was in Aitutaki, however, given the high levels of social and political fragmentation in the Melanesian countries and the low levels of donor support to their Fisheries Departments.

The evidence at hand does not appear to support the argument that traditional serial closures are an “adaptive” form of management for nearshore fisheries in general in the Western Pacific. A closer examination of each fishery shows that some species, including trochus, have fared much better under this system than others, and that stock dynamics for the different fisheries are better explained using the framework outlined above. Serial closures do not appear to be likely to adapt to the inevitable increase in fishing effort that accompanies growing human populations and rising commodity prices driven by increased demand from China, along with the growing scarcity of many marine products. What is clearly needed across the region is greater support to governments to assist in establishing effective and transparent monitoring and regulatory measures to prevent further stock collapses and (if possible) rehabilitate severely depleted fisheries such as those discussed here.



Figure 1.
Wild male trochus spawning
(Solomon Islands).

References

- Amos M. 2007. Vanuatu fishery resource profiles. Apia: Secretariat of the Pacific Regional Environment Programme. 208 p.
- Cinner J., Marnane M.J., McClanahan T.R. and Almany G.R. 2005. Periodic closures as adaptive coral reef management in the Indo-Pacific. *Ecology and Society* 11(1):31.
- Dalzell P. 1993. Small pelagic fishes. p. 97–133. In: A. Wright and L. Hill (eds). *Nearshore marine resources of the South Pacific*. Suva: Institute of Pacific Studies, Forum Fisheries Agency, International Centre for Ocean Development.
- Foale S.J. 1998a. Assessment and management of the trochus fishery at West Nggela, Solomon Islands: An interdisciplinary approach. *Ocean and Coastal Management* 40:187–205.
- Foale S.J. 1998b. The role of customary marine tenure and local knowledge in fishery management at West Nggela, Solomon Islands. *Zoology Department, The University of Melbourne*. 249 p.
- Foale S.J. 2000. Social dimensions of trochus fishery management in Solomon Islands. *SPC Trochus Information Bulletin* 6:5–10.
- Foale S.J. 2006. The intersection of scientific and indigenous ecological knowledge in coastal Melanesia: Implications for contemporary marine resource management. *International Social Science Journal* 58(187):129–137.
- Foale S.J. and Day R.W. 1997. Stock assessment of trochus (*Trochus niloticus*) fisheries at West Nggela, Solomon Islands, with notes on management. *Fisheries Research* 33:1–16.
- Hickey F. 2006. Traditional marine resource management in Vanuatu: Acknowledging, supporting and strengthening indigenous management systems. *SPC Traditional Marine Resource Management and Knowledge Information Bulletin* 20:11–23.
- Johannes R.E. 2002. The renaissance of community-based marine resource management in Oceania. *Annual Review of Ecology and Systematics* 33:317–340.
- Lincoln-Smith M.P., Pitt K.A., Bell J.D. and Mapstone B.D. 2006. Using impact assessment methods to determine the effects of a marine reserve on abundances and sizes of valuable tropical invertebrates. *Canadian Journal of Fisheries and Aquatic Sciences* 63(6):1251–1266.
- Nash W.J. 1993. Trochus. p. 451–496. In: A. Wright and L. Hill (eds). *Nearshore marine resources of the South Pacific*. Suva: Institute of Pacific Studies, Forum Fisheries Agency, International Centre for Ocean Development.
- Nash W., Adams T., Tuara P., Terekia O., Munro D., Amos M., Leqata J., Mataiti N., Teopenga M. and Whitford J. 1995. The Aitutaki trochus fishery: A case study. Noumea: SPC. 72 p.
- National Fisheries Authority (Papua New Guinea) 2005. Small-scale fisheries in New Ireland Province: Landing, market and buyer surveys in Kavieng. Kavieng: National Fisheries Authority Coastal Fisheries Management and Development Project. 77 p.
- National Fisheries Authority (Papua New Guinea) 2007a. Sea cucumber survey – New Ireland Province. Kavieng: National Fisheries Authority and Coastal Fisheries Management and Development Project. 39 p.
- National Fisheries Authority (Papua New Guinea) 2007b. Small-scale fisheries in Milne Bay Province: landing, market and buyer surveys in Alotau. Kavieng: National Fisheries Authority Coastal Fisheries Management and Development Project. 43 p.
- Pauly D., Christensen V., Dalsgaard J., Froese R. and Torres F. 1998. Fishing down marine food webs. *Science* 279(5352):860–863.
- Polunin N.V.C. 1984. Do traditional marine “reserves” conserve? A view of Indonesian and New Guinean evidence. p. 267–283. In: K. Ruddle and T. Akimichi (eds). *Maritime Institutions in the Western Pacific*. Osaka: National Museum of Ethnology.
- Ramohia P. 2006. Fisheries resources: Commercially important macroinvertebrates. p. 530. In: A. Green, P. Lokani, W. Atu et al. (eds). *Solomon Islands marine assessment: Technical report of the survey conducted May 13 – June 17, 2004*. Brisbane: The Nature Conservancy.
- Sabetian A. and Foale S.J. 2006. Evolution of the artisanal fisher; case-studies from Solomon Islands and Papua New Guinea. *SPC Traditional Marine Resource Management and Knowledge Information Bulletin* 20:3–10.
- Sadovy Y. and Cheung W.L. 2003. Near extinction of a highly fecund fish: the one that nearly got away. *Fish and Fisheries* 4(1):86–99.
- Skewes T., Kinch J., Polon P., Dennis D., Seeto P., Taranto T., Lokani P., Wassenberg T., Koutsoukos A. and Sarke J. 2002. Research for sustainable use of beche-de-mer resources in Milne Bay Province, Papua New Guinea. Cleveland, CSIRO Division of Marine Research: 40 p.
- Skewes T., Kinch J., Polon P., Dennis D., Seeto P., Taranto T., Lokani P., Wassenberg T., Koutsoukos A. and Sarke J. 2003. Distribution and abundance of reef resources in Milne Bay Province, Papua New Guinea: Giant clams and other species. CSIRO Division of Marine Research Final Report. Cleveland, Australia, CSIRO: 29 p.
- Yamaguchi M. 1993. Green snail. p. 497–511. In: A. Wright and L. Hill (eds). *Nearshore marine resources of the South Pacific*. Suva: Institute of Pacific Studies, Forum Fisheries Agency, International Centre for Ocean Development.